WHEN TRUST MATTERS

Acceptance criteria for new grid connections near nuclear power plants in the Nordics

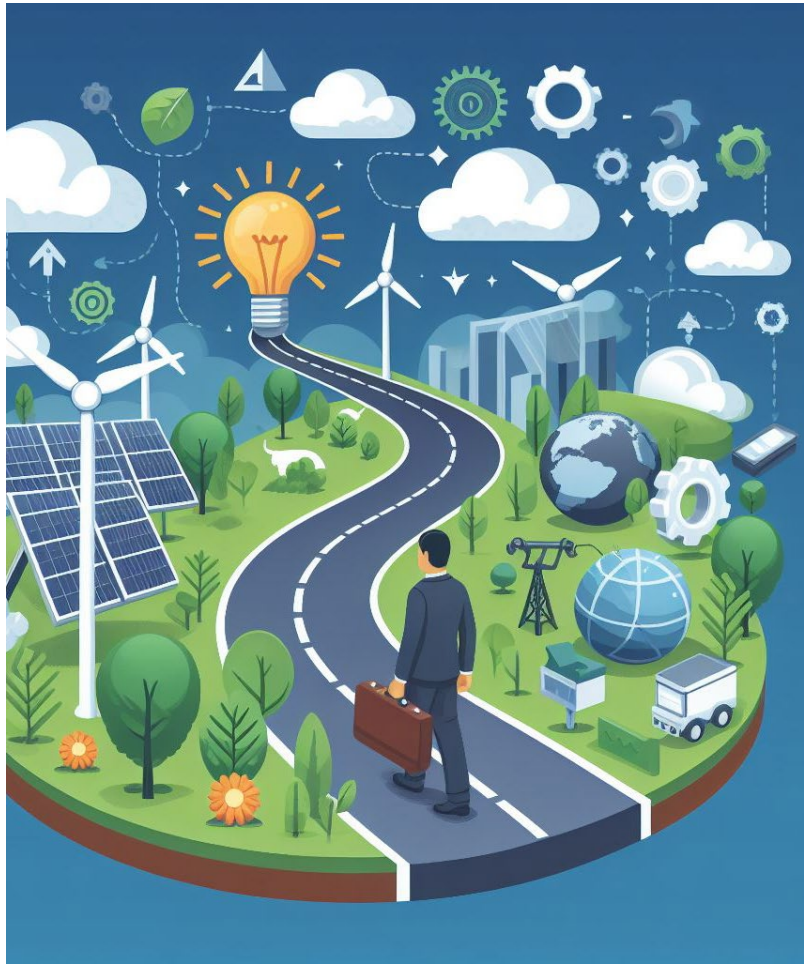
GINO KKU53542 - Challenges for the power system of the future and today's NPPs

Project Manager: Lucas Thomée

12 November 2024

Agenda

- Background to the project
- Project organization
- Content
- Execution
- Primary results
- Roles and responsibilities
- Discussions



Background

- Nuclear power accounts for a significant share of electricity generation in Sweden and Finland.
- July 2024:
  - Sweden: 40%
  - Finland: 60%
- The nuclear plants are crucial for the reliability and stability of the Nordic synchronous system.

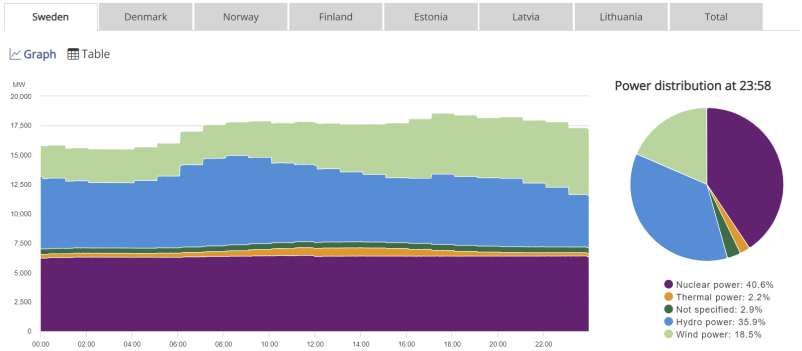
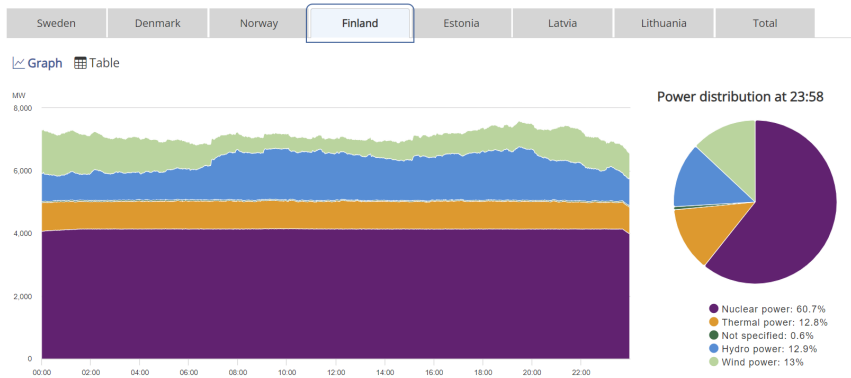


Figure 2-1: Existing transmission grid near NPPs (Olkiluoto to the West and Loviisa to the East) in Finland[4].

Figure 2-3: Existing transmission grid near NPPs (Forsmark to the North, Ringhals to the West, Oskarshamn to the East) in Sweden[4].



Background

- Extensive plans for new large generation and consumption facilities:
  - Offshore wind
  - Onshore wind
  - Solar PV
  - Storage
  - Hydrogen electrolysers
  - Data centres
  - Industries

- The power system of the future has few similarities with the system when the NPPs were built.

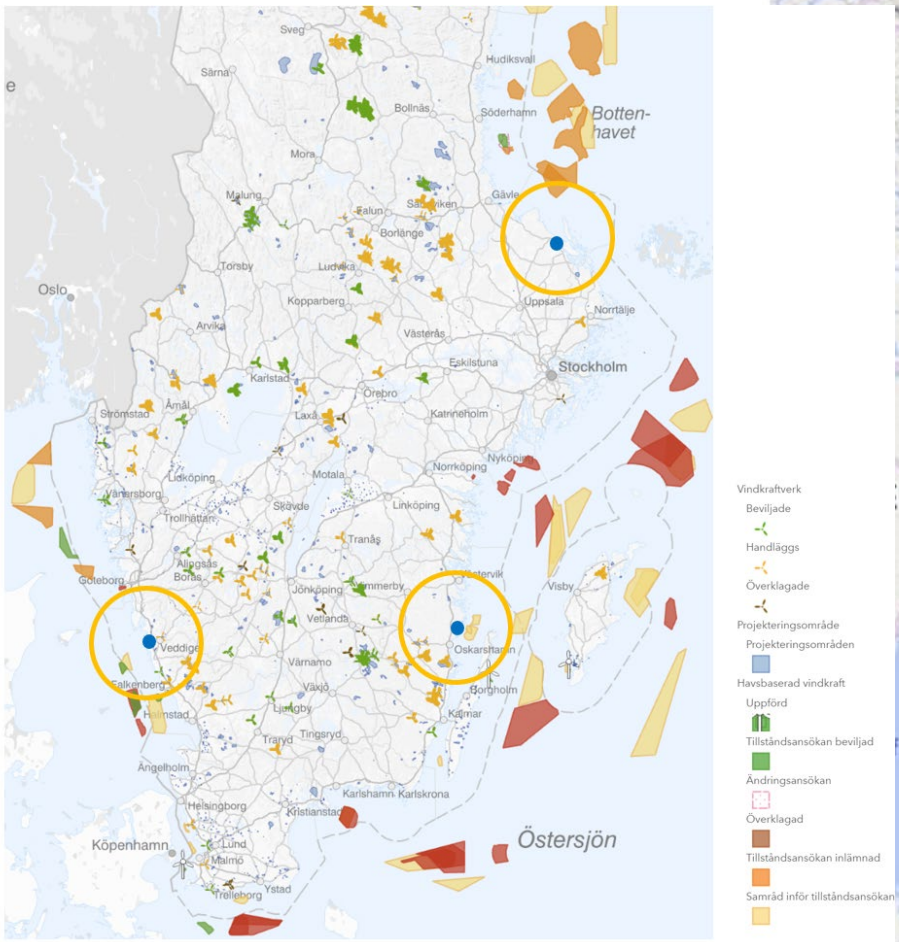


Figure 2-5: Planned onshore and offshore wind projects[6] in Sweden with the existing NPPs

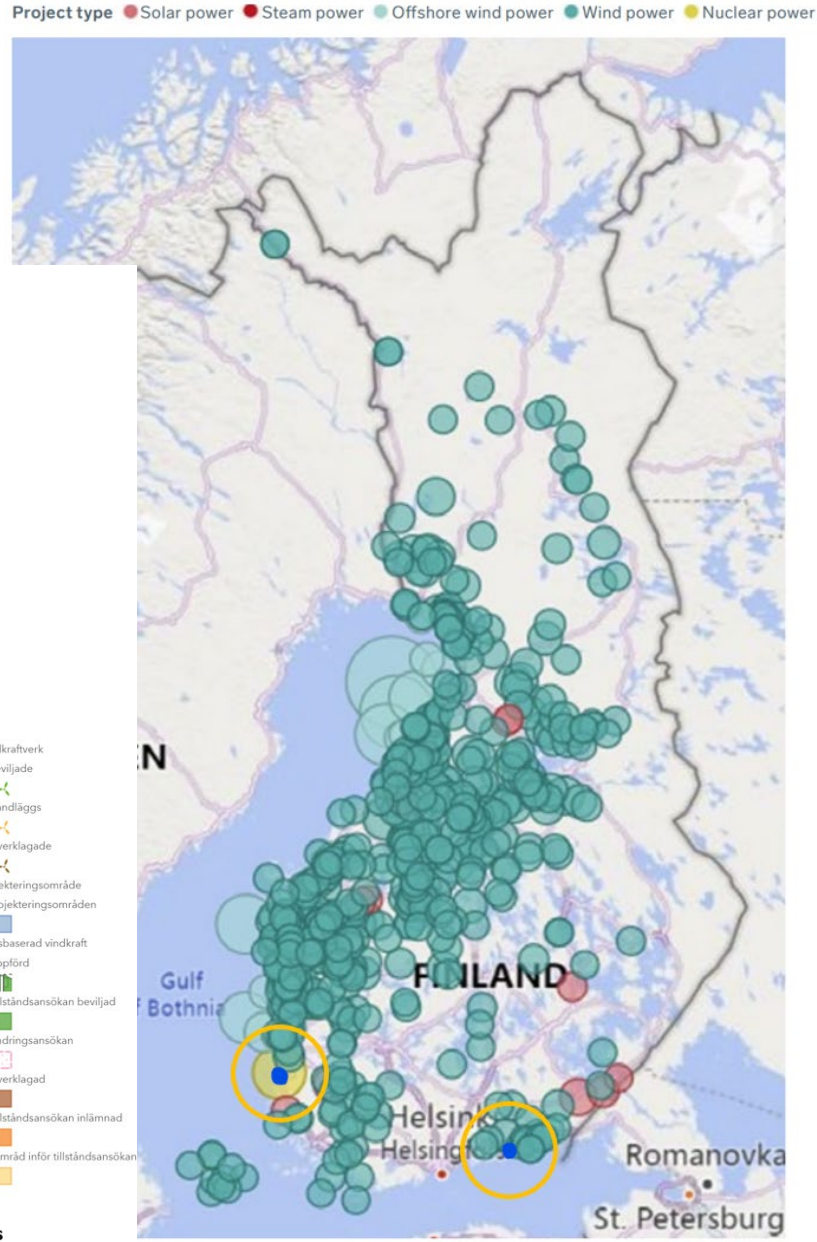
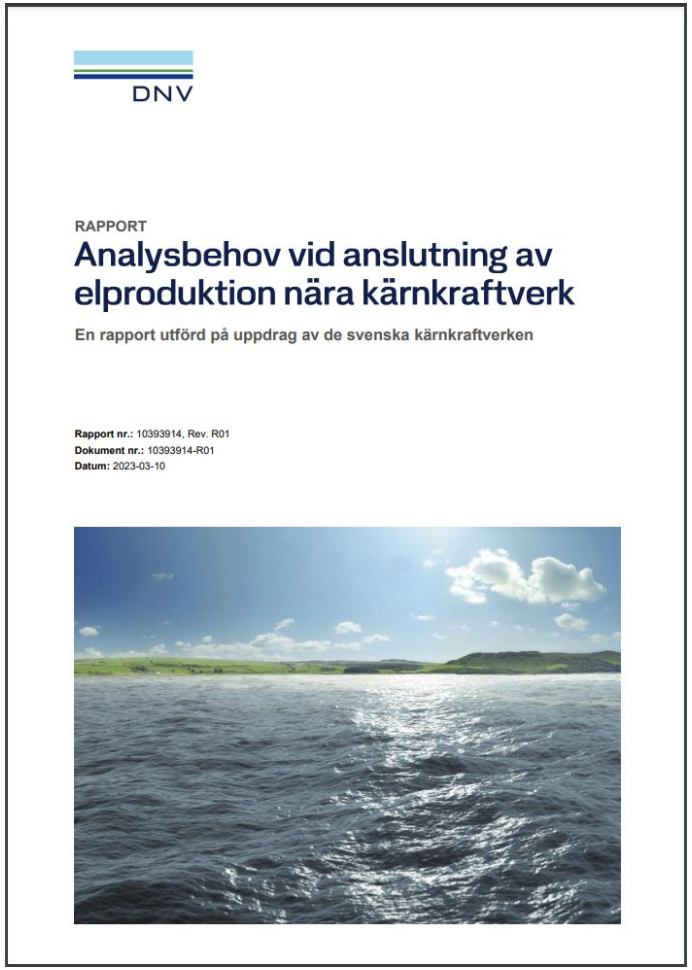


Figure 2-2: Location of power generation projects in Finland[3] with the locations of existing nuclear plants in blue with yellow circle.

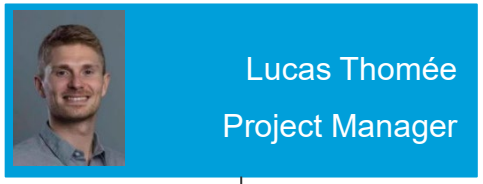
Background to the project

- "Analysbehov vid anslutning av elproduktion nära kärnkraftverk" Conducted on behalf of the nuclear power plants in Sweden.
- Summarized studies and analyses that should be conducted:
  - Network availability
  - Power quality
  - Sudden event in the new facility, such as failure or connection
  - Sudden event in the power system, such as failure or disconnection
  - Resonance and damping
  - Stability and fault tolerance within the additional facility
- Lacking specification of acceptance criteria!



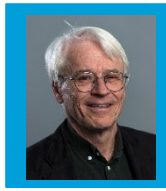
Meet the project team!

DNV

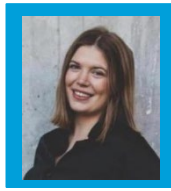


Lucas Thomée
Project Manager

Daniel Karlsson
Quality Assurance



Lars Messing
Technical expert
Protection topics



Matilda Arvidsson
Engineer
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Reference group

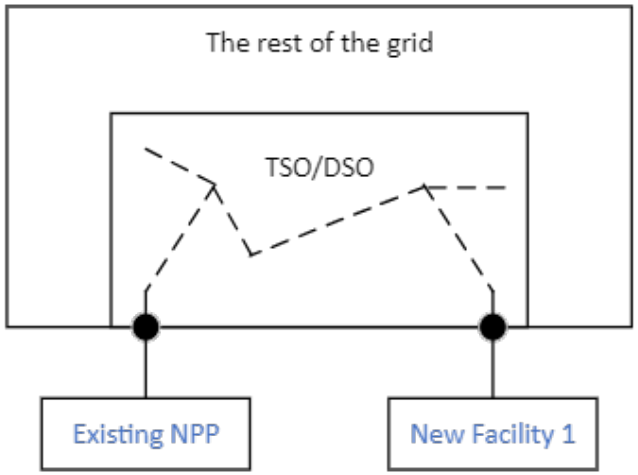
- Magnus Knutsson, Vattenfall
- Per Lamell, Vattenfall
- Jonas Jönsson, OKG
- Ari Kanerva, Fortum

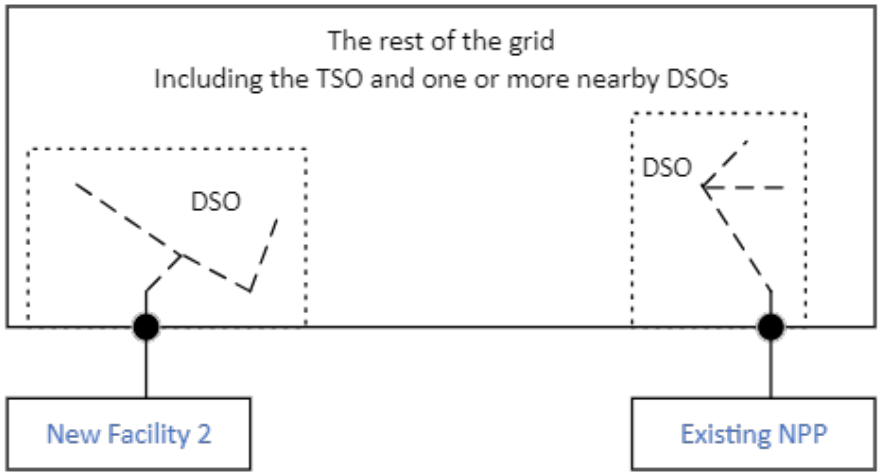
Project content

1. *Aim*: To specify acceptance criteria for the analyses of new grid connections near nuclear power plants.
2. *The New Electric Environment*: Existing grid, new connections & critical grid conditions
3. *Experience – Historical Overview of Events*
4. *Power System Condition Characteristics:* Known phenomena & Changes due to new grid conditions, NPPs' perspective.
5. *Required Studies and Acceptance Criteria*
6. *Roles and Responsibilities*

Execution – Description of the analysis method

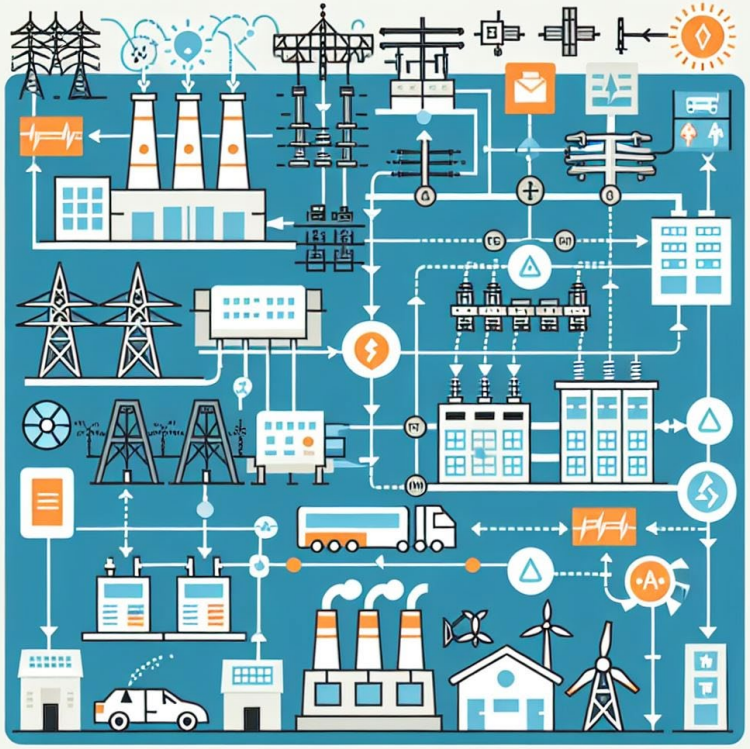
- Definition of “**nearby**”:
  - “nearby” existing NPPs, refers to “electrical distance” with potentially significant impact on the grid conditions at the connection point of the nearby NPP.
  - Depends on the degree of meshing and the short-circuit power of the grid.
  - If a “potential significant impact” from the connection of the new facility is identified, the upcoming facility should be regarded as “nearby”.





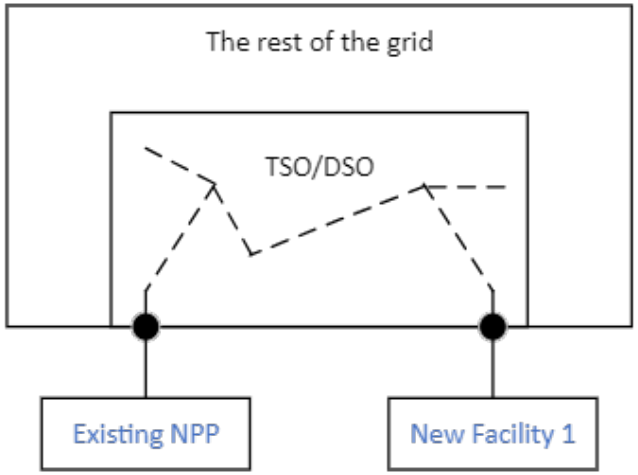
Execution – Description of the analysis method

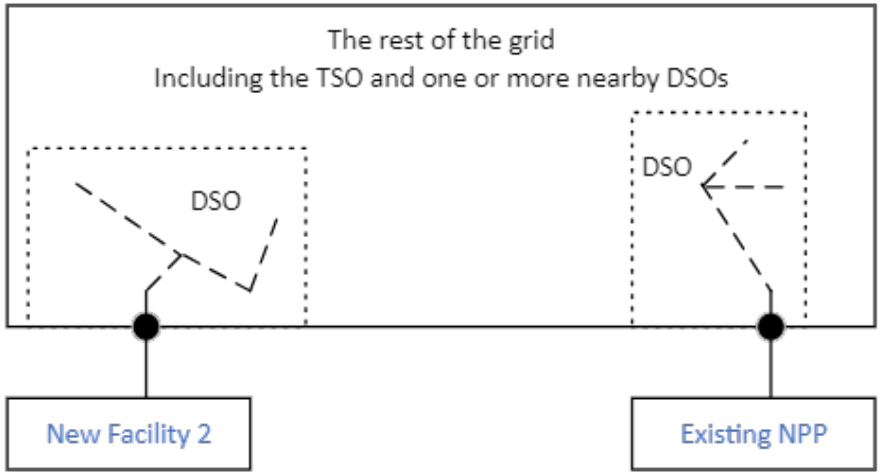
- Studies and analysis related to:
  - **Grid availability**: Overall availability of power infeed or supply to the NPP
  - **Power quality**: Voltage level, reactive power exchange, harmonics, flicker, asymmetry, DC content
  - **Sudden events in the grid**: Switching or faults (large disturbances)
  - **Sudden events in the new facility**: Switching or faults (large disturbances)
  - **Resonance and damping**: impedance characteristics, eigen-frequencies, SubSynchronous Resonance (SSR)
  - **Stability and fault tolerance in the new facility**: converter control stability, solid protection scheme against faults and disturbances



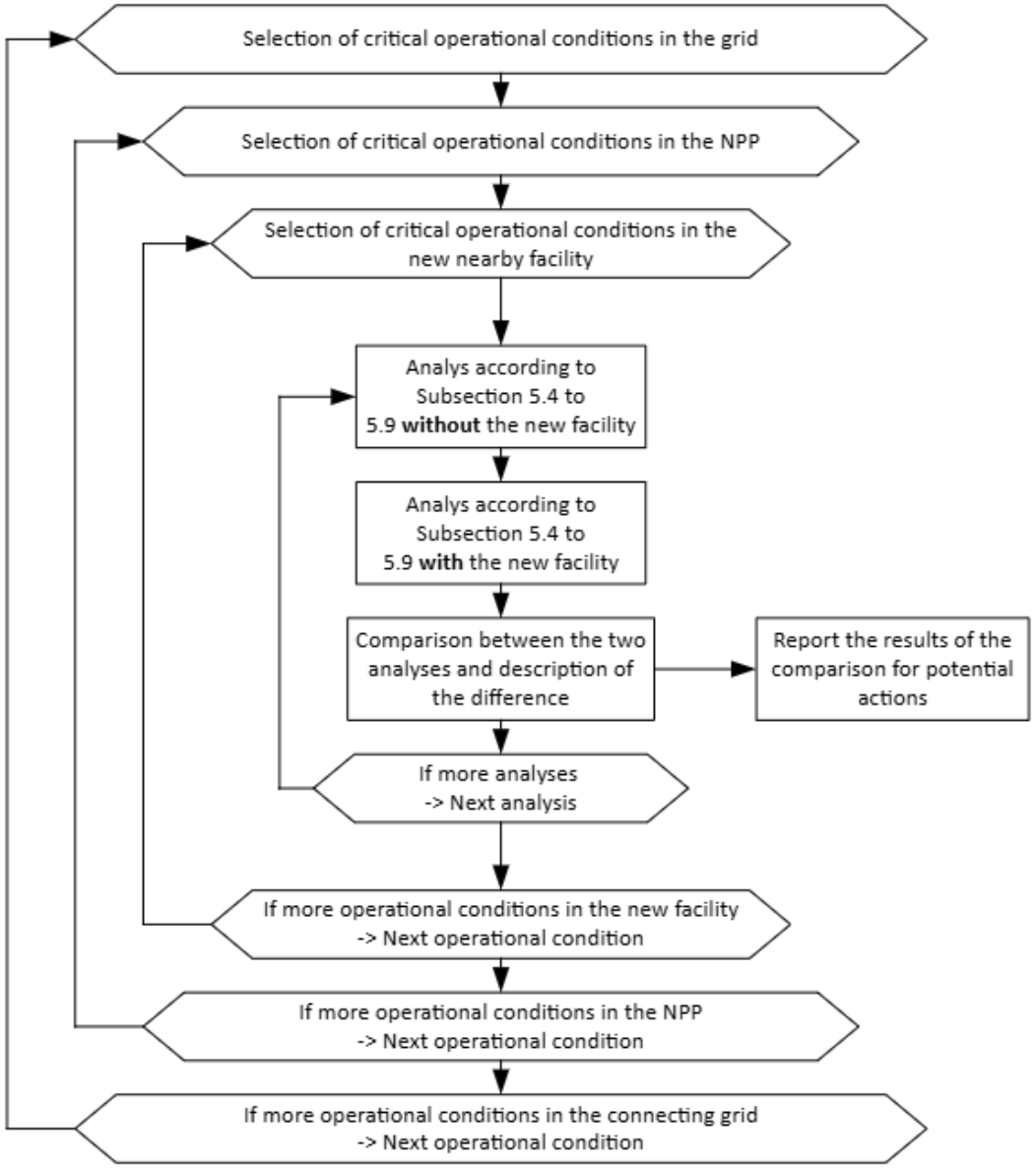
Execution – Description of analysis method

- System is divided into three parts:
  1. The existing NPP
  2. New connection facility
     I. Facility 1: connected to main transmission grid connection
     II. Facility 2: connected to the supply grid (70-130 kV)
  3. The rest of the grid (TSO/DSO)





Execution – Description of analysis method



Subsection 5.4 - Grid availability

Subsection 5.5 - Power quality

Subsection 5.6 - Sudden events in the grid

Subsection 5.7 - Sudden events in the new facility

Subsection 5.8 - Resonance and damping

Subsection 5.9 - Stability and fault tolerance in the new facility

Primary results

- Overall acceptance criteria:

1. Open and transparent involvement of all stakeholders in the entire process of planning, establishment and operation of the new nearby facility.

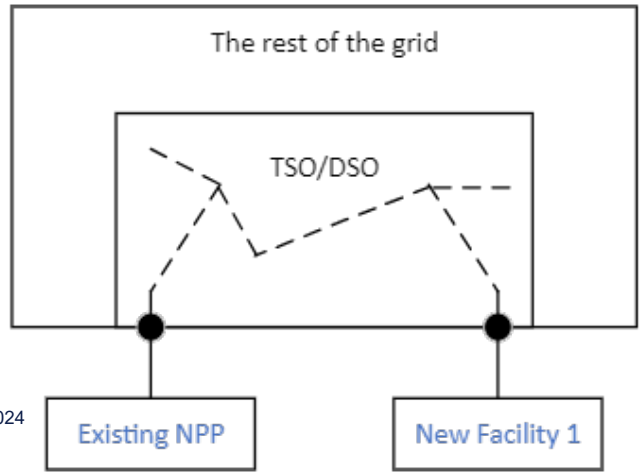
2. No significant negative impact on the nuclear power plant, including:
   a. Operational security, related to power infeed and supply
   b. Internal losses and faults in the nuclear power plant
   c. Wear and tear, and lifetime impact on the nuclear power plant equipment

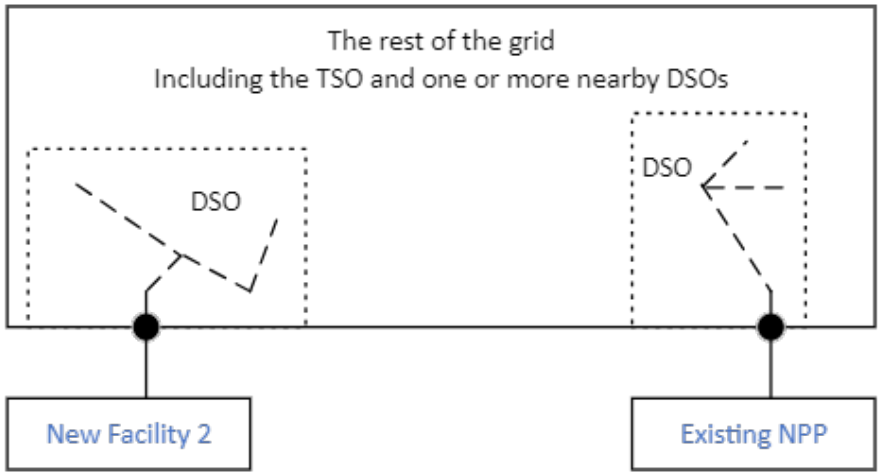
Primary results

Characteristic	Summarized acceptance criteria
Grid availability	- The design, operation, and maintenance of the new grid expansion and new facility must be accomplished in such a way that the grid availability at the NPP connection point is not challenged.
Power quality	- Short-term abnormal voltage conditions (above 110% or below 90% of normal operational voltage) at any NPP grid connection point must not increase. - The new facility must not change the NPP reactive power exchange required to maintain the desired voltage level at the NPP connection point. - Any changes in maximum or minimum short circuit current contribution from the connecting grid at the connection point must be continuously shared with the NPP. - Voltage asymmetry at the connection points of the NPP should not exceed 1% negative sequence voltage. - The level of harmonics, subharmonics, inter-harmonics, or supra-harmonics at the NPP connection points must not change considerably due to the new facility. - The amount and characteristics of voltage dips, swells, or fast voltage changes must not change considerably due to the new facility's connection, commissioning, or operation. - Flicker levels (short-term Pst and long-term Plt) must not change considerably due to the connection or operation of the new facility. - The new facility must not cause or contribute to any DC voltage component at any NPP connection point.
Sudden events in the grid and the new facility	- New facilities shall not significantly influence the rate or type of sudden events (such as faults and switching), as experienced at the NPP point of connection.
Resonance and damping	- Comprehensive and detailed resonance and damping studies, where the NPP is involved from the planning stage are required to ensure proper future operation of both the existing NPP and the new facility, as well as of the transmission grid.
Stability and fault tolerance in the new facility	- Any event or abnormal condition within the new facility, which might influence the secure operation in the NPP, shall be properly handled within the new facility to minimize such a risk for negative influence on the operation of the NPP. - The NPP must be involved to ensure such a design, all the way, from the planning, design, and to the operation phase.

Roles and responsibilities

- No direct contractual relationship between the NPP and the new facility, all passed through the grid owner/s.
  - NPP to keep track of what is happening in the vicinity of the grid connection.
  - TSO/DSO and the connecting facility to be transparent, responsive and cooperative in the grid analyses.
- International perspective:
  - NPPs are directly involved in connections of new facilities (especially wind & solar).
  - Meeting twice per year with the respective grid owner to discuss plans for new connections.
  - E.g. new offshore wind connection → grid owner is investigating impact on the NPP turbine and generator set





Thank you!

Questions?

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