IMPLEMENTATION OF RESERVE TRADING IN SMM ENTSO-E CONTROL BLOCK

G. JAKUPOVIĆ, N. ČUKALEVSKI
Mihajlo Pupin Institute,
University of Belgrade
SERBIA

N. OBRADOVIĆ, D. ANIČIĆ
Elektromreža Srbije –
Serbian Transmission System and Market Operator,
Belgrade
SERBIA

SUMMARY

In coordination with ENTSO-E and Energy Community, the balancing market with exchange of reserves is developed in SEE region. The first step in development of balancing market implemented within SMM control block is tertiary (replacement) reserve trade. In this paper authors will present current implementation of reserve trading within SMM (Serbia, Macedonia, Montenegro) ENTSO-E control block, and also the plans for future development of reserve trading system within the control block. Authors will present both principles of replacement reserve trading within the software support for replacement reserve trading implemented within SMM LFC block controller system in Serbian National Control Center (Serbian TSO is a block coordinator). At the end of paper the authors will briefly present ongoing activities and future plans for further implementation of reserve trading, including the secondary reserve trading.

KEYWORDS

Reserve trading, ENTSO-E control block, software implementation
1. INTRODUCTION

During the last two decades the European energy sector passed through a lot of changes. Unbundling and the permanent development of the European energy market raised, among the others, the question of cross border exchange of reserves. The problem is difficult and still not completely solved. If someone wants to exchange the energy across the border between two TSOs, he will need free cross-border capacity on the connecting tie-lines. When purchasing reserve TSO wants to have full access to the reserve during the whole period of the contract validity. Consequently, if TSO wants to buy for example a tertiary reserve in the neighbouring country it has to reserve cross border capacity in the amount of purchased reserve. That means that the reserved capacity will remain unused, except for the periods when the reserve is activated. And that could or could not happen. On the congested borders that mean that the capacity available for the market will be additionally reduced because of the possible exchange of reserve that could or could not happened. The result is that, at the moment, European TSOs does not exchange large amount of reserves.

The exchange a primary reserve is most developed one, since energy activated in primary reserve uses Transmission Reliability Margin (TRM) between two TSOs and not the cross-border available capacity. In a way GCC (Grid Control Calculation) is a kind of cross-border exchange of secondary reserve. But even in GCC, real-time exchange programs between two TSOs could be established only if there is available transmission capacity.

One of the main tasks of the most important European energy organizations (ENTSO-E, ACER…) is a constant development of the European energy market. And as a part of this task is a development and increase of cross-border exchange of reserves. Future introduction of Network Codes should incentivize TSOs to develop the procedures in order to exchange the active power reserves.

2. RESERVE TRADE IN SMM BLOCK

Serbian TSO, JP EMS, is responsible for the operation of the transmission network in Serbia. JP EMS has to closely follow the European rules of network operation, since the Serbian network is an integral part of the interconnection Continental Europe and JP EMS is a member of ENTSO-e. According to that rules, TSOs are allowed to fulfil some obligations together if they create a Control Block (CB). At the beginning of the last decade of the previous century JP EMS, together with MEPSO (FYR Macedonia TSO) and CGES (Montenegrin TSO), created a control block (JIEL). In 2007 the block has been reorganized and named SMM (Serbia, Macedonia and Montenegro).

Few years ago, SMM CB members decided to prepare for the period when Network codes will become operational and to explore possible benefits. The most obvious one was the fact that the amount of necessary active power reserves will in the future be calculated on the control block level. That means that each control block member will be able to reduce the purchased amount of reserves and consequently reduce costs. The prerequisite is, of course, the opening of possibility for SMM CB TSOs to exchange the reserves among them. If TSOs decides to calculate the amount of necessary reserve on the level of control block, then the whole amount of the reserve should be available for each TSO all the time.

The work has started in 2014, and in April 2015 PE EMS and CGES signed the contract about cross border exchange of tertiary reserves. For the time being, MEPSO does not participate in
the exchange of tertiary reserve due to some regulatory problems. It is expected that MEPSO is going to solve problems and sign the contract with CGES and JP EMS until the end of 2016.

Since the contract between PE EMS and CGES is just the first step, two TSOs are now able to exchange just their surpluses of tertiary reserve. The precondition is that there is enough available transmission capacity between Serbia and Montenegro, what is usually the case. During the preparations for the implementation of the contract, PE EMS has fully automatized the process of activation of cross-border exchange of reserve. The software that reduces the effort of dispatchers and the possibility of error has been developed and LFC program has been modified accordingly.

3. LFC/SMM CONTROL SYSTEM

When, at the end of 2007, Serbian TSO have taken over the coordination of joint billing and control block of Electric Power Industries of Serbia, Montenegro and Macedonia (ENTSO-E SMM control block) new control system with new software organization and functions were introduced as described in [1, 2].

Major functions of this control system are:

- Simultaneous calculation of area control errors (ACE’s) for all members of SMM block (Serbia, Macedonia and Montenegro) and for a SMM block as a whole.
- Tracking interchange, compensation and frequency schedules for all block members.
- Tracking of all relevant data for control block performance assessment and billing calculation (performed by integrated energy accounting system). Those data are retrieved from ETSO scheduling and Market Management System via Serbian TSO Energy Accounting System.
- Providing all data to be sent to ENTSO-E Energy Awareness System (EAS).
- Provides interfaces with SCADA/EMS system and other relevant information systems in Serbian TSO.
- Provides user interfaces for control block operators.
- It also interfaces, indirectly through SCADA/EMS system, with other block members control centres by using IEC 60870-6 TASE2 (ICCP) protocol.
- SMM LFC block controller does not perform direct control of regulating units (sending raise/lower pulses) but relies on individual member TSO’s SCADA/EMS system to perform these actions instead.

The SMM block controller is directly coupled and share same configuration database with the AGC controller for Serbian TSO which provides functions like:

- All standard AGC functions:
  - Unit control module (which may be set point or raise-lower pulse based)
  - Independent ACE calculation, in addition to ACE calculation performed by block controller.
• Proportional-Integral (PI) control module
• Alarm processing and generation, etc.

• Control performance assessment, including calculation, tracking of frequency quality indices.

• Primary, secondary and tertiary reserve tracking, evaluation and reporting.

• Scheduling functions and related schedule database are expanded in order to support reserve scheduling and modelling.

• Database and software support for reserve sharing and market functions.

• Virtual tie-lines and virtual generation are now supported (but still not used, except experimentally, since those are intended for future reserve and control sharing in line with future market rules).

Figure 1 describes architecture of SCADA/EMS elements related to AGC/Block controller operation. Other SCADA/EMS elements are not shown.

Figure 1 Overview of SMM LFC block controller system architecture

AGC and block controller use dedicated database server for configuration, model and scheduling data, where AGC/block controller scheduling module interfaces with external Energy Accounting System (EAC), ETSO Scheduling System (ESS) and Market Management System (MMS). Those external information systems are source of scheduling data in normal real-time operation. In case of failure scheduling data may be entered manually by operator via dedicated user interface. All retrieved (or manually entered) scheduling data are stored in relational database, from where they can be accessed by other software modules.
Real-time AGC control, SMM LFC block controller, performance tracking and reserve monitoring modules are installed at dual redundant SCADA/EMS servers, and are directly coupled with SCADA kernel. They (particularly performance tracking and reserve monitoring modules) also interface with historical database (HIS) on historical data archival server, from where they obtain data needed for performance calculations and similar tasks.

All servers are using 64-bit Linux OS (Centos 6.x), which is chosen in preference to Microsoft Windows due expected better stability and shorter interruptions of service, open-source model which enables system developers to, for example, access driver sources and identify, debug and even correct some problems without waiting for driver vendor to provide solutions. Particular Linux distribution (Centos 6.x) was chosen because it is based on, and 100% compatible with, Red Hat Enterprise Linux which is perceived as extremely stable and “industrial grade”. All server applications (AGC, block controller, SCADA, network applications) are developed using programing languages C and C++. HMI applications are developed using Java 1.7 and C++ with Qt 4.x cross-platform framework. Java and Qt are chosen for development of HMI in order to provide cross-platform compatibility and easy porting to both Linux and Windows. In standard configuration all operator stations (not shown at figure 1.) are Microsoft Windows based. Such configuration enables operators to use at same station both SCADA/EMS HMI and standard Office and other tools they are familiar with.

4. ACTIVATION OF TERTIARY RESERVE OFFERS

PE EMS has developed a software application that helps dispatchers during the process of cross border activation of tertiary reserve. It also automatize of preparation of PE EMS tertiary reserve offers and their sending to CGES.

On the day D, at 16:00 application sends a tertiary reserve offer to CGES for the whole day D+1. This offer is just indicative and can be changed 30 min before the beginning of the hour. So, the offer for the available tertiary reserve between 12:00 and 13:00 can be modified until 11:30. After 11:30 that offer becomes mandatory.

When PE EMS decides to activate tertiary reserve in Montenegro, the procedure starts with phone conversation of two TSOs dispatchers. Then PE EMS dispatcher enters the transaction data into the dedicated application. Application checks are the entered values complaint with the offer and if the total energy exchanged during the hour is a whole number. If everything is good, application creates Reserve activation request in PDF format and CSV file with the data that describes the activated tertiary reserve. Those two documents are automatically sent to CGES and to a number of predefined e-mail addresses.

CGES dispatcher signs the Reserve activation request and sends it back PE EMS. He also sends files in PDF and CSV format. PE EMS software imports data from CSV file. After that everything is ready for the activation of the tertiary reserve. With one push of the button, PE EMS dispatcher activates the tertiary reserve. Application sends the information about the activated reserve to the predefined mailing list. It also sends the change of the exchange program to the PE EMS accounting EAS database. From EAS database the new exchange program is sent to SCADA/EMS system and AGC application.

If CGES activates the reserve in Serbia, the procedure is similar. CGES sends to PE EMS PDF and CSV files and PE EMS application import data from CSV file. Application sends
the information about the activated reserve to the predefined mailing list and to the EAS database.

5. IMPLEMENTATION OF TERTIARY (REPLACEMENT) RESERVE SHARING MECHANISM

In operation without tertiary reserve sharing SMM block controller calculates area control errors (ACE’s) for each control block member as:

\[ ACE_k = (P_k - P_{k0}) + B_{fk} (f - f_k) \]  

(1)

Symbols used in above equation (1) are:

- \( ACE \) – Area control error of k-th control area in SMM block
- \( P_k \) – Net interchange of k-th control area
- \( P_{k0} \) – Effective net interchange schedule of k-th control area
- \( B_{fk} \) – Area frequency regulation constant
- \( f \) – Actual (measured) frequency
- \( f_0 \) – Scheduled frequency

Equation (1) is used when SMM block controller operate in so called “pluralistic mode”. SMM block controller may also operate in “hierarchical mode” when area control errors for each participating member are augmented with additional component proportional to whole SMM block ACE:

\[ ACE_k = (P_k - P_{k0}) + B_{fk} (f - f_k) + h_k ACE_{SMM} \]  

(2)

In above equation \( h_k \) is hierarchical regulation participation coefficient of k-th member company, and it is always:

\[ \sum h_k = 1 \]  

(3)

Whole SMM block ACE is calculated as:

\[ ACE_{SMM} = (P_{SMM} - P_{SMM0}) + B_{fSMM} (f - f_0) = \sum_k (P_k - P_{k0}) + \sum_k B_{fk} (f - f_k) \]  

(4)

Hierarchical control mode is usually not used in normal SMM block operation.

Effective net interchange schedule \( P_{k0} \) consists of three components

\[ P_{k0} = S_{k0} + C_{k0} + R_{k0} \]  

(5)

Symbols used in above equation (5) are:

- \( S_{k0} \) – Interchange schedule without compensation and ramping
- \( C_{k0} \) – Compensation schedule
$R_{k0}$ – Part due to schedule ramping which starts at some predefined time $T$ before end of schedule cycle and ends after period $T$ in new schedule cycle (if 1 hour schedule cycle is used then $T$ is usually set to 5 min) as illustrated in figure 2.

![Figure 2 Illustration of schedule "ramping"]

Tertiary reserve sharing is implemented in by introducing the “Interchange Schedule Offsets”, that is effective interchange is augmented with additional component $\Delta P_{TR,k}$ due to tertiary reserve sharing (6).

$$P_{k0}^* = P_{k0} + \Delta P_{TR,k} \quad (6)$$

Value $P_{k0}^*$ is then used for all ACE calculations instead of $P_{k0}$. Usually interchange schedule offsets $\Delta P_{TR,k}$ have much smaller values than respective $P_{k0}$ so they are not additionally “ramped” (Figure 3).

![Figure 3 Interchange schedule with component for tertiary reserve trade]

If all tertiary reserve sharing/trading is performed within SMM block (i.e. there is no reserve sharing with control areas outside control block) then value block area control error $ACE_{SMM}$ is unaffected by reserve sharing because it is always

$$\sum_k \Delta P_{TR,k} = 0 \quad (7)$$

when sharing is performed only within control block ($k$ denotes $k$-th SMM block member).

That means that change of exchange program between two TSOs within the same control block does not influence the exchange program of the whole control block towards the rest of
the interconnection. Consequently there is no need to declare change to the Continental Europe interconnection.

Interchange schedule offsets $\Delta P_{TR,k}$ are scheduled in shorter time frames (currently 5 min) than regular interchange schedules (1 hour or 15 min). Interchange schedule offsets are provided by EAS database in the form of CSV files. Those files contain 288 offsets (for every 5 minute interval) for each block member, for each UTC day present in schedule file.

These files are sent by means of automated SFTP (Secure FTP) script to server hosting AGC/SMM block controller database (AGC database server shown at figure 1). At AGC database server dedicated loader application checks every 60 seconds if new interchange offset schedules file is available, and if available it is loaded automatically. Load procedure discards all schedules in past, and for current 5 min interval, only schedules for future time intervals are imported.

Dispatchers may use standard AGC scheduling HMI to inspect imported values for interchange offsets (as shown at Figure 4). In case that, for any reason, CSV files with offsets became unavailable or corrupted, dispatchers may use AGC scheduling HMI for manual entry of schedules. In case of prolonged unavailability of this or other schedules appropriate SCADA alarms are automatically issued.

 Dispatchers may control if those offsets are used by turning them on or off at appropriate AGC&SMM block controller HMI.

6. CONCLUSION

Paper describes the new procedure that allows Serbian (PE EMS) and Montenegrin (CGES) TSO to exchange tertiary reserve. TSOs are motivated by the new European Network Codes that allow calculation of necessary reserve on the control block level. The prerequisite is that
control block members are able to exchange reserves among themselves. For the time being, only two members of SMM control block are able to exchange tertiary reserve. Macedonia has to solve some regulatory issues before to join the process. The paper describes the newly developed software and its modifications that allow smooth functioning of the procedure/mechanism.

The reserve exchange started in April 2015 and during the first year of operation tertiary reserve exchange flowed smoothly across the border allowing both TSOs to maintain the security of their system.

BIBLIOGRAPHY


