

NUCLEAR POWER AND THE WORLD IN TRANSITION

An overview on the status and the outlook of Nuclear Power Programs

Karel Wagner

Abstract

Paper evaluates the present state and the outlook of nuclear energy on the basis of an analysis of the main interconnected issues: economic, ecological, sociological.

The economic factors influence is shown on the background of the nuclear power implemented as an one of the substituting sources of energy, emphasizing the impact of oil crises in the last two decades. The environmental subsequences of electricity generation by different technologies are discussed. The social and political conditions for the safe and disciplined implementation of nuclear energy are demonstrated on the history of Czechoslovak and Soviet nuclear programs, comparing their approach to the nuclear safety with that applied in western philosophy.

The bad experience of the public with its involvement in the decision-making process dated from the time of the first Czechoslovak NPP construction is being still felt, even if the approach to the public under new political regime has been changed to comply with the world-wide practice.

The lack of the safety culture in former Soviet Union is regarded now, also by some Russian and Ukrainian authorities as the main reason of Chernobyl accident and as a negative factor in the process of its liquidation, too.

Paper is concluded by the short assessment of the influence of both public opinion and energy availability on the present and expected nuclear choice in all important industrial countries.

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If we should evaluate the present state and the outlook of nuclear energy in satisfying the country's global energy demands, we cannot avoid a complex analysis of the problem, namely we have to find out which interacting factors should be taken into account, and how they manifest themselves in different areas, under different economic conditions or under different political systems.

As the first step in the process of learning this problem, we should try to sort these influences into several main categories.

To begin with, there are **strategical and economic issues**, i.e. the amount of energy necessary for an assumed development of economy, structure of this energy, how expensive it may become, which and how accessible (both technically and politically) sources of energy can be relied upon and which options there may be available. These strategical and economic issues, from the very beginnings of the industrial revolution gradually influenced the mastering of all basic sources of energy (wood, coal, oil, gas, nuclear, renewable) because the sufficiency and the accessibility of energy were and are, together with the more recent automation, the essential driving forces of scientific and technological progress. In this succession nuclear energy obviously represents another and, at least temporary important, global source of energy, even if its present economic advantages may not necessarily last.

The second category of influences includes **ecological issues**. The acceleration of technological progress, the extensive exhaustion of natural resources and other negative impacts of technical civilization (even if they are happening in the smaller part of the world) on the whole life had induced futurologists to issue their warnings decades ago, in fact much earlier than similar considerations, though somewhat differently oriented, were motivated by the development of nuclear power. Nevertheless, in last five to ten years instead of signals

of potential danger we are confronted with an imminent, direct menace to human civilization and with the risk that the time we may have to avert this threat is nearly out. In this ecological context the phenomenon of the nuclear power is controversial. It has a significant potential to improve the ecological impacts of mankind's global provision with energy, can, however, worsen them tremendously and for a long time. That is why the ecological interdependences are for advocates and opponents of the nuclear option much more disputable than economical ones.

The next important group of problems which influence acceptability of nuclear energy belong to the **sphere of sociology and politology**, i.e. they try to resolve the question whether some or other society is for the utilization of nuclear energy prepared psychologically, ethically and politically (in the broadest sense).

Potential Role of Nuclear Power

The influence of mastering energy sources which substitute and multiply the power of man on civilization is obvious since long ago. Without fire, without power of wind and water and without using animals for the transportation, we would hardly come near to technical civilization.

The process of substitution of one energy source by another is typical and it repeats itself. We all know that the advance of nuclear power was much quicker and what more - due to the concentrated efforts of scientists and engineers contributed by alert and diffident public - it proceeded with uncomparable smaller number of accidents and disasters than did other types of energy. However, this too fast deployment of nuclear energy, especially in its beginnings brought about many problems and has impacted public acceptance as well.

Nevertheless, the old smooth course of development and substitution of different energy sources existed only until some phenomena accompanying power generation exceeded the level which nature itself or human society is capable or willing to tolerate. Then occurs, at least temporarily, the break of continuous advance and usually we speak about

crisis. In past twenty years we experienced more such energy crises than during two hundred years of the industrial revolution.

Typical for this sort of events were two, so called oil crises in seventees, even if they had certain dissimilarities. The movements of oil prices and production between 1955 and 1990 suggest a great deal about causes and solutions of those crises. However, this is not our problem.

For us there would be more interesting the time projection of these oil crises onto the plane of development (and crises) of nuclear power, as characterized by dependence of construction starts of nuclear power plants in the member states of the IAEA and the comparison of the influence of these oil crises and that of the two main nuclear accidents, i.e. Three Mile Island and Chernobyl (Fig 1).

It is beyond dispute that the original "boom" of nuclear power during 1965 - 1970 which can be ascribed to a spontaneous enthusiasm over a new, apparently non-exhaustible source

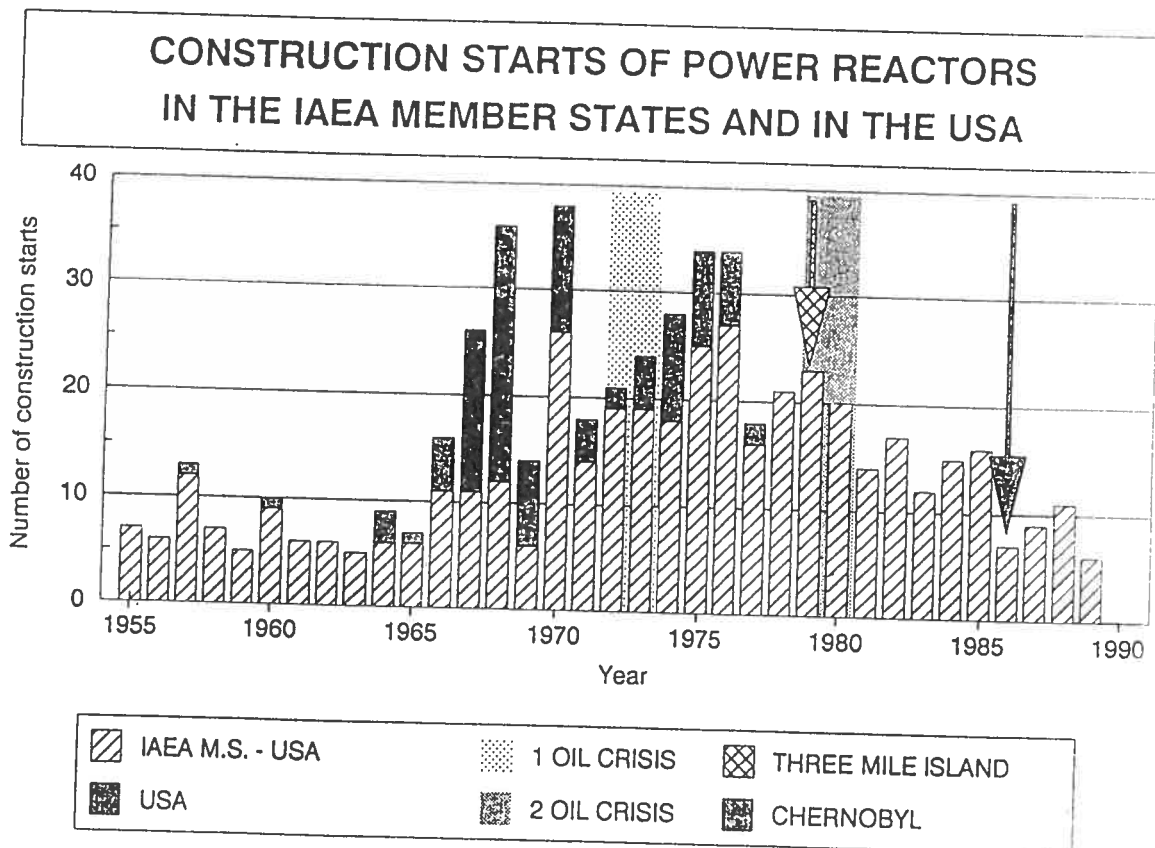


FIG. 1

of cheap energy, was in the next phase (1973 - 1978) stimulated by the first oil crisis (1973 - 1974), the role of nuclear power in getting over this crisis was commonly recognized.

However, the similar reaction on the second oil crisis did not come, certainly as a result of the Three Mile Island accident in March 1979. This accident caused a number of parallel responses whose consequences were often of contradictory nature:

- it has clearly influenced public opinion and its negative attitude to nuclear power plants, first in the U.S.A. and later on - also in other countries,
- between professionals, it initiated an extensive revision of approaches to the nuclear power plants safety and thus - contributed to the enhancement of nuclear safety in conceptual designs, in quality of manufacturing as well as in operational supervision,
- it caused substantial rise in price of nuclear electricity due to two facts:
 - expences on additional safety measures
 - thorough and therefore slow licencing.

So, we are witnessing the process that safety issues and efforts to satisfy all public demands (mostly justified) for highest safety level gradually liquidate the main advantage of nuclear power plants, i.e. the relative cheapness of nuclear electricity. Having in mind that investment costs of nuclear power plants constitute the major share of all costs, we easily recognize that nuclear power plants are very sensitive to prolonged licencing procedures which up to now are being protracted at will by environmentalists, this being true not only for nuclear power plants. Therefore the uncertainty in the results of protracted licencing procedures is now becoming one of the major issues in decision-making on new nuclear investments.

Acceptability and necessity of nuclear power

In the era of jets, consumer electronic and the revolution in informatics it would be a naive anachronism to demand that men would be satisfied only with what the nature itself can offer. In such a case we would have to part not only with civilization, culture but finally reject the humanity. However, it goes without saying that a certain consensus with nature must be achieved, otherwise together with nature and through it the mankind will destroy itself.

Nuclear energy and radiation connected with it is for nature nothing new or special. Each star and our sun, too, represent fusion reactors. Radiation has its sources on Earth and in space, mankind and other living organisms are adapted to its natural background. Nevertheless, the value of natural background, similarly as values of other important life factors, cannot be significantly changed without taking a risk of unforeseeable consequences.

Impacts of the Chernobyl accident reminded us for the first time that risks of even peaceful uses of nuclear energy are not only theoretical but that they are real ones. So, the questions are being asked not only by general public, but by scientists, economists, and decision-makers as well. These questions demand straightforward answers:

- Do we need nuclear power at all?
- Couldn't we under conditions of sustainable conservations manage with other sources of energy?

The answers are not simple and cannot be resolved separately without taking into consideration all other factors which endanger mankind, as are doing not only all the opponents of nuclear energy but also a certain part of the environmentalists. It is certainly too petty to worry about radiation dangers from operating nuclear power plants and not be able to get rid of the menace represented by the military or even terroristic misuse of nuclear energy. What good it will do us to abandon nuclear energy in order to free next generations for hundreds and thousands years from the problems of spent fuel (which solution is by now known and further developed), if we would not survive next century because of other phenomena caused by non-nuclear energy!

Nuclear power is at present nor the only and neither the main source of energy, it is also nor the only and neither the main pollutant. We have no reason to assume that nuclear energy will unconditionally remain the only source of energy after all other sources known now will be exhausted or unacceptable.

However, present 400 nuclear power plants with the output of one sixth of world's total electricity production, especially in the regions where there is a shortage of other sources, prove that not now and obviously also not in the near future we can manage without it, and if we do so - it will be at the risk of far greater damage to human beings and nature.

So, if we can't do without nuclear power in the next fifty or hundred years, the next pragmatic questions about nuclear power are:

- What to do in order to minimize the present and future threats to mankind due to the **temporary** use of nuclear power?
- What to do in order to be able to abandon nuclear power as soon as possible and with minimal losses?

The answers to the first question from the standpoint of the operational safety of nuclear power plants are already solved quite satisfactory and as far as the spent fuel disposal concerns, it is being intensively developed and there is no reason to suppose that it will not be ready in time.

The answers to the second question are to be found in the progress of non-nuclear science and technology. The decision-makers must see to it that the mankind and its political and technological forces look for and find in time the positive answers to the both categories of questions. Also, that general public is informed truthfully about all these problems and perspectives and can put together its own realistic opinion on the possibilities and consequences of various energy sources.

Making the nuclear energy safer and looking for a substitute for nuclear power are therefore not only technological and economic issues, they actually constitute our obligation,

they are our countervalue in the agreement with nature for the temporal permission to use nuclear energy.

Ethical and sociological context of nuclear power

The fact that the first use of nuclear energy was demonstrated as mushroom clouds over Hiroshima and Nagasaki marks the public approach to this new type of energy up to now.

However, when a possibility to use this energy for peaceful purposes occurred, there was no shortage of the willingness and means to make use of this source, and on both sides of at that time politically and ideologically divided world. But just here came for both camps so characteristic "display of characters".

In the former Soviet Union which was laboriously catching up with the USA's start in the military uses of nuclear power, the peaceful use has become a propagandistic ideological tool, although after the war there was not much resources left for the disciplined implementation of such a complicated technology. So happened that soon after the startup of "the first nuclear power plant in the world" - a 5 MW graphite-water reactor (incidentally it was a prototype of the Chernobyl's reactor type) in the USSR's Obninsk back in 1954, the Soviet Union was surpassed all along the line by the development of nuclear power plants in the USA, UK and also in other smaller countries. This happened despite the fact that those democratic countries had been constructing their first nuclear power plants under the existence of active anti-nuclear opposition.

Sir Winston Churchill allegedly said that democracy is one of the less efficient forms of government but that nothing better has been yet discovered. It is rather incredible how these words were confirmed in nuclear energy development and utilization. The level of nuclear safety in democratic countries is the result not only of scientific analyses but is given by the process of decision-making and by discussions of the informed public with the advised political representatives, e.g. through the public hearings on important projects.

This process is not proof against demagogy and misuse, and it was just this open democratic platform for the decisions which may well led, after two nuclear accidents, to the actual moratorium on new power plants in many countries. However, along with it, this democratic approach succeeded in bringing the nuclear safety in these countries to the up to now acceptable level.

On the other hand, in Soviet Union and in former socialist countries the problem of the setting of acceptable nuclear safety level and conditions, as well as of the whole safety philosophy became a bureaucratic issue of narrow political, scientific and economic authorities and was in advance taken out of the sphere of cognizance and influence of the general public.

This can be manifested on the **history of the safety development at the first Czechoslovak industrial power plant - VVER-440, Soviet type.**

The design of these, so called V-230 model reactors, dates back to mid-sixties. Their safety philosophy corresponded to contemporary Soviet approach: overevaluating prevention of accidents by declared (but not consistently performed) testing and quality control at the expense of adequate measures for the mitigation of accident consequences.

This approach could be probably justified for some of Soviet sparsely populated regions, but would be hardly applicable at that time, the same as now, neither in the majority of European countries with demographic situation similar to that of Czechoslovakia, nor in the USA. The reactor design lacked not only a containment but also many other safety features, since the rupture of the main piping had been not regarded as the design basis accident.

Numerous shortcomings of this design were recognized by many knowledgeable and responsible persons in Czechoslovakia. So, long before commissioning of the two first VVER - 440/230 reactors, at the stage of the site licencing, the Regulatory Department of the Czechoslovak Atomic Energy Commission formulated four conditions qualifying lincencing of these reactors in Czechoslovakia. The Governmental Decree of March 19, 1970 made these conditions official. They regulated:

- quality control programs
- nuclear power plants siting
- safety assurance and safety documentation
- emergency planning and preparedness.

At that time there was no Czechoslovak or Soviet legislation on nuclear safety, and it should be emphasized that the mentioned document was based mostly on the IAEA and western regulations.

Their implementation became a constant source of conflicts with both the Soviet suppliers and the Czechoslovak political leadership because the imposed requirements were highly above customary practice in both countries. As a consequence, we did not succeed in fulfilment of all issues of the Decree, especially in the area of quality control documentation on Soviet supplies. Therefore we repeated a number of quality control procedures during primary circuit assembling stage (if there was a possibility). The quality assurance program at this NPP has been much more thorough having the periodic tests more frequently than a standard one.

The absence of the atomic legislation and of the set of safety regulations has been felt as a very negative factor during the construction and commissioning of our first NPP. Therefore in 1984, after due preparation, the law No 28/1984 on "The State Supervision over the Nuclear Safety of Nuclear Installations" has been passed. In accordance with this law, the Czechoslovak Atomic Energy Commission was and is the body which issues safety regulations covering all phases of NPPs siting, designing, manufacturing, commissioning and operation. Under totalitarian regime in Czechoslovakia, before 1989, the implementation of these regulations has been often hindered by conflicting economic interests, and only after 1989 the law No 28/1984 could be applied without any constraints. However, this law from the beginning had a very positive function in the safety regulation, introducing such documents as Safety Reports, Technical Specifications etc, which the Soviet practice did not recognize.

Non-open nuclear policy and bureaucratic process of decision-making in siting and choosing nuclear power plants capacity, together with unilateral orientation on out-dated Soviet reactor types, brought about, after 1989 change, a great many both justified and unjustified objections against Soviet reactors and against nuclear power plants in general. Such opposition could have been probably partly avoided by employing an open approach to the public with the emphasis of the fact that the ČSFR is one of those countries where the implementation of nuclear power under careful observation of all safety measures represents the main solution - how to mitigate negative ecological impacts of electricity generation. Unfortunately, a part of the Czechoslovak environmental movements acquired the illusion that energy conservation and renewable sources could fully substitute the exhausted or unacceptable fossil energy sources. Part of our unfortunate heritage from the totalitarian regime is the predisposition of our immature public opinion to be misled by arguments ostensibly worried about the future (of radioactive wastes, for example), but in fact - unrealistic and scientifically incorrect.

The similar negative influence of non-democratic regime on the issues of reactor safety in the former Soviet Union has been clearly demonstrated by Chernobyl lesson.

The Chernobyl accident happened in the USSR not because Soviet scientists or designers were incompetent, but because they have not worked in a democratic country, where due to matter-of-course mechanism of public reviewing prior to decision-making, as well as due to the exact recognition of individual responsibilities, the regulatory body would have never licenced reactors with features of RBMK type.

The Soviet report presented to the IAEA in 1986 fall, even if it was unprecedently detailed and open, still did not say, or rather tried to conceal, that the main causes of the disaster were neither technical faults nor operators errors only, but the lack of "Safety Culture" as a result of general political and technological isolation of Soviet system.

The fact that new leaders in the former USSR are now accepting the similar conclusions is a sign of the changes in psychological and sociopolitical atmosphere there. At the First

International Andrey Sakharov Congress "Peace, Progress and Human Rights", Moscow, May 21 - 25, 1991 an important contribution named "Main causes and circumstances of the Chernobyl accident" has been presented by Mr. N. Shteinberg, Vice - Chairman of the former USSR's State Committee for the Supervision of Safety in Industry and Nuclear Power, now - Chairman of the new State Committee of Ukraine on Nuclear and Radiation Safety. Besides the very detailed physical and thermotechnical description of the accident progress with a number of new details, the author stressed some general causes of the Chernobyl accident:

- The lack of legal framework defining the rights, duties and responsibilities of those engaged in peaceful utilization of nuclear energy in the country. Each "participant" of the process is responsible only for those parts of the job which he directly performs, and nobody carries the full and primary responsibility for the safety of nuclear power plant, as a whole.
- There was an inadequate quality assurance in the Soviet nuclear program, allowing some organizations manufacture "something" inadequate and some others - operate this "something" inappropriately. This resulted from the fact that for a long time there had been no effective regulatory authority.
- Inadequate handling of the human factor, improper comprehension of motives of persons behaviour and overevaluating the man's reliability .
- For decades Soviet regime taught people to reach targets with any means employed, regardless of consequences. Actually, Chernobyl plant's personnel overcame obstacles they encountered while implementing the testing program, by violating some safety measures fixed in the operational procedures, being led by the unbreakable habit to go to the extremes for the fulfilment of their task.
- Inadequate attention on the part of designers to lessons learnt from operating experience all over the world. So, the important problems were neglected, even those which had fatal consequences.

The crisis of non-democratic Soviet system became apparent after the Chernobyl accident anew. The range of the disaster, however objectively large, could have impacted population to a much lesser degree if the straight and timely information had been given to the public and if public had the confidence in the conscience and competence of the governmental and local authorities.

All that should be taken into consideration when and wherever decision - makers will be next facing the public with the design of a new nuclear power plant.

The existing acceptance of nuclear power in the world

Let us see how all these factors, especially the two main nuclear accidents, have influenced the public opinion and anti-nuclear movements in individual countries. According to the outcome of the opinion pools on decision-making in nuclear option one can distinguish the following groups of countries:

- a) Countries with strong and well established nuclear power which is being increased by new constructions: France, Japan, Republic of Korea, the UK
- b) Countries with strong and well established nuclear power which has been limited or stopped in last years: the USA, Sweden, the FRG, Canada, Spain, Argentina, Finland
- c) Countries which started on nuclear power with a delay and now are trying to reach an average level: the USSR, the CSFR, Hungary, Romania, Bulgaria, India, China
- d) Countries with medium nuclear power or without it at all, some of which have explicitly declared their abandoning the nuclear option: Austria, Denmark, Greece, Italy, Switzerland, Ireland.

Coming back to:

- a) It is not by chance, that the first group (France, Japan, Korea, UK) is formed by developed countries with rather high population density and limited fossil energy

sources. These countries utilized their scientific and industrial potential to overcome their shortage of natural energy resources taking also care to manage the safety aspects of nuclear energy and to win the confidence of the public. Typical are the attitudes of France and Japan. France has combined its scientific achievements with the open information policy and succeeded in winning the broad public support. Now the top position of France in the share of "nuclear" electricity generation has become a pride of the nation. Nevertheless, problems attached to spent fuel and high level radioactive wastes disposal still remain to solve.

Japan, with even more tight balance of energy sources and demands, managed to build and to continue in building a strong nuclear power in the country with more than 300 people per square km and a high seismic activity. Remarkable is the fact, that according to the survey performed in October 1991 by Japanese Research Council for Energy and Information Technology, the ratio of people accepting the utilization of nuclear power is increasing: 73 percent in 1989, 75 percent in 1990 and 79 percent in 1991, in spite of another result of the same survey showing that about 60 percent of population envisage the possible occurrence of serious accidents in nuclear power plants.

The republic of Korea is in a position similar to Japan with a more important share of nuclear power and some persisting problems of public acceptance originated in the previous regime.

- b) The UK is not a typical case for the first group and, probably it can be put rather in the second group. This second group includes countries, where the half of the world nuclear capacities (160.000 MW out of 326.000 MW) is concentrated. These countries started to build their nuclear power as the first ones, had available both scientific and industrial potential, but their nuclear option had been made because of economic reasons rather than as a result of a lack of other energy resources. Most of these countries

are also very environmentally conscious. Therefore both big nuclear accidents provoked there strong antinuclear movements based more on emotional arguments than on rational ones, simply because these countries could afford it. Now, with new facts obvious while using fossile energy sources with their consequences in air pollutions and green-house effect, the attitude of the public is slowly changing. We should take into account, that these countries possess a big scientific potential, enabling them to solve succesfully most of safety, environmental and operational problems accompanying nuclear energy. The success of nuclear revival in at least some of these countries will have a decisive impact on the further development of public attitude towards nuclear energy world-wide. And of course, the main condition for such a development is the safe and reliable operation of all NPPs now in the operation anywhere.

- c) The situation in former socialist countries is rather specific and uncertain. The 48.000 MWe in operation in these countries (a seventh of world's NPP output) reflect the delay in the nuclear start of these countries. Their present program declaring on going on with construction of another 30.000 MWe will definitely undergo some corrections due to economic reasons and public refusal. Economic problems have stopped the nuclear program in Poland and limited it in allmost all other countries of this group.

Trying to understand and to solve the problems of public acceptance of nuclear energy in post-communist countries, we must take into account the following moments:

- previous unquestioned orientation on nuclear energy, but late and undisciplined implemented,
- autoritative decisions of the authorities as to the extent, location and safety level concerns, without any public hearings,
- restoring of democracy and freedom of information, together with raising interest in environment gave rise to antinuclear movements,

- a general bad experience with the honesty and expertise of the governmental structures of the sole ruling party broke the confidence of people in to state bodies, including the nuclear regulatory office.
- d) The last group of countries declaring their abandoning the nuclear option are of minor economic and political importance, with the exception of Italy, whose return to the nuclear club is expected soon.

The antinuclear opinion which succeeded in putting some kind of moratorium on new NPP constructions in these countries can actually lose its influence very quickly due to global environmental considerations.

In general, the attitude of most countries and that of their public will develop according to complex situation on the market of energy and at the same time depending on environmental and safety issues.

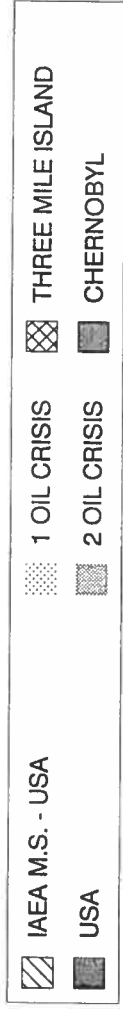
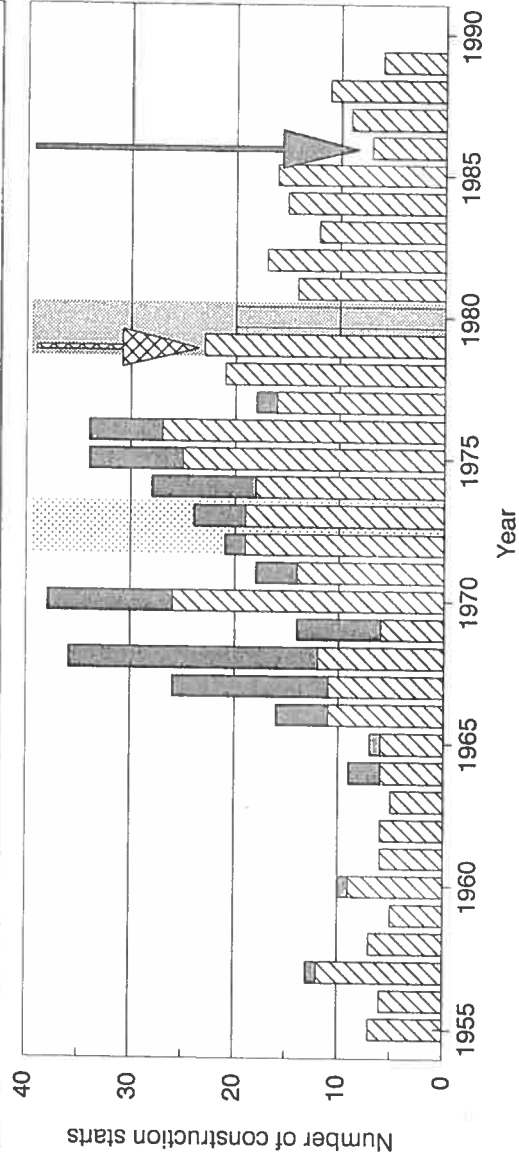
Conclusion

The energy demands in the world increase while fossil resources are being exhausted and the ecological harmfulness of their overuse becomes a public knowledge. Therefore an appropriate and temporary revival of nuclear energy is generally expected. The safe and responsibly implemented nuclear energy will, however, have to overcome yet a number of obstacles and barriers. These barriers are of the two types:

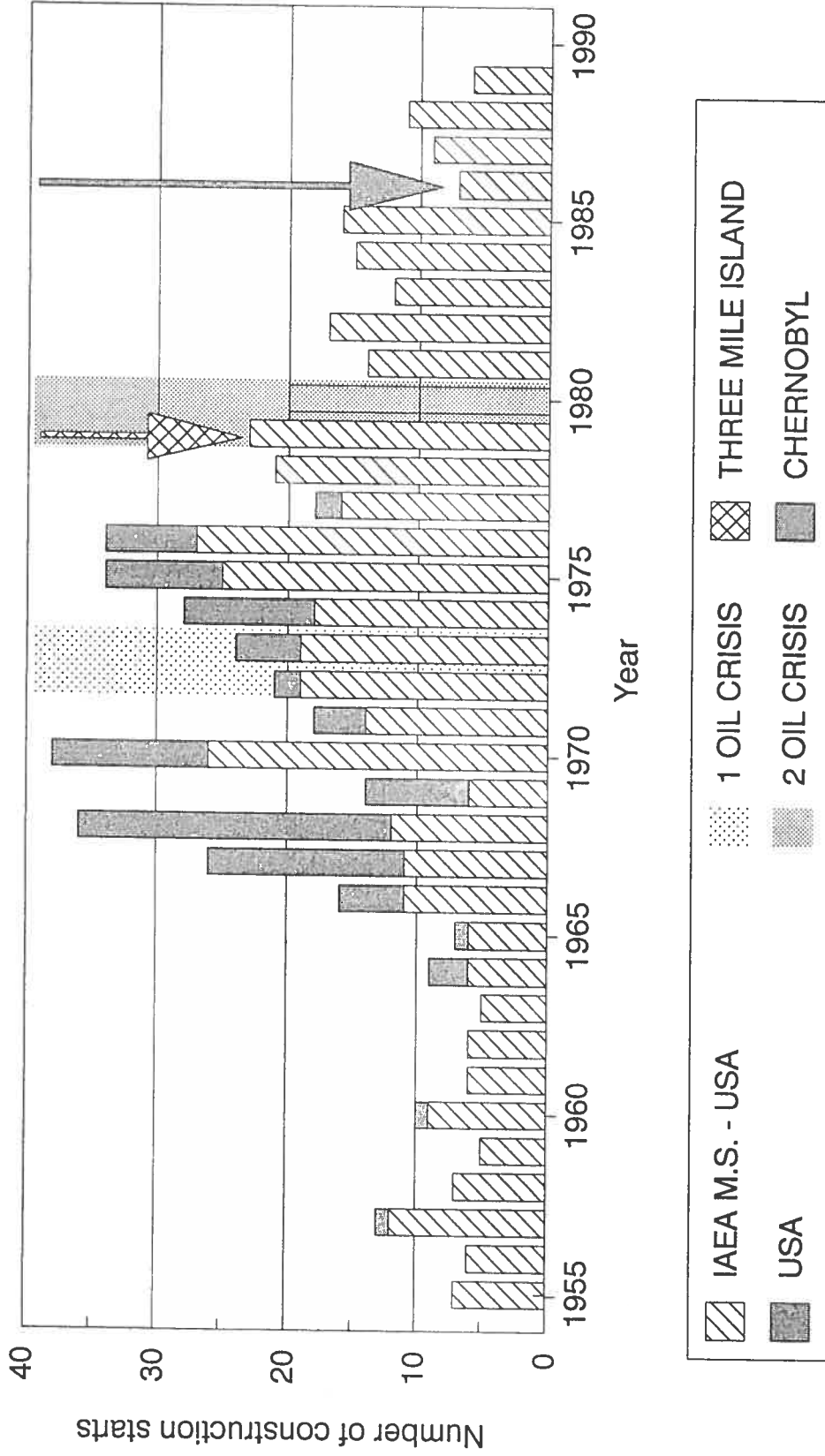
- The first are objective ones, follow from the complexity of nuclear power and from the scope of possible risks connected with it. They could be overcome by continued increase of nuclear safety in all stages of NPP construction, as the experience confirms that. It is up to authorized decision-makers to make sure that nuclear safety requirements will be implemented by nuclear operators and manufacturers in such a way that risk and economic issues will be balanced against economic and ecological needs of a society. General public must be kept informed about these efforts and about their practical results, and gradually acquire own long-term experience that nuclear power is not only safe but also ecologically beneficial.

- The second barriers, those non-objective, originate in prejudice, in old, mostly already overcome mistakes of the manufacturers and operators, but also in the demagogic misuse of non-sufficient knowledge of a part of the public, employed by some low-principled mass media to gain audience and the popularity by a cheap sensation. In the former socialist countries, there is an additional factor of the public distrust to state authorities and institutions, including those responsible for the regulation of nuclear safety. The only way how to limit the negative influence of these non-rational attitudes (to eliminate them is and will be probably impossible) is the same as in the first case, i.e. to win the public confidence.

CONSTRUCTION STARTS OF POWER REACTORS IN THE IAEA MEMBER STATES AND IN THE USA



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