Electricity supply in Central and Eastern European countries: The role of nuclear energy

Throughout the region, countries are facing decisions about how to meet a latent demand for electricity services

by
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Electricity services are closely related to the quality of life. In Central and Eastern Europe (CEE) there is a vast reservoir of unsatisfied demand in the residential sector, and economic development will surely provide driving forces for more electricity consumption in the industrial sector.

Countries that once belonged to the Eastern European bloc, which had a rather rigid and centrally planned economic system, have developed nuclear power on a considerable scale as a source for electricity generation. As these countries embark on a process of political and economic reform, the question arises how these changes will influence the future development of nuclear energy.

This article looks at the situation from a number of perspectives. It will briefly review electricity supply and demand in this region and the present status of the nuclear programmes. It will then deal in more detail with the main issues related to nuclear energy and other electricity generation sources, and with the role that the IAEA can play in the planning, development, and safety of nuclear power in the region.

Electricity demand and supply

Electricity consumption in the CEE region has grown steadily during the last decade but at a lower rate than in other regions of the world: While the annual growth rate of electricity consumption averaged 2.3% in CEE between 1960 and 1990, it averaged 2.7% in countries of the Organisation for Economic Co-operation and Development (OECD) and 6.8% in developing countries during the same period.

By 1990, the CEE's electricity consumption had reached some 2300 terawatt-hours (TWh), or about 20% of the world's total consumption of 11 600 TWh that year. The share of electricity in primary energy consumption is roughly 28% in CEE as compared to 38% in OECD countries and 24% in developing countries. On a *per capita* basis, the annual electricity consumption in the CEE region is about 5.4 megawatt-hours (MWh). This is considerably lower than in OECD countries, where it is 7.7 MWh, but much higher than in developing countries, where it is only 0.7 MWh.

Throughout the region, the outlook for electricity demand is dominated by uncertainties about economic growth as well as institutional and structural changes. The economy in some of the countries is declining, which causes electricity demand to flatten or even decrease. Since there is no historical analogy of transition from a centrally planned economy towards a market economy, it is difficult to foresee when and how the recovery will take place. How this will affect the energy and electricity sectors is even more difficult to predict.

The potential for greater energy efficiency is high both in the industrial and residential sectors; significant savings are also possible in electricity generation, transmission, and distribution. However, while the CEE's average *per capita* electricity consumption is rather high, the demand for electricity services is far from reaching the saturation level.

Given the potential for efficiency improvement, it may still be possible to reduce electricity intensity; nevertheless, more supply is likely to be needed for industrial development and to

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enable improved living conditions for the population. In the long term, as economic recovery occurs, a substantial latent demand for electricity services *per capita* will be the dominant characteristic of the region.

The effect of institutional changes on electricity demand will be complex, at least in the near term. While higher prices and market competition should encourage efficiency, social and economic needs will lead to increased potential demand. Emerging regional environmental concerns also could have an impact on consumption patterns and policies, especially in the energy sector.

Concerning energy resources, the situation is somewhat different from country to country. As the successor to the Soviet Union, the Commonwealth of Independent States (CIS) has vast coal, oil, gas, hydro, and uranium resources, and Poland has rich coal deposits. Other countries have to import a large proportion of their energy needs. Overall, the region has been a net exporter of energy, mainly because of the large exports of the former Soviet Union. The situation is different for some countries, however. At the beginning of the 1990s, the share of imports in primary energy consumption amounted to 66% in Bulgaria, 37% in Hungary and 32% in what is now the Czech and Slovak Republics.

Except in Albania, where hydropower produces nearly 90% of the electricity, the main source of electricity in the region is fossil fuels. Other CEE countries have potential hydro resources, but they have not been in a position to develop them because of environmental constraints in many cases.

To reduce their dependence on imports, as well as on coal transportation, the CEE countries opted for the development of nuclear power. This development was facilitated and encouraged by the existence in the former Soviet Union of a large nuclear power and nuclear fuel cycle infrastructure. The Soviet industry had the capability of supplying components and services in the nuclear sector throughout the region. Furthermore several CEE countries having natural uranium resources were able to produce uranium concentrates for their own supply and even for export.

Another important factor was the contractual arrangements offered by the former Soviet Union for supplying fuel cycle services. Of particular importance was the agreement to take back the fuel supplied, after irradiation, without requiring the countries operating nuclear power plants to subsequently take back the high-level radioactive waste produced from reprocessing the fuel. These arrangements allowed the importers of nuclear power plants to avoid investing in long-term storage facilities for spent fuel or high-level waste.

Moreover, centrally planned economies do favor a consistent implementation of nuclear programmes. In such economies, once the technical and economic studies have been performed and the political decisions taken, the governmental authorities in all the related economic sectors have the obligation to support the implementation of the approved policy and programmes.

Electricity supply (1990)

Total electricity	2 300 TWh (20% of world total)
Electricity per capita	5.4 MWh
Share of electricity in primary energy	28%

Nuclear power capacity (1991)

	Installed capacity		Electricity generation	
	No. of units	GW(e)	TWh	Nuclear share (% of total)
Bulgaria	6	3.5	13	34
Czech and Slovak Republics	8	3.3	22	29
Hungary	4	1.6	13	48
Slovenia	1	0.6	5	6
Ex-USSR*	45	34.7	212	13
Regional total	64	43.7	265	12

*Includes Lithuania, Russia, and Ukraine.

Electricity supply and nuclear power capacity in Central and Eastern Europe

Current status of nuclear programmes

At the beginning of 1992, there were 64 nuclear power plants connected to the grids in CEE countries. The plants have a total electrical generating capacity of 43.75 gigawatts-electric (GWe). This represents more than 13% of the installed nuclear capacity in the world. Operating nuclear power plants are located in Bulgaria, the Czech and Slovak Republics, Hungary, Lithuania, Slovenia, and the CIS.

With the exception of Slovenia, and Romania where no nuclear plants are operating but five are being built, all the CEE countries based their nuclear power programmes on reactor types developed by the former Soviet Union. In Slovenia, a 660-MWe pressurized water reactor (PWR), imported from the USA and manufactured by Westinghouse, came into operation in 1983. The planned plants in Romania are of Canadian design.

Two basic designs were developed industrially by the former Soviet Union: pressurized light-water reactors (WWER) and graphite-

moderated water-cooled reactors (RBMK). Only WWER units were exported.

RBMK plants, which were constructed solely for operation within the former Soviet Union, are now operating in Lithuania, Russia, and Ukraine. Twenty units of this type, most of them having a capacity of 1000 MWe, were connected to the grid by the end of 1991, representing a total capacity of some 16 GWe. These units are refueled while operating, which provides a high availability factor and leads to considerable economic advantages. However, they have important safety shortcomings, as demonstrated by the Chernobyl accident in 1986. Consequently, the decision was made to discontinue the RBMK's development and to significantly improve the safety level of those under operation or in an advanced stage of construction.

Three WWER models have been developed. The first model — the 440/230 — has a capacity of 400 MWe and was developed during the 1960s. The second one — the 440/213 — has the same capacity but an improved design, mainly of the safety equipment. The third and more advanced WWER model — the WWER-1000 with a capacity of 1000 MWe — was developed in the early 1980s and its safety concept is similar to that of PWRs in operation throughout the world.

WWER-440 plants are operating in Bulgaria, the Czech and Slovak Republics, Hungary, and Russia, while WWER-1000 plants are operating in Bulgaria, Russia, and Ukraine.

By developing their nuclear power programmes, CEE countries have considerably reduced their reliance on coal for electricity generation. At the beginning of 1992, nuclear's share of electricity generation in the CEE region was 12%; this share was 48% in Hungary, 34% in Bulgaria, 29% in the Czech and Slovak Repubics, 13% in the CIS, and 6% in the former Yugoslavia.

With a nuclear electricity generation of 212 TWh in 1991, the former Soviet Union was the world's third largest producer of nuclear generated electricity, exceeded only by the United States and France. The former Czechoslovakia with 22 TWh, Bulgaria with 13 TWh, and Hungary with 13 TWh also stood among the largest nuclear electricity producers in the world in 1991. In these countries nuclear power has become a main source of electricity supply and an established component of the energy mix.

In the face of environmental and other concerns, more nuclear plants are being built in some CEE countries. At the beginning of 1992, 36 nuclear units, with a total capacity of 28 GWe were under construction in the region. This represents nearly 45% of the nuclear capacity under construction in the world. Twenty-four units were under construction in Russia and Ukraine, six in the Czech and Slovak Republics, five in Romania, and one in Lithuania.

In Russia and the Ukraine, most of the reactors under construction, 21 units, are of the WWER 1000 type; three RBMK units, whose construction started before 1986, also are projected to be completed with enhanced safety levels. For most plants under construction in these countries, the civil works started some 10 years ago and they should be put into service in the coming years. However, given the present economic situation, some delays are likely to occur. If construction stays on schedule, the total nuclear capacity in these countries by the mid-1990s would equal the present operating nuclear capacity in France. It should be mentioned that the former Soviet Union's nuclear programme has been substantially reduced, first after the Chernobyl accident and then by the economic crisis. Of 43 units on which construction work had begun, 12 have been cancelled and the pace of construction of the others has been slowed by new licensing procedures and shortage of funds.

In the Czech and Slovak Republics, the four WWER-440s at Mochovce and the two WWER-1000s at Temelin, whose construction started in the mid-1980s, are expected to be in commercial operation before 1995. Their operation would double the total combined nuclear capacity of these countries, from 3.5 GWe to 7 GWe.

In Romania, the construction of five units of Canadian design started in 1980. These units, supplied by AECL, are being built with strong support by the Canadian industry. The start of operation of the first unit is scheduled for 1993 and the total capacity of some 3 GWe is expected to be fully operational by the end of the decade.

Beyond the units under construction, nuclear plants are planned in most CEE countries, including those which have none under construction today. Hungary, which already produces half of its electricity from nuclear power plants, is heavily dependent on imports for its electricity supply and is likely to order new nuclear plants of Western type by the turn of the century. Poland decided in December 1990 to discontinue the construction of its first nuclear power plant, two units of the WWER-440 type imported from the former Soviet Union. At that time, 40% of the construction had been completed, but the project was abandoned mainly under the pressure of public opinion; the decision was also supported by technical and economic analyses in the context of a recession. However, the nuclear option remains attractive in this country. It is seen mainly as an alternative to coal-fired power plants, taking into account both the environmental impacts of coal burning

and the possibility of relying on Western nuclear technology.

In Russia, the government was reported to have approved plans in early 1993 for construction of more than 25 nuclear plants over the next 20 years. The plans are subject to local governmental approvals and the availability of funds.

Safety and environmental issues

Concern over the health and environmental effects of human activities is growing everywhere but perhaps more strikingly in the CEE region. There, it has emerged in the context of drastic socio-political changes over the past several years.

Public hostility to nuclear power became acute after the Chernobyl accident, since it was felt that the level of safety of nuclear plants of Soviet design was inadequate. Also at that same time, health and environmental impacts associated with burning of fossil fuels, especially coal, and with hydropower plants became an important concern for the population. Hydropower development is rather limited in Central Europe because of environmental constraints, as was demonstrated over the past year by the withdrawal of some large hydroelectric projects.

Regarding nuclear facilities, it should be recognized that some aspects of the centrally planned economic system were not conducive to the attainment of a high level of safety, neither in the design nor the operation of nuclear facilities. The current international safety reviews of nuclear power plants in the region will certainly provide a better assessment of the problems and help to design programmes for enhancing the safety of these plants. For the new generation of nuclear power plants, CEE countries will benefit from exchange of information and transfer of technology made easier by the political and economic changes.

Atmospheric pollution has proven to be an important problem in CEE countries. Their economic development was based mainly on energy intensive industries and environmental protection measures were not considered a priority. Carbon dioxide emissions *per capita* in this region are rather high compared to the level of Western European countries. Annually these emissions average four tonnes of carbon *per capita* in Bulgaria, the former Czechoslovakia, and the former Soviet Union; three tonnes in Poland and two tonnes in Hungary. This compares to two tonnes *per capita* in Japan; 1.6 tonnes in France; and more than five tonnes in the United States (a level that was also reached by the former German Democratic Republic). *(See graph.)*

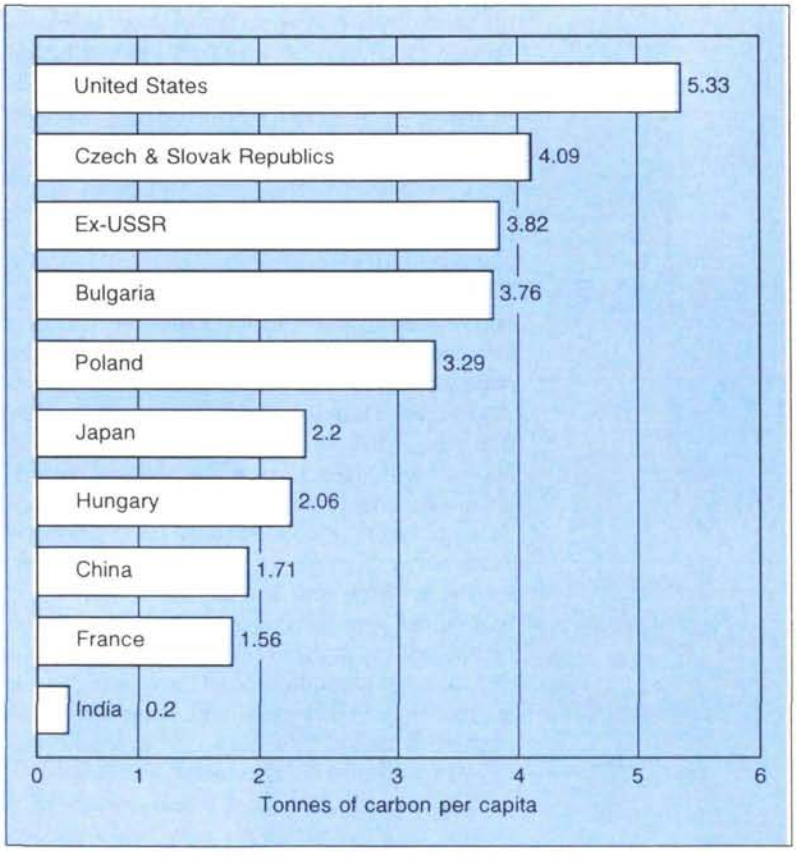
Other gaseous emissions from burning fossil fuels also are rather high in the region and have already resulted in noticeable health and environmental impacts. The large use of low-grade fuels such as brown coal, lignite, and peat is one of the main sources of atmospheric pollution in the region. This situation is a strong incentive to develop alternative sources for electricity generation.

Safety assistance and the IAEA's role

Within the framework of its overall safety services, and in response to requests from Member States of the CEE region, the IAEA has developed programmes to assess and enhance the safety of nuclear power plants of Soviet design. More than a dozen missions have been sent to power plants in the CEE region under IAEA programmes known as OSART and ASSET. These programmes assist national safety authorities and operating organizations in their efforts to ensure safety in the construction and operation of nuclear power plants.

Separately, an international programme initiated in late 1990 and now largely completed involved a broad review of the WWER-440/230 plants and safety review missions to ten of these operating reactors. The programme identified

CO_2 emissions per capita in 1988



and evaluated deficiencies of safety significance, and issued recommendations and guidance on priorities for corrective measures. The IAEA also convened a meeting of international experts to provide a technical basis for a comprehensive safety review of RBMK reactors, as the first step of a co-ordinated programme to improve their safety.

In addition to these safety services, the IAEA carries out activities in energy, electricity, and nuclear power planning. The aim here is to provide information and support to Member States for planning the introduction of nuclear power in their energy supply system, when it constitutes a viable option.

Specific overall objectives address several areas: strengthening the capability of Member States for analyzing the future evolution of energy and electricity demand and supply; planning the possible role of nuclear power in electricity supply based on comprehensive assessments of the various options, taking into account their economic potential and their health and environmental impacts; assessing the infrastructure, staffing, and financing capabilities in the country and the need for their improvement; and assisting in the implementation of nuclear projects.

Since the planning for electricity services is becoming more and more complex, the IAEA is making a major effort to develop improved methodologies for comprehensively assessing different options. They incorporate not only economic aspects but also health and environmental risks and impacts. This programme is carried out in close co-operation with other international organizations.

Methodologies developed by the Agency for energy, electricity, and nuclear power planning have been transferred to most of the CEE countries (Albania, Bulgaria, Czech and Slovak Republics, Hungary, Poland, Romania, Russia, and Slovenia). In connection with this transfer, substantial training in the use of these tools has been supplied to specialists from these countries who attended training courses organised regularly by the IAEA. In 1991, for instance, a project was carried out in Romania on the conduct of studies for energy demand forecasting and electricity planning; the project is being extended to examine the overall energy supply system in the long run, taking into account the infrastructure requirements and the environmental impacts. Additionally, a national seminar was held to help upgrade the capabilities of Czech and Slovak engineers and economists with respect to comparative technical and economic evaluation of bids from different nuclear plant suppliers.

The introduction of nuclear power in a country requires careful planning, and decisions need to be based on a series of interrelated studies and analyses, each one with a specific objective. These need to be conducted in a logical sequence, from the pre-feasibility stage with an analysis of the overall viability of the nuclear option, to the detailed feasibility study of the nuclear power programme, and finally to the planning and implementation of the nuclear power plants. The IAEA has developed methodologies and tools and offers assistance to interested Member States in all phases of such studies. This assistance could be useful for CEE countries in transition from centrally planned economies to market driven economies by helping them to improve their approach to planning and decision-making in the electricity sector, taking into account the full costs to society of alternative strategies.

Participation of specialists from CEE countries in IAEA training programmes and technical assistance projects has created a core of experts in the area of energy, electricity, and nuclear power planning. These specialists are already working on the improvement of the IAEA's methodologies and on their adaptation to the specific conditions of their countries.

Future developments

It is well known that the development of nuclear power programmes requires stability and predictability in the political and institutional situation of a country. The nuclear programmes of CEE countries have obviously been seriously affected by the transition to market economies and its consequences on the decision-making framework within the context of overall economic conditions.

However, nuclear power has reached the stage of commercial development in most CEE countries and regionally it represents a main component of electricity supplies. As a consequence of present uncertainties and economic recession, the installed nuclear capacity in the region is likely to remain unchanged until about 1995. There are likely to be delays, however, in completing units under construction because of more stringent safety regulations, financing difficulties, and in some cases public opposition.

In the longer term, economic and environmental factors are likely to stimulate the expansion of nuclear power, provided that the safety levels of nuclear power plants in operation and under construction are enhanced—and the public is convinced that this has been achieved. ❐