An Overview of Site Survey, Site Selection and Site Evaluation for Nuclear Power Plants

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Background

1.2 This Safety Guide supersedes IAEA Safety Guide 50-SG-S9 Site Survey for Nuclear Power Plants [1] which was issued in 1984 as part of the Nuclear Safety Series (NUSS). It also takes account of the Safety Requirements on Site Evaluation for Nuclear Installations NS-R-3 [2] especially in relation to exclusion criteria for the site selection of nuclear power plants.
Scope

1.4 This Safety Guide explicitly addresses only the safety aspects of site selection for nuclear power plants. It is recognized and acknowledged that there are other aspects that play a very important role in a site survey, such as technology, economics, non-radiological environmental impact, public opinion, etc. These aspects are addressed in a document under preparation by the Department of Nuclear Energy which is being developed in coordination with the present safety guide.
1.5 Based on a graded approach, safety aspects related to the site survey process may vary with time. As the process progresses to screen out more and more sites (and therefore retain only a few sites), the importance of safety aspects become more pronounced. The data collected and the methods used for these few sites need to be treated with similar care and scrutiny as for the finally selected site because for this site (i.e. the preferred candidate site), these data are eventually used in the licensing process of the installation.
Stages of Site Related Activities

- **SITE SURVEY STAGE:** Identification of potential regions, potential sites and candidate sites through screening and comparison.
- **SITE SELECTION STAGE:** Evaluation aiming at selecting the final site through the ranking of candidate sites.
- **SITE ASSESSMENT STAGE:** Confirmation of acceptability and complete site characterization; Derivation of site related design basis.
- **PRE-OPERATIONAL STAGE:** Confirmatory and monitoring work.
- **OPERATIONAL STAGE:** Confirmatory, monitoring and re-evaluation as per Periodic Safety Reviews.
Decision Steps

• Decision regarding the ‘acceptability’ of the preferred candidate site, i.e. confirmation that the site has no characteristics that would preclude the safe operation of a nuclear installation.

• Decision related design basis parameters based on the Site Evaluation Report.

• The approval of the PSAR which, inter alia, demonstrates that the site related design basis parameters have been appropriately accounted for through conservative design, site protection measures or administrative means.
Site Selection Process

- Region of Interest
- Regional Analysis
- Potential Sites
- Screening
- Candidate Sites
- Comparison and Ranking
- Preferred Candidate Sites
Safety Related Screening Criteria

• 3.5 Where reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation, an alternative site shall be considered.

• 3.6 If the evaluation shows that there is a potential for collapse, subsidence or uplift of the surface that could affect the safety of the nuclear installation, practicable engineering solutions shall be provided or otherwise the site shall be deemed unsuitable.
• 3.7 If the potential for soil liquefaction is found to be unacceptable, the site shall be deemed unsuitable unless practicable engineering solutions are demonstrated to be available.

• 3.8 The hazards associated with an airplane crash to be considered shall include impact, fire and explosions. If the assessment indicates that the hazards are unacceptable and if no practicable solutions are available, then the site shall be deemed unsuitable. The airplane crash event mentioned here is considered to be of accidental origin.
Safety Related Screening Criteria (Cont’d)

- 3.9 Hazards associated with chemical explosions shall be expressed in terms of overpressure and toxicity (if applicable), with account taken of the effect of distance. A site shall be considered unsuitable if such activities take place in its vicinity and there are no practical solutions available.

- 3.10 The region shall be investigated for installations (including installations within the site boundary) in which flammable, explosive, asphyxiating, toxic, corrosive or radioactive materials are stored, processed, transported and otherwise dealt with that, if released under normal or accident conditions, could jeopardize the safety of the installation. If the effects of such phenomena and occurrences would produce an unacceptable hazard and if no practicable solution is available, the site shall be deemed unsuitable.
• 3.11 Potential natural and human induced events that could cause a loss of function of systems required for the long term removal of heat from the core shall be identified, such as the blockage or diversion of a river, the depletion of a reservoir, an excessive amount of marine organisms, the blockage of a reservoir or cooling tower by freezing or the formation of ice, ship collisions, oil spills and fires. If the hazards for the nuclear installation are unacceptable and no practicable solution is available, the site shall be deemed unsuitable.
3.12 Exclusion criteria that are used in screening out potential or candidate sites, are generally related not only to weaknesses related to site conditions but also the feasibility of engineering solutions to compensate for these weaknesses either through design or site protection measures. Therefore, existence of a certain hazard or even the high likelihood of its occurrence should not constitute the sole basis upon which an exclusion criterion is based. Screening out based on an arbitrary safety criterion may discard a site having otherwise positive safety qualities and finally result in the choice of a site that may be less ‘safe’ than the one that has been discarded.
One example of exclusion criteria that has been used (and or proposed) by some regulators involves earthquake intensity, e.g. excluding areas with $I_{MSK} > VII$. There are three major issues with such an exclusion criterion as follows:
Arbitrary Exclusion Criteria (Example)

- The value (e.g. VII or VIII) is arbitrary and not specifically related to safety. It is a conditional criterion – i.e. linked to plant design. Most standard designs envelope intensities such as these. However, if a site is screened out because of this reason and it has otherwise very favorable site properties (e.g. soil conditions, flood protection, good atmospheric dispersion), then this criterion actually may damage nuclear safety.
Arbitrary Exclusion Criteria (Example)

• If this criterion is used because in a country it is thought that the value will never be exceeded, then the criterion is not really needed. It may, however, give the wrong message regarding NPPs located in such areas in the world (i.e. they are located in what the particular regulator considers to be exclusionary areas and therefore unsafe). This is clearly not in the spirit of the global nuclear safety regime.
Arbitrary Exclusion Criteria (Example)

- The context in which the value ($I_{\text{MSK}}$) can be used is unclear. It makes a big difference if this is meant to be an observed value or the result of a hazard evaluation. In other words, its enforcement will be very problematic and lead to controversy.
5.44 As an initial assessment, a simplified screening criterion is recommended. Using publically available information, evidence of past tsunami occurrence should be reviewed for the site region. For such purpose, the collected information should be organised and a specific list of tsunamis relevant to the site should be prepared. If the site is located in an area which shows no evidence of past tsunami occurrence and:

• is located at more than 10 km from the coastal shoreline, or at more than 1 km from a lake or a fjord shoreline, or
• at more than 50 m elevation from the water level,

no specific further investigations and studies need to be performed to analyse the tsunami hazard in the site.

5.45 In all cases, the safety required volume of cooling water should be secured in case of a tsunami occurrence, because of the potential for low water level to impact the intake water system for several hours.
3.13 For safety related issues comparison within topics is generally quite straightforward. For example, sites with relatively higher seismic hazard would be penalized in comparison with those in more stable areas. What is more difficult is comparison across topics, in other words comparing a site with higher seismic hazard but lower flood hazard with another site having the opposite characteristics. There are various ways of dealing with this type of situation where weights may be assigned to different topics that contribute to the process.
• 3.15 If there are an unreasonably large number of sites to be compared, then a screening process may be used first whereby some preference (not exclusion) criteria are introduced to decrease the number of potential sites to a manageable number. This is an iterative process because if at the end of the initial preferential screening very few sites are left, then the criteria may be adjusted.
3.17 The candidate sites are ranked in order to identify the preferred candidate site or several preferred candidate sites. Ranking involves cross comparison of sites with respect to all their attributes, both safety related and non-safety related. This may involve weighting of various attributes in a matrix form. It is also possible to quantify the differences of each site with respect to a reference site/plant combination. For many of the attributes it may be possible to use the differential cost (with respect to a reference site/plant combination) as the quantification parameter.
SITE SELECTION AND EVALUATION

Detailed and specific evaluation of the “candidate sites”.

Selection of the site.

For the selected site, detailed and specific investigations and studies result in the:

• demonstration of the acceptability of the site on the basis of established criteria,
• derivation of the site related design bases for the facility.
SITE EVALUATION – Aspects to be considered

• Effects of the region on the plant – i.e. external events occurring in the region, which could be of natural or human induced origin,

• Effects of the plant on the region – i.e. characteristics of the site and its environment which could influence the transfer of released radioactive material to persons and to the environment,

• Population characteristics of the region (i.e. density and distribution and others) in relation to the possibility of implementing emergency measures
SITE SELECTION AND EVALUATION DOCUMENTS

SAFETY + NON-SAFETY

SAFETY

SAFETY GUIDE
DS424 NUCLEAR SAFETY INFRASTRUCTURE
(under development)

SAFETY GUIDE
SG-S9 (To be revised)
Safety Criteria for Site Selection (DS433)

NON-SAFETY

MILESTONES NUCLEAR INFRASTRUCTURE DEVELOPMENT DOCUMENT

MANAGING SITING ACTIVITIES
SITE SELECTION AND EVALUATION DOCUMENTS

SAFETY + NON-SAFETY

1. NS-R-3 Site Requirements
2. NS-G-3.1 Human Induced Hazards
3. NS-G-3.2 Dispersion air and water
4. NS-G-3.3 Seismic Hazards
5. NS-G-3.4 Meteorological Hazards
6. NS-G-3.5 Flooding Hazards
7. NS-G-3.6 Geotechnical Aspects
8. DS-405 Volcanic Hazards
9. SAFETY GUIDE SG-S9 (To be revised)
   Safety Criteria for Site Survey and Selection

MANAGING SITING ACTIVITIES
The progressive implementation of the following Safety Requirements:

- 2.1 to 2.29, 3.1 to 3.55, and 4.1 to 4.15, 6.1 to 6.9 of NS-R-3;
- 3.126 of GSR Part 3 (revision of BSS 115);

necessitates that:

IN PHASE 1:

ACTION 1: The Government should ensure that potential sites are identified and candidate sites are selected on the basis of a set of defined criteria, at a regional scale and using available data.

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A set of criteria needs to be identified from the beginning of Phase 1, related to acceptability and comparison of sites, taking into account safety-related and non safety-related aspects. It is important to properly address both due to the interface between them. This will provide for a smooth development of the site selection and evaluation process during the following phases, with no need for coming back to earlier steps due to the lack of suitable available sites.
ACTION 2: The regulatory body should establish specific safety requirements for site evaluation, including the process for authorizing the selected site, in compliance with applicable IAEA Safety Standards.
ACTION 3: The operating organization should complete the investigations related to the suitability of the candidate sites and select the preferred candidate site for the first NPP, using specific site data, information, studies and assessments conducted with the full temporal and spatial scales of investigations.
ACTION 4: The operating organization should prepare the Site Evaluation Report (SER) and submit it to the regulatory body, based on a full assessment of the selected site and including the confirmation of site acceptability and the characterization of the site for the definition of the site related design basis parameters.
6.1. As a function of the management system, an adequate quality assurance programme shall be established to control the effectiveness of the execution of the site investigations and assessments and engineering activities performed in the different stages of the site selection and site evaluation process.

6.2. The quality assurance programme shall cover the organization, planning, work control, personnel qualification and training, verification and documentation for the activities to ensure that the required quality is achieved.
6.8. When developing the structured approach to grading the application of the Quality Assurance Program, the following could be considered:

(a) The intended end use of the knowledge and data that result from site evaluation activities, in particular, in terms of their consequences for safety;

(b) The capability to demonstrate, test or repeat results;
Management Systems and QA (Cont’d)

- (c) The scale and technical complexity of the site evaluation activity, whether it is a new or proven concept or a model that is being applied or an extension of a new application;
- (d) The managerial complexity of the activity and the involvement and coordination of multiple disciplines, work units or internal or external organizations, with divided or contingent objectives and responsibilities,
- (e) The extent to which other site evaluation work, or later work, depends on the results of the site evaluation activities;
- (f) The expectation for, or the desired use or application of, the results.