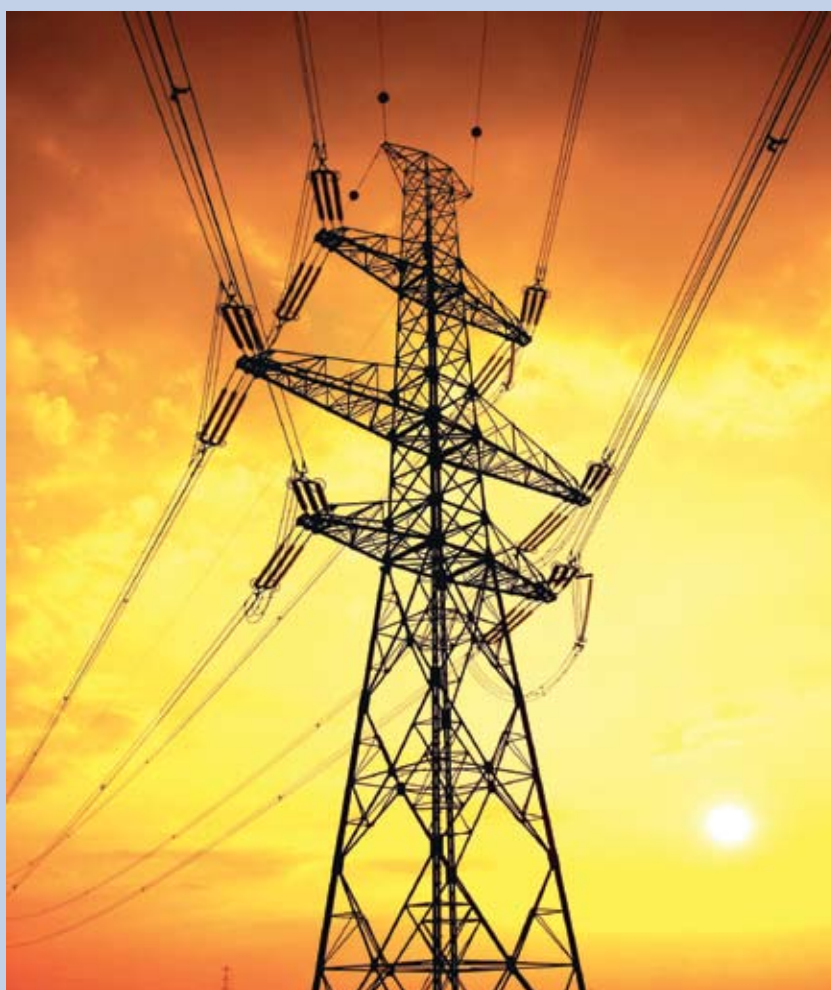




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Electric power, transportation infrastructure and high-tech and innovative industries are key areas of the Bank's financial activity. In line with its charter, the Bank views information and research support for integration in Eurasia as a priority of its analytical work.

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Abbreviations

CES – Common Economic Space
CIS – Commonwealth of Independent States
COTC – Commission for Operational and Technological Coordination
EDB – Eurasian Development Bank
ESI SB RAS – Melentiev Energy Systems Institute, Siberian Branch of the Russian Academy of Sciences
EurAsEC – Eurasian Economic Community
FGC – Federal Grid Company
GRES – state regional electric power plant
GW – gigawatt
HPP – hydropower plant
IAEA – International Atomic Energy Agency
IPS – Integrated power system
ISO – International organisation for standardisation
JV – joint venture
KEGOC – Kazakhstan Electricity Grid Operating Company
KOREM – Kazakhstan Operator of Electric Energy and Power Market
kV – kilovolt
kW – kilowatt
kWh – kilowatt-hour
MW – megawatt
NPP – nuclear power plant
PSH – pumped-storage hydropower
TESIS – Trans-European Synchronously Interconnected Electric Power System
TPP – thermal power plant
TWh – terawatt-hour
UES – Unified Energy System
UPS – unified power system

Main Conclusions

1. By 2010 the total installed capacity of power plants in the Eurasian Development Bank's (EDB) member states had reached 270 GW with generation of 1,190 TWh. The type of power plants that operate or are under construction in the EDB countries include thermal power plants, hydropower and pumped-storage hydropower plants, nuclear power plants, and renewable energy power plants. Fossil-fuelled thermal power plants dominate the generating capacity and this situation has remained practically unchanged in recent years. However, the structure of electricity generating capacities differs between countries depending on the availability, or lack, of certain energy resources in a given country. For example, hydropower dominates the power sectors of Tajikistan and Kyrgyzstan.
2. The EDB member states are building an electricity grid with the primary aim of creating and strengthening their national grid infrastructures so that they are able to supply electricity to all consumers, including those in remote regions.
3. External power grids linking EDB member states with each other and foreign countries are well developed, except for Armenia, whose power system is geographically disconnected from the power grids of the EDB and CIS member states, and Tajikistan, whose electricity network has been isolated from other EDB countries since late 2009.
4. The EDB member states trade in electricity with each other and with third countries. Since mid-2000s, electricity exports and imports have decreased by more than 30% and 60% respectively. The reasons for these declines include increased domestic consumption, economic recession, and the reluctance of certain parties to make compromises in energy trading.
5. In most EDB member states, internal electricity demand is driven primarily by the industrial sector. In certain cases, however, such as in Tajikistan and Armenia, it is the utilities and general household consumption that shape demand patterns.
6. The EDB member states cooperate intensively with each other in the construction, acquisition, management and operation of power facilities, the development of design documents, and in the supply, installation and maintenance of power-generating and electrical equipment. Russia is one of the key players in this cooperation. A significant presence of investors and suppliers from third countries in the power markets of the EDB member states poses serious competition to Russian suppliers.
7. The EDB member states face serious challenges in the development of their electric power markets, especially the depreciation of key production assets in all countries. The depreciation of fixed assets averages 40–60% but can be as high as 90%, restricting efficiency in the sector (high costs of fuel needed for electricity generation and losses during power transmission and distribution). Although in recent years there has been a greater tendency to modernise and upgrade equipment, the technological gap between the EDB country's electricity sector and the global industry has not been bridged. Efficiency is also restricted by deficiencies in the electrical engineering sector, the high cost of equipment, the low impact of innovation, and imbalanced structure of generating capacities. The latter leads to suboptimal operation system and requires a national electric power system to swap energy with neighbouring grids. Moreover, electric power assets are less effectively managed in some countries.

8. A number of obstacles to deeper integration remain, including the recurring suspension of electricity exports and imports, outages in interstate electricity grids, and even a disconnection of the national power system and discontinuation of its parallel operation with other power systems (as it happened with Tajikistan). In addition, the development of generating capacities and grid infrastructure in the regions that face power shortages and depend on electricity imports reinforces the electrical independence of the EDB member states and weakens their integration in the power sector.
9. System effects, including regime, structural and other effects, can play a significant role in the interaction of national power systems. Some of these effects already exist, both in the relationships between the EDB member states and in their relationships with third countries. However, they are still considerably weaker than they could be.
10. The principles of creating and organising the common electric power market of the Commonwealth of Independent States (CIS) and EDB countries, which have been defined by respective agreements, need to be reviewed in the light of Russia's experience in operating a liberalised competitive market. This experience cannot be deemed successful and many experts assert that market reforms in the Russian power sector have failed to achieve their objectives.
11. Multinational initiatives are being developed with the aim of deepening integration in the electric power sector between the CIS, EurAsEC and EDB countries. They include the Strategy for Interaction and Cooperation between the CIS Member States in the Field of Electric Power, the Concept for and the Agreement on the Establishment of the Common Electric Power Market of the CIS Member States, and other documents. In the long run, integration initiatives should result in the creation of a common electric power space, which would encompass not only national power sectors and systems, but also related industries such as fuel production, electrical and electronics engineering and professional education.

Introduction

Being one of the primary industries, the electric power sector plays a vital role in social and economic development of any country. Therefore, it is identified as one of the priority economic sectors of all the EDB member states and of the Bank's investment and lending activities. The sector's sustainable development and robust functioning contribute, to a considerable extent, to the energy security of countries and their successful economic development.

The objective of this sector report is to study integration processes in the electric power sectors of the EDB member states: the Republic of Armenia, the Republic of Belarus, the Republic of Kazakhstan, the Kyrgyz Republic, the Russian Federation, and the Republic of Tajikistan. This report continues the research initiated by the EDB in 2008 (Vinokurov, 2008) and provides new information about integration processes in the power systems and sectors of the EDB member states.

The report analyses the power sectors of the EDB member states and, in particular, changes that have occurred in recent years, key trends in the development of generating capacities and power grids, and electricity exports and imports. It also examines the main challenges to development and the key drivers of electricity demand.

The report studies power transit and cross-border trade in electricity, system effects of the national power systems' integration, mutual investment in the power sector, and supplies of power-generating and electrical equipment. In addition, the report analyses joint interstate initiatives, including the future establishment of a common electric power market, and examines possibilities of introducing uniform technical and environmental standards and a legal framework, regulating the common market. Recommendations are provided on how to deepen integration in the region and foster the creation of the common electric power space, with an emphasis on the EDB's role in this process.

It should be noted, however, that the inconsistency of data provided by different sources demanded for an additional verification and comparison of data to determine the most reliable sources.

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

1.1. Overview of the region's electric power sector development in 2006–2010

Total electricity consumption in the EDB member states amounted to around 1,175 TWh in 2010 (see Table 1.1), with Armenia accounting for less than 0.5% of the total and Russia, the largest economy in the region and the post-Soviet space as a whole, for about 87%.

Generally, the annual average growth rate of electricity consumption in the EDB member states made up around 1.1% in 2006–2010, while during the pre-crisis period of 2006–2008 and the post-crisis recovery it stood at 2.3% and 4.7% per annum respectively. These rates vary significantly between countries. Electricity consumption in Kyrgyzstan and Tajikistan decreased not only because of the global crisis but also due to a number of domestic problems including political instability (mostly in Kyrgyzstan). Armenia's consumption remained practically unchanged while Belarus saw some growth. Russia and Kazakhstan had the largest increase in consumption, with Russia accounting for approximately 77% of the overall growth in consumption in all the EDB member states. This figure is lower than Russia's share in overall electricity consumption. This is explained by the fact that Kazakhstan has significantly increased its consumption, thereby reducing Russia's share.

A decline in consumption in 2009 was mainly driven by the global financial crisis and subsequent recession in economic activity in general and in energy-intensive sectors in particular. The overall decrease in consumption amounted to 4.5%. However, in 2010 electricity consumption exceeded the precrisis level of 2008.

The analysis of average per capita electricity consumption yields interesting results. This figure might be an indicator of the socioeconomic development of a country. It indicates the amount of electricity supplied to the manufacturing, agricultural and service sectors of the economy and the use of electrical appliances by households. As shown in Table 1.1, per capita electricity consumption in the EDB member states exceeds 6,300 kWh, which is significantly higher than the European average. Yet it varies significantly between countries. Russia is the obvious leader with consumption exceeding 7,000 kWh per capita at the end of the period analysed. The figure is also high in Kazakhstan, being roughly equal to the European average. Armenia's consumption is noticeably lower than the global level, while Kyrgyzstan and Tajikistan are somewhere below it. Belarus has an average level of consumption.

Aggregate electricity generation in 2010 totalled 1,190.5 TWh, including 810.7 TWh (68%) produced by thermal power plants (TPPs), 206.6 TWh (17%) by hydropower plants (HPPs), and 173.2 TWh (15%) by nuclear power plants (NPPs) (see Table 1.1). It should be noted that pumped-storage hydroelectric (PSH) plants does not play significant role in generating the power. At present, only Russia has PSH plants with a total capacity of 1,200/1,320 MW (turbine/pump generation).

In 2006–2010 total electricity generation in all countries increased by 54.4 TWh, including 48.8 TWh by TPPs and 14.2 TWh by NPPs. Hydropower plants reduced generation by 8.6 TWh over the period, due to the accident on the Sayano-Shushensk HPP in 2009 and the difficult hydrological situation on Kyrgyz and Tajik HPPs.

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

Table 1.1.
Electric power balance in the EDB member states

Country	Years	Generation (TWh)					Annual consumption *				Exchange with other countries (TWh)			
		Total	TPPs	HPPs	NPPs	Other power plants	TWh	Population (million people)	kWh per capita	Export	Import	Balance	Share in consumption (%)	
Armenia	2006	5.94	1.48	1.82	2.64	0.003	5.54	3.22	1,721	0.76	0.36	0.4	7.22	
	2007	5.9	1.49	1.85	2.55	0.003	5.87	3.22	1,821	0.45	0.42	0.03	0.56	
	2008	6.12	1.85	1.8	2.46	0.002	6.1	3.23	1,888	0.36	0.34	0.02	0.28	
	2009	5.67	1.13	2.05	2.49	0.004	5.63	3.24	1,737	0.34	0.29	0.05	0.8	
	2010	6.49	1.44	2.56	2.49	0.007	5.68	3.25	1,746	1.06	0.25	0.82	14.36	
Belarus	2006	31.81	31.78	0.04		0.001	36.17	9.63	3,756	1.12	5.48	-4.36	-12.05	
	2007	31.83	31.79	0.04		0.001	36.17	9.58	3,776	0	4.34	-4.34	-12.01	
	2008	35.05	35.01	0.04		0.001	36.89	9.54	3,867	0.56	2.4	-1.84	-4.98	
	2009	30.41	30.36	0.05		0.001	34.88	9.51	3,668	0.01	4.48	-4.47	-12.82	
	2010	34.9	34.85	0.05		0.001	37.6	9.5	3,958	0.27	2.97	-2.7	-7.18	
Kazakh-	2006	71.66	63.89	7.77		N/A	71.88	15.21	4,726	3.73	3.96	-0.23	-0.31	
	2007	76.37	68.22	8.15		N/A	76.44	15.4	4,964	3.31	3.38	-0.08	-0.1	
	2008	80.08	72.64	7.44		N/A	80.62	15.57	5,178	2.24	2.78	-0.55	-0.68	
	2009	78.43	71.57	6.86		N/A	77.96	15.78	4,940	2.25	1.77	0.48	0.61	
	2010	82.63	74.6	8.02		0.008	84.10	16.04	5,243	1.54	3.01	-1.47	-1.75	
Kyrgyz-	2006	14.52	0.87	13.65		N/A	12.06	5.19	2,324	2.46	0	2.46	20.39	
	2007	14.83	0.83	14		N/A	12.45	5.25	2,372	2.38	0	2.38	19.11	
	2008	11.79	1.03	10.76		N/A	11.22	5.29	2,120	0.58	0.01	0.57	5.1	
	2009	11.08	0.99	10.1		N/A	10.05	5.35	1,878	1.03	0	1.03	10.29	
	2010	12.06	0.72	11.35		N/A	10.5	5.42	1,938	1.64	0.08	1.56	14.85	
Russia	2006	995.76	663.7	175.2	156.4	0.46	980	142.75	6,865	20.93	5.17	15.76	1.61	
	2007	1,015.3	676.3	179	160	N/A	1,002.5	142.22	7,049	18.47	5.67	12.8	1.28	
	2008	1,040.43	710.14	166.73	163.1	0.46	1,022.79	142.01	7,202	20.59	3.1	17.49	1.71	
	2009	992	651.8	176.1	163.58	0.522	976.99	141.9	6,885	18.04	3.02	15.01	1.54	
	2010	1,038	699.1	168.2	170.7	N/A	1,020.98	142.96	7,142	19.95	2.92	17.02	1.67	

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

Country	Years	Generation (TWh)					Annual consumption *				Exchange with other countries (TWh)			
		Total	TPPs	HPPs	NPPs	Other power plants	TWh	Population (million people)	kWh per capita		Export	Import	Balance	Share in consumption (%)
Tajikistan	2006	16.94	0.22	16.2		N/A	17.53	6.92	2,533		4.43	5.02	-0.59	-3.38
	2007	17.48	0.36	17.11		N/A	17.58	7.06	2,490		4.45	4.55	-0.11	-0.6
	2008	16.15	0.3	15.85		N/A	17.03	7.22	2,359		4.35	5.23	-0.88	-5.19
	2009	16.12	0.22	15.9		N/A	16.06	7.37	2,179		4.23	4.17	0.06	0.36
	2010	16.44	0.03	16.4		N/A	16.58	7.53	2,201		0.18	0.32	-0.14	-0.85
Total	2006	1,136.63	761.92	215.2	159.04	0.464	1,123.18	182.92	6,140		33.42	19.98	13.44	13.48
	2007	1,161.7	778.99	220.15	162.55	N/A	1,151.01	182.73	6,299		29.05	18.37	10.69	8.24
	2008	1,189.61	820.98	202.61	165.56	0.463	1,174.65	182.86	6,424		28.67	13.86	14.81	-3.76
	2009	1,133.71	756.06	211.05	166.07	0.527	1,121.56	183.15	6,124		25.89	13.73	12.16	0.78
	2010	1,190.51	810.74	206.57	173.19	N/A	1,175.43	184.7	6,364		24.63	9.55	15.09	21.1

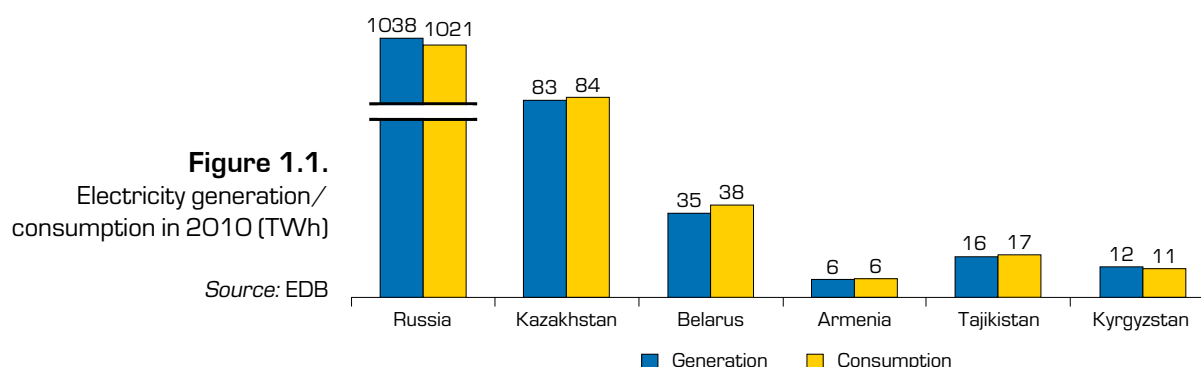
Source: ESI SB RAS

Note: * official websites of the CIS Electric Energy Council, the Belenergo State Production Association, EurAsEC, CIS Interstate Statistical Committee, national statistics agencies of the CIS countries (Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia, and Tajikistan), KOREM, KEGOC, System Operator – Central Dispatch Department of the Unified Energy System;

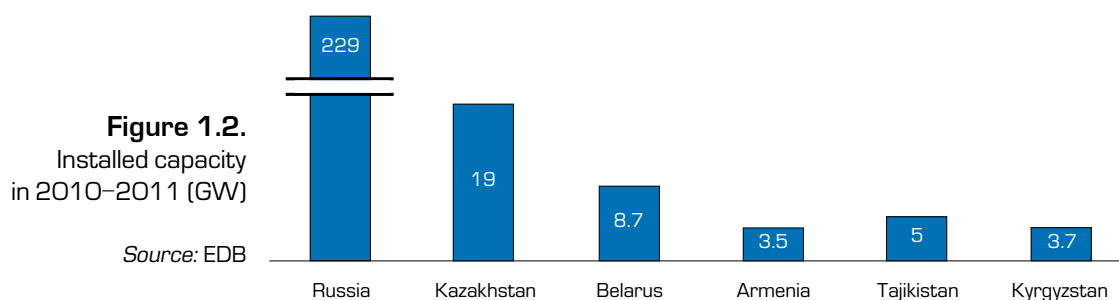
** N/A – data not available

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

The aggregate power generation in the EDB member states grew steadily in 2006–2008 to reach 1,189.6 TWh in the pre-crisis year of 2008. In 2009 it fell to 1,133.7 TWh, primarily because of a decrease in consumption. The overall decrease in consumption in all countries made up 4.7% as compared to 2008, including 13% in Belarus, 7% in Armenia, 6% in Kyrgyzstan, 4.7% in Russia, and 2% in Kazakhstan.



In early 2011 the total installed capacity of power plants in the EDB member states amounted to approximately 270 GW (see Figure 1.2).



Generating capacity was structured as follows TPPs accounted for 69% of the total installed capacity (185.9 GW), HPPs 22% (58.7 GW) and NPPs 9% (24.7 GW). A comparison between the structures of generating capacities and electricity generation indicates that the share of TPPs in both cases is approximately the same. The share of hydropower in electricity generation is less and the share of nuclear power in electricity generation is much greater than in the structure of generating capacities (see Table 1.2). This can be explained by the fact that HPPs are classified as peaking power plants, while NPPs are base load power plants.

Thermal generation is the predominant power source in most countries, except Tajikistan and Kyrgyzstan (see Figure 1.3). Hydropower accounts for a considerable share of generating capacity in Armenia (33%) and Russia (21%) where its development is favoured by the availability of hydropower resources. Armenia and Russia are the only two countries among the EDB member states that have nuclear power plants.

The overall growth of all types of generating capacity over the period under review was around 10 GW (see Table 1.3). The capacity of TPPs increased by 7.1 GW, HPPs by 2.3 GW and NPPs by 0.6 GW. Russia accounts for 7.4 GW (or almost 75%) of the total growth.

The year 2010 saw the highest growth in installed capacity (over 3.7 GW), which accounted for about 40% of the total increase over the period. Even in the crisis year of 2009 installed capacity grew by more than 2 GW.

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

Country	Years	Installed capacity, GW				
		Total	TPPs	HPPs and PSH plants	NPPs	Other power plants
Armenia	2006	3.24	1.78	1.05	0.41	0.003
	2007	3.18	1.7	1.07	0.41	0.003
	2008	3.19	1.7	1.08	0.41	0.003
	2009	3.21	1.69	1.1	0.41	0.003
	2010	3.51	1.93	1.16	0.41	0.004
Belarus	2006	7.95	7.71	0.01		N/A
	2007	8.03	8.01	0.01		N/A
	2008	7.69	7.68	0.01		N/A
	2009	8.29	8.27	0.01		N/A
	2010	8.68	8.66	0.02		N/A
Kazakhstan	2006	18.77	16.53	2.25		N/A
	2007	18.98	16.73	2.25		N/A
	2008	18.99	16.73	2.26		N/A
	2009	19.13	16.86	2.26		N/A
	2010	19.59	17.25	2.27		0.07
Kyrgyzstan	2006	3.73	0.78	2.94		N/A
	2007	3.74	0.79	2.95		N/A
	2008	3.74	0.8	2.94		N/A
	2009	3.74	0.8	2.94		N/A
	2010	3.67	0.72	2.95		N/A
Russia	2006	221.4	151.6	46.1	23.7	N/A
	2007	223.98	153.44	46.8	23.74	N/A
	2008	225.54	155.08	47.16	23.3	N/A
	2009	226.07	155.37	47.4	23.3	N/A
	2010	229.22	157	47.5	24.3	0.42
Tajikistan	2006	4.36	0.32	4.04		N/A
	2007	4.24	0.2	4.04		N/A
	2008	4.24	0.2	4.04		N/A
	2009	5.02	0.32	4.71		N/A
	2010	5.11	0.32	4.79		N/A
Total	2006	259.44	178.72	56.39	24.11	N/A
	2007	262.14	180.87	57.11	24.15	N/A
	2008	263.39	182.19	57.49	23.71	N/A
	2009	265.45	183.31	58.43	23.71	N/A
	2010	269.34	185.88	58.69	24.71	0.49

Table 1.2.

Installed capacity of power plants

Source: ESI SB RAS

Note: N/A – data not available

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

Figure 1.3.
Structure of installed
capacity in 2010

Source: EDB

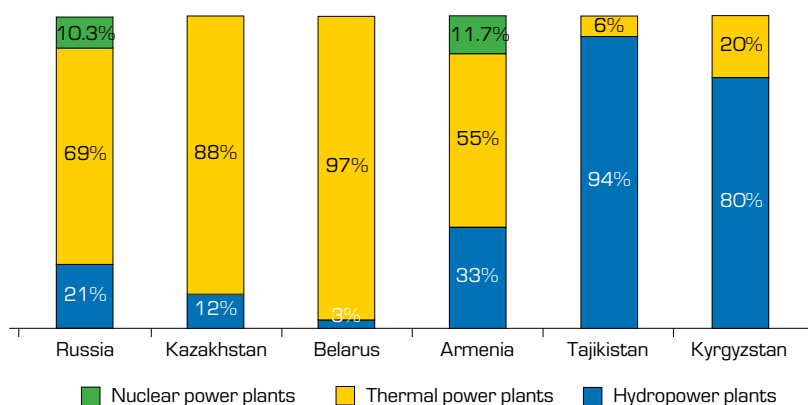


Table 1.3.
Change in installed capacity
(GW)

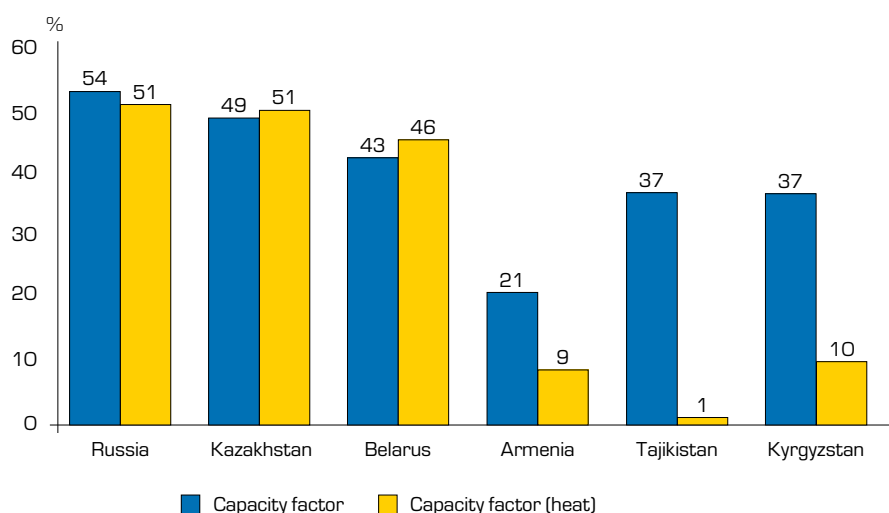
Source: ESI SB RAS

Power plants		TPPs	HPPs	NPPs	Total
Years	2007	2.16	0.72	0.04	2.92
	2008	1.32	0.38	-0.44	1.25
	2009	1.12	0.94	0	2.06
	2010	2.57	0.26	1	3.83
Country	Armenia	0.16	0.11		0.27
	Belarus	0.95	0		0.95
	Kazakhstan	0.73	0.03		0.76
	Kyrgyzstan	-0.07	0.01		-0.06
	Russia	5.4	1.4	0.6	7.4
	Tajikistan	0	0.75		0.75
Total		7.163	2.3	0.6	10.06

The capacity factor differs between countries (see Figure 1.4). It defines the efficiency of existing capacity, including the technological efficiency of the power sector, the qualification of personnel, the overall organisation of the sector at the state level, and many other factors.

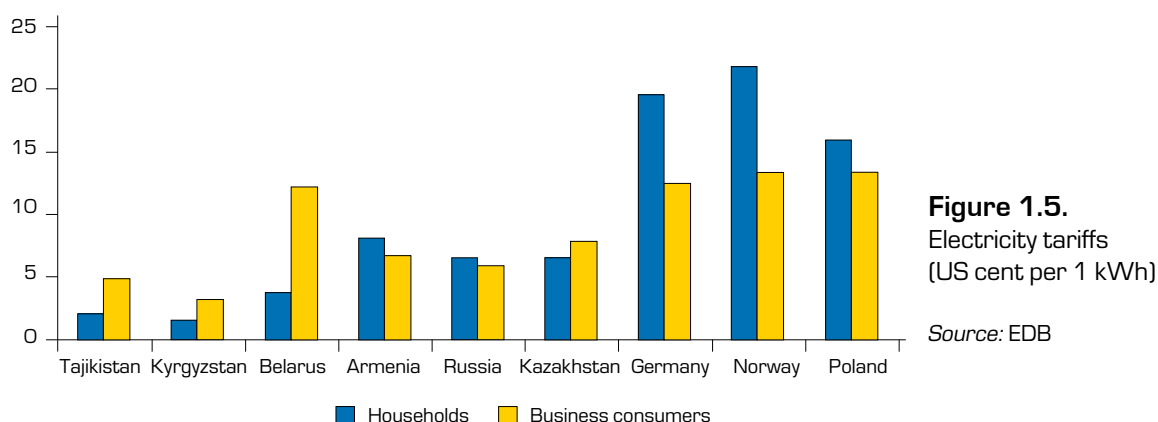
Figure 1.4.
Capacity factor in 2010

Source: EDB

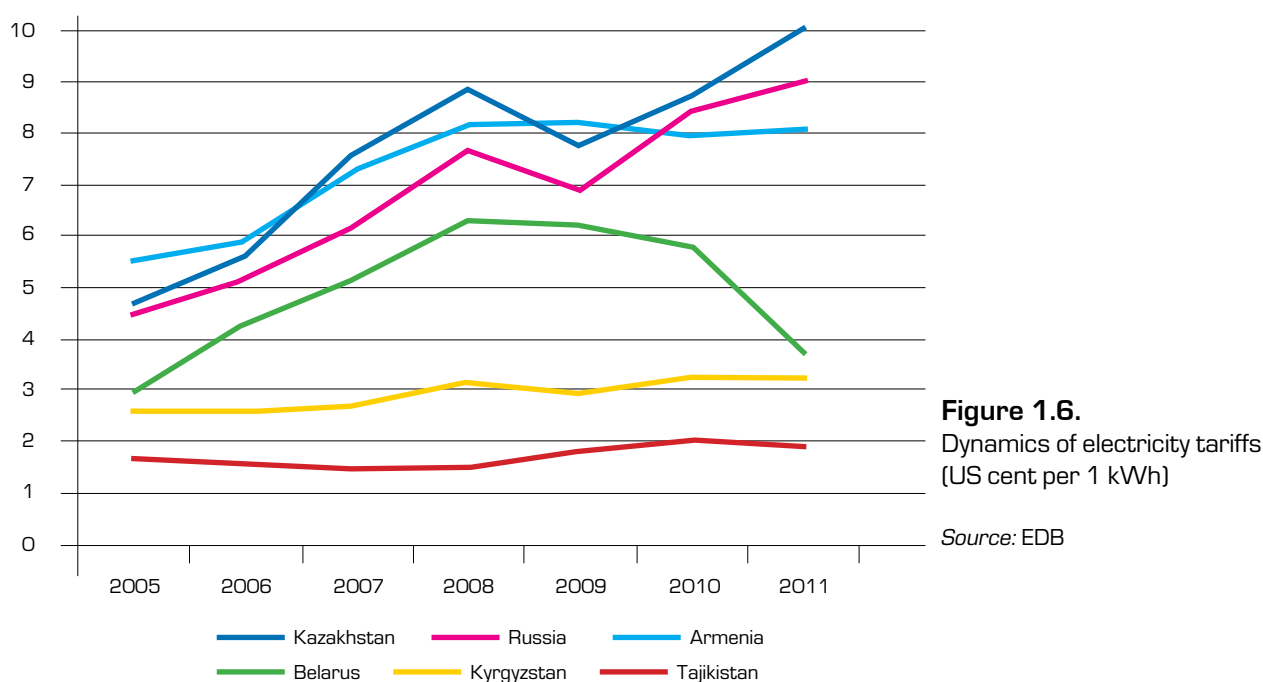


Analysis shows that electricity tariffs in the region are significantly lower than worldwide, which in turn influences the investment attractiveness of the sector. *Figure 1.5* demonstrates that in some countries business consumers subsidise households.

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States



The period analysed was marked by a constant increase in electricity prices (see Figure 1.6), which remained relatively stable only in Kyrgyzstan and Tajikistan. During the crisis years of 2008 and 2009 electricity tariffs were insignificantly decreased, however, starting from mid-2009 prices grew in Kazakhstan and Russia. Belarus saw the cut in tariffs due to the economic situation in the country in general and devaluation of the national currency in particular.



Generation capacities were expanded in 2006–2010 through the reconstruction and upgrading of existing power plants and the construction of new ones. Russia commissioned the 2,010 MW Bureya HPP (2007); 425 MW power unit at Mosenergo TPP-21 (2008); 330 MW power unit at the Kashira GRES (2009); 450 MW unit at INTER RAO UES' Kaliningrad TPP-2 (2010); 393 MW combined cycle block at OGK-4's Shatura GRES (2010); and 1,000 MW reactor at Rosenergoatom Concern's Rostov NPP (2010) (Shmatko, 2011). Other countries commissioned the following new large facilities and units: a 325 MW power unit at Eurasian Energy Corporation's Aksu GRES (Kazakhstan, 2010); 240 MW unit at the Yerevan TPP (Armenia, 2010); 670 MW unit at Sangtuda-1 HPP (Tajikistan, 2009); and 120 MW power unit at Kambarata-2 HPP (Kyrgyzstan, 2010).

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

International organisations supported hydropower development in most of the countries, primarily through the construction of small HPPs within renewable energy development programs under the Kyoto Protocol and with a view to enhance energy saving. In particular, Armenia built 56 small HPPs in 2008–2011 for a total of approximately \$45 million (News.am, 2010) and Tajikistan commissioned 158 small plants in 2010 with capacities of between 20 kWh and 1,500 kWh to provide electricity to remote villages (UNSD, 2011).

Electricity grid upgrades performed in 2006–2011 in Armenia, Belarus, Kazakhstan and Russia helped to significantly reduce transmission losses (Belenergo, 2011; FGC, 2011; KEGOC, 2011).

In December 2009 Kazakhstan completed the construction of an additional 500 kV North–South transmission line to improve electricity supplies in its southern regions. Now, the electricity surplus generated in the north, which was previously exported to Russia, can be transmitted to the south, thus reducing electricity imports from neighbouring Central Asian countries.

In 2008–2009 Tajikistan commissioned the 220 kV Lolazor–Khatlon, Lolazor–Sangtuda and Sangtuda–VATZ transmission lines and the 220 kV Khatlon and Lolazor substations. In 2010 the country launched the 500 kV South–North high-voltage transmission line from Regar to Khujand (386 km), linking the southern and northern grids in a unified power grid.

Russia's Unified Energy System (UES) works in conjunction with the UES of Kazakhstan. The power grids of Uzbekistan, Kyrgyzstan and the southern part of Kazakhstan's UES form the Central Asian integrated power system (IPS). During the period under review, the Central Asian IPS faced numerous outages of the adjoining interstate electrical grids. As a result Tajikistan was disconnected from the Central Asian IPS and, consequently, from the unified power systems (UPS) of the EDB member states. Armenia cooperates with the Iranian power system due to its geographical isolation from the post-Soviet IPS, which impedes mutually beneficial export and import of electricity and integration benefits of cooperation between the national power systems.

The power sectors of the EDB member states are fairly well developed with different types of power plants, including thermal power plants (condensation and cogeneration plants), hydropower and PSH plants, nuclear plants, renewable energy plants and electric networks (transmission lines and substations) of various voltage classes of up to 750 kV.

External electricity grids that connect the EDB member states with each other (except Armenia, which is geographically cut off and not connected to the CIS power systems) and with third countries are also well developed. The bulk of interstate grids operate using alternating current, except Russia's UES and the Nordel network that use direct current.

The structure of capacities and their contribution to total electricity generation vary from country to country depending on the availability, or absence, of certain resources. Kyrgyzstan and Tajikistan, with hydropower plants dominating their generating capacity structure and share of total generation, as well as very limited exchange of electricity with other Central Asian countries, suffer from seasonal imbalances in electricity production and consumption.

Other EDB member states where thermal power plants are the dominant source of base energy, such as Belarus and Russia's Kaliningrad exclave, face the challenge of covering variable daytime demand.

Although significant modernisation is being undertaken in the region's power sectors they still generally rely on obsolete equipment.

1.2. Challenges in the power sectors

The electric power network of the EDB member states was formed in Soviet times. More than twenty years after the collapse of the Soviet Union this network has deteriorated to a much greater extent than it has been developed. The governments of some of the countries have been more focused on issues of the underdevelopment of their economies, their strong dependence on imported power-generating equipment, lack of investment, and the exacerbation of other nationwide problems.

Technologically the power sectors of all countries remained practically unchanged since the early 1990s with many of the Soviet-era problems of the power industry still in place. Some countries faced energy shortages. The sector's fixed assets are obsolete in all countries. Poor maintenance and inadequate modernisation of power-generating and network equipment, as well as management facilities have resulted in their deterioration, higher accident and downtime rates, and lower efficiency.

Despite the commissioning of generating and grid facilities in all the EDB member states, reliance upon obsolete power-generating and electrical equipment is still high. As at January 1, 2009, 70% of Kazakhstan's generating equipment and 65% of its electrical grid assets were obsolete (Kazakhstan Research Institute for Energy, 2011).

As at January 1, 2010, the share of obsolete production assets in the Belarusian power system made up 52.1%, down 9.5% compared to 2005, due to the modernisation and upgrade of major equipment (Ministry of Energy of the Republic of Belarus, 2011). Although this figure is lower in Russia, it still exceeds 40% (Volkov, 2010).

Reforms and liberalisation in the sector have not achieved the intended results. Decentralisation has destroyed the integrity of the management system while the technological unity and transmission interconnectivity of the power supply systems preserved. The change in forms of ownership and efficiency criteria have resulted in significant discrimination in the salaries of managers and workers, corruption, loss of motivation and productivity, and poor discipline. In addition, the sector lacks qualified personnel.

Other challenges include failure to monitor the interstate net power flow, power outfeed/infeed at the borders of power grids, unauthorised electricity transit through the adjacent national grids, and maintenance of acceptable electrical modes in the IPS/UES and the EDB member states, in particular in the Central Asian subsystem. These problems affect the reliability and synchronisation of the national power systems. The challenges are common to all the EurAsEC countries, although their effects differ in each country.

1.3. Key drivers of electricity demand

As shown in *Table 1.4*, industrial electric power consumption dominates in most countries, with the highest rates present in Kazakhstan (64%), Russia (55%), Belarus and Tajikistan (below 50%). In Tajikistan, the aluminium sector accounts for the largest share of industrial

Country	Industrial production and construction	Agriculture	Transport and communications	Utilities and social sphere
Armenia	23.4	2.2	2.1	29
Belarus	48.1	9.8	4.5	N/A
Kazakhstan	64	2	6.1	N/A
Kyrgyzstan	N/A	N/A	N/A	57.3
Russia	55	2	9	12
Tajikistan	44.8	21.7	1	N/A

Table 1.4.
Structure of electricity consumption in 2010 (%)

Source: ESI SB RAS

Note: data from the CIS Interstate Statistical Committee, national statistics agencies of the CIS countries (Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia, and Tajikistan); N/A – data not available

1. Main Trends in the Development of the Electric Power Sectors of the EDB Member States

consumption (about 80%) (News.tj, 2011a). Thus, industries are the major electricity consumers in these countries.

Agricultural consumption of electricity is also high in Tajikistan (over 20% of total consumption), so agriculture can be seen as another driver of electricity demand in the country.

In Armenia, utilities and the social sector (which includes the general population) account for the largest share of electricity consumption (29%) while industrial consumption has a lower share. Together they account for more than 50% of electricity demand in the country.

Kyrgyzstan's key electricity consumers are utilities and the social sector (including population). They account for almost 60% of consumption in the country.

Alongside with internal sources of electricity consumption, external export demand should also be taken into account. *Table 1.5* provides an estimate of electricity exports as a percentage of generation. In most of the countries this ratio is insignificant, ranging in between 1% and 2%, while Armenia's and Kyrgyzstan's electricity exports account for 14–16% of generation. Therefore, Armenian and Kyrgyz external electricity demand can be shaped by power exports.

Country	2008	2009	2010
Armenia	5.9	5.9	16.4
Belarus	1.6	0	0.8
Kazakhstan	2.8	2.9	1.9
Kyrgyzstan	4.9	9.3	13.6
Russia	2	1.8	1.9
Tajikistan	26.9	26.2	1.1

Table 1.5.

The ratio of electricity exports to generation (%)

Source: ESI SB RAS

The analysis shows that exports can vary significantly as a proportion of the total generated power. Electricity exports were considerably lower in Armenia in previous years and their growth in 2010 was driven by higher generation at TPPs (due to an increase in their capacity) and HPPs (due to the need to increase water intake from Lake Sevan and boost hydro generation accordingly).

On the contrary, electricity exports in Tajikistan were significantly higher in previous years than they are now, making it possible to suggest that external demand actually drove Tajikistan's electricity exports. However, the country lost its export opportunities with the disconnection from the Central Asian IPS. Currently, Tajikistan is setting up electricity exports to Afghanistan and has ambitious plans to expand exports to South Asia.

Therefore, industrial enterprises act as key drivers of electricity consumption in the EDB member states, although in some cases they may be substituted by utilities and social services, including population, as in Tajikistan and Armenia. External export demand for electricity is mostly insignificant, however in some cases and at certain stages it can play an important role, as in Tajikistan, requiring additional partnership with other members of the integrated power grid.

1.4. Trends in the development of the power sectors in EDB member states

So far, the analysis has outlined a number of trends in the power sectors of the EDB member states. Some of them have already been formed, while others are just beginning to emerge. On the whole, the region has demonstrated growth in electricity consumption and production. A moderate decline was registered in the crisis year of 2009, however in 2010 electricity

consumption restored and exceeded the pre-crisis level of 2008. Russia and Kazakhstan saw the largest growth, while consumption and generation declined in Kyrgyzstan and Tajikistan.

The countries under review can be divided into two groups in terms of electricity consumption: (i) those with growing gross and steadily high specific consumption (Russia, Kazakhstan and Belarus), and (ii) those with declining gross and low specific consumption (Tajikistan, Kyrgyzstan and Armenia).

In general, during the period under review, the industry demonstrated stable growth in generating capacity, even in the crisis year, accelerating by the end of the period. At the same time, the expansion of Kazakhstan's generating capacity was not sufficient to meet increasing electricity demand.

Fossil-fuelled TPPs dominate in the region and this situation remained practically unchanged throughout the period. Hydropower dominates in Tajikistan and Kyrgyzstan. The generation pattern varies from year to year due to stochastic HPP reservoir inflows.

The EDB member states are constructing their electrical grids and improving national infrastructures so that they are able to supply electricity to all regions, including remote ones.

Despite the commissioning of new facilities, reconstruction and modernisation of existing plants, the proportion of obsolete power-generating and network equipment in the region is still high. The modernisation process needs to be speeded up. Over the period studied, exports and imports of electricity between the EDB member states were declining steadily. This trend can be expanded to all post-Soviet space.

In fact, the development of electricity generating facilities and power grid infrastructure in energy-deficient regions that depend on electricity imports, as well as the decline in electric power exports and imports, and outages of the interstate electrical grids reinforce electrical independence of the EDB member states and weaken integration of their power sectors.

2. Basic Integration Initiatives

2.1. Electricity exports and imports in the region

Electricity exports and imports between the EDB member states were diminishing steadily in the period under consideration; exports decreased almost 30% between 2006 and 2010 and imports decreased by more than 50%. In some years there was an insignificant fall in net power flow. This is due to a number of factors: disagreements over gas and electricity supplies to Belarus from Russia, problems with the Central Asian IPS, fuel and energy crisis in Tajikistan and Kyrgyzstan, as well as increase in domestic consumption in Kazakhstan with subsequent decline in the country's export potential leading to Kazakhstan's transformation to a net importer of electricity.

In 2010 Russia threatened to stop supplying electricity to Belarus because of disagreements over contract terms. At the same time, repairs on the power transmission line from the Smolensk NPP to the Belorusskaya substation hampered electricity transit of Russian electricity through Belarus to the Baltic States.

Over the 2006–2010 period, Russia, Armenia and Kyrgyzstan were net exporters of electric power and Belarus, Kazakhstan and Tajikistan net importers. Kazakhstan managed to meet domestic electricity demand and become a net exporter only in the crisis year of 2009. In late 2005 and early 2006 Kazakhstan suffered an acute shortage of electricity and imported power from neighbouring countries (Podkovalnikov et al., 2010).

Belarus and Tajikistan rely on electricity imports for several reasons. For Belarus, imports are an economic necessity. It is more profitable for the country to buy electricity abroad than to produce it at its own power plants, because imported electricity is cheaper. The fuel used to generate electricity in Belarus makes its own product very expensive (Volkova et al., 2011).

In Tajikistan, hydropower plants produce the majority of the country's electricity, which is why generation varies seasonally and annually. In years when water supplies are lower, HPPs do not produce enough energy and the country has to import electricity to make up the shortfall. However, even in years of average and plentiful water supply, electricity has to be imported to meet the peak autumn and winter demand, because hydropower production is still limited and output cannot be distributed to meet varying demand over a year.

Kyrgyzstan, where generation is consistently higher than annual consumption, faces the same problems as Tajikistan during peak seasons and has to import electricity to maintain the power balance.

2.1.1. Armenia

The commercial operations of the Armenian power system are limited to electricity trading with Georgia, Nagorno–Karabakh and Iran (see Table 2.1).

The electricity exports and imports balance was more than twenty times higher in 2010 than the year earlier, increasing from 0.045 TWh to 0.815 TWh and the share of export in electricity consumption grew from 0.8% to 14.36%. In 2010 total electricity exports stood at 1,061 TWh and imports 0.246 TWh.

Before 2010 the balance of Armenian electricity trade with Iran was almost at zero, as Armenia exported the power to Iran in April–September and imported in October–March. This seasonal exchange allows the countries to use the system effect of covering the seasonal periods of peak demand. In 2010 Armenia's trade in electricity with Iran had a positive balance of 904.6 million kWh.

Country	2008		2009		2010		Jan–Oct 2011	
	Export	Import	Export	Import	Export	Import	Export	Import
Nagorno–Karabakh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Georgia	0	0	0	19.8	0	89.4	0	117.5
Iran	359.6	337.8	335.96*	271.2*	1,061.2*	156.6*	N/A	N/A
Total	359.6	343.4	336	291	1,061.2	246	1,400	N/A
Balance	16.2		45		815.2			

Table 2.1.
Electricity exports
and imports by Armenia
in 2008–2010*

Source: ESI SB RAS, based on data from the National Statistical Service of the Republic of Armenia; the Electricity System Commercial Operator of Georgia (ESCO)

Note: N/A – data not available; *estimates by the authors

On May 14, 2009 Iran began supplying gas to Armenia via the Iran–Armenia gas pipeline. Under the «gas for electricity» programme, Armenia pays for Iranian gas supplies with electricity at a rate of 3 kWh per 1 m³ of gas. Some of the electricity generated using Iranian gas is supplied to the Electrical Networks of Armenia company. A new unit at the Yerevan TPP, which was commissioned in 2010, is the main source of electricity exports under the «gas for electricity» programme (NIRA Aksakal News, 2011). Armenia plans to supply 2.4 billion kWh of electricity to Iran annually and Iran has committed to supply 801 million m³ of gas to Armenia (News.am, 2011).

To boost electricity exchanges between Iran, Armenia and Georgia, a new power transmission line is being designed (Panarmenian.net, 2011). The Iran–Armenia high-voltage line is being constructed by Sanir (Iran), at an estimated cost of €100–105 million.

2.1.2. Belarus

Belarus is a net importer of electricity and one of the biggest importers of Russian electric power, together with Finland and Kazakhstan.

In 2008–2010 Belarus imported electricity from Russia, Ukraine, Latvia and Lithuania and exported to Poland and Lithuania (see Table 2.2).

	2008		2009		2010		Jan–Oct 2011	
	Export	Import	Export	Import	Export	Import	Export	Import
Russia	0	2,168.4	0	2,908	0	30.3	N/A	N/A
Ukraine	0	0.7	0	1,213.6	0	2,940.6	N/A	1926.5
Latvia	0	70.3	0	58.1	0	0	N/A	N/A
Lithuania	0	157.6	7.3	298.3	269.8	0	N/A	N/A
Poland	557.8	–	0	–	0	–	N/A	N/A
Total	557.8	2397	7.3	4478	269.8	2970	N/A	N/A
Balance	–1,839.2		–4,470.7		–2,700.2		N/A	

Table 2.2.
Electricity exports and
imports between Belarus
and neighbouring countries
(million kWh)

Source: official website of the National Statistical Committee of the Republic of Belarus.

Note: N/A – data not available

In 2008 Belarus exported electricity to Poland only, from selected units of the Beryozovskaya GRES, and those exports totalled 557.8 million kWh. Exports to Poland began in 2003, but due to their unprofitability they were suspended in subsequent years. Belarus turned to supply power primarily to Lithuania and, in much smaller quantities, to Latvia (Belstat, 2011; Belenergo, 2011).

Imported electricity accounted for 6.5% of the Belarusian power balance in 2008, 12.8% in 2009, and 7.9% in 2010. The main suppliers of electricity were Russia in 2008 and 2009

(2.2 and 2.9 billion kWh respectively) and Ukraine in 2010 (2.9 billion kWh). In 2010 Russian electricity imports fell by almost one hundred times from 2.9 to 0.032 billion kWh.

In early 2011 Belarus significantly increased imports from Russia compared to 2008 and 2009. In January–June 2011, Russian imports totalled around 1.59 billion kWh (Me–press. kiev.ua, 2011). According to the Ukrainian Ministry of Fuel and Energy, in January–October 2011 Belarus imported 1.93 billion kWh from Ukraine, down 15.4% year–on–year (Interfax. by, 2011).

Electric power was supplied under agreements on parallel operation and other contracts. The interruptions in supply in 2008, 2010 and 2011 were caused by different factors, including noncompliance with these agreements.

Along with importing power from Russia, Belarus transits Russian electricity to Kaliningrad exclave and Lithuania. The volume of electricity transit depends on commercial contracts negotiated by each of the parallel power systems (FGC, 2011). Belarus imported 4,602 million kWh from Russia (including for subsequent transit) in 2008, 4,184.7 million kWh in 2009, and 2,510.6 million kWh in 2010. Electricity transit to Kaliningrad Region from Russia through Belarus and Lithuania totalled 1.143 TWh in 2008, 1.260 TWh in 2009, and 0.915 TWh in 2010 (Government of Kaliningrad Region, 2010; Belarusian Reporter, 2010; Regional Forum, 2011). Russian electricity is transited under Common Economic Space (CES) agreements guaranteeing access to the services of natural monopolies in the power sector, including pricing and tariff policies.

Russia and Belarus have made claims against each other regarding unauthorised transit of electricity through their respective grids. Technological problems do arise when transit volume increases, and unauthorised transit still needs to be paid for (Bigpowernews.ru, 2011; Newsinfo. ru, 2010).

2.1.3. Kazakhstan

As shown in *Table 2.3*, Kazakhstan was mostly a net importer of electricity in 2006–2010. Only in the crisis year of 2009 Kazakhstan was a net exporter, possibly because of decreased domestic consumption caused by the economic slowdown. In the first nine months of 2011, net electricity imports exceeded the 2010 figure. Electricity exports went down during the period under review.

Table 2.3.
Electricity imports and
exports by Kazakhstan
(million kWh)

Indicator	2008	2009	2010	Jan–Sep 2011
Imports	2,780.1	1,771.7	3,009.5	2,299.6
from Russia	2,205.1	584.6	1,375.6	N/A
from Kyrgyzstan	553.9	967.9	1,633.9	N/A
from Tajikistan	21.1	219.2	0	N/A
Exports	2,234.7	2,245.8	1,538	704.7
to Russia	2,213.6	2,157.4	1,538	N/A
to Kyrgyzstan	0	0	0	N/A
to Tajikistan	21.1	88.4	0	N/A
Balance, overall	–545.4	474.1	1,471.5	–1,594.9
including:				
with Russia	–8.5	–1,572.8	–162.4	–704.7
Central Asia	553.9	1,098.7	1,633.9	2,299.6
with Kyrgyzstan	553.9	967.9	1,633.9	2,125
with Tajikistan	0	130.8	0	N/A

Source: ESI SB RAS, data from
KOREM; KEGOC

Note: N/A – data not available

Kazakhstan's main partner in Central Asia is Kyrgyzstan. Imports from this country are growing steadily and even outpaced Russian imports in 2010. In the first nine months of 2011, Kazakhstan imported 2.125 TWh of electricity from Kyrgyzstan (KABAR, 2011).

Before 2010 Tajikistan was a member of the Central Asian IPS and exchanged small volumes of electricity with Kazakhstan, which was transited through Kyrgyzstan. When Tajikistan was disconnected from the IPS, this exchange stopped.

Although Kazakhstan operates in parallel with Uzbekistan, there were no significant electricity flows between the countries over the period studied.

Kazakhstan is Russia's main electricity trading partner and the main exporter of electricity to Russia in the context of cooperation between the EDB and CIS member states. In 2009 and 2010 Kazakhstan accounted for 70% and 52% of Russia's electricity imports respectively.

There were several reasons for the decrease in Russian imports, including an improvement in Kazakhstan's domestic electricity's links. In 2008, a new interregional high-voltage line was commissioned: the 500 kV 500km Northern Kazakhstan–Aktobe Region line connected the Aktobe Region to electricity generation facilities in Northern Kazakhstan.

The increase in net power flow between Kazakhstan and Russia in 2009 was caused, to a significant extent, by the accident on the Sayano–Shushensk HPP. The emergency shutdown of the plant necessitated transmission of reserve power from the Siberian IPS and the increased use of power from the Urals and mid-Volga systems transmitted to Siberia through Kazakhstan (Energy Forecasting Agency, 2010).

Because of the limited transit capacity of the Urals–Kazakhstan–Siberia system, Kazakhstan's maintenance of the agreed power balance is vital in preventing overload on the lines by non-scheduled flows.

Table 2.4 shows the estimated transit from the Urals IPS to the Siberian IPS through Kazakhstan. Although these are estimates, they illustrate Kazakhstan's role in ensuring sustainable power supplies to Siberia and the European part of Russia.

In November 2008 the EDB signed a \$30.5 million seven-year loan agreement with the Batys Transit concession company to construct the Northern Kazakhstan–Aktobe Region power line. The Samruk Kazyna National Welfare Fund and KEGOC (Kazakhstan Electricity Grid Operating Company) also participated in the project.

The power system of the European section of Russia's UES, including the Urals and Siberian IPS, interacts with Kazakhstan's power system. Transit capacity is determined by the static and dynamic stability criteria that define maximum power flows between the Urals and Kazakhstan, Kazakhstan and Siberia, and within the northern part of Kazakhstan's grid. The average transit load is 350–400 MW. In September 2009, the power flow from the Urals IPS to the Siberian IPS increased from 135 MW per hour to 825 MW (Federation Council, 2009).

Indicator	2008	2009	2010
Received by Russia from Kazakhstan	4,090	5,737	5,985
Siberian IPS	4,088	5,737	5,985
South IPS	2		
Kazakhstan's electricity exports to Russia	2,213.6	2,157.4	1,538
Total electricity transit	1,876.4	3,579.6	4,447

Table 2.4.

Electricity transmission by Russia through Kazakhstan's power system (million kWh)

Source: ESI SB RAS, based on data from KOREM; KEGOC; System Operator – Central Dispatch Department

2.1.4. Kyrgyzstan

In 2010 the balance of electricity exports and imports was 1.559 TWh (see Table 2.5). Kazakhstan was Kyrgyzstan's largest export customer. Kyrgyz exports and the net power flow were growing steadily over the period. The country also transits electricity.

2. Basic Integration Initiatives

Table 2.5.

Electricity exports and imports between Kyrgyzstan and neighbouring countries (million kWh)

Source: ESI SB RAS, based on data from the National Statistical Committee of the Kyrgyz Republic; Statistics Agency under the President of the Kyrgyz Republic; KEGOC

Note: N/A – data not available

Indicator	2008	2009	2010	Jan–Sept 2011	Jan–Sept 2010 (for reference)
Import	6.9	0	76.3	N/A	N/A
Uzbekistan	6.9	insignificant	76.3	N/A	N/A
Export	578.9	1,033.8	1,635.4	N/A	N/A
Kazakhstan	555.3	968.5	1,634.6	2,125	1,100
Tajikistan	23.6	7.7	0	N/A	N/A
China	N/A	N/A	N/A	0.864	0.799
Uzbekistan	N/A	N/A	N/A	N/A	N/A
Balance	572	1,033.8	1,559.1	N/A	N/A
Transit from Tajikistan to Kazakhstan	21.1	219.2	0	N/A	N/A
Transit from Kazakhstan to Tajikistan	21.1	88.4	0	N/A	N/A

The electricity exchange between Kyrgyzstan and Tajikistan (before it was disconnected from the Central Asian IPS) took place primarily in winter when Kyrgyzstan's supplies were used to compensate for power deficit in the north of Tajikistan. Small amounts of electricity were exported to Uzbekistan under intergovernmental irrigation agreements covering water and power exchange (Inogate, 2011).

Since December 2009, partly because of Tajikistan's disconnection from the system, Kyrgyzstan has been supplying electricity primarily to Kazakhstan and China. The imports have been insignificant. The Kyrgyz power system, despite domestic shortages, remains a net exporter of electricity.

In the first nine months of 2011 exports to China reached 864,000 kWh (a year-on-year increase of 65,000 kWh) (Munaigaz.kz, 2011). Supplies to Uzbekistan have grown considerably in recent years (KABAR, 2011). In November 2011 Kyrgyzstan's Electric Power Plants JSC and Uzberkenergo signed an agreement to export 500 million kWh from Kyrgyzstan to Uzbekistan priced at US\$3.38 cent per kWh. As at December 14, 2011, 139 million kWh had been supplied to Uzbekistan (Rosbalt, 2011).

2.1.5. Russia

Table 2.6 shows Russia's exports and imports of electricity. The decline in Russia's trade with neighbouring countries in 2009, compared to 2008, resulted from an overall reduction in consumption in other countries because of the global financial crisis. In 2010 Russia's net power flow increased by more than 10% year-on-year to 17.02 billion kWh. The main importers of Russian electricity in 2010 were Finland (58.4%), Lithuania (25.6%), and Kazakhstan (6.9%). Small volumes were transmitted to Norway, Belarus, Latvia, Ukraine, South Ossetia and Mongolia. The exchanges with Georgia and Azerbaijan were seasonal. The redistribution of supplies between the countries was caused by two main factors: the decommissioning in 2010 of the Ignalina NPP (Lithuania) and the repair, during that year, of the 750 kV power line between Smolensk NPP and the Belorusskaya substation in Belarus (INTER RAO UES, 2011).

In addition to exports and imports shown in the table, Russia supplied electricity (without importing it) from its own generating facilities located in other countries: it supplied Iran from the Hrazdan TPP in Armenia and Romania from the Moldavskaya GRES in Moldova. In 2010 Russia began supplying Turkey with electricity transited via Georgia (Energo-news.ru, 2010; INTER RAO UES, 2011).

Indicator	2008	2009	2010	Jan–Sept 2011	Jan–Sept 2010 (for reference)
Neighbouring countries					
Export, total	9,334.7	5,074.6	6,898.8	N/A	N/A
including: Ukraine	1,110.9	22	32		
Belarus	2,168.4	2,908	30.3		
Latvia	1,617.9	656	7		
Lithuania	1561	410	5,106		
Kazakhstan	2,205.1	584.6	1,375.6		
Georgia	560.1	348	211.9	205.2	38.6
Azerbaijan	111.3	21	18		
South Ossetia		125	118		
Import, total	3,079.3	3,002.3	2,902.1	N/A	N/A
including: Kazakhstan	2,213.6	2,119	1,498		
Ukraine		0.5	81		
Lithuania	97.5	199	3		
Georgia	432.7	525.8	1,117.1	574.5	1,051.8
Azerbaijan	335.5	158	203		
Balance	6,255.4	2,072.3	3,996.7		
Other countries					
Export, total	11,254.9	12,962	13,047	9,611.3	N/A
including: Finland	10,883	11,708	11,639	8,480	8,496
Norway	176.5	227	211	131	155
Mongolia	195.4	182	214	206	
China	0	845	983	925.3	
Import, total	21	21	21	N/A	N/A
Mongolia	21	21	21		
Balance	11,233.9	12,941	13,026	N/A	N/A
Total					
Export	20,589.6	18,036.6	19,945.8	16,576	13,523
Import	3,100.3	3,023.3	2,923.1	995.5	1,390.7
Balance	17,638.1	15,013.3	17,022.7	15,580	12,132.5

Table 2.6.

Russian electricity exports and imports (million kWh)

Source: ESI SB RAS, based on data from Belenergo, CIS Interstate Statistical Committee, Russia's Federal State Statistics Service, INTER RAO UES; KOREM, KEGOC, System Operator – Central Dispatch Department, Electricity System Commercial Operator (ESCO) of Georgia, European Network of Transmission System Operators for Electricity (ENTSOE).

Note: N/A – data not available

Exports grew and imports declined in 2011, creating a record high net power flow for the period 2008–2011. In the first nine months of 2011, the balance of exports and imports reached 15.6 TWh, up almost 3.5 TWh year-on-year. The increase in exports was due in particular to the restoration of supplies to Belarus, increased exports to China and Mongolia, and the launch of the second unit at the Kaliningrad TPP in 2010 (which made it possible to export its excess production to Lithuania and Belarus).

In 2009 electricity supplies to China were restarted. They amounted to 854 million kWh in 2009, 983 million kWh in 2010, and 925 million kWh in the first nine months of 2011 (up 25% year-on-year) (Eastern Energy Company, 2011).

From January to September 2011, the Eastern Energy Company JSC, a Russian electricity exporter in its far eastern region, exported over 206 million kWh to Mongolia (Eastern Energy Company, 2011). Russian electricity is primarily used in Mongolia at times of peak demand and to supply isolated border areas.

The following should be noted with regard to Russia's electricity trade with other EDB member states. Belarus is Russia's traditional partner, yet cooperation between the two in 2008–2010 was far from stable. Exports and imports between Russia and Kazakhstan did not change drastically over the same period, but the trend was downward. Belarus and Kazakhstan accounted for around 50% of Russian exports to neighbouring countries in 2008. This increased to almost 70% in 2009, but dropped to 20% in 2010 (because of the decrease in imports by Belarus). Kazakhstan supplied almost 70% of Russian imports from neighbouring countries in 2008–2009, falling to 50% in 2010.

2.1.6. Tajikistan

As shown in *Table 2.7* below, in 2008–2009 Tajikistan's most significant electricity exchanges were with Uzbekistan and Turkmenistan, while its exchange with Kazakhstan and Kyrgyzstan was lower.

Table 2.7.
Electricity exports
and imports by Tajikistan
(million kWh)

Source: Petrov (2010); Abdul Razique Samadi (2011); official website of the Agency on Statistics under the President the Republic of Tajikistan (<http://www.stat.tj>).

Note: N/A – data not available

	2008	2009	2010	Jan–Oct 2011	Jan–Oct 2010 (for reference)
Import	5,229.6	4,168.7	321.4	65	310.5
Uzbekistan	3,984.2	3,404.6	321.4	N/A	N/A
Turkmenistan	1,200.7	668	0	N/A	N/A
Kazakhstan	21.1	88.4	0	N/A	N/A
Kyrgyzstan	23.6	7.7	0	N/A	N/A
Export	4,346.1	4,227.3	179.8	136.6	153.4
Uzbekistan	4,279.1	3,933.8	0	N/A	N/A
Kazakhstan	21.1	219.2		N/A	N/A
Kyrgyzstan	0	0		N/A	N/A
Afghanistan	45.9	74.3	179.8	N/A	N/A
Balance	–883.5	58.6	–141.6	71.6	–157.1

Before it was disconnected from the Central Asian IPS, Tajikistan supplied electricity each year to the Surxondaryo Province in southern Uzbekistan, and received the same amount of electricity in its northern Sughd Province from Uzbekistan's Syrdarya GRES. Tajikistan and Uzbekistan also exchanged electricity as allowed by their joint responsibility to regulate water discharge from the Kairakkum reservoir. During the crop-cultivation season Tajikistan supplied water and surplus electricity to Uzbekistan and Uzbekistan returned the same amount of electricity to Tajikistan in winter when Tajikistan suffered power shortages (TopTJ.com, 2009). Kyrgyzstan and Tajikistan exchanged electricity primarily in winter.

Turkmenistan was an important electricity supplier. Until the end of April 2009, under a five-year intergovernmental agreement signed in 2007, Tajikistan imported turkmenian electricity from September to May of each year, transiting it through Uzbekistan. In 2009 Tajikistan failed to reach a transit agreement with Uzbekenergo. It should be noted that Uzbekistan also benefited from these electricity swaps since they reduced overloading and helped ease shortfalls in the western part of the Uzbek power system (TopTJ.com, 2009).

In 2010 Tajikistan imported small volumes of electricity from Uzbekistan only. Uzbekistan continued to supply 360 GWh a year to Tajikistan's remote northern regions, via 220 kV and 110 kV transmission lines. The supplies were prepaid every ten days.

Tajikistan exports electricity to Afghanistan only. At present, its daily exports stand at 15 MW for US\$3.5 cent per 1 kWh. According to forecasts, exports may exceed 1 billion kWh in spring and summer (Avesta.tj, 2011).

2.2. Mutual investments in 2008–2011

The Agreement on the Promotion and Mutual Protection of Investments signed by EurAsEC member states in December 2008 has had a positive effect on mutual investment.

Establishment of long-term relationships can depend on mutual investment and the purchase of power facilities in the EDB member states, and on mutual supplies of power-generating and electrical equipment at sites under construction (including lifetime maintenance of equipment by suppliers). It should be noted that investors and suppliers from third countries, including the US and China who are important competitors, play significant role in developing the energy markets of the EDB member states.

Facility	Company	Ownership	Capacity	Investment, timeframes	Note
Armenia					
Armenian NPP	INTER RAO UES	trust management	815 (407.5*) MW		In November 2011 Inter RAO began negotiations on the termination of management
Hrazdan TPP	INTER RAO UES	100% owner	1,110 MW		Until 2011 the plant was owned by Rosneftegas (100% minus one share owned by Rosimushchestvo)
Hrazdan TPP (Unit 5)	ArmRosgasprom	100% owner	480 MW	ArmRosgasprom's investment programme in Armenia for 2009–2011 (\$169.6 million)	Construction reaching completion. ArmRosgasprom is an Armenian–Russian joint venture 80% owned by Gazprom
Sevan–Hrazdan cascade of HPPs	RusHydro	90% owner	561.4 MW	Investment programme for 2008–2010 (\$30 million)	International Energy Corporation, until 2011 owned by Inter RAO UES
Electrical Networks of Armenia	INTER RAO UES	100% owner	29,600 km	Investment programme for 2009–2011 (\$180.3 million)	In March 2009 INTER RAO UES consolidated 100% of shares; before that INTER RAO UES owned 67%
Kazakhstan					
Ekibastuz GRES–2 (Kazakhstan)	INTER RAO UES	50% owner	1,000 MW	Construction of a 500 MW Unit 3 (\$770 million)	Financed by Vnesheconombank, EDB and Halyk bank of Kazakhstan
Kyrgyzstan					
Kambarata–1 HPP	INTER RAO UES	Kyrgyz–Russian JV (50%/50%)	1,900 (0*) MW	A \$1.7 billion loan from Russia, starting 2011	
Kambarata–2 HPP			360 (110*) MW	A \$300 million loan from Russia, 2009	
Tajikistan					
Sangtuda–1 HPP	Rosatom (60.13%); INTER RAO UES (14.87%)	Russian–Tajik JV (75%/25%)	670 MW	RUR 16 billion invested by Russia in construction in 2005–2009	Russia owns 75% of shares of Sangtuda–1 HPP

Table 2.8.
Russia's foreign electric power assets and investments (as of November 2011)

Source: ESI SB RAS
Note: * – operating

Table 2.9. Development, production and supply of electric power equipment and design documents by Russian companies (November 2011)

Facility	Company	Form of contract	Equipment	Investments, timeframes
Armenia				
Armenian NPP	TVEL JSC	Supply and research and engineering support to the use of nuclear fuel	Nuclear fuel for the plant	Long-term contract
	ARMZ Uranium Holding	Geological exploration		
	Rosatom	Technical assistance from IAEA to improve safety at the plant		RUR 2,040 million in 2008 (financing from Russia's contribution to the IAEA extra-budgetary fund)
	Rosatom	Design of a new unit at the plant	Design documents	2010 – to date
Belarus				
Lukoml GRES	Power Machines	Manufacture and supply of equipment	Manufacture and supply of equipment for the modernisation of a 300 MW Unit 3	Contract value \$7 million, 2010
Vitebsk TPP	Power Machines	Manufacture and supply of equipment	Manufacture and shipment of a 50 MW steam turbine PT-40/50-8.8-1.0 and a generator	2010–2011, completed
Polotsk HPP	Technopromexport	Design, construction, supply and installation of equipment, start-up and commissioning of a hydro unit	Construction of a 21.6 MW hydropower plant	A loan from EDB in the amount of 450.3 billion Belarusian roubles
Kazakhstan				
Ekibastuz GRES-2	Consortium of COTES-Kazakhstan and COTES (Novosibirsk)	Preparation of Unit 3 design estimates	Design documents	2010 – to date
Kazakhmys Corp. GRES	Power Machines	Manufacture and supply of equipment	Steam turbine K-55-90 and turbine generator T3FP-63	2008

Facility	Company	Form of contract	Equipment	Investments, timeframes
Karaganda TPP-3	Power Machines	Manufacture and supply of equipment	Steam turbine T-120/140-12.8 (150 MW) turbine generator (160 MW) with an excitation system, and auxiliary equipment for the turbine generator	Contracted in 2010, supplied in 2011
Bukhtarma HPP (reconstruction)	Power Machines	Modernisation	82 MW hydro turbine	2009
Ust-Kamenogorsk HPP	Elisib	Manufacture and supply of equipment	hydro-generator SV 1160/180/72	First half of 2011
Astana TPP-2	The Ural Turbine Works		Steam turbine T-120/130-12.8-8 MO	First half of 2011
Kyrgyzstan				
Kambarata-2 HPP	Leningrad Metal Works	Manufacture and supply of equipment	Two 122.5 MW hydro turbines	2008
Tajikistan				
Sangtuda-1 HPP	Power Machines	Manufacture and supply of equipment	186.1 MW hydro-generator SV 1260/182-60, hydro turbines RO-75-V-600	2007-2008

Source: ESI SB FIAS

2.2.1. Russia and Armenia

Russia's INTER RAO UES owns 100% of the Electrical Networks of Armenia, an Armenian monopoly distributor of electric power. INTER RAO investment programme for 2009–2010 included \$180.3 million for special programmes and enhancement of its services (Ministry of Economic Development of the Russian Federation, 2011). In 2010 Electrical Networks of Armenia reconstructed sixteen substations with a voltage of 6/35/110 kV.

INTER RAO UES investment programme for 2008–2010 included spending of \$30 million to upgrade the Yerevan, Argel and Arzni HPPs and overhaul the Sevan and Kanaker HPPs. The overhaul of Sevan and Kanaker has been completed and the modernisation of the other facilities is under way. In the summer of 2010, the dam height at Lake Sevan was elevated and this was expected to increase electricity generation by the Sevan–Hrazdan cascade. The company is expected to invest around \$40 million by 2013, including \$20 million to modernize the HPPs (INTER RAO UES, 2011b).

Rosneftgas owns four units at the Hrazdan Energy Company (Hrazdan TPP), with a total installed capacity of 1,100 MW. In 2002 ownership of the Hrazdan plant was transferred to Russia as payment of the Armenian government's \$31 million debt (Oilcapital.ru, 2009). The Russian government transferred 100% of shares in the company to INTER RAO UES (except Unit 5) (News.am, 2011b).

The construction of Unit 5 is under way at the Hrazdan plant. It is owned by ArmRosgasprom, an Armenian–Russian JV with 80% of stock owned by Gazprom. ArmRosgasprom's investment programme in Armenia for 2009–2011 totalled \$169.6 million (Ministry of Economic Development, 2011).

Russian–Armenian cooperation in nuclear power generation goes in line with the Intergovernmental Agreement on Cooperation in the Peaceful Use of Nuclear Energy dated September 25, 2000. The Agreement covers the safety operations at the Armenian NPP and the supply of nuclear fuel. Fuel is supplied by TVEL under a contract signed in 2005. Rosatom is responsible for coordinating the participation of Russian organisations in the execution of four technical cooperation projects carried out by the International Atomic Energy Agency (IAEA) to improve safety at the plant. These projects are financed by Russia's contribution to the IAEA's extra-budgetary fund. In 2008, to finance safety improvements at the plant, Russia transferred RUR 2.04 billion to Armenia from the IAEA fund to support projects implemented under the IAEA's Technical Cooperation Programme for 2009–2011 (Atomenergoprom, 2011).

On August 20, 2010 the governments of Russia and Armenia signed the Agreement on Cooperation in Constructing New Units at the Nuclear Power Plant in Armenia (Atomenergoprom, 2011). The first facility to be constructed is a 1,000 MW generating unit. According to the Armenian Ministry of Energy, the project's estimated cost amounted to \$5–6 billion (BigpowerNews.ru, 2011). In 2006, the Armenian parliament abolished the state's monopoly right to own new nuclear power units in order to attract foreign capital to the project. Construction was scheduled to begin in 2011 and the new unit is due to be commissioned by 2017 (BigpowerNews.ru, 2011).

EDB's Sector Report no. 11, Russian and Kazakh Nuclear Energy: Trends in Economic Cooperation, provides more information about Russian and Armenian joint initiatives in the peaceful use of nuclear energy.

2.2.2. Russia and Belarus

The investment cooperation between Russia and Belarus in 2008–2011 focused on different areas, including the supply of power equipment. Since 2005, Power Machines¹ has been involved

¹ Russia's leading producer of power equipment, uniting large electrical engineering enterprises, including the Leningrad Metal Works, Energosila, the Kaluga Turbine Works, and the Turbine Blades Plant, among others.

in the upgrade of Belarus' largest TPP, the Lukoml GRES. In 2010 Power Machines OJSC and Vitebskenergo Republican Unitary Enterprise signed a contract for the manufacture and supply of equipment to upgrade Unit 3 of the Lukoml GRES, with a contract value estimated at \$7 million (Power Machines, 2011; Energyland.info, 2010).

Under the agreement signed in August 2010 with Vitebskenergo, the Kaluga Turbine Works (part of the Power Machines group) manufactured and supplied equipment for the Vitebsk TPP. The group also provided installation, start-up and training (Bigpowernews.ru, 2011).

Vitebskenergo is implementing construction of the 21.6 MW Polotsk HPP on the Western Dvina, due to be commissioned in 2016. This project is implemented under the State Programme for Innovative Development of the Republic of Belarus for 2011–2015, and has an estimated cost of 450.3 billion Belarusian roubles (Bigpowernews.ru, 2011). After the purchase of the main equipment a contract was concluded with Technopromexport (part of the Russian Technologies State Corporation) for the construction of a hydro unit at the Polotsk plant. Technopromexport is to provide design, construction, supply and installation of equipment, start-up and commissioning.

EDB and Vitebskenergo signed a ten-year loan agreement to finance the project in November 2010. The power plant will generate 112 million kWh a year. The project cost is \$1.427 billion, including \$99.8 million provided by the EDB.

On March 15, 2011, at a Council of Ministers session in Minsk, the governments of Russia and Belarus signed an agreement to construct a nuclear power plant in Belarus. The state enterprise «Directorate for Nuclear Power Plant Construction» (Belarus) and Atomstroyexport JSC (Russia) also signed a contract in 2011. The parties agreed that construction costs would be based on the same pricing formula as those used for nuclear plants built in Russia (Energy Strategy, 2011). Loan financing for construction will be extended once the parties have signed an agreement on a Russian government loan. The estimated total investment (and loan amount respectively) for the Belarusian NPP will make up \$6–6.5 billion. Social, transport and production infrastructure will cost an additional \$2.5–3 billion (Atominfo.ru, 2011).

2.2.3. Russia and Kazakhstan

The construction of Unit 3 at Ekibastuz GRES–2, which is jointly owned by Samruk Energo (50%) and INTER RAO UES (50%), will raise the plant's capacity by 50% to 1,500 MW.

In addition, Bogatyr Komir, a Kazakh–Russian JV, is developing the Bogatyr coal deposit which supplies coal to Ekibastuz GRES–2. This company is owned by Samruk Kazyna and RUSAL on a parity basis (Aleamar, 2009).

Russia is manufacturing, supplying and installing equipment at other Kazakh power stations. In 2008 Power Machines manufactured and supplied a K–55–90 steam turbine and a T3FP–63 turbine generator to Kazakhmys Corp. GRES (Bigpowernews.ru, 2011).

The governments of Russia and Kazakhstan signed an agreement on the construction and operation of Unit 3 at Ekibastuz GRES-2 on September 11, 2009. The project cost is estimated at \$800 million. Financing terms were agreed in the summer of 2010 in Kazakhstan. The document was signed by EDB, Vnesheconombank, Ekibastuz GRES-2 JSC, Samruk Energo and INTER RAO UES. In accordance with the agreement, EDB and Vnesheconombank will provide a multi-currency 15-year loan for a total of \$770 million, on a parity basis. Halyk Bank of Kazakhstan also became party to the agreement in June 2011 as the third lender.

In June 2010 Karaganda Energotsentr (Kazakhstan) contracted Power Machines to manufacture and supply equipment for a 150 MW fifth unit (currently under construction) at Karaganda TPP–3. In March 2011 the turbine generator was commissioned (Bigpowernews.ru, 2011). Power Machines also provided supervision, start-up and training.

EDB agreed to finance Kazakhstan's largest coal producer, Bogatyr Komir. EDB's seven-year loan for a total of up to \$50 million will be used to purchase up-to-date equipment and machinery. The increase in coal supplies is expected to boost mutual trade between Russia and Kazakhstan by \$30 million a year. In addition, about 80% of the required equipment (worth around \$40 million) will be supplied to the project by Russian enterprises.

In June 2011 a long-term programme for the re-equipment and reconstruction of the Bukhtarma HPP, which is being implemented since 2001, was completed. The ninth power unit (Unit 7 at the plant) and a turbine upgraded by Power Machines were commissioned. As a result the plant's capacity rose from 75 MW to 82 MW (Power Machines, 2011b).

Kazakhstan and Russia are keen to develop and integrate their nuclear sectors. EDB's Sector Report no. 11, Russian and Kazakh Nuclear Energy: Trends in Economic Cooperation, provides more information on this issue.

2.2.4. Russia and Kyrgyzstan

Russian investment in the Kyrgyz economy consists mainly of the setting up the subsidiary companies and joint ventures in strategic sectors. In April 2009, INTER RAO UES and Kyrgyzstan's Electric Power Plants JSC agreed to build the 1,900 MW Kambarata-1 HPP as a 50/50 joint venture (Alemar, 2009).

The construction cost was estimated at \$3 billion (Dw-world.de, 2010). Russia was expected to provide a \$2 billion loan from the federal budget and INTER RAO UES' funds.

In May 2011 a Kyrgyz-Russian working group was set up to control the implementation of the project. In October 2011 Russia confirmed its intention to provide a \$2.1 billion loan for Kambarata-1 HPP and the upper Naryn cascade of HPPs (four hydropower plants with a capacity of up to 300 MW) for a term of 20 years, including the 8-year grace period and the annual interest rate of 3% (24.kg, 2011). The majority of the loan (\$1.7 billion) is likely to be spent on the construction of Kambarata-1 HPP.

Russia is also partnering with Kyrgyzstan in the completion of Kambarata-2 HPP. Construction of the 360 MW plant (three 120 MW units) began in 1986 but was suspended in the early 1990s when funds ran out. Leningrad Metal Works (Power Machines Group) supplied the first unit. Funds injected by the Kyrgyz government and loaned by Russia in 2009 were invested into the project. Now the plant's capacity is 120 MW, and full generating capacity should be reached in 2015. A total of \$195.164 million were allocated for research, design, construction and equipment for Kambarata-2 HPP, including \$77 million from the Kyrgyz budget, over \$8.505 million from Kyrgyzstan's Electric Power Plants JSC (general originator of the project) own funds, and a loan of \$109.65 million (Government of the Kyrgyz Republic, 2011).

RusHydro and INTER RAO UES, together with Kyrgyzstan's Electric Power Plants JSC, are studying the possibilities for the development of the Naryn River hydro potential particularly along its upper reach, and conducting feasibility studies for both large and small hydro projects (Cleandex.ru, 2011).

2.2.5. Russia and Tajikistan

In February 2005 Sangtuda-1 HPP, a Russian-Tajik JV, was created with a view to the plant's construction and its subsequent operation. Russia invested over RUR16 billion in the HPP construction (Sangtuda-1 HPP, 2011). In 2010 the plant generated 1.633 billion kWh of electricity. As at June 1, 2011, Rosatomprom owned a 60.13% stake in Sangtuda-1 HPP, the Tajik government had 25% plus one share, and INTER RAO UES owned 14.87% (Sangtuda-1 HPP, 2011).

The construction of the Rogun Hydropower Plant, with an installed capacity of 3.6 GW and long-term average production of 13.1 TWh a year, was suspended after the collapse of the Soviet Union. Located on the Vakhsh River, the plant was expected to become the largest

hydropower plant in Central Asia. The majority of the plant's hydraulic structures have been destroyed by seasonal floods. The investment needed to launch the first three Rogun units is estimated at \$1.3–1.5 billion. The commissioning of all six units will require approximately \$4 billion.

INTER RAO UES and RUSAL considered a possibility of taking part in the completion of the Rogun HPP, however it was not implemented. Russian–Tajik cooperation in this project is currently limited to the drafting of engineering documents for the hydro unit (Hydroproject, 2011).

2.2.6. Russia, Kyrgyzstan and Tajikistan

Kyrgyzstan, Tajikistan, Afghanistan and Pakistan are the four countries cooperating in the CASA–1000 project involving the construction of two high-voltage interstate power transmission lines and three substations in Kabul, Peshawar and Sangtuda to export electricity from Tajikistan and Kyrgyzstan to Afghanistan and Pakistan. INTER RAO UES also plans to take part in this project (Bigpowernews.ru, 2011).

The project was assessed positively by the World Bank. Its preliminary cost is estimated at \$1.5–2 billion. Russia intends to invest at least \$500 million in CASA–1000 (Bigpowernews.ru, 2011).

2.2.7. Kazakhstan and Kyrgyzstan

In June 2011 the countries signed a protocol to set up a Kyrgyz–Kazakh investment fund and a number of other documents on cooperation (Fergananews.com, 2011). The \$100 million investment fund will be used to finance industrial projects in Kyrgyzstan, including those in the power sector. Kazakhstan intends to invest up to \$12 million to help Kyrgyzstan meet its high demand for power and heat next autumn and winter.

The National Electrical Grid of Kyrgyzstan and Kazakhstan's KEGOC have also signed an agreement on cooperation in the power sector.

* * *

The above analysis illustrates that mutual investments in the power sectors of EDB member states over the 2006–2010 period were primarily unilateral and mostly Russian. This was also one of the conclusions of the EDB's study in 2008 (Vinokurov, 2008) and the situation has not changed since. Investment in power facilities are backed by supplies of electrical and power-generating equipment, the majority of which is also produced in Russia.

Clearly, integration between the EDB member states is gathering pace.

2.3. Implemented system effects

Electricity exchanges do have an effect on the integrated national power systems of the EDB member states. These effects illustrate, to a certain extent, the level of integration of their power systems. At present, Belarus, Russia, Kazakhstan and Kyrgyzstan are contributing to the evolution of power system's integration while Armenia and Tajikistan (following its isolation from the Central Asian IPS in late 2009) operate independently of the integrated system.

Armenia works in tandem with the Iranian power system to cover seasonal high demand (NARUC, 2011). Armenia's peak season is in the winter while Iran's in the summer. The countries exchange seasonal flows of electricity by loading their plants during low-demand periods and assisting each other in covering peak loads.

Belarus is reducing expenditure on the fuel necessary to generate electricity by increasing its imports from Russia. This helps minimise electricity prices for Belarusian consumers thus achieving a regime effect (Volkova et al., 2011a). Russia generates an economic effect through its electricity exports.

Cooperation between Russia and Belarus will have a more substantial regime effect in the future. With the commissioning of the Belarusian NPP, a base load power plant, Belarus will face a greater challenge of covering the variations in demand through the day. At night Belarus will need to transmit surplus electricity to neighbouring countries, including Russia, which should help to reduce cycle capacity problems (Volkova et al., 2011a).

Central Asian countries and Russia (partly through Kazakhstan's grids) used Kyrgyz and, until 2009, Tajik hydropower resources (KOREM, 2011). This helped improve the operating rates at several power plants in these countries and reduced generating costs generally. Consumer prices for electricity were lowered to a minimum level to achieve a regime effect, which, due to political tensions between the Central Asian states, was not fully implemented and is currently not realised in practice.

In recent years Tajikistan has not had an opportunity to supply its seasonal surpluses of electricity to the Central Asian IPS but did attempt to supply to Afghanistan, thereby achieving regime effects outside the post-Soviet space (Ministry of Energy and Industry, 2011a).

Electricity exchanges between the Siberian IPS and the Urals IPS via KEGOC's (Kazakhstan) grids have usually been carried out from Siberia to the Urals (European part of Russia) during evening-time peak hours and from the Urals to Siberia during night off-peak hours in the European part of Russia. This helped to implement a regime effect of regulating daily demand in the European part of Russia through the exchange of electricity between these two regions also using Kazakhstan's northern grids.

The cooperation between the national power systems of the EDB member states has helped to improve the reliability of power supplies to consumers (e.g., using Kazakhstan's northern electrical grids to transmit electricity from the European part of Russia and the Urals to the Siberian IPS to cover its shortages caused by the Sayano-Shushensk HPP accident in 2009) (Volkova et al., 2011a).

In 2008, in order to mitigate power shortages resulting from an accident at Belarus' Lukoml GRES, the lacking amount of electricity was supplied by Russia, Lithuania and Latvia (Lenta.ru, 2008) via the power plants in the north-western IPS and the Baltic States that were loaded following the instructions of the System Operator of the Unified Energy System (UES System Operator, 2008).

The power systems of the EDB member states cover four time zones and daily peak hours in different systems do not coincide. It is expected that, given socioeconomic development, the winter peak loads in Kyrgyzstan and South Kazakhstan will be replaced by summer peak demand (Belyayev et al., 2008). There will be a similar effect in Tajikistan. The unification of systems with winter and summer peak loads will have significant integration effects, saving generating capacity and lowering the cost of construction and operation of generating facilities. Given the daily differences in peak demand and the variation in generating capacities between the national power systems, closer cooperation between Central Asian EDB member states, primarily with Russia, where peak demand is in winter, is expected to produce the greatest capacity-saving and regime integration effects for all countries.

3. Common electric power market of the CIS and EurAsEC: Status and Challenges

3.1. Interstate initiatives on establishing a common CIS electricity market

The power systems of the CIS countries emerged after the collapse of the USSR when the Soviet power complex was divided between them. Integration processes in the CIS power sectors began on February 14, 1992 when the Agreement on the Coordination of Interstate Relations in the Field of Electric Power in the CIS (CIS, 1992) was signed by the Heads of States. In accordance with the agreement, the countries formed the CIS Electric Energy Council (Mishuk, 2008).

To ensure the reliable operation of the power systems and to create a basis for mutually beneficial cooperation, the CIS Electric Energy Council approved the Agreement on Parallel Operation of the CIS Power Grids, which defined the common principles of parallel operation (Mishuk, 2008).

On November 26, 1998, the Agreement on Ensuring Parallel Operation of the Electric Power Systems of the CIS Member States was signed (CIS, 1998). This was the very first legal instrument (Mishuk, 2011) governing interaction between countries and enterprises regarding the parallel operation of the power grids on commercial terms. The agreement was signed by Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Uzbekistan and Ukraine (the latter with a modest proviso). Within the framework of the Agreement the parties reached corresponding bilateral and multilateral agreements (CIS, 1998).

So, on November 22, 1999, Belarus and Russia signed an agreement to create an integrated power system (Agreement, 1999); on June 15, 2000 the parallel operation of the Kazakh and Russian UES was reinstated; and in September 2000 the power grids of Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan that were parties to the Central Asian IPS together with Kazakhstan's electricity system launched their first time ever parallel operation. By 2001 the Agreement on Ensuring Parallel Operation of the Electric Power Systems of the CIS Member States had made it possible to establish an integrated power system between the CIS member states, which subsequently enabled the power grids of the CIS countries (except Armenia) to work in parallel mode (Mishuk, 2011).

On January 25, 2000 twelve countries signed the Agreement on the Transit of Electric Power among the CIS Member States (CIS, 2000). Pursuant to the agreement (CIS, 1998), the Council of Heads of States approved the Concept for the Formation of the Common Electric Power Market of the CIS Member States (CIS, 2005a).

The Concept encompasses shared approaches to the common electric power market in the CIS. It takes into account the key principles of the unification and liberalisation of the European power markets as embodied in European Parliament and European Council directives and provides the basis for further regulation in this area.

The main objective of the Concept is to create a common electric power market in the CIS based on the power systems that work in parallel and on the principles of national equality, fair competition, and mutual benefit.

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The Concept defines a functional structure of a future common electric power market based on the following relationships between participants:

- wholesale purchases and sales of electricity with independent pricing agreed between buyers and sellers;
- a centralised electricity market;
- a balancing market; and
- a market for system and auxiliary services, including a mechanism for using power reserves, regulating capacity and maintaining the energy balance.

On May 30, 2008 the EurAsEC Energy Policy Council approved the draft Concept, which was ratified by heads of governments on December 12, 2008.

On May 25, 2007 six CIS countries (Russia, Kazakhstan, Belarus, Kyrgyzstan, Tajikistan and Armenia) drafted the Agreement on the Formation of the Common CIS Electric Power Market. However, Ukraine, Azerbaijan, Turkmenistan, Uzbekistan, Georgia and Moldova refused to sign up to the new document and the parties made a decision to continue operations within the framework of the previously signed agreement. In order to establish a common electric power market, the member countries must undertake to maintain the energy balance and ensure mutual reserves of capacity. This will improve the reliability of power supplies and ensure optimal use of fuel, energy and hydropower resources. In addition, the countries will need to provide electricity transit through their territories.

By creating the common electric power market, the CIS countries plan to gradually open up their domestic markets to each other. This will make it possible for suppliers or buyers of electricity in one country to access the transmission system, select counterparties, and enter into contracts in another country.

The 32nd CIS Electric Energy Council decided that the common electric power market would be formed in three stages.

The first stage will create trade in electricity between the CIS member states using international transmission lines and transit via the power systems of third countries. It will increase the number of participants on national markets; boost the development of a day-ahead market; and ensure free electricity pricing on national markets.

The second stage involves the emergence of competing national power markets in CIS countries, liberalisation of electricity exports and imports, and coordination of national grids and commercial operators.

The third stage implies the full launch of the common electric power market, based on uniform rules for all participants.

On November 22, 2007 twelve countries, including Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia and Tajikistan, signed the Agreement on the Harmonisation of Customs Procedures for the Transmission of Electric Power across the Customs Borders of the CIS Member States (CIS, 2007a). This agreement aims to harmonise and simplify customs procedures for transmitting electricity between national power grids. The standard procedure for electric power is specified in a customs declaration once the base period expires and there are special rules for the customs clearance and control of power flows through borders.

The approval in 2008 of the CIS Economic Development Strategy for a period to 2020 became an important milestone in the coordination of the power sectors of the CIS member countries.

On November 20, 2009 the CIS member states signed an agreement on cooperation in operating interstate power transmission lines, which set forth the requirements for reliable and efficient grid operation to coordinate electricity transit.

The agreements signed have defined the prospects for electricity cooperation between the CIS countries, including:

- the sustainable and predictable development of international trade in electricity for a relatively long term; and
- economic efficiency for all participants.

Each country's energy policy is largely shaped by an energy strategy which prioritises long-term international cooperation. This shared priority recognises the desire to ensure the most efficient use of the energy potential of each country so that they can be integrated into the global power market and consolidate its position, and derive the greatest possible benefit for the national economy.

Achieving the strategic objectives of CIS member states depends on the following:

- the countries' national interests should be taken into account in shaping the common electric power market to ensure predictable development of their electrical grids;
- the common electric power market should reliably meet demand and ensure, inter alia, the reasonable pricing of exports;
- mutual penetration of national power markets by electricity companies should be guaranteed; and
- effective international cooperation should be developed in the sector.

The development of the CIS power sector can be efficiently coordinated only by harmonising the main objectives of the long-term energy policies by the CIS member states (Shmatko, 2009).

On March 18–19, 2010 the Coordination Council for the Implementation of the Strategy of the CIS Member States for Interaction and Cooperation in the Field of Electric Energy approved new organisational, legal, technological and economic principles of the parallel operation of the CIS power grids. Moreover, in 2010 the CIS Electric Energy Council adopted a master plan for the establishment of the common electric power market of the CIS member states (Mishuk, 2011).

At present, eleven out of twelve CIS power grids operate in parallel mode with the Baltic States. Efforts are being made to prepare the CIS and Baltic States' IPS to operate in parallel with the Trans-European Synchronously Interconnected Electric Power System (TESIS).

To date, the CIS has adopted over twenty basic interstate agreements and regulations governing joint interstate initiatives formulated by the CIS Electric Energy Council with regard to the following:

- electricity transit;
- mutual assistance in case of accidents or other emergencies at power facilities;
- energy efficiency and conservation;
- creation and efficient use of reserve resources;
- formation of the common electric power market;
- setting of a common time for reading electricity meters on interstate power transmission lines; and
- harmonisation of customs procedures for the cross-border transmission of electricity and operation of interstate power transmission lines within national grids.

3.2. Energy cooperation within the EurAsEC

EurAsEC's energy priorities for the near future include:

- creating a common energy market by encouraging mutually beneficial cooperation, harmonising national legislation, creating a wholesale electricity market and developing transit potential;
- supplying adequate energy resources to domestic markets and increasing their exports to third countries by cooperating with EurAsEC countries and with international organisations, and by developing new hydrocarbon fields, hydrocarbon processing, and free movement and transportation of energy resources;
- creating a shared information system by aligning tariff, tax and customs policies and creating the conditions to encourage investment;
- coordinating shared use of Central Asian water, fuel and energy resources, resolving the problems attached to energy supplies and water use, and adopting a unified energy balance;
- integrating EurAsEC into the global fuel and energy system, cooperating with foreign investors to develop the sector, improving the efficiency of traditional markets and developing new ones; and
- ensuring energy security and creating the conditions for sustainable economic growth.

To this end, the EurAsEC member states need to develop a uniform and comprehensive energy policy for the use of their resources, which would radically change EurAsEC's role in global energy trade and change its status from a supplier of raw materials to an independent participant in the global energy market.

The EurAsEC Interstate Council approved the energy policy framework on February 28, 2003. The policy represents the countries' official understanding of the objectives, tasks, principles, key areas and mechanisms for the implementation of their energy policies (EurAsEC, 2003).

The objective of the EurAsEC member states' energy policy is to ensure their energy independence and security by creating a common market in energy resources and a reliable energy base for their sustainable economic growth. The policy focuses on the member states' fuel and energy sectors.

EurAsEC member states also approved the Agreement on the Formation of the Unified Information System for the Energy Market. The database of the shared information system is expected to include member states' laws and regulations, international agreements and EurAsEC resolutions, documents issued by the EurAsEC Interstate Committee's Energy Policy Council and other international organisations, statistics on aspects of energy sector development, information on strategic energy development and national standards and on prices and tariffs in wholesale and retail energy markets.

Therefore, a coordinated policy on the formation of the EurAsEC's common energy market should become a valuable tool in international cooperation (Sarsembekov, 2008).

3.3. Features of energy cooperation in Central Asia

Central Asia is able to meet its own energy needs because it has huge water, fuel and energy resources, the geographical distribution of which is, however, uneven (Kasymova, 2010).

Central Asia's energy issues have historically been connected to the region's use of water. The mountainous countries of Kyrgyzstan and Tajikistan, which are located in the upper reaches of the Syrdarya and Amudarya (that together form about 80% of the total river flow), have significant hydropower resources but lack oil and gas and therefore experience energy

shortages. Kazakhstan, Uzbekistan and Turkmenistan, which are located downstream on the Amudarya and Syrdarya, boast considerable fossil fuel reserves (oil, coal and gas) and, in addition, use these rivers extensively. Kazakhstan accounts for 77.4% of the hydrocarbon fuel in Central Asia, Uzbekistan 12.7% and Turkmenistan 6.7% (Yasinsky et al., 2011). Therefore Kazakhstan, Uzbekistan and Turkmenistan base their power systems on thermal power plants while Tajikistan and Kyrgyzstan, together in possession of 90% of the region's hydro potential, have highly manoeuvrable hydropower plants (Ibragimova, 2010). Kyrgyzstan and Tajikistan sometimes account for 90% of hydropower generation in Central Asia (UN, 2002). Kazakhstan and Uzbekistan account for 81% of total fuel and energy generation and 83.5% of their consumption in the region (Ibragimova, 2010).

3.3.1. Central Asian Integrated Power System

In the period under consideration the situation with regard to electricity generation in the region was challenging. To meet agricultural demand for water (mainly from the Uzbek cotton industry) hydropower plants on the Naryn and Vakhsh rivers in Kyrgyzstan and Tajikistan had to release significant amounts of water to downstream areas during cultivation periods. Because of the low load in the Central Asian IPS during summer months, HPPs had lower demand in summer and discharged large volumes of water for irrigation. This made it impossible to accumulate water for peak winter demand. Because of the lack of hydropower resources over this period, the Central Asian IPS experienced shortages in its energy balance, especially in low-rainfall years.

In 2006–2011 Kyrgyzstan and Tajikistan had suffered electricity shortages. Starting March 2008 Kyrgyzstan faced an acute energy crisis caused in part by the lack of water in the Toktogul HPP reservoir in autumn and winter. The water shortage resulted in the country's citizens being without electricity for twelve hours a day on average. Since October 1, 2009 outages in Kyrgyzstan have reduced to an average of six hours a day (CIS Power System, 2009).

The energy crisis in Tajikistan, which worsened further in 2008, was caused by the country's failure to generate enough electricity during peak periods and a drastic reduction in its imports from its main suppliers – Uzbekistan and Kyrgyzstan – after Tajikistan withdrew from the Central Asian IPS in 2009. Tajikistan's industrial consumers still experience power cuts in autumn and winter (Soros Kyrgyzstan, 2011) and the country uses a system of scheduled/rolling outages during peak hours, which causes substantial economic losses. Electricity consumption is also rationed, to mitigate the problem. During the period of high heating demand, accident rates surge and the consistency of electricity supplies to consumers worsens considerably. The country still needs to limit electricity supplies and this situation is not expected to change within at least next two years (Tjknews.ru, 2011).

3.3.2. Parallel operation of Central Asian power grids

Given the concerns over the challenges posed by the new market conditions, in June 1999 Kyrgyzstan, Kazakhstan, Tajikistan and Uzbekistan signed an intergovernmental agreement to ensure their equal rights and obligations in operating their power grids in parallel mode (Central Asia, 1999).

The establishment of a common market in Central Asia requires resolution of an array of economic, legal and technical issues, which are still being negotiated. The power market needs to be based on the parallel operation of the power systems of Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan within the Central Asian IPS. The transfer of the Central Asian systems to parallel operation is critical since this would allow electricity supplies to third countries to be increased, at least once a centralised electricity market is formed.

However, despite the agreements, some countries repeatedly breached the agreed rates of electricity supply and offtake from the common grid. Failure by one of the parties to comply with the agreed terms caused losses to all countries (Kasymova, 2010).

On December 1, 2009 Uzbekistan withdrew from the Central Asian IPS because the system was unable to generate the required quantities of electricity during peak morning hours (Ibragimova, 2010). However, uninterrupted supplies of electricity to the whole Central Asian region depend on the Energiya Coordination and Dispatch Centre, which is located in the Uzbek capital of Tashkent and transmits electricity to all countries in the region. Uzbekistan's withdrawal from the Central Asian IPS has resulted in power shortages in Kyrgyzstan, Tajikistan and southern regions of Kazakhstan. In winter 2008, Uzbekistan, blaming technical problems in the national grid, discontinued the transit of Turkmen electricity to Tajikistan, violating the terms of a transit agreement between the three countries. As a result, Tajikistan resorted to unauthorised offtake of electricity from the Central Asian IPS. This resulted in accidents at power units in southern Kazakhstan and northern Kyrgyzstan, and Kazakhstan's unilateral withdrawal from the integrated power system. Turkmenistan withdrew from the Central Asian IPS in June 2003 (Zhavoronkova, 2009).

Kazakhstan repeatedly stated that there were problems in the operation of the Central Asian IPS (in particular, its unbalanced operation) and demanded that control over transmission to be improved. Only southern regions of Kazakhstan depend on the Central Asian IPS while its northern regions are connected to Russian grids, which are capable of supplying electricity to all of Kazakhstan. Kazakhstan's exit from the Central Asian IPS will reduce power supplies to neighbouring Kyrgyzstan, where the Central Asian IPS accounts for 70% of supplies (Neft Rossii, 2009). Tajikistan's Sughd Province, with a population of more than 2 million, depends on the Uzbek electricity also supplied through the Central Asian IPS (ROS-ELECTRO.RU, 2009). Other Tajik regions receive electricity from Turkmenistan, using the same Uzbek transmission lines. The breakdown of the common power system may result in a complete blackout in Tajikistan.

The Tajik power system has repeatedly breached the principles of parallel operation and created dangerous situations in the integrated system. This prompted Uzbekenergo to discontinue parallel operation with Barki Tojik in December 2009.

Today, the Central Asian states differ considerably in the level and speed of their economic and social reforms, the state regulation of production and finance, and their foreign political standing. The previously well-functioning mechanism of mutual water and fuel supplies in Central Asia has practically failed, meaning that the countries adopt different positions with regard to integration processes in general and the power sector in particular.

The countries that are net importers of fuel and energy had serious difficulties finding enough foreign currency to buy energy abroad and ensuring the greatest possible supply from their domestic sources and fossil fuel reserves. As for exporters, securing investment in their fuel and energy sectors in the amounts necessary to maintain stable power supplies to the economy and population and a level of exports that would meet economic objectives is their prime challenge (UN, 2002).

Therefore, due to various reasons the Central Asian IPS is not operating as a common power system as it once did and the exchange of electricity between the countries has declined significantly.

3.4. Barriers to a common electric power market

The prerequisites for integrating the EDB member states' power systems were established in Soviet times and have been determining cooperation between these countries since the collapse of the Soviet Union. Many agreements on parallel operation of the power systems of different countries were signed, including the October 2011 agreement on the CIS free trade zone which concerns, among other things, the power sector. However, such initiatives have faced difficulties in recent years (Vinokurov, 2008), which prevent them achieving their goal quickly.

One of the challenges is historical: the power sectors of these countries vary in their level of development and structure. This is a result of the centralised approach to locating generating facilities and developing electricity grids under the Soviet common power system. Power stations were built to facilitate the centralised supply of power to large areas, regardless of the administrative borders between the Soviet republics. Generating capacity was determined according to the demand in each of these areas. Transmission lines were designed and built to distribute the electricity produced by these power plants to different power centres, also regardless of borders. After the dissolution of the Soviet Union, many transmission lines became trans-border lines. Instead of system-forming role, they are used to export and import electricity at agreed prices.

There is still a need to coordinate the development of generating facilities and electrical grids in certain CIS countries. Although historical differences in their available energy resources was a driver for cooperation and the formation of trade ties between them in the power sector, it complicates the coordination of investment policies because of the energy security requirements which arise in the context of liberalisation of national economies and power sectors.

The problems associated with creating a common CIS electricity market are also linked to the power sector's status as an important facet of economic management. The power sectors are natural monopolies, which create difficulties in short-term and long-term pricing, restrict competition, and complicate, to a significant extent, their balanced and efficient development. Therefore, state management and regulation need to be maintained to improve the efficiency and reliability of power supplies. Efforts to create and operate wholesale electricity markets in Russia and other countries (Podkovalnikov, 2011) have shown that assumptions regarding the market's role as a regulator were misplaced. Many of these countries are now reconsidering their attitude towards liberalisation. This is why Russia, as expected, is continuing its market reforms, which are aimed at giving the power market a more efficient structure.

Difficulties also arise in creating a common market because the countries are employing different market models and vary in the level of liberalisation and reform they have achieved.

Although more than twenty years have passed since the collapse of the Soviet Union, the countries that emerged from former Soviet republics still face some intractable problems. These are mainly connected with their interaction in the use of natural energy resources and pricing, in particular the use of Caspian energy resources and the pricing of Russian gas and its transportation to European countries.

One of the problems associated with the common power market, and which is peculiar to Central Asia, is the need to resolve disagreements over the use of the power and water resources of trans-border rivers such as the Naryn and Vakhsh, among others. These disagreements have been caused by (a) the construction of cascades of HPPs in Tajikistan and Kyrgyzstan, (b) the requirement to provide an optimal water use schedule to all countries located downstream of the trans-border rivers in use, and (c) significant differences in seasonal water demand and energy efficiency of hydropower plants.

To overcome these disagreements, generating facilities, transmission lines (including interstate lines) and reservoirs need to be developed further and mechanisms of regional cooperation need to be created (Vinokurov et al., 2007). The EurAsEC Integration Committee is involved in efforts to resolve this problem.

There are several organisational, legal and methodological challenges which also obstruct the creation and development of the common electric power market in the CIS.

Global experience (Belyayev et al., 2008), of creating common electric power markets shows that it is a lengthy and complex process. First, countries enter into bilateral agreements on parallel operation of their national power grids. In the CIS, such agreements were made

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between Russia, on the one hand, and Kazakhstan, Belarus, Ukraine and Kyrgyzstan on the other. They govern relationships but do not provide a basis for free trade.

The next stage is the conclusion of multilateral agreements and the creation of regional integrated power systems. However, in order to use these as a network infrastructure for regional power markets, the countries that are party to these agreements need to enter into special agreements to provide access to the services of their natural monopolies in the power sector and to define pricing and tariff policies. In this case this becomes possible only after the formation of the Customs Union and the Common Economic Space of Russia, Kazakhstan and Belarus. An additional requirement is the creation of a single management body to oversee long-term operation, a common market operator, and an agreed regulatory framework.

The integrated power system of the former Soviet republics actually exists, indeed the global power market recognises the Unified/Integrated Power System. However, in order to establish the common electric power market on the basis of this entity, a common regulatory framework needs to be created and approved and all the above problems resolved. This is a challenging task if the different economic interests of CIS countries and their different understanding of energy security are to be taken into account.

4. Formulating Uniform Technical and Environmental Standards and a Legal Framework

There are many arguments for developing consistent technological and environmental standards and creating a uniform legal framework to govern the evolution and functioning of the power sectors in the CIS and the Baltic States. It is important to ensure first of all that such an extensive and complex interstate power system as the UPS/IPS is operating reliably and sustainably.

The UPS/IPS inherited the infrastructure of the Unified Power System of the USSR, which had been designed and operated as an integral project. All the technological requirements that ensured its viability were complied with, including automatic frequency and flow control, the capacities and location of active power reserves, the control of reactive power voltage and flows, centralised control of operational modes, and the development of generating facilities and other elements of electrical grids. The fact that the Soviet UPS had been functioning for many years is a proof of its viability and efficiency. From a modern point of view, its only drawback was its insufficient attention to environmental requirements.

After the collapse of the Soviet Union, this power system became an interstate one. Institutionally it was divided into fifteen national power grids. The new circumstances required coordinated management of the UPS/IPS as an interstate power system. In legal terms, this was formalised by a framework agreement on parallel operation of national power grids (Yasinsky et al., 2009). The CIS countries set up a common coordinator in the power sector, the Electric Energy Council.

The Council and its working groups developed a number of agreements and contracts to ensure CIS power systems were operating sustainably. These instruments were signed by the CIS Council of Heads of States once consensus was reached.

Currently, a legal framework is in the pipeline which will regulate the power sectors of the CIS and the Baltic States as they pursue their strategy of liberalisation. In other words, the activities of power sector regulators in different countries are being coordinated in order to reach consensus on and ensure compliance with technological and environmental standards required of the interstate power system.

For a common electric power market to exist in the CIS, there has to be commercial integration, and a single supra-national regulator must be in place.

In addition, as global experience shows (Pineau et al., 2004), different countries have different approaches to integrated power systems and these approaches depend on their attitude toward regional political and economic integration. The Scandinavian power markets are the most integrated. The countries of South and North America have partially integrated their power sectors: despite the existence of the North American Free Trade Agreement (NAFTA), the USA and Canada have very different approaches to the liberalisation of the power sector and the creation of power markets in various states. To resolve problems associated with synchronising the operating phases of different parts of national power systems, these systems are often separated by DC lines and links (Belyayev et al., 2008).

The aforesaid arguments point to the conclusion that, if the CIS needs to create a fully integrated common electric power space, further extensive rationalisation is still required. Integration in the power sector is impossible without economic integration. Political aspirations and political will should play a part in this process. At present, the administrations of the CIS countries clearly lack motivation in this area.

The documents drafted by the Electric Energy Council and adopted by the CIS Council of Heads of States are often only advisory and decisions taken are often ignored, even with regard to the critical issue of guaranteeing reliable parallel operation of the CIS national power grids. The absence of compulsory requirements for managers of these systems, and economic sanctions for failing to operate the interstate power system sustainably, have negative technological and economic effects and result in considerable losses to participants in the sector.

Harmonising power sector relationships in CIS countries, which are at different stages of their economic development and integration, can be a long process, made even longer by delays in decision-making. These factors hinder the creation of uniform technological regulations and a legislative framework to govern the common electric power market.

Thus, the technological basis for integrating the CIS countries and the Baltic States is the existing IPS network that emerged from the Soviet unified power system. However, coordinated regulation and commercial integration depend in particular upon the economic relationships between countries and the political will of their governments.

4.1. Challenges of uniform technical regulation

The need to ensure that the UPS/IPS operated reliably in parallel mode while the CIS power grids were managed independently required the adoption of new regulations. To this end the CIS Electric Energy Council approved the following documents (Volosskiy, 2009):

- the Blueprint for Frequency Control in the Integrated Power System;
- the Guidelines for Quantifying and Locating Active Power Reserves;
- The Rules for Power Flow Scheduling; and
- the Rules for Reactive Power Voltage and Flow Control.

Global progress in the power sector involved changing control technologies and switching from analogue to digital technologies. However, this process took too long even in Russia, resulting in the need to modernise the power sector particularly and the country's economy generally. The process is constrained by technological shortcomings, the consequent underdevelopment of production, and a shortage of qualified personnel. A significant proportion of the necessary equipment has now been imported. Therefore, in order to introduce new technologies, the CIS countries will need scientific and technological expertise, and considerable time and investments, to put them in place and launch mass production. The Interstate Programme for Innovative Cooperation between the CIS Member States until 2020 was developed to achieve this goal (CIS, 2011).

The unification of technological requirements for the power sector is being pursued to ensure electricity supplies are sustainable and reliable in all the CIS member states.

The reform and restructuring of the national power grids and the creation of national power markets, which differ in structure and level of development, call for more stringent requirements for their parallel operation. New requirements have emerged, such as the hourly metering of commercial and technological flows of electricity. Regulations and standards adopted by the CIS Electric Energy Council needed modification.

The CIS Blueprint for Cooperation dated November 20, 2009 lists, among other priorities, the development of harmonised technical regulations in the sphere of electric power in order to ensure reliable parallel operation of the national power grids. The Commission for Operational and Technological Coordination (COTC) and the Executive Committee of the CIS Electric Energy Council drafted new technical regulations. Once approved by the Electric Energy Council, technical regulations can be adopted in the form of an international agreement or by their inclusion in national laws in accordance with the countries' internal procedures. The COTC submitted three documents for the Council's approval (Smi2.ru, 2009):

1. Basic Requirements and Recommendations for the Organisation and Operation of Relays and Automatic Reclosing Relays in 220–750 kV Interstate Electric Power Transmission Lines connecting the Electric Power Systems of the CIS Countries, as well as Autotransformers Relating to these Electric Power Transmission Lines. The objective of this proposal was to improve the reliability of interstate electricity supplies and the stability of cross-border power systems in the CIS. The document proposes the use of uniform relays and automatic reclosing relays and coordination of maintenance, inspections and adjustment.
2. Basic Technical Requirements for Frequency Controls aims to establish automatic frequency controls for the operational dispatch service coordinating the parallel power systems. The recommendations aim to coordinate uniform approaches to and requirements for equipment and software used in automatic frequency controls in the CIS integrated power system. These measures are expected to improve reliability and stability of each power system and the integrated system as a whole.
3. Generation Regulations for Emergency Control in the IPS/UPS drafted by the Emergency Control working group establishing the general principles for setting up and operating emergency controls in the IPS/UPS and the parties' interaction in this area. The regulations provide the specifications for emergency controls and the data collection and distribution system.

The way in which the national wholesale and balancing electricity markets currently work means new schemes are required to govern billing systems for electricity and to improve their accuracy. The parallel operation of power grids is impossible without harmonised billing standards and a legitimate procedure for acknowledging billing data for transmission lines that connect the CIS power markets. Electrical grid-operating companies are in urgent need of the following documentation (Komkova, 2008):

- rules for the certification of electricity meters on interstate transmission lines;
- a unified format for the exchange of data on interstate power flows between the CIS member states;
- regulations for metering interstate power flows; and
- advanced automation techniques and new (digital) metering technologies.

The CIS Electric Energy Council has already approved the Procedure for quantifying interstate electricity exports and imports in the CIS common electric power market and the recommended Agreement on the exchange of routine technological and statistical information on parallel operation. The objective of the latter document is to improve dispatch management in the parallel power grids of the CIS and the Baltic States (FGC, 2011a).

To conclude, unified technical regulations for the power sectors of the CIS member states are needed to ensure the interstate IPS/UPS and the national grids it unites function consistently and reliably.

4.2. Initiatives on formulating uniform principles of a common electric power market establishment

A number of standards were adopted in 2009 to promote interstate cooperation in standardisation, energy conservation and energy efficiency. The CIS Interstate Council is working on an interstate programme for energy saving, energy efficiency and energy resources.

In 2011, the CIS countries adopted the Framework Programme for Cooperation between the CIS Member States in the Field of Peaceful use of Nuclear Power until 2020 («CIS Nuclear Cooperation»). In the same year they also approved a draft agreement on the coordination of interstate relationships. Measures are being taken, furthermore, to align initiatives to develop and use hydropower resources. These include the Blueprint for the Efficient Use of Hydropower Resources in Central Asia, which has been developed by EurAsEC. The CIS Integration Committee also created a working group to refine this document and design a coordinated mechanism for regulating hydropower resources in the Syrdarya and Amudarya river basins. Independent international experts are helping to draft the blueprint.

In late 2010 the CIS Council of Heads of States approved a method for forecasting production and consumption of energy resources until 2020. The document presents three possible options for the joint development of the CIS power sectors, suggesting that:

- the main trends that emerged before the crisis might continue (with the 2008–2009 events taken into account) (moderate/conservative scenario);
- the energy saving and energy efficiency policies can be implemented (innovation scenario); or
- the development potential of the CIS member states can be significantly increased (ambitious scenario).

Belarus is implementing national standards that comply with international regulations. These documents specify the requirements for equipment which will use fuel and energy resources efficiently to produce heat and electricity. The country plans to adopt a set of national standards for heat generating equipment that will be harmonised with the European standards. Two standards were made effective on July 1, 2010:

1. GOST ISO 13602–1–2009. Technical Energy Systems. Methods for Analysis. Part 1: General; and
2. GOST ISO 13602–2–2009. Technical Energy Systems. Methods for Analysis. Part 2: Weighting and Aggregation of Energywares.

These standards describe methods for analysing, characterising and comparing technical energy systems with all their risk factors and for weighting and aggregation of energywares to ensure that energyware statistics at different levels of aggregation is transparent and comparable. This would indicate that the EDB member states should be able to create a coordinated system of national standards using as an exemplar standards such as the ISO's, as Belarus has done. This system would greatly encourage interstate initiatives in the power sector, its related industries and in other sectors.

To develop and implement joint innovation projects in different sectors the CIS Interstate Innovative Nanotechnology Centre was set up at the Joint Institute for Nuclear Research in the Dubna, special economic zone. The centre was founded by fifteen research institutes, universities and businesses from nine CIS member states, including the EDB member states.

In accordance with the first milestone plan (2009–2011) of the CIS Economic Development Strategy until 2020, Russia is developing 162 national standards that are harmonised with European standards, including those relating to energy efficiency, energy saving and energy resources.

Because of Russia's leading position in the field, the CIS Executive Committee asked the Russian Ministry of Energy to include in its research and development plans the drafting of the CIS blueprint for renewable energy sources.

Given existing and emerging challenges, significant effort is required in order to coordinate the power sectors and implement the Interstate Targeted Programme for Innovative Cooperation between the CIS Member States until 2020. Promising infrastructure projects aimed at making technological advances in nuclear power and the use of alternative sources of fuel and energy must also be continued.

4.3. Environmental requirements

Environmental sustainability is an essential element of the modern power industry and critical to energy security. Therefore all levels of management need a coordinated approach to environmental protection. The principle task of the CIS Electric Energy Council is to deepen multilateral cooperation in seeking solutions to environmental and resource problems and in improving and harmonising regulation.

The CIS power sectors are mostly based on thermal power plants. The introduction of new technologies at these plants requires changes in fuel supply and compliance with new emissions and discharge standards by employing the best available technology. For gas-fuelled plants, such technologies include combined cycles, gas turbine links to steam units and gas turbines with heat recovery. Fossil-fuel plants can be fitted with environmentally friendly Circulating fluidized bed combustion firing technology, coal gasification and new critical pressure coal units with an efficiency of 45–46%, which helps to significantly reduce coal burning by TPPs. Ekibastuz GRES-2 will be fitted with these new technologies.

With improvements in the efficiency of conventional technologies and the development of new techniques, renewable sources of energy are becoming increasingly important. All the CIS countries are striving to use renewable energy and to provide the legal, economic and organisational basis for their greater adoption. The EurAsEC's model law On Alternative Energy says that the construction of small power plants are governed by the same laws that govern the construction of large facilities. A legal framework, incentives for investments, beneficial financing conditions, and a favourable tax and lending environment are needed to develop small power plants (Baltinfo.ru, 2009).

The CIS Electric Energy Council's agenda for energy efficiency and renewables includes the drafting of regulations, project monitoring, analysis of investment policies, and a review of the existing programmes.

The International Centre for Sustainable Energy Development has prepared a renewable energy strategy to help attract investment in new technologies. To promote renewable energy in the CIS countries are suggested to create a supranational body. Its functions would include the drawing up of state initiatives and legislation and coordination of cooperation.

In December 2011 the CIS Economic Council set up a working group to report in 2012 on renewable energy cooperation between the CIS countries.

4.4. Creating a uniform legal framework

Regulations governing interaction between the CIS countries in assuring parallel operation of their power systems and international trade in electricity are continuously modified. Much of the work of the CIS Electric Energy Council and the Council of Heads of States is aimed at establishing legislation surrounding the common electric power market.

Regulations were initially put in place to commercialise relationships between the CIS power sectors, based on use of the IPS/UPS electrical infrastructure.

4. Formulating Uniform Technical and Environmental Standards and a Legal Framework

In 2011 the Executive Committee of the CIS Electric Energy Council issued draft Guidelines for the Calculation of Payments for Electricity Transmission and Transit in the CIS Integrated Power System.

These documents were needed to achieve the very first stage of the common electric power market, i.e., to expand bilateral cross-border trade in electricity between the CIS member states.

In fact, bilateral trade in electricity under parallel operation agreements has proved quite successful in practice.

Cooperation between Russia, Belarus and Kazakhstan has been particularly fruitful in this regard. These countries signed up to the agreement creating the CES on December 20, 2011. Kyrgyzstan, Tajikistan and Ukraine joined the agreement as observers. These countries have actively cooperated for some time and the legal framework for their collaboration was refined in 2008–2011.

In 2008 the governments of Russia and Kyrgyzstan signed a new agreement on cooperation in the power sector. Kyrgyzstan undertook to free up the transmission and transit of electricity produced in specified units via its grids and to sell it under direct agreement at home and/or abroad at prices approved by feasibility study as being economically reasonable.

In April 2010, pursuant to the agreement between Russia and Kazakhstan to ensure parallel operation of their UES, their governments signed:

- an agreement between KEGOC and FGC UES/System Operator UES on parallel operation of the electric power systems of Kazakhstan and Russia;
- an agreement between KEGOC and INTER RAO UES on the sale of electricity to balance hourly fluctuations in electricity transmission across the border between Russia and Kazakhstan; and
- an agreement between KEGOC and FGC UES (in accordance with the agreement of FGC UES) on electricity transmission/transit.

These agreements place on a commercial footing the services the Russian and Kazakh UES provide to each other. Since May 2010 Russia has been paying for electricity transmitted/transited via Kazakh grids. KEGOC, the system operator of Kazakhstan's UES, pays for the maintenance of standard frequency. Until May 2010 frequency was controlled in exchange for electricity transit (FGC, 2011b).

On June 17, 2010 a technical agreement was reached on parallel operation of the power systems of Russia, Belarus and Ukraine (Central Dispatch Department, 2011; UES System Operator, 2010). This document governs interaction between system operators and grid companies operating the power systems of the countries in parallel. The agreement sets out the responsibilities of, and required interaction between the parties, including coordinated planning and provision of agreed hourly net power flows, frequency control and the operation of interstate transmission lines.

This agreement was necessitated by the need to improve legislation governing the parallel operation of the Russian, Ukrainian and Belarusian integrated power systems. Also in 2010 an agreement was signed on the maintenance and use of the emergency electricity reserve in the BRELL Ring² (UES System Operator, 2010a).

² The power systems of Belarus, Russia, Estonia, Latvia and Lithuania form the so-called BRELL Ring, the operation of which is coordinated by the Agreement on Parallel Operation of the BRELL Power Systems signed in 2001

In 2009 EurAsEC governments met to approve draft international agreements, including the Protocol on the Terms of Transmission of Electric Power between the Republic of Belarus, the Republic of Kazakhstan and the Russian Federation, and the Agreement on Ensuring Access to the Services of Natural Monopolies, including the Basics of Pricing and Tariff Policies, in the Sphere of Electric Energy.

As a result the following documents were signed in 2010:

- the trilateral Agreement of November 19, 2010 on Ensuring Access to the Services of Natural Monopolies in the Sphere of Electric Energy, including the Basics of Pricing and Tariff Policies³;
- the Agreement of December 9, 2010 on the Uniform Principles and Rules for the Regulation of Operations of Natural Monopolies; and
- the Agreement of December 9, 2010 on the Uniform Principles and Rules of Competition.

The first of these agreements establishes the principles of interaction between the parties in interstate electricity transmission. The parties, as far as their technological capabilities allow, undertake to provide unrestricted access to these services, which are to be used primarily to meet domestic demand in the member states. Transit is provided in accordance with respective agreements. The internal balance of a national power system is to be ensured irrespective of the origin of electricity, its destination or owner. The agreement creates equal terms for the provision of services by natural monopolies in the power sector, unless this contradicts the national laws of the respective country. The agreement also provides for the use of uniform methods of interstate electricity transmission between the CES member states (in an appendix to the agreement), including the procedure for determining the technological conditions and volumes of interstate transmission, and coordinated approaches to pricing.

In November 2011 Belarus ratified the intergovernmental Agreement on Certain Measures to Ensure Parallel Operation of the Belarusian IPS and Russian UES. In particular, the agreement allows Belenergo and INTER RAO UES to create a joint venture in Belarus to install DC lines with third countries.

In 2012 the interstate transmission of electricity between the CES countries, including via the Russian UES grids, finally became possible.

However, to create a common electric power market involving Russia, Belarus and Kazakhstan, their interaction still needs to be adapted by their transition to CES principles. All the legal instruments forged between them require significant modification in order to ensure more extensive coordination of regulation and commercial integration in the power sector.

For the common electric power market to be created in the CIS, the necessary legislative foundations still need to be put in place. Moreover, it seems that stated intentions to form this common market, which will incorporate spot, power, services, and futures markets, (Vinokurov, 2008) lacks substantive follow up. To ensure free trade between all the CIS electrical companies the electricity grids of the interstate IPS/UPS need to be considerably more advanced. It is practically impossible to avoid transit through different countries given the region's geography and the existing configuration of interstate electrical grids. Therefore, conflict of commercial interests and the need to maintain energy security in separate states are unavoidable.

Efforts to form the Common Economic Space, or the common electric power space, make no mention of political integration.

³ Ratified by Resolution R-548/2010 of the Constitutional Court of the Republic of Belarus on 24 December 2010, Law 455-IV ZRK of the Republic of Kazakhstan on July 8, 2011, and Federal Law 174-FZ of the Russian Federation on July 11, 2011

4. Formulating Uniform Technical and Environmental Standards and a Legal Framework

Those working to create the common electric power market of the CIS and EDB member states should take into account Russia's recent experience of creating a competitive power market, with fully liberalised pricing from January 1, 2011. The price liberalisation caused serious problems: significant price increases, manipulation of prices and electricity production volumes by market players; and insufficient market incentives for investment in and development of generating capacities (Podkovalnikov, 2011). To resolve these problems the structure, regulation and legislative basis of the Russian power market need to be improved.

Developing effective legislation seemingly requires a more realistic approach to the formation of the common electric power market in the CIS.

5. Recommendations for Deepening Integration Processes in the Region

This analysis allows certain recommendations to be drawn up as to how integration can be deepened and the creation of the common electric power market and interstate IPS be speeded up in the region, with the EDB's role emphasised.

1. A comprehensive approach to integration initiatives would be effective, provided that such initiatives cover not only national power sectors and systems, but also related sectors, including production of energy resources, electrical engineering, electronics, and professional education.
2. Agreements between the EDB member states as parties to cooperation in the electrical energy sector are needed and they should be primarily multilateral, including as many participants as possible.
3. National standards in the electric power sector, electrical engineering and related sectors should be developed on the basis of a single regulatory framework, in particular the one used by the International Organisation for Standardisation (ISO).
4. Interstate electricity trading relationships should be forged based on the modified principles proposed by previous agreements regarding the formation and organisation of the common electric power market, taking into account Russia's experience of organising a competitive market.
5. The irrigation and energy disputes in Central Asia should be settled, parallel operation of the Central Asian IPS should be restored, and all its participants should comply with dispatch requirements. The lack of understanding and cooperation in this area causes significant damage to energy and economic integration, without which further integration in Central Asia and the post-Soviet space as a whole is impossible.
6. Efforts to develop the CIS power systems jointly should give way to coordinated development of national energy sectors. Mechanisms are needed to ensure their functions are coordinated.
7. National power sectors and the interstate grid infrastructure need to be upgraded and renewed to improve the reliability of electricity supplies to consumers and electricity exchange. This would provide a solid basis for deepening energy integration between the EDB member states. EDB's participation as a source of necessary funding could be extended.

To foster integration in the electric power sectors of the EurAsEC member states and advance the creation of a common power system in the region, the following measures are essential:

- uniform methods for calculating electricity transit tariffs should be developed;
- national laws of the EurAsEC countries should be unified to support mutually beneficial cooperation in the power sector;
- regulations are needed to ensure electricity producers from the EurAsEC member states have equal access to its electricity market;
- tariff policies should be adjusted so that the majority of Central Asian power projects can go ahead even without the involvement of foreign investors;
- obsolete equipment in electrical grids and at power plants should be replaced;

5. Recommendations for Deepening Integration Processes in the Region

- legislation is needed to make projects in the power sector more attractive to investors;
- the improvement of fuel and energy transportation infrastructure in the region should be continued;
- national power systems should apply market principles;
- key features of a unified energy policy need to be determined taking into account global trends and the need to ensure the best possible use of energy resources;
- cooperation with foreign investors should be extended in order to improve the efficiency of conventional and new energy sources;
- EurAsEC member states should adopt a professional development programme for the power sector.

Conclusion

The main objective of this report was to analyse the current state of electric power sectors in the EDB member states. Its comprehensive analysis identified the main trends in developing generating capacities and electrical grids, as well as electricity exports and imports.

In addition, the report analyses the existing electricity generating capacity and consumption in the EDB member states and major interstate integration initiatives, including mutual trade and investment and the formation of the common electric power space, integrated systems and markets. It analyses challenges and obstacles to electric energy integration and makes conclusions and recommendations as to how integration in the region can be improved.

Overall, during the period under review, the electric power sectors of the EDB member states have demonstrated stable growth in generating capacity, which was maintained even in the crisis year.

Fossil-fuelled TPPs dominate the structure of generating capacity and this remained practically unchanged during the period studied. Hydropower is the main generator in Tajikistan and Kyrgyzstan. Electricity generation in these countries varies year by year because of stochastic flow of water into the plants' reservoirs.

Electricity exports and imports between the EDB member states decreased significantly and consistently over the period analysed.

The electric power sector is a driver of integration processes in related industries and sectors. Given its extensive infrastructural role for production industries and society it remains a leading sector in the EDB economies and the post-Soviet space as a whole.

The development of the electric power sector of the EDB countries in the context of integration still needs to be studied. This report continues EDB's studies of sectoral integration in the region and integration of the region's countries into the global community.

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Journal of Eurasian Economic Integration

The Journal of Eurasian Economic Integration is a quarterly academic and analytical journal published in Russian by the Eurasian Development Bank. The members of Editorial board and Advisory council are distinguished academicians, practitioners and experts in regional integration. Eurasian Economic Integration brings together academic and analytical articles, reviews of books relating to regional integration, interviews and quarterly chronicles of regional integration. With its focus on economics, the journal is a rich source of material addressing a broad range of issues specific to Eurasian integration. These include integration theory and its relevance to the development context; economic integration (trade, investment, financial institutions); institutional integration; cooperation issues in the post-Soviet space; and international experience of regional integration. The first issue was published in the third quarter of 2008.

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- Development banks' operations and activities in the CIS countries and issues of cooperation.

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