INTEGRATED PLANNING FOR NUCLEAR SITING - THE SOUTH AFRICAN EXPERIENCE

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SUMMARY

This paper describes the process involved in the current national programme to identify potential sites for nuclear power development in South Africa. A description is given of the sensitivity studies - the evaluation of the potential perturbations to and opportunities for the biophysical and socio-economic environments and the suitability studies - the evaluation of environmental influences on geotechnical, safety and financial considerations. This programme is divorced from any decision of whether or not to build further nuclear power station in South Africa. The programme described is a long-range land-use planning exercise considered expedient in the face of competition for land that share similar requirements as those of nuclear power station sites. It is also designed to streamline nuclear power station lead times and to make national and regional planners aware of Eskom's requirements in the drafting of their policies and plans.

INTRODUCTION

Integrated planning for nuclear siting is a complex managerial task. It calls for the integration of environmental criteria alonside geotechnical, engineering, financial, legal and public safety issues. This holistic approach to siting is a relatively new departure in facility siting that formerly paid only limited attention to considerations other than engineering variables and investment decisions.[1] (Locational decisions have to satisfy not only technical criteria but also environmental and safety constraints - a balanced judgement is needed.[1] Integrated planning calls for the incorporation of a diverse array of stakeholer's interests. These must include such groups as landowners, local authorities, public regulatory authorities and other vested interest groups. The esoteric nature of nuclear power has tended to preclude such participants in nuclear site planning in the past. The whole process must be understandable since far more than the power industries interest are at stake.

This integrated approach is consistant with Eskom's Environmental Impact Management Directive, (EV1011 of 1988)[2] which has the stated objective of "the assessment, management and control of the impacts of Eskom's activities on the total environment ... ". In addition this directive, inter alia, requires the performance of Environmental Impact Assessments (EIA'S) that systematically examine the consequences of Eskom's activities on the built and natural environment and evaluates the implications of alternative courses of action before an implementation decision is made. This process aims to reconcile the diverse interests of internal and external stake-holders.

Without this genuine open, participative (within the bounds of commercial expediency) and thoroughly comprehensive process in which various, often conflicting, variables are weighed and reconsiled costly time delays can be expected during the siting process. This is however, by no means an easy exercise because of the difficulty of evaluating the various components of subjective and more objective opinions and judgements.

The process entered into by Eskom goes beyond identifying simply "feasible" or "viable" sites but rather sites that exhibit an imbalance between minimal environmental sensitivity and maximal engineering suitability. This is not a narrowly defined engineering task but one that seeks optimal trade-offs between the often conflicting objectives of environment, technology and finance.

THE SOUTH AFRICAN EXPERIENCE

In 1982 Eskom embarked on a ten year multi-disciplinary, land-use planning exercise to identify potential nuclear power station sites (a pool of sites) that exhibit an optimum balance between technical and financial suitability and sites where social and environmental impacts are considered to be relatively easily managable. At the outset it must be appreciated that the decision sought was one concerning the purchase of potential sites for nuclear power station siting and as such is independent of a decision of whether or not to build further nuclear power stations in South Africa.

This programmes was considered expedient for three major reasons. Firstly, the likelihood that nuclear power station sites would become increasingly important into the 21st century when alternatives to coal fired plant would have to be

sought. Secondly, because the land use pressures (both for development and conservation) on the land resources, particular the coastline, of South Africa are escalating and continuously reducing the options available to Eskom. Thirdly, Nuclear plants have stringent siting requirements which require detailed time consuming evaluative lead times. It is therefore considered important to maintain flexibility by identifying potential sites, well ahead of a requirement decision so that Eskom's interests can be incorporated into the land-use plans of governmental agencies and measures are taken to ensure that the sites remain acceptable.

A policy of openness has been central to this exercise. To reinforce this philosophy the regional and sites specific environmental studies have been contracted out to locally based universities and consultants with explicit requirements that they incorporate the maximum local expertise and stakeholder participation in their evaluative work including those without formal channels of representation. Eskom has to date utilised the expertise of the universities of Port Elizabeth and Rhodes for the Eastern Cape studies, the University of Natal for the Natal region and the Universities of Cape Town and Stellenbosch for the Southern Cape region and current studies in the West coast region. The diverse array of methodologies and reporting format has, however, presented difficulties in inter-regional and site comparisons at a broader, national level.

To ensure an on-going and impartial peer review process a review group was established comprising expert environmental planners from each of the Council for the Environment, the University of the Witwatersrand and the Division of Estuarine, Marine and Atmospheric Sciences and Technology of the CSIR.

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Given the dynamics of land-use, technological change, public perceptions etc a flexible and creative character has been built into the planning process. This enabled continual evaluation of earlier criteria and decisions and restricted premature foreclosure as new information emerges and effectively precludes the classification of, all but the most obvious, exclusions.

PROCESS

A systematic, structured planning process has been developed. This progresses through four broad stages - national, *regional, area and site(s).* The level of investigation increasing in rigour and detail as it progresses through these stages, ie reconnaissance detail at the national level, to extremely detailed at the site specific level.

In contrast to coal fired and hydro power stations, nuclear power stations are relatively 'foot loose' with regard to fuel source. Nuclear stations have the inherent advantage that the cost per unit of electricity is broadly the same irrespective of where the station is located. Whilst due regard has to be given to access to the national transmission grid (and implications of this to reliability of supply and transmission economics) the existence of this bulk transmission system ensures that there is no overriding need to locate near to the source of fuel.

On the other hand certain criteria exercise a locational influence. The scarcity of an abundant supply of water in the interior of South Africa and its erratic availability dictate that it is preferable to locate a direct cooled nuclear power

plant within the coastal zone, where abundant and reliable cooling water exists. Cooling water demands are estimated to be 40 cubic metres per second for a 1000 MW reactor.[3]

The South African siting exercise is a national investigation in contrast to the more 'ad hoc' and piecemeal nuclear siting exercises that are commonly carried out elsewhere in the world.[1]

The initial level of information gathering involved in the investigation, was limited to broad-brush reconnaissance, general consultations and literature reviews. The major "decision criteria" comprised availability of water (cooling and potable), political boundaries, high population densities (urban and rural), high seismic risk, geological formations and conditions, areas with conservation status or value (eg national parks, estuaries, etc), proximity to hazardous land usage, poor warm water diffusion and mixing characteristics, etc. It should be noted that, with some obvious exceptions, few of the criteria are absolute constraints. They can be altered at costs measured in economic or environmental terms.

By using the 'McHarg overlay' technique a composite map was derived, screening out unacceptable regions and indicating regions for investigation at a more detailed regional planning level. In order to develop a priority programme from the nineteen candidate regions identified in this way, the nominal group decision-making technique was used. During this process two candidate regions (De Hoop and Ystervarkpunt) were lost due to their acquisition by developers with similar siting criteria, thus demonstrating the pressing competition for such remote areas that exists.

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The first regions investigated were Alexandria and Oyster Bay, east and west of Port Elizabeth respectively. These have been followed by Northern Natal, Southern Cape (east of Gansbaai) and current investigations are taking place in the North-Western Cape Coast.

The outcome of these studies are that the total search areas of Alexandria and Northern Natal have been removed from consideration and large parts of the Southern and Western Cape regions have been dismissed from further detailed study. Viable sites have been investigated in the remaining areas and after comparative studies of the merits and implications of various candidate sites three potential nuclear power station sites have been identified. Negotiations are underway for the purchase of two adjacent sites in the Eastern Cape (Tony's Bay and Thyspunt) and one in the Southern Cape (Bantamsklip). Further viable sites (technically and environmentally) in both the Eastern and Southern Cape have been dropped from consideration because of the social sensitivities which existed.

Once the purchase of (or options on) these sites is complete, a long-term monitoring, management, community liaison and information update programme will be initiated, again making use of local expertise where it exists.

At periodic points during these investigations the affected interest groups have been advised of the status of investigations and their views sought. This on-going participative approach is in marked contrast to earlier approaches of 'decide-announce-defend' that have been used elsewhere. On-going participation will not overcome opposition to nuclear power developments, or the "NIMBY" (not in my backyard), or

"LULU" (locally unwanted land uses) scenarios.[4] It will however, reduce unwarranted fears, dispel rumours or misunderstanding and make integratory programmes easier to design. Equally it will educate and sensitise local people to appreciate national needs, ultimately enhancing the prospects of public acceptability and trust. The incorporation of local knowledge and expertise clearly resulted in more informed decision-making and acceptance of the outcomes.

PROJECT SPECIFICATIONS

One problem that exists with long-range land use planning, is that decisions have to rely on assumptions and uncertain circumstances to a greater degree than shorter range planning. This has been the case in trying to anticipate the detailed nature of the design, technology and requirements of a nuclear power plant that will be employed in the 21st century in order that potential perturbations can be understood. To facilitate this evaluation, a hypothetical project description was prepared and distributed to the environmental scientists engaged in impact prediction in the environmental evaluation study.[3]

This situation presents an opportunity as well as a constraint. It enables environmental factors that were identified in the evaluation stage, to influence ultimate design and layout options. For example, rather than being constrained to an evaluation of a predetermined inlet/outfall cooling water system, the evaluating team could consider the 'pro's and con's' of the widest range of cooling system options.

The evaluation of the different combinations of environmental effects at each candidate site is no easy exercise. Some

potential impacts can be reasonably accurately predicted (eg impacts of thermal pollution). The focus is essentially on informed judgement that strives for a balance between economic, technological and environmental consequences. This makes the incorporation of diverse experts from a wide range of disciplines all the more important.

SCOPING

In the early days of environmental impact appraisal (EIA) it was considered an inevitable requirement to amass data on every conceivable facet of the potentially affected environment. This resulted in the production of volumnious environmental reports to ensure that no part of the environment was overlooked. It soon, however, became obvious that this exercise was financially burdensome, time consuming and indeed unnecessary.

The cost-effective, streamlining of "EIA'S" has been achieved by the procedure (which has proved of immense value to Eskom's nuclear siting exercise) known as 'scoping'. Scoping was developed in the USA during the latter 1970's.[5] It is a simple, early and open process which involves the public, the authorities and experts in a joint fact finding exercise to determine the issues to be addressed (the scope). Furthermore it facilitates the identification of the significant issues related to a proposed action, that will require detailed study in the environmental evaluation. In this way issues that are not considered significant, or have been covered by prior review, are eliminated from detailed study. Issues of limited importance are merely stated in the report(s) with reasons as to why they are not considered significant.

Through early scoping meetings, the task were streamlined to a consideration of those issues which were pertinent, thereby overcoming the frequent criticism of the EIA process of producing irrelevant baseline environmental characteristics.

SENSITIVITY AND SUITABILITY

A distinction, by no means absolete, has been adopted to facilitate division of labour in the siting exercise. Two broad categories of responsibility have been developed; sensitivity and suitability.

Sensitivity studies take as their point of departure those environmental aspects that may potentially be perturbed by the purchase, construction, operation and decommissioning of a nuclear power station. These include such aspects as the terrestrial, freshwater and marine environments and the social and economic characteristics of the area of study. Suitability studies have as their central focus those aspects of the environment that will potentially impact the construction and operational considerations (including financial implications) of a proposed nuclear power station. The relative degree of overall attractiveness of an area and site is in this way established.

SENSITIVITY ISSUES

Siting of nuclear facilities must be more than a variable that influences the economics of operation and construction.[1] It must ensure avoidance of negative impacts on significant environmental resources and socio-economic disruption. There can be few more complex concepts than 'environment'. It is a multi-dimensional inter-connection of systems - biological,

physical, social, cultural and economic - in time and space. As such it calls for an holistic approach that promotes inter-disciplinary planning. The differing methodologies of the disciplines involved, ensure that environmental planning is an uneasy blend of art (value-judgements) and science, many aspects of which are not amenable to ready quantification.

The broad methodology involved is to initially characterise the environment in question and to hypothetically superimpose the proposed development. From this exercise an indication of the likely potential perturbations can be identified and their significance indicated by experts and stakeholders in the field(s) concerned. Joint discussions then determine if these impacts are acceptable, or can be adequately managed, or whether they are of such significance that they preclude further consideration of a region, area or site.

Brevity precludes detailed consideration of the various environmental investigations. This information is available in the documentation prepared in the siting studies.[6][7][8][9]

The nature and scope of environmental studies, however, included a consideration of the total environment (bio-physical, social, cultural and economic) and potential impacts (positive and negative) on these components. By way of example these studies have included consideration of the potential effects (direct and indirect) of the purchase, construction, operation and eventual decommissioning of a nuclear plant on important terrestrial and marine species and habitats. This indicates the uniqueness of habitats and ecosystems within the study area, their existing or potential productivity, the consequences of their potential disruption

or destruction and their vulnerability to potential perturbations.

In similar vein the resilience of existing or planned human activities have been assessed in the light of the potential influx of construction and operations personnel. Particular emphasis is placed on the compatability, or otherwise, of existing or planned economic activities in the region or study area. Indications are given of the potential affects of nuclear power development on local labour supply, social infrastructure, cultural (and archaeological) resources, recreational areas, etc.

SUITABILITY ISSUES

The investigations that are required to be carried out to determine the suitability of a particular site, or group of sites, for future nuclear power stations, concentrate on evaluating the physical characteristics of the potential site and its environment and their potential implications on the plant. For this purpose a multi-disciplinary approach by various technical sciences is required.

The major issue in nuclear siting concerns the assessment of the impact of near-field natural or man-induced hazards on the safety of the nuclear power station. The natural hazards include earthquakes, winds and flooding from inland and marine sources, etc. These are all categorised as low probability - high consequence natural events, over which man has no control both in magnitude or time of occurrence. Man-induced hazards include aircraft craches, shipping (with associated oil spills), sabotage and nearby industrial explosions, all of which may adversely affect the safe operation of a nuclear

power station. Most of these can be defined with a reasonable degree of certainty, which dictates appropriate design specifications to minimise their impact.

Earthquakes potentially have the highest probability of causing catastrophic damage to a nuclear station. Therefore the geological, seismic and engineering characteristics of a site and their impacts on their environs must be investigated in appropriate scope and detail to provide adequate assurance that they are sufficiently well understood. This is done to provide an acceptable evaluation of the candidate site, such that engineering solutions can be found for potential geological and seismic effects.

The geotechnical investigations are also carried out in two phases.[10] The first being a regional geological survey, conducted both on-land and under the sea, of a particular portion of the coast line, which extends up to 30 kms inland and about the same distance out to sea.

The geological mapping consists of a structural analysis which is augmented by aerial magnetic surveys, ground geophysics, seismic analysis, satellite imagery, geomorphology, geo-hydrology, marine surveying and drilling. All the data produced from the above surveys are combined into a comprehensive geological map at a scale of about 1:100 000 which defines the regional tectonic frame-work within which the potential sites are located.

In particular, the localities of all the faults and where possible their characteristics are determined in order to make an assessment of their relative ages, ie., the geological period within which the last and earlier movements took place.

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This analysis is done to identify potentially hazardous "capable faults" on which there has been movement, at or near the ground surface, at least once within the past 35 000 years or movements of a recurring nature within the past 500 000 years.

It is important to note that the safety of a nuclear power station is influenced by the land and marine geology, the latter being difficult to map. The use of aerial magnetic data has proven to be invaluable in the interpretation of both the offshore geology and on-shore formations covered with young deposits. Using this data potential sites, between 2 - 3 km in length, are identified on which the second phase of detailed geotechnical studies are undertaken.

Coastal areas are often covered by a layer of sand or calcarenite having a thickness of between 1 and 100 m with the only outcrop being along the beach front. The detailed investigations commence with structural mapping of the outcrop at a scale of 1:1 000 which is supplemented by diamond drilling. In addition, geohydrological surveys are carried out to determine the ground water regime and chemistry as well as the engineering qualities of the base and overlaying formations. These studies also provide information related to the adequacy of construction materials.

Candidate sites that proceed through the regional screening phase, are subjected to an engineering economic study, to assess whether there are any severe cost penalties that whould preclude the use of a site. These studies include design aspects of the foundations, particularly for earthquake requirements, marine cooling systems, terrace construction based on topography and bedrock elevations, physical

infrastructure such as access roads, potable water for domestic and construction use, links to the electrical transmission systems, nuclear fuel and waste transportaion systems and general security.

As with the sensitivity investigations the suitability studies initially commenced in the Eastern Cape candidate regions. The studies concluded that there were no suitable sites around Alexandria. These findings concurred with the opinions expressed by the sensitivity team. From the suitability point of view the rock formations of Alexandria were found to be composed of deep semi- to un-consolidated beds which form the Algoa Bay coast line. The beds were unsuitable for the founding of a nuclear power station, particularly when considering the requirements for earthquake design criteria. Three technically suitable sites were identified in the Oyster Bay area. Two are adjacent and are in the process of being purchased.

The next regions investigated, were along the Southern Cape and Northern Natal coastlines. In the Southern Cape, between Arniston and Gansbaai, the geology was found to be extremely complex due to the intensive folding of the bedrock which occurred during the formation of the Cape Fold Mountains and subsequent faulting that occurred later during the split up of Gondwanaland. The ages of the various faults were determined by a detailed study of the geology and geomorphology. It was possible to identify which faults are considered to be important for the safety analysis of the power station and which faults were of such an age that they are considered to be inactive. Two technically suitable sites were identified in the Southern Cape.

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Similar studies were done in the Northern Natal study area which stretched from Port Durnford in the north to Salt Rock in the south. Although the Natal coast was found to be relatively free of significant folding, the presence of major potentially active faults along the coast line, were identified. One technically suitable site was found on the Natal North Coast.

In conjuction with the sensitivity studies, the outcome of these investigations indicated that one site in the Southern Cape area were suitable for the siting of nuclear power stations, while no suitable site was found in the Northern Natal area. One of the technically suitable sites in the Southern Cape was relinquished due to social sensitivity. Suitability investigations are continuing alongside sensitivity studies in the West coast candidate region.

DEMOGRAPHIC AND PSYCHO-SOCIAL

The locational component is a variable that determines the consequences of any reactor accident (however improbable this may be). It is true that engineering safety measures, theoretically at least, provide a dimension to nuclear power station siting. Yet it is generally accepted that the additional cost of 'more remote' siting, is an agreeable premium to pay against incidents and allow for easier emergency preparedness programmes.

Given the assumption that nuclear safety is an inverse function of distance (time and space) from nuclear power plant(s), demographic criteria have been laid down by the Council for Nuclear Safety. In essence the current criteria constitute an exclusion of resident population within 1,5 kms

of a reactor, less than 2 000 in a 30° sector 5 kms out, less than 10 000 in a 30° sector 16 km out and the total population not to exceed 2 million within a 50 km radius of a reactor.[3]

Psycho-social studies have been carried out at each of the areas under investigation. The principal concern of these studies is to ensure that the national interests of nuclear power development, are not arbitrarily imposed on what may be interpreted as more 'parochial' interests. These latter local interests must be evaluated and understood and integrated into the siting process just as the national interests must be explained to, and understood by, local communities. The resilience of local communities, their needs and aspirations have been given particular attention throughout the siting exercise.[9] The level of detail of these studies exceeds that generally carried out elsewhere in the world.[10]

CONCLUSION

In South Africa "EIA's" are not mandatory. The Environment conservation Act (Act 100 of 1989) enables the Minister for Environment Affairs to call for an 'EIA' to be carried out if he deems it necessary, One can therefore reliably anticipate that the siting of a nuclear power station will be subjected to this requirement. Nonetheless this places the initiative and the onus on the developer to adopt a high level of self regulation commensurate with the highest standards of site selection exhibited elsewhere. Eskom has reviewed these standards and is convinced that it does indeed rank amongst the world leaders in all aspects of the process of site selection [1][12][13][14][15], adheres to the guidelines prescribed by the Council for the Environment[16], as well as the

stringent licensing requirements of the Council for Nuclear Safety.

Rushed siting decisions will have far reaching, often irreversible and maybe even catastrophic outcomes. The investment in a structured, systematic siting process is therefore not only prudent but essential. Without a clearly defined and structured siting process, acceptable options may be overlooked. Non-nationwide analysis will be unable to demonstrate, with any degree of confidence, that the options chosen, are indeed the most acceptable of all the options available, they will simply be the preferred sites from a limited range of options considered.

The culmination of a thorough siting exercise will be the availability of acceptable sites that can be developed to secure future supplies of electricity to customers. A 'best site' is an unattainable goal because of the divergent views of the different disciplines of what constitutes 'best'. Some acceptable sites, however, are realistically available. These sites will minimize costs, meet all licensing and legislative requirements and be technically feasible. Equally they will be broadly acceptable to the local community, be capable of operation within the desired safety margins as well as within levels of tolerable environmental impact and minimal conflict.

Given the comprehensiveness of the criteria employed in the current investigations, it is becoming apparent that South Africa has limited acceptable nuclear power station sites. Special measures have therefore been instituted to ensure their viability untill such time as they are used. These measures include the monitoring of environmental variables, which would lead to a better understanding of the natural

processes in the area, the creation of secondary opportunities eg aquaculture, desalination, etc and statutory measures on a regional and national level to ensure that surrounding land-use (both current and future) do not render the sites unuseable.

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