Lappeenranta University of Technology
Department of Electrical Engineering

Project report

Electricity Market Mechanisms in Russia

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Preface

This research report is based on the work done by Dmitry Kuleshov in completing his Master's Thesis *Electricity Market Mechanisms in Russia*. The topic of the work, the financing, and the advisory group for the work were provided by the Finnish Energy Industries. This support is gratefully acknowledged by the authors of this report. The work itself was carried out in the Laboratory of Electricity Markets and Power Systems in Lappeenranta University of Technology during the spring of 2008. The supervisor of the work was Prof. Satu Viljainen.

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1 Introduction

Russian electricity sector is in the middle of restructuring that is characterized by the opening of the wholesale electricity market to competition while retaining the natural monopoly positions in electricity network operations. The principles of the current development were laid down in the Resolution given by the Government of Russian Federation in 1 September 2006. The Resolution introduced new market rules for electricity markets. The goal of this report is to explain how the Russian wholesale electricity market is designed to work under the new rules.

According to the plans, the new market model for the wholesale electricity market is expected to be completed by 2011. The new electricity market model includes a market for long-term bilateral contracts, a competitive day-ahead spot market, and an intraday market for electricity. In addition, there is a specific market for capacity. Future plans regarding the electricity market reform also include putting in place markets for ancillary services, financial transmission rights (FTRs), and electricity derivatives. Timetables for setting up these markets were not specified at the time of writing this report. During the transition period towards the new electricity market model, the regulated long-term contracts for electricity continue to exist, but the amount of electricity sold through these contracts is gradually diminishing.

In the new market setting, the price of electricity market is based on supply and demand. In the price calculation, a so called nodal pricing principle is applied; that is, the competitive equilibrium price is calculated for each predefined node of the Russian electricity system. The number of nodes in the European part of Russian Federation is over 6000; and in Siberia, there are approximately 600 nodes. Nodal prices take into account the technical restrictions of the electricity system as well as the losses resulting from transmitting electricity. The nodal prices are calculated based on the forecasted load flows by a specific market operator, based on the forecasted load flows in the system for each hour of the following day. The market operator works in close co-operation with the system operator that is responsible for the physical operation of the electricity system.

Following the introductory Chapter 1, the report is organized as follows. Chapter 2 briefly discusses the basis and motivations of the electricity market reform. Chapter 3 describes the principles of nodal pricing. Chapter 4 explains in detail the functioning of the Russian wholesale electricity market. Chapter 5 compares and contrasts the characteristics of Russian and the Nordic wholesale electricity markets. Chapter 6 concludes.

2 Reforming of Russian electricity market: conception and current state of affairs

The goal of the ongoing electricity market reform is to create a well operating competitive wholesale electricity market in Russia. The reform includes dividing the electric power industry into natural monopoly and competitive sectors. At the start of the electricity market reform, all vertically integrated joint-stock companies were first divided, according to their operation, into electricity generating, transmission network, distribution network, electricity selling, maintenance and other companies. These companies were later combined into set of new companies.

The reform includes a privatization plan concerning most companies that operate in the competitive sectors (e.g. heat production, electricity selling, and construction of electricity networks and power plants). However, strategically important assets, such as nuclear and hydro stations, can be privatized only partially with the retention of government control. Control of the natural monopoly companies (i.e. electricity network companies) will be implemented by the government.

The coordinator of the reform, that is RAO UES, will be disbanded after the main steps of the reform have been completed, and all of the assets of RAO UES have been allocated to the horizontally integrated companies. The target structure of the electric power industry is illustrated in Figure 2.1.

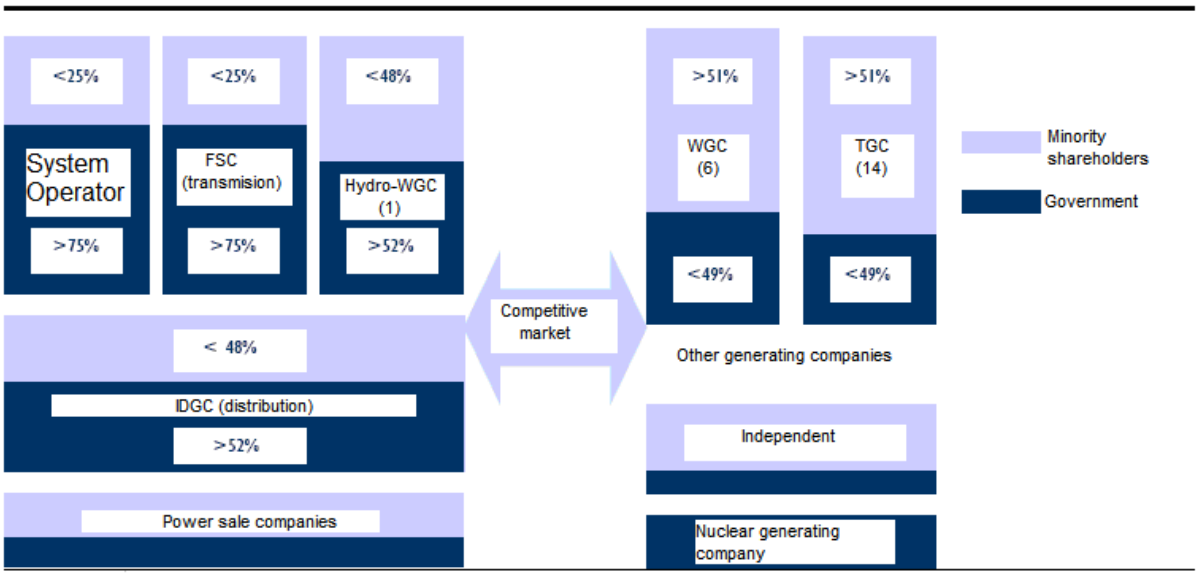


Figure 2.1. Structure of electric power industry. (Gazprombank 07)

The new model of wholesale electricity market NOREM came into force 1 September 2006. In its the initial stage, the model includes both regulated and free bilateral contracts. Later the regulated bilateral contracts will be substituted by free bilateral contracts. The government controls the prices of the regulated contracts. As the reform proceeds, the share of regulated contracts in the wholesale electricity markets will gradually decrease.

Electricity that is not sold through regulated bilateral contracts should be traded with non-controllable prices in frames of free bilateral contracts, or in the day-ahead market of electricity. The latter is also termed as the spot market of electricity.

In the day-ahead market, the NP "ATS" (Noncommercial Partnership "Administrator of Trade System", later referred to simply as ATS) implements a competitive selection of all bids for electricity from sellers and buyers for the following day, and determines the hourly prices and volumes regarding electricity delivery during the next day. Participants of the market compete with each others at the auction. As a result of the auction, hourly schedules of generation or consumption are obtained for the following day. After the spot-market closes, deviations from the initially forecasted values are traded in the balancing market; that is, through intraday trading. The balancing market closes one hour before the actual time of delivery of electricity.

The new wholesale electricity market model includes capacity trading, which is expected to ensure reliable and sustainable electricity supplies. Participating in the capacity market is mandatory for the participants of the wholesale electricity market. Before the new wholesale market rules were introduced, generators received payment only for 85% of their installed capacity. For the buyers, the payment for this capacity was included in the flat-rate tariff of electricity. Now there are separate payments for electricity and capacity. When selling capacity, generators are obliged to maintain their equipment in proper condition in order to be ready to produce electricity according to the schedule provided by the System Operator. In addition, generators should participate in primary frequency response, etc. Capacity payment depends on the fulfillment of obligations. The capacity market aims at increasing reliability of the energy system in conditions of growing electricity demand.

In order to encourage investments, new capacities (that were not included in the forecasted balance for 2007 prepared by the Federal Service of Tariff, FST) will be traded in the wholesale market at free unregulated prices. The same applies for new consumers in electricity wholesale markets – they may conclude regulated contracts only if in 2007 there existed technical conditions for their connection to the grid.

2.1 TGCs and WGCs

At the start of the Russian electricity market reform, the activities of RAO UES were separated from each others. Several new companies were formed to perform the unbundled activities as follows:

1) Electricity generation: WGCs, TGCs, independent electricity generators
2) Electricity selling: regional electricity selling companies
3) Electricity transmission: Federal Grid Company that controls the united national network, regional transmission network companies
4) Electricity distribution: Interregional Distribution Grid Companies
5) Electricity system operation and the market operation: System Operator, ATS

TGCs (Territorial generating companies) form the basis of the regional systems. They operate in both electricity and heat production. TGCs were formed by restructuring the previously existed AO-Energos. At present, there are 14 TGCs. The geographical areas of the TGCs are presented in Figure 2.2.

Figure 2.2. Allocation of TGCs. (Exchange 08)

The three biggest TGCs are: TGC-3 (Mosenergo), TGC-7 (Volga) and TGC-1. The last one operates in the North-West part of Russia, in the regions of St. Petersburg, Karelia, Leningradskaya region and Murmansky. These regions are characterized by high economic growth rate and, correspondingly, growing demand for electricity. TGC-1 is also connected to the Nordic electricity market through its connection to the Finnish electricity system. TGC-1 has an installed electrical capacity of 6250 MW and heat capacity of 14735 Gkcal. Hydro power constitutes about 46 % of the installed electrical capacity of TGC-1. The company is also the main supplier of heat in its operating regions, providing for instance 48% of the heat consumed in St. Petersburg. (TGC-1 07)

WGCs (Wholesale Generating Companies) are another type of generating companies. They specialize in the production of electric energy only. The six thermal WGCs were separated from RAO UES. Each WGC owns large heat stations that are situated in different parts of the country. WGCs are the main participants of the competitive wholesale electricity market.

The capacities and the forecasted electricity and heat production of some of the TGCs and WGCs are presented in Table 2.1.

Table 2.1. Basic production parameters of TGC/WGC. (Chikunov 05)

	Installed capacity [GW]	Forecasted production of e/e Bln. kWh	Forecasted production of h/e Bln. Gkcal
TGC-1	6,3	25,3	29,7
TGC-2	2,5	9,6	18,3
TGC-3	10,6	60,9	71,1
TGC-4	3,5	13,1	25,1
TGC-5	2,5	10,2	16,5
TGC-8	3,8	22,6	16,7
TGC-9	3,3	57,8	46,9
TGC-14	0,6	3,2	4,1
WGC-3	8,5	27,9	1,2
WGC-5	8,7	12,0	2,0
WGC-6	9,0	27,5	4,7
Total	58,8	244,8	236,3

2.2 FGC (Federal Grid Company)

The Unified National Electrical Network forms the electrical system of Russia, gathering stations and nodes for parallel work, and maintaining electricity transfers between them. All objects of the electrical system are governed by the Federal Grid company (FGC).

In addition to FGC, there exists seven Interregional Main Grid Companies (IMGCs) that were formed in 2003. The IMGCs operate as joint-stock companies, and they are named in accordance with their operating areas as follows: IMGC Vostok, IMGC Sybirea, IMGC Center, IMGC South, IMGC Volga, IMGC North-West, and IMGC Ural.

Finally, by 2007 also the formation of Main Grid Companies (MGCs) had been accomplished, and 56 MGCs had been formed and registered. It is assumed that later all the IMGCs and MGCs will be gathered under control of FGC.

Grid companies are responsible for loss compensation in their networks. They participate in the wholesale electricity market as buyers, purchasing electricity to cover the losses. Grid companies buy electricity with fixed tariff stated by FST (Federal Service of Tariff) for them. In order to provide procurements of electricity, grid companies also purchase volumes of capacity in the Capacity market.

2.3 DGCs (Distribution Grid companies)

In electricity distribution level, 58 DGCs were organized during the years 2004-2006. After completing the first stage, they were ntegrated into four Interregional Distribution Grid Companies (IDGCs). The form of operation of the IDGCs is joint-stock company, and they are named in accordance with their operating areas as follows: IDGC Center and Northern Kaukas, IDGC Northern-West, IDGC Ural and Volga, and IDGC Sybirea.

2.4 ATS

ATS (Noncommercial Partnership “Administrator of Trade System”) is the market operator in the Russian wholesale electricity market. It organizes the trades on the wholesale market of electricity. The information regarding all trades in wholesale electricity markets are to be submitted to ATS by the wholesale market participants.

In carrying out its tasks, ATS has several important roles in the Russian electricity markets. First, it operates as a power exchange and regulatory agency. Second, it implements the balancing calculations, financial accounting and forecasting. Third, it controls the spot-market and balancing-market trades as well as trading through regulated and free bilateral contracts. Fourth, it protects the interests of market participants. And fifth, it monitors all market operations. (ATS 08a)

ATS works is close co-operation with System Operator (SO) that is responsible for the actual optimization of the use of the transmission system. SO does this after obtaining the data from the wholesale market participants about their forecasted hourly production and consumption. SO implements the full estimation of the state of the network, including power flows, voltage levels in all the nodes of the grid, losses in transmission lines, transformers and other equipment. SO sends the results of optimization to ATS for the calculation of the prices in every node of the grid.

2.5 SO (System Operator)

System Operator (Central Dispatching Control of UES) is the organization that controls the physical operation of the grid. System operator is allowed to send dispatching commands to all market participants (generators and customers with regulated loads).

2.6 Privileged status of new capacities

Essential feature of the NOREM is the division of present and planned capacities that are enter the market in 2008 and after when considering their work in different segments of the electricity markets: prices of electricity produced in stations built after 2007 are determined by the markets, and the prices of electricity of the existing stations are liberalized gradually. In other words, all new stations operate in free markets, with probably higher prices than those in the regulated market. This allows for investments in new stations. The existing stations will enter the competitive market gradually.(Gazprombank 07)

3 Nodal Pricing

3.1 Computed model

The computed model is a simulating model that integrates information that contain the main characteristics of the network and the energy system equipment, and the topology and parameters of the transmission lines. It is used for the determination of power flows, generating schedule and prices in every node of two price area in Russian wholesale electricity market. The model is updated for every 24 hours trading cycles in the day-ahead market. The list of parameters of the computed model is shown in Table 3.1.

Table 3.1. Parameters of the computed model.(Barkin 05)

Parameters of the computed model:	"Europe"	"Siberia"
Nodes (including technical restrictions)	6040	602
Lines (including technical characteristics)	7074	660
Selected objects of generation which form the technical restrictions	657	99
Controlled cross-sections (including the line's list, upper and lower power flow restrictions)	230	18

The computed model contains data about the known system restrictions, and the losses in the electricity system. The calculations with the computed model yield the equilibrium prices in every node of the electricity system. An illustration of nodes is shown in Figure 3.1.

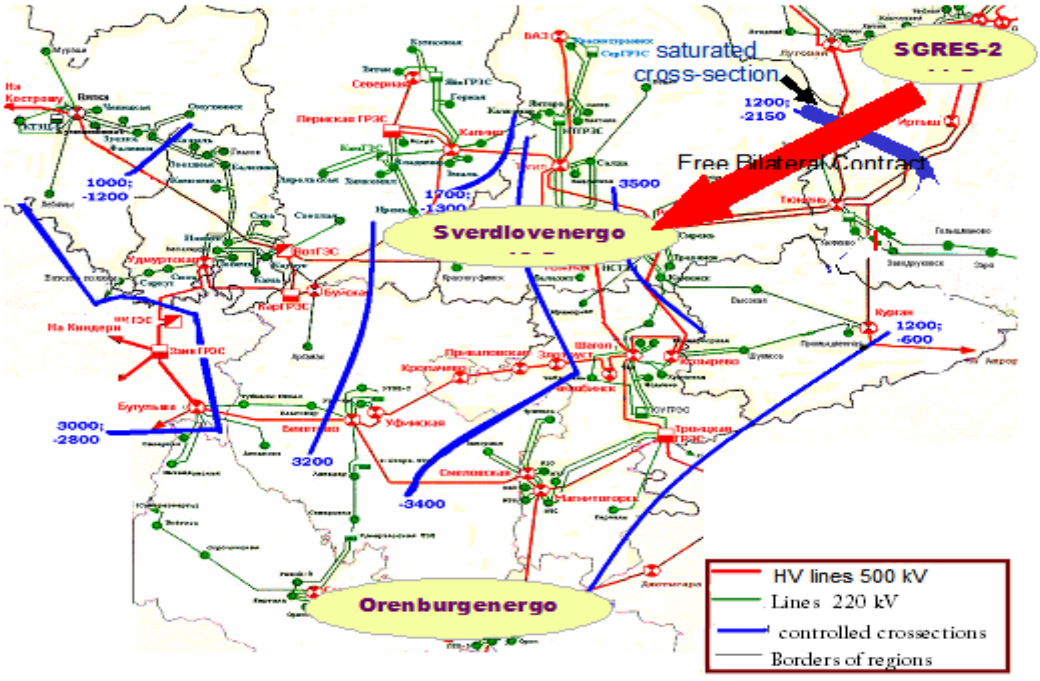


Figure 3.1. The nodal price illustration.(Barkin 05)

3.2 Points of delivery

Point of delivery is a place within the electricity system that is used by a participant of a wholesale electricity market for the fulfillment of that participant's obligations implied in contract. The point of the delivery is specified by the System Operator for every participant of the wholesale electricity market.

Group of Delivery Points (GPD) is a combination of points of delivery of several participants. The combination is always referred to as one node of the computed model or technically indivisible object of the system.

Points of delivery form a Group of Delivery Points (GPD) if the following condition is met: simultaneous disconnection of all points of delivery from the external network leads to the situation in which the object (power station) is isolated from electrical network. An illustration of a GPD is shown in Figure 3.2. The participant of the wholesale electricity market that concludes an agreement of trade should specify his GPD in all the concluded contracts.

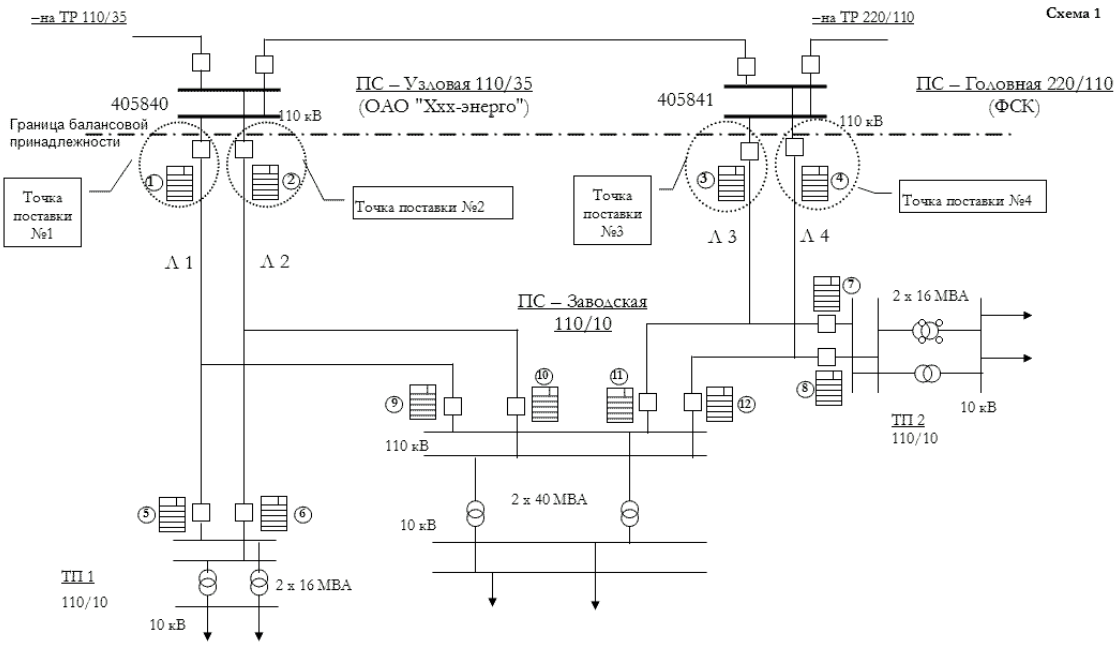


Figure 3.2 The GPD of the 110 kV sub-station

In Figure 3.2., the dashed line reveals the border of balance belonging. The location of the points of delivery is illustrated by the circles (i.e. there is 4 points of delivery).

3.3 Pricing mechanism in electricity market in Russia

The nodal pricing mechanism is used in the Russian wholesale electricity market because of the differences in the generation costs in different regions, and the insufficient transmission capacities between regions that do not allow the prices to even out in the different regions. For instance, the price of electricity in Siberia is always lower than the price in European part of Russia because of the large quantity of cheap electricity generated by Siberian hydro stations. Due to network congestions, it is impossible to transfer energy in desired volumes from one region to another.

Nodal prices are considered as high precision indicators of what it costs to use the electricity system because they include: the costs of electricity generation, the costs of losses, and the costs of the limited capacity utilization. Nodal prices are calculated by the market operator ATS for each hour of the trading cycle (the 24 hours of following day). Each GPD of the market participants is referred to as a node in the computed model used by the ATS, and the prices are determined for every node of the model.

At present, the wholesale electricity markets consist of the regulated and free sectors of trade. In order to take this into account, ATS uses data from various different sources in the nodal price calculation. For instance, the System Operator submits preliminary dispatching schedule of generating objects calculated on the basis of planned hourly consumption. The System Operator also presents refreshed equivalent circuit of electrical network in European part of Russia for each hour of the following day. In addition to data regarding the regulated sector, the market participants also submit to ATS their bids for purchase/sale in the free sector of trade. On the basis of the obtained data, ATS determines nodal prices and forms the hourly schedule of trade for the participants of the wholesale electricity market. (Energy market 04)

3.4 Principles of nodal pricing

The three main steps of the nodal price calculation are: 1) obtaining the load flow data through real measurements or imitating equations for each time interval of the calculation; 2) forming a financial model that is based on the financial balances in the nodes and branches of the Unified Electricity System (UES); and 3) deriving a system of linear equations or graph models based on the results of the first two steps, and solving the equations to obtain the nodal prices. The last step is usually called a posteriori analyze. The nodal prices gained through the equations determine the procurement cost in a particular node. The customers' procurement accruals are equal to the total charges of the generating companies. (Gamm 04)

4 Wholesale electricity market in Russia

At present, electricity selling in the Russian wholesale electricity market takes place in regulated and free sectors. However, according to the reform plans, the regulated sector will cease to exist by 2011. This will leave the free sector as the sole form of business in the wholesale electricity trading. Long term contracts will still be allowed for the market participants, but the pricing of the contracts will be done on market-based basis. Currently the longest free bilateral contracts cover the following six months. Volumes of electricity that are not traded through bilateral contracts can be sold in the day-ahead spot market of electricity. Buyer and sellers submit their bids to the market without knowing the bids of the other market participants, and equilibrium prices for each node of the electricity system is formed based on the supply and demand bids. If the market participants need to make adjustments to their forecasted production or consumption after the spot market auction, they are able to do it through intraday trading in the balancing market. In other words, the balancing market provides the market participants with the opportunity to correct any observed imbalances voluntarily. The balancing market is open until one hour before the delivery time. After the delivery of electricity, accounts are settled financially.

A simplified illustration of the structure of Russian wholesale electricity market is presented in Figure 4.1.

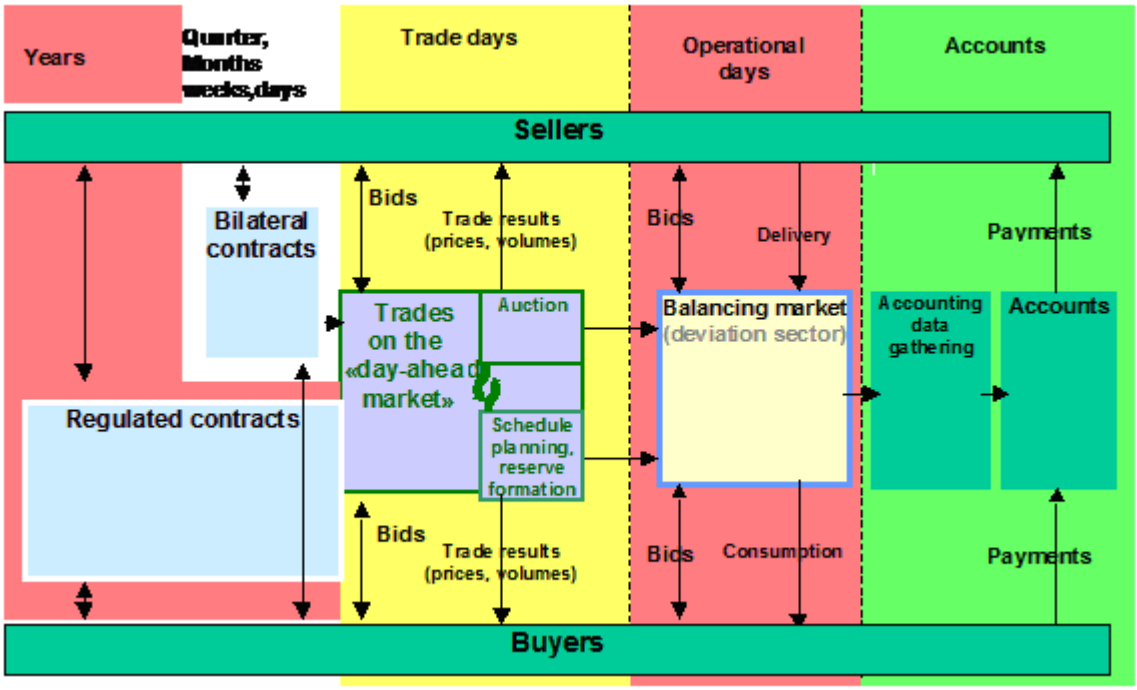


Figure 4.1 A simplified illustration of the Russian wholesale electricity market.

The following example considers how an electricity generator might operate in the wholesale electricity market pictured in Figure 4.1.

First, the generator may participate in the regulated trade. The generator has long-termed regulated contracts with buyers, and these contracts cover 75% of his electricity sales. The price of electricity sold through these contracts is fixed by the tariff regulator FST.

Second, the volumes of electricity that are not sold through the regulated contracts can be sold trough free bilateral contracts or in the day-ahead market. In the first case, the generator states, in agreement with the buyer, the price of electricity and the volume of the contract. If the generators chooses to operate in the day-ahead market, he then submits his bids for the price and volume electricity that he wishes to sell. In his bid, the generator is allowed to define three different price-volume pairs. Based on supply and demand, the market operator ATS calculates the prices of electricity in each node of the electricity system. If the generator's bid is accepted, he is obliged to sell the required amount of electricity at the equilibrium price defined for the node that he is connected to.

Third, in the balancing market, the generator's bids made to the day-ahead market are retained as such. Buyers of electricity may change their bids. ATS calculates new equilibrium prices, and the generator may sell electricity at this price.

In the following sections 4.1-4.5, the principles of operation of the different parts of the Russian wholesale electricity market, including the capacity market, are explained in more detail.

4.1 Regulated contracts

Regulated contract is a long-term bilateral agreement to trade electricity with a fixed tariff. Regulated contract binds both the seller and the buyer of electricity, and the minimum duration of the contract is one year. The price of electricity that is traded through regulated contracts is set by the government authority FST (Federal Service of Tariffs). FST operates only in the regulated sector of the wholesale electricity market.

4.1.1. System of regulated contracts

The present system of regulated contracts between the buyers and sellers of the wholesale electricity market was introduced in 2006. In 2006, regulated contracts were concluded until the end of that year. Since 2007, sellers and buyers have been allowed to enter into long-term contracts (from 1 year and more). Duration of the contracts is stated by the Ministry for Industry and Energy of Russia (Minpromenergo).

Conditions of regulated contracts are stated by FST and cannot be changed by participants unless they both agree on the changes. If both participants are willing to change the terms of the contract, then they are allowed to inform the ATS and get the permission to change the contract prices or volumes.

All the "old" market participants in the wholesale electricity market are obliged to trade through the regulated contracts. Electricity generation capacities that enter the market in 2008 or after are excluded from the obligation. According to the government directive, the share of regulated contracts on the wholesale market is gradually decreasing, as illustrated in Figure 4.2. At the start of 2011, all electricity is expected to be traded with unregulated prices (RAO UES 06).

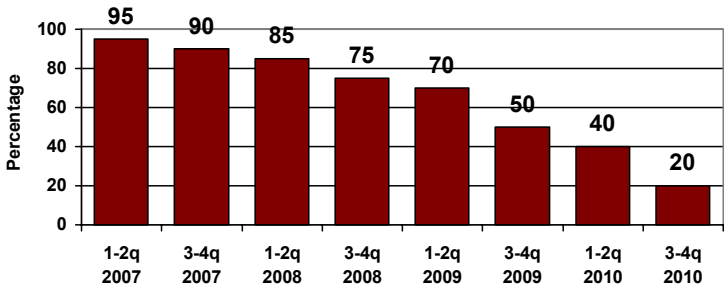


Figure 4.2. Illustration of the share of electricity that is sold through regulated contracts (RAO UES 06).

Buyers and sellers of regulated contracts are assigned by the ATS. Purchasers are permitted to reduce the volumes that are bought through regulated contracts no more than by 15 percents each year. Buyer and supplier, if they have a mutual agreement, can also reduce the volume of sale and purchase but no more than by 15 percents. (RAO UES 06)

4.1.2. Prices of regulated contracts

Prices of electricity that sold through regulated contracts is determined based on the costs of electricity generation. A double-rate tariff defined for the generated electricity; that is, the generator obtains financial income from both selling the electrical energy and on the basis of the installed capacity. The latter one is a payment for maintaining the readiness to generate electricity. Tariffs for electricity and capacity of different electricity generation types are shown in Table 4.1.

Table 4.1. Formulas of electricity and power tariff calculation. (Ovsyinnikova 07)

	Power tariff rate (rub/MW.month)	Electricity tariff rate (rub/MW.h)
Heat Stations	$T_P = \frac{TP_P}{N_y \cdot m}$	$T_{el} = \frac{C_{fuel} \cdot (1+r) + C_{el}}{V^{planned}}$
Hydro Stations	$T_P = \frac{0{,}95 \cdot TP_\Sigma}{N_y \cdot m}$	$T_{el} = \frac{0{,}05 \cdot TP_\Sigma}{V^{planned}}$
Nuclear Stations	$T_P = \frac{SGI^P}{N_y \cdot m}$	$T_{el} = \frac{SGI^{el}}{V^{planned}}$

Where:

TP_P =indispensable monetary resources that are used to keep the power at working level during regulation

TP_Σ =planned volume of total production

N_y =installed station capacity

m =number of months in period of regulation

C_{fuel} =fuel costs

r =operating ratio

C_{el} = NIOKR fund contributions and property insurance costs

$V^{planned}$ =planned volume of delivery

SGI^P =the necessary gross income of generating company referred to power service

SGI^{el} =the necessary gross income of generating company referred to electricity production

The method of complete costs allows determining the minimum price level of the company. It is calculated as follows (Ovsyinnikova 07):

$T_{av} = \frac{SGI}{V^{planned}}$ = the minimum price level of the company

Price of electricity generated in heat stations is always 2-3 times higher than the price of electricity generated in nuclear stations. Also, the tariff of heat stations does not contain investments, where as the tariff of electricity generated in nuclear stations includes an investment component. The costs of electricity generation in nuclear stations are small in comparison with costs of other generating companies except for hydro stations. In the case of nuclear stations, the tariff of electricity is not fixed. From 2001, it has increased by more than two times and it is still rising, mainly because of the nuclear fuel price increases and inflation.

4.1.3. Trading through regulated contracts

In general, electricity generating companies are the sellers of regulated contracts, and the electricity selling companies, guaranteed suppliers and large customers are the buyers the contracts. The maximum allowed duration of the regulated contract depends on type of buyer as follows:

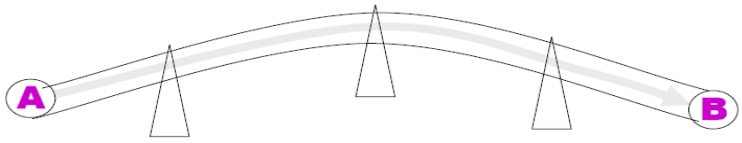
1) Guaranteed suppliers and electricity selling companies that sell electricity to domestic customers (households) form the 1st group buyers; these buyers are allowed to enter regulated contracts with the maximum duration of 3 years
2) Large industrial customers form the 2nd group of buyers; these buyers are allowed to enter into regulated contracts with the maximum duration of 5 years
3) Guaranteed suppliers and independent electricity selling companies supplying retail customers (banks, schools, shops and others) for the 3rd group buyers; these buyers are allowed to enter into regulated contracts with the duration of 1 year

Guaranteed supplier is an organization that is obliged to make a contract with any customer that is located in his operating area and is willing to buy electricity. If the customer is not satisfied with his other supplier, he can address the guaranteed supplier at any time he wishes.

Regulated contracts are so called take–or–pay -contracts (Pikin 05):

- The buyer pays for the volume of electricity indicated in the contract, and the payment does not depend on the actual consumption
- The surplus of electricity can be sold, e.g. in the spot-market
- The supplier can choose whether to produce the volume of electricity indicated in the contract, or whether to buy this volume in the spot-market
- The supplier shall provide volume of electricity indicated in the contract

Deviations from the planned hourly volumes of consumption can be bought or sold though free bilateral contracts or in the day-ahead market. For the purpose of losses compensation, an additional 3 % is included in the forecasted volumes of electricity, as illustrated in Figure 4.3.



Supplier produces 103 kWh | In order to obtain 100 kWh in point B, it is necessary to produce 103 kWh in point A | Consumer gets 100 kWh

Figure 4.3. Illustration of losses accounting. (CARANA 03)

4.2 Day-ahead market

In the day-ahead market, the market participants may submit their bids for the full volumes of consumption and production. The results of the competitive bids selection then form the basis of the modes of production and consumption planned by the SO. According to the rules of trade, bids of the generators with the lowest price are satisfied first.

4.2.1. Auctions in the day-ahead market

By the time of auction, participants have a significant amount of information in relation to both production and consumption. Retailers will know with some certainty what their own customer demand is likely to be, and the generators will have a reasonable understanding of the plant operations at present, and the likely schedules for plant operations for the following day. While there is a lot of information available at the day-ahead stage, it is important to note that there is still significant scope for error in all forecasts. Generation and demand conditions can easily change within a day.

The main goal of the day-ahead auction is to obtain equilibrium prices and volumes that allow to form the system mode considering the system restrictions, transmission capacity and losses. If restrictions are not included in planning, it will be impossible to implement the compiled schedule of the delivery. The real system mode will deflect from the planned and it could lead to the expensive and large balancing market. An illustration of spot-market auctions is shown in Figure 4.4.

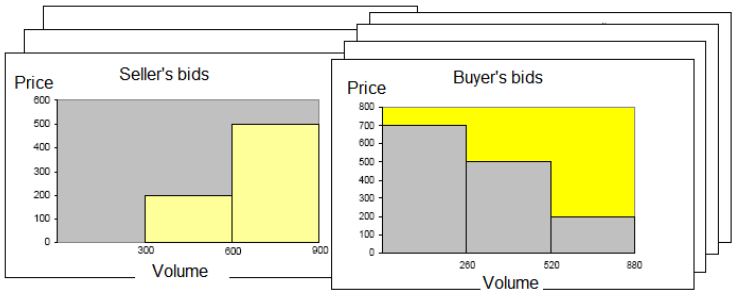


Figure 4.4. Bilateral spot-market auction (CARANA 03)

For the seller, the point (C,V) of the bid diagram indicates the willingness to sell the volume V with the price that is not lower than C. For the buyer, the point (C,V) of the bid diagram indicates the willingness to buy the volume V with the price that is not higher than C.

The equilibrium price forms when:

1) All volumes of sale stated with a lower price are accepted.
2) All volumes of purchasing stated with a higher price are accepted.

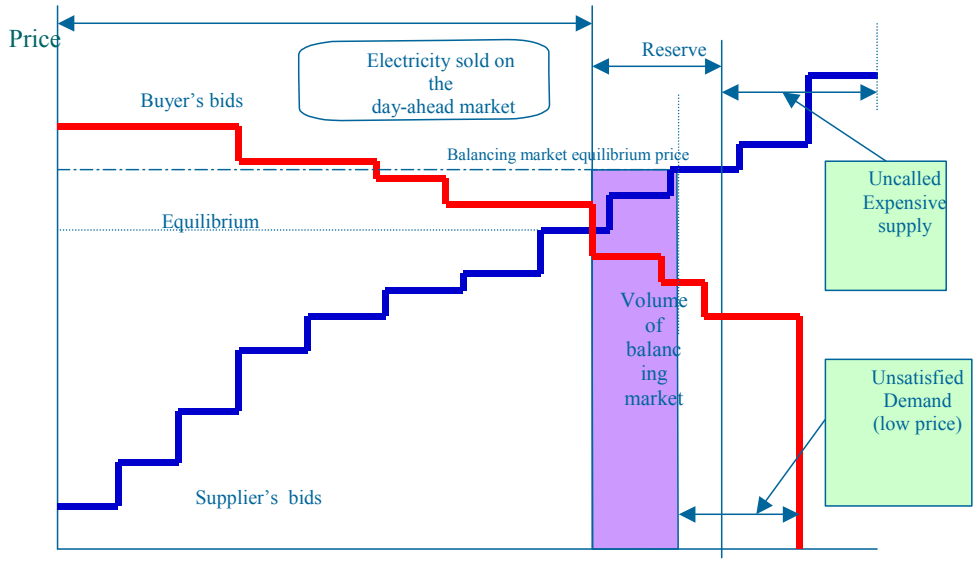


Figure 4.5. Equilibrium price definition (Barkin 05)

4.2.2. Implementation of trade

Buyers no later than 24 hours before trade submit to the SO their maximum hourly volumes of consumption. Proceeding from hourly volumes of consumption forecasted by the SO and maximum hourly volumes of consumption stated by buyers, the SO determines limits of hourly planned production of energy (min and max capacity values of generating equipment). These limits provide the fulfillment of the mode chosen by the SO with allowance for system congestions, losses, claims for power reserve maintenances, and support for the quality of electricity.

Above mentioned limits are taken into account during bids selections. ATS implements competitive bids selections and, as the result, determines for each hour and every price area:

1) Volumes of planned hourly production and consumption for every participant's GPD. These volumes are signaled by the ATS to market participants and the SO within a day before the actual delivery.
2) The equilibrium prices at each node of the electricity system (i.e. the prices of volumes that are included in the hourly production and consumption plans).

Equilibrium price is the price of 1 MWh of energy. All planned hourly volumes determined as the result of competitive bids selection and referred to the node are sold or bought with the equilibrium price of that node.

In the day-ahead market, participants can submit their bids for any volumes with any price of electricity they desire.

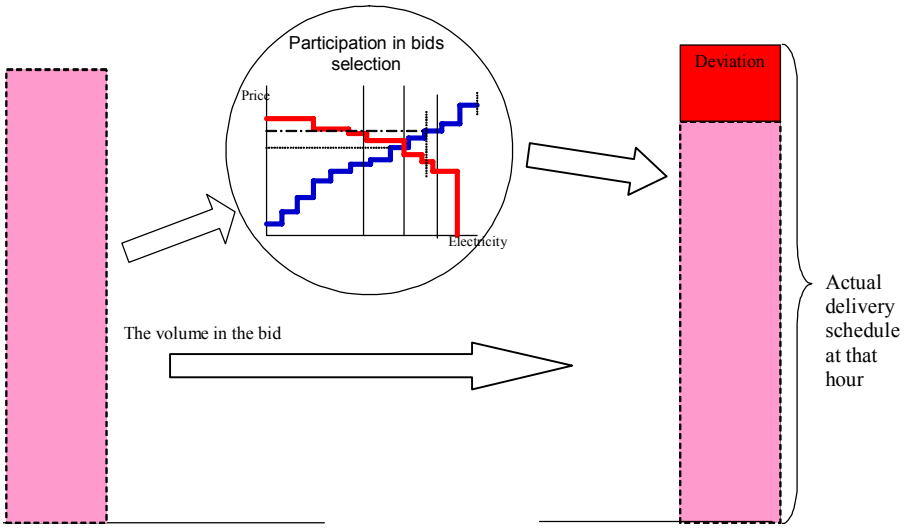


Figure 4.6 Buyer's participation on the day-ahead market (ATS 06a)

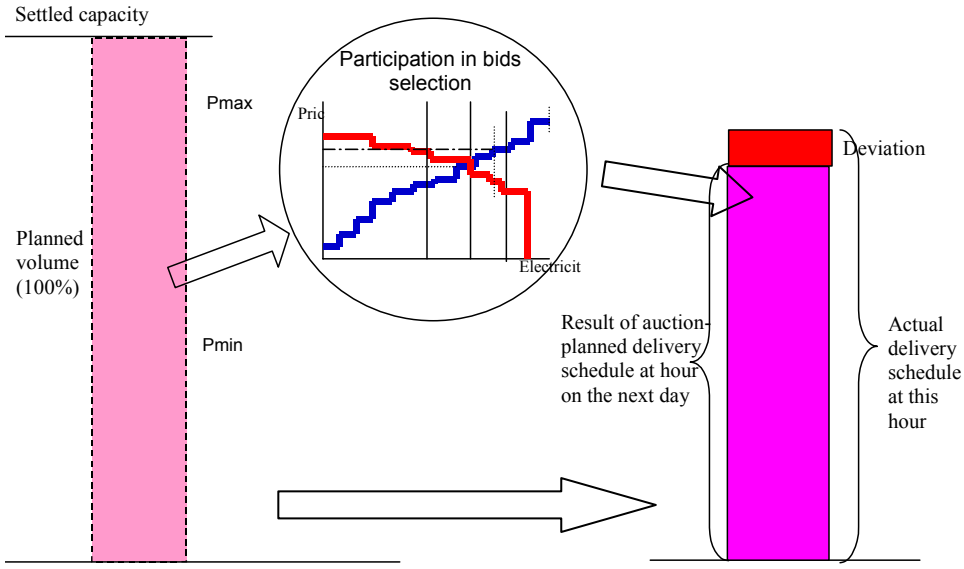


Figure 4.7 Seller's participation on the day-ahead market (ATS 06a)

Bids are submitted by participants concerning their points of delivery where they intend to buy or sell electricity or power. Every point of delivery, or group of delivery points (GPD), is related to some node of the computed model. The market operator ATS calculates equilibrium prices for 6040 nodes in European part and Ural and for 602 nodes in Siberia. The choice of node's quantity is carried out by the System Operator: nodes that are under control of the System Operator form the basis of the computed model. Extensions of the nodes will be not effective if the new computed mode is not guaranteed by the System Operator. Decreasing of the node's quantity is not recommended because of the insufficient detailing of the electric mode (undesirable deviations).

ATS should include, in the hourly production and consumption plans, those volumes of electricity that have the lowest price in sellers' bids, and those volumes of electricity that that have the highest price in buyers' bids (priority for those who could pay more for electricity; their bids are satisfied first).

Equilibrium price (spot-price) of electricity is set by the ATS for each hour of the following day, and for each node of the computed model, if the following conditions are met:

1) Equilibrium prices for electricity are equal for all volumes that are produced or consumed in particular node of the computed model
2) For seller, the equilibrium price cannot be lower than the prices specified in his bid
3) For buyer, the equilibrium price cannot be higher than the prices specified in his bid
4) Equilibrium prices should reflect the influence of system's limits and losses

A competitive bids selection in the day-ahead market is carried out in a form of calculations for each price area. The hourly equilibrium prices and the planned volumes of production/consumption for all participants are calculated. In a process of price selection in the spot-market, the volumes of electricity indicated in the bids are included in hourly production/consumption plans except in the following cases:

1) All volumes cannot be delivered due to technical constraints.
2) The volumes specified in buyers' (sellers') bids exceed the summarized volumes specified in sellers' (buyers') bids.

During the competitive selections of bids, ATS considers all information about functioning of UES that is given by the System Operator:

1) Data about the currency (actual) model for the trading day
2) Data about restrictions in work of hydro stations
3) Data about reserves of capacity and their locations
4) The volumes of electricity flowing through the border of UES and foreign countries
5) Technical limits (min) of electricity stations

Hourly prices and volumes of electricity are published on the website of ATS, for instance, in forms illustrated in Figure 4.9. and Figure 4.10.

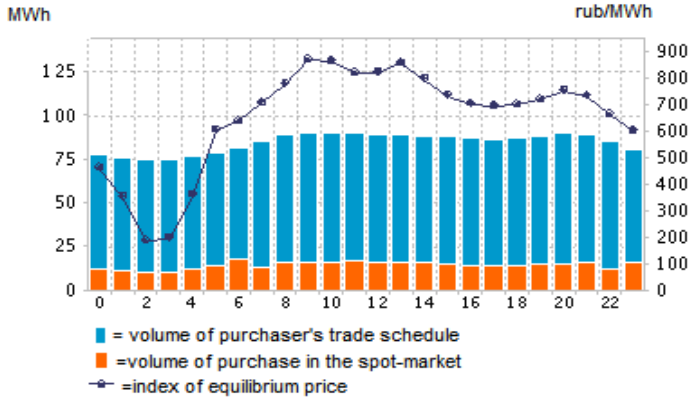


Figure 4.9 Hourly prices and volumes of trades for the first price area (ATS 08a)

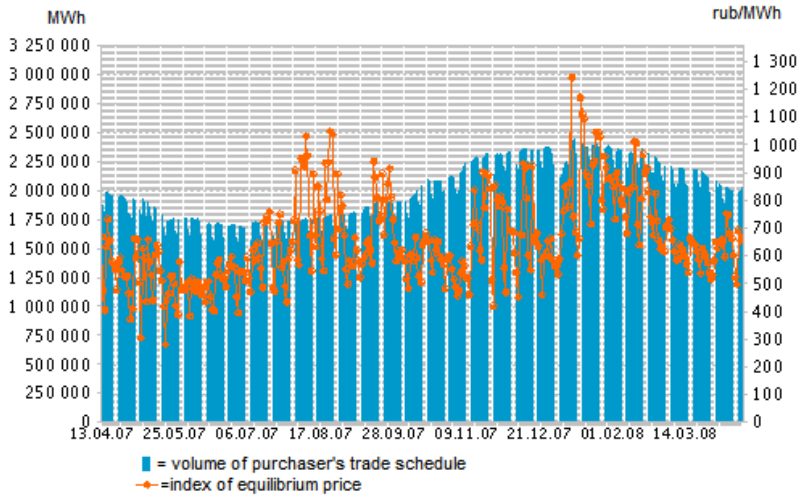


Figure 4.10 Annual prices and volumes of trade for the first price area (ATS 08a)

The counterparty of the trading in the day-ahead market is CFA (Center of Financial Accounts).

4.3 Balancing market

After the spot-market closes, participants can sell or buy the surplus or deficit of electricity in the balancing market (BM). The trading cycle to calculate the prices of balancing electricity is carried out no later than one hour before the actual delivery. Participants submit their bids for the balancing purposes to the ATS, which calculates the balancing prices for deviations in every node of the UES (the same mechanism of price formation that is used in the spot-market, is also applied in the balancing market). Generators' bids are the same that they submitted in the day-ahead market but consumers with regulated loads may change their bids. The volume of electricity acquired (sold) by participant in the balancing market is equal to positive or negative difference between his actual and planned consumption (production). Approximately 5-10 % of all volumes are traded in the balancing market. Figure 4.12 and Figure 4.13 illustrate the link between day-ahead market and balancing market.

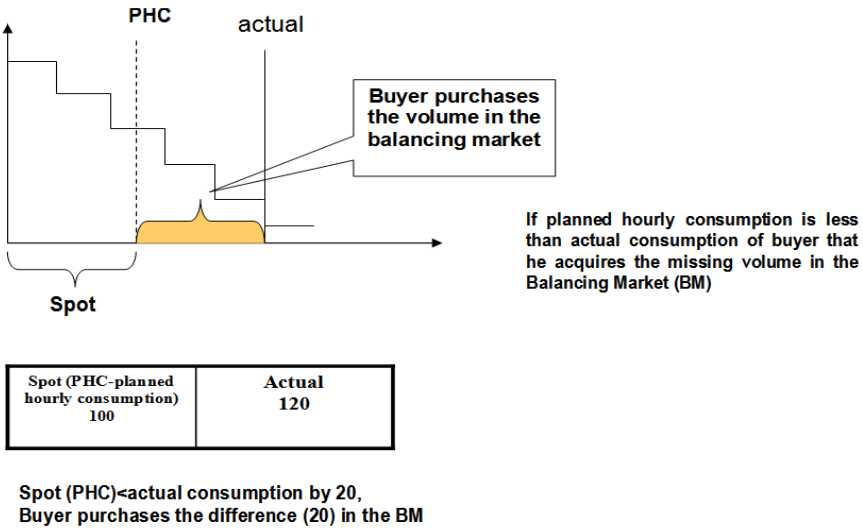


Figure 4.12. Day-ahead and balancing market purchases for buyer (up-deviation). (NOREM 06)

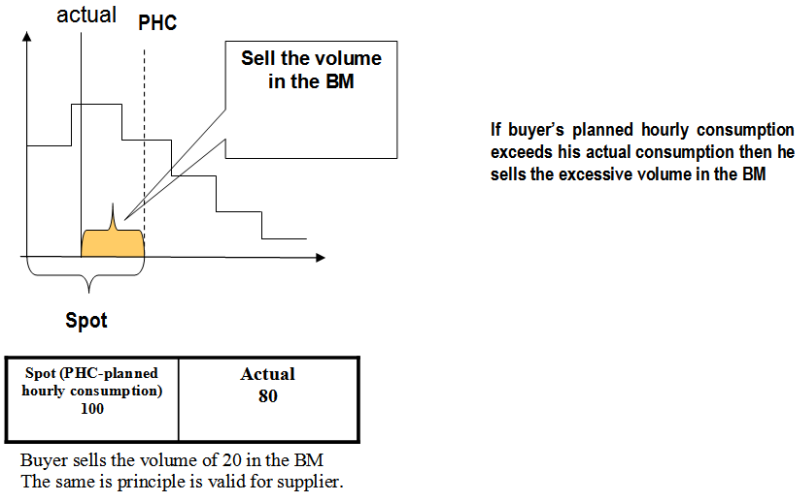


Figure 4.13. Day-ahead and balancing market purchases for buyer (down-deviation). (NOREM 06)

4.3.1. Internal and external initiative

The costs of deviations from planned production or consumption is determined based on whether the cause of deviation is internal or external in nature. Therefore, it is necessary to distinguish between the internal and external initiative that causes deviations from planned volumes.

Internal initiative:

1) Demand of electricity of those participants that do not fulfill their planned consumption or deliveries because of their own reasons (no violations from other participants or the system). It could be, for instance, generator's failure or transformer's breakdown in participant's station.
2) Demand of electricity (through the SO) of all participants because purchased or sold volumes cannot be realized due to technical reasons. These deviations are fixed by the SO or by commercial accounting gauges.

External initiative:

Producers of electricity and customers with regulated load that are able to compensate deviations for production and consumption balancing are chosen by the SO. Examples of external initiative are the SO commands and relay protection operations.

Internal initiative involves additional payments for the deviations of planned production or consumption. In case of internal initiative, producer sells his up-deviations (volumes that exceed his production) with lower price and purchases down-deviations (missing volumes of his planned production) with higher price in comparison with spot price in his GPD. Buyer acquires up-deviations with higher price and sells down-deviations with lower price. Internal deviations are accounted for every GPD.

External initiative is incorrigible. Participants have additional revenues in comparison with planned trade. In case of external initiative, producer sells his up-deviations (volumes that exceed his production) with higher price, and purchases down-deviations (missing volumes of his planned production) with lower price in comparison with spot price in his GPD. Buyer acquires up-deviations with lower price and sells down-deviations with higher price. The deviation caused by external initiative is determined for each hour and for every participant's GPD by multiplying the difference between dispatching volume and planned hourly

consumption (production) and the value of unplanned deviations caused by relay operation and commands from the SO.

4.3.2. Volumes and prices in the BM

In the balancing market, the volumes that are deflected from actual consumption and production and that could cover deviations are selected, and the costs of the deviations are determined and paid. Generators' bids in the balancing market are the same as those in the day-ahead market.

The costs of deviations are determined for every market participant as follows:

1) The prices of electricity needed for system balancing at each hour are obtained as a result of competitive bids selection, and applied according to the directions of volume changes and initiatives.
2) The volumes of deviations and reasons that caused these deviations are calculated

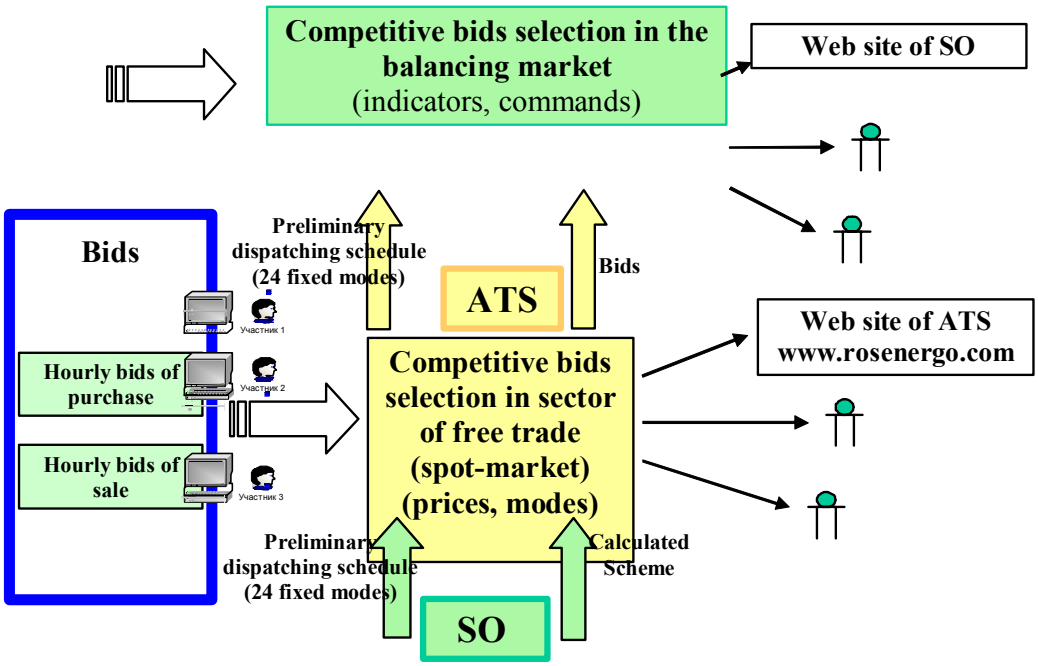


Figure 4.14 The scheme of trade in the balancing market.(ATS 05)

Equilibrium prices for balancing and dispatching volumes are calculated with the computed model (the same that is used in the day-ahead market). The price of system balancing is defined for each hour of actual delivery, and for every node of computed model. The price of system balancing in a particular node of the computed model is the maximum value of price in that node (it could be the price of balancing electricity or the spot-market price) if the volumes increase. The price of system balancing in the node is the lowest price of electricity in case of volume decrease. The price determination of up- and down-balancing is illustrated in Figure 4.15.

Figure 4.15 Prices of balancing. (ATS 05)

The cost of deviation for the participant is obtained by multiplying the volume of deviation with the price of balancing in the participant's GPD.

In order to choose the generating equipment that will be used in handling deviations, the SO determines minimum and maximum hourly values of generators' productions. After competitive bids selections, SO sends its commands to these generators and they reduce or increase their output of energy in their GPD in accordance with schedule submitted by the SO (regulation implemented within internal initiative).

Daily volumes and prices in the balancing market are published on the SO website, for instance, in a form illustrated in Figure 4.16.

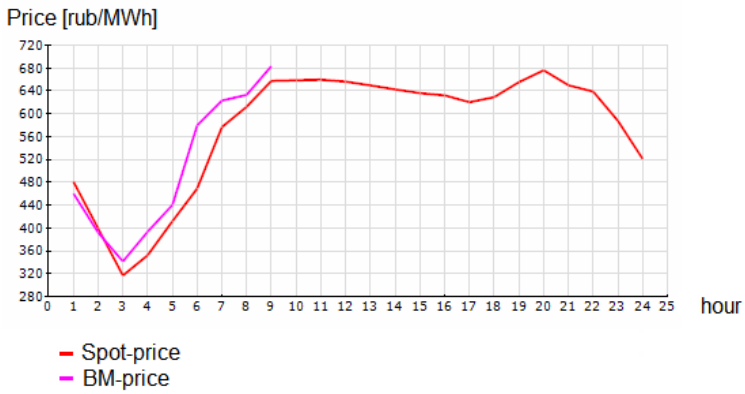


Figure 4.16 Level of prices in balancing market and in spot-market for one trading cycle.(SO-CDU 08)

4.3.3. Operative price accepting bid

One of the features of trade in the balancing market is the possibility for market participants to do their operative price accepting bid that reflect their intentions to buy or sell the specified volume of electricity with the equilibrium price that was obtained as a result of competitive bids selections.

The main idea is simple: if participant's deviations occur because of his own mistake (internal initiative) he could do his operative price accepting bid and there is a possibility that his internal deviation may be useful for system. In that case, the deviation may be viewed by the SO as a result external initiative. This is a possibility of hedging that does not work regularly. If the participant's operative price accepting bid is passed, (accepted by the SO), then the measuring systems maintained in the participant's GPD fixes the deviation equal to zero. Participant does not pay a penalty. If the prices in the balancing market are high (more than price in regulated sector and spot-market), then the participant could make some profit. For instance, if the participant could increase his generation (with low cost price) when the prices

in the BM are higher than prices in regulated sector (peak hours of frost when the expensive generation is used) he could get extra profit.

Operative price accepting bid should contain:

1) The code of GPD of generation or object of consumption referred to GPD of consumption with regulated load
2) Indication of hour (period of validity of operative price accepting bid is one hour). The operative price accepting bid is submitted concerning this hour.
3) Volume of energy:
    - on which that participant in GPD of generation could increase his volume of generation independently of prices formed as a result of competitive bids selections
    - on which that participant in GPD of generation could decrease his volume of generation independently of prices formed as a result of competitive bids selections
    - on which that participant in object of consumption referred to GPD of consumption with regulated load could increase his volume of consumption independently of prices formed as a result of competitive bids selections
    - on which that participant in object of consumption referred to GPD of consumption with regulated load could decrease his volume of consumption independently of prices formed as a result of competitive bids selections

4) Participant's identification data, for instance, in the form shown in Figure in 4.17.

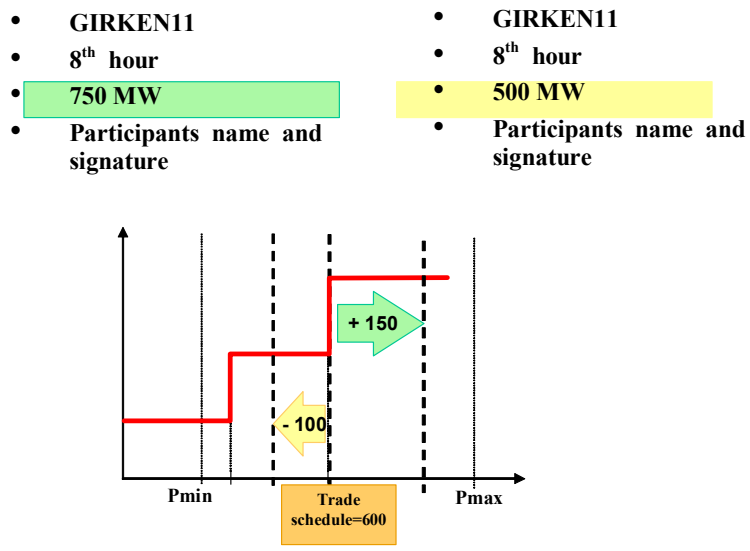


Figure 4.17. Example of accepting bid (ATS 05)

4.3.4. Deviations in regulated sector

Costs of deviations for participants that are not involved in competitive trade are accounted through special formulas which consider their location, type of initiative and other things. In the case of these participants, all their deviations are exposed to penalty.

4.4 Free Bilateral Contracts (FBC)

4.4.1. The purpose of the Free Bilateral Contracts

The main goal of making free bilateral contracts (FBC) is hedging against price changes. The price volatility related to the Russian wholesale market is an abrupt problem for those participants who are interested in stable operations (fixed money flows).

When buying/selling electricity in the spot market, market participants are exposed to a price risk. However, participants have the possibility to hedge against the price risk by using FBCs. The transactions of the wholesale market participant may include following operations:

1) electricity is purchased by buyer/sold by supplier in the spot-market with equilibrium price
2) electricity is purchased by supplier/sold by buyer in the spot-market in fulfillment of regulated contracts
3) electricity is purchased by supplier/sold by buyer in the spot-market in fulfillment of diversified FBCs

The FBCs can also be used in speculative transactions. For instance the procurement of the exceeded volume through the FBC is implemented with the goal of subsequent resale in the spot-market.

Thus, the following values of electricity are paid with free prices that are determined in free bilateral contracts, and as the result of competitive selections of the bids in the day-ahead market:

1) Value of electricity in frames of planned hourly consumption (production) that was not bought (sold) through regulated contracts
2) Value of electricity required by supplier to fulfill his obligations in regulated contracts that was not included in his planned hourly production
3) Value of consumption that was bought by participant in regulated contract and that exceeds his planed hourly consumption

When trading in the wholesale market and, especially, when trading through free bilateral contracts, it is necessary to distinguish the GPD of generation and GPD of consumption.

GPD of consumption is the location where:

1) buyer of electricity and power is planning to consume the volume stipulated in the free bilateral contract (if the buyer of electricity and power is a buyer of the FBC then he should specify the GPD of buyer).
2) buyer of electricity and power is planning to sell the volume stipulated in the FBC (if the buyer of electricity and power is seller of the FBC then he should specify the GPD of seller).

GPD of generation is the location where:

1) supplier of electricity and power is planning to generate the volume stipulated in the contract (if the supplier of electricity and power is seller of he FBC then he should specify the GPD of seller).
2) supplier of electricity and power is planning to buy the volume stipulated in the contract (if the buyer of electricity and power is buyer of the FBC than he should specify the GPD of buyer).

In addtion, the GPD of the FBC should be specified in the contract. The GPD of the FBC is the GPD in which the participants agree to pay for the losses or system restrictions. In other words, the GPD of the FBC is the place in the network, where the ownership of traded electricity is transmitted from one contract party to another. Usually, the price in the GPD of the FBC is calculated by the ATS after participants have done their bids in the day-ahead market. This price is used when calculating the payments related to the contract (i.e. when one side pays to another the price difference between two the GPDs that participate in the transaction).

In the case of two participants, the prices are different in their GPDs of generation and consumption. This price difference is called the nodal price difference, and it equals the losses and restriction costs. The price difference should be covered somehow, and this should be considered in the final price of the FBC. In practice, participants generally accept a certain virtual point that is located in the middle of their GPDs, as the GPD of the FBC. If the GPD of FBC coincides with GPD of the seller, then the nodal price difference is paid by the buyer. If the GPD of FBC coincides with GPD of the buyer, the nodal price difference is paid by the seller. In any other case, the buyer of the FBC pays for the price difference between his GPD and GPD of the FBC. Similarly, the seller pays for the price difference between his GPD and GPD of the FBC.

4.4.2. Implementation of trade through FBC

The principles of trade through the FBCs are illustrated by an example for which the following conditions and assumptions apply:

1) The participant of the market sells the electricity. This participant could be:
    - generator with a surplus of electricity (the volume of generation exceeds the volume sold through regulated contracts)
    - customer with a surplus of electricity (consumption is less than what is bought through regulated contract)
2) The volume of the participant's trade on the spot-market equals the surplus, which is assumed to be 50 MW.
3) The participant acts as a seller. He sells the volume of 10 MW in the spot-market, and the volume of 40 MW through FBC (i.e. the volume of the FBC is 40 MW).
4) The contract price specified in the FBC is 500 rub.
5) For the simplicity, it is assumed that the GPD of the FBC is the same as the GPD of the seller.
6) The price in the GPD of the FBC (the price of the GPD of the seller) is the spot-price.

In the first case, the price in the GPD of the FBC (the spot-price) is assumed to be 550 rub.

<u>Without the FBC:</u>

- Sale: 50*550=27500 rub
- Total: 27500 rub

<u>With the FBC:</u>

- Sale: 50*550=27500 rub
- From the buyer the seller gets: 40*500=20000 rub
- Seller pays in support of the operation through the FBC (covers the price differences between his GPD and the buyer's GPD): 40*550=-22000 rub
- Total:27500+20000-22000=25500 rub

In the first case, it is profitable for the seller to sell all the surplus of electricity in the spot-market.

In the second case, the price in the GPD of the FBC (the spot-price) is assumed to be 250 rub.

Without the FBC:

- Sale: 50*250=12500 rub
- Total: 12500 rub

With the FBC:

- Sale: 50*250=12500 rub
- From the buyer the seller gets: 40*500=20000 rub
- Seller pays in support of the operation through the FBC: 40*250=-10000 rub
- Total: 12500+20000-10000=22500 rub

In the second case, it is profitable to sell the surplus of electricity through the FBC, and the seller managed to hedge his sales. The importance of appropriate price hedging increases as the liberalization of electricity markets proceeds.

Next, the use of FBC is considered from the buyer's point of view.

1) The price in GPD of the buyer is 500 rub (= spot-price in his GPD).
2) The price in GPD of the seller is 600 rub (= spot-price in his GPD).
3) We assume that the GPD of the FBC is the same as the GPD of the seller.
4) The contract price is 550 rub, and the contract volume is 1 MW.

Implementation of trade:

1) The buyer should buy the volume in the spot-market with the price 500 rub.
2) Then he buys this volume through the FBC with the price 550 rub.
3) He sells in support of the operation through the FBC with the price 600 rub.
4) Buyer's final result will be: 1*500+1*550-1*600=450 rub.

The buyer in this situation has paid only 450 rub for the bought electricity.

When entering into the contract, the participants do not know what will be the spot-price when the contract is realized. This price will be determined by the ATS, and it equals the price in the GPD of the FBC. The financial result is a difference between that price (spot-price) and the price of FBC (which was agreed before).

The following items should be defined in the FBC:

1) The GPD of the seller/buyer
2) The GPD of the FBC
3) The method of the price accounting
4) The price of contract
5) The time of contract realization
6) The volume of contract

4.4.3. The role of ATS

After participants have done their bids, the project of free bilateral contract is formed. Also, the statement of the contract's registration and the schedule of delivery are accepted. Every side of the bargain should sign the contract within one day. After signing, the statement and the schedule is passed on to the register of the ATS. When this is done, the participants wait for the realization of the contract. On the day of realization, the ATS calculates the payments related to the support of the operation and sends the reports with the assignment of price in the GPD of the FBC to the participants. Comparing the price in GPD of the FBC and the price of the contract participants can calculate their financial results.

4.4.4. The role of CFA (Center of Financial Accounts)

The CFA is the branch department of ATS. It performs services concerning the contract's organization in the wholesale market, and the financial accounting between participants of the market. The payment for the CFA services equals to 0.16rub/MWh. All trade agreements are implemented through the CFA.

4.4.5. Registration of FBC

The request for the registration of the FBC should be sent by participants to ATS no later than two days before the actual delivery time. The request is submitted through a special (closed) software that is available only for the participants of the wholesale electricity market. The schedule (diagram) of the delivery of electricity is submitted to ATS in electronic format. The participants are also expected to notify ATS about the possible changes made to the FBC.

4.4.6. Hubs

When trading through the FBCs was first started, there was no place where participant of the market could offer their volumes and bids and find a contract with desirable conditions. The process of finding a counterparty was difficult for the participants. There was an abrupt demand for the new system of searching.

The commodity exchange "ARENA" is a universal communicating mechanism with an open price formation. ARENA gives to the participants the opportunity to enter into FBCs with each others. In the contracts, the GPD of the FBC is substituted by a Hub index.

Hub is a combination of nodes that are characterized by the common dynamics regarding their equilibrium price fluctuations. It gives a clear public price reference for electricity trading. The average price for a hub is determined based on the prices in the day-ahead market. In Russian wholesale electricity market, there are six hubs. For each hub, an index reflecting the average price in that hub is calculated. Hub index is the average value of spot-prices in the nodes of the computed model located within the hub. Hub indices are calculated for the 24 hours of each day of the year by the ATS. Hub indices are published in the website of ATS. An geographical illustration of hubs in the Russian wholesale electricity market is presented in Figure 4.18.

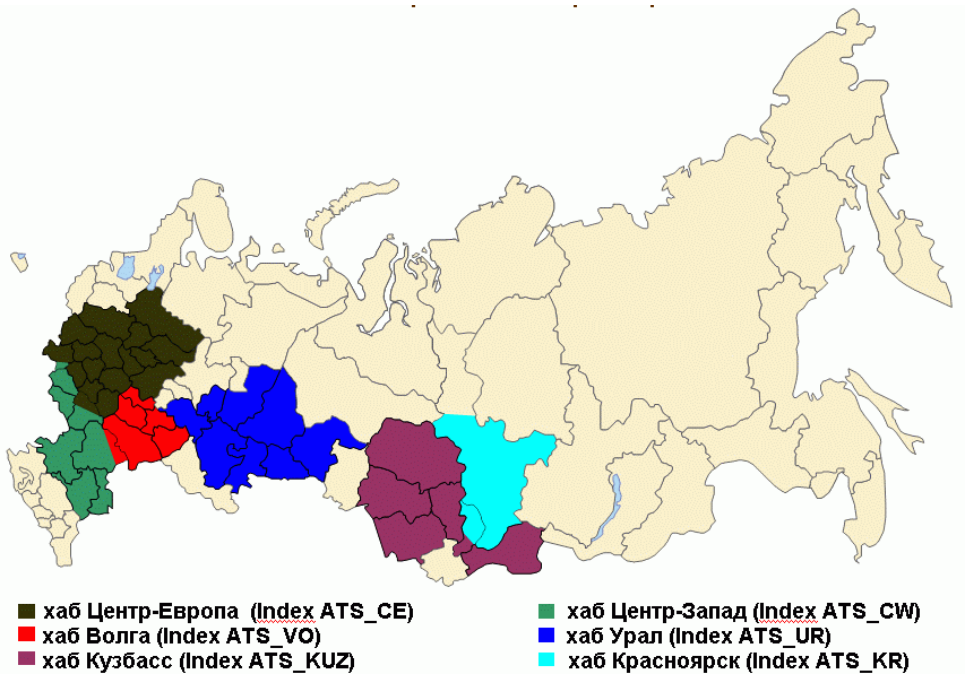


Figure 4.18. The map of hubs (ATS 08a)

The hub becomes non-effective if the dynamics of the hub index's fluctuation differs from the dynamics of the equilibrium price fluctuations in the nodes that are included in the price area of the hub. In this case, ATS could change the borders of the hub, or split original hub into several separate hubs.

4.4.7. The trading mechanism

The importance of hubs lays in the fact that hub indices can be used as the reference prices in FBCs. Hence, the prices in participants' GPDs are compared to pre-specified hub indices when calculating the financial results of FBCs. The effectiveness of price hedging directly depends on the correlation between the price in GPD of the participant and the hub's index that is used as the reference in the FBC.

For instance, if the participant's price follows the fluctuation of price in hub "Central":

- the price in his GPD increases when the price in the hub "Central" increases
- the price in his GPD decreases when the price in the hub "Central" decreases

Consequently,

- GPD of the participant 220 490 520 720 610 520 470
- hub index of "Central" 200 470 500 700 590 500 450

and the difference between the GPD of the participant and the hub index is always 20.

If the correlation between participant's GPD and hub is close to 100%, then the effectiveness of the hedging will also be close to 100%.

If it is necessary to buy in the participant's GPD with the price that is not higher than 520, participant should buy a standard contract in the hub with the price 500. He should make a bid on the ARENA that he could buy with the price 500 and lower.

If it is necessary to sell in the participant's GPD with the price that is not lower than 520, participant should buy a standard contract in the hub with the price 500. He should make a bid on the ARENA that he could sell with the price 500 and higher. The following example shows the fulfillment of trade at the commodity exchange "ARENA" (ARENA 08b).

Example

The buyer is planning to buy in his GPD with the price of 460. The buyer concludes the FBC on the ARENA (exchange) in the Central Hub. ARENA sets the GPD of the contract to be the GPD of the buyer. The price in the buyer's GPD is always on 10 less than in the Central hub. The price in the seller's GPD is always on 20 higher than in the Central hub. The seller could sell with the price of 490, and the buyer could buy with the price of 460.

Seller:

Hub	200	470	500	700	590
GPD	220	490	520	720	610

Buyer:

Hub	200	470	500	550	700
GPD	190	460	490	540	690

The market participants agree the contract price to be 470.

Even if at the moment of calculation, there are prices in the "Central" hub are equal to 200 or 700, the price of the FBC will be fixed.

FBC = P_bid + (P_GPD_buyer - P_hub)

FBC = 470 + (190 - 200) =460
FBC = 470 + (690 - 700) =460

For the buyer:
In the first case, the buyer buys through the FBC with the price of 460. Then he sells in support of the operation through the FBC with the price 190 and buys electricity in the spot-market with the price of 190 in his GPD.
The financial result of the buyer is: -460+190-190=-460

In the second case, the buyer buys through the FBC with the price of 460. Then he sells in support of the operation through the FBC with the price 690 and buys electricity in the spot-market with the price of 690 in his GPD.
The financial result of the buyer is: -460+690-690=-460

For the seller:
In the first case, the seller sells through the FBC with the price of 460. Then he buys in support of the operation through the FBC with the price 190 and sells electricity in the spot-market with the price of 220 in his GPD.
The financial result of the seller is: 460-190+220=490

In the second case, the seller sells through the contract with the price of 460. Then he buys in support of the operation through the FBC with the price of 690 and sells electricity in the spot-market with the price of 720 in his GPD.
The financial result of the seller is: 460-690+720=490

Conclusion: it is possible to hedge with the FBC concluded at ARENA.

4.4.8. Types of contracts

The diversity of contract conditions resulted in a small set of the most demanded standard conditions (e.g. delivery at peak hour, delivery at off-peak hours and others).

Contracts that realized at the ARENA differ regarding the following characteristics:

- period of delivery (Day, Week, Month, Quarter, Half-year)
- selection of delivery days in a month (All days, Working days, Holidays)
- hours of delivery (Base load, Peak hours, Minimum hours, Off-peak hours)
- type of reduction (Take-or-pay, Seller, Buyer, Minimum in pair)
- hub (Central, Central-West, Volga, Ural, Kuzbass, Krasnoyarsk)

Every contract has its own unique code that is of the form:

ABCD-EEXX-YYY,

where
A = delivery period
B = selection of day
C = hour of delivery
D = type of reduction
EE = hub
XX = year
YYY = serial number of delivery in specified year

For instance:
WABT-CE07-035 = the contract according to which electricity will be delivered at all hours on all days of week 35 in 2007 in the hub "Central", without any reductions in the delivered electricity
MHMG-UR07-008 = the contract according which electricity will be delivered at off-peak hours on the week-end days of august 2007 in the hub "Ural" with the reduction of the seller's delivery. (ARENA 08a)

4.4.9. Conclusion on FBCs

The main goal of FBCs is hedging against undesirable price changing. Participants of the wholesale market independently determine prices for electricity and volume of deliveries of the FBCs. Suppliers and buyers of electricity who enter into the FBC should cover the difference between spot prices in GDPs of buyers and sellers. The supplier that has entered into FBC should deliver electricity according to conditions (volume and price) agreed in the contract. That could be done by including this specified volume (part of volume) of electricity in the supplier's planned hourly production. The rest of the required volume could be acquired in the spot-market. FBCs and their changes are notified to ATS.

4.5 Capacity trade

4.5.1. Capacity market

Capacity is a special commodity that can be sold or bought. If participant buys capacity in the wholesale market that means that he acquires a right to claim the supplier's equipment readiness (availability) to produce electrical energy with desired quality and in indispensable

quantity. The main goal of capacity market is to provide availability of short-, middle- and long-term generating capacities that are sufficient to cover all consumption of electricity with proper quality and quantity at any time.

In 2006-2007, capacity trade was implemented only through the regulated contracts. At the start of 2008, the new competitive mechanism of capacity trade was introduced. This meant the liberalization of capacity trade (decrease of capacity trade through regulated contracts) with the same rates as electricity. All new capacities are bought/sold with free (unregulated) prices.

4.5.2. Regulated trade

In the regulated sector, the suppliers sell the capacity V1+V2+V3 with tariff stated by the FST (Figure 4.20).

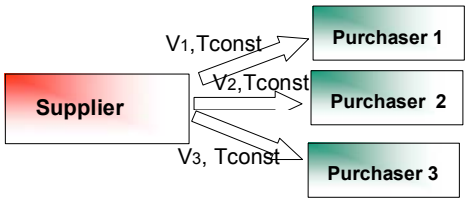


Figure 4.20. Sale of capacity. (Usman 07)

For the purchaser the acquired volume of capacity is equal to maximum consumption V1+V2+V3 multiplied by a specified reserve ratio (Figure 4.21).

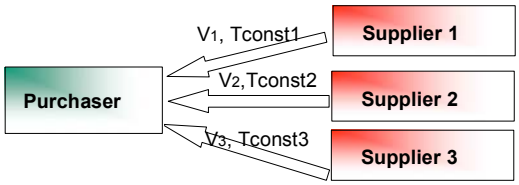


Figure 4.21. Purchase of capacity. (Usman 07)

The cost of purchased capacity is equal to multiplication of volume and indicative price stated by the FST for every buyer of capacity (indicative price of capacity is the average cost of capacity unit that is accounted in goals of regulated contract formation). Suppliers within the price area have an agreement that forces them to bear collective responsibility.

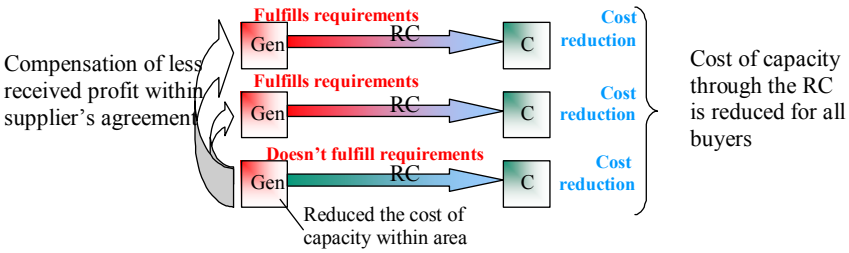


Figure 4.22. Collective responsibility of suppliers (Usman 07)

4.5.3. Competitive trade

Competitive mechanisms of capacity trade include:

1) Purchase/sale of capacity through the free bilateral contracts (prices and volumes are stated by participants)
2) Purchase/sale of capacity through the unitized side (CFA) as a result of bids selections (for those participants that were selected in competitive bids selections):
    - Sale of capacity with price that is specified in supplier's bid

- Purchase of capacity with price that is accounted by the ATS (average sale price of all suppliers)

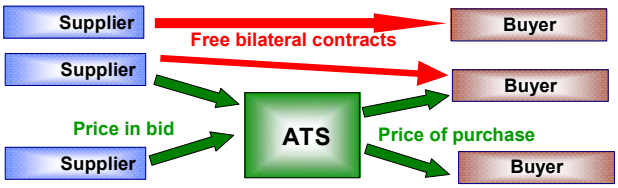


Figure 4.23. The scheme of trade (Gotlib 07)

The main features of capacity trade are:

1) Competitive selection of suppliers in order to cover the consumption through:
   - Long term auction of capacity (4 years before the moment of delivery obligations). The first contract in 2008 with date of expiration in 2012. Opportunity to sell capacity as a result of selections within 10 years.
   - Adjustment auction in period from 1 to 4 years before the moment of delivery obligations takes place. The first contract in 2007 for the year 2008. Short term contract (transient) are concluded one year ahead.
2) Formation of long term participant's obligations

Long term auctions (4 years ahead) take place every year for the purpose of capacity selection that is needed to cover volumes that were not covered through previous auctions. Participants (suppliers) submit their bids with indication of granted volumes and annual capacity fee (rub/MW). Further, during the auction, the volumes with lower price in desired quantity are being selected. The quantity of chosen volumes should be enough to cover the forecasted consumption. A uniform price for capacity is not formed during auction. Every selected supplier has its own unique payment for capacity in accordance with his price bid. Due to the specificity of different types of generation, capacity trade is not profitable for some companies. Payments for capacity are calculated in accordance with the fixed costs of generators. Nuclear stations have the highest fixed costs of production (90%), then hydro stations (60-70%) and heat stations (30%). (Orenburg 08)

At any time, before the seller chooses his type of participation (which are stated below), any supplier independently of his participation or nonparticipation in capacity auction could sell his capacity through the free bilateral contracts (including long-term contracts) which are concluded between buyer and seller.

4.5.4. Types of suppliers

There are two types of suppliers in the capacity market. Suppliers that were selected based on the results of capacity auction, annually, can choose their type of participation and become a "tariff" or "free" supplier. First selection should be done before September of the year H-1 (H is the year when obligation starts). Participants can then change their position every year within 10 years. (Orenburg 08)

Types of suppliers:

1) "Tariff" supplier within next year sells capacity with price stated in his bid. He requests the Federal Service of Tariff to set the electricity tariff for him. Then, this supplier sells electricity (in the spot-market and in the balancing market) not with a spot-price but with a price that does not exceed the electricity tariff, stated for this supplier by the FST. This suppliers is not allowed to conclude free bilateral contracts.

2) "Free" supplier within next year sells capacity with free market prices (spot-prices). He does not obtain payments for capacity specified in his bid (thus, he is allowed to conclude free bilateral contracts).

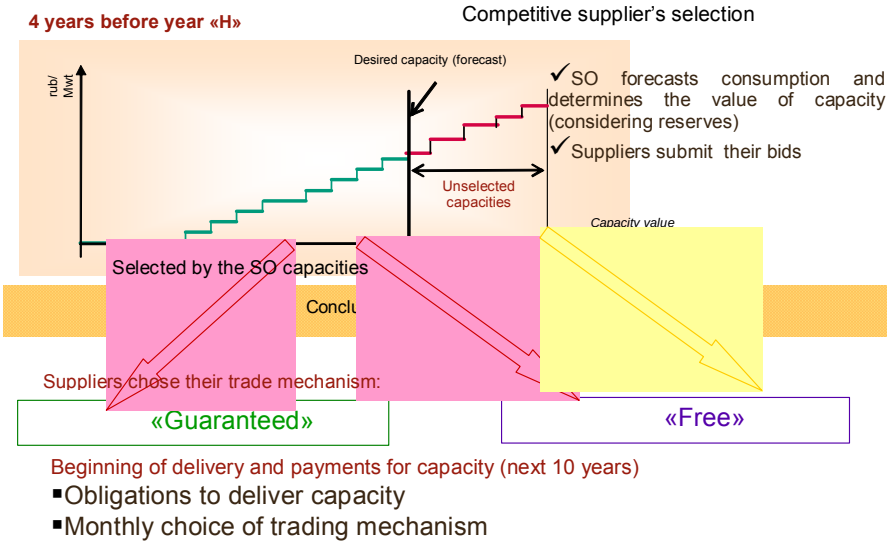


Figure 4.24. Capacity market structure (Usman 07)

4.5.5. Sale of capacity

Specificity of generating capacities (that are referred to RAO "UES") participation in the capacity market:

1) Obligatory participation in auction and conclusion of free bilateral contracts for free volumes (volumes that were not traded through regulated contracts)
2) Capacities that were built in accordance with RAO "UES" investment program must participate in capacity auctions.

Selections of capacity:

1) Territory is divided into areas with free power flows
2) For every area of free power flow, the SO determines:
   - The volume of desired capacity (planned peak consumption)
   - Technical parameters
3) Suppliers make their bids for competitive capacity selection
4) Suppliers that stated the lowest prices in their bids are used first

Selected suppliers should provide capacity availability. They get the guarantee of capacity service payments for 10 years (opportunity to sell their capacity with price that was stated in their bids or with free prices).

Supplier's obligations are:

1) Provide the capacity (readiness of generating equipment to produce the desired volume of electricity) of specified type (with specified parameters of maneuverability) in volume that was indicated in his bid
2) Confirm the equipment's readiness regularly to the SO before the obligations start
3) Maintain the equipment readiness to produce electricity during terms of obligations

If generating equipment has not been ready for work by the time of supplier's obligations start, or if it has been damaged during terms of obligations, supplier should pay a penalty. The penalty is equal to the cost of building of new capacity in appropriate volume. (Orenburg 08)

4.5.6. Purchase of capacity

Purchase capacity is obligatory for all buyers in the wholesale electricity market. Purchase of different types of capacity (maneuvering/non-maneuvering) takes place in proportion determined by the SO, in summarized quantity that is equal to peak consumption multiplied by reserve ratio. In other words, capacity is purchased in accordance to actual consumption. All selected capacities are spread between purchasers in compliance to their peak consumption. Purchaser is allowed to plan his own consumption (group 1), or accept the forecast of the SO (group 2). Large customers with individual GPD could do independent forecasting. Independent long-termed planning of peak consumption gives them availability to buy the necessary volume of capacity (taking into account the reserve ratio which was stated by the SO 4 years before date "H"). In that case customers are allowed to adjust their planned consumption and sell/buy the surplus/deficit of capacity in adjustment auction. Buyers that planned their consumption themselves and did not buy the sufficient volume of capacity, are first cut from obtaining the needed capacity in case there is a lack of capacity. Buyers that accept the forecast of the SO, pay for all actual consumed capacity with allowance for the actual reserve ratio (defined by the SO in accordance with actual consumption of all buyers located in area of free power flow). (Orenburg 08)

The value of necessary capacity in whole system is determined in accordance with following order:

1) Definition of free power flow areas. Demand and offer are aggregated within those areas and separate auction takes place.
2) Demand for capacity in each year in every area of free power flow is formed by the SO on the basis of the following information:
    - Forecasts of peak consumption and daily deviations from planned consumption in every area
    - Principles of reserve ratio determination that specify necessary reserve of capacity in every area
    - Structure of capacity (maneuverable or non-maneuverable)

Results of forecasting:

- Free power flow areas
- Aggregate maximum of consumption in every area of free power flow
- Reserve ratios
- Aggregate demand for capacity with allowance of reserving
- Proportion of maneuverable or non-maneuverable capacity in every area of free power flows

Technical requirements for participants are the following:

1) Equipment of existed stations should be prepared for work during the terms of obligations
2) New stations should be opened up no later than date when the obligation begins
3) Location of new generating objects within area of capacity trade where the auction takes place
4) Technical characteristics of new generating objects including the level of maneuverability (rate and range of load shedding and load on)

4.5.7. Process of capacity trade

The year of obligation is defined as lasting from the 1 of December to 30 of November.

Four years before the date "H"

1) Participants that decided to plan their consumption themselves, submit to the SO their applications for capacity consumption in year "H"
2) SO plans full volume of consumption within price areas
3) SO defines areas of free power flows for year "H" and determines volumes of power flows between them
4) SO determines reserve ratio for every area of free power flows and reports it to those buyers that plan consumption themselves
5) In every area of free power flow, the SO determines the value of necessary capacity as multiplication of planned maximum of consumption within that area and reserve ratio
6) SO determines the structure (maneuverable or non-maneuverable) of capacity for every area of free power flows
7) SO registers free bilateral contracts between buyers and sellers
8) SO determines the volume of purchase for the year "H"
9) Sellers submit their bids with indication of volumes and price of capacity that they intend to sell in the year "H"

Two years before the date "H"

1) SO updates forecast of consumption in the year "H"
2) SO implements the certification of all chosen capacities for the year "H"
3) SO determines the deficit of capacity for the year "H" and organizes an adjustment auction

The cost of capacity for those buyers that did not buy it with free prices is defined as average of all "tariff" seller prices.

5 Russian and Nordic electricity markets in comparison

This chapter focuses on comparing and contrasting the characteristics of the emerging Russian electricity market with the integrated Nordic electricity market encompassing Finland, Sweden, Norway, and Denmark.

5.1 Electricity market restructuring

The restructuring of the wholesale electricity market brought the Russian electricity sector into a new era. The restructuring meant that all the vertically integrated joint-stock companies that had previously been responsible for electricity generation, transmission and distribution services in their operating areas, and that had controlled all the electricity production and consumption, ceased to exist. Instead, the assets of the vertically integrated companies were divided between newly formed companies in accordance with these companies' fields of operation. Consequently, a set of new companies, including the territorial and wholesale generating companies, Federal Grid Company, several distribution grid companies, and the dispatching management company (System Operator) were formed. Some of the new companies were partially or completely privatized, which allowed for indispensable private investments in these companies. In the new market setting, electricity generation and selling became competitive activities, while the dispatching, transmission and distribution services remained as monopolies.

In the Nordic countries, the liberalization of electricity sector in 1990s had also resulted in competitive environment in electricity generation and selling, and had left the electricity network operations as natural monopolies. In contrast to the Russian reform, the electricity market reforms in the Nordic countries were carried out without privatization.

5.2 Transmission networks

In Russia, a so called ISO-model is applied in organizing the transmission network operations. This means that there exists both a federal grid company that owns the transmission networks, and an independent system operator that is responsible for operating the networks. The tasks of the Federal Grid Company (FGC) include: 1) the maintenance of high voltage transmission of electricity within the Russian UES; 2) the providing of the export and import operations; 3) the development and reinforcement of the Russian UES; and 4) the providing of the control unity, transmission tariff regulation, etc. In Russia, there is also seven Interregional Main Grid Companies (IMGC) and 56 Main Grid Companies (MGC) that provide transmission network services in different regions of the country. The costs of transmission services are included in the nodal prices of electricity; that is, the costs of using the transmission network vary from one network customer to another in accordance with their geographical locations within the electricity system.

In contrast to the Russian approach, a common Nordic and European approach is to have a so called transmission system operator that both owns and operates the transmission networks. Typically there is one national transmission system operator that is responsible for the high voltage electricity transmission. Charges for the transmission services and for the electric energy are completely separated from each others, and a so called point tariff principle is applied in transmission pricing; that is, the transmission charge of does not depend on the network customer's geographical location within the network.

5.3 Electricity trading and price formation

5.3.1. Russian system

In Russia, there is no one single market price for electricity that would commonly be used as a reference price in any transactions carried out in the electricity market. The basis of price formation in the Russian wholesale electricity market lays on applying the nodal pricing; that is, the model for price calculation takes into account the forecasted power flows between the nodes of the electricity system, the price of electricity varies from one node to another. Nodal prices include both the costs of electricity production and the costs of electricity transmission. This mechanism of price formation helps to identify areas with excess of demand and deficit of production (prices of electricity are high in these areas).

The nodal prices are calculated by a so called Noncommercial Partnership "Administrator of Trade System" (ATS) that acts as the market operator in the Russian wholesale electricity markets. Calculation of the nodal prices is done on the basis of the production and consumption forecasts, and the information about power flows in the electricity system. ATS receives the necessary information from the System Operator. In addition to operating the day-ahead market, ATS also operates the so called balancing market of electricity, which is an intraday market designed to provide the market participants with an opportunity to fine-tune their on electricity balances after the spot-market closes. It is also noteworthy that in the Russian system the balancing market and the regulating power market are integrated in the Russian system. All the parts of the wholesale electricity market are controlled by the market operator ATS and the system operator SO.

Table 5.1 summarizes some the basic features of trading in the Russian electricity market. It should, however, be noted that the formation of all the markets in Russia has not been completed, yet. For instance, the option trade in not yet in place.

Table 5.1. Trading in the Russian electricity market.

Market place	Physical trade	Financial Trade
NP "ATS" SO	Day-ahead market Balancing market	Options Capacity trade
"ARENA"		Free Bilateral Contracts

5.3.2. Nordic system

In the Nordic countries, electricity trading takes place in the Nordic power exchange NordPool. The forms of trading include the physical trading of electricity in the spot-market, and the financial trading. Financial markets provide means for price hedging against undesired price development, and also for the speculative trading with the electricity derivatives. Bilateral trading, regarding both physical and financial contracts, is also possible in the Nordic electricity market. In the spot-market, sellers and buyers of electricity submit their bids to the power exchange, which are then matched in such way a that the prices and quantities of electricity are settled for all the hours of the following day. Fine-tuning of electricity balances is possible through intraday trading after the spot-market closes.

In the spot-market, the core responsibilities of NordPool include (Nord Pool 04):

1) Providing a reference price for Nordic electricity markets
2) Operating the spot-market and organized market of financial products (forwards, futures and option contract)
3) Acting as neutral and reliable contract counterparty to electricity market participants

4) Using the spot market's price mechanisms to alleviate grid congestions (capacity bottlenecks) through optimal use of available capacity
5) Reporting all the traded power deliveries and take-off schedules to the transmission network operators

In NordPool, as a result of competitive bids selections in the day-ahead market (the spot-market), a common system price is formed for the whole market area, assuming that there is no congestion in the network. Hence, the system price is the same for all market participants. In case of congestion, so called area prices are introduced. A special financial instrument, Contracts for Difference (CfD), has been designed to hedge against the differences between area prices and the system price.

Table 5.2. presents some of the features of the operating environment of electricity trading in the Nordic countries.

Table 5.2. Trading in Nordic electricity market (Wangensteen 2006)

Market place	Physical trade	Financial trade
Nord Pool	Elspot Elbas (Finland, Sweden, Denmark)	Futures Forwards Options CfDs
System Operator	Regulating power market (RPM) RP options (Norway)	
Bilateral (Brokers, traders)	Full delivery Load factor contracts	Forwards Options

5.4 Long-term trading

In Russia, the wholesale electricity market is currently undergoing a transient period, and the drastic changes are being introduced in the market conditions. According to the government rulings, all regulated trade is to be replaced gradually by competitive trade by 2011. The ongoing reform that started in 2006 is expected to be fully completed in 2014. All electricity trade will then be carried out in competitive market. In 2008, significant volumes of electricity (around 75-80%) are still traded through regulated contracts with regulated prices. Other volumes that are not covered with regulated contracts must be sold or acquired in the spot-market of electricity, or through free bilateral contracts. In the latter case, participants themselves agree the price and volume of the contract, and one side is obliged to pay for the other side the difference between the contract price and the reference price.

In the sector of free electricity trade in Russia, contracts can be made in a special market place called "ARENA"; that is in a commodity exchange. Hub mechanism has also been introduced in order to simplify the trade through free bilateral contracts. According to plans, hubs will later be used also in option trade. All bilateral contracts are traded under the control of the ATS and CFA. The length of the free bilateral contracts is half a year at maximum. Regulated contracts at present may cover the following three years at maximum, but the share of these contracts is decreasing. It remains to be seen whether the maximum length of free bilateral contract is allowed to increase in the future when the regulated contracts cease to exist.

In Russia, there is also a special capacity market of electricity. The capacity market can be considered as a financial market because no physical delivery of electricity takes place in the capacity market. Capacity contract gives the buyer the right to claim the equipment readiness

to produce electricity. Capacity contracts are made well in advance (4 years) before the obligations indicated in them begin.

In Nordic countries, long-term trading of electricity takes place in the financial market of NordPool in which forwards, futures and options are traded, and in the OTC markets through bilateral trading. In the former case, NordPool is the counterparty of trade, which contributes to avoiding the risk of counterparty default. Participants fix the price of electricity in the contacts, and one side is obliged to pay to another the difference between price in contract and price in the spot-market at the time of contract realization. The longest standardized forward contracts have a time horizon of five years.

5.5 Short-term contracts

5.5.1. Spot-market

In Russia, there is no one common spot-price of electricity for all market participants. Prices are calculated by the ATS for every node of UES separately. Transmission costs are included in the nodal prices. In the day-ahead market, participants are allowed to submit altogether three bids with indication of different (highest and lowest) volumes and prices for each hour of the following day. In the Leningradsky region of Russian market, the participants should submit there bids no later than 13.00 (Moscow time). One hour later, ATS transfers the bids to the SO (during day of the delivery the bids with lower price will being satisfied first). ATS determines nodal prices and the trade schedule for each market participants by using the computed model at 17.30 (Moscow time). In the North-West part of Russia, the average electricity spot-prices is equal to 18-22 euro/MWh.

In the Nordic electricity spot-market, buyers and sellers submit their bids concerning the electricity deliveries of the following day one day ahead (62 price–volume -combinations are allowed). Deadline for submitting the bids for the following day's delivery hours is 13.00, and the system price obtained approximately at 14.00 (Finnish time). Based on supply and demand, NordPool calculates a system price (uniform equilibrium price) for the Nordic electricity market for all the hours of the following day. System restrictions are not taken into account in the first round of price calculation. If transmission network congestions occur, area prices are introduced.

5.5.2. Balance power trade and regulating power markets

In Russian wholesale electricity market, the balance power trade and the regulating power market are integrated into one balancing market. Generators and participants with regulated loads participate the price formation in the balancing market (participants that have measuring devices in their points of delivery). Participants submit their bids for the balancing purposes to the ATS, which calculates the balancing prices for deviations in every node of the UES (the same mechanism of price formation that is used in the spot-market, is also applied in the balancing market). In the generators' case, the same bids are used both in the balancing market and in the spot-market. Only buyers of electricity are allowed to set new prices for the deviations of planned hourly consumption. In the balancing market, payments for deviations depend on type of initiative that caused the deviation. The price of system balancing in a particular node of the computed model is the maximum value of price in that node (it could be the price of balancing electricity, or the spot-market price). The cost of deviation is obtained by multiplying the volume of deviation (considering the type of deviation) with the price of deviation determined by the ATS.

In the Nordic electricity market, intraday trading takes place in Elbas market, which is a short term market for physical electricity trading. It enables trading close to real time 24 hours a day, seven days a week, covering individual hours up to one hour before delivery. Elbas give the market participants the opportunity to adjust their balance closer to real time. Of the Nordic countries, Elbas market is open in Finland, Sweden and Denmark.

In the Nordic countries, regulating power trade takes place in separate markets. Regulating power markets are maintained by transmission system operators. In Finland, for instance the holders of capacity that wish to operate in that market must have a real-time measurement equipment that provides the system operator with information about participant's consumption or generation. Generators and customers with regulated load submit their bids to the system operator. The bid should contain information about the capacity that could be used, and the price for it. The bids could be made simultaneously with bids in other markets from the beginning of the day but no later than 30 min before actual regulating takes place. System Operator sets all bids in ascending order. According to a type of regulation (up- and down regulation) different bids are used. The up-regulation price for an hour of use is the price of the most expensive up-regulation. Down-regulation price is the price of the cheapest down-regulation used.

5.6 Interaction of Nordic and Russian electricity markets

5.6.1. Exports from Russia to Finland

Deficit of mineral resources have brought Nordic countries to situation when they are forced to buy energy from other countries. For instance, approximately 50% of heat and electrical energy consumption in Finland are provided through the purchases of coal, gas and oil in Russia. The share of Russian electricity constitutes approximately 10-15% of whole consumption in Finland. Export operations from Russian is implemented by "Inter RAO UES" that is a monopolist in this field in Russia. In the North-West part of Russia, the transit of electricity is implemented through the Viborgskaya substation. Three lines that work in parallel have transit capacity of 1400 MW. There are some new projects in Russia today concerning the export operations. According to these projects exported to Finland, electricity may be doubled after year 2020. New capacities will be introduced in years 2016-2020 (second DC-station with the capacity of 500 MW).

Export of electricity takes place within the limits set in regulated contracts. The price of exported electricity is fixed, and it is around 50% higher than price of electricity in North-West region of Russia. The transboundary tariff of electricity transit is stated by the Finnish transmission system operator Fingrid for "Inter RAO UES", and it is equal to 4.3euro/MWh. It was lower in the beginning of year 2007 (approx. 3.5 euro/MWh). The tariff changing was done by the Fingrid after export interruptions in 2006 when, due to cold winter and the increased electricity demand in Russia, deliveries were redirected by the RAO UES to the internal market. The tariff increase was done in order to archive reliable supply. Fingrid estimated that capacity reserves should contain three heat stations with the total capacity of 600 MW, and that 50 % of the reserve maintenance should be covered by "Inter RAO UES". At present, there are five contracts of export between Fingrid and Inter RAO. The volume of exported electricity could be reduced by "Inter RAO UES" by no more than 40%. The first contracts expire in 2009. (Kommersant 06)

Despite of the transboundary constraints, the selling of Russian electricity in Nordic countries is more profitable than selling electricity in the internal market. The price of exported electricity is equal to 30 euro/MWh.

5.6.2. Possibilities of market-based co-operation

Spot-market prices in North-West part of Russia have generally been 40-50% lower than the spot-prices in the Nordel area. Opening of short-term trading between countries would cause price changes on both sides of the border. The average spot-price in North-West part of Russia would increase and force price changes also in other parts of the electricity markets; that is, in the balancing market and the market of free bilateral contracts. In the regulated contracts, the price is stated for every participant by the FST (Federal Service of Tariffs), and it can be changed only if both contract parties agree about the changes. Even if generators wanted to increase prices, they simply would not be allowed to do under the prevailing regulated contracts.

A significant obstacle to the integration of the Russian and Nordic physical electricity markets (e.g. through market coupling mechanism) is caused by the different pricing mechanisms that are applied in these markets. In the Nordic markets, there is one common price for electricity, where as in Russia separate prices of electricity are determined for each node of the system. From the Nordic perspective, some benefits could perhaps be gained, if the imported Russian electricity was sold in NordPool. At present, the price of the exported electricity fixed in advance, and it is based on the average price level in the Nordel area. From the Russian point of view, connection to Finland could perhaps be viewed as one node even if the price of the exported electricity was determined in the market.

At present, it is difficult to forecast the possibilities of closer co-operation because of the lack of sufficient interconnections between the two systems. Bringing the operation of the two markets closer together depends, among other things, on the physical transmission capacity between Russia and Finland. The existing DC-stations at the border between the two countries have no reversing equipment; that is, electricity can be transmitted only in one direction: from Russia to Finland. The question of new reversing equipment installation is currently under consideration.

6 Conclusion

In Russia, the electric power industry had not been a very efficient sector before 2006 when the implementation of new market mechanisms started. The first steps towards the new electricity market structure had been taken already in late 1990s and early 2000s, when the Russian government had decided to reorganize the electricity sector in Russia. A part of the restructuring process had been the division of all electrical companies in accordance to their field of operation. This was a preparation for a more extensive reform in the Russian wholesale market of electricity; a reform that targeted to creating a well functioning competitive market in electricity. The reform is expected to be fully completed by 2014.

The goal of reform of 2006 was to replace the inefficient regulated electricity sector in Russia with a more efficient one. The liberalization of the electricity market was to be carried out gradually. During the reform, old contracts were designed to be replaced by new competitive relations between the buyers and sellers of electricity. Consequently, according to government directive, volumes of electricity that traded in regulated sector are being decreased while the volumes of electricity that are exposed to competition are increasing. In order to increase competition, the system of free bilateral contracts, the day-ahead market, and balancing market were introduced in 2006. The competitive capacity market was opened in 2008. The purpose of the capacity market is to provide an insurance of stable and reliable electricity production. In the future, markets of transmission rights and option trade are also expected to be started.

The goal of this report was to provide the readers with information about the market mechanisms in the restructured Russian wholesale electricity market. In order to do this, detailed descriptions about the market mechanisms and procedures found in the Russian electricity market were given in the report. Also, the market mechanisms applied in the Russian and the Nordic electricity markets were briefly compared and contrasted. For instance, the pricing mechanism in the day-ahead spot-trade of electricity were found to be completely different in these two market areas. In addition, the pricing of network services is done according to different principles. In the Nordic countries, a so called point tariff principle is applied, which means that the network charge is basically indifferent of the market participant's geographical location within the network. In Russia, the costs of network services are not considered separately; instead, they are implemented in the nodal prices of electricity, and they can vary in accordance with the market participant's geographical location.

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