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The Electric Energy Market in Greece: New Aspects and Trends

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Abstract: A report of some significant aspects of the Greek electric energy market is presented in this paper. The paper comprises two parts. First, the European and Greek institutional frame for the liberalization of the electric energy market is presented. The most important laws and directives concerning the electric energy market liberalization are reported and analyzed. Second, the study is focused on the present status of the electric power generation in Greece, as well as on the increase rate of the electric power consumption in Greece.

Key-Words: - Electric energy market liberalization, legal frame, investment motives, electricity consumption

1 Introduction

This work constitutes an integrated report on the Greek electric energy market and an assessment of the liberalization of the Greek electric energy market. In the early 80's economists argued that the termination of national monopolies in the production and supply of electrical energy and introduction of new producers and suppliers in the energy market would be more efficient to consumers, leading to open competition and a significant decrease in electricity prices. The above has accelerated the need to create a suitable institutional frame for the liberalization of the Greek electric energy market and to invest in new technologies for power production. Taking into account that the liberalization of energy markets across Europe was one of the priorities of the European Committee, a lot of contemplation and a number of new proposals have been made. The maturing of the environmental awareness of decision makers, as well as the penetration of renewable energy sources and distributed generation units in general, created a new perspective in the European Union (EU), as well as in Greece. An assessment of the level of penetration of privately owned electric power generation companies (using gas or Renewable Energy Sources), as well as a statistical analysis of the increase rate of electric power consumption in Greece, is presented in this paper.

2 Institutional frame

2.1 The institutional frame in the EU

2.1.1 Directive of Electric Energy 96/92

The basic directive that determines the operation of the electric energy market in the EU is Directive 96/92, which is partially in force today. The EU Directive 96/92 defines common rules for the production, transmission, distribution and supply of electric energy in the EU, imposing minimal operational specifications for the internal electric energy market of the EU, with which all Member States should comply in national level. The directive

imposes the unbundling of individual activities of integrated electric energy enterprises, it allows third parties to apply for licenses for production and supply of electric energy, it requires the establishment of an Independent System Operator (ISO) for the management of the high voltage transmission system, and it allows the access of third parties in the transmission system and in the distribution network on the basis of transparent and objective criteria.

2.1.2 Directive of Electric Energy 2003/54

The main points of the new Directive of Electric Energy 2003/54 are the following:

- Acceleration of liberalization of the electricity market, so that from 1 July 2004 each not residential customer and from 1 July 2007 all customers (including residential), can be provided electric energy from a supplier of their choice.
- Imposition of stricter obligations concerning the unbundling of integrated electric energy enterprises, forcing them to segregate the activities of transmission and distribution, which will be held by independent legal entities in the case of vertically integrated enterprises.
- Strengthening of the role of regulating authorities to ensure that the tariffs of transmission and distribution do not impose discriminations and reflect the actual costs.
- Supervision of the security of supply, by engaging in competitive processes that contribute in the security of supply.
- Adoption of common minimal specifications related to the benefit of common utility services, especially for the socially weak categories of consumers

2.2. The institutional frame in Greece

2.2.1 Law 2773/1999

The main regulations of Law 2773/1999 for the energy market liberalization are briefly mentioned below:

- The energy sector is overseen by the Minister of Development.
- The Regulatory Authority for Energy (RAE) is founded as an independent authority with main obligations the control and the supervision of the liberalized energy market.
- The Minister of Development and the RAE should take actions in order to protect the environment, to meet the demand in electric energy, to check whether the holders of generation and supply licenses are capable of financing their activities or not, to promote competition in the sectors of electric energy generation and supply, to protect the interests of consumers, to promote efficiency, to take into consideration the expenses for Research and Development (R&D), and, finally, to protect the public health and safety.
- Any activity in the electric energy sector (production, transmission, distribution or supply) requires the issuing of a license. The licenses are granted by the Minister of Development after consultation of RAE, according to the provisions of the Regulation of Production and Supply Licenses of electric energy.
- The Public Power Corporation (PPC) maintains the ownership of the interconnected transmission system, while the right of management and expansion is granted to the Hellenic Transmission System Operator (HTSO).
- The PPC maintains the ownership of the distribution network, as well as the right of its management.
- The Electric Energy Market Operation is based on four codes, which are approved by the Minister: the Code of the Transmission System Operation, which regulates the normal operation of the interconnected transmission system, the Code of Electric Energy Transactions, which regulates the economic transactions with regard to the interconnected transmission system, the Code of Distribution Network Operation and the Code of Energy Supply to Customers.
- As a vertically integrated enterprise, the PPC should keep separate accounts for the activities of production, transmission and distribution (unbundling).
- The HTSO should provide electric energy to the load, based on the economic offers (bids) that are submitted in the day-ahead market by all technically available production units, which make offers that reflect their incremental cost. The HTSO should also take into consideration the technical restrictions of the transmission network, and its obligation to give priority to plants that use Renewable Energy Sources (RES), co-generation plants and plants that use domestic sources of energy.
- The tariffs for all electric energy enterprises, with the exception of the tariffs of supply of eligible customers, are approved by the Minister of Development after consultation of RAE.

2.2.2 Law 3175/2003

The more important modifications of law 3175/2003 to the Law 2773/1999 are the following:

- Establishment of the day-ahead market: The currently applied mechanism of load distribution, which was determined on the basis of the daily offers submitted in the HTSO by the technically available units of production, taking into account their variable cost, was modified. A day-ahead market is created, operating on the basis of independently determined hourly offers by the units to the HTSO, under the condition that at least the variable cost of operation of corresponding unit of production will be reflected in each submitted offer.
- Ancillary services: Special contracts for the supply of ancillary services can be made between the HTSO and private generation companies, in order to improve the quality of the power supplied to customers.
- Clearing of Differences: A new definition of differences is introduced: they are defined as the differences between the programmed injection and/or absorptions of energy to or from the system in the day-ahead market and the corresponding energy quantities that were injected or absorbed by the system in real time operation.
- Mechanisms for sufficient power production: The HTSO conducts a competition and makes contracts of electric energy production with privately-owned units, so that it ensures the safety of system supply. In a first phase, the HTSO will conduct a competition for power contracts up to 900 MW. This power will come from new privately-owned generation plants that will be incorporated in the interconnected system until 1.7.2007. During this period the HTSO can conduct a competition for contracts for additional power up to 400 MW. In the latter competition the PPC can participate with the same rules as the privately-owned generation companies. The HTSO can exercise several other practices to guarantee the sufficient supply of loads (under supervision by RAE).
- Supply: The definition of suppliers of electric energy has been extended to include commercial companies. Also, supply licenses are now provided not only to those who possess sufficient potential of production inside the EU, but also to those who are able to ensure availability of sufficient power from other producers inside the EU (e.g. based on contracts).
- Production license to the PPC for 1600 MW: PPC is granted a production license to build new power plants or the renew the existing power plants for 1600 MW, under the condition that a number of old power plants of PPC with the same amount of power will be set in cold reserve.
- Eligible customers: From 1 July 2004 each not residential customer and from 1 July 2007 all customers of the Greek interconnected system (including residential), can be eligible customers (they can be provided electric energy from a supplier of their choice).

2.3. Transmission system operation and electric energy transactions code

The new code for transmission system management and energy transactions [1], that is currently under public consideration, introduces a new power exchange logic: in case of congestion in the lines connecting the power production center of northern Greece with the consumption center of southern Greece, two different (fictitious) power exchange markets will operate, computing two different Spot Market Prices (SMPs); one for the northern area and one for the southern area. The SMP of the southern area will be greater in value than the corresponding SMP of the northern area. Therefore, the producers located in the southern area will be paid an increased price for each produced MW. Thus, the new code proposed by the RAE gives a clear motive to privately owned generation companies to install new power plants in the southern area.

3 Present status of electric power generation in Greece

The Liberalization of the Greek Energy Market has motivated a lot of private companies to invest in the construction of new electricity generation units. The PPC was found in a transient situation that created legal impediments in the submission of applications for new power plants during 1999-2001. Thus, the great number of applications for new power plants in 2001 (shown on Table 1), in contrast to 2002, is mainly attributed to the fact that the applications of period 1999-2001 are accumulated in 2001. The

Table 1. Positive consultations of RAE for new units, in MW

Region	2001	2002	2003
Southern Greece	1587.72	658.85	3420.81
Northern Greece	2267.08	232.27	472.59
Islands	153.46	71.56	335.99

great number of applications by privately owned companies in 2003 is partly attributed to Law 3175/2003 that was voted and placed in force in 2003.

An important ratio of the new licenses is related to natural gas units. A number of licenses summing up to more than 1000 MW for thermal units and co-generation units (Combined Heat and Power (CHP)) using gas have already been approved. The majority of the approved licenses concern units of combined circle summing up to more than 3300 MW. There also exist an increasing number of applications for wind parks as well as a constant demand for small hydroelectric units. The total power production of all these hydroelectric units is almost 200 MW per year, which corresponds to the construction of a large hydroelectric unit each year. Finally, there also exists a remarkable interest for electricity generation from biomass, which can be continued regarding the constant interest of industries to use their waste for electricity generation

The applications for electricity generation using photovoltaic (F/V) is insignificant, a strange incident for a country with great potential in solar energy. The above is attributed to the fact that the F/Vs have not yet developed an economically efficient technology, as compared to the other RES. Finally, there exist a small number of licenses for electric power generation using geothermic energy, since a continuously increasing number of provinces are

interested in electric power generation from landfill places.

However, in 01/05/2005 the majority of the total installed power in Greece, is still owned by the PPC. Only one privately owned gas plant exists in southern Greece (with capacity equal to 150 MW), which was constructed in order to provide the necessary reserves and to ensure voltage stability in the southern consumption area, especially during the Olympic Games in Athens. The new unit has been eventually in an operation mode by October 2004, under a special contract with the HTSO. Another generation plant is planned to operate by October 2005 (with capacity equal to 400 MW) in the northern area (owned by "Hellenic Petroleum").

A significant issue is that the PPC has not yet implemented the unbundling of its activities (production, distribution and supply of electrical energy), as it was obliged to do by the EU Directive 96/92. Greece has been convicted for the above purposeless delay by the EU.

Although the new code (see Section 2.3) has a better perspective for new generation plants than the previous operating codes, the greatest potential investors of power plants in Greece have recently expressed their disappointment for the arrangements of the new code, arguing that more decisive measures should have been taken in order to open competition in the electric power generation in our country. On the other hand, potential investors in electric power supply are satisfied with the arrangements of the new code, arguing that is tends towards the full liberalization of the electric energy supply sector.

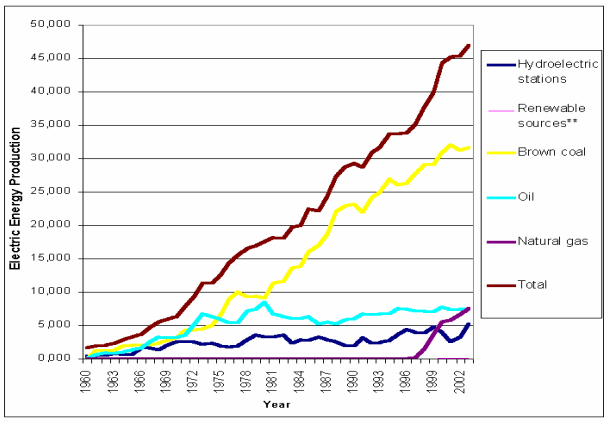

Fig. 1. Electric energy production, in GWh

4 Electricity consumption

4.1. Present status of electricity consumption

The total electricity consumption consists of the following uses: domestic, agricultural, commercial, industrial and other uses. Fig. 2 illustrates the rate of increase of each separate use for years 1960-2003. The domestic and commercial electricity demand present the highest increase rates. The domestic electric power demand increase in the last 5 years is attributed to the installation of a large number of air-conditioners throughout the whole country, while the increase in commercial use is attributed to the significant growth of the sector of "services". Industrial use, that dominated in the final electricity consumption from 1961 to 1995, is stabilizing in recent years, due to the fast deindustrialization of Greece in the last decade. Agricultural use has not increased significantly through time. The total electricity consumption in Greece increases faster than in the other European countries. The total electricity consumption has reached 47,160 GWh in 2002 (6,1% up as compared to 2001) and 49,596 GWh in 2003 (5,2% up as compared to 2002).

Many researches have tried to forecast the increase rate in electric energy consumption in Greece, providing unsatisfactory and inaccurate results. In the last years the electric energy consumption exhibits an excessive increase [2].

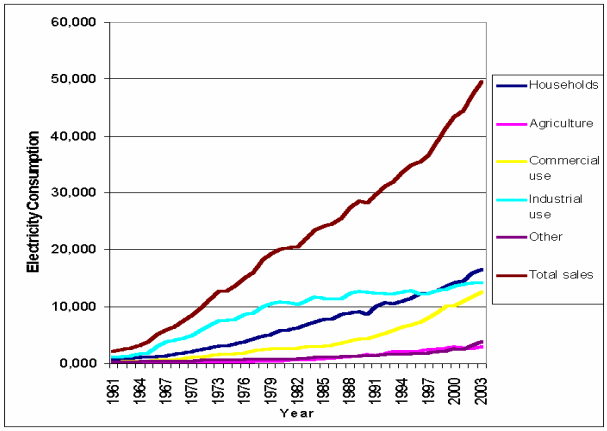

Fig. 2. Electricity consumption by use, in GWh

4.2. Literature review for Electricity Consumption Forecasting

A variety of methods have been employed for electricity consumption forecasting, according to the nature of the data available and the desired nature and level of detail of the forecasts. Each approach usually employs one or more methods, comparing them in order to arrive at a more accurate forecast. Several past methods are presented in this section.

Lendasse et al. (2002) [3] examined a quasi-automatic method using a non-linear projection named Curvilinear Component Analysis (CCA) to build a regressor, and then applied it to the Polish energy system. The nonlinear model used for the prediction is a Kohonen map (self-organizing map).

Hirschhausen and Andres (2000) [4] investigated several scenarios of electricity demand in China until 2010, at national and regional level, taking into account the recent macroeconomic downturn in the Chinese economy and the potential effects of deregulation and price increases in the power sector. A simple Cobb-Douglas function has been applied.

Narayan and Smyth (2005) [5] examined the relationship between electricity consumption, employment and real income in Australia within a cointegration and causality framework. The Box Jenkins autoregressive integrated moving average (ARIMA) model has been used to forecast per capita electricity consumption in Australia for years 2000-2010. In-sample forecasts of electricity consumption, the Theil index and the mean absolute percentage error have been calculated as measures of forecasting accuracy.

Yan (1995) [6] tried to force the characteristics and to estimate urban household-electricity use in China from 1985 to 1993. The rise of per-capita electricity use has been driven by increase in disposable income, and that per-capita electricity use may be expressed as the function of per-capita GNP, concerning the years 1985-1993.

Al-Faris (2002) [7] has used cointegration techniques to study the effects of economic variables on electricity demand in the Cooperation Council countries (GCC) countries (Saudi Arabia, UAE, Kuwait, Oman, Bahrain and Qatar). Statistical investigations had confirmed the existence of unit root in all time series employed in the study, which called for the use of cointegration and error-correction methodologies. The Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests have been applied to examine the properties of the time series.

Ghosh (2002) [8] has investigated the existence and direction of Granger causality between electricity consumption and economic growth in India using the annual data covering the period 1950-51 to 1996-97. Phillips-Perron tests have been performed, which revealed that both the series, after logarithmic transformation, were non-stationary and individually integrated of order one.

4.3. Forecasting Electricity Consumption

4.3.1. Data and Methodology

Time series models are based on the notion that the series to be forecasted has been generated by a stochastic (or random) process, with a structure that can be characterized and described. If the time series to be forecasted has been generated by a stochastic process, it is assumed that each value $y_1, y_2, \ldots, y_t$ in the series is drawn randomly from a probability distribution. A model of this process attempts to describe the characteristics of its randomness. An example of a stochastic time series is the random walk process, where y_t is determined by:

$$y_t = y_{t-1} + \varepsilon_t$$
with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_s) = 0$ for $t \neq s$

An extension of the random walk process is the random walk with drift. This process accounts for a trend (upward or downward) in the series y_t and thereby allows to embody that trend in the forecast. In this series, y_t is determined by:

$$y_t = d + y_{t-1} + \varepsilon_t$$

The coefficient d is the drift term. Thus, y_t will increase by d compared to y_{t-1} whatever the particular realization of ε_t, and on the average the process will tend to move upward (for $d > 0$) [9].

Time series models make efficient use of available historical records of electricity consumption for short-term forecasting. Here, the electricity consumption is expressed purely as a function of

time, rather than by relating it to other economic, demographic, policy and technological variables [10]. This function of time is obtained as the function that best explains the available data, and is observed to be most suitable for short-term predictions [11].

Our approach examines historical electricity consumption data in Greece from 1961 to 2003. The total consumption of electric energy is consisted of the following uses: domestic, agricultural, commercial, industrial and other uses. The random walk with drift model is applied in order to forecast electricity consumption in Greece for years 2004-2010, using the econometric software E-Views 4.0 [12].

4.3.2. Results and Analysis

An individual forecasting with the "random walk with drift" model is performed for each separate use. Fig. 3 present the forecasting results by use and the total electricity consumption for years 2004-2010.

It is concluded that domestic and commercial uses will prevail in the forthcoming years, having the highest increase rates. The industrial use, that dominated in the total electricity consumption from 1961 to 1995, will remain almost stable till 2010 and its share in total consumption will slightly decrease. The total consumption of electric energy in Greece will still increase significantly through time at rates higher than in the other European countries. Total demand for electrical energy will reach 63.978 KWh. in 2010, having an increase equal to 36,4% as compared to 2003. Therefore, additional electric power production will be required in the near future to meet the excessive electric power demand.

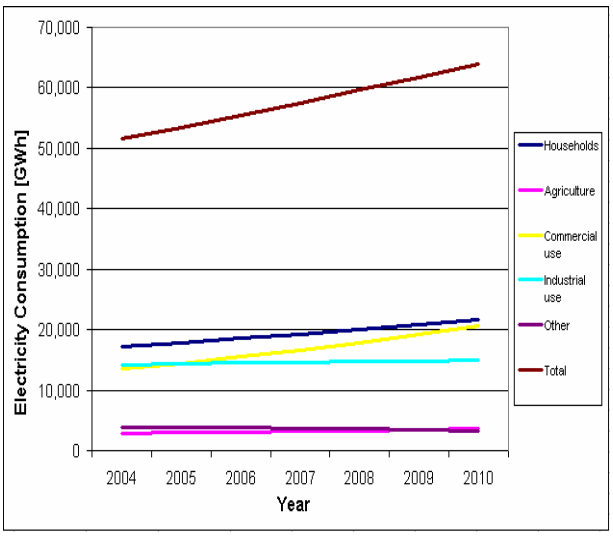

Fig. 3. Electricity consumption forecast, in GWh

5 Conclusions

The main objective of this paper is to present the basic characteristics of the Greek electric energy market and to provide new trends and aspects. The EU Directives that act as basis for the institutional frame for the Greek electric energy market have been reported. The basic features of the laws for the liberalization of the Greek electric energy market have also been presented. The paper has demonstrated the current status of electric power generation as well as the increase rate of the electric energy consumption in Greece. Considering the present status of the liberalized energy market, the investment motives for electric power generation, and the great increase in electric energy consumption, a safe conclusion can be drawn that the Greek electric energy market offers great opportunities for investments and potential for low risk profits.

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