Project memo

Roadmap for building public and societal acceptance for CCS from waste incineration, taking into account local, national and European policy frameworks

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Summary

This report presents a roadmap for building public and societal acceptance for carbon capture and storage (CCS) from waste-to-energy incineration in Trondheim, Norway. It is designed for both policymakers and academic readers, integrating local, national, and European policy frameworks alongside structured short-term (to 2030) and long-term (to 2050) actions. The roadmap is grounded in two attached tables detailing acceptance objectives, stakeholder engagement, key performance indicators (KPIs), and risk mitigations. The analysis draws from Trondheim's participation in the NetZeroCities (NZC) Pilot Cities initiative and the 2025 Trondheim Citizen Assembly (Folkepanel) on CCS. We diagnose typical acceptance barriers-perceptions of moral hazard, safety, costs, and greenwashing-and map these to targeted strategies: transparent monitoring and third-party verification, equity-oriented cost design, institutionalized public participation, and continuous communication. Policy alignment with European measures such as the Net-Zero Industry Act and the Industrial Carbon Management Strategy, as well as Norwegian instruments including Longship, Northern Lights, CLIMIT, and Enova, is emphasized. The report concludes with strategic recommendations and measurable KPIs to secure a continuing societal mandate.

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1. Introduction and Context for CCS in Waste Incineration

Climate policymakers recognize carbon capture and storage (CCS) as a crucial tool for mitigating emissions from hard-to-abate sectors on the path to climate neutrality.[1] [2] One such sector is municipal waste management: even with ambitious recycling and waste reduction efforts, waste-to-energy incineration of residual waste produces significant CO_2 emissions. Trondheim, Norway's third-largest city, exemplifies this challenge. By 2030, Trondheim aims to cut direct greenhouse gas emissions by 80% and offset the remainder to achieve full climate neutrality.[3] Currently, about one-quarter of the city's emissions come from its waste-to-energy plant, which burns unsortable waste and supplies district heating. Installing CCS at this facility could capture an estimated 220,000 tonnes of CO_2 per year, dramatically reducing emissions by preventing CO_2 from entering the atmosphere.[4] Importantly, roughly half of these emissions are biogenic (from organic waste), so their capture and storage would count as negative emissions, aligning with the need for carbon removals to meet climate targets.

However, implementing CCS on a waste incinerator is not only a technical and economic endeavour but also a social one. Public acceptance and trust are pivotal to project success. The Trondheim CCS initiative faces unique governance circumstances: the city does not own the plant (it is operated by Lunera Energi, an energy company), meaning the municipality must act through partnership rather than direct control.[3] This necessitates close cooperation between public authorities and the company, and strategic engagement with the community to build understanding and support. The project is part of Trondheim's participation in the EU NetZeroCities Pilot Cities program, which positions it as a test bed for climate neutrality solutions. As such, it is not just a local engineering project, but also a learning model for how cities can drive decarbonization through CCS in waste management, even when infrastructure is owned by external actors.

This report provides an academic and policy-oriented roadmap for building public and societal acceptance of CCS at Trondheim's waste incineration plant. It draws on insights from the NetZeroCities (NZC) Pilot Cities project in Trondheim, the 2025 Trondheim Citizen Assembly (Folkepanel) on CCS, and relevant policy frameworks at the local, national, and European levels (including the EU's Net-Zero Industry Act and Industrial Carbon Management Strategy, Norway's Longship project and funding programs like CLIMIT/Enova, and emerging carbon removal certification schemes). We outline short-term and long-term actions (summarized in structured tables) to engage stakeholders, address public perceptions, integrate participatory processes, manage risks, and track progress via key performance indicators (KPIs). The goal is to provide Trondheim municipality and Lunera Energi with a plausible roadmap for CCS deployment in waste incineration earns and sustains a broad societal mandate.

2. Public Perceptions and Acceptance Challenges

Large-scale CCS projects worldwide have historically faced public perception challenges, ranging from safety fears to scepticism about their role in climate strategies. Understanding these perceptions is the first step to building acceptance. Surveys and case studies indicate that public awareness of CCS is often low, and opinions can be ambivalent or divided.[5] [6] [7] For example, in countries like Germany, public opposition comparing CO_2 storage to nuclear waste disposal led to legal bans on onshore CO_2 storage. Even in Norway, a country generally familiar with CCS due to its oil and gas industry experience, acceptance has nuances. National polling shows a strong majority (over 80%) of Norwegians support CCS for mitigating domestic emissions, but support drops if CO_2 from other countries would be imported for storage in Norway.[5] This highlights how trust and fairness perceptions (who benefits and who bears risk or burden) influence acceptance.

At the local level, Trondheim's citizen panel on CCS in 2025 – based on OECD principles[8] - provided direct insight into community attitudes and concerns. Rather than a simple "yes or no" on the project, the citizens' assembly, a representative group of 19 residents selected by lot, was asked how to implement the CCS project in a *socially just and publicly understandable* way. Over four workshops, participants learned

about CCS from experts, deliberated on its implications, and then presented 15 recommendations to the city government.[9] These recommendations reveal key acceptance factors:

- Equity and cost distribution: The panel insisted the costs of CCS must be shared fairly across society. In their top recommendations, they urged that those with the largest carbon footprints should pay more, implementing a principle that "high climate footprint = high payment". Practically, this means distributing costs among the state, municipality, industry, and citizens such that fees correspond to the amount of waste each produces (directly or indirectly). They also warned that the project must not exacerbate social inequality, calling for special consideration to protect low-income households from undue financial burden. In short, climate measures should be just, not regressive.

- Transparency and information: Another clear message was to ensure transparency in decision-making and accessible information. The citizens recommended that Trondheim municipality maintain a transparent process, providing precise and relevant information about the CCS project (and other climate measures) in clear, non-technical language. They felt that broad support is only possible if people have *trustworthy information* on the project's necessity, costs, benefits, and risks. This also links to informed consent: people are more likely to accept a project if they feel they understand it and if authorities openly share data (for instance, emissions monitored, safety reports, etc.).

- Broad engagement and participation: The panel emphasized early and meaningful involvement of stakeholders. They urged the city and relevant actors to involve citizens at an early stage – not just in Trondheim but also in any other communities affected by the project (e.g. along transport routes). This implies that public engagement should go beyond one-off consultations; it should be continuous and inclusive, giving people a sense of agency in how the project is implemented. Participatory methods like the Citizen Assembly itself help legitimize decisions by incorporating community perspectives into project planning.

- Continued waste reduction efforts: A prominent concern was the so-called *moral hazard* of CCS in waste management, the fear that implementing carbon capture might serve as an "excuse to burn waste" or reduce motivation for recycling and waste reduction. Participants stipulated that even if CCS is realized at Tiller (the waste plant site), the municipality must continue strengthening reuse, waste reduction, and sorting incentives. In other words, CCS should not undermine the waste hierarchy; it must be presented and managed as a *complement* to, not a substitute for, waste prevention and circular economy measures. This addresses a broader critique often levied by environmental NGOs that CCS could perpetuate unsustainable practices if misused. The Trondheim public wants assurance that CCS will tackle *unavoidable* emissions, while upstream efforts to minimize waste remain relentless.

- Safety and environmental concerns: Though the Trondheim panel focused more on fairness and process, safety is a common public concern with CCS. People unfamiliar with CCS might worry about CO_2 leakage, accidents during transport, or potential environmental impacts of storing CO_2 underground (even though the immediate local impact is minimal compared to, for example, an oil spill). To build trust, these concerns must be proactively addressed. Therefore, a 2027 objective in the roadmap is to "build trust in safety & monitoring" by conducting transparent risk assessments and even including CCS in emergency preparedness drills. This reflects the principle that demonstrating safety (through independent monitoring, rigorous regulation, and involving first responders in planning) can alleviate public fears over the long term.

- Credibility and "greenwashing" fears: Another challenge is ensuring the project's environmental integrity is credible. Some critics might label CCS as "greenwashing" if they suspect it's used to

enable business-as-usual operations with only superficial climate benefit. To counter this, the roadmap includes actions like commissioning independent third-party audits and publishing full life-cycle analyses (LCA) of the CCS system by 2029. Open data and peer-reviewed validation can demonstrate that the carbon reductions are real and substantial, helping convince sceptics that CCS is delivering genuine climate value rather than serving as "window dressing" for polluters.

In summary, public acceptance of CCS in waste incineration hinges on trust, trust that the project will *deliver* promised climate benefits, *operate safely*, *use resources responsibly*, and *complement* broader sustainability goals. It also hinges on the sense of fairness, that the initiative is not imposed on the public for corporate benefit, but rather co-created with the community's values in mind (fair costs, democratic participation, transparency). The Trondheim Citizen Assembly experience shows that when given the chance, the public can engage deeply with these complex issues and offer nuanced support conditional on certain safeguards and commitments. These insights directly inform the roadmap actions proposed, ensuring that technical deployment goes hand-in-hand with social issues.

2.1 Policy Framework Analysis: Local, National, and European Context

Implementing CCS at a municipal waste facility involves navigating a multi-layered policy landscape. Acceptance will depend not only on local community buy-in, but also on supportive policies and signals from higher levels of government. Here we analyse relevant policy frameworks and initiatives at the local (city), national (Norway), and European scales, and how they enable or condition the CCS roadmap.

2.2 Local Policy Context – Trondheim's Climate Strategy and Initiatives

Trondheim has positioned itself as a frontrunner in urban climate action. As one of 112 European cities in the EU's Mission for Climate-Neutral and Smart Cities by 2030, Trondheim has committed to an ambitious climate strategy. The city's climate action plan (often termed the Climate City Contract) rests on four pillars: becoming *climate neutral*, *energy smart*, *circular*, and *climate resilient*.[10] The CCS project at the waste incinerator aligns with these goals on multiple fronts, it directly cuts emissions from a major source (advancing neutrality), decarbonizes district heating (advancing energy efficiency and clean energy use), reinforces the circular economy by addressing end-of-life emissions (complementing waste reduction efforts), and demonstrates innovation that can enhance climate resilience.

Local political support for CCS has been evident. Trondheim's city government (byråd) has treated the waste CCS project as a key climate measure. Indeed, one of the target outcomes by 2030 is to have a "broad social mandate" for CCS, symbolized by a formal City Council motion reconfirming support for the project. Integration into city planning is also underway: for example, Trondheim's Climate Plan is expected to reference CCS in the waste sector as part of reaching net-zero. The city has also leveraged participation in networks – by 2030 they aim to showcase the CCS project in European city networks and gain recognition, which can further validate the project locally. Being acknowledged by peer cities or initiatives (like the NetZeroCities program) can enhance local legitimacy, contributing to acceptance.

The Trondheim citizens' assembly on CCS itself is part of an EU-supported local initiative. It was conducted as an EU pilot project with support from NetZeroCities.[11] The willingness of the municipality to experiment with deliberative democracy and possibly institutionalize it (the 2025 panel was Trondheim's third use of this method) reflects a local governance innovation. Such participatory policymaking is aligned with OECD best-practice principles for deliberative processes and signals to the public that the city values their voice in shaping complex projects. This local approach can be seen as a policy framework in itself – one of governance – that prioritizes stakeholder engagement and trust-building as an integral part of climate project implementation.

In terms of local regulation, waste incineration with CCS at Tiller likely requires updates to permits or local environmental regulations (for example, to account for CO_2 capture operations and transport). Trondheim's role includes ensuring these regulatory processes are transparent and that preparedness (a municipal responsibility) incorporates CCS scenarios.

2.3 National Policy Framework – Norway's CCS Strategy (Longship, CLIMIT, Enova)

Norway has been a pioneer in CCS development, viewing it as essential to decarbonize heavy industries and generate new industrial opportunities. The Norwegian government's flagship CCS effort is Longship (Langskip), a full-chain demonstration project comprised of CO_2 capture at industrial sites, plus transport and storage in the North Sea. Announced in 2020, Longship was touted as "Norway's moon landing" for climate technology[12] and represents Norway's largest climate investment to date.[13] It includes *Northern Lights*, the joint venture by Equinor, Shell, and TotalEnergies that provides open-access CO_2 transport and storage infrastructure. Phase 1 of Northern Lights, now operational in 2025, offers 1.5 million tonnes/year of storage capacity and has already commenced injecting CO_2 2.6 km beneath the seabed.[14] This capacity was filled initially by CO_2 from a cement plant (Heidelberg's Norcem) captured under Longship support. The Norwegian state covered ~2/3 of the cost of the first capture project (Norcem) and storage network, amounting to NOK 16.8 billion (~€1.6 billion) in support.[12]

Longship also envisioned a second capture project at Oslo's Klemetsrud waste-to-energy plant (previously Fortum Oslo Varme, now Hafslund Oslo Celsio), capable of capturing ~400,000 tonnes CO_2 per year.[15] The government made its funding contingent on the project securing the rest of the investment from external sources (e.g. EU funds or private investors).[12] As of 2022, that waste-CCS project did obtain significant co-funding, including an EU Innovation Fund grant and commitments from private tech companies via a carbon removal purchase agreement, enabling it to proceed.[16] [17] This case sets a precedent for Trondheim: national co-financing can be pivotal, but local projects may need to tap diverse funding streams (European funds, carbon credit buyers, etc.) to materialize. By 2028, the Trondheim roadmap anticipates signing regional Memoranda of Understanding (MoUs) and publishing an updated business model for CO_2 management, likely drawing lessons from Oslo's financing approach and potentially partnering with other regional emitters to achieve economies of scale.

Beyond Longship, Norway supports CCS through research and market incentives. The CLIMIT programme is Norway's national R&D and pilot funding program for CCS, jointly run by Gassnova (the state CCS enterprise) and the Research Council. For over 20 years, CLIMIT has funded research, development, and demonstration projects to advance CCS technologies.[18] It has covered everything from capture technology innovation to storage monitoring techniques. Trondheim's CCS project can benefit from CLIMIT support for any novel components (for instance, testing new solvent technologies for flue gas or improving energy efficiency of capture from biogenic emissions). In the roadmap, national R&D support via CLIMIT is noted as an enabler particularly in the 2027–2029 timeframe, e.g. to develop sound Monitoring, Reporting and Verification (MRV) plans and optimize the capture process.

Similarly, Enova, a state-owned climate funding agency under the Ministry of Climate and Environment, provides grants for implementation of cutting-edge emissions reduction projects. Enova has previously supported industrial CCS feasibility studies and energy efficiency upgrades. The roadmap envisions Enova (and/or related programs) contributing to de-risking the CCS project around 2027, aligning with the national goal to promote innovation in hard-to-abate sectors.[19] By demonstrating active national backing (financial and technical), these programs help build public confidence that CCS is a serious, government-supported climate solution and not solely an industry experiment.

Norway's broader climate policy also underpins CCS deployment. Norway aligns with the EU on emission targets (at least 55% reduction by 2030 from 1990 levels) and has a net-zero 2050 goal. The government's official climate plans highlight CCS as necessary for emissions cuts in sectors like cement, waste, and chemicals, where direct electrification or alternatives are limited. Norway also views CCS as

an economic opportunity: by becoming a CO_2 storage hub for Europe, Norway can create jobs and value from its offshore geology. Norway aims to be a storage provider for European CO_2, effectively exporting storage services to European companies.[20] This is relevant to Trondheim because the long-term viability of the waste CCS project may include connecting to a larger network that imports CO_2 from elsewhere. Public acceptance in Norway for such a role is not yet a given (as noted, there is public caution about importing CO_2), so Norwegian policymakers are crafting narratives around responsibility and opportunity, e.g., emphasizing that using Norway's offshore storage for international CO_2 can strengthen climate action globally while leveraging Norway's expertise. Maintaining strong political consensus on CCS (historically bipartisan in Norway) is important to avoid policy swings that could alarm the public or investors. The Longship project had broad parliamentary support in 2020,[12] albeit with some political pushback recently, still indicating stable backing that should be communicated to local stakeholders as a sign of commitment.

2.4 European Policy Framework – EU Initiatives (NZIA, ICMS, Carbon Removal Certification)

At the European level, recent policy developments significantly favour CCS deployment, which can bolster local projects like Trondheim's both directly (through funding/regulation) and indirectly (through normative support and targets). The EU Net-Zero Industry Act (NZIA), enacted in 2023, explicitly lists CCS as a strategic net-zero technology and sets a landmark target: by 2030, the EU must establish at least 50 million tonnes per year of CO_2 injection capacity in geological storage.[21] This 50 Mt goal – roughly equivalent to 10% of EU industrial emissions, is now a *legally binding obligation* primarily placed on the oil and gas industry, which is required to develop storage sites for captured CO_2. The NZIA's inclusion of CCS means faster permitting processes for CCS facilities might be possible (the Act aims to streamline permits for net-zero tech projects), and it signals to markets that carbon storage is a critical part of Europe's decarbonization. The NZIA goal and status of CCS as strategic technology provide high-level validation: local stakeholders can see that it aligns with EU priorities and is not an isolated venture. Moreover, the NZIA may unlock or redirect funding (e.g. through the Innovation Fund or other mechanisms) to CCS projects to reach that 50 Mt capacity.

Complementing the NZIA, the European Commission released the Industrial Carbon Management Strategy (ICMS) in 2024.[22] The ICMS lays out a comprehensive roadmap for scaling carbon capture, utilization, and storage across Europe's industrial sectors in line with climate targets. Notably, it extends the vision beyond 2030: the ICMS targets an annual CO_2 injection capacity of 250 million tonnes by 2040 in the European Economic Area.[23] It addresses barriers such as the business case, regulatory gaps, and infrastructure needs. For instance, the ICMS calls for guidance to standardize CO_2 storage permitting by 2025 and for an EU-wide CO_2 transport and storage infrastructure planning mechanism. These efforts will facilitate projects like Trondheim's by improving the availability of transport networks (pipelines, shipping routes) and storage sites. Indeed, by 2030, the EU foresees CO_2 transport networks spanning thousands of kilometers to connect sources and sinks. Trondheim's captured CO_2 will likely be shipped to the Northern Lights storage; EU support for cross-border CO_2 shipping (for example, classifying CO_2 as non-hazardous for transport, funding import/export terminals) is vital. The ICMS also encourages Member States (and Norway as an EEA member) to provide co-funding and consider instruments like Contracts for Difference for carbon management, which could underpin the economics of waste CCS by bridging the gap between cost and carbon price.

Another emerging pillar in the EU framework is the Carbon Removal Certification Framework (CRCF). Adopted in 2024, this regulation establishes a voluntary EU-wide system for certifying carbon dioxide removals.[24] It creates criteria and methodologies to validate when a process is delivering net removals (as opposed to merely reducing emissions). This is directly relevant to CCS on waste incineration because a portion of the waste CO_2 is biogenic. If Trondheim's waste CCS captures, say, 50% biogenic CO_2, that portion could be certified as a carbon removal (essentially bioenergy with CCS, or BECCS). By the 2040s, as the roadmap suggests, Trondheim may integrate negative emissions into its strategy – potentially blending biomass or other biogenic waste to increase the biogenic share. Under the EU certification, those

removals could generate certificates that have market or compliance value. The roadmap anticipates that by 2041–2045, the project will verify removals with at least ≥50% biogenic CO_2 in the captured mix. For policymakers, this opens pathways to monetize negative emissions (e.g., via selling removal credits) or count them toward climate neutrality pledges. However, it also introduces a communication challenge: public acceptance of selling carbon credits can be mixed. The roadmap flags a potential "credit backlash", if citizens perceive that companies profit from carbon credits without local benefit, or that removals are used to offset others' emissions, it might create scepticism. This underscores that any involvement in carbon markets must be coupled with transparency and demonstrated local benefits (for example, revenue from credit sales invested in community climate projects, as a mitigation strategy).

Lastly, EU waste and climate policies may increasingly intersect with CCS. While currently municipal waste incineration is outside the EU Emissions Trading System (ETS), there have been discussions about including it in the ETS by 2028 or later as part of tightening climate regulations. If that happens, the price of emitting CO_2 from waste plants will rise, strengthening the financial case for CCS (to avoid carbon costs). It would also signal to the public that emitting from waste is no longer free, aligning economic incentives with climate goals. Even if not formally in the ETS yet, Trondheim's proactive approach anticipates a future where unabated incineration could face penalties, thereby framing CCS as a forward-looking solution to keep waste management viable in a carbon-constrained world (mitigating "cost backlash" by highlighting that CCS avoids future carbon taxes or ETS costs).

In summary, the European policy environment is increasingly favourable for CCS: strategic targets (50 Mt by 2030) to drive scale, funding and regulatory support via NZIA and ICMS, and new mechanisms to recognize carbon removals. Trondheim's CCS roadmap explicitly ties into these frameworks – for example, referencing the NZIA 50 Mt target for 2030 and the EU's 2040 climate target of a 90% emission cut – to ensure local actions are synergistic with EU ambitions. This multi-level alignment not only facilitates resources and knowledge exchange but also provides a narrative of legitimacy.

3. Short-Term Roadmap: 2030

Building on the understanding of public concerns and policy supports, the following recommended short-term roadmap (to 2030) outlines yearly objectives and actions for Trondheim municipality and Lunera Energi to foster public acceptance of the waste CCS project. It is structured by year, detailing the *acceptance objective*, key actions for both the city and the company, relevant policy enablers, target stakeholders, KPIs, and risk mitigation measures. Table 1 presents a summary of the short-term roadmap:

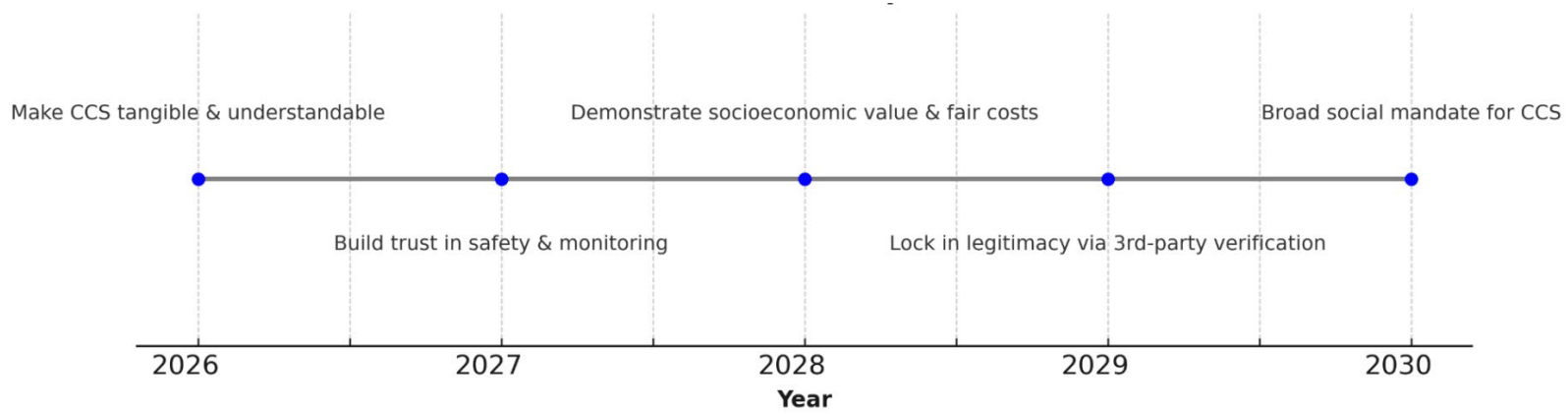
Table 1. Short-Term Roadmap (2026–2030) for Public & Societal Acceptance of WtE-CCS in Trondheim.

Year	Acceptance objective	Trondheim municipality – key actions	Lunera Energi – key actions	Policy & enablers	Stakeholder engagement focus	KPIs (acceptance & transparency)	Risks & mitigations
2026	Make CCS at Tiller tangible & understandable	Launch explainer, climate plan updates	Publish project brief, host tours & Q&A	EU: NZIA 50 Mt/yr target, ICMS; National: Longship/Northern Lights; Local: Trondheim climate plan	Households, NGOs, neighbourhood committees	≥70% awareness, 2000 residents engaged through various media channels, quarterly fact sheets	Risk: 'CCS = excuse to burn waste'. Mitigation: link to waste hierarchy & circularity
2027	Build trust in safety & monitoring	Community advisory panel, include CCS in emergency exercises	Engage national and municipal policymakers through structured dialogue; align business model with emerging regulatory frameworks Publish MRV plan(Monitoring, Reporting and Verification), release performance dashboards	EU: ICMS roadmap; National: CLIMIT/Enova supports; Local: CCS integration in preparedness	Local authorities, first responders, businesses, unions	CAP established, 100% recommendations tracked, zero incidents	Risk: Safety concerns. Mitigation: transparent risk assessments & drills
2028	Demonstrate socioeconomic value & fair costs	Cost impact explainer, regional CO_2 hub forum	Sign regional Memorandum of Understanding (MoUs), publish business updated model Launch public information campaign, publish cost and benefit assessments	EU: ICMS, NZIA networks; National: Northern Lights expansion	Low-income households, consumer council, municipalities	Impact review, ≥60% see CCS heat as good value, 2+ partners in forum	Risk: Cost backlash. Mitigation: phased tariffs, highlight ETS avoidance

2029	Lock in legitimacy via third-party verification	Commission NTNU/SINTEF audits, embed CCS in training	3rd-party verification, publish cradle-to-storage LCA Establish citizen advisory forum and stakeholder dialogue platform	EU: ICMS indicators; National: CLIMIT/R&D support	Academia, teachers, apprentices	Independent audit, 3000+ students engaged, annual scorecard	Risk: Greenwashing claims. Mitigation: open datasets, peer review
2030	Broad social mandate for CCS	Council motion reaffirming CCS, showcase in EU city networks	Publish 5-year performance report, host international open day Implement financing model combining national support, EU funding, and limited local contributions	EU: NZIA 2030 target; National: Longship integrated	City networks, media, cultural institutions	≥70–75% support, 90%+ trust in safety, recognition by EU city networks	Risk: Policy shifts. Mitigation: diversify funding & options

Acronyms: EU = European Union; NZIA = Net-Zero Industry Act; ICMS = Industrial Carbon Management Strategy; CAP = Community Advisory Panel; MRV = Monitoring, Reporting & Verification; LCA = Life-Cycle Assessment.

Figure 1. Simplified visual graph of Short-Term Roadmap (2026–2030) for Public & Societal Acceptance of CCS at Tiller Waste-to-Energy.



The short-term roadmap above focuses on making the project acceptable to the public in its initial years. In 2026, the emphasis is on awareness and education – turning the abstract concept of CCS into something concrete that citizens can see, learn about, and discuss. This includes publishing explanatory materials, incorporating CCS into education, and continuing to physically opening up the facility for tours. Early transparency and outreach address the knowledge gap of the project (people can put a place and process to the idea of CCS). The success metric is high awareness (targeting ≥70% awareness) and direct engagement of a sizable number of residents. Notably, the identified risk – "CCS = excuse to burn waste" – is countered by consistently framing CCS as part of *responsible waste management*, not a license for more waste. The communication strategy here ties the project to Trondheim's efforts in recycling and waste reduction, showing that CCS is the "end-of-pipe" solution for what can't be otherwise avoided.

The establishment of a Community Advisory Panel institutionalizes citizen involvement, giving community stakeholders a seat at the table to monitor progress, flag concerns, and influence decisions. This fosters co-ownership of the project's oversight. Simultaneously, emergency preparedness integration demonstrates that authorities are taking potential risks seriously (even if major incidents are unlikely, planning for them shows diligence). The goal of zero incidents is not just for safety itself but to maintain trust – one accident or leak could severely set back public confidence. The presence of national R&D support (CLIMIT/Enova) for monitoring technology or safety improvements can be highlighted to the public as building confidence.

In 2028, as the project matures towards operation, public attention will shift to evaluating economic terms. Hence the focus on socio-economic value and cost fairness. The city and company must articulate the financial impacts: How might this affect the cost of waste management or district heating tariffs? What are the funding sources (e.g., state support, EU grants, carbon credits) and how do they offset costs for locals? Conducting a cost impact explainer and engaging consumer groups will help pre-empt misunderstandings. The KPI of at least 60% perceiving CCS heat as good value is key – majority support that it's worth the money will defuse cost objections.

By 2029, assuming the facility is operational or about to be, the strategy is to cement legitimacy through independent verification. The involvement of third parties (e.g., researchers from NTNU/SINTEF) to audit the project's outcomes and environmental performance will add credibility. Publishing a full life-cycle carbon accounting (from construction of the capture unit to the CO_2's final storage) addresses any lingering questions about net benefit. Engaging students and academia also serve a dual purpose: it educates the next generation in CCS as a topic of study. The risk of "greenwashing" is best mitigated by transparency and independent oversight, which are exactly the actions in 2029. Essentially, by the end of 2029, the aim is that an informed observer (NGOs or media outlets) can access all relevant data and third-party evaluations to conclude the project is legitimate.

Finally, in 2030, the project should seek a "broad social mandate," implying that CCS has moved from a novel idea to an accepted, even appreciated, part of Trondheim's climate policy landscape. The mitigation for policy risk – diversifying funding – will have been addressed if by 2030 the project's economics involve a mix of stakeholders (city, state, EU, private sector, perhaps carbon credit revenue) so that no single political decision can sink the project. This financial resilience is part of earning long-term public trust: people are more likely to support a project they see as sustainably financed rather than one budget cut away from cancellation.

In sum, the 2026–2030 roadmap gradually shifts focus from awareness (knowledge) → trust (safety & transparency) → value (cost-benefit) → legitimacy (external validation and integration). Each year's plan builds on the last, continuously engaging stakeholders and responding to emerging concerns. By 2030, CCS at the waste plant should be an integrated element of Trondheim's climate action, with citizens seeing it as "our project" – one that reflects their input, addresses their concerns, and contributes to shared goals.

4. Long-Term Roadmap: 2050

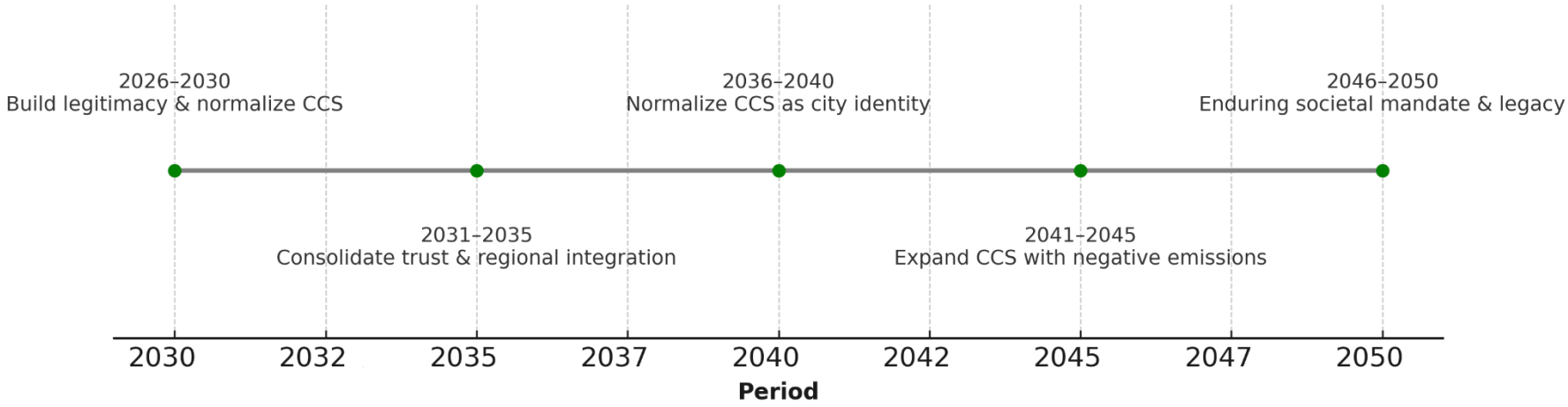
Looking beyond 2030, continuing public acceptance will require sustained effort as the project transitions from initial implementation to long-term operation and potential expansion (such as incorporating negative emissions). The long-term roadmap (to 2050) outlines acceptance objectives for successive phases, roughly aligned with major shifts in context (e.g., scaling up CCS network, normalizing the technology in society, integrating carbon removals). Table 2 summarizes the long-term roadmap in multi-year periods:

Table 2. Long-Term Roadmap (2026–2050) for Enduring Societal Acceptance of WtE-CCS.

Period	Acceptance objective	Trondheim municipality – key actions	Lunera Energi – key actions	Policy & enablers	Stakeholder engagement focus	KPIs (acceptance & transparency)	Risks & mitigations
2026–2030	Build initial legitimacy & normalize CCS	Communication strategy, embedding CCS in climate plan, citizen panel, schools	Publish CCS brief, tours, transparent MRV & LCA	EU: NZIA, ICMS; National: Longship/Northern Lights; Local: Climate-neutrality goal	Households, NGOs, unions, businesses	≥70% awareness, CAP established, annual MRV, >60% support	Risk: 'CCS = excuse to burn waste'. Mitigation: emphasize waste hierarchy
2031–2035	Consolidate trust & regional integration	Trøndelag CCS hub, regional plans, expand education	Regional emitter partnerships, optimize capture, publish impacts	EU: ICMS mid-term review; National: expanded storage	Other industries, municipalities, vocational schools	≥75% trust, 2–3 partners, cost transparency	Risk: Cost backlash. Mitigation: social tariff models, innovation funds
2036–2040	Normalise CCS as part of city identity	Integrate CCS in cultural/heritage storytelling, permanent climate forum	Stable >90% efficiency, community benefit fund	EU: 2040 target (90% cut); ICMS consolidation	Cultural institutions, citizen assemblies	≥80% support, CCS in curriculum, annual benefit report	Risk: Policy uncertainty. Mitigation: diversify climate measures
2041–2045	Expand CCS role with negative emissions	Narrative shift to resilience & circularity; integrate BECCS	Pilot BECCS, verify removals, engage with EU removals registry	EU: Negative emissions frameworks, carbon removal certification; National: storage hub	City networks, credit buyers, researchers	Verified removals, ≥50% biogenic CO_2, ≥80% support	Risk: Credit backlash. Mitigation: local benefit emphasis, transparency
2046–2050	Enduring societal mandate & legacy	Institutionalize CCS in neutrality strategy, embed in heritage narrative	25-year review, explore utilization/decommissioning	EU: 2050 net-zero; National: Norway as EU storage provider	EU policymakers, climate networks, heritage bodies	≥85% support, 25-year review published, CCS part of city heritage	Risk: Lock-in critique. Mitigation: show declining waste, focus on negative emissions

Acronyms: BECCS = Bioenergy with CCS; DACCS = Direct Air Carbon Capture & Storage.

Figure 2. Simplified visual graph of Long-Term Roadmap (2026–2050) for Enduring Societal Acceptance of WtE- CCS.



The long-term roadmap is organized into phases that reflect how public acceptance and engagement strategies ought to evolve as CCS moves from novelty to normalcy, and as external conditions change. Key themes include regional collaboration, cultural integration, negative emissions, and ensuring a lasting positive legitimacy.

During 2026–2030 (initial phase), the groundwork is laid for legitimacy. Many actions here mirror those already detailed in the short-term plan (since this period overlaps), emphasizing embedding the project in official plans and communication. The idea is to fully integrate CCS into Trondheim's climate narrative by 2030, so that it is viewed as a natural component of the city's strategy (not a standalone experiment). By achieving >60% support by 2030 and having annual transparent reporting, the city ensures the foundation is solid. The recurring risk of "CCS = excuse for waste" is noted even in this phase, underlining that consistent messaging over multiple years is needed to dispel that notion.

In 2031–2035, the focus shifts to scaling and regional integration. By this time, assuming success at Tiller, there may be interest from other emitters (e.g., industries in Trøndelag region) to connect to the CO_2 transport/storage infrastructure. Collaborative efforts can improve public perception by demonstrating broader benefits: Trondheim's project might enable neighbouring communities or factories to also cut emissions, multiplying climate impact. The municipality's role expands to being a regional coordinator or hub facilitator. Maintaining cost transparency is critical here; if new partners join, the finances might change (e.g., maybe revenue from others buying into the storage capacity). The risk of cost concerns resurfaces, so mitigating measures like social tariffs (ensuring fairness in who pays) and innovation funding to reduce costs per ton are proposed. Successfully communicating economic benefits (like new jobs in carbon logistics or revenues from offering storage services to others) will help counter any narrative that Trondheim bears costs for others' benefit.

By 2036–2040, CCS should ideally be a normal part of city operations, akin to the wastewater treatment or recycling system. The risk here is "policy uncertainty", e.g., if global/climate politics take a turn and support for climate action wanes, or if some argue resources should shift elsewhere. Trondheim can mitigate that by continuously highlighting that CCS was implemented alongside a suite of measures (not at their expense) and by ensuring local leaders remain advocates in national/EU forums to keep climate policy consistent.

The 2041–2045 phase introduces *innovation in negative emissions*. As easy emissions sources are eliminated, attention turns to going net-negative. Trondheim's waste CCS by now might increasingly capture biogenic CO_2 (if waste volumes shrink, the plant might co-incinerate more biomass or use bio-waste) or even integrate with direct air capture if technology allows. Public acceptance of this evolution requires education on what negative emissions are and why they're needed (the climate math of balancing residual emissions). Engaging the public on such forward-looking concepts keeps them part of the journey. The risk of "credit backlash" is noteworthy; selling removal credits can be sensitive if locals feel their climate action is being commercialized or letting others off the hook. The mitigation is to manage it transparently and ensure locals see benefit or at least consent to how credits are used. By including NGOs and having open discussions, Trondheim can navigate the ethics of carbon removals. If done right, by 2045 the city could be celebrated for contributing to net-negative efforts, with strong support (target ≥80% still) and with its citizens understanding that they are helping solve not just the city's emissions but part of a global solution.

Finally, 2046–2050 is about culminating the project's legitimacy. As 2050 approaches, Europe and Norway aim to be net-zero, and Trondheim's CCS will have been running for around 25 years. At this stage, long-term questions arise: Will the plant continue operating past 2050 (if waste generation has drastically reduced by then due to circular economy success)? How will infrastructure be decommissioned or repurposed eventually? It's important these questions be handled openly *well in advance*, so the public sees there is a responsible end-of-life or next-life strategy. Conducting a 25-year review around 2049 provides a full

account of what the project achieved, emissions prevented, climate impact, costs, social impact, essentially closing the loop to the promises made back in the 2020s. The risk is the notion that by investing in CCS, maybe the city slowed down innovation in waste reduction or got stuck with a single solution. The mitigation is to demonstrate that was not the case: show data that waste volumes did decline (meaning the city did pursue reduction strongly), and that CCS scaled accordingly or eventually tapered as less waste was incinerated.

Overall, the long-term roadmap ensures that societal acceptance is continuously cultivated and not taken for granted. Public attitudes can change over time, especially as new generations come of age and as external events (accidents, climate impacts, economic shifts) influence opinions. Thus, the roadmap envisions a dynamic engagement strategy: always informing, involving, and adapting to maintain trust. By 2050, CCS at Trondheim's waste plant should ideally be seen as a hallmark of the city's environmental leadership.

5. Integration of Participatory Approaches and Stakeholder Engagement

A standout feature of Trondheim's approach, and a key recommendation for any city pursuing CCS, is the integration of participatory approaches to ensure societal buy-in. Traditional top-down decision-making is ill-suited to projects like CCS that involve complex science, perceived risks, and ethical questions about climate responsibility. The *"quadruple helix"* model of innovation ought to be utilised: involving not just government, industry, and academia (the classic triple helix), but also citizens as an equal part of the equation. This inclusion of the public in technological governance is fundamental for legitimacy.

The 2025 citizens' assembly (folkepanel) on CCS is a prime example. The municipality invited, through stratified random sampling, 19 residents spanning various ages, professions, and neighbourhoods, to deliberate on the CCS project over multiple sessions.[11] Participants were given balanced information from experts (including researchers, the utility, and NGOs), then facilitated to discuss and form recommendations. This process follows international best practices for deliberative democracy (as outlined by OECD[25]) and has precedents in solving contentious issues (e.g., climate assemblies in France, citizens' juries in Ireland). By both national and international standards (size and scope), Trondheim's citizen panel was a success: it achieved a relatively high retention (19 of 30 selected completed all sessions) and generated 15 concrete recommendations that were presented directly to local policymakers. This not only produced valuable substantive input (as detailed earlier) but also had a broader effect: it demonstrated to the wider public that *citizens* could understand CCS and contribute meaningfully, potentially increasing public confidence in the collective decision-making process. It also likely increased the legitimacy of the project since those who might have been sceptics could be reassured that there was appropriate citizen engagement.

Moving forward, the roadmap embeds participatory engagement at multiple points: establishing a Community Advisory Panel (CAP) by 2027 is a way to make citizen involvement permanent, beyond a one-off assembly. A CAP would include local community representatives, perhaps some members of the Citizen Assembly alongside other stakeholders (like a school representative, a local business owner, etc.), meeting periodically to review project progress and advise the municipality and Lunera Energi. This continuous dialogue can catch issues early (for example, if there's an uptick in public concern or a specific concern like construction noise or increased truck traffic, the CAP can flag it, and solutions can be co-developed). Tracking CAP recommendations (one KPI) shows a commitment that input will be heard and responded to.

The roadmap also envisions citizen assemblies or panels being institutionalized. The 2025 panel was not the first in Trondheim, and officials expressed intent to use this method more routinely. Institutionalization could mean, for instance, making a citizens' assembly a standard part of major project planning or setting up

a city office for public deliberation. In terms of acceptance, this normalizes citizen co-decision in climate actions.

Beyond formal assemblies, stakeholder engagement includes targeted outreach to specific groups as noted in the roadmap. Working with NGOs and local environmental groups is also wise, Trondheim can bring them into dialogue (as they did by providing diverse perspectives to the Citizen Assembly). If NGOs see that the project is addressing concerns (like not undermining recycling), they may offer cautious support or at least not vehement opposition, which helps broader public sentiment.

Finally, participation is not just about formal meetings; it's also about how information flows. The plan for annual reports, public dashboards, open days, etc., means that at any given time interested citizens can find out what's happening with the CCS project. The difference between a well-informed public and a misinformed one often comes down to proactive communication. Trondheim appears intent on sharing both successes and challenges openly. This two-way communication (with feedback loops like surveys, panels, and advisory groups) will make the public feel respected and heard. In contrast, had the city chosen a technocratic, closed approach, it might breed suspicion or opposition.

Participatory approaches are a cornerstone of building societal acceptance. They improve the project by incorporating local knowledge and values, and they improve the public's perception by building trust and a sense of agency. Trondheim's roadmap could serve as a model for other cities: combining expert-driven policy with citizen-driven deliberation yields more rigorous, democratically legitimate outcomes. As climate solutions often require changes that affect communities, such hybrid governance may become increasingly essential.

6. Risks, Mitigations, and Key Performance Indicators

The development of CCS in waste incineration comes with several risks to public acceptance, many of which we have touched on. It is crucial for project planners to continuously assess these risks and implement mitigation strategies. Concurrently, tracking progress through KPIs related to acceptance and transparency can provide quantitative evidence of whether public trust is being maintained and where more work is needed.

6.1 Key Risks and Mitigations:

- "Burn More Waste" Perception: A recurring risk noted is the public fear that CCS will serve as a license to continue or even increase incineration, potentially undermining waste reduction efforts (in essence, a technology lock-in or moral hazard concern). Mitigation: The messaging and policy must consistently reinforce commitment to the waste hierarchy. For example, Trondheim's strategy to publish data on waste throughput and recycling rates alongside CCS performance is a way to show that waste volumes are not increasing because of CCS – ideally they are decreasing due to separate policies. In public communications, city officials tie CCS to *unavoidable* waste emissions, and simultaneously highlight new recycling initiatives or reduction campaigns. By the 2040s, showing a declining trend in total waste incinerated would be the ultimate proof that CCS did not stall progress on circular economy.

- Safety Concerns (Leaks/Accidents): The thought of transporting and storing CO_2 can evoke concern – images of a leaks (even if unrealistic with proper site selection) or accidents during CO_2 tanker transport. Mitigation: Transparency and preparation. Norway's regulatory regime for CO_2 storage is stringent (leveraging decades of offshore CO_2 injection experience at Sleipner), and communicating that track record is helpful. The zero-incident KPI each year is ambitious, but the project will strive for it, and in the event of any minor incident, a rapid, transparent response will be critical to

maintaining trust (acknowledging what happened, how it's fixed, and what will prevent a recurrence).

- Cost and Economic Risks: If the project leads to noticeable cost increases for residents (through waste fees or heating prices), there is a risk of backlash, especially if people feel costs are unfair or benefits unclear. This risk could spike in times of economic difficulty or if energy prices are high. Mitigation: Keeping the cost distribution fair is key. As recommended by the Citizen Assembly, ensuring low-income households are shielded (perhaps through targeted subsidies or using revenues to offset their costs) will prevent social equity issues.

- Greenwashing and Efficacy Doubts: Some stakeholders (particularly environmental NGOs or critical media) might suspect that the project over-claims its climate benefits or hides problems – the "greenwashing" risk. Mitigation: Third-party involvement for accountability. By 2029, plans for independent audits and a cradle-to-storage LCA. The willingness to expose the project to scientific scrutiny and then share the results (good or bad) builds credibility.

- Political and Policy Instability: Changes in political leadership or policy priorities at the city or national level could change support or funding for the project. Mitigation: Achieve institutional entrenchment and multi-partisan support. At national level, continued broad consensus on climate policy including CCS (which Norway has had) is important.

- Carbon Credit / Ethics Concerns: In the later stages, if the project gets into selling carbon removal credits, there is a risk some local or global observers might criticize it as enabling emitters elsewhere or commodifying local climate action. Mitigation: Transparency and local benefit use of proceeds. Government can, for instance, involve the public in deciding how any revenue from carbon credits is spent – e.g., channel it into a climate fund (as noted, a possible benefit fund by 2036–2040). This way, credits are seen as generating local good, not just corporate profit. Also, strict adherence to high-integrity certification (so only net removals after thorough accounting are sold, avoiding double-counting or exaggeration) will make the practice more acceptable.

6.2 Key Performance Indicators (KPIs):

The roadmap includes quantifiable KPIs related to acceptance and transparency. These serve two purposes: they guide the implementers in terms of targets to hit (which keeps the focus on the "soft" social side, not just the technical CO_2 tonnes captured), and they provide a mechanism to demonstrate success or need for improvement to both leaders and the public.

Some major KPIs and their significance:

- Awareness Levels (≥70% awareness by 2026, maintained thereafter): Measuring public awareness via surveys is fundamental, if a large portion of the populace is unaware of the project, misinformation can fill the void. Achieving high awareness early (and presumably higher as years go on) means outreach is effective.

- Support/Opposition Levels (e.g., >60% support by 2030, rising to 75–85% in later years): These metrics gauge public opinion directly. They would likely come from polling or the city's citizen surveys. The trend is as important as the absolute number, one expects as familiarity increases, so should support.

- Trust in Safety (>90% trust by 2030): Trust is slightly different from support, someone might support the idea but still harbour fears. Including a metric on trust in safety will reflect whether

communication on risk and actual safety performance is convincing the public. High trust levels likely correlate with the absence of incidents and the presence of effective risk communication.

- Engagement Numbers (e.g., number of residents engaged, etc.): These are tangible counts of how many people have been reached through tours, meetings, programs. If targets aren't met, it may mean outreach isn't extensive enough or needs diversification (maybe some demographics aren't being reached).

- CAP or Assembly Outcomes (e.g., CAP established, % recommendations acted upon): A KPI of "100% of CAP recommendations tracked" or similar indicates responsiveness. It's not to say all recommendations must be implemented, but tracking means each gets an official response or consideration. This ensures citizen input is taken seriously, which in turn encourages future participation (people see their input wasn't ignored). If this KPI fails (recommendations languish) trust can erode.

- Information Transparency (e.g., quarterly fact sheets, annual MRV reports, scorecards published): These deliverables are themselves KPIs, ensuring that they actually go out on schedule. Publicly releasing information at regular intervals sets transparency, thus, adherence to these outputs is critical.

Regularly monitoring these KPIs and publishing them is itself a measure. It demonstrates an evidence-based approach to public engagement.

In summary, the combination of risk management and KPIs creates a feedback loop: mitigation strategies address known or anticipated public concerns, and KPIs measure if those strategies are working (with respect to public perception). This approach turns societal acceptance into a deliverable outcome that is planned, resourced, and evaluated, rather than an afterthought. It transforms "social license" from a vague notion into a set of concrete targets that are pursued with the same rigor as engineering targets, a model that any CCS project should emulate to ensure technology and society advance hand-in-hand.

7. Strategic Recommendations for Policy and Communication

Drawing together the analysis above, this section provides strategic recommendations for both policymakers and project stakeholders (Trondheim municipality and Lunera Energi) to achieve and sustain public acceptance of CCS in waste incineration. These recommendations are aligned with the roadmap's insights, intended to guide decision-making and communication:

1. Anchor CCS in a Holistic Climate Strategy: Present CCS not as an isolated high-tech fix, but as part of a comprehensive climate solution portfolio. Policymakers should explicitly link CCS to waste reduction, recycling, and other climate measures in plans and communications, underscoring synergy rather than trade-off.

2. Prioritize Fairness and Cost Equity Mechanisms: Implement concrete policies to ensure equitable cost distribution of the CCS project. This may include sliding scales for fees, subsidies for vulnerable groups, or spreading costs across multiple funding sources (national/EU grants, cross-sector partnerships) so that individual households are not overburdened. Clearly communicate these measures to the public. By visibly protecting low-income residents (e.g., through energy bill support funded by CCS revenue or savings), the project can be portrayed as not only climate-friendly but socially just, in line with Just Transition values.

3. Maintain Transparency and Open Data Practices: Stakeholders must commit to maximum transparency at all stages. In practice, this means: publish performance data (capture rates, downtimes, emissions avoided) in near real-time on public dashboards; release all safety and environmental monitoring reports; share contracts and agreements related to the project (except legitimate commercial confidences). Additionally, consider creating a public-facing CCS data portal where interested citizens, researchers, or journalists can access data about the project's operation and environmental impact.

4. Institutionalize Public Engagement in Governance: Embed citizens' assemblies or panels as a norm for major climate projects. Policymakers could develop a guideline that any significant climate infrastructure project (beyond a certain scale) will be accompanied by a representative citizen panel to deliberate on its implementation. This not only benefits the CCS project but strengthens democratic governance for future issues.

5. Ensure Multi-Level Policy Alignment: For policymakers, it's important to align local projects with national and EU policy frameworks, not only on paper but through active policymaking. Trondheim's case benefits greatly from EU and national support; reciprocally, Trondheim should support upward for policies that help CCS acceptance. Such vertical integration helps smooth out inconsistencies – for example, if the EU were to propose including waste incineration in the ETS, Trondheim can provide input on how that might affect local acceptance and what safety nets to include.

6. Monitor, Evaluate, and Adjust: Finally, public acceptance should be treated as an iterative process. Continuously monitor the KPIs discussed (awareness, support levels, etc.) and gather both qualitative and quantitative feedback through surveys or other channels. Having a formal annual review of the engagement strategy itself could be beneficial, ideally involving the community panel. In essence, apply a learning-by-doing approach: each year learn from the previous year's engagement outcomes and community feedback, then refine methods.

By implementing these recommendations, Trondheim municipality and Lunera Energi, along with support from national and EU partners, can foster a sound enabling environment for CCS in waste incineration. The approach ought to be inclusive, transparent, and adaptive, combining the rigour of policy frameworks with community engagement. This comprehensive strategy not only increases the likelihood of sustaining success for the CCS project at Tiller but also strengthens democratic climate action capacity in Trondheim for future challenges.

8. Conclusion

In conclusion, building public and societal acceptance for CCS from waste incineration is an achievable goal, as evidenced by the progress in Trondheim to date. It requires deliberate effort across technical, social, and political dimensions. By following short- and long-term actions, rooted in effective communication, participatory governance, supportive policies, risk management, and continuous learning, cities can gain the "social license" needed to deploy advanced climate technologies. Trondheim's experience serves as a valuable case study for other European cities, demonstrating how the lessons emerging from NZC and pilot-city initiatives can be translated into practical, scalable approaches to urban climate action.

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