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Program area Nuclear
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Strategy plan

GINO

- Grid interference on nuclear power plant operations

Period: 2016-01-01 to 2018-12-31

Summary

This R&D program aims at gaining better understanding and possibility to pro-actively minimize interference on nuclear power plant (NPP) operation due to issues in the external grid. The benefits include revised safety and assessed safety margins, avoidance of extended outages and maintenance periods, fewer unplanned shut-downs, and lower cost of component replacement.

The proposed activities include survey of operational events from the off-site power system with focus on retrofit of mitigating actions, methodologies to verify that the outer grounding line network in the nuclear power plants is intact, a generic lightning model of the Nordic nuclear power plants to study how lightning strikes at overhead power lines are transmitted on-site, survey on new electrical devices with different technology compared to existing electrical devices, and sub-synchronous resonance (SSR) phenomenon and modelling combined with hybrid simulations.

1. Vision

The external grid should not cause any unforeseen impact on systems or functions causing interruption in any plant state.

2. Benefits and deliverables

2.1. Receivers of expected benefits/deliverables

The main receivers are the NPP operators, to revise safety, achieve excellent plant availability, minimise unplanned shutdowns and maintenance needs, and maintain all safety margins. The results are also of great importance to the plant owners, such as optimising operating costs and investment strategies.

The radiation safety authorities (SSM, STUK) have an interest in the benefits of this program to better validate safety margins.

The transmission system operator (TSOs Svenska Kraftnät and FinGrid) benefits from several of the outcomes, such as improved plant reliability and stable production.

The public will benefit from lower risk of power outages following severe occurrences in the electric grid.

2.2. Expected benefits

The benefits from the program include better knowledge of risks in external grid interference from several different possible events, improved modelling of specific occurrences leading to possible pro-active measures, lower costs for component replacement, and avoidance of extended outage due to better understanding of most vulnerable components. Increased preparedness and robustness against unknown or unidentified events and patterns are also expected benefits.

2.3. Expected deliverables

List of expected outcomes and milestones of the program for 2016-2018:

Action	Deliverable	Expected end date
A.1	Lessons learned and implementation of mitigating measures	Q2, 2016
A.2	Report on grounding verification methodologies including lessons learnt from Barsebäck	Q1, 2018
A.3	Report on lightning modelling with recommendations on limiting vulnerability to over-voltage	Q4, 2018
B.1	Conclusions and recommendations on new electrical devices	Q2, 2017
C.1	Describe phenomenon and what technical information is needed to do SSR calculations	Q4, 2017
Workshop	Meeting to discuss results, synergies and future strategies	Annually

In addition, progress reports for all activities are to be prepared regularly.

3. Focus areas and activity plan

The proposed activities in the Strategy plan have, in addition to program area “Nuclear”, also strong links to the Energiforsk program areas “Electricity Networks, wind power and photovoltaics” and “Hydro power” since similar problems exist also in those areas. The program considers external disturbances affecting the on-site power system in the NPPs. However, internal disturbances are included as well.

Three focus areas have been identified:

A. External grid effects on components

B. Replacement strategies

C. Electromechanical resonance phenomena in the external grid

3.1 **Focus area A: External grid effects on components**

Activity A.1: Survey of operational events from the off-site power system with focus on retrofit of mitigating actions

Investigation of relevant disturbances to support the decision process with a toolbox of mitigating actions. Phase 1 results in a summary of occurred events around the world, both in nuclear as well as conventional power plants, including assessment of the most relevant types of disturbances. Phase 2 assembles mitigating countermeasures that have been, or are ready to be, retrofitted into existing plants.

The main result of the activity is a knowledge database with:

- Description of relevant disturbances including reference list
- Root cause for the disturbances
- Impact of the disturbances
- Lessons learned, implementation and recommendation of mitigating measures
- Presentation of existing equipment

This activity is already planned to start in Q4 2015 with results to be presented at a program workshop in Q2 2016.

Activity A.2: Survey of methodologies to verify that the outer grounding line network in the nuclear power plants is intact

Synergies are expected with the Energiforsk Electricity Networks Research Area. The main result of the activity is a report with:

- Results from literature study/benchmark.
- Description of the grounding line network in Nordic nuclear power plants.
- Description of relevant methodologies.
- Results from the on-site tests in Barsebäck.
- Recommendation of an appropriate testing method to be used for the earth grid evaluation.
- Lessons learned from Barsebäck which can be applied on other NPPs.

Activity A.3: Generic lightning model of the Nordic nuclear power plants to study lightning impact due to conducting.

The main result of the activity is a report with:

- Description of the installed safety devices handling overvoltage in case of a lightning strike.
- Description of the use case defined for the simulations.
- Generic model for analysis of lightning including component description.
- Results from the simulations.
- Recommendations of improvements regarding the results gained.

3.2 Focus area B: Replacement strategies

Activity B.1: Survey on new electrical devices with different technology compared to existing electrical devices

Synergies are expected with the Energiforsk ENSRIC program as well as the OECD/NEA work on digital components. The main result of the activity is a report with:

- Results from literature study/benchmark.
- Description of which equipment is included in the survey such as circuit breakers, surge arresters, solid state devices and so on.
- Sources used for the survey.
- Knowledge database with pros and cons for technologies within each type of equipment category.
- Conclusions and recommendations.

3.3. Focus area C: Electromechanical resonance phenomena in external grid

Activity C.1: Sub-synchronous resonance phenomenon and modelling combined with hybrid simulations

Initially, this activity will be further elaborated at a workshop. The expected main outcomes of the activity are to:

- Describe phenomenon and what technical information is needed to do SSR calculations.
- Determine if the network includes any critical frequency or resonance.
- Present how the turbine-generator critical frequencies/torsional modes can be calculated.
- Evaluate and conclude the study, incl. what to proceed with.

3.4. Time plan

A workshop is to be held annually to address progress and conclusions in the activities, ways forward, and synergies within Energiforsk. It is suggested to initiate focus area A with activity A.1 already during Q3 2015 and continue with A.2 in Q2 2016. Focus area B is also of high priority and has an expected long duration, why it is of interest to start work early in the program and it is proposed to commence by Q3 2016. Focus area C is proposed to start during 2017, however, an initial workshop is planned to discuss activity specifications in early 2016. Results from activity A.1 will also be presented at that workshop.

4. Governance

The R&D program is governed by a steering group of members from each Nordic NPP: Forsmark (Per Lamell, Thomas Smed), Ringhals (Magnus Knutsson, Sofia Johansson), OKG (Jonas Jönsson), Olkiluoto (Ismo Sandback) and possibly Fortum. The steering group includes also one member from Energiforsk (Monika Adsten). The safety authorities (SSM, STUK) and TSOs (SvK, FinGrid) can also be represented in the steering board if they co-finance the program.

5. Background

Needs and challenges of the nuclear industry

A pre-study within Energiforsk has been carried out where needs and challenges highlighted by the nuclear industry suggested this nuclear R&D program. The benefits identified include revised safety and assessed safety margins, shorter maintenance periods, fewer unplanned shut-downs, and lower cost of component replacement. The exchange of knowledge between varied fields, such as settings for relay protection and analysis methods, generic simulations and literature studies, were pointed out as areas suitable for cooperation. A significant outcome is better dialog with the manufacturer, international organizations and authorities.