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Belarus
Energy Sector Review

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The first draft of the report was prepared in February 1994. A follow-up mission discussed the draft with the Government in Belarus in April, and prepared a short and medium term action plan. The Review and the Action Plan was presented to the Government in January 1995. Based on comments from the Government, the Review was finalized in February 1995.

The study drew on a number of earlier World Bank reports on Belarus such as the Country Economic Memorandum, Environment Strategy Study, Forestry Development Project, Rehabilitation Loan, and on the energy sector reviews for Lithuania and Ukraine. We wish to thank the authors of these reports for allowing us to use some of their findings.

BELARUS

ENERGY SECTOR REVIEW

Executive Summary

i. Belarus relies almost exclusively on imported fuels to cover its energy needs. As part of the Soviet Union, Belarus had access to crude oil and natural gas from Russia below world prices. This easy access led to systematic under-pricing of energy and raw materials that, in turn, led to usage per unit of output substantially higher than in market economies. Out-of-date and often inappropriate technologies produced high volumes of waste. Price distortions and the absence of private property rights created a bias against investments in energy efficiency, pollution abatement, adequate maintenance of plants, and recycling.

ii. Recently, it has become clear that Belarus is not able to produce enough exportable goods to support the energy requirements of an economy which is so highly energy intensive and import dependent. At the same time, the Government has recognized that the potential for improving the efficiency of energy consumption is great. It has also recognized that changes are needed in the organization and management of the energy sector to improve the efficiency of energy supply. In mid-1993, the Minister of Power and the Chairman of the Committee for Energy Savings and Control approached the World Bank for assistance in revising the country's energy strategy.

iii. This report provides the basis for a comprehensive energy strategy which takes into account the new political and economic realities in Belarus. Its recommendations are based on (i) the Government's long term energy program; (ii) new ideas from Belarussian energy experts; and (iii) the experience of the World Bank and other international agencies. The cornerstones of the proposed medium term energy strategy are:

- the gradual elimination and improved targeting of energy price subsidies, and the liberalization of energy prices in those subsectors, that are not natural monopolies;
- the use of market mechanisms rather than administrative norms to allocate scarce energy resources;
- the development of a domestic capability to provide energy efficiency services;
- the improvement of the security of energy supply by increasing crude oil and gas reserves, expanding the use of domestic renewable energy sources, and improving the reliability and efficiency of electricity supply from existing thermal power plants;
- the separation of the Government's policy making, regulatory, and ownership functions; and
- the promotion of competition in oil production, refining and marketing, solid fuel production, distribution and marketing, and electricity generation.

iv. The main findings and recommendations of the report are summarized below.

Energy Demand

v. Energy consumption per capita was about 4,400 kilogram oil equivalent in Belarus in 1990, which is quite high even by Western European standards. Based on a cross-country analysis of the relationship between energy consumption and GDP, Belarus used about 40 percent more energy in 1990

than might be expected (using the average predicted value) on the basis of its estimated per capita GDP level. Over the period of 1991-93, the cumulative drop in primary energy use was 30%, compared to the 25% decline in GDP, suggesting that some improvement in aggregate energy efficiency has occurred already. It appears that sectoral changes in output, triggered by the collapse of the ex-USSR market for the more energy-intensive Belarussian products, have been responsible for most of the improvement in the energy/GDP ratio. There is little evidence of significant efficiency gains at the sectoral, sub-sectoral and product levels, despite the large untapped reservoir of energy efficiency.

vi. In 1993, industrial enterprises focussed their activities on protecting their allocation of energy supplies, instead of using these supplies efficiently. The Government's response was to authorize the Committee of Energy Savings and Control to extend the use of energy consumption norms to previously unregulated consumers/processes. The system of administrative norms and penalties is a poor substitute for economic cost-based energy prices. As soon as energy prices are raised to reflect economic costs, the penalties for over-the-norm consumption should be abolished. Appropriate energy prices, together with the imposition of hard budget constraints implying a genuine threat of bankruptcy, will provide the right conditions for price-driven structural change and energy efficiency improvements. The supply of gas, heat and electricity to those enterprises and organizations that accumulated large payment arrears should be reduced to the technically safe minimum. At the same time, the rationing of supply to those enterprises that are able to pay a price based on the full cost of energy should be eliminated. To assist energy saving efforts, the Government should foster the development of industrial organizations whose function is to provide, on a consulting basis, detailed plant energy audits, to recommend energy saving measures to individual industrial plants, to assist in putting such measures in place, and to run energy efficiency courses at the plant level.

vii. The future evolution of energy demand will depend on the pace of economic reform, including real increases in energy prices and the hardening of the enterprises' budget constraints. Energy demand forecasts based on a dynamic consumption model suggest that primary energy demand will continue to decline in the next few years, and, even after the economy resumes growth, it will not reach the 1990 level again before 2010. Primary energy demand is expected to decline more rapidly under a comprehensive reform scenario, and, despite a higher corresponding GDP after 1998, will be about 5 mtoe/year less than in the slow reform scenario. Under both scenarios, the substitution of gas for oil continues, and gas consumption recovers its historical peak before 2005. Electricity demand is expected to behave similarly to primary energy demand, surpassing its 1990 level only 15-20 years later.

Energy Supply

viii. **Domestic resources and supply**. Due to the drop in energy consumption, the share of domestically supplied energy in total primary energy consumption increased from 8.1% in 1990 to 11.9%. Belarus is relatively poorly endowed with non-renewable fuel resources. Available resources consist of oil, oil shale, brown coal and peat. However, only crude oil resources are significant. There is an urgent need to modernize the technological base of oil exploration and production to avoid a decline of crude oil production. Renewable resources, especially wood, are potentially more significant. Taking into account ecological constraints and the impact of the Chernobyl accident, about 8 million (solid) m^3 of firewood per year can be harvested, compared to the recent production of about 5 million m^3 per year. Furthermore, there are about 1 million m^3 of unutilized wood waste in industry. In order to utilize these reserves, substantial investments will be needed in wood harvesting as well as in wood burning facilities over an extended period.

ix. **Fuel import**. Russia is the sole supplier of imported fuels for Belarus. The Government's long term energy program, for reasons related to supply security, discussed a number of alternatives for fuel purchases (e.g., coal from Poland or Australia, gas from Turkmenistan or Norway, oil from the Middle East). While reducing the dependency of Belarus on a single fuel supplier increases the security of energy supply, this will not come without costs. Belarus is located on the export corridor from Russia to Europe, therefore the cost of supplying the domestic needs of Belarus will always be lower than delivering Russian oil and gas to the rest of Europe. If Russia can price its energy exports competitively in Europe, it should be able to do so even more in Belarus. Therefore, strictly on the basis of supply costs, Russia is the least cost source of imported oil and gas for Belarus, and it is doubtful that the improvement in supply security would justify the significant additional (investment and recurrent) costs of importing oil or gas from other countries. Not alternative import sources, but the gradual expansion of the capacity of crude oil and gas storage facilities (to 2 mt for oil and 2 bcm for natural gas) provides the cost-effective way of increasing the security of fuel supply for Belarus. In addition, the strengthening of the relationship between Belarussian refineries and Russian crude producers could also increase crude oil supply security.

x. **Electricity import**. Belarus has not experienced costly disruptions in electricity imports. Although sudden increases in the cost of imported electricity shocked the power industry in 1992-93, these increases simply mirrored the increases in imported fuel costs. The existence of high capacity power connections to three countries significantly reduces the ability of any of these countries to achieve and exploit a monopoly position on the Belarussian electricity market. The Government's long term energy program set a goal of self-sufficiency in electricity generation after the year 2005. The expected further decrease in electricity demand will temporarily reduce the gap between peak power demand and domestically available generation capacity in 1995-98, therefore there is no urgency to invest in capacity expansion with the sole purpose of increasing the self-sufficiency of electricity supply (this does not imply that investments in rehabilitation or capacity expansion are not needed -- see para. xxv below). In the medium term, the economic viability of investments in new generation aimed at replacing electricity imports will depend on the reliability and cost of imported electricity. Meanwhile, permitting suppliers in all neighboring countries to compete on the Belarussian electricity market and keeping adequate fuel reserves for domestic power plants are the cost effective measures to increase the security of electricity supply.

Sector Management, Regulation and Ownership

xi. **Sector management**. In Belarus, there are several organizations reporting directly to the Council of Ministers with major responsibilities in the energy sector. This makes the task of sector management, coordination and supervision very difficult. Recognizing this, the Government has recently started a process of unifying the management of the sector. The proposed establishment of a new Ministry of Fuel and Energy is an important step in the right direction, and should be implemented as a matter of high priority. The new Ministry should develop an arms' length relationship with the enterprises in the energy sector. This could be achieved by the separation of the ownership function from the coordination and policy making role of the Ministry. The first steps should be the corporatization of all enterprises in the energy sector, and establishment of holding companies to act as intermediate owners in the power and oil subsectors, thereby ensuring that the Ministry will not have direct responsibility for production (no "khozyaystvennie funktsii").

xii. **Regulation**. The Prices Department of the Ministry of Economy, although it is independent from the energy agencies, does not meet all the requirements for a regulatory authority. Its focus is on only one aspect of regulation, prices, while other important aspects, such as the quality of service, are somewhat neglected. Its procedures and decisions are not transparent, and are subject to approval by the government. Therefore, in the medium term, there is a need to establish an open, independent, legally based energy regulatory system by which the interests of the customers (both residential and industrial), the central and local governments, potential creditors and the regulated enterprises are all taken into account. The same agency may regulate the whole energy sector, or specialized agencies may be established for power, gas, etc. The top management of the regulatory authority (or authorities) should have a high degree of job security and should be appointed by the Prime Minister or the Deputy Prime Minister for a fixed time period. The regulators should (a) promote competition in oil and gas production, oil refining and distribution, coal mining and distribution, electricity and heat generation and energy trade; and (b) closely regulate the non-competitive energy activities such as gas, electricity and heat transmission and distribution. Promotion of competition will require demonopolization, and changes in ownership (see below).

xiii. **Ownership and restructuring**. The energy sector in Belarus is organized on the basis of a number of monopolies with limited operational autonomy. International experience amply demonstrated the large efficiency gains associated with the indroduction of competition. Even for natural monopolies, significant improvements in production efficiency were recorded when the operation of enterprises was put on a commercial basis with increased autonomy for management. In order to realize these gains, there is a need to corporatize and restructure the enterprises in the energy sector in Belarus:

- **Oil exploration and production**. The policy development, supervisory and long term scientific functions of Belarusgeologia should be separated from the petroleum exploration function. The exploration function could be transferred to Belarusneft, or the Government may decide to create one independent exploration and development entity by merging the relevant departments of Belarusneft and Belarusgeologia. Belarusneft should be corporatized (i.e., transformed into a joint-stock company), with the majority ownership function assigned initially to the new Ministry of Fuel and Energy or to GKI. In the medium term, most of the stocks could be offered to foreign and domestic private investors.

- **Oil transportation.** An oil transportation pipeline is a natural monopoly and it requires regulation. The two pipeline companies operating the northern and southern lines should treat all potential users in a fair and non-discriminatory way (i.e., operate as open access pipelines), while should be allowed to earn adequate return on their capital. Assuming the existence of a proper regulatory framework, state ownership of the pipeline companies is not an economic necessity. The companies should be corporatized and, in the long run, shares could be offered to foreign or domestic private investors.

- **Oil refining and distribution** is a subsector that should operate on a competitive basis. That implies freedom of entry and exit, liberalization of foreign trade and decontrol of domestic prices. In addition, the refineries and the distribution companies are prime targets for future privatization. The restructuring and corporatization of the oil refining industry should aim to solve the major problems of supply insecurity, foreign exchange shortages, obsolescence, and excess capacity. Following corporatization, the refineries should be allowed to make their own business decisions under well defined regulations for taxation, accountability and performance. Distribution by oil tank trucks (mostly used by oil marketing companies moving products to retail outlets) should be fully privatized preferably with different private transportation companies competing in the same marketplace.

- **Gas transmission**. Gas transmission is a natural monopoly. Recently, the Government has submitted a proposal to the Supreme Soviet to amend the law to permit the corporatization of Beltransgaz and establishment of a joint stock company with RAO Gazprom. Whether the incorporation of Beltransgaz into RAO Gazprom is concluded or not, the operation of the transmission system will need to comply with the laws and regulations of Belarus. In the long run, the transmission system should operate as an open access pipeline serving gas exporters and importers.

- **Gas and solid fuel distribution**. Beltopgaz is currently responsible for four different functions. Among these functions, only natural gas distribution is a natural monopoly, while the other functions can be carried out competitively. Therefore, these function should be separated by (a) corporatizing the seven "oblgaz", the pipeline construction and design companies, and establishing a holding company (Belgaz) as the main shareholder; (b) establishing a corporation for LPG bottling and distribution; (c) establishing a corporation for peat harvesting and briquetting; and (d) placing the local fuel distributing outlets ("gorraytopsbit") directly under their respective local governments. In the medium term, stocks in the oblgaz, pipeline design and construction, LPG and peat corporations could be offered to foreign investors. Also, the "gorraytopsbit" enterprises should be privatized, parallel with the liberalization of the trade of solid fuels.

- **Electricity**. Vertically integrated regional monopolies are responsible for electricity supply in Belarus. It is possible to introduce competition in electricity supply if these monopolies are broken up into separate companies responsible for generation, transmission and distribution. All generators (including cogenerators in the industrial sector) must be allowed open access to the transmission network and have the right to sell bulk power to distributors and large users at unregulated prices. Also, generators and other independent producers must be allowed to bid for the right to develop new generating capacity. Generating plants abroad are potential competitors on the Belarussian electricity market. A system of gradually increasing quotas of direct supply contracts between domestic customers and foreign suppliers (allocated to Lithuania, Poland, Russia and Ukraine) will be needed to strike a balance between the objectives of efficiency and supply security. These changes will require the drafting and adoption of an electricity law that lays down, among other things, the respective roles of market competition and Government regulation, the functions of the regulatory agency and the rights of potential private and foreign participants in the supply of electricity.

- **Heat**. The restructuring of the electricity subsector proposed above will increase the autonomy of the large combined heat and power plants, and therefore will facilitate competition between heat generators. Since the cost of transporting heat over long distances is prohibitive, competition in heat supply can only be local in nature. In Belarus, the development of competition in heat supply in a specific city will depend on the availability of a significant number of independent heat producers (e.g., industrial enterprises) in the direct neighborhood of the district heating network who are interested in selling heat through the network. Therefore, supply conditions could differ dramatically between cities, and there is only a minimal need for regulation on a nationwide basis. The functions of regulating transmission/distribution systems, issuing heat supply licenses and awarding contracts could be delegated to the municipal executive councils. The proposed energy regulatory authority could provide technical standards for the systems and carry out an oversight function in cooperation with the Ministry of Housing and Communal Services.

Energy Prices

xiv. In 1993, the applied system of energy price control in Belarus was (a) inefficient, since the prices that were kept below import costs discouraged energy savings and misallocated fuel and energy supplies; (b) damaging for macroeconomic stability, since it required subsidies at a rapidly increasing scale that undermined efforts to contain the budget deficit and negatively affected industrial competitiveness; (c) unsustainable, since it did not permit the generation of revenues to maintain/rehabilitate assets in the energy sector; and (d) non-conducive to market development, since it forestalled competition among energy suppliers. There is a need for a comprehensive energy price reform that should be closely coordinated with the proposed organizational restructuring of the energy sector (see para. xiii). The price reform itself would have no additional inflationary effect, since the alternative -- low energy prices for many categories of consumers paid from budgetary subsidies and cross-subsidies -- is equally inflationary. In fact, competition will increase the efficiency of energy supply industry and thereby result in lower energy costs in the medium term.

xv. **Non-household prices**. The Government should complete the liberalization of the refining and trade of oil products by eliminating all remaining price controls, margin controls, and directed supplies and other forms of regulatory constraints. The price of "clearing" (i.e., state procured) oil for the refineries should be set to match (on a monthly basis) the average price the refineries pay for crude oil (of similar quality) imported outside the clearing agreement with Russia. The price of domestically produced crude oil should be liberalized. The system of "talons" provided to government organizations for the purchase of automotive fuels represents an unnecessary intervention in the operation of the market, and should be eliminated (not organizations, but individuals need social protection). Following the institutional separation of the activities of Beltopgaz and the corporatization of the relevant companies, the production, trade and distribution of solid fuels and LPG should be liberalized, including the elimination of price controls at all government levels. Also, as soon as the separation of electricity generation from transmission and distribution is implemented and a system for competitive supply of electricity is established, prices for electricity generators can be liberalized (i.e., the price of electricity for final consumers would be the sum of unregulated generation and supply, plus regulated transmission and distribution costs). The Government should encourage Belarussian power and gas utilities to develop time-of-day, seasonal and interruptible tariffs.

xvi. **Household prices**. The first step is to stop the escalation of household energy subsidies. Therefore, a severalfold increase of household energy prices should be implemented as soon as possible.

In addition, a medium-term program should be developed to gradually eliminate household energy subsidies.

xvii. The second step is to create incentives for the households to save energy. That requires the increase of the price of the last unit of energy consumed (i.e., the marginal price) to the cost of supply. For electricity, natural gas and heat, the subsidized price should apply only to the first block of consumption corresponding to a "basic need" level. The implementation of the program should be linked to a nationwide program of installing gas and heat consumption metering\control devices for individual houses or apartment blocks. The rationing system for subsidized solid fuels should be expanded to LPG and heating oil. The price of these non-network fuels (solid fuels, LPG and heating oil) for additional (above the "basic need") purchases should be liberalized (see above).

xviii. Third, the targetting of the subsidy to the lowest income groups (i.e., to decrease the "leakage" of the subsidy to medium and high income households) should be improved in the medium term. Also, the method of subsidization should be changed so it does not interfere with the operation of the market. This can be achieved by setting up a system whereby local governments subsidize the energy consumption of low income households. A possible method is to provide "talons" to low income households that could be applied towards the purchase of fuels and energy from any supplier. The "talons" would have a monthly established face value, and, at the end of each month, suppliers would submit their talons to local governments for refunds.

Investments and Financing Options

xix. Taking into account the expected decrease of energy demand, condition of the capital stock, and the availability of domestic energy sources, investment planning should (a) concentrate on investment that would bring fast loss reduction, energy efficiency and conservation gains; (b) emphasize rehabilitation of existing facilities rather than construction of new ones; (c) increase fuel storage capacity to reduce exposure to supply interruptions; (d) convert facilities to indigenous fuels, to the extent economically and environmentally acceptable; and (e) maintain or enhance transit capacities to take full advantage of the location of Belarus between Russia and the major European markets. Based on these broad priorities, a number of investments in each subsector are listed below.

xx. **Oil exploration and production**. Modern high resolution and/or 3-D seismic surveys are needed to replace the currently used obsolete exploration systems. In order to strengthen the exploration and development capacity, a contract should be signed with an internationally experienced company. The contract should include the seismic survey of targeted (and limited) critical areas, on-the-job training of Belarussian staff in the use of modern equipment to its full potential, and the transfer of ownership of the equipment at the end of the contract. The maintenance of oil production levels requires the installation of high capacity and high pressure submersible pumps, increased well maintenance, and heavier and more efficient workover rigs, particularly for deep and complex repair jobs, so that well down time is minimized. There are several oil fields with individual wells producing well below their potential because of extremely tight oil formations. These formations should be stimulated by hydrofracturing that will improve the productivity and allow the oil entrapped in the matrix to access the well bore.

xxi. **Oil transport, storage and refining**. Although oil pipelines need improved maintenance and some technology upgrades, there is no need for capacity expansion. In order to increase supply security, there is a need to construct additional crude oil storage tanks with a capacity of about 1 mt. Both oil refineries urgently need upgrading to increase the share of higher value products in their output. The Government should assist the corporatized refineries by arranging their ownership structure in a way that matches their resource requirements (capital, raw materials, modern technology and managerial expertise) with potential suppliers of these resources.

xxii. **Gas storage and transmission**. The development of a new storage field is of high priority, since the single underground gas storage at Osipovichi is inadequate to meet winter peak demands. In addition, the new field would increase the general reliability of the transmission system. To prevent the development of bottlenecks, a number of aging turbo-compressors need to be replaced in the gas transmission system. Certain parts of the transmission lines have been in service for 30 years, and will also need to be rehabilitated. Due to the expected drop in gas demand in Ukraine and Belarus in the next couple of years, the existing transit system (with rehabilitation and proper maintenance) will be able to deliver more gas to Western and Central Europe. Only after this additional transit capacity is exhausted (or gas demand in Ukraine and Belarus recovers), should the most cost-effective investment in additional capacity (i.e., the one with the lowest cost per additional cubic meter gas delivered) be implemented. It is important that the transit (and storage) fee and the transmission margin is established in a way that includes allowances for the costs of high priority investments. Otherwise Beltransgaz -- as an independent corporation or as a subsidiary of RAO Gazprom -- will find it difficult to attract the necessary funds to finance the foreign cost of these investments.

xxiii. **Gas distribution**. Although total natural gas demand will decrease in Belarus, the residential market is likely to experience further growth. In response, Beltopgaz prepared ambitious plans to expand the distribution network to both urban and rural areas. While natural gas is probably the most economic fuel in cities, in rural areas, where customer density is low, other fuels are probably more economic. Therefore, network expansion should focus on high density urban areas. A program to reduce the number of unmetered customers should be developed, focussing first on commercial establishments, and residential consumers who use natural gas for both cooking and heating. The gas distribution control and dispatch system is obsolete and inadequate. As the residential load increases, the dispatching system must be strengthened to ensure the reliability and safety of the network. Financing of investments in gas distribution will depend on the pricing policy followed by the Government. The Government may authorize the oblgaz companies to focus the expansion of the distribution system on those areas, where the customers are willing to finance part of the investment cost. In the long run, proper pricing of the gas should enable the oblgaz companies to accumulate funds (supplemented by borrowing) to finance the gas distribution expansion program.

xxiv. **Solid fuels**. Wood appears to be the only solid fuel with a potential for increased utilization. Most of the increase should come from the increased production of firewood, requiring investments in wood harvesting and transport facilities. In addition, the Government should explore and encourage the development of additional wood applications in (a) industrial boilers of wood manufacturing industries and other industrial plants; (b) small power plants; and (c) heat-only-boilers of the district heating systems. In all three areas, there are many opportunities for wood conversion of boilers that were initially designed for solid fuel, typically coal.

xxv. **Electricity generation**. Although the decrease of electricity demand is expected to continue, it does not eliminate the need for investments in electricity generation. First, the rehabilitation of some of the oldest CHP units (Minsk TEC-2, Minsk TEC-3, Orsha, possibly also Svetlogorsk) is of high priority. Specifically, there is a need to (a) improve the fuel conversion efficiency of older units by rehabilitation, repowering, or replacement; (b) introduce energy saving measures at the CHP plants such as variable speed drives; (c) convert boilers at selected smaller power plants to wood chips and wood waste; (d) modernize operational control systems; and (e) install modern emission control and monitoring devices. Second, depending on the evolution of demand and the cost of imported electricity, it might be economically justified to put new capacity on line in 1999 or 2000, requiring the start of construction in 1995-97. Based on calculations with a generation capacity optimization model, the installation of single and combined cycle gas turbine units appears to be the least cost solution. However, nuclear power generation may also become economically viable if the price of imported gas increases substantially. Third, around the year 2000, there will be a need to rehabilitate the two large electricity-only plants at Lukoml and Beryoza.

xxvi. **Electricity dispatch and transmission**. Since 1992, the Belarus power system has been controlled from the national dispatch center in Minsk, with telephone links to the regional control centers. Regional control centers receive information from the local distribution networks, and also from terminals in the power plants. The national dispatch center needs to be upgraded to improve telecommunication and control facilities, and also to install modern computer programs for optimal (economic) dispatch of power plants. In addition to the completion of two major transmission lines under construction (a 330 kV line between Mozyr and Gomel, and between Minsk and Slutsk), there are plans to expand the 330 kV network by constructing 700 km of new lines in the period 1993-95, and additional 622 km in the period 1996-2000. Since the existing transmission system is adequate to serve electricity transmission needs, these additional expansions may not be of high priority. Renovation of old and unreliable lines using new and more durable materials, improvement of substations, installation of variable compensators of reactive power, and purchase of modern maintenance equipment will reduce system losses, and have the highest priority in the short and medium term.

xxvii. Availability of financing for the investments in the electricity subsector will depend largely on one factor: the relationship of electricity prices to the costs of electricity generation, transmission and distribution. If prices are inadequate to cover costs, the power industry will be unable to generate investment funds internally. As a result, neither domestic banks nor foreign lending agencies will consider the industry creditworthy, and the Government will be forced to return to the old practice of financing investments directly from the budget. Due to low prices, consumers will be less interested in energy conservation. Demand will grow more rapidly, necessitating even more investments -- the difference in investment costs between the low and high electricity demand scenarios is about US$ 600 million in 1994-2010 (operating costs are also higher, by about US$ 1,900 million, under the high demand scenario). Budget subsidies at such a large scale will seriously endanger the success of the macroeconomic stabilization program. In contrast, by setting electricity prices higher, the Government will reduce electricity demand, thereby reducing investment and operating costs in the power industry. Also, higher prices will allow the power industry to accumulate significant internally generated funds. In turn, that will ensure access for the industry to both domestic and foreign lending institutions. Assuming that the necessary institutional changes are implemented, private investors may be willing to commit some of their funds as equity to support the investment program.

xxviii. **District heat**. District heating has been developed in Belarus beyond what is economically justified. Therefore, the extension of district heating systems should proceed only in cases where it can be shown as clearly economical compared with other options. Such cases could be those where surplus heat is available from power plants at short distance, the density of the population is sufficiently high, and heating networks exist in the vicinity. For any new housing development, alternative heating methods, such as gas distribution to individual buildings or apartments and local boilers burning indigenous fuels such as wood chips should be considered. In order to reduce energy losses, improve dispatch, control, and metering, the district heating networks need extensive rehabilitation and modernization. In each city, the modernization program should include boilers, dispatch, transmission, distribution and also the end-users. In view of the current extremely low payments from households, there are only two possible financing sources in the short run: local government budgets and support from the central government. Over time, if the proposal to target subsidies to low income households is implemented, the price of district heat can be increased so that user charges become a significant financing source for system improvements. This would also facilitate the involvement of foreign lending agencies in the proposed district heating modernization program.

I. INTRODUCTION

1. Belarus has an area of 207,600 km^2 (equal to about two times the size of Hungary or Bulgaria), stretching 560 km from North to South and 650 km from East to West. It is bordered by Poland in the West, Russia in the East, Lithuania and Latvia in the North and Ukraine in the South. Extensive plains dominate the landscape: the highest elevation is only 307 meters above sea level. A chain of hills running latitudinally divides the country into a northern part where rivers drain into the Baltic Sea and a southern part that belongs to the basin of the Black Sea. The climate is mild continental (monthly average temperatures are in the range of -7 to +18 centigrade) and moderately wet, resulting in an abundance of marshy land that covers more than 20 percent of the country. Apart from potassium chloride, peat and a limited amount of crude oil, Belarus lacks significant mineral resources.

2. Belarus is a middle-income country with a population of 10.3 million and an estimated per capita income of US$2,920 in 1992.[1] In 1989, 78 percent of the population was of Belarussian origin, 13 percent Russian, 4 percent Polish and 3 percent Ukrainian. Average population density is 49 persons per km^2, relatively low by European standards. About 67 percent of the population live in towns, compared to 32 percent in 1960. The shift from rural to urban population was a gradual process. Minsk, the capital city, had a population of 1,634 thousand in 1991. Other large cities are Gomel (503,000), Mogilev (363,000), Vitebsk (362,000), Grodno (285,000), Brest (277,000), Bobruysk (223,000), Borisov (150,000), Orsha (125,000), Pinsk (124,000), Mozyr (103,000) and Novopolotsk (97,000). The country is administratively divided into six oblasts (named after the six largest cities), and 117 rayons.

3. Belarus was declared an independent republic in September 1991, following the disintegration of the political and economic system of the former Soviet Union. The Government adopted a cautious approach to economic reform and has been slower than Poland, Russia or the Baltics in designing and implementing programs leading to the introduction of a market economy.

4. In the past, all segments of economic activity were controlled by the state. Soviet centralized industrial development policy made Belarus the "assembly line of the Union." It specialized in high-skilled labor intensive activities such as machine building, textiles, wood products, meat and dairy production. In addition, Belarus became a significant producer of mineral fertilizers and basic chemical and petrochemical products. It was a net importer of energy, metallurgical and agricultural products and a net exporter of machinery and consumer goods. Although export and import volumes represented about half of the gross domestic product, close to 90 percent of trade was carried out with other republics of the former Soviet Union and the economy was insulated from international competition. Massive price distortions and state control over resource allocations characterized the economic system.

5. Despite having significant renewable energy sources (but only modest oil and coal deposits), the practically unlimited availability of cheap crude oil and natural gas from Russia sustained an economy which relied almost exclusively on oil and gas for its energy needs. Systematic under-pricing of energy and raw materials led to usage per unit of output substantially higher than in market economies. Prevailing technologies, often out-of-date and inappropriate, produced high volumes of waste. Price distortions, subsidies and the absence of private property rights created a bias against investments in energy efficiency improvements, pollution abatement, adequate maintenance of existing plants and recycling.

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1 Source: World Bank Atlas, December 1993. Estimates for economies of the former Soviet Union are subject to more than the usual range of uncertainty and should be regarded as preliminary.

6. The disintegration of the former Soviet Union had a dramatic impact on the reliability and costs of imported energy for Belarus. In order to cover increasing import costs, Belarus needed to increase the volume and competitiveness of its exports of machinery and consumer goods. In response to the changing circumstances, a new long term energy program was developed in 1992. The program was based on the following five principles: (i) priority of social objectives over economic or other considerations; (ii) emphasis on energy savings; (iii) self-sufficiency in electricity generation and installed generating capacity; (iv) maximum possible extension of the life of existing equipment; and (v) compliance with environmental protection requirements.

7. The long term program recognized that the most significant untapped energy reserves were in energy consumption rather than production. The program proposed the application of both market based and administrative instruments to utilize these reserves. After taking into account the economically justified efficiency improvements, the program estimated that both electricity and fuel demand, following a short period of stagnation between 1990 and 1995, would continue to grow and be about 25 percent higher in 2010 than in 1990. Supply from domestic sources (oil, peat, and renewables) would increase only slightly, and most of the demand growth would be met by expanding natural gas imports. In order to achieve self-sufficiency in electricity generation, the program proposed the construction of 8,800 MW new electricity generating capacity (including 1,000 MW nuclear capacity) in the 1991-2010 period. The program also recognized the need to retire old plants with a total capacity of 2,560 MW (most of the retirement would take place after the year 2000). Due to the emphasis on domestic power generation and on the increasing utilization of natural gas, future investments were to be concentrated in the power and gas subsectors.

8. Recent developments have raised doubts about the viability of the long term program. First, it has become clear that Belarus is not able to produce enough exportable goods to support the energy requirements of an economy which is so highly energy intensive and energy import dependent. During 1992 and the first half of 1993, Belarus accumulated Rrb 190 billion "technical credits" from the Central Bank of Russia, which was converted into a long term loan of US$ 385 million (with zero interest) in September 1993. At the same time, the Russian Government informed Belarus that its willingness to continue the delivery of energy without the corresponding payment was limited. Second, it has become clear that the evolution of energy demand in the 1992-1995 period will be different from the one predicted in the long term program. The program underestimated the impact of economic recession and paid little attention to the role energy prices could play in realizing savings in energy consumption. Third, it became widely recognized that changes would be necessary in the organization and management of the energy sector to improve the efficiency of energy supply. In mid-1993, the Minister of Power and the Chairman of the Committee for Energy Savings and Control approached the Bank for assistance in revising and expanding the Government's energy strategy.

9. This report, a product of several months of cooperation between World Bank, USAID, EBRD staff and Belarussian specialists in government agencies and energy sector enterprises, is intended to provide the basis for a comprehensive energy strategy which takes into account the new political and economic realities in Belarus. The report utilizes many recommendations of the long term program mentioned above and also reflects several other ideas from Belarussian experts working in the energy sector. The report presents an action plan, consisting of measures in the area of institutional development, regulatory policy, pricing, trade, investments, and technical assistance, which is aimed at developing a modern energy sector well-suited to operate in a market environment. The report recognizes that an energy strategy should be based on the prioritization of options, should be within the limits of financial, technical and institutional capabilities, and should be acceptable to the public in terms of its environmental consequences.

10. Chapter II of the report describes recent economic developments and the role of the energy sector in Belarus. Chapter III presents a forecast of aggregate energy demand and a set of non-pricing measures to improve energy efficiency. The supply of energy from domestic sources and import is reviewed in Chapter IV. Chapter V analyses organizational arrangements in the energy sector. Chapter VI describes the pricing of energy. Chapter VII provides a detailed description of subsector issues in the oil, gas, solid fuels, electricity and district heat subsectors, including investment priorities. Chapter VIII discusses financing options. Finally, the last chapter lays out an action plan for the adoption of essential measures.

II. ENERGY AND THE ECONOMY

A. Macroeconomic Performance and Reform[2]

11. During the 1980s the economy of Belarus grew at an average rate of 4.8 percent per annum.[3] In 1990, reflecting the downturn being experienced elsewhere in the former Soviet Union (FSU), economic activity in Belarus began to slow, and net material product declined by 3 percent. The dissolution of the FSU in 1991 was a major shock to the Belarussian economy. Demand for commodities produced by Belarus, particularly investment goods, consumer durables and military equipment, sharply contracted, while supplies of raw materials and imported energy were curtailed and the terms of trade declined. The Government's initial response to the terms of trade shock and the loss of export markets was to rely on existing administrative structures to regulate production and prices. These policies which essentially postponed structural adjustment to the external shocks limited the decline in output to about 1% in 1991. The situation, though, deteriorated in 1992 when the decline in inter-republican trade began to affect all sectors of the economy. It is estimated that GDP declined by 10% in 1992 and by an additional 12% during 1993.

12. Following price liberalization in Russia, inflation spilled over to Belarus starting in early 1992. It is estimated that inflation averaged about 1,000% during 1992, and remained very high, at about 25% per month, during most of 1993. The Government has followed relatively conservative fiscal policies. The consolidated Government budget (including republican and local government budgets) was in surplus until 1992, when a deficit of about 2% of GDP was recorded. The consolidated budget deficit in 1993 increased to about 6% of GDP, mostly as a result of declining fiscal revenues following the drop in economic activity.

13. In May 1992, the shortage of ruble notes in Belarus led to the introduction of a parallel currency, the Belarussian ruble, which by end-1992 accounted for 80% of the currency in circulation. Starting in November 1992, non-cash transactions have been denominated in separate units of account, distinguished by country and with a flexible exchange rate determined in the "soft currency" auction market. The exchange rate of the non-cash Belarussian ruble has since steadily depreciated vis-a-vis the Russian ruble, from 1:1 in November 1992 to 4.2:1 in November 1993. The depreciation of the non-cash Belarussian ruble has been even more pronounced vis-a-vis the convertible currencies; the National Bank of Belarus paid 6,750 Belarussian rubles for one US dollars at the end of November 1993. The value of cash Belarussian rubles was about 40 percent higher.

14. In 1992, the Government began to establish the basic legislative and institutional infrastructure necessary for market reforms. After numerous institutional and legislative framework changes made in 1992, the pace of reform accelerated substantially in 1993 due to the Government's recognition of the irreversibility of the external shocks resulting from the dissolution of the FSU and the need for significant structural adjustment to put in place incentives for more efficient resource allocation. To support the macroeconomic stabilization measures and structural reforms undertaken and planned, the International Monetary Fund provided a Systemic Transformation Facility in July 1993, and the World Bank approved a Rehabilitation Loan in November 1993.

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2 This section is based on Reports No. 11349-BY (Country Economic Memorandum) and P-6147-BY (Rehabilitation Loan), World Bank, 1993.

3 The growth rate refers to the Net Material Product.

15. In September 1993, Belarus signed an agreement with Russia and four other former Soviet republics to establish a new economic and monetary union. Within the framework of this multilateral agreement, and a subsequent bilateral agreement with Russia, Belarus would harmonize economic legislation and policies with those of Russia, as a precondition to a monetary union in which the Central Bank of Russia would have the lead role. Uncertainties have remained on the modalities and time frame of the process. The task of harmonizing economic legislation is formidable, including areas such as taxation, enterprise activities, financial sector, domestic and international trade.

16. Many policies contained in the Government's reform program (macroeconomic stabilization, privatization, imposition of hard budget constraints on industrial enterprises, and trade liberalization), particularly if coupled with appropriate energy pricing policies, could be expected to reduce the energy intensiveness of the Belarussian economy. Under the reform program the Government intends to eliminate the remaining price restrictions, with the exception of a limited group of necessities, certain energy products and communal services; and prices have been raised substantially for goods still subject to administrative controls. Prices and other incentives which encourage more efficient use of energy, mineral and water resources will also reduce air and water pollution and improve the status of environment in Belarus.[4] These considerations reinforce the case for moving as rapidly as possible to implement the economic reform measures.

B. The Structure of the Economy

17. The share of the industrial sector (including construction) in the GDP was 43 percent in Belarus in 1990.[5] While this figure is substantially higher than in Western Europe (the average for the EC was 34 percent in 1989), it is equal to the average in the former Soviet Union.[6] The share of agriculture (23 percent) in the GDP in Belarus is also higher than in Western Europe, leaving a relatively small share for communications, transport and services (34 percent). Since the services sector is generally less energy intensive than industry, it is not surprising that the Belarussian economy is more energy intensive than Western European economies (for further information on energy intensity, see Chapter III, Section A below).

18. However, there are significant differences between the energy intensity of various industrial processes, i.e., the structure of industry also matters. Because of distorted figures expressed in monetary values, industrial employment figures were used as a proxy to compare the structure of industry in Belarus to other republics in the former Soviet Union. In 1990, the shares of the power, metallurgy, and mining subsectors in Belarus were lower, while the shares of wood and paper, chemical and light industries were higher than in the Soviet Union as a whole.[7] This observation suggests that the structure of the industry in Belarus was somewhat biased in favor of those branches, which are typically less energy intensive.

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4 For a review of environmental status and policies, see "Belarus - Environment Strategy Study", Report No. 11926-BY, World Bank, 1993.

5 Measured in current prices, see "Trends in Developing Economies", World Bank, September 1993.

6 Based on 1989 figures in P. Marer, J. Arvay, J. O'Connor, M. Schrenk and D. Swanson, "Historically Planned Economies: A Guide to the Data", World Bank, 1992.

7 Source: USSR Labor Statistics, 1990 (prepared by Goskomstat for the World Bank).

19. Structural changes that occured in the 1991-93 period point in the same direction.[8] The subsectors whose total decline in gross output in the last three years (in real terms) was larger than the industrial average (-22%) are fuel industry (-67%), food processing (-32%), chemical and petrochemical industry (-30%), and construction materials industry (-26%). In contrast, machinery, forestry, wood processing and paper, and light industry were the best performers. Light industry even registered a gain of 2.5% in real terms, while forestry, wood processing and paper industry declined only by 0.9%, and machinery production declined by 6%. These developments probably neutralized the sector-by-sector increases in the energy intensity of production caused by the drop in economic output in the 1991-93 period.

C. The Role of the Energy Sector

20. The share of the energy sector in gross material output was about 9% in 1991. The energy sector employed about 5% of the labor force and 12% of fixed assets, demonstrating that production, transformation and distribution of energy is one of the most capital intensive activites.[9] Energy price subsidies, representing about 4 and 6 percent of total government expenditures in 1992 and 1993, respectively, created a rapidly escalating burden on the budget. In terms of foreign trade, fuels and electricity represented about 18% of total imports from the FSU and 30% of exports outside the FSU in 1991 (the last year when the Soviet Union still existed). The situation changed drastically in the next two years, and the share of oil, gas and electricity reached about 60% of imports from the FSU (and about 40% of total imports) in 1993, while energy exports almost disappeared. Energy imports were the main cause of the foreign trade deficit with Russia, the most important trading partner for Belarus. The expected increase of energy import prices will lead to further deterioration in the terms-of-trade for Belarus.[10] In summary, energy production, import and consumption are the dominant factors determining the balance of payments, and also present a potential problem for the balance of the budget in Belarus.

[8] Source: Goskomstat. Due to large changes in relative prices in the same period, these figures are subject to more than the usual range of uncertainty.

[9] These figures are based on a 1991 input-output table prepared by Goskomstat. The energy sector includes fuel production, power and heat, and the whole chemical industry, since data was not available for the petrochemical industry only.

[10] It is estimated that the eventual move to world market prices in trade between the former Soviet republics will cause a (cumulative) 29 percent terms-of-trade loss for Belarus. Source: "How Moving to World Prices Affects the Terms of Trade in 15 Countries of the Former Soviet Union" Policy Research Working Paper No. 1074, World Bank, January 1993.

III. ENERGY DEMAND AND EFFICIENCY IMPROVEMENTS

A. Aggregate Energy Consumption[11]

21. Energy consumption per capita was about 4,400 kilogram oil equivalent (koe) in Belarus in 1990, which is quite high even by Western European standards. The energy intensity of GDP is estimated at 1.4 koe/US$, which is several times higher than in the most developed countries. However, energy consumption per unit of GDP usually decreases at a higher level of development. In order to compare Belarussian energy consumption to energy consumption in other countries, it is necessary to quantify that relationship. Nineteen countries (see Table 1 below) were selected on the basis of climatic conditions not drastically different from that of Belarus and, using data from the Bank's 1992 World Development Report, a cross-country analysis of the relationship between energy consumption and GDP was carried out. The results suggest that Belarus used about 40 percent more energy in 1990 than might be expected (using the average predicted value) on the basis of its estimated per capita GDP level (see Figure 1).

TABLE 1. INTERNATIONAL COMPARISON OF ENERGY CONSUMPTION

1990 Figures Country	*Energy Con/* cap. (koe)	*GDP* (Mill$)	*Population* (thousands)	*GDP/cap ($)*	*En. Cons/GDP* (koe/1000$)
Argentina	1801	93260	32300	2887	624
Bulgaria	4945	19910	8800	2263	2186
Poland	3416	63590	38200	1665	2052
Chile	887	27790	13200	2105	421
Hungary	3211	32920	10600	3106	1034
Yugoslavia	2409	82310	23800	3548	697
Czechoslovakia	5081	44450	15700	2831	1795
South Korea	1898	236400	42800	5523	344
Ireland	2653	42500	3500	12143	218
New Zealand	4971	42760	3400	12576	395
United Kingdom	3646	975150	57400	16989	215
Netherlands	5123	279150	14900	18735	273
Belgium	4852	192390	10000	19239	252
Austria	3503	157380	7700	20439	171
France	3845	1190780	56400	21113	182
Denmark	3618	130960	5100	25678	141
W. Germany	3491	1488210	62000	24003	145
Sweden	6347	228110	8600	26524	239
Finland	5650	137250	5000	27450	206
Belarus	4370	32030	10300	3110	1405

Source: Bank Estimates for Belarus, World Development Report (1992) for other countries.

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11 In Belarus, statistical data on energy consumption are limited and there are serious gaps and inconsistencies among the data reported by various government agencies. The limited quantity and the overall poor quality of data (except for electricity) make the monitoring of changes in consumption a very difficult task. To make things worse, the authorities do not compile a consistent and comprehensive energy balance sheet. For the purpose of this report, a detailed energy balance was prepared for 1990 (see Table 1 in Annex 1). In addition, aggregate energy balances for 1985 and the 1990-93 period were prepared to track recent trends in primary energy consumption. These balances should be considered tentative and preliminary due to serious deficiencies in the underlying data. Data for 1992 and 1993 are particularly uncertain and subject to change as more reliable information becomes available. Much of the uncertainty concerns the oil product flows. The 1993 data are based on partially actual data or estimates made by the authorities and Bank staff.

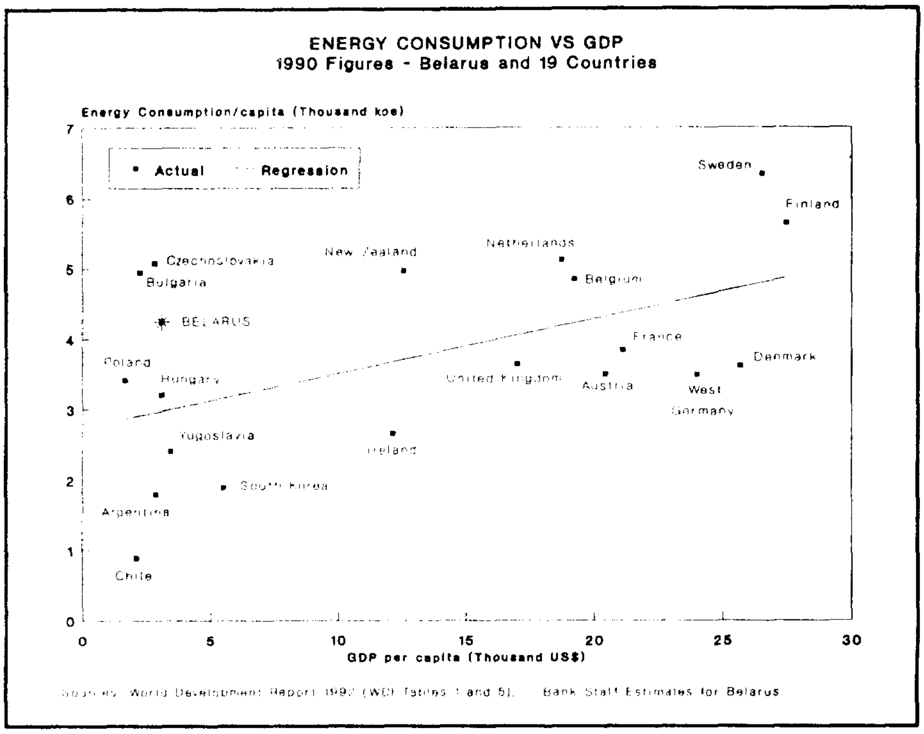

Figure 1

22. In 1990, final energy demand represented 75% of primary energy consumption. Within total final energy demand, the shares of oil products and heat were unusually high (see Figure 2 for the composition of final demand in 1990. The industrial sector (including construction) represented 43% percent of final energy demand, which is not a very high share in international comparison (see Figure 3). The households' share of final energy consumption was very low, due to extensive reliance on district heating, small apartment sizes, and lack of modern appliances.

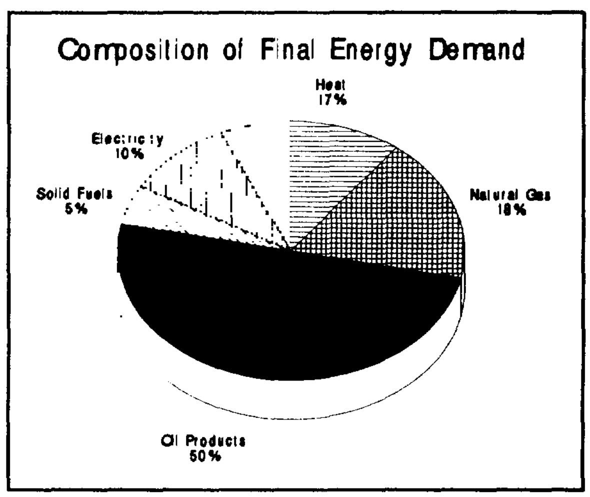

Figure 2

23. Primary energy consumption grew 1.9% per annum on average during the pre-crisis period of 1985-1990. The trend was broken in 1991, when energy use experienced a modest decline (-0.2%). In the following years, energy consumption tumbled at a rate of -16% in 1992 and -15% in 1993 as Belarus slid into a deep economic crisis. Over the period 1991-93, the cumulative drop in primary energy use was 29%, compared to the 25% decline in GDP, providing evidence that some improvement in aggregate energy efficiency (defined as energy use per unit of real GDP) has occurred. The sectoral changes in output, triggered by the collapse of the ex-USSR market for the more energy-intensive Belarussian products, have been responsible for most of the improvement in the energy/GDP ratio. There is little widespread evidence of significant efficiency gains at the sectoral, sub-sectoral and product levels, despite the large untapped reservoir of energy efficiency (see Section C below). Whether these "structural" savings have a permanent character remains to be seen. It is reasonable to assume that they have a reversible component if Belarus succeeds in recapturing the lost markets, mostly in Russia, for its traditional exports such as refined oil products, fertilizers, synthetic fibers and heavy machinery.

24. Recently, the primary energy mix has undergone a major change as natural gas has been substituted for oil in a one-to-one fashion (Table 2). During 1992-93, gas increased its relative share especially remarkably in the power plant fuel market (from 41% in 1990 to 65% in 1993) as Belarus had to cope with sharp cuts in crude oil imports, while gas imports kept rising. Thus, the lop-sided fuel mix in 1985 (with oil occupying a dominant share) is evolving toward a more balanced pattern, with oil and gas jointly meeting almost 90% of the country's current primary energy needs.

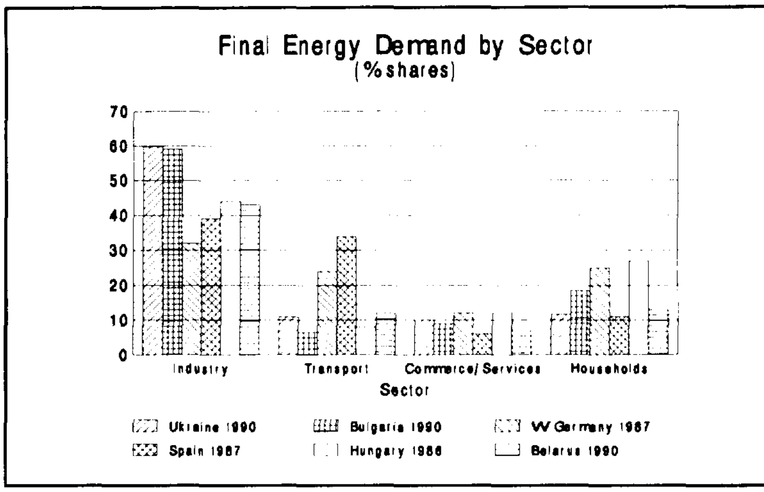

Figure 3

TABLE 2. FUEL MIX OF PRIMARY ENERGY CONSUMPTION, 1985-93
(in percent)

	1985	1990	1991	1992	1993
Coal	3.4	2.1	1.7	1.7	2.1
Peat	2.0	1.4	1.6	2.0	2.2
Wood	2.2	1.6	1.7	2.2	2.8
Oil	70.8	62.6	61.7	53.8	48.9
Gas	17.7	27.0	27.5	36.0	39.2
Electricity (net imports)	3.9	5.3	5.8	4.3	4.7
TOTAL	100	100	100	100	100

B. Household Energy Consumption

25. In early 1994, a survey of 3,000 households was carried out to collect information on the energy consumption of Belarussian households (see Annex 2 for more details). Based on the findings of the survey, Table 3 presents the level and mix of energy usage for the residential sector in Belarus. In a cross-country comparison, per capita household energy use in Belarus is about one-third lower than that of the more developed European countries (Figure 4). A notable feature of the residential energy mix is the high (about one-third) share of district heat, reflecting the extremely high heating network density in urban areas. Another unique characteristic is the large share of traditional fuels (firewood and peat briquette), from which households derive more than one-third of their energy consumption. More than 40% of the households use firewood (although only 25-30% use significant amounts of it) -- an exceptionally high percentage for an industrialized, middle-income European country. The large weight of the traditional fuels reflects favorable domestic resource endowment and lower costs compared to the modern non-network fuels such as heating oil, LPG and coal. The relative share of traditional fuels is

88% in the rural areas, compared to 16% in cities and towns. The different patterns of energy consumption between rural and urban areas reflect (i) differences in incomes; (ii) easy access to fuelwood in rural areas; and (iii) constraints on the access to district heat and natural gas. The survey also revealed the dependence of lower income households on "traditional" fuels, especially firewood. As high as 76% of low-income households use firewood, while this ratio is only 14% in the highest income category. Higher income households, especially in urban areas, derive most of their energy from the district heat, natural gas and electricity networks.

TABLE 3. PATTERN OF HOUSEHOLD ENERGY USE[a]

	toe/capita/year	%
Electricity	0.035	7.5
Central heating	0.150	32.2
Natural gas	0.066	14.2
LPG	0.034	7.3
Firewood	0.090	19.3
Peat briquette	0.070	15.0
Coal	0.021	4.5
Total energy	0.466	100.0

[a] Excluding transport.
Source: Household Energy Survey

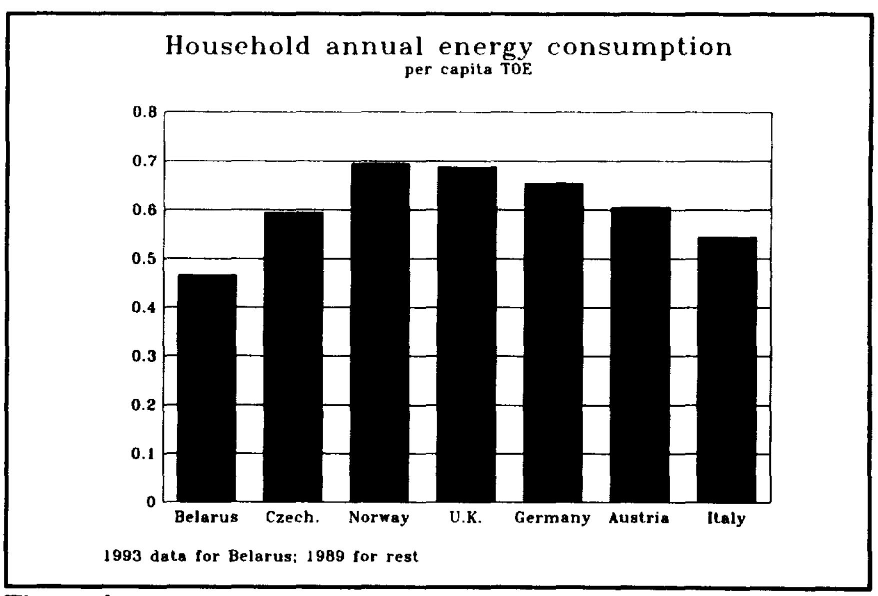

Figure 4

26. Despite rapid growth in residential electricity consumption in recent years (18% between 1990 and 1993), the survey suggests that Belarussian households are "under-electrified". One of the indicators, the share of electricity in overall energy consumption (7.5%) compares poorly with the OECD Europe (average of 23%), or the typical ratio of the more developed Central European countries (an average of 17% for Hungary, Poland and the former Czechoslovakia). The survey points to a close correlation between electricity use and income. The low market penetration of electric heating and cooking devices indicate that in Belarus, in contrast to Central and Western European

countries, electricity gained little market share from fuels through substitution. The market penetration of other electric appliances is high only in the case of television sets (95%) and refrigerators (90%), while it is relatively limited for washing machines (only 60% of households have them). Energy-intensive appliances like freezer, dish washer and air conditioning have an insignificant market penetration. Leisure appliance ownership is also extremely small. The presently undersaturated appliance market points to a potentially sizable pent-up demand for electric appliances, and portends a rapid rise in the share of the residential sector in total power consumption.

27. The survey has found a high level consumer ignorance about energy saving opportunities. Although consumers appear to be aware of some simple measures, as high as 60% of the respondents admitted that they do not know how to achieve substantial energy savings in their homes. High "consumer ignorance" appears also to be related to the households' frustration with their technical inability to control the flow of district heat to their homes. There is a strong perception among households that, while improving energy efficiency would reduce the energy bill, the financing of higher efficiency would be too costly for the family, i.e., the savings on the energy bill would not compensate for expenses. This view was shared by 57% of the respondents (by 50% even among the high-income families). The reason could be a combination of factors: i) the currently heavily subsidized energy prices (see Chapter VI below); (ii) households (implicitly) may use a very high discount rate in calculating the present value of future cost savings; and (iii) energy-efficient appliances and energy-efficiency improving devices are not available in retail stores in Belarus.[12]

C. Energy Efficiency Improvements

28. Energy intensities have recently increased in many sectors of the Belarussian economy, as "fixed" energy requirements, i.e., those which do not vary as a function of (decreasing) output, assumed a larger share of total energy consumption. Notwithstanding the increases in nominal prices, real prices of gas, heat and electricity were well below world levels during most of 1993. As a result, energy represented no more than 5 percent of production costs in most industries, leaving little interest on the part of plant managers to allocate limited capital to energy saving investments. Moreover, previously guaranteed markets for products instilled an attitude among managers that higher production costs could merely be "marked up" through higher prices to a captive market. Even among those who recognize the need to manage costs in order to ensure commercial success, unstable price regimes for all product inputs make it difficult to estimate the cost-effectiveness of energy efficiency measures and justify the associated investments.

29. Plant managers' activities are centered on protecting allotted energy supplies, instead of using these supplies efficiently. Planning and economics departments of enterprises develop forecasts of energy requirements to meet production goals based on existing energy intensity, and energy departments have as their main effort the maintenance of equipment using energy so as to stay within the domain of allotments. No attention is paid to breaking this pattern and examining energy consumption. There is generally some level of awareness that energy is being wasted; however, incentives to eliminate the waste are lacking.

30. The long term energy program submitted to the Government in 1992 (see Chapter I above) included detailed estimates for the energy savings potential in the main sectors of the economy. Total technical potential was estimated at 12.6 mtoe, equal to about one third of total energy consumption in

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12 The Committee of Energy Savings and Control have recently initiated a program to increase consumer awareness and knowledge of energy conservation options.

1992. The sectors with the largest estimated savings potential were (i) households and communal services (3.8 mtoe); (ii) chemical and petrochemical industry (2.5 mtoe); (iii) power industry (1.7 mtoe); and (iv) production of construction materials (0.8 mtoe). However, only a fraction of the total technical savings potential was considered economically attractive: 2.1 mtoe in 1995, 3.9 mtoe in 2000, 5.3 mtoe in 2005 and 6.7 mtoe in 2010. The program identified a number of technological improvements (regulation and automatization of industrial processes, insulation of buildings, etc.), however, it contained very little about the economic mechanism that was expected to make these improvements happen.

31. In 1993, following the establishment of the Committee of Energy Savings and Control, a concentrated effort was initiated to improve the energy efficiency of the Belarussian economy. The Committee has started programs for (i) the production of modern instrumentation and control equipment; (ii) energy audits for industrial enterprises; (iii) the design and establishment of a fund to support investments in energy efficiency improvements; and (iv) increased consumer awareness and knowledge of energy saving options. In these activities, the Committee received valuable assistance from the European Community Energy Center. However, the main focus of the activities of the Committee was the development and enforcement of energy consumption norms. The norms are revised every three years. Despite the well-known inefficiency of central planning, the Government's response to the growing imbalance of supply and demand was to authorize the Committee of Energy Savings and Control to extend the use of norms to previously unregulated consumers/processes in 1994. The new norms were expected to be introduced on January 1, 1994 for the period 1994-1996. The norms serve two purposes. When enough energy is available to meet demand, the norms are applied to penalize the "excess" energy consumption of enterprises -- energy use above the norms is charged five to ten times above the original price. When energy demand exceeds available supply, the norms serve as the basis to allocate (ration) limited supplies.

32. An example is the new system of power rationing. Government resolution 581 dated August 30, 1993 tightened the rationing of power, citing the expected severe fuel shortage during the coming winter. The present system runs from October 1, 1993 to October 1, 1994. The rations are specified by the Central Dispatch Center through the six regional power associations under the direction of the top management of the Ministry of Power, which has to seek the approval of the Council of Ministers for the overall extent and timetable of the restrictions. The regional power associations sign a contract with medium and large users in which the extent and scheduling of the restrictions are fixed. The Ministry bears overall responsibility for implementation of the restrictions. The list of rationed enterprises is determined by the State Committee for Economy and Planning (Gosekonomplan). Those exempted from rationing include enterprises operating on a continuous technological basis, the food industry, transport and telecommunications, most of the communal services, and households. As a general rule, power supply should not be curtailed by more than 25% relative to the level registered in December 1992. During the last quarter of 1993, the extent of power cuts was about 15% for industry (relative to the same period a year earlier) and 8-9% for the economy as a whole. Enterprises that use more power than allowed pay a fine amounting to 10 times of the value of the overused quantity and face the possibility of a complete cut-off from service.

33. With extensive reliance on a system of norms and supply rationing, the Government is impeding the operation of the emerging market. The use of industrial energy efficiency targets in setting penalties will likely be ineffective or counterproductive, due in large part to differences in products, material inputs, accounting, etc., as well as the significant administrative costs associated with policing this effort. The penalties create incentives to improve energy efficiency only to the extent that enterprises want to stay within the bounds of allocated energy resources, and therefore cannot tap into the full potential for energy efficiency improvements. Furthermore, if prices reflect economic cost, there is no

reason to penalize excess energy consumption. Limiting supply to those enterprises that want to consume more energy and are able to pay a price which covers full costs prevents these profitable enterprises from expanding and prolongs the economic recession. In summary, the system of norms and penalties are a poor substitute for economic cost based energy prices. *As soon as energy prices reflect economic costs (see Chapter VI below), the penalties for over the norms consumption should be abolished. Not norms, but prices should be used to ensure the proper allocation of limited energy supplies. The norms could be used as indicators to assist enterprise managers in setting targets and judging the performance of their companies in terms of energy efficiency.*

34. Appropriate energy prices, together with the imposition of hard budget constraints implying a genuine threat of bankruptcy, could provide the right conditions for price-driven structural change and energy efficiency improvements. In fact, in market economies it is through the financial system that inefficient companies can be forced by the market to raise efficiency or go out of business. In the case of Belarus, recognition of the true opportunity cost of capital could shift the emphasis away from large capital investment towards more efficient investment patterns, for example which would upgrade existing capital equipment or incorporate new technology with consequent reductions in average energy use per unit of output. However, while direct budget subsidies to industry have been eliminated, enterprises are not yet facing a hard budget constraint; they can still secure credit from the banking system without necessarily having to demonstrate creditworthiness. Companies have also been able to retain financial resources through accumulation of inter-enterprise arrears. *Hence the privatization, demonopolization, enterprise reform and financial sector programs, which are just beginning to be introduced, will need to focus on creating hard budget conditions if they are also to assist with energy efficiency objectives.*

35. Non-payment for delivered energy is probably the single largest item responsible for the growth of inter-enterprise arrears. The supply of energy without the corresponding payment (i) results in growing debt to Russia; (ii) adversely affects the financial position of the enterprises in the energy sector and endangers their ability to raise funds for needed rehabilitation; (iii) reduces incentives for energy savings; (iv) slows down the progress of industrial restructuring; and (v) softens the budget constraints of enterprises and erodes financial discipline. *Raising prices to the level of economic cost and reducing electricity, gas and heat supply to the technically safe minimum to enterprises who do not pay would eliminate the need for norms and rationing.* The case of electricity supply and demand at the end of 1993 provides an example. At the end of of 1993, following substantial increases in the price of electricity, the price for industrial customers reached the level of economic cost. Had supply to all (non-household) customers whose accumulated payment arrears exceeded 30 days been cut back to the technologically safe minimum, the electricity available would have been enough to meet demand without any restrictions.

36. The objective of the Committee of Energy Savings to provide meters and control devices in all sectors is laudable. Without metering and control, energy users have no incentive or ability to respond to prices and modify their energy use. The provision of meters and controls should be combined with a more differentiated pricing scheme which reflects the varying temporal and spatial nature of energy costs (see Chapter VI below). In addition to these initial critical steps, *the program of detailed audits to help energy users to identify cost-effective opportunities for reducing energy use should be expanded.* The pilot projects already underway with the assistance of the EC Energy Center demonstrated the potential thermal and electricity savings in a number of enterprises. The planned Energy Efficiency Demonstration Zones Project to be financed by UNDP and executed by UN ECE will select two to three zones to demonstrate the viability of energy efficiency measures in the industrial, service and residential sectors. Although simple maintenance activities that have no cost/low cost or require small capital investment can produce meaningful energy reduction benefits, it appears that even more improvement can

be realized by reorganizing and restructuring the largest energy consuming manufacturing enterprises. *By preparing estimates of potential energy savings and the costs of energy efficiency investments, the energy audits could provide information for the restructuring effort regarding the future viability of industrial enterprises.*

37. There are only a few organizations in the country capable of carrying out energy audits and assisting enterprises to use these audits to develop energy conservation strategies. Enterprises seem to believe that they can rely on past associations with technical institutes to solve their energy problems, including some in Russia, but this may not be tenable. To assist energy conservation efforts (in response to real energy price increases), *the Government should foster the development of industrial organizations whose function is to provide, on a consulting basis, detailed plant energy audits, to recommend conservation measures to individual operating plants, to assist in putting such measures in place and to run energy conservation courses at the plant level.*

D. Energy Demand Forecast

38. **Methodology and assumptions**. The energy demand projections presented below are based on two alternative economic reform outcomes. Scenario A assumes a comprehensive and radical reform process, including raising energy prices to economic levels in the near future, the strict enforcement of hard budget constraints for enterprises, and other relevant reform measures. Although the economy's decline is greater than in the alternative scenario, the subsequent recovery is stronger and the economy reaches a higher rate of growth in the long run. Scenario B reflects slower paced reforms, meaning that the completion of the price adjustment is deferred and enterprise budget constraints are less stringent than in Scenario A. Consequently, the slump in total output is more protracted, the subsequent recovery is milder, and the long-run rate of growth is lower than under Scenario A. Importantly, the pressure on enterprises to restructure towards a less energy-intensive product mix and to use energy more efficiently is weaker in Scenario B than in Scenario A. As a result, the energy intensity of GDP shows a more favorable path for Scenario A.

39. For the purpose of long-term projections, a straightforward dynamic consumption model has been specified for oil, natural gas and electricity, which together account for about 95% of total energy consumption of Belarus. The forecasting model is able to explore the effects of changes in the rate of growth of GDP, price changes (including lagged effects) and structural shifts in total output. The price- an nonprice-induced changes in the composition of total output are introduced through adjustments to the historical income (GDP) elasticities. Interfuel substitution enters the model indirectly through the assumed extent of price changes and price elasticities for the individual fuels. The general form of the model is:

$$C_t = A\,Y_t^b \prod_{i=1}^{n} P_{t-i+1}^{c_i}\,(u_t)\,,$$

where C is electricity consumption, Y is real GDP, P is the real price of energy, b is energy/GDP elasticity, c_i's represent the structure of lagged price elasticity coefficients, A is a constant, t denotes year, and u is the error term.

40. The key assumptions underlying the illustrative scenarios are:

(i) **Macroeconomic performance**. The assumed paths for GDP are presented in Figure 5. Under both scenarios, GDP continues to contract in the near future, but the extent and duration of the decline are different. In Scenario A, following a sharp fall, GDP bottoms out in 1996 and then, after a short period of recovery, increases at 5% per year over 1998-2010. Under Scenario B, the slump in GDP is shallower and lasts somewhat longer, the recovery is weaker and the post-recovery (1999-2010) growth rate, at 4.0% per annum, is lower.

(ii) **Structural shifts in total output.** Because the capital stock built during decades of central planning is grossly out of sync with the structure of capital that the market economy would call for, Belarus enterprises must make drastic changes in their product mix under any reform scenario. These shifts are assumed to benefit the consumer industries, high technology manufacturing and services at the expense of the presently oversized heavy industry (most notably oil refining, chemicals/ petrochemicals and machine-building), which has an excessive orientation on armaments production, and production of intermediate and capital goods for the collapsed former USSR market. The structural changes are introduced by means of adjustment of the historical GDP elasticity of consumption (estimated for the 1985-92 period at 2.8 for natural gas, 1.2 for oil and 1.0 for electricity). In Scenario A, this coefficient drops faster and to a lower level than in Scenario B, where the speed of capital-stock turnover is slower and the associated structural shakeout is less pronounced.

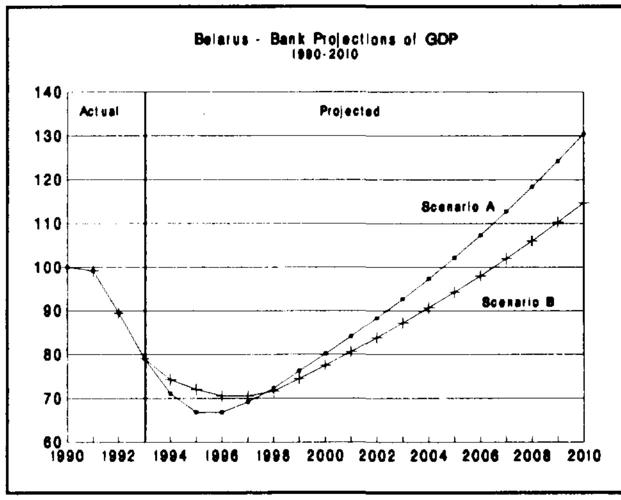

Figure 5

(iii) Real price adjustment. Under both scenarios, energy prices are assumed to rise relative to the 1993 levels, but the time profile and magnitude of the increases vary across scenarios and fuels. For the end of 1993, the degree of pricing distortion was approximated by comparing domestic energy prices with the estimated full economic cost (for details, see Section C of Chapter VI below). In Scenario A, domestic prices are aligned with economic cost by the end of 1996; in Scenario B, the adjustment is completed by the year 2000. In the case of electricity and natural gas, it is more realistic to expect that the extremely low current residential rates will be adjusted more slowly than the industrial rates. To reflect this lag, residential electricity and gas prices are assumed to achieve full cost recovery in 2000 (in Scenario A) and in 2005 (in Scenario B).

(iv) **Price responsiveness**. Consumer sensitivity to changes in energy prices corresponds to that of a reformed semi-market economy proxied by Hungary. The short- and long-run elasticities are -0.08 and -0.32, respectively, for oil; -0.05 and -0.16 for natural gas; and -0.08 and -0.14 for electricity, using 3-to-5 year linear distributed lags.

41. **Primary energy consumption**. The bottom-up approach, aggregating oil and natural gas consumption forecasts, was used to derive the future trends in primary energy use. Because of their small weights in total consumption, peat, coal, wood and net electricity imports were combined under the

category "other energy," whose share in primary energy use was assumed to remain constant at the recently recorded level (an average 9% during 1990-93) over the projection period. Primary energy demand is projected to fall until 1996-97 under both scenarios (see Figure 6). Under Scenario A, energy use continues its steep downward trend until 1996, due the severe slump in GDP, the intense price shock, and the assumed intersectoral shifts in total output. Energy demand bottoms out in 1996 at about 52% of its pre-crisis (1990) reference level. During the period 1998-2010, consumption recovers at a rate of 3.5% per year. Even at the end of the forecast period (2010), the predicted consumption level stands about 15% lower than the reference level. Scenario B portrays a more moderate negative demand shock for the near future, because (i) the price adjustment is phased over a longer period; (ii) the structural shakeout is less intense; and (iii) the GDP decline is smaller than in Scenario A. After bottoming out in 1997 at about 60% of its 1990 level, demand picks up at 3.6% per year over 1998-2000, approaching the pre-crisis level in 2010.

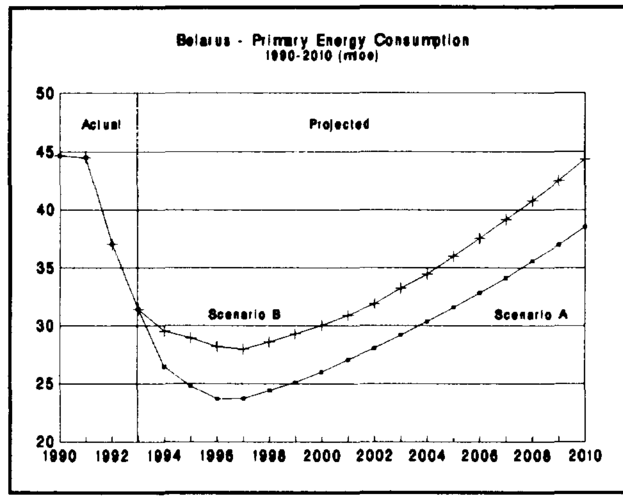

Figure 6

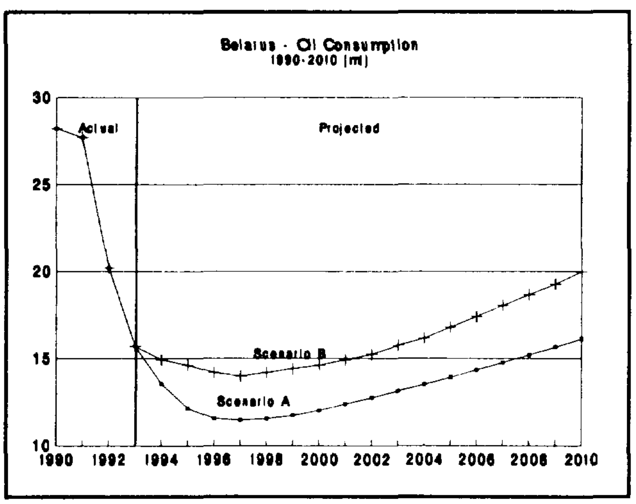

Figure 7

42. **Oil consumption**. In Scenario A, oil consumption continues to fall until 1996-97, when projected use is down by as much as 60%, compared with the 1990 reference level (Figure 7). In the following period, oil consumption picks up at a relatively moderate pace (2.6% per year during 1998-2010) to reach about 16 million tons by 2010, about 55% of the 1990 level. Under Scenario B, the short-run dip in consumption is considerably less sharp and, after leveling out in 1997, it recovers at 2.8% per year during the remainder of the forecast period to reach about 19 million tons in 2010. In that year, oil usage stands at as low as 55% (Scenario A) and 68% (Scenario B) of the pre-crisis level.

43. **Gas consumption**. As expected, the sharpest temporary drop in gas usage occurs in Scenario A (Figure 8). The macroeconomic slump and the heavy price shock work in tandem to cause a 23% reduction in consumption between 1993 and 1996. Soon, however, the price impact is overriden by the vigorous economic growth assumed in this scenario. The high GDP elasticity of gas usage, even with downward adjustments to accommodate sectoral shifts in total output away from energy-intensive activities, sets the stage for a fairly rapid buildup in consumption. By 2000 gas use approximates the 1990 level and exceeds it by a growing margin in the subsequent years. In 2010, consumption, at 23 BCM, is about 60% higher than the level registered in 1990. In Scenario B, the less severe early economic depression and the more moderate price impact cause only a relatively small decrease in consumption, which hits bottom in 1996-97 (at 96% of the 1990 level), when GDP growth effects

compensate for the relatively modest price and structural effects. The pre-crisis level is reached in 1998, and in 2000 and 2010 consumption levels are up by 10% and 75%, respectively, compared with the reference level. These forecasts are considerably lower than the projection contained in the 1992 Energy Program of the Government (see Chapter I), where gas consumption is to rise to 28.1 bcm in 2000 and 33 bcm in 2010, implying a nearly 80% increase between 1993 and 2000, and an additional 17% increase between 2000-2010. Even the higher Bank forecast (Scenario B) stands at only 57% (in 2000) and 77% of the official projection (in the case of Scenario A, the respective numbers are 50% and 70%).

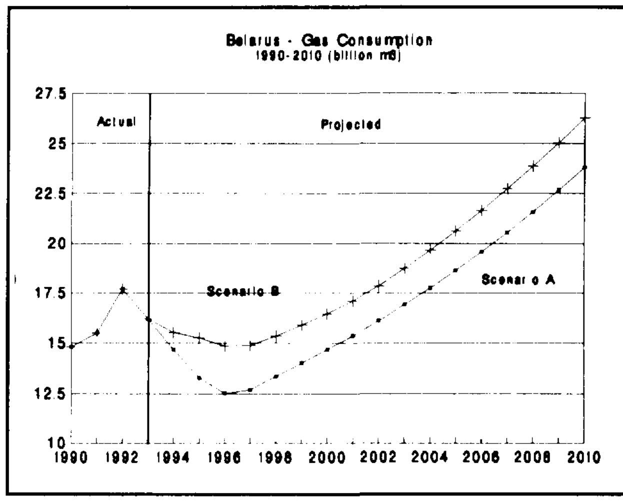

Figure 8

44. **Electricity consumption**. The forecasts are shown in Figure 9, together with two predictions prepared by the authorities for comparison. In Scenario A, power consumption decreases steeply until 1996. Demand levels out in 1997 at 60% of the reference (1990) level. During the period 1998-2010, consumption recovers at a rate of 4.4% per year, reaching the pre-crisis level only towards the end of the forecast period. Scenario B illustrates a more subdued demand shock for the near future due to the more phased price effect and a weaker structural shakeout relative to the alternative scenario. After bottoming out in 1997-98 at about 70% of its 1990 level, demand growth resumes at 3.9% per year over 1998-2000, reaching the pre-crisis level by 2007. The difference between the official and Bank forecasts is sizable, although it narrows toward the end of the projection horizon. The discrepancy is especially large for the medium term: in 2000, the Bank forecasts stand 25% (Scenario B) to 33% (Scenario A) lower than the 1993 Ministry of Power (Minenergo) forecast, the less buoyant of the official predictions.

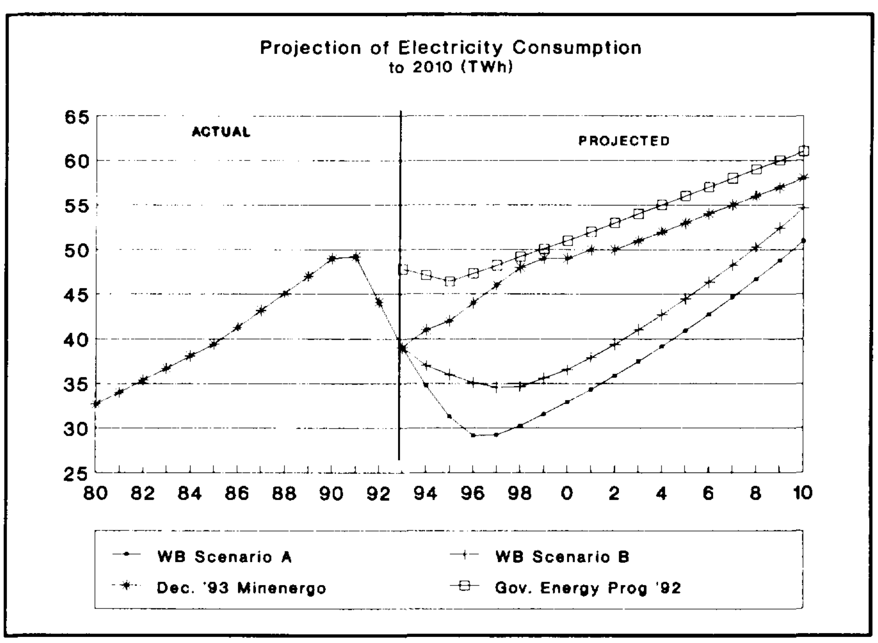

Figure 9

45. **Role of energy prices**. For an illustration of the magnitude of the demand-dampening effect of the presumed price rises, Figure 10 and 11 isolate the price impact from other demand shaping forces for electricity. As expected, owing to the much greater initial price shock in Scenario A, the cumulative magnitude of the price effect is markedly larger than in the other scenario. Other things being equal, without the price impact the level of power consumption would be 25% higher in 2000. In Scenario B, the differential price effect is smaller (about 10% in 2000). Clearly, with the set of assumptions underlying the two scenarios, energy-price increases drive in large measure the temporary downturn in consumption across fuels.

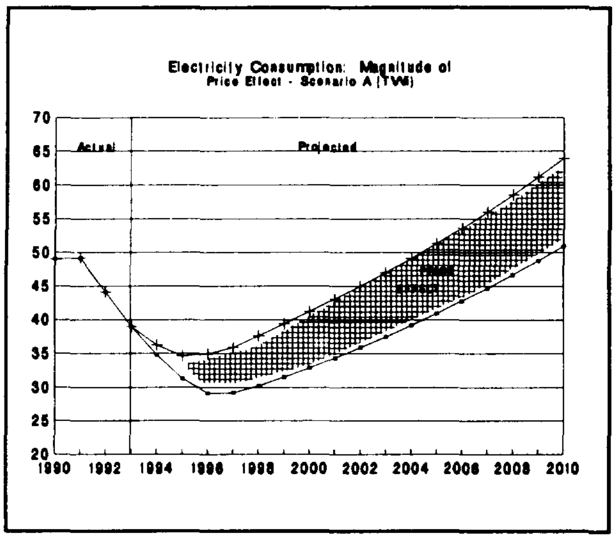

Figure 10

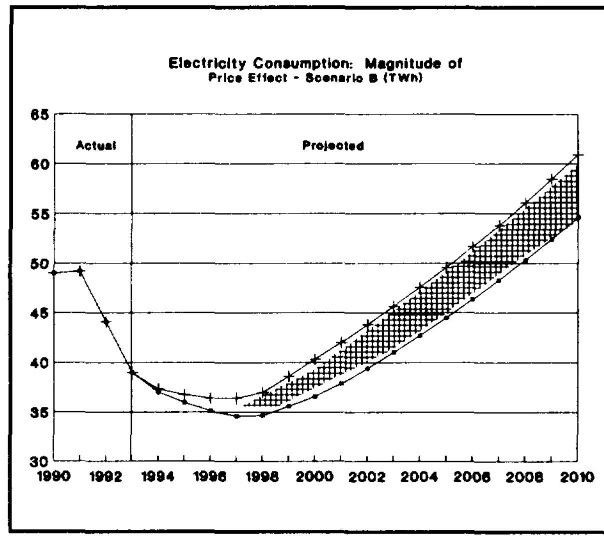

Figure 11

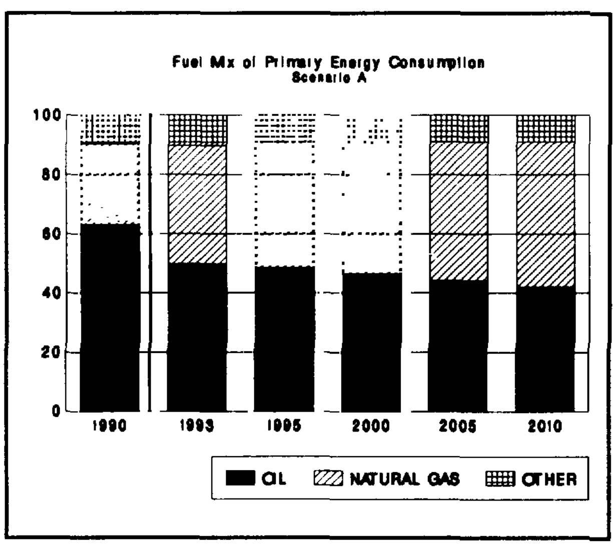

Figure 12

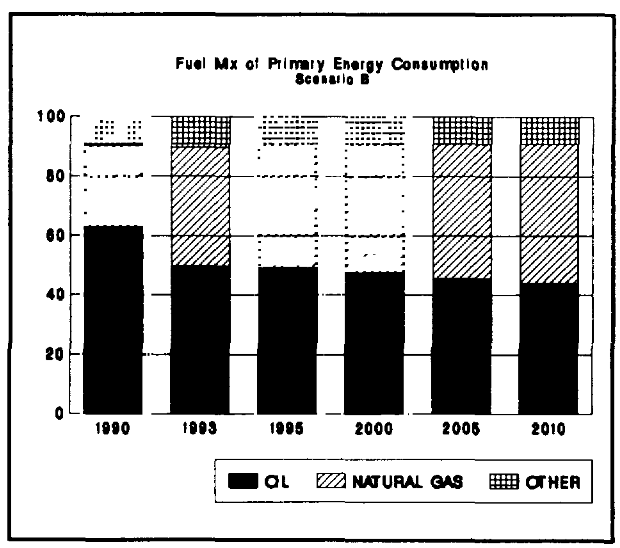

Figure 13

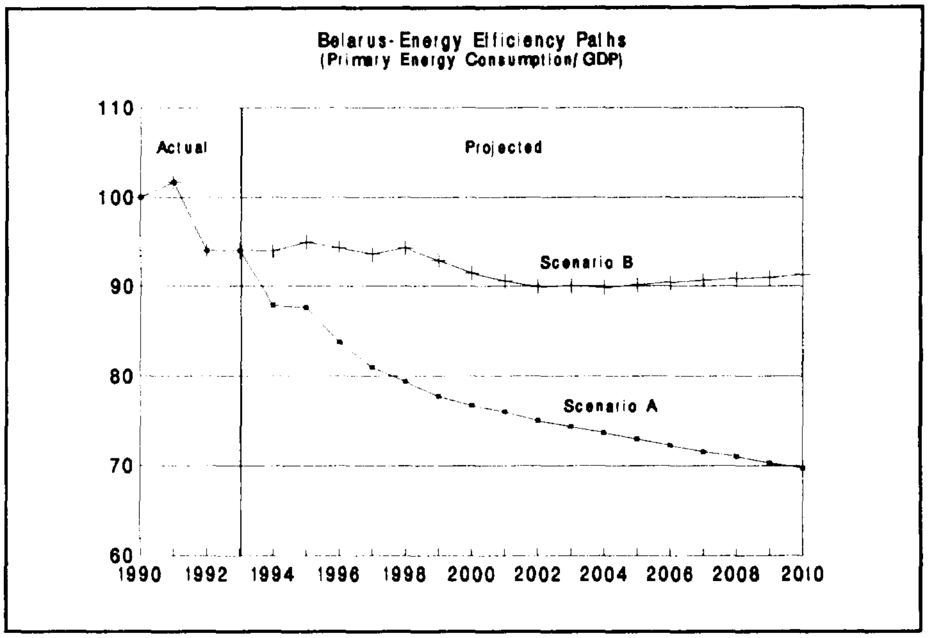

Figure 14

46. **Changes in the fuel mix**. The shares of major fuels in primary energy consumption were derived from the consumption projections, and they are shown in Figure 12 and 13. In both scenarios, the gas-for-oil substitution sustains, but it is proceeding at a much more moderate pace than observed in the recent period. The previously lop-sided (oil dominated) fuel mix is seen to evolve towards a more balanced pattern, with oil and gas taking roughly equal shares during most of the post-1995 period. Towards the end of the forecast period, the share of natural gas is forecast to exceed that of oil under both scenarios.

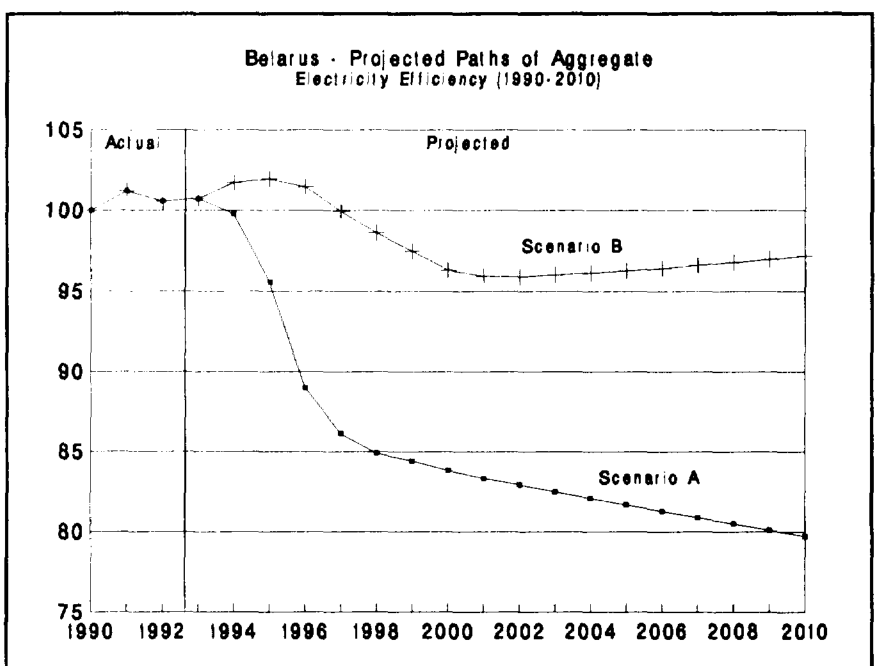

Figure 15

47. **Energy efficiency trends.** These trends were derived from the projection results and the assumptions about the future paths of GDP. The trends are illustrated for primary energy and electricity in Figure 14 and 15. Aggregate energy efficiency is defined as total primary energy (or gross electricity) consumption per unit of real GDP. As Figure 14 shows, unit energy requirements in Scenario A fall at an annual rate of 1.8% per year between 1993 and 2010, which is close to the rate of decline registered for the OECD countries during the 1973-1990 period (1.7%). Given the large scope for energy savings in Belarus, this outcome seems plausible. By contrast, Scenario B portrays a lack-lustre efficiency path, with unit energy requirements falling at a statistically insignificant rate. Protracted price adjustments and relatively moderate structural changes are the key factors underlying this poor performance in energy efficiency. Under the specified conditions of this scenario, the energy-intensity bias of the Belarus economy is preserved despite the considerable reservoir of untapped energy efficiency that exists today. The projected paths of aggregate electricity efficiency largely mirror those displayed for primary energy. While in Scenario A electricity intensity of GDP drops by an annual average of 1.4% over 1993-2010, practically no gain is shown in Scenario B.

IV. ENERGY SUPPLY AND TRADE

A. Domestic Primary Energy Resources and Supply

48. The decreasing trend of domestic primary energy production was arrested in Belarus in the early 1990s. Total domestic primary energy production stabilized at about 3.8 mtoe per year in 1990-1993 (see Table 3 below). In the same period, due to the drop in energy consumption, the share of domestically supplied energy in total primary energy consumption increased significantly from 8.1% to 11.9%. This section reviews the availability of energy resources in Belarus in order to assess the potential for the further growth of domestic primary energy supply.

TABLE 4: PRIMARY ENERGY SUPPLY AND CONSUMPTION

Production	1985	1990	1991	1992	1993(est.)
Crude Oil (mt)	2.109	2.054	2.008	2.060	2.000
Natural Gas (bcm)	0.244	0.297	0.293	0.292	0.225
Peat (mt)	4.532	3.457	3.888	4.181	4.000
Wood (solid, mm3)	5.000	4.000	4.300	4.600	5.000
Hydro (TWh)	0.020	0.020	0.018	0.017	0.019
Total (mtoe)	**4.027**	**3.641**	**3.724**	**3.881**	**3.807**
Imports					
Coal (mt)	3.562	2.462	1.989	1.616	1.764
Crude Oil (mt)	36.890	38.475	34.860	19.747	12.400
Oil Products (mt)	2.311	1.221	1.028	1.797	2.700
Natural gas, net (bcm)	8.700	14.708	14.929	16.371	15.250
Electricity (TWh)	6.300	9.429	10.403	6.504	6.005
Total (mtoe)	**49.212**	**54.927**	**51.357**	**37.061**	**29.642**
Exports					
Crude Oil (mt)		1.054	1.060	1.058	0.108
Oil Products (mt)	12.319	12.983	9.617	1.601	1.436
Total (mtoe)	**12.319**	**14.037**	**10.677**	**2.659**	**1.544**
Stock changes (mtoe)	NA	0.454	0.473	-0.774	0.099
Primary Energy Consumption	**40.920**	**44.985**	**44.877**	**37.509**	**32.004**
Annual Percentage Change		1.92*	-0.24	-16.42	-14.68

* Average for 1985-90
Note: A ton of oil equivalent (toe) is defined as 10 million kcal or 10 Gcal.
The applied conversion factors are: coal, 0.39; crude oil and oil products, 1.0; natural gas, 0.81; peat and wood, 0.18; electricity, 0.25.

49. **Non-renewable resources**. Belarus is relatively poorly endowed with non-renewable fuel resources. Available resources consist of oil, oil shale, brown coal and peat. Oil, oil shale and coal resources are placed into seven categories. Reserves comprise the first four categories (proven producing, proven non-producing, probable and possible) and are the more certain projected amounts within total resources. From the volumetrically calculated geological in situ figures the "recoverable" figures are projected using a recovery factor, which is usually over-estimated. The most important difference compared to North American requirements is that even proven reserves are not required to be economically recoverable under existing conditions. The reserves are screened with a very simplified economic criteria, i.e., they must be of "commercial size" and exploitable in industrial scale using existing technology. Due to this difference, the recoverable reserve estimates are too high (in the case of oil, about 25 percent for proven reserves, and 50 percent for probable and possible reserves compared to North American standards). Reliable reserves are essential to production planning. *Therefore, reserves should be re-examined by including economic viability in the classification criteria.*

50. Crude oil is the most significant non-renewable resource. Proven reserves are located in the Rechitsa rayon in the Gomel oblast. The geological setting of the oil fields is quite complex. The oil reservoirs are situated between and below thick salt beds. Extreme faulting and warping of beds adds to the complications and makes identification and definition of potential reservoirs, and even discovered fields, extremely difficult. Reserves being exploited are of high quality (0.3% sulfur content), however, the average productivity of existing wells is decreasing as many of the developed reservoirs have passed their peak oil production phase. Well fluids contain an increasing proportion of water and net oil flows per well are decreasing. Cumulative crude oil production was about 94 mt up to the end of 1993. Crude oil production sharply declined from a peak of 8 mt in the mid-seventies to 2.55 mt in 1980. It further decreased to about 2 mt per year in 1985, and has remained steady at that level since. Associated with the crude oil, about 0.3 bcm per year natural gas is produced, processed and fed into the gas transmission system. A further decline of oil and gas production to about 1.4 mt and 0.16 bcm, respectively, by the year 2000 seems to be unavoidable, unless tertiary recovery facilities are installed or substantial new reserves are proven in the near future (an unlikely development, given that most of the large structures have already been located and developed).

51. Based on preliminary exploration in the Zhitkovichi rayon in Gomel oblast, total oil shale resources are estimated at 8 billion tons. Of this, only 3.5 billion tons (2.6 bt at Turov and 0.9 bt at Luban) have been proven, occuring in a 1 to 6 m wide band at a depth of 66 to 300 m. However, the oil shale is of very poor quality (1200-1300 kcal/kg calorific value, 60-85% ash, 5-8% resin, and 15-20% organic content). Based on these parameters, it is unlikely that production would be economic.

52. Brown coal deposits were discovered in connection with exploration for oil and gas. About 500 mt are prognosticated, however, only 120 mt has been proven so far, located in three deposits also in the Zhitkovichi rayon. One of the deposits (46 mt), occuring in a shallow layer at a depth of 30 to 65 meters, is suitable for open pit mining. The other two deposits are deeper (100 to 300 meters) and mining would first require the draining of wetlands to below the peat levels. The coal has 3,000-3,500 kcal/kg calorific value, 20% ash and 1.5% sulfur content (however, the calorific value of the product would be substantially lower, if open pit mining technology was applied). The long term energy program (prepared in 1992) investigated the possibility of mining 2 mt of coal per year, however, the alternative of importing coal from Russia was considered environmentally and economically superior.

53. Four to five million tons of peat were produced annually during the last ten years, most of which was harvested at locations near 37 peat briquetting plants. The production amounted to about four million tons in 1993. Most of the peat harvested is used in briquette production, sometimes mixed with imported coal (some briquetting plants also use the peat as an energy source). About 2 mt of briquette was produced in 1993. About 800,000 tons of peat harvested were applied as a fertilizer and soil conditioner in 1993. It is estimated that 20% of total peat resources have been extracted already. The Government, in order to protect agricultural lands and wetlands, has decided to restrict peat production to the already harvested deposits. Therefore, only about 11% percent of total peat resources can be considered as energy reserves. Due to the limitation on fuel reserves, there is little possibility for increased peat production. The target in the long term energy program is the production of 2.2 mt of peat briquette per year.

54. **Renewable resources.**[13] Wood is the most significant renewable energy resource in Belarus. The total standing stock of wood is about 1 billion (solid) m^3 covering about 8 million hectares. The annual increase in wood biomass is currently estimated at 25 million m^3. According to official estimates, the total annual harvest of wood was 10-12 million m^3 in the last three decades. The harvest of industrial roundwood represented 6-7 million m^3, and 4-5 million m^3 was cut for firewood. About 40% of industrial roundwood was harvested represented wastes, out of which 1-1.5 million m^3 were burned in boilers. Households either purchase firewood from district level distribution organizations, or obtain it directly from forestry enterprises (there is considerable uncertainty concerning the total household consumption of firewood).

55. Given the need to build up standing stock (due to a very unbalanced distribution in age classes) and taking into account that only about 80% of the forested area is exploitable (due to forests contamination from the Chernobyl accident and the environmental protection of certain forested areas), the annual allowable cut is estimated at 15 million m^3. On this basis, 3-4 million m^3 per year of additional wood can be considered available. Furthermore, there are about 1 million m^3 of unutilized wood waste in industry. This 4 million m^3 supplemental wood reserve represents an energy value of approximately 7 million Gcal or 0.7 million toe. In order to utilize this reserve, substantial investments will be needed in wood harvesting as well as in wood burning facilities over an extended period.

56. The possibility of increasing the utilization of wood as a source of energy was not included in the Government's long term energy program. The program focussed on other, currently unutilized renewable resources, such as hydropower, biogas, wind, and solar energy. There are 9 small hydropower plants that produced 18.7 GWh electricity (about 45,000 toe primary energy) in 1993. However, the potential for the increased utilization of these resources is very limited. The long term energy program estimated that these sources may substitute for 100,000 toe of fuel in the year 2000 and 170,000 toe in 2005. In addition, municipal waste could also serve as a source of energy. The economic potential estimated in the long term program was 80,000 toe in 2000 and 190,000 toe in 2010.

57. **Summary**. Wood represents the most significant opportunity for an expansion of domestic primary energy production. Assuming that, with adequate investments and modern technology, the decrease of oil production is avoided, the supply of domestically produced primary energy can be

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[13] This section is partly based on Report No. 12511-BY, "Staff Appraisal Report - Belarus Forestry Development Project", World Bank, 1994.

gradually increased from the current 3.8 mtoe/year to about 5 mtoe/year in the next decade. Depending on the evolution of primary energy demand, the share of domestically produced energy in the energy balance may reach 15-20% in the year 2000.

B. Transformation, Transport and Distribution of Primary Energy

58. **Briquettes**. There are 37 factories producing peat briquettes. With the exception of two, all the factories harvest their own peat reserves (two factories have already exhausted their nearby reserves and receive peat from other sites). As mentioned above, the factories produce about 2 mt of briquette per year. The factories are generally located away from major urban centers. The briquettes are produced in mixed form with coal (about 0.1 mt/year coal is used for that purpose) and/or lignin, and also as pure peat briquettes. The briquettes are transported by truck and rail to the 117 rayon-level distribution centers. The mix of solid fuels, including briquettes, produced and sold in Belarus, corresponds to the type of devices utilized in small, mostly rural communities. Wood is preferred for the traditional Russian stove, peat or mixed peat briquettes are preferred for cooking stoves, and coal is preferred in small boilers.

59. **Oil products**. The Novopolotsk and Mozyr refineries (with design capacities of 24 and 16 mt/year, respectively) process the domestically produced and imported crude oil. Both refineries are of simple configuration, lacking secondary processing facilities, producing only 40-45% of crude feedstock as high value light products. The technology used at both refineries is relatively old and inefficient. The two refineries are connected by long-distance crude oil pipelines to producing areas in Western Siberia. The total crude oil storage capacity next to the refineries is about 0.8 mt. Product pipelines, running parallel to the crude pipelines, connect the Novopolotsk refinery to Latvia and the Mozyr refinery to Hungary. In addition, a separate product pipeline transports diesel oil and gasoline from Novopolotsk to Minsk. Most of the products (except aromatics and other specialties) are piped to bulk plants for off-take and for further shipment (mostly by rail) to 42 main storage terminals for distribution. The total capacity of storage terminals is about 1 mt. From the terminals, tanker trucks deliver the products to large industrial consumers and about 360 retail pump stations. The refineries produced 13.6 mt oil products in 1993, about one third of their historical peak production in 1989. Although the share of light products in total oil product consumption increased and the share of mazut decreased between 1990 and 1993, the refineries did not upgrade their facilities, and the share of mazut in total refinery production remained stable at 46-48%. As a result, there was a shift from exporting to importing light products.

60. **Gas**. The gas transmission system consists of 2,792 km of pipelines with a diameter of 720 mm or larger plus more than 1,000 km smaller lateral pipelines to the city gate stations. There are six mainline compressor stations (total capacity 706 MW) and one storage field with a working gas capacity of 0.42 bcm. The system delivers all of the imported gas from the Russian border to the city gate stations serving the distribution networks and provides transit service for Russian gas delivered to Poland, Lithuania, Latvia and Kaliningrad. A portion of the gas which is delivered via Ukraine, Slovakia and the Czech Republic to Western Europe is also transported through Belarus. The natural gas distribution system, with a network length of about 12,000 km, delivers gas to 62 cities and serves about 1.2 million residential units, and 50.000 other customers (90 percent of the residential customers use the gas for cooking only). In addition, 21 vehicle refueling stations provide about 0.1 bcm/year compressed natural gas (CNG) for trucks and buses. Approximately 2 million residential customers use liquid

petroleum gas (LPG) for cooking. Most of the LPG is delivered in 21- and 5-kg bottles. There are 14 bottling stations serving the rayon-level retail outlets. LPG is also used as automotive fuel.

61. **Electricity**. There are 22 public thermal power plants in the power subsector, with a total nameplate capacity of 7,033 MW. Small power plants under the industrial, transport, agriculture and other sectors have a total capacity of 188 MW. In addition, there are 9 small hydropower plants with a total installed capacity of about 6 MW. With the exception of three plants producing only electricity, all other plants produce both electricity and heat. The boilers at 10 larger plants have been modified for dual firing and therefore can be fueled either with fuel oil (mazut) or with natural gas, depending on the availability of fuel. The thermal power plants have a total storage capacity of 1.25 mt of fuel oil. None of the larger power plants burns solid fuels. There is no nuclear generating capacity in Belarus. Gross domestic generation decreased from 39.7 TWh in 1990 to 33.5 TWh in 1993. The existing transmission system has a length of 32,773 km, operating at 750 kV, 330 kV, 220 kV, 110 kV and 35 kV with 50 Hz, and is connected to Lithuania, Russia, Ukraine and Poland. The distribution network consists of 10 kV and 380 V lines with a length of 113,000 km and 130,000 km, respectively.

62. **District heat**. The 19 combined heat and power (CHP) plants have a heat production capacity of 8,230 Gcal/h (in addition, the Beryoza and Lukoml single purpose power plants also have about 100 Gcal/hour capacity). The total capacity of about 4,000 heat only boilers (HOB) is 5,600 Gcal/h. In addition, industrial boiler houses also provide heat to the district heating networks. About 50% of households obtain their heat from the heating networks; in Minsk, this fraction rises to about 80% of all consumers whereas in the countryside, the proportion is a low 5%. The total length of district heating networks in the country is about 5,000 km. In 1990, heat supply to the networks was about 58 million Gcal, of which 43.5 million Gcal came from CHP plants, 10 million Gcal from HOBs, and about 4 million Gcal from industrial boiler houses. Total heat supply decreased to about 54 million Gcal in 1992, mostly due to a decrease of supply from CHP plants (40.6 million Gcal) and industrial boiler houses (3.7 million Gcal).

C. Import and Export of Energy

63. Traditionally, Belarus has been a net importer of crude oil, natural gas, coal and electricity and a net exporter of oil products. The volume of total energy imports (measured in calorific value) decreased by almost 50% between 1990 and 1993, from 55 mtoe to 30 mtoe (see Table 3 above). Crude oil imports, dropping to less than one third of their 1990 volume, took the hardest hit. The trend of decreasing coal imports (already present in the 1980s) was continued. Interestingly, natural gas and oil product imports in 1993 were above the quantities imported in 1990. The volume of energy exports was 14 mtoe in 1990, consisting of 1 mt of (domestically produced) crude oil and 13 mt of oil products. In 1993, energy exports decreased to 1.5 mtoe, consisting of 0.1 mt of crude oil and 1.4 mt of oil products (mostly from toll refining, see below).

64. **Crude oil**. Crude oil and natural gas are imported from Russia. There are significant differences between the arrangements applied for the import of oil and gas, the two major fuels the Belorussian economy relies on. In 1993, based on the intergovernment agreement, Belarus paid for most of the Russian oil in kind. Russia set the total crude oil export quota for Belarus at 16 mt. Within the quota, 11.4 mt of crude oil was included in a clearing agreement, while the rest could be purchased by Belarus at prices applying to CIS exports. The clearing agreement specified a list of goods to be

exchanged between Russia and Belarus. The volume of deliveries was determined so that trade would be balanced at world market prices. The total value of exports/imports under the clearing agreement was calculated at US$ 1.85 billion. In exchange for the crude oil, Belarus agreed to export trucks, tractors, refrigerators, television sets, milk, butter and other (mostly finished) goods. It was agreed that goods to be exchanged will be exempt from export taxes.

65. Responsibility for implementing the clearing agreement was assigned to Roskontrakt in Russia and the Ministry of Resources in Belarus. Both organizations had the right to sell (on the domestic market) the goods received under the agreement at prices set without interference from the exporting country. The revenue from the sales of imported goods was supposed to cover the cost of purchasing from the domestic suppliers the goods exported under the agreement. By the time the clearing agreement was signed (in February) and the individual contracts for the supplies of specific goods were negotiated (in March), Russia had already delivered more than 2 mt of crude oil. A further delay of about one month on the Belarussian side was due to difficulties in organizing the deliveries of various consumer goods according to the agreed specifications. The arrears peaked in April at US$ 350 million. In order to pay suppliers, Roskontrakt had to borrow Russian rubles from the central bank. The interest on that credit was later converted to US$ (based on an interest rate in effect on international capital markets) to be paid with Belarussian goods subject to the clearing agreement. Due to increasing deliveries of goods from Belarus and decreasing oil deliveries from Russia, total cumulative deliveries under the clearing agreement reached a balance by early December 1993. However, the value of actual deliveries (expressed in world market prices) was about 40% below the originally planned sum of US$ 1.85 billion. Specifically, Belarus received only 8.5 mt of crude oil under the clearing agreement in 1993. In addition, 3.9 mt of oil was imported partly under toll refining agreements (i.e., the refineries received a processing fee but did not own the oil), partly under "commercial" purchases within the quota. The importance of "commercial" purchases increased substantially in the last two month, following the liberalization of crude oil imports and oil product exports.

66. Despite the advance deliveries of crude oil from Russia, the Ministry of Resources also run into difficulties paying its domestic suppliers. The origin of the problem was the extremely low price applied by the Ministry when it sold the crude oil to the refineries in the first half of 1993. Following the approval of a subsidy of Brb 125 billion to cover the Ministry's previous losses, the Government decided to raise the price of crude oil to a level which fully covered payments to domestic suppliers in the last four months of 1993.

67. The clearing agreement proved to be unpopular with Belarussian suppliers. Many enterprises complained that Roskontrakt "dumped" their products on the Russian market at very low prices, damaging their ability to negotiate higher prices for additional or future exports. Most of the benefits from the agreement accrued to Belarussian consumers who received cheap oil products refined from the "clearing" oil. Despite the notional price of US$ 128/t in the clearing agreement, the average cost of imported crude oil for the Belarussian economy was only US$ 40-50/t. The difference was due to the low cost of producing the goods delivered to Russia. In comparison, the cost of oil imported outside the clearing agreement (but still within the allocated quota) was equivalent to about US$ 80/t in September and reached US$ 90/t by the end of 1993. In summary, the clearing agreement provided secure markets for the Belarussian products and softened the blow of increasing oil prices in intra-CIS trade.

68. **Natural gas**. In 1993, natural gas was not included in the clearing agreement. Gas imports within the 16.3 bcm quota, with the exception of about 2 bcm gas received in lieu of gas transit fees, had to be paid in cash (in Russian rubles) based on the price applied by Russia for exports to the CIS. Although this price remained in the first five months of the year (US$ 15-20/tcm), it started to increase rapidly in June and reached US$74 by December 1993. The replacement of old rubles in Russia and the imposition of strict credit limits by the Russian Central Bank on the correspondent account of Belarus led to a payment crisis for Belarus in the summer of 1993. Due to the trade imbalance, the National Bank of Belarus could not convert the Belarussian ruble holdings of Beltransgaz (the enterprise importing gas) to Russian rubles. In order to make at least minimal payments, Beltransgaz purchased Russian rubles on the open market, which put downward pressure on the value of the Belarussian ruble. The Government, in order to avoid the rapid collapse of the domestic currency, discouraged this practice and payments for gas essentially stopped. In response, gas deliveries from Russia dropped to one third of their normal level in August. After Russia converted the payment arrears to long term debt and provided an additional credit line of Rrb 70 billion, gas deliveries returned to their planned levels. However, Belarussian payments could not keep pace with the rapidly increasing gas prices and arrears reached Rrb 185 billion at the end of November. A moderate decrease of gas deliveries (by about 15%) coincided with decreased oil deliveries under the clearing agreement and an unusually long spell of cold weather. The result was a reduction of fuel stocks to a dangerously low level equivalent to about two weeks of consumption in December 1993. Due to the temporary curtailments of deliveries, total gas imports were 15.3 bcm in 1993, about 7% less than in 1992.

69. **Electricity**. Net electricity imports were about 10 TWh in 1989-91, representing about 20 % of domestic demand. Most imports came from Lithuania (Ignalina Nuclear Power Plant) and Russia (Smolensk Nuclear Power Plant). In 1992, electricity imports dropped to 6.5 TWh, of which 2.6 TWh were supplied from Russia and 3.9 TWh from Lithuania (small amounts came from Ukraine and Latvia). In 1993, electricity imports were not included in the clearing agreement and had to be paid in cash. In May 1993, Lithuania set the price of electricity at DM 0.025/kWh, equivalent to about US$ 0.016 or Rrb 19/kWh. The price of electricity imported from Russia was only Rrb 10.8/kWh at that time, making it more advantageous for Belarus to import electricity from Russia. Electricity imports from Lithuania were stopped. The payment crisis at the end of the summer of 1993 also affected the payments for electricity, and significant arrears (about Rrb 17 billion by September 1993) were accumulated. Russia, however, did not curtail electricity exports, thereby creating an additional incentive for Belarus not to import electricity from Lithuania. By the end of the year, the price Russia charged for electricity reached about Rrb 20/kWh, almost equal to the price offered by Lithuania. It is worth noting that these prices were still significantly below the electricity export prices offered elsewhere in Europe. Electricity imports for the year as a whole were 6.0 TWh (4.2 TWh from Russia and 1.8 TWh from Lithuania).

70. **Oil exports**. As mentioned above, Belarus used to be a large exporter of oil products. Even in 1990, when energy consumption was at its historic peak, the combined capacity of the oil refineries was about 13 mt higher than the domestic consumption of refined products. In the past, Belarus sold the surplus production to all-union enterprises which exported part of the products to Western Europe and Asia (however, hard currency earnings did not accrue to the Belarussian enterprises). As the price of the crude oil approached world market prices, the utilization of the Belarussian refineries decreased, leading to a large drop in oil product exports (due to their obsolete configuration and inefficiency, the operation of the refineries is uneconomic if both input and output are valued at world

market prices). The other significant energy export item, domestically produced crude oil, virtually disappeared in 1993. It was decided that the agreement, whereby low sulfur Belarussian crude oil was refined in Ukraine (to avoid mixing it with high sulfur imported oil) in exchange for oil products and other commodities, was not advantageous for Belarus anymore.

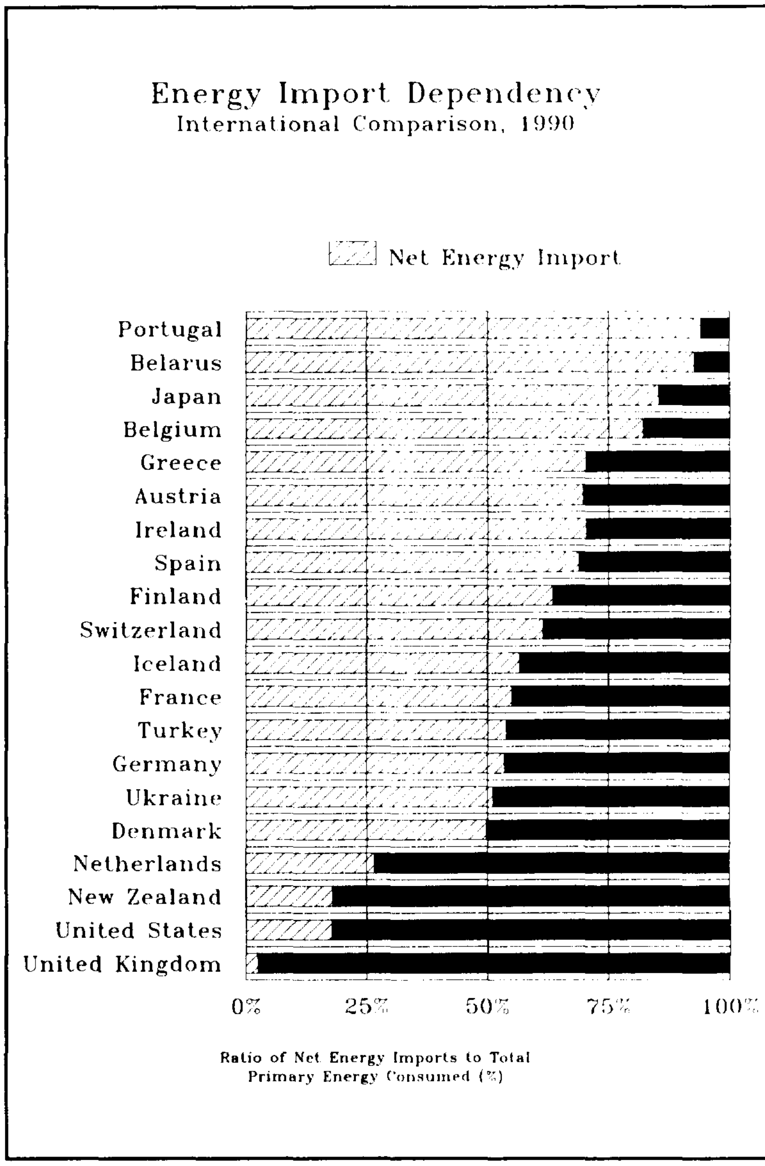
71. **Transit revenues**. Belarus receives significant revenues from transit services provided to Russia. In 1993, oil transit fees were received in cash and consisted of both Russian rubles and US dollars. The agreed schedule of oil pipeline fees applicable after November 1, 1993 stipulated a fee of Rrb 500-1,300 plus US$ 0.73 per ton of oil transited through Belarus, with the Rrb component of the fee depending on the route. About Rrb 20 billion and US$ 6.4 million will be received in 1993. Assuming that transit fees stay at their current level and transit deliveries are similar to 1993, total revenues from oil transit will be about Rrb 54 billion plus US$ 38 million in 1994. On January 1, 1993, the gas transit fee was Rrb 27.3/tcm/100km. It increased to Rrb 180/tcm/100km in February, and was unchanged until August. In August, it was increased to Rrb 1,100/tcm/100km; in September - Rrb 1,200/tcm/100km; in October - Rrb 1,330/tcm/100km; in November - Rrb 1,460/tcm/100km; and in December - Rrb 1,944/tcm/100km. The weighted average transit distance in Belarus is 550.8km. Based on actual transit volumes, Belarus should have received approximately Rrb 35 billion in November-December. Rather than paying in cash, RAO Gazprom credited the transit fees against gas purchases; the fees covered the cost of about 15 percent of imported gas for Belarus.

D. Security of Energy Supply

72. In 1990, net energy imports accounted for 92% of the primary energy consumption in Belarus. This was a very high percentage in international comparison (see Figure 16 below). The share of imported energy decreased to 90% over the next three years, due to a small increase in domestic energy production coupled with a large drop in total energy consumption. As argued above, there is potential for further increase in the ratio of energy self-sufficiency. However, the realization of that potential will depend on the successful promotion of investment in domestic primary energy production and in energy efficiency improvements. *Energy savings not only reduce costs, but also have a positive impact on supply security, arguing for the early introduction of policies (such as hard budget constraints and economic cost based prices) that best stimulate energy savings.*

73. Because the infrastructure to import large volumes of oil and gas from other countries simply does not exist, Russia will remain, at least in the medium term, the main source of imported fuels for Belarus. The future of the clearing agreement with Russia is unclear. Russia indicated that it might be willing to negotiate a new agreement for 1994, however, the new agreement is unlikely to include more than 5 mt of crude oil. It is virtually certain that the role of crude oil purchases outside the scope of the clearing agreement will increase in the medium term. In addition, Russia may reduce the crude oil quota for the CIS countries (including Belarus), thereby reducing the implicit subsidy provided to all CIS importers. Crude oil above the quota would still be available, subject to the same conditions as any non-CIS export. On this basis, the average cost of imported crude oil for Belarus may increase by more than 50% in the medium term. The Government's strategy is to counter this tendency by signing an agreement on a monetary/customs union with Russia, ensuring that Belarus has priority access to Russian crude oil in the CIS.

74. It is unlikely that Russia will reduce the natural gas quota for Belarus.[14] However, the future price of imported gas is uncertain. Although an increase over the average 1993 import cost of about US$ 30/tcm is unavoidable, the price of imported gas may well be lower for the next couple of years than in December 1993. For Russia, the netback value of gas on the Belarussian border (based on an export price of US$ 70-80/tcm at the German border and a transit fee of US$ 1.0-1.5/tcm/ /100km) is only US$50-60/tcm. Furthermore, Russia may not be able to sell the gas saved in Belarus to Western Europe in the short run. Developing a market for additional natural gas sales takes time. Finally, demand for Russian gas might be below the supply potential (determined by known reserves) even in the long run. In that case, the value of gas for Russia would be equal to the long run marginal cost, currently estimated at about US$40/tcm at the Belarussian border.



Source: IEA 1992, World Bank estimates for Belarus and Ukraine
Figure 16

75. Over time, infrastructure constraints on alternative import sources can be eliminated. The long term energy program prepared in 1992 mentioned a number of alternatives for fuel purchases (e.g., coal from Poland or Australia, gas from Turkmenistan or Norway, oil from the Middle East). While reducing the dependency of Belarus on a single fuel supplier (Russia) undoubtedly increases the security of energy supply, this will not come without costs. Belarus is located on the export corridor from Russia to Europe. The cost of supplying the domestic needs of Belarus will always be lower than delivering Russian oil and gas to the rest of Europe. If Russia can price its energy exports competitively

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[14] In a protocol signed by the Prime Ministers of Russia and Belarus in September 1993, the Russian Government stated that it would "assist" Belarus in increasing its gas imports to 21 bcm in 1995, 26 bcm in 2000 and 33 bcm in 2010.

in Europe, it should be able to do so even more in Belarus. Therefore, strictly on the basis of supply costs, Russia is the least cost source of imported oil and gas for Belarus, and it is doubtful that the improvement in supply security would justify the significant additional (investment and recurrent) costs of importing oil or gas from other countries. *Not alternative import sources, but the gradual expansion of the capacity of crude oil and gas storage facilities (to 2 mt for oil and 2 bcm for natural gas) provides the cost-effective way of increasing the security of fuel supply for Belarus. The strengthening of the relationship between Belarussian refineries and Russian crude producers could also increase crude supply security and reduce excess refining capacity.*

76. While fuels can be stored, the storage of electricity is practically impossible. Therefore, import dependency in the case of electricity is generally considered more disadvantageous than in the case of fuels. This explains why the long term energy program set a goal of self-sufficiency in electricity generation after the year 2005. It is important, however, to make a distinction between supply security and self-sufficiency. Clearly, 100% self-sufficiency does not imply 100% supply security, since unforeseen events can happen not only abroad, but also domestically. Increasing self-sufficiency is not the only way to increase supply security -- the import can be made more reliable, too. Furthermore, the reliability of electricity import compensating for insufficient domestic generation capacity affects supply security differently than the reliability of electricity import purchased because of its low cost. The latter has no effect on supply security, as long as fuel is readily available to run domestic plants in case of a disruption in import electricity flows. Finally, supply security is not an absolute goal. It has costs and benefits that have to be balanced, i.e., on the margin, the cost of further increasing supply security should be the same as the cost of supply interruptions.

77. Under demand scenario A (low demand), peak power demand that cannot be met domestically (without any rehabilitation or expansion of generating capacity while using a 13% reserve capacity requirement) is reduced from about 1,500 MW in 1993 to about 400 MW in 1994, and is completely eliminated in 1995-1998, i.e., reduced electricity demand "automatically" increases the potential level of self-sufficiency. Taking into account high priority rehabilitations, the capacity gap does not return until 2000, and the 1993 level of import dependency (in terms of capacity) is not exceeded until 2004. Even under scenario B (high demand), the 1993 level of import dependency is maintained until 2003 without any new capacity additions (see Annex 3).

78. Belarus has not experienced costly disruptions in electricity imports. Although sudden increases in the cost of imported electricity shocked the power industry in 1992-93, these increases simply mirrored the increases in imported fuel costs. The existence of high capacity power connections to three countries significantly reduces the ability of any of these countries to achieve and exploit a monopoly position on the Belarussian electricity market. About US$ 1,150 million of additional investments would be needed in the 2002-05 period in order to eliminate electricity imports after 2005. Whether these investments can be justified economically depends on the future cost of imported electricity. An analysis carried out with a generation optimization model shows that, if the cost of imported electricity exceeds US$ 0.04/kWh (in constant 1993 dollars) after 2005, the replacement of import with domestic generation will be the least cost solution. However, if the cost of imported electricity does not exceed US$ 0.03/kWh, continuing the import of electricity will present a lower cost alternative than investing in additional generation capacity. *The analysis suggests that there is no urgency to invest in capacity expansion with the sole purpose of increasing the self-sufficiency of electricity generation (however, this does not imply that investments in rehabilitation and new capacity are not needed; see Section D of*

Chapter VII). Permitting suppliers in all neighboring countries to compete on the Belarussian electricity market and keeping adequate fuel reserves for domestic power plants are the cost effective measures to increase the security of electricity supply. If major changes occur (or are expected to occur) in electricity demand or the reliability and cost of imported electricity in the future, this strategy will need to be reevaluated.

V. ORGANIZATION OF THE ENERGY SECTOR

A. Enterprises and Agencies

79. **Geology and exploration**. Belarusgeologia (an enterprise providing geological services under the State Committee of Industry[15]) and Belarusneft (the state owned oil producer under the Committee of Oil and Chemistry) have overlapping responsibilities for the exploration of oil and gas in Belarus. Initially, Belarusgeologia was responsible for the early phases of geophysical work to identify all fossil fuel and mineral resources. This included gathering field data and doing preliminary drilling to confirm deposits. Further exploration, development and production of oil and gas was conducted by Belarusneft (the state oil production enterprise), and included the bulk of the drilling and seismic analysis. Belarusneft is also involved in drilling and seismic activities in other parts of the FSU, mainly in western Siberia. Over the last few years, however, Belarusneft has assumed the bulk of the responsibility for the exploration and development of the country's oil and gas resources. A third enterprise with a capability to perform seismic geophysical work is Zapadneftgeofizika, an enterprise that has contracts in Belarus, Russia, Yemen, Syria and other countries.

80. **Petroleum industry**. Belarusneft consists of 21 enterprises involved in oil exploration, drilling and production, research and development, maintenance and collective farming. About half of its 15,000 employees are working in Russia. Formerly under Transneft (of the FSU), the operation of the crude oil pipelines in Belarus is now the responsibility of two companies, the Novopolotsk "Druzhba" Pipeline Company in the north, and the Gomel "Druzhba" Pipeline Company in the south. In 1992, Belarusneft was under the Ministry of Resources, and the two pipeline companies, the oil product transportation, storage and distribution facilities belonged to the State Committee of Oil Products. The two refineries were under the State Committee of Industry. In early 1993, in order to improve coordination and management, a Committee of Oil and Chemistry was formed, with a role to supervise all enterprises in the subsector.

81. **Gas industry**. Zapadtransgas, a concern in the former Soviet Union with headquarters in Minsk, operated the high pressure transmission pipelines and the associated storage facilities in Belarus, and also in Lithuania and Latvia. The distribution of natural gas and LPG was the responsibility of seven regional gas (oblgaz) enterprises under the State Committee for Fuel and Gasification in Belarus (Goskomtopgaz). In late 1992, Beltransgaz inherited the facilities on Belarussian territory from Zapadtransgaz. In early 1993, Goskomtopgaz was transformed into a concern, Beltopgaz. Beltransgaz

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[15] According to the Soviet model, the two basic categories of government agencies were Ministry and State Committee (or Committee). A Ministry was responsible for the implementation of government policy in a particular sector of the economy and represented the owner of all enterprises in that sector. A State Committee or Committee implemented government policy in an area which cut across several sectors of the economy, such as planning or environmental protection. State Committees and Committees did not own enterprises and were not responsible for production (although there were exceptions). Both the head of a Ministry and the Chairman of a State Committee were appointed by the Supreme Soviet and were regular members of the Council of Ministers. The Chairman of a Committee was appointed by the Council of Ministers. With some modifications, Belarus still followed this model in the early 1990s. However, the basis for differentiating between Ministries and State Committees was slowly disappearing. Several State Committees (or Committees) owned enterprises and there were plans to formulate Ministries without direct production responsibilities.

imports the gas from RAO Gazprom and delivers it through the city gate stations to the oblgaz enterprises to be delivered to end users. Beltransgaz has seven regional divisions operating the compressor stations, pipelines and the CNG stations in their respective areas. In addition, there is a division operating the Osipovichi storage facility. The headquarters staff provides engineering services for all divisions. Under Beltopgaz, the seven oblgaz enterprises (one for each oblast and one for Minsk City) operate as autonomous cost centers. However, Beltopgaz kept the right to reallocate profit between the oblgaz companies. Each oblgaz is divided into gorgaz units, corresponding to the rayon administrative level. Other sub-divisions within Beltopgaz include three enterprises for gas pipeline construction; one enterprise for general construction such as housing and office buildings; a design institute; and other support facilities such as a standards laboratory, and a training center.

82. **Solid fuels**. Beltopgaz is also responsible for the production of peat and the distribution of solid fuels (coal, wood, and peat briquettes) to non-industrial customers. The distribution function is implemented by 117 service enterprises ("gorraytopsbit"), one in each rayon. The service enterprises have dual subordination -- each "gorraytopsbit" reports both to the respective local government and Beltopgaz. Beltopgaz cannot move profit from one "gorraytopsbit" to another. Coal import and distribution for industrial use is carried out by the Ministry of Resources. Fuelwood is produced by the 86 rayon level enterprises under the Ministry of Forestry, and also by Bellesprom, an association of 32 logging and wood processing enterprises.

83. **Electricity**. Before independence, the Belarussian power industry was under Belarusenergo, a territorial association of the power utilities in Belarus. In 1992, Belarusenergo was transformed into the Ministry of Power (Minenergo). Minenergo supervises six regional integrated power utilities (one in each oblast), the central dispatch center, three technical institutes and 17 manufacturing, construction and maintenance enterprises.

84. **District heat**. The power plants under Minenergo also produce thermal energy for district heating in 17 large and medium sized cities in Belarus. Thermal energy is delivered through the transmission system to district heat distribution networks, operated by municipal level district heating enterprises reporting to the municipal executive councils and the Ministry of Housing and Communal Services. Both the regional utilities and the municipal district heating enterprises operate a number of heat only boilers to cover peak demand. In addition, 208 towns with 10,000 or more inhabitants have district heating facilities under the municipal authorities. Not only residential buildings, but industrial enterprises and the service sector also purchase heat from the district heating networks.

85. **Energy savings**. The Committee of Energy Savings and Control was established in 1993 with the purpose to promote energy savings by (i) managing research and development of energy saving and non-traditional energy supply technologies; (ii) establishing and overseeing the production of metering, regulating and control devices, and other energy efficiency equipment; (iii) developing economic instruments for energy savings; and (iv) supervising a network of inspectorates. The task of the energy inspectorates (energonadzor) is to ensure that the energy consumption of regulated consumers stays within the norms, or, if the the norms are exceeded, the consumer pays the stipulated penalty (see Section C of Chapter III above).

86. **Regulation**. The State Price Committee (Goskomtsen), the former price regulator, was merged with the State Planning Committee (the former Gosplan) in 1991. The newly formed State Committee for Economy and Planning (Gosekonomplan) took the lead in establishing energy prices in

1992. In 1993, the role of Gosekonomplan was changed to the approval of energy prices proposed by the various agencies and enterprises listed above. In addition to acting as the price regulator in the energy sector, Gosekonomplan determined the main direction of fuel and energy flows by maintaining (although in a reduced scope) the system of state orders inherited from the former economic mechanism based on central planning.

B. Sector Management, Regulation and Ownership

87. **Basic principles**. Governments have three basic functions in the energy sector: (i) management and coordination, covering the major strategic decisions that affect the sector and those areas where the government is seeking a wider national interest than implied by the objectives of the energy enterprises alone; (ii) regulation, whereby the government seeks to ensure that the consumer has appropriate protection in respect of prices and quality of supply; and (iii) ownership, i.e., ensuring an adequate financial return on the nation's investments in the sector. These three functions are not without conflicts; for example, the owner and regulator roles conflict over the question what is the desirable level of consumer prices, and the policy making and ownership roles conflict over the question what is the desirable level of competition from the private sector or abroad. For this reason, these roles are usually given separate entities in market economies, i.e., separate entities/agencies are responsible for management, regulation and ownership. This helps to create transparency in the way governments interact with the sector, which is a condition for attracting private capital.

88. Economic activities can be divided into two groups. The first group contains natural monopolies, i.e., activities which, for technological and other reasons, are most efficiently carried out by a single organization.[16] Within the energy sector, oil transportation (via pipelines) and the transmission/distribution of gas, electricity and district heat belong to that group. The second group contains activities which can be carried out competitively. Within the energy sector, production and distribution of solid fuels, oil production, refining and distribution, and electricity and heat generation belong to that group. Depending on specific circumstances, many forms of competition can be chosen -- at the wholesale level, at the retail level, competition for the right to operate (lease) certain assets, or carry out certain activities (i.e., for concessions). Specifically, a system of competitive bidding for leases can be introduced as an interim stage until favorable conditions for divestiture are developed.

89. **Sector management and coordination**. In Belarus, as described in Section A above, there are several organizations reporting directly to the Council of Ministers with major responsibilities in the energy sector. This makes the task of sector management, coordination and supervision very difficult. Recognizing this, the Government has recently started a process of unifying the management of the sector. First, the supervision of most of the agencies operating in the energy sector was assigned to one of the Deputy Prime Ministers in October 1993. In addition, the Government requested approval from the Supreme Soviet for the establishment of a new Ministry of Fuel and Energy. The responsibilities of the Ministry would include power, gas, oil and solid fuels. *This study considers the proposed establishment of the Ministry an important step in the right direction and encourages its implementation as a matter of high priority.*

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16 Natural monopoly, as defined by economists, is an activity with increasing return to scale or positive economies of scale.

90. **Regulation**. For the provision of most goods and services, the objectives of the Government's regulatory function are best achieved by maintaining a competitive business environment, i.e., competition provides the best protection for consumers in terms of both quality and price. For natural monopolies, where competition is not a feasible option, separation of the ownership and regulatory functions is probably the key step towards adequate consumer protection. The regulator needs to apply industry specific price regulation formulas or criteria to control the changes of prices, and it should also exercise control over the obligations to supply and connect, quality of service and customer rights. The regulatory authority must achieve a high level of public confidence, including the confidence of both customers and potential investors. For example, private investors will be reluctant to invest in the power industry or in other utilities with large sunk costs, unless they are confident that the risk of expropriation (by keeping prices so low that capital costs cannot be recovered) is low.

91. In order to achieve the confidence of the public, the regulatory authority needs autonomy, objectivity and transparency. The regulator must have autonomy from the executive arm of the government, so it is not governed by short term political interests. Also, it must be independent and seen to be independent of the enterprises that are being regulated. This can be achieved if the regulator is granted political and financial independence, with full control over its own budget and personnel. The regulator must make objective decisions based on law and the available data, and its conclusions must follow logically from these elements. Its rulings should not require government approval, and only the courts should be able to overrule them. Finally, the regulatory authority must be transparent in that it consults with all major interested parties, including, of course, the enterprises being regulated, and it should publish how its major decisions were arrived at.

92. The Prices Department of the Ministry of Economy, although it is independent from the energy agencies, does not meet all the requirements for a regulatory authority. Its focus is on only one aspect of regulation, prices, while other important aspects, such as the quality of service, are somewhat neglected. Its procedures and decisions are not transparent, and are subject to approval by the government. Therefore, *in the medium term, there is a need to establish an open, independent, legally based energy regulatory system by which the interests of the customers (both residential and industrial), the central and local governments, potential creditors and the regulated enterprises are all taken into account*. The same agency may regulate the whole energy sector, or specialized agencies may be established for power, gas, etc.[17] The top management of the regulatory authority (or authorities) should have a high degree of job security and should be appointed by the Prime Minister for a fixed time period. It should promote competition in oil and gas production, oil refining and distribution, coal mining and distribution, electricity and heat generation and energy trade. It should closely regulate the non-competitive energy activities such as gas, electricity and heat transmission and distribution.

93. **Ownership**. The objective of the ownership function of the Government is to ensure that state-owned enterprises are subject to pressure to improve their efficiency. Competitive markets create this pressure more effectively than bureaucracies. International experience amply demonstrated the large efficiency gains associated with the indroduction of competition. Even for natural monopolies, significant improvements in production efficiency were recorded when the operation of enterprises was put on a

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17 Both options have advantages and disadvantages. On the one hand, a single regulator for the energy sector is more likely to apply consistent regulatory policies across the various subsectors. This arrangement will also minimize administrative costs. On the other hand, having separate regulatory authorities for each subsector results in more focussed accountability and promotes the specialization of regulatory staff.

commercial basis with increased autonomy for management. The Government should set short and medium term financial targets, however, once these targets are set, the enterprises should be operated on a commercial basis and the Government should not interfere in their day-to-day management. Excessive control undermines the responsibility that the management has for performance. There is a danger that the establishment of the new Ministry of Fuel and Energy, despite being fully justified from the point of view of effective sector management, will lead to a return to the old central planning system. The new Ministry should develop an arms' length relationship with the enterprises in the energy sector. This could be achieved by the separation of the ownership function from the coordination and policy making role of the Ministry. *The first steps should be the corporatization of all enterprises in the energy sector, and establishment of holding companies to act as intermediate owners in the power and gas subsectors, thereby ensuring that the Ministry will not have direct responsibility for production (no "khozyaystvennie funktsii").*

C. Options for the Restructuring of Subsectors

94. **Oil Exploration and Production**. All mineral resources are likely to remain under state ownership. However, that does not mean that there are no alternatives to a state monopoly in the exploration and extraction of crude oil. In order to create conditions for competition, the policy development, supervisory and long term scientific functions of Belarusgeologia should be separated from the petroleum exploration function. The exploration function could be transferred to Belarusneft (that is the more common structure around the world), or the Government may decide to create one independent exploration and development entity by merging the relevant departments of Belarusneft and Belarusgeologia. Parallel with that step, *the Government should draft a petroleum law which would establish a licensing/concession regime with rules governing procedures for the exploration and development of oil fields*. This is a necessary condition for attracting foreign investment and modern technology into the subsector, which, in return, are the conditions to arrest the production decline (because of the low productivity of reservoirs, it will pose a considerable challange to attract foreign investors to Belarus).[18]

95. *Belarusneft should be corporatized (i.e., transformed into a joint-stock company), with the majority ownership function assigned initially to the new Ministry of Fuel and Energy or to GKI.*[19] *In the medium term, most of the stocks could be offered to foreign and domestic private investors. Corporatization should be followed by (or implemented together with) restructuring, with a view towards efficient commercial performance.* This will require a thorough analysis of the changing market and inter-government arrangements, and an identification of Belarusneft's core business activities, essential support functions, and other non-essential activities.

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[18] The concession system would determine the conditions, procedures, and benefits for private oil companies willing to risk their capital to explore for oil in Belarus. Foreign oil companies could also be invited to bid for the right to extract crude oil from existing, depleted fields by applying secondary or tertiary recovery methods. The improvement of the general legal system, the development of a sound banking system and the adoption and implementation of a clear privatization strategy would be additional (although not specific to the energy sector) measures to facilitate a substantial increase in foreign direct investment.

[19] In 1993, about 30% of profits were placed into a fund for employees to buy stock in the company when it is corporatized.

96. **Oil transportation**. An oil transportation pipeline is a natural monopoly and it requires regulation. *The companies operating pipelines should treat all potential users in a fair and non-discriminatory way (i.e., operate as open access pipelines), while should be allowed to earn adequate return on their capital.* Assuming the existence of a proper regulatory framework, state ownership of the pipeline companies is not an economic necessity. *The companies should be corporatized and, in the long run, shares could be offered to foreign or domestic private investors.*

97. **Oil refining and distribution** is a subsector that should operate on a competitive basis. That implies freedom of entry and exit, liberalization of foreign trade and decontrol of domestic prices. In addition, the refineries and the distribution companies are prime targets for future privatization. The Government has already made significant progress in this area. Resolution 666 of the Council of Ministers liberalized the domestic and foreign trade of oil and oil products (except for products refined from the "clearing" and domestically produced oil) and authorized private construction and leasing of oil distribution and marketing facilities starting October 10, 1993. The restructuring of the oil refining industry should aim to solve the major problems of supply insecurity, foreign exchange shortages, obsolescence, and excess capacity. The current strategy of the Committee of Oil and Chemistry in dealing with these problems is to corporatize the refineries, to exchange shares with Western Siberian crude producers, to seek longer term crude supply commitments, to promote toll refining, to obtain external financing for upgrading investments, and to repay external loans with proceeds from future exports of additional light products obtained from the upgrading investments (see Chapter VII for more detail).

98. *Following corporatization, the refineries should be allowed to make their own business decisions under well defined regulations for taxation, accountability and performance.* Specifically, refineries should be free to arrange their own partnerships, negotiate their own crude supplies, plan their own product slates, establish the prices at the refinery gate, and develop their investment program. The corporatized enterprises should also gradually spin-off all activities not directly related to the oil business, such as the facilities maintained for the benefit of the oil workers and their families. Selling or transferring these activities to independent service companies would increase the profits available for re-investment.

99. *Distribution by oil tank trucks (mostly used by oil marketing companies moving products to retail outlets) should be fully privatized preferably with different private transportation companies competing in the same marketplace.* Already, private companies are allowed to operate in oil marketing and retailing and sell at decontrolled prices. Private companies can build service stations or rent them from the state owned marketing company. *Remaining constraints to competition should be removed by eliminating hidden subsidies, special prices and state orders, and by ensuring equal access for all marketing companies to oil products from the refineries, to transportation services, and to other facilities necessary for efficient marketing.* Private companies should have the freedom to choose between importing or lifting products from the refineries -- guided by cost considerations. More than one marketing company should be encouraged to operate and compete in any given market area.

100. **Gas transmission**. Currently, Beltransgaz acts as a holding company for the regional transmission and storage enterprises. According to the law on corporatization, gas pipeline assets cannot be corporatized. However, the Government has submitted a proposal to the Supreme Soviet to amend the law to permit the corporatization and eventual sale of Beltransgaz to RAO Gazprom. The sale price

is expected to be 0.6% of RAO Gazprom's stock.[20] If the agreement is implemented, RAO Gazprom will own the natural gas storage field, the laterals from the main pipelines, the city gate stations and the compressed natural gas (CNG) fueling stations. Beltransgaz would operate as a division of Gazprom, but ultimately its activities would be controlled from the corporate headquarters in Moscow. This might create some operating problems. For example, Gazprom may want to operate the Osipovichi storage field for the benefit of transit service rather than to protect deliveries to Minsk, which is the primary role of the field right now. One solution would be for Bel(top)gaz to lease the field and sign an operating agreement with Gazprom. In addition, there is no reason why Gazprom should be involved in marketing CNG. These stations also could be leased (or purchased) back from Gazprom and operated by Bel(top)gaz. Gas transmission is an industry with a positive economy of scale, i.e., it is a natural monopoly. *Whether the sale of Beltransgaz is concluded or not, the transmission system will need to remain under the jurisdiction of the Belarussian regulatory authority. In the long run, the transmission system should operate as an open access pipeline serving gas exporters and importers.*

101. **Gas and solid fuel distribution**. Beltopgaz is responsible for four different activities: (i) natural gas distribution; (ii) LPG bottling and distribution; (iii) peat harvesting and briquetting; and (iv) marketing of solid fuels. One of these activities, natural gas distribution, is a natural monopoly. The other three activities can be carried out competitively. Therefore, these activities should be separated by *(i) corporatizing the seven oblgaz, the three pipeline construction and the design companies and establishing a holding company (Belgaz) as the main shareholder; (ii) establishing a corporation for LPG bottling and distribution; (iii) establishing a corporation for peat harvesting and briquetting; and (iv) placing the "gorraytopsbit" directly under their respective local governments. Also, the trade of solid fuels should be demonopolized and liberalized, followed by the privatization of the "gorraytopsbit".* In the medium term, stocks in the oblgaz, LPG and peat corporations could be offered to foreign investors.

102. **Electricity**. Economics textbooks used to cite power utilities as prime examples for a natural monopoly. However, recent technological advances in electricity generation (gas-fired combined-cycle turbines and cogeneration options) have significantly decreased the validity of the economies-of-scale argument (however, it is still valid for transmission and distribution). Furthermore, several countries (e.g., United Kingdom, Norway, Chile, United States, Canada) have implemented changes in their regulatory and institutional system which created a certain level of competition among electricity generators. These developments prove that there is no need to treat generation as a natural monopoly and, more importantly, also demonstrate that regulatory reforms can bring significant efficiency improvements in electricity supply.

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[20] In order to estimate the monetary value of the agreed sale price of Beltransgaz, one needs to know the basis for calculating the value of RAO Gazprom's assets. If the assets included only the pipelines, storage and other transmission facilities, the monetary value of 0.6% of Gazprom's stock would be much lower than if gas reserves were also included among the assets.

103. A comprehensive reform of the Belarussian power industry should include the separation of generation, transmission and distribution functions, commercialization[21] of electricity supply, introduction of competition and the promotion of private sector participation. *The introduction of competition requires the breaking up of the current vertically integrated structure into separate companies responsible for generation, transmission and distribution.* All generators (including cogenerators in the industrial sector) must be allowed open access to the transmission network and have the right to sell bulk power to distributors and large users at freely contracted prices. Also, generators and other independent producers must be allowed to bid for the right to develop new generating capacity. Prices charged by the transmission and distribution companies will continue to be regulated. The restructuring will bring significant benefits. Decisions about generation capacity development will be more solid economically and financially. There will be clear incentives and pressures to reduce operation costs. Transparent prices, which better reflect costs and reduce the extensive cross-subsidization, will send the right signals to electricity consumers. The needs of the customers will be in the focus of service improvements efforts. Most of these benefits will come from a new, competitive set-up for the operation of the industry and will not depend on privatization, which may or may not be the ultimate objective of the Government. *These changes will require the drafting and adoption of an electricity law that lays down, among other things, the respective roles of market competition and Government regulation, the functions of the regulatory agency and the rights of potential private and foreign participants in the supply of electricity. The law should establish a licensing regime with rules governing procedures for obtaining generation licenses and operation of the transmission and distribution systems.*

104. Minenergo, with assistance provided by EC TACIS, has already started the development of a detailed restructuring plan.[22] The draft plan, prepared at the end of 1993, outlined a four-year program, consisting of five phases:

(a) Starting immediately, costs would be separated according to generation, transmission, distribution and heat supply, and the legislative work to set up Belarus Energy Company (BEC) as a state owned corporation would be initiated;

(b) Within six month, BEC would be established, with the Ministry acting as both the owner and the regulator;

(c) By the end of year 1, a Systems Division within BEC would be established, with responsibility for planning, despatch and the operation and maintenance of the high voltage grid;

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21 Commercialization means that an enterprise stops to operate like a government department and adopts commercial management and operation practices. Enterprise management is primarily judged on the basis of profitability and has no responsibility for the achievement of social objectives. The enterprise is explicitly compensated from the budget for the provision of non-commercial services, which are gradually phased out. The company may either retain its status as a state-owned enterprise or be converted to a joint-stock company subject to corporate law.

22 WS Atkins International (with London Economics and Scottish Power) was the consultant assisting Minenergo in that process.

(d) By the end of year 3, the 14 largest power plants would be separated from the regional utilities and combined into one or two Generation Divisions. At the same time, regional distribution companies would be formed as individual profit centers; and

(e) By the end of year 4, the Systems and Generation Divisions would become separate companies, owned by BEC which would become a holding company.

105. The proposed plan carefully outlined the required changes in planning, budgeting, accounting and tariff setting, thereby ensuring that the organizational changes would be supported by the modernization of management and financial systems. However, the length of the transition period needed between the establishment of the Belarussian Electricity Company and the setting up of the separate generation, transmission and distribution companies seems to be overestimated. Based on the experience of other countries, two years (rather than 3.5 years) may prove to be sufficient. With adequate level of technical assistance, the establishment of separate enterprises will speed up the introduction of proper transfer pricing arrangements and contractual relationships.

106. Although the main thrust of the proposed plan is consistent with the reform outlined above, the proposal preserves some features from the past, and also leaves certain questions unanswered. First, the Ministry of Power (or the new Ministry of Fuel and Energy) would combine the roles of policy making, ownership and regulation. The process of setting electricity tariffs would be subject to short term political interests (the proposal includes periodic approval of tariffs by the Council of Ministers), and the independence of the regulator from the regulated industry would be doubtful. For example, the Ministry as the owner of generating plants would not be interested in providing access to the transmission system to independent power producers. One option is to divide regulatory functions between the Ministry of Economy and the new Ministry of Fuel and Energy. The Ministry of Economy would continue to focus on prices, while the new Ministry would issue licenses, safeguard and encourage competition, control obligations to supply and connect, and determine the quality of service. Although this arrangement might prove to be workable after the establishment of the holding company for the subsector, it would not be without disadvantages. The Ministry of Fuel and Energy would still combine (some of the) roles of the regulator with responsibilities for policy development and ownership. The Ministry of Economy would continue to regulate prices in a non-transparent way, without adequate assurances for consistency and stability. Therefore, *in the medium term, both Ministries should give up their regulatory functions and transfer it to the new energy regulatory authority (see above).*

107. Second, the proposal does not describe the participants and the rules governing the envisaged power supply market. In view of the small number of domestic suppliers (two generating companies and possibly a few independent generators in the long run), the role played by electricity import will be particularly important. Following the completion of the new 750 kV line to Smolensk, the combined capacity of power connections to Lithuania, Russia and Ukraine has reached 7,000 MW, matching the available domestic generating capacity (6,931 MW). Therefore, generating plants abroad are significant potential competitors on the Belarussian electricity market. The crucial question is whether it would be beneficial to allow open access to the transmission system for these plants (e.g., to allow a Russian electricity supplier to enter directly into a contract with a Belarussian customer), or contracting with foreign suppliers should be restricted to Central Dispatch. The existence of competition from abroad, even if channeled through Central Dispatch, would prevent the emergence of a duopolistic market. *A system of gradually increasing quotas of direct supply contracts between domestic customers*

and foreign suppliers (allocated to Lithuania, Russia, Ukraine and Poland) may be needed to strike a balance between the objectives of efficiency and supply security.[23]

108. **Heat**. The introduction of competition in the generation of heat requires changes similar to the ones proposed for the electricity subsector (in fact, the restructuring of the electricity subsector proposed above will increase the autonomy of the large CHP plants, and therefore will facilitate competition between heat generators). However, since the cost of transporting heat over long distances is prohibitive, the competition has to be local in nature and will depend on the availability of a significant number of independent generators in the direct neighborhood of the district heating network who are interested in selling heat. Since supply conditions (generation, transmission and distribution costs, the balance of supply and demand, the number of independent suppliers) could differ dramatically between cities, there is only a minimal need for regulation on a nationwide basis. *The functions of regulating transmission/distribution systems, issuing heat supply licenses and awarding contracts could be delegated to the municipal executive councils.* The proposed energy regulatory authority could provide technical standards for the systems and carry out an oversight function in cooperation with the Ministry of Housing and Communal Services.

23 The plants best positioned to supply power to the Belarussian market are almost exclusively nuclear plants (Ignalina, Smolensk, Chernobyl and Rovno, all within a distance of 100 km from the Belarussian border). Nuclear power plants are characterized by relatively small recurrent and large sunk costs, thereby particularly well-suited for the implementation of predatory pricing.

VI. ENERGY PRICES, SUBSIDIES AND TAXES

A. The System of Energy Pricing and Taxation

109. In 1993, the Government applied a variety of instruments to control energy prices. The Ministry of Economy set the price of (i) domestically produced and imported "clearing" crude oil; (ii) oil products refined from domestic and "clearing" oil (including LPG); (iii) domestically produced and imported natural gas (except as automotive fuel); and (iv) heat and hot water for household use. Proposals to change these prices were prepared by the Committee of Oil and Chemistry, the Ministry of Resources, Beltransgaz, Beltopgaz and the Ministry of Housing and Communal services. The Ministry of Power set electricity prices, but prices had to be approved by the Ministry of Economy. The price of heat for non-household consumption was determined by local governments, based on recommendations from the Ministry of Power, the Ministry of Economy and the Ministry of Housing and Communal Services. Local governments also set the prices of solid fuels for household use, based on budgetary subsidies received from the Ministry of Finance. The price of firewood and peat briquette for industrial use was (in theory) uncontrolled, however, the actual supply outside the state order system was negligible. Therefore, until October, only coal prices for industrial use, and the price of natural gas as automotive fuel were free. On October 10, 1993, Resolution 666 of the Council of Ministers lifted margin controls on the refining and distribution of oil products that originated from "commercial" imports, thereby partially liberalizing oil product prices.

110. The widespread use of price controls served two objectives. First, prices were differentiated according to the consumers' perceived ability to pay and their importance from the point of view of the national economy. Accordingly, household energy prices were set well below financial costs. Prices for other consumers were set to cover at least "sebestoimost", i.e., the sum of operation, maintenance and depreciation costs. Prices that (fully or partly) covered the cost of cross-subsidies to households and also included a margin for profit[24] were charged only to industrial consumers, while the agriculture, transport and services sectors all qualified for various levels of discounts. It was the task of the system of state orders to ensure that fuels and energy reached the designated "priority" sectors, despite the non-profitability of providing supplies to these consumers. Second, prices were controlled to prevent monopolists from abusing their market position, i.e., to protect all consumers from prices that would have generated excessive profits.

111. A value added tax (VAT) of 25% applied to all non-residential energy use, except to gasoline, which was subject to an 8% excise tax. An additional 20% tax applied to all automotive fuels (in order to prevent a cascading effect, the fuel tax and the excise tax applied only to the first transaction, normally at the wholesale level). A 3% tax was levied at the refinery gate on all refined products, except automotive fuels, and placed in a fund to regulate (subsidize) retail prices. There was an export tax on hard currency revenues (10% tax plus a 20% surrender requirement), however, oil refineries were given an exemption starting October 1993. Natural resource extraction fees applied to peat and crude oil production, however, the level of the fees were set extremely low. The oil production and pipeline companies paid an income tax of 50% of gross profits, while the profit tax for other enterprises in the energy sector was 30%. The cost of a variety of worker facilities are not tax deductible, and has to be paid out of after-tax profits. For a typical enterprise, these costs include the construction and

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24 Twenty percent was the maximum profit margin permitted. In fact, a substantial part of the profit was used to cover expenditures that should have been included among the labor costs.

maintenance of vacation, sport, and cultural facilities, children camps, canteens, general stores, and providing subsidized food for workers.

B. Energy Prices at the End of 1993

112. **Oil**. Belarusneft, the domestic crude oil producer, received Brb 140,000/t for the oil sold to the refineries in November 1993. The price was set to cover operating costs, depreciation and provide a 20 percent profit margin. However, the price was substantially below crude oil import costs (the lowest cost imported "clearing" oil was sold to the refineries at a price of Brb 340,000/t, while the cost of "commercial" oil was about Brb 600,000/t), and did not provide for the modernization of obsolete production equipment. In a market based system, the higher grade domestic crude would command a higher price than the imported Russian crude. Belarusneft sold associated gas (after extracting gas liquids) directly to the distributor (Beltopgaz) at a price also several times lower than the cost of imports.

113. Oil products refined from domestic and "clearing" crude oil fell within a controlled system of "cost-plus" pricing. Ex-refinery prices were set by the Ministry of Economy according to a formula based on the crude oil price paid by the refinery to the Ministry of Resources plus total average unit refinery operating costs plus taxes (see above) plus a 20% margin for most products (for heavy fuel oil, the margin was only 5%). These controlled prices for the final consumers were Brb 890/l for gasoline, Brb 800/l for diesel oil, Brb 95/l for home heating oil and Brb 324,000/t for heavy fuel oil. Uncontrolled prices of "commercially" refined or imported oil products were about 100% higher for automotive fuels, and 40% higher for fuel oil. In practice, automotive fuel at the controlled price was available only for "talons" (i.e., purchase permits issued by the Committee of Oil and Chemistry to certain organizations, state owned enterprises and agricultural cooperatives).

114. **Gas**. The border price for natural gas imports was established by an intergovernmental agreement and is payable to RAO Gazprom in Russian rubles. In January 1993, the border price was Rrb 2,500/tcm, and as of December 1, 1993 the price reached Rrb 88,750/tcm. To the border price Beltransgaz added (after approval from the Ministry of Economy) a transmission margin, which was intended to recover all operation, maintenance and depreciation costs plus a 20% margin for gross profit. The transmission margin was about Rrb 6,000/tcm in November 1993. The depreciation allowance was not adequate to recover the replacement cost of assets. However, this problem was negligible compared to the revenue shortfall caused by the non-payment of bills by several large gas consumers (see below).

115. Beltopgaz added a distribution margin to the price it paid to Beltransgaz. In November 1993, the distribution margin was Rrb (or Brb, depending on the consumer) 1,200/tcm, which was inadequate to recover all costs and a proper depreciation allowance. The gas price for industry and agriculture was set in Russian rubles, while households paid in Belarussian rubles. The price for industrial users and for electricity generation was Rrb 88,160/tcm. Gas used for agriculture and food processing was priced at Rrb 77,550/tcm. The price of natural gas and LPG for household consumers was set by a decree of the Ministry of Economy adopted on October 1, 1993. The decree established prices for five natural gas and seven LPG customer classifications, including LPG sold as vehicle fuel. For households with gas meters (very few such homes exist), a volumetric price of Brb 15,300/tcm was applied. In the absence of consumption metering, the tariff for gas used for cooking and water heating was based on the number of occupants. The tariff for gas used for space heating was based on square meters of living space occupied by the tenants (area for kitchen, corridors, lavatories, etc. was not included), with different price for the summer and for the heating season. The average price in

November 1993 for cooking/heating households was Brb 10,080/tcm, while for cooking only households Brb 15,300/tcm. The price of bottled LPG delivered to the house was set at Brb 115/kg. The price of LPG delivered to individual apartments through pipes from a central reservoir was Brb 690/person/month for cooking only, and Brb 1,080/person/month when used also for water heating. The price of liquid gas sold as vehicle fuel was Brb 160/l (approximately Brb 370,000/t).

116. In 1993, Beltopgaz established a service cut-off policy. According to the policy, 30 days after the bill is unpaid the customer receives a warning that service will be stopped. If payment is not forthcoming in 7 to 10 days, all but essential deliveries are suspended. As of December 1, 1993, Beltopgaz had cut off service to 29 industrial customers and 41 were receiving only partial deliveries. However, deliveries continued to many customers in arrears (e.g., the power industry), since the continued operation of those industries was considered a national priority. This factor also contributed to the accumulation of arrears to RAO Gazprom of about Rrb 200 billion in early December 1993.

117. **Solid fuels**. The price of solid fuels varied across local governments. The producers of peat briquettes received about Brb 50,000/t, while retail outlets ("gorraytopsbit") sold briquettes to households for Brb 15,000-30,000/t plus a transportation charge of about Brb 600/km. The forestry enterprises were paid Brb 10,000-14,000 per storage cubic meter (scm)[25] of firewood, while households paid Brb 5,000/scm, plus about Brb 1,600/scm for cutting, Brb 1,600/scm for loading and Brb 600/km for delivering the wood. At these prices, households were permitted to purchase, for one heating season, 2.5t of briquette plus 2-4scm of firewood, or 7-9scm of firewood only (the higher figure applied to the Northern part of the country). Additional firewood was priced two to three times higher. Households could also purchase a permit to collect firewood directly from the forest. Coal was sold at a price of Brb 40,000 - 45,000/t to households (plus the same transportation charge as for other solid fuels). The price of coal for industrial consumers was set by the market at Rrb 50,000-60,000/t.

118. **Electricity**. On January 1, 1993, regional differences in electricity prices were eliminated. After August 30, 1993, prices for industrial consumers were set in a combination of Russian and Belarussian rubles, while other consumers paid in domestic currency only. The price for medium size industrial users was Rrb 73.3 plus Brb 38.1 per kWh in November. The agriculture sector paid Brb 36.9/kWh, and households Brb 13.3 kWh (this was the average -- the price for urban households was about one third higher than for rural households). The average electricity tariff for all sales was about Rrb 25 plus Brb 30 per kWh. The Ministry of Power operated a fund to redistribute revenues between the six regional utilities according to differences in their production costs.

119. Practically all electricity consumers are metered. Households are asked to monitor their consumption and for every 100 kWh consumed have to buy a "talon" from the post office ("talons" are priced according to the prevailing electricity tariff). After writing the meter reading on the "talon", the household puts the "talon" in a safe place. When the inspector comes to read the meter (usually 1 or 2 times per year), he asks for the "talons" as a proof of payment, cuts them in half, and takes one half with him for accounting purposes. The system seems to work well and there were almost no households in arrears at the end of 1993. Non-payments were taken seriously, and resulted in interruption of delivery if necessary. Theft of electricity was rare and not a significant problem. If a meter had been tampered with, the customer had to pay for a new meter plus for the estimated maximum possible use during the

[25] One solid cubic meter of wood equals 1.43 storage cubic meters or about 0.7 metric ton.

period in question. However, the situation was dramatically different with non-household consumers. At the end of November 1993, total arrears were estimated at Brb 360 billion, most of it in the chemical, petrochemical, metallurgy, electronical and machine building industries. As a result, the Ministry of Power was in arrears of Rrb 100 billion for natural gas consumption.

120. **Heat**. Households are not metered and pay a price based on the square meters of living space occupied. In November 1993, the price was Brb 128/m^2, equivalent to about Brb 2,750/Gcal. Hot water is paid on a per capita basis; the price was Brb 370/person. Payments are made monthly in a combined bill for rent, water, sewerage, telephone, radio, television and other services. If payments are late, the bill is increased by 3% as a penalty. Payment arrears were not significant at the end of 1993.

121. Heat prices for other consumers were determined by local governments, based on guidance from the central government. In November 1993, industrial enterprises in Minsk paid Brb 165,584/Gcal, service establishments Brb 73,844/Gcal, greenhouses Brb 63,084/Gcal, and agencies dependent on the budget Brb 15,711/Gcal. The average price charged by Minskenergo, the main heat supplier for the city, was Brb 55,198/Gcal.

C. Effects of the Pricing System

122. Table 5 compares the November 1993 energy prices to the economic cost. For natural gas, crude oil and oil products, the economic cost is estimated as the sum of the border price plus domestic transport and distribution costs. The border price of oil and oil products is based on "commercial" imports. For all other fuels and energy, the economic cost is based on the cost of domestic production, transport (transmission) and distribution. Due to the availability of excess firewood as a byproduct of sanitary cuts and thinnings, no stumpage fee or replacement cost is included in the production cost of firewood. For briquette, the production cost includes the restoration of land where peat is extracted. The production cost of heat is based on heat-only-boilers. All estimates of domestic economic costs include a 10% rate of return on capital assets valued at replacement cost.

123. The comparison of implicit exchange rates (defined as the ratio of consumer price to economic cost) to the actual exchange rates (about Brb 6,000/US$ for "beznalichniye" and Brb 4,000/US$ for "nalichniye" or cash rubles in November 1993) shows that:

(i) household energy prices, with the exception of automotive fuels, were set at a very small fraction of economic costs;

(ii) most industrial energy prices covered 40 to 80 percent of economic cost;

(iii) the industrial price of natural gas was almost equal to the economic cost, and the price of electricity and heat were above economic cost;

(iv) the producer prices of natural (associated) gas, crude oil, heat and electricity were substantially below the economic cost of production.

124. There were several factors that contributed to the low level of energy prices. First, in the period of rapid inflation and import cost increases, the approval of price adjustments was slow and lagged behind cost increases. Second, capital assets were undervalued in 1993, therefore the contribution

from amortization funds was inadequate to cover recurring equipment replacement costs and rehabilitation works needed to maintain facilities. Third, the pricing formula applied by the Ministry of Economy controlled profit margins on the basis of operating and depreciation costs, and did not explicitly consider financing needs or a rate of return on capital investments. Fourth, household energy prices, with the exception of electricity, were subsidized from the budget.

TABLE 5. ENERGY PRICES IN BELARUS (NOVEMBER 1993)

Product	Producer Price (Brb)[1]	Consumer Price (Brb)		Full Economic cost (US$)[2]		Implicit Exch. Rate (US$/Brb)[3]	
		Industry[1]	Household	Industry	Household	Industry	Household
Firewood (cum)	30,000	38,000	18,000	15	25	2,533	720
Briquette (ton)	50,000	60,000	25,000	30	40	2,000	625
Nat. gas ('000cum)	4,350	366,000	10,080	70	85	5,229	119
Crude oil (ton)[4]	140,000	340,000		110		3,091	
Gasoline 92 (ton)[5]	845,000	1,157,000	1,157,000	245	245	4,722	4,722
Diesel oil (ton)[5]	640,000	784,000	960,000	200	220	3,920	4,364
Heating oil (ton)[5]	560,000	650,000	114,000	195	205	3,333	556
LPG (ton)[5]	452,000	370,000	115,000	230	260	1,608	442
Fuel oil (t)[5]	310,000	324,000		70		4,630	
Heat (Gcal)[6]	55,198	165,584	2,750	25	35	6,623	79
Electricity (MWh)	135,000	346,000	13,000	35	45	9,886	288

Notes:
1/ Prices set in Russian rubles are multiplied by 4.2
2/ Assumes 10% rate of return on invested capital valued at replacement cost
3/ Implicit exchange rates are equal to the ratio of consumer price to economic cost
4/ Industrial price refers to "clearing" oil
5/ Consumer prices refer to the state order system. LPG industrial price refers to transport
6/ Heat prices refer to the city of Minsk

Source: Gosekonomplan, Ministry of Power, Committee of Oil, Beltopgaz, Ministry of Communal Services and Bank staff estimates

125. The household price subsidies included in the revised 1993 budget (prepared in September) were Brb 19.2 billion for solid fuels; Brb 13.2 billion for natural gas and LPG; and Brb 63.6 billion for district heating (only to municipal district heating enterprises, since the supply costs of regional power utilities were cross-subsized from industrial heat and electricity sales). The sum of these subsidies represented 2.4% of total budget expenditures (estimated at Brb 4 trillion). The actual amount of subsidies was significantly larger, due to the rapid depreciation of the Belarussian currency against the Russian ruble in the second half of 1993 (see Section A of Chapter II). Subsidies were particularly large during the last three month of the year; household energy prices were left unadjusted between October

1 and December 31, while the cost of imported fuels (expressed in domestic currency) almost doubled. Unless strict limits are introduced, energy price subsidies will make it increasingly difficult to contain the budget deficit in 1994.

126. In 1993, the bulk of the household energy price subsidy was provided outside the budget. First, the extensive cross-subsidies in the district heating, electricity and natural gas subsectors put the burden on the industrial consumers, not on the budget. Second, the accounting practice that continued adding Russian rubles to Belarussian rubles using an exchange rate of 1:1 even when the National Bank's rate was 4.2:1 kept the true level of household price subsidies hidden. Based on the difference between the actual price and the economic cost of household energy, the total sum of "economic" (as opposed to financial) subsidies can be calculated. Had the difference been the same for the whole year as in November, total "economic" household energy price subsidies would have been about US$ 900 million in 1993. Within that amount, subsidies for district heat represented about US$ 500 million, electricity US$ 200 million, natural gas US$ 87 million, LPG US$ 77 million and solid fuels US$ 45 million. In other words, the bulk of the "economic" household energy price subsidy was in those subsectors that are natural monopolies: district heat, electricity and natural gas. These network energy services are particularly well-suited for cross-subsidization.

127. Cross-subsidies, however, are not without negative effects. As fuel imports are approaching world market prices, the requirement that the subsidy to household consumers be covered from a surcharge on industrial sales will lead to a level of electricity, heat and natural gas prices for industrial consumers that is higher than in market economies, thereby it will hurt the international competitiveness of Belarussian industry. In fact, industrial electricity prices may have reached that level already. In addition, the surcharges create incentives to rely on other energy sources, even if the economic cost of the alternative source is higher. Examples are the supply of own heat rather than buying heat from a cogeneration plant, or the substitution of fuel oil (a non-network fuel) for natural gas. If these "self-defence" strategies are adopted by many enterprises, their actions will ultimately erode the base for cross-subsidies.

128. Whether the government subsidizes energy consumption or not, it will not change the fact that now Belarus pays higher prices for energy than in the past. Direct and indirect subsidies move part of that burden from those who consume the energy to the population at large. While it is not known who are the losers and winners in that redistribution, it is clear that the more energy a household consumes, the more subsidy it receives. In addition to causing distortions in the economy (since the revenue to pay for the subsidy has to be raised somehow), the household energy price subsidy has the undesirable side effect of discouraging energy conservation. Many energy saving measures that are worth undertaking at prices that reflect the full cost of energy will not be implemented by the households at the current very low prices. The high subsidy makes it difficult to introduce gas and heat consumption metering, since the high cost of the meter (compared to the price of energy) makes the purchase of a meter unattractive for households. Even if the utility is willing to pay for the meter, energy savings due to the "metering effect"[26] may be so low that the economic benefits of metering may not be large enough to justify

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[26] The "metering effect" is the drop in consumption following the installation of a meter. It is a function of the household's demand curve and the marginal price of energy (i.e., the higher the price and the more elastic the demand curve, the larger the "metering effect").

expenses. In addition, extremely low district heat, natural gas, heating oil and LPG prices reduce the demand for domestically produced solid fuels, contributing to the large energy import bill.

TABLE 6. CROSS-COUNTRY COMPARISON OF THE SHARE OF ENERGY EXPENDITURES IN HOUSEHOLD INCOME

Energy Expenditures/Income Ratio (%)			
Belarus[1]		Other Countries	
Average	5.0	Poland	8.2
		Hungary	6.5
Low-income	>10.0	Czechoslovakia	6.2
Middle-low	7.4	OECD Europe	4.5
Middle-high	3.2	Developing Countries[2]	12.5
High	<2.4		

Notes:

1/ Income groups (Brb/month/household): low: < 50,000; middle-low: 50,001-100,00; middle-high: 100,001-300,000; high: > 300,001.

2/ Average of urban households in 12 countries (Thailand, Yemen, Bolivia, Haiti, Cape Verde, Zimbabwe, Philippines, Burkina Faso, Mauritania, Indonesia, Zambia, and China).

Source: Belarus Household Energy Survey and World Bank

129. Based on the findings of the household energy survey (see Annex 2), Belarussian households, on average, spend 5% of their disposable income[27] on energy, excluding automotive fuels (see Table 6). While this share is close to the average for Western Europe, it stands lower than the typical ratio for Central Europe, and is much lower than average for developing countries. There are significant differences in the share of energy expenditures across income classes; the highest income households spend less than 3% of their income on energy, this share is over 10% among the poorest families (about a tenth of all households), and more than 7% among the middle-low income families (28% of the households).[28] Most of the lower income families live in rural areas. The typical household

27 No reliable official data are available on household incomes. The four income groups were derived from information provided by the respondents. It is a familiar phenomenon that households usually underreport their actual income, which introduces an upward bias in the energy/income ratio.

28 This skewed pattern of energy expenditures among high and low income families is not specific to Belarus. It is an internationally observable tendency that poor families expend a significantly greater proportion of their budgets on energy than do wealthier households. Typically, surveys for developing countries report that the poor spend between 10 and 15% of their income on energy.

belonging to the middle-high income bracket (these comprise half of the households in Belarus) spends, on average, only slightly more than 3% of its income on energy. While the majority of the households disfavor further increases in energy prices (although resistance is "only" 34% among high income respondents), as much as 60% of the respondents would accept higher energy prices if the price increase were softened by direct income support (compensation) to low income households.

130. Although domestically produced crude oil is of better quality than imported oil, it was sold at a price that was below the cost of import in 1993. This did not leave enough revenue to modernize oil exploration and production, and also made the subsector unattractive for foreign investors. The price control of oil products under the state order system decreased incentives for energy savings, and invited corruption, since potential private gains for the people involved in the distribution of the "talons" were very large. The low margins applied for the transmission and distribution of gas, electricity and district heat did not provide adequate revenues to maintain assets and to reduce distribution losses. The control of prices for the generation of electricity and heat, and the production of solid fuels did not permit competition between the suppliers.

131. In summary, the applied system of energy price control in Belarus was (i) inefficient, since it discouraged energy savings and misallocated fuel and energy supplies; (ii) damaging for macroeconomic stability, since it required subsidies at a rapidly increasing scale that undermined efforts to contain the budget deficit and negatively affected industrial competitiveness; (iii) unsustainable, since it did not permit the generation of revenues to maintain/rehabilitate assets in the energy sector; and (iv) anti-market, since it forestalled competition among energy suppliers. There is a need for a comprehensive energy price reform that should be closely coordinated with the proposed organizational restructuring of the energy sector (see Chapter V above).

D. Energy Price Reform

132. **Non-household energy prices.** As described above, the intention of the Government was to set the price of non-household energy to cover the average financial costs of supply. If competition between suppliers is feasible, price controls, even when implemented properly, are inferior to a liberalized pricing system that would exert competitive pressures to reduce costs and increase productivity. Therefore, price regulation should be maintained only for those activities that are natural monopolies.

133. *The Government should complete the liberalization of the refining and trade of oil products by eliminating all remaining price controls, margin controls, and directed supplies and other forms of regulatory constraints. The price of "clearing" oil for the refineries should be set to match (on a monthly basis) the average price the refineries pay for crude oil (of similar quality) imported outside the "clearing" agreement. The price of domestically produced crude oil should be liberalized.* If a higher price can be obtained abroad, possibly reflecting the premium quality of this crude oil, then the domestic crude producer should be free to export the oil rather than selling it to the domestic refinery. Free market prices for domestic crude oil will help attract foreign oil companies to invest in domestic oil exploration or secondary/tertiary oil recovery. By adjusting natural resource and profit taxes, the Government will be able to capture eventual "windfall" profits for the budget. *The system of "talons" for automotive fuels represents an unnecessary intervention in the operation of the market, and should be eliminated* (not organizations, but individuals need social protection).

134. *Following the institutional separation of the activities of Beltopgaz and the corporatization of the relevant companies (see Section C of Chapter V above), the production, trade and distribution of solid fuels and LPG should be liberalized, including the elimination of price controls at all government levels. Also, as soon as the separation of electricity generation from transmission and distribution is implemented and a system for competitive supply of electricity is established, prices for electricity generators can be liberalized* (i.e., the price of electricity for final consumers would be the sum of unregulated generation and supply, plus regulated transmission and distribution costs).

135. The rest of the activities in the energy sector - oil transportation, operation of electricity, heat and gas transmission and distribution networks - are natural monopolies. *In the short term, the Government should adopt a policy of monthly price adjustments to keep pace with increasing fuel costs and to reflect internal cash generation requirements at the enterprise level derived from the financing needs of adequate rehabilitation and investment programs* (see Chapter VIII).

136. In the medium term, the regulator (initially Gosekonomplan and later the proposed energy regulatory authority - see Chapter V above), could adopt various methodologies for the control of prices. The main considerations which should be taken into account in selecting a regulatory system are: (i) administrative simplicity; (ii) ability to respond quickly to changes in imported fuel costs; and (iii) flexibility to take into account the financing needs of economically justified rehabilitation and investment plans. The US approach, for example, allows regulated companies to earn a reasonable rate of return so they can (i) maintain their facilities; (ii) generate funds for financing replacement and part of their expansion costs; (iii) borrow funds at commercial interest rates; and, in the long term, (iv) raise funds in the capital markets. Also, the regulator's task is to ensure that the utilities' expenditures are prudent and that their investments are economically justified ("used and useful"). In the UK approach, the regulator allows prices to be raised according to the general level of inflation minus a percentage reflecting the estimated potential for efficiency improvements, plus a percentage based on the need to expand the system. Under both regulatory systems, regulators ensure that tariffs for each class of consumers are reasonable given the costs of servicing that consumer class and the kind of services provided. There is more experience with the application of the US approach, however, it is also more complex. The UK system is less intrusive, provides clear financial incentives to control costs, however, it is more vulnerable to interpretations, and the corresponding higher uncertainty may lead to under-investment. In view of the current distorted relative prices, rapid inflationary environment and chronic levels of underinvestment in the last two years, the adoption of rate-of-return regulation seems to be the preferred alternative for Belarus.

137. Prices should become the primary instrument for energy demand management in Belarus. Under the current pricing regime, consumers pay the same price for electricity irrespective of the time of their electricity consumption.[29] However, the cost of supply is time dependent, i.e., it is higher than the average cost in the peak demand periods (there is a morning and evening peak in Belarus), and lower at night. Similar considerations apply to natural gas consumption, but on a seasonal basis. In the summer, Beltransgaz pumps gas to underground storage facilities. The gas is withdrawn in the heating season, when demand is higher than the volume of gas import (that does not fluctuate seasonally). As

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[29] In 1993, the Ministry of Power introduced time-of-day electricity pricing for a few industrial enterprises which were willing to purchase time-of-day meters. It is planned that the scheme will be expanded in 1994.

a result, supply costs are higher in the winter. In many countries, these differences are embedded in time-of-day electricity tariffs and seasonal gas tariffs applicable to medium and large customers. Also, electricity and gas utilities offer interruptible supply contracts. Interruptible contracts charge lower prices to customers whose supply can be interrupted in the time of peak demand. These pricing techniques proved very successful in postponing the need for new capacity development. *The Government should encourage Belarussian power and gas utilities to develop time-of-day, seasonal and interruptible tariffs.*

138. **Household energy prices**. The first step is to stop the escalation of household energy subsidies. *Therefore, a severalfold increase of household energy prices should be implemented as soon as possible. In addition, a medium-term program should be developed to gradually eliminate household energy subsidies.* The development of the program should be based on a careful analysis of household energy consumption for various home heating modes and income levels based on the results of the household energy survey described in Section B of Chapter III above. *In order to assist the population to make the right decisions when purchasing new energy consuming/heating devices or improving their homes, the schedule of energy price increases should be announced in advance, together with detailed information on energy saving options.*

139. The second step is to create incentives for the households to save energy. That requires the increase of the price of the last unit of energy consumed (i.e., the marginal price) to the cost of supply:

(i) *For electricity, the subsidized price should apply only to the first block of consumption corresponding to a "basic need" level (e.g., 50 kWh/month/household). Following the installation of meters, a similarly subsidized price should apply also to the first block of gas and district heat consumption (e.g., 7 Gcal/heating season/household for heat, and 1,000 m^3/heating season/household for gas used for space heating plus 35 m^3/month/household for cooking and water heating).*[30] The price of energy consumption exceeding the "basic need" level should be set on the basis of supply cost, including the relatively high cost of small-scale distribution. *The implementation of the program should be linked to a nationwide program of installing gas and heat consumption metering\control devices for individual houses or apartment blocks.* In addition, the adequacy of (reduced) subsidies should be monitored against the non-payments of electricity, gas and heat bills; if the share of households in arrears exceeds 3%, the next price increase will be postponed until arrears drop below 3%. In the long run, tariffs should be divided into variable (i.e., dependent on the quantity consumes), and fixed charges, based on variable and fixed costs of supply. However, as long as the households' ability to pay (taking into account social considerations) is below the variable cost of supply, the introduction of fixed charges should be postponed. Priority should be given to setting the level of the variable charge right, so households are given proper incentives to save energy.

30 Alternatively, the size of the first (subsidized) consumption block may depend on the number of persons in a household (e.g., 2 Gcal/heating season/person for heat, and 300 m^3/heating season/person for gas). However, it should not depend directly on the size of the apartment/house occupied.

(ii) The current rationing system for subsidized solid fuels (see Section C above) has already introduced such a "basic need" approach. *The same system should be expanded to LPG and heating oil. The price of these non-network fuels (solid fuels, LPG and heating oil) for additional (above the "basic need") purchases should be liberalized (see above).*

140. Third, the targetting of the subsidy to the lowest income groups (i.e., to decrease the "leakage" of the subsidy to medium and high income households) should be improved in the medium term. Also, the method of subsidization should be changed so it does not interfere with the operation of the market. *This can be achieved by setting up a system whereby local governments subsidize the energy consumption of low income households.* A possible method is to provide "talons" to low income households that could be applied towards the purchase of fuels and energy from any supplier. The "talons" would have a monthly established face value, and, at the end of each month, suppliers would submit their talons to local governments for refunds.

141. In summary, the proposed energy price reform would ensure that both import and domestic costs of energy supply (including capital costs) are fully passed on to consumers. These objectives would be achieved by the gradual elimination and improved targeting of subsidies to consumers, and the introduction of competition and price liberalization in those subsectors, that are not natural monopolies. The price reform itself would have no additional inflationary effect, since the alternative -- low energy prices for certain classes of consumers paid from budgetary subsidies and cross-subsidies -- is equally inflationary. In fact, competition will increase the efficiency of energy supply industry and thereby result in lower energy costs in the medium term. Positive effects of the energy price reform are contingent on the adoption of a strict macroeconomic stabilization program which would effectively harden the budget constraint of both the energy producing and energy consuming enterprises. In the long run, further adjustment of energy prices to reflect the environmental costs of energy production and consumption will be also advisable.

VII. INVESTMENT PRIORITIES AND OTHER SUBSECTOR ISSUES

142. **Principles for investment planning**. The critical parameters that will determine the kind and volume of needed investment in the energy sector are:

(i) Demand forecasts for various forms of energy (see Chapter III above). Based on actual consumption figures to date and on expected future economic developments, forecasts are expected to show a dramatic decline in fuel and energy demand in the next three years with gradual recovery thereafter;

(ii) The condition of the present capital stock. In most instances, this stock is of old age, uses antiquated technology, lacks in regular maintenance, suffers from a shortage of spare parts, and, in some cases, is far from optimal or competitive operation;

(iii) The level of losses occurring at energy production and supply facilities and the potential for energy efficiency gains and loss reduction;

(iv) The opportunities for fuel substitution and diversification to reduce dependence on imported fuels or dependence on a sole source of supply; and

(v) The competition for investment funds among the various sectors of the economy. These funds, either from the state budget or from potential domestic or international investors and financing institutions, are expected to be rather limited in the medium term.

143. Based on the above observations, investment planning should

(i) concentrate on investment that would bring fast loss reduction, energy efficiency and conservation gains;

(ii) emphasize rehabilitation of existing facilities rather than construction of new facilities;

(iii) increase fuel storage capacity to reduce the exposure of Belarus to supply interruptions;

(iv) convert facilities to indigenous fuels, to the extent environmentally acceptable; and

(v) maintain and, if needed, enhance transit capacities to take full advantage of the location of Belarus between Russia and the major European markets.

A. Oil

144. **Oil consumption**. During 1985-91, oil product consumption held steady at about 26 million tons per year, but it took a sharp downturn in 1992 (-24%) and 1993 (-24%) due to large relative increases in oil prices and the slumping economy.[31] In 1993, consumption was only 57% of the level registered in 1990 (see Table 6). The structure of consumption experienced a steady shift towards

[31] Oil consumption figures are fraught with considerable uncertainty due to conflicting official data, lack of data on kerosene (jet fuel) use, and significant unreported cross-border trade in refined products.

distillate products, with a corresponding decline in heavy fuel oil (mazut). About 7 mt of mazut was used in 1993, representing half of the pre-crisis (1990) level of consumption. Mazut is used predominantly for power and heat generation, which represented about 60-63% of total consumption in the 1990-1993 period. The share of industry, ranking second, accounted for 29% of total consumption in 1990. Gasoline consumption (including naphtha) experienced less change in the past three years, with the estimated 1993 consumption, at about 2.3 mt, being only 25% lower than the level registered in 1990. Diesel oil consumption decreased even less, by about 20% only between 1990 and 1993. Among the main diesel oil consuming sectors, transportation and agriculture stand out with a combined share of about 60%.

145. **Crude oil exploration**. There are 472 currently producing wells in Belarus. The drilling company (within Belarusneft) used to drill about 30 development and 10 exploratory wells annually, however, with limited financial resources, the amount of drilling has started to decrease recently. The success rate of drilling is 30-33%. With better seismic and analytical equipment, the company feels it could improve its success factor and reduce exploration costs. *High resolution and/or 3-D seismic surveys are needed to replace the currently employed crude systems that are about twenty years old.* However, the equipment by itself may not be sufficient to strengthen exploration and development capacity. This would be better achieved through a contract with an internationally experienced company. The contract should include the seismic survey of targeted (and limited) critical areas, on-the-job training of Belarussian staff in the use of modern equipment to its full potential, and the transfer of ownership of the equipment to the local enterprise(s) at the end of the contract.

146. **Crude oil and associated gas production**. The average productivity of existing wells is decreasing with time as many of the developed reservoirs have passed their peak oil production phase. Oil production levels from these reservoirs could be maintained by pumping out larger volumes of fluid. *This would require the installation of high capacity and high pressure submersible pumps (at a cost of about US$60,000 each). The increased volumes will contribute to greater well maintenance needs, and the need for heavier and more efficient workover rigs, particularly for deep and complex repair jobs, so that well down time is minimized (rig costs are estimated at US$500,000 each).* Additionally, there are several fields in which individual wells are producing well below their potential because of extremely tight oil formations. These formations could be stimulated by hydrofracturing which will improve the productivity and allow the oil entrapped in the matrix to access the well bore, thus increasing ultimate oil recovery. The associated gas processing plant is currently operating at lower than its design capacity due to the reduced amount of available gas. Its compressors are very inefficient (consuming about 8% of the gas input), very old (19 years) and require frequent (every 720 hours) repair (annual maintenance costs for these compressors were estimated by Belarusneft at US$600,000). *The 13 compressors should be replaced by two or three high capacity more efficient turbo-compressors of modern design with total annualized maintenance costs of about US$100,000/year.*

TABLE 6. OIL BALANCE, 1990-1993 ('000 ton)

	1990	1991	1992 (est.)	1993 (est.)
Net Crude Supply	**39475**	**35860**	**20750**	**14292**
Domestic Production	2054	2008	2060	2000
Imports - Clearing/Quota	38475	33960	13940	8500
Imports - Other Commercial/Toll	0	900	5810	3900
Exports	-1054	-1008	-1060	-108
Import of Oil Products	**1221**	**1028**	**1797**	**2700**
LPG	120	122	220	222
Gasoline	24	153	300	548
Diesel	820	664	0	941
Mazut	257	88	400	500
Kerosene	0	0	877	489
Export of Oil Products	**-12983**	**-9617**	**-1601**	**-1436**
LPG	0	0	0	0
Gasoline	-1962	-1368	-27	-50
Diesel	-5309	-3985	-1025	-1086
Mazut	-4662	-3476	-404	-200
Kerosene	-227	-178	-1	
Non-energy products	-824	-610	-144	-100
Total Refinery Output	**38113**	**34488**	**19412**	**13666**
LPG	233	228	136	108
Gasoline (incl. naptha)	4994	4325	2482	1802
Diesel (incl. Heating Oil, Motor Fuel)	8431	7529	4922	3314
Mazut (incl. E-4 Fuel Oil)	17980	16715	9007	6462
Kerosene (incl. Jet Fuel)	3585	3065	1323	889
Non-energy Products (incl. asphalts, lubes, etc.)	2891	2627	1542	1091
Domestic Consumption	**26351**	**25899**	**19608**	**14930**
LPG	353	350	356	330
Gasoline	3056	3110	2755	2300
Diesel	3942	4208	3897	3169
Mazut	13576	13327	9003	6762
Kerosene	3358	2888	2200	1378
Non-energy products	2067	2017	1398	991

147. **Crude oil transportation and storage**. The major crude oil pipelines are about 30 years old, and are part of the "Druzhba" system transporting oil from Tyumen (Western Siberia) to Central Europe, Belarus, Ukraine, Lithuania and a port (Ventspils) in Latvia (see Map A at the end of the report). The northern "Druzhba" line is connected to Novopolotsk, and the southern line to Mozyr. A branch line transports the domestically produced oil to the southern "Druzhba" line, for delivery to Mozyr and a refinery in Ukraine. In addition, a crude oil pipeline running from the Surgut fields to Novopolotsk was constructed about 10 years ago. The northern "Druzhba" line has a capacity of 70 mt/year, the southern line about 65 mt/year. The actual utilization of the two lines dropped to about 25 and 40 mt, respectively, in 1993. The pipeline companies also operate crude oil storage facilities at Novopolotsk (480,000 tons), Mozyr (300,000 tons) and Rechitsa (15,000 tons, near to the domestic production fields). *Although the pipelines need improved maintenance and some technology upgrades, there is no need for capacity expansion. In order to increase supply security, there is a need to construct additional crude oil storage tanks with a capacity of about 1 mt. This will require about US$ 170 million for the tanks, plus an additional US$ 100 million to cover the cost of the crude oil* (the modernization of existing fixed roof storage tanks may require additional funds).

148. **Crude oil refining**. Belarus has two oil refineries, at Novopolotsk and Mozyr, built in the second half of the 60s and 70s, respectively. Both refineries are of simple configuration, lacking secondary processing facilities, producing only 40-45% of crude feedstock as high value light products. The technology used is relatively old and inefficient. In 1989, the refineries operated at full capacity, producing, respectively, 23.7 mt and 15.7 mt of oil products. Their combined production declined from 38.1 mt in 1990 to an estimated 13.5 mt for 1993, with the sharpest declines occuring in 1992-93 (see Table 5 above). Crude oil purchased for cash within the Russian export quota for Belarus, and crude oil processed for suppliers who retain ownership of the crude oil and the refined products (toll refining) are increasingly replacing the oil supplied under inter-governmental barter (clearing) arrangements. These sources of supply are supplemented by domestically produced crude oil. However, until upgrading investments are in place at Mozyr, the high grade domestic crude is wasted because the potentially larger share of light products cannot technically be extracted at this time. *Belarus could probably gain from exporting its high grade crude at a premium price and using the proceeds to import a larger volume of lower quality Russian crude.*

149. The product slate of the refineries did not follow the recent shift in domestic consumption towards light products, and there was a substantial increase in the import of light products in 1992 and 1993. According to the Government's long term energy program, the volume of oil refining needed to meet domestic demand for oil products would be 18 mt in 1995 and 20 mt/year in 2000-2010. However, the demand for oil products in Belarus is not expected to surpass the 1993 level in the next 10-15 years (see Chapter III above). Therefore, the only (limited) possibility to raise the capacity utilization of the refineries is oil product export. However, if both input and output were valued at international prices, the refineries would operate with a negative value added. In addition, excess refinery capacity is widespread in Eastern and Central Europe. *The refineries have recognized these problems, and started the development of rehabilitation/upgrading strategies:*

- **Mozyr**. The refinery consists of two atmospheric distillation units, each with a capacity of 8 mt/year; two catalytic reformers, each with 1 mt/year gasoline production capacity; two hydrotreatment units for jet fuel, and two for diesel desulfurization. A number of international consulting firms are assisting the refinery to develop the upgrading strategy. The main element of the strategy is the upgrading of one train with the addition of a vacuum distillation unit plus a 4 mt/year fluid catalytic cracking unit (the latter would use heavy vacuum gasoil as its main feed). The first stage of upgrading would raise the share of light products from 43% to 62.5% for half of the original capacity of the refinery. Subsequent upgrading may add a hydrocracker, visbreaker, and a delayed coker, but these would be phased in based on market developments and availability of funds. The cost of investments required for the first stage is estimated at US$300 million. Additional options examined by refinery management are the purchase of surplus mazut from neighboring countries to use as feedstock for the cracking unit (instead of obtaining mazut from crude oil processed in the distillation units).

- **Novopolotsk.** Originally a 24 mt/year simple crude oil processing facility, the capacity of the refinery has been derated to about 20 mt/year. Novopolotsk is also assisted by international consultants to develop an upgrading strategy, but the process is less advanced than in Mozyr. The first stage of the upgrade is expected to center around a hydrocracker (2-4 mt/year capacity) and a vacuum distillation unit, that will provide the refinery with the flexibility to maximize gasoline, jet fuel or diesel production. This flexibility to "customize" products would be of particular attraction to toll refiners. As with the Mozyr refinery, subsequent additions would be determined by market developments and availability of funds. Investment costs for the first stage upgrading are estimated at US$ 400-600 million.

150. **Oil product transport and storage.** Most of the products (except aromatics, lube oils and other specialties) are piped to bulk plants for off-take and for further shipment (mostly by rail) to 42 main storage terminals (with a total capacity of about 1 mt) for distribution. The bulk plants are close to the refineries. Five years ago, a 280 km long product pipeline was constructed from Novopolotsk, past two bulk plants, to transport diesel oil and gasoline to Minsk. In addition, the product pipeline system includes earlier constructed sections of long distance pipelines connecting Ufa (Russia) to the Ventspils port in Latvia via Novopolotsk, and Ufa to Hungary via Mozyr. The pipelines were built to transport gasoline and diesel oil, but are seriously underutilized (the northern line is apparently shut). Although the pipelines run parallel to the "Druzhba" crude oil line, no Belarussian company has operational control over the product lines.

151. Product pipelines are the cheapest form of transport for large volumes of products from the Belarussian refineries, particularly for export. Other means of transport make product exports less competitive (transportation by rail is becoming more and more expensive as freight rates are approaching full costs). *An agreement among Belarus, Latvia, and Russia to re-open the product pipeline from Novopolotsk to Ventspils could open up new oil product export opportunities (apparently, adequate tankage capacity exists at the export terminal for product accumulation for transfer to ships).*

152. **Oil product distribution and marketing.** From the storage terminals, tanker trucks deliver the products to large industrial consumers and about 360 retail pump stations. About 220 retail stations are for the general public, while the remaining serve (or used to serve) the government fleet of transport vehicles only. The equipment used to distribute and sell oil products is out of date and needs modernization. For example, the tanker trucks are old and have very low tank capacity that raises the fuel cost of distribution. *Substantial investments are needed to overhaul, modernize, and replace most of the facilities.*

B. Gas

153. **Gas consumption.** Natural gas has been the most dynamic component of the country's energy consumption, expanding at 10% annually over 1985-92 and meeting the bulk of the incremental

demand for energy. The rising trend was interrupted in 1993 when consumption dropped by 10% to 15.9 BCM. As shown in Table 7, almost half of the gas is burnt in the electricity/heat subsector, where gas made a large inroad at the expense of heavy fuel oil (the gas share in this subsector rose to 60% in 1993 from 40% in 1990). Industry is the next major end-user with about one-fifth of total consumption in 1993. Within the industrial sector, the chemical/petrochemical sector is a major consumer (although its gas usage dropped considerably in recent years), accounting for about half of industrial consumption. Natural gas is used as feedstock to produce nitrogenous fertilizer. Agriculture is the only major productive sector whose gas usage -- for crop drying and other purposes -- experiences continuous growth. Representing about 6% of total consumption, the direct household use of gas (about 1.2 million households use natural gas, 90% for cooking only) is very low in international comparison, although it has been growing at an average rate of 8% per year recently. About 90 million cubic meters of compressed natural gas (CNG) is used as an automotive fuel for trucks and buses. Approximately 9,000 heavy duty trucks and 100 city buses are operating on CNG supplied from 5 refueling stations in Minsk and 16 refueling stations in other parts of the country.

TABLE 7. NATURAL GAS SUPPLY/DEMAND
(million cubic meters)

SUPPLY	1990	1991	1992	1993 (est.)
Production	297.0	293.0	292.0	225.0
Imports (incl. transit)	42325.1	42077.9	37192.3	36621.1
TOTAL SUPPLY	42622.1	42370.9	37484.3	36846.1
DEMAND				
TRANSIT	**27616.9**	**27148.5**	**20820.9**	**20621.1**
Industry	3628	3655.9	3429	2700.0
Public Power and Heat	7050.9	7412.9	9718.5	9176.1
Transportation	88.9	88.4	98.3	96.2
Construction	188.4	203	207.3	200.0
Agriculture	1042.8	1151.6	1250.2	1250.0
Residential	701.9	768.8	847.8	885.0
Other	1791	1910.8	1881.2	1598.4
Distribution Losses	111	107.2	101.1	130.3
Use for Transmission Compressor Fuel	166	151.6	115.7	137.0
Transmission Losses	47.9	49.7	43.5	52.0
TOTAL DOMESTIC CONSUMPTION	14816.8	15499.9	17692.6	16225.0
Stock Change (incl. storage in Latvia)	290.9	-163.8	-1233.1	0
Unaccounted For	479.3	-113.7	203.9	0

154. Households are also heavily dependent on liquid petroleum gas (LPG). Approximately 2 million residential customers use LPG, mostly for cooking. LPG is also used as a vehicle fuel. In total, households receive 93% of the approximately 360,000 tons consumed each year.

Three factories consume approximately 18,000 tons/year and the balance is used as transportation fuel. It is expected that the level of consumption will remain about constant over the next several years (while the factories will be converted to natural gas, there are plans to build additional vehicle fueling stations).

155. **The natural gas transmission system.** Beltransgaz operates 2792 km of transmission line of 720 mm diameter and larger, and a number of smaller lateral lines to city gate stations. The transmission system is relatively new; the three principal east-west trunk lines running from the Russian border to the Ukrainian border started operation in 1975, 1978 and 1982 (see Table 8 below and Map A at the end of the report). The lateral pipeline from the main lines to the Polish border (near Brest) was commissioned in 1985. The line from Minsk to the Lithuanian border delivering gas for Lithuania and Latvia as well as gas for transit to Kaliningrad was completed in 1988. Construction of the Torzhok/Dolina pipeline started in the mid-1980s, but was delayed due to the explosion of the Chernobyl plant that contaminated the region. The Belarussian portion of the line was completed and put in service in 1993. However, delays completing the Russian section of the line have forced Beltransgaz to "back-feed" gas to the Gomel region via the Minsk/Gomel line, which in turn has created some operating pressure problems. The current capacity of the pipeline is only 13.5 bcm/year, since the planned compressor stations on the line have not been constructed yet.

156. Beltransgaz operates one storage field located at Osipovichi (between Minsk and Bobruysk). It is an aquifer-type reservoir with a working gas capacity of 420 million cubic meters and buffer gas volume of 380 million cubic meters. It is used primarily to ensure gas deliveries to Minsk in the winter. The buffer gas ratio is relatively low compared with other aquifer storage fields (this may indicate that the reservoir has a favorable geological structure or that the delivery capacity has not been thoroughly tested).

TABLE 8. LARGE DIAMETER GAS PIPELINES

Inlet/Outlet	Length (km)	Diameter (mm)	Built (yr)	Purpose
Torzhok/Ivatsevichi I	454	1220	1975	Ukraine Transit
Torzhok/Ivatsevichi II	454	1220	1978	Ukraine Transit
Torzhok/Ivatsevichi III	454	1220	1982	Ukraine Transit
Ivatsevichi/Dolina I	146	1220	1977	Ukraine Transit
Ivatsevichi/Dolina II	146	1220	1981	Ukraine Transit
Minsk/Vilnius	196	1220	1988	Lithuania Transit
Kobrin/Poland	87.5	1020	1985	Poland Transit
Minsk/Gomel	315	720	1984	Local Delivery
Ivatsevichi/Grodno	175	720	1989	Local Delivery
Torzhok/Dolina	364	1420	Const.	Ukraine Transit

157. There are six mainline compressor stations, with 146 turbo-compressor units having a total nameplate capacity of 706 MW. Six gas engine driven reciprocating compressors are installed at the Osipovichi storage field. All of the compressor units, except 16 units of 6.3 MW capacity at the Nesvizh station, are driven by electric motors. The units at Nesvizh station are driven by Russian aircraft derivative turbines manufactured in Samara. The location, power rating and year of installation for all compressor units are shown in Table 9.

TABLE 9. GAS COMPRESSOR STATIONS

Location	Units	Total Power	In Service
Electric Motor Drive			
Orsha #1	10	40,000	1976
Orsha #2	10	40,000	1979
Orsha #3	10	40,000	1982
Krupki #1	10	40,000	1976
Krupki #2	10	40,000	1978
Krupki #3	10	40,000	1983
Minsk #1	10	40,000	1975
Minsk #2	10	40,000	1978
Minsk #3	10	40,000	1982
Ivatsevichi #1	10	40,000	1976
Ivatsevichi #2	5	62,500	1981
Ivatsevichi #3	5	62,500	1982
Kobrin #1	10	40,000	1977
Kobrin #2	10	40,000	1982
Gas Turbine Prime Mover			
Nesvizh #1	10	63,000	1979
Nesvizh #2	6	37,800	1982
Gas Engine Prime Mover			
Osipovichi (Storage)	6	4,400	1976

158. **Investments in gas transmission and storage.** Beltransgaz has prepared a five year investment program that would upgrade the existing high pressure system, expand its capacity for internal delivery of gas to the distributor (Beltopgaz), and increase the gas transit capacity. The principal components of the program are:

(i) Replacement of 16 gas-turbine prime movers at the Nesvizh station with higher efficiency units that are also less polluting. The gas turbines are approaching the end of their useful lives (three units, No. 5, 7 and 13 have more than 40,000 hours of operation and are candidates for early replacement). Beltransgaz is negotiating with the Russian manufacturer in Samara to buy new gas turbines which would operate at 33 - 35% thermal efficiency. The new units would be developed based on a marine gas turbine which has never been used to drive gas compressors;

(ii) Development of the Pribug underground storage field. The field, consisting of three aquifer zones located at various levels of depth, is currently being tested. Delineation wells are being drilled and gas testing is scheduled to start in 1995. It is anticipated that full working gas capacity of 1.3 bcm will be developed in 1997 and 1998. If the tests prove the technical integrity of the reservoirs, funds will be required to conduct additional tests, to drill and complete the injection and withdrawal wells, and to install surface facilities. The largest single cost item will be the provision of about 1.5 bcm buffer gas;

(iii) Construction of lateral lines and city gate stations. To keep pace with the projected increased demand for residential and industrial consumers, Beltransgaz plans to build 17 new city gate stations and reconstruct 60 km of lateral lines; and

(iv) Construction of seven additional compressed natural gas (CNG) vehicle fueling stations.

159. The aging turbo-compressors at the Nesvizh station are essential part of the gas transit and the in-country delivery system. *If they are not replaced, transit capacity (and transit revenues) and local deliveries will decline.* The foreign exchange (Russian rubles or convertible currency) cost of replacing the three oldest units is estimated at US$ 15 million equivalent. *Certain parts of the transmission lines have been in service for 30 years, and will also need to be rehabilitated. The development of the new storage field is of equally high priority, since the single underground gas storage at Osipovichi is inadequate to meet winter peak demands.* In addition, the new field would increase the general reliability of the system. The total cost of the gas storage project is estimated at US$ 150 million, including the cost of buffer gas (US$ 75 million). The foreign exchange cost of equipment (for gas injection, well tubulars and safety) is estimated at US$ 15-25 million, depending on the geological characteristics of the reservoirs.

160. In view of the expected drop in gas consumption in Belarus (see Section D of Chapter III), *the construction of new city gate stations and lateral lines should be prioritized and implemented in several phases.* There has been no economic analysis of the benefits of CNG use versus gasoline or diesel fuel, but in most market economy countries, the economic benefits of CNG are marginal so long as the trucks and buses must operate on a dual-fuel system. Therefore, *investment in new CNG stations should be deferred until an analysis of the costs and benefits of substituting CNG for gasoline/diesel oil is carried out.* The analysis should be based on a number of scenarios for the economic costs of these fuels, and take into account environmental effects.

161. Although not included in the five year investment plan, other projects are also under consideration. Three projects would further expand the transit gas capacity. The first project is the construction of compressor stations on the Torzhok/Dolina pipeline. The 1420 mm diameter line was designed to transport 30 bcm/year gas when all of the compressor stations are operating. The original designed called for four stations to be built on Belarussian territory, but the Chernobyl nuclear accident

contaminated the region and construction was not permitted for health reasons. Following changes in design (a segment of the line was moved about 90 km to the West) and the natural decrease in radiation, the sites are no longer considered dangerous. When the stations and the Smolensk- Belarussian border link are completed, about 20 bcm/year of additional transit capacity will be available up to the Ukrainian/Belarussian border. The second project would expand pipeline capacity to the Polish border. There is about 10 bcm/year of excess capacity in the transit system upstream of Minsk. Beltransgaz can add 7-10 bcm/year to the capacity from Minsk to the border near Brest by constructing 239 km of 1420 mm pipeline. The Polish partner would have to build 320 km of line from the Polish to the German border to provide an outlet for the gas. The third project is the construction of two new 1420 mm pipelines in the 1995-2002 period. The pipelines would have a capacity of 2 x 32 bcm/year, and would transport gas from the Yamal peninsula to Germany via Belarus and Poland.

162. Assuming that additional gas is available from Russia, the economic viability of these projects will depend on the evolution of demand for Russian gas in Western and Central Europe, Ukraine, and Belarus. Due to the expected drop in gas demand in Ukraine and Belarus in the next couple of years, the existing transit system (with rehabilitation and efficiency improvements) will be able to deliver more gas to Western and Central Europe. *Only after this additional transit capacity is exhausted (or gas demand in Ukraine and Belarus recovers), should the most cost effective investment (i.e., the one with the lowest cost per additional cubic meter gas delivered) be implemented.* The construction of the missing compressor stations on the Torzhok/Dolina line is most likely to meet that criterion.

163. In view of the age of the transmission lines, the soil conditions and the maintenance program, a major pipeline rehabilitation program will probably not be required. Based on findings in Russia and Ukraine, some of the valves may need to be repaired or replaced, the cathodic protection system may need to be repaired or upgraded, and the Supervisory Control and Data Acquisition System (SCADA) may need to be improved (Beltransgaz has developed and installed SCADA systems at three of the operating centers). Beltransgaz has recently started (with assistance from a Western European gas company) the development of a program to recover the "let-down" energy available at city gate stations when the pressure is reduced from transmission line pressure to distribution system pressure. *This has been used in other parts of the world, and may prove to be an economic method to conserve energy also in Belarus.*

164. **The gas distribution system**. The natural gas distribution system, with a network length of about 12,000 km, delivers gas to 62 cities. It includes 3,960 km high pressure, 1,658 km medium pressure and 6,540 low pressure lines, and 1,444 pressure control stations. There are also 1,581 km of pipeline distributing LPG from central reservoirs (see Table 10).

165. **Investments in natural gas distribution**. Beltopgaz prepared a five-year investment program focussing primarily on three goals:

(a) Expansion of the distribution network. Priority is given to the settlements along the Torzhok/Dolina pipeline near the Chernobyl exclusion zone, but the current program of expanding the urban networks is also planned to be continued;

(b) Installation of a SCADA system; and

(c) Installation of meters for commercial and residential consumers and the replacement of inaccurate low pressure industrial meters.

TABLE 10: GAS DISTRIBUTION SYSTEM

	Number of Cust.		Length of Pipelines (in km)				
Oblast	**Nat. Gas**	**Liq. Gas**	**Nat. Gas High Press.**	**Nat. Gas Med. Press.**	**Nat. Gas Low Press.**	**Liq. Gas**	**Number of Regulating Stations**
Brest	162283	321358	658.9	269.1	1264.2	275.6	304
Vitebsk	110176	380820	221.2	147.1	318.7	334.9	50
Gomel	230291	329458	557.3	320.7	1546.1	246.6	192
Grodno	155171	236909	983.1	328.7	1114.7	78.3	313
Minsk City	393213	27326	508.0	390	1084.0	14.7	336
Minsk Oblast	92764	418836	711.3	115.9	950.5	302.9	195
Mogilev	106023	319719	320.2	86.5	261.8	328.1	54
TOTAL	**1249921**	**2034426**	**3960**	**1658**	**6540**	**1581.1**	**1444**

166. Although total natural gas demand is expected to decrease in Belarus, the residential market is likely to experience further growth. Natural gas may be the most economic fuel in urban areas, but in rural areas, where customer density is low, other fuels are probably more economic. Beltopgaz plans to expand the distribution network by 1,500 km/year. Half of the pipes will be made of steel, and the other half will utilize polyethylene (PE). While materials for the steel networks can be manufactured locally, the PE pipes must be imported. *The application of PE pipes should be based on a detailed comparison of the costs and benefits of the two technologies*. Since plastic pipes already exists in Belarus, it will be relatively straightforward to carry out the comparison.[32] If the application of PE pipes proves to be viable, the foreign exchange component of the system expansion will be about US$4.5 million per year (based on international prices for the PE pipes and fittings).

167. The gas distribution control and dispatch system is obsolete and inadequate. As the residential load increases, the dispatching system must be strengthened to ensure the reliability and safety of the network. The 1,444 pressure control stations are manually operated. The ones that are linked to the dispatch center in Minsk are connected by dedicated telephone lines. A preliminary study estimated the cost of a remote control system that would upgrade the dispatching capability to Western European standards at about US$ 14 million. This relatively high cost is due to the planned heavy reliance on remote control pressure regulators and valves. *The installation of a conventional, reliable SCADA system with a cost of about US$ 4 million would probably be more cost effective than a remote control system.*

168. Beltopgaz plans to install 10,000 meters in 1994 and 50,000 meters per year afterwards, with a long term goal of metering all customers. The contract for the purchase of 10,000 meters needed

[32] A similar study financed by EC TACIS has been started in Ukraine in February 1994. The results of the study may be applicable to Belarus as well.

in 1994 has already been signed with a US firm at a cost of about US$ 100 per meter (including freight and import duties). Beltopgaz expects that the cost will decrease to US$ 65/meter in the future. The economic benefits of metering depend on the volume of gas saved due to the "metering effect", i.e., the elimination of consumption that has a lower value than the price paid by the user. Since gas savings due to the "metering effect" are proportional to the volume of consumption, the economic benefits per meter installed are larger for high volume users. *Therefore, the installation of meters should first focus on commercial establishments and residential consumers who use natural gas for both cooking and heating.* There are about 120,000 such customers. If the metering program is limited to these customers for the first five years, a target of installing about 25,000 meters per year will be enough to achieve full coverage. The cost of this program will be approximately US$2 million per year during the 1995 - 1998 period.

169. Although Beltopgaz have not included network rehabilitation and upgrading of system protection equipment in its investment plan, experience in Russia, Ukraine and other countries has shown that *the current methods and equipment for pipeline condition surveys, leak detection and cathodic protection are inadequate and obsolete. A detailed technical audit will be required to define the priority needs.* It is expected that the cost of materials and equipment imported for that purpose will be about US$4 million.

170. **Investments in LPG storage and distribution**. The liquid gas bulk storage and bottling plants rely on rail deliveries. On-site storage capacity is equal to seven-day deliveries. This low storage ratio places customers at risk and limits the ability of Beltopgas to buy large spot shipments. Therefore, Beltopgaz plans to expand on-site storage capacity to 15 days at the Klimovichi, Kalinkovichi, Baranovichi, Zhodino and Knyaginino centers. *The investments will improve both supply security and safety, and are economically justified.* The cost of the program is estimated at US$2.5-3.0 million per year in the 1995-98 period (bulk of the investment costs will be in foreign exchange, since LPG storage tanks are not manufactured in Belarus).

171. Beltopgaz also plans to construct ten new liquid gas vehicle fueling stations (in addition to the 21 stations already operating). *This investment is probably not justified economically in view of the high delivered cost of LPG.* A project to extract LPG from the natural gas delivered by Beltransgaz at the city gate stations is under consideration. This would be a high risk project, due to the low propane/butane content of the gas, and the possibility that, if extracting the liquid gas is indeed economic, RAO Gazprom may install extraction plants upstream from the Belarus border. Therefore, *it is very unlikely that the proposed stripping plants are economically justified.*

C. Solid Fuels

172. **Coal**. Coal use in Belarus is very small in international comparison. While coal represents more than 10 percent of primary energy consumption in most countries in Europe, its share was only 2 percent in Belarus in 1993. Since coal is the most polluting fuel, the low share of coal in the energy balance of Belarus brings significant environmental benefits. There are no Belarussian equivalents of the polluted regions of Northern Bohemia, Silesia or the Donbass in Ukraine. Since no increase in coal demand is expected, *there is no need for major investments in domestic coal production, transport or distribution (the development of domestic coal deposits for export is obviously uneconomic).*

173. **Other solid fuels**. Belarus is already utilizing significant amounts of firewood and wood wastes, peat, and to a smaller degree municipal waste. The contribution of these energy sources to the supply of primary energy was about 5% in 1993. Due to difficulties of measurement and widespread

non-commercial use of these fuels, the quality of data on the utilization of these resources is particularly low. Imprecise measurements are attributable to varying moisture contents and the bulky nature of the materials. Many kinds of of non-commercial uses, such as the utilization of wood waste at industries and small scale collection of firewood in rural areas, go unrecorded.

174. There are two approaches for obtaining energy from the utilization of municipal waste. One is the use of recovered methane, the other is the direct combustion of landfill material. There is no estimate of the methane potentially available at the 150 landfills in Belarus. A factor limiting the utilization of the existing stock of waste is the location of the landfill sites. Since most of the landfills are located far from human settlements, there is no demand for energy in the immediate vicinity of the sites. An example is a landfill located approximately 30 kilometers south of Brest that has no adjacent thermal demand. While transmission lines are only about 4 kilometers from the site, all other site infrastructure would have to be provided if an urban waste and wood fired power plant were to be considered. Based on this, development of a new site would probably be too costly. A less costly alternative would be the utilization of newly generated waste. An intermediate site located between Brest and the landfill could be considered and would have the advantage of reducing waste transport costs. Wastes would be hauled a shorter distance, and only the remaining ash and other non-combustibles would be sent to the landfill. If it was mixed with wood wastes, the volume and type of municipal waste generated (about 12,000 m^3 per month) would be sufficient to fuel a 15 MW plant. However, the cost of pollution control equipment due to the widespread contamination of municipal waste with toxic waste of industrial origin could make the project uneconomic.

175. A more promising approach is the utilization of less polluting fuels in already existing facilities. As described in Section A of Chapter IV above, a significant increase in the energy applications of wood is possible. *Most of the increase would come from the increased production of firewood, requiring investments in wood harvesting and transport facilities.*[33] *However, the increased utilization of industrial wood wastes could also provide an important contribution.* An example is the Novo-Sveryenskyi Sawmill in the city of Stolbtsy. Thermal demand at the facility is provided with a 12 Gcal/hour capacity boiler fueled with natural gas, and electricity is purchased from the grid. The wood waste available at the site amounts to 40,800 cubic meters per year. In every oblast in Belarus, large amounts of wood waste are being landfilled. The disposal of wood waste is not without costs. In urban areas, waste disposal has significant transport and handling costs, plus a fee for using the landfill. Even in rural areas, improper disposal may have negative environmental consequences. In Roslavl in the Minsk oblast, for example, waste from a sawmill is being dumped into an adjacent wetland area.

176. The main opportunities for additional wood applications are in (i) industrial boilers of wood manufacturing industries and other industrial plants; (ii) small power plants; and (iii) heat-only-boilers of the district heating systems. *In all three areas (industrial plants, power plants and district heating systems), there are many opportunities for wood conversion of boilers that were initially designed for solid fuel, typically coal.* Some of these boilers have been converted to natural gas or mazut, but can be readily converted back to accept wood. For example, there are 276 boiler houses (a boiler house typically includes two or more boilers) under the municipal district heating authorities that are currently using solid fuel. In addition, many boilers currently using mazut or natural gas are capable of using solid fuels. The conversion method depends on the boilers. One possibility is to build unloading, storage, and feed systems for the boilers that are able to burn wood chips or wood waste directly. Another option is

[33] An example is the World Bank financed Forestry Development Project (US$54.7 million total cost) to be implemented in 1994-1998. The intensified silviculture component of the project (US$ 16.2 million) will result in the production of 1.3 million solid m^3 per year firewood due to incremental thinnings.

to add a wood gasifier to feed gas to boilers that are using natural gas and/or mazut, and are not of sufficient size and configuration to handle wood directly.

177. Boilers to be converted should meet several criteria. First, a selected boiler should have sufficient load to justify the investment (there are many underutilized boiler houses in Belarus). Boilers that operate in base load (i.e., serve constant demand such as hot water) are particularly well-suited for conversion. Second, the boiler should not be located very far from the source of wood supply (i.e., within a 50 km radius). Third, the environmental impact of the converted boiler should be acceptable. Modern wood boilers and power plants are considerably less polluting than older, poorly designed or operated wood boilers. The modern facilities are common in Scandinavia, the United States, and Canada, and are able to meet stringent air pollution regulations. A particular advantage of wood and wood waste is the very low sulfur content of the fuel. To the extent that wood chips from forest thinnings are used (as opposed to industrial plant wood waste), proper silvicultural practices would be required in the harvest, chipping, and transport of wood.

178. The cost of boiler conversion is estimated at US$ 0.3-0.5 million per Gcal/hour boiler capacity (the lower figure applies to industrial plant conversions, the higher one to small district heating boilers). Cost differences are attributable to economies of scale, as well as differences in equipment needs at industrial sites, power plants, and district heating sites (wood industry boilers already have the waste on site and would not need new unloading and processing facilities). The first step in a long term program of increased utilization of firewood and wood waste should be the selection and implementation of a number of small projects to demonstrate the technical, economic and environmental viability of boiler conversion:

(i) conversion of industrial boilers with a total capacity of 15-20 Gcal/hour to wood waste;

(ii) conversion of one power plant of up to 20 MW to wood chips; and

(iii) conversion of district heating boilers with a total capacity of 15-20 Gcal/hour to wood chips or wood waste.

The total cost of these projects is estimated at US$ 25 million, of which US$ 20 million would be in foreign exchange. A draft terms-of-reference for the feasibility study is attached in Annex 5.

D. Electricity

179. **Electricity consumption**. After growing vigorously (at 4.2% per year) during the 1980s, gross power consumption (which includes own use and grid losses) stalled in 1991, and dropped by more than 20% in the following two years to 39 TWh in 1993. Peak demand decreased from 8,544 MW in 1990 to 7,260 MW in 1993, or by 15%. The economic downturn, the ongoing intersectoral shifts away from the most electricity-intensive activities (most notably, oil refining and chemicals/petrochemicals), and the severe restrictions on usage (i.e., rationing) account for the bulk of the consumption decline. There is no hard evidence to suggest that higher power tariffs have so far played an appreciable demand-moderating role. Electricity consuming enterprises continue to face soft budget constraints manifested, for example, in widespread non-payment for electricity over lengthy periods of time.

TABLE 11. SECTORAL COMPOSITION OF ELECTRICITY CONSUMPTION (% of gross consumption)

Sector	1990	1993
Industry	48.2	40.5
Fuels	3.7	1.8
Ferrous metals	1.8	2.3
Nonferrous metals	0.2	0.0
Chemicals/petrochemicals	14.9	12.3
Machinery	12.2	11.5
Wood, paper & pulp	1.8	2.6
Building materials	2.9	3.1
Light industry	3.3	3.6
Food	2.9	3.1
Other	4.5	1.0
Agriculture	10.0	11.0
Construction	1.0	1.0
Transport	6.3	5.9
Municipal/residential	18.8	24.9
Urban	14.5	NA
Rural	4.3	NA
Own use	6.9	7.7
Network losses	8.8	9.0
TOTAL	**100.0**	**100.0**

180. The electricity consumption decline is broad-based, affecting almost all sectors of the economy. Among the major sectors, industry experienced a cumulative 33% drop during 1990-1993. Thus, industry's share in total electricity consumption fell from 48% in 1990 to 40% in 1993 (see Table 11). Within industry, the chemical/petrochemical sector (accounting for one-third of industrial power usage) registered the steepest fall in 1993 (-21%); the sector's cumulative decline for 1990-93 can be put at 34%. Machinery, the next largest industrial user of power, registered a 25% drop over 1990-93. Households are the only sector experiencing growth, despite falling real incomes. During 1991-93, residential consumption was up by 18% (25% in urban areas) and thus the share of households in total consumption went up from 7% in 1990 to 11% in 1993 (which is still less than half of the Western European average). In addition to the continued underpricing of residential power and the ongoing release of part of the considerable pent-up demand for appliances, residential demand appears to be influenced by the (i) electricity-for-fuel substitution driven by the growing distortion in relative energy prices charged for households (power tariffs lag much behind rises in fuel prices); and (ii) increased use of supplementary electric space heaters due to the reduced supplies of hot water and heating to apartment

blocks in winter. Additional demand-increasing factors might have been the substantial rise in various small-scale industrial and service activities conducted in homes, and the recently mandated installation of electric cooking stoves in newly constructed multi-storey apartment blocks.

181. There is no evidence that efficiency improvements have contributed to the decline in power consumption in recent years. On the contrary, the electricity intensity of GDP edged up slightly between 1990 and 1993, and a number of electricity-intensive activities experienced a deterioration in their efficiency performance. For example, over 1990-93, specific electricity use (in terms of kWh per ton of output) went up by 36% in oil refining, 21% in sulfuric acid production, 12% in potash fertilizer production, 10% in the cement industry, 8% in the paper industry, 7% in brick production, 5% in synthetic fiber production, and 2.5% in electric arc furnaces producing steel. Among other things, the low capacity utilization might have contributed to the worsening efficiency record.

182. The daily variation of the electric load is characterized by two peak periods. The first period is between about 9 AM and 12 AM, the second peak falls between the hours of about 5 PM and 10 PM, depending on the season. The daily load profile for typical working days during winter, spring, summer and fall are shown in Figures 1-4 in Annex 1. Comparing the 1992 and 1993 load curves, the load decrease was most pronounced during the fall, when a difference of about 1,000 MW could be observed. Maximum and minimum monthly demand curves for the years 1991-93 indicate a typical winter peaking system (see Figure 5 in Annex 1). Both the maximum demand and the largest minimum demand occurs in the month of February. Table 12 shows that the system load factor has started to decrease, due to the growing share of residential consumption.

TABLE 12. POWER SYSTEM LOAD FACTORS

	1990	1991	1992	1993
Maximum Demand (MW)	8544	8562	7792	7260
Gross Consumption (GWh)	48936	49117	44076	39665
Load Factor (%)	65.4	65.5	64.6	62.4

183. **Power generation**. There are 22 thermal power plants under the Ministry of Power, with a total nameplate capacity of 7,033 MW (see Table 2 in Annex 1). Three plants (Beryoza, Lukoml and Belarus) are electric power generating plants, all others are combined heat and power plants. Small power plants under the industrial, transport, agriculture and other sectors have a total capacity of 188 MW. In addition, there are 9 small hydropower plants with a total installed capacity of about 6 MW. There is no nuclear generating capacity in Belarus. Total available generating capacity, due to technical limitations, was 6,931 MW at the end of in 1993. Taking into account major planned overhauls (155 MW), routine maintenance (135 MW), forced outage (300 MW), spinning reserve (141 MW), and cold reserve (395 MW), total on line capacity was about 5,800 MW, or almost 1,500 MW below the peak load measured during the year. Gross domestic generation decreased from 39.5 TWh in 1990 to 33.4 TWh in 1993 (see Table 3 in Annex 1 for monthly electricity generation in 1989-93). Maximum electrical energy generation coincides with the high district heating loads occurring during the winter.

184. The boilers at 10 larger plants have been modified for dual firing and therefore can be fueled either with fuel oil (mazut) or with natural gas, depending on the availability of fuel. In response

to decreasing crude oil supplies as well as environmental concerns (mazut contains 2.2-2.7% sulfur), the Government has decided to rely on gas as the main fuel for electricity generation. The resulting shift in fuels use is shown in Table 13 below (more detailed information on the fuel consumption of various plants is presented in Table 4 of Annex 1):

TABLE 13. FUEL USE IN THE ELECTRICITY SUBSECTOR[34]

	1990	1991	1992	1993
Mazut (1,000 t)	8546.0	8312.4	5564.9	4094.9
Natural Gas (million m^3)	7046.9	7415.0	9707.1	9176.1

185. Despite their age, most of the power plants are a reliable source of power, due, to a large extent, to the utilization of relatively benign fuels. However, the original useful lifetime of plant components have been exhausted in some of the older plants, and the plants are ready for major rehabilitation/modernization or replacement. A brief review of three of the oldest plants (Minsk TEC-2, Minsk TEC-3, and Svetlogorsk) has shown that the plants suffer from the lack of spare parts and chemicals and inadequate maintenance. The combustion and other control systems are obsolete, emission control and monitoring devices do not exist, and make-up water and waste-water treatment systems are of old technology and inadequate. More specifically, the generating equipment at the Minsk TEC-2 is a likely candidate for replacement, and so is the first stage (original phase) installation of Minsk TEC-3. The Svetlogorsk power plant has just replaced both its second phase machines (65 and 50 MW turbines), but its first phase units (four units 45 MW each) are also candidates for replacement or rehabilitation. In addition, all three power plants would benefit from rehabilitation of their fuel burning and control systems, the installation of emission control and monitoring systems, and the modernization of their water treatment systems.

186. Generally, the main environmental concern of the authorities is the emissions of sulfur and nitrogen oxides. In order to reduce ambient SO_2 concentrations, environmental authorities mandated that plants located in the vicinity of populated areas should rely on natural gas for at least 90% of their fuel needs. In addition, during rehabilitation projects, the furnace burners have been or are being modified to reduce nitrogen oxide emissions. *These measures represent the most cost effective methods to reduce SO_2 and NO_x emissions.*

187. **Generation planning**. The objective of the Government's long term energy program is to make Belarus independent of imported electricity by the year 2005. In the 1991-2010 period, the program proposed (i) the rehabilitation/modernization of 3,540 MW generation capacity; (ii) the retirement of 2,560 MW generation capacity (460 MW in 1991-2000); and (iii) the construction of 8,800 MW generation capacity (1,300 MW in 1991-95, 2,000 MW in 1996-2000, 2,900 MW in 2001-05, and 2,600 MW in 2006-10). Most of the planned new/replaced capacity would be single and combined cycle

[34] In addition, about 60 million m^3 of refinery gas produced during the first stage of the refinery process at Novopolotsk is utilized in the adjacent power plant.

gas turbines. However, several other options are being considered, including oil and gas-burning steam plants, and nuclear power.

188. Originally, the construction of two VVER-1000 units was planned at Rudensk, near Minsk, and four VVER-1000 units at a site near Lukoml (in addition to generating power, the Rudensk nuclear plant would have provided heat for Minsk). Following the Chernobyl accident, all activities were stopped although there exist some infrastructure and foundation work at Rudensk. Both sites have recently been found unsuitable from the point of view of nuclear safety; Rudensk is now considered to be too close to Minsk, while the other site has geological problems (Rudensk has been selected as the site for a new thermal power plant, Minsk TEC-5). As a result, the authorities are considering 15 new locations as possible sites for future nuclear plants. In addition, a public education effort has been mounted to counter the bias against nuclear power due to Chernobyl. The authorities have emphasized that new, advanced technologies will be considered for the prospective plants, and expressed their intention to base the selection process on international bidding.

189. The continuing decrease of electricity demand is expected to reduce the gap between maximum loads and domestic generation capacity. Under demand scenario A (low demand associated with a comprehensive economic reform), peak demand that cannot be met domestically (without any rehabilitation or expansion of generating capacity while maintaining a 13% reserve capacity requirement) is reduced from about 1,500 MW in 1993 to about 400 MW in 1994, and is completely eliminated in 1995-1998. Under scenario B, the capacity gap is about 500-800 MW in 1994-98. That does not mean that there is no need for investments. First, the rehabilitation of some of the oldest CHP units (Minsk TEC-2, Minsk TEC-3, Orsha, possibly also Svetlogorsk) is of high priority. *Specifically, there is a need to (i) improve the fuel conversion efficiency of older units by rehabilitation, repowering, or replacement; (ii) introduce energy saving measures at the CHP plants such as variable speed drives; (iii) convert boilers at selected smaller power plants to wood chips and wood waste; (iv) modernize operational control systems; and (v) install modern emission control and monitoring devices* (the draft TOR for a comprehensive engineering analysis to prioritize the rehabilitation program is attached in Annex 6). *Around the year 2000, there will be a need to rehabilitate also the two large electricity-only plants at Lukoml and Beryoza. Depending on the evolution of demand and the cost of imported electricity, it might be economically justified to put new capacity on line in 1999 or 2000, requiring the start of construction in 1995 or 1996.* However, the total amount of new generating capacity needed in the 1994-2010 period is only 3,800-6,200 MW, substantially less than the 8,800 MW proposed in the Government's long term energy program prepared in 1992.

190. Based on calculations with a generation capacity optimization model, the installation of single and combined cycle gas turbine units appears to be the least cost solution (see Annex 3). These units have several advantages: (i) a thermal efficiency of more than 50% (combined cycle); (ii) relatively low capital cost (currently about US $300-400/kW for simple cycle and US $700-800/kW for combined cycle); (iii) high environmental compatibility; (iv) flexibility to burn either natural gas or liquid fuels; (v) short period of construction owing to modular designs and packaging; and (vi) availability of both small (50-120 MW) and medium sizes (120-450 MW in combined cycle). Owing to items (iii)-(vi), the units provide considerable flexibility, allowing for the adjustment of the investment plan to changing demand and supply conditions.

191. Currently, power is generated mainly by baseloaded or intermediate load plants. The system has negligible hydro capacity, no gas turbines and thus lacks flexible peaking capacity. This was less of a concern in the past, because industrial demand dominated the demand curve. However, as commercial and residential consumption are becoming more pronounced, the installation of flexible

peaking capacity (single cycle gas turbines) may become necessary. The optimal amount of peaking capacity will depend on the extent that electricity import can play a regulating role in the future.

192. Present generation nuclear designs would cost about US $2,000-2,500 per installed kW for capital cost and would take, under optimistic assumptions, 6-8 years to complete. Even assuming the availability of low cost nuclear fuel (US$ 0.005 per kWh electricity output), and using the high demand and high electricity import cost scenario, the model did not include the nuclear option in the least cost generation plan. However, the nuclear option may become economically viable if the price of imported natural gas substantially increases. *Therefore, the decision about the construction of a nuclear power plant should be postponed, and the evolution of electricity demand, the cost of imported gas, and the cost of nuclear technology should be closely monitored.* New generation designs are expected to have higher safety levels, simpler and easier to operate, and less costly and time consuming to build. However, even under the most optimistic circumstances, such an advanced technology plant could not come on line in Belarus before 2005.

193. A nuclear power program requires extensive (i) institutions framework for supervision and regulation; (ii) capability for comprehensive environmental impact assessments; (iii) industrial infrastructure; and (iv) the development of a "safety culture" (the lack of which was the primary cause of the Chernobyl, as well as of other less serious accidents around the world). The Government of Belarus and the Parliament has started the work on a nuclear safety law in 1993. The first draft of the law needs numerous improvements and clarifications, and would benefit from assistance provided by foreign specialists experienced in nuclear legal matters. A special UNDP/IAEA program, initiated in May 1993 in Vienna, could provide resources for technical assistance in this area.

194. Due to extensive reliance on all-union level expertise in the past, domestic generation planning capabilities are inadequate in Belarus. In order to develop a least cost generation plan and revise it time-to-time taking into account new developments, *specialists under the Ministry of Power should be trained in the application of modern generation planning methods and the Ministry should obtain the required hardware and software tools.* The role of generation planning is expected to change in the future. It will be only one of the tools used to check that proposed investments are consistent with the least cost principle. Following the introduction of competition among generators, investments should be subjected to market tests, e.g., to competitive bidding for the right to supply power.

195. **Electricity dispatch**. Prior to the break-up of the Soviet Union, control of the whole Integrated Power Transmission System of the USSR was based in Moscow with the main dispatch centre for the north-western region in Riga (Latvia). The Belarus system is now controlled from the national dispatch center in Minsk, with telephone links to the regional control centers. All regional utilities (except Minskenergo) operate a regional control center. The regional control centers receive information from the local distribution networks, and also from terminals in the power plants. *The national dispatch center needs to be upgraded to improve telecommunication and control facilities, and also to install modern computer programs for optimal (economic) dispatch of power plants.*

196. **Electricity transmission and distribution**. At the end of 1991, the length of the transmission network was 32,773 km, consisting of 343 km of 750 kV lines, 3,350 km of 330 kV lines, 2,280 km of 220 kV lines, 15,100 km of 110 kV lines, and 11,700 km of 35 kV lines. The 750 kV line between Ignalina (Lithuania) and Starue Dorogi, the principal (switching) substation is operating at 330 kV only (see Map B at the end of the report). A single circuit 750 kV line from Starue Dorogi to Smolensk in Russia was commissioned at the end of 1993 and feeds the Belarussian system via a 750/330 kV transformer at Starue Dorogi. Most of the 220 kV lines are installed system in the western part of

the country. The remaining main network consist of 330 kV transmission lines. The distribution system consists of 113,000 km of 10 kV lines and 130,000 km of 380 V lines. There are 64,700 transformation stations installed at the 10/0,38 kV level. The 330 kV and 220 kV switchyards are of the outdoor open design with airblast live tank circuit breakers. Circuit protection uses electro-mechanical relays of conventional design.

197. Electricity can be exchanged with Lithuania, Poland, Russia and Ukraine. The available transfer capacity of the major connecting lines (330 kV or higher) is listed below:

(i) 2,850 MW from Lithuania (3 x 330 kV lines, plus a 750 kV line operated at 330 kV);

(ii) 3,390 MW from Russia (3 x 330 kV lines, plus a new 750 kV to Smolensk);

(iii) 780 MW from Ukraine (2 x 330 kV lines).

Although the volume of electricity imports was significant, and Belarus also provided wheeling services to Russia (see Table 14), the large transfer capacity was underutilized in all directions in 1990-93.

TABLE 14: ELECTRICITY BALANCE

	1990	1991	1992	1993
Domestic Production	39508	38714	37574	33352
Total Energy Inflows[35]	14969	14557	10077	6130
Barter Imports (only as counterpart of barter electricity exports)	4737	3792	3405	NA
Other Imports	9429	10403	6504	6005
Wheeling Charges[36] (only if charged in electricity)	NA	NA	NA	NA
Wheeled Energy In	803	362	168	125
Total Energy Outflows	5540	4154	3573	125
Barter Export (counterpart of barter elect. imports)	4737	3792	3405	NA
Other Exports	0	0	0	0
Wheeled Energy Out	803	362	168	125
Net Energy Inflows (2-8)	9429	10403	6504	6005
Domestic Consumption	48937	49117	44078	39357

35 Energy exchanged with Russia is not included for 1993.

36 Assumed to be zero in the balance.

198. Substantial work on the optimization of substations and installations of shunt condenser batteries at industrial consumers was carried out during the 1980s. As a result of fitting the energy grid with reactive power compensation devices, the compensation capacity increased from 0.25 MVAR/MW to 0.35 MVAR/MW. It was assumed that excessive reactive power due to load drops would be absorbed by special devices (controlled shunt reactors) installed at the 330 kV substations. The use of these compensators would provide not only merely normal voltage levels in the system under minimum load conditions, but also provide transmission loss reductions. Due to lack of investment resources, however, the shunt reactors have not been installed. Therefore, when a load drop occurs, all condenser batteries in the energy grid need to be turned off, resulting in an increase of losses. To overcome these difficulties reactive power compensation devices with total capacity of about 500 MVAR need to be installed at the substations. Furthermore, new condenser batteries (with the same total capacity) and the replacement of defective capacitors in the existing batteries is also required.

199. Difficulties with obtaining spare parts from the original manufacturer make the maintenance of the 330 kV, 220 kV and 110 kV switchgears problematic. Segments of the 10 kV and 380 V distribution networks have low reliability, since they have been designed and built according to standards that are now considered obsolete (for example, 2% of the 10 kV lines and 61% of the 380 V lines were installed on wooden poles, while the rest of the lines were installed on reinforced concrete poles).

200. Approximately 30,000 km of 10 kV lines and 40,000 km of 380 V lines are slated for replacement. About 9,000 transformer stations at the 10 kV/380 V level (out of a total of 64,700) require urgent refurbishment. 330 kV transmission lines are presently under construction from Minsk to Slutsk, and from Mozyr to Gomel. The latter will close the southeastern loop to increase the reliability of service when the Chernobyl nuclear plant is closed. In addition to these ongoing activities, there are plans to expand the 330 kV network by constructing 700 km of new lines in the period 1993-95, and additional 622 km in the period 1996-2000.

201. Since the existing transmission system is adequate to serve electricity transmission needs, these additional expansions may not be of high priority. *Renovation of old and unreliable lines using new and more durable materials, improvement of substations, installation of variable compensators of reactive power, and purchase of modern maintenance equipment will reduce system losses, and have the highest priority in the short and medium term.* The foreign exchange cost of these improvements is estimated at US$ 20 million.

E. District Heat

202. **Heat demand**. While extremely cold weather seldom occurs in Belarus, the country has a fairly long heating season, from October to April. During this period, the outdoor temperature can be rather low (January average minus 7°C), requiring continuous heating of all residential buildings, as well as offices and factories. In all large cities in Belarus, this is accomplished by centralized district heating systems supplying the final consumers with hot water through steel pipes. About 50% of households obtain their heat from the heating networks; in Minsk, this fraction rises to about 80% of all consumers whereas in the countryside, the proportion is a low 5%. In 1990, total heat supply to the networks was about 58 million Gcal (this figure does not include about 50 million Gcal heat produced by industrial enterprises for their own consumption). Total heat supply decreased to about 54 million Gcal in 1992, failing to meet residential demand in certain periods. The quality of service further deteriorated in 1993 -- the temperature inside residential buildings was below 15°C for several weeks in November and December.

203. **Heat generation**. Steam and hot water are provided by combined heat and power (CHP) plants and heat only boilers (HOBs). The combined generation of heat and power is considered advantageous, due to the substantial (up to 60%) energy savings achievable as well as its environmental compatibility, compared to individual house heating. To accomplish energy savings, however, a number of technical prerequisites have to be met; the transmission and distribution system should be well insulated and the consumer installations should be able to respond to meteorological conditions and customer requirements.

204. In 1992, 21 power plants with a heat production capacity of 8,430 Gcal/h supplied 40.6 million Gcal. Close to 10 million Gcal was supplied by about 3,800 HOBs, with a total capacity of about 5,600 Gcal/h. Within that total, about 3,700 HOBs with a capacity of about 4,500 Gcal/hour were under the municipalities (see Table 5 in Annex 1), while the rest of the HOBs were operated by the regional power utilities. In addition, industrial boiler houses provided about 3.7 million Gcal heat to the district heating networks. The HOBs provide peak capacity for networks connected to CHPs, and provide both base and peak loads elsewhere.

205. The large number of networks (about 200) relying exclusively on HOBs partially negates the main potential advantage of centralized district heating (i.e., inexpensive, low-grade heat as byproduct from power plants). District heating has been developed in Belarus beyond what is economically justified. Therefore, *the extension of district heating systems should proceed only in cases where it can be shown as clearly economical compared with other options*. Such cases could be those where surplus heat is available from power plants at short distance, the density of the population is sufficiently high, and heating networks exist in the vicinity. For any new housing development, alternative heating methods, such as gas distribution to individual buildings or apartments and local boilers burning indigenous fuels such as wood chips should be considered (modern gas boilers, down to the size which is suitable for individual buildings, operate with very high fuel efficiency).

206. The total fuel use of the 3,700 HOBs under the municipalities was about 0.76 mtoe in 1992, consisting of natural gas (46%), mazut (28%), light heating (diesel) oil (21%), and coal (4%). Many of the HOBs are not adequately maintained or repaired, because of shortages of boiler tubes, various materials, and spare parts. The heating surfaces of boilers using mazut or coal are often covered by soot, which reduces heat transfer. The damaged boiler tubes are plugged, which decreases the total amount of heat exchange surface, leading to higher flue gas temperature and increased losses with flue gas discharge. Leaky boiler casings and/or ducts lead to increased air infiltration into the boilers, causing furnace cooling, carbon monoxide generation, and overloading of induce draft fans by parasitic air. *The purchase of boiler tubes, spare parts and other materials is urgently needed (estimated total cost US$ 5 million).*

207. In the allocation of fuel (natural gas or mazut), there is no attempt to differentiate between steam and hot water boilers. Hot water boilers utilizing high-sulfur mazut are sensitive to return water temperature. In order to prevent the corrosion of heating surfaces, return water temperature must not go below 104°C when high-sulfur mazut is used. Such return temperatures are never achieved at HOBs, requiring recirculation of water to raise water temperature (i.e., hot water from the boiler is injected into the return water to achieve 104°C). When the hot water boiler is fueled by natural gas, the return water temperature does not matter, therefore the electricity intensive recirculation can be avoided. *Therefore, mazut currently used in hot water HOBs should be replaced with natural gas* (steam boilers are less subject to the corrosion caused by sulfur in fuel oil). *In addition, selected boilers should be converted to burn wood chips or wood waste (see Section C above).*

208. *The energy efficiency of many HOBs equipped with forced draft fans can be increased by the installation of additional heat exchangers for flue gases.* The heat exchangers will utilize the heat content of flue gases for air preheating or make-up water heating. A good candidate for such an investment is the "Shabany" boiler house in Minsk. The boiler house is an independent heat source operating for about 4,000 hours per year. The capacity of the boilers at the facility ranges from 100 to 180 Gcal/hour. In 1990, the fuel efficiency of the boiler house was 86.8%, which is too low for a modern facility. With additional heat exchangers, fuel efficiency could be increased by 10%.

209. **Heat dispatch**. The district heat neworks have no dispatching capability to allow the least expensive source of heat (i.e., HOB or CHP plant) to supply the load at any given time. The energy efficiency of boilers differ significantly because of design, age, level of maintenance etc. Also, boilers frequently run for long periods of time at low loads, resulting in the idle operation of auxiliary equipment, such as fans and pumps. In fact, various parts of the networks, even if physically connected, work as separate circuits, since neither automatic valves, controlled from the central dispatch center, nor computer hardware and software for economic dispatching are available. *The acquisition of equipment and software for cost-based dispatch of the largest district heating networks is of very high priority (estimated cost about US$ 2 million).*

210. Due to the lack of variable speed drives for the pumping stations, the district heating networks are operated with variable temperature and constant flow, i.e., the amount of the thermal energy supplied to end users is controlled (according to the temperature of outdoor air) by the change of temperature of outgoing water. This method of operation requires intensive pumping even when heating requirements are low. In addition, the outgoing water temperatures tend to fall to low levels (e.g. 70-80°C), which seriously degrades the quality of service. *Therefore, the constant flow - variable temperature operation should be converted to a variable flow - constant temperature mode.*

211. **Heat transmission and distribution**. The total length of the district networks is about 5,000 km. About 60% of the pipelines are under the municipalities and 40% under the power utilities. There are about 1,000 substations, separating space heating pipes from the supply of hot water. However, many municipal networks have no substations, i.e., the same pipes provide both space heating and hot water services. This design does not provide the separation between primary and secondary circulation, thereby reducing the scope for temperature and pressure control and decreasing energy efficiency. *Therefore, all directly connected networks should be converted to indirect connections with substations separating the primary and secondary circuits.*

212. In systems with substations, the make-up water requirements are a good indication of the extent of leakage. Due to the high degree of corrosion, water (and consequent energy) losses are massive. For example, the Minsk TEC-4 power plant pumps about 20,000 tons/hour of water into the city's heating network. The make-up water requirement is about 600 tons/hour, representing losses of about 3% of flow. This is thirty times higher than water losses in well operated systems in Western Europe, where 0.1% losses are standard.

213. Leakage does not seem to be caused by internal corrosion, because the quality of water used for make-up water is generally good. Water and heat losses are mostly caused by the external corrosion of underground pipes and deteriorated insulation. Most of underground pipes are laid out in small, shallow concrete channels, many of which are filled with water for part of the year. Three main reasons account for this: (i) groundwater leakage through the seals between different sections of the channels; (ii) leakage of other water pipes laid out above the channels; and (iii) leakage of the district heating pipes themselves inside the channels. The channels filled with water present two problems.

First, the rate of external corrosion is accelerated, especially for locations susceptible to stray voltage. Second, moisture decreases the effectiveness of insulation and increases its rate of decay. *The use of preinsulated pipes covered by corrosion resistant enamel or waterproof insulation provides the best solution to reduce thermal losses from underground piping.* The installation of these pipes should include measures to eliminate water and moisture from the channels. There is considerable experience with the application of such pipes in Denmark, Germany and in other countries. The cost of replacing 1 km of transmission (main) pipe by enamel covered pipe is estimated at US$ 100,000-150,000. *In addition, equipment for nondestructive testing of underground pipes should also be purchased to locate leaks and weak pipes that need replacement in a timely manner.*

214. In networks supplied from CHP plants, low lying locations experience excess pressure created by the pumps installed at the plants. In order to protect the radiators in the serviced buildings, pressure-reducing pumps were installed. The pumps increase the velocity of water flow in the distribution pipes, that, in turn, increases the average temperature of water in the return mains. The result is increased temperature of steam extraction at the cogeneration turbines and reduced electricity output. There are two possible solutions. The first one is the installation of intermediate heat exchangers to avoid the supply of high pressure water into the buildings. The second solution is the installation of hydroelectric turbines on the transmission (main) pipelines to reduce pressure and to produce electricity (for example, about 30 turbines of 300 kW each would be needed with a total cost of about US$2 million in Minsk). *A cost/benefit analysis is needed to determine which solution is preferable.*

215. **End use of district heat**. The end users are the service sector, residential buildings, and a limited number of industries. Only industrial consumers are metered. Reaching the residential buildings, the water enters a venturi nozzle with the purpose of mixing the supply water with the return water (this lowers the temperature of the water circulating in the radiators, and thereby prevents burns by people touching the radiators). In many buildings, radiators are fed from vertical risers, as apposed to lateral distribution on each floor as employed in Western Europe. The consequence of this practice is that individual regulation in the apartments is not possible and heat consumption measurement of each tenant is severely hampered. Since payments do not reflect actual consumption, there are no incentives to conserve energy and apartment temperatures are regulated by opening the windows. Heat losses are further aggravated by the fact that walls and ceilings in the buildings are not insulated. Studies from other parts of the former Soviet Union estimated that, in buildings with lateral distribution of heat on each floor, 50% reduction of energy consumption could be achieved through (i) thermal insulation of buildings; (ii) thermostatic valves in each apartment (room); (iii) double glazing of windows; (iv) individual payment for heat from each tenant based on actual consumption. In buildings with vertical distribution lines, the installation of heat consumption meters and regulators for the whole building will probably be the cost-effective solution. *In order to demonstrate and verify the energy saving potential and actual costs of these measures, complete "thermal updating" of various types of apartment blocks should be implemented. Following the evaluation of the costs and benefits of demonstration projects, each municipality should develop a district heat metering program, starting with the highest volume users. For systems with separate heat and hot water pipes, the installation of individual hot water consumption meters should be immediately started.*

VIII. FINANCING OPTIONS

216. As described above, investments in the energy sector should primarily focus on the rehabilitation of existing capital stock. In contrast with past practices, the highest priority should be given to efficiency improvements rather than capacity expansion. Assuming that the institutional restructuring of the energy sector is implemented and prices are set properly, most of the investments can be financed without direct budgetary support. The Government's role should be restricted to facilitating access to technical assistance, providing loan guarantees for essential investments in facilities that remain in the property of the state, and creating the regulatory and macroeconomic framework needed to attract investments in the private sector. The exceptions are (i) non-commercial investments that increase the security of fuel and energy supply for the nation as a whole; and (ii) investments that create the conditions for the reduction and eventual elimination of household energy subsidies, e.g., metering of gas and heat consumption.

217. **Oil**. Liberalization of the price of domestically produced oil is not only a necessary condition to attract foreign direct investment, but will also help Belarusneft to accumulate and reinvest profits to strengthen its exploration and development capabilities and to promote itself as an attractive joint-venture partner for foreign companies. The oil pipeline companies are profitable and cash rich, and will be able to generate the modest resources needed to implement technology upgrades.[37] *Although part of the additional crude oil storage facilities that are required to increase supply security may find commercial use, most of the construction cost will likely need to be financed by the state.* However, the build-up of the strategic crude oil reserve can be extended over several years.

218. Faced with the critical constraints of foreign exchange needed to upgrade the refineries to respond to changes in the market, and shortage of working capital to purchase crude oil, the Committee of Oil and Chemistry plans to convert the refineries into joint-stock companies, with Russian oil producers taking shares (up to 40%) in exchange for crude oil supply contracts. The remaining shares would be owned by employee funds and the state. *The detailed structure of ownership should be determined by matching the resource needs of the corporation (capital, raw materials, technology and managerial expertise) with potential suppliers of these resources.* Recognizing that, refinery managers are negotiating the exchange of shares in their refineries for shares in Russian crude oil producing enterprises (Megionneftegas or Najabskneftegas in the case of the Mozyr refinery, and Surgutneftegas for Novopolotsk). Eventually, the refineries would also offer up to 25% of their stock to foreign oil companies to obtain capital and technology for modernization (and possibly also to gain improved access to export markets for some of the refined products). Following the feasibility studies for modernization, the refineries have started active discussions with equipment manufacturers, export credits, and international financing institutions. For example, in the case of Mozyr, US$ 40 million is to come from the refinery's own cash generation, US$ 100 million in equipment supplier credits to be repaid from exports, and US$ 130 million in a loan requested from development banks.

219. Resolution 666 of the Council of Ministers allows private suppliers to sell crude oil, to distribute and to retail oil products at free market prices. While in 1993 about 80% of oil products were sold by state owned marketing companies, more private oil distribution is expected for 1994 (at the end of 1993, private companies lifted about 60% of the oil products refined by the refineries). In addition to helping the refineries to arrange the necessary financing, the Resolution is also expected to facilitate financing for the modernization of the distribution and marketing of oil products. Under Resolution 666,

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[37] For example, the southern pipeline company, headquartered in Gomel, reported an operating profit of Brb 35 billion for the first 10 months of 1993 (operating costs were Brb 5 billion).

local governments can authorize the private construction of automotive fuel stations. Government enterprises and organizations are authorized to lease or sell to private companies the existing service stations, vehicles, equipment, and other facilities necessary for oil product storage, transportation, and marketing.

220. **Gas**. The replacement of the aging turbo-compressors, the development of additional gas storage capacity, and the eventual expansion of transit capacity will require substantial investments. *It is important that the transit (and storage) fee and the transmission margin is established in a way that includes allowances for the costs of high priority investments.* Otherwise Beltransgaz -- as an independent corporation or as a subsidiary of RAO Gazprom -- will find it difficult to attract the necessary funds to finance the foreign cost of these investments.

221. Financing of investments in gas distribution will depend on the pricing policy followed by the Government. If the price of gas for household consumers continues to be heavily subsidized, these investments costs will ultimately have to be borne by the budget. Gas is a convenient, clean and efficient fuel for household consumption. This is reflected in the willingness of households in other countries to pay the full cost for gas services. *The Government may authorize the oblgaz companies to focus the expansion of the distribution system on those areas, where the customers are willing to finance part of the investment cost.* This approach has been tried in other countries (France and Hungary, for example), and proved to be very successful in alleviating the shortage of funds for system expansion.[38] *In the long run, proper pricing of the gas should enable the oblgaz companies to accumulate funds (supplemented by borrowing) to finance the gas distribution expansion program.*

222. The current plans assume that the households will pay the full price for gas meters. In order to ensure that purchasing meters will be in the interest of the households, Beltopgaz asked the Ministry of Economy to revise the current norms for the billing of non-metered households. The new system would be based on (i) uniform volumetric gas price; (ii) the gas input rating of the appliances in each household; and (iii) relatively high assumed rates of appliance use. For example, a household using one gas stove for cooking would be billed for 45 m^3 of gas per month. If the household also operates a heating unit, they would be billed for 1,080 m^3 of gas per month in the heating season. In comparison, the norms applied in 1993 were 11 m^3/person/month for cooking, and 330 m^3/month for heating (in the heating season, assuming 40 m^2 of living space). Beltopgaz estimates that the actual consumption following the installation of meters would be half of the new norms, providing enough incentives for the households to buy the meters.

223. Based on experience in other countries, households are seldom interested in energy savings investments with repayment periods longer than 3 years. Assuming that (i) the proposed pricing system is implemented with a volumetric price of Brb 15.3/m^3; (ii) the cost of the meter (including installation) is US$ 80/household; (iii) metered households indeed consume 50% less than the new

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38 The direct financing of system expansion/connection costs by the new customers raises the issue of fairness. Existing customers received their connections free of charge or for a nominal fee. In order to partly alleviate these concerns, the proposed financing scheme could be operated on a voluntary basis, whereby communities who are willing to contribute would be connected first. In addition, after prices increase to a level which covers system expansion costs, customers' prepayments can be deducted from their monthly bills.

norms;[39] and (iv) for non-metered households, the average value of the second half of gas consumed is 50% of the gas price,[40] the payback period for a meter is 160 years for cooking, and 16 years for heating. While a more than 50-fold price increase is needed to make the purchase of meters financially attractive for cooking only households, a five- to sixfold increase would be enough for heating customers. Therefore, even if focussed on the high volume users, the metering program will initially require an element of subsidy to make it financially viable. Following increases in the real, inflation adjusted price of gas, and the demonstration of savings potentially available for metered households, the metering program can become self-financing.

224. **Solid fuels**. *Assuming that the price of solid fuels is liberalized (see Chapter VI Section D), investments in the increased harvesting and transportation of firewood are expected to be profitable from the beginning.* There is a need for Government intervention on the demand side; Belarussian enterprises are not familiar with modern wood burning technologies, therefore the commercial viability of converting boilers to wood chips or wood waste will need to be demonstrated. *However, it should be restricted to the arrangement of financing and technical assistance, since fuel cost savings due to the conversion are expected to be sufficient to recover investment expenditures.*

225. **Electricity**. Due to the inevitable drop in electricity demand, investments in electricity generation up to the year 2000 are expected to be focussed on rehabilitation, with relatively limited expenses on capacity expansion. Total investment costs (including dispatch, transmission and distribution) in 1994-2000 are estimated at US$ 700-1,500 million, depending on the evolution of electricity demand and the cost of imported electricity. Although, for the sake of simplicity, these (very preliminary) cost estimates are expressed in US$, it is estimated that about 50-70 percent of these costs will be incurred in domestic currency. Undoubtedly, both foreign exchange and domestic currency requirements are still substantial even under the low demand scenario.[41] In principle, financing can originate from the following sources: (i) internally generated funds in the power industry; (ii) domestic borrowing; (iii) foreign borrowing; (iv) domestic equity investments; (v) foreign equity investments; (vi) domestic grants from the budget; and (vii) grants from foreign aid agencies.

226. Availability of financing out of the first five sources will depend largely on one factor: the relationship of electricity prices to the costs of electricity generation, transmission and distribution. If prices are inadequate to cover costs, the power industry will be unable to generate investment funds internally. As a result, neither domestic banks nor foreign lending agencies (such as the World Bank) will consider the industry creditworthy. Neither will investors be interested in taking equity positions. Since foreign grants, even under the most optimistic scenario, will cover only a small fraction of the investment costs, the Government will be forced to return to the old practice of financing investments directly from the budget. Due to low prices, consumers will be less interested in energy conservation. Demand will grow more rapidly, necessitating even more investments -- the difference in investment costs in 1994-2010 between the low and high electricity demand scenarios is about US$ 600 million (operating

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39 As described in Section C of Chapter VI above, the actual consumption following the installation of the meters will depend on the volumetric gas price.

40 This is an approximation. It is true if the demand curve is a linear function of the gas price.

41 In comparison, total revenues from electricity sales in 1993 were equivalent to about US$ 0.5 billion. However, assuming that average electricity prices are increased to the equivalent of 5 UScents per kWh in 1996-2000, these investment costs will represent not more than about 10-15% of electricity sales in the five year period.

costs are also higher, by about US$ 1,900 million, under the high demand scenario). Budget subsidies at such a large scale will seriously endanger the success of the macroeconomic stabilization program. Also, the financing of hard currency requirements without access to foreign borrowing will lead to severe hard currency shortages in other sectors of the economy.

227. *In addition to decreasing investment and operating costs, higher electricity prices will result in a profitable power industry that will accumulate significant internally generated funds.* In turn, that will ensure access for the industry to both domestic and foreign lending institutions. Assuming that the necessary institutional changes are implemented, private investors may be willing to commit some of their funds as equity to support the investment program. Due to the transfer of modern technology and know-how, this process will result in a more efficiently operating power industry.

228. **District heat**. The rehabilitation and modernization of the district heating system will be expensive and should proceed in stages. The cost of the "thermal updating" of apartment blocks (see Chapter VII above), if it proves economic, would be additional. In view of the current extremely low payments from households, there are only two possible financing sources in the short run: local government budgets and support from the central government. *Over time, if the proposal to target subsidies to low income households is implemented (see Chapter VI), the price of district heat can be increased so that user charges become a significant financing source for system improvements.* The Government should assist municipalities to obtain technical assistance from multi- and bilateral sources to carry out the necessary technical reviews and prepare system rehabilitation/modernization plans.[42]

[42] EC TACIS and USAID have already earmarked funds for technical assistance to Belarus in district heating. Both agencies plan to finance feasibility studies for the rehabilitation of district heating in selected cities, and provide assistance and training to introduce modern operation and management methods.

IX. ACTION PLAN

229. The cornerstones of the proposed medium term energy strategy are (i) the gradual elimination and improved targeting of energy price subsidies, and the liberalization of energy prices in those subsectors, that are not natural monopolies; (ii) the use of prices and market mechanisms rather than norms to allocate scarce energy resources; (iii) the development of a domestic capability to provide energy efficiency improvement services and new incentives for energy utilities to promote energy saving measures among customers; (iv) the improvement of the security of energy supply by increasing crude oil and gas reserves, expanding the use of domestic renewable energy sources, and improving the reliability and efficiency of electricity supply from existing thermal power plants; (v) the separation of the Government's policy making, ownership, and regulatory functions; and (vi) the promotion of competition in oil production, refining and marketing, solid fuel production, distribution and marketing, and electricity generation. The action plan below summarizes the most important measures needed for the implementation of the proposed medium term energy strategy. The plan, which is presented in a tabular format, indicates for each action the responsible agency, whether there is a need for technical assistance and a schedule for implementation.

BELARUS
ENERGY SECTOR ACTION PLAN

No.	Text Para. Ref.	AREA/ISSUE	ACTION	RESPON-SIBLE	TA	IMPLEMENTATION				
						94	95	96	97	98-2000
1.		**SECTOR MANAGEMENT AND REGULATION**								
1.1	89	Large number of organizations reporting directly to the Council of Ministers, hampering the coordination, development and implementation of energy sector policies	Set up a new Ministry of Fuel and Energy with responsibility for the whole energy sector	Council of Ministers	X	*				
1.2	92	The regulation of energy prices is not transparent, disconnected from the regulation of the quality of service, and subject to short term political interests	Set up a transparent, independent, legally based regulatory system to regulate gas, electricity and heat transmission/distribution utilities, and promote competition in oil production, oil refining/distribution, solid fuel production/distribution and electricity generation	Council of Ministers	X		*	*	*	
1.3	94 103	Lack of legal basis for competition and private investment in oil exploration and development, and electricity supply	Draft petroleum and electricity laws to establish licencing/concession regimes and to promote competition and foreign investment. Submit the laws to the Parliament	Council of Ministers/ Minenergo/ Comm. of Oil/Belgeol	X		*	*		
2.		**ENERGY PRICES**								
2.1	133	Because the price of domestically produced crude oil is set below the market value, it is inadequate to finance the modernization of oil exploration and production	Liberalize the price of domestically produced crude oil. Adjust natural resource and profit taxes to capture part of additional income for the budget	Min. of Econ./Min. of Finance		*	*			
2.2	133	"Clearing oil" is sold to the refineries at low prices, requiring the control of the prices of refined products	Set the price of "clearing" oil monthly to match the price of commercially imported crude oil of similar quality. Liberalize oil product prices	Min. of Economy/ Comm. of Oil		*	*			
2.3	134	Electricity and heat producer prices are inadequate to cover replacement and rehabilitation costs, do not take into account future investment needs and follow fuel price increases with a considerable lag. Fixed prices do not allow competition between electricity generators	Adopt a policy of quarterly price adjustments and a revised pricing formula which takes into account internal cash generation requirements to finance an adequate rehabilitation and investment program. Liberalize prices for electricity generators after a competitive electricity supply system is established	Council of Ministers/ Min. of Economy/ Minenergo	X	*	*	*		
2.4	135	Prices paid to the operators of oil, gas and district heat pipelines, and the electricity transmission and distribution services are low and not regulated in a transparent manner	Adopt price regulation formulas which allow these transmission and distrubution networks to recover their operating costs and generate funds for replacement and future capacity expansion	Ministry of Economy	X	*	*			
2.5	137	Electricity and gas prices do not reflect supply cost differences between peak and off-peak demand periods	Encourage electricity and gas utilities to introduce time-of-day, seasonal and interruptible tariffs	Ministry of Economy	X	*	*			
2.6	138	Household fuel and energy prices cover only a small fraction of costs, requiring large subsidies from the budget	Design a medium term program to gradually decrease household energy subsidies. Announce publicly the schedule of energy price increases in advance	Council of Ministers/ Min. of Economy	X	*				

BELARUS
ENERGY SECTOR ACTION PLAN

No.	Text Para. Ref.	AREA/ISSUE	ACTION	RESPON-SIBLE	TA	IMPLEMENTATION				
						94	95	96	97	98-2000
2.7	139	Low fuel and energy prices and unmetered consumption do not provide incentives for household energy savings	Set the price of electricity, heat and natural gas above a minimum consumption level equal to the full economic cost, parallel with the installation of meters. Liberalize the price of solid fuels, LPG, and heating oil, while providing a limited amount of solid fuels, LPG and heating oil at subsidized prices to households	Council of Ministers/ Min. of Economy/ Minenergo/ Beltopgaz/ local government		*	*	*		
2.8	140	Fuel and energy price subsidies are not targeted to low income households	Set up a financing and administrative mechanism for a sytem of "talons" to be provided by local governments to low income households. The "talons" will have a value expressed in rubles to be applied towards the purchase of a specific fuel or energy service from any supplier	Min. of Finance/ local government	X		*	*		
3.		**ENERGY CONSERVATION**								
3.1	33-35	The system of norms, penalties and supply rationing is a poor substitute for economic cost based prices, and allocation of resources by the market	Ensure that non-household fuel and energy prices are equal to economic cost, and cut electricity, gas and heat supplies to the tehcnically safe minimum to enterprises and organizations with substantial arrears. Abolish penalties for above the norm consumption	Ministry of Economy/ Minenergo/ Beltopgaz		*				
3.2	36-37	Only a few organizations exist which can carry out industrial energy audits and assist enterprises to develop energy conservation strategies	Obtain foreign technical assistance to carry out industrial energy audits. Ensure that the audits are carried out jointly with domestic energy efficiency organizations. Promote the development of domestic firms which can provide energy conservation/efficiency services on a commercial basis	Comm. of Energy Savings and Control	X	*	*	*	*	*
3.3	27 31	Households are not aware of energy saving possibilities	Prepare and implement a nationwide program to inform/educate the public about energy saving opportunities	Comm. of Energy Savings/	X	*	*	*		
4.		**OIL SUBSECTOR**								
4.1	75 147 217	Oil supply security	Expand crude oil storage capacity	Min. of Economy/ Comm. of Oil	X		*	*	*	*
4.2	94 95	Crude oil exploration and production are monopolized and lack modern technology	Separate exploration from Belgeologia. Corporatize Belarusneft and offer shares to domestic and foreign private investors. Invite foreign companies to bid for the exploration and development of oil fields	C.of Min/ Belgeologia /Comm. of Oil	X	*	*	*	*	
4.3	97 98 218	Lack of capital for the upgrading of refineries	Corporatize refineries. Determine the structure of ownership by taking into account the needs of the refineries for capital, crude oil, modern technology and coomercial skills	Committee of Oil and Chemistry	X	*	*			

BELARUS
ENERGY SECTOR ACTION PLAN

No.	Text Para. Ref.	AREA/ISSUE	ACTION	RESPON-SIBLE	TA	IMPLEMENTATION				
						94	95	96	97	98-2000
4.4	99 151 219	Obsolete oil product distribution and marketing facilities	Privatize road transportation of oil products. Privatize motor vehicle fuel marketing organizations and stations	Committee of Oil and Chemistry	X	*	*	*		
5.		**GAS SUBSECTOR**								
5.1	75 159 220	Gas storage capacity is inadequate to provide supply security and respond to seasonality of demand	Develop the new Pribug storage field	Beltransgaz	X	*	*	*	*	
5.2	100 162 220	A number of turbo-compressors have exceeded their normal operating life. Domestic transmission and transit capacity expansion plans are not prioritized	Replace old turbo-compressor units. Develop a phased program for the construction of new city-gate stations and branch lines. Analyse the cost-effectiveness of various options for transit capacity expansion and implement the highest priority option after existing transit capacity is fully exhausted	Beltransgaz		*	*	*	*	*
5.3	101	Beltopgaz is responsible for a number of activities with different economic characteristics	Break-up Beltopgaz. Corporatize the seven oblgaz, the three pipeline construction and the design companies, and establish a holding company (Belgaz) as the main shareholder. Establish a separate corporation for LPG bottling and distribution (see also 6.1)	Council of Ministers	X		*	*		
5.4	169	Current methods and equipment for distribution pipeline condition surveys, leak detection and cathodic protection are inadequate and obsolete	Carry out a detailed technical audit to define priority needs. Implement rehabilitation program	Beltopgaz	X	*	*	*	*	*
5.5	167	Gas distribution control and dispatch system is obsolete and inadequate	Install a conventional, reliable SCADA system	Beltopgaz	X		*	*		
5.6	168 223	Gas consumption of residential and small commercial consumers is not metered	Develop and implement a metering program with initial focus on commercial establishment and those residential consumers who use gas for heating purposes	Beltopgaz		*	*	*	*	
5.7	166 221	Expected further growth of residential demand for gas	Focus distribution system expansion on those communities/districts in urban areas, who are willing to contribute financially. Evaluate the costs and benefits of using PE pipes	Beltopgaz/ local government	X	*	*	*	*	*
5.8	170 171	Inadequate LPG storage capacity. Doubtful viability of planned investments in LPG motor vehicle fueling stations and plants to extract LPG from imported natural gas	Expand on-site storage capacity at the LPG bottling plants. Evaluate the economic costs and benefits of using LPG as motor vehicle fuel and extracting LPG from natural gas	Beltopgaz	X	*	*	*		
6.		**SOLID FUELS**								
6.1	101	Beltopgaz is responsible for a number of activities with different economic characteristics	Establish a corporation for peat harvesting and briquetting. Place the "gorraytopsbit" directly under the local governments. Parallel with the liberalization of the trade of solid fuels, privatize each "gorraytopsbit"	Council of Ministers/ local government	X		*	*	*	
6.2	55 175	Wood is an underutilized renewable energy source	Invest in wood harvesting and transport facilities. Increase forest thinnings and sanitary cuts	Ministry of Forestry	X	*	*	*	*	

BELARUS
ENERGY SECTOR ACTION PLAN

No.	Text Para. Ref.	AREA/ISSUE	ACTION	RESPON-SIBLE	TA	IMPLEMENTATION				
						94	95	96	97	98-2000
6.3	176-178 224	(same as above)	Implement demonstration projects by converting boilers in industrial enterprises, power plants and district heating systems to wood chips and wood waste	Bellesprom/ Minenergo/ local government	X		*	*	*	
7.		**ELECTRICITY SUBSECTOR**								
7.1	89 103-106	Minenergo acts as a Ministry, a regulatory agency and as the headquarters of a large integrated utility	Set up a national electricity company. Transfer Minenergo's regulatory functions to the new energy regulatory authority. Minenergo (as part of the new Ministry of Fuel and Energy) should focus on policy development and strategic decisions in the power industry	Council of Ministers	X	*	*			
7.2	103 107	Lack of competition in electricity supply	Separate the largest power plants from the regional utilities and establish one or two generating company. Separate high voltage transmission from the regional utilities and establish a national transmission company. Introduce a system of gradually increasing quotas for direct supply contracts between domestic customers and foreign suppliers	Minenergo	X			*	*	*
7.3	189	A number of combined heat and power plants have already reached the end of their design life, and the oldest units in other power plants are approaching it	Prepare a rehabilitation/retirement program on the basis of detailed feasibility studies. Implement the program	Minenergo	X	*	*	*	*	*
7.4	78 189-194	The need for new generating capacity depends on the evolution of electricity demand and the cost of imported electricity	Obtain the required expertise, hardware and software tools for the in-house application of modern generation planning methods. Monitor demand and regularly update the least-cost generation plan. Decide on new capacity accordingly	Minenergo	X	*	*	*		
7.5	195	Obsolete communication facilities and lack of computer programs hamper the optimal dispatching of power plants	Improve telecommunication facilities and install modern computer programs for economically optimal dispatch of power plants	Minenergo	X	*	*	*		
7.6	198-201	Unreliable distribution lines, insufficient capacity of reactive power compensation devices, lack of spare parts and modern maintenance equipment increase transmission and distribution losses	Renovate old distribution lines, rehabilitate substations, purchase modern maintenance equipment, etc. to reduce system losses	Minenergo	X	*	*	*	*	*
7.7	200-201	Planned expansion of the 330 kV transmission network	Revise and prioritize the 330 kV transmission expansion plan taking into account new demand projections, and the reliability of the transmission system	Minenergo	X	*	*			
8.		**DISTRICT HEAT**								
8.1	108	The potential for competition between heat suppliers is different between cities. There is no need for detailed regulation of district heating systems on a nationwide basis	Delegate responsibility for issuing heat supply licences and regulating heat transmission and distribution systems to the municipal executive councils. Preserve an oversight function and provide technical and service standards at the national level	Min.of Ec./ Min. of Housing and Comm. Services/ Minenergo	X	*	*			

BELARUS
ENERGY SECTOR ACTION PLAN

No.	Text Para. Ref.	AREA/ISSUE	ACTION	RESPONSIBLE	TA	IMPLEMENTATION 94	95	96	97	98-2000
8.2	205	District heating has been developed beyond what is economically justified	Connect new urban housing developments to the natural gas network. Expand district heating only when surplus heat is available from a nearby power plant and the transmission system has been already installed	Min. of Housing and Comm. Services/ local government		*	*	*	*	*
8.3	206-208	Inadequate maintenance of heat-only-boilers. Unutilized energy content of flue gases. Hot water boilers using mazut require costly recirculation of water	Purchase boiler tubes, spare parts and other materials. Replace mazut with natural gas in hot water boilers. Install heat exchangers to recover the heat from flue gases	Min. of Housing and Comm. Services/ local government		*	*	*		
8.4	209-210	No capability for least cost dispatch of heat sources. Inefficient constant flow - variable temperature operation	Purchase hardware and software for cost-based dispatch of the largest networks. Convert to a variable flow - constant temperature mode by installing variable speed drives	Minenergo/ local government	X		*	*	*	*
8.5	211	Lack of substations in some networks result in the same pipes providing both space heating and hot water services, reduced scope for control and decreased energy efficiency	Convert to indirect connections by separating the primary and secondary circuits with substations	Minenergo/ Min. of Housing and Comm. Services/ local government			*	*	*	*
8.6	212-213	High thermal losses in the transmission/distribution system due to water-filled channels and inadequate insulation of pipes	Gradually replace old lines with preinsulated, corrosion resistant pipes. Purchase equipment for non-destructive testing to locate leaks and weak pipes	Minenergo/ Min. of Housing and Comm. Services/ local government			*	*	*	*
8.7	215	Inadequate thermal insulation of apartment buildings and lack of heat consumption metering	Implement complete "thermal updating" of representative apartment blocks in Minsk and other large cities. Study the effectiveness of these measures and prepare a nationwide program to decrease energy losses in residential buildings	Min. of Housing and Comm. Services/ local government	X		*	*	*	*

ANNEX 1
Table 1

ENERGY BALANCE FOR BELARUS, 1990 (PJ)

	Coal	Peat	Peat Briquettes	Crude Oil	Gasoline	Diesel	Heavy Fuel Oil	LPG	Kerosene	Non-energy products	Natural gas	Refinery Gas	Wood	Primary Electricity** (Hydro)	Primary Electricity** (Imported)	Electricity	Heat	TOTAL
Indigenous Production		25.91		86.00							10.07		30.15	0.21				152
Imports	40.20		0.01	1610.87	1.06	35.02	10.44	5.43			498.80				98.69			2301
Exports		-0.02	-0.12	-44.13	-86.25	-226.72	-189.33		-9.79	-34.50								-591
Stock Change	1.39	2.65	0.08	1.76	0.75	1.11	1.50				9.87							19
TOTAL ENERGY REQUIREMENT	41.59	28.54	-0.04	1654.50	-84.45	-190.59	-177.39	5.43	-9.79	-34.50	518.74	0.00	30.15	0.21	98.69	0.00	0.00	1881
INTERMEDIATE AND FINAL USE																		
IN ENERGY INDUSTRY	-20	-22	25	-1654	218	321	360	10	155	121	-266	0	-0	-0	-99	141	239	-472
Fuels Industry	-0.15				-0.04	-0.38	-25.46									-6.50		-33
Briquetting	-8.20	-21.37	29.00															-1
Petroleum Refineries	-0.05			-1653	219.54	360.05	730.20	10.04	154.60	121.04		2.95				-1.44		-56
Public Power/Heat Plants	-10.10		-3.74	-0.17	-0.04	-31.60	-325.59				-231.50	-2.95		-0.21	-98.69	164.00	198.87	-342
Industrial Power/Heat Plants*							-10.69				-10.69					0.94	16.75	-4
Municipal Heating Plants	-1.15					-6.01	-8.02				-13.17		-0.35				25.64	-3
Transmission/Distribution Loss	-0.20	-0.57		-1.59	-1.32	-1.37	-0.77				-11.02					-15.54	-2.13	-35
TOTAL FINAL CONSUMPTION	21.75	6.61	25.22	0.00	133.69	130.09	182.27	15.47	144.81	86.54	252.35	0.00	29.80	0.00	0.00	141.45	239.12	1409
TOTAL INDUSTRY	1.11	3.22	1.33	0.00	27.76	3.37	160.62	0.70	0.00	64.90	123.04	0.00	0.48		0.00	77.86	110.65	575
Ferrous Metallurgy		..					..									3.14	..	..
Non-Ferrous Metallurgy		..					..				4.31						..	..
Chemical Industry	0.03	..	1.11		27.37	0.38	..				64.30					24.73	..	..
Wood Industry	0.03	..			0.18	0.43	..						0.48			3.37	..	..
Machinebuilding Industry		..			0.18	0.81	..				21.67					21.60	..	..
Construction Materials	1.01	..			0.04	0.77	..				28.66					5.86	..	..
Light Industry	0.03	..				0.09	..				4.10					5.89	..	..
Food Processing	0.01	..				0.90	..									4.25	..	..
Other Sectors		..	0.23				..									9.03	..	..
TOTAL CONSTRUCTION					1.54	10.51	0.69				6.39		0.01			1.93		21
TOTAL TRANSPORT	0.29				78.56	59.02	0.20	0		11	3.01					10.97		163
TOTAL OTHER	20.35	0.88	23.89	0.00	25.83	57.19	20.75	14.66	144.81	10.83	119.91	0.00	29.32	0.00	0.00	50.69	128.47	648
Agriculture	0.77	0.12			3.60	42.88	1.46			5.41	35.36		0.41			20.80	2.87	114
Residential	17.85	0.01	21.99		16.31			14.66		2.70	23.80		28.25			4.19	62.80	193
Services/Commercial		0.75	1.83		0.44	2.78	7.80			2.71	40.74					15.00	20.93	93
Other	1.73	0.01	0.07		5.47	11.53	11.49		144.81		20.00		0.66			10.70	41.87	248

* Commercially sold power and heat only
** Primary electricity is taken into account with a conversion factor of 1kWh = 10.47 MJ

BELARUS
ENERGY SECTOR REVIEW

Table 2: Salient Features of Power Plants

District/Plant	Capacity	No. of Units	Primary Fuel	Startup Date
BREST-ENERGO				
Berezov	940 MW	6	M	1961
Brest	11 MW	2	M	
Baranoviu	12 MW	1	M	
Pinsk	4 MW	1	M	
VITEBSK-ENERGO				
Lukoml	2400 MW	8	G/M	1968
Novopolotsk	505 MW	8	G/M	1977
Vitebsk	70 MW	2	M	1954
Belorus	17 MW	1	M	
Orsha	6 MW	1	M	
Polotzk	2 MW	1	M	
GOMEL-ENERGO				
Gomel	360 MW	2	G/M	1986
Mozyr	195 MW	2	M	1973
Svetlogorsk	260 MW	4	G/M	1958
GRODNO-ENERGO				
Grodno	170 MW	4	G/M	1970
Lida	5 MW	1	M	
MINSK-ENERGO				
Minsk 2	33 MW	3	G/M	1947
Minsk 3	420 MW	8	G/M	1951
Minsk 4	1030 MW	5	G/M	1977
Zhodisk	54 MW	2	G/M	1951
MOGILEV-ENERGO				
Mogilev 1	14 MW	4	M	
Mogilev 2	345 MW	5	M	1969
Bobruisk 2	180 MW	2	G/M	1970

G - Natural Gas
M - Mazut

BELARUS
ENERGY SECTOR REVIEW

Table 3: Electric Power Generation
(Million Kwh)

Month	1989	1990	1991	1992	1993
January	3,690	3,963	4,044	3,591	3,488
February	3,163	3,253	3,656	3,499	3,090
March	3,240	3,302	3,566	3,150	3,023
April	2,858	3,186	3,186	3,077	2,649
May	2,804	3,141	2,931	2,773	2,620
June	3,054	2,983	2,390	2,596	2,585
July	2,878	2,959	2,672	2,506	2,528
August	3,033	2,992	2,903	2,673	2,257
September	2,928	3,002	2,887	2,892	2,308
October	3,382	3,249	3,246	3,509	2,568
November	3,442	3,525	3,491	3,501	2,969
December	3,981	3,953	3,742	3,807	3,267
TOTAL	**38,453**	**39,508**	**38,714**	**37,574**	**33,352**

BELARUS
ENERGY SECTOR REVIEW

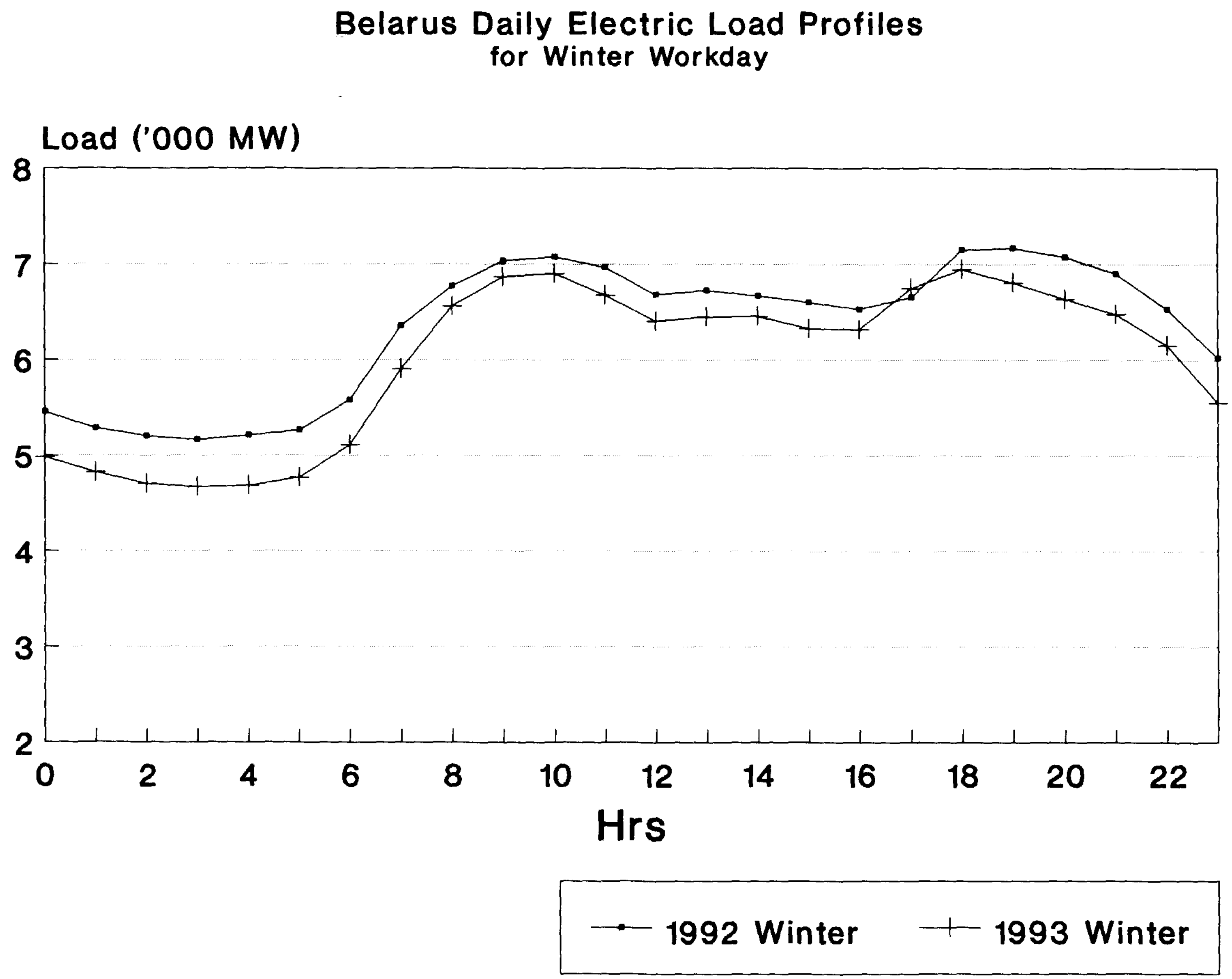
Table 4: Fuel Use in Power Generation

District/Plant	1990		1991		1992		1993 (10 month)	
	Mazut	Natural Gas	Mazut	Natural Gas	Mazut	Natural Gas	Mazut	Natural Gas
Brest-Energo								
Berezov	593.60	994.80	558.10	934.20	338.30	1,148.90	135.30	975.80
Brest	0.70	71.70	3.60	70.00	0.10	67.20	0.80	47.10
Baranoviu	15.30	124.30	12.20	129.10	2.50	129.20	0.60	90.90
Pinsk	129.00	-	135.30	-	118.50	-	80.40	-
Vitebsk-Energo								
Lukoml	3,280.40	-	2,544.20	784.40	1,336.90	2041.20	439.60	2213.30
Novopolotsk	1,243.60	-	1,278.70	-	1,053.50	-	765.90	-
Vitebsk	210.80	-	214.40	-	203.20	-	143.60	-
Belarus	19.60	-	20.80	-	20.50	-	14.50	-
Orsha	79.60	-	82.40	-	74.60	-	55.80	-
Polozk	37.80	-	40.40	-	46.60	-	33.20	-
Gomel-Energo								
Gomel	52.80	609.50	79.20	624.60	19.20	726.10	99.60	354.00
Mozyr	381.10	-	450.30	-	376.10	-	263.20	-
Svetlogorsk	35.70	693.10	81.60	558.90	23.80	604.50	72.60	333.50
Grodno-Energo								
Grodno	133.10	541.90	163.20	493.70	38.60	611.80	92.60	340.80
Lidsk	7.00	99.80	3.20	106.20	0.40	103.80	3.70	73.60
Minsk-Energo								
Minsk 2	2.40	277.40	8.40	287.00	4.80	257.30	8.20	175.30
Minsk 3	64.60	1,039.50	185.00	937.50	75.00	998.70	117.90	604.10
Minsk 4	282.20	1,336.70	454.70	1,026.10	253.90	1,363.30	239.20	999.80
Zhodisk	9.10	168.50	16.00	172.00	2.10	176.30	4.10	112.30
Mogilev-Energo								
Mogilev 1	196.80	-	178.90	23.20	33.70	173.70	10.10	133.50
Mogilev 2	774.40	-	816.90	-	743.60	-	508.60	-
Bobruisk	726.20	-	698.80	29.80	566.40	81.40	292.60	184.30
Small plants and Heat Only Boilers	270.20	1,089.80	286.10	1,238.30	232.60	1,223.70	158.80	859.80
TOTAL	**8,546.00**	**7,047.00**	**8,312.40**	**7,415.00**	**5,564.90**	**9,707.10**	**3,540.90**	**7,498.10**

Table 5: Data on District Heating Systems Under the Authority of the Ministry of Communal and Municipal Services

Oblast	Brest	Vitebsk	Gomel	Grodno	Mogilev	Minsk	City of Minsk	Total in the Country
Number of Boiler Houses	169	161	256	147	195	82	43	1,053
Number of Boiler Houses by Fuel Type:								
Solid	69	62	32	29	72	10	2	276
Stove Fuel	11	68	98	38	106	18	0	339
Mazout	5	24	8	11	11	38	0	97
Natural Gas	84	7	118	69	6	16	41	341
Heat Capacity, Gcal/hr	604.5	645	949.1	826	572.6	610.2	252.6	4,460
Number of Installed Boilers	595	498	964	495	716	270	167	3,705
Length of System of Double Pipes (km)	404.4	314	451.1	403	441.5	510.4	250	2,774
Number of Thermal Substations	247	37	97	199	165	106	117	968
Annual Heat Generation from own Sources (Gcal)	820,157	854,900	1,305,981	1,138,545	688,462	989,000	326,009	6,123,054
Heat Purchased (Gcal)	1,217,657	2,199,800	1,651,589	908,391	2,040,296	2,212,000	2,298,164	12,527,897
Heat Purchased from Ministry of Power (Gcal)	668,484	1,171,000	716,057	698,967	1,674,236	1,602,000	2,270,495	8,801,239
Heat Generation & Purchase Total (Gcal)	2,037,814	3,054,700	2,957,570	2,046,936	2,728,758	3,201,000	2,624,173	18,650,951
Thermal Losses (Gcal)	27,650	47,700	62,111	97,650	98,448	100,000	75,599	509,158
Fuel Consumption, tce/year	145,571	156,959	234,147	201,566	129,637	169,712	54,571	1,092,163

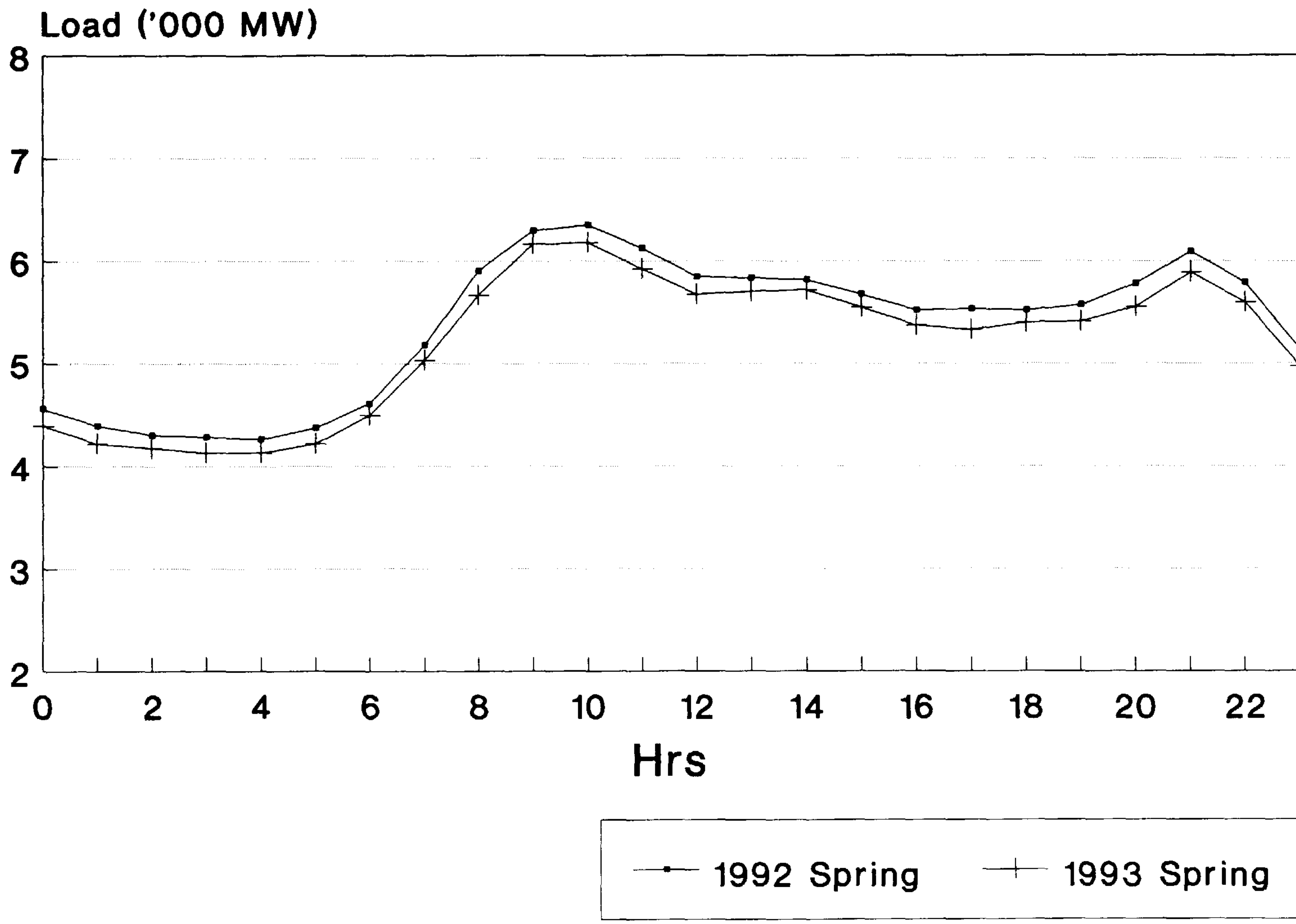
Source: Annual report of the Ministry of Communal and Municipal Services for 1992.



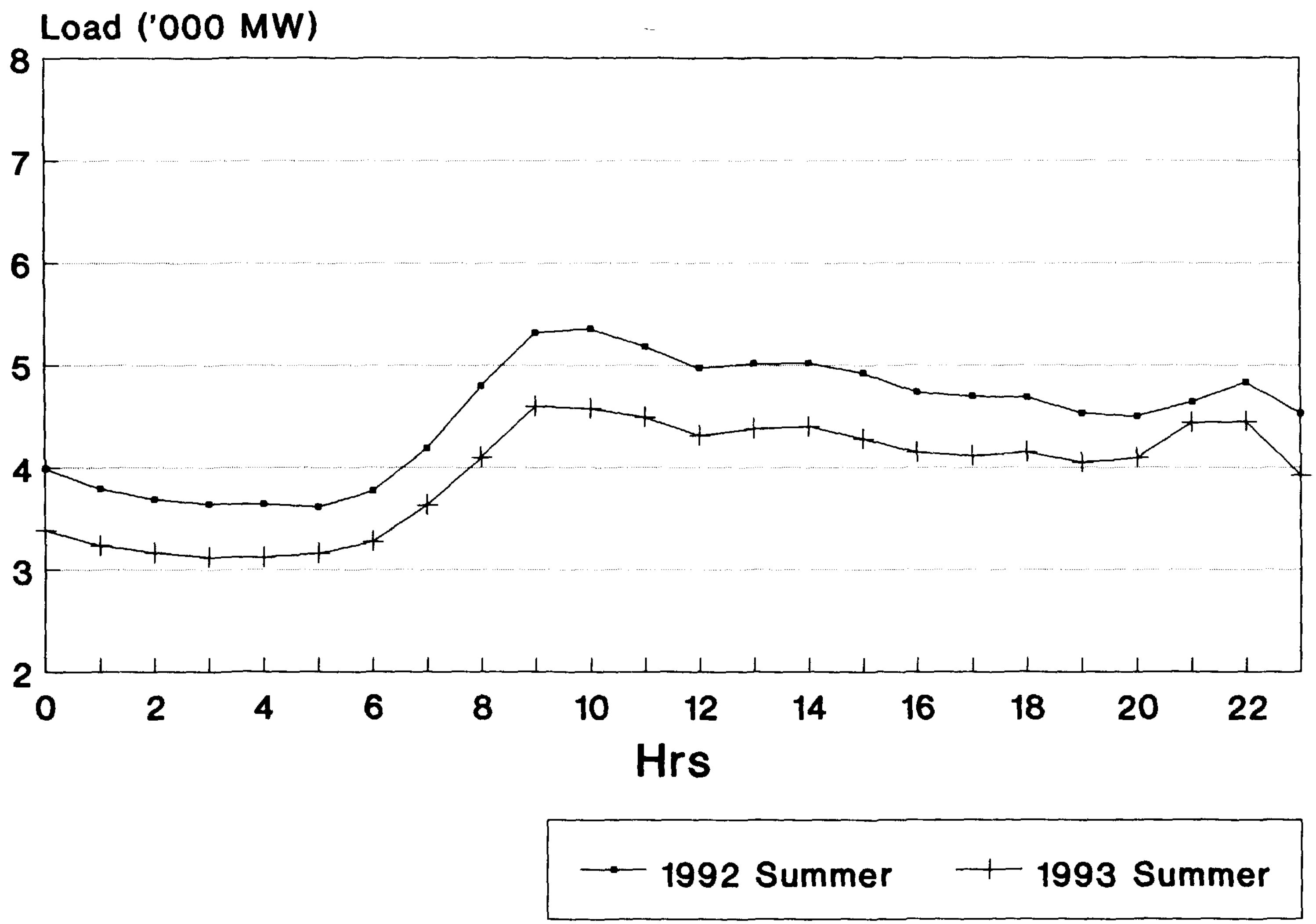
ANNEX 1
Figure 1

ANNEX 1
Figure 2

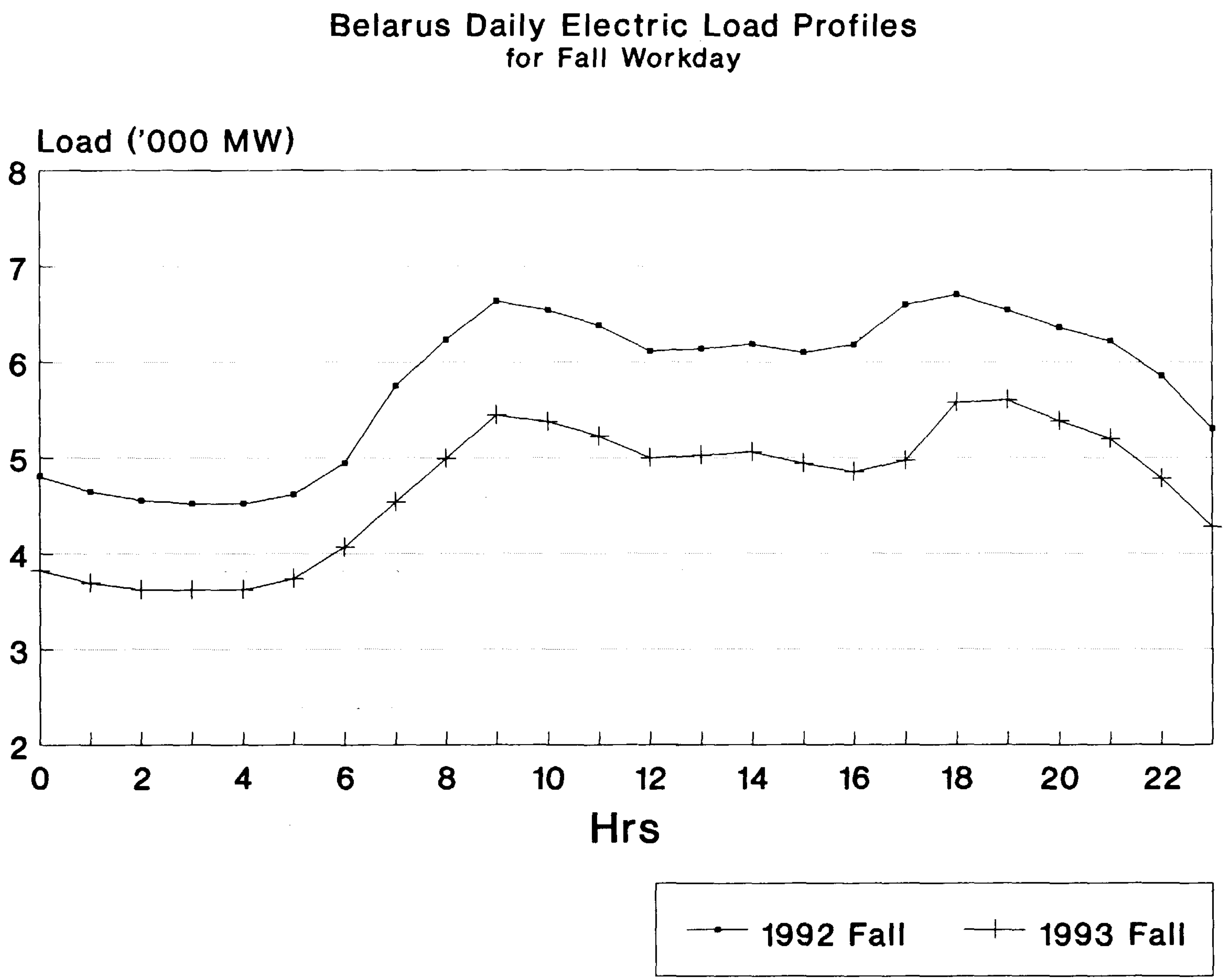
Belarus Daily Electric Load Profiles
for Spring Workday

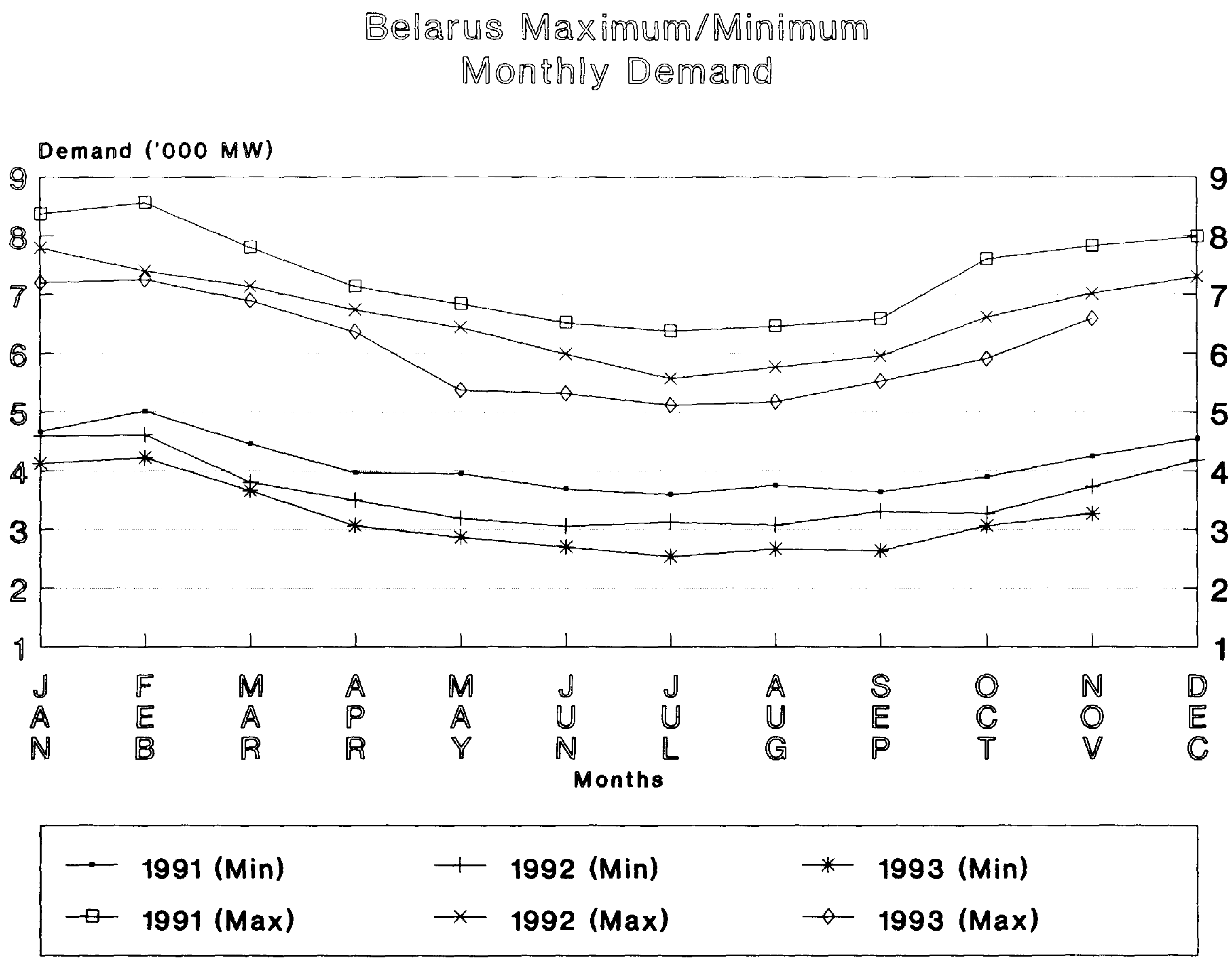


Belarus Daily Electric Load Profiles
for Summer Workday



ANNEX 1
Figure 4





ANNEX 1
Figure 5

BELARUS

ENERGY SECTOR REVIEW

The National Household Energy Survey:

Patterns of Energy Demand in the Residential Sector

A. Introduction

1. In Belarus, systematic data on patterns of use and supply of energy for the household sector is lacking. There is no reliable information on the consumption levels for the significant "traditional" fuels (firewood and peat), the ownership of appliances, the obstacles and incentives for fuel switching and energy conservation, and the "social dimension" of energy use, including the ability or willingness of households at various income levels to pay prices that reflect economic costs. This severely limits the scope for disaggregated end-use analysis, assessment of conservation potential, and the formulation of effective pricing and energy policies. The principal purpose of the national household energy survey was to develop a detailed energy profile of Belarussian households and thus provide a solid empirical basis for designing effective policies for the sector.

2. The specific objectives of the study were as follows:

- to estimate household energy expenditure in disposable income;
- to determine attitudes toward possible energy price changes and the affordability for households of higher energy prices;
- to determine the fuel mix of household consumption, especially the share of traditional fuels such as firewood;
- to identify the level and pattern of appliance ownership.
- to ascertain consumer attitudes to fuel switching and energy conservation.

3. **Methodology.** In this statistically representative survey, 3,000 households were interviewed in early 1994. A three-stage random sampling design was used to determine the sample: first, the country was divided into four strata (the six regional capital cities, cities with more than 50,000 inhabitants, small towns and urban settlements, and rural areas or rayons); next, sample areas were randomly selected within each stratum; and finally, survey points were randomly selected within each sampling area.

4. The questionnaire was based on similar household energy surveys conducted in other countries, with some modification to reflect the peculiarities of the energy situation in Belarus.

B. Socio-Economic Profile of Households in Belarus

5. The population of Belarus is 10.3 million, and most people (65%) live in urban areas. The average household consists of three persons: the figure is slightly larger in urban areas (3.1), particularly in the regional capitals (3.4). The smallest households are found in the countryside (2.8).

6. Due to the difficulty in obtaining housing, it is common to find two generations residing within a single apartment in the urban areas. The average dwelling consists of two rooms. Sixty-nine percent of households reside in either a two- or three-room dwelling. In urban areas, two-room dwellings (42%) and apartment complexes (74%) are the most common types of dwellings found, whereas in rural areas, 83% of households have their own home, and approximately the same proportion of households live in one- (25%), two- (35%), and three-room (32%) dwellings.

Table 1: Housing Structure of Belarus

	BELARUS	Urban	Rural
Type of Residence			
Apartment Complex	49%	74%	13%
Own House	45%	19%	83%
Apartment within a House	2%	2%	3%
Worker Dormitory	3%	6%	0%
Number of Rooms			
1	21%	18%	25%
2	39%	42%	35%
3	30%	29%	32%
4	9%	9%	8%
5	2%	2%	1%
Average Number of Rooms	2.2	2.3	2.2

Source: Belarus Household Energy Survey, 1994

7. Usually, in the three-member household, two persons contribute to family earnings. Most households supplement their income with some self-subsistence activities, even in urban areas. For example, the dacha serves more as an additional source of income rather than a place for recreation. About half of these households are able to provide 25% of their food needs. In rural areas, self-subsistence activities contribute an even larger share to total food needs, with 25% of households producing half of their food.

8. **Household energy expenditure patterns.** Although rural households have a much lower income than the national average, they have a higher energy expenditure than urban households. Although energy bills do increase as income levels rise, low-income households nevertheless pay relatively more

for energy than other income categories: at least 10% of their income is expended for energy, while the highest income group pays a maximum of 2.5% of their income for energy.[1] The cost of network fuels represents 86% of the urban household energy bill, compared to 33% for rural households.

Table 2: Household Income Profile

	BELARUS	Urban	Rural
Household Size	3.0	3.1	2.8
# of Persons Working	1.3	1.5	1.0
# of Persons Receiving Benefits	.8	.7	1.0
Source of Income			
Salary Only	32%	38%	23%
Salary + Food Sales	2%	0%	5%
Salary + Family Transfers	8%	11%	3%
Salary + Pension	29%	31%	25%
Food Sales + Pension	2%	0%	4%
Pension Only	27%	19%	39%
Family Transfers Only	1%	1%	0%
Income Groups			
Low	11%	5%	18%
Middle-low	28%	20%	40%
Middle	49%	55%	39%
High	12%	19%	2%
Income Groups reported for December 1993 (Brb/month/household)		**Low < 50,000 Brb** **Middle-low 50,001 - 100,000 Brb** **Middle 100,001 - 300,000 Brb** **High > 300,001 Brb**	
source: Belarus Household Energy Survey, 1994			

9. **Household energy prices.** The price structure for network fuel that is not metered, such as district heating, natural gas and piped LPG, is based on national consumption norms. Households pay a flat rate for each member of the household. Electricity is charged according to consumption (per kWh) as electricity is metered. Regarding natural gas, only a few homes have meters installed.

1/ The energy expenditure analysis is based on official prices as of December 1993.

Table 3: Monthly Household Energy Expenditure by Income Group

INCOME CATEGORY	BELARUS	Urban	Rural
Low-income group	5051	4091	5449
Middle-low income group	5521	4841	6011
Middle-income group	6485	6156	7156
High	7312	7299	7464
Income Groups reported for December 1993 (Brb/month/household)	**Low < 50,000 Brb** **Middle-low 50,001 - 100,000 Brb** **Middle 100,001 - 300,000 Brb** **High > 300,001 Brb**		
source: Belarus Household Energy Survey, 1994			

10. In contrast to network fuels, no national price structure exists for non-network fuels. Prices vary significantly from region to region, depending on availability and quality of the fuel.

11. **Affordability**. Most survey respondents (76%) stated that they would not be able to afford higher energy prices. The income group most tolerant to possible price increases was the highest income group: 34% did not foresee problems with higher prices and 21% did not regard electricity as expensive.

12. **Prices and energy conservation.** One out of every two households did not agree that higher energy prices would be an incentive for energy conservation. They perceive their energy consumption as very low already, and given higher prices, they would nevertheless maintain current energy consumption levels. However, the majority of households (87%) agreed that they could reduce energy expenditures through conservation.

13. Ninety-six percent of respondents were conscious of the fact that conserving energy is important for their country but they do not know how to conserve energy. They were aware of some basic measures, such as closing curtains at night (71%), or switching off lights when they leave a room (84%).

C. Patterns of Household Energy Use

Table 4: Percentage of Households Using Each Type of Energy

ENERGY TYPE	BELARUS	Urban	Rural
Electricity	100	100	100
District Heating	51	78	13
Natural Gas	35	59	1
LPG	61	37	95
Firewood	45	16	88
Peat Briquettes	21	9	38
Coal	5	4	6
Heating Oil	0	0	0
source: Belarus Household Energy Survey, 1994			

14. **Fuel mix.** Households rely on more than one fuel to meet their energy requirements. Usually, they use a combination of fuels to meet a particular end-use. At the national level, 69% of households have only one heating fuel; however, only 42% of rural households use a single heating fuel, and only 33% of them use a single fuel for cooking. In contrast, 95% of urban households cook with one type of fuel.

15. **Heating fuels.** The Belarussian heating system is characterized by a large central heating network (district heating), which provides heat not only to urban areas, but to some rural areas as well. District heating is the only heating mode for 72% of urban households, and 87% of these households identified district heat as their most preferred heating mode. Neither natural gas nor electricity are widely used for heating purposes. In contrast, firewood is the main heating fuel for rural households: it is the only mode of heating for 26% of rural inhabitants, and 28% of rural inhabitants combine wood with peat briquettes to heat their homes. For rural households, district heating and firewood were identified as the most preferred heating modes.

16. **Cooking fuels.** Urban households either cook with natural gas (60%) or with LPG (40%), and only 6% use electricity for cooking. Much like their counterparts in the West, the urban households rely on only one cooking fuel (95%). In contrast to their urban counterparts, only 37% of rural households cook exclusively with one fuel--LPG. Due to both tradition and low-income constraints, 64% of rural households cook with both firewood and LPG. Moreover, a seasonal pattern exists for the use of firewood: in wintertime, the rural households that heat their home with firewood also cook from the same source for dinner, whereas during summer, the use of LPG is more prevalent among the rural households.

17. Although only 1% of rural households cook exclusively with natural gas, it is the most preferred cooking fuel for both urban and rural households. Moreover, rural households that do not have access to natural gas desire it, although LPG and natural gas yield the same results in quality of cooking. This preference is most likely related to the difficulties associated with LPG use (refilling LPG bottles or delivery problems in remote areas).

D. Network Fuel Use According to Fuel Type

Electricity

18. **Electricity supply.** Electricity is supplied to all households in urban areas as well as in rural areas. Practically all consumers are metered, either by means of an individual meter (98%), or collective meters, for example, in worker dormitories. The few households that are not metered (1%) obtain electricity free of charge from their enterprise. Almost all meters are checked **(read?)** by a controller at least once a year (93%); about half of the meters are checked twice a year. In addition, meters in urban areas are checked **(read?)** more often than those in the rural areas.

19. **Electricity payments.** Unlike other network fuels, households know both the amount of electricity they consume, and how much they pay for it. The payment system is based on coupons or "talons,"[2] which the households usually have to purchase in advance at the savings bank or post office. Fifty % of households overall and 70% of urban households purchase the coupons on a monthly basis. In rural areas, coupons are purchased directly from the controller at each visit.

2/ One coupon represents 100 kWh.

20. **Electricity consumption.** On average for the year, a household consumes 88 kWh per month. From October to April, during the heating season, the monthly electricity consumption is 105 kWh (mostly for lighting purposes). During the rest of the year--May to September--monthly consumption decreases to 73 kWh for rural households, 99 kWh for urban households, and 64 kWh for Belarus as a whole. Households perceive residential electricity consumption to be low.

Table 5: Electricity Consumption Based on Households' Own Estimates

	BELARUS	Urban	Rural
January 1994 kWh/household/month	115	126	97
May to September 1993	64	74	50
October to April 1993-1994	105	117	89
source: Belarus Household Energy Survey, 1994			

21. Low-income households consume less electricity than higher-income groups--60 kWh and 113 kWh respectively. About a fifth of the poorest households consume less than 50 kWh per month (block 1), while less than 3% of the richest households fall into this category. Moreover, less than 9% of the households belonging to the two highest income groups consume within the block 1 category. At least a third of the households in the two highest income groups consume more than 100 kWh per month.

22. **Electricity end-uses.** Electricity is used primarily for lighting and to operate household appliances; it is rarely used for cooking (5%) or heating (3%) purposes. In general, there are no major differences in electricity end-use across income groups, although low-income groups tend to own fewer household appliances.

Table 6: Percentage of Households Using Electricity For Each Type of End-Use

	BELARUS	Urban	Rural
TYPE OF END-USE			
Lighting	100	100	100
Household Appliances	97	99	95
Heating Water	7	5	10
Cooking	5	5	4
Heating	3	2	5
source: Belarus Household Energy Survey, 1994			

23. **Household attitudes towards electricity.** Despite the recent increase in the price of the electricity coupon, 72% of households stated that they do not have problems in meeting their electricity expenditures. Nonetheless, 86% of the households consider electricity to be expensive. Only half of the

respondents expressed an opinion on the eventual introduction of a two-part billing system (i.e., having a lower rate after 9 p.m.). Overall respondents believe that such a system could lead to lower electricity bills.

24. Neither a fine nor disconnection are regarded as serious threats by the majority of households in the case of non-payment. The households usually purchase a sufficient number of coupons to cover their electricity bills, and 57% of them think that a fine will never be imposed on customers who do not have enough coupons when checked by the controller. Those who believe that they will not be disconnected even if they do not pay their bill are even more prevalent (69%).

25. Households report that electricity services provided to the residential sector is reliable, with consumers rarely experiencing unscheduled power cuts or voltage drops.

District Heating

26. District heating (DH) supply dramatically differs between urban and rural areas: 78% of urban households are DH customers, while this ratio is only 13% for rural households. DH is especeailly dominant in the large cities (see Table).

Table 7: District Heating Supply

	BELARUS	Regional Capitals	Cities > 50,000 persons	Towns	Rural districts
% of Households with District Heating	51%	89%	81%	52%	13%

27. **Regional availability of district heating.** DH is most widespread in Minsk (66%) and Gomel (61%) regions, and least in Vitebsk (38%) and Mogilev (31%).

REGION:	Minsk	Gomel	Grodno	Brest	Vitebsk	Mogilev
% of Households with District Heating	66%	61%	53%	41%	38%	31%

28. About 56% of the customers were satisfied with the district heating system, however, many complained about insufficient heat. Thirty-five % find their home cold in the winter. Fifteen % of the households reported that they supplement district heating supply with a space heater. Although most customers believed that the installation of a regulator would allow them to control the temperature in their home, and thus increase their comfort level, they did not think that this would have an impact on their bill. One out of five district heating customers was interested in heat meter.

29. Most households did not know the price they pay for district heating. This ignorance is due to the billing system, which "hides" the heating bill within the cost of rent (80% of district heating customers).

Natural Gas

30. Natural gas is almost exclusively available only in urban areas (35% of urban households), as only 1% of households in rural areas have access to natural gas. There is a strong relationship between income level and natural gas use: as income rises, so does natural gas use (see table below).

Table 8: Natural Gas Use According to Income Level

	BELARUS	Low	Middle-low	Middle	High
% of Households Using Natural Gas		14%	21%	40%	64%

Income Groups reported for December 1993 (Brb/month/household)	**Low < 50,000 Brb** **Middle-low 50,001 - 100,000 Brb** **Middle 100,001 - 300,000 Brb** **High > 300,001 Brb**

31. **Regional pattern of natural gas use.** Natural gas use is most significant in the Minsk region (61%); in contrast, no natural gas use was reported amongst households in the Vitebsk region. A similar proportion of households use natural gas in the Mogilev (22%), Gomel (23%), and Grodno (23%) regions. The Brest region (49%) has the second highest percentage of households that use natural gas.

Table 9: Percentage of Households Using Natural Gas for Each Type of End-Use

	BELARUS
END USES	
Cooking	100%
Heating Water	37%
Heating	11%
Cooking Only	61%
Cooking and Heating Water	28%
Cooking and Heating	2%
Cooking / Heating Water / Heating	9%
source: Belarus Household Energy Survey, 1994	

32. **Natural gas end-use**[3]**.** In Belarus, natural gas is predominantly used for cooking, either exclusively for this purpose (61% of households), or in combination with other purposes (e.g., cooking and heating, 2%). A relatively large percentage of households also use natural gas for heating water (37%). However, much fewer households, 11%, use natural gas for heating their homes, and fewer still for both cooking and heating (2%) (see table above).

33. **Natural gas prices and metering.** Few natural gas customers are metered. The gas bill is based on the number of occupants in the apartment, and is included in the monthly rent. Although these customers are used to having an electricity meter, 59% of them do not want a gas meter in their homes. The remaining 41% of the customers interested in gas meters think that it will allow them to decrease the gas bill.

LPG

34. Almost all rural households (95%) are LPG users; in contrast, the percentage of LPG user households in urban areas is almost three times less. In terms of income, the following profile is found for households using LPG: the majority of low- and middle-low groups (75% each) use this fuel; this proportion falls as income rises and only 33% of the high-income group use this fuel.

3/ All natural gas user-households in rural areas use this fuel for the purposes of cooking, heating water, and heating their homes *together*; however, since the percentage of rural households that use natural gas is so insignificant (1% of total user-households), this analysis applies to the urban households, and the rural households are entirely excluded.

35. **Seasonal vs. regular users.** The LPG market is characterized by its dichotomous consumer profile: regular vs. seasonal customers. Regular customers are those who use LPG in their primary residence, such as urban homes connected to the LPG network or rural households that use bottled LPG for cooking. About 11% of LPG users are seasonal customers. LPG is either supplied via pipeline or bottles to about 2 million customers. One out of every five LPG customers has LPG delivered to them by pipeline.

36. **LPG end-uses.** Almost all rural households cook with LPG; however, only 30% use it exclusively for cooking. LPG is usually combined with wood (64%). During the heating season, these two fuel types are used together, while in summertime, LPG is usually the only cooking fuel. Households reported that they are reducing the consumption of LPG.

E. Solid Fuel Use by Households

Fuelwood

37. A higher percentage of rural households use wood as a fuel than urban households: 88% and 16%, respectively. There is a strong correlation between fuelwood use and income level: 75% of low-income households, 62% middle-low, 37% middle, and only 14% of the high-income households use wood. Most households purchase their wood (94% of urban and 71% of rural households), although almost a fifth of wood-users in the low-income group collect it themselves.

Table 10: Fuelwood End-Uses During the Heating Season

FUELWOOD END-USE:	BELARUS	Urban	Rural
Heating	66%	77%	63%
Cooking	24%	15%	27%
Heating Water	8%	8%	8%
Other	2%	1%	2%

source: Belarus Household Energy Survey, 1994

Peat Briquettes

38. The urban/rural divide is significant in the case of this fuel as well. Peat briquettes are used by 39% of the rural households and by only 9% in urban areas. The use of peat briquettes has an inverse relationship with income: this fuel is most prevalent in the low-income group (38%), followed by the low-middle-income (29%), middle-income (16%), and the high-income group (7%).

39. Peat briquettes are used mainly as a heating fuel and very rarely alone (only in 4% of households). Twenty-eight % of rural households report using it with firewood.

40. **The peat briquette market.** Households can purchase peat briquettes at a low (subsidised) price up to a certain limit, which is set by the local fuel distribution center. For purchases beyond the limit, customers must pay a 50% premium. Customers usually purchase peat briquettes in advance, and stock up their supply. Seventy % of peat briquette users make their purchases during the summertime. Twenty

% of the peat customers made no purchases in 1993, but utilized the stock they had built during the preceding years.

Coal

41. Coal is rarely used by households in Belarus: only 5% of survey respondents reported coal use at all. In addition, there is little variation of coal use across income groups. Households that use coal can be found for the most part in small rural towns.

42. Among the households that use coal, annual consumption per household is 0.2 tons. Slightly more coal is used in rural areas: 0.24 tons vs. 0.12 for urban households. Coal is used almost exclusively for heating (94% for urban users, 97% for rural users).

43. Low-income groups in rural areas reported using more coal now than before (63% of low-income and 57% of low-middle-income group), in contrast to their urban counterparts, who reported less consumption than before (69% in low-income and 33% in low-middle-income). Barely any of these urban households reported increased coal use. In general, the trend in urban areas is the same (67%), with a slight bias towards decreased use (19%), in contrast to the rural households, among which there is an upward trend for coal use.

F. Patterns of Appliance Ownership

44. Ninety % of households own a single-door refrigerator (without a freezer). Freezers are found in only 2% of households. Washing machine penetration is 60%. Electric water heater is operated by only 6% of the families.

Table 11: Electrical Appliance & Equipment Endowment

	BELARUS	Low	Middle low	Middle high	High
Type of Electrical Appliance/Equipment					
Electric Cooking Range	9	8	5	10	10
Refrigerator	90	62	84	97	99
Freezer	2	0	1	1	5
Washing Machine	60	34	47	70	80
Water Heater	6	6	8	6	3
Space Heater	10	10	10		
Television Set	95	78	93	99	99
VCR	5	1	2	5	13
Stereo System	13	7	10	14	23

source: Belarus Household Energy Survey, 1994

45. A television set, either black & white or color, can be found in 95% of the homes. Color TVs have been introduced within the last five years. Luxury items like VCR is rare in Belarus: only 5% of the households have one (13% in the high income group). Stereo systems are also a luxury in Belarus and relatively uncommon, with 14% ownership among households in general (23% in the highest-income category).

46. Cooking with electricity is not widely practiced in Belarus. Less than 10% of households own an electric cooking device. It is usually a small electric range (a hot plate) used predominantly for boiling water or warming food. Combined electric stove/oven appliances are installed mostly in new apartments. Space heaters are owned by 10% of households (16% in the high-income group).

47. **Income level and appliance endowment.** As indicated above, the high-income groups are better endowed with household appliances than low-income groups. Almost all households within the high-income group have a refrigerator (99% vs. 62% in low-income households); a TV set (99% vs. 78%); and a washing machine (80% vs. 34%). The high-income households that owned a washing machine often expressed a desire to replace the old one. Of the households that expressed an intention to buy new appliances in the near future, 26% identified a refrigerator, 16% a color TV set, 14% a washing machine, and 12% a VCR.

48. Although electric cooking appliances or space heaters are not widely used at present, utilization of such appliances will most likely increase in the future. New apartments are equipped with electric cookers and due to the energy crisis this past winter, the district heating supply was halted in mid-April, one month earlier than in the past. Furthermore, urban households reported that district heating was insufficient this past winter season.

49. **Installed capacity.** The typical household in Belarus owns few household appliances. The majority of homes have a refrigerator and a television set, and wealthier households possess a washing machine as well. This low level of electrical appliances corresponds to low installed capacity in the homes, ranging from 1699 watts in rural homes to 1937 watts in urban homes. Installed capacity increases with rising income levels: the highest income group has an installed capacity twice as high as homes belonging to the lowest-income category (2375 vs. 1204 watts).

Table 12: Electricity: Installed Capacity Within Households by Income Group

	BELARUS	Low	Middle-low	Middle	High
Total Installed capacity (watts)					
Household Appliances	840	517	698	939	1056
Cooking	410	293	388	422	518
Lighting	399	266	332	431	546
Entertainment Equipment	127	90	110	134	168
Heating	66	38	45	80	87

source: Belarus Household Energy Survey, 1994

50. Most homes are characterized by relatively low level of lighting, with total installed wattage for lighting being 399 Watts on average. In general, homes in urban areas have better lighting (429 Watts) than those in rural areas (357 Watts). However, this divergence is more significant across income groups: high-income households have an averrage of 546 Watt installed lighting capacity, whereas the low-income households have only 266 Watt.

BELARUS

ENERGY SECTOR REVIEW

ELECTRICITY GENERATION PLANNING

A. Methodology and Main Assumptions

1. Production of electricity in Belarus is based entirely on power plants which use heavy fuel oil (mazut) and natural gas as primary fuels[1]. Most of them are combined heat-and-power plants. In general, there is a lack of generating capacity, and Belarus has been importing about 20% of its electricity demand in recent years. As a result of overall economic decline, electricity consumption decreased in the last two years, and is likely to decrease further in the nearest future. This will lessen temporarily import needs, but the problem of inadequate production capacity and structure will persist in the long term. A serious problem is the age of existing plants. More than 70% of generating units (measured in production capacity) are older than 20 years, and about 20% are older than 30 years (Figure 1). Another problem in the Belarus power system operation is lack of peaking and regulating capability, which makes it impossible for the system to work independently from the power systems of the neighboring Russia and Lituania.

2. A least-cost analysis of the Belarus power system expansion alternatives for the period 1994-2010 has been carried out using ELECTRIC module of ENPEP software package, which is a PC version of WASP-III computer program[2]. General methodology of the WASP model is to find the least-cost power system expansion plan matching projected electricity demand, while maintaining reliability of the system operation at a prescribed level. The model takes into account both maintenance requirements and operational reliability of generating units. The system costs include investment costs, costs of financing during construction, operation and maintenance costs, and cost of energy not served.

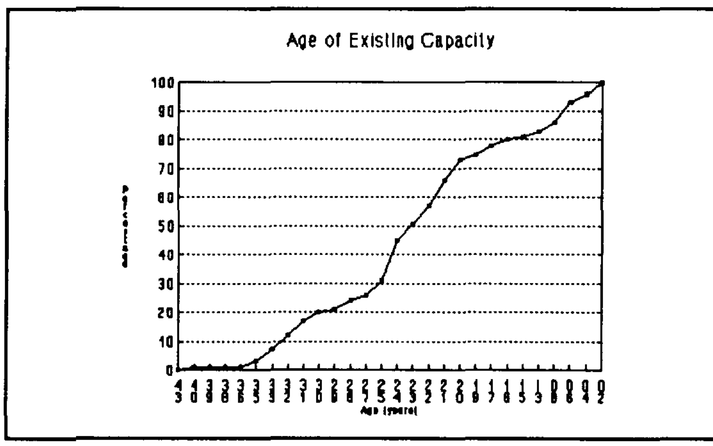


Figure 1

[1] There are, actually, 9 hydro plants, but their total capacity and energy production (6.5 MW and 18.7 GWh, respectively, in 1993) are very small in comparison with the total system capacity and energy production (6931 MW, and 33352 GWh, respectively, in 1993).

[2] ENPEP - ENergy and Power Evaluation Program, developed by Argonne National Laboratory, Argonne Illinois; WASP - Wien Automatic System Planning Package, of International Atomic Energy Agency, Vienna, Austria.

3. The main assumptions of the analysis concern the system demand, unit retirement schedule, commitments to rehabilitation of existing and addition of new units, fuel mix, electricity imports, composition and characteristics of new generating units proposed for the system expansion, and various cost components and parameters. The assumptions are discussed next[3].

TABLE 1: ELECTRICITY DEMAND AND SYSTEM CAPACITY AFTER RETIREMENTS

	Low Demand		High Demand		Existing Capacity
Year	Energy (GWh)	Load (MW)	Energy (GWh)	Load (MW)	
1993	39357	7260	39357	7260	6931
1994	34770	6402	37030	6818	6931
1995	31300	5791	36000	6661	6931
1996	29140	5435	35110	6549	6913
1997	29200	5482	34580	6493	6778
1998	30220	5702	34630	6534	6748
1999	31550	5983	35600	6751	6698
2000	32900	6260	36580	6960	6698
2001	34340	6533	37890	7209	6598
2002	35890	6828	39390	7494	6548
2003	37480	7131	41020	7804	6038
2004	39160	7451	42710	8126	5978
2005	40920	7785	44480	8463	5768
2006	42750	8134	46330	8815	5674
2007	44670	8499	48280	9186	5674
2008	46680	8881	50310	9572	5384
2009	48770	9279	52420	9973	5277
2010	50960	9696	54630	10394	5217

3 One of the major options in matching power supply and demand is demand-side management. It is not discussed in this section, in which demand side is taken as fixed and given exogenously. Energy conservation and improvements in end-use efficiency are, however, important measures, which can be very cost-effective and, in case of Belarus, very relevant.

4. **Electricity Demand**. Two electricity demand scenarios were prepared by the World Bank (see Section III). The yearly load factors[4] decline gradually from the present level of 0.62 to 0.60 by year 2000, remaining at that level through the rest of the planning period. The maximum yearly loads for both energy demand scenarios were derived from the energy projections and the load factors assumption, as given in Table 1. In addition to satisfying the peak loads, the system is required to have 13% reserve in capacity, which is a standard planning requirement for the Belarus system.

5. The system load is modeled by four load duration curves[5]: winter, spring, summer and fall. The system peak occurs in the winter period. Typical seasonal daily load profiles, and yearly maximum and minimum monthly loads and energy are given in Annex 1.

6. **Retirement Schedule**. The following retirement plan has been adopted (notation, e.g., 3x100 in 1999, means that 3 units of 100 MW are retired in year 1999):

Berezov	3x150 in 2003
Novopolotsk	2x60 in 2001, 2x50 in 2006, 1x50 in 2009
Mozyr	1x60 in 2003
Svetlogorsk	1x60 in 2005, 1x50 in 2008
Grodno	1x60 in 2010
Minsk TEC-3	2x60 in 2005, 2x100 in 2008
Bobruysk	1x60 in 2004, 1x60 in 2009
Mogilev	1x50 in 2005, 1x50 in 2008

The unit capacities are given in nominal terms, which may not necessarily reflect their effective generation capacity rates.

7. **Firm Commitments**. The WASP model handles existing units and units committed to future additions (in the WASP terminology: the fixed system) in a different manner than the candidate units[6]. Only the Orsha power plant (62MW combined cycle unit) has been modeled as a new firm commitment, coming on line in 1996. Units that will undergo rehabilitation are also modeled as a part of the fixed system. Based on a preliminary assessment of Minenergo's rehabilitation plan, it was assumed that the following units will be rehabilitated rather than retired (numbers in parenthesis represent years in which the rehabilitations start): Minsk TEC-3, 25 MW units (1996); Svetlogorsk TEC, 15 MW and 45 MW units (1997), Minsk TEC-2, 31 MW (1998), and Mogilev 60MW units (1999 and 2002, respectively). Period for which a unit being rehabilitated is out of service is assumed to be two years.

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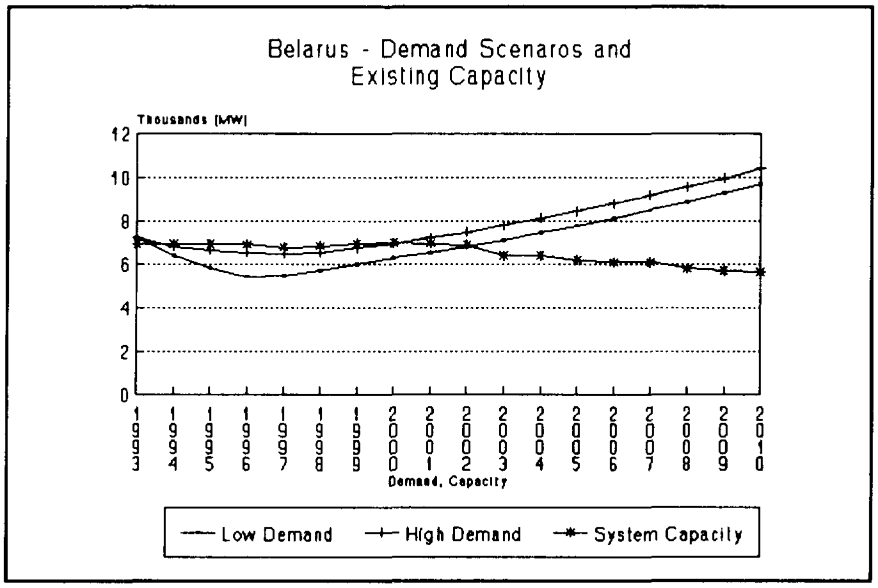
4 Load factor for a given period is defined as ratio of average load versus peak load in that period.

5 Load duration curve for a given time period represents, for a given load level between minimal and maximal load of the period, duration of time for which the system load has is greater than the given load level.

6 The term "candidate units" refers to units that are considered as candidates for system expansion.

8. Figure 2 gives the system generating capacity taking into account the retirement schedule and firm capacity rehabilitations (including Orsha), and the two demand scenarios.



9. **Candidate Units**. Units which are considered as candidates for the system expansion are the following:

Combined cycle gas turbines (100 MW, 320 MW, 450 MW)
Pulverized coal unit, 500 MW
Single cycle gas turbine, 120 MW
Gas/mazut steam units, 250 MW and 320 MW
Nuclear unit, 500 MW.

Imports are also considered as one of the competing options for the capacity additions.

10. **Fuel Prices**. Price of natural gas is assumed to escalate from \$55/tcm in 1994 to \$80/tcm in 2010, in real terms, in 1993 US\$, with uniform growth rate over the period. Similarly, price of mazut increases from \$60/ton in 1994 to \$75/ton in 2010, and of coal from \$30/ton to \$35/ton. Calorific values of the fuels are assumed at 8.1 Gcal/tcm (gas), 9.7 Gcal/ton (mazut), and 5 Gcal/ton (coal). This leads to the following prices for 1994: natural gas US\$6.79/Gcal, mazut US\$6.186/Gcal, coal US\$6.00/Gcal. Price of nuclear fuel is assumed at US\$6 per MWh electricity produced.

11. **Price of Electricity Imports**. Two scenarios are assumed for prices of imported electricity. The first (low) scenario supposes that the import prices will increase from US\$0.025 per kWh in 1994 to US\$0.03 per kWh in 2010, with uniform growth rate. The second (high) scenario takes costs of US\$0.025/kWH in 1994 and US\$0.045/kWh in 2010 assuming, again, uniform growth rate in between. All prices are in constant 1993 US\$.

12. **Investment Costs**. The following investment costs and construction periods are assumed for the candidate units:

Type of unit:	Cost of Investment (US$/KW)	Construction time (years)
Combined cycle gas turbines		
100 MW	800	4
320 MW	785	4
450 MW	770	4
Pulverized coal unit, 500 MW	1500	5
Single cycle gas turbine, 120 MW	357	3
Gas/mazut steam units		
250 MW	920	4
320 MW	900	4
Nuclear, 500 MW	2000	6

The prices include interest during construction.

13. **Other assumptions**. Operation and maintenance costs are assumed to escalate at the rate of 5% annually in real terms. Discount rates, used both for levelizing all costs and for calculation of interest during construction, are assumed at 10%.

14. No quantity constraints are imposed on fuel availability. Most of the plants in Belarus can burn either gas or heavy fuel oil. In the model, the existing plants are assumed to use preferred fuel, i.e., the fuel that was used predominantly in 1993.

15. Imports are assumed to provide additional capacity needed to satisfy demand for years for which new capacity can not be added to the system. The first year, in which imports are not used to complement domestic production, is 1995 in the low demand scenario, and 1999 in the high demand scenario.

16. Tables 2 and 3 of the Annex summarize data used in the computer simulations.

B. Definition of Scenarios

17. The scenarios evaluated are defined in terms of the following parameters: (a) energy demand, (b) prices of electricity imports, and (c) maximum level of imports. The two demand scenarios (high and low) and the two electricity import price scenarios (also high and low) have already been described. In the high import scenario, electricity imports are assumed to be constrained by their historic maximum (about 20% of the peak load); the low import scenario, designed to determine financial implications of self-sufficiency in the production of electrical energy, eliminates imports after year 2005.

18. All combinations of the values of the parameters define eight cases in total. In addition, a case in which a nuclear unit was added to the system as a firm commitment was evaluated in order to assess its cost implications. The cases are:

Case 1: Low demand, low import prices, high electricity imports.

Case 2: Low demand, low import prices, low electricity imports.

Case 3: Low demand, high import prices, high electricity imports.

Case 4: Low demand, high import prices, low electricity imports.

Case 5: High demand, low import prices, high electricity imports.

Case 6: High demand, low import prices, low electricity imports.

Case 7: High demand, high import prices, high electricity imports.

Case 8: High demand, high import prices, low electricity imports.

Case 9: High demand, high import prices, low electricity imports, a nuclear unit added to the system in 2008.

19. The choice of technology and size of the units for capacity additions were evaluated within each scenario.

C. Results

20. Tables 4, 5 and 6.a, 6.b, 6.c present the least-cost solutions for the system expansion for each case[7].

21. **Choice of technology**. The following conclusions can be made in regard to the optimal choice of technology and composition of the units for capacity additions:

(i) Preferred technology is gas turbine, both as combined cycle and single cycle units. This can be expected because of their relatively low investment costs, especially for single cycle turbines, and high thermal efficiency of the combined cycle technology.

(ii) Steam technology is consistently rejected on the least-cost basis, regardless of the type of fuel used. It is inferior to the gas turbine technology in terms of both the investment costs and the fuel efficiency. However, security of electricity production with respect to supply

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7 Although the cost is often the most significant criterion associated with an expansion plan, it is not the only one; there are other important criteria which can affect decisions and should be taken into account. To mention just few: security and reliability of the primary fuel supply which emphasize fuel diversity, availability of local technology, experience and expertise, environmental concerns. These criteria can modify choices made on the cost-only basis.

of primary fuels is an argument in favor of steam technology. Boilers designed for dual firing can switch between using gas or mazut, depending on availability and prices of the fuels. Presence of coal units would further diversify primary fuels options. The same argument can be used for nuclear technology, which is also rejected on the least cost basis in each of the eight cases in which it was offered as an option.

(iii) Units of all three sizes (100MW, 320 MW, 450MW) offered for combined cycle technology are present in optimal solutions in all cases evaluated.

(iv) Presence of single cycle gas turbines in all solutions is particularly important. They are needed as peaking units to improve regulatory capability of the system, and they appear to be also cost effective.

(v) Imports are cost effective under the low import price scenario only (Cases 1, 2, 5 and 6). Investment costs for new units, which would substitute imports, outweigh benefits from lower operating and maintenance costs. This is not the case in the high import price cases (Cases 3, 4, 7 and 8), in which imports are rejected in favor of building additional domestic production capacity.

22. **Capacity additions.** Needs for capacity additions, after netting out capacity of imports, range between 3830 MW and 5340 MW in the low demand scenarios, and between 4630 MW and 6150 MW in the high demand scenarios. In the low demand cases, there is no capacity shortage between 1994 and 2000. Although it is cost effective to add new capacity in year 2000 in the case of low import prices, if that capacity is substituted in 2000 and 2001 (and with imports being proposed as the least cost solution for 2003 and 2004) building a new capacity can be postponed until 2004. If import prices are high, all other factors being equal, it is better to build new units than to import; in this case first new capacity should be added in 2000. In the high demand cases, there is a continuous capacity shortage throughout the whole planning period. It is covered by imports, until first new unit is added in 1999. After that, the capacity deficit is filled by combinations of imports and new units in the low import price cases, and by new units only in the high import price cases.

23. **Investment requirements**. Investment requirements are implied by the capacity addition needs. In the low demand cases, the total investments[8] required for the planning period are US$2.7 billion (in constant 1993 US$) if electricity import prices follow their low case, and US$3.9 billion if the import prices follow the high case. Investment funds are needed starting in 1996; however, if the first unit proposed in the least cost solution is substituted by imports, then no investment funds may be needed until year 2000.

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[8] The investment costs in Tables 5 and 6 do not include rehabilitation costs for the plants planned for rehabilitation (see paragraph 7), and investment costs of the Orsha plant. The total rehabilitation costs are estimated at US$124.5 million (415 MW capacity at the costs of US$300 per KW). The foreign cost of Orsha plant is estimated at US$27.4 million and DM30.8 million, equivalent to about ECU41 million combined. Additional ECU 7.1 million is planned in local costs. Operation and maintenance costs of these units are, however, included in the corresponding WASP figures.

24. The high demand cases present heavier investment requirements: US$3.4 billion in total in the case of low import prices, and US$4.5 billion in the case of high import prices. Even if the first proposed unit (requiring investments as early as 1995) is delayed and replaced by imports, investments will be postponed only until 1997.

25. **Cost of self-sufficiency in electricity production.** Cost of self-sufficiency in electricity production after year 2005 can be assessed by comparing Cases 1 and 2, under the low demand scenario, and 5 and 6, under the high demand scenario. Investment requirements are much higher (42% in low demand scenario, 34% in the high demand scenario), although this effect is partially offset by somewhat lower operating costs.

26. **Costs of higher demand.** Differences in investments between the two demand scenarios have already been discussed (paragraphs 24, 25). Operating costs are also significantly higher for the high demand cases. Under the most favorable cost conditions (low electricity import prices, imports allowed through the entire planning period), investment costs and operating costs are higher 22% and 10% respectively, in the high demand scenario (Cases 1 and 5). In addition, investments requirements are shifted at least one year forward in the low demand cases (1995 versus 1996), relative to their high demand counterparts.

27. **Nuclear Option.** Nuclear technology has been consistently rejected in all the scenarios. Since it is an interesting option from the aspect of power supply security, one case (Case 9) has been defined in which the construction of a 500 MW nuclear unit is started in 1998, in order to assess additional costs associated with building a nuclear plant. All other parameters in Case 9 are set as in Case 8 (high demand, imports not allowed after 2005, import prices high). Simulation gave the following results: total construction costs for the planning period increased by US$947 million (from US$4531 million to US$5478 million), while the system operating costs slightly decreased (by US$ 47 million).

28. The true cost of a nuclear option can vary widely, depending on the nuclear technology used, plant site, environmental aspects, availability of local nuclear industry and expertise, regulatory requirements, etc.. Since nuclear plants have a long construction period and high capital costs, the length of the planning period in the model (1994-2010) may not be sufficient for the proper analysis of the nuclear option. In addition, the economic viability of nuclear power is affected by the cost of the alternative modes of power generation. For example, nuclear power could become an economically attractive option if the price of imported gas (and fuel oil) increases substantially in the future. In order to increase the depth of the analysis of the nuclear option, it is necessary to carry out a sensitivity analysis with respect to all these factors. In view of declining electricity demand, however, there is no urgency to decide now about the construction of a nuclear power plant. The Ministry of Power should closely monitor the evolution of electricity demand, the cost of imported gas, and the cost of nuclear technology, and regularly update its least cost planning analysis.

TABLE 2: WASP DATA FOR THE EXISTING PLANTS

Plant	No. of Units	Base Power	Max. Power (MW)	Base Heat Rate (KCal/KWh)	Avg. Incre. Heat Rate (KCal/KWh)	Fuel Cost (US cents/Kcal)	Fuel Type	Spinning Reserve	Forced Outage Rate	Maint. Requirements	Maintenance Class	Non-Fuel O& M Costs	
												Fixed $/KW m	Variable $/MWh
Berezov	4	70	150	2734	2202	663.3	3	10	1.8	21	150	1.4	2
Berezov	2	70	160	2734	2208	663.3	3	10	1.9	23	160	1.4	2
Lukoml	2	120	300	2358	2117	663.3	3	10	1.5	23	300	1.4	2
Lukoml	6	120	300	2356	2088	663.3	3	10	1.5	24	300	1.4	2
Novopolotsk	2	30	50	1820	1353	618.6	2	10	1.5	18	55	1.4	2
Novopolotsk	4	30	47	1820	1353	618.6	2	10	1.5	16	50	1.4	2
Novopolotsk	1	30	60	1820	1353	618.6	2	10	1.5	14	60	1.4	2
Novopolotsk	1	30	135	1820	1353	618.6	2	10	1.5	17	135	1.4	2
Mozyr	1	30	60	2320	1914	618.6	2	10	1.5	13	60	1.4	2
Mozyr	1	50	135	2370	1914	618.6	2	10	1.5	19	135	1.4	2
Svetlogorsk	1	15	15	2170	1120	663.3	3	0	1.5	10	15	1.4	2
Svetlogorsk	3	25	40	2170	1120	663.3	3	10	1.5	10	45	1.4	2
Svetlogorsk	1	30	50	1890	1633	663.3	3	10	1.5	35	60	1.4	2
Svetlogorsk	1	20	50	1890	1633	663.3	3	10	1.5	24	50	1.4	2
Gomel	2	60	180	2030	1715	663.3	3	10	1.5	21	180	1.4	2
Grodno	2	30	60	1960	2339	663.3	3	10	1.5	13	60	1.4	2
Grodno	1	30	50	1960	2339	663.3	3	10	1.5	11	50	1.4	2
Minsk TEC-3	4	13	20	1141	3409	663.3	3	10	1.5	18	25	1.4	2
Minsk TEC-3	2	30	60	1520	1820	663.3	3	10	3	22	60	1.4	2
Minsk TEC-3	2	50	100	1520	1820	663.3	3	10	5.2	43	100	1.4	2
Minsk TEC-4	1	30	50	2100	2100	663.3	3	10	3.4	15	60	1.4	2
Minsk TEC-4	2	45	110	2100	2100	663.3	3	10	1.5	19	110	1.4	2

Plant	No. of Units	Base Power	Max. Power (MW)	Base Heat Rate (KCal/KWh)	Avg. Incre. Heat Rate (KCal/KWh)	Fuel Cost (US cents/Kcal)	Fuel Type	Spinning Reserve	Forced Outage Rate	Maint. Requirements	Maintenance Class	Non-Fuel O& M Costs	
												Fixed $/KW m	Variable $/MWh
Minsk TEC-4	3	100	250	2310	1143	663.3	3	10	4.5	28	250	1.4	2
Bobruysk	3	40	60	1790	1790	610	2	10	6.7	22	60	1.4	2
Mogilev	2	30	50	1780	1780	610	2	10	1.5	14	60	1.4	2
Mogilev	2	30	40	1780	1780	610	2	10	1.5	13	50	1.4	2
Mogilev	1	60	130	1780	1780	610	2	10	1.5	16	135	1.4	2
Small Plants	17	10	15	1250	1250	663.3	3	5	1.5	21	91	1.4	2

TABLE 3: WASP DATA FOR CANDIDATE UNITS

Unit	Base Power (MW)	Max. Power (MW)	Base Heat Rate (KCal/ KWh)	Average Incre. Heat Rate (KCal/ KWh)	Fuel Cost (US Cents/ KCal)	Fuel Type	Spinning Reserve (%)	Forced Outage Rate (%)	Main. Require. (MW)	Main. Class (MW)	Non-fuel O&M Cost	
											Fixed (US$/ KW m)	Variable (US$/ MWh)
Gas Turbine, Single Cycle	90	120	2900	2900	663.3	3	10	2	14	120	1	1
Gas Turbine, Combined Cycle	60	100	1800	1800	663.3	3	5	2	21	100	1.4	1.9
Gas Turbine, Combined Cycle	180	320	1780	1780	663.6	3	5	2	28	320	1.4	1.9
Gas Turbine, Combined Cycle	250	450	1720	1720	663.6	3	5	2	28	450	1.4	1.9
Steam Unit, Gas	100	250	2310	1543	663.6	3	5	2	28	250	1.4	2
Steam Unit, Gas	100	320	2350	2350	663.6	3	5	2	28	320	1.4	2
Pulverized Coal	150	500	2300	2300	594.2	1	5	2	35	500	2.1	3.8
Nuclear	450	500	2500	2300	244	0	0	20	45	500	1.8	2

TABLE4: CANDIDATEUNITS IN OPTIMALEXPANSION PLANS

	Case 1	Case 2	Case 3, 4	Case 5	Case 6	Cases 7,8	Case 9
Gas Turbine, Single Cycle, 120MW	5	5	5	5	5	5	5
Gas Turbine, Combined Cycle 100MW	6	5	5	5	4	6	6
Gas Turbine, Combined Cycle 320 MW	4	2	2	4	2	7	4
Gas Turbine, Combined Cycle 450MW	3	8	8	5	10	6	7
Steam Unit, Gas 250MW	0	0	0	0	0	0	0
Stem Unit, Gas 320MW	0	0	0	0	0	0	0
Pulverized Coal 500MW	0	0	0	0	0	0	0
Nuclear 500MW	0	0	0	0	0	0	1

TABLE 5: BELARUS POWER SYSTEM EXPANSION PLANNING - INVESTMENT REQUIREMENTS

Case		1	2	3, 4	5	6	7, 8	9
Demand		Low	Low	Low	High	High	High	High
Imports		Allowed	No after 2005	All/No aft. 2005	Allowed	No after 2005	All/No aft. 2005	No after 2005
Import Prices		Low	Low	High	Low	Low	High	High
Nuclear Plant		Option	Option	Option	Option	Option	Option	Fixed
Capital Cash Flows (in const. 1993 US$, millions)								
1993								
1994								
1995					21	21	21	21
1996		21	21	21	97	97	107	107
1997		97	97	97	185	185	240	240
1998		164	164	185	161	161	226	226
1999		64	64	203	185	185	252	252
2000		21	0	380	161	161	358	358
2001		97	29	504	185	180	474	474
2002		183	241	379	166	227	421	421
2003		189	612	299	229	585	381	431
2004		284	903	320	307	901	371	484
2005		376	600	356	396	606	410	696
2006		467	431	419	479	432	483	841
2007		425	391	389	422	403	429	521
2008		274	261	261	278	279	281	330
2009		76	74	74	79	79	79	79
2010								
Total Capital Cost (1993-2010)		**2739**	**3889**	**3889**	**3351**	**4502**	**4531**	**5478**
Total Cost of Oper. (1993-2010)		**17952**	**17635**	**17355**	**19680**	**19367**	**19182**	**19135**
Total Levelized Cost		7945	8045	8142	8778	8896	8968	9005
New Capac. Composition (in year 2010) (MW)	Imports	1500	0	0	1500	0	0	0
	SCGT-120	600	600	600	600	600	600	600
	CCGT-100	600	500	500	500	400	600	600
	CCGT-320	1280	640	640	1280	640	2240	1280
	CCGT-450	1350	3600	3600	2250	4500	2700	3150
	NUCL-500	0	0	0	0	0	0	500
	TOTAL	5330	5340	5340	6130	6140	6140	6130
First Unit in Year:		2000	2000	2000	1999	1999	1999	1999

TABLE 6.a: POWER SYSTEM EXPANSION PLANNING - CAPACITY ADDITIONS AND INVESTMENTS

LOW DEMAND CASES

	Case 1				Case 2				Cases 3, 4			
Year	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)
1993												
1994	500		500		500		500		500		500	
1995												
1996				21				21				21
1997				97				97				97
1998				164				164				185
1999				64				64				203
2000		450	450	21		450	450	0		450	450	380
2001				97				29				504
2002	500		500	183	500		500	241		450	450	379
2003	1250		1250	189	1250		1250	612		900	900	299
2004	1250	450	1700	284	1250	360	1610	903		450	450	320
2005	1500	240	1740	376	1500	320	1820	600		420	420	356
2006	1500	560	2060	467		2000	2000	431		440	440	419
2007	1500	320	1820	425		450	450	391		450	450	389
2008	1500	740	2240	274		670	670	261		690	690	261
2009	1500	550	2050	76		550	550	74		550	550	74
2010	1500	520	2020			540	540			540	540	
Totals		**3830**		**2739**		**5340**		**3889**		**5340**		**3889**

TABLE 6.b: POWER SYSTEM EXPANSION PLANNING - CAPACITY ADDITIONS AND INVESTMENTS

HIGH DEMAND CASES

	Case 5				Case 6				Cases 7,8			
Year	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)	Imports (MW)	Cap. Add (MW)	Total (MW)	Inv. ('93 US$mil)
1993												
1994	100		1000		1000		1000		1000		1000	
1995	750		750	21	750		750	21	750		750	21
1996	750		750	97	750		750	97	750		750	107
1997	750		750	185	750		750	185	750		750	240
1998	750		750	161	750		750	161	750		750	226
1999	250	450	700	185	250	450	700	185		690	690	252
2000	500		450	161	500		500	161		240	240	358
2001	500	450	950	185	500	450	950	180		320	320	474
2002	500		750	166	750		750	227		320	320	421
2003	1250	450	1700	229	1250	450	1700	585		890	890	381
2004	1500		1500	307	1500		1500	901		420	420	371
2005	500	570	2070	396	1500	560	2060	606		550	550	410
2006	1500	480	1980	479		2010	2010	432		450	450	483
2007	1500	420	1920	422		450	450	403		420	420	429
2008	11500	740	2240	278		650	650	279		740	740	281
2009	1500	520	2020	79		570	570	79		550	550	79
2010	1500	550	2050			550	550			550	550	
Totals		**4630**		**3351**		**6140**		**4502**		**6140**		**4531**

TABLE 6.c: POWER SYSTEM EXPANSION PLANNING - CAPACITY ADDITIONS AND INVESTMENTS

NUCLEAR OPTION

	Case 9			
Year	**Imports (MW)**	**Cap. Add (MW)**	**Total (MW)**	**Inv. ('93 US$mill)**
1993				
1994	1000		1000	
1995	750		750	21
1996	750		750	107
1997	750		750	240
1998	750		750	226
1999		690	690	252
2000		240	240	358
2001		320	320	474
2002		320	320	421
2003		890	890	431
2004		420	420	484
2005		550	550	696
2006		450	450	841
2007		450	450	521
2008		750	750	330
2009		500	500	79
2010		550	550	
Totals		**6130**		**5478**

BELARUS

BOILER CONVERSION COMPONENT

Terms of Reference

1. The Government of Belarus (GoB) intends to convert a total of six boilers, presently burning petroleum fuels (heavy fuel oil, gas oil or natural gas), into wood and wood-waste burning boilers. Wood wastes and the initial identification of boiler houses which could be converted to utilize this waste economically have been estimated. Wood waste is an indigenous fuel available at certain industrial facilities and through thinning operations associated with forest management. Wood and wood waste utilization systems are common in market economies such as Sweden, Finland, Canada, and the U.S. The feasibility study will cover the conversions of approximately six boilers: two at industrial sites, one power plant, and three district heating systems. An introduction and broad terms of reference for the work involved are presented below.

A. Introduction

2. The rapid escalation of oil and gas prices to world market levels following the breakup of the former Soviet Union (FSU) has made it necessary for Belarus, a net primary energy importer, to develop and expand the utilization of indigenous energy resources. Wood fuel has been identified as having a high and immediate potential for displacing imported energy. Based on the potential for environmentally sustainable increases in harvests from domestic forests, and from increased utilization of wood wastes, a joint World Bank, EBRD and USAID mission (in December 1993) estimated an annual availability of 7 million cubic meters of wood fuel for initial planning purposes. This wood resource has an energy value of approximately 1.3 million tons of oil equivalent (mtoe), or 4% of Belarus' estimated 1993 primary energy consumption. Based on 1990 data, existing energy applications amount to 2.2 million cubic meters/year, or about 0.4 mtoe.

3. There are three primary opportunities for additional wood applications: (a) Rural or small town district heating systems under the Ministry of Housing and Municipal Services; (b) industrial boilers in wood manufacturing industries; and (c) boilers under Belarusenergo, the integrated Belarus electricity company. A desirable investment plan could include three types of projects:

- (i) conversion of three rural district heating boilers in the range of 1 to 20 Gcal/hour ($10 million);
- (ii) conversion of one power plant (5-20 MW) at Belarusenergo ($8-10 million); and
- (c) conversion of two boilers at wood industries under Belesprom (US$6-8 million).

Initial sites for possible boiler conversion have been identified but need to be investigated and confirmed by the Consultant. Cost estimates are indicative and the total cost of US$25 millon includes local costs of US$5 million. It is estimated that investments being considered would use less than 3% of the waste wood available, however, they would demonstrate the technical and economic viability of the concept and would set a precedent for subsequent investments.

B. Consultant's Terms of Reference

4. The study will address the technical, economic and financial viability of the conversions, and their environmental impact and sustainability. The Consultant's main tasks include:

- **Site Selection:** Based on preliminary identification, select boilers most amenable to conversion to wood fuels. Criteria would include: (a) need for replacement; (b) location near waste wood sources; (c) heat/electricity demand and the load factors (applications with continuous, year round load are likely to have the most favorable economics); and (d) the financial stability of the entities within which the boilers are located. Judgement on the financial prospects of the entity is needed in order to ensure the sustainability of project benefits with regard to continued maintenance of equipment. A rudimentary screening, based on sales, price and cost data, would be adequate.

- **Resource Availability and Access:** Estimate wood fuel availability in the vicinity of selected sites from forests and/or wood processing industries, the infrastructure to transport the wood fuel, and other site requirements.

- **Environmental Impact Assessment:** Identify all possible environmental impacts, and means of mitigating negative effects, including (a) those resulting from expanding the energy use of wood (such as illegal harvesting, diversion of non-waste wood for fuel purposes, risk of use of contaminated wood, etc.); (b) status of regulations and regulatory agencies; (c) methods of wood collection, transport, and storage; and (d) boiler operations (including safety) and emissions. Guidelines for the environmental review are attached.

- **Basic Engineering:** Specify wood fuel handling (receiving, processing, storing, metering, and feeding) equipment and boiler modifications required. New boiler and ancillary equipment may be required at some sites.

- **Air Pollution Control:** Specify air pollution monitoring and control equipment, with the control equipment designed to meet relevant Belarussian standards.

- **Cost Estimates:** Provide cost estimates for (a) equipment and materials; (b) civil works; (c) installation; (d) transportation; (e) training and technical assistance (as needed); and (f) physical and price contingencies. Costs should be based on reliable supply sources (probably western sources) with supply from CIS countries as an alternative case, and should be broken into their foreign exchange and local currency components.

- **Technical and Economic Feasibility Analysis:** Justify the engineering design selected (least-cost analysis), and perform an economic cost-benefit analysis for each boiler conversion. A "with" and "without" project analysis is likely to be most suitable for economic justification. Costs would include investment and operating costs, while benefits would include the value of fossil fuels replaced. Externalities, such as environmental impacts, should be factored into the analysis and be based on local and regional considerations.

- **Project Implementation and Technical Assistance:** Assess the capacity of the implementing entities to carry out the conversions according to World Bank guidelines (procurement, project accounting, reporting, etc.) and identify assistance needed to strengthen implementation capacity.

Define an implementation schedule, highlighting key milestones, and list performance indicators which can be monitored during project implementation.

C. Schedule and Outputs

5. The work would start in April 1994. Three reports would be required: (a) a brief report indicating the sites selected, the basis of selection, and the main environmental issues identified which will be addressed in the full study (within one month of inception of the study) (b) a draft final report covering the scope of work outlined above; and (c) a final report. All reports are to be prepared in English, however, the executive summaries should be translated into Russian and sent to the respective Belarussian authorities along with the main reports. Reports in English should be sent to the World Bank and other project donors/financiers. The draft final report is to be distributed by June 30, 1994 for review, and discussed with the Belarus authorities and the World Bank in early July. Based on these discussions, the final report would be issued by July 31, 1994.

D. Staffing

6. The following staff requirements are anticipated:

- **Site Selection, Engineering, and Cost & Benefits Estimation:** Three engineers and one accountant/financial analyst for 5 weeks: 20 person-weeks

- **Economic Analysis:** One economist for 4 weeks: 4 person-weeks

- **Environmental Impact Assessment:** One environmental specialist for 3 weeks: 3 person-weeks

- **Project Management:** One engineer or economist for 3 weeks: 3 person-weeks

Total Foreign Consultants: **30 person-weeks**

Local Consultants: 2 Engineers for 6 person-weeks each: Total **12 person-weeks**

- **Travel:** Two week trip for project manager. Two week trip for six people (three engineers, one environmental specialist, one accountant, and one economist). Total of seven trips for a total of 14 weeks.

BELARUS
ENERGY SECTOR REVIEW

Thermal Power Plant Rehabilitation Study
Terms of Reference

A. Introduction

1. The rapid escalation of oil and gas prices to world market levels following the breakup of the former Soviet Union (FSU) has made it necessary for Belarus, a net primary energy importer and an energy intense economy, to quickly undertake investments to reduce its energy intensity. A priority area where this energy intensity, and production costs, can be reduced is in electricity generation. Under the proposed project, the thermal power rehabilitation component would rehabilitate selected older or less efficient units to increase their thermal efficiency (which would in turn reduce their consumption of fuel), increase their electric and heat output, improve their reliability and availability, and reduce their pollutant emissions. The safety of operation would also be enhanced. One of the options of unit reconstruction would be the dismantling and replacement of these older units by newer technologies, for example gas turbine, combined cycle (GTCC) units (i.e. a radical reconstruction or repowering).

2. Based on their age, the need for reliable and efficient supply for commercial and residential consumers, and their energy efficiency improvement potential, the following three power plants (in order of priority) have been identified for possible rehabilitation:

(a) Minsk TEC-3: 420 MWe capacity, 8 units (Startup: 1951)
(b) Minsk TEC-2: 31 MWe capacity, 3 units (Startup: 1947)
(c) Svetlogorsk TEC: 270 MWe capacity, 4 units (Startup: 1958)

3. A preliminary review of the design and operation of these plants has revealed that some original components are old and unreliable (having exhausted their useful operating lives), the equipment suffers from the lack of maintenance, spare parts and chemicals are unavailable, control systems are obsolete, emission control and monitoring devices do not exist, and make-up water and waste-water treatment systems are inadequate and of old technology. More specifically, the generating equipment at the Minsk TEC-2 is a likely candidate for replacement by a GTCC plant and so is the first stage (original phase) installation of the Minsk TEC-3. The Svetlogorsk TEC power plant has just replaced both its second phase machines (65 and 50 MW turbines), but its first phase units (four units 45 MW each) are also candidates for replacement or rehabilitation. In summary, all three power plants would benefit from rehabilitation of their fuel burning and control systems, the installation of emission control and monitoring systems and the modernization of their water treatment systems.

4. **Sector Organization:** The Ministry of Energy (Power) of Belarus is a vertically integrated state-owned utility responsible for the planning, design, procurement, construction and operation of the generation, transmission and distribution of electric power and for producing a large part of the thermal energy for industrial use and district heating in the country. The Ministry of Communal Services (Minzhilcomhoz) provides the heat and operates the district heating networks in those small towns and villages in which combined-heat-and-power (CHP) plants do not exist. The Ministry of Energy carries out many ancillary functions in connection with these responsibilities including procurement of fuel,

arranging for fuel delivery to its power stations, meeting environmental requirements, construction of facilities, maintenance, etc.

5. **Installed Capacity:** Total installed generating capacity in December 1993 was about 6,800 MW, consisting of thermal power units burning natural gas or heavy fuel oil (HFO, also referred to as mazout). Most of the thermal stations are equipped with multiple fuel boilers which can burn either mazout or natural gas, and are capable of co-firing these fuels. The system has limited hydro, and no coal, gas turbine (single or combined cycle) or nuclear capacity.

6. **Environmental Performance:** The mazout is high in sulfur, varying from about 2.5 to 3.5 percent sulfur. In order to avoid sulfur oxide emissions to the atmosphere, because of low volumes of storage capacity at the plants and because natural gas has been generally available up to now, the thermal plants have been using gas much more heavily than mazout. Since many plants are located in or near cities, the problem of NOx emissions has also been a concern. The MoE expresses a great deal of interest in reducing NOx emissions from some boilers through combustion modification and other techniques. As prices of fuels are nearing more realistic levels, with gas becoming more expensive than high-sulfur mazout, a shift to mazout is likely. No reliable ambient air quality data were available at the time of the World Bank mission, but because of the large capacities of some of the thermal power stations and their proximity to populated areas, it would be reasonable that any proposed rehabilitation, repowering, or life extension project should include some provisions for improved emissions control.

7. Nearly all the power generating units are constructed in accordance with standard designs prevalent throughout the former Soviet Union (FSU) and the CMEA countries. A general description and status of the Electricity Subsector (including a list of power units) is presented in the Attachment.

B. Consultant Terms of Reference

8. The Consultant would work with the MoE and the plant management. Separate feasibility studies are to be conducted for each of the plants in two phases:

- **Phase 1:** Completion of a screening and inception report assessing if the plant could potentially be rehabilitated economically, or whether it should be retired; and

- **Phase 2:** Dependent on MoE decision after Phase 1, completion of the rehabilitation/repowering full feasibility study according to TORs below.

9. **Objective:** The overall objective each study is to: (a) identify a least cost rehabilitation program for the plant (within a budget constraint of US$75 million for each plant); and (b) prepare a feasibility report addressing the technical, and economic viability of the rehabilitation activities recommended, their sustainability with respect to the environmental impact and the financial condition of the plant, and the capacity of the plant to implement the project according to World Bank requirements. In preparing the feasibility studies, the consultants will draw on preliminary studies/assessments already completed on the Power subsector in Belarus.

10. **Organization:** In order to minimize overlap and duplication, and to benefit from potential synergies, one Consultant would be responsible for the feasibility studies for Minsk TEC-2 and TEC-3, while a separate Consultant would be responsible for the Svetlogorsk TEC study.

11. **Main Tasks**

Analysis of Present Condition/Basic Data Report:

(i) Describe briefly, and provide key data, on actual and name-plate plant characteristics. Data and analysis required includes measurement of the heat rate of units, operational life, prospects for life-extension based on the condition of material and equipment, limitations of plant systems, record of forced and unforced outages, and an assessment of operating, maintenance and safety practices, and environmental performance (particularly monitoring and control of noxious gas emissions and waste water treatment). A significant amount of this data for each plant may already be available and only require compilation.

(ii) Visit (if necessary) manufacturers of boilers, turbo-generators, and other equipment in service in Belarus to obtain more detailed equipment design information and historical data on industry-wide in-service performance. Alternatively, performance data could be collected from other operating plants in Belarus.

Least-Cost Rehabilitation Program: Based on the situation analysis and budget constraints, prepare a least-cost rehabilitation program for the plant which includes:

(i) **Basic Engineering:** Technically and economically justified investments and maintenance work needed to extend the life of the units by five to ten years while meeting internationally accepted norms for availability, reliability and efficiency for units of comparable age as well as meeting applicable environmental standards. In searching for the most economic solution, the Consultant will estimate costs and benefits of all reasonable options for rehabilitation and life extension, e.g., rehabilitate as is or repower unit utilizing gas turbines as topping units.

(ii) **Cost Estimates:** Provide cost estimates for (a) equipment and materials; (b) civil works; (c) installation; (d) transportation; (e) training and technical assistance (as needed); and (f) physical and price contingencies. Costs should be based on reliable supply sources (probably western sources) with supply from CIS countries as an alternative case, and should be broken into their foreign exchange and local currency components (at an agreed upon exchange rate).

Environmental Review: Review current operations and projected changes as a consequence of the rehabilitation including:

(i) Fuel types, transport, and storage, and associated hazards;

(ii) Model air pollution dispersion for the power plants to examine several scenarios, including: (a) exclusive use of worst possible fuel (highest sulfur content); (b) expected fuel use pattern; and (c) exclusive use of best fuel (gas). Calculate expected emissions of particulate matter (from oil combustion), sulfur dioxide (SO_2), and nitrogen dioxides (NO_x) under each scenario, and their concentrations at potentially sensitive receptors (population centers, sensitive crop areas, etc.) and at points of maximum ground level concentrations;

(iii) Relationship between the project's impact on air quality and current environmental standards in Belarus, and those proposed by the Commission for the European Communities (CEC) and the World Bank;

(iv) Use, or proposed use, of CFCs, PCBs, and asbestos; and

(v) Reported health effects in the region of the plant.

Environmental Recommendations: The Consultant shall provide the following recommendations:

(i) **Environmental Mitigation Plan** for both the short term (immediate, low-cost actions which will improve emission control, and meet national standards) and the long term (e.g., meeting internationally acceptable standards) in a cost effective manner. Actions proposed should be described along with expected benefits, and estimated investment and operating costs. It will be important to liaise with the Ministry of Environment in order to coordinate plant level investment proposals with national and local pollution abatement strategies. Guidelines of the World Bank requirements for environmental assessments, Operational Directive 4.01, will be provided separately; and

(ii) **Institutional Strengthening Plan:** Provide recommendations for training and technical assistance (including terms of reference) to develop the in-plant capacity to address environmental issues associated with the environmental mitigation plan.

Institutional Capacity Building: At the plant level, identify critical areas which could most benefit from the transfer of international expertise. The Consultant would prepare terms of reference which can be used to procure suitable technical assistance in the areas identified. Specific areas include general management strengthening, maintenance scheduling, inventory management, boiler startup and shut-down procedures, cost accounting and financial management. In addition, the Consultant shall:

(i) Examine problems of fuel procurement and acquisition, and define the scope of work at the plant level necessary to maintain/upgrade facilities which receive fuel.

(ii) Review the financial operations of the plant and prepare a financing plan for the proposed rehabilitation project.

Technical and Economic Feasibility Analysis: Justify the engineering design selected (least-cost analysis), and perform an economic cost-benefit analysis for the rehabilitation. A "with" and "without" project analysis is likely to be most suitable for economic justification. Externalities, such as environmental impacts, should be factored into the analysis and be based on local and regional considerations.

Project Implementation and Technical Assistance:

(i) Provide technical specifications for equipment/materials recommended so that the information may be used to prepare bidding documents for procurement according to World Bank guidelines (which include international competitive bidding).

(ii) Assess the capacity of the implementing entities to carry out the rehabilitation program according to World Bank guidelines (procurement, project accounting, reporting, etc.) and identify assistance needed to strengthen implementation capacity.

(iii) Define an implementation schedule, highlighting key milestones, and list performance indicators which can be monitored during project implementation.

(iv) Determine the outage time for the proposed rehabilitation (construction, commissioning and acceptance testing). The Consultant will recommend a schedule for unit rehabilitation/life extension that will minimize plant unavailability consistent with the load demand curve for Belarus.

C. Responsibilities of the Ministry of Energy (MoE)

11. The MoE will be responsible for overseeing the work of the Consultant. It order to facilitate the work required, and its timely completion, the MoE will:

(a) Constitute a Working Group within the Ministry of Energy, with participation of staff from the plants to be rehabilitated and experts from specialized technical Belarussian institutes to review, guide, and accept the work of the Consultant;

(b) The Consultant, in cooperation with the Working Group, will outline a detailed work plan for its activities, including visits to the plant, and the services and support expected from the MoE. The Consultant will provide the Working Group with a list of the inspection instruments, and metallurgical laboratory testing equipment needed and determine what is readily available in Belarus and what would be brought in by the Consultant; and

(c) The MoE will arrange for representatives of the appropriate plant engineering and design organizations, familiar with the principles and basis of plant design, to discuss with and assist the Consultant in carrying out the necessary inspection.

D. Study Schedule and Reporting

12. The study is expected to begin in April 1994 and be completed within a six month period. The following reports would be required (in English to the World Bank and other funding agencies, and in Russian to the MoE):

(a) a screening and inception report covering Phase 1, and outlining the Phase II work plan as agreed with MoE (within one-two months of awarding the contract);

(b) An informal interim report (after three months) summarizing preliminary results and recommendations resulting from the inspections and initial assessments;

(c) A draft final report one month after completion of the work (not later than September 15, 1994). MoE and the World Bank will review the report and submit comments to the Consultant within one month of receiving the report; and

(d) A final report within one month of receipt of the comments, the Consultant will prepare the final project report. The Consultant will prepare and supply 3 copies of the final project report in English to each of the funding agencies and the World Bank, and 10 copies in Russian to the MoE.

E. Staffing

13. The Consultant would try to maximize the use of local expertise (with due regard to the quality and timeliness of the final report) and will be responsible for arranging and funding all required translation and secretarial services. It is expected that the Consultant's team would include the following skills (one person may combine more than one skill):

(i) Organization Coordinator;
(ii) Boiler Inspector experienced in the manufacture/maintenance of utility boilers;
(iii) Turbine Inspector experienced in turbine manufacture/maintenance;
(iv) Generator Inspector (electrical engineer with experience in generator maintenance, testing and inspection with a major electric utility);
(v) Balance-of-Plant (BOP) Inspector with broad familiarity with operation and maintenance of power plant equipment such as condensers, pumping stations, cooling towers, unfired heat exchangers or feedwater heaters, water treatment equipment and pumps, and large fans;
(vi) Fuel Acquisition Expert;
(vii) Instrumentation and Control Inspector;
(viii) Metallurgy Specialist with broad experience to cover problems with generator materials (laminated metallic parts, generator conductors and generator cooling systems, e.g.) as well as the steam turbine, steam boiler and main steam piping materials that are exposed to high temperatures and pressures;
(ix) Electrical Testing Expert preferably from a utility electrical testing laboratory with access to instruments, and with extensive power plant electrical testing experience;
(x) Environmental Specialist;
(xi) Power Generation Planner/Economist;
(xii) Financial Analyst; and
(xiv) Qualified Quantity Surveyor - Cost Estimator.

F. Cost Estimate

	US$
Consultant fees (40 foreign and 20 local staff-weeks)	200,000
Travel, lodging, subsistence	50,000
Office supplies, translations, HQ support	50,000
Inspection/diagnostic equipment	50,000
Total cost	**350,000**

Of which US$100,000 is estimated for Phase 1, and about US$50,000 is estimated specifically for the environmental review.

BELARUS
ENERGY SECTOR REVIEW

Transmission and Dispatch System: Rehabilitation and Upgrade Feasibility Study

Terms of Reference

1. The Government of Belarus (GoB) intends to build a new 110 kV substation, rehabilitate two more substations of the electricity transmission and distribution (T&D) system, and automate the electricity network in a rural area of the Minsk region. The Belarus Ministry of Power (MoP) would like to introduce western technology as a means of enhancing system capability, improving system control and reducing losses.

A. Introduction

2. The rapid escalation of oil and gas prices to world market levels following the breakup of the former Soviet Union (FSU) has made it necessary for Belarus, a net primary energy importer and an energy intense economy, to quickly undertake investments to reduce its energy intensity. A priority area where this energy intensity can be reduced is through loss reduction and reliability improvement in the T&D system.

3. The structure and extent of the existing transmission system is adequate to service most of the Republic's electric energy transmission needs, except in certain areas of Minsk, where the T&D system is old and overloaded causing frequent outages. Studies carried out by local research institutes indicate the need for a new substation, rehabilitation of two more substations and the necessity for automation/modernization of parts of the electric network. The need for a large new substation has been also identified, in Yuzhnaya, but the GoB decided to pursue less capital-intensive options at the present time. It is proposed, therefore, by the GoB to replace a new 110 kV substation in Antonishki, rehabilitate two more substations, in Kolyadichi and Storozhovskaya, and automate the electric network in the rural area of Pookhovichi.

4. The following requirements for improved operation and maintenance of the transmission system were identified, in order of priority:

(i) New 110 kV substation at Antonishki including two 60 MVA transformers with 110 kV switchgear, automation and control system, and communication with the existing power system. This substation will supply electricity to two new residential districts of Minsk, Sukhorevo and Malinovka, and supplement the already overloaded transmission system in the Minsk area.

(ii) Rehabilitation and upgrade of the 330 kV Kolyadichi substation with installation of new 200 MVA transformer; rehabilitation of a 330 kV switchgear; rehabilitation and upgrade of an 110 kV switchgear; and modernization of the existing controls and electro-mechanical relay protection systems.

(iii) Rehabilitation of an 110 kV substation at Storozhovskaya, which supplies electricity to the central part of Minsk including a new residential district and the public transportation system. This project will include: one 63 MVA transformer, rehabilitation of an existing switchgear, and modernization of the control system.

(iv) Automation of the electric network (110/10 kV) in the rural district of Pookhovichi. This rehabilitation will improve the system reliability, reduce operating costs and increase electricity to residential and agricultural production areas.

5. The estimated cost for this component would be about US$25 million, consisting of US$20 million in foreign and US$5 million in local costs. The Bank mission, supported by preliminary calculations by local institutes, estimated that the energy savings from loss reduction and increase in system capacity and reliability will be adequate to justify the planned expenditure.

6. **Sector Organization:** The Ministry of Power (MoP) of Belarus is a vertically integrated state-owned utility responsible for the planning, design, procurement, construction and operation of the generation, transmission and distribution of electric power and for producing a large part of the thermal energy for industrial use and district heating in the country. The Ministry of Communal Services (Minzhilcomhoz) provides the heat and operates the district heating networks of the smaller towns and villages where combined-heat-and-power (CHP) plants do not exist. MoP carries out many ancillary functions in connection with these responsibilities including procurement of fuel, arranging for fuel delivery to its power stations, meeting environmental requirements, construction of facilities, maintenance, etc.

7. **Installed Electric Power Capacity:** Total installed generating capacity in December 1993 was about 6,800 MW, consisting of thermal power units burning natural gas or heavy fuel oil (HFO, also referred to as mazut). Most of the thermal stations are equipped with multiple fuel boilers which can burn either mazut or natural gas, and are capable of co-firing these fuels. The system has limited hydro, and no coal, gas turbine (single or combined cycle) or nuclear capacity. The transmission system has a length of 32,773 km, operating at 330 kV, 220 kV, 110 kV and 35 kV with 50 Hz, and it is connected to Lithuania, Russia, Ukraine and Poland. The distribution network consists of 10 kV and 380 V lines with length of 113,000 km and 130,000 km, respectively.

8. Nearly all of the power systems are constructed in accordance with standard designs prevalent throughout the former Soviet Union (FSU) and the CMEA countries. (A general description of the Electricity Subsector is presented in Annex 1 or page 63).

B. Consultant[1] Terms of Reference

9. **Objective:** The study will (i) assess the cost-effectiveness of the proposed projects and prioritize them for financing, (ii) identify appropriate T&D technologies and suppliers, and (iii) develop preliminary specifications and budgetary cost estimates.

10. The Consultant would review the present condition of the system and the studies performed by Minskenergo and local research institutes, which analyze the power flows through the T&D system, will identify changes in electricity flows, determine active and reactive power flows and bottlenecks, and

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1 The term ***consultant*** is used in this document to mean a lead consulting/engineering organization with subcontractors, both local (from Belarus) and from overseas.

identify the equipment needed to upgrade system operation and bring about loss reduction. This feasibility study is expected to entail three visits to Belarus, each requiring about two weeks:

The first field visit would concentrate on data gathering from Minskenergo, and review of previous studies performed by Belarussian organizations. Following the first visit, the remaining tasks will be described in detail (in the project workplan) including the required analyses to assess the cost-effectiveness of the proposed projects and the most suitable technologies and equipment suppliers.

The second field visit would review the preliminary cost-effectiveness analyses and recommendations of the Consultant, as well as evaluations of suitable technologies.

The third field visit would present the recommendations, cost estimates and cost-benefit analyses to MoP and Minskenergo, and would collect any final information needed for the final report.

11. Following the field visits and analysis of the data collected, a final report will be delivered which will present the result of each of the tasks described below. This final report will be used to prepare the bidding documents for procurement of all or some of the proposed projects and should, therefore, include appendices with technical specifications for equipment.

12. **Main Tasks**

Task 1. Data Gathering and Project WorkPlan

The purpose of this task is to gather all the relevant information available and finalize the project workplan. Upon commencement of the project, the Consultant will send a team of experts to visit Minsk, Belarus for a 2 to 3-week mission. The purpose of the mission will be to initiate the project, establish working relationships and responsibilities, collect available system and project-related studies and data, identify additional data needed, and agree upon a detailed project work plan with Minskenergo. Data/information will include, but not be limited to, studies performed by Belarussian organizations and data regarding the Minskenergo T&D system in its present operating condition (design data and historical data on system reliability, type of equipment failures, and maintenance records). Also, information will be gathered on the future expansion or change in electricity flow patterns. Other on-going relevant projects will be identified and exchange of information arrangements will be made to avoid duplication of effort.

The Consultant will evaluate the available studies, identify additional analyses needed to determine the cost effectiveness (technical, economic and financial feasibility) of each of the proposed projects/components, make working arrangements with Belarussian research institutes and potentially other organizations to participate in this feasibility study. Finally, the Consultant will develop a workplan detailing the remaining tasks and begin preparing the feasibility studies.

Task 2. New Substation in Antonishki, Minsk

The purpose of this task is to review and evaluate the proposed new 110 kV substation at Antonishki, which includes two 60 MVA transformers with 110 kV switchgear, control system, and communication with the existing power system, and assist Minskenergo to prepare bid documents so that procurement of goods and services meets World Bank requirements of international competitive bidding. This substation will supply electricity to two new residential districts, Sukhorevo and Malinovka, and supplement the already overloaded transmission system in the Minsk area. Project requirements and preliminary design specifications have been already developed by the Byelorussian State Design and Survey and Scientific Research Institute, Minsk. After review of these documents, the Consultant will:

- advise Minskenergo on the design and proposed scope of work
- identify suitable technologies, especially western technologies, and suppliers
- assess the economic and financial viability of the project, and
- assess the project's impact on system operation, reliability and operating costs.

Task 3. Rehabilitation of the Kolyadichi substation

The purpose of this task is to review the proposed rehabilitation and upgrading of the 330 kV Kolyadichi substation with installation of new 200 MVA transformer, rehabilitation of a 330 kV switchgear, rehabilitation and upgrade of an 110 kV switchgear, and rehabilitation of the existing relay protection system. The Consultant will review the project requirements and preliminary design specifications, which have been already developed by the Byelorussian State Design and Survey and Scientific Research Institute, Minsk, and:

- advise Minskenergo on the design and proposed scope of work
- identify potential testing, which may be needed to assess the remaining life of critical components
- identify suitable technologies, especially western technologies, and suppliers
- assess the project's economic and financial viability and its impact on system operation, reliability and operating costs.

Also, the Consultant will identify environmental issues associated with the operation of the present and rehabilitated facilities, and propose ways to address them.

Task 4. Rehabilitation of the Storozhovskaya substation

The purpose of this project is to review the proposed rehabilitation of an 110 kV substation at Storozhovskaya, assess its cost-effectiveness and assist Minskenergo to prepare bid documents so that procurement of goods and services meets World Bank requirements of international competitive bidding. The Storozhovskaya substation supplies electricity to the central part of Minsk including a new residential district and the public transportation system. The proposed project includes: one 63 MVA transformer, rehabilitation of an existing switchgear, and modernization of the control system. This rehabilitation will improve the system reliability, reduce losses and increase electricity to the public transportation system and residential neighborhoods of Minsk.

Similarly to Task #3, the Consultant will review the project requirements and preliminary design specifications, which have been already developed by the Byelorussian State Design and Survey and Scientific Research Institute, Minsk, and:

- advise Minskenergo on the design and proposed scope of work
- identify potential testing, which may be needed to assess the remaining life key components
- identify suitable technologies, especially western technologies, and suppliers
- assess the project's cost-effectiveness and impact on system operation, reliability and operating costs.

Also, the Consultant will identify environmental issues associated with the operation of the present and rehabilitated facilities, and propose ways to address them.

Task 5. Automation and modernization of the electric network in Pookhovichi, District

The purpose of this task is to assist Minskenergo in defining the scope of work of Pookhovichi automation/modernization project, assess its cost-effectiveness relative to the other proposed T&D projects (Tasks 2-4), identify suitable technologies and suppliers, and prepare preliminary design specifications. The automation of the Pookhovichi electric network (110/10 kV) will improve the system reliability, reduce operating costs and increase electricity to residential and agricultural production areas. The Consultant will review the configuration, status, operating characteristics and historical data of this network, and work with Minskenergo to set project objectives, define scope of work, identify suitable technologies and suppliers, develop preliminary specifications and cost estimates, and assess the project's cost-effectiveness.

Task 6: Compile and Finalize the Feasibility Study Report

The Consultant will prepare a feasibility study report presenting the background information in a clear and concise manner, brief description of the proposed options, cost estimate and impact of each option on the Minsk and Belarus electric network, and recommendations regarding the priority of each option. The final report will include also technical specifications for equipment and materials recommended, so that the information may be used for preparing bidding documents for procurement according to World Bank Guidelines (which include international competitive bidding).

In addition, the final report will include an **assessment of the capacity of the implementing entities** to carry out the T&D rehabilitation program according to World Bank guidelines (procurement, project accounting, reporting, etc.) and identify technical assistance needed to strengthen implementation capacity. For example, Minskenergo could be trained in planning and implementing T&D rehabilitation projects, including utilization of modern techniques and cost-benefit analyses. The Consultant would prepare terms of reference which can be used to procure suitable technical assistance in the areas identified. Specific areas include general management strengthening, maintenance scheduling, inventory management, cost accounting and financial management.

C. Responsibilities of Minskenergo

13. Minskenergo will be responsible for overseeing the work of the Consultant. In order to facilitate the work required, and its timely completion, Minskenergo will:

(a) Constitute a Working Group within Minskenergo, with participation of staff from other relevant organizations and experts from specialized technical Belarussian institutes to review, guide, and accept the work of the Consultant; also, Minskenergo will appoint a Project Director (or equivalent) to be the main interface between the Project Manager of the Consultant and Minskenergo. It will be the responsibility of the Project Director to solicit the advise of the Working Group in a timely manner to comply with the outlined project schedule.

(b) The Consultant, in cooperation with the Project Director, will outline a detailed work plan for its activities, including visits to the plant, and the services and support expected from the Working Group; and

(c) The Working Group will assist in arranging for representatives of the appropriate engineering and design organizations, familiar with the principles and basis of system design, to discuss with and assist the Consultant in carrying out the necessary inspections and design work.

D. Study Schedule and Reporting

14. The study is expected to begin in May 1994 and be completed within a six month period. The following reports would be required (in English to the World Bank and other funding agencies, and in Russian to the MoP):

(a) a brief report outlining the workplan as agreed with MoP (within one month of the awarding of the contract);

(b) An informal interim report (after three months) summarizing preliminary results and recommendations resulting from the Consultant initial reviews and analyses;

(c) A draft final report (not later than October 15, 1994). Minskenergo and the World Bank will review the report and submit comments to the Consultant within one month of receiving the report; and

(d) A final report within one month of receipt of the comments, the Consultant will prepare the final project report. The Consultant will prepare and supply 3 copies of the final project report in English to each of the funding agencies and the World Bank, and 10 copies in Russian to Minskenergo.

E. Staffing

15. The Consultant would try to maximize the use of local expertise (with due regard to the quality and timeliness of the final report). The Consultant's team would include the following skills (one person may combine more than one skill): Project and general organization management; (b) Transmission and Distribution engineering; (c) Communications specialist; (d) System automation and management information specialist; (e) T&D rehabilitation specialist; (f) Commercial/Business management specialist/financial analyst; (g) Procurement specialist; and (h) Project economist.

F. Cost Estimate

	US$
Consultant fees (20 foreign and 10 local staff-weeks)	100,000
Travel, lodging, subsistence	50,000
Office supplies, translations, HQ support	25,000
Inspection/diagnostic equipment	25,000
Total cost	200,000

BELARUS
ENERGY SECTOR REVIEW

District Heating Rehabilitation Component Feasibility Study
Terms of Reference

1. The Government of Belarus (GoB) intends to rehabilitate heat generation and distribution system in Minsk. The objective of the rehabilitation component is to improve fuel efficiency and environmental performance, reduce technical and commercial losses, extend the remaining useful life of the systems, and introduce institutional and tariff reforms necessary for an efficient district heating system.

A. Introduction

2. The rapid escalation of oil and gas prices to world market levels following the breakup of the former Soviet Union (FSU) has made it necessary for Belarus, a net primary energy importer and an energy intense economy, to quickly undertake investments to reduce its energy intensity. A priority area where this energy intensity, and production costs, can be reduced is in the district heating systems. A preliminary assessment by a joint World Bank, EBRD and USAID mission to Belarus in December 1993 identified the following key characteristics and main problems of the DH system:

3. **System:** District heating (DH) supplies a large portion of thermal energy to consumers in the Republic of Belarus. According the data from the Government Energy Program, the total generation of thermal energy in year 1990 for the country was 112 million Gcal (MGcal) mainly from:

Combined-Heat-and-Power (CHP) Plants	43.5 MGcal (38.8%)
Heat-Only-Boilers (HOB)	10.0 MGcal (9%)
Industrial (and DH) Boiler Houses	54.0 MGcal (48%)

4. Initial DH system diagnostics and investment proposals have been developed by "BELNIPIenergoprom" (research and design institute) and Minskenergo. In addition, the EU Energy Center in Minsk is coordinating DH system rehabilitation and institutional strengthening studies for the republic.

5. **Organization - General:** Cogeneration Power Plants (CPP) are under authority of Ministry of Power (MOP), the exception is very small ones located at industrial facilities. Also under authority of MOP are large DH stations, usually of heat capacity more than 100 Gcal/hr. The Industrial Boiler Houses mainly provide steam and hot water to industrial facilities and to DH systems in nearby cities, and are under the authority of various industrial ministries. The third source of DH supply are Central Boiler Houses, which are less than 100 Gcal/hr (usually less than 20 Gcal/hr) and are under the authority of Ministry of Housing and Communal Services (MOHCS). Such boiler houses are located in small cities and rural areas, when CPP or IBH are not present. In large cities, all heating mains and block distribution pipes up to the entry into the thermal substations or up to the gates of industrial facilities are under authority of MOP. Thermal substations and piping after substations (including pipes inside the buildings) are under MOHCS. The piping and equipment designated exclusively for industrial facilities are operated by personnel of appropriate industrial facilities.

6. **Organization - Project:** The Minsk District Heating Authority, under Minskenergo, is responsible for operating the Minsk TEC-2 CHP plant, all heat transmission for Minsk, and most of heat distribution. In addition to the TEC-2 plant, heat is generated from the Minsk TEC-3 and TEC-4 CHP plants (under Minskenergo), 3 "emergency" and 3 local HOBs under the DH authority, some smaller boiler houses under the municipality, and some industrial boilers. The heat transmission and distribution network under the DH authority consists of about 1,200 km of pipeline, a central dispatch center, and pumping stations. The Minsk DH authority is responsible for preparing the proposed rehabilitation component.

7. **Main Problems**

The main problems of the Minsk DH systems, as discussed with the local officials, are as follows:

DH Network: The district heating systems are operated with variable temperature and constant flow which requires high pumping energy even when the heating requirements are low. This prevents the utilization of the whole potential of the DH network. Constant flow operation also requires the pressure to be kept unnecessarily high which in turn increases leakages in the network.

Main Pipes: Old age of equipment and a high degree of corrosion, external and internal, causes massive water losses with consequent losses of heat and high makeup water requirements. The corrosion of pipes may be external or internal and may be caused by poorly maintained and inadequately drained pipe culverts (external), or by poor water quality inside the pipes (internal). According the data provided by Minsk District Heating Authority the thermal losses from system in the year 1991 were 10.17%. Such data cannot be considered reliable because of absence of metering.

Minsk TEC-2, Combined-Heat-and-Power (CHP) Plant: The first of the three units of the Minsk TEC-2 CHP plant was commissioned in 1927 and units No.2 and 3 were commissioned in the 1940's. The plant has a total power generating capacity of 31 MWe. The plant is in a rather good condition considering the age and operating hours of the generating equipment. However, a reliable heat supply to the central area of Minsk calls for measures to improve the performance and reliability of the plant. A comprehensive study on rehabilitation options for the Minsk TEC-2 has been prepared by a local engineering institute in October 1992.

Boilers: Inadequate maintenance, mainly because of shortages of boiler tubes, various materials, and spare parts. The damaged boiler tubes usually are plugged, and the total amount of heat exchange surface is decreased, leading to higher flue gas temperature and increased losses with flue gas discharge. Leaky boiler casings and/or ducts lead to increased air infiltration into the boilers. This causes furnace cooling, carbon monoxide generation, and overloading of induced draft fans by parasitic air.

Dispatch: Dispatch of heating loads is not sufficiently managed between the interconnected boiler houses and/or between boilers within individual boiler houses. The efficiencies of boilers differ significantly because of design, age, level of maintenance etc.

Fuel Distribution: No comprehensive program of fuel distribution (natural gas or mazut) between steam and water boilers. The efficiency of hot-water boilers is sharply decreased when they utilize high-sulphur mazout, especially with low return water temperature. Return water temperature must not go below 104° C to prevent corrosion of heating surfaces when high-sulphur mazout is used.

Pressure Reduction: Pressure-reducing pumps installed on the return heating mains (as a means of protecting radiators of buildings located at low sites against excess pressure) decrease efficiency. Excess pressure is created in some low sites by heating pumps installed at power plants located on sites with high elevation. The reducing pumps increase the pressure drop in building heating pipes, which increases the velocity of water flow. This, in turn, decreases the heat rejection per cubic meter of water and increases the average temperature of water in the return mains and, as a result, the temperature of heating steam extraction from the cogeneration turbines is increased which decreases power generation. In the case of heating boilers, higher return water temperatures result in increased flue-gas temperature.

Building Envelop: Very poor insulation of existing buildings. A demand-side program should be investigated to determine the needed investments in materials for the weatherization and insulation of buildings, heat metering, and control of heat consumption at the building level. A pilot program, with possible funding under the Global Environmental Facility (GEF), is planned to support the larger program proposed by the European Union THERMIE program.

B. Consultant Terms of Reference

8. **Objectives:** The objectives of the feasibility study are to identify and prepare an investment project for the following key areas of the Minsk district heating network operations:

(i) Rehabilitation of the Kedyshko boiler house and heating network in this area of Minsk
(ii) Upgrading maintenance capability (particularly improved pipeline insulation technology)
(iii) Rehabilitation of the Minsk TEC-2 combined-heat-and-power plant.

Project feasibility is to be assessed from the technical, economic, and environmental view points. In addition the consultant would recommend tariff regimes needed to support the financial viability of the project and of the district heating system. Although institutional restructuring is not within the scope of work of this study, the Consultant (consulting company) would be required to draw up terms of reference for such a study if necessary (depending on restructuring proposals and actions recommended by other studies).

9. The DH network connected with the main boiler plant at Kedyshko was selected based on its exemplary structure and the reasonably good condition. The maximum present heat demand of the network is approximately 400 Gcal/h. The rehabilitation of this network will be an example for the future rehabilitations of other DH networks in Belarus. In defining the recommended investments, the Consultant will:

- Identify rehabilitation options in the main boiler house and in the related DH network
- Calculate hydraulic regimes of the DH system per different thermal loads, and determine minimum pressure level into the supply mains after the main heat source

- Prepare a phased program for changing from constant flow to variable flow to ensure sufficient, but not excessive, heat supply service level
- Identify the main leakage potential in different parts of the network and prepare a phased program for the investments required to eliminate leakages
- Determine the substations where the biggest benefits can be achieved by new substation connections for hot tap water and the radiator network
- Determine the need and concept for energy meters and control arrangements

10. Old age of equipment and a high degree of corrosion and wear requires an efficient maintenance work shop with updated technological capabilities. To strengthen the maintenance capabilities of the Minsk DH Network Company the Consultant will prepare an investment program which especially emphasizes the replacement and insulation of worn-out DH piping. In defining the recommended investments, the Consultant will:

- Review the present maintenance policies and organization
- Review the present facilities
- Review the procedure for the replacement of worn-out piping
- Identify the bottlenecks of the maintenance system
- Investigate critical sections of the system where cost effective benefits can be achieved through the introduction of new technology (e.g. pre-insulated pipes).

11. The Minsk TEC-2 power and heat plant is at the end of its useful life with declining efficiency and reliability. The objective of this component of the study is to: (a) assess the technical and economic feasibility of Minsk TEC-2 rehabilitation; and (b) identify a least cost rehabilitation program for the plant. In defining the investment program the Consultant will:

- Review and evaluate the rehabilitation study prepared by the local engineering institute
- Review the operating and maintenance history of the plant
- Identify all rehabilitation options including their technical, environmental and economic characteristics.
- Identify all repowering options, that use gas-turbine-combined-cycle technology

12. **Scope of Work:** The study would cover all aspects of the DH system connected to the boiler at Kedyshko beginning from fuel supply and storage, and through the boiler house and the distribution network to the main substations and residential areas. The Consultant should draw on information available from already completed studies and preliminary assessments, and maximize the utilization of local expertise. "BELNIPIenergoprom", Minskenergo and the EU Energy Center in Minsk should be consulted for background and diagnostics work already completed. The Consultant's specific tasks would include:

Analysis of Present Condition/Basic Data Report:

(i) Describe and provide key data for the Kedyshko district heating network and its operational status (including actual versus name-plate characteristics). In collaboration with the Minsk DH authority, the consultant should evaluate the data on present DH network, the main boiler house, pumping stations, piping and substations including instrumentation and controls. The analysis will also cover water cleaning and makeup water treatment plants. Data and analysis required includes an extensive use of hydraulic simulation by computer as basis for the most economic options of the present rehabilitation program and future development. Using the hydraulic calculation program, the consultant will determine the temperature and pressure levels, and the network configuration that best fits all given process restrictions. The hydraulic simulation shall be able to resolve non-symmetrical hydraulic flows and the ability to simulate various consumer interfaces in simultaneous calculation. Further, the data and analysis required includes identification of heat and water losses.

(ii) Describe and provide key data for the present maintenance management, procedures and facilities. In collaboration with the Minsk DH authority, the Consultant should evaluate the present procedures especially focusing the actions required for improved insulation, corrosion resistance and replacement of worn-out DH piping. This evaluation would cover all aspects beginning from the procurement of pipes to the acceptance testing of the pipes.

(iii) Describe and provide key data for TEC-2 on actual and name-plate plant characteristics as well as its operational status. Data and analysis required includes review of the heat rate of TEC-2, system heat losses, prospects for life-extension based on the condition of material and equipment, limitations of plant systems, record of forced and unforced outages, an assessment of operating, maintenance and safety practices, and of environmental performance (particularly monitoring and control of noxious gas emissions and waste water treatment). A significant amount of this data for each plant may already be available and only require compilation.

Least-Cost Rehabilitation Program: Based on the situation analysis and budget constraints, prepare a least-cost rehabilitation program which includes:

(i) **Basic Engineering:** Technically and economically justified investments and maintenance work needed to reduce system heat and water losses, and improve overall efficiency of the DH network and the work needed to extend the life of TEC-2 by five to ten years and to rehabilitate the main boiler plant at Kedyshko to meet typical (internationally accepted) norms for availability, reliability and efficiency for units of comparable age as well as meeting applicable environmental standards. In searching for the most economic solution, the Consultant will estimate costs and benefits of all reasonable options for rehabilitation and life extension.

Technically and economically justified investments to increase the capability of the maintenance organization especially in the successful replacement of the worn-out piping.

(ii) **Cost Estimates:** Provide cost estimates for (a) equipment and materials; (b) civil works; (c) installation; (d) transportation; (e) training and technical assistance (as needed); and (f) physical and price contingencies. Costs should be based on reliable supply sources (probably western sources) with supply from CIS countries as an alternative case, and should be broken into their foreign exchange and local currency components (at an agreed upon exchange rate).

Environmental Review and Mitigation Plan: Review current operations and projected changes as a consequence of the rehabilitation, and propose a mitigation plan as outlined in the attached guidelines. Specific issues would include:

(i) An assessment of hazards associated with the transport and storage of fuels (for TEC-2 and the selected heat-only boilers) and recommended mitigative measures;

(ii) Measure present NO_x, CO and C_xH_y emissions of TEC-2 and the main boiler house at Kedyshko;

(iii) Model air pollution dispersion for TEC-2 to examine several scenarios, including: (a) exclusive use of worst possible fuel (highest sulfur content); (b) expected fuel use pattern; and (c) exclusive use of best fuel (gas). Calculate expected emissions of particulate matter (from oil combustion), sulfur dioxide (SO_2), and nitrogen dioxides (NO_x) under each scenario, and their concentrations at points of maximum ground level concentrations;

(iv) Relationship between the project's impact on air quality and current environmental standards in Belarus, and those proposed by the Commission for the European Communities (CEC) and the World Bank;

(v) Use, or proposed use, of CFCs, PCBs, and asbestos;

(vi) Reported health effects in the region of the plant; and

(vii) Recommendation for environmental management.

Institutional Capacity Building and Financial Analysis: Identify critical areas which could most benefit from the transfer of international expertise. The Consultant would prepare terms of reference which can be used to procure suitable technical assistance in the areas identified. Specific areas include general management strengthening, maintenance scheduling, inventory management, load dispatch management, cost accounting and financial management. In addition, the Consultant shall specifically review the financial operations of the DH system and prepare financial projections based on existing tariffs and those proposed by the Consultant.

Technical and Economic Feasibility Analysis: Justify the engineering design selected (least-cost analysis), and perform an economic cost-benefit analysis for the rehabilitation. A "with" and "without" project analysis is likely to be most suitable for economic justification. Externalities, such as environmental impacts, should be factored into the analysis and be based on local and regional considerations.

Project Implementation and Technical Assistance:

(i) Provide technical specifications for equipment/materials recommended so that the information may be used to prepare bidding documents for procurement according to World Bank guidelines (which include international competitive bidding).

(ii) Assess the capacity of the implementing entities to carry out the rehabilitation program according to World Bank guidelines (procurement, project accounting, reporting, etc.) and identify assistance needed to strengthen implementation capacity.

(iii) Define an implementation schedule, highlighting key milestones, and list performance indicators which can be monitored during project implementation.

(iv) Determine the outage time for the proposed rehabilitation (construction, commissioning and testing). The Consultant will recommend a rehabilitation schedule that will minimize system unavailability consistent with seasonal demand.

Final report: The following is proposed as a guideline for the structure of the final report:

1. Executive Summary
2. Introduction
3. System Analysis (for each component)
   3.1 Organization Structure
   3.2 Physical Infrastructure

3.3 Operations and Maintenance
3.4 Financial Condition and Commercial Performance
3.5 Environmental Analysis

4. Rehabilitation Action Plan (for each component)
    4.1 Least-Cost Investment Program
    4.2 Training Requirements
    4.3 Costs and Benefits
    4.4 Actions to Strengthen Commercial Performance
    4.5 Longer-term issues/upgrades to be considered in a follow-up project/study
5. Economic and Financial Analysis
    5.1 Economic Cost-Benefit Analysis
    5.2 Financial Projections and Recommended Tariffs and Rate Structure
6. Implementation Schedule and Performance Indicators

Annex Technical Specifications for Bidding Documents

C. Responsibilities of the Government of Belarus

13. The GoB has designated the Minsk DH Authority (under Minskenergo) to be responsible for overseeing the work of the Consultant. It order to facilitate the work required, and its timely completion, the DH authority will:

(a) Constitute a Working Group within MoP and Minskenergo headed by a senior staff member and including operations and design experts from the company and specialized Belarussian institutes to assist, review, guide, and accept the work of the Consultant; also, the Ministry will appoint a Project Director (or equivalent) to be the main interface between the Project Manager and the GoB. It will be the responsibility of the Project Director to solicit the advise of the Working Group in a timely manner to comply with the outlined project schedule.

(b) The Consultant, in cooperation with the Project Director and the Working Group, will outline a detailed work plan, including site visits and the services and support expected from the DH authority. The Consultant will provide the PPU with a list of the inspection instruments and determine what is readily available in Belarus and what would be brought in by the Consultant;

(c) Minskenergo will provide the Consultant with all the necessary data and background material for the Consultant to perform the tasks to prepare the project according to these terms of reference; and

(d) Minskenergo will arrange for representatives of the appropriate engineering and design organizations, familiar with the principles and basis of system design, to discuss with and assist the Consultant in carrying out the necessary inspections.

(e) Minskenergo will be responsible for performing the baseline environmental test as well as the tests required for the assessment of the remaining life of the components as specified in the previous tasks. The Consultant will review and advise on the required test matrix, testing procedures and data analysis.

D. Study Schedule and Reporting

14. The study is expected to begin in May 1994 and be completed within a six month period. The following reports would be required (in English to the World Bank and other funding agencies, and in Russian to the MoE):

(a) a brief inception report outlining the work plan as agreed with the Working Group (within one month of the awarding of the contract);
(b) An informal interim report (after three months) summarizing preliminary results and recommendations resulting from the inspections and initial assessments;
(c) A draft final report one month after completion of the work (not later than November 15, 1994). The PPU and the World Bank will review the report and submit comments to the Consultant within one month of receiving the report; and
(d) A final report within one month of receipt of the comments, the Consultant will prepare the final project report. The Consultant will prepare and supply 3 copies of the final project report in English to each of the funding agencies and the World Bank, and 10 copies in Russian to the PPU.

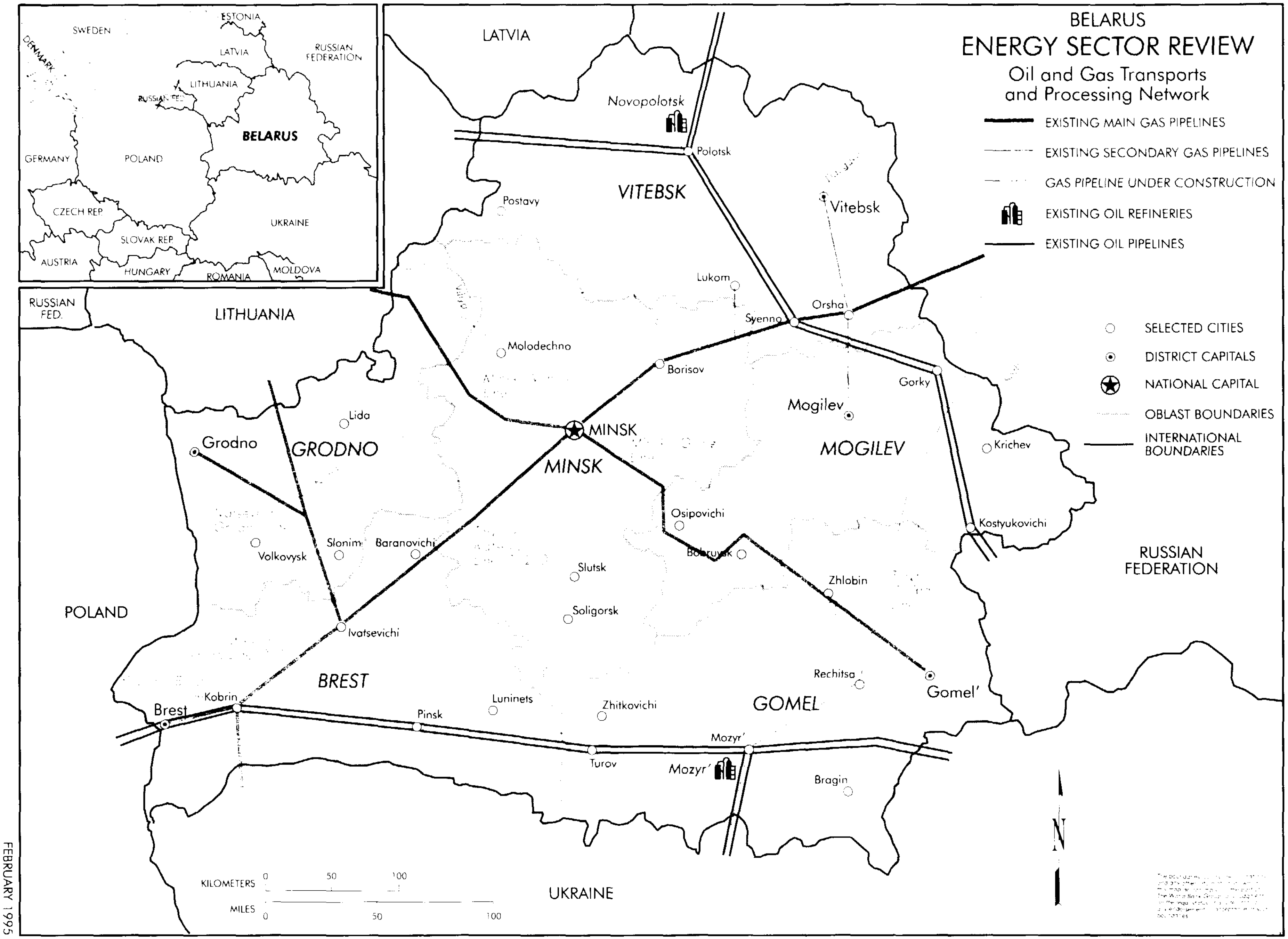
E. Staffing

15. The Consultant would try to maximize the use of local expertise (with due regard to the quality and timeliness of the final report) and will be responsible for arranging and funding all required translation and secretarial services. It is expected that the Consultant's team would include the following skills (one person may combine more than one skill):

(a) Project and general organization manager;
(b) DH system engineer;
(c) Water treatment specialist;
(d) Boiler Inspector
(e) Turbine/Generator Inspector
(f) Environmental Specialist
(g) Procurement and scheduling engineer;
(h) Project economist;
(i) Financial analyst.

F. Cost Estimate

	US$
Consultant fees (40 foreign and 20 local staff-weeks)	200,000
Travel, lodging, subsistence	50,000
Office supplies, translations, HQ support	50,000
Inspection/diagnostic equipment	50,000
Total cost	**350,000**


BELARUS
ENERGY SECTOR REVIEW
Oil and Gas Transports
and Processing Network
EXISTING MAIN GAS PIPELINES
EXISTING SECONDARY GAS PIPELINES
GAS PIPELINE UNDER CONSTRUCTION
EXISTING OIL REFINERIES
EXISTING OIL PIPELINES
SELECTED CITIES
DISTRICT CAPITALS
NATIONAL CAPITAL
OBLAST BOUNDARIES
INTERNATIONAL BOUNDARIES
SWEDEN
ESTONIA
DENMARK
LATVIA
RUSSIAN FEDERATION
LITHUANIA
RUSSIAN FED.
BELARUS
GERMANY
POLAND
CZECH REP
SLOVAK REP
UKRAINE
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ROMANIA
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Polotsk
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MOGILEV
Krichev
Osipovichi
Kostyukovichi
Slonim
Baranovichi
Volkovysk
Bobruysk
Slutsk
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RUSSIAN FEDERATION
POLAND
Soligorsk
Ivatsevichi
Rechitsa
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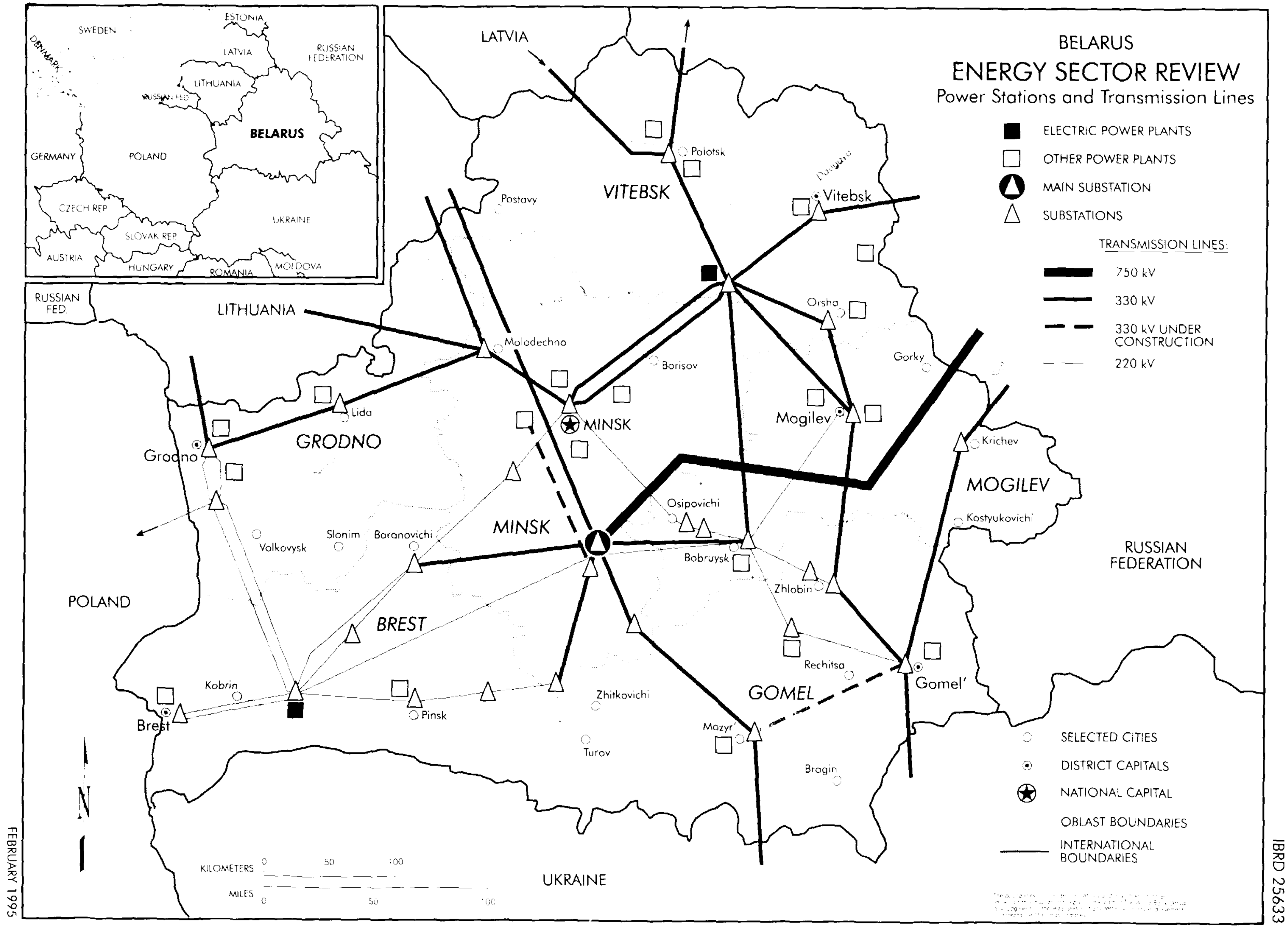

BELARUS
ENERGY SECTOR REVIEW
Power Stations and Transmission Lines
ELECTRIC POWER PLANTS
OTHER POWER PLANTS
MAIN SUBSTATION
SUBSTATIONS
TRANSMISSION LINES:
750 kV
330 kV
330 kV UNDER CONSTRUCTION
220 kV
SELECTED CITIES
DISTRICT CAPITALS
NATIONAL CAPITAL
OBLAST BOUNDARIES
INTERNATIONAL BOUNDARIES
SWEDEN
ESTONIA
DENMARK
LATVIA
RUSSIAN FEDERATION
LITHUANIA
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CZECH REP
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IMAGING

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