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State of the Art Mapping of the Initiating Event Identification Methods by Bibliometric Analysis

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Abstract. Probabilistic Safety Assessment (PSA) can be used to evaluate the safety of Nuclear Power Plants (NPPs). To improve NPPs' safety, reactor safety technology is always developing. Each technology will have a different hazard that can cause an Initiating Event (IE). Of course, this development will affect IE. IE is the event that can affect normal operation and have the potential to cause worst-case conditions when the mitigation system does not work properly. A comprehensive, detailed bibliometric analysis of NPP PSA and IE remains absent from the literature. The objective of this paper is to discuss existing research and identify future trends through bibliometric analysis and a literature review in the PSA and IE domains. The search criteria include the keywords, publication period, publication type, and language. Ninety-five scientific papers were identified during the first screening and were included in the bibliometric analysis. The Bibliometric analysis will represent the keyword network using VOSviewer 1.6.20. The second screening stage is used to strengthen the analysis and generate 43 articles as objects for the literature review. The results showed that the topic of identifying and developing identification methods has not been widely discussed and has become an important research topic. The results of this analysis strengthen the research hypothesis that developing IE methods for new technology NPPs, including High Temperature Gas Cooled Reactors (HTGRs), is feasible.

Keywords: Nuclear Reactor, Process Safety, Reference Analysis

INTRODUCTION

As an archipelago country, Indonesian electrical systems are mostly interconnected on the larger islands, but some smaller islands remain isolated and still face electricity shortages (Budi *et al.*, 2024). One potential solution to Indonesia's electrical grid issue is the use of a Small Modular Reactor (SMR), which could

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electrify many small, isolated islands (Deswandri *et al*., 2024). SMR is an advanced technology with a maximum power capacity of 300 MWe per unit. The SMR types are High Temperature Gas Cooled Reactors (HTGRs), Water Cooled Reactors (WCRs), i.e., Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs), Molten Salt Reactors (MSRs), and Micro Modular Reactors (MMRs). From the safety and economic perspectives, each reactor type offers advantages and challenges. One of the SMR types is the HTGR, designed to possess inherent safety, reliability, and high efficiency. The high-temperature output can supply electricity and be implemented in the cogeneration process and several industrial process applications, i.e., desalination, coal gasification/liquefaction, and hydrogen production (Riyandwita *et al*., 2023). Although many studies confirm that HTGRs have excellent safety (Trianti *et al*., 2023), commercial operational experience remains limited (Deswandri *et al*., 2024).

The International Atomic Energy Agency (IAEA) recommends the use of a Probabilistic Safety Assessment (PSA) to evaluate the performance of reactor safety systems. PSA has been widely used to evaluate NPP safety systems, identify design vulnerabilities, develop accident scenarios, assess the installation's safety level, and estimate potential risks (Tyas, Purba, Sukmana, 2024). PSA Level 1 starts by identifying the Initiating Event (IE) that can disrupt the operation. IE is defined as all postulated events that could potentially cause serious consequences and therefore need to be considered in design because they have a significant frequency of occurrence (IAEA, 2019). An IE can cause accidents when its mitigation systems fail. IEs include external hazards, internal hazards, component failures, or human errors (Purba, 2018), and a combination thereof.

The development of reactor design, including safety technology, will change IE. One challenge in developing a new reactor is identifying the IE. As learned from the Fukushima Daiichi accident, a low frequency of IE can pose a significant risk if they cannot be identified, prevented, and mitigated. The IAEA has issued a list of initiating events for several types of PWRs, BWRs, and research reactors. The availability of data and information is very helpful. Still, limited operational experience and limited ability to conduct PSAs on new reactor types will make it difficult to obtain a detailed list of IEs (So and Kim, 2021), and may not be relevant for HTGR. Every development in design and safety technology can change IE. No guideline must be followed in identifying IE for a new NPP. However, identification generally relies on a combination of methods (Zhou *et al*., 2023), as each method has advantages and limitations.

In determining the research topic, it is necessary to conduct a study that demonstrates the topic's novelty. Various approaches can be used to examine the trend of a study, producing more comprehensive, detailed, and visual results, including bibliometric analysis and literature reviews. As far as the author knows, such a comprehensive and detailed bibliometric visual analysis and literature review of PSA Level 1 and initiating events for NPPs, is still missing. It is necessary to conduct a bibliometric analysis that is complemented by a literature review to identify future research topics.

The objectives of this paper are (i) to identify keywords in the domain of PSA Level 1 and initiating events, (ii) to discuss the limitations of existing research on PSA Level 1 and initiating events, and (iii) to assist

readers in identifying the trends in PSA research in the future. This study introduces the scientific mapping of the PSA Level 1 approaches and identifies initiating events, and provides recommendations for future research directions. The rest of the paper is structured as follows. The stages of the bibliometric and literature review methodology are described in Section 2. Section 3 discusses the results, including the search criteria, the keyword network, the gaps in existing research, and potential future research directions. Finally, Section 4 is the conclusion of this research.

METHODOLOGY

This research combines bibliometric analysis and literature review to investigate the limitations of existing research and identify possible future research directions within the scope of safety assessment, PSA, and IE.

The methodology is presented in Figure 1 and consists of four steps. The first step is the first screening, which involves selecting a publication database and determining the search criteria. The search criteria include keywords, publication period, publication type, and language. The second step is the bibliometric analysis. In this step, the obtained data are analyzed using VOSviewer 1.6.20 to identify keyword networks and infrequently occurring keywords.

To obtain a more in-depth analysis, a literature review was conducted in the last step. The scientific papers included in this review were selected through a second screening generated in the third step. The fourth step is the literature review, which includes describing the research questions and presenting the results. In this last step, research questions are evaluated, and the results are analyzed and discussed.

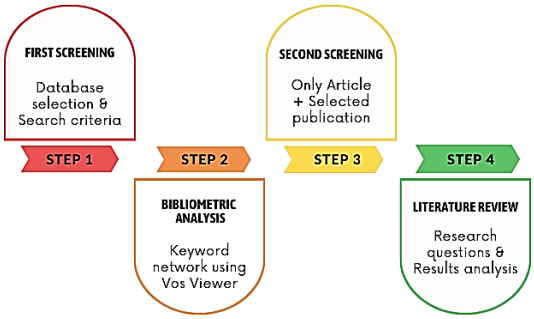

Fig. 1: Stage of bibliometric analysis and literature review

RESULTS AND DISCUSSION

First Screening

Database Selection

This study used scientific publications retrieved from the Scopus database, which is widely acknowledged as the largest peer-reviewed academic database across various research fields (Piwowar-Sulej *et al.*, 2023). Scopus database is also regarded as the greatest citation and abstract collection encompassing a broad range of research areas (Hashem E AR *et al.*, 2023). According to other studies, the Scopus database is significantly more thorough than the WoS database, as it includes articles indexed in WoS and offers broader coverage (Kiflee, Hasbullah, Madli, 2024). This is based on the overlap technique. Numerous types of bibliometric research have used Scopus data as a source. Various analyses are supported by the many quality attributes of Scopus that have been specified (Yu, Zhang, Labeau, 2024).

Search Criteria

It was necessary to specify the publication search criteria after deciding on the scientific database to be used. Generally,

the primary search parameters are utilized by selecting keywords, year limits, languages, and document types. Table 1 shows the filtering criteria. The terms "safety assessment," "risk assessment," "probability safety assessment," and "initiating event" are used in the literature search across "article titles, abstracts, and keywords" to ensure thorough results. During the search, articles were screened using a publication-year limit of 2018 to 2024. This time restriction is intended to maximize the currency, relevance, and methodological focus of the literature review. Another search criterion is that the articles be in English, with the scope limited to journal articles, review papers, and conference papers. The search was conducted in May 2024. From the first screening, we obtained 95 scientific papers as input for bibliometric analysis.

Table 1. Search criteria on Scopus database

Criteria	Searching
Keyword	"safety assessment", "risk assessment", "probabilistic safety assessment", and "initiating events"
Year	2018 until 2024
Language	English
Document Type	An article, review, and conference paper

Bibliometric Analysis

To create easily readable statistics and visualize networks of the primary co-occurrence keywords, the screening database was fed into VOSviewer 1.6.20. A two-dimensional network generated by VOSviewer 1.6.20, based on nations, authors, co-authorship, citations, co-citations, and keyword co-occurrences, provides an effective summary of the results (Iuliis *et al.*, 2024). The first screening yielded 95 scientific papers for the bibliometric analysis. Ninety-five scientific papers were entered into VOSviewer 1.6.20 with 3 co-occurrence criteria, 5 clusters, and keyword cleaning or filtering (removing the same and less important keywords). The results yielded 49 keywords, forming a keyword network as shown in Figure 2.

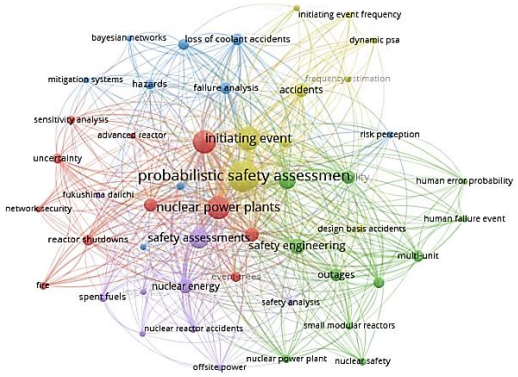

Fig. 2: PSA and IE keyword network (*3 co-occurrence criteria, 5 clusters with 49 keywords*)

Bibliometric analysis focused on analyzing keywords from 95 scientific works and citations for certain scientific works. Keywords are sorted from the most general words to the specific words. The words start from "safety assessment", "risk assessment", "probabilistic safety assessment", and "initiating events". Derivatives or more specific words from IE are DBA and DEC. A helicopter-view illustration of the relationship between these words is presented in Figure 3.

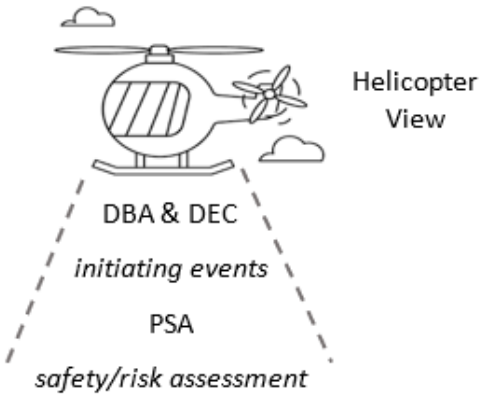

Fig. 3: Helicopter view for keywords relation

The network amongst safety assessment, PSA, IE, DBA, and DEC is presented in Figure 4.

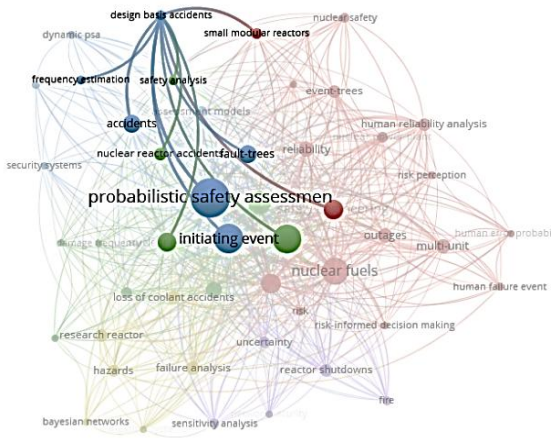

Fig. 4: DBA and DEC keyword network

From this figure, it can be seen that the network amongst PSA, IE, and SMR with DBA is small, and the keyword DEC does not appear. An analysis of the generated keyword network indicates that research on these topics is still limited. This result offers the opportunity to do further research on the topic. To strengthen this bibliometric analysis, in-depth literature reviews were needed.

Second Screening

A second screening was conducted for the 95 scientific papers obtained in the previous step. The selected publication type was only articles. The results of the second screening, along with several selected other publications, yielded 43 scientific papers that became the objects of the literature review.

Literature Review

Five research questions emerged from the literature review. Those questions are (1) papers identification (the author's name, year, keywords, or title, (2) reactor type, (3) methodology, (4) results or merits, and (5) limitations (related to the research topic). The literature review results are shown in the appendix.

From the 43 scientific papers that are the objects of the literature review, the analysis was based on the type of reactor or object; most are PWR (24), several research reactors (eight), several SMRs (six), other objects (three), and the last are all types of reactors (two). The other objects are a shipping accident, a geological repository for PWR spent fuel, and the transportation of radioactive materials by train.

Analysis of the methodology reveals that most scientific papers use only one type of IE, *i.e.*, DBA or DEC. Furthermore, this IE is evaluated probabilistically and/or deterministically to ensure its safety level. 11 scientific papers analyze how IE is identified using existing methods such as MLD, HAZOP, FMEA, and database-based approaches. Only one scientific paper has developed an IE identification method that combines internal and human events and analyzes them using the Human HAZOP method. The author associates the limitations of each scientific paper with its research topic, and the results show that there is still little research on developing an IE identification method. The composition of the results of the literature review of those 43 scientific works is presented in Figures 5 and 6.

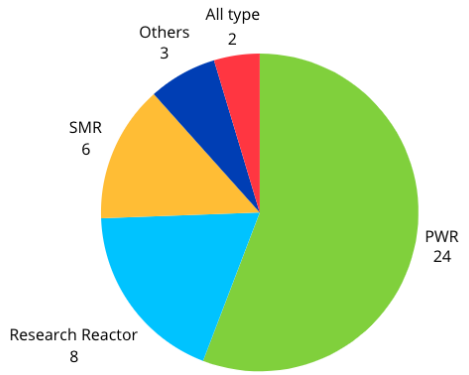

Fig. 5: Results composition based on reactor type or object

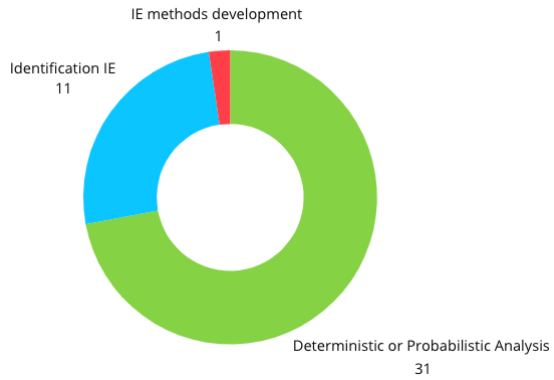

Fig. 6: Results composition based on methodology

The results answer the objectives of this study as stated in the introduction. The results of the keyword network between PSA, IE, DBA, and DEC are quite weak. The weakness of this network shows that there is still a lack of research on IE identification to obtain DBA and DEC. The literature review shows that 6 of 43 objects are SMR. There are still a few studies discussing PSA and IE as the object of SMR research. Moreover, there is very little research that develops methods for identifying IE using a research reactor as the object of study. From the explanation above, we can propose future research topics for the development of IE identification for new NPPs. The Flowchart and results of the bibliometric analysis and literature review in the field of IE identification are presented in Figure 7. The figure illustrates the article numbers (n) generated after applying the search criteria and the results throughout the methodology.

CONCLUSIONS

The development of reactor technology needs to be followed by the development of methodologies to identify related IE. This research adopts a scientific approach, combining bibliometric analysis with a literature review to map the state of the art of IE identification approaches. This study identifies keywords, discusses the research gaps and limitations of existing research, and outlines future research directions in the domain of PSA Level 1 and IE. With a selection of keywords, period, publication type, and language, 95 documents are obtained from the Scopus database. All documents were bibliometrically analyzed using VOSviewer 1.6.20, and the results reveal weaknesses in the PSA, IE, DBA, and DEC keyword networks. The bibliometric analysis is then strengthened through literature reviews to yield in-depth results. Hence, the second screening is conducted on the 95 documents obtained. This second screening results in 43 articles as the objects of the literature review. The literature review is conducted in five research questions. The literature review results show that most of the articles choose one type of IE (DBA/DEC). Furthermore, this IE will be evaluated probabilistically and/or deterministically to ensure safety. 11 articles analyze how the initial events are identified using methods such as MLD, HAZOP, and others. And only one article develops an IE identification method that combines internal and human events called Human HAZOP. The bibliometric analysis and literature review results indicate that the development of IE identification methods for new NPPs is an important future research topic. This methodology can also be applied to bibliometric analysis and literature reviews of other objects.

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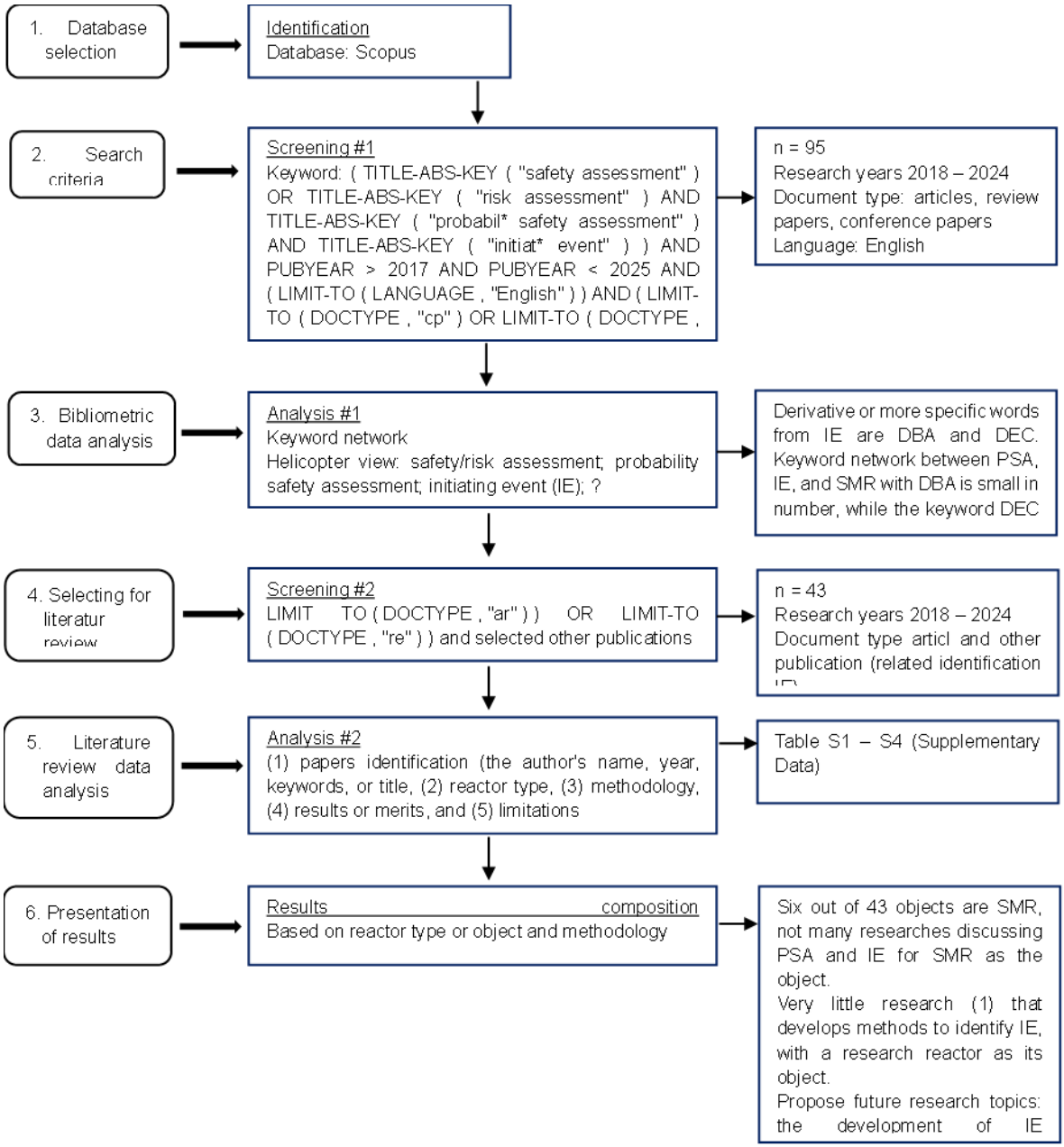

Fig. 7: Flowchart and results of bibliometric analysis and literature review

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Supplementary Data

Table S1. PWRs focused studies

No	Paper (Author, Year)	Methodology	Merits	Limitations
1.	Mikhalycheva & Trifonov, 2024	PSA Level 1 using the program code RiskSpectrum PSA	Identifying the critical probability of accident sequences, developing the recommendations to improve the VVER reliability and safety	Chosen IE: Loss of Coolant Accident (middle leakages accident)
2.	Yu *et al*., 2024	Integrated Safety Margin Quantification (ISMQ)	Probabilistic safety assessment is combined with deterministic safety assessment, while considering various types of uncertainties	Chosen IE: Small-Break Loss of Coolant Accident (SBLOCA)
3.	Mendizábal *et al.*, 2024	Integrated methods (IDPSA) combine deterministic (E-BEPU), DPSA, and the safety margin probabilistic quantifications.	These integrated methods can be used to analyze NPP Design Extension Conditions (DECs), especially DEC-A	Need further research on the design of current small modular reactors, Chosen IE: Loss of Coolant Accident
4.	BinKhadim & Zubair, 2024	AIMS-PSA approach is applied to assess the APR1400 risk	The PRA approach is used by regulatory body to plan the inspection program	Chosen IE: LOCA transients
5.	Picoco & Rychkov, 2023	A dynamic PSA toolbox can be used to optimize support studies for a classical (ET/FT) PSA model	MBLOCA with the possible failure of the HPSI system can be analysed (thermal hydraulic supporting the HRA analysis)	Chosen IE: MBLOCA
6.	M. C. Kim, 2023	Provides general ISLOCA frequency formulas	Provides a more rigorous derivation and formula of an ISLOCA frequency, which is higher than assurance on the conventional formulas	Chosen IE: ISLOCA
7.	Coleman *et al.,* 2023	PSA Level 1 using AIMS-PSA software	The common cause failure (CCFs) contributing to the core damage is identified and the understanding of the impact of CCFs on multi-unit site risk is enhanced	Chosen IE: station blackout (SBO) events and loss-of-offsite-power (LOOP) events
8.	Foerster *et al.*, 2022	Interaction of 3 projects: NARSIS (Extended PSA), R2CA (safety analysis for best estimate evaluations of the radiological consequences are harmonized), BESEP (support safety margin determination)	The three projects deal with various assessment methodologies and support the harmonization of various safety assessment methodologies for evaluating different existing NPP designs and foreseen concepts, such as SMR	Chosen IE: LOCA transients
9.	Yoon & Kim, 2022	probabilistic safety analysis (PSA) model to assess the inter-units radioactive influence at a multi-unit's site	The adverse effect of radioactive release on operator actions in a multi-unit's site can be effectively evaluated by the proposed approach	Chosen IE: multi-units' loss of offsite power (LOOP)

No	Paper (Author, Year)	Methodology	Merits	Limitations
10.	Afshar *et al.,* 2021	The Fuel Damage Frequency (FDF) in spent fuel pool (SFP) is evaluated by PSA Level 1 using SAPHIRE code	First time assessment of FDF in SFP, the efficiency and adequacy of portable mitigating equipment post-Fukushima actions	There are 6 IE, but it doesn't explain how to identify the IE
11.	Choi & Seok, 2021	Probabilistic safety assessment (PSA) to assess the SFP risk	The framework of SFP-PSA can be used to other plants by cautiously applying plant-specific information.	FMEA is applied for finding any other initiating events, but the paper does not show how to do it
12.	Lim & Park, 2020	The frequencies of plant-specific IE related to the transients of the grid system are estimated using the HLO experiences of OPR1000 plants over the last decade	Incorporating plant-specific HLO-related design features is recommended when IEFs for more realistic at-power PSAs in Korea are estimated	The estimation of the IEFs is intended to improve the practice of IE analysis
13.	Arigi, Park, & Kim, 2020	A set of MU HFE dependency evaluation elements and their evaluation criteria are developed based on the framework of the single-unit evaluation	In the case of MU PSA, the new proposed method can fill the gap of an HFE dependency analysis method	Selecting MU IE: MU loss of offsite power, MU loss of condenser vacuum, MU general transient, and MU loss of ultimate heat sink.
14.	Jung & Kang, 2020	A fire PSA model is constructed using initiating event fault trees	The results confirm that the CDFs increase if the fire-induced IE FTs involve relatively many OR logic gates.	Logic deduction diagram (IE FT): difficult when data about the plants is limited and there are no tools like "deviation" in HAZOP
15.	Arigi, Park, Lim, *et al.,* 2020	Human-induced initiating events for multi-units	A novel process to identify and quantify the category-B actions for a multi-unit's incident scenarios and calculate the human-induced IE frequency.	Chosen IE: loss of offsite power
16.	Kang, 2020	IE Fault Tree PSA	The LOCCWS IE FT for an actual fire event PSA model could be constructed by considering only IE initiators	Chosen IE: loss of component cooling water system (LOCCWS)
17.	D. S. Kim *et al.,* 2020	Provides the method of IE frequencies using time-trend analysis: Bayesian update of the Jeffreys' noninformative	Future PSA for Korean NPPs can be updated by applying IE frequency distributions generated in this study	Chosen IE: loss of offsite power
18.	Tabadar *et al.,* 2019	PSA using SAPHIRE software	A significant decrease in CDF can be achieved by applying portable equipment (the location of those needs to be further studied to resist floods, tsunamis, or earthquakes).	Chosen IE: loss of ultimate heat sink (LUHS) and station blackout
19.	B. Kim & NO, 2019	Safety margin estimation by combining the realistic	Specify the mathematical definition of the safety margin, evaluate and suggest the	Chosen IE: station blackout, one of the

No	Paper (Author, Year)	Methodology	Merits	Limitations
		safety limit and the safety analyses, which integrates PSA with DSA	approach to calculate the safety margin	DEC accidents in OPR-1000
20.	Zubair & Ishag, 2018	Risk Spectrum PSA	The most promising elements are investigated to improve the reliability of the RPS	There are 171 basic events, but the paper does not show how to get it
21.	Čepin, 2018	Shutdown PSA: IE fault tree	Variability durations of the plant operating states are revealed amongst different shutdowns, which causes large differences in risk	The state of the models presented in real examples is limited to level 1 only.
22.	Kamyab *et al.,* 2018	MCNP and SAPHIRE are applied for probabilistic model	Sensitivity analyses are accomplished to find out the worst combination of the stuck control assemblies, regarding their distance (both relative and to the center of the core)	Chosen IE: ATWS sequences upon loss of offsite power (LOOP)
23.	H. Kim *et al.,* 2018	Integrating prognostics and PSA	A new methodology was developed by considering the idea of condition-based prognostics to analyze plant-specific aging effects	Chosen IE: steam generator tube rupture
24.	Kang & Jung, 2018	Internal fire event PSA with two different SSIE FTs	SSIE FT models with only fire IE initiators might underestimate the real fire-induced risk	Chosen IE: fire-induced support system initiating event fault tree (SSIE FT) models
25.	Mohsendokht *et al.,* 2018	PSA study evaluates the safety improvement of NPP against LOOP accident	The obtained PSA results show a significant decrease in the CDF, indicating the improvement in the NPP safety against LOOP.	Chosen IE: Loss of offsite power (LOOP)
26.	T. Kim, 2018	The frontier between medium-break and large-break loss-of-coolant accidents using thermal-hydraulic code, TRACE	The frontier should be extended from 6 to 10 based on the required safety functions and system responses	Chosen IE: large break loss-of-coolant accidents

Table S2. SMRs focused studies

No	Paper (Author, Year)	Methodology	Merits	Limitations
1.	Zhou *et al.,* 2023	MLD Master Logic Diagram (MLD) combines the list of initial events and the theory of initiating event analysis of NPPs, ie. HTGR, MSR, and PWR.	Research on the initiating events of HTGR induced by Helium-xenon is still limited. Initiating events of SIMONS are investigated and analyzed in this study	SIMONS is still in the conceptual design stage, the design of some systems of SIMMONS is still not yet completed. MLD needs to be improved
2.	Hamza *et al.*, 2024	IE method: MLD, heat balance fault tree, FMEA, contemporary and historical sources mean frequency estimation and uncertainty parameters of initiating event groups	A high degree of confidence can be achieved to identify a set of initiating events in its completeness; frequency of those initiating events can be estimated along with the uncertainty parameters	Different initiating events might be identified by different methodologies, therefore it was necessary to apply multiple approaches or develop a new method
3.	So & Kim, 2021	PSA Level 1 is applied from initiating event selections to the CDF quantification	The findings (initiating event category selection, basic assumptions, and lessons learned) can contribute to other NPP types in the conceptual design phases	IE from the literature review: Referring to IAEA-TECDOC-719 and WASH-1400
4.	Chisholm *et al.*, 2020	Combination of (9, 28, 30, 33, 34) and HAZOP to identify IE	MSRE have low operating experience and low risk-informed, this research presented the potentially risk-significant PIEs identified during the analysis of the MSRE design	MLD and hazop are performed separately, not yet combining these 2 methods, or developing methods.
5.	Deng *et al.*, 2020	PSA Level 1 and risk-informed approach	Provides a technical reference for future new nuclear reactor design	Logic deduction diagram (MLD): difficult when data about the plants is limited and there are no tools like “deviation” in HAZOP
6.	Purba, 2018	IE identification using MLD	The proposed MLD is feasible to find HTGR-initiating events.	MLD needs to be improved

Table S3. Research Reactors focused studies

No	Paper (Author, Year)	Methodology	Merits	Limitations
1.	Tyas *et al.,* 2023	HAZOP	Evaluation list of IE of RSG GAS	The HAZOP method does not systematically identify the basic event
2.	Lee & Jang, 2021	An advanced Information Management System-Probabilistic Safety Assessment (AIMS-PSA) is combined with a Fault Tree Reliability Evaluation eXpert (FTREX) to perform risk evaluation.	The risk reduction is evaluated due to the changes in the design of cooling water injections when a beam tube rupture occurs	Chosen IE: beam tube rupture
3.	Vechgama *et al.,* 2021	Human-Hazard and Operability (Human-HAZOP) analysis and Hazard and Operability (HAZOP) analysis	Developed new method: Human-HAZOP analysis, updated IE frequencies (generic and plant-specific data of TRR-1/M1, together with the application of Bayesian updating)	The Hazop method does not systematically identify the basic event
4.	Lee, 2021	AIMS-PSA and FTREX	The sensitivity analysis enhanced safety (the research reactor safety was significantly improved by reducing risk approximately ten times)	Using MLD to identify and list initiating events
5.	Ameyaw *et al.,* 2021	PSA Level 1	Safety issues and cost-effective solutions to safety problems arising during the design of 10MW VVR are identified	Chosen IE: LOCA and flow blockage (FB)
6.	Lee, 2019	PSA Level 1	The safety of the research reactor was significantly improved; the risk was considerably reduced	There are initiating events, but the paper does not show how to do it
7.	Maskin *et al.,* 2018	PSA Level 1, quantification IEFs	PSA technical staff can analyze and treat initial incident event data, including, type and what data needs to be collected	The IE was identified in a previous study
8.	Ameyaw *et al.*, 2018	The methodology involves the listing approach, the IE screening approach and the grouping methodologies.	Provided a set of IEs, providing confidence in the completeness of the PSA study	MLD and FMEA are performed separately, not yet combining these 2 methods or developed methods.

Table S4. Other focused studies

No	Paper (Author, Year)	Object	Methodology	Merits	Limitations
1.	Kumar, 2024	Transportation of radioactive materials via train	PSA Level 1 to assess safety transportation of radioactive materials via train	Describes different train accident scenarios and the probability of each occurring and its consequences	Identifies IE (what can go wrong in the transport of radioactive materials), but there is no information about the method for identification IE
2.	Bogalecka & Dąbrowska, 2023	Shipping accident	Monte Carlo Simulation Approach: Critical Infrastructure Accident Consequences (CIAC) methods	The consequences of shipping accidents can be analyzed by linking initiating event (IE), environmental threats (ET), and environmental degradation (ED)	Chosen IE: from another research
3.	Jeong & Cho, 2020	Geological repository of PWR spent fuels	AIMS-PSA Manager and Radiological Safety Analysis Computer (RSAC) is applied to evaluate exposure doses	The operational safety assessment framework can improve the design of a spent fuel disposal facility	Selecting IE using the HAZOP method. The Hazop method does not systematically identify the basic event