Approaches to social license to operate (SLO) in emerging nuclear projects

Research report

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27-Feb-2026

This study was conducted in a project “Exploring approaches to social license to operate in emerging nuclear projects” between September 2025 and January 2026. The project was funded by the National Nuclear Safety and Waste Management Research Programme, SAFER2028. The objective of the project was to build understanding of SLO in emerging nuclear projects and advance the knowledge of how and through what kinds of mechanisms SLO is linked to overall safety.

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1 Introduction

This research report focuses on advancing the understanding of *the social license to operate (SLO)* in the context of emerging nuclear projects and their ecosystems, such as small modular reactors (SMRs). As projects increasingly impact communities and environments, understanding social acceptability has become essential for project success and long-term sustainability (Brunet and Baba, 2023). The management of community relations and SLO are among the most critical business risks in many industry sectors (Baba *et al.*, 2021).

Particular focus is placed on developing a conceptual understanding of SLO in nuclear project contexts, understanding its antecedents and consequences, as well as the strategies suggested to manage it efficiently and effectively. Furthermore, the aim is to build an in-depth understanding of the connection between how overall nuclear safety is connected to the establishment and maintenance of SLO in emerging nuclear projects, which is a very uncharted territory in research. As the concept of SLO originates from the mining sector and has been more limitedly used in the nuclear context, conceptual and theoretical understanding of established SLO frameworks, best practices, and factors impacting SLO is built by analyzing research in the sectors where SLO of projects as a concept is already established, including the mining, renewable energy, and infrastructure sectors. In addition, existing research on SLO in the context of nuclear projects and SMRs is analyzed. Furthermore, expert interviews with nuclear sector professionals within power companies and regulator are conducted to further advance the understanding of SLO in the context of emerging nuclear projects.

The objective of this report is to build a comprehensive understanding of SLO in emerging nuclear projects and advance the knowledge of how and through what kinds of mechanisms SLO is linked to overall safety. The specific research questions are as follows:

- What is SLO in the context of emerging nuclear projects?
- Who are the stakeholders that may have an impact on SLO or are affected by it in the context of emerging nuclear projects?
- What are the antecedents of SLO and the mechanisms through which it can be established and maintained in emerging nuclear projects?

- How do digital tools impact the establishment and maintenance of SLO in emerging nuclear projects?
- How is SLO connected to the overall safety in the context of emerging nuclear projects?

Within the context of nuclear energy, concepts closely related to SLO, such as *social acceptance, social acceptability, citizen acceptance, public acceptance, local community acceptance, public attitudes, public perception, and stakeholder engagement,* are typically more extensively used. Although some sources tend to treat the concepts of SLO and social acceptance as synonyms, there is a dominant shared view that the concepts are slightly different and may operate at different levels of analysis. While *social acceptability* refers to a population's or community's assessment that a project or industry is acceptable or desirable (Baba et al., 2021), *social acceptance* refers to the extent to which communities, stakeholders, residents, or citizens approve of or are willing to tolerate a new technology, project, policy, or practice. Social acceptance typically addresses the question of whether people accept this project or technology. It is not treated as a strict binary (accepted vs. not accepted) but can be viewed as a spectrum or ladder support. Different stakeholders may accept a project to varying degrees and at different project stages. For example, a community might be initially skeptical but become more accepting over time if the benefits are demonstrated. Social acceptance is closely related to the idea of a "social mandate" for a project and is sometimes discussed in terms of community acceptance (local level), socio-political acceptance (broader public and policy level), and market acceptance (investors and markets). It is worth noting that some literature differentiates "acceptance" (an existing attitude of support) from "acceptability," which can imply a normative evaluation of whether a project should be accepted (i.e., whether it meets certain conditions or values to be considered acceptable).

Instead, SLO has been defined as the " social approval of those affected by a certain business activity" (Melé and Armengou, 2016) or as ''The degree of match between stakeholders' individual expectations of corporate behavior and companies' actual behavior'' (Salzmann et al., 2006), or as "stakeholders' acceptance of the company's operations or its projects" (Baba and Dahan, 2023). Therefore, a company or project can only gain a SLO through the broad acceptance of its activities by society and/or the local community (Wilburn and Wilburn, 2014). From this perspective, social acceptance is essentially an outcome – a state of public opinion – indicating support or tolerance for the

project. High social acceptance is a precursor to obtaining a robust social license, but broad acceptance alone is not identical to having a social license, as the latter implies a more formalized, ongoing relationship between the project and the community.

Both social acceptance and SLO share central elements that are crucial for their existence, including trust, alignment with societal/community values, environmental and social impact, and fairness. Table 1 presents key differences between social acceptance and SLO.

Table 1. Differences of social acceptance and SLO

CHARACTERISTIC	SOCIAL ACCEPTANCE	SOCIAL LICENSE TO OPERATE (SLO)
Definition	General approval or support from stakeholders towards a project or technology	Ongoing approval and legitimacy granted by stakeholders and the community for a company's operations
Scope	Broad, encompassing various sectors and technologies	Often specific to resource-extractive industries but expanding to other sectors
Key dimensions	Socio-political acceptance Community acceptance Market acceptance	Trust Legitimacy Procedural and distributional fairness
Stakeholder influence	Stakeholders can be passive or active (e.g. prosumers in energy)	Stakeholders are critical, with their trust and engagement being central to maintaining SLO Focus on stakeholder dialogue and relationship development.
Temporal nature	Can be static or change over time based on new information or context	It is dynamic and can vary over time, requiring continuous engagement and reassessment.
Measurement	Often assessed through surveys and perception studies	Measured through trust models, procedural fairness, and community engagement levels
Key factors	Trust Environmental sustainability Alignment with societal values	Trust Fairness Community engagement Environmental and social impacts

Stakeholder engagement, in turn, is closely linked to the process of establishing SLO, as it can be defined as “Various means, including organizational activities and arrangements, used to involve stakeholders in the project's operations or

decision-making and to engage them for long-term value creation" (Greenwood, 2007). This refers to the processes and efforts of project proponents (or authorities) to involve stakeholders in dialogue, decision-making, and benefit-sharing related to the project. Stakeholders include all groups or individuals affected by or interested in the project, from local community members and indigenous groups to NGOs, government bodies, and even a broader public audience (Aaltonen, 2010).

Effective stakeholder engagement is widely regarded as essential for earning social acceptance and SLO. Through engagement, a company can demonstrate transparency, responsiveness, and respect for community input, which are the building blocks of trust (Lehtinen and Aaltonen, 2024). It is also important to distinguish engagement from the acceptance it seeks to create: one can have extensive engagement but still face opposition and lack SLO if that engagement is perceived as insincere or if underlying issues (such as value conflicts) remain unresolved (National Academies of Sciences, Engineering, and Medicine, 2024). However, meaningful engagement is a prerequisite for achieving a social license.

In summary, social acceptance/acceptability describes the state of public support and alignment of a project with societal expectations, whereas stakeholder engagement describes the active efforts to establish and maintain that support and alignment. SLO ties these together – it can be viewed as a concept that captures the idea of an ongoing acceptance/approval granted by the stakeholders to the project or project organization, earned through effective engagement and responsible conduct.

This report is primarily focused on the concept of SLO, while we acknowledge research that has been conducted with the related concepts of social acceptance, social acceptability, and public acceptance in the context of nuclear energy.

2 Research method

First, this research project and report address the concept of SLO through a literature review, examining how SLO has been conceptualized in academic and industry contexts. As the academic literature on SLO may employ partially overlapping concepts of social acceptance and community approval, these terms have also been used as search criteria. A cross-sectoral analysis of reported SLO case studies was conducted to gain broader insights into the shared patterns and sector-specific characteristics.

Second, empirical data were collected through interviews with key actors in Finland's nuclear sector, providing insights into stakeholder perspectives and sectoral dynamics. Ten expert interviews with professionals from power companies and regulator organization were conducted. The interviewees represented Fortum, Teollisuuden Voima, and the Radiation and Nuclear Safety Authority (STUK). Semi-structured individual interviews were conducted between 27.10 – 21.11.2025. The interviews were conducted remotely and lasted approximately 60 minutes. In addition to the interviewee, at least two authors of this study were always present.

The interviews were recorded with the participants' consent. Interview data were analyzed using qualitative content analysis methods to contextualize the SLO concept within the nuclear industry, highlighting unique challenges and opportunities, especially in connection with safety matters. Interviews and existing literature have informed the authors' understanding of the concepts, significance, mechanisms, and practices related to social acceptability and SLO.

In addition, building on the abovementioned foundation and this report, a GenAI-enhanced educational chatbot was developed to communicate research findings. The research results will be presented and discussed at a results workshop in January 2026.

3 Social license to operate (SLO)

3.1 SLO definitions

The term *SLO* began to be used in the late 1990s to describe the attitudes and expectations of local communities toward nearby industries and businesses. Initially, SLO was used to characterize a problematic situation between a local community and an industrial operator, in which social acceptance and the license to operate had been lost or had not been achieved. The term was initially used in the context of extractive industries such as forestry and mining. (Breakey *et al.*, 2025; Owen and Kemp 2013; Parsons *et al.*, 2014; Santiago *et al.*, 2021).

As the understanding and use of the term SLO have evolved and extended, it has been associated with a variety of meanings, definitions, and frameworks. Many of the definitions refer to observed social phenomena, such as whether the local community accepts the operations and presence of the company and the level of their acceptance. Unlike formal legal licenses, SLO relies on stakeholders' subjective perceptions and attitudes towards a company. The SLO is a "soft contract" that complements the legal license (Demuijnck and Fasterling, 2016) and enables the project to proceed without conflicts. **At its core, it refers to an informal, unwritten social contract where the project has ongoing approval and broad acceptance from society, particularly from the local community and stakeholders, to conduct its activities.** The moral acceptance aspect of the SLO refers to legitimacy, meaning that the company's actions are experienced as appropriate, fair, and honest by stakeholder groups. (Breakey *et al.*, 2025)

The nature of SLO is nowadays increasingly viewed as dynamic, with the relationship between the company and the community being continuously developed and sustained (Baba, Sasaki, *et al.*, 2021). Obtaining SLO is not a one-time event, but requires planning, assessment, and management throughout a company's operations related to emerging or ongoing projects. SLO is also fragile in the sense that it can be easily withdrawn if new information raises fresh concerns among stakeholders (Prno and Scott Slocombe, 2012). The SLO can be considered a tool for promoting collaboration between stakeholders and companies.

Table 2 presents ten central SLO definitions from the literature. The definitions were classified into categories according to their key elements and emphasis.

Table 2. SLO definitions

#	Category	Description	Source
1	Legitimacy-Based	SLO is seen as a form of legitimacy granted by communities based on alignment with social norms, laws, and cultural expectations.	(Gehman et al., 2017)
2	Level of acceptance or approval	SLO refers to the level of acceptance or approval of company activities by local people, authorities, and stakeholders, emphasizing the importance of support beyond legal permits	(Tufan-Demirel and Ertunç, 2019)
3	Ongoing process	SLO means ongoing acceptance or approval from the local community and other stakeholders	(Parsons *et al.*, 2014)
4	Continuum model	SLO exists on a spectrum from withheld → acceptance → approval → co-ownership, reflecting varying degrees of community support. A tiered model with the following levels: legitimacy → credibility → trust → psychological identification (co-ownership).	(Thomson and Boutilier, 2011)
5	Context-specific	A form of social acceptance or approval… a socially constructed perception that your company or project has a legitimate place in the community	(Moffat and Zhang, 2014)
6	Company-community relations	SLO describes a specific aspect of company-community relations in resource-extractive projects, focusing on resolving social and economic impacts	(Koivurova et al., 2015)
7	Tool for managing risks	A 'socio-political' risk framework that advises managers to identify and deal with powerful or influential stakeholder networks in order to secure access to resources	(Demuijnck and Fasterling, 2016)
8	Stakeholder engagement	The ongoing acceptance of operations by consequential stakeholders who are directly affected by and have the power to impact operations.	(Breakey et al., 2025)

		SLO is defined as a dynamic process of building relationships through early and continuous community engagement.	
9	Tool for managing relations	SLO is a tool for companies to manage their relations with local communities, particularly in sectors like nuclear waste management	(Lehtonen *et al.*, 2020)
10	Strategy for understanding society and culture	SLO provides a strategy to understand the society and culture in which a company wishes to do business, aiming to secure consent from stakeholders	(Wilburn and Wilburn, 2014)

3.2 SLO frameworks

Two viewpoints on SLO can be identified in the literature. In the first discourse, SLO is defined as a static property, meaning it is viewed as an end state or outcome that organizations aim to achieve using best practices and tools. In this view, a project or company may seek to obtain SLO by fostering strong stakeholder relationships, applying best practices, and implementing strategies specifically designed to gain or maintain SLO (Baba and Dahan, 2023; Boutilier and Zdziarski, 2017; Vanclay and Hanna, 2019).

The second approach views SLO as processual and dynamic, where SLO is not a fixed or one-time achievement, but rather a continuum of acceptance and an evolving relationship between a project or company and its stakeholders (Baba, Sasaki, *et al.*, 2021; Chen *et al.*, 2019; Rooney *et al.*, 2014). In this dynamic approach, regular assessments of the level of SLO and making necessary adjustments based on feedback and changing circumstances help in maintaining SLO. Proactive engagement with stakeholders to address potential risks and issues is a key component of a dynamic approach.

The following subsections present some well-known SLO frameworks. These frameworks can be used to analyze and build community acceptance, where stakeholder engagement and dialogue are central to the process. SLO frameworks help understand the importance of social acceptability from the perspectives of project continuity, risk management, and avoiding conflicts between projects/organizations and stakeholders.

3.2.1 The pyramid model

The level of SLO achievement in the community can be described and assessed using various models and frameworks. Thomson and Boutilier's SLO framework is one of the most widely recognized models for conceptualizing and assessing community acceptance of corporate activities, particularly in sectors such as mining and energy. The framework in Figure 1 presents SLO as a four-level hierarchy, illustrating the varying degrees of social approval a company may receive from local stakeholders (Thomson and Boutilier, 2011).

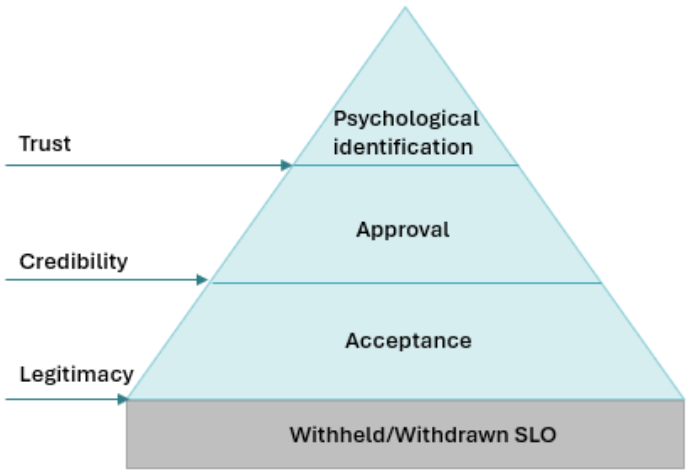

Figure 1. The pyramid model of SLO, modified from (Thomson and Boutilier, 2011)

The levels of the model from top to bottom are *withholding/withdrawal*, acceptance, approval, and psychological identification, which is often referred to as co-ownership. Withholding and withdrawal mean that the community either refuses to grant approval or actively withdraws its previously given support. This level indicates a high risk for the organization or project and may result in resistance, protests, and negative publicity for the project. In the worst-case scenario, an organization may face legal challenges or a loss of access to resources, such as funding or labor. The first threshold for achieving a SLO is meeting all legal requirements and obtaining the necessary permits to operate.

Acceptance means that the project is tolerated by the local community, but the approval may be reluctant or conditional in nature. There may be some skepticism or partially hesitant support, making acceptance a fragile state that can be quickly and easily withdrawn. The community may have some concerns

but also sees some benefits from the project, such as bringing jobs and infrastructure improvements. The company has established legitimacy in its project actions, but challenges remain in fully earning the community's credibility and trust. At this level, the company achieves only minimum legitimacy and credibility. There may be an uneasy peace: the project can operate, but it faces ongoing scrutiny, and issues must be carefully managed to prevent license withdrawal

At the *approval* level, the community actively supports the project and expresses confidence in the company's intentions and its operations. This is often the most commonly granted level of SLO. Community leaders or stakeholder groups publicly and openly support the project, and the company is generally perceived as a credible and responsible actor and "a good neighbor". Trust is still in the process of being built, which requires open, transparent, and constructive communication between the project or company and its stakeholders. Achieving approval typically requires a company to demonstrate credibility (e.g., honesty, keeping commitments) and deliver benefits to the community.

Psychological Identification and co-ownership are the highest level of SLO where the community identifies with the project feeling deep trust, emotional connection or pride. Achieving this level may be challenging. The community and the company view each other as partners, and a sense of co-ownership exists. Achieving this level requires deep trust and ongoing dialogue and may, therefore, take a long time to build. For example, a community that has hosted a nuclear plant for decades with close ties and where residents identify with the plant's presence and economic contribution may exhibit strong support.

Progression through these SLO levels depends on meeting three core criteria, as illustrated in Figure 1. *Legitimacy* means that the company's actions are experienced as appropriate, fair, and honest. Actions and operations should be in line with the community's values, norms, and expectations. Companies should demonstrate respect for local people and cultural practices and comply with relevant laws. For a nuclear project, legitimacy might mean aligning with societal values (e.g., contributing to climate goals, operating safely under strict regulations, and respecting locals say in siting).

Credibility refers to the company being seen as consistent, competent, and reliable in its project communications and actions. This requires the provision of accurate, timely, and transparent information to stakeholders through active communication practices. When a company does what it says it will do, finishes its work on time, and keeps people in the community informed, it builds a

reputation as a trustworthy and professional actor. This helps the public view the company as credible.

Trust is the belief that the company acts with good intentions and in the best interest of the community. This means that the company is open about risks and uncertainties and shows responsiveness to concerns and challenging situations. Trust can be developed and improved by involving the community in the decision-making process.

The pyramid framework can be illustrated as a dynamic arrowhead structure emphasizing the cumulative and continuous nature of SLO development. It also includes quantitative tools for assessing the level of social license, making it a practical instrument for researchers and practitioners. The arrow model, as shown in Figure 2, consists of four key elements shaping the acquisition of SLO: economic legitimacy, socio-political legitimacy, interactional trust, and institutionalized trust with relevant metrics (Thomson and Boutilier, 2011).

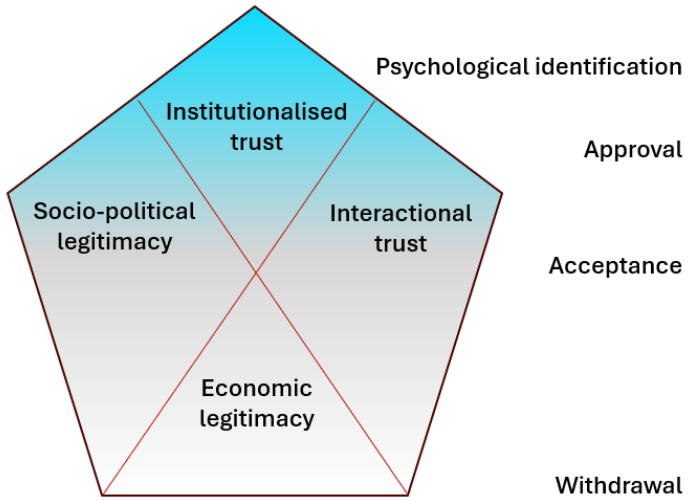

Figure 2. Key elements constituting and impacting SLO modified from (Thomson and Boutilier, 2011)

In Figure 2, *economic legitimacy* means that community people see the project as fair, especially in how its costs and benefits are shared. *Socio-political legitimacy* helps a project gain genuine public approval. To achieve that, the company must show that it respects and protects the community's social, environmental, and cultural values. To earn this, the organization should listen to local concerns, keep the community informed honestly and transparently, and

show that the benefits are greater than the possible negative impacts. (Jijelava and Vanclay, 2018; Thomson and Boutilier, 2011)

Interactional trust means that the community believes that the company is honest and keeps its promises. Building this trust requires ongoing two-way communication between the company and the community. *Institutionalized trust* represents “full trust” between a company/organization and the community, where they see each other as partners (Jijelava and Vanclay, 2017; Koivurova *et al.*, 2015). To gain high trust in the context of nuclear projects, the state's central role should be recognized. The state influences energy policy, owns or co-owns key institutions, and is responsible for managing long-term safety, which are issues that matter deeply to citizens. (Lehtonen *et al.*, 2020).

3.2.2 Scalar SLO model

Scalar SLO model is a conceptual framework developed to better understand and measure the SLO in the context of mining and other resource-based industries, particularly within Europe. It was established during the Horizon 2020 MIREU project (Mining and Metallurgy Regions of the EU), which aimed to strengthen the social acceptance of mining in European regions. The scalar SLO model introduces the community and societal dimensions to complete and expand the pyramid model concept and framework of Thomson and Boutilier (2011). The model also addresses the possibility of losing SLO. (Lesser *et al.*, 2021)Figure 3 illustrates the drivers of SLO in the scalar SLO model. The levels build upon one another from the bottom to the top of the pyramid, meaning that to achieve benefit sharing and collaboration, community support, engagement, and acceptance must first be secured.

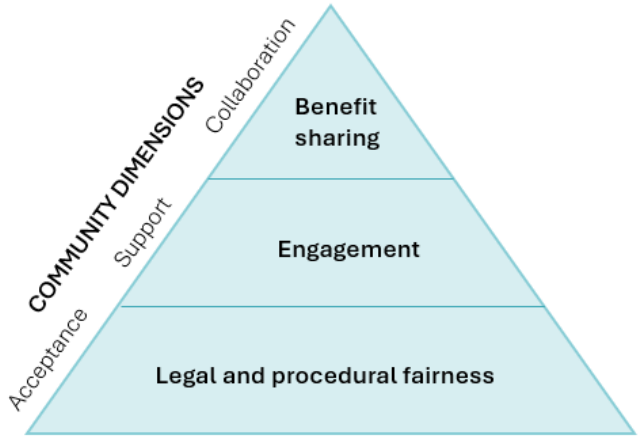

Figure 3. Drivers of SLO modified from (Lesser *et al.*, 2021)

Figure 4 illustrates the drivers of the loss of SLO in the scalar SLO model. The levels build upon each other from the top to the bottom of the pyramid. A lack of legitimacy toward the project or industry occurs before the loss of confidence and the emergence of value clashes between the project/industry and the community. Societal dimensions highlight tensions such as lack of acceptance, resistance, and protests.

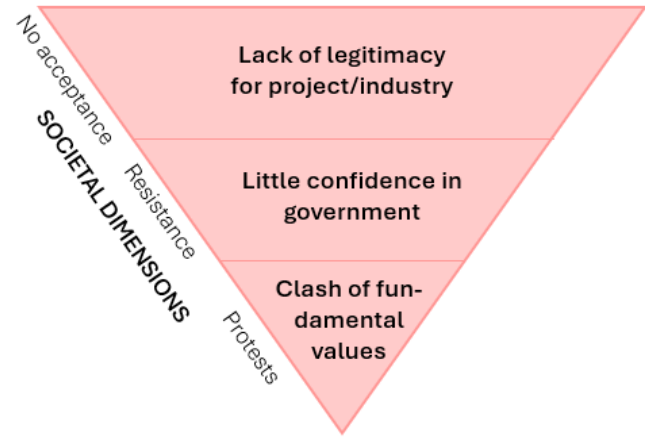

Figure 4. Drivers of the loss of SLO modified from (Lesser *et al.*, 2021)

3.2.3 The three-strand model of SLO

The three-strand model of SLO was developed by Gunningham *et al.* (2004) during pulp-mill environmental performance research. SLO is seen as an independent factor that helps companies improve environmental performance activities and go beyond compliance with existing regulations, in addition to economic and legal licenses. The licenses depicted in Figure 5 are interrelated, where the legal license represents regulatory compliance, the social license represents community and activist approval, and the economic license represents profitability and investor support. A later variation of the model by Morrison (2014) replaces the economic license with a political license, where governments, voters, party members, and politicians play an important role in giving authority to companies.

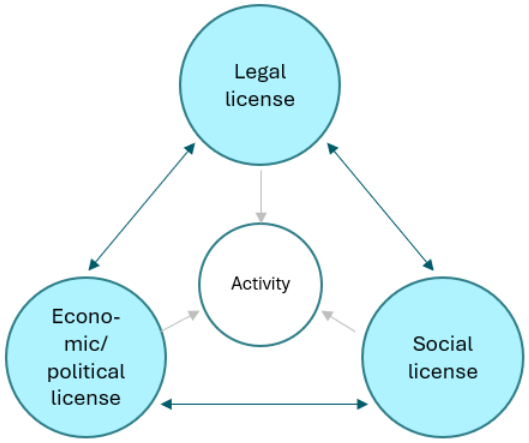

Figure 5. The three-strand model modified from (Morrison, 2014)

3.2.4 The triangle model of SLO

The triangle model of social acceptance views SLO as the result of three types of acceptance processes. It was created to help explain why, even though people generally support new renewable energy technologies, it can still be very hard to get individual projects approved and constructed. Socio-political acceptance means “public opinion,” which is the broadest, most general level of acceptance of policies and technologies given by key stakeholders and policymakers. Community acceptance addresses procedural and distributional justice and the trust of local stakeholders in the company/project. Market

acceptance deals with the process of market adoption of innovations and technology by consumers and investors. (Wüstenhagen *et al.*, 2007)

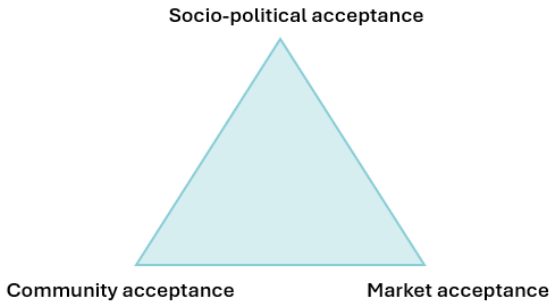

Figure 6. The triangle model of social acceptance modified from (Wüstenhagen et al., 2007)

3.2.5 Framework of organizational factors affecting SLO

Baba et al. (2024) studied and created a framework to understand how organizational antecedents help foster SLO. The authors present a three-part integrated framework that organizes the inter-organizational factors contributing to SLO. The framework divides these factors into three levels, as illustrated in Figure 7. The organizational level addresses strategy, structure, and culture; the departmental level addresses professional competence, continuous approach, and co-construction process; and the individual level addresses thematic expertise, contextual knowledge, and soft skills. The framework provides practical guidance on how a company can prepare to support and build SLO. (Baba *et al.*, 2024)

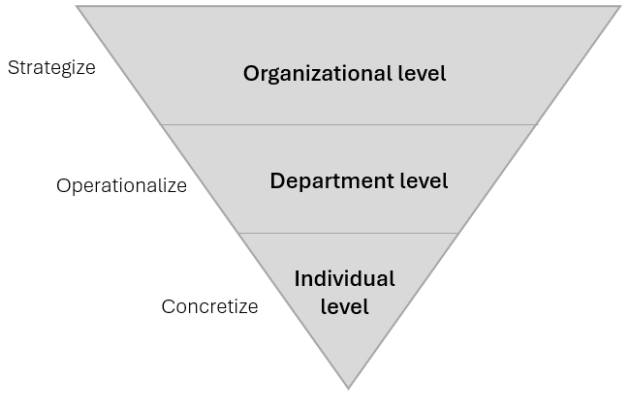

Figure 7. Organizational factors to develop SLO modified from (Baba *et al.*, 2024)

3.3 Practices, methods and strategies to establish and maintain SLO

In practice, the establishment and maintenance of SLO can involve various types of engagement activities with stakeholders over the lifecycle of a project. These SLO building and maintenance activities may operate at different levels (individual, organization, and industry) and take place across various channels, platforms, and organizational interfaces in projects (Lehtinen and Aaltonen, 2024).

At the local level, engaging community stakeholders who do not have an official or contractual link to the project organization but are the primary beneficiaries (or, in some cases, suffer from negative externalities) of the project is especially relevant in the context of projects to ensure social and sustainable value creation and the project's license to operate (Derakhshan and Turner, 2022; Di Maddaloni and Davis, 2018).

Strategies for establishing and building SLO at the local level are closely related to stakeholder engagement activities and can be divided into *informing, consulting, collaborating, co-deciding, and empowering* (Luyet *et al.*, 2012). These activities are explained in detail in Table 3. Table 3 also includes potential example activities related to different community stakeholder engagement modes in the context of SMR projects.

Table 3. Five degrees of community stakeholder engagement in a project context (adapted from Lehtinen and Aaltonen, 2024).

Degree of community stakeholder engagement	Project organization's activities to engage community stakeholders	Example in the context of SMR projects
Information	Project organizations offer information about projects to stakeholders with an emphasis on one-way communication. • Example: Project organization posts timely, relevant, and reliable information about the project and its content.	• Publishing plain-language explainers on SMR technology, safety features, siting criteria, and anticipated benefits and risks. • Releasing news pieces and expert interviews on safety, waste management and regulatory oversight. • Creating visualizations or virtual tours showing what the SMR plant and its surrounding areas would look like. • Sending project updates via newsletters or community information letters. • Establishing a local information center or showroom where residents can view information about the upcoming project/plant. • Disseminating FAQs, for example, online addressing common concerns (waste, accidents, emergency preparedness). • Providing transparent access to environmental impact screening information and regulatory process timelines.
Consultation	The project organization presents the project to community stakeholders with the expectation of collecting input (e.g., suggestions, ideas, or opinions), which may or may not affect decision-making in the project. • Example: The project organization asks for suggestions, ideas, or opinions on the project, starting with the theme of Why this project.	• Conducting public information and listening sessions where residents can ask questions about safety, environmental impacts, siting, waste transport, etc. • Running surveys or opinion polls (digital and in-person) to gather concerns related to, for example, host community benefits. • Hosting focus group discussions with specific groups, such as local businesses, schools, local community groups, minority groups, or environmental NGOs. • Opening comment periods for draft documents (e.g., environmental

		scoping reports and safety case summaries). • Using online feedback portals where citizens can submit concerns about topics. • Inviting regulatory authorities, independent experts, and NGOs to participate in a broad dialogue on why an SMR is being considered in that region. • Organizing stakeholder workshops on themes such as “SMRs and local development” or “Community expectations for long-term environmental monitoring.”
Collaboration	The project organization presents the project to community stakeholders with the expectation of collecting input that affects the project’s decision-making. • Example: Similar to the consultation above, but the difference is the assumed effect on decision-making.	• Establishing a Local Stakeholder Working Group (LSWG), including residents, municipal leaders, environmental groups, and local industry representatives. • Co-designing aspects of the project such as: – visual landscaping and site layout, – traffic and transport routes, – community benefit packages, – long-term environmental monitoring programs. • Running collaborative risk workshops where stakeholders assess emergency preparedness, communication plans, and monitoring strategies • Engaging local schools, vocational institutions, and universities in education and training partnerships related to nuclear safety, decommissioning skills, or STEM programs. • Organizing joint site visits to existing nuclear plants or SMR demonstration facilities to build a shared understanding of operational practices. • Demonstrating how stakeholder feedback shapes project decisions (e.g., reducing the construction footprint).
Co-decision	Project organizations and community stakeholders work together to reach an agreement or decision.	• Co-deciding on the scope of community benefit programs, such as local infrastructure improvements and training investments.

	• For example, the project organization hosts an online workshop session with community stakeholders to reach an agreement/decision on acute project issues.	• Co-deciding aspects of emergency preparedness, including the location of evacuation information signage and community or volunteer training programs. • Agreeing on the conditions under which the project may proceed to the next phase (e.g., community support benchmarks, independent review requirements).
Empowerment	The project organization delegates decision-making authority to community stakeholders. • Example: Like the co-decision above, but the difference is the delegation of decision-making power.	• Giving community representatives the power to determine spending priorities within a host community benefits program. • Enabling a community-led review panel to approve communication practices, such as emergency communication materials or the operating principles of a community information center.

In the context of stakeholder engagement and the establishment of an SLO, communication with stakeholders plays a key role. Stakeholder communication is defined as a conversation between an organization and its stakeholders (Kujala and Sachs, 2019). From a project organization perspective, there are two primary modes of communication: communicating to (stakeholder debate) and communicating with stakeholders (stakeholder dialogue) (Freeman *et al.*, 2017). In stakeholder debates, project organizations confront and defend their agendas to achieve their own organizational objectives and see themselves in competition with community stakeholders (Kaptein and Tulder, 2003). *Stakeholder dialogue,* in turn, means that a project organization is constructive, focuses on emphatic collaboration, exchanges opinions, interests, and expectations with community stakeholders, gives voice to them, listens to their concerns, and seeks to find mutually beneficial outcomes, reflecting the normative stance of stakeholder theory (Lehtimaki and Kujala, 2017). Past research has recognized the strengths of stakeholder dialogue in communication (Bebbington *et al.*, 2007; Vinnari and Dillard, 2016).

Traditionally, much of the dialogue-based stakeholder engagement and consultation has taken place face-to-face, for example, in traditional public hearing sessions that require physical presence (Lehtinen and Aaltonen, 2024). Since the corona pandemic, remote participation in consultation and engagement sessions has become more common. Public hearing sessions have

been identified as events that also entail the risk of generating conflict, as they do not always provide opportunities to resolve the issues that are raised. The format usually involves experts and authorities on stage and the public in a mass audience, which is a difficult environment to facilitate full participation. Attendance is often low, and only a small proportion of the audience can express their opinions. Those present do not necessarily represent the public as a whole; therefore, there is a risk that the processes tend to be dominated by a vocal minority. However, as a relatively inexpensive mechanism for providing information, they can give citizens and local communities an opportunity to obtain information and have their say directly to authorities or policymakers, and if held sufficiently early, they could also influence project practices.

3.3.1 Digital platforms and channels to establish and maintain SLO

Digital channels play a crucial role in SLO building across various challenging and contested projects. They have been found to complement the traditional forms, means, and channels of engagement: they provide opportunities for stakeholder participation that are not tied into, for example, certain time and place and can lead to, for example, increased levels of a project's SLO. Simultaneously, they provide means for real-time communication, enhanced participation, collaboration, and feedback, which may help address stakeholder concerns promptly and maintain continuous engagement. (Lehtinen and Aaltonen, 2024). However, challenges such as maintaining engagement and coordinating multiple channels need to be addressed.

Recently, the use of digital social media platforms, such as Facebook and Twitter, has become common in infrastructure project contexts, and digital platforms have rapidly become a key channel for engaging community stakeholders and improving their SLO during the project implementation phase (Ninan *et al.*, 2019). In the UK, for instance, the London Crossrail and High Speed Rail 2 project organizations use their official Twitter (now X) and Facebook accounts for transparent disclosure of information to their communities, such as upcoming interruptions and new decisions and plans that spur discussion on the project's value creation and distribution and contribute to community stakeholders' online engagement.

Social media are effective and efficient means of reaching a wide range of community stakeholders, for whom social media are increasingly a natural way to communicate in projects (Lobo and Abid, 2020). This facilitates the

achievement of the *breadth of stakeholder communication*, which may build SLO. For instance, X (previously Twitter) or Facebook can be used to appeal to community stakeholders, provide progress updates, promote the project organization, and deliver targeted marketing, helping to build a positive brand image and support project activities (Ninan et al., 2019).

Project organizations can also use social media for stakeholder dialogue to exchange and accumulate knowledge (Lehtinen and Aaltonen, 2024), facilitating *the depth of stakeholder communication*. For example, social media can be used for rapid communication between community stakeholders and project organizations, accelerating the exchange of information and offering community stakeholders an easy way to participate in value creation activities (Toukola and Ahola, 2022). Social media also enables real-time feedback and interaction, which are crucial for maintaining engagement and addressing stakeholder concerns.

However, various challenges related to the use of digital channels in the establishment of the SLO have been identified. First, sustaining engagement, especially among non-attenders, is challenging. Therefore, social modes of engagement, including face-to-face interaction, long-term relationship building, and continuous interaction, are essential to keep stakeholders involved. Human oversight is therefore necessary to prevent potential misinterpretation of data and ensure that accurate information is spread, for example, in the social media account of the project. (Lehtinen and Aaltonen, 2024). Debated discussions in these accounts have also proven to create the dangers of polarizing discussions. From the perspective of communication departments, digital channels require the coordination of multiple channels.

Social media research related to discourse on nuclear energy and nuclear projects has also been conducted (Table 4).

Table 4. Summary of studies on social media and nuclear power

Context / Case	Focus and data	Key findings	Source
United States: Social media sentiment on nuclear power	Analysis of ~300,000 X (formerly Twitter) posts from the U.S. between 2008–2023 related to nuclear power. Sentiments were classified as positive, neutral, or negative	Most posts were neutral. Positive sentiment outweighed negative sentiment (approximately 54% positive). However, negative themes, particularly nuclear waste, safety, and costs, were highly visible and shaped the tone of	(Kwon *et al.*, 2024)

	using a large-scale computational analysis.	public debate. The overall sentiment may be positive, but opposition remains strong and influential online.	
Finland: Fennovoima nuclear project	Discourse analysis of social media, mainstream media, political debate, and communications by the Ministry of Employment and the Economy (MEE) and politicians.	A "pro-nuclear" hegemonic discourse was thus constructed. Opposition was stigmatized on social media (e.g., criticism framed as outdated or illegitimate), and opposing views received less visibility. Political culture and media practices shaped what was considered legitimate public discourse and a socially acceptable opposition.	(Lounasmeri, 2022)
China: Pengze inland nuclear power project	Case study of online mobilization, activist networking, and media use in the context of nuclear power opposition.	Social media enabled information sharing, networking, and public mobilization, playing a key role in initiating and sustaining resistance against the project. Online activism increased the visibility of concerns despite limited formal participation channels.	(Deng et al., 2023)
OECD/NEA: Communication and social media in nuclear projects	Desk study of 13 societal case studies on communication among nuclear project developers, regulators, decision-makers, media and stakeholders. Additional analysis of regulatory organizations' use of social media.	Communication is often partial, participation is limited, and public discourse is strongly shaped by the media. Transparency, openness, fairness, and perceived opportunities to influence decisions were decisive factors for public trust. Many nuclear regulators actively monitor social media to identify concerns, misinformation, and emerging fears, and sometimes respond directly to them.	(NEA, 2020)

Finally, there is growing interest in using Generative AI to enhance engagement and dialogue in multi-stakeholder and negotiation settings to develop SLO

(Anthony *et al.*, 2023; Benbya *et al.*, 2024). AI agents presenting diverse viewpoints may, for example, help foster mutual understanding among stakeholders, which in turn supports the development of an SLO. AI tools also have the potential to support communication by tailoring messages to local languages and contexts, helping stakeholders better understand key information. Some studies have also been conducted using AI-driven research to analyze narrative construction and emotional resonance evolving among stakeholders (Rodolaki *et al.*, 2025). AI-powered tools, such as social listening and sentiment analysis, may help organizations understand and respond to community concerns, fostering trust and improving their reputation (Buhas *et al.*, 2024). These tools may support proactive stakeholder engagement and demonstrate responsiveness to societal expectations. Therefore, they may hold potential for future development in the application of AI within the context of SLO. However, more research in this area is needed that also considers the responsible use of AI and its potential dark sides and risks.

3.4 SLO within mining and renewable energy sectors

Research interest in social acceptance and SLO has grown significantly since the concepts first emerged in the mining sector in the late 1990s. Over time, the research landscape has broadened to include sectors such as energy, forestry and cotton cultivation. SLO has also been adopted as a management tool in diverse fields, including equestrian sports, finance, education, and marine aquaculture. Between 2007 and 2013, 61.5% of academic publications on the topic originated from the mining industry, followed by 15.4% from the energy sector, and 7.7% each from marine activities, medical/health research, and corporate social responsibility (CSR). In the 2020–2025 period, mining remains the dominant focus (31.9%), but attention has increasingly shifted toward CSR and business strategy (8.2%), breeding and farming (11.1%), infrastructure (6.8%), and continued interest in energy (9.2%), and marine activities (5.3%). (Chen *et al.*, 2025)

3.4.1 Mining

Within the mining industry, SLO research emphasizes the critical roles of community acceptance, engagement, and trust-building. The concept is often framed as a tool for conflict mitigation, given that mining projects frequently

encounter strong resistance owing to land use conflicts and environmental concerns. Table 5 presents selected examples of SLO research in the mining sector categorized by focus area.

Table 5. Examples of SLO research in the mining sector

#	Focus area	Source
1	Factors affecting SLO	(Jartti et al., 2020; Litmanen et al., 2016; Parsons et al., 2014; Prno, 2013)
2	Stakeholder engagement and trust-building	(Cesar, 2019; Moffat and Zhang, 2014; Tuulentie *et al.*, 2019)
3	SLO frameworks and assessing SLO	(Koivurova et al., 2015; Komnitsas, 2020; Prno and Scott Slocombe, 2012)
4	Engagement issues and conflicts	(Cesar and Jhony, 2021; Dauda, 2022)
5	SLO and CSR	(Lindman et al., 2020; Matebesi and Twala, 2024; Saenz, 2021)

The mining sector also has the International Council on Mining and Metals (ICMM) sustainability framework that stresses the role of stakeholder engagement and socio-economic contributions in developing SLO (International Council on Mining and Metals, 2024)

The following three examples describe case studies conducted in the SLO context and their key findings in the mining sector.

1. A case study from Peru explores how mining companies obtain an SLO by building legitimacy and trust with local communities. This study presents a comparative case analysis of two mining operations, and its qualitative examination reveals a five-part model for achieving social acceptance and SLO. This model consists of three components of legitimacy: pragmatic, moral, and cognitive, and two components of trust: decision-maker and situational factors. The research demonstrates that mining companies must identify feasible strategies and undertake a variety of actions to ensure the continuity of their operations and avoid conflicts. These actions include stakeholder engagement, information transparency, and a consensus-based approach with stakeholders and the community. (Saenz, 2021)

2. A case study from Finland addresses the successful approach of gaining and maintaining SLO in the case of the Kylylahti polymetallic mine in Polvijärvi, Eastern Finland. Mining operations in the area were widely accepted, and no significant local

conflicts occurred. The mine benefited from historical legitimacy and achieved high local acceptance through proactive concern management and trust building. Key issues included traffic and potential lake pollution, which the company addressed through collaborative solutions with Pro-Polvijärvi activists. Although some expected local benefits did not materialize, acceptance remained strong. The Kylylahti case highlights the importance of respectful engagement with local concerns to sustain trust. The paper also points out that a region's local mining narrative and prior experiences as a mining area can foster a positive attitude toward new mining initiatives. It concludes that the conditions for achieving an SLO result from a combination of the local narrative and the mining company's concrete actions. (Mononen and Sairinen, 2021)

3. A case study is related to a conflict between a large Guatemalan construction materials firm and the local indigenous population in Guatemala. Local residents actively opposed the project due to environmental concerns, threats to their agricultural livelihoods and violations of their collective property rights. To address this resistance, the state and the firm included the presence of state forces and the pressure on activist leaders. Another strategy was to actively seek SLO of the affected local population by capturing and controlling new participatory democracy institutions. They promoted a "depoliticized" vision of development that framed mining as complementary to local socioeconomic progress and provided tangible benefits to build community support. The case study concludes that while this strategy resulted in increased transparency and service provision and generated consent among many community members, it achieved only limited success in securing an SLO. The active opposition movement, which was strategically excluded from participatory institutions, continued to resist the firm's operations. The firm failed to secure a full SLO, resulting in years of project delays. The firm was unable to engage with residents living near the mining site and failed to establish itself as a trustworthy actor. Earning an SLO involves building trust, showing respect, and sincerely engaging with local communities from the earliest phases of project planning. (Costanza, 2016)

3.4.2 Renewable energy

SLO in the energy sector includes both renewable energy sources, such as solar, wind, and hydropower, and nuclear energy, along with associated infrastructure and energy distribution systems. A central theme in SLO research in this sector is justice, particularly procedural fairness, which refers to the transparency and equity of decision-making processes that affect local communities and stakeholders. Key elements for ensuring procedural fairness to gain and maintain SLO include inclusive participation, where communities are given opportunities to express concerns and influence outcomes. Access to

timely, accurate, and understandable information on project benefits, risks, and alternatives is also essential for building trust. A lack of procedural fairness and community support can lead to public opposition, resulting in project delays, cancellations, and financial losses for the operating companies. Table 6 presents selected examples of SLO research in the energy sector categorized by focus area.

Table 6. Examples of SLO research in the energy sector

#	Focus area	Source
1	Factors affecting SLO	(Brueckner and Eabrasu, 2018; Stephens and Robinson, 2021)
2	Stakeholder engagement and trust-building	(Barich et al., 2022; Hall et al., 2015; Moffat et al., 2016; Smits et al., 2016)
3	Engagement issues and conflicts	(Xu et al., 2023)
4	Energy justice, fairness	(Minadakis and Vega-Araújo, 2024; Walsh and Haggerty, 2020)

The following three examples briefly describe case studies conducted in the SLO context and their key findings from the renewable energy sector.

1. A case study on the context of Australian wind farms explores SLO concept and its potential role in enhancing the acceptance of wind farms and fostering community engagement. This study examines why wind farms face opposition from local communities despite public support for renewable energy. The overall social acceptance of wind power is based on public attitudes regarding the broader environmental benefits of wind energy; however, negative views are affected by local and specific aspects such as noise, visual changes, and unequal financial gain. Unequal compensation, place attachment, emotional bonds and how people feel connected to the area where they live, and inadequate consultations have caused local opposition to wind farms. Thirty interviews across nine wind farms were conducted with stakeholders representing wind companies, local government authorities, local opposition, local support, and turbine hosts. In conclusion, the research findings suggest that community acceptance of wind farms can be increased by intentionally adopting an SLO approach. Wind farm developers could apply an improved consultation model to engage local communities to complement formal regulatory processes. This study proposes practical steps, features, and a framework for gaining and maintaining a wind farm SLO. (Hall et al., 2015)

2. In a case study from China, SLO of waste-to-energy (WTE) plants in the Yangtze River Delta region was assessed. The study employs case analyses of four typical waste-to-energy facilities and a survey conducted among local residents to explore their

attitudes toward and acceptance of these potentially harmful or hazardous facilities. The results show that the SLO is relatively low, and conflicts with local residents have existed. The conclusions include recommendations for improving public acceptance and SLO for WTE initiatives. For example, the government and businesses should work together to share more positive information, help people understand WTE projects better, and improve the public's perception of them. Companies should communicate continuously with stakeholders to build consensus and trust to gain SLO. Companies should support decision-making processes that involve local communities and respect their cultural traditions. Government departments can strengthen stakeholder support by adopting social licensing as a policy and including the SLO in approval decisions. (He *et al.*, 2023)

3. This case study addresses the social acceptance of hydrogen technologies as promising low-carbon energy sources. The study was conducted in Germany in 2019. To implement hydrogen technology on a large scale, new piping infrastructure and comprehensive modifications to the existing system are necessary. Although hydrogen technology is generally well accepted, public support drops significantly when it comes to implementing infrastructure in one's own neighborhood (a phenomenon known as NIMBY, Not In My Back Yard). This study analyzed the gap between different levels of public acceptance using a classification of supporters, opponents, indifferent individuals, and NIMBY types. Multivariate analysis shows that this divergence is significantly influenced by project-related factors, such as trust in stakeholders, as well as location-based and personal factors. Men tend to be more supportive than NIMBY compared to women, and young people (<35) are more likely to show NIMBY attitudes than older ones. Trust in actors and stakeholders is an important factor affecting public acceptance. The results indicate that NIMBY individuals' concerns can be mitigated by the active participation of residents. Trust can be built by actively involving community members in the planning process of the project. (Schönauer and Glanz, 2022)

3.5 SLO within the nuclear industry

3.5.1 SLO research and practical guidelines within nuclear industry

Recognizing the challenge and importance of SLO and stakeholder engagement, organizations such as the OECD Nuclear Energy Agency (NEA) (NEA, 2017, 2025) and IAEA (IAEA, 2021) have produced guidance on stakeholder involvement in nuclear projects. IAEA's communications toolbox emphasizes that maintaining a social license requires ongoing engagement, transparency, and trust: *"Having a social license refers to a project having*

ongoing approval in the local community and among other stakeholders." This is achieved through open communication and stakeholder trust-building (IAEA, 2025). The World Nuclear Association (WNA, 2025), representing the global nuclear industry, has also highlighted public acceptance as a key factor in the future of nuclear power. The WNA's Charter of Ethics includes commitments to interact with the public with honesty and to continuously improve safety, which indirectly relates to the social license. Industry's best practices for SLO include setting up local liaison committees around plants, funding local educational and environmental initiatives, hosting site tours and information days to explain operations, and quickly addressing any incidents or concerns with full transparency. A practical example is how some nuclear operators distribute regular newsletters or run visitor centers that keep the community informed.

A particularity that builds SLO in some countries is that formal decision-making processes explicitly integrate social-licence considerations. For instance, according to current legislation, Finland's Nuclear Energy Act requires a new nuclear facility to obtain a positive Decision-in-Principle from the government, which must then be ratified by Parliament. Crucially, the host municipality must consent to the project at this stage (Nuclear Energy Act 990/1987). This effectively gives the local community a legal veto, ensuring that local SLO is a precondition for the project's progress. Such formal processes acknowledge the importance of social license at the local level and attempt to align formal licensing with social acceptance, which is an example of bridging the gap between "legal license" and "social license."

3.5.2 Factors affecting SLO in the context of nuclear projects

Nuclear power is an example of a sector in which social acceptance can make or break projects. The SLO of nuclear projects is a complex phenomenon influenced by various factors operating at different levels. Such a project and its SLO always require *national political acceptance* (because nuclear projects are high-profile and often state-linked) and *local acceptance*. These can diverge; for example, a country's population might broadly accept the role of nuclear power (macro-level acceptance and SLO), but a specific town might oppose a reactor in its vicinity (micro-level SLO license lacking). Factors that influence the SLO of nuclear projects are, hence, related to both the overall acceptance of nuclear technology at the societal level and project-specific factors. Based on prior

research, we can classify the factors that may affect the SLO of nuclear projects into the following categories: 1) trust in key actors (including authorities and nuclear power companies) and the credibility of key actors; 2) perceived risks and benefits of nuclear power and the project; 3) project stakeholders' characteristics and demographic factors; 4) socio-political context; 5) project-specific factors; and 6) stakeholder engagement activities, project communication processes, and their content. Table 7 summarizes prior research on these factors and discusses their effects on SLO.

Table 7. Factors that impact SLO in nuclear projects based on research

Key elements	Implications on SLO
Trust in companies involved in the project and trust in state authorities	Trust in governmental and local entities (managing authorities and safety authorities) enhances public confidence and acceptance in nuclear projects (Ram Mohan and Namboodhiry, 2020).
	An important element in creating trust is the perceived credibility of the responsible organization and regulatory agency or agencies. (NEA, 2025; 2017)
	The perceived commitment of nuclear companies to social and environmental responsibilities enhances overall trust.
	The presence of a strict, independent nuclear safety regulator. The risks associated with nuclear energy are technical, and the public generally lacks the means to independently verify safety. Therefore, people rely on regulators (NEA, 2025)
Perceived risks and benefits of the project	Higher perceived risks (associated with nuclear power), such as potential accidents or environmental impacts, lead to lower levels of acceptance.
	Perceived risks related to economic issues, such as the impact on property values or local employment.
	The benefits to the area can include jobs, tax revenues, economic output, labor income, and incentives to the local community (IAEA, 2021).
	In China, benefit perception was a key factor in nuclear power acceptance (Zhu *et al.*, 2020)
	The impact on local employment, energy prices, and environmental impact was considered.

Stakeholders' socio-demographic factors and knowledge of nuclear technology	A greater understanding of nuclear technology and safety measures can improve public acceptance. (IAEA, 2021) Different demographic groups (e.g., age, gender, education) may have varying levels of acceptance (studies are mixed around the impacts). Education and economic situation: Higher education levels can lead to better understanding and acceptance, whereas improved living standards may reduce acceptance because of increased risk aversion (Kim *et al.*, 2020).
Socio-political context	Political affiliations and community engagement can either support or hinder public acceptance. Political polarization: Political affiliations and policies of political parties can heavily influence acceptance. Supporters of pro-nuclear parties tend to have higher benefit perceptions, whereas opponents have higher risk perceptions.
Procedural and distributional justice (Stakeholder engagement process and activities)	If the process of engagement is experienced as transparent and just, social acceptance is higher. If the perceived distribution of outcomes (benefits and harm) is considered fair, social acceptance is higher.
Media/tone and content communication	Media presentation: Effective communication through the media, including the presentation of pros and cons, can shape public support. Positive media coverage and transparent information dissemination are essential for ensuring social acceptance. Media influence: The frequency and trust in social media information can shape knowledge and perceptions about nuclear power, thereby influencing acceptance (Zhu *et al.*, 2020) Simple, non-technical communication increases social acceptance (IAEA, 2025)
Local context and site-specific factors	Community acceptance: The deployment of SMRs in multiple locations requires a paradigm shift in community engagement. Site-specific opposition is likely to be a significant obstacle, similar to other controversial facilities (Alexander and Walker, 2018; Tuler and Webler, 2024) Proximity to plant: People living closer to nuclear plants are generally less willing to accept them due to heightened risk perception (Guo and Ren, 2017)

3.5.3 SLO research and practical guidelines within nuclear industry

Total safety in the nuclear energy context aims to ensure that nuclear energy is safe, not only technically but also socially and environmentally. This approach includes the protection of people, the environment, and society by addressing all aspects of nuclear safety throughout the entire life cycle of nuclear facilities. Hyvärinen et al. (2022) have introduced the overall safety concept for nuclear power plants (ORSAC). The ORSAC framework offers tools to visualize and assess safety issues and their justification by integrating internal organizational, societal, technical, and political factors with core safety functions, such as reactivity control, heat removal, and radioactive confinement. (Hyvärinen *et al.*, 2022) The following areas of nuclear safety can be identified:

- **Technical safety**: Reliable reactor design, safety systems, and accident-prevention mechanisms.
- **Operational safety**: Procedures, training, and maintenance to ensure safe daily functioning.
- **Radiation protection**: Measures to limit exposure to ionizing radiation.
- **Waste and decommissioning safety**: Safe handling of radioactive waste and facility shutdown.
- **Security and safeguards**: Protection against sabotage, terrorism, and the misuse of nuclear materials.
- **Emergency preparedness**: Plans and infrastructure to respond to accidents or disasters.
- **Safety culture**: Organizational commitment to safety at all levels of the organization.
- **Public trust and communication**: Transparent risk communication and stakeholder engagement.

Safety in the context of nuclear energy can be understood as the state of being protected from risks such as nuclear accidents or radiation release. Technical

safety involves systems such as containment structures, redundant cooling systems, and emergency protocols, which impact low accident rates. However, perceived risk, which is how the public feels about nuclear energy, needs to be addressed. Effective and transparent risk communication is essential for building trust in nuclear safety. Communication and stakeholder engagement are key components of building public acceptance and SLO. (Duguay and Hoornweg, 2010; Ram Mohan and Namboodhiry, 2020).

Public acceptance and trust in nuclear energy are largely shaped by perceptions of safety. Key nuclear energy safety concerns are related to siting, risks of reactor accidents, radiation, natural hazards, cybersecurity threats, and sabotage. Major incidents such as Chernobyl and Fukushima remain deeply rooted in public memory, making safety measures, technological solutions, and safety culture (emphasizing transparency, accountability, and continuous improvement) key concerns for both regulators and operators (Pidgeon, 1991; Roh and Kim, 2017). A strong safety culture within nuclear organizations ensures that risks are continuously monitored and mitigated, with regulatory bodies such as the IAEA and national authorities playing a key role.

Nuclear safety is increasingly recognized as critical for the successful deployment and operation of nuclear technologies (Agyekum *et al.*, 2025). As nuclear energy becomes more integrated into society, the demand for accessible, accurate, and timely safety information increases. Low social acceptance can significantly delay or block nuclear projects, especially during the siting and licensing phases. This is an important concern, particularly when communities are expected to host both power plants and long-term waste storage facilities. (Keto *et al.*, 2023)

SLO is closely linked to how stakeholders perceive safety, both physical (e.g., environmental, occupational, public health risks) and procedural (e.g., transparency, fairness, responsiveness). Poor communication can amplify perceived risks, whereas better dialogue can reduce uncertainty and mistrust. In the nuclear industry, where safety incidents have severe consequences, responsiveness in communication is critical. Safety information often fails to reach all relevant communities because of jargon, technical barriers, or language differences. Consequently, misunderstandings between stakeholders and operators can lead to conflicts, delayed interventions, and overlooked risks. A social license functions as a safety mechanism. Without it, operations can be disrupted, protests may escalate, or oversight can be weakened. Strengthening dialogue and trust between operators and stakeholders leads to safer and more stable operation.

Three key focus areas related to SA and SLO in the context of nuclear energy and its relationship with safety can be identified in existing research. *Public perception* explores public attitudes, risk perception, and factors influencing the acceptance of nuclear energy. *The impact of accidents* examines how major events and accidents affect public and political responses to nuclear energy. *National case studies* have investigated the social and political contexts of nuclear energy acceptance in different countries. Table 8 presents a brief list of research papers categorized by focus area and research theme.

Table 8. Examples of SLO and safety research in the nuclear sector

#	Focus area	Themes	Source
1	Public perception	Risk acceptability, perceived risks	(Huhtala and Remes, 2017; Nam-Speers *et al.*, 2023)
2	Impact of accidents	Endorsing nuclear energy safety, trust, global attitudes and country specific policy responses	(Kim *et al.*, 2013; Roh and Kim, 2017; Visschers and Siegrist, 2013)
3	National case studies	National energy policies, information quality and communication, trust in the government and regulators, perceived benefits vs. perceived risks	(Alzahrani *et al.*, 2023; Lee *et al.*, 2025; Smolinski *et al.*, 2024; Wang *et al.*, 2024)

4 The establishment and maintenance of SLO in SMR projects

4.1 Small modular reactors

Small Modular Reactors (SMRs) are nuclear reactors designed for industrial-scale electricity, heat, and process applications, typically with an output below approximately 300 MWe (or 1000 MWt) per unit. They can be installed in modular clusters at the same site and rely on advanced safety features to ensure safe operation. Some are light-water reactors (LWRs), and others use alternative coolants (IAEA, 2018a).

The IAEA's Advances in Small Modular Reactor Technology Developments and Advanced Reactor Information System (ARIS) provide comprehensive overviews of ongoing SMR initiatives (International Atomic Energy Agency, 2017; Ingersoll & Carelli, 2020). In the European energy context, SMRs are particularly appealing because they can be deployed close to demand centers and utilize existing infrastructure, especially at former coal power plant sites with grid and cooling connections (Europe Beyond Coal, 2022). For Europe, SMRs offer a pathway to "coal-to-nuclear" conversion, as hundreds of coal power plant sites already possess suitable infrastructure, typically designed for capacities below 300 MWe (Europe Beyond Coal, 2022).

The main advantages of SMR technology are stated to lie in safety, deployability, and versatility. Their small size and high surface-to-volume ratio enable passive decay heat removal, allowing designs that are independent of active cooling systems. This can reduce the required emergency planning zone (EPZ) and expand the siting options near industrial or urban areas (IAEA, 2018a). In turn, modular factory fabrication and transportable components can shorten construction schedules, reduce project risks, and open financing opportunities for smaller owners, such as municipalities or industrial consortia (Ingersoll and Carelli, 2014; Mignacca and Locatelli, 2020).

However, SMRs face significant economic and implementation challenges. The costs and schedules for first-of-a-kind (FOAK) units remain uncertain, and learning effects require the serial production of multiple identical units, necessitating design convergence on a limited set of reference models

(Mignacca & Locatelli, 2020). While smaller in capacity, SMRs are still nuclear installations that require substantial upfront investment, extensive preconstruction planning, and licensing. Rapid large-scale deployment could create supply chain bottlenecks and skilled labor shortages, and public acceptance remains crucial given that SMRs would be more numerous and closer to population centers (Guo & Ren, 2017). Overall, the levelized cost of electricity depends heavily on the deployment scale, learning effects, and financing conditions (Lovering *et al.*, 2016).

In Europe, the licensing process for SMRs builds on IAEA safety standards and national regulatory practices. The main stages of licensing include site suitability assessment (covering natural and human-induced hazards and long-term monitoring), environmental impact assessment and emergency planning (EPZ determination), and plant design safety assessment, leading to construction and operating permits (IAEA, 2018b). For SMRs, regulatory discussions increasingly emphasize risk-informed, technology-inclusive, and graded approach principles. Under the graded approach, the level of analysis, verification, and documentation is commensurate with the facility's potential hazard without compromising safety.

International cooperation, such as the IAEA's SMR Regulators' Forum and regulatory coordination in Europe, is seen as crucial for harmonizing approaches and shortening first-of-a-kind approval timelines (IAEA SMR Regulators' Forum, 2018). Overall, with coordinated regulatory harmonization, site development, industrial scaling, and skills investment, SMR technology could become a significant pillar of Europe's secure, low-carbon, and flexible energy system by the 2030s (Ingersoll & Carelli, 2020).

4.2 SLO of SMRs

As has been highlighted, the social license for nuclear energy projects is very much about trust, legitimacy, and benefits for stakeholders: trust that the plant will operate safely and transparently, legitimacy in terms of aligning with societal goals (such as climate mitigation and energy security), and bringing benefits particularly to those who live with the plant. Because SMRs are just now moving from design to deployment, there is relatively limited empirical data on public attitudes toward SMRs. However, some studies have emerged. Recent research on the social acceptance of SMRs indicates that public acceptance drivers for SMRs share similarities with large reactors (safety perception, trust in management, and perceived benefits); however, there may also be differences

in emphasis (Cho and Lee, 2025) and in areas of concern (Ecosens conference presentations, 2025). Large reactors are few and centralized, whereas SMRs can be deployed at many sites closer to population centers. This may increase the number and diversity of the affected stakeholders.

An important feature that needs to be considered is that the situation regarding the SLO of SMRs is still forming, as public awareness of SMRs tends to be low, and the attitudes of the public are forming and being shaped. An international survey in Europe found that knowledge levels about SMRs are low, and attitudes are not strongly formed, suggesting a need for public education as these technologies are introduced (Ecosens, 2025). Overall, many people, for example, do not yet distinguish SMRs from traditional reactors, and their knowledge of them remains very limited. Surveys in multiple European countries show that only a minority of citizens have heard of SMRs (Ecosens, 2025). When the SMR concept is explained, support often increases, especially in communities that are familiar with nuclear energy. As the field of SMR acceptability research is still developing, early decisions and communication strategies will strongly shape public perceptions. In essence, SMRs are entering a pre-existing narrative about nuclear energy, and how they are framed could significantly influence their social license (Ecosens, 2025).

In the following, the salient themes around the public's perception of SMRs are discussed, including 1) proximity and siting concerns, 2) SMRs acceptability's dependence on perceived risks and benefits 3) waste question 4) importance of education 5) credibility of actors related to SMRs 6) regulatory frameworks and 7) effective engagement methods in SMRs to increase SLO.

4.2.1 Proximity and siting concerns

A distinctive aspect of many SMR proposals is siting them in locations closer to end-use or population centers (for example, an SMR for district heating on the edge of a city or an SMR at an industrial park near a town). This is different from the traditional approach of siting large NPPs in remote areas with exclusion zones. SMRs often include smaller Emergency Planning Zones (EPZ) owing to their safety features. From a technical perspective, a smaller EPZ is positive (less off-site risk). From a social perspective, people may live much closer to a reactor than they are used to, which could heighten public concern about everyday proximity to nuclear material (Tuler and Webler, 2024). For instance, urban residents might worry about evacuation plans even if the risk is extremely low. The notion of a reactor in one's "backyard" might be unsettling until trust is

established. Establishing and maintaining SLO in these cases requires transparent communication. However, if an SMR is sited at an existing nuclear site or a remote location, gaining local acceptance might be easier because the community is already familiar with nuclear operations or because few people live nearby. This implies that each scenario requires tailored SLO strategies. For example, in Canada, questions related to siting in disadvantaged communities or peripheral regions and intergenerational justice regarding nuclear waste are also raised and connected to the overall theme of energy and environmental justice.

4.2.2 SMR acceptability depends on perceived benefits and risks

In public attitudes, SMRs are seen as promising due to their small size, modularity, and potential suitability for industrial clusters or remote communities. Their value in climate mitigation, energy security, reliable energy supply, jobs, and industrial competitiveness has also been highlighted as a perceived benefit. Some have also argued that SMRs could improve public acceptance of nuclear energy overall, as they are smaller (potentially perceived as less imposing), many designs have inherent safety that reduces the perception of accident risks, and they could be deployed in a more distributed manner, bringing local benefits to more communities.

Some communities view SMRs favorably when they are linked to local development. For example, an EFI Foundation (Jeong, 2024) study focusing on U.S. communities that have expressed interest in hosting SMRs found that economic and social benefits are the strongest drivers of community acceptance. Communities that see SMRs as a source of jobs, investment, or as a replacement for coal plants are more likely to support them. This suggests that if SMR projects are positioned as part of a larger economic development narrative – creating local employment, using local supply chains, and providing not just electricity but also heat or other community benefits – the social license is easier to obtain. The same study recommends that developers partner with local industries and articulate long-term regional benefits (e.g., pairing SMRs with industry to ensure steady jobs and energy supply) (Jeong, 2024).

At the same time, SMRs are viewed as new, less proven, and even experimental technologies, which increases perceptions of uncertainty. Distributed deployment also raises concerns regarding oversight, transportation, and cumulative risks. Concerns have also been raised in public discussions about

waste management, accidents, and security. There is also an ongoing debate about whether SMRs can be cost-competitive, which may influence public perception. Concerns include first-of-a-kind risks and the potential for perceived lock-in to costly energy pathways. (Cho and Lee, 2025)

4.2.3 Waste question

Host community stakeholders have been particularly interested in "What happens to the spent fuel?" Given the small size of SMRs, the spent fuel volumes per reactor are smaller. A community considering an SMR will want assurance that waste will be safely managed and will not become an indefinite local burden. Communicating that a long-term solution is in place can help SLO. Elsewhere, however, the lack of a clear waste strategy can undermine the social license for new nuclear power plants of any size. Even if an SMR is easier to site than a large plant, without a disposal path for its spent fuel, opposition may arise from those concerned about leaving a toxic legacy. Distributed SMRs may also raise concerns about physical security, cybersecurity, and increased fuel and waste transportation.

4.2.4 Importance of education

Because SMRs are new, education is paramount (Sahagún-Aguilar and Hurlbert 2025). Materials that explain how an SMR works, its safety features, differences from past reactors, and how emergencies would be handled are needed in layperson terms. Trustworthy information, possibly delivered by independent experts (university scientists, etc.), can help prevent misinformation from filling the void. The EFI (2024) report suggests building a knowledge database and funding local groups to disseminate information on SMRs. The goal is to empower the community with knowledge so that they can make informed judgments rather than relying on gut fears or exaggerated claims.

4.2.5 The credibility of actors related to SMRs

Some SMR projects are driven by private companies (e.g., startup ventures) in partnership with utilities or governments. Here, SLO of the project may depend on perceptions of the operating entity's trustworthiness. A large, state-owned utility might be trusted or disliked based on history, and a new startup might face the challenge of being unknown to the public. Thus, building a corporate

reputation in the community is part of SLO. This can involve hiring locally, establishing local offices and representatives, and attending community events. In other words, becoming a familiar and integrated presence, rather than a distant outsider.

Acceptability is also associated with trust in institutions, including regulators, political decision-makers, and operators. If citizens perceive that participation is symbolic or that decisions have already been made, legitimacy may deteriorate quickly. Ecosens examples show how poor governance practices undermine acceptability (Ecosens, 2025).

4.2.6 Regulatory frameworks

The regulatory frameworks for SMRs are evolving, and some worry that "rushing" SMRs to market might cut corners in terms of safety. It is essential that SLO not be compromised by any relaxation in the safety review. As noted earlier, demonstrating a rigorous, transparent regulatory process for SMRs will help SLO because people gain confidence that proper checks and balances exist.

4.2.7 Effective engagement methods for SMR projects' SLO

The Ecosens project (Ecosens, 2025) has focused on effective engagement methods in SMR projects, which can be seen as a means of establishing and maintaining their SLO. This study emphasizes the following elements of effective stakeholder engagement in SMR projects.

Early, continuous, and genuine engagement

SMR developers must engage communities early, even before any formal project announcement**.** By reaching out to local stakeholders in small groups early on, developers can gauge community sentiment, identify key concerns, and co-design certain project aspects to align with local values. This early engagement can also build a group of informed local supporters who understand the technology used. Participation should begin before the siting and remain continuous throughout the SMR project lifecycle. It is important to focus on transparent, long-term communication and collaboration with local stakeholders.

Deliberative methods: Citizen assemblies, scenario workshops, and multi-stakeholder deliberative processes foster deeper learning than one-way information sessions.

Independent expertise: Citizens value access to independent experts beyond the project proponent.

Inclusion of vulnerable or often overlooked groups: Indigenous groups, remote communities, youth, and marginalized groups must be proactively included.

Transparency about uncertainties: Open discussion of technological, financial, and regulatory uncertainties builds more trust than overconfident messaging.

5 Empirical part: SLO and SMRs

The empirical part of the study presents the research findings based on interviews with experts from Finland. During the interviews, discussions focused on terminology, significance, practices, and operational models of social acceptability; cooperation with authorities; and the connection between the SLO and overall nuclear safety, particularly in the context of small modular reactors. The interview content was analyzed using qualitative content analysis methods and is presented in the following sections, organized according to the main themes of the interview framework.

5.1 SLO as a phenomenon

All interviewees widely recognized and understood the concepts of SLO and SA. SLO is understood as an 'informal but essential acceptance' based on trust and interaction. Although the term SLO may not always be used, the interviewees mentioned synonyms for SLO, such as general acceptability, responsibility, and stakeholder collaboration. Several interviewees described SLO as a set of "societal prerequisites," which is not a formal permit but a condition that, in practice, is considered as critical as regulatory licensing. The concepts of corporate social responsibility and safety culture also emerged in the SLO discussions. Some interviewees emphasized that both national and local acceptability are necessary prerequisites for establishing new nuclear power operations, emphasizing the salience of SLO in the nuclear energy sector.

SLO is understood as acceptance across multiple societal levels, rather than by a single stakeholder group. These levels typically include local communities, such as nearby residents, property owners, and municipalities; national audiences, including policymakers and the media; and institutional actors, such as regulators and other authorities. Consequently, SLO is perceived as a multi-layered form of legitimacy encompassing local, national, and institutional dimensions.

Based on the interviews, SLO and SA refer to the community's informal yet essential approval of nuclear power operations. It is not a legal permit but rather a continuous relationship built on trust, transparency, and perceived safety between the operator, authorities, and citizens. The interview material emphasizes that in the context of nuclear power, a social license is particularly

linked to understanding risks, a sense of safety (perceived safety), and how credibly and transparently different actors communicate. Historical accidents, such as Chernobyl and Fukushima, have also shaped people's perceptions in Finland and increased the need for ongoing clarity and openness. According to some interviewees, people find it difficult to grasp, for example, the effects of radiation, which makes communication sensitive: a poorly timed or unclear message can increase fear even when there is no real danger. Thus, according to the interviewees, a social license is also tied to the experience of safety, not only technical safety. The interviewees also highlighted that an SLO can be achieved and maintained only if the work for it is consistently open, interactive, and responsible.

Annual surveys conducted by Energy Industry Finland indicate that nuclear power enjoys broad public acceptance as an energy source in Finland. According to the interviewees, this is influenced by the pragmatic nature of Finns, their tendency to stick to decisions, and their trust in authorities and experts. Furthermore, the interviewees viewed solving the challenge of final disposal of spent fuel, recognizing nuclear power as important for energy security, and maintaining strong trust in authorities as helping to build and maintain a high level of SLO in the nuclear energy context. The geopolitical situation and green transition in energy production are also seen to support the acceptance of nuclear energy and, hence, the establishment of SLO in SMRs. STUK's role as the authority that promotes and oversees nuclear safety is considered significant both nationally and internationally. Finland has a long history of operating large nuclear power plants in Loviisa and Eurajoki, where established practices for maintaining a social license to operate with different stakeholders are in place. Cooperation and the division of responsibilities between the regulator and the energy company are well-established and seamless, positively affecting the building and maintenance of SLO.

5.2 Processes and practices

The interviews discussed the approaches and practices that influenced the SLO. The analyzed responses of the interviewees are presented in Table 9.

Table 9. Processes and practices related to SLO

Theme/process	Interview findings	Best practices
Stakeholder engagement	Open and proactive discussions and active presence are important,	- Confidence in the process of developing nuclear facilities, from

	including ongoing and regular dialogues with local citizens, decision-makers, and local communities. Trust develops through social engagement.	land-use planning and EIA to sound government decisions - Formal hearings according to legal procedures (EIA) - Unformal hearings and discussions face-to-face and in public meetings - Active engagement with policymakers
Open communication and transparency	Regular and transparent communication regarding operations, risks, and problems. Discussions at both local and national levels are important.	- Pro-active and early communication of changes in operations - Multichannel communications through various methods and media - Timely incident response - Personalized messaging for stakeholders and groups with varying needs - Feedback and information channels availability (on-line, social media, etc.) - News and information distribution via local newspapers and infoletters/-magazines - Presence on forums and conferences - Providing accurate, fact-based information to mainstream media to prevent the spread of misinformation on social media.
Local interaction and presence	Maintaining relationships, especially with residents near nuclear facilities, is due to perceived risks and the need for a sense of safety.	- Sponsoring, co-operation with schools and local services/companies - Showroom - Arranging and participating local events
Cooperation with regulatory authorities	Clear division of responsibilities between the regulator and the operator. The regulator does not advocate nuclear power but acts as an independent regulatory authority overseeing nuclear safety.	- Incidents are partly communicated through STUK, as it is perceived as an objective source - STUK's neutral role and good reputation supports building trust - Individual protection must always be ensured regardless of facility location
Safety development and ensurance	Both factual and perceived/psychological safety are essential prerequisites for developing and maintaining an SLO.	- STUK inspectors are present at the nuclear power plant, have access to relevant information systems, and participate in meetings

	Safety is connected to organizational safety and competence. “No plant will be built in Finland unless it is safe”	- Safety plans and instructions are updated and safety drills organized on regular basis - When building safety, it is essential to consider not only technical safety but also human actions and potential errors - Cyber-security concerns must be addressed - In safety reporting, work-place safety and radiaton safety are emphasized - Well-being workforce makes fewer mistakes
Risk communication strategy	Consistent, fact-based communication during and after accidents or disturbances is important for maintaining SLO. Poor communication can erode trust.	- A balance must be found between transparent communication and excessive risk awareness to avoid creating unnecessary fears - Communication emphasizes benefits rather than risks - In case of incidents or disturbances, accurate facts and calming information should be provided without delay
Education and strengthening basic understanding of nuclear technology	Understanding nuclear power technology helps to create and enhance trust and acceptance	- Providing foundational knowledge about nuclear power and radiation at schools - Ensuring competence development for future employees in nuclear energy companies

5.3 Special characteristics of SLO in SMR projects

Based on the interview data, the social license to operate (SLO) for small nuclear power projects is built largely on the same principles as for large nuclear power plants. As one expert noted, “the principles are the same as for large plants,” referring to the fact that the importance of trust, transparency, and interaction does not change with plant size. Long-term relationship building with the local community remains key, and in municipalities that already host nuclear facilities, this long-term work is visible in more positive attitudes. For example, in Loviisa acceptance is high because “trust and cooperation have been built for a long

time." Interviewees emphasized that in established nuclear localities new projects may also be easier, since "from the perspective of an existing site, operations are always easier than a completely new one, because people are already used to it."

However, SMR projects have some distinctive characteristics that set them apart from more traditional nuclear power projects and require attention in SLO management. First, small reactors are often intended to be located closer to consumers and population centers, for example, near cities to produce district heat. The safety/emergency planning zone is estimated to be smaller, which means that a plant could be located significantly closer to housing than people are accustomed to with large reactors. According to the interviewees, this may introduce "new concerns" for local residents. According to interviewees, the appearance of an SMR in a neighborhood raises classic "Not In My Back Yard" questions, even if general attitudes toward new reactors are positive. At the local level, people consider practical impacts on their everyday environment: "what is the value of my apartment, is it safe to move around near the plant (fences, guards), will there be noise during construction, how will risk preparedness such as evacuations be handled." In other words, acceptability is shaped through concrete everyday perspectives: residents think about how proximity to the plant affects their safety and life.

Second, SMR projects face new questions related to technology and safety arrangements that may influence perceptions. A small reactor is smaller in physical size and power than a traditional plant, which may mitigate some risks. One interviewee highlighted that "the risk of a severe accident is probably small; there is less radioactive material in a small plant than in a large one." In addition, new reactor designs often rely on passive safety systems, which are believed to reduce the possibility of human error. These factors create potential for a positive image. Several interviewees, however, warned against excessive optimism. According to them, there may be even a bit of "overhyping" around small nuclear, and the assumption that SMRs would be "automatically safe" was seen as problematic if risks are not discussed sufficiently openly. Although the light-water reactor technology behind many SMRs is familiar and proven, some newer technologies are still in the prototype stage. Therefore, both regulators and industry must think carefully about how to justify and communicate safety so that "talking about it does not turn against the message." In Finland, a reform of nuclear energy legislation is underway in a more technology-neutral direction, while also considering how to ensure that new operators have sufficient competence to guarantee safe operation.

Third, the SLO for SMR projects may be influenced by new types of actors and the siting environments. Large incumbent nuclear companies in Finland enjoy relatively high trust and have a track record of safe operations. The SMR boom may bring new companies into the sector (municipal energy companies or new consortia) that do not have equivalent track records. The data identified both opportunities and risks in this entry of “new competitors”: it can bring innovation and accelerate projects, but concerns remain about risk levels and ensuring competence. Interviewees stressed that it must be ensured that even smaller actors can maintain a strong safety culture and adequate resources for robust safety oversight. In its ongoing regulatory reform, STUK is considering, for example, how much in-house nuclear competence should be required from a future licensee compared to competence acquired externally. It is important to ensure that the operating organization has sufficient nuclear safety competence inside the organization. The background of the plant supplier may also influence public opinion: one interviewee mentioned that for the public, the supplier’s nationality may have “a certain tonal difference,” which directly affects social acceptability.

Fourth, the interview data strongly highlighted the need for local engagement in SMR projects. Because this involves new technology in potentially new environments, companies must invest more in proactive communication and stakeholder participation. One interviewee stated that communication for a new project differs from the “routine operations” of an established plant and “should be started as early as possible.” Concretely, this means active presence in the locality already from the early planning phase: “it is important that already in the early design phase we are engaging the community, that we are reachable.” Several interviewees recommended face-to-face events where open discussions could take place with residents. Representatives of power companies, for example, highlighted the importance of organizing public events regularly for stakeholders to develop an SLO. Especially in a new potential SMR locality, practical resident questions must be anticipated: “people worry what happens to land value etc.,” so Q&A situations must be prepared carefully.

Uncertainty was repeatedly mentioned as a challenging factor for SLO. If people are not given information in time, rumors and worry begin to grow: “uncertainty eats away, for example what will happen to my cottage plot.” Therefore, open information sharing through multiple channels (local newspapers, residents’ evenings, social media) and genuine opportunities for people to influence planning are central to building a license to operate. It should be noted that in Finland, legislation guarantees certain influence mechanisms at the local level, most importantly, municipalities’ veto rights in nuclear power plant zoning. The

data emphasized maintaining this local decision-making power: “preserving the veto right is important” going forward as well, so that citizens feel projects are not “steamrolled” over the community’s will. Likewise, the environmental impact assessment (EIA) process was seen as an essential forum where citizens can influence decisions, even if the Nuclear Energy Act is reformed “From the residents’ perspective, the EIA process is the essential” stage for acceptability.

In summary, the interviews indicate that the SLO for SMR projects in Finland is built largely on familiar elements: trust in the regulator, trust in licensees’ safe operations, open communication, and local partnerships. Simultaneously, SMR technology creates new expectations and fears that must be managed in a balanced manner. On the positive side, combating climate change and improving supply security have been observed to give small reactors a favorable resonance in public discussions. One interviewee stated that “SMR is good for the energy transition and cleaner energy,” and for example “green electricity and security of supply” were mentioned as benefits that strengthen a positive image. However, it was emphasized that a positive image must not be based on unfounded hype. Public trust cannot be nurtured unless risks and safety measures are discussed honestly. Therefore, the social license requires realistic communication: it must be made clear that even if reactors are small, they are “real reactors” that still require equally careful safety management. This message has been well understood in Finland, where the general acceptance of nuclear energy has risen to record levels, partly because concrete safety work (such as spent fuel disposal) has been demonstrably achieved successfully. In SMR projects, continuing the same transparent work, combined with sensitivity to listening to new types of local concerns, is crucial for achieving an SLO.

5.4 Connections to safety

Based on the interviews, nuclear safety and SLO are inseparably linked in the nuclear energy sector. The social license is seen as being built on the premise that safety is non-negotiable: acceptability “is not the main point but safety,” as one interviewee emphasized. In other words, an organization must first ensure that its facility is unquestionably safe, and only then can it expect the trust of the community and stakeholders. One interviewee summarized it as: “in SLO, nuclear safety is at the core.” Trust does not emerge without a foundation of safety. However, without social trust, it is difficult to maintain a favorable operating environment for safe operations.

Safety performance and trust

From the power company's perspective, the relationship between the social license and safety begins with its actions. Interviewees emphasized the importance of a strong safety culture: a nuclear sector actor must first ensure that "we ourselves are confident that [the plant] is safe." Only then can it convince both the regulator and the public of a plant's safety. This suggests that a social license is a consequence of ensuring and credibly demonstrating technical and operational safety externally. When a company "does things well" and maintains a high level of safety, it lays the foundation for public acceptance. In practice this means continuous investment in developing safety culture: "continuous improvement of safety culture, operating culture, [and] procedures" were mentioned as ways for the organization to show it is a "responsible actor." Safety also includes broader environmental responsibility, such as the management of cooling water, waste, and other environmental issues, because these factors affect public perceptions of acceptability.

Perceived role of the regulator

In Finland, the licensee bears an unambiguous responsibility for the safety of the facility. Social license to operate is primarily based on the public's and stakeholders' perceptions, and it is also seen to rest on strict oversight exercised by an independent regulator. Many interviewees noted that, in addition to ensuring safe operations, STUK's reputation as a "strict authority" is important for general acceptance and SLO. Citizens trust that Finland will not "build a plant that is not safe." STUK's statements and participation have been observed to have a strong credibility effect in the eyes of citizens.

The relationship between the regulator and licensees was described as flexible but exacting: STUK does not compromise requirements but engages openly with operators, creating an atmosphere where issues can be discussed openly. This is important so that companies dare to report deviations and areas for improvement openly, without fear of unreasonable sanctions. Ultimately, open reporting serves both safety and trust, and hence, SLO. Interviews also suggested that transparency in Finnish nuclear operations is at a good level because of this trust: "Because STUK is trusted, it is not being challenged all the time. Therefore, we can move forward and use resources on safety, so we do not have to defend ourselves and fight with opponents." This comment suggests that trust in the regulator frees resources for both the regulator and industry to focus on what matters, that is, maintaining safety. Thus, trust strengthens safety: when external suspicion decreases, it is possible to focus proactively on risk management rather than reactively defending reputation.

Comprehensive security and the feeling of safety

In the interview data, the social license was linked to the broader concept of comprehensive security. In the nuclear context, comprehensive security is understood to cover, in addition to technical and physical safety, cybersecurity and dimensions of social security. A social license can be seen as a component of social security. This refers to the community's felt sense of safety and trust that operations are supervised and risks controlled. One interviewee referred to STUK's strategy, where the aim is to maintain citizens' "feeling of safety" and even measure how it develops. In practice, this means that statistical safety alone is insufficient; people's *experience* of safety must be considered. "STUK exists so that citizens are safe," but equally "we communicate things so that citizens do not worry and fret unnecessarily," one interviewee stated. In all communication and actions, the aim is to create and maintain an atmosphere in which the nearby community feels safe living next to a nuclear facility. This extends, for example, to public reporting of radiation measurements and open communication in abnormal situations so that suspicions do not arise. A few concrete examples were mentioned: nuclear companies organize regular emergency preparedness exercises, which can sometimes involve stakeholders (e.g., local schools and authorities). There are also planned communication exercises where handling "rumours and disinformation" in a crisis situation is practiced. Such anticipation improves readiness to maintain public trust and SLO if something unexpected occurs. Interviewees observed that incorrect information about nuclear energy occasionally circulates in Finland, especially on online discussion boards, but media expertise has improved: journalists know how to seek correct information from experts. Spreading accurate information is a means of curbing unwarranted concerns.

The interviews also raised an interesting observation about the workplace's internal sense of safety: the social license does not only affect neighbors, but also the plant's personnel. If strong opposition or demonstrations were to occur around a nuclear plant, it would "disturb the feeling of safety" among employees. Working in peace is a component of safety; personnel must be able to concentrate on safe operations without pressure from protests outside or uncertainty about the project's future due to social conflict. For this reason, nuclear sector actors actively seek to manage opposition through dialogue: "we aim to respond openly and broadly to questions (nuclear safety, other environmental issues).to show that we are a responsible actor." Openness and listening calm the situation and prevent misunderstandings from escalating into safety-related conflicts.

The impact of safety incidents on the SLO

Historical examples support the view that social licenses are fragile if safety fails. Interviewees referred to the Chernobyl and Fukushima accidents, after which “support for nuclear power” was temporarily affected in Finland. Rebuilding trust always takes time and requires transparency. Finnish nuclear sector actors have learned from these events that even minor disturbances must be addressed publicly. As an example, a case was mentioned in which a fire broke out in a temporary building at a plant site. On social media, false information about an “accident” spread, which was corrected by an authority statement emphasizing that there was no danger. Such situations show how important real-time and honest communication about safety is: if communication fails or information is withheld, trust can erode very quickly. Conversely, Finnish openness in the nuclear sector has produced results: the public has seen that safety is regularly assessed and improvements are proactively implemented. This has helped maintain the acceptance of nuclear power in Finland in recent years, despite global accidents.

In summary, the interviews conveyed a clear message: *safety and SLO go hand in hand.* Safe operation is a precondition for social acceptance, and reciprocally, a positive social license creates conditions in which safety can be ensured in the best possible way. Trust provides the space to focus on what matters. This can be described as a positive cycle: when a nuclear company invests in safety and open communication, it gains trust from society, and when societal trust is high, the company can focus even more on maintaining safety without disturbances. Therefore, safety should not be viewed separately from its social context. One interviewee captured this well: “acceptability brings a feeling of safety; perceived safety is important.” This crystallizes the point that the goal of nuclear safety, that is, protecting people, is achieved best when people also feel safe and trustful. This is precisely what safeguarding the social license to operate aims to support.

6 Conclusions

6.1 Dimensions of SLO in SMRs

Figure 8 presents the SLO framework for SMRs, synthesizing findings from the literature and interviews. The framework conceptualizes SLO in this context through four interrelated dimensions: safety, trust, legitimacy, and benefit-sharing. These dimensions represent the essential domains of public concern and stakeholder engagement that collectively shape SLO of SMR projects. Transparent and open communication is at the center of the framework, functioning as the operational core that enables each dimension to be activated and sustained.

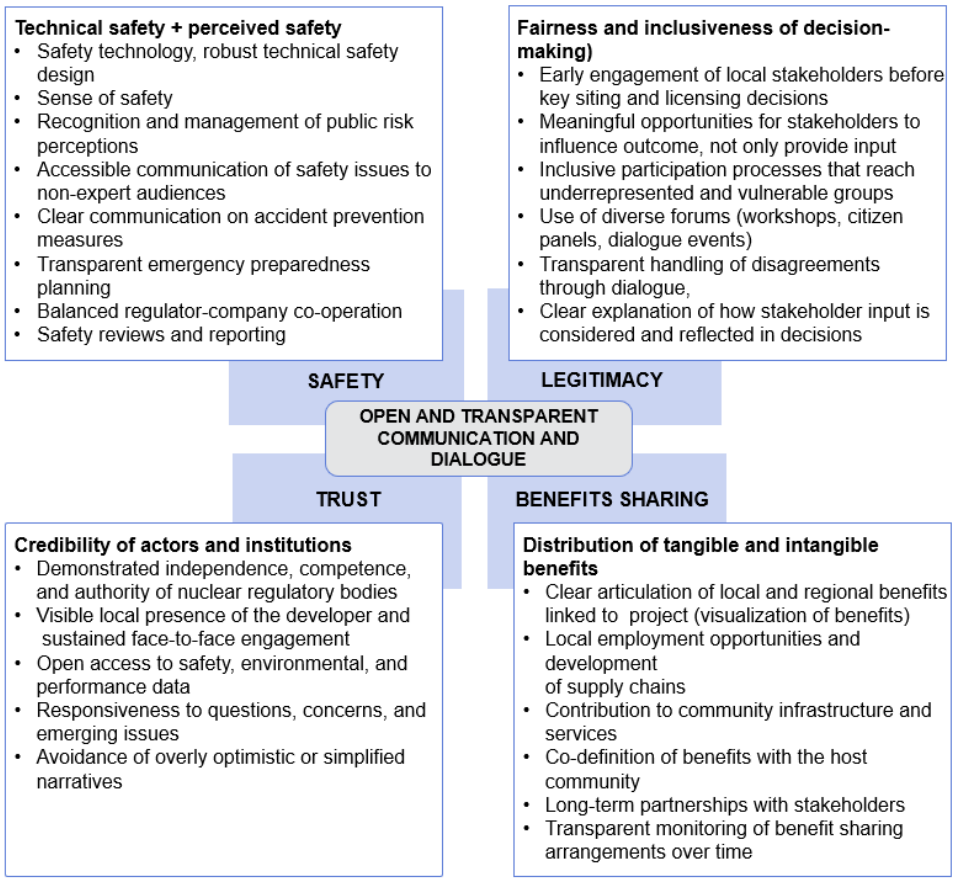

Figure 8. Dimensions of SLO in SMR projects

The *safety dimension* includes both the objective management of risks through technical design, such as passive safety systems, accident prevention protocols, and emergency preparedness, and the public's subjective sense of safety. In the context of SMRs, particularly when located near population centers, managing perceptions of safety is as important as demonstrating their engineering reliability. Project developers can support this by communicating safety strategies in accessible terms, inviting independent safety reviews from trusted institutions, and providing regular updates on safety performance, incident reporting and emergency procedures. Regarding the safety dimension, some key questions to consider include the following:

- What safety features and technologies are in place, and how are they communicated to the public?
- How is emergency preparedness addressed?
- How are public perceptions of risk assessed and responded?
- Are safety-related incidents or updates reported openly and promptly, and through what channels?

The *trust dimension* focuses on the credibility of the actors involved, including institutional and corporate stakeholders. In the nuclear field and SMR projects, trust must be built and maintained through visible regulatory oversight, long-term responsibility, and transparent governance. This can be fostered by clearly communicating the independence and authority of regulators, maintaining accountability through open data and reporting practices, and enhancing local trust by ensuring that the developer is physically present in the community, responds actively to concerns, and provides local employment opportunities. Key questions to consider for trust include the following:

- Who are the key actors responsible for the project, and do they have credible track records in nuclear safety and community engagement?
- How transparent are the project developers' intentions, actions, and communications?
- What mechanisms exist for local residents to ask questions and receive timely and trustworthy answers?

- How is the independence and competence of the regulatory authority demonstrated and communicated to the public?
- Are local stakeholders involved in monitoring, reviewing, or providing input to the project over time?

The *legitimacy dimension* addresses the fairness and inclusiveness of decision-making processes. In SMR development, legitimacy is strengthened by engaging communities early in the planning process and ensuring that they have a real influence over project decisions. This may include organizing citizen assemblies, stakeholder workshops, and participatory planning forums, where local values and concerns are openly discussed. In the Finnish context, upholding municipal veto rights in land use planning and maintaining the relevance of the Environmental Impact Assessment (EIA) process are particularly important. Key questions to consider for legitimacy include the following:

- How are local stakeholders engaged before key decisions, such as siting or licensing, are made?
- Do community members feel that they have a genuine influence over the process, or is their participation symbolic?
- Are engagement processes inclusive of vulnerable or underrepresented groups (e.g., youth, minorities, rural residents)?
- How are disagreements or concerns addressed through dialogue, redesign, or other mechanisms?

The *benefit-sharing dimension* concerns delivering tangible and equitable benefits to stakeholders, especially host communities. In SMR projects, this may include job creation, tax revenue, access to district heating, infrastructure improvements, and alignment with broader regional development and energy transition goals. Developers can promote benefit sharing by establishing community benefit agreements, ensuring local procurement of services and labor, and communicating clearly how benefits will be distributed and monitored over time. Key questions to consider for benefit-sharing include the following:

- What tangible benefits will the local community receive from the project (e.g., jobs, energy, services)?

- How are the benefits distributed? Are they equitable, long-term, and clearly communicated?
- How has the community been involved in defining the benefits that matter most to them?
- How are the benefits communicated to local community stakeholders in an understandable manner?
- Are community benefit agreements or long-term partnerships established and maintained?
- How will the project's benefits be monitored and adapted over time to match the community's needs?

Placing transparent and open communication at the center of the framework highlights the foundational role of dialogue in enabling all four dimensions. SLO cannot be achieved solely through technical performance or economic incentives. It must be actively sustained through clear, continuous, and inclusive communication with all stakeholders. This includes acknowledging uncertainties, providing opportunities for feedback, correcting misinformation, and ensuring that diverse perspectives are integrated throughout the project lifecycle.

6.2 Key lessons for building SMR SLO

Based on both the research and the interviews, we identified key lessons for building and sustaining SLO in SMR projects. Together, these lessons highlight that SLO is not a technical add-on but a long-term, relational process that must be addressed proactively throughout the SMR project lifecycle.

Table 10.

Key lessons from literature review	
Acceptability is a long-term process: early projects shape expectations	Public perceptions of SMRs are strongly influenced by the planning, communication, and governance of the first projects. Early SMR projects function as reference cases that shape expectations locally, nationally, and internationally. Decisions made in the early stages can either strengthen or undermine the perceived legitimacy of the entire technology.

Low awareness is not the same as opposition: attitudes are still fluid	In many contexts, low public awareness of SMRs should not be interpreted as implicit acceptance or resistance to them. Instead, this indicates that attitudes are still being formed and can evolve in multiple directions. This creates both opportunities and risks: early engagement can build understanding and trust, whereas neglect or one-sided communication may lead to polarization once attention increases.
Institutional trust is most important: without trust, technical arguments fail	Trust in institutions, regulators, project developers, and decision-making processes are fundamental prerequisites for SLO. Even robust technical safety arguments have limited persuasive power if institutional trust is low. Conversely, high trust can mitigate uncertainty and facilitate constructive dialogue in the presence of unresolved technical questions.
Energy-security framing helps but is insufficient alone	Framing SMRs in terms of energy security, self-sufficiency, and climate change mitigation can increase their initial acceptability. However, such macro-level arguments rarely address local concerns related to safety, siting, costs, and quality of life. SLO requires a connection between national and global benefits and locally meaningful outcomes.
Deliberative and continuous engagement reduces conflict	One-off consultations or late-stage information campaigns are insufficient for building an SLO. Continuous deliberative engagement that allows stakeholders to express concerns, ask questions, and influence decisions can reduce conflict and foster mutual understanding. SLO is strengthened when engagement is treated as an ongoing dialogue, rather than a formal requirement.
Poor participation practices harm the legitimacy of the entire technology	Inadequate or poorly designed participation processes not only affect individual projects but can also damage the legitimacy of SMR technology more broadly. A lack of transparency or exclusion of key stakeholders can generate distrust that spills over to other projects and future deployments.
SMRs are not automatically more acceptable than large reactors	Despite their smaller size and modular design, SMRs are not inherently perceived as being more acceptable than large nuclear reactors. Public acceptance depends less on reactor size and more on governance quality, safety perceptions, trust, and engagement practices. Overstating the “smallness” advantage may, therefore, undermine credibility.
Fair distribution of benefits and burdens is essential	SLO is closely linked to perceptions of fairness. Stakeholders assess not only the overall project benefits but also how costs, risks, and benefits are distributed across different groups. Unequal distribution or unclear benefit-sharing mechanisms can erode acceptance, even when overall attitudes toward nuclear energy are positive.

Information provision alone does not create acceptance	Providing factual information and technical explanations is necessary but insufficient for building an SLO. Acceptance is shaped by values, emotions, trust, and lived experiences, not just knowledge deficits. Therefore, effective SLO strategies combine information with dialogue, responsiveness, and recognition of stakeholder concerns.
Transparency and adaptability are critical under uncertainty	SMR projects involve technological, regulatory, and economic uncertainty. Attempts to downplay or conceal uncertainties can undermine trust. Transparency about what is known, what is uncertain, and how uncertainties are managed strengthens SLO, particularly when project organizations demonstrate a willingness to adapt plans in response to stakeholder input.
Key lessons from industry interviews	
SLO is enacted through practices, not terminology	The interviews indicated that SLO was rarely explicitly discussed as a formal concept. Instead, its principles are embedded in everyday practices related to responsibility, transparency, safety assurance, and stakeholder interaction. This suggests that, in the nuclear context, SLO functions as an implicit operational logic rather than an explicit managerial framework. Acceptance is built through consistent action over time rather than through the adoption of specific labels or concepts.
Institutional trust is the foundation of SLO	Trust in institutions, particularly nuclear regulator, is a decisive factor in SLO. Interviewees repeatedly emphasized that public confidence in nuclear energy is strongly linked to the perceived independence, strictness, and credibility of the regulatory authorities. This institutional trust reduces societal uncertainty and supports acceptance, even in complex and high-risk technological contexts.
Technical safety and perceived safety must be addressed simultaneously	While technical safety is ensured through rigorous design and regulation, SLO depends heavily on perceived safety. Interviewees highlighted that societal acceptance is shaped by how safety is communicated, how oversight is made visible, and how deviations or incidents are handled. Therefore, managing SLO requires continuous attention to both objective safety performance and subjective perceptions of safety.
Local acceptance is built through long-term, face-to-face engagement	The interviews underline the importance of sustained personal interaction in building local acceptance. Physical presence, informal encounters, and ongoing dialogue were considered more effective than one-off consultations or remote communications. Especially in new SMR locations, early and continuous engagement is essential for establishing trust and credibility at the local level.
	SMRs are often associated with positive expectations regarding their size, safety features, and climate benefits.

SMRs generate optimism but also risks of oversimplification	However, the interviewees warned against overly simplified or overly optimistic narratives that portray SMRs as inherently safe or unproblematic. Such framing may create unrealistic expectations and undermine trust if uncertainties and trade-offs become visible later.
Proximity increases the emotional and personal dimensions of SLO	Because SMRs may be located closer to population centers, their acceptance is influenced by everyday concerns such as housing values, landscape impacts, noise, security arrangements, and emergency preparedness. The interviews show that proximity transforms SLO from an abstract societal issue into a personal and emotionally charged matter, requiring highly context-specific engagement approaches.
Communication is a core component of total safety	Interviewees described media and social media as both opportunities and risks for SLO. While they enable rapid information sharing, they can also amplify misunderstandings and conflicts. Coordinated, timely, and credible communication, particularly between operators and authorities, is therefore a crucial element of total safety and social license management.
SLO is an integral part of total security	The interviews position SLO as closely intertwined with broader notions of total security. The technical, organizational, regulatory, social, and psychological dimensions of safety are deeply connected. A strong social license supports stable operations, reduces conflict, and enhances societal resilience, whereas a weakened SLO can indirectly undermine overall safety.

6.3 Future research agenda

This research report demonstrates that although the concept of SLO is increasingly applied in the context of nuclear energy and SMRs, several important research gaps remain. Future research is needed to deepen conceptual clarity, strengthen empirical understanding, and develop practical approaches that support the establishment and long-term maintenance of SLO in emerging nuclear projects. Both the literature review and interview findings indicate that SLO in nuclear contexts is a dynamic, relational, and institutionally embedded phenomenon that requires a more nuanced and context-sensitive investigation.

A key area for future research is the temporal nature of the SLO. Much of the existing literature implicitly treats SLO as a relatively static condition or focuses on single project phases. There is a clear need for lifecycle-oriented research that examines how SLO is built, challenged, weakened, and potentially regained at different stages of SMR projects, from early siting and design through licensing, construction, operation, and eventual decommissioning. Longitudinal studies following SMR projects over time could provide valuable insights into how stakeholder expectations, trust, and risk perceptions evolve and how engagement strategies may need to adapt across project phases. In addition, the development of models and frameworks that would support anticipating the existing level of SLO in the early stages of SMR projects would be helpful for practice.

Another critical research avenue relates to the close interconnection between SLO, safety, and perceived safety. In the nuclear energy sector, technical safety alone is insufficient to ensure societal acceptance. Future research could examine the mechanisms through which technical safety, safety culture, regulatory oversight, and communication practices translate into societal trust and acceptance. In particular, more empirical work could investigate how perceived safety is formed, how it differs from expert risk assessments, and how mismatches between technical safety and public perception can be managed. Future research could also explore how safety incidents, near-misses, and regulatory decisions affect SLO over time and how transparency and openness can mitigate the potential negative impacts on trust. A better understanding of the SLO benefits and risks related to collaborative regulator-power company relationships would also be of value.

The strong role of the state further differentiates nuclear projects from other SLO contexts. Future research could therefore examine how institutional trust, regulatory credibility, and governance arrangements shape SLO in nuclear and SMR projects. This includes studying how formal decision-making processes, such as municipal consent procedures, parliamentary approval, and environmental impact assessments, interact with informal social license dynamics. Comparative governance studies across countries with different regulatory cultures could be particularly valuable, as could research examining how changes in nuclear legislation, such as reforms to the Finnish Nuclear Energy Act, influence the establishment and maintenance of SLO.

As SMRs are expected to be deployed in more diverse locations and often closer to population centers, future research could pay increased attention to

stakeholder diversity and questions of procedural and distributional justice. This includes examining how benefits and burdens are distributed across different societal groups, how vulnerable or marginalized stakeholders can be included in engagement processes, and how local contexts, identities, and place attachment shape acceptance. Future research could also explore how SLO dynamics differ between established nuclear communities and new host communities with no prior experience of nuclear facilities.

Digitalization is another important area for future research. Digital platforms play a significant role in stakeholder communication and public discourse on nuclear projects; however, their implications for SLO remain insufficiently understood. Future research should investigate how digital channels, social media, and online participation tools shape SLO, both positively and negatively. This includes studying polarization dynamics, misinformation, trust in digital communication, and coordinating multiple engagement channels. Importantly, future research should examine how digital engagement complements, rather than replaces, face-to-face interaction and long-term relationship building.

A particularly underexplored research area concerns the role of artificial intelligence, especially generative AI, in the establishment and maintenance of SLO. While AI tools are increasingly used for communication, analysis, and decision support, there is limited research-based knowledge on how they affect trust, legitimacy, and stakeholder relationships in high-risk and contested project contexts, such as nuclear energy. Future research could examine how AI can be used responsibly to support SLO, for example, through proactive analysis of stakeholder concerns, scenario simulations, and the development of participatory tools that foster dialogue and mutual understanding. GenAI-enhanced case simulation applications, educational chatbots, and AI-supported deliberative tools offer promising avenues for supporting learning, transparency, and inclusive engagement.

Simultaneously, research could critically assess the risks associated with AI use in SLO contexts. These include issues related to perceived authenticity, accountability, bias, over-automation, and the potential erosion of trust if AI-generated communication is perceived as being manipulative or impersonal. Comparative studies on human-led versus AI-supported engagement, as well as research on design principles for trustworthy and ethically sound AI applications, could be essential for understanding when AI enhances and undermines SLO.

Finally, both the literature and interview findings underline the importance of viewing SLO as part of a broader total security framework. Future research could explore how social licenses interact with organizational safety culture, employee well-being, crisis preparedness, and societal resilience. This perspective shifts the attention from SLO as a purely social or communicative issue toward understanding it as a systemic condition that supports the safe, stable, and legitimate operation of critical infrastructure. Research that translates conceptual and empirical insights into integrative models, guidelines, and practical tools for operators, regulators, and policymakers could be valuable. Action-oriented and design-oriented research approaches, such as action design research and participatory experimentation, could be well suited for advancing both scientific understanding and practical impact in this field.

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