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Nuclear waste disposal

Harmonising environmental impact assessment processes for geological repositories for nuclear waste in the European Union

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A recent study, carried out for Directorate General for the Environment of the European Commission, investigated the scope and application of environmental impact assessment (EIA) legislation and current EIA practice in Member States (15) and applicant countries of Central and Eastern Europe (10), specifically in relation to the geological disposal of radioactive waste. Legal provisions were assessed against the requirements of the European Union EIA Directives, along with the extent to which international 'best practice' has been adopted in each country. The study also derived an approach to EIA, capable of adoption in all 25 study countries, which would lead to consistency and best practice in the context of geological repositories.

Keywords: nuclear waste; European Union; environmental impact assessment

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NUCLEAR WASTE IS HELD in many countries around the world and primarily results from either civil nuclear programmes or military nuclear programmes (House of Lords Select Committee on Science and Technology, 1999). It is a characteristic of all radioactive materials, including nuclear waste, that they have the potential to cause harm both to human beings and to the environment. Nuclear waste continues to accumulate and, at present, all long-lived waste has to be held in storage pending a solution being found as to how it can either be disposed of or otherwise managed.

Table 1 indicates those countries that have civil nuclear programmes together with the share of electricity generation attributable to nuclear power. This does not quantify the problem in terms of the amount of waste held, but does give an impression of the scale of the problem.

Waste is categorised as high-level (HLW), intermediate-level (ILW) and low-level (LLW) (Electrowatt-Ekono, 1999). Whilst LLW is primarily disposed of in special surface facilities, ILW and HLW require a different disposal solution taking into account the longevity of the radioactivity of the waste and the greater potential for harm to the environment and human beings.

The UK, for example, had stocks of 72,750 cubic metres of high- and intermediate-level radioactive waste in April 1998 (Electrowatt-Ekono, 1999) and has yet to agree on a policy for its final disposal. Future estimates in the UK are for another 135,000 cubic metres of conditioned ILW and HLW (that is waste after conversion into a solid and stable form

Table 1. Nuclear share of electricity generation
(at March 1998)

Country	Percentage of electricity generated by nuclear power stations
Lithuania	81.5
France	78.2
Belgium	60.1
Ukraine	46.8
Sweden	46.2
Bulgaria	45.4
Slovak Republic	44.0
Switzerland	40.6
Slovenia	39.9
Hungary	39.9
Japan	35.2
Republic of Korea	34.1
Germany	31.8
Finland	30.4
Spain	29.3
Taiwan	29.1
United Kingdom	27.5
Armenia	25.7
United States	20.1
Czech Republic	19.3
Canada	14.2
Russian Federation	13.6
Argentina	11.4
Romania	9.7
Mexico	6.5
South Africa	6.5
Netherlands	2.8
India	2.3
Brazil	1.0
China	0.8
Kazakhstan	0.6
Pakistan	0.6

Source: House of Lords Select Committee on Science and Technology (1999)

suitable for storage) to be created after 1998 mainly through decommissioning nuclear power stations (Electrowatt-Ekono, 1999).

Some countries have had nuclear programmes of one form or another since the 1940s, and there is a widespread legacy of waste which has to be dealt with in some way. One of the favoured management options for long-lived radioactive waste is disposal in geological repositories, although this requires suitable geological formations (House of Lords Select Committee on Science and Technology, 1999).

In principle, the process of selecting a site for a facility for disposal of radioactive waste could follow an approach based on screening of potential sites on the basis of pre-established technical and other criteria, or an approach based on volunteerism by local communities, or on some combination of these two approaches. Regardless of the precise method adopted for site selection, the siting process will generally be organised in the following four stages, as set out by the International Atomic Energy Agency (IAEA, 1994):

- concept and planning;
- national and area survey;
- site characterisation; and
- site confirmation.

In developing guidance for carrying out environmental impact assessment (EIA) it is essential to be sympathetic to these stages, which are well accepted, and also to the requirement on developers to produce other documentation in order to obtain operating licenses.

Progress with radioactive waste storage

An overview of the plans for management of high level waste and spent fuel in the member states of the European Union is presented in Table 2. It can be seen that there is variation across the European Union (EU) on the issue of dealing with radioactive waste in the long-term and there is no consensus that a geological repository is the correct disposal option in the short term. The country which has progressed the furthest with the geological disposal option is

Table 2. Plans for management of high-level waste and spent fuel in the EU member states

Country	
Belgium	At least 50 years interim storage Investigations in Boom clay at Mol-Dessel HADES underground research laboratory
Finland	Site selection in progress, Olkiluoto preferred site Decision-in-principle expected soon Construction of repository to start in 2010
France	Law of 1991 defines research in parallel on partitioning and transmutation, disposal and long-term storage Authorisation given for two underground laboratories to make geological site investigations for a repository
Germany	Extensive investigations of the salt dome in Gorleben Shafts and exploration galleries built At present work suspended pending a re-examination of siting criteria Repository in operation 2030
Spain	R&D to continue but at a lower pace, and with no further geological investigations R&D on partitioning and transmutation No decision on the final strategy will be made until 2010
Sweden	Site selection in progress Technical, geological and socio-economic studies are performed in six municipalities In 2001 three municipalities were proposed for detailed geological investigations Step-wise decision process, including step-wise construction of the repository
United Kingdom	Revision of the policy for long-term management of radioactive waste initiated Recommendations by a House of Lords Select Committee
Italy, Netherlands	Policy is deep disposal after 50–100 years storage

Source: Adapted from Forsström and Taylor (2000)

Finland (Taylor, 2000a) and an environmental impact assessment report was published in 1999 (Posiva Oy, 1999).

EU nuclear safety is governed by the 1957 Euratom Treaty, which gives member states jurisdiction and largely sidelines the EU institutions (*ENDS Daily*, 2000). Indeed, the Euratom Treaty was primarily drafted to accelerate civilian nuclear power, and radioactive waste was not a paramount concern. That this is the case is reflected by the fact that the Euratom Treaty has only one reference to radioactive waste management, in Article 37 (Taylor, 2000b). This is a cause for concern with regard to consistency of approach in neighbouring countries, with considerable scope being given to individual member states in dealing with radioactive waste.

Table 2 indicates that some countries favour geological repositories as a disposal option, and this has been the position for some years. Why then, the delay? Taylor (2000b) cites the opposition from large sectors of the public to the majority of siting proposals. This makes it very difficult to obtain political support; this in turn leads to delay, which creates suspicion in the minds of the public, perpetuating the problem.

The Environmental Assessment Directive (85/337/EEC as amended by 97/11/EC) introduced under the Treaty of Rome has been seen by the European Commission as a means of achieving greater consistency in decision processes relating to nuclear installations. The purpose of this study then, was not to derive some innovative and unique approach to EIA to solve a particular problem, rather it was to identify a suitable approach to EIA which can be adopted both in member states and applicant countries, which complies with the existing EIA Directive and Commission guidance on EIA (see CEC, 1994; 1995; 1996; Walker and Johnston, 1999) and presents best (and realistic) practice.

A particular issue is nuclear safety within applicant countries to the EU, some with significant nuclear programmes as a legacy of the USSR (see Table 1). Many of these countries have reactors that will shortly be decommissioned, accelerating the need for final disposal options to be approved for radioactive waste.

The use of the Environmental Assessment Directive in this context is interesting. The original difficulties experienced in drafting this Directive are well known (see Wathern, 1988), with the estimated range of draft directives being put at between 20 and 50 versions, and the time taken between the initial discussions and the eventual adoption of the EIA Directive being a decade. Wathern (1988) concluded that the Directive introduced "… only the most meagre of provisions for project assessment which do no more than formalize those that already exist in most member states".

The use of directives as legal instruments gives member states the scope to meet the imposed obligations in a flexible way (Ball and Bell, 1991, page 44). Directives are already the result of much debate and compromise amongst the member states and, therefore, the fact that, more than a decade later and after its first amendment, it is seen potentially as a tool for bringing more consistency is perhaps surprising. However, this should be seen in the context of it being adopted under the Treaty of Rome and potentially being used as a means of providing more consistency than can easily be achieved under the Euratom Treaty.

In addition, the argument could be made that the existence of workable guidance, if widely accessible and acceptable, may help to achieve greater consistency of approach. Furthermore, the European Commission takes the view that EIA is probably the most important tool in the decision process for a waste management facility. As the EIA involves consultation with all concerned parties, including the authorities and the public, it should be "… a joint product of the local community and the waste management agency" (Forsström and Taylor, 2000), thus making EIA a tool for developing a long-term strategy for waste management that carries broad public support.

This trend in innovative use of the EIA Directive is continuing with another European Commission study being commissioned to present guidance on EIA for decommissioning nuclear power stations set to be completed in March 2001, again facilitating greater consistency of approach to decision-making about these projects. A separate study for the Directorate General for Research of the European Commission has identified that the Environmental Assessment Directive is the only European legislation that includes the term "cultural heritage" and is attempting to derive guidelines for properly including cultural heritage issues within an environmental impact statement (EIS) and, again, providing some consistency.

Under the Environmental Assessment Directive 85/337/EEC (Council of the European Communities, 1985) environmental impact assessment was a mandatory requirement for all installations "solely designed for the permanent storage or the final disposal of radioactive waste" in all member states. This requirement was extended to "installations

An environmental impact assessment is a necessary and important part of the development of a geological repository for the long-term or final storage of radioactive waste and for the development of a long-term surface storage facility

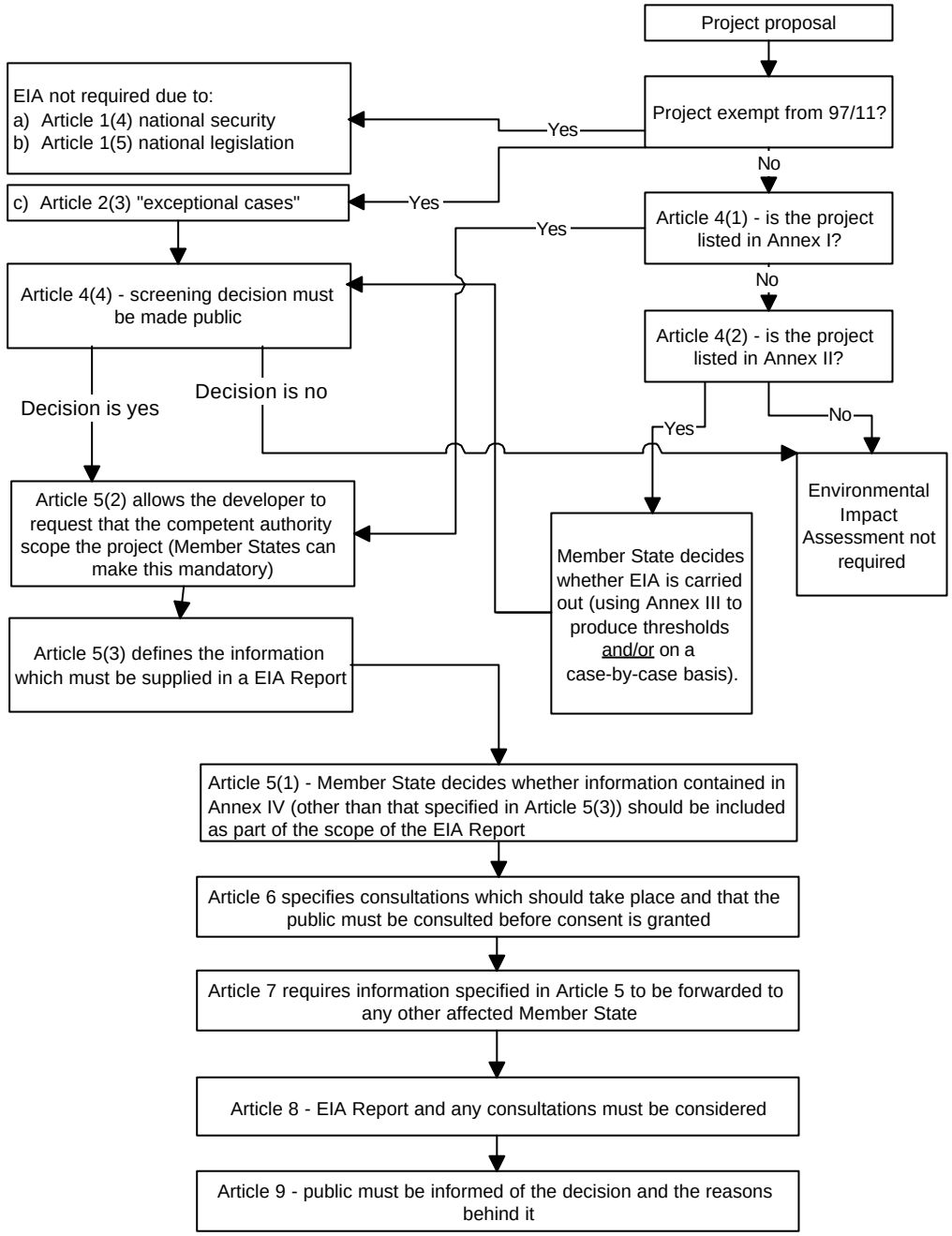

Figure 1. Environmental assessment requirements under the amended Environmental Assessment Directive (97/11/EC)

designed … solely for the storage (planned for more than 10 years) of … radioactive waste in a different site than the production site" by Directive 97/11/EC (Council of the European Communities, 1997) which came into force in March 1999.

Figure 1 indicates the basic requirements of the Directive, as amended ('the amended Directive'). An EIA is therefore a necessary and important part of the development of a geological repository for the long-term or final storage of radioactive waste and for the development of a long-term surface storage facility.

This paper details a consistent approach for the EIA, capable of being practically applied in 25 countries. As with the Directive itself, the approach is necessarily the result of compromise.

Study approach

The design of EIA guidance, which can be accepted by all stakeholders in the process of siting a geological repository for disposal or long-term storage of nuclear waste in 25 countries with different cultures, is fraught with difficulty. A move towards an idealistic EIA procedure is likely to be poorly received by the agencies responsible for siting the repositories. On the other hand, an approach favouring low-cost solutions and minimal stakeholder involvement is likely to antagonise the public. With this in mind, the study has involved a variety of stakeholders in developing the EIA approach presented here.

The basic study approach was primarily to gather information using a combination of questionnaire

surveys, literature reviews and Internet searches. The data were collated, analysed, and then discussed in depth at a two-day workshop, which allowed delegates from those countries investigated to verify the accuracy of the information, and to propose amendments and 'sign on' to the proposed approach.

Literature searches have been used successfully in European Commission studies in EIA (see Walker and Johnston, 1999), and a wealth of information can be found in the literature (see, for example, Petts, 1999) and on web pages (see, for example, the EIA Centre web pages at http://www.art.man.ac.uk/eia/EIAC.HTM). Nevertheless, in the context of studies on legal procedures, they can describe outdated legislation and care was taken to identify where this was the case.

The relevant regulatory framework comprises the EIA Directive and the Euratom Treaty. In addition, further influence can be expected from the Århus Convention (UNECE, 1998) which will require greater public involvement at the earlier stages of the EIA process. Indeed, the European Commission has now got as far as adopting, on 18 January 2001, a proposal for a Directive amending the EIA Directive (CEC, 2001).

An important element of the consent process for repository development is the preparation of a 'safety case'[1] for review by the nuclear safety authorities before a licence to start construction of a repository is granted. In deriving a consistent EIA approach, the importance of the safety case was noted in this context and it was felt that important information, particularly on human health impacts, would feed directly into the EIA itself.

Whilst the study did determine the EIA legislation currently effective in each member state, a more important focus was to determine current practice related both to the EIA procedure and to public participation as a component of that procedure. As the siting of geological repositories is likely to be highly contentious, the development of guidance consistent with the Århus Convention (UNECE, 1998) was clearly important.

Within these target countries over 900 questionnaires were sent to radioactive waste specialists, such as the radioactive waste agencies, authorities, and specific government departments, and also to a wider range of EIA specialists able to comment on the more general EIA requirements as well as offering an external opinion of public participation within the existing EIA procedures.

The detail of the research approach, and the results (including workshop report) are contained within four study reports: O'Sullivan *et al.* (1999a; 1999b; 1999c) and O'Sullivan and Bond (1999).

Consistency issues

It was clear from the analysis that there was broad compliance with Directive 85/337/EEC in all member states and that progress towards compliance with the amended Directive seemed to be good. However, there is a lot of scope for variation in approaches within the constraints imposed by directives. Those identified were used as one of the bases for producing the guidance and are as follows:

- Non-technical summaries of the EISs are required by the Directive, but three of the accession countries still had no legal requirement for these.
- Additional categories of impacts studied, though not required under the Directive, were required in Germany which has specific additional requirements to study geomechanical stability, nuclear and criticality safety as well as health protection for employees.
- Availability of publicly-available guidelines are indicative of efforts to implement the obligations imposed in a clear and transparently accountable way, but, in the member states, the respondents from Belgium, Germany and Italy indicated that no such general guidance was available. In the accession countries, the evidence indicated that guidance documentation is sparse in its occurrence; one possible explanation for this is that there is insufficient experience to be able to indicate best practice for all the components of an EIA study.
- Scoping is still only advisory under the amended Directive and it appears that some member states approach the issue of establishing the contents of EIA reports (scoping) in a more systematic and defined way than others and there is some inconsistency in the issues considered in EIA reports in different member states. In particular, in some (for example, The Netherlands), detailed terms of reference for the EIA report are established in advance of the environmental assessment. In terms of specified contents of EISs, Belgium, did not appear to consider social impacts and Belgium and Austria, did not appear to include economic impacts.

  All accession countries either indicated the contents of EIA reports in legislation, or required the competent authority to scope the contents (though it is not clear whether they must always request certain minimum contents). In terms of the issues considered in an EIA report, the applicant countries generally require all the information specified in the Directive. There are some exceptions, and these tend to be issues such as archaeological heritage, material assets and architectural heritage. Whilst it is possible that issues are indeed ignored, another possible explanation is that these issues are considered under a different heading and it is necessary for terms to be clearly defined to ensure legal compliance.
- Timing of the EIA is a critical issue; in general, the earlier EIA takes place the more opportunity exists for the assessment itself to influence the development of the project for which consent is

being sought. It is apparent that, in practice, there are wide variations in the timing of application of EIA across the member states and accession countries. As a result, the inherent value of the EIA process will vary across member states.

- There appears to be some diversity of approach between member states on the extent to which an EIA report is expected to discuss the reasons for choosing a particular option in the context of the main alternatives considered. There was no such specific requirement in Belgium, France, Ireland, Italy or the UK at the time of the study, and five accession countries did not require the consideration of alternatives in an EIA report either. Note that Article 5(3) of the amended Directive requires the developer to provide "an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects".
- Enforcement of mitigation measures varies significantly across the members states of the EU, though this is probably because nuclear facilities generally require consents under more than one piece of domestic legislation, that is, consent to operate a nuclear facility as well as development consent under land-use planning legislation. In these circumstances the main regulatory authorities for implementation of such projects are generally those dealing with nuclear or environmental safety issues, so they are not usually responsible for ensuring that requirements established during the development consent process are implemented in practice. By contrast, the legislation in all accession countries required the enforcement of mitigation measures written into the EIA, although the actual practice in this regard was not clear.
- It is frequently argued that the value of EIA depends on the effectiveness of public participation within the process (see Wood, 1995; Petts, 1999). The extent and timing of public involvement in environmental assessment appears to vary widely across member states. From the assessment of questionnaire results, the ranking indicated in Table 3 was produced to illustrate the stage at which public involvement appears to be most common. As might be expected, formal public involvement is greatest at the decision stage, in accordance with the requirements of the amended Directive. There appeared to be a high level of involvement also at the scoping stage, perhaps reflecting a belief that consensus about development proposals is more likely to result from early public involvement.

  Evidence from all countries indicated that, as a general rule, developers and NGOs (non-governmental organisations) showed little interest in the actual mechanics of public participation because their priorities are more issues-based. In central and eastern European countries, NGOs were often perceived by authorities to be the public, thus consultation was concentrated on NGOs. In the member states, evidence points to the fact that it is the developers who most need to change attitudes to public involvement as public bodies frequently act to support communities; in central and eastern Europe, this support for communities was less clear at the time of the study.

Table 3. Stage of EIA process at which public involvement takes place most commonly in Member States only

Rank	Stage
1	Post EIA submission, pre-decision
2	Scoping
3=	EIA report preparation stage
3=	Consideration of alternatives
4	Post-decision, pre-initiation of project
5	Screening

Scope and contents of EIA reports

The study formulated a summary of the main components of an EIA report based on the information specified in Annex IV of the Directive, whilst taking into account the specific characteristics of a facility for the long-term storage or disposal of radioactive waste. These are listed below.

Non-technical summary

The non-technical summary should outline the proposal and its assessed implications in language that is readily understandable to members of the public.

Project background

This should explain the background to the project, the role of the environmental assessment in the context of the decision-making process, project timescales, the purpose of the EIA report in particular and the arrangements for taking account of the views of the public and other interested parties.

In the EU, formal public involvement is greatest at the decision stage: there is also considerable involvement at the scoping stage, perhaps reflecting a belief that consensus on development proposals is more likely to result from early public participation

Definitions

A set of definitions should be agreed at the beginning of the EIA process by all stakeholders. This will enable constructive and worthwhile dialogue to take place between the developers and other parties.

Policy, legal and administrative framework

This section should outline the legal and regulatory framework within which the project is being developed, including the processes for site selection and policy requirements relating to retrievability of waste.

Public participation

Details of the public participation that has taken place during the EIA process up to the point at which the EIA report itself has been produced needs to be described. The nature of the participation should be clearly detailed and justified in order to clarify the degree of involvement of the public. This section should indicate the interaction with the public which is scheduled in the post-decision phase.

Need for a disposal/storage facility

It will be necessary to set out the reasons for the proposal in the context of the inventory of radioactive wastes and the alternative waste management options considered.

Existing environment

The report should include a comprehensive description of the existing environment, providing a baseline against which the assessed impacts can be considered.

Description of the project

The physical characteristics of the project, land-use requirements and the main environmental impacts should be described. This should include a description of design provision relating to waste retrieval where appropriate. Where it is intended to undertake further site characterisation as part of the site confirmation activity, the planned experimental programme should be discussed.

Site selection

The basis for the choice of the selected site should be explained, in terms of the strategy for evaluation of alternative sites (guidelines for site selection) and consideration of the characteristics of the main potential sites (including geological setting, hydrogeology, local natural and built environment, socio-economic issues and population densities).

Assessment of impacts

The assessed radiological impact from the project during its operational phase and potential long-term impacts should be discussed. This should include impacts on the natural environment as well as on the workforce and the general public.

The report should also present the results of the assessment of impacts resulting from the construction and operation of the facility, including social and economic impacts, impacts on local natural resources, transport-related issues and potential impacts because of the presence of materials which present a chemical hazard.

Prevention, reduction, mitigation of adverse effects

The EIA Report should describe the proposed measures to address the identified impacts, together with an indication of timescale and cost implications.

Suggested process for geological repositories

Development consent, as discussed in the Directive, implies the granting of permission to proceed with that part of the project involving "interventions in the natural surroundings and landscape" including "the execution of construction works or of other installations of schemes" (Article 1). The Directive requirements therefore relate largely to the site selection phase, though it is implicit that national authorities should attempt to ensure that the measures proposed to address environmental impacts are implemented in practice.

Under Article 8 of the Directive the body responsible for deciding whether development consent is granted for a project coming within the scope of the Directive (the competent authority) must take account of:

- the information supplied in the EIA report; and
- the results of the necessary consultations with the public and other relevant authorities (including in other member states where appropriate).

Although the environmental assessment process is linked to the consent process there are no strict requirements as to the extent to which these two activities are integrated. The EIA report could be regarded as one of many submissions from the proponent to the competent authority, or it could be used to draw together all the main arguments being advanced by the proponent for seeking to proceed with a particular project. The study favoured the latter approach.

The requirement for the assessment to include an outline of the main alternatives studied has already been detailed. The practical effect of this is to make it obligatory (for installations for which an environmental assessment is required) for a developer to

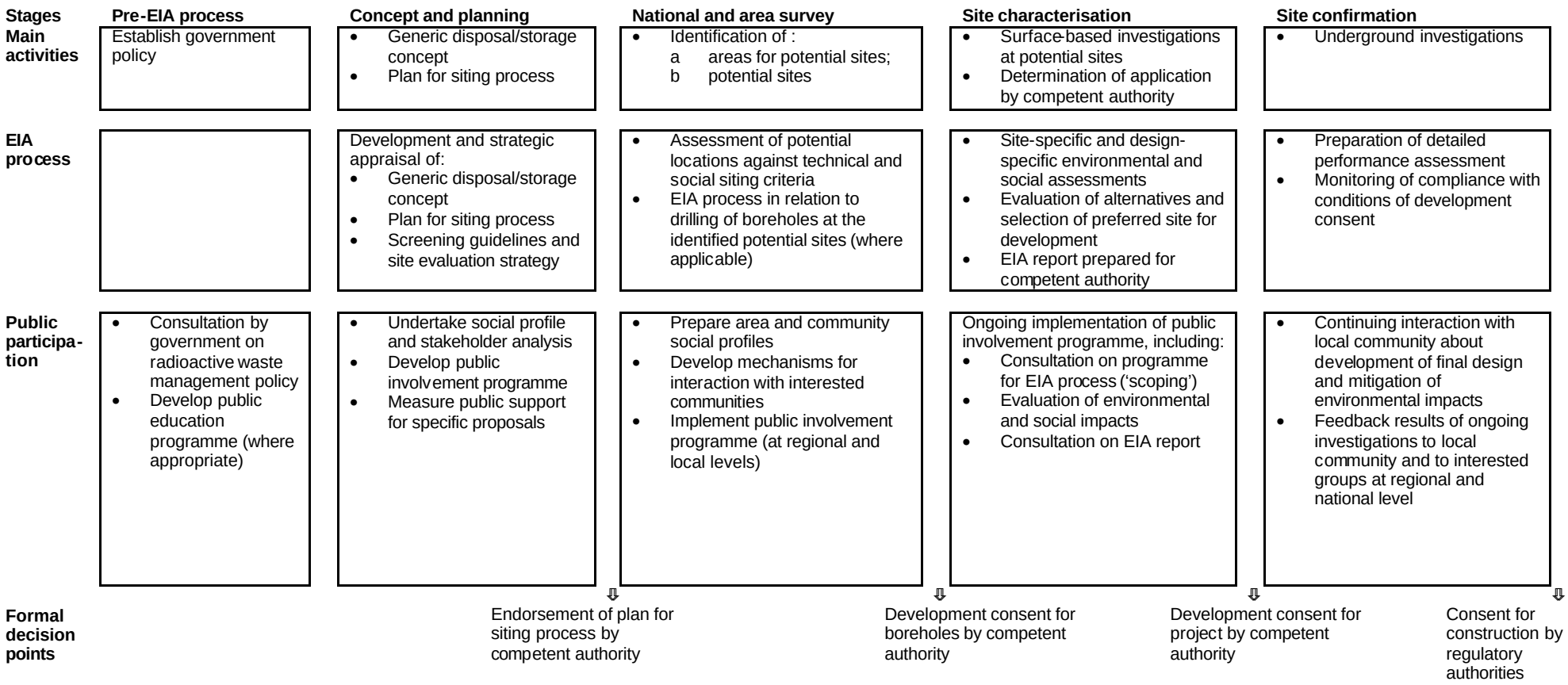

Figure 2. Proposed EIA process for a geological repository or long-term storage facility

study alternative options to that being proposed in any application for development consent, unless there clearly are no real alternatives. Therefore, although there is no explicit requirement for the EIA process to be integrated closely into the process of site selection and project development, the requirement to outline the main alternatives studied makes this unavoidable. The EIA report should incorporate information on the assessed performance of the preferred site for development together with comparative information for alternative sites.

In principle the requirement on a developer to give details about the main alternatives studied applies both to the waste management process being advanced and to the choice of a particular site for development of a disposal facility. Consideration of alternative waste management options could take place in connection with an application for development consent at a specific site, or this could largely be addressed in advance of site selection through a strategic environmental assessment of waste management options.

The model process proposed in the study report is based around these stages, and is shown schematically in Figure 2.

As discussed earlier the proposed process is developed around the four stages of the siting process as set out by the IAEA. The major decision milestone is the point at which consent is sought from the competent authority to proceed with development of the facility. It is suggested that the application for development consent should be made following the selection of a preferred site, that is, at the end of the site characterisation phase.

In line with this, the formal EIA process, for the preferred site and for the main alternative sites, would be undertaken during the site characterisation phase. It would be expected that consent granted then by the competent authority would be made subject to the satisfactory completion of underground testing during the site confirmation phase. Nuclear safety legislation in most member states would require a further formal consent, for example, by regulatory authorities, before starting construction of the major components of the facility.

During the early phases of the siting exercise, prior to the identification of specific sites for investigation, it is proposed that a more generic evaluation of impacts is done, as part of a process of dialogue with stakeholders about the general long-term strategy for waste management and the basis for the chosen disposal concept.

Conclusions

It is clear that the increasing volumes of long-lived radioactive waste pose a serious problem, both within Europe and beyond its borders. Taking the UK as an example, the volume of intermediate and high-level radioactive waste is set to increase significantly in the future, primarily as a result of the decommissioning of nuclear power stations. Decisions have to be made about the long-term storage of this waste, and a viable option is disposal in geological repositories.

The European Commission has identified the Environmental Assessment Directive as a tool which can potentially bring about some consistency in the procedures used for siting geological repositories. Environmental impact assessment has a role to play in ensuring that decisions on the future storage or disposal of a large volume of radioactive waste are made based on good environmental knowledge. A multidisciplinary team has used consultation with stakeholders to develop a flexible EIA approach compatible with the Directive on environmental assessment, to use for these future decisions.

The research carried out for this study demonstrates that EIA is a versatile tool and can be readily adapted for use in the consideration of contentious projects which are already subject to their own evaluation procedures. Verification of the acceptability of the approach for application throughout the European Union and accession countries was carried out at a workshop involving the identified stakeholders.

Obviously, disposal of radioactive waste is an emotive issue. The study presented here recognised this and has indicated good-practice approaches for involving the public fully in EIAs for geological repositories for nuclear waste.

The study reported in this paper potentially heralds a new era of innovative applications of the EIA Directive. The text of the Directive adopted in 1985, initially considered as being vague by many, may well come to be regarded as being versatile instead.

Note

1. A collection of arguments, at a given stage of repository development, in support of the long-term safety of the repository. A safety case comprises the findings of a safety assessment and a statement of confidence in these findings (OECD, 1999).

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