

J. Sandberg – G. Thuma – G. Georgesu

Probabilistic Safety Analysis of Non-Seismic External Hazards

OECD/NEA Task on
PSA of Non-Seismic Off-Site External Events

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The Impact of Climate Change on
the Safety Significance of Harsh Weather
Conditions in Germany

OECD/NEA Task on PSA of Non-Seismic Off-Site External Events

- Background
- General Information
- Subject Areas of the Questionnaire
- Results
- Task Group Conclusions
- Task Group Recommendations

Background

- Increased interest in non-seismic external events
- Tendency towards full scope PSA
- Probabilistic safety objectives
- Natural catastrophes in recent years
- NPP operating events due to harsh weather conditions
- Discussion on climate change
- Successful work on seismic PSA already performed by NEA

General Information on the OECD/NEA Task on PSA of Non-Seismic Off-Site External Events

- Task started in spring 2007
- Based on the evaluation of a questionnaire
 - 4 main subject areas
 - Answers to the questionnaire were given by 12 NEA countries (regulatory authorities or TSOs):
 - Canada, Belgium, Finland, France, Germany, Japan, Korea, Mexico, Slovakia, Switzerland, USA and Taiwan (an observer in NEA)
- Task report published in March 2009:
Probabilistic Safety Analysis (PSA) of Other External Events Than Earthquake, NEA/CSNI/R(2009)4

Subject Areas (1)

1. Regulatory requirements and status of EE PSA
 - Regulatory requirements
 - Current status
 - Objectives
 - National/international guides/standards used

2. Definition and scope of EE PSA
 - Criteria for including events in EE PSA
 - Scope of external hazards to be analysed

Subject Areas (2)

3. Analysis methods

- Identification of potentially significant events
- Combinations of hazards
- Screening
- Frequency estimation
- Identification of initiating events
- Impact on plant systems and secondary effects
- Impact on operators
- Multi-unit impacts
- PSA models
- Recent developments and research

Subject Areas (3)

4. Results and application
 - Results and plant improvements
 - Integration into overall PSA
 - Example events

Results: Regulatory Requirements and Status

- Trend towards requirements for EE PSA
 - Number of countries with requirements

Operating Reactors		New Reactors	
Level 1	Level 2	Level 1	Level 2
4/12	4/12	7/11	6/11

- Varied role of EE PSA
 - General PSA goals
(risk understanding, demonstration of safety goals, identification of vulnerabilities, assessment of modifications, etc.)
 - Assessment of adequacy of design basis (some countries)
- National standards/guides (Germany, Slovakia, Sweden, USA)

Results: EE PSA Definition and Scope

- EE PSA often start with a predefined exhaustive list of hazards
 - In some countries it is limited to a small set of hazards
- In general, events not involving simultaneous initiating event (transient, shutdown) and degradation of safety systems are screened out
- Some EEs are typically included in internal events PSA
 - Loss of off-site power (no additional EE-caused failures)
 - Loss of ultimate heat sink (no additional EE-caused failures)

Results: Analysis Methods (1)

- Mixed screening methods
 - Expected intensity low compared to the design values
 - Frequency below specified cut-off
 - Warning time available for shutdown (in full power PSA)
 - Qualitative analysis
- Consideration of multiple hazards (to some degree, in some countries)
- EE effects on operator performance are considered (in some countries)

Results: Analysis Methods (2)

- Mixed treatment of multi-unit effects
 - Some countries address cross-ties
 - Some countries address negative dependencies (e.g., resource sharing)
- Mixed level of integration in PSA models
- Various research activities are ongoing
 - Frequency-intensity for wind, temperature and seawater level
 - Tsunami PSA
 - Effects of climate change
 - Integrated PSA
 - Standardized models
- No indications of a necessity to change the analysis methods

Results: EE PSA Results and Applications

- EEs can contribute to the overall risk
 - But in general no dominant contribution
- No major vulnerabilities identified
 - But consideration of plant modifications and changes to operating procedures for several plants
- EE PSA results have also been used to, e.g., develop emergency exercises
- Uncertainties are an important issue in EE PSAs
 - But in general no specific information on the treatment of uncertainties has been provided

Task Group Conclusions (1)

- Non-seismic external events, as a group, do not appear to be dominant risk contributors.
- However, depending upon the specifics of the plant design and location, such events can be significant contributors.
- The frequency and intensity of extreme weather events, and consequently their risk significance, may be affected by natural climate variability and by human-induced global warming.
- So far little information is available on the prediction of changes, especially on a regional level, but intensive research is going on worldwide.

Task Group Conclusions (2)

- More work, including research, is needed also in the following areas
 - Uncertainties related to extreme weather conditions
 - Treatment of dependencies
 - Between external events
 - Between initiating events and safety system failures
 - Criteria for screening out certain phenomena

Task Group Recommendations

- Recommendations proposed to all parties active in the PSA field, including international organizations, utilities, regulatory authorities, PSA consultants and research organizations:
 - Follow research on climate change and its effects (including potential effects on nuclear power plants).
 - Re-evaluate the situation on external events PSA in a few years.
 - Encourage analysis of operating events caused by external hazards.
 - Participate in sessions on external events in international conferences, e.g. PSAM and PSA.

The Impact of Climate Change on the Safety Significance of Harsh Weather Conditions in Germany

- Introduction
 - EE PSA in Germany
 - PSA for Harsh Weather Conditions
- Impact of Climate Change on the Safety Significance of Harsh Weather Conditions
 - General Approach
 - Climate Change
 - International Operating Experience
 - Consequences for the safety of German NPPs

EE PSA in Germany

- Safety reviews have to be performed on a decennial basis
 - Sicherheitsstatusanalyse (SSA)
 - Probabilistische Sicherheitsanalyse (PSA)
 - Deterministische Sicherheitsanalyse (DSA)
- Since 2005 the PSA includes external hazards
 - Aircraft crash
 - Explosion
 - Flooding
 - Earthquake

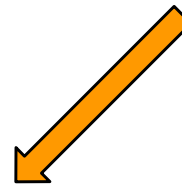
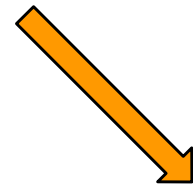
PSA for Harsh Weather Conditions

- Harsh Weather Conditions
 - Storms
 - Adverse long-term weather conditions
- At the moment only flooding has to be considered in the PSA
 - No major contribution to the overall core damage frequency is expected from other harsh weather conditions
- But what about the future?
 - Will climate change have an effect on the safety significance of harsh weather conditions in the near future?

General Approach

Assessment of the regional-scale (Germany) climate impact

Evaluation of the international operating experience of NPPs with respect to harsh weather conditions



Comparison of the expected future meteorological conditions with present-day operating experience

Climate Change

- Climate on earth has always been subject to (partially dramatic) changes
- Most publications on (present-day) climate change refer to the assessment reports of the *Intergovernmental Panel on Climate Change (IPCC)*
 - WG 1 - The Physical Science Basis
 - WG 2 - Impacts, Adaption and Vulnerability
 - WG 3 - Mitigation of Climate Change
- Local climate change effects can be distinctly different from global effects

Global Climate Projections (IPCC, 4. AR, WG 1)

- Present-day global warming rate: approx. 0.7°C per 100 yrs
- The projected warming within the next decades barely depends on the assumption on the future CO_2 emission
- From mid-century on emission scenarios become more important (range: 1.8°C – 4.0°C per 100 yrs)
- The expected global distribution of precipitation will be very heterogeneous
 - Increase of precipitation at higher latitudes
 - Decrease of precipitation in the tropics and in the Mediterranean region

Regional Scale Climate Impact

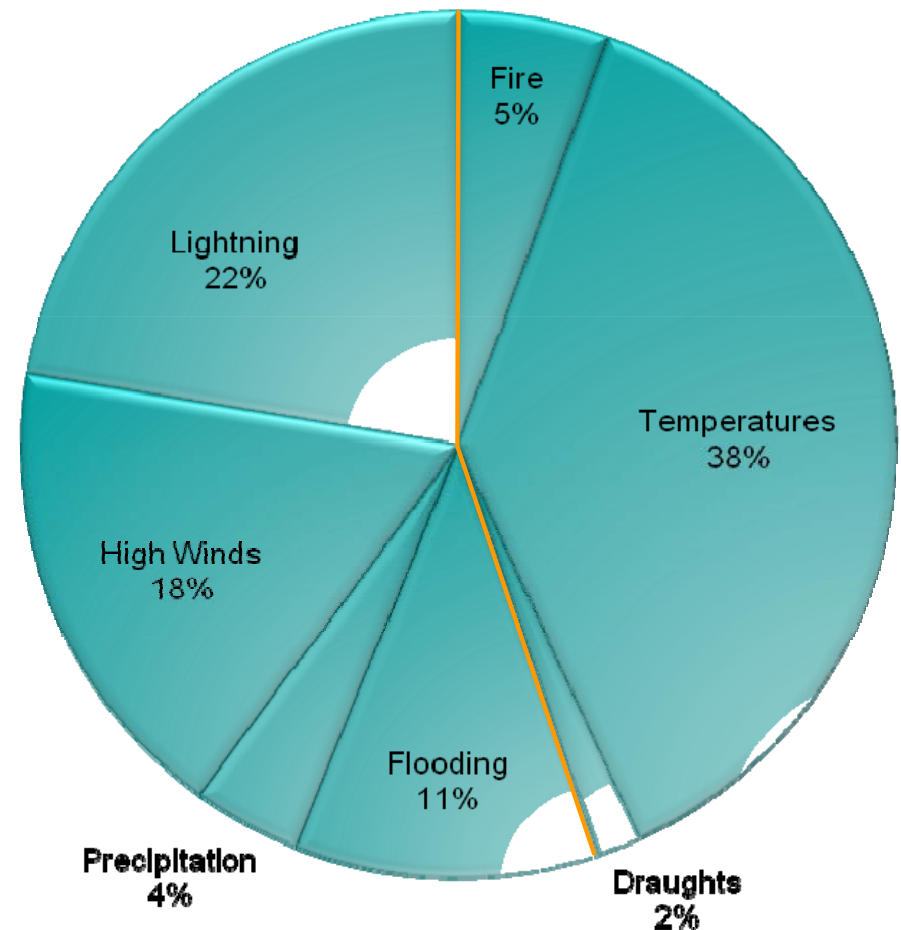
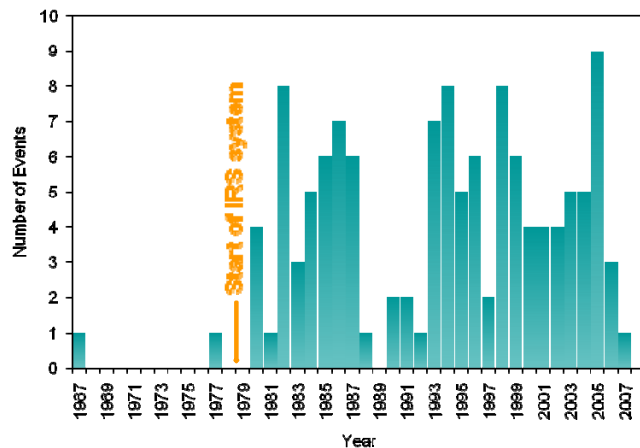
- Projections for Germany indicate only moderate changes:
 - Summer
 - High temperatures and long-lasting droughts will become more frequent
 - Winter
 - Less days exhibiting frost
 - Precipitation predominantly as rain (instead of snow)
 - Total amount of precipitation will increase
 - Frequency of heavy rainfall events will increase
 - Intensity of gales might possibly increase
 - Tornadoes might become more frequent
 - Frequency of thunderstorms and probability of lightning strikes will increase

Evaluation of the International Operating Experience

- Information sources:
 - Incident Reporting System - IRS
 - International Nuclear Event Scale - INES
 - Vertiefte Ereignisauswertung / Besondere Vorkommnisse – VERA
- Hazard spectrum
 - High wind – Temperature effects (including icing)
 - Flooding – Draught
 - Precipitation – Lightning
 - Fires
- Total number of events: 125

Operating Experience with Harsh Weather Conditions

- Almost all events were covered by the plant design
 - Only in a few exceptional cases safety margins were utilized
- Typical Effects:
 - Disturbance of I&C equipment
 - Effects on the cooling water supply



Consequences for the safety of German NPPs

- Due to the moderate climate impact expected for Germany, we will not face more severe events than those covered by our assessment of the international operating experience
 - ⇒ No significant increase in the contribution of harsh weather conditions to the overall risk to NPPs in Germany
 - ⇒ At the moment there is no need to extend the scope of the PSA in Germany to other harsh weather conditions than flooding

For further information please contact

OECD task on EE PSA:

Dr. Jorma Sandberg
phone: +358-9-75988363
email: Jorma.Sandberg@stuk.fi

Radiation & Nuclear Safety Authority (STUK)

Climate Impact on the Safety of German NPPs:

Dr. Gernot Thuma
phone: +49-221-2068607
email: Gernot.Thuma@grs.de

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH