Public attitudes towards small modular reactors

An emerging research field and evidence from six countries

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Executive summary

This deliverable report D1.1 of the HORIZON-EURATOM ECOSENS project, 'Economic and Social Considerations for the Future of Nuclear Energy in Society,' presents findings obtained in 2023-2024 by qualitative and quantitative studies of public attitudes regarding new nuclear technology, specifically Small Modular Reactors (SMRs). Compared to the vast literature on large traditional reactors, very little is known about the public's perceptions of this new technology or the willingness of local communities to potentially host an SMR facility. ECOSENS research helps to fill the gap. Through a diversity of social sciences and humanities (SSH) approaches, it provides insights into perceived risks, benefits and potentials of SMR nuclear energy technologies, by citizens in six countries: Belgium, the Czech Republic, Spain, Slovenia, Slovakia, and the United Kingdom. Views on the role of SMRs to address societal challenges such as the climate crisis, sustainability, and energy security, and on stakeholder engagement in decision making, are explored through surveys, focus groups, interviews, and workshops or panels, with the participation of citizens, civil society and elected authorities.

Section 1 recalls the rise of nuclear energy in the 1960s, how the 1986 Chernobyl accident focused concern on safety and 'public acceptance', and how nuclear 'renaissance' has been diversely justified in discourse by the climate crisis or reconsidered in the light of the 2011 Fukushima accident. SMRs emerge most recently as a potentially more flexible, cost-effective, and safer alternative to traditional large-scale nuclear reactors (section 1.3). These compact nuclear fission reactors, with an electrical output of less than 300 MWe per unit, are promoted as suitable for a wide range of applications, from electricity generation to industrial heat production and desalination. As first-of-a-kind projects, their development at scale faces the hurdle of securing financing and regulatory approval. Radioactive waste management, grid integration, safety, and security stand out as concerns to be resolved. In this context, it is appropriate that a multidisciplinary SSH approach be taken (1.4) to explore the emergence of this new technology in the spheres of public decision and perception.

Using an open definition of stakeholders, interested parties and the public (1.5), ECOSENS conducted desk, quantitative and qualitative research to capture views, concerns and expectations about SMR technology. Table 2 outlines methods and samples in six project countries and at the international level.

Section 2, after reviewing prior findings on the relationship between public opinion and the politics of nuclear energy, summarises the status of SMR development in the six countries (2.2). The differential integration of SMRs in energy policy across European Member States (2.3) suggests that politicians see the potential of SMRs as a long-term proposition rather than an imminent solution.

Section 3 presents views of SMRs by the public. Representative national surveys in Belgium, the Czech Republic, and Spain suggest low awareness of the technology. Ratings (section 3.2) assign middling or positive performance on criteria such as risk, pollution, build or production costs, environmental impact, and supply reliability. Some citizens anticipate job creation and economic benefits (though Spanish participants see significantly more negative socio-economic impacts than do Czechs). Most respondents think SMRs should provide a moderate to large part of the 2050 energy mix (section 3.3).

Documents from environmental NGOs (3.4) typically cite as areas of doubt on SMR viability: absence of a successful demonstrator; high financial costs per unit; challenges to SMRs as a safer, cleaner alternative to large reactors. The decentralized character of SMRs is seen to multiply safety and security risks, with waste composition and behaviour negating potential gains in terms of volume.

Section 4 considers the perception of climate change and energy security. Prior studies show that stakeholders concerned by energy security tend to support nuclear energy, while those concerned by climate change tend, in contrast, not to support nuclear energy. ECOSENS focus groups and surveys (section 4.2) find that climate change, although not uniformly recognized as anthropogenic, is a matter of concern and calls for action (such as reducing reliance on fossil fuels). Participants, especially those favourable to nuclear energy, tend to state that SMRs could contribute to reducing CO_2 emissions. They diverge on whether SMRs can come online fast enough to mitigate the climate crisis, and whether it is

nonetheless better to pursue development to reap later benefits. The overall role of SMRs in adaptation to climate change remains ambiguous in surveys. Some focus group members insist on the need to consider the entire SMR life cycle before passing judgment.

Publics surveyed in Belgium and Spain express substantial concern about national dependence on energy imports and the risk of unaffordable electricity (section 4.3), more so than Czech participants. Belgian and Czech respondents are much more likely than the Spanish to view that SMRs can prevent electricity shortages. Focus group members find that SMRs may offer some benefits of a secure and stable supply and could complement intermittent renewable technologies. Nonetheless, critics evoke concerns for safety, cost competitiveness, and waste handling. Additionally, diverse obstacles to SMR development are named: potential public opposition, impact on local life and landscape, legislative or licensing limitations, the technology's immaturity (experimental phase of development), the lack of unity and consistency in (nuclear) energy politics under different governments, and the lack of EU-level convergence when it comes to choosing which SMR technologies to pursue further.

Section 5 compares views on SMRs with those on large traditional nuclear reactors (LTRs). It contrasts European Commission's enthusiasm for SMR benefits with focus group members' inability to make detailed comparisons given their relative lack of knowledge. Nonetheless, some participants raise concerns about more, smaller reactors multiplying siting conflicts, whereas others see desirable outlooks: local benefits made accessible to more communities, and accelerating industrial transition by, e.g. the use of brownfields. Some also view SMRs as less financially or functionally risky than megaprojects. Still, according to the survey, only Belgian respondents find (to a small majority) that it would make more sense to construct several SMRs rather than one LTR.

The surveys asked those who felt SMRs could be part of their country's 2050 energy mix to assess the acceptability of SMR siting in various locations (5.2). Unsurprisingly, just one-third of those respondents state they might envision an SMR closer than 10 km to their own residence – this set being composed predominantly of men, of nuclear energy supporters, and of persons less concerned by climate change. Half would accept siting at more than 10 km, or on the outskirts of existing LTRs. Constructing an SMR within an existing LTR site is most acceptable. Focus groups and interviews in Slovenia and Czechia revealed two groups that appear to be more open to SMR construction near their place of residence: those accustomed to the risks and benefits of an existing LTR in their region; those with coal generation, who see siting an SMR as a way of rebuilding their region and securing its future prosperity. In a country-specific question, 74% of surveyed Czechs agreed with the notion of siting an SMR at a phased-out coal-fired plant.

Section 6 explores citizens' trust in government decision making and their desired level of participation in SMR siting decisions. Prior studies have identified social trust in government as a key element of democratic governance of complex technologies. Social trust encompasses perceptions of competence, fairness, responsiveness, inclusiveness and transparency (of institutions and of decision-making processes). When present, social trust tends to diminish perceptions of risk, whereas risk perception is heightened in cases where stakeholders feel that their values and goals are not shared by responsible authorities. ECOSENS surveys found only low to moderate trust in national governments on nuclear issues and siting fairness, particularly low in Spain.

Effective citizen participation in decision making (section 6.2) usually enhances trust and the perceived fairness of processes. Focus group members insisted on the need to inform the public from the early stages, creating access to 'factual' and 'correct' information about SMRs. Scepticism was expressed, however, regarding more engaged forms of participation, described as delaying decisions and spawning protest and cancellation. Some argued that decisions on SMRs should be taken by expert committees of scientists (rather than politicians), to ensure that decisions take into account all relevant aspects, not just economic or political interests. By contrast, surveys showed a high demand for public participation, particularly through dialogue. Here, Spanish respondents stood out in their preference to be engaged, moreover, as full partners in decision-making.

Section 6.3 shares insights from local elected representatives from communities hosting (large) nuclear facilities. Their experience could be useful for SMR processes. They reported a lack of dialogue between national and local authorities, despite the latter's active role and proven expertise in managing multiple energy projects that have a significant impact on local infrastructure and provision of services. When the Dutch municipality of Borsele was asked to consider siting two LTRs, the local elected authorities created a citizen assembly of 100 persons, including specialized resident experts, to represent the 15 townships and 13,000 families. This assembly developed 39 terms and conditions to host the reactors, reflecting needs and aspirations for local quality of life. It also revealed that older citizens and future decision makers (those under the age of 35) differ in their views on nuclear energy.

An ECOSENS international stakeholder panel (section 6.4) discussed public participation in SMR decisions. Panellists urged that these be approached in the context of a larger, technologically neutral discussion of energy options. They called for early dialogue at several administrative levels, with an active partnership role for local authorities. Participants called for open and transparent information to the public on SMR benefits and risks, and a realistic, critical assessment of energy security as well as costs.

Section 7 sums up findings and conclusions. SMRs remain a relatively little-known technology to the European public, mirroring their uneven presence in national policies or forecasting. Surveys of representative populations of three EU countries show variability in perceptions of SMR safety, of the technical, economic or social value of this option to fight energy insecurity or climate change, or of SMRs' advantages over large traditional reactors. Nonetheless, the surveyed publics tend to see SMRs as part of the energy mix in 2050. While some focus group participants called for technocratic processes to ensure that SMR decisions are based on appropriate expertise, a relatively strong demand was seen through surveys for fair participation in decision making from early stages, including access to structured dialogue or even partnership approaches. Social trust, described as a key factor in technological governance, is found to be low. Stakeholders converged on the idea that reliable, transparent information should support consideration of costs and risks across the SMR technology life cycle, and that the broad expertise of local authorities, who manage the parallel concerns of the community, should be respected.

Introduction

This research report aims to foster debate on the emerging findings of social sciences and humanities studies concerning societal aspects of small modular reactors (SMRs). While many countries within the European Union (EU) and beyond envision SMRs as a promising alternative to large traditional reactors (LTRs) to boost the provision of (nuclear) energy, the specific societal implications of these technologies have been little studied. The following sections outline the diverse data gathered in Task 1.1 of the ECOSENS project, centred around examining empirical evidence on public attitudes towards the SMR technology. Putting some of our key findings in a broader context of research and practice, this report collates input from researchers with specialization in various branches of social sciences and beyond, complying with the interdisciplinary nature of the subject under study. As such, the investigation is in line with the recommendations of the international SHARE platform (Social sciences and Humanities in ionizing RAdiation research, visit https://www.ssh-share.eu/).

ECOSENS Work Package 1 assessed collaboratively the role of nuclear energy in the (imagined) energy worlds of European societies. Four tasks were pursued. First, to provide insights into the perceived risks, benefits and potentials of nuclear energy, Task 1.1 (object of the present report) employed a blend of qualitative and quantitative approaches to study public attitudes in six countries: Belgium, the Czech Republic, Spain, Slovenia, Slovakia, and the United Kingdom. Second, Task 1.2 examined citizens' motivations for engaging with nuclear energy in the context of societal challenges, such as the climate crisis, sustainability, or energy security. Third, Task 1.3 scrutinized and updated recommendations on stakeholder engagement in nuclear research and policy. Finally, in Task 1.4, stakeholder engagement workshops gathered some views of civil society on nuclear energy and the green transition. These tasks complemented substantive research in other ECOSENS Work Packages on assessing the sustainability of the whole cycle of nuclear power (WP2) and developing a 'system of provision' approach to describing the economics of nuclear power (WP3). This report is thus also an invitation to explore the wealth of results produced by ECOSENS that, we believe, will continue to grow (visit https://ecosens-project.eu/).

This report is organized into six thematic sections. Section 1 sketches a broader background for the study of nuclear energy in society to situate our contribution concerning public attitudes to SMRs, including an explanation of the methodology used. Narrowing down the scope, Section 2 clarifies the societal dynamics around SMRs by interlinking public opinion and nuclear energy policy development, and by summarizing observations regarding the level of SMR technology uptake in six countries. The report goes on to present selected quantitative and qualitative research findings, starting with Section 3 on awareness of SMRs and imagining their future use, as well as rating of the technology and its socioeconomic impacts by the public. Section 4 puts attitudes towards SMRs in the context of current climate change and energy security challenges, and Section 5 compares the public acceptability of SMRs versus LTRs. Lastly, Section 6 focuses on topics related to decision-making processes about SMRs, such as trust in government or public participation, and provides insights from stakeholder meetings.

This report targets the varied community of experts and stakeholders involved or interested in the ways nuclear energy develops as part of contemporary societies. It will help researchers and practitioners to better understand the nascent research field of social aspects of SMRs. The more the promise of SMR technologies will materialize, the more needful it will be to study its entanglement with societies.

1. Nuclear energy, societies, and public opinion on SMRs

1.1 The politics of nuclear energy – a (very) short history

Nuclear energy is a 'product' of modernity. While the physics groundwork had developed since the end of the 19th century, the insight that a controlled neutron-driven fission reaction could be a new source of energy came with the development of the atomic bomb before, during, and after the Second World War. In the first wave, in the 1950s, multiple countries opted for nuclear energy as a major source of electricity production. During the 1960s, nuclear power achieved the status of a technically proven and commercially viable energy source. By the middle of the decade, electric power utilities were placing their orders for nuclear plants on a routine basis, and by 1970 there were already 90 nuclear units operating in 15 countries (Char & Csik, 1987). This positive trend was further stimulated by the 1970s oil crisis. The nuclear accident of Chernobyl in 1986 put a halt to this evolution, and concerns of safety and – in a later stage - 'public acceptance' became a prime concern for the nuclear industry and related international organisations. The event also boosted further ecological awareness and global and local anti-nuclear movements. Despite this, the later post-Chernobyl period saw a new boost for nuclear energy in the way that its justification was presented as a trade-off in the frame of a 'bigger problem': climate change and the need for 'sustainable energy systems'. The focus of political and public attention also shifted from safety to waste. The 'nuclear renaissance' of the 1990s, announced in both the US and Europe, did not materialise as expected. Nuclear projects were set up in Finland and France but struggled from the beginning with construction costs and planning. As a result of the Fukushima nuclear accident in 2011, safety became again a top priority in public and political discourse. After Fukushima, countries reconsidered their nuclear policies, although not always in the same direction. While the event set into motion the formal nuclear phase-out in Germany, the UK, for example, saw no reason to change their new-built policy. Also, the international nuclear advocacy organisations saw no reason to change course. The World Nuclear Association declared that 'the future of nuclear energy in most countries is likely to be much the same after the ramifications of the Fukushima accident are fully considered as it was before the accident, though there will be some safety benefits from lessons learned' (Hore-Lacy, 2011, p. 645). Research on the recent history of nuclear development is needed to understand what stimulates the 'second nuclear renaissance' of the last years. Climate change and its faltering international negotiations remain the main driver, but concerns about energy security and the recent shift to more right-wing politics in several industrialised countries may be seen as additional incentives.

While climate change has been a major justification for pro-nuclear politics, nonetheless nuclear energy was formerly a non-topic in formal climate change negotiations facilitated by the United Nations. UN member states historically made no effort to bring the issue of nuclear energy to the global political agenda. After Kyoto (1997), nuclear has never been officially debated as a potential base load 'avoidance' energy technology within the Framework Convention on Climate Change negotiations. In the United Nations Commission on Sustainable Development negotiation process at UNCSD9 in 2001, countries 'agreed to disagree' on nuclear energy. At UNCSD15 on the theme of energy in 2007, nuclear was mentioned in a paragraph that every country has the right to choose for nuclear under the condition it does so 'responsibly'. At the UN World Summit on Sustainable Development ('Rio+20') in 2012, the final text of the Summit reaffirmed support for 'national policies' using an 'appropriate energy mix' and explicitly referred to 'renewable energy sources and cleaner fossil fuel technologies'. The word 'nuclear' does not appear in the entire text. This historical situation recently came to an end. A clear sign of the latest nuclear renaissance is that nuclear lately became an official topic in UN climate change negotiations. At the UNFCCC COP28 climate change conference in Dubai in 2023, nuclear appeared for the first time in the official negotiation texts. As the IAEA declared at the end of the conference: 'For the first time since the annual climate summits commenced in 1995, the 198 signatory countries to the UN Framework Convention on Climate Change (UNFCCC) officially called for accelerating the deployment of low-emission technologies including nuclear energy to help achieve deep and rapid decarbonization, particularly in hard-to-abate sectors such as industry and through the low carbon production of hydrogen' (IAEA, 2023).

1.2 Integrating social sciences and humanities in nuclear energy research

Meanwhile, the societal debate around nuclear energy remains polarised. From a philosophical point of view, the problem of 'nuclear energy: yes or no' may be called a problem complicated by 'moral pluralism': independent of the science base, opinions remain divided and even incommensurable as they refer to various fundamental ethical values stimulating risk perception independently of empirical knowledge. While the positive contribution of nuclear to combating climate change is evident, it is essentially impossible to 'balance' this benefit (because of 'incomparability') with the risk of proliferation or a nuclear accident and the challenges coming with the disposal of high-level waste (siting issues, safety, intergenerational ethics). There exist rational arguments underpinning the statement that 'nuclear energy can contribute to sustainable energy governance' just as there exist rational arguments claiming it cannot and would rather threaten sustainable energy governance. Researching the nuclear energy problem, therefore, requires a holistic perspective and a transdisciplinary and inclusive approach, integrating social sciences and humanities (SSH) research, as well as non-scientific expertise, with attention to technoscientific, economic, social, political, and ethical aspects. If nuclear energy is a product of modernity, then a SSH approach may start by considering five evolutions presented in Table 1 that, from a historical perspective, made up modernity.

Table 1. Five evolutions of modernity

Science & technology	The development and application of modern science and technology in various contexts of the society's organisation (health, food, water, housing, communication, energy, transport, industry, …)
Politics	The emergence of democracy, the nation-state and international politics, the idea of the possibility to peacefully live together with 'disagreements' (tolerance, pluralism, politics as organized 'competition of opinions')
Economics	The emergence of globalised markets and the financial economy
Culture	The emergence of popular culture and modern and postmodern art
The social	The emergence of new relational lifestyles and new forms of communication

1.3 The emergence of SMRs

SMRs may represent a significant advancement in nuclear energy technology, potentially offering a more flexible, potentially cost-effective, and safer alternative to traditional large-scale nuclear reactors. SMRs are defined as nuclear fission reactors with an electrical output of less than 300 MWe per unit, significantly smaller than conventional reactors, which often exceed 1,000 MWe (IAEA, 2020). Their compact size and modular design are deemed to make them suitable for a wide range of applications, from electricity generation to industrial heat production and desalination. Their key characteristics and advantages are (WNR, 2024):

- <u>Modularity and Factory Fabrication:</u> One of the most distinctive features of SMRs is their modular design. Unlike traditional reactors, which are constructed entirely on-site, SMRs are planned to be built in modules in a factory setting. These modules are then transported to the deployment site for assembly. This approach reduces construction timelines, minimizes costs, and improves quality control by leveraging standardized manufacturing processes.

- Scalability: Multiple units should be deployed incrementally to match growing energy demands, making them ideal for regions with limited infrastructure or smaller electricity grids. This modular scalability also allows for phased investment, reducing financial risks compared to large-scale reactors.
- Enhanced Safety: Many SMR designs incorporate advanced safety features, including passive safety systems, which are typical for modern nuclear reactors. These systems rely on natural physical processes, such as gravity and convection, to shut down and cool the reactor in emergencies without requiring external power or human intervention. This inherent safety is expected to reduce the risk of accidents and enhance public confidence in nuclear energy.
- Flexibility in Applications: Beyond electricity generation, the use of SMRs is explored for a variety of applications, including hydrogen production, water desalination, and providing process heat for industrial applications. This versatility is expected to make them a valuable tool for addressing both energy needs and environmental challenges.

SMRs also face several significant challenges that must be addressed to enable their broad adoption (NEA, 2021). Economically, the high initial development costs and the need to achieve economies of scale pose barriers, as securing financing for unproven technologies remains difficult. Regulatory hurdles are another major challenge, with complex approval processes and a lack of harmonized international standards delaying deployment. First-of-a-kind (FOAK) projects often experience delays and cost overruns, further complicating efforts to demonstrate the viability of SMRs. Technically, SMRs must prove their long-term performance, reliability, and safety, particularly in waste management and grid integration, especially in remote or off-grid locations. Public perception is also a critical issue, as there are considerable concerns about nuclear safety, radioactive waste management, and security threats.

Additionally, for new technologies and even for traditional nuclear technologies – due to very few new constructions – developing a robust supply chain for modular components and addressing skilled workforce shortages are key operational challenges. Finally, SMRs face strong competition from rapidly advancing renewable energy technologies and energy storage solutions, which are becoming increasingly cost-competitive. Addressing these challenges will require collaboration among governments, industry, and stakeholders to unlock the potential of SMRs in the global energy transition.

1.4 SMRs in the perspective of social sciences and humanities

The EU Green Deal recognised the potential contribution of nuclear technologies to planned reductions in carbon emissions. This inclusion was controversial. Conflicting views on nuclear matters are as old as the technology itself. Globally, there are more than 80 SMR designs at different stages of development across 18 countries[1]. Like many areas of scientific research, advances in nuclear knowledge and technology are entangled with wider concerns such as economic growth and are concurrently shaped by market behaviour (Stengers, 2018). SMRs, as a technology-in-development, with distinctive features, require particular forms of social scientific scrutiny, as outlined by the “Collingridge dilemma” (Collingridge, 1982). In the early stages of development, when the technology holds on to multiple potential future directions and forms, the possibilities for influencing the direction of development remains high. Once technologies are more fully formed and determined, with their trajectories clearer,

[1] https://energy.ec.europa.eu/topics/nuclear-energy/small-modular-reactors/small-modular-reactors-explained_en#:~:text=Globally%2C%20there%20are%20more%20than,of%20development%20across%2018%20countries.

the capacity to influence or control development is reduced and eventually removed. Choices (design, fuel sources, siting possibilities) become 'locked in' at various stages along the development path.

Exploring technologies as they emerge into the public sphere is therefore critical for a range of reasons. For one, as Collingridge (ibid.) noted, certain kinds of commercial outcome tend to be prioritised in the earlier stages of development, rather than alternatives such as 'the public good'. This dominance of economic thinking has the effect of closing down the imagination of other potential ways forward. The casting of SMRs by some countries as a sustainability option concurrently reduces sustainability to a purely economic calculus. Benefits for the public good and the broader definition of sustainability need to be brought to the fore alongside economic arguments in order to gain a more rounded assessment of SMR futures. When much is at stake in SMR development and potential deployment, upstream decisions about forms of investment or technological development are *ethical* choices and require scrutiny beyond the mere economic.

Callon et al. (Callon et al., 2009) developed the concept of *technical democracy* to describe new forms of public engagement with potentially controversial technologies, and argued to move away from the limitations of so-called 'hybrid forums'. Hybrid forums enable a diversity of viewpoints and a range of stakeholders to come together but often maintain uneven power dynamics and can be seen as opportunities to constrain public debate while apparently enabling it. Such forums exist, they argue, as technological advancements concurrently generate new, or exacerbate existing, uncertainties. Handling uncertainty effectively requires diversity of thinking and multiple perspectives; yet in much technology development such diversity is absent. By drawing on a broader range of data, theories and approaches, a more complete picture can emerge, and more effective ways forward can be identified.

1.5 Our methodology to examine public attitudes

In line with the Aarhus Convention, the term public is understood in this document as "one or more natural or legal persons and, in accordance with national legislation or practice, their associations, organizations or groups" (UNECE, 1998, Article 2, Paragraph 4). Likewise, the International Atomic Energy Agency defines "interested parties" as individuals or groups concerned with, affected by, or having the potential to influence the safety of nuclear facilities and activities (IAEA, 2017). These parties encompass various groups, including the general public, governmental bodies, professionals, non-governmental organizations (NGOs), civil society organizations (CSOs), media, and others. The ECOSENS project used this broad term for interested parties, often referred to as stakeholders.

Social scientific research in the ECOSENS project aimed to capture the diversity of views, concerns, and expectations surrounding SMR technology, particularly in the context of climate change and energy security issues. As summarized in Table 1, our activities progressed through three stages in 2023 and 2024, employing a mixed-methods research design that involved document research, qualitative data collection, and quantitative data collection.

To ensure as much data comparability as possible across countries, we prepared and followed detailed research protocols for conducting the document research and focus group discussions. Moreover, we developed a generic questionnaire that we used in all three public opinion surveys (including a textual stimulus describing SMRs, without referring to any specific SMR technology). On the other hand, the focus group formats, participant recruitment, and, to some extent, even the research protocol content varied across individual countries, considering country-specific contexts. In some countries, alternative or additional methods of qualitative data collection were employed. For these reasons, qualitative data must primarily be interpreted within the specific participant group.

Table 2. Data collection methods

Country	Stage 1: Document research	Stage 2 Qualitative data	Stage 3 Quantitative data
Belgium	Generic research protocol for all countries consulting different sources (e.g., policy papers, energy strategies, climate action plans, media debate, scholarly literature, public opinion surveys, and others) to provide details on possible plans concerning SMRs.	**Four focus groups *(in situ)*** • Two with members of local partnership organizations for disposal of (short-lived) radioactive waste in the communities of Dessel and Mol, in the vicinity of a planned Lead Fast Reactor-SMR demonstrator (conducted in Flemish - 26/03/24) • One with the general public (conducted in Flemish language) (conducted in Flemish - 23/04/24) • And one with students from the University of Antwerp (conducted in Flemish - 16/04/24)	**Public opinion survey** • A sample (n=1200) of Belgians aged 16+ representative for gender, three age categories, province, and education (November-December 2024).
Czechia		**Two focus groups *(in situ)*** • One in the region with an operating coal power plant Tušimice that might become a site for SMR after coal phase-out (12/02/24) • One in the region with an operating nuclear power plant Temelín (13/02/24) • The participants were members of the public or representatives of local stakeholders.	**Public opinion survey** • A representative sample (n=1022) of Czechs aged 15 and above, based on multistage stratified random sampling (August 2024).
Spain		**Two focus groups *(online)*** • One with members of the general public from Spain (4/11/23) • One with residents near Spanish nuclear power plants (4/12/2023).	**Public opinion survey** • A representative sample (n=1001) of Spaniards aged 18+ representative for age and gender (July 2024).
Slovenia		**One focus group *(in situ)* and interviews** • Focus group with informed participants from research, education, environmental NGOs, and political representatives (18/04/24). • Six semi-structured interviews with representatives of responsible organisations (April to July 2024).	---
Slovakia		**Debate and a survey among students** • A debate with students from the voluntary course Environmental Management at the University in Banská Bystrica, following the ECOSENS partner representative's lecture on SMRs. • A Survey among 41 students at the University in Banská Bystrica, Faculty of Economics.	---
United Kingdom		**Interviews and secondary data** • Semi-structured interviews with current and past members of the nuclear industry, government bodies, and NGOs. • Secondary data review based on existing surveys conducted in the UK in 2021 and additional reports and surveys outcomes dating back to 2017	---

International	Reports of environmental NGOs	**Seminar on new nuclear development** • Co-organized by the Group of European municipalities with nuclear facilities (GMF) and the French Association of Communes Hosting Nuclear Facilities in Saint-Vulbas on 23-24 May 2024. • Participants (60 in total) were mayors, deputy mayors, and councillors, mainly from France (47) and also representatives from Finland, Hungary, Netherlands, Sweden, Spain, and the UK.	---
		Stakeholder panel • Organized on June 10, 2024, participants were experts representing policy makers (experienced with local, national and EU level policy), researchers (leading the site selection for LILW repository in Slovenia with adopted location in 2010), NGOs (member of Friends of the Earth Europe involved in many nuclear issues) and the European associations of local communities hosting nuclear facilities (GMF executive director).	---

2. The societal dynamics around SMRs

2.1 Public opinion and the politics of nuclear energy

Scholars have extensively examined the interplay between policymaking, public opinion, and contextual factors in the energy sector, in particular regarding nuclear energy production (e.g. Baumgartner & Jones, 1991; Müller & Thurner, 2017). Several theories help explain policy decisions in general (Cairney, 2020); however, when it comes to nuclear energy, scholars have primarily adopted two approaches: one based on political and social science, which examines the role of various actors (Hegelich et al., 2015), and another grounded in environmental studies, which focuses on risk assessments (Dincer, 2002).

Theories on democracy suggest that politicians should be responsive to public opinion, and policy decisions should reflect the public's stance on the issue. However, research on nuclear energy policy making highlights the conditional nature of public opinion influence. For example, in France, public opinion was found to affect nuclear policy only when mainstream parties had strategic incentives to politicize the issue (Brouard & Guinaudeau, 2015). Similarly, Bernardi et al. found that after the Fukushima nuclear disaster, public opinion mainly amplified the influence of social movements on nuclear policy (Bernardi et al., 2018). A broader comparative study on energy policy making across European countries by Müller & Thurner revealed mixed results (Müller & Thurner, 2017). It suggested that, while in most cases, public opinion does have some impact on nuclear energy policy, there are also cases where public opinion does not inform policymakers. However, when dealing with complex topics like nuclear energy or emerging nuclear technologies, public knowledge is often limited, and formulating an opinion is rather challenging. As a result, people may rely on party cues to shape their opinions (Latré, Thijssen, & Perko, 2019).

The Social Amplification of Risk Framework (SARF) (Kasperson & Kasperson, 1996) gave attention to how the amplification or attenuation of risk in public discourse, mainly through mass media, may influence decision-making. A risk in SARF is defined as "a situation or an event where something of human value (including humans themselves) is at stake and where the outcome is uncertain" (Rosa, 2003; pp. 56). In this context, research consistently shows that nuclear accidents, such as Chernobyl (1986) and Fukushima (2011), significantly diminish public support for nuclear power. However, this effect diminishes over time. According to Renn (Renn, 1990), the speed and extent of recovery depend on pre-accident public sentiment and whether the post-accident debate introduces new perspectives.

Further research on significant events such as accidents has investigated how these guide attention towards a particular problem and have the capacity to alter the political agenda and initiate policy change (Baumgartner & Jones, 1991). Public opinion and policy-making are affected by significant events described as "sudden, relatively rare, that can reasonably be defined as harmful […] and that are known to policy makers and the public virtually simultaneously" (Birkland, 2010; pp. 22).

The recent armed conflict in Ukraine is one such event, as it has heightened uncertainty regarding energy provision in many EU Member States. This led to a re-evaluation and significant shifts in energy policy-making in Europe. In particular, policy positions on nuclear energy have evolved in a more favourable direction for the nuclear industry (European Parliament, 2024). Before 2022, nuclear energy production in the EU made up 13% of the energy mix (European Parliament, 2025). Today, three years after the invasion by Russia of Ukraine, some policy decisions related to nuclear energy are changing to increase nuclear energy production in the future. For example, Belgium, despite its ongoing nuclear phase-out, has decided in 2024 to invest in the development and deployment of Small Modular Reactors (SMRs)[2]. Slovenia has opted to expand its nuclear energy production and has initiated the process of building a

[2] https://www.world-nuclear-news.org/Articles/Belgium-government-allocates-funding-for-SMR-resea

new nuclear reactor and exploring the deployment of new nuclear technologies such as SMRs[3]. Meanwhile, Italy, a non-nuclear country since the Chernobyl accident in 1986, has signed a Memorandum of Understanding with France's EDF to collaborate on industrial applications of SMRs[4]. With or without relationship to the alteration in natural gas supply, some EU Member States are extending the operational lifetime of their nuclear power plants (NPPs) (e.g., the Czech Republic) or building new reactors (e.g., Slovakia, Slovenia, Finland, France) and preparing for new build (e.g., Poland, Lithuania).

Changes in nuclear energy policy have not been driven solely by sudden significant events, but also by long-term processes such as the climate crisis. This is, for instance, reflected in the EU's energy taxonomy regulation, which aims to identify sustainable economic activities as part of Europe's goal to become the first climate-neutral continent. The debate over whether nuclear energy should be included in this taxonomy has been ongoing for several years. On January 1, 2022, the European Commission (EC) put forward a controversial proposal to classify nuclear energy as green and climate neutral. While some experts and Member State representatives supported this decision—citing energy security, reduced greenhouse gas emissions, and advancements in safer nuclear technologies like SMRs—others strongly opposed it. Critics raised concerns about safety and security risks, including potential terrorist attacks, nuclear proliferation, and accidents, as well as the long-term environmental impacts of radioactive waste.

2.2 SMRs in six countries under study

An ECOSENS Milestone document provides a detailed overview of the emergence of Small Modular Reactors (SMRs) within national public debates and energy strategies across several European countries, including Slovenia, Spain, the Czech Republic, Belgium, Slovakia, and the United Kingdom. SMRs are emerging as a potential component of national energy strategies in several European countries, but the level of political support, public awareness, and media coverage varies widely. The Czech Republic and the UK are leading the way in terms of active pursuit of SMRs, while other countries like Spain, Belgium, and Slovenia are more cautious, and Slovakia has yet to develop a clear position.

Slovenia's National Energy and Climate Plan (NECP) includes scenarios for the construction of a new nuclear power plant and the potential deployment of SMRs by 2050. The government has also adopted a resolution on the long-term peaceful use of nuclear energy, which mentions SMRs as a future energy source. Until recently (October 2024), the public debate in Slovenia was heavily influenced by the referendum on the construction of a second nuclear power plant; however, after the cancellation of the referendum, there has not been a lot of discussion about nuclear reactors. SMRs are seen as a potential future technology, but public awareness is limited, and the focus remains on traditional nuclear power plants. Slovenia is participating in the U.S.-led Project Phoenix[5], which explores the feasibility of converting coal plants to SMRs. Some institutions in the country are also part of the European Industrial Alliance on SMRs[6].

Spain's energy strategy focuses on phasing out nuclear energy and increasing the share of renewable energy sources. The National Integrated Energy and Climate Plan (PNIEC) does not mention SMRs, and the government has no plans to develop new nuclear technologies. There is limited public awareness of SMRs in Spain. Media coverage is sparse. However, the few articles that mention SMRs often highlight their potential benefits but also note the lack of political support for nuclear energy. Despite the lack of political support, Spanish research institutions and companies are actively involved in SMR-

[3] https://www.world-nuclear-news.org/articles/slovenias-gen-to-intensify-study-of-smr-options
[4] https://www.world-nuclear-news.org/articles/french-italian-collaboration-on-smr-deployment
[5] https://www.state.gov/bureau-of-international-security-and-nonproliferation/releases/2025/01/project-phoenix
[6] https://single-market-economy.ec.europa.eu/industry/industrial-alliances/european-industrial-alliance-small-modular-reactors_en

related research and development. The Spanish Nuclear Fission Energy Technology Platform (CEIDEN) has established an SMR working group, and several universities and companies are engaged in SMR research.

The Czech Republic is actively pursuing the expansion of nuclear energy, including the construction of new conventional reactors and the potential deployment of SMR. The draft of the Updated National Energy Concept (as of March 2025 in the inter-ministerial comment procedure and not yet approved by the Government) mentions SMRs as a key component of the country's energy mix, and the government is exploring various investment models for SMR deployment. Public opinion is generally supportive of nuclear energy, and SMRs are viewed as a promising technology. However, there is limited public awareness of SMRs, and the debate is confined mainly to experts and policymakers. The Czech Republic also has several domestic SMR design concepts in the early stages of development, and the state-owned utility ČEZ is actively exploring partnerships with international SMR technology providers.

At the time of data gathering, Belgium had a nuclear phase-out law in place; however, the government committed €100 million to research on SMRs, with a focus on lead-cooled SMRs, the goal being to have a demonstrator SMR operational by 2035-2040. Public opinion on nuclear energy is divided, with some supporting the extension of existing reactor lifetimes and others advocating for a complete phase-out. SMRs are seen as a potential compromise, but there is limited public awareness of the technology. Media coverage of SMRs has increased significantly since 2021, notably after the government announced funding for SMR research. The media often frames SMRs as an improved nuclear technology and as a solution to energy security and climate change.

Slovakia has a long history of nuclear energy, but it lacks an official strategy for SMRs. The country is exploring the feasibility of SMRs through the U.S. Department of State Phoenix Project, which aims to convert coal plants to SMRs. Public awareness of SMRs is very low, and there is little public debate on the topic. The only public discussion has been among students and academics, with limited engagement from the broader public. Slovak research institutions are involved in SMR-related research, but there is no clear national strategy for SMR deployment.

The UK Government has been actively pursuing SMRs as part of its net-zero energy strategy. An SMR design competition was launched in 2023, and several companies are actively developing SMR proposals. Currently, three SMR designs are undergoing a 'Generic Design Assessment' by the Office for Nuclear Regulation. The UK aims to have the first SMR operational by the early 2030s. However, public awareness of SMRs in the UK is low, and there is limited public debate on the topic. The focus of public discourse has been more on large-scale nuclear projects and renewables. The government is concurrently exploring various financing models for SMR deployment. With a change in the UK Government in May 2024, aspects of the previous government's policies on nuclear energy development are planned to be reopened for debate in 2025.

2.3 Integration of SMRs in national energy policies

The consideration of SMRs as an energy generation technology, as indicated by qualitative investigations conducted in six EU countries (summarized in Table 1 and detailed in an ECOSENS project milestone document), varies significantly across European countries, influenced by national energy strategies, public attitudes, and policy support. While some countries see SMRs as a promising component of future energy systems, others view them with scepticism due to economic, regulatory, and social concerns.

In Slovakia, SMRs are not yet perceived as a viable energy solution, as discussions around their feasibility remain limited. Although feasibility studies have been initiated, public awareness and stakeholder engagement are minimal, and the absence of official communication has left local municipalities uninformed. This lack of visibility contributes to an uncertain future for SMRs in

Slovakia, where nuclear energy is generally accepted, but new technologies like SMRs have not yet entered mainstream discourse.

Slovenia acknowledges SMRs as a potential long-term energy source, integrating them into national energy planning with a target for implementation by 2050. However, their perceived potential remains limited due to uncertainties regarding economic feasibility, regulatory frameworks, and technological readiness. While policymakers generally support nuclear energy, there is little concrete momentum for SMR deployment. Compared to traditional nuclear power, SMRs are viewed with scepticism, as their smaller scale does not necessarily translate into lower costs or simplified deployment. The technology is viewed as too immature to address short-term energy security or climate challenges effectively.

In the Czech Republic, SMRs are considered an important element of future energy policy, particularly in the context of replacing coal-fired power plants and stabilizing renewables. The government has actively pursued partnerships, such as its collaboration with Rolls-Royce, and strategic energy plans emphasize the role of SMRs in securing a long-term energy supply. However, while the energy sector and policymakers recognize their potential, public awareness remains low, and concerns persist about high costs and uncertain financial models. While nuclear energy enjoys strong public support, the perception of SMRs as an immediate solution is tempered by the long timelines required for licensing and construction.

Belgium's stance on SMRs has been more ambiguous. While previous governments remained officially committed to a nuclear phase-out consolidated in law since 2003, the current government (installed at the beginning of 2025) has announced it would revise that law and investigate the possibility of extending the nuclear capacity to up to 4GW. Meanwhile, the previous government had already allocated significant resources for SMR research, reflecting a recognition of their potential role in energy security. The nuclear research sector, particularly the Belgian Nuclear Research Centre, views SMRs as a viable next-generation technology, with a lead-cooled SMR demonstrator planned for the late 2030s. However, political uncertainty and public scepticism are perceived to be key potential barriers. Media discussions often highlighted unrealistic timelines, economic challenges, and safety concerns, suggesting that while SMRs hold theoretical potential, their practical implementation faces significant hurdles.

Spain presents one of the least favourable environments for SMR development. The country's energy policies prioritize renewable energy and hydrogen, with no official support for new nuclear technologies. The phase-out of existing nuclear power plants is well underway, and SMRs are not included in the national energy strategy. Although some industry stakeholders and research institutions have explored SMR technology, public awareness is extremely low, and media coverage is sparse. Among the citizens, perceptions of SMRs are largely negative, with concerns about SMRs centred on waste management, safety, and economic viability. Residents near existing nuclear plants tend to be more open to SMRs than other members of the public, viewing them as a means to maintain local economic stability. Despite this, the lack of political support and regulatory pathways severely limits the perceived potential of SMRs in Spain.

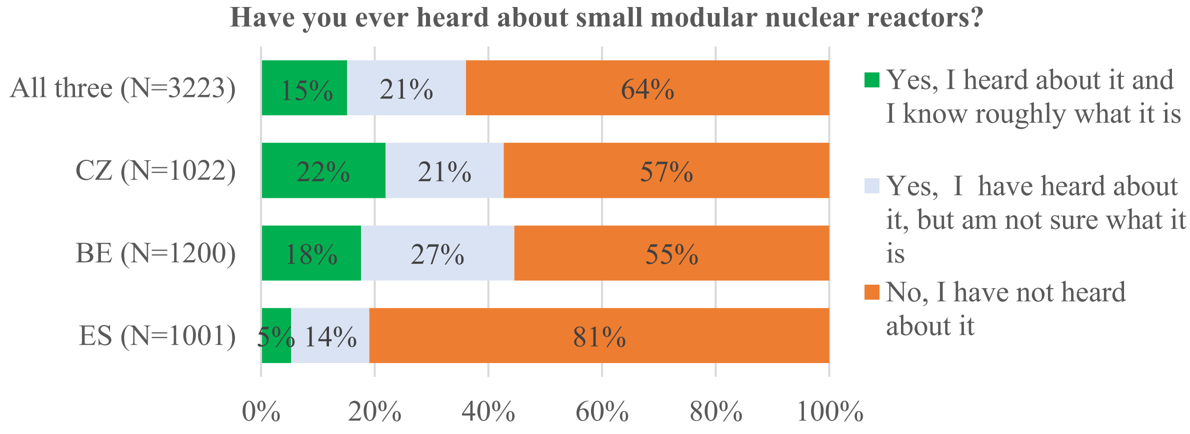
Overall, the perceived potential of SMRs as an energy generation technology remains highly variable across Europe. In countries like the Czech Republic and Belgium, SMRs are seen as a potential energy solution, albeit with significant economic and regulatory challenges. In Slovenia and Slovakia, their role is still unclear, with little concrete progress or strong public support. Meanwhile, Spain's political and policy landscape offers no immediate pathway for SMR development. Across all countries, SMRs are generally viewed as a longer-term possibility rather than an imminent energy solution, with their success depending on economic competitiveness, regulatory adaptation, and public acceptance.

3. The views of SMRs by the public

3.1 Awareness of the technology

Results from the ECOSENS survey data in three EU countries highlight a low awareness of SMRs among citizens: only 15% of survey respondents said they had heard of SMRs and had a rough idea of what they were, while a further 21% said they had heard of them but were unsure what they are. The remaining 61% of respondents have no idea what SMRs are. However, there are significant differences between the three surveyed countries: Spain has the lowest awareness of SMRs, with a considerably higher percentage of unknowns than the other two (see Figure 1). While in Spain only 5% of respondents said they had heard of SMRs and knew what they were, this figure was 18% in Belgium and 22% in the Czech Republic.

Figure 1. Awareness of SMR technology among the public



Data source: 2024 public opinion surveys in Belgium, Spain, and Czechia.

At Matej Bel University in Banská Bystrica (UMB), Slovakia, an ad hoc survey was conducted with 41 students from the Faculty of Economics who voluntarily enrolled in the Environmental Management course, which included a lecture on SMRs. Twenty-five of these students first heard about SMRs only during this lecture. Of the 16 students who were already aware of SMRs, 14 stated the internet (including social media), eight specialised or professional journals (including online versions), six Slovak public television or radio, four commercial television or radio, and three opinion-forming daily newspapers (including online versions) as sources where they had encountered mentions of SMRs.

In the UK, in the summer of 2021, the government Department for Business, Energy and Industrial Strategy published a Public Attitudes Tracker that surveyed the awareness of SMRs among UK citizens (BEIS, 2022). The study found that half of the respondents (54%) had never heard of SMRs, 39% knew little or hardly anything, and 7% estimated they knew a fair amount about SMRs. The report stated that men were more likely to be aware of SMRs than women (57% compared to 35% respectively), and respondents educated at degree level were more likely to be aware than those with no qualifications (54% compared to 34% respectively).

Regarding the participants in the ECOSENS focus groups with residents of nuclear municipalities or broader publics in Spain, none of the participants were aware of SMR technology. In contrast, in the Czech Republic, almost all participants manifested some level of awareness about SMRs as emerging nuclear energy technology, but the views expressed testified that knowledge of the technology was rather limited and fragmentary. Several participants confused two existing small research reactors located in Prague with small modular reactors (SMRs), while others mentioned a variety of more or less accurate facts or contextual factors. Additionally, the imaginary aspects of SMR technology in the Czech

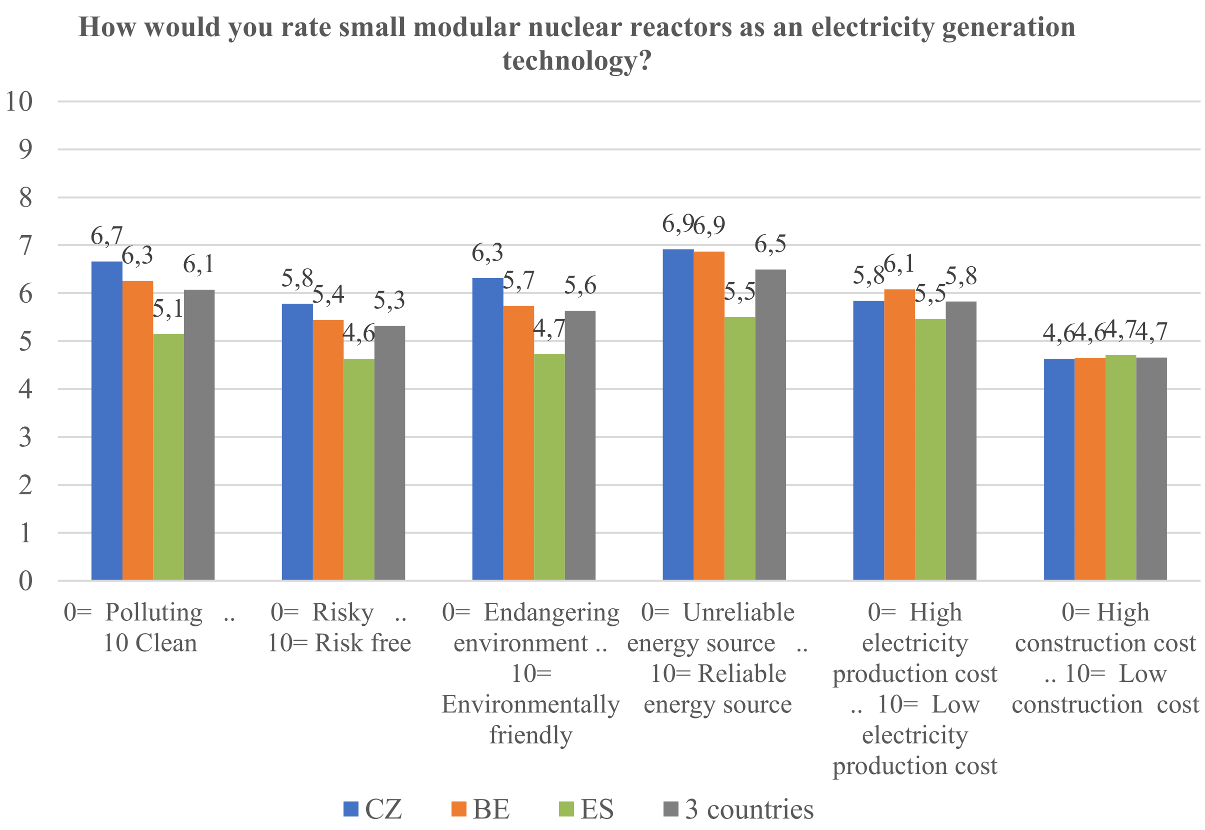
Republic were featured in the focus group discussion. One participant recalled the "hype" or phantasy about the massive use of nuclear energy by the population in the 1950s U.S. and contemplated that one day "perhaps everybody will have his or her SMR at home" on a "kitchen counter", similarly to the depiction in a popular science-fiction book by Douglas Adams, The Hitchhiker's Guide to the Galaxy.

In Belgium, several of the focus group participants stated that they had at least heard of SMRs, and sometimes even about specific SMR types, notably in connection with research on lead-cooled SMRs in Belgium. Given that the focus groups in Belgium were announced as opportunities to discuss SMR technology development and that respondents voluntarily participated and were, hence, self-selected, this was, of course, not surprising. However, in all focus groups, participants repeatedly mentioned their lack of clear and independent information to form opinions about SMRs. They argued that factual information is needed, explaining SMR's risks and benefits clearly.

3.2 Rating of the technology and its socio-economic impacts

ECOSENS public opinion surveys asked the question: *How would you rate small modular nuclear reactors as an electricity generation technology?".* The respondents answered on a response scale from 0 to 10 to assess pollution, riskiness, environmental impact, reliability, electricity production costs, and construction costs (in Figure 2). All ratings had the same direction, so the higher the score, the more favourable the perception.

Figure 2. Rating of SMR technology by the public (average scores)



Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

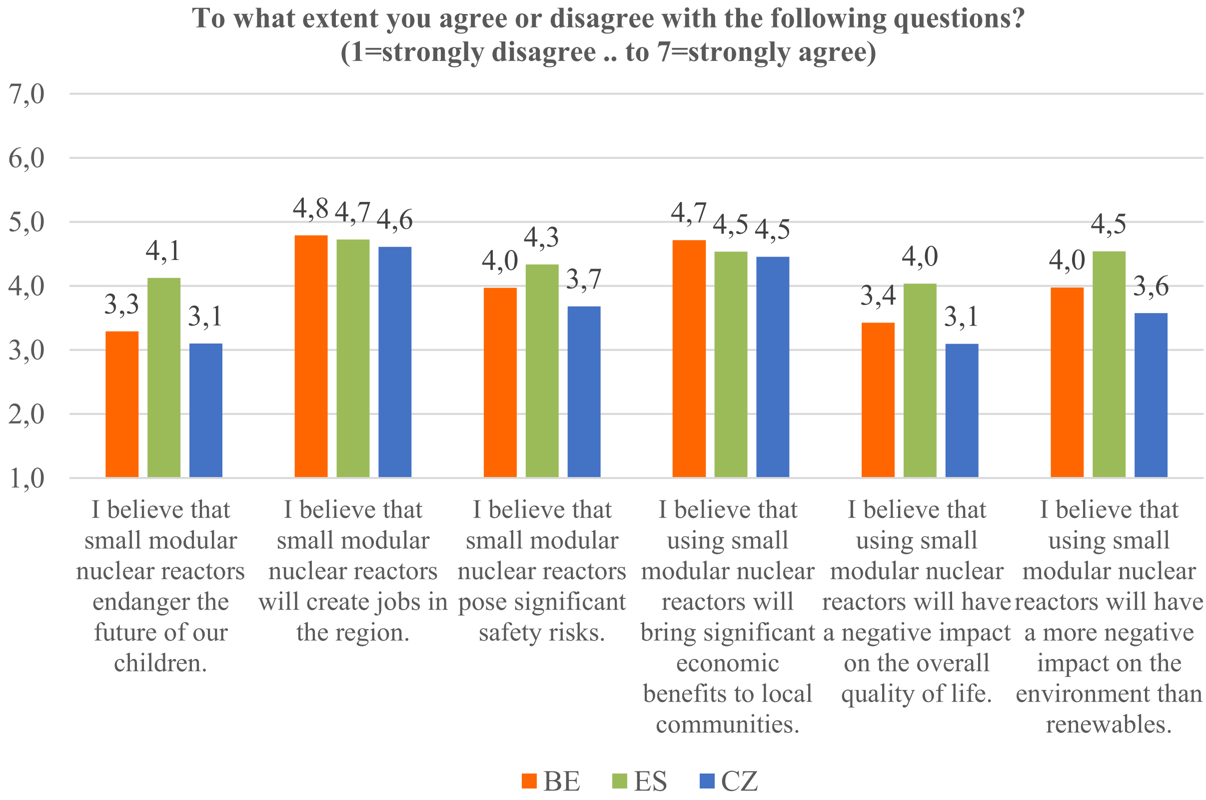
Figure 2 shows that overall, positive ratings prevailed (mean scores above 5), except for construction costs, with a mean of 4.7, which was rated similarly by all three countries. The highest overall score attributed to the reliability of the energy source suggests that, especially in the Czech Republic and

Belgium (where the mean score for reliability was 6.9), SMRs are seen as a potentially reliable technology, even if there is no real experience with their operation in Europe. The Czech Republic stands out as a country with the most favourable expectations towards SMRs. Importantly, for some respondents, it was difficult to provide an answer to some of the items. For instance, 28% in Spain and around 20% in Belgium and the Czech Republic chose the "I don't know" response category for both items related to costs. Shares of this response category in other items did not exceed 12% in Belgium and 10% in the Czech Republic, but ranged between 17% and 21% in Spain (see Appendix B for more details).

The survey also inquired about possible socio-economic impacts of SMRs. We used a seven-point scale ranging from 1 ("strongly disagree") to 7 ("strongly agree") to gauge the level of agreement or disagreement with different statements. The higher the average score, the higher the agreement with the given (positive or negative) impact. Figure 3 presents the results.

Generally, respondents in all three countries were predominantly optimistic that SMR technology would create jobs and entail significant economic benefits for local communities. On the other hand, the statements "SMRs pose significant safety risks" and "SMRs will have a more negative environmental impact on the environment" are close to the average rating (4.0) in Belgium and Czech Republic, signalling an ambivalent perception by the public; at the same time views regarding these issues are predominantly negative in Spain. Finally, respondents in Belgium and Czechia perceived SMRs somewhat less often (average below 4.0 for both) as "endangering the future of children" or "leading to a more negative quality of life", while public views in Spain were ambivalent in this regard (average at or close to 4.0). Overall, the negative rating of SMR technology's socio-economic impacts was significantly stronger in Spain and less strong among the Czechs.

Figure 3. Rating of socio-economic impacts of SMRs by the public



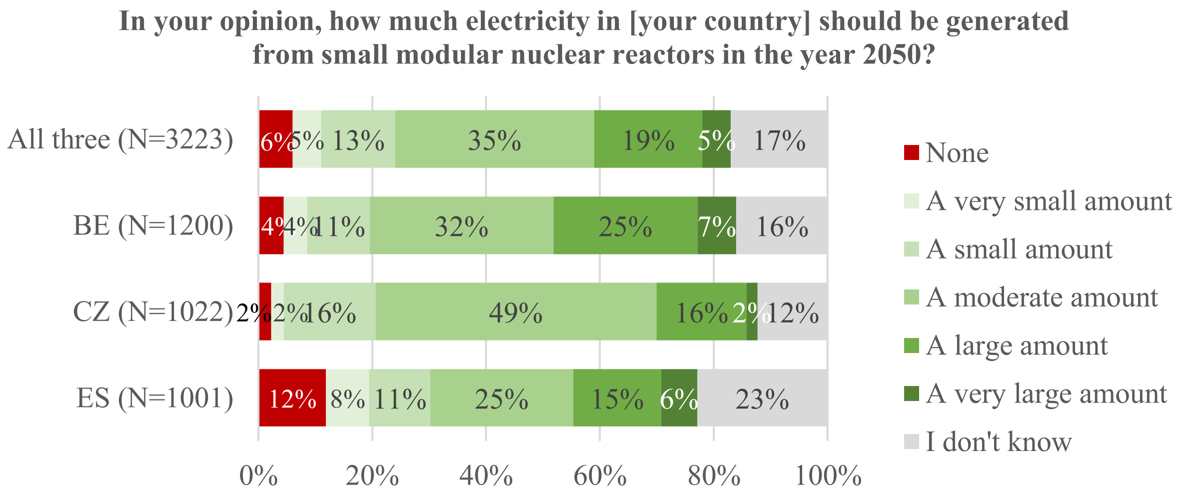
Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

3.3 Imagining SMRs in 2050

Participants in the ECOSENS survey were asked the question *"In your opinion, how much electricity in [your country] should be generated from small modular reactors in 2050?"*. The results in Figure 4 show that the majority of respondents (77%) in all countries envision SMRs as part of the future 2050 energy mix, while relatively few (6%) imagine the contrary. In terms of individual countries, the lowest level of scepticism (lowest % of respondents who see no role for SMRs) is in the Czech Republic, at 2%, and the highest is in Spain, at 12%.

Moreover, most of the respondents believe that the share of SMRs in the 2050 energy mix will be higher than small. In Belgium, the Czech Republic, and Spain, the respondents who are optimistic about the future use of SMRs mainly chose the response categories "a moderate amount", "a large amount", and "a very large amount". So, rather surprisingly, despite a limited awareness of SMRs (Figure 1), respondents tend to trust the potential of the technology.

Figure 4. The imagined input of SMRs in 2050



Data source: 2024 public opinion surveys in Belgium(N=1200), Spain (N=1001), and Czechia (N=1022).

3.4 Doubts about the viability of SMRs

Publicly available reports commonly cited by environmental NGOs often referred to three reasons why the viability of SMRs remained uncertain as of mid-2024:

- unsuccessful long-term struggles of the nuclear industry to get one 'real SMR' into commercial operation;
- long-term persistent assessments/expectations of high financial costs per unit;
- statements by SMRs promoters regarding higher safety/security and/or nuclear waste issues favouring SMRs over large light-water reactors.

Addressing their manufacturing paradigm, multiple reports have substantiated that existing reactors classified by the nuclear industry as SMRs do not meet the criteria for the serial factory production of reactor components, which is central to the so-called 'modular' [part of the] definition' (FOE Australia, 2023, p. 6). Moreover, the only two such reactors currently in operation seem to "exhibit familiar problems of massive cost blowouts and multi-year delays" (FOE Australia, 2023, p. 6). The *World Nuclear Industry Status Report 2024* asserted that "few existing [future SMRs related] cost estimates—and these are necessarily speculative—show that SMRs will be more expensive per unit of installed capacity than large reactors" (Schneider et al., 2024, p. 365). Moreover, all ancillary costs—encompassing operations and maintenance, decommissioning, and waste management—similarly appear to significantly impact the currently lacking viability of SMRs (Schlissel & Wamsted, 2024).

Some environmental NGOs consulted in the preparation of this report stressed that, while assessing risks is inherently difficult, using multiple sites for SMRs to generate the same volume of electricity would increase risks relevant to several empirically existing vulnerabilities. For example, these sites may be easier targets for malicious actors and raise the risk of fissionable material theft—issues that are less common with well-protected traditional large-scale nuclear reactors.

Regarding back-end issues, environmental NGOs have typically criticised SMR promoters' statements that “SMRs will reduce the intractable problem of long-lived radioactive waste management by generating less waste, or even by “recycling” their own wastes or those generated by other reactors” (Lyman, 2024). NGOs often based their arguments on peer-reviewed academic research suggesting that SMRs exacerbate existing nuclear back-end challenges due to enhanced neutron leakage, persistently high concentrations of fissile nuclides, and the continued generation of geochemically mobile fission products, which could critically impact geologic repository performance beyond mere volumetric considerations (Krall et al., 2022).

Overall, according to the *World Nuclear Industry Status Report 2024*, the current empirical state of the art regarding SMRs might best be characterised by the Dakota native tribes' saying/metaphor: 'Once you’re on a dead horse, you dismount quickly.' The reason for this was referenced by NuScale's CEO when presenting the termination of this company’s ‘Utah Associated Municipal Power Systems’ (UAMPS) SMR project (Schneider et al., 2024, p. 365).

4. Climate change and energy security considerations

4.1 The debate on the role of nuclear energy

The energy crisis of 2021–2023, exacerbated significantly by the Russian invasion of Ukraine, was a major geopolitically destabilizing event with a lasting global impact. In line with the historical observation that crises tend to generate progress on energy policy (Grossman, 2015), it pushed many countries to realign their national energy strategies. In Europe, the Green Deal project of reaching climate neutrality by 2050 has been confronted with unprecedented energy security challenges since its announcement in late 2019. Consequently, several EU countries started reconsidering or reaffirming the role of nuclear energy as a baseload source that allows for coupling the advancement of decarbonization goals with energy security concerns. In July 2022, nuclear energy was included in the EU Taxonomy of Sustainable Activities after intensive negotiations among the EU member states. These developments suggest that the negative effect of the Fukushima nuclear disaster in 2011 is largely over. A recent report by the International Energy Agency points out that "interest in nuclear energy today is at its highest levels since the oil crises of the 1970s, with support for expanding the use of nuclear power now in place in more than 40 countries" (IEA, 2025).

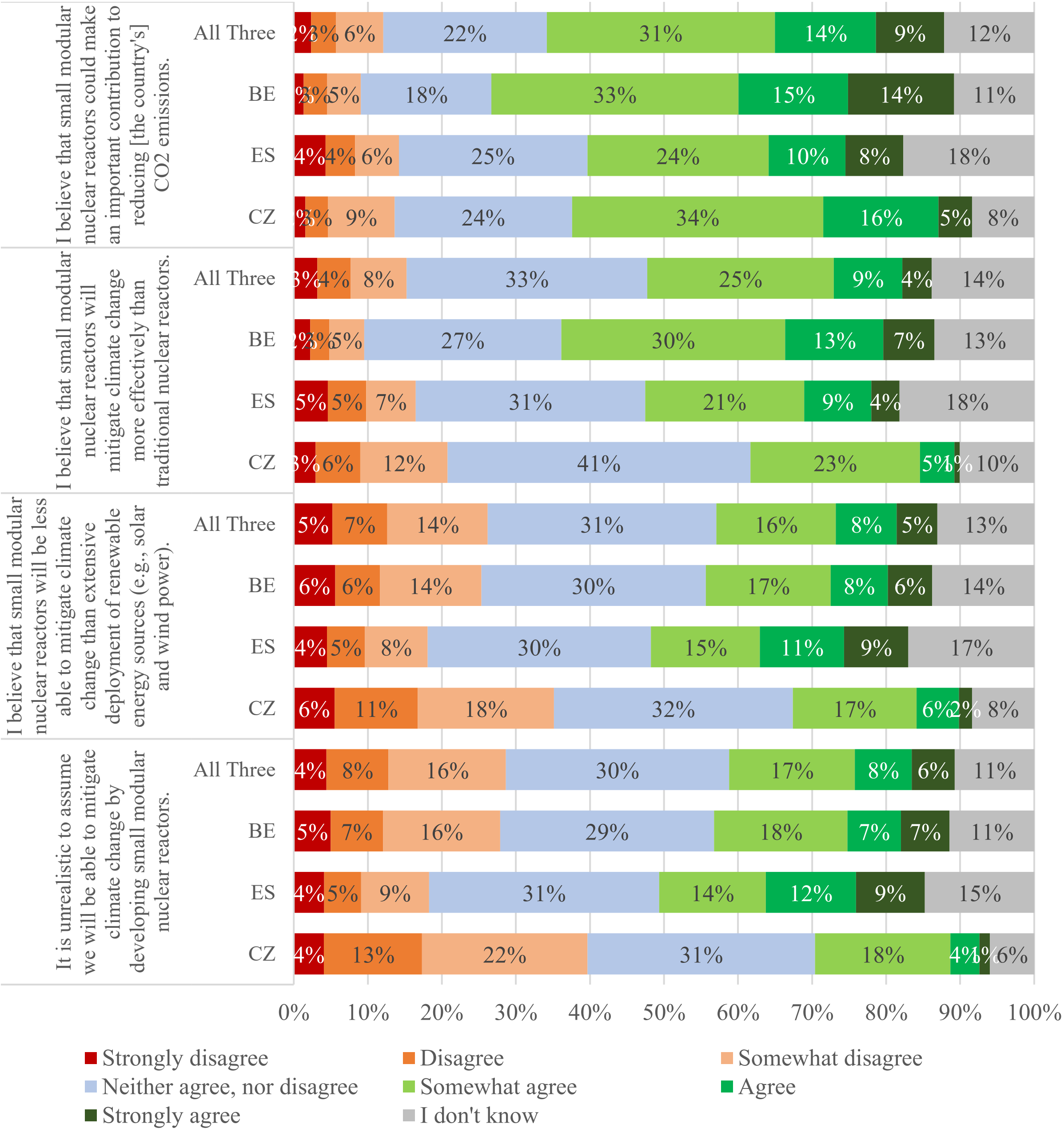
However, the issue of nuclear energy has always divided the public, and the appreciation for nuclear energy within the policy planning community does not automatically entail increased public support. Consequently, the importance of research into public attitudes towards nuclear energy is growing. A systematic literature review within the ECOSENS project focused on how climate change and energy security considerations affect public attitudes towards nuclear energy (Durdovic et al., 2024). 82 articles published in English since 2011 and indexed in scientific databases were selected for the review. The results show that public support for nuclear energy is generally negatively associated with climate change concerns and positively associated with concerns for energy security. Moreover, the higher the perceived benefits of nuclear energy for energy security and, to a lesser extent, for mitigating climate change, the more open or (sometimes reluctantly) favourable attitudes towards nuclear energy are. Finally, the literature review revealed that people evaluate nuclear energy's benefits regarding climate change and energy security depending on the specific national context.

The public debate on SMR technologies as a viable commercial alternative to nuclear power production has intensified over the last three years. The International Energy Agency highlights SMRs as a potential "catalyst for change" that might "bring new business models into play" in the forthcoming era of nuclear energy (IEA, 2025, p. 11). Research institutes and companies from most EU member states participate in the European Industrial Alliance on SMRs to coordinate research, development, manufacturing, financing, licensing, and other activities needed to establish and consolidate an SMR industry in the future (EC, 2025). Based on energy strategy considerations, many EU Member States either take concrete steps towards deploying SMRs soon or explore this option. Yet, compared to the vast literature on large traditional reactors, very little is known from available scientific studies about the public's perceptions of this new technology or the willingness of local communities to potentially host an SMR facility.

4.2 SMRs as a way of coping with climate change

Focus group discussions and surveys revealed that climate change is an important concern for many of the participating respondents. Some differences seemed to exist in perceptions regarding the urgency and origins of climate change. For instance, 8% in Belgium, 10% in Spain and 18% in Czechia tended to disagree in the ECOSENS surveys that climate change is mostly caused by human activity, while more than 75% in Spain and Belgium, and 65% in Czechia, tended to agree that this is the case (see Appendix B). Climate change and its effects were generally considered to require action, also in the field of energy production. This was exemplified by citizens participating in focus groups by the recurring argument that energy production based on fossil fuels was outdated and should be discontinued. However, in Czechia, some respondents also expressed some nostalgia towards coal-fired energy production.

Figure 5. Perceived climate benefit of SMRs



Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

Attitudes and opinions on SMRs are clearly still developing. Nevertheless, the potential contributions of SMRs to the reduction of carbon emissions seem to be recognised, particularly in countries with a favourable attitude towards nuclear energy. For instance, 62% of the ECOSENS survey respondents in Belgium and 54% in Czechia and 43% in Spain believe that SMRs could make an important contribution to reducing the country's CO_2 emissions, while only 9% in Belgium and 14% in both Czechia and Spain disagreed with this statement. This was also reflected in focus group discussions, where nuclear energy, in general, and SMRs, in particular, were recurrently referred to as a potential and viable option to tackle climate change, due to their low carbon emissions.

At the same time, views are divided in terms of SMRs' role in mitigating climate change. Spanish and Belgian respondents in the ECOSENS survey are more sceptical than Czech respondents. Specifically, in Belgium 32% agree with the statement that "it is unrealistic to assume that we will be able to mitigate climate change by developing SMRs" (28% disagree), and 36% agree in Spain (18% disagree), while 24% agree in Czech Republic (40% disagree). In focus group discussions, this division surfaced most clearly along two themes: the environmental and climate change effects of SMRs and the timing of SMR development. Regarding the former, some respondents demonstrated scepticism towards claims of a low environmental impact of SMRs due to their low carbon emissions. In the Czech Republic, a respondent emphasized, for example, the issue of radioactive waste, and how, without it being resolved, SMRs would not be able to live up to their environmental promises. In Belgium, various respondents commented that for any energy production technology, hence also SMRs, the whole life cycle needs to be considered when assessing the potential environmental impact and its relation to climate change. Doubts were expressed regarding the low carbon emissions –and broader environmental impact- of SMRs when considering also the fuel sourcing, plant construction and/or decommissioning of the facility, among others. Regarding timing, some focus groups participants considered that SMR development and implementation would take too long to be of much benefit in the fight against climate change and emphasised that action needs to be taken now. Other participants acknowledged that it might indeed take several years before SMRs will be operational, but, nevertheless, argued that it is better to have them late than never, to mitigate climate change.

Comparisons between SMRs and large traditional reactors or renewables reveal different perceptions in Belgium, Spain and the Czech Republic, as well as a rather large percentage of respondents without an outspoken opinion on such comparisons. While half of the Belgian respondents in the ECOSENS survey believe that SMRs would be able to mitigate climate change more effectively than large traditional reactors (10% disagree and 27% have a neutral stance), this amounts to 34% in Spain (16% disagree and 31% have a neutral stance), and 28% in Czechia (21% disagree and 41% have a neutral stance). At the same time, comparisons between SMRs and renewables were more favourable to SMRs among respondents from the Czech Republic than among those from Spain and Belgium.

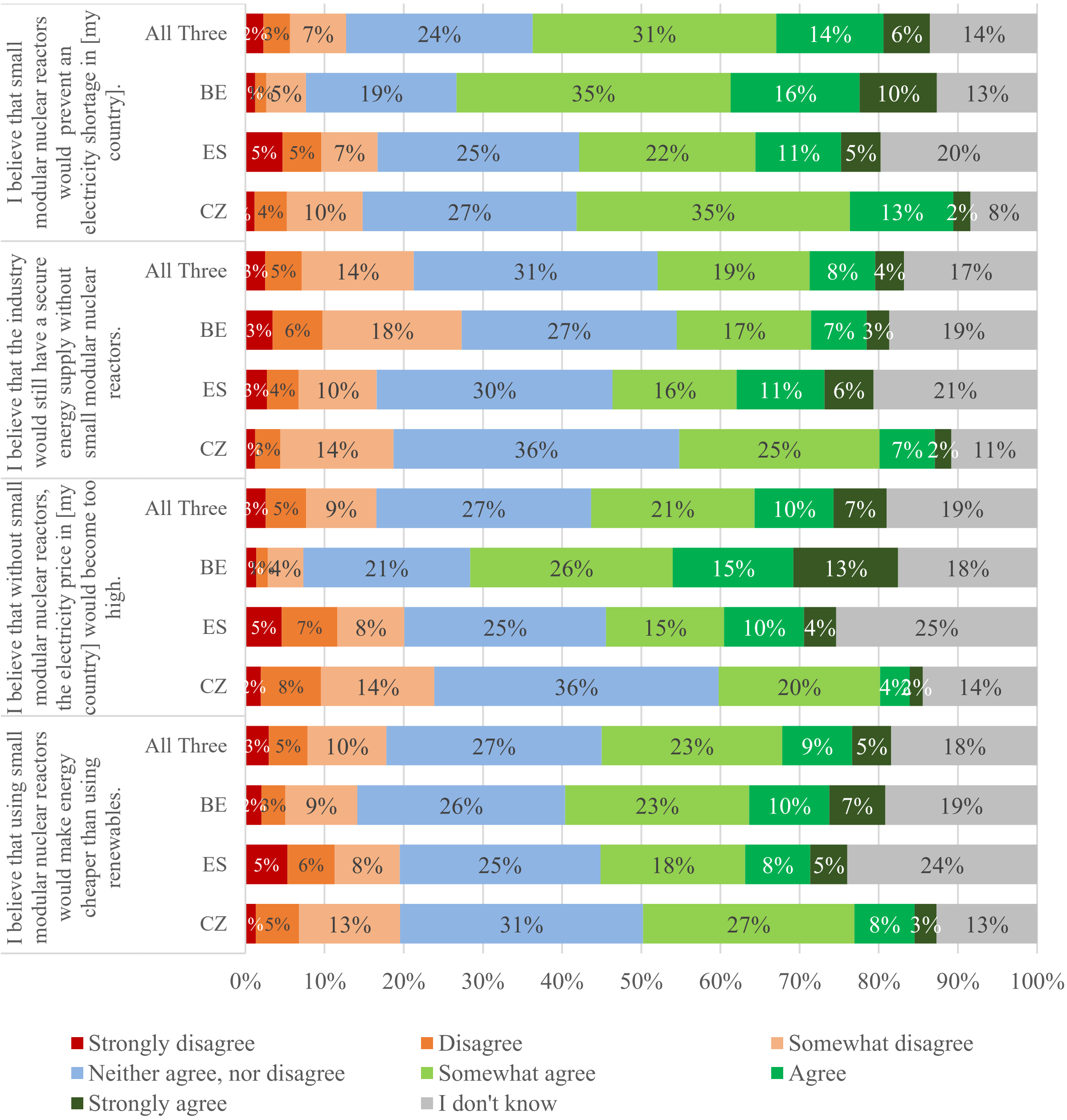
4.3 SMRs and energy security challenges

In the wake of the energy crisis, citizens participating in focus groups pointed out the significance of energy supply security, the negative effects of dependence on other countries, and the rise in energy prices. Such concerns were mirrored in the ECOSENS survey results showing, for instance, that over 70% of Belgian citizens and about 65% of Spanish citizens are quite concerned that electricity would become unaffordable or that the country is too dependent on energy imports (vs. less than 34% in Czechia) (see Appendix B).

Concerns regarding the supply of energy were raised in connection with the phasing out of nuclear power stations (NPPs) by focus group members from Belgium and Spain (mostly by those living near NPPs). Overall, attitudes towards SMRs tended to be favourable among focus group participants, with some perceived benefits for enhancing energy security. SMRs were deemed a realistic choice if they provided supply stability independent of external factors (especially weather conditions), while allowing for increased energy production scalability. Furthermore, they are seen to potentially contribute to diversifying energy sources to complement renewable energies.

On the other hand, there were critical views on adopting SMRs, with the primary points of contention being related to safety concerns associated with nuclear energy, the competitiveness of construction and production costs, and the handling of radioactive waste. Additionally, a variety of obstacles that SMRs would need to overcome were discussed, such as potential public opposition, the impact on local life and the landscape, legislative or licensing limitations, the technology's immaturity (experimental phase of development), the lack of unity and consistency in (nuclear) energy politics under different governments, and the lack of EU-level convergence when it comes to choosing which SMR technologies to pursue further.

Figure 6. SMRs and energy security considerations



Data source: 2024 public opinion surveys in Belgium(N=1200), Spain (N=1001), and Czechia (N=1022).

In terms of quantitative data, observations presented in Figure 6 suggest a relative predominance of positive perceptions of SMRs' contribution to energy security. Half of the total ECOSENS survey respondents considered that SMRs could prevent electricity shortages in their countries, with a notable difference between Belgium (61%) and the Czech Republic (50%), compared to Spain (38%). Regarding electricity costs, Belgian survey respondents strongly supported much more the idea that without SMRs, the price would become too high (54%), compared to the other countries (29% and 26%). A similar percentage of respondents from Belgium (40%) and the Czech Republic (38%) agreed that using SMRs would make energy cheaper than using renewables. This percentage was lower for respondents from Spain (31%), the only country not envisioning SMRs in its national energy strategy. In contrast, a third of the Spanish (33%) and Czech samples (34%) agreed that the industry would still have a secure energy supply without deploying SMRs.

5. SMRs and large traditional nuclear reactors

5.1 SMRs compared to LTRs

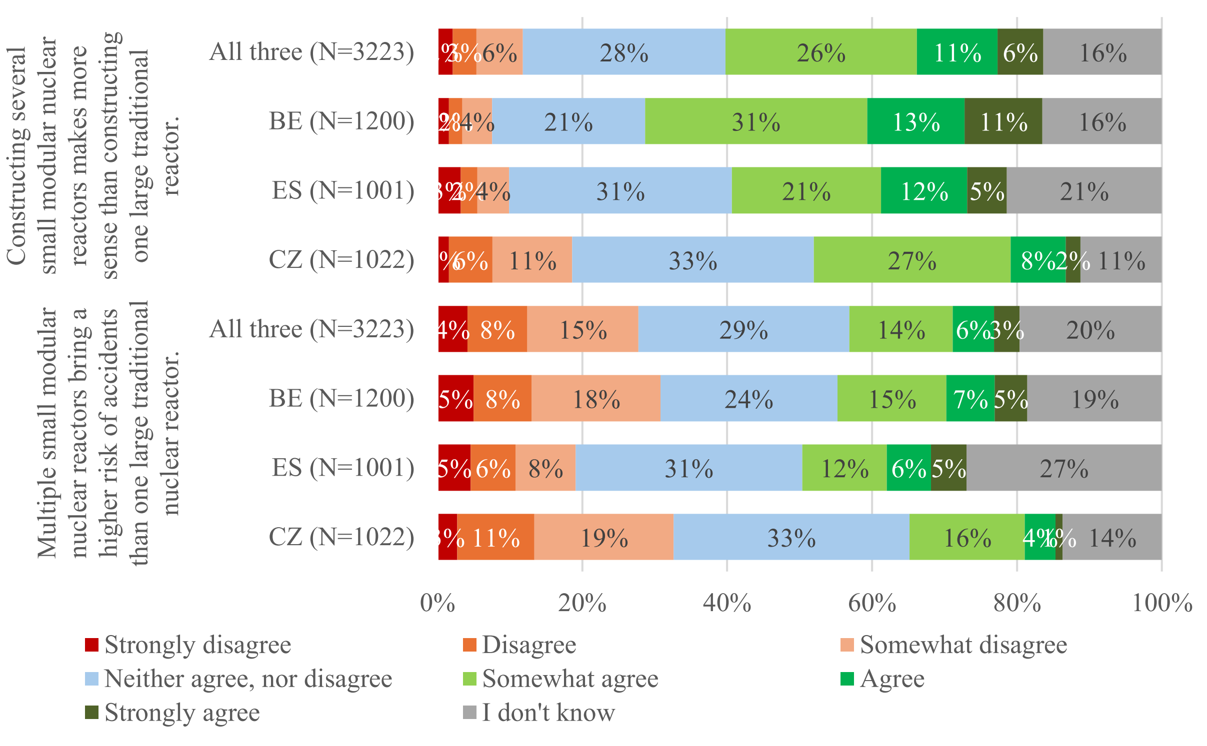
According to a 2024 update on the development of SMRs by the IAEA, there were 68 active SMR designs (i.e., designs confirmed to the IAEA) in 2024 (IAEA, 2024), and in October 2024, IAEA Director General Rafael Grossi claimed that SMRs are "becoming a reality" (WNN, 2024). Similarly, the recent IEA report on nuclear energy appears rather confident about the global uptake of SMRs as a commercial power generation technology in the near future, starting from the 2030s (IEA, 2025). Little room is left in these documents for scepticism (SMRs as an uncompetitive hype), which was inherent to the debate on SMRs since the early 2010s (e.g., Ramana & Mian, 2014; Sovacool & Ramana, 2015). The European Commission's explanation of SMRs highlights the general advantages of the technology, also in comparison with LTRs (EC, 2024), such as contribution to decarbonisation, flexibility stemming from smaller sizes, modularity in the production and assembly of parts, supply stability, and good compatibility with renewables or hydrogen within the energy system. Yet, it is not clear whether diverse relevant stakeholders and local publics know or agree with these arguments concerning the added value of the technology compared to LTRs, which may be a precondition for seeking public acceptance of a potential SMR siting project.

The focus group discussions with citizens revealed uncertainties about the specific role that SMRs might play in the energy system in the future. While the number of news and expert statements on SMRs conveyed by media has increased since 2021 in some countries (e.g., in Belgium), which might be an important source of information, public debate has been limited. Correspondingly, citizens struggled to clearly distinguish between LTRs and SMRs, compare the technology differences, and evaluate SMRs as an energy production option. Despite the attributes of "small" and "modular" providing basic clues for understanding, most citizens participating in focus groups found it difficult to grasp the technical meaning of these terms and describe possible advantages of SMRs over LTRs.

Importantly, even individuals with a pronuclear attitude expressed certain doubts: many smaller reactors would, in their view, entail more construction sites, more investments, more safety or security risks, and a higher need for experts involved in projects in different locations, while LTRs avoid this fragmentation of efforts and can deliver power on a large scale. On the other hand, some of the focus groups participants who were concerned about the viability of LTRs, e.g., in terms of safety, high construction costs, or other megaproject challenges, tended to perceive SMRs as a less risky, less costly and more decentralised alternative. In addition, SMR projects could secure the spread of potential benefits (investments, jobs, energy independence, etc.) among many different regions and accelerate the transformation of industrial areas (e.g., by using brownfields from phased-out coal power plants).

The survey data presented in Figure 7 show how SMR and LTR technologies compare in the eyes of citizens from Belgium, Spain and the Czech Republic. First, almost half of the respondents (43%) recognise to some extent the promise of SMRs for developing nuclear energy, but differences are apparent among the three countries under study. While in Belgium, 55% agreed that constructing several SMRs would make more sense than one LTR, only 37% or 38% agreed with the statement in the other two countries, and a higher disagreement was present in Czechia. Further analysis will be needed to explain this difference. Second, although most respondents, especially in Belgium and the Czech Republic, do not agree with the statement that SMRs entail a higher risk of accidents than LTRs, the data suggest that SMR technology may evoke a sense of higher risk. A relatively similar share of respondents in all three countries (23%, 27%, and 22%) agreed that the risk of accidents is higher in SMRs than in LTRs. Moreover, in Spain, the only country not planning to deploy SMRs as of 2024, disagreement with the statement was clearly the lowest (19% compared to 33% in Czechia), indicating a lower trust in the safety of the technology.

Figure 7. Comparing SMRs and LTRs



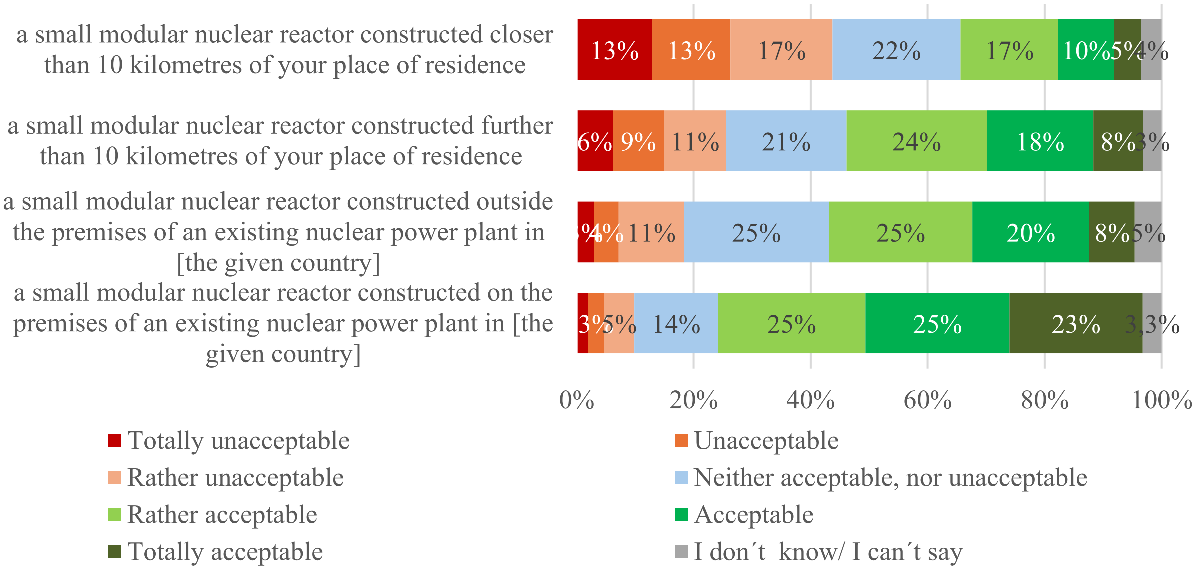
Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

5.2 Public acceptance of siting an SMR in different locations

Projects of building nuclear facilities (power plants, research infrastructure, storage facilities, geological repositories for final disposal, or others) typically raise public concerns and opposition. Public acceptance of siting and constructing an SMR by the local population is a specific part of a broader research field concerning different facets of public attitudes towards nuclear energy, such as risk and benefit perception, knowledge and understanding of information, trust in authorities involved, values and ideological or political affiliation, sociodemographic characteristics, and other. As SMRs are an emerging nuclear technology with several siting and construction projects foreseen within the EU in the next ten to twenty years, it is vital to study how the general public and the public in potential host locations perceive the technology, including the question of geographical proximity of a hypothetical future SMR power plant to residential areas. Besides showing that the issue of geographical proximity matters, the ECOSENS data reveal several key insights.

Based on the public opinion survey results, Figure 8 presents how acceptable or unacceptable the respondents find the possibility of constructing an SMR in different locations. Only those positive about the technology, who believed that SMRs should be part of the country's energy mix in 2050, were asked the question. Somewhat unsurprisingly, only a limited share of less than one-third of these respondents (32%) would be to some extent willing to accept an SMR closer than 10 kilometres to their place of residence, and this attitude was statistically more frequent among men, supporters of nuclear energy, and people less concerned about climate change. Considering a distance of more than 10 kilometres, the acceptance level reached half of the respondents (50%) and basically overlapped with the acceptance of an SMR construction outside the premises of existing nuclear power plants (53%). Finally, building an SMR at the existing nuclear power plant presents the most acceptable option. The value of 71% of respondents within the subset of SMR optimists who indicated this option exceeded the share of 52% in the overall sample who stated being in favour of nuclear energy.

Figure 8. Acceptability of siting and SMR in different locations



Data source: 2024 public opinion surveys; only respondents who believed that SMRs should be part of the country's energy mix in 2050 were asked the question, in Belgium (N = 954), Spain (N = 653), and Czechia (N = 873).

Nevertheless, a caveat should be pointed out. While the survey data show the level of acceptance of siting an SMR expressed by respondents at the moment of measurement, the possible introduction of SMRs in the future will develop via individual projects in specific contexts and locations, in the course of which unpredictable bottlenecks may arise and provoke opposition. As of late 2024, no firm SMR siting decisions have been made among the six countries researched. Yet, according to publicly available information, feasibility studies focusing on industrial sites or former coal power plants are underway in Slovenia and Czechia. In this respect, the findings from qualitative data reveal two groups that are more open to SMR construction near their place of residence: first, participants from regions with a nuclear power plant who are already accustomed to the risks and benefits thereof, and second, participants from a region with a coal power plant, who tend to understand a potential SMR project as a way of rebuilding their region and securing its future prosperity.

In Czechia, an additional survey question that asked the subset of SMR believers about the acceptance of siting an SMR at a phased-out coal power plant yielded 74% of answers viewing this option as acceptable.

6. Decision-making about SMRs

This section explores questions related to citizens' trust in government decision making on nuclear energy and their desired level of participation in decisions concerning the siting of SMRs at their place of residence.

6.1 Trust in the Government from a comparative perspective

Trust has been at the core of many social science studies in the nuclear field in the last decades, with a focus on trust in nuclear actors (governments, scientists, risk management institutions, and nuclear industry) (social trust), or trust in the science underlying nuclear technology development (epistemic trust).

Social trust refers to relying on the providers of risk-related information (e.g., institutions responsible for risk management) in order to make judgments on risks and benefits of technologies (e.g., nuclear power) for which they feel they do not possess enough personal knowledge (Siegrist & Cvetkovich, 2000; Renn, 2008, p. 123). Scholars have noted that, in such cases, "*personal experience of risk has been increasingly replaced by external information"* (Renn, 2008, p. 123). Due to the asymmetry of technical knowledge between experts and publics, trust in governments is deemed a key element of democratic governance processes of complex technologies. (Rosa & Clark, 1999). Trust in risk management institutions or operators has been argued to shape perceptions of risks and (some) benefits of nuclear energy – before and after a nuclear accident –, radioactive waste disposals or decommissioning of nuclear installations (higher trust being associated with less negative risk perceptions and higher perception of some benefits) or the acceptability of nuclear energy (higher trust associated with more positive attitudes towards nuclear energy) (Flynn et al., 1992; Hietala & Geysmans, 2022; Hoti et al., 2021; Renn, 2008; Siegrist & Visschers, 2013; Visschers et al., 2011). Other, cross-cultural studies (Slovic et al., 2000) suggested that trust in experts, governments, and other nuclear actors mediates the relationship between risk perception and attitudes towards nuclear power. Social science studies have also highlighted the multidimensionality of social trust, which encompasses perceptions of competence, as well as values such as fairness, responsiveness, inclusiveness, and transparency (Renn, 2008, p. 124). It was shown that the perceived divergence between the interests and goals of responsible authorities and those of citizens has a stronger influence on (negative) risk perceptions than the perceived competence and trustworthiness dimensions of social trust (Sjöberg, 2008; Sjöberg & Herber, 2008).

Scholars point out that trust should not be seen as unidirectional from the public towards nuclear actors: the extent to which nuclear authorities and industry trust civil society to play a substantive role in nuclear decision making ("reciprocal trust") is an equally important, albeit less brought to attention, factor (Dawson & Darst, 2006).

Furthermore, social trust is not only a matter of pre-existing trust but is also created (or lost) through the decision process. A decision process that is perceived as fair, i.e. open and transparent, with clear rules, high level of citizen involvement and impact on decisions, and use independent expertise, thus contrary to a top-down technological approach, influences in a positive way the perception of the process and its outcome, and has the potential to generate social trust (Krütli et al., 2012).

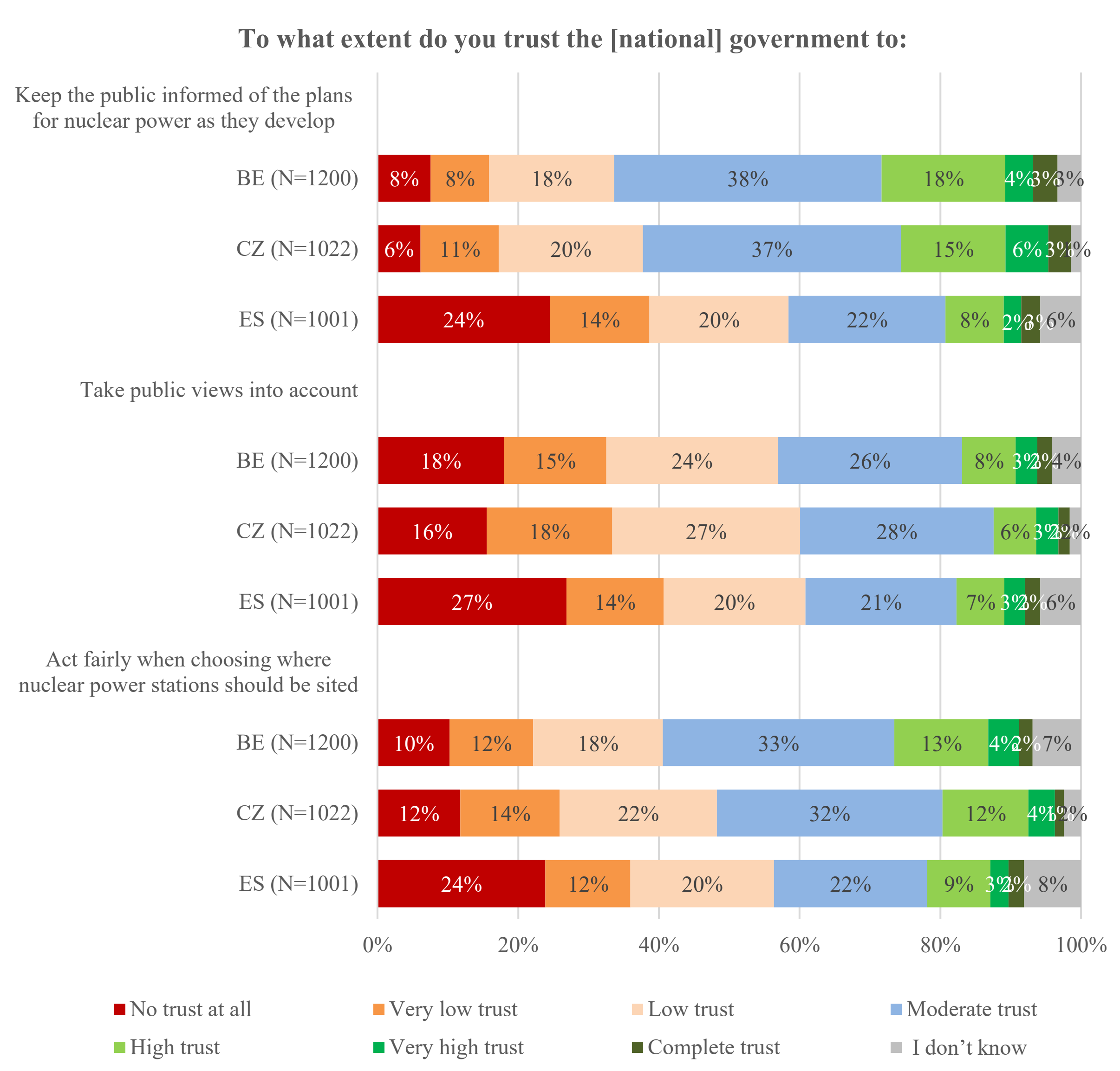
Studies also investigated how epistemic trust relates (positive association) with lower risk perceptions, as well as the connections between enhanced precautionary attitudes and (lower) epistemic trust (Sjöberg & Herber, 2008; Sjöberg, 2009).

Results from the ECOSENS surveys in Belgium, the Czech Republic, and Spain found low to moderate trust in national governments regarding several aspects of nuclear energy decision-making. Trust levels are particularly low among Spanish respondents. For instance, in Spain, 58% have low or no trust at all in the government for informing citizens about nuclear energy plans, while this is 34% in Belgium and

37% in Czechia. However, in all three countries there is a similarly high distrust in the national governments as regards taking public views into account: 57% have none or low trust, 26%, moderate and 13% high to complete trust in Belgium; 61%, 28% and 10% in Czechia; and 61%; 21% and 12% in Spain.

When it comes to acting fairly in siting decisions, less than 20% in all three countries expressed high trust in the national government, with Spanish respondents markedly more negative than respondents from Belgium and Czechia.

Figure 9. Trust in national government as regards nuclear decision-making



Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

In several of the focus groups, participants also expressed distrust in government and politicians regarding nuclear decisions, criticising the perceived lack of effectiveness on, e.g., radioactive waste disposal (Spain), or the long-term vision and policy coherence (Belgium).

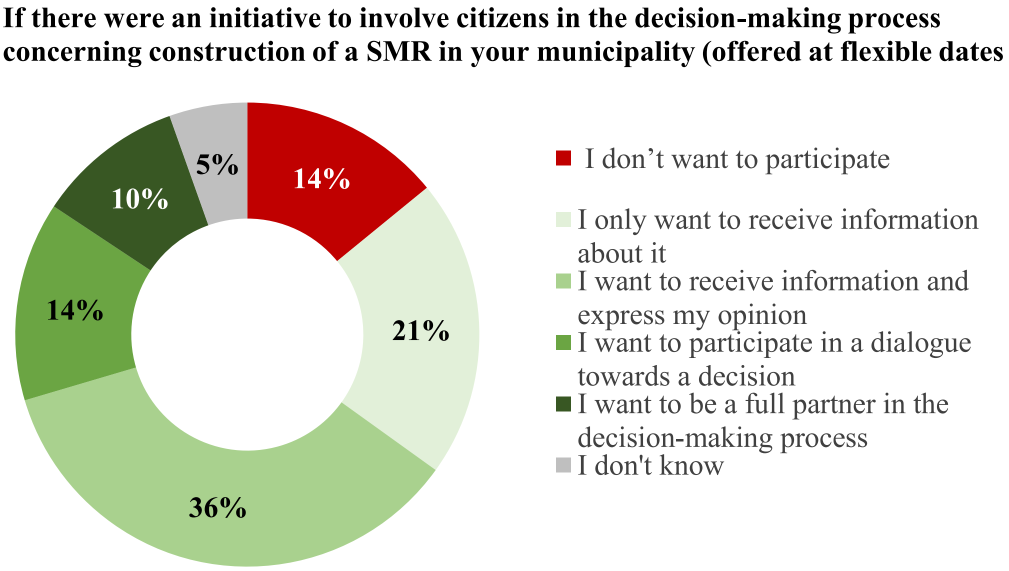
6.2 Public participation in decision-making

Effective public participation in decision-making on matters pertaining to the environment and access to justice is not only a normative requirement prescribed in international conventions (e.g., the Aarhus Convention) and regulations (e.g., the EU Environmental Impact Assessment Directive 2011/92/EU, as amended by 2014/52/EU). It also plays a substantial role in enhancing decision-making processes and outcomes, fostering social trust, and increasing the perceived fairness of decision-making processes and their outcomes by incorporating diverse knowledge and values.

Moreover, as highlighted by the ECOSENS stakeholder panel organised in June 2024 at the international RICOMET conference[7], public engagement is critical for the transition towards sustainable energy production and consumption, given the long-term demands of related policies and the potential lack of consistency in energy policy decisions.

In some of the ECOSENS focus groups, the topic of public participation was also discussed. In Spain, for example, a majority of participants argued in favour of involving citizens in SMR development at an early stage, particularly as regards information provision. Access to information was highlighted as a key prerequisite for citizens having informed opinions on SMR projects, as opposed to them being guided by ‘misinformation’ and ‘incorrect’ knowledge. How the provision of ‘factual’ or ‘correct’ information should be approached in a context of SMR development, which is still characterized by high levels of uncertainty, was not deeply discussed in the focus groups.

Figure 10. Citizens' willingness to participate in decision-making on SMRs



Data source: 2024 public opinion surveys in Belgium (N=1200), Spain (N=1001), and Czechia (N=1022).

As regards more interactive or engaged forms of participation (e.g., consultation, involvement in decision-making), in some focus groups (e.g. in Spain or Belgium) critical views and scepticism were also expressed as regards the need for and value of such participation, as this was deemed to delay decisions, and potentially result in protests and projects’ cancellation. Such views can be interpreted in light of the broader theme of expert-driven decision-making on SMRs, which emerged in various countries. Some participants argued that decisions on SMR development and implementation should be

[7] https://ecosens-project.eu/public-participation-in-decisions-related-to-small-modular-reactors-smrs/

taken by expert committees, populated by scientists rather than politicians, to ensure that decisions take into account all relevant aspects, not just economic or political interests. Preferences for such technocratic approaches to decision-making were found among focus group participants in the Czech Republic and Belgium.

Opposite to this, results from the large-scale ECOSENS surveys in Belgium, the Czech Republic and Spain showed a high demand for public participation in decision processes concerning potential SMR siting in all countries. From 56% in Belgium, up to 60% in Czech Republic and 63% Spain expressed preference for active forms of engagement, either expressing their opinion, being involved in a dialogue or even as full partners in decision processes on SMR (see table in Appendix B). Preference towards active participation was particularly high in Spain, where 17% expressed willingness to be engaged as a full partner, while this was indicated by 9% in Belgium and 6% in Czechia.

6.3 Insights from the group of communities with nuclear facilities

Insights from local elected representatives were provided at the seminar on new nuclear development co-organised by the Group of European Municipalities with Nuclear Facilities (GMF), in collaboration with the French association of communes hosting nuclear power plants (ARCICEN). The event took place on 24-25 May 2024 in Saint Vulbas, France, with support from ECOSENS. Mayors from Finland (Eurajoki), France (Penly, Gravelines and Bugey, the three sites selected to host EPR2 reactors), Netherlands (Borsele), Sweden (Östhammar) and the United Kingdom (Cumberland) shared their experience regarding how local communities can actively participate in the decisions regarding nuclear facilities as well as the challenges and opportunities these developments present. In addition, the president of the community of municipalities of Portes de Meuse, which hosts Cigéo, France's Industrial Centre for geological disposal of radioactive waste, presented the experience of Bure. Although the event mostly focused on large-scale nuclear facilities rather than SMRs, it yielded insights concerning local community involvement potentially valuable for future SMR projects.

The main concerns of the mayors participating in this event included the lack of dialogue between the national decision-makers and the local-level representatives. Decisions regarding the siting of nuclear facilities are often made at the national level without considering the opinion, vision or expectations of the local community. In most cases, local communities manage multiple ongoing energy projects, such as grid lines, wind energy or power stations, among others, each of which presents its own set of challenges. Furthermore, beyond construction and operational site requirements, these facilities have significant impacts on local infrastructure, which need to be considered. These include accommodating an incoming workforce, enhancing regional nuclear sector skills through training programs, addressing issues related to land ownership, and improving transport and mobility systems. Additional considerations involve the capacity of local services, catering facilities, leisure offerings, access to healthcare, public amenities, and landscape planning. Fiscal mechanisms and resources provided by national authorities and the nuclear industry are often insufficient to adequately prepare local communities for these complex challenges.

One of the examples from the seminar worth highlighting in this report is the approach followed by the municipality of Borsele (Netherlands) regarding the possible siting of two new nuclear reactors in their area. The municipality reflected on how to get involved in this debate at the national level and how to explore residents' opinions. For this, the mayor, aldermen and the responsible environmental manager in the energy transition in Borsele visited all 15 villages which form Borsele and talked with the inhabitants. Citizens requested the local authority to be proactive, to use the local knowledge and to start a process to involve the community. The local authority opted for constituting a citizen assembly consisting of 100 people, 50% male, 50% female and 50% people under 35 years old because they are the future decision-makers. Borsele has 13,000 families with a total of 22,000 inhabitants. The local council sent a letter to all the families asking who would be interested in participating in this process. There were 350 reactions. At least 50 people from the 350 reactions met the criteria of being younger than 35 years old. Finally, 100 people were selected. The letter also included the local council's interest in engaging local experts on different topics (e.g. nuclear waste, landscape, etc). 35 people responded, and a specialised company subcontracted by the local authority selected 15 local experts living in the municipality.

The citizen assembly met several times. During the first meetings, the citizens discussed how to organise themselves, vote and make decisions. Local knowledge was brought into these meetings through the 15 local experts. It was also essential to involve proactively the councillors in setting criteria and deciding how to develop the process. The participation process did not aim to discuss whether citizens are pro or antinuclear, but which terms and conditions would be presented to the government in case new nuclear reactors were to be sited in Borsele. After the 2nd meeting, seven participants were selected to visit Hinkley Point C to learn about the implications of building a nuclear power plant. These seven people reported back to the group of 100 and continued to work on 39 terms and conditions under 10 topics (construction space and logistics; health and safety; climate, energy and sustainability; landscape, wildlife and recreation; communication and support; construction and other nuisance; ownership; housing, living, quality of life and facilities; education, knowledge and economic development and compensation and recompense). Subsequently, the citizen assembly met with the council members and the municipal council adopted the document setting out the 39 terms and conditions.

The national Ministry of Climate and Energy participated at the outset of the process, emphasising the importance of community involvement and consideration of the terms and conditions by the national authorities. When the terms and conditions were finalised, the city assembly travelled to the Hague to present the conditions to the government and the parliament. After that, national elections were held in June 2024, and a new minister was elected. The terms and conditions need to be reviewed in the next months, and new citizens will be involved in the assembly to continue working until the central government makes the final decision on the location of the new nuclear reactors.

The lessons learned from the process in Borsele are the following:

- Local governments need to be proactive and develop their own strategy of engagement, separately from the processes undertaken by the central government or the nuclear industry;
- Involving the community and the citizens with local knowledge and expertise adds value when discussing the quality of life of the community;
- The young generation has in general a different opinion about nuclear compared to older generations, and it is important to involve the future decision-makers.

6.4 Insights from an international stakeholder panel

In the framework of the second ECOSENS Scientific Event, an international stakeholder panel was organised on the topic of "Public participation in decisions related to Small Modular Reactors", on June 10, 2024, adjacent to the RICOMET 2024 conference. The panel focused on how and who to involve in these decisions, emphasizing the importance of public engagement in shaping the future of SMRs and nuclear energy. It brought together experts representing policy makers (experienced with local, national and EU level policy), researchers (leading the site selection for LILW repository in Slovenia with adopted location in 2010), an NGO (member of Friends of the Earth Europe involved in many nuclear issues) and the European associations of local communities hosting nuclear facilities (director of GMF) to discuss public participation in the development of SMRs and broader nuclear energy issues.

Key points from various speakers, highlighting their perspectives on early involvement, technological neutrality, energy security, and public engagement strategies, are summarised below:

- *Technological Neutrality and Climate Goals:* One panellist, former mayor of Krško (municipality with operating NPP in Slovenia) and between 2019-2024 member of the European Parliament, emphasized the importance of technological neutrality in addressing climate change and transitioning to a low-carbon economy. He advocated for the inclusion of nuclear energy, particularly SMRs, as part of the solution in combination with renewable sources. He stressed that early public engagement is crucial to explain both the benefits and risks of SMRs, especially during the early development stages of the technology.

- *Public Involvement in Nuclear Waste Management:* Another speaker shared the experience with public involvement in the siting of a low and intermediate-level waste (LILW) repository in Slovenia. Drawing on this experience, she highlighted the importance of opening dialogue at several levels, including local citizens and NGOs, from the very beginning of the project. In the case of LILW, this approach ensured that the local population was informed and engaged in the decision-making process, which helped mitigate opposition but also increased knowledge among citizens.
- *Challenges and Scepticism:* Scepticism about the feasibility and cost-effectiveness of SMRs was also discussed. Some panellists argued that while SMRs are presented as new technology, they might only offer incremental improvements over existing reactors. Concerns were raised about the economic viability and readiness of SMR technology, given the historical challenges in the nuclear industry. Additionally, the need for critical expertise and realistic assessments of energy security was emphasized.
- *Role of Local Authorities and Early Engagement:* The role of local authorities in the public engagement process was highlighted by the representative from the network of European municipalities hosting nuclear facilities (GMF). She stressed the need for mayors and local leaders to be seen as partners in the decision-making process, rather than just stakeholders. This partnership involves listening to citizens' concerns and ensuring their voices are heard early in the planning stages.
- *Global and Local Perspectives on Nuclear Expansion:* The panellists discussed the global context of nuclear expansion, referencing the nuclear pledge signed by 25 countries to triple the number of nuclear power plants by 2050. The feasibility of this goal was questioned, particularly in terms of the financial, environmental, and social costs involved. Examples from countries like France, China, and India were used to illustrate the scale and challenges of nuclear energy expansion.

The discussion concluded with a call for transparent, honest communication with the public about the potential benefits and risks of SMRs and nuclear energy. The need for early and meaningful public engagement was reiterated as essential for gaining public trust and support for nuclear projects. The panellists agreed that while nuclear energy, including SMRs, could play a role in achieving climate goals, it must be approached with careful consideration of all associated challenges and costs.

7. ECOSENS research into public attitudes towards SMRs: Conclusions and the road ahead

This report presents selected data and findings from the research into public attitudes towards SMRs conducted within the ECOSENS project. Further scientific publications are in preparation to exploit the wealth of empirical evidence gathered.

Based on our research, we conclude that SMRs remain a relatively little-known technology to the European public, mirroring their uneven presence in national policies or forecasting. Representative surveys from the three countries reveal variability in perceptions of SMR safety, as well as the technical, economic, or social value of this option in combating energy insecurity or climate change, or the advantages of SMRs over large traditional reactors. Overall, while SMRs are perceived positively in terms of reliability and socio-economic benefits, construction costs are perceived negatively, and safety risk and environmental impact are perceived ambivalently. Similarly, views are divided regarding the role of SMRs in mitigating climate change, with some believing the technology development would take too long to significantly contribute to tackling the climate crisis.

Accordingly, providing information about the technology is the necessary first step to cultivate attitudes towards SMRs and enable public involvement. In addition, as concerns about "over-promise" of SMRs exist among experts and stakeholders, expectations should be managed realistically to avoid public disillusionment. In particular, environmental NGOs question the operational feasibility and economic viability of SMRs and point out safety risks.

Despite the lack of information, there is a strong tendency in the public to envision SMRs as part of the future energy mix in 2050. If the site on the premises of an existing nuclear power plant is chosen for an SMR construction, the declared public acceptability is significantly higher. Yet any route from the realm of imaginaries and non-binding declarations towards a real local project remains rather blurry. In public opinion surveys, we observed a low level of trust in governments regarding decision-making on nuclear issues, as well as an unequivocal demand for public participation. However, we also noted a preference for a more technocratic approach among some qualitative research participants.

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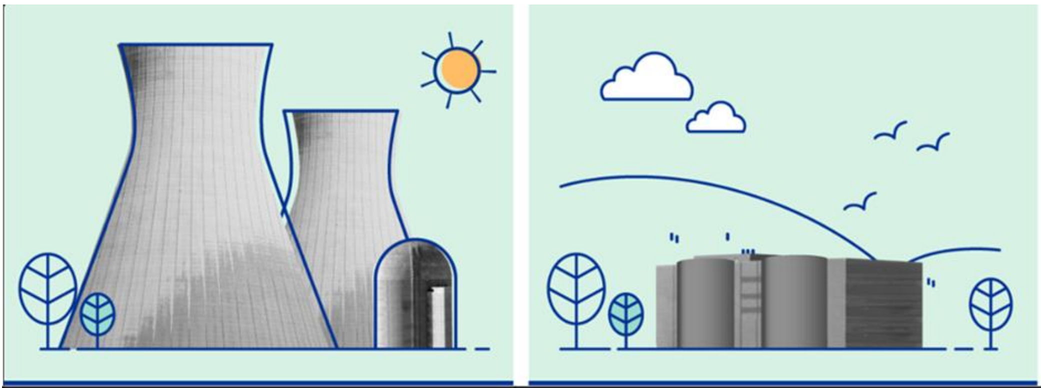
9. Appendix A: Information provided in surveys

Factual information describing the technology drew on available material from the International Atomic Energy Agency and other sources.



Large traditional reactors	**Small modular nuclear reactors**
Power: more than 700 MW(e)	Power: up to 300 MW(e)

Source: IAEA (not shown to respondents)

Small modular reactors (SMR) are advanced nuclear reactors that are currently being investigated in several countries, including [country], in the search for low-carbon and reliable energy technologies. They are:

1. Small – compared to traditional nuclear reactors, they are smaller in size and have a lower power capacity (about one-third or less).

2. Modular – they may be produced in series in a factory and can be used independently or as coupled modules.

3. Reactors – they use nuclear fission to generate heat to produce energy.

Development of small modular nuclear reactors seeks to improve the characteristics of existing reactors on multiple grounds, e.g. safety, lower proliferation risks, reduced volumes of radioactive waste, or more efficient use of fuel. However, the technology is still under development and is not a proven and ready to use solution.

10. Appendix B: Selected country-specific data from ECOSENS surveys

10.1 Climate perceptions

Climate change beliefs and perceptions BE (N=1200)								
	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
I believe that climate change is occurring.	2%	2%	4%	10%	21%	19%	40%	1%
Climate change is mostly caused by human activity.	3%	1%	4%	13%	21%	23%	34%	2%
Climate change brings about serious consequences.	1%	1%	2%	9%	21%	23%	41%	2%
Climate change is likely to have a big impact on people like me.	2%	3%	9%	21%	24%	20%	16%	4%
I am reducing my energy consumption to help tackle climate change.	4%	4%	8%	20%	30%	18%	15%	1%
It is a moral responsibility to tackle climate change in order to protect human life on Earth.	2%	1%	3%	12%	27%	22%	31%	2%
	1= Not at all			4= To some extent			7= Very much	I don't know
How worried, if at all, are you about climate change?	3%	4%	6%	20%	28%	23%	15%	0.4%
Climate change beliefs and perceptions ES (N=1001)								
	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
I believe that climate change is occurring.	3%	2%	3%	13%	12%	21%	46%	0%
Climate change is mostly caused by human activity.	3%	3%	4%	12%	13%	21%	44%	0%
Climate change brings about serious consequences.	2%	2%	2%	11%	11%	19%	51%	1%
Climate change is likely to have a big impact on people like me.	3%	3%	4%	17%	16%	26%	26%	3%

I am reducing my energy consumption to help tackle climate change.	5%	5%	6%	22%	22%	22%	18%	1%
It is a moral responsibility to tackle climate change in order to protect human life on Earth.	3%	3%	3%	14%	11%	23%	41%	1%
	1= Not at all			4= To some extent			7= Very much	I don't know
How worried, if at all, are you about climate change?	3%	3%	2%	17%	14%	19%	42%	0.0%
Climate change beliefs and perceptions CZ (N=1022)								
	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
I believe that climate change is occurring.	2%	2%	7%	11%	32%	24%	24%	0%
Climate change is mostly caused by human activity.	4%	4%	10%	17%	31%	19%	14%	1%
Climate change brings about serious consequences.	2%	1%	7%	13%	30%	26%	20%	1%
Climate change is likely to have a big impact on people like me.	1%	5%	14%	18%	26%	22%	12%	1%
I am reducing my energy consumption to help tackle climate change.	4%	7%	12%	22%	28%	19%	7%	1%
It is a moral responsibility to tackle climate change in order to protect human life on Earth.	3%	3%	4%	15%	32%	23%	18%	2%
	1= Not at all			4= To some extent			7= Very much	I don't know
How worried, if at all, are you about climate change?	7%	7%	7%	45%	15%	10%	9%	0.1%

10.2 Energy security perceptions

To what extent are you concerned about the following issues: BE (N=1200)								
	Not at all concerned	Very little concerned	Little concerned	Moderately concerned	Quite concerned	Very concerned	Extremely concerned	I don't know
That electricity would become unaffordable in [your country]	1%	1%	7%	13%	16%	26%	35%	1%
That [your country] will become too dependent on energy imports from other countries	1%	2%	8%	17%	17%	29%	24%	2%
That cyber-attacks will cause interruptions to electricity supply	2%	4%	14%	18%	20%	24%	15%	3%
That global supplies of fossil fuels (e.g. coal and gas) will run out	6%	6%	22%	19%	20%	15%	9%	4%
That there will be power cuts	2%	4%	18%	19%	20%	22%	12%	2%
That armed conflicts will cause disruptions to energy supplies	2%	3%	11%	18%	20%	25%	20%	3%
That [your country] is too dependent on imports of raw materials for energy production	1%	2%	8%	18%	19%	29%	21%	3%
To what extent are you concerned about the following issues: ES (N=1001)								
	Not at all concerned	Very little concerned	Little concerned	Moderately concerned	Quite concerned	Very concerned	Extremely concerned	I don't know
That electricity would become unaffordable in [your country]	2%	2%	8%	22%	24%	21%	19%	1%
That [your country] will become too dependent on energy imports from other countries	2%	2%	6%	22%	25%	25%	15%	3%
That cyber-attacks will cause interruptions to electricity supply	3%	4%	10%	25%	25%	17%	11%	5%
That global supplies of fossil fuels (e.g. coal and gas) will run out	7%	4%	13%	31%	21%	14%	7%	3%
That there will be power cuts	3%	4%	12%	26%	25%	15%	11%	3%
That armed conflicts will cause disruptions to energy supplies	3%	4%	10%	24%	25%	19%	13%	3%
That [your country] is too dependent on imports of raw materials for energy production	2%	2%	5%	22%	28%	21%	14%	5%

To what extent are you concerned about the following issues: CZ (N=1022)								
	Not at all concerned	Very little concerned	Little concerned	Moderately concerned	Quite concerned	Very concerned	Extremely concerned	I don't know
That electricity would become unaffordable in [your country]	7%	23%	22%	14%	18%	10%	5%	1%
That [your country] will become too dependent on energy imports from other countries	7%	20%	20%	17%	18%	13%	3%	2%
That cyber-attacks will cause interruptions to electricity supply	7%	25%	24%	19%	14%	7%	1%	3%
That global supplies of fossil fuels (e.g. coal and gas) will run out	9%	25%	22%	18%	16%	7%	2%	2%
That there will be power cuts	8%	29%	21%	18%	14%	7%	2%	1%
That armed conflicts will cause disruptions to energy supplies	5%	23%	25%	18%	16%	9%	2%	2%
That [your country] is too dependent on imports of raw materials for energy production	5%	14%	24%	18%	21%	14%	2%	2%

10.3 Overall evaluation of SMRs

How would you rate small modular nuclear reactors as an electricity generation technology? BE (N=1193): % of respondents												
	0	1	2	3	4	5	6	7	8	9	10	I don't know
0= Polluting .. 10 Clean	2%	1%	2%	4%	5%	16%	15%	17%	14%	6%	5%	12%
0= Risky .. 10= Risk free	3%	2%	4%	7%	10%	20%	13%	14%	9%	4%	2%	11%
0= Endangering environment .. 10= Environmentally friendly	2%	2%	4%	5%	8%	21%	13%	13%	11%	5%	4%	11%
0= Unreliable energy source .. 10= Reliable energy source	1%	0%	1%	2%	4%	14%	13%	19%	17%	9%	9%	11%
0= High electricity production cost .. 10= Low electricity production cost	1%	1%	2%	4%	6%	20%	12%	15%	12%	4%	4%	19%
0= High construction cost .. 10= Low construction cost	4%	4%	9%	11%	7%	20%	9%	10%	5%	2%	2%	17%
How would you rate small modular nuclear reactors as an electricity generation technology? ES (N=1001)												
0= Polluting .. 10 Clean	8%	2%	5%	6%	5%	18%	9%	10%	8%	3%	4%	21%
0= Risky .. 10= Risk free	10%	2%	4%	7%	8%	19%	9%	10%	7%	3%	1%	19%
0= Endangering environment .. 10= Environmentally friendly	10%	2%	6%	7%	10%	16%	11%	8%	6%	3%	4%	17%
0= Unreliable energy source .. 10= Reliable energy source	7%	2%	4%	5%	6%	16%	11%	11%	8%	5%	6%	20%
0= High electricity production cost .. 10= Low electricity production cost	5%	1%	3%	4%	6%	19%	8%	11%	7%	3%	5%	28%
0= High construction cost .. 10= Low construction cost	7%	3%	4%	7%	7%	17%	9%	7%	6%	2%	2%	28%

How would you rate small modular nuclear reactors as an electricity generation technology? CZ (N=1022)											
0= Polluting .. 10 Clean	1%	1%	3%	4%	6%	17%	9%	13%	16%	10%	11%	10%
0= Risky .. 10= Risk free	3%	1%	4%	6%	6%	21%	12%	17%	12%	6%	2%	9%
0= Endangering environment .. 10= Environmentally friendly	1%	1%	3%	6%	7%	20%	10%	12%	14%	8%	9%	9%
0= Unreliable energy source .. 10= Reliable energy source	2%	1%	1%	3%	4%	18%	9%	14%	13%	9%	17%	10%
0= High electricity production cost .. 10= Low electricity production cost	2%	1%	2%	5%	7%	25%	10%	14%	9%	3%	6%	15%
0= High construction cost .. 10= Low construction cost	3%	3%	7%	10%	10%	25%	10%	7%	4%	1%	2%	16%

10.4 Perceived socio-economic impacts of SMR for communities

Perceptions of SMR socio-economic impacts: BE (N=1200)								
I believe that mall modular nuclear reactors....	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
... endanger the future of our children.	15%	13%	22%	21%	11%	3%	4%	12%
.. will create jobs in the region.	1%	2%	7%	23%	37%	12%	7%	12%
...will pose significant safety risks.	6%	8%	16%	28%	19%	8%	5%	11%
... will bring significant economic benefits to local communities.	1%	2%	7%	25%	32%	14%	6%	13%
...will have a negative impact on the overall quality og life.	10%	12%	24%	23%	10%	4%	3%	13%
...[using SMR] will have a more negative impact on the environment than renewables.	8%	8%	15%	26%	19%	6%	7%	11%
Perceptions of SMR socio-economic impacts: ES (N=1001)								
I believe that mall modular nuclear reactors....	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
... endanger the future of our children.	6%	10%	9%	24%	14%	8%	9%	20%
.. will create jobs in the region.	2%	3%	5%	23%	28%	15%	7%	16%
...will pose significant safety risks.	4%	7%	8%	25%	17%	10%	9%	19%
... will bring significant economic benefits to local communities.	3%	4%	6%	27%	23%	13%	6%	18%
...will have a negative impact on the overall quality og life.	5%	10%	11%	27%	13%	8%	6%	18%
...[using SMR] will have a more negative impact on the environment than renewables.	4%	6%	8%	23%	16%	12%	13%	17%
Perceptions of SMR socio-economic impacts: CZ (N=1022)								
I believe that mall modular nuclear reactors....	Strongly disagree	Disagree	Somewhat disagree	Neither agree, nor disagree	Somewhat agree	Agree	Strongly agree	I don't know
... endanger the future of our children.	10%	22%	24%	23%	7%	3%	1%	9%

.. will create jobs in the region.	0%	4%	8%	23%	43%	12%	3%	6%
...will pose significant safety risks.	4%	13%	23%	29%	18%	4%	1%	7%
... will bring significant economic benefits to local communities.	1%	3%	8%	33%	35%	10%	1%	8%
...will have a negative impact on the overall quality og life.	9%	23%	26%	25%	8%	3%	0%	7%
...[using SMR] will have a more negative impact on the environment than renewables.	5%	15%	22%	28%	17%	3%	1%	9%

10.5 Perceived role of SMR in the energy mix

In your opinion, how much electricity in [your country] should be generated from small modular nuclear reactors in the year 2050?							
	None	A very small amount	A small amount	A moderate amount	A large amount	A very large amount	I don't know
BE (N=1200)	4%	4%	11%	32%	25%	7%	16%
ES (N=1001)	12%	8%	11%	25%	15%	6%	23%
CZ (N=1022)	2%	2%	16%	49%	16%	2%	12%
3 countries (N=3223)	6%	5%	13%	36%	19%	5%	17%

10.6 SMR siting preferences

How acceptable, or unacceptable, would you find the construction of a small modular nuclear reactor? (only respondents who consider that SMRs should be part of the 2050 energy mix)								
	Totally unacceptable	Unacceptable	Rather unacceptable	Neither acceptable, nor unacceptable	Rather acceptable	Acceptable	Totally acceptable	Don´t know/ can´t say
a small modular nuclear reactor constructed closer than 10 kilometres of your place of residence								
BE (N=954)	11%	11%	16%	21%	20%	10%	6%	5%
ES (N=653)	21%	15%	16%	21%	12%	7%	4%	5%
CZ (N=873)	9%	15%	20%	24%	17%	11%	3%	1%
a small modular nuclear reactor constructed further than 10 kilometres of your place of residence								
BE (N=954)	5%	8%	8%	20%	26%	20%	10%	4%
ES (N=653)	11%	12%	10%	23%	17%	14%	7%	5%
CZ (N=873)	4%	8%	13%	19%	27%	19%	8%	1%
a small modular nuclear reactor constructed on the premises of an existing nuclear power plant in [my country]								
BE (N=954)	1%	2%	3%	12%	28%	24%	28%	3%
ES (N=653)	3%	4%	6%	20%	22%	23%	16%	6%
CZ (N=873)	2%	3%	7%	13%	25%	27%	22%	1%
a small modular nuclear reactor constructed outside the premises on an existing nuclear power plant in [my country]								
BE (N=954)	2%	4%	11%	23%	25%	21%	9%	6%
ES (N=653)	6%	6%	11%	30%	19%	14%	6%	7%
CZ (N=873)	2%	3%	12%	23%	28%	24%	7%	2%

10.7 Participation intention in SMR siting decisions

If there were an initiative to involve citizens in the decision-making process concerning construction of a SMR in your municipality (offered at flexible dates and hours), and anybody could participate, to what extent would you like to do so?						
	I don't want to participate	I only want to receive information about it	I want to receive information and express my opinion	I want to participate in a dialogue towards a decision	I want to be a full partner in the decision-making process	I don't know
BE (N=1200)	18%	18%	34%	14%	9%	8%
ES (N=1001)	15%	16%	34%	12%	17%	6%
CZ (N=1022)	9%	28%	38%	16%	6%	3%
3 countries (N=3223)	14%	21%	36%	14%	10%	5%