



Deliverable D6.15

Policy-Oriented guidelines and recommendations to advance societal responses to Radon and NORM exposure

Work Package 6



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Executive Summary

This policy-oriented document provides **policymakers** with direct access to evidence-based recommendations from the RadoNorm WP6 (Societal Aspects) research, translating them into actionable policy guidance. It bridges the gap between researchers and decision-makers, ensuring that policies on radon and naturally occurring radioactive materials (NORM) are informed by robust evidence, context-specific insights, and tested methods. The recommendations are organised into the following fields:

1. **Recommendations for policymakers to enhance citizen science initiatives addressing radon and NORM** – Establish clear project concepts with measurable goals, ensure realistic timelines (preferably over six months), apply open science principles, and integrate behavioural and socio-cultural impact assessments. Focus on intrinsic motivation, inclusive recruitment beyond aware groups, capacity building with DIY tools, and co-creation approaches involving citizens in all stages from planning to dissemination.
2. **Recommendations for policymakers to enhance evidence-based decision-making using data collected through quantitative methods** – Detect and adjust for satisficing behaviours in surveys, apply “local exclusion, global control” analysis, balance survey scales, reduce cognitive burden, integrate methodological experiments, ensure cultural adaptation and validation, and standardise cross-national comparative designs.
3. **Recommendations for policymakers to enhance evidence-based decision-making using data collected through qualitative methods** – Promote inclusive sampling, document protocols transparently, use rigorous coding and triangulation methods, include illustrative quotes, and invest in qualitative research training.
4. **Recommendations for policymakers to make evidence-based decisions regarding communication about radon or NORM** – Use tailored push–pull strategies, conduct contextual analysis, address behavioural determinants, segment audiences, design staged communication along the behavioural change continuum, and address dual radon realities in spa contexts with balanced messaging.
5. **Recommendations for policymakers to address the societal complexities associated with radon spas** – Communicate transparently about radon’s dual perception, differentiate contexts and exposures, engage health professionals as credible multipliers, and coordinate messages between therapeutic and public health actors.
6. **Recommendations for policymakers to manage radiological risks from geothermal installations, addressing societal challenges** – Conduct repeated radionuclide characterisation, train all workers including contractors, enforce sector-specific protocols, run joint awareness campaigns, harmonise legislation, share good practices, and explore reuse of residues in line with circular economy principles.
7. **Recommendations for policymakers and regulatory authorities on addressing social considerations related to building materials containing NORM** – Enact harmonised EU standards, fast-track approval processes, leverage public procurement, offer targeted incentives, enforce worker protections, engage the public directly, and ensure independent oversight of material safety certification.

8. **Recommendations for policymakers on addressing societal uncertainties in environmental remediation of NORM and historically contaminated sites** – Integrate stakeholder engagement in all phases, openly address differences in uncertainty framing, tailor solutions to site context, adapt to changing concerns, proactively manage media narratives, bridge expert–public gaps, and fund interdisciplinary social research.
9. **Recommendations for policymakers to implement a sustainable approach and circular economy in NORM and radon management** – Embed NORM and radon controls in circular economy strategies, promote safe valorisation of residues, require radon-safe design in buildings, certify recycling routes for NORM materials, incentivise public engagement, integrate monitoring systems, and align with initiatives such as the Beating Cancer Plan, New European Bauhaus, Clean Air programmes, and Sustainable Development Goals (SDGs).

Together, these **nine specific recommendation fields** provide a **comprehensive, evidence-based roadmap** to integrate science into policy and ensure sustainable radon and NORM management across Europe.

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1. Introduction

Policy-Oriented Guidelines and Recommendations to advance societal responses to Radon and NORM exposure support evidence-based policymaking by bridging the gap between policymakers—who should ideally develop public policies grounded in sound scientific evidence—and the scientists who generate that evidence. This document is based on the RadoNorm WP6 (Societal aspects) research results and is:

- Sharing links to cutting-edge research that highlights key challenges and opportunities
- Providing links to practical tools and training materials to enhance the capacity of both scientists and policymakers in effective communication and collaboration
- Building robust science-for-policy ecosystems that foster mutual understanding and trust
- Nurturing an active, interconnected community of stakeholders across the EU to promote ongoing dialogue and knowledge exchange

By connecting these two worlds, the guidelines empower policy makers and facilitate well-informed decisions that reflect the best available science for the benefit of the society.

The following policy-making fields are addressed in this document:

- Recommendations for strengthening citizen science,
- Recommendations to improve methods for social data collection,
- Recommendations related to the quantitative methods for instance surveys,
- Recommendations related to the qualitative methods for instance interviews,
- Recommendations to improve communication efforts,
- Recommendations for authorities in countries with radon spas,
- Recommendations related to managing radiological risks in geothermal energy production,
- Recommendations related to NORM for buildings,
- Recommendations related to NORM legacy and
- Recommendations for sustainability and circular economy in NORM and radon exposures.

Together, these guidelines provide a comprehensive framework for translating scientific knowledge into practical, culturally sensitive, and sustainable policies that can effectively reduce radon and NORM risks across Europe.

2. Recommendations for strengthening citizen science

Recommendations for policymakers to enhance citizen science initiatives addressing radon and NORM¹:

1. Design and plan the project

- Establish a clear project concept from the outset, with well-defined objectives, achievable goals, and tangible contributions to radon measurement and mitigation.
- Ensure that activities are feasible for citizen scientists to complete within the project timeframe and resources.
- Incorporate assessment of behavioural and socio-cultural impacts, as well as changes in participants' knowledge and radiation protection behaviours.
- Include a realistic project duration — preferably longer than six months — to enable meaningful participation in all research stages, from planning to analysis and dissemination.
- Apply open science principles, ensuring transparency, ethical standards, and robust data protection for personal and sensitive information.

2. Engage and motivate participants

- Prioritise intrinsic motivation (personal interest, sense of contribution, curiosity, enjoyment) over extrinsic rewards to ensure long-term engagement and higher retention rates.
- Communicate the scientific value and societal impact of contributions, highlighting benefits to safety, public health, and community well-being.
- Address key motivators:
 - Safety and societal stability
 - Benevolence and universalism (helping others, environmental responsibility)
 - Self-direction (learning and knowledge acquisition)
 - Enjoyment and social interaction (hedonism and self-expansion)
- For younger participants, balance extrinsic incentives (career development, recognition) with opportunities for skill-building and contribution to science.
- Provide varied engagement pathways so that different demographic groups (students, retirees, families, underrepresented communities) can participate meaningfully at multiple stages.
- Maintain engagement for participants whose radon measurement results are below risk thresholds by offering follow-up learning, peer-sharing activities, and roles in awareness campaigns.

¹ Recommendations related to citizen science for evidence-based policymaking are based on the following documents:

- Martell, M., Perko, T., Tomkiv, Y., Long, S., Dowdall, A., Kenens, J. (2021) Evaluation of citizen science contributions to radon research. *Journal of Environmental Radioactivity* 237. <https://doi.org/10.1016/j.jenvrad.2021.106685>
- Filograna, A., Martell, M. and Gignac (2023) Citizen engagement, motivation and recruitment, *Citizen science lighthouse*, December 2023. The digital magazine of the European Citizen Science collaboration group.
- Hoedoafia MA, Martell M and Perko T (2024) Evaluating citizen science projects: insights from radon research. *Front. Environ. Sci.* 12:1436283. doi: 10.3389/fenvs.2024.1436283
- Martell, M., Perko T. and Hoedoafia MA (2025) Evaluation of the RadoNorm Citizen Science Incubator (in submission).
- Chapter "radon and citizen science" co-authored by the WP6 leader (Tanja Perko) and the Task leader on citizen science (Meritxell Martell) and all the coordinators of the pilot citizen science projects (Sylvain Andresz and Caroline Schieber in France, Yevgeniya Tomkiv in Norway, Alison Dowdall and Leo McKittrick in Ireland and Veronika Oláhne Groma in Hungary) published in the book "Communicating Public Health Risk. The Case of Radon Gas" edited by José Sixto-García, Sara Pérez-Seijo and Berta García-Orosa (2025).
- Perko, T., Martell, M., Hoedoafia MA (2025) Beyond Data Collection: Unravelling the Motivations Driving Citizen Scientist Engagement (submitted in *Nature - Humanities and Social Sciences Communications*).

3. Be inclusive and pay attention to diversity

- Broaden recruitment beyond already-aware groups (e.g., those who already borrowed radon monitors) to reach populations with low radon or NORM awareness.
- Develop targeted outreach for underrepresented groups (younger homeowners, families with children, diverse ethnic and cultural backgrounds).
- Use schools, libraries, and community hubs to attract participants from different social environments.
- Increase youth participation through curriculum integration, technology-driven data collection tools, and peer-to-peer educational activities.

4. Build capacity and provide support

- Offer simple, accessible mitigation or remediation solutions alongside technical guidance.
- Provide training, Do-it-Yourself tools, and resources for measurement and mitigation, with opportunities to consult building and mitigation professionals before action.
- Build skilled project teams with expertise in radon research, citizen science methods, and community engagement.

5. Encourage collaboration and co-creation

- Encourage partnerships between authorities, researchers, NGOs, and local organisations to enhance recruitment, dissemination, and technical support.
- Shift from a primarily top-down to a bottom-up, co-creation approach, giving citizens a stronger role in shaping project goals, methods, and outputs.
- Engage citizens not only in data collection but also in data interpretation, co-creation of communication strategies, organisation of dissemination events, and contribution to research publications.
- Leverage cross-disciplinary collaborations (architecture, design, arts, environmental science) to integrate radon mitigation into broader sustainability initiatives (e.g., European Green Deal, New European Bauhaus).

6. Communicate and reach out

- Use multi-channel outreach: social media, traditional media, webinars, blogs, local events, and informal spaces (shopping centres, village intersections, private homes).
- Promote mutual learning spaces where citizens and experts can exchange perspectives, bridging knowledge and perception gaps.
- Develop risk communication strategies tailored to different cultural and social contexts.

7. Monitor, evaluate, and ensure sustainability

- Conduct science-based surveys to understand why people choose to measure and/or mitigate radon or radioactivity, and how awareness translates into action.
- Track motivation, participation patterns, and cultural factors influencing radiation protection behaviour.
- Evaluate short- and long-term impacts of projects, including public health outcomes, policy influence, and community capacity for ongoing action.
- Secure adequate budgets and resources to ensure projects can track long-term outcomes.



Figure 1: Recommendations for policymakers to enhance citizen science initiatives addressing radon and NORM, (Image created using ChatGPT, OpenAI).

3. Recommendations to improve methods for social data collection

Recommendations for policymakers to enhance evidence-based decision-making using data collected through quantitative methods

Recommendations to strengthen evidence-based policymaking through improved quantitative research methods like surveys²:

1. Monitor and address satisficing behaviours in survey data
 - Recognize that some respondents may provide minimal-effort answers. Require survey designs to include multiple indicators of satisficing, enabling accurate detection and adjustment of such answers. This ensures policymakers rely on valid, high-quality data when shaping public health strategies.
2. Apply a “local exclusion, global control” approach in data analysis
 - Encourage the use of analytic techniques that exclude satisficing responses only on the affected survey scales, while retaining valid data elsewhere. This preserves the integrity and statistical power of research findings thereby supporting policy decisions.
3. Promote the use of balanced combinations of survey scales
 - Support the deployment of both balanced (positively and negatively worded) and non-balanced scales, carefully validated for the target population. This improves detection of response biases while maintaining measurement validity critical for reliable policy insights.
4. Reduce respondent cognitive burden in survey design
 - Advocate for shorter, user-friendly questionnaires with engaging elements like visuals, especially in populations with limited prior knowledge or motivation. This enhances response accuracy, providing policymakers with dependable data on public perceptions and behaviours.
5. Integrate methodological experiments into substantive surveys
 - Encourage embedding methodological tests (e.g., alternative question formats) within larger surveys to continuously improve data quality and understanding of survey effects on responses. Such iterative refinement strengthens the scientific foundation of policy-relevant research.
6. Ensure research explicitly accounts for socio-cultural and contextual diversity

² Recommendations related to the qualitative methods supporting data collection for evidence-based policymaking are based on the following documents:

- Tomkiv, Y., Muric, M., Perko, T., Zeleznik, N., Dumitrescu, A., Hevey, D., . . . Meskens, G. (2021). *Deliverable 6.1: Collection of existing methods, databases, scales, protocols and other tools – state of the art*. Retrieved from <https://repository.uantwerpen.be/docstore/d:irua:14418>
- Martell, M., & Perko, T. (2024). *Deliverable 6.3: Training material on how to apply the methodological toolbox*. Retrieved from <https://www.radonorm.eu/publications/deliverables/>
- Perko, T., & Martell, M. (2023). *Deliverable 6.2: Open source toolbox of qualitative and quantitative methods and scales to investigate affected populations' and stakeholders' risk perceptions, views, opinions, motivations, attitudes and behaviour in radon areas and NORM exposures including methodological guidelines*. Retrieved from <https://www.radonorm.eu/publications/deliverables/>

- Require that research used for policymaking clearly describes socio-economic, cultural, political, and historical factors influencing public behaviour. This transparency strengthens the applicability and transferability of findings across different communities and regions.
7. Support cross-national and comparative research initiatives
 - Promote studies conducted in parallel across multiple countries to reveal local, national, and global influences on radon-related behaviour and policy effectiveness. This helps identify universally effective practices while respecting regional and cultural specificities.
 8. Mandate use of culturally adapted and validated measurement tools
 - Insist that survey instruments are appropriately translated, culturally adapted, and validated for the populations studied, preserving theoretical consistency. This ensures data comparability and accuracy across diverse contexts relevant for EU-wide policy formulation.
 9. Address challenges of equivalence in comparative research designs
 - Establish standards for consistent data collection modes, sampling strategies, question wording, and survey contexts in cross-cultural studies to enable meaningful, reliable comparisons that inform policymaking across varied socio-cultural environments.
 10. Promote critical reflection on methodological limitations and biases
 - Foster an evidence culture where policymakers and researchers remain aware of potential biases, sampling issues, and methodological constraints. This vigilance is key to producing robust, comprehensive social science evidence to guide effective radon and public health policies.

Recommendations to Strengthen Evidence-Based Policymaking through Improved quantitative research methods



Figure 2: Recommendations for policymakers to enhance evidence-based decision-making using data collected through quantitative methods (Image created using ChatGPT, OpenAI).

3.1 Recommendations related to the qualitative methods e.g. interviews

Recommendations for policymakers to enhance evidence-based decision-making using data collected through qualitative methods³:

1. Encourage inclusive sampling across diverse population categories
 - Authorities should promote research designs that actively include a broad range of citizen groups, ensuring better representation and a more comprehensive understanding of radon-related issues in different social contexts.
2. Support transparency and detailed documentation of research protocols
 - Require researchers to clearly describe sampling methods, recruitment strategies (including incentives), and data analysis procedures to improve reproducibility and the trustworthiness of qualitative findings.
3. Promote rigorous qualitative data analysis practices
 - Emphasize the importance of detailed coding procedures, clear categorization, and explicit explanation of how bias is minimized during analysis to strengthen the validity of conclusions drawn from qualitative studies.
4. Foster credibility through validation and triangulation methods
 - Encourage researchers to apply inter-coder agreement assessments, respondent validation, and triangulation across methods, theories, investigators, and data sources to enhance the credibility and dependability of qualitative research outcomes.
5. Require use of illustrative data to support findings
 - Advocate for the inclusion of direct participant quotes in reports and publications to provide transparent evidence for interpretations and increase the accessibility and impact of the research.
6. Invest in training and capacity-building on qualitative research standards
 - Provide resources and training to researchers and institutions on best practices for qualitative research rigor, including reflexivity and transferability assessments, to elevate the overall quality and policy relevance of radon and NORM-related social research.

³ Recommendations related to the quantitative methods supporting data collection for evidence-based policymaking are based on the following documents:

- Muric, M., Thijssen, P., Turcanu, C., Perko, T., & Tomkiv, Y. (2023). Foxes caught in the same snare: a methodological review of social radon studies. *Journal of Risk Research*, 26(3), 273-301. doi:10.1080/13669877.2022.2127850
- Martell, M., & Perko, T. (2024). *Deliverable 6.3: Training material on how to apply the methodological toolbox*. Retrieved from <https://www.radonorm.eu/publications/deliverables/>
- Perko, T., & Martell, M. (2023). *Deliverable 6.2: Open source toolbox of qualitative and quantitative methods and scales to investigate affected populations' and stakeholders' risk perceptions, views, opinions, motivations, attitudes and behaviour in radon areas and NORM exposures including methodological guidelines*. Retrieved from <https://www.radonorm.eu/publications/deliverables/>
- Perko, T., Thijssen, P., Hevey, D., Turcanu, C., & Muric, M. (2024). Measuring societal attitudes and behaviours towards radon indoors: A case study of Slovenia. *Journal of Environmental Radioactivity*, 272, 107355. doi:<https://doi.org/10.1016/j.jenvrad.2023.107355>
- Perko, T., Turcanu, C., Hoti, F., Thijssen, P., & Muric, M. (2021). *RadoNorm pilot study report from public opinion survey, Belgium 2020-2021 : development of a modular questionnaire for investigating societal aspects of radon and NORM*. Retrieved from
- Tomkiv, Y., Muric, M., Perko, T., Zeleznik, N., Dumitrescu, A., Hevey, D., . . . Meskens, G. (2021). *Deliverable 6.1: Collection of existing methods, databases, scales, protocols and other tools – state of the art*. Retrieved from <https://repository.uantwerpen.be/docstore/d:irua:14418>



Figure 3: Recommendations for policymakers to enhance evidence-based decision-making using data collected through qualitative methods, (Image created using ChatGPT, OpenAI).

4. Recommendations to improve communication efforts

Recommendations for policymakers to make evidence-based decisions regarding communication about radon or NORM⁴:

1. Recognize and tailor communication to different target groups
 - Understand that radon communication serves multiple needs: broad communication aimed at the general public to promote testing and mitigation, and stakeholder communication targeting intermediaries like family doctors, local officials, architects, and construction workers. Stakeholders should be well-informed and empowered to act as radon ambassadors to effectively influence the wider population.
2. Utilize both push and pull communication channels strategically
 - Implement a combination of push communication (e.g., advertisements on buses, radio, social media sponsored ads) that proactively reaches the audience, and pull communication (e.g., brochures in doctor's offices, informative websites) that responds to audience-initiated interest. Integrate these approaches to guide the public from awareness to action effectively.
3. Conduct thorough contextual analysis before designing communication strategies
 - Systematically analyse the current radiation exposure situation, desired outcomes, target groups, environmental factors (legislation, availability of test kits and mitigation services), and behavioural determinants. This evidence-based understanding enables the design of context-specific messages that address existing barriers and leverage facilitators.
4. Identify and address key behavioural determinants influencing radon-related actions
 - Base communication efforts on evidence regarding determinants such as awareness, knowledge, social norms, self-efficacy, perceived risk severity, and response efficacy. For example, emphasizing social norms (e.g., increasing numbers of people testing) can motivate behaviour change.

⁴ Recommendations related to the evidence-based communication are based on the following documents:

- Apers S. (2025): (In)visible and (in)vincible?: Designing theory-based, evidence-based, and strategic communication materials to increase radon detection intentions, PhD thesis, University Antwerp, doi: 10.63028/10067/2122950151162165141
- Apers S., Perko T. and Vandebosch H (2025): Recommendations for the large-scale implementation of communication tools, M83, RadoNorm Milestone.
- Apers, S., H. Vandebosch, and T. Perko, Clearing the Air: A Systematic Review of Mass Media Campaigns to Increase Indoor Radon Testing and Remediation. Communications, 2023. <https://doi.org/10.1515/commun-2021-0141>.
- Hevey, D., et al., A psycho-social-environmental lens on radon air pollutant: authorities', mitigation contractors', and residents' perceptions of barriers and facilitators to domestic radon mitigation. Frontiers in Public Health, 2023.
- Apers, S., et al., Co-Designing Communication: A Design Thinking Approach Applied to Radon Health Communication. Int J Environ Res Public Health, 2023. 20(6).
- Perko, T., & Hevey, D. (2024). Communicating radon risks: The impact of different risk formulations on risk perception and protection intention. Journal of Risk Research, 27(4), 562-580. <https://doi.org/10.1080/13669877.2024.2387346>.
- Perko, T., M. Martell, and R. Geysmans, review and evaluation of national radon action plans-MJXA23001ENN. Radiation Protection, 2024. 199.

5. Segment target audiences and tailor messages accordingly
 - Differentiate communication by audience segments (e.g., young homebuyers vs. families) and behavioural stages, using relevant formats and messages to enhance personal relevance and effectiveness. Tailored communication maximizes engagement and impact.
6. Structure communication efforts along the behavioural change continuum
 - Organize messaging to progressively move audiences through stages of awareness, interest, consideration, and behaviour, acknowledging that adoption of radon mitigation takes time. Early messages should raise awareness and spark interest; later messages should facilitate easy access to testing and mitigation services.
7. Leverage creative and culturally sensitive content formats
 - Incorporate strategies such as humour, narratives, and dynamic norms to capture attention and foster positive emotional associations with radon mitigation. Test culturally sensitive content prior to broad dissemination to avoid misunderstandings or backlash.
8. Capitalize on social media's potential for cost-effective communication
 - Utilize social media platforms for both organic growth (long-term relationship building) and paid advertising (targeted push communication). Social media offers extensive reach, precise targeting, diverse content formats, and opportunities for user interaction at relatively low cost.
9. Ensure foundational communication materials are accessible and understandable
 - Provide clear, easy-to-understand communication resources (e.g., websites, brochures) that balance technical accuracy with accessibility. Start with simple messaging and provide pathways for audiences to explore more detailed information, accommodating different levels of interest and knowledge.
10. Evaluate and optimize communication campaigns continuously
 - Before launching campaigns, confirm that communication infrastructure and content are in place. Use data and feedback to adjust strategies over time. Collaborate with communication experts, align messaging with relevant timing (e.g., heating season), learn from others' experiences, and remain open to innovation grounded in theory and evidence.
11. Countries with radon spas should address the controversy surrounding radon's dual perception as both a therapeutic agent and a carcinogen in their communication strategies.
 - Such communication strategies should carefully balance messages to acknowledge this controversy, ensuring transparency and clarity to avoid confusion and mistrust among the public while promoting evidence-based radon risk awareness and mitigation.
12. Develop multifaceted/multi-framing radon communication strategies that address both perception and practical barriers
 - Authorities should design communication campaigns that use multiple framings of radon risk—such as “naturally radioactive gas” and “indoor air pollution”—to reach different audience segments. These campaigns should also directly address the perceived burdens of remediation, and the stigma associated with radon, as these factors can moderate the impact of risk framing on mitigation intentions. Messaging should be staged over time, tailored to different decision points, and contextualized alongside other environmental risks to maintain public attention and encourage both testing and remediation.



Figure 4: Recommendations for policymakers to make evidence-based decisions regarding communication about radon or NORM, (Image created using ChatGPT, OpenAI).

5. Recommendations for authorities in countries with radon spas

Recommendations for policymakers to address the societal complexities associated with radon spas⁵:

1. Acknowledge and explain the existence of two radon realities
 - Recognize both the perception of radon as a therapeutic agent in spa contexts and as a carcinogenic hazard in homes, schools, and workplaces. Clearly communicate the characteristics of both realities so the public can understand how these perspectives coexist and why protective measures remain essential in certain settings.
2. Integrate and present both realities transparently
 - Provide information about both radon realities together in a clear, transparent, and accessible way. Transparency fosters public trust, while short and straightforward messages enhance understanding.
3. Differentiate contexts of radon use and radon risk
 - Clearly explain the different contexts in which radon is used for therapeutic purposes versus when it poses a health risk. Emphasize the main differences in exposure type, dose, and setting to avoid confusion.
4. Engage health professionals as key communicators
 - Involve doctors, general practitioners, and public health authorities in delivering holistic radon information to people encountering radon in any form. These stakeholders should act as credible multipliers, combining messages about both radon realities with guidance on health protection.
5. Foster collaboration between institutions in both radon contexts
 - Encourage cooperation between organizations operating in therapeutic and public health radon contexts. Develop joint communication strategies that maintain balance, preserve the relevance of messages in each context, and clearly distinguish between the two realities. Harmonized communication sends a strong signal that both perspectives are valid yet distinct, ultimately supporting better public health outcomes.

⁵ Recommendations for authorities in countries with radon spas are based on the following documents:

Himmelbauer K., Mihók P., Pözl-Viol C., Geysmans R., Perko T. (2024): Report on controversies between "radon as treatment in radon spas" and "radon as threat in health communication campaigns, Deliverable 6.14, RadoNorm.
Geysmans, R., Perko, T., Keser, M., Pözl-Viol, C., Fojtíková, I., & Mihók, P. (2022). Cure or Carcinogen? A Framing Analysis of European Radon Spa Websites. *International Journal of Public Health*, 67. <https://doi.org/10.3389/ijph.2022.1604559>.



Figure 5: Recommendations for policymakers to address the societal complexities associated with radon spa, (Image created using ChatGPT, OpenAI).

6. Recommendations related to managing radiological risks in geothermal energy production

Recommendations for policymakers to manage radiological risks from geothermal installations, addressing societal challenges such as safety culture and public perception ⁶:

1. Conduct repeated and wide-ranging characterization studies and measurements across geothermal installations to monitor concentrations of naturally occurring radionuclides and detect changes over time or between sites.
2. Ensure that plant operators and contractors, particularly temporary workers unfamiliar with radiological protection, receive transparent communication and targeted training on radiation risks and protective measures.
3. Develop and enforce clear sector-specific protocols and procedures for handling, storing, and disposing of NORM residues, scaling, and sludges, in line with the EU Basic Safety Standards directive and national regulations.
4. Maintain and strengthen awareness campaigns on NORM risks for the geothermal sector, led jointly by the industry and radiation authorities, to prevent complacency when measured levels are low.
5. Foster a robust legislative and regulatory framework, harmonized across countries, that clearly communicates requirements to geothermal industry stakeholders and is rigorously enforced.
6. Encourage collaboration between radiation regulators, geothermal industry bodies, and plant operators to share good practices and align safety culture across sites.
7. Evaluate cost-effective solutions for long-term handling of NORM materials, including exploring their potential reuse as resources in line with circular economy and sustainability principles.
8. Assess the need for broader stakeholder or public communication on NORM risks from geothermal installations, balancing transparency with the avoidance of unnecessary public alarm.

⁶ Recommendations related to managing radiological risks in geothermal energy production are based on the following documents:

Geysmans R. et al (2024): Data on societal aspects of radiation protection related to radon in geothermal energy projects obtained, Milestone 88, RadoNorm

Geysmans R et al (in submission): Radiological risks in geothermal energy production: a multidisciplinary study on hazard, risk perception, and radiation protection behaviour, (second review as in August, 2025)



Figure 6: Recommendations for policymakers to manage radiological risks from geothermal installations, addressing societal challenges such as safety culture and public perception. (Image created using ChatGPT, OpenAI).

7. Recommendations for stakeholders on addressing social considerations related to building materials containing NORM

Recommendations for stakeholders on addressing social considerations related to building materials containing naturally occurring radioactive materials⁷:

7.1 Recommendation for industry (Cement and construction sectors)

- Push for regulatory clarity – Join EU MS standard-setting bodies and/or national standard-setting bodies and demand consistent, science-based rules for NORM-containing binders.
- Invest in innovation infrastructure – Upgrade facilities to integrate alternative materials and meet CO₂ reduction targets.
- Lead public engagement campaigns – Partner with architects, engineers, and independent scientists to explain safety, performance, and environmental benefits in clear, relatable terms.
- Tailor messaging to local contexts – Provide extra transparency and third-party validation in sensitive markets.
- Protect workers – Implement mandatory safety training, strict handling protocols, and supply protective gear for all staff working with NORM by-products.
- Show safety through action – Publish independent safety test results and make site visits open to regulators and the public.



Figure 7: Recommendations for industry on addressing social considerations related to building materials containing naturally occurring radioactive materials (Image created using ChatGPT, OpenAI).

⁷ Recommendations for stakeholders on addressing social considerations related to building materials containing NORM are based on the following document:

Love N. (2025): Acceptance of NORM-contained By-products for Sustainable Cement: Industry and End-user Perspectives, Doctoral dissertation, <https://researchportal.sckcen.be/en/publications/acceptance-of-norm-contained-by-products-for-sustainable-cement-i>

7.2 Recommendations for policymakers and regulatory authorities

- Enact harmonised EU standards – Align safety, performance, and sustainability metrics across all member states.
- Fast-track approval processes – Reduce delays by streamlining certification for sustainable building materials.
- Use public procurement as leverage – Require low-carbon, certified materials in government-funded projects.
- Offer targeted incentives – Provide subsidies, tax credits, or CO₂-based levies to encourage adoption.
- Enforce robust worker protections – Mandate strict occupational health and safety rules for handling NORM materials.
- Engage the public directly – Create forums, citizen panels, and information portals to address concerns and build trust.
- Guarantee certification transparency – Require independent oversight for all material safety certifications.



Figure 8: Recommendations for policymakers and authorities on addressing social considerations related to building materials containing naturally occurring radioactive materials (Image created using ChatGPT, OpenAI).

7.3 Recommendation for marketing and communication managers

- Localise campaigns – e.g. Belgium: Highlight environmental impact, CO₂ savings, and circular economy benefits; showcase regulatory compliance; Czechia: Focus on proven safety and durability; use case studies and transparent safety data to overcome historical concerns; Slovenia: Emphasise affordability; pair messages with economic incentives and endorsements from scientists.
- Inspire trust through people – Use architects, scientists, and respected industry experts as spokespersons.
- Balance facts with emotions – Combine safety and performance evidence with positive narratives that link to community pride, health, and sustainability.
- Respond quickly to misinformation – Monitor media and social channels and counter myths with verified facts.



Figure 9: Recommendations for marketing and communication managers on addressing social considerations related to building materials containing naturally occurring radioactive materials (Image created using ChatGPT, OpenAI).

7.4 Recommendations for scholars and academic researchers

- Prioritise societal research – Focus on cultural attitudes, trust dynamics, and public perception of radiological risks.
- Adopt mixed-method approaches – Start with in-depth interviews, then validate findings with large-scale surveys.
- Select relevant participants – Target actual decision-makers in construction material purchases rather than public samples.
- Integrate risk perception models – Apply psychometric characteristics (dread, familiarity, controllability) to understand acceptance drivers.
- Map trust networks – Identify the most trusted actors in each country and study how they influence adoption decisions.
- Share findings beyond academia – Publish accessible summaries for policymakers, industry, and the public.

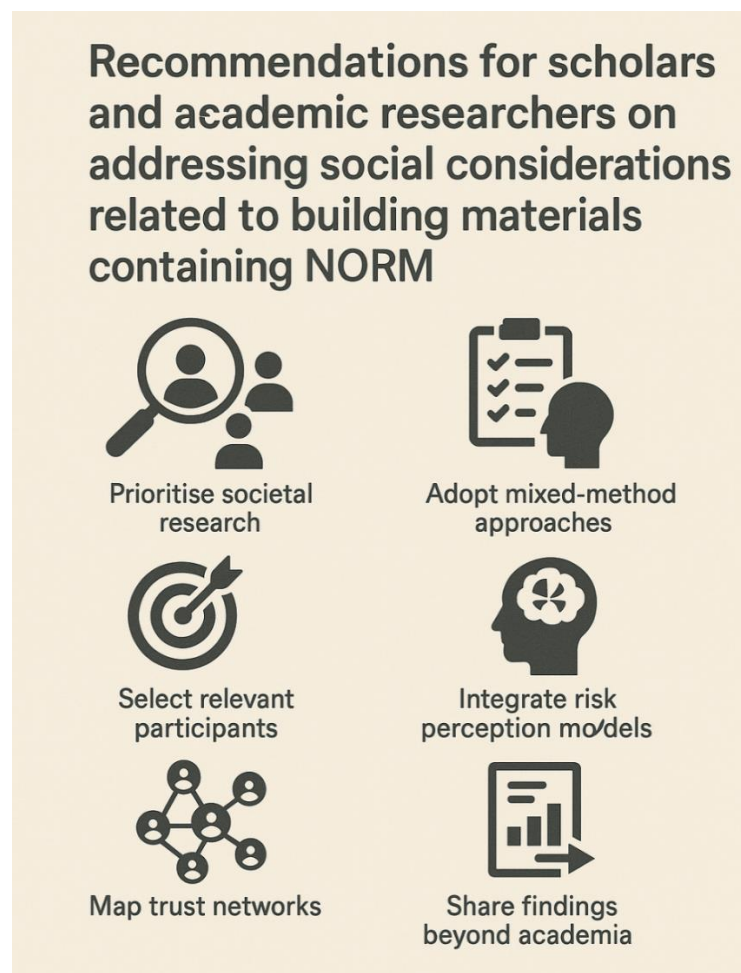


Figure 10: Recommendations for scholars and academic researchers on addressing social considerations related to building materials containing naturally occurring radioactive materials (Image created using ChatGPT, OpenAI).

8. Recommendations on addressing societal uncertainties in environmental remediation of NORM and historical contaminated sites

Recommendations for policymakers on addressing societal uncertainties in environmental remediation of NORM and historical contaminated sites⁸

1. Integrate stakeholder engagement at every stage
 - Establish structured and continuous engagement with citizens, industry, authorities, and experts before, during, and after remediation.
2. Ensure that differences in how each group perceives and frames uncertainties are openly discussed to foster mutual understanding and trust.
 - Acknowledge and map diverse uncertainties
3. Identify the technical, social, financial, legal, and health-related uncertainties faced by different stakeholders.
 - Pay special attention to societal uncertainties such as conflicting needs, land-use decisions, and trustworthiness of actors, which are often overlooked by technical experts.
4. Ensure context-sensitive solutions
5. Tailor remediation strategies to the site's history, socio-political environment, and economic context.
 - Avoid “one-size-fits-all” approaches—recognize that each site's uncertainties evolve differently over time.
6. Address temporal changes in concerns
 - Monitor and adapt to changing societal concerns as remediation progresses.
 - Track both resolved uncertainties and emerging ones, adapting strategies accordingly.
7. Strengthen media communication
 - Recognize that mass media tends to focus on management, legal, and health uncertainties—address these proactively in public messaging.
 - Provide clear, transparent, and consistent updates to counter misinformation and align public perception with scientific realities.
8. Bridge the expert–public gap
 - Support experts in addressing societal aspects alongside technical issues.
 - Provide training and tools to help reconcile public expectations with scientific imperatives.

⁸ Recommendations for policymakers on addressing societal uncertainties in environmental remediation of NORM and historical contaminated sites are based on the following document:

Perko, Tanja and Abelshausen, Bieke and Turcanu, Catrinel, Understanding Stakeholder Uncertainties in Environmental Remediation: Lessons from Belgium's Industrial Legacy of Mixed Radioactive-Chemical Contamination. Available at SSRN: <https://ssrn.com/abstract=5015734>

9. Promote long-term trust building

- Maintain openness about decision-making, roles, and responsibilities.
- Encourage third-party validation and independent oversight to reinforce credibility.

10. Fund and integrate social research

- Invest in interdisciplinary research to understand cultural attitudes, trust dynamics, and perception of risk.



Figure 11: Recommendations for policymakers on addressing societal uncertainties in environmental remediation of NORM and historical contaminated sites (Image created using ChatGPT, OpenAI).

9. Recommendations to implement a sustainable approach and circular economy in NORM and radon management

Recommendations for policymakers to implement a sustainable approach and circular economy in NORM and radon management⁹

1. Embed NORM and radon controls in national strategies
 - Integrate NORM and radon exposure management into circular economy policies and building codes.
 - Define clear accountability frameworks for regulators, industry, and municipalities to safeguard health while enabling sustainable material reuse.
 - Use established indicators to prevent greenwashing.
2. Enable safe recovery and reuse of resources
 - Promote safe valorisation of low-activity NORM residues in construction and infrastructure, following clearance/exemption criteria.
 - Require closed-loop production systems in NORM-generating industries to cut reliance on primary raw materials.
3. Mandate radon-safe, low-impact building design
 - Require radon-resistant construction standards in new builds and major renovations.
 - Incentivise retrofits that combine radon mitigation with energy efficiency upgrades.
4. Create certified pathways for circular NORM materials
 - Establish certified recycling and reprocessing routes for trace-NORM content materials with full traceability and radiation safety compliance.
 - Fund market development for secondary raw materials from safely processed residues.
5. Drive public engagement and behavioural change
 - Co-create clear, practical guidance with communities on safe material reuse and radon risk reduction.
 - Offer incentives for citizen-led radon testing and adoption of low-carbon remediation techniques.
6. Invest in monitoring, innovation, and improvement
 - Implement integrated monitoring systems for NORM reuse and radon exposure trends, connected to open data platforms.
 - Support R&D in low-energy processing, radon capture, and innovative circular building methods.
7. Align with EU and global initiatives
 - Connect national efforts with existing European Commission programs such as the Beating Cancer Plan, New European Bauhaus, Clean Air initiatives, and the UN Sustainable Development Goals (SDGs).
 - Leverage these frameworks for funding, policy alignment, and shared best practices.

⁹ Recommendations policymakers to implement a sustainable approach and circular economy in NORM and radon management are based on the following documents:

Love N. (2025): Acceptance of NORM-contained By-products for Sustainable Cement: Industry and End-user Perspectives, Doctoral dissertation, <https://researchportal.sckcen.be/en/publications/acceptance-of-norm-contained-by-products-for-sustainable-cement-i>

Mihok P. et al (2025): Updated strategic research agenda for social science and humanities research in the field of radon and NORM, Deliverable 6.16, RadoNorm

Recommendations for policymakers to implement a sustainable approach and circular economy in NORM and radon management



1 Embed NORM and radon controls in national strategies



2 Enable safe recovery and reuse of resources



3 Mandate radon-safe, low-impact building design



4 Create certified pathways for circular NORM materials



5 Drive public engagement and behavioral change



6 Invest in monitoring, innovation and improvement



7 Align with EU and global initiatives



Figure 12: Recommendations for policymakers to implement a sustainable approach and circular economy in NORM and radon management (Image created using ChatGPT, OpenAI).