Nuclear Power as a Public Issue: Protection of the Public Interest

by Jan M. Døderlein

In evaluating the desired role of nuclear power, the overall perspective of the role of energy in society should be applied. Views on the role of electric energy and its production forms need to be integrated in an overall cost-risk-benefit analysis on overall economic growth [1], energy use and energy conservation. The formidable difficulties of total cost-risk-benefit analyses (predicting the values of future societies, devising accounting methods for weighting present and future costs and benefits, feedback between development of large-scale technology and the development of societal values and of society, etc.) should make us settle for less comprehensive and perhaps semiquantitative analyses. The necessary technological and scientific basis for useful analysis is available. The societal risk-benefit criteria, the institutional apparatus, and the political ability and willingness to apply rational cost-risk-benefit analyses do not seem to be equally well developed.

A specific difficulty for evaluations of electric power production systems is the incomplete analysis of the benefit, electricity. There is a detrimental lack of factual, detailed and understandable data on the benefit of electric power within a systematic structure of categories similar to that used for analyses of detrimental impacts of power production and use (see section below on systematic technology evaluation).

TECHNOLOGICAL RISK AS A FACTOR IN PUBLIC ACCEPTANCE

Responsible and detailed risk evaluations for the nuclear fuel cycle are numerous, technologically convincing and consistent in showing low overall risks. In spite of this, risk aversion is a factor in public and political reluctance to accept nuclear power in some regions and countries [2, 3, 4]. An increasing attention to technological risks in general is also apparent. Two causes seem to be particularily important in this context. Increasing the size of individual industrial plant concentrates disamenities and risks in space and time, thus focusing attention on these negative factors, while the benefits are spread in time and space. Improved welfare and population health, in conjuction with increasing use of technology, have increased the relative importance of technological risks at the expense of traditional health and death risks (illness, etc.).

Protection of the public interest must rationally be based on management of the *objective* real risks to individuals and society. Public reactions to technological risks are, however, usually dominated by risks as *perceived* by individuals, being the feeling of uncertainty (or lack of knowledge) and fear that an event or situation can have undesirable consequences [4]. Decision-making based on the public's perceived risks will often be irrational and counterproductive to risk reduction.

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Some form of the following procedure is believed to be required in order to improve substantially our rational and our objective understanding and management of technological risks (no implication on the feasibility of the procedure is intended). Risk situations are statistical in character. Logically, statistical questions require statistical answers. Thus the use of the concept of probability is necessary. There is a widespread confusion between the objective numerical interpretation of probability and the subjective interpretation of probability [5]. The latter interpretation clearly dominates. The subjective interpretation assumes that the use of probability is caused by our lack of knowledge, probability measures the degree of our "belief" in theories or knowledge of events (Bayesian probability). This subjective interpretation is clearly nonempirical. Furthermore it seems unreasonable to expect to obtain knowledge (i.e. probabilities) from lack of knowledge [5]. Thus, unless one dispenses with the subjective probability interpretation it will not be posssible to obtain empirically useful probabilistic answers to risk (statistical) questions, and rational risk analyses cannot be performed. A major obstacle to assessing the acceptability of nuclear risks is the lack of a reference level for societally acceptable risk, an answer to the question "how safe is safe enough?". While such a level clearly depends on many subjective factors, the level can only be determined on the basis of an objective intepretation of statistical knowledge, of probability.

When society, through its accepted political institutions, has decided on societally acceptable levels of risk, the science of risk analysis can be applied to advantage in promoting rationally based protection of the public from real empirical risks.

THE NUCLEAR CONTROVERSY, SOME COMMENTS

Nuclear power has been integrated into society in a number of countries without much attention from the public or from political institutions and organizations. In many countries there is, however, increasing controversy over nuclear power. The debate has been developing over the years, focusing at this time on three main questions: a presumed increase in the risk of proliferation of nuclear explosives, the handling of radioactive waste, and risks for major nuclear reactor catastrophes. Indications are, however, that there are several more deepseated forces behind the controversy than these (and other) specific and mainly technical issues [6]. This topic will be discussed further in the section below on philosophical and societal background.

Among the many groups critical of nuclear power, two have been particularly prominent over the past few years. They are characterized by their emotional and irrational approach. One group consists of people for which nuclear power is apparently a vehicle for self-realization. They seem to play out some of their inner and emotional needs by taking an active part in the controversy, and the factual nuclear issues seem to play a secondary role. The following quote illustrates the point:

> "We are here to begin democratic control of technology".
>
> — Ralph Nader, at major US anti-nuclear meeting

The other emotional group of critics is composed of professional and amateur politicians, notably some members of leftist groups, anarchists, populists and environmentalists. Nuclear questions, real or imagined, are means by which they seek to further their own political goals, sometimes clandestinely, sometimes openly as the following two quotes indicate:

> "Actually I think in order to achieve a truly sensible resource utilization in the USA, it is necessary to socialize the economy in a classical marxist sense".
>
> — Barry Commoner, in a debate on nuclear power

> "In nuclear power the nuclear technologists wield power to control society. Democratic government through e.g. parliament easily becomes illusory".
>
> — Leading Norwegian Environmentalist

Religious organizations are also beginning to take stand in the nuclear energy question. The Committee on Inquiry on the Plutonium Economy of the National Council of Churches of Christ in the USA has issued a proposal for a statement recommending a ban on use of plutonium, and opposing nuclear power in general [7]. The proposal and its background material are ambiguous on whether it is intended to influence the nuclear power question via the democratic institutions, or by influencing religious beliefs. One reaction to the statement has been given in the context of the issues of the welfare of future generations and the rich versus the poor nations:

> "Such issues tend to get ignored when technocrats dominate the debate, so it may take the churches to tell us whether plutonium is a gift from God or a temptation sent by the devil".
>
> — P.M. Boffey, Science [8]

Nuclear critics rarely support their assertions with reasoned arguments or with facts, and they consistently invoke the opinions of some distinguished scientists, some Nobel Prize winners and some professional societies, ignoring others who disagree with their views Thus many nuclear critics seem to share one characteristic: they accept authoritarianism as a road to knowledge, often to the exclusion of other sources of knowledge.

More than in other contemporary debates on technology, a small number of activists, scientists and professionals have provided both focus and leadership for the anti-nuclear movement. The role of the professional in the nuclear controversy will be discussed below. (For further comments on the controversy see Ref. [6]).

THE PHILOSOPHICAL AND SOCIETAL BACKGROUND

As indicated above, the nuclear controversy has more complex and deepseated causes than the widely discussed technological issues. One important part of the background is a carry-over to nuclear power of the fear of atomic bombs initiated in 1945 and furthered by the atomic bomb fallout and test ban issues of the late 1950s. Another cause is the fact that nuclear technology came to maturity exactly when in industrial societies attention was rightfully focused more than in previous times on the environmental aspects of industrial and energy production. Therefore, in many countries nuclear installations are the only type of electric power plant for which detailed safety and environmental evaluations by government agencies are required, and where these evaluations are open to direct public participation. Thus, the temporal coincidence of nuclear power and environmental concerns is believed by many to be an important catalyst in bringing forth the nuclear issue. Reinforcing this specific nuclear aspect is a more widespread anti-technology feeling, which manifests itself in debates on as diverse topics as oil production in Norway and airport constructions in Japan and the U.K.

Beginning in about the 18th century, natural science was increasingly taken into use as a substitute for religion, and as an ethical foundation for an existence philosophy. Over the past 50 years science has increasingly lost this role, leading to a mystic-religious vacuum with many people. In their fear of a spiritual vacuum, many apparently try to fill the vacuum with something outside of science. At the same time some professionals continue to use the scientific approach as a practical basis for filling their needs for mysticism and religion. Feeling intuitively, but diffusely, that science has no value as a basis for religious feelings, many turn in anger on science and technology, which they perceive as "the God that failed". They then topple science from its fake pedestal as a guide for ethical human action. Unfortunately, in disappointed mysticist blindness they also remove science and technology from its essential and rightful role as an important guide to practical running of modern society. Whether cause or effect, this is coupled with a clearly evident upsurge in emotionalism and irrationalism in our society (see Ref. [6] for nuclear context, Ref. [9] for sociological background, and Ref. [10] for the importance of irrationalism).

Returning to confusion in the application of the concept of probability outlined in the technological risk section above, we observe in the nuclear debate a continuing quest for authoritative causal-mechanistic answers from science and technology to statistical questions, questions which we have seen can "only" be provided with non-absolute objective probabilistic answers. Nowhere is this more evident than in the confused requirements for absolutely risk-free radioactive waste management and absolute guarantees against potential reactor catastrophes.

In what many see as an increasingly technology-oriented society, anxiety is often felt in the face of a development and a future we do not understand and cannot predict. Contrary to popular belief, this is not specific to our time. Fundamentally all human actions have unexpected consequences, and man has never been able to predict developments which depend on growth and change of his knowledge.

One perspective on the nuclear issue, then, is that our major problem may be that of fighting irrationalism and emotionalism as applied to solving the real physical problems of reducing human suffering. The fight is, however, *not* against emotions and the irrational as such.

PUBLIC INTEREST AND THE PROFESSIONAL

Assimilation of science and technology in the culture of industrialized society is, and may continue to be, incomplete. Thus we find an insufficient understanding of the fact that natural sciences and technology are disciplines that can be applied for the attainment of ends chosen, but not disciplines of the science and art of the choosing of ends. The information that science and technology can usually give, namely alternative means to attain specific goals, is often felt as insufficient. In the nuclear issue, as in other issues, this manifests itself in a vain quest for authoritative answers from science on "what is good for society?". Another aspect of this is (as indicated in the technological risk section) a desire for ultimate objectivity believed to be attainable through science.

What then is "scientific objectivity"? Two views appear to prevail. The dominant view is that objectivity rests with the mental and psychological attitude of the scientist, in his impartial and unemotional attitude to his subject matter. This view is both erroneous and dangerous. It is erroneous because scientists are primarily ordinary human beings and only secondarily scientists. And it is impossible for all of us, also for the scientists, to be completely unemotional and impartial. When this is discovered, we are led to believe that scientific objectivity does not exist. This belief is dangerous since it deprives us of our rationality, of our contact with the world of nature through objective knowledge. It is conjectured that this may be one important factor in creating a lack of credibility in scientists and hence in science.

There is another view of scientific objectivity, a useful view accepted by many scientists. This concept of objectivity is created by requiring that science should be free and public. The scientist should submit his reasonings, theories and empirical results to free and open critique by his colleagues and his peers within his chosen field. In the discussion and the evaluation it is accepted that a prerequisite is to have a critical attitude without recourse or reference to authorities or outside interest. A fundamental part of the open and public character of science is that scientific results should be testable and repeatable by all those who know the required scientific techniques. And only after such intersubjective critique and testing have been performed do we expect that a scientifically objective result has been obtained, a result which (in all its incompleteness and with all its uncertainties) can be presented and temporarily accepted outside the scientific community. That such a result has neither absolute authority nor lasting validity in all its details may be regrettable, but nevertheless must be recognized as a fact of life and science.

Failure to understand these views on scientific objectivity is at the root of misconceptions and misuse of the roles of science and scientists in societal issues, including the nuclear issue. The misuse of world models, scientific arrogance, and public manifestos from scientists, are three important and well known examples from the nuclear controversy where irrationalism in convolution with this failure is at play.

A misuse of science in trying to obtain authoritative answers is found in some applications of the world models created by science over the past few years. These models have been used to predict future societal developments, the predictions sometimes containing future societal cataclysms. Such predictions have catalysed many leading personalities in politics, science and technology to shoulder the burden of guilt associated with present and future negative impacts of expanded industrialization. This burden of guilt sometimes transforms itself into actions to steer the development of society away from these perceived cataclysms. Such actions provide some world models and their predictions with the combined authority of science and leading personalities in society. This authority is merited neither by the scientific validity of the models nor by the convolution of societal authority and the "authority" of science.

Some members of some professions appear to believe that, because of their special background, their political conclusions are based on sounder analysis of the evidence than the public. If one expects the public to have confidence in the role of professionals in decisions, the opinions of highly regarded experts within their chosen profession must be accorded a certain authority within the limits of scientific objectivity. But it is equally important not to support a carry-over of professional authority to political and ethical questions. Such a carry-over may be indicative of intellectual arrogance.

In the past years we have seen a plethora of manifestos and statements for or against nuclear power by Nobel Prize winners, by groups of scientists and by various professional societies. To increase the authority and hence the impact of the statements, the eminent and special qualifications of the participants are always emphasized. Practically without exception, the participants in the anti-nuclear manifestos have no technical and no practical background in fields relevant to nuclear technology, and hence misuse the objectivity of science. Against the participants in pro-nuclear manifestos, this criticism is less relevant.

One criticism is valid against all manifestos on nuclear power. The scale and timing of the introduction of nuclear power is a major and complex decision, resting on technical, economic, political and other societal considerations. In a democratic society such decisions are not left to scientists and technologists, but to elected political officials. A professional using his backgound in support of personal views on societal questions, tries to carry his professional "authority" over into fields where he should no longer have such "authority", into fields where his opinions should be weighted on the principle of "one man, one vote" [11].

One important role of the professional in the nuclear issue will thus be to fight emotionalism and irrationalism applied to his professional field. And in this it is presumably a prerequisite for retaining public credibility that he works within the realm of scientific objectivity proper.

SYSTEMATIC TECHNOLOGY EVALUATION

If we do not improve our control of assimilation of large-scale technologies into society, we may end up with technology controlling the development of society. Realizing this, some seek to stop the further applications of science and technology, apparently not appreciating that deinvention of scientific discoveries has never succeeded. At the same time, the environmental movement contains the seed of a new dimension in controlling large-scale technologies. Such control as has been proposed by environmentalists as well as that which has been applied so far, has been ad hoc and unsystematic. This is clearly illustrated by the following fact. Rules and regulations for nuclear power generally contain requirements for societal cost-risk-benefit analysis. Thus information on environmental and health detriments of nuclear power is produced. However, as already indicated, criteria against which these detriments can be measured are lacking. More important, similar information for alternative energy production systems is neither required nor produced, and a societal optimization of energy production becomes impossible.

A systematics is needed for establishing societal criteria for optimization and control of technology. The costs and benefits, or impacts, of technology, specifically energy production, need to be considered in three dimensions: space, time and society. Any impact classification should presumably include the areas of health, environment, resource considerations, economy, and political-societal impacts. Within the present rudimentary state of the art, qualitative criteria and evaluations must be accepted and can be useful. An example of the qualitative structure of a systematic technology evaluation scheme is given in **Table I.**

As indicated, it may be useful to divide the parameter variations in each of the dimensions into three ranges. Furthermore it is necessary to distinguish between the extension of the agent causing the effect (e.g. air pollution), and the extension of the effect itself (e.g. short-term effects like bronchitis vs. medium-term effects like cancer).

Table I. Elements of Technology Evaluation Systematics

Impact \ Dimension[a]	Space			Time			Society		
	Local	Regional	Global	Short	Medium	Long	Individual	Group	Humanity
Health	x[b]	x	x	x	x	x	x	x	x
Environment	x	x	x	x	x	x	x	x	x
Resource	—	x	x	—	x	x	—	x	x
Economy	x	x	x	x	x	—	—	x	x
Societal	x	x	—	—	x	x	—	x	x
Political	—	x	x	x	x	—	—	x	—

a Each impact needs to be considered in two additional parameter ranges the extension of the *agent* causing the impact (e.g. air pollution) and the extension of the *impact* itself (e g cancer).
b x = to be evaluated, — = not relevant

When evaluating energy production systems, the total system must be considered, from fuel production through energy production plant to waste handling While this is normally done for nuclear power, the evaluation is not complete for other energy forms (for instance, the waste from fossil-fuel energy production is disregarded).

The very substantial societal costs incurred by disregarding a systematic evaluation and selection of alternatives are illustrated in the following example on evaluating health

Table II. Illustrative cost of public fatalities in the USA from electricity production pollution in the period 1975–2000 [3]

Item	Nuclear[a]	Coal[b]
Assumed electricity generation 1975–2000, equivalent to	35 000 TW h 5400 plant-years	35 000 TW h 5400 plant-years
Assumed radiation-induced cancer fatalities per plant-year	0 2	—
Assumed air pollution-induced fatalities per plant-year	—	44
Assumed fatalities in period 1975–2000	<1100	240 000
Social cost at US $300 000 per fatality	<US $330 X 10^6	US $72 000 X 10^6

a Total social costs for nuclear power may be larger and are not dominated by pollution
b Pollution-generated illness (not included) and fatalities probably dominate social costs. Fatality estimates are highly uncertain and could range from 10 000 to more than 500 000.

effects of power production [3]. **Table II** shows an estimated cost of public fatalities that might be caused by the general air pollution from nuclear- or coal-generated electricity in the United States in the period 1975–2000. Numbers are especially uncertain for fossil fuel and should be taken as indications only. (An example of a more comprehensive evaluation covering the total social costs of coal and nuclear electricity production is given in Ref. [12]).

Attention is drawn to the last row of **Table I**, representing political impacts of energy production. An example of an important impact is the question of potential proliferation of nuclear explosives because of plutonium produced in power reactors. While many point to the importance of this aspect, it should not be forgotten that serious political impacts in fact have arisen and may continue to arise within other energy production systems, for instance the oil fuel system. Perhaps the major difference in the case of the plutonium proliferation is the unique political agreement on the international non-proliferation treaty. Similar treaties have apparently never been applied to war materials or products from, for instance, oil, or to non-nuclear weapons.

While many other energy system evaluation schemes are possible, one feature of the scheme indicated above should be quite general. The impacts should be considered in terms of beneficial or detrimental effects to man and his environment, not as is often done in non-nuclear areas, in terms of secondary parameters such as tons of oil spilled, concentration of harmful materials in air and water, etc.

Finally, it is emphasized that the systematic technology evaluation also requires an analysis which so far has almost never been performed: an analysis not only of alternative technologies, but also of the alternative of abstaining altogether from the products and the use of a given technology. Relevant to the nuclear issue is the fact that an evaluation has never been performed of health, environmental, resource, economic, social and political impacts of not maintaining or expanding electric power production.

THE PLACE OF FACTS IN A WORLD OF VALUES

All human action will entail unforeseen consequences. Plans for actions cannot be based solely on factual proofs and logical deductions: they must finally rest on political decisions made in the face of uncertainty, a point which gives a perspective on the place of scientific and technological fact in a world of individual and societal values. Clearly, a number of *irrational, emotional* and *ethical* factors and demands may be of importance in a choice of power plants for electricity production. But an evaluation of *rational* and *quantifiable* factors tells us how many lives, which environmental improvements, what economic and social advantages we may have to sacrifice in order to satisfy such emotional demands.
In protecting the public interest, the importance of the irrational factors in the nuclear issue must be recognized, but as many problems as possible should be decided on a reasoned, factual and rational basis.

The place of facts in a world of human values should be set by the values, but facts cannot be changed by values.

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