Ancillary Services Management in an Open Market Environment

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Abstract: - In accordance with accepted package of Energy laws in 2001 and their harmonization with Directive 2003/54/EC in 2004 beginning the process of opening and liberalization of electric power sector in the Republic of Croatia. The Energy law stipulates the following activities of the power sector generation of electricity (apart from electricity generation for eligible customers): transmission of electricity, distribution of electricity, retail supply of electricity (apart from retail supply of electricity for customers free to chose the supplier) as well as organization of the electricity market. This article gives an overview of ancillary services and describes ways to measure, estimate and allocate costs for some ancillary services. Also, there is a description of the current situations in some countries in southeast Europe.

Key Words: - Ancillary Services, Deregulation, Electricity Market, Frequency Regulation, Reactive Power Regulation, Reserves, Transmission System Operator

1 Introduction

In the past, electric power systems were dominated by large companies which controlled production, transmission and distribution of the electrical energy within the respective territory. Such companies are called vertically integrated companies and they were the only supplier of electrical energy in a certain region and their obligation was to provide electrical energy to all consumers.

At the beginning of the last decade of the 20th century, electric power systems throughout the world started reforms regarding production, transmission and distribution. The main goals of these reforms are achieved by setting clear boundaries between production and sale of electric energy and the control of the power system. Once vertically integrated activities regarding production, transmission and distribution have become completely independent. Production companies and electric power plants sell electric energy by means of long term contracts with customers or by short term supply bidding on the current market and in both cases competition is present.

Due to economy of scale, transmission has remained a natural monopoly. The free access to the transmission system is a very important factor in deregulated system. In order to enable equal access conditions to transmission system for both producers and customers, transmission system operator has to be independent with regard to other participants on the market.

System operator is the central coordinator and is responsible for reliability and safety of the system. System operator controls the services referring to the transmission of electric energy; it is responsible for schedule as well as for the control of the system. It also has to ensure the demanded quality and safety level and to carry out correction measures when the problems in the electric power system occur. System operator can also control market administration, organize electric power auctions and control bidding procedures as well as carry out testing of production units.

In electric power systems, beside basic power supply, there are other services such as planning, frequency and active power regulation, voltage and reactive power regulation, rotating reserve etc. These services are called ancillary services. They were not separated in vertical integrated systems, i.e. they were part of electric power supply.

However, in many countries instantaneous electric power markets developed and private producers were allowed a free access to the network. In such deregulated system, ancillary services were not a part of the power supply anymore, they are charged separately and the system operator has to buy them from the supplier of these services. An important factor for correct functioning of the system are the questions concerning ancillary services price, i.e. tariff/payment system which gives all participants on the market equal conditions and enables them to meet their expenses.

This paper presents all important questions concerning ancillary services of the system. The market with ancillary services is described as a whole and from different points of view. Four most important and most frequent services of the system are also described. Different market models are presented, evaluation and technical conditions which have to be fulfilled by the suppliers.

2 Some Market Properties of the Ancillary Services

2.1 Ancillary Services as seen by Buyers, Customers and the System Operator

For the customer, ancillary services are integrated to its electricity supply and are thus not separately distinguishable. Any subject connected to the network is the buyer of the system ancillary services. Ancillary services affect the buyer when electric power quality and continuity of supply is considered.

For the producers, which are either vertically integrated companies or independent producers, ancillary services include all operations which have to be carried out in order to ensure the correct functioning of the system. This includes all operations except active power supply, such as production or consumption of reactive power, voltage and frequency regulation, adequate rotating reserve, giving information about future availability etc.

Finally, system independent operator is the link between producers and customers. It collects contributions of particular electric power producers, deals with system economic control and offers its own services in order to ensure continuous supply to the customers. All this calls for resources and implies costs. It therefore raises the problem of evaluating the cost for the system, compensation of service suppliers and the allocation of costs to service customers.

2 Classification and Definition of System Ancillary Services

Ancillary services are all services which support elementary functions of electric power system, i.e. active power production and electric power supply to the customers, and they are supplied by subjects dealing with production, control and transmission of electric power. These services are necessary for transmission of electric energy along with adequate reliability of the system and for the required safety and quality level.

There are several, somewhat different, definitions of the system ancillary services. European UCTE Operation Handbook defines ancillary services as "Interconnected Operations Services identified as necessary to effect a transfer of electricity between purchasing and selling entities (transmission) and which a provider of transmission services must include in an open access transmission tariff".

In Croatia, ancillary services are defined in the national grid code as "purchasable, individual services, provided by the network customer (e.g. producer) or the distribution system operator upon the transmission system operator's request." AS providers' costs are refunded by the TSO.

One of the most important documents for the AS commercialization process is the FERC (Federal Energy Regulatory Commission) Order 888. It defines ancillary services as "services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system". The Order 888 also defines cost components to open access transmission tariff. In the US, there are 26 different ancillary services, but only six of them are obligatory.

It is estimated that AS related costs sum up to 12 billion \$ per year, which is 10% of total electricity expenses. Therefore, FERC proposes creating a market for these services: *regulation, spinning reserve* and *supplemental reserve*. These services are more closely

described in this article.

Table.1 Ancillary Services Classifications by FERC

Production	Distribution	System operator	Transmission
Automatic Load Shedding	Demand side management	Administrati ve Service	Transmission maintenance
Service	Local reactive support	Curtailment Management	Transmission reserve
Energy imbalance	Power quality services	Dynamic scheduling	
Frequency regulation	System reactive support	Dynamic voltage support	
Load following		Generation dispatch	
Non-spinning reserve		Generation scheduling	
Operating Reserve - Supplemental		Metering Services	
Reactive Supply and Voltage		Static scheduling	
Control		Transmissio n dispatch	
Real power loss compensation			
Restoration Service			

3 Reactive Power Regulation

This service is also called voltage regulation or reactive power regulation service and its function is to control reactive power flows in order to keep determined voltage levels. Reactive power flows have considerable influence on voltage value in nods and because of that it is necessary to keep balance between production and consumption of the reactive power. On the other hand, reactive power flows should be decreased as much as possible and in so doing, the quantity of active power is increased and the losses in the system are decreased. This is the reason why voltage should be controlled on the local level and the price of this service depends considerably on the location of the reactive power source in the system.

In a vertically integrated electric power utility, reactive power supply was one of their activities and all expenses due to reactive power were included in the customers' bill. In deregulated electric power markets, the system operator has to provide a sufficient quantity of reactive power in order to deliver contracted quantity of active power. Since it is not desirable to transmit reactive power to long distances, consumption in the system should be taken into consideration as well as consumer structure and reactive power source availability. In a private and deregulated electric power system, independent producers have devices for producing reactive power while the system operator takes care of the supply by means of contracts.

Completely competitive markets of reactive power regulation as well as ideal tariff model have not been developed yet. Some of the obstacles in creating such market are:

a) Reactive power regulation service has to be offered on the local basis which means that the price of one Mvar is not the same everywhere in the system. If reactive power regulation market were organized in the same way as active power market, it could happen that the system operator would be forced to make contracts with reactive power producers located on inadequate locations (regarding the system safety), but are offering the lowest prices.

b)Reactive power generated in static compensation devices cannot be compensated for as an ancillary service. If the owners of capacitor banks, SVC and FACTS systems were allowed to offer services for reactive power regulation, competition would be increased and at the same time, the market would be more efficient.

c)Long term contracts of reactive power supply could reduce market power considerably and prevent producers to sell reactive power at prices higher than the limiting ones.

3.1 Establishing Reactive Power Market

During reactive power market establishing it is important to define two terms, i.e. expected payment function (EPF) and costs of losses.

EPF is a mathematical formulation of producer's costs, i.e. producer's expectation for costs reimbursements. Producers whose generators produce reactive power for the market are exposed to different expenses depending on the operation mode. Some of these expenses are very difficult to define, while some of them are difficult to quantify. Therefore, during establishing the market, an adequate mechanism for compensating these costs has to be created.

Costs of losses are one factor in expected payment function. Reactive power produced or spent in the generator increases active power losses in their rotor windings. These active power losses are reactive power non linear function. Although this component is considerably smaller compared to other system losses, it should also be taken into consideration.

3.2 Structure of the Reactive Power Offers

With regard to reactive power production, synchronous generator operation may be divided into three regions (fig. 1):

1) Area $1 - (0 - Q_{basic})$: Production in this region caters for the reactive power needed by the generator to

maintain its own equipment. Therefore any reactive power generated in this region does not qualify as an ancillary service.

- 2) Area 2 $(Q_{basic}-Q_A, 0- Q_{Min})$: This region represents that amount of reactive power, which the generator can provide or absorb, without having to reschedule its real power generation. However, as mentioned earlier, this will increase the generator's real power losses in the windings. These losses increase with the amount of reactive power generated or absorbed. Therefore, the generator will expect to be paid for the cost of losses (probably at the prevailing spot-market rates) and also for making available its service.
- 3) Area 3 ($Q_A Q_B$): This region represents the amount of reactive power that a generator is willing to produce at the cost of having to reduce its real power generation. The generator stands to lose revenue from the unfulfilled real power selling contracts. The financial compensation that the generator expects from its reactive power service is the revenue lost due to its scheduled real power sell.

On the liberalized market, the system operator cannot evaluate the generator's EPF. More convenient option for the system operator is to collect all offers for reactive power from the producers based on EPF structure. The general EPF function as well as offer structure can be formulated as:

$$EPF_{i} = a_{0} + \int_{Q_{\min}}^{0} m_{1}dQ + \int_{Q_{base}}^{Q_{A}} m_{2}dQ + \int_{Q_{A}}^{Q_{B}} (m_{3}Q)dQ$$
(1)

The factors in (1) represent various components of reactive power cost:

A	
a_0	availability price offer
m_1	price offer for the operation in the area $(Q_{\text{basic}}-Q_A)$
m_2	price offer for the operation in the area (0-Q _{Min})
m_3	opportunity cost price offer for the operation in the area $(Q_A - Q_B)$

Similar considerations also refer to the synchronous compensator. The only difference is that synchronous compensator offers cannot include opportunity cost component because it does not produce active power.



Fig.1 Structure of reactive power production costs

The availability payment covers a part of the initial investment into the generator which enables it to produce reactive power. It is very difficult to separate this component from the overall initial investment, so it covers only a small part of initial investments. Normal operation payments include generator driving costs due to reactive power regulation service and it represents active power losses in the generator.

4 Frequency Regulation

Frequency regulation is the control of the system frequency by maintaining the real time balance between generation and load of the active power.

When a disturbance occurs in the system, there is a difference between active power generation and load,) the balance is deteriorated, and system frequency differs from its rated value causing turbine generators to act promptly, i.e. generation is changed and it is called primary regulation of frequency. The generation change combined with load change of frequency dependent consumers, helps in preventing further increase of varying frequency with regard to its rated value. If the primary regulation has been successful, the system regains its stability, but the frequency is different from its rated value. This is good as far as the stability of the system is concerned, but some undesirable power flows occur and the area control error is accumulated. In order to shift the frequency to its rated value, it is necessary to change production power defined values of regulating electric power plants, depending on new balance between production and consumption. The latter belongs to secondary regulation of frequency, and can be carried out automatically (automatic generation control) or manually. In most electric power systems, secondary regulation is carried out automatically. Tertiary regulation implies each setting, either automatic or manual, of device parameters which participate in secondary regulation because of the need to enable required secondary regulation reserve or economically optimal distribution of secondary regulation power to production units which participate in the secondary regulation.

There are two models for the frequency regulation service, i.e. "purchase" or "bilateral". In the first case, system operator buys active power (from the producer or the consumer) in approximately real time. Some countries have already accepted this scheme of frequency regulation, e.g. in Scandinavia (NORDEL system). Bilateral model can be applied in countries where the system operator does not have the obligation to supply frequency regulation services; customers themselves buy load monitoring service.

4.1 The Purpose of Frequency Regulation

Consumers – The quality of electric energy supplied to the customers should be in accordance with its application. Electrical devices, from large industrial facilities to simple electrical bulbs require a frequency within a certain range in which its changes will not damage either the device or deteriorate its performance. Consumers are also exposed to shut off risks because of under frequency unloading and which they cannot control.

Producers – Equipment for electric energy production also requires preservation of frequency within adequate limits where its changes will not have harmful influence on equipment reliability, operation quality or life time. The loss of a part of the production may lead to further disturbances and the breakdown of the whole power system. Besides, constant frequency enables load distribution to aggregates, i.e. schedules.

Network – In some parts of the electric power systems connected by relatively weak power lines, uncoordinated operations for frequency correction may cause overloading, instability or problems with voltage regulation. The operation at low frequency may also cause damage due to high magnetic flows in transformers.

Market – On the market, there is a risk connected to the interaction of frequency changes and market functioning. Frequency changes cause changes in production and consumption resulting in their influence on the market. Uncoordinated actions between interconnected markets may cause energy amount deviation with regard to their contracted values.

4.2 Frequency Regulation Costs

In vertically integrated utilities, the costs of providing frequency control are the incremental costs of providing plant with frequency control capability, maintenance due to frequency control activity, holding generation capacity in reserve and possibly any benefits given to consumers for the ability to shed their load. These costs are difficult to quantify. A market for frequency control services may assist in the evaluation of these costs. However, in a market environment, prices are more reflective of business opportunity than the actual costs of service delivery. The traditional view that frequency should be controlled within a narrow range in the absence of contingency events is often challenged by the market costs of doing so. In some cases, probabilistic definition of frequency standards (e.g. keeping the frequency within a certain range for a certain percentage of time) may provide additional flexibility to achieve a more economic outcome.

4.3 Frequency Regulation Provision

There are several ways of providing frequency regulation services on market environment:

- 1) Compulsory service providing (e.g. as a condition for connection or any other legal contract),
- 2) Contractual service providing (e.g. by periodical bidding),
- 3) Market (e.g. current market of the system ancillary services).

These methods can be combined in order to cover for all time frames. Compulsory service providing implies a moderate risk, i.e. the service might not be satisfactory for driving standards. A bigger risk is that there are too many services available because it leads to unnecessary expenses. On the contrary, in the case of contractual service providing and the market, much bigger risk is the lack of frequency regulation service than its surplus.

Depending on the market structure for providing services a market operator, system operator or some other body representing the industry may be responsible. If the market operator is not directly responsible, it is necessary to consult him in order to decrease the risk concerning inefficient frequency regulation services.

5 Reserves

In most systems, the reserve is divided into rotating (hot) or additional (non-rotating, cold). Additional reserve consists of aggregates which are not connected to the grid; therefore instantaneous response is not required from them. It includes different forms, even voluntary remote shutting off with the purpose to liberate rotating reserve capacities due to other possible disturbances in the system. Both additional and rotating reserve have got certain fixed expenses connected to availability of additional aggregates, but there are no expenses for fuel while the maintenance of aggregates is rarer and more simple. Its amount should generally be equal or a more than the sum of maximum power of the two biggest aggregates in the power plant.

Reserves are designed to respond to uncertainties and needed for maintaining the integrity of the transmission system in the presence of disturbances. Reserves are important both for energy and for reactive power. The two main disturbances are generation outages and load variations. An arbitrary but widely accepted classification organizes reserve services into three time frames:

Spinning reserves. Their time of response is from a few seconds to about 5 minutes. It is not necessary for spinning reserves to be able to deliver power for a long period of time since these are eventually displaced by the supplemental reserves

Supplemental reserves. These reserves have the response time from several minutes to half an hour. Supplemental reserves are used for stabilizing the system frequency and energy balancing within a control area. After some prescribed time they are replaced by

Backup reserves. These can sty in service for a longer period of time, but are not expected to come on line for some time (30 minutes or more).

Frequency control, load following and reserves services are closely relates, but distinct services. Although the objective of reserves is the same as for frequency control and load following (maintaining a balance between supply and demand), the situations in which it is needed are different. Reserves are intended to deal primarily with outages and disturbances.

A very important factor for keeping adequate rotating reserve is that the reserve must be divided to more aggregates in the system. If most or all reserve is contributed to one aggregate in the system, the total response is limited by the speed (MW/min) with which this aggregate can lift its power. Besides, by dividing reserve to more aggregates, electric energy system stability is reduced, and the dropout of connecting lines or other elements in the system may occur.

Dominant criteria for determining necessary rotating reserve do not take into consideration either dynamic characteristics of the generator response or the load behavior or the expense for providing rotating reserve as well as the risk for the system in case the latter is not engaged. Moreover, it is necessary to check the reserve location for the single failure (safety n-l) in every point of the system in order to verify the technical possibility of engaging the total available reserve if needed. New methods for defining the necessary reserve together with probability evaluation about aggregate availability and consumption uncertainty take into consideration market conditions on electric energy market as well as on driving reserve market. Since the speed of aggregate power increase is different, the price of rotating reserve which can be obtained is different, too. If in the case of disturbance the total or partial rotating reserve is engaged, it is necessary to replace it by admitting the aggregates in the minute reserve.

At some point, reserves are no longer an issue for an operator to be concerned about and become an issue for market to resolve. However, market must provide at all times the operator with an operable system under all foreseeable circumstances.

The cost of providing the service depends on the requirements of the system. One of the most important principles for measuring and pricing reserve services has to do with opportunity costs. In general, a generating has three choices: staying off line (providing backup reserves), coming on line at less than maximum power (providing spinning reserve) and coming online at full power (not providing any reserve services). The best choice depends on generating unit's efficiency.

5.1 Rotating Reserve Market Structure

Certain market structures allow aggregate owners to offer rotating reserve and energy at the same time. If the price of the rotating reserve is high enough compared to the final price which is possible on the energy market, the owners of certain aggregates will decide on rotating reserve insurance instead of energy production. Rotating reserve market and energy market are closely connected. In order to achieve maximal efficiency of transmission and production resources, the connection between rotating reserve and energy market should be considered. For choosing the best schedule, regarding transmission limitation, safety and rotating reserve itself, optimization packages are used.

The system operator may apply optimization schemes for energy market and rotating reserve, respectively. The question is - how to coordinate the two markets? The second question is how to distribute rotating reserve if the system suffers transmission choke. Some operators use heuristic methods in order to divide the correlation and/or simply ignore choke influence on the rotating reserve market. If the market of energy and the market of rotating reserve are considered separately, then there are two possibilities (Possibility 1 and 2) for satisfying consumption and rotating reserve needed. Possibility 3 combines energy market and rotating reserve market, i.e. it coordinates automatically energy market and rotating reserve market and considers choke influences on rotating reserve market.

- Possibility 1 If the most expensive aggregates for satisfying rotating reserve needs are chosen first, the schedule of other capacities for the required consumption, due to transmission system limitations, might be impossible. In that case, the system operator will accept offers on the energy market which are needed to eliminate lines' overloading (although these offers are not very acceptable when prices are concerned).
- 2) *Possibility 2* First, aggregates which cause the smallest expenses satisfy consumers' requirements. After that, remaining capacities satisfy rotating reserve needs. If this would cause the lack of rotating reserve on the market, the system operator will have to accept more expensive offers in order to supply the required amount.
- 3) *Possibility 3* If energy market and rotating market are optimized together, it is possible to distribute rotating reserve among all potential aggregates so as to reduce the overall expenses of the system.

6 Black Start

Black Start is the procedure to recover from a total or partial shutdown of the transmission system which has caused an extensive loss of supplies. In general, all power stations need an electrical supply to start up: under normal operation this supply would come from the transmission or distribution system. Under emergency conditions Black Start stations receive this electrical supply from small auxiliary generating plant located on-site (a small gas turbine or a diesel plant). Once running, a large generating unit can then be used to energize part of the local network and provide supplies for other stations within its area. It would not be efficient, either economically or technically, if all power stations were obliged to provide a Black Start service. Rather, the ISO looks to contract with generators that are perceived to be particularly effective in strategic areas on the system.

Situations in which black start is used are very rare, but economic and social consequences of the electric energy systems blackout are huge. Therefore, investments in blackout prevention are worthwhile. Detailed procedures for planning and testing of the zero voltage starting do not exist. In the past, this service was the responsibility of vertically integrated companies. In such companies, system operator would be in charge of controlling production and transmission capacities in the case of electric energy system breakdown as well as for deciding between the damage of the equipment and the damage caused by the interruption of customers' supply.

A power station with a Black Start capability will want revenue to recover the costs of making a Black Start facility available. A significant proportion of this income will consist of a Black Start availability payment. The Black Start plant may be installed solely to provide a Black Start service. Alternatively, it can also be used for other energy-related services such as peak lopping and standing reserve. In addition to the above "holding payments", further payments are made when the service is utilized - both for testing purposes and in the event of a Black Start. There are four types of expenses connected to zero voltage starting service:

1. Expenses connected power plants themselves.

2. They include investment costs, testing, education; damages caused for giving this service and expenses for fuel used during zero voltage starting.

3. Transmission system expenses which include investments (for communication equipment, synchronization, regulation and switch outer

supply etc), planning, and education and overtime work in the case of breakdown.

4. Regulation expenses which include investments and driving expenses for planning, testing and education.

5. Electric power plants expenses which are not equipped for zero voltage start, but they start production fast, anyway. They include expenses for damages on equipment (e.g. turbine damages caused by operation under frequency different than the rated one).

Competitive markets could develop for black start capability. If there were enough generators located so that they can provide the black start service, the competition among them may be enough to allow markets to determine the prices of this service. The control-area operator is the only buyer because it is responsible for determining how much of the resources to acquire and how to deploy them. The system-control and transmission portions of system black start cannot be provided competitively.

7 Cost Allocation of Ancillary Services

Since ancillary services are essential to reliability, it is not always possible to obtain all ancillary services by market means. These services often have low marginal costs. Thus, it is common that market pricing the service at marginal cost pricing will not result in sufficient compensation to the providers of the service, and it will lead to lower reliability. In these cases, it becomes necessary to split the payments for the service into a market component and a cost-allocation component. While some AS can be purchased from markets, other services may be more effectively handled by the transmission entity alone. The cost incurred for acquiring these services is then shared among the transmission system users. To promote economic efficiency in resource utilization cost allocation based on marginal cost is most desirable because it is compatible with a competitive economic environment. Table 2 shows cost component percentages in the total cost for some of the most important ancillary services.

Table 2 Cost Allocation of Ancillary Services

	% of total cost			
AS	Installed capacity (long-term expense)	Reserved Capacity (daily expense)	Capacity usage (real time)	
Primary Regulation	95%	5%	0%	
Secondary regulation	5%	75%	20%	
Tertiary regulation	-	10%	90%	
Voltage regulation	65%	5%	30%	
Black start	90%	10%	0%	

8 Ancillary Services in Croatia

The processes of privatization, deregulation and market establishment in Croatia are still at the beginning. Ancillary services are defined as possible single services given by the network user (e.g. producer) or distribution system operator at the request of transmission system operator and for that (technical solutions, driving costs) transmission system operator expects to be paid. These services are used by transmission system operator for realizing system's services. Wind turbines with asynchronous drives are a particular type of production units to which, as a rule, regulations of these Network rules regarding ancillary service are not applied.

According to electric power system grid code brought by the Ministry of Economy, Labor and Entrepreneurship, four attributed ancillary system services are defined (in the Grid Codes they are named Electric power system services):

- 1) Frequency regulation,
- 2) Voltage regulation,
- 3) Black start,
- 4) System operation.

Besides these there are two non-attributed services in the transmission system (for which the supplier is not identifiable):

- 1) Reactive power production for the power factor correction,
- 2) Providing non-standard services

A market for these services does not exist and the prices are regulated.

The Croatian tariff system recognizes six different ancillary services, but it does not determine their prices:

- 1) secondary and tertiary frequency regulation,
- 2) reactive power,
- 3) ability to operate in an island operation mode for several hours,
- 4) power plant ability to instantly re-connect to the power system (the power plant must be able to supply itself for a short period of time),
- 5) black start.

The system services no. 3) and 4) are not standard ancillary services, but are mentioned in Croatian Grid code.

9 Ancillary Services in the Southeast Europe

Since there is no unique definition of ancillary services in the world, this chapter gives an overview of ancillary services market in the Southeast Europe.

9.1 Slovenia

Energy Agency of the Republic of Slovenia carries outspecific responsibilities under the Energy Act, with the purpose of providing transparent and nondiscriminatory operation of the electricity and natural gas markets in the interest of all participants. It determines the prices for the use of energy networks in a manner that encourages the efficiency of providers and users separately for transmission and distribution networks, and individual systemic services, except for those services for which a competitive market is organized. The following ancillary services are recognized by the Slovenian TSO:

- frequency regulation,
- voltage regulation,
- energy imbalance,
- black start,
- transmission network losses,
- load shedding.

Ancillary services costs are covered by the transmission network fee. All ancillary services have a cumulative price (Table 3).

Table 3 Ancillary Services Price in Slovenia

Voltage	Other Services (€kW/month)	Other Services (€kWh)	Reactive Power (€kvarh	-
high	0,17890	-	0,00626	- ,
medium	0,17890	-	0,00835	-
low	0,17890	0,00127	0,00835	_

9.2 Bosnia and Herzegovina

Ancillary services are not mentioned in the Bosnian Grid code, but the National Regulatory Agency issued a tariff system for the following ancillary services:

- primary frequency regulation,
- secondary frequency regulation,
- tertiary frequency regulation,
- reactive power and voltage regulation,
- black start,
- excessive consumption of reactive power.

The same Resolution defines the necessary secondary and tertiary frequency regulation power and the hydro power plants that provide it. The ancillary service prices are given in Table 4.

Ancillary Service	Price
Primary Frequency Regulation	-
Secondary Frequency Regulation	5,41c€kW
Tertiary Frequency Regulation	3,07 c€kW
Black Start	-
Reactive Power and Voltage Regulation	-
Excessive Consumption of Reactive Power	0,49 c€kvarh

9.1 Serbia

Serbian grid code defines seven ancillary services:

- primary frequency regulation,
- secondary frequency regulation,
- tertiary frequency regulation,
- voltage regulation,
- transmission network losses and
- black start (this service is divided into two

sub-services: generator black start and the ability to work in an island operation mode). Ancillary service prices are still undefined.

9.1 Montenegro

There is a temporary Grid code which separates ancillary services into three categories:

- Generator: primary and secondary frequency regulation, reactive power, spinning reserve and black start.
- Transmission: voltage regulation and reactive power regulation.
- Consumer: load shedding and reactive power compensation.

There are only three system-wide ancillary services:

- frequency regulation,
- reactive power and voltage regulation and
- black start.

Ancillary service prices are still undefined.

9.1 Former Yugoslav Republic of Macedonia

There are five ancillary services defined by the Macedonian Grid code:

- primary reserve,
- secondary reserve,
- tertiary reserve,
- voltage regulation and
- black start.

Ancillary service prices are still undefined.

10 Conclusion

Although definitions for ancillary system services are not unambiguous and each country adapts them to specific characteristics of its own power system, there is a certain number of services which appear in similar forms in almost all countries which have liberalized systems. Even greater differences appear between subjects which offer services and the ways in which prices and payments are determined. The goal of this paper is to introduce and explain the basic characteristics of electric power liberalized market, and to emphasize the problems which appear when ancillary services have to be defined, applied, measured and evaluated.

Processes of liberalization and deregulation in Croatia are still going on and ancillary services cannot be regarded in the market context. During ancillary service market establishment the size and particularities of the Croatian system should be taken into consideration and apply the model which will not

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create monopoly or withdrawal of the suppliers from the market, lack of capacity and high prices. The market itself cannot fulfill these requirements so regulatory bodies should be given a fair share of the authority.

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