A LONG - TERM CONTRACTS PORTFOLIO MANAGEMENT

CONFERENCE
"THE EUROPEAN ELECTRICITY MARKET"
SEPTEMBER 20-22, 2004, LODZ, POLAND

Tomasz SAŁATA
EuroCIM
Warsaw (Poland)

Jarosław PROTASIEWICZ
EuroCIM
Warsaw (Poland)

Abstract

In this paper we present a tool for long – term contracts portfolio management in electric energy market. The tool we present, „EC_Plan”, is a part of ECIX-Energia system supporting electric energy turnover. In first part of this article we give short description of EuroCIM company, system ECIX-Energia and module EC_Plan. Next part consists of definition task for optimizing costs of buying energy. Last part consist of proposed solution for defined task. Optimal solution is derived using simplex method.

1. INTRODUCTION

1.1. Electric energy market in Poland

Electric energy market is classified with respect to the amount of volume turnover and to the degree of market freedom. Two main segments, where division is based on the volume of turnover, can be pointed out. They are: retail market and wholesale market. However using the market freedom as a criterion, they can be divided into regulated market and competitive market. Participants of retail market are so-called „rates consumers“. They are only passive consumers of electric energy supplied by special distribution companies which are exposed for all risk having roots in buying and supplying electric energy. Prices of electric energy and charge for delivery are fixed in tariff (hence the term „tariff customers”) approved by The Energy Regulatory Authority of Poland. Electric market in Poland is gradually deregulated what appears among other things in, that tariff customers gradually are allowed to choose deliver. Customers who use this right are becoming Third Party Access customers. Third Party Access (TPA) means being a third participant of the competitive electric market, after producers (power plants) and distributors. A schedule of receiving the right for choosing deliverer by customers is determined in decree of Ministry of Economy from 6 August 1998 with further changes. The main criterion for receive TPA right is amount of consumed energy per year. Retail market is regulated market, which will be partly transformed into competitive market on the basis of TPA principle. Participants of wholesale market are producers (mainly big power plants), electric agents (turnover companies and distribution companies) as well as consumers of energy (working independently). All entities participating in electric energy market were defined in regulations of this market. The subject of further considerations is wholesale market, which is also competitive market. We distinguish segments of this market:

bilateral contracts market, exchange market and balancing market. Bilateral forward agreements are freely signed in the bilateral contracts market between the participants. The exchange market is place were participants make buying and selling offers. A price and a volume is fixed in trading session on the basis of demand and supply curve. However balancing market is place were portfolios of all participants are balanced in real time.

1.2 ECIX-Energia System

ECIX-Energia System is dedicated to support trading electric energy in wholesale market and retail markets. This system includes complete set of tools for realizing all business and technical processes which are necessary to trade in electric energy market.

Those processes are:

- Receiving and managing measurement data for energy or weather factors;
- Prediction of demand for electric energy and power
- Analysis process indexes in particular parts of the electric market
- Long–term contracts portfolio management that means planning strategy for the market
- Middle–term contracts portfolio management which mainly consists of making trading diagrams and negotiating these diagrams
- Short–term contracts portfolio balancing that assumes support for SPOT transactions, support for preparing offers to Next Day Market in Power Exchange and preparing offers in other serial trading,
- Monitoring of fulfilling requirements for buying co generation energy and green energy
- Management of local markets in the full scope
- Accounting for both wholesale and local contracts, accounting payments for transition of energy and deviations from declared plans

![Fig. 1 Main process in ECIX-Energia system](image)

ECIX-Energia system modular architecture helps to adjust it to customers expectations. This system is mainly dedicated for:

- energy trading companies which operate in wholesale and local markets
- producers of electric energy: big system power plants and local energy sources
- operators of local balancing group that buy energy in wholesale market and sell it for own local customers
- customers that want to participate in electric market

1.3 EC_Plan module

EC_Plan module is a part of ECIX-Energia system. It is designed to help long term contracts portfolio management, what includes long term planning, analyzing of different strategies and making trading diagrams. All those tasks we name in this article just “planning”. The main aim
planning procedure is to choose the most profitable offers that satisfy owner’s portfolio’s requirements and limitations from set of accessible offers. This process could be automatic according to user request.

User could create many different structures buying plans which are company strategies. One of them is chosen as obligatory company strategy. Of course this strategy should be the most optimal and profitable what this module helps do it.

Strategies consist many segments like portfolio consist many market segments. Segments of a strategy consist many components like contract offers.

The first step in planning procedure is construction structure company buying plans that means buying portfolio. User define portfolio time horizon, demand for energy and segment of the market with its percentage amount in whole market.

\[ e_{k}^{RB} = Z_{k} - \sum_{i=1}^{O} e_{ki} \quad (2.2) \]

where:

- \( Z_{k} \) - predicted demand in hour \( k \),
- \( c_{ki} \) - a price of energy from offer \( i \) in hour \( k \),
- \( c_{k}^{RB} \) - predicted price of purchasing energy in Balancing Market in hour \( K \),
- \( K \) - number of hours,
- \( O \) - number of offers in group.

The task of choosing contract offers is solved in two stages. A group offers as some subset from set of all offers is defined in the first step. A minimal costs of energy purchase is calculated in second step, when trading diagrams are generated:

\[ C_{\min} = \min_{e} C \quad (2.3) \]

Tasks with small amount of offers in the set of all offers (about to 10) could be solved by generating all the possible combinations. Tasks with larger amount of offers are solved using evolutionary algorithm.

**2.2. Limitations**

Primary constraints result from predicted demand curve for electric energy. The sum of energy which is purchased in individual hours shouldn’t exceed forecasted demands:
The sources of next constraints are contracts conditions. Contracts are signed for some time and could be signed with many deliverers at the same time. Contract conditions are following: minimal and maximal sum of energy in specific time zones and sub-periods whole period when trade agreement is in force:

\[ \sum_{i=1}^{O} e_{ki} \leq Z_k \]  
\[ \sum_{k \in M_{wi}} e_{ki} \leq S_{wi}^{MAX} \]  
\[ \sum_{k \in M_{wi}} e_{ki} \geq S_{wi}^{MIN} \]  

where:
- \( w \) - an index of offer condition,
- \( M_{wi} \) - a set of hours that belong to time zone specified in condition of offer \( i \),
- \( S_{wi}^{MIN} \) - minimal energy value in particular hours of time zones sub-periods:

\[ e_{ki} \leq E_{wi}^{MAX} \text{ dla } k \in M_{wi} \]  
\[ e_{ki} \geq E_{wi}^{MIN} \text{ dla } k \in M_{wi} \]  

Conditions of offers are defining also minimal and maximal energy values in particular hours of time zones sub-periods:

\[ \sum_{i=1}^{N} e_{ki} + e_{RB k} = Z_k \]  

2.3. Linear integer programming problem

The task formulated in pervious chapter is transformed to form linear integer programming problem in the form::

\[ F_{max} \rightarrow A^T x \]  
\[ A = [a_1 \cdots a_N], \quad x = [x_1 \cdots x_N] \geq 0 \]  
\[ C x \leq B \]  

where:
- \( A \) - prices vector,
- \( x \) - variables vector,
with constraints:
\[ C = \begin{bmatrix} c_{11} & \cdots & c_{1N} \\ \vdots & \ddots & \vdots \\ c_{M1} & \cdots & c_{MN} \end{bmatrix}, \quad B = \begin{bmatrix} b_1 \\ \vdots \\ b_M \end{bmatrix} \]

where:
- \( C \) - matrix which elements are equal to 0, -1 or 1,
- \( B \) - values of constraint vector
- \( N \) - number of variables,
- \( M \) - number of constraints.

For instance, assuming: \( N = 2 \) and \( M = 4 \), the problem is received for which the space of feasible solutions could be presented in plane like in Fig 4.

**Fig. 4 – The idea linear programming.**

Equality constraints form area of feasible solutions. The optimal solution is located on the edge of the area of feasible solutions and on the straight line of equality constraint.

### 4. PROBLEM SOLUTION

The linear integer programming problem is solved with simplex method. This method searches solution's area in ordered way and returns integer solution.

The processes: defining problem, solving and calculating a result are repeated for all possible offers combinations. The best solution is noted by program.

### 5. PROBLEM EXAMPLE

Let's consider time horizon up to 5 days and only 5 offers are available. Here are offers conditions:

**TABLE 1.** Conditions of contract offers.

<table>
<thead>
<tr>
<th>Period</th>
<th>S</th>
<th>( S_{\text{min}} )</th>
<th>( S_{\text{max}} )</th>
<th>( E_{\text{min}} )</th>
<th>( E_{\text{max}} )</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offer 1</td>
<td>11.01–12.01</td>
<td>1</td>
<td>3500</td>
<td>8500</td>
<td>150</td>
<td>1200</td>
</tr>
<tr>
<td>Offer 2</td>
<td>11.01–15.01</td>
<td>0</td>
<td>10190</td>
<td>12600</td>
<td>91</td>
<td>121</td>
</tr>
<tr>
<td>Offer 3</td>
<td>11.01–15.01</td>
<td>1</td>
<td>3000</td>
<td>7000</td>
<td>104</td>
<td>194</td>
</tr>
<tr>
<td>Offer 4</td>
<td>11.01–15.01</td>
<td>2</td>
<td>3600</td>
<td>8400</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Offer 5</td>
<td>11.01–15.01</td>
<td>3</td>
<td>19470</td>
<td>30360</td>
<td>150</td>
<td>290</td>
</tr>
<tr>
<td>Offer 1</td>
<td>11.01–15.01</td>
<td>1</td>
<td>2880</td>
<td>6480</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Offer 2</td>
<td>11.01–15.01</td>
<td>2</td>
<td>3000</td>
<td>5000</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Offer 3</td>
<td>11.01–15.01</td>
<td>4</td>
<td>1200</td>
<td>3600</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>Offer 5</td>
<td>11.01–15.01</td>
<td>5</td>
<td>11520</td>
<td>13800</td>
<td>180</td>
<td>230</td>
</tr>
</tbody>
</table>

The summarized demand for energy in this period is equal to 90190.40 MWh. Its hourly values oscillate from 550 MWh to 950 MWh. It is assumed that that a price of energy in Balancing Market is constant and is equal to 170 zł / MWh.

At the first glance is difficult to guess which offers are optimal and which offers should be chosen. Maybe offers with the the lowest purchase price are optimal? But those offers have to much many energy.
The computer with 800Mhz processor in 5 minutes checked 31 possible combinations of groups of offers. The following group of purchase offers with trading diagrams was received as a result of computations:

**Table 2.** Chosen contract offers

<table>
<thead>
<tr>
<th>Period</th>
<th>S</th>
<th>$S_{\text{min}}$</th>
<th>$S_{\text{max}}$</th>
<th>$S$</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offer 1, Contracting party 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.01–12.01</td>
<td>1</td>
<td>3500</td>
<td>8500</td>
<td>4262</td>
<td>121</td>
</tr>
<tr>
<td>11.01–12.01</td>
<td>3</td>
<td>10000</td>
<td>30000</td>
<td>18399</td>
<td>130</td>
</tr>
<tr>
<td>14.01–15.01</td>
<td>0</td>
<td>4000</td>
<td>20000</td>
<td>20000</td>
<td>119</td>
</tr>
<tr>
<td>Offer 5, Contracting party 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.01–15.01</td>
<td>1</td>
<td>2880</td>
<td>6480</td>
<td>2880</td>
<td>178</td>
</tr>
<tr>
<td>11.01–15.01</td>
<td>2</td>
<td>3000</td>
<td>5000</td>
<td>5000</td>
<td>125</td>
</tr>
<tr>
<td>11.01–15.01</td>
<td>4</td>
<td>1200</td>
<td>3400</td>
<td>2700</td>
<td>135</td>
</tr>
<tr>
<td>11.01–15.01</td>
<td>5</td>
<td>11520</td>
<td>13800</td>
<td>13800</td>
<td>112</td>
</tr>
</tbody>
</table>

Even short analysis of the solution (Tab. 2) proves that all constraints are satisfied. Two important program’s behaviors should be noted. When prices in offer is higher than purchase price in Balancing market, the program tries to fix the lowest volume energy to buy and vice versa, when prices are lower then purchase prices in Balancing market, the program tries to fix as many as possible volume of energy. Of course all constraints couldn’t be crossed.

**Fig. 5** – The best solution – the most profitable offers group.

**Fig. 6** – Charts: demand form energy, realization admitted plan and non-balance.

### 6. CONCLUSION

The observations mentioned before prove that applied method turn out to be useful and gives optimal solutions what means the most profitable. Proposed module and the whole ECIX-Energia system could considerably aid in planning long-term horizon in Trading Company.

### 7. REFERENCES

3. J. Protasiewicz, P. S. Szczepaniak, *Modeling of electric energy exchange in Poland – a next day market problem*, 4 Ukrainian – Polish Conference Environmental Mechanics, Methods of
4. Computer Science and Simulations, Lviv, 24-26 June 2004,

**EuroCIM company**
EuroCIM company was established in 1986. The main fields of interests is designing, developing, deploying and servicing informatics business systems which are dedicated to support economical activities. Its two main products are: ECIX@pl system for supporting company management and ECIX-Energia system for supporting turnover of electric energy. EuroCIM realizes system for individual orders, too.

Tomasz Sałata
was born in Siedlce, Poland. He received the M.Sc. degree in Control Systems from Warsaw University of Technology, Faculty of Electronics and Information Technology University. Presently he works as a programmer in EuroCIM Spółka z o.o. His areas of interest include optimisation methods and electric energy market.

Mailing address:
Tomasz Sałata
EuroCIM Spółka z o.o.
ul. Zdrojowa 80, 02-927 Warszawa
POLAND

Phone: (+48) (22) 842-03-72.
Fax: (+48) (22) 642-55-07.
e-mail: tsalata@eurocim.neostrada.pl

Jarosław Protasiewicz
was born in Wiżajny, Poland. He received the M.Sc. degree in Automatic and Robotic from Białystok Technical University, Faculty of Electric Engineering. Presently he works as programmer in EuroCIM Spółka z o.o. and studies PhD in Systems Research Institute Polish Academy of Sciences, Faculty of computer science in management. His areas of interest include artificial intelligence and electric energy market.

Mailing address:
Jarosław Protasiewicz
EuroCIM Spółka z o.o.
ul. Zdrojowa 80, 02-927 Warszawa
POLAND
Phone: (+48) (22) 842-03-72.
Fax: (+48) (22) 642-55-07.
e-mail: jprotas@eurocim.neostrada.pl