"*National Energy Futures Analysis and Energy Security Perspectives in the Russian Far East*"

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TABLE OF CONTENTS

I. Introduction

The Russian Far East (RFE) encompasses a territory of 6.2 million square km (or 36.4 percent of the territory of Russia) though the RFE population of about 7.3 million inhabitants accounts for only 5 percent of the total population of the country.

In terms of administrative division, the Russian Far East consists of separate administrative units. According to the Constitution, the RFE includes the Republic of Sakha (Yakutiya), the Jewish Autonomous territory, the Chukotka Autonomous territory, the Primorskiy territory, the Khabarovsk territory, the Amursk territory, the Kamchatka territory (with the Koryak 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 and energy development.

The analysis of energy paths of the RFE is a subject of thinking of several organizations in the Far East and in Russia. Several studies devoted to the analysis of different aspects of the region's energy future development have been conducted in the Russian Far East over the last five years. The central point for the energy development of the Far East, incorporated in the most recently completed studies, is the policy of active development of the region, which is based on the necessity of accelerated development of the Far East through utilization of its natural and energy resources and through integration of the RFE into the Northeast Asia economic and energy area.

"Active Development approach" is strategically aimed at attraction of the economic resources to the region based on the region's comparative advantages which are influential backgrounds of the energy development forecasts for the Russian Far East.

A new key factor for the regional energy futures forecast is the concept of energy security. This concept today is coming to the forefront in Russia and in the Russian Far East. It claims, formally, to have a basic multi-objective goal of the regional energy development. Informally, the goal is to provide a secure, environmentally sustainable energy supply for the Russian Far East at minimal cost.

This paper is devoted to summarizing the ideas and the results of the most representative studies on future energy development of the Far East.

II. The Present-day Trends

The fuel-and-power sector is represented in the Russian Far East by the coal, oil-and-gas, oil refinery industries, and also by enterprises of electricity.

Historically, the energy sector of the RFE has been predominantly created as a necessary energy supply support for the region-wide development, virtually without any serious achievements in the production of fuel-and-power products for interregional and external economic exchange.

Modest economic performance of the Russian Far East compared to the national economic performance has conditioned, among other things, a small importance of the Far Eastern production and consumption of energy resources relative to the national ones (Table 1). In 1997 production of the primary energy resources in the Russian Far East is about only 2 percent of that of Russia as a whole. The regional share in the national primary energy consumption is 4.3 percent. The production of electricity made 4.3 percent.

(1) General Indicators of Russia and the Far East (as of 1997)

	Russia	**the Far East**	Share of the Far East, %
Territory, million sq. km	17.1	6.2	36.4
Population, million of inhabitants	147.1	7.3	5.0
GDP, billion rubles	2,522	139.2	5.5
Primary Energy Production, million TCE	1,388	27.9	2.0
Primary Energy Consumption, million TCE	905	40.4	4.3

Source: Rossiiskiy Statisticheskiy Ezhegodnik. Goskomstat Rossii. Moskva, 1999. Data from Economic Research Institute (ERI).

The period of 1980-1990 was a period of dynamic growth in the Far East for the production and consumption of primary energy, and also of final energy products. The demand for primary energy has continuously grown at an average annual rate of 2.7 percent, for electricity – 4.5 percent. Over ten years the production of primary energy has grown by 35 percent, and electricity – by 57 percent. At that, the Far East has constantly experienced lack of productive capacities to meet the growing energy demand.

In the1980s, the current technological pattern of the Far-Eastern fuel and power sector was formed, which in the 1990s did not undergo any substantial modifications (except for the coal industry).

The situation formed in energy balance development of the RFE during economic transformations (1992-1998) was not something original in comparison with general economic

situation in the country and the region. In a main sense, the basic parameters of the dynamics of energy balance of the RFE were under pressure of two key factors:

1. Inertia of the highly capital-intensive structure of supply and consumption of energy. This structure, to a prevailing degree, was created under conditions of the centralized economy and cannot be considerably reconstructed under the influence of the newest final market demand, generated during a short, by energy standards, time interval;

2. Long system crisis of the Russian economy and its regions.

In the aggregate, the influence of these factors did not change a long-term crisis character of energy supply of the Far Eastern consumers, but essentially changed its contents during market transformations. In the first case, the problem of constant shortage of energy (more precisely speaking, shortage of energy production capacities), characteristic for the Soviet period, was transformed to a problem of rather high cost of energy supply in the region. The pressure on the part of the second, more global factor, though it has no direct energy grounds, acquired for the energy industry of the RFE an extremely urgent character. It is the most solidly and vividly displayed in the sphere of financing of the assets of energy producers. The consequence of a general system crisis is a grave payment crisis. One should frankly admit that the financial system of the fuel and power enterprises of the RFE is a central problem, which has provoked the energy crisis in the region.

During economic transformations there was an essential reduction in the scale of the RFE energy balance. The reduction in the scale of the energy balance of the region affected all stages of the energy flow. In 1998, in comparison with the achieved maximum levels of the 1985-1991 period, the production of coal made 48 percent, oil - 72 percent, natural gas - 100 percent, the production of electricity – 74.5 percent, oil refining – 36.6 percent (Table 2). According to our estimations, on the whole the production of primary energy in the RFE in 1997 made 68 percent from the level of 1990, gross energy consumption – 67 percent, at the reduction of the industrial product of the region to 43 percent.

(2) Actual Production of Energy Resources in the RFE

	1985-1991 (maximum level)	1995	1998	1999
Coal, million t	57.2	33.9	27.5	29.1
Electricity Generation, billion kWh	45.3	37.1	33.7	35.9
Oil, million t	2.6	1.9	1.86	2.1
Natural gas, billion. ì^3	3.4	3.3	3.4	3.4
Oil refining, million t	10.1	3.4	3.7	5.4

Source: Data from the Statistical Committees of the RFE.

Since 1999 the development trend of the economy and the energy sector of the Far East has changed positively as compared to a sharply negative trend of the period of 1992-1998. The positive trend has been conditioned by a complex effect of the profound rouble devaluation

and growth of world prices for oil. There has been observed a growth in production of electricity, coal, petroleum products, and an increase in effective export. At the same time, in practically all Far-Eastern territories, internal energy consumption has been growing. For instance, in 1999 electricity consumption in the region increased by 6.2 percent. There appeared a positive tendency toward improvement of the structure of payment turnover of fuel and power companies.

The structure of the Russian Far East's Energy Balance has historically been based on a rather high energy dependence. In 1997 more than 36 percent of total primary energy consumption in the Far East was covered by domestic import of crude oil, coal, and petroleum. The energy mix was dominated by coal (47.4 percent) and petroleum (36.1 percent), with a modest share of natural gas (10.2 percent).

It should be noted that the pattern of energy consumption of the Russian Far East differs significantly from that of the whole state. Russia utilizes a lot more natural gas and consumes a lot less coal.

III. Institutions involved in the analysis of energy futures in the Russian Far East

During the period of centralized economy in Russia and in the Far East there was an institutional system of long-term planning and forecasting of energy development. In this system the Far East was considered as a uniform large region. However, during economic reform the system of planning and forecasting of energy development of the country and the region was actually destroyed. The activity of the several centers of the strategic energy futures analysis in Russia and in the Far East was stopped.

Due to efforts in academic circles and experts within a number of federal and regional authorities, a system of strategic planning of the fuel and power sector of Russia is being gradually restored. One of the most remarkable events here is the development of Energy Strategy of Russia [i]. In 1995 Energy Strategy of Russia for the period up to 2005 received a formal approval on the part of the executive authority of the country [ii]. In 1999-2000 the development of the new version of Energy Strategy of Russia for the period up to 2020 has been carried out by the order of the Ministry of Energy.

However, in Energy Strategy of Russia the detailed development of fuel and power industries of the large regions of the country (the Urals, Siberia, the Far East) has not been examined yet. In regional aspect the basic priorities of national strategy have been formulated, the aggregated parameters of energy supply and consumption have been shown.

Energy problems of the RFE are the subject of attention on the part of several organizations. Because of the long crisis and difficulties in economy and energy of Russia and the Far East, comprehensive analysis of long-term energy paths of the RFE is rather seldom done in comparison with the period of the Soviet era. In the last 5-6 years research focused on development of separate branches of energy and of separate sub regions of the Far East have dominated.

Institutions, which are involved in the analysis of energy futures of the Far East:

Public.

Ministry of Energy (Federal Government, Moscow);

Ministry of Economic Development (Federal Government, Moscow);

The Institute of Energy Strategy (Moscow). Affiliated with Ministry of Energy of Russia;

The Institute of Microeconomics (Moscow). Affiliated with Ministry of Economic Development of Russia;

Energy departments of regional administrations of the Far East (each administrative territory of the region).

Academic.

The Energy Research Institute (Russian Academy of Sciences, Moscow);

The Energy Systems Institute (Russian Academy of Sciences, Siberian Branch, Irkutsk);

The Institute of Physical and Technological Problems of the North (Russian Academy of Sciences, Siberian Branch, Yakutsk);

The Economic Research Institute (Russian Academy of Sciences, Far Eastern Branch, Khabarovsk).

Private.

The Designing Institute of Electric Power Industry of the Far East ("Dalenergosetproekt" Institute, Vladivostok). Affiliated with JSC "Dalenergo";

The Designing Institute of Coal Industry of the Far East ("DalvostNIIproektugol" Institute, Vladivostok);

The Designing Institute of Oil and Gas Industry of the Sakhalin territory ("SakhalinNIPImorneft" Institute, Okha). Affiliated with JSC "Rosneft-Sakhalinmorneftegas";

The Far Eastern Representative of JSC "Unified Power Grid of Russia" (Khabrovsk).

IV. Energy Security Options in Russia and in the Russian Far East

In strategic energy research, the Energy Security Concept today in Russia and in the Far East is coming to the forefront and formally claims to have a basic function preference status in energy analysis. However, so far the comprehensive Energy Security Concept has been largely of a tentative character rather than extensively normative. It should be admitted that the energy security issue has not so far been studied in energy forecasts for the Far East. However, certain aspects of this problem are surely taken into account.

The modern legislative approach of Russia to energy security (ES) is based on the purposes of maintenance of military security of the country and on the requirements of contingency plans for management under extreme conditions. There are Laws in Russia "On emergency situations," "On the material reserve," "On safety of hydrotechnical facilities," "On the

subsurface," and a number of other laws and governmental decrees which regulate different requirements for tech-nical safety in the power industry, for the creation of strategic fuel stocks, the creation of the strategic reserves of the discovered fuel deposits and other requirements.

Now ES in Russia gets additional dimensions which probably soon will receive realization in the governmental Doctrine of National Energy Security in Russia[iii]. These new dimensions have appeared in the draft of Energy Strategy of Russia for the period up to 2020.

According to Energy Strategy, Energy Security implies in Russia protection of a person, society, state, and its economy from the threats of inadequacies in meeting their energy demands by technically, economically and ecologically accessible fuel –and power resources of an reasonable quality. The accepted levels of such protection correspond to the full meeting of the reasonable demands under normal conditions and to the guaranteed meeting of the minimum required demands under extreme conditions[iv].

Energy Security is treated in terms of existence of Threats to Energy Security of the country. Voropai *et al.*[v] have grouped these Threats into six classes presented in Table 3.

(3) Main Threats to Energy Security of Russia

Group of Threats	Threats
I. Economic	Shortage of investments; Financial destabilization of economy, non-payments; Low technical level of energy equipment; Excessive concentration in energy supply; Weak diversification of energy supply; Insufficient energy reserves; Excessive energy intensity of economy; Leading growth of energy demand;
II. Socio-political	Labor conflicts; Political, ethnic conflicts; Excessive environmental impacts of energy sector; Ecological extremism;
III. External economic and external political	High dependence of domestic energy producers on imported equipment and materials, disruption of delivery; Discrimination measures against Russia and its businesses; Critical dependency of state budget revenues on the receipts from energy resources export;
IV. Technogenic	Aging, wear of energy producing equipment; Accidents, explosions, fires on the energy objects;
V. Natural	Natural disasters (earthquakes, storms, floodings, etc.); Severe winters; Long-term low waters on the rivers with hydro-power plants;
VI. Managerial-legal	Incompleteness and imperfection of energy-related legislation; Inefficient energy saving policy

This is quite a wide approach to analyzing Energy Security. The Energy Security of Russia and of the Russian Far East, analyzed in a more pragmatic context, is represented by the following areas of concern:

- energy supply of economic growth;
- tecnnical and technological reliability of energy;
- structural security of energy development;
- environmental sustainability of energy development.

It is important to mention also that Russia and the Russian Far East approach the problem of Energy Security mostly in terms of physical disruption and impact rather than in economic terms.

Energy Security in Russia, at the level of general principles, requires decisions and measures minimizing the risks of appearance of threats to ES. The basic principles of the ES provision in Russia are as follows:

- sufficient energy supply;
- energy independence of Russia;
- diversification of fuels and energy;
- development of multilateral energy cooperation;
- the necessary material, technical and structural reservation;
- ecological acceptability;
- a governmental energy saving policy;
- adequate compensation for non-renewable primary energy resources;
- timely capital assets renovation in the power sector;

So, Energy Security in Russia is viewed in terms of risk of demonstration of threat to ES. The difficulty for the analysis is the fact that only a small part of threats to ES (technogenic, natural) allows an objective approach to measurement of the probability of unfavorable events (threats). The larger part of threats to ES has an uncertain character and can be taken into account in the analysis only on the basis of subjective probability opinions of experts, analysts, decision-makers. For this reason it is impossible to offer a universal positive pattern of analysis as well as making of effective decisions with regard for the energy security requirements.

As has been noted above, in the energy forecasts made for the Far East, the problem of ES is not studied directly. Implicitly from the works available one can single out the following positions, which by nature correspond to the principles of ES provision in the Far East:

- overcoming the internal energy crisis in the Far East;

- energy supply of the regional economic growth;
- enhance energy cooperation with NEA countries;
- technical and structural reservation;
- diversification of energy balance;
- energy saving policy;
- energy independence of the Far East;
- ecological acceptability of the power industry development.

V. Comparative Advantages Backgrounds of Energy Futures Analysis in the Russian Far East

The concept of the region's energy and economy active development is at the forefront of Energy Futures Analysis in the Russian Far East and has at its basis the comparative advantages theory.

The idea of regions' competitiveness in interregional division of economic activity is based on competition to attract economic resources to the region. The regions that continuously raise their competitiveness by different regimes and methods and can attract a large share of resources and market will win in a competitive struggle.

Strategically, the Far East's regional authorities are compelled to compete strictly for the distribution of resources in favor of energy projects of their own territory, using, together with the managers of the concerned energy companies, a diverse set of measures of influence, in order to mark and enhance the comparative advantages of their own projects.

The comparative advantages of the Far Eastern energy sector can be presented in the focus of the following determinants:

Geopolitical:

G.1. General Geopolitics
G.2. Regional Geopolitics

Economic:

E.1. Basic factor conditions
E.2. Availability of the supporting infrastructure
E.3. Conditions of the domestic demand
E.4. Conditions of external demand

Our approach to classification of the indicated above determinants is rather conditional, since these determinants exist not as a set of isolated components, but as a dynamic system.

It should be noted that the comparative advantages of the energy of the Far East, by number of determinants, have a contradictory character and they are not absolute.

G.1. General Geopolitics

At present the trends and potential of energy development of the Russian Far East can be considered within the general economic and political strategy of Russia in the eastern geopolitical direction.

Russia has a strategic problem in the Asia Pacific Region, a problem of consolidation in the subregion of Northeast Asia, and in the Asian-Pacific region as a whole, as an influential subject. The interests of Russia as a Euro-Asian power, undoubtedly, face not only the West, but also the eastern geopolitical direction. The growing importance of the Asian-Pacific region in the world economy will increase, in perspective, the significance of the Russian Far Eastern territories as an adjacent zone.

The full-scale development of the Far Eastern energy resources with the purpose for them to enter the energy intensive APR and NEA markets can create material grounds for enhancement of Russia's geopolitical positions in this strategically important region of the world.

G.2. Regional Geopolitics

Over the period of economic reform in Russia, under crisis conditions the Far East has almost lost its development potential. The industrial product in 1998 made 40% of the 1991 level, the volume of investment in fixed capital in 1997 made only 17.7% . The Far East's development during economic reform is characterized by the contraction of the region's share in the Russian economy in most economic indicators, and the diminution of its role in Russia's economic circulation. Since 1992, continuous outflow of the poplulation from the Far East has been observed.

According to regional leaders and experts dealing with the Far East's problems, the creation of an effective social-economic system in the Far East, strengthening of Russia's strategic positions in the Pacific region should be effected only under conditions of pursuing a long-term state policy directed at accelerating the rate of the Far East's development, creating a stable economic system in the Far East, integrated into the international market.

A certain positive example in strengthening the RFE's geo-regional position is the adoption, in 1996, of a Federal Program of the Social and Economic Development of the Russian Far East up to 2005. The Program legally consolidates the strategic interests and long-term priorities of Russia with regard to the eastern regions of Russia. Though the Program is implemented with great difficulties, at present it is a political and institutional recognition of the Far East as an important region of the country in pursuing the eastern geopolicy of Russia.

The general economic crisis in the Far East is accompanied by an energy crisis. Therefore it is believed that state support of the regional development in the Far East should first of all imply solution of the energy problem.

This determinant has a negative character. However it is an important background in energy forecasts for the Far East. It is an advantage in the sense that it is used for an objective appeal to the federal government in order to obtain assistance and preferences (that is, resources) for the general regional and energy development.

E.1. Basic factor conditions

In the vast territory of the Russian Far East titanic reserves of diverse primary energy resources are concentrated. In the region there are not only traditional commercial primary energy resources - coal, oil, natural gas, hydro-power - but also a wide range of nontraditional sources of primary energy (tidal, geothermal, wind, solar, etc.). The general amount of potential oil resources is estimated here to be 29 billion tonnes, of natural gas - 23 trillion m^3, coal 2.2 - 3.5 trillion tonnes. Geological exploration of the potential resources remains low. At present, the degree of exploration of oil potential resources in the Far East makes less than 2.5%, of natural gas - about 10%, of coal - less than 2%.

The discovered reserves of solely commercial primary energy resources amount in the Far East almost to 16 billion tonnes of oil equivalent (TOE), from which over 3 billion TOE account for high quality and transportable crude oil and natural gas resources (Table 4). The probable output of major and middling rivers of the RFE is estimated to be 1008 billion kWh of average annual output.

The discovered primary energy reserves in the region are sufficient to provide the production of primary and transformed energy resources, which exceed tens and hundreds of times the obtained maximum levels of internal energy consumption of the Russian Far East.

(4) Discovered Reserves* of Primary Energy of the RFE, (MTOE**)

	Coal	Oil	Natural Gas	Hydro	Total
Republic of Sakha	6,700	375	1,200	115.5	8,390.5
Magadan territory	710	14	13.3	33	770.3
Kamchatka territory	160	0	20.3	11.6	191.9
Amur territory	1,150	0	0	17.5	1,167.5
Khabarovsk territory	1,280	0	1.75	45.5	1,327.3
Primorskii territory	1,400	0	0	5.8	1,405.8
Sakhalin territory	1,080	620	850	1.1	2,551.1
The RFE as whole	12,480	1,010	2,085.4	230	15,802.4

* The estimates are made for coal as of 01.01.97, oil and natural gas as of 01.01.95 by categories A+B+C1+C2. For hydro theoretical potential is shown.
** MTOE – million tonnes of oil equivalent.
Source: Data from ERI.

E.2. Availability of the supporting infrastructure

The vast territory and uneven character of economic development of the Far East have formed several local types of general purpose infrastructure in the region. In the most developed

southern districts there exists a fairly developed general purpose infrastructure that currently has vacant reserves of production potential - railroad network (Trans-Siberian, the Baikal-Amur Railway), sea ports, roads, and communications.

On the other hand, the highest quality prospective energy reserves in the RFE are concentrated in severe, least developed and hard–to-access northern districts, and also in the shelf zones of the Far-Eastern and arctic seas, which have no adequate infrastructure and developed transport links with the districts of concentration of industry, population and external markets.

E.3. Conditions of the domestic demand.

The conditions of domestic demand for energy have so far exerted a restraining influence on the establishment of comparative advantages in the production of energy resources.

The enormous territory, uneven character of industrial development, location of key industrial centers in separate localities separated by large undeveloped spaces hinder the creation in the RFE of an integrated fuel-and-power system like those of Siberia and the European part of Russia. The low concentration of energy consumers (particularly in the vast northern and north-eastern districts) compels one to base energy supply of the industrial centers on relatively small (with some exceptions) energy enterprises. A relatively low scale of home demand, which has been falling in volume over the recent years, objectively restricts the potential of withdrawal by enterprises of the RFE power industry of the economies of scale effect which is traditionally high in the energy sector.

Proceeding from the extent and the most optimistic assessment of the dynamics of internal energy consumption, it is not possible to count on the creation in the region of powerful fuel-and-energy projects, on the basis of resources of the Elginskiy hard coal deposit, the resources of hydrocarbons of Western and Central Yakutiya, the shelves of the eastern and arctic seas (including the projects on the Sakhalin offshore zone), the cascade of Uchur hydro-power plants, the set of powerful thermal power plants in Sakhalin, the Tugur tidal power plant. However, even taking into account the grave restrictions in the infrasructure, these projects are on the whole commercially effective due to a high effect of the economies of scale.

E.4. Conditions of external demand.

The favorable geographic position of the Far East makes it possible to use its rich energy potential on large energy resource markets of the APR and, above all, the NEA.

Within the NEA region, the conditions of external demand for energy exert an influence, incomparable with internal, on the assessment of production potential of the energy sector in the Far East.

For the Far East of principal importance is the correlation between consumption and production of primary energy in leading countries of the NEA region (Japan, China, South Korea). This correlation shows a high dependency of the energy balance of these countries on external import of basic fossil energy resources - oil, natural gas, coal. According to the forecasts of various research institutions, in the future NEA countries will increase import of primary energy resources. So far, the participation of Far Eastern suppliers of energy resources in covering import of NEA countries has been symbolic.

At different stages of feasibility in the Far East are a few large-scale export-oriented projects.

The projects for the development of oil-and-gas resources on the north-eastern shelf of the Sakhalin Island.

Here, at a high degree of economic and legal readiness, are major international projects Sakhalin-1, Sakhalin-2, and Sakhalin-3. The conception of the Sakhalin shelf development envisages licensing, consecutive in time, of the parts Sakhalin-4,5,6, and so on (approximately up to 10).

The projects on the Sakhalin shelf are planned to be developed jointly with large corporations (Exxon, Shell, Mitsui, Mobil, Texaco, BP Amoco, and others). All Sakhalin projects envisage oil and natural gas deliveries for export to NEA countries as well as to the domestic market.

Some of the characteristics of Sakhalin shelf projects are shown in Table 5.

The project Sakhalin-2 is under practical development. Currently, the first offshore platform in the Piltun-Astokhskoe License Area is already installed. The initial complex for the extraction of oil, given a name "Vityaz,'" comprises a marine drilling platform ("Molikpaq"), a floating oil storage & offloading tanker, and a subsea pipeline. It is planned this year to extract 1.5 million. tonnes of oil.

The projects Sakhalin-1 and Sakhalin-3 are at the stage of pre-feasibility studies.

(5) Characteristics of Sakhalin Offshore Projects.

	Projected reserves		Expected maximum annual output		Estimated costs, $US billion
	Oil and condensate, million tonnes	Gas, billion. m^3	Oil and condensate, million tonnes	Gas, billion. m^3	
Sakhalin-1	324	421	24.1	17.0	10
Sakhalin-2	100	494	7.9	15.7	15
Sakhalin-3 (Kirinskiy block)	453	970	n/a	17.7	15
Sakhalin-3 (Ayshskiy and East Odoptu blocks)	114	513	n/a	n/a	n/a
Sakhalin-4	123	540	n/a	n/a	n/a
Sakhalin-5	154	450	n/a	n/a	n/a

Source: Data from JSC "Rosneft-Sakhalinmorneftegas"; S. Stefanopoulos, 1998. The Oil and Gas Industry of Sakhalin Island. An Introduction. Russian Far East Update and Pacific Russia Oil and Gas Report. Elisa Miller, editor and publisher. Seattle, USA. The future of Oil and Gas in the Russian Far East. Financial Times Energy. London. 1999.

The development of oil-and-gas resources of central and west Yakutiya, with orientation towards pipeline export of natural gas to the NEA region.

In Yakutiia the basic oil-and-gas deposits are concentrated in its central and south-eastern part and are complex. Important for export are natural gas resources. Oil extraction is oriented towards local demands. There exist different variants of development of Yakutian oil and gas deposits with the prospect of pipeline export of natural gas to the Korean Peninsula, China, and potentially to Japan.

In 1996, representatives of South Korean and Yakutian companies completed a feasibility study on the development and transportation of Yakutian gas (project Sakha-gas, Table 6). The Sakha-gas project was oriented towards the development and exploitation of gas and oil fields in central and south-western Yakutiya with the construction of a 6,600 km, 20-32 billion m^3/y gas pipeline from Yakutiya to South Korea via Tynda-Blagoveschensk-Khabarovsk-Vladivostok-Pyongyang.

As resources for the project Sakha-gas, 11 deposits have been chosen with total predicted reserves of about 4,000 billion m^3 (the confirmed reserves are about 1,000 billion m^3)[vi].

(6) Basic Indicators of the Sakha-gas Project

	Variants			
	I	II	III	IV
Maximum annual output, billion m^3	34.7	34.7	43.7	43.7
Maximum annual export, billion m^3	13.7	20.5	19.2	28.1
Total investments, $US billion	17.4	18.2	22.6	23.5
including pipeline costs	9.6	10.5	11.8	12.6

Source: Energy and Mineral Resources of the Far East and Trans-Baikal Regions: An Investment Atlas. Khabarovsk. Inter-Regional Association for Economic Cooperation. 1997, p. 102.

South Yakutiya-Sakhalin-Japan electricity bridge "Far East - Japan".

In 1997 Russian electricity holding JSC "UES of Russia" ("RAO EES Rossii") announced the project of the creation of a high-capacity electricity bridge "Russia - Japan" through the construction of two large thermal power plants on Sakhalin Island, on the basis of natural gas of the shelf and coal of the Solntsevskoe deposit (south-western coast of Sakhalin Island), the construction on the Aldan river's tributaries of the cascade of hydro-power plants (South Yakutiya), of total installed capacity about 11,000 MW, with subsequent transmission of electricity from these thermal and hydro-power plants via DC transmission lines to Hokkaido and Honshu of Japan (Table 7). Four major power plants built in southern Yakutiya and Sakhlin could supply Japan with 20 billion kWh annually at the first stage and up to nearly 50 billion kWh after the electricity bridge's completion.

(7) Indices of Electricity Bridge "Far East - Japan" Project.

	Designed installed capacity, million kW	Output per year, billion kWh	Cost estimated, billion $US
Coal-fired thermal power plant in Sakhalin	2,100	12.0	8.0
Gas-fired power plant in Sakhalin (steam-and-gas cycle)	3,920	23.5	
HPP in South Yakutiya (Uchur river)	3,700	17.0	7.0
HPP in South Yakutiya (Timpton river)	1,300	6.0	2.6
South Yakutiya-Sakhalin-Japan HV transmission lines (via DC converter)	11,000	appr. 50.0	6.6

Source: Vladimir I. Ivanov. Towards a Comprehensive Approach to Energy Projects in Eastern Russia. Paper presented at the Workshop on Energy Security and Development in Northeast Asia: Prospects for Cooperative Policies. Niigata, December 17-19, 1999; Pasport kontseptsii sozdaniya i ispol'zovaniya elektroenergeticheskogo potentsiala o. Sakhalin. RAO EES Rossii. Moskva. 1997.

Elginskiy hard coal project (Table 8)

This project is oriented towards the construction of a large Elginskiy open-pit coal mine in South Yakutiya of high-quality hard coal (proved reserves of 2.5 billion tonnes). The Elginskiy deposit's coals are fit for coking and for energy use. The coals are characterized by a low content of sulfur, phosphorus and moisture. Their caloric value is 6930-7385 kcal/kg. The main difficulty for the Elginskiy deposit development is the necessity for transport infrastructure construction (a railway about 370 km long).

(8) Elginskiy Hard Coal Project Indices.

Lower heating value, kcal/kg	Sulfur (daf, %)	Ash (daf, %)	W, %	Phosphorus, (P, %)	Reserves, billion tonnes	Designed capacity, million tonnes per year	Expected investments, $US billion
6930-7385	0.18-0.5	15-30	3-7	0.001-0.045	2.5	10-20	2.2

Source: Data from "Yakutugol" Company; 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.

Interstate electricity ties of IPG "Vostok" with China and the two Koreas.

There are favorable geographic and technological opportunities for interstate electricity cooperation in the southern part of the Russian Far East where the Integrated Power Grid "Vostok" (IPG "Vostok") operates (Amur territory, Khabarovsk territory, Primorsky territory). The initial process of international electricity integration is based on border trade in electricity with the forthcoming step-by-step transition to large-scale energy transmission and to international market of electricity in the Northeast Asia region. It would enable the participating countries to gain substantial economic benefit from the joint operation of the system due to the saving of reserves, fuel, mutual assistance, and so on.

Considering the size of the ongoing and planned thermal power plants, hydro- and probably nuclear power stations in the IPG "Vostok", their productivity, and their location, these projects could also contribute to electricity export to China, and North and South Korea[vii].

VI. Description of Studies for Energy Futures Analysis in the Russian Far East.

All energy futures analyses for the Russian Far East performed in the last five years are formed on about the same type of backgrounds, key uncertainties, and basic recommendations as for economic growth in the region and its energy sector development. Here a high strategic uncertainty is a key characteristic of the future analyses made.

The key uncertainties are the following:

- uncertainty as to social-economic stabilization in Russia;
- uncertainty as to the dynamics and future economic pattern of the Far East;
- uncertainty as to the dynamics and future energy consumption pattern;
- uncertainty as to sources of financing of the energy projects;
- uncertainty as to technical-economic performances of equipment and energy installations, future prices for energy resources in the region and on external markets;
- uncertainty as to opportunities and scope of cooperation with foreign companies in terms of foreign investment in the development of energy projects in the Far East, opportunities of obtaining innovative foreign equipment, opportunities of energy resources export from the Russian Far East to NEA markets.

To overcome and partially to resolve these uncertainties, experts apply two main methods:

- methodology of the scenario approach to determining strategic parameters of development of the Far East's economy and power industry, based on subjective expectations of experts involved in the analysis;

- adoption of the strategy of active development of the Far East's economy and energy sector;

The active development strategy is based on the necessity:

- to grant the Far East special status by the state;
- to allocate state subsidies to the Far East;
- to establish preferential institutional treatment in the Far East, primarily to perform operations connected with the international market. This implies creation in the Far East of more liberal conditions than in Russia as a whole for movement of capital, technologies, and people between the Russian Far East and its foreign counterparts.

State assistance and ownership internationalization are the key methods to overcome uncertainty in the Far East's energy sector development.

All the studies conducted are based on approximately the same strategic backgrounds and recommendations as to the Far East's energy sector development. Objectively, here specialists and experts have no principal disagreements.

Basic backgrounds for the region's energy sector development are the following:

- availability in the Far East of large and diverse primary energy resources;
- necessity to restore economic growth in the region;
- necessity to overcome energy crisis in the region;
- favorable geographic position of the region compared to the dynamically developed NEA countries;
- presence of the structural backgrounds for integration of the Far East's energy resources into the NEA energy space;
- necessity to enhance Russia's geopolitical role in the Pacific region through accelerated development of the Russian Far East's economy and its involvement in extensive cooperation with APR and NEA countries.

In a general structural aspect, the basic strategic decisions on the formation of effective structure of energy balance in the RFE envisage:

- increase in energy and economic efficiency of all stages of production, conversion, distribution, and final use of energy;
- sharp increase in the share of natural gas and crude oil in regional production of energy resources and expansion of their use in internal energy consumption. The basis of such decisions is large-scale development of oil and gas resources of the Sakhalin shelf, the Republic of Sakha (Yakutiya), and local development of gas reserves in Kamchatka;

- active participation of the Far Eastern fuel and energy resources in the energy markets of the NEA countries;

- stabilization and then escalation of the volumes of coal production mainly in open mines and increase of coal quality by means of development of the processes of its enrichment;

- intensification of development of local energy resources and non-traditional sources of energy;

- rejection of excessive centralization and concentration of power supply and rational combination of centralized and local systems of energy supply;

- further development of electrification; diversifying of the raw base of the electricity industry by means of proportional participation in the electricity generation of coal, natural gas, hydro-, and probably, nuclear and non-traditional sources of energy; development of electricity trade with the NEA countries; and purchase of the effects of joint (parallel) work of interconnected power systems of Siberia, the Russian Far East, China, Japan, and North and South Korea;

- technological updating of the types of generating equipment of thermal power plants by using ecologically safe coal-fired power generating units, introduction of modern types of equipment with steam-and-gas cycle, and gas turbine units;

- increase, at the expense of sufficient volume of exploration and prospecting works, of regional primary energy potential;

- ecological and technical safety of the sources of energy and reliability of power supply of the consumers.

With all the objective difficulties in conducting an energy futures analysis in the Russian Far East, the common drawback of the studies conducted is insufficient attention to the strategic problems of the energy ecological safety and the problems of energy security, particularly international aspects of these problems in the NEA region. One should admit that the problems of restoration of economic and energy development in the Far East, commercial criteria, and goals remain dominant determinants in energy futures analyses in the Russian Far East.

VI. 1. Study on Comprehensive Energy Plan in East Siberia and Far East of the Russian Federation.

The Study[viii] had been implemented by group of Russian and Japanese experts under supervision of IEEJ (Institute of Energy Economics, Tokyo, Japan) and ERIR (Energy Research Institute, Moscow, Russia) during 1992-1995.

The ultimate objective of the Study is to establish a comprehensive energy master plan in East Siberia and the Russian Far East.

Objectives include:

1. Development of an energy supply and demand forecast up to 2010;

2. Development of an infrastructure plan regarding export of East Siberia's and the RFE's energy resources to NEA;

3. Development of institutional measures in Russia for regional energy resources development.

S-1. Economic Growth Backgrounds.

The backgrounds for economic development of the Russian Far East and East Siberia that were stated in the Study were based on the backgrounds of economic growth in Russia as a whole. The economic growth dynamics were based on the expectation of the final date of economic decline in Russia and the expert assessments of the 1990 GNP level restoration by 2010 (Table 9).

(9) Economic Growth Scenario for Russia and the Far East

Scenario	Estimated final date of GNP decline	Level of GNP 2010 to GNP 1990, %	AAGR*** from GNP bottom up to 2010, %
Optimistic*	1995	124	21.4
Probable*	1995	100	19.6
External**	1998	108	27.2

* Proposed by Russian experts
** Proposed by Japanese experts
*** AAGR – Average Annual Growth Rate

In subsequent analysis the experts used only an External Scenario. The possible pattern for the Far East's economy was not studied for this scenario. It was assumed that the basis of the region's economic growth would be made mainly by the region's natural resources (non-ferrous metallurgy, iron, wood, wood processing, oil, and gas).

S-2. Energy Demand Premises.

The dynamics and structure of energy demand stated in the Study were assessed on the basis of an External Scenario for economic growth. The Study examines the dynamics and pattern of final energy consumption and the demand dynamics for certain energy resources. An hypothesis was adopted that total final energy consumption would increase to 107% of the 1990 level in

2010. In the period 1995-2010, the final energy consumption pattern was to remain relatively stable both by energy sources and by sectors (Tables 10 & 11).

The pattern and dynamics of gross energy consumption were not considered in the Study.

(10) Final Energy Consumption by Sector in the Far East, MTOE

	1990 (actual)	1995 (estimated)	2005 (forecast)	2010 (forecast)
Industry	11.5	9.7	12.0	12.8
Transport	11.3	8.4	9.3	9.6
Other Sectors	10.0	11.0	11.4	12.0
Non-energy use	0.2	0.2	0.6	0.9
Total	33.0	29.3	33.3	35.3

(11) Final Energy Consumption by Sources in the Far East, MTOE

	1990 (actual)	1995 (estimated)	2005 (forecast)	2010 (forecast)
Heat	9.8	9.4	9.8	10.0
Electricity	3.0	2.6	3.3	3.8
Gas	0.8	0.8	1.7	2.8
Petroleums	15.7	13.7	14.7	14.8
Coal	3.0	2.9	3.1	3.2
Other sources	0.7	0.6	0.7	0.7
Total	33.0	30.0	33.3	35.3

S-3. Energy Supply/ Demand Forecasts.

In the Study the focus of attention was analysis of the future situation in the Russian Far East (also East Siberia) in terms of certain energy resources: oil, natural gas, coal, and electricity. The emphasis was shifted to evaluations of economic feasibility of the proposed energy projects' development and opportunities to organize energy resource export from East Siberia and the Far East to NEA countries.

S-4. Electricity supply/demand forecasts.

Levels of supply and demand for electricity in the Far East were predicted to reach the levels shown in Table 12. The total additional capacity to be gained through the construction of new

hydro and thermal power plants and the total additional capacity to be gained through the updating of existing fuel-based power plants is shown in the table below.

(12) Projected Demand for and Supply of Electricity in the Far East

	1990 (actual)	2005	2010
Total electric regional demand, billion kWh	47.3	60.6	66.8
Supply, billion kWh :			
Hydro-power	11	17	20
Thermal power	36	43	44
Nuclear power	0.3	0.6	2.8*
Existing Production, billion kWh	47.3	22.8	11.0
Required Production of new development, billion kWh	0	37.8	55.8
Necessary additional power capacity, MW	0	9,100	11,700
Hydro: New	0	2,400	3,000
Thermal: New	0	0	0
Re-built	0	6,500	8,700

* As a probable variant through the construction of a new nuclear power plant of 1,000-2,000 MW located either in Khabarovsk territory or in Primorsky territory.

The following table provides a list of those projects that in the Study were deemed to be particularly promising in terms of the ease of the construction of power plants and transmission lines.

(13) List of Recommended Electric Power Constructions

	Capacity, MW	Output, billion kWh	Investments, million $US
Bureiskaya and Nizhne-Bureiskaya HPP (under construction)	2,430	8.6	2,580
Urgalskaya HPP (new)	600	1.8	1,260
Re-built TPPs	8,700	44	5,900

The Study emphasized the creation of a self-balanced electric energy system in the Far East primarily on the basis of reconstruction and updating of operating thermal power plants and completion of construction of the Bureiskaya and Nizhne-Bureiskaya hydro-power plants in the Amur territory.

S-5. Coal supply/demand forecasts.

The Study notes availability in the Russian Far East of large proved coal reserves (over 30 billion tonnes). However, in economic respect more attractive in the Far East are mainly brown coal reserves (16.4 billion. tonnes of proved reserves). With the exception of a small proportion of the total reserves, the quality of the brown coal in the RFE is good, with sulfur content ranging from a low of 0.13% to a high of 0.87%. Hard and brown coal reserves in the RFE include a certain portion of reserves with high ash content.

Levels of supply and demand for coal in the Far East calculated in accordance with the external economic development scenario are shown in the Table 14.

(14) Forecasted Demand for and Supply of Coal in the Far East

	1990 (actual)	2005	2010
Coal Demand, MTOE	16.5	20.7	22.1
Coal Production, MTOE	20.1*	15.2	15.7
Total Coal Production, million tonnes	49.8	55.0	55.2
Existing Production, million tonnes	49.8	29.5	27.0
Required Production of new development, million tonnes	0	25.5	28.2

* Surplus was mainly conditioned by extraction of coking coal in South Yakutiya that was utilized outside the region.

Actually, due to the uncertain situation regarding natural gas extraction in the Far East, the experts in the Study proposed that the growth of the region's basic demand for primary energy be covered by coal. Based on the results of the energy supply optimization and individual resource production volume analyses, as well as considering the expected investment shortage, the experts recommended to use coal imported from East Siberia to meet the regional demand for coal.

Those hard coal-mining projects that had been selected for consideration in the Study as a result of their high potential for new development in the Far East are listed in Table 15.

(15) Promising Hard Coal Development Projects in the Far East.

	Name of Hard Coal Project		
	Urgalsky (open cut)	Ogodzhinsky (open cut)	Elginsky (open cut)
Location (Administrative Area)	Khabarovsk (north-west)	Amurskaya (north)	Yakutiya (south)
Reserves, billion. tonnes	1.2	0.04*	2.9
Operating Capacity, million tonnes/ y	2.0	0.1	-
Designed Capacity, million tonnes/ y	5.5	10.0	10.0
Total investments, billion $US	0.6	1.5**	2.1**
Characteristics:			
Caloric Value, daf*** kcal/ kg	7,420	7,400	8,100
Sulfur, daf %	0.3	0.5	0.4
Ash, %	34.5	40.0	15-30

* Probable reserves of 0.8 billion tonnes

** The amount of investments requires constructing railroad lines to service these remote locations.

*** dry ash free

S-6. Oil and Gas supply/demand forecasts.

The experts in the Study focused their great attention on examination of opportunities for efficient productive capacities in the development of oil and gas deposits in East Siberia and the Russian Far East. According to the author, this was caused by the following reasons:

- There are favorable prospects for oil and gas export to NEA countries;
- The main promising oil and gas deposits for development in these regions of Russia require high investment which can be made only by large foreign companies;
- Effective oil and gas production is necessary in amounts exceeding the most optimistic estimations of internal demand for these energy resources;
- Economic instability in Russia creates increased risks for investors in terms of planning the sale of production, first of all, on the internal market of Siberia and the Far East;
- For the safe compensation of costs and investors' rates of return it is necessary to export a considerable part of oil and natural gas.

For these reasons the experts did not pay much attention to the dynamics of internal demand for oil and gas. To be more exact, they estimated minimal export volumes of oil and gas which would be necessary for profitable development of oil and gas deposits in East Siberia and the Far East. The excess of resources over minimal effective export volumes was designated for internal use.

Two basic promising centers of oil and gas extraction were distinguished in the Study: the Siberian Platform and Sakhalin Offshore.

The levels of extraction of natural gas and oil and the feasible schedules of hydrocarbon supplies for export to NEA countries from the sea deposits within the projects Sakhalin-1, Sakhalin-2 are given in Tables 16 & 17.

Another variant has been proposed in the Study connected with joint development of hydrocarbons within the south-west and central districts of Yakutiya, the neighboring deposits of the Irkutsk, and the Krasnoyarsk territories, which are situated on the geologically single Siberian Platform (Tables 16 & 17). The total recoverable reserves of the Siberian Platform constitute almost 1300 million tons of oil and more than 3.6 trillion m^3 of natural gas.

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 billion 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, with recoverable reserves of 870 billion m^3) and a group of Yakutian fields with overall reserves of 1190 billion m^3 (Srednevilyuyskoye, Srednetyungskoye, Chayadinskoye, and others). The cost of the development plan for gas resources on the Siberian Platform and their delivery for export to NEA countries is estimated at 34-37 billion dollars (depending on the variants of routes of the large-scale gas pipelines), 11 billion dollars of which are intended for the development of the gas deposits of Yakutiya, for building there pipelines to provide gas to local areas, and building feeder pipelines to be connected to the large-scale pipeline.

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

(16) Proposed production and distribution of oil in the Siberian Platform and in the Sakhalin Offshore, (million. tonnes)

	1994 (actual)	2005	2010
Siberian Platform deposits:			
Extraction	0.16	26.0	46.0
including Yakutiya	0.16	1.9	2.0
Consumption in Yakutiya	0.16	1.9	2.0
Export	0	0	18.7
Sakhalin Offshore:			
Extraction	1.5*	10.3	27.0
Local consumption	1.0	2.3	3.0
Export	0.5	8.0	24.0

* Extraction on Sakhalin mainland

(17) Proposed production and distribution of natural gas in the Siberian Platform and in the Sakhalin Offshore, (billion m^3)

	1994(actual)	2005	2010
Siberian Platform deposits:			
Extraction	6.3	35.2	46.7
including Yakutiya	1.6	13.8	18.7
Consumption in Yakutiya	1.6	2.2	2.7
Export	0	27-29	31-33
Sakhalin Offshore:			
Extraction	1.8*	16.5	24.5
Local consumption	1.8	4.0	4.5
Export	0	12.5	20.0

* Extraction on Sakhalin mainland

S-7. Building of Infrastructure.

In the Study it was indicated that in both East Siberia and the Far East the areas in which energy resources are located are far removed from the centers of energy consumption, and for this reason it would be necessary to build the infrastructure needed to ship energy products from the sites where they are produced to these centers of consumption.

The Study considered only big strategic variants: shipments of energy resources with emphasis on effective energy resource export from East Siberia and the Far East. The following variants of energy resource transportation were considered:

- The use of the Trans-Siberian and Baikal-Amur railroads for shipments of coal and oil. However if export plans require crude oil export above the critical level of 17 million tonnes per year, it will be necessary to construct a large-scale trunk pipeline;

- The construction of a large-scale trunk pipeline for the export of natural gas from the Siberian Platform including construction of LNG Terminals in destination points;

- The construction of local oil and gas trunk pipelines on Sakhalin[ix] to transfer oil and gas from offshore to the south of the island for the subsequent marine export of the products;

- The construction of an HV DC transmission line for electricity export to China and Japan from East Siberia and South Yakutiya;

- The construction of two supporting railroad lines for their use in development of hard coal deposits in the South Yakutiya and in the Amur territory (Elginskoe Coal Field Development Railroad (374 km), Ogodzhinskoe Coal Field Development (144 km)).

For the construction of main oil and gas trunk pipelines from East Siberia, the Study recommended two alternative variants for subsequent analysis: East-West Route and Southbound Route. Their characteristics are shown in Table 18.

(18) Indices of Export Trunk Oil-and-Gas Pipelines from East Siberia to NEA

	OIL		GAS	
	East-West Route	Southbound Route	East-West Route	Southbound Route
Itinerary	Ust-Kut (Irkutsk) – Chita – Harbin – Zarubino (Primorsky)	Ust-Kut (Irkutsk) – Ulaanbaatar – Beijin - Tanggu	Ust-Kut (Irkutsk) – Tynda (Amur) – Harbin – Zarubino (Primorsky)	Ust-Kut (Irkutsk) – Ulaanbaatar – Beijin - Tanggu
Pipe Diameter (mm) Pipe Length (km)	762 3,500	762 2,700	1,422 3,500	1,422 2,700
Operation Start	2010	2010	2005	2005
Design Capacity	25 million tonnes per year	25 million tonnes per year	34 billion. m^3 per year, 12 million t of LNG	34 billion. m^3 per year, 12 million t of LNG
Investments, billion. $US	4.4	3.5	13.9	11.5

Rough calculations were made to create a test proposal for the use of the excess of hydro-power resources in East Siberia and the Far East in electricity which might then be exported via high-voltage DC transmission lines to China and to Hokkaido in Japan. The plan provides for the construction of HV DC transmission lines with a capacity of 5,200 MW (750 kV).

Table 19 provides a list of some rough estimates of the cost of construction of the transmission lines provided for in this plan.

(19) Estimated HV DC Transmissions Costs

Route	Distance, (km)	Investments (million $US)	
		Transmission lines	DC Substation
East Siberia - Beijing	2,800	3,350	900
South Yakutiya - Beijing	2,100	2,700	950
East Siberia - Hokkaido	4,600	8,230	900
South Yakutiya - Hokkaido	2,200	3,730	950

Since the variant of electricity export from South Yakutiya required the construction there of new hydro-power plants, the main priority in the Study was given to the plan of electricity export from Irkutsk and Krasnoyarsk (towards China) where energy surplus already exists on operating hydro-power plants.

As to its contents the Study cannot be referred to as a comprehensive plan of development of the power industry in the Far East and East Siberia. It has a clear supply-side and also export-oriented character. However, the Study had a significant positive meaning for the subsequent research for better understanding of the possibilities and constraints in the development of energy resources of the Far East and East Siberia. It is largely due to this Study that the ideology of active 'regional development is gaining its strength in the Far East and is directed at integration of the economy and power industry of the region into the NEA economic and energy space.

VI.2. Comprehensive Program "Long-term Energy Development of East Siberia and the Far East up to 2020"

The draft of the Comprehensive Program "Long-term Energy Development of East Siberia and the Far East up to 2020""[x] (hereinafter referred to as "the "Program"") has been developed by a group of specialists from different organizations of East Siberia and the Far East under supervision of Energy Systems Institute (Siberian Branch of Russian Academy of Sciences, Irkutsk). The Far East's participants in the Program are:

- Economic Research Institute (Far Eastern Branch of RAS, Khabarovsk);
- "Dal'energosetproekt" Institute (Electricity Industry, Vladivostok);
- The Far Eastern Representative of JSC "Unified Power Grid of Russia" (Khabrovsk).
- Institute of Physical and Technological Problems of the North (Siberian Branch of RAS, Yakutsk);

It is assumed that the officials of regional authorities and representatives of the main energy companies of East Siberia and the Far East will be involved in the expertise of the draft of the Program. The Program has been implemented by order of the Ministry of Energy of the Russian Government[xi].

The Program has included the provisions of the following studies executed in previous years for the Far East :

- Study on Comprehensive Energy Plan in East Siberia and the Far East of the Russian Federation (1995);
- Development of Coal Industry of the Khabarovsk territory (1996);
- Program of Stabilization and Development of Electric Power Industry of Republic of Sakha (Yakutiya) (1997);
- Mechanisms of Stabilization and Optimization of Fuel and Energy Industries of the Far East under New Economic Conditions (1997);
- Development of Electric Power Industry of the Far East up to 2010 (1998);

- Federal Program of Gasification of the Sakhalin, Khabarovsk, Primorsky Territories (1999);

- Program for the Development of Fuel and Power Industries of the Primorsky Territory up to 2010 (1999);

The Program's main objective is determining the optimum development scenarios of the fuel-and-energy sector of eastern Russia's regions with a view to work out a common state energy policy in these regions.

P-1. Economic and Energy Consumption Growth Premises.

Undoubtedly, the Program has been implemented under substantial uncertainties as to future development of the economy and energy of the Far East. However, considering its governmental status, the authors of the Program have purposefully chosen the policy of active development of the region, based on the necessity of accelerated development of the Far East and its integration in the NEA economic space. Though the Program inevitably faces different variants in realization of the active development policy, on the whole one development scenario has been realized in it.

Due to large statistical difficulties, an assessment of future economic pattern has not been made, nor has possible sector energy consumption been specified in the Program.

The main qualitative preconditions for implementation in the Far East of an active (accelerated) development policy are the following:

1. The logic of the Far East's active development realization includes three equal policy blocs:

- Structural transformation of the economy;

- Furthering attraction of population to the region;

- The region's involvement in the NEA and APR economic system.

2. The basis of the region's potential economic growth is its comparative advantages in the field of elaboration of diverse natural resources (including energy resources), which are enhanced by a favorable geographic position in relation to big NEA and APR markets. Export specialization of the Far East based on natural resource use can be a core of the social-economic development of the region in the first quarter of the 21st century.

3. The region's development should be based on the factor of openness of the economy. This implies introduction of a liberal treatment to facilitate ownership internationalization in the region.

4. Considering the low population of the region, it would be proper to direct the formation of an open economy at the creation of a common economic (but not political) space of the Far East and China, primarily north-eastern Chinese provinces. It would be necessary for this to ease restrictions on the free movement of capital, technologies, and labor force, and to promote integration of transport and energy systems.

5. The natural-resource export-oriented policy of the regional development and the cooperation with the Chinese economy are simultaneously to promote:

- diversification of the economic structure of the Far East through the development of infrastructure, transport, and raw material processing industries;

- formation of a set of high-tech industries using technological innovations (including military equipment production), also oriented for export.

Thus, the structure of the Far East's economy will be gradually shifted toward increase of the share of the secondary and tertiary sectors, which in the authors' opinion will stabilize in the period 2015-2025.

In the authors' view, such an assessment of the future structure of the Far East's economy should provide, along with energy saving measures, reduction of energy intensity of the region's GDP.

The energy consumption dynamics will be characterized by higher electricity consumption rates at moderate growth rates of commercial heat supply due to development of individual housing and the consumers' choice of autonomous heat supply.

Basic indicators of economic growth and energy demand growth are shown in Table 20.

(20) Forecasted Indicators of Economic Growth and Energy Demand Growth in the Far East

	2001-2005	2006-2010	2011-2020
GDP (AAGR*, %)			
Russia	4.9	6.5	5.9
Far East	5.0	6.7	6.5
Energy Consumption in the Far East (AAGR*, %)			
Primary Energy	2.8	3.2	3.0
Electricity	3.2	3.3	3.3
Commercial Heat	1.3	1.5	1.3
Fuels for Generation and Direct Consumption**	2.5	2.8	2.8
Primary Energy Intensity of GDP (2000 = 1)	0.85 (2005)	0.68 (2010)	0.5 (2020)

* Average Annual Growth Rate

** Excluding motor fuels

P-2. Demand/ Supply Forecasts by Sources.

On the whole, energy resources production and development in the Far East will be promoted by the following factors:

- current and projected large-scale dependence of NEA countries on imported primary energy;

- promotion of restructuring of energy policy in the countries of the NEA aimed at liberalization and openness of energy markets of NEA countries;

- development of large oiland-gas deposits, which are attractive for foreign investments, on the Sahkalin offshore and in Yakutiya, with guaranteed market sales on internal and external markets achieved through production-sharing schemes;

- consumers' choice of high-quality fuel resources and, first of all, natural gas;

- desire of the region's electric companies to diversify the structure of energy generation sources through proportional use of coal, natural gas, hydro-, and, possibly, nuclear energy;

- aspiration of electricity producers to develop cooperative links with neighboring NEA countries;

- aspiration on the part of regional authorities and Far-Eastern energy companies to provide and maintain energy independence of the Far East in terms of electricity, coal, oil products, and, possibly, crude oil.

With the expected favorable combination of these factors, the structure of energy consumption and the energy import-export balance in the Far East will change considerably.

The dynamics of the development of the energy sector in the region, by the authors estimation, will involve two periods of development.

The first period of 2001-2010 (Recovery Development – RD).

The RD period assumes economic growth recovery in the region, overcoming negative consequences of the long decline in economic activity in the region's economy and energy sector. The increase in energy consumption in this period on the whole will be provided by underused capacities in the electric power and oil-processing industries. Shortage of coal in the region will stimulate the development of coal production up to the amount of its internal consumption. The demand for crude oil will be covered basically through oil shipments from West Siberia. The most important expected results at the RD stage are:

- Realization of the program of reconstruction and modernization of obsolete equipment of the thermal power plants. It will be necessary to execute complete replacement, by 2010, of over 3,000 MW of installed capacity of thermal power plants (more than 33% of the present installed capacity residing in TPPs).

- Completion of the construction of the Bureiskaya and Nizhne-Bureiskaya HPP (2,430 MW) in the IPG ""Vostok"" zone, with the output growth of about 8 billion kWh.

- Construction of relatively small open-cut coal mines in all subregions of the Far East with coal production amounting to 36-38 million tons (basically brown coal). Though

the discovered coal resources allow higher coal production, the increase in coal output will be restrained by high expectations of consumers in terms of natural gas.

- Energy resource export will be covered by coal deliveries from South Yakutiia (operating Nerungrinsky open-cut), crude oil from the Sakhalin shelf (Sakhalin-2 project), possible construction of export HV transmission lines in the IPG ""Vostok"" zone and the north-eastern Chinese provinces, in connection with the completion of construction of the Bureiskaya and Nizhne-Bureiskaya HPP in the Amur Territory.

- Development of a small gas deposit in Kamchatka and switching the main energy generation sources in Petropavlovsk-Kamchatsky to gas. Construction in Kamchatka of two electric power plants on a geothermal deposit.

- Construction of a small nuclear power plant in Chukotka, replacing Bilibinskaya NPP.

On the whole, by 2010 basic trends will show in the energy consumption pattern of the region, which in the main will be realized after 2010.

The turning-point for significant structural changes in energy production and consumption in the Far East will be the second period, 2010-2020 (Active Development—AD).

In the AD period the development of active extraction of natural gas and oil on the Sakhalin offshore and in Yakutiya will be of critical importance. In the AD period further increase of hydro-power output is expected, due to construction of new HPPs in Khabarovsk, Amur, Primorskiy, and Magadan territories.

After 2010, the Far East should become an active net-exporter of oil, natural gas, electricity and coal.

Basic expected results in the AD period are the following:

- Sharp increase of extraction of natural gas and oil on the Sakhalin shelf up to the amounts, respectively, of 35 billion m^3 and 30 million tonnes per year. Building in Sakhalin, Khabarovsk, and Primorsky territories of the needed gas transportation infrastructure.

- Sharp change of fuel balance structure of thermal power plants and boilers in Sakhalin, Khabarovsk, and Primorsky territories by replacement of coal with natural gas from the Sakhalin shelf.

- Development of oil-and-gas deposits in central and west Yakutiya with gas production of up to 20 billion m^3 and oil production of up to 1.5 million tonnes. Construction of a main export gas pipeline to China.

- Development of the Elginsky hard coal field in south Yakutiya.

- The start of realization of the Electricity Bridge Project ""Far East - Japan"" with the construction in Sakhalin of two large thermal power plants.

- Coal production will be maintained at a relatively stable level of about 38 million tonnes tones (not including the Elginsky hard coal field, which is supposed to be developed for export purposes).

- The variant of construction of a large nuclear power plant (about 2,000 MW) can be considered in the south of Primorsky territory, with the aim of electricity export. However, this variant will strongly compete with the construction here of a thermal power plant working on gas from the Sakhalin shelf.

- Large-scale technological re-equipment of thermal power plants in the Russian Far East with the orientation to advanced types of equipment (steam-and-gas units, ecologically safe coal units).

At the AD stage it is expected that the energy independence strategy of the Far East will be realized practically for all kinds of energy resources.

Also, according to authors of the Program, during the forecast period the use of non-traditional energy sources (wind power, small HPPs, solar, geothermal power) and small fuel deposits in remote districts of the North will be encouraged. However, the role of non-traditional energy sources in the total energy balance of the Far East will be insignificant.

Tables 21, 22, 23, 24, and 25 show estimates of basic structural and volume changes in the energy sector dynamics up to 2020. From the tables it is clear that global priorities of the energy policy of the Far East are the following:

- reorientation to natural gas use;

- hydro-power development;

- export expansion;

- region's energy independence.

(21) Projected Output of Fuels and Energy in the Far East

	1995 (actual)	2005	2010	2015	2020
Electricity, billion. kWh	38.5	46.75	54.1	62.8	89.3
Commercial Heat, million Gcal	80.0	76.3	82.5	89.5	96.4
Coal, MTOE	13.0	14.0	14.6	15.4	19.0
Oil, million tonnes	1.6	3.5	11.1	28.0	31.5
Gas, billion. m^3	3.2	6.5	26.0	35.8	55.3
Total primary fuels, MTOE	17.2	22.75	47.0	72.8	123.3

(22) Projected Consumption of Fuels and Energy in the Far East

	1995 (actual)	2005	2010	2015	2020
Electricity, billion. kWh	38.1	42.5	49.9	59.1	68.7
Coal, MTOE	13.8	12.5	12.9	13.0	12.1
Fuel Oil, MTOE	3.6	2.5	2.4	2.3	1.5
Gas, billion. m^3	3.2	5.1	7.0	10.0	19.5
Fuels for Generation and Direct Consumption*, MTOE	22.9	21.5	23.6	26.0	32.1

* This definition covers coal, gas, fuel oil, and other fuels (wood, LPG, diesel for generation, coke, etc.) excluding motor fuels.

(23) Forecasted Energy Export of the Far East

	1995 (actual)	2005	2010	2015	2020
Electricity, billion. kWh	0.14	4.0	4.0	3.7	20.6
Hard Coal, million tonnes	2.4	4.0	4.0	4.0-5.0	10.0
Gas, billion. m^3	0	1.4	19.0	25.8	35.8
Oil, million tonnes	0.8	2.5	6.0	17.0	20.0

(24) Projected Structure of Electricity Output in the Far East, (%)

	1995 (actual)	2005	2010	2015	2020
TPP	70.7	61.8	61.6	60.1	61.3
HPP	26.1	33.2	32.8	34.5	30.5
NPP	0.8	0.5	0.5	0.4	4.3**
Others*	2.5	4.5	5.1	4.9	3.9
Total	100	100	100	100	100

* Local small installations (diesel, non-traditional sources).
** Portion mainly determined by construction of NPP in Primorsky territory

(25) Projected Structure of Fuels for Generation and Direct Consumption, (%)

	1995 (actual)	2005	2010	2015	2020
Coal	60.1	58.1	54.7	49.8	37.6
Gas	11.8	19.4	24.3	31.2	49.3
Fuel Oil	15.6	11.8	10.3	8.8	4.8
Others	12.5	10.7	10.6	10.1	8.3
Total	100	100	100	100	100

P-3. Infrastructure Requirements.

The Strategy of development of the Far East's energy sector, proposed in the Program, certainly requires an extensive program to build new infrastructure for production and social purposes, since the key prospective centers of fuel and energy production are located in poorly developed or undeveloped remote regions. Hence, the highest input is required to create specialized "big" transport infrastructure: main trunk gas-and-oil pipelines, a LNG plant, marine terminals, and construction of HV transmission lines and substations.

The most capital-intensive plans for building infrastructure are connected with the development of large export-oriented oil and gas deposits and construction of electric power plants and HV transmission lines. The necessary new installed capacities and their capital costs are represented in Tables 26 and 27.

The Program proposes a plan of gradual formation of a common gas transportation system in the East of Russia (East Siberia and the Russian Far East), which would enable gas supply to the most developed centers in the Far East and East Siberia (Pic. 1)

According to the plan, the key centers of natural gas extraction in East Siberia and the Russian Far East will be the following:

- Sobinskoe gas field (Krasnoyarsk);
- Kovykta gas field (Irkutsk);
- Gas fields in Western and Central Yakutiya;
- Sakhalin offshore oil-and-gas fields;
- Local gas fields in Kamchatka.

The key centers of gas consumption:

- Krasnoyarsk;
- Irkutsk;

- Ulan-Ude;
- Chita;
- Yakutsk;
- Blagoveschensk;
- Khabarovsk;
- Komsomolsk-on-Amur;
- Vladivostok;
- Sakhalin;
- Petropavlovsk-Kamchatsky.

The authors of the Program believe that this plan should become a part of a more extensive plan to organize the pipeline gas international market in NEA, in which East Siberia and the Far East of Russia, Japan, China, and North and South Korea would be integrated.

The plan is so expensive and complexthat it cannot be implemented by the efforts of only one country. A multilateral approach is needed here.

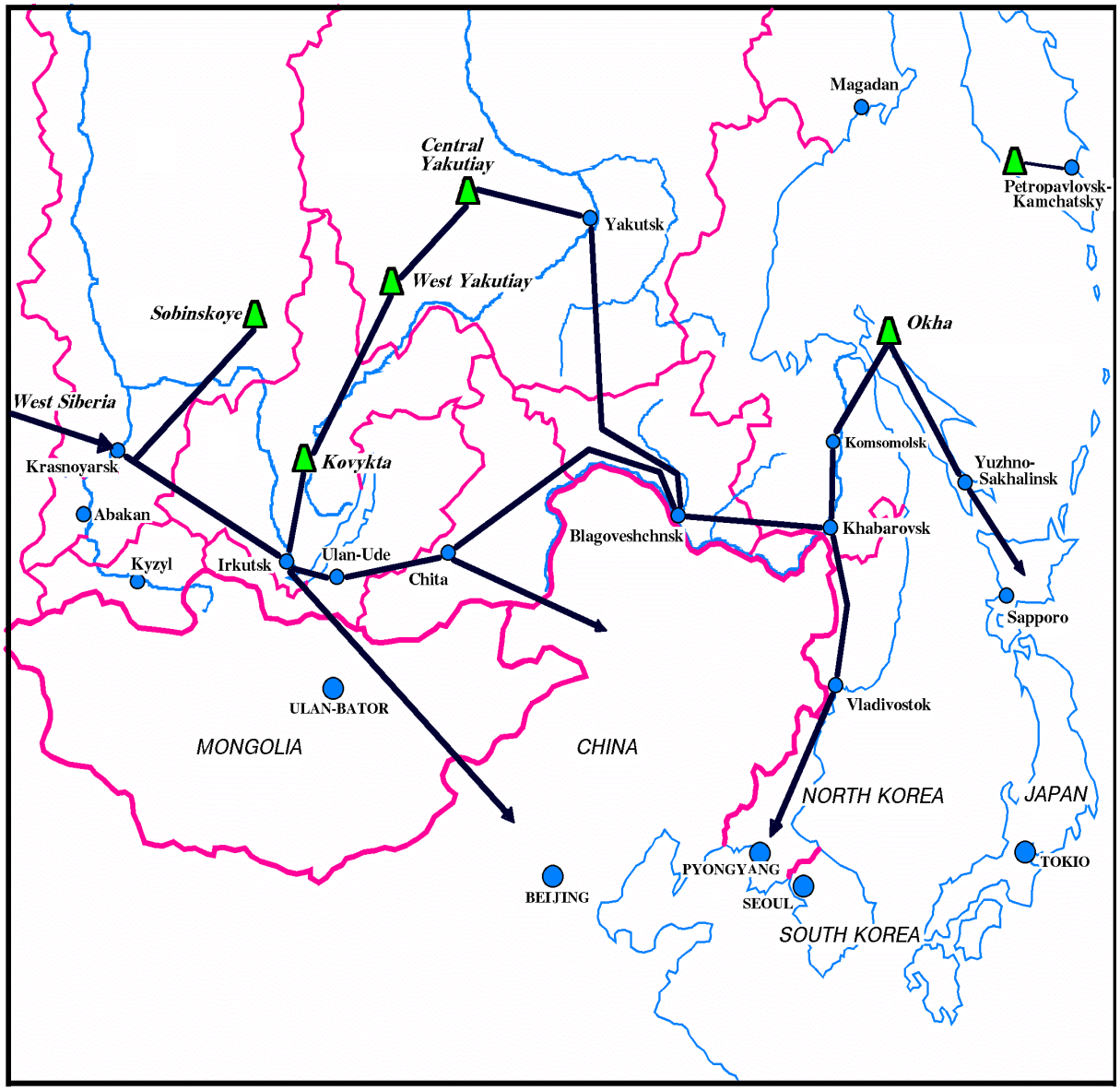
The Program proposes the organization of the electricity exports from the Russian Far East and East Siberia to NEA countries through a construction of a number of interstate HV transmission lines (IHVTLs) (Pic. 2).

At the first stage the Program offers construction of the following IHVTLs:

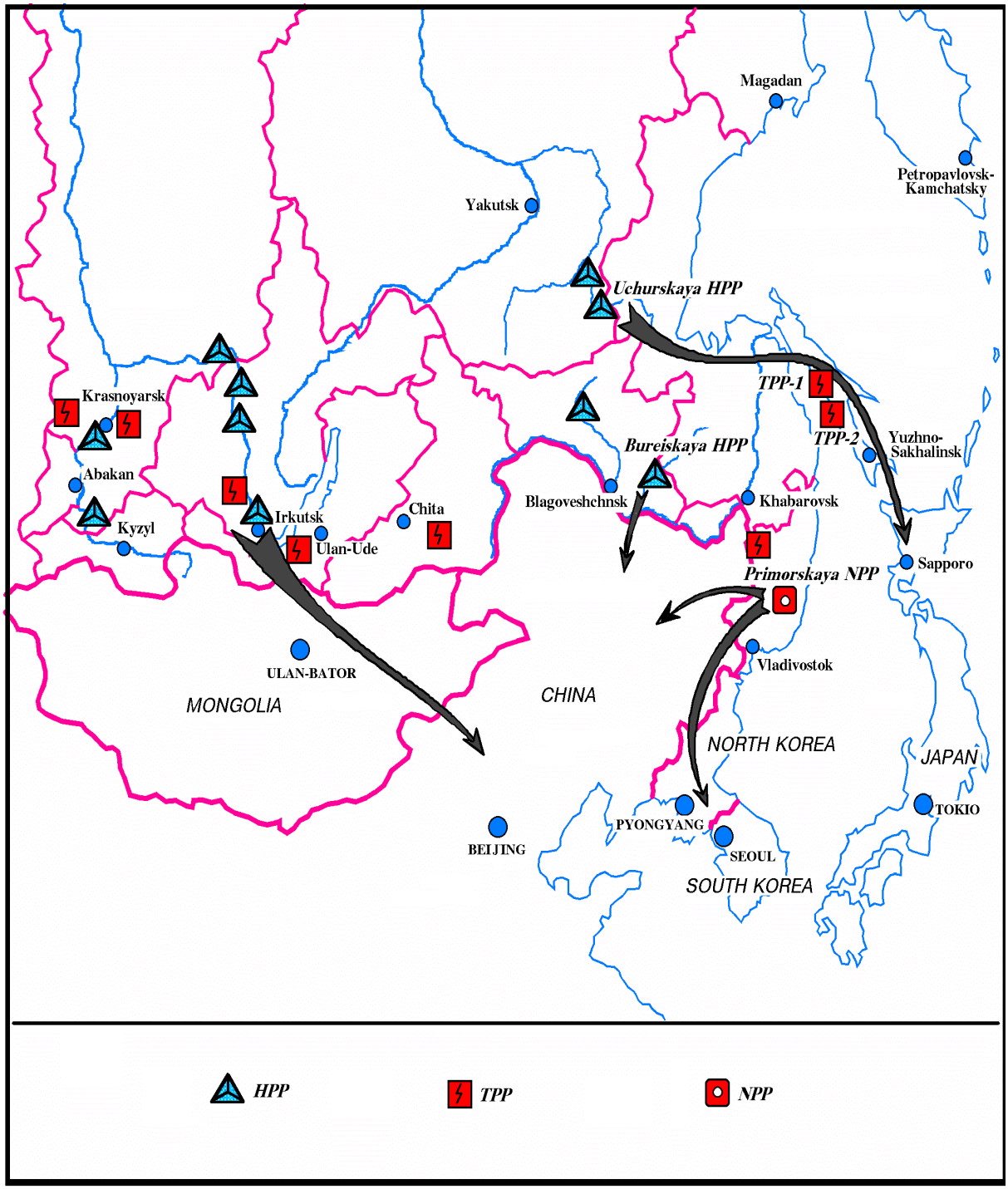
- "Bratsk – Beijing" (length: 2600 km, voltage: ± 600 kV, capacity: 3,000 MW, annual output: 18 billion kWh, estimated cost: 1.5 billion $US);
- "Bureiskaya HPP – Kharbin" (length: 700 km, voltage: ± 400 kV, capacity: 2,000 MW, annual output: 7 billion kWh, estimated cost: 400 million $US).

At the second stage (2010 – 2020), an integration of power systems of East Siberia and the Far East with power systems of the NEA countries could be strengthened through a construction of the new power plants and the IHVTLs:

- "Sakhalin – Japan" (length: 470 kV, voltage: ± 500 kV, capacity: 4,000 MW, annual output: 22 billion kWh, estimated cost: 2.6 billion $US). The construction of a new gas TPP in Sakhalin would be required (4.1 billion $US). Over the period 2010 – 2020 the further development of the electricity bridge "Sakhalin – Japan" would be possible through a construction of HPPs on the Uchur river in South Yakutiya.
- "Primorskiy Territory – DPRK – ROK" (length: 1,100 km, voltage: ± 500 kV, capacity: 4,000 MW, annual output: 15 billion kWh, estimated cost: 2.2 billion $US). The construction of a new nuclear power plant in Primorie would be proposed (2.8 billion $US).



Pic. 1. Projected a Common Gas Transportation System in the East of Russia



Pic. 2.Large-scale Electricity Flows from "East Siberia - Far East" to NEA countries

(26) Estimated Requirements for New and Re-built Capacities in the Far East, MW

	2001-2005	2006-2010	2011-2015	2016-2020
Total	1644	3439	1710	6983
HPP	579	1936	214	648
TPP	1000	1255	1260	4850
NPP		60		1280
Others	65	188	236	205

(27) Estimated Investments for Electricity Development in the Far East, billion $US

	2001- 2005	2006-2010	2011-2020	2001-2020
Power Plants	2.9	9.5	17.1	29.5
HV Transmission Lines	0.6	0.9	5.0	6.5
TOTAL	4.8	20.9	39.9	65.6

P-4. Energy Security Aspects.

In the Program, energy security (ES) is considered fragmentarily and mainly declaratively.

On the whole, ES problems are presented in two aspects:

- Strategic security of the Far East's energy balance structure;
- Energy efficiency and environmental sustainability in energy development.

According to the Program, strategic security of the Far East's energy balance structure should be provided by state regulation and monitoring of the following norms and amounts:

- norms of the admissible degree of production assets wearing of the most important branches and enterprises in the region's energy sector. It is necessary to control for wearing of equipment level, primarily in electric energy, the systems of commercial heating, at oil processing plants;
- norms of strategic reserves of productive capacities for energy resources production. For example, in the Program the reserve capacities norm of 20% (of the expected maximum load) has been adopted for the electricity industry;
- amounts of annual investments in key enterprises of the region's energy sector, which are required to provide strategic volumes of energy resources production;

- amounts of seasonal and strategic fuel stocks and reserves;

- norms of diversification levels of the energy balance structure.

An important element in providing Energy Security in the Far East is a reduction in the ecological impact of the energy sector.

Energy enterprises in the Far East are the biggest contaminators of the environment. They emit, on average, about 50% of all pollutants in the region's atmosphere, about 30% of sewage, over 30% of solid wastes, and up to 70% of the total amount of greenhouse gases.

The Program believes that economically effective development of the energy field should combine with ecological well-being.

The basic principles of realization of environmentally sustainable energy development are the following:

- energy saving and increase in efficiency of energy use. The current energy saving potential of about 35-40% of overall energy consumption should be gradually realized.

- ecological improvement of energy technologies at functioning and new enterprises, which provide reduction in the share of emissions to the atmosphere of sulfur and nitric oxides, greenhouse gases, and particulates.

- development of capacities of existing and new thermal power plants should proceed with the use of new technologies. For electric power plants working on gas such technologies include: steam-and-gas cycle, gas-turbine superstructures of steam-cycle units, and small gas-turbine cogeneration units. At electric power plants burning coal: the ecologically safe technologies of fuel burning in steam cycle and in steam-and gas units with coal gasification.

- ecological improvement of the structure of the energy balance of the Far East and its subregions. The planned gas transformation of the region's energy balance allows one substantially to improve environmental parameters of energy development. However, this effect competes with the requirement for energy balance diversification.

- facilitation of inclusion in the energy balance of renewable energy sources in order to sustain the potential of non-renewable energy resources for future generation;

- increase of technical reliability of the system of production, processing, and trasportation of energy resources with the aim of preventing technical and ecological accidents.

One of the possible ways to realize environmental sustainability in energy development is the use of the Joint Implementation mechanism within the Kyoto Protocol.

In the framework of this mechanism, the Japanese government has already offered a number of projects to reconstruct and update thermal power plants in the Russian Far East, with granting of low-interest credits and advanced technologies for energy generation and utilization of harmful discharges.

On the whole, the Program assumes that together with energy conservation and other measures, energy development of the Far East will not result in the increase of harmful discharges to the environment.

VII. ENDNOTES

[i] Novaya energeticheskaya politika Rossii. Moskva: Energoatomizdat, 1995. Energeticheskaya strategiya Rossii (osnovnii polozheniya). Moskva, 1995.

[ii] Ukaz Prezidenta Rossii # 472 ot 07.05.95 "Ob osnovnykh napravleniyah energeticheskoi politiki Rossii na period do 2010 goda.

[iii] It was announced by the Secretary of the Russian Security Council S. Ivanov at the All-Russian meeting on the problems of development of the fuel-and-energy complex of Russia in the city of Surgut in March, 2000.

[iv] Osnovnye polozheniya Energeticheskoi Strategii Rossii na period do 2020 goda. (proekt). Moskva. 2000, pp. 10-11.

[v] N. I. Voropai, S. M. Klimenko, G. F. Kovalev, L. D. Krivorutsky, N. I. Pyatkova, S. M. Senderov, G. B. Slavin. Energy Security as a factor of the common energy space formation in East Asia. In Eastern Energy Policy of Russia and Problems of Integration into the Energy Space of the Asia-Pacific Regions, Proceedings of the International Conference, September 22-26, Irkutsk, p. 171. In more detail about problems of ES and Threats to ES also see N. I. Voropai, *et al*. Some problems of energy security of Russia and its regions. In Energetika Rossii v prekhodny period: problemy i nauchniye osnovy razvitiya i upravlenia. Novosibirsk. Nauka. 1996. pp. 23-35. V. V. Bushuev, A. M. Mastepanov, P. I. Rodionov. Energeticheskaya Bezopasnost' Rossii. In Gazovaya promyshlennost'. 1997. # 8, pp. 12-15. N. I. Voropai, *et al*. Influence of energy security requirements on functioning and development of fuel-and-energy complex. Chapter 7. In Fuel and Energy Complex of Russia: Current State and Prospects. A. P. Merenkov, N. I. Voropai, Yu. D. Kononov, and B. G. Saneev, Editors. Novosibirsk. Nauka. 1999, pp. 99-120. (rus).

[vi] At present, the project Sakha-gas has not got further development due to a number of reasons. Reportedly, in April 1999 Yakutian company "Sakhaneftegas" signed an agreement with the Chinese National Gas Company to conduct a feasibility study on the construction of a 4,400 km gas pipeline from the Botuobinsky area (south-west of Yakutiya) to Beijing with maximum export of 20 BCM annually. See V. M. Vlasov, V. M. Efimov, V. D. Matveev. The main aspects of participation of the Republic of Sakha (Yakutiya) in interstate gas projects. In Proceedings of the 5th International Conference on Northeast Asian Natural Gas Pipeline. Yakutsk, Republic of Sakha, Russia. 25-27 July, 1999, p. 19.

[vii] See Ognev, Alexander. The Energy Sector of Far Eastern Russia: Prospects for Exports. Paper presented at the Workshop on Energy Security and Development in Northeast Asia:

Prospects for Cooperative Policies. Niigata, December 17-19, 1999. Kalashnikov, Victor D. Electric Power Industry of the Russian Far East: Status and Prerequisites for Cooperation in Northeast Asia. Paper presented at the Workshop on the Future of Regional Electric Power Grids in Northeast Asia. East-West Center. Honolulu, Hawaii, 28-29 July, 1997.

[viii] 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.

[ix] According to pre-feasibility studies of Sakahalin-1 & Sakhalin-2 projects (executed, respectively, in 1993 and in 1991) the plans for creation of transport infrastructure envisage construction of a 680 km trunk oil pipeline from the north-east of the island towards its south with designed capacity of 26 million tons, a 680 km gas pipeline with capacity of 19 billion. m^3 In Prigorodnoe (Korsakov district) a LNG plant of 9-12 million tons of LNG and some other special facilities for handling marine export shipments of LNG and crude oil will be located.

[x] Komplexnaya Programma "Razvitie toplivno-energeticheskogo komplexa Vostochnoy Sibiri i Dal'nego Vostoka" (proekt). Institute System Energetiki SO RAN. Irkutsk. Avgust 2000. (Draft).

[xi] Ministry of Energy of the Russian Government passed a decision on elaboration of this Project, first of all, under pressure of the Far East regional authorities, which are constantly demanding the federal Government work out a State Program of the Far East's Power Industries Development. The federal Government agreed in principle to this demand. At the same time, regarding strategic orientation of East Siberian energy recources towards Asia, the Government offered to work out a joint long-term development program of the power industries of the Russian Far East and East Siberia.