Preem CCS
2019 - 2021

Forskning, demonstration och förutsättningar för CCS på Svenska västkusten

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2022-04-21

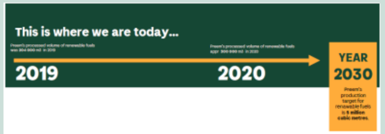
Unique collaboration made this project happen

- **Preem** and **Chalmers University of Technology** have previously studied CCS with good collaboration
- **Equinor** and Northern Lights provide valuable information about the value chain
- **Sintef's** extensive experience of CCS investigations is a very valuable contribution
- **Aker Carbon Capture's** technical solutions and Mobile Test Unit provide the practical knowledge and experience for the project to build on
- **Gassnova** and **the Swedish Energy Agency** financially supporting the project

3 year project 2019 - 2022

Budget 28 Mkr

Overview of activities in Preem CCS

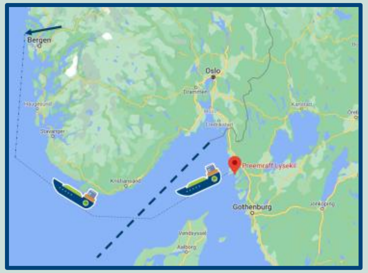


Roadmap for CO_2 emissions reduction via CCS for the Preem refineries

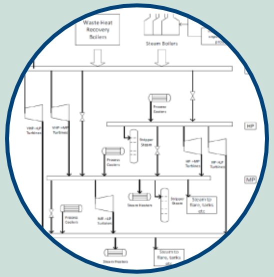
Described in the Synthesis report

CO_2 capture on-site demonstration

Transborder CO_2 transport for permanent storage – regulatory aspects

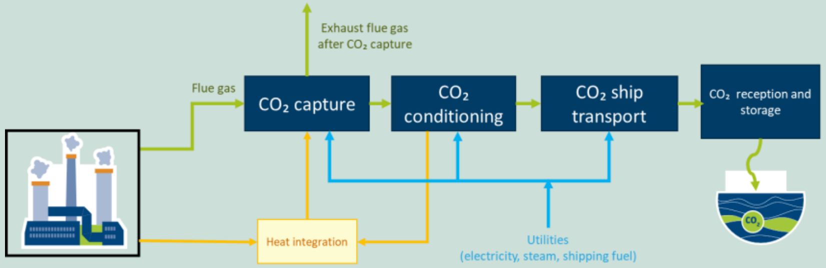


More efficient CO_2-capture, risk and cost reduction



Efficient use of residual heat – heat integration study
+ Compact heat exchangers

CCS chain analysis



Pilot scale testing of CO_2 capture at the Lysekil refinery

Pilot-scale testing of CO_2 capture from flue gases at refinery's hydrogen production unit (HPU)

Baseline emissions (corresponding to assumed future emissions with increase H_2 production in HPU):

- 1.855 Mt CO_2/a (refinery)
- 685 kt CO_2/a (HPU, CO_2 concentration 18-20vol%_CO_2,wet)

Aker Carbon Capture (ACC) mobile test unit (MTU)

- **capture capacity: up to 3 ton CO_2/day**

2 test campaigns

- Campaign 1: MEA solvent (30wt.%)
- Campaign 2: ACC's proprietary solvent S26

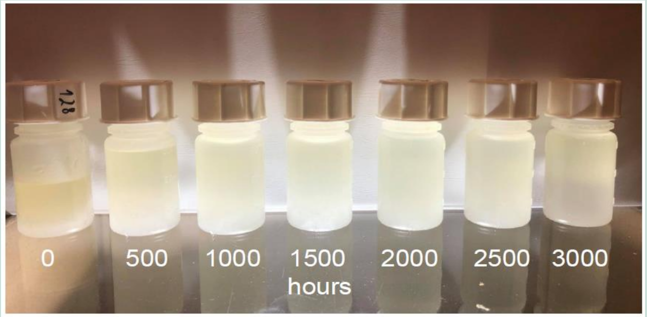
Main results of pilot scale testing

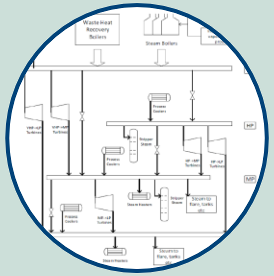
Campaign 1 MEA solvent

- **Approx. 500 hrs of operation,** 90% capture rate
- 57 tonnes CO_2 captured
- **Good performance of anti-mist design**
- **Clear indications of solvent degradation and loss**

Campaign 2 S26 proprietary solvent

- **Approx. 3000 hrs of operation** @90% capture rate (campaign 2 included some runs at higher capture rate)
- 363 tonnes CO_2 captured
- ***Energy performance*: SRD values 15–18% below those obtained during MEA campaign**
- ***Solvent degradation and losses*: one order of magnitude below measured values during MEA campaign**





Heat integration study - Conclusions

Heat supply for solvent regeneration is a major cost contributor

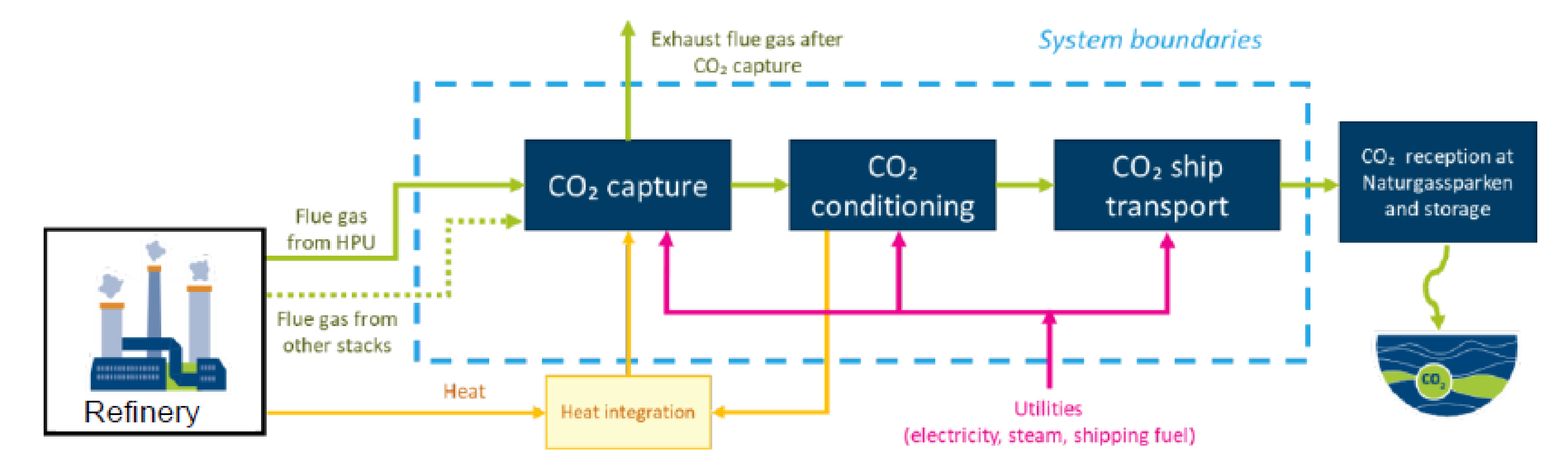
Recovery of residual heat at site could supply **~40%** of heat required to mitigate ~80% of the CO_2 emitted today at the Lysekil refinery (MEA capture; 90% capture rate)

Almost all heat needed for HPU capture from residual heat

Main gains with maximal recovery of residual heat:

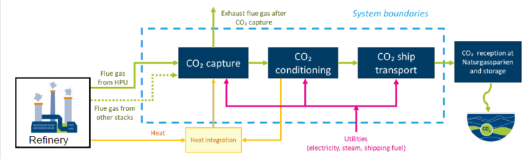
- **Maximizes CO_2 abatement if implemented in combination with heat pumps and electric boilers**
- **Minimizes the import of external energy and use of additional fossil fuels.**
- **Can save 29-36% of annual CO_2 capture cost compared to relying on external energy alone**

CCS Chain analysis



Case	CO_2 source at the Preem refineries	Approx. capture (90% of yearly emissions of corresponding stacks) [Mt CO_2/a]	Transport pressure [barg]
Case 1	Lysekil: HPU flue gas (SMR)	~0.616	15
Case 1A	Lysekil: HPU flue gas (SMR)	~0.616	7
Case 2	Lysekil: HPU+ combined stack 2 (low sulphur)	~0.940	15
Case 3	Lysekil: HPU + FCC	~0.799	15
Case 4	Lysekil: HPU + FCC + combined stack 1 + 2	~1.581	15
Case 5	HPU flue gas in Lysekil and Gothenburg	~0.916	15

Objective: **Evaluate technical feasibility and cost of the CCS chain** including CO_2 capture and transportation by ship to storage facilities off the Norwegian west coast



CCS Chain analysis - Conclusions

- 0.6–1.6 Mt/a of CO_2 can be captured with **calculated avoidance costs in the range 94–128 €/t CO_2-avoided** (storage cost not included)
- Capturing **larger volumes of CO_2 does not lead to lower specific avoidance costs**
- Reducing the **transport pressure to 7 barg leads to 44% lower costs** for on-site storage, loading and shipping
- The high-volume capture scenario (1.6 Mt/a of CO_2) **could potentially trigger implementation of Phase 2 of the Northern Lights project** (requires a CO_2 supply of 1.5-5 Mt CO_2/a)

More important lessons from the project

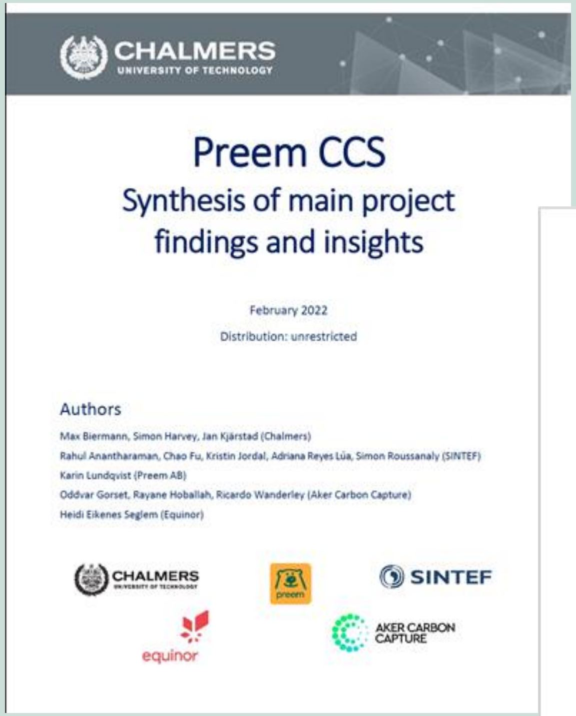
- **Proven robustness of the technology**
- **Regulatory barriers are removed but there is still work to do**
- **The entire value chain must be secured in the form of agreements, monitoring and regulations in place**

Read the reports from the project

Project web page
https://www.preem.se/foretag/kund-hos-preem/hallbart-foretagande/har-ska-koldioxiden-fangas-in/

Preem CCS Synthesis of main project findings.pdf

Preem CCS Legal and Regulatory.pdf


CHALMERS
UNIVERSITY OF TECHNOLOGY

Preem CCS
Synthesis of main project findings and insights

February 2022
Distribution: unrestricted

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SINTEF

Project Report

Legal and regulatory framework for Swedish/Norwegian CCS cooperation

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Report No:
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Clients:
Gassnova, Energimyndigheten, Preem AB

Technology for a better society

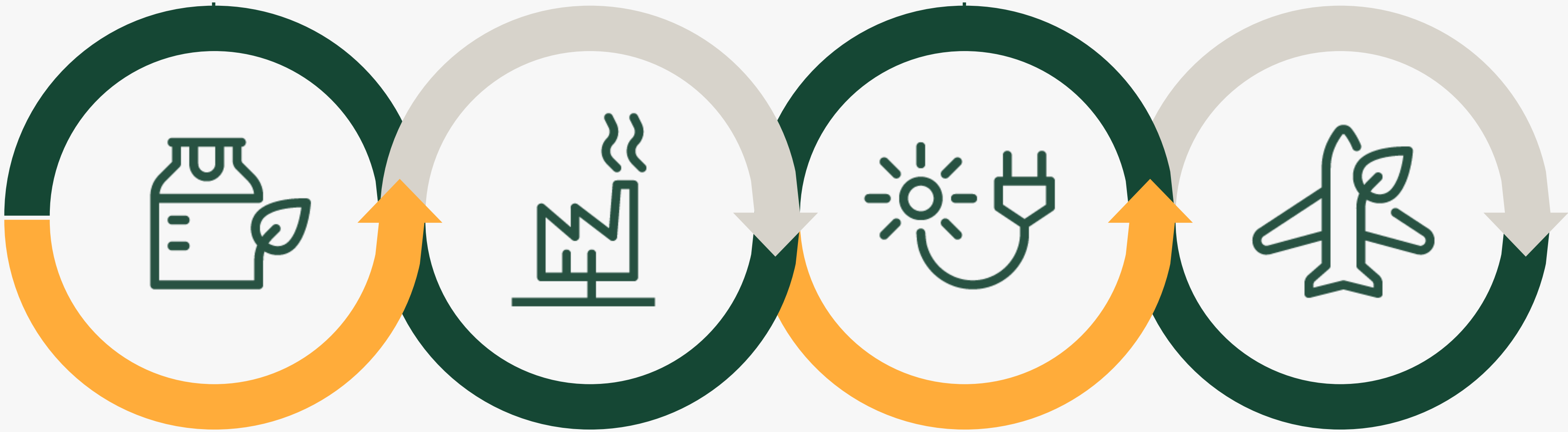
Preem's way forward

From fossil to climate neutral in 2035

Is it really possible?

01. Customize the refineries
so that fossil crude oil can be replaced by renewable raw materials

03. Replace natural gas
with renewable gas and production of fossil-free hydrogen



02. Establish CO_2 capture
facilities and evaluate compensatory measures

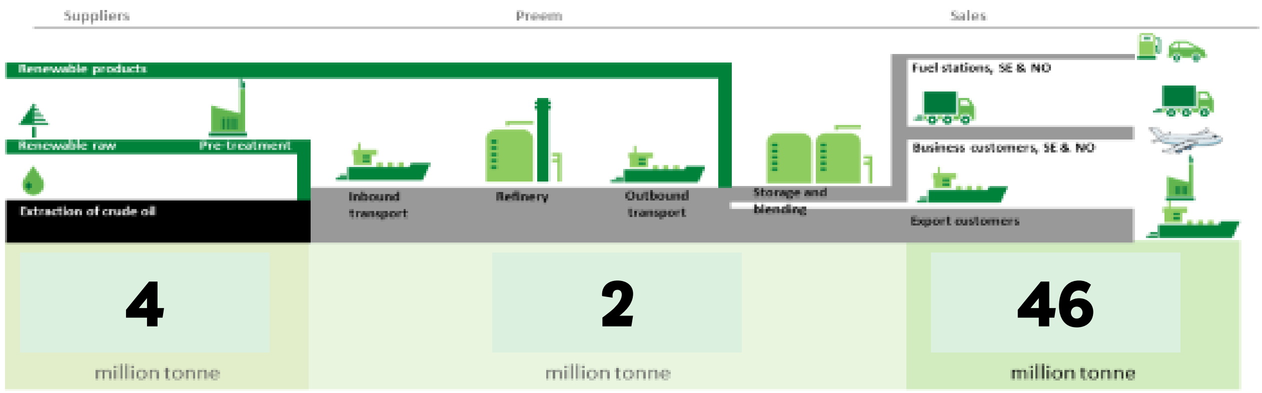
04. Adapt production capacity
and broaden operations to include more products and offerings in demand in a sustainable society

In 2010 Preem started renewable co-processing

Preem processed 340,000 m^3 of renewable raw materials in 2021

Why study CCS ?

Preem's most important contribution* to the climate goals is to reduce CO_2 in the end-use phase



million ton per year

*Refers to quantified emissions in 2018 and in prioritized emission categories as specified by the GHG protocol's "scope 3 standard"

- **CCS complements the transition from fossil to renewable production**
- **CCS with an increasing amount of bio-CCS**

And how can there be a full-scale CCS facility in place?

- We are looking at developing CCS for both refineries, Göteborg and Lysekil
- Implementation is depending on the time schedule of our transition projects and permit processes
- Fossil CCS is included in EU ETS, bio-CCS need other incentives.
- When the low-carbon hydrogen is used for renewables production, it brings value through the reduction quota regulation.
- In Lysekil we have our own harbor facilities
- In Göteborg we are part of the cluster project CinfraCap

CinfraCap

preem

CinfraCap

Captured carbon dioxide - from capture plant to quayside

The optimal solution for the future, for CSS logistics and infrastructure in Gothenburg

Phase I – 2020/21 project leader Preem
Phase II – 2021/22 project leader Nordion Energi and Göteborg Energi

We find the solution together

CinfraCap is a unique collaborative project with companies that share the ambition to reduce climate-affecting emissions here and now.

The project is supported by Industriklivet, the Swedish Energy Agency's climate initiative.

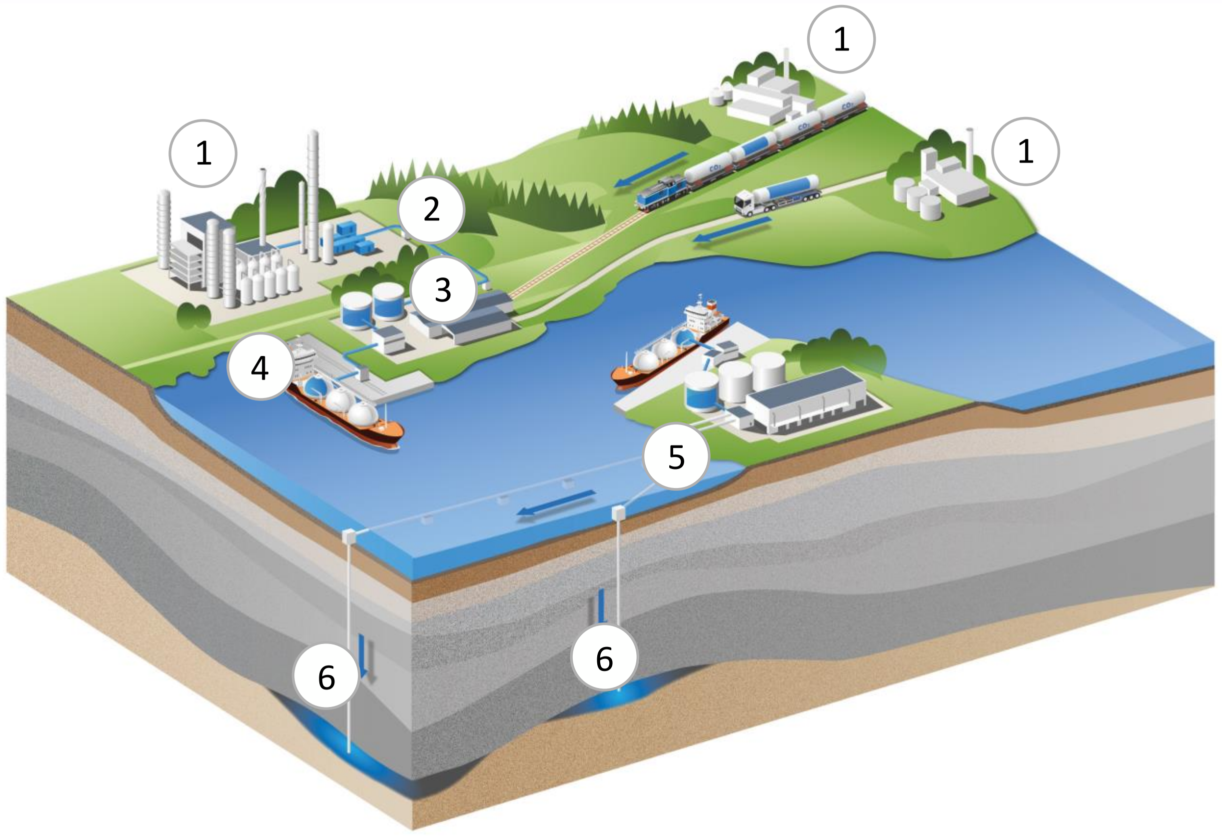
Project web page
https://www.goteborgshamn.se/hamnens-projekt/cinfracap/

Prestudy report phase I
https://www.goteborgshamn.se/globalassets/cinfracap-forstudie-23-april-2021.pdf

Design requirements

CCS value chain

1. Capture of CO_2
2. Transport of CO_2
    - Pipeline – liquid
    - Pipeline – gas
    - Tanker – liquid
    - Railway - liquid
3. CinfraCap - CO_2 terminal,
    - Intermediate storage and potential liquefaction
4. Loading to ships of liquid CO_2
5. Ship transport and Recieving facility
6. Geological storage



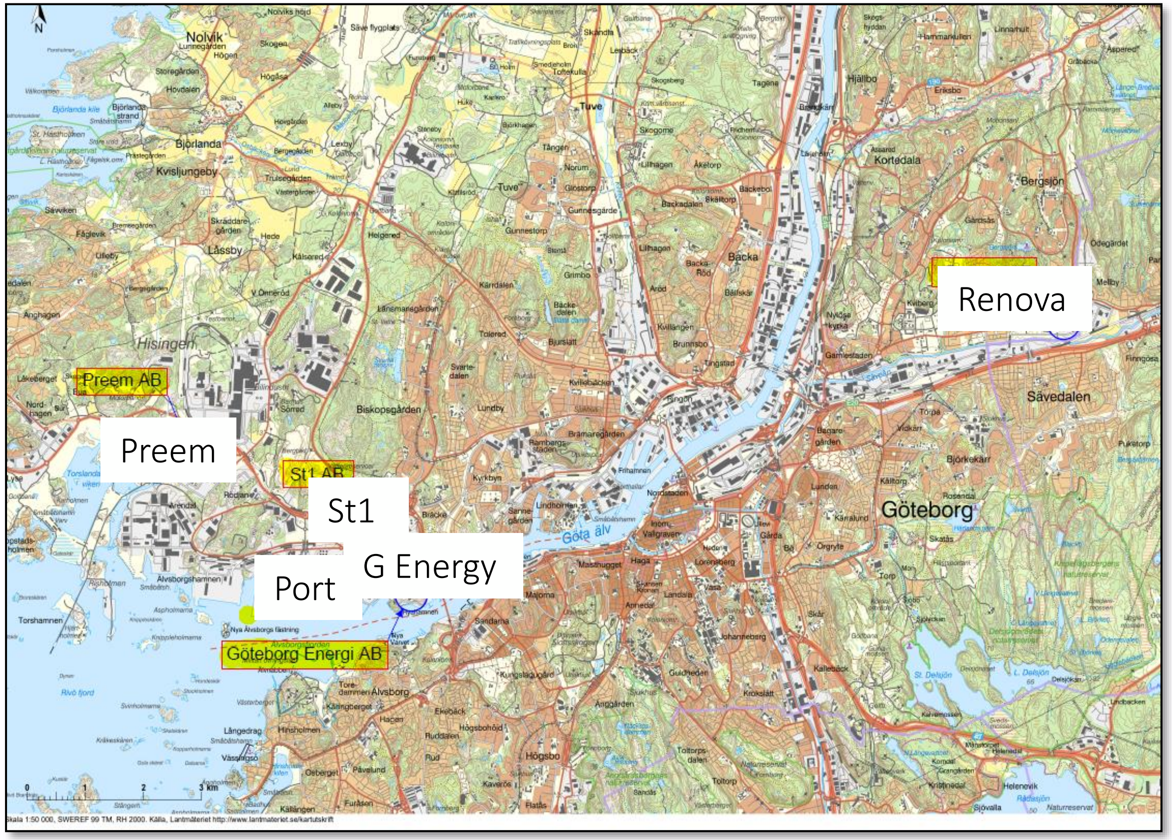
Incoming steams from the capture plants to the loading arm for export of CO_2 to ships at the quay.

Scope of the CinfraCap feasibility study

Capture → Pre-treatment → Transport → Liquefaction → Transport → Intermediate storage → Export to ship → Ship transport → Recieving facility → Geological storage

Design requirements

The parties - facilities physical location



Kick-off "Phase II" 26/1. Phase II ongoing until 30/10 aiming at producing input for BED/FEED.

WP1. Project management, communication

WP2. Technical design and cost calculations

WP3. Synchronization non- technical milestones

WP4. Potential locations final storage

WP5. Business model

WP6. Inventory permitting

WP7. Project risk analysis

CinfraCap

Tack för visat intresse

Overview of the project “Preem CCS”

General description of the project

Work packages	**Responsible**
• **WP0 Project management**	Preem
• **WP1 Demonstration of CO_2 capture on site**	Aker CC
• **WP2 Process evaluation and integration of full-scale CCS**	Chalmers
• **WP3 CCS value chain analysis: CO_2 capture, liquefaction and transport**	SINTEF
• **WP4 Identification of legal and regulatory barriers**	SINTEF
• **WP5 Definition of a roadmap for CO_2 reduction at Preemraff Lysekil**	Chalmers

What happens now?

- The “Preem CCS” has created trust to take the next steps e.g., a feasibility study for a full-scale facility
- Continued work with partners regarding the value chain in the form of agreements, regulations and permits
- The economic conditions need to be developed and fully understood, and become clear for the entire value chain