ELECTRIC POWER INDUSTRY OF THE RUSSIAN FAR EAST: STATUS AND PREREQUESITES FOR COOPERATION IN NORTH-EAST ASIA

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ABSTRACT

The Russian Far East (RFE) encompasses a territory of 6.2 million square kilometers, or 36.4 percent of the territory of the Russian Federation. The RFE has traditionally been regarded as a region rich in natural resources. It has large reserves of various primary energy resources. Owing to its geographic position, the Northeast Asia (NEA) region holds the best potential for economic cooperation with the RFE in such technologically complex energy project areas as electricity. The aim of this paper is to demonstrate that energy and electricity in the RFE have great potential for the development of energy-related cooperation within the NEA region. The potential for energy cooperation proceeds from 1) the strategic advantages of a coordinated energy policy in the region; 2) the complementary nature of energy resources and energy needs between the countries of NEA; and 3) the efficiency inherent in the creation of integrated electric systems. Unfortunately, at present there exists a fairly low level of the international contact on energy issues in the NEA region. This paper does not offer any specific international projects in the field of energy. However, it aims to promote productive discussion on cooperation in the sphere of energy by providing extensive and diverse information on the RFE (energy) situation—its geography, economy, technology, legislation, and the nature of its energy resources. In particular, it seeks to give a concise idea of the problems and potentialities of the RFE electricity sector. This, it is hoped, will facilitate cooperation among NEA countries in the field of energy.

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1. INTRODUCTION

The Russian Far East (RFE) encompasses a territory of 6.2 million square kilometers, or 36.4 percent of the territory of the Russian Federation, though the RFE population of about 7,800,000 accounts for only 5.3 percent of the total population in Russia. The RFE has traditionally been regarded as a region rich in natural resources. Although its full potential is not yet thoroughly explored and studied, the known reserves of natural resources confirm this opinion. For a long time the RFE has been the largest supplier of products in the raw-material industries on the Russian market. Its share of total national production in the extractive branches make the RFE second only to Western Siberia (17.1 percent in the Far East, compared to 36 percent in Western Siberia). The RFE occupies a leading position on the Russian market with respect to some individual products.

Non-coincidentally, the most developed sector of the Far Eastern economy consists of those industries engaged in the extraction and exploitation of natural resources. In the Soviet era the entire economic development of the region was subordinated to military-strategic objectives. This strategy aimed at creating a relatively "closed" economy—that is, one oriented toward the domestic market.

After the economic reform of Russia started, the situation with regard to the economy of the RFE has undergone significant changes. The RFE has found itself in a difficult situation: simultaneously, it faced the need for structural transformation and for reorientation toward the markets of the Asian-Pacific region and especially North-East Asia (NEA). This set of dual targets has driven active attempts to find a solution to social and economic crisis, and those efforts concentrate on providing active and effective ways to include the Russian Far East in international cooperation.

An important role in the development of international contacts can be fulfilled by the energy sector of the RFE. The RFE has large reserves of various primary energy resources, which can be effectively used in different forms of international cooperation. It is the sector of primary energy resources of the RFE that currently presents real international projects. At the same time, owing to its highly appropriate geographic position, the NEA region has favorable potentialities for the organization of economic cooperation in such a technologically complex energy sector as electricity.

As a rule, there is a certain distance between the potentialities and real projects. The purpose of this paper is not so great as to eliminate that distance completely. The aim of the paper is to demonstrate the fact that energy and electricity of the RFE have a profound potential for the development of energy interaction in the NEA region.

In terms of administrative division, the RFE consists of separate administrative units. At present it includes the Republic of Sakha (Yakutiya), the Jewish Autonomous territory, the Chukchi Autonomous territory, the Primorskiy territory, the Khabarovsk territory, the Amursk territory, the Kamchatka territory (with the Koriak Autonomous territory), the Magadan territory and the

Sakhalin territory. These territorial-administrative units are highly differentiated with respect to the conditions and results of economic, energy and electricity development. The most developed are southern regions—the Amursk territory, the Primorskiy territory, the Khabarovsk territory, the Jewish Autonomous territory.

The above mentioned administrative divisions were formed in the RFE after 1992. This fact creates some difficulties when performing significant quantitative comparisons of modern energy indicators with basic indicators of 1990-1991. Therefore, in the present report, the author uses, as a rule, the former, "soviet" administrative division, namely:

- the Republic of Sakha (Yakutiya);
- the Primorskiy territory;
- the Khabarovsk territory (with the Jewish Autonomous territory);
- the Amursk territory;
- the Kamchatka territory (with the Koriak Autonomous territory);
- the Magadan territory (with the Chukchi Autonomous territory);
- the Sakhalin territory.

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2. ENERGY RESOURCES FOR POWER GENERATION

The vast territory of the Russian Far East has a major potential of almost all known commercial primary energy resources. The overall amount of the potential oil resources in the RFE is estimated 8.9 bln tons, of natural gas - 24 trln m^3, of coal- 1.2 trln tons. However, their geological exploration has for a long time been rather insufficient. The ratio of the confirmed reserves to the value of initial potential resources constitutes: for oil - less than 8 percent, for natural gas - 9.6 percent, for coal - only 2.5 percent.

The peculiarity of the geographic position and climatic conditions of the RFE territories have conditioned here the availability of a set of non-conventional sources of energy (wind, geothermal, tidal, solar).

In absolute measurement, the discovered reserves base in the Far East, according to its geological potentialities, can provide production of natural energy resources, which will several times exceed the own demand of the region in primary energy. However, these potentialities, largely, have a probable character, are insufficiently studied and are not always characterized by the sufficient economic and quality parameters of the deposits.

The characteristic feature of the Far East is an extremely uneven location of the natural fuel-and-power resources. The largest potential sources of energy are located in the severe, least developed areas of the North, difficult of access and without infrastructure and developed transport connections with the areas where industry, agriculture and population are concentrated.

As far as energy supply is concerned, a special place is occupied by the Republic of Sakha (Yakutiya). It comprises over 90 percent of potential and almost 50 percent of recoverable coal reserves, over 50 percent of potential hydropower, almost 60 percent of recoverable natural gas reserves of the region.

The largest resources of oil, natural gas and coal are located in the Sakhalin territory.

Vast resources of coal and hydropower are concentrated in the Magadan territory. A rather low degree of energy resources provision is characteristic of the Kamchatka territory, though it has favorable conditions for geothermal energy utilization.

The southern zone of the RFE (the Amursk territory, the Khabarovsk territory, the Primorskiy territory) differs substantially from the North-Eastern areas in energy resources provision. Here 65 percent of primary energy of the entire RFE is consumed. At the same time, the share of the southern regions in the potential resources of coal of the RFE constitutes only 1.2 percent (for recoverable coal reserves - 33 percent). The recoverable reserves of oil and natural gas here are very insignificant.

With the mentioned limitation of fuel resources, the southern RFE zone accounts for over 12 percent of national hydropower.

Coal

Coal is a traditional source of energy in the RFE. In the recent 15 years its share in the gross primary energy production steadily constitutes 70 percent. The recoverable reserves of coal in the Far East amount to almost 30 bln tons (table 2.1).

It should be noted that the discovered coal reserves have at present insufficient economic parameters for extraction. Even those less than 40 percent of the reserves that are being developed by operating mines of the RFE, one can indicate as relatively effective reserves.

As of December 31, 1995 the Russian Far East had 25 coal mines and 14 open coal-mining pits with a total productive capacity of 44.7 mln tons. In 1995 extraction of coal amounted to 33.85 mln tons, of which 11.3 mln tons came from mines and 22.5 mln tons from open-pit mining. The output consisted of 15.8 mln tons of bituminous coal and 18 mln tons of brown coal.

Table 2.1
The RFE Coal Reserves, bln tones

Territory	Initial recoverable reserves*	Effective reserves**
Yakutiya, total bituminous	14.1 8.2	0.34 NA
Magadan, total bituminous	2.9 1.1	0.05
Kamchatka, total bituminous	0.28 0.01	NA
Amursk, total bituminous	3.9 0.04	0
Khabarovsk, total bituminous	2.0 2.0	NA
Primorskiy, total bituminous	4.1 0.8	0.37
Sakhalin, total bituminous	2.4 1.1	0
The RFE as a whole, total Bituminous	29.8 13.5	0.76

* Data as of 1.01.92

** The part of operating reserves that has sufficient economic and qualitative parameters. The estimation was made in 1994.

Source: Data from Geological Committee of Russian Federation, state company "Rosugol".

The coals have diverse qualitative parameters. The average heat value of brown coals ranges from 10 to 19 MGJ per kilogram, for bituminous coals the range is from 20 to 29 MGJ per kilogram. The coals have a low sulfur content (0.5-0.8 percent), a low and average ash content (15-25 percent). Urgal bituminous coals (the Khabarovsk territory) have a high-sulfur content - 35 percent. Coals for energy purpose are not subject to washing.

The recently implemented pre-feasibility studies show the limited potentials for a large-scale development of the coal industry in the Far East. The currently pursued state policy of restructuring of the RFE coal industry is directed towards the elimination of unprofitable enterprises and creation of competitive profitable ones by means of development of mainly the open-pit method of coal extraction and creation of small efficient coal companies. In the nearest 10 years the coal extraction will be oriented towards local demand and will not exceed 45-50 mln tons.

Oil and Gas

All administrative territories of the RFE have potential hydrocarbon resources. The oil-and-gas resources of Sakhalin, the south-west and central Yakutiya are of major interest in terms of

possible scope of development and influence on the situation in the domestic and foreign market of energy products (table 2.2).

Table 2.2
Initial Recoverable Reserves of Natural Gas and Oil in the RFE (as of 1.01.92)

Territory	Natural Gas, bln m^3	Oil, mln tones
Yakutiya*	1332.4	254.3
Sakhalin*		
Total	944	433
Land	120	170
Shelf	824	263
Magadan	14.7	9.6
Kamchatka	22.6	-
Khabarovsk	1.0	-
The RFE as a whole	2314.7	697

* Data as of 1.01.94.
Source: Data from Geological Committee of Russian Federation.

Initial recoverable reserves of oil and gas in 62 deposits of the continental part of the Sakhalin Island constitute 170 mln tons of oil and 120 bln m^3 of natural gas. Among them, according to the sum of recoverable reserves of oil and gas, seven deposits are considered average-scale and fifty-five - small-scale.

The eight discovered deposits of the shelf contain, respectively, 263 mln tons and 824 bln m^3. The seven deposits of the Sakhalin shelf belong to the category of large ones. They include the largest in the Far East reserves: of natural gas - Lunskoye (about 400 bln m^3), and of oil - Arkutun-Daginskoye (probable resources are over 500 mln tons).

In Sakhalin, the development of the shelf resources is of main importance for a large-scale development of the oil-and-gas industry.

In the Republic of Sakha more than 30 deposits of oil and gas have been discovered, with initial recoverable oil reserves of 254 mln tons and gas reserves 1310 bln m^3. The degree of exploration of the reserves is fairly low. All the oil deposits are complex, and have been discovered in the south-west of Yakutiya in the Nepsko-Botuobinskiy district.

The main gas fields are primarily located in deposits in the central part of Yakutiya.

The current industrial development of oil-and-gas resources is conducted on land in Sakhalin and the Republic of Sakha (Yakutiya). Almost all crude oil is extracted in Sakhalin.
Up to now, the local production of crude oil and gas in the RFE has had a low share in gross primary energy consumption in the RFE - about 10 percent.

Hydropower resources

The overall energy potential of middling and major rivers in the RFE is estimated as 1008 bln kWh (with taking into account the small rivers - 1139 bln kWh), which constitutes 42 percent of the hydroelectric potential of Russia (table 2.3). Sixty-eight percent of the total volume of potential hydro resources of the RFE can serve for technical utilization. According to the estimations made in the late 1980-ies, about 294 bln kWh of the RFE hydropower potential were regarded as economically effective.

Table 2.3
Hydropower Resources of the RFE (major and middling rivers).

Territory	Total Electric Power, GW	Probable Output	
		bln kWh	%
Primorskiy	2.9	25.4	2.5
Khabarovsk	22.8	200	19.8
Amursk	8.7	76	7.5
Kamchatka	5.8	50.6	5.0
Magadan	16.5	144.2	14.3
Sakhalin	0.5	4.7	0.5
Yakutiya	52.0	507.5	50.4
The RFE as a whole	109.2	1008.2	100

Source: Fuel and energy resources of the Far East and the trends for their utilization./ V.S. Turetskiy, L.I. Boyarinova, L.N. Staroselets. Vladivostok: FEB AS of the USSR, 1986.(Russian)

More than a half of the RFE hydroelectric potential is concentrated in Yakutiya. The Magadan territory, the Amursk territory and the Khabarovsk territory have large resources of hydropower and favorable conditions for their development. The Sakhalin and Kamchatka territories have limited potentialities for the construction of major hydropower plants (mainly because the rivers are oriented toward fisheries).

The today's level of the practical use of hydropower resources in the RFE is extremely low - only 1 percent of the gross hydroelectric potential (including those under construction - 2.3 percent).

At present, four major hydro power plants (HPPs) with total installed capacity of 3.33 GW are at different levels of construction: the Bureyskaya and Nizhne-bureiskaya HPPs with total installed capacity of 2.4 GW, Vilyuiskaya HPP-3 (0.36 GW), Ust'-Srednekanskaya HPP (0.55 GW).

The projects of the construction of four HPPs with total installed capacity of 5.2 GW are under discussion. The basic indices of the operating and constructed HPPs in the RFE are shown in the table 2.4.

Table 2.4

Basic indices of HPPs in the RFE

Name of HPP	Territory	Installed capacity, MW	Average output per annum, bln kWh	Year of Commission of the first turbogenerator
Operating HPPs				
Vilyuiskaya 1,2	Yakutiya	680	2.66	NA
Zeyskaya	Amursk	1330	4.9	NA
Kolymskaya	Magadan	900	3.28	1982
HPPs under construction				
Bureyskaya	Amursk	2000	7.0	1999
Nizhne-Bureyskaya	Amursk	428	1.6	2003
Vilyuiskaya 3	Yakutiya	360	1.2	1998
Ust'-Srednekanskaya	Magadan	550	2.2	NA
Tolmachevskaya	Kamchatka	45	0.8	1998

Source: Data from Institute “Dal'energoset'proekt”.

Currently, the RFE shows keen interest to the construction of small HPPs with capacity from 0.1 to 100 MW. It is significant that before the 1980-ies several small HPPs were exploited. However, the inexpensiveness and the availability of fossil fuels in the former USSR ousted them gradually from the energy balance. The small HPPs were dismantled. The production of the necessary equipment was stopped, too.

At present, feasibility studies have been fulfilled on the construction of small HPPs in the Amursk and Kamchatka territories (where the Tolmachevskaya HPP is being already constructed). All the RFE territories have a potential for construction of small HPPs.

Tidal power sources

The RFE coast is characterized by a large potential of tidal energy. Particularly special is the coast of the sea of Okhotsk, where tides are up to 14 m high. The most appropriate for the construction of tidal power plants (TPPs) are the ranges in the Penzhinskiy (Kamchatka, Magadan) and Tugurskiy (Khabarovsk) bays. At the end of 1980-ies, a pre-feasibility study was conducted on the construction of the Penzhinskaya TPP (with capacity of up to 80 GW) and a feasibility study for the Tugurskaya TPP (6.8 GW) with total output about 320 bln kWh. Those were titanic projects with large capital investments and complex operating conditions of electricity production. At present, no projects of tidal power plants are considered.

Non-conventional Renewable Power Sources (NCRPSs)

In recent years, the RFE shows an active interest to the use of non-conventional power sources (wind, solar, geothermal, biomass), particularly profitable in decentralized energy supply.

Unfortunately, the level of study of the NCRPSs potential in the RFE is relatively low. The absence of pre-feasibility and feasibility studies, undoubtedly, restrains the use of NCRPSs. Solely the administrations of the Amursk, Kamchatka and Sakhalin territories carry out an active work to organize feasibility studies on the use of NCRPSs and further transfer of information to potential private users.

The potentialities of use of wind, geothermal, small hydropower, and partially solar energy are studied most of all. The issues of use of thermal pumps are also analyzed.

The level of practical use of NCRPSs remains very low. There is a small Pauzhetskaya geothermal power plant (GPP) which functions in Kamchatka (there the Verhne-Mutnovskaya GPP with capacity 12 MW is being built), and there operate several units of wind installations. The main obstacles are: information gap, absence of technologies, lack of funds.

There exist different estimations of the NCRPSs in the RFE. The degree of trust in them is low. To illustrate this, we cite a variant of estimation of the NCRPSs potential (table 2.5).

Table 2.5
Distribution of NCRPSs potential for the RFE and Russia, mln tce (tones of coal equivalent)

	Geothermal Resources	Biomass	Wind	Solar	Total
Russia	115	35	22	4.24	176.2
The RFE	40	2.2	6.7	1.58	50.4

Source: Data from Institute “Dal'energoset'proekt”.

3. ELECTRIC POWER INDUSTRY OF THE RUSSIAN FAR EAST: STATUS AND PROBLEMS

3.1. Electric Power Plants

The general number of electric power plants in the RFE in the early 1990-ies comprised about 8750 installations of total installed capacity over 13 GW. At the end of 1996, 11.4 GW of the installations belonged to public utility power plants, which produced over 98 percent of total electric output in the RFE. Twenty-three public utility power plants comprise almost 10 GW of electric capacity.

Electric power industry is a basic sector of the fuel-and-power productive complex (FPC) of the RFE. It comprises more than 70 percent of the FPC fixed capital in the RFE. Electric power industry transforms about 53 percent of primary energy, consumed in the Far East.

The vast territory, unsteadiness in the industrial development, location of the main industrial centers in the districts that are separated by large undeveloped areas, hinder the creation in the Far

East of a unified energy system. A small concentration of energy consumers (especially in the vast northern and north-eastern areas) makes energy supply of the industrial units to be based in relatively small energy enterprises.

Favorable conditions for the effective concentration of electricity production are in the most developed part of the RFE - its southern zone (the Amursk, the Khabarovsk and the Primorskiy territories). Those areas comprise 66 percent of the total population in the RFE, produce 60 percent of the net material product of the RFE, consume 65 percent of primary energy and 62 percent of the RFE electricity.

The public utility power plants, according to the terminology, adopted in Russia, perform *centralized electric supply*. As to the developed part of the RFE, more than 90 percent of it is covered by the centralized electric supply.

Electricity is mainly produced at thermal power plants (74 percent of the total installed capacity). Over the recent six years, no significant changes have occurred in the structure of installed capacity in the RFE (table 3.1).

Table 3.1
The installed capacity and output of public utility power plants in the RFE

	Total	Thermal	Hydro	Nuclear
		1990		
Installed capacity, MW	11300	8644	2698	48
Output, bln kWh	45.3	34.1	10.8	0.33
		1996		
Installed capacity, MW	11384	8425.6	2910	48
Output, bln kWh	36.1	26.4	9.6	0.17

Source: Data from “Vostokenergo” company.

The thermal electric power plants operating on fossil fuels have for a long time provided a major portion in electricity production - in fact, two thirds of it. The electricity production in the Khabarovsk, the Primorskiy, the Sakhalin and the Kamchatka territories is based entirely on thermal electric power plants. As the natural result, the thermal power plants form the image and the level of technological and economic efficiency of electricity production in the RFE.

The characteristic historic feature of interconnected power systems of the former USSR, Russia and the RFE is an extensive development of commercial heat supply (according to the Russian terminology - *centralized heat supply*) on the basis of large utility boilers and heat-and-power supply capacities of thermal power plants (Cogeneration Plants - CP). In the structure of installed capacity of thermal power plants in the RFE, the portion of heat-and-power supply capacities constitutes more than 51 percent (4.3 GW). A unique for Russia structure of power plants is created in the Khabarovsk territory. There, 95 percent of the installed capacity are heat-and-power supply capacities.

The operating equipment of the main thermal power plants in the RFE is constructed on the classic steam cycle. About 0.4 GW of gas turbine units is operating in the RFE as well (mainly, in Yakutiya). Generating equipment with steam-and-gas cycle is not used.

Because of small concentration of electric loads in the RFE (particularly, in the northern areas), application of modern powerful condensing and heat-and-power supply equipment in unit performance with steam conditions at turbine inlet 13-24 MPa, 540-565 C, is objectively limited. The total installed capacity of condensing units with unit capacity of 210 MW (steam conditions 13 MPa, 565 C) is 1.265 GW. The total installed capacity of heat-and-power supply units with unit capacity 180 MW (steam conditions 13 MPa, 555 C) is 1.08 GW. All the generating equipment in unit performance is installed at electric power plants of the southern zone of the Russian Far East (the Primorskaya TPP, the Khabarovskaya CP-3, the Komsomolskaya CP-3, the Neryungrinskaya TPP).

For a number of reasons, the RFE continues to exploit economically inefficient, outdated and worn-out generating equipment with steam conditions at turbine inlet of 9 MPa and less, of the total installed capacity about 3.8 GW.

For a long time the RFE power plants supply with fossil fuel has been primarily based on local coal, natural gas, petroleum (chiefly fuel oil). Natural gas is used only in Sakhalin, in the Khabarovsk territory and Yakutiya. The structure of fossil fuel consumption is shown in the table 3.2.

Table 3.2
The structure of fossil fuel consumption at the RFE public utility power plants, %

Year	Total	Coal	Petroleum	Natural Gas
1990	100	67.5	21.6	10.9
1996	100	71	12.5	16.3

Source: Data from the Khabarovsk Economic Research Institute (ERI), “Vostokenergo” company.

The technology of coal combustion is traditional coal dust with rather low energy and, particularly, environmental characteristics. So far, the RFE thermal power plants have not used coal-fired boilers with new types of furnaces, as well as fluidized-bed coal-fired boilers, boilers with in-cycle coal firing. Coal for energy use is not preliminarily washed. Part of the supplied coal is of very low quality (particularly, in the Primorskiy and the Amursk territories). Part of the used coal does not correspond to design parameters of the installed boiler equipment of power plants. Because of the worn-out equipment, lack of steam capacity, low quality of fuel and manufacturing defects of the installed equipment, actual available capacity of public utility power plants in the RFE is lower than the installed capacity by 1 GW (table 3.4). In fact, over the recent 15 years, there has not been any notable progressive changes in the technological level of production of

electricity and commercial heat in the RFE. The present parameters of energy efficiency of the RFE power plants (first of all, thermal PPs) were achieved as early as the 1980s.

Estimating objectively the technological level of thermal power plants in the RFE, we can note that for that level, the RFE has fairly good characteristics of efficiency of energy production. They are managed to be maintained by means of cogeneration of electricity and heat at heat-and-power supply facilities. The average energy efficiency in electricity production in the RFE makes 33-34 percent. The efficiency of condensing units of 210 MW constitutes 32 percent. The efficiency of heat-and-power supply units of 180 MW - 45 percent - corresponds to the performance characteristics of the best world types. It should be noted that, owing to cogeneration of electricity and heat, the efficiency parameters at electric power plants in Russia depend on the accounting rules of dividing fuel costs between electricity and heat. In 1996 the decision was made to change the accounting rules of dividing fuel costs between electricity and heat. As a result, the electricity efficiency parameters dropped, and the heat efficiency parameters increased. Currently, the average efficiency in electricity makes 31.4 percent. The efficiency of heat production increased from 78.6 percent to almost 90 percent (see the table 3.3).

Table 3.3
Average specific fuel consumption on electricity and heat output for the RFE public TPPs.
(electricity, gce/kWh; heat, kg ce/Gcal)

Territory	1990		1995		1995*	
	Electric	Heat	Electric	Heat	Electric	Heat
Amursk	373.2	188.4	372	194.5	405.8	166.5
Primorskiy	393.9	182.2	412	186.2	420	170
Kamchatka	352.4	170.8	335	172.6	360	139.5
Magadan	425	196.3	468.7	205	551.8	187.6
Sakhalin	357.5	173.9	388	177.2	419.8	156.4
Khabarovsk	292.1	179.1	272.6	180.6	343.5	150
Yakutiya	357.4	174	387.1	173.5	390.5	171.6
The RFE as a whole	356.8	180	359.9	182	392	159.1

* New accounting rules for dividing fuel costs.
Source: Data from “Vostokenergo” company.

The electricity supply from utility power plants is fulfilled by ten electric utility companies, which have the status of joint-stock companies and are, mainly, organized according to territorial division. The electric utilities own 11.2 GW of the installed capacity. They produce 95 percent of total electricity and 42 percent of commercial heat of the RFE.

Table 3.4
Capacity, electricity and heat output of the RFE public utility electric companies,
(capacity as of December 1996 - MW; electric output - bln kWh; heat output - mln Gcal)

Company	Territory	Installed Capacity	Available Capacity	Output in 1996	
				electric	heat
1. “Amurenergo”	Amursk	529.3	508.7	1.8	1.75
2. “Zeiyskaya HPP “	Amursk	1330	1330	4.3	0.24
3. “Dalenergo “	Primorskiy	1196.6	965	3.9	4.8
4. “ Primorskaya TPP”	Primorskiy	1495	1132	3.8	0.26
5. “Khabarovskenergo “	Khabarovsk	1973.1	1811.2	7.6	14.3
6. Block-plants	Khabarovsk	35	35	0.02	
7. “Kamchatskenergo”	Kamchatka	533.4	528.4	1.5	1.0
8. “Magadanenergo “	Magadan	553.3	544.4	0.5	2.1
9. “Bilibinskaya NPP “	Magadan	48	48	0.17	
10. “Kolymaenergo”	Magadan	900	700	2.5	0
11. Block-plants	Magadan	7.6	7.6	0.18	
12. “Sakhalinenergo “	Sakhalin	619	607	2.44	3.2
13 Block-plants	Sakhalin	129.6	45	0.08	
14. “Yakutskenergo”	Yakutiya	2034.2	2058	7.4	5.8
Total	Far East	11384.1	10320.7	36.1	33.4

Source: Data from “Vostokenergo” company.

Besides, electric network connects to about 20 industrial power plants (in Russia they are called *block-plants*) and a small state nuclear power plant (Bilibinskaya NPP). Their total installed capacity amounts to 0.172 GW. As a rule, these power plants are not involved in meeting peak load of the interconnected power systems (except the Bilibinskaya NPP). The capacity of utility electric companies and industrial power plants (block-plants) of the RFE is shown in the table 3.4.

3.2. Electric Network

According to soviet era tradition they formally consider that the Far East has seven power systems (according to soviet territorial division): Amurskaya, Khabarovskaya, Dal'nevostochnaya (the Primorsky territory), Sakhalinskaya, Magadanskaya, Kamchatskaya, Yakutskaya power systems. From the technical point of the view there are a few interconnected power systems (IPSs) in the RFE.

The Amurskaya, Primorskaya, Khabarovskaya power systems and Yuzhno-Yakutskiy power district (South Yakutiya power district) are connected by transmission lines of 220-500 kV, and have unified operation, integrated load and form the Integrated Power Grid “Vostok” (IPG “Vostok”). The IPG “Vostok” controls 7 GW of the installed capacity.

The Sakhalinskaya, Magadanskaya, Kamchatskaya, Yakutskaya power systems (excluding Yuzhno-Yakutskiy power district) function independently from IPG “Vostok” and consist, in their turn, of separately operating power districts.

The IPSs of the Far East have no electric connections with the Unified Power Grid of Russia.

The RFE energy systems operate on the following high voltage scale: 10-35-110-220-500 kV. In the Magadan territory there is one transmission line on the voltage 154 kV.

Total circuit length of the transmission lines of 35-500 kV, at the end of 1996, made more than 47.7 thousand kilometers. The number of substations of 35-500 kV was 1234, of total capacity over 30200 MVA.

The voltage 500 kV is used only in the IPG "Vostok". In the other areas the highest voltage is 220 kV (in Kamchatka - 110 kV).

In Russia unified frequency of 50 Hz is in operation.

The RFE power systems use alternating current only.

To control operating conditions, telecommunications facilities are employed in the RFE power systems. These facilities include systems of telemeasurement of frequency, power and voltage, telephone connections, high-frequency channels, mobile wireless stations and others. The circuit length of multichannel microwave communications is only one thousand kilometers. Satellite communications are not used.

3.3. Operating conditions

The Separate Power Systems

Normal load conditions are provided in all power districts. All separate power systems have sufficient amount of generating capacities and provide large reserve capacities (table 3.5). There are some problems of peak-load equipment in Kamchatka and Sakhalin. In recent years no cases of deviation from the operating standards of frequency and voltage have been registered. The dynamics of operating conditions of electric consumption is approximately the same - peak loads are registered in winter. Daily disparity of loads varies much in different local energy districts - from 0.5 in Central Yakutiya to 0.9 in West Yakutiya.

Table 3.5
The dynamics of peak loads, the available capacities, the ratios of daily and seasonal variability in loads of the separate power systems in the RFE in 1995 (summary data on local energy districts).

Territorial Power System	Available capacity, MW	Winter peak, MW	The ratio of daily variability in load (winter)	The ratio of seasonal variability in load (summer to winter)
Kamchatskaya	528.8	306	0.62	0.54

Magadanskaya	1186.5	567	0.86	0.56
Sakhalinskaya	652	486	0.65	0.63
Yakutskaya*	1840	1142	0.8	0.45

* Including Yuzhno-Yakutskiy power district
Source: Data from the Institute "Dal'energoset'proekt".

The Integrated Power Grid "Vostok"

The IPG "Vostok is the largest power system in the RFE. Operating conditions control is more complicated there than in separate power systems. The electric utility companies, included in the IPG "Vostok," operate for an integrated load. Operating conditions of utilization of electric capacity of each power plant are monitored by the Unified Dispatching Center (located in Khabarovsk).

In point of strategy, the disposition of power plants in the IPG "Vostok" has been made to perform an active exchange of electric power and electric energy among the power systems within the IPG "Vostok". The main surplus of electric power have formed and is being formed in the western sector of the IPG "Vostok" - in the Amursk territory and South Yakutiya.

For the realization of electricity exchange between the western and south-eastern sectors in the IPG "Vostok" a high-voltage transit of 220-500 kV is formed: the Neryungrinskaya TPP - Zeyskaya HPP - Khabarovskaya power system - Primorskaya TPP - southern part of the Primorskiy territory.

The basic operating functions (disposition of the reserve capacities, regulation of frequency, meeting the variations of electric load) in the IPG "Vostok" is fulfilled mainly by the Zeyskaya hydropower plant. The conditions of electricity consumption in the IPG "Vostok" are characterized by a high density of daily and weekly electric load curve and a rather expressed seasonal disparity of the loads. Over the recent five years, daily disparity of electricity consumption at winter peak loads makes 0.76 and in summer - 0.71. The ratio of the summer peak loads to the winter ones is 0.56-0.57.

Owing to disproportionate disposition of the basic and flexible turbogenerators, during a day and during a year rather substantial reversible electricity exchange is performed within the IPG "Vostok". Besides, the most high-capacity electric power plants in the IPG "Vostok" - the Zeyskaya HPP, Primorskaya TPP - are remote from the load center. As a result, the IPG "Vostok" has for a long time undergone high transmission losses in the electric network (that is, 10-11 percent of electricity generated at power stations minus power plant own-use)[1]. The existing network of 220-500 kV at present provides mainly transmission of the required amounts of power and electricity. At the same time, the carrying capacity of the interconnected transmission lines is insufficient for the maximum effective use of the capacity of the IPG "Vostok" power stations.

There act limitations of the carrying capacity in accordance with the norms of dynamic and static stability of electricity transmissions in the directions "Neryungrinskaya TPP - the Amursk

territory", "the Amursk territory - the Khabarovsk territory", "the Primorskaya TPP - the south of Primorskiy territory". Electricity transmission on the intersystem connection: the Khabarovskaya CP-3 - Primorskaya TPP, Khabarovskaya CP-3 - SS 220 kV Levoberezhnaya is limited by thermal resistance.

Under conditions of constant decline in electricity consumption, the coverage of loads in the IPG "Vostok" is performed with normal frequency parameters and with increasing the amounts of the reserve capacities. The decline in electricity consumption has unexpectedly intensified the problem of reactive power compensation in the power systems. Some sectors of high-voltage transmission lines of 220-500 kV have difficulties in providing stable voltage conditions. The characteristics of power and electricity balances in the IPG "Vostok" are shown in the table 3.6, 3.7.

Table 3.6
Power Balance of the IPG "Vostok at Winter Peak, MW

	1991	1993	1995
1. Peak load	5263	5010	4592
2. Export to China	0	0	17
3. Transmission to the Chita territory	128	162	88
Total Demand	5391	5172	4697
4. Actual reserve	844	1023	1498
Meeting:			
5. Total installed capacity	6968	6963	6959
6. Total available capacity	6235	6195	6195
7. Balance of energy exchange among power systems (plus - transmitted energy; minus - received energy)			
Amurskaya	+146	+135	+433
Khabarovskaya	-222	-51	-238
Primorskaya	-23	-201	-255
Yuzhno-Yakutskiy power district	+99	+117	+60

Source: Data from the Institute "Dal'energoset'proekt".

Table 3.7
Electricity balance of the IPG "Vostok", bln kWh

	1991	1993	1995
1. Demand	31.0	27.8	24.65
2. Export to China	0	0.03	0.14
3. Transmission to the Chita territory	0.7	0.7	0.42
Total Demand	31.7	28.5	25.2
4. Total output	31.7	28.5	25.2
Hydro Power Plants	5.9	4.95	5.0
Heat-and-power supply facilities	15.6	15.0	13.2

Condensing facilities	10.2	8.6	7.0
5. Balance of energy exchange among power systems (plus - transmitted energy; minus - received energy)			
Amurskaya	-0.55	-0.5	+0.2
Khabarovskaya	-0.99	-0.16	-0.2
Primorskaya	-0.11	-0.17	-0.76
Yuzhno-Yakutskiy power district	+1.65	+0.8	+0.75

Source: Data from the Institute “Dal'energoset'proekt”.

3.4. Electricity Rate System

According to the Federal Law “On the natural monopolies”, production of electricity and centralized heat by electric Utilities belongs to the sphere of natural monopoly. In compliance with the Law, the state regulates price formation on electricity and centralized heat. Regulation of tariffs for heat and electricity is realized by the Federal Power Commission and the Regional Power Commissions on a single methodic basis.

When regulating the tariffs, major attention is paid to the revenue requirement of the electric utility company. Principally, revenue requirement, or cost of service, in Russia is calculated according to the formula:

RR = OM+E+D+T+P
RR - revenue requirement;
OM - operating expenses and maintenance;
E - environmental charges;
P - necessary profit.

The cost of service includes three functional elements: a) costs of power supply (profit, taxes, amortization, environmental charges, compensation of employees); b) variable costs (fuel expenses only); c) costs related to the connection of consumers.

Electricity Rate System is yet insufficiently developed, unfair and contradictory. It has the following fundamental drawbacks:

1. The concept “Rate of Return to capital suppliers” has not been elaborated yet. The mass of profit is regulated exclusively subjectively by each Regional Power Commission. This approach to regulation of rate of return does not defend electric companies from governmental arbitrary rules. The approach actually prevents the possibilities of attraction of financial resources at the market of funds.

2. Beginning from 1991 and up to now, in the tariff system, the practice of cross-subsidizing has been used between separate categories of consumers. The residential, agricultural consumers who have electricity delivered with the largest expenses, in fact, pay for the electricity in prices which are lower than the costs. The appeared difference is covered by the tariffs for major industrial

consumers and transport. The correlation of electricity tariffs for households to industrial sector tariffs in 1996 made on average in the RFE 0.29 (in 1995 - 0.26).

3. In the Far East the system of double-rate tariffs is used only for industrial consumers with connected capacity of 750 kVA and higher. In the structure of consumption the share of these consumers makes 27%. Other consumers make payments for electricity by one-rate tariffs.

4. The system of tariff regulation has underdeveloped mechanisms of rating of expenses, public supervision and auditing of the costs of electric companies.

3.5. The System of Electricity Trade

Electricity trade is performed on a two-level market - wholesale and retail market.

In the retail market, only *regional electric public utility companies* have the right to trade ("Amurenergo, "Khabarovskenergo", "Dal'energo", "Sakhalinenergo", "Kamchatskenergo", "Magadanenergo", "Yakutsenergo"). The trade is conducted by the tariffs, established by the Regional Power Commission.

Actual wholesale market functions only in the IPG "Vostok" zone. The following electric Utilities have the right to trade on the wholesale electricity market: "Amurenergo", "Khabarovskenergo", "Dal'energo", "Yakutskenergo", "Zeiskaya HPP" and "Primorskaya TPP". The final consumers do not have the right to enter the wholesale market. The tariffs for the wholesale market are established by the Federal Power Commission.

The trade on the wholesale market is carried on with the active participation of the Russian joint-stock company "Unified Power Grid" ("UPG of Russia"), in the person of its Central Dispatching Department (CDD). The CDD acts as an all-Russian trade agent. The CDD, on a country-wide scale, purchases electricity in the wholesale market and sells it to electric Utilities. At that, one and the same technologically single IPS has different tariffs for the purchase and sale of electricity on the wholesale market. As a result, the CDD fulfills redistribution of incomes from trade on the wholesale electricity market between different companies throughout the country (this is one of the ways of subsidizing policy of the electric sector of the RFE).

As yet, the system of trade on the wholesale market is not perfect, as it restrains the competitive incentives of the market participants. The following two basic drawbacks of the system can be singled out:

-The electric Utilities engaged in retail trade are permitted to trade on the wholesale market by an individual but invariable one-rate tariff. The tariff covers only fuel costs;

-In the IPG" Vostok" there act an administrative principle of managing the dispatching operating conditions. This contradicts business incentives of the electric companies, since the expenses on electric energy production (and, consequently, revenues) depend on the operating conditions of the electric power plants.

Currently, a project of a new system of trade in electricity in Russia is under way. It will probably eliminate the drawbacks of the existing system.

3.6. Energy/Electricity Demand and Supply Conditions

The energy demand-supply conditions of the RFE areas in the recent five years should be considered within the drastic economic transformations, which began in Russia in 1992.

At present, energy supply of the Russian Far East is fulfilled under conditions of an acute crisis. Particularly critical situation has formed in power supply systems and centralized heat supply systems. Owing to the lack of fuel at the fall and winter periods in some of the RFE areas (the Pimorskiy territory, the Sakhalin territory, the Kamchatka territory), limitations for the deliveries of electricity and centralized heat are being introduced.

The unfavorable current dynamics of production and consumption of energy is outwardly conditioned by a very severe financial crisis. Systematic defaults (non-payments) for fuel and power, which the energy sector and the whole Russian economy have faced from the very reform's beginning, have a scope that is phenomenal according to the world standards. Electric Utilities of the Far East suffer from non-payments most of all. Since 1993 and up to now, the share of expired debts in the debtor indebtedness of the regional electric Utilities, as a rule, has amounted to 80 percent. In the actually paid electricity and heat, the share of cash (as they currently say in Russia - “live money”), at best, does not exceed 25-30 percent.

The defaults of payment not only undermine the liquidity of the companies and systematically create the most acute tension in fuel supply, especially, in electricity and heat supply. Constant shortage of working capital, as well, impedes the implementation of the required investment programs. High inflation and general economic instability in 1992-1996 have closed an access of the energy companies to the market of loan capitals. As a result, total investments in the electric power industry in 1995 were reduced, in contrast with the investments of the late 1980-ies, by 3.5.

The non-payments of 1996-1997 have acquired one more negative meaning. Defaults of payment are difficult to be converted into normal rubles and cannot be converted into hard currencies. Thus, defaults of payment paralyze freedom of the choice of markets. The result of loss of such freedom is a consent to consume primary and, consequently, final power resources at relatively high prices, including higher than the world prices.

The negative situation in energy production and consumption is not confined to the cash flow crisis only. The crisis has structured basis. It is stipulated by the imposition of very radical economic transformations on real, formed within a long time technological and economic conditions of production and consumption of power resources. We can indicate these historic conditions as following:

The energy policy in regard to the RFE has for a long time been oriented toward active supplies there of crude oil and petroleum products, and from the second half of the 1980-ies - of coal, from the remote areas of Siberia and Zabaikalye. As a result, a specific structure of primary energy balance has formed in the Russian Far East, which is built on high energy dependencies (in 1990, 47.5 percent of gross primary energy consumption was based on the domestic import of energy) and on the dominance in energy consumption of coal and, particularly, petroleum fuels, with a rather modest share of natural gas. On the whole, Russia incomparably more uses qualitative and effective resources - oil, hydropower, nuclear power and, especially, natural gas (table 3.10).

Up to 1992, the prices for power resources in the RFE have for a long time been artificially lowered. That was ensured by subsidizing of the energy enterprises, as well as subsidizing of fuel transportation. Electric Utilities were profitable. But their profitability was low and of artificial nature because of active subsidizing of fuel resources. Capital investments in all energy enterprises were practically completely funded from the state budget.

The long-term subsidizing of production and consumption of power resources created an illusion of relatively inexpensive energy in the Far East. Undercharges for energy influenced, accordingly, the efficiency of energy consumption and the formation of a technological basis of energy consumption. Undercharges for energy consumption did not stimulate energy saving.

The basic measures of the economic reform were related to the problem of financial stabilization in the Russian economy and the achievement of profitability of energy companies.

The most dramatic process for producers and consumers of energy in the RFE has been the process of bringing in correspondence of energy prices with the level of actual costs of energy production.

In 1992 the prices for power resources went up drastically. In the non-monopolized sectors of energy (coal, oil, petroleum) the prices were liberalized. Along with it, the subsidies for power resources transportation were abolished. The government also offered the energy companies to independently pursue the investment policy. These measures led to a general growth of prices for power resources in Russia. As shown in table 3.8, price increase in energy supply industries exceeded the whole industrial rate of price increase more than twice. Thus, there occurred a sharp change in the parity of prices between the energy sector and the other economic sectors.

The RFE, with a high degree of energy dependence on the external deliveries of fuel, underwent higher rates of increase in prices for power resources, as compared with Russia on the whole. Table 3.8, through the example of the Khabarovsk territory, shows the actual dynamics of the rates of growth of producer's prices in the RFE areas. Here one should note that the average costs of extraction and transformation of primary energy resources in the RFE have always been higher than in Russia on average (especially, in comparison with Siberia).

Table 3.8

Producer's price rate of growth in the Industrial sector of the Khabarovsk territory and the whole Russia (in times, December to December of preceding year.)

	1992	1993	1994	1995	1995 to 1991
The whole Industry	34.5	10.4	2.9	2.8	*2915*
	33.8	10	3.3	2.8	*3125*
Electric Power Industry	60.3	7.0	3.4	4.3	*6170*
	55.1	13.6	3.3	3	*7420*
Petroleum Industry	188.1	6.2	2.7	2.6	*8190*
	92.7	7.3	3	2.9	*5890*

Note: in the numerator - Khabarovsk., in the denominator - Russia.
Source: Data from Statistical Committee of the Khabarovsk territory, Statistical Committee of Russia.

The higher rates of growth of prices for energy resulted in the fact that prices for crude oil, petroleum, imported coal as well as tariffs on electricity and centralized heat in the RFE are among the highest in Russia.

The sharply increased prices for energy exerted a powerful price pressure on the structure of costs of the consumers. For example, in the Khabvarovsk territory the share of fuel and power costs in the whole industrial costs increased more than twice (table 3.9). That was completely natural, since capital intensive and inertial technological basis of energy consumption could not be reconstructed at such speedy rates. Thus, as a result of the drastic economic transformations, in the RFE the situation of ineffective energy consumption has formed.

High prices for energy have activated the incentives for energy saving. Unfortunately, a severe general economic crisis has actually blocked real energy conservation programs. The main problem is the fact that there is no funds and no access to funds. As shown in table 3.9, inefficiency of energy consumption is, in fact, conserved - energy intensity of the economy grows (the table shows electricity intensity of the Khabarovsk industrial product), and the relative share of fuel and power expenses in the total industrial costs also grows.

Table 3.9
The characteristics of energy costs in the Industry of the Khabarovsk territory.

	1990	1992	1994	1995
Share of energy expenses in the total expenses of Industry , %	5.8	13.2	12.4	15
Share of energy expenses in the Industrial material costs only, %	9.1	18.6	22.2	26
Electricity intensity of the Industrial Product, kWh/ruble	0.8	0.72	1.1	1.2

Note: All figures disregarding Electric Power Industry.
Source: Calculated on data from Statistical Committee of the Khabarovsk territory.

Such is an economic background for the development of the current situation in the RFE energy sector. In the outward, during the reform, general reduction of the energy balance scale takes place in the RFE (table 3.10). The reduction of production and consumption of power resources is conditioned by the general system decline in the economy. Gross domestic product of the Russian Far East in 1995 made only 54.7 percent of the GDP in 1990. Primary energy consumption in the RFE in 1996 made 61.4 percent of the 1990 level. The orientation towards market criteria of efficiency when using power resources has led to major structural changes in energy consumption in the RFE. Over the period of six years, in the structure of primary energy consumption, the share of expensive petroleum fuels has been managed to drop from 46.7 percent in 1990 to 35 percent in 1996 (in fact, petroleum fuels were replaced by relatively cheap coals). In energy production (table 3.11), the stable factors are production of natural gas and crude oil, though their role in production and consumption of primary energy in the RFE is not prevailing yet.

Table 3.10
Primary energy consumption and share of import in the RFE in 1990-1996

	Coal	Natural Gas	Petroleum	Hydro and Nuclear	Others	Total
1990Consumption, mln toe	18.6	2.6	22.3	1.9	2.5	48
Structure of consumption, %	38.8	5.4	46.6	3.9	5.2	100
Import, %	14	0	91	0	0	47.5
Consumption in 1996, mln toe	13.5	2.6	10.5	2.2	0.7	29.5
Structure of consumption, %	45.8	8.8	35.6	7.5	2.4	100
Import, %	16	0	90	0	0	39.5
Energy Consumption Structure in Russia (1994), %*	18.6	47.9	29.0	4.5		100

* Calculated for commercial primary energy resources only.
Source: Data from ERI.

The dynamics of energy balance in the RFE is influenced most of all by the reduction of production in the basic fuel industry of the region - coal industry, where the decline of production began as early as 1989. Over the recent eight years reduction of coal extraction made 25 mln tones. Though, over the years of economic reform, it has almost not aggravated the energy dependence of the Far East, since the reduction in coal production was almost fully compensated by the decline in internal energy consumption.

Table 3.11
Dynamics of production of primary and final energy resources in the RFE.

Resources	1991	1995	1996	col.4/col.2 (%%)
1	2	3	4	5
Coal, mln tones	49.8*	33.8	32.1	64.4
Oil, mln tones	1.97	1.9	1.78	90.4
Natural Gas, bln m^3	3.4	3.3	3.4	100
Primary oil refining, mln tones	10.1	3.4	3.4	33.6
Commercial Heat, mln Gcal	110.2*	80.8	NA	73.3
Electricity, bln kWh	48.2	38.5	37.4	77.6
Electricity (Russia as a whole), bln kWh	1082.2	860	847.2	78.3

* Data of 1990;
Source: Data from ERI, Statistical Committee of Russia.

It is certain that the general tendency of decline affected the RFE electricity balance as well (table 3.12). Since 1992, the consumption and output of electricity in the region have annually decreased, though at a lower rate than the reduction of GDP and gross primary energy consumption. Gross electricity production by all types of electric power plants in 1996, as compared to 1991 (peak of production and consumption of electricity), was reduced by more than 10 bln kWh, that is, by 22.4 percent. Energy production at public utility power stations in 1996, as compared to 1991, decreased by 8.6 bln kWh (that is, by 19 percent). Gross electricity consumption in 1996, as compared to 1990, decreased by 9.3 bln kWh (that is, by 20 percent)[2]. The figures for the final electricity consumption are 9.2 bln kWh and 24 percent, respectively.

Table 3.12
Electricity Balance of the Russian Far East, bln kWh

	1990	1995	1996
Gross output	47.4	38.5	37.4
Including Electric Utilities and block-Plants	44.6	37.1	36.7
Import	0	0	0
Transmission to the Chita territory	0.86	0.42	0.02
Export	0	0.14	0.15
Gross Consumption	46.5	38	37.2
Power Plants Own Use	4.25	3.7	3.6
Transmission Losses	3.95	4.87	4.6
Final Consumption	38.3	29.4	29.1
Industrial sector	16.6	11.2	11.0
Construction sector	2.1	1.1	1.0
Transport sector	4.3	3.4	3.2
Agricultural sector (operation needs)	2.65	NA	1.8
Public/ Commercial sectors	4.46	NA	3.0
Residential sector	8.2	NA	9.1

Source: Data from Statistical Committee of Russia

The decline in electricity consumption is conditioned by the general decline in economic activity and embraces the productive sector of regional economy - industry, agriculture (for operation uses), transport, construction and public/commercial sector. The only sector with stable electricity consumption is residential sector.

It would seem that intensive rates of the drop in loads and electricity consumption could relieve the technological and economic conditions of electricity supply of the consumers. The average capacity factor of electric Utilities in the RFE in 1996 made 36.2 percent, while in 1989 - 45.8 percent (table 3.13). The capacity factor for thermal power plants was reduced more than 13 percent, and for power stations with condensing equipment - 19 percent. The capacity factor of cogeneration plants decreases least of all. However, it is almost impossible to use cogeneration plants less than 3500 hours a year, since the CPs give 60 percent of the electricity output in the mode of simultaneous output of heat (for CPs it is the most economical operating conditions).

Table 3.13
Installed capacity factor for the RFE Electric Utilities, %

	1989	1996
The whole power plants	45.8	36.2
Thermal PPs, total	48.3	35
Condensing equipment	48	29
Heat-and-power supply equipment	48.6	41.3

Source: Data from "Vostokenergo" company, ERI.

Actually, electric companies of the RFE have great difficulties in maintaining the standards in provision of the consumers with electricity and heat. Because of the severe financial crisis, thermal power plants operate under conditions of constant lack of fuel, limited maintenance and investment programs.

Another problem is conditioned by high electricity and centralized heat tariffs, which, chiefly because of the pressure of fuel costs, are constantly growing.

The great differences in the levels of prices for power resources in the RFE, as compared with other territories of Russia, which emerged at the very beginning of the reform, have stipulated the insistent demands of the local administrations in the RFE to the Federal government to allocate subsidies (to be more exact, to recover subsidies) for the RFE energy sector. In the main, the demands concern the introduction of preferential transport tariffs for the deliveries of crude oil, coal and petroleum products to the FRE, and also the allocations of governmental grants for investment programs in the electric and coal industries of the Russian Far East.

For a period of the economic reform, the energy sector of the RFE has been receiving subsidies from the Federal center. On the whole, the policy of subsidizing has neither clear purposes nor a logical and stable mechanism. The local authorities constantly demand subsidies, and the Federal government promises much, but fulfills little. At present, in connection with easing of inflation, the great hopes of the RFE energy sector are connected with attraction of private capital.

Currently, the sale of electricity by regional electric Utilities is effected by the tariffs below the cost or low profitability tariffs (table 3.14).

Table 3.14
Average tariffs on electricity and heat, production profitability of electricity and heat in the RFE regional electric Utilities.

Regional Electric Utility	Electricity				Heat	
	1995		1996		1996	
	Tariff, cent/kWh	Profitability, %	Tariff, cent/kWh	Profitability, %	Tariff, $/Gcal	Profitability, %
Amurenergo	3.6	+5.6	5	+10	34.5	+36.8
Dalenergo	3.4	-26.5	5.5	-12.7	27.7	-5.8
Kamchatskenergo	7.8	-14	13.3	-18	36	+5.3
Magadanenergo	4	+5	5.8	-8.6	55.4	+23.8
Sakhalinenergo	4.8	-16.7	7.1	-21	22.5	+8
Khabarovskenergo	3.8	+8	5.7	-1.7	27.7	+22.7
Yakutskenergo	3.9	+5	4.5	-2.2	20.2	+15.3

Note: Profitability is a share of profits in tariff.
Source: Calculated on data from “Vostokenergo” company.

The electric utilities try to compensate the losses of incomes by selling commercial heat, and by the subsidies from the Federal center. The companies “Dal'energo”, “Sakhalinenergo”, “Kamchatskenergo” in 1995-1996 had net losses from the operating activity. The “Dal'energo” company was unprofitable in 1994-1996 even with taking into account the received subsidies. Despite the low and negative parameters of production profitability, the tariffs for electricity in regional electric companies in the RFE are fairly high. Their dynamics is marked by constant growth and is highly determined by market conditions for fuel.

Presently, the RFE energy sector is at the beginning of a complex transition period, which is connected with a fundamental change of the model of economic development of Russia. But it seems obvious that, on the one hand, the region will have to continue the complicated process of adaptation to the conditions of expensive energy, and, on the other hand, - to continue the formation of an efficient productive structure of the power industry.

Briefly, the main trends of the RFE energy strategy for the nearest 5-10 years are the following:

- stabilization of balances of payment of energy companies;
- an active policy of energy saving;
- gradual technological improvements in the productive structure of electricity, mainly by means of retrofitting and updating of operating equipment of thermal power plants with the aim of

improving their energy efficiency and, particularly, environmental efficiency. Completing the construction of the Bureyskaya HPP and Ust'-Srednekanskaya HPP.

- improvement of the fossil fuel structure in the southern zone of the RFE and in Sakhalin by means of development of oil-and-gas projects on the Sakhalin shelf;

- broad development of non-conventional energy sources (geothermal, wind, solar) and small hydro power plants;

- effective policy of export and import in the sphere of trade in fuel and power resources in the NEA region, as well as in the field of exchange of modern technologies of the production and consumption of energy.

4. THE RUSSIAN FAR EAST AND ENERGY COOPERATION IN THE NORTH-EAST ASIA

4.1. Introduction

At present the trends and potential of energy cooperation and interaction of the Russian Far East with the North-East Asia countries can be considered within general economic and political strategy of Russia in the eastern geopolitical direction.

Until the middle 1980-ies the main commodity flows from the territory of the former Soviet Union were obviously oriented towards the countries of Western and Eastern Europe, while the trade-economic relations with countries of the Asia-Pacific Region (APR) lagged behind. At that period, the APR countries accounted for only about 10 percent of the country's foreign trade turnover.

Starting with the second half of the 1980-ies, the new leaders of the former USSR, and afterwards - of Russia, began to attach particular importance to reinforcement of economic and political positions of the country in the East. It was determined by two main reasons. In the first place, the tendencies towards the increase in the share of APR in the world economy and politics began to notably show. Secondly, the change in geopolitical status of Russia after disintegration of the USSR took place. After the USSR's collapse, Russia lost a half of its seaports and the direct access to the world trade routes in the south and in the west. It still more strengthened the importance of the Asian-Pacific line in the development of international economic cooperation. As a result, the share of APR countries in the Russian foreign trade grew from 12 percent in 1991 to approximately 20 percent at the present time. Especially visible is the tendency towards expansion of economic cooperation with the countries of North-East Asia (14 percent of the overall trade turnover of Russia with foreign countries).

The most promising Russian region in terms of development of cooperation with NEA is the Far East. At present, the Far East accounts for more than a half of the foreign trade turnover of Russia with NEA countries (mainly Japan, the Republic of Korea, China). In the foreign trade

turnover of the Far East (4,6 bln dollars in 1996), NEA countries account for 60 percent (in export - over 70 percent).

In the economy of the Far-Eastern region, the economic ties with NEA countries are of marked importance. It can be explained by a number of factors.

Firstly, the RFE has an essential natural resources potential. This determines the demand of the RFE itself for the development of relations with the adjacent countries, as well as the interest of foreign partners in economic cooperation with the region.

Secondly, owing to its geographic situation, the RFE has some advantages in the development of economic relations with NEA countries, in comparison with other regions of Russia.

Thirdly, the negative aftereffects of the political and economic reforms in Russia destroyed the traditional economic ties of the RFE with the European part of Russia and other republics of the former USSR. This placed the Far East, with its raw materials specialization, in a very difficult position. The RFE has virtually no other alternative than that of extensive development of foreign economic cooperation. The foreign economic orientation of the RFE is the most important factor of the long-term development of the region.

An important place in the development of international cooperation is occupied by the Far East energy sector. The energy strategy of the Far East proceeds from the fact that foreign economic cooperation can, and is to become a major additional stabilization factor in the energy of the Far East and its efficient development.

Having a large potential of commercial primary energy resources, the RFE is fairly considered a potential effective energy supplier on the APR market, and particularly, the NEA market.

The development of the leading countries - Japan, China, South Korea - in the last 15 years is followed by a very dynamic growth of energy consumption, reaching in Japan 3.3 percent, in China 4.6 percent, in Korea over 8 percent per year. The total gross energy consumption in those countries in 1994 amounted to almost 1300 mln toe (tones of oil equivalent) or more than 30 percent of the APR countries.

However, among these countries only China has a relatively balanced value of the production-consumption of primary energy, though the structure of primary energy balance has a large proportion of coal. While keeping high rates of economic growth, China will inevitably face the problem of energy balance reconstruction towards highly effective energy resources - natural gas, oil, electricity.

The Russian economists assume, that with maintaining the present rates of the economy growth and restricting coal consumption, China can become a net importer of the high-quality energy resources (oil, natural gas, electricity).

Japan and South Korea have, undoubtedly, a qualitative structure of energy consumption. The proportion of effective energy resources in the consumption of primary energy in these countries has reached 80 percent, including oil and natural gas - over 65 percent. Japan and South Korea are lacking sufficient primary energy sources. The present level of their production has a symbolic meaning, compared to the scales of consumption. Hence, Japan and Korea have a very high degree of energy dependence in all types of natural fuel, which exceeds 80 percent of the overall energy consumption, and there are no grounds for its reduction (table 4.1.). The RFE energy resources can efficiently diversify the structure of suppliers of primary energy resources to Japan and South Korea.

Table 4.1
Import of the energy resources of NEA countries in 1993, mln toe

Country	Crude oil and petroleum	LNG	Coal	Share of import in overall energy consumption
China	-	-	3.5	little
Japan	252.8	50.7	74.6	82.7
Republic of Korea	77.1	5.7	20.4	83.5
Mongolia	0.6	-	-	70.0

Source: Data from Siberian Energy Institute.

A potential participant of the international energy exchanges is, according to the RFE, North Korea. We do not have precise data available on the scale and structure of production-consumption of primary energy in the Korean People's Democratic Republic (KRDR). It is known, however, that in the KPDR no deposits of oil and natural gas have been so far discovered. The production of primary energy in the KPDR is represented mainly by coal and hydropower.

In terms of feasible projects in the field of energy, the RFE has a potential for cooperation in different energy sectors (oil, gas, coal, electricity), and in different forms as well.

International integration of the RFE energy is oriented towards the following trends:

1) Active policy in the field of effective export of the energy resources to NEA countries;

2) Attraction of foreign capital and modern scientific and technological equipment to the production, distribution and consumption of the energy resources. Creation, with these purposes, of a stable legislation;

3) Application of the experience and technologies of the NEA countries in the field of energy-saving programs;

4) Creation of effective international associations in different energy sectors;

5) Carrying out a coordinated energy policy in the field of environmental standards.

Within these forms, one can single out a number of specific projects and trends for international cooperation.

4.2. Cooperation in the Sphere of Primary Energy Resources

The change in the structure of fuel supplies in the RFE
It is significant that in the bulk of the considered foreign trade projects the RFE is commonly regarded as a major supplier of various energy resources to the NEA markets. In point of strategy, it is correct. However, the current situation with the energy supply in the Far-Eastern areas creates another picture of the possible interactions between the NEA countries and the RFE in the nearest 4 to 6 years.

The RFE can reorient the existing energy dependence on Siberia toward external import from the NEA countries.

According to our estimations, all the RFE areas, except Yakutiya and the Amurskaya territory, can fulfill an effective replacement of the Siberian coal suppliers. An effective replacement is also possible with regard to the coal of South Yakutiya, delivered to the Khabarovsk, the Primorskiy, the Sakhalin territories. Effective import of coal from the foreign market to the RFE at present can amount to 2-3 mln toe per year[3].

The coastal areas of the RFE (the Magadan territory, the Kamchatka territory, partially - the Sakhalin territory, the southern part of the Primorskiy territory) can effectively import petroleum products from Japan and South Korea. The effective import can constitute 4 to 6 mln toe per year[4].

Cooperation in the sphere of coal resources development
The RFE has large coal resources. Nevertheless, a long decline and a severe structure crisis in the coal industry of the RFE has made it necessary in recent years to deliver 6-8 mln tonnes of coal per year to the Far East from Siberia. The RFE has a number of promising coal deposits. However, their exploitation is delayed due to the lack of domestic investment.

Cooperation in the sphere of oil and gas resources

Sakhalin projects. Oil and gas sector is, undoubtedly, one of the major sectors for cooperation within NEA. It is conditioned by the potential capacity of the NEA markets with regard to oil-and-gas resources.

Realistic prospects for major international projects appear in connection with development of oil and gas deposits on the Sakhalin shelf. At present, implementation of international projects Sakhalin -1, Sakhalin-2 (total volume of investments about 25 bln dollars) has already started on the Sakhalin shelf. The contract Sakhalin-3 is being underway. The levels of extraction of natural

gas and oil, the feasible schedules of hydrocarbons supplies for export to NEA countries (mainly Japan, South Korea) from the sea deposits within the projects Sakhalin-1, Sakhalin-2 are given in table 4.2.

Table 4.2
The dynamics of extraction and distribution of hydrocarbons under the projects Sakhalin-1, Sakhalin-2

	Crude oil, mln t			Natural gas, bln m^3		
	Extraction	Export	Domestic	Extraction	Export*	Domestic
1996 (actual)**	1.5	0.37***	1.1****	1.78	0	1.78
2000	2.7	2.1	0.6	0	0	0
2005	14	9	5	15.2	8	7.2
2010	25.5	20.5	5	19.9	9.1	10.8

* - Export of natural gas will be performed only in a liquified form.
** - The current production of hydrocarbons on the land of the Sakhalin Island.
*** - The data of 1995
**** - The estimation.
Source: Data from “Rosneft'-Sakhalinmorneftegas” company.

The project of oil and gas supplies from Siberia and Yakutiya

In Yakutiya, only natural gas resources are of export importance. So far, there hasn't been any feasibility studies of development and supply of natural gas of Yakutian deposits.

However, independent realization of the natural gas supply from Yakutiya to NEA countries is doubtful. It is caused by a keen competition on the part of major Siberian oil and gas fields.

The eastern trend is considered, at present, the one of priority by the largest fuel-energy areas of West Siberia and, especially, East Siberia. Siberia comprises almost 85 percent (840 mln toe) of the Russian primary energy resources production. Siberia accounts for 85 percent of the confirmed Russian reserves of natural gas (that is 1/3 of the world reserves), 65 percent of oil and 75 percent of coal.

In 1995-1996, within the Comprehensive Energy Plan in East Siberia and the RFE[5], a variant has been proposed, connected with joint development of hydrocarbon raw materials resources not only within the south-west and central districts of Yakutiya, but also including the neighboring deposits of the Irkutsk and the Krasnoyarsk territories, which are situated on a geologically single Siberian Platform (project “The Siberian Platform”). The total recoverable reserves of the Siberian Platform constitute almost 1300 mln tons of oil and more than 3,6 trillion m^3 of natural gas. The project is aimed at satisfaction of local demand for oil, natural gas, as well as intensive export supplies to NEA countries (table 4.3).

The availability of the confirmed large natural gas deposits on the Siberian Platform and the prospects of their growth make it possible to create in the region a powerful gas-extracting industry with annual gas production of 40-50 bln m^3. During the creation of a large-scale gas pipeline under the project for the development of the Siberian Platform deposits, it is intended to use, first of all, the largest in Siberia and the Far East Kovictinskoye gas field in the Irkutsk territory (the recoverable reserves 870 bln m^3), and a group of Yakutian fields with overall reserves 1190 bln m^3 (Srednevilyuyskoye, Srednetyungskoye, Chayadinskoye, and others). The cost of the plan of development of the oil and gas resources of the Siberian Platform and their deliveries for export to NEA countries is estimated at 34-37 bln dollars (depending on the variants of routes of the large-scale oil-and-gas pipelines), 11 bln dollars of which are intended for the development of gas deposits of Yakutiya and for building there pipelines for providing gas to local areas, and building feeder pipelines to be connected to the large-scale pipeline.

The project also proposes organization on the Siberian Platform of a large-scale oil industry on the basis of Yurubchenskoye-Tokhomskoye deposit in the Krasnoyarsk territory (360 mln tons of the reserves), Verkhnechonskoye in the north of the Irkutsk territory (224 mln tons), Talakanskoye and Srednebotyubinskoye deposits in west Yakutiya (157 mln tons). The project envisages development of the Yakutian oil reserves solely for internal consumption.

Table 4.3
The prediction of oil and natural gas production in the Siberian Platform deposits and planning the supplies for export to NEA countries

	1994(actual)	2005	2010
Crude oil, mln tons			
Extraction	0.16	26.0	46.0
including Yakutuiya	0.16	1.9	2.0
Consumption in Yakutuiya	0.16	1.9	2.0
Export	0	0	18.7
Natural gas, bln m^3			
Extraction	6.3	35.2	46.7
Including Yakutuiya	1.6	13.8	18.7
Consumption in Yakutuiya	1.6	2.2	2.7
Export	0	27-29	31-33

Source: Study on comprehensive energy plan in East Siberia and Far East of the Russian Federation. Executive Summary. /The Energy Research Institute of the Russian Academy of Sciences, the Institute of Energy Economics, Japan. September 1995. (Engl.)

5. NORTH-EAST ASIA COOPERATION IN THE FIELD OF ELECTRICITY: PREREQUISITES FROM THE RFE ELECTRIC POWER INDUSTRY

5.1. Introduction

The prospects of the RFE cooperation with NEA countries in the field of electricity are less impressive as compared to the oil-and-gas sector. It is possible that the fairly modest ideas of the scope of cooperation in the electricity sector are the result of insufficient study of the prospects of international cooperation.

In terms of the Far East, strategically, unequal provision of different NEA countries with energy resources, different structure of electric power plants and possibility of their rational use within major interconnected power systems (IPSs) provide opportunities for the creation of international energy integration in the NEA region.

The integration IPSs in NEA is expedient due to favorable geographic and economic conditions. In our opinion, the basis for the integration of electricity is to be formed by scientific, institutional, legal and industrial mechanisms at the international level under conditions of operation of different models of the economy and electricity of NEA countries.

It is indisputable that the organization of joint work of the IPSs is to be executed according to the principles of state sovereignty over the power facilities and resources, voluntariness and efficiency of functioning of the international electricity exchange.

The economic-and-technical features of the production, distribution and consumption of electricity have conditioned the efficiency of interconnection of separate IPSs for parallel operation and creation of large integrated power grids (IPGs).

The maximum economic and technological efficiency of interconnection of international power systems (International Integrated Power Grid - IIPG) is achieved when its participants are willing to work for an integrated load. In this case, a complete coordination of members of the International Integrated Power Grid is achieved, at the level of a long-term and effective planning of the IIPG development, coordinated investment policy and dispatching control (an ideal variant of the International Integrated Power Grid).

For the ideal variant of the International IPG, the following basic economic and technical factors of the parallel operation efficiency become apparent:

1. *Frequency effect*, caused by a lesser influence on the frequency of a turbogenerator or a user in emergencies in major IPS as compared to small IPS. As a result, in a major IPS the necessary stand-by facilities (reserve capacity) are reduced. Besides, the unit capacity of turbogenerators of the power stations and transmission lines is not limited, which permits to enhance the effect of economies on scale.

2. The effect of economies of necessary generating capacity. This effect is provided by:
- combination of daily and seasonal maximum loads;
- reduction of the reserve capacity in a single IPS;

- reduction of the reserve capacity by optimization of the ordinary and extra-ordinary maintenance program;
- increase in the guaranteed HPP capacity when covering loads, which is caused by divergence of favorable/unfavorable conditions of river flows;
- decrease in the duplicating capacity for power plants, operating from non-traditional energy sources;

3. The structural effect, conditioned by the ability of International IPG to create a rational structure of power plants while planning an effective electricity exchange among different points of the International IPG, both within one country and between different countries.

4. The environmental effect, conditioned by optimization of loading of the power plants according to the criterion of minimizing ecological damage.

5. The adaptive effect, conditioned by the capability of a major IPS for adaptation to changes in the outer conditions.

On the way of creation of the International IPG in the NEA region there can be obstacles connected with the following conditions:

- Decline in economic efficiency of electricity transportation with the increase in distance of energy transportation;
- Possible technical difficulties of control over the extensive energy transmission lines, operating on alternating current;
- The presence of different types of economies in NEA countries (centralized economy, transition economy with the elements of market economy), strategic uncertainty of the economy and energy development, different and unstable models of the energy regulation, different principles of electricity rate system;
- The political and economic reasons of the countries-participants of the IIPG (e.g., energy independence and security).
- Taking into consideration the possible positive and negative factors of creation of the International Integrated Power Grid in the NEA region, at present it appears difficult, without a comprehensive study, to form a conclusion about the level of efficiency of the IIPS creation within the NEA region. In order to form this conclusion, it would be necessary to fulfill jointly, at the international level, the following:
- An analysis of the economic and technical prerequisites for interconnection of the countries-participants IPSs;
- An analysis of the possible variants of creation of the International IPG;
- An estimation of the efficiency of creation of the International IPG and establishment of international electric connections;
- An analysis of the institutional issues for the effective existence and development of the International IPG.

So far, it has not been possible to fulfill, at an international level, a comprehensive study on substantiation of the International IPG creation in the NEA region. In any case, the author did not

have an opportunity to become familiar with the study. There are available either global-level studies, intended for setting the problem of creation of the Global IPG in the world, or small private projects which aim at studying the issues of electricity exchange in some frontier points of the RFE and China.

Below we set forth some estimations of a possible participation of the RFE electricity in international electricity exchange in the NEA region. They concern the principle possibilities of energy exchange in the region in terms of the RFE electricity. For the most part, they relate to technical and economic prerequisites for electricity supplies from the RFE to NEA. The estimations are made under conditions of a very low level of knowledge about electricity of the adjacent counties. Lack of information does not permit to make precise estimations of possible efficiency of integrated operation of the IPSs of NEA countries and the RFE.

On the whole, in recent years electric companies of the RFE demonstrate a certain interest for international cooperation in the NEA region. However, the policy of the RFE electric companies in relation to organization of electricity exchange in the NEA region is, on the whole, rather restricted and even passive. It can be briefly characterized by the following statements:

The RFE electric companies have not, as yet, considered plans of creation in the NEA region of an “ideal” (as it was mentioned above) International IPG, which could operate for an integrated load. Possibly, it is a result of the low level of international coordination in the issues of the IPG creation.

The RFE electric companies are, at present, oriented towards the policy of solely an export of electricity. It is mainly caused by a sharp decline in domestic electric consumption in the RFE and the emergence of the excess of electric power and electric output in the RFE. The export strategy is also maintained by the possible construction of highly efficient new power plants in the RFE, the energy of which can be exported (mainly to Japan or China).

The IPG “Vostok,” and, possibly, the Sakhalin territory have the main potential for supplying electricity for export (in the case of construction of new major power plants in Sakhalin).
Export of electricity from the RFE is considered only in the volumes that allow the IPG “Vostok” to self-balance when fulfilling the domestic standards of reliability of electricity supply.
The RFE electric companies are careful in their approach to coordination of operating conditions during creation of major international electric interconnections. Transmission of large energy volumes is mainly planned either via AC transmission lines, but with DC converter substation, or via DC transmission lines. In this case, energy exchange is not dependent on fluctuations of frequency and voltage in the connected IPS. A DC transmission line provides stability of flow of power and feasibility of its swift alteration without direct influence on the turbogenerators of power plants.

5.2. Electricity exchange between the RFE, China, and North Korea

At the international level the contacts for the development of international electric connections were implemented with representatives of China and North Korea.

China

In 1989 the joint Russian-Chinese study “The Outline of a comprehensive use of water resources of the border sectors of the Argun' and the Amur rivers” was completed. The study proposed a construction of a chain consisting of six HPPs in the border sectors, of total capacity about 3 GW, with electric output about 20 bln kWh. It was projected to divide the electric output equally between China and Russia.

However, the project of construction of joint hydro-power plants on the Argun' and Amur rivers received an extremely negative response on the part of the public and administrations of the adjacent regions of the Far East (mainly, for environmental reasons).

At the beginning of the 1990-ies the Chinese side addressed the electric Utility “Amurenergo” with a proposal to organize export of electricity to the local districts of Heiluntszyan. The negotiations were successfully completed. As a result, an international transmission line of 110 kV (design voltage 220 kV) Blagoveschensk - Haihe was constructed. Export of electricity has been fulfilled from 1992. The maximum annual supply was 140 mln kWh.

At the end of 1996 to the west of Blagoveschensk the construction of another AC transmission line of 110 kV was completed (Sivaki - Kuznetsovo - Shipachzhan').

In 1993 the Chinese applied to the “Amurenergo” company with a more impressive proposal. They offered to conclude a compensation Agreement on commercial cooperation during the construction of Bureyskaya and Nizhne-Bureyskaya HPPs in the Amursk territory. China offered its commercial participation at the completing stage of construction of these Russian hydro-power stations. To compensate its participation in the HPP construction, the Chinese side proposed, that it should receive electricity supplies from the Bureyskaya HPP annually in the amount of 1.7 bln kWh of electric output and 465 MW power.

Technically, the Agreement on the electricity supplies from the Bureyskaya HPP was supposed to be fulfilled by means of the transmission line of 500 kV “Bureyskaya HPP - Harbin”. In the course of preparation of the Agreement, several variants of organizing the transfer of electricity were analyzed (AC/DC, integrated/separate operation of the Russian and Chinese IPS).

The proposal of the Chinese side was highly promising for the Russian side, taking into account the current economic situation in the RFE and the prospective estimations of the demand for electricity in the southern part of the RFE. At least, it could be discussed in various commercial variants. However, the idea of the Agreement aroused a keen emotional opposition on the part of local governments of the Far East South (particularly, the Khabarovsk and the Primorskiy territories). The Bureyskaya HPP is not a property of the “Amurenergo” company. Its construction is funded by the Russian Federal budget. The Bureyskaya HPP is an object of interregional importance. The Bureyskaya HPP can provide the IPG “Vostok” market with inexpensive energy. That was the main argument of the local authorities in the south of the RFE.

The negotiations with the Chinese side were interrupted in 1993 without any results.

North Korea

In 1985 the government of the former USSR signed the Agreement with the KPDR on the construction in the KPDR (district Sinpo) of a Soviet nuclear power station. Apparently, intending to accelerate implementation of the project, or attempting to find other variants for resolution of its energy problems, the Korean side, in 1988, sent its representatives to the RFE with the proposal for cooperation in the field of electricity.

The KPDR offered the following variants:

1) The USSR should conduct the construction in the KPDR of a nuclear power station of power 4 GW (4 units by 1 GW each), two units of which of frequency 50 Hz were supposed to be connected to the IPG "Vostok".

2) In case of rejection of the NPP construction, the KPDR requested that it should been supplied from the IPG "Vostok" from 60 to 1000 MW of basic power annually. To begin with, the KPDR requested about 300 mln kWh per year for electricity supply of its northern regions. Since the IPSs of the KPDR and Russia operate on different frequency parameters, the KPDR offered to allot in the North of its territory a specific "load island" with the frequency of 50 Hz.

As a compensation for the energy supplies, the KPDR suggested, that Korean workers should participate in the construction of the Far-Eastern energy objects, and in prospect North Korea suggested return supplies to the IPG "Vostok" of peak power of its HPPs to the extent of 500 MW (via DC converter substation).

In the late 1980-ies the IPG "Vostok" had no excess of electricity. The IPG "Vostok" declared to the Koreans that at the first stage the amount of energy supplies to the " load island" will amount to no more than 100 mln kWh per year.

In 1989 the negotiations stopped for unknown reasons, and have not been resumed up to now.

5.3. Prerequisites for electricity export to China and North Korea

The main potentialities for the organization of international electric connections are concentrated in the south of the RFE, where the IPG "Vostok" operates (South Yakutiya, the Amursk territory, the Khabarovsk territory, the Jewish Autonomous territory, the Primorskiy territory). The possibilities for organization of electric connections of the other RFE regions with NEA countries are doubtful due to the remoteness of those regions and small amounts of electricity production.

The main prerequisites for the organization of electricity export are conditioned by a sharp decline in electricity consumption in the Far-Eastern regions. The ongoing severe economic crisis in Russia and the RFE creates a great uncertainties to the future demand for electricity.

At present, there exist different estimations of the future demand for electricity at the period up to 2010. In the recent three or four years, the predicting estimations for the demand for electricity in the southern area of the RFE have persistently declined.

By the author's estimations, the 1990 level of demand for electricity in the IPG “Vostok” can possibly be restored at the period between 2000-2005. Further, a stable growth of electricity consumption at an annual level of 4-5 percent is expected. In 2010 the demand for electricity can possibly constitute 38-43 bln kWh (30.5 bln kWh in 1990).

If we take into account the above-mentioned dynamics of demand, then the total demand for capacity of the IPG “Vostok” power plants should amount to (with regard to the standard for the necessary reserve capacity[6], dismantling and retrofitting of the operational equipment):

	1990 (actual)	1996 (actual)	2000	2005	2010
Necessary power plants capacity of the IPG “Vostok”, GW	6.3	6.3	6.0-6.46	7.15-7.85	8.8-9.9

At the period up to 2010, in the IPG “Vostok” a number of power units are to be installed. It is conditioned by retrofitting projects, updating and expansion of the operational thermal power plants (the Khabarovskaya CP-3, the Komsomolskaya CP-3, the Primorskaya TPP, the Amurskaya CP-1), and also by the projects of construction of new power stations. At present new power plants are being built: a major Bureyskaya HPP with the contraregulator (Nizhne-Bureiskaya HPP) of total design capacity 2.428 GW, the Ussuriyskaya CP (0.360 GW).

The projects of construction of other new power plants are under discussion, for example: the Far-Eastern NPP, the Primorskaya NPP, the Urgalskaya HPP-1, the Dal'nerechenskaya HPP, the Nakhodkinskaya CP, the Khabarovskaya CP-4, and a number of other power stations.

According to the careful estimations made within the IPG “Vostok”, taking into account the existing construction sites and the project feasibility, (and also expecting stabilization of funding of the construction work), the following dynamics of electric capacity can be expected in the IPG “Vostok”:

	1997-99	2000	2005	2010
Available power plants capacity of IPG “Vostok”, GW	6.15	7.3	10.0	11.0
Including the capacity of the new PPs, GW	0	0.510	2.98	3.4
The Bureyskaya HPP	0	0.5	2.0	2.0
The Nizhne-Bureyskaya HPP	0	0	0.214	0.428
The Ussuriyskaya CP	0	0	0.36	0.36
CP Nakhodka	0	0	0.04	0.2

Basing on the given above estimations of the demand and dynamics of electric capacity, one can expect excess of electric power and electric output in the IPG "Vostok" at the period up to 2010 (table 5.2, 5.6; the tables are in the end of section 5.3). Already at the present time, the IPG "Vostok" has excessive electric power, which at the period to 2000 account for more than 0.5 GW at winter peak load. After 2000 it can constitute from 1 to 2.5 GW. Apparently, the excess of electric power can be offered for supply to the foreign market in the adjacent NEA countries, first of all China and the KPDR.

The given above estimations of the electric power excess in the IPG "Vostok" are obtained by the analysis of electric power balances in the IPG "Vostok" during the hours of a winter peak loads. Under conditions of the night and day minimum of the load schedule, the excess of electric power increase at different periods up to 2-4 GW (table 5.1). This excess rises (but not greatly) in the summer time - during seasonal decline in electric consumption (annual disparity of the electric load in the IPG "Vostok" - the ratio P(maximum summer)/P (maximum winter) - constitutes on average 0.6)[7].

Table 5.1
Correlation demand/production of electric power in the IPG "Vostok" at winter maximum/minimum load, GW

	1997-1999		2000		2005		2010	
	max	min	max	min	max	min	max	min
Demand for electric power*	5.7	4.4	6.2	4.8	7.5	5.8	9.3	7.2
Available capacity	6.15	6.15	7.3	7.3	10	10	11	11
Balance	+0.5	+1.75	+1.1	+2.5	+2.5	+4.2	+1.7	+3.8

* Including the necessary reserve capacity
Source: The author's estimations

Evidently, in order to balance the operating conditions of electricity consumption in the IPG "Vostok", a profound daily unloading of the flexible power plants will be necessary. In fact, at the points of minimum loads in the IPG "Vostok", the turbogenerators of the Zeyskaya and Bureyskaya HPP (3.3 GW in total) should be suspended.

It should be noted, that the amounts of excessive electric power and electric output in separate IPSs of the IPG "Vostok" are different (tables 5.3, 5.4, 5.5; the tables are in the end of section 5.3). Practically, the entire surplus of electric power is concentrated in the Amursk territory and South Yakutiya (Yuzhno-Yakutskiy power district)[8]. The Khabarovsk and the Primorskiy territories at the peak load hours have to receive power from the Amursk territory and South Yakutiya. At the time of minimum load all energy systems can self-balance. At that, in the IPG

"Vostok" on the whole, as mentioned above, a profound unloading of flexible turbogenerators is necessary.

The peak-load conditions in the IPS is the main and most complex period in electricity supply. As shown in the tables, the maximum load in the IPG "Vostok" at the period up to 2000 is predicted in favorable conditions with a large reserve of generating capacity.

The excess of electric power also leads to a substantial excess of electric output in the IPG "Vostok" (table 5.6; the table is in the end of section 5.3). This excess is formed in all IPSs of the IPG "Vostok". Even using only the currently-operational capacities, and providing a relatively moderate yearly loading of the turbogenerators of thermal power plants (4500-4600 hours), in 1997-1999 the IPG "Vostok" would have stable electricity surplus of 1.5-1.6 bln kWh.

After completing the construction (after the year of 2000) of the Bureiskaya HPP, Nizhnebureiskaya HPP, Ussuriyskaya CP, the extension of the Khabarovskaya HPP-3, Komsomolskaya CP-3 (these are actually realistic projects), a substantial surplus of electric output will form in the IPG "Vostok". Taking into account moderate loading of the turbogenerators of thermal PPs (4500-4600 hours), a surplus of electric output can vary on average from 3.5 bln kWh in the years of 2000-2003, to 10 bln kWh in 2005, and up to 6 bln kWh in 2010.

Thus, summing up, we can expect the following average volumes of electricity export from the IPG "Vostok" to the adjacent NEA countries:

	1997-1999	2000	2005	2010
Power at the point of winter peak, GW	0.5	0.8-1.3	2-2.8	1-2.2
Power at the point of winter minimum, GW	1.5	2.5	4.2	3.8
Electricity, bln kWh	1-1.7	2.8-5	9-12	3.5-9

Note: As in the case with primary energy resources, a major competitor of the RFE in electricity export to NEA countries can be East Siberia. At present, owing to the decline in electricity consumption, great excess of inexpensive electricity (20-25 bln Kwh) has formed in East Siberia at major hydro power stations. Electric companies of East Siberia, particularly the "Irkutskenergo" company, are currently discussing the projects of electricity supplies to the south-east direction (Mongolia, China). This project was recently discussed during the visit of the Russian Prime-Minister Chernomyrdin to China.

Table 5.2
IPG "Vostok" Electric Power Balance (winter maximum), GW

	1990 (actual)	1996 (actual)	1997-1999	2000	2005	2010

Maximum Demand	5.5	4.54	4.7	5.0-5.4	5.96-6.54	7.3-8.3
Reserve	0.7	0.9	0.9	1.0-1.1	1.2-1.3	1.5-1.7
Transmission to other IPSs	0.16	0.085	0.025	0.03	0.03	0.03
Total Demand	6.3	5.5	5.7	6.0-6.5	7.2-7.9	8.8-10
Available PPs capacity	6.3	6.27	6.2	7.3	10	11
Balance	0	+0.7	+0.5	+1.3 - +0.8	+2.8-+2.1	+2.2-+1.0

Source: The data from “Vostokenergo” company; the author's estimations.

Table 5.3
The Primorsky Territory Electric Power Balance (winter peak), GW

	1990 (actual)	1995 (actual)	1997-1999	2000	2005	2010
Maximum Demand	2.1	1.8	1.9	1.95-2.1	2.3-2.6	2.8-3.3
Reserve	0.18	0.6	0.4	0.4	0.45-0.5	0.6-0.65
Transmission to other IPSs	0	0	0	0	0	0
Total Demand	2.32	2.3	2.3	2.4-2.5	2.8-3.1	3.4-4
Available PPs capacity	2.2	2.1	2.1	2.4	3	3.5
Balance	-0.12	-0.2	-0.2	0 - -0.1	+0.2--0.1	+0.1--0.5

Source: The data from “Vostokenergo” company; the author's estimations.

Table 5.4
The Khabarovsk Territory Electric Power Balance (winter peak), GW

	1990 (actual)	1995 (actual)	1997-1999	2000	2005	2010
Maximum Demand	1.7	1.4	1.5	1.5-1.6	1.8-2	2.2-2.5
Reserve	0.1	0.4	0.3	0.3	0.4	0.45
Transmission to other IPSs	0	0	0	0	0	0
Total Demand	1.8	1.8	1.8	1.8-1.9	2.2-2.4	2.65-3
Available PPs capacity	1.6	1.6	1.6	1.9	2.1	2.4
Balance	-0.2	-0.2	-0.2	+0.1 - 0	-0.1- -0.3	-0.2- -0.6

Source: The data from “Vostokenergo” company; the author's estimations.

Table 5.5
The Amursk Territory Electric Power Balance (winter peak), GW

	1990 (actual)	1995 (actual)	1997-1999	2000	2005	2010
Maximum Demand	1.4	1.1	1.2	1.2-1.3	1.4-1.6	1.75-2.0
Reserve	0.35	0.2	0.2	0.25	0.3	0.4
Transmission to other IPSs	0.16	0.1	0.025	0.025	0.03	0.03
including Export to China	0	0.02	0.025	0.025	0.03	0.03
Total Demand	1.9	1.4	1.2	1.5-1.6	1.7-1.9	2.1-2.4
Available PPs capacity	1.85	1.85	1.85	2.4	4.3	4.6
Balance	-0.05	+0.35	+0.55	+0.9 - +0.8	+2.6- +2.4	+2.5- +2.2

Source: The data from “Vostokenergo” company; the author's estimations.

Table 5.6
Electricity Balance of IPG "Vostok", bln kWh

	1990 (actual)	1995 (actual)	1997-1999	2000	2005	2010
Demand	30.5	23.7	25	26-28	31-34	38-43
Transmission to other IPSs	0.85	0.6	0.15	0.15	0.15	0.15
including Export to China	0	0.15	0.15	0.15	0.15	0.15
Total Demand	31.3	24.3	25.15	26.15-28.15	31.15-34.15	38.15-43.15
Generation:						
Hydro PPs	6.2	4.3	4.9	5.9	13.5	14.5
Thermal PPs: case 1.	25.1	20.3	20.25	20.1-22.1	17.5-20.5	23.5-28.5
Duration of TPPs capacity-use per year, hours	5000	3240	4200	3700-4050	2700-3200	3360-4050
Total Output	31.3	24.3	25.15	26.15-28.15	31.15-34.15	38.15-43.15
Balance	0	0	0	0	0	0
Thermal PPs: case 2.			22	25.1	29.7	32.2
Duration of TPPs capacity-use per year, hours			4600	4600	4600	4600
Total Output			26.9	31	43.2	46.7
Balance			+1.7	+4.8-+2.8	+12-+9	+8.5-+3.5
Thermal PPs: case 3.			24	27.3	32.3	35
Duration of TPPs capacity-use per year, hours			5000	5000	5000	5000
Total Output			28.9	33.2	45.8	49.5
Balance			+3.7	+7-+5	+14.5-+11.5	+11.4-+6.4

Source: The data from "Vostokenergo" company; the author's estimations.

5.4. The projected schedules of electricity supplies to NEA countries

Theoretically, the existing in the IPG "Vostok" electric network makes it possible to perform electricity supply for export from all the border districts in the south of the RFE.
Though the major surplus of electricity in the IPG "Vostok" is concentrated mainly in the Amursk territory and the South Yakutiya power district, the current availability of a high-voltage route of 220-500 kV and the plans of its further development: "South Yakutiya - the South of the Primorskiy territory" (Neryungrinskaya TPP - Zeyskaya HPP - Bureyskaya HPP - SS 500 kV Khabarovskaya, SS 500 kV Khekhtsyr -Primorskaya TPP -SS 500 kV Dal'nevostochnaya - SS 500 kV Vladivostok) - permit to perform electricity transmission for export with a view to

optimize electricity supplies (disposition of feeding points and possible centers of loading, efficient distribution of power-flows in the IPG “Vostok”).

On the whole, export electricity transmission can be performed in different voltage ranges - from 35 kV to 500 kV.

At present, the restricted conditions for electricity export are in the southern part of the Primorskiy territory, where 90 percent of the Primorskiy territory energy consumption is concentrated. The electricity supply of this region is about 50 percent provided by the Primorskaya TPP. Expansion of export in the south of the Primorskiy territory can be possible after the completion of a high-voltage circle - “SS 500 kV Dal'nevostochnaya - SS 500 kV Vladivostok - SS 500 kV Nakhodka”. The export possibilities of the south of the Primorskiy territory can substantially expand, if a new power station will be constructed there (the project of a NPP is under discussion).

The closest international electric connections can be organized with China.
Geographically, the IPG “Vostok” has an extensive border with China - approximately 2000 km. The most part of the border passes along large rivers - the Amur river and the Ussuri. The most extensive border is with the Chinese province Heiluntszyan. The extent of the border with the province Tszilin'- about 150 km.

China, as a dynamically developed country, is of greatest interest in point of significant demand for electricity export from the IPG “Vostok”.

With the data at hand, the main centers of electric loads in border provinces of the North-East China are located in the districts Harbin, Tszyamusy, Tszisi, Hunchun'. These points, according to our data, are most preferable for studying the issues of powerful electric connections of the voltage 220-500 kV.

The variants for the routes of possible energy transmission in the KPDR are relatively limited. The RFE's border with the KPDR is only 18 km long, in the Khasanskiy district of the Primorskiy territory. Organization of export with the KPDR is possible on the voltage of 110-220 kV after the construction of the substation Kraskino of 220 kV and the transmission line of 220 kV “SS Vladivostok - SS Kraskino” has been completed.

At the same time, the territories if the Khasanskiy district, the cities of Vladivostok and Nakhodka are included in the zone of the international project “Economic Development Region of the Tumangan River”, or “Big Tumangan”, which is promising for cooperation in NEA. According to the project “Tumangan”, at the delta of the river Tumangan, at the junction of the borders of three states (Russia, China, the KPDR), it is planned to form a major transport, industrial, financial, commercial and processing zone.

Though industrial development of the Tumangan Economic Development Area (TEDA) does not, as yet, presuppose specialization in energy, it is obvious that industrial development of the TEDA

will require creation of the necessary social and industrial infrastructure, including creation of the electric supply system.

Actually, the RFE estimates rather negatively a possibility of its geopolitical benefit from the project “Tumangan” development[9]. However, the RFE has no direct means for closing the project. Therefore, the RFE has no other strategic alternative than to take an all-round part in the project “Tumangan”.

It is no doubt that a productive variant of this participation can be the preparation of the project on electric infrastructure development in the TEDA.

Due to a slow advancement of the entire project “Tumangan” and its unclear strategic contours, the issues of organization of the TEDA electric supply have not yet been analyzed on the Russian part (at least, on the part of the RFE). It is unclear, how, in terms of institution, to organize electric supply of the “Tumangan” area. Most likely, the territory of TDA, after having been jointly studied, will have to be divided into several segments, for the purpose of electric supply. One part of the segments will be supplied with electricity by national electric companies, the other part - by means of establishing a special energy corporation of the RFE, China and the KPDR.

The main variants of the high-voltage transmission lines to China and the KPDR, which have been preliminarily analyzed by the RFE electric companies (for the period by the year 2005), are shown in table 5.7.

The technological characteristics of functioning of the electric power industry (continuity of production, distribution and consumption of electricity) make special demands of energy exchange organization. The characteristics of possible technological variants of electricity exchange depend on the conventional national standards of electricity supply. The availability in the KPDR of industrial frequency of 60 Hz limits the number of variants of electricity exchange with the KPDR. Actually, electric connection with the KPDR can be established only through direct current. There can be more variants of parallel operation with China than with the KPDR.

Table 5.7
Possible International Transmission Lines

Route of Transmission	Transmission Length (Russia + foreign territory), km	Voltage, kV	The marginal Power Transmission, MW
The Amursk territory			
The Bureiskaya HPP* - Harbin	150+550= 700	500	600
SS Amurskay - Tsitsikar	150+450= 600	500	600
SS Blagoveschensk - Haihe - Beian'	15+250= 265	220	250
the Raichikhinskaya TPP - Sun'he	70+30=100	220	250
the Nizhne-Bureiskaya TPP* - Sun'he	130+30= 160	220	250
The Khabarovsk territory and the Jewish Autonomous territory			
SS Khabarovskaya - Shuan'shan'	150+150= 300	500	750
SS Khekhtsir* - Shuan'shan'	50+300= 350	500	600-700
SS Ekaterino - Nikolskoye* - Hegen	15+150= 165	220	250
SS Gidroliznaya - Futszin'	20+200=220	220	150
The Primorskiy territory			
The Primorskaya TPP - Shuan'shan'	30+200= 230	500 (220)	800-900 (250)
SS Dalnevoatochnaya - Tszisi	100+30= 130	220 (500)	250
SS Lesozavodsk - Baotsin	15+140= 155	220	100-250
SS Pogranichnaya* - Tsisi	15+120= 135	220	150-200
SS Kraskino* - Hunchun'	30+20= 50	110 (220)	120-200
SS Kraskino* - the KPDR	50+30= 80	110 (220)	120-200

* under construction or design.
Source: Data from the Institute “Dal'energoset'proekt”, “Vostokenergo” company

The following alternatives can be considered when constructing variants of electric connections: Installation of an AC high-voltage transmission line during the parallel operation of the IPG “Vostok” and the energy system of the North-East China. This variant is the most complex in terms of conditions and emergency control. In this case, regulation of frequency and active power should be conducted by both countries. Special attention should be given to the analysis of the issues of static and dynamic stability of international electricity transmission.

1.The installation of a DC high-voltage transmission line. A DC transmission line permits asynchronous operating conditions of the connected energy systems with independent regulation of frequency and voltage. A limited operating control is required. Emergency control is not required.

2.This variant of organization of international connection can also include installation of an AC transmission line with a DC converter substation.

3.Installation of an AC high-voltage transmission line with a separation of a number of turbogenerators to a Russian power plant from the IPG “Vostok”. In that case, the amount of the transmitted power should exactly correspond to the power of separated turbogenerators. The operating and emergency control is mainly exercised by the country-receiver of electricity with the installation of devices of emergency shut-off of the Russian turbogenerators.
It is obvious that the variants with DC facilities will be the most expensive.

Dispatching control

In all the variants of integrated operation of the energy systems of different countries, there is no necessity for the establishment of a special super-national Dispatching Organ. However, a coordinated work of the dispatching services of different countries is necessary. On the Russian side, with large export electricity supplies (over 50 MW), the dispatching control should be performed from the Dispatching Center of the IPG “Vostok” and the dispatching point of the electric company which will execute electricity supply.

To conduct an effective dispatching control, it is necessary to create an international system of telecommunications to control power, frequency and voltage.

The system of payments for the electricity supplies

Contract prices:
The focus and the most complex point in the procedure of concluding a feasible international contract on electricity supply is price. Electricity price is of major importance when estimating economic efficiency of the electricity export projects. The current prices for electricity in the RFE, for a number of reasons, cannot be an exact reference point for the contract prices for export.

General approach to the establishment of prices for electricity is approximately clear. The tariffs should be formed on the basis of a principle “Cost of service”. Basing on the principle “Cost of service”, the tariffs for electricity should include the following three elements: a) costs of providing power; b) variable costs; c) costs connected with the export transmission line. Of these three elements, the “c)” point can be calculated rather easily.

Calculation of the points “a)” and “b)” can encounter some of the difficulties for the RFE electricity, namely:

High instability and uncertainty in the situation with fuel;

Instability of the rules of electricity trade and not quite developed level of electricity rate system, operating in Russia. The presence of the practice of subsidizing of the electric Utilities, the

presence of the practice of cross-subsidizing between different electric companies, different kinds of products (heat, electricity) and between different categories of consumers;

Unsteadiness in the correlation between the domestic inflation rate and the tempo of change of the ruble exchange rate;

Formal and informal opportunities of the RFE local authorities to influence the decisions on export and the export prices for electricity.

Two variants are possible for the calculation of export tariffs (within these two variants different combinations are possible):

A. On the basis of average costs of the electric plant which performs electricity supply for export;

B. On the basis of costs of production and distribution of electricity, which form, on the average, in the IPG "Vostok".

In the "A" variant, the price for electricity production can fluctuate from 1 to 6 cents/kWh, in the "B" variant - from 6 to 10 cents/kWh.

The form of payments according to the export contracts

National currencies of Russia, China, the KPDR do not belong to the category of freely convertible. This creates difficulties in organizing electricity exchange (especially with North Korea), which require special discussion when determining a form of payment. Since the policy of a partial convertibility of the ruble functions in Russia, the RFE electric companies, in the foreign trade in electricity, will calculate the tariffs in hard currency. As a form of payment, three variants can be used (or their combinations):

Payment in hard currency (the most desirable variant, but at the same time, the most doubtful practically);

Payment in national currencies. This variant will be quite possible in payments between the RFE and China, if China and Russia sign a special agreement on payments.

Compensation (barter) form of payment, when in exchange for electricity, goods and services are provided. This variant is acceptable for all potential participants, though it is least attractive, as it complicates the procedure of mutual payments.

6. Conclusion

The favorable geographic position and the characteristics of structures of the fuel and energy balances of the NEA countries condition favorable potentialities in energy cooperation in the region. These potentialities proceed from 1) the strategic effects of a coordinated energy policy in the region; 2) mutual supplement of the structures of energy balances of the NEA countries in the sphere of primary energy resources; 3) the efficiency of creation of integrated electric systems.

Unfortunately, one can note a fairly low present level of the international contacts in the issues of energy in the NEA region. Possibly, this is one of the reasons why the potential for energy cooperation in the region still remains rather a potential than a policy of active actions.

The present report has not offered any specific international projects in the field of energy. First of all, it is conditioned by the problem of the lack of information on the adjacent countries. For the productive discussion of cooperation in the sphere of energy extensive and diverse information is necessary: on the nature and resources, geography, economy, technology, legislation, and so on. The present paper, to a larger extent, aimed at giving a concise idea of the problems and potentialities of the RFE electricity, which will facilitate (as the author hopes) a certain orientation in the analysis of cooperation potential of the NEA countries in the field of energy.

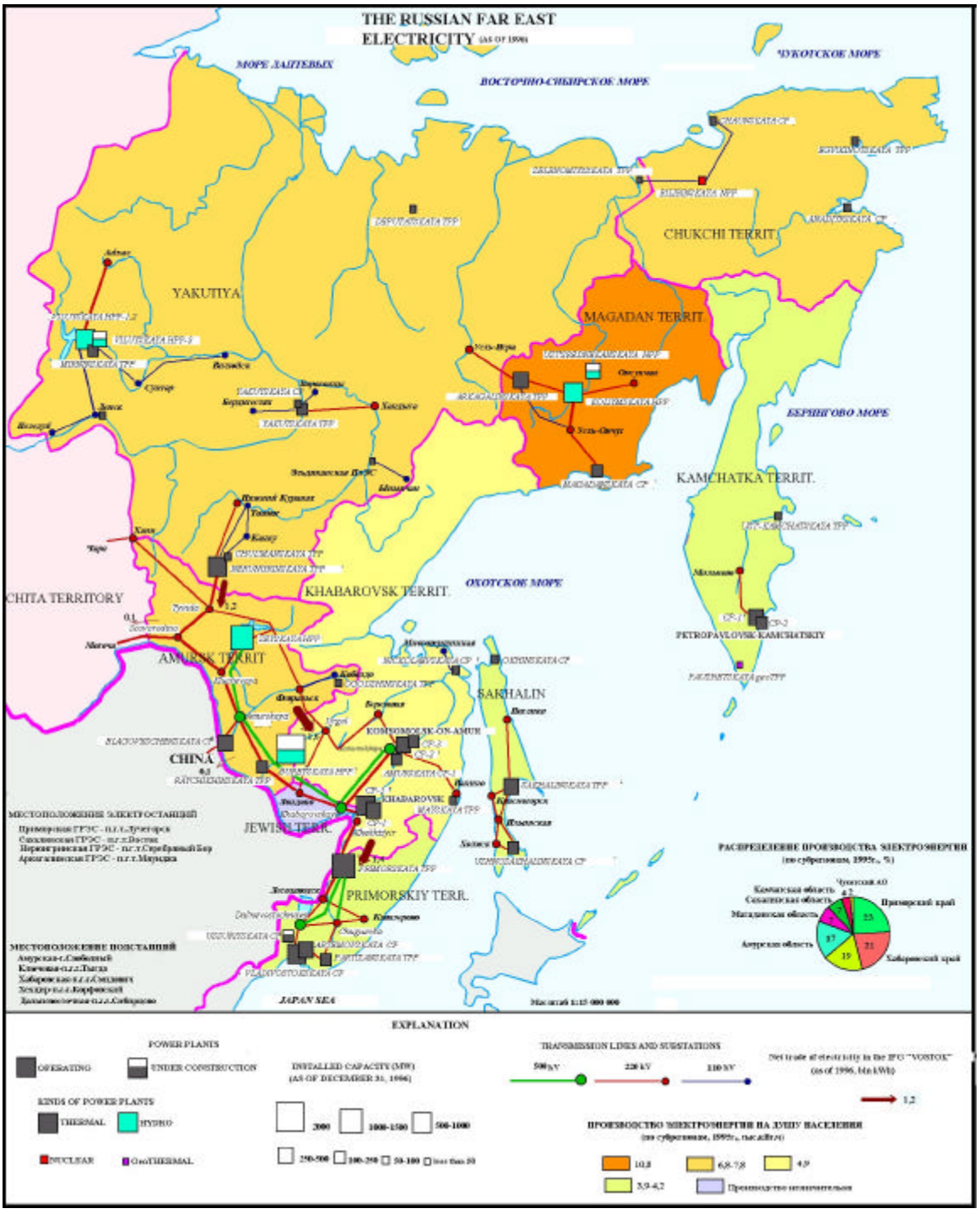
7. ATTACHMENT 1: The list of the main operating Power Plants of the RFE.

Company, Power Plant	Territory	Capacity (as of December 31, 1996)		Main Fuel
		Installed	Available	
1. AMURENERGO – total	Amursk	529.3	508.7	
1.1 Blagoveschenskaya CP		280	280	coal
1.2 Raichikhinskaya TPP		227	214	coal
1.3 Ogodzhinskaya TPP		22.3	14.7	coal
2. ZEYSKAYA HPP	Amursk	1330	1330	
2.1 Zeyskaya HPP		1330	1330	
3. DALENERGO – total	Primorskiy	1196.6	965	
3.1 Artemovskaya CP		404	404	coal
3.2 Vladivostokskaya CP		575	373	coal
3.3 Partizanskaya TPP		212	188	coal
4. PRIMORSKAYA TPP – total	Primorskiy	1495	1132	
4.1 Primorskaya TPP		1495	1132	coal
5. KAMCHATSKENERGO – total	Kamchatka	533.4	528.4	
5.1 Kamchatskaya CP-1		259	259	fuel oil
5.2 Kamchatskaya CP-2		160	160	fuel oil
6. MAGADANENERGO – total	Magadan, Chukchi	553.3	544.4	
6.1 Arkagalinskaya TPP		224	224	coal
6.2 Magadanskaya CP		112	112	coal
6.3 Anadyrskaya CP		66	66	coal
6.4 Chaunskaya CP		42.5	34.6	coal
6.5 Egvikonotskaya TPP		35.3	35.3	coal
6.6 Zelenomysskaya TPP		24	24	diesel

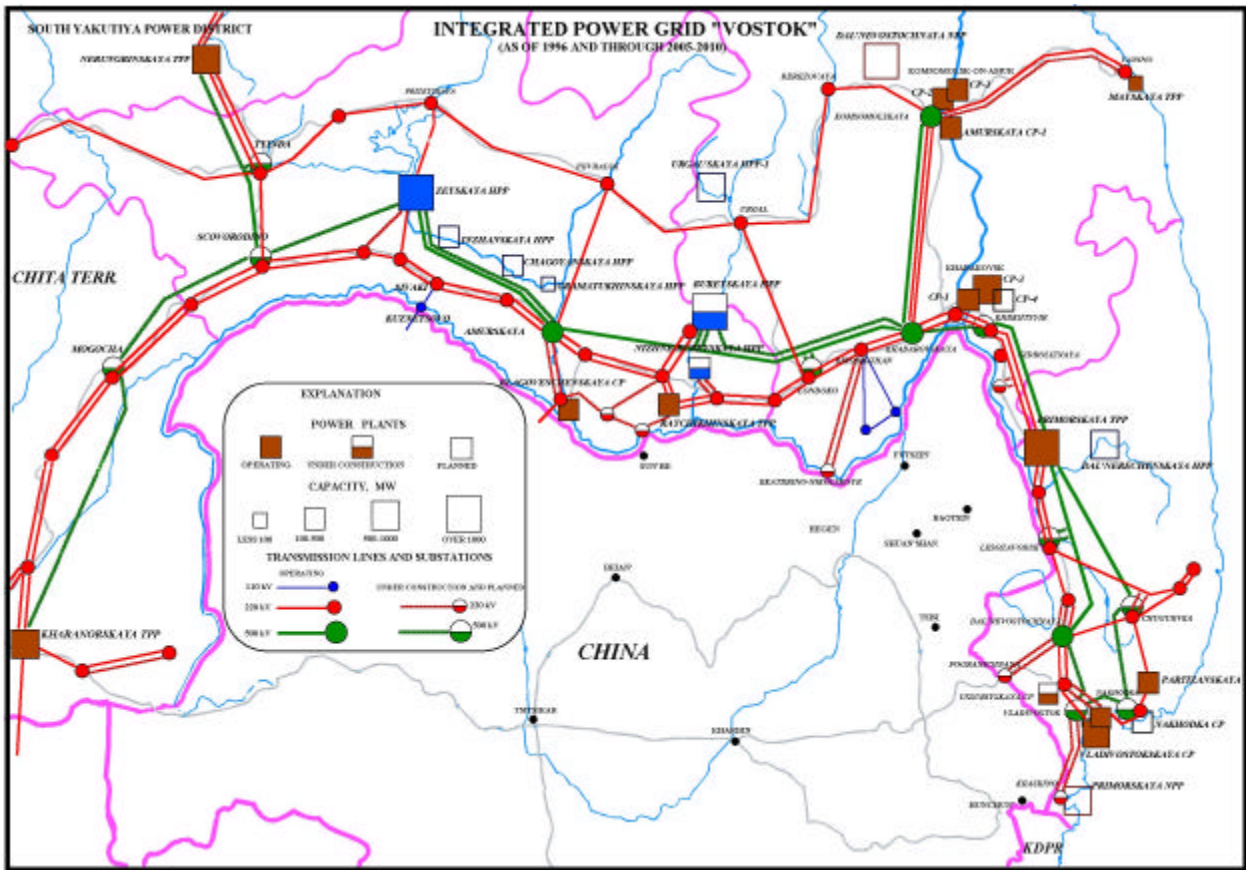
7. KOLYMAENERGO – total	Magadan	900	700	
7.1 Kolymskaya HPP		900	700	
8. BYLYBINSKAYA NPP –total	Chukchi	48	48	nuclear
9. SAKHALINENERGO – total	Sakhalin	619	607	
9.1 Sakhalinskaya TPP		315	303	coal
9.2 Uzhno-Sakhalinskaya CP		225	225	coal
9.3 Okhinskaya CP		75	75	gas
10. KHABAROVSKENERGO – total	Khabarovsk, Jewish	1973.1	1811.2	
10.1 Khabarovskaya CP-1		462.5	356.6	coal
10.2 Khabarovskaya CP-3		540	540	coal
10.3 Komsosmolskaya CP-2		275.5	275.5	gas, coal
10.4 Komsomolskaya CP-3		180	180	fuel oil
10.5 Amurskaya CP-1		285	285	coal
10.6 Maiskaya TPP		98.8	98.9	coal, diesel
10.7 Nickolaevskaya CP		130.6	130.6	fuel oil
11. YAKUTSKENERGO – total	Yakutiya	2034.2	2058.4	
11.1 Yakutskaya TPP		210	235.2	gas
11.2 Viluiskaya HPP-1,2		680	680	
11.3 Mirninskaya TPP		120	120	gas
11.4 Nerungrinskaya TPP		570	570	coal
11.5 Chul'manskaya TPP		48	48	coal
11.6 Deputataskaya TPP		76	76	diesel

Source: Data from “Vostokenergo” company.

8. ATTACHMENT 2: MAP - The Russian Far East Electricity (as of 1996)



9. ATTACHMENT 3: MAP - Integrated Power Grid “Vostok”



10. ENDNOTES

[1]In 1995-1996 transmission and distribution losses were increased by including unregistered electricity consumption in the item "transmission losses".

[2] In the first quarter of 1997, the decrease of electricity consumption of 3 percent was registered again (relatively to the first quarter of 1996).

[3] From all territories of the RFE only the Khabarovsk territory imported near 35-40 thousand tons per year of Chinese coal in 1995-1996 (less than 1 percent of the total coal consumption in the Khabarovsk terr.).

[4] At present, only the Kamchatka territory practically completely has reoriented its petroleum supply towards import from the foreign market.

[5] Study on comprehensive energy plan in East Siberia and Far East of the Russian Federation. Executive Summary. /The Energy Research Institute of the Russian Academy of Sciences, the Institute of Energy Economics, Japan. September 1995.(Engl.)
Merenkov A.P., Saneev B.G., Sokolov A.D. The major priorities and problems on the structural reconstruction of the Siberian fuel-and-power industry. Irkutsk: Siberian Energy Institute RAS, 1996. (Russian.)

[6] At present, in all power systems of the RFE the standard rate of the reserve capacity is twenty percent of the maximum load. In our opinion, this rate is too high. For example, ten years ago the reserve rate was 16 percent of the peak-load.

[7] To be exact, available capacities of the IPG "Vostok" during the summer operation should be decreased by a certain amount of heat-and-power supply capacities. During the summer operation, when the heat consumption is low, the electric utilization of cogeneration plants is economiccaly inefficient.

[8] The surplus of electricity in the South Yakutiya power district is provided by the Nerungrinskaya TPP (its current installed capacity is 0.57 GW). By the year 2005 we forecast that during the peak-loads, the power transmission from the Nerungrinskaya TPP to other areas of IPG "Vostok" will range from 0.2 to 0.3 GW.

[9] One can read about it in more detal in: The project "Tumangan": Realities and Prospects. In: The Russian Far East: An Economic Survey. Second edition, revised and supplemented. Economic Research Institute. Pavel A. Minakir, editor; translated and edited by Gregory L. Freeze, 1996. P. 249-255. (engl.)