

WP5; Enabling Sustainable Business Model

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CCWaste4NetZero

Authors

Bjørn Hølaas, Morten Fossum, Karianne Stræte Resell, Marie Bysveen, Kristin Jordal, Michael Becidan, Raymond Andreas Stokke, Markus Steen.

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1 INTRODUCTION

The CCWaSte4NetZero Pilot City-project is a pioneering initiative aimed at implementing Carbon Capture and Storage (CCS) in a waste-to-energy (WtE) facility in Trondheim, as part of Trondheim's strategy to achieve climate neutrality by 2030. Recognizing that WtE incineration is one of the city's largest single sources of emissions, the project aims to establish a common starting point by engaging key stakeholders, including municipal authorities, industrial actors, research institutions, and the public, to align on the importance of WtE/CCS.

A central focus of the projects' Work Package 5 (WP5) is to develop viable business model for CCS from the WtE plant in Trondheim.

This report summarizes the activities ACT 34, 35, 36, 37, 38, 39,40, 41, 42, and 43 in WP5.

2 WP 5.1; REQUIREMENTS FOR A VIABLE BUSINESS MODEL FOR WTE FOR THE TRONDHEIM PLANT

2.1 ACT 36 Financial status (Capex/Opex) for the CCS-project in Trondheim, including status financial model

Financial status

The estimates for Capex/Opex are partly based on AACE Class 4 estimates, +/- 30% (CC plant), and AACE Class 5 estimates, +/- 50%.(pipeline and intermediate storage)

Capex

Carbon capture plant	3686 MNOK
Transport to, and Intermediate storage	678 MNOK
Contingency	625 MNOK
Total	4988 MNOK

Opex

CC plant	70 MNOK/y
Intermediate storage	12 MNOK/y
Transport to, and permanent storage	153 MNOK/y
Total	235 MNOK/y

Levelized cost of carbon capture (LCCC)

Since today's commercial conditions currently not are sufficient to establish a robust business case, we have not spent time entering detailed figures for e.g. NPV calculations. The main focus has been various LCCC calculations.

LCCC is a cost calculation methodology designed to capture the full lifecycle cost per ton of CO₂ captured in a CCS project.

Calculations are based on results from the Concept study. All figures are real, i.e. adjusted for price increases/inflation, and do not include tax considerations. The result of the calculations shows an LCCC of approx. 3000 NOK/tCO₂ (uncertainty -30/+50).

2.2 ACT 41 Understand position, preferred business model, of Norwegian Industry actors, NGO's and other WtE facilities

NGOs/Norwegian Industry

Both Bellona and ZERO are important contributors to establishing robust and viable regulatory and commercial conditions that enable the realisation of CCS.

The environmental organisation Zero emphasises that CO₂ capture is a crucial technology for achieving climate targets, especially in sectors where it is difficult to reduce emissions through other means. Regarding waste incineration, Zero believes that CO₂ capture is absolutely necessary to reduce the significant emissions generated by combustion of residual waste. They point out that without the capture and storage of CO₂ from waste incineration, it will be extremely challenging to achieve net zero emissions in this sector. Zero also highlights that waste incineration without CO₂ capture could undermine the green transition, and that support schemes and clear regulatory frameworks are important for realising such projects.

Bellona has long been a strong advocate for the development and implementation of CO₂ capture as an essential climate measure. The organisation underscores that CO₂ capture is crucial for reducing emissions from sectors where alternative solutions are hard to find, including waste incineration. Bellona points out that without the capture and storage of CO₂ from the combustion of residual waste, it will be nearly impossible to achieve significant emission reductions in this sector. Furthermore, they believe that the establishment of support schemes and predictable regulatory conditions is vital for enabling investments in such solutions, ensuring that CO₂ capture from waste incineration is realised and contributes to achieving national and international climate goals.

Norwegian industry has generally expressed support for carbon capture as an important tool for reducing emissions and ensuring the long-term competitiveness of the land-based industrial sector. Many stakeholders view carbon capture as key to meet both national and international climate requirements, while also helping to maintain jobs and industrial activity in Norway. At the same time, it is pointed out that the reality for land-based industry depends on clear framework conditions, predictable support schemes, and the availability of infrastructure for CO₂ transport and storage.

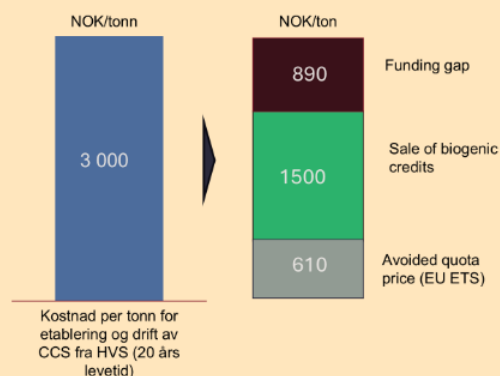
Business model WtE

The regulatory and commercial landscape affecting CCS from WtE plants in Norway is complex and fragmented. The CCS project has alone and together with other waste incineration plants in Norway worked to ensure sufficient clarification of the commercial conditions. This is important to assess the realism of realization, and also give further direction for the project.

The business model for carbon capture and storage (CCS) in waste incineration centres on two primary revenue streams: (i) avoidance of fossil CO₂ taxes and (ii) income from the sale of biogenic carbon removal credits (CRCs). The potential inclusion of waste incineration in the EU Emissions Trading System (EU ETS) is a significant factor, with clarity expected in July 2026 when the EU presents its proposal. For fossil CO₂, future EU ETS pricing will be crucial, while for biogenic CO₂, the ability to sell CRCs has been confirmed with preliminary price/value.

The combined revenues from tax avoidance and CRC sales are currently insufficient to cover the estimated cost of implementing a CCS value chain (NOK 3,000/tCO₂ by 2031/32). Three supplementary mechanisms have been identified to address this financial gap: support from the EU Innovation Fund and Enova, support scheme for transport and storage, and a national support scheme involving a reversed tax.

Financing needs – assuming EU ETS



Financing gap can be solved through one or a combination of several measures:

- Investment support from Enova and/or the EU Innovation Fund:
 - Support scheme under development by Enova, expected Q4 2026
 - Annual calls from the EU Innovation Fund
- Reduction of transport and storage costs:
 - Support scheme under development by Enova, expected during 2026
 - Important that this results in *real* lower costs for the emitter
- Rights-based reversed tax for storage of biogenic emissions:
 - Being assessed by the Norwegian government for the 2027 national budget

30

The Norwegian government is exploring financial incentives for CCS, with a proposed reversed tax for biogenic CO₂ capture and storage. This scheme is under development and will be presented in the National budget for 2027; its future is not guaranteed.

The business model for CCS in waste incineration is evolving, with policy developments at both EU and national levels influencing project viability. Key next steps include monitoring EU ETS proposals, engaging with national tax authorities, maintaining dialogue with CRC buyers, preparing for EU Innovation Fund/Enova applications, advocating for regulatory changes, and influencing the design of financial support mechanisms. Ongoing analysis and stakeholder engagement are essential to ensure project readiness as new regulatory and commercial frameworks emerge.

2.3 ACT 43 Market assessment for carbon removals (market platforms, price forecast, customer attractivity etc.)

The WtE plant in Trondheim is well positioned to generate and sell high-quality carbon removal credits (CRCs) by capturing and permanently storing biogenic CO₂ emissions. Norway's leadership in carbon capture and storage (CCS) and growing international demand for durable removals create favourable market conditions. However, the sector faces regulatory uncertainties, especially regarding the EU Emissions Trading System (ETS) and the inclusion of WtE and carbon dioxide removal (CDR), fragmented standards for CRCs and limited subsidies.

To address these challenges, it is advisable for WtE CDR stakeholders to certify projects under reputable standards such as the Integrity Council for the Voluntary Carbon Market (ICVCM), target buyers with aligned values, and ensure registry and quantification practices adhere to ICROA and ISO standards. Monitoring policy developments and transparent communication about the type and quality of removals are also essential.

Globally, carbon removal regulations are evolving towards greater integration, were EU has introduced a Carbon Removal Certification Framework (CRCF) which is a trusted regulatory framework, expected to increase the price and value of high-quality carbon credits. While Norway is advanced in CCS, it lacks explicit national CDR targets and comprehensive regulatory clarity, making further subsidies and clear

frameworks necessary for full-scale deployment. The voluntary carbon market (VCM) is increasingly relevant but quality, regulatory certainty, and public acceptance remain key challenges. Achieving “EU-certified” status would enhance credibility and open up new market and subsidy opportunities for the WtE plant in Trondheim.

The standards and registries landscape is complex, with no single best standard; Isometric, Verra, and Puro are highlighted as strong options. Early engagement with multiple programmes is recommended to retain flexibility. Monitoring, Reporting, and Verification (MRV) requirements are demanding, necessitating robust systems for emissions measurement, documentation, and third-party verification.

The CRC market has expanded significantly since 2019, but prices remain volatile and the need for additionality and public funding is pronounced, particularly in Norway’s WtE sector. As 2030 approaches, new buyers from hard-to-decarbonise sectors are expected to enter the market, with Norwegian projects seen as reliable sources due to mature infrastructure and regulations. This could give increased prices. Hafslund Celcio have conformed through agreement with both Frontier and Microsoft that it’s possible to sell CRCs from WtE plant at a fairly good price.

Issuing CRCs is a lengthy and resource-intensive process, often taking up to 24 months, so early preparation is crucial. It’s necessary to build a dedicated commercial team, deepen understanding of market and regulatory requirements, and ensure robust technical and MRV foundations. Public funding advocacy should continue alongside project and CRC development to strengthen the business case and support climate goals.

2.4 ACT 35 Status technology and value chain for the CCS-project in Trondheim

There are four alternatives for post-combustion CO₂ capture technologies: (i) chemical absorption, (ii) adsorption; (iii) membrane; (iv) chemical looping; and (v) cryogenic. Besides liquid amine CO₂ absorption (chemical absorption), there are no examples or sources documenting relevant full-scale tests of technologies efficiency on waste combustion flue gas.

The selected concept is based on the most mature post-combustion technology, that is chemical absorption of CO₂ using liquid amine solvents. The design is a stick build concept with energy integration securing the thermal supply to the district heating system to be at the same capacity as today. Captured CO₂ is to be transported by pipeline to an intermediate storage, nearby the city of Trondheim, and further transport by ships to Northern Lights facilities for final storage.

CC plant

Concept studies (pre-FEED) have been carried out for the capture plant, including compression and liquefaction, with three suppliers of CO₂ capture plant. The results from the three independent concept studies confirm that there are technical and commercial available solutions for amine-based CO₂ capture for the WtE plant in Trondheim, given its specific conditions. The results also indicate that a 95% capture rate of CO₂ may be possible. The suppliers have confirmed that they can meet the requirements for emissions to air and water, as well as noise. In addition employee safety regarding maintenance and escape routes have been considered. The concept is documented in a design basis ready for FEEDS studies.

Transport to and Intermediate storage

Five different sites for intermediate storage project have evaluated. The studies included CO₂ terminal and HUB evaluation, safety/dispersion analysis, pipeline evaluation, process and layout evaluation and constructability. It’s confirmed that there are several options, with two preferred sites.

The preferred solution for transport to intermediate storage is a concept with pipeline transport. Conducted studies include route assessments, regulatory requirements, geotechnical evaluation, and safety/risk assessment. An overall assessment show that a pipeline solution has lower risk and cost compared with truck transport. The solution with pipeline also reduces noise challenges at the CC plan, as the liquefaction and compression equipment is moved to the intermediate storage.

The intermediate storage capacity is according to the CO₂ production and the frequency of ship transport to the final storage handling facility. The basic concept is based on an intermediate storage capacity of approx. 3600 tons, representing four days production and one day spare. The concept is documented in a design basis ready for FEED studies.

Ship transport and permanent storage

CCUS mid-Norway Cluster (Franzefoss Minerals, Wacher Chemie, Equinor Tjeldbergodden, Hydro Sunndalsøra, Statkraft Varme) have evaluated several solutions for common solutions for ship transport and permanent storage. The studies shows a potential of approx. 20% cost savings with a common solution for 1,5 – 1,7 Mton/y of CO₂. Mainly due to different maturity of the companies CO₂ projects and timelines there is not possible to establish a large-scale solution before 2035 – 2040. The CCS Project has also investigated the possibility of contracting its own vessel and have a dialog with an external provider, CCB, which have a quay and a concept for smaller ships at Northern Lights (NL) inlet terminal at Øygarden outside of Bergen.

Studies have been carried out, both independently and as part of the CCUS Mid-Norway Cluster, on possible concepts for permanent storage. Several licenses have been awarded in the Norwegian Sea, but as of today and until 2033-35, the only available alternative is NL. Based on this, final storage is planned at the NLs facilities

2.5 ACT 42 Establish design criteria for possible financial support with type and organization

There are some key characteristics that need to be considered when establishing criteria for financial support for CCS from EfW facilities:

- Often produces both electricity and district heating (CHP), helping to relieve the power grid.
- An important component in the circular economy and the final treatment of residual waste.
- CCS implementation contributes to the decarbonisation of a “hard-to-abate” sector, encompassing both biogenic and fossil CO₂.
- Many WtE plants are publicly owned – often by municipalities or intermunicipal companies, which are subject to strict investment rules (procurement, state aid, etc.) and where challenging ownership economics limit access to capital and reduce the ability to take risks.

Overacting premises/frameworks for a support scheme:

- Socio-economically efficient use of funds.
- Simple to administer – both for authorities and bidders.
- Lowest possible cost for the highest volume of CO₂ captured.
- The support must be decisive for projects that are realistically feasible.
- The instrument should be designed to contribute to predictability, both in terms of support level and timeframe

Design

It is not particularly important which type of mechanism is used; whether it is reverse auction, CFD, etc. The most important is that:

- The support should be designed as an auction that cover both fossil and biogenic CO₂.
- Several criteria beyond costs should be included in the assessment (e.g., societal benefit with percentage-based weighting).
- Separate auctions targeted at the waste sector should be implemented; alternatively, parts of the total framework can be reserved for specific sectors (e.g. waste incineration).
- The deadline for project start should not be set to less than 4–6 years after support is awarded.

3 WP 5.2 REQUIREMENTS FOR A VIABLE BUSINESS MODEL FOR CCS-PROJECTS FROM WASTE INCINERATION (REPORT). GENERIC MODEL

3.1 ACT 37 Assessment of technology and value chain development (cost reductions). Assessment of waste value chain, roles and responsibilities and climate footprint.

Technology

There are several ongoing research and development projects of other technologies, which is important to seek for more technical and cost efficient solutions. But as described in Act 35, besides liquid amine CO₂ absorption (chemical absorption), there are today no examples or sources documenting relevant full-scale tests of technologies efficiency on waste combustion flue gas.

Value chain development

There are several opportunities for cost reductions throughout the value chain for CO₂ management. CO₂ capture technology, requirements for CO₂ specification, and economies of scale can contribute to lower costs, while energy demand, capture rate, and CO₂ quality affect efficiency.

For transport, pooling volumes from multiple emitters allows for savings through better utilisation of vessels, potentially shorter distances to permanent storage sites, and increased competition. With regard to permanent storage, having more providers will further reduce costs, and competition stimulates the development of more and better solutions.

Waste value chain, roles and responsibilities

Lunera Energi's waste incineration plant ensures responsible final treatment of approximately 220,000 tons per year of sorted residual waste from both households (Municipal solid waste, MSW), commercial activities and industry (C&I waste). The natural geographic area from the south of Nordland county to the north of Innlandet county. Various inter-municipal waste companies are responsible for collecting and handling waste from households and service industries (MSW), while commercial waste companies have their own collection solutions.

Lunera Energi, a private actor, secures access and pricing for the treatment of waste through various private/public tenders, both from inter-municipal waste management companies, commercial waste companies, and various waste brokers.

Each municipality sets the waste collection charges/fees (*renovasjonsgebyret*) that cover municipal waste (i.e., not all types of waste) removal, covering sorting, transportation, and treatment services. These fees must not exceed the actual costs of providing that service, a fundamental financial principle used by municipalities in Norway (*selvkostprinsippet* - The Cost Recovery Principle or Self-Cost Principle).

Climate footprint

Without measures to reduce greenhouse gas emissions from the WtE plant in Trondheim, it is expected that over a 50-year lifespan, the facility will result in emissions of approximately 12 million tonnes of fossil and biogenic CO₂e.

Based on a capture rate of 90%, CCS from the WtE facility in Trondheim will result in total emissions from construction and operation of just under 1,950,000 tonnes of fossil and biogenic CO₂e over the 50-year lifespan.

The net reduction in greenhouse gas emissions will then be just over 10 million tonnes of fossil and biogenic CO₂e over the 50-year lifespan.

Based on the carbon capture plant's estimated capture rate of 90%, emissions related to construction, operation, and transport will be nearly "neutralised" on day 346 with CCS. For the remaining 49 years and 19 days, the facility will reduce carbon in the atmosphere.

3.2 ACT 40 Explore revenue and financial support models/structures including solutions from other countries such as UK, Sweden, Denmark and Netherlands

The assessment of models/structures in UK, Sweden, Denmark and Netherlands shows that the main structure is based on Reverse auctions and contracts for difference (CFDs)

Reverse Auctions

Reverse auctions can take different forms, with the common feature that the most cost-effective projects are prioritised for support. Reverse auctions are highlighted as a mechanism for allocating support to projects in wind, solar, CCS, hydrogen, and negative emissions. These auctions are used to select projects based on criteria such as technology type, capacity, contract duration, and flexibility.

Here, the authorities define a budget or volume, and industry actors submit bids based on their cost per unit (e.g., EUR per tonne of CO₂ stored or EUR per kWh of energy produced). The lowest bid(s) win, and a contract for difference (CfD) can be signed.

Contracts for Difference (CfDs)

Contracts for Difference (CfDs) can be incorporated into the design of a reverse auction model. CfDs guarantee income for producers by compensating for the difference between market price and production cost, reducing risk and encouraging investment in CCS and renewable energy.

Country Comparisons, key learnings

Transparency Is Critical: Several countries, especially the UK, highlight that a lack of transparency in the process can lead to delays, stakeholder frustration, and difficulty in making adjustments after launch.

Clear guidelines and open communication are essential for building trust and ensuring effective implementation.

Project Maturity Matters: Successful schemes prioritize mature projects—those with high technical maturity covering the whole value chain, and with secured additional income streams or support mechanisms. Immature projects often face delays, regulatory hurdles, and risk of failure, as seen in UK and Norwegian case studies.

Flexibility and Adaptability: Countries like Denmark and the Netherlands emphasize the need for flexible contract structures that can adapt to changing market conditions and evolving technologies. Long-term contracts are valuable, but mechanisms must allow for periodic review and adjustment.

Stakeholder Feedback Improves Outcomes

Incorporating feedback from project developers, industry experts, and regulatory authorities leads to better-designed support schemes. Continuous improvement and adaptation are recurring themes, especially in France and Germany.

Risk Allocation and Cost Structure

Effective financial support models balance risk between government and project developers. The Netherlands and Sweden focus on designing contracts that share financial risk and incentivize innovation.

Regulatory Alignment and Challenges; Aligning national schemes with EU guidelines is a challenge, particularly for Norway. Regulatory bodies (e.g., ESA) can introduce complexity and uncertainty, making early engagement and compliance planning essential.

3.3 ACT 38 Status and development pathways for regulatory framework (politics, regulations and directives in EU and Norway)

Norway:

The Norwegian CCS regulatory environment is primarily centred on the Longship project, but several ongoing initiatives and regulatory discussions affect the sector. The proposed National budget for 2027 may introduce a reversed tax for carbon removals, while key assessments and roadmaps (such as Virkemidler for karbonfangst fra industri og avfallsforbrenning 2025 and Veikart 2050) are shaping future development. In addition Enova is working with a possible investment programs and support scheme for transport and permanent storage. Waste incineration is currently subject to a national CO₂ tax (NOK 900/ton., but with 25% discount.

In the National budget for 2025 the general tax is expected to increase to NOK 2400 in 2030 and NOK 3400 in 2035. Implementing CCS will avoid WtE plants paying this tax for the fossil share of CO₂ captured and stored, which is estimated to around 40 % of total captured CO₂. However, future inclusion of WtE in the EU ETS may change these dynamics, potentially replacing the national tax or introducing a hybrid system.

Norway has issued 13 licences for CO₂ storage on the Norwegian Shelf, but only one, Northern Lights, is commercially operative, presenting challenges for smaller projects. The government is committed to facilitating further commercial storage, were Gassnovas report, Veikart 2050, provide guidance for reducing emissions from Norwegian land-based industry and WtE. For the CCS project in Trondheim the only available CO₂ storage in 2030/2031 is Northern Lights. There are several options. but these storages will not be available before after 2035.

Europe

The EU Emission Trading Scheme (ETS) is the main instrument for reducing fossil GHG emissions, and is being reformed to accelerate reductions. Waste incineration could be included from 2028, requiring purchase of emission credits for fossil CO₂ emissions. Under the current rules, only fossil CO₂ is covered, with biogenic CO₂ exempt. There is ongoing consideration of integrating negative emissions (carbon removals) into the ETS, which could allow facilities like WtE plants to sell verified removal credits. This could be very important as part of financing CCS. The price of ETS allowances is expected to rise, increasing incentives for CCS.

Industrial Accelerator Act (IAA), previously referred to as the Industrial Decarbonisation Accelerator Act, is a key legislative proposal from the European Commission expected to be adopted in spring 2026. Its purpose is to strengthen the competitiveness of European industry, accelerate decarbonisation, and ensure "Made in Europe" criteria in strategic sectors.

Adoption of CRCF, the European Union has officially initiated the adoption and implementation of the Carbon Removal and Carbon Farming (CRCF) Regulation (Regulation (EU) 2024/3012), which was published on December 6, 2024. This framework establishes the first EU-wide voluntary system for certifying high-quality carbon removals, aiming to boost investment in technologies that remove CO₂ from the atmosphere and support sustainable carbon farming practices.

Industrial Decarbonisation Bank (IDB) is a new flagship initiative under the EU's Clean Industrial Deal, aiming to mobilise over €100 billion for the decarbonisation of European industry. The bank does not operate as a traditional bank, but rather as a financing platform under the future Competitiveness Fund and support the rollout of mature technologies to reduce emissions in energy-intensive industries

The Net-Zero Industry Act (NZIA) is a cornerstone of the EU's Green Deal Industrial Plan, which officially entered into force on June 29, 2024. Its primary goal is to scale up the manufacturing of clean technologies within the EU to meet at least 40% of the annual deployment needs by 2030.

For companies, the EU taxonomy means that the ability to document “green” activities directly influences both access to finance and the cost of borrowing. Banks use the taxonomy to achieve their own sustainability goals, which provides advantages for businesses that comply with the regulations. EfW plant are not included so far

Global

Article 6 of the Paris Agreement allows for voluntary cooperation and trading of both emission reductions and removals. Bilateral agreements (Article 6.2) enable countries to trade mitigation outcomes, with Norway and Switzerland already establishing a framework for cross-border CO₂ transport and storage. Article 6.4 sets up a centralised market for high-quality carbon credits, but methodologies for novel removal technologies are still in development. Risks remain concerning the durability and quality of credits. Nearly 100 bilateral deals have been signed globally, signalling increased interest and potential for Norwegian storage capacity and domestic capture projects.

3.4 ACT 39 Assessment of methods/business models from other/similar markets to reach political targets with success- evaluate financial opportunities/support schemes (EU-Norway)

Framework from EU

EU advice and guidelines

The EU has clear guidelines and advice regarding the use of reverse auctions, and Norway has limited freedom to establish an auction if the support could lead to unfair advantages for one or more actors in Norway or other countries. Support schemes must be approved by the EU, and Norway must submit potential terms to the EU before the system is implemented. Examples of challenges include Denmark having to stop the "Open Door Offshore Wind Scheme" after objections from the EU, and the EU Court of Justice suspending support for projects that violate EU rules, such as the UK Capacity Market.

EU guidelines for state support schemes

Competition-based allocation: Support must be provided through auctions with multiple participants, with some exceptions.

Technology neutrality: All technologies should be considered on an equal basis, with some exceptions.

Effective environmental benefits: Projects receiving support must deliver real environmental gains, for example, CO₂ reduction.

No expected market viability: Support should only be given to projects that would not be profitable without support.

Possible consequences for WtE: Lower competitiveness for projects with higher costs, underestimation of societal benefit and local value, focus on projects delivering the greatest CO₂ reduction, strict requirements for documentation and evaluation.

EU Innovation Fund

The EU Innovation Fund is a major funding programme for low-carbon technologies, offering approximately €38 billion between 2020 and 2030. It can cover up to 60% of investment and operating costs for carbon capture projects over a 10-year period.

Lessons learned from previous auctions; Sørlige Nordsjø II, Utsira Nord and Statkraft

Weighting and assessment criteria are crucial

In both Sørlige Nordsjø II and Utsira Nord, considerable emphasis has been placed on several

assessment criteria, such as cost-effectiveness, maturity, innovation and technology assessment, as well as positive additional effects. This approach provides a more holistic evaluation of the projects, but also makes the competition demanding for participants.

Market uncertainty and risk lead to dropouts

Many participants withdrew from the auctions, particularly in Sørlige Nordsjø II, due to high costs and uncertainty in the market. This demonstrates that support schemes must be designed to provide sufficient predictability and risk reduction for participants.

Changes in support structure and criteria

For Utsira Nord, the support structure has been modified to include both investment contributions and a two-way contract for difference, and the criteria have become more specific. There is also a greater focus on cost assessment and inflation adjustment, which may contribute to a more targeted and fair allocation.

The processes are characterised by limited transparency and delays

Experiences from both Norway and the United Kingdom show that processes are often not very transparent, marked by delays and difficult to alter after launch. Maturity and securing alternative income sources/support mechanisms are important success factors, but there is still uncertainty connected to the further process and regulatory challenges, especially regarding ESA.

Main learnings:

To succeed with support schemes and auctions for CCS and renewable energy in Norway, it is essential to ensure clear and predictable frameworks, weight criteria that provide real value, and secure transparency and flexibility in the processes. Market uncertainty and regulatory challenges must be actively managed to avoid dropouts and delays.

4 WP 5.3 SYNTHESIS REPORT: INTEGRATE FINDINGS FROM WP 2-4 TO SUPPORT A HOLISTIC BUSINESS MODEL

4.1 ACT 34 Integrate findings from WP 2-4 and consider impact on WP5

A collaborative approach is necessary to implement CCS successfully. To get a total picture as foundation for establishing a sustainable business model (WP5), and how to best implement CCS on Lunera Energy's WtE plant, it's important to take in consideration finding and recommendation from WP2: identify barriers and drivers, WP3: citizens engagement and stakeholder involvement and WP4; the climate plan and Climate City Contract.

For additional information and details see separate reports from WP2, WP3 and WP4.

4.1.1 WP2; Identify barriers and enablers (Sintef Energy)

A central focus of the projects' Work Package 2 (WP2) is to develop a shared understanding of systemic challenges and opportunities, ensuring that WtE-CCS is integrated into the city's broader climate action and circular economy strategies

4.1.1.1 Overview of policy and framework conditions for CCS in waste incineration plants on EU, national and local levels

The policy and regulatory frameworks for waste, CCUS and waste-CCUS are complex, intertwined and constantly evolving. This makes it challenging to develop a viable business case for CCS since lack of necessary policies and regulatory framework hampers progress.

Central EU policies and regulations

European Green Deal's focus on emissions reduction and climate neutrality, including the central role of CCUS in decarbonizing industry.

The Carbon Border Adjustment Mechanism (CBAM), fully implemented from 2026 and joined by Norway, targets carbon pricing for imported goods and aims to prevent carbon leakage.

The Industrial Carbon Management Strategy (2024) integrates CO₂ capture, storage, use, and transport, supporting EU targets for emission reductions by 2030 and 2040, and scaling storage capacity.

The Net Zero Industry Act (NZIA) sets a goal of 50 million tons CO₂ storage by 2030, with Norway's CCS projects eligible for inclusion.

The Clean Industrial Deal (CID, 2025) mobilizes €100 billion for clean tech and decarbonization, focusing on growth, lower energy costs, job creation, and support for energy-intensive sectors.

The Carbon Removals and Carbon Farming Regulation (CRCF, 2024) introduces an EU-wide certification framework for carbon removal, farming, and storage, with Norway adapting nationally.

The EU Emissions Trading System (ETS) is strengthened to incentivize CCS/CCU and support industrial decarbonization, especially regarding cross-border infrastructure. Forthcoming acts, such as the Industrial Decarbonization Accelerator Act and Industrial Accelerator Act, aim to boost competitiveness and decarbonization in energy-intensive industries.

Financial mechanisms include Carbon Contracts for Difference (CCfDs), state guarantees, and insurance, with the EU Innovation Fund and Modernization Fund as key sources. The Industrial Decarbonisation Bank (IDB), under CID, supports mature technologies and commercial markets for carbon management. The development of CO₂ transport infrastructure and markets is underway, with new legislation expected in late 2026.

Waste treatment and WtE Sector specific regulation (focus on CCS)

The Waste Framework Directive and the BREF BAT WI set legally binding emission limits for WtE, which are transposed into Norwegian law and could be directly relevant for CCS integration to meet stricter emission standards.

The Norwegian Waste Incineration Tax on fossil CO₂ emissions creates financial incentives to reduce emissions, making CCS an attractive option.

The EU Emissions Trading System (EU-ETS) currently excludes WtE, but a 2026 review may propose inclusion, potentially increasing the cost of CO₂ emissions for WtE plants and further incentivizing CCS deployment.

The EU Taxonomy currently excludes WtE (with or without CCS) from being classified as "green" investments, which limits access to sustainable finance for CCS projects in this sector. However, activities directly related to CCS may qualify as green if they meet specific technical criteria.

The general regulatory push for reduced landfill, higher sorting and recycling rates, and producer responsibility (EPR schemes) for waste also increases pressure on WtE facilities to adopt sustainable practices like CCS to remain compliant and competitive in the evolving regulatory landscape.

National and local CCS-related Policies

Norway has established a national framework supporting the development of carbon capture and storage (CCS), notably through the Longship CCS Project, which includes Northern Lights—the world's first cross-border CO₂ transport and storage facility. In August 2025, the first volumes of CO₂ were successfully injected and stored. The Norwegian government is also pursuing increased fossil CO₂

taxation to encourage CCS adoption, especially from waste-to-energy (WtE) sources, and to boost material recycling. These taxes may be replaced by the EU Emissions Trading System (EU ETS) by 2035

Locally, Trondheim is working to ensure its CCS initiatives align with broader regulations, while advocating for necessary policy changes. The city focuses on integrating WtE-CCS with waste reduction and recycling within a circular economy framework. Key policies include: the Trondheim Promise (Municipal Master Plan 2020–2032), which aims for a greener and more circular society; the Municipal Plan for Waste Management (2018–2030), targeting at least 65% material recovery of municipal waste to meet tightening EU requirements; and the Climate Promises (Municipal Plan for Energy and Climate 2024–2030), which mandates an 80% reduction in direct greenhouse gas emissions by 2030, requires waste to be managed without emissions, and identifies CCS as crucial for achieving climate neutrality.

Possible national (Norwegian) policy and financing instruments for CCS

CCS is projected to deliver about one third of Norway's emission reduction by 2035, with the Norwegian Environment Agency stressing the essential role of carbon capture from waste incineration plants. Policy measures should target key obstacles: incomplete CO₂ pricing, additional costs for scaling and commercialization, and coordination challenges—particularly the lack of a regulatory framework for CO₂ transport and storage.

Economic policy tools relevant for CCS at waste-to-energy (WtE) plants include CO₂ pricing, support for commercial maturity, and government coordination of infrastructure. The principal recommendation is to implement CCfDs, which can be tailored to address varying CO₂ pricing, mitigate future price risks, and cover extra costs associated with commercial maturity. These contracts could be awarded competitively or through negotiation.

Many elements of the regulatory and funding tools for CCS are still under development, shifting and unstable (both at the EU and) at the national level. These uncertainties are a major hinder to the deployment of CCS. Recent efforts include analysis and report from eg. Clean Air Force Task's work on CCfD design, Baringa's 2026 report identifying investment barriers, Prosess21 2026 report with recommendations on how to scale-up CCS in Norway, CCS roundtable in early 2026 with key actors (eg. Bellona, SINTEF), how to enable the large-scale deployment of CCS in Norway and Norwegian Environment Agency 2026 report on the importance of CCS WtE is a key measure for Norway to reach its climate goals.

As of March 2026, Norway's CCS regulatory focus is on the Longship project, with several initiatives underway. The proposed 2027 national budget may introduce a reverse tax for carbon removals, and Enova is exploring an investment program and support scheme for transport and permanent storage. KAN's updated position calls for a reverse CO₂ tax aligned with the fossil tax, investment support for capture projects and CO₂ terminals, and the possibility to combine support schemes with the sale of carbon removal certificates.

4.1.1.2 Experiences and learnings from several European cities implementing Carbon Capture and Storage (CCS) in waste incineration

Main cross-cutting findings from Hafslund Celsio (Norway), Rakkestad (Norway), Zurich (Switzerland) and Helsingborg and Stockholm Exergi (Sweden) include:

- **Regulatory Processes:** Implementing CCS requires substantial time and effort regarding regulatory compliance, such as zoning plans, environmental impact assessments, dispersion analysis, and emission permits. Early focus on these aspects is essential for project progression.
- **Transport and Storage:** Deciding on the method of transporting CO₂ (e.g. truck or pipeline) and ensuring access to intermediate and permanent storage facilities is a key consideration.
- **Infrastructure and Constructability:** Securing the area for CCS plants, optimising layout, and ensuring constructability are vital for success.

- **Organisational Capacity:** Establishing a robust project organisation with adequate internal competence and capacity is necessary for effective execution.
- **Business Planning:** Optimising the business case, securing financing, and exploring potential revenue streams, including biogenic credits, are critical for long-term viability.
- **Stakeholder Management:** Early communication and involvement of municipal authorities and neighbouring third parties fosters project acceptance and smooth implementation.
- **Knowledge Sharing Networks:** Participation in national and European CCS networks, such as the KAN-network and EU projects, facilitates alignment with broader developments and access to shared infrastructure solutions.
- **Public Engagement and Policy Integration:** Zurich has successfully embedded CCS into climate policies and prioritised public communication and engagement, as evidenced by referendums and tailored information strategies. This has increased acceptance and clarified the role of CCS within wider climate strategies.
- **Technological and Economic Innovations:** Technological optimisation for energy and cost efficiency is ongoing. Business models increasingly rely on selling negative emissions, climate-neutral district heating, and leveraging funding from EU and national sources.
- **Local Adaptation:** Each city faces unique conditions—such as infrastructure, public perception, political support, and regulatory environments—requiring tailored approaches to CCS implementation.

Overall, the collective experience highlights the importance of early regulatory engagement, robust organisational structures, innovative financing, and proactive stakeholder communication. By integrating these lessons, Trondheim and similar cities can refine their strategies and roadmaps for successful CCS deployment in waste-to-energy plants.

4.1.1.3 Learnings from ongoing research projects

The CCWaSte4NetZero project builds upon previous and ongoing CCS research projects, including:

1. **ACCSESS** (EU Horizon 2020 led by SINTEF Energy Research): Focuses on providing access to cost-efficient, replicable, safe and flexible CCUS, including CCS as an enabler for sustainable urban development. A handbook with the aim to support informed adoption of CCS in urban areas. Personnel from Trondheim municipality have contributed with input to this handbook.
2. **CaptureX** (Norwegian Research Council (RCN) & CLIMIT): Investigates socio-technical challenges in CCS adoption, including public perception and policy barriers.
3. **CCS Mid-Norway Project** (Gassnova & CLIMIT): Focuses on regional CCS implementation, emphasizing the benefits of locally coordinated logistics and cost-sharing.
4. **Deployment of BECCUS Value Chains** (IEA Bioenergy inter-task project) and especially WP2 – Full-scale Waste-to-Energy CCS (Hafslund Celsio Klemetsrud plant in Oslo) in Norway: presenting the key technical, logistical as well as economical aspects of the project including a timeline
5. **CircWtE** (RCN KSP project) focuses on the future of waste management in a circular economy, including WtE, as well as future trends regarding MSW streams amounts and compositions including biogenic/fossil C

ACCSESS

ACCSESS demonstrates that deploying CCUS in WtE and urban industrial settings is not a single technical challenge, but a question of readiness across multiple dimensions: technical, infrastructural, economic, regulatory, and societal.

From a technical perspective, the project shows that solvent-based CO₂ capture can operate under real WtE conditions despite fluctuating flue gas composition and elevated contaminants. Pilot experience confirms feasibility, while also highlighting increased solvent degradation, space constraints, and

energy-integration challenges. Successful implementation therefore depends on site-specific, integrated design of combustion, flue gas cleaning, and capture systems.

In terms of system and infrastructure readiness, ACCSESS underlines that planning capture alone is insufficient. Early engagement with CO₂ transport and storage providers, alignment on CO₂ quality requirements, and clustering of emitters are essential to reduce costs and enable deployment. For urban WtE plants, logistical constraints coexist with opportunities linked to biogenic CO₂ and potential carbon-removal pathways.

Regarding economic readiness, value-chain analysis shows that CCUS costs can be absorbed with only minor end-consumer price impacts when distributed along product chains, while delivering substantial emission reductions. In the WtE sector, the biogenic share of emissions strengthens business cases and shifts CCUS from a pure cost toward a climate-value proposition.

Regulatory readiness emerges as a decisive enabler. European and Norwegian frameworks provide permitting pathways for CCS, but impose strict requirements on emissions, monitoring, wastewater management, and environmental risk assessment. Regulation therefore shapes CCS design choices and timelines, making early dialogue with authorities critical.

Finally, societal readiness remains fragile. While CCUS is often recognised as a climate solution, public and media discourse tends to be cautious or negative, driven by concerns over cost, risk, and transparency. ACCSESS highlights the central role of municipalities in building legitimacy through stakeholder coordination, public engagement, and integration of CCUS into broader urban climate strategies.

Overall, ACCSESS shows that CCUS in WtE is feasible, but only deployable at scale when engineering, infrastructure, regulation, markets, and public trust are aligned.

Capture X

In the WtE sector, most large Norwegian incinerator operators view CCS as vital for reducing greenhouse gas emissions. Municipal climate targets, particularly in major cities, are a strong driver. Economic conditions have been challenging, limiting financial capacity for CCS investment. Successful CCS business models, such as Hafslund Celsio in Oslo, rely on revenues from capturing and storing biogenic CO₂ (BECCS – CDR). CCS solutions must be tailored to each plant and space constraints are common. CCS affects integration with district heating and electricity networks, often reducing energy output. Access to CO₂ transport and storage infrastructure remains a major hurdle, except for Longship participants. Public acceptance of CCS is generally positive, though local concerns (area use, traffic, emissions) arise and may increase as projects advance

Key findings include:

- Since the Paris Agreement (2015), CCS has gained importance in climate mitigation, especially in energy-intensive industries.
- Norway is seen as an leader in CCS, notably through the Longship demonstration project. However, current policies and frameworks are insufficient to support large-scale CCS investments, resulting in only small projects and pilots beyond Longship.
- A challenge for CCS in Norway, outside the oil and gas sector, is the small and dispersed emission points, making CO₂ transport and storage infrastructure development difficult. Regional initiatives for co-developing infrastructure are ongoing but require significant coordination. In the absence of storage prospects, actors explore CCU opportunities.
- CCS is one of several emission reduction options for many emitters (e.g., electrification, hydrogen, biofuels), with potential synergies and competition between these strategies.
- CCS legitimacy in Norway is generally high, but local social acceptability can change as projects mature. Transparent stakeholder engagement is crucial.

CCUS mid-Norway

Between 2021 and 2025, the CCS Mid-Norway Project united five major CO₂ emitters (Elkem Thamshavn (phase 1), Hydro Sunndalsøra (phase 2), Equinor Tjeldbergodden, Franzefoss Minerals (NorFraKalk & Verdalskalk), Statkraft Varme (now Lunera Energi), and Wacker Chemicals Norway (Holla). Main topic was to explore shared solutions for ship transport and permanent storage. The initiative identified significant potential for synergy, estimating around 20% cost savings through collaboration. However, differing timelines among the companies mean these benefits likely cannot be realized before 2035, at the earliest. Despite these obstacles, the cluster strengthened its influence when presenting a unified position to Norwegian authorities regarding support for transport and storage. The collaboration resulted in increased competence for all participants, enabled by both internal knowledge sharing and engagement with other clusters.

Deployment of BECCUS Value Chain

Key learnings include the importance of persistence and reevaluation, recognizing that timelines often exceed expectations, and not underestimating the infrastructure requirements such as electricity, transport, space, and harbour facilities. Effective project organization and management are crucial, as are considerations of political and societal perceptions. The integration of new technology within an existing operational facility presents complex interface challenges, such as additional flue gas cleaning. A strategic cost-reduction phase, including changes in suppliers, proved risky but ultimately revitalised the project. Most difficulties encountered to date have not been directly related to carbon capture and storage itself.

The report also highlights the potential for new revenue streams, noting that roughly half of the CO₂ emitted from WtE plants is biogenic. Permanent storage of this CO₂ could result in net atmospheric removal, allowing the sale of carbon removal certificates on the voluntary carbon removal market. Hafslund Celsio has entered into agreements in 2025 with Frontier and Microsoft for the offtake of several hundred thousand tonnes of CO₂.

CircWtE

Projections suggest that the overall quantity of waste processed by WtE facilities may decline over the next decade, though this reduction could be minor due to population growth and rising affluence, with local differences expected.

The combustion characteristics of waste destined for WtE, such as lower heating value and moisture content, are anticipated to change, potentially affecting plant operations. However, the biogenic proportion of CO₂ emissions is likely to remain stable at around 50%

Furthermore, substantial volumes of Norwegian waste, primarily residual and wood waste, are exported to Sweden for incineration and district heating—over 800,000 tonnes in 2024—while Norway itself incinerated approximately 1,600,000 tonnes of MSW in the same year. Changes in this cross-border waste trade could influence CCS efforts in Norway, and the implementation of CCS may also affect future waste transport between countries

4.1.1.4 Conclusion and recommendations

The CCWaSte4NetZero project represents a crucial step in Trondheim's journey toward climate neutrality. By addressing technical, financial, and social challenges associated with CCS for WtE, the project:

- Strengthens policy frameworks at municipal, national, and EU levels.
- Develops a viable business model that balances costs, incentives, and regulatory support.
- Enhances public and stakeholder engagement.
- Leverages international best practices from Zurich, Oslo, and European CCS initiatives.
- Integrates research insights from ACCSESS, CaptureX, and other CCS and/or waste projects.

By combining technology, governance, finance, and public participation, this project sets the foundation for a replicable CCS model that other European cities can adopt. Based on the knowledge and insights contained in this report (incl. references), the following concrete recommendations articulated along 14 axes are proposed as key ingredients in a WtE CCS cookbook:

1. Societal aspects

1. Communicate **CCS through co-benefits, such as** cleaner air and climate neutrality.
2. Use **targeted/tailored public engagement** on a regular basis.
3. Develop and use **transparent communication tools** (incl. infographic) for emissions, costs, benefits & risks to build and foster trust.

2. Regional and national coordination

1. Align municipal climate, waste & energy plans.
2. Implement **a regional waste strategy** for predictable CO₂ capture operation.
3. Explore **coordination possibilities with other regional CO₂ emitters**, to leverage funding/innovation/impact opportunities.
4. **Push for national authorities to deliver** a stable framework for incentive instruments (such as CCfD, reversed auctions) and regulations, as well as strategic coordination for infrastructure.

3. Infrastructure

1. Reserve **space** for equipment, i.e. absorber/stripper, DCC & buffer tanks.
2. Secure **transport and storage MoUs** early.
3. Evaluate infrastructure **synergies with regional CCS clusters** to reduce costs.

4. Business models

1. Explore how to **stack revenues** such as Innovation Fund, national funding opportunities, ETS avoidance + CDR/removals + waste fees + energy sales.
2. Explore opportunities for **private capital** investments

5. EU ETS

1. Prepare **ETS-ready MRV systems** using the mandatory EU monitoring plans required from 2024.
2. Run **ETS-scenario modelling** to replace the Norwegian combustion tax with future ETS cost curves.
3. Push nationally for **predictable CO₂-pricing** across waste fractions to reduce uncertainty.

6. EPR (Extended Producer Responsibility)

1. Support **modulated EPR fees** for hard-to-recycle plastics (and textiles) to finance CCS on fossil CO₂.
2. Document the **avoidance value** of CO₂ emissions from fossil plastics and textiles combustion.
3. Collaborate with national authorities for **EPR revenue to co-fund CCS OPEX** at WtE plants.

7. CDR (Carbon Dioxide Removal)

1. Implement **high-quality biogenic MRV**, aligned with CRCF/VCM rules.
2. Pilot **third-party verification** early, aligned with CRCF/VCM rules.
3. Explore **long-term offtake agreements** for stable CDR revenues.

8. EU Taxonomy

1. Attempt to obtain **green loan for CCS** even if WtE remains excluded.
2. Collaborate on approaches to validate that only **non-recyclable** (and difficult to recycle) **residual waste** is treated by WtE - critical for possible inclusion.

9. Permitting

1. Explore **permitting pathways** with authorities (integrated vs separated).
2. Conduct **baseline environmental surveys** early (air, soil, water).
3. CO₂ capture with amines – agree on **amine/nitrosamine (degradation products) modelling approach** (formation, dispersion and destruction processes) with the authorities.

10. Plant operation - WtE & CO₂ capture

1. WtE - Consider upgrading, if necessary, **flue gas treatment to meet capture-quality requirements**.
2. CO₂ capture with amines – monitor **solvent degradation** to evaluate need to improve plant operation.
3. CO₂ capture – **Tailor DCC operation** to incoming gas and capture technology.

11. Waste

1. Implement continuous **waste composition monitoring** to reduce CO₂ capture process fluctuations.
2. Strengthen quality control on **waste sorting** to stabilise WtE feedstock.

12. Energy

1. Quantify **energy demand impacts** and integrate CCS into energy planning to maintain energy security.
2. Investigate **energy integration solutions** to reduce the CO₂ capture energy penalty.
3. Use CCS to communicate about **climate-positive district heating** from waste (biogenic fraction).

13. Circular Economy

1. Consider implementing **advanced mixed waste sorting** alongside CCS.
2. Evaluate **CRM recovery from WtE bottom & fly ash** as potential additional revenue stream.
3. Communicate **WtE CCS** as a **complement to recycling**—not a competitor.

14. Innovation/R&D

1. Develop **alternatives to amine-based capture technologies**.
2. Assess **WtE sector-specific flue gas characteristics** to understand resulting CO₂ capture requirements.
3. Join **modelling** research - energy integration, techno-economic analysis, national/European infrastructure.

4.2.1 WP3; Social and Political Acceptance (Sintef Digital)

The development of a sustainable business model for WtE-CCS in Trondheim depends not only on technological and financial feasibility but also on social and political acceptance. Public legitimacy is particularly important for large infrastructure projects that involve public funding, local environmental considerations, and long-term policy commitments. Insights from the Trondheim Climate Surveys (2024–

2025) and the 2025 Citizen Assembly (Folkepanel) provide a basis for understanding local attitudes toward CCS, identifying potential barriers, and translating these insights into strategic implications for the WtE-CCS business model.

Together, these participatory, qualitative and quantitative data sources highlight three central dimensions of acceptance: (1) general climate awareness and support for emission reduction measures, (2) conditional support for CCS depending on fairness and cost distribution, and (3) strong expectations regarding transparency, risk management, and citizen involvement in decision-making processes.

4.2.1.1 Public Attitudes Toward CCS and Climate Action

The Trondheim Climate Surveys demonstrate that climate change is widely recognised as an important societal challenge. A majority of respondents consider achieving the city's climate goals to be important, with 70–75% supporting efforts to reach Trondheim's 2030 climate target. At the same time, public confidence in achieving these goals has slightly declined between 2024 and 2025, reflecting a similar trend nationally. Both in Trondheim and nationally there is however a call for action to reduce greenhouse gas emissions. This suggests a need for stronger engagement and communication from public authorities and key actors.

Regarding CCS specifically, survey results indicate cautious but generally positive attitudes. Approximately 54% of respondents in 2025 view carbon capture at the waste incineration plant as a good climate initiative. In addition, around 46% agree that emissions from the waste incinerator must be reduced, and among those who have formed an opinion, the majority supports such reductions. However, a significant share of respondents remain neutral or uncertain, which may reflect limited knowledge about CCS technologies or uncertainty about their benefits.

Public acceptance declines when the financial implications of CCS are introduced. Survey results show divided opinions on whether residents should pay higher waste management fees to fund carbon capture. Approximately 40% of respondents support higher fees, while around 35% oppose them. The surveys also show that higher-income households are more willing to pay additional costs than lower-income groups. This highlights the importance of designing financing mechanisms that are perceived as fair and socially balanced.

Another relevant finding concerns broader climate attitudes. Residents strongly support nature-based climate measures, such as protecting ecosystems that store CO₂. More than 80% of respondents consider strengthening nature's carbon storage capacity essential. While this support does not directly translate to industrial carbon capture, it indicates a general willingness to support climate mitigation when the environmental benefits are clearly communicated.

Several structural drivers and barriers emerge from the survey results:

Key Drivers

- Recognition that emissions from waste incineration should be reduced.
- Majority support for CCS as a climate solution when costs and risks are manageable.
- Growing concern about climate impacts and preparedness.
- Strong support for complementary climate actions such as renewable energy and nature-based carbon storage.

Key Barriers

- Uncertainty about the costs of CCS and willingness to pay.
- Limited knowledge about CCS technologies and their benefits.

- Declining trust in the city's ability to meet its climate targets.
- Concern about fairness, particularly for lower-income households.

These patterns suggest that the CCS project must be framed not only as a technical climate solution but as part of a broader and equitable climate transition.

Overall, the survey results indicate a stable but cautious acceptance of CCS. Citizens generally support emission reductions and recognise the need for technological solutions, but they remain sensitive to issues of cost distribution, transparency, and perceived environmental impact.

4.2.1.2 Insights from the Citizen Assembly (Folkepanel)

The 2025 Citizen Assembly organised by Trondheim municipality provides deeper qualitative insight into how citizens evaluate CCS when given time, information, and the opportunity to deliberate collectively. The assembly consisted of randomly (stratified) selected residents representing different demographic groups and perspectives, who participated in a structured deliberation process over several sessions.

After reviewing expert input and discussing the issue, the assembly produced fifteen recommendations structured around six themes: economics and cost distribution, democratic governance, responsibility and ethics, risk management, local impacts, and waste reduction and circularity. These recommendations provide valuable guidance for designing socially sound CCS business models.

The recommendations demonstrate that citizens are generally open to CCS as part of Trondheim's climate strategy, but they emphasise several conditions for legitimacy:

Economics and cost distribution

The assembly emphasised that the costs of CCS should be distributed fairly among national authorities, municipalities, industry, and citizens. The principle that actors with higher climate footprints should contribute more was widely supported. Importantly, the assembly stressed that financing mechanisms should avoid reinforcing social inequality, and special attention should be given to low-income households.

Democratic governance

Another central recommendation concerns transparency and public communication. Citizens emphasised that decision-making processes must be transparent and that residents should have access to clear and understandable information about project costs, benefits, and risks. They also recommended continued public involvement in future decision processes to maintain legitimacy.

Responsibility and ethics

The Citizens' Assembly recommended that local leadership ensure that responsibility for a comprehensive and effective implementation of CCS is taken at the national level, and that it is anchored locally, nationally, and globally.

Risk management

The assembly highlighted the importance of addressing potential environmental and health risks associated with CCS infrastructure. Risk assessments and mitigation measures should be conducted thoroughly and communicated clearly to the public.

Local impacts

Participants also emphasised the importance of managing local impacts, including logistics, transportation infrastructure, and potential noise or environmental disturbances in affected areas.

Waste reduction and circularity

Finally, the assembly stressed that CCS must not undermine waste reduction strategies. Policies promoting reuse, recycling, and reduced consumption should remain priorities even if carbon capture is implemented. In other words, carbon capture as a ‘technical fix’ needs to complement the more general shift towards a circular economy.

These recommendations provide valuable guidance for designing a socially acceptable business model and governance framework for WtE-CCS.

4.2.1.4. Synthesis of Acceptance Drivers and Barriers

Combining the survey results and citizen assembly findings provides a comprehensive understanding of the societal conditions influencing CCS implementation in Trondheim.

Several drivers of acceptance can be identified. First, there is a strong normative basis for emission reduction, as most residents support climate action and recognise the importance of reducing emissions from waste incineration. Second, CCS is generally perceived as a legitimate climate solution when presented as part of a broader strategy to achieve climate neutrality. Third, participatory processes such as citizen assemblies can increase understanding and acceptance by providing citizens with opportunities to engage with the topic in depth.

At the same time, several barriers must be addressed. Public acceptance is sensitive to perceived fairness in cost distribution. If CCS is primarily financed through higher waste fees for households, support may decline significantly. In addition, uncertainty about technology, environmental risks, and economic impacts may contribute to public scepticism. Finally, declining confidence in the city’s climate targets may weaken public engagement if communication and transparency are not improved.

These insights highlight the importance of integrating social considerations into the CCS business model. Financial mechanisms, communication strategies, and stakeholder engagement processes must be designed to address societal expectations and build long-term trust.

4.2.1.5. Implications for the CCS Business Model

The combined insights from surveys and the citizen assembly suggest that the business model for CCS must incorporate social and governance dimensions alongside financial and technical considerations.

In particular, the findings imply that public acceptance depends on four interconnected factors:

1. Perceived fairness of financing mechanisms
2. Transparency and clarity in communication
3. Demonstrated climate effectiveness
4. Protection of local communities and social equity

These elements must be reflected in the overall business model design, including revenue structures, stakeholder engagement strategies, and policy instruments.

Table 1. Implications for Business Model

Public Concern / Driver	Evidence from Survey	Evidence from Citizen Assembly	Business Model Implication
Climate mitigation support	Majority support emission reductions and view CCS positively	Assembly acknowledged CCS as necessary for climate neutrality	Frame CCS as essential component of Trondheim’s climate strategy

Public Concern / Driver	Evidence from Survey	Evidence from Citizen Assembly	Business Model Implication
Cost fairness	Public is divided on higher waste fees	Recommendation that costs follow “polluter(s) pay” principle and protect low-income groups	Design financing mechanisms with progressive cost distribution and national co-funding
Trust and transparency	Declining confidence in climate targets	Strong emphasis on transparent processes and accessible information	Establish transparent governance and regular public reporting
Knowledge and awareness	Many respondents remain uncertain about CCS	Assembly requested clear communication about all benefits and risks	Develop long-term communication and engagement strategy

Overall, these implications indicate that societal acceptance must be treated as a core component of the CCS business model rather than a peripheral issue.

4.2.1.6 Strategic Roadmap for Building Acceptance (2027–2032)

For CCS projects in publicly owned infrastructure such as WtE plants, the boundary between technical infrastructure and public policy is particularly significant. The project will interact directly with municipal services, waste management systems, and potentially household waste fees.

Consequently, social acceptance influences several strategic elements of the business model:

Revenue and financing mechanisms

The surveys suggest limited public willingness to finance CCS through significant increases in waste management fees alone. Therefore, the business model should rely on a diversified financing structure including national support schemes, EU funding instruments, carbon removal credits, and potentially ETS-related revenues. Such diversification reduces the financial burden on households and improves social acceptance.

Policy alignment

Political acceptance is closely tied to alignment with national and EU climate policies. Citizens and stakeholders expect projects to contribute meaningfully to climate targets and to operate within transparent regulatory frameworks.

Stakeholder engagement

Continuous engagement with citizens, local communities, NGOs, and industry actors will be essential to maintain legitimacy over the long development timeline of CCS infrastructure. An important element is transparency in waste management: ensuring confidence that incineration (i.e. energy recovery) does not replace (but complements) material recovery (e.g. recycling, reuse).

Co-benefits

Highlighting co-benefits such as green jobs, technological leadership, and contributions to energy security and the shift towards a circular economy can strengthen societal support.

4.2.1.7 Strategic Road-Map for Social and Political Acceptance (2027–2032)

To operationalise these insights, a structured roadmap is needed to integrate social and political acceptance into the CCS business model over time.

The roadmap reflects a progression from political anchoring and regulatory alignment, through enhanced communication and citizen involvement, to the implementation of fair financing mechanisms and the

demonstration of tangible climate benefits. In the initial phase, securing political support and stable framework conditions is prioritised to reduce investment risk and enable project realisation. This is followed by increased transparency and public engagement to build trust and legitimacy. In later stages, the focus shifts toward expanding and further demonstrating measurable climate outcomes and integrating CCS into broader circular economy strategies.

Table 2. Strategic Road-Map for Social and Political Acceptance (2027–2032)

Period	Strategic Focus	Key Actions	Expected Outcome
2027	Work on political acceptance for the WtE-CCS business model	Engage national and municipal policymakers through structured dialogue; align business model with emerging regulatory frameworks	Broad political support and regulatory alignment, enabling stable framework conditions and reduced investment risk
2028	More active communication starts	Launch public information campaign, publish cost and benefit assessments	Increased public awareness and trust in the project
2029	Participatory governance	Establish citizen advisory forum and stakeholder dialogue platform	Strengthened democratic legitimacy
2030	Fair financing mechanisms	Implement financing model combining national support, EU funding, and limited local contributions	Improved public acceptance of funding model
2031	Demonstration of climate benefits	Publish verified emission reduction results and climate impact assessments	Reinforced perception of CCS effectiveness
2032	Long-term integration	Integrate CCS into broader circular economy and waste reduction policies	Stable political and societal support

Summarized, the roadmap emphasises that both social and political acceptance is dynamic and must be continuously strengthened through coordinated actions across policy governance, communication, and business model development.

4.2.1.8 Conclusion

The integration of survey data and citizen assembly recommendations demonstrates that social and political acceptance is a critical enabling factor for WtE-CCS deployment in Trondheim. Public attitudes towards CCS are generally supportive but conditional on fairness, transparency, and meaningful public participation.

The results indicate that citizens recognise the need for emission reductions and accept CCS as part of a broader climate strategy. However, acceptance depends on ensuring equitable cost distribution, providing accessible information, and maintaining strong democratic engagement throughout the project lifecycle.

For the WtE-CCS business model, this means that economic and technical considerations must be complemented by sound stakeholder engagement strategies and socially balanced financing mechanisms. If these conditions are met, CCS at the Trondheim WtE plant has the potential not only to contribute significantly to emission reductions but also to serve as a socially legitimate component of the city's transition toward climate neutrality.

4.3.1 WP4: The climate plan and Climate City Contract. (Trondheim Municipality)

4.3.1.1 Trondheim's Climate Management

Trondheim has demonstrated a long-standing commitment to climate governance, beginning with its first municipal climate and energy plan in 2001, which has since been revised multiple times. In April 2024, the latest iteration, Klimaløftene ("climate pledges"), was adopted, forming the strategic backbone for Trondheim's participation in the EU Cities Mission. The four climate pledges focus on achieving climate neutrality, energy efficiency, circular resource use, and climate resilience.

A key area in the latest plan is carbon sequestration, emphasizing that to become climate-neutral by 2030, Trondheim must reduce direct emissions by at least 80% and offset the remainder, with potential CO₂ capture at the waste incineration plant being a crucial component.

Since 2018, Trondheim has integrated a cross-sectoral climate budget into its yearly municipal budget, ensuring continual updates and broad organisational involvement in climate action. Notably, the 2026 climate budget includes measures to phase out fossil fuels in district heating and to pilot carbon capture at the Tiller waste-to-energy facility, supported by Collaboration between Trondheim Municipality, Sintef and Statkraft Varme, with funding from the EU Cities Mission

As one of the 112 cities in the EU's Cities Mission (Climate-Neutral and Smart Cities), Trondheim delivered the first version of Climate City Contract (CCC) in autumn 2024, and receiving the Mission Label in 2025. The CCC outlines commitments, an action plan, and an investment plan, signed by city leadership and key partners, serving as both a mobilisation and management tool. With the Mission Label, Trondheim receives support from the Climate City Capital Hub to develop bankable climate actions.

The city's climate governance has been recognised internationally, landing a spot on the CDP Cities A List for four consecutive years, highlighting leadership in climate disclosure and action. In 2025, Trondheim was among 120 cities globally to receive an A rating.

Politically, Trondheim shifted to a parliamentary governance model in June 2024, underpinned by the Leangen Declaration, which remains the guiding document for the current city government. The Declaration commits that The City Government shall "contribute to binding investment decisions for carbon capture from point emissions".

4.3.1.2 WtE-CCS Shall Not Hinder the Circular Economy

Concerns have been raised that investing in Waste-to-Energy with Carbon Capture and Storage (WtE-CCS) could impede the development of the circular economy. However, in Trondheim, both the municipality and the facility owner are committed to balancing priorities so that WtE-CCS does not interfere with circular economy objectives.

One of Trondheim's key societal development goals is to become a greener and more circular city, as outlined in the Municipal Master Plan (Trondheimsløftet). The city employs a range of policies and programmes to advance resource management in areas such as waste, nature, food, agriculture, buildings and construction, procurement, sustainable value creation and even library services. Notable programmes include:

Municipal Waste Management

The City Council adopted the Municipal Waste Plan in 2019, laying the groundwork for comprehensive and long-term waste management, covering household waste, municipal operations and public spaces. The plan is currently being revised.

In 2025, Trondheim Municipality sent about 22,500 tonnes of residual waste for incineration. Lunera Energi, a private company, manages the facility, and household waste delivery depends on public procurement decisions.

Trondheim uses differentiated waste fees based on the amount of residual waste each household produces, encouraging recycling and source separation. Fees must only cover actual waste management costs, and whether CCS is considered a “necessary” cost is subject to ongoing debate.

From Waste to Resources – ECT Pilot

“From Waste to Resource” (2023–2030) is Trondheim’s flagship circular economy programme, funded by the municipal business fund. It supports collaboration between researchers, businesses and municipal units, targeting plastics, textiles, construction waste and food waste, with the aim of creating green jobs and circular services.

Action Plan for Circular Economy – Kick-off

Circular economy is increasingly important in EU politics and resource security. In April 2026, Trondheim began drafting its Action Plan for Circular Economy, aiming to address societal challenges using existing best practices and knowledge, with contributions from diverse municipal units.

4.3.1.3 The Triple Helix Partnership in Trondheim

The Waste-to-Energy with Carbon Capture and Storage (WtE-CCS) project in Trondheim is founded on a triple helix partnership model, integrating public, private, and research sectors. The consortium includes Trondheim Municipality (public authority), Statkraft Varme/Lunera Energi (the private plant owner), and two SINTEF research institutions (SINTEF Energi and SINTEF Digital). This collaboration leverages SINTEF’s extensive experience in carbon capture technologies and international projects, while the plant’s fully private ownership by Lunera Energi AS is quite rare among similar facilities.

In June 2023 a formal collaboration agreements between Trondheim Municipality, Statkraft Varme, and SINTEF have reinforced their shared commitment to climate, environmental, and circular economy objectives. The PCP project has further strengthened this partnership, ensuring coordinated efforts towards advancing WtE-CCS in Trondheim while aligning with the city’s broader circular economy goals.

4.3.1.4 Learning & capabilities

[What Carbon Capture is Teaching Trondheim About Climate Transformation](#) (NetZeroCities):

- (1) Learning to think like a business. The lack of ownership has placed the city in a role of orchestration and matchmaking. To do this job effectively, Trondheim Municipality is embedding itself in the decision-making logic of the plant owner and trying to understand what a viable business case for CCS would look like.

Workshops they organised with Statkraft and SINTEF, a leading Norwegian research institute, revealed how business decisions heavily depend on factors like operational costs, timelines, and emerging carbon markets. By bringing this experience into the municipality, Trondheim is positioning itself to work more efficiently with companies and increase the number of such partnerships in future.

- (2) Listening to citizens. The city invited a randomly selected group of residents to take part in a series of four workshops focused on one key question: How can the CCS project be implemented in a way that is socially just and publicly understandable? All four workshops took place in June,

with citizens presenting their recommendations to the city government. This was not the first citizens' assembly, but this time Trondheim Municipality aims for institutionalisation of this method. The results will lead to more spaces for community engagement in municipal decision-making across the whole organisation.