Participants' Briefing Handout

DISCUSSION GROUP 2:

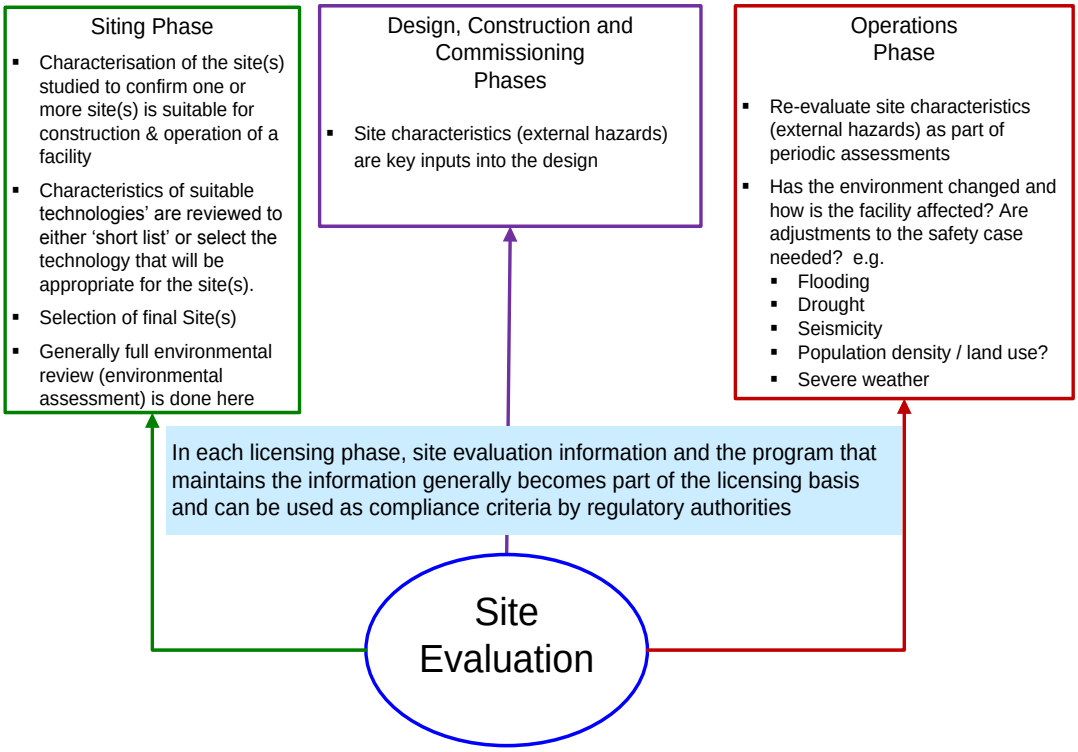
Siting Considerations for SMRs

	Name	Affiliation
Topic Lead:	Marcel de Vos	CNSC – Canada (regulator)
Topic Co-Lead:	Dr. Ferhat Aziz	BATAN – Indonesia (National Nuclear Energy Agency)
Facilitator:	Kamran Qureshi	IAEA
Technical Facilitators:	Sujit Samaddar Yoshi Fukushima	IAEA
Rapporteur:		

1. Background Information for Topic

As discussed in IAEA Safety Requirements Document NS-R-3, *Site Evaluation for Nuclear Installations*, siting considerations and site evaluation are key in establishing and maintaining a strong safety case for a facility over its full life cycle.

Figure 1:
How Site Evaluation Information is Used in the Various Licensing Phases



The public in any member state will have expectations that Small and Medium Sized Reactors[1] (SMRs) will offer a level of safety that equals or even surpasses that found in both existing and new large Nuclear Power Plants (NPPs). These designs will also be expected to address the same siting requirements as their larger cousins, albeit taking into account their smaller size and touted lower risks associated with these designs.

[1] including those designs which are intended to be modular

The December 2012 IAEA INPRO Consultancy on SMR Licensing and Safety Issues recognized that SMRs may challenge traditional siting thinking in some areas. This discussion topic was developed to identify some of the key areas that SMRs will challenge and to frame the discussions at the 2013 INPRO Discussion Forum.

It should be noted that there are, arguably, two very distinct groups of SMRs emerging and these two groups were considered by the December 2012 consultancy:

- **First Group**: Reactor facilities that are simply smaller versions of existing NPP designs. These designs may be constructed in a modular fashion, contain passive features, and even be situated below-grade but are otherwise very similar in operational characteristics to traditional NPPs and are fuelled / refuelled on-site. Some designs may be so-called "Generation IV" designs employing less traditional core cooling concepts such as gas-cooled, liquid metal cooled. Larger marine-based designs (ship or barge) would also fit in this category. Siting Issues for this class of facilities tend to be centered around the following:

    - Because they may be sited in places that would not be considered for NPPs (closer to cities, near industrial complexes, or in extreme remote locations etc) There is a desire for additional flexibility in setting and satisfying emergency planning requirements (i.e. using a risk-informed approach rather than more traditional deterministic means) – this would involve discussions about areas such as how source term calculations influence decision-making for emergency planning zones

    - There are many new countries with small grids who may consider building these facilities over NPPs. These countries in particular would have to address sites lacking in infrastructure. (i.e. How can a site be rendered suitable where basic infrastructure does not exist yet?) In some cases, infrastructure would have to be developed and installed just to do the site evaluation work.

    - Spent fuel management on site at SMR facilities may be of concern to the public. (this issue becomes more dominant the smaller the reactor facility is)

    - For marine-based facilities (ship or barge based). How would NS-R-3 siting requirements and guidance be applied?

- **Second Group**: Reactor facilities that are significantly smaller (approx. 2 to 100 MWe). The reactor module itself would likely be fabricated / assembled, fuelled and sealed at reactor vendor's manufacturing / assembly 'factory'. and shipped to and from a site in its fuelled state. Although a few designs may be more traditional water-cooled designs, the majority are likely to be Generation IV designs employing more novel core-cooling concepts such as gas-cooled, liquid metal cooled. Smaller marine-based designs (ship or

barge) would also fit in this category. These facilities share the above issues but are also challenged by the following:

- Because these reactors are transported fully fuelled, how does the transport route fit into the siting process? How does one examine potential environmental impacts along the route of travel in an objective and scientific manner?
- How will issues around crossing international borders be addressed? (particularly when crossing through a number of countries along the route)

2. List of consolidated issues for this topic

1. Determining source terms for non-water cooled SMRs or novel fuels.
    - Discussion on the impacts of source terms on size of emergency planning zones for SMRs
2. Siting considerations for fuelled transportable reactors (including marine applications)
    - Discuss whether the existing requirements and guidance contained in IAEA NS-R-3 *Site Evaluation for Nuclear Installations* and supporting topical safety guides are sufficient to address this class of reactor facilities?
    - Addressing special emergency planning needs
    - Transportation issues – including crossing jurisdictional boundaries and handling of used fuel
    - Characterising potential environmental impacts during transport
3. Sites in regions lacking in fundamental infrastructure (including extreme remote sites)
    - Addressing emergency planning needs
    - Impacts on security
    - What is the role of design in this case?

3. Brief description of each issue

A. **Issue**: Determining source terms for non-water cooled SMRs or novel fuels
B. Brief description 1) concept and background – source terms for a number of SMR designs will be different from those more traditionally understood to be dominant for existing fleet reactors. There is a need to discuss the how these different source terms are calculated and how they may affect emergency planning issues. (including how they affect zone sizing) 2) specific sub-issues and concerns to be discussed and addressed: Is there a need to update current IAEA information and/or guidance around the calculation of source terms?
C. List of potential experts to be invited on that issue - no background presentations needed for this session - government and utility emergency planning experts with an experience in source term calculation

A. **Issue**: Siting considerations for fuelled transportable reactors and marine-based reactor facilities

B. Brief description

1) concept and background – Discussion around where NS-R-3 addresses / does not address specific siting issues for these particular types of reactor. For issues not addressed, the is a need to discuss how requirements and guidance should be addressed both by the IAEA (in existing or new documents), by Member States or by another more multi-state collaborative means.

2) specific sub-issues and concerns to be discussed and addressed:

- Application of NS-R-3 – where are requirements addressed / not addressed?
- How are external hazards characterised for marine-based facilities?
- Addressing special emergency planning needs during transport to and from site and for marine-based sites
- Transportation issues – including crossing jurisdictional boundaries and handling of used fuel
- Characterising potential environmental impacts during transport

C. List of potential experts to be invited on that issue

- no background presentations needed for this session
- government and utility emergency planning experts
- regulator for vendor countries proposing marine based reactors

D. **Issue**: Sites in regions lacking in fundamental infrastructure (including extreme remote sites)

E. Brief description

1) concept and background – There is potential for SMRs to be sited in countries or regions inside a country where basic infrastructure to support facility operation or emergency planning is insufficient or does not exist (e.g. roads, hospitals, local emergency response capabilities). This is particularly true in very remote regions such as in the far north or in areas of very low population density where a project such as a mine needs to establish stand-alone power infrastructure. There is likely also the need to install infrastructure to perform site evaluation in advance of the site being officially selected.

   Even if SMR designs are made more inherently safe, adequate infrastructure for emergency planning needs to exist from a defence-in-depth perspective to respond to plant emergencies as well as from a public confidence perspective. This area will discuss what additional areas need to be addressed in requirements such as those contained in NS-R-3 to address this issue.

2) specific sub-issues and concerns to be discussed and addressed:

   - Addressing emergency planning needs
   - Impacts on security
   - What is the role of design versus emergency planning? How can additional design reduce the need for extensive emergency planning and security?

F. List of potential experts to be invited on that issue

- no background presentations needed for this session
- government and utility emergency planning experts
- regulators

4. Breakout Session Organization

4.1 Format of Session:

Topic Lead, Co-Lead, IAEA staff member in role as facilitators

If less than 10 attendees: A single discussion group

If more than 10 attendees: Multiple discussion groups of no less than 5 people.

4.2 List of Necessary Session Materials:

- Pens and note-pads for all participants
- Computer and projector (for use by presenters and topic rapporteur)
- Electronic copy of IAEA PowerPoint template, and Topic Report template (for use by rapporteur to produce a topical report and presentation for the Plenary)
- A copy of this planning sheet for all participants
- 1 reference copy of the Terms of Reference of the Dialogue Forum
- 3 reference copies of IAEA NS-R-3 Site Evaluation for Nuclear Installations
- 1 reference copy of each of the following IAEA Specific Safety Guides :
  - NS-G-1.5 *External Events Excluding Earthquakes in the Design of Nuclear Power Plants*
  - NS-G-3.1 *External Human Induced Events in Site Evaluation for Nuclear Power Plants*
  - NS-G-3.2 *Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants*
  - NS-G-3.4 *Meteorological Events in Site Evaluation for Nuclear Power Plants*
  - NS-G-3.5 *Flood Hazard for Nuclear Power Plants on Coastal and River Sites*
  - NS-G-3.6 *Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants*
  - SSG-9 *Seismic Hazards in Site Evaluation for Nuclear Installations Specific Safety Guide*
  - SSG-21 *Volcanic Hazards in Site Evaluation for Nuclear Installations*

4.3 Discussion Process Outline

Presentation 1 by Lead – 15 minutes - Brief overview of how the discussions are to proceed.

Presentation 2 by IAEA technical facilitator knowledgeable in Siting Issues – 30 min - Cover existing IAEA site evaluation information and changes in progress as a result of Fukushima.

Confirm with attendees whether there are additional issues over and above those listed in this document that:

- should be discussed in this forum
- are noteworthy to point out to the IAEA for future discussion at a later date

Break into working groups and appoint a leader for each group to guide work and record results of discussions.

- Go through each of the three issues listed in the document as well as 'extras' agreed upon by the topic attendees and assign a specific block of time to be allotted to each over the next 3 days to ensure they are all covered.
- For multiple discussion groups – the groups should consider dividing the case studies up among each other such that all 3 case studies are addressed in the discussions.
- Discuss each issue and record observations, findings and possible paths forward to address finding. The results of discussions of each issue should reflect primarily the views of technology users and regulators but be well-informed by the views of other valuable attendees (vendors, industry groups, regulator forums)
    - The primary focus of the discussions should discuss: where gaps in IAEA guidance and requirements may exist for SMRs, the roles member state government agencies as well as industry (utilities and vendors) can play in identifying and resolving gaps in national regulatory frameworks.
    - Paths forward to be addressed by the IAEA should be discussed with attending IAEA representative to ensure it is reasonable and workable
    - Where no agreement can be reached for a discussion, the reason for the lack of agreement should be recorded such that the differing viewpoints can be understood
- At the end of each breakout session day, the topic rapporteur collects all the group results and documents them in the official topic report.

- On Wednesday afternoon, All Session Leaders will report to the plenary on status of sessions identifying progress, challenges and any needed programme adjustments such reassignments, combining groups etc.
- On Thursday, the group should focus efforts on finalizing the topic report and presentation for the Plenary. Finalized work to go to Discussion Forum Rapporteur at 1800h at the latest.

4.4 Case Studies for use in the Group Discussions

In order to facilitate focused discussions, three case studies have been provided on the following pages. Each case study is meant to illustrate different real world siting challenges that face member states for different SMR applications. Each case study involves a hypothetical member state with real world conditions and challenges and is not meant to single out any existing member state.

CONSIDERATIONS AND ASSUMPTIONS COMMON TO ALL CASE STUDIES

The following considerations and assumptions should be taken into account in each of the three following case studies.

- The member state has no current domestic experience with nuclear power.

- The member state's regulatory body and regulatory framework is at an early stage of development. As a result, the regulator and the utility are working with the country-of-origin's regulatory body and vendors / utilities to understand the rules under which the technology has been or is being designed and reviewed.

- In parallel with developing a national regulatory framework, the member state will be relying heavily on the IAEA's safety and security framework documents as part of their overall regulatory strategy.

- The member state's regulatory framework will be designed to be technology neutral (i.e. not based on a single technology) and will employ a mix of performance-based and prescriptive requirements.

- Assume there is political/civil unrest in the member state and significant threats to nuclear facilities cannot be discounted.

Note: Additional member state attributes are assigned in each case study to introduce different challenges to siting.

CASE STUDY #1:

Siting in a Densely Populated Member State with Significant External Hazards

A member state has chosen to investigate possible candidate sites for a number of possible 2-unit sites utilizing a reactor type expected to have an electrical output of approximately 200 MWe per unit.

Key Considerations:

- Additional Member State Attributes for this case study:
    - Due to geology and geographical features, the interior of the country is sparsely inhabited and the population is distributed along the coast-line with higher density regions cities near natural coastal harbours. The member state has only recently begun examining the need for greater controls over land-use planning due to overcrowding in certain parts of the country.
    - Population density as a whole is high and land for industrial use is generally at a premium. Remote nuclear sites in this member site are not an option.
- The preferred reactor type will be a foreign design and will be sited below-grade (i.e. majority of the nuclear island is underground). The member state is also considering an above-ground design as an alternative technology.
- The majority of power being supplied to the existing grid comes from a limited number of generation sources spread throughout the country. Typical existing supply source output to the grid is 100-200 MWe but there are also many smaller contributors to the grid. The existing grid has reliability issues because growth of the population has outpaced the deployment of new power supply. The intent is to have the nuclear units sited to improve grid reliability.
- The member state is exposed to significant and possible coincidental external hazards. It experiences periodic volcanism and significant seismic activity from both inside and outside the member state. Infrastructure has existed for some time to measure and characterise hazards and this infrastructure has received a reasonable amount of support from the government allowing it to modernize with time. Emergency services exist to cope with these events however they have never been tested for response under multiple scenarios.
- The only real source of viable condenser cooling water comes from the coastal ocean.

CASE STUDY #2:

Siting a Marine-based nuclear power and steam technology

A member state has chosen to encourage regional economic growth in a currently undeveloped and underserviced coastal region of the country by siting a number of industrial projects there. (project zone) The projects being contemplated for the first phase of the project zone are:

- an oil refinery
- a liquefied natural gas production facility
- an offshore tanker loading terminal for each of the above

The member state has plans in place to expand the project zone for additional projects over the next 50 years.

The projects are expected to be very energy intensive and there is a need for both electricity and process heating steam. Surplus power will be being made available to the national / regional grid.

Key Considerations:

- Additional Member State Attributes for this case study:
    - Population density of the member state as a whole is low to medium.
    - The proposed site locations are chosen. It is expected that a city of about 50,000 people will emerge near the project zone. This city will grow as the project zone grows.
    - The geography of the coastline region is low-lying (elevation low compared to sea-level) and is exposed to seasonal monsoons, and other tropical storms. Tsunamis have been recorded from offshore seismic events.
    - Seismic activity in the local region are poorly documented but anecdotally it is a low seismic region.
- Assume that land-based nuclear power facilities in that region are not an option.
- The preferred reactor type will be a single-sourced foreign design.
- The majority of power being supplied to the existing grid comes from a limited number of generation sources spread throughout the country. Typical existing supply source output to the grid is 100-200 MWe but there are also many smaller contributors to the grid. The existing grid has reliability issues because growth of the population has outpaced the deployment of new power supply. It is not certain whether these nuclear units would improve overall grid reliability because of the significant project zone energy demand.
- In the region, there is no infrastructure to measure and characterise hazards.

- There are no existing emergency services in the region. The nearest existing region with significant hospitals, fire-rescue, police is 200 km away by poorly serviced roads.
- The only real source of viable condenser cooling water comes from the coastal ocean.

CASE STUDY #3:

Siting a fleet of micro-nuclear power facilities in an extreme remote region

A member state has a large region of the country which is unserviced by power grids. Other regional services such as hospitals, police, roads etc. are minimal and the sites would require basic infrastructure (roads, camps) to be developed as early as the site evaluation stage. Hundreds of small communities no larger than 1000 people per community are distributed throughout this region, generally located near deep freshwater aquifers, small freshwater lakes or rivers and ocean shorelines or adjacent to major natural resource projects (e.g. mining projects). These communities or sites are in some cases hundreds of kilometres apart from each other.

Power at each of these locations is generated using small fixed fossil-fuel sources that are becoming unreliable and uneconomical. The member state does not have the resources to expand either regional or national grids to this region. As a result, the utilities that support the existing regional population are considering the deployment of a number of 10 MWe micro-nuclear facilities to provide both electrical power and process steam (assume for heater or water purification).

Key Considerations:

- Additional Member State Attributes for this case study:
    - The geology and geography of the various sites in the region varies, however all sites in the region experience extreme temperatures and precipitation events. These events have led to long periods of isolation where travel to and from the sites is not possible.
    - Seismic activity in the whole region is poorly documented but anecdotally it is a low seismic region.
- The preferred reactor type will be a single-sourced foreign design. The design employs a sealed and fuelled reactor module that is delivered from the vendor nation to the site and removed from the site back to an offsite disposal facility when the core is depleted. The vendor's intent is to have only a limited skeleton staff on site to operate and maintain each facility. The units are being designed to be autonomous and remotely monitored. Remote operator intervention is designed to be a secondary response.
- In the region, there is no infrastructure to measure and characterise hazards.
- There are no significant emergency services in the region. Each community or project is supported locally. Typically, the nearest existing region with significant hospitals, fire-rescue, police is more than 500 km away by in some cases, seasonally serviced roads, in other cases only by air transport.

- During extreme temperatures and precipitation events, it is normal that offsite emergency services can be delayed by days to weeks.
- There is nowhere to evacuate the population of a site to if a nuclear accident reaches a sheltering or evacuation threshold.

Appendix A:

Original List of Identified Issues for Topic 2: Site and Siting Considerations of SMRs

1. Flexibility in emergency planning requirements, accident response, application of graded approach (Cross-cutting with 1 and 3)
2. Siting issues for SMRs including transportable NPPs (Cross-cutting with 1)
3. Site lacking in infrastructure (Cross-cutting with topic 4)
4. Environmental impact (Cross-cutting with topics 4 and 5)
5. Source term calculation (Cross-cutting with topics 1 and 3)
6. Spent fuel management (Cross-cutting with topics 1 and 5)
7. Transportation of fuelled-NPPs (modules) – fits all topics.
8. Safeguard-ability (Cross-cutting with 4 and 5)