



Rinat Abdurafikov

Russian electricity market

| Current state and perspectives

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Title Russian electricity market Current state and perspectives		
Abstract <p>The Russian electricity market is currently in transition. The restructuring of the sector has been completed and former public vertically integrated monopolies have been unbundled and partly privatised. The government retained control in all the network companies, the system operator, nuclear generation, and hydro generation. The state retains control also via ownership in several TGCs and WGCs in the strategic regions of Moscow and Saint-Petersburg via the state owned gas monopoly Gazprom.</p> <p>The liberalization takes place within two price zones, Europe and Siberia, where more than 90%, 913 TWh in 2007, of Russian electricity consumption takes place. In the rest of Russia, e.g. the Far East and isolated areas like Kaliningrad, electricity is supplied at regulated rates.</p> <p>Only a minor part of electricity in the price zones is currently traded at free prices. The share of electricity traded at free market prices will increase according to the liberalization schedule, reaching ca 90%, all except households, by 2011.</p> <p>Wholesale electricity market bids are aggregated in a detailed power system model of the Russian power grid, taking into account the physical locations of the facilities. The resulting 7700+ nodal market prices, scattered across the 7 time zones of the Russian market area, capture costs of congestion and load losses in the grid. The price level of electricity seems to be rather low at a glance – about 21€ and 15€ per MWh in Europe and Siberia respectively. On the other hand, wholesale market buyers have to pay for capacity availability, on average around 3000€/MW monthly.</p> <p>With greater share of electricity traded at free prices there will be an increased need to hedge price risks. For this reason a financial market is planned. There are also plans for support schemes for renewable generation and to limit environmental pollution as well as ancillary services markets. Some areas do not experience a likewise opening of the competition in Russia, for example the fuel markets. Almost all natural gas is supplied by a single vertically integrated company, coal markets are local and oil has always been used only as a back-up fuel.</p>		
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Preface

This report contains the research results related to future development trends in the Russian electricity markets. The research behind this study was done by VTT Technical Research Centre of Finland (VTT). The topic is included in the subtask concerning electricity market development in the research project “SEKKI – The Competitiveness of Finnish Energy Industry under Changing Climate Policy”. Results from other subtasks of the SEKKI research project are presented in separate reports and conference articles. The main results of SEKKI are in addition presented in a summary report.

The SEKKI research was carried out as a joint research project of VTT, MTT Agrifood Research Finland (MTT) and the Bank of Finland Institute for Economics in Transition (BOFIT). The coordinating partner was VTT. The research was part of Climbus-programme by Tekes, the Finnish Funding Agency for Technology. SEKKI was financed by Fingrid Oyj, Fortum Oyj, Gasum Oyj, Metso Power Oy, the Federation of Finnish Technology Industries, Ministry of Foreign Affairs of Finland, ÅF-Consult, VTT and MTT in addition to Tekes.

The coordinators and responsible managers of the joint research project were Technology Manager Sanna Syri (until 30.9.2008) and Vice President, R&D Kari Larjava (since 1.10.2008). As project manager served Senior Research Scientist Tiina Koljonen from VTT. Responsible manager of MTT’s subproject was Senior Researcher Katri Pahkala and of BOFIT’s subproject Research Supervisor Iikka Korhonen. Chairman of the project’s advisory board was Risto Lindroos (Fingrid). Members of the advisory board were Marjatta Aarniala (Tekes), Björn Ahlnäs (Gasum), Timo Airaksinen (the Federation of Finnish Technology Industries), Karoliina Anttonen (Ministry of Foreign Affairs of Finland), Pekka Järvinen (ÅF-Consult), Pirjo Peltonen-Sainio (MTT), Matti Rautanen (Metso Power), Eero Vartiainen (Fortum), Pekka Sutela (BOFIT), Satu Helynen (VTT), Kari Larjava (VTT), Sanna Syri (VTT) and Tiina Koljonen (secretary, VTT).

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February 2009

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List of Symbols

UPS, IPS – Unified Power System, Interregional Power System

HVDC – High Voltage Direct Current

TGC, WGC – Territorial Generation Company, Wholesale Generation Company

FGC, UNEG – Federal Grid Company, Unified National Electric Grid

ES, GS – Energy Strategy, General Scheme

MC – Market Council

ATS – Administrator of the Trading System

M&A – Mergers and Acquisitions

RAB – Regulated Asset Base

FAS, FTS – Federal Antimonopoly Service, Federal Tariff Service

LMP – Locational Marginal Pricing

FBCE(C) – Free Bilateral Contract on Electricity (and Capacity)

HGC, HCS – Hourly Generation Schedule, Hourly Consumption Schedule

RC, RV, BV – Regulated Contract, Regulated Volume, Basic Volume

DAM – Day Ahead Market

BM – Balancing Market

CCL – Consumers with Controlled Load

RES – Renewable Energy Sources

RGC – Regional Generation Company

TPP, HPP – Thermal Power Plant, Hydro Power Plant

1. Introduction

During the past decade deregulation in electricity sector has become a worldwide tendency. Introduction of market mechanisms and competition into the spheres of electricity production and sales, despite of technological complexities and opposition, was acknowledged to be the most economically efficient way of the sector's functioning for the society. However, power supply reliability and security considerations call for strict observance of engineering standards and practices, while due to existence of natural monopolies, inelasticity of demand, purposes of attaining strategic targets and variety of other reasons, market regulation and supervision are required. The electricity markets, although having very much in common, could differ one from another in terms of rules and practical arrangements. This paper describes the main aspects of Russian electricity market design.

For years power supply service had been provided by a vertically integrated monopoly, which dissolved in the course of restructuring in the mid 2008. Nowadays there are plenty of generation companies serving the needs of economy. Although the target structure of the sector has been attained, gradual liberalization of electricity prices is still underway. The overall goal of the reform in Russia was to improve efficiency of the sector and to attract private investors.

The report begins with a brief overview of Russian electricity sector – structure of the main grid, generation capacities, electricity consumption forecasts as well as the new organizations and companies appeared as a result of the reform. Chapter 3 is devoted to state planning and contain information on energy strategy, regulating authorities and their roles as well as mechanisms which have an impact on functioning of the wholesale electricity and capacity payments markets, outlined in Chapter 4. Fuel markets, final end-customer electricity price components, such as regulated tariffs, costs of supporting the development of generation based on renewable energy sources are discussed in Chapter 5. This report is supplemented with a number of appendices containing additional information and details.

2. Russian electricity sector

2.1 Structure and operation of power grid

Historically development of the Unified Power System (UPS) of Russia has been a gradual process in a course of which regional power systems are integrated into Interregional Power Systems (IPS), with further interconnection of the latter ones (as a rule, by means of long-distance overhead lines). Nowadays there are 6 self-balanced IPS operating in parallel¹ which makes transfer of electricity over 6 time zones possible. The seventh, IPS of the Far East, operates separately with alterable² break point located on 220 kV line connecting regional power systems of Chita and Amur regions. Such an integration, besides of improved reliability, brings certain economic advantages – less total generation capacity is needed thanks to smoother aggregated load curve and lower amount of reserve capacity needed at overhaul periods; ability to extended use of the cheapest remote power plants and a possibility to increase sizes of single generation units thus increasing their fuel efficiency.

¹ IPS of North-West, Centre, Middle Volga, Urals, South and Siberia.

² The break point is located in Amurenergo (normally) or Chitaenergo (in case of power shortage in Chita region).



Figure 1. Interregional Power Systems.

In 2007 electricity producers of centralized power supply area served customers with aggregate consumption share of ca 98 per cent of the total. [1] The UPS of Russia has extensive links with neighbouring countries, especially with power system of Baltic States, Belarus, Ukraine and Kazakhstan. Insignificant amounts of electricity are exported to Norway, Mongolia and China. To Finland electricity is exported mainly via back-to-back HVDC converter station; another operational DC link connects IPS of South with Donbas area in Ukraine³. UPS of Russia integrates power systems of Baltic States and CIS-countries providing frequency regulation services.

2.2 Electricity consumption and age structure of power plants

After USSR collapse, followed by economic downturn and slump in consumption of electricity, – investments in the sector fell, new generation capacities were not needed and modernization of the generation facilities was slow. Electricity sector remained a vertically integrated monopoly with all the inherent inefficiencies.

³ 800 kV DC overhead line Volga hydro power plant – substation Mikhailovka.

2. Russian electricity sector

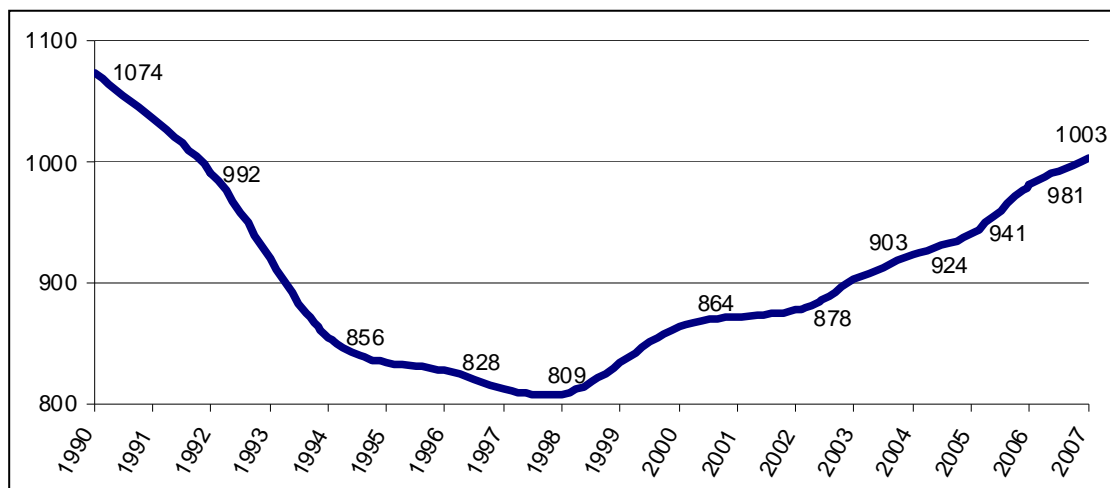


Figure 2. Russian electricity consumption (domestic supply), TWh [1, 2].

The growth of electricity consumption, ageing capital assets predetermined the need for huge investments in the electricity sector to sustain appropriate quality and security of supply. Other reasons for restructuring of the electricity sector were poor technological parameters (e.g. fuel rate, that could affect competitiveness of Russian enterprises via fuel cost component in the price of a final product), low pay discipline, closed market access. Deterioration problem still persists – on average power plants' equipment is around 30 years old. The age structure of installed generation capacity in Russia as of 01.01.2007 is presented on Figure 3.

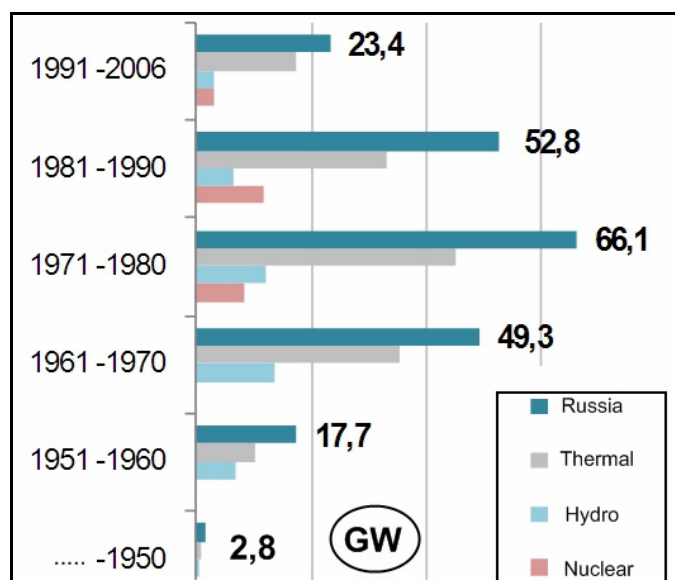


Figure 3. Breakdown of installed generation capacity by type and commissioning year.

As of 01.01.2007⁴ the total installed capacity of Russia amounted to 220.9 GW, of which centralized supply area (UPS of Russia) accounts for 210.8 GW [2], of which hydro – 44.9 (21%), nuclear – 23.5 (11%) and 142.4 GW of thermal power (gas and coal 40 and 28 per cent respectively) [3]. Development of remaining capacity based on expected retirement of aged generation equipment is shown in Figure 4 below.

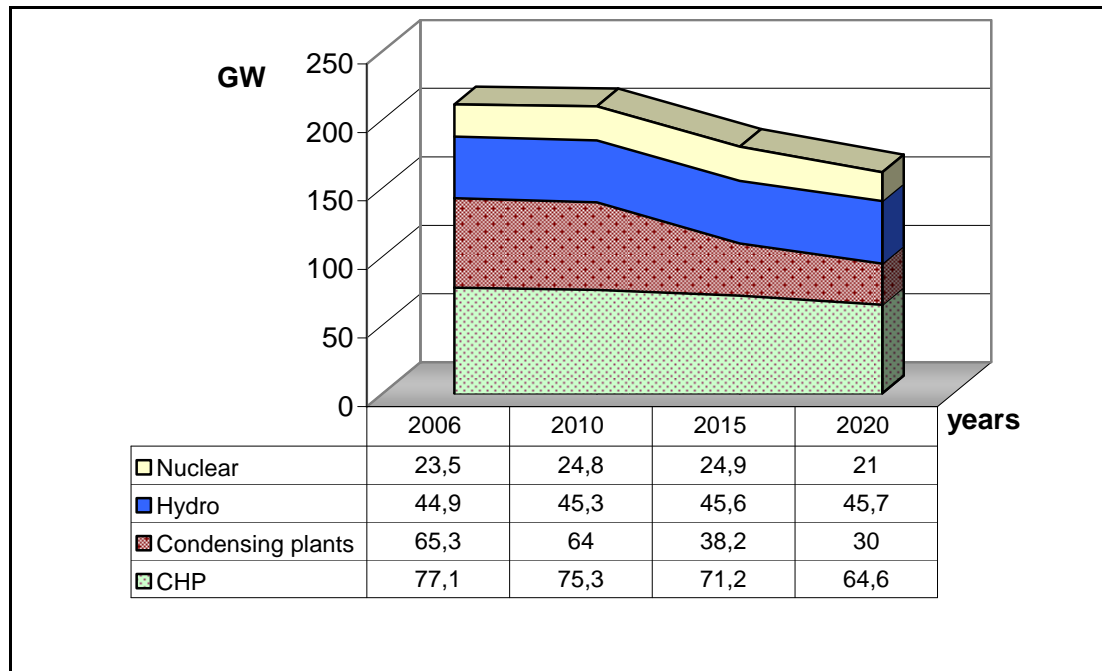


Figure 4. Dynamics of remaining generation capacity by type [3].

2.3 Electricity sector reform

In order to address the problems of electricity sector and improve its efficiency, the government of Russia launched power sector restructuring. The official date of the beginning of the reform is March 26, 2003 when a set of laws was signed by the president. It took several years to restructure 73 “Energos” of the RAO UES (former monopoly) and approach the target configuration, to form generation and supply companies that would become private and compete on the wholesale market. The government retained control in all the network companies, System Operator, nuclear (Rosenergoatom) and hydro generation companies (RusHydro⁵). In the process of restructuring RAO’s thermal power plants 6 Wholesale (formed of large-scale plants)

⁴ As of 01.01.2008: Russia – 215.4 GW, UPS of Russia – 210.0 GW; commissioning of new capacity during 2007 – 2087.9 MW [4].

⁵ Formerly known as HydroWGC.

2. Russian electricity sector

and 14 Territorial (rest of the power plants of several adjacent “Energos”) Generation Companies (WGCs and TGCs) were created. The power plants which were included in a certain company had been selected so as to limit the possibilities of wielding market power on liberalized electricity market. This predetermined application of an extraterritorial principle when forming the WGCs, which means that each of them represent an association of several large-scale power plants, located in different regions. Another requirement was to ensure comparable starting conditions on the market (in terms of installed capacity, average deterioration rates and age of the equipment, expected profitability, etc.). The TGCs besides of electricity production are also involved in heat supply.

The network companies mentioned above are 12 Interregional Distribution Companies and Federal Grid Company (FGC), which operates the Unified National Electric Grid (UNEG). Criteria for attribution of network assets to the UNEG set out by government⁶ are the following:

1. Cable or overhead power lines of 330 kV or higher designed⁷ voltage levels;
2. Power lines of 220 kV designed voltage which:
 - Connect power plants of market participants to UNEG
 - Interconnect regional power systems of Russia
 - Connect aggregate load of 125 MVA and above to UNEG
 - Interconnect the lines listed above
3. Cross-border power lines
4. Substations, connected with the above listed lines except for those owned by generating companies.

⁶ Regulation 41 of 26.01.2006.

⁷ There are power lines operating at lower than designed voltage level for various reasons.

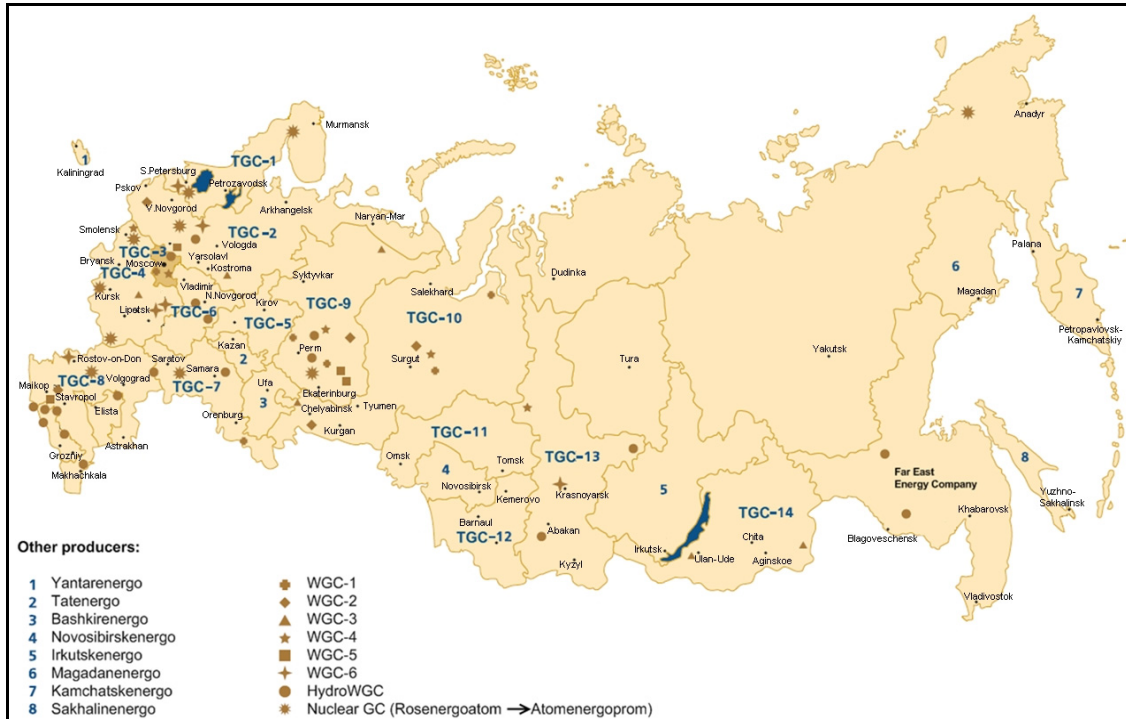


Figure 5. Locations of TGCs, power plants of WGCs, nuclear generation company, ter. ritories served by independent “Energos” (denoted 2-5) and remote territories (1, 6-8).

The investment phase of the reform started on August 7, 2006 when RAO UES approved its first 5-year investment programme for years 2006–2010. [5] There were formed lists of projects concerning investments in modernization of existing facilities and new construction. In order to ensure implementation of the investments programs, the formed generation companies were obliged to sign so-called “agreements on capacity provisioning” prior to going public. These agreements provide for considerable penalties in case significant⁸ shifts in the implementation occur and at the same time secure⁹ sale of these capacities on capacity payments market. However such a control over strategy of a generation company concerns only a part of their investment programs, and aims to earmark the funds obtained from sales of shares belonged to the Russian Federation for implementation of the short and medium term projects (to be accomplished mainly by 2011), considered as feasible and important for economic development of the country. Starting from 2011, the generation adequacy should be guaranteed through mechanisms provided for by target model of capacity payments market (Section 4.3.2).

⁸ 1-year delay is allowed without paying penalties.

⁹ It is guaranteed that the capacity constructed within 5-year investment programmes passes capacity auctions during 10 years after commissioning.

3. Centralized planning in power industry

Electricity is regarded as an absolute necessity in a nowadays society, being one of the key factors for economic development of a country. High importance of power supply reliability is proven by values of lost load, which sometimes estimated to more than 100 times of ordinary electricity price. Besides the risk of generation capacity deficiency, there is another risk – poor diversification of power plants’ fuel mix, or preference to a single type of fuel, which has to do with national energy security concerns.

On July 1, 2008 the former monopoly RAO UES of Russia ceased to exist as a centralized control centre for various associate companies. By 2011 all the electricity, except for households’ consumption, which hovers around 10%, will be traded on liberalized wholesale electricity market¹⁰. Immature electricity market, existence of public companies, involved in electricity transmission (FGC) and production (RusHydro and Rosenergoatom), necessitates long-term state planning in order to satisfy growing demand for electric energy.

To date, several long and medium term programs have been devised, among them the most prominent are:

- Energy strategy of Russia for the period of up to 2030 (to be accomplished by end 2008) [6]
- Target vision of Russian power industry development for the period of up to 2030 (RAO UES, 2006) [7]
- General Scheme for the Installation of Electricity Industry Facilities until the year 2020 (adopted in February, 2008) [3]
- Fundamentals of engineering policy for the power industry of Russia until 2030 (June, 2008) [8]
- RAO UES of Russia Investment Programme for 2008–2012 [9].

¹⁰ In regions, listed in Appendix B.

There are other programmes exist, such as those concerning development of nuclear and hydro power industries¹¹, but they seem to losing their relevance due to adoption of the listed above. Levels of electricity consumption, assumed by several of the programmes are shown in Table 1.

Table 1. Forecasts of electricity consumption in Russia, TWh [3, 7, 11, 12].

	2010	2015	2020	2025	2030
Energy strategy-2030					
“Energy resources” scenario	1075	1210	1375	1510	1750
“Innovative economy” scenario	1090	1230	1480	1725	2000
General Scheme-2020					
“Baseline” scenario	1197	1426	1710	-	-
“Maximum” scenario	1260	1600	2000	-	-
Target vision for power industry-2030					
Target vision-2	1120	1366	1700	-	2090
Target vision-3	1131	1442	1900	-	2950
Concept of long term economic development-2030					
“Business as usual” scenario	-	1259	1408	-	1704
“Energy resources” scenario	-	1380	1650	1925	2190
“Innovative economy” scenario	-	1365	1640	1900	2150

3.1 Energy strategy

Energy strategy (ES) for the period until 2020 [10] that is currently effective (adopted in 2003), determines long-term state energy policy. The aim of energy policy is “to maximize utilization efficiency of natural energy resources and energy sector potential for the growth of economy and population living standards”. The strategy implements policy guidelines such as energy security, environmental safety, energy efficiency etc. A number of numerical parameters of the ES-2020 turned out to be outdated already in 2005¹², and a new ES-2030 is to be elaborated by the end of 2008.

According to the ES-2030 concept [6], the main strategic goals in power and heat industries (besides common supply reliability, efficiency and sustainable development

¹¹ Federal programmes named Development of nuclear industry of Russia for 2007–2010 and outlook until 2015 and Development programme for hydropower industry of Russia for the period of up to 2020 and outlook until 2030.

¹² During 2000–2005 GDP growth amounted to 34,7% (expected max. 27%); production of primary resources overreached expected values by 4,4% (oil – 5,4%, gas – 3,7%, coal – 6,4%, electricity – 1,7%); internal consumption of primary energy resources increased by 6,2% instead of planned 8,2 (energy intensity decreased by 21% vs. assumed 15%); exports of energy resources grew by 43,6% vs. planned 30,9%; slower growth of hydrocarbon reserves vs. production growth; underinvestment (especially in power industry and production of natural gas).

3. Centralized planning in power industry

based on new technologies) are development of the Unified Power System and its integration with other power unions in Eurasia, efficient use of cogeneration, development of decentralized power and heat supply, reduction of environmental impact. In order to achieve the targets, the following is contemplated:

- Completion of electricity sector reform, development of the programme for heat sector reforming; maintaining investment attractiveness;
- Anticipatory (leading) modernization and reduction of assets' deterioration rate in power and heat industries;
- Improvement in load following capability in power industry and reduction in specific fuel consumption in the sphere of thermal power generation;
- Substitution of gas in power industry for coal and nuclear power; deployment of combined-cycle units that would help reduce amounts of gas combustion;
- Generation based on local fuels and renewable energy sources;
- Extension of power lines' capacities.

3.2 The General Scheme

The General Scheme¹³ is a plan containing list of sites and regions to install generation and network facilities of federal level¹⁴ and to provide reliable supply of electrical and heat energy to the economy and population based on consumption forecasts, made for the country and its regions [3]. The main task is declared to be formation of economically efficient structure of generation and network facilities and prevention of forecast power and electricity deficits in a most efficient way. There are two scenarios of electricity consumption upon which the General Scheme relies – baseline and maximum scenario (Figure 6, Table 1, Appendix A).

¹³ General Scheme for the Installation of Electricity Industry Facilities until the year 2020.

¹⁴ All nuclear power plants, thermal power plants of installed capacity ≥ 500 MW, hydro power plants ≥ 300 MW, transmission lines ≥ 330 kV, and electricity networks 220 kV intended for connection of new power plants, tie-lines connecting adjacent power systems and cross-border lines.

3. Centralized planning in power industry

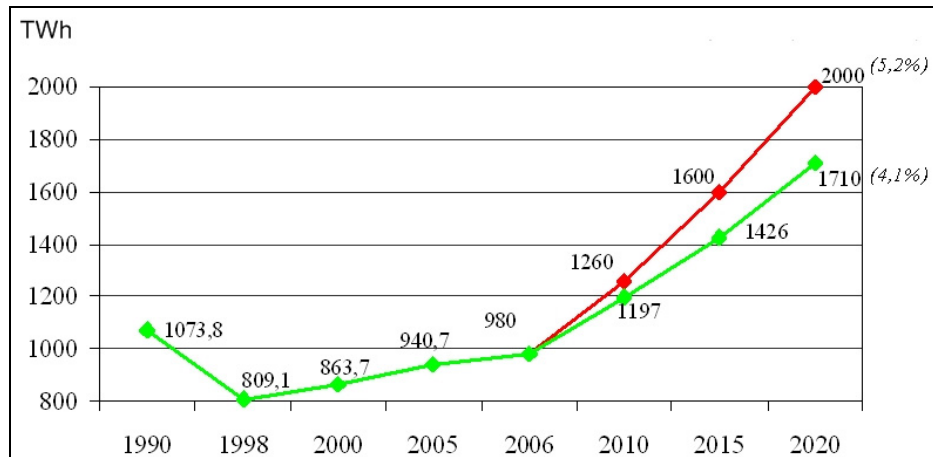


Figure 6. Electricity consumption assumed by General Scheme, TWh (annualized growth 2007–2020 is given in parentheses) [3].

The priorities of the General Scheme comply with ES-2030 policy according to which gas content of power industry fuel mix is to be reduced, through extensive development of nuclear, hydro and coal-fired generation. Efficient structure of generation facilities, assumed by the General Scheme, is given in Table 2.

Table 2. Development of total installed capacity of Russia within centralized power supply area (baseline scenario), GW [3].

Installed capacity / Years	2006	2010	2015	2020
Total, of them:	210,8	243,8	297,5	347,4
1. Hydro	44,9	49,2	57,1	71,7
2. Nuclear	23,5	26,9	38,1	53,2
3. Total thermal power plants:	142,4	167,7	202,3	222,5
1) Total CHP plants, including:	77,1	93,2	107,8	113,7
steam-turbine (gas-and-oil burning)	43,2	43	40,9	36,5
combined cycle and gas turbine	1,1	15,3	27,9	36
steam-turbine (hard fuels)	32,8	34,9	39	41,2
2) Condensing power plants, including:	65,3	74,5	94,5	108,8
steam-turbine (gas-and-oil burning)	37,5	37,3	14,3	6,8
combined cycle and gas turbine	2,7	9,9	30,2	38,5
steam-turbine (hard fuels)	25,1	27,3	50	63,5

3. Centralized planning in power industry

According to the baseline scenario commissioning of 186 GW¹⁵ of generation capacity by 2020 will be necessary taking into account expected phasing-outs. Construction of generation and network facilities will require significant investments. The implied sources of investments are own funds (amortization, profits, for network companies also connection fees) and external funds (bonds or equity offering and loans). Envisaged federal financing corresponds to values budgeted for special-purpose programs. The total of investments in baseline scenario during 2006–2020 amounts to 11616.3×10⁹ RUR (325×10⁹€) in electricity generation and 9078.8×10⁹ RUR (252×10⁹€) in electrical networks (Appendix A).

Forecast growth of electricity production and transformation of total fuel mix will condition demand for fuel. The final decisions concerning choices of fuel for thermal power plants are to be made by investors, and the data in the table below is a preliminary estimate.

Table 3. Fuel need for thermal power plants in baseline scenario, mln t.c.e.¹⁶ [3].

Fuel type/Years	2006	2010	2015	2020
Gas	201	232,4	238,9	241,5
HFO	10,6	13	7,1	6,7
Coal	74,8	101,8	142,2	168,9
Other fuels	8,7	9,6	10,6	10,8
Total	295,1	356,8	398,8	427,9

However, the values of electricity consumption presented in the General Scheme are often said to be overestimated and it becomes more and more apparent. One of the instruments for monitoring of the General Scheme is electricity and power balance forecasting which is performed by specialized agency, which has inherited the task from the former monopoly. In addition System Operator also performs 5 year forecasts. These estimates are made annually and the latest values are shown on Figure 7:

¹⁵ of them 49 GW are CHP plants.

¹⁶ 1 tonne of coal equivalent = 34.1208424 TJ (Russian state committee of statistics, regulation 46 of 23.06.1999) [13].

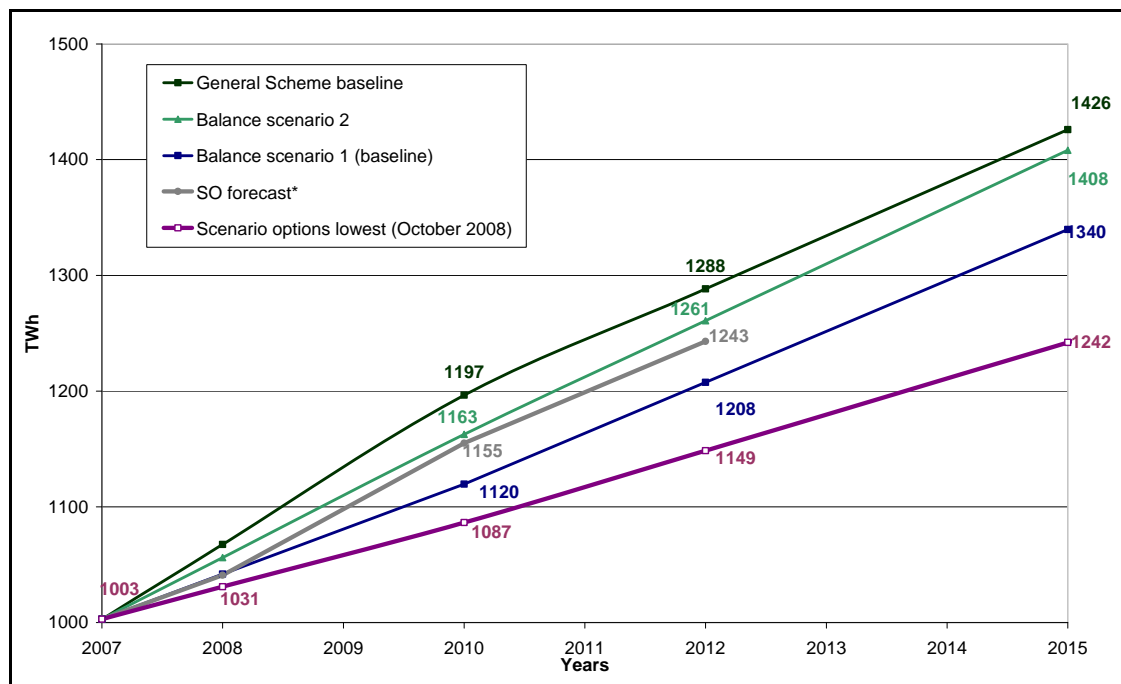


Figure 7. Comparison of medium term electricity consumption forecasts¹⁷ 2012–2015, TWh [3, 14, 15, 42].

3.3 Five-year investment programmes

Development of five-year cumulative investment programmes of RAO UES were based on forecast balances of electricity sector, priority programmes aimed at avoidance of power shortages, etc. The cumulative programmes represent lists of investment projects, containing sites, capacities, implementation dates and information concerning financing (sources and amounts). The latest programme [9] for 2008–2012, based on the General Scheme, envisages capital expenditure of about 120×10^9 € (4375868 mln RUR). Sources and breakdown of the expenditures by business are shown on Figure 8.

¹⁷ The forecast of the system operator is adjusted by 13 TWh, which correspond to annual consumption of isolated territories (see Figure 10) of the eastern parts of Russia [3] for the purposes of proper comparison.

3. Centralized planning in power industry

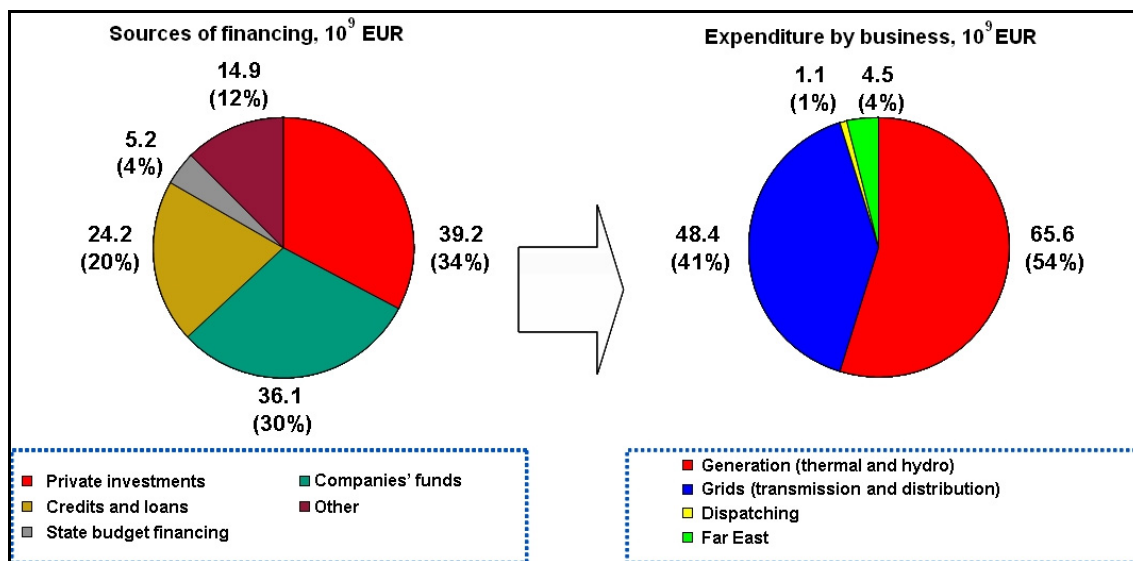


Figure 8. Investment program of RAO UES for 2008–2012 [9, 16].

Expenditures on hydro and thermal generation contemplate construction of over 42.7 GW of generation capacity.

Table 4. Generation capacity to be commissioned in 2008–2012 by generation companies created in the course of electricity sector restructuring, MW [9].

	2008	2009	2010	2011	2012	Total 2008-2012
Thermal	1 725	4 823	11 668	11 464	8 170	37 849
RusHydro	410	155	1 104	1 879	1 371	4 918

In the future, the scope of investment programmes for every generation company will be determined by the results of long-term capacity auctions. Timely and accurate implementation of projects is supervised by the System Operator.

3.4 Mechanisms of state energy policy

There are variety of ways and methods available for the state to exert influence on companies' behaviour, and thus on the development of power industry:

- Economic regulation (tariffs, taxes, duties, price caps, antitrust regulations, etc.)
- Investment support (public-private partnership)
- Technical regulation.

The main authorities, responsible for these functions are presented on Figure 9.

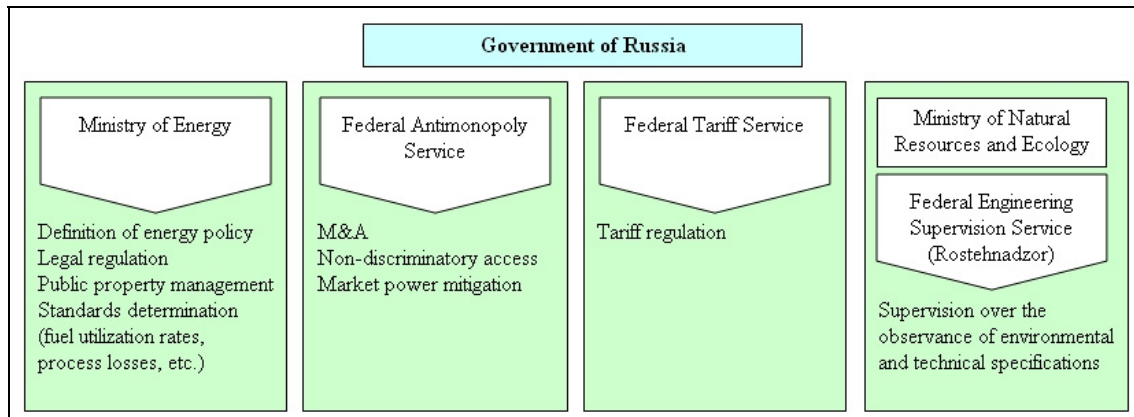


Figure 9. Major government bodies determining the development of power industry.

Further development of the wholesale market is based on self-regulation through increased role of recently established non-commercial organization – Market Council (MC), endowed with considerable powers to control the commercial (ATS¹⁸) and technical infrastructure companies (SO, Federal Grid Company). The MC is a member organization for power industry entities and large-scale consumers of electricity and heat, which works out a common position of the wholesale and retail market agents and elaborates and supervises observance of regulations, governing market functioning.

The concept of long term economic development, published by Ministry of Economy in August 2008 [12] outlines some principles of tariff regulation in the infrastructure sectors of economy. Formation of a new tariff regulatory framework will be finished in 2011–2014. Liberalized share of electricity and capacity payments markets will reach 100% on January 1, 2011. As from 2010 in regulated sectors, such as electricity transmission and distribution (from 2009) a transition to longer periods of regulation (3–5 year tariffs) employing the return of Regulated Asset Base (RAB) method will be accomplished. By 2014 electricity tariffs for households will be raised to economically justified level, assuming that operations related to production, transmission, sale and dispatch are performed with a minimum rate of return. The electricity tariffs for non-price areas¹⁹ will remain regulated for households until 2015–2017, and by 2017 electricity supplies for all the consumers are planned to be liberalized. In addition, gradual transition to net-back pricing method for domestic gas supplies is envisaged. This means that gas prices on domestic wholesale market will be based on the average of export prices net of transmission and sales costs (gas price formula).

In terms of antitrust regulation, the law on power industry [17] determines the dominance threshold on the market. An undertaking is considered as dominant in cases when its share of installed capacity or share in electricity generation in a free electricity

¹⁸ ATS is a short for Administrator of the Trading System.

¹⁹ Regions of Kaliningrad, Arkhangelsk, Komi Republic and Far Eastern Federal District.

3. Centralized planning in power industry

transfer zone²⁰ exceeds 20 per cent. In order to prevent abuse of market power, there is a system of price monitoring on wholesale electricity market. [18] In case electricity prices increase substantially²¹, the ATS examines all the underlying reasons and inform the Federal Antimonopoly Service (FAS) of them. Depending on results of case investigation the following measures may be applied against an undertaking found guilty of electricity prices manipulation:

- State price regulation (tariffs)
- Restriction on prices submitted when bidding
- Introduction of a limitation such as obligation to submit only price-taking bids.

In cases of continuous exertion of market power by an undertaking on wholesale or retail markets, a decision on compulsory unbundling can be taken as a result of an investigation.

Technical regulation of the power industry is based primarily on state technical policy, determining environmental and technological standards of the equipment to be put into operation. In 2008 RAO UES devised Main Aspects of Technical Policy²² [8, 19], which prescribes types of replacing facilities and their specifications, concerning load following capability, fuel utilization rates, emissions of nitrogen, sulphur, particulates and utilization of cooling water.

3.5 Guarantee mechanism

In order to support investments during transitional period of electricity reform, the investment guarantee mechanism was created [20] as a remedy for existing, or forecast significant power shortages in regions of Russia. Investors in the energy projects are selected through a tender process, which results in conclusion of availability contracts between the investor and the SO. The guarantee itself consists of a fixed yearly payments for “services related to formation of perspective capacity reserve” paid during ten years (duration of such contracts) to the investor by the SO, who defrays these costs through its regulated tariff. Participation on capacity payments market is not allowed for these generators and their electricity output is remunerated based on a formula²³, in case

²⁰ Areas of the Unified Power System, where no significant internal congestion exists so that the competitors can substitute each other’s products (electricity and capacity produced by facilities with similar technical specifications), while the possibilities to substitute products in neighbouring areas are restricted to values of transmission limits (Figure 27).

²¹ When equilibrium hourly prices in 10 per cent of nodes in a price zone raise by more than a certain value compared to corresponding hourly prices in previous periods (day and week – by 50 per cent, month and quarter – by 30 per cent) or raise by more than 1.5 of an agent’s regulated tariff.

²² The concept is planned to be revised so as to include issues related to nuclear power industry.

²³ The components of the formula are gas price, calorific value, fuel utilization rate for various operating modes, planned duration of these modes, etc. [21].

natural gas is used as fuel, or fixed price stated in contracts concluded with tenders' winners.

Such method is generally referred to as competitive tendering, and is considered as an exceptional measure²⁴ to be used for maintaining security of supply, as it is believed to discourage investments outside of the scheme. For this reason, the application of the guarantee mechanism in Russia is strictly limited to selected geographical locations, experiencing power shortages, limited in time and volume of capacity to be commissioned (5000 MW in the period of 2006–2010).

²⁴ Also in European Union (EU Directive 2003/54/EC) [22].

4. Wholesale electricity (capacity) market

On Russian wholesale electricity (capacity) market trade in electricity is complemented with trade in capacity and all the agents buying electricity from the wholesale market have to purchase availability of generation capacity (ex ante) – mechanisms of capacity trade are discussed in Chapter 4.3. As for trading in electricity, locational marginal pricing²⁵ (LMP) is used for determination of market agents' traded volumes and these volumes' prices in every location²⁶. In Russian documentation, these locations, which are registered after each of the market agents, are termed supply points or group of supply points, which physically represent points, where equipment is connected to power grid.

4.1 Market agents

In order to obtain a status of a wholesale market agent (participant), there are certain eligibility criteria which must be met. These, besides of others, envisage minimum quantitative parameters, presented in Table 5.

Table 5. Quantitative requirements for entering the wholesale market.

Market Agents	Min. locational	Min. aggregate	Comments
1. Generators	5 MW	5 MW	Installed generation capacity
2. Consumers	0.75 MVA	20 MVA	Connected load
3. Sales companies	0.75 MVA	20 MVA	Contracts on retail market
4. Guaranteeing suppliers	0	0	Contracts on retail market
5. Export/Import operator	0.75/5	20/5	Export/Import contracts

²⁵ Also referred to as congestion pricing, nodal pricing.

²⁶ Locations mean physical places in a power grid (e.g. locations where generators inject power or where consumers withdraw it).

Guaranteeing suppliers²⁷ – are supply companies operating on certain licensed territories, which never overlap, where they serve retail market customers. A Guaranteeing supplier is obliged to enter in a public electricity supply contract with any buyer²⁸, located on a corresponding territory, who requests the service.

Besides the agents, listed in Table 5, who trade on the wholesale market, there are grid companies, whose participation is limited to purchasing certain volumes of electricity and capacity to cover part²⁹ of transmission losses.

4.2 Trading in electricity on the wholesale market

On Russian wholesale market electricity and capacity are traded at regulated and free prices. The territory of the country is split into non-price zones as well as isolated areas, where due to lack of competition electricity is traded at regulated prices³⁰, and two price zones where trading at free prices is possible (Figure 10). The regions of Russia included in price zones are listed in Appendix B.



Figure 10. Price and non-price zones.

²⁷ Also known as suppliers of last resort.

²⁸ Except for the cases when the buyer is an energy sales company breaking payment obligations.

²⁹ The remainder losses are accounted in nodal prices and regulated contracts.

³⁰ There are limited power flows between the territories of price and non-price zones. Market agents, located on the territory of a non-price zone participate in trading with agents located in price zones within limits of these power flows (100% of the flow accounted in yearly forecast balance – by regulated contracts, the rest is purchased or sold at free prices in a price zone).

4. Wholesale electricity (capacity) market

Wholesale trading at regulated prices is carried out employing a system of regulated contracts concluded between the market agents, while remaining uncontracted volumes of electricity are traded at free prices on day ahead, balancing and free bilateral contracts markets.

4.2.1 Trading at regulated prices

Yearly tariffs for power industry enterprises are set by Federal Tariff Service (FTS) and regional regulators. The process of tariff calculation requires knowledge concerning volumes of service provided by every enterprise on the market so as to divide their “costs plus profits”³¹ by these volumes thus obtaining tariff per unit of service or commodity. In order to determine the volumes, tariff regulator uses forecast balance of electricity production and supply³², based on information collected from market participants as well as local authorities, system operator and grid companies. Besides of tariffs, the forecast balance yields volumes of monthly electricity production and generation capacities for producers while for consumers – monthly total and peak consumption. These volumes are used not only for tariff-setting purposes, but also serve as a departure point in setting volumes traded on capacity payments market and in the process of trade liberalization. The allocations planned for 2007 by market agent are used in determination of their *basic volumes of electricity*.

A wholesale buyer’s basic volume of electricity equals his allocation increased by 3 per cent, and for producers it is determined so as to cover buyers’ basic volumes:

$$V_{Basic\ Electricity}^{Buyer} = V_{FTS-2007\ Electricity}^{Buyer} \times 1,03 \quad \sum V_{Basic\ Electricity}^{Buyer} = \sum V_{Basic\ Electricity}^{Producer}$$

The 3 per cent of increase is introduced in order to include transmission losses³³.

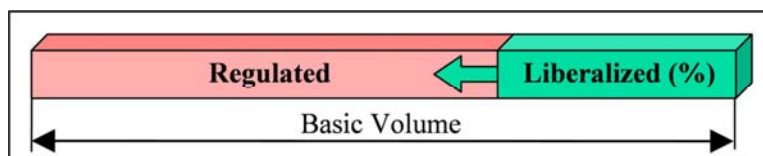


Figure 11. Reduction of volumes traded at regulated prices.

Liberalization of trade on the wholesale and retail markets is based on gradual reduction of regulated volumes, as shown on Figure 11, according to the following liberalization schedule, which however, is not applicable to households’ consumption:

³¹ Minimum gross receipts, necessary for proper operation of an enterprise.

³² FTS-balance – consolidated forecast balance for production and supply of electricity and capacity within the unified power system of Russia by regions (Appendix C).

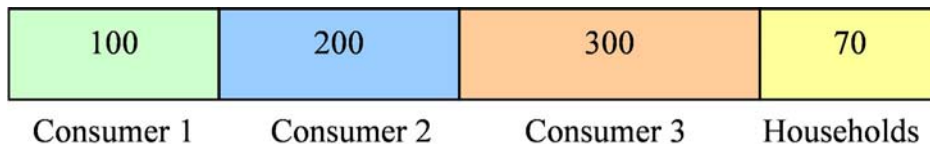
³³ This part is excluded from network operators’ transmission tariffs.

Table 6. Liberalization of the regulated volumes.

Periods (dd/mm/yyyy)	Max and min shares of regulated volumes in the basic volume
until 31.12.2008	70 – 75%
1.01.2009–30.06.2009	65 – 70%
1.07.2009–31.12.2009	60 – 65%
1.01.2010–30.06.2010	35 – 40%
1.07.2010–31.12.2010	15 – 20%
1.01.2011–31.12.2014	households' consumption ³⁴

As a result, minimum and maximum regulated volumes are established. The maximum regulated volume comprises current year's volumes allocated to households.

Example 1. Let us consider an example where an energy sales company is serving a number of retail market consumers and a number of households³⁵. Suppose the company's planned volume for November, 2007 amounted to 650 units of which 68 corresponded to households. Increased by 3 per cent these volumes would total approximately 670 units:



Then, for the same month of 2008, provided that households' consumption increased by 10 units, the maximum regulated volume for the energy sales company equals:

$$V_{Reg}^{MAX} = (670 - 70) \times 0.75 + 70 + 10 \times 1.03 = 540.3$$

All the regulated volumes are traded by regulated contracts³⁶. The scope of regulated contracts is not limited to electricity – capacity is an integral part of them³⁷. A typical regulated contract contains hourly schedule of electricity, monthly value of capacity and

³⁴ Annual forecast balance also accounts households' consumption. For the period 2011–2014, these volumes will be set by the corresponding yearly FTS balances and will be supplied under regulated contracts by generators, appointed by the government, to guaranteeing suppliers. However, the amount of electricity delivered under such contracts by a single producer is limited to 35 per cent of its total production in 2010 [23].

³⁵ Not necessarily physically served households, it could also include households' consumption of this energy sales company's clients.

³⁶ Sometimes referred to as vesting contracts.

³⁷ Formation of regulated volumes of capacity is discussed in section 4.3.1.

4. Wholesale electricity (capacity) market

locations of the counterparts. Prices on electricity and capacity delivered under such contracts are always set equal to generator's tariff – that's why they were called regulated contracts. As from 2008, generators' tariffs are calculated by way of indexing the ones set for a preceding year applying public formulae which establish dependency of prices on forecast inflation, fuel prices, water taxes for hydropower plants, etc., as well as account deviations of actual values from forecast (ex post).

As all the financial settlements concerning electricity on the wholesale market are based on hourly volumes there is a need to determine hourly volumes sold or purchased at regulated prices. For this purpose, the basic volumes of electricity are distributed by hours of a year using statistical data by way of splitting the year into 60 typical periods defined by approximately similar loads and content of dispatched generation equipment.

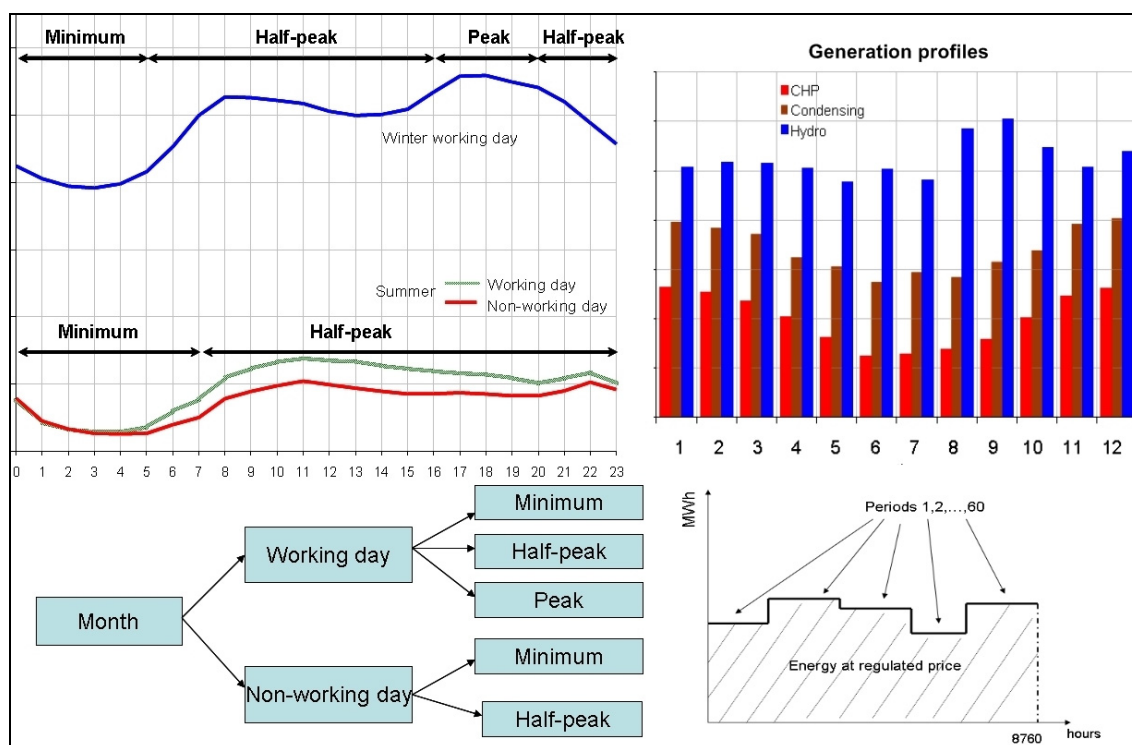


Figure 12. Typical periods.

Eventually, after hourly regulated volumes have been defined, market operator determines counterparties to regulated contracts and volumes traded. During the matching process technical and cost constraints are taken into account. Technical constraints could be briefly explained as observance of instantaneous power balance guaranteeing that regulated volumes are supplied sufficiently at every instant of time. The sufficiency of supply is ensured in every typical period by accounting firm power³⁸

³⁸ Firm power is estimated using statistical data of minimum hydro power plant's output, combined cycle output of CHP plants, planned overhauls and amounts external of power flows (e.g. export contracts).

of the suppliers. The cost constraints of matching secure energy sales companies from losses when selling regulated volumes on retail market at regulated end-user's tariffs.³⁹ The federal tariff regulator (FTS) sets so-called indicative (reference) prices⁴⁰ of electricity and capacity purchased on the wholesale market which are used in the process of matching. The economic criteria is that under a whole set of regulated contracts in a given year a buyer's aggregated outlays on electricity and capacity should not exceed aggregated costs of these volumes determined at indicative price on electricity and at indicative price for capacity respectively.

As a result of the matching process every market agent, who trades at regulated prices, obtains a portfolio of regulated contracts:

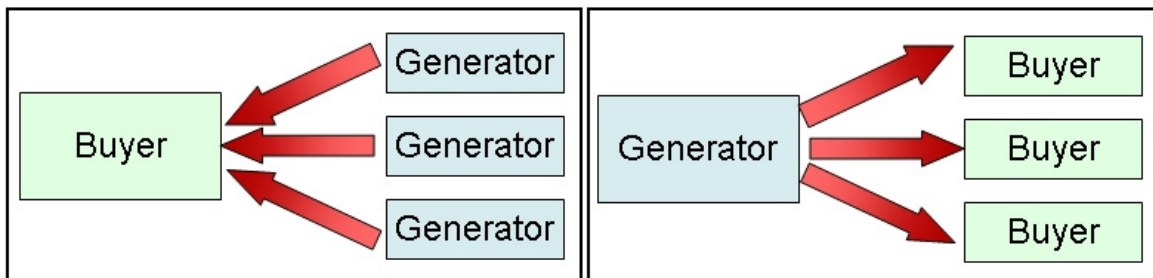


Figure 13. Portfolios of regulated contracts.

The buying parties are allowed to reduce their regulated volumes of electricity and (or) capacity within the range of minimum and maximum values⁴¹ – in this case the volumes under each regulated contract from the buyer's portfolio are reduced proportionately, or from only those contracts concluded with generators with whom an agreement was reached⁴². Such a voluntary change is taken into account on the following steps of liberalization – maximum regulated volume for this buyer is decreased by volume of the reduction.

Example 2. Let us again consider the same energy sales company (see Example 1). Suppose it has a portfolio of regulated contracts for its total regulated volume of 530 electricity units, which has been established in the course of matching, concluded with 3 generators as shown on Figure 13 (left) for 30, 200 and 300 units of electricity, and 10,

³⁹ A lesson learned from California electricity crisis, see Figure 37.

⁴⁰ Indicative prices significantly vary by region, for 2008 within the range from 75 to 1050 RUR/MWh (approx. 2–29 €) for electricity and from 44kRUR/MW to 545kRUR/MW (1200–14900 €) for monthly capacity payments.

⁴¹ In the example of energy sales company the range is 500.3 to 540.3 units (70 and 75 per cent respectively).

⁴² In cases of voluntary reductions a generator's regulated volumes should remain within minimum and maximum limits.

4. Wholesale electricity (capacity) market

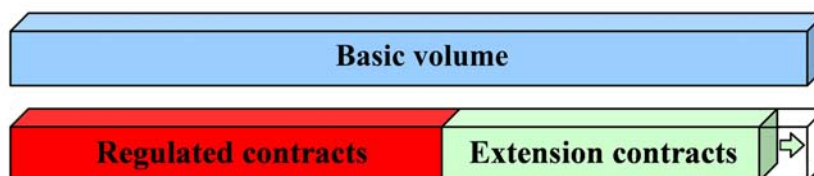
90 and 500 units of capacity respectively (see Figure 14). Suppose the minimum regulated volume of capacity for the period is 400.

Electricity				Capacity			
Gen 1	Gen 2	Gen 3	ΣEnergy	Gen 1	Gen 2	Gen 3	Σcapacity
Original contracts:							
30	200	300	530	10	90	500	600
Decision: reduce total amount of electricity by 2 per cent:							
29,4	196	294	519,4				
Agreement with G1 reached - reduction of electricity by 10 units:							
19,4	196	294	509,4				
Agreement with G2 - reduction of electricity by 5 units, and capacity by 50:							
19,4	191	294	504,4	10	40	500	550
Total of voluntary reduction of regulated volumes:							
			25,6				50
Reduction by agreements							
10	5				50		

Figure 14. Example of voluntary liberalization.

Ultimately, for the energy sales company in the following period (in November 2009) the maximum regulated volumes determined as in Example 1, will be further reduced by 25.6 units of electricity and 50 units of capacity.

Besides of that, the buyer and supplier may enter into free bilateral contracts on electricity (FBCE) and (or) free bilateral contracts of electricity and capacity⁴³ (FBCEC) – within agreed volumes of reduction. These free bilateral contracts are often referred to as “extension contracts”:



In Example 2 the energy sales company can contract for up to 10 and 5 units of electricity with generator 1 and generator 2 respectively, or can contract FBCEC with generator 2. Delivery of the capacity under FBCECs within values of reductions is guaranteed from technical point of view, since instantaneous power balance was considered when matching counterparts to regulated contracts.

⁴³ These contracts are somewhat similar to regulated contracts whereas both electricity and capacity are traded, although amounts and prices are determined by the parties. The FBCECs are further discussed in section 4.3.1.3.

For certain qualifying buyers regulated volumes can be delivered under long-term regulated contracts.⁴⁴ A wholesale market buyer qualifies for long-term regulated contracts if his locational connected load is at least 4 MVA and automatic metering systems meet technical specifications (which until September 2010 are not strict for other buyers). Besides of qualifying buyers, there are 15 large-scale industrial consumers (e.g. 8 aluminum plants) supplied under long-term regulated contracts⁴⁵. All the long-term contracts are taken into account in a process of matching counterparties to yearly regulated contracts.

Electricity under regulated contracts is delivered on “take or pay” principle, which means that a generator should either produce it or purchase the remainder at free market price.

Although locational pricing is discussed only in the following sections, it has been mentioned already that it results in hourly locational prices as well as volumes determined for agents registered in these locations. For generators these volumes are called hourly generation schedules (HGS), and for buyers – hourly consumption schedules (HCS).

Example 3. Let us again, by way of example, examine participation of the same energy sales company on the wholesale market in a given hour when its total regulated volume is 100 MW to be supplied under 3 regulated contracts (RCs) – 5, 40 and 55 MW. These volumes are supplied at generators’ tariffs (20, 10 and 15€/MWh). In the process of day-ahead market clearing locational prices and buyer’s scheduled consumption for the hour in question were determined. Then two alternatives are possible – hourly regulated volume (RV) is either more or less than hourly consumption schedule (HCS). Financial settlements, arising in both cases are shown on Figure 15. Financial settlement of all the transactions is performed by market operator (ATS).⁴⁶

⁴⁴ In such cases the whole portfolios should consist of long-term contracts; qualification requirements are set by former Ministry of Industry and Energy (order 135 of April 23, 2007).

⁴⁵ The list of these buyers is approved by special government resolution 1802 of December 22, 2006.

⁴⁶ When entering the wholesale market, agents authorize the market operator to perform the transactions on their behalf.

4. Wholesale electricity (capacity) market

	RC 1 (Generator 1)	RC 2 (Generator 2)	RC 3 (Generator 3)	Comments
Buyer' regulated volume (RV), MW	5	40	55	Total = 100 MW (100%)
Generators' tariffs	20 €	10 €	15 €	Prices in RCs
Prices at generators' locations	50 €	40 €	5 €	Locational prices determined on day ahead
Price at buyer's location	55 €			
Buyer pays to generators (take or pay)	100 €	400 €	825 €	Total = 1325€
Possibility 1: RV<HCS				Suppose, HCS=120 MW
Buyer purchases 120-100=20 MW in its own location and pays 20×55€=1100€				
				Result: 120 MW purchased, 1100€+1325€=2425€ paid
Possibility 2: RV>HCS				Suppose, HCS=80 MW
Buyer sells 100-80=20 MW back to generators at their locations (in keeping with volumes under regulated contracts)				
Buyer sells to generators	1 MW (20MW×5%)	8 MW (20MW×40%)	11 MW (20MW×55%)	20 MW sold back
Buyer receives from generators	50,00 €	320,00 €	55,00 €	Total=425€
				Result: 80 MW purchased, 1325€-425€ paid

Figure 15. Financial settlement of regulated contracts from buyer's point of view.

The settlement process of generators' regulated contracts is similar. When $RV < HGS$, the generator buys the difference in his own location. Otherwise, (when $RV > HGS$) the generator sells the difference proportionately in locations of his counterparties to regulated contracts.

All the differences between scheduled and regulated volumes of electricity can be traded not only at competitive locational prices determined on day-ahead market, but also by means of free bilateral contracts (FBCEs and FBCECs).

4.2.2 Locational marginal pricing

Naturally, prices of electricity differ by locations, since costs of production vary from one power plant to another and possibilities for electricity transport are limited (which is especially true for Russian power system). Moreover, there are losses of electricity, which take place in a process of electricity transmission. One of the benefits of locational pricing is that it reveals costs of congestion, which allows for even better allocation of grid investments and also forms market signals for investments in new capacity (since, other factors being equal, it would be profitable to build a generation facility in a location where market price is higher).

Determination of locational prices calls for centralized computation, which is performed employing a mathematical computational model which in turn relies on a circuit diagram representing elements of the power system.

The computational model [24] of the power system is used to calculate physically realizable volumes of electricity production and consumption, and their corresponding prices. The model used in Russia accommodates the following set of data:

1. circuit diagram of the power system (110–750 kV)
 - a. power lines and their transmission limits⁴⁷
 - b. generators connected to the switchgears
 - c. external parameters (elements outside of Russian power system)
2. parameters and modes of power consumption⁴⁸
3. parameters and modes of operation for generation equipment
 - a. rated, maximum available and minimum power output
 - b. generation ramping parameters⁴⁹
4. system conditions
 - a. limits in power flows in cross-sections
 - b. reserve requirements (e.g. amount of spinning reserve⁵⁰)
 - c. other limitations, such as technical requirements on nodal values of voltage and reactive power
 - d. integral production limits⁵¹.

In order to take part in a trading process, the market participants submit their hourly bids for every of their locations. However, the locations should not be mixed up with nodes of the computational model. This can be explained by way of example on Figure 16, which represents an imaginary part of the power system and one of the possible⁵² solutions.

⁴⁷ Thermal and contingency limits for 750 kV and only thermal limits for 110 kV.

⁴⁸ Consumption of electricity depends on voltage. In the model $P = \text{const}$, while $Q = f(V)$, where P and Q are active and reactive power.

⁴⁹ Speed at which generator's output can be varied (i.e. $\Delta P/\Delta t$).

⁵⁰ Generators, able to increase their output, which are synchronized with the AC system and therefore the fastest to respond on contingencies.

⁵¹ Integral production limits (i.e. maximum energy production during certain period) are caused by restrictions on primary energy usage – for example, for hydro power plants these could be related to usage of water reservoirs; in Russia there are daily limits set on gas withdrawals from natural gas supply system for every large gas consumer. Excess withdrawals entail penalties (10 or 50 per cent of contract price, depending on a season [25]) for gas consumers.

⁵² Here some reservations are required since configuration and amount of nodes depend on parameters of the power lines connecting the switchgears; in some rare cases the nodes may be tied to locations of generators and consumers at the same time, etc.

4. Wholesale electricity (capacity) market

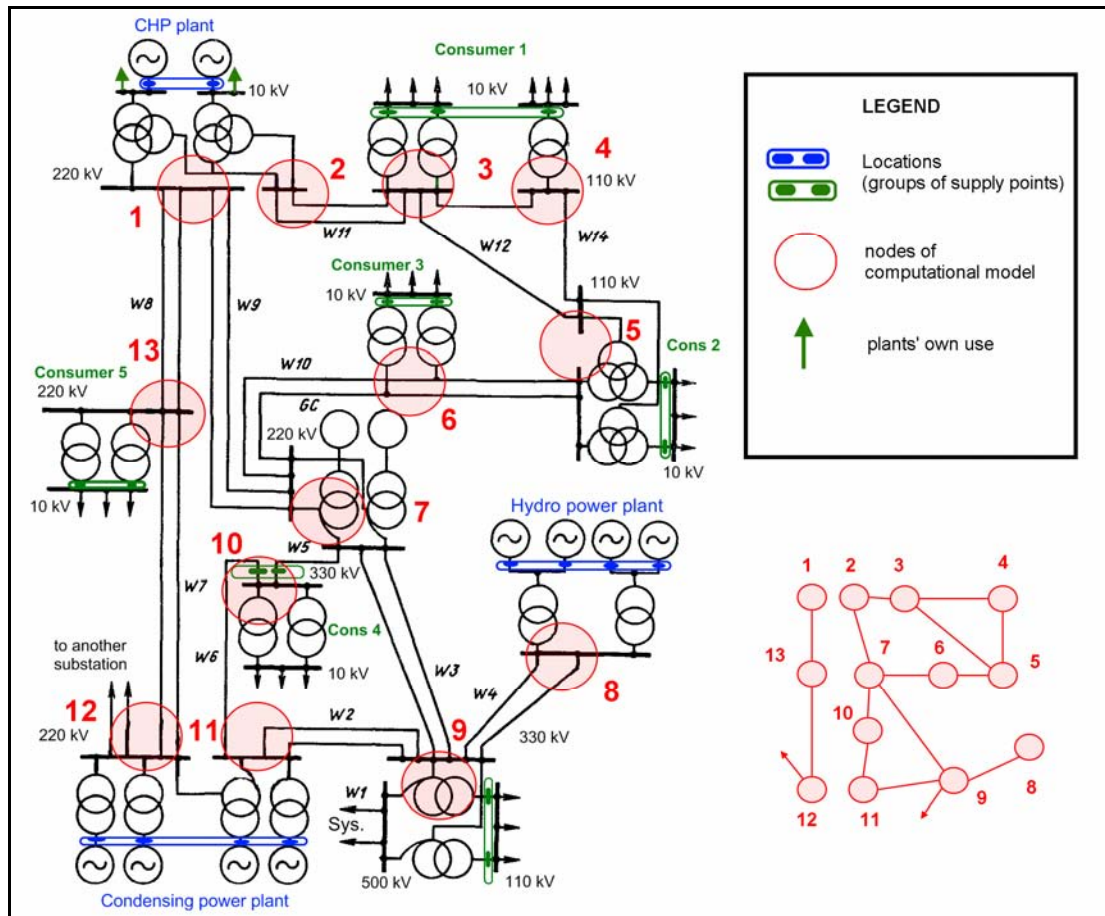


Figure 16. Nodes of the computational model.

As seen from the Figure 16, the condensing power plant's location corresponds to two nodes of a computational model. All the locations are attached to nodes by means of predetermined ratio coefficients, which allows for allocating locational volumes by nodes of the computational model. For example, volumes of power, submitted by the condensing power plant, will be split by nodes 11 and 12, as shown below on Figure 17.

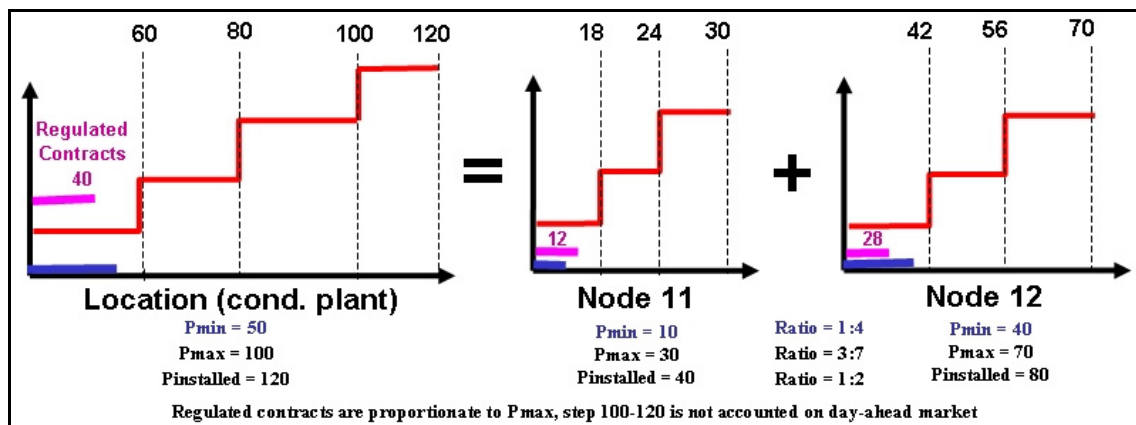


Figure 17. Allocation of locational volumes by nodes.

As seen, for such a generator its original bid's volumes are split, while the prices remain intact⁵³. In similar way, for every locational volume of a market participant, there is a corresponding modeled nodal volume.

Thus, the process of power system modelling yields a mathematical model (graph) consisting of nodes and branches. As of February, 2008 there were 7778 nodes, 11895 branches, 542 power plants, 2081 units and 428 controlled cross-sections⁵⁴ in the computational model.

4.2.3 Day ahead market

There is a single market operator (ATS) who determines the final financial obligations and claims for every market agents resulting from day-ahead and balancing markets' clearing. As bilateral contracts on electricity (regulated and free ones) are settled against locational prices, all of the contracts should be registered with the ATS. The whole process of the trading is shown on Figure 18.

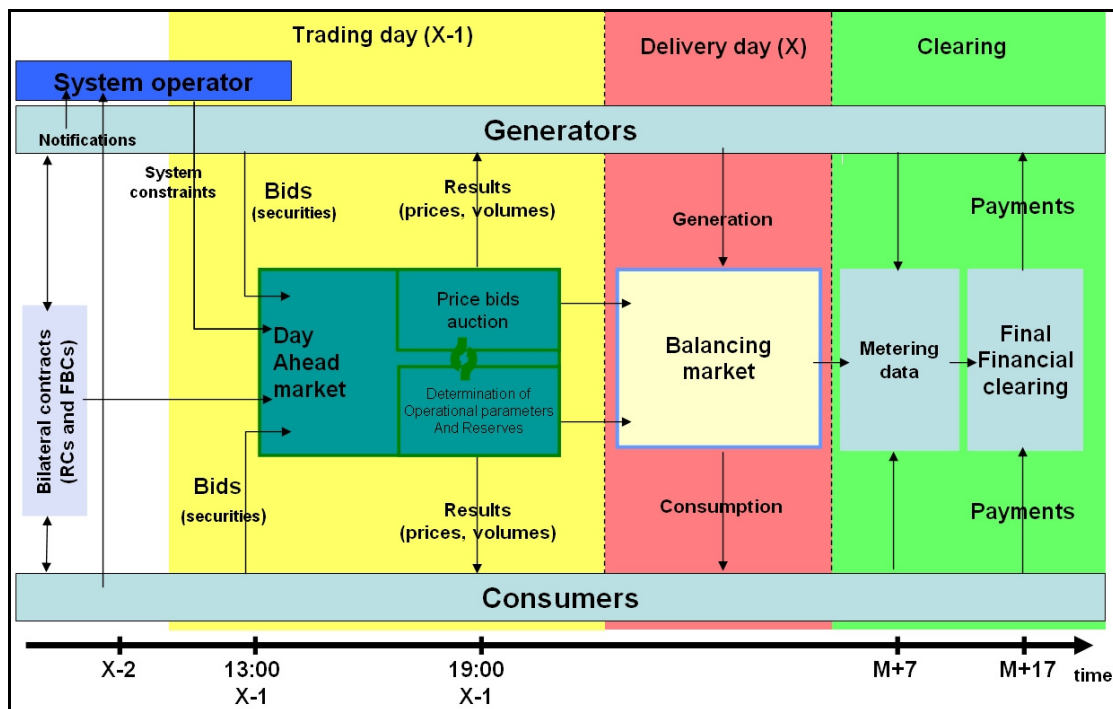


Figure 18. Process of trading in electricity on the wholesale market.

⁵³ Actually this only partly holds true, because the original bid is being checked and altered if needed so as to accommodate price-taking volumes (e.g. minimum output requirements), power plants' own use; example on figure 12 is only to explain the essence of the rationing coefficient.

⁵⁴ Controlled cross-section – is a part of a transmission system for which transmission limits apply.

4. Wholesale electricity (capacity) market

One day prior to submitting bids to day-ahead market (or two days before physical delivery) at the latest, all the market agents notify the system operator (SO) of their planned hourly parameters, such as maximum consumption, minimum and maximum output of generation units and their maximum own use, planned hourly export and import, ratio coefficients for locations where consumers are connected and other data as market rules require. Additionally, the selling agents inform the SO of their start-up and shutdown costs, as well as maximum hourly prices to be submitted on day-ahead and balancing markets.

On the grounds of collected information, own consumption forecasts (made by dispatching areas, so as to determine the amount of reserves needed for system security) and planned power lines maintenance, the SO chooses the generation units to be committed during the period and updates the set of constraints used in the calculation model, including forecast own use by power plants. This process is called model actualization. The system operator delivers the parameters of the actualized model to the market operator (ATS) to be used in day-ahead market clearing.

By 1 p.m. of the day preceding the physical delivery the market agents may submit their price bids to the ATS. The price bids of the generators could be of two types – hourly non-integral bids for 24 hours and integral bids either for 24 hours, or for 2 periods of hours from 0 to 9 and 10 to 23. Integral bids are introduced for intra-day production optimization of thermal power plants.

All the bids should be submitted for the whole working capacity⁵⁵ of the generating facilities. This requirement aims to fight abuse of market power preventing withdrawals of capacity from the market (which is tantamount to shifting the supply curve horizontally thus raising the equilibrium price). The bids submitted by generators and consumers contain 3 main price steps (for up to working capacity) and an optional additional one (from working up to installed capacity). These bids are adjusted by the ATS when transforming them into nodal modeled price steps in case maximum consumption of buyers or power plants' own use deviates significantly⁵⁶ from planned maximum values (SO's estimate by types of technology).

Own use in the model is represented as a separate location where the generators purchase energy needed for technological processes of energy production. The separation is needed in order to account for consumption of energy, supplied directly to consumers from generators' substations, as well as for overly own use. Own use is

⁵⁵ Working capacity is determined as a part of the maximum available capacity of electricity and heat generation facilities, with the exception of capacity of electric power facilities suspended for maintenance and decommissioned in accordance with the established procedure (agreed with the SO and in certain cases also with an executive authority).

⁵⁶ When the maximum consumption in a bid exceeds locational planned maximum by 110 MW or 50 per cent (25 per cent for guaranteeing supplier) – the ATS will reduce consumption stated in the bid; when bid's consumption is lower than 75 per cent (15 per cent for guaranteeing supplier) of the planned maximum – the ATS will increase the consumption stated in the bid.

shown on Figure 16 for CHP plant. For the volume of maximum own use consumption, the ATS forms a modeled regulated contract and corresponding price-taking bid. The ATS also integrates mandatory price taking steps into the bids of corresponding generators for the amount of their technical minimums of generation (P_{\min}), and volumes of forced hydro generation caused by technological and ecological requirements (floods). Besides of mandatory price taking, the agents may wish to extend their price-taking volumes in bid steps (for instance, in order to deliver contracted amounts instead of purchasing them), since price taking volumes are the cheapest and included⁵⁷ into the HGS (hourly generation schedule).

Similar to modeling bids as shown on Figure 17, the volumes submitted in every location result in an adjusted modeled price bid:

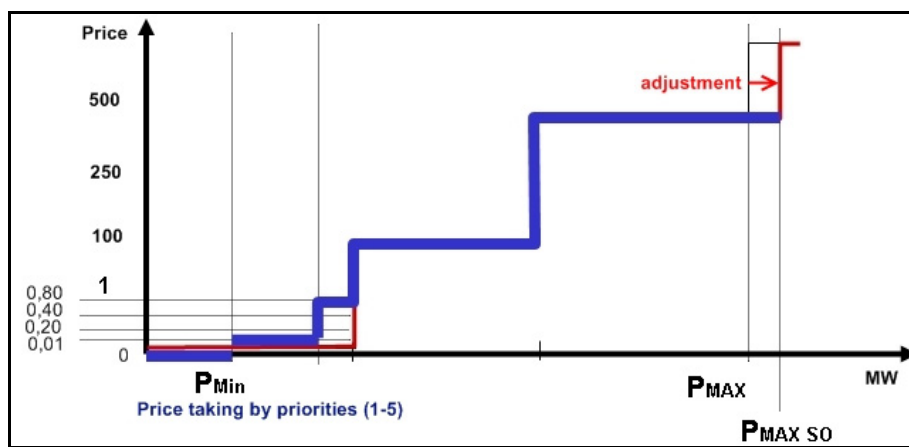


Figure 19. Modeled price bid of a producer in a node, adjusted by P_{\max} and built-in price-taking volumes.

In the same way modeled price bids of the consumers are found in corresponding nodes.

In order to calculate nodal equilibrium prices and volumes to be included in hourly schedules (HGS and HCS), the optimization problem is solved [26] for 24 intervals (hours) simultaneously, subject to constraints⁵⁸, where decision variables are hourly schedules of generation and consumption on the wholesale market, by way of finding the maximum of a linear target social welfare function:

⁵⁷ Except for cases when it is not technically possible to deliver the entire amounts, or when due to high content of price taking the equilibrium is found on a price-taking segment of demand or supply curve. Then, the price taking volumes are included into the HGS by priorities shown on Figure 19.

⁵⁸ Balance constraints (balance of active and reactive power in the nodes, nonlinear equalities describing dependence of active and reactive power flows in the branches from magnitude and phases of voltages), limitations on active power flows through controlled cross-sections, electricity production and consumption constraints (active and reactive power, limits on reserves of active power, integral limitations on fuel and water content, limits on active power production based on ramping characteristics), limited voltage deviations from nominal values in the nodes.

4. Wholesale electricity (capacity) market

$$\sum_h \left\{ \sum_{t \in h} \sum_{\tilde{n}} \sum_l c_{ct}^l P_{ct}(l) - \sum_{g \in I} \sum_l c_{gh}^l \sum_{t \in h} P_{gt}(l) - \sum_{g \notin I} \sum_{t \in h} \sum_l c_{gt}^l P_{gt}(l) \right\} \rightarrow \max_{P_{gt}(l), Q_{gt}, P_{ct}(l), V_j^t, d_j^t}$$

Where h – is a period containing hours $t=1..10$ ($h=1$) and $t=11..24$ ($h=2$); I – indices of the generators g , submitted integral bids.

c_{ct}^l – price component of price step l in a modeled nodal bid of a consumer c at hour t

c_{gt}^l – price component of step l in modeled nodal bid of a generator g at hour t

$P_{gt}(l)$, $P_{ct}(l)$ – volumes of price steps l of generator's g (consumer's c) price bids, included in generation (consumption) schedules for hour t .

The problem is solved by way of finding Lagrange multipliers, which are interpreted as nodal equilibrium prices, congestion prices, generators' and producers' surpluses.

All the volumes of electricity in a node are sold and purchased at one single equilibrium nodal price. The nodal price never exceeds the price in a bid submitted by a consumer for the volume included in his hourly consumption schedule, and likewise, is never less than the price in a generator's bid corresponding to his volume included into hourly generation schedule.

The nodal prices in every node include costs of congestion and losses. In order to avoid double pricing of transmission losses⁵⁹, the SO finds the hourly load losses in the power lines (covered by the model) based on the parameters of the electrical modes of power system operation (resulting from day-ahead market schedules) applying the formula of Ohm's law⁶⁰. Amount of load losses accounted in nodal prices is excluded from transmission tariffs (Section 5).

4.2.4 Balancing market

Naturally, actual values of generation and consumption differ from the planned hourly schedules of the day-ahead market. These differences are traded on the balancing market. Extending the example of an energy-sales company, the volumes of deviations correspond to the differences between actual consumption and hourly consumption schedule as shown on Figure 20.

⁵⁹ The reason for possible double pricing is that network companies' transmission tariffs account for standard value of losses [27] (technological standards are set by Ministry of Energy).

⁶⁰ Loss of active power in a branch kl , $\Delta p_{kl} = \left| \frac{V_k^i - V_l^i}{(R_{kl} + iX_{kl})} \right|^2 R_{kl}$, where V – voltages; R, X – branch resistance and reactance; k and l – nodes.

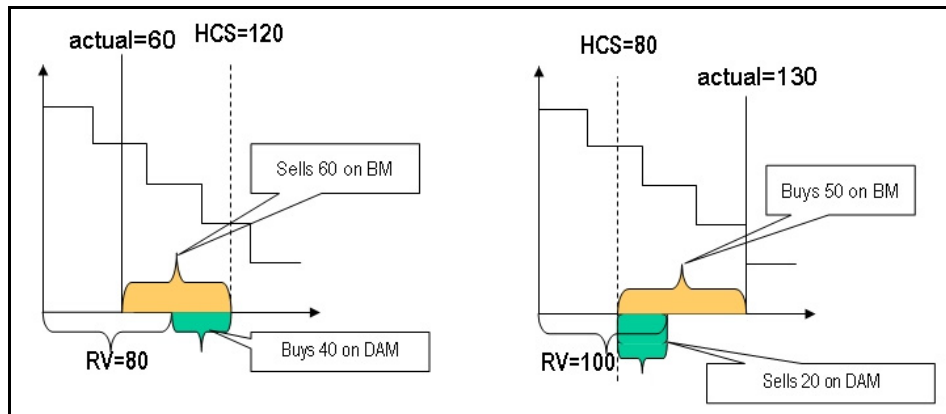


Figure 20. Volumes traded on the balancing market (deviations).

In case actual consumption exceeds scheduled on the day-ahead market, there is a need to produce the corresponding amount of electricity to balance the system. The balancing effect can be reached not only by way of additional generation but also through reduction of consumption. Consumers participating in system balancing are called consumers with controlled load (CCL), which typically represent large scale industrial enterprises able to respond on the SO's commands (e.g. by way of changing output of generation facilities located on their territory).

The generators and CCLs compete on the balancing market with their bids for system balancing. For the generators these are the same as submitted on the day-ahead market, excepting hydro and pumping storage power plants whose bids on the balancing market are price-taking. Consumers with controlled load may submit their price bids (on negative consumption) by 5 p.m. of the day (X-1) preceding to delivery day (X). After that the agents can adjust the volumes submitting operative price-taking bids.⁶¹ One hour before delivery the SO chooses the nodal volumes included in hourly dispatching volumes (i.e. volumes balancing forecast consumption in the following hour) also aiming to maximize social welfare. The computational model is used in the market clearing, and in every node dispatching volumes and corresponding price indicators as well as prices for system balancing upwards (downwards) are found. The indicator is a minimum price that balances dispatching volumes in a node, determined based on the bids for system balancing (i.e. ordinary consumers, generators not submitted price bids on day-ahead market, etc. do not form the price indicators).

⁶¹ The gate for submitting price-taking bids (submitted to the SO) closes 360 minutes before the competitive procedure of the balancing market [28].

4. Wholesale electricity (capacity) market

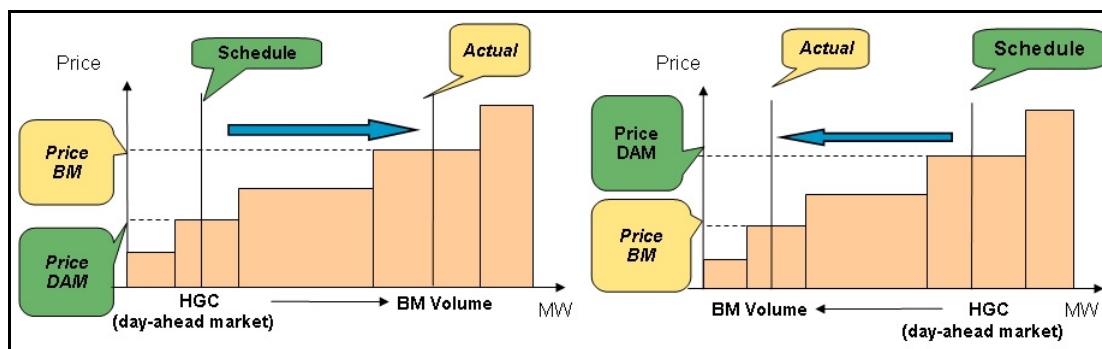


Figure 21. Equilibrium price on the balancing market.

The SO performs the dispatch on the grounds of determined nodal dispatching volumes giving out the commands to increase or reduce production (consumption). The part of total⁶² deviations that arise from following the SO's commands is considered as deviation at external initiative (IE). The remaining part of the deviation is considered as deviation at own initiative (IO).

The deviations can be of two types: deviation upwards (+) means that actual volume exceeds scheduled volume, and deviation downwards (-) means that actual volume is lower than scheduled. For instance, in case actual volume for an agent exceeds scheduled, then for a generator it means that the generator sells the difference to the market, while for consumer it would mean purchasing the difference.

Table 7. Financial transactions for deviations.

Deviation	Generators	Consumers
Up (+)	Sale	Purchase
Down (-)	Purchase	Sale

Equilibrium price for system balancing upwards (P_+) equals maximum value from the indicator (i) and day-ahead market price, and equilibrium price for balancing downwards (P_-) is determined as minimum value of the same:

$$P_+ = \max \{i, P_{dam}\}; P_- = \min \{i, P_{dam}\}$$

The balancing market is designed to create incentives for the agents to execute the SO's commands (external initiative), and to keep within scheduled volumes, as deviations at own initiative are never profitable compared to purchasing or sales on day-ahead market. The initiatives are priced as shown on Figure 22:

⁶² Total hourly deviation is the difference between the actual (meter readings) and day-ahead market schedule.

	Generators, submitted price bids	Hydro and pumped storage power plants	Participants of the BM submitted operative price-taking bids	Participants, not submitted price bids, or disqualified	Consumers with controlled load (CCLs)	Ordinary consumers
IE+ / IE-	Max (i; P bid) Min (i; P bid)	Max (i ; Tariff) Min (i ; Tariff)	Indicator (i)	Indicator (i)	Min (i ; P bid) Max (i ; P bid)	$\frac{1}{2} P-$ $2 P+$
IO+ / IO-	Min (P- ; P bid) Max (P+ ; P bid)	Min (P- ; Tariff) Max (P+ ; Tariff)	P- P+	P- P+	Max (P+ ; P bid) Min (P- ; P bid)	P+ P-

Figure 22. Prices for deviations at own and external initiative.

The total cost of deviations, for a market agent is a sum of the costs in its every location (the deviations are not aggregated).

An example of a generator’s deviations and corresponding types of initiatives are shown on Figure 23.

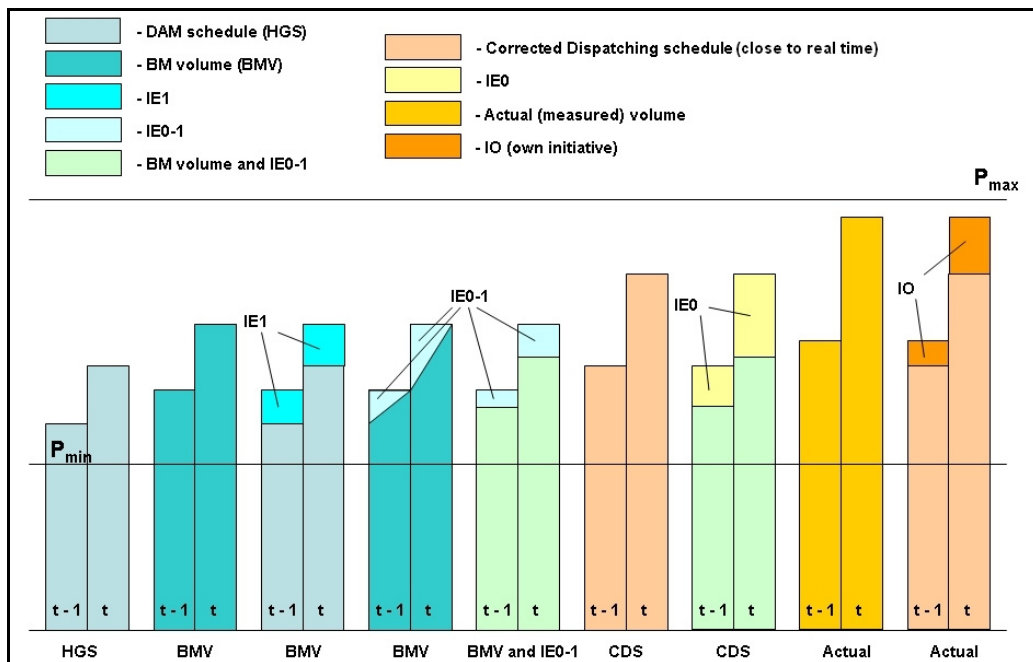


Figure 23. Generator's deviations.

As seen from Figure 23, the difference between balancing market volume (set one hour prior to delivery) and day-ahead schedule (determined on preceding day) is a deviation IE1, which is diminished (or increased) by component IE0-1 (triangle) – since the dispatching schedules are established at the end of each hour. Then, due to close to real time dispatch there are additional deviations at external initiative, occurring within the hour (IE0). The differences between actual (metered) hourly generation and corrected dispatching schedules are own initiatives (IO). The components of initiatives, in every individual hour may differ by direction (up or down).

4. Wholesale electricity (capacity) market

In order to calculate financial results of the balancing market, the ATS collects meter readings, information from the SO regarding deviations at external initiative and calculates volumes of deviations at own initiative. In case cost imbalance occurs (i.e. calculated payment obligations do not balance receipts), then it is distributed among the agents in a way, creating for them additional incentives to execute external commands. The deficits are compensated by those deviated at own initiatives, and surpluses are distributed among the agents deviated at external initiatives, and consumers, whose deviations at own initiatives were low.

Market agents can conclude free bilateral contracts for trading in deviations. The contracts are concluded for volumes of electricity corresponding to certain initiatives and directions (upwards or downwards) of deviations. The counterparties to such contracts pay for losses and congestion (similar to free bilateral contracts on electricity).

4.2.5 Bilateral contracts and hedging

Free bilateral contracts can be concluded between the agents located in a single price zone. The counterparties agree upon contract price and schedule of delivery (hourly volumes), which is reported to the ATS, since the parties have to pay costs related to delivery (costs of load losses and congestion). The price of each MW delivered equals to difference between corresponding locational prices. Besides of own locations, the parties specify an arbitrary reference location (location of delivery) that could be any one they choose in a price zone.

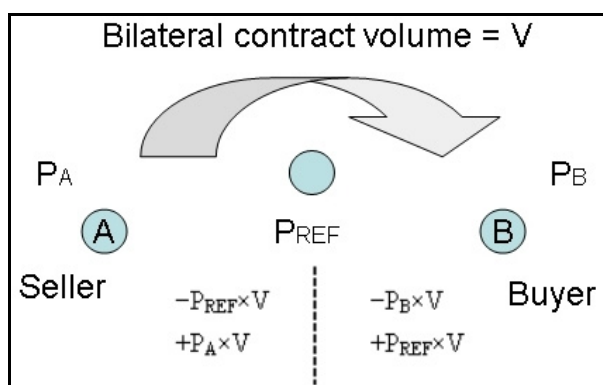


Figure 24. Location of delivery.

Every hour the ATS settle bilateral contracts against locational prices. The seller delivers contracted volume V to reference location, i.e. purchases it there and sells in location A. Likewise, the buyer delivers volume V from reference location to that of its own. In a process of settlement the ATS forms and executes these deals (Figure 24) automatically on behalf of the agents involved.

Settling bilateral contracts this way yields the desired outcome inasmuch as agents' joint result is $-(P_B - P_A) \times V$. Introduction of reference location makes bilateral contracts a standard but flexible tool. For instance, the parties to the contract shown on Figure 24 may agree that the delivery location coincide with say, location A. It would mean that financial result for seller (A) is hedged, since it wouldn't pay anything for delivery, and all the risks of nodal price volatility are passed on the buyer. It is clear that for a party to bilateral contract, whose location doesn't coincide with reference location, financial

result is always uncertain. The buyer, bearing the risks, faces a problem of defining acceptable contract price. Solving the problem calls for understanding the factors determining price in location of delivery (A), which considerably complicates the problem and forces the buyer to reject contracts unless price is so low that it includes buyer's premium.

It is possible to attain price transparency by way of settling the contracts against hubs, where formation of prices is public and clear for all agents⁶³. Hub is a set of nodes featuring a pre-established degree of nodal price correlation. It means that nodal prices formed on day-ahead market in the nodes of which a hub consists can deviate from hub index for a maximum of certain value (up to 20 per cent) known for every hub. There are six hubs on Russian wholesale market of which four are located in price zone 1 and the rest – in price zone 2.

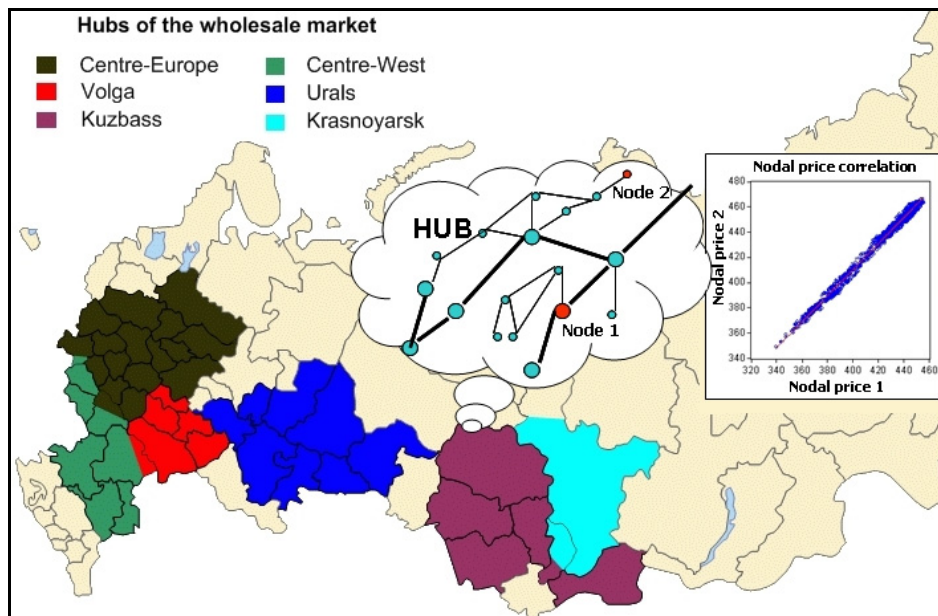


Figure 25. Hubs of Russian wholesale electricity market.

An example of setting hub as a delivery location is presented below on Figure 26, with the results of hedging shown in circles for seller and buyer.

⁶³ These public prices are called hub indices. Hourly hub index is an arithmetic mean of corresponding nodal prices.

4. Wholesale electricity (capacity) market

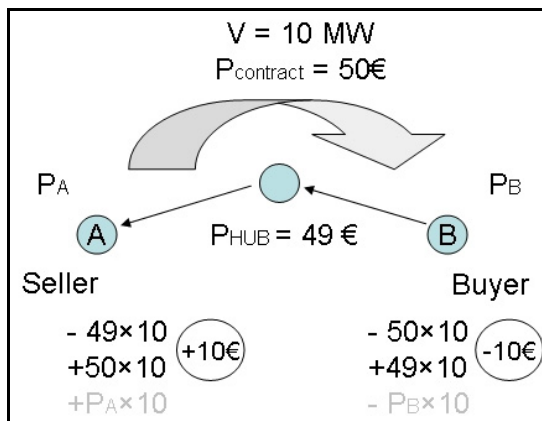


Figure 26. Hub as a location of delivery.

As hubs physically do not exist, they cannot be set as a location of delivery, but by defining contract prices in a special way the equivalent is reached:

$$\bar{P}_{Contract} = P_{Contract} + (P_{REF} - P_{HUB})$$

For instance, if reference location is agreed to coincide with location A, then contract price would equal P_A+1 and given contracted volume 10 MW, the total financial results for buyer and seller would be:

$$R_{SELLER} = -P_A \times 10 + (P_A + 1) \times 10 + P_A \times 10 = P_A \times 10 + 10;$$

$$R_{BUYER} = -(P_A + 1) \times 10 + P_A \times 10 - P_B \times 10 = -P_B \times 10 - 10.$$

As seen from the equations, the last summands correspond to hedging results shown on Figure 26.

In the same way, defining contract prices by formulas, it is possible to realize put and call options: $P = \text{MAX} \{P_{location}, P_{strike}\}$ or $P = \text{MIN} \{P_{location}, P_{strike}\}$. There are also types of bilateral contracts in which hourly volume of delivery is adjusted depending on day-ahead market results – for instance, FBCEs concluded to cover differences between day-ahead market schedules (HGS or HCS) and hourly volumes delivered under regulated contracts. Free bilateral contracts on electricity essentially are forward contracts. Currently there is only one venue (Arena) where the contracts are traded centrally, but amount of contracts offered for sale are low. Liquidity is expected to increase with future market liberalization causing growing demand for financial products.

4.3 Capacity payments market

Guaranteeing reliability of electricity supply in the medium and long term is a strategic objective of any power system. To meet the objective, available generation capacity in the power system must be sufficient to cover load under peak demand conditions. Due to significant yearly variations of electricity consumption, a considerable part of generation units remain idle during certain seasons of a year and the last increment of generation capacity may not be dispatched at all, remaining in reserve awaiting low-probable level of peak load (e.g. extraordinarily cold winter or hot summer) to occur. The owners of peak capacity, operating only a few hours in a year, must be able to

remunerate costs related to keeping their equipment ready, and besides that, incentives should exist for investments in replacement, rehabilitation or new construction projects to meet forecast demand. Investments in power industry feature high price of mistakes due to capital intensiveness of the sector and long periods of projects recoupment. In a deregulated context investment decisions taken by risk-averse private investors, driven by cost-effectiveness, are complicated due to existence of future uncertainties, such as levels of long-term demand, supply, fuel prices, regulatory and overall economic development (for instance, borrowing costs). Demand activity in the short-term is considered to play a certain role, preventing supply shortages, but it doesn't eliminate high prices. In Russia, from among other alternatives⁶⁴, it was decided to supplement the energy market with a market for capacity payments.

According to Russian legislation generating companies are required to keep books of their fixed and variable costs related to electricity production separately (accounting unbundling). It is also planned to amend legislation so as to obligate the generators to construct new replacement capacity or to upgrade existing as soon as their facilities' deterioration rate reaches 90 or 70 per cent correspondingly, which is equivalent to banning capacity decommissioning without proper substitute. Yet, at the moment, taking capacity out of operation is allowed only upon approval of the SO and local executive authority.

The primary purpose of the capacity payments market is maintaining of such a quantity of generation capacity in a power system in a short, medium and long term, which would be enough for covering power system's peak loads at any instant of time and to observe quality and reliability requirements (including capacity margins⁶⁵).

Briefly the essence of a capacity payments market is that all the buying entities are obliged to contract peak-hour availability of generation (more precisely – target amount of generation capacity, which equals to total peak load plus a reserve margin), in keeping with their contribution to aggregate load at the moment of peak demand. According to Russian law on power industry, every buyer of electricity on the wholesale market is obliged to procure prescribed amounts of capacity.

Capacity is a fairly unique commodity – readiness of a certain generation unit to start produce electricity in contracted amounts whenever it is called upon. In contrast to electricity, capacity payments are based on monthly fees, charged for each megawatt of qualifying generation capacity. For the purposes of capacity payments market, the power system of Russia is split into free electricity transfer zones⁶⁶ – areas where due to technical parameters of the power system it is possible to transfer substantial amounts of

⁶⁴ The most prominent alternatives are: SO investments in peaking units, competitive tendering, additional capacity payments, reliability options (contracts).

⁶⁵ To account for an unexpected outage of the largest unit, system service reserves and additional margins.

⁶⁶ The zones and limitations on power flows between them are determined by the SO yearly. See also footnote 20.

4. Wholesale electricity (capacity) market

electricity throughout them. For year 2009 the System Operator established 28 free electricity transfer zones, [29] which are presented on Figure 27. Interzonal flow limits could be found in Appendix E.

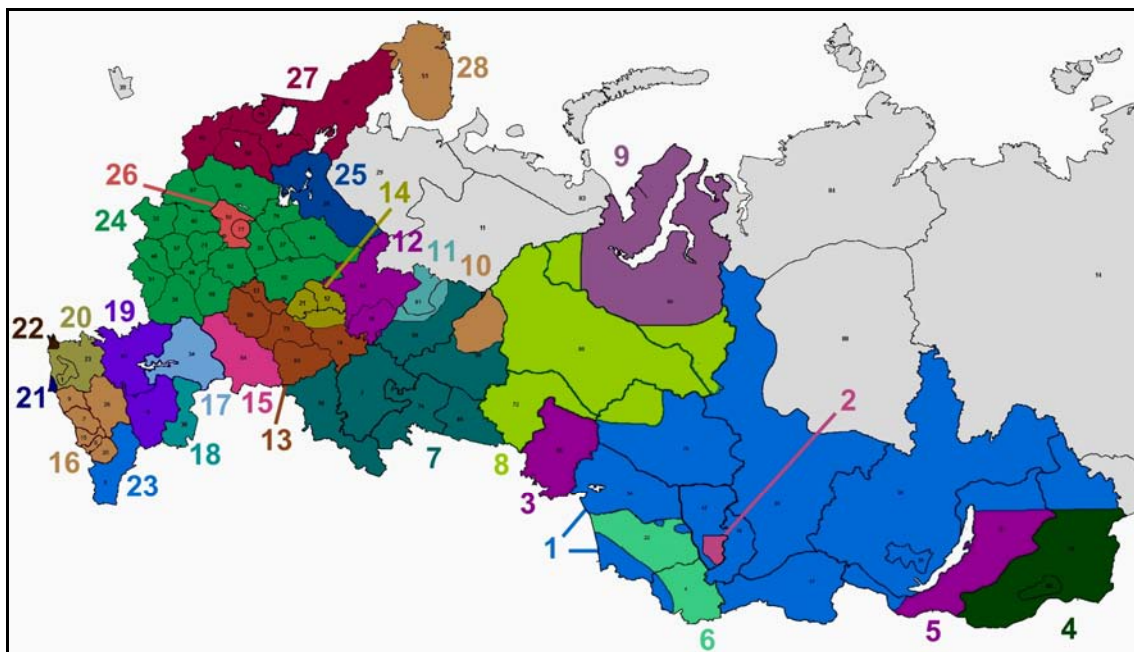


Figure 27. Free electricity transfer zones (coloured), established for year 2009.

The target design envisages conducting long term (4 year ahead) successive yearly auctions starting from 2009. Results of the first long-term auctions will concern years 2011–2014. During the period until these results are in force – the capacity payments market will operate under the rules of transitional market model (until 2011).

4.3.1 Transitional model

Before liberalization of trading in capacity that has started in July, 2008 all the generation capacities were traded at regulated tariffs, set for producers by federal regulator (FTS). Formerly, these tariffs were set for each MW of installed capacity ensuring remuneration generators' fixed costs. As from mid 2008 only available⁶⁷ generation capacities are paid for (regulated capacity tariffs were recalculated). The step taken towards capacity trade liberalization is of great significance, as far as on average capacity payments account for nearly 60 per cent in generators' sales proceeds on the wholesale market (Ponomarev, ATS).

⁶⁷ Available generation capacity – is a part of installed capacity net of not usable due to technical reasons (e.g. insufficient cooling, chimneys' draught, technical state of facilities, utilization of fuels that differ from designed, etc.) In Russia available generation capacity approximately amounts to 188 GW (installed – to 216 GW).

4.3.1.1 Trading in capacity at regulated prices

The principles of capacity trade liberalization are similar to those of electricity, discussed above in Section 4.2.1 in terms of liberalization schedule (Table 6) and households' volumes. Like in the case of electricity, the volumes of capacity traded at regulated prices are determined for an agent as a share of his basic volume of capacity, which are reduced gradually.

The basic volumes (BV) are determined from FTS balances as follows:

- For a generator:
 1. Installed capacity for December 2007 is found from FTS-2007 (G^{dec07})
 2. The months $\{m_1, \dots, m_n\}$, for which installed capacity equals G^{dec07} are found from FTS-2007 and FTS-2008.
 3. Basic volume equals to maximum of available capacities set for these months⁶⁸: $BV = \text{Max}\{Gm_{1 \text{ available}}, \dots, Gm_{n \text{ available}}\}$
- For a buyer:
 1. Monthly volumes of capacity are determined for the buyer in FTS-2008
 2. Reserve coefficients for regulated trade (K_{reg}) are found as a sum of basic volumes of the generators delivering capacity to a price zone divided by sum of buyers' volumes of capacity
 3. Basic volume is a product of monthly capacity volume and corresponding reserve coefficient: $BV = C^{FTS-2008} \times K_{reg}$.

To insure reliability of their own supply, the buyers are required to pay for reserve capacity as well. The idea of reserve coefficient is shown on Figure 28. It allows for establishing fair volume of service for each of the consumers, since the volume of reserve capacity is allocated proportionally to their peak loads.

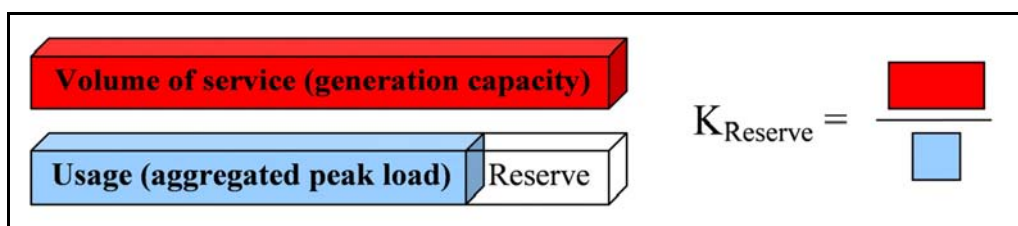


Figure 28. Capacity reserve coefficient.

⁶⁸ Even without commissioning/decommissioning these capacities may change within a year: installed capacity may be changed due to “relabeling” (e.g. after certain part of a generating facility has been upgraded) and available – due to changes in non-usable capacity (e.g. seasonal reduction of heat consumption may reduce available electricity generation capacity of CHP plants – cooling water restrictions, etc.)

Trading in capacity at regulated prices is carried out by means of regulated contracts⁶⁹. In addition, volumes of capacity for transmission losses compensation (determined by yearly FTS-balance), not covered by regulated contracts are purchased by the Federal Grid Company at regulated tariffs.

4.3.1.2 Capacity auctions and delivery

In order to set volumes of service the System Operator determines amounts of available capacity in every price zone, on the grounds of FTS-balance⁷⁰, and diminishes them by volumes constructed employing “guarantee mechanism” (Section 3.5). The generators submit their price bids to yearly capacity auctions run by the SO in the end of a preceding year. Prior to conducting the auction, the SO with regard to every of the price zones announces volumes of service, expected consumption of electricity and capacity⁷¹, planned reserve coefficients (Kplan). The SO also publishes a list of free electricity transfer zones and flow limits⁷² between them. The volumes of capacity submitted to the auctions by a generator are limited to corresponding values fixed in FTS-balance. Moreover, these volumes are split into “new” and “old” components, towards which the generators state monthly prices (bids). Part of capacity, accounted in FTS-2007 (which is partly traded at regulated prices) is considered to be “old”, while all the capacity built after electricity liberalization started is regarded as “new”. There is a price cap for “old” capacity, which equals to the generator’s tariff. As for “new” capacity, the price bids are required to be “economically justified” and, therefore, subject to the Market Council’s approval. In case capacity is to be put into operation or decommissioned during the period in question – the bids should contain dates of these events. Along with the bids, generators submit technical parameters of the equipment as well.

⁶⁹ Volumes of capacity purchased under regulated contracts could be adjusted slightly, in order to observe cost constraints of the process of matching counterparties to these contracts (described in section 4.2.1).

⁷⁰ Therefore, in the transitional model, all the amounts of available generation capacity are sold (there is no “not needed capacity” shown on Figure 29).

⁷¹ Consumption of capacity is practically the same as aggregated peak load.

⁷² Two limits per interface (depending on direction of the flow).

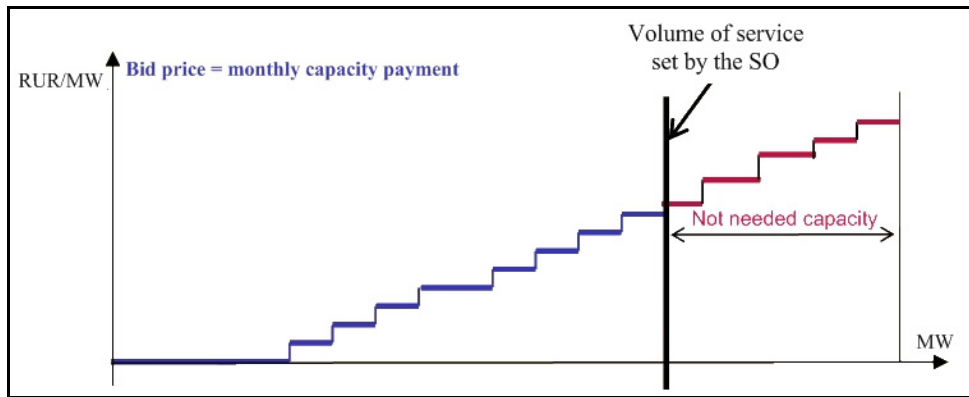


Figure 29. Capacity auction.

The auction results in volumes of capacity to be delivered by the generators ($G^{delivery}$) in each of the free electricity transfer zones, and free prices of these volumes, equal to bid prices (pay-as-bid). After the auction and prior to the period of delivery, the SO performs certification of the generation facilities by volumes and parameters, thus determining non-certified volumes, which should be purchased by the generator⁷³, and certified volumes intended for delivery.

In regard to the certified delivery volumes, supply obligations arise for the generators, which can be fulfilled by keeping the capacity available and timely commissioning facilities planned to be put into operation. Keeping capacity available is generally understood as maintaining technical parameters at certified level, which is verified by the SO (on the grounds of agents' operations on day-ahead and balancing markets). In case a generator fails to keep capacity supply obligations, then amount of capacity payments to all of the generators in a price zone is reduced⁷⁴, and the generator who caused the reduction (who "spoil" the quality of service) compensates financial losses to the other generators of the pool (price zone).

⁷³ In order to create incentives for generators to submit proper price bids, the purchasing price for non-certified volumes ($G_{non\ cert}$) equals to the generator's bid price increased by factor 1.3 or maximum bid price accepted on the auction, increased by 10 per cent: $P_{non\ cert} = MIN(1.3P_{bid}; 1.1P_{max\ auction\ bid})$.

⁷⁴ Depending on reasons, resulting in the reduction, various reduction factors apply (set by FTS). In addition, the reduction takes place in ascertained cases of electricity price manipulation.

4. Wholesale electricity (capacity) market

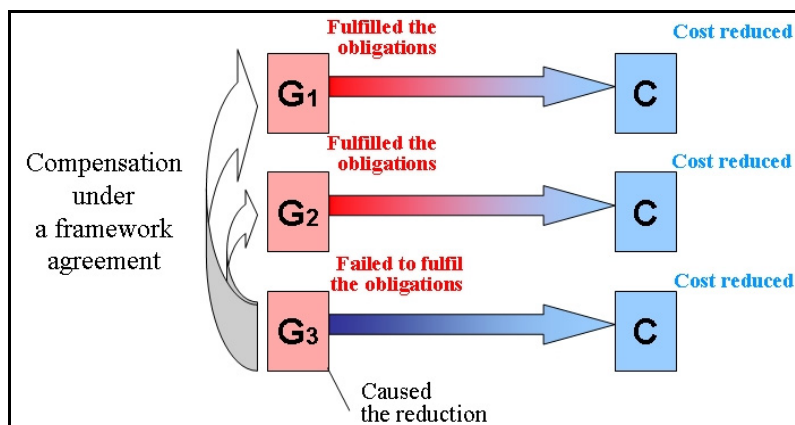


Figure 30. Pool of generators.

4.3.1.3 Trading in capacity at free prices

There are several possibilities for trading at free prices – by means of free bilateral contracts on electricity and capacity (FBCECs), trade based on a capacity auction's results and trading in capacity delivered under “agreements on capacity provisioning” (Section 2.3).

Capacity can be traded by monthly free bilateral contracts on electricity and capacity (FBCECs) of three types:

- 1) “Extension contracts”, concluded for volumes of voluntary liberalization (example 2)
- 2) Contracts traded on commodity exchanges⁷⁵
- 3) Contracts for “new” capacity.

At the moment only one commodity exchange has been licensed to organize trading in such contracts. The commodity trade principles envisage trading in standardized contracts on electricity and capacity, consisting of base, half-peak and peak packages as illustrated on Figure 31.

⁷⁵ Except for “old” capacity of hydro and nuclear power plants, for whom sales on the capacity payments market are guaranteed at their bid prices (not exceeding tariffs).

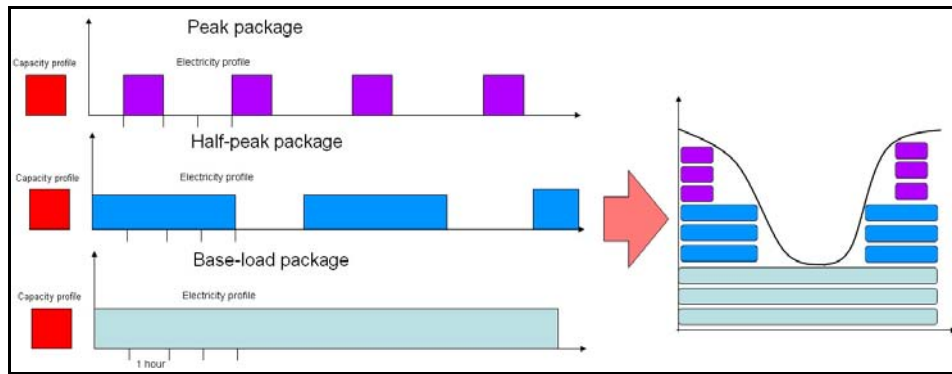


Figure 31. Trading in standard contracts on commodity exchanges.

As from 2009, amounts of capacity not sold by regulated and free contracts, should be offered for trading on commodity exchanges, otherwise these amounts are not paid.

Delivery of capacity under bilateral contracts between free electricity transfer zones is limited to interzonal flow limits. Transmission capacity of an interface, not used for deliveries under regulated and “extension” contracts is distributed between generators in proportion to their certified capacities. Therefore, interzonal deliveries of “new” and capacity traded on commodity exchanges is limited to quotas (Figure 32).

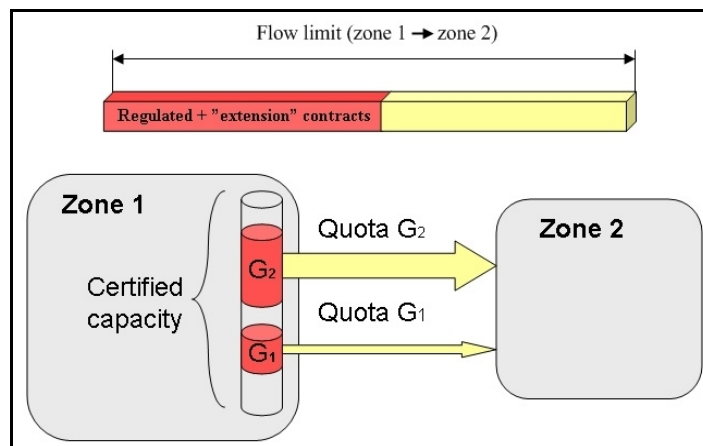


Figure 32. Allocation of quotas on interzonal deliveries.

Overreaching the quotas entail charges for generators. The penalty is a difference between auction price and generator’s bid price, paid for each MW of the excess. The generators can sell the quotas to each other.

An example of a generator’s participation on capacity payments market is shown on Figure 33. First, the generator submits price bid for capacity auction conducted in December for the following year (year of delivery). Then, prior to the year of delivery, the SO establishes it’s certified volumes, which are further traded, and not certified ones, for which the generator pays penalty. Part of the certified volume is covered by monthly regulated volumes, to be supplied under regulated contracts. In order to sell the rest of capacity, the generator is searching for counterparties to enter into bilateral contracts with

4. Wholesale electricity (capacity) market

and also offers capacity for trading on commodity exchanges. These free bilateral contracts on electricity and capacity should be registered with the ATS prior to month of delivery. The remainder is sold on the auction, and the generator is remunerated at its bid price multiplied by readiness factor⁷⁶ and seasonal factor (K_{season})⁷⁷, which reflects the need for generating capacity in (a price zone of) the power system by months.

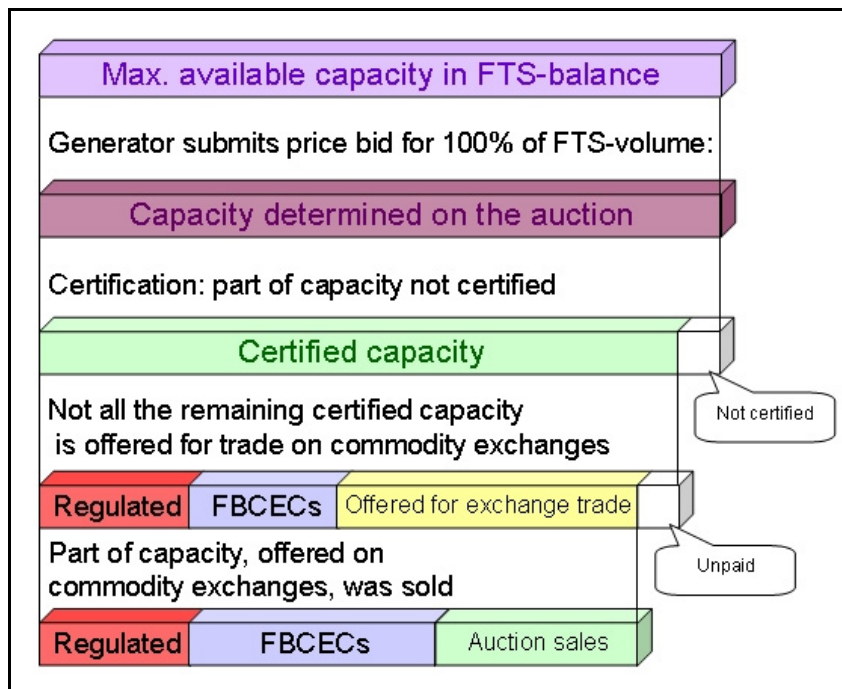


Figure 33. Participation of generator on capacity payments market.

It is possible that a generator buys more capacity under bilateral (regulated and free) contracts than allowed – the excess is to be sold on the auction.

The annual capacity auctions entail obligations to pay the certified volumes for buyers. Amount of purchasing by an individual buyer in a month is determined as actual (measured⁷⁸) consumption times actual reserve coefficient (K_{actual}), set monthly by price zone⁷⁹:

$$K_{Actual} = \frac{G^{Delivery} - G^{Not\ offered\ on\ CE} + G^{Retail\ Market} + G^{Capacity\ provisioning\ contract}}{C^{Actual} + G^{Retail\ Market} + C^{Federal\ Grid\ Company}} \quad (2)$$

⁷⁶ Readiness factor accounts reduction of capacity price arising when one of the pool generators fails to keep its supply obligations.

⁷⁷ Calculated on the grounds of statistical data for 3 preceding years, as averaged system peak loads of the month in question (3 peaks) divided by the average value of monthly peaks (36 peaks). For 2nd half 2008, it ranges between 0.774 and 1.228.

⁷⁸ Actual consumption in a month is an average of registered daily peak loads (from measured at hours, predetermined by the SO).

⁷⁹ In formula (2) volumes of actual consumption do not include standard (approved) own use by plants.

The purchasing volumes, allocated on capacity buyers are partly covered by regulated contracts and contracts with “old” hydro and nuclear power plants, and the remaining part may be procured by means of FBCECs and auction purchases.

It has been mentioned already (footnote 75), that generation capacity of “old” hydro and nuclear power plants is prioritized. These capacities are remunerated at bid prices (not exceeding tariffs, as far as the capacity is “old”) times seasonal coefficients. Every buyer purchases a share of the total prioritized capacity under bilateral contracts on capacity (BCC)⁸⁰. The counterparties to BCCs are matched in such a way that average weighted price paid for each prioritized MW in a price zone was equal for all buyers. An example of buyer’s participation on capacity payments market is presented on Figure 34.

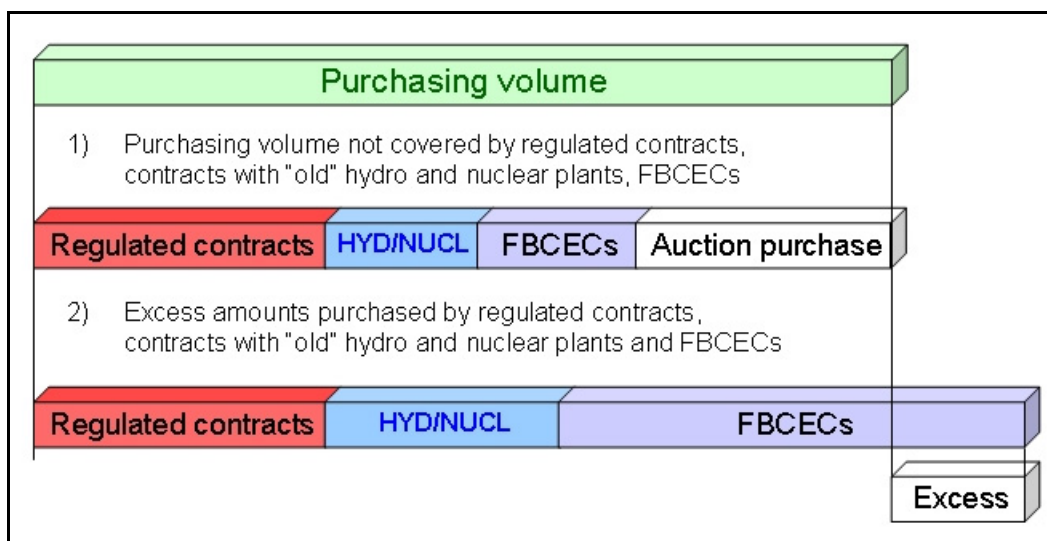


Figure 34. Participation of a buyer on capacity payments market.

Amounts of excess capacity, purchased by bilateral contracts of all kinds are sold at auction sales price (average weighted price, paid to generators for non-prioritized capacity sold on the auction), while amounts purchased on the auction by buyers are paid at auction purchasing price.

Capacity delivered under agreements on capacity provisioning is traded on the market by any of the mechanisms applicable for “new” capacity. The generators, constructing capacity as a part of RAO-investment programmes are allowed to postpone commissioning by 1 year without paying charges. In this event, the not-commissioned capacity does not pass through yearly capacity auction, but it is remunerated at auction sales price during the first year. In the following years the not-commissioned capacity is not only unpaid, but also charged at 30 per cent of auction purchasing price. Functioning of a simplified capacity payments market is shown on Table 8.

⁸⁰ No electricity is supplied.

Table 8. Simplified example of Russian capacity payments market (1 month).

Generators	Bid prices	Bid volumes	Certified (V _{cert})	Not-certified	K _{season}	Bid prices x K _{season}	Average weighted auction sales price	V _{regulated}	V _{FBCECs}	V _{auction} (sale/purchase)
G1	1 000,0 €	60	60	0	0,9	900,0 €	432,97 €	40	10	10
G2	500,0 €	40	35	5		450,0 €		30	47	-42
G3	400,0 €	150	150	0		360,0 €		60	26	64
G4 old hydro/nuclear	850,0 €	30	25	5	765,0 €	20				
G5 investments prog	420,0 €	10	3 units not passed the auction		378,0 €	0		14	-4	
Total		Delivery: 277	277	10		150		97	28	

Buyers	Peak load	K _{actual}	V _{purchasing}	V _{regulated}	V _{basic}	V _{liberalized}	V _{old hydro/nuclear}	V _{at free prices}	V _{FBCECs}	V _{auction} (purchase/sale)
C1	70	1,108	77,56	40	50	10	1,75	35,81	25,81	10
C2	80		88,64	50	75	25	4,39	34,25	39,25	-5
C3	100		110,80	60	82	22	3,86	46,94	31,94	15
Total	250	Purchasing: 277	277	150	57	10	117	97	20	

(in keeping with V_{liberalized}) (offered on C.Ex)

Penalty fund			
Contributors	Max auction bid*	Own bid*	penalty rate
G1	900,00 €		
G2		450,00 €	585
G4 old hydro/nuclear		765,00 €	990
Total			7 875,00 €

*taking K_{season} into account
The penalty fund is distributed 50/50 among selling generators and purchasing consumers on the auction

Distribution			
Beneficiaries	V _{cert} (for G) and V _{purchasing} (for C)	Share in total	Ratio
G1	60	0,217	0,286
G3	150	0,542	0,714
C1	77,56	0,280	0,412
C3	110,8	0,400	0,588
Total			7 875,00 €

Auction results	
Volumes	Auction prices
Total sale	432,97 €
Total purchase	454,90 €
G4 pays penalty	32 297,72 €
1st year of G5 operation (support)	At auction sale price
28-20=	8

Comment: Auction purchasing price equals to average weighted values of generators' and buyers' sales on the auction.

Assumptions: No flows, no deliveries on retail market, no purchasing by Federal Grid Company for losses compensation. We suppose that generators G1, G2, G3, G5 offer their whole capacity on commodity exchanges and observe capacity supply obligations.

The amounts of reductions caused by breaking capacity supply obligations (see Section 4.3.1.2) affect (reduce) the auction sales price, as well as auction purchasing price. The cheapest non-regulated generation capacity is being contracted by FBCECs that leads to auction purchasing price growth (since it is an average-weighted price of remaining expensive capacity and exceeds capacity sold on the auction at auction sales price).

Preliminary average-weighted prices (results of yearly auctions by months) and monthly auction purchasing prices (ex-post) are published by the ATS.

Table 9. Auction prices of generation capacity in 2008, EUR/MW per month [30].

Price zone	Parameter	July	August	September	October	November	December
1	K_{season}	0,84	0,87	0,95	1,06	1,12	1,16
	Preliminary sales price	2 260 €	2 344 €	2 561 €	2 872 €	3 041 €	3 141 €
	Auction purchasing price	2 763 €	3 077 €	3 413 €	3 885 €	4 371 €	
2	K_{season}	0,77	0,82	0,95	1,06	1,17	1,23
	Preliminary sales price	2 127 €	2 260 €	2 620 €	2 916 €	3 234 €	3 386 €
	Auction purchasing price	2 387 €	2 571 €	3 107 €	3 447 €	3 793 €	
Exchange rate = 40							

The Federal Grid Company purchases availability of generation capacity to cover transmission losses⁸¹ by regulated contracts and auction purchases.

4.3.2 Target model

In contrast to auctions of transitional model, the long-term capacity auctions will be conducted in every free electricity transfer zone that may potentially facilitate attaining strategic goals related to power plants fuel mix by way of prioritizing certain type of generation technology on the auction. Nuclear and hydro power plants will submit only price-taking bids to the auctions and there is even a chance that their capacity will not be paid at all since, according to preliminary calculations made by Ministry of Energy (not published), remuneration of these generators from trading on day-ahead market will be sufficient to cover their fixed costs. Another of the main distinctions of the target model is that free bilateral contracts (FBCECs) should be concluded prior to capacity auctions, in which the contracted volumes of capacity are accounted as price-taking volumes.

Generation capacity on the auctions falls into two categories – “existing” and “new commissioning”. The regulator sets price caps by the categories equal to operating costs and operating costs plus return on investments. For the volumes of capacity, which passes a long-term auction, capacity payments are guaranteed at bid price during 1 year for “existing”, and during not yet defined period (5 to 10 years) – for “new commissioning” volumes. The latter ones do not submit price bids on the following auctions during the period of guarantee, when these volumes are considered as price-taking. During the following years capacity payments for them are adjusted yearly by

⁸¹ The monthly planned volume (FTS-balance) multiplied by K_{actual} .

4. Wholesale electricity (capacity) market

inflation indicators. For example, volumes of capacity commissioned in 2011 (as shown on Figure 35, assuming 5-year guarantee) are paid at bid price in 2011, starting from 2012 and until 2016 at adjusted bid prices. From 2016 onwards these volumes participate on the auctions as “existing” ones.

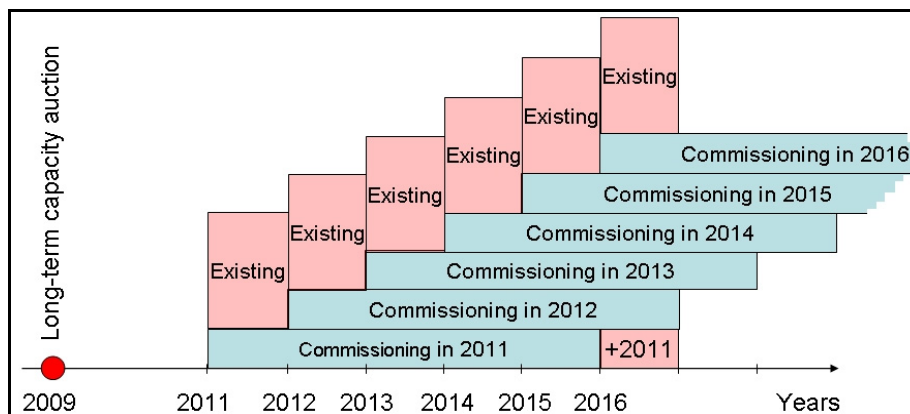


Figure 35. Existing and newly commissioned capacity in target model.

Besides of the generators, consumers with controllable load will participate on the market as well, submitting their bids with regard to volumes of voluntary load shedding. Alike generators, such consumers will be required to pass an annual certification (SO) for volumes and technical parameters.

In addition to price caps, the government will define the demand curve by way of setting reserve coefficients (Figure 36). Introduction of demand elasticity reduces amount of reserves⁸² in power system when capacity price is high and increases reserves when price is low.

Similar to transitional model, all the volumes of capacity passing capacity auctions are paid by consumers as their actual consumption times actual reserve coefficient. New model envisages an option of self-planning for certain consumers (e.g. large-scale industry), except for guaranteeing suppliers and energy sales companies serving households. These consumers submit their planned volumes of consumption (constant value during 4 years) to the SO. In case actual consumption exceeds planned, then consumer purchases additional capacity (at actual price), otherwise – sells excess at a lower price. Amounts of an individual buyer’s purchasing under FBCECs will be limited so as to eliminate arbitrage opportunities and ensure parity among the consumers. Thus, a buyer’s purchasing volumes consist of three parts – FBCECs with generators offering “existing” or “new” capacity and volumes purchased on capacity auction.

⁸² Within acceptable limits: suggested $K_1=1.18$; $K_2=1.20$; $K_3=1.32$ (recommended values of reserves are 17 and 12 per cent of aggregated peak load for European and Siberian parts of the UPS respectively).

4. Wholesale electricity (capacity) market

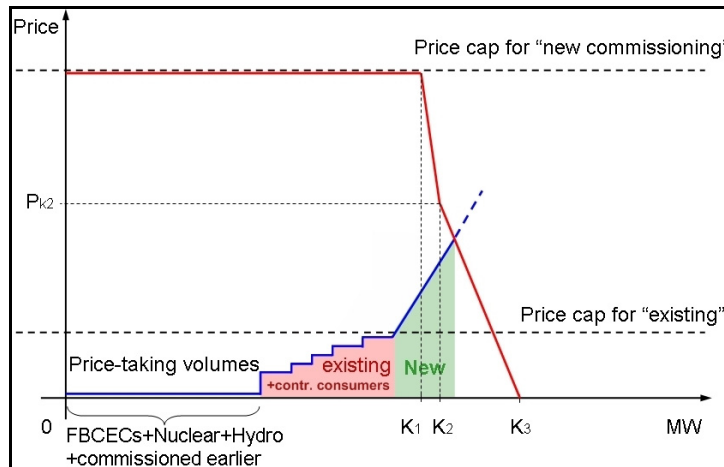


Figure 36. Long-term capacity auction with demand elasticity.

One of the most acute problems with capacity mechanisms is how to encourage construction of not only peaking facilities (low fixed costs and expensive electricity) but also capacity based on technologies featuring longer utilization times (utilization factors). To address the issue a mechanism of reliability options is implemented on several markets worldwide that calls for setting an option strike price on day-ahead market. In terms of long-term auctions there is a need to set the strike price very carefully, since in case it is too low the generators won't get sufficient remuneration while setting the strike price too high leads to acceptance of more peaking units than desired. Another scheme, not yet implemented worldwide but presented in Russia, suggests auctioning capacity based on total costs requiring the price bids to contain both capacity and electricity prices. According to the latter scheme, electricity generated on the equipment with capacities sold via the auctions is capped on the day-ahead market by electricity price submitted to auction in a bid, and electricity produced by the ones, sold under FBCECs is freely traded on day-ahead market (Table 10).

Table 10. Proposed variant of trading in electricity and capacity in the target model.

	Auction		FBCECs	
	Capacity	Electricity	Capacity	Electricity
Suppliers	at bid price	not exceeding bid price	at contract price	at free price
Buyers	Mandatory purchasing of the volumes not covered by FBCECs		Voluntary purchasing	

4. Wholesale electricity (capacity) market

The model of capacity auctioning based on total costs urges the buyers to enter into bilateral contracts, since purchasing on the auction is more expensive. The same holds true for the generators, since they would be able to make some extra profits on day-ahead market.

It is obvious, that both the methods exert influence on day-ahead market prices. But irrespectively of auctioning criteria, which are yet to be approved, the model envisaging long-term auctions, with guaranteed capacity payments during 5–10 years regularly adjusted by inflation, is able to create incentives for investments, since an investor is confident of having a return⁸³. When amount of capacity determined on long-term auction is insufficient, there is still time and the SO announces tenders (“guarantee mechanism”) starting at double price of constructing the fastest-to-build type of capacity. In case the latter also fails then, as a last resort, the government invests in generation capacity or transmission grid.

4.4 Ancillary services market

Ancillary services are essential for power systems’ functioning and keeping technical parameters within acceptable levels. These services mainly include frequency (active power) and voltage (reactive power) regulation. Provisioning of the services necessitate adequate remuneration of associated costs, and even compensation for lost profits. For example, the generators, forming spinning reserve could increase their output easily and sell it on day-ahead market. It is easy to establish the providers and their contributions to the total volume of ancillary services, but it isn’t simple when it comes to consumers. For that reason, the SO acts as a single buyer on every segment of ancillary services market (ASM). These segments represent zones, determined by the SO, where agents of ASM compete for provisioning of a certain service during following 8–10 years by way of bidding on tenders organized by the system operator.

Launching the market for ancillary services is scheduled for 2009. The event won’t have any effect on electricity price until liberalization is complete, since corresponding costs are included in regulated tariffs of generators and consumers with controlled load, but afterwards the ASM becomes an only source to remunerate the costs related to provisioning of the services.

⁸³ It is worth mentioning here that owners of new power plants should build power lines at their own expense to the nearest substation of UNEG (Federal Grid Company) to be connected to transmission grid.

5. Electricity price

5.1 Components of end-user electricity price

The prices that customers pay for electricity service depend on various factors and besides of electricity and capacity components (free and regulated) include costs of services inherent in the process of delivery and sales. These costs are paid in a form of network tariffs (delivery), tariffs of the SO and ATS as well as sales markups.

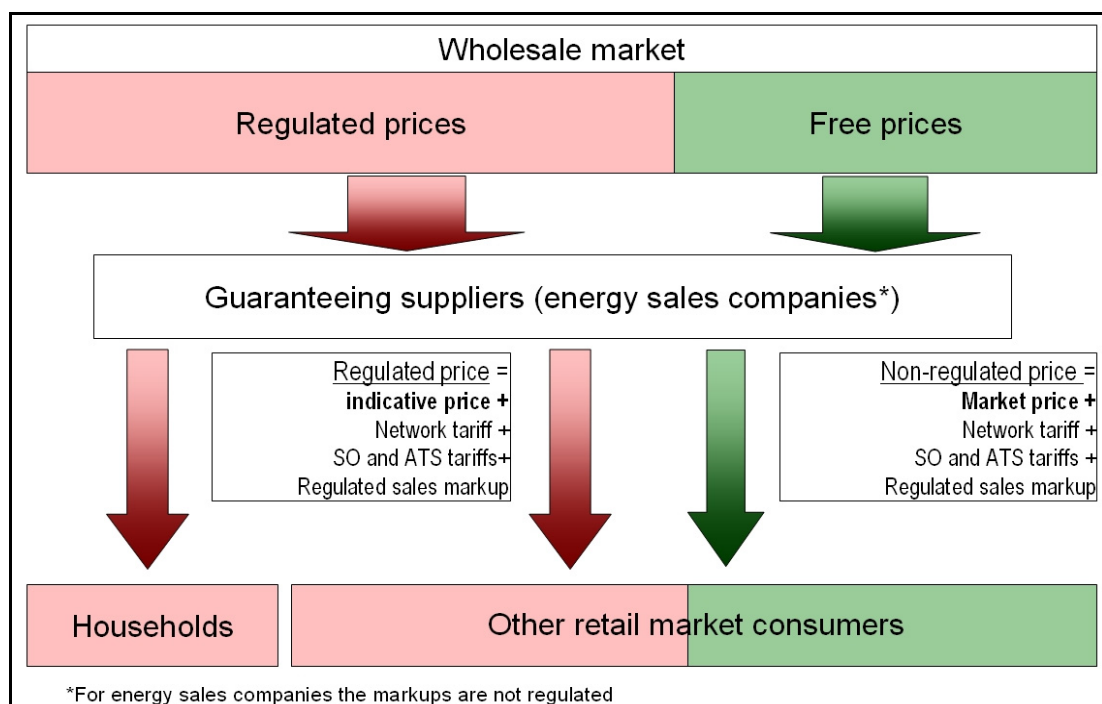


Figure 37. Structure of retail market price.

Tariffs of the system operator and trade system administrator are determined by federal regulator (FTS).

5. Electricity price

Table 11. Tariffs⁸⁴ of the system and commercial operators in 2009 [31, 32].

	Tariff	Units
ATS and CFS*	0,02 €	MWh
System Operator	190,41 €	MW month

*Center for Financial Settlements

Network tariffs and guaranteeing suppliers' sales markups are set by regional regulators. Sales markups are determined on cost-plus principle and vary greatly by suppliers, since the costs depend on sizes and amount of retail market customers. For instance, the costs of a supplier serving primarily households are considerably higher than of the one serving few industrial consumers due to expenses related to billing and collection of meter readings. In general the regulated markups are set around 1–3 €/MWh.

Transmission tariffs consist of fixed and variable components determined differentially by four voltage levels – high, two medium ones and low voltage⁸⁵.

Table 12. Maximum⁸⁶ transmission tariffs and tariffs of the Federal Grid Company in selected regions in 2008, EUR [33, 34].

Region	Fixed (maintenance), monthly per MW					Variable (standard process losses), per MWh				
	HV	MV1	MV2	LV	FGC	HV	MV1	MV2	LV	FGC
Moscow	4 436	5 541	9 746	10 514	1 365	0,86	1,50	2,30	5,39	24,90
Moscow region	9 491	17 098	16 916	17 729		0,72	2,10	3,82	7,87	20,38
Saint-Petersburg	6 034	8 814	8 228	7 421		0,41	0,76	4,11	9,21	26,79
Leningrad region	7 997	10 017	8 780	13 956		0,81	1,19	4,21	11,26	20,66
Tyumen region	8 899	21 582	12 098	16 296		0,53	4,62	1,94	3,83	17,03

As mentioned above in Section 4.2.3, the load losses are excluded from payments for transmission services. This can be illustrated by simplified example presented on Figure 38, where we assume that consumers are connected to 10 kV distribution network on the territory of Tyumen region.

⁸⁴ All the tariffs and prices in this working paper are presented assuming that 1 EUR buys 35.3 RUR.

⁸⁵ HV – 110 kV and above; MV1 – 35 kV; MV2 – 20÷1 kV; LV – 0.4 kV and below.

⁸⁶ Maximum regional tariffs, set by FTS, to be observed by regional regulators.

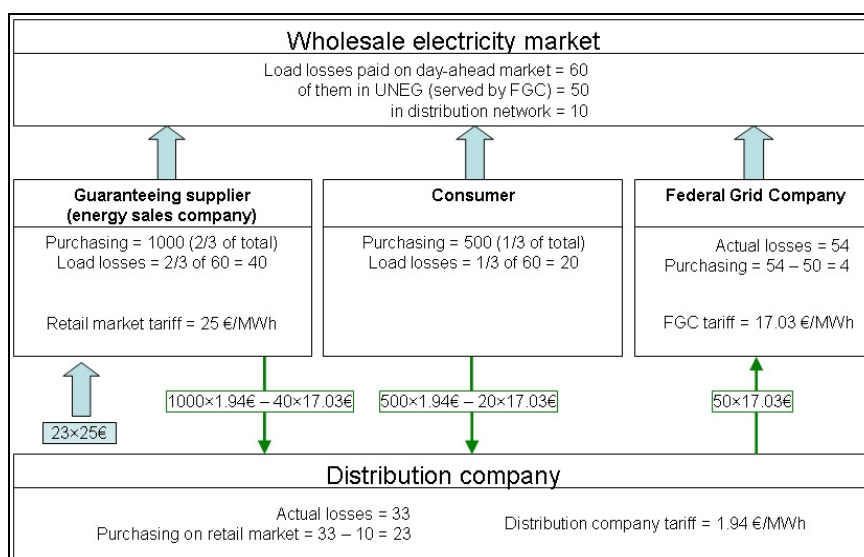


Figure 38. Accounting load losses in transmission tariffs.

In addition to standard process losses (technological standards are set by Ministry of Energy), the consumers are charged at fixed monthly rates for networks upkeep.

Regional levels of regulated prices, at which consumers purchase electricity from the wholesale market, approximately correspond to indicative prices set by FTS and used for matching the counterparties to regulated contracts. Purchasing costs of electricity on the wholesale market in a certain period depend on free prices and corresponding volumes bought by means of free bilateral contracts as well as volumes, purchased on day-ahead and balancing markets, where prices are determined by the law of supply and demand.

As from 2008 so-called mechanism of price smoothening is used on the wholesale market. The essence of the mechanism is that total hourly demand D in a price zone is reduced by “irregular consumption fluctuations” S , resulting in a new price zone demand level $D' = D - S$. The most expensive volumes in generators’ hourly bids falling on S are found by nodes and remunerated on pay-as-bid principle while the nodal demand curves are shifted leftwards, thus reducing clearing prices. An hourly shift S in a price zone equals to $6\sqrt{D}$, which is about 2–4 per cent of the demand⁸⁷. The Market Council is expected to come up with an improved smoothening mechanism (where S is a variable value dependant upon a typical period via seasonal coefficients) in the nearest future. Besides of that, starting from 2009 influence of exports will not be taken into

⁸⁷ In August 2008, for a period of maintenance repairs the total hourly shift was set to $12\sqrt{D}$ by special decision of the Market Council [36].

5. Electricity price

account when determining equilibrium prices (S will be determined as maximal value of “irregular consumption fluctuations” and exports from a price zone). [26, 35]

5.2 Wholesale electricity prices and fuel markets

Free electricity prices reflect variable (mainly fuel) costs of marginal power plants. Fuel costs of nuclear and hydro power plants are considerably lower⁸⁸ than those of coal or gas-fired generation units, who are price makers in the majority of cases.

Natural gas is mostly⁸⁹ purchased at regulated wholesale prices, which in gas supply contracts should be within minimum and maximum limits determined by FTS for every region. Minimum regulated wholesale price for Russian non-household consumers in 2008 on average amounts to 48 €/1000m³, while the upper price limits are determined as minimum prices increased by a certain value⁹⁰. These values are gradually reduced causing price limits convergence – starting from 2011 all the gas (limited and above the limits) will be priced evenly [42]. On May 6, 2008 the government approved “maximum price levels on products and services of natural monopolies in 2008–2011”, which represent a schedule of regulated gas price annual increases in this period. According to the schedule, the wholesale price for non-household consumers increases on average by 19.6 per cent in 2009 and by 27.7 per cent in 2010. [41]

Table 13. Regulated wholesale gas prices for industrial consumers in 2008 and 2009 [43, 44]. Regulated price levels in 2010–2011, €/1000m³.

Region / Period	2008		1-2Q 2009		3-4Q 2009		1-2Q 2010		3-4Q 2010		2011
	Pmin	Pmax	Pmin	Pmax	Pmin	Pmax	Pmin	Pmax	Pmin	Pmax	MAX
Moscow and region	50,54	75,81	57,51	80,51	65,44	85,07	73,95	88,74	83,56	91,92	116,98
S-Petersburg, L. region	48,95	73,43	55,55	77,77	63,12	82,05	71,32	85,59	80,59	88,65	112,83
Tyumen region	39,09	58,64	43,48	60,88	48,36	62,86	54,64	65,57	61,75	67,92	86,45
Yam.Nenets AA (lowest)	27,59	41,39	31,44	44,02	35,81	46,55	40,46	48,55	45,72	50,29	64,01
Average (65 regions)	47,99	71,98	54,14	75,81	61,10	79,41	69,05	82,86	78,02	85,83	109,23

⁸⁸ As far as no new nuclear units were commissioned since 2007, production of the “old” ones is capped by regulated tariff (4.68 €/MWh in 2009 [37]). Hydro power plants pay taxes on water use 0.15÷0.4 €/MWh (depending on water basin) [38].

⁸⁹ Maximum trading at non-regulated prices in 2008 (on Mezhhregiongaz trading site) is 15×10⁹m³ that corresponds to 3.5 per cent of total domestic consumption (420×10⁹m³ in 2008); actual traded volume in 2007 amounted to 7×10⁹m³, of which 55 per cent purchased by electricity sector enterprises [39].

⁹⁰ In 2008 – 1.5; 1st half 2009 – 1.4; 2nd half 2009 – 1.3; 1st half 2010 – 1.2; 2nd half 2010 – 1.1 [40].

End-user prices also include payments for gas distribution and supply (sales) services, which are regulated and together add about 5–10 €/1000m³ to consumers' bills.

As from 2011 it is planned to set regional wholesale prices for non-household consumers ($P_{regional}$) quarterly, calculating them by the following gas price formula. [45, 46]

$$P_{REGIONAL} = (P_{EXPORT}^{NON\ CIS-COUNTRIES} \times \left(\frac{100\% - ED_{EFFECTIVE} \%}{100\%} \right) - F^{CUSTOMS} - T^{ABROAD} - T^{RUSSIA}) \times K_{REGIONAL} \quad (3)$$

The principle of this method, called net-back pricing, is that price in a certain region equals to regional coefficient ($K_{regional}$) times the price in a (virtual) location of gas production, which is calculated as average export price net of the costs related to delivery – transportation, storage and sales (T) as well as customs fees ($F^{customs}$) and export duties (ED)⁹¹. Export price (P_{export}), which is the main component in formula, is determined as average export price realized in a preceding base period⁹² and therefore lags behind the export price by several months. The federal regulator FTS publishes domestic gas prices calculated by gas formula for information purposes. These prices for the same regions are presented in Table 14 below.

Table 14. Calculated net-back gas prices for year 2008, €/1000m³ [49].

Region / Period	2008 (formula)			
	1Q	2Q	3Q	4Q
Moscow and Moscow region	112,45 €	115,09 €	128,41 €	145,30 €
Saint-Petersburg and Leningrad region	108,92 €	111,48 €	124,38 €	140,73 €
Tyumen region	86,99 €	89,03 €	99,33 €	112,39 €
Yamalo-Nenets A. Area (min price)	61,39 €	62,84 €	70,11 €	79,33 €
Average (65 regions)	106,80 €	109,35 €	121,95 €	137,96 €
Average export price	186,06 €	191,44 €	209,55 €	232,49 €
period	Jan-Sep'07	Apr-Dec'07	Jul'07-Mar'08	Oct'07-Jun'08

Average export price is dependant upon prices in long-term international gas supply contracts, which are normally tied to prices of oil products traded on European commodity exchanges and are also determined with several months' time lags. Consequently, the level of gas prices in 2011 and afterwards could be forecast by means of various regression models.

⁹¹ The duty on gas exports equals to 30 per cent, [47] but the formula uses an effective value because part of gas exports (e.g. part of exports via “blue stream” pipeline until 2016 [48]) is exempted from duties.

⁹² For example, when calculating the price for the first quarter of 2011, the export price will be determined as an average value for the period of January – September, 2010.

5. Electricity price

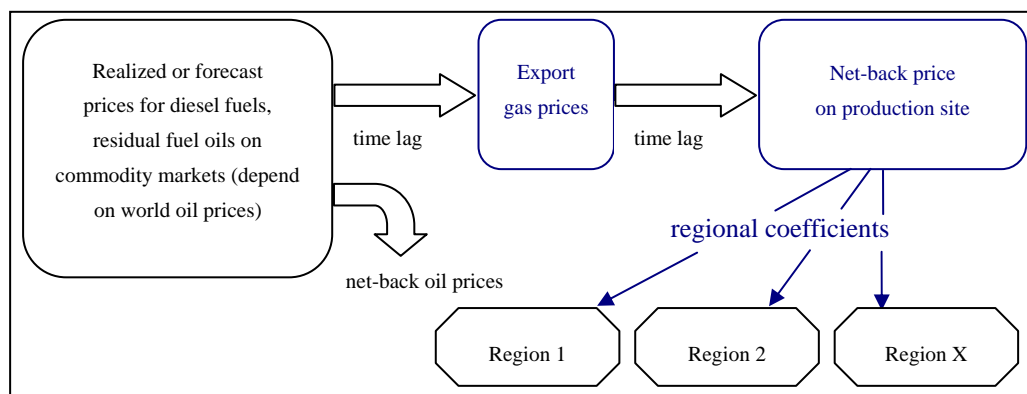


Figure 39. Forecasting prices on internal fuel markets.

Fuel oil is traded at free market prices. In Russian power industry it is generally used as back-up fuel and account for approximately 2–4 per cent of thermal generation.

During past decade natural gas has been cheaper than coal (and much cheaper than oil) in terms of equivalent fuel that led to growth of its share in power plants' fuel mix. [50] Increasing prices of natural gas will, without proper antimonopoly supervision, cause growth of coal prices due to very poor competition on domestic market of steam coals (monopoly or bilateral monopoly), which has to do with historical development of the electricity sector. As a general rule, construction sites for power plants are selected taking into account transportation costs and for that reason a lot of coal-fired power plants are located close to sea ports, railroads or coal production sites. In Russia coal-fired generation facilities were primarily built in the vicinity of coal fields and were designed to burn only a single type of coal mined locally. Bearing in mind considerable investments required for reconstruction of existing facilities (in order to being capable of burning wider range of coals) and railway tariffs, which account for 30–80 per cent of final consumers' coal costs (Rashevskiy, SUEK), it could be concluded that coal producers will tend to maintain price parity with natural gas. Historical values of gas-to-coal price ratio and projections until 2020 (assuming the government's plan until 2011) are presented below.

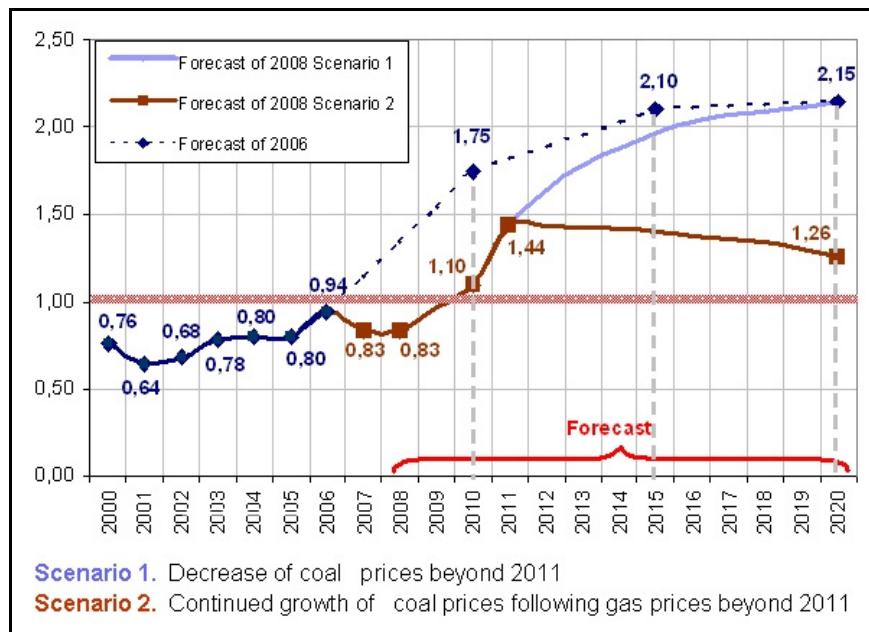


Figure 40. Forecast of gas/coal price ratio until 2020, thermal equivalent [51].

Implementation of technical policy [8] may help improve competition on coal market, since it envisages not only development of combustion technologies (ability of new power plants to burn coals of different calorific and ash content characteristics), but also standardization of coals (production of several typical homogeneous coal blends by enterprises of coal-mining industry).

5.3 Renewable energy sources. Emissions

The latest changes to the law on power industry laid down definition⁹³ of renewable energy sources (RES). The government sets RES targets as a percentage of total electricity production and determines action plans for achieving them. In order to qualify for state support, the owners of generation facilities producing electricity from renewable energy sources are required to obtain RES-certificates from the Market Council. [52] The state support will be provided in a form of subsidies from federal

⁹³ Renewable energy means solar, wind, hydro energy (including waste water energy), except when such energy is used by pumped-storage power plants; tidal energy, wave energy of water bodies, including water basins, rivers, seas, oceans, geothermal energy using natural underground transfer fluids, low-potential thermal energy of earth, air, water using special transfer fluids, biomass, including plants grown specially for power generation, including trees, as well as production and consumption waste, with the exception of waste received during the use of hydrocarbon feedstock and fuel, biogas, gas released from production and consumption waste at the sites for the disposal of such waste; gas formed at coal sites [17].

5. Electricity price

budget for compensation of grid connection costs. It is planned that RES-generators will be receiving fixed regulated premiums for produced electricity on top of equilibrium market price. Amount of produced electricity from RES and binding for purchasing upon wholesale market buyers will be confirmed by non-tradable certificates of origin (CeO) issued and cancelled electronically.

Preliminary assessment of the premiums' influence on electricity costs is presented below and is based on suggested [53] periods and amounts of the premiums.

Table 15. Increment of electricity prices from RES obligations (prices of 2008).

Type of RES	Premium validity, years	Premium per MWh	2008	2010	2015	2020
			RES-targets (generation, TWh)			
Small hydro (<25 MW)	10	64,59 €	2,8	3,5	10	20
Wind energy	10	122,10 €	0,0097	0,21	2,6	17,5
Geothermal energy	10	101,70 €	0,4	0,6	2	5
Biomass	7	55,24 €	5,2	13,5	22	34,9
Tidal energy	15	144,48 €	0	0	0,024	2,3
Solar energy	15	473,94 €	0,00002	0,00003	0,002	0,018
Other	10	84,99 €	0	0	0,08	0,5
Production from RES, TWh			8,41	17,81	36,71	80,22
Total burden, mln €			510,0	1058,5	2393,3	5189,7
Consumption (GS-2020 baseline), TWh			1000	1196,6	1426,3	1710
Increment of costs per MWh			0,51 €	0,88 €	1,68 €	3,03 €

The cost increments will not affect wholesale electricity price, but they will show up in financial obligations (bills) of wholesale market buyers.

According to the law on power industry, grid entities shall compensate losses in their grids by purchasing electricity produced primarily (in the first place) by certified RES-generators. Consequently, variable components of grid companies' transmission tariffs should account for that. The RES-targets and estimates of renewable energy sources' potentials could be found in Appendix D.

Besides of the above, declared targets of GDP energy intensity reduction in the period until 2020 by 40 per cent of 2007 level [54] envisage tightening of environmental legislation. At present environmental charges on average amount to 0.1 per cent of generation companies' sales revenues. [55] Total amount of environmental payments for discharging pollutants into atmospheric air or water bodies is calculated using standard rates R (set in 2005) increased by various coefficients times emission volumes of corresponding pollutants. (4) The standard rates (two values per tonne of a discharge)

are set for 225 air pollutants including several⁹⁴ major greenhouse gases as well as 143 water polluting substances – within authorized allowances (*AA*) and within maximum allowances (*MA*). Volume of pollution beyond maximum allowance (*BMA*) is charged at five times the rate R^{MA} .

$$T = I^{Year} \times K^{Urban} \times K^{Territory} \times (R^{AA} \times AA + R^{MA} \times (MA - AA) + R^{MA} \times 5 \times BMA) \quad (4)$$

Yearly indexation coefficient (equals to 1.21 in 2008) is determined yearly by the government when drawing up the state budget. Urban coefficient 1.2 is applicable for several substances (e.g. NO_2) that significantly impact air of cities. The third coefficient in (4) accounts for environmental condition of certain territories or water basins⁹⁵.

Table 16. Examples of standard rates charged for emissions into the atmospheric air by stationary sources, €/tonne [56].

Pollutant	Standard rate	
	within authorized allowances (R^{AA})	within maximum allowances (R^{MA})
Nitrogen dioxide	1,47	7,37
Nitrogen oxide	0,99	4,96
Methane	1,42	7,08
Carbon oxide	0,02	0,08
Sulfur dioxide	0,59	2,97

It is suggested to set the allowances based on parameters of the best available technologies [57, 42] – in this case ecological payments will increase significantly (for some power plants by up to 300–800 per cent). [55] Current level of thermal power plants' pollutants emissions could be found in Appendix D.

Figure 41 depicts development of carbon dioxide emissions⁹⁶ from public electricity and heat production – historical data 1990–2006 [59] and estimate until 2020. The estimate is based on fuel need (Table 3) in baseline scenario of the General Scheme (which, in principle, should account for energy efficiency developments, etc.) and country-specific CO_2 emission factors⁹⁷.

⁹⁴ NO , NO_2 , CH_4 , CO , SO_2 , gases of NMVOC group.

⁹⁵ The coefficient varies by regions: for air pollution – from 1 (Far East) to 2 (Urals); for water – from 1 to 2.2; On specially protected natural territories (e.g. national parks, etc) additional coefficient 2 applies.

⁹⁶ Pure CO_2 , not CO_2 -equivalent.

⁹⁷ The coefficients account for fractions of non-oxidized carbon, ($\text{tCO}_2/\text{t.c.e.}$): Natural gas – 1.62; Coal – 2.76; HFO – 2.28 [58, 60].

5. Electricity price

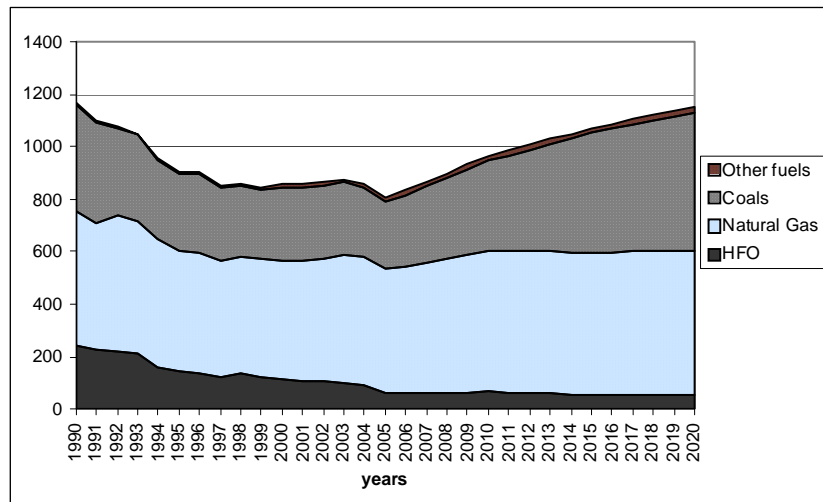


Figure 41. Emissions of carbon dioxide from electricity and heat production, Tg.

It is assumed here, that during 2007–2020 emissions from “other fuels” and heat-only facilities remain constant, while increases of heat production (Appendix A) are attained solely through expansion of cogeneration at CHP plants envisaged by the General Scheme. These assumptions let us to evaluate the contribution of CO₂ emissions that arise from fossil fuels combustion (mainly from coal) in baseline scenario of the GS-2020 to those resulting from total public electricity and heat production.

It can be concluded that in this sector emissions of CO₂ may approach 1990 level⁹⁸ by 2020 in this unlikely scenario.

⁹⁸ 1990 is the base year for greenhouse gases under the Kyoto protocol except for F-gases, for which the base year is 1995.

6. Summary and conclusions

In the course of restructuring of Russian electricity sector the target structure has been reached and the former monopoly dissolved. Currently the electricity market is on the stage of transition towards liberalization of prices. This liberalization concerns the territories of price zones, where more than 90 per cent of Russian electricity consumption takes place. The price level of electricity seems to be rather small at a glance – about 21€ and 15€ per MWh in price zone “Europe” and “Siberia” respectively. It should be borne in mind that all the wholesale market buyers have to pay for electricity service availability in the form of capacity payments (on average around 3000€/MW monthly). The “short” capacity payments market has been launched in July 2008. Starting from 2009 the generation capacity products will be traded on commodity exchanges.

The State controls the sector not only through regulators and infrastructure companies, but also via ownership in the nuclear generation company, hydro wholesale generation company as well as in several territorial and wholesale generation companies in the “strategic” regions of Moscow and Saint-Petersburg via the gas monopoly Gazprom. According to tariff regulation strategy, the regulated domestic gas price will be increasing by 27.7 per cent both in 2009 and 2010⁹⁹. This growth will certainly reflect on electricity market prices. In general, fuels market in Russia lacking competition – vast majority of natural gas is supplied by a single vertically integrated company, coal markets are local and oil has always been used only as a back-up fuel.

With greater share of electricity traded at free prices there will be an increased need to hedge price risks. For this reason it is planned to organize a financial market. In addition, price liberalization necessitate emergence of an ancillary services markets, since currently these services are remunerated through regulated tariffs on electricity

⁹⁹ In December, 2008 it has been decided to adjust the schedule presented in Table 13 and to smoothen the transition by increasing the gas prices quarterly – by 5, 7, 7 and 6.2 per cent, which leads to the same growth rate December 2008-to-December 2009.

6. Summary and conclusions

and capacity. It is planned to launch support schemes for renewable generation and to limit environmental pollution.

Another important aspect is updating the technical regulations and standards. The outdated existing ones often lead to higher steel intensiveness (generation capacity investments and thus, capacity payments) and poor energy conversion and conservation parameters compared to benchmark analogues. The latter helps improve energy efficiency and therefore, reduces the need for new generation capacity.

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Appendix A

Table A1. Forecast of electricity consumption in Russia by energy regions, TWh [3].

Area	Reported values		Baseline scenario			Max. scenario
	2005	2006	2010	2015	2020	2020
IPS of North-West ¹	83,7	87	114,3	141,9	175,5	184
IPS of Centre	224,6	234,7	288,7	355,9	433,9	478
IPS of Middle Volga	80,6	84	98,8	110,6	125,3	158
IPS of South	73,5	76,4	94,1	110,9	126	155,7
IPS of Urals	228,1	241,7	293,6	349,6	420,8	470,2
IPS of Siberia	190,8	196,2	239,8	278	330,8	425,6
East total, including:	38,7	39	45,5	56,1	72,6	98,2
IPS of Far East	27,1	27,2	31,9	40,3	50,7	68,9
Eastern isolated areas	11,6	11,8	13,6	15,8	21,9	29,3
Total centralized area	920	959	1174,8	1403	1684,9	1969,7
Total²	940,7	980	1196,6	1426,3	1710	2000

¹ including Kaliningrad region

² including distributed (decentralized) supply

Table A2. Estimated investments in baseline scenario of the General Scheme-2020, 10⁹EUR (money-of-the-day) [3].

	2006-2010	2011-2015	2016-2020	2006-2020
Hydro power plants	25,4		32,2	57,7
Nuclear power plants	44,6		41,8	86,4
Thermal power plants	121,0		64,0	185,0
Total electricity generation	191,0		138,1	329,1
Unified National Electric Grid	20,3	46,2	71,5	138,0
including:				
new construction	14,7	32,9	53,5	101,1
renovations	4,6	10,4	13,2	28,2
other	1,0	2,9	4,8	8,8
Distribution Networks	20,0	42,2	57,0	119,2
including:				
new construction	9,7	22,4	29,9	62,0
renovations	8,7	17,2	23,5	49,5
other	1,5	2,6	3,6	7,7
Total electrical networks	40,3	88,4	128,5	257,2
Total			266,6	586,3

Appendix A

Table A3. Production of heat in Russia, PJ [10, 42, 64].

	2006	2010	2015	2020
Generation Companies ³	2308	2408	2665	2883
Autoproducers	549	636	697	697
Total Russia ⁴	6430	6794	7099	7447

³ Including generation companies' boiler plants

⁴ Production by centralized sources (capacity over 87.1 GJ/hour); decentralized \approx 2600 PJ in 2006

Appendix B

The list of the subjects of the Russian Federation, whose territories are united into the price zones of the wholesale market of electrical energy (capacity) of the transitional period

I. The First Price Zone (the Zone of Europe and the Urals)

Republic of Adygeya, Republic of Bashkortostan, Republic of Daghestan, Republic of Ingushetia, Kabardino-Balkar Republic, Republic of Kalmykia, Karachayevo-Cherkess Republic, Republic of Karelia, Republic of Marii El, Republic of Mordovia, Republic of North Osetia – Alania, Republic of Tatarstan, Udmurtian Republic, Chechen Republic and Chuvash Republic;

Krasnodar Territory and Stavropol Territory;

Astrakhan Region, Belgorod Region, Bryansk Region, Vladimir Region, Volgograd Region, Vologda Region, Voronezh Region, Ivanovo Region, Kaluga Region, Kirov Region, Kostroma Region, Kurgan Region, Kursk Region, Leningrad Region, Lipetsk Region, Moscow Region, Murmansk Region, Nizhnij Novgorod Region, Novgorod Region, Orenburg Region, Oryol Region, Penza Region, Perm Region, Pskov Region, Rostov Region, Ryazan Region, Samara Region, Saratov Region, Sverdlovsk Region, Smolensk Region, Tambov Region, Tver Region, a part of the territory of Tomsk Region, to which electrical energy is supplied from the territory of the Interregional Power System of the Urals, Tula Region, Tyumen Region, Ulyanovsk Region, Chelyabinsk Region and Yaroslavl Region;

The City of Moscow and the City of St.Petersburg;

Komi-Permyak Autonomous Area, Nenets Autonomous Area, Khanty-Mansi Autonomous Area – Yugra, Yamalo-Nenets Autonomous Area.

II. The Second Price Zone (Siberian Zone)

Republic of Altai, Republic of Buryatia, Republic of Tyva and Republic of Khakasia;

Altai Territory and Krasnoyarsk Territory;

Irkutsk Region, Kemerovo Region, Novosibirsk Region, Omsk Region, Tomsk Region with the exception of the territory included into the first price zone, and Chita Region;

Aginsk Buryat Autonomous Area and Ust-Orda Buryat Autonomous Area.

(Source – Government decision 217 of April 15, 2005)

Appendix C

Forecast balance is formed by the Federal Tariff Service by regions, slotted by quarters and months. It is used as a basis for determination of regulated tariffs for electricity, capacity and a number of services. FTS-balance is based on forecast data submitted by market agents (such as expected consumption, peak loads, offers on electricity and power balances of the power plants and network companies' expectations of the volumes to be purchased to compensate for losses, including those arising from import-export operations). The buyers of electricity and capacity on the wholesale level determine consumption and peak load on the grounds of end-users' applications reflecting their economic and energy-efficiency developments. Local authorities estimate demand for a region taking into account dynamics of consumption of 3 preceding years.

Depending on plant, the hydropower production is calculated with account taken of average annual production or firm energy (guaranteed volume of energy), reservoir level at the beginning of planning period and hydrological year. Electricity, produced in a combined cycle is of the top-priority when including in the balance. Generation of new plants is based on their commissioning dates and expected heat loads; condensing units – based on cost parameters and transmission capacities, etc.

Besides price setting purposes the data of yearly forecast balances serve as a departure point in determination of liberalized volumes and volumes of capacity traded on capacity payments market. After FTS-balance is formed, the allocations (tariff-balance decisions) are reported to market agents.

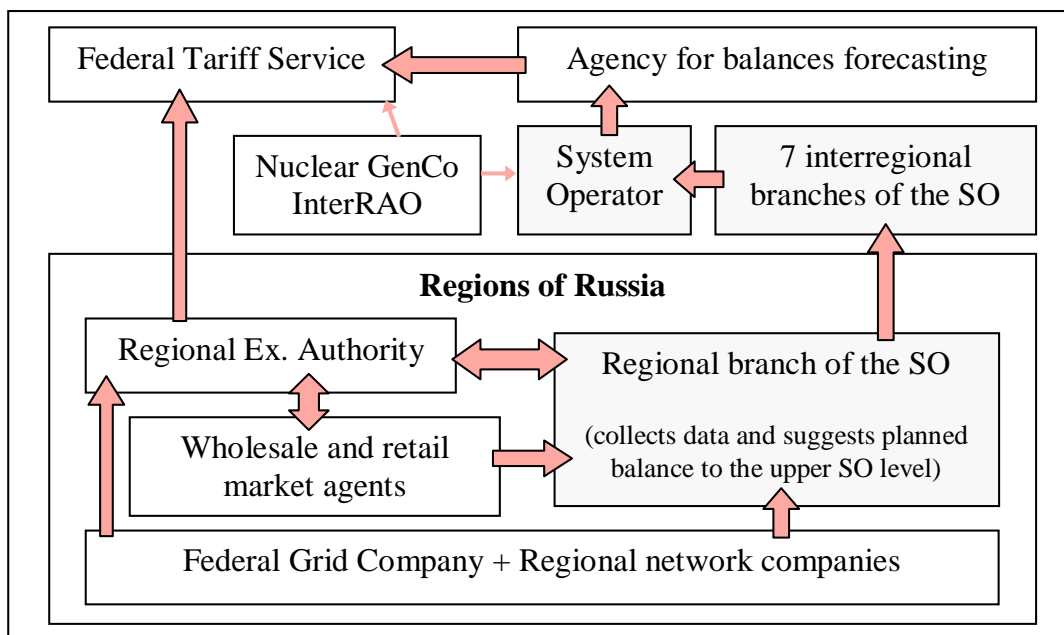


Figure C1. Formation of the FTS balance.

Table C1. Forecast balance for 2008 (within the UPS of Russia) [61].

	Units	Years	
		2007 (actual)	2008 (forecast)
1. Electricity Production, total	TWh	997,3	1042,4
including:			
a) Total Thermal Power Plants (TPP)	TWh	611,7	659,5
of them by WGCs	TWh	256,8	265,6
by TGC, RGC, TPP of "Energos"	TWh	354,9	393,9
b) Total Hydro Power Plants (HPP)	TWh	177,7	171,3
of them by WGCs	TWh	82,3	80,8
by TGC, RGC, HPP of "Energos*"	TWh	95,4	90,5
c) Power Plants of retail market	TWh	49,6	50,2
d) Nuclear Power Plants	TWh	158,3	161,4
2. Electricity Consumption, total	TWh	985,6	1034,5
3. Export/Import balance, total	TWh	-11,7	-7,9
4. Heat energy	mln. Gcal**	514,9	591,9
	PJ	2242,4	2577,8

* including Krasnoyarsk Hydro Power Plant

** 1 Gcal = 0.1486 t.c.e. = 4355.11 MJ [13]

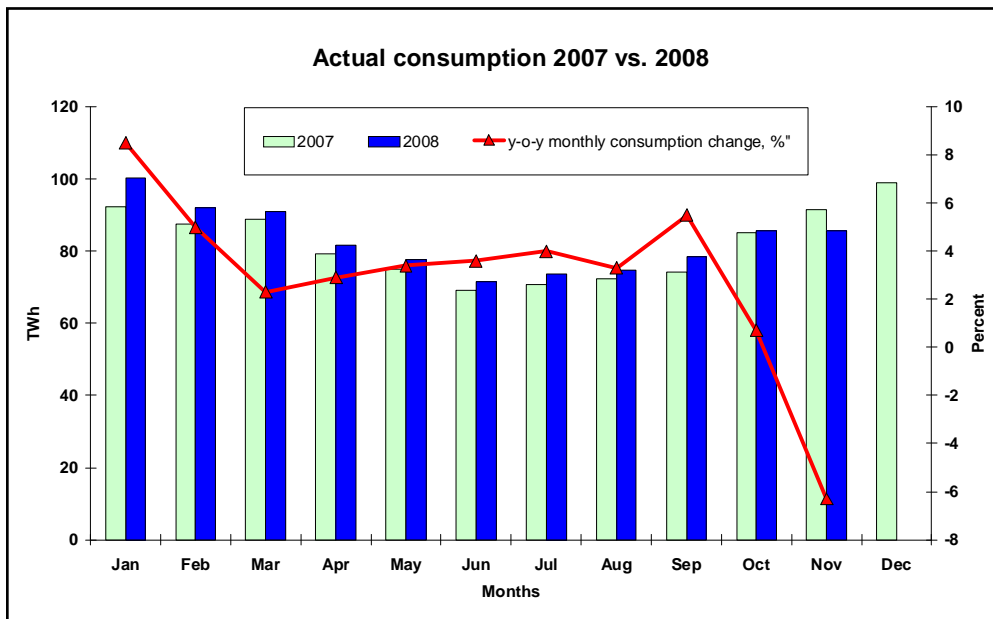


Figure C2. Actual monthly electricity consumption in 2007 and 2008.

Appendix D

Table D1. Target production of electricity from renewable energy sources, TWh [53, 62].

Type of RES / Years	2008	2010	2015	2020
Hydro power plants, >25MW	174	168	193	284
Small hydro power plants	2,8	3,5	10	20
Wind	0,0097	0,21	2,6	17,5
Geothermal	0,4	0,6	2	5
Biomass	5,2	13,5	22	34,9
Tidal	0	0	0,024	2,3
Solar	0,00002	0,00003	0,002	0,018
Other	0	0	0,08	0,5
Total production from RES	182,41	185,81	229,706	364,218
Total (the same in PJ)	656,7	668,9	826,9	1311,2

Table D2. Technical and economic potentials of RES in Russia, PJ [62, 10, 63].

Type of RES	Gross	Technical	Economic
Low potential thermal energy	15386	3370	1055
Solar energy	67407480	67407	366
Energy of biomass	293076	1553	1026
Wind energy	761998	58615	1758
Geothermal energy	-	-	3370
Small-scale hydro power	10551	3652	1911
Total	-	-	9487
Total in ES-2020 (adopted in 2003)	$\approx 68,5 \times 10^6$	134815	7913

Appendix D

Table D3. Thermal power plants' emissions into the atmosphere, 10³ t [51].

Pollutants	2006	2007
SO ₂	1066,6	946,8
NO _x	755,6	738,5
Particulates (ash)	920,5	875,3
Other	201,8	206,5
Total	2944,5	2767,1
Emissions of CO ₂ , (in Tg)	470,0	458,2

Appendix E

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
1	638	1200	650	412	1095																								
2																													
3																													
4					200																								
5	440			320																									
6	682																												
7								1550		680	1300	835																	
8									1143																				
9								240																					
10							42																						
11							991																						
12							1344																						
13							1556							1164															
14													1144																
15													2954																
16																													
17															205														
18																			335	157									
19																	21												
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