A Comparison of International Regulatory Organizations and Licensing Procedures for New Nuclear Power Plants

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Abstract
The paper considers issues concerning the safety regulation and the licensing of new nuclear power plants. The paper considers both design safety approval and issues of site licensing. Advice from international organisations is summarised. Nuclear power plant approval is primarily a national responsibility and the procedures of seven countries (Canada, France, Germany, Japan, Switzerland, the UK and the USA) are considered and compared. In some cases historical approaches are discussed, either because of a current national policy against new nuclear build or because of recent changes to relevant policy. Four factors are given emphasis in the paper: regulatory independence, consultation, transparency of process and the complexity of the legislative framework. The paper concludes with summary recommendations for best practice.

Introduction

After some decades of stagnation, a nuclear revival is underway in several western countries. This is mainly due to four factors: increasing political instability in some major fossil-fuel exporting countries; declining domestic natural energy resources; growing concerns about climate change and greenhouse gas emissions, and increasing demand for electricity.

However, if nuclear power plants are to be built again, then fresh attention must be paid to their design approval, their siting and their licensing. This paper considers the procedures adopted in seven leading countries for the approval of new nuclear power plants.

The usual steps for a project of new nuclear power plant construction are in order: selection of a site, construction of the power plant, testing of the facility and finally operation the plant within prescribed limits.

At the heart of the process, public acceptance is a prerequisite which is most important during the siting step. If one accepts a site for a new nuclear plant, one must also accept wider national or regional need for a new nuclear plant. Western public anxiety towards nuclear power emerged strongly after the accidents of Three-Mile Island, PA, USA in 1979 and Chernobyl, Ukraine in 1986. Arguably, in addition, the modern public fundamentally mistrusts political elites and large companies. In the case of nuclear power mistrust can run even deeper because of an historical association between nuclear innovation and the military. The military legacies of nuclear power result in a widespread perception, and arguably a reality, of top-down nuclear strategy surrounded by a climate of secrecy. Publics and other stakeholders are therefore likely to be highly sensitised to the democratic features of siting policy and are likely to give great emphasis to safety issues during the licensing process of any new nuclear plant.

Furthermore, in recent years environmental groups have greatly improved the effectiveness of their actions such that they can threaten the planned implementation of government policy and business strategy. The February 2007 judgement by Justice Sullivan in the UK is noteworthy in this regard. In that judgement he concurred with Greenpeace's assessment that the UK Government's consultation on nuclear new build policy had been inadequate given prior undertakings.

Processes for democratic public participation must be receptive to the remarks of all stakeholders while being robust enough to resist forces that seek to undermine proper policy processes. Also, the licensing system must give attention to investors' economic concerns, as no project is likely to receive investments as long as costs remain uncertain. In the case of nuclear power key investor concerns are administrative procedure costs, a fear of technical difficulties, and project delays incurred by long public inquiries.

Nuclear power planning is highly cross-disciplinary and relates to numerous technical and social issues. Nuclear power can provide stable base-load electricity from relatively few large-scale sites. The technology is highly complex, it requires an especially skilled workforce, it requires access to significant quantities of cooling water, and it yields radioactive spent fuel (waste) and leaves a decommissioning legacy. During licensing, the regulator

must therefore have a thorough and informed appreciation of each aspect of the whole project.

A comparison of different national regulatory and legislative systems has the potential to be informative. Indeed, actors in nuclear power are increasingly internationalized: the nuclear industry and utilities are becoming multinational; environmental groups are active in most countries running nuclear programmes; and citizens in different countries now have common references points (e.g. the Chernobyl disaster had international impacts and is perceived as a global catastrophe rather than as simply an accident in the Ukraine). Advocates and opponents of nuclear new build face common global issues, but must undertake their activities via national or sub-national regulatory and legal landscapes. Comparing different countries' procedures, while keeping in mind local cultural fundamentals, is the basis of the work reported here.

In addition, most countries under this review have not built nuclear plants in recent years. Their licensing procedures have in most cases therefore remained unchanged. International cross-comparison may help benchmark their relative efficiencies. These questions are all the more interesting because little academic work has been done on these questions. Some studies compared national regulatory and legislative regimes in the late 1960s (ENEA 1969, Puget 1967) but the subject has been relatively neglected since then. One exception has been the recent Nuclear Energy Agency publications on the different national systems (NEA 2000, 2001, 2003). Unfortunately, however, the NEA does not analyse its data comparatively.

This paper aims at giving an overview of the regulatory and legislative systems currently used in Canada, France, Germany, Japan, Switzerland, the United-Kingdom and the United States of America together with their common international legal basis.

This analysis is restricted to civil nuclear power plant licensing. Defence and other nuclear installations are not covered. Neither are the economic and security issues of nuclear regulation. The whole licensing procedure for the plant construction and operation is reviewed, but decommissioning issues are not considered in depth. This is because in part the issues of end-of-life decommissioning, when examined from a perspective prior to initial construction, are predominantly economic rather than legal or technical. In addition decommissioning wastes differ from fuel cycle wastes raising issues beyond those that can properly be considered here.

The factors that we consider are the regulator's independence from the government, especially the nature of the licensing authority; the licensing authority's consultation with external bodies; the licensing process (including process steps, public participation, regulatory conditions and time limits); and the number of laws governing nuclear new build. Together, these give us a

way to evaluate the effectiveness of the nuclear power plant approval processes.

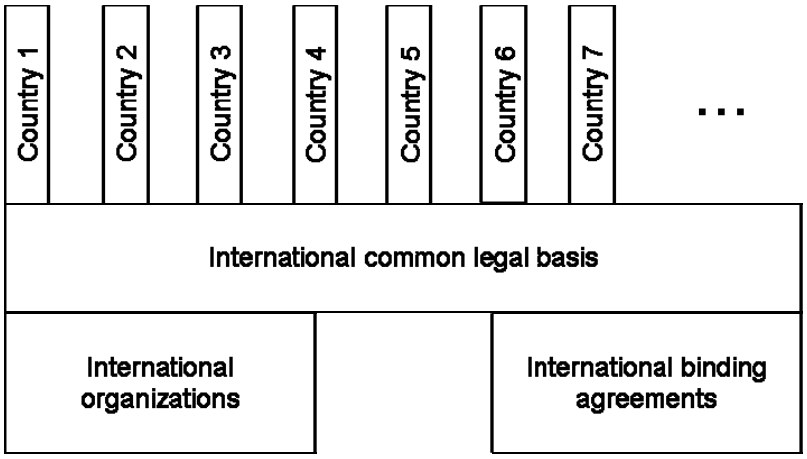

Figure 1. National and International Factors in Nuclear power Plant Siting

National systems are based on an international common basis which gathers together worldwide principles from international organizations. This international basis is founded on both international organizations' recommendations and on formal international binding agreements. Against the backdrop of international obligations, individual countries develop national systems particular to their tradition and history.

1. International Standards

Several factors, particularly the accidents of Three-Mile Island and Chernobyl and the post-Cold-War context, have driven most nuclear countries in recent years towards improved international policy coordination.

At the international level, the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) are the main organizations generating nuclear regulations. The IAEA is a United-Nations autonomous body, while the NEA is an Organisation for Economic Cooperation and Development (OECD) agency. All countries under review in this paper participate in both forums.

At the regional level, some regulators have gathered into associations to share best practices. The Western European Nuclear Regulators Association (WENRA) gathers European regulators (in particular the European countries reviewed here) to harmonize national regulations for the common European

electricity market. The International Nuclear Regulatory Association aims at similar, although less integrated, regulatory harmonisation. It informally gathers together the heads of national regulators from around the world.

The international common basis to nuclear siting is embodied in two main sets of texts:

- The international binding agreements:
    - the Convention on Nuclear Safety (1994) which commits participating States to maintain high levels of safety by setting international benchmarks (Jankowitsch-Prevor 2006)
    - the Paris Convention (1960), and its Vienna equivalent, established under the auspices of the IAEA (1996) on Civil Liability for Nuclear Damage.

- The international non-binding standards set by the IAEA
    - IAEA Safety Fundamentals on The Safety of Nuclear Installations, which states general principles accepted by member States (IAEA 1993);
    - the Safety Requirements, particularly on the Legal and Governmental Infrastructures for Nuclear Radiation, Radioactive Waste and Transport Safety (IAEA GS-R-1 2000) and its related Guide on Organization and Staffing of the Regulatory Body for Nuclear Facilities (IAEA GS-G-1.1 2002), the former strongly recommending a general organization and the latter giving more precise and less binding advice;
    - IAEA Safety Guide on Site Evaluation for Nuclear Installations (IAEA NS-R-3 2003).

All countries under review in this paper accept in full the texts described above.

These texts establish principles that are recommended to, and are usually met by, signatory countries. The first principle of interest here is the licensee's prime responsibility for the safety of its nuclear installation.

The second principle is the independence of the regulatory body from any organisation promoting the nuclear industry. In countries with a strong indigenous nuclear industry, such as the countries reviewed here (with the exception of Switzerland), nuclear power plant construction is usually in the policy domain of the national department for industry.

This second principle supports further the independence of the nuclear safety regulator from the government. Moreover, the IAEA recommends a proper empowerment of the safety regulator, especially that it should have delegated to it the formal authority to licence. The Agency argues that the regulator's credibility to the general public may be enhanced by such constitutional arrangements. Despite independence, the regulator should nevertheless be

accountable to the national government or other high political authorities such as national parliaments (IAEA GS-G-1.1 2002).

The third principle recommends public participation as a compulsory step during the licensing process, particularly during the period of site review (CNS). The IAEA also recommends that government and regulators consult with independent expert advisory bodies.

Finally, the IAEA recommends a special assessment of several steps during the licensing process (IAEA GS-R-1 2000):

- Before authorizing the construction of a new nuclear power plant (site characteristics, applicant capability, design safety features, decommissioning arrangements);
- During construction (as-documented construction for each part of the plant);
- Before the beginning of commissioning
- Before loading the fuel (as-built design, non-nuclear and nuclear tests, operational limits, provision for radiological protection);
- Before commencing full operations of the plant.

The IAEA lists general technical factors to be included in a site assessment (IAEA 2003):

- earthquakes
- meteorological events
- flooding
- geotechnical hazards
- external human induced events
- atmospheric, surface water and groundwater dispersion of radioactive material
- population distribution
- uses of land and water in the region
- ambient radioactivity

Most countries have integrated all these factors. However, these requirements are not prescriptive and national differences are expected and accepted. It is therefore useful to look at the different national systems in operation in key nuclear countries.

2. National Regulatory Systems

In this paper we separate the analysis of national policy structures into on the one hand an assessment of regulatory systems and on the other and assessment of the licensing processes. We do this because these two

aspects involve the four main interest groups differently (the public, environmentalists, regulators and companies).

National regulatory systems are the subject of significant comment from the public and media. Such comments can influence regulatory decisions. On the other hand, companies are more interested in more specific licensing processes as these determine the certainty of project costs and can more directly influence local public acceptance of a new nuclear plant.

Preliminary remarks

First, France has very recently implemented a reform which transforms its regulator's status into an independent authority. As this change was voted only in June 2006, we will present both the situation before and after the reform. It is arguable that this transition has been motivated by an intent on the part of the French government to ensure compliance with the letter of the IAEA recommendations while doing relatively little to alter the fundamentals of policy implementation. Such a thesis posits that France lags in implementing the spirit of the IAEA's suggestions while it presents a formal compliance with best practice.

Similarly, the USA has since 1992 put in place a reform of the licensing system. The previous system is still available and usable, but is now joined by a new alternative licensing process. So we will also present both of them.

It is arguable that Switzerland and the UK are now the countries with the weakest indigenous civil nuclear engineering industries. The UK is home to the recently broken-up nuclear fuel cycle and research company BNFL. The break-up of BNFL included the sale of the US-based reactor designers Westinghouse to a consortium including Toshiba of Japan. Switzerland no longer has any indigenous nuclear power design capacity following the sale of ABB's nuclear business to BNFL and its integration into Westinghouse, prior to the subsequent sale of Westinghouse itself. The UK and Switzerland have numerous engineering and science-based companies able to contribute to nuclear new build programmes. Nevertheless it appears probable that both countries have left behind any notions of industrial policy for their nuclear industries. Both countries believe that their engineering firms must compete in the global marketplace and that it is not the role of national energy policy to favour indigenous manufacturing industries. If this premise is correct and relatively atypical among the nations considered, then is arguable that the Swiss and British publics may trust their national regulators more than publics in other countries might trust their regulators.

Germany in 1998 implemented a policy of slow nuclear phase-out. Germany's licensing system prior to 1998 was interestingly unique, because of its flexibility and its decentralization. For these reasons pre-1998 German approaches are discussed in this paper. Most relevant data come from the

first CNS report (September 1998) before the political decision of nuclear phase-out was taken (October 1998).

The UK regulatory system is relatively complex with complicated responsibility arrangements. The UK situation is in a state of flux at the time of writing this paper. The Energy Review 2006 puts various proposals forward for consultation with a closing date of 31 October 2006 (DTI, 2006a). The Health and Safety Executive has put forward its own recommendations in a recent report (HSE,2006b)

Also, it is worth mentioning that uniquely among other countries, the UK licensing system is not prescriptive. The HSE sets goals, but the licensee can undertake whatever action it chooses to meet these targets. It must merely demonstrate the equivalent safety of its preferred approach or argue that the costs required to execute HSE recommendations are excessive (HSE 2002). Approaches to securing safety can therefore differ from licensee to licensee.

Another important consideration is that the whole domain of the HSE the safety culture is based upon the “ALARP” principle – As Low As Reasonably Practicable. As such the UK has what we might regard as a pragmatic approach to safety rather than a more mechanistic check-list approach. In its recent Expert Report the UK Health and Safety Executive resists moves towards other international norms (para 95): “Some nuclear proponents have expressed interest in the concept of international ‘off-the-shelf’ designs that could potentially be built identically in different countries and should, according to these proponents, be judged against common international standards. They see this as a means driving international competition and reducing costs. We view this as impracticable at present.” (HSE,2006b)

The related notion of ALARA (As Low As Reasonably Achievable) has currency in North America, particularly in Canada where such considerations have been adopted into legislation. Despite this the United Kingdom nuclear regulatory system is unique in its broad acceptance of flexible technological options to achieve regulatory compliance.

National regulatory practices

There are two main observable extremes of regulatory position. Regulators can be an integral part of the government bureaucracy or, in contrast, can be totally independent and protected from political influence.

The countries where the regulator is, or was, integrated into government are:

- France before the 2006 reform

    - The Autorité de Sûreté Nucléaire (ASN) was a cross-ministerial service under the joint responsibility of the Ministers of Environment, of Health and of Industry.
- Germany according to regulations pre-dating the 1998 phase-out decision
    - The competent licensing authorities are the Länder (usually competent State ministries) where the plant is planned to be installed. There are therefore different geographical regulators in Germany which are integrated in the various federal states.
- Japan
    - The Nuclear and Industrial Safety Agency (NISA) is an independent "special organization" within the Ministry of Economy, Trade and Industry (METI), appointed by the Minister. In accord with the IAEA recommendations, its functions are substantially separated from policy bodies promoting the nuclear industry (CNS Japan 2004).
- Switzerland
    - The Swiss Federal Nuclear Safety Inspectorate (HSK) belongs to the Federal Office of Energy (FOE), under the Federal Department for Environment, Transport, Energy & Communication (ETEC).

It is worth mentioning that even though the above regulators are in each case part of the government, they are always set up as government agencies independent other government bodies promoting nuclear energy. In this way these countries meet the requirements of CNS article 7.

In contrast, some countries have an officially independent regulator:

- Canada
    - The Canadian Nuclear Safety Commission (CNSC) is an independent federal agency and is a quasi-administrative tribunal. The Commission is appointed by the federal government (GoC 2004).
- France (after the 2006 reform)
    - Now, the ASN is independent. The directing Commission is appointed by the French President and the presidents of the National Assembly and Senate.
- USA
    - The Nuclear Regulatory Commission (NRC) is absolutely independent from the government. The US President appoints the commission and its chairman who are confirmed by the Senate.

The UK, however, has an unusual mixed position:

- The Health and Safety Executive (HSE) is the executive arm of the Health and Safety Commission (HSC). The HSC is a Non-

Departmental Public Body under a shared responsibility of different government departments. It has nominated Commissioners, but their remit extends far beyond matters of nuclear safety. Responsibilities are assigned to different Secretaries of State (SoS) by administrative arrangements (HSE 2001, DTI 2006). The Commission is appointed and sponsored by the Secretary of State for Work and Pensions following consultation with other SoS.

The HSE is independent from any government department but it remains under SoS responsibility. The SoS for Trade and Industry is responsible for the HSE's nuclear safety activity.

Licensing authority

The traditional regulator positions described above can greatly impact on other responsibilities.

In case of regulators integrated within a government department, and for France after its reform, the government always has fundamental powers. It issues licences and is the single authority capable of prosecuting misbehaving operators. In contrast, in countries with independent regulators, such as in the USA and Canada, these powers are delegated, to the regulators.

Finally, the UK once again has a unique approach: the HSE issues nuclear-related licences following consent by the SoS for Trade and Industry. The HSE however can prosecute any operator independently of government instruction.

Most countries reviewed here have not implemented the IAEA's recommendations on regulatory independence and have left the governments holding the final licensing decisions, upon recommendation of the regulatory body *stricto sensu*.

Accountabilities

Systems of accountabilities are also dependent on the regulator's position. Government-integrated regulators report to governments whereas independent regulators report to national or regional Parliaments.

The UK system is again mixed as the SoS for Trade and Industry is accountable before Parliament for HSE's activities in nuclear safety.

Specialization of the regulator

All countries reviewed here, with the exception of the UK and to a lesser extent Japan, have regulators specialized only in nuclear safety of civil nuclear installations. The UK HSE is the sole general safety regulator. It is responsible for enforcing all industrial safety regulations – except railway safety (delegated to Office for Railway Regulation in April 2006) and aviation (Civil Aviation Authority). Despite its wide-ranging responsibilities the HSE retains a coherent and strong team dedicated to specific nuclear matters – the Nuclear Safety Directorate employing more than 250 people (NSD 2006). The Nuclear Safety Directorate has management responsibility for a statutory body the Nuclear Installations Inspectorate (NII). In effect the NSD and the NII may be thought of as the same organisation.

The Japanese Nuclear and Industrial Safety Agency regulates the energy industry in general (including electricity, natural gas, petroleum and particularly nuclear energy matters).

Control of the regulator by other authorities

Japan runs a unique system of double-checking every administrative decision taken by the regulator. The Prime Minister's Nuclear Safety Commission has full power for evaluating NISA decisions. NISA and METI in particular must report to the NSC.

Similarly, the US NRC has established an internal advisory committee as an independent committee in charge of double-checking every licensing decision (USNRC 2006). The committee is set up as a forum for experts from different fields and most meetings are open to the public.

Alongside these formal systems, most countries have also implemented more informal double-check systems. Usually, the national parliament runs specialized committees scrutinizing the regulators. For instance, the French Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques is scrutinizing nuclear power in France informally and issues reports for that purpose, usually on an annual basis.

Governments can also indirectly exert influence on the regulator through the budget approval process. For instance, the US White House's Office for Budget and Management indirectly impacts on the NRC by evaluating the budget to be sought from the US Congress for NRC operations (Viscusi 2005).

Finally, in Germany, the federal government supervises nuclear safety regulations executed by the Länder by issuing nationally binding regulations.

We note that the independence of the French ASN is constitutionally weaker than that of the US NRC or the Canadian CNSC. It does not issue licences, it cannot prosecute operators and it reports to the government.

3. Licensing Processes

Alongside the IAEA recommendations to assess particularly the site and basic safety features of the design; the construction; the pre-commissioning tests and operation, most countries have developed their own licensing processes. Even though most of them put intermediary hold points at each stage, it is interesting to examine the different licences put in place. Indeed, each licence is a separate legal process which has its own characteristics. In particular, it determines the scope for public inputs.

Each national system is presented below.

Canada
Canada has a relatively simple licensing system (CNSC 2006):

1. Environmental Assessment (EA)
    - The Minister of Environment, the CNSC or both together appoint a panel to conduct the EA. The Canadian Environmental Assessment Agency and eventually other federal authorities participate in the process. The public is consulted at different stages. It is noteworthy that the CEAA funds participants to come and prepare their intervention during the public hearings.
2. Site preparation
    - Focuses only on the site characteristics. Two separate public hearings must be held to review the documents and to include the public's remarks over a period of ninety days.
3. Construction
    - The design and its fit onto the particular site are then assessed.
4. Operation
    - The operating licence is issued after checking the as-built plan and running tests.

France
France is the sole country with two licences required for operating a new NPP.

1. Usually an informal presentation by the applicant
    - The socio-economic benefits are reviewed by the General Directorate for Energy and Raw Material (DGEMP) and the ASN informally pre-reviews the site characteristics and reactor design in case of a new design.
2. Creation

- Includes siting, design, environmental impact study and construction. There is at least one public hearing at this stage.

3. Provisional operation
    - Pre-commissioning tests are done at this stage.
4. Operation

There is also a licence for Water drawing and gaseous and liquid effluents reviewed during the licence creation phase.

Germany

Germany used to have a very flexible process. Indeed, two licences, eventually granted altogether, were compulsory for a new plant.

1. Construction
2. Operation.

However, the procedure could be split into several licensing steps (partial licences):

- siting and construction of essential civil structures (the design would be reviewed at this stage)
- construction of the systems and components important to safety
- handling and storage of fuel elements (in particular, initial fuel loading)
- nuclear commissioning
- continuous operation

The decision for the process to be followed was taken by the Länder on a case-by-case basis, depending on the NPP's expected safety.

In addition, a regional planning procedure (concerning any industrial installation) was performed before the beginning of the nuclear procedures to assess all project impacts on public, traffic ways, regional development, countryside protection and nature conservation.

Finally, the Länder had full authority over water use. Such limits were therefore heterogeneous throughout Germany.

The process was relatively similar for any licence. Participation of the general public was actively sought.

- the project was publicly announced and all application documents were disclosed at nearby locations for two months
- one public hearing was held.

The competent authority performed the Environmental Impact Assessment which was critical for the final decision. Other competent authorities reviewed the water utilisation, emissions protection and nature conservation.

Japan
Japan is particular because the site licensing is split into two steps: planning and "establishment" (CNS Japan 2004):

1. Planning stage
    - This evaluates the project's pertinence and the main site characteristics. METI holds one public hearing. A draft Environmental Impact Assessment is carried out.
2. Establishment
    - The adequacy of the basic design and the site is assessed. An Environmental Impact Assessment is completed. A second public hearing is held by the NSC.
3. Construction
4. Operation stage

Switzerland
The Swiss licensing process philosophy is interesting as it separates the non-technical and the technical decisions. After a general approval of the project during the site licence review, theoretically by the whole nation, the technical requirements for construction, commissioning and operation are decided by the competent authorities with limited public consultation (CNS Switzerland 2004).

1. General licence
    - This reviews the site and the main project characteristics, especially radioactive waste management. The canton containing the proposed site, the neighbouring cantons and nation states are consulted. The public is consulted thoroughly. A referendum can be held concerning the project.
2. Construction
3. Commissioning and operation

Each licence includes an extensive public consultation.

United-Kingdom
To build a nuclear power station in the UK involves a number of different permits, consents and licences (Buttery 2006). The main ones are:

- To build:
    - Consent under the Electricity Act
    - Planning Permission under the Town & Country Planning Act (TCPA)
    - A Nuclear Site Licence under the Nuclear Installations Act
- To operate
    - A Nuclear Site Licence under the Nuclear Installations Act (the same as noted above)
    - Discharge Consents under the Radioactive Substances Act and the Environmental Protection Act
    - A Grid Connection Agreement

There are also other environmental and security related processes to go through.

Importantly the UK issues only one Site Licence for the design, siting, construction, commissioning, operation, modifications, and eventually decommissioning of a nuclear power plant. Intermediary conditions (testing of systems, the introduction of radioactive material (fuel), the start of active commissioning, and the beginning of operations) are decided by the HSE. The single Site Licence process includes the submission of three separate safety cases and formal consents are required at each of these three steps for project progress (Buttery 2006).

As for public hearings, “there are no formal rules or procedures for the processes that lead to and follow the granting of a Nuclear Site Licence” (CNS UK 2002). Public hearings are thus not mandatory (though usually some are held as part of the Electricity Act consent or the awarding of Planning Permission. The powers of Planning Permission and the Electricity Act fall to two different government departments in practice the Secretary of State for Trade and Industry can assume responsibility for both aspects and authorise a single public consultation process using powers of “deemed planning permission” (Buttery 2006). Interestingly the public inquiry process is formally separate form processes associated with the Nuclear Site Licence.

United States of America

The USA has two parallel systems either may be adopted for a nuclear new build project.

The historical system is a two-step process (NRC 2005):

1. Construction permit
    - Review of the design, site and construction plans. A public meeting is compulsory, held after performing a safety and environmental assessment (both by the NRC).
2. Operation permit
    - Review of the final design and as-built plant and performs operational tests.

The new system (not yet tested) is made of three licences. The first two are optional, but they ease and accelerate the process for the final compulsory step:

- Design Certification (DC)
- Early Site Permit (ESP)
    - The NRC evaluates the site compatibility with plant designs. Public participates at different stages.

- Combined Construction and Operation Licence (COL)
    - It follows exactly the same process as the previous policy. Public input is restricted to construction and operation issues only (if DC and ESP have already been granted).

The following charts summarize the above description:

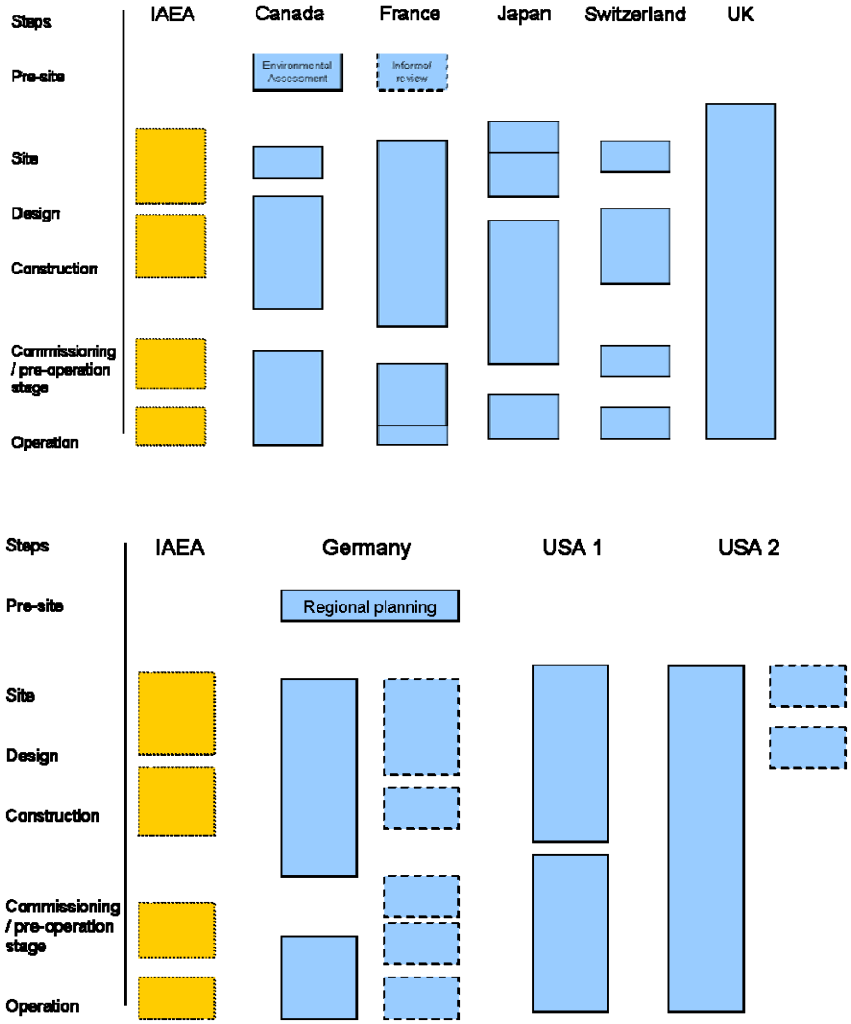

Figure 2 Schematic representation of the scope of various project approval steps in several countries.

Licence time limits

Licensing time limits are particularly important. If issued, licences have a time limit, this means that, on expiry, the licensees must apply for a new licence and hence undertake the whole process again. This is logical for the regulator, because it represents a new process. The public is usually consulted once again. Regulators can check thoroughly the licensed plant safety level.

Apart from the countries where the regulator is independent, all countries issue licences with no time limits.

For Canada, licences are very short. They are valid for only 2 to 5 years. Each renewal includes again a public participation. This enables a close scrutiny of licensees.

In the USA, the licences are valid for 40 years and renewable for 10 to 20 years.

For the other countries, regulators operate a periodic, thorough inspection of each plant, usually every 10 years (e.g. in France).

Public involvement

Public participation levels differ from country to country.

Pubic hearings are not compulsory in the UK although the most recent projects for new nuclear power plants have included several public hearings (see for instance Layfield, 1987 for the description of the public inquiry for the last power plant built in the UK, Sizewell B). It is noteworthy that the nuclear power plant planned for Hinkley Point C in the south-west of England received planning permission but was never constructed following privatisation and liberalisation of the English and Welsh electricity industry.

France, Germany and the USA have at least one public hearing.

Concerning France, in addition to public hearings during the creation process, the administratively independent National Commission for Public Debate (CNDP) can order public hearings on any subject independently from the ASN decisions and process. Its responsibilities cover any regional planning project of certain importance. For instance, the CNDP held public hearings for the creation of an EPR in Flamanville.

Japan runs 2 public hearings for each site licence.

Canada and Switzerland are the countries which involve the public the most. They do it differently however. The former usually holds public hearings at each licence issuance, i.e. once every two to five years. Furthermore, it funds objectors to come and participate during the Environmental Assessment. The latter involves the public at a very large scale during the site licence phase. The whole country can even decide through a referendum if 50,000 voters so petition. It is worth stressing again that Switzerland has two characteristics that favour extensive public involvement. First Switzerland, with its weak federal government, has a long and strong tradition of national referendums and citizen activism. Second, as noted previously Switzerland has a limited domestic nuclear industry and perhaps the public can be confident that policy is restricted to issues of energy policy and public safety and not affected by concerns for state industrial policy or subject to lobbying from powerful corporate factions.

Involvement of external bodies by the regulator during the licensing process

Again, this varies significantly from country to country. While the US NRC reviews licence applications without involving any other agency, Canada and the UK always involve environmental agencies. Japan and Switzerland involve few outside technical bodies.

France's and especially Germany's regulators consult other bodies extensively. The former consults mainly competent authorities: technical bodies, responsible ministers (Health, Environment and Industry), competent ministers (Transport, Home Affairs, Agriculture etc.) and prefects. The latter country, Germany, involves even more authorities. The Länder consult technical bodies, competent State authorities (environment, health, work…) and traditionally it engages independent consultants. The Federal Government involves different technical commissions, competent federal authorities and the Kerntechnischer Ausschuß (KTA) which is a special commission made of the different interest groups.

4. Efficiency of Nuclear Legislation

An indicator of legislative efficiency may be the number of relevant legislative texts (laws, government ordinances, and other legal regulations). Indeed, arguably the lower the number of laws, the simpler the legislation and the more transparent its operation. It is important to acknowledge that despite the existence of numerous laws, nuclear legislation may not automatically be unclear, but even in those cases legislative complexity may increase the risk of Acts conflicting on a specific issue.

It is important to recognise that the indicator of the number of laws alone is insufficient. One needs to make a further distinction between the types of texts and additional factors such as the age of the laws, their redundancy, and their degree of relevance to nuclear power or their level of precision.

For the general purpose of this part, we just look at the number of laws relevant to nuclear power in general:

- Canada (CNS Canada 2001)
    - There are 6 main laws (Atomic Energy Control Act, Nuclear Safety and Control Act, Nuclear Liability Act, Canadian Environmental Assessment Act, Nuclear Energy Act, Nuclear Fuel Waste Act) and numerous regulatory documents
- France

  - The national parliament has been notably absent from the nuclear legislation making. Before the recent reform, nuclear legislation was set up by successive governmental decrees, with lesser powers than parliamentary Acts.
  - There are therefore fewer than 10 Acts but there are more than 50 decrees, ordinances and resolutions, each deals with a precise aspect of nuclear power plants (IAEA France 2005).

- Germany
  - There are roughly 15 main Acts, ordinances and criteria dealing with nuclear energy (IAEA Germany 2005).
- Japan
  - There are fewer than 10 main Acts dealing with nuclear issues in general. They are very clearly organized, but more than 30 Acts are invoked during the licensing process (IAEA Japan 2005).
- Switzerland
  - There are fewer than 10 main Acts and fewer than 15 main decrees and ordinances (IAEA Switzerland 2005).
- UK
  - There are more than 25 Acts and 30 regulations and orders related to nuclear power issues (IAEA UK 2005).
- USA
  - There are 10 main Acts on nuclear and more than 25 Acts dealing partly with nuclear matters (IAEA USA 2005, CNS USA 2004). There are in addition state legislation and approximately 200 regulations under the US Code of Federal Legislation (Title 10).

Therefore, while the UK, the USA and especially France have numerous nuclear laws, Canada, Germany, Japan and Switzerland have relatively few.

5. Synthesis

The structure of regulatory organizations appears to be greatly dependent on the extent of government's direct involvement in nuclear policy. In countries where government plays an important role (France, Germany, Japan, Switzerland), the regulator is usually integrated within the government and is relatively weak. In particular, the safety regulator lacks licensing authority and reports extensively to government.

Independent structures in Canada and the USA are the opposite: the regulator is independent from the government, issues licences and reports to the national Legislature directly.

Interestingly, independent regulators issue time-limited licences in contrast to the State-integrated ones.

Most regulators are controlled either by government's offices or by Parliamentary committees, the extreme case being Japan with a special commission double-checking every regulatory decision.

The UK holds a particular place with a complex organization of responsibilities and accountabilities. The UK regulator is also the only one non-specialized in nuclear.

The licensing system does not depend on the regulatory organization. We can note the following:

- Countries have different licensing systems. The emphasis put on certain aspects of a new NPP project differs from country to country. The site, design, construction, pre-commissioning tests and operation are subject to different licences which may gather several steps within one.
- The UK and the new US licensing system, if no ESP and DC are applied, are single-licence systems.
- While most countries only hold one or two public hearings, Canada and Switzerland involve the public more significantly both in terms of the frequency of and the scale of interactions.
- Similarly, France and Germany consult extensively with external bodies contrary to other countries where at most, only the Environmental Agency or other technical bodies are consulted.

6. Best Practice in Nuclear Legal Processes

We propose a generic model based on practices observed in the different countries reviewed here. We make this proposal conscious that any such general policy recommendation must be adjusted to suit local requirements.

We suggest that public and environmental groups have a great interest in the process and structures of regulation. Investors, however, are more specifically interested in the licensing processes and the consequent efficient of decision-making. In this respect simplicity, fairness, speed and transparency would appear to be key requirements for investors. In cost terms an important issue is that private investors should not be required to risk large amounts of capital in advance of regulatory hurdles. However, despite that, we see advantages for societal acceptance in breaking the

approval process into a series of discrete and specific licensing steps. Care is therefore needed to balance issues of effective stakeholder engagement and the management of economic risk for investors.

Regulatory organization

In most countries having a domestic nuclear industry, it seems advisable to have an independent regulator. This ensures to both the public and to environmental groups that nuclear project regulatory decisions are not biased by inappropriate factors.

We note that populations might prefer governments, or perhaps preferably parliaments, to take the final and formal licensing decisions so that elected and publicly accountable persons are responsible for the final decisions, and not, as is sometimes perceived, an obscure independent organization. This would run counter to IAEA recommendations and furthermore would be likely the undermine the full independence of the regulator. The double-check process operated in Japan might be explored as a way to allow for political accountability while facilitating regulatory independence.

It is also advisable that the nuclear safety regulator be a specialised expert agency. Nuclear power is complex and it raises special political, sociological and technical issues. Such an approach has been chosen by most countries reviewed here.

On safety and environmental matters, nuclear regulators should consult extensively with external expert bodies. This would incorporate external resources and competencies. A double-check system, such as that in operation in Japan, may also reassure anxious populations as well as regulators over the appropriateness of regulatory decisions.

Finally, legislative efficiency is extremely important. In particular, the number of relevant laws should be limited, ideally to not more than 10, to cover every aspect of nuclear energy regulation, including safety.

In time it seems sensible that the European Union should consider the possibility of a single European Union safety regulator, specially for the important step of “design approval”, i.e excluding site-specific considerations. At present various EU countries have distinct local approaches and attitudes to nuclear safety regulation and there is little prospect of short-term progress in this regard. This shall be a matter of further investigation and we hope to publish more on such aspects in future.

Licensing process

The licensing process should be split into different steps. Indeed, each licence is a separate legal process. The main licensing conditions would then

be clearly defined by law and the split of the overall project review should help organizing efficiently the whole review. The steps that could be assessed are:

- Design
    - A generic design certification is required by the nuclear industry as a way to streamline future applications by taking already achieved work (EDF 2006). Public participation should be sought on design issues, but at this stage be restricted to those issues. In particular opportunities should be given for outside expert individuals and groups to offer comment and insight.
- Siting
    - It is a critical stage for the acceptance of the project. The site selection is deeply embedded into the whole project discussion. It should need a special licence with thorough public participation. The Swiss general licence is to be commended.
- Construction, pre-commissioning tests and operation
    - These are highly technical steps and hence should seek an extensive consultation of expert bodies while restricting public inputs. Nevertheless they should be subject to transparency and open to public scrutiny.

Investors often stress the critical importance of clear and prescriptive licensing conditions. They guarantee applicants a clear set of points to be met and hence enable them to price the project with certainty. They should not be expected to invest in a context of uncertain project costs. Environmentalists perceive the need for clear licensing conditions to be determined once and for all through a democratic consultation. Aligning these expectations is a challenge for policy.

We see merit in the Canadian policy of funding for objectors in the licensing process. Indeed, our research discussions have indicated that there appears to be widespread sympathy for such measures. It is arguable that public inquiries are somewhat unfair, because companies enjoy large financial resources while local interest groups usually only have modest resources.

Time limited licensing provides key benefits. First, it ensures the public, environmentalists and regulators a high level of safety as it forces up-to-date best practice and a close scrutiny of licensees. Second, the public may feel nuclear power to be more accountable if public input is sought frequently over the lifetime of the nuclear power plant. Experts have found that a main reason that the public are anxious about nuclear power is its perceived lack of controllability and reversibility (Grimston and Beck 2002). This anxiety impacts on its public acceptability. If the public appreciate that each decision is reversible and the project is firmly controlled over time at each licence renewal then it may greatly ease acceptance. The time limit should correspond to the frequency of thorough inspections carried out in most

countries, i.e. every 10 years so that the whole system is coherent with each stakeholder's expectations.

Therefore, we advise a public participation modelled on the Canadian and Swiss paradigms. Public should first be consulted at a large-scale during the siting process and then consulted further over the lifetime of the project at each licence renewal.

The tables below summarize the different recommendations arising from the main policy actors, as estimated from informal interviews with them conducted during background research for this paper.

		Public	Environm.	Investors	Nuclear regulation
Simplicity	Few laws	✓✓	✓✓	✓✓✓	✓✓
	Independent regulator	✓✓✓	✓✓✓	✓	✓✓✓
	Specialized regulator	✓	✓	✓	✓✓✓
Safety	Extensive consultation of expert bodies	✓✓	✓✓		✓✓✓
	Double-check system	✓✓✓	✓✓		✓✓✓
Democracy	Government issuance of licenses	✓✓✓ (?)	?		
	Parliament approval of government's decisions	✓✓✓	✓✓✓		
	Large-scale public participation	✓✓✓	✓✓✓		
	Often public participation	✓✓✓	✓✓✓		

Table 1 Actors' interest in each recommendation concerning the regulatory organization

	Remarks	Public	Environ.	Investors	Nuclear regulation
Siting	Include the acceptance of the whole project and should need a thorough public consultation	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Design certification	Use of previous work to streamline future applications		✓	✓✓✓	✓
Construction / operation	Public consultation could be restricted during these technical steps. Two licenses may be better.			✓✓✓	
Optional licenses	To give incentives to investors (but if not, the resulting single license may be inefficient)			✓✓	✓
Time limit to licenses	Maybe every 10 years (usual thorough inspection)	✓✓✓	✓✓✓		✓✓✓
Prescriptive licensing conditions	National homogeneous and clear regulatory conditions	✓✓✓	✓✓✓	✓✓✓	✓✓

Table 2 Actors' interest in each recommendation concerning the licensing process

Conclusion

The legal process followed for licensing new nuclear power plants is critical to the effective deployment of an energy policy that considers nuclear power to be a possible part of the national, or regional, energy mix. The proper assessment of a nuclear new build project relies upon a regulatory organization that splits responsibilities and accountabilities in its licensing process and to a lesser extent its nuclear legislation.

We find that it is very helpful to compare international best practice in nuclear licensing. The internationalization of utilities and environmentalist groups may push for an international harmonization which should be taken as an

opportunity to improve all licensing and regulatory processes. In this way, we trust improved policy procedures may be identified.

After reviewing the national systems of seven developed countries with nuclear power experience, and their common international basis, we put forward recommendations for building a reference regulatory framework.

The regulatory organization influences the perception by the public and environmental groups of regulatory and political decisions. We recommend therefore the creation of an independent specialized regulator. It should consult extensively with other expert bodies as a way to ensure the soundness of its decisions. A double-check system could be put in place as an additional precaution. Based on the regulator's recommendations, assumed appropriate with such an organization, the government should issue the licences, possibly after parliamentary approval.

The licensing process is mostly important to investors which are mainly concerned with an expeditious process; as for them a slow decision can be worse than an adverse decision. An efficient licensing process with different licences and prescriptive conditions is important in this respect. The licensing steps are of particular importance. They organize the necessary public participation processes and ensure that national conditions are met. Finally, issuing time-limited licences could greatly facilitate public acceptance of the project and would be consistent with a thorough public participation at the siting stage. Nuclear could then be perceived as more reversible, controllable and democratic, factors not usually associated with nuclear power.

Legislators should ensure that a reduced, up-to-date and coherent set of laws covers each aspect of nuclear safety. Though this indicator should be supplemented by others, we suggest that no more than 10 main laws should be in force.

Our findings may help the building of a reference solution. Searching for a good regulatory and licensing solution is an important and topical issue because of growing concerns for climate change and energy security. In many countries nuclear licensing processes today lag best practice as developed in other sectors and in academic research. This paper hopes to improve the effective implementation of nuclear energy policy by examining what those involved in nuclear licensing can learn from each other's practices. Clearly this is only a small part of wider set of best practices that should be factored into nuclear licensing policy, but we hope that it is helpful nonetheless.

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