Futures for nuclear energy?
Social, economic and environmental considerations

ECOSENS Project Conference 2025

PROGRAM AND BOOK OF ABSTRACTS

8-9 September 2025, Milano, Italy

Title	ECOSENS Project Conference 2025 Futures for nuclear energy? Social, economic and environmental considerations
Subtitle	Program and Book of Abstracts
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Cover Designer	Barbara Horvat (Milan Vidmar Electric Power Research Institute)
Cover Graphics	Barbara Horvat (Milan Vidmar Electric Power Research Institute)
Conference	ECOSENS Final Conference
Date and Location	8-9 September 2025, Milano, Italy
International Organising Committee	Giorgio Locatelli (Politecnico di Milano, School of Management), Nadja Železnik (Milan Vidmar Electric Power Research Institute), Barbara Horvat (Milan Vidmar Electric Power Research Institute), Giacomo Dei (Politecnico di Milano, School of Management)
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Published by	Milan Vidmar Electric Power Research Institute, Hajdrihova 2, 1000 Ljubljana, Slovenia https://www.eimv.si/, info@eimv.si
Issued by	ECOSENS Project Consortium
Publication Type	E-book
Edition	1st
Available at	https://ecosens-project.eu/other-documents/
doi	http://dx.doi.org/DOI:10.20348/STOREDB/1227
Published at	Ljubljana, September 2025

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The event is under the patronage of the ECOSENS project, which has received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union, European Commission or European Atomic Energy Community (granting authority). Neither the European Union nor the granting authority can be held responsible for them.

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID 247294723
ISBN 978-961-6688-14-7 (PDF)

Futures for nuclear energy? : social, economic and environmental considerations : ECOSENS Project Conference 2025 : program and book of abstracts : 8-9 September 2025, Milano, Italy. 1st ed. Ljubljana: Milan Vidmar Electric Power Research Institute, 2025. 1 spletni vir (1 datoteka PDF), tabele, graf. prikazi. Barbara Horvat (urednik), Nadja Železnik (urednik)

Način dostopa (URL): https://ecosens-project.eu/other-documents/
doi: http://dx.doi.org/DOI:10.20348/STOREDB/1227

ISBN	978-961-6688-14-7 (PDF)
doi	http://dx.doi.org/DOI:10.20348/STOREDB/1227
Price	Free copy
For publisher	Dr. Nadja Železnik
Attribution	Horvat, B., Železnik, N. (2025). Futures for nuclear energy? : social, economic and environmental considerations : ECOSENS Project Conference 2025 : program and book of abstracts. Milan Vidmar Electric Power Research Institute. ISBN 978-961-6688-14-7, DOI: http://dx.doi.org/DOI:10.20348/STOREDB/1227

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Foreword

Dear participants, esteemed guests, and contributors,

It is my great honour and pleasure to welcome you to the ECOSENS Project Conference 2025, held in Milano at the Politecnico di Milano. On behalf of the Organising Committee, I extend my warm greetings to all who have joined us for this important event marking the conclusion of the ECOSENS project.

Following several years of collaborative research and dialogue under the Euratom Research and Training Programme, the ECOSENS final conference provides a unique opportunity to reflect on the project's achievements and to discuss the broader future of nuclear energy. With its focus on the intersection of social, economic, and environmental considerations, the conference aims to capture the diversity of perspectives, approaches, and debates that shape the nuclear field today.

The scientific programme brings together a wide array of contributions spanning across four thematic areas: Societal Perspectives, Sustainability Assessment, Socio-Economic Models, and Historical and Ethical Reflections. In total, thirty-six abstracts from across Europe illustrate the breadth of expertise and the richness of dialogue that this event seeks to foster. Beyond the formal sessions, the conference also provides a valuable setting for informal exchanges, networking, and the building of new collaborations that will continue to advance this important field.

In conclusion, I wish to express my sincere gratitude to all authors and speakers for their valuable contributions, to the Programme and Organising Committees for their dedicated efforts, and to the European Union for its financial support through the Euratom Research and Training Programme. A special word of thanks also goes to our hosts, Politecnico di Milano, for providing such an excellent environment for our meeting.

I warmly wish you all an inspiring and fruitful conference.

Sincerely,

Nadja Železnik, for the ECOSENS Organising Committee

Conference Topics

As the role of nuclear energy in future energy systems continues to prompt debate across societies, there is an urgent need to explore its potential through interdisciplinary and socially responsive perspectives. The ECISENS project addresses this complexity by examining how nuclear energy intersects with key social, economic, and environmental considerations. ECOSENS final conference brings together researchers, practitioners, and stakeholders to reflect on the diverse factors shaping the future of nuclear energy. Four thematic areas guide the discussion: societal perspectives on nuclear technologies and the role of public engagement; assessments of sustainability across environmental, economic, and social dimensions; the development of socio-economic models to evaluate nuclear energy's broader implications; and historical as well as ethical reflections that help frame nuclear futures in light of past experiences and value-based considerations.

Societal Perspectives explores how different stakeholders and the broader public perceive the risks, benefits, and potential of nuclear technologies, particularly in the face of pressing societal challenges such as the climate crisis, sustainable development, and energy security. This thematic area addresses the evolving expectations and concerns of various groups regarding both established and emerging nuclear technologies, and highlights the importance of meaningful stakeholder engagement and tailored communication strategies. It also emphasises the need for inter- and transdisciplinary research approaches that can bridge scientific, social, and policy dimensions to foster more inclusive, informed, and context-sensitive decision-making processes.

Sustainability Assessment focuses on the long-term viability of energy systems, considering comprehensive approaches such as life-cycle analysis, resilience evaluation, and system integration. This theme examines the environmental, economic, and social impacts of various energy technologies that play a role in the transition to more sustainable energy futures, often through in-depth case studies. Particular attention is given to nuclear energy as a low-carbon option, including the potential contributions of small modular reactors (SMRs) and advanced nuclear technologies. The theme also addresses the complex interplay of synergies and trade-offs between energy security, climate change mitigation, and social equity, exploring how nuclear energy fits within broader goals of sustainability and just transition.

Socio-Economic Models examines the development and application of both quantitative and qualitative models to better understand the potential role of nuclear energy in contemporary society. This theme includes innovative approaches to socio-economic assessment that engage a wide range of stakeholders (such as suppliers, investors, consumers, and policymakers) to reflect diverse perspectives and priorities. It also encompasses broader models that address systemic aspects of the nuclear sector, including supply chains, policy frameworks, and governance structures. By integrating empirical insights with strategic foresight, this thematic area contributes to a more comprehensive understanding of nuclear energy's societal dimensions.

Historical and Ethical Reflections offers critical insights into the present and future of nuclear energy by examining its development through historical cases and past societal experiences. This theme underscores the value of learning from earlier trajectories to better understand current dynamics and decision-making processes. In parallel, it engages with ethical frameworks that help assess the challenges, responsibilities, and underlying values associated with the use of nuclear technologies in society. By bridging historical awareness with ethical reflection, this area encourages a more thoughtful and contextually grounded approach to nuclear energy policy and practice.

Topic #1: Societal Perspectives

A Comparative Analysis of Anti-nuclear Protesters in Western Europe

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Our study investigates the socio-demographic profiles, emotional drivers, and framing strategies of anti-nuclear protesters across Belgium, Switzerland, Sweden, and the Netherlands. Building on data from the Caught in the Act of Protest project, we analyze 1,850 responses to closed- and open-ended survey questions. Protesters show a high degree of socio-demographic homogeneity: they are highly educated, politically left-leaning, middle-class, with a slight overrepresentation of women. Moreover, they are emotionally engaged, particularly expressing anger and worry. We further explore how protesters frame nuclear energy issues, drawing on collective action frame theory, which distinguishes between three frame types: diagnostic frames, which identify problems and attribute blame; prognostic frames, which propose solutions and strategies; and motivational frames, which offer justifications for action and participation. We used an open-source large language model to analyse the open-ended responses. We find that protesters typically diagnose nuclear power as inherently dangerous. They see the issue as politically mismanaged, with nuclear lobbies, companies, and governments putting economic profit above public and environmental safety. Protesters see renewable energy investments, behavioral change, and more and better information about nuclear energy as potential solutions. Their motivations to protest relate to environmental responsibility (a call for the use of renewables) and public safety. Although these themes recur consistently, notable cross-national differences emerge, particularly in assigning blame and prioritizing solutions. These results align closely with climate protest narratives identified in other research, revealing how anti-nuclear activism contributes to broader environmental mobilization and informs the debate on public engagement, energy transitions, and the acceptability of nuclear energy amidst the climate crisis.

Integration of Nuclear Projects in Local Communities

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This presentation summarises the views of municipalities hosting nuclear facilities regarding the challenges of the new nuclear revival, with a particular focus on France.

Three nuclear communes in France - Penly, Gravelines and Bugey - have been chosen as sites for constructing new nuclear reactors under the EPR2 programme. The objectives are to contribute to the decarbonisation of the economy; enable France to pursue a sovereign energy policy and develop employment and re-industrialisation in the regions. Technical criteria as well as the strong support of the host communities and regions, which host already nuclear facilities, were decisive factors in the choice of these sites. National public debates have been organised for each project to inform the public, allow them to ask questions, give advice, propose alternatives and collectively deliberate on the matter.

The construction of these new nuclear reactors involves complex land planning issues at regional level, such as accommodation for staff, adaptation of public services, transportation alternatives to avoid overcrowded roads and skilled workforce, among others. Environmental compensation schemes may need to be aligned with local authorities' sustainable development strategies. Despite the opportunities, the logistical difficulties and legal barriers for developing such complex projects are significant. The collaborative engagement of local communities, industry and government is essential for the execution of such projects. Although SMRs may not entail the same complexities due to their smaller scale, this presentation seeks to examine key comparative elements of analysis that are vital for organising such initiatives at the local level.

Framing Nuclear: An Analysis of Online Political Discourse on Nuclear Energy in Belgium

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This study analyzes how Belgian politicians and political parties discuss nuclear energy on X (formerly Twitter), focusing on framing patterns from January 2019 to August 2024. Using Coosto, 5,419 tweets from 79 prominent Flemish politicians and their parties were collected. While this abstract reports findings from Flemish politicians, we are currently extending our analysis to include Walloon data, which will be presented at the conference. We applied an annotation strategy involving two large language models and a dictionary-based method to annotate five energy policy frames previously identified in the literature: energy security, clean energy, economic growth, nuclear safety, and energy affordability. Our analysis reveals significant politicization of nuclear energy discourse. Opposition parties, particularly N-VA and Vlaams Belang, dominate discussions, emphasizing energy security and clean energy frames. The Russian invasion of Ukraine in 2022 notably increased the salience of energy security, making it the dominant frame. Conversely, affordability declined in prominence. Furthermore, our research identifies distinct framing patterns concerning small modular reactors (SMRs). While general nuclear discussions prioritize clean energy and energy security, discourse on SMRs prominently features economic growth and nuclear safety, with centrist parties like CD&V and Open VLD actively shaping this debate. These findings highlight how geopolitical events and party ideologies shape public discourse on nuclear energy, underlining the need for nuanced stakeholder engagement strategies. This research provides critical insights into the interplay between politics and energy policy framing, informing effective communication on nuclear energy.

Generational Shifts in the Perception of Nuclear Power Plants in Communities Surrounding old Sites

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Controversial infrastructures such as prisons, nuclear power plants, and waste-to-energy facilities often face resistance from host communities. Existing research suggests that areas already hosting such facilities show greater social acceptance than new, unexposed locations. However, whether this acceptance persists after a facility's closure remains underexplored. This study addresses this gap by examining community attitudes toward new nuclear power plants near old sites, emphasizing the roles of historical experience, generational differences, and symbolic meanings.

Drawing on structured interviews with 437 local residents, the research finds that communities near old nuclear plants display a higher degree of acceptance for new projects than the general population. This trend can be attributed to a "memory factor" among older generations, who recall the operational benefits of the former plant such as economic advantages, leading to reduced NIMBY (Not In My Back Yard) attitudes. However, this effect weakens with younger generations who lack direct experience with the plant, and whose views tend to align more closely with national levels of acceptance.

Importantly, the study reveals that familiarity, rather than technical knowledge, is a key driver of public opinion, highlighting the symbolic significance of nuclear infrastructure. Arguments supporting and opposing new projects often rely on similar narratives, underscoring the polarizing nature of the issue. These findings challenge the assumption of community homogeneity and advocate for more nuanced, adaptive approaches to stakeholder engagement that account for varied experiences, intergenerational memory, and symbolic associations in infrastructure planning.

Some Remarks Concerning NGO Engagement in the ECOSENS Project

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This presentation aims to summarise and discuss key findings obtained from interactions with representatives of non-governmental organisations (NGOs) within the ECOSENS project's Work Packages (WPs) 2 and 3, as well as the complete absence of the activities and/or interest of Slovak environmental NGOs in ECOSENS-related issues (WP 1). Its main focus concerns key messages from NGO representatives who participated in ECOSENS events dedicated to assessing the sustainability of the entire nuclear power cycle (WP 2) and the System of Provision (SoP) approach (WP 3), which were presented orally to the ECOSENS subtask 3.6 leader only after these events. The presentation will also briefly include experiences from Slovakia, where, despite having the second highest proportion of electricity generated by nuclear power plants (NPPs) globally (after France), there has recently been a complete absence of Slovak NGOs' interest in ECOSENS-related activities (WP 1). Moreover, Slovak NGOs have not carried out any relevant activity with regard to the Environmental Impact Assessment (EIA) process for the new nuclear power plant (NPP) at Jaslovské Bohunice or plans to locate small modular reactors (SMRs) in Slovakia. In this context, the presentation will mention the previously identified UNCLE phenomenon (Unlimited Nuclear Consultations Leading to Exhaustion), which might partially explain why even major international environmental NGOs and European NGO networks have significantly reduced or entirely eliminated their capacity for activities concerning new NPPs and SMRs in the ECOSENS project.

Keywords: Non-governmental organisations' (NGOs'); NGO engagement; ECOSENS events; UNCLE phenomenon; Slovakia

Community Engagement and Evidence-Based Risk Communication in Environmental Impact Assessment for Small Modular Reactors

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The deployment of Small Modular Reactors (SMRs) in Europe requires comprehensive Environmental Impact Assessment (EIA) to evaluate potential environmental and socio-economic effects before construction begins. While EIA serves as a critical decision-support tool for authorities, it is not merely a technical exercise; it inherently involves value judgments and must integrate the perspectives of diverse stakeholders, including the public. Current EIA processes for nuclear technologies often lack robust, participatory mechanisms contributing to low trust, limited community engagement and consequently to weak decision-making process. In addition, practical guidelines for transparent and evidence-based risk communication are currently lacking. .

The research CATAPULT aims to develop a comprehensive framework—both theoretical and practical—for engaging citizens, communities, and stakeholders in the EIA of SMR projects. Key objectives include: co-designing risk communication strategies and materials with citizens to ensure clarity, relevance, and accessibility; providing actionable guidance for effective, transparent risk communication tailored to different audiences and national contexts and identifying knowledge gaps, beliefs, and perceived needs related to EIA processes, with a focus on equity and equality.

A mixed-methods approach will be employed, including semi-structured interviews, design thinking workshops, and Delphi studies conducted in Portugal, Spain, Belgium as well as at the European level. The initial phase will assess knowledge and public understanding of EIA, participation needs, and equity and equality concerns. Subsequent stages will evaluate optimal formats and strategies for communicating SMRs EIA results, ensuring accessibility and engagement of non-experts, in a transparent way. The final phase will focus on integrating citizen perspectives into expert-driven EIA processes and developing mechanisms to ensure community impact on guidance documents.

The research plan and expected results will be presented, highlighting the importance of early, transparent, and inclusive engagement to build trust and improve decision-making for SMRs deployment in Europe.

Acknowledgements: The research is conducted in the context of the CATAPULT project which received the funding from the European Partnership for Radiation Protection Research PIANOFORTE Horizon Euratom research - 101061037 under PIANOFORTE funding agreement ref. ASNR 2025-0018.

The Greening of Nuclear Power: Addressing the Challenge of Doing STS on Small Modular Reactors

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Globally, governments and the nuclear industry have demonstrated an ever-growing interest in the development of Small Modular Reactors (SMRs). Current consultation on a UK Green Taxonomy proposes to include nuclear energy as 'green', as part of the national net zero ambitions, in line with the EU taxonomy on sustainable activities. A seemingly united front for SMR development and deployment comes from across the political spectrum, despite a 'rollercoaster' of nuclear policy changes over past decades. Large scale new nuclear plants are being built and more are planned, yet SMRs are also proposed as part of the 'energy mix'. Official rationales now incorporate the need for economic growth and skills development, sitting alongside the 'low carbon' arguments for SMRs. Our paper analyses the current policy and industry enthusiasm, detailing the complex rationales at the core of this political ambition and the strategy currently deployed by the UK government to materialise SMRs. The paper is based on an EU-funded project (ECOSENS), that addresses the socio-economic dimensions of new nuclear technologies. A series of individual interviews with actors in governmental bodies, NGOs, and industry was complemented by analysis of official and grey literatures. Our analysis asks what new forms of nuclearity are generated in the context of the political imperative of SMR development? What is present and absent in public discourse around the promotion of an SMR future? And, what forms of STS practice are needed to attend to nuclear matters that cut across policy, academic and industry spaces?

Public and Stakeholder Engagement in the Small Modular Reactor (SMR) Ecosystem of the European Industrial Alliance

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This paper focuses on the importance of effective stakeholder engagement in the development, demonstration, and deployment of Small Modular Reactors (SMRs) in the European Union. The Technical Working Group on Public Engagement (TWG5)of the European Industrial Alliance (EIA) on SMRs will be presented as a one of the tools to foster broad stakeholder engagement within the SMR ecosystem in Europe. The overarching objective of TWG5 is to identify priorities and outline targeted actions on how to launch an open, transparent, and inclusive dialogue with social partners, stakeholders, and civil society, particularly on topics which are relevant to the SMR project development, such as the siting process, nuclear safety, radioactive waste management, and non-proliferation (safeguards). An Action Plan has been developed for promoting public and stakeholder engagement in the context of the development and deployment of the first SMR projects, anticipated by early 2030s.

A number of challenges have been formulated by considering the needs expressed by the first batch of the nice Project Working Groups supported under the Alliance, as well as the feedback gathered from the TWG5 members. A number of actions have been defined including: a) collecting baseline information on societal aspects of SMRs, b) actions on public communication and outreach, c) actions on stakeholder engagement and collaboration and d) actions to foster networking, collaboration and knowledge exchange among the Alliance members and to promote the EIA on SMRs.

The Action Plan and the future tasks to be undertaken by the TWG5 will be presented as a means to promote future coordinated efforts to align stakeholder expectations.

SMR Development in Belgium
Making Experience Count

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In recent years, nuclear energy has in many countries (re)gained political interest and support. Especially small modular reactors (SMRs) are considered as the latest tool for battling climate change and assuring energy security. Also the Belgian federal government has expressed an interest in SMRs. In 2022, the national government approved a EUR 100 million investment in research on SMR technologies to be conducted by the Belgian Nuclear Research Centre (SCK CEN). This commitment was reaffirmed and expanded upon in the '2025–2029 coalition agreement' which includes the intention to draft a support plan for the development, construction and commissioning of the first SMR in Belgium. This presentation will first contextualize the state of SMR development in Belgium, focusing on the efforts of SCK CEN to develop and construct an SMR technology demonstrator. Second, it will delve into one of the institute's central arguments for pursuing a Lead-cooled Fast-spectrum Reactor (LFR): its strong and demonstrated expertise in heavy liquid metal (HLM) technology. Institutions often emphasize continuity with past experiences to enhance the legitimacy and credibility of new projects. Yet, it remains unclear how such experience is practically mobilized in research and development contexts. This presentation explores what it means, in practice, for a nuclear research institute to make experience actionable; it discusses the situated work required to render past experience useful and ultimately relevant. This study draws on data collected within the framework of a doctoral project, including in-depth interviews, observations and document- and frame analyses.

Public Attitudes Towards Small Modular Reactors as an Emerging Field of Social Research

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The development of small modular reactors (SMRs) offers an alternative to large traditional reactors (LTRs), and some countries in Europe are considering or planning to implement SMR construction projects. Compared to the vast literature on LTRs, little is known about the public's perceptions or views of SMRs or the willingness of local communities to potentially host an SMR facility. An international and multidisciplinary team of researchers addressed this topic in the context of current climate change and energy security challenges. In 2024, we conducted research in six European countries: Belgium, Spain, the Czech Republic, Slovenia, Slovakia, and the United Kingdom. Our approach combined quantitative methods, including representative public opinion surveys in the first three countries, with qualitative methods such as desk research, focus group discussions, expert interviews, and other techniques in all six countries. Our findings indicate that although media coverage of the expert debate surrounding SMRs has increased in the last two to three years, partly due to the nuclear revival following the energy crisis, the public remains largely unaware of the technology. There is a demand for more factual and accurate information. The potential benefits of SMRs are primarily seen by the public as contributing to long-term energy security, rather than as an immediate solution for the climate crisis. Additionally, many individuals struggle to recognize the advantages of SMRs, which are still considered an unproven technology, in comparison to the established high energy production capacity of LTRs. The oral presentation will outline our methodology and key research findings, inviting the audience to engage with the data collected and publications that report on our results.

Media Reporting on Small Modular Reactors in Sweden – Benefits, Risks and Actors Involved

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This study focuses on the introduction of new nuclear, particularly Small Modular Reactors (SMRs) in Sweden. The Swedish Government has decided on a revival for nuclear energy where SMRs are an important contribution to reach the goal of a total output of at least 2 500 MW by 2035. In this stage when much is unclear about the re-introduction and SMRs are under development media is an important agenda setter. The framing of the technology in terms of benefits, risks, uncertainties inform possible understanding of the technology. Positions can be expressed by different actors and can also become a way for different actors to position themselves, create alliances and marginalize competing messages. This presentation is based on an analysis of the framing of SMRs in Swedish media particularly how benefits and risks are articulated and which actors participate in shaping the image. To this end a content analysis of Swedish news media from 2020 until 2024 is conducted. The study shows how the character of the reporting changes over time but overall SMRs are framed as better and different than existing nuclear power plants and as a solution to contemporary challenges such as energy security, climate crisis and high prices on energy. Benefits rather than risks are covered. The reporting is also characterised by fuzziness; terminology shifts and benefits of SMRs are confused with generation IV nuclear reactors. Taken together the frame makes it hard to understand SMRs in general and risks in particular.

How do we Build Stakeholder Engagement During the Deployment of a Fleet of SMRS in an Embarking Country?

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Orlen Synthos Green Energy (OSGE) is a Polish-based company leading a project to build a fleet of SMRs designed by GE Hitachi Nuclear Energy—BWRX-300. Additionally, Poland is an embarking country, with its first nuclear power unit expected to be ready in the late 30s. The government's strategy only includes the construction of large-scale nuclear power plants (the state strategy in this area is expected to be updated).

From the very beginning, making the project credible in the eyes of stakeholders was one of the most important challenges the company faced. There are no examples of conducting stakeholder relations in the implementation of investments in a fleet of small modular reactors. Therefore, no reference project or case study for OSGE had been available.

The presentation / speech will show the company's activities and lessons learnt, with a particular focus on the aspects specific to SMRS.

OSGE has built a stakeholder relations strategy from the ground up at every level - from decision-makers (convincing that SMRs can become an important element in decarbonising the country and building energy security) through market experts and media (SMRs as a solution ready-to-deploy, not a “PPT project” for the far future) to local communities (technology safety and the possibility of siting near human settlements).

Currently, the support for nuclear energy in Poland (in general, without distinction large or small reactors) is above 90 percent.

Stakeholder and Public Engagement in Environmental Impact Assessments: Considerations and Lessons for the Implementation of Small Modular Reactors

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Emerging nuclear technologies such as Small Modular Reactors (SMRs) have recently gained significant scientific, governmental, and public interest worldwide. These SMR projects require Environmental Impact Assessment (EIA) processes to identify, describe and assess the environmental and socioeconomic impacts of these facilities. Stakeholders (e.g., industry experts, relevant governmental agencies, nuclear regulatory bodies, etc.) and the general public (e.g., individuals living near proposed SMRs locations) are expected to be involved in this EIA process at different stages, within the scope of the detailed EIA (i.e., environmental scoping report) and the EIA report finalization. These opportunities for involvement may take different forms, such as public meetings, hearings, answering questionnaires and online consultations, among others.

By discussing concerns and expectations regarding the implementation of SMRs, developing the project in accordance with both parties' requirements, engaging the stakeholders in the decision-making, and ensuring all ethical and environmental guidelines are appropriately met, the EIA process enhances transparency and trust between parties, mitigates environmental and social concerns, manages short- and long-term risks, and promotes proactive collaboration towards a decision. However, there are persistent obstacles to effective stakeholder engagement such as: low community participation, low trust among stakeholders, use of complex technical language and dis-misinformation concerning the project, among other factors.

To obtain a comprehensive understanding of the current limitations of, and opportunities for, stakeholder engagement practices within EIA processes regarding SMRs, a scoping review is conducted considering nuclear technologies. The goal is to compare practices in public engagement and communication, answering the main research question: What are the reported barriers and facilitators of stakeholder engagement in the EIA process when comparing SMRs versus large nuclear reactors?

This review is conducted utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Protocol, to ensure a rigorous and replicable approach. Searches are carried out in the WoS Core Collection and Scopus, in English, Spanish and Portuguese, using terms relevant to the engagement process in EIAs: Environmental Impact Assessment and stakeholder engagement or public participation or consultation or communication; additional searches using synonyms are also conducted and detailed in the full review.

From the findings of this review, recommendations aimed at enhancing future stakeholder engagement in EIA processes of emerging nuclear technologies, will be presented. The proposals are intended to inform the EIA for implementation of SMRs across European Member States, while enhancing the co-decision-making process.

Acknowledgements: This research is conducted in the context of the CATAPULT Project which received funding from the European Partnership for Radiation Protection Research PIANOFORTE Horizon Euratom Research (101061037) under the PIANOFORTE Funding Agreement Ref. ASNR 2025-0018.

The Presenting Author has received funding from the European Union's "EURATOM" research and innovation program under the 101061037 Grant Agreement, in the form of an Early Career Researchers Travel Grant.

Understanding Public Attitudes Towards SMRs in Belgium, Czech Republic and Spain

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While extensive research has been dedicated to studying factors influencing attitudes towards nuclear energy and large traditional reactors, this topic has been less addressed for the case of Small Modular Reactors (SMR). In this contribution we focus on the desired contribution of SMRs in the national electricity mix in and the acceptability of an SMR within 10 km from one's residence. We investigate how these are shaped by theory-driven factors including perceptions of SMRs impact on i) carbon emissions, ii) energy security, iii) environmental impact, iv) socio-economic benefits for communities, and v) societal risks, alongside more general concerns and beliefs regarding climate change, energy security and nuclear decision-making. Data underlying this study have been collected in 2024 through online panel surveys with representative samples of the population in Belgium (N=1200), Czech Republic (N=1022) and Spain (N=1001) in the framework of the European project ECOSENS.

Results from linear regression models show that -in all countries- the desired role of SMRs in national electricity production is influenced by the perceived benefit of SMR for energy security and the extent to which people believe that SMRs provide a clean and environmentally friendly energy source. The perceived contribution of SMRs to reducing CO2 emissions has a direct effect only in Czech Republic and Belgium. Instead, general climate concern has a direct (negative) impact on attitudes towards SMRs in Spain, but only limitedly so in Belgium and not at all in Czechia. Perceived societal risks have a direct (negative) impact only in Belgium and Spain.

As regards acceptability of an SMR within 10 km from one's residence, this is influenced by perceived environmental friendliness of SMRs, perceived societal risks (negative relationship), perceived inclusiveness of nuclear decision making, SMRs contribution to CO2 emissions reduction and general climate concerns (negative relationship) in all countries, while SMRs' perceived energy security benefit has a direct impact only in Belgium. Contrary to expectations, while socio-economic benefit for communities was significantly correlated with acceptability of an SMR in close proximity to people's residence (particularly in Belgium and Spain), it did not have a direct effect on acceptability.

Results from this study will be interpreted against the backdrop of existing research into public attitudes towards nuclear energy, especially in the context of climate change and energy security challenges.

Acknowledgements: This study was conducted in the framework of the European project ECOSENS. This project has received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920. We are thankful to participants in the pilot studies carried out at University of Antwerp and SCK CEN in Belgium, CIEMAT in Spain, and the Institute of Sociology of the Czech Academy of Sciences in the Czech Republic.

Public Attitudes toward Small Modular Reactors (SMRs) in Slovenia

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The case study explores the evolving discourse around small modular reactors (SMRs) in Slovenia, within the broader context of national energy policy and nuclear development. Slovenia, already a nuclear country with one operational nuclear power plant (NPP) at Krško, is currently advancing plans for a second reactor (NEK2) and gradually engaging in discussions about SMRs as a future energy option.

At present, SMRs are only marginally included in Slovenia's strategic documents, with the updated National Energy and Climate Plan (NEPN) proposing a potential SMR deployment by 2050. There are no concrete implementation plans, siting decisions, or financial models in place. However, Slovenia has joined international initiatives, such as the USA-led PHOENIX project and the EU SMR industrial alliance and has launched a pre-feasibility study on SMRs through a multi-stakeholder coalition coordinated by the Ministry for the Environment, Climate and Energy (MOPE), however, including just official actors.

Qualitative research included semi-structured interviews with six key stakeholders ranging from governmental and regulatory authorities to energy companies and former political leaders, as well as one expert focus group with seven experts in the energy/nuclear field. The interviews revealed general institutional openness toward SMRs, citing long-term benefits such as energy security, reduced carbon emissions, and decentralisation. Nonetheless, interviewees noted serious challenges, including regulatory gaps, lack of investor and technical capacity, unclear economic viability, and an underdeveloped workforce. The expert focus group discussion reflected cautious interest in SMRs, as well as the widespread scepticism. Participants, though supportive of nuclear energy in general, viewed SMRs as technologically immature, financially uncertain, and insufficiently distinct from traditional NPPs in terms of waste and safety. While the smaller scale of SMRs was seen as potentially advantageous for siting flexibility, concerns were raised about public opposition, especially if SMRs were located near urban areas. Notably, participants criticised the current public information campaigns around nuclear energy linked with new nuclear built as biased and lacking in transparency, which they feared could undermine public trust.

Currently, there is no specific public opinion data on SMRs in Slovenia. However, historical surveys show a gradual decline in public concern about nuclear safety. Still, the broader nuclear debate remains politically sensitive, especially around the NEK2 project, which was to be subjected to a public referendum in 2024; however, the referendum was later cancelled due to procedural concerns.

Overall, Slovenia's engagement with SMRs remains exploratory. While key actors acknowledge their potential role in the future energy mix, especially as a complement to NEK2, substantial technical, regulatory, and social groundwork is still required. The findings highlight the importance of inclusive, transparent public engagement and the development of robust institutional frameworks to support any future SMR deployment.

Keywords: Slovenia; Small Modular Reactors (SMRs); Public attitudes; Energy policy; Stakeholder engagement

Acknowledgements: This study has received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920 (ECOSENS - Economic and Social Considerations for the Future of Nuclear Energy in Society).

Perceptions and Prospects for Lead-Cooled Nuclear Technologies: Insights from R&D and Public stakeholders in Belgium

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While water-cooled reactors continue to dominate the global nuclear fleet, alternative coolants have been explored since the early days of nuclear energy. Over the past 25 years, Belgium has made significant investments in research on lead-cooled nuclear technologies. This work initially centred on developing an accelerator-driven system (the MYRRHA project) and, more recently, has extended to designing a lead-cooled Small Modular Reactor (SMR). This contribution examines how R&D professionals and the broader public perceive this emerging nuclear innovation, paying specific attention to potential benefits, drawbacks and challenges. Drawing on workshops and a Socio-Technical Integration Research (STIR) study, we explore the everyday experiences and work of researchers at the Belgian nuclear research centre SCK CEN. A key finding is the limited sense of agency researchers report in shaping research directions, pointing to perceived structural constraints such as secrecy, organizational hierarchies, and resource limitations. In parallel, a World Café captured citizens' views on the development and possible deployment of lead-cooled reactors. These dialogues reveal diverse societal perspectives on nuclear innovation, including hopes, doubts, and concerns. By combining these insights, the study highlights how differing perceptions persist between stakeholder groups and identifies opportunities for better aligning technological development with societal values. This work underscores the importance of fostering stronger sociotechnical integration to support responsible research and innovation in the nuclear field and beyond.

Stakeholder Engagement and Transdisciplinary Collaborations in Nuclear Decision-making in Different EU Countries: Results from an Online Survey

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In the nuclear energy field, the uptake of recommendations on stakeholder engagement in energy governance and transdisciplinary collaborations are fundamental to enhancing the effectiveness and sustainability of energy policies. This study examined the uptake of these recommendations in different EU countries, and the challenges and drivers for the effective adoption of the recommendations. An online survey was distributed to stakeholders from various countries, yielding 66 responses. Overall, respondents from all countries rated the current level of participatory governance on nuclear issues as inadequate, particularly with regard to the closure of nuclear power plants and the decommissioning of nuclear reactors. While all respondents considered recommendations for improving participatory governance to be important, they believed that these recommendations were being implemented at a moderate to low level. "Transparency about objectives, decisions taken, and expected results" was the most highly valued recommendation. In contrast, "providing the appropriate means to support participation" and "establishing legislative and administrative frameworks" were the least implemented. The results showed a general concern about the lack of reliable information, emphasising the need for action to ensure citizens have access to accurate and trustworthy information. Improving transparency in decision-making at the government and nuclear sector levels was essential to building public confidence. In conclusion, while the importance of participatory governance in nuclear energy is widely acknowledged, its implementation remains limited across EU countries. Strengthening transparency and providing reliable information are key steps toward fostering a more effective stakeholder engagement in energy governance.

When Public and Stakeholder Engagement Fails: The Slovenian Nuclear Referendum Case

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The Slovenian government—a country operating a single nuclear power reactor that supplies approximately 20 % of its annual electricity consumption—announced plans to expand nuclear energy production by constructing a second reactor by 2040. As part of this initiative, the government proposed a referendum in May 2024, which was approved by parliament on October 10th and scheduled to be held already on 24th of November 2024. However, just two weeks after parliamentary approval, the referendum was cancelled on October 24th due to mounting public pressure.

This study examines what happened during the process of preparations for implementing one of the most democratic public engagement tools—a referendum. Specifically, it explores how a unique opportunity for broad stakeholder participation deteriorated into a failure of public and stakeholder engagement.

A mixed-methods approach was employed, including interviews with 6 representatives of official stakeholders with particular role in nuclear sector; media content analysis of the daily newspaper "Dnevnik" and the weekly supplement "Sobotna priloga" of another daily newspaper "Delo" (covering the period from May 7th to November 24th, 2024); and a systematic review of governmental and parliamentary documents related to the referendum. The study identifies the stakeholders involved and excluded from public debate, exposes attempts of manipulation, and analyzes the themes that were emphasized or omitted during public discourse.

The findings reveal that the manipulation of stakeholder engagement for propaganda purposes can not only undermine effective decision-making in nuclear energy policy but also erode public trust in democratic processes and future technological developments. Drawing on lessons from the Slovenian case, this research offers valuable insights for decision-making processes related to nuclear technologies more broadly and SMR in specific.

Acknowledgements: This study has partially received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920 (ECOSENS - Economic and Social Considerations for the Future of Nuclear Energy in Society). The first author conducted the data collection during a scientific visit to the Faculty of Social Sciences, University of Ljubljana (March–April 2025), supported by the Public Scholarship Fund of the Republic of Slovenia (349th public call).

Stakeholder Engagement in Spanish Nuclear Phase-out and Decommissioning Decision-making

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Spain's National Integrated Energy and Climate Plan 2021–2030 states that the companies owning the nuclear power plants and the National Radioactive Waste Company (Enresa) have unanimously agreed- with government approval-on a schedule for the planned/coordinated and gradual shutdown of the country's seven remaining active nuclear reactors. This study analyses the participation of stakeholders in the main political decision-making processes related to the phasing out and decommissioning of the nuclear reactors in Spain. The methodological design included a documentary review, semi-structured interviews with some relevant stakeholders, an analysis of parliamentary questions, and an overview of media coverage. A total of 14 interviews were conducted, with representatives from different sectors: research organisations and universities (N=2), industry (N=5), NGOs and associations (N=5), public authorities (N=1) and media (N=1). The results showed that the decision-making process for phasing out nuclear power in Spain did not involve all relevant stakeholders. The government made this decision through negotiations with the electricity companies. It was perceived that political and economic interests primarily influenced these decisions, leading to inadequate stakeholder involvement, a worrying lack of transparency, limited scientific advice, insufficient expert debate, and a noticeable lack of public engagement with significant economic, social, and environmental impacts.

Adolescents Radiation Risk Perception Survey towards a Transdisciplinary Approach

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The present work exemplifies a transdisciplinary research, where societal impact is the central aim of the research. Departing from the perspective of risk perception, our goal is to foster adolescents' engagement with nuclear sciences and technologies by inviting them to answer a survey about the topic before a field trip to Technological and Nuclear Campus at University of Lisbon. The survey, hosted at a blog built ad propositum, asks adolescents, between 16 and 20 years of age, what they know about risks, which risks concern them the most and what are their thoughts about radiation risk. The survey has open-ended questions, questions of multiple choice and questions with a ranking system all aimed at raising awareness for the topic of nuclear sciences and technologies.

Risk is a commonly used word and one easy to understand but difficult to define. Different disciplines apply their own bodies of knowledge to framework uncertainties and convert them into measurable risks. Furthermore, the concept of risk can have both positive and negative connotations. Mathematically speaking, a common formula or method for quantifying risk is the product of probability and consequences. Several risk measures can be used individually or together to perform a risk assessment and risk assessment is one of several domains encompassed in risk analysis the others being risk perception and communication, risk management and governance. Each domain is a research subject in itself.

From the multitude of existing risks, radiation risk is one of the risks studied most thoroughly due to its potential impact. Radiation risk implies the collaboration of multiple disciplines, e.g. physics, chemistry, biology, medicine, radiation protection and thus it is intrinsically multidisciplinary. When stepping into the specific realms of ionizing radiation risk perception, one moves from multidisciplinary research into interdisciplinary research carried out through a collaboration between natural sciences, social sciences and humanities, aiming to draw theories explaining for instance how we apprehend such complex concepts and arrive at informed decisions.

Results being gathered thus far shall be presented.

Slovenia's Nuclear Energy Debate and Stakeholder Engagement in the NEPN Process

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The Slovenian case study within the ECOSENS project explores the country's evolving nuclear energy policy, focusing on the development and revision of its National Energy and Climate Plan (NEPN). Slovenia, a long-standing nuclear nation with one nuclear power plant Krško in operation and strong intension to build second unit at same site, presents a case where nuclear energy enjoys political support, yet public and stakeholder engagement remains limited and controversial.

The NEPN, mandated under EU Regulation 2018/1999, serves as Slovenia's central strategic energy planning document. The 2020 NEPN enabled the government to issue an energy permit for a new nuclear unit, without thorough consideration of public consultation feedback. Stakeholder engagement in the NEPN drafting process was formally well organised but lacked transparency and accountability, as many public comments were left unaddressed or received generic replies. The process raised concerns among civil society actors about the authenticity of participation and the adequacy of responses to citizen concerns.

The 2024 NEPN revision process aimed to address some of these shortcomings by initiating a more structured consultation phase. However, early assessments suggest persistent challenges in effectively integrating diverse stakeholder perspectives. The political context further complicates the issue; a national referendum on the NEK2 project was initially planned for 2024 but subsequently cancelled, eroding trust in the inclusiveness of the decision-making process. Interviews and document analysis reveal that pro-nuclear arguments dominate the political and expert discourse, framing nuclear energy as essential for climate neutrality, energy security, and economic stability. Public opinion, while generally favourable toward nuclear power, remains nuanced, with concerns about safety, waste, and the openness of governmental decisions. Critics have highlighted the overreliance on expert-driven narratives and the insufficient incorporation of socio-environmental justice, local concerns, and ethical considerations. The debate was largely shaped by a narrow group of institutional actors, with civil society and alternative voices underrepresented.

The case underscores the need for a more inclusive, deliberative, and transparent governance model for nuclear policy in Slovenia. Key recommendations include institutionalising multi-level dialogue mechanisms, improving responsiveness to public input, increasing support for independent expert and civil society participation and ensuring that nuclear decisions align with broader sustainability and democratic values.

Slovenia's experience offers important lessons for integrating technical, political, and social dimensions in energy policy. While nuclear energy may remain a strategic pillar, its legitimacy increasingly depends on how decisions are made and whose voices are heard.

Keywords: Slovenia; Nuclear energy policy; National Energy and Climate Plan (NEPN); Stakeholder engagement; Energy governance

Acknowledgements: This study has received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920 (ECOSENS - Economic and Social Considerations for the Future of Nuclear Energy in Society).

Topic #2: Sustainability Assessment

The art and science of imagining energy futures

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What energy future do we desire? What energy future is possible? Which values and artefacts (storylines, narratives, concepts, symbols, models, …) do we use to 'imagine' these futures? Imagining energy futures is a complex thought experiment in which one needs to consider not only economic strategies, environmental threats such as climate change and considerations of social justice, but also the impact of conflict and war. Scientists, politicians, activists and citizens may disagree on what energy future is needed and possible but, apparently, there is also no consensus on what future we desire. While anyone would reasonably say that energy should be produced in an environmentally friendly way and be affordable for all, different visions exist on how to get there.

The ECOSENS international workshop "The art and science of imagining energy futures" took these thoughts as a vantage point to engage in deeper thinking about 'sustainability assessment' and other formal approaches to future thinking in the context of energy governance. The idea is that unveiling what references we use to express what we desire, hope, fear and believe should be the first step in an assessment exercise credible for all involved stakeholders.

The presentation will reflect on the outcome of the workshop and suggest recommendations and other food for thought for anyone concerned with 'the energy future we want'.

The Role of Nuclear Energy in Securing a Resilient, Renewable-Dominated Power System

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The transition toward carbon neutrality is fundamentally anchored in a significant and accelerating increase in the share of renewable energy sources—particularly variable renewables such as wind and solar photovoltaic (PV) power. While these sources offer substantial environmental and economic benefits, their inherent variability poses considerable challenges for power system stability and reliability. Chief among these challenges are the need to ensure continuous baseload power supply and to integrate large-scale, efficient energy storage solutions.

At present, energy storage for variable renewables is predominantly reliant on battery technologies. While effective for short-duration balancing, batteries involve substantial raw material requirements and generate end-of-life waste, raising sustainability concerns. In contrast, nuclear energy offers a low-carbon, high-reliability option capable of providing consistent baseload power. However, conventional nuclear power plants are often limited in operational flexibility, making them less compatible with highly dynamic, renewable-dominated grids.

Emerging technologies such as Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs) have introduced enhanced flexibility features, enabling them to better adapt to variable net loads. This study analyzes the potential role of flexible nuclear technologies in supporting a fully decarbonized electricity system, using the FRAMES computational tool. The analysis incorporates real-world generation data from solar PV, wind, and hydro sources in Romania and evaluates system behavior under scenarios that assume a complete phase-out of fossil-based generation and constrained energy storage capacity.

The paper specifically examines the operational performance and limitations of two advanced reactor types: the integral Pressurized Water Reactor (iPWR) SMR and the Lead-cooled Fast Reactor (LFR) AMR. Their ability to respond to the variability and intermittency imposed by high renewable penetration is assessed, offering insights into the strategic integration of flexible nuclear power within a sustainable and resilient future energy mix. The results are presented in terms of integration costs and technical constraints, adapted to the discussion with a large category of stakeholders.

Looking for a new way to gather stakeholder input to technoscientific assessment

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ECOSENS developed a methodology to co-evaluate the main energy technologies involved in the energy transition—namely, variable renewables, hydro, nuclear, and gas, considering their entire lifecycle. The paper presents the attempt to integrate the contribution of stakeholders to such complex, technically grounded sustainability assessment.

The participatory process engaged 40 individuals, equally divided between participants with technical expertise (not necessarily in the energy sector) and those with socio-humanistic backgrounds. Participants were provided with foundational information on the sustainability performance of the four technologies and invited to engage in a structured evaluation using a comprehensive set of 62 indicators.

The paper highlights the potential of participatory approaches to produce input for technically grounded decision-making, while also discussing key challenges, including the complexity of the assessment framework especially the judgement of the entire lifecycle, the interdependence of energy mix components, and the substantial effort required from participants.

The results, based on the averaged individual responses and average overall rating (for environmental, economic, and social pillars), suggest that respondents perceived no major differences among the evaluated technologies, with none approaching the maximum score. Future applications of the methodology should focus on capturing more subtle distinctions, while recognizing that all technologies are viewed as valuable for the energy transition, with their differences influenced by technological advancements and market dynamics within specific contexts.

Engaging stakeholders in energy life cycle sustainability assessment: Critiques and recommendations for the ECOSENS methodology

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The ECOSENS project undertook a participative assessment of the sustainability performance of key energy technologies driving the green transition: intermittent renewables (wind and solar), hydropower, nuclear power, and natural gas. Upstream, diverse stakeholders were called upon in 2023 to shape and validate the proposed assessment methodology covering environmental, economic and social pillars. Then the approach was tested in 2024 by a detailed consultation to assess 62 indicators (20 energy/technologies professionals and 20 social science professionals replied), relying on both raters' own knowledge and fiches providing sustainability data. A report was published on the ECOSENS website in January 2025. Subsequently, a new set of stakeholders including some NGO and CSO representatives attending a webinar input their critiques and recommendations, focusing on 8 contentious indicators, those revealing striking dissensus among the 40 raters on nuclear energy sustainability performance. This presentation briefly outlines the post hoc critiques and derived recommendations, in order to launch discussion about how a diversity of stakeholders can effectively participate in energy sustainability assessment intended to help guide decision making on nuclear power in the 2050 energy mix.

The upstream methodological workshop is reported here: https://ecosens-project.eu/decarbonizing-europes-energysystem-checking-and-choosingindicators-for-a-sustainabilityassessment/

The test assessment is reported here: https://ecosens-project.eu/deliverable-2-4-investigation-on-the-sustainability-of-theentire-life-cycle-of-nuclear-power/

Critiques and recommendations for improvement will be reported in ECOSENS Deliverable 2.5, incorporating input from the September 2025 conference discussion.

References

[1] https://ecosens-project.eu/decarbonizing-europes-energysystem-checking-and-choosingindicators-for-a-sustainabilityassessment/
[2] https://ecosens-project.eu/deliverable-2-4-investigation-on-the-sustainability-of-theentire-life-cycle-of-nuclear-power/

Topic #3: Socio-Economic Models

Discounting the Future? Reviewing Social Discount Rate Calculation Methods for Nuclear Infrastructure Investments

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Selecting an appropriate Social Discount Rate (SDR) represents a key challenge in assessing long-term public investments, especially those involving large-scale, capital-intensive, and sustainability-oriented infrastructure such as nuclear infrastructure. The lack of consensus on SDR estimation methodologies leads to substantial disparities in discount rates across contexts, influencing policy decisions and the perceived feasibility of long-lived projects. This study offers a comprehensive review of the principal SDR estimation frameworks, including the Social Rate of Time Preference (SRTP), the Social Opportunity Cost of Capital (SOC), and declining discount rate models such as Weitzman's Gamma Discounting and the Ramsey-Gollier formulation.

Through a comparative analysis of SDR applications in 18 countries, the research illustrates how variations in economic conditions, institutional settings, and regulatory frameworks influence national discounting practices. The findings emphasize that SDR selection is not merely a technical exercise but a normative choice with profound implications for infrastructure planning, particularly for nuclear infrastructure, where long project lifespans and intergenerational trade-offs are central.

By connecting theoretical models with empirical practices, this study provides critical insights for policymakers aiming to align economic evaluation methods with sustainability goals. It advocates for more context-sensitive and transparent SDR calculation methods to ensure that investment decisions in nuclear infrastructure and similar long-term projects adequately reflect both present needs and future societal benefits.

Retirement or Renewal? Investigating Life-Extension Projects in the USA Nuclear Large Technological Systems

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To maintain and strengthen the role of nuclear within national energy systems, it is essential not only to invest in new reactor construction but also to extend the operational life of existing nuclear plants. This goal is primarily achieved through license renewal and life-extension programs. However, these strategic interventions are not always pursued, threatening the survival of nuclear large technological systems (LTS), especially as reactor fleets age. This paper investigates the key factors that shape the decision-making process regarding license renewal, life extension, and related capital investments. Focusing on the United States, characterized by a mature nuclear LTS with many reactors that already granted license extensions, some undergoing subsequent renewals, and others facing early retirement despite renewal approval, the study draws upon semi-structured interviews with senior nuclear professionals. The findings reveal that economic and temporal factors play a decisive role in life-extension projects. Specifically, electricity market conditions, competition with other energy sources (particularly natural gas), and the availability of risk-mitigating mechanisms such as power purchase agreements are identified as critical drivers. Importantly, the study highlights that, unlike common concerns in nuclear project development related to cost overruns and schedule delays, the primary barriers in life-extension projects lie on the revenue side. This research offers important insights for policymakers and industry leaders seeking to maintain and improve nuclear LTSs.

Building Nuclear Plants: A Study on Drivers and Barriers

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Many nuclear power projects (NPPs) have been cancelled before construction begins, often after substantial planning expenditures. However, there has been no systematic investigation into why some NPPs advance to construction while others do not. Using a multiple case study approach, we examined how project governance influences the decision to proceed with or cancel NPP construction. Specifically, we identified the key drivers and barriers to construction. Our analysis highlights the importance of factors such as utility and vendor ownership structures, project leverage structures, government involvement, and the distribution of completion and market risks. These insights can help practitioners and policymakers assess the viability of NPPs and develop more effective governance strategies to support the start of construction. This study also lays a foundation for further research on governance and business models within the nuclear industry.

Keywords: Project governance; Financing; Funding; Risk allocation; Risk sharing

Financing Small Modular Reactors: Implications on Bankability

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This study identifies the implications of financing Small Modular Reactors (SMRs) on the bankability of SMR projects. While SMRs are often promoted as more financeable than conventional large reactors, they still remain complex to finance. The links between financing features and bankability outcomes remain underexplored.

A qualitative research design based on an abductive approach is employed to identify the key financing features, mediators, and bankability drivers.

The study develops a theoretical framework in which financing features such as self-financing, servitisation, cogeneration prospects, smaller project size, and volume deployment causally affect dimensions of bankability. Each financing feature enables positive and negative forces, mediated by co-siting economies, learning effects, workforce availability, and supply chain development.

Findings provide insights for SMR developers, investors, and policymakers to design financing structures that enhance positive pathways while mitigating vulnerabilities that could inhibit project viability.

The Impact of Nuclear Energy Integration in the 2050 Fully Decarbonized Belgian Energy System

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Over the course of 2024, Energyville joined forces with key industry partners – Arcelor-Mittal, BASF, Elia, Fluxys and Luminus. Together we drafted 3 main pathways (Rotors, Reactors and Imports scenario) to fully decarbonize the Belgian energy system by 2050. With the combination of TIMES energy system modelling expertise and industrial insights and know-how, these scenarios present a balanced and feasible approach towards full decarbonization. Due to the broad nature of differing assumptions, and the extensive sensitivity analysis, the results allow for a detailed analysis of the impact of nuclear energy in the future energy system.

In the presentation we provide insights into questions like: How does nuclear energy interact with high levels of renewable energy in terms of dispatch profiles? How does nuclear energy affect decarbonization choices in final energy consumption like industry, residential, transport, etc? How does nuclear energy affect the dependency on energy imports and the prices risk associated with that? How does nuclear energy affect the expected electricity price cost basis?

The presented results will be based on public information available on the Paths2050 website [1], combined with additional internal analysis.

References

[1] Juan Correa Laguna, Pieter Lodewijks, Andrea Moglianesi, Wouter Nijs, Luc Van Wortswinkel, (2025), Paths2050 - 2025 edition - website (Main Edition 2025 | Energy outlook)

Topic #4: Historical and Ethical Reflections

Nuclear Norway: Should Thorium be Part of the Deal?

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The debate on whether Norway should adopt nuclear energy has been receiving a lot of attention in the past years. The need for emission-free and stable energy sources that can help deal with the natural and climate crisis and meet an increasing need for power as well as technological development in the field of nuclear have been fuelling this discussion. In addition, several private actors in collaboration with Norwegian municipalities have plans for the establishment of nuclear power production. However, if Norway was to go nuclear, what would this potential nuclear future look like? Norwegian Nuclear Research Centre is organising a workshop on June 17th 2025 to explore and debate the pros and cons of including thorium in a nuclear programme.

The workshop will bring together a broad range of stakeholders, covering academia, authorities and industry, to exchange views and participate in facilitated discussion. Plenary presentations will address the role of thorium in nuclear industry and its asset as a Norwegian resource as well as general perspectives from other countries. Small break-out group discussions will map out the potential benefits, opportunities and challenges, and identify areas of consensus and dissent between participants.

The workshop will discuss a variety of issues including nuclear legacy in Norway, fuel cycle, reactor technology, molten salt and small modular reactors, thorium reserves in Norway, nuclear driven ships/vessels, waste and nuclear risks. This talk will present workshop objectives, procedures and results.

Acknowledgements: This work is part of the GIROSCOPE project, funded as part of PIANOFORTE Partnership, which received funding from European Union's "EURATOM" R&I programme, under grant agreement 101061037.

System Momentum and Exogenous Events: Understanding the Resilience of Nuclear Large Technological Systems

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As the need to reduce greenhouse gas emissions grows, nuclear energy is increasingly viewed as a vital carbon-free baseload power source. Its expansion, however, depends on the development of Large Technological Systems (LTSs), complex socio-technical networks combining material infrastructure with institutional, political, and cultural elements. While prior research has explored the emergence and consolidation of nuclear LTSs, less attention has been paid to their momentum and resilience, particularly their ability to absorb or adapt to external shocks.

This paper fills this gap by analyzing the historical trajectories of nuclear LTSs in four European countries (i.e., France, the United Kingdom, Germany, and Italy) through a multiple case study approach. It examines how various factors (socio-economic, political, technological, socio-cultural, and environmental) shaped national responses to major external events such as the 1970s oil crisis and the Chernobyl and Fukushima accidents.

Findings show that the configuration of these factors before such events significantly influenced each country's post-crisis path. France and the UK reinforced their nuclear systems, while Germany and Italy saw destabilization leading to nuclear phase-outs. The study proposes a new framework for understanding nuclear LTS momentum as a function of the alignment among key system components. This framework offers valuable insights for policymakers by highlighting the importance of pre-existing system configurations in shaping long-term resilience, suggesting where interventions may strengthen a nuclear LTS's ability to withstand future shocks.

How Nuclear Promises are Made Credible and Legitimate: Historical Examples of SMRs, Fast Breeders, and Megaprojects in Canada, France, and the UK

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Research in sociology and Science and Technology Studies (STS) has demonstrated the importance of the so-called techno-scientific promises for the development and deployment of new technologies. To earn the needed support from investors, policymakers, stakeholders, and public at large, a promise must be legitimate, that is, perceived as a solution to a widely recognised and urgent societal problem, and appear as credible in terms of its practical viability.

The small modular reactors (SMRs) are the latest in the long series of techno-scientific promises in the nuclear sector. This historical legacy sets nuclear technologies apart from many other techno-sciences, yet SMRs exhibit many of the typical characteristics of techno-scientific promises, most notably the simultaneous claim of novelty and ordinariness: they are portrayed as a radically novel technology, yet at the same time as "nothing new", based on tried and proven technologies.

Taking Canada, France, and the UK as case studies, this paper explores such duality by analysing the role of two historical precedents in the construction of the SMR promise: 1) the long experience of fast breeder reactors used to lend credibility for the promise, and 2) the recent, largely problematic experience of Generation III nuclear reactor projects in the West, to legitimise the need of SMRs as a radically novel innovation. The analysis builds on three large corpora of press articles in Canada, France, and the UK from 2000 to 2024, analysed with the help of the socio-informatic toolkit developed by French pragmatic sociologists and centred around the Prospéro software.

How a Green, Sustainable City Faces the Two Dirty Ends of the Nuclear Chain? Uranium Mining and High-Level Radioactive Waste Disposal in Pécs

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Under the EU's 2019 Green Deal strategy, the taxonomy already classified nuclear energy – alongside natural gas – as environmentally sustainable for the transitional period. Recently, startling projections have suggested that achieving net-zero greenhouse gas emissions by 2050 would require the EU to commission as many as 500(!) small modular reactors (SMRs).

Proponents of nuclear power often counter public resistance with claims that nuclear plants are clean and safe to operate, creating numerous well-paid jobs that drive local economic growth through strong purchasing power and tax contributions. Yet in the case of SMRs, these promised benefits are increasingly questioned. When it comes to uranium mining and high-level radioactive waste (HLW) repositories, such arguments lose almost all credibility.

The city of Pécs – with its 2,000-year-old Roman heritage and a population of 150,000 – once hosted a uranium mine operated under Soviet-Russian control, which was closed in 1997. Even today, restoration efforts and the protection of the city's vulnerable water resources require ongoing commitment. In recent years, various investors have sought to reopen the mine, a move the city is resisting through legal measures. At the same time, the Hungarian government is planning to site the national HLW deep geological repository just outside the city. Both projects have been firmly rejected by the Pécs city council and face widespread public opposition.

Pécs was named the European Capital of Culture in 2010 and joined the EU's Net Zero Cities and 100 Climate-Neutral and Smart Cities initiatives in 2022. The city envisions its future based on environmentally friendly, high value-added industries, top-tier higher education, and advanced healthcare, cultural, and tourism services.

The question remains: how can this forward-looking and ambitious vision be reconciled with the two dirtiest ends of the nuclear chain.

The Never-ending Struggle for Transparency, Participation and Justice Regarding Nuclear Projects in Bulgaria – Civil Society, Courts, Professional Obfuscators and Media Dependence

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The presentation focuses on a brief representation of the main public affairs, initiatives and manipulative theses in the field of nuclear energy in Bulgaria for a period of two decades back in time. There are two different narratives in – figuratively speaking – two separate worlds of public communication regarding nuclear projects and theses in Bulgaria. The mass one is that of politicians, professional obfuscators and dependent mass media. It is mainly propagandistic and manipulative in nature. The other is the civil one - a difficult for the mass audience narrative regarding the true complex problems, incidents, shortcomings and violations affecting nuclear projects and facilities, the decisions on which civil society appeals in court. The main objects in the presentation are the Kozloduy NPP, the unbuilt Belene NPP and the radioactive waste projects.

ECOSENS Recommendations

Practical Recommendations for Enhanced Mechanisms of Interaction Between Citizens, Civil Society, Decision-makers, and Researchers

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The European project ECOSENS ("Economic and Social Considerations for the Future of Nuclear Energy in Society"), a Coordination and Support Action under Euratom, addresses the societal dimensions of nuclear energy in the context of climate change, sustainable development, and energy security. Recognising that effective, transparent, and inclusive governance of nuclear technologies requires active participation of citizens and civil society, ECOSENS examined current practices and gaps in stakeholder engagement across Europe.

Through a multi-method approach, including surveys, interviews, case studies, and deliberative workshops, the project assessed public attitudes, reviewed existing recommendations, and explored participatory processes in areas such as nuclear innovation, Small Modular Reactors (SMRs), radioactive waste management, and energy policy. Findings reveal a persistent discrepancy between legal commitments to stakeholder engagement and actual practice, often marked by technocratic approaches, fragmented responsibilities, and limited transparency.

Drawing on interdisciplinary dialogue and input from an international workshop and panel discussion, ECOSENS formulated a set of practical recommendations for strengthening engagement mechanisms. Recommendations cover legal and institutional frameworks, transparency and communication, diversity and inclusion, and the integration of social sciences and humanities into nuclear R&D. Key proposals include institutionalising early and continuous participation, creating independent oversight mechanisms, supporting civil society organisations (including environmental NGOs) with stable funding, enhancing community rights in siting processes, and embedding participatory approaches into sustainability assessments and long-term energy strategies.

By bridging techno-scientific and societal perspectives, ECOSENS recommendations aim to foster more democratic, legitimate, and socially robust decision making in nuclear governance. They also contribute to broader energy transitions by ensuring that nuclear policies are not only technically sound but also publicly accountable and societally desirable.

Keywords: Stakeholder engagement; Nuclear governance; Civil society; Sustainability transitions; Energy policy

https://ecosens-project.eu/

ECOSENS

Economic and Social Considerations for the Future of Nuclear Energy in Society and social considerations

Practical recommendations for enhanced mechanisms of interaction between citizens, civil society, decision-makers, and researchers

ECOSENS WP1 participants, Correspondence: catrinel.turcanu@sckcen.be

Introduction

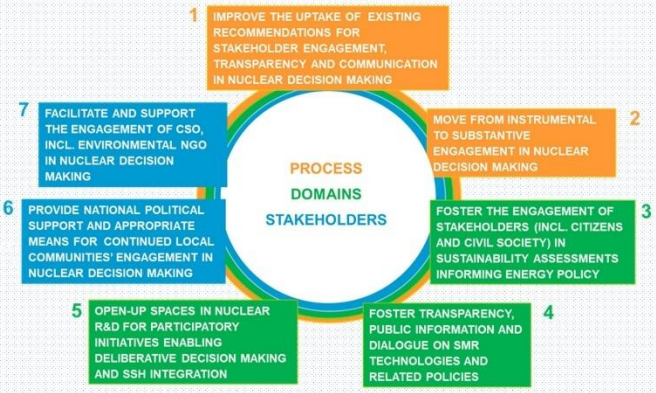
- Citizen and civil society engagement in nuclear and energy policy is essential for meeting climate goals and sustainable energy transitions.
- Participation is a legal right (protected, e.g. by the Aarhus Convention and the EU Environmental Impact Assessment Directive), ensuring legitimate, just and democratic decisions, and a key element of nuclear technology governance and societal transitions towards sustainability.
- The ECOSENS project explored, among others, stakeholder engagement in nuclear energy governance.
- Recommendations have been formulated for enhanced interaction between citizens, civil society, decision-makers, and researchers in nuclear decision making and energy policy.

Methods

- Multi-method case studies: Focus groups, interviews, surveys (nationally representative and targeted groups), case studies conducted in several countries (Belgium, Spain, Czech Republic, Slovakia, Slovenia, UK).
- Desk research and reviews: Critical review of existing international guidelines and EU project recommendations on stakeholder engagement in nuclear governance.
- Workshops and dialogues: Deliberative workshops, interdisciplinary dialogues, and stakeholder panels (e.g., RICOMET, SHARE platform, GMF municipalities group) to co-develop perspectives and recommendations.
- This approach ensured that the recommendations are grounded in diverse evidence, cross-country perspectives, and inclusive stakeholder deliberation.

ECOSENS Stakeholder Engagement Needs based on existing recommendations in the nuclear field

ECOSENS recommendations for improved stakeholder engagement in nuclear decision making and energy policy



Recommendations concern the following types of stakeholders:

- Political stakeholders, e.g. National governments and prime ministerial offices, especially those coordinating long-term energy strategy and net-zero goals, Relevant ministries, Regional and local authorities, Regulatory bodies, Political decision makers
- Industry stakeholders, e.g. Nuclear industry, Actors involved in nuclear innovation
- Academic stakeholders, e.g. Researchers from universities and research centres, Organisations working in nuclear innovation and R&D, Institutions conducting sustainability assessments and supportive research, Institutions deciding on R&D funding and trajectories
- Societal stakeholders, e.g. Civil Society Organisations, Local communities.
- Environment stakeholders, e.g. Environmental NGOs

Recommendations, including actions and inspiring examples are available at :

Key messages

- Inclusive participation ensures legitimacy, justice, and democratic governance in energy and nuclear technology transitions.
- Legal rights to participation must be matched by early and substantive involvement.
- Integrating social sciences, humanities, and civil society perspectives ensures more robust and adaptive decisions.
- Long-term political commitment, resources, and institutional infrastructures are key to participatory governance.

This Project has received funds from the European Commission under the Horizon Europe EURATOM Programme, GA 1010920

Closing Section

Summary of the Program

8th September 2025	
9.00-9.30	*Opening the Event*
9.30-10.45	*Topic #2: Sustainability Assessment*
10.45-11.15	*Coffee Break*
11.15-12.45	*Topic #1: Societal Perspectives*
12.45-14.00	*Lunch*
14.00-15.45	*Topic #1: Societal Perspectives*
15.45-16.15	*Coffee Break*
16.15-17.45	*Topic #1: Societal Perspectives*

9th September 2025	
9.00-10.30	*Topic #3: Socio-Economic Models*
10.30-11.00	*Coffee Break*
11.00-12.30	*Topic #1: Societal Perspectives*
12.30-13.45	*Lunch*
13.45-15.15	*Topic #4: Historical and Ethical Reflections*
15.15-15.45	*Coffee Break*
15.45-16.45	*Pannel Discussion*
16.45-17.00	*Closing the Event*

Acknowledgements

The Organising Committee of the ECOSENS Project Conference would like to sincerely thank all participants for their valuable contributions. It is your presence and your work that make this conference a meaningful and enriching event.

We would also like to extend our gratitude to the European Union for its financial support through the Euratom Research and Training Programme, which made this conference and the broader ECOSENS project possible.

Finally, we warmly thank Politecnico di Milano for generously hosting the event in Milano and for providing an excellent environment for exchange and discussion.

Thank you all for your contribution.

ECOSENS Project Conference: Program and Book of Abstracts

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Doi
http://dx.doi.org/DOI:10.20348/STOREDB/1227

ISBN
978-961-6688-14-7
(PDF)

Keywords:
ECOSENS,
Nuclear energy,
Societal perspectives,
Sustainability assessment,
Socio-economic models,
Ethical reflections

The ECOSENS Project Conference 2025, titled "Futures for nuclear energy? Social, economic and environmental considerations", held on 8–9 September 2025 in Milano, Italy, marked the conclusion of the ECOSENS Project, an interdisciplinary initiative funded under the Euratom Research and Training Programme. Gathering researchers, practitioners, and policymakers from across Europe, the event offered a unique platform to explore the complex intersection of nuclear energy with social, economic, and environmental dimensions. The Program and Book of Abstracts encapsulates the intellectual breadth and depth of the conference, highlighting ongoing debates and emerging insights that are shaping Europe's nuclear future.

The conference structure was organised around four core thematic areas. The first, Societal Perspectives, examined how the public and various stakeholders perceive nuclear technologies, particularly in the context of small modular reactors (SMRs), climate change, and energy security. This topic, which featured the largest number of contributions, included 21 abstracts addressing themes such as public attitudes, media discourse, generational shifts in perception, and stakeholder engagement practices across different European countries.

The second theme, Sustainability Assessment, focused on evaluating nuclear and other energy technologies through comprehensive life-cycle and system integration analyses. Four abstracts explored methodological approaches to participatory assessment, stakeholder involvement in sustainability evaluations, and the challenges of aligning technical analysis with societal expectations.

Socio-Economic Models formed the third topic, comprising six abstracts. These contributions investigated the economic viability of nuclear technologies, the financing and bankability of SMR projects, and the broader implications of nuclear integration within decarbonisation scenarios. Innovative modelling techniques and governance strategies were discussed to better understand investment dynamics and long-term infrastructure planning.

Finally, the theme of Historical and Ethical Reflections brought a critical dimension to the conference, with five abstracts delving into past experiences, value-based considerations, and the political narratives that shape public trust and legitimacy in nuclear decision-making. Case studies ranged from Norway and Hungary to broader cross-national analyses, highlighting the persistent tensions between local opposition, national policy ambitions, and ethical dilemmas.

Altogether, the 36 abstracts collected in this volume reflect the ECOSENS project's commitment to fostering a more inclusive, transparent, and

multidisciplinary dialogue on the future of nuclear energy. By bridging technical expertise with societal insight, the conference underscored the importance of integrating diverse perspectives into energy governance at a time when Europe seeks sustainable and socially acceptable pathways to decarbonisation.

2025

September

8-9

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