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A SOFTWARE TOOL FOR ELECTRICITY MARKET TRADE PRICE ANALYSIS

Summary. The deregulated electricity markets promote competition between producers on the wholesale market and between suppliers in the wholesale and retail market, with the aim to obtain lower prices and improved consumer satisfaction. In order to be able to provide lower prices and diversified services to their clients, the suppliers must strive to minimize the market acquisition costs for electricity. This paper presents the software solution used by a Romanian electricity supplier for optimizing the wholesale electricity acquisition costs in the Romanian centralized bilateral electricity contract trading markets.

Keywords: electricity markets, trade price analysis, software

1. Introduction.

The first deregulated electricity markets started to operate in the last decade before the year 2000, when competitive trading of electricity was seen as the best way to promote innovation in the industry, together with service improvement and price lowering at the end consumers. Today, at European Union level, following the provisions of the Third Legislative Package issued in 2009, the aim is to create a common European, fully interconnected market, in order to promote unrestricted electricity trade between countries and accommodate the envisioned target of 50% generation from renewable sources by 2030 [1,2].

Romania is part of this common European market, being included into the Central Eastern Europe regional market, together with Czech Republic, Hungary, Poland, Slovakia and Slovenia. The Romanian commercial market operator is OPCOM, which manages electricity trade between producers and suppliers on the wholesale market, using a contract market and a SPOT market [3]. The market deregulation process started in 1998. In 2007, all consumers, regardless of their size and type, became eligible. Starting from September 2012 the mandatory regulated consumer tariffs were gradually replaced by negotiated tariffs. The process was concluded in January 1, 2014 for non-residential consumers and on January 1, 2018 for residential consumers. Also, while in the EU the residential electricity consumption

fell by 0.9%, and electricity generation has reduced by 2.5%, between 2005-2015, Romania was one of the states in which the actual trend was opposite, showing the highest increase of residential consumption, of 31%, and a rise of more than 10% in generation, according to EUROSTAT data [4]. It should be noted that in 2015, the electricity deliveries from renewable resources (wind, solar and biomass) were at 14,18% from the total delivery, with a comparable figure for 2017 [5,6]. With the deregulation of residential consumer tariffs just completed, and the increase of supplier offers for residential consumers seen in the last 1-2 years, the rate of supplier switching is expected to increase among residential consumers supplied by the old, previously vertically integrated traditional suppliers.

At the same time, in the recent years, trading prices in the Day-Ahead market showed two major spikes: one in January 2017 and one in August 2017 [3]. The prices increased up to three times over the average values seen in the last five years. Coupled with the fact that, in Romania, the day-ahead market accounts for nearly 50% of the traded electricity, this put a high pressure on the trading activity and end consumer prices, especially for industry clients.

These realities emphasize the suppliers' need to minimize the risk of engaging in unprofitable trade and to optimize the earned revenue in volatile market conditions and expected increasing small consumers portfolios, by having a clear overview on the historical and recent price variations, at global market level and on specific market segments of interest.

This paper presents the features of a software tool named GTMarket, used by a Romanian wholesale and retail market supplier for the analysis and management of electricity market trade costs. The software application performs the analysis of the market trading history on medium term (up to 6 months – 1 year), and provides statistical information and forecasted values useful for optimizing electricity acquisition costs. Market players number, traded volumes and prices are analyzed and classified according to user defined criteria. Price estimations are provided at trading product level. For these purposes, statistical and computational intelligence algorithms are used.

2. The GTMarket software application

In the Romanian wholesale electricity market, traders can buy or sell energy using the Bilateral Contracts market or the Day-Ahead and Intraday market. The Bilateral Contracts market has two segments: the Over the Counter Market (in Romanian, PC-OTC), and the Centralized Bilateral Contract Market (PCCB), the latter having three types of trading mechanisms: Continuous Negotiation (PCCB-NC), Extended Auctioning (PCCB-LE) and Fuel Processing (PCCB-PC). The last one is used only in market crisis situations.

The supplier which uses the GTMarket software application is active on the Continuous Negotiation, Extended Auctioning, Over-The-Counter and Day-Ahead markets. In the

GTMarket software application, the reference trading products used for analysis are those provided by the Continuous Negotiation Bilateral Contracts Market mechanism. Thus, weekly, monthly, quarterly and yearly trading products are analyzed. However, for later development purposes, all other standard trading products from other markets are also archived locally in the database. The only exception is non-standard delivery period products from the Extended Auction Bilateral Contracts Market (products which do not have a standard delivery period – month, quarter, semester, year, or which do not begin at the starting date of a standard delivery period).

Day-Ahead Market results are provided for comparison purposes only. For each hour of the day, the trading price and total traded electricity quantity are archived.

The application uses a Microsoft SQL database, which is managed from the application itself, using a custom-built management module. The information from this database is retrieved at runtime and it is processed in order to provide the following types of information: trading history analysis, in order to identify the evolution of the number of participants, the volumes of traded energy and trading prices, on all markets and on each market for which archived data is available; summary information of relevance, such as average and weighted average trading prices, average, maximum and minimum price comparison between markets; trading price forecast for all analyzed markets, at trading product level, using customizable historical data intervals. All these analyses are performed in order to help the user choose the best market for trading in a specific day.

As depicted in Fig. 1, the GTMarket software application has 4 modules:

- A database management module, used to archive the trading data published by OPCOM.
- An analysis module, for global and single market analysis.
- A statistical analysis module, for quantity-based trade analysis.
- A forecast module, provided for price estimation.

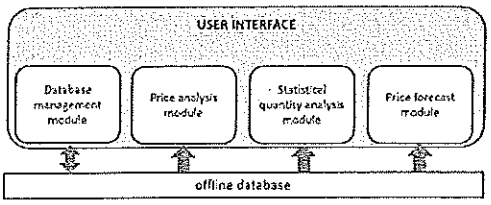

Fig. 1 – The basic structure of the GTMarket software application

All the modules are integrated in a common Graphical User Interface (GUI). The GUI provides tools for numerical and graphical data representation, and it is built to allow a very simple and intuitive user experience, together with low hardware requirements, for compatibility with older workstations. The graphical information is viewed in bar and line

plots. The numerical results can be viewed in tabular form and optionally saved using CSV files.

The statistical and forecast modules provide at least two different methods for the same task, thus providing the user with powerful comparison and analysis tools.

The next paragraphs will describe the features of the analysis, statistical and forecast modules.

3.1. The analysis module

This module is intended for global and single market analysis focused on trading prices. The global analysis allows for a comparison between the trading prices of similar products types on all three bilateral markets for bilateral contracts for which the application stores data: the Continuous Negotiation, the Extended Auctioning and the Over-The-Counter Bilateral Contracts markets, while single market analysis focuses on a specific market.

By using a group of dropdown menus located in the left side of the window (Fig. 2), the user can narrow down the list of displayed contract types. The product type (weekly / monthly / quarterly / yearly) and a time interval (week of year / month / quarter/ year) can be selected.

After the user clicks on a specific trading product, the application retrieves from the database and displays all the offers concluded for that product type, and all similar products from the other markets. For each date in which completed offers exist, the trading prices and quantities traded in the Day-Ahead market are also displayed. Summary data, which make a comparison between all markets regarding average, minimum and maximum prices, is displayed in a secondary table, located below the main table (Fig. 2) The default display option is a table, as in Fig. 2, but a graphical representations are also available at the click of a specific button (Fig. 3). The tabular data can also be saved in CSV files.

The single market analysis provides multiple filtering criteria for displaying trading results for a single market only. For a given market, the user can choose, for instance, to view results for products traded on a specific date, for a specific product type or in which the selling party was a specific trader. The results are displayed in the same manner, in numerical (Fig. 4) or graphical representations (Fig. 5). The tabular data can also be saved in CSV files.

A particular feature of this analysis type is the detection of the so-called non-conform offers, which denote offers whose trading prices deviate unacceptably from the average price of the associated trading product. Such offers are initially emphasized using a color code, and can be permanently marked as such in the database. The blue lines in the table shown in Fig. 4 denote offers which are detected as non-conform, but have not yet been marked in the database. The time interval for which the reference average price is computed, and the allowed price deviation in %, are user-configurable.

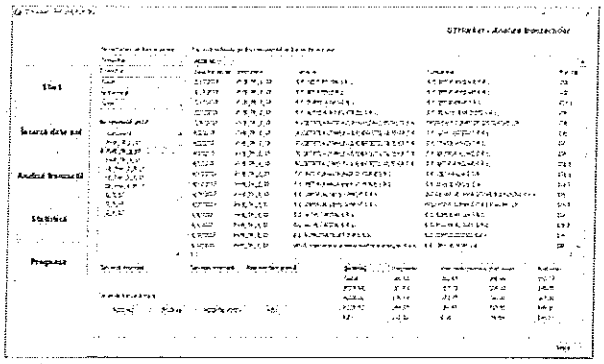

Fig. 2 – The numerical results window for the global market analysis module

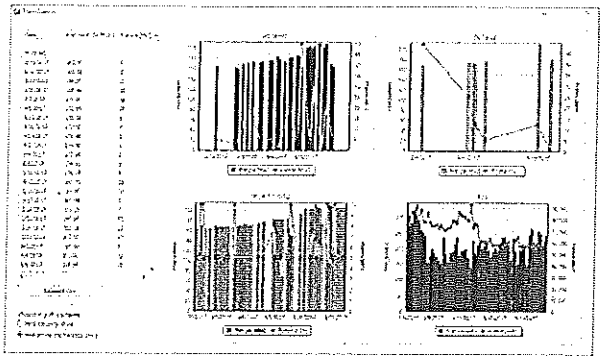

Fig. 3 – The graphical results window for the global market analysis module

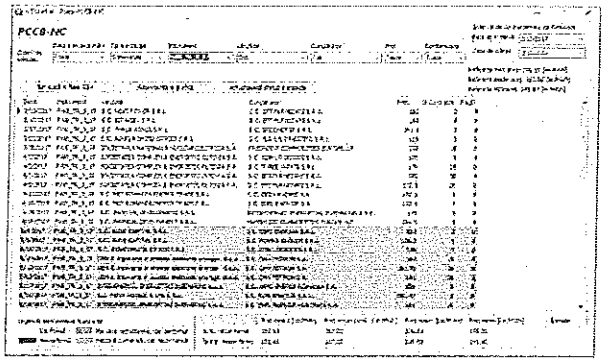

Fig. 4 – The numerical results window for the single market analysis module

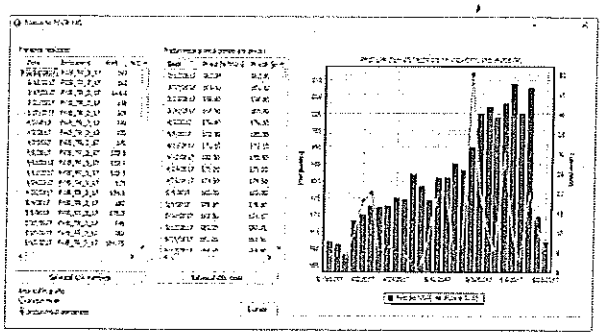

Fig. 5 – The graphical results window for the single market analysis module

3.2. The statistical module

The GTMarket software application also provides market trading analysis based on traded electricity quantities, given as active powers, in MW. By selecting a product, in a specific market, the user can perform a grouping of the offers traded for that specific trading product. Two grouping methods are available:

- A threshold-based method, which divides by default the traded quantities into three groups: 0-4 MW, 4-10 MW, >10 MW. These limits are user-configurable.
- Automatic grouping, which uses K-Means, a simple but powerful clustering algorithm [7], which requires only the number of maximum used clusters.

While the threshold-based method is grouping the transactions according to user-specified limits, the automatic clustering method discovers by itself the quantity thresholds which exist in the offers traded for a chosen standardized trading product. This can give valuable insight about the quantities that were traded on a specific market.

Regardless of the method used, the results are the same, as depicted in Fig. 6: a detailed list containing the transactions grouped by price, and a summary table

3.3. The forecasting module

The forecasting module is intended for the estimation of trading prices of individual trading products. A polynomial regression model is implemented in the application, where the user can choose the degree of the polynomial between *n=1* (linear regression), *n=2* or *n=3*.

When the user chooses a product for price forecast, the application displays the prices archived in the database, allowing the possibility of narrowing the start and end date according to preference. Next, the degree of the regression, between 1 and 3, and the future date for which the price will be estimated must be chosen. The application computes the estimated price and shows the result (Fig. 7).

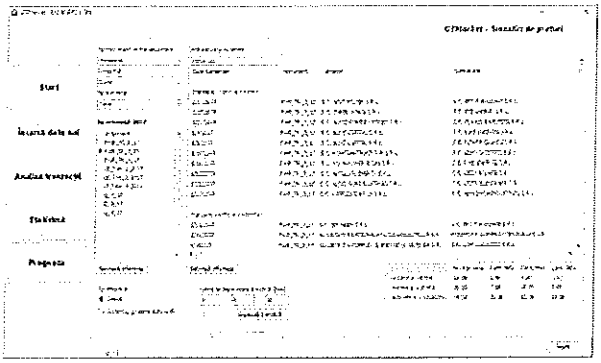

Fig. 6 – The grouping results obtained with the statistical module

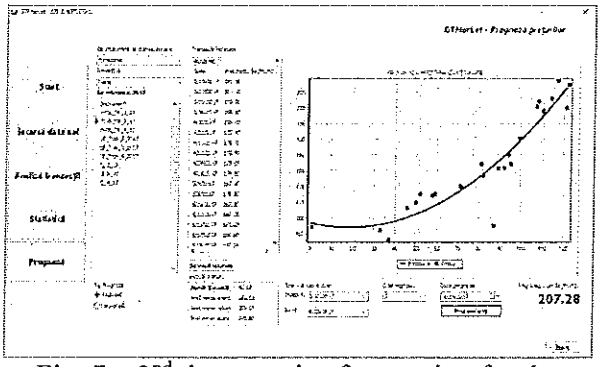

Fig. 7 – 2nd degree price forecasting for the FWB_TR_3_2017 trading product

4. Results

Results for the analysis module

If in the main window the user has selected the FWB_TR_3_17 product type from the list (which denotes the third quarter, year 2017 trading product from the Continuous Negotiation Bilateral Contracts Market), the main table in global analysis mode will display trading results for the following product types which are equivalent as delivery timeframe:

- FWB_TR_3_17 from the Continuous Negotiation Bilateral Contracts Market
- Q_3_17 from the Over-The-Counter Bilateral Contracts Market
- LE_Trim_3_2017 from the Extended Auctioning Bilateral Contracts Market

together with the prices and quantities traded in the Day-Ahead market. These results are depicted in Fig. 4 and Fig. 5.

The summary result table will display the results from Table 1. Analyzing the average and weighted average prices, it is obvious that the preferred market for electricity acquisition, should be the Extended Auction market, while the Day-Ahead market has the highest prices, as expected.

Table 1 - Summary results for the third quarter trading product type contract type, year 2017

Market	Avg. price [lei / MWh]	Weighted avg. price [lei / MWh]	Max. Price [lei / MWh]	Min. price [lei / MWh]
Global	188.61	182.64	340.69	143.37
Cont. Neg.	182.65	187.22	209.00	145.00
Ext. Auct.	175.14	172.77	210.00	167.00
OTC	184.33	184.97	213.00	149.10
Day-Ahead	212.32	N/A	340.69	143.37

Results for the statistical module

For the statistical module, the comparison made in Tables 2 and 3 for the FWB_TR_3_17 trading product from the Continuous Negotiation Bilateral Contracts Market, the standard trading product for the third quarter of year 2017, shows very different grouping results with the two methods, when the same number of groups, 3, is used.

Table 2 – Grouping of the FWB_TR_3_17 product into three groups, using the threshold method

Group name	No. of trades	Avg. quantity for group [MW]	Max. quantity for group [MW]	Min. quantity for group [MW]
[0, 4] MW	10	2.40	4	1
(4,10] MW	16	7.50	10	5
>10 MW	14	25.36	50	15

Table 3 – Grouping of the FWB_TR_3_17 product into three groups, using the K-Means method

Group name	No. of trades	Avg. quantity for group [MW]	Max. quantity for group [MW]	Min. quantity for group [MW]
Group 1	19	3.89	8	1
Grpup 2	17	15.59	25	10
Group 3	4	40	50	30

It can be seen that, for this instrument, the preferred traded quantities were below 8 or between 10 and 25 MW, which is only incompletely reflected using the threshold method.

Results for the forecasting module

For testing the price estimation accuracy, three random trading products were chosen from the database, with sufficient trading history data points for regression. For these products, the last known traded price was estimated using the prices archived for the prior dates. If the last or first points in the regression series were outliers, they were discarded. The results can be seen in Table 4.

Table 4 - Forecasting results with the polynomial regression types implemented in the application

Trading product	Real price [Lei/MWh]	Estimated price [Lei/MWh] (n is the polynomial regression degree)		
		n=1	n=2	n=3
FWB_TR_3_2007	207.50	199.27	207.28	209.74
FWB_L_Jul_17	218.81	192.01	216.86	235.33
FWB_L_Feb_17	232.6	187.10	226.89	239.6

It can be seen that the second-degree polynomial is the best choice for estimation. The performance of the other two methods is not satisfactory, but it could be influenced by the presence of some outliers in the historic data, which can be seen in Fig. 7 for the FWB_TR_3_2007 trading product. A solution for overcoming this problem is to implement in the application the possibility of removing certain data points from the regression series, or to use another forecast method.

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