INL/CON-16-39981
PREPRINT

# OVERVIEW OF THE ACTIVITIES OF THE NUCLEAR ENERGY AGENCY WORKING GROUP ON EXTERNAL EVENTS

## 13th International Conference on Probabilistic Safety Assessment and Management (PSAM 13) (2016)

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October 2016

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U.S. Department of Energy
National Laboratory
operated by
Battelle Energy Alliance

# OVERVIEW OF THE ACTIVITIES OF THE NUCLEAR ENERGY AGENCY WORKING GROUP ON EXTERNAL EVENTS

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*The Orgranisation for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) has established a Working Group on External Events (WGEV) that provides a forum for subject matter experts from the nuclear industry and regulators to improve the understanding and treatment of external hazards that would support the continued safety performance of nuclear installations, and improve the effectiveness of regulatory practices, in NEA member countries. This report provides a description of the ongoing work of the WGEV. The work of the WGEV includes the collection of information and conducting a workshop on severe weather and storm surge that brought together a diverse group of subject matter experts to identify commendable practices related to the treatment of severe weather and storm surge consideration in regulatory and operational decision-making. Other work of the WGEV includes looking at science-based screening of external events that are factored into decisions on the safe operation of nuclear facilities; and identification of commendable practices and knowledge gaps on riverine flooding.*

## I. BACKGROUND

The Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. The European Commission also takes part in the work of the Agency. Activities of the NEA and the International Atomic Energy Agency are complementary in supporting the peaceful uses of nuclear energy.

The mission of the NEA is:

- To assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- To provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of senior scientists and engineers with broad responsibilities for safety technology and research programmes, as well as representatives

from regulatory authorities. Figure 1 provides the structure and scope of activities being undertaken by CSNI. It was created in 1973 to develop and co-ordinate the activities of the NEA concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations.

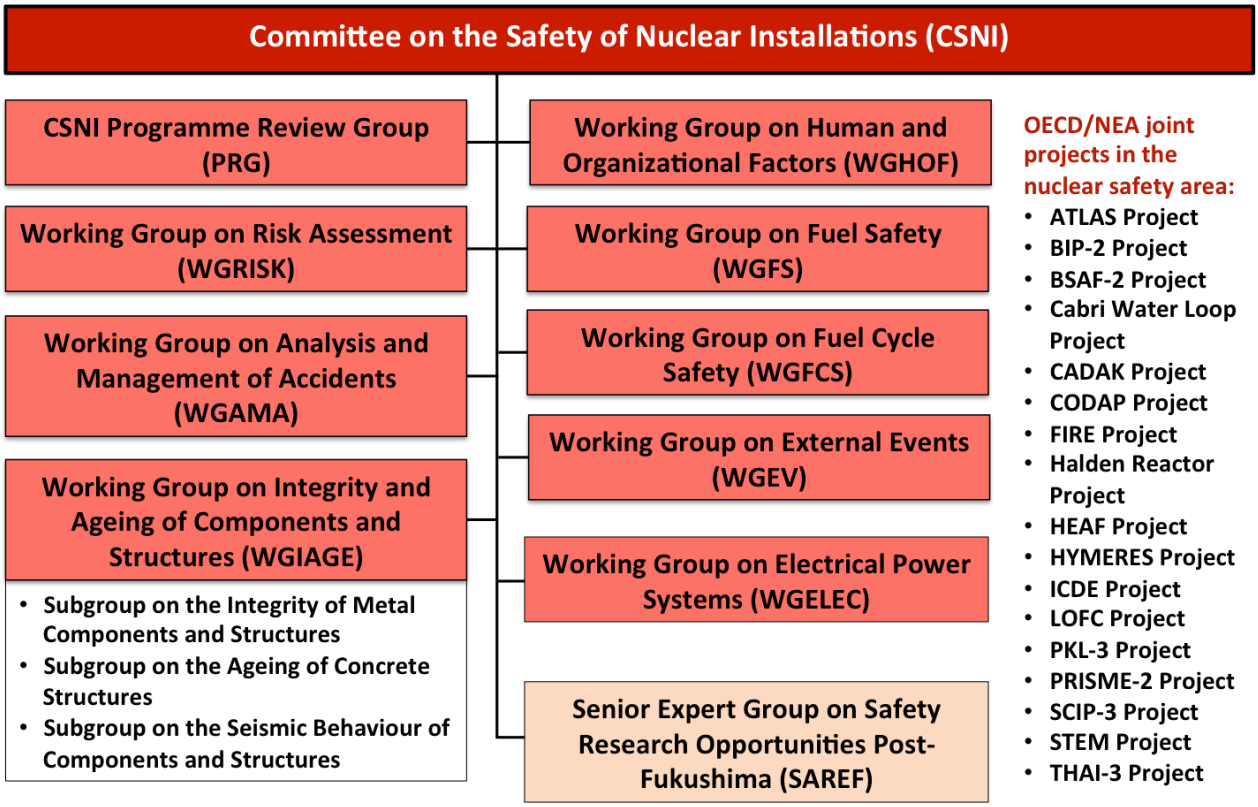


Figure 1: Structure of the Committee on the Safety of Nuclear Installations (CSNI)

The committee's purpose is to foster international co-operation in nuclear safety among NEA member countries. The main tasks of the CSNI are to exchange technical information and to promote collaboration between research, development, engineering and regulatory organisations; to review operating experience and the state of knowledge on selected topics of nuclear safety technology and safety assessment; to initiate and conduct programmes to overcome discrepancies, develop improvements and reach consensus on technical issues; and to promote the co-ordination of work that serves to maintain competence in nuclear safety matters, including the establishment of joint undertakings.

The priority of the CSNI is on the safety of nuclear installations and the design and construction of new reactors and installations. For advanced reactor designs, the committee provides a forum for improving safety-related knowledge and a vehicle for joint research.

In 2014, the CSNI elevated the Task Group on Natural External Events to a Working Group on External Events (WGEV). The main mission of the CSNI WGEV is to improve the understanding and treatment of external hazards that would support the continued safety performance of nuclear installations, and improve the effectiveness of regulatory practices, in NEA member countries.

## II. PROGRAMME OF WORK

The focus of the WGEV's activities is external hazards that are of sufficient common interest to allow sharing of approaches for analysis and oversight. There are however some external events that are under the programme of work for other NEA working groups. For example, determination the consequences of seismic hazards is performed by the Seismic Subgroup of the CSNI Working Group on Integrity and Ageing of Components and Structures (WGIAGE).

The activities of the WGEV concentrate primarily on natural hazards. Man-made hazards are addressed only if there is a particular link to a natural hazard, e.g. when a man-made hazard is used as a bounding/covering event for a natural hazard (for instance: protection against high winds is thought to be ensured by design against explosion pressure waves). The scope of work of the WGEV might be extended to include man-made hazards if a need for specific activities in this direction is identified.

A principle function of the WGEV is that for external hazards, experience, lessons-learned and regulatory approaches are shared, and research activities and initiatives are identified to address knowledge gaps that contribute uncertainties in analyses and decision-making. Members are representatives from regulatory bodies or technical organizations with expertise relevant to external events (e.g. geosciences such as meteorology, geology, hydrology, etc.).

To achieve its mandate, the WGEV meets annually to review its program of work and identify activities that should be added. The Working Group is led by a chair, supported by a bureau of up to six of the leading members of the working group. Specifically, the WGEV:

1. Constitutes a forum for exchange of information and experience on external events in Member countries, thereby promoting co-operation and maintaining an effective and efficient network of experts.

2. Identifies and prioritises current and emerging issues, or knowledge gaps requiring research, related to external events.

3. Identifies issues that appear most suitable to be addressed by WGEV in a co-ordinated way across the international community.

4. Facilitates international convergence on safety issues related to external events and, where practicable, seeks to develop a shared understanding and common positions on important issues.

5. Compares, and where possible benchmarks, practices and methodologies currently applied by Member countries in the assessment of safety-relevant external events.

6. Collaborates with, and supports cross-cutting initiatives proposed by other NEA groups. This includes ensuring that CSNI, the Committee on Nuclear Regulatory Activities (CNRA), the Committee on Radiation Protection and Public Health (CRPPH), and other organizations are consulted as appropriate when potential cross-cutting work on external events is proposed by WGEV.

7. Facilitate specialist meetings, workshops and other means of fostering international collaboration with nuclear and other industries, where appropriate, to further its objectives.

The overall aim of WGEV is to identify best practises for characterizing external hazards, and combinations of external hazards, assessing their consequences and providing effective protective features and strategies. The Working Group has the following six goals to govern the work scope and to provide the technical basis required to properly characterize the risks associated with external events.

Goal 1 - Regulation of [the response to] External Hazards: Identify the requirements and best practises in addressing external hazards to ensure nuclear safety.

Goal 2 - Technical Basis for External Hazards [Characterization], Data Collection, Quantification and Addressing Uncertainty: Identify best practises for characterizing external hazards in terms of frequency, magnitude and duration.

Goal 3 - Combinations of Inter-related Hazards: Identify best practises for assessing combinations of hazards, either simultaneous or sequential, that are otherwise independent and individually assessed may not be challenging, but when combined within scenarios of interrelated events can pose a significant risk.

Goal 4 - Probabilistic Methods to Characterize External Hazards: Working closely with the NEA Working Group on Risk Assessment (WGRISK), identify best practices for determining hazard curves for evaluation of the impacts of external hazards on safety of nuclear installations.

Goal 5 - Challenges and Impacts: Identify best practises to ensure potential consequences and common-mode failures, including direct and indirect effects from the hazard have been considered.

Goal 6 - Effective Protection and Mitigation Concepts: Identify best practises for evaluating the effectiveness of protection features and mitigation strategies.

In principle, the WGEV focuses its activities on 1) high consequence / low frequency external events; 2) external hazards that could potentially result in an event of high safety significance, broad relevance, and interest (i.e. affect more than a few countries); 3) uncertainties and technical issues associated external event hazard assessment methodologies and practises that could benefit from the ongoing work and cooperative efforts; and 4) external hazards that potentially could result in operational challenges and affect all the units on a site, and different sites at the same time.

To achieve the goals, WGEV employs the following strategies:

- Seeks to understand the commonalities and differences in the state-of-the-practices among the countries, either regulatory or technically (e.g., use of probabilistic and/or deterministic methods, etc.).
- Focuses on how various external hazard assessment parameters were used to establish the design basis limits and associated margins (e.g., considerations given to beyond-design-basis cliff edge effects).
- Leverages SMEs from National Institutes or Agencies, and Universities to aid in defining the external events characteristics (e.g. including complex hazards that may produce several interrelated hazards); that may have significant effects on a nuclear site and plant safety – in terms of frequency, magnitude and duration (e.g., wind speed, water volume, etc.) – particularly when historical records are relatively short term (e.g., less than 100 years); and that may potentially not be representative of stationary normalities (e.g., rare and extreme regional weather patterns).
- Understand the current state-of-practise for assessing combinations of hazards (e.g., storm surge; high-tide level, plus very high winds, etc.) that are otherwise independent and individually assessed that may not be challenging, but when combined within scenarios of interrelated events could pose a significant risk (e.g., 100-year flood and mild earthquake, or river flood with high winds, 100-year storm and high storm surge).
- Seek to understand and categorize the direct, indirect, and common-cause effects on safety resulting from external events by engaging SME to assist with the identification of a full range of potential effects and consequences. For example, high winds can impose loads directly on a nuclear plant, but can also indirectly affect supplies of power and cooling water. Alternatively, an earthquake may lead to a dam failure which can cause flooding and loss of power.
- Focus on understanding how changes to the environment and the land use conditions can impact the dynamics and severity of weather driven external events. Specifically, it is important to understand the practises of accounting for the effects of climate change and other environmental changes that can contribute to the severity of natural external hazards over the lifetime of a nuclear site.
- Leverage SME to assist with defining the criteria and characteristics used to design protective measures for various external events. Additional focus will be sought for SMEs on how assess their effectiveness (e.g. using hazard-specific fragility estimates, walkdowns, and exercises for procedures and strategies, etc.).
- Engage National SMEs with the responsibility for forecasting, monitoring, alerting, and warning the general public and critical facilities of the severity of a pending external event (e.g., weather monitoring and flood forecasting, etc.). Additionally, seek to understand the expected actions and resources needed to effectively mitigate potential risks with real-time predictive onset of impact information (e.g., pre-established time limits to reach safe-cold shutdown and implementing supplementary measures).
- Engage and collaborate with other NEA working groups, as appropriate, such as WGIAGE (seismic and structural), WGRISK (probabilistic and deterministic hazard assessment methods and outputs), WGHOF (human factors and reliability support related to the implementation of mitigation measures), WGOE (operational experience), WGRNR (plant siting and external event considerations), and WPNEM (external event emergency preparedness and mitigation).

## III. ACTIVITIES OF THE WGEV

As the WGEV considered the external hazards that were of common interest and that reflected potential benefit from international collaboration, the following topics were identified:

- Severe Weather and Coastal Storms: Tropical and extra tropical, high winds, intense wide spread precipitation (wet of frozen), lightning, coupled with airborne debris and storm surge with waterborne debris.
- Severe Local Storms: Tornados, high winds, local intense precipitation coupled with intense lightning.
- Riverine Flooding: Causal factors – frequent storms (rain or snow) affecting the watershed, dam failure(s) – associated hazards include waterborne debris, erosion, wind driven wave, high river water velocities etc.
- Extreme Temperatures: Extreme prolonged heat or extreme prolonged cold)
- Tsunami: Extreme storm surge propagation resulting from seismic event.
- Dam Failures: Dam failure mechanisms for various dam types; dam failure breach modelling; safety assessment and maintenance, etc.

From these topics, WGEV first focused on better understanding how regulators addressed actions to respond to severe weather and coastal storms. The work of the WGEV built upon a survey prepared the Task Group on Natural External Events (TGNEV) and submitted to the NEA member countries. This survey sought out information on how the contributing countries review and assess the adequacy of protection against tropical cyclones (Including typhoons and hurricanes), tropical and extra-tropical storms, and the storm surge associated with these severe weather phenomenon. Based on this survey, the WGEV concluded that there would be benefit realized by:

1. Gaining an in-depth understanding of how a deterministic storm surge assessment methodology is conducted, including the data requirements, and the assumptions used to determine the design basis levels for storm surge events;
2. Gaining an in-depth understanding of probabilistic and statistical analysis, including the treatment of uncertainties, the data requirements, and the assumptions used to define the design basis surge level; and
3. Understanding the limitations of the historical record / data for a particular nuclear power plant site (both in time and number of events), and how methods are used to combine the outcomes and insights from deterministic and probabilistic approaches.

On February 24 – 26, 2016, the NEA hosted a workshop on Severe Weather and Storm Surge. The workshop was set up with three sessions – Regulatory Objectives and Approaches to Accomplish Them – Severe Weather Assessment & Societal Impacts (Protecting People and Infrastructure) – Informing the Regulatory Process through gap analysis. The workshop built upon the work done in the summer of 2014 to survey NEA members on practices understanding and analysis of severe weather events involving high winds and flooding. The results of the survey are documented in a CSNI Technical Note, NEA/SEN/SIN/WGEV(2015)1, "Technical Note on Severe Weather with Concurrent Flooding and High Wind."

There were 45 workshop participants with representatives from Belgium, Canada, France, Germany, Japan, Netherlands, South Korea, Sweden, Switzerland, and the United States of America. In addition, a representative from the European Commission, a representative from the World Meteorological Organization (WMO), and two representatives from Jensen Hughes (a US commercial vendor) participated in the workshop. The attendees included researchers from universities, national weather services, commercial vendors, and other national agencies working in the management of coastal resources, nuclear regulatory technical support organizations, and nuclear regulators.

In Session 1, some of the commendable practices identified included the use of information from other industries to obtain a broader perspective on how to address the questions raised in the assessment of external hazards; the practice of characterizing and propagating uncertainties in assessing external hazards for consideration in regulatory decision making; rigorous testing of protective measures where practical. Challenges identified include the Western European Nuclear Regulators Association (WENRA) reference level for protections to recurrence intervals of $10^{-4}$ for external hazards; and addressing large uncertainties associated with rare events. Knowledge gaps were identified related to climate change impacts on external hazards assessment; and the appropriate probabilistic metric (i.e., the WENRA reference level of $10^{-4}$) for making regulatory decisions considering insights that might be gained from physics-based analysis approaches.

In Session 2, a commendable practice was identified related to the development of enhanced storm surge forecasting and visualization tools that can be used in real time to support decision making at the local and regional level. Challenges were noted in how to assess and interpret the frequency of occurrence of rare events; the need for additional computational power to run more advanced analytical models; and determining the appropriate balance of different modeling and analytical approaches to meeting the needs of decision makers and appropriately assess the external hazard in the timeframe available.

In Session 3, participants discussed areas where the continued engagement of the nuclear and non-nuclear subject matter experts would be beneficial. These include, in part, the technical fidelity needed to make a particular decision, either regulatory or related to a protective measure in response to a hazard. Also, it was made very clear that communication is critical - not just about the hazard assessment, but on sharing the work being done by different organizations, in different countries, on severe weather to support building a common language and approaches to addressing the hazards. Enhanced communication was recognized as providing the opportunity to ensure that the right experts are brought to assess events in advance of them occurring and during the event itself. Further, the workshop participants recognized the importance of providing appropriate metrics for determining the magnitude of hazards that need to be considered in regulatory decision making and questioned whether the return period for external hazards was the appropriate metric.

In closing the workshop, the participants expressed the strongly held view that the timing of the workshop, and bringing together subject matter experts from a wide range of industries and organizations, was extremely important. The ongoing activities of many of the participants in their own organizations will be able to take advantage of the broader community of subject matter experts that were brought together by this workshop, achieving one of the primary objectives.

### III.A. Other WGEV Activities

The WGEV is currently performing an assessment of the current state of practice in the science-based screening of external hazards. This work focuses on the use of an absolute frequency to screen external events as potential sources of hazards to nuclear facilities. This work will explore enhanced screening approaches that look at a risk-informed (frequency/consequence) mechanisms to determine natural limits to modelling for certain types of initiating events. Further, it will explore screening approaches that rely on physical conditions (e.g., maximum atmospheric precipitation concentration may limit rainfall events) that may limit the frequency or magnitude of external hazards. Included in the screening consideration will be the idea of how uncertainty may be captured and how it impacts potential screening approaches. A review of the relevant technical literature (including research from operations research and decision sciences) will be performed to ascertain the current state of the art in assessing probabilistic hazards and applying the results within a decision-making framework (i.e. setting of appropriate policy goals). The results of this assessment will be used to identify both best practices and gaps in screening approaches currently in use for NPP risk assessment.

Another area currently being examined by the WGEV is riverine flooding. The scope of work under this activity includes conducting a survey that is intended to lead to an informed understanding of the regulatory requirements as well as the scientific and technical approaches used by mature nuclear regulatory authorities to deal with riverine floods. Further, the survey will address all relevant aspects of hazard assessment and flood control measures at nuclear facilities (e.g. availability of data, assessment methods, and protection measures). It will build on the approach that was undertaken to address severe weather hazards and include lessons learned from recent operating experience (e.g. at Fort Calhoun NPP). Following an initial assessment of the survey results, a workshop will be planned and held to involve relevant experts (could include non-nuclear experts) in identifying activities required to address knowledge gaps and potential for further improvements. Following the evaluation of the survey, a workshop will be held to involve a broader range of engineers, hydrologists and other experts in this subject - also from non-nuclear fields - to address key issues and identified technology gaps. The discussions will help to specify further research and develop needs and potential for improvements in nuclear facility design.