Nuclear power in the East: cause for fear, or for hope?

In eastern Europe, nuclear energy is the critical edge between going forward and going down. Western cooperation in upgrading safety and expanding capacity is key. Emmanuel Grenier reports.

The following article was translated from the French journal Fusion, *No. 46.*

On April 6, in the "secret town" of Tomsk-7 in Siberia, a stockpile containing nitroacetic solutions of uranium and of fission wastes from the treatment of nuclear fuel, exploded. Fortunately, the incident, classed as level three, did not destroy the building, and there were no injuries. Nonetheless, the immediate environment was contaminated by radioactive materials. Russian authorities say it was "the most serious accident since Chernobyl" (class 3 out of a scale of 7). Installations of this type pose a very worrisome problem in the former U.S.S.R.: Unlike nuclear plants, which are inspected when they are on line and are stable when they are not, these chemically explosive stockpiles are becoming dangerous as maintenance becomes lax, often because funds are lacking. By contrast, the East's nuclear plants are not the potential bombs they have been described as, even though they do require serious upgrading.

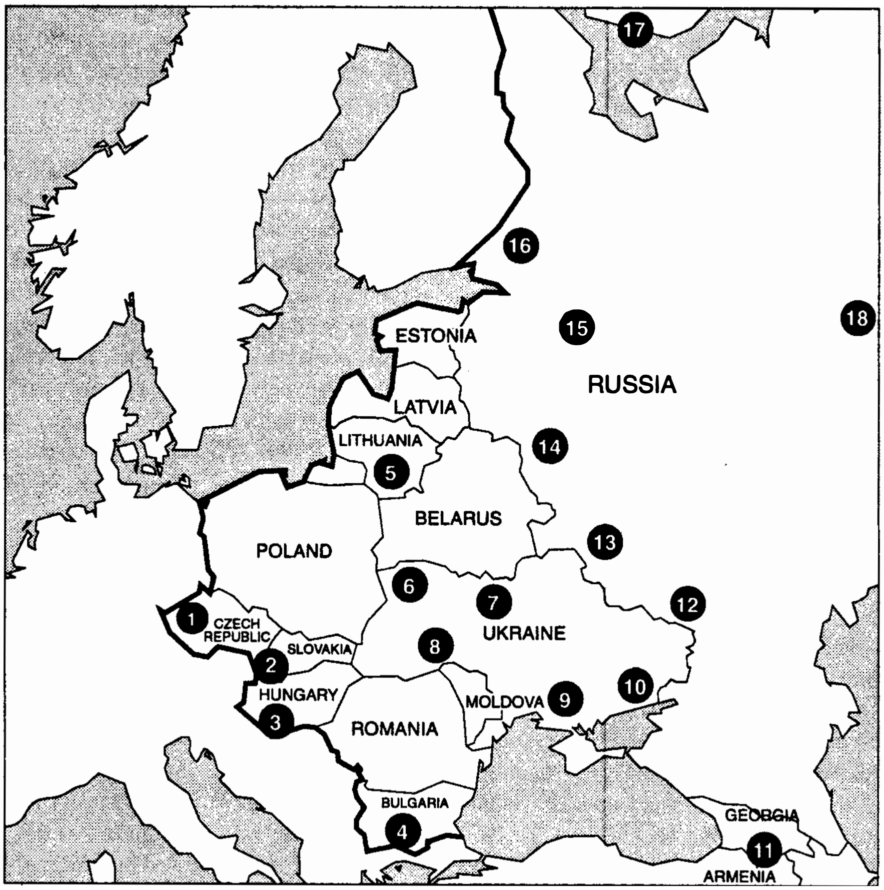
"Sixteen Chernobyls Are Operating!" "The East on the Verge of a New Nuclear Catastrophe"; "Kozloduy, A Potential Bomb"; these are the kinds of sensational headlines one can regularly read in the western press or in the press releases of certain ecologist organizations. The interest in the nuclear plants in the former Comecon countries was greatly increased after the fall of the Berlin Wall in 1989, which allowed a much greater opening toward the West and made it easier to visit nuclear sites. Moreover, movements for national liberation and independence, such as Ukraine's Rukh, became mobilized around defending the environment and health; when they came to power, these themes came with them. It can never be understated how fundamental a role Chernobyl played in the collapse of the U.S.S.R. Nuclear power in the East is therefore in the spotlight.

The Chernobyl accident poses several fundamental questions: What type of aid should be provided to Russia and its former satellites? What is the future of nuclear power in the world? One may well ask whether the panic-mongering sparked by these "cursed" plants is based on fact. Is the competence of Russia's scientists and engineers as mediocre as some have claimed? What are the true energy needs? How can France and Germany use their far-reaching cooperation to make a positive intervention in the field of nuclear energy? These are the questions raised in this report.

Before its dissolution, the U.S.S.R. was the third largest civilian nuclear power, in terms of installed power, at 35,000 MWe—behind the United States (102,000 MWe) and France (56,000 MWe). In 1990, its 42 reactors produced 211.5 billion kwh, constituting 12.2% of total electricity production.

The breakup of the Comecon [the socialist bloc's trading organization, the Council for Mutual Economic Assistance] and the collapse of the U.S.S.R. have produced different results in the nuclear community, depending on the rapport each nation had with Moscow. Thus, in Hungary, where the separation process was already well under way, the authorities for operations and safety had already acquired a certain independence. The four VVER power stations (pressurized water-type reactors) function there under relatively satisfactory conditions. The situation is similar with the plant in the former Czechoslovakia, which played, along with Skoda, an important role in the manufacturing components for nuclear plants. On the other hand, in countries such as Bulgaria or Lithuania, the departure of Russian technicians has brought about disorganization and dependence, with respect to both operations and safety. Western aid, mostly from Sweden in

FIGURE 1
Nuclear plants in eastern Europe



1. Dukovany: VVER 440-213 (2)
2. Bohunice: VVER 440-213 (2) and VVER 440-230 (2)
3. Paks: VVER 440-213 (4)
4. Kozloduy: VVER 440-230 (4) and VVER 1000-320 (2)
5. Ignalina: RBMK 1500 (2)
6. Rovno: VVER 1000-320 (1) and VVER 440-213 (2)
7. Chernobyl: RBMK 1000 (3)
8. Khmelnitski: VVER 440-213 (1)
9. Nikolaev: VVER 1000-320 (3)
10. Zaporozhe: VVER 1000-320 (5)
11. Oktemberyan: VVER 440-230 (2)
12. Novovoronezh: VVER 440-230 (2) and VVER 1000-320 (1)
13. Kursk: RBMK 1000 (4)
14. Smolensk: RBMK 1000 (3)
15. Kalinin: VVER 1000-320 (2)
16. Sosnovy-Bor: RBMK 1000 (4)
17. Kola: VVER 440-230 (2) and VVER 440-213 (2)
18. Balakovo: VVER 1000-320 (3)

the case of Lithuania, is therefore vital to preventing a new accident.

What type of reactors?

The reactors of Soviet design represented about 11% of nuclear reactors in use in the world (see **Figure 1**). The VVER reactors are the only ones that were exported outside the U.S.S.R. There are three generations: in chronological order, the 440 MWe model 230, the 440 MWe model 213, and the 1,000 MWe. Otherwise, there is the famous RBMK graphite-water reactor, one of whose models, Unit 4 at Chernobyl, exploded on April 26, 1986.

The generic problem in all Soviet reactors, with the exception of the VVER 1000, is that they do not incorporate the design of "defense in depth" utilized in the West. This principle consists of minimizing risk by intervening at three possible levels:

1) to prevent accidents by the quality of design and construction;

2) to inspect the installation and control it in order to permanently prevent its going outside the range of normal functioning (safety systems);

3) to design safeguard systems in the eventuality of an accident, and thereby limit the consequences.

Another generic problem is organization. In contrast to what exists in France, where each person's role is codified according to written procedures, generally no one knows who is doing what. Communication of instructions generally takes place orally. Insofar as they exist, procedures are limited to the operation and do not include maintenance or unforeseen situations, whereas in France, everything that is done during the course of maintenance operations is carefully noted down. Finally, the training of personnel is incomplete, for lack of resources.

The human factor

This problem of organization is reflected at the level of the role of safety agencies, whose authority over operators is not nearly as well established as in the West: Often enough, the imperative for production supersedes the imperative for safety. The "culture of safety," the glue that holds together all elements of nuclear safety, does not exist. The Three Mile Island accident in 1979 in the United States proved the security and viability of the concept of defense in depth: Despite an incredible combination of human errors, the containment structure kept all radioactive products within the building. This accident was useful in prompting the western countries to completely review their approach to this culture of safety, at all levels. Drawing lessons from the accident, they took note of the importance of this culture and developed it. But, in the East, they were unable or unwilling to change their attitude. The Russians in particular neglected the importance of the human factor, and only began to take it into account after the catastrophe at Chernobyl.

This latter has amply shown that there was a lack of safety organization at all levels. Recall that the accident did not take place under normal conditions, but during an experiment in nuclear physics. In the wake of various circumstances, this experiment, planned to be carried out under half-power, had been conducted under low power—in other words, in the most unstable area of the reactor. In order to conduct the experiment, the plant operators straightforwardly took the reactor safety mechanisms off line—an unthinkable act in France. When the experiment went ahead at 1 a.m., the catastrophe occurred: The chain reaction was unleashed, the power was multiplied by a factor of 100 in a few seconds, causing the fuel elements to split. The overheated fuel, coming into contact with the water, split it into oxygen-hydrogen, which caused the explosion and the release of radioactive particles. Note that, all the same, this explosion, equivalent to 60 tons of TNT, bore no resemblance to a nuclear explosion: Reactor No. 3, back-to-back with the disabled reactor No. 4, continued to function, despite the terrific fires that were so near. "The entire main cause of the accident" is tied to "an unimaginable accumulation of transgressions of the rules and procedures for operation of plant by the operations personnel," concluded the first official Soviet report on the accident.

What is reassuring for the future is that, after the breakup of the U.S.S.R., an agency for control of nuclear safety and radio-protection, Gosatomnadzor, was created in Russia. This seems to have some authority over the Atomic Energy Ministry, which was pretty much omnipotent before 1986 and which gave little notice to anything safety inspectors said. After three accidents—still unknown in the West—at the RBMK plant at Sosnovy Bor, the first in the RBMK series, in 1974-75, the inspectors had recommended "developing a more rapid backup emergency shutdown system in order to compensate for the effects of a positive void should a fuel element rupture." (See below for an explanation of the fuel element.) As the report on the Chernobyl accident remarked, "Alas, these recommendations were not followed." Thus, over two and a half years before the accident, Soviet safety inspectors had pointed out the faulty design of this emergency shutdown. According to the same report, "the agency drew attention to the extreme danger represented" by this system, and proposed corrective measures which, if applied, would have prevented the accident. But the measures apparently were not applied. In 1986, the operations director for nuclear plants was a Mr. Veretenikov, a good Communist, but a man who knew absolutely nothing about reactor technology. He had just spent 15 years at Gosplan.

Today the situation is quite different: As in the West, safety engineers stay on site at the power plants, and they have unlimited authority to shut down a nuclear unit. And this is not theoretical: According to Aleksandr Grigorov, deputy director for this office, in 1992, Gosatomnadzor required the complete shutdown of two unsafe units, and the sidelining of three others until they are modernized. Therefore, there is reason to hope.

The problems with the RBMK reactor

However, aside from these human problems, linked to the absence of a safety culture and to the Soviet system itself, there are definitely problems in design. The RBMK reactor operates only in the former Soviet Union. The Soviet technology was looked into by both France and Great Britain when they considered replacing their own national graphite gas procedures. Both rejected it, feeling that it was not safe enough. This type of reactor operates with boiling water: The cooling pipes are permanently filled with a mix of water and steam. But the latter does not transfer heat as well as the former; hence, when there is an excess of steam, the temperature rises. This effect is called "the positive void coefficient": when the power of the reactor increases, its reactivity also increases. It is precisely the opposite with the French pressurized water plants: The more the power increases, the more difficult it becomes to increase it further. This characteristic makes the RBMK reactor far easier to handle, but far more dangerous to run, than western reactors.

The other major problem of the RBMK from the standpoint of safety lies in the emergency shutdown system. The control rods, which slow down the nuclear reaction by inserting neutron-absorbing materials (in this case boron carbide), move far too slowly. Worse yet, they include a particularly serious design error, because they begin by increasing the power before stopping the reactor. The "fuel elements" must be mentioned again, which are completely peculiar to the RBMK: these fuel elements are made of zirconium alloy which cross the graphite pile. They contain both the nuclear fuel and circulate the liquid coolant. When subjected to strong radiation, they are quite fragile and break as soon as the temperature, normally at 284°C, reaches 550°C. There have already been two accidents of this sort: at Chernobyl 1 in September 1982, and at Sosnovy Bor, near St. Petersburg, as recently as March 1992.

Finally, a major failing is the total absence of containment for the six old RBMK reactors, constructed between 1954 and 1967, and the mediocrity of the containment for the 10 others, built since 1968. In none of these cases has a sealed structure been employed, as in the West, to prevent radioactive products from spreading into the environment.

Positive changes

Since the accident at Chernobyl, and in collaboration with the International Atomic Energy Agency (IAEA), the Russians have taken measures in the areas of design and monitoring of the core, and in protection of the reactor, allowing, in part, a remediation of the problems: They essentially aim at reducing the positive void coefficient and improving the efficiency of shutdown systems. These measures have been largely implemented at RBMK reactors still on line. Other improvements are planned, including the development of an ultra-rapid shutdown system by the injection of helium-3, a better cooling system for the control rods, and the decrease of the volume of graphite in the reactor core, which will reduce the ratio between volume of moderator and fuel and a hence reduce the void coefficient. The analyses of the scenario of the Chernobyl accident that were undertaken by the Kurchatov and Entek institutes (the latter is responsible for modernization measures to improve RBMK safety) established that "the accident could have been avoided if only one of the following improvements had already been operational" at the time: a change in design of control elements (no positive effect in the case of emergency shutdown), incorporation of absorption rods of reduced length in the shutdown system, or a larger minimum reserve of operational reactivity. "Since then, all three measures have been taken at all RBMK plants."

During the IAEA meeting in Vienna from Oct. 27-Nov. 5, 1992, western safety experts were able to quite freely and openly discuss with their Russian, Ukrainian, and Lithuanian colleagues the entirety of these measures, whether in place or projected. They arrived at the conclusion "that an immediate shutdown of the power stations, as sometimes demanded by certain people in the West, is not justified." Moreover, they made 16 recommendations and underscored that the operator's personal for activating the safety functions still played too important a role. While still objecting that the role of Russian safety authorities is sufficiently visible and independent, the western experts nonetheless applauded the fact that the states that utilize the RBMK are openly willing to discuss safety problems and objectively examine their critical conclusions.

The VVER 440 reactors

But the RBMKs only make up only a minority of the reactors of Soviet design. In fact, all new construction of RBMKs was definitively halted after the Chernobyl accident, and thus the risk they represent will be diminished, with most of the reactors finishing their lifespan within the next decade. The essential questions have to be raised about the VVER reactors: Are they as dangerous as the RBMKs? Should all reactor construction be stopped, or should operation of already-built ones perhaps be interrupted as soon as possible? These are the questions being legitimately raised by neighbors of those countries operating the VVERs. In order to attempt a response, we must first examine the three very different types of VVER reactors.

The first, designed at the end of the 1950s, the VVER 440 MW model 230, poses the most worrisome problems. The containment is inadequate, insufficient consideration of seismic risks (the two reactors sited in Armenia were shut down after the earthquake, although they suffered no damage, but today, given the dramatic situation in the country, their restarting is being considered), the vessel is overly sensitive to radiation because the water between the core and the lining of the vessel is too shallow, and it has inadequate fire protection; all this adds up to a large negative balance for safety. The VVER 440-230 nonetheless possesses several strong points: a large mass of water in the primary circuit permits a greater time lag before intervention, should there be an anomaly (this time lag is even greater than, for example, those available in French equipment). Again, in the primary circuit, the gates allow isolation of each circuit, of which there are six altogether, each outfitted with a submerged rotary pump.

The VVER 440 model 213 corrects some of the drawbacks of the 230 model: It has a redundant safety injection system for the primary circuit, comprised of four accumulators, three high-pressure pumps, and three low-pressure pumps, in principle making it possible to cope with a break in the piping. The reactor vessel is fitted with stainless steel, and the primary pumps are equipped with a flywheel which keeps them circulating longer in case of an accident. What remain are the problems of containment and the sensitivity of the lining to radiation. Notwithstanding, the level of security is a net improvement over the model 230.

The VVER 1000

The design dates from the beginning of the 1970s, and the first unit of this model came into service in 1980 in Novovoronezh. It is very similar to the 900 MWe units of Electricité de France (EDF): This is a reactor with four primary circuits, housed inside a concrete containment structure. The safety systems have a third order redundancy (this means that two breakdowns can take place simultaneously without putting the security in danger, since the third system is available to ensure safeguards).

The western nations have generally chosen to intervene on the VVER, and consider the RBMKs to be ultimately doomed. They think it were better to complete the VVERs under construction rather than stop, and to let the RBMKs continue operations. With the modifications contributed by western countries and the rapid progress in the mode of operation achieved by eastern European authorities, operating the VVER 1000 no longer poses any generic problems.

The intervention of EDF

Under the aegis of the World Association of Nuclear Operators (WANO), Electricité de France (EDF) has worked at several nuclear sites in eastern and central Europe. We will take the example of Kozloduy, since it is the most indicative of what can be done (see box). EDF in general limits itself to technical interventions in the operational security. It cannot, of course, change the design and quality of the equipment—aspects of safety that we have cited above in describing the "defense in depth." Financing for the interventions can be found in three ways. Credits for studies are generally provided by the European Community (EC); those earmarked for large equipment come from the World Bank or the European Bank for Reconstruction and Development (EBRD). Finally, for emergency undertakings, EDF can even unblock its own funds: In the case of Kozloduy, EDF offered the operators a truck, environment similar to those used around French plants, for inspecting the envronment.

In general the interventions were extremely well received, especially since they usually occurred as part of a pairing process: A small handful of engineers in a French plant (one or two full-time engineers and others on a part-time basis) permanently follow the progress of the power plant with which it is paired. Kozloduy is paired with the power plant at Bugey, Nogent-sur-Seine with Bohunice in Slovakia, and Saint-Alban with Dukovany in the Czech Republic. Two other pairs are planned for Russia—Paluel with Balakovo and Penly with Novovoronezh—and two for Ukraine—Golfech with Rovno and again Bugey with Zaporozhe. There is even talk of pairing supergenerators, which would link Creys-Malville with Beloyarsk. Finally, EDF and Cogema have set up the first two information centers on nuclear energy in Russia.

These pairings include not only engineers, although they are the pivots for the operation. Regular exchanges, very frank discussions on documentation, methods of operation, training, and procedures, brings two technical cultures, as well as both peoples, closer together—indispensable for a healthy cooperation.

Of course, problems are not limited to management or transformations in defective power plants. They also touch on supply of fuel and uncertainty with respect to personnel. As with all skilled personnel, those who work in the nuclear industry are tempted to emigrate to the extent their incomes continue to drop. For the moment, this problem is not so critical, but may well become so if the disorganization of the country continues. Another source of uncertainty remains with the organization of the electrical system itself: While the Thatcher model—complete privatization—seems to be on the back burner since the beginning of 1993, numerous countries are still considering an option consistent with full-tilt liberalizing of their electricity production. Only Hungary and Romania have stabilized, opting for a system closer to that of France, with a national company.

Franco-German cooperation

Franco-German cooperation is doing well in the area of safety, since, after the July 19, 1989 accord, already-existing ties between the Institute for Nuclear Protection and Safety (IPSN) and its German counterpart, GRS, had already been expanded. This expansion took the form of a common structure, called Riskaudit-IPSN/GRS International. The main motivation for creating Riskaudit was to facilitate cooperation of the two countries in eastern Europe, a desire explicitly stated by their heads of state at the May 1991 summit in Lille. Riskaudit then came into being in October 1992, as a European Grouping for Economic Involvement, with equal participation by IPSN and GRS. It is based at Fontenay-aux-Roses, at the headquarters of IPSN. It is not meant to be redundant, but rather to act as a light structure for direction and coordination between the two institutes.

Riskaudit is thus very oriented toward the East, as seen in the creation of two offices, one in Moscow and the other in Kiev, intended to assure a more on-the-scene presence and to facilitate setting up different programs for evaluating safety: Joint safety evaluations have already been carried out in Greifswald in the former German Democratic Republic, in Stendal. Others will undoubtedly take place at Temelin (Czech Republic) and at Rovno (Ukraine). On Feb. 23, 1993, the Moscow branch was inaugurated to great fanfare; Mr. Teske, a German, will direct it. The branch in Kiev does not

Kozloduy, a success story

The case of the Kozloduy No. 2 nuclear plant in Bulgaria demonstrates the effectiveness of international cooperation in nuclear safety. In May 1991, the International Atomic Energy Agency demanded an emergency shutdown of the plant. But this was out of the question, in an economic situation already at the limit of what could be tolerated. The Bulgarians nonetheless agreed to shut down the two most dangerous reactors, those in Units 1 and 2, which are VVER 440-230 types. EDF has undertaken the work, under the aegis of WANO, beginning with Unit 2. Thirteen months later, "the international authorities do not recognize the power plant they had seen 18 months earlier," said Henri Guimbail, international nuclear safety expert attached to the Production Transport Service at EDF. According to him, "The nuclear plant itself is sturdy and viable. The margins of autonomy are quite large. There still exists an intrinsic safety factor, since they possess a far greater stock of re-cooling water than we use. But their regulations are not ours. That is where we have to intervene."

In September 1992, two small fires broke out at Reactors 5 and 6, affecting the electrical systems. But they were quickly repaired, and today five out of the six units are functioning in a completely acceptable manner.—*Emmanuel Grenier* yet have offices, but its director, Igor Golicheff of France, has already been named and is active. While awaiting the ability to intervene directly, he is actively preparing himself, and is studying the Russian language in Paris. The office is expected to open in the summer or by October at the latest.

If, with Riskaudit, Franco-German cooperation gains a foothold in the East, cooperation on nuclear safety matters will be the imperative first step. The accords signed between Framatome and Siemens led to the establishment of NPI, a firm whose goal is to export a jointly built reactor, and later, to construct a European pressurized water reactor. A prototype will be started up in 1995 and will begin commercial operations toward 1997. IPSN and GRS have begun examining the European NPI project. This provides a quite original solution to re-cooling the core in case of meltdown: A large slab of cement, somewhat slanted, installed beneath the reactor vessel allows the melting fuel to be spread out in order to be more easily cooled. A reserve of 150 cubic meters of water with added boron (to slow the neutrons) is placed where the fuel would end up in case of an accident. According to Riskaudit, what is needed is a "convergence of approaches in the French and German safety techniques, beneficial to the joint development of concepts for new reactors by the industry of both countries. In the long run, this convergence will favor harmonization of the safety approaches of EC countries."

The relations of Riskaudit with scientific and engineering experts in Ukraine and Russia are generally excellent. French and German mission specialists in safety are not effectively cut off from their area; they spend a great deal of time in discussions with their eastern European colleagues. The latter are all the more receptive, since they take place on equal footing. This openness toward western aid may be strained when they see the experts named under the EC procedural regulations arrive from Italy, since that country officially renounced nuclear energy after it was voted on in a referendum. To be given advice by people who have less experience than you do, is often too much for Russian pride!

Responsible specialists

After the accident at Chernobyl, and in the context of the general collapse of communism, it was commonplace to think that everything that came from Russia was primitive and archaic, or even that Russian technology and science were for the most part behind their western equivalents. This thinking doesn't cohere with reality, and in fact can impede good East-West collaboration. For example, the plant operators at Kozloduy have denounced the incredible number of visits which they have had from experts (bearing no relationship whatever to the real material needs they have) and the condescension with which they are treated. However "competent the operators are, they simply lack a culture of safety," confirms IPSN's Igor Golicheff. A cultural change is in the process of taking hold, under the twin pressures of public opinion and necessity. Everyone today is well aware, given the still fragile state of the new-found democracy in these countries, that a continuation of nuclear power demands this cultural change as well as more transparency.

The Green ostriches

Not everyone is hoping for these changes. Some do-gooders have effectively demanded an immediate halt to nuclear energy in the East. The Green caucus in the European Parliament sponsored a resolution in 1992 demanding that the European Community interrupt all technical and financial aid for upgrading eastern European power plants. Then they formed a European organization, Contratom, which accused the nuclear industry of seeking "to use this situation [in the East] to reverse its own economic decline, by proposing costly modernization of old reactors or their replacement by western models." Contratom demanded: "Let's stop puttering around! Let's campaign to stop the western nuclear lobby in the East!" Their solution? Gas turbines, for $6 billion, could replace all the western plants—at a cost, according to them, "ten times less than the cost of repairing nuclear plants." The extremism of their figures is astounding. The estimate of the G-7 is only $700 million over four years, which is far from the $6 billion declared by the Greens. But above all, they take no account of a fundamental point: There is not enough gas production in today's Russia. Exports have been massively increased in order to earn desperately needed foreign exchange. An increase in production in order to replace nuclear plants presupposes expenditures for infrastructure (gas pipelines, etc.) far more significant than the $6 billion they mentioned—infrastructure which in any case would not be built in a day.

Others, like ultra-malthusian Jacques Cousteau, rely on the conclusions drawn by two notoriously anti-nuclear activists, Raymond Sené (GSIEN) and Robert Pollard of the Union of Concerned Scientists, to demand the "definitive shutdown" of Units 1 through 4 of Kozloduy. Let's quote the catastrophic prose of the Cousteau team, which visibly seeks to play on fear: "The entirety of Europe is being held hostage by the fist of the 'nucleocrats.' Everything must be done to halt the most dangerous plants, whether they are the RBMK type like Chernobyl or VVER like Kozloduy. This goes to the heart of security for all Europeans." The Cousteau team acknowledges the need to put alternative measures into place if they want to close Kozloduy, but it proposes nothing more than "definition of a long-term energy policy, based on energy efficiency and nuclear non-proliferation."

If energy savings are certainly necessary in countries where "temperature is often adjusted by opening a window," they are nonetheless insufficient to supply the need. Gas? None of the countries have access to it in great volume except Russia. To propose it for Bulgaria, as Ségolène Royal has, verges on ignoring the financial and economic situation in these countries. Coal? Just look at the situation in Poland and

TABLE 1
Profile of nuclear energy in some former communist countries

Country	Installed nuclear power	Percentage of electricity from nuclear power	Reference year
Russia	18,000MW	11%	1990
Ukraine	12,000MW	23%	1989
Lithuania	2,500MW	56%	1989
Bulgaria	3,760MW	35%	1989
Czech and Slovak Federated Republic	3,520 MW	28%	1990
Hungary	1,760MW	48%	1990

former Czechoslovakia to realize what this proposal means for the health of the men, women, and children of these countries. Never mind the forests, so dear to our ecologists.

The nuclear imperative

Therefore, it is necessary to continue, and indeed to increase exploitation of nuclear energy. As we have already said at the beginning of this article, in the former Soviet Union as a whole, nuclear made up no more than 12% of electricity production (see **Table 1**). But this average figure does not take regional factors into account. Within this vast territory, which has never had the interconnection we enjoy in western Europe, we must reason along regional lines. And at this level, in those places where they have been installed, nuclear power plants hold a preponderant place in the electrical equation. In other words, it is not possible to do without nuclear power, without causing damage. The case of Kozloduy is again exemplary: In order to go ahead with modifications deemed indispensable on the two first units, it was necessary to close them in May 1991. For the local population, this shutdown translated into rolling electricity blackouts three hours each day, over the course of two winters.

That said, we should absolutely not minimize the major impact of the Chernobyl accident throughout all the countries in the East. To take Bulgaria again, this impact was translated into a massive growth in the anti-nuclear movement, to the point that 54% wanted the construction site for the second Bulgarian nuclear plant at Béléné to be shut down. In 1991, the government resolved to do so.

In Ukraine, the situation is even worse: Parliament, pushed by the fact that over 90% of the population is anti-nuclear, voted a resolution declaring a moratorium on all construction of new nuclear plants, including those nearing completion. The government issued a decree aimed at the cessation of operation of the three remaining units at Chernobyl for 1993. But nothing is simple! Since the meeting of the Group of 24 at Brussels in March, the representative of the state committee for nuclear energy allowed the shutdown dates for the three units to be postponed to 1995, 1997, and 2005. In the meantime, they will still build a small electrical power plant in order to continue feeding the primary circuit pumps, so the reactor can continue to be cooled after its shutdown. Whatever the case may be, the shutdown cannot come before 1994.

As for the Parliament decree, it has been openly violated. Construction of the power plant at Zaporozhe is 99% completed. At Rovno (where the fourth unit is 80% complete) and at Nicolaev, they have also opted for the politics of the *fait accompli*. The state committee has elsewhere stated its desire to "reverse the moratorium." A sign of this reversal is the global accord signed in February 1993 between the prime ministers of Russia and Ukraine on the matter of pursuing development of nuclear energy. It encompasses both development and construction of nuclear plants as well as reactor components, the fuel cycle, research reactors, planning operation, training personnel, dismantling of old installations, and finally radiation protection and safety.

Meanwhile, the Czech Republic has decided to complete construction of the two units of the new nuclear complex at Temelin, despite opposition to the project. The ministers responsible for economic, industrial, and ecology questions took the decision "for economic and ecological reasons." These installations will act to decrease energy dependence and the environmental pollution in the north of Bohemia, which came from coal-fired plants that were terribly polluting.

Strong necessity in Russia

Similarly, the Russian Ministry for Atomic Energy has quite clearly shown its desire to continue with nuclear development. It has just signed an accord with the French Atomic Energy Commission (CEA) confirming their collaboration on all major issues of civilian nuclear uses. In addition, it has signed a contract with the American firm General Atomics for initiating a joint venture aimed at developing a modular high-temperature helium-cooled reactor. This type of reactor has the advantage of being able to burn plutonium from military sources, which Russia has great access to following the strategic arms accords signed with the United States. "If we utilize plutonium, we can destroy about 95% in operation. The Russian scientists have been very active in the development of plutonium-based fuel, and they are working at this very moment with us on the issue," said a spokesman for General Atomics, based in San Diego, California.

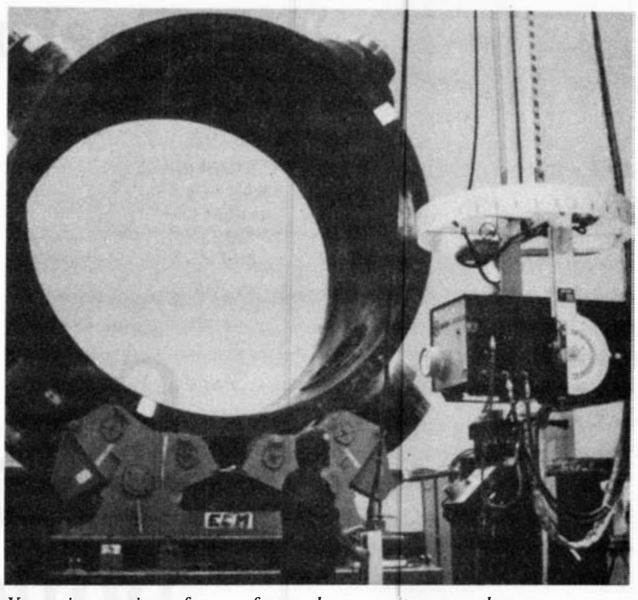
But this represents future activity. Let's come back to the inevitable decision by the eastern countries to continue to operate their nuclear plants. Does this run the risk of an incident? Yes, like any human activity, and this risk is certainly greater than those we would find acceptable in western Europe. Speaking fairly, does this decision pose a risk to western Europe? One can reasonably assert, no. The cloud from Chernobyl, which was so much talked about, corresponded to no more than the equivalent or less irradiation one would get during a plane trip to the United States. But above all, we must evaluate the risk represented by the shutdown of nuclear plants, without a viable alternative solution: The lack of electricity would be translated immediately into a general decrease in living standards and hence ultimately into an increase in mortality. This decision therefore seems reasonably acceptable to us, and it is in no case an act of thoughtless folly, as some have been saying.

We have seen that the reactors of the East are rustic, that is, both simple and sturdy. They have serious safety failings which can be partly remedied. Nonetheless, the accumulated experience corresponds to over 1,000 years of reactor operation. This experience has been laced with incidents, the most serious having, of course, been Chernobyl. But we must not forget that, if the operators had not disconnected the safety systems, their other errors would have only led to a reactor shutdown. Paradoxically, one can say that, with the opening to the West, the goodwill in cooperation on both sides (understood to be in their mutual interests), and the progressive improvement in the VVER plants, the nuclear situation has never been better. Certainly, risks are still far too significant. But they were all the more so when we had little or no information about them. It is in this sense that nuclear energy can be a hope for the East—hope for a better environment, and most particularly for better air quality; hope for a more reasonable kind of technological development, because it takes man above all into account.

A duty to provide aid

Now that we have access to information on these risks and hopes, we in the West must not panic, but must take action. We have seen that there is no dearth of goodwill. The French and Germans have been able to put competition to one side in order to act together where it is necessary. International organizations are redoubling their appeals for help. The EC quite easily released funds in order to intervene. That was when the problems started: Sir Leon Brittan, then commissioner for competition—defying critics who were saying that "when there is a fire, you don't endlessly discuss which firefighters are least expensive"—decided to take the usual step of calling for bids. The result: months of added delay, and a bid that ultimately fell to Westinghouse.

Still, all hopes rested on the EBRD, which was commissioned by the Group of Seven to manage a fund earmarked for the improvement of nuclear safety in central and eastern Europe. The objective is to respond to immediate safety needs of the oldest power plants. Jacques Attali, EBRD chairman, stated: "I have very happy that, as we requested eight months ago, the G-7 has finally decided to set up this fund. We are now able to move quickly to provide eagerly awaited equipment in order to repair those reactors that can be repaired, and close the ones that are most dangerous. We



X-ray inspection of part of a nuclear reactor vessel at a Framatome factory in France. The western European nuclear industry has a longstanding safety policy of "defense in depth," and can make major contributions to improving conditions in eastern Europe's nuclear systems.

are beginning by improving fire prevention in the RBMK models and the VVER 440-230 models." The special EBRD funds, as opposed to the EC credits that support research studies, strongly center around financing equipment. The EBRD, which has already received promises for ECU 40 million from Germany, France, and Britain, estimates it will be able to receive "several hundreds of millions of ECUs over three years," which is roughly the higher amount estimated by the G-7 for completion of emergency work.

Whatever the figure, if aid is to be effective, we must reject the ultra-liberal philosophy that has prevailed so far and which is prejudicial to both the real economy in general and to nuclear safety in particular. The center for observation and planning at the French Ministry of Foreign Trade, in a note on economic relations with Russia, acknowledges this in clear but diplomatic terms: "It is obvious that aid is suffering from unrealistic conditions placed on it by the International Monetary Fund (IMF) under color of economic reforms: macroeconomic objectives that are impossible to attain (balancing the budget) or premature (total price liberalization, ruble convertibility) in the absence of indispensable structural conditions." The official French agency thus calls into question the IMF policy, "whose doctrines are currently unclear and are even becoming the object of much discussion, above all internally."

The problem of nuclear energy in the East therefore represents a microcosm which fairly reflects all the problems posed by the collapse of the U.S.S.R. and the liberation of its peoples, as well as what action the West should take on site.