

CONGESTIONS IN ELECTRICITY TRANSMISSION SYSTEM CASE STUDY

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Rezumat. În lucrare se prezintă problema congestiilor din sistemele electroenergetice de transport și din rețelele transfrontaliere. Metodele de management al congestiilor sunt următoarele: limitarea accesului la rețeaua de transport, lista de priorități (primul venit, primul servit), raționalizare pro-rata, licitații explicite, licitații implicite, divizarea pieței, redispeșterizarea și redispeșterizarea coordonată transfrontalieră. Studiul de caz se referă la un sistem real, de mari dimensiuni, reprezentat de subsistemul aflat în gestiunea Sucursalei de Transport Timișoara a C.N.T.E.E. Transelectrica.

Abstract. This paper aims to present the congestion problem within the power transmission systems and cross-border transmission networks. The worldwide congestion management applied methods are the following ones: limited access to transmission network, priority list (first come, first served), pro-rata rationing, explicit auctions, implicit auctions, market splitting, redispatching and cross-border co-ordinated redispatching. The case study is represented by a real, large scale power system, operated by Timisoara Transmission Subsidiary of C.N.T.E.E. Transelectrica.

Keywords: congestion, transmission system, redispatching method, transmission system operators

1. Introduction

European electric power systems, initially interconnected for reliability reasons, are used for commercial purposes too, through energy trading in electricity markets at national, regional or inter-regional level [1], [2]. In any market power is necessary to avoid limiting transactions. This limitation is due to limitations of equipment used in the production and transmission of electricity. It became clear that in order to stimulate competition and provide open access to electricity transmission network, there will be situations in limit operation or even exceeded these limits (congestion). The congestion appearance on network elements leads to visible increasing the values marginal prices and redispatching of power generated is no longer done only in terms of the offer price, including in discussion the "cost" of congestion too. Independent system operator will intervene to eliminate congestion. If the system has lacks of sufficient resources to solve the congestion, it may appeal to one of the following situations:

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- It is acceptable an exceeding of limit value for some network elements;
- It is modified favorable the system topology;
- It is reduced the value of consumed power in some buses, where the thing is possible, which introduces supplementary charges for “compensation” of involved consumer.

In this paper, congestion management methods used in Europe are presented, with the legal framework for their implementation. The case study is effectuated on a large system, which includes the Western, South West and Northwest power system of Romania. Starting from the base case, the authors are analyzing the congestions, in case of one circuit simultaneously disconnecting of the double circuit 220 kV Porțile de Fier-Reșița, respectively Reșița-Timișoara overhead power lines. The measures necessary to be taken are presented [10].

2. Congestion management in European electricity markets

The Failures from electric power systems, which occurred both in Europe and the U.S., included congestion management in a very actuality area. Congestion Management treats the link between transmission capacity and the electricity market and power flow operational management on the border lines.

Congestion management is going through four sequential steps (Fig. 1) [3].

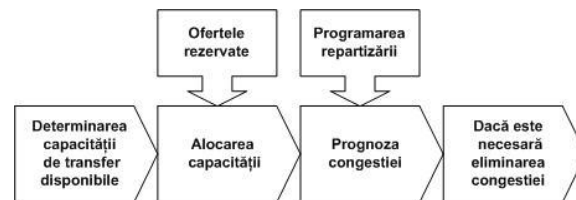


Fig. 1. Congestion Management Stages

- Step 1. There is determined the available capacity of electricity transmission network and trading period (the next day, long term and during the day). During calculations it is necessary maximum transparency and the procedure used must be known to all participants in the electric power market and accepted by the relevant regulatory authorities.
- Step 2. There is realized the distribution of transmission capacity available to users of the electricity transmission network. There are a variety of methods that can be used for this purpose (for example, implicit or explicit auctions).
- Step 3. Transmission and system operators make a "forecast" the congestion appearance, based on the latest information on the state electricity transmission system (including generation offers and consumers bid). Operators determine whether network security limits are violated.

Step 4. If security limits are reached, the transmission system operators will take measures to eliminate congestion. Such measures may include actions by the inherent network (such as power transformers plots) and redispatching actions (change of power generated and possibly power consumption).

Congestion management methods used in Europe [4] [5] [6] are:

1. *Transmission access limitation*. This method is characterized by access rationed and the links are in DC, each link having a different ownership. It does not involve any economic signal and is not based on the market, but some users may benefit from cross-border trade. Transmission capacity of link (transmission line) is reserved for participants in transmission contracts for a fixed period of time, for example, one year.
2. *Priority list* (first-come first-served). Transmission and system operators from a region determine the allocation of available transfer capacity on a regular basis (daily, weekly or monthly) until the entire amount of the available transfer capacity is allocated. The allocation is done after certain priority criteria, new market participants are more disadvantaged (discriminated). The method is characterized by a limited transparency of transactions privacy. Participants in the electricity market are encouraged to reserve capacity in advance for periods of time, allowing thus a better assessment of security of electricity transmission systems.
3. *Pro-rata rationing*. The method is characterized by confidentiality of trade transparency, but results in inefficient use of power system: each participant in the electricity market is relatively limited capacity allocated by the transmission system. Is not defined a "priority" real. All energy transactions are accepted by transmission and system operator, but are limited if there is congestion in the transmission system. Capacity price is set arbitrarily by the regulatory authority at a level that has not economically efficient. This method is used in regions where there isn't congestion.
4. *Explicit auctions*. TSO operators sell their cross-border capacity to best bidder from electric power market. Auction design variants are possible through auction mechanisms and trading intervals (days, weeks, months and even years). Explicit auctions separate power flow from the transmission capacity. The disadvantage is that it requires separate transactions for energy and to obtain transmission capacity. Thus, increasing complexity of cross-border trade and therefore may represent a barrier to trade. Auctions present a revenue opportunity for the electric power market participants. Several features can be mentioned: economic signals, transparency, non-discrimination, perfect market adoption. This type of auction is often a coordinated joint mechanism between transmission and system operators involved.

5. *Implicit auctions.* If congestion on transmission lines (available transfer capacity has been reached) exists, the electricity price is divided into zones. Bidding mechanism is coordinated jointly by the operators involved TSOs. A centralized power exchange is necessary. Transmission and system operators add a supplementary tax for each participant using the transmission line or cross-border line. Market operator sets the supplementary tax in such a way that many electricity cross-borders are accepted since the transport capacity available to do so. This method does not separate the power flow of transmission capacity, so the process is easier for market participants. As explicit auctions, there is a revenue opportunity for electricity market participants. And other features can be mentioned: economic signals, non-discrimination, transparency and efficient signals to market participants.
6. *Market splitting.* This method is characterized by splitting a power exchange (PX) offers in geographical areas with limited capacity exchange. Price is determined and provided by the volume of requests and the power generated throughout the existing market. Then, transmission and system operators calculate power flow and identify congested lines. Geographical areas, consisting of one or more areas of tender, virtually define congestion. In each geographical area, a new spot price is defined, the flows along the areas being limited to the capacity of cross-border lines. When each area has its own spot price: the downstream areas of congestion will have the highest price, while upstream, the lowest price. When price-demand effect is visible (demand decreases as price increases), the congestion is eliminated completely by following the market mechanism: demand reduction in areas with high price and its growth in low cost areas. Obviously, the opposite is observed on the power generated. The method has the advantage of a competition with an increasing degree and reduces inflated prices. Under this mechanism is a single price, which is available to all participants in the market, but particularly electricity producers. It is recommended to have a common market structure and organization for both sides of a cross-border.
7. *Redispatching.* At first, electricity transactions in the market are fixed as there are no limitations. These transactions result in net transfer capacity exceeded. In this case, the transmission and system operator (TSO) made redispatching of generating units in its area of control, helping solve this part of the congestion more precisely the net power flow is identical with the available capacity of the line. Prices are higher in downstream than in upstream and in this case, there are additional costs which will be awarded to operators, costs which could be allocated to parties responsible for economic efficiency. In redispatching mechanism, TSO operators must require information about prices to determine the loading or diminishing the generating units.

8. *Cross-border co-ordinated redispatching*. This method is an extension of the redispatching method, to several TSO operators. In the event of congestion, operators are coordinated their redispatching, being capable to appeal produced groups located outside the control area with neighboring operators help. The method is more transparent, but can provide generators located downstream of a congested line power in the market. Solution long-term contracts provide a better guarantee for the operators. Costs of cross-border co-ordinated redispatching should be allocated to the participants responsible for congestion. Also, customers should be able to choose between changing behavior or pay the price of redispatching. It does not allocate additional revenue TSO operators. But it is an advanced service organized by TSOs to provide more market liquidity.

3. The legislative framework for congestion management

Explicit development of Congestion Management Guide is referred to 7th Forum in Florence on November 2000, which were agreed to set the congestion management methods and mechanisms for explicit auctions. In June 2003 the Commission adopted the Regulation 1228/2003 [7], which establishes the conditions of network access for cross-border exchanges in electricity. The regulation entered into force on 1 July 2004.

Annex, which includes Congestion Management Guide, improved in 6 November 2006, follows the decision of Europe Union Commission. Regulation 1228/2003 has subsequently been replaced in July 2009 by Regulation 714/2009. However the relevant dispositions concerning the assessment and capacity allocation, which were included in the November 2006 in Regulation amendment 1228/2003, remain unchanged. It allows some interpretations on the concept of reliability and possible methodologies that can be applied to compensate for limitations.

Progresses on congestion management were not limited to Florence Forum and the development of regulations on implicit and explicit auctions. For example, ETSO (Association of Transmission and System Operators in Europe) and EuroPEX (Association of European power Exchanges) have developed influential papers on congestion management and flow based on market redispatching (September 2004) [8] and a coordinated model for inter-regional congestion management (January 2009) [9]. In addition, European National Regulatory Authorities (NRAs) are currently adopting a more proactive approach to monitoring the activity effective of interconnection, with annual reports issued by the Authority on achieving progress.

4. Numerical application

It is considered DET vest system, including the Western, Southwest and Northwest of Romania's power system, covered mainly Craiova Territorial Electric Power

Operator and, partially, Timișoara and Cluj Territorial Electric Power Operator. The system has a number of 88 buses, a number of 35 sources and 42 consumers (Fig. 2). For reasons of space it will not include data on the system buses and network elements parameters.

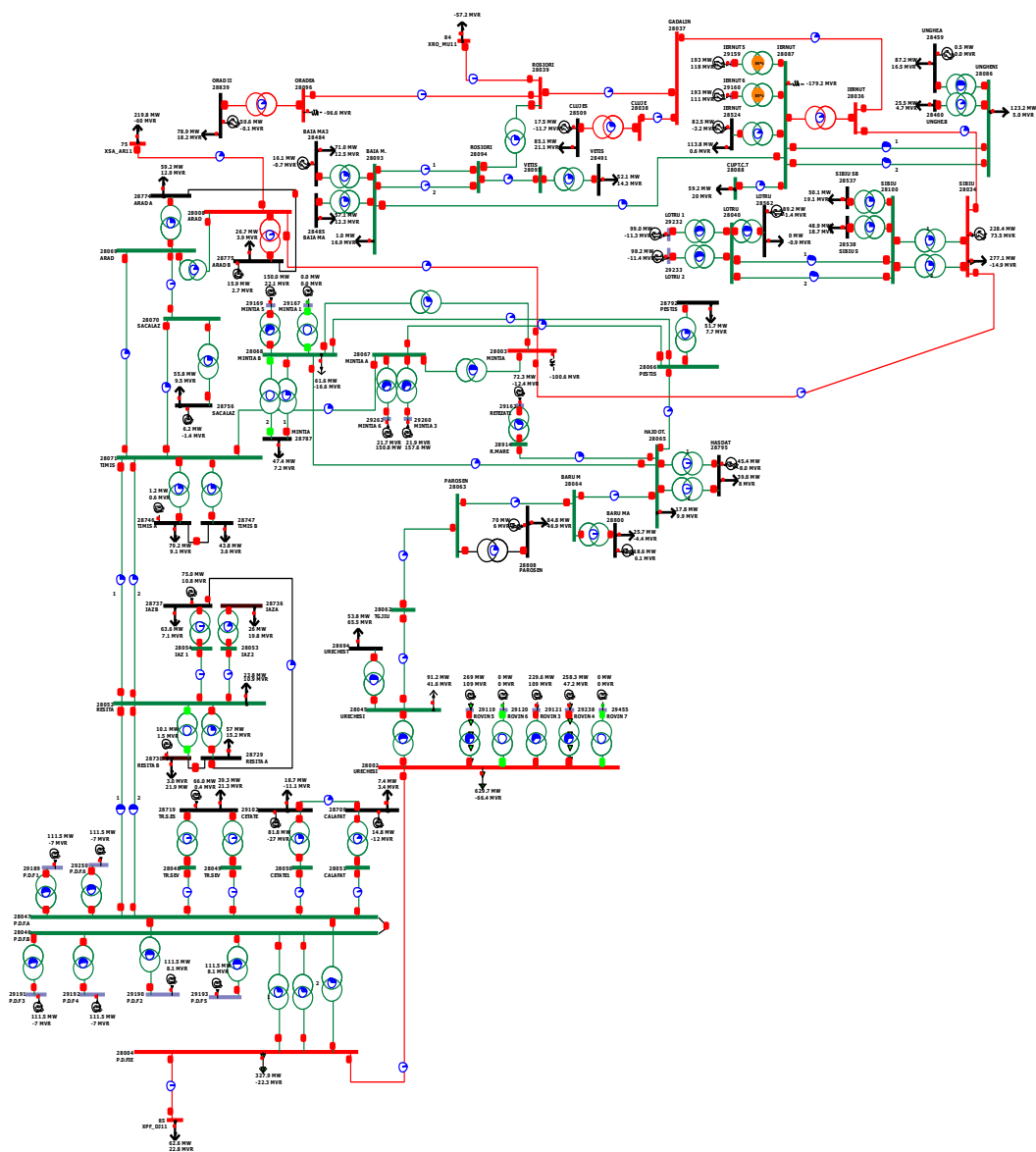


Fig. 2. Structure of power system subsystem from Western, Southwest and Northwest of Romania

The regime obtained in case of one circuit simultaneously disconnecting of the double circuit 220 kV Porțile de Fier-Reșița, respectively Reșița-Timișoara is presented in figure 3.

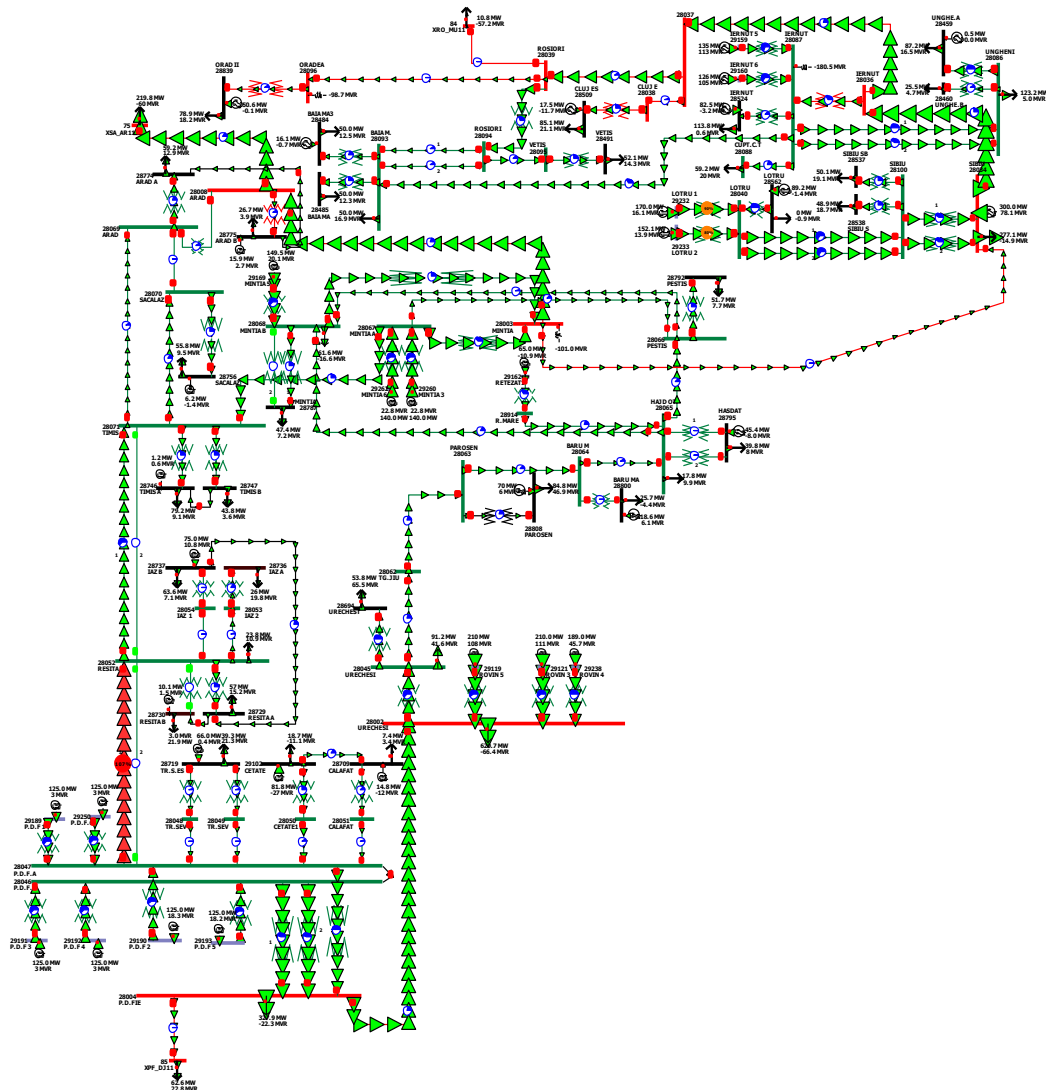


Fig. 3. Regime with congestion on Porțile de Fier – Reșița line

These simultaneous disconnections caused the overloading to 107% of second line circuit of Porțile de Fier -Resita. Voltage levels in buses are in admissible domain. Hourly system operation is 126,667 \$/h and the penalty cost is lower (15,254.5 \$/hr). For local marginal prices, the maximum value is obviously localized in Resita and Iaz area and minimum values belong to Porțile de Fier, Calafat and Drobeta Turnu-Severin areas.

To eliminate the congestion Timișoara Territorial Electric Power Operator reduced power consumption in Reșița A, Reșița and Reșița B buses with a total of 65 MW. Hourly cost has value 126667 \$/h. All local marginal prices are around 42 \$/MWh value. The regime obtained after solving the congestion is presented in fig.4.

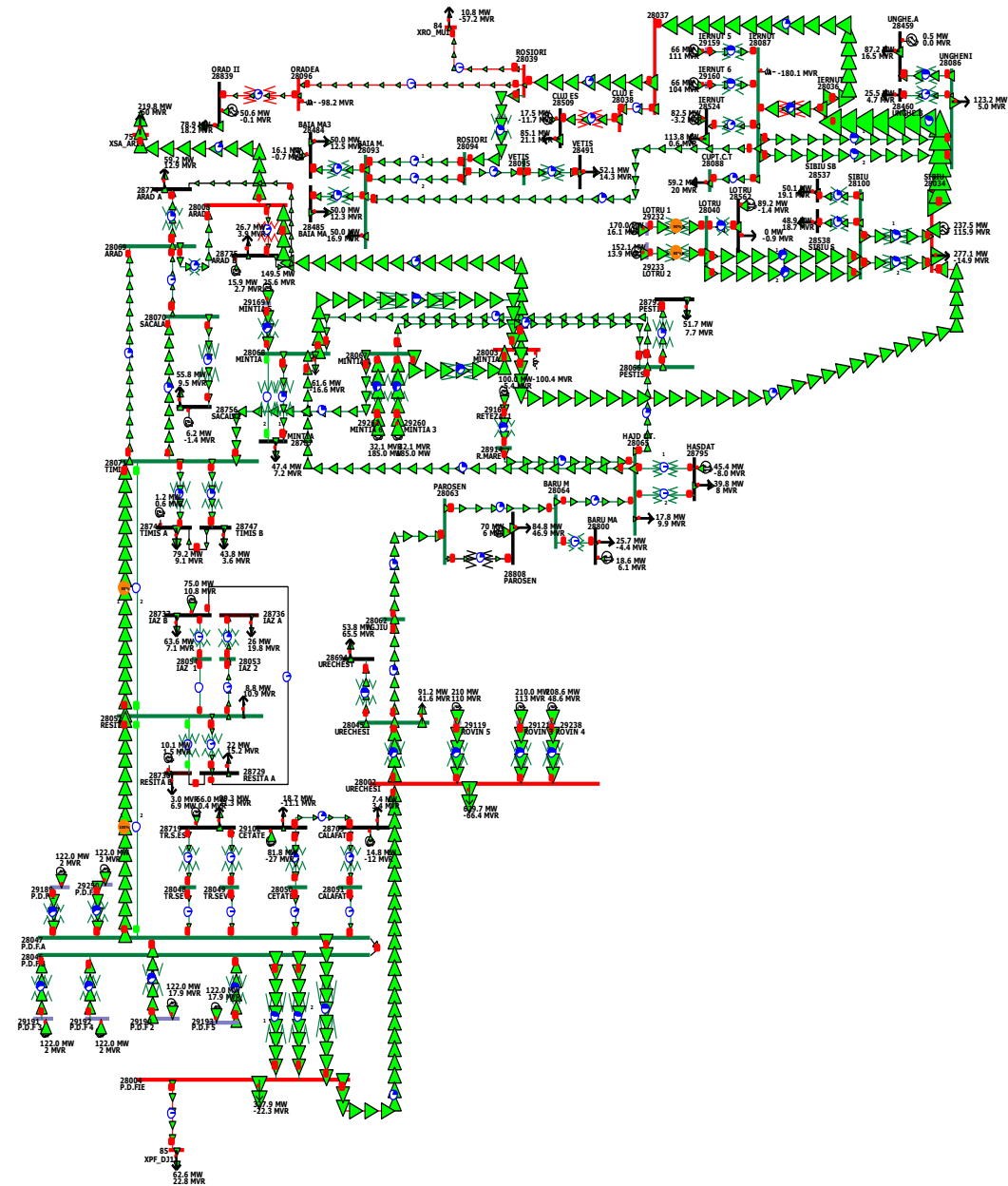


Fig. 4. Regime with congestion resolved on Porțile de Fier – Reșița line

Also, generated powers of groups from Porțile de Fier, Iernut and Sibiu were reduced and generated powers of the group Rovinari 5, Paroșeni, Mintia 3 and Mintia 6 have been increased. Another category of groups have retained their original value. In this case can be mentioned groups 3 and Rovinari 3, Rovinari 5, Iernut and groups from Lotru. Redispatching way of producing energy sources is presented in Fig. 5.

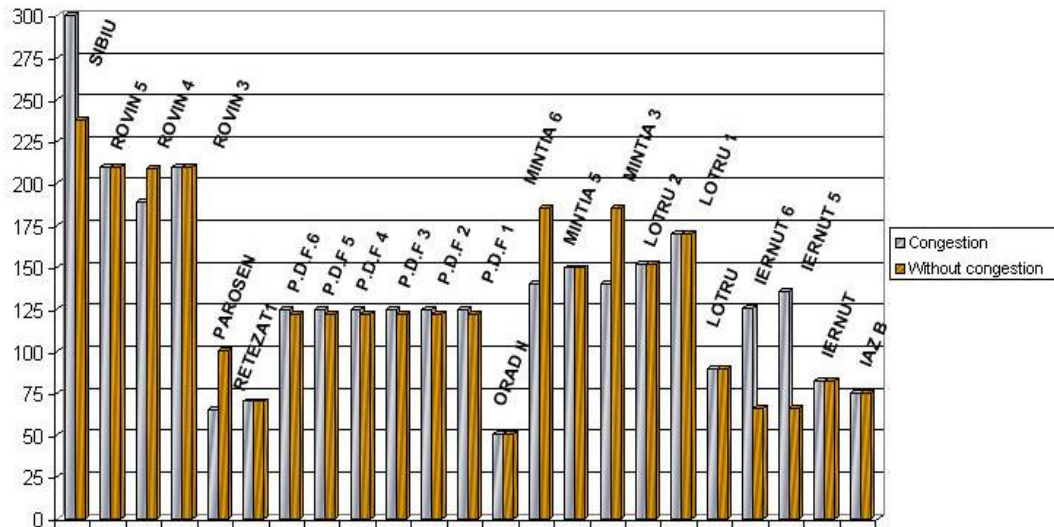


Fig. 5. Redispaching of energy generated groups

Conclusions

Currently, congestion management is one of the most powerful and dominant mechanisms in regional or inter-regional electricity markets.

In practice, internal congestion and cross-border congestion seems to be the result of regional decisions and priorities enacted separately in each Member State.

Also it can be referred the operational cooperation between territorial operators.

For case study regime analysis, the congestion has been solved successfully by changing power flow due to decrease of power consumption and redispaching of energy generated groups.

System structure plays a positive role in solving the congestion.

It is mentioned, availability of generation reserves, respectively the congestion management mechanism chosen.

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