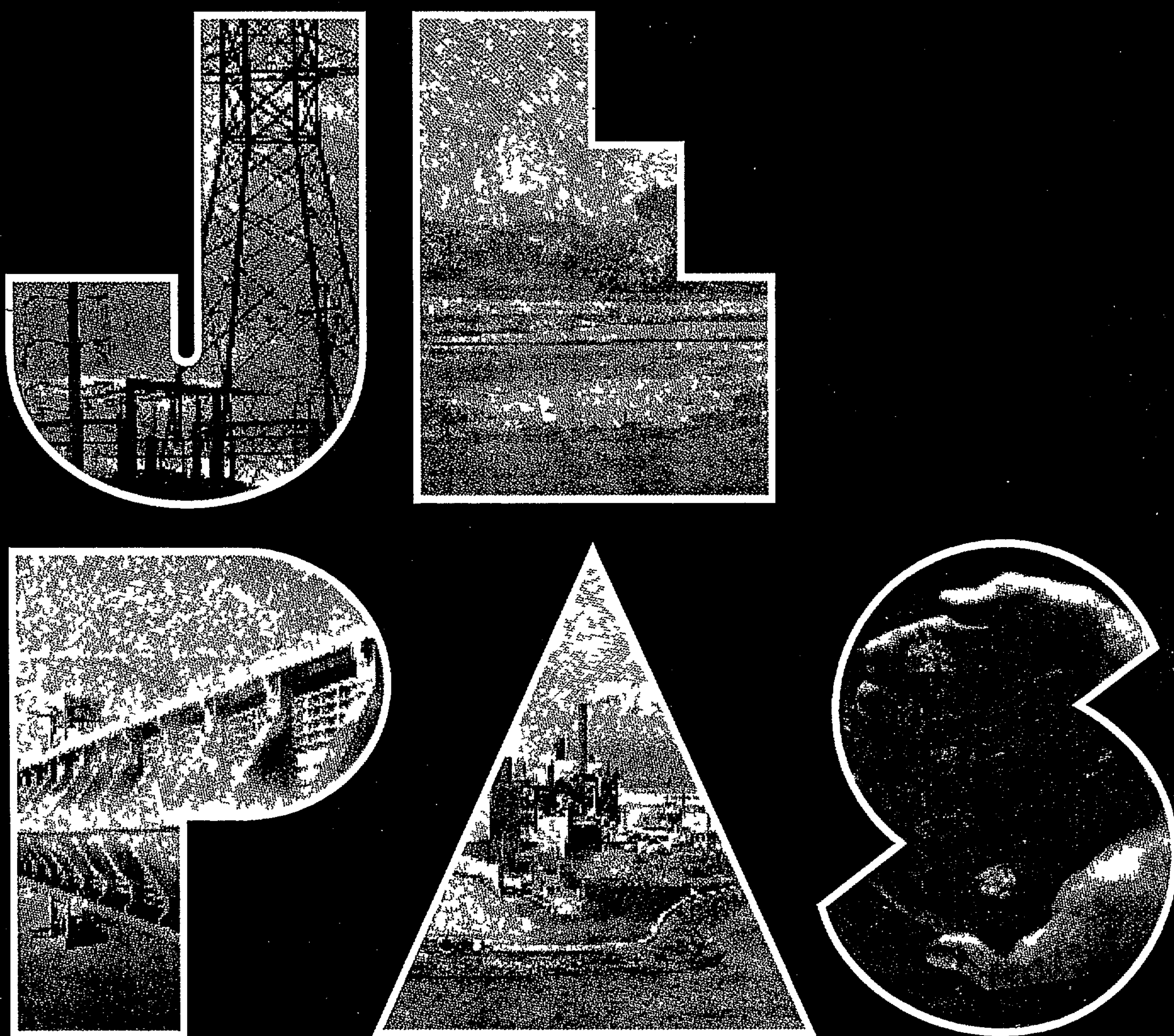
JOINT ELECTRIC POWER ALTERNATIVES STUDY

An Investment Program for Russia



Prepared for:

Energy Policy Committee of the
U.S.–Russia Joint Commission on
Economic and Technological Cooperation

Final Report
June 1995

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Main Document
Appendices

Appendix A	Energy Strategy of Russia
Appendix B	Scenarios for Power Sector Development and Investment in Russia
Appendix C	Least Cost Planning for the Russian Power Sector
Appendix D	Time-Phased Energy Efficiency Plan for Russia
Appendix E	Barriers to Energy Efficiency in Russia and their Removal
Appendix F	Thermal Power Plant Options
Appendix G	Joint Parallel Nuclear Alternatives Study for Russia Final Report
Appendix H	Transmission and Control
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Appendix J	Institutional and Regulatory Reform Issues
Appendix K	Financing
Appendix L	Russian Power Production and the Environment

Заместитель Министра
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№ 18/01-12/92

На № __________ от 21 05 96

Dear

In 1995, as part of activities of the Russian-American Commission on Economic and Technological Cooperation Energy Policy Committee, the Joint Electric Power Alternatives Study was completed The main results of the Joint Study, which covered both nuclear and non-nuclear power and recommended an investment program for Russia, were presented to the governments of Russia and the United States

The Joint Study determined the investment needs of the Russian electric power sector and energy conservation potential for the next fifteen years under a variety of economic development scenarios The Study examined a wide range of issues influencing investment requirements, including the possibility of applying new and more efficient technologies of energy generation and consumption, options for nuclear generator safety upgrades and decommissioning, environmental standards, and financing sources

I have the honor of inviting you to take part in the presentation of the results of this Study The presentation will take place on June 3, 1996 at the Olympic Penta Renaissance hotel An agenda is enclosed As this invitation is strictly personal, the favor of a reply to the conference organizers, Hagler Bailly Consulting, by phone (7095) 956-2684 or fax 956-2682 is requested

Sincerely,

V Bushuev

Тип «Нефтяник» 1996 Зак 537/2—15 000

MAIN RESULTS OF THE US-RUSSIA JOINT ELECTRIC POWER ALTERNATIVES STUDY (NUCLEAR AND NON-NUCLEAR)

June 3, 1996

Olympic Penta Renaissance Hotel
181/1 Olympyisky Prospect, Moscow

Agenda

9 00 - 9 30	Registration
9 30 - 10 00	Welcome and Introduction - Deputy Minister V Bushuev, Ministry of Fuel and Energy, and Deputy Minister V Sidorenko, Ministry of Nuclear Power
10 00 - 10 45	The Joint Electric Power Alternatives Study and The Joint Parallel Nuclear Alternatives Study goals and methodology, general results by the joint Co-Chairs of the Coordination Committee Dr A Mastepanov, Mr G Nefedov, Ms C Kessler
10 45 - 11 00	Coffee Break
11 00 - 12 00	Presentation by the Working Group Co-Chairs results, conclusions and recommendations

WG-1	Energy Efficiency	Mr Kogan	Full Professor, Economics ENIN Krzhizhanovsky
WG-2	Thermal Power Plants Teploelectroproject	Mr Trushin	Full Professor, Technical Sciences, Director General,
WG-3	Nuclear	Dr Chernillyn	Full Professor, Technical Sciences, Kurchatov Institute
WG-4	Hydroelectric Power, Transmission and Dispatch	Mr Smirnov	Full Professor, Technical Sciences, Director, Energosetproject

WG-5	Strategy and Integration	Dr Makarov	President, The Energy Research Institute, Russian Academy of Sciences, Professor
WG-5	Strategy and Integration	Mr deTerra	Director, Hagler Bailly Consulting

12 00 - 12 45	Discussion on the results of the presentations
12 45 - 1 15	Restructuring of the Russian Electric Power Sector, Status and Plans - presentations by RAO EES Rossii, Ministry of Economy, Ministry of Nuclear Power
1 15 - 1 30	The Federal Energy Commission Comments by Mr Y Korsun, Chairman of the Federal Energy Commission
1 30 - 1 45	Closing remarks Conclusions and Recommendations
1 45 - 3 00	Lunch
3 00 - 3 30	Press Conference

For information or to confirm reservation call or fax Mr Bowden, Hagler Bailly Consulting, Inc , Moscow (Ph)956-2684, (F)956-2682

Joint Electric Power Alternatives Study

An Investment Program for Russia

Executive Summary

Prepared for

Energy Policy Committee of the
U S -Russia Joint Commission on
Economic and Technological Cooperation

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Figure 1
Russian Electric Power System by Region
Sweden
Finland
Kaliningrad
NORTH WEST
St Petersburg
1550
900
CENTER
Moscow
Ukraine
3000
2800
MIDDLE VOLGA
1800
1500
TYUMEN
URALS
2800
NORTH CAUCASUS
1400
1200
Kazakhstan
SIBERIA
FAR EAST
China
KEY
Integrated Power System (IPS)
United Power System (UPS) of Far East
Isolated electric power systems and electric power districts in Siberia and Far East
= Nuclear power plants
= Nuclear power plants under construction
= Major transmission projects
= Inter regional transmission (MW)
1 Leningrad
2 Kola
3 Kursk
4 Smolensk
5 Kalinin
6 Novovoronezh
7 Balakovo
8 Beloyarskaya
9 Bilibino
10 Rostov
U S – Russian Joint Energy Alternatives Study
April 1995

EXECUTIVE SUMMARY

THE JEPAS

1 Following an agreement between Vice President Gore and Prime Minister Chernomyrdin in late 1993, the Russian Federation and the United States decided to undertake the Joint Electric Power Alternatives Study (JEPAS), whose terms of reference included the following

> The Russian electric power sector will require major investments over the coming decades The sector's main problems include the high proportion of thermal generating plants which are currently beyond their planned operational life spans, doubts about the safety of older nuclear plants, and highly inefficient patterns of electricity use In the present state of the Russian economy, federal budget financing of power sector development has all but ended while new financing mechanisms appropriate to a market economy have not yet developed
>
> The international community, including the leaders of the G-7 group, attaches great importance to joint efforts in helping to solve these problems Fundamental conditions of investment in this most important sector of the Russian economy should be identified on a priority basis

2 This Joint Study has identified investment requirements for the Russian electric power sector and opportunities for energy efficiency over the next fifteen years under two scenarios that differ in their assumptions about the timing and speed of Russia's economic recovery The Study addresses a broad range of issues affecting investment, such as the scope for new advanced, more efficient generation and end-use technologies, nuclear safety upgrades and decommissioning options, environmental standards, sources of financing, and energy policy impacts on investment choices This Study is expected to have a major influence on Russian power sector investment, including environment and safety considerations, and to provide a basis for follow-on actions by countries and institutions with an interest in Russia's economic future This executive summary sets out recommendations for consideration by Vice President Gore and Prime Minister Chernomyrdin

3 The two governments formed five joint working groups of experts to carry out the analytical work, supervised by an inter-governmental committee comprising concerned ministries and agencies The Study used two electric power integrated planning models that are complementary The Russian simulation model incorporates 1) detailed expert

knowledge of the entire Russian power system 2) screening analysis of the cost-effectiveness of supply and energy efficiency options, and 3) fuel supply constraints and environmental impacts The American integrated resource planning model uses least-cost optimization techniques to analyze the same set of issues as the Russian model The Joint Study uses the technical flexibility of the American model to study the sensitivity of answers to a wide range of economic uncertainties and policy questions Both sides in the Joint Study recognize that while the model results do not determine an investment plan for the Russian power sector, they are an important aid to its formulation

4 The data generated by the working groups were used in the two models to identify the mix of technologies that would be needed to meet Russia's electricity demand under two scenarios year-by-year through the year 2010

5 The two scenarios considered in this Study were based on two views of Russian economic performance and electricity demand, set forth in the *Russian Energy Strategy (Main Directions)*, and on a set of assumptions regarding the pace and degree of success of measures to control inflation and reform the economy Time-phased investment and fuel requirements were estimated using the two planning models Financing requirements were calculated from the total costs of the investments, and potential domestic and foreign sources of finance were identified All of the scenarios and financing requirements are based on assumptions about future developments of the Russian economy that are subject to uncertainties, and the team has prepared an investment strategy that addresses the main elements of uncertainty As the future direction of reform and the rate of evolution to a market economy become clearer, it will be necessary to undertake periodic re-evaluations of investment priorities

THE RUSSIAN ELECTRIC POWER SYSTEM

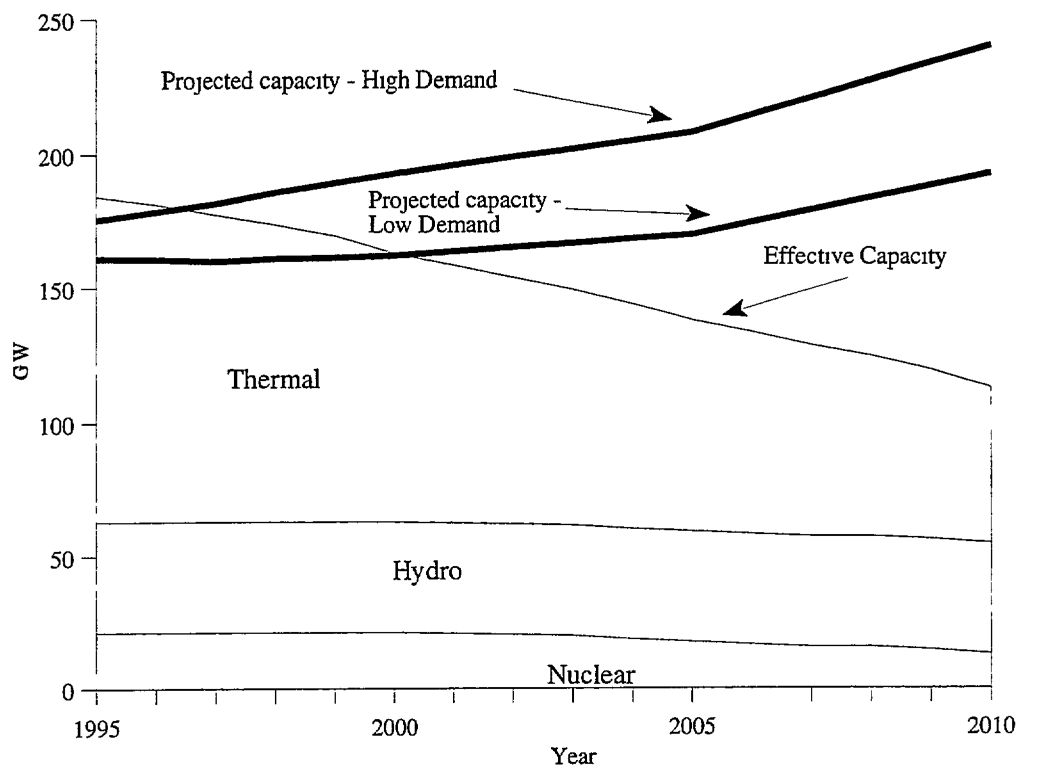
6 Russia's installed generating capacity in 1994 was 215 GW, of which 21% was hydroelectric (45 GW), 10% was nuclear (21 GW), and 69% was fossil-fired thermal (149 GW), including 73 GW of combined heat and power (CHP) stations Natural gas provides 65% of the fuel required by fossil thermal plants, coal provides 25% and residual fuel oil (mazut) provides 10% In 1990, Russia's per capita electricity consumption was 5,360 kWh, similar in magnitude to that of France (5,350 kWh) or Japan (6,140 kWh), but well below that of Canada and the United States

7 Industry's share of final electricity consumption in Russia dropped from 67% in 1980 to 56% in 1993 In the United States the comparable figure is 27%, in Japan 52%, and in Germany 42% In Russia, agriculture used 13% of electricity, transport used 10% and other sectors, including buildings, used 21% in 1993

8 The Integrated Power System (IPS) is composed of seven regional power systems the North-West, Center, Middle Volga, North Caucasus, Urals (including Tyumen), Siberia, and the Far East The first six of these are interconnected through a transmission network with lines rated at 330 kV and above The IPS spans 9,000 km west to east and six time zones (see Figure 1) The Russian electricity industry is made up of 51 large generators, 72 regional "AO Energos" that provide distribution, as well as electricity and heat production, and the transmission and dispatch operations This industry is currently in the process of being restructured and privatized to create a more efficient sector based on the principles of competition

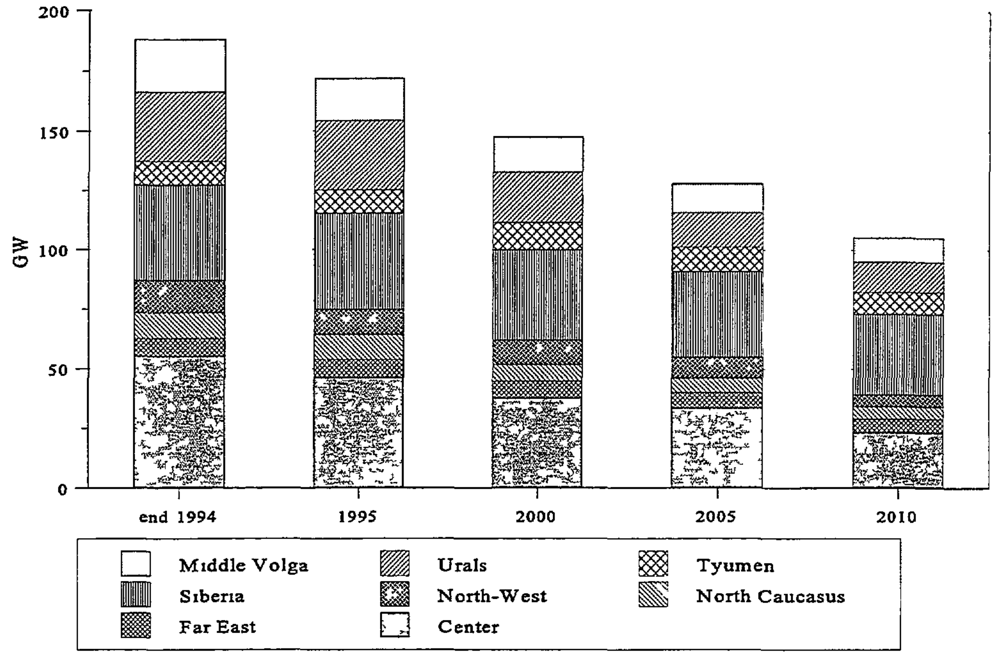
9 Out of the existing generation capacity, 80 GW (600 units) of fossil thermal plants and 8 GW of nuclear capacity will reach the end of their service life by the year 2010 Figure 2 shows the possible evolution of all generating capacity according to the established schedule of power plant retirements This calculation did not take into account life extensions, rehabilitations or additions of new plants Superimposed on this plant retirement pattern are the two scenarios for electricity demand that form the basis of the Joint Study Russia as a whole remains comfortably in surplus for the next four to seven years, depending on demand growth However, the same is not true for the North Caucasus, Urals, Transbaikalia and a few other regions, which are already in deficit Figure 3 shows the pattern of capacity retirement on a regional basis

Figure 2
Effective Capacity Reduction Dynamics for Russia's Power Plants



Note The effective capacity is determined by adjusting the actual installed capacity by an amount equal to the fraction of total capacity that is historically out of service due to routine maintenance or equipment failures The adjustment factor used in this study is 13 %

Figure 3
Available Electric Generating Capacity by Region* (1994-2010)



Note *Available capacity reflects currently installed capacity and its decline resulting from scheduled retirement The figure shown for end 1994 does not include capacity in isolated systems but does include nuclear generating capacity to be removed from service for safety upgrades

ELECTRICITY DEMAND AND RUSSIA'S OPTIONS TO MEET DEMAND

10 The high reputation of Russia's electric power industry is built on providing a reliable supply to meet the needs of the economy This dictates the need to project and ensure investments in generation, transmission and energy efficiency that will be sufficient to meet future demand in a reliable, safe and environmentally sound manner Under-investment could leave the country unable to meet all demand, while over-investment would be a misuse of scarce financial resources whose cost would be borne by users Variations in the timing and shape of Russia's recovery from economic depression and dislocation must be taken into account in estimating investment needs, and this Study has

used two electricity demand scenarios taken from the *Russian Energy Strategy*, which was adopted in 1994 These demand scenarios have embedded in them no cost/low cost energy efficiency measures as well as energy conservation resulting from structural changes in the Russian economy

- ***Demand Scenario A (High Demand)*** is based on an official Russian economic forecast that assumes a quick turnaround, with recovery starting in 1997 and GDP reaching its 1990 level by the year 2004

- ***Demand Scenario B (Low Demand)*** is based on an official Russian economic forecast that assumes recovery might not start until 2000, and that by 2010 the GDP would only have reached just over 70% of its 1990 level

- ***Fuel and electricity prices*** are assumed in the Study to rise to levels needed to cover production costs and provide a return to investors An analysis of the impact of domestic prices at world levels was also conducted

11 The JEPAS Working Groups developed options and their costs for potential future developments in energy efficiency, thermal power, nuclear power and hydro power generation, transmission and dispatch Major options considered in the Study are as follows

- **Energy Efficiency** - Working Group 1

  - New, more efficient electricity-using technologies (lighting, motors, etc) and their likely implementation schedule

- **Fossil Thermal Generation** - Working Group 2

  - Rehabilitation and modernization, including combined cycle and advanced combustion technologies
  - Life extension
  - Construction of new coal and gas power plants
  - Fuel switching (re-powering) and modernization
  - Emission control technologies

- **Nuclear Power Generation** - Working Group 3

- Safety upgrades to first-generation reactors (RBMK and VVER 440-230) to allow them to operate until the end of their service lives
- Russian and U S decommissioning practices for first-generation reactors
- Re-powering of the Rostov 1 reactor as a fossil-fired unit
- Completion of the Kalinin 3 unit
- Safety upgrades to operating VVER 440/213 and 1000 reactors
- Construction of new-generation NP-500 reactors

▸ **Hydroelectric Generation** - Working Group 4

- Completion of on-going rehabilitation at four plants
- Rehabilitation of four additional plants
- Completion of six plants now under construction
- Construction of three new plants

▸ **Transmission, Dispatch and Control** - Working Group 4

- Reinforcement of existing inter-regional connections
- Improvement of system network control within regions
- Improvement of distribution network to reduce losses

KEY STUDY FINDINGS

12 The JEPAS confirmed the importance of the further development of Russia's electric power sector in assuring its economic development and socio-economic stability during this period of transition The principal conclusions of the JEPAS are consistent with the importance given to the electric power sector in the *Russian Energy Strategy* The Study indicates that it would be important for Russia to undertake certain high-priority projects on a time-phased basis over the next 10-15 years to maximize the effectiveness of its power sector and energy efficiency investment decisions The amount of financing required over the next ten years could range from $32 to $81 billion, depending on the demand for electricity The Study also indicates the need for support from the international financial community during 1995 through 1997 for high-priority projects costing approximately $2-4 billion

13 The JEPAS analysis indicates the following ranking of priorities during the period 1995-2000 1) improvements in the efficiency of electricity end-use 2) nuclear safety upgrades, particularly for first-generation nuclear power reactors where approved by the

regulator 3) further development of the Integrated Power System through the expansion and strengthening of inter-regional and intra-regional transmission, particularly between surplus and deficit areas, and the modernizing of control/dispatch centers, 4) fossil thermal plant modernization and rehabilitation using improved technology, with the consideration of life extension options, 5) completion of those nuclear power plants that are in advanced stages of construction, 6) construction of new gas-fired simple cycle and combined cycle plants, and 7) completion of the detailed design for new generation nuclear power plants to enable their certification by regulatory authorities

14 The Study's analysis also shows that during the period 2000-2005, it will be increasingly important to complete large under-construction hydroelectric plants, to construct clean coal generation plants, and to construct new-generation nuclear power plants A priority of Russia's long-term scientific and technological policy should be the development of new-generation design NP 500 and NP 1000 nuclear power plants and cleaner coal power units as well as developing the potential for their manufacturing, to provide for the commissioning by 2010 of new nuclear capacity and of environmentally-cleaner coal fired units

Energy Efficiency

15 The JEPAS analysis shows that energy efficiency should be given a high priority There is a large potential for energy efficiency improvements throughout the Russian economy Power consumption could be reduced by up to 29 billion kilowatt-hours (bkWh) by the year 2000 and 112 bkWh per year by the year 2010, just by installing efficient end-use technologies (see Table 1) In all sectors of the Russian economy, a significant portion of the savings potential is associated with lighting and motors improvements The changes in the demand for and use of electricity will vary in different service areas of the AO Energos, depending upon the effect of economic restructuring on local economic activities To be most successful, energy efficiency programs must be designed for these unique local conditions

16 The energy efficiency savings noted above could be achieved at relatively low cost The average life cycle costs of energy saved by the measures recommended in this study is approximately one U S cent per kWh Although the cost of replacing of outdated equipment with new equipment is high, the incremental cost caused by using new energy-efficient equipment is relatively low and easily justified economically (see Table 2)

Table 1
Annual Electricity Savings and Total Incremental Cost for the Year 2010 (from Measures Screened at 4 ¢/kWh and Less)

Sector	Savings bkWh		Incremental Capital Cost ($ million)	
	High Demand	Low Demand	High Demand	Low Demand
Industrial	61 1	37 5	6 382	3 950
Residential	15 1	11 7	3 278	2 545
Transportation	5 1	4 8	146	139
Agriculture	11 3	8 8	232	182
Service	19 5	15 1	2 223	1 726
Total	112 0	78 0	12 262	8 542

1 'Incremental cost is the difference in cost between replacement with energy-efficient equipment versus replacement in kind

2 The above numbers do not include energy savings resulting from low-cost/no cost measures and from structural changes in the Russian economy

Table 2
Costs of Illustrative Demand-Side Measures

Description of Measure	Sector	Cost[1] (¢/kWh)	Savings in 2010 Under High Demand
Adjustable Speed Drive Motors >135 horsepower	Industrial	2 05	10 4 bkWh
Compact Fluorescent Bulbs	Residential	3 02	9 7 bkWh
Recuperative Braking	Transport	1 17	1 5 bkWh
Mercury Lamps & Fixtures	Agriculture	- 0 56[2]	2 3 bkWh
Adjustable Speed Drive Water Pumps	Service	1 94	3 9 bkWh

Note 1 The costs presented for the illustrative measures are the total incremental costs of the measures divided by their cumulative energy savings

2 A negative value indicates that use of the energy efficiency technology will reduce costs in addition to saving energy

17 At present, there are some barriers to the installation of efficient technologies Energy-efficient equipment is not always available in Russia There is a considerable shortage of financing available for energy efficiency

18 Priority should be given to investments to develop the capability for mass producing energy-efficient motors and new lighting technologies (such as compact fluorescent bulbs and metal halide lights), as well as implementing new manufacturing methods (i e , process changes) for oil and chemical plants using high-quality catalysts Demonstration projects for energy-efficient technologies should be established and assistance provided for carrying out energy audits Investments should also be made to set up information and training programs in the area of energy savings

19 Regulatory, institutional and economic measures must be undertaken before energy efficiency programs can be implemented In the near future, the Law on Energy Conservation must be passed Government support for energy efficiency should include tax and customs duties-based incentives and loans and accelerated depreciation

Supply Alternatives

20 The JEPAS Working Groups identified and screened an array of investment options including 1) energy efficiency improvements in the industrial, residential, transportation, agriculture, and services sectors, 2) thermal power plant modernization, conversion, fuel switching, life extension, and new plant completions, 3) the completion, safety upgrade, and/or decommissioning of nuclear plants, 4) the rehabilitation, modernization and expansion of existing hydro plants and the construction of new hydro plants, and 5) transmission and dispatch projects Table 3 provides illustrative capital costs for selected generation capacity additions

Table 3
Illustrative Resource Costs Used in JEPAS Modeling

	1995	2000	2010
	Capital Costs $/kW	Capital Costs $/kW	Capital Costs $/kW
New Plants			
Pulverized Coal	942	1 083	1 486
Combined Cycle	682	782	988
Hydro	924 to 1 590	1 146 to 1 972	1 737 to 2 989
Nuclear	1 144	1 281	1 970
Modernizations			
CPP (Oil/Gas)	552	623	787
CPP (Coal)	552	661	938
CHP (Oil/Gas)	455	545	747
CHP (Coal)	619	776	1 121
All costs are expressed in January 1994 U S dollars			

Thermal Power

21 Some 79 GW of existing thermal plant capacity, which is evenly divided between CPP and CHP units, will reach the end of its service life by the year 2010 This retiring capacity represents 40% of the current total electric generating capacity within Russia More than 54 GW of this capacity is located in three regions -- the Center, the Urals and Siberia Approximately 39 GW of the retiring capacity will have reached the end of its life by the year 2000 and more than 13 GW of this total has already reached its maximum design life

22 The modeling results indicate that new and reconstructed thermal power plants would account for 75-80% of the total generating capacity to be installed

23 Under high demand growth, about 28 GW of Russia's generating capacity would be installed through the year 2000, while 9 GW would be required if demand growth is slower during the same period Given the lead times for the construction of new plants and the reconstruction of existing capacities, these results dictate the urgent need for an aggressive development program Near-term new plant capacity is needed in the North Caucasus, Urals and Transbaikalia

24 The North Caucasus is an example of a region with significant near-term need for additional power generation capacity This need has resulted from the retirement of older thermal units and from the loss of power supplied via Ukraine At the North Caucasus sub-regional level, the Krasnodar Krai (Kubanenergo) has the largest self-generating capacity deficiency in the region Cognizant of this need, RAO EES Rossii, Kubanenergo and others have formulated plans to build modern gas-fired combined cycle units in the Kubanenergo system The modeling results support this approach Such a project would also serve as a major demonstration of this highly efficient and environmentally sound technology, and as a blueprint for replication in other parts of Russia

25 The rehabilitation of thermal plants that are scheduled to be retired will play a significant role in meeting future power needs, however, the investment costs are significant Life extension provides an opportunity to reduce investment requirements Therefore, plant-level evaluations of rehabilitation and life extension options are recommended for thermal power plants

26 Russia is on the verge of promulgating environmental emission standards The present institutional framework for monitoring and enforcement is still evolving New, more stringent environmental standards are being developed for thermal power plants These standards should allow for differentiation among new, existing and rehabilitated thermal plants Programs should be developed to 1) identify the best emission reduction technologies for each plant and 2) provide support for the domestic production of those technologies For coal-fired plants, technologies such as low-NO_x burners, fabric filters for particulate collection, flue gas desulfurization and circulating fluid bed boilers should all be considered Continuous emission monitoring equipment should be employed to ensure compliance with emission limits

27 Advanced technologies such as gas turbine combined cycles and circulating fluid bed boilers should be given serious consideration to improve thermal efficiencies and environmental performance, and to take advantage of the availability of low-quality solid fuel Developing manufacturing capability for these advanced technologies, through joint ventures or other means, should be further encouraged

Nuclear Energy

28 The *Russian Energy Strategy* emphasizes the importance of nuclear power in Russia's economic development under the new conditions Nuclear power plays a significant role in the country's development The JEPAS has confirmed the important contribution that nuclear power makes to the Russian power sector The Study found that future investment in the power sector should include investments in nuclear power plant upgrades, plant completions, evolutionary plant designs, and where appropriate, decommissioning

29 The JEPAS found that investments in nuclear power plant safety upgrades are competitive with investments in alternative energy sources It is economic to continue the operation of most existing nuclear power plants with the completion of safety upgrades evaluated in this Study and where approved by regulatory authority The implementation of such safety upgrades could encourage foreign investment in Russia's nuclear power sector In the initial study period, investments in safety upgrades of the existing nuclear power plants are considered as a priority whether demand growth is high or low

30 The JEPAS shows that, with the scheduled service life remaining, it is not economic to implement all of the safety upgrades evaluated in the Study for Kola 1 and 2 and Novorovonezh 3 and 4 (and Leningrad-1 if demand growth is low) The decommissioning of these units should be considered comprehensively, on the basis of local area conditions and on a site-specific basis

31 The completion and commissioning of Rostov 1, Kursk 5, Kalinin 3, and Balakovo 5 and 6 should be considered in the context of regional least-cost plans and following their full safety review Rostov 1 and Kalinin 3 have been identified as priorities for investment

32 New nuclear capacity was found to be an economic supply option in some regions The design of the NP-500 and NP-1000 evolutionary reactors, which will be the basis for the future development of the nuclear energy sector, should be developed to a sufficient level of detail so as to permit their certification by the regulatory body

33 Legislation required to support the safe development and operation of nuclear power in Russia should be completed as soon as possible

34 While the JEPAS estimated the cost of nuclear power plant safety upgrades, it did not quantify the safety significance of each of these upgrade measures There are, however, existing studies conducted both in Russia and internationally that have assessed the safety significance of many of these upgrades It may be useful to conduct a new study, combining the results of the above work, to look at the question of how to maximize the safety benefit of investments in safety upgrades within the limitations of the available financing, and to assess the level of safety improvement derived from implementing each measure

Hydro

35 Eight existing hydro power plants have been identified as eligible for rehabilitation to permit their continued operation after 2000 These plants' rehabilitation would cost approximately $900 million between 1995 and 2001 Detailed designs, cost estimates and financing plans should be prepared for hydro rehabilitation projects that are viable under

regional least-cost plans The completion of six plants under construction and three new plants were also identified as potential investments at a cost of $4 8 billion

Transmission and Dispatch

36 Russia's transmission system needs to be modernized to provide for higher efficiency and the ability to transfer power among regions for the ultimate development of an electricity market Intra-regional and inter-regional transmission projects/programs have been identified for priority investment, two of which are described below

37 Two priority transmission projects are recommended in the North-West Region and for interties among the Middle Volga, Center and North Caucasus regions The North-West Region reinforcement projects, at an approximate cost of $775 million, consist of 330 kV and 750 kV lines complete with substations, and are designed to strengthen the supply to the nuclear plants The second priority project (four-500 kV lines at a cost of $430 million) has been planned and at present is in the implementation phase It will reinforce the internal systems of the Middle Volga and Center regions to enable increased transfers to the North Caucasus and Center regions

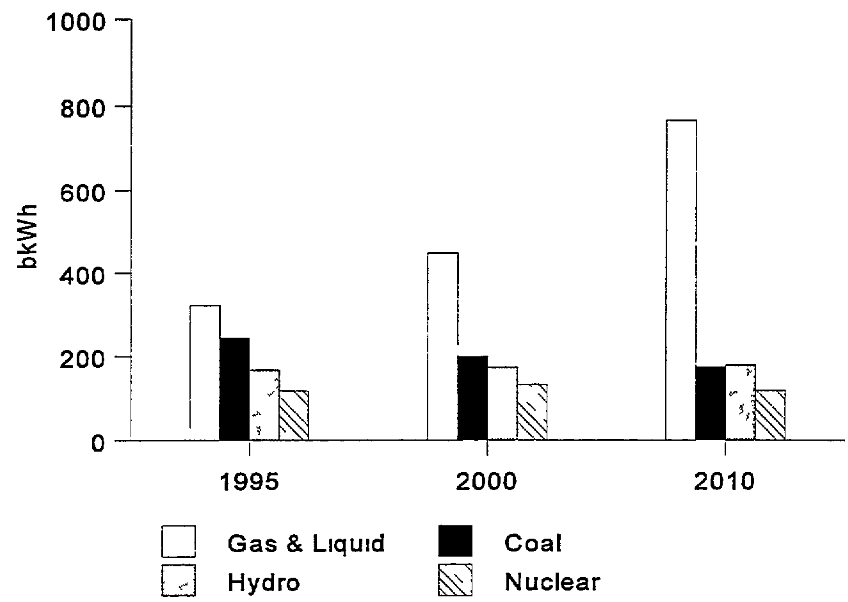
38 A detailed study is recommended to evaluate the construction of a high-voltage transmission line of 3-6 GW capacity between Siberia and Center regions

39 Some upgrades are urgently needed for the control, communications and dispatch systems of the Integrated Power System due to inadequate technology Two control and dispatch projects have been prioritized for early investment, namely the Central Dispatch Office and the North-West Dispatch Center for an aggregate cost of $80 million Such upgrades will accommodate similar upgrades in other regions of the IPS

Projected Electric Power Generation

40 The amount of electricity generated from natural gas is expected to rise significantly under both scenarios because generation from natural gas using combined cycle and simple cycle technologies is economically competitive in many regions of Russia Generation from hydroelectric sources is also expected to increase in both scenarios, but by a much smaller amount Nuclear generation is expected to increase in both scenarios until the year 2000, in the high demand scenario it will increase slightly after 2000, while in the low demand scenario it will decline after 2000 Coal use will decline in both scenarios Figure 4 shows estimates of electricity generation by fuel source over the period of the study, as indicated by the U S model for the high demand scenario For the low demand scenario a similar trend is expected, but at a slower rate

Figure 4
Electricity Output by Fuel Type (High Demand)



RUSSIA'S PREFERRED INVESTMENT PROGRAM FOR THE POWER SECTOR

41 The Russian side recognizes the value and importance of the results of the Joint Study, and has developed a Preferred Investment Program based upon the JEPAS This program adapts the JEPAS results to take account of (1) constraints on the availability of investment capital over the next five years, (2) socio-economic policies with respect to employment in the fuel and energy complex, and (3) energy policy with respect to domestic and export uses of natural gas The Russian side anticipates that technology investments will be made along the lines indicated in Table 4, but that final decisions on individual power sector projects will result from a blend of investor preferences and governmental incentives, including research and development

Table 4
Capacity Additions and Replacements for the IPS for the Preferred Investment Program (GW)

	1995 2000		2001-2005	
	HIGH DEMAND	LOW DEMAND	HIGH DEMAND	LOW DEMAND
ALL TYPES				
New units	13 - 14 9	1 5 - 2	10 12 9	9 3 - 11
Rehabilitations and Upgrades	17 - 17 6	7	27 27 6	18 7 - 19
Total Additions	30 - 32 5	8 5 - 9	37 40 5	28 - 30
Hydroelectric Plants Total	0 6	0 4	2 - 2 3	2 1 - 2 5
Nuclear Power Plants Total	2 0	1 0	2 7 - 3 3	0
Thermal Heat and Power Plants				
New Units	7 4	0 1 - 0 6	3 8 - 4 4	6 0
Rehabilitations and Upgrades	12 - 12 1	5 7	12 - 12 6	12 1 - 12 5
Total Additions	19 5	5 8 - 6 3	15 8 - 17 0	18 1 - 18 5
Conventional Thermal Plants				
New Units	4 9	0	2 - 2 9	1 2 - 2
Rehabilitations and Upgrades *	5 - 5 5	1 3	14 5 - 15 0	6 6 - 7
Total Additions	10 4	1 3	16 5 - 17 9	7 8 - 9

* including rehabilitation using simple cycle gas turbines

Finance

42 It is difficult for lenders to assess the creditworthiness of potential borrowers in Russia's electric power industry A legal and regulatory system for the new industry structure is not yet in place The non-payments problem remains (for some companies 45% of billings are unpaid), although there are mechanisms such as bills of exchange and barter to overcome short-term difficulties At present there is no long-term lending in rubles, and short-term annual rates are measured in hundreds of percent Punitive taxes, inflation, and the inability of the industry to cover its costs in revenues are some of the problems faced by the sector Despite the uncertainties of the current situation, the power

sector needs to mobilize funds for operations and investment The sector does not generate significant amounts of foreign exchange, and so it is more difficult to attract foreign lending and investment than is the case for the oil and gas sectors

43 The amount of financing required over the next ten years could range from $32 to $81 billion, depending primarily on the demand for electricity Over this period, it is expected that the power sector will need to generate 65-75% of its financing requirements ($21-$61 billion) from internally-generated funds The sector will need to ensure that tariffs are set at levels that cover operating costs and the costs of its capital investment program The tariff increases needed to cover the capital investment requirements over the study period are estimated to be less than 1 cent per kilowatt-hour, no matter how the program is financed, although financing with debt would decrease the tariff impact in the near term

44 It is estimated that the power sector will be able to borrow up to approximately 20-30% of its capital requirements ($6-$24 billion) Total borrowing will be limited for several reasons 1) the creditworthiness of power sector enterprises will take time to establish and will be greatly influenced by the general economic and business climate in Russia, 2) medium- and long-term domestic capital is not available in Russia and will take years to develop, and 3) foreign sources of borrowing, while extremely important as gap financing over the short term, will be limited in the long term because of the large domestic content in power sector investments and the foreign exchange risk inherent in repaying dollar-denominated debt with domestic revenues

45 Project financing and innovative financing mechanisms could speed up the process at which debt could be made available, but will still take time to structure and negotiate These mechanisms include independent power projects, sales of generating assets, leasing, energy savings contracts, and barter and counter-trade

46 The role of the Russian Government in developing financing for the power sector is important Government decisions on the sale of power sector enterprises, the use of the proceeds, and the future industry structure will influence the amount of funds available and which entities (private/public, generation/transmission/distribution) will have access to markets and financing The willingness of the government to provide sovereign guarantees on foreign loans will affect the amount of foreign borrowing available, especially during the next three years Tax policies for power sector enterprises will influence the amount of internally-generated funds available for the investment program Tax credits, accelerated depreciation and lower tax rates would improve the power sector's ability to become financially independent Direct subsidies or credits from the government may be required to provide financing for nuclear unit safety upgrades and energy efficiency improvements

FINAL RECOMMENDATIONS AND CONCLUSIONS

47 To realize potential energy savings of 29 bkWh by the year 2000 and up to 112 bkWh by 2010, market-oriented incentives should be introduced to improve end-use efficiencies The development of energy service companies and joint ventures should be encouraged These would provide equipment, energy management techniques and financing for energy efficiency improvement

48 Where approved by the regulatory authority, economically justified program safety upgrades of RBMKs (9,000 - 11,000 MW) and of first-generation VVER nuclear power reactors (880 MW) should be implemented This is estimated to require $1 0 billion between 1995 and 2000 Russian Government financial support and, to the extent possible, support from international financial institutions will be needed to undertake these upgrades

49 A major goal for RAO EES Rossii and the AO Energos should be the rehabilitation and modernization of older thermal plants so as to extend their operating lives and to improve their environmental and operational performance Approximately 79 GW fall into this category, of which about 39 GW will require modernization by the year 2000 Plant-level evaluations should be undertaken to determine rehabilitation requirements and the extent to which life extension at lower capital cost may be possible In addition, Russia should place high priority in its technological and investment policy for the power sector on using simple cycle and combined cycle gas turbines (4,000 - 18,000 MW by 2000, 38,000 to 83,000 MW by 2010) and on developing the domestic capability for their manufacturing, including joint ventures with Western partners

50 Further detailed study, including project identification, of the electricity and fuel supply situation in the North Caucasus, Urals, and TransBaikalia should be given high priority This work should take into account specific factors at the local level and apply least-cost utility planning tools It is estimated that 24,000 - 36,000 MW of new capacity will be required in these regions, as well as the strengthening and expansion of transmission interties Further feasibility studies are needed for the western and eastern extension of transmission between Siberian hydro capacity and demand centers in European Russia and TransBaikalia In addition, the issues in electricity interconnection among the CIS republics and other neighboring countries should be investigated, including the potential for electricity trade with China, Central Europe and other countries

51 The investment requirements for energy generation capacity replacements and additions, efficiency, and transmission improvements are listed in Table 5

Table 5
Investment Requirements Indicated by the JEPAS Findings
($ billion)

	High Demand	**Low Demand**
Generation		
1995 - 2000	21 - 26	9 - 10
2001 - 2005	25 - 32	14 - 20
Subtotal	46 - 58	23 - 30
Energy Efficiency		
1995 - 2000	3-4	2-3
2001 - 2005	5-11	3-8
Subtotal	8-15	5-11
Transmission		
1995 2000	2-3	1-3
2001 - 2005	5-5	3-5
Subtotal	7-8	4 8
All Requirements		
1995 - 2000	26-34	12-16
2001 - 2005	35-48	20 33
Total	61-81	32 40

52 Regional investment requirements under high and low demand are shown in Figures 5 and 6

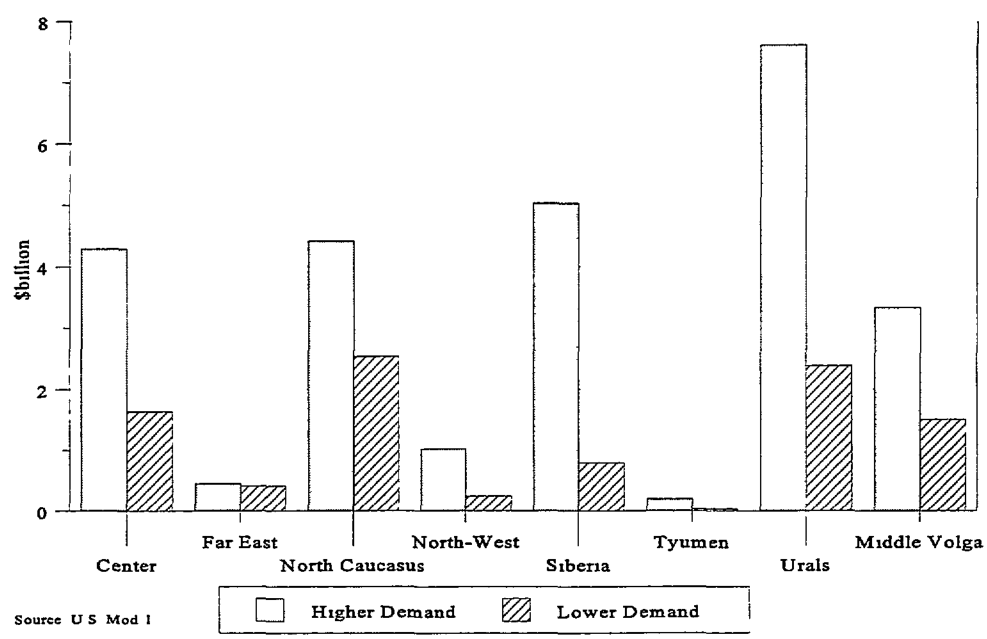
53 Russian Federation Government support is needed to ensure the further development of the power sector under conditions of widening economic reforms and to create conditions conducive to attracting financing and capital investment An improved state system of regulating natural monopolies, which includes state regulation of electricity and heat rates at both the federal and regional levels, as well as an appropriate legal and standards infrastructure are needed Economic and commercial mechanisms are needed to implement the principle of self-financing in the power sector This would increase internal cash generation by power entities and improve the efficiency of allocation of these funds through depreciation and retained earnings of operating entities As a transition measure to a new regulatory system, a mechanism should be established to

facilitate the rational allocation of power sector investment funds between the federal and regional levels, and to create incentives to attract funds into the power sector from both domestic and foreign sources on both an equity and debt basis

54 It is also recommended that the part of retained earnings which is directed into investment be made tax deductible, including the part collected through centralized investment funds

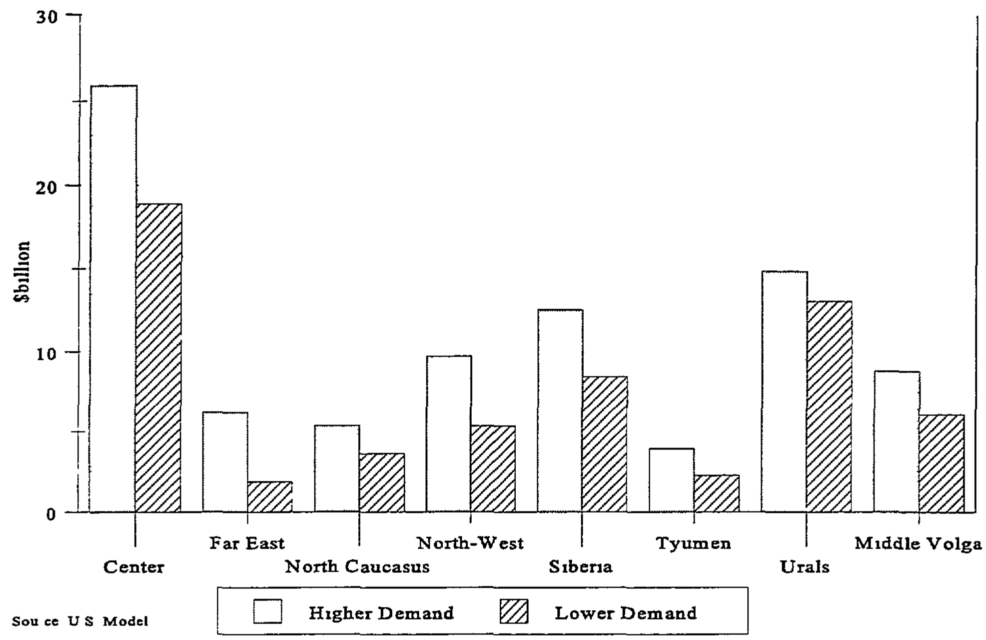
55 Economic stimuli should be created to attract investment into the power sector by establishing government guarantees at both the federal and regional levels, and permitting reasonable levels of return on investment As an interim measure, funds should be generated at the federal level to finance modernization and rehabilitation, and a mechanism should be developed to allocate these funds between the federal and regional levels

Figure 5
Indicated Power Sector Investment by Region from 1995-2000 for Higher and Lower Demand ($billion)



Source U S Mod I

Figure 6
Indicated Power Sector Investment by Region from 2000-2010 for Higher and Lower Demand ($billion)



Sou ce U S Model

56 In the nuclear power sector, an economic mechanism should be developed that increases internally generated funds through tariffs without damaging the competitiveness of nuclear energy in the energy market A portion of these internally generated funds would be centralized in a national reserve which would finance priority safety upgrades, plant completions, decommissioning, and new nuclear power plant construction Opportunities should be created to attract loans into the nuclear sector with corresponding government guarantees The possibility to convert the nuclear sector into stock companies should be studied as well as the corresponding issue of guarantees for potential domestic and foreign investors

57 On the basis of further changes and definition of the ownership structure, the restructuring of the power sector should proceed to set up a competitive environment and to improve rate setting in electric energy markets

58 A legal and tax infrastructure conducive to investment by independent power producers should be created

59 It ıs necessary to develop a comprehensıve program for the publıc sale of government-held power sector stock at an acceptable value Funds from these sales should be used for reınvestment to provıde needed ınvestment capıtal for the power sector

ILLUSTRATIVE PROJECTS

(Excerpt from JEPAS Final Report)

The Joint Study was asked to summarize projects that had already been identified by Russian and foreign institutions and enterprises, and that might be candidates for funding by international lenders and/or investors The list below is not intended to be exhaustive It is a representative set of named projects, some of which have already been the subject of pre-feasibility and feasibility studies, and memorandums of agreement

List of Projects Evaluated for Possible Financing
(Table 5-4 of JEPAS)

1	Krasnodar Power Plant	A 3 x 450 MW, gas-fired power plant near the town of Mostovskaya in North Caucasus
2	Urengoi Power Plant	A 4 x 225 MW plus 24 MW, gas-fired steam turbine near Yamalo Nenets in Tyumen
3	Cherepovets Trans Line	A 270 km, 750 kV transmission line in the North-West that would permit the Cherepovets region to be supplied from the Kalininskaya Power Plant
4	Beloparoskaya Hydro Plant	A 103 MW peaking hydroelectric power plant in the North-West
5	Shakhtinskaya CHP Plant	A partially-built 70 MW CHP plant at Shakhti in the North Caucasus
6	Kamenskaya CHP Plant	A 90 MW CHP plant at Rostov in North Caucasus
7	Cherepetz Power Plant	Rehabilitation of 4 x 150 MW and 3 x 300 MW, coal-fired units in the Cherepetz State District in the Central Region
8	Shuikino Power Plant	A 2 x 450 MW expansion of the Shuikino Power Plant
9	Kola-St Petersburg	A 330 kV line from Kola to Karelia and a Transmission Line 750 kV line from Karelia to St Petersburg
10	North-West to Center Transmission Line	A 330 kV and a 750 kV line between the two regions
11	North-West Region Power	Reconstruction of the power control center for the North-West Region
12	Moscow Central Dispatch Office	Modernization of the Moscow Central Dispatch Office
13	Moscow Oil Refinery	Energy conservation
14	Lenenergo Power Plant	Repowering the Lenenergo Power Station by adding three 50 MW gas turbines
15	RBMK power plants	Develop decommissioning plans

16	NP500	Initiate siting and project preparation procedures for licensing a new NP500
17	Kalinin NPP	Complete construction of Kalinin 3
18	Rostov NPP	Complete construction of Rostov 1