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

Project Number: 101060920

## Deliverable 4.3 Report on stakeholders' engagement

Work Package 4

Lead Beneficiary: EIMV

Due date: 31/08/2025 Released on: 30/08/2025

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| **Dissemination Level** | | |
|---|---|---|
| **PU** | Public | **X** |
| **RE** | Restricted to project partners and EC | |
| **SEN** | Sensitive (EU-restricted) | |

Funded by the European Union

**Project information**

| | |
|---|---|
| Project full title: | Economic and Social Considerations for the Future of Nuclear Energy in Society |
| Acronym: | ECOSENS |
| Funding scheme: | CSA |
| ECGA number: | 101060920 |
| Call/topic | HORIZON-EURATOM-2021-NRT-01-14 |
| Coordinator: | Regia Autonoma Tehnologii pentru Energia Nucleara (RATEN) - Daniela Diaconu |
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| Start date - End date: | 1 October 2022 - 30 September 2025 (36 months) |
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**Document information**

| | |
|---|---|
| Deliverable Title | Report on stakeholders' engagement |
| Deliverable No. | D4.3 |
| Work Package No. | 4 |
| Work Package Title | Communication, Dissemination and Exploitation of Results |
| Lead Beneficiary | EIMV |
| Contractual Delivery Date | 31/08/2025 |
| Actual Delivery Date | 30/08/2025 |
| Type | R |
| Dissemination level | PU |
| Authors | Nadja Železnik, Matija Simon (EIMV) |

**To be cited as:**

Železnik N. & Simon M., (2025): Report on stakeholders' engagement, ECOSENS Deliverable D4.3, http://dx.doi.org/DOI:10.20348/STOREDB/1223

Funded by the European Union

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**Acknowledgement**

This project 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.



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## Executive Summary

This deliverable documents how ECOSENS (2022-2025) involved a broad, plural set of stakeholders to ground its scientific work on nuclear energy in societal realities. Across workshops, a webinar, and four scientific events, the project used open, deliberative formats to show up values, scrutinize assumptions, and co-shape tools for sustainability and socio-economic assessment. Nearly sixty distinct external stakeholders from academia, industry, government, NGOs, local partnerships, and high-level political actors participated, representing more than a dozen countries across Europe.

The first event was a two-day Brussels workshop combined "futures thinking" with technical critique to steer ECOSENS's life-cycle sustainability framework toward scenario-based comparisons and explicit treatment of social and ethical dimensions. Participants stressed that sustainability assessment is itself a deliberative process that must be transparent about value judgments. A follow-up international online webinar refined 2050 scenario assumptions, urging inclusion of disruption cases and clearer tracing of non-linear drivers (e.g., behaviour change, electrification). This checkpoint strengthened the credibility of subsequent modelling work.

The second event was the first Scientific Event which tested the sustainability theme in a public forum. Panellists from local communities, NGOs, research, and industry converged on three messages: assess nuclear within whole-system scenarios face unique long-term risks (waste, accidents, geopolitics) and recognize the inherently political nature of assessment choices. These insights fed back into ECOSENS's methodology.

Third event was two parts Scientific Event whereas Part 1 focused on public participation for Small Modular Reactors. Stakeholders emphasized early, transparent, and inclusive engagement beyond siting thus covering research funding, strategy, and value warned against over-promising, and highlighted the role of municipal partnerships. Practical recommendations included national engagement strategies and use of deliberative mini-publics. Part 2 of the second Scientific Event stress-tested the System of Provision (SoP) socio-economic model. Stakeholders welcomed its breadth but pressed for clearer terminology, transparent weighting, country-specific flexibility, and participatory modelling so outputs become discussion aids rather than black-box scores.

The final event ECOSENS Conference connected societal, sustainability, and economic strands. It reinforced that durable nuclear governance depends on institutional transparency, ethical reflection (e.g., intergenerational waste), and tools that support pluralistic decision-making and not single "answers."

Overall ECOSENS shows that Europe's nuclear choices cannot be resolved by technical analysis alone. Sustainable pathways whether nuclear-inclusive or not require co-created tools, iterative stakeholder dialogue, and governance that aligns technological possibilities with democratic legitimacy and societal values.

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# 1 Introduction

ECOSENS (Economic and Social Considerations for the Future of Nuclear Energy in Society) is a Euratom-funded project (2022-2025) that created a neutral space for collaboration between nuclear experts and a broad range of stakeholders. A core aim of the project was to integrate societal perspectives into assessing the sustainability of nuclear energy, by opening technoscientific issues to social, political, cultural, and ethical scrutiny. To achieve this, ECOSENS actively engaged stakeholders through a series of workshops, webinars, and public events from 2023 to 2025. These engagement activities were designed to gather diverse input, encourage dialogue, and democratize the discussion on nuclear energy futures.

The stakeholder engagement process spanned multiple events, each building on the insights of the previous ones. Early workshops in March 2023 focused on imagining energy futures and refining the project's sustainability assessment methodology. A subsequent webinar in June 2023 brought stakeholders together to review and adjust assumptions for long-term energy scenarios. Following these initial exchanges, the project organized four scientific events between 2023 and 2025 to share findings and deepen discussions. These events progressively addressed key themes: the first examined sustainability assessment methods, the next two (in two parts) explored public participation and socio-economic modelling, and the final conference in 2025 integrated these perspectives into broader governance considerations. Throughout all engagements, ECOSENS emphasized a pluralistic approach and bringing together experts, policymakers, industry, civil society and public voices, not to seek consensus, but to hear diverse viewpoints in an open dialogue.

This report provides an overview of the stakeholder participation in ECOSENS and summarizes each major engagement event. Section 2 presents aggregate statistics on stakeholder involvement, illustrating the diversity and scope of participation. Section 3 offers a chronological account of the events, detailing the context, themes, and stakeholder contributions in each. Finally, Section 4 concludes with reflections on the role and outcomes of stakeholder engagement in the project, and Section 5 lists references. By documenting these activities and their outcomes, Deliverable D4.3 highlights how inclusive engagement was leveraged to enrich the project's research and to ground its findings in societal realities.

# 2 Overview of Stakeholder Participation in Statistics

Over the course of the ECOSENS project, 59 distinct stakeholders participated in the engagement activities (workshops, webinar, scientific events and conference). These participants came from a wide variety of backgrounds like academic, policy, industry, and civil society and brought diverse expertise to the table. Many were invited as independent experts or representatives of key stakeholder groups to ensure a balanced dialogue. The project sought to involve stakeholders holding different views on energy futures, creating a *"neutral space"* for discussion where no technology advocacy was assumed. Notably, stakeholder participants ranged from researchers and technical experts to policymakers, regulators, NGO activists, and local community representatives, reflecting the multifaceted social context of nuclear energy.

### 2.1.1 Participation by stakeholder type

Among the engaged stakeholders were *academic and research experts* (from universities and institutes across Europe), *industry and technical specialists* (including representatives of the nuclear sector and energy agencies), *policy makers* (such as members of parliament and government agency officials), and *civil society actors*. Civil society was represented through *non-governmental organizations (NGOs)* focused on environment or transparency (e.g. Greenpeace, Friends of the Earth), local partnership groups from nuclear host communities (e.g. Belgium's STORA and MONA committees), and broader European networks dealing with transparency in nuclear field (e.g. Nuclear Transparency Watch). Several participants were from national radioactive waste management organizations (e.g. ONDRAF/NIRAS in Belgium, ZUOP in Poland) or advisory bodies, contributing practical perspectives from the field. High-level political engagement was also achieved: for example, a Member of the European Parliament participated in discussions on new reactor technologies. This rich mix ensured that voices from NGOs, local communities, industry associations (such as *Nucleareurope*), and government all contributed to ECOSENS dialogues. Participation of stakeholders by type is presented by pie chart in Figure 1.

Stakeholders were identified and grouped drawing on the Quintuple Helix model, which is particularly relevant for ECOSENS as it is deemed to provide a "framework for transdisciplinary (and interdisciplinary) analysis of sustainable development and social ecology" (Carayannis et al., 2012). The Quintuple Helix Model emphasises the interconnections between knowledge, innovation and the natural environment. The five helices include:

1. The research (SSH and non-SSH) and education system, e.g. universities, higher education systems, research centres and schools;
2. The economic system, e.g. nuclear industry, other relevant industry (e.g. energy distribution), firms, services and banks;
3. The natural environment, e.g. environmental NGOs;
4. The media-based and culture-based public, e.g. local communities, Civil Society Organisations, Local Information Committees, social networks, media;
5. The political system, e.g. regulator, government agencies, politicians.

Such division of stakeholders was used also in the Figure 1. The largest share is represented by Research and Education, comprising 24 stakeholders, followed by Environment and NGOs with 21 stakeholders. Both of these groups account for the majority of the total. Two categories, Political / Regulatory and Media & Public, each include 6 stakeholders, forming moderately sized

but equal segments. The smallest category is Economic / Industry, with only 2 stakeholders, making it the least represented group.

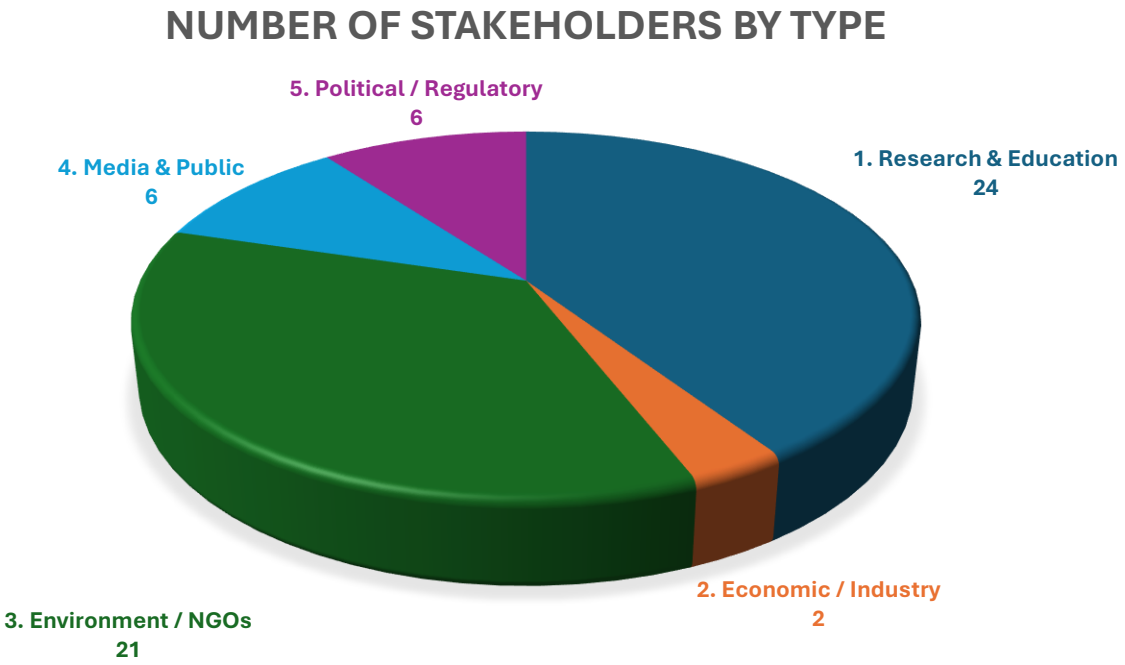



*Figure 1: Participating stakeholders presented by type*

### 2.1.2 Geographical reach

Stakeholder engagement in ECOSENS was international in scope. The ~60 individuals involved were based in over a dozen countries spanning Western, Central, and Eastern Europe, with a few from outside Europe. Participants hailed from Austria, Belgium, Bulgaria, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, the UK, and beyond (including Canada, Pakistan and Japan, via embassy or expert representation). This geographic diversity brought a variety of national perspectives on nuclear energy and energy transitions. Many events were held in conjunction with international conferences or online, facilitating broader European participation. All events were conducted in English, and when held in-person, also offered hybrid online access to enable remote stakeholders to join.

### 2.1.3 Attendance and repeat participation

Each engagement event gathered between ~5 and 25 participants, not counting project team members. The initial March 2023 workshop was one of the largest dedicated sessions with over 20 stakeholder experts attending in person. Subsequent scientific panel events typically featured smaller invited panels (around 5-6 panellists) joined by additional audience members (conference attendees or webinar participants) in a hybrid format. Several stakeholders remained involved across multiple events - for instance, some experts from the first workshops continued to contribute at later panels and the final conference. This continuity helped carry forward insights from one stage to the next. At the same time, new stakeholders were introduced at different stages to widen the discussion. The overall outcome was a network of engaged

stakeholders who collectively informed the project's methodology, provided feedback on interim results, and discussed broader implications of ECOSENS findings.

In summary, the project's stakeholder engagement succeeded in assembling a diverse cohort of experts and interested parties. By the end of ECOSENS, nearly 60 external stakeholders had directly contributed to its activities. Their inputs - whether through brainstorming exercises, panel debates, or feedback on models - ensured that the project's outcomes were grounded in real-world concerns and viewpoints. The statistics demonstrate not only broad participation but also balanced representation, which is vital for legitimacy in discussions about the future of nuclear energy. The following section details the engagement events chronologically, highlighting the context and stakeholder contributions in each.

# 3 Events

This section provides an overview of the major stakeholder engagement events in ECOSENS, presented in chronological order. Each sub-section describes the event's purpose, format, key stakeholder groups involved, and main discussion points or outcomes. The events range from internal workshops and webinars aimed at developing the ECOSENS assessment framework, to public scientific sessions and the final conference disseminating project findings. Together, they illustrate the evolving narrative of stakeholder engagement in the project.

## 3.1 March 2023: "The Art and Science of Imagining Energy Futures" Workshop (Brussels)

The first stakeholder engagement was an in-person workshops held on 29-30 March 2023 in Brussels, organized under ECOSENS Work Packages 1 and 2 (Appendix 1). Titled *"The art and science of imagining energy futures" (Day 1) and "Decarbonizing Europe's energy system: Checking and choosing indicators for a sustainability assessment"* (Day 2) this two-day workshop convened stakeholders to collaboratively explore how future European energy scenarios are imagined and to inform the project's emerging sustainability assessment approach. Around 20 participants attended, coming from academic, civil society and policy backgrounds. This included social scientists, economists, environmental NGOs, industry experts, and policy advisors from across Europe, ensuring a broad mix of perspectives in the room.

### 3.1.1 Purpose and format

The workshop aimed to capture stakeholder input on both qualitative and quantitative aspects of ECOSENS's work. The first ECOSENS stakeholder workshop aimed to explore how different imaginaries of Europe's energy future are constructed and to test draft approaches for the project's sustainability assessment. On the first day, participants engaged in interactive exercises to articulate their visions of energy futures, discuss underlying values and worldviews, and consider how different imaginaries (visions, narratives, images) influence energy debates. This creative "futures thinking" session set the stage for the more technical discussions that followed. On the second day (30 March 2023), the focus shifted to the project's sustainability assessment methodology: stakeholders critically reviewed the proposed approach, including the criteria and indicators to be used for evaluating energy options. Organizers presented a draft framework for life-cycle sustainability assessment of nuclear and alternative energy systems, and participants provided feedback on its scope and assumptions. The event combined plenary sessions, breakout groups, and facilitated discussions, ensuring that participants could articulate their own visions and critique proposed methodologies.

### 3.1.2 Stakeholder contributions

Imagining futures. During the first part, stakeholders highlighted a range of imagined energy futures, from high-tech, nuclear-inclusive scenarios to renewable-dominated visions and reflected on the societal values (e.g. innovation, equity, security) associated with each. This exercise underscored the plurality of possible futures and the importance of acknowledging different stakeholder values in energy planning.

Methodological critique. In the second part, participants offered constructive criticism of the draft assessment methodology. For example, stakeholders questioned the weighting of sustainability criteria and whether the method adequately addressed qualitative factors like

public acceptance and ethical considerations. They also suggested that the assessment should compare whole energy system scenarios (integrated mixes of technologies) rather than just individual technologies in isolation. Insights from this workshop helped refine the ECOSENS approach - notably, they reinforced that the process of assessing sustainability is "a deliberation process in itself," requiring transparency about value judgments and active stakeholder involvement in defining what sustainability means. The outcomes of the March workshop were documented in an internal report and fed directly into the project's next steps.

Stakeholders highlighted the multiplicity of possible energy futures. Some emphasised renewable-dominated scenarios rooted in sufficiency, equity, and environmental protection, while others underscored technology-driven pathways including nuclear, prioritising innovation and energy security. A central message was that these divergent imaginaries reflect different underlying worldviews and values, which must be made explicit in any assessment framework.

On the methodological side, participants critiqued the proposed sustainability assessment framework. Concerns included:

- **Indicator selection and weighting**: Stakeholders argued that quantitative criteria alone cannot capture crucial qualitative aspects such as societal acceptance, ethical dimensions, and intergenerational justice.
- **System-level perspective**: They advised comparing *whole energy system scenarios* (e.g. mixes of nuclear, renewables, and efficiency measures) instead of evaluating individual technologies in isolation.
- **Transparency**: Participants stressed that sustainability assessment should be understood as a *deliberative process in itself*—requiring openness about value judgements and methodological assumptions.

### 3.1.3 Outcomes

The March 2023 workshop laid the conceptual foundation for ECOSENS's subsequent scenario and assessment work. Key outcomes included:

- Recognition that sustainability assessment is a socio-political process as much as a technical one.
- Agreement that indicator choice and weighting must be transparent, participatory, and sensitive to different national or cultural contexts.
- A methodological shift towards comparing *scenarios* rather than isolated technologies, thereby aligning the project with systemic perspectives on energy transitions.

Together, the Brussels discussions and the linked indicator workshop provided ECOSENS with both **conceptual orientation** (acknowledging plural imaginaries) and **practical refinements** (improving the sustainability framework), ensuring that the project's later modelling and assessment work was better grounded in stakeholder input.

## 3.2 June 2023: "Decarbonizing Europe's Energy System 2" Webinar (Online)

On 26 June 2023, ECOSENS held a two-hour international webinar via Zoom as a follow-up to the March workshops. The webinar, titled *"Decarbonizing Europe's Energy System 2: Clarifying non-linear assumptions about energy demand to 2050,"* was part of Work Package 2 efforts to refine scenario assumptions for the sustainability assessment. Its purpose was to review and tune the key input assumptions behind mid-century energy scenarios, with stakeholder input, considering recent crises and potential disruptors to linear trends. By convening stakeholders online, the project broadened participation to those unable to travel, ensuring continuity of dialogue from the earlier in-person workshop.

### 3.2.1 Participants

This webinar gathered a mix of specialist and non-specialist stakeholders including energy modelers, policy analysts, industry representatives, and NGO experts. About half of the attendees had also participated in the March 2023 workshop, providing continuity, while others were new contributors with fresh viewpoints. Importantly, stakeholders represented different perspectives on the energy transition, from proponents of ambitious renewable deployment to those emphasizing security of supply (some with nuclear industry background). All were reminded that participation in ECOSENS events did not imply endorsement of any technology in particular the aim was to hear *diverse perspectives rather than to seek consensus*.

### 3.2.2 Focus and discussion

The webinar focused on examining assumptions for Europe's energy demand and supply by 2050 under various decarbonization pathways. Key factors discussed included demographic trends, economic growth, technological innovation rates, climate policy stringency, and potential disruptions (e.g. pandemics, geopolitical conflicts) that could upset linear projections. Stakeholders reviewed a background working paper (ECOSENS D2.2a) outlining baseline assumptions derived from EU reference scenarios and other models. They were asked to critically "tune" these assumptions: for instance, suggesting higher or lower estimates for energy efficiency improvements, electrification rates, or societal behaviour changes, based on recent evidence or expert judgment. There was robust discussion on the plausibility of non-linear changes - for example, could Europe see radical demand reductions due to lifestyle shifts, or conversely, surges in energy use from new tech like EVs and heat pumps? Participants stressed that transparency in scenario building is crucial, and that assumptions should be grounded in stakeholder-informed reasoning.

### 3.2.3 Outcomes

The webinar yielded a set of refined assumptions and alternative scenario narratives that fed into the ECOSENS modelling work. Notably, stakeholders urged the project team to incorporate "disruption scenarios" (e.g. an extended gas supply crisis or faster-than-expected renewable rollout) rather than only smooth trajectories to 2050. They also highlighted socio-economic drivers: one insight was that *social and cultural trends* (e.g. public acceptance of certain technologies, or post-2030 lifestyle changes among youth) might significantly influence demand. These inputs helped ECOSENS adopt a more realistic and tested set of scenario assumptions, improving the robustness of the subsequent sustainability assessment. The webinar demonstrated the value of mid-course stakeholder checkpoints: by consulting a broad group in

an open forum, the project increased the credibility of its modelling assumptions and ensured they were scrutinized from multiple angles.

## 3.3 August 2023: First ECOSENS Scientific Event - RICOMET Conference, Dessel (Belgium)

As the project moved further into its research phase, it launched a series of public scientific events to disseminate preliminary findings and engage the wider community. The First ECOSENS Scientific Event was organized on 29 August 2023 in Dessel, Belgium, as part of the 9th RICOMET conference (a well-known international conference on risk communication and nuclear topics). The event was titled *"Powering the Future Responsibly: Assessing the Sustainability of Nuclear Energy."* Unlike earlier internal workshops, this was a hybrid panel session open to all RICOMET attendees (with Zoom access for remote participants), marking ECOSENS's debut on a broader stage. The choice of RICOMET provided an excellent opportunity to reach stakeholders from the nuclear communication, regulatory, and research communities attending the conference.

### 3.3.1 Participation

The Dessel event gathered a panel of six invited stakeholders representing different sectors, alongside ECOSENS project speakers. Panellists included representatives of local community partnerships involved in nuclear waste governance in Belgium (from STORA and MONA), an environmental NGO (Greenpeace/NTW), an energy NGO (France's négaWatt association), an industry/technical expert (from VITO, an energy research institute), and an innovation/academia representative (a sustainability start-up founder). This panel composition embodied the project's goal of bringing together policymakers, NGOs, local community voices, practitioners and researchers in a single discussion. In addition to the panel, dozens of conference participants attended the session in-person, and others joined online, contributing questions and comments. ECOSENS researchers moderated the discussion and presented project updates, but the focus was on stakeholder panel insights.

### 3.3.2 Discussion topics

The session explored the environmental, social, and economic dimensions essential for evaluating the long-term viability of nuclear energy in a future energy mix. Panellists were prompted to discuss how nuclear power's sustainability should be assessed in the context of climate goals and alongside other energy sources. Key points of debate included:

- **Assessment methodologies:** Panellists discussed current approaches to sustainability assessment (e.g. life-cycle assessment, NESA, INPRO methodologies). Several argued for improving these tools to *fairly evaluate different energy sources without bias*, noting that assessments must cover not only greenhouse emissions but also criteria like waste management, decommissioning, and accident risks. Some criticized existing studies for comparing technologies in isolation instead, whole energy system scenarios should be assessed (e.g. nuclear-inclusive scenario vs 100% renewables scenario) to understand relative roles.
- **Unique risks of nuclear:** Participants from civil society emphasized nuclear energy's unique long-term risks (e.g. radioactive waste disposal, nuclear proliferation and accident impacts) which are hard to quantify in traditional metrics. Local community representatives offered insight from areas hosting nuclear facilities - for example, they

noted that in communities familiar with nuclear operations, public trust can be high, and people recognize benefits like employment, yet intergenerational responsibilities (waste far into the future) weigh heavily.

- **Public perception and engagement:** The discussion underscored the importance of public participation in making nuclear sustainability assessments more robust. Panellists agreed that engaging stakeholders and the public is essential for an *inclusive and comprehensive assessment process*, since values and acceptability play a huge role in defining "sustainability" for nuclear options. However, they acknowledged the challenges: meaningful engagement is difficult due to technical knowledge gaps, limited public interest, and the time-consuming nature of deliberative processes. Strategies to enhance public involvement were debated, such as using citizen panels or improving risk communication. The session made clear that without public and stakeholder input, any sustainability evaluation of nuclear would be incomplete and potentially lack legitimacy.
- **Political and strategic context:** Many speakers noted that sustainability assessments are not purely technical exercises but inherently political. Choices about which criteria to prioritize or which future scenarios to consider reflect societal values and political priorities. The panel highlighted recent geopolitical and market disruptions (e.g. the war in Ukraine, energy price shocks) as reminders that resilience and contingency should factor into energy planning alongside sustainability. Nuclear role, some argued, should be examined in terms of contributing to a resilient energy system under stress scenarios, not just in an ideal steady-state future. Others countered that focusing on worst-case contingencies could entrench dependence on high-risk technologies, advocating instead for minimizing vulnerabilities (for example, reducing energy demand and diversifying supply).

### 3.3.3 Outcomes

This first scientific event served as an *"entry point"* for broader discussions initiated by ECOSENS. It validated several principles for the project. Firstly, stakeholder feedback confirmed the need for ECOSENS to treat sustainability assessment as a transparent, inclusive process rather than a black-box model. Secondly, insights from the panel were used to fine-tune the project's approach - for instance, incorporating more scenario-based comparisons and explicitly acknowledging political dimensions in the assessment framework. The event concluded that sustainability assessments of energy options must integrate diverse viewpoints and acknowledge their political nature, and that tools developed by ECOSENS should ultimately support inclusive, democratic decision-making on energy futures. A summary report with anonymized transcription of the panel was made available on the project website for transparency. The positive reception of this event set the stage for subsequent ECOSENS panels that would delve deeper into specific themes like public participation and socio-economic modelling.

## 3.4 June 2024: Second Scientific Event (Part 1) - Public Participation in SMR Decisions (Ljubljana)

The Second ECOSENS Scientific Event was a two-part series in 2024, thematically focused on public participation and socio-economic evaluation. Part 1 took place on 10 June 2024 in Ljubljana, Slovenia, during the RICOMET 2024 conference. Titled *"Public Participation in Decisions Related to Small Modular Reactors (SMRs),"* this event examined how the public and stakeholders can be involved in decision-making processes for emerging nuclear technologies,

particularly SMRs. The choice of SMRs as a focal topic was timely, given the growing interest in deploying small modular reactors in Europe and the associated debates about their acceptance and governance. By hosting this panel at RICOMET, ECOSENS again tapped into an international gathering of nuclear communication and society experts.

### 3.4.1 Participants

The Ljubljana panel featured a diverse group of stakeholders as speakers, reflecting multiple facets of the SMR debate. Participants included a Member of the European Parliament (an advocate for regional development and innovation), a representative of an environmental NGO (Friends of the Earth Europe) critical of nuclear expansion, a senior advisor from the Slovenian Parliament (bringing a national policy perspective), and experts in stakeholder engagement and local partnerships (including ECOSENS researchers with experience in community dialogue). Additionally, local officials and industry observers attended in the audience. The panel was moderated by ECOSENS team members, who first presented findings from the project relevant to public perception of SMRs - for example, recent *focus group studies in six countries* under Work Package 1 that revealed mixed public views on SMRs. This provided an evidence-based springboard for the stakeholder debate.

### 3.4.2 Key discussion points

The session tackled both the opportunities and the challenges of involving the public in decisions about SMR projects:

- **Transparency and trust:** Participants agreed that any consideration of SMRs must start with *transparent communication* about risks, benefits, and uncertainties. Given that SMRs are a relatively new and in some ways unproven technology, public awareness remains limited and often coloured by perceptions of nuclear power in general. The policymaker on the panel stressed that early transparency is essential to build trust, especially if countries are deciding whether to include SMRs in their energy strategy. Panellists cited historical lessons from nuclear waste siting - showing that trust, once lost, is hard to regain - as a cautionary tale for SMR deployment strategies.
- **Democratic decision-making:** There was extensive discussion on *when and how the public should be engaged* if an SMR project is proposed. Several speakers argued for early-stage participation: not waiting until a reactor site is selected or a project is nearly approved but involving citizens in framing the problem (do we need this technology?), in reviewing safety and sustainability criteria, and even in shaping R&D priorities. Examples were shared of good practices: in the Netherlands, for instance, citizen panels have been used to deliberate on energy scenarios. In Slovenia, local partnerships have provided communities near existing reactors a voice in oversight. These models could inform participatory approaches for SMRs. On the other hand, panellists noted that broad participation can be resource-intensive and must be genuinely influential (not just token consultation) to be meaningful.
- **Role of local authorities and communities:** An SMR project, if pursued, would likely impact specific localities. The panel highlighted the need to engage municipal authorities and community stakeholders from the outset. A local-level perspective was given: if, say, a municipality in Slovenia or elsewhere is considered for an SMR, the local government and public should partner in decision processes - potentially through agreements or community benefits - rather than being passive recipients of a top-down decision. The

concept of "partnership" was emphasized, drawing parallels to how some European countries involve communities in renewable energy projects or waste facility siting through co-design and benefit-sharing.

- **Critiques and caution:** The NGO representatives voiced scepticism about SMRs, questioning whether they truly represent a *meaningful innovation or just a repackaging of old nuclear technology*. They argued that sweeping promises (e.g. that SMRs will be cheaper, faster to build, and solve waste issues) are risky - if governments "over-promise" unproven benefits, it could backfire and further erode public trust when challenges emerge. Sober realism was advised: policymakers should rigorously evaluate alternative solutions (like renewables + storage) alongside SMRs, and clearly communicate the uncertainties, rather than presenting SMRs as a guaranteed silver bullet. Some participants also noted the geopolitical dimension: SMR designs might be imported, raising questions about national control and long-term fuel supply, which should be openly discussed with stakeholders.

### 3.4.3 Outcomes

The Ljubljana event underscored that public participation is not a peripheral aspect but central to the viability of new nuclear endeavours like SMRs. The dialogue generated several practical recommendations, such as developing national public engagement strategies for SMRs (well ahead of any deployment decision), ensuring regulatory processes are open and inclusive, and exploring innovative tools (e.g. citizen juries, online deliberation platforms) to expand participation. The session's findings reinforced ECOSENS's own research: public acceptance of nuclear innovations will depend on transparent, *early and continuous engagement*, and on situating the discussion within broader societal values and policy goals. A detailed transcription of the panel was recorded for project use, and a summary was posted on the ECOSENS website. These insights fed into the second part of the event series in Bucharest, where the focus shifted to socio-economic evaluation - another domain where stakeholder involvement is key.

## 3.5 October 2024: Second Scientific Event (Part 2) - Socio-economic Role of Nuclear Consultation (Bucharest)

The second part of the 2024 scientific event took place on 1 October 2024 in Bucharest, Romania, in the form of a dedicated ECOSENS stakeholder consultation. This session, effectively the Third Scientific Event of the project, was titled *"A Novel Approach to Assess and Establish the Socio-economic Role of Nuclear Energy at Country Level."* It built upon the Ljubljana discussions by moving from social participation issues to the realm of economic modeling and evidence-based decision-making. The Bucharest event was smaller in scale - essentially a consultative workshop - aimed at *testing a new assessment model* developed in ECOSENS and gathering expert feedback on its applicability for national energy strategy decisions.

### 3.5.1 Context

By this stage, ECOSENS had developed a prototype of its System of Provision (SoP) model - a novel socio-economic assessment framework intended to evaluate nuclear energy's contribution to a country's economy and society. The model incorporates indicators beyond the usual cost metrics, including factors like the Social Discount Rate, circular economy contributions, job creation, and societal well-being measures. The Bucharest consultation was

convened to present this model to stakeholders and get their critiques, suggestions, and validation on whether the approach resonates with policy needs.

### 3.5.2 Participants

Given the technical nature of this event, the stakeholder group was more specialized. It included NGO representatives with economics and transparency expertise, and other independent experts familiar with energy policy assessment. Notably, participants included a member of Nuclear Transparency Watch (NTW) and a representative of the UK's Cumbria Trust (a community-based group concerned with nuclear projects). Both individuals brought civil society perspectives on economic evaluation of nuclear projects - one at a European advocacy level and one from a local community advocacy angle. ECOSENS modellers and economists were also present to explain the SoP framework. The session was informal and conversational, with a transcript kept (later anonymized) for the project record.

### 3.5.3 Focus of discussion

The primary agenda was to critically assess the socio-economic model proposed by ECOSENS. Stakeholders were walked through a demonstration of the model using a hypothetical country case. Key points examined included:

- **Selection of indicators:** Participants probed why certain socio-economic indicators were chosen and how they were defined. There was debate on including measures like *public subsidies, long-term waste liabilities, opportunity costs* of nuclear vs. other investments, and how to quantify fewer tangible benefits (e.g. energy security, local skill development). Stakeholders generally welcomed the model's "conceptual ambition" in broadening the scope of analysis but noted the need for further refinement of indicators and clarity in definitions. For instance, how to ensure the Social Discount Rate used in the model truly reflects societal preferences and not just expert assumptions? The feedback emphasized making the model flexible to different national contexts, as each country may value aspects differently.

- **Aggregation and weighting:** A technical discussion revolved around how the model aggregates various indicators into an overall assessment. Stakeholders cautioned against any opaque weighting schemes that might hide value judgments. They stressed that transparency in weighting is crucial - if one country prioritizes, say, job creation over short-term costs, the model should allow that to be seen and adjusted. This again highlighted the inherently political nature of such assessments: deciding weights is effectively deciding policy priorities. The participants suggested that instead of a single composite score, the model could present a dashboard of outcomes for each indicator, leaving the "balancing" to policymakers through a deliberative process.

- **Usefulness for decision-making:** The consultation also questioned how such a model would be used in practice. Stakeholders considered scenarios like a government evaluating whether to invest in a new reactor versus renewables. They felt the model could be very useful to structure evidence in those debates, but only if stakeholders are involved in its development and interpretation. They advocated for *participatory modelling*: involving not just economists, but also community representatives, industry, etc., in refining the model assumptions for a given country. This would improve legitimacy and ensure the model's outputs are understood and trusted by non-experts. One participant noted that models can inadvertently serve political agendas if developed in

isolation, whereas a co-created model can become a *"dynamic instrument for steering strategic energy debates"* rather than a static report.

### 3.5.4 Outcomes

The Bucharest event provided valuable external validation and critique of the ECOSENS socio-economic assessment approach. The immediate outcome was a set of recommendations to the project team, such as simplifying certain model components for clarity, explicitly noting where normative choices (value judgments) are made, and planning user guides to help policymakers interpret results. The discussion reaffirmed that economic modelling in the nuclear domain must be participatory and transparent, capable of reflecting contested values and national specificities. By integrating this stakeholder feedback, ECOSENS strengthened its final outputs - ensuring the socio-economic model would be more user-friendly and attuned to real-world policy environments. Moreover, this consultation expanded the debate on *participation*: it illustrated that stakeholder engagement is not only about public acceptance of technology (as in Ljubljana's SMR focus) but also about co-designing the analytical tools that inform policy decisions. In doing so, it bridged the gap between qualitative participation and quantitative modeling, setting the scene for the project's culmination.

## 3.6 September 2025: Fourth Scientific Event - Final Conference (Milan, Italy)

The stakeholder engagement series culminated in the ECOSENS Final Conference, held on 8-9 September 2025 in Milan, Italy. As the Fourth and final Scientific Event, this conference was titled *"Futures for Nuclear Energy? Social, Economic and Environmental Considerations."* It was a two-day event bringing together project members, external experts, and stakeholders from across Europe to reflect on the interdisciplinary results of ECOSENS and discuss future implications. The conference was structured around several thematic sessions (tracks) and panel discussions, effectively synthesizing the themes of all prior engagements - from sustainability assessment and public engagement to socio-economic modelling and governance.

### 3.6.1 Participation

The final conference had the broadest attendance of all events, gathering researchers, policymakers, industry stakeholders, NGO representatives, and others in a single forum. There were attendees from at least 15 countries, including high-level participants such as national energy agency officials, members of regulatory bodies and technical support organizations (e.g. representatives from the French ASN/IRSN), academics from various universities, and civil society leaders from international networks (Greenpeace, Nuclear Transparency Watch, etc.). Many of the stakeholders who had engaged earlier in the project (through workshops or panels) joined the conference, alongside new faces interested in ECOSENS findings. This mix of continuity and fresh input enriched the discussions. The event format combined presentations of research papers (from ECOSENS Work Packages) with panel debates where stakeholders could respond and broaden the perspective. Notably, one panel featured national case studies (with speakers from different countries) to discuss how nuclear energy's role is perceived and managed in their contexts - highlighting issues of transparency and public trust at the country level.

### 3.6.2 Themes and discussions

Over the two days, the conference covered multiple themes, but some cross-cutting highlights include:

- **Integrative insights:** The conference underscored the interconnected nature of social, economic, and environmental aspects in nuclear energy debates. Sessions revisited topics from earlier events - for instance, re-examining SMRs but now including institutional readiness considerations and historical lessons or discussing sustainability assessment with the added perspective of the finalized ECOSENS model results. Participants noted how issues of public trust, economic rationale, and environmental impact are entwined and must be addressed together. The overarching message was that sustainable nuclear governance must be participatory, interdisciplinary, and context-sensitive, rather than siloed into technical or policy domains.

- **Policy tools and decision-making:** A major focus was on how the findings and tools developed by ECOSENS could inform real-world decisions. The sustainability assessment framework and the SoP socio-economic model were showcased. Stakeholders responded by emphasizing that policy tools should support pluralistic decision-making rather than give one-size-fits-all answers. For example, an interactive demonstration showed how changing certain assumptions in the model (e.g. discount rate, or societal risk aversion level) alters the outcomes, reinforcing that these tools are aids for discussion, not arbiters of "the truth." Many participants encouraged continued refinement of the tools *through stakeholder co-creation* even beyond the project's end. In other words, the dialogue initiated by ECOSENS should carry on, with its tools serving as living frameworks that stakeholders can adapt and use in their own national or local contexts.

- **Institutional and ethical considerations:** There was substantial dialogue about the role of institutions and historical memory in shaping futures for nuclear energy. Presenters showed examples of how lack of transparency or past policy inconsistencies have undermined trust in certain countries, leading to project delays or public backlash. Conversely, where institutions have actively engaged stakeholders (e.g. through independent oversight committees or ethical review panels), outcomes tend to be more robust and accepted. Participants concurred that the *future of nuclear energy will depend not only on technical innovation but on the ability of institutions to align technological possibilities with democratic legitimacy and societal expectations*. Ethical dimensions - such as intergenerational justice concerning nuclear waste, or equity in energy access - were raised as critical considerations that must be part of any forward-looking discussion on nuclear energy (hence the question mark in the conference title "Futures for Nuclear Energy?" signifying that it is a choice to be made collectively).

### 3.6.3 Outcomes

The final conference acted as both a capstone and a springboard. It *consolidated the learnings* of ECOSENS events: participants widely acknowledged that any sustainable pathway for nuclear (or any energy technology) requires genuine stakeholder engagement and societal buy-in at every step. There was a strong consensus that the frameworks and dialogues developed in ECOSENS provide a valuable foundation for future projects and policy processes, though they should be regarded as the beginning of a larger conversation, not a definitive conclusion. Concretely, the

conference proceedings (Deliverable D4.6) captured key recommendations - for example, to integrate ECOSENS's approach into EU and national energy planning exercises, and to maintain the networks of stakeholders beyond the project's life. By the end of the event, the tone was forward-looking: ECOSENS had demonstrated an approach to bridging technical analysis with participatory governance, and now it would be up to the broader community (researchers, decision-makers, civil society) to carry this approach further in addressing Europe's complex energy future. In summary, the Milan final event showcased the power of sustained stakeholder engagement - illustrating that when experts and stakeholders deliberate together, the outcomes are more nuanced, resilient, and legitimately grounded in societal values.

# 4 Conclusions

Stakeholder engagement in the ECOSENS project proved to be both challenging and invaluable. Through the numerous workshops, webinars, panels, and conferences, the project demonstrated how inclusive dialogue can enrich research on the future of nuclear energy. One overarching conclusion is that technical assessments of energy options gain legitimacy and depth when opened to stakeholder input. ECOSENS found that sustainability assessment is not a purely technical pursuit but *"inevitably a political process,"* wherein the inclusion or exclusion of certain criteria, and the interpretation of results, reflect societal values. By involving stakeholders from different walks of life, the project made these underlying values explicit and subject to discussion.

The engagement process also highlighted several important lessons and recommendations for future initiatives:

- **Diversity of perspectives is essential:** Bringing together stakeholders with divergent views (from pro-nuclear industry experts to critical NGOs and neutral academics) was sometimes difficult, but it ensured that blind spots were addressed. The dialogues revealed points of consensus (e.g. the need for transparent, inclusive decision-making) as well as genuine disagreements. Both are instructive. Future energy policy deliberations should continue to invite a broad spectrum of voices, as this plurality leads to more robust and well-rounded outcomes.

- **Early and continuous engagement:** A clear finding was that public and stakeholder engagement should not be an afterthought. In ECOSENS, stakeholders were involved from the outset - helping shape research questions and methods - and stayed involved through to the final results. This continuous engagement-built trust and buy-in. It contrasts with a scenario where stakeholders might only be consulted at the end of a study, which can lead to scepticism. The project recommends embedding stakeholder participation at multiple stages of research and decision cycles, thereby creating a feedback loop where interim results are validated and improved by those who will be affected by or who will implement the outcomes.

- **Transparency and communication:** The project underscored that complex models and assessments must be communicated in an accessible way if stakeholders are to meaningfully engage. ECOSENS had to translate technical jargon into plain language (for example, explaining the concept of a social discount rate, or life-cycle analysis, to non-specialists). Doing so not only allowed stakeholders to participate, but also improved the researchers' own understanding - forcing clarity and justification of assumptions. The principle of "open modelling" - where assumptions and data are openly shared for stakeholders to review - was shown to greatly enhance credibility. Future projects should adopt open science communication practices to facilitate stakeholder co-analysis.

- **Institutional support for participatory processes:** One challenge noted was the resource and time intensity of deep engagement. Meaningful participation is *time-consuming and requires commitment*. ECOSENS benefited from being a multi-year, funded project that could dedicate effort to these activities. For broader application, institutions (whether at EU or national level) should provide support - in terms of funding, policy mandates, or frameworks - to integrate stakeholder engagement into energy planning. The payoff, as ECOSENS shows, is decisions that are more robust and

democratically grounded. Neglecting engagement can lead to decisions that fail in implementation due to public opposition or overlooked factors.

In conclusion, ECOSENS's stakeholder engagement activities significantly enhanced the project's outcomes and relevance. The project not only produced technical findings on sustainability of nuclear energy but also modelled a process of how to talk about those findings in a societal context. By the end of the project, there was broad agreement among participants that the future of nuclear energy (and indeed any energy technology in society) will depend as much on social license and governance as on engineering and economics. Tools and assessments must therefore be developed with stakeholders, not behind closed doors. ECOSENS leaves a legacy of an enriched network of stakeholders and a set of participatory methods that can be applied in future endeavours. The central message is clear: inclusive, evidence-based and transparent engagement is not just a nice-to-have, but a necessity for sustainable energy decision-making. By recognizing and acting on this, policymakers and project developers can greatly improve the quality and legitimacy of the choices that lie ahead in Europe's energy transition.

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    - *ECOSENS Scientific Event - Bucharest 2024* ("A Novel Approach to Assess the Socio-economic Role of Nuclear Energy").
    - *ECOSENS Final Conference - Milan 2025* ("Futures for Nuclear Energy? Social, economic and environmental considerations").

# 6 Appendix 1: March 2023 ECOSENS Stakeholder Workshops (Brussels, Belgium)

**Brussels, Belgium, Club University Foundation, 29 March 2023, 14:00-17:30**
**International Stakeholder Workshop - "The art and science of imagining energy futures"**

**Introduction:** This in-person workshop brought together diverse stakeholders (academic, civil society, policy) to explore "the art and science of imagining energy futures." It aimed to reveal the various worldviews, values, and narratives that shape how different people imagine a desirable energy future. By engaging participants in creative group discussions, the workshop served as an illustrative exercise in sustainability thinking - emphasizing that envisioning "the future we want" is a complex, inherently political process influenced by current societal challenges, conflicts, and differing values. Insights from this workshop were later fed into the ECOSENS project's methodology development.

**Agenda:** *(29 March 2023)*

- **14:00-14:10** - Welcome & Introduction to the ECOSENS project - *Catrinel Turcanu (SCK CEN)*
- **14:10-14:25** - Welcome address - *Domenico Rossetti di Valdalbero (DG RTD, European Commission)*
- **14:25-14:45** - *Introductory talk:* "The art and science of imagining energy futures" - *Gaston Meskens (SCK CEN & Univ. of Ghent)*
- **14:45-15:45** - **Discussion Session 1 (in 3 breakout groups):** *Imagining energy futures* - Participants considered how multiple possible and desired energy futures can be recognized, how worldviews and values shape these imaginings, and what artifacts (storylines, narratives, images, models, etc.) we use to express them.
- **15:45-16:00** - *Coffee break*
- **16:00-17:00** - **Discussion Session 2 (in 3 groups):** *Sustainability assessment as a deliberation process* - Participants deliberated the meaning of "sustainability" (especially social sustainability) in assessment practice, what values are missing in traditional approaches, and how to ensure assessment criteria reflect diverse worldviews (noting the limits of purely quantifiable information).
- **17:00-17:30** - Summary of key ideas & wrap-up - *Claire Mays (Symlog)*

**Brussels, Belgium, Club University Foundation, 30 March 2023, 10:00 - 16:00**
**International Stakeholder Workshop - "Decarbonizing Europe's energy system: Checking and choosing indicators for a sustainability assessment"**

The European Green Deal is the ambition to create the first carbon-neutral continent by 2050. To get there, Member States commit to cutting greenhouse gas emissions into less than half by 2030. This interim target depends on achieving changes in the energy mix: a higher share – 40% – should be supplied by renewable energy sources. How should that mix be composed? Which are the favored technologies? Are they available and how will they perform? What may be the place for nuclear generation technologies, old and new, in the mix? What are the criteria for proposing

and evaluating respective shares? Who has a voice in selecting those criteria and in checking whether they are met?

Robust and accepted assessment methods are required to inform complex energy mix decisions in Europe. But the landscape is not static. In the run-up period to 2030 huge contextual forces move the cursor. At the least, these include: energy supply effects of the Russian offensive on Ukraine; the ramping up of unpredictable and heavy weather impacts throughout European territories; rising demand to be heard from diverse sectors of society coupled with a strong diversity of opinion and priorities. Looking farther towards 2050, innovation and disruptive technologies will affect generation sources, and a plethora of factors – economic, social and environmental – will influence consumption needs. Assessment of energy technologies, to understand their potential and their desirability for 2030 and beyond, must embrace their sustainability over time and in the face of multiple pressures.

The European project ECOSENS invites you to participate in a demonstrator exercise. We have the task to develop and test a sustainability assessment methodology integrating a societal perspective on Europe's future energy system that includes advanced and innovative technologies (comparing renewable and nuclear sources). We invite a group of specialist and non-specialist stakeholders to review the proposed assessment approach, help refine it through critical perspective and judgments, and recommend directions to European policy makers.

On Thursday 30 March 2023 ECOSENS organizes a by-invitation, in-person, hands-on workshop in Brussels.

At this Second International Workshop, ECOSENS partners will present a proposed sustainability assessment methodology and hear your comments on its fitness for purpose. Together we will check that the selected method when applied can assess a complete energy system including renewables, nuclear, and any other sources; can include emerging technologies and future markets; can deliver a European-level result; can take into account special circumstances and specific choices made by Member States or societal stakeholders.

We will engage you in interpreting, selecting and ranking (weighting) the criteria to be used when applying the assessment method to estimate the profile and performance of electricity generation technologies at horizon 2030, 2050, and beyond.

- The workshop is very interactive, with short opening presentations followed by group and sub-group discussions and collaborative tasks.
- The outcome will be a written synthesis of judgments and advice regarding the proposed methodology, and participants' list of selected/defined criteria and the weights they should be given. It is not planned to seek consensus, but rather to record different perspectives.
- This workshop will be preceded on 29 March by an optional workshop on 'Art and Science of imagining energy futures'. Visions and vocabulary emerging there should help facilitate the multi-stakeholder debates during our work together on 30 March.
- Participants will receive documentation clarifying the workshop tasks, and an anonymous questionnaire to assemble viewpoints to be interpreted (co-constructed) by the group.
- A follow-up workshop will be held online in June 2023, to review and respond to a draft analysis of further assessment elements: societal and technological impacts on the future energy market.

# 7 Appendix 2: June 2023 ECOSENS Webinar (Online)

**Online (Zoom), 26 June 2023, 13:30-15:30 CEST**
**International Webinar - "Decarbonizing Europe's Energy System 2: Clarifying non-linear assumptions about energy demand to 2050"**

**Introduction:** This two-hour interactive webinar convened specialist and non-specialist stakeholders across Europe to review and refine the assumptions used in ECOSENS's mid-century energy demand projections. The context is ECOSENS's goal to develop a life-cycle sustainability assessment of future energy systems (including advanced nuclear technologies) to inform Green Transition policies. Many drivers of Europe's energy future - demographics, consumption, decarbonization measures - can be reasonably projected, but others (technology, economy, geopolitics) are far more uncertain. Thus, ECOSENS sought stakeholder input to "stress-test" its assumptions against disruptive scenarios. On 26 June 2023, ECOSENS hosted this webinar (titled *"Decarbonizing Europe's Energy System 2: Clarifying non-linear assumptions about energy demand to 2050"*) to openly discuss possible demographic, environmental, economic, technological, political, social, and cultural evolutions to 2050. The webinar did not aim for consensus, but to hear diverse perspectives, participation was explicitly neutral regarding support for or against nuclear or any technology. Stakeholders' insights from this session would feed into refining the ECOSENS scenario assumptions and ensuring transparency in the modeling process.

**Agenda:** *(26 June 2023)* The webinar opened with a scientific background presentation, followed by three interactive exercises and a plenary discussion.

- **13:30-13:50** - *Presentation:* Overview of mid-century energy demand drivers and ECOSENS assumptions - *Marin Constantin (RATEN)* introduced key projections for 2050 (covering factors like population, economic growth, technology, policy, etc.). Participants had received a working paper (Deliverable D2.2a1) beforehand outlining these assumptions.
- **13:50-14:10** - **Exercise A: "Holism"** - Attendees discussed the interlinkages among different drivers of energy demand. They were prompted to identify how changes in one factor (e.g. demographics, technology, geopolitics) might influence others.
- **14:10-14:30** - **Exercise B: "Sufficiency"** - Participants considered a future where strong sufficiency policies (to curb energy demand) are implemented. They debated which drivers a sufficiency strategy should target, why, and the expected effects on energy demand.
- **14:30-14:50** - **Exercise C: "Worst-case scenario"** - Participants envisioned a hypothetical 2050 scenario where the energy transition fails and severe top-down austerity measures are imposed. They reflected on how societal attitudes and energy demand might evolve under such a catastrophic context.
- **14:50-15:30** - **Plenary Discussion and Wrap-Up** - The group reconvened to share insights from each exercise, address questions, and identify areas of consensus or divergence. Moderators summarized key points and outlined next steps for how the input would inform ECOSENS analyses.

# 8 Appendix 3: August 2023 ECOSENS Scientific Event at RICOMET 2023 (Dessel, Belgium)

**Dessel, Belgium, RICOMET 2023 venue, 29 August 2023, 13:30-17:30**
**First ECOSENS Scientific Event - "Powering the Future Responsibly: Assessing the Sustainability of Nuclear Energy" (Panel Discussion)**

**Introduction:** The focus of this event was the ECOSENS sustainability assessment methodology, which integrates a societal perspective into Europe's future energy system including advanced nuclear technologies. The session consolidated stakeholder input gathered during ECOSENS workshops in March 2023 and shared results from a 2050 energy scenario exercise held earlier that day. The event was held in a hybrid format and welcomed both RICOMET conference participants and a broader audience interested in the social, economic, and environmental issues of future energy.

**Agenda:**

- 13:30-14:30 Introduction:
    - Overview of ECOSENS – *Daniela Diaconu (RATEN)*
    - Feedback from the morning's 2050 Scenario workshop – *Marc Poumadère (Symlog)*
    - Insights from the March 2023 methodological workshop and stakeholder input – *Claire Mays (Symlog)*
    - Methodological progress and uptake of insights for the ECOSENS sustainability assessment – *Marin Constantin (RATEN)*
- 14:30-15:30 Panel discussion: *Assessing the Sustainability of Nuclear Energy* (Moderated by Gaston Meskens, SCK CEN, with invited panellists from civil society, industry, and NGOs)
- 16:00-16:55 Workshop: Group work on Energy Demand Drivers (moderated by Aylin Erden, SYMLOG, and Marin Constantin, RATEN). Participants examined and debated the societal and technological assumptions used for the ECOSENS 2050 energy demand scenario.
- 16:55-17:00 Closing remarks: Wrap-up by *Daniela Diaconu (RATEN)*

# 9 Appendix 4: June 2024 ECOSENS Scientific Event at RICOMET 2024 (Ljubljana, Slovenia)

**Ljubljana, Slovenia, Best Western Premier Hotel Slon (RICOMET 2024), 10 June 2024, 16:00-17:30**
**Second ECOSENS Scientific Event (Part 1) - "Public Participation in Decisions Related to Small Modular Reactors (SMRs)" (Panel Discussion)**

RICOMET 2024, Ljubljana, Slovenia – 10 June 2024 (16:00-17:30) Second ECOSENS Scientific Event (Part 1): *Public Participation in Decisions Related to Small Modular Nuclear Reactors (SMRs)* (Panel discussion)

**Introduction:** Small Modular Reactors (SMRs) are attracting increasing interest in several European countries, although their benefits and characteristics remain debated. This panel discussion explored how and when the public should be involved in decision-making on SMR technology, identifying potential participation challenges and opportunities based on past experiences with public engagement. The topic is timely, as the introduction of SMRs is expected to pose new social and economic challenges in the near future.

**Agenda:**

- 16:00-16:10 Welcome and overview of the ECOSENS project – *Daniela Diaconu (RATEN)*
- 16:10-16:25 Selected results from the ECOSENS project – *Gaston Meskens & Robbe Geysmans (SCK CEN)*
- 16:25-17:15 Panel discussion: Public participation in decisions related to SMRs. *Moderators:* Gaston Meskens & Robbe Geysmans (SCK CEN) *Panellists:* Franc Bogovič (Member of European Parliament), Miroslav Gregorič (Slovenian Parliament), Patricia Lorenz (Friends of the Earth Europe), Meritxell Martell (GMF), Nadja Železnik (EIMV) *Rapporteur:* Willem Brabants (University of Liège & SCK CEN)
- 17:15-17:30 Q&A and wrap-up – *Willem Brabants (University of Liège & SCK CEN)*
- 17:30-17:35 Closing remarks – *Daniela Diaconu (RATEN)*

**Main topics addressed:** The discussion focused on the ideal stages to involve the public in SMR-related decisions, specific challenges and opportunities for effective participation, and lessons learned from past nuclear or energy projects relevant to public engagement in new SMR initiatives.

# 10 Appendix 5: October 2024 ECOSENS Consultation Event (Bucharest, Romania)

**Bucharest, Romania, Pullman Bucharest World Trade Center, 1 October 2024, 9:00-17:00**
**Second ECOSENS Scientific Event (Part 2) - "A Novel Approach to Assess and Establish the Socio-economic Role of Nuclear Energy at Country Level"**

**Introduction:** This scientific event introduced a new comprehensive socio-economic model for assessing nuclear energy, based on the System of Provision (SoP) approach. The aim was to overcome shortcomings of existing purely economic models by using a broad set of indicators relevant to various stakeholders (investors, consumers, governments, suppliers). The event presented the current progress of Work Package 3, exploring the SoP-based model along with socio-economic concepts like the Social Discount Rate (SDR) and Circular Economy principles in the context of nuclear energy. Participants were encouraged to discuss different modeling options and frameworks, ensuring an interactive exchange.

**Agenda:**

- 9:00-9:15 Welcome and introduction to the ECOSENS project – *Daniela Diaconu (RATEN)* and *Nadja Železnik (EIMV)*
- 9:15-9:35 Introduction to Work Package 3 (objectives, tasks, deliverables) – *Giorgio Locatelli (POLIMI)*
- 9:35-9:55 System of Provision approach: literature review (methodology, findings) – *Giacomo Dei (POLIMI)*
- 9:55-10:15 Applying the SoP approach to the French nuclear energy system – *Giacomo Dei (POLIMI)*
- 10:45-11:15 A novel model for nuclear energy based on the SoP approach – *Giorgio Locatelli (POLIMI)*
- 11:15-12:45 Group work and discussion (interactive session)
- 13:45-14:05 Social Discount Rate in nuclear projects – overview of calculation methods – *Giacomo Dei (POLIMI)*
- 14:05-14:25 Public acceptance of nuclear power plants near existing sites (case study from Italy) – *Benito Mignacca (UNICAS)* and *Giorgio Locatelli (POLIMI)*
- 14:25-15:30 Group work and discussion (interactive session)
- 16:00-16:20 Circular Economy concepts in nuclear mega-projects (life-extension as a CE strategy) – *Benito Mignacca (UNICAS)*
- 16:20-16:50 Closing remarks – *Daniela Diaconu (RATEN)*

# 11 Appendix 6: September 2025 ECOSENS Final Conference (Milan, Italy)

**Milano, Italy, Politecnico di Milano (Bovisa Campus), 8-9 September 2025**
**ECOSENS Final Scientific Conference - "Futures for Nuclear Energy? Social, Economic and Environmental Considerations"**

**Introduction:** Our society faces urgent challenges in decarbonizing energy and ensuring economic, environmental, and social sustainability amid growing energy demand. Nuclear energy offers a potentially important yet contested low-carbon option to tackle these challenges. Worldwide, advanced nuclear technologies and Small Modular Reactors (SMRs) are gaining attention for their promise to improve safety, reduce proliferation risks and waste, and use fuel more efficiently, although these technologies are still under development in Europe and not yet proven. In this context, it is essential to situate new and emerging nuclear technologies within their broader social, political, cultural, and ethical contexts. This final ECOSENS conference created an interdisciplinary space for research, dialogue, and collaboration among researchers, civil society, and other stakeholders.

**Key Topics:** The two-day conference in Milan combined topical presentations with structured and informal opportunities for dialogue. Contributions included research findings, critical reflections, practical insights, and project-based studies aligned with ECOSENS themes. The core topics of the conference were:

- *Societal Perspectives:* Public and stakeholder perceptions of the risks, benefits, and potential of nuclear technologies (including new technologies like SMRs) in the context of major societal challenges (climate crisis, sustainable development, energy security), as well as needs for stakeholder engagement and effective communication, and inter/transdisciplinary research initiatives.
- *Sustainability Assessment:* Long-term sustainability of energy systems, including life-cycle analysis, resilience, and system integration; case studies on environmental, economic, and social impacts of various energy technologies; the role of SMRs and advanced nuclear technologies in low-carbon energy futures; and the synergies or trade-offs between energy security, climate change mitigation, and social equity in the nuclear context.
- *Socio-Economic Models:* New quantitative and qualitative models for assessing the role of nuclear energy in society; experiences with socio-economic assessments involving stakeholders (suppliers, investors, consumers, governments); and broad-scope models addressing the nuclear supply chain, policy, and governance aspects.
- *Historical and Ethical Reflections:* Understanding current trajectories of nuclear energy development through historical cases and past experiences; and ethical frameworks to evaluate challenges and values in the use of nuclear energy in society.

Conference Format: The program featured thematic sessions aligned with the ECOSENS project's core topics. Each speaker was allocated 15 minutes including Q&A, and each session concluded with a moderated discussion to encourage exchange across perspectives. The conference concluded with a panel discussion on implementing the stakeholder engagement recommendations developed during the ECOSENS project. Panellists from academia, industry,

civil society, and policymaking reflected on the practical challenges and opportunities for more inclusive engagement in nuclear energy governance.

**Agenda:**
*Day 1:*

- 9:00-9:30 ECOSENS project – objectives and achievements – *Daniela Diaconu (RATEN)*
- 9:30-9:45 *The art and science of imagining energy futures* – Gaston Meskens (SCK CEN)
- 9:45-10:00 *The Role of Nuclear Energy in Securing a Resilient, Renewable-Dominated Power System* – Marin Constantin (RATEN)
- 10:00-10:15 *Looking for a new way to gather stakeholder input to technoscientific assessment* – Marin Constantin (RATEN)
- 10:15-10:30 *Engaging stakeholders in energy life cycle sustainability assessment: critiques and recommendations for the ECOSENS methodology* – Claire Mays (Symlog)
- 10:30-10:45 Moderated discussion (Q&A with all presenters)
- 11:15-11:30 *A comparative analysis of anti-nuclear protesters in Western Europe* – Anouk Luypaert (University of Antwerp)
- 11:30-11:45 *Integration of nuclear projects in local communities* – Meritxell Martell (Mérience)
- 11:45-12:00 *Framing Nuclear: an analysis of online political discourse on nuclear energy in Belgium* – Peter Thijssen (University of Antwerp)
- 12:00-12:15 *Generational shifts in the perception of nuclear power plants in communities surrounding old sites* – Giorgio Locatelli (POLIMI)
- 12:15-12:30 *Some remarks concerning NGO engagement in the ECOSENS project* – Peter Mihok (UMB)
- 12:30-12:45 Moderated discussion (Q&A with all presenters)
- 14:00-14:15 *Community engagement and evidence-based risk communication in environmental impact assessment for SMRs* – Rui Gaspar (Lusófona University)
- 14:15-14:30 *The greening of nuclear power: the challenge of doing STS on SMRs* – Susan Molyneux-Hodgson (University of Exeter)
- 14:30-14:45 *Public and stakeholder engagement in the SMR ecosystem of the European Industrial Alliance* – Meritxell Martell (Mérience)
- 14:45-15:00 *SMR development in Belgium: making experience count* – Willem Brabants (SCK CEN / ULiège)
- 15:00-15:15 *Public attitudes towards SMRs as an emerging field of social research* – Martin Durdovic (Czech Academy of Sciences)
- 15:15-15:30 *Media reporting on SMRs in Sweden – benefits, risks and actors involved* – Åsa Thelander (Lund University)

- 15:30-15:45 Moderated discussion (Q&A with all presenters)
- 16:15-16:30 *How do we build stakeholder engagement during the deployment of a fleet of SMRs in an embarking country?* – Mariusz Ilnicki (Orlen Synthos Green Energy)
- 16:30-16:45 *Stakeholder and public engagement in Environmental Impact Assessments: lessons for SMR implementation* – Jonathan Reese (Lusófona University)
- 16:45-17:00 *Understanding public attitudes towards SMRs in Belgium, Czech Republic and Spain* – Catrinel Turcanu (SCK CEN)
- 17:00-17:15 *Public attitudes toward SMRs in Slovenia* – Nadja Železnik (EIMV)
- 17:15-17:30 *Perceptions and prospects for lead-cooled nuclear technologies: insights from R&D and stakeholders in Belgium* – Robbe Geysmans (SCK CEN)
- 17:30-17:45 Moderated discussion (Q&A with all presenters)

*Day 2:*

- 9:00-9:15 *Discounting the Future? Reviewing social discount rate calculation methods for nuclear infrastructure investments* – Giacomo Dei (POLIMI)
- 9:15-9:30 *Retirement or renewal? Investigating life-extension projects in U.S. nuclear megaprojects* – Benito Mignacca (Technical University of Sofia)
- 9:30-9:45 *Building nuclear plants: a study on drivers and barriers* – Alessandra D'Alessandro (POLIMI)
- 9:45-10:00 *Valorization of LFR-SMR energy output in off-grid configurations* – Kerem Enes Ayyildiz (SCK CEN)
- 10:00-10:15 *Financing SMRs: implications for bankability* – Rohunsingh Sam (University of Leeds)
- 10:15-10:30 *The impact of nuclear energy integration in a fully decarbonized 2050 Belgian energy system* – Luc Van Wortswinkel (VITO / EnergyVille)
- 10:30-10:45 Moderated discussion (Q&A with all presenters)
- 11:15-11:30 *Stakeholder engagement and transdisciplinary collaboration in nuclear decision-making across EU countries: survey results* – Roser Sala (CIEMAT)
- 11:30-11:45 *When public and stakeholder engagement fails: the Slovenian nuclear referendum case* – Tanja Perko (SCK CEN)
- 11:45-12:00 *Stakeholder engagement in Spain's nuclear phase-out and decommissioning decision-making* – Lila Gonçalves (CIEMAT)
- 12:00-12:15 *Slovenia's nuclear energy debate and stakeholder engagement in the NEPN process* – Barbara Horvat (EIMV)
- 12:15-12:30 *Adolescents' radiation risk perception – a survey toward a transdisciplinary approach* – Ana Rita Melo (Lusófona University)
- 12:30-12:45 Moderated discussion (Q&A with all presenters)

- 14:00-14:15 *Nuclear Norway: should thorium be part of the deal?* – Yevgeniya Tomkiv (NMBU)
- 14:15-14:30 *System momentum and exogenous events: resilience of nuclear large technological systems* – Giacomo Dei (POLIMI)
- 14:30-14:45 *How nuclear promises are made credible and legitimate – historical examples of SMRs, fast breeders, and megaprojects (Canada, France, UK)* – Markku Lehtonen (Pompeu Fabra University)
- 14:45-15:00 *How a "green, sustainable" city faces the two dirty ends of the nuclear chain – uranium mining and radioactive waste disposal in Pécs* – József Kóbor (NTW / University of Pécs)
- 15:00-15:15 *Transparency, participation and justice in Bulgarian nuclear projects – civil society, courts, and media* – Petar Kardzhilov (NTW)
- 15:30-15:45 Moderated discussion (Q&A with all presenters)
- 16:15-17:15 Panel: Actions for implementing ECOSENS stakeholder engagement recommendations (moderated by Susan Molyneux-Hodgson, University of Exeter)
- 17:15-17:30 Closing of the event – *Daniela Diaconu (RATEN)*

**Target Audience:** Researchers and practitioners interested in the societal, environmental, and economic aspects of nuclear energy – including representatives from civil society, academia, industry, and government (approximately 50–60 participants).

**Format:** Moderated plenary sessions (thematic presentations with Q&A), interactive discussions, and a concluding panel debate on stakeholder engagement in nuclear governance.