

Staged siting strategy

Multinational siting strategies can be modelled directly on successful, modern, national siting approaches since both approaches face very similar challenges.

By Neil Chapman and Charles McCombie

National and multinational disposal projects both have to go through exactly the same technical and stakeholder involvement steps. They may take many years to achieve siting successfully and, indeed, should avoid the premature selection of potential sites. The essence of any successful siting programme is that it is consensual and inclusive from the outset and all aspects of the repository project are transparent. The process must allow for active inclusion of the local communities at all stages.

We have developed a model approach to siting a multinational repository, based around a European case study. The approach could be adapted readily to any group of countries worldwide wishing to share waste management facilities. The process proposed is based on modern consensual national siting programmes. As in the national case, it may be a long time before success is reached and a suitable site agreed upon. As in national programmes, the absence of a final site during the long process should not be

taken as a sign that the disposal programme is not credible.

The multinational model approach is driven by the interest of communities in hosting a repository, with national governments required to take only a secondary role, after they have first agreed that they wish to participate in the project or, at a minimum, will not prevent local communities in their country from volunteering.

The essence of this model is that it takes the burden of leadership of a very sensitive project off those national governments, who may be unwilling to be in the vanguard of such a programme. For those national governments who believe that they should have complete competence in repository siting, it requires that they acknowledge and support the decision powers of local communities. In fact, it would require local communities to act in an international arena – to consider themselves regionally and not just nationally. This is perhaps something relatively new in planning and decision-making, although elements of such a process are

already visible in the European Union. We believe that such community far-sightedness, along with appreciation of the potential economic and societal benefits that would accrue to a host community, may make siting a shared repository considerably less difficult than critics of multinational solutions assert.

CONSTRAINTS

In common with the most recent national repository development projects, we advocate a gradual multi-step process (frequently referred to as 'staging') to achieve a disposal solution. The principles of such an approach have been described in overview documents such as the report *One Step at a Time* produced by the National Research Council of the US National Academies and *Stepwise Approach to Decision Making for Long-term Radioactive Waste Management: Experience, Issues and Guiding Principles*, produced by the OECD Nuclear Energy Agency.

An example of the staging approach in a national disposal programme is the 2005 proposal by the Canadian Nuclear Waste Management Organization (NWMO) for a disposal programme for spent fuel, with clear targets but a continuing capability for adapting the project to meet demands at future times ('adaptive staging'). In Canada, a programme of consultation and discussions has led to the identification of direct geological disposal of spent fuel, with a period of interim storage, as the preferred option. A similar option was chosen in the UK from among those considered in 2006 by the Committee on Radioactive Waste Management (CoRWM). In most countries, however, this long-term management strategy was agreed upon without a similar period of overall 'options consultation'. As stated earlier and as will become clear below, there are many parallels between applications of the adaptive staging approach at the national and multinational levels.

For a multinational project, the suggested approach is one that can run



Objectors to a national LLW disposal site in the Republic of Korea. Most nuclear power generating countries have learned to their cost that siting a waste repository is a challenge

for some considerable time in parallel with national siting efforts without prejudicing their outcome. A key aspect of the process proposed here is that it allows a progressive approach to identifying both host countries and host sites. The approach specifically avoids requiring partners in a shared multinational project to commit themselves at the outset to being a potential host country for a repository, or even to agree on a common optimised development timescale. For technical, programmatic, financial or political reasons, several stages of agreement will be required before a host emerges. Each level will be informed by progressively clearer, project-specific and quantitative information (on costs, benefits and impacts, for example) that will establish exactly what is being committed to by partners. As this process progresses, the improved information and the stepwise and largely reversible growth in project commitments should provide partners with increasing confidence in the eventual solution. In short – these delicate developments cannot be rushed.

Since the option to reprocess rather than dispose directly of spent fuel may be kept open by some potential partners in a multinational project, the proposed programme aims to deliver a site suitable for disposal of all types of spent fuel, vitrified high-level waste (HLW) and long-lived intermediate-level waste (ILW) and also for long-term storage of fuel that might be later reprocessed.

Volunteering approach

A very important challenge is to develop a suitable process for ensuring that all stakeholders are involved in appropriate ways, especially national governments and local communities. Current international views are that an entirely prescriptive approach (where technical choices are made by experts and then attempts are made to convince specific communities) is unworkable. The opposite end of the ‘siting spectrum’ is pure volunteering, in which any interested country and community can come forward, explore the issues and, if it wishes, be evaluated for suitability, with the implementer prepared to show technical flexibility, provided a safe and economic solution can be developed. In the volunteer model, the implementer does not seek sites, but waits for volunteers to propose potential sites whose suitability will be objectively assessed.

The strategy proposed here is a volunteer model incorporating stake-

holder involvement at all stages. It is technically guided at the outset only insofar that clearly unsuitable regions are excluded at the start. Consequently, it incorporates the flexibility to evaluate objectively any proposals that might emerge from volunteer communities or regions or countries, from the start of the programme.

An important underpinning aspect of this approach is the initial assumption that any location that is not obviously unsuitable on the basis of existing knowledge is worth considering on its merits as a possible repository site. This is the approach currently being taken by national disposal programmes in the UK and in Japan. It is based on the knowledge that many different geological environments can provide acceptable isolation and containment conditions and that many different repository concepts have been designed to take advantage of this range of conditions. The obvious rider to this model is that a volunteer location (in a non-excluded area) might well be rejected after only limited investigations, if these indicate that it would be too difficult to make a reliable safety case or too costly to adapt designs to site conditions. The essential element, however, is to maintain flexibility and not to exclude interested communities if there is a realistic likelihood that they could prove suitable.

A central matter for immediate discussion with partner countries will be how to solicit volunteers. This discussion must consider the geographical levels at which volunteers are sought (community, county/district, region, country) and the roles and responsibilities of actors involved at each level. The latter point raises a list of sensitive questions, including:

- Must volunteering countries already have identified potential host communities?
- Does the government of a country have to actively volunteer or, more passively, simply agree not to block any local volunteers?
- Can local communities volunteer before national agreements are reached?
- At which of the above levels is consent to volunteer required?
- How does one define sufficient acceptance at each of the levels?
- Who has veto or withdrawal rights and at which project stages can these be exercised?
- Who negotiates the levels and the distribution of benefits for volunteers?

Goals and guiding principles

The overall goals of the multinational siting programme are to enable the implementing body to:

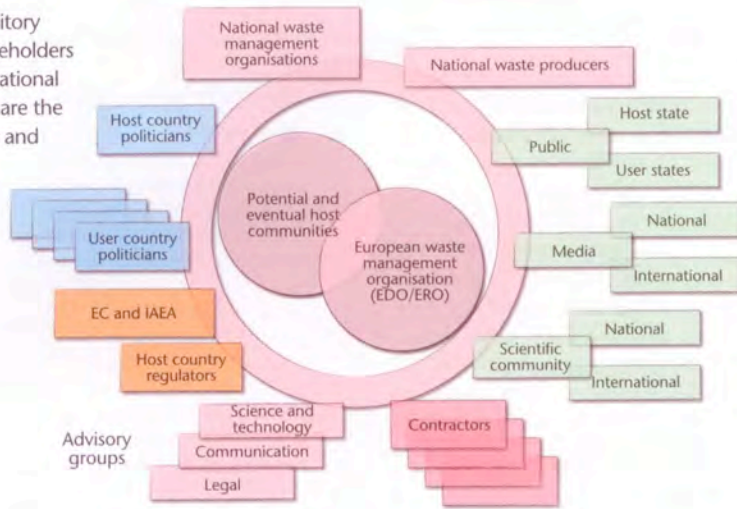
- Deliver, within a 10-20 year time window and with an economically justifiable approach, a site or sites that are technically, politically and societally acceptable for a deep geological repository (possibly also site/sites for long-term interim storage facilities), for all relevant long-lived radioactive wastes produced in the partner countries.
- Show that the selected site(s) meet all nationally and internationally accepted standards with respect to operational and long-term safety and environmental impact.
- Pursue a staged and progressive approach to identifying both host communities (sites) and host countries at an appropriate time in the project schedule, while avoiding premature, external pressures to identify hosts at the outset.
- Work in harmony with parallel national siting programmes, especially as some partner countries may be taking a ‘dual track’ approach in which they pursue both national and multinational options.
- Maintain flexibility and responsiveness in its operations, while presenting its work in a clear, transparent and auditable fashion.

The following guiding principles have been used in establishing the proposed siting strategy presented here. The siting approach should:

- Be based upon a transparent selection process associated with agreed and well-defined siting factors that identify clearly unsuitable areas (using exclusion factors), required (necessary) characteristics and preferred (favourable) properties of suitable sites.
- Seek volunteer host countries and communities from within the wide regions that are not excluded *a priori* and evaluate them on their merits.
- Take into full consideration the political and cultural challenges associated with its multinational nature.
- Be published in advance of any work starting and allow a period for consultation with key national and international stakeholders during a period when the overall legitimacy of the siting programme is being established.
- Be structured in clear steps with clear decision points and well-defined responsibilities for all stakeholders involved at these points.
- Be flexible enough to adapt to changing requirements over the course of the project and the findings of each stage – it should be amenable to adjustment to accommodate stakeholder requirements at key stages.
- Provide up-to-date information to the publics and stakeholders at each stage, with defined mechanisms and decision points for public feedback throughout the programme.
- Not aim at finding the ‘safest site’ (as this can never be demonstrated) but at finding safe sites that are the most suitable, taking all siting factors into account.
- Where there is more than one potential site, be able to compare these transparently using the siting factors and the selection process referred to above.
- Involve the regulatory agencies of potential host countries and all partner countries from the outset, to facilitate their work and make the licensing steps more transparent and efficient.
- Achieve a solution on the required timescales at reasonable cost and with reasonable use of resources.

It is expected that the answers to these questions could differ across the partner countries, but we present below a model for how the process might be structured. The approach favoured by the authors is to place the initiative firmly in the hands of local communities, once certain boundary conditions have been established. The sequence proposed in our model is as follows:

In a multinational repository project, even more stakeholders are involved than in a national case. The core partners are the repository implementer and the host community



1. A group of countries comes together to explore the possibility of sharing a geological repository. Having established the way in which they will work together they give wide publicity to the project, explaining all aspects including initial aims with respect to national and community benefits, and they announce that a volunteer process will be launched in the near future.
2. With the involvement of a wide range of national and international stakeholders they establish a common set of technically based exclusion criteria to remove from consideration clearly unsuitable land areas within all their countries. It is expected that national databases would play a central role in establishing which areas are affected by the exclusion factors and that national agencies (for example, geological surveys) would be pivotal in applying the factors.
3. Communities in non-excluded areas in all the countries are invited to express interest (on a non-committing basis) in the possibility of being a host for the repository, thus starting the siting process described

later. National governments would agree not to stand in the way of this process – indeed, they may actively encourage it.

4. Participating national governments would be free to solicit specific volunteer communities that they considered might have a particular interest in the project or have particularly favourable characteristics for hosting a repository.
5. Up to a pre-defined 'point of commitment' (probably after several years of site investigations), both interested communities and national governments would be free to withdraw from the process.

Some additional factors need to be considered in this simple model. For example, partner countries might enter the project at different stages. Only when the largest programmes likely to be in the eventual project are known with more confidence can a realistic estimate be made of the costs of repository implementation and of the scale of benefits and impacts to the host country and community. The size of these will be key factors for any community or country making a decision on whether to move to the next stage of siting as a potential host. This again illustrates that too early a commitment on hosting could be inappropriate.

A further question concerns how existing national siting programmes can be incorporated into this model. Partner countries that already have developed national siting programmes will be readily able to pool their knowledge, but they will also have to decide how to deal with sites and communities that are already being considered as possible national repository locations – will these sites be in the 'pool' of potentially interested communities, not in the pool, in the pool at the start

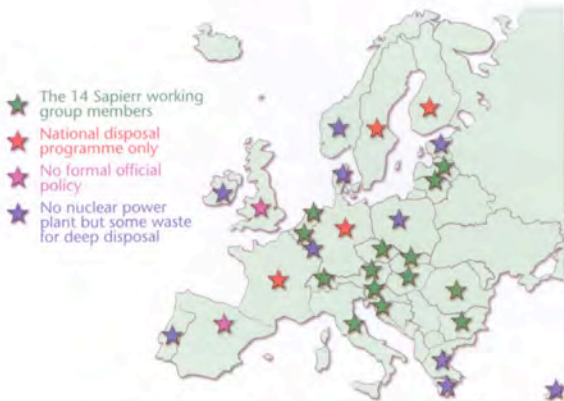
or only in the pool later? For some countries this will be an especially sensitive issue to resolve and would clearly need consultation with potential host communities already identified.

Siting timescale

A time constraint for the overall siting programme (*ie* up to the point of commencement of repository operation) is likely to be between 15 and 20 years. This is broadly consistent with experience in past successful programmes like those in Finland and Sweden and with plans for future siting work in other national programmes such as those in Canada and Switzerland. The aim in developing the following siting strategy has been to fit into this schedule.

Here, as in all national programmes, the actual time required will be affected by factors whose impact is difficult to judge. On one hand, after almost 35 years of work on national siting programmes, it ought to be possible to learn the key lessons, avoid obvious obstacles and proceed relatively quickly today. Any regional programme will build upon decades of progress in associated national programmes and will not be starting from scratch. On the other hand, we have learned from the extensive experience of national programmes to anticipate delays in the delicate task of siting repositories. An optimistic, minimum schedule would be around five years to establish the organisational infrastructure and agreements and carry out the initial site identifications, a further five years to carry out detailed site investigations for the surface and another five years to construct access works, carry out further confirmatory underground investigations and submit a licence application to begin operations. Allowing for delays and licence review, this optimistic 15 years schedule could stretch out to 20 years.

An important factor is the length of an interim storage stage for spent fuel that might be planned before disposal. In principle, it is feasible to postpone implementation of the repository for a long period, even after a site has been identified and confirmed. Cost savings may be achieved by this extended storage strategy and it may be politically acceptable, especially if the storage is at the various existing national waste production facilities. If national storage capacity becomes tight, or if there are security arguments for reducing the numbers of spent fuel storage sites, and interim storage is planned at the multinational disposal site, there



The potential for shared regional solutions in Europe. If there are no regional repositories implemented in Europe, all of the marked countries will need a national facility

could be stronger reasons for moving ahead with the multinational facility. Nevertheless, the strategy presented here would allow either 'holding' the reserved disposal site (with or without an interim store) or else moving smoothly to waste disposal as soon as the siting process is completed. By that time, some of the fuel inventory will be sufficiently cooled (40-50 years) that immediate disposal would be feasible, if required. The repository could also be used for the disposal of other long-lived wastes as soon as it is available.

In considering the way that the overall programme schedule can be tailored to meet political and economic desires, a possible over-riding driver might be that of maintaining the global credibility of nuclear power expansion by ensuring that a disposal solution is actually achievable for all countries regardless of the size of their nuclear programme. Having a concrete disposal plan with a clear chance of success because of its tangible components (like an agreed multinational site and a cost sharing concept) could be a key element of national energy and environmental strategies over the next decades, when many countries will be seeking to expand or extend their nuclear power capacities. Moving forward expeditiously to a solution while there is the will and the means will enhance credibility. Repeated and circular discussion with no significant progress will play into the hands of those opposed to the essential role of nuclear power.

A further constraint on the proposed strategy is the time that may be required for consultation and decision-making. Experience has shown that, even in national programmes, this time is difficult to predict, and that these processes introduce uncertainties on the outcome at some key decision points. In the multinational case, contact with all relevant stakeholders in participant countries is obviously more challenging and consideration may need to be given to a staged approach, where stakeholders are brought into the process at the most appropriate time. For example, it may not be practicable or appropriate to try to engage with all municipalities in a country with respect to the first, high-level decision by a government simply to become involved (without commitment) in establishing the initial partnering organisation. However, it is essential to

communicate openly to the public all progress in the project and to solicit feedback on interim decisions. This can help minimise the time needed for societal debate and political decisions on later choices and decisions.

If there is only one volunteer, progressing to site investigations is straightforward, but the consequent risk that the initial stages of investigation may show that the site is not suitable must be recognised. If there are multiple volunteers, a further important consideration is whether a parallel or sequential approach is adopted for site investigations once candidate sites have been identified. Parallel investigations of several potential sites increase costs but provide greater confidence that a suitable site can be found and its acceptability demonstrated in a limited time period. Sequential investigations are potentially cheaper, provided an acceptable site can be found among the first one or two evaluated, but run the risk of taking much longer if early sites prove unacceptable. They also preclude the transparency and confidence-building that can be provided by demonstrably keeping options open and by being able to compare sites. In the model strategy presented here, we have used the parallel approach, but indicated where and how a sequential approach could affect programme flexibility.

Implementing agency

A key, non-technical decision concerns the domicile of the multinational repository organisation. It is assumed here that the initial organisation – the non-profit European development organisation (EDO) in the European model developed in the Sapierr (Support Action on a Pilot Initiative for European Regional Repositories) project – would be established in a 'neutral' country that would not prejudice final siting. All work through to the point of site selection would be done through this organisation. Since site investigations may be carried out in various countries, this allows efficient utilisation of a central pool of expertise. Clearly, however, local liaison to, and involvement of, the potential host countries and communities must be strong.

At the time of a decision to submit a licence, a new entity (perhaps a daughter organisation) should be established in the host country: in fact, in the host community. This will almost certainly be necessary for licensing purposes

and, in any case, sends an important public signal. In the European model, this second organisation is called the European repository organisation (ERO). Sapierr characterises the two organisations as follows:

European development organisation

The EDO is the initiating, non-profit organisation for a shared geological disposal facilities project. Its objective is to establish the systems, structures and agreements and carry out all the work necessary for putting in place a shared waste management solution and geological repository (or repositories). This work would continue through the investigation of potential sites and up to the point of licence application to begin the construction of a repository. At this point, the EDO may decide to transform into or separately establish the ERO.

European repository organisation

The ERO is the implementing organisation for waste disposal. The ERO would be the licence holder for the repository and responsible for all subsequent operational activities in a host country that has agreed to dispose of wastes from other European countries. The form for the ERO will be chosen at a future date by the members of the EDO, assuming that they come to the conclusion that the EDO organisation needs to be altered. The choice will also be strongly influenced by the preferences of the country or countries that have been identified as repository hosts. The ERO could be either non-profit or commercial in structure.

STAGES, ACTIVITIES AND DECISIONS

A model, stepped approach to a repository siting programme is presented in tabular form to allow easier representation of the stages proposed (see pages 32-33). The stages go up to the point of licensing a repository for operation. Various milestone documents that the EDO will produce at key stages are identified.

The initial stages are those that most strongly differentiate multinational approaches from their national equivalents. Stages 16 to 20 of the strategy lie at the interface between final site approval and repository construction, and all stages lie within the 15-20 year period discussed above.

Milestone documents

In the early stages 1 to 4, the initial documents produced detail the agreed

strategic plan and the legal, financial and organisational issues to be settled for the formal partnering organisation established. Subsequently, the following key technical documents would be produced in this strategy:

Project plan

The management structure, aims, milestones and operational model for the project, based on consultations with stakeholders and including the legal and financial terms of reference for participating countries and other stakeholders. The project plan will be revised from time to time in the course of the programme.

Stakeholder engagement plan

A transparent description of the engagement process and of the rights and responsibilities of all stakeholders at each stage in the repository development.

Strategic environmental assessment

A formal evaluation, defined by the European Environmental Agency as being "normally applied to policies, plans, programmes and groups of projects. Strategic environmental assessment (SEA) provides the potential opportunity to avoid the preparation and implementation of inappropriate plants, programmes and projects and assists in the identification and evaluation of project alternatives and identification of cumulative effects. SEA comprises two main types: sectoral SEA (applied when many new projects fall within one sector) and regional SEA (applied when broad economic development is planned within one region)."

Siting factors

These include:

- Exclusion factors: a list of broad geological and non-geological features that would exclude a region from the siting process. These might include the presence of mineral provinces or extensive, deep, exploitable aquifer formations or could be institutional or planning restrictions.
- Acceptability requirements: definition, quantitative where appropriate, of unacceptable conditions for a disposal site. The sites will be tested against these simple criteria before they can be shortlisted, in stage 10, as acceptable for final, detailed evaluation.
- Preference factors, which will be used at various stages of the

programme to compare sites to see how well they meet a range of goals (eg safety, environmental impact, cost, national and local design/operational requirements and preferences).

Site characterisation plan

This describes the detailed methodology and approach for the initial and detailed site characterisation work, with costs and timescales, for the specific sites emerging from discussions with interested communities.

Site descriptive model

The site descriptive model (SDM) is an integrated description of all the geological and ecological features of the site in a form that illustrates understanding of how site conditions are related and have evolved. The SDMs will form the basis for building safety and performance assessment models and the final SDM will be a cornerstone of the safety case for licensing.

Repository reference design

An initial design intended to fit a repository into the site conditions known at the time of the preliminary field investigations.

Selection reports

These explain the rationale for the selection of sites for preliminary field investigation and a final site, showing that their choice has followed the project and national policies and guidelines.

Preliminary safety evaluation

The first part of this document comprises a comparison of site conditions with those in the acceptability requirements. The second part presents preliminary performance assessment results for the reference design at the site. It is expected that this will be an incomplete description at this stage.

Initial repository design

Developed at the end of the detailed site investigation stage, this fits the repository into the defined site conditions (eg major fracture/deformation zone geometry and variable rock engineering properties). At this stage it would be expected that the implementer's parallel repository design programme would have settled upon the final design concept.

Comprehensive safety assessment report

This includes full safety and performance assessment of the sites that can be used to assist the decision of which site to select for the repository.

Repository design description

The fully optimised repository design that utilises the underground rock characterisation facility (URCF) data to refine the details of the design to site conditions at the selected repository site. It will be used as the basis for the repository construction and operation licence and will identify in detail the way that the design will adapt to conditions encountered during disposal tunnel and emplacement zone excavation.

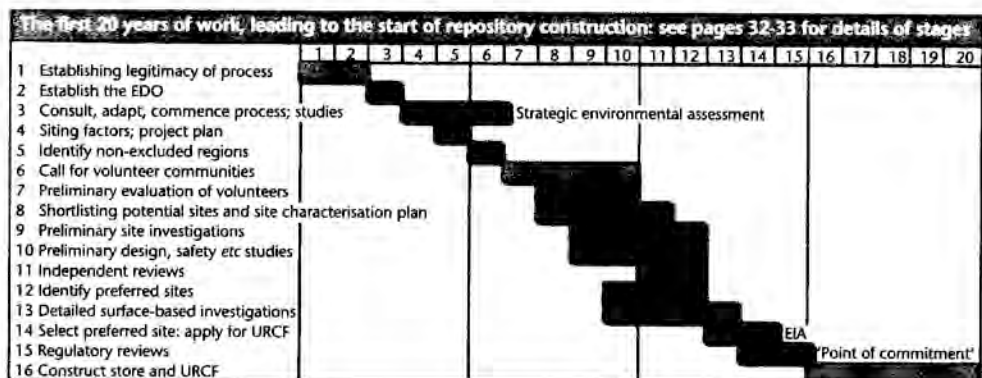
Final safety assessment report

The final, comprehensive safety case for licensing the repository, including the detailed safety assessment and all necessary supporting arguments that illustrate repository performance and quantify uncertainties.

Environmental impact assessment

The standard documentation required for large infrastructure development that describes the full environmental impacts of constructing and operating a URCF and a repository at the preferred site.

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In multinational, as in national siting processes, a staged approach lasting many years is required. The period required to reach a preferred site and begin underground work is likely to be around 15-20 years

Model repository siting programme

Activities

Stage 1

Establishing legitimacy of process

- Identify the countries that wish to become the initial partners in the multinational venture.
- National governments nominate, approve or acknowledge those organisations from their country that will be partners in the EDO. They transparently inform their citizens of this decision and its implications.
- The partners together define all other national and international stakeholders and their roles in the process.
- The partners define the methodology and strategy for the initial stages of implementation, up to the point of producing a comprehensive project plan in stage 4.

Stage 2

Establishment and operation of the initial waste management implementation body – the EDO. This includes defining and setting up its structure, functions, staffing, budget, quality management system and interactions with other organisations.

Stage 3

This stage would involve a period of consultation with all key stakeholders. This will lead to adaptation of the strategy and approach suggested here, to meet stakeholder requirements.

The EDO clarifies with national governments and the European Commission or Parliament the following:

- Approach to identification of host country and site.
- Volunteering mechanism and structure.
- A framework for national and community benefit schemes.
- Community involvement framework.
- Public communications programme.

The EDO collaborates closely with national governments to ensure understandable, comprehensive information is available to communities and that mechanisms for community interactions are developed and implemented. The EDO then commences the voluntary siting process.

The EDO will also need to establish, in parallel to this siting programme and integrated with it:

- Legal and financial capabilities and studies.
- A regularly maintained combined waste inventory based on national inventories.
- Repository concepts and repository design programme.
- A design programme for interim storage facility.
- A performance and safety assessment modelling capability.
- An environmental assessment capability.
- A continuing programme for managing its stakeholder interactions.

This stage is likely to require the development and submission of a strategic environmental assessment for a regional repository, at a non-site-specific level.

Stage 4

Definition of siting factors, which would include:

- Exclusion criteria, taking both technical and non-technical aspects into consideration to allow removal of clearly unsuitable regions from consideration as volunteers.
- Technical acceptability requirements for repository sites, related to safety performance and the feasibility of constructing and operating a repository. These will include both quantitative and qualitative requirements of the site.
- Preference factors that are not essential but which enhance practicality, operability, economic or societal benefits. Many of these could be community-specific and the input of volunteer communities to extending and refining the factors is included in stage 7.

The EDO and national experts together collection and integrate national information databases to allow technically unsuitable regions to be identified and guidelines for essential and preferred properties of suitable sites to be established.

Definition of the overall project plan, including the fundamental legal and financial structures and benefits.

Key decisions

Decisions on the framework, strategy and funding.

Overall agreement among key stakeholders to proceed with an approved strategy.

EDO responsibilities, staffing, budget, interactions and quality system.

Agreement on these issues.

Publication of the siting strategy and guidelines.

Establishment of 1- and 5-year rolling plans in the work areas identified.

Agreement on exclusion criteria for unsuitable areas and acceptability requirements for suitable sites.

Activities

Stage 5

Identification of broad, non-excluded siting regions within the partner countries from the databases developed in stage 4. It is likely that land areas within all partner countries would be included in this stage, without prejudice to final siting, which will require national and community assent.

This stage can be accomplished largely using available data sources (collected in stage 4), which will include past and current national siting study databases.

Stage 6

Explicit calls for potentially interested communities in the non-excluded areas to come forward and enter discussions. This initial step in volunteering would not require a non-retractable commitment but rather a willingness to participate in the process.

Stage 7

National scale discussions with government representatives of potential host countries. Formation of country-specific teams for local-scale (*ie* community) discussions with stakeholder groups involving community councils, representatives and landowners in potentially interested areas.

Review and possible revision of technical and non-technical siting factors and of benefits packages, based on direct interactions with local community representatives.

Initial evaluations of suitability of interested communities, based upon assessment and interpretation of all available data. The project needs to clearly identify those communities that may have little chance of proving technically suitable after further investigation.

Update the project plan to define the specific impacts on a country and community of repository hosting.

Stage 8

Definition of a shortlist of potentially suitable sites for investigation. Presentation of this in a selection report to the EDO board, governments of potential host countries, regulators of these countries.

The main objective of the EDO's and national governments' reviews at this stage would be to confirm that the process of selection has been legitimate and has followed the approach established in stage 1. The regulators, on the other hand, would be expected to confirm that the chosen sites showed sufficient promise with respect to their technical properties to proceed to field investigation.

Decision by partner governments, possibly based on national preliminary discussions with potential host communities, on whether and with which provisos they would come forward as potential host countries if the subsequent process of comparing potential sites favours a location in their country. This is obviously a critical decision point for the programme.

Completion of outline site characterisation plans for work in the potential sites, which may have widely differing characteristics (host rock, topography, access, etc).

Stage 9

Formation of site characterisation teams with strong liaison to specific host countries and communities. Preliminary field investigations at each potential site, involving surface geophysical, geological and ecological surveys, and some drilling to explore the deep rock environment.

There is a balance between the time and funding needed for work in stages 9 to 11 and the number of potential sites investigated. Over-commitment to too many potential sites needs to be avoided, whilst still aiming for a low risk of failure to find a good site. In a multinational programme, the goal may actually be to identify more than one final site if regional repository solutions rather than a single shared facility are sought. For simplicity, however, we will assume a single preferred site is the aim. Most national programmes have opted to look at about four sites at this stage and we assume that number as a model here. From this stage on, we assume that investigations proceed in parallel. Sequential investigation is possible, but introduces uncertainty on the length of stages 9 to 11.

Key decisions

Agreement on non-excluded land areas.

Agreements on the level and timing of benefits packages at the national and community levels.

Confirmation of potential siting areas that meet with national and local stakeholder approval.

Identification of potential sites for first priority investigation, and of a reserve list.

Political and public consultation on the proposed choice of candidates.

Government and regulatory approval to proceed with investigations at specific sites.

Activities

Stage 10

Preparation of site descriptive models (integrated descriptions of all site properties as understood at the time), preliminary repository reference designs and performance of evaluations to produce first preliminary safety evaluations documenting comparison of sites with the acceptability requirements and initial groundwater flow and transport calculations.

This stage would involve regular interaction with local communities to share decisions about critical design and operational aspects that would affect the communities, and with the national regulators and their expert advisers to keep them fully informed of progress and allow them to influence the work in terms of its likelihood to produce sufficient information to allow licensing.

Results will be publicly documented and dialogue will be encouraged.

Stage 11

External independent review of site descriptive models and preliminary safety evaluations and regulatory review of progress.

This stage will need to consider the waste inventory for disposal and it is suggested that a decision on the acceptability of co-location of interim storage and encapsulation facilities should be taken in stage 12.

Stage 12

Multi-attribute analysis, with comprehensive stakeholder involvement, using the preferred factors (technical and non-technical) to prioritise preferred sites from the potential sites for the repository and other facilities.

Typically, it would be expected that a minimum of two sites entered the detailed investigation phase, to minimise risk, to provide a comparison and to ensure that a reserve or alternative option remains open. It will thus be necessary, once again, to consider whether to adopt a parallel or sequential approach. If there is strong stakeholder requirement for the option to compare sites, then the parallel approach is most appropriate. It is also appropriate for minimising time schedule risks and we assume that this approach is used for stage 13.

At this stage, practical considerations on the location of interim waste storage facilities and encapsulation plants will feature strongly in the multi-attribute analysis.

Stage 13

Detailed site investigations of selected sites, involving further surface-based investigations aimed at narrowing in to a volume of rock for the repository and producing improved site descriptive models, initial repository designs and comprehensive safety assessment reports based upon these, showing the long-term performance of the specific designs at each of the sites.

The EDO would maintain the option to break off work at a site if it became clear that it would be difficult to meet design or safety case requirements. However, unless there are clear indications of this nature, it is recommended to complete work on two or more sites, so as to allow an open comparison of options in stage 14.

Again, it is important to note that the exact style of investigations will be site-dependent and will need to take account of the most appropriate technologies that will be available at the time.

Stage 14

Selection of preferred site or sites

Selection of preferred site, based on multi-attribute analyses involving all relevant stakeholders. Local community relations and national attitudes play a strong role, together with safety, technical and economic factors.

Key decisions

Definition of those potential sites that pass 'acceptability requirements'.

Dropping of any sites that fail.

Peer-review informed regulatory approval of this stage of the programme.

Identification of sites for detailed investigation.

Decisions on number of sites to be investigated and on parallel versus sequential procedure for the detailed investigation phase.

Location of ancillary waste management facilities.

Activities

Stage 14 (continued)

Preparation and submission of a construction licence application, based upon the milestone documents of stage 13, for the development of an underground rock characterisation facility (URCF) at the preferred site. It is assumed that implementation of an URCF directly precedes implementation of a repository; thus this decision implies that no separate, extended multi-decade interim storage would be implemented. If it had been decided that interim storage should be deep underground, then a URCF could also be required immediately.

Preparation and submission of a licence application to construct an interim storage facility at the chosen site. The nature and size of the inventory will depend upon storage available at other locations, such as reactor sites.

Environmental impact assessments

At this stage it will also be necessary to produce site specific environmental impact assessments documenting the full environmental impacts of constructing and operating a URCF and a repository and an interim storage facility at the site.

Stage 15

Regulatory review with respect to:

- Acceptability of the site for a repository (if confirmed by further underground characterisation work) and hence approval (if requested) of construction of a URCF.
- Or approval to 'hold' the site as acceptable for a repository (if confirmed by further underground characterisation work in the future).
- And approval to construct an interim storage facility.

Consultation of the local and national publics of the potential hosts to confirm acceptance of the facilities (if technical suitability continues to be confirmed by national regulators).

It is likely that all stakeholders will agree that this stage represents the 'point of commitment' beyond which it would not be possible to withdraw from the project.

Stage 16

Construction of interim storage facility and submission and regulatory review of operating licence application.

If decided to proceed with the repository, construction and operation of URCF that would later form part of the access works for the repository.

The work will lead to the production of a repository design description and repository safety case to be documented in a final safety assessment report for repository construction licensing.

Stage 17

Submission of repository construction and operation licence application.

Stage 18

Regulatory review.

Stage 19

Start of parallel construction and operation.

Stage 20

First emplacement of waste.

Key decisions

This is the first milestone at which a dedicated repository organisation domiciled in the potential host country could be established – possibly with direct participation of the national government and/or the local community.

Whether to move ahead with repository construction, or 'hold' the preferred site and apply only for approval to construct a storage facility, and, if so, what type of store to build.

Technical approval of the preferred site for construction of URCF. Technical approval of construction of interim storage facility.

Political and public assent to hosting the facilities.

Approval of operating licence for interim storage facility.

Approval to construct and operate the repository.