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THE ECONOMIC RATIONALE OF THE STRUCTURAL AND REGULATORY REFORM OF THE MEXICAN ELECTRICITY SECTOR.

Abstract

We analyzed the Mexican proposal to restructure the electricity sector. The main results that we get are the following. First, given the current technologies for generation that belong to CFE and LFC and the new technologies that are more likely to get into the generation business, we conclude that the Australian model should be implemented in Mexico. This model asks for a stand by or reserve market to cover the excess demand in the peak period. Second, given the presence of economies of scale in transmission in Mexico, we conclude that in the first stage the Vogelsang's proposal of regulation should be implemented. Latter on, once the market is mature, the Hogan's proposal could be implemented. Third, the industrial tariffs are more likely to decrease after the reforms take place. The argument is based on the presences of subsidies for the residential tariffs. Finally, we make an argument to say that it is better to have the generation system and the dispatch in different entities. Although we loss some efficiency for not having these two firms integrated, we get benefits from expansion of generation. Given the situation of our market, the bigger gains are in the expansion of generation.

Resumen

Analizamos la propuesta de reestructuración del sector eléctrico. Los principales resultados que encontramos son los siguientes. Primero, dada la tecnología para generación que utiliza CFE y LFC y las nuevas tecnologías que entrarán al negocio de la generación, concluimos que el modelo Australiano debería ser implementado en México. Este modelo propone cubrir los excesos de demanda en periodos pico a través de un mercado stand by o de reserva. Segundo, dada la presencia de economías de escala en México, concluimos que en una primera instancia a propuesta de Vogelsang de regulación en transmisión se debería de implementar. Más adelante, cuando el mercado sea más maduro, la propuesta de Hogan se podría implementar. Tercero, las tarifas industriales tienen una probabilidad más alta de disminuir después de que se implementen las reformas. El argumento se basa en los montos de los subsidios que reciben las tarifas industriales y residenciales. Finalmente, presentamos un argumento para justificar que es mejor tener de manera separada a la transmisión y al despacho. Aunque esto generará una pérdida de eficiencia por no tener coordinación con las actividades integradas, se tendrán los benéficos por la expansión en generación. Dada la situación del sector eléctrico mexicano, las ganancias mayores están dadas en la expansión de generación.

Introduction[*]

In this paper we analyze the proposal submitted by the Mexican President to the Congress to amend articles 27 and 28 of the Mexican Constitution in order to carry out a structural reform and enhance private investment in the Mexican electricity industry. Also, according to the latter news, the proposal of the Partido Accion Nacional goes on the same way, with some differences. For this reason, the argument that we present in the paper applies to both proposals of reform.

We put the structure of the industry in context of the most recent literature of Market Architecture together with the traditional elements of vertical and horizontal integration. We analyze the current status of the industry in terms of efficiency, tariffs, and demand. We also present a discussion about the generation and transmission issues that are present in the proposal. We discuss what is the best model for generation and for transmission in order to get the best outcomes in terms of expansion and tariffs.

Our main results are the following. First, we find that given the available information about the different plant of the current structure of Comision Federal de Electricidad and Luz y Fuerza del Centro and the obsolescence of technology the model that would produce better results in terms of capacity and tariffs of generation is the so called Australian Model. This model says that in order to enhance generation, the excess demand must satisfied from a reserve or standby market.

Second, in order to discriminate between Hogan's locational pricing and Vogelsang's regulation for the case of transmission, we make an argument of economies of scale. In this case, given that the presence of economies of scale are important, we consider that in a first stage the Vogelsang's model fits better the Mexican industry. That is, the reform should ask for some regulation of tariffs for the case of transmission, in order to get the needed expansion of the grid. Otherwise, if the Hogan's proposal is implemented, there could be incentive problems for no to expand the grid and get higher tariffs due to congestion.

Third we analyze the electricity tariffs in the Mexican industry. Based on the available information, we conclude that the industrial tariffs are more likely to decrease than the residential tariffs. The main argument is that while the industrial tariffs are paying almost the cost of provision of the service, the residential tariffs have a subsidy of around 50%. Once these subsides are eliminated, both tariffs would go up and then would tend to decrease because of the efficiency gains. However, given the amount of the subsidy, the gains are going to be more visible on the industrial tariffs.

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Finally, we analyze the trade off between two positions for the case of the dispatch. On the one hand, there is the position that asks for an integration of the Transmission Company and the dispatch to take advantages of the coordination. In this way there should be less congestion problems and lower rates of energy losses. On the other, the position that asks for separated entities to give more incentives for generations. Each one of these positions take into account one of the two effects that are present in this context. However, given the situation of the Mexican electricity industry, the gains for having better incentives in generations are bigger that the gains for having an integrated transmission-dispatch system. This is particularly important for Mexico, where the industry is not as mature, as it is needed to implement the integrated system. This was the case of United Kingdom, where there were no gains from generation but only gains from integration because the industry was mature in that country.

The structure of the paper is the following. In Section 1, we present an analytical review for the electricity market. We present an interesting vision of the market, the so-called market Architecture. We also discuss the basic literature on vertical and horizontal integration and the decision between privatization and public or private ownership. In Section 2, there is a discussion of some of the international experiences on the electricity industry's reforms. In Section 3, we discuss the Mexican proposal. In Section 4, the British and Australian models for handling excess demand are analyzed. In section 5, we discuss the main alternatives for transmission system and we make an argument to decide between them for Mexico. Finally, in Section 6 we state the conclusions of the paper.

1. Analytical Review

Market Architecture

Recently a new discipline of economics is arising, Market Architecture, which analyzes classic economic issues about how details of market organization of an industry affect performance of economic agents (see R. Wilson (1999)). Processes of liberalization, structural reform, industrial reorganization, and privatization are present worldwide in most infrastructure sectors that seek increased economic efficiency. Questions regarding market design have to be initially solved due to coexistence of contestable and monopolistic areas. For example, in airlines and trucking regulation of market power is achieved through contestability while in telecommunications and natural gas transportation competitiveness is enforced through open access by competing carriers. Unbundling across electricity and gas industries is also seen as a means to expose cross subsidies. Privatization is further regarded as necessary to attract investment in most infrastructure industries. This is the case of the Mexican Reform on Ports. After the reform, there has been an increase of private firms providing almost all the services in the Mexican Ports.

Economists then become "engineers" or "architects" in the sense that they design the features of an economic building (the market) using as instruments a number of theoretical and practical mechanisms, in search of solidity, stability, and efficiency. As with any architectural process, the technology available to the architect-economist constrains her/his design possibilities. R. Wilson (1999) analyzes these issues for the electricity industry, which is plagued with incomplete and imperfect markets. He identifies a set of issues that complicate efficient market design. Electricity is an economic good that is expensive to store and that can hardly be metered. Moreover, transmission from generation plants to consumption centers is usually too complex and unstable, and can be affected by capacity constraints. Due to the electricity-flow nature, rights in the electricity transmission are difficult to be defined since electricity cannot be owned. Instead, rights usually exist to withdraw or inject power at specific points of the transmission grid. Other obstacles for market design are due to the need of energy and transmission provision in order to meet demand at real time as well as of reserves to meet random demand shocks.

Hogan (1999a) summarizes the state-of-the-art consensus regarding the optimal market design for an electricity industry based on both theoretical and international-practical experiences. Power generation and electricity marketing are considered as contestable, while transmission and distribution remain with naturally monopolistic characteristics.[1] Ideally, these activities are to be separated – in terms of ownership— in a competitive wholesale electricity market structure.

Additionally, a continuous electricity spot market is needed but the transmission system vulnerability may impede its operation. A system operator (SO) is thus needed in order to coordinate real-time operations from an engineering technical scope as well as from an economic perspective. According to Hogan (1999a), the SO must be allowed to offer the economic dispatch service based on marginal-cost power pricing, and participation in the dispatch should be voluntary. The pool service provides the means by which generation costs are minimized through merit-order bids that selects generators based on their generation price, and establishes as the market price the price-bid of the last dispatched generator.[2] The

[1] Technological advances in thermo electrical generation have recently turned this activity into a contestable one. However, hydro electrical and nuclear generation typically retain huge sunk costs and cost subadditivity.

[2] Wolfram (1999) analyzes the recent "Programme to Reform the Electricity Trading Arrangements" (RETA) that will be used in the British electricity industry starting September 2000. One of the proposed polices is that generators are paid in the pool market their actual bids instead of the last accepted bid. This means changing from a uniform-price auction to a discriminatory auction. Wolfram argues that the latter auction may lead to less competition and higher prices than the former auction.

SO operates a sequence of day-ahead and real-time operation as well as longer time frames. The system's stability is also maintained by the SO through the management of a pre-arranged system of reserves. A continuous balance is achieved using the submitted offers and several categories of reserves including regulation capacity, operating reserves, replacement reserves and reliability-must-run.

Contracts for differences provide generators and purchasers freedom to carry out bilateral contracts and ensure that any imbalance in production or consumption is settled though the pool price. In these contracts the parties mutually insure each other covering the difference between the contracted price and the market price. Bilateral contracts may be physical contracts for actual production or financial contracts. According to Wilson (1999), in mature systems the pattern of energy transactions is 80% contracted long term, 20% day-ahead, and less than 10% spot.

The SO has a (natural) monopoly over its functions. However, another design issue arises regarding SO's organization and institutional characteristics such as governance, incentives, regulation, and economic objective function. A centralized SO could imitate vertically integrated operations through an overall optimization of operational decisions and long-term contracting among participants. This minimizes the costs of ensuring reliability and of coordinating generation, transmission and reserves. However, Wilson (1999) argues that centralization lacks of incentives for cost minimization since pool bids do not reflect actual costs (like in the British electricity market). On the contrary, tiny decentralized SO would manage transmission and reserves with small intrusion into energy markets. A decentralized SO provides more incentives for competitiveness but entails deficiencies in coordination, incomplete markets, and imperfect pricing. A decentralized SO is supported by Hogan (1999a), which believes that the pool dispatch function must ideally be separated from other economic activities.

Wilson (1999) believes that centralization is preferable under the presence of a vigorous competition and adequate technical and economic optimization of an electricity industry, while decentralization is better when incentives for cost minimization and good scheduling decisions by each participant's pool are more important than coordination in electricity markets. A decentralized SO permits a sequential optimization of the markets for energy, transmission and reserves (both spot and forward) while a centralized system attempts a simultaneous optimization of all these three markets. Likewise, in a fully decentralized system the SO has full control of the real-time dispatch and reserve options are not voluntary while in decentralized systems participation in forward markets for reserves and in the spot market is voluntary. Reliability is therefore greater under a centralized system than under a decentralized system.

Vertical and Horizontal Structure

In most of the cases where there has been a restructure of the electricity industry, the arrangement before that was an industry that was vertically integrated. There was only one company in charge of generation, transmission, distribution and commercialization. There is a monopoly at all levels of the industry. This industry structure allows the monopoly to take advantage of the economies of scale and to construct bigger plants. Another advantages of this structure is that it permits the implementation of subsidies for the agents with lower incomes. In this case, almost all the risk is imposed on the final consumers through the cost-of-service regulation. But, this provides no incentives to the monopoly to reduce costs, so that it is likely that the enterprise would be inefficient. Another argument about the inefficiency of the firm is that it gets subsidies from the government, so that its incentives for not to reduce its costs are stronger.

It was under these structures of the industry that most of the reforms took place. However, there were a few exceptions where there was some degree of competition in some sectors of the industry, mainly in generation. These reforms asked for a different structure of the industry. The alternatives were the so-called Purchasing Agency, the Wholesale Competition, and the Retail Competition. All these three models avoid as much as possible having a vertically integrated industry.

Public vs. Private Property

There is a debate about what is the ownership arrangement that would generate the best outcomes in the industry. The discussion is whether or not the government should own all or part of the industry. Ownership can be divided in three levels. First, a government department with no separate accounts, and often with responsibilities that are only remotely connected to electricity production (such as providing housing and schools for employees). Second, a government-owned company or nationalized industry. And third, a privately owned industry.

Institutional Endowment and Reform

It was under the above conditions that started the movement to change the institutional arrangement of the industry. The reforms asked for restructuring the industry. This was about commercial arrangements for selling energy, separating or "unbundling" integrated industry structures and introducing competition and choice. This does not imply that the industry should be privatized. The main objective was to introduce competition and choice. In order to get these objectives done, privatization is a tool that could be used; but it is not the goal.

There are two issues that are the main objectives of the government that are in this process. The first one is related to changes in the management and ownership of the industry. The end pint in this process is privatization. The second one is related to the structure of the industry. The end point in this process in the introduction of competition and choice.

There exist four possible configurations of the industry that can be implemented in this industry. The first one that was discussed in the above section is about the vertical integration of the industry. In this case we have a monopoly, where there in no competition at all. The second one allows competition in generation. In this case, a single buyer or a purchasing agency chooses among the different generators where to buy. The third one introduces competition in generation and wholesale supply, in this case the distribution companies can choose their suppliers. Finally, the fourth one allows also consumers to choose supplier. In this case there is full retail competition.

The targets of restructuring the industry are focused on getting better investment decisions, on better use of existing plants, on having better management, and on having better choices for customers. The majority of the changes in these reforms is the change in ownership and management, where the owners are those agents "who are entitled to the profits of the industry".

The three most common forms of ownership/arrangement are the following. (a) Direct government ownership: government both owns and has direct managerial control over the industry. Investment is done with government appropriations, prices are set by, and revenue are remitted to, the government. The industry is viewed as "infrastructure" ad the government is not concerned with investment appraisal and efficiency. (b) Government-owned corporation: government owns a corporation, which manages the industry, so that government is one step removed from day to day control. There may be an independent regulatory agency, or the government department may approve prices and investment policy. And, (c) privately owned corporation: private ownership of the corporation and its assets. These companies (joint stock companies) may be listed on the stock exchanges and are expected to make profits for their shareholders. These companies are generally regulated by an independent regulator. The level of government control may depend more on the intentions and behavior of the government on the organization of the sector.

Privatization

Privatization is the move from a government corporation to a privately held corporation. It is the end point of a continuum of changes in ownership and management. The ability of the government to raise "low-cost" capital is both a plus and a minus for government ownership. It enables infrastructure investment, but it can result in overbuilding of risky and capital-intensive projects, which only look good at low cost of capital, and which the market would never support. But public ownership can work the other way, especially if the ability to set rational prices is constrained by the political necessity to keep inflation under control. This can result in the starvation of the government-owned industry investment funds

2. International Experiences

America

In Latin America there are a lot of cases of restructuration based on competition, participation of the private sector, and regulation for incentives. The usual way was to restructure the industry and then get into privatization. However, in Brazil they started with privatization and then get into the restructuration of the sector.

The very first place to start this process was Chile in the early 1980s. They used a combination of the three components: opening of the sector to competition, participation of the private sector and regulation for incentives. However, they faced some problems because there were only one dominant firm in the generation and the transmission market. In order to reduce this market power, there were necessary some adjustments over time. This same model was applied with some modifications in Argentina (1992), Peru (1993), Colombia (1994-1995) and Bolivia (1995).

There is another policy that has been adopted for countries that face higher demand growth rates and/or budget constraints. In this case, they have adopted a partial opening to the private sector in generation. This is the case of Mexico, Jamaica, Dominique Republic, Costa Rica, Ecuador and Honduras. This model is the first step on the way of getting to the Chilean model. An important element to get private investment in generation is via the independent power producers (IPP).

In the United States and Canada the reform is taken as a mean to have more competition among the states and regions, to get more private investment, and to create new jobs. In the United States this process has taken place at two levels: the national level and the state level. At the national level there are initiatives about transmission and trade among states. One of the main objectives is to recover the sunk costs of the existing firms. At the state level, California and the Northern States in the east coast are the leaders in this process because they have an independent operator of the system, competition in generation and sales, desincorporate the transmission, and deregulate the sector. There is competition in sales in California, Massachusetts, New York, Pennsylvania, and Rhode Island.

In Canada, the structural change is at the county level. One of the main results is the integration with the electricity industry in the United States. In Alberta, in 1996, it was created the competitive market in generation. In Ontario, the main firm (Ontario Hydro) was divided in two independent firms, one for generation and another for transmission and distribution. The generation firm will compete with others in a competitive market. The Transmission Company will be a regulated monopoly that will allow all firms to access the network.

The main difference among the changes in Latin America and North America is that in Latin America the change is at the national level while in the United States and Canada is at the state or county level.

Western Europe

In Western Europe, after the directives adopted by the European parliament in 1997 and 1998, there has been a process of increased competition and integration in its electricity markets. Under these changes, the independent producers can have access to the networks of all the countries and consumers have freedom to choose firms where to buy. This eliminates the local monopoly in every country. England and Wales were the very first to start this process in 1990. In these countries all the firms were privatized. Norway was the second in 1993. In this case, the restructuration was via regulation for incentives with public firms. After these cases, another countries like Portugal, Finland, Sweden and Spain started the same process. The directive of February 19th, 1999 mandates all the countries to liberalize at least 26% of their markets. This percentage is to increase to 30% in 2000 and to 35% in 2003. Nowadays the competition among these countries is around 60% of the market. The opening to competition in United Kingdom, Germany, Norway, Sweden and Finland is complete. However, countries like Spain, Holland, Belgium, and Austria are on the way to get competition in the industry.

Eastern Europe

The objective of these countries is to get enough resources to replace their old technologies and to improve the quality of their services. In order to do that, they use a combination of privatization, institutional changes and tariff regulation. Hungry, Poland, and Ukraine are the leaders in this process. Hungary privatized 6 distributors and all generation except nucleoelectric. Poland divided its company in two firms, one for distribution and one for generations allowing for competition in generation. Ukraine performed a vertical and horizontal separation creating a competitive market. The Check Republic is in the process of privatizing its generation and transmission companies and is also considering privatizing distribution. The main problem in this country is that the buyers, residential and industrial, do not have money to pay the bills.

Asia

In the Far East the private sector is involved in generation under the scheme of IPP. These firms sell their production to the local firm, the only buyer in most cases. These investments require long term contracts and need to have the government guarantee. These contracts last for 30 years and the State takes all the risks in these investments

Japan, as USA and Germany, have had an electricity industry that is essentially private. There are 10 regional firms vertically integrated that make up 75% of the market. The other 25% is provided by the State. In order to reduce the high tariffs, Japan is promoting the reform in the sector to introduce more competition in other sectors of the industry to reduce the cost of the service.

On the other hand, countries like China and India need huge investments in the industry but have budget constraints that pose pressure on them. Given this situation, they are promoting private investment to cover their needs. These two countries have not implemented a coherent reform; they are only worried about getting investment. For this reason, although they have a bigger system than Pakistan, they have attracted less investment because Pakistan has implemented a better restructuration.

Finally, some other countries that also have implemented reforms are Philippines, Malaysia, and Thailand. The problems were diverse. Philippines had bad quality in the service and suffered continuous interruptions. The State promoted changes in the sector via IPP. Nowadays, there are 35 IPP's, one of which provide 35% to the total generation. Malaysia had an increasing demand and government did not have resources. In this case, the State also opened the sector via IP's. Now there are 6 IPP's. Thailand permitted private investments in the sector to reduce the monopoly power of its company.

Oceania

New Zealand and Australia have followed a model of competition to restructure their electricity industries. The first one to start this process was New Zealand in 1987. After that, in 1991, Australia stated its process with the goal of having a competitive market by 1999. The State of Victoria divided its State Company in three different activities, generation, transmission and distribution. The privatization process started in 1995. The policy that is used in Australia to handle the cases of demand peaks is discussed in Section 3.

Relevant cases for Mexico

We study with more detail the cases of Chile, United Kingdom, Argentina, Norway, and Spain.

Chile

The main purpose of the Chilean reform was to increase the efficiency in the sector by introducing competition. They were facing high growth rates in demand that asked for private investment in the sector. Before 1982, all the activities were performed by the State and the companies that provided the service were vertically integrated. The reform started with the Decreto de Ley DFL1, Ley Federal de Servicios Electricos.

The reformed sector has the following characteristics. Segmentation: there are 36 companies for distribution, 4 big companies for generation, one big transmission system (93%) and 3 small transmission systems to cover the rest of the market. Privatization: almost all the industry is privatized. Dispatch of energy: it is done by the Centro de Despacho Económico de Carga (CDEC), which is under the control of the main generator of the system. Regulator: The CNE regulates distribution and tariffs for consumers with demand of less than 2 MW. Tariffs for distribution for small consumption: these are computed based on the node prices for energy plus the value added in generation taking into account some price of reference (the cost of the service of distribution of a theoretic efficient company). Large users: consumers with demands higher than 2 MW are allowed to buy from the generating or distribution companies at unregulated prices. Markets: generators can sell its production in three markets: the mercantile exchange (offering production at marginal cost) market for bilateral contracts (selling to large users) and a regulated market (selling for distributors).

The main achievements of the Chilean reform are the attraction of private capital in the sector, the improvement in the quality of the service, and the security of the service. A special feature in this case was the investment of funds from the pension system.

However the success of the companies in saving energy losses, it is not clear that these gains were directed to the consumers because of the high proportion of the market that is in hands of one company. The residential tariffs are the higher in Latin America, although these have been decreasing in real terms over time.

New England and Wales

They restructure their sectors in 1990. In this case the growth in demand was not a problem. The problem was the old technology they have in place and had to be replaced. The State decided to set the institutional framework to have a competitive market to give incentives to the private sector to invest in the industry. However, there was some resistance by the Monopoly Company who asked government to perform such investments. The reform implied the division of generation and transmission and allow the new generation companies to compete with new technologies. In this case the new generation has been higher than the needed demand and less costly than estimated.

The current characteristics of the system are the following: (a) Segmentation for generation, transmission, distribution and sales. (b) Generation was privatized in two big companies, national Power and PowerGen, and the nuclear generation was initially in public hands in the company Nuclear Electric. (c) Transmission was concentrated in the National Grid Company (d)Distribution was privatized in 12 areas of distribution (c) an electricity market was created and it is under control of the Transmission Company.

This reform has been successful. The main results are he following. First, an increase of new capacity with the installation of 15 GW (an increase of 25%). The main source is combined cycle of low cost. These new technology has replaced the one that used carbon and combustoleo (less efficient and more polluting). Second, the estimation for generation in 1990 was 2.8-2.9 peñiques per kWh. The actual figure is 2.2-2.3 peñiques per kWh (20% lower than estimated). Third, electricity prices have decreased for all consumers: residential 23%, industrial 24%, and commercial 30%. Finally, the standard of service have increase: complaints have decreased 62%.

This reform is in continuous change. Nowadays, the regulator stated that it is needed more competition because of the market power that the two big generating companies have. This allows them to set higher prices and get higher profits. Even though these firms have market power, the tariffs have decreased in real terms since the reform and they are the lowest in Europe. Under this new reform the two big companies are to be divided in smaller ones to get more companies involved in the competition in generation.

Argentina

The main problems in this country were the lack of investment in the electricity sector, the high growth rate of demand (higher than 7% per year) and the frequent interruptions in the service. These conditions were the result of the structure of the industry, where some elements were the same that were present in other countries. For example, all activities were performed by the state, the companies that provided the electricity service were vertically integrated and had high deficits, the government was facing budget constraints to meet the financial demands in the sector. An additional feature in this case was that the government used the electricity tariffs as a mean to control inflation.

Under these conditions, the government started it s reform in 1992 under the following criteria. Segmentation and privatization: Three public companies were divide into 21 generating companies, one concessionaire for the high voltage transmission grid, 5 regional companies for transmission and three companies for distribution in the Buenos Aires region. Creation of a competitive electricity market based on bids (MEM): The price is determined each hour based on the marginal cost of the central dispatch. A new entity, CAMMESA, was created to serve as the system and market operator. Regional prices: prices vary from region to region and reflect the transmission costs and the congestion of the grid. Limited access to large users: The large consumers can buy from generating companies or directly from the MEM. Creation of an independent federal regulator (ENRE): In coordination with the local regulators, they set the rules for transmission, distribution, and tariffs. They use incentives to get efficiency. Finally, there is open access to the transmission and distribution grids to promote competition in the industry.

There is an interesting characteristic of this reform. It is that the expansion of the transmission grids is promoted by the consumers and not by the concessionaire of the transmission grid. The success of the reform is clear, the private sector has financed generation, transmission and distributions.

The main achievements are the following. The number of generating companies increase from 14 to 45 (40 are private). The prices in the MEM have declined 50%. The industrial tariffs have decreased 14.3%. The increase in generation capacity was around 5,700 MW between 1993 and 1998 and are expected another 5,650 by 2004. The energy losses in transmission and distribution have decreased from more than 20% in 1992 to less than 10% in 1997. The participation in the MEM increased form 60 players in 1993 to 1230 in December 1997. Moreover, there is currently an excess capacity in the Argentinean market. For this reason there is a decrease in prices in the electricity market that have benefited all consumers and increase the competitiveness of the economy. Now, the government is focusing on introducing new reforms to get more efficiency in the industry.

Norway

Until 1990, the Norwegian policy was to concentrate the sector activities in 20 vertically integrated companies. The main reason for the reform were the excess capacity, the need for improvements in the operative performance of the system, and the inefficient allocation of resources

The new government started the reform in the sector by introducing competition and segmentation in the industry. The restructuration did not involve a change in property. Around 85% of the total generation is public, 30% from the national company Statkraft and 55% from local companies. The private sector provides only 15% of generation. Another public company (Statnett) is in charge of the transmission grid and the electricity market is in hands of the subsidiary public company Statnett Marked. There are 200 local distribution companies.

There is open access for third parties to the transmission and distribution grids and there is competition in the commercialization for all consumers. There are three separated markets: the short run one (mercantile exchange for electricity), the long run one (bilateral contracts), and the spot market. In this case there is almost no reduction, and some time there is an increase, of tariffs. The reason may be that there is competition among public companies, which do not have the right incentives for efficiency. The Norwegian reform put some pressure on Sweden and Finland to reform their electricity sectors. Now, they exchange electricity over their grids.

Spain

This experience is different from the others we analyze above. The electricity industry in Spin was a mixed system; mainly private, but with State coordination. There was an excess capacity in generation. However, the was a severe financial crisis in the companies in the sector. The reform in this case was based on the following criteria. A new regulatory framework based on competition in generation and supply. The natural monopolies in transmission and distribution were maintained. Generation: creation of a competitive market with free entry of new generators. Transmission and distribution: new system with tariffs for open access to the grids. Commercialization: gradual process of liberalization for consumer to choose supplier. The State fixed a transition period of 10 years in order for average tariffs to decline according to a benchmark. Although this process started in 1996, up to now there are no clear results of this reform.

3. The Mexican Reform Proposal

Description of the Proposal

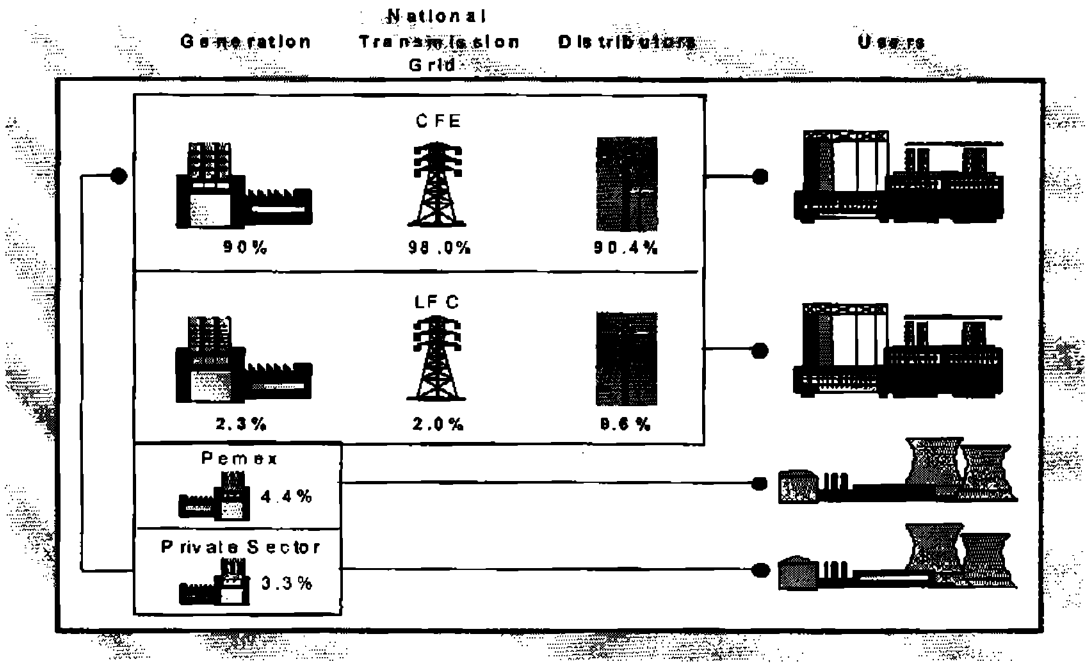
The president of Mexico submitted a proposal to Congress to amend articles 27 and 28 of the Mexican Constitution in order to carry out a structural reform and enhance private investment in the Mexican electricity industry. This proposal is under review by the Mexican Congress and has been stalled due to the election period that culminated in July 2nd, 2000. It is expected that it will again be discussed in Congress during the 2000 fall sessions, or in the spring sessions of 2001 once the new president of Mexico has taken office. According to Mexican authorities, this reform is needed so as to rapidly increase the supply of electricity to meet a 6.1% annual demand growth for electricity in the 2000-2005 period, and to improve and expand the transmission and distribution network capacities.

According to the latest SE's estimations,[3] Mexico needs to generate 22,248 megawatts (MW) and to invest USD 48.7 billion in the next ten years to meet national needs on electricity generation (USD 17.4 billion), transmission (USD 9.4 billion), distribution (7.2 billion), operation and maintenance (USD 9.6 billion), capital payments (USD 5.1 billion). This figure amounts to one fourth of the 1999's total Mexican public budget and is more than the whole resources in that year devoted to education and social security. Likewise, the required increase in generation capacity is greater than the current total installed capacity of the country of 35,526 MW, which was built in more than one century. In average, around 2 thousand megawatts will have to be invested each year, which is equivalent to 10 plants of 225 MW per year. This is an unprecedented growth in capacity generation in Mexico's history. Of the 22,248 MW required, only around 6,444 MW are under construction or being bid.

The current structure of the Mexican electricity sector is characterized by two vertically integrated state monopolies: the Comision Federal de Electricidad (CFE), which serves most of the country, and Luz y Fuerza del Centro (LFC), which covers central states (Mexico, Morelos, Hidalgo and Puebla) and the Federal District. These two firms carry out generation, transmission, distribution and marketing activities in a monopolistic fashion. As shown in figure 1, there is very limited private participation in self-generation, co-generation, build-lease-transfer (BLT) projects and independent production (IPP), modalities that were opened to private initiatives by the 1992 reforms to the Electricity Law. Power surpluses produced under the two first schemes have to be sold to the CFE or exported, while IPP's sell their supply to the CFE under long-term contracts that transfer the risks of projects to the public sector and which translate into contingent liability for the government. Up to 1999, 4,548.9 MW of capacity had been assigned by the CFE to 14 projects through public bids. 1,336.7 MW under the BLT scheme and 2,948.2 MW under the IPP scheme. Another 900 MW are expected to be bid in three more IPP projects in the short run. However, there is still an additional capacity of 15,804 MW that has to be met, which means more opportunities for private investors (see table "28", page 111, Secretaria de Energia (1999)).

[3] See Secretaria de Energia (1999)

Figure 1. Current Structure of the Electricity Industry



Source: Prospectiva 1999-2008, Secretaria de Energia (Table 28, page. 111)

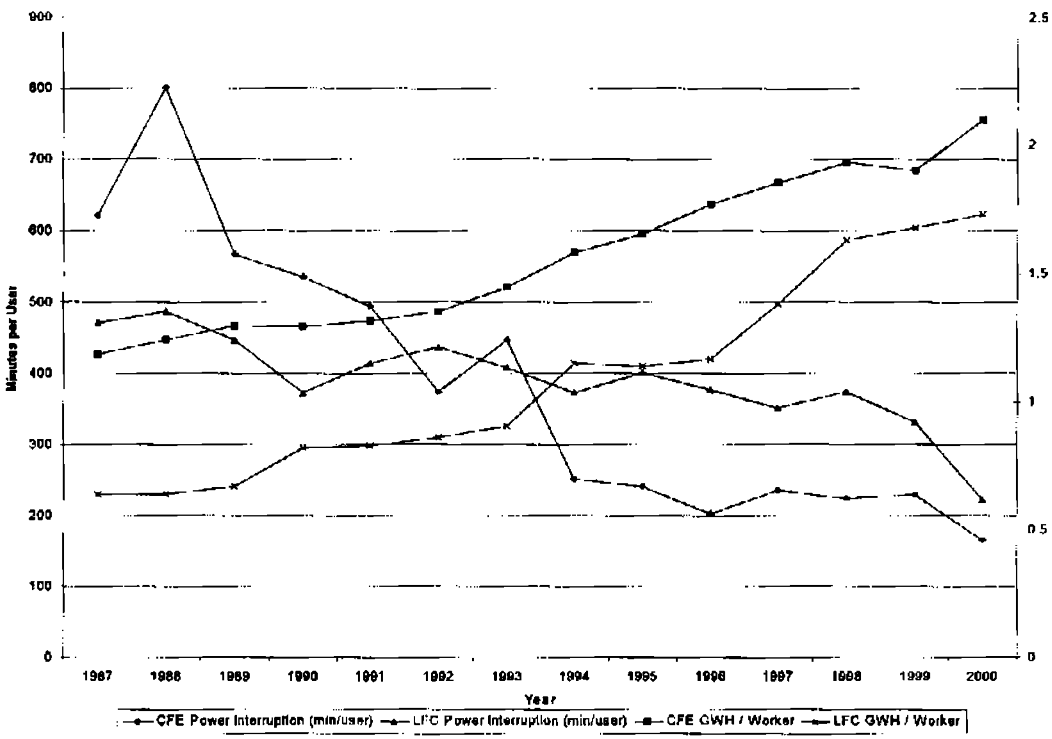
Table 1. Relationship price/cost and subsidies in 1998

	Relationship price/cost			*Subsidy (millions of pesos)*		
Sector	*CFE*	*LFC*	*SEN*	*CFE*	*LFC*	*SEN*
Residential	0.44	0.32	0.41	14,157.1	5,414.0	19,571.1
Commercial	1.21	0.59	0.91	-------	2,369.2	2,369.2
Services	0.97	0.91	0.95	92.3	121.5	213.8
Agriculture	0.31	0.22	0.31	3,847.2	76.9	3,924.1
Industrial	0.93	0.88	0.87	1,935.1	3,216.5	5,151.6
TOTAL	0.72	0.55	0.68	20,031.7	11,198.1	31,229.8

Source: Secretaria de Energia.

Even though the State has been successful in building an important infrastructure through the vertically integrated monopolistic model, several reasons justify the restructuring of the Mexican electricity sector in order to meet the enormous growing demand for electricity. First, CFE and LFC currently do not have the financial and technical capacities to meet the needed increase in power generation by its own means. As an example on the financial side, in 1999, the CFE had losses of USD 4.623 billion due to credit and financing contract acquisitions. Its profits summed USD 1.1 billion but it received government subsidies of USD 3.18 billion. In Table 1, we have information for 1998 for the subsidies that CFE and LFC received from the federal government.

Figure 2. Efficiency Measures for CFE and LFC



On the technical side, the measures of efficiency are against CFE and LFC (see Figure 2). By comparing these efficiency measures with the ones from Australia, France and United States, we have the following. In Australia (for the company VIC), the energy sold per worker is about 4.5 GWH/worker, wile it is about 1.85 GWH/worker in CFE and 1.6 GWH/worker in LFC. On the other hand, while in France and in the United States, the power interruption per user is 115 and 120 minutes, respectively; in CFE and LFC, it is 230 and 331 minutes, respectively.

Second, the long-term purchase contracts (BLT and IPP project)s with the CFE pose a huge burden on the net present value of the Mexican public budget.

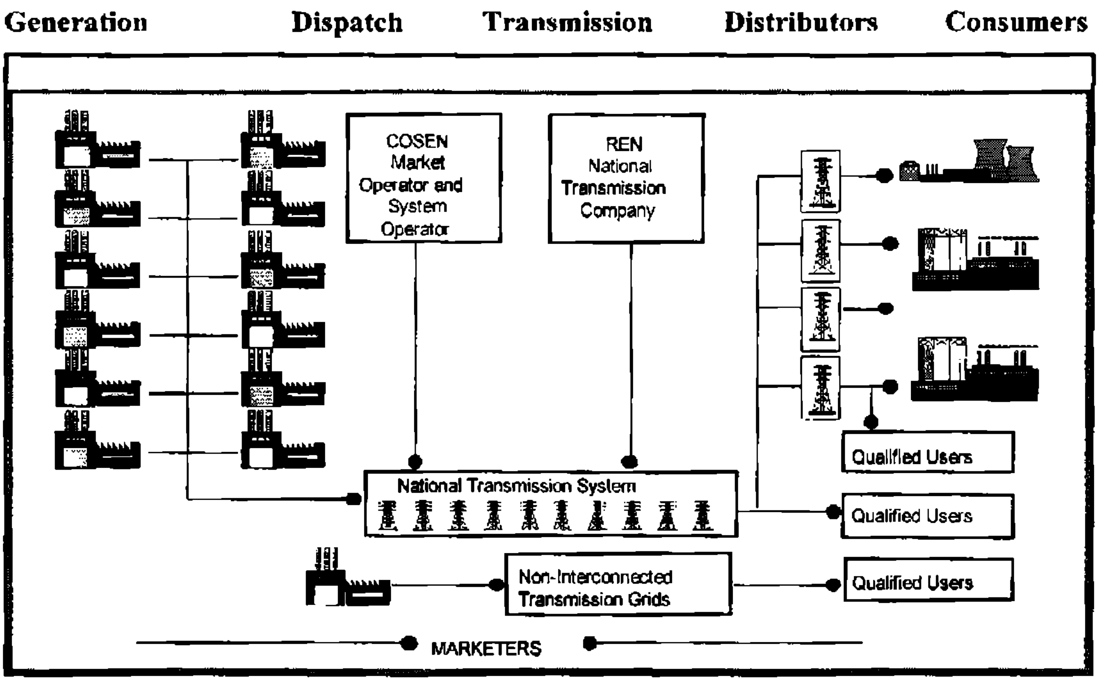
Third, the additional investment requirements of the electricity sector during the coming years will place an unprecedented burden on the budget and financing capacity of the public sector. This means that the government might have to divert resources away from other social priorities such as education, social security and poverty relief. According to SHCP and SE data, the government has to meet the following budget requirements during the 2001-2006 period: USD 10 to 12 billion for poverty relief, USD 20 billion for contingent debt, and USD 20 billion for basic infrastructure (highways, electricity, ports, etc.). Thus, in order to meet the increasing financial needs of the national electricity sector the government would have to allocate all the infrastructure resources to electricity for the next two and a half years, or all the poverty-relief resources for the next four years.

The 1999 reform therefore proposes an ambitious structural reorganization of the electricity industry (see figure 3) so as to increase power generation in the country. The reform foresees that competition and private investment will be permitted in generation, transmission, distribution, and marketing. Meanwhile, nuclear generation, some hydro generation (in the south of the country), and the system operation (ISO) will remain in the hands of the State. Natural monopolies, such as transmission and distribution, are to be subject to regulation due to its naturally monopolistic nature. Generation and marketing activities are contestable and regulators will thus make sure that competition takes place without artificial entry barriers. The new organization of the industry requires important legal constitutional changes as well as the issue of a new electricity industry law and some other secondary legislation.

Under the proposal, the reform process is organized in three stages. In the first stage, CFE and LFC will be transformed into several generation, transmission, and distribution companies at arm's length. The government-run ISO is also created in this stage, as well as the State Company in charge of nuclear generation. The basic rules for the electricity market and the regulatory framework are designed as well. This stage has been already accomplished through what is known as a "shadow market" that started to operate in the mid of 2000.

The operation of the wholesale electricity market occurs during a second stage where generation and marketing --as well as transmission networks not interconnected to the national transmission system-- are opened up to private investment. During this stage markets start to work. The ISO begins to operate its (physical and financial) dispatch functions. Private and public generators compete for contracts with distribution companies and large consumers. Bilateral contracts between distribution companies –and large consumers-- and private generators are also allowed. Marketers and brokers begin their operations. Finally, in the last stage the state-owned generation, transmission and distribution companies are privatized. Other specific policy decisions are sketched in the annex.

Figure 3. Vision of the new electricity industry



From our point of view, the reform proposal reaches a balanced combination between application of state-of-the-art economic theory and international experiences with consideration of the specific characteristics of the Mexican electricity industry. However, there have been some radical criticisms to the proposal as well as other more technical suggestions to improve it. We next address the latter issue and provide our point of view regarding the main pros and cons of the reform. We then address the analysis of some radical points of view against structural reform and privatization of the electricity sector.

Pros of the Reform

A first pro of the reform is that it foresees privatization as a means and not as an end in itself. The SE seems to be looking first for a competitive market through the virtual restructuring of the sector, and a sound regulatory and institutional framework. After this structural and regulatory reordering, the market starts to work and private investment in new generation and marketing activities is allowed. Only at the end of these processes the privatization stage is conceived. However, even in the case that there is not a privatization process, the electricity industry would gain in productive and allocative efficiencies due to the economic and institutional reform.

Positive aspects of the reform proposal can also be observed in its long-run vision of the electricity industry:

- Liberalization of contestable markets (generation and commercialization) and regulation of naturally monopolistic sectors (transmission and distribution) are proposed
- The design of incentive compatible mechanisms for the wholesale electricity market (MEM) is sought. For example, the existence of a pool for the MEM does not preclude the possibility of bilateral "contracts by differences" between generators and distributors or large consumers. Likewise, there are several price mechanisms that seek for short-run and long-run efficiencies: regional prices (whenever there are transmission bottlenecks), "cost-of-failure" price term (for cases of excess demand or lack of supply), real-time prices (to take care of differences between forecasted and actual generation), and hedging mechanisms.
- Long-term bilateral contracts are written as financial instruments with payments indexed to the short-term pool price.
- Both system operations and market operations are integrated in the COSEN. Hogan (1999 b) argues that this is a desirable feature since network interactions in an electric system have commercial implications.
- An incentive kind of regulation is proposed for distribution and transmission tariffs.
- Potential access pricing problems are localized and combated through vertical disintegration in: generation and distribution, transmission and distribution, and distribution and marketing inside the own distributor area.
- A transparent and focused lump-sum subsidy policy is envisaged.
- The specific characteristics of the Mexican electricity sector are considered. For example, hydro generation in the south of the country and nuclear generation would remain in State hands due to social concerns.
- The State maintains an important strategic control of the sector (ISO functions, nuclear and hydro generation, and distribution and transmission concessions) but it does not run the risks of private IPP projects. Soft budget constraints of previously public firms now become binding constraints.
- A smooth transition towards a mature functioning of the industry is foreseen. In particular, incentives for initial development of generation are provided through transition contracts that guarantee generators purchases from distributors and positive factors added to the electricity price (K factor) to promote production.

Cons of the reform

Lack of mechanisms that provide incentives for transmission expansion is, from our point of view, one of the main omissions in the reform proposal. Property rights of the national electricity transmission network (REN) are not clearly defined. The manuscript states that the SE will be in charge of planning the expansion of the transmission network, something that contradicts the market-oriented philosophy of the proposal. The proposal repeatedly mentions that the State will not bear risks nor provide guarantees to private investors. However, this does not seem true for the REN since the SE will be responsible for its expansion.

Moreover, there are really no coordinated incentives that solve problems of short-run congestion, recuperation of long-run fixed costs, and investment to intertemporally expand transmission network capacity. This is a critical flaw because generation development can be hindered by bottlenecks in the transmission network.

The theoretical and practical solution to the expansion of the transmission network is not an easy task. It involves correctly defining transmission property rights, as well as properly differentiating the functions of the REN, the ISO (COSEN), and the SE with respect to transmission capacity expansion. It also requires designing transmission tariff regulation that provides incentives to the REN to optimally utilize capacity in the short run, and to invest in capacity enhancement in the long run. In section 3.4 we analyze these issues in a more technical fashion.

Another issue that needs further elaboration is regarding the structure of incentives of the ISO or COSEN. It seems that COSEN is a non-profit dispatch entity and hence its objective function is not very clear. Additionally, COSEN functions should be clearly specified so that they do not overlap with those of the CRE, the SE and the REN on issues such as transmission network expansion.

Regarding vertical disintegration measures, there remain at least three important access-pricing problems. The proposal explicitly separates distribution from marketing activities inside the same distribution zone. The distributor has the exclusive right to provide a bundled service (including electricity plus transmission and distribution services) to consumers that consume less than 5.0 GWh. It can also provide this service to large consumers that consume more than 5.0 GWh. However, the distributor's marketing subsidiary cannot compete within the distribution service area with other marketers for large consumers.

Notwithstanding, access problems subsist because the distributor implicitly competes in marketing activities inside his service area since large consumers can acquire the distributor's bundled service. This can also originate cross subsidization by the distributor between large consumers and small consumers, so that the distributor offers competitive deals in the wholesale market and charge high prices in the retail market. A preferred solution to this problem would be to open the retail market to competition and carry out regulation of the distributor marketing activities to avoid undue access price discrimination. Moreover, as Hogan (1999 b) argues, it is difficult to maintain customer boundaries and, furthermore, small consumers indirectly benefit from competition.

A second access-pricing problem arises in the second stage of implementation of the reform. During this stage competition is foreseen between private and public generators for contracts with large consumers, distributors and marketers. Lack of regulation that precludes undue discrimination against private generators during the second stage (by, say, the State distributors) may cause unfavorable initial conditions for them when the third privatization stage starts to operate.

A third access-pricing problem is bilateral contracts between generators and distributors with large participation of a single company. A possible solution would be that the generator is allowed to supply electricity to its distribution subsidiary only through the pool.

Another crucial topic that we believe is not appropriately discussed in the reform proposal is the incentives for generation capacity enhancement, in particular during peak periods. The proposal presents a pricing mechanism so the price paid to all generators is set equal to the offer of the last generator dispatched in each hour. However, during periods of high demand the market price rule is modified when reserve capacity margins are low. The market price is then defined as the weighted average of two factors: the price of the last accepted offer to generate (LAO) and the cost of failure (CFALLA). The weight is the loss of load probability (LOLP). The formula for the market price is then:

$$\text{Market price} = LAO * (1\text{-}LOLP) + CFALLA * LOLP$$

where: $0 \leq LOLP \leq 1$.

The greater the surplus capacity (high reserve margin), the smaller is LOLP and the market price will be determined almost entirely by LAO. Generators would add capacity when the expected sum of all these payments over all hours of the year were greater than the cost of installing new capacity. Additionally, the proposal foresees the use of another capacity payment to generators, the "K factor", to introduce additional incentives for new generation while the MEM becomes established. The K Factor payment is charged to the distributors and thereby passed on to consumers. It is applied as an annual fixed payment to new generators per KW of available capacity. The size of the K Factor payment would be decided by auction.

We think that CFALLA and K terms are mechanisms that artificially increase the price of electricity and produce high rents. The use of these terms, even during peak periods, promote collusion in the generation market as can be theoretically and empirically shown. Moreover, these terms are also against the explicit purpose of the proposal to regulate market-powered segments and promote competition in contestable markets of the Mexican electricity market. In accordance to such a regulatory philosophy, we recommend that a market price is always used for transactions and that generation shortages are met in a "bypass" market by plants that supply electricity when reserve capacity margins are low. This market would normally consists of a small number of plants like those that are not normally dispatched due to their high marginal costs, or those that are able to supply both at non-peak and peak periods.

Another issue is with respect to the proposed mechanism to incorporate IPP's into the reform. The main problem is what to do with the long-term contracts that the State has signed to buy electricity from the IPP's. The proposal states that such contracts will be transferred in the privatization stage to the new generation companies that will in turn pass their obligations to new distributors through transition contracts. Distributors will finally recover these costs through increased tariffs to consumers.

A basic problem with this scheme is that it will contribute, together with the price factors K and CFALLA, to increase final price to consumers. Additionally, sudden increases in final prices are a common problem during transition stages of structural reform processes due to the elimination of subsidies. Therefore, the Mexican government should be careful in carrying out a selective subsidy policy to attenuate distributive negative effects of sudden price increases. For example, recuperation of the long-term contract IPP obligations could be differed as much as possible over time.

Radical Criticisms

Some analysts in Mexico are worried that the structural reform of the electricity sector and privatization of assets of CFE and LFC might imply lower level of national social welfare. This issue might be addressed by comparing implied social-welfare effects of the reform on:

(a) Social spending of the government of resources coming from CFE and LFC (transfers to consumers, price subsidies, and so forth), and subsidized employment benefits to workers of State monopolies, vs.

(b) Social gains from adding value to the whole industry due to more competition associated to liberalization and privatization of generation and distribution of electricity State assets, which translates in lower tariffs, cost efficiencies and, in the long run, more productive employment (as opposed to inefficient subsidized employment).

Intuitively, welfare associated with (b) should be larger than welfare associated with (a) in developing countries (like Mexico) where public funds are scarce and transfers and subsidies are typically financed through social distortionary public policies and taxation.

Another concern is that the reform might endanger Mexican sovereignty. The main question here is whether leaving in foreign private hands the energy assets of the country might compromise the independence of the country and affect the dignity of the Mexican people. On the former issue, maybe the greatest historical popular fear for Mexicans is that most of the public assets end up in hands of US firms so that the US could use this strategic advantage in order to influence Mexican policy making. A sensible response to this question could be that, first of all, it is very unlikely that only US firms could win all the bids for the State generation and distribution assets as it has been observed in the tenders for distribution of natural gas.[4] In second place, the possibility of a single US firm of winning several important bid contests is scarce due to anti-merger policies in Mexico. Finally, sovereignty concerns seems as a XIX century concern in the nowadays-global world where creation of economic value and equality of distribution of wealth seem more sensible social objectives than national sovereignty.

Demand Growth, Impact of the Reform on Tariffs

The electricity industry in Mexico, although have been successful up to now in meeting the national demand is facing an unprecedented growth rates of demand. This growth will impose pressure over the industry, which will be hard to satisfy under the present structure of the industry. The estimation of annual growth is between 5.6% (Diaz Flores, 1999) and 6% (SE). The main components of this increasing demand are the industrial (60%) and the residential (23%), where the

[4] European firms have been more successful than US firms in such bids. The reason is that, due to its public nature, Spanish and French firms are more financially patient, forward looking and non-myopic profit maximizing than US firms (see Rosellon and Halpern (2000 a, b)).

demand by the industrial consumers is growing faster than the residential's. Moreover, if the Mexican economy is to grow at faster rates than the ones we saw in the last years, the needs will be more than the stated above. For these reasons, and as discussed in the previous sections, there is an increasing need of private investment in the industry to meet the national demand growth.

On the other hand, an important issue that must be analyzed is the impact of the reform on the tariffs. As shown in Table 1, tariffs are highly subsidized by the government. This subsidy scheme present the following characteristics. First, the main recipients of the subsidy are the residential users. Consumers who buy from CFE get a subsidy of 56% and those who buy from LFC get a subsidy of 68%. As we see form these numbers there is a discrimination among residential users. Moreover, it is known that this subsidy scheme is regressive. The 40% f residential users with lower consumption (less than 75 Kwh/month) gets 10% of the total subsidy. On the other hand, the 20% with higher consumption (higher than 200 Kwh/month) gets 40% of the total subsidy. Second, the higher subsidies go to the agricultural sector. Third, the industrial users are almost covering the cost of provision. Finally, the proportion of subsidy that each company gets is different. CFE gets, in average, a subsidy of 28%, wile LFC gets, in average, 45%. From these numbers we see than it is also a regional discrimination.

Analyzing this information together with data form efficiency in CFE and LFC, we can see that there would be two effects working in opposite directions. On the one hand, as we get more efficiency n the sector, there should be a decline in the cost of production. This reduction, under the new structure of the industry should be passed to the consumers under lower tariffs. On the other hand, if the subsidies are eliminated, the tariffs paid by the consumers will be increased in the amount of the subsidy. The net effect is unclear. However, given that the industrial users receive a small subsidy, they would be enjoying lower tariffs after the restructuring of the industry. The impact on the tariffs for the residential users is harder to predict.

4. Structure of Incentives for Generation Development

As discussed in Section 2, the proposal to restructure the Mexican electric sector presents a pricing mechanism that artificially increases the price of electricity during periods of high demand. This policy is similar to policies implemented in other restructured electricity industries as in the UK. Although, this measure might generate investment incentives it also promotes collusion in the generation market as can be empirically and theoretically shown.[5] The main reason is that the artificial

[5] The existence of a duopoly in the UK electricity market is a well-known market failure

increase of price ends up creating monopolistic rents that motivates the existence of a few number generating plants.

We next formally see that other kinds of policies for generation enhancement can result in better outcomes. For example, in the Australian electricity market the use of a pool price together with a "bypass" market to meet generation shortages has provided satisfactory results. The bypass market would normally consist of plants not normally dispatched in the pool, and those capable to supply both at non-peak and peak periods. We will show under what conditions this mechanism provides better social results than a policy of arbitrary manipulation of prices.

The British Model

Let us first study a simple stylized version of the English model for enhancement of generation capacity. Assume that the inverse demand function at a peak period has the form:

$$p(Q) + \Delta p(Q) = a(1+k) - bQ(1+k) \tag{1}$$

where P(Q) is the inverse demand function, Q is the amount of electricity generated, a>0 and b>0 are positive constants, and k>0 is a factor added to the price of electricity during peak periods.[6] Suppose there are only two firms, firm 1 and firm 2, so that $Q = q_1 + q_2$ (where q_1 and q_2 are the amounts of electricity generated by firm 1 and firm 2, respectively) and thus

$$p(Q) + \Delta p(Q) = a(1+k) - b(q_1 + q_2)(1+k) \tag{2}$$

The cost functions for each firm are

$$c_1(q_1) = c_1 q_1 \qquad \text{and} \qquad c_2(q_2) = c_2 q_2$$

where c_1 and c_2 are the marginal costs of power generation for firms 1 and 2, respectively, and $c_1 < c_2$. The profit maximization problem for firm 1 is then

$$\max_{q_1} \Pi_1 = \left[a(1+k) - b(q_1 + q_2)(1+k)\right]q_1 - c_1 q_1 \tag{3}$$

[6] *k* would therefore contain terms such as "*cfalla*" and "*k factor*".

The first order condition is:

$$q_1 = \frac{1}{2}\left[\frac{a(1+k)-c_1}{b(1+k)} - q_2\right] \tag{4}$$

The analogous maximization problem for firm 2 is

$$\max_{q_2} \Pi_2 = [a(1+k) - b(q_1+q_2)(1+k)]q_2 - c_2 q_2 \tag{5}$$

The first order condition is:

$$q_2 = \frac{1}{2}\left[\frac{a(1+k)-c_2}{b(1+k)} - q_1\right] \tag{6}$$

From 4 and 6 we obtain the optimal quantities of a Cournot duopoly

$$q_1^* = \frac{1}{3}\left[\frac{a(1+k)-c_1}{b(1+k)}\right] + \frac{1}{3}\left[\frac{c_2-c_1}{b(1+k)}\right] \tag{7}$$

and

$$q_2^* = \frac{1}{3}\left[\frac{a(1+k)-c_1}{b(1+k)}\right] - \frac{2}{3}\left[\frac{c_2-c_1}{b(1+k)}\right] \tag{8}$$

Substituting 7 and 8 into 2 we get the optimal level for the price of electricity in the British model

$$p^*(Q) + \Delta p^*(Q) = \frac{1}{3}a(1+k) + \frac{1}{3}(c_1 + c_2) \tag{9}$$

Equilibrium profits for firms 1 and 2 are then

$$\Pi_1^* = \frac{1}{9}\frac{a^2(1+k)}{b} - \frac{4}{9}c_1\left(\frac{a}{b}\right) + \frac{2}{9}c_2\left(\frac{a}{b}\right) + \frac{4}{9}\frac{c_1^2}{b(1+k)} - \frac{4}{9}\frac{c_1c_2}{b(1+k)} + \frac{1}{9}\frac{c_2^2}{b(1+k)} \quad (10)$$

and

$$\Pi_2^* = \frac{1}{9}\frac{a^2(1+k)}{b} + \frac{2}{9}c_1\left(\frac{a}{b}\right) - \frac{4}{9}c_2\left(\frac{a}{b}\right) + \frac{1}{9}\frac{c_1^2}{b(1+k)} - \frac{4}{9}\frac{c_1c_2}{b(1+k)} + \frac{4}{9}\frac{c_2^2}{b(1+k)} \quad (11)$$

Given that

$$q_1 + q_2 = \frac{2}{3}\left(\frac{a}{b}\right) - \frac{1}{3}\frac{c_1}{b(1+k)} - \frac{1}{3}\frac{c_2}{b(1+k)}$$

we can use 9 to obtain total consumer surplus under the British model

$$CS_1 = \frac{1}{2}\left[\frac{4}{9}\frac{a^2(1+k)}{b} - \frac{4}{9}c_1\left(\frac{a}{b}\right) - \frac{4}{9}c_2\left(\frac{a}{b}\right) + \frac{1}{9}\frac{c_1^2}{b(1+k)} + \frac{1}{9}\frac{c_2^2}{b(1+k)} + \frac{2}{9}\frac{c_1c_2}{b(1+k)}\right] \quad (12)$$

and the net social benefit, equal to the sum of total profits plus total consumer surplus

$$NSB = \Pi_1 + \Pi_2 + EC$$

$$= \frac{4}{9}\frac{a^2(1+k)}{b} - \frac{4}{9}c_1\left(\frac{a}{b}\right) - \frac{4}{9}c_2\left(\frac{a}{b}\right) + \frac{11}{18}\frac{c_1^2}{b(1+k)} + \frac{11}{18}\frac{c_2^2}{b(1+k)} + \frac{7}{9}\frac{c_1c_2}{b(1+k)} \quad (13)$$

Note that that this expression is mainly determined by the value of k (the term that artificially increases the price of electricity) and the marginal costs of each firm.

The Australian Model

Let us now formally analyze the Australian model in which excess demand is satisfied in a reserve or standby market. Assume again that there are only two firms.

Firm 1 is a monopoly in the pool market while firm 2 is also a (regulated) monopoly but operating in a reserve market. Firm 2 only takes care of excess demand.

Firm 1's inverse demand function is given by

$$\hat{p}(\hat{q}_1) = \hat{a} - \hat{b}\hat{q}_1 \tag{14}$$

and its cost function is

$$c(\hat{q}_1) = \hat{c}_1\hat{q}_1 \tag{15}$$

The profit maximization problem of firm 1 is then:

$$\max_{\hat{q}_1} \ \hat{\Pi}_1 = (\hat{a} - \hat{b}\hat{q}_1)\hat{q}_1 - \hat{c}_1\hat{q}_1 \tag{16}$$

with first order condition

$$\hat{q}_1 = \frac{\hat{a} - \hat{c}_1}{2\hat{b}} \tag{17}$$

Thus, the equilibrium price is:

$$\hat{p}^*(\hat{q}_1) = \frac{\hat{a} - \hat{c}_1}{2} \tag{18}$$

and the equilibrium profits of firm 1 are:

$$\hat{\Pi}^*{}_1 = \hat{b}\left[\frac{\hat{a} - \hat{c}_1}{2\hat{b}}\right]^2 \tag{19}$$

Firm 2 only operates to satisfy excess demand at a peak period. This firm faces an inverse demand function of the form:

$$\hat{p}(\hat{q}_2) + \Delta\hat{p}(\hat{q}_2) = \hat{a}(1 + \hat{k}) - \hat{b}\hat{q}(1 + k) \tag{20}$$

and its cost function is

$$\hat{c}(\hat{q}_2) = \hat{c}_2\hat{q}_2 \tag{21}$$

Firm 2's profit maximization problem is

$$\max_{q_2} \quad \hat{\Pi}_2 = [\hat{p}(\hat{q}_2) + \Delta\hat{p}(\hat{q}_2)]\hat{q}_2 - \hat{c}_2\hat{q}_2$$

with first order condition

$$\hat{q}_2^* = \frac{\hat{a}(1+\hat{k}) - \hat{c}_2}{2\hat{b}(1+\hat{k})} \tag{22}$$

The optimal price for the electricity generated by firm 2 is then given by

$$\hat{p}^*(\hat{q}_2) + \Delta\hat{p}^*(\hat{q}_2) = \frac{1}{2}\hat{a}(1+\hat{k}) + \frac{\hat{c}_2}{2} \tag{23}$$

and optimal profits by

$$\hat{\Pi}^*_2 = \frac{1}{4}\frac{\hat{a}^2(1+\hat{k})}{\hat{b}} - \frac{1}{2}\hat{c}_2\left(\frac{\hat{a}}{\hat{b}}\right) + \frac{1}{4}\frac{\hat{c}_2^2}{\hat{b}(1+\hat{k})} \tag{24}$$

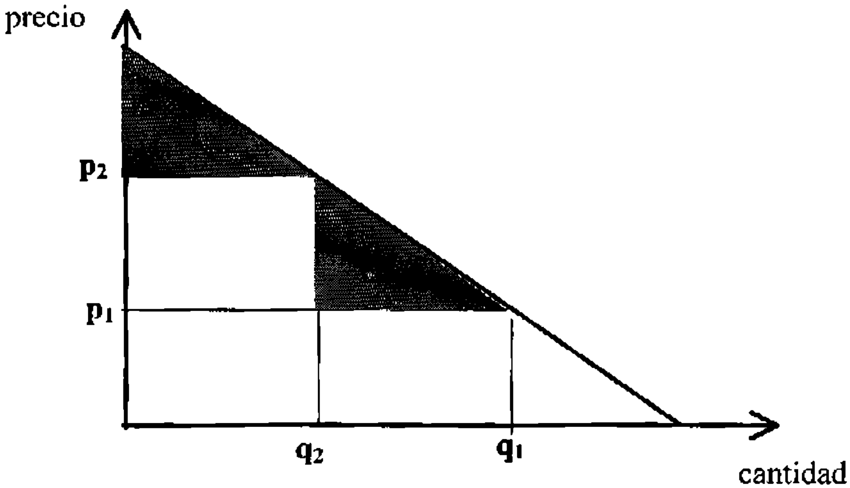
Now assume $c_1 \langle c_2$ (since the firms that operate in the pool are typically more efficient than the firms that operate in the reserve market). Then

$$\hat{q}_1^* = \frac{\hat{a} - \hat{c}_1}{2\hat{b}} \quad \rangle \quad \hat{q}_2^* = \frac{\hat{a}(1+\hat{k}) - \hat{c}_2}{2\hat{b}(1+\hat{k})} \tag{25}$$

and

$$\hat{p}^*(\hat{q}_1) = \frac{\hat{a} - \hat{c}_1}{2} \quad \langle \quad \hat{p}^*(\hat{q}_2) + \Delta\hat{p}^*(\hat{q}_2) = \frac{1}{2}\hat{a}(1+\hat{k}) + \frac{\hat{c}_2}{2} \tag{26}$$

Consumer surplus is thus given by the shadowed area in the following figure



That is, consumer surplus is equal to:

$$EC = \frac{1}{2} q_2 (p - p_2) + \frac{1}{2} (q_1 - q_2)(p_2 - p_1)$$

$$EC = \frac{1}{8}\frac{a^2(1+k)}{b} - \frac{1}{8}c_2\left(\frac{a}{b}\right) - \frac{1}{8}c_1\left(\frac{a}{b}\right) + \frac{1}{8}\frac{c_1 c_2}{b(1+k)} + \frac{1}{8}\frac{c_1}{(1+k)}\left(\frac{a}{b}\right) + \frac{1}{8}\frac{c_2}{(1+k)}\left(\frac{a}{b}\right) \tag{27}$$

Hence, net social benefit in the Australian model is

$$NSB = \frac{3}{8}\frac{a^2(1+k)}{b} + \frac{1}{4}\left(\frac{a^2}{b}\right) + \frac{1}{8}\left(\frac{a}{b}\right)\frac{c_1}{(1+k)} - \frac{1}{8}\left(\frac{a}{b}\right)\frac{c_2}{(1+k)} - \frac{5}{8}c_1\left(\frac{a}{b}\right) - \frac{5}{8}c_2\left(\frac{a}{b}\right)$$
$$+ \frac{1}{4}\frac{c_1^2}{b} + \frac{1}{4}\frac{c_2^2}{b(1+k)} + \frac{1}{8}\frac{c_1 c_2}{b(1+k)} \tag{28}$$

Comparison of the Australian and British models

Once we have obtained the equilibrium values for quantities, prices, profits, consumer surplus and net social benefits in both models, it is possible to compare under what conditions one policy is superior to the other. For this purpose we will assume that generators in Australia and the UK face the same cost and demand functions, that is

$$\hat{a} = a$$
$$\hat{b} = b$$
$$\hat{q}_i = q_i, i = 1,2$$
$$\hat{c}_i = ci, i = 1,2$$

We carry out the comparison both at the firm level and at the social level. Total profits under the Australian model are greater than total profits under the British model if

$$\Pi_I - \Pi_A \rangle\ 0$$

or

$$\frac{5}{18}c_1\left(\frac{a}{b}\right) - \frac{5}{18}c_2\left(\frac{a}{b}\right) + \frac{5}{9}\frac{c_1^2}{b(1+k)} - \frac{8}{9}\frac{c_1c_2}{b(1+k)} - \frac{11}{36}\frac{c_2^2}{b(1+k)} \rangle\ \frac{1}{4}\frac{a^2}{b} - \frac{5}{18}\frac{a^2(1+k)}{b} \qquad (29)$$

while consumer surplus in the Australian model is greater than consumer surplus under the English model if

$$CS_A - CS_I \rangle\ 0$$

or

$$\frac{5}{18}\left(\frac{a}{b}\right)c_1 - \frac{5}{18}\frac{c_2}{(1+k)} + \frac{1}{(1+k)}\left[\frac{5}{9}c_1^2 - \frac{11}{36}c_2^2 + \frac{c_1}{4} - \frac{8}{9}c_2\right] \rangle\ \frac{1}{36}\frac{a^2(1+k)}{b} + \frac{a^2}{b} \qquad (30)$$

Given that $c_2 < c_1$, it is evident from these equations that profits, consumer surplus and net social benefits are greater under the Australian model than under the English model the greater is the value of $(c_2 - c_1)$. That is, the Australian model provides better social and private outcomes for economies where the marginal cost difference between modern and old plants is large enough.

Moreover, both models can also be compared in terms of implied electricity prices. According to equation (26), the equilibrium reserve-market price in the Australian model is greater than the corresponding spot price. However, what is the relation between the former price and the equilibrium price of the British model? It can be shown that

$$p^*(q_1+q_2)+\Delta p^*(q_1+q_2) > \hat{p}^*(\hat{q}_2)+\Delta\hat{p}^*(\hat{q}_2)$$

whenever the difference (c_2 – c_1) is again sufficiently large. That is, the implementation of a bypass reserve market makes social sense in terms of prices only if there is a large efficiency gap between old and new generation plants. In such a case, the implementation of the British solution would only create an artificially high rent that could provide incentives for a development of oligopoly generation markets.

The above results imply that the use of the Australian model in the Mexican electricity sector would make sense only if it can be technically proved that the cost difference between old hydroelectric plants and new thermoelectric plants is such that inequalities (28) and (29) are met. Tables 2 and 3 show the costs of production and the investment costs for different generation plants.

Table 2. Production costs for different generation plants

Type	*Production cost per MWh (dollars)*
Conventional thermoelectric	42.68
Combined cycle	26.54
Hydrocarbon	32.03
Hydroelectric	19.20

Table 3. Investment costs for different generation plants

Type	*Investment cost per MWh (millions of USD)*
Nucleoelectric	1,700
Hydroelectric	1,000
Combined Cycle	500-600
Turboelectric	637-6652

It can be observed that there exist significant differences between hydro generation plants and hydrocarbon generation plants in terms of investment and cost of production. Therefore, the measures given in Figure 2, the data shown in Tables 2 and 3, and the obsolescence of some of the actual generating plants, suggest that the creation of a regulated reserve market and the elimination of any surplus factor (such as "CFALLA" and "K" factor") in the spot price of electricity are changes needed in the reform proposal for the Mexican electricity industry.

5. Expansion of the Transmission Network

Electricity transmission requires of adequate incentives to solve short-run congestion problems, recuperation of long-term fixed costs, and investment to intertemporally expand the network. Lack of attention to this problem could hinder the development of generation due to capacity shortages of the transmission network. From an institutional perspective, adequate development of transmission requires of precisely differentiating the functions of the Transmission Company from the central dispatch, the energy ministry and the regulatory entity.

From the point of view of economic theory, there are at least two theoretical approaches that seek to solve the duality of incentives for optimal utilization of capacity transmission, in the short run, and investment in network development, in the long run. In one approach, the transmission system is defined as a national transmission system (as the REN) and the solution is derived from the correct definition of transmission congestion contracts and locational prices. Another possibility is using regulation, via non-linear price caps, in independent transmission systems.

The reform proposal for the Mexican electricity sector mentions financial transmission rights very briefly, and broadly defines that a price-cap mechanism will be used to regulate electricity transmission. These issues require of further development. We next proceed to analyze them.

Transmission Rights and Locational Prices

Hogan (1999 a) proposes the use of market mechanisms to deal with the problem of the commons associated with network externalities in a manner that transmission development is consistent with a competitive generation sector. Transmission "rights" can be created and allocated, and market players can use them to match power flows or trade them in a secondary market. The definition of these rights together with coordination by the pool and spot market locational prices define the opportunity costs of transmission and determine the market value for transmission titles.

Locational spot prices arise from the difference of electricity prices between locations due to transmission bottlenecks. Under economic dispatch by an ISO, the determination of locational marginal costs of additional power is feasible. In fact, Hogan (1999 a) shows that these marginal costs would be the equilibrium prices under ideal perfect competitive conditions. Transmission spot tariffs derive from the difference in the locational prices. Hogan further argues that in an ISO model it is important to be most specific when defining locational prices. There is not really a sound reason to average congestion costs over large zones, and pricing by nodes is not complex under competitive markets.[7]

However, Hogan explains that in a transmission network it is troublesome to define property rights that avoid overuse by the commons. This is due to the several externality problems present in the transmission network that become more critical as there is more competition among the various economic agents.[8] In fact, Hogan argues that the industry has never been able to define operable property rights in electricity transmission. Tradeable transmission "rights" thus take the form of transmission "congestion contracts" in a pool-based, short-term electricity market. Transmission congestion contracts can be defined between locations so that congestion payments are done to holders of congestion contracts. The ISO coordinates these transactions and, with opportunity pricing, physical transmission trading becomes equivalent to financial economic dispatch.

Residual Regulation for Independent Transmission Companies

No matter how ambitious a structural reform process may be electricity transmission generally preserves its technological characteristics of natural monopoly. The costs of a transmission company are generally sunk and, therefore, its main problem is short-run utilization of capacity. Main variable costs are associated to congestion. In the long run, however, the Transmission Company has to find an optimum between network expansion and investment-cost minimization. Regulation of transmission must solve a duality on the incentives for the transmission firm in the short term and the long term since, under a non adequate tariff scheme, the firm could find profitable not to solve congestion problems nor

[7] Hogan (1999a) further argues that nodal prices provide the principles for economic dispatch and "are self policing and self auditing" (p. 40) while zonal pricing imply deviations from reliable dispatch. For example, generators that have a lower bid price than the zonal price ("constrained off" generators) and that are located in nodes within the zone have an incentive to self-schedule in bilateral contracts, compromising congestion management by the ISO.

[8] Externalities in electricity transmission are mainly due to "loop-flow" problems, which arise through interactions in the transmission network. These interactions are such that power flows in one network interface can have important effects on the capacity of other relatively far away interfaces. The effects of loop flow in a competitive market imply that it is not possible to define the "available transmission capacity" in a point of time without the existence of complete information about the use of the network at the time. Likewise, transmission opportunity costs and pricing critically depend on the marginal costs of power at each location. Energy costs and transmission costs are not independent since they are determined simultaneously in the dispatch and the spot market.

investing in network expansion. Likewise, tariff regulation should provide incentives to smooth load patterns out, minimize distances between generation plants and distribution zones, and provide service with an adequate technical quality on frequency, voltage, and emergency responses.

Vogelsang (1999 a, 1999 b) analyzes these issues for an independent transmission company (TRANSCO) so as to abstract from competitive concerns and concentrate on regulation of the naturally monopolistic characteristics of transmission. Price regulation can be analyzed from two perspectives: regulation of "price level" and regulation of "price structure" (see Brown et al (1991). Price level regulation refers to the long-run distribution of rents and risks between consumers and the regulated firm. Price structure regulation refers to the short-run allocation of costs and benefits among distinct types of consumers.

On one hand, Vogelsang (1999 a) believes that price cap regulation (together with typical inflation (RPI) and efficiency factors (X), and cost of service every five years) is the best price-level regulatory option for electricity transmission tariffs. Since transmission costs are so dependent on geographic localization, the construction of an adequate cost or price benchmark would not be feasible, and pure cost of service would be too cumbersome to implement.

On the other hand, price structure regulation can be used to solve congestion problems of transmission lines, in the short run, as well as capital costs and investment issues, in the long run. Intense congestion can be profitable for the TRANSCO and, thus, the TRANSCO might have few incentives to invest when new capacity is needed. Vogelsang (1999 a) explains that long-run incentives and short-run incentives are usually difficult to coordinate. He proposes a two-part tariff with variable (or usage) charges, and a single fixed (or capacity) charge. In his single-period profit maximization model, congestion problems are solved through the variable charges. Recuperation of long-term capital costs is achieved through the fixed charge, while incentives for investment in expansion of the network are reached by a rebalancing of the fixed charge and the variable charge. Transmitted volumes for each type of service are used as weights for the corresponding different prices so that TRANSCO's profits increase as capacity utilization and network expansion increases. In equilibrium, rebalancing of fixed and variable charges depends on the ratio between the output weight and the number of consumers.

Incentives for investment in Vogelsang's model crucially depend on the type of weights used. For each service, a Laspeyres index uses the volume of the previous period as weight for the price. When this type of weight is used, the TRANSCO will not immediately invest the total difference between current capacity and optimal capacity since the TRANSCO faces a tension between gains from congestion or increases in the capacity charge. The TRANSCO does not immediately equate the marginal income from investing (given by consumers' willingness to pay) with the marginal cost of investment. However, investment will continue through time until it converges to the optimal level, and transmission tariffs in turn will converge to Ramsey prices.[9]

Broadly speaking, Vogelsang's mechanism work as follows. In times of excess of capacity, the variable charge of the two-part tariff decreases causing an increase in consumption. The fix charge, in turn, augments so that total income increases in spite of the diminishment of the variable charge. As a consequence, the TRANSCO does not invest more in capacity expansion and net profits grow since costs do not augment. On the contrary, when there is congestion in capacity the variable charge will be a pure congestion charge and, if congestion charges are in the margin greater than the marginal costs of expanding capacity, the TRANSCO will have incentives to invest in new capacity.

Vogelsang (1999 b) further expands the mechanism to general non-linear tariffs. In such case, the firm would further create new sets of goods (resembling third-degree price discrimination) that would consist of quantity segments. So, if there is a quantity segment for every n units a consumer of x units will buy x/n goods with x/n different prices.[10] He also studies the application to electricity transmission. He proposes defining variable fees to cover short run congestion charges, power losses and ancillary services. The TRANSCO would establish variable charges ex ante and fixed fees are determined afterwards so that the price structure could be changed on short notice to accommodate changes in demand and supply conditions. The price cap would also have to include last period quantities -- for peak and off-peak-- as weights.

In the extreme, variable charges may be the actual spot prices so that they change almost instantaneously and differ by geographic area, zones, or even nodes. Under this assumption, fixed fees would have to be determined at the end of each period to provide premia and penalties for variations in the variable fees.[11] Weights would be assigned to each spot price according to previous period peak and off-peak quantities. There would be many small subperiods which share the same capacity constraint so that in off-peak subperiods marginal cost is zero, while in peak subperiods marginal cost is positive and equal to partial derivative of the cost function with respect to the capacity constraint. Profit maximization subject to the

[9] These results are true only if it is assumed that the cost and demand functions are stable and that the TRANSCO does not have strategic conduct in setting its prices. (See Vogelsang (1999), pp.28-31). In the case of changing cost and demand functions, or non myopic profit maximization, convergence to ramsey prices under the Laspeyres index cannot be guaranteed (see Ramirez and Rosellon).

[10] Vogelsang argues that regulatory administration under such non-linear price caps would increase workload but no more complexity is introduced. The regulated firm might have metering problems and estimation of demand of each quantity segment.

[11] So, for example, when there is too much congestion in a period the variable fee will adjust upwards and the fixed fee will have to be adjusted downwards.

price-cap constraint implies that prices will converge to the values of marginal cost in both peak and off-peak periods.

There are, however, implementation complications because the TRANSCO will want to trade until immediately before the transaction takes place (due to the spot pricing nature of the mechanism). Moreover weights cannot be precisely defined since it is impossible to identify periods of last year with periods of the current year. Therefore, all subperiods have to be assigned to a single common weight which imply an average-revenue constraint as described by Ramirez and Rosellon (2000). The use of this constraint produces first-order conditions different from the optimal conditions since the average revenue constraint is softer than the Laspeyres one (see Bradley and Price (1991), and Sappington and Sibley (1992)). Vogelsang then proposes additional constraints to the price cap, including market rules that assure competitive spot prices[12] and weights restricted to peak quantities. These additional conditions assure lower prices and more investment over time.

Regarding fixed fees, Vogelsang proposes to define them heterogeneously so that the fixed fee really pays for a service (called access or capacity) demanded along with usage so that the two-part tariff may actually consist of two linear prices for two services. There are three alternatives for the unit of consumption of the now "variable" fixed fee. First, fixed fees might pay for total capacity provided by the TRANSCO. Second, the quantity used to calculate the fixed fee could be individualized and defined by the capacity demanded at the peak. Third, the fixed fee could be allowed to grow according to a predicted rate. The first option leads to overinvestment, the second to underinvestment, and the third one depends on the growth prediction.

Vogelsang (1999 b) analyzes the possibilities for the growth rate of the fixed fee and analyzes two alternatives. The first one is that exogenous benchmarks are used (such as regional GDP growth or growth in electricity consumption). The second possibility is to define the growth rate using an incentive compatible mechanism. In this last option, there would be a trade off between the growth rate "g" and the efficiency factor X, since an increase in X reduces profits. The regulator would offer the TRANSCO a menu of combinations (X,g) to choose from.

It is important to point out that the Hogan's proposal and the Vogelsang's proposal are not really incompatible. The price cap mechanism can be applied under the ISO/REN approach. In fact, Vogelsang (1999 b) argues that an ISO is important in order to coordinate a competitive market for congestion pricing. The ISO would run the short-term utilization of the transmission system, while the TRANSCO would own and physically operate the transmission network and collect congestion charges and fixed fees. However, Vogelsang also points out that the ISO needs a

[12] Market rules imply setting the spot price equal to zero for off-peak subperiods and according to inverse demand in peak subperiods.

well-defined objective function and that the variables that might influence this objective function could be the total amount traded over the transmission system and the average nodal price difference.

Economies of Scale and Transmission

The crucial issue to determine which of these alternative fits better the Mexican case is related to the presence of economies of scale in transmission. The proposal of Hogan gives efficient results if there are no economies of scale or, if they exist, they are too small to have influence on the system. If they are important, then a small expansion of the transmission grid will have an important impact on tariffs. If this is the case, there would be no incentive to expand the grid because the reduction in the transmission tariffs would not be compensated by the increase in demand. However, if the presence of economics of scale is negligible, then the effect on tariffs would be very small. In such a case there would be incentives to expand the grid.

Under the Hogan's proposal, if the difference in the locational prices is big enough to incentive the investment and if the impact of the expansion on the tariffs is small enough, then the incentives to expand the transmission grids arise naturally.

Let us analyze the Mexican electricity industry to know if there exist economies of sale in transmission. Transmission is an important component of the electricity industry. It must guarantee that the flow is transported with the required quality and voltage. It must minimize the congestion and the loss of energy in he system. It must guarantee access to all the generators at the same conditions. In order to perform all these activities correctly, it must schedule its growth rate. It is at this point that the economies of scale become important.

We say that there are economies of scale in transmission if the investment in expansion is so productive that the equilibrium tariffs decrease to such a level that there are no incentives to invest. In this case, the concessionaire (or the owner) gets a bigger return by not expanding the grid because of the higher tariffs he is charging. Under these circumstances, he will not expand unless there exists some proportion of demand that is willing to pay a tariff big enough for the expansion of the grid to compensate the concessionaire for the gains that he would give up. This is one of the main problems that must be analyzed in the case of transmission. The "best" solution for this case is impose some regulation over the concessionaire to ask him for the needed expansion. However, the regulatory agency must be careful because it could be possible that the concessionary had losses due to the expansion imposed.

Finally, given the historic average growth rate in expansion, Zepeda (2000) finds that the presence of economies of scale is important in the transmission grid.

The way of measuring that is related to the energy losses in the system and the congestion of the grid. Therefore, if the expected increase in demand is going to be satisfied, the transmission must expand at much higher rates to avoid congestion and loss of energy.

Therefore, under these conditions it is a better policy to implement the Vogelsang's proposal and regulate the transmission tariffs and rate of expansion to avoid the problem posed by the presence of economies of scale. Once the system is mature, it is possible to impellents the Hogan's proposal to get further increase in efficiency.

Transmission and Dispatch

Based on all the arguments presented and the analyses we did above, we conclude that the best configuration of transmission and dispatch is to have them in separated entities. In this case there exists a trade off between the gains in coordination and the gains in incentives for generation. If there is integration between transmission and dispatch here are gains in coordination which decrease the congestions and the loss of energy entering into the system. On the other hand, having them separated gives gains in incentives for generation, where there is going to be more installed capacity. Given that the Mexican electricity industry is not mature enough and one of the main difficulties that is facing is the high growth rates of demand, we conclude that the best configuration for our industry is to have transmission and dispatch in different entities.

Linkage between Gas and Electricity Reforms

Natural gas is a vital fuel for power generation in Mexico. Around 51.7% of total generation capacity by 1997 was hydrocarbon based. Natural gas represents 16.15% of total fuel consumption of generation plants in Mexico, while fuel oil is 63.16%, coal 12.31% and diesel 1.35%. Natural gas is expected to increase its share according to the enactment in 2002 of environmental standards that will require the substitution of high- sulfur fuel oil for natural gas. Additionally, most of the IPP projects bid by the CFE are for plants that use natural gas. In fact, these projects usually include both the generation plant plus the gas pipeline connecting the plant with the gas source. Moreover, the restructuring proposal presented by the president of Mexico to congress in February 1999 basically foresees that private investment will flow to natural-gas based plants, since nuclear generation and an important part of hydro generation remain in State hands. This demand growth will imply a significant increase in gas penetration in the energy matrix. Between 1998-2007, the share of natural gas in energy consumption is expected to increase from around 18% to 58.1% for thermal power generation.

Natural gas production is therefore crucial for the growth of the electric sector. Natural-gas demand from power generators in the 2000-2007 period will annually increase 14.89%. Table 9 presents more detailed data on natural-gas demand according to the most recent prospective study of the SE. It can be observed that it is expected that consumption will grow 9.12% per year from 1998 through 2007. It is noticeable that demand grows 22% from 1998 through 1999 due to demand from electricity generators and oil production. In the 2000-2001 period it is expected also a huge increase in demand from power generation of 20%. The large annual growth rate of the electricity sector's natural gas demand due to generation plants that will be converted to natural gas (4.0 GW), public and private stations currently undergoing construction or bidding processes (6.7 GW) and stations built to meet future additional capacity requirements (15.8 %).

The SE and PEMEX have just announced an ambitious program, Plan Estrategico de Gas Natural (PEG), in order to cope with this demand. According to the PEG, PEMEX plans to double its natural gas production in from 200-2008 passing from 131 thousand cubic meters per day to 238 thousand cubic meters per day. PEMEX strategy in the short run (1999-2001) is to invest USD 5.6 billion of which USD 3.7 billion will be used to develop non-associated gas fields of Macuspana, Veracruz, and Burgos, in the northeast of Mexico. The analysis of the likely future evolution of domestic production, however, has to be skeptical since PEMEX's investment program in gas is typically behind schedule, and funded below the true cost. Likewise, future imports and productions depend on whether PEMEX actually gets funding for long term exploration and production effort, and how delayed it is in delivering on it. PEMEX has historically lagged planned production target dates by several years with cost overruns all of which imply less gas than planned, much later than forecasted. This carries to the logical conclusion of accelerating amounts of imports that, combined with the netback domestic gas methodology (see annex for a description of this methodology), could imply an increase of absolute levels of the price of gas in Mexico and possible volatility. New arrangements for risk sharing with experienced private companies should therefore be considered in the near term with associated changes in licensing, taxation and audit policies and practices.

There is also a question regarding the type of contracts that the generators will be able to arrange in order to meet their natural-gas needs. The main issue here is that PEMEX is in most of the cases the only source of gas. In case of a competitive marketing activity in gas delivery, this would not matter that much because the generator could select the best contract from the several marketing companies. However, under the current regulatory framework PEMEX has the virtual monopoly in any kind of gas (spot or futures) contracts because of its vertical integration and the existence of its marketing subsidiary. The CRE just published the directive on first hand sales on February 2000 (see Comision Reguladora de Energia 2000) in order to regulate the marketing relations of PEMEX with its customers. This directive requires that PEMEX does not unduly discriminate among consumers. This means that PEMEX will have to offer the same deals to northern generation plants that have access to more competitive contracts (because of closeness to the US market), and to southern generators that only have access to PEMEX gas. Therefore, if PEMEX makes a price discount to a generator in the north it has to offer the same discount to a similar generator in the south. The idea of the CRE with these measures is that, by having the same price of gas, competition among generators will only take place in aspects related to technical and financial issues.

Even though it proposes several important regulatory measures,[13] the first-hand-sales directive did no take deep steps to have real competition in gas marketing activities. The asymmetry of information between PEMEX and the CRE seems to be much more dramatic in this area than in any other area of regulation. The amount and diversity of strategic games that PEMEX might play with any kinds of contracts for different types of consumers are enormous for a small regulator (see Brito and Rosellon (1999)) due to PEMEX private information regarding its performance and own technological characteristics.

Therefore, the current model of generation enhancement based on IPP generation is between a monopsony buyer (CFE) and a monopoly supplier (PEMEX). This does not seem to be consistent with a competitive market structure. This could affect the performance of electricity generation since, generally speaking, 60% of the total costs of a power generator is due to fuel cost. Moreover, in case of a complete deregulation of the electricity sector, it is not clear that the monopolistic structure of gas marketing in Mexico will be able to respond with the same flexible kind of contracts that than a free competitive gas marketing structure.

Hence, the main policy recommendation for having a competitive natural-gas market would be that PEMEX is not permitted to discount the maximum price of domestic natural gas and the transportation rates (see Brito and Rosellon (1999)). This is equivalent to not letting PEMEX to commercialize gas. This rule is needed due to PEMEX vertical integration in production, transportation, and marketing of gas. Marketing is a contestable market (maybe more contestable than production) and there seems no to be a sound economic reason to virtually leave gas commercialization as a state monopoly. The fear of having few private marketers that may extract all the marketing markups after liberalization does not seem to be a

[13] See annex for a detailed description of CRE's directive on first hand sales.

valid concern. The experience of the US natural-gas market is a counter example for such hypothesis.

Another crucial issue is the expansion of PEMEX transportation capacity in order to satisfy gas demand from power generation. PEMEX is by far the dominant actor in transport and marketing and the interplay in both activities may continue to discourage private interest in developing gas transport infrastructure. The combined IPP/gas transport projects tendered by CFE can be seen as y stop-gap measures to deal with this problem.

According to PEMEX transportation permit (approved during summer 1999) PEMEX transportation system will grow at an annual rate of 11.0% in order to meet demand needs including the demand growth from electricity generators. In 1999, demand and supply for natural gas in Mexico will be 4,824 and 4,838 million cubic feet per day (mcfd), respectively, in 2000-2001 5,096 mcfd and 5,111 mcfd, and in 2002-2003 5,259 mcfd and 5,275 mcfd, respectively. PEMEX will face this increase in demand by expanding its transportation capacity (see table 11).[14] As shown, the increase of pipeline capacity will barely cope with the increase of demand, and there could be bottlenecks during peak periods.[15] A very strong case can be then made that a policy that makes sure that there is always sufficient pipeline capacity so that the gas market can always clear should be followed.[16]

There is another peculiarity with the structure of incentives for location of new generation plants and transmission lines. Such location will be mainly determined by the current PEMEX natural-gas transportation system that is subsequently determined by PEMEX monopoly and vertical integration status.[17] In

[14] These calculations are based on estimates of injection and extraction requirements at each node (Comision Reguladora de Energia (1999), appendix 3.1), flow and capacity technical information for each transportation sector (annex 3, appendix 3.1 and 3.2), repowering needs at each compression station (appendix 3.1), and investment needs for expansion of the pipeline network (annex 6.2.1).

[15] Especially important is the 1597 kilometer-long pipeline system in the Reynosa and Monterrey operating sectors where a huge increase of demand is expected and where two of the three compression stations are old. There are three compression stations located in these sectors. In the Monterrey sector there are two old "reciprocate" compression stations "Ojo Caliente", and "Santa Catarina", with more than 30 years of operation, and with huge drops in pressure and low volumes. In the Reynosa sector there is a "turbo compression" station" that was constructed in 1997.

[16] Such a policy could consist of consumers paying to PEMEX expansions of the pipeline system. This would generate sufficient savings to the consumers of gas that they will be willing to pay for such investment.[16] According to PEMEX transportation permit, pipeline expansion can be done in two ways. A "rolled in" methodology can be applied when the expansion is beneficial for all consumers, while an incremental cost method is applied in other cases. It must be pointed out that interconnections with the US also have to be expanded. PEMEX is currently working to expand its capacity in Reynosa.

[17] Since PEMEX is vertically integrated in transportation and marketing, there are little incentives for the construction of new natural-gas transportation routes that are somewhat close to the PEMEX pipeline network. PEMEX could discourage many new transportation projects through

other words, the location of new gas-fired producing sources in the Mexican electricity sector will be determined not by demand conditions but by closeness to the PEMEX pipeline network.

6. Conclusions

We analyzed the Mexican proposal to restructure the electricity sector. The main results that we get are the following. First, given the current technologies for generation that belong to CFE and LFC and the new technologies that are more likely to get into the generation business, we conclude that the Australian model should be implemented in Mexico. This model ask for a stand by or reserve market to cover the excess demand in the peak period. Second, given the presence of economies of scale in transmission in Mexico, we conclude that in the first stage the Vogelsang's proposal of regulation should be implemented. Latter on, once the market is mature, the Hogan's proposal could be implemented. Third, the industrial tariffs are more likely to decrease after the reforms takes place. The argument is based on the presences of subsidies for the residential tariffs. Finally, we make an argument to say that it is better to have the generation system and the dispatch in different entities. Although we loss some efficiency for not having these two firms integrated, we get benefits from expansion of generation. Given the situation of our market, the bigger gains are in the expansion of generation.

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marketing and manipulation of pipeline capacity. This then implies that the shape and capacity of the current transportation network will hardly be modified according to market criteria.

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ANNEX

THE CRE'S NETBACK FORMULA FOR REGULATION OF NATURAL-GAS PRICE IN MEXICO

The formula used by the CRE to regulate domestic natural gas takes as benchmark the price of natural gas in Southeast Texas (Houston Ship Channel hub) and adds net transport costs to southeast Mexico, where more than 80% of total Mexican natural gas is produced as a byproduct of oil extraction. More specifically, the price cap gas for the Mexican natural gas is equal to the price in Southeast Texas plus transport costs from Texas to the arbitrage point (i.e., the point where northern and southern flows meet, and the price from both sources is equal) less transport costs from the arbitrage point to Ciudad PEMEX.

Brito and Rosellón (1998) formally study the mechanisms for linking the Mexican market for natural gas with the North American market and show that the netback rule results from solving a well-defined welfare maximization model. In fact, they show that this methodology is an application of the Little-Mirrlees principle (see Little and Mirrlees (1968)), and that the Houston Market has a broad market of future contracts to intertemporally hedge from externalities. The formula, however, can also lead to incentives to increase the price of domestic natural gas by diverting production from the regulated market. PEMEX can sell gas to its own subsidiaries or simply reduce its production in order to bring the arbitrage point south an provoke an increase of the domestic natural gas price two times greater than the value of marginal cost of transportation. Brito, Littlejohn, and Rosellón 2000 derive this last result from a general model.

Brito and Rosellón (1998) further study the effects of reductions in import tariffs, technical export restrictions and investment in production facilities on the Mexican natural gas price. Reducing the import tariffs does not increase importation of natural gas from the US and will have little impact on the price. Additionally, it is socially optimal to develop new gas production sources closest to the arbitrage point rather than to the center of consumption. These (counterintuitive) results are due to the existence of a monopoly in production and the use of the netback formula, but the authors demonstrate that the formula is the second best option to complete liberalization in production.

Brito and Rosellón (1999) study the implications on efficient marketing of gas in Mexico of linking the Mexican market for natural gas with the North American market. They find that the netback policy is critically conditional on the existence of adequate pipeline capacity. If there is insufficient capacity, the movement of gas will not clear markets and it will be impossible to implement the netback rule. Rents will accrue to PEMEX. For example, PEMEX can capture the rents associated with the constraint by selling output forward and could then become a monopoly in the forward firm-service market. They further argue that PEMEX should be permitted to enter into spot contracts or future contracts to sell gas; however, the price of gas should always be the net back price based on the Houston Ship Channel at the time of delivery. PEMEX should not be permitted to discount the price of gas from the Houston netback price, or the regulated transport tariffs, even in a nondiscriminatory fashion because it can carry out several strategies (such as cross subsidies) and evade regulation. PEMEX or consumers of gas can actually use the Houston market for hedging of speculative transactions.

THE CRE'S DIRECTIVE ON FIRST HAND SALES OF NATURAL GAS

On February 23, 2000, the CRE emitted the directive on first hand sales of natural gas (see Comision Reguladora de Energia (2000)). This directive was issued 5 years after liberalization process begun because regulators initially believed that competition of gas marketing activities was assured by the contestable nature of such a market. However, vertical integration of PEMEX in production, transportation and commercialization has in practice proven to hinder the implementation of regulation and competitiveness in gas marketing. PEMEX marketing subsidiary is becoming a virtual monopoly in most gas marketing contracts inside Mexico.

The new directive states that PEMEX must unbundle its services in its first hand sales, but permits PEMEX to sell gas below the maximum regulated price. It also permits PEMEX to negotiate long-term contracts at a price below the maximum allowed by regulation and requires that PEMEX does not make cross subsidies between marketing activities and first hand sales. PEMEX also has to present detailed information on its marketing activities and transportation, distribution and storage contracts, as well as on gas sales, prices, gas availability, import and export volumes, national gas balance, and methodologies for price discounts. Additionally, the directive sets the rules for the general format of PEMEX's contracts on first-hand sales (general terms and conditions). The directive also requires that PEMEX's officials involved in first hand sales and marketing do not have access to information regarding applications, contracts and operative conditions of the transportation system that was not previously made public. Violators to this regulation will be subject to sanctions. The directive also states that PEMEX cannot sell gas under any undue condition, such as selling gas under the condition that another service is acquired from PEMEX.

The underlying assumption of the directive on first hand sales is that PEMEX will remain, as in the case of production, a monopoly in gas marketing. According to Brito and Rosellón (1999), through this decision regulators are trying to regulate the evils on gas marketing of PEMEX' vertical integration. Moreover, as in the case of production, regulators implicitly are letting PEMEX be a monopoly in gas marketing. Possibly, the rationale for this decision is to maintain the gas marketing rents within a monopolistic state Mexican firm rather than with the monopolistic foreign marketing firms that typically characterize the natural gas commercialization market. These rents might be redistributed later through transfers from the government to consumers.

Although the directive states important regulatory measures, the asymmetry of information between the state monopoly and the Commission seems to make this task extremely difficult. PEMEX might use its private information and vertical integration in order to evade regulation, in particular price and rate regulation. Moreover, even though the first-hand-sale directive also states that consumers can at any time modify its gas contract with PEMEX – which opens the door for possible contracts with other gas marketers-- it seems unlikely that there will be entrance of other marketing competitors and, therefore, the flexibility in gas contracts that could be present in a competitive commercial environment. This could have non-desirable consequences for the competitive evolution of the Mexican gas industry, as well as in the development of the electricity industry that is mainly focused towards hydrocarbon based generation.

SPECIFIC POLICY DECISIONS OF THE MEXICAN ELECTRICITY REFORM

Exclusivity in the Distribution Service: • The country is split into separate distribution zones • 30-year renewable concessions under public-service regime • Economically viable demand must be met by the distributor. Government will support service in poor and rural areas through investment support mechanisms • No exclusivity in distribution due to the possibility of subdistributors. • Bypass from the distributor only granted to consumers with more than 5.0 Gwh of annual consumption	Access to services: • Open access to transmission • Distribution: bypass only for large consumers • Large consumers can participate in the wholesale electricity market
Marketers: • Will need a permit to operate • Prices of marketing services will not be regulated • Marketing activities performed through a subsidiary • Distributors will be allowed to perform marketing activities outside their own service area.	Regulatory authority: • CRE approves the operation rules of the electric market and dispatch • CRE regulates transmission and distribution tariffs
Vertical Integration: • Vertical separation between transmission and generation, and transmission and distribution • Distribution companies can only hold a minor participation in generation (and vice versa) • Distribution companies can only carry out marketing activities outside their own distribution area • One subsidiary for each activity	Dispatch Functions: • The state will be in charge of the operation of the national transmission grid and the electricity market • Short run electricity market (pool) • Long run bilateral contracts • ISO dispatch generators according to their prices (starting with the generator with the lowest price) until the energy demand is met. The market price is equal to the price bid of the last generator that was dispatched • Regional prices when there are transmission restrictions • Real time prices to pay or charge for differences between expected energy and finally generated energy • "Cost-of-failure" term in energy prices to remedy deficits in supply; hedging mechanisms.

Table 4. Maximum average transport capacity of PEMEX´s national pipeline system

Units	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*
MMGcal/Year	421.5	445.3	445.3	459.5	459.5
MMPCD	4,824	5,096	5,096	5,259	5,259

Source: Comisión Reguladora de Energía (1999).

Table 5. Natural-Gas Consumption in Mexico by sector (thousand of cubic meters per day)

Sector	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Electricity	10,902.0	13,167.3	13,988.4	13,931.9	15,237.3	16,870.5	22,466.4	31,351.6	47,157.6	50,366.7	55,513.1	62,470.8	70,052.8	76,751.3	82,819.2
Industry	22,746.9	23,304.7	25,655.0	27,070.9	27,824.1	46,607.6	50,402.3	52,242.6	55,012.0	58,108.0	62,205.3	64,956.4	67,772.2	70,822.0	74,201.5
Oil	44,902.8	47,461.1	45,382.8	48,996.6	52,223.6	47,888.8	63,387.4	50,758.7	58,747.6	62,064.0	63,415.2	65,391.1	68,485.9	70,184.8	71,474.3
Own consumption	34,141.6	34,524.0	33,410.9	34,167.1	33,623.4										
Raw Material	4,695.7	5,835.4	5,555.8	5,261.3	4,159.7										
Internal Recycling	6,065.7	7,551.7	6,416.1	9,568.2	14,440.5										
Residential and commercial consumption	2,605.1	2,254.0	1,789.6	2,633.5	2,820.4	2,453.9	2,937.6	3,414.7	4,124.8	5,371.8	7,053.1	8,937.4	10,506.7	11,612.7	12,373.8
Vehicles						0.0	96.3	407.8	747.6	1,178.0	1,687.7	2,205.9	2,749.6	3,409.3	4,496.7
Total	81,156.8	86,187.1	86,185.8	92,632.9	98,105.4	113,820.8	139,290.0	138,175.4	165,807.6	177,088.4	189,874.3	203,961.6	219,567.2	232,780.1	245,365.5

Table 6. Average Natural Gas Demand by Sector. 1999-2008

Sector	Percentage
Residential and Services	4%
Pemex	35%
Industrial	30%
Electric	30%
Vehicle	1%

Source: SE