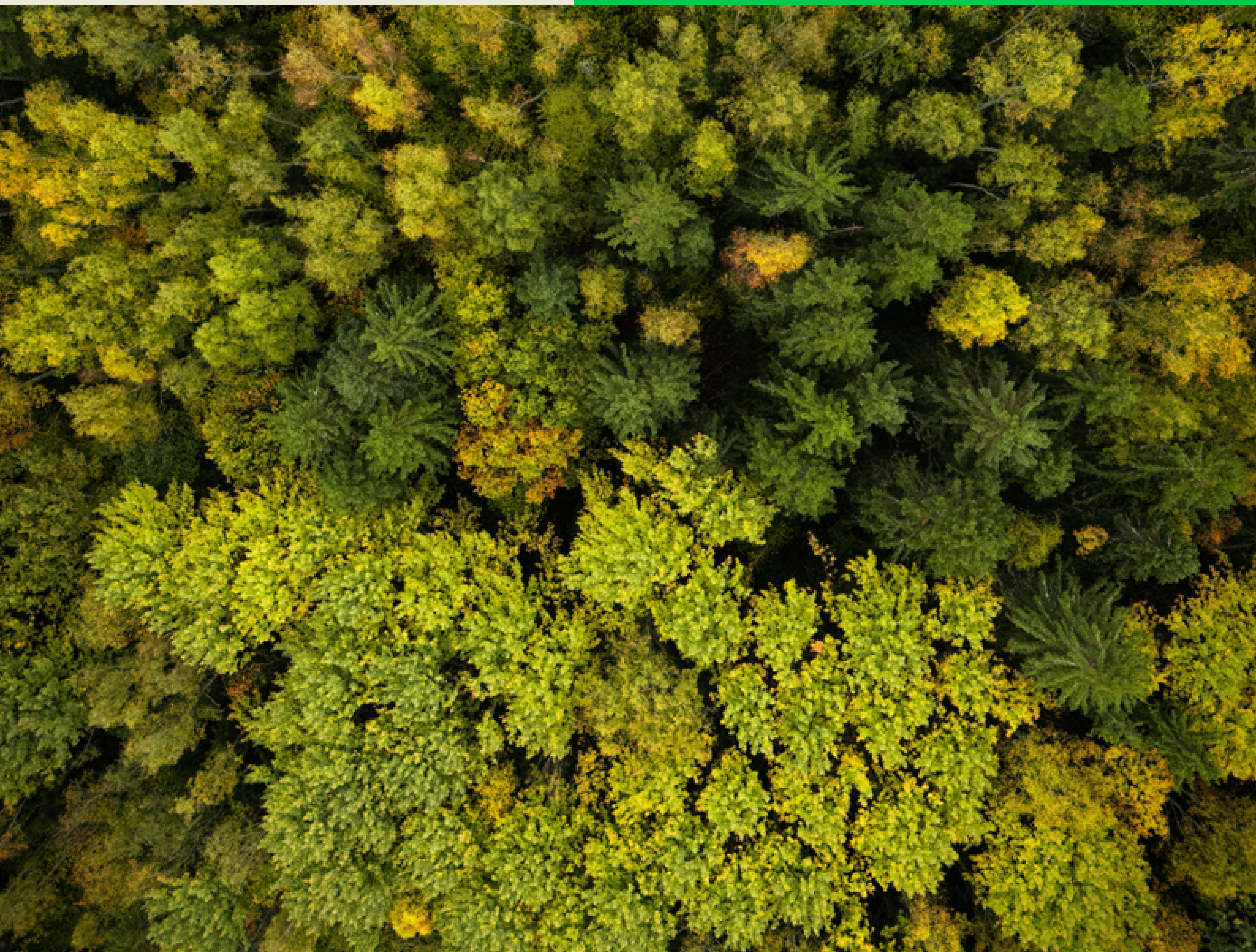
CARBON REMOVAL READINESS ASSESSMENT

Finland's potential to deploy CDR at scale and speed

Background report

November 2025



A collaboration between

carbon gap

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About the Carbon Removal Readiness Assessment project

Many governments have committed to net zero; moreover, the IPCC forecasts the need for hundreds of billions of tonnes of carbon dioxide removal (CDR) to stabilise global temperatures well below 2°C. Yet, few if any countries currently have a robust plan in place to develop and deploy atmospheric CDR at the capacity required to counteract remaining emissions at the point of net zero. Forecasted CDR needs are typically at global scale, failing to inform CDR planning and policy design at the country level.

The Carbon Removal Readiness Assessments (CRRA) aim to fill this information gap and to support national policymakers in complementing their climate strategies with ambitious yet realistic CDR goals. The CRRA estimate how much CDR countries can realistically deploy using a bottom-up approach and provide country-specific roadmaps designed with local stakeholders to assist decision-makers in understanding the opportunities and the actions needed to realise them.

Acknowledgments

This report was prepared by Sweco Finland and Carbon Gap using Carbon Gap's CRRA methodology and materials. We wish to give special thanks to the stakeholders who were interviewed as part of the development of this Background Report on CDR in Finland. We also wish to thank the many experts who generously provided data and insights, the external reviewers for their thoughtful input, and the Grantham Foundation for making this project possible.

Disclaimer

This document presents a quantified estimate of Finland's potential for the deployment of CDR methods. Given that many approaches are still in early development, the analysis involves significant uncertainty—some methods may prove unviable, while others not included here could mature more rapidly than expected.. As with other CDR studies, this assessment is limited by a lack of accurate and reliable data from official sources, particularly on resource availability for CDR. While relevant resources may exist, no formal policies currently reserve them for CDR over other green transition initiatives, such as CO_2 utilisation in synthetic fuels or industrial processes.

Consequently, the analysis in this report involves assumptions made by the project team to estimate the deployment potential. The land use sector, central to natural carbon sinks and several nature-based CDR methods, is particularly influential, and future policy or management changes could significantly alter Finland's CDR outlook.

Executive summary

With just a decade remaining until Finland's 2035 net zero target – and a negative trend on its primary carbon sink, the LULUCF sector - the country is adjusting its climate strategy. The need to deploy carbon dioxide removal (CDR) as a complement to emission reductions and to expand and diversify anthropogenic carbon sinks has been evidenced in the IPCC's AR6 report. For Finland, this need is especially urgent. Rapid and well-designed policy changes are essential to enable the emergence of significant CDR capacity and keep climate goals within reach.

This report provides initial quantified insights into Finland's potential to deploy carbon dioxide removal (CDR) in support of ambitious yet responsible CDR goals. Grounded in a bottom-up analysis of Finland's available resources, this study estimates both theoretical and realistic potentials for implementing various CDR methods through 2050. Recognising that CDR deployment is not solely a technical challenge, the report also analyses the 'social geography' of the issue – capturing stakeholder perspectives, including those of the public through a citizen panel discussion.

The assessment follows six key steps:

1. Identification and selection of relevant CDR methods
2. Mapping of available resources for CDR, including renewable electricity, waste heat, biomass, land, water, and geological storage capacity among others.
3. Estimation of the maximum theoretical CDR potential
4. Evaluation of Finland's regulatory, economic, and political landscape
5. Analysis of societal attitudes toward CDR deployment in Finland, based on stakeholder interviews and a citizen panel
6. Estimation of realistic CDR potential for 2035 and 2050 based on three scenarios.

Main results on Finlands' CDR potential

The report reviews a range of CDR methods – grouped into ecosystem management, biomass conversion, geochemical, and synthetic approaches – and assesses their respective theoretical and realistic potentials based on Finland's available resources. This "maximalist" assessment initially leads to a **theoretical CDR potential of around 120 $MtCO_2$/year in Finland by 2050**, assuming all available resources (after priority uses) were entirely directed towards CDR – which would be unattainable in real-world conditions. The theoretical potential is dominated by methods in the land-use sector, notably reduced forest harvesting (~37 $MtCO_2$ / year) and the expansion of agroforestry (~31 $MtCO_2$ / year), followed by BECCS (~20 $MtCO_2$ / year) and DACCS (~19 Mt CO_2 / year). Additional methods contributing to the theoretical CDR potential include enhanced rock weathering, ocean alkalinity enhancement, afforestation, durable bio-based products, and biochar.

To assess Finland's realistic CDR potential, **three scenarios** were developed. Two scenarios focused on nature: **Scenario A1 (Focus on nature – higher felling, NH-HF)** and **Scenario A2 (Focus on nature – lower felling, FN-LF)**. The third scenario, **Scenario B (Leveraging technology – higher feeling, LT-HF)**, explores the integration of technological CDR methods. All scenarios are modelled for two key milestones: 2035, aligned with Finland's climate target, and 2050, aligned with the EU's net-zero target.

This study builds on the Prime Minister's Office's climate and energy scenario (PEIKKO) as a foundation for estimating Finland's carbon gap – the quantity of emissions that must be removed to reach carbon neutrality by 2035. According to PEIKKO, this gap ranges between **16 and 18 $MtCO_2$ / year**. The results of the assessment are presented in Figure 1.

Scenarios A1 and A2 showcase Finland's potential for CDR if only methods rooted in nature are deployed. In this report, these two scenarios include **pasture and cropland management, enhanced rock weathering, durable bio-based products, and various forms of forest management practices.** Both scenarios apply the same suite of methods, with the key variable being the level of forest harvesting (i.e. fellings): Scenario **A1 (FN-HF) with higher harvesting levels** and **A2 (FN-LF) with lower harvesting levels.**[1] Under **Scenario A1**, the potential is ~4 $MtCO_2$ in 2035 and

1. In scenario A1 and scenario B, the harvesting levels are assumed to be 81.9 million m3 (2035) and 81.4 million m3 (2050). In scenario A2, the harvesting levels are assumed to be 70 million m3 (2035) and 69.5 million m3 (2050) (PEIKKO).

~13 $MtCO_2$ in 2050. In contrast, **Scenario A2** yields significantly higher potential - ~22 $MtCO_2$ in 2035 and **~37 $MtCO_2$ in 2050** - highlighting the impact of forest preservation on long-term carbon removal capacity.

Scenario B (LT-HF) outlines a more diverse pathway that involves deploying both conventional CDR methods included in scenarios A1 and A2 and novel CDR methods. **In addition to the methods listed in scenarios A1 and A2, this scenario incorporates biochar, BECCS, and DACCS**. To reflect a higher level of ambition while maintaining realism, Scenario B **assumes the same harvesting levels as Scenario A1**, i.e., the growth of harvesting levels is expected to continue in the future as well. In scenario B, the potential is ~14 $MtCO_2$ in 2035 and **~28 $MtCO_2$ in 2050.** Once the calculation was finalised, BECCS overruled the deployment of DACCS due to limited storage capacity and other factors such as energy efficiency and political will favouring BECCS. For these reasons, DACCS is not utilised in the realistic scenarios even though it was included in the calculations. A dedicated sensitivity analysis about the possibility of DACCS is discussed in chapter 7.

The scenarios were designed to align with the core principles of Finland's climate strategies, highlighting the pivotal role of the land use sector in both national emissions and the pursuit of climate targets, while also accounting for the strength and influence of the country's forest industry.

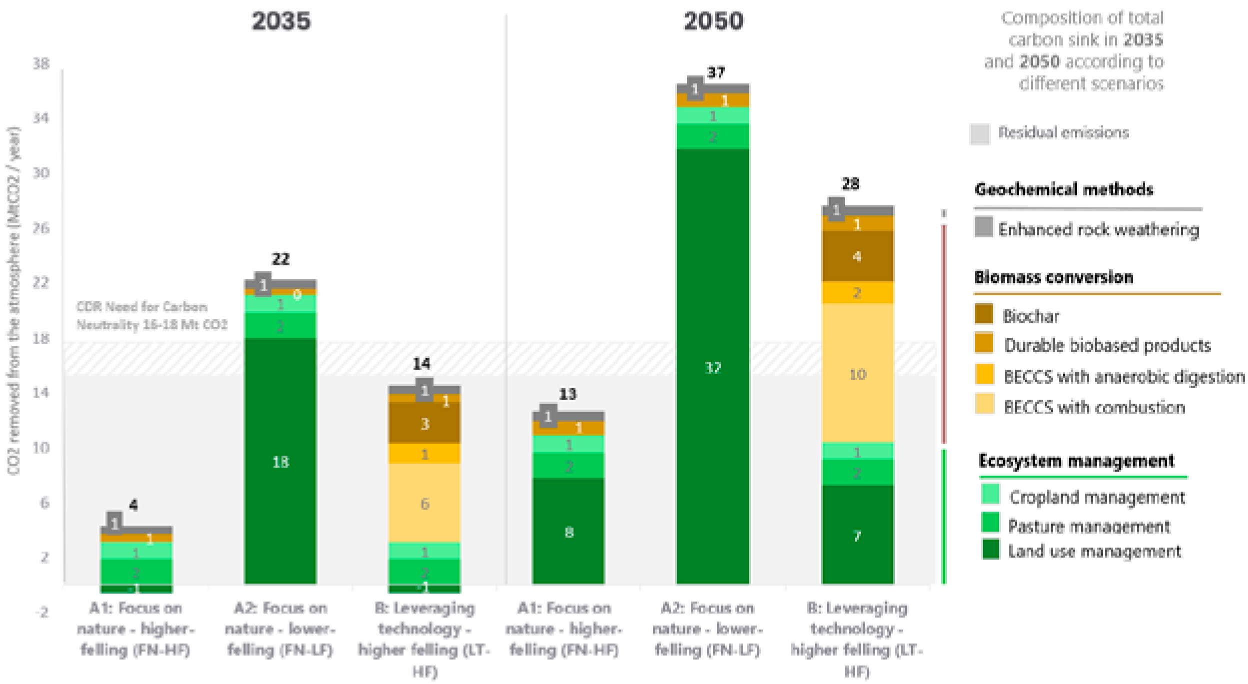

Figure 1. Finland's realistic CDR potential in 2035 and 2050 compared to the remaining carbon gap. Land use management consists of forest management, afforestation, cropland and pasture management in peatlands and wetland restoration (see Annex E for further details). Negative values in this graph represent GHG emissions, indicating that the natural sink operates as a source under scenarios A1 and B in 2035.

Key takeaways

1. **CDR is essential to help Finland close the remaining carbon gap and achieve carbon neutrality by 2035.** Both nature-based solutions and technical carbon sinks offer Finland opportunities to support the ongoing decarbonisation process. Scenario B is considered the most realistic pathway, as it reflects the expected development of the land use sector and the needs of Finnish industry over the next decade. It shows that incorporating technical CDR can help close the carbon gap even with moderate adjustments to harvesting levels, though this does not diminish the importance of sustainable forest management and broader mitigation efforts across sectors.

2. **Forest harvesting levels remain one of the most decisive factors in achieving Finland's climate neutrality, no matter how advanced or diversified the CDR portfolio becomes.** Scenarios A1 and A2 in this study clearly demonstrate the dramatic impact that changes in forest harvesting can have on carbon sink capacity—especially by 2035. For years, harvesting levels and forest management have been central to Finnish climate policy. The land-use sector, once a reliable net carbon sink, was a key reason Finland felt confident in setting one of the world's most ambitious climate neutrality targets. However, since that commitment, the land-use sector has become an emission source. Despite this reversal, policy action to address harvesting practices has been minimal. This study shows that even with a broad deployment of technical CDR methods, harvesting levels continue to exert outsized influence on Finland's ability to meet its climate goals.

3. **Geological storage capacity is the primary constraint across all scenarios.** In all scenarios, geological storage capacity emerges as the most limiting factor for technical CDR methods. Biomass availability is not a constraint – Finland possesses sufficient resources to support widespread deployment of BECCS, even under significantly reduced harvesting levels. In Scenario B, 10-30% of potentially available biomass suitable for CDR remains unused, underscoring the feasibility of BECCS despite lower forest biomass availability. However, both BECCS and DACCS are particularly constrained by the limited geological storage potential within Finland. This necessitates reliance on cross-border storage solutions or smaller-scale alternatives, such as incorporating storage in construction materials. Due to these limitations, DACCS was excluded from Finland's realistic CDR portfolio, as BECCS offers greater energy efficiency and better alignment with the country's industrial infrastructure. Nonetheless, DACCS could still be pursued if adequate storage capacity is secured or if policy shifts start favouring DACCS over BECCS. Deploying DACCS could be possible due to the already low carbon intensity of the power grid and the ambitious plans to expand electricity production as described in Chapter 3, resulting in potentially large amounts of decarbonised energy available to be used by DACCS. A sensitivity analysis for deploying DACCS is described in Chapter 7.

4. **Finland's social geography supports the deployment of CDR.** The stakeholder interviews and citizen panel were quite clear that increasing CDR should be encouraged as one means of reaching the climate neutrality target and subsequently carbon negativity. Interviewed stakeholders and citizen panel participants preferred the methods rooted on nature, but BECCS and biochar were noted as promising technical methods. CDR and so-called technical sinks have recently entered the Finnish political discourse. During the preparation of the renewed Climate and Energy Strategy in 2025, dedicated economic support for BECCS has been on the table, proving that CDR is seen as a viable option to explore in Finland.

In sum, the realistic potential scenarios presented in this report should not be interpreted as forecasts, but as illustrative pathways. Although both scenarios should be feasible, the actual level of CDR achieved in Finland by 2035 and 2050 will depend on significant investments, strategic political choices, and the evolution of relevant markets.

The concrete actions needed to unlock this potential will be outlined in a separate Roadmap for CDR deployment in Finland, building on the foundations laid out in this background report.

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List of abbreviations

BAU	Business as usual	LUKE	Luonnonvarakeskus – Natural Resource Institute
bcm	Billion cubic meters	m^3	Cubic meters
BECCS	Bioenergy with carbon capture and storage	mcm	Million cubic meters
CAPEX	Capital expenses	mm	Milli-meter
CCS	Carbon capture and storage	MRV	Monitoring, reporting, and verification
CCUS	Carbon capture, utilisation and storage	Mt	Million tonnes
CDR	Carbon dioxide removal	$MtCO_2$	million tonnes of carbon dioxide
CHP	Combined heat and power	MTK	The Central Union of Agricultural Producers and Forest Owners
CL	Carbon Limits	Mtpa	Million tonnes per annum
CO_2	Carbon dioxide	MW	Megawatts
CO_2e	Carbon dioxide equivalents	NATO	North Atlantic Treaty Organisation
COP	Conference of the Parties	NDC	Nationally determined contribution
CRCF	Carbon Removal Certification Framework	NECP	National Energy and Climate Plan
DAC	Direct air capture	NTC	Net Transfer Capacity
DACCS	Direct air carbon capture and storage	OAE	Ocean alkalinity enhancement
DOCCS	Direct ocean carbon capture and storage	OECD	Organisation for Economic Co-operation and Development
EEA	European Environmental Agency	OPEX	Operational expenses
EEZ	European Economic Zone	pH	Potential of Hydrogen
ESR	Effort Sharing Regulation	PEIKKO	Perus skenaariot energia ja ilmasto
ETS	Emission Trading System	QGIS	Quantum Geographic Information System
EU	European Union	R&D&I / RDI	Research, development and innovation
EUR	Euro (€)	S-DAC	Solid sorbent direct air capture
GDP	Gross domestic product	SMR	Small modular reactors
GHG	Greenhouse gases	STEM	Science, technology, engineering, and mathematics
Gt	Giga-tonne	SYKE	Suomen ympäristökeskus Finnish Environmental Institute
GTK	Geological Survey of Finland	t	Tonnes (metric)
GW	Gigawatts	tha/kha	Thousand hectares
IEA	International Energy Agency	TRL	Technology readiness level
IMF	International Monetary Fund	TSO	Transmission system operator
IPCC	Intergovernmental Panel on Climate Change	TWh	Terawatt-hour
km	Kilometre	UNFCCC	United Nations Framework Convention on Climate Change
km^2	Square kilometres	USD	United States Dollar ($)
Kt	Kilotonne	VCM	Voluntary carbon market
kV	Kilo-Volt	VTT	Teknologian tutkimuskeskus - Technical Research Centre of Finland
LCA	Life cycle assessment	WEM	With Existing Measures
LULUCF	Land use, land use change, and forestry		

1. Introduction

Climate change is one of the most significant challenges of the 21st century, endangering ecosystems, human health, economies, and global security. In response, the 2015 Paris Agreement committed signatories to:

> ***Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change.***[2]

Meeting these targets requires not only rapid and deep emissions reductions across all sectors, but also the removal of carbon dioxide (CO_2) from the atmosphere to offset residual emissions.[3] With a 70% likelihood that the 1.5°C threshold will be temporarily exceeded between 2025 and 2029,[4] CDR is increasingly viewed as a critical tool—not just for balancing emissions, but for actively reversing temperature overshoot. Its role will be essential throughout the remainder of this century to help bring global temperatures back within safe limits.

CDR refers to anthropogenic processes used to remove CO_2 from the atmosphere and store it to prevent further warming. CDR is not an alternative to emissions reductions, but it is a necessary addition, particularly in hard-to-decarbonise industries such as agriculture, aviation, and heavy industry.[5] CDR methods range from biological and nature-based solutions to technological processes that physically and-chemically separate CO_2 directly from the air and store it durably in underground geological formations.

Despite growing recognition, CDR faces significant uncertainties around technical maturity, economic feasibility, environmental risks, and public acceptance. Country-specific assessments are crucial for tailoring solutions to local socio-economic and geographical contexts, thereby enhancing the feasibility and effectiveness of these solutions.

The European Union (EU) has committed to achieving greenhouse gas (GHG) neutrality by 2050 and net-negative thereafter,[6] and as a member state, Finland must chart its own path toward this goal. Finland was selected for the Carbon Removal Readiness Assessment (CRRA) project due to its substantial theoretical CDR potential, its early-stage national dialogue on the topic, and the need for tailored strategies that reflect its distinct socio-economic and geographic conditions.

This report addresses a critical gap in the literature by evaluating Finland's readiness for CDR, mapping existing capacities, barriers, and opportunities. It offers actionable insights for policy makers, multidisciplinary researchers, and stakeholders aspiring to integrate CDR within national climate strategies – advancing Finland's contribution to global climate goals and sustainable development.

This report was prepared using a bottom-up approach, which included desk research, interviews with relevant national stakeholders, and public engagement through a citizen panel.

The following Chapter 2 outlines the various CDR methods available and the ones selected for this study. Chapter 3 then describes Finland's geographical landscape, including current and prospective resources and feedstocks necessary to deploy CDR. In Chapter 4, a preliminary estimation of CDR potential is presented based only on the physical resources – the so-called "theoretical" potential. Following this, chapters 5 and 6 outline Finland's social geography by analysing the socio-economic, regulatory, and political landscape to describe the results of the stakeholder interviews and citizen panel. Finally, Chapter 7 presents the estimation of CDR potential across various scenarios, taking into account the results of both physical and social geography. The report concludes with targeted recommendations for policymakers, researchers, and stakeholders, aimed at integrating CDR into national climate strategies and advancing Finland's contribution to global climate goals.

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2 United Nations Framework Convention on Climate Change. Paris Agreement, Article 2 (2015). https://unfccc.int/sites/default/files/english_paris_agreement.pdf

3 IPCC. Climate Change 2022: Mitigation of Climate Change. Summary for Policymakers. Contribution of Working Group III to the Sixth Assessment Report of the IPCC (2022). https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf

4 World Meteorological Organisation. WMO Global Annual to Decadal Climate Update (2025–2029). (2025). https://wmo.int/publication-series/wmo-global-annual-decadal-climate-update-2025-2029

5 IPCC. Global Warming of 1.5 ºC. An IPCC Special Report on the impacts of global warming of 1.5 ºC above pre-industrial levels and related global greenhouse gas emission pathways, Glossary (2018). https://www.ipcc.ch/sr15/chapter/glossary/

6 European Commission. The European Green Deal. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. (2019). https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

2. CDR pathways and their resource requirements

This report's definition of CDR follows three key principles:

1. The CO_2 captured must come from the atmosphere (or oceans), not from fossil sources;

2. The subsequent storage must be durable over climate-relevant timescales (typically decades to centuries or millennia), in either geological, terrestrial, oceanic, or durable products;

3. The removal must be the result of human intervention, additional to the Earth's natural carbon cycling[7];

It is important to clearly distinguish CDR from other related concepts, such as carbon capture and utilisation (CCU) and carbon capture and storage (CCS). While CCU and CCS share some components with certain CDR methods, they do not necessarily result in durable net removal of CO_2 from the atmosphere, as illustrated in Figure 2.

2.1 Diversity of CDR methods

The effectiveness of CDR methods depends not only on the amount of CO_2 removed, but also, among other factors, on the durability of storage, scalability towards climate-meaningful volumes, measurability, additionality, and social acceptability. CDR methods can be classified into four main categories: enhanced ecosystem management, biomass conversion or preservation, geochemical and synthetic CDR, as illustrated in Figure 3.

2.1.1 Enhanced ecosystem management

CDR methods based on enhanced ecosystem management increase the amount of CO_2 sequestered and retained across both natural and managed ecosystems. By optimising land use or restoring degraded or altered ecosystems, these approaches strengthen the capacity of natural ecosystems to operate as carbon sinks. Methods within this category include:

- **Afforestation** creates new forests by planting trees on land that previously lacked forest cover, often targeting degraded farmland, grasslands, or other open areas.

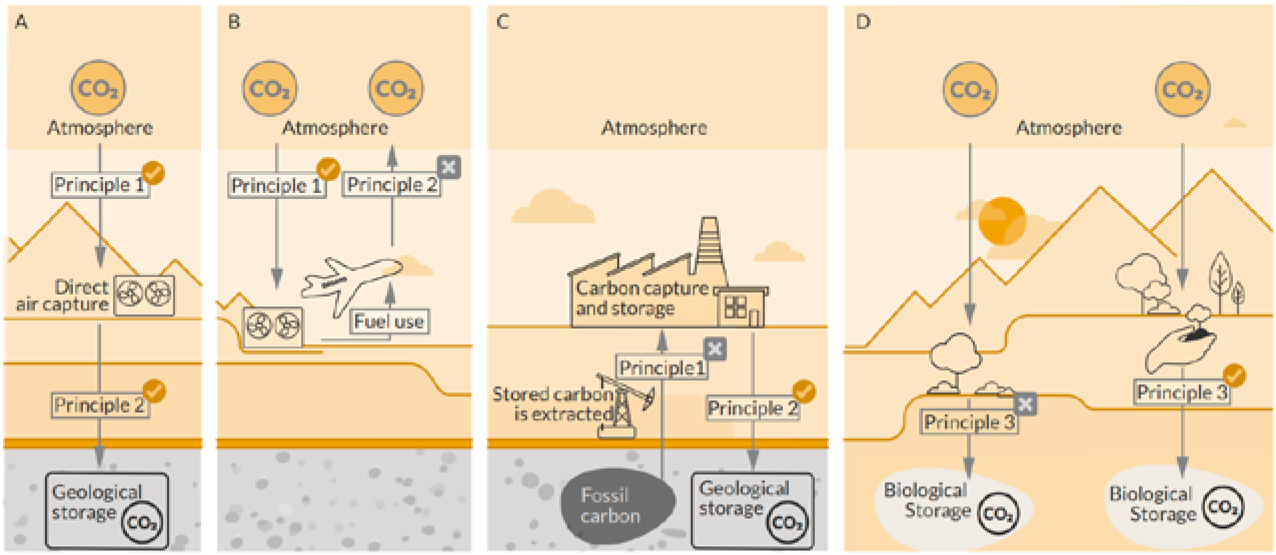

Figure 2. Image A illustrates direct air capture (DAC) with permanent geological storage, a configuration that satisfies all three core principles of carbon dioxide removal. In contrast, Image B depicts DAC where the captured CO_2 is used in short-lived products such as fuels, thereby failing to meet Principle 2 on durability. Image C shows the capture and geological storage of fossil-derived CO_2, which does not meet Principle 1, as it does not remove carbon already in the atmosphere. Image D presents natural processes like tree growth, which fall short of Principle 3 unless actively enhanced through human intervention (Source: the State of CDR report, 2024).

7 Smith, S. et al. The State of Carbon Dioxide Removal 2024 - 2nd Edition. DOI 10.17605/OSF.IO/F85QJ (2024)

- **Reforestation** restores tree cover on land that has been deforested or ecologically degraded, helping to restore ecosystem function and carbon storage.
- **Forest management** enhances forestry practices to increase carbon sequestration within forest ecosystems, including extended rotation periods, reduced harvesting, and conservation of old-growth stands.
- **Agroforestry** integrates trees and shrubs into agricultural systems, combining crop and livestock production with vegetation to improve resilience, biodiversity, productivity, and carbon storage.
- **Soil carbon sequestration** enhances soil organic carbon through regenerative practices in cropland and pasture management, including no-till farming, cover cropping, compost application, and crop rotations, thereby reducing emissions and improving soil health.
- **Peatland restoration** aims to restore the natural capacity of peatlands to store carbon.
- **Blue carbon** focuses on the restoration and conservation of coastal ecosystems, such as mangroves, salt marshes, and seagrasses, that naturally capture and store large amounts of carbon in their biomass and sediments.

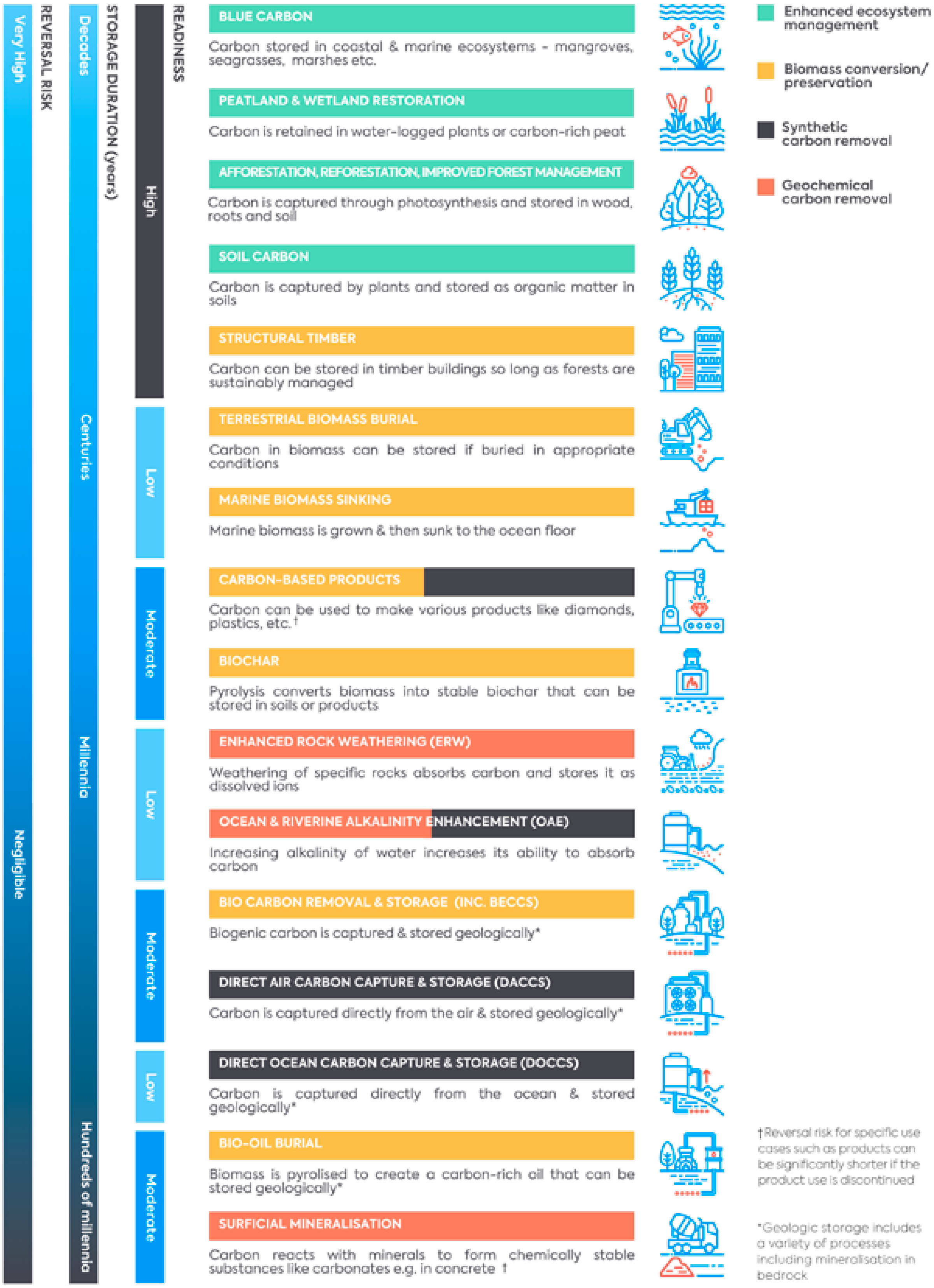

Figure 3. CDR Methods with their respective storage duration and deployment readiness (Carbon Gap).

2.1.2 Biomass conversion/preservation

Biomass-based CDR methods harness the natural ability of plants to absorb atmospheric CO_2 through photosynthesis, storing it in their biomass - leaves, stems, roots, and other organic tissues. To prevent carbon dioxide from returning to the atmosphere via natural decomposition or combustion, these approaches deliberately intervene in the carbon cycle. Biomass is intentionally processed in ways that stabilise or permanently sequester the captured carbon, ensuring long-term storage. Methods included in this category are:

1. **Durable bio-based products** refer to carbon stored in materials such as timber and bioplastics. These products delay carbon release by extending the lifecycle of biomass-derived carbon.

2. **Biochar** is produced through the pyrolysis of biomass under low-oxygen conditions, resulting in a stable, carbon-rich material. When applied to soils or materials, biochar resists decomposition and stores carbon for decades to millennia.

3. **Bio-Oil Storage** converts biomass into bio-oil via pyrolysis and injects it into stable geological formations. This method sequesters liquid carbon underground for hundreds to thousands of years.

4. **Bioenergy with Carbon Capture and Storage (BECCS)** combines the use of biomass with CO_2 capture and geological storage. It prevents CO_2 release from biomass combustion or processing, enabling net-negative emissions.

    a. **BECCS with Combustion** captures CO_2 from biomass combustion in power or industrial plants and stores it underground, while generating usable energy.

    b. **BECCS with Anaerobic Digestion/ Fermentation** captures CO_2 released during biomass breakdown for biogas or ethanol production, diverting it to secure geological storage.

5. **Marine Biomass Sinking** cultivates or collects seaweed and other marine biomass, depositing it in deep ocean layers (greater than 1,000 m). This accelerates the natural carbon pump and sequesters carbon for centuries to millennia.

6. **Terrestrial Biomass Burial** involves harvesting plant biomass and burying it in engineered, low-oxygen environments to prevent decomposition. This method locks carbon absorbed via photosynthesis into stable storage for extended timescales.

2.1.3 Geochemical carbon removal

Geochemical and ocean-based methods accelerate or enhance naturally occurring chemical interactions between carbon dioxide and reactive rocks or minerals. In nature, such reactions unfold slowly over geological timescales. However, by increasing the surface area of reactive materials—typically through grinding—and applying them to terrestrial or marine environments, the rate of CO_2 conversion and storage can be significantly enhanced. Key methods include:

1. **Enhanced Rock Weathering (ERW)** involves the application of finely ground silicate minerals to soils, where they react with CO_2 to form stable carbonates, thereby sequestering carbon over long timescales.

2. **Ocean Alkalinity Enhancement (OAE)** increases seawater alkalinity to accelerate the natural absorption of CO_2, converting it into stable bicarbonate and carbonate ions.

    a. **Mineral OAE** involves dissolving alkaline minerals (e.g., olivine, lime) into seawater to boost alkalinity and enhance CO_2 uptake.

    b. **Electrochemical OAE** uses electricity to modify seawater chemistry, increasing its alkalinity and, therefore, its capacity to absorb and retain CO_2.

3. **Carbon mineralisation** facilitates the reaction of CO_2 with calcium- or magnesium-rich rocks to form solid carbonates. This can occur in separate plants (ex situ) or within porous rock formations (in situ), enabling permanent carbon storage.

4. **Ocean fertilisation** adds nutrients to ocean regions to stimulate phytoplankton growth and CO_2 uptake. It can be done with iron, nitrogen/ phosphorus, or artificial upwelling. Overall, results are variable and may involve ecological risks and rapid carbon re-release.

2.1.4 Synthetic carbon removal

Synthetic carbon removal encompasses engineered systems designed to extract CO_2 from the atmosphere or oceans and store it permanently. Two principal approaches in this category are Direct Air Carbon

Capture and Storage (DACCS) and Direct Ocean Carbon Capture and Storage (DOCCS). Both offer the advantage of long-term, measurable carbon sequestration.

1. **Direct Air Carbon Capture and Storage (DACCS)** involves capturing CO_2 directly from ambient air using solid sorbents or liquid solvents. Once captured, the CO_2 is released through the application of heat, pressure, or chemical reactions, yielding a purified CO_2 stream. This concentrated CO_2 is then compressed and stored in geological formations or other long-term sequestration sites.

   a. **Electrochemical DACCS** utilises electrochemical reactions to capture and release CO_2 selectively.

   b. **Moisture-Swing DACCS** employs sorbents that adsorb CO_2 in dry conditions and release it when exposed to moisture.

   c. **Mineral Looping DACCS** captures CO_2 by reacting it with Ca- or Mg-rich minerals, forming stable carbonates such as calcite or magnesite.

   d. **Low-Temperature DACCS** (<100 °C) uses solid amine sorbents or alkaline solutions, often powered by low-grade or waste heat, to capture CO_2.

   e. **High-temperature DACCS** (>400 °C) techniques, such as calcium looping, operate at elevated temperatures, enabling rapid CO_2 capture.

2. **Direct Ocean Carbon Capture and Storage (DOCCS)** targets CO_2 dissolved in seawater, where it exists in large quantities as part of the ocean's inorganic carbon pool. The pH swing method alters chemical equilibria to release CO_2 from solution, allowing it to be captured and stored permanently.

2.2 Selected CDR methods

Finland's diverse territory and advanced economy provide a strong foundation for deploying a wide range of CDR methods. Land- and biomass-based approaches appear particularly promising, supported by the country's extensive forests and established bioeconomy.

Certain CDR methods were excluded from this assessment due to environmental, regulatory, and infrastructural constraints. Terrestrial biomass burial

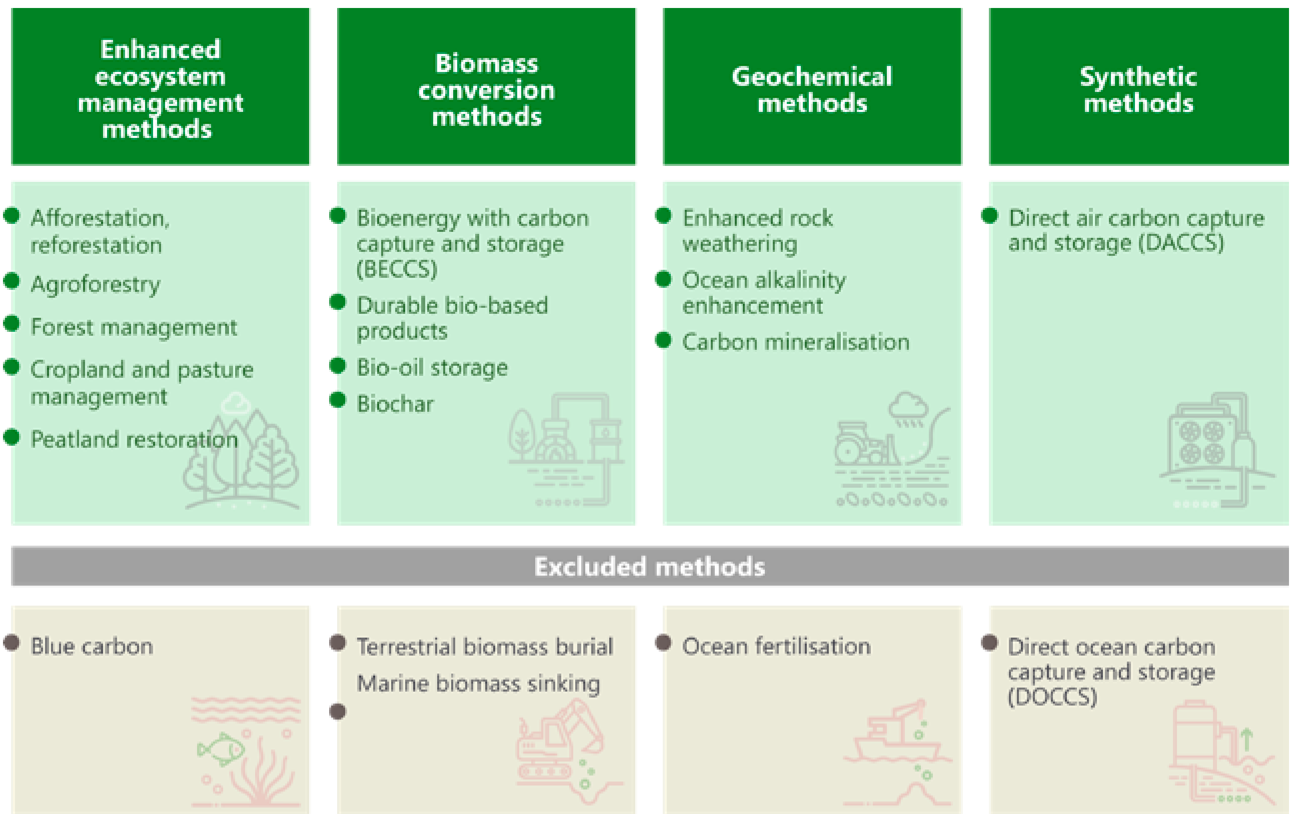

Figure 4. Summary of the CDR methods included and excluded from the study.

was excluded due to low technological maturity and the economic value of biomass in other applications. Ocean-based approaches - including blue carbon, ocean alkalinisation (OAE), marine biomass sinking, ocean fertilisation, and DOCCS were deemed unsuitable due to the Baltic Sea's shallow depth, limited water exchange, ecological degradation, and vulnerability to chemical disturbances, especially in the Gulf of Finland and the Archipelago Sea.[8] While recent studies suggest OAE may hold theoretical promise in the Baltic context[9], practical application remains limited and research in Finland is minimal. Preliminary assessments suggest that altering seawater chemistry could pose serious ecological risks[10]. Regulatory hurdles and challenges in reliably measuring effectiveness further complicate deployment. As a result, OAE is included in the theoretical potential estimates but excluded from the realistic potential calculations. DOCCS was also excluded due to its low technology readiness level and uncertain performance under Baltic conditions, making large-scale deployment premature.

The selected and excluded methods are summarised in Figure 4.

2.3 Resource requirements for selected CDR methods

To assess the deployment potential of each CDR method, it is essential to understand their resource requirements - such as water usage, land area, and energy consumption - per net tonne of CO_2 removed. However, accurately quantifying these inputs presents two key challenges:

- The diversity of CDR methods, each with multiple variants that differ significantly in design, scale, and operational parameters.
- Limited availability of reliable data, as most methods remain in early stages of development and lack robust field-based evidence.

Moreover, comparing methods requires a consistent basis. Since all CDR approaches generate some GHG emissions during operation, resource requirements must be evaluated per net tonne of CO_2 removed - accounting for emissions subtracted from gross removal volumes. This makes life cycle analysis (LCA) a crucial tool for generating reliable and meaningful data.

The scientific literature offers valuable insights, particularly due to its methodological transparency and rigorous peer review. However, most studies rely

on laboratory-scale experiments or modelling, often based on limited datasets. As a result, their applicability

8 Krause-Jensen, D. et al. Nordic blue carbon ecosystems: Status and outlook. Front. Mar. Sci. 9, 847544 (2022) https://doi.org/10.3389/fmars.2022.847544 ; Röhr, M. E., Boström, C., Canal-Vergés, P., and Holmer, M.: Blue carbon stocks in Baltic Sea eelgrass (Zostera marina) meadows, Biogeosciences, 13, 6139–6153, https://doi.org/10.5194/bg-13-6139-2016, 2016.

9 Dale, A. W. et al. Seafloor alkalinity enhancement as a carbon dioxide removal strategy in the Baltic Sea. Commun. Earth Environ. 5, 1569 (2024). https://doi.org/10.1038/s43247-024-01569-3 ; Howard, J. et al. Blue carbon as a nature-based climate solution: A Nordic perspective. Front. Clim. 7, 1450468 (2025). https://doi.org/10.3389/fclim.2025.1450468

10 Kujanpää L. et al., 2023

to real-world conditions remains uncertain, and few include comprehensive LCAs.

Operational data from companies - those developing pilot projects or commercial-scale deployments - is rare but increasingly available. For instance, application files submitted to the Frontier fund provide performance metrics from actual projects. While these figures reflect current technological capabilities more accurately, they are often self-reported and lack peer review, making them "declarative" in nature.

To overcome these limitations and build a robust database of resource requirements, Carbon Gap partnered with RMI. The resulting dataset is grounded in three complementary sources: peer-reviewed scientific literature, publicly available Frontier fund applications (across three cohorts), and direct surveys conducted with active CDR operators.

The database will continue to evolve after the publication of this report, but at the time of publication, it includes:

- 442 data points obtained from 129 scientific articles;
- 200 data points obtained from 113 Frontier files;
- 330 data points obtained from 57 survey responses.

The database is accessible from the *CRRA website*.

The data was compiled to produce consolidated values for each of the resources required for CDR methods. These values are used in the rest of the report to estimate the potential of CDR methods based on the available resource feedstocks. When values are not available from the database or if alternative values are more relevant to the national context, they are explicitly reported, along with their source.

3. Finland's physical geography (resources and feedstocks)

Finland offers sufficient, or in some cases abundant, resources to support various CDR methods, including freshwater, renewable energy, and biomass. However, its geographic and geological features present notable limitations: the country's only maritime access is to the semi-enclosed Baltic Sea, and it lacks suitable geological formations for long-term carbon storage. The following overview examines key resources to evaluate both the theoretical and realistic potential for deploying CDR technologies in Finland.

3.1 Energy

Finland has a robust energy system, featuring key elements for supporting a CDR sector, such as a reliable electricity grid with interconnectors to other Nordic and Baltic countries, strong integration between district heating and electricity systems, and excellent wind power conditions that have enabled rapid development. Today, Finland is a net electricity importer, limiting availability of electricity for CDR. However, renewable electricity capacity, especially wind, is expected to grow significantly, creating an **estimated electricity surplus of approximately 25-30 TWh by 2050**. Total heat production in 2023 (the most recent data available at the time of writing) reached 83 TWh, primarily from district heating and industrial sources. Thermal energy available for CDR comes primarily from waste heat generation, which is currently approximately 130 TWh, of which 35 TWh is estimated to be technically and economically feasible to utilise.[11]

3.1.1 Electricity

In Finland, electricity is produced primarily through separate electricity production, which is mainly based on low-emission forms of energy generation. In 2024, total **electricity production** was approximately 80 TWh per year - **83 TWh** if including net imports of 3 TWh.[12]

Most of the electricity is produced using nuclear power, accounting for 40% of the separate electricity production in 2024. In addition to nuclear power, significant forms of production include wind power (24%) and hydropower (17%). Electricity is also produced using solar power (1% in 2024) and condensing power (4% in 2024). Still, their role in total production is minor, and condensing power is primarily used as backup to meet demand during peak consumption. In separate electricity production, the share of low-emission electricity exceeds 95%, and the share of renewable energy sources was 56% in 20241. In addition, electricity is produced in combined heat and power (CHP) plants, which produced approximately 14.3 TWh of electricity in 2024.[14]

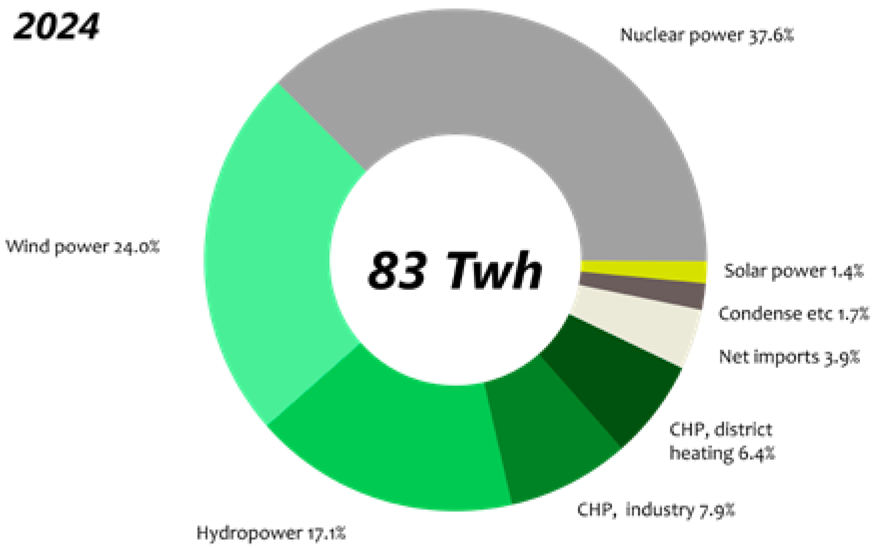

Figure 5. Distribution of electricity production methods by Finnish Energy.

11 Afry 2020. Energiatehokkuusdirektiivin mukainen selvitys hukkalämmön potentiaalista ja kustannushyötyanalyysi tehokkaasta lämmityksestä.

12 Finnish Energy 2024. Sähköntuotanto. https://energia.fi/energiatietoa/energiantuotanto/sahkontuotanto/

13 Finnish Energy 2024. Sähköntuotanto. https://energia.fi/energiatietoa/energiantuotanto/sahkontuotanto/

14 Finnish Energy 2024. Sähköntuotanto. https://energia.fi/energiatietoa/energiantuotanto/sahkontuotanto/

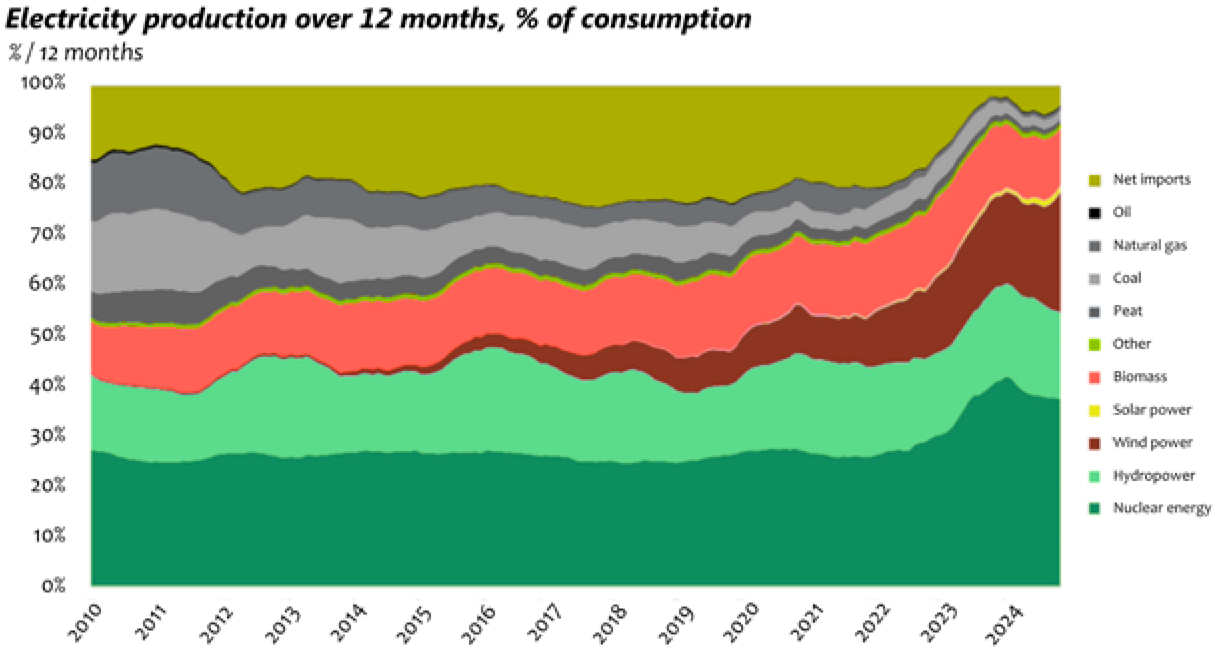

Figure 6. Shares of energy sources and net imports in Finland's electricity production in 2010 to 2024.[15]

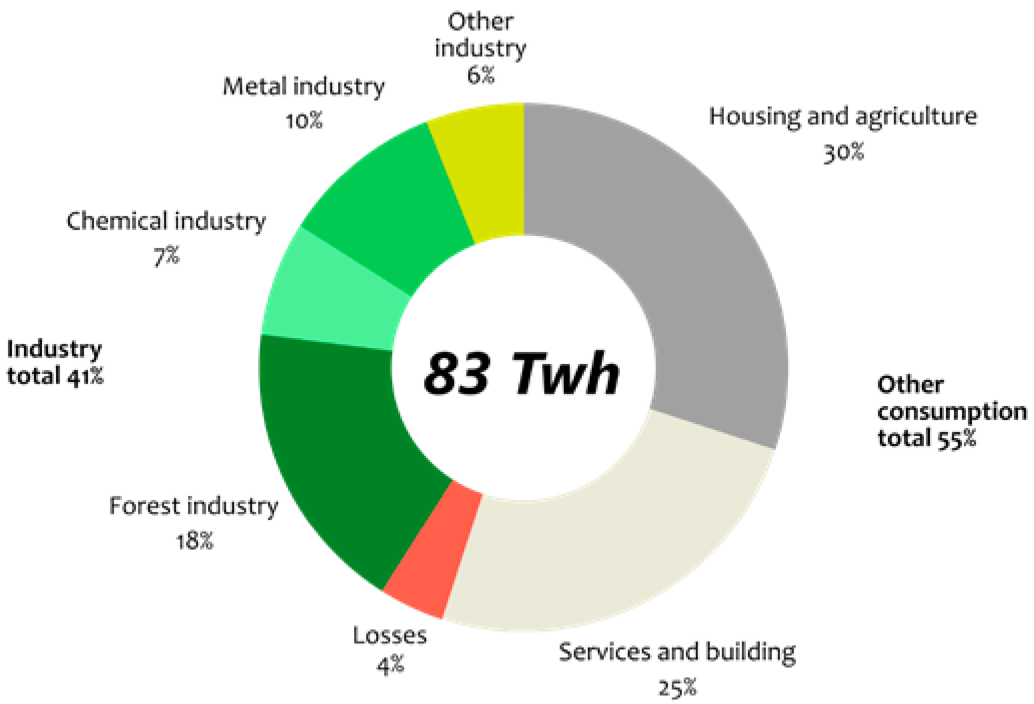

Figure 7. The distribution of electricity consumption in 2024.[14]

15 Finnish Energy 2025. Sähkötilastot. https://energia.fi/tilastot/sahkotilastot/

Electricity production based on renewable energy sources is expected to grow significantly in the coming years, supporting the country's goal of achieving carbon neutrality by 2035. Figure 5 illustrates the breakdown of electricity production methods, while Figure 6 shows the evolution of energy supply in Finland's electricity generation from 2010 to 2024. As the share of low-carbon electricity production has increased, emissions from the energy sector have decreased by more than 50% compared to 2010 levels1. Expected further development of electricity production is described in more detail in the energy scenarios section 3.1.2.

Finland's **electricity consumption** was **83 TWh** in 2024, with demand fluctuating significantly across seasons. Winter consumption peaks due to heating needs, while summer demand can fall by over 40% compared to the coldest months.[17] Figure 7 illustrates the breakdown of total electricity consumption for 2024.

Approximately 40% of electricity consumption is used in industry, particularly the forestry, metals, and chemicals industries, making Finland one of Europe's largest industrial electricity consumers[18]. In addition, various green transition projects reported by the Confederation of Finnish Industries, such as hydrogen and battery plants, as well as data centre projects[19], are expected to significantly increase electricity consumption if realised. **Finland's annual electricity consumption is projected to rise to over 200 TWh by 2050**, and industry plays a significant role in this estimate.[20]

Finland has traditionally consumed slightly more electricity than it produces, but benefits from flexible imports through the Nordic electricity market and reliable transmission infrastructure – primarily with Sweden.[5] The national grid is highly reliable, with nearly 100% transmission reliability in 2024[21], supported by 14,500 km of transmission lines and over 120 substations.[6] Finland operates within the Nordic synchronous area (with Sweden, Norway, and Eastern Denmark) and is connected to Estonia and Central Europe via direct current links. The system is continuously developed to meet evolving demands. Fingrid, the national grid operator, is actively upgrading the system to meet growing demand and support Finland's 2035 carbon neutrality target, which requires major expansion of clean electricity production and consumption.[22]

3.1.2 Electricity production scenarios

Several scenarios for scaling up clean electricity production have been developed. The most recent scenarios, evaluating the available electricity for CDR in Finland for 2035 and 2050, include projections published by the transmission grid operator Fingrid[4] and an advocacy organisation for the energy industry, Energiateollisuus[8], in 2025, as well as by the consulting company Afry[7] in 2020. These scenarios vary in ambition for low-carbon energy production and are summarised in Figure 8.Across all scenarios, wind power shows the strongest growth, while solar and nuclear expand moderately. Hydropower remains stable, and CHP, which is included in 'other combustion', declines toward 2050. Depending on the mix of technologies and ambition level, **domestic electricity production by 2040–2050 ranges from 91 to 234 TWh**, shaped by factors such as hydrogen production, power demand forecasts, and the development of small modular reactors (SMRs). Electricity consumption is also expected to rise, though more gradually than production capacity.

The production scenarios have been used to assess both the theoretical and realistic electricity production from various sources and, thus, the corresponding availability for carbon removal methods. **For theoretical potential, the highest capacity estimates for each low-carbon source were projected** based on the scenarios and combined to maximise low-carbon electricity production, assuming technical feasibility. However, such a portfolio is unlikely to materialise without substantial efforts and investments in both supply and demand. By 2050, this kind of production portfolio would consist of 14 TWh of hydropower, 272 TWh of wind power, 18.5 TWh of solar power, 38 TWh of nuclear power, and 11 TWh of CHP, resulting in a total of 353.5 TWh per year.

Of the scenarios presented, the Fingrid climate-neutral growth scenario was deemed to be most appropriate. This scenario involves 240 TWh consumption in

16 Finnish Energy 2024: Sähkövuosi 2024 https://energia.fi/wp-content/uploads/2025/01/Sahkovuosi-2024_20250115.pdf

17 The Finnish Energy 2024. Sähköntuotanto ja -käyttö. https://energia.fi/tilastot/sahkotilastot/sahkontuotanto-ja-kaytto/

18 Finnish Energy 2025: Sähkövuosi 2024 https://energia.fi/wp-content/uploads/2025/01/Sahkovuosi-2024_20250115.pdf

19 Confederation of Finnish Industries 2025. Green investments in Finland. https://ek.fi/en/green-investments-in-finland/

20 Fingrid 2025. Sähköjärjestelmävisio 2023. https://www.fingrid.fi/kantaverkko/kehittaminen/sahkojarjestelmavisio/

21 Statistics Finland 2024. Sähkön hankinta ja kokonaiskulutus. https://pxdata.stat.fi/PxWeb/pxweb/fi/StatFin/StatFin__ehk/statfin_ehk_pxt_12su.px/table/tableViewLayout1/

22 Fingrid 2024. Suomen sähköjärjestelmä. https://www.fingrid.fi/kantaverkko/kehittaminen/suomen-sahkojarjestelma/

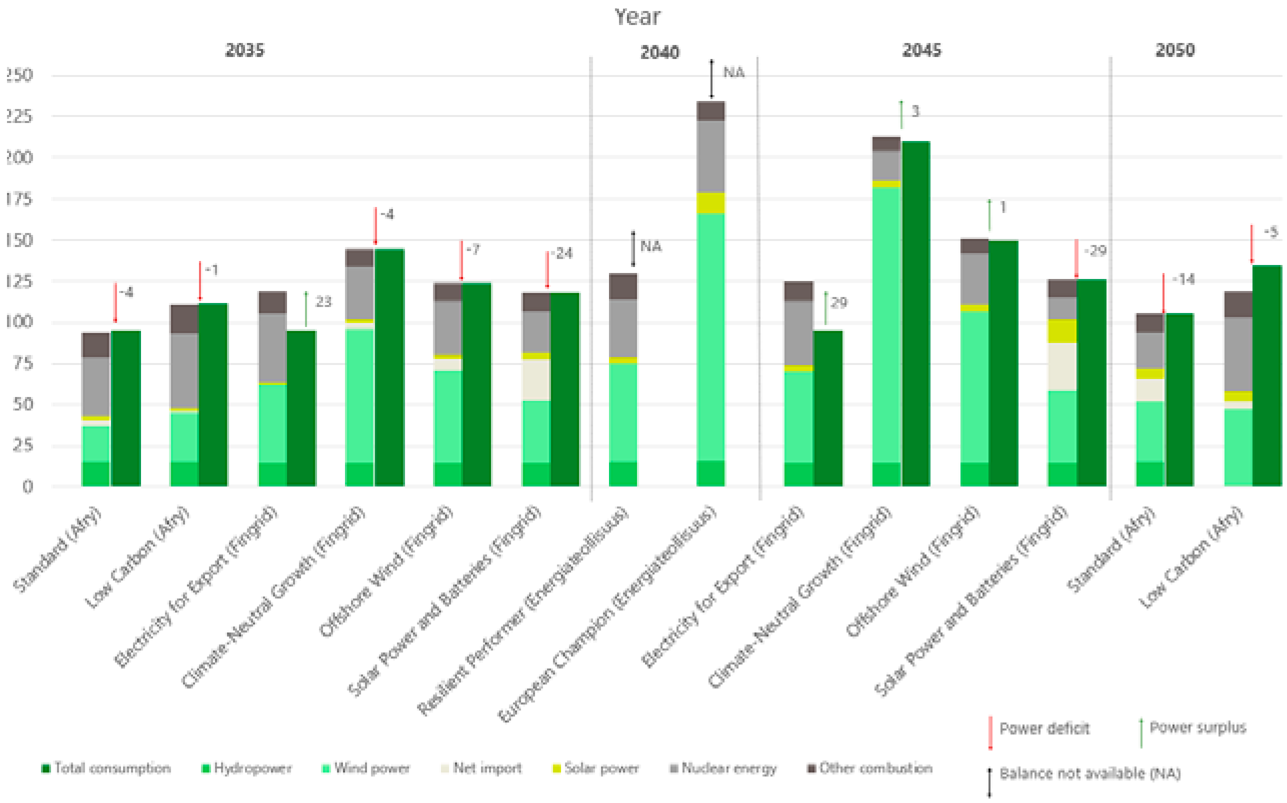

Figure 8. Summary of electricity production scenarios (including imports) by Afry[23], Energiateollisuus[24], and Fingrid.[4]

2050. Of this total, about 30 TWh is estimated to be consumed in CCU projects, which, in the theoretical potential, has been allocated to CCS - particularly DACCS. Under this scenario, we estimate that 141 TWh of electricity could be available for CDR, derived from surplus electricity (111 TWh) in the national balance and the conversion of CCU to CCS (30 TWh).

For realistic CDR scenarios, the more ambitious scenario for 2040, **Energiateollisuus European Champion scenario, was selected as a basis for electricity production capacities**, while the consumption (240 TWh per year) scenario was maintained.

In 2035, 15 TWh of hydro power, 101 TWh of wind power, 5 TWh of solar power, 40 TWh of nuclear power, and 12 TWh of combined power and heat are produced, resulting in total electricity production of 174 TWh. The projected consumption is 145 TWh, resulting in an electricity surplus of 29 TWh available for CDR. Similarly to the theoretical scenario, the consumption has also been assumed to reduce in other sectors, and 30 TWh is to be reallocated for CDR; thus, the total availability is assumed to be 59 TWh.

In the projected 2050 scenario, the production portfolio consists of 16 TWh of hydro power, 230 TWh of wind power, 20 TWh of solar power, 50 TWh of nuclear, and 10 TWh of CHP, resulting in a total of 326 TWh of electricity produced. Therefore, an electricity surplus of 84 TWh per year would be available for CDR. With a consumption estimate of 242 TWh and 30 TWh of consumption reallocated for CDR, the total availability is 111 TWh.

In conclusion, **low-carbon electricity generation – particularly from wind power - is expected to increase significantly by 2050**, leading to a surplus in most the production scenarios in the national electricity balance. This surplus is expected to provide relatively strong availability of resources for CDR. It should be noted that the **theoretical surplus of 111 TWh** reflects an **optimised projection balancing electricity production and consumption to maximise availability for CDR**. This surplus is not directly visible in the current figures. Its actual

23 Afry 2020. Low carbon roadmap. https://energia.fi/wp-content/uploads/2023/08/Taustaraportti_-_Finnish_Energy_Low_carbon_roadmap.pd

24 Energiateollisuus (engl. Finnish Energy) 2024. Visio menestyvän Suomen energiatulevaisuudesta. https://energia.fi/meista/visio/visio-menestyvan-suomen-energiatulevaisuudesta/

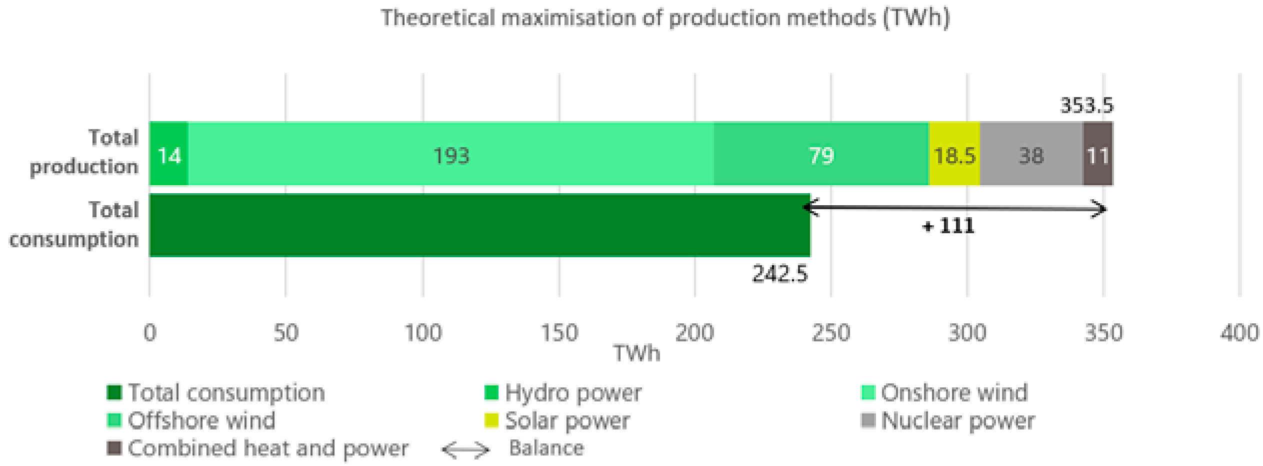

Figure 9. Projection of theoretical maximisation of electricity production methods in 2045 based on the Fingrid climate growth scenario.

utilisation will depend heavily on developments in other sectors, particularly hydrogen production and the broader green transition.

3.1.3 Thermal energy (incl. waste heat)

Total district heat and industrial heat production in Finland was **83 TWh** in 2023[25] (data for 2024 was not available at the time of writing). In addition to district and industrial sources, heat is also generated through small-scale production and separate heating of buildings. However, official statistics only cover district and industrial heat, with no precise data available for small-scale and separate heating, as these typically occur within private households. The distribution of total energy consumption for 2024 is not available at the time of writing. For 2023, total heat consumption reached **132 TWh**, of which 80 TWh was used in buildings and 52 TWh in industry.[26] Figure 10 illustrates the breakdown of total energy consumption for 2023. Notably, in 2023, industrial heat was primarily produced using renewable energy and waste heat, while about one fifth was derived from fossil fuels.

In contrast, buildings were heated using small-scale wood incineration (20%), fossil fuels (10%), heat pumps (10%), electricity (20%), and district heating (40%)[9]. There are no scenarios yet available showing future sources of heat production. According to electricity production scenarios, the share of renewables is expected to increase significantly, indicating the emergence of electrification through renewable electricity and sectoral integration, especially in district heating.

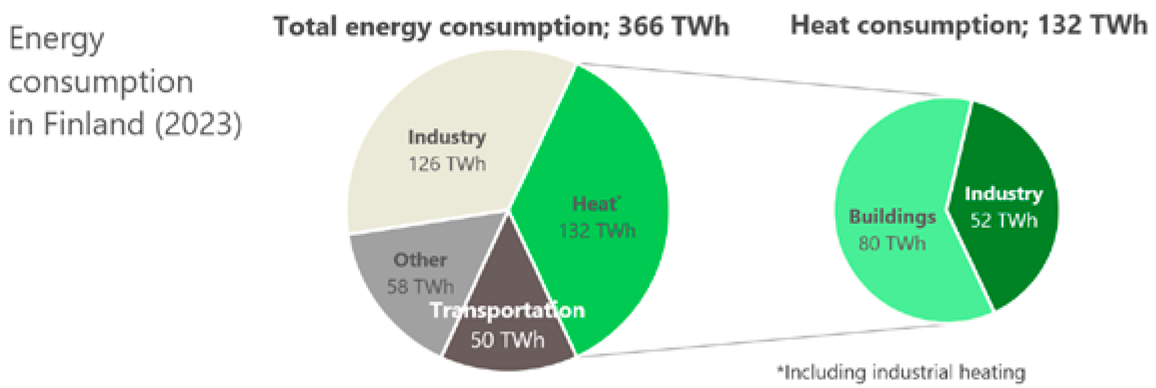

Figure 10. Total energy consumption in Finland and the share of heat consumption in 2023.[27]

25 Tilastokeskus, 2023. Sähkön ja lämmön tuotanto ja polttoaineet tuotantomuodoittain 2023

26 Rämä, 2023. Millä Suomi lämpeää? Katsaus lämmöntuotantoon ja käyttöön

27 Statistics Finland. (2025). Kasvihuonekaasupäästöt Suomessa, 1990-2024*. Statistics Finland: https://pxdata.stat.fi/PxWeb/pxweb/fi/StatFin/StatFin__khki/statfin_khki_pxt_138v.px/ Rämä, M. (2023). Millä Suomi lämpeää? Katsaus lämmöntuotantoon ja käyttöön. Espoo: VTT.

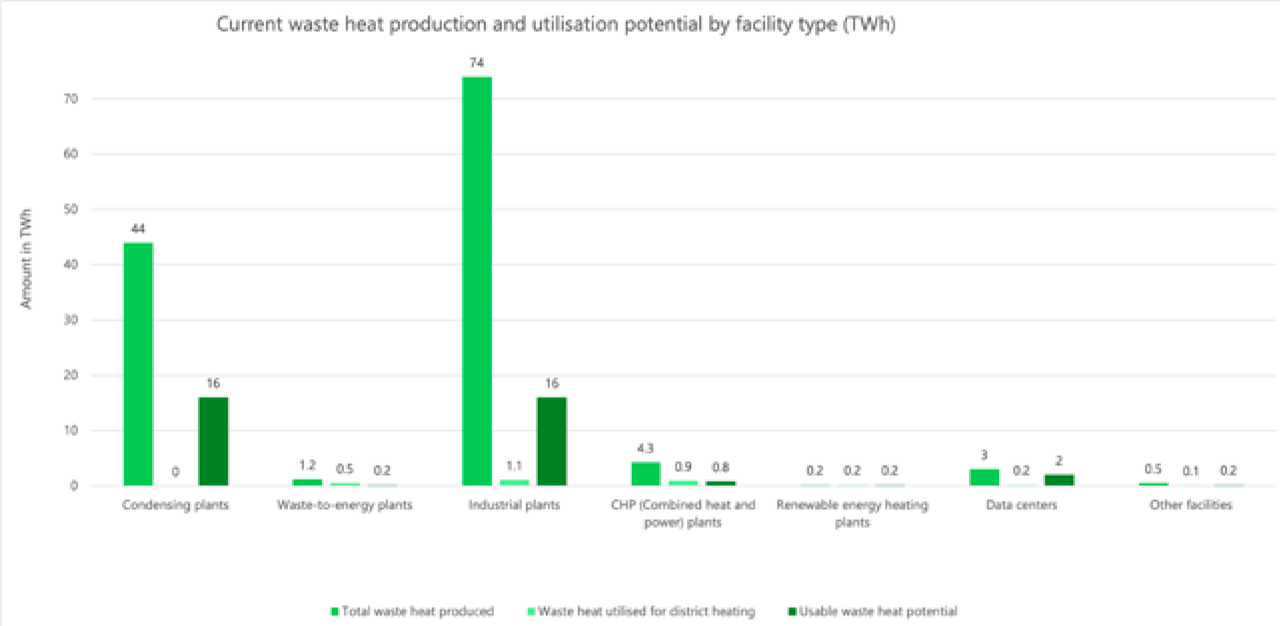

Figure 11. Current waste heat production and utilisation potential by facility type in TWh.[10]

In Finland, heat production is closely aligned with demand, with district heating serving as a cornerstone of the national heating system. Unlike much of Europe, district heating is widely adopted in Finland, supplying the majority of building heating. It plays a pivotal role in supporting Finland's carbon neutrality goals by enabling a diversified energy mix and facilitating the efficient use of waste heat. In 2023, nearly 70% of district heating was carbon-neutral, with fossil fuels were primarily used to cover peak demand periods[9]. Although district heating offers flexible production to match consumption, it generates minimal surplus heat suitable for CDR. High grade industrial heat suitable for CDR purposes is already fully consumed by industry, while any excess heat from the district heating network does not meet the temperature demands of CDR, being at temperatures of well below 100°C. Consequently, **only waste heat, mainly from industry, is available for carbon removal**. Finland produces about **130 TWh** of waste heat annually, of which **35 TWh** is considered techno-economically feasible for recovery, and 3 TWh is currently used in district heating[28]. Figure 11 shows waste heat production and utilisation potential.

While this techno-economically feasible waste heat may also be at low temperature, it could be used by CDR systems operating at low or ambient temperatures (such as S-DACCS), currently resulting in approximately 35 TWh. Currently, no detailed scenarios exist for future thermal energy production and consumption. Overall consumption is expected to remain relatively stable, with production adjusted to meet demand. Waste heat generation – especially in industrial sectors - is expected to rise, but its recovery, particularly in district heating, is unlikely to become more efficient. As a result, **the availability of waste heat for CDR is not expected to grow significantly**. Meanwhile, production is expected to shift towards low-carbon technologies like electric boilers, heat pumps, and energy storage systems.

3.2 Water

Finland's abundant freshwater resources provide a strong foundation for supporting CDR technologies. Many CDR methods - such as certain forms of direct air capture, mineralisation, and biomass processing – depend also on freshwater for chemical reactions, cooling, or material handling. Assessing its availability and distribution is therefore key to evaluating deployment potential.

As one of Europe's most water-rich countries, Finland benefits from a diverse mix of groundwater, surface water, and rainwater[29]. The landscape includes around 57,000 lakes over one hectare, and up to 300,000 when smaller ones are counted. While many of these lakes are relatively shallow and hold modest volumes, they collectively contribute to an **annual renewable**

28 Afry 2020. Energiatehokkuusdirektiivin mukainen selvitys hukkalämmön potentiaalista ja kustannushyötyanalyysi tehokkaasta lämmityksestä.

29 FAO 2022. Aquastat. https://data.apps.fao.org/aquastat/?lang=en

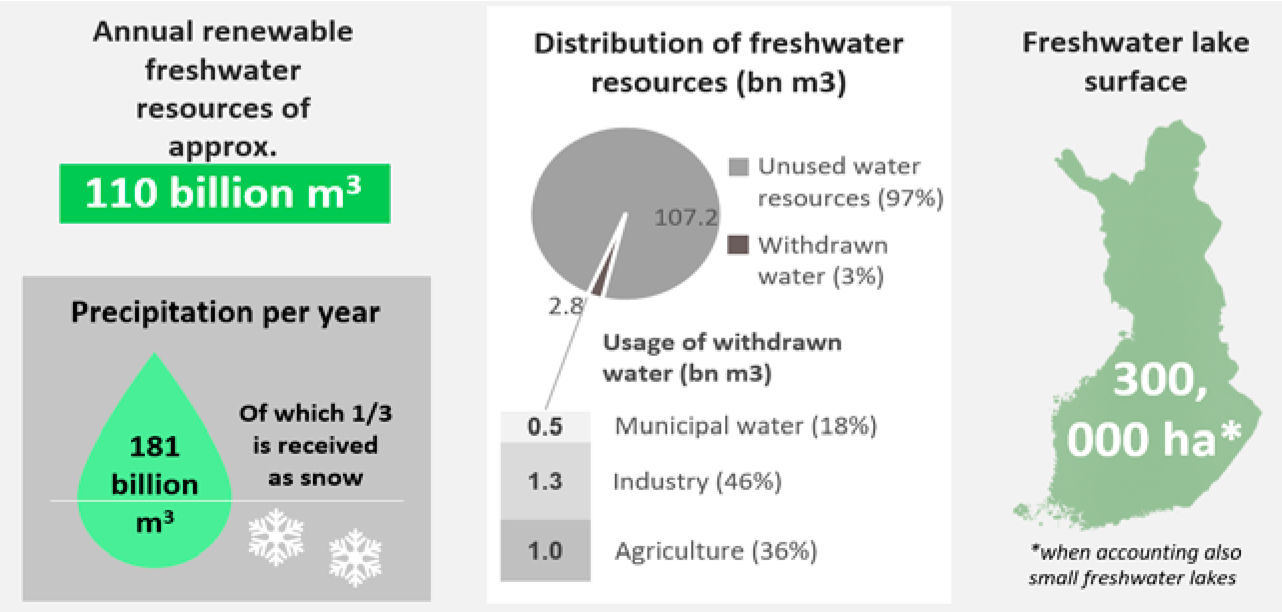

Figure 12. Overview of freshwater resources in Finland.

freshwater supply of roughly 110 bcm, with surface water accounting for the majority.[30]

Finland receives about 181 bcm of precipitation annually - high by European standards. With climate change, precipitation is expected to rise by around 5% in summer and up to 15% in winter[18], with increased winter rainfall boosting groundwater levels in some regions. Despite Finland's overall water abundance, climate change may lead to summer droughts, particularly in the already water-stressed southeast.[3]

In 2022, **total water withdrawal was about 2.8 bcm**, with usage distributed across agriculture (36%), industry (46%), and municipal water use (18%)[1]. This accounts for just 3% of Finland's annual renewable freshwater resources (see Figure 12), highlighting its low withdrawal intensity compared to other EU countries.

Municipal water use relies heavily on groundwater due to its natural purity. In fact, 42% of municipal water originates from groundwater and 16% from artificial groundwater. Yet, only around 12% of total groundwater reserves are withdrawn, indicating sustainable use.[31]

Water consumption in Finland has been steadily declining and is expected to continue this trajectory. Per capita municipal water use dropped from roughly 300 litres per person per day in 1970 to about 200 litres in 2024[32], largely due more efficient household appliances. Industrial water use has also seen significant reductions. For example, the pulp and paper industry, once highly water-intensive, reduced water consumption from 150 m^3 per ton of pulp produced in the 1970s to just 5–50 m^3 per ton today.[33]

The Finnish water and wastewater treatment systems and distribution networks are extensive and provide high-quality water to nearly all the Finnish population. The municipal water network spans 100,000 km in length, and the wastewater network covers 50,000 km.[34] However, the municipal water network is rapidly aging, with an average age of 50 years and an ever-increasing need for renovation.[35]

Because water is relatively abundant in Finland, it is unlikely to become a limiting resource for CDR deployment. Both industrial and municipal water consumption have declined since the late 20th century, and current usage levels are not expected to increase enough to constrain CDR efforts. Instead,

30 Finnish Environmental Institute 2022. Kuinka paljon järvissä on vettä ? https://www.vesi.fi/vesitieto/kuinka-paljon-jarvissa-on-vetta/

31 Ministry of Agriculture and Forestry 2019. Vesihuollon tilastoja. https://mmm.fi/-/vesihuollon-tilastoja

32 Finnish Environmental Institute 2025. Veden ominaiskäyttö. https://raportit.ymparisto.fi/ReportServer/Pages/ReportViewer.aspx?%2fJulkiraportti-Veden%20ominaiskaytto

33 Finnish Forest Industries 2019. Metsäteollisuus on onnistunut vesiensuojelutyössä erinomaisesti. https://metsateollisuus.fi/uutishuone/metsateollisuus-onnistunut-vesiensuojelutyossa-erinomaisesti/

34 Finnish Water Utilities Association n.d. Mitä on vesihuolto. https://www.vesilaitosyhdistys.fi/mita-on-vesihuolto/verkostot-ja-pumppaamot/

35 Finnish Environmental Institute 2021. Vesihuollon tila Suomessa. https://www.vesi.fi/teemasivu/vesihuollon-tila-suomessa/

aging water distribution infrastructure is more likely to be a limiting factor than water availability itself. Nonetheless, climate change leads to some unpredictability in future water availability and an increase in seasonal droughts in select parts of the country, which should be considered in the regional planning of CDR methods that require water.

3.3 Land

Finnish land area presents strong potential for CDR. **Finland's total area is 33,843** kha[36], of which 90% is land area and about 10% (3,456 kha) consists of inland waters.[37] Additionally, 5,258 kha of territorial sea waters lie in the Baltic Sea. Built-up land covers just 5% (1,522 kha) of the land area, leaving substantial room for land-based CDR strategies. According to the classification used in the National Greenhouse Gas Inventory, forest land accounts for about 70% of Finland's land area, followed by wetlands (10%), cropland (8%), and grassland (0.8%) (see Figure 13)[38]. The distribution of land classes has shown minimal variation over recent decades and the distribution is expected to remain similar in the future.

3.3.1 Forest land

According to the National Forest Inventory (NFI), Finland's forest land and poorly productive forest land produce an **annual growth of 103 Mm^3,** with the **total growing stock exceeding 2 500 Mm^3** [39]. Over the past century, the yearly growth of the growing stock has more than doubled, though recent years have seen a slowdown. This decline is influenced by factors such as changes in the forest age structure, increased forest damage, and rising tree mortality, though some causes remain

About a third of Finland's commercial forests are peatland forests, growing on drained peat soils that store large amounts of carbon. Managing these forests is therefore crucial to maintaining the country's overall forest carbon balance.[40] There are two main types: nutrient-rich peat forests, typically dominated by spruce or deciduous trees, which emit more carbon than they absorb through litterfall; and nutrient-poor peat forests, which release minimal carbon due to slower decomposition of peat and litter. In pine-dominated stands, dense undergrowth

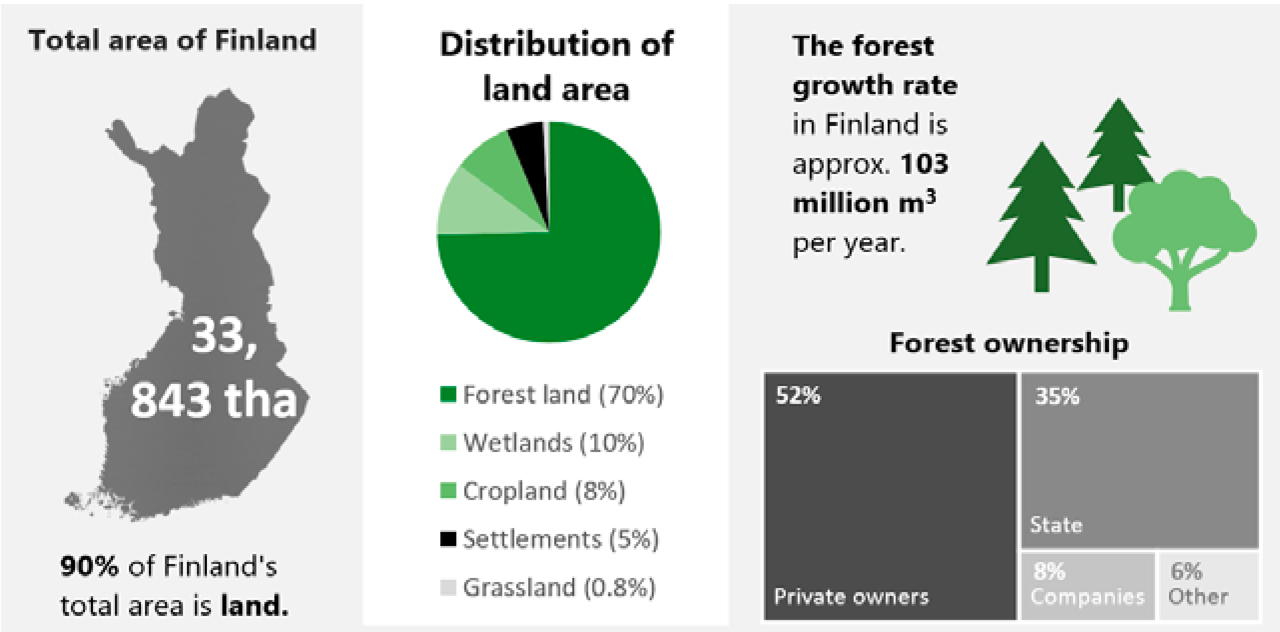

Figure 13. Overview of Finland's land area and forests according to the National Greenhouse Gas Inventory.[21] Species composition of forest land is dominated by pine (less than 66%), followed by spruce (25%) and deciduous trees (10%).

36 1 tha/kha = 1,000 ha. Unit used in the National GHG inventory report.

37 Statistics Finland 2024. Greenhouse gas emissions in Finland 1990 to 2022

38 Finnish national land use classification system that is based on the National Forest Inventory (NFI) method differs from the IPCC land use classification. In this report we use IPCC classification as it is used in Finnish national GHG inventory reports and more commonly in the climate scenario context.

39 National Resources institute Finland 2024. Metsävaratiedot. https://www.luke.fi/fi/uutiset/metsavaratiedot-puuston-maara-kasvaa-edelleen-vaikka-vuotuinen-kasvuvauhti-on-hidastunut

40 The Ministry of Agriculture and Forrestry. Accessed 18.10.2025: https://mmm.fi/luonto-ja-ilmasto/maapera

contributes slowly decomposing litter to the soil.[41]

Finland's land ownership structure plays a key role in land use policy: 52% of forestry land is owned by private forest owners, 35% by the state, 8% by companies, and 6% by municipalities, parishes, and communities. The ownership structure affects the feasibility and the political tools needed to enable different CDR methods in the land-use sector. **The high proportion of private ownership can pose challenges for the rapid implementation of CDR measures**, requiring tailored policy tools and incentives.

Land-use changes that reduce forest area include construction, field clearing, peat extraction, and reservoir development. Conversely, some fields have been afforested or reforested, contributing to the expansion of forestry land.

3.3.2 Cropland and grassland

Of the approximately **2.2 Mha** (incl. fallow land) in agricultural use, approximately 1.9 Mha (86%) are mineral soil fields. The use of mineral soil fields varies from region to region. In southern and western Finland, mainly annual crops, such as cereals and rapeseed, are cultivated. In Eastern and Northern Finland, more grasses and silage grasses are used. Livestock and crop farms have largely diverged from each other, which has made crop rotations more one-sided. The carbon content of mineral soils has decreased steadily (0,4 % per year) over the past decades, and cropland is a source of carbon[42]. The carbon content of cropland can be increased through various cultivation and soil improvement measures.

Approximately 10-12% (270 kha) of Finland's arable land is peatland.[43] Peatland fields have a peat layer of varying thickness containing organic matter (and carbon). In cultivation, peat gradually decomposes and releases bound carbon into the atmosphere. Cultivated peatlands are a significant source of GHGs in Finland, accounting for more than half of agricultural emissions.[44] About 66% of the peatland fields are grasslands, and about 33% are used for annual species, such as oats, barley, wheat, or legumes.

3.3.3 Areas suitable for afforestation

The most suitable areas for afforestation in Finland could be fields outside agricultural use (so-called wastelands) and peatlands that have been freed from peat production. According to Tapio's report prepared in 2020[45], there would be a total of about **110 kha of wasteland** and just under **10 kha of disused peat production areas**. 2-3 kha hectares of areas are freed up from peat production every year. According to a survey conducted by the Bioenergy Association (2019), approximately 75% of these areas are afforested or were naturally forested. The most significant afforestation potential is in the regions of Lapland, Kainuu, Ostrobothnia, and North Karelia[46]. About 75% of the wastelands are located on mineral soils and 25% on peatlands. Areas situated in peatlands, in particular, would be favourable for reforestation in terms of climate benefits.

3.3.4 Opportunities for wetland restoration

A significant share of Finland's peatlands – across forestry, agriculture, and peat production sites - are suitable for restoration as wetlands. Restoration measures typically include blocking drainage ditches and removing trees to re-establish natural hydrology. Particularly promising are **drained peatlands deemed unprofitable for forestry**, which account for nearly **800 kha**, or about 20% of Finland's forest-drained peatlands. Most of these areas are low in nutrients, making them unsuitable for timber production, while roughly 10% are nutrient-rich but suffer from nutrient imbalances.[47]

From a climate perspective, restoring nutrient-rich peatlands offers the most significant immediate benefit, as these sites currently emit the highest levels of GHGs. In contrast, nutrient-poor peatland

41 LUKE. Suometsät ja ilmasto. Accessed 18.10.2025: https://www.luke.fi/fi/ajankohtaista/teemat-ja-kampanjat/suometsat/suometsat-ja-ilmasto

42 Natural Resources Institute Finland 2019. Carbon content in arable soil. https://www.luke.fi/en/statistics/indicators/cap-indicators/carbon-content-in-arable-soil

43 Natural Resources Institute Finland 2024. Turvepeltojen käytön tiekartta vuoteen 2050. https://jukuri.luke.fi/items/bb6c45df-2a80-422d-9d63-3409b41799c3

44 The Finnish Climate Panel 2021: Miksi turvepeltoja tarvitaan ilmastotalkoisiin? – Ilmastopaneeli

45 Natural Resources Institute Finland 2021. Climate action in the land use sector, Estimate of emission reduction opportunities. https://jukuri.luke.fi/server/api/core/bitstreams/64b3ee1a-1345-4ae0-8ef9-2e14e79fc768/content

46 Ministry of Agriculture and Forestry of Finland 2022. Government Report on the Climate Plan for the Land Use Sector. https://julkaisut.valtioneuvosto.fi/handle/10024/164927

47 Kojola, et al. 2015. Synthesis report on utilisation of peatland forests for biomass production

forests may take decades or even centuries to deliver measurable climate benefits[48], which is too late from the perspective of urgent climate goals. Nonetheless, these areas still warrant restoration due to their high biodiversity value. Rewetting former peat production sites can yield rapid climate gains, as CO_2 emissions cease and the soil begins to act as a carbon sink.

For peatland fields, restoration into wetlands depends on suitable topographical and hydrological conditions. According to MTK's Agricultural Climate Roadmap (2024), approximately **60 kha of thick peat fields are technically suitable for rewetting**. However, many of these are actively used by animal farms that depend on peat fields, limiting short-term restoration potential. In such cases, controlled drainage – raising water levels moderately – can offer a compromise.[49]

Under the EU Restoration Regulation, Member states are required to restore 40% of peatlands by 2040 and 50% by 2050, placing Finland under increasing pressure to scale up restoration efforts. Peat production has already declined by over 60% since 2010, driven by rising emission costs.[50]

3.3.5 Climate measures in the land use sector

Since 2018, Finland's land use sector has been a source of GHG emissions.[51] While forest biomass and the soils of mineral lands continue to act as carbon sinks, drained peatland soils have become emission sources – the latest inventory shows that their emissions now exceed the carbon sequestration capacity of forests. Additional sources of emissions include croplands, grasslands, settlements, and wetlands, particularly peat production areas (see Figure 14). The carbon sink from wood products[52] fluctuates annually depending on production volumes.

To address these challenges, a range of climate

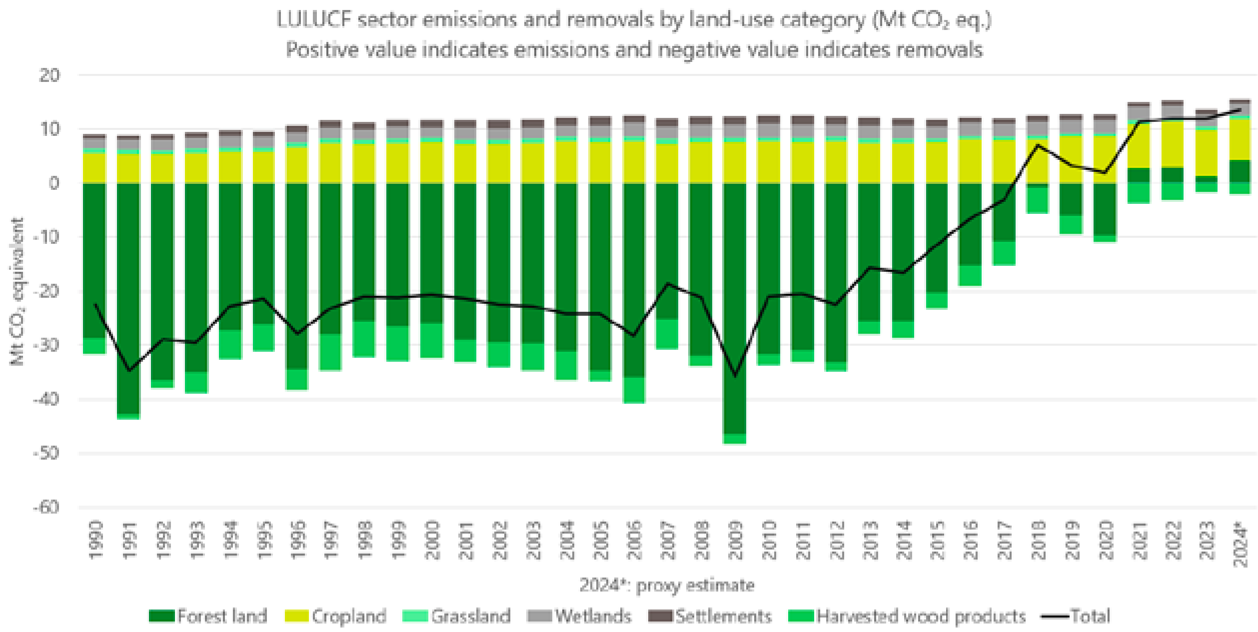

Figure 14. LULUCF sector emissions and removals in Finland.[52]

48 Tolvanen et al. 2018. Further use of drained peatlands unsuitable for forestry use.

49 Ministry of Agriculture and Forestry of Finland 2024. Maatalouden ilmastotyökartta. https://www.mtk.fi/documents/d/mtk/maatalouden_ilmastotiekartta_2024_netti

50 ARFY 2023. Kotimaisten polttoaineiden toimintaympäristö ja käyttöarviot 2028 saakka. https://afry.com/sites/default/files/2023-02/kotimaisten_polttoaineiden_toimintaymparisto_ja_kayttoarviot_2028_saakka_loppuraportti_8.2.2023.pdf

51 Natural Resources Institute Finland 2023. Kasvihuonekaasuinventaario 2023. https://www.luke.fi/fi/uutiset/kasvihuonekaasuinventaario-2023-maataloussektorin-ja-maankayttosektorin-lopulliset-tulokset-hyvin-lahella-ennakkotuloksia

52 When reporting the changes in the carbon storage of wood products, the main categories are sawn timber, wood-based panels, paper and cardboard. In the calculations, these are further divided into more specific subcategories. Ministry of the Agriculture and Forestry ; https://mmm.fi/maankayttosektorin-ilmastosuunnitelma/puutuotteet-hiilivarastoina

53 Statistics Finland 2025. Kasvihuonekaasupäästöt Suomessa, 1990-2024*. https://pxdata.stat.fi/PxWeb/pxweb/fi/StatFin/StatFin__khki/statfin_khki_pxt_138v.px

mitigation measures and their potential have been evaluated in both the Climate Plan for the Land Use Sector and in a separate assessment by the Natural Resources Institute (Luke).[54] Key strategies focus on forest management, including fertilising forests, managing seedling stands in a timely manner, extending the rotation period of the growing stock, reducing harvesting levels, increasing the share of long-lived wood products, afforestation of abandoned agricultural lands, expanding protected areas, and reducing deforestation.

In addition, strategies to reduce emissions in mineral and peatland fields were identified. For peatland areas, measures include reducing annual and grassland cultivation, afforestation, transitioning to wetland

Land use type	Current extension (kha)*	CDR measures available	Max area available for CDR (kha)**
Land area	30,387		-
Built-up land	1,522		-
Forest land	21,841	Avoiding deforestation	10
		Fertilisation (ash)	1,890
		Fertilisation (N)	750
		Tending of seedling and young forest stands	30/year until 2035
		Forest management	All managed forest land
		Increase of nature conserva-tion areas	10/year until 2035
		Decrease of forest harvest-ing levels	All managed forest land
		Increase of dead wood	All managed forest land
of which peatland forests	*5,909*	*Management of organic forest land*	*All managed forest land*
Drained peatlands unprofit-able for forestry	800***	Restoration	80 (nutrient-rich sites)
Cropland	2,505	Agroforestry	All cropland area***
of which mineral soil fields	*1,900****	*Management of mineral cropland*	*1900*
of which peatland	*270****	*Management of organic cropland*	*323 (includes partly grass-land)*
Grassland	247	Afforestation/ reforestation	110
of which peatland	*69*		
Wetlands	6,418	Wetland management/ restoration	87
of which peat extraction areas	*99*	*Afforestation/reforestation*	*9*
		Wetland restoration	*12*
of which inland waters	*3,456*		
Total land and inland water	**33,843**		

*Table 1. Land areas and theoretical availability for different CDR measures. *Source: LUKE 2022, **Source: Natural Resources Institute Finland. Please visit the original source for further reasoning and assumptions for each measure and availability.***Agricultural climate roadmap 2024.*[55]

54 Natural Resources Institute Finland 2021. Climate measures in the land use sector: An assessment of emission reduction potential. Natural Resources and Bioeconomy Research 7/2021

55 Lehtonen et al. 2024. Maatalouden ilmastotiekartta, päivitetyt skenaariot ja arviot päästövähennyksistä vuoteen 2035 ja 2050 https://www.mtk.fi/documents/d/mtk/maatalouden_ilmastotiekartta_2024_netti

farming, or full rewetting to restore natural hydrology. For mineral soils, emissions reduction efforts focus on increasing the use of catch crops and green fallows, carbon farming in grasslands, and enhancing the productivity of fields. Key carbon farming techniques include crop rotation, cultivation of deep-rooted crops and nitrogen-fixing plants, reducing tillage, use of autumn-sown crops, or application of soil amendments such as manure and biochar.

Among all land use strategies, the most significant carbon removal potential lies in forest biomass and forest soil. Therefore, the **most impactful measures** for meeting climate targets include **reducing deforestation, limiting harvesting levels in commercial forests, and cutting soil emissions from peatlands**. The theoretical availability of land areas for different CDR measures was assessed based on the Natural Resources Institute's estimates[35] and the National GHG Inventory, see Table 1.

3.3.6 Coastal areas

Finland has a natural **shoreline of 47,400 km with the Baltic Sea** that combines to the North Sea through the Kattegat strait between Sweden and Denmark. The Baltic Sea covers 13% of Finland's total area, and its coastline winds from Tornio to Virolahti.

The open sea and archipelago of the Baltic Sea include the Gulf of Finland, the Archipelago Sea, the Bothnian Sea, the Bothnian Bay, and the Quark, each of which has its own unique marine biodiversity. The archipelago area in Finland covers approximately 56,000 km² and accounts for about 15% of the total area of mainland Finland.

Over half of the 45 habitat types found on the coast are endangered. Rocky shores and air-breathing vegetation such as reed beds represent the healthiest conditions, while natural sandy and dune shores – as well as shores covered with sea lavender and sea rocket – are in poor conditions. Natural meadow shores, coastal shrublands, and forests require more substantial protection efforts.[56]

The Baltic Sea is a shallow inland sea suffering from severe eutrophication. It spans 392,000 km² with a volume of 21,000 km³ and an average depth of just 55 m – far shallower than seas like the Mediterranean (1,000 m) or the oceans (several km). Its maximum depth reaches only 460 m.[57]

Weak water circulation exacerbates eutrophication, and limited connections to other seas restrict the inflow of saline water. Instead, the sea receives continuous freshwater input from rivers and rainfall, resulting in low-salinity brackish conditions. Pollution from the wastewater of around 85 million people across 14 basin states has heavily impacted the sea. Finland has the most significant coastal share of the Baltic Sea. Nutrient runoff from vast agricultural areas, especially in Finland, further intensifies the degradation.[58]

CDR approaches related to blue carbon face both physical and societal limitations due to the unique characteristics of the Baltic Sea. Despite decades of ongoing restoration efforts, the sea's degraded state remains a significant obstacle. **Given its poor condition, the Baltic Sea is not being considered a viable candidate for effective CDR implementation**. Studies collectively indicate that further research is necessary to understand the localised effects of methods such as ocean alkalinity enhancement and to ensure environmentally safe implementation.

3.4 Biomass feedstocks

Biomass feedstocks offer significant potential for CDR in Finland. Various CDR pathways can leverage biomass, including BECCS via combustion or fermentation, biochar production, and the creation of long-lived biobased materials. In the Finnish context, the most relevant biomass sources for CDR can be broadly grouped into three categories: organic waste, agricultural side streams, and forest biomass. Given that the forest industry remains one of Finland's most significant economic sectors - accounting for approximately 17% of national exports in 2024[59] - forest biomass stands out as the most critical feedstock to evaluate for large-scale biomass-based CDR deployment.

3.4.1 Forest biomass

Finland has vast forests from which pulp, energy wood, and wood products are produced. In 2023, about **76 Mm³ of wood was harvested**, of which 20% was harvested for energy wood, about 46% for pulp production, and 34% for the sawmilling and

56 Finnish nature conservation association 2024. Itämeri. https://www.sll.fi/opi-lisaa/vedet/itameri/

57 Finnish meteorological institute, n.d. Itämeren muoto, ala ja tilavuus: https://www.ilmatieteenlaitos.fi/itameren-muoto-ala-ja-tilavuus

58 Baltic Sea Action Group, n.d. Itämeri – Merien omalaatuinen kuopus: https://www.bsag.fi/itameri/

59 Finnish Forest Industries 2025. Metsäteollisuus numeroina https://metsateollisuus.fi/uutishuone/metsateollisuus-numeroina/

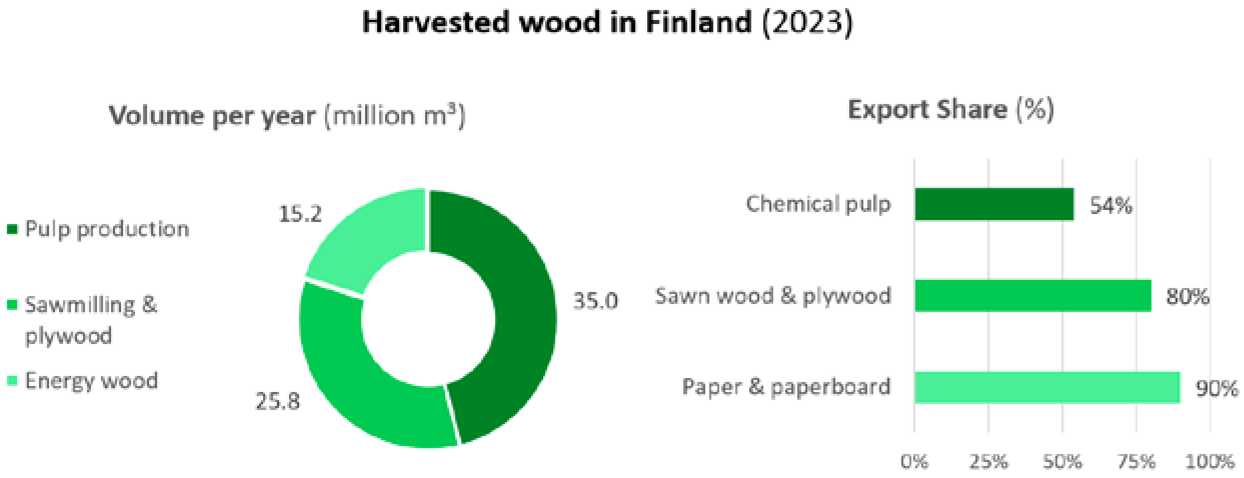

Figure 15. Harvested wood in Finland.[40][39]

plywood industries[60] (see Figure 14). Most wood industry products are exported. Over 90% of paper and paperboard, 54% of chemical pulp, and about 80% of sawn wood and plywood products were exported in 2024[61]. Forest removals categorised into the main products are listed in Figure 15.

Both the forest industry and the Finnish energy sector use a significant amount of wood and wood industry side streams (particularly black liquor) for energy production.[62] The existing wood combustion facilities present a considerable deployment potential for BECCS. A key advantage is that **Finnish energy production and forest industry facilities are relatively large and centralised**, with, for example, centralised district heat production being commonplace **creating an opportunity for CCS retrofit to enable BECCS**. Extensive wood combustion facilities tend to be in hubs around Finland, which the Technical Research Centre of Finland has studied, and could be connected by a CCUS logistical network.[63] Of the approximately 44.2 Mt of biogenic CO_2e emitted annually in Finland, the study estimated that about 21 Mt could be collected through BECCS deployed in the most significant hubs. Therefore, although BECCS is unfeasible for deployment in smaller wood combustion facilities, Finland has high potential for facilities that are large and central enough for deployment.

The Finnish forest industry has become increasingly concentrated around pulp, paper, and paperboard products. There is discussion both politically and within the forest industry to aim to increase the degree of processing of products to a higher level of refinement that would bring more value to the Finnish economy. Among the proposed high-value products are engineered wood materials for construction, which offer potential for CDR. However, not all refined wood products contribute meaningfully to CDR, as many - such as textiles, packaging, and pharmaceuticals - are short-lived and do not retain carbon over extended periods[64]. Increasing the share of harvested wood allocated to long-lived products would therefore require a substantial transformation in the Finnish forest industry's product portfolio.

To optimise CDR potential, forests must be considered both as carbon sinks in their natural state and as sources of wood-based products that can contribute to long-term carbon storage. **Maximising wood harvests is not compatible with optimal CDR outcomes, as it reduces the carbon stock maintained in growing forests.**[65] In Finland, determining appropriate harvest levels is a politically sensitive issue. The forest industry remains a cornerstone of the national economy. Yet, Finland's climate targets depend on its forests continuing to act as net carbon sinks and ideally increasing their CDR contribution[66] - more discussion

60 Natural Resource Institute Finland 2023. Use balance of Finnish forest industry by year, supply/usage and product. https://statdb.luke.fi/PxWeb/pxweb/fi/LUKE/LUKE__04%20Metsa__04%20Talous__15%20Metsatilinpito/01_Metsasektorin_kayttotase.px/

61 Finnish Forest Industries 2025. Viennin osuus metsäteollisuuden tuotannosta. Available : https://metsateollisuus.fi/uutishuone/viennin-osuus-metsateollisuuden-tuotannosta/

62 Statistics Finland, 2023. Bioperäinen hiilidioksidi. Available : https://stat.fi/meta/kas/bioperainen_hii.html

63 VTT Technological Research Centre of Finland Ltd 2024. Outlook of CO2 logistics in Finland for CCUS

64 Österberg et al 2024. Lankusta lääkkeisiin, Tuoteportfolion arvonnoususta uutta arvonlisää metsäsektorille

65 Seppälä et al 2022. Metsät ja ilmasto: hakkuut, hiilinielut ja puun käytön korvaushyödyt

66 Finnish Government 2022. Valtioneuvoston selonteko maankäyttösektorin maankäyttösektorin

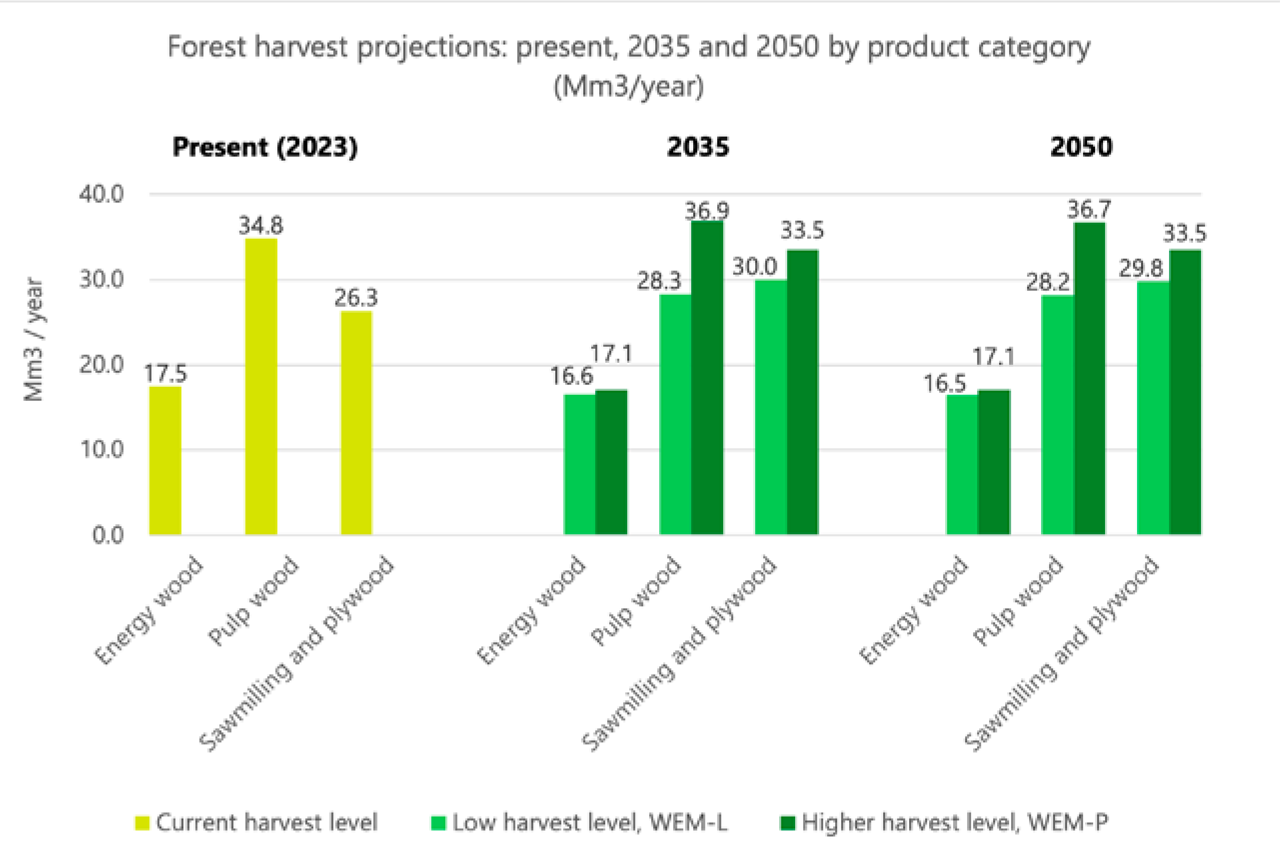

Figure 16. Forest harvest volumes for 2023[68] and future projections[48] for 2035 and 2050, broken down by the industrial sectors in which the harvested biomass is used. Low harvest levels were used in the theoretical maximum CDR scenario, and both low and high harvest levels were used in the realistic scenarios.

about the CDR potential of forests in earlier parts of Chapter 3.

The Natural Resources Institute of Finland estimates the maximum sustainable yield to be about 97 Mm^3 per year between 2029 and 2048[67]. However, this estimate is based solely on forest growth potential and does not consider the effects on forest carbon sinks or broader sustainability aspects, such as biodiversity. In contrast, the Finnish Climate Panel estimates suggest **that to meet the 2035 climate neutrality target**, annual harvests should be reduced from current levels to around **62 Mm^3 annually by 2030**[32] (Natural Resources Institute Finland, 2023).

The Finnish Government has developed baseline scenarios to evaluate how existing climate policies may contribute to national climate targets through 2055, depicted in Figure 16.[69] Each scenario includes projections for forest harvest volumes and the resulting land sector emissions and removals. A clear pattern emerges: higher economic growth correlates with increased forest harvesting and elevated net emissions from the land-use sector. These scenarios are further explored in Chapter 7.

In conclusion, **wood offers substantial CDR potential for Finland**, primarily due to its abundance and central role in the national economy. However, **maximising wood harvests does not equate to maximising CDR, as excessive harvesting can undermine the forest's function as a natural carbon sink**. To fully realise the climate benefits of forests, their CDR potential must be assessed holistically - considering both the carbon stored in standing biomass and the carbon that can be sequestered through harvested wood products.

Wood is a major energy source in Finland, particularly within the forest industry and the broader energy sector. This makes **large-scale wood combustion a viable candidate for CDR deployment through**

67 Natural Resources Institute Finland 2023. Maximum sustained yield. Available : http://mela2.metla.fi/mela/tupa/index.php

68 National Resources Institute Finland. 2023. Use balance of Finnish forest industry by year, supply/usage and product

69 Finnish Government 2024. Baseline scenarios for energy and climate policy package towards zero emissions

BECCS. Only a small fraction of wood-based products currently serves as long-term carbon storage. The majority - such as pulp and paper – are short-lived and offer minimal CDR value.

Enhancing the CDR contribution of wood products would require a strategic shift in production—from short-lived goods **to long-lived materials and biochar**. While the exact volume of wood that could be redirected toward CDR is uncertain, a portion of Finland's wood product exports (see Figure 14) could theoretically be transitioned to products with greater carbon storage potential.

3.4.2 Organic waste

The most significant sources of municipal and industrial waste were considered here for their CDR potential. Finland has separate collections for different waste types. However, the collection rates for municipal biowaste remain low, as mixed waste contains a high biowaste content of approximately 40%[70]. Currently, wood waste and mixed waste are primarily incinerated, while biowaste and sewage sludge are typically treated through anaerobic digestion or composting[39]. **Recycling was considered a priority use over CDR, and therefore, recycled fractions were excluded from the amount available for CDR**. No formal figures on waste projections were available, so estimates were made based on national targets for recycling and population projections. The waste amounts, projections, and descriptions of the available fractions for CDR are listed in Table 2. More detailed methodology and assumptions used to compile the values are listed in Annex A.

Organic waste presents moderate CDR potential for Finland. For the waste types that are currently being treated with methods compatible with CDR methods (BECCS with combustion or anaerobic digestion), the waste streams are estimated to be almost entirely available for the corresponding CDR methods (see Table 3), based on the assumption that centralised waste treatment facilities in Finland are large enough for BECCS deployment. Recycling and other circular uses of waste are the main constraints for waste feedstock availability in the future, which are considered in projections of future availability.

3.4.3 Agricultural side streams

Despite climatic constraints that limit optimal agricultural conditions, Finland's domestic agricultural sector produces nearly as much food as it consumes. The country traditionally produces a substantial amount of grain and grasses and has a significant presence in animal agriculture.[71] As a sparsely populated nation, Finland had about 42,000 farms in 2023, of which the vast majority were family-owned. The number of farms has been steadily decreasing while the average farm size has increased.[72] In particular, the number of meat and dairy cattle farms has been declining.[73]

For agricultural biomass, only agricultural side streams that are not purpose-grown for food or other applications were considered. **The most significant biomass source is livestock manure**, especially cattle, of which there is currently often an oversupply in proportion to the fertilisation needed for local fields. Other potential CDR feedstocks include unutilised or underutilised crop residues such as cereal straw and potato tops, biomass from fallow and buffer zones, and the potential portion of grass or green manuring sward harvests that could be diverted to CDR. Manure and agricultural side streams are currently mainly used for fertilisation and conservation of soil carbon content in fields, and therefore cannot all be used for CDR. Half of the crop residues and manure were estimated to be prioritised for use in fields and unavailable for CDR.[74]

70 Statistics Finland 2023. Yhdyskuntajätteen kierrätysaste romahti – Suomi ei kulje mukana muun Euroopan kehityksessä. https://stat.fi/tietotrendit/artikkelit/2023/yhdyskuntajatteen-kierratysaste-romahti-suomi-ei-kulje-mukana-muun-euroopan-kehityksessa.

71 Natural Resources Institute Finland 2022. Maatalouden rakennemuutos jatkuu. Available : https://www.luke.fi/fi/uutiset/maatalouden-rakennemuutos-jatkuu

72 Natural Resource Institute Finland 2024. Yhä harvempi maatalous- ja puutarhayritys tuottaa ruokamme. https://www.luke.fi/fi/uutiset/yha-harvempi-maatalous-ja-puutarhayritys-tuottaa-ruokamme

73 Natural Resources Institute Finland 2022. Maatalouden rakennemuutos jatkuu. https://www.luke.fi/fi/uutiset/maatalouden-rakennemuutos-jatkuu Available : https://www.luke.fi/fi/uutiset/maatalouden-rakennemuutos-jatkuu

74 Natural Resources Institute Finland, n. d. Pelto. https://www.luke.fi/fi/luonnonvaratieto/tiedetta-ja-tietoa-luonnonvaroista-luonnonvaroista/biomassaatlas/biomassaatlaksen-biomassat/pelto

Type of waste		Current amount (2024)	Projected amount (2035)	Projected amount (2050)	Current use and availability for CDR
Municipal waste	Paper and cardboard	408,636[70]	-	-	Unavailable for CDR as recycling is prioritised.
	Mixed waste	421,814[51]	322,963	253,618	Currently used for energy production. Estimated to be fully available for CDR.
	Biowaste	120,321[51]	168,894	206,313	Currently primarily used for composting and anaerobic digestion and assumed to be fully available for BECCS with AD.
	Wood waste	52,029[51]	76,470	89,215	58% utilised for recycling and reuse and 33% for energy production. Amount used for energy production assumed to be available for BECCS with combustion with slight decrease as recycling increases.
Industrial waste	Paper and cardboard	334,000[71]	-	-	Unavailable for CDR as recycling is prioritised.
	Wood waste	1,831,500[52]	2,691,824	3,140,461	58% utilised for recycling and reuse, and 33% for energy production. Amount used for energy production assumed to be available for BECCS with combustion with slight decrease as recycling increases.
	Black liquor	1,934,850[40]	1,144,269 – 1,941,640	1,140,226 – 1,829,479	Currently used for energy production for the wood industry – all can be assumed to be available for BECCS with combustion. Future amount depends on forest harvest which were estimated based on Finnish Government climate scenarios[53].
	Animal and plant matter	442,200[52]	442,200	442,200	Utilised for animal feed and miscellaneous applications – About 50% is currently assumed to be available for BECCS with AD, but the share is expected to slightly decrease in the future as a growing portion is prioritised for animal feed.
	Sludge	21,793[72]	19,614	17,435	Currently fermented and used for anaerobic digestion. It is theoretically assumed to be fully available for BECCS with AD, with a realistic availability of about 70%.

Table 2. Current and projected industrial and organic waste amounts (2024, 2035, 2050). Units in dry tons/year.[75] [76] [77]

75 Natural Resources Institute Finland. 2025. Biomass Atlas. https://biomassa-atlas.luke.fi/?lang=en

76 Statistics Finland 2022. Waste generation by industry by Year, NACE, Information and Waste class

77 Statistics Finland 2023. Municipal waste by treatment method in Finland by Year and Information. https://statfin.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__jate/statfin_jate_pxt_12cv.px

Type of waste	Current amount (2024)	Projected amount (2035)	Projected amount (2050)	Current use and availability for CDR
Grasses	4,075,995[78]	3,660,847	4,151,476	Currently used as animal feed. Up to 40% could be freed for CDR based on extrapolation of livestock projections[73].
Cereal straw	2,129,546[58]	2,025,246	2,227,770	Currently used in field, for animal bedding, and energy production. Estimated 50% available for CDR through anaerobic digestion or combustion.
Manure	1,297,428[58]	1,359,210	1,420,992	Currently used for fertilisation in fields but there is oversupply. Estimated 50% could be used for CDR through anaerobic digestion.
Fallow	1,027,033[79]	1,027,033	1,027,033	Unused potential available for CDR through anaerobic digestion.
Potential additional harvest of green manuring sward	124,604[58]	117,274	131,933	Unused potential available for CDR through anaerobic digestion.
Stems from peas and broad beans	33,580[58]	51,254	51,254	About 50% needed in field but rest estimated available for CDR through anaerobic digestion.
Straw of herbage seed crops	37,433[58]	35,231	39,635	About 50% needed in field but rest estimated available for CDR through anaerobic digestion.
Potato tops	17,801[58]	27,170	27,170	Currently left in field or fed to animals. About 50% needed in field but rest estimated available for CDR through anaerobic digestion.
Sugar beet tops	3,969[58]	6,057	6,057	
Stems of oils crops	17,433[58]	26,608	26,608	About 50% needed in field but rest estimated available for CDR through anaerobic digestion.
Biomass of buffer zone vegetation	20,690[58]	20,690	20,690	Unused potential available for CDR through anaerobic digestion.

Table 3. Current and projected agricultural side-stream amounts (2024, 2035, 2050). Units in dry tons/year

The current total available quantities of different agricultural resources are presented in Table 3, with detailed assumptions outlined in Annex A. Data on agricultural side streams were primarily sourced from the Biomass Atlas, compiled by the Natural Resources Institute Finland.[45] In addition, the report by Sustainable Bioenergy Solutions for Tomorrow on Finland's biogas potential served as a key reference for identifying relevant feedstocks and informing assumptions about their availability and technical feasibility.[78]

Agricultural side streams represent a significant untapped resource for CDR. According to projections by the Finnish Government, production levels in the agricultural sector are expected to remain stable80 over the coming decades, suggesting that these feedstocks will likely remain available for CDR applications. Although some constraints exist, such as competing priority uses in fields and logistical challenges in collection, these side streams are currently underutilised, presenting an opportunity to redirect a substantial portion toward CDR efforts. Harnessing them for CDR, for example, through anaerobic digestion coupled with BECCS, would require targeted investments in infrastructure and processing facilities. Furthermore, while these resources are not yet fully exploited, emerging research into alternative applications - such as biofuels and bio-composite materials - may lead to competing uses in the future, potentially affecting their availability for CDR deployment.

78 Marttinen;Luostarinen;Winquist;& Timonen 2015. Rural biogas: feasibility and role in Finnish energy system

79 Natural Resources Institute Finland. 2021. Biomass Atlas. https://biomassa-atlas.luke.fi/?lang=en.

80 Marttinen;Luostarinen;Winquist;& Timonen 2015. Rural biogas: feasibility and role in Finnish energy system.

*Figure 17. Mineral extraction in Finland in 2023.[64] *No data available for basalt as it is produced only in limited quantities.*

3.4.4 Other biomass feedstocks

Many other smaller biomass streams could be used for CDR that were not included in this high-level assessment of CDR potential and that would require more systematic research into the potential amounts available. In addition to the feedstocks listed above, common reed is also included as a potential CDR feedstock, as it grows abundantly in Finnish waters and is a contributor to eutrophication in both the Baltic Sea and lakes. It is currently not widely utilised, although research on its utilisation is ongoing. For CDR, it could be used through combustion or anaerobic digestion with BECCS or potentially even as biochar. In Southern Finland, it is estimated that 760,000 tons would be available each year, although not all of it is feasible to harvest.[81]

3.5 Mineral feedstocks

In Finland, several mineral feedstocks technically suitable for carbon removal purposes have been identified, such as serpentine, dolomite, olivine, calcium silicate, pyroxenes, amphibole, and talc.82 83 However, there is reliable data available only for industrial minerals and therefore, some minerals for which data on deposits is insufficient, such as olivine and amphibole, are not further discussed in this report. In general, data on total deposits of minerals is relatively scarce, and thus, the availability for CDR purposes is discussed through reported extraction volumes.

Of the industrial minerals suitable for CDR, **carbonates, calcite (limestone), dolomite, wollastonite, and talc are the most important minerals** mined in Finland (see Figure 16). Basalt production is minimal, with no available data on exact production volumes. As such, it is considered insignificant for carbon sequestration purposes.

3.5.1 Limestone

Amongst the mineral feedstocks, **limestone is the most important raw material for the Finnish industry**, and is used in, for example, the enrichment processes of metal refining, cement production, and as a building material in mine filling. A total of approximately **5.3 Mt** of limestone and gypsum were mined in 2023. The production volumes of limestone and gypsum have slightly decreased from the peak production of the 2010s but have nevertheless remained relatively stable at the average level of about **6.5 Mt** during the reporting period of 2010-2023 (5.3 Mt in 2023). Production is expected to continue at a similar level, with a 10% increase anticipated from 2035 to 2050.

Industrial demand for limestone products is evident in Finland's trade volumes, with imports far exceeding exports. In 2023, limestone imports reached 1.3 Mt, while exports were just 0.016 Mt - highlighting strong domestic demand from the Finnish industry and limited availability for CDR applications. However, with the increasing adoption of more sustainable bio-based construction materials, such as wood, and a gradual shift in production practices, it is assumed that limestone demand will decrease and that an estimated 15% of the **limestone** production volume - approximately **0.8 Mt in 2035** and **0.88 Mt in 2050 - could be allocated to CDR** methods like enhanced rock weathering and carbon mineralisation.

3.5.2 Chalk, dolomite, talc, magnesite, and wollastonite

Chalk and dolomite have been quarried significantly less than limestone, about **0.3 Mt** in 2023.[50] **Talc** is also produced in Finland with an average annual output of **0.3 Mt**.[81] However, as a by-product of talc production, talc mines produce **magnesite** sand suitable for carbon sequestration, which was produced in 2022 in the amount of **0.3 Mt**.[82] Wollastonite is produced annually at a rate of about 0.01 Mt52. Like for limestone, the production of these minerals is expected to remain stable.

Dolomite exports are minimal compared to imports, reflecting its importance to the Finnish industry

81 Ministry of Economic Affairs and Employment of Finland 2021. Toimialaraportit: Kaivosteollisuus

82 Ministry of Economic Affairs and Employment of Finland 2023. Kaivosalan toimialaraportti 2023

and, therefore, its limited availability for CDR. Consequently, only exported volume - approximately **700 tonnes per year - is assumed to be available for CDR** across all scenarios. In the case of **talc**, while volumes are reported solely in monetary terms, the data indicates that exports (valued at EUR 47 million in 2022) significantly exceed imports[52] (EUR 1.6 million in 2022). Based on this disparity, an estimated maximum of **0.29Mt** per year is considered potentially available for CDR use.

Finland offers partially suitable conditions for enhanced rock weathering and carbon mineralisation. While the country possesses some of the necessary minerals, it lacks access to the full range required for optimal implementation of these methods. Enhanced rock weathering in particular, remains an underexplored approach as there is limited research about the method but possibilities for deployment in existing mines seem promising. Carbon mineralisation would require the use of silicate minerals (e.g. serpentinite) which are widely available in Finland. However, current environmental legislation prohibits their use, presenting a significant regulatory barrier.

3.6 CO_2 storage

Finland's **geological storage capacity for carbon dioxide is extremely limited**, as confirmed by existing studies and national CCS scenarios. To make effective use of geological storage, captured CO_2 would likely need to be exported to countries with suitable infrastructure and capacity, such as Norway.

Domestically, the most viable options for CO_2 storage lie in **ex situ mineralisation** and carbon sequestration into durable products. This includes mineralisation using mine tailings and concrete waste, as well as incorporation into long-lasting materials such as CO_2-cured concrete and bio-based products - further detailed in the biomass section of this report.

There is also identified potential for **in situ mineralisation**, particularly in serpentine rock formations in Eastern Finland. However, current environmental legislation prohibits its implementation, limiting its feasibility in the near term.

3.6.1 Geological storage

Finland does not have its own inland geological storage. Finland's bedrock is mainly of pre-Cambrian age and has no hydrocarbon deposits.[83] Most sedimentary rocks are compact, which makes the occurrence of salt groundwater unlikely. In general, Finland's crystalline bedrock is not favourable for large-scale CO_2 storage, as the free pore space of hard granite and gneiss rocks is minimal.[53]

In addition to underground geological formations, carbon dioxide can be geologically stored under the sea. According to Teir et al., the most suitable undersea storage sites - similar to onshore reservoirs - are located at depths greater than 800 m[82], where the pressure is high enough to keep the CO_2 liquid and thus prevent it from leaking back into the atmosphere. However, there are no existing opportunities for large-scale storage of carbon dioxide, such as old gas and oil reservoirs in Finland's territorial waters in the Baltic Sea, nor studies on the topic, and thus, **undersea storage is not considered feasible in Finland** in this context. If suitable undersea geologic storage sites are found in the Baltic Sea, it would require extensive drilling, which is theoretically possible yet unlikely to turn out to be techno-economically feasible. In addition, the Baltic Sea is also more exposed to the risks of undersea geological storage than deeper and larger seas, because of the potential acidification caused by the dissolution of CO_2 via leaking and the resulting accelerated dissolution of heavy metals.[84] **CO_2 is most likely going to be exported to other countries'** storage facilities, such as Northern Lights in Norway. There is variation in estimations of how the geological storage potential will develop in the future and how much could be exported from Finland. According to the Finnish Energy Agency, approximately **10 $MtCO_2$ of overseas storage capacity per year is currently available** (i.e. it has not been reserved by any specific country).[85]

In situ mineralisation

Despite the lack of geologic storage, in situ mineralisation potential has been identified, especially in Eastern Finland, where serpentinite, which is suitable for carbon sequestration, is estimated to be found in about 85 km^3, and which would enable an estimated **2-3 $GtCO_2$** to be stored as carbonates[86]. However, serpentine rocks, and gravel areas are protected

83 Teir et. al. 2011. CO2 capture and geological storage applications in Finland

84 Teir; Arasto; Sormunen; Jussila-Suokas; Saari 2016. Hiilidioksidin talteenotto ja varastointi

85 Energiavirasto 2024. Mitä ovat teknologiset hiilinielut?

86 VTT 2010. Potential for carbon capture and storage (CCS) in the Nordic region, 71

habitat types under the Nature Conservation Act, and they must not be destroyed or weakened. For this reason, the realistic carbon sequestration potential of serpentine deposits is **considered to be zero**[87].

Other permanent storage

Permanent CO_2 storage potential also exists in mine tailings and durable construction materials, with CO_2-cured concrete identified as a particularly promising option. In Finland, the most favourable sources for carbon mineralisation include process waste from ultramafic minerals and side streams from metal and mineral production.[55] Additional mineral by-products from industrial processes—such as ash from waste incineration, paper deinking residues, ash from coal-fired power plants, and cement production waste—also offer potential for CO_2 fixation.[88] The potential for mine tailings and other industrial side streams to store CO_2 permanently is estimated to be **0.5-2.0 MtCO₂ per year**[89] and for CO_2-based construction materials approximately 0.2 $MtCO_2$ per year by 2040.[90]

Exports

Due to the lack of industrial-scale storage sites in Finland that meet the requirements for carbon capture and permanent geological storage, the country's ability to utilise geological storage depends largely on the availability of storage sites located abroad. The closest geological storage sites to Finland are in Norway and Denmark, with which Finland signed a cross-border cooperation agreement in autumn 2025 to enable the transport and storage of CO_2. While exact figures on export volumes are not available, the Finnish Climate Change Panel[91] and the Energy Authority[92] have estimated that the available geological storage capacity in Northern Europe will be approximately 10 $MtCO_2$ per year by 2030. This amount is assumed to be realistically accessible to Finland by 2050, considering the expected development of geological storage potential across Europe. **By 2035**, approximately **6 $MtCO_2$** per year of this capacity is expected to be realistically available[91] and in export-focused carbon capture scenarios, described in more detail in section 3.7, the **export capacity** has been estimated at up to **18.1 $MtCO_2$ per year by 2050**, which has been used as the assumed export capacity in the calculation of theoretical potential.

3.7 CO_2 transport infrastructure

Currently, Finland lacks a dedicated infrastructure for transporting CO_2. Nevertheless, the economic potential of the CO_2 market is under active investigation, and multiple infrastructure development scenarios have already been published.[93 94 72]

Finland has been recognised as having significant potential for BECCU, primarily due to the abundant availability of biogenic CO_2 and the limited geological storage capacity, which generally favours utilisation pathways over permanent storage. Major CO_2 emission sources (≥100 $ktCO_2$), particularly from the

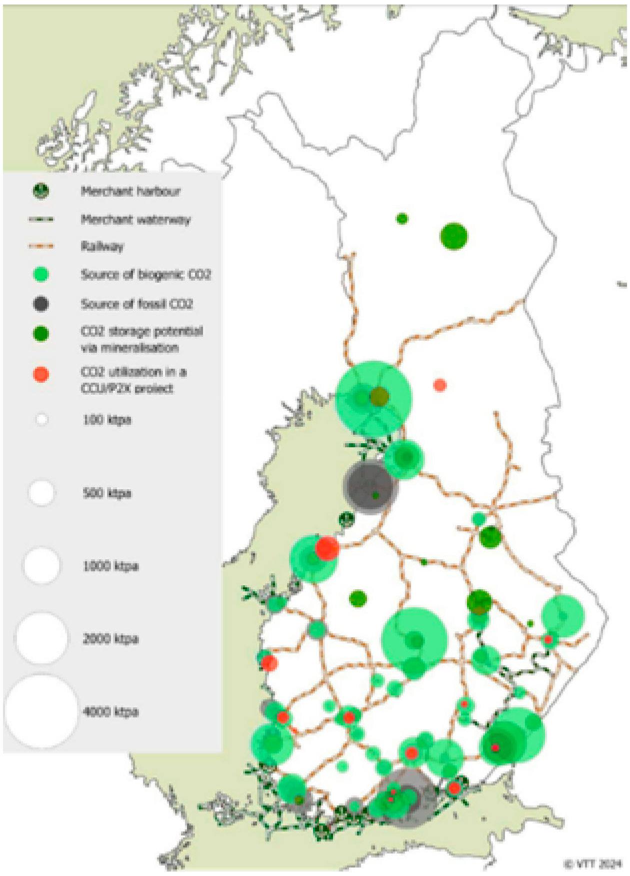

Figure 18. Point sources of CO_2 emissions exceeding 100 $ktCO_2$ per year.[95]

87 Finlex 2025. Valtioneuvoston asetys luonnosuojelusta 1066/2023

88 Teir 2008. Fixation of CO2 by carbonation of mineral wastes and industrial by-products. Seminar presentation

89 Kujanpää et al 2023. Carbon dioxide use and removal - Prospects and policies

90 VTT 2024. Selvitys hiilidioksidin ja talteenoton hyötykäytön potentiaalista

91 The Finnish Climate Change Panel 2024: Opprtunities provided by technological carbon sinks and the means for their advancement Finland

92 Energiavirasto 2024: Mitä ovat teknologiset hiilinielut?

93 Kujanpää et al. 2011. Cross-border CO2 infrastructure options for CCS demonstration in Finland. Energy Procedia. Vol 4. pp. 2425-2431

94 Kujanpää et al. 2014. Scenarios and new technologies for a North-European CO2 transport infrastructure in 2050. Energy Procedia. Vol 63. pp. 2738-2756

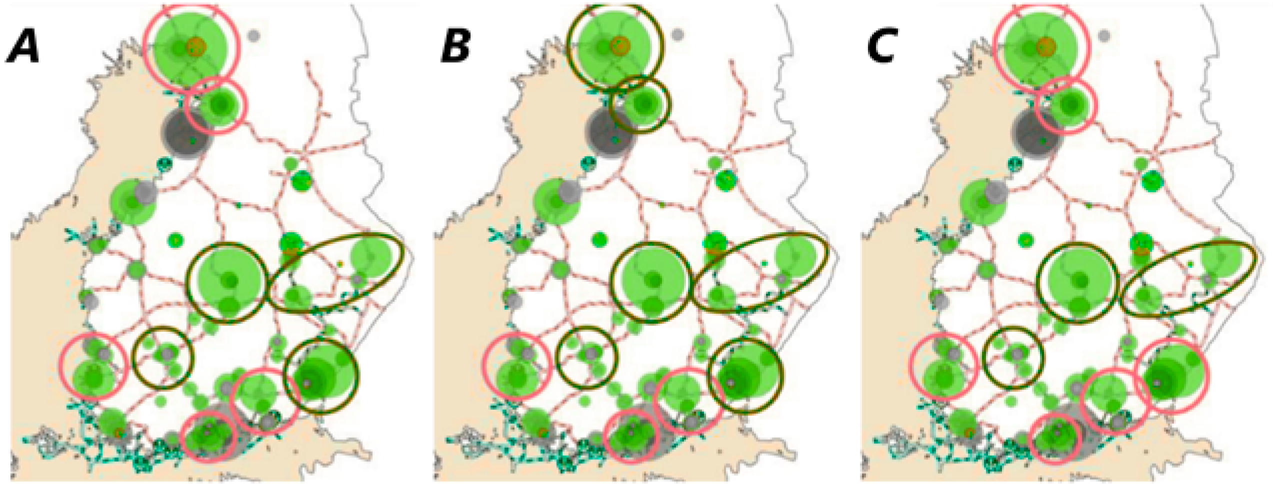

Figure 19. Scenarios for the formation of CO_2 hubs. Orange circles illustrate storage hubs and blue circles illustrate utilisation hubs.[95]

forest industry and bioenergy production, are evenly distributed across the country, with the exception of Northern Lapland. Many of these point sources are located along the coastline or adjacent to the existing railway network, creating favourable conditions for the development of a comprehensive CO_2 transport infrastructure. The point sources exceeding 100 ktCO_2 are illustrated in Figure 17.

Despite the greater interest in CCU pathways over CCS, achieving climate targets will likely require permanent storage - particularly through export routes - alongside other carbon removal methods. A recent study by VTT and the Finnish Bioenergy Association assessed the infrastructure needs and optimal balance between BECCU and BECCS in Finland.

The study identified nine major CO_2 hubs at Finland's largest emission sources, supported by a centralised transport network, as the most feasible approach for advancing CCUS deployment. These hubs could collectively handle up to 25.2 MtCO_2 annually, with 21.0 Mt from biogenic sources. Three scenarios were

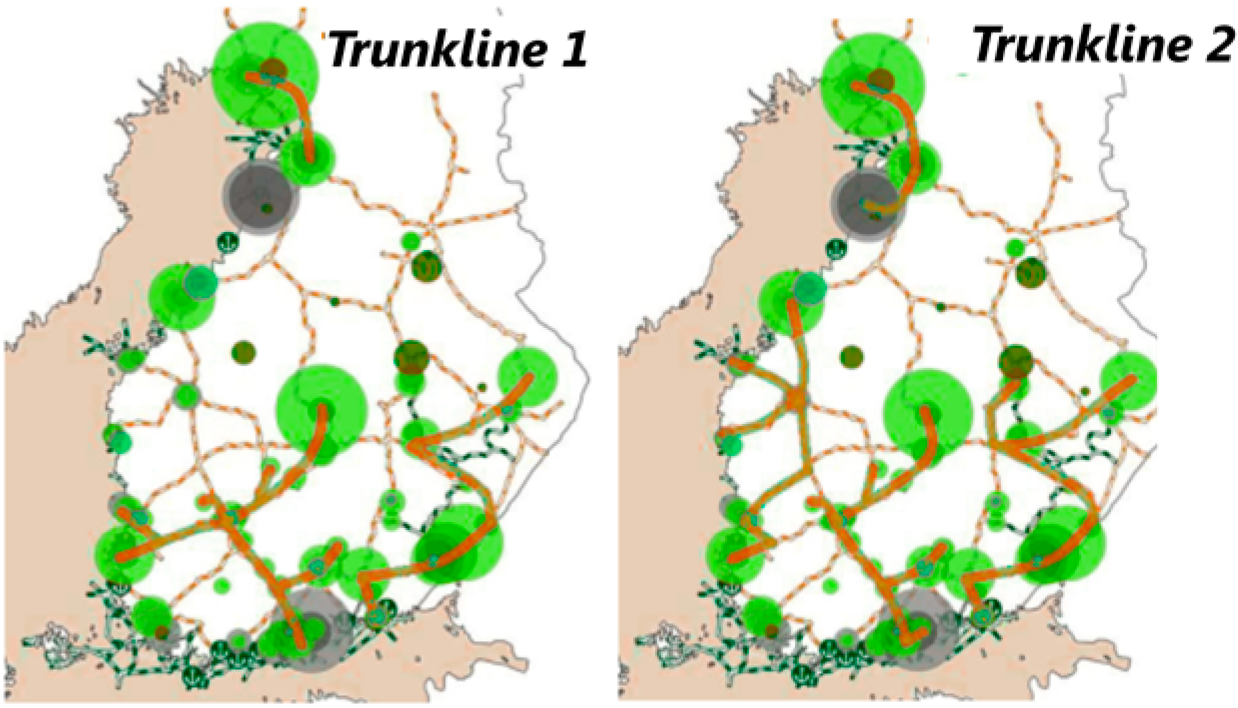

Figure 20. Pipeline connections Trunkline 1 and 2 for CO_2 transportation proposed in the report by VTT and Bioenergy.[95]

95 VTT and Bioenergia ry 2024. Outlook of CO2 logistics in Finland for CCUS: https://www.bioenergia.fi/wp-content/uploads/2024/10/PUBLIC-SUMMARY-REPORT-CO2-LOGISTICS_Bioenergiary-VTT-04-10-2024.pdf

proposed, varying in the share of CO_2 allocated to utilisation versus storage.

The most techno-economically viable scenario prioritised CO_2 utilisation while still incorporating geological storage: 6.1 $MtCO_2$ per year would be transported for permanent storage, and 19.1 $MtCO_2$ per year from six hubs would be allocated for utilisation, maintaining the full collection potential of 25.2 $MtCO_2$ annually. In an export-focused scenario, 18.1 $MtCO_2$ was exported to overseas geologic storage. All scenarios relied primarily on existing railway infrastructure, with coastal hubs prioritised for storage and export to minimise inland transport needs.[96] Figure 18 illustrates the configuration of the three key CO_2 hubs.

The report also evaluated the most promising pipeline route options—namely Trunkline 1 and Trunkline 2—connecting major point sources to potential export terminals, as illustrated in Figure 19. However, none of the scenarios deemed pipeline infrastructure techno-economically viable within the Finnish context.[60] These findings align with previous studies on CCUS in Finland, which consistently highlight the greater feasibility of CCU over CCS and the challenges associated with establishing dedicated pipeline networks. Consequently, pipelines, along with long-distance transport via truck, rail, or ship, are considered negligible contributors to carbon sequestration throughout the report's review period, which extends to 2050.

Currently, several CCU projects are underway in Finland, with the primary focus on producing synthetic fuels, where CCU is integrated in the immediate vicinity of a point emission source, and infrastructure is not required for long-distance transport. The most significant projects include the SHARC project by Neste, which aims to store and utilise around 400,000 tCO_2 per year, and the projects by Helen, Westenergy, and Rengas, aiming to capture around 20,000 tCO_2 per year each.[58]

3.8 Natural conditions

The climate of Finland is characterised by significant seasonal variation. In 2024,[97] average winter temperatures ranged from -14 °C in Lapland to -1 °C in Eastern Finland, while the average summer temperature across the country was 16.2 °C. The mean annual temperature of the country for the period 1991–2020 was 2.9 °C.[82] The implications of seasonal variation on electricity consumption are presented in section 3.1.1. Due to its northern location, climate change is causing Finland's annual temperature to rise 1.6 times[98] faster than the global average. It is estimated that, if global GHG emissions can be limited even moderately (SSP2-4.5 scenario), Finland's temperatures could increase by 2-7 °C in winter and 1-5 °C in summer between 1981–2010 and 2070–2099.[83]

Finland receives relatively high annual precipitation, totalling approximately 181 bcm, some of which falls as snow.[99] The amount of precipitation is projected to increase because of climate change.[100] More detailed information on precipitation and the anticipated impacts of climate change on water resources is presented in section 3.2.

3.9 Restricted areas

Restricted areas, or areas that are not available for any or most of the CDR methods in Finland, include nature conservation areas, wilderness areas, and military areas, totalling 6,6 Mha. Additionally, nationally valuable landscapes and archaeological sites were excluded from the scope of this report. **All restricted areas were omitted from CDR potential calculations, with one exception**: nationally valuable landscapes situated on managed agricultural land, where cropland and pasture management practices remain applicable.

96 Kujanpää ; Linjala ; Mäkikouri 2024. Outlook of CO2 logistics in Finland for CCUS

97 Finnish Meteorological Institute 2024. Vuosi 2024. https://www.ilmatieteenlaitos.fi/vuosi-2024

98 Ruosteenoja & Jylhä 2021. Projected climate change in Finland during the 21st century calculated from CMIP6 model simulations. https://assets.ctfassets.net/hli0qi7fbbos/1sJBYdUbndwx6uB1Ldnfcs/ad144a51396826ff229debbfc951a09b/ilmastonmuutosskenaariot_cmip6_verkko.pdf

99 FAO 2022. Aquastat. https://data.apps.fao.org/aquastat/?lang=en

100 Finnish Environmental Institute 2021. Miten ilmastonmuutos vaikuttaa vesivaroihin eri vuodenaikoina. https://www.vesi.fi/vesitieto/miten-ilmastonmuutos-vaikuttaa-vesivaroihin-eri-vuodenaikoina/

4. CDR theoretical potential (Could do)

To estimate Finland's theoretical CDR potential, the analysis first assesses the maximum availability of relevant resources - such as biomass, land, and energy - while preserving their essential priority uses. This hypothetical scenario assumes full mobilisation of all suitable resources for CDR, without factoring in real-world constraints, competing demands from other sectors, or societal readiness. While not practically feasible, this upper-bound estimate serves as a benchmark for understanding what could be achieved under extraordinary circumstances, akin to a nationwide mobilisation effort to address climate change. This theoretical maximum helps frame the more realistic estimates presented in Chapter 7.

4.1 Methodology for the theoretical potential

To assess the theoretical potential, it is necessary to estimate the availability of each resource needed to implement CDR methods. Most methods rely on multiple inputs - such as electricity, water, or heat – and therefore compete for the same resources. The calculation of theoretical potential is based on a **bottom-up approach** of assessing how the physical resources (described in Chapter 3) should be used optimally to maximise overall removal potential. For each CDR method it is firstly defined what is the primary resource – or resources – needed, and resources are then allocated optimally to the different methods based on which method requires the less resources per net tonne of CO_2. The methodology and database used for this optimisation is described in section 2.3. Based on this allocation it is then calculated how much of CO_2 could be removed with existing resources using the portfolio of methods in the most optimal way.

In the Finnish context, **storage capacity is the most contentious and limiting resource** for deploying CDR methods. Moreover, **various CDR methods compete** for similar types of biomass feedstocks - especially **wood-based biomass**. Alongside energy efficiency, economic feasibility was also considered in the resource allocation process to the extent reasonable, i.e. on a qualitative level – no economic variables were factored in the calculation. For example, despite biochar's technical efficiency, allocating the majority of wood-based biomass to its production is not justified due to limited market demand compared to other CDR pathways. For CDR methods where biomass feedstocks can be clearly assigned without competition from other CDR methods, the CDR potential was calculated by applying conversion factors to translate available biomass into equivalent tons of CO_2.

An **exception** to the bottom-up assessment is the calculation of the land use sector CDR potential, where **resource allocation of arable land was complemented by** existing assessments of CDR potential of land use sector, especially in forests (**the PEIKKO-scenarios**). This exception is due to the significant role of the land-use sector, particularly forest areas, in Finland's emissions, and the vast and rigorous amount of existing research and calculations done to understand the carbon sinks and carbon removal potential of the land use sector, particularly forests. Additionally, the database available for resource optimisation (described in chapter 2.3.), which was otherwise used in assessing Finland's CDR potential in this report, did not include references or data for peatlands, Finnish forest management, or the effect of harvesting levels, which are a major factor in Finland.

Many Finnish organisations, like the Natural Resources Institute Finland, the Finnish Climate Panel, the Prime Minister's Office, and the Central Union of Agricultural Producers and Forest Owners (MTK), have estimated the CDR potential of the land use sector from a technical and economic feasibility perspective, or for the use of different climate scenarios and roadmaps. However, they have not assessed it from a highly theoretical 'all-in' point of view.

The bottom-up approach was applied for mineral land areas suitable for afforestation, reforestation, cropland and pasture management, and agroforestry. For the remaining components of the land use sector, CDR potential was estimated using a combination of external data sources:

- The Natural Resources Institute Finland's (LUKE)[101] assessment of the potential of various mitigation measures, developed to support the preparation of the Land Use Sector Climate Plan (MISU)
- The Prime Minister's Office's climate and energy scenario analysis (PEIKKO)[102]

101 Natural Resources Institute Finland 2021. Maankäyttösektorin ilmastotoimenpiteet: Arvio päästövähennysmahdollisuuksista. https://urn.fi/URN:ISBN:978-952-380-152-3

102 Finnish Government 2024. Baseline scenarios for energy and climate policy package towards zero emissions http://urn.fi/URN:ISBN:978-952-383-219-0

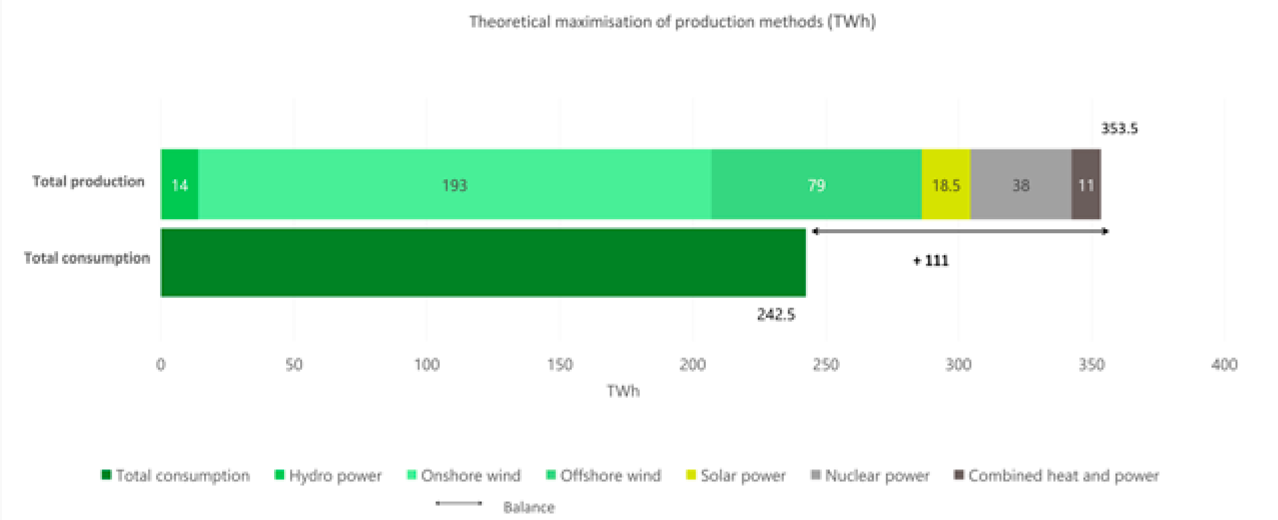

Figure 21. Theoretical maximum capacity of different electricity production methods in 2050.

4.2 Theoretical CDR potential in Finland

The **theoretical CDR potential** for Finland in 2050 is **~120 $MtCO_2$ per year** (Table 4). This potential is dominated by methods in the land-use sector, particularly through **reduced forest harvesting (~37 $MtCO_2$ / year)** and the expansion of **agroforestry (~31 $MtCO_2$ / year)**, as well as **BECCS (~20 $MtCO_2$ / year)** and **DACCS (~19 Mt CO_2 / year)**. Other methods contributing to the theoretical CDR potential include enhanced rock weathering, mineral ocean alkalinity enhancement, afforestation, durable bio-based products, and biochar.

It is important to remember that this potential is purely theoretical. It is achieved if all Finnish biomass available after allocation to priority uses is assigned to CDR methods. This scenario includes the

CDR method	CDR theoretical potential by 2050 ($MtCO_2$/year)	Notes
Reduced forest harvesting	37	The potential is based on the existing research drawn from PEIKKO scenarios and not based on the bottom-up optimisation of resources.
Forest management[103]	6	
Agroforestry	31	Likely an overestimated method in the Finnish context, as the conversion factors applied do not adequately reflect the realities of Finland's agricultural conditions. Finland-specific conversion factors were not available.
BECCS	20	BECCS is prioritised over DACCS due to high availability of biogenic CO_2 from e.g. energy and forest industry.
DACCS	19	DACCS is primarily limited by lack of permanent storage capacity and regarding L-DACCS, by availability of high-grade thermal energy. The availability of low-carbon electricity is not a limiting factor for DACCS. The DACCS methods that got potential based on the resource optimisation were electrochemical DACCS and moisture-swing DACCS.
Biochar	6	
Enhanced rock weathering	1.3	Limited by availability of suitable mineral feedstock.
Durable bio-based products	0.5	
Mineral ocean alkalinity enhancement	0.03	
Total	**~120**	Most limiting factor for technical methods such as BECCS and DACCS is geological storage capacity.

Table 4. Finland's theoretical CDR potential by 2050.

103 Forest management includes fertilisation, increase of dead wood, tending of young forest stands, longer rotation period, avoiding deforestation, management of peatland forest.

assumption that the majority of the Finnish forest industry's export volumes would shift to CDR, which is a highly theoretical scenario, reflecting a wartime effort to fight climate change. Additionally, it assumes that Finland develops its renewable energy capacity to the maximum (according to the different energy scenarios described in Chapter 3) (see Figure 20) to allocate all the surplus electricity (111 TWh) to CDR methods such as DACCS. The availability of thermal energy is limited to waste heat, of which 35 TWh has been evaluated as techno-economically feasible to utilise, allocated for methods such as S-DACCS.

A significant factor contributing to the theoretical CDR potential is the assumption that there is ample storage available for carbon. **Geologic storage is assumed to be available for 18 Mt**, according to the CCUS scenarios by VTT and Bioenergy Ry[104]. Allocation of geologic CO_2 storage was prioritised for BECCS over DACCS, as it is more efficient to capture CO_2 from flue gases than from air. The combustion of biomass is projected to continue in Finland in the coming decades by the forest industry, ensuring ample biogenic CO_2 availability. Thermal energy was not considered a limiting resource for BECCS. Instead, an additional 7%[105] biomass raw material was included to account for the extra resources needed when integrating BECCS into an incineration process.

The theoretical CDR potential accounts for storage via **in-situ mineralisation in serpentinite, mine tailings, and CO_2-cured concrete, with a combined estimated capacity of ~22 Mt CO_2**. Due to legal restrictions in Finland, however, serpentinite is excluded from the realistic CDR potential.

To calculate the theoretical net carbon balance for the land use sector, we assumed that the emissions from cropland, grassland, wetlands, and settlements were at the same level as in the Prime Minister's Office's PEIKKO WEM-L scenario.

The theoretical CDR potential was calculated under the assumption that all mineral agricultural land in Finland could be used for agroforestry.[106] However, the estimated contribution from agroforestry is likely overstated, given the uncertainty surrounding its applicability in Finnish conditions. The conversion factors used in the analysis are based on sources external to Finland, which may not accurately reflect local ecological and agricultural realities. Nevertheless, the findings suggest that Finland possesses a substantial land area with potentially high CDR capacity - warranting further investigation. Despite this, agroforestry was excluded from the calculation of realistic CDR potential due to its current limited implementation and the lack of evidence regarding its suitability in the Finnish context.

104 VTT and Finnish Bioenergy Ry 2024: Outlook of CO2 logistics in Finland for CCUS

105 Gustafsson et. al. 2021. BECCS with combined heat and power: assessing the energy penalty. https://doi.org/10.1016/j.ijggc.2020.103248

106 Organic peatlands were left out of the calculation due to lack of optimisation data

5. Existing policy

This chapter explores how CDR is currently reflected in Finland's emissions trends, targets, and planning instruments. It assesses the country's role within the EU's collective climate commitments, examines the political and legal frameworks shaping the national approach, and identifies existing support mechanisms for innovation and deployment. Finally, it outlines the key actors driving CDR-related developments and highlights upcoming policy shifts that may significantly alter the country's current trajectory.

5.1 CDR within Finland's climate strategy

Finland has committed to achieving net-zero emissions by 2035,[107] with the ambition to reach net-negative emissions shortly thereafter. This goal is enshrined in the updated **Climate Change Act** that came into force in 2024.[108] The Act sets GHG emissions reduction targets of -60% by 2030, -80% by 2040, and -90% - with an aspirational goal of 95% - by 2050, relative to 1990 levels.[109]

Implementation of the Act is supported by annual reports and will be further guided by **Finland's first long-term climate plan, scheduled for adoption in 2025**. The measures outlined in this plan are embedded across several policy instruments, most notably the Climate and Energy Strategy, the Medium-term Climate Policy Plan (KAISU) and the Climate Plan for the Land Use Sector (MISU). Each of these policy documents is revised once per government term. Currently, both KAISU and the Climate and Energy strategy are undergoing updates, with revised versions expected to be published in late 2025.

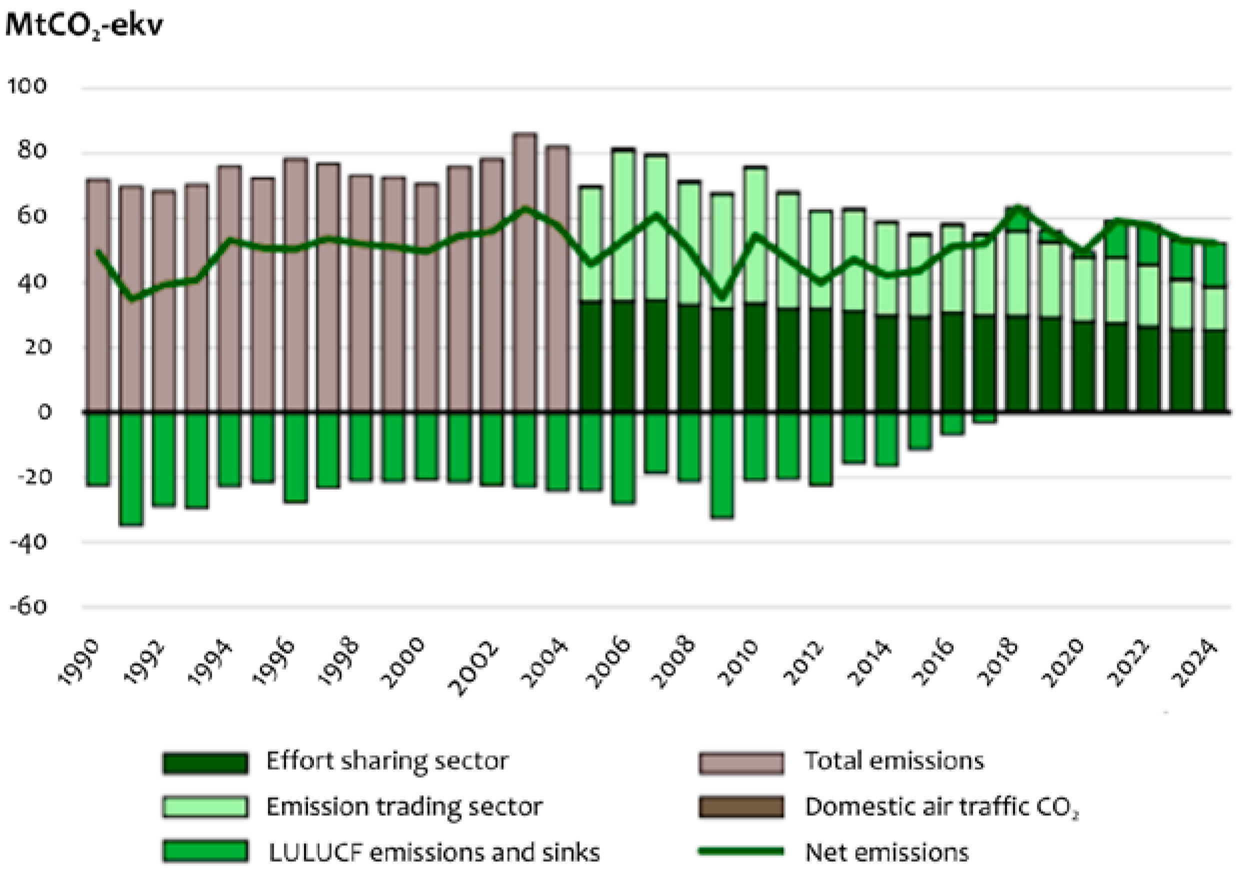

Figure 22. Development of total emissions 1990–2024. Negative values describe situations where the land use sector was a net sink. Total emissions refer to the combined emissions of the emissions trading and effort sharing sectors. From 2005 onwards, total emissions, excluding the LULUCF sector, have been divided into the effort-sharing and emissions-trading sectors. Source: Ministry of the Environment.[109] *The 2024 data are preliminary estimates.*

107 Ministry of Finance Finland 2022. Net-Zero Government Initiative (NZGI) Finland. https://www.sustainability.gov/pdfs/finland-nzgi-roadmap.pdf

108 Finlex 2022. Climate Change Act 423/2022. http://data.finlex.fi/eli/sd/2022/423/ajantasa/2024-12-19/fin

109 Ministry of the Environment 2025. Annual Climate Report. http://urn.fi/URN:ISBN:978-952-361-686-8

Finland's net zero commitment relies heavily on carbon sinks within the Land use, land use change and forestry (LULUCF) sector - primarily forestland and cropland - as well as on sector-specific low-carbon roadmaps first introduced in 2020 and largely updated in 2025. However, this heavy dependence on forestry poses risks. According to the latest national inventory, **Finland's land use sector has been a net source of emissions since 2018**, with forest land contributing to emissions since 2021.[110]

Beyond natural carbon sinks, Finland is beginning to explore technological solutions such as CCS, CCU, and CDR. In the current climate and energy strategy, there is no mention of carbon removals; only carbon sequestration is mentioned. Currently, the only mention close to CDR practices is an action to: "*assess the need to create a regulatory framework for technical negative emissions*".[111] The current government plan includes technical carbon sinks as one solution to aid Finland's carbon neutrality target, and it is expected that the updated Climate and Energy strategy could contain specific policy instruments to technical CDR methods.[112] The current government programme was also a turning point regarding CDR, and technical sinks were mentioned for the first time as a mean to reach carbon neutrality.

As **Finland's national CCS law** (416/2012) **prohibits geological storage of CO_2**, there are no permitted storage sites in the country. In 2025, Finland made two **non-binding agreements** (Memorandum of Understanding) regarding the **cross-border transportation of CO_2** with the purpose of permanent geological storage with Norway[113] and Denmark.[114] Finland also participates in various groups and networks, for example, under the Nordic Council of Ministers, which provides opportunities to discuss CCUS-related issues at the intra-regional level[83].

Finland has not yet published precise estimates for the volume of CDR required to meet its carbon neutrality target. However, the Technical Research Centre of Finland (VTT) has projected that by 2050, the country could potentially capture around 9 Mt CO_2 annually through BECCS.[115]

In 2021, the Ministry of the Environment outlined three scenarios for achieving carbon neutrality incorporating both natural carbon sinks and technological removal methods.[116]

- **With Existing Measures (without novel carbon removals)**: in this scenario, Finland achieves carbon neutrality as early as 2025, provided that net carbon sinks reach -30 Mt CO_2e.
- **Continuous Growth (without carbon removals)**: in this scenario, carbon neutrality is reached by 2035 with an 87.5% reduction in GHG emissions by 2050 compared to 1990. This scenario does not include CCS, but the land use sector's sink should be about -45 Mt CO_2e.
- **Savings (with carbon removals)**: in this scenario, carbon neutrality is reached by 2035 with 90% emissions reduction by 2050 compared to 1990. This scenario includes technological removals with BECCS, but only after 2030. The assumption is that BECCS accounts for -14Mt CO_2e in 2050. The land use sector's net sinks in this scenario are -20 Mt CO_2e.

Finland's current climate neutrality strategy excludes the use of international carbon offsets.[117] However, in the carbon removal credit market, Finland holds considerable potential for exporting carbon removal credits - particularly through forest-based biomass solutions.[118]

110 Natural Resources Institute Finland 2025. Preliminary greenhouse gas inventory results for 2023. https://www.luke.fi/en/news/preliminary-greenhouse-gas-inventory-results-for-2023-forest-land-has-turned-into-an-emission-source-because-the-carbon-sink-of-trees-no-longer-cover-emissions-from-forest-soil

111 Ministry of Economic Affairs and Employment of Finland 2022. Hiilineutraali Suomi 2035. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164321/TEM_2022_53.pdf?sequence=1&isAllowed=y

112 Ministry of the Environment, Finland 2025. Net-Zero Industry Act – Transparency of CO_2 storage capacity data. https://ym.fi/documents/1410903/33891761/Report_Finland_21_2_3.pdf/686ad63f-8d84-cedd-b61b-be0032cb9707/Report_Finland_21_2_3.pdf?t=1738655357342

113 The Government of Finland 2025 : https://valtioneuvosto.fi/-/1410903/suomi-ja-norja-vahvistavat-yhteistyota-hiilidioksidin-talteenotossa-kuljettamisessa-ja-varastoinnissa

114 The Government of Finland 2025: https://valtioneuvosto.fi/-/1410903/suomi-ja-tanska-sopivat-puitteista-hiilidioksidin-kuljettamiselle-ja-varastoinnille

115 Koljonen et. al. 2021. Hiilineutraali Suomi 2035 – ilmasto- ja energiapolitiikan toimet ja vaikutukset. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163638/VNTEAS_2021_62.pdf?sequence=1&isAllowed=y

116 Kalliokoski 2021. Options for carbon dioxide removal: https://climatedialogue.eu/sites/default/files/2021-08/Finland%20-%20Carbon%20dioxide%20removal-workshop_18062021_TK.pdf

117 Ministry of the Environment, Finland 2025. Voluntary carbon offsetting. https://ym.fi/en/voluntary-carbon-offsetting?

118 Kujanpää et. al. 2023. Carbon dioxide use and removal. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164795/VNTEAS_2023_19.pdf?sequence=1&isAllowed=y

Finland's NDC is part of the EU's joint NDC, which reflect legally binding targets established under the EU Climate Law. Through this framework, the EU and its member states collectively commit to reducing net GHG emissions by at least 55% by 2030 compared to 1990 levels. The updated NDC, submitted in 2023,[119] reaffirms the EU's objective of achieving climate neutrality by 2050 at the latest, with aspirations for net-negative emissions thereafter. However, the NDC does not explicitly reference CDR as a pathway to meet these targets.

Outside the scope of the NDC, the EU has introduced dedicated legislation addressing carbon removals and carbon farming through the **Carbon Removal Certification Framework (CRCF)**, which aims to establish standards and transparency for CDR activities across member states.[120]

5.2 Legal frameworks relevant to CDR

Finland's legal framework for carbon removal is anchored in the 2022 Climate Act, which formalises the 2035 carbon neutrality target, defines the role of the Finnish Climate Change Panel, and safeguards Sámi rights in climate policymaking.

- **Climate Act 423/2022**:[121] this landmark legislation sets Finland's climate neutrality target and mandates emission reduction goals based on the Finnish Climate Change Panel's recommendations. It also aims to strengthen carbon sinks. The Act establishes a comprehensive climate policy planning system consisting of four key plans:
  - Mid-term climate change policy plan (current from 2022)[122]
  - National Climate Change Adaptation Plan 2030 (from 2022)[123]
  - Climate Plan for the Land Use Sector (from 2022)[124]
  - Climate and energy strategy (from 2022)

Additionally, the Act requires an **Annual Climate Report** to track emission trends, evaluate progress toward reduction targets, and identify the need for further action.

Beyond the Climate Act, several other laws regulate the potential implementation of large-scale CDR in Finland. The most relevant are outlined below.

- **Act on Separation and Storage of Carbon Dioxide 416/2012**:[125] prohibits the geological storage of carbon dioxide within Finland's territory and Finland's exclusive economic zone (EEZ), both geologically and in the water column. However, this prohibition does not apply to the geological storage of carbon dioxide if the amount to be stored is less than 100,000 tons and the purpose of storage is research, development, and testing of new products and methods. This act also stipulates that CO_2 captured in Finland may be transferred for geological storage only within EU member states' territories or their EEZ.
- **London Protocol**: while it initially prohibited CO_2 export for storage, a 2019 resolution allows provisional application of a 2009 amendment enabling exports between consenting parties. Finland has accepted both the amendment and the resolution, has concluded a bilateral agreement with Norway, and is in the process of finalising one with Denmark - opening concrete pathways for offshore carbon storage collaboration and future CDR deployment.
- **Environmental Protection Act 527/2014**: governs the permitting requirements for carbon capture and storage (CCS). It also mandates that waste incineration plants with a nominal capacity of at least 300 MW must include an assessment of carbon capture feasibility in their environmental permit application. If conditions for carbon capture are met, the permit must require the facility to reserve adequate space for capture and pressurisation equipment.
- **Waste Act 646/2011 and Environmental permits**: to date, Finland has not issued an environmental permit for a direct air capture (DAC) facility. Authorities require detailed project information to

119 European Union 2023. The update of the nationally determined contribution of the European Union and its Member States. https://unfccc.int/sites/default/files/NDC/2023-10/ES-2023-10-17%20EU%20submission%20NDC%20update.pdf

120 European Union 2024. Regulation (EU) 2024/3012 of the European Parliament and of the Council of 27 November 2024 establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202403012

121 Finlex 2022. Climate Change Act 423/2022

122 Ministry of the Environment 2025. Medium-term Climate Policy plan. https://ym.fi/en/medium-term-climate-change-policy-plan

123 Ministry of Agriculture and Forestry of Finland 2023. National Climate Change Adaptation Plan 2030. https://mmm.fi/en/nature-and-climate/climate-change-adaptation/national-climate-change-adaptation-plan-2030

124 Ministry of Agriculture and Forestry of Finland 2023. Climate measures in the land use sector. https://mmm.fi/en/climate-plan-for-the-land-use-sector

125 Finlex 2012. Laki hiilidioksidin talteenottamisesta ja varastoinnista 416/2012

determine applicable permit requirements, which are expected to align with those for other industrial operations. Although Finland lacks specific legislation on carbon capture, all operations must comply with stringent national standards for CO_2 stream quality. CO_2 streams may contain trace substances from processing or capture, as well as small quantities of monitoring agents used during transport. These substances must not pose risks to human health, environmental safety, or operational integrity. Under the Waste Act (646/2011), waste materials cannot be added to CO_2 streams as a means of disposal. Carbon capture operators are obliged to investigate the composition of carbon dioxide streams and assess any associated risks. Carbon dioxide can only be captured if risk assessments confirm that concentrations of any other substances meet regulatory limits. Detailed records must be maintained for CO_2 delivered to geological storage.[126]

- **Construction Act**: entered into force on 1 January 2025, mandates that the Government will emit decrees specifying the criteria for what constitutes low-carbon buildings.[127]

- **Decree 1027/2024**: published in December 2024 and effective from 1 January 2026, allows carbon storage in building materials - including through carbonation - to be accounted for in carbon footprint assessments. This enables certain CDR methods to contribute directly to reducing the carbon footprint of buildings.[128]

In 2023, a temporary law (823/2025) was introduced to make it easier for green transition projects to get permits. This law is in effect from 2023 to 2026. Some green transition projects, especially those involving CCUS, can get priority in environmental and water management permit procedures. To get this priority treatment, these projects must pass the Do No Significant Harm (DNSH) assessment. Starting in 2026, one-stop services and streamlined permit procedures will be available for these projects.

5.3 Support for R&D and Innovation

Finland's Research, Development and Innovation (RDI) system is driven by strong higher education institutions working in partnership with public and private research bodies, companies, and other organisations. The Ministry of Education, Science and Culture oversees higher education and science, while the Ministry of Economic Affairs and Employment manages innovation policy. The Research and Innovation Council, chaired by the Prime Minister, coordinates the development of Finland's innovation system.[129] **Although CDR is not a current RDI priority, Finland conducts extensive research on forests and their role as carbon sinks**.

The Technical Research Centre of Finland (**VTT**) is a key cooperation partner for companies, research institutes, higher education institutions, and policymakers both nationally and internationally, and it has a **dedicated CDR programme**.

In the National Roadmap for RDI, released in 2020 and updated in 2021, a new partnership model for RDI work was developed. The new partnership model responds to the wishes of the private sector for a radical renewal in the use of public funding for the development of ecosystems (research, development, and growth) as well as creating new operating models for testing, piloting, and scaling innovations. The new model will also better group national programme financing with EU and other international funding. Partnerships target key growth areas and the selections for funding are made on a competitive basis.[130]

In recent years, Finland has funded some CDR-focused research programmes through the Finnish Academy (Suomen Akatemia). The IBC-Carbon research programme (until 2023) explored forest ecosystems, conservation and carbon sinks,[131] while the ongoing CO-CARBON programme (2023-2026) investigates how urban green spaces can act as a carbon sink.[132] **From October 2025, a CO_2CREATION programme will incorporate multidisciplinary research to**

126 Business Finland 2024. Your guide to green permitting in Finland. https://www.businessfinland.com/news/2024/your-guide-to-green-permitting-in-finland

127 https://www.finlex.fi/fi/lainsaadanto/saadoskokoelma/2023/751

128 https://www.finlex.fi/fi/lainsaadanto/saadoskokoelma/2024/1027#Lidm46263582166496

129 Research.fi 2025. Research and Innovation System. https://research.fi/en/science-innovation-policy/research-innovation-system

130 Ibid.

131 Finnish Environment Institute 2025. IBC-Carbon: Metsäluonnon monimuotoisuuden suojelu ja hiilen sitominen muuttuvassa. https://www.syke.fi/fi/projektit/ibc-carbon

132 CO-CARBON 2025. Tavoitteena hiiliviisas kaupunkivihreä. https://cocarbon.fi/

provide policy recommendations about CDR.[133]

State funded innovation support is quite limited and focused to be awarded via Business Finland (BF), which supports especially SMEs that are seeking international market. BF also supports research institutions and public-private-partnership initiative. In 2024, a dedicated low carbon hydrogen and carbon capture call was organised as part of Finland Recovery and Resilience Facility (RRF) funding. Most of BF's innovation support is loan based and can be used in all RDI activities. The vast majority of RDI work is done with private equity and public funding is typically between 30-50% of the total costs of the project. In 2024, the former dedicated Climate Fund was merged to TESI, the Finnish Industry Investment Ltd, that invests in startups, scale-ups and large new industrial projects. It has funded for example Biochar investments.[134]

Apart from the public RDI funding, private foundations are significant funders in the Finnish RDI scene. In 2023 foundations provided almost 300 M€ for research.[135] One example of a major foundation in Finnish Climate RDI space is the TAH-Foundation that currently focuses on Accelerating Climate Efforts and investments.[136]

5.4 On the horizon

As noted and further discussed in chapter 6, **CDR remains an emerging topic in Finnish climate policy**. Existing strategies and policies either omit or explicitly reject technological carbon removal and storage. However, during the preparation of this report, several government-led strategy updates and legislative reforms are underway that may signal a shift in this stance. Most notably, the draft renewed **Climate and Energy Strategy**[137] **includes provisions for CDR** and dedicated law for subsidising BECCS is currently under preparation (August 2025).[138]

In Finland, climate policy has primarily focused on the land use sector and industry-level low-carbon roadmaps. Key strategies include expanding renewable energy production and promoting the bioeconomy as pathways toward a fossil-neutral society while continuing to leverage the country's significant forest industry.

Strengths	*Opportunities*
• Level of ambition is high and commitment to carbon neutrality has been agreed amongst the main parliamentary parties and there are no foreseen changes to this for the next government coalition. • Climate Law codifies the target into law.	• Technical CDR is seen as a new opportunity and mentioned in current government programme as well as currently prepared Climate and Energy strategy • Separate support mechanism for BECCS currently under preparation
Weaknesses	***Threats***
• No state intervention to use carbon trading and/or increase foreign investments to increase CDR • Low funding throughout the value/innovation chain	• Lack of storage capacity and CO_2 infrastructure investments can halt investments to capturing technology • Increased focus on security may shift societal and monetary priorities away from climate action, potentially reducing or slowing down investments and regulatory development needed for CDR.

Table 5. Finland's current policy framework and environment strengths and weaknesses.

133 University of Oulu 2025 : https://www.oulu.fi/fi/uutiset/suomen-akatemialta-oulun-yliopistoon-kaksi-merkittavaa-hankerahoitusta-tekoalya-hyodyntavaan

134 Tesi 2025. Carbo Culture. https://tesi.fi/case/carbo-culture/

135 Säätiöt ja Rahastot ry 2024. Jäsensäätiöiden tuen 2023 kohdentuminen. https://saatiotrahastot.fi/wp-content/uploads/2024/09/Selvitys-saatiotuesta-2023.pdf

136 TAH Foundation n.d. Accelerating Climate Efforts and Investments (ACE). https://tahsaatio.fi/en/accelerating-climate-efforts-and-investments-ace/

137 Lausuntopalvelu 2025. Lausuntopyyntö kansallisen energia- ja ilmastostrategian luonnoksesta. https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposalId=d3a6b34b-c3dd-4336-b91b-74285c68bb4c&proposalLanguage=da4408c3-39e4-4f5a-84db-84481bafc744

138 Lausuntopalvelu 2025. Valtioneuvoston asetus teollisuuden bioperäisen hiilidioksidin talteenoton edistämiseksi myönnettävästä avustuksesta https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposalId=688c91e8-ff21-490c-a174-36bde5912516

5.4.1 CDR players

In Finland, despite limited governmental support and the absence of a clearly defined CDR strategy, a dynamic ecosystem is emerging. It comprises Research, Development, and Innovation (RDI) institutions, pioneering CDR start-ups, and established corporations exploring CDR solutions. The key actors currently shaping this landscape are presented in Figure 23.

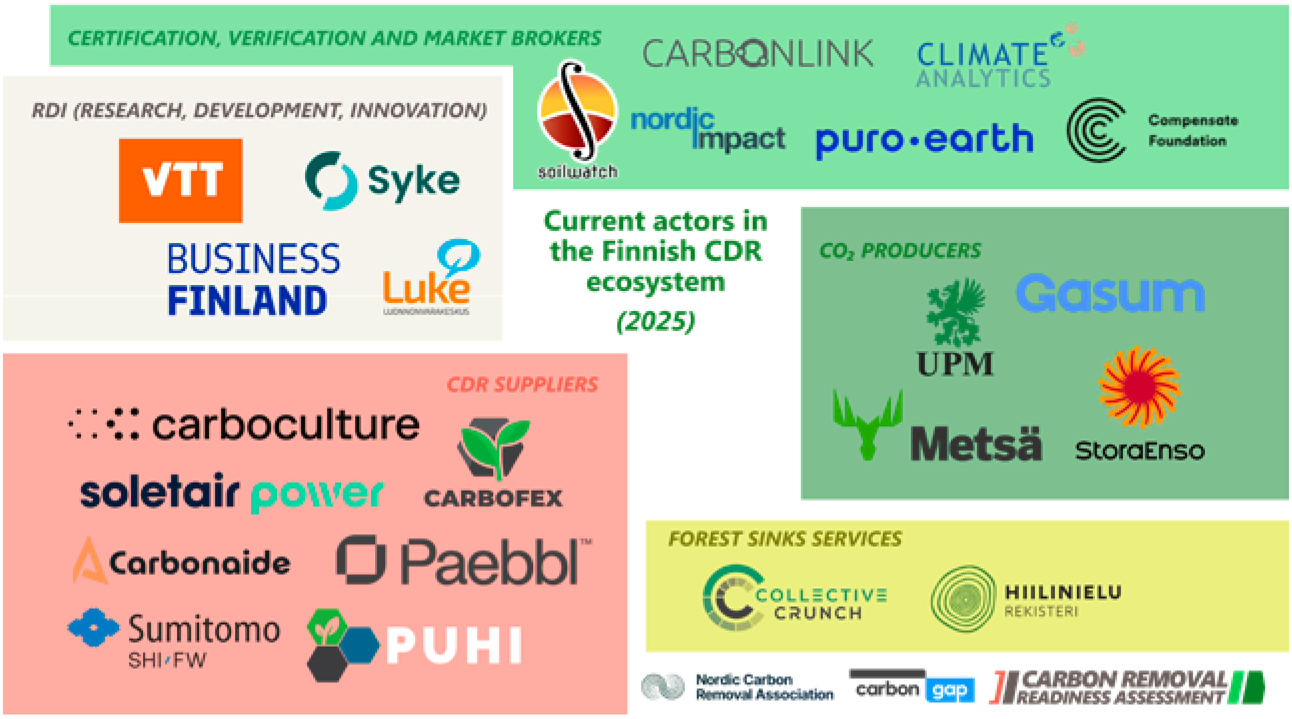

Figure 23. Current main actors in the Finnish CDR ecosystem.

6. Finland's social geography

Finland's strong climate commitment, highly educated population, and deep cultural connection to nature - reflected in widespread private forest ownership - create a solid foundation for deploying CDR. These societal strengths offer unique opportunities. However, recent shifts in national focus toward physical security and economic uncertainty have diverted attention from climate priorities, risking a slowdown in momentum just as the 2035 carbon neutrality deadline approaches.

6.1 Overview

This section aims to paint an objective picture of the social geography of Finland, identifying the main enablers and limitations to the deployment of CDR. The first section consists of description of Finnish from economic and political standpoint, what Finnish human resources looks like and what the industrial structure is currently and how it could be used in CDR. After this, summaries of stakeholder interviews and citizen panel are provided. More in depth results of these can be found in Annex A.

6.1.1 Economy

According to the Ministry of Finance (2025[148]) Finland's gross domestic product (GDP) contracted by 0.1% on an annual basis in 2024, but the economy returned to grow during 2025. Slowing inflation and falling interest rates are boosting consumption, while recovery in construction, the energy transition, and defence procurement are driving investment. GDP is projected to grow by 1.3% in 2025, 1.6% in 2026, and 1.5% in 2027.[149]

GDP (billion USD)	295.532[140]
Growth 2024	0.1[141]
Productivity	$82.96 per hour worked[142]
Unemployment	8.8 %
Main Sectors	61.4% Services, 23.9% Industry (Forestry & Paper, Tech & Electronics, ICT, Energy), 2.3% Agriculture (2023)[143]
Trends	• Slow growth: recovering after 2022 recession. • A slowdown in inflation and lowered interest rates.[144] • Tight labour market: unemployment with skill mismatches. • Fiscal consolidation: government reducing spending to stabilise finances.[145]
Carbon intensity	Moderate (equal to EU average 0.22): 0.22 kg/€ (GHG emissions intensity of gross value added)[146]
GDP per capita (Current USD)	52,925.7[147]
HDI (2022)	0,942
CO_2 emissions (tons) in 2023	32,270,000[148]

Table 6. Finland's key economic indicators.

139 World Bank 2025. GDP – Finland. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=FI

140 Ministry of Finance, Economic Survey, Spring 2025: https://vm.fi/en/economic-survey-spring-2025#/

141 OECD 2025. Productivity levels 2023 [US per hour worked, current prices] OECD Data Explorer • Productivity levels

142 Statista 2025. Finland: Share of economic sectors in the gross domestic product. Finland - share of economic sectors in the gross domestic product 2013-2023| Statista

143 Ministry of Finance, Economic Survey, Spring 2025: https://vm.fi/en/economic-survey-spring-2025#/

144 European Commission 2023. Country report Finland. 2023 Country Report - Finland

145 Eurostat 2024. Greenhouse gas emission accounts. https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=661410

146 World bank 2025. GDP per capita (current US$). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?name_desc=false

147 EDGAR – Emissions Database for Global Atmospheric Research 2024. GHG emissions of all world countries. https://edgar.jrc.ec.europa.eu/report_2024?vis=co2tot#emissions_table

148 Ministry of Finance, Economic Survey, Spring 2025: https://vm.fi/en/economic-survey-spring-2025#/

149 Ibid. Ministry of Finance, Economic Survey, Spring 2025: https://vm.fi/en/economic-survey-spring-2025#/

Although the labour market recovery has lagged, unemployment is expected to decline from 8.8% in 2025 to 7.9% in 2027, as economic conditions improve. However, growth prospects remain vulnerable to external risks - particularly US trade policy. If current tariffs persist, economic performance in 2025 and 2026 could fall short of expectations.

6.1.2 Political and public landscape

Finland is a multiparty democracy where coalition governments are the norm. The current government is led by Prime Minister Petteri Orpo and his centre-right party, the National Coalition (Kokoomus). The coalition also includes the Finns Party (Perussuomalaiset, PS), often described as right-wing populist; the Swedish People's Party of Finland (RKP), which leans liberal; and the Christian Democrats (KD), a socially conservative centre-right party. The opposition at the time of writing this report (October 2025) comprises the Social Democratic Party (SDP), the Left Alliance, the Green Party, the Centre Party, and Movement Now (Liike Nyt). Finnish coalition politics are characterised by flexibility, with no rigid blocs allowing ideologically diverse parties to form governing alliances.

Parliamentary elections are held every four years, with the most recent taking place in 2023. The next scheduled parliamentary election is set for 2027. In 2025, municipal and regional council elections were conducted, resulting in a notable decline in support for the Finns Party, which lost several seats across local councils. Conversely, the SDP experienced gains in both voter support and council representation. While these local election outcomes reflect shifts in public sentiment, they do not directly alter national policy, as the prime minister's party -the National Coalition - maintained its overall support and governing position.

Over the past three government terms, Finland's political approach to climate action have evolved.

- In 2015-2019, under the Sipilä Government led by the Centre Party, The Finns, and the National Coalition, the focus was on promoting the bioeconomy. Climate policy remained largely confined to the Ministry of the Environment and was not a central political priority.
- In 2019-2023, under Rinne and Marin's government, the coalition (SDP, Left Alliance, the Greens, Swedish People's Party, Centre) set an ambitious goal of achieving carbon neutrality by 2035 – hailed as one of the most progressive climate agendas globally. Early actions included codifying climate law, launching a climate fund, and integrating climate policy across ministries. However, external crises—COVID-19, Russia's invasion of Ukraine, and Finland's NATO accession—limited progress, leading to public disappointment over the pace of implementation.
- 2023-present (Orpo government), the current coalition (National Coalition, The Finns, RKP and KD) has scaled back climate policy implementation while maintaining the 2035 neutrality target. Notably, the government programme introduced CDR as a strategic component for the first time and is planning on providing budget support for technical carbon sinks[150].

The most notable factors in the Finnish climate discourse at the political level focus on:

- **Forests and emissions**: forests are central to Finland's climate strategy. A LUKE study[151] revealed that due to excessive harvesting, forest lands have become net emitters, sparking a heated debate over balancing forest industry interests with the need to restore carbon sinks. While industry-specific carbon roadmaps were developed under the Rinne/Marin government and updated under Orpo, no major new initiatives have emerged. The current government does not plan to restrict harvesting but aims to explore alternative methods to enhance forest sinks.
- **CDR and land use**: CDR has not been a prominent part in the Finnish climate policy, apart from afforestation and increasing the carbon sinks in Finland. As described in chapter 3, Finnish forests are largely owned by private landowners, which fragments the decision making around forests. The METSO programme provides these private forest owners with an incentive to protect their forests instead of harvesting them. It has been popular but underfunded.
- **Peat phase-out**: historically a major peat producer for energy and agriculture, Finland decided in 2021 to end peat use for energy by 2030. Support for the phase out has come from both national funds and the EU's Just Transition

150 Finnish Government 2024. Prime Minister Orpo's Government : Long-term economic adjustment continues, focus shifts to growth. https://valtioneuvosto.fi/en/-/prime-minister-orpo-s-government-long-term-economic-adjustment-continues-focus-shifts-to-growth

151 Natural Resources Institute Finland 2025. Preliminary greenhouse gas inventory results for 2023. https://www.luke.fi/en/news/preliminary-greenhouse-gas-inventory-results-for-2023-forest-land-has-turned-into-an-emission-source-because-the-carbon-sink-of-trees-no-longer-cover-emissions-from-forest-soil

Fund.

- **Emerging CDR technologies**: as of 2025, Finland is beginning to advance CDR through technologies like BECCS and BECCU marking a notable shift in its climate strategy.

6.1.3 Relationship to ecology

Finland and Finnish people have traditionally felt very strongly connected to nature and many of Finland's national characteristics are linked to nature – for instance the national tagline being land of the thousands lakes. Finns also attribute their status as the happiest country in the world according to the happiness index partly due to our connection to nature. Most Finns live very close to some sort of nature, be it city parks or forests, nature conservation cites, natural parks or privately owned forests. The "everyone's rights" guarantee that walking, hiking, camping and collecting berries and mushrooms are free and available for everyone. In the recent years, this perception of Finland being very connected to nature and pro nature conservation has been up to debate as discussions about nature conservation and needs of industries such as the forest industry have heated.

According to the 2025 Climate and Nature Barometers[152], the awareness of the global impacts of climate change and biodiversity loss is strong among Finns with 86 % of respondents consider that the impacts of climate change can already be seen in different parts of the world and 88 % see the same for biodiversity loss and more than half have observed biodiversity loss in local environment.

At the moment, a particular focus in the public discussion on climate policy is on achieving the climate neutrality target set in the national Climate Act and on increasing the forest carbon sinks and reservoirs. One of the most contested questions of the barometer was whether Finland should take adequate climate actions to achieve carbon neutrality by 2035 by only having 62 % of the respondents in favour of this, although support for this had grown since the previous barometer in 2023 by 4 %. On the contrary tough, 75% of the respondents consider that more attention should be paid to forest harvesting and to management practices in order to preserve carbon sinks.

The respondents of the barometers see that municipalities, companies, state actors and international organisations all have power in climate action and clear majority (86%) consider that Finland can improve its competitiveness by exporting clean technology solutions to the world. A clear majority (80%) consider that companies should also be required to take action to reduce emissions.

Since the IPCC 2018 report on climate crisis, more activism around climate have been emerging but in the recent years, climate activism has not been as prominent as it was in the early years. On top of widespread climate demonstrations, the local chapter of the Extinction Rebellion (FI: Extinction Rebellion) has made several civil disobediences campaigns a year resulting in heated debate around climate activism. There have so far been two notable court cases where the Finnish government has been challenged due to lack of effort to combat climate change. The supreme court dismissed the complaint since the government had made some new actions based on the climate review 2024.[153]

6.1.4 Human resources

Finland's workforce is well-positioned for CDR deployment, with strong academic and industry expertise in fields like biology, geology, energy engineering, and organic farming. While education outcomes have declined in recent years, the overall skill level remains high, and the workforce shows readiness for upskilling.

According to the VISIOS report[154], skills needed for the green transition align closely with the current skill profile of the Finnish workforce, easing the shift to CDR-related industries. However, critical gaps remain in:

- **Technical and Engineering skills**: high-level scientific knowledge and practical technical skills for design, production and installation of new technologies, such as solar panels.
- **Operational and Management Skills:** essential for designing green services and products and integrating sustainable practices into organisational operations.
- **Sustainability Skills:** required across all education levels and programs to support transformative change.
- **Transversal Skills:** including soft skills and sustainability thinking in everyday work and life in a more sustainable society.

152 Ministry of the Environment 2025. Climate and Nature Barometer 2025. https://ym.emmi.fi/l/xgQhLFtkVNx7

153 Supreme Administrative Court of Finland 2025. Ennakkopäätös KHO:2025:2. https://www.kho.fi/fi/index/paatokset/ennakkopaatokset/1735886394202.html

154 Prime Minister's Office 2023. Vihreän siirtymän osaamis- ja koulutustarpeet VISIOS. https://julkaisut.valtioneuvosto.fi/handle/10024/164892

Finland will face growing competition for green talent as it strives to achieve a green transition. The development of sustainable public procurement and vocational education indicates efforts to prepare and enhance the workforce for future challenges.

Thus, Finland is relatively well-prepared in terms of available human resources but must continue to develop specific green skills and compete effectively in the global market to meet future demands. However, recent cuts to adult re-education funding may hinder career transitions. Current efforts focus on aligning first-time secondary and higher education to match the green transition skill needs.

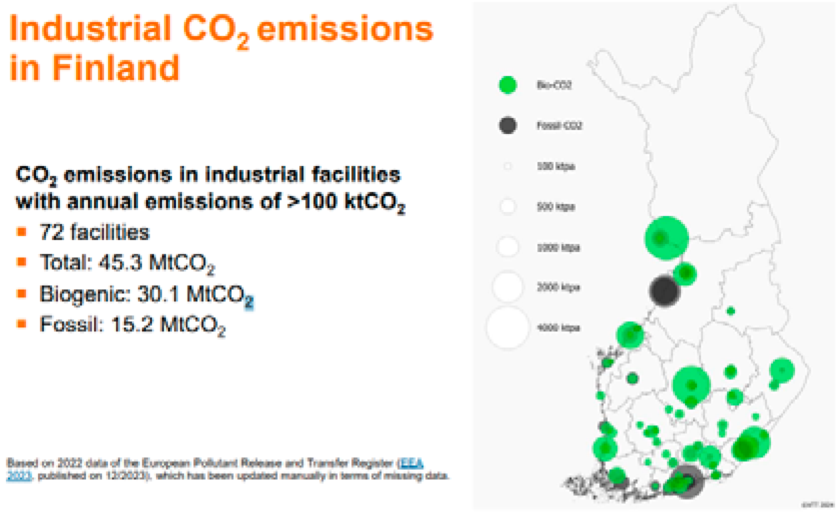

Figure 24. Industrial CO_2 emissions in Finland, VTT 2024.

6.1.5 Industrial integration

Finland is home to several emerging and operational ecosystems supporting CDR, with growing industrial integration across sectors. In 2024, VTT conducted a study on CCU commissioned by four major industry groups: Finnish Forest industries, Chemical industries, Energy industry, and Technology industries. The study aimed to develop business cases for CCU and CCS, as illustrated in Figure 22. Additionally, Bioenergia ry maintains an up-to-date interactive map highlighting ongoing and planned investments in bio-CCUS and biochar initiatives[155].

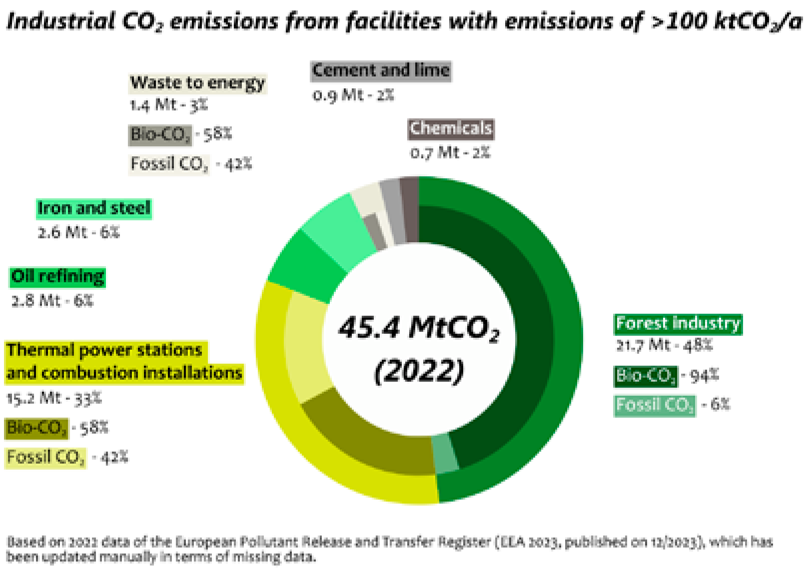

Figure 25. Industrial CO_2 emissions from facilities with emissions of >100ktCO_2/year.

Agriculture

In 2014, the Ministry of Agriculture and Forestry published a guide for climate-friendly agriculture, which was updated in 2024. The revised edition includes information on carbon farming and enhanced rock weathering in Finland, outlining their current status, and future potential[156]. In 2023, a research project on carbon farming was launched by an agriculture company and the Finnish

155 Bioenergia Ry 2025. Projects on the map: bio-CCUS & biochar. https://www.bioenergia.fi/en/bio-ccus-biochar/

156 Ministry of Agriculture and Forestry 2024. Climate Programme for Agriculture [original version] http://urn.fi/URN:ISBN:978-952-453-871-8; Maatalouden ilmastotyökartta [updated version] maatalouden_ilmastotiekartta_2024_netti

Meteorological Institute.[157] Timely results from this initiative are available through a dedicated project database.[158] Additionally, in 2020 the Baltic Sea Action Group - a non-profit organisation focused on sustainable farming practices to protect the Baltic Sea - published a sector-specific guide on carbon farming for agricultural stakeholders.[159]

Forest industry

Finland's forest industry is a cornerstone of the national economy, contributing approximately 16.8% of goods exports and generating around €3.1 billion in annual tax revenue. While its exact share of GDP is hard to isolate due to overlapping sectors, its economic footprint is substantial - procurement for harvesting and timber transport alone reached €1.2 billion in 2023, and combined value added from forestry and forest industry totalled €10.5 billion in 2022.[160]

A study by VTT found that the forest industry accounts for 48% of Finland's industrial CO_2 emissions, 94% of which are biogenic.[161] Research into carbon management is ongoing, but the industry faces considerable economic pressures that challenge its path toward sustainable development. To support climate-conscious practices, Metsähallitus - an organisation that uses, manages, and protects state-owned land and water areas under its control in a sustainable manner - has issued guidelines promoting climate-conscious forest economy and decision-making in forest management.[162]

Buildings, concrete, demolition

The Confederation of Finnish Construction Industries RT is driving research in low-carbon construction, concrete, and demolition, prioritising emissions reductions over direct CDR in its carbon neutrality roadmap.[163] Concrete production remains a major source of emissions, though Finland's existing concrete stock sequesters about 0.1 $MtCO_2$ annually - about 10% of the cement industry's emissions - and has permanently stored roughly 4 $MtCO_2$ to date.[164]

A major regulatory shift is now underway with the new Building Act, which came into force in January 2025. Starting in 2026, all construction projects comply with low-carbon design standards. Building permit applications will require a climate assessment that reports both the carbon footprint and handprint across the building's full life cycle, using standardised evaluation methods and national emissions data. Carbon footprints must remain within defined thresholds[165] - potentially accelerating the adoption of carbon and bio-based building materials in construction, thereby increasing CDR potential.

Energy industry

The Energy Industries association and its member companies are active in developing industrial integration for carbon capturing, but mostly for creating biogas and biofuels, and not storing and removing carbon. Bioneregy ry is active in developing the whole value chain for CCUS especially for biogenic CO_2 and has commissioned studies on CDR infrastructure.[166] The most prominent industrial integration in the energy sector is Vantaan Energia's plan to capture and store 600,000 tons of carbon coming from its waste management facility.[167]

157 Läntmännen Agro 2023. Extensive research on carbon sequestration launched in Finland. Extensive research on carbon sequestration launched in Finland | Lantmännen Agro

158 Field Observatory 2025. How much carbon do plants and soil sequester? https://www.fieldobservatory.org/index.php/home/

159 Heinonsalo, J. 2020. Hiiliopas: Katsaus maaperän hiileen ja hiiliviljelyn perusteisiin. BSAG-hiiliopas-1.-painos-2020.pdf

160 Ministry of Agriculture and Forestry of Finland 2025. Metsien taloudellinen merkitys.: https://mmm.fi/metsat/metsatalous/metsatalouden-kestavyys/metsien-taloudellinen-merkitys

161 VTT Technical Research Centre of Finland 2024. Selvitys hiilidioksidin talteenoton ja hyötykäytön kansallisesta ilmasto- ja talouspotentiaalista. https://metsateollisuus.fi/wp-content/uploads/2025/02/66c81a80456d0b63f25c89b9_VTT20projektiraportti_Selvitys20hiilidioksidin20talteenoton20ja20hyC3B-6tykC3A4ytC3B6n20potentiaalista.pdf

162 Metsähallitus 2024. Climate Smart Forestry. https://www.e-julkaisu.fi/metsahallitus/ilmastoviisas_metsatalous/mobile.html#pid=1

163 Rakennusteollisuus RT 2023. Rakennetun ympäristön hiilielinkaaren nykytila. https://rt.fi/wp-content/uploads/2023/11/rt-1-rakennetun-ympariston-hiilielinkaaren-nykytila.pdf

164 Finnish Association of Construction Product Industries 2025. Carbon sequestration in concrete. https://hiilineutraalisuomi.syke.fi/en/projects/canemure/results-of-the-subprojects/finnish-association-of-construction-product-industries/

165 Finnish Government 2024. Building Act and amendments come into force at the beginning of the year. https://valtioneuvosto.fi/-/1410903/rakentamislaki-seka-siihen-tehdyt-korjaukset-voimaan-vuoden-alusta

166 Bioenergia ry 2024. Suomesta runsaasti hankkeita hiilidioksidin talteenottoon – nyt panostettava myös kuljetusmahdollisuuksiin. https://www.bioenergia.fi/2024/04/16/suomessa-runsaasti-hankkeita-hiilidioksidin-talteenotto-nyt-panostettava-myos-kuljetusmahdollisuuksiin/()

167 Vantaan Energia 2024. Hiilidioksidin talteenotto ja varastointi. https://www.vantaanenergia.fi/tietoa-meista/hankkeet/hiilidioksidin-talteenotto-ja-varastointi/()

6.1.6 Cultural, aesthetic, religious and ethical considerations

Culturally, Finnish people tend to value environmental sustainability and nature conservation, which underpins broad support for climate mitigation efforts, including CDR technologies. Finland's pristine landscapes are deeply cherished, making CDR approaches that minimise visual impact or integrate seamlessly with the natural environment especially preferable. While Finland is largely secular, environmental stewardship remains strong - rooted in Lutheran traditions and indigenous beliefs that emphasise Earth's protection. These values reinforce the need for CDR to be implemented transparently, fairly, and with minimal negative impacts on communities and ecosystems.

A key cultural and ethical consideration for CDR deployment involves the Sámi people, who inhabit northern Finland's indigenous territory of Sápmi. Lapland, where over 80% of Finland's mineral exploration occurred in 2022, offers ideal conditions for mining, wind energy, hydropower, and forestry. However, land use pressures and renewable energy projects threaten both the region's nature and Sámi reindeer herding - a vital livelihood and cultural practice[168]. Many Sámi view such investments as a form of green colonialism.

Around 90% of the Sámi homeland is state-owned land managed by Metsähallitus. Of this, 72% is designated as protected and wilderness areas under Metsähallitus Natural Heritage Services, while 13% is classified as natural resource areas overseen by Metsähallitus Property Development. Forestry accounts for 15% of the land, with about half actively used for logging operations.

Any new investments that would either be in the Sámi homeland areas or impact the Sámi culture should be approved by the Sámi council. While several green transition projects are under consideration, their cumulative impact is widely seen by Sámi communities as incompatible with preserving their culture and way of life.

6.2 Stakeholder interviews

This section summarises the insights gathered from interviews with 15 stakeholders representing academic, political, advocacy, and industry perspectives in the field of CDR and climate policy (as per Table 7). The interviews were conducted during April and May 2025, for a total of 15 Hours, and explored three core dimensions:

- Awareness and knowledge of CDR and its various methods
- Awareness and views on Finland's existing climate policy
- Views on the deployment of CDR in Finland, including method-specific observations.

The findings offer a multi-dimensional view of Finland's stance on climate action, highlighting its readiness to integrate CDR into mitigation strategies. They also shed light on the perceived opportunities and barriers associated with different CDR approaches, as seen through the lens of diverse stakeholders.

Stakeholder type	Stakeholders interviewed
Public entities and administrations	Ministry of the Environment
	Ministry of Agriculture and Forestry
	Ministry of Economic Affairs and Employment
	Prime Minister's Office / Sustainability Panel
Academy and research centres	Technical Research Centre – VTT
	Natural Resources Institute Finland – LUKE
	Geological Survey of Finland – GTK
Industry and private sector organisations	The Central Union of Agricultural Producers and Forest Owners - MTK
	Technology industries of Finland
	Nordea
	Bioenergy Association
	Forest industries
	New Sustainability Company
NGOs and civil society	WWF
	Carbon Sink Finland ry

Table 7. List of stakeholders interviewed.

168 Metsähallitus 2024. Saamelaisten kotiseutualueen luonnonvarasuunnitelma 2022–2027. https://www.metsa.fi/maat-ja-vedet/alueiden-kayton-suunnittelu/toiminta-saamelaisten-kotiseutualueella/()()

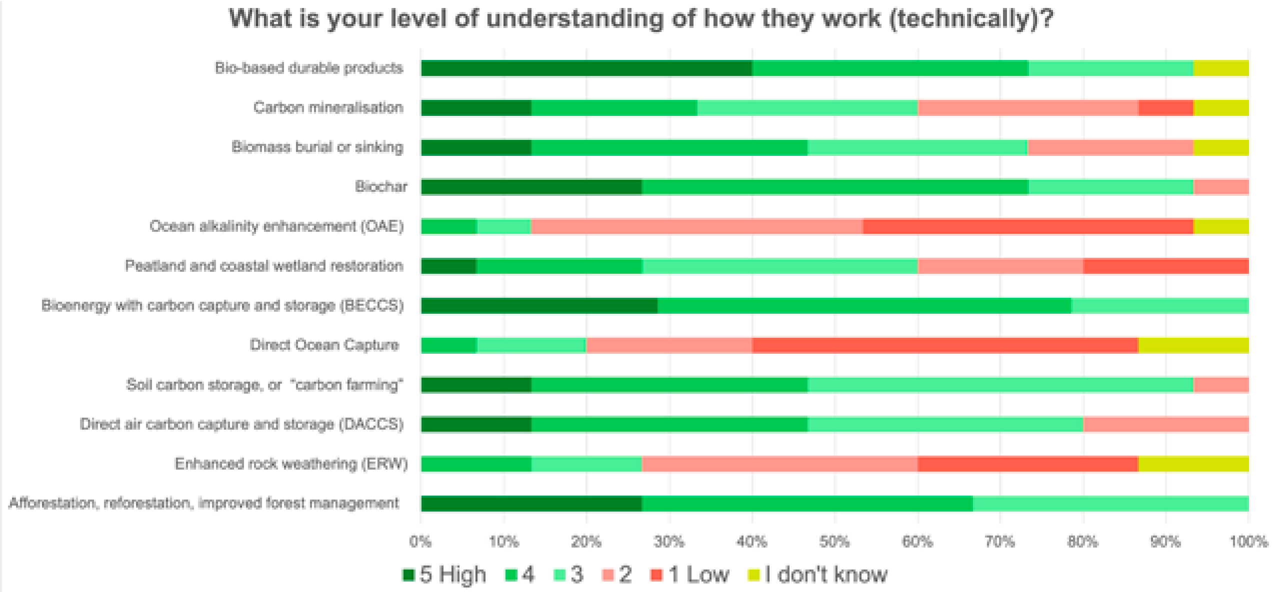

Figure 26. What is the level of understanding of how the various CDR methods work (n=17).

The key insights from the interviews are summarised below. A detailed breakdown by stakeholder category is provided in Annex C.

6.2.1 Awareness and knowledge of CDR and its various methods

The level of awareness and knowledge of CDR methods varies among stakeholders. Ministries and knowledge institutions generally have a strong understanding of various CDR methods, particularly BECCS, biochar, and nature-based solutions such as afforestation, reforestation, and peatland restoration. Civil society organisations are well-versed in nature-based solutions, such as forest and peatland restoration, but are less familiar with technologically complex methods. Industry organisations and the private sector also demonstrate a solid understanding of BECCS and other technical removals, as well as nature-based solutions. Generally, the techniques relating to oceans and minerals were the least known methods.

6.2.2 Awareness and views on Finland's existing climate policy

Interviews revealed that **stakeholders across all groups are well aware of Finland's ambitious goal to achieve carbon neutrality by 2035**. They acknowledged progress in renewable energy and energy efficiency, but consistently highlighted a gap between the ambition of the target and the current pace of implementation. There was broad agreement that more substantial financial and regulatory support is needed—particularly for emissions reduction initiatives and emerging CDR technologies. Many emphasised the heavy reliance on forest carbon sinks, which recent recalculations show are insufficient to meet the target. Even if other sectors outside LULUCF meet their specific goals, stakeholders expressed doubt that the overall neutrality target can be achieved without significant adjustments.

Ministries emphasise the need for comprehensive policy frameworks, while civil society highlights the importance of industry actors adopting sustainable practices when developing climate solutions, warning against unintended consequences, such as biodiversity loss. Meanwhile, knowledge institutions and industry organisations advocate for stronger technological and economic investments to support Finland's ambitious climate targets and ensure long-term viability.

Stakeholders generally believe that the current role of CDR in Finnish climate policy is emerging but not yet prominent. They recognise that Finland has historically focused on emission reduction strategies, renewable energy adoption, and energy efficiency as primary tools to combat climate change. While CDR is increasingly seen as essential, it is relatively new in the context of Finland's climate policy and has not been a central component until recently.

Ministries and knowledge institutions acknowledge that Finland is beginning to integrate CDR into

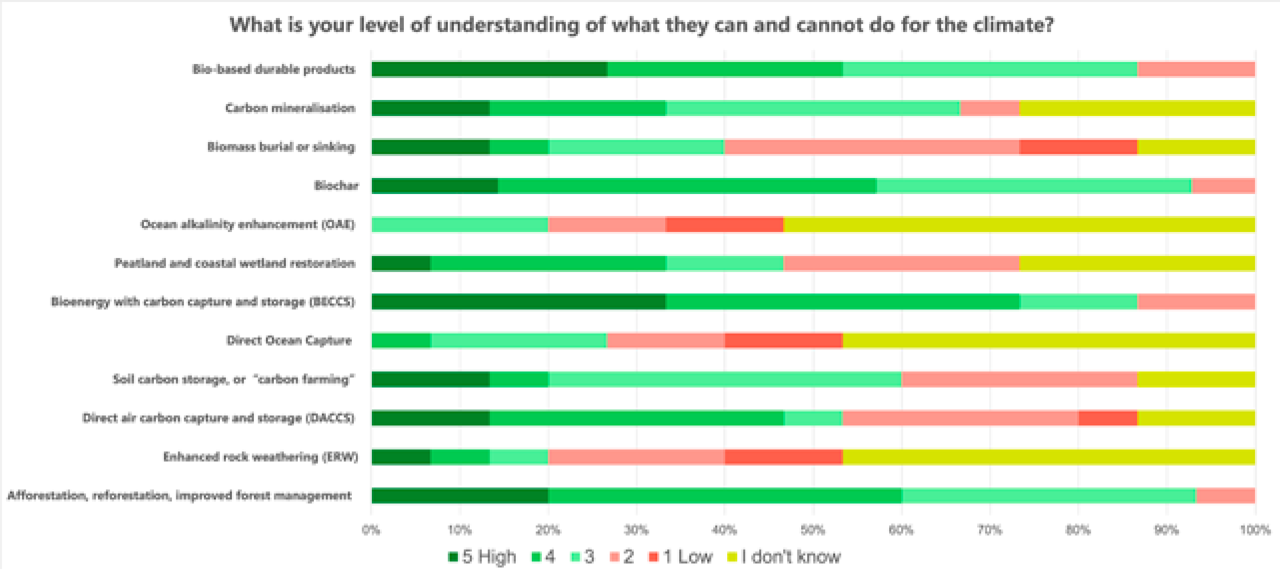

Figure 27. What is your understanding of how effective the methods are in climate change mitigation (n=17).

national strategies, but it is still in the early stages of development and deployment. Civil society emphasises the need for more robust policy frameworks and comprehensive support to elevate the prominence of CDR. Industry organisations and the private sector recognise the potential economic benefits of CDR, but note that the current reliance is more on traditional methods rather than CDR technologies.

Overall, stakeholders suggest that while Finland is starting to recognise the importance of CDR, it has yet to become a significant focus within the climate policy. There is a consensus that more emphasis, investment, and policy support are required to fully integrate and scale up CDR as a critical component of Finland's approach to achieving carbon neutrality.

6.2.3 Views on the deployment of CDR in Finland

Stakeholders generally view CDR positively as a necessary tool to combat climate change. There is strong support for deploying well-understood and proven methods, such as biochar, BECCS, afforestation, and reforestation. Ministries and knowledge institutions emphasise the need for technological advancements and policy support to enhance scalability and effectiveness. Civil society advocates for comprehensive policy frameworks and stakeholder engagement to ensure successful deployment. Industry organisations and the private sector stress the importance of economic viability and financial measures to facilitate CDR projects. Concerns about feasibility, cost, and ecological impacts are more pronounced regarding less familiar methods like direct air capture and marine chemical balance manipulation.

6.2.4 Conclusion on the stakeholder interviews

Based on stakeholder interviews, the **preferred CDR methods** for scaling up in Finland include **BECCS, biochar, afforestation and reforestation, enhanced rock weathering, soil carbon storage/ carbon farming, and peatland and coastal wetland restoration**. These methods are preferred for their practicality, environmental benefits, scalability, and alignment with Finland's existing expertise and sustainability goals. Conversely, methods like **direct air capture and marine chemical balance manipulation are less preferred** due to high costs, energy requirements, technical challenges, and potential ecological impacts. Lack of geological storage complicates the discussion.

Further analysis from the interviews per interviewed group and by the discussed method can be found in Annex C.

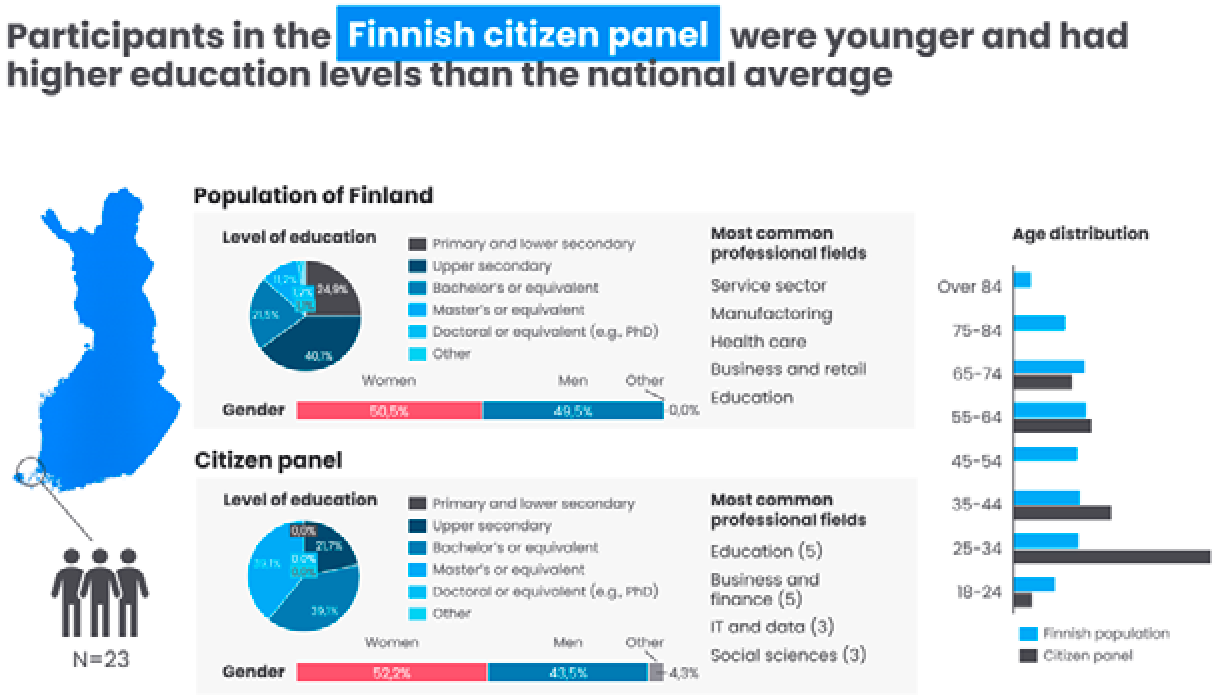

Figure 28. Finnish Citizen panel participants as a sample vs. Finnish overall populations.

6.3 Citizen panel

The Finnish citizen panel was hosted in May 2025 in the Turku region. 23[169] participants of varying backgrounds participated in the discussion (see Figure 28).

The citizen panel results aligned closely with findings from the stakeholder interviews and served as a valuable foundation for further analysis of Finland's realistic potential for CDR. However, the composition of the Finnish **citizen panel did not reflect a representative sample of the broader population** and therefore cannot be considered indicative of national sentiment. A more comprehensive overview of public attitudes toward climate change and climate action is provided in Chapter 5. The citizen panel should be viewed as a single qualitative data point from a group discussion, with the important caveat that its results are not statistically significant.

Prior to the panel, participants received one-page summaries outlining each CDR method, including their advantages, drawbacks, and the broader context of CDR, its definition and relevance. This material was provided both in written form and through a webinar, available live and on demand. Participants completed a pre-panel survey capturing their initial views on the methods; the graphs presented in this section are based on those responses. The three-hour live panel consisted of discussions in small groups, followed by a plenary session. Citizen panel participants were encouraged to share their perspectives openly and request additional information as needed.

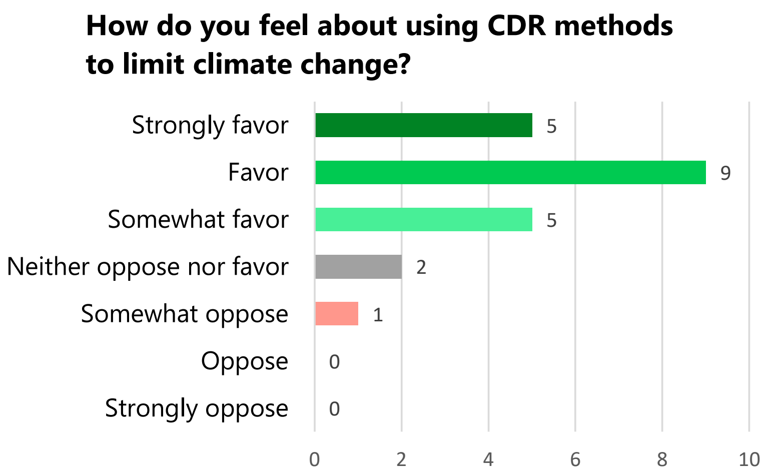

Figure 29. Answers of the citizen panel participants in the pre-survey question "How do you feel about using CDR methods to limit climate change?" Number of responses on the x-axis.

169 One participant cancelled on the day of panel, resulting in a final total of 22 participants.

The dialogue was structured method-by-method, beginning with perceived benefits and concerns, and culminating in a synthesis of preferred CDR approaches for Finland.

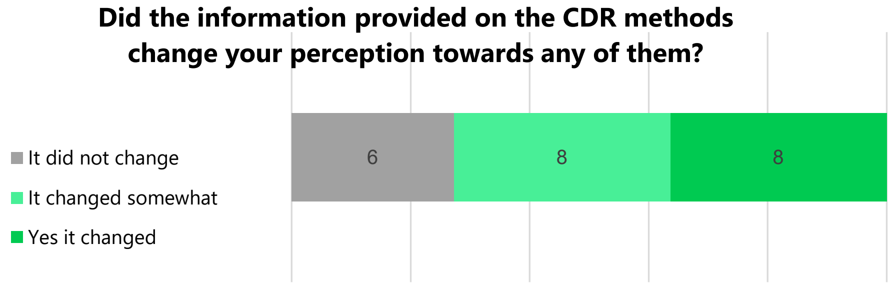

Figure 31. Answers of the citizen panel participants in the pre-survey question "Did the information provided on the CDR methods change your perception towards any of them?" Number of responses.

6.3.1 Awareness and views of stakeholders on the existing climate policy and CDR methods

The majority of Finnish citizen panel participants viewed CDR positively in the context of climate action (see Figure 29). However, many acknowledged - both in the pre-panel survey and early discussions, some even beforehand - that their understanding of CDR and its individual methods was limited. One participant captured a sentiment echoed within their small group, stating:

> ***"Generally open to all methods, since all avenues should at least be further assessed how well they fit into Finland – I'm here to learn more, and if I learn something concerning any of the methods, I'll let you know!"***
>
> *Participant in the Finnish citizen panel – paraphrased.*

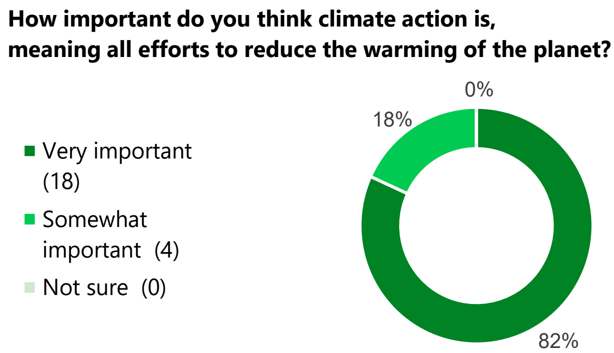

Figure 30. Answers of the citizen panel participants in the pre-survey question: "How important do you think climate action is, meaning all efforts to reduce the warming of the planet?" Number of responses in the brackets.

The group seemed to either be climate conscious or at least neutral about climate action (see Figure 30). No outright climate change deniers or even participants who would propose not investing resources and making regulations to fight climate change were in the group. This is one of the caveats of the citizen panel present in the discussion: the group was more favourable to climate action in general than the average Finnish population. One participant was more critical of Finland's efforts to mitigate climate change and cited comparisons to China's and India's emissions as doubts about the effectiveness of Finnish actions in making a change.

Some participants were more worried than others that CDR would be used as a scapegoat for emission reductions and highlighted throughout the panel that the first priority needs to be emission reductions, and that CDR cannot, in any case, be a reason not to do something that would hinder the transformation from a fossil-based society to a carbon neutral society. Most participants did not voice this as a concern, mostly due to their lack of understanding of how CDR and emission reductions are linked.

Throughout the panel, participants' views on individual CDR methods evolved, though shifts were typically a deepening of initial impressions rather than a reversal from positive to negative or vice versa. This trend likely stemmed from the limited starting knowledge reflected in the pre-survey. In small group discussions, participants with stronger opinions often influenced others, shaping the group's overall perception.

For example, enhanced rock weathering initially scored below average in the pre-survey, with many participants expressing unfamiliarity. However, as a few voiced positive impressions during the discussion, the group's overall stance shifted toward favourability. Similarly, biomass sinking and burial were perceived as suspicious - particularly around the idea of burying biomass - but after group dialogue, participants adopted a more neutral or even positive view.

> ***"The versatility of the methods was surprising, and the general image became more positive, for example, that it would also be possible to have a positive impact on nature."***
>
> ***"There were more methods than I expected, and most of them used natural or natural processes in some way."***
>
> ***"All in all, the methods were very unknown to me beforehand. Almost all the information was new."***
>
> *Participants in the Finnish citizen panel – paraphrased.*

6.3.3 Views on the deployment of CDR in Finland

Nature-based solutions were overall more favoured than technical solutions, and using carbon dioxide in some way was seen as more desirable than storing it (see also Figure 32 results from the pre-survey). Partly this was due to the citizen panel participants' lack of understanding of the technical solutions compared to natural ones, and partly linked to the citizen panel participants' strong desire to have other benefits from CDR than just climate benefits. The panellists also wanted to supplement their preferred selection of CDR methods with at least one technical method, and from those, BECCS seemed to be preferred over DACCS or DOCCS. This was also linked to the strong desire to link the CDR action to otherwise beneficial actions and panellist felt that since Finland has robust forest industry and biogenic CO_2 can be captured from pre-existing facilities, it would be more cost effective and possibilities for ecosystems are more prominent that in the other methods.

Biochar, carbon mineralisation, and carbon- and bio-based products were generally viewed as favourable CDR approaches, despite some reservations. Participants appreciated that these methods offer additional benefits beyond carbon removal, as they actively utilise captured carbon rather than simply storing it. Many saw this as a strength, particularly because these approaches can reduce emissions in other sectors—a point that resonated with those concerned about CDR diverting attention from broader emission reduction efforts

Across all groups, there was strong consensus on which measures should be excluded from their preferred mix of CDR methods. The most contested approaches were those involving ocean-based interventions and carbon storage or burial. Of these, biomass burial was ultimately viewed as neutral but

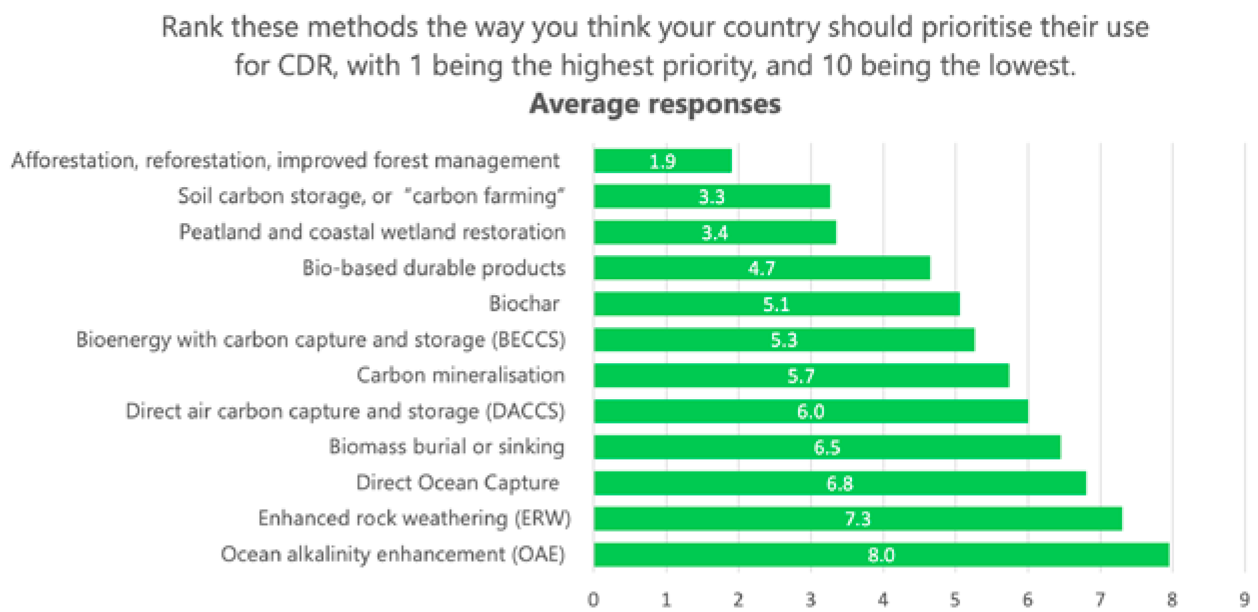

Figure 32. Preferred combination of CDR methods based on the responses of the citizen panel participants in the pre-survey.

unnecessary. In contrast, **biomass sinking, DOC, and ocean alkalinity enhancement were consistently identified as red lines by all groups**. DAC elicited mixed reactions—while some participants saw potential, it was ultimately overshadowed by BECCS, which was considered a more favourable alternative.

The reasons certain methods were deemed undesirable closely mirrored the criteria that made others appealing: a lack of co-benefits beyond carbon removal, potential risks to biodiversity, limited geological storage capacity in Finland, and lingering scepticism even after group discussions. One particularly salient issue for participants was Finland's absence of suitable geological storage. Many expressed discomfort with the idea of transporting CO_2 abroad, citing both the high cost of infrastructure and ethical concerns. For some, exporting carbon for storage felt akin to outsourcing waste—raising questions about responsibility and fairness in climate action.

> ***I don't like the idea of us dumping our waste to others - we should be able to deal with our own problems"***
>
> *Participant in the Finnish citizen panel – paraphrased.*

Read more in-depth analysis from the citizen panel in Annex D.

6.3.4 Conclusion on the citizen panel

While the Finnish citizen panel's findings cannot be considered a direct reflection of the entire population, the overall sentiment closely aligns with responses from the national climate barometer presented in Chapter 5. Participants generally favoured methods that were nature-based or offered additional societal, economic, or ecological benefits — as illustrated in Figure 31. In contrast, approaches perceived as solely focused on carbon removal, posing risks to biodiversity, being prohibitively expensive, or unfamiliar to the panelists received the most critical feedback.

As the panel progressed, participants grew increasingly confident in their understanding and opinions of various CDR methods. Initially, most expressed uncertainty and a lack of familiarity with the approaches discussed. However, by the end of the process, they were able to articulate clear preferences and rationales for the methods they found most favourable. Overall, panelists viewed CDR as a promising tool in the fight against climate change. They supported further research and policy development to ensure that all viable options are explored and that the most beneficial methods—regardless of their type—are ultimately implemented.

Most preferred methods

- Reforestation, afforestation, improved forest management
- Soil carbon sequestration
- Peatland, coastal, and wetland restoration
- BECCS
- Biochar
- Durable biobased materials
- Carbon mineralisation

Least preferred methods

- Direct ocean capture
- Ocean alkalinity enhancement
- Biomass sinking
- Direct air capture
- Enhanced rock weathering
- Biomass burial

Figure 33. Finnish citizen panel participants' most preferred and least preferred methods.

7. Finland's realistic potential to deploy CDR (Can do)

Building on the resource overview in chapter 3 and the theoretical CDR potential outlined in chapter 4, this chapter revises assumptions around resource availability and selected CDR methods to incorporate stakeholder perspectives, public sentiment, and the legal and socio-economic considerations discussed in chapters 5 and 6. Based on this integrated analysis, the study estimates the **realistic potential** – defined as the **volumes of CDR that can be deployed with high confidence in the foreseeable future**. Within this framework, multiple scenarios remain possible, largely shaped by Finland's level of ambition. This chapter explores those pathways in detail.

7.1. Background

To contextualise Finland's realistic CDR potential and the scenarios reflecting varying levels of CDR deployment ambition, this assessment draws on governmental research – specifically the PEIKKO[170] scenario calculations – evaluating Finland's progress toward its 2035 carbon neutrality target under current climate and energy policies.

The PEIKKO study outlines three distinct pathways for GHG emissions and energy balances under existing energy and climate policy frameworks: a baseline scenario with existing measures (WEM-Basic), and two alternative pathways - WEM-High and WEM-Low. The key distinctions between these scenarios stem from variations in the operating environment, economic growth trajectories, and the realisation of green investments. These factors significantly influence the pace and extent of decarbonisation, particularly within the agriculture and transport sectors.

According to the PEIKKO scenarios, Finland is not on track to meet its carbon neutrality target by 2035. In both the WEM-Basic and WEM-High scenarios, the estimated **emissions gap ranges from 16 to 19 MtCO_2e by 2035**, highlighting the need for additional mitigation measures, particularly CDR strategies. In contrast, the WEM-Low scenario, which assumes slower economic growth, results in stronger net carbon sinks within the land use sector, reducing the gap to just 2 MtCO_2e by 2035.

This chapter explores whether scaling up a portfolio of CDR methods could effectively close the emissions gap, enabling Finland not only to reach its carbon neutrality target but also to move toward net-negative emissions shortly thereafter. For planning purposes, the analysis focuses on the 16–19 Mt CO_2e gap identified in the WEM-Basic and WEM-High scenarios, whose assumptions are more closely aligned with current trends, particularly in land use dynamics.

7.2 Methodology for the realistic CDR potential

The calculation of the realistic CDR potential in Finland was carried out using the same methodology and approach as the theoretical potential presented in Chapter 4. However, it incorporates additional constraints, such as the regulatory and economic context, as well as public support. The assessment of public support is based on the views gathered through the stakeholder interviews and the citizen panel described in Chapter 6.

The estimated resource availability for CDR in the realistic potential is more conservative than in the theoretical assessment presented in Chapter 4. While the theoretical potential assumes that all available resources are allocated to CDR, the realistic potential accounts for competing demands and constraints, resulting in lower projected CDR volumes. These more cautious estimates are based on the following considerations:

- **Techno-economic feasibility**: in addition to physical constraints, resource use was evaluated in terms of what is reasonably feasible from a techno-economic perspective—particularly for resources that are contested among multiple CDR methods. However, macroeconomic variables such as GDP growth, cost levels, interest rates, and existing financial support mechanisms were not included as dynamic inputs.
- **Technological deployment**: the pace and scope of technology rollout were adjusted to reflect realistic expectations. For example, electricity production growth was modelled using a more realistic scenario than assumed for theoretical potential, and adoption rates for technologies such as BECCS and DACCS were estimated for 2035 and 2050 based on plausible deployment trajectories.
- **Legislative constraints**: legal limitations were incorporated where they clearly and significantly limit the availability of certain resources. The most notable example is serpentinite, which is suitable for in-situ mineralisation but excluded from the

170 The Prime Minister's Office 2024. Climate and energy scenarios. http://urn.fi/URN:ISBN:978-952-383-219-0

realistic potential due to current prohibitions under Finnish law.

- **Social acceptance** was assessed through public support, as determined by input from stakeholder interviews and the citizen panel. Social acceptance was treated as a limiting factor for certain methods, particularly DACCS and ocean-based approaches such as ocean alkalinity enhancement, which were excluded from the realistic potential.

As with the theoretical potential, a bottom-up approach was applied to most CDR methods. Exceptions include several land-use sector methods, for the same reasons outlined in section 4.1. For the realistic CDR potential, the land use sector potential was derived from Finland's national PEIKKO scenarios.[137]

7.3 Realistic CDR potential scenarios

Three scenarios are envisioned for the development of CDR in Finland: **two scenarios** are **focused on nature**, one where the harvesting levels (i.e. fellings) are higher (Scenario A1 FN-HF) and one where the harvesting levels are lower (Scenario A2 FN-LF) and **one scenario where technology is leveraged** (Scenario B LT-HF). All scenarios are modelled at two different points in time: the short term, which is 2035 and tied to Finland's climate target, and the long term, which is 2050 and tied to the EU's net-zero target.

Scenarios A1 FN-HF and A2 FN-LF showcases Finland's potential for CDR if mostly traditional methods that focus on natural solutions are deployed. These methods include pasture and cropland management, enhanced weathering, durable bio-based products, and various forms of forest management practices. **Scenario A is divided into two different scenarios** based on the harvesting levels to showcase the impact of forest use on CDR potential: **Scenario A1 with higher felling levels and Scenario A2 with lower felling levels**. In scenario A1, the harvesting levels are assumed to be 81.9 Mm3 (2035)[144] and 81.4 Mm3 (2050).[144] In scenario A2, the harvesting levels are assumed to be 70 Mm^3 (2035)[144] and 69.5 Mm^3 (2050).[144] In 2024, a total of **73.7 Mm^3 of stem wood was harvested in Finland**, 85% of which was industrial roundwood and 15% energy wood. The total amount felled was 1% higher than in the previous year. The volume of total drain increased by 1% to 89.6 Mm^3.[171]

Scenario B outlines an alternative pathway where both traditional methods and novel technical CDR methods are deployed. **In addition to the methods deployed in Scenarios A1 and A2, this scenario incorporates biochar, BECCS, and DACCS**. To reflect a higher level of ambition while maintaining realism, **Scenario B assumes the same harvesting levels as Scenario A1**, i.e., the growth of harvesting levels is expected to continue in the future as well. However, carbon recovery is enhanced through the deployment of BECCS and biochar, and the inclusion of side streams from the mining industry further contributes to the overall CDR potential.

The scenarios were designed to align with the core principles of Finland's climate strategies, highlighting the pivotal role of the land use sector in both national emissions and the pursuit of climate targets, while also accounting for the strength and influence of the country's forest industry.

7.3.1 Scenario A1 and A2: Focus on nature

In scenario A the total CDR potential is **~4 $MtCO_2$** with a higher forest harvesting level (A1 FN-HF) and **~22 $MtCO_2$** with a lower forest harvesting level (A2 FN-LF) in 2035.

In 2050, the total CDR potential is **~13 $MtCO_2$** with a higher forest harvesting level (A1 FN-HF), and **~37 $MtCO_2$** with a lower forest harvesting level (A2 FN-LF). The carbon removal capacities for each method are summarised in Figure 34.

Forest harvesting levels - and consequently, **CDR methods tied to land use management**[172] **- play a decisive role in determining Finland's total CDR potential**, as shown in Figure 32. As described in Chapter 3, under higher harvesting levels, the land use sector continues to be a net source of emissions by 2035. In contrast, lower harvesting levels enable the sector to remove up to ~18 $MtCO_2$ annually by that year. Looking ahead to 2050, land use management contributes to annual removals of ~8 $MtCO_2$ in Scenario A1 and ~32 $MtCO_2$ in Scenario A2 FN-LF, depending on the intensity of forest harvesting.

Other important CDR methods include **pasture and cropland management**, which account for approximately 3 $MtCO_2$ in each scenario, both in 2035 and 2050. **Durable bio-based products** sequester around 0.5 $MtCO_2$ in 2035 and 1 $MtCO_2$ in 2050.

171 Natural Resources Institute Finland 2025. Total roundwood removals and drain by region 2024. https://www.luke.fi/en/statistics/total-roundwood-removals-and-drain/total-roundwood-removals-and-drain-by-region-2024

172 Land use management refers to all land use sector methods used in the PEIKKO scenarios that were calculated outside the optimisation tool used in this report, which follows Carbon Gap's CDR taxonomy. The PEIKKO scenarios include methods for forest management, forest harvesting levels, afforestation, cropland and pasture management in peatlands and wetland restoration. For further details, see Annex E.

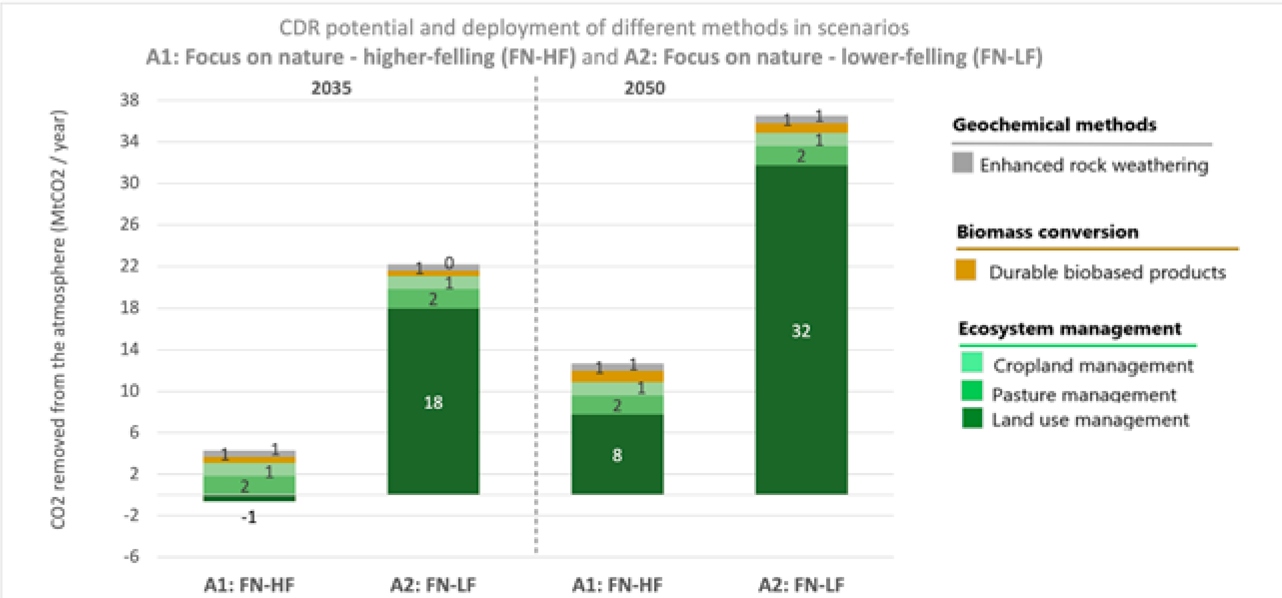

Figure 34. CDR realistic potential of different methods in scenario A1 and A2. Land use management covers most of the potential in both scenarios. The potential to increase CDR with nature-based methods is multiplied in 2050 compared to 2035, as the methods require more time to have an impact. Negative values in this graph represent GHG emissions, indicating that the natural sink operates as a source under scenario A1 in 2035.

Enhanced rock weathering is also deployed with 0.7-0.8 $MtCO_2$ per year. Limestone's critical role in the Finnish industrial sector constrains the availability of minerals suitable for carbon sequestration, thereby limiting the potential for CDR.

Methods irrelevant for Finland due to technical, regulatory, or social restrictions were ocean alkalinity enhancement and coastal revegetation. As scenario A focuses only on nature-based CDR methods, none of the technical methods were considered. Details of the assumptions and limiting factors are presented in Annex A.

Scenario A1 FN-HF, with high harvesting levels, can be considered realistic. It is, however, based on deploying various forest management practices, like fertilisation, increase of retention trees, and continuous-cover forestry, which might be challenging considering the dominance of privately owned forests. Additionally, while enhanced rock weathering plays a key role in this scenario, it is not currently deployed on a large scale in Finland. Overall, considering the structure of Finland's industry sector and the availability of biogenic CO_2, **scenario A1 FN-HF is more realistic than scenario A2 FN-LF**, which would require changes in Finland's industrial profile and new regulations for privately owned forests that would limit the sale of wood to forest industries. This would have a negative economic impact not only on industry actors but also directly on individuals and other private forest owners, such as municipalities and church congregations, and

thus cause a significant political hurdle.

7.3.2 Scenario B: Leveraging technology

In Scenario B (LT-HF), technological CDR methods were deployed alongside nature-based methods. The scenario only includes the **higher forest harvesting level** to investigate if the carbon neutrality targets are plausible via the additional CDR methods, regardless of the land use sector remaining as an emission source. In this scenario, the CDR potential is **~14 $MtCO_2$ in 2035** and **~28 $MtCO_2$ in 2050**. The employed methods and their carbon removal capacities are summarised in Figure 35.

Similar to Scenarios A1 and A2, **pasture and cropland management** are deployed to remove approximately ~3 $MtCO_2$ per year in total for both 2035 and 2050. **Enhanced rock weathering** removes approximately 0.7 $MtCO_2$ per year in both 2035 and 2050. Carbon sequestration via **durable bio-based products** remains consistent, removing about 0.5 $MtCO_2$ per year in 2035 and 1 $MtCO_2$ per year in 2050. Based on the PEIKKO scenarios, **land use management** remains an emission source in 2035, yet land use management methods are expected to improve towards 2050 to remove ~7 $MtCO_2$ in total. The land

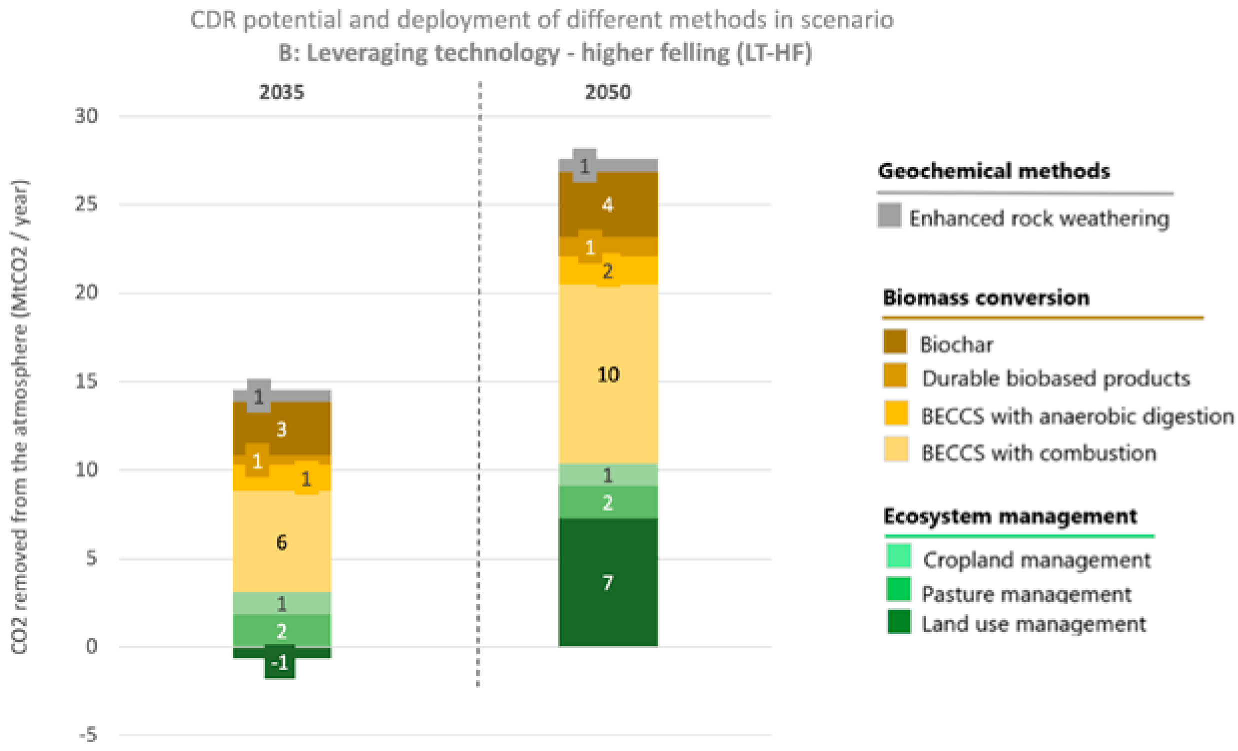

Figure 35. CDR potential of different methods in scenario B. Land use management loses significance as technical CDR methods are included in the calculation. Negative values in this graph represent GHG emissions, indicating that the natural sink operates as a source under scenario B in 2035.

management results[173] are presented more granularly, using IPCC land classification, in Table 8.

The land use sector calculations in scenario A1 are based on the PEIKKO WEM-L scenario with harvesting volumes like in WEM-P and A2 on PEIKKO WEM-L scenario[137]. The measures and harvesting volumes from Scenario B are based on the WEM-P scenario. The land use sector measures for all WEM scenarios are listed in Annex E.[174]

In addition to nature-based methods, biomass is allocated to technical CDR methods, including biochar and BECCS, with both anaerobic digestion and combustion. **BECCS** is especially promising when combined **with combustion** power plants, given the high availability of biogenic CO_2 point sources in Finland, resulting in a CDR potential of ~6 $MtCO_2$ per year in 2035 and **10 $MtCO_2$ per year** in 2050. All of the wood allocated to combustion with BECCS is wood that is already intended for energy use in existing or upcoming bioenergy facilities. Therefore, BECCS would be materialised primarily through retrofitting existing bioenergy facilities. Existing or planned bioenergy facilities present abundant potential for BECCS considering CO_2 storage limitations, and BECCS is unlikely to become a driver for further wood demand.

Share of **BECCS with anaerobic digestion** is also notable, with a CDR potential of 1.5 $MtCO_2$ per year in 2035 and **1.6 $MtCO_2$ per year in 2050**. Although there is an increasing amount of biogas production and anaerobic digestion capacity that could be retrofitted for BECCS, realising the total CDR potential would require a significant amount of greenfield facilities for the biomass fractions that are currently unused. Despite being less compatible with existing uses of biomass compared to BECCS, **biochar** presents even higher potential – estimated at ~3 $MtCO_2$ per year in 2035 and ~4 $MtCO_2$ per year in 2050.

Geological storage capacity creates the most significant limitation for BECCS and DACCS in the realistic potential estimate. **Even if the harvesting levels are reduced from the business-as-usual level assumed in Scenario B, Finland would still have plenty of wood-based biomass**, e.g., for

173 Cropland and pasture management are separated from the other land management methods due to different sources and calculation methods. Land management CDR potential is based on the PEIKKO scenarios.

174 Koljonen et. al. 2021. Hiilineutraali Suomi 2035 – ilmasto- ja energiapolitiikan toimet ja vaikutukset https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163638/VNTEAS_2021_62.pdf?sequence=1&isAllowed=y

Scenario	A1		A2		B	
Description:	Significant efforts in LULUCF sector for CDR		Significant efforts in LULUCF sector for CDR, low harvesting level		Significant efforts in enabling technical CDR	
Year	**2035**	**2050**	**2035**	**2050**	**2035**	**2050**
Forest land	-8.28	-16.4	-26.9	-40.39	-8.28	-16.4
Cropland	5.94	5.91	5.94	5.91	6.03	6.45
Grassland	0.71	0.66	0.71	0.66	0.71	0.66
Wetland	1.25	1.23	1.25	1.23	1.18	1.16
Settlement	1.01	0.82	1.01	0.82	1.01	0.84
net SUM, Mt-CO2e/year	**0.63**	**-7.78**	**-17.99**	**-31.77**	**0.65**	**-7.29**

Table 8. Land management results across scenarios. Negative values indicate removals and positive values indicate emissions.

BECCS. In Scenario B, 10-30% of potentially available biomass resources for CDR are unused due to storage limitations, which indicates that BECCS could be deployed widely even if forest biomass availability was reduced. If the harvest levels were decreased to those in the low-felling-scenario A2, there would still continue to be enough biomass and storage would remain the limiting factor (12.1 Mt CO_2 BECCS potential in 2035 and 2050 compared to 7 and 11.7 Mt CO_2 storage capacity respectively).

In addition to BECCS, **DACCS was also included in the calculation**, but the available storage capacity ran out without even accounting for the full capacity of BECCS. Allocation of geologic CO_2 storage was prioritised for BECCS over DACCS, as it is more energy efficient to capture CO_2 from flue gases than from air. Thus, DACCS is not utilised to its full potential. Still, if in situ mineralisation or significantly increased international storage capacity becomes available for Finland, then there would be more potential in DACCS. (In theoretical potential calculations, it is estimated that Finland could deploy 19 Mt CO_2 annually by 2050). **In the event of significant pressure to decrease harvesting, DACCS could serve as a secondary method in scenario B, utilising the storage capacity that would not be used in BECCS**.

SENSITIVITY ANALYSIS: Could Finland implement DACCS?

In this report, BECCS is prioritised over DACCS as the primary technological CDR method due to the abundant availability of biogenic CO_2, its energy efficiency, Finland's political priorities and lack of geological storage being the main reasons for the prioritisation. While the rationale for prioritising BECCS is clear, we explored whether deploying DACCS could be realistic if half of Finland's available storage capacity was allocated to it.

The effect of allocating half of the geological storage to DACCS was evaluated as a sensitivity analysis. This means that 50% less BECCS would be implemented compared to the baseline Scenario B. About 35-50% (or 6-8 dry Mt of woody biomass per year) of the available biomass would be left unused for CDR compared to 10-30% in the baseline Scenario B results. However, **lower implementation of BECCS is unlikely to lead to lower forest harvests as energy and material use are the main drivers for harvesting levels in Finland**. To implement DACCS, 0.3-3 TWh/year and 0.5-4.5 TWh/year (1 to 4 % of the total availability) of electricity would be needed in 2035 and 2050, depending on the DACCS method. In conclusion, **availability of electricity is not a limiting factor for implementing DACCS even if the storage capacity was increased significantly**.

Finland has a good availability of biogenic CO_2 emissions, a significant manufacturing industry with established value chains, and technological expertise, making the inclusion of technical methods in CDR methods justified. However, realising the calculated BECCS and biochar potential, especially by 2035, would require significant industrial investment decisions in the short term – such as financial support mechanisms and a clarification of the value creation opportunities in the markets for permanent carbon removals. The realisation of Finland's BECCS potential may also be limited by biogenic CO_2 primarily being directed towards usage (BECCU). Since the scenario is based on the same assumptions as scenario A1 for nature-based methods, the challenge to deploy those, especially related to forestry, is the high level of private ownership of forests in Finland.

7.4 Resource allocation

Finland has **good availability of** resources necessary for CDR, particularly **biomass and renewable electricity**, which are essential for technical methods such as DACCS, BECCS, and biochar. However, the **limited capacity for geological CO_2 storage** appears to be the main constraint on the country's overall CDR potential. As a result, Finland's CDR potential is mostly driven by the availability of biomass, forests, and the rest of the land-use sector. The key assumptions regarding the allocation of resources in Scenarios A and B (energy, mineral feedstock, and storage resources) are presented in Table 9. For biomass, the assumptions are presented in section 7.4.4 and Annex A, and for the land-use sector in Annese E. The more detailed description and background for different resources can be found in Chapter 3.

In the resource allocation, arable land includes all mineral agricultural land, and it can be used for cropland, pasture management, or agroforestry. Agricultural peatland was excluded due to limited data. Non-arable land was not used in the resource allocations and optimisation, as the land area was not considered a restrictive resource for the DACCS methods. Unspecified land refers to the land available for afforestation and reforestation.

In the realistic CDR potential scenarios, carbon removal in Finland is expected to rely predominantly on approaches based on biomass and the land-use sector. This dependency is particularly evident in the influence that harvesting volumes have on the overall removal potential, which will be discussed in more detail in section 7.4.4. The scenarios assume full

Resource	Amount available for CDR (2035)	Amount available for CDR (2050)	Key assumptions
Electricity	59 TWh	114 TWh	All surplus electricity was included in the balance. Additionally, 30 MW from the CCU consumption scenario estimate was reallocated to CDR.
Thermal energy	18 TWh	27 TWh	50-75% of techno-economically feasible waste heat was assumed to be available for CDR.
Mineral feedstock	1.4 Mt	1.8 Mt	Minerals with low domestic industrial relevance or primarily exported are considered available for CDR. For limestone, only exported amounts were allocated to CDR due to its importance to Finnish industry.
Storage capacity	7.2 MtCO2	11.7 MtCO2	For mine tailings and CO_2-cured concrete, 50-100% of the reported potential was considered available. For geological storage (achieved through export), 60-100% of unreserved capacity (i.e. storage sites not currently fully booked) was used.

Table 9. Key assumptions in allocating energy, mineral feedstocks, and storage capacities.

	2035	2035	2035	2050	2050	2050
Resources	**A1**	**A2**	**B**	**A1**	**A2**	**B**
Mineral feedstock						
Wollastonite	100 %	100 %	100 %	100 %	100 %	100 %
Limestone, talc, magnesite and dolomite	100 %	100 %	100 %	100 %	100 %	100 %
Biomass	**13 %**	**11 %**	**66 %**	**22 %**	**20 %**	**88 %**
Land						
Arable land	100 %	100 %	100 %	100 %	100 %	100 %
Unspecified land (afforesta-tion, reforestation)	100 %	100 %	100 %	100 %	100 %	100 %
Energy						
Electrical energy	0 %	0 %	0 %	0 %	0 %	0 %
Thermal energy	0 %	0 %	0 %	0 %	0 %	0 %
CO2 storage						
Domestic storage	100 %	100 %	100 %	100 %	100 %	100 %
Exports	100 %	100 %	100 %	100 %	100 %	100 %
Water[174]	-	-	-	-	-	-

Table 10. Proportion of resources consumed for CDR across scenarios. All resources available for CDR are used at their maximum except biomass, which is constrained by limited CO_2 storage capacity. No additional energy is consumed by the CDR methods; the energy penalty for BECCS is already reflected in fuel consumption.

utilisation of the land areas considered realistically available for carbon removal, along with minerals suitable for enhanced rock weathering, such as wollastonite and limestone.

In the theoretical potential estimate, and one of the realistic potential estimates (Scenario B), **biomass is used for BECCS as much as storage capacity allows**. As shown in Table 10, biomass availability exceeds CO_2 storage capacity by a significant margin, making storage the primary limiting factor - even if biomass availability were substantially lower. In contrast, scenarios A1 and A2 show low biomass utilisation due to the exclusion of BECCS as a CDR method. Among the considered approaches, durable bio-based products are the only method that results in a large volume of unused potential.

By contrast, **abundant energy resources are not consumed in these scenarios**, since energy-intensive methods like DACCS cannot be effectively deployed due to limited storage capacity. For BECCS, the impacts of electricity and heat requirements on plant efficiency and fuel use are accounted for implicitly in the biomass consumption figures in Table 12. Consequently, the availability of energy does not constrain Finland's overall carbon removal potential.

7.4.1 Allocation of energy resources

The assessment of energy availability was based on a 2024 scenario published by the Finnish Energy Industry, which describes the projected development of Finland's electricity generation and is presented in more detail in Chapter 3. Electricity availability was assumed to correspond to the surplus electricity in the balance, amounting to 29 TWh in 2035 and 84 TWh in 2050. In the scenarios, the electricity demand of CCU methods was estimated at several tens of megawatts, and even in the realistic scenarios, 30 TWh of this demand was assumed to be reallocated from CCU methods to CDR methods.

In the realistic scenarios, thermal energy availability for CDR was assumed to be limited to waste heat, since Finland's highly integrated and flexible energy system enables heat production to be optimised to meet consumption without additional energy use. Of the estimated 35 TWh of technically and economically utilisable annual waste heat, 50% is assumed to be available for CDR methods by 2035, increasing to 75% by 2050.

The results indicate that **neither electricity nor heat constitutes a limiting factor for CDR potential**.

175 Water is not considered as a resource since it is not a limiting factor nor is it utilised in the methods considered in the realistic scenarios. More insights on water as a resource for CDR are in chapter 3.

Instead, as mentioned above, a broader deployment of electricity- and heat-consuming CDR methods would require significant expansion of the available CO_2 storage capacity.

7.4.2 Allocation of mineral feedstocks

In the realistic scenarios, **minerals are used for both enhanced rock weathering and for CO_2 storage** - particularly through binding in mining residues and CO_2-based concrete. The quantities of wollastonite and limestone suitable for enhanced rock weathering were assessed to be lower than in the theoretical potential, at 0.007–0.008 Mt and 0.8–0.9 Mt in 2035 and 2050, respectively. These volumes were fully utilised across all scenarios. Other mineral resources, including dolomite, talc, and magnesite, were estimated at ~0.6 Mt in total in both 2035 and 2050. As such, the **limited availability of suitable minerals represents a constraint on the overall CDR potential**.

7.4.3 Allocation of CO_2 storage resources

Clearly, **the most significant limiting factor in the realistic scenarios is CO_2 storage capacity**. This includes both the export of CO_2 to foreign geological storage sites and domestic carbon binding in mining residues and CO_2-based concrete. **Foreign CO_2 storage** – accounting for most of the total capacity - **is assumed to be 6 Mt in 2035 and 10 Mt in 2050** based on scenarios presented in sections 3.6 and 3.7. **Domestic carbon binding potential** in mining residues and concrete was estimated at ~1 Mt in 2035, rising to **~1.5 Mt by 2050**. In all scenarios for Finland's realistic CDR potential, the available storage capacity is fully allocated to CO_2 captured via BECCS, leaving no capacity to serve other CDR methods relying on CO_2 storage, like DACCS. Currently, the government of Finland has Memoranda of Understanding to export CO_2 to Norway[176] and Denmark.[177]

7.4.4 Allocation of biomass resources

For the realistic CDR potential, the availability of biomass resources was estimated to be lower than in the theoretical scenario due to competing uses and practical and financial feasibility constraints.

This section is structured by looking at realistic availability of non-forest biomass (Table 11) and forest biomass (Table 12). Annex A lists more detailed assumptions on how resource projections were made.

For Scenarios A1 and A2 (with an emphasis on nature-based methods), **bio-based products were considered the only CDR method for biomass**. Therefore, only feedstocks suitable for bio-based products were included in these scenarios, and all other feedstocks were disregarded for CDR. As a result, about 10-22% of the biomass resources assumed available in these scenarios are used for CDR in Scenario A1 and A2.

In Scenario B, all the included CDR methods using biomass were considered. This means that all biomass feedstocks – forest and non-forest biomass – were considered. Similarly to the theoretical scenario, geological storage was prioritised for BECCS over DACCS. Regardless, geological storage became the limiting resource for BECCS deployment, and **about 7 $MtCO_2e$ (2035) and 3 $MtCO_2e$ (2050) more CDR could have been deployed through BECCS if geological storage was not a limiting factor**. As a result, about 70-90% of the biomass resources assumed to be available are consumed for CDR in Scenario B.

For forest biomass, two different harvest levels were used to illustrate the overall impact of harvest amounts and land use emissions on CDR potential. For Scenario A (with nature-based methods), both a higher harvest amount (A1) and a lower harvest amount (A2) were calculated. For Scenario B, only a higher harvest amount was used. The amounts of wood raw material and their allocation to CDR methods are shown in Table 12, and more detailed assumptions on projections are listed in Annex A. Note that for Scenarios A1 and A2, products were considered the only CDR method for biomass, and the resources allocated to other methods were disregarded.

For saw milling and pulp wood that have existing uses, a portion of the exported quantities was assumed available for CDR as products and biochar. This would require transitioning current production to new products. However, it is already a goal of the Finnish forest industry to move towards higher-value products; therefore, directing a portion of exports to CDR was considered realistic.

176 Ministry of the Environment. 2025. https://ym.fi/-/suomi-ja-norja-vahvistavat-yhteistyota-hiilidioksidin-talteenotossa-kuljettamisessa-ja-varastoinnissa?languageId=en_US

177 The Ministry of The Environment. 2025. https://ym.fi/en/-/finland-and-denmark-agree-on-framework-for-co2-transport-and-storage

Type of biomass	Total projected amount (2035)	Amount available for CDR (2035)	Total projected amount (2050)	Amount available for CDR (2050)	Allocation to CDR methods	Key assumptions
Biowaste	168,894[178]	168,894	206,313	206,313	BECCS with AD (anaerobic digestion)	
Mixed waste	322,963[147]	322,963	253,618	253,618	BECCS with combustion	After excluding volumes for priority use, incinerated amounts assumed available for CDR.
Municipal wood waste	76,470[147]	76,470	89,215	26,764		
Industrial wood waste	2,691,824[148]	807,547	3,140,461	942,138		
Animal and plant matter	442,200[148]	198,990	442,200	176,880	BECCS with AD	
Sludge	19,614[179]	13,730	17,435	12,204		Assumed 80% practical availability
Cereal straw	2,025,246[148]	648,079	2,227,770	712,886	Suitable for several methods but allocated to biochar due to limited storage	After excluding volumes for priority use, assumed 80% of theoretical maximum available for CDR.
Stems from peas and broad beans	51,254[148]	20,502	51,254	20,502	BECCS with AD	
Potato tops	27,170[148]	10,868	27,170	10,868		
Sugar beet tops	6,057[148]	2,423	6,057	2,423		
Potential additional harvest of green manuring sward	117,274[148]	93,819	131,933	105,547		
Straw of herbage seed crops	35,231[148]	14,092	39,635	15,854	Suitable for several methods but allocated to biochar due to limited storage	
Fallow	1,027,033[180]	40,722[148]	1,027,033	40,722	BECCS with AD	
Biomass of buffer zone vegetation	31,579[148]	25,263	20,690	16,552		
Stems of oils crops	26,608[148]	10,643	26,608	10,643		
Grasses	3,660,847[148]	1,301,040	4,151,476	1,490,775		
Manure	1,359,210[148]	543 684	1,420,992	568,397		
Common reed	304,000[181]	15,200	304,000	15,200	Suitable for several methods but allocated to biochar due to limited storage	Realistic harvesting amount[150]

*Table 11. Amounts of **non-forest biomass** resources available for realistic CDR potential. Figures in dry tons.*

178 Projection based on data from Statistics Finland. 2023. Municipal waste by treatment method in Finland by Year, Jätejae and Information

179 Projection based on data from Natural Resources Institute Finland. 2025. Biomass Atlas. https://biomassa-atlas.luke.fi/?lang=en

180 Marttinen;Luostarinen;Winquist;& Timonen 2015. Rural biogas: feasibility and role in Finnish energy system

181 Hyvärinen et al. 2017. Uutta liiketoimintaa vesistöjen ravinteista. National Resources Institute Finland

more comprehensive analysis of these methods is presented in Annex F.

Type of wood	Total projected amount (2035)	Amount available for CDR (2035)	Total projected amount (2050)	Amount available for CDR (2050)	Allocation to CDR methods	Key assumptions
Wood for saw milling and plywood	High harvest: 13,936, 000[182]	High: 1,393,600	High: 13,936,000[151]	High: 2,787,200	Products	Assumed 20% (2035) and 40% (2050) of exports could be directed to products.
	Low harvest: 12,480,000[151]	Low: 1,248,000	Low: 12,396,800[151]	Low: 2,479,360		
Side stream wood from saw milling industry	High: 6,968,000	High: 3,484,000	High: 6,968,000	High: 3,484,000	BECCS with combustion 80% Biochar 20%	Assumed 50% available and feasible for CDR.
	Low: 6,240,000	Low: 4,992,000	Low: 6,198,400	Low: 4,958,720		
Wood used for pulp production	High: 15,350,400[151]	High: 767,520	High: 15,267,200[151]	High: 1,526,720	Products 70% Biochar 30%	Assumed 10% (2035) and 20% (2050) of exports could be directed to CDR.
	Low: 11,772,800[151]	Low: 588,640	Low: 11,731,200[151]	Low: 1,173,120		
Black liquor	High: 1,941,640	High: 1,941,640	High: 1,829,479	High: 1,829,479		Currently used for energy so assumed all available for BECCS.
	Low: 1,489,117	Low: 1,489,117	Low: 1,405,758	Low: 1,405,758		
Wood used for energy	High: 6,905,600[151]	High: 3,314,688	High: 6,864,000[151]	High: 3,294,720	BECCS with combustion	Assumed that BECCS deployable in 80% of wood-combusting facilities. Small-scale wood combustion excluded.
	Low: 6,905,600[151]	Low: 2,209,792	Low: 6,864,000[151]	Low: 2,196,480		Assumed that 80% of industrial energy wood is available for BECCS. Small-scale wood combustion excluded.

*Table 12. Total and available amounts of **forest biomass** resources with **high** harvest amounts according to WEM-P scenario[151] (Scenarios A1 and B) and **low** harvest amounts according to WEM-L scenario[151] (Scenario A2). Figures in dry tons.*

7.5. Supporting views on the scenarios based on social geography of Finland

As part of the assessment, various stakeholders were interviewed, a group of private citizens was heard, and the social geography of Finland was examined. The full findings from these can be found in Chapter 6. In Table 13, the synthesis of these is brought together with the conclusions on resource availability and calculation of the CDR potential. The categories of various CDR methods presented here are those that were utilised in interviews and the citizen panel, and differ in some cases from the final categorisation used in the scenarios for CDR potential in Finland. A more comprehensive analysis of these methods is presented in Annex F.

182 Finnish Government 2024. Baseline scenarios for energy and climate policy package towards zero emissions

Method	Citizen panel	Stakeholder interviews	Available resources	Final analysis
Afforestation, reforestation, improved forest management	Highly favourable	Highly favourable	Favourable	Favourable. Afforestation and reforestation have low potential, but forest management presents significant potential
Carbon & bio-based products	Highly favourable	Highly favourable	Neutral	Favourable. However, currently most wood biomass goes to short circulation products
Petland and coastal wetland restoration	Highly favourable	Favourable	Favourable	Highly favourable Highly political question but also already happening
Bioenergy with capture and storage (BECCS)	Favourable	Highly favourable	Favourable	Favourable. Plenty of biogenic CO_2 available but currently used or planned to be used elsewhere e.g. for synthetic fuels and deployment would require major upfront investment
Carbon mineralisation	Favourable	Favourable	Favourable	Favourable. Plenty of resources available but their usage in other economic activities is high. Links to mining were seen as both positive and negative factors in interviews and citizen panel. In-situ mineralisation currently prohibited
Soil carbon storage / carbon farming	Highly favourable	Favourable	Favourable	Favourable. Strong potential, but would require substantial reforms to financial support mechanisms at both national and EU levels.
Biochar	Favourable	Favourable	Neutral	Favourable. High potential, but the method was unfamiliar to both interviewees and the citizen panel.
Enhanced rock weathering	Unfavourable	Favourable	Favourable	Neutral. Abundant resources but usage is high, links to mining seen as both positive and negative in interviews and citizen panel
Direct air capture & storage	Favourable	Neutral	Highly unfavourable	Unfavourable. High costs, lack of storage and lack of available thermal energy
Biomass sinking and burial	Unfavourable	Unfavourable	Unfavourable	Unfavourable. Competing uses for biomass
Direct ocean capture	Unfavourable	Highly unfavourable	N/A	Unfavourable. The Baltic Sea is environmentally sensitive. Limited research and TRL.
Ocean alkalinity enhancement	Highly unfavourable	N/A	N/A	Highly unfavourable. The Baltic Sea is environmentally sensitive. More research required.

Table 13. Summary table on the results of how plausible a method's deployment would be in Finland.

7.6 Estimated cost of implementing the scenarios

While this background report has not included a full techno-economic assessment of the various CDR methods, some reflection on the methods' economic feasibility was done while deciding on the emphasis given to the different CDR methods within the selected methods portfolio. For example, DACCS is largely considered to be more expensive (and less energy efficient) than BECCS, so BECCS was preferred over DACCS. The assessment of CDR potential does not estimate the cost of individual investment needed for carbon capturing, storing, or required infrastructure. Additionally, most of these costs would be highly specific to each individual investment, the economic situation of the company, and various other variables.

Nevertheless, the Finnish Climate Panel estimates that by 2030, the unit cost of permanently storing carbon from Finland's industrial emission sources could range between €120–240 per tonne of CO_2, assuming capture occurs at a commercial-scale facility. This estimate includes carbon capture, pressurisation, transport, and storage. However, the panel does not specify the location or method of storage - factors that could significantly influence the final cost.[183]

The panel highlights that BECCS is estimated to be less expensive than certain CO_2 utilisation pathways, such as synthetic fuel production. Yet, despite higher costs, utilisation may offer more straightforward routes to commercial viability due to existing market structures and demand. Capturing 5 $MtCO_2$ of biogenic CO_2 annually from Finland's three largest emitters is estimated to cost between €605 million and €705 million. For DACCS, the panel references ESABCC's projection that by 2035, unit costs could range from €500-€1,000/tCO_2 - reflecting the technological and economic challenges still facing this approach.[184]

The unit cost for land use-based methods has been evaluated by the Finnish Environment Institute SYKE[185] to be:

- Reforestation: €4-98/tCO_2e
- Peatland restoration: €7-71/tCO_2e
- Soil sequestration: €8-53/tCO_2e

Based on these high-level estimations, it can be concluded that **Scenario A1 and A2 would be significantly more cost-effective than Scenario B, which would require significant investments from private companies and national funding**.

183 The Finnish Climate Panel. 2023. Teknologisten hiilinielujen mahdollisuudet ja niiden edistäminen Suomessa https://ilmastopaneeli.fi/hae-julkaisuja/teknologisten-hiilinielujen-mahdollisuudet-ja-niiden-edistaminen-suomessa/

184 The Finnish Climate Panel. 2025. Suomen hiilineutraaliuspolku Arvio hiilineutraaliuden saavuttamisesta ja sen keinoista : https://ilmastopaneeli.fi/hallinta/wp-content/uploads/2025/04/Ilmastopaneelin-julkaisuja-1-2025-Suomen-hiilineutraaliuspolku-Arvio-hiilineutraaliuden-saavuttamisesta-ja-sen-keinoista.pdf

185 Suomen ympäristökeskuksen raportteja 33. 2024. Opas maankäyttösektorin ilmastotoimien hyödyntämiseen kuntien ilmasto- ja luontotyössä. https://mmm.fi/documents/1410837/147048451/Opas+maank%C3%A4ytt%C3%B6sektorin+ilmastotoimien+hy%C3%B6dynt%C3%A4miseen+kuntien+ilmasto-+ja+luontoty%C3%B6ss%C3%A4+KUNTANIELU.pdf/eda973c0-d91d-8094-4949-c1b502d28d2b/Opas+maank%C3%A4ytt%C3%B6sektorin+ilmastotoimien+hy%C3%B6dynt%C3%A4miseen+kuntien+ilmasto-+ja+luontoty%C3%B6ss%C3%A4+KUNTANIELU.pdf?t=1738682425426

8. Conclusions

Scaling up the deployment of carbon dioxide removal (CDR) capacities is now essential if Finland is to achieve its climate objectives. Though there have been studies to assess the potential of natural forest sinks and bioenergy with carbon capture and storage (BECCS), these assessments have been limited in scope and they have not encompassed the full range of available CDR methods. As a result, key information needed to plan the organised deployment of a diversified portfolio of CDR methods has been missing. There is limited awareness of Finland's capacity to deploy CDR at scale, and no national strategy currently exists to guide such efforts.

This report addressed that gap by exploring Finland's potential to implement a broad portfolio of CDR solutions - evaluating approaches that could help the country meet, or even surpass, its climate targets. Importantly, the deployment of CDR is not merely a technical challenge; it is embedded in societal dynamics and requires active engagement from stakeholders and communities.

To reflect this reality and enhance the relevance of the findings for decision-makers, the methodology used in this report emphasises three key dimensions:

- Comprehensive assessment of all available CDR methods and their interconnections.
- Bottom-up analysis of potential, grounded in actual resource availability.
- Consideration of Finland's unique 'social geography' - the societal, cultural, and regional factors that shape the feasibility and acceptance of CDR.

A variety of methods

Of the many existing and proposed (CDR) methods, this study focused on those with potential for large-scale deployment in Finland by 2050. Several approaches were excluded due to environmental, regulatory, or infrastructural limitations specific to the Finnish context.

Ocean-based approaches – such as blue carbon and DOCSS – were deemed unsuitable given the Baltic Sea's shallow depth, ecological fragility, and sensitivity to chemical disruption. While future research may uncover viable CDR options for the Baltic, there is currently not enough data to support even a theoretical assessment of their potential.

High-temperature direct air carbon capture and storage (DACCS) and in-situ carbon mineralisation were also excluded from the realistic potentials. Finland lacks the necessary energy resources and geological storage capacity, and environmental regulations - particularly those concerning silicate materials such as serpentine - pose significant barriers to implementation.

Among forestry-based approaches, agroforestry was included only in the theoretical potential assessment due to insufficient research on its applicability and effectiveness in Finland.

Despite these exclusions, the final portfolio of CDR methods used in the deployment scenarios encompasses all four major categories: (i) Enhanced ecosystem management, (ii) Biomass conversion/preservation, (iii) Geochemical carbon removal, and (iv) Synthetic carbon removal.

The proposed deployment scenarios were formed based on the set of methods used: if only nature-based methods are deployed, or if both nature-based and technological methods are deployed. Forest harvesting levels - and consequently, CDR methods tied to land use management - play a decisive role in determining Finland's total CDR potential. Other important CDR methods include pasture and cropland management. Some methods, such as enhanced rock weathering and durable bio-based products, offer more limited potential in the Finnish context. In general, nature-based CDR methods are considered more cost-effective and require less upfront investment compared to novel approaches like BECCS. BECCS (and DACCS if it were incentivised) offers significant theoretical potential in Finland to generate permanent CDR, but faces the practical limitation of the lack of storage, and could be limited by deployment speed. Therefore, by 2035, BECCS cannot substitute efforts in restoring the land sink, but its deployment is nonetheless important to diversify the sinks, and to put it on track to deliver significant amounts by 2050..

Bottom-up analysis

The theoretical and realistic CDR potentials were estimated using a bottom-up analysis. The process began by assessing the quantity of resources available in Finland for various CDR methods. Each method was then linked to a primary limiting resource - such as land, biomass, or energy - and resources were allocated to the most efficient methods in terms of CO_2 removal per unit of resource. This optimisation ensured the highest possible overall removal potential.

For the theoretical potential, all available resources were considered without constraints. In contrast, the realistic potential was adjusted to reflect real-world limitations, taking into account competing demands such as energy production, biomass utilisation, and land availability.

The bottom-up assessment provided a detailed estimate of how much CO_2 Finland could realistically remove by deploying its resources across a diverse portfolio of CDR pathways. One exception to this method was the land-use sector, where resource allocation was supplemented by existing national assessments. This deviation reflects the sector's critical role - particularly forest areas - in Finland's emissions profile, and the extensive body of research already available in this domain.

Social geography

Finland's social geography provides a strong foundation for advancing robust CDR policies and investments. At the time of writing, several key policy frameworks are undergoing revision, which is expected to enhance the regulatory landscape for CDR. Notably, technical carbon sinks were introduced into Finnish climate policy through the current government programme. The national energy and climate strategy is also being updated, with expectations that it will formally incorporate CDR as a pathway to achieving climate targets. A dedicated investment support instrument for BECCS is currently in development.

Finland has set one of the world's most ambitious climate neutrality targets – 2035 - and this goal enjoys broad societal support. Major industries have developed credible carbon neutrality roadmaps, and substantial progress has been made in reducing emissions. However, the land use sector remains a significant challenge due to its persistent emissions. The current government has faced criticism for insufficient action toward meeting the neutrality target, and integrating CDR could be a strategic lever to close that gap.

Nature and environmental conservation hold deep cultural significance in Finnish society. In a national citizen panel, participants expressed general support for CDR deployment, despite limited understanding of the specific methods involved. Stakeholder interviews highlighted the availability of biogenic CO_2 as a key opportunity for Finland's CDR potential.

Nonetheless, several barriers hinder the realisation of this potential. Chief among them are the absence of a well-developed value chain and the lack of geological storage capacity. Finland's CO_2 infrastructure is still largely undeveloped, and foundational investments in transport and storage systems are needed before large-scale capture projects can proceed. Yet without demand from capture initiatives, infrastructure investment remains stalled. Because financial incentives for permanent CO_2 storage are not yet viable, biogenic CO_2 is increasingly being diverted to other uses, such as synthetic fuel production. While these applications can complement CDR efforts, they may also divert attention and investment away from long-term removal strategies.

Policy changes decisive to realise the potential

This study identifies a real opportunity for Finland to deploy a diversified CDR portfolio and meet its climate targets. Yet, several barriers stand in the way of realising the identified potential. Chief among them are the absence of a well-developed value chain and the lack of geological storage capacity. Finland's CO_2 infrastructure is still largely undeveloped, and foundational investments in transport and storage systems are needed before large-scale capture projects can proceed.. Because financial incentives for permanent CO_2 storage are not yet viable, biogenic CO_2 is increasingly being diverted to other uses, such as synthetic fuel production. While these applications can complement CDR efforts, they may also divert attention and investment away from long-term removal strategies.

The recent decline in the LULUCF capacity to remove carbon from the atmosphere, combined with the challenges and uncertainties identified in this study for each of the possible CDR methods, make it clear that Finland cannot afford to pick winners or place too big bets on a limited number of preferred methods. Instead, a diversified portfolio approach - where multiple methods are incentivised in parallel - is required to increase the resilience of Finland's climate strategy against unexpected shortcomings. This demands the rapid development of a robust policy mix. As part of the carbon removal readiness assessment, this report is accompanied by a roadmap where the project team together with 25+ Finnish stakeholders laid out a series of strategic actions to unlock the country's CDR potential.

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Annex A: Assumptions and methodology for biomass resource amounts and projections

	Type of biomass	General assumptions	Assumptions for current amount and projections
Municipal waste	Biowaste	30% dry matter content estimated[186]	As of 2023 according to Statistics Finland, 45% of waste is recycled. The goal for 2030 is 60% and this same goal is assumed for 2035.[187] No goals are available for 2050, so recycling is assumed to increase to 70%. Waste amounts assumed to increase with population.[188]
Municipal waste	Mixed waste	Assumed 50% biomass content and 70% dry matter content.[189]	Mixed waste assumed to decrease in the same ratio as recycled waste increases.[187] Waste amounts assumed to increase with population.[188]
Municipal waste	Wood waste	45% dry matter content estimated.[191]	Of separately collected wood, currently 58% recycled and 33% incinerated with energy recovery.[190] Waste amounts assumed to increase with population.[188] Unknown how much of wood waste is separately collected so assumed that 60% and 70% recycling goals apply to recycling of separately collected wood.
Industrial waste	Wood waste	45% dry matter content estimated.[191]	It is assumed that the amount of waste increases in the same proportion as municipal waste due to increased recycling. Recycling percentage of waste wood is currently 2% according to Statistics Finland. The Finnish waste strategy has a goal to recycle 70% of construction wood by 2030[187] so the amount of wood available in 2030 excludes the amount for recycling. No projection is available for 2050 so the same 70% recycling rate is assumed then as well.
Industrial waste	Animal and plant matter	Assumed 30% dry matter content based on biowaste.	50% assumed to be used for animal feed.[192] Amount assumed to stay the same because significant portion of animal and plant matter already separately collected so increased recycling assumed to have small impact on this waste category. The amount available for CDR assumed to slightly decrease due to use in higher priority sources such as animal feed. It is assumed 55% in 2030 to be used elsewhere and 60% in 2050.
Industrial waste	Sludge	Estimated 1% dry matter content.[193]	Sludge from household wastewater treatment excluded because there is overlap in data with sludges from businesses. Sludge from businesses is the larger material stream and therefore included here. In 2023, 83% of sludge was fermented.[194] It is assumed there is no priority use for sludge and that therefore all could theoretically be fermented for CDR. There are no projections available on sludge so the amount assumed to decrease 10% by 2035 and 20% by 2050 due to material efficiency improvements.
Agricultural side streams	Cereal straw	90% dry matter content[195]	For available amount, 50% assumed unavailable because straw should be left in the field every other year for soil carbon.[196] 20% of collected straw assumed to be used for animal bedding.[192] The amount of straw available in the future assumed to correlate with the the amount of cultivation area for grain. Estimates for cultivation area estimated from Finnish PEIKKO BAU scenario.[197]

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186 VTT Technical Research Centre of Finland Ltd. 2009. Yhdyskuntajätteen hyödyntäminen biojalostamossa.

187 Minstry of the Environment 2021. Uusi jäteasetus velvoittaa nykyistä tehokkaampaan erilliskeräykseen ja kierrätykseen. Available : https://ym.fi/-/uusi-jateasetus-velvoittaa-nykyista-tehokkaampaan-erilliskerayksen-ja-kierratykseen. Accessed 12.5.2025

188 Statistics Finland 2025. 128t -- Population by age and sex in population projections for different years, whole country. Available: https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__vaenn/statfin_vaenn_pxt_128t.px/. Accessed 23.4.2025.

189 Huttunen, Marika 2019. KAUSIVAIHTELUIDEN VAIKUTUS KIERRÄTYSPOLTTOAINEEN (YHDYSKUNTAJÄTE) KÄYTETTÄVYYTEEN ENERGIANTUOTANNOSSA.

190 VTT Technical Research Centre of Finland Ltd. 1996. Jätepaperin polton ympäristövaikutukset systeemiratkaisuna.

191 Statistics Finland. 2023. Municipal waste by treatment method in Finland by Year, Jätejae and Information.

192 Marttinen et al. 2015. Rural biogas: feasibility and role in Finnish energy system. Sustainable Bioenergy Solutions for Tomorrow.

193 Kulusjärvi, Arttu 2024. TEOLLISUUDEN LIETTEIDEN KUIVAUS RUUVIKUIVAIMELLA.

194 Finnish Water Utilities Association 2025. Yhdyskuntalietteen käsittelyn ja hyödyntämisen nykytilannekatsaus vuosilta 2021–2023.

195 Natural Resources Institute Finland. Pelto. Available: https://www.luke.fi/fi/luonnonvaratieto/tiedetta-ja-tietoa-luonnonvaroista-luonnonvaroista/biomassaatlas/biomassaatlaksen-biomassat/pelto. Accessed 10.6.2025

196 Finnish Government 2024. Baseline scenarios for energy and climate policy package towards zero emissions.

197 National Resources Institute Finland. 2021. Biomassa-atlas.

Agricultural side streams	Stems from peas and broad bean	Assumed 40% dry matter content	For available amount, 50% assumed unavailable because should be left in the field every other year for soil carbon.[195] The Finnish PEIKKO BAU scenario predicts the amount of cultivation area for plants other than grains will increase.[196]
	Potato tops	Assumed same dry matter content as sugar beet tops	Assumed half left in field for soil carbon and fertilization similarly to straw. The Finnish PEIKKO scenario base scenario predicts the amount of cultivation area to remain approximately the same until 2055.[196]
	Sugar beet tops	13% dry matter content[197]	Assumed half left in field for soil carbon and fertilization similarly to straw. The Finnish PEIKKO BAU scenario predict the amount of cultivation area to remain approximately the same until 2055.[196]
	Potential additional harvest of green manuring sward	Assumed 40% dry matter content	Amount assumed to change in the future in proportion to average plant cultivation area in Finland. The Finnish PEIKKO BAU scenario used as projection.[196]
	Straw of herbage seed crops	Assumed same dry matter content as cereal straw	For available amount, 50% assumed unavailable because straw should be left in the field every other year for soil carbon.[195] Amount assumed to change in the future in proportion to average plant cultivation area in Finland. The Finnish PEIKKO BAU scenario used as projection.[196]
	Fallow	40% dry matter content[197]	The total potential is from a different source that includes fields that likely would be forested in theoretical potential[7] and therefore smaller Luke value of fallow[197] used for estimate of available biomass. According to PEIKKO scenarios, due to overall decrease in the amount of cultivation area, the amount of fallow increases from 300,000 ha to 500,000 ha.[196] It is assumed the amount of fallow biomass increases in the same proportion.
	Biomass of buffer zone vegetation	40% dry matter content[197]	Buffer zone vegetation needs to be removed anyway so full amount assumed to be available for CDR.[192] No statistics available on future projection so assumed to stay the same.
	Stems of oils crops	40% dry matter content	Assumed half left in field for soil carbon and fertilisation similarly to straw. The Finnish PEIKKO BAU scenario predict the amount of cultivation area to remain approximately the same until 2055.[196]
	Grasses	Assumed 40% dry matter content.	Includes silage sward, hay, and fresh silage sward. This is not a side stream but a main product of which there is some availability for other uses such as biogas[197,195] Available amount extrapolated from Rural Biogas report based on the decreased amount of ruminating animals and horses from 2012-2024.[197] Projection based on PEIKKO BAU scenario on land area projection for grass.[196]
	Manure	Cattle main source of manure so average dry matter content of slurry, dry, and urine taken for dry matter content (10%).[197]	Slurry, urine, and solid manure added together.[197] Ex-housing manure amounts used because manure should be stored minimally. Dairy cattle is the largest source of manure in Finland, and therefore PEIKKO BAU scenario projections on milk production used to formulate projections for manure amounts.[196] Assumed 50% of manure available for CDR and rest used for e.g. fertilization or infeasible to collect.
Forest biomass	Wood for saw milling and plywood	Converted from m^3 to dry tons using conversion factors (0,416 t/m^3) from Natural Resources Institute.	Based on forest industry mass balance from 2023[198], about half of the wood actually ends up in the end products and the rest in side products. According to Forest Industries Association, 80% of sawmill and veneer products are exported so that amount is assumed to be theoretically available for CDR.[199] An additional 5% assumed to be available for CDR in long-term products from domestic use in the theoretical scenario. For realistic scenarios, a portion of exports assumed available for CDR.
	Side stream wood from saw milling industry		Assumed half of input in sawmilling industry ends up as side products.[198] In maximum scenario, assumed all is available for CDR.

198 Natural Resources Institute Finland 2024. Yhä suurempi osa puun kuiva-aineesta päätyy energiaksi. Available: https://www.luke.fi/fi/uutiset/yha-suurempi-osa-puun-kuivaaineesta-paatyy-energiaksi. Accessed 3.6.2025

199 Finnish Forest Industries 2025. Production and export of the forest industry 2024. Available: https://metsateollisuus.fi/tilastot/. Accessed 3.6.2025

Forest biomass	Wood used for pulp production	Converted from m^3 to dry tons using conversion factors (0,416 t/m^3) from Natural Resources Institute.	Note there is overlap between this figure and the amount of black liquor because black liquor is a product of pulp production. Based on the forest industry mass balance from 2023[198], about half of the wood actually used for pulp production ends up as pulp and the rest as side products. According to Forest Industries Association, 54% of chemical pulp is exported so this amount is assumed to be usable for CDR in the theoretical scenario and a portion of in the realistic scenarios.
	Wood used for energy		This value includes harvested energy wood. About 40% of energy wood used in small scale housing so this amount excluded from CDR.[198]
	Black liquor	Estimated 15% dry matter content[200]	Amount assumed to change relative to pulp production, taking into account reduced pulp production if pulp wood is directed to CDR. 2023 black liquor amounts used for extrapolation.[201] Combusted for energy so assumed theoretically all usable for CDR.

Table A.1 below shows a more detailed picture of how the availability of biomass was considered in this study as there are several streams of biomass that can be utilised in CDR deployment.

Annex B. Resource allocation methodology for CDR methods in theoretical potential

Allocation of biomass resources

Table B.1 lists the biomass resources, their availability, and allocation to CDR methods in the theoretical CDR potential calculation. The raw-material-specific availability and other assumptions for biomass are listed in Annex A. The raw materials were allocated to CDR methods based on their current use or technical suitability if no use currently exists. When several different CDR methods were equally viable for a biomass feedstock, methods were prioritised based on resource efficiency.

For forest biomass, wood harvest amounts were selected in alignment with the assumptions made for the land use sector CDR and net emissions. The forest harvest amounts were set at the level of PEIKKO WEM-L scenario, which has the lowest harvest amounts of the three scenarios included in the report. For wood intended for pulp production and sawmilling, exported quantities were assumed to be available for CDR (54% and 80%, respectively in 2024). The highest-quality sawmilling wood was allocated to products and pulp wood 70% to products and 30% to biochar based on current production trends while also accommodating for potential future upscaling of biochar production. Forecasting the role of biochar in the future is difficult as it is an innovative product not yet in large-scale production in Finland. Therefore, the allocations of feedstock to biochar are optimistic.

Type of biomass	Total projected amount 2050 (dry tons)	Amount available for CDR 2050 (dry tons)	CDR method allocation
Biowaste	206,313[202]	206,313	BECCS with AD
Mixed waste	253,618[202]	253,618	BECCS with combustion
Wood waste	89,215[202]	26,764	
Wood waste	3,140,461[203]	942,138	
Animal and plant matter	442,200[203]	176,880	BECCS with AD
Sludge	17,435[203]	17,435	
Cereal straw	2,227,770[203]	891,108	BECCS with AD Biochar BECCS with combustion
Stems from peas and broadbean	51,254[203]	25,627	BECCS with AD

200 Martikainen, Kati 2017. Ligniinin ja mustalipeän käyttö polttoaineena ja jatkojalosteena.

201 National Resources Institute Finland. 2023. Use balance of Finnish forest industry by year, supply/usage and product.

202 Projection based on data from Statistics Finland. 2023. Municipal waste by treatment method in Finland by Year, Jätejae and Information.

203 Projection based on data from Natural Resources Institute Finland. 2025. Biomass Atlas. https://biomassa-atlas.luke.fi/?lang=en.

Potato tops	27,170[203]	13,585	BECCS with AD
Sugar beet tops	6,057[203]	3,029	
Potential additional harvest of green manuring sward	131,933[203]	131,933	
Straw of herbage seed crops	39,635[203]	19,817	BECCS with AD Biochar BECCS with combustion
Fallow	1,027,033[204]	50,903[2]	BECCS with AD
Biomass of buffer zone vegetation	20,690[203]	20,690	
Stems of oils crops	26,608[203]	13,304	
Grasses	4,151,476[203]	1,863,469	
Manure	1,420,992[203]	710,496	
Wood for saw milling and plywood	12,396,800[205]	5,268,640	Products
Side stream wood from saw milling industry	6,198,400	6,198,400	BECCS with combustion 80% Biochar 20%
Wood used for pulp production	11,731,200[205]	3,167,424	Products 70% Biochar 30%
Black liquor	1,140,226	1,140,226	BECCS with combustion
Wood used for energy	6,864,000[205]	4,118,400	
Common reed	304,000[206]	304,000	BECCS with AD Biochar BECCS with combustion

Table B.1. Theoretical maximum biomass feedstock amounts and allocation to CDR methods

Annex C. Stakeholder interviews' detailed analysis

Ministries

Awareness and Views on Existing Climate Policy

- General Awareness: Ministries are well-informed about Finland's climate policy, including its targets, incentives, achievements and failures.
- Targets and Ambition: ministries acknowledge the 2035 carbon neutrality target as ambitious, noting it relies on forest sink estimates that have since been revised downward, raising concerns about feasibility.
- Incentives: Views vary, with some ministries suggesting more robust financial and regulatory support for carbon reduction initiatives.
- Achievements and Failures: While progress in renewable energy and energy efficiency is recognised, ministries highlight the need for more comprehensive support for CDR technologies.

Ministries demonstrate a strong awareness of Finland's climate policy, recognising its notable achievements in promoting renewable energy and improving energy efficiency. However, they emphasise the need for more robust financial and regulatory mechanisms to support carbon reduction initiatives. While carbon dioxide removal (CDR) is acknowledged as an emerging element within the national climate strategy, it remains relatively marginal. Ministries note that Finland has traditionally focused on emission reduction rather than removal. To elevate the role of CDR, they stress the importance of developing comprehensive policy frameworks that can

204 Projection based on data from Marttinen et al. 2015. Rural biogas: feasibility and role in Finnish energy system. Sustainable Bioenergy Solutions for Tomorrow.

205 The Prime Minister's Office 2024. Baseline scenarios for energy and climate policy package towards zero emissions.

206 Hyvärinen et al. 2017. Uutta liiketoimintaa vesistöjen ravinteista. National Resources Institute Finland.

integrate it more fully into national strategies and enhance its contribution to climate targets. Most ministries interviewed do not anticipate any major shifts in Finnish climate policy during the current governmental term, which runs until 2027.

Awareness and knowledge of CDR and Different Methods

- General Knowledge: Ministries have a solid understanding of various CDR methods.
- Familiar Methods: BECCS, Biochar, afforestation, and reforestation are well-known and frequently discussed.
- Less Known Methods: Ocean alkaline enhancement and direct ocean capture are less familiar and less discussed among ministries.

Ministries identify biochar, afforestation, and reforestation as the most promising CDR methods for Finland, citing their practicality, environmental co-benefits, and strong alignment with the country's existing expertise in forestry and agriculture. Biochar is particularly favoured for its dual role in enhancing soil health and sequestering carbon. BECCS is also viewed positively, largely due to its synergies with Finland's forest industries and the ready availability of biogenic CO_2. Moreover, BECCS has emerged as a new policy focus under the current government term. Enhanced weathering is considered promising as well, given Finland's favourable geological conditions. In contrast, direct air capture is viewed less favourably due to its high costs and energy demands, while Ocean alkaline enhancement is seen as technically complex and potentially harmful to fragile ecosystems.

Views on Deployment of CDR and Use to Fight Climate Change

- General Views: Ministries generally view CDR positively as a necessary tool to fight climate change.
- Support for Deployment: Strong support exists for deploying well-understood and proven methods like biochar and afforestation/reforestation.
- Concerns: Concerns about feasibility, cost, and ecological impact of less familiar methods like direct air capture and ocean alkalinity enhancement.

To effectively scale CDR in Finland, ministries advocate for comprehensive policy frameworks that provide financial incentives and regulatory support for CDR projects from the EU. They emphasise the need for technological advancements and collaboration among stakeholders to enhance the feasibility and scalability of CDR methods. Ministries also call for increased investment in research and development to support innovative CDR technologies and practices.

Knowledge Institutes

Awareness and Views on Existing Climate Policy

- General Awareness: Knowledge institutes demonstrate a strong understanding of Finland's climate policy, including its targets, incentives, and achievements/failures.
- Targets and Ambition: They recognise the ambitious climate targets and the importance of integrating CDR into national strategies.
- Incentives: Institutes advocate for more robust policy frameworks and technological investments to support CDR deployment.
- Achievements and Failures: While acknowledging Finland's progress in renewable energy and energy efficiency, they highlight the need for greater support for innovative CDR technologies.

Interviewed knowledge institutes consistently stress that CDR is essential for achieving Finland's climate goals. However, they note that CDR has yet to become a prominent or active component of current climate policy. They call for significant technological and economic investments, alongside comprehensive policy reforms, to elevate CDR's role and ensure its integration into Finland's long-term climate strategy.

Awareness/Knowledge of CDR and Different Methods

- General Knowledge: Strong understanding of various CDR methods.
- Familiar Methods: Familiar with BECCS, biochar, enhanced weathering, and afforestation/reforestation.
- Less Known Methods: Less familiar with ocean alkalinity enhancement and direct ocean capture.

Knowledge institutes identify biochar, enhanced weathering, and afforestation/reforestation as the most promising CDR methods for Finland. BECCS is also viewed favourably, primarily due to the ready availability of biogenic CO_2 and existing industrial infrastructure. Biochar stands out for its dual benefits in soil health and carbon sequestration, while enhanced weathering is considered promising given Finland's suitable geological conditions. Afforestation and reforestation are recognised not only for their carbon capture potential but also for their positive impact on biodiversity. In contrast, direct air capture is seen as less viable due to its high energy demands and costs, and ocean alkalinisation is viewed unfavourably because of technical complexities and ecological risks.

Views on Deployment of CDR and Use to Fight Climate Change

- General Views: Knowledge institutes view CDR as critical to achieving climate targets.
- Support for Deployment: Support for deploying technologically advanced methods and natural solutions like biochar, enhanced weathering, and afforestation/reforestation.
- Concerns: Emphasise the need for technological advancements, policy support, and stakeholder collaboration to overcome challenges.

Knowledge institutes advocate for significant technological advancements and economic investments to support the deployment of CDR methods. They emphasise the need for supportive policies and stakeholder collaboration to overcome challenges and enhance the scalability of CDR technologies. Increased funding for research and development is also seen as crucial to advancing innovative CDR solutions and practices in Finland.

Civil Society

Awareness and Views on Existing Climate Policy

- General Awareness: Aware of Finland's climate policy and the ambitious targets set.
- Targets and Ambition: Support the ambitious climate targets and advocate for measures with significant climate benefits.
- Incentives: Suggest comprehensive policy frameworks to support environmental sustainability and CDR initiatives.
- Achievements and Failures: Recognise achievements in renewable energy but stress the need for more focus on sustainable CDR practices that would not cause harm to e.g. biodiversity. Especially increased use of biomass needs to be carefully considered.

Civil society organisations are aware of Finland's climate policy and support its ambitious targets for carbon neutrality. They recognise achievements in renewable energy but emphasise the need for more focus on sustainable CDR practices. CDR is seen as a relatively new component of climate policy, and civil society advocates for its increased prominence and integration into national strategies.

Awareness/Knowledge of CDR and Different Methods

- General Knowledge: Good understanding of various CDR methods.
- Familiar Methods: Familiar with natural solutions like biochar, afforestation/reforestation, and peatland restoration.
- Less Known Methods: Less familiar with technologically complex methods like ocean alkalinity enhancement and direct ocean capture.

Civil society highlights biochar, afforestation/reforestation, and peatland restoration as the most promising CDR methods for Finland. Biochar is favoured for its dual benefits of enhancing soil health and sequestering carbon, while afforestation and reforestation are recognised for their effectiveness in capturing CO_2 and maintaining biodiversity. Peatland restoration is seen as a valuable method for long-term carbon storage. Direct air capture and ocean alkalinity enhancement are viewed unfavourably due to high costs, technical complexity, and potential ecological impacts. Environmental organisations were more critical of several CDR methods, particularly those involving technological solutions, pointing to some early pilot projects with questionable results that undermined confidence in these approaches. Voluntary carbon markets have failed to gain trust due to issues with credibility and implementation, both domestically and internationally. Civil society advocates for sustainable practices that provide significant climate benefits, such as enhancing natural carbon sinks like forests and peatlands. They stress the importance of a hierarchical approach where emission reductions are prioritised first, and only the remaining emissions are addressed through carbon removal

Views on Deployment of CDR and Use to Fight Climate Change

- General Views: Civil society organisations view CDR as essential for fighting climate change.
- Support for Deployment: Strong support for deploying natural and sustainable CDR methods that align with environmental goals.
- Concerns: Advocate for stakeholder engagement and policy support to ensure successful deployment. Currently the civil society actors such as nature or social NGOs are not engaged in CDR discussions and their role in policy development and implementation in the Finnish society is critical.

Civil society advocates for comprehensive policy frameworks that support sustainable CDR practices and ensure environmental sustainability. They emphasise the importance of stakeholder engagement and collaboration to successfully deploy CDR methods. Increased investment in research and development is also seen as essential to advancing sustainable and innovative CDR solutions.

Industry Organisation and Private Sector

Awareness and Views on Existing Climate Policy

- General Awareness: Industry organisations and the private sector are aware of Finland's climate policy, targets, incentives, and achievements/failures.
- Targets and Ambition: Recognise the ambitious target of achieving carbon neutrality by 2035.
- Incentives: Emphasise the need for financial measures and policy support to facilitate CDR projects.
- Achievements and Failures: Acknowledge successes in renewable energy adoption but highlight areas for improvement, such as more comprehensive support for CDR technologies.

Industry organisations and the private sector are well aware of Finland's climate policy, including its targets, incentives, and achievements. They recognise the ambitious target of achieving carbon neutrality by 2035 but emphasise the need for financial measures and policy support to facilitate CDR projects. CDR is seen as an emerging but crucial component of the climate policy, requiring more focus and investment to become prominent.

Awareness/Knowledge of CDR and Different Methods

- General Knowledge: Solid understanding of various CDR methods.
- Familiar Methods: BECCS, Biochar, afforestation/reforestation, and soil carbon storage are well-known and frequently discussed.
- Less Known Methods: Ocean alkaline enhancement and direct ocean capture are less familiar and less discussed.

Industry organisations and the private sector identify BECCS, biochar, afforestation/reforestation, and soil carbon storage as the most promising CDR methods for Finland. BECCS is favoured due to the availability of biogenic CO_2 and possible industry integrations that could bring added value to the Finnish economy. Biochar is favoured for its practicality and benefits in improving soil health and sequestering carbon, while afforestation and reforestation are recognised for their effectiveness in capturing CO_2 and enhancing forestry practices. Soil carbon storage is seen as valuable for improving agricultural practices and sequestering carbon. Direct air capture and ocean alkaline enhancement are viewed unfavourably due to high costs, energy requirements, and technical barriers.

Views on Deployment of CDR and Use to Fight Climate Change

- General Views: CDR generally viewed positively as a necessary tool to fight climate change.
- Support for Deployment: Strong support exists for deploying well-understood and proven methods like biochar and afforestation/reforestation.
- Concerns: Concerns about feasibility, cost, and ecological impact of less familiar methods like direct air capture and ocean alkaline enhancement.

To scale CDR in Finland, industry organisations and the private sector advocate for financial incentives and policy support to facilitate CDR projects. They emphasise the importance of economic viability and investment in research and development to advance CDR technologies. Collaboration among stakeholders is also seen as crucial to enhancing the feasibility and scalability of CDR methods. Increased funding and support for innovative CDR solutions are essential to achieving climate targets and integrating CDR into Finland's climate policy.

Preferred CDR Methods for Scaling Up in Finland Based on stakeholder interviews

A preferred combination of CDR methods to deploy in Finland was drawn from stakeholder discussions and pre-survey (see Figure C.1). While the stakeholders somewhat agreed on the most and least favoured methods, there were also methods with more deviation of opinions, such as biomass burial and sinking, and DACCS. Stakeholders' reasonings for the perceived potential for each method are discussed in the following sections.

BECCS

Reasons for preference:

- Availability of biogenic CO_2 now and in the future due to forest industry being very prominent in Finland and its role in the Finnish economy not being challenged
- Suitable conditions with pre-existing industrial integration opportunities

Reasons for limited preference:

- Costly investments with long process from start to finish that lowers the readiness of the method

- Competing uses for the biogenic CO_2 that are already being deployed
- Underdeveloped value chain from collection to storage or usage
- Some present worries over increased usage of biomass and stress the need to avoid being dependent on biomass, especially from increased forest usage.

Biochar

Note on biochar: Biochar was rarely mentioned unprompted by stakeholders, either as a preferred or unpreferred method. It was also not identified as a technique unfamiliar to those interviewed. However, when specifically asked about biochar, interviewees expressed generally positive or neutral attitudes. Many noted that biochar appears to be a relatively new approach, but one with promising potential. Recent investments in biochar production were viewed as encouraging signs of its growing relevance.

Reasons for Preference:

- Dual Benefit: Biochar is favoured due to its dual benefits of improving soil health and sequestering carbon. Stakeholders recognise that biochar enhances soil fertility and organic carbon content, making it a practical and environmentally beneficial method.
- Practicality and scalability: Leveraging agricultural and forestry residues for biochar production aligns closely with Finland's established strengths in these sectors. Stakeholders view this approach as both economically viable and attractive for future investment, citing its compatibility with existing infrastructure and expertise, making it a feasible option for widespread implementation.

Afforestation and Reforestation

Reasons for Preference:

- Extensive Forest Resources: Stakeholders identify afforestation and reforestation as highly effective methods for carbon sequestration due to Finland's vast forest resources.
- Environmental Benefits: These methods are recognised for their positive impacts on biodiversity and ecological balance. Stakeholders emphasise that afforestation and reforestation can significantly enhance carbon capture while maintaining environmental sustainability.
- Existing Expertise: Finland's well-established forest management practices make afforestation and reforestation practical and scalable.

Reasons for limited preference:

- Forest policy is quite complex in Finland and has a lot of conflicting interests.
- Forest ownership in Finland is predominantly held by private individuals and organisations. For decades, forest management guidelines have prioritised economic value creation. Shifting this long-standing focus presents a political risk, as it challenges entrenched interests and established practices.
- Any changes to the forest industry's operating environment would trigger significant societal debate. In times of economic downturn, such reforms are viewed as politically and practically unfeasible, given the sector's deep-rooted economic and cultural importance.

Enhanced Rock Weathering

Reasons for Preference:

- Geological Conditions: Enhanced weathering is considered by stakeholders promising in Finland, thanks to its favourable geology and abundant mineral resources that can be used to capture CO_2 as stable carbonates.
- Long-Term Stability: The method provides a stable and permanent form of carbon storage, making it an attractive option for long-term carbon sequestration.
- Technological Feasibility: Although it requires significant infrastructure and investment, stakeholders believe enhanced weathering is technologically feasible and scalable.

Reasons for limited preference:

- Many interviewees were unfamiliar with the method.
- Mining is already under intense scrutiny in Finland. While its use in CDR could offer environmental benefits, some interviewees questioned whether introducing this additional dimension might complicate the broader debate—potentially making it harder, both legally and in the eyes of stakeholders that oppose mining - to advance mining for minerals essential to the green transition.

Soil Carbon Storage / Carbon Farming

Reasons for Preference:

- Agricultural Benefits: Stakeholders favour soil carbon storage and carbon farming due to their potential to improve soil health and fertility. These methods are seen as practical applications within existing agricultural

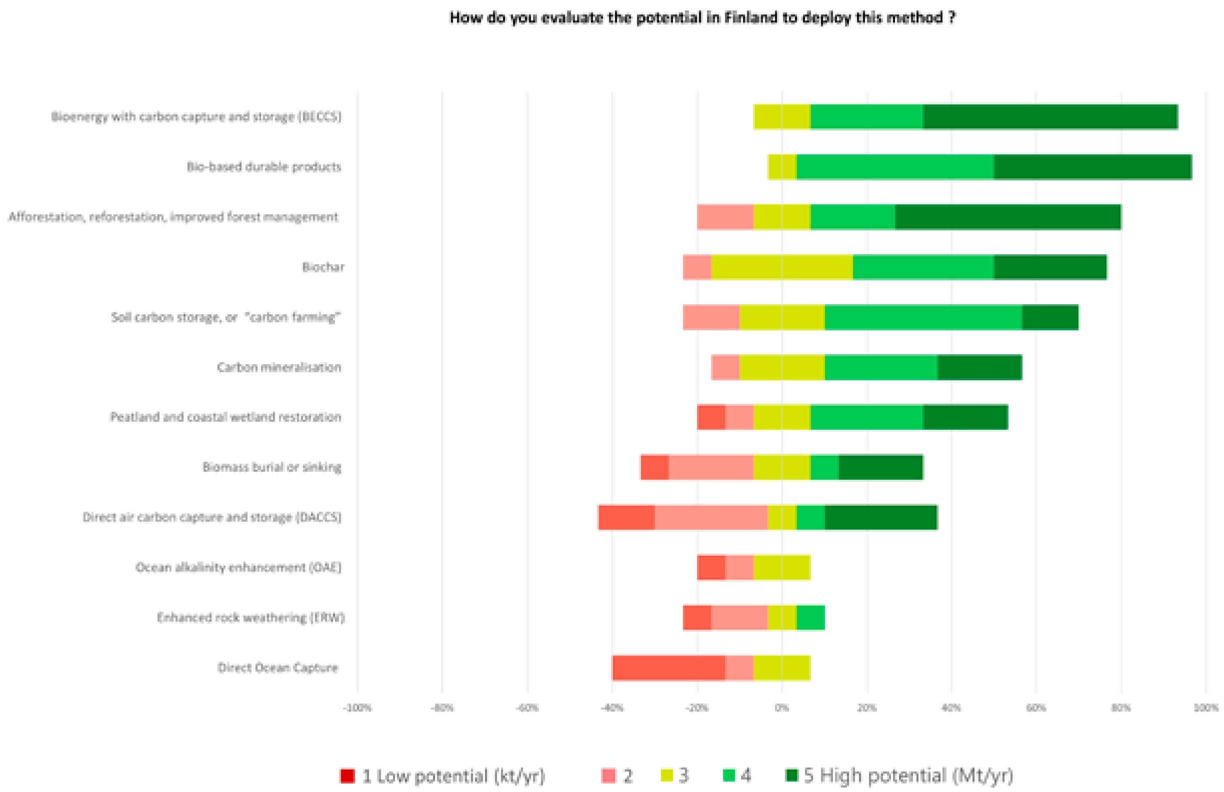

Figure C.1: Answers of the stakeholders in the pre-survey question: How do you evaluate the potential in Finland to deploy this method? In the graph the CDR methods have been ranked according to weighed average, showing the most favoured on the top.

practices.

- Environmental Impact: Enhancing soil carbon content has positive impacts on soil health and biodiversity.
- Scalability: Soil carbon storage and carbon farming can be integrated into current agricultural practices, making them scalable and feasible.

Reasons for limited preference:

- Monetary support instruments in Finland and EU limits the potential at least in short term.

Peatland and Coastal Wetland Restoration

Reasons for Preference:

- Environmental Benefits: Stakeholders highlight the restoration of peatlands and coastal wetlands as valuable methods for enhancing biodiversity and long-term carbon storage. These practices are seen as environmentally sustainable and beneficial for ecosystem restoration.
- Long-Term Impact: Restoring peatlands and coastal wetlands offers strong potential for long-term carbon sequestration, positioning them as compelling options for large-scale climate mitigation in Finland.
- Alignment with Sustainability Goals: These methods align with Finland's environmental sustainability goals, ensuring the preservation of natural habitats while capturing CO_2.

Reasons for limited preference:

- Some interviewees expressed support for all restoration efforts but emphasised that these should prioritise biodiversity. They noted that such an approach might limit the CDR potential in certain cases.
- Some interviewees did not understand the method and how it will contribute to CDR.

Less Preferred Methods based on stakeholder interviews

Direct Air Capture & Storage

Reasons for Limited Preference:

- High Costs: Stakeholders view direct air capture unfavourably due to its significant financial investment requirements and lack of national capital and investment opportunities.
- Energy Consumption: The high energy requirements of this method limit its feasibility and scalability.
- Technological Barriers: Current technological limitations make direct air capture less practical for widespread implementation.
- Storage Capacity: Interviewed stakeholders expressed a preference for scaling up BECCS. They noted that DACCS could be considered if additional CO_2 storage capacity becomes available, either within Finland or elsewhere in Europe.

Reasons for preference:

- The method could theoretically be implemented almost anywhere, and it does not need to be linked to a pre-existing facility so there is more flexibility on location.
- Some interviewees suggested that Finnish companies and experts could play a meaningful role in

implementing DACCS, even outside Finland. Such involvement would enhance Finland's technical capacity and deepen national understanding of the method.

- If financing and incentive mechanisms are established, and carbon capture and storage becomes economically viable, the method should be reconsidered for broader implementation.

Ocean Alkalinisation Enhancement and Direct Ocean Capture

- Technical Challenges: This method faces significant technical barriers to implementation.
- Ecological Impact: Potential negative impacts on marine ecosystems make stakeholders cautious about its feasibility.
- Unknown Potential: Limited knowledge and understanding of its applications contribute to lower preference among stakeholders.

Note: None of the interviewed stakeholders felt sufficiently informed to offer detailed assessments of these methods. However, those who did share insights expressed a preference for land-based approaches over implementation in the Baltic Sea, citing the sea's degraded ecological condition as a key concern.

Annex D. Citizen panel views on the presented methods

This annex includes further analysis on citizen panel views of various CDR methods and their reasoning for the preferences.

Permanent storage vs. carbon dioxide utilisation

Introducing the idea of carbon credits and how creating permanent storage can provide income to countries and companies changed, some panelist minds and some went as far as planning to investigate carbon markets themselves later in order to see if they as individuals could participate in carbon markets. This sentiment and ponder of weather scaling CDR always requires major investments, or if it could be done modularly via many smaller implementations was also something that the participants felt would be attractive. For instance, discussion about utilising burning outhouses at summer cottages for producing biochar was had in one small group. This idea was shortly disregarded due to the need for much higher temperatures needed in biochar production that are used in the outhouses, but it reflects the panelist openness to think outside of the box when it comes to new solutions, and their strong desire to link climate benefits to other benefits such as biodiversity and economic benefits and focusing on national strengths.

Greenwashing doubts

Doubts regarded in these methods were linked to suspicion of greenwashing and over promising results. For biochar, the first response for the method was "sounds greenwashing" due to the term char, in Finnish meaning coal and panelist felt that combining terms bio and coal cannot be true but once discussions were had about the method, panelist understood the methodology better and ended up preferring the method. For carbon mineralisation (as well as enhanced rock weathering), the main doubt for most panelists were the methods links to mining practices. Although they appreciated that the methods could lessen the emissions of mining and that the methods use byproducts of mining so that the methods don't require new mines, part of the panelist still felt that by linking CDR to mining operations, it could provide more positive attention than deserved.

"Although maybe not new mines are created because of this, it could make them more acceptable for general population and I don't want that" - Panellist, paraphrased

What ended up making carbon mineralisation as possible method to be included in the desired combination over enhanced rock weathering, was once again mineralised carbon's links to other benefits. Some panelists were very interested in possibilities of creating concrete out of mineralised carbon and saw major potential for this in Finland and globally. For carbon and biobased products, greenwashing was also the first thing in their mind since they combined the concept with consumer goods such as paper plates or bioplastic bags. Once it was discussed, that this method is not for consumer goods but industrial implementation and construction in order to reach needed storage times, the panelist once again agreed that the measure is desirable as it can create value outside of CDR.

Any method relating to the Baltic Sea was met with high levels of suspicion

The methods that had links to oceans were deemed as absolute no-go. Some reasons to this are very specific for Finland, Finnish language and the location of the panel. In Finnish language, the methods refer to sea's and oceans, and as Finland has coastline to Baltic Sea, not oceans and thus they understandably were most concerned about actions happening in the Baltic Sea. The panel was hosted in a coastal city that has a very long history of restoring the health of the Baltic Sea, which is extremely sensitive and the health of the marine ecosystem in the Baltic Sea is very delicate., the panelists were very adamant that no interventions to the Baltic Sea should be made without absolute certainty that they would not hinder the restoration efforts done. The panelist felt it being impossible to be sure, that the methods would not do this. The panelist were self aware, that they lack understanding of the methods, but at the same time, they were also very direct in their distaste with all of the methods involving seas and oceans.

Biomass sinking and burial was first seen as suspicious but eventually neutrally

For biomass sinking and burial, the participants' first reaction was that it sounded scary. Once discussions were held, they remained against biomass sinking due to it needing more resources and causing possible harm to marine ecosystems, but burying biomass was seen more neutral. The panelists noted that since biomass is natural substance and not for instance similar matter to nuclear waste, it does not seem to cause harm or danger, but they also felt that it lacks the co-benefits they were trying to establish for the selected methods. They were also cautious of biomass being needed elsewhere and that scaling the method significantly could lead to biodiversity loss if biomass would be grown for specifically this purpose.

DACCS was viewed neutrally but participants did not understand the method very well

Direct air capture and storage was met with neutrality, but hesitations about cost effectiveness, lack of storages in Finland and lack of co-benefits. The panelists did not disregard the method as a whole, but felt that it should not be Finland's first priority when scaling CDR methods. Some discussions were had about where direct capture should be done. Few participants proposed that capturing should be done in immediate closure to storage to limit the needs to transport carbon and thus making the whole process more smooth and possibly more cost effective.

Annex E. Land use sector CDR methods in the realistic scenarios (from PEIKKO scenarios)

Table E.1 below includes the land area available for land use sector methods, as used in the calculations across all scenarios, taken directly from the PEIKKO scenario data. Please see more info on the scenarios and assumptions used from the original source.

Measure	Area and description
Climate actions by Metsähallitus	Fertilisation 30,000 ha/year in forests owned by Metsähallitus
Preventing deforestation	800 ha/year on mineral soils and 900 ha/year on peat soils
Temporary afforestation support for idle areas	Afforestation around 3000 ha/year
Afforestation of poorly productive peat fields	1200 ha/year in Southern Finland and 600 ha/year in Northern Finland during 2025-2029
Grass cultivation on peat soils with elevated groundwater level -30 cm	20,000 ha in 2030, 32,500 ha in 2035
Cultivation on peat soils with elevated water level (Reed canary-grass etc.) -30 cm	5000 ha in 2030, 10,000 ha in 2035
Cultivation on peat soils with elevated water level (Bulrush, Sundew etc.) -5 – -10 cm	2500 ha in 2030, 5000 ha in 2035
Climate wetlands on peat fields	4000 ha in 2030, 7500 ha in 2035
Grasses on peat fields	40,000 ha/year (of which additional 10,000 ha/year)
Convert poorly productive, thick peat fields and bog bottoms to wetlands	10,000 ha of peat fields in 2030, 20,000 ha of bog bottoms in 2030
Avoidance of restoration ditching with thinnings in fertile spruce swamps and barren pine swamps	1000 ha/year
Upper thinning on fertile spruce swamps as last thinning before regeneration	6000 ha/year
Promote ash fertilisation of peat forests	37,000 ha/year (increase of 26,000 ha/year)
Promote fertilisation of mineral soil forests	50,000 ha/year (increase of 24,000 ha/year)
Promote rapid and efficient forest regeneration	Forests are regenerated promptly after clear-cut in all forest stock scenarios
Increase the carbon stock of deadwood in managed forests for biodiversity and climate reasons by leaving retention trees	Increase the number of retention trees in clear-cuts from 5 to 7 m^3 per hectare

Annex F. Further analysis on CDR methods based on social geography

This annex outlines the realistic potential of each CDR method based on calculation results, stakeholder and citizen panel perspectives, societal factors that may hinder implementation, and the availability of resources to support each method.

Afforestation, reforestation and improved forest management used in scenarios A1, A2 and B

- **Realistic potential in 2035 and 2050:** Among these measures, afforestation and reforestation offer more limited potential compared to improved forest management. Finland lacks sufficiently large areas for large-scale afforestation or reforestation to deliver significant impact. However, modifying current forest management practices—particularly by adjusting harvest levels—could substantially enhance Finland's natural carbon sinks and generate additional carbon removals.

- **Citizen panel and stakeholder interview result: Positive.** These methods are seen as primary ways to increase CDR in Finland.

- **Possible societal hindrance of deployment:** Forest management and usage is highly political and deeply personal in Finland. Forest and land ownership are divided into 600,000 individual forest owners who own approximately 440,000 forest properties. Private citizens and families own 50–60% of Finland's commercial forest area, depending on how forest is defined. The forest industry employs 37,000 people and accounts for approximately 16.8% of the value of Finland's goods exports . According to customs statistics, forest industry products worth EUR 12.1 billion were exported in 2024.

- **Available resources:** managed peatland forests, managed mineral land forests, agricultural wasteland, peatland fields/agricultural land.

Carbon and Bio-based products used in scenarios A1, A2 and B

- **Realistic potential in 2035 and 2050:** The potential is relatively modest, estimated between 460 ktCO_2 and 1 MtCO_2. However, it delivers measurable results as early as the 2035 scenario.

- **Citizen panel and stakeholder interview result:** Positive. Citizen panel participants viewed this method as highly favourable due to its additional benefits and straightforward logic. While stakeholders did not identify it as a high-potential option, they expressed no significant concerns or objections to its use.

- **Possible societal hindrance of deployment:** While the scenario shows limited potential, the constraint lies not in resource availability but in market demand. The Finnish forest sector is keen to shift from pulp production to higher-value wood products, yet uncertainty remains about the existence and scale of viable markets for these alternatives. At present, only a small share of wood products are long-lived, limiting their contribution to long-term carbon storage.

- **Available resources:** Wood is abundantly available in Finland, but much of it is currently directed toward pulp production rather than being used for higher-value products.

Peatland and Coastal Wetland Restoration used in scenarios A1, A2 and B

- **Realistic potential in 2035 and 2050:** Potential is small, with an estimated 30,000 ha expected to be restored by 2035.

- **Citizen panel and stakeholder interview result:** Positive. Stakeholders and citizen panel participants appreciated the benefits of these methods to biodiversity. Some voiced concerns over the timeline of when the climate benefits could be realised with these methods.

- **Possible societal hindrance of deployment:** Finland has a long history of peat production, which until recently was a significant source of GHG emissions. In response, decisions have been made to restore peatlands, and former production areas now receive support through the Just Transition Fund. Peatland restoration was a highly politicised issue in Finland a few years ago, but declining market demand has led to a notable reduction in peat production in recent years.

- **Available resources:** There are approximately 800,000 ha of potential sites for re-wetting in Finland, but only a small fraction of these can realistically be restored due to practical, ecological, or economic constraints.

Bioenergy with Carbon Capture and Storage (BECCS) Used in scenario B

- **Realistic potential in 2035 and 2050:** High potential scenario B with over 6 $MtCO_2$ removed in 2035 and 20 $MtCO_2$ removed in 2050. The realistic potential is limited more by storage capacity than available resources.

- **Citizen panel and stakeholder interview result:** Positive. Stakeholder interviews identified BECCS as one of the most promising CDR methods for Finland, largely due to the strong role of the forest industry and the abundant availability of biogenic CO_2 as a by-product. While citizen panel participants had limited understanding of the method, they nonetheless perceived its potential as high. In contrast, nature NGOs expressed critical views, raising concerns about the method's increasing reliance on biomass and its potential environmental impacts.

- **Possible societal hindrance of deployment:** Limiting factors for BECSS include competing uses for biogenic CO_2, particularly in the production of bio-based fuels. While some facilities have already invested in CO_2 capture technologies, Finland's limited geological storage capacity remains a significant barrier to large-scale deployment. On the positive side, Finland benefits from a strong industrial ecosystem and active government support for BECCS. However, increasing reliance on biomass is viewed critically and may trigger societal debate, especially concerning sustainability and land-use impacts.

- **Available resources:** Given the strength of Finland's forestry sector and its extensive use of biomass as raw material, there is a substantial supply of biogenic CO_2 available for BECCS. Agricultural side streams—such as manure and crop residues—also offer promising potential, particularly when combined with anaerobic digestion technologies, further expanding the scope for BECCS deployment in Finland.

Carbon mineralisation This method is treated as a storage solution in this report. In the theoretical potential, it is used as storage for DACCS but excluded from realistic potential scenarios due to current limitations in feasibility or deployment.

- **Realistic potential in 2035 and 2050:** none

- **Citizen panel and stakeholder interview result:** This method received mixed reviews, with hesitation from stakeholders and citizen panel participants due to its linkage to mines. However, both stakeholders and citizens were intrigued by the potential of utilising mineralised carbon in construction, especially in concrete. Some activities are underway in the industry to make this method a feasible deployment of CDR in Finland, even in the short term.

- **Possible societal hindrance of deployment:** Use of serpentinite is forbitten in the Finnish environmental protection act.

- **Available resources:** Finland has required serpentinite minerals for the method but their use is currently prohibited by law.

Soil carbon sequestration (crop, grasslands) used in scenario A1, A2 and B

- Citizen panel and stakeholder interview result: Neutral positive. Stakeholders and citizen panel participants recognised the method's added benefits for biodiversity and food security, but expressed concerns about its high costs and challenges in scaling up deployment.

- Possible societal hindrance of deployment: Carbon farming has gradually gained support among Finnish farmers, with little resistance to adopting new practices—provided that adequate financial incentives are in place. However, the EU's Common Agricultural Policy (CAP) currently lacks targeted support for carbon farming. While Finland's national support mechanisms promote some carbon-friendly practices, they are insufficient on their own to drive widespread adoption. To make carbon farming scalable, substantial reforms to both political frameworks and compensation models are needed.

- Available resources: Despite Finland's northern location, the agricultural sector remains economically significant, contributing 1.9% to the national GDP. Agricultural and horticultural enterprises collectively manage approximately 2.3 million hectares of farmland, with the average farm size reaching 51 ha.

Biochar used in scenario B

- Realistic potential in 2035 and 2050: The method is considered to have relatively high potential, with over 3 $MtCO_2$ projected by 2035. However, growth beyond that is expected to be modest, reaching an estimated 3.6 $MtCO_2$ by 2050. As a relatively new and innovative approach, its role in Finland remains difficult to assess with certainty. Current estimates may be somewhat optimistic, yet it's possible that its impact could exceed expectations as technologies and market conditions evolve.

- Citizen panel and stakeholder interview result: Neutrally positive. Citizen panel participants were generally intrigued by the method, though many lacked a clear understanding of how it functions. Among stakeholders, biochar was not widely discussed; however, those who did mention it regarded it as a promising option with potential for carbon removal.

- Possible societal hindrance of deployment: As a relatively new and still unfamiliar method, biochar lacks strong market-driven momentum and investment incentives. However, interest is growing, and the overall trend is moving upward.

- Available resources: Resources are not a limiting factor for biochar production, and since the method is inherently self-storing, Finland's limited CO_2 storage capacity does not pose a constraint to its deployment.

Enhanced Rock Weathering Used in scenarios A1, A2 and B

- Realistic potential in 2035 and 2050: Potential is relatively low, between 600 $ktCO_2$ and 700 $MtCO_2$ but the method is potential for 2035.

- Citizen panel and stakeholder interview result: Mixed reviews. The method was only partially familiar to the stakeholders interviewed, with few able to offer detailed insights. Those with greater awareness generally viewed it positively. Initial reactions from the citizen panel were more critical, largely due to the method's association with the mining industry. While some participants appreciated the use of by-products from existing mines, others voiced concern that carbon removal could inadvertently legitimise or encourage expanded mining activities.

- Possible societal hindrance of deployment: One advantage of the method is its alignment with Finland's existing and planned mining operations, which are supported by the country's rich reserves of minerals essential for green transition technologies, such as those used in battery production. However, this connection to the mining sector is viewed ambivalently by the public—seen as both a practical benefit and a potential drawback, due to concerns about environmental impact and the expansion of extractive activities.

- Available resources: Finland does not have basalt and olivine but other minerals are available.

Direct Air Capture and Storage (DACCS) Not used in realistic scenarios due to lack of storage capacity.

- Realistic potential in 2035 and 2050: DACCS as a method for Finland is seen as possible but unfeasible method in the short to medium long term, especially for the short-term target of carbon neutrality of

2035. This is due to lack of current investments and funding in Finland, lack of geological storage, lack of electricity and power grid needed for DACCS. Therefore, DACCS is only included in the theoretical potential.

- Citizen panel and stakeholder interview result: Neutral. Citizen panel participants and stakeholder interviewees viewed DACCS as a long-shot method—potentially viable if investment costs were to decrease significantly from current levels.
- Possible societal hindrance of deployment: Currently a lack of active actors and investment plans in DACCS, as attention and resources are primarily directed toward BECCS.

Biomass sinking and burial Not used in realistic scenarios

- Realistic potential in 2035 and 2050: none
- Citizen panel and stakeholder interview result: Neutral negative. Stakeholders and citizen panel participants generally felt that in Finland, biomass should be utilised rather than buried, with biomass sinking viewed even more negatively than conventional burial. While some respondents expressed neutral views—citing the method's perceived safety and its direct, long-lasting impact—overall sentiment leaned toward preferring more productive uses of biomass.
- Possible societal hindrance of deployment: lack of economic benefits and competing use cases for biomass.
- Available resources: Plenty of biomass but currently it is being used for other sources. Some land available for biomass growing.

Ocean Alkalinity Enhancement Not used in realistic scenarios

- Realistic potential in 2035 and 2050: none. The Baltic Sea is badly eutrophicated and it could benefit from alkalinity enhancement that could lead to enhanced carbon capturing capacities of the sea plants. However, strong public and institutional sentiment against intervening in the Baltic Sea - especially in ways that might pose short- or long-term risks - has hindered the consideration of this method. Currently, there is insufficient scientific evidence to confirm its suitability for the Baltic's unique ecological conditions. As a result, despite its theoretical promise, alkalinity enhancement is not included in realistic scenarios for scalable CDR deployment. That said, if robust studies and impact assessments were to demonstrate that the method could simultaneously support carbon removal and contribute to the ecological restoration of the Baltic Sea, it would likely gain significant traction. Finnish citizens, policymakers, companies, and NGOs share a deep sense of stewardship for the Baltic, and any solution that aligns climate action with restoration goals would be seen as both viable and highly attractive.

Direct Ocean Capture Not used in realistic scenarios

- In Finland, this method would involve direct carbon capture from the Baltic Sea. However, it is not considered a realistic option for large-scale deployment and was excluded from the theoretical and realistic scenarios. Both stakeholder interviews and citizen panel discussions revealed strong opposition to the method. The Baltic Sea is already ecologically fragile, and there is a significant lack of research on the potential impacts of carbon capture in such a sensitive marine environment.

ABOUT

Carbon Gap

Carbon Gap was established to be Europe's first philanthropically funded environmental advocacy organisation, focusing exclusively on CDR. The mission is to ensure that Europe becomes a leader in developing and deploying CDR solutions at scale in a safe and equitable manner to preserve a stable climate. Carbon Gap is coordinating the delivery of the project that has produced this report.

www.carbongap.org

Sweco

Sweco is Europe's leading engineering and architecture consultancy. Sweco Finland's Strategic Sustainability Consultancy was responsible for this report.

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