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CCS at the Klemetsrud WtE plant in Oslo, Norway

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IEA Bioenergy Task 36

Hybrid workshop: Biomass combustion and CCUS

IEA Bioenergy Intertask BECCUS, 21.09.2023



Technology for a better society



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Scope

- Longship, Norway's full-scale CCS project
- Northern Lights, CO₂ transport and storage infrastructure
- The Klemetsrud WtE carbon capture project:
 - Key WtE plant data
 - Carbon capture and transport and storage
 - Comments on WtE & CCS operation
 - A short recent timeline
 - The budget up early 2023
 - The April 2023 announcement



The Klemetsrud WtE plant, photo: Hafslund Oslo Celsio



Longship

- Longship is the Norwegian Government's full-scale carbon capture and storage project

The three elements of Longship:

- **Capture of CO₂** at the Heidelberg Materials (previously Norcem) **cement factory** in Brevik.
- **Capture of CO₂** at the Hafslund Oslo Celsio **waste-to-energy plant** (previously Fortum Oslo Varme) in Klemetsrud, Oslo.
- A combined **transport and storage solution**, managed by **Northern Lights JV DA**.

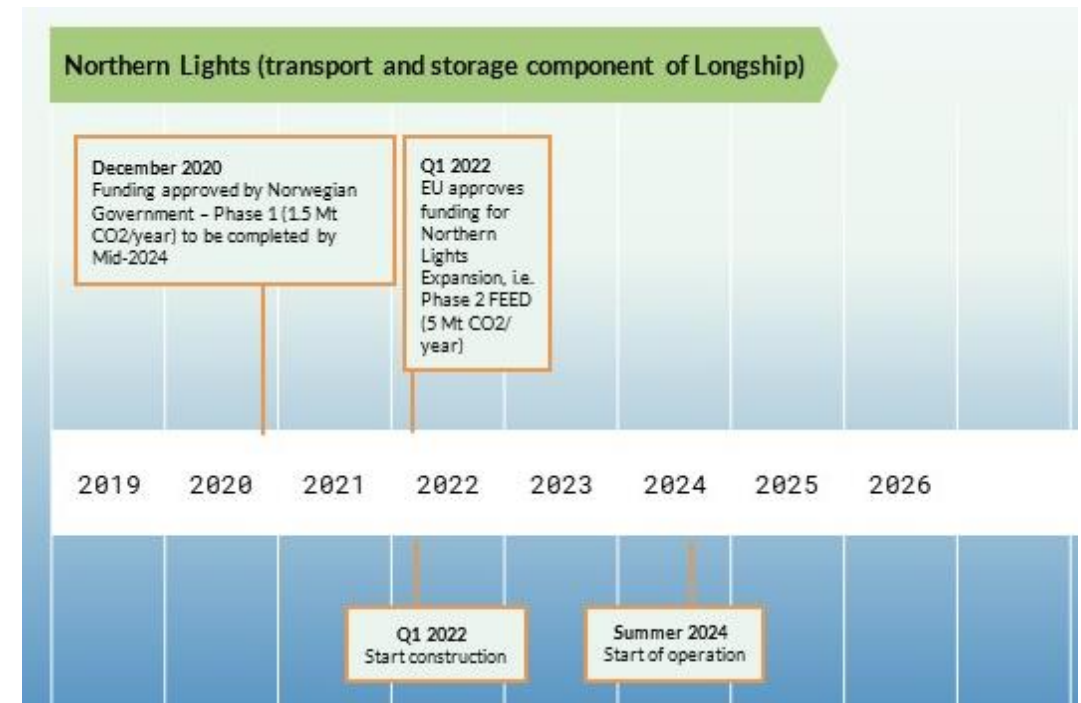


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Northern Lights

- Northern Lights: the world's first open-source* CO₂ transport and storage infrastructure
- Owners Equinor, Shell, and TotalEnergies
- Supported by the Norwegian Government

* Contract signed with Ørsted (Denmark) for example



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Quality specification for liquified CO₂



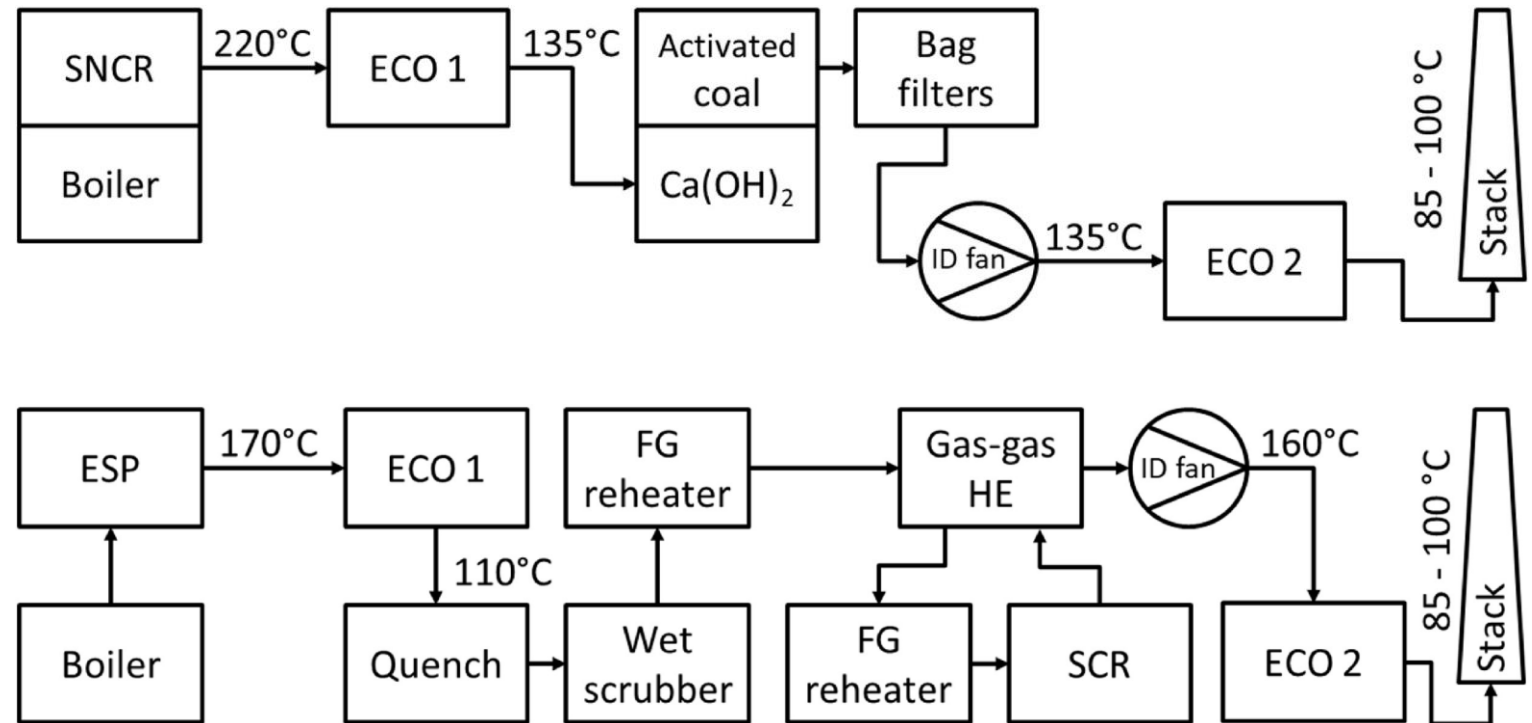
Component	Concentration, ppm (mol)
Water (H ₂ O)	≤ 30
Oxygen (O ₂)	≤ 10
Sulphur oxides (SO _x)	≤ 10
Nitric oxide/Nitrogen dioxide (NO _x)	≤ 10
Hydrogen sulphide (H ₂ S)	≤ 9
Carbon monoxide (CO)	≤ 100
Amine	≤ 10
Ammonia (NH ₃)	≤ 10
Hydrogen (H ₂)	≤ 50
Formaldehyde	≤ 20
Acetaldehyde	≤ 20
Mercury (Hg)	≤ 0.03
Cadmium (Cd), Thallium, (Tl)	Sum ≤ 0.03



Non-condensable gases are components that, when pure, will be in gaseous form at 15 barg and -26°C. The content of non-condensable gasses will be limited by the actual solubility of the liquid CO₂ in the interim storage tanks at the capture plants.

The Klemetsrud WtE plant key data

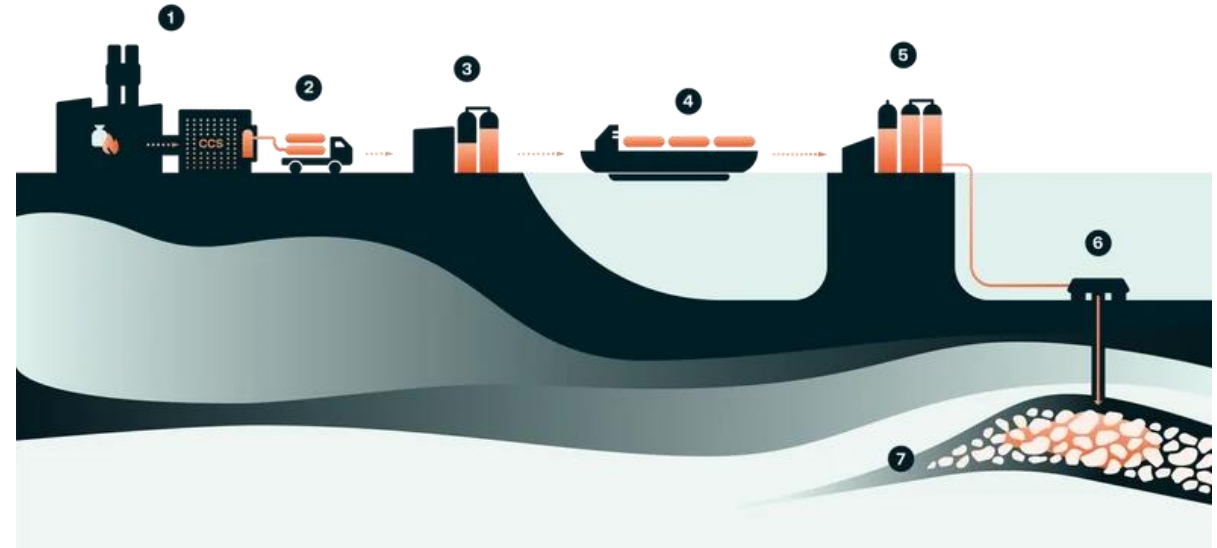
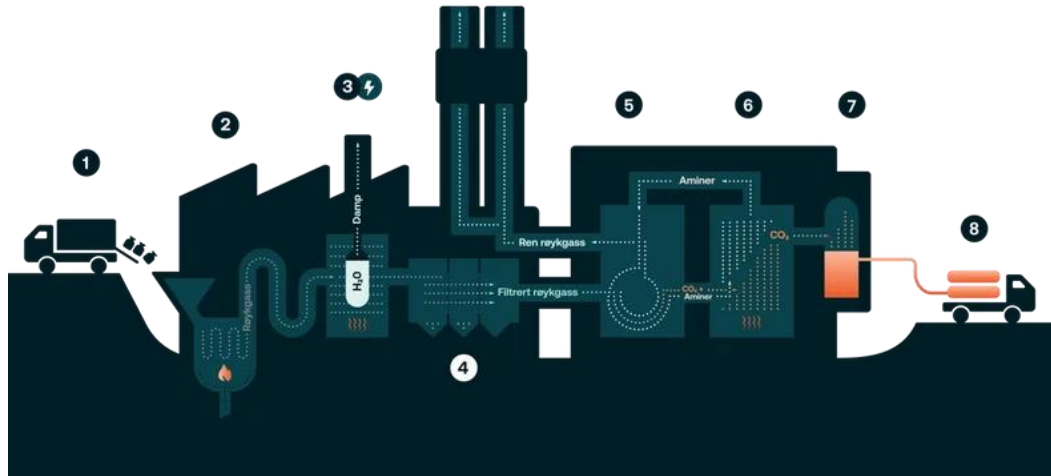
- 3 lines (K1&K2 + K3) →
- Approx. 400 kt/y residual waste (commercial, industrial, households)
- Ca. 400 kt/y CO₂ (14% of Oslo's emissions)
- District heat & electricity production





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Carbon capture and transport and storage from Klemetsrud



www.celsio.no

- Capture by amines
- Conditioning (liquefaction) on-site
- Transport by trucks to a temporary storage (harbour) before transport by ship to permanent storage (Northern Lights) off-shore



A few comments about WtE & CC operation

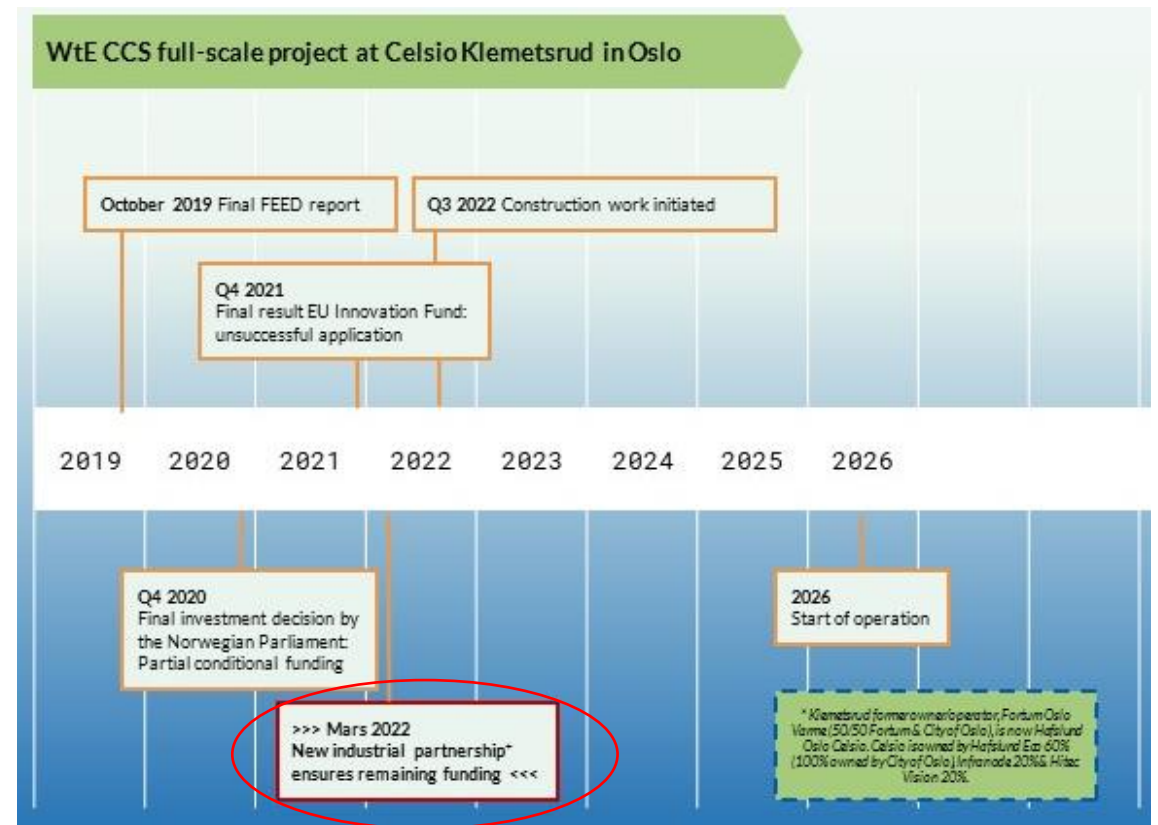
- Amines
- Several experimental campaigns carried out (ref. article)
- Flue gas composition & fluctuations – a challenge?
- Excess heat in the summer – integration?



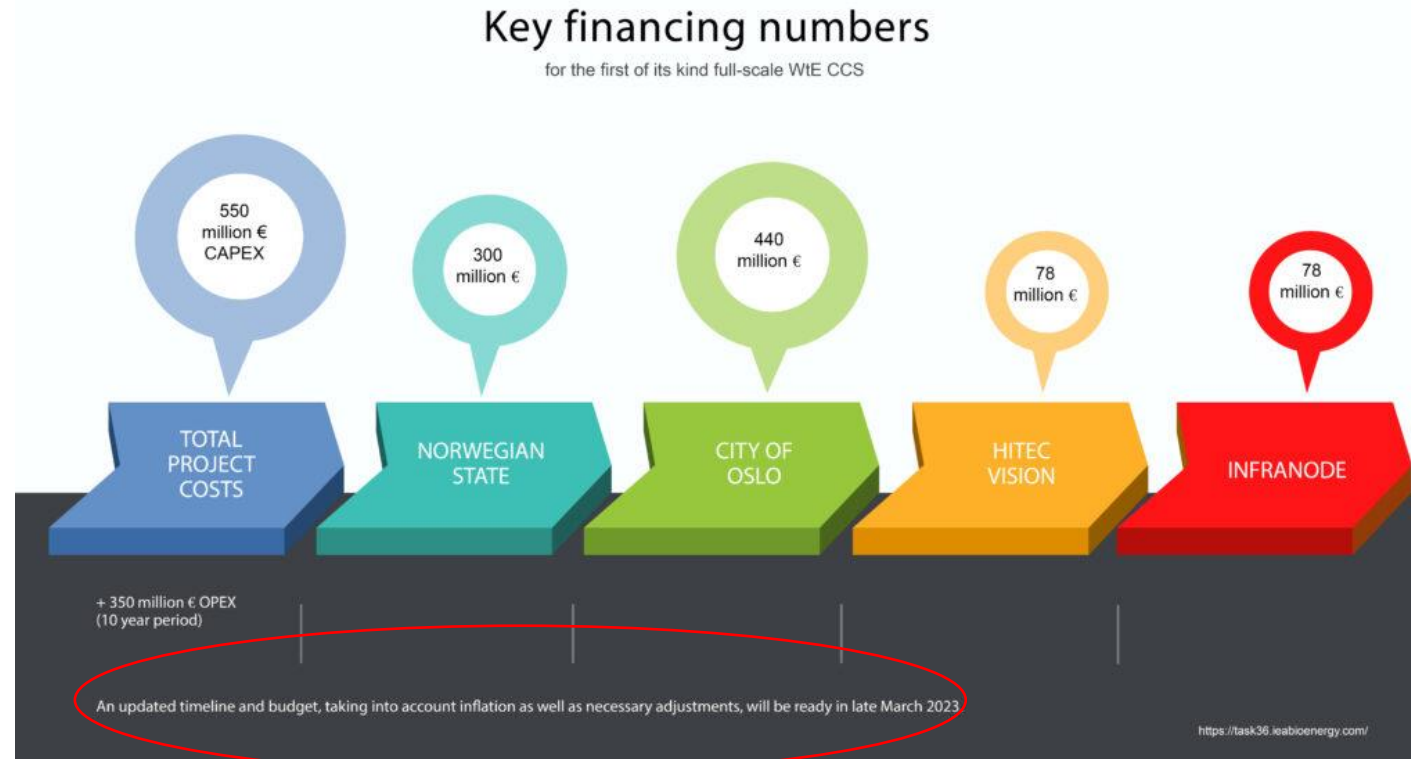
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A short recent timeline *up to March/April 2023*

- First feasibility study initiated in 2015
- Several pilot campaigns
- Demolition and construction started in the summer of 2022



The budget *as it was up to early 2023*



- 1 € = ca.10 Norwegian kroner (figure)



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The April 2023 announcement

- The updated budget estimate shown a *significant* increase in materials and energy costs mainly due to:
 - Inflation
 - Geopolitical instability
 - Unfavourable exchange rate (weaker Norwegian currency, 1€ = ca. 11.5 Norwegian kroner as of today)
- But also: a revised harbour alternative, access to electricity, real estate, project organisation

=> It was decided to halt the project immediately and initiate a *12-month cost-reduction phase*



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