New Reactor Siting in Finland
Hanhikivi site in Pyhäjoki –
STUK preliminary safety assessment

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Contents of the presentation

This presentation is based on STUK preliminary safety assessment of Fennovoima Decision in Principle application.

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http://www.stuk.fi/ydinturvallisuus/ydinvoimalaitokset/uudet_laitosyksikot/en_GB/uudet_laitosyksikot/_files/82886816940818858/default/STUK-Fennovoima_PreliminarySafetyAssessment%20_Appendix2.pdf

Status of new reactor projects

- Three applications submitted for first step - Decision in Principle
  - Teollisuuden Voima Ltd (TVO)
  - Fortum Power and Heat Ltd
  - Fennovoima Ltd (2 possible sites)
- STUK performed preliminary safety assessment in DiP phase
  - Statement on TVO, Fortum and Fennovoima applications all published
- Government's decision - 2 applications approved
  - Teollisuuden Voima Ltd
  - Fennovoima Ltd
- Parliament has ratified Government's decision 1.7.2010
  - the applicants have sent nuclear safety related bid requirements to STUK for information.
  - That was the first step for STUK to prepare regulatory project for construction license review.

General Considerations in NPP Siting

- A variety of factors must be considered in the selection of a NPP site
  - economical, technical, environmental and safety
  - examples
    - availability of cooling water
    - power transmission grid connections
    - transport routes
    - availability of services
    - land use: population, agriculture, fishing, traffic, industries
- Only safety issues are considered in this presentation
  - effects of the site on the plant design
    - identification of external hazards - natural and human induced
    - design bases for external events
    - site layout
  - effects of the plant on the site environment
    - radiation safety
    - emergency preparedness (separate presentation)
      - plant and authorities
      - interaction with land use planning
  - some factors have technical, economical, environmental and safety aspects, e.g., grid connections, cooling water supply

Legislation and conventions

- NPP siting is covered by several fields of national legislation and international conventions, e.g.
  - nuclear
  - environmental
  - land use and building
- IAEA sponsored conventions and IAEA regulations on nuclear safety
- International environmental conventions
- EU directives in the European Union
- International regulations and treaties are implemented in national legislation

International environmental conventions and regulations, examples

- Espoo convention 1991 on EIA
  - Convention on Environmental Impact Assessment in a Transboundary Context (UNECE, United Nations Economic Commission for Europe)
  - International hearing processes may be quite extensive
- Aarhus Convention 1998 (UNECE)
  - Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters
- regional marine protection conventions
  - OSPAR (Atlantic Ocean), HELCOM (Baltic Sea)
- EU directives and EURATOM Treaty in the European Union
  - EIA Directive (85/337/EEC, 97/11/EC)
  - environmental directives (biodiversity, birdlife)
    - Natura 2000 network of natural reserves
    - sometimes extensive clarifications are required

Siting and site evaluation

- **Siting** is the process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design bases. (IAEA Safety Guide NS-R-3, 2003)

- Existing sites
  - site characterization is updated for new units
  - site related design requirements are determined according to current regulatory requirements
- New sites
  - an extensive siting process

- **Environmental Impact Assessment** (EIA) can be an essential part of the siting process
  - role and timing of EIA depends on national legislation

Siting

The ***process* of selecting a suitable site** for a *facility*, including appropriate ***assessment* and definition of the related *design bases***.

- The *siting process* consists of site *survey* and *site selection*.
  - Site *survey* is the *process* of identifying candidate sites after the investigation of a large region and the rejection of unsuitable sites
  - *Site selection* is the *process* of assessing the remaining sites by *screening* and comparing them on the basis of *safety* and other considerations to select one or more preferred candidate sites

- For a waste *repository*, the *siting process* is particularly crucial to long term *safety*; it may therefore be a particularly extensive *process*, including *Site confirmation as a separate stage*

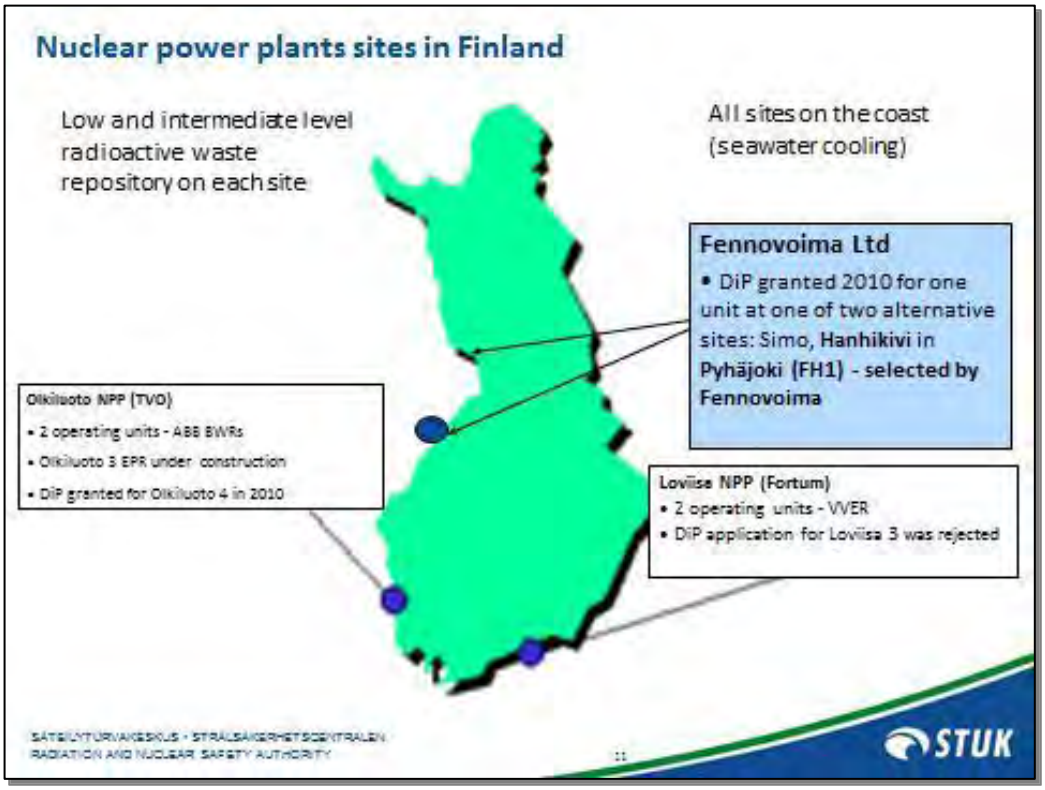
OECD/NEA comparison of siting practices

- NEA has published recently *Report on the Survey on Regulation of Site Selection and Preparation*, NEA/CNRA/R(2010)3
- Produced by CNRA Working Group on the Regulation of New Reactors
- Based on information from 15 countries (10 European countries and Canada, Japan, Korea, United Arab Emirates, USA)

Site characterization

Information on the following topics is required for site evaluation and determination of plant design values for external events

- Natural conditions
  - Geology and seismology
  - Hydrology
  - Meteorology
- Human activities
  - Transport routes (sea, land and air routes, pipelines)
    - oil and hazardous substances
    - airports
  - Industrial activities
    - production, storage
  - Agriculture
  - Population


Nuclear power plants sites in Finland
Low and intermediate level radioactive waste repository on each site
All sites on the coast (seawater cooling)
Fennovoima Ltd
• DiP granted 2010 for one unit at one of two alternative sites: Simo, Hanhikivi in Pyhäjoki (FH1) - selected by Fennovoima
Olkiluoto NPP (TVO)
• 2 operating units - ABB BWRs
• Olkiluoto 3 EPR under construction
• DiP granted for Olkiluoto 4 in 2010
Loviisa NPP (Fortum)
• 2 operating units - VVER
• DiP application for Loviisa 3 was rejected
STUK


Hanhikivi site in Pyhäjoki (FH1)
Photos: Fennovoima
STUK

Selected Hanhikivi site in Pyhäjoki (FH1)

- Hanhikivi headland in Pyhäjoki is in a sparsely populated area
- There are no permanent residents on the headland, and there are relatively fewer leisure homes here than elsewhere on the waterfront in Pyhäjoki
- The community nearest to the proposed site of the Nuclear Power Plant is the village of Parhalahti, some 4 km away. Parhalahti has a permanent population of about 400.

Geology - Finnish experiences

- Several important risk factors are excluded in Finland due to site geology
  - landslides, mudslides
  - avalanches
  - soil subsidence
  - soil liquefaction
- A special feature in Finland: on-site low and intermediate level radioactive waste final disposal facilities
  - both existing NPP sites have their own rock cavern repositories
  - planned also on the Hanhikivi NPP site
  - some additional geological considerations in siting

Hanhikivi site in Pyhäjoki (FH1)

- The Hanhikivi area is very low. At the proposed nuclear power plant site, the ground is on average only +1.5 m above sea level (N60 system).
- Soil surveys have been conducted at 80 points at the Hanhikivi site.
- The bedrock level is mainly between +1 and –3 m. At one of the survey points, the bedrock is some 14 m below ground level, but this point would not be under the reactor. There is some exposed bedrock at the site; generally the rock is covered by layers of loose moraine.
- The bedrock at the Hanhikivi site is conglomerate about 1,900 million years old and suitable in its properties for the construction of a nuclear power plant.

Hanhikivi site in Pyhäjoki (FH1)

- Preliminary studies suggest that the Hanhikivi headland is a uniform section of bedrock, with little or no fracturing.
- The fine-grained rock type in the area, smooth apertures and other geological properties relevant for construction will be taken into account in the design and building technology solutions of the reactor waste final repository.
- In summer 2009, Fennovoima commissioned rock surveys involving two boreholes, two drilled holes, tension measurements and seismic soundings.
  - fracture density in the bedrock in the area is variable but mainly low or moderate
  - No broad fault zones were found in the drill sampling, though minor fracture zones and individual fractures with high water conductivity were found.

The rock studies at Hanhikivi revealed no disadvantageous properties that would have a bearing on the construction of the power plant or of the reactor waste repository.

Hanhikivi site in Pyhäjoki (FH1)

- There are no industrial facilities, warehouses or other facilities near Hanhikivi that might cause a hazard at the proposed power plant.
- The nearest major industrial facilities are the Rautaruukki steel mill in Raahe and the Polargas air gas plant and LPG storage some 15 km from Hanhikivi.
- Highway 8 runs about 5 km from the proposed site, to the east of the Hanhikivi headland. The nearest airports are Oulu airport at Oulunsalo about 70 km away and the general aviation airfield of Raahe-Pattijoki about 30 km away.
- No public roads run through the site area. Two access routes are planned for the site.

Grid connection

- A new 400 kV power line will be needed to connect the new power plant unit to the national grid, and 100 kV power lines at the chosen site will have to be strengthened.
- Under the Electricity Market Act, responsibility for developing the national grid and maintaining its systems rests with national grid company Fingrid.
- Fingrid is obliged to strengthen the national grid as required. There shall be separate EIA procedures for new grid connections.

IAEA seismic requirements

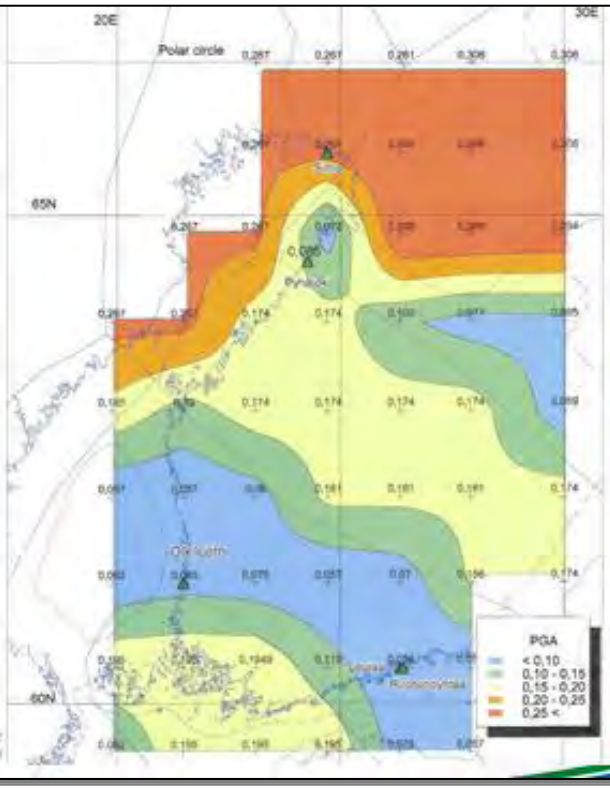
- Evaluation of Seismic Hazards for Nuclear Power Plants, Safety Guide NS-G-3.3, 2003
- Seismic Design and Qualification for Nuclear Power Plants, Safety Guide, NS-G-1.6, 2003
- Safe shutdown earthquake (level 2) and possibly lower operating basis earthquake (level 1)
  - peak ground acceleration (PGA) and
  - ground response spectrum
- Seismic hazard studies required
  - deterministic or probabilistic
- Minimum recommended design PGA is 0.1-g
  - even if hazard studies indicate a lower PGA
- Updated guide "Evaluation of Seismic Hazard for Nuclear Installations" SSG-9, 2010
  - discussion on minimum PGA (0.15 ·g proposed but 0.1 g was retained)

Seismology - Finnish experiences

- Old bedrock, hard crystalline rock (gneiss, granite)
- Intraplate region, far from plate collision areas
- Low seismic activity
  - no dangerous earthquakes have been observed
    - highest recorded magnitude ~ 4.5 Richter
    - historical evidence of magnitude ~ 5.5
    - regional differences
  - however, microseismic events are fairly common
    - possibly due to continuing bedrock uplifting after ice age
- Seismic loads are not considered separately in the general building code
- No seismic requirements when the operating plants were built
  - seismic PRAs revealed some potential problem areas in operating units
    - anchorage of equipment
      - electric cabinets, batteries
      - some large tanks
    - certain relay types
    - significant risk reduction was achieved with simple plant modifications

Seismic requirements in Finland

- Requirements for nuclear power plants are set forth in Guide YVL 2.6
- Design earthquake corresponds to return period of 100000 years (50% confidence level)
  - peak ground acceleration (PGA)
  - ground response spectrum
- PGA 0.06·g - 0.2·g in southern Finland (100000 year return period)
  - at current sites Loviisa and Olkiluoto PGA is 0.06 - 0.085 ·g
  - design value 0.1 g according to the current IAEA recommendation (NS-G-3.3)
  - ground response spectrum maximum at 10 Hz
- Preliminary quantitative hazard estimates have been done for candidate sites in northern Finland
  - higher seismic activity
  - PGA up to 0.09·g - 0.16·g in Hanhikivi – Fennovoima consider 0.2 g
  - ground response spectrum maximum at high frequency, up to 25 Hz



Peak ground acceleration PGA (g) for 100 000 year median return period in Finland

Range 0.05 g - 0.3 g

source J. Saari et al. ÅF-Consult, 2009

Meteorology and hydrology

Examples of phenomena considered in NPP design

- Highest and lowest outdoor air temperature
  - instantaneous, short term, long term
- Air humidity
- Extreme wind speed
  - including tornadoes (trombs) and downbursts
- Sea/river/lake water temperature
  - high temparature
  - subcooling, frazil ice formation
- Sea/river/lake water level: extreme high and low
- Impuries in water: organic, mud, oil, chemicals
- Ice conditions, packed ice in Hanhikivi
- Precipitation
- Snow load
- Lightning (peak current, rise time etc.)

Fennovoima has sent to STUK most of the proposed design base values, which shall be approved during the construction license phase

Meteorology and hydrology - Finnish experiences

- No detailed quantitative requirements in current YVL guides
- Quantitative risk targets provide some guidance
  - core damage frequency < 1E-5/a
  - large release frequency < 5E-7/a
  - no single factor shall dominate
- Intensity-frequency distributions have been determined based on available observations
  - reliable observations for ~ 100 years
  - return periods of interest up to 10 000 - 1 000 000 years
  - uncertainties are very large at high return periods
- Combinations of correlated events are potentially important
  - snow and wind: potential for loss of offsite power and simultaneous failure of diesel generators due to combustion air intake blockage

Conclusions

- Siting and EIA are important phases of a NPP project and its licensing – however in Finnish NPP licensing system the site characteristics shall be approved in construction licence phase
- International conventions, requirements and guides
- National nuclear legislation and other fields of legislation
- Wide spectrum of issues
  - effects of the plant on the population and environment
    - normal operation
    - accident situations
  - effects of the site conditions on the plant
    - natural conditions
    - human induced effects

References

Finnish guides on siting and external events

available at www.stuk.fi > In English > Publications > Regulatory Guides

YVL 1.0 Safety criteria for design of nuclear power plants
YVL 1.10 Requirements for siting a nuclear power plant
YVL 2.6 Seismic events and nuclear power plants
YVL 7.4 Nuclear power plant emergency preparedness

Preliminary safety assessments of new projects

www.stuk.fi
EN > Nuclear Safety > Nuclear power plants > New nuclear power plants

Decisions in Principle

www.tem.fi > In English > Energy > Nuclear Energy


References, EIA in Finland
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http://www.tem.fi > In English > Energy > Nuclear Energy
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– EIA programs, reports and Contact Authority's statements
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