

"Dunărea de Jos" University of Galați, Doctoral School of Social Sciences

DOCTORAL THESIS SUMMARY

Contributions in Modelling the Possibilities of Trading the Electricity on Electric Energy Market

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Galați, 2017

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Key words: trading, electricity, econometric methods, ARMA method, VAR method, Taguchi method, renewable energy, nuclear energy, price prediction, DAM price

Summary

Global economic and social development are characterized by an increase in energy consumption. Due to the possibilities to be easily transported at great distances, but also to the multitude of forms that electricity can take, it has played a very important role in the progress of mankind. Together with the national and international context regarding the use of energy resources, the price forecasts are of particular importance. Predictive activity is in fact the most important activity of a trader. The more the predictions are closer to reality, the better the moment of sale or purchase, and thus the level of profitability can be dimensioned. There is no clear estimation program or methodology, but instead there is a whole range of platforms that generate short-term weather forecasts and which are published in real-time levels of production capacities at national and European level. Along with this information, price estimatives use time series, meaning past price values, with a certain amount of cyclicity.

Through this paper I performed a simultaneous analysis of the DAM price values, as well as the correlations between the energy variables that contribute significantly to the formation of the price. Thus, chapter I deals with the existing framework for energy actions, based on the production - consumption - price relation. I have also made a comparative study with Bulgaria, a state with which we have close cooperation relations in the field of electricity trading due to the physical approach. Chapter II focuses on the opportunity of developing nuclear energy in Romania; the purpose of this chapter is to clarify the necessity and the impact of any decision - whether or not to continue the nuclear project - on the energy mix and on the price. Chapter III is based on the modeling of the electricity price on historical, daily consecutive time series, the price prediction for the period immediately following the one under analysis, as well as the interdependencies between the active production variables that influence the formation of the price.

Specialized literature deals extensively with the field of energy systems, both technically, but also economically. The price of electricity affects the economy as a whole, which is why the electricity pricing mechanism is particularly interesting because it produces strong effects on all industrial and non-industrial branches. There is a number of world leaders in the development of energy systems as well as leaders in innovative ideas. These cases are specifically studied: the US as a mature and stable energy state, Germany as the first state to decide to eliminate the nuclear energy from the energy mix, the United Arab Emirates as a state that has been for decades in an economic boom, China as a state that uses more than 60% fossil fuel with high combustion temperature, so energy inefficient. In all cases, the impact on the price of the decision on the dynamics of energy mixes, by using various dimensions of nuclear sources (Germany aims to eliminate it, emerging countries make decisions according to their own mixes, economically developing countries intensely develop this type of energy), is also regarded as a unanimous view, reflected in institutional decisions, with the need to use green energies.

Also, together with the energy mix, as the main factor of price influence, there should be considered other variables: stock exchange quotations, energy situation of neighboring countries, shocks affecting prices. Thus, in future approaches to forecasting electricity prices, the informational horizon is much broader, as a much wider variety of aspects can be taken into account, thus giving a much closer forecast to reality.

The importance of the National Energy System as a strategic branch in the Romanian economy has always determined a special attention given to this segment of activity. Romania has a wide range of energy resources, using them simultaneously and in different proportions depending on the needs of the economy and the costs involved. The dynamics of the National Energy System is permanent, the changes have begun at the end of the 1990s and continue depending on new needs or new directions of development at national, European and world level. One of these development directions concerns the growing use of renewable energies. The importance of Nuclear Energetic System has led to a very high involvement of the state authorities in regulating and monitoring the proper functioning in this field, and therefore the state-owned enterprises have a very important role in the development of energy partnership relations. These enterprises are governed by the National Regulatory Authority for Energy, which is mainly legislative, Transelectrica, with a key role in the management and operation of the electricity transmission system and Opcom – the Operator of Electricity and Natural Gas Market in Romania, with a commercial role - electricity exchange. All three institutions are in close and permanent collaboration.

As a rule, in Romania, due to the weak production processes at national level and to the excess capacity of production, there is a surplus in the production-consumption balance in 2017, a surplus which is partly exported, partly used by the secondary and tertiary adjustments of the positive imbalances. Neighboring countries acquire energy from Romania as it is cheaper than in their own country. One of the partner states is Bulgaria, which has a net importer position in the relationship with Romania. Bulgaria's production capacities are similar to those of Romania in terms of diversity of resources used. The degree of development and liberalization of the Bulgarian electricity market is inferior to the Romanian market, due to the slow process of modernization, the free market DAM segment being put into operation at the beginning of 2016 compared to Romania, which made the first steps towards liberalization in 2000.

The most important barometer that is considered in analyzing the opportunity of developing different types of energy is, along with their utility, their profitability. Consequently, medium and long-term predictions of electricity prices play a key role. On the Romanian market, Nuclearelectrica is one of the major players, active on all types of centralized markets, therefore the limitation of the shareholder's right of trading by the main shareholder - the Romanian state - is only related to the supply at regulated prices. These quotas will be reduced to 0 at the beginning of 2018.

The commissioning of additional production units has beneficial effects both at the national level, through the financial results but also at local level, such an openness influencing the community in which these production units operate. Regarding the expansion of NPP's work, the social impact will be particularly high. Leaving aside the obvious local impact, the expansion of NPP's activity offers the possibility of major investment developments by reinvesting profits. Thus, together with the development of Tarnița - Lăpușești Pumping Pipe Hydropower Project (CHEAP) and the connection cable with Turkey, NPP intends to become a national electricity supplier, thus offering the possibility to offer producer price of electricity for the entire population.

Feasibility studies developed over time on a number of occasions and in different investment phases were based on the past experience of putting into operation the first two production units, but also the current situation of the parts, consumables, fuel, heavy water and HR. Due to the very large initial expenses and also to the strategic sector at national level, the state involvement

is financially necessary, being the one that will choose the potential investors. At the level of 2017, the only ones approved to analyze the archives is a Chinese company, a worldwide nuclear power developer. At national level, the development of nuclear energy by investing in Units 3 and 4 is a main goal since 2010. These investments are necessary, on the one hand, due to the aging of existing production units and on the other hand to increase the portfolio of activities owned by Cernavoda NPP.

From a commercial point of view, NPP is actively participating in all energy markets in Romania, supplying strictly national electricity. Taking into account that there is a given, constant and permanent level of production, price predictions do not specifically determine a certain trader's commercial behavior in the sense that the production in it's whole must be provided irrespective of the level of the market price from a particular moment. This is manifested at the level of all producers, the impossibility of having stocks in energy, which sometimes leads them to make less profitable decisions. However, the key to success is this specific prediction, however, suggesting the most advantageous times for sale, the company being forced to ensure that all production is marketed under long-term contracts during those periods.

For price predictions, I used the ARMA model of time series analysis as a basic method. The mobility of the ARMA model is limited by the stability of the data series. I chose the historical analysis T, T-1 and I found that the series is not stationary in the level, the differences between the daily values being very high, which is why I chose to continue using the model on the price index. Using the AR1 ARMA variant I managed to get a stationary level and to predict with higher or lower errors the DAM prices for Q2 2016. To check the veracity of the model I also had to check if the errors occurred after the analysis are sporadic errors – situation that would be desirable, or errors with correlations between them. This is proven by the ARCH test. The test went wrong for the consecutive data series, which is why I analyzed the differences between successive terms at two levels, in which case the test went out properly - the probability level must be less than the significance level chosen for modeling. In the case of errors, their normal distribution must take the shape of Gauss's bell.

Using the VAR autoregressive vector model, I tested the stability of the historical series for the production data from each source included in the price prediction, most of which were non-stationary series, with significant differences in total production per delivery days. Also, with the VAR model I analyzed the correlations between the consumption, production and coal variables, the shocks applied to one of the variables being partly explained by the fluctuations of the others. For example, at a minimal shock intensity, the results of the shock-shifting change accounted for 99.92% of consumption, 0.07% of production change and 0.01% of changes in coal production. Depending on the intensity of the shock, different levels of variation in consumption can be explained by varying levels of variation of the other elements included in the model.

The DAM price prediction is important insofar as the profitability of the enterprise is pursued, but also the recovery of the initial investment. The calculations made by the most recent feasibility studies, aggregating the current level of costs by the total number of hours of operation, show that the approximately EUR 5 billion initial investment, cumulated with EUR 200 million maintenance and operating costs, for a production of 5 Millions of MW/year at an average price of 153 lei (the average DAM price traded in Q4 2016 for 2017), would result in an annual turnover of 800 million euros, a profit of 600 million euros, recovery of the investment in about 9 years, the period lasting up to 10 years depending on the lending facilities obtained by the investors. The

lifetime of a nuclear power plant until the reconditioning phase is 25 years and the recovery of the investment in less than half of the total productive life of the two units is a very attractive estimate for the parties involved.

Price dynamics is not one of the elements underlying the decision to develop nuclear activity in Romania, but rather its necessity in the context of maintaining supply security and a sufficiently diverse mix of energy so that in fact none of the resources can be irreplaceable. Price predictions and investment profitability are mainly sensitive barometers for private investors, even though the state is not interested in investing in an unprofitable affair. To the extent that the level of demand is high enough and given that the old production units will be out of service or will require substantial and long-term investments for the purpose of upgrading, the profitability of the investment in the two nuclear units is not called into question.

The electricity market has always been closely monitored by global, European and national bodies, representing both an opportunity for financial development and a necessity at the level of a strategic branch of each individual state. Particularly concerned by electricity issues, electric energy literature deals with economic issues in a very broad way, addressing concrete cases of countries that have taken various measures to influence prices by sizing energy mixes, as well as a wide range of other factors which influence prices indirectly. Thus, the case of Germany, which has decided to close all nuclear fuel production units, is especially studied, together with the cases of the United Arab Emirates and China, which are very much developing nuclear energy, representing real models of support for this type of energy at world level. Studies conducted in different countries conclude that the presence of nuclear energy in the energy mix of a state determines a lower electricity price level with unanimously accepted macroeconomic and microeconomic benefits compared to the absence of this component.

At European level, the completion of the internal market of the European Union has, since its inception, sought, among other things, the removal of trade barriers, the similarity of policies applied by each European country and the use of free pricing mechanisms based on demand and supply. It was also intended to adopt measures capable of providing a high level of protection to the final consumer, all of which cannot be applied without the establishment of technical interconnections for the transport of electricity between Member States. From the energetical point of view, the establishment of appropriate measures for each state was a difficult approach for specialists in the field, because each state measures its electricity production according to the available resources. However, the set of 20-20-20 measures aimed at adopting a common framework of the first steps in environmental protection is pursuing for each of the EU members.

Regarding the commercialization of electricity, Romania has a modern and competitive market, integrated almost entirely within the general framework established by the European Union, being at the end of its complete liberalization and in full accordance with the mechanisms of the West European countries, big players on European markets being also active on the Romanian market. Electricity is traded freely and independently, strictly on the centralized market managed by Opcom.

During the paper, one of the central objectives I have been pursuing was to highlight the interdependence between the social part related to the community and the environment and the financial side, where I aimed, on the one hand, the calculation of the costs necessary for the commissioning, but also calculations regarding the estimation of the prices which can be obtained for that production. Thus, although the costs are relatively invariable, depending to a very small

extent on the internal factors of the enterprise, the same is the price, its free trading mechanism does not offer too great a possibility of influence, and if provided, the generation of such a volume of electricity would only contribute to lowering the market price. In this regard, in the last part of the paper, I aimed to make realistic price predictions on medium term - a semester - that could help the enterprise not necessarily to make decisions whether to produce or not, but rather to have a clear picture on future results so that any fluctuation, with or without positive effects on profitability, will not surprise the management of the company.

The hypothesis from which I started refers to the cyclicity of the events that lead to the determination of the price of electricity and to the fact that the real predictions of the energy traders take into account time series. As a novelty, I chose the corroboration of different econometric models to determine in real terms the DAM results for the second quarter of 2016. I also used the DOE Taguchi method to determine the effect that different variables have on the price. In order to validate these assumptions, I chose the initial data sample from which I started the analysis. For the novelty of the information, but also to have a time series quantitatively relevant, I chose to model the daily time series for the period January 2015 - March 2016. Then I established the categories of econometric indicators that fit this study, I processed and interpreted the statistical data related to the selected indicators, for the period mentioned, the data for April - June 2016 being forecasted. I chose Eviews programme to run hypotheses using several models: the ARMA model (linear stationary model for time series analysis, verifies data series stability), exponential smoothing methods for predicted values, analysis of the correlation between the variables included in the study using the correlation matrix model, VAR study model of endogenous lag variables up to level -8, Granger test for causality analysis between variables whose data series are stationary. I chose Minitab program to analyze on short average series of data the influence of renewable energy sources on the DAM price.

The most important contribution to this paper is the analysis of the influence of the historical series on the current price and, on this basis, the realization of realistic price predictions. The results obtained following the application of the working methodology can be summarized as follows:

1. For the DAM price variable, the data series is not stationary in level and can not be taken into account in modeling, that is why I have re-modeled the series using the price index, thus resulting the staticity of the series.
2. For the test not to be affected by significant errors, there must be no causal links between these errors. For the 2nd difference in the DMA index data series, the ARCH test indicates that there is no correlation between errors, therefore the analysis of the series obtained compared to the actual value recorded on the market by calculating the forecast error will generate the appropriate method for diminishing this error.
3. For a more verifiable calculation, the closest result to reality was obtained with double exponential smoothing.
4. The variable corelogram accurately indicates interdependencies between variables.
5. An eventual shock applied to the consuming-coal-production series analyzed by the VAR model indicates the percentage of interdependence between these variables, the coal being in 2017 the main resource used for electricity production and therefore the most influential factor of price calculation.

6. The sporadic impact of renewable energies on daily weights in the consumer basket, calculated using the Taguchi Method, is significant.
7. In the energy context of 2017, to maintain prices at an acceptable or even competitive level, the development of nuclear energy is a must.

The difficulty of this study lies in the multitude of variables to be taken into consideration, but also in the permanent dynamics of the national energy system, which must be fully in line with regional and European dynamics. The studied model can be applied in practice under a stable market that provides information on the factors under study, factors with a relatively predictable short-term fluctuations and a cyclical dynamics.