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Prospects for public participation on nuclear risks and policy options: innovations in governance practices for sustainable development in the European Union

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Abstract

We outline the potential participative governance and risk management in application to technological choices in the nuclear sector within the European Union (EU). Well-conducted public participation, stakeholder consultation and deliberation procedures can enhance the policy process and improve the robustness of strategies dealing with high-stakes investment and risk management challenges. Key nuclear issues now confronting EU member states are: public concern with large-scale environmental and health issues; the Chernobyl accident (and others less catastrophic) whose effect has been to erode public confidence and trust in the nuclear sector; the maturity of the nuclear plant, hence the emerging prominence of waste transportation, reprocessing and disposal issues as part of historical liability within the EU; the nuclear energy heritage of central and eastern European candidate countries to EU accession. The obligatory management of inherited technological risks and uncertainties on large temporal and geographical scales, is a novel feature of technology assessment and governance. Progress in the nuclear sector will aid the development of methodologies for technological foresight and risk governance in fields other than the nuclear alone. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

This paper discusses participative governance and risk management in application to technological choices in the nuclear sector within the European Union (EU). We seek to explain

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why, and how, well-conducted public participation, stakeholder consultation and deliberation procedures can enhance the policy process and improve the robustness of strategies dealing with high-stakes investment and risk management challenges now confronting EU member states. This means to identify and explain procedures that can be seen as legitimate and practicable not just for governments and the European Commission, but also for the public at large, for non-government stakeholders and, particularly, the industries implicated in the nuclear sector. The present section introduces the overall argument. Section 2 recapitulates on major features of nuclear energy governance in the EU from the 1950s to the present day. Section 3 discusses the emerging issue of historical liability in the nuclear sector. Section 4 deepens the diagnosis of the new governance challenges, addressing uncertainties in energy futures, reactor waste siting and disposal, nuclear installation safety in EU accession countries of eastern Europe, and innovative fuel and waste disposal cycles. Section 5 explores prospects for participative governance in EU nuclear matters and Section 6 concludes.

For the purposes of this discussion, the following definition of governance will be retained: "Governance is the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and a co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest" [1].

Governance in this definition does not refer exclusively to the intervention of the State, but covers all sets of rules, decision-making procedures, and programmatic activities that serve to define social practices, guide the interactions and manage the conflicts that may arise among those participating in these practices. In the case of nuclear energy, pros and cons are quickly identifiable. For the proponents of nuclear energy, the nuclear electric sector is uniquely qualified to make a major contribution in Europe along several axes.

- It may help to provide Europe with a secure and sustainable electricity supply at a competitive price.
- It can make a significant contribution to economic resilience and environmental performance goals, as a component in a diversified energy supply portfolio (inter alia, reducing overall emissions of CO_2).
- Efforts to develop the safety and security of nuclear energy systems can strengthen the Community's industrial competitiveness, through focusing and exploiting European technological expertise.
- Lessons learned in the nuclear domain about risk management, governance and communication can be extended to other technology choice and environmental policy arenas in Europe and world-wide.

The context of this 'nuclear promise' is, however, the mastery of a triple challenge of high systems uncertainties, high economic decision stakes and high public sensitivities nourished by (in some cases) strong moral and political convictions.

There are currently (in 1999) about 140 major nuclear units generating electricity in Europe. Their nuclear power supplies more than 30% of the EU's electricity. This is a very substantial capital and technological investment. At present, no new plants are being built or on order. There are two main reasons for this.

1. The limited commercial attractiveness of nuclear capacity. In the face of present trends of liberalisation and denationalisation of energy markets, the private sector is working with the hypothesis that other forms of energy, particularly gas, will be cheaper and less risky for the foreseeable future (in France, the saturation for demand of base-load electricity is also an important factor, in the context of EU liberalisation).
2. Public disquiet, relating to questions about reactor safety and radioactive waste transport, storage and disposal.

These two factors — wariness of the part of the public and limited commercial attractiveness — are evidently linked. Preoccupations about reactor safety can slow down construction and increase costs, partly because of engineering requirements and partly because of local resistance sometimes backed by legal objections and public inquiries. Also, a reluctance to take on responsibilities for waste storage and disposal in countries where no long-term repository has been licensed and/or where the legal framework for responsibilities is not stabilised, increases perceived risk to investors as well as scepticism of members of the public.

Whatever the views for or against nuclear, if divisive (and potentially destructive) conflicts are to be kept manageable, then the factors that currently obstruct expanded exploitation of nuclear energy must be deeply understood in their societal as well as engineering dimensions. Stakeholder participation frameworks that can permit testing of the viability and acceptability of practical solutions to the outstanding scientific and technical problems and public concerns, are one contribution to this conflict management goal (see [2,3]).

Participative practices are here understood to entail bringing together technical and scientific expertise with the knowledge held by stakeholder groups and the public at large, in a context where wider social dimensions of quality assurance and legitimacy can be aired. Through more participative processes, the technical and economic issues of risk governance and investment choices may be opened up to the full dimensions of social demand. In many countries in Europe, a social demand has built up for an opening up of decision processes, and in particular for a re-insertion of expertise on nuclear matters within wider social processes of decision justification and quality assurance. [1] This has come as something as a surprise to the established authorities, yet, for a variety of reasons, a progressive shift to more participative modes of nuclear policy evaluation and governance now seems unavoidable. In other fields of technology, health and environmental risk evaluation and management, European legislation has, over the past 20 years, evolved from a principle that the public has 'the right to be informed' about immediate dangers, through to the 'right to participate' actively in planning, emergency preparation and investment decision situations [4]. [2] In this sense, the active agency of the general public — that is, their roles and their rights to take action in certain political domains as citizens, as representatives of certain interests, and as consumers — is being progressively enhanced. No longer is the 'general public' being defined (implicitly or explicitly) as an undifferentiated mass of rather ignorant people, but rather it is portrayed as a community of diverse actors, individual and collective, having specific spheres of competence and interest of direct relevance to planning, risk management and decision-making. Although these developments have taken place largely

[1] For a discussion of quality assurance in complex scientific and expert processes, see [5].

[2] Our diagnosis of the evolution of European governance is strongly indebted to the work of De Marchi et al. (see [4]).

outside the nuclear domain to date, it seems likely that future governance of the nuclear sector will follow the same path.

The nuclear sector presents certain particularities — long active lifetime of components and wastes, severity and irreversibility of possible health and environmental impacts, high public sensitivities and divergence of opinions, and a link to military operations. Yet, these features are not uniquely attached to the nuclear industry: we can see comparable features, more or less pronounced, whenever a technology entails profound interactions with biological and physico-chemical structures (genetically modified organisms, atmospheric emissions and climate change, and so on). When stakes are high, values diverge and time-scales are long, purely 'technical' or expert approaches to risk assessment and governance are not robust. Our argument is that the best hope for a robust governance process that can mobilise the necessary expertise while maintaining trust and political legitimacy is through a process of deep and wide participation of stakeholders in the judgements, management and decisions.

A strong theme of contemporary risk governance and technology choice is an improved understanding of the significance of irreversibilities in technology choices. In particular, with nuclear wastes, new generations in European societies (and elsewhere) are addressing themselves to a 'heritage of the past' — an inherited nuclear electric capacity, and the accompanying inherited uncertainties and risks. Radio-protection and waste management are part of what is now referred to as 'historical liability'. Societies having adopted nuclear electricity must, even if they now choose to abandon it, live for a very long time with the question of waste management and possible adverse impacts. There is a big challenge to maintain expertise in a situation where some of the glamour of the new technology is gone, but where economic dependence (for energy supply) and health and environment concerns require continued watchfulness and investment.

2. The EU historical context for nuclear governance

The recognition of the European citizens' 'right' to taking part in policy decisions on risks and the environment is, as we have noted, now strongly established as a guiding principle of the European legislation and policy for risk governance, management and appraisal (in addition to [4], also see [6,7]). Yet, a full realisation of this model of participative governance requires broad changes in terms of professional and institutional practices, and the implementation of new tools and procedures for information sharing, deliberation and participation. In this section, some key elements of the historical and institutional context for the emergence of participative governance procedures in the nuclear sector within the EU are outlined.

2.1. The Euratom treaty

In the preamble of the *Euratom treaty* establishing the European Atomic Energy Community in 1958, the signatory powers recognised the importance of nuclear energy for peaceful uses and expressed the will "to create the conditions necessary for the development of a powerful nuclear industry". At the time when the Treaty was signed the main orientation was to the development of nuclear industry for increasing energy supply and, as such, generating economic wealth. Peacetime exploitation of nuclear energy was to bring a better quality of life, economic security and improved international relations. Health and safety matters were subsumed within this orientation, mostly in terms of procedures for establishing basic standards for the protection of the health and safety of the workers and the general public against the dangers of ionising radiation.

Common standards of protection were laid down for the first time in a Directive of 1959, subsequently amended several times in the sixties and seventies in the light of new scientific knowledge concerning radiation protection. [3] The importance of training and information for workers is constantly stressed. Modifications to the standards were made in the early eighties. The new norms required, among other things, that exposed workers, apprentices and students be informed of the risks involved in their work and are appropriately trained in the field of radiation protection. Also, workers must have access to the results of the exposure measurements and the biological examinations concerning them. In 1990, a supplementary directive was adopted, dealing with operational protection arrangements for outside workers performing activities in controlled areas. No similar provisions are yet established for the general population in case of the release of radiation.

We may note two features of this period.

1. An acceptance by the public of the benefits of nuclear technology is considered as a fundamental element for the development of research and practical applications. This is expected on two grounds: (a) the promise of increased welfare; and (b) public trust that all the possible negative effects of the peaceful use of nuclear energy are known and controlled.
2. Though workers and the public at large are the major subjects of concern, they remain passive subjects, to be taken care of through expert competence. In 1957, it was still possible to design a legal framework within which the general public was not explicitly acknowledged as an active subject, with a say in issues of concern. The task of taking care of its needs and concerns were assigned exclusively to high level governing and scientific institutions.

We can thus characterise the regulatory framework through to the 1980s under the general heading of 'need to know'. Immediately interested parties are informed about radiological risks only if and when this is considered necessary to preserve their health and safety.

2.2. A changing social demand

Over time, things have changed dramatically due to historical transformations which have concerned not just nuclear energy but technology, science and society at large. We may note the following.

- Emerging public concern with large-scale environmental and health issues, and the associated changes to regulatory frameworks. These issues include notably: (1) major industrial risks such as the Seveso and Bhopal accidents; (2) risks associated with the agro-food

[3] De Marchi [8] provides a list of legal references.

sector (including the 'mad cow', dioxin-contamination of chickens, and so on); (3) irreversibilities associated with 'global' pollution issues such as ozone layer depletion and the enhanced greenhouse effect; and (4) bio-technologies involving cloning and genetic modification.

- The Three Mile Island and Chernobyl accidents (and others less publicised or less catastrophic) whose effect has been to erode public confidence and trust in the nuclear sector. An essential basis for this growing public distrust lies in the frequent deliberate concealment of information and cover-ups by governments about nuclear incidents and accidents.
- The maturity of the nuclear plant, hence the emerging prominence of waste transportation, reprocessing and disposal issues as part of historical liability within the EU.
- The nuclear energy heritage of the candidate countries to EU accession. Enlargement will change the nuclear energy map of the EU. Some of the candidate countries depend heavily on the production of energy by nuclear power; and in some, the state of the industry is not adequate by EU standards.

In this changed context, the *fifth action programme on the environment* published in 1993 [9], again stresses the importance of societal consensus on nuclear matters: "It is particularly important to the nuclear energy sector that public confidence in it be maintained or even enhanced [...]. This will require wide-spread public information from credible sources. The national authorities and the utilities themselves have the primary role in this regard". A special effort is foreseen "in the field of information and education of the public on radioactivity and radiation protection aspects". However, the explicit reference to 'credible sources' now highlights the fact that public trust can no longer be taken for granted.

2.3. *In the wake of Chernobyl*

Just as the Seveso industrial accident in 1976 triggered the conception and implementation of comprehensive legislation providing for information to the public allowing an active role in risk assessment and emergency preparations, so the 1986 Chernobyl reactor accident has triggered some important, though gradual changes. In its aftermath a number of regulations were issued, both under the Euratom and the EEC treaties, concerning maximum permitted levels of radioactive contamination in foodstuffs and animal feeds after a nuclear accident or radiological emergency, and concerning also imports of agricultural products originating in third countries. [4] Also a decision was passed to favour and speed the circulation of information among member states and the Commission in the event of a radiological emergency caused by an accident or by the detection of abnormal levels of radioactivity either within or outside the territory of a Member State [10]. Here, the early diffusion of information is judged necessary in order to provide the effective application of agreed standards for protection of the population throughout the Community.

There were also more subtle societal changes. Though some arguments were made that such an accident could not happen in western countries (implying inadequate security or technological expertise in the Soviet Union), it became empirically clear to all that the possible consequences of a nuclear accident could be far reaching in geographical terms

[4] Relevant legal references can be found in De Marchi [8].

and in their socio-economic consequences. The confused debate that ensued, brought to public attention the divergences of opinion between scientists, experts, regulators, public agencies, activist groups and others [11–13].

In this context, the issue of public information on radiological emergencies was first addressed in Community legislation, through an ad hoc directive of 1989 devoted to public information about health protection measures and actions in the event of a radiological emergency [14]. This directive was followed by a Commission communication containing advice for its implementation [15]. These stipulations are an outgrowth of previous regulations, adapted to respond to a growing social demand for the 'right to know'.

- Required on the one hand, is information in the event of a radiological emergency. This has to be provided without delay to the population actually affected, and should cover 'the facts' of the emergency, the steps to be taken and the appropriate health protection measures applicable to the case.
- Required on the other hand, is preventive information. The norm is modelled upon the Seveso Directive. The facilities or activities where a radiological emergency can be originated are required to be listed in detail, including nuclear reactors and any other nuclear-fuel-cycle facility; radioactive waste-management facilities; transport and storage of nuclear fuels or radioactive wastes; manufacture, use, storage and transport of radioisotopes for agricultural, industrial, medical and related scientific and research purposes; and finally the use of radioisotopes for power generation in space vehicles.

One objective of the directive and the follow-up communication was to rebuild confidence within the population. The provisions were partly aimed to provide evidence that the responsible persons and organisations are able to manage conceivable radiological emergencies. Enhancement of public confidence could, in this view, contribute to the assurance of a high level of consensus on the acceptability of nuclear technology as a whole, despite Chernobyl and other misadventures. [5]

The events of subsequent years — including the renunciation (more or less decisive) by some member states of nuclear technology, at least in the near future (e.g. Sweden, Germany) — show that high public confidence and trust, establishing the acceptability of nuclear energy developments, have not been fully restored.

2.4. Permanent controversy

Despite concerns with atmospheric pollution and climate change effects associated with fossil fuels, nuclear energy remains the most controversial energy source in Europe. As an example, Table 1 lists opposition rates in some EU countries.

Confirmed supporters of nuclear energy constituted, in 1997, less than one-third of the surveyed populations in all EU countries. Even in countries (such as France) where the fraction in opposition was relatively low, a large part of the population expressed itself as hesitant. The public hesitancy is focused around high costs and doubt about economic necessity; fear of large-scale catastrophes; and storage of nuclear waste. [6] Beliefs that

[5] A similar hope for the positive role of good communication is expressed, with regard to radioactive waste management (in European Commission) [16].

[6] For some interpretative analyses, see for example [17–19,53].

Table 1
Opposition to nuclear energy in population[a]

More than 50% opposition	Denmark, Ireland, Greece, and Portugal
More than 40% opposition	West-Germany, Spain, Luxembourg
More than 30% opposition	Belgium, East-Germany, Italy, The Netherlands, UK
More than 20% opposition	France

[a] Adapted from the 1997 Eurobarometer [52].

reasonable alternatives to nuclear energy are available and feasible (if only the political system would change its priorities) are correlated significantly with a lack of trust in governmental and economic institutions. On the other side, people with a more pro-nuclear attitude tend to hold the views that, in the long-run, nuclear energy is a necessary energy source and that the institutions which promote or control nuclear energy, are trustworthy and credible. This deep politicisation of attitudes highlights the importance of exchanges of perspectives and negotiated policies that can avoid useless conflagrations.

3. The challenge of 'historical liability' in the nuclear sector

3.1. High stakes and uncertain facts concerning nuclear energy

The reasons for lack of public confidence in nuclear energy are complex, and partly have to do with societal changes not specifically related to the nuclear sector. One factor is the increasing recognition that the pursuit of sustainable economic development through science and technology is not without risks, and some of these risks are inherent in the potentialities of science and technology themselves [20–23]. In a general sense:

- The permanent process of pushing back the frontiers of knowledge and science-based interventions also confronts us, in new ways, with the limits to our knowledge and intervention capacity.
- Our knowledge advances permit more and more sophisticated interventions in ecosystem functioning and in the components of life itself; yet our scientific understanding of the physical environment and of the impacts of human activity on life process and ecosystems remains incomplete and in many cases lags far behind our interventions.
- Science-based innovation has, in the past, contributed to industrialisation processes that have proven highly disruptive to ecosystems at local and global levels. Many new commercially attractive technologies may also be incompatible with ecological stability and environmental quality goals.

The Chernobyl accident has given an example, in the nuclear domain that (1) the 'facts' in a situation of emergency are often uncertain and (2) the socio-economic as well as environmental consequences of an accident can be heavy and irreversible. The challenges for governance posed by this problem of incomplete knowledge about possible risks (ex ante) having possibly very serious consequences (ex post) have become increasingly visible. It is knowledge itself, not just the communication of information, that may be lacking in a real situation of risk management.

This consideration features strongly in the current debates over the management of the 'downstream' stages of the nuclear fuel cycle — the transportation of nuclear wastes, the options for long-term storage and disposal of reactor wastes, and the decommissioning of reactors [24–26]. The incompleteness of knowledge and the irreversibility of technological decisions (with the risks that they may entail) mean that societies are required to "participate in the risks together" [26], and this implies addressing social as well as technical issues of risk acceptability.

3.2. *The new dimensions of 'historical liability'*

High stakes decisions in the nuclear reactor waste storage and disposal field must be taken within the next few years, or else they will occur by default. A comparable situation is seen to prevail in other domains of technology and environmental policy, e.g. global atmospheric pollution issues (CFCs impact on ozone layer; greenhouse gas emissions policies); health and environmental risks of pesticide residues; genetic modification technologies (in medical, agricultural and industrial applications) including environmental release of GMOs; life engineering such as cloning. It is noted that, first, public trust in non-transparent expert processes of risk assessment and regulation is much lower now than 20 years ago and second, regulatory procedures based on expert evaluations (such as CBA, scientifically-based safety standards, probabilistic risk-benefit assessments, ALARA), no matter how well conducted, are insufficient for robust public and private decision-making. This inadequacy is by now demonstrated by the historical record (see [2,7,13,27–29]).

A satisfactory explanation of this insufficiency is not found in assertions of the irrationality of the members of society, but rather by attention to the inherent properties of the situations.

- Irreducible uncertainties (unpredictability of complex systems, real yet unquantifiable risks to health, environmental damage, loss of economic opportunity).
- Plurality of social values and hence divergent concerns and justification criteria.
- High decision stakes (including commercial and military interests, risks of social disruption, possible severe irreversible impacts on health of populations and/or life support systems) and long risk/impact time-horizons.

The problem of incomplete knowledge about possible long-term consequences of technology choices has led to the formulation of two complementary governance principles.

1. On the ex ante side, reflecting a desire to avoid or prevent undesirable adverse effects, is the emergence of the *precautionary principle* in policy frameworks and legislation. In the Rio declaration, for instance, this principle is stated as follows: "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" [30]. [7]

[7] On the precautionary principle, also see [31–33].

2. On the ex post side, reflecting the fact of having to live with consequences of past decisions (including any unwanted side-effects or accidents), is the notion of *historical liability* enunciated at societal as well as juridical levels. [8]

The nuclear sector has introduced novelty in human technological history through the particular confrontation with irreversibility imposed by risks of ionising radiations and radio-contamination. In this context, it is not sufficient just to speak for a precautionary approach to new developments. More critical is to confront historical liability and, in this context, the *requirements of memory* that will extend centuries into the future. The question arises: how to maintain know-how in order to govern the collective nuclear heritage, given the possibly decreasing level of interest by new generations of students, taxpayers, and so forth? This radical novelty in technology management is what imposes the requirement for innovation also in the fields of risk assessment and governance procedures.

3.3. Challenges for participative governance procedures in the nuclear sector

There are thus several technical dimensions of reactor safety and the fuel cycle themselves that, in today's context, pose novel scientific and governance challenges.

- Managing the 'nuclear park': uncertainties about future energy needs, and risks associated with extending the lifetime of existing reactors beyond their originally envisaged span (Section 4.1).
- Disposal of waste and decommissioning of existing nuclear installations, including technical know-how, cost-effectiveness and radiation protection for workers and the public (Section 4.2).
- Reactors in the former Soviet bloc — some of which are within accession countries that could soon belong to the EU (Section 4.3).
- Risk assessment for new reactor concepts, including design options related to waste re-processing goals (Section 4.4).

Problems of *public trust* are at the heart of each of these four issues, concerning not only safety, but also the *accountability* of private sector organisations and public sector authorities for very major expenditures of taxpayers', shareholders' and consumers' money.

4. Charting Europe's nuclear future

4.1. Highly indeterminate energy futures

The economic importance of nuclear fission energy is indicated by its current 33% share of the electricity supply in the EU and the big component of nuclear energy supply in several accession countries. The nuclear industry provides about 400,000 highly skilled jobs in the EU, some of which are filled by small and medium size enterprises (SME)

[8] In law, for instance, this translated into the development of the concept of 'objective responsibility'. For example, in the US, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), adopted in 1980, which introduces an objective responsibility for 'potentially responsible' persons.

providing services to the utilities and vendors. Supporting, servicing and maintaining the existing reactors is a large international business with an annual world-wide turnover in excess of 10 billion Euro. Decommissioning of nuclear installations is a growing sector of activity internationally, and one that will become more and more important in the future.

Yet, the place of nuclear energy in Europe's future is shrouded in several uncertainties including technological developments, energy consumption in the developing world, environmental policies including international agreements on global warming, political stability in the oil and natural gas producing countries, the extent of undiscovered oil and gas reserves, and the development of renewable energy technologies. [9] Deliberation must be kept open on various concepts and options, while also pursuing clarification of risks and of technical and economic performance potentials. For example, the extension of the lifetime of existing reactors beyond their originally envisaged span can have several positive features — notably the added-value obtained from an existing capital asset, reduction in the needs for new major nuclear investments, and also the avoidance of a possible return to fossil fuels implying an increase of greenhouse gas emissions. But, it can also entail new risks associated with the fatiguing of structures and build-up of radioactivity. These questions take on particularly acute significance in the case of the EU accession candidate countries (see Section 4.3).

4.2. Controversies over reactor waste disposal

Waste disposal and the future decommissioning of existing reactors is a key dimension of meeting the challenge of historical liability. The next few decades will see a necessary expansion of Europe's decommissioning industry, whose effectiveness must be beyond doubt. Although there are already significant regulatory procedures in place concerning nuclear waste transportation and disposal, [10] within the next decade, major decisions must be taken in several European countries concerning the different long-term waste management strategies, including geological storage/disposal options and innovative concepts of spent fuel partitioning and transmutation. [11] Long-term commitments must be made concerning the restoration and management of contaminated environments and the surveillance of storage facilities.

The dilemmas associated with radioactive waste disposal have already led de facto to the emergence of deliberative procedures in several European countries, as exemplified by the two following examples, in France and in the UK. [12]

- At the beginning of the French nuclear programme, waste disposal was not an urgent problem. Experts started early to develop technical research on this topic. But only

[9] For elements of bibliography on nuclear energy forecast scenarios, see [34–39].

[10] For legal references on the transportation of radioactive wastes, waste disposal and decommissioning, see [8].

[11] In partitioning, one seeks the separation of the long-lived radionuclides (notably plutonium and americium) from the radioactive waste by selective chemical processes. Transmutation is a form of incineration in reactors or special burners that is intended to lead to a decrease of the mean lifetime of the radioactive waste by transforming the long-lived radionuclides into stable nuclides or radionuclides with shorter lifetimes.

[12] For an analysis of these and other existing participative approaches to nuclear policy issues, see [42,43]. The OECD has also engaged in reflections on stakeholders participation: its nuclear energy agency has recently launched an "international forum on stakeholder confidence in the area of radioactive waste management" for which an inaugural workshop was held in Paris in August 2000.

by the mid-1980s did the question become 'critical'. By then, there was an increasing amount of radioactive waste to be stored, and the environmental organisations were becoming more vociferous about the long-term consequences associated with the waste management options. Among international experts, a convergence was taking place towards geological disposal as the reference solution. In the late 1980s the French National Agency for Radioactive Waste Management (ANDRA) began its first major design studies for underground laboratories. This awoke some violent expressions of opposition from local populations as well as from concerned environmental groups. In fact, the risk management system led to dissatisfaction, misunderstanding, loss of confidence, because decisions were mainly taken on the basis of opaque technical considerations and safety criteria. In December 1991, a law (the Loi Bataille) was passed, which introduced a new process for evaluating the different management options for high-level radioactive waste involving various stakeholders in the site selection process. A permanent political surveillance is now established through a scientific committee and mandatory annual reporting to the Parliament by the government. This law also acknowledges diversity in social concerns and choice criteria as well as uncertainty, and provides for three complementary programmes of research, including the concept of 'retrievability' from deep disposal in accordance with the precautionary principle.

- In the UK, radioactive waste management has had a longer controversial history than in France. Following the recommendation of the Royal Commission on Environmental Pollution, in a report published in 1976 [40], it was decided to develop a long-term solution for the management of radioactive waste. Opposition to proposals for a near-surface solution led to a decision in 1986 to consider only a deep repository for intermediate level waste. Although 12 potential sites were identified, there was public opposition to feasibility studies at all of the potential locations. Sellafield in west Cumbria, the location of British Nuclear Fuel's reprocessing plant, was eventually chosen as the site for an evaluation of the safety issues. Following extensive scientific studies, an application was made in 1995 for planning permission to construct an underground rock laboratory at the Sellafield site. Cumbria County Council's decision not to grant permission was contested by the industry and resulted in a public inquiry. The whole process, which has cost the industry an estimated £500 million, came to a final halt in 1997 when the Secretary of State for the Environment upheld the County Council's decision. This left the UK without a viable long-term strategy for dealing with radioactive waste. The issue was consequently the subject of an inquiry by the House of Lords Science and Technology Committee; the Committee's report recommended widespread public consultation before the government formulates a policy [41]. As a first step towards involving a wider range of stakeholders in the issue, an independently facilitated consensus conference was convened in May 1999, involving a panel drawn from members of the lay public and a range of expert witnesses [44]. Contrary to the situation in France, where the scope for stakeholders participation is limited to the site selection process, it is the whole policy that is put into question in the UK case.

As shown by experience in other fields (e.g. Brent Spar oil platform; mad cow disease; regulatory framework for release of genetically modified organisms in Europe), it is desirable that stakeholder participation and consultation become pro-active and not just

Table 2
Nuclear plants in applicant countries[a]

	Units in operation		Under construction		Nuclear share of electricity
	No.	MWe	No.	MWe	
Czech Republic	4	1648	2	1824	19.3
Hungary	4	1729			39.9
Slovenia	1	632			39.9
Lithuania	2	2370			81.5
Romania	1	650	1	650	9.7
Slovak Republic	4	1632	4	1552	44.0
Bulgaria	6	3538			45.4

[a] Data from IAEA [38].

reactive after controversy (see the paper by Faucheux and Hue in this issue, also see [2,45–47]).

4.3. Nuclear safety in the EU accession countries

Reactors in the former Soviet bloc pose, in the EU context, a unique dimension of historical liability and of international concertation. The EU, recognising that nuclear safety is a trans-frontier problem, has been a major provider of aid to the former communist eastern European countries. [13] In particular, many of these countries being candidates for 'accession' to an enlarged EU, nuclear safety has been made an important criterion for entry. The stock of existing reactors in accession countries is indeed quite large (see Table 2).

In most applicant countries, the safety of nuclear power plants has already been reinforced through technical upgrading and the strengthening of nuclear regulatory authorities. The reactors can be divided into three classes: those of older eastern design (oldest VVER and first generation of RBMK reactor); those of newer design; those of western design. The most delicate cases are old Kozloduy units 1 and 2 in Bulgaria, Bohunice V1 units in Slovakia and Ignalina unit 1 in Lithuania. In these cases, the feasible work would still not bring them up to western safety standards. The stated EU objective as regards the accession countries has been to close the oldest reactors (four in Bulgaria, two in Slovakia and two in Lithuania). But, it has been established that the countries concerned would not go along with this [48]. The reasons include the importance of the capital investment and the increased energy supply vulnerability and trade balance stresses that this may entail.

So, an alternative being suggested is for closure at the end of the programmed lifetime. This illustrates the tensions of making compromises between economic, safety and other strategic security goals, and shows the prospects for a participative approach (a) to define as

[13] An overview of work done so far and considerations of what might be done in the future are found in European Commission [36]. The Community has so far provided more than 40% of the total assistance from western countries to date. This compares to about 17% from the United States, 9% from Japan and 21% from individual European nations. A group of independent high level experts was constituted at the beginning of 1998 and asked to give advice on the nuclear safety policies being applied through the Phare and Tacis programmes [48].

good as possible acceptable compromise solutions and (b) for capacity building on a partnership basis in the areas of risk management and communication in the accession countries.

According to the Contzen panel estimates [48], the resources necessary for the safety upgrading of all nuclear reactors in the east (somewhere between 75 and 200 million Euro per reactor) go way beyond what the EU's budget is likely to provide. In this context, prospects of economic and technological interdependence within the enlarged Community take on great strategic importance. Participative procedures aimed at defining key strategic issues and priorities for collaborative R&D between east and west are needed. R&D could be a cornerstone of future contacts with eastern countries, enlarging the co-operation upstream of technical and industrial support.

4.4. Waste disposal and prospects for innovative fuel cycle technologies

Global developments in the 1990s have presented the international community with the challenge of a growing accumulation of plutonium originating from both civilian and military nuclear programmes. Plutonium is a potentially valuable energy source, but is also highly dangerous because of its potential health hazards and its possible use for the production of nuclear weapons. There is widespread disquiet about the disposal of radioactive reactor wastes, including questions about very long lifetime waste products, about reactor decommissioning and about the risks of weapons-grade fuel proliferation. There is, as yet, no general agreement — either technical or political — on-what mix of on-site storage, long-term repositories, partitioning and transmutation might offer a satisfactory solution. These challenges must be faced even if no new plants will be ordered because the present reactors will be producing waste well into the next century and this waste will need to be disposed of and the contaminated sites cleaned up.

Looking to the next generation of facilities that may be built, where commercial use of nuclear power for electricity is largely divorced from military considerations, the questions of social acceptability will revolve significantly around safety assurance as well as economic viability questions. A number of technological solutions are currently being explored that could reduce both the lifetime of the radioactive waste and the amount of material in circulation that could be used for weapons production (see, e.g. [49–51]). Today's generation of nuclear fuel cycle issues centre around considerations on the use of mixed (Pu-U)-oxide fuel. Correspondingly, waste management gives an important place to the long-term storage/disposal of spent fuel and highly active waste in geological repositories. New reactor concepts explore whether and to what extent these basic orientations can be displaced. The new design concepts typically aim at:

- reducing the unit costs of nuclear power (e.g. improved process efficiencies, low fuel and operating costs);
- high reactor safety;
- reducing the radiotoxicity of the wastes generated (through, first, reduced quantities of radioactive wastes and, second, less final output of the most highly toxic and/or long-lived components in the radioactive waste, including plutonium and other actinides).

Various innovative concepts in nuclear fission energy are all broadly in line with what might be called the "holistic fuel cycle strategy". This means to integrate within a single design concept, the selected options covering fuel manufacture, reactor systems, recovery and recycling (optimisation of the utilisation of fissile material), safeguards, waste management and decommissioning. The innovative cycles aim at either generating ultra-high burn-up fuel in a once-through cycle or to recycle the by-products of the fission process back to the reactor in order to cope with the problem of long-lived nuclear waste. [14] The innovative reactor concepts can be classified in three categories: (i) advanced fast Pu burning reactors; (ii) gas-cooled reactors; and (iii) accelerator driven systems or hybrid systems. These concepts introduce new variables that, on the one hand, define research trajectories that may contribute to maintaining nuclear expertise in the scientific and technical communities of Europe and, on the other hand, introduce waste-reduction technologies that may bear significantly on the social acceptability of nuclear technology. Whether or not these sophisticated technological options can be implemented reliably and at a commercially viable cost, is a matter that must be opened up to expert and wider societal appraisal. Implementation of the new concepts would have to surmount two challenges.

1. The major investments required. After some less than satisfying experiences with liquid metal fast breeder reactors and nuclear fusion, European governments may be reluctant to fund costly demonstration projects whose returns are financially as well as politically uncertain.
2. The current low public trust in the nuclear industry (it seems plausible that the sorts of doubts currently expressed about nuclear safety — notably on radioactive waste transport and storage — may arise concerning innovative fuel cycle and separation concepts).

5. Prospects for participative governance in EU nuclear matters

To summarise, not only countries in the EU, but many neighbours are locked into nuclear power in the sense that they have built nuclear power plants and depend on those plants for a significant portion of their power. Whatever their future energy choices, they will have to live with the past ones. Over the years, a massive public distrust of the nuclear industry has emerged, because of a series of accidents and clear evidence that those involved have not always been truthful. This has led to situations where development has been halted. Yet the current commitments and existing plants raise unavoidable problems of decommissioning and disposal of nuclear waste. Decisions will need to be taken and this will not be possible without the rebuilding of a certain degree of trust between the different actors. Because nuclear technologies are characterised by high initial research and implementation costs, relatively long productive lifetimes, and long historical liability, both the costs and the benefits must be borne by society at large (for example, application of safety standards and radioactive waste disposal require integrated solutions). Investigations of participative governance seek to highlight new opportunities and forms of co-ordination between key actors in the nuclear sector and stakeholders of the wider community. Governance acts not just on the specific content of decisions, but more especially on the level of

[14] See, for example, NEA workshop on the back-end of the fuel cycle in a 1000 GWe nuclear scenario [49]; NEA workshop on advanced reactors with innovative fuels [50]; international symposium on nuclear fuel cycle and reactor strategies: adjusting to new realities [51].

institutional frameworks, communication and organisational strategies. The design of consultative procedures for information sharing and appraisal of costs, risks and benefits by potentially dissenting or untrusting stakeholders, is a real challenge in a domain that has, historically, been rather secretive.

5.1. Participative initiatives in the EU nuclear domain

The beginnings of a new and enhanced role of public and stakeholder participation as a dimension of participative decision-making can already be seen in some political and legislative developments at both the European and the Member State levels.

- As mentioned already in Section 2, increased attention has recently been given to the public communication and human resources aspects of emergency response capacity in the case of a severe accident. The idea is that good lines of communication between stakeholders and understanding of the competencies and expectations of each, can greatly improve accident response capacity and this is, in itself, a benefit of participative governance procedures.
- The 1999 resolution of the EU committee of the regions concerning the siting of nuclear facilities as well as nuclear waste management and disposal sites [54] requires that the decision process should involve local and all other citizens concerned. The local or regional authority should be given the final decision on whether a facility should be accepted or not. Power plants and waste management facilities must be subject to an environmental impact assessment, which, if correctly undertaken, also offers a framework for public information, increased participation and the consideration of alternatives. These provisions are radical by comparison with the authorisation procedures for nuclear facilities prevailing in most member states up until now.

In parallel, participative governance principles also begin to appear in the research and development strategy. The European Commission is committed, through the Euratom treaty and elsewhere, to provide and promote scientific research that can improve the robustness and legitimacy in policies looking toward the future. In particular, the goal of the current (in 1999) Euratom nuclear energy research programme is to help exploit the full potential of nuclear energy (both fusion and fission), in a sustainable manner, by making current technologies safer and more economical, and by exploring promising new concepts for the fuel cycle, for radioactive waste management, and for risk governance. There is sought, inter alia, the "development of approaches to governance (i.e. the processes of assessment, management and regulation) of risk that are more efficient (in time and resources), less controversial and capable of gaining public trust and confidence, together with guidance on their application in the nuclear sector". It is insisted (ibid.) that: "social trust, transparency, stakeholder involvement and effective communication have, inter alia, been identified as key elements of better governance and should be addressed" [55].

Each of these terrains of action open up the scope for innovative approaches to risk governance and the appraisal of technological options. Robust procedures require, on the one hand, to continually improve the scientific basis for safety assessments and, on the other hand, to establish better methods for integrating this expert knowledge into its social and political deliberations on acceptability and legitimacy of the technology choices.

5.2. The ambition of participative governance

In this perspective, participative procedures have several attractive features.

- They allow to focus in a structured way on the various types of uncertainties involved.
- Through reciprocal communication between different groups, they permit the emergence of good understanding of the origins and nature of public concerns about attitudes towards waste disposal, decommissioning and new fuel cycle options.
- They are transparent, leading potentially to judgements and recommendations that are defensible and capable of gaining public trust and confidence. The integration of stakeholders within a process of reasoned argumentation and deliberation can have a decisive influence on the subsequent acceptability of proposed courses of action (see [56–58]).

Where economic interests are very heterogeneous, attitudes within societies are divided, and so the divergences over appropriate decision criteria are irreducible, decision quality assurance may more convincingly be sought through allying expertise to stakeholder negotiation than through appealing to sophisticated techniques of quantification (e.g. statistical lives saved, and so on). The key argument for participative governance approaches is that prospects for socially satisfactory choices may be explored through bringing stakeholder perspectives into constructive dialogue with each other, in order to search for common ground. That is, it can be hoped that efforts at deliberate involvement of stakeholders can define domains of pragmatic and principled compromise which respect the sensibilities of the different protagonists.

This multi-stakeholder decision-process is thus characterised by a change of emphasis. Moving beyond sole expert concern with (technical) quality of inputs for a decision problem and for communication to the public, it focuses on reciprocal communication quality, negotiation and exchanges of stakeholder experience within the evaluation and decision process itself. Such approaches aim to achieve quality goals along the following axes.

- Scientific quality assurance in a context of complexity, high systems uncertainties and social indeterminacy.
- The credibility of economic, scientific and technical inputs to decision-making for nuclear policy and management within the EU.
- Socially, economically and technically robust choices in the nuclear field, particularly with the technological choice for waste in the long-term.
- Wide social legitimacy of the decisions taken.

To achieve these quality goals, consultative process design is critical. The general performance considerations must be translated into specific procedures and outcomes, which will be differentiated according to the types of group or agent in society.

5.3. Science quality and communication quality

The stakeholders typically extend across: government agencies and regulatory bodies; concerned citizens and the wider public; the scientific community; industrial and commercial interests; NGOs and 'public interest' activist groups. Apart from concern for technical and scientific quality control, some of the key social science dimensions of communication and consultative procedures include [2]:

- identification and development of elements of common problem definition and common language;
- understanding of the assumptions underlying expert evaluation techniques, of the terms in which these techniques can contribute to reasoned decisions, and limitations to their application;
- sharing of the reasons and justifications brought by the different social groups to the deliberation process;
- high status to participation by professionals and lay people in the consultative processes;
- skill development and professionalisation of the participants in new deliberative processes;
- search for novel and compromise solutions based on respect of divergent criteria and the need for a coexistence.

In the nuclear field, as in other sectors of society, participative procedures can enhance transparency and accountability, while also encouraging sharing of experiences.

5.4. Fields for action

Participative governance in this way establishes an institutional framework and orientation for the emergence and testing of new forms of public good research, new concepts for commercialisation and new regulatory procedures. Examples are the following.

- Enhancement of expertise in accident management (e.g. knowledge of technical and human contributing factors to risks, co-ordination of human resources in an emergency). Participative approaches are needed for co-ordinating technical knowledge and institutional response capacity.
- Efforts to improve the safety of the eastern European reactors (including both accession countries and other CIS countries) could be enhanced by harmonisation and sharing of experience. Once these are resolved, the future might well involve co-operation between EU experts and policymakers, and those of eastern European countries, in combined efforts to implement innovative fuel cycle and waste solutions.
- Should radically new types of reactor be seriously proposed — for example, accelerator driven systems — then participative procedures could be applied to build public trust in the assessment of potential and risks of these systems. Acceptance or otherwise of these reactors will rest heavily on fuel-cycle and waste disposal considerations rather than reactor safety grounds alone, and this reinforces the pertinence of risk appraisal procedures open to the public and to stakeholders.
- During the decommissioning of nuclear installations, specialised engineering expertise which might be supplied on a contractual basis, must be co-ordinated with verification, waste storage and disposal, and public communication activities. Clear signals about the directions of nuclear enterprise, including a high profile and status given to decommissioning and waste management activities, could play a very important part in maintaining the prestige and perceived relevance of scientific and technical competence, hence the attractiveness of work in the sector as a career option.

- The new generation of reactor, reprocessing and separation concepts involve (inter alia) some quite sophisticated physical and chemical processes. These can be sources of pride and fascination to scientists and technicians, but any perceived lack of transparency concerning performance and risks can, in the current climate of suspicion, excite alarm and rejection. Deliberation between stakeholders supported by independent validation of key information, can enhance credibility of research and demonstration conclusions concerning (i) real construction and operating costs; (ii) the benefits to be attained (electricity, waste disposal, other); and (iii) the uncertainties and risks (to health, to the environment, and also in financial terms) of each technological option. This participation reduces the dangers of recommendations being too tightly dependent, or seeming to be so, on lobbies for the nuclear industry or for the interests of a specific research community.
- Modern sensory equipment and computer-based communications technologies permit the generation of huge amounts of data, such as permanent monitoring of reactor behaviour and of stocked wastes. Also, telecommunications permit instantaneous exchange of images and information. However, the datasets, sensor signals or video images are useful only if analysed and intelligently deployed for human decision-making. For this reason, technical and human organisational dimensions of information systems will become a key issue, as well as the interdependence of both dimensions. An example on the technical side is the possible design of automated decision processes to review relevant information from a variety of sources such as waste storage sites. An example on the human side is the need to understand the contingencies of effective communication, motivation and behaviour in situations of possible urgency, so as to mobilise appropriate expertise and civil defence response. An example of the interdependence of the technical and human dimensions is the need to take into account and manage the relationship between humans and the operating systems they design or operate. Being designed and built by humans, the systems are subject to human errors, and so is their operation. Moreover, computer based systems can also have internal difficulties and are subject to external tampering. The reliability of communication systems (including vehicles, telephone and Internet), and familiarity with back-up options, is crucial.
- EU and Member State nuclear-related research and technological development is financed partly through national programmes and partly through the Commission's framework programmes. It is hard to find experts who are knowledgeable enough to decide priorities within these programmes and to evaluate research propositions but who are not themselves representing interest groups. One possible solution is not to seek for wholly 'objective' evaluators but, rather, to design a process that is robust and transparent through establishing an accountability of different stakeholders and evaluation perspectives (including divergences within the expert community) through a deliberative process.

These examples show the desirability of good understanding and effective communication between disparate groups in society, both for quality and safety assurance under normal operating conditions and for emergency response. Beyond technical adequacy of equipment and operational checks, the best form of quality assurance is through human accountability. The tensions between stakeholders can, in a situation of underlying trust, work to reinforce the engagement of people to do 'reality checks', that is, verification of what is really going on.

6. Conclusion: nuclear energy and sustainable development?

The European Commission's fifth action programme on the environment 'towards sustainability', adopted in 1993, put forward a vision of a sustainable development that seeks not only to reconcile economic well-being and equity goals with environmental quality and ecosystem conservation objectives, but also to define a socio-political dimension of European development [9]. The purposeful co-operation is envisaged of public authorities, private and public enterprises and the general public as stakeholders in European societies.

Environmental and social cohesion challenges are especially linked by the requirements of risk management and the question of trustworthiness of regulators and industry stakeholders in the public's view. The fifth action programme has targeted the integrating of environmental considerations in five key economic sectors: (1) industry; (2) energy; (3) transport; (4) agriculture; and (5) tourism. Priority themes of action are specified, which include climate change, air acidification and quality, protection of nature and biodiversity, water resources management, urban environment, coastal zones, waste management, nuclear and chemical risk and accident management. The relative significance of each of these sectors and issues varies from member country to member country, but it can be seen that environmental impacts of energy production and use, and the mastery of nuclear (as well as other) risks are prominent in the profile.

More generally, the sustainable development literature emphasises the need to find a balance between contrasting considerations. For example, a reconciliation of the benefits of market economics (such as incentives towards high productivity and technological innovation, responsiveness to consumers' demands), with social goals including security and the protection of environmental quality.

- On the one hand, firms come increasingly to consider the necessity of "taking the environment into account" not just as an exogenously imposed cost or constraint, but also as a strategic opportunity. Necessity is thus converted into virtue.
- Conversely, public authorities and theorists concerned with environmental regulation have given attention to the extent to which environmental goals might be 'internalised' in norms of good commercial practice.

Here, we note complementary evolutions taking place in the private sector and in regulatory theory and practice (see Faucheux and Hue in this issue; also see [59,60]). Decentralised strategies based on market incentives alone cannot be expected to lead to satisfactory outcomes. Leaving too much up to the market can lead to 'locked-in' technological and social options being chosen which do not contribute to overall goals of ecological, social and economic sustainability. This is why it is important to affirm, as complements to competitiveness, other notions such as public interest and collective responsibility for the future which must be taken into account in adopting new environmental regulatory systems. This accounts for the multiple ambition of participative governance, aimed at defining wider social responsibilities (at local, national and international levels) and at mobilising the knowledge and interests of different public and private stakeholder groups, in order to identify opportunities, master risks, and co-ordinate action based on the key decisions. Achievement of social cohesiveness and environmental quality as well as economic performance objectives, hinges on developing new regulatory conventions.

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