Design and Implementation of Regional Balancing Mechanism Software

COSTIN CEPISCA  
Politehnica University of Bucharest  
ROMANIA  
costin.cepisca@upb.ro

SORIN DAN GRIGORESCU  
Politehnica University of Bucharest  
ROMANIA  
sorin.grigorescu@upb.ro

GEORGE SERITAN  
Politehnica University of Bucharest  
ROMANIA  
george.seritan@upb.ro

COSMIN KARL BANICA  
Politehnica University of Bucharest  
ROMANIA  
cosmin@wing.ro

Abstract: - The paper presents a specially developed software solution for a Regional Balancing Energy Mechanism. After the presentation of structure and functions of balance energy exchanges model among the TSOs (Transmission System Operators), the software developed is detailed.

Key-Words: - Regional Balancing Mechanism, Energy, Software, Day-Ahead, Intraday, TSO

1 Introduction
The development of electricity markets in the European Union is closely related to liberalization of the electric power sector, and competition in generation and supply requires the creation of an Internal Electricity Market that includes an increased number of countries. The Directive 2009/72/EC [1] sets the legal framework for a competitive market and recent studies seek to ensure limitation due to congestion problems [2], [3].

Open RBM (Regional Balancing Mechanism) Software developed under FP7 EU funded project named SEETSOC (South-East European TSO Challenges) is a tool of regional balancing mechanism with the goal of facilitating balance energy exchanges among the South East Europe TSOs [4].

Open RBM software product has a modular design using standard and web-based interfaces and can be accessed through web services for system users. It could also be used as a stand-alone application which can be installed anywhere within a TSO’s operational network and can be integrated into existing Market Management Systems [5], [6], [7]. The client’s offer program is written in standard C++, using the Qt framework, for developing software with graphical user interface (GUI). It makes use of a code generator (the Meta Object Compiler) together with several macros. Non-GUI features are: XML parsing, SQL database access, thread management, network support and a cross-platform API for file handling. The program supports a wide range of compilers, including the GCC C++ compiler and the Visual Studio suite [11]. The server-side program is based on the Web2py framework, which includes several Open Source modules for XML parsing, a comprehensive Database Abstraction Layer and support for automatic management and deployment of the applications [8].
2 General SEETSOC Approach

To provide the appropriate RBM solution, SEETSOC research team assessed and analyzed functions and transactions on the current national BMs and identified the following basic options [9]:

- A central platform for the RBM that is operated by the Operator of the SEE – RBM trading platform (RBM – O), as Imbalance Settlement Responsible (ISR) and the contracting party of corresponding BEPs for all transactions concluded in the RMSEs;
- TSOs as Balance Energy Participants (BEPs), as well as control area BRPs, submit day-ahead (D-1) and intraday (D) bids to RBM platform, separately for up- and down-ward regulation;
- The Balance Energy (BE) price is determined for the required BE, which is found at the intersection of sell-bid and buy-bid merit order curves for each type of BE;
- The allocation of interconnection capacity for the central RBM platform is cost-free, i.e., balancing bids are activated only when they can be transferred through non-congested borders;
- Selected bids are transformed into BE transactions (as imbalance quantity–price pairs) after their execution and settlement;
- Offer execution and corresponding BE volume are the result of TSOs’ purchasing orders for the use of accepted BE bids;
- The imbalance price in each balancing interval is determined so that BE value equals the total power imbalance value.

3 RBM Process

3.1 General Structure

The RBM for both the day-ahead and intraday transactions determines the transaction volumes and payments resulting from the selected offers in a three step procedure – Fig.1:

- Placing of offers for each balancing interval and each BE type followed by their formal acceptance/rejection;
- Offer selection. A fixed and firm schedule bidding for the BE is carried out that ensures transaction selection and pricing, i.e. the establishment of RBME clearing prices.
- Transaction settlement. The schedule is executed during the dispatching imbalance day (D). For each balancing interval, the quantity–price pair is established based on the final dispatch order for the BE purchase.

The RMSE Transactions Steps – Fig.2:

Step 1: validated and accepted bids are arranged in Merit Order (MO), separately for each regulation type and each hour of Delivery Day, as follows: Buy MO - sell type bids, lowest to the highest price; Sell MO - buy type bids, highest to the lowest price.

Step 2: The Line Overload Clearing (LOC) Module is activated to mitigate congestion;

Step 3: The LOC module can either adjust or cancel certain sell and buy offers for minimum congestion cost;

Step 4: Ignored or constrained bids are registered in RBM data base;

Step 5: If there are bids reduced or cancelled, go to Step 1;

Step 6: Calculation and pricing of balance energy (RMSE Clearing Price).

3.2 Day-Ahead and Intraday Balance Energy Transactions

The process is presented in Fig.2. The Sell-type offers are sent by the TSOs with exceeding energy balance, whereas the Buy-type offers are sent by the TSOs with a deficit in the energy balance. The offers are selected in Merit Order (MO) for each regulation type and each hour of Delivery Day (D). The cheapest units for both the generation uploaded or downloaded are selected. The unitary price of the unit last called upon in each hour is found at the intersection of the sell and buy merit order curves; this defines the price of BE for the specific hour, i.e., the RMSE clearing price for the particular balancing interval. The offers are checked against the available transmission capacity of cross-border interconnections in the region; this function is carried out by the Clearing Balance Energy on RMSE subsystem.
An Intraday (ID) market provides a service to market participants to adjust their balance before the operational hour. This will reduce the balancing actions to be carried out by the dispatching operator in real time.

3.3 Clearing Balance Energy on RMBE

The offers are accepted into the RMB system after offer gate opening. All certified users are able to see the offer gate status in a dedicated section of the RMB application. Offer reception into the system contains two steps: offer parsing and offer validation [10].

ATC compliance is checked on the base of PTDFs coefficients. In this case, a balancing energy offer is related to a CB border. The clearing mechanism is based on the Merit Order with multiple sellers and buyers. The clearing price is not influenced by transmission congestion because the CB transmission capacity is allocated free of charge. After each offer submission, the system sends an ACK (acknowledgement) which certifies the formal acceptance/rejection of offer into the RMB system. In case of rejection, the ACK will specify the reason for the rejection. Under XML parsing, one error leads to the rejection of the entire XML (all offers within the XML will be rejected). After parsing, each formally accepted offer is validated according to the settings established in the system. The validation process releases an ACK to inform the TSOs about the validity of daily offers. Each offer is stored into the system (regardless of its status – accepted/rejected) with a unique ID together with the submission time stamp and status (accepted or rejected), and the user that submitted the offer. Until the gate closure time of offers (a general parameter for the system), users can cancel one or more bids (even the entire offer) by submitting a higher bid version with zero price and zero quantity.

The RBM system calculates the final dispatch order as the sum of all dispatch orders for both up-ward and down-ward regulation issued for the respective hour. The transactions are established for each TSO as imbalance quantity – price pairs. Transactions settlement is based on the Surplus/Deficit Inbalance Prices for each balancing interval.

4 Application Architecture

The software use Web2py, a full-stack framework with full support for:
- HTTP requests, HTTP responses, cookies, sessions;
- Multiple protocols: HTML/XML, REST, ATOM and RSS, RTF and CSV, JSON, JSON-RPC and XML-RPC, AMF-RPC (Flash/Flex) and SOAP;
- CRUD API;
- Multiple authentication mechanisms and role-based access control;
- Database abstraction layer (DAL);
- RAM, disk, and memcached-based caching for scalability;
- Internationalization support;
- Query for Ajax and UI effects;
- Automatic logging of errors with context.

Web2py uses the WSGI protocol, the Python-oriented protocol for communication. The main reasons why we chose Web2py are:
- It implements a coherent and abstracted API for all the features, which ensured that we could concentrate on developing the application without breaking any intended deployment environment.
- It is fully open-source, with a strong corporate backing and a well-crafted release cycle. Thus, we avoided any kind of vendor lock-in while ensuring that we can continue supporting the application for several years.

The major application controllers are presented in Fig.3, each with their well-defined functions.

![Fig. 3. Controllers and functions](image)

The controllers, models, modules and views directories contain the application code itself. The other directories contain static application content (user-generated or not, e.g. the uploads directory.
contains the uploaded offers) or various other files used internally.
The directory structure of the application shows roughly the view in Table 1.

Table 1.

<table>
<thead>
<tr>
<th>Directory structure of the application</th>
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<tbody>
<tr>
<td>4.0K drwxr-x 2 1000 4.0K Feb 25 20:20 cache/</td>
</tr>
<tr>
<td>4.0K drwxr-x 2 1000 4.0K Apr 15 19:51 controllers/</td>
</tr>
<tr>
<td>4.0K drwxr-x 2 1000 4.0K Feb 25 20:20 cron/</td>
</tr>
<tr>
<td>4.0K drwxr-x 2 1000 4.0K Apr 15 19:54 controllers/</td>
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<td>36K drwxr-x 2 1000 36K Apr 15 19:53 errors/</td>
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<td>4.0K drwxr-x 2 1000 4.0K Feb 25 20:20 languages/</td>
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</tr>
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</tr>
<tr>
<td>4.0K drwxr-x 9 1000 4.0K Feb 25 20:20 views/</td>
</tr>
</tbody>
</table>

5 Example of use – User Level
User level Offer interface performs the following functions:
a. Start with an XML offer file – Fig.4. Go to the Upload Offer page and select it for uploading.
b. Repeat.
c. At any point in time, you can view all your history in the “Offers history” page – Fig.5.

6 Conclusions
The paper presents the developments related to the new software for electricity interconnected networks, a tool of regional balancing mechanism among the South East Europe TSOs. The solutions of RBM software for Day-Ahead and Intraday functions are met with modular design using standard and web-based interfaces and web services for system users.

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References: