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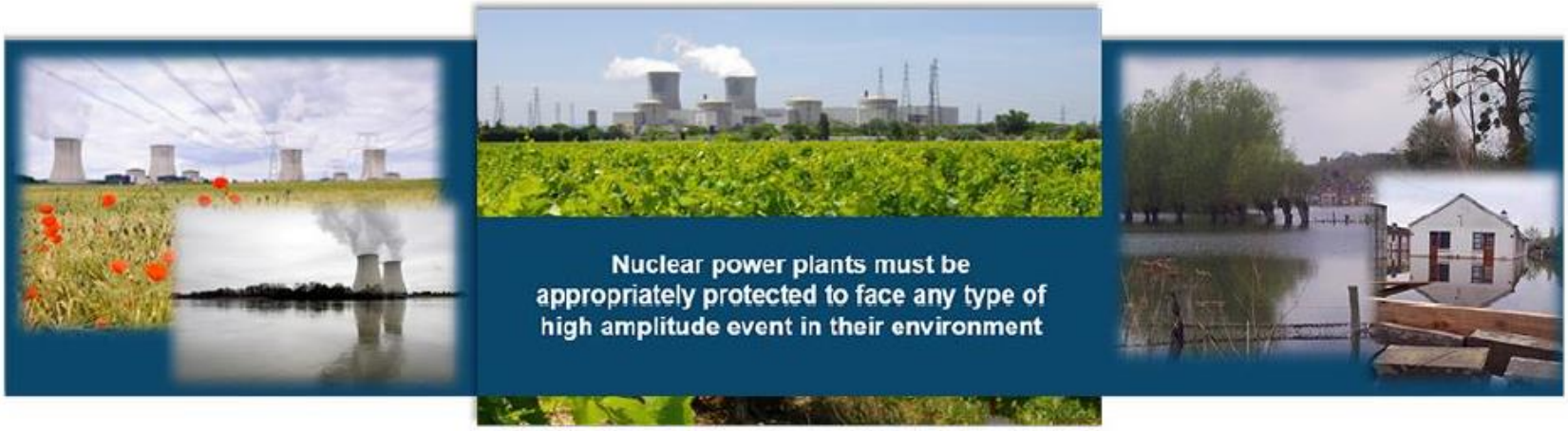
Findings and perspectives for research or collaborative activities from the European project ASAMPSA_E



ASAMPSA_E OBJECTIVES

Project concept 7th FP (EC call – November 2012)

- The nuclear accident in Japan resulted from the combination of two correlated extreme external events (earthquake and tsunami). The consequences (flooding in particular) went beyond what was considered in the initial NPP design.
- Such situations can be identified using PSA methodology that complements the deterministic approach for beyond design accidents. If the performance of a Level 1-Level 2 PSA concludes that such a low probability event can lead to extreme consequences, the industry (system suppliers and utilities) or the Safety Authorities may take appropriate decisions to reinforce the defence in depth of the plant.
- Main ASAMPSA_E objective was to promote/identify appropriate methods/guidance applicable to examine, with PSAs, the NPPs safety (in their environment) after last reinforcements (e.g. post Fukushima Dai-Ichi accident).

"Extended PSA" definition

An *extended PSA* (probabilistic safety assessment) applies to a site of one or several Nuclear Power Plant(s) (NPP(s)) and its environment. It intends to calculate the risk induced by the main sources of radioactivity (reactor core and spent fuel storages, other sources) on the site, taking into account all operating states for each main source and all possible relevant accident initiating events (both internal and external) affecting one NPP or the whole site.

- The ASAMPSA_E project aimed at helping European stakeholders to develop efficiently such *extended PSA* and verify that all *dominant risks* are identified and managed.

For existing NPPs, there is a link to be done with the "design extension conditions" concept as defined by IAEA or WENRA

Partners

Beneficiary Number *	Beneficiary name	Beneficiary short name	Country
1(coordinator)	Institute for Radiological Protection and Nuclear Safety	IRSN	France
2	Gesellschaft für Anlagen- und Reaktorsicherheit mbH	GRS	Germany
3	AMEC NNC Limited	AMEC NNC	United-Kingdom
4	Ricerca sul Sistema Energetico	RSE S.p.A.	Italy
5	Scandpower	SCANDPOWER	Sweden
6	Nuclear Research Institute Rez pl	UJV	Czech
7	Universität Wien	UNIVIE	Austria
8	Cazzoli Consulting	CCA	Switzerland
9	Italian National Agency for New Technologies, Energy and the Sustainable Economic Development	ENEA	Italy
10	Nuclear Research and consultancy Group	NRG	Nederland
11	IBERDROLA Ingeniería y Construcción S.A.U	IEC	Spain
12	Electricité de France	EDF	France
13	Lietuvos energetikos institutas (Lithuanian Energy Institute)	LEI	Lithuania
14	NUBIKI	NUBIKI	Hungary
15	Forsmark kraftgrupp AB	FKA	Sweden
16	AREVA NP SAS France	AREVA NP SAS	France
17	NCBJ Institute	NCBJ	Poland
18	State Scientific and Technical Center for Nuclear and Radiation Safety"	SSTC	Ukraine
19	VUJE	VUJE	Slovakia
20	NIER Ingegneria	NIER	Italy
21	VGB PowerTech e. V	VGB	Germany
22	TRACTEBEL ENGINEERING S.A.	TRACTEBEL	Belgium
23	BeL V	BeL V	Belgium
24	Institut Jozef Stefan	JSI	Slovenia
25	Institute of nuclear research and nuclear energy – Bulgarian Academia of science	INRNE	Bulgaria
26	Regia Autonoma Pentru Activatati Nucleare Droberta Tr. Severin RA Suc	INR	Roumania
27	Technical University of Sofia – Research and Development Sector	TUS	Bulgaria
28	AREXIS S.A.R.L.	AREXIS	France

External Expert Advisory Board (EEAB)

1	US-NRC	US
2	JANSI	Japan
3	TEPCO	Japan

ASAMPSA_E KEY DATES

- JULY 1st 2013 : kick-off meeting at IRSN, Fontenay-aux-Roses
- MAY 26-28th 2014 : first End-Users workshop hosted by FKA, Uppsala
- MAY 10th 2016 to JULY 20th : all ASAMPSA_E reports have been sent for external review
- SEPT,12-14th 2016 : second End-Users workshop, Vienna University.
- APRIL 30th 2017 : final versions of the ASAMPSA_E reports are be publically available.

27 TECHNICAL REPORTS ARE AVAILABLE ON THE ASAMPSA_E WEBSITE (www.asampsa.eu)

General issues for PSA

D30.2 Lessons of the Fukushima Dai-ichi accident for PSA
D21.2 List of external hazards to be considered in ASAMPSA_E
D30.7 vol 1 Extended PSA and its Use in Decision Making (summary)
D30.7 vol 2 Methodology for Selecting Initiating Events and Hazards for Consideration in an Extended PSA
D30.7 vol 3 Risk metrics for extended PSA
D30.7 vol 4 The Link between the Defence-in-Depth Concept and Extended PSA
D30.7 vol 5 The PSA assessment of Defense-in-Depth – Memorandum and proposals

External hazards and PSA

D50.15 vol 1 Report 1 – Guidance document on practices to model and implement EARTHQUAKE hazards in extended PSA (final version)- Volume 1
D50.15 vol 2 Report 1 – Guidance document on practices to model and implement EARTHQUAKE hazards in extended PSA (final version)-Volume 2
D50.16 Report 2 – Guidance document on practices to model and implement FLOODING hazards in extended PSA (final version)
D50.17 Report 3 – Guidance document on practices to model and implement EXTREME WEATHER hazards in extended PSA (final version)
D50.18 Report 4 – Guidance document on practices to model and implement LIGHTNING hazards in extended PSA (final version)
D50.19 Report 5 – Guidance document on practices to model and implement BIOLOGICAL hazards in extended PSA (final version)
D50.20 Report 6 – Guidance document on practices to model and implement MAN-MADE HAZARDS AND AIRCRAFT CRASH in extended PSA (final version)

27 TECHNICAL REPORTS ARE AVAILABLE ON THE ASAMPSA_E WEBSITE (www.asampsa.eu)

L2 PSA and severe accident management strategies

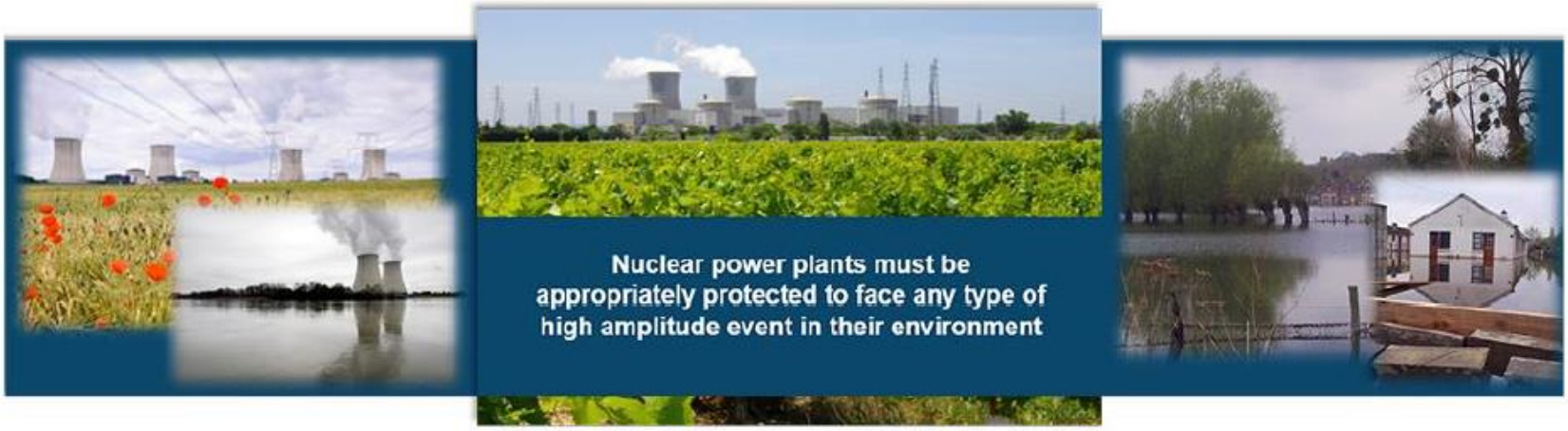
ASAMPSA2- ASAMPSA2_guidelines_vol1_L2PSA_general.pdf
ASAMPSA2- ASAMPSA2_guidelines_vol2_L2 genII&III reactors.pdf
ASAMPSA2- ASAMPSA2_guidelines_vol3_genIV.pdf
D40.7 vol1 ASAMPSA_E guidance for L2 PSA – Summary
D40.7 vol2 ASAMPSA_E guidance for L2 PSA- Implementing External Events in L2 PSA
D40.7 vol3 ASAMPSA_E guidance for L2 PSA – Guidance on the verification and improvement of SAM strategies with L2 PSA
D40.7 vol4 Complement of existing ASAMPSA2 guidance for shutdown states of reactors, spent fuel pool and recent R&D

PSA End-Users survey learnings

D10.2 Synthesis of the initial survey related to PSAs End-Users needs
D10.5 Synthesis report of the End-Users survey and review of ASAMPSA_E guidance, and final workshop conclusions. Identification of follow-up useful activities after ASAMPSA_E

Bibliography

D21.1 Bibliography – Existing Guidance for External Hazard Modelling
D22.1 Summary report of already existing guidance on the implementation of External Hazards in extended Level 1 PSA
D40.2 Summary report of already published guidance on L2 PSA for external hazards, shutdown states, spent fuel storage
D30.1 Bibliography on regulatory requirements on the implementation of defense in depth for nuclear power plants



FINDINGS AND PERSPECTIVES

Perspectives *[getting future extended PSA ?]*

- The PSA community is facing a series of complex and difficult problems to extend the existing PSAs ; efforts and support from research shall be maintained to progressively increase the quality of these studies, identify remaining weaknesses and opportunities for further improvement in NPPs and provide relevant inputs for decision-making.

See

- ASAMPSA_E, 2016, *Lessons of the Fukushima Dai-ichi accident for PSA*
- *All other reports*

Perspectives *[initial list of hazards for extended PSA]*

- The list of hazards developed in ASAMPSA_E is a relevant starting point for screening initiating events; from this list, an appropriate site specific list of hazards and hazard combinations can be built; there is no need to complete this list of hazards; its implementation for a site is a considerable task.

See

- ASAMPSA_E, 2017, *List of external hazards to be considered in ASAMPSA_E,*

Perspectives *[screening]*

- **Similar methodologies to select initiating events and hazards for an extended PSA (during screening) are applied in different countries**; the screening task is crucial in order to allocate resources on topics where the risk is dominant; the process requires views on larger scales than single reactors, because additional threats may arise from the site and its surrounding area.

See

- ASAMPSA_E, 2017, *Methodology for Selecting Initiating Events and Hazards for Consideration in an Extended PSA*

Perspectives *[PSA risk metrics]*

- A number of risk metrics is available for L1 and L2 PSA and these can be used for extended PSA. Using **a "global risk"** approach to consider extended PSA results in decision-making has **advantages** such as the easier comparison with acceptance criteria, but also has **dis-advantages** (e.g. the "quality" of the different parts of such extended PSAs cannot be homogeneous or important aspects of the full risk profile can be hidden). It can be **practical to clearly separate the PSA elements** (internal events PSA, earthquake PSA, flooding PSA, fire PSA, extreme weather PSA, …) and to have **a special treatment for highly uncertain elements**.

See

- ASAMPSA_E, 2017; *Risk Metrics and Measures for an Extended PSA*

Perspectives *[PSA and DiD]*

- PSA results can be used to investigate the application of the defense-in-depth (DiD) on a NPP for both, design and operation. This is a useful application of PSAs. A majority of the ASAMPSA_E partners consider that the PSA models in event trees structure can be developed **independently** of the DiD application for a NPP.

See

- ASAMPSA_E, 2017, *The Link between the Defence-in-Depth Concept and Extended PSA*

Perspectives *[from topical reports] (1/2)*

- The **geosciences cannot yet support the determination of both frequencies and features of rare natural events** for PSA with sufficient accuracy, for example:
  - assessments of all types of natural hazard are generally based **on short time series of data** (decades to few hundred years only), which make predictions for events with low occurrence probabilities (10^{-4} and less) extremely challenging,
  - seismic hazard assessments are mainly based on historical seismic data and **only very limited information on active faults** is available, although such information increases the reliability of hazard predictions,
  - **extreme weather conditions** are identified as a significant contributor to the risk of accident but there is a lack of available methodologies to assess the frequencies of severe events including combined and correlated events,

Perspectives *[from topical reports] (2/2)*

- Lightning impacts are in general not considered in PSA, except as a contributor to the external grid failure. After ASAMPSA_E **it is still open if (and how) PSA** shall be developed to examine impacts and faults propagation in electrical systems.

See

- ASAMPSA_E, 2017, *Guidance documents on practices to model and implement EARTHQUAKE, FLOODING, EXTREME WEATHER, LIGHTNING, BIOLOGICAL, MAN-MADE AND AIRCRAFT CRASH hazards in extended PSA*
- *(6 reports)*

Perspectives *[external hazards in L2 PSA]*

- External hazards L2 PSA models can be developed based on the existing L2 PSA and used methodologies ; **there are limited hazards specific aspects**,
- External hazards L2 PSA is not yet a common practice and should be developed **during the coming years**.

See

- ASAMPSA_E, 2017, *Implementing external Events modelling in Level 2 PSA*,

Perspectives *[L2 PSA and SAM strategies]*

- Extended L2 PSA is **a valuable tool for further improving SAM strategies** and further research is recommended. International exchanges on good practices should be pursued.

See

- ASAMPSA_E, 2017, *Verification and improvement of SAM strategies with L2 PSA*.

Perspectives *[L2 PSA – General, R&D]*

- Research which could help improving existing L2 PSA, on :
  - long term resilience of containment in severe accident conditions,
  - improved fission product modelling using the recent R&D programs,
  - detailed modelling of flammable gas (propagation outside the main containment into auxiliary buildings, the containment venting system), impact of containment spray system activation, probabilities of ignition for potentially flammable atmosphere in different parts of the plant),
  - modelling the uncertainties that can impact the accident progression paths.

See

- ASAMPSA_E, 2017, *Verification and improvement of SAM strategies with L2 PSA*.

Perspectives 1/2 *[Multi-units PSA]*

- Multi-units PSA are far from the common existing practices although developments are now on-going in some countries. It is premature to harmonize practices while sharing successful technics is encouraged. Nevertheless, some conclusions are proposed :
  - there is **no justification to limit the PSA scope to single NPPs**: the specific risks associated with the presence of several NPPs on a site have to be identified and quantified,
  - the selection of initiating events (screening) is **common for single unit (SU) and multi units (MU) PSA**,
  - the common **risk measures** (CDF, FDF, LRF, LERF) for SU PSA **can be easily extended to MU PSA**,
  - the **quantitative probabilistic safety criteria** that should be associated to MU PSA have to be **further discussed** and harmonized at the international level,

Perspectives 2/2 *[Multi-units PSA]*

- defining **the structure of the event trees** for a MU PSA appears to be challenging due to the number of basic events to be considered and due to the interaction between the L1 and the L2 PSA parts of the modelling,
- **robust separation** between NPP units helps also in building a MU PSA model,
- the HRA is of key importance for MU PSA but it can be recommend to focus the analysis **on few important management strategies at a site scale**.

See

- ESREL 2017, *Objectives, challenges and development of multi-unit PSA – considerations from the ASAMPSA_E project.*

Perspectives (1/3) *[from PSA End-Users workshop]*

- Comparison at international level on risk informed decision-making using extended PSA,
- Comparison on the importance of non-safety system and secondary impacts in external hazards assessment,
- Research on earthquake aftershocks modelling (probabilities of occurrence, magnitude),
- Research on application of fault rupture modelling for earthquake PSA,
- Research on methods to calculate the probability of fire induced by earthquakes,
- Sharing experience on multi unit PSA practices,
- Research on combination of hazards assessment and modelling,

Perspectives (2/3) *[from PSA End-Users workshop]*

- Exchanges on uncertainties in the assessment of flooding event frequency for the different causes or assessment of SSCs fragilities for flooding (e.g.: water propagation modelling),
- Comparison of methodologies to assess simultaneous accidents in reactor and SFP,
- Research on applicable methodologies to predict extreme weather conditions,
- Organisation of a benchmark on existing PSA with regard to LUHS (loss of ultimate heat sink): risk quantification and UHS design comparison (with back fitting examples),

Perspectives (3/3) *[from PSA End-Users workshop]*

- In relation with PSA activities, further exchanges on calibration of lightning protections and comparison with solutions applied in other area (data server, military applications, communication devices, airplane traffic, etc.),
- Exchanges on external hazards L2 PSA developments, including modelling of offsite emergency rescue teams and mobile equipment.

See

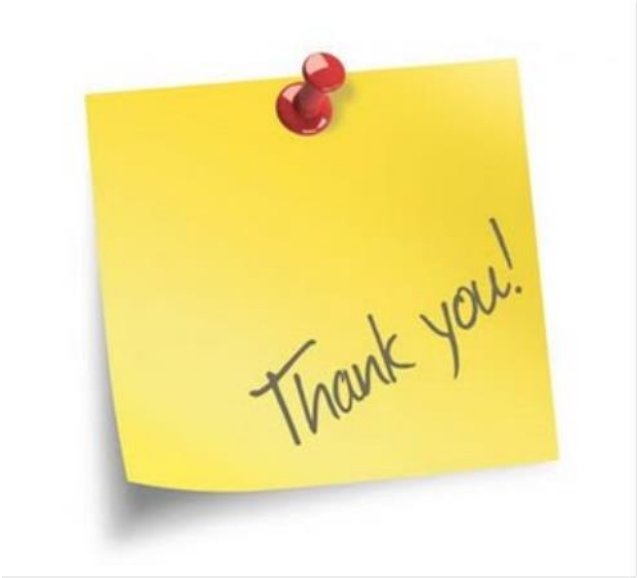
- ASAMPSA_E, 2017, *Synthesis report of the End-Users survey and review of ASAMPSA_E guidance and final workshop conclusions. Identification of follow-up useful activities after ASAMPSA_E*

CONCLUSION (1/2)

- The project ASAMPSA_E was intended to promote and help the development of high quality PSA for NPPs in Europe, with a larger scope. This task is now on-going in some countries. The ASAMPSA_E guidance reports can be applied as starting point.
- Representatives of a number of PSA teams' showed interest for the ASAMPSA_E project during its development. This project, with open results, was quite unique in terms of diversity of topics examined during a rather limited time period.
- The ASAMPSA_E project also identify a number of issues that must be solved to extend the scope of existing PSA and some expectations from research activities.

CONCLUSION (2/2)

- Undoubtfully, the PSA teams in different countries will progressively find the solutions to develop these extended PSA.
- It would be valuable, after this ASAMPSA_E project, to organize **a new European framework** where these teams can present their solutions, explain remaining difficulties, with the objective to contribute to the progressive increase of the quality of these extended PSAs in all countries.
  - [Discussions on this opportunity are on-going]


Thank you!


QUESTIONS ?