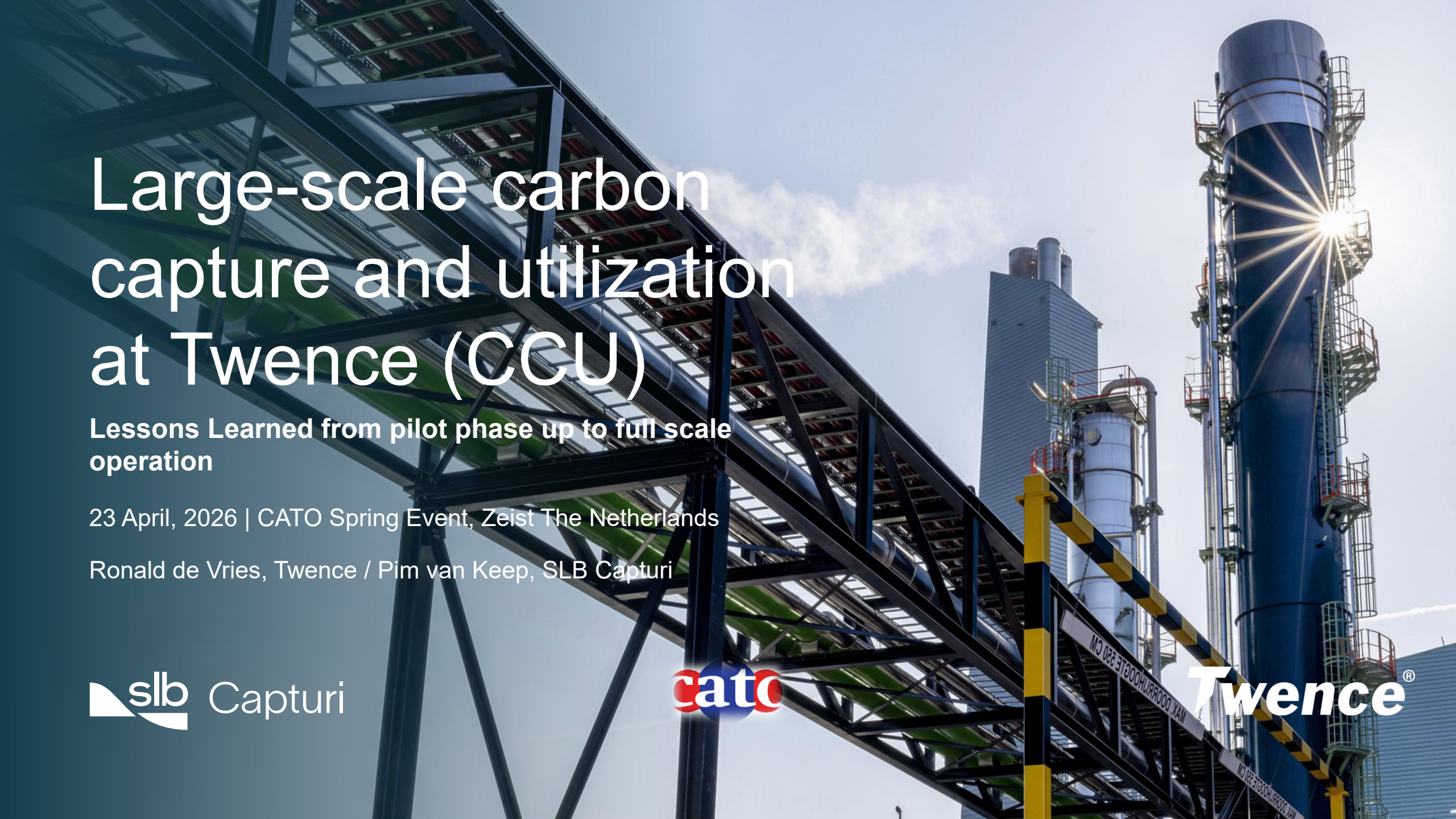

Large-scale carbon capture and utilization at Twence (CCU)

Lessons Learned from pilot phase up to full scale operation

23 April, 2026 | CATO Spring Event, Zeist The Netherlands

Ronald de Vries, Twence / Pim van Keep, SLB Capturi

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Full Scale CCU Project at Twence

- Journey to full scale level
- Lessons learned
- Preconditions for EU State Aid
- CCS infrastructure in NL
- Cross Border CCS options
- **How to de-risk future CCUS projects?**

Journey to full scale project development

Lessons Learned from Pilot CCU	Feasibility and Basis of Design	CCU –Project Development (100 kton/a)	Realization and Start Full Scale Operation	2nd and 3rd Extension of CCU / CCS projects
2015 onwards	*2016 onwards*	*2017 onwards*	*2021-2024*	*2025 – 2032*

- Key Success Factors: EIA | Permit | LCA | End of Waste
- CO_2 Off Take Contracts depend on Funding Challenge
- Funding Challenge depends on subsidy schemes
- Specific subsidy schemes depend on:
  - Scalability
  - Innovative character
  - Eligibility with applicable State Aid legislation
  - Compliance with Art.107 of the TFEU

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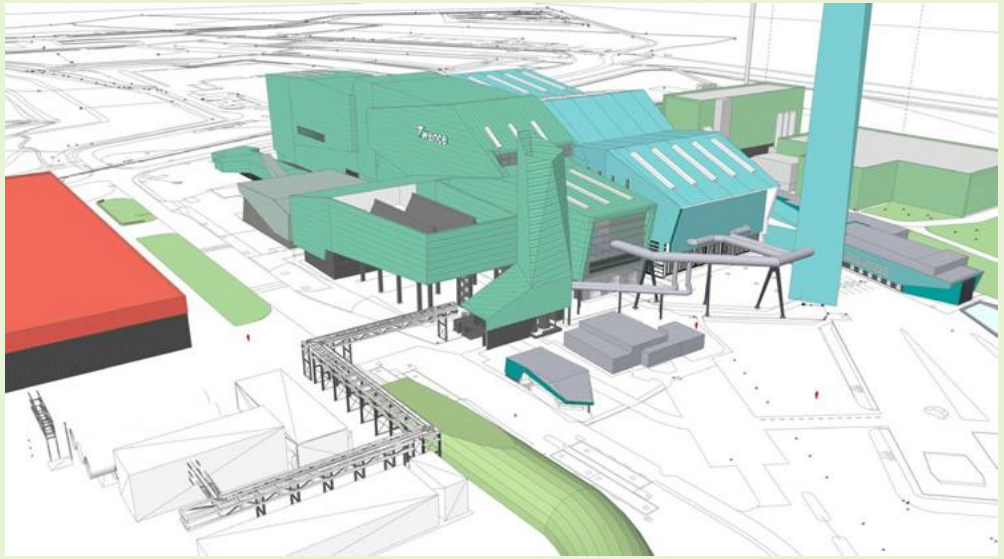
Completion of Full Scale CO_2 Capturing Unit at Twence

Absorber & Stripper

Artist Impression of the installation



Storage tanks for liquid CO_2

Characteristics used by Dutch Government (PBL, 2022)

- Capex : 59 million euro (14 tph)
- Opex : 1,8 million euro per annum
- Heat consumption : 1.028 kWh_{th}/ton of CO_2
- Electricity consumption : 212 kWh_e/ton of CO_2
- CO_2-emission reduction : 0,93 ton of CO_2 per ton as a result of avoided natural gas consumption by horticulture sector

Status at present:

- Ready For Use since January 2025
- Start full operations 2Q 2025
- Capacity 12,5 tons of CO_2/hour
- Supply of liquid CO_2 to green houses
- Food grade quality

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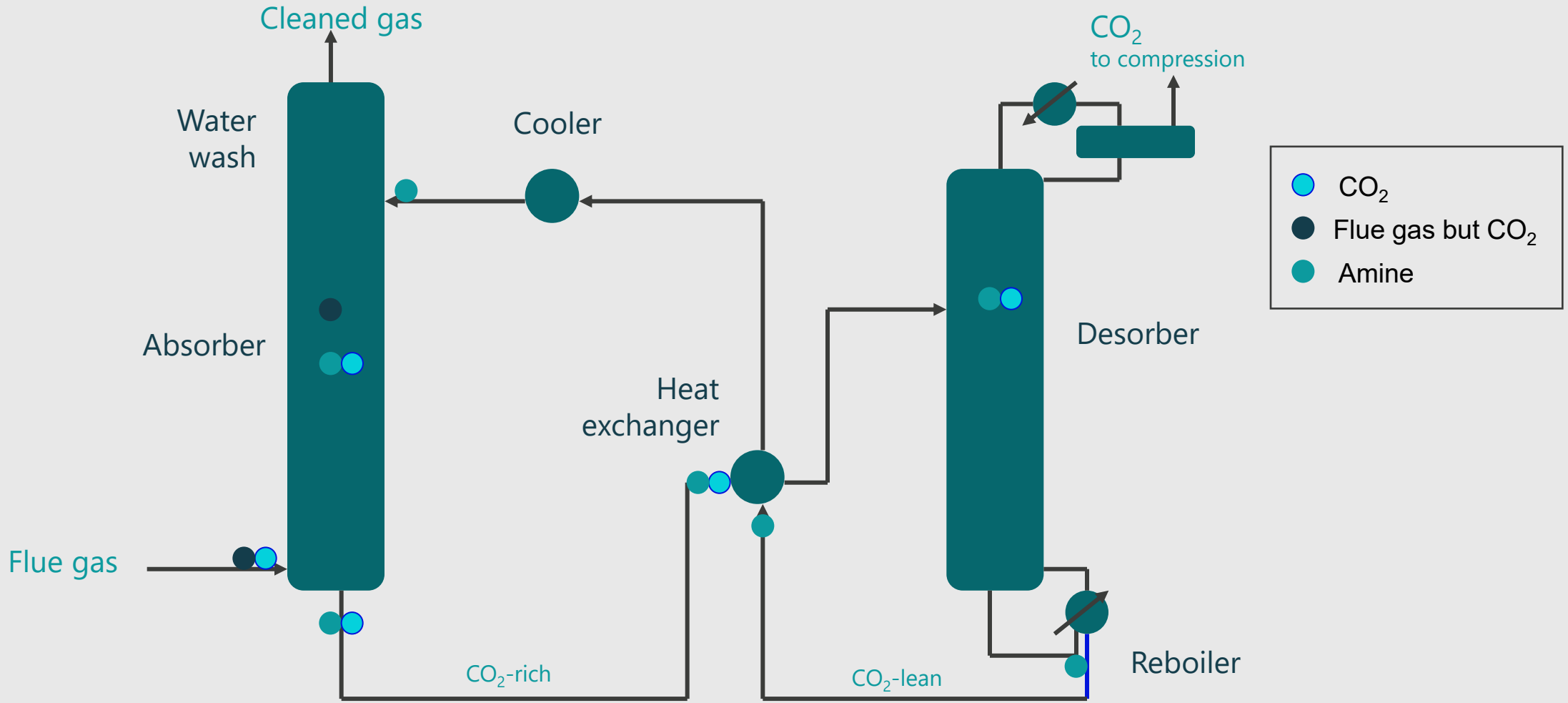
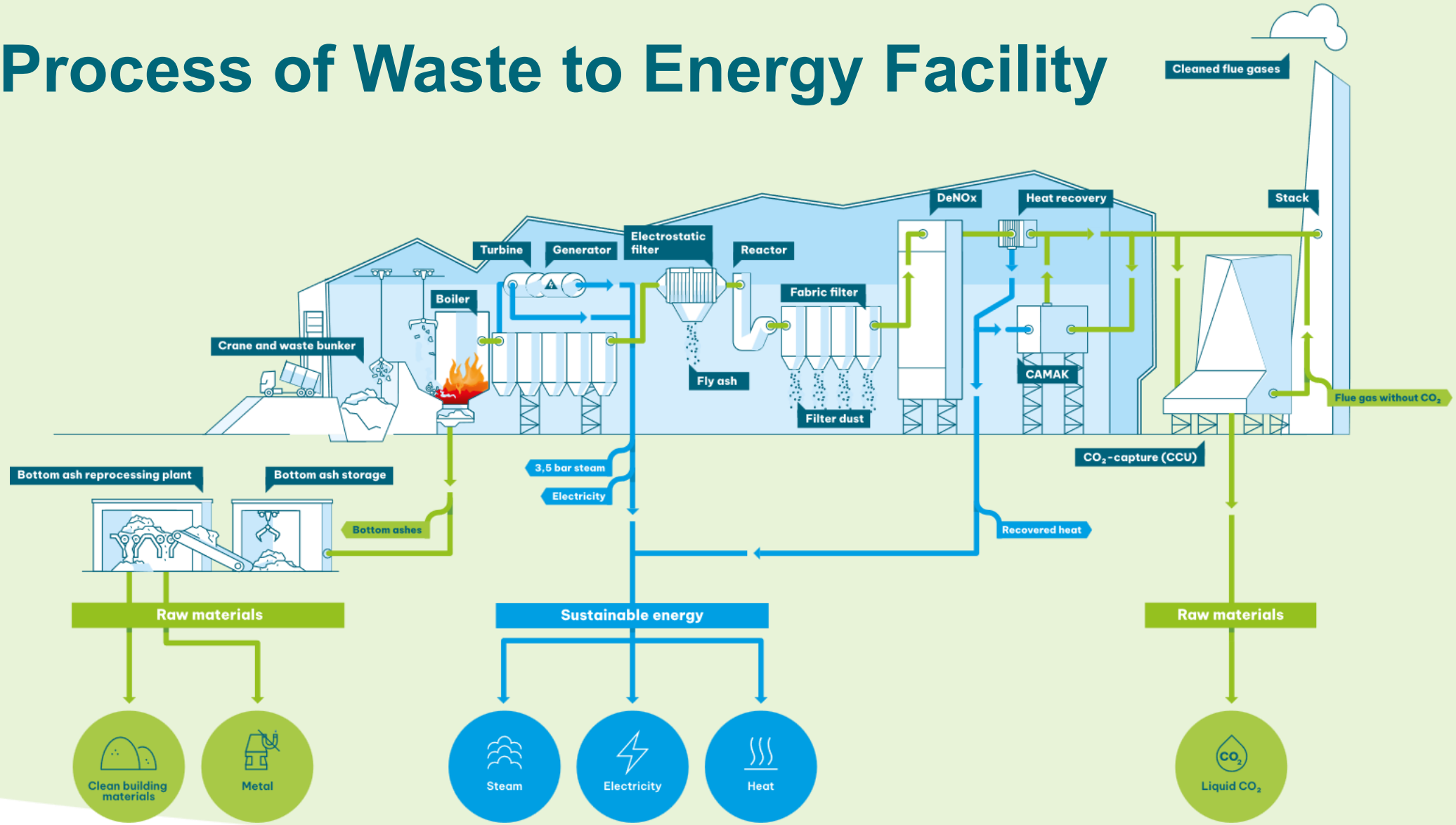
Process of Pilot Plant and Full Scale CCU Plant



Process of Waste to Energy Facility



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Preconditions for state aid and EU approval

Criteria assessed by DG Competition

- Environmental protection
- Market and re-use CO2 produced by Twence

Conclusions

- Reduction fossil CO2 at Greenhouses
- Sustainable and circular product chains

Conclusion State Aid Approval (2022)

overall balance with regard to the objective of common interest

of environmental protection is positive

- Before FID (2022), subsidy schemes were not available for this 1^{rst} of a kind CCU facility
- Currently, we have generic OPEX subsidy schemes (SDE++),
  but we need CAPEX support schemes for upscaling CC(U)S projects too
- Looking ahead, new CAPEX subsidy schemes will be necessary to make future CCUS infrastructure eligible for financing


Absorber
Desorber
Modular Just Catch™ 100
Process Equiment
Air Cooling Bank
Liquefaction
Truck Loading Stations
Tank Storage
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Lessons learned from Construction and Commissioning

From 2021 onwards until now at Twence Hengelo

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Operational learnings

Challenges during commissioning

- Challenges related to the interface between the separation unit and the compressor and condensing unit
- Implementation of changes to prevent the carryover of trace elements
- Compensating measures to reduce noise levels at adjacent neighborhood

Operational performance

- First modular carbon capture project of its kind
- Stable capture performance
- Capacity: >12.5 tons/hour
- Energy consumption lower than design

December 2021
Signed Contracts

Februar 2023
Installed Columns

End 2023
Mechanically complete preparation for commisioning

Q3 2024
Improvements installed

December 2024
Final commissioning

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Updated CCUS Roadmap => Net Zero in 2030

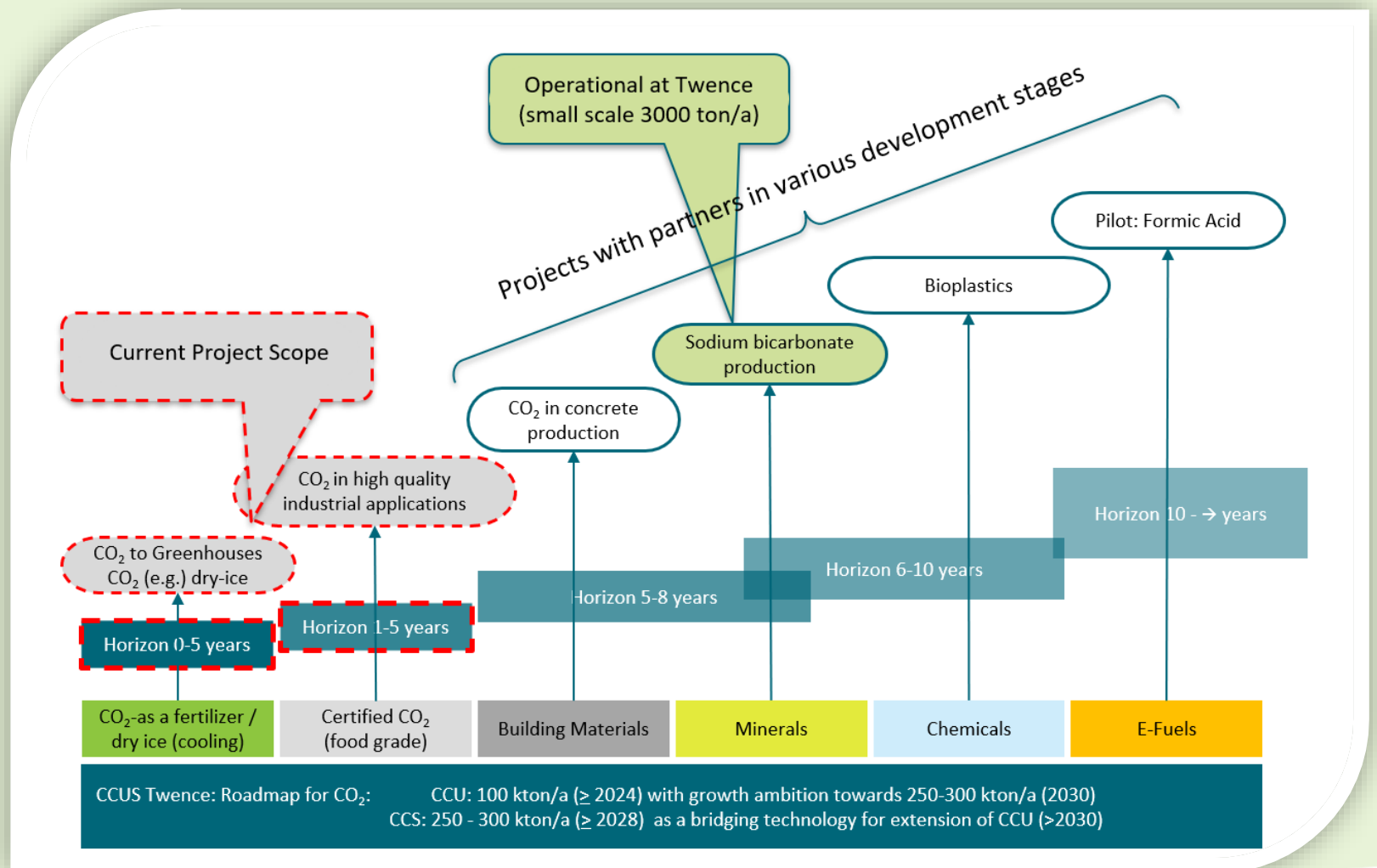
CCU routes:

- CO_2 to Greenhouses
- CO_2 to industry for dry ice and food grade applications
- CO_2 to minerals

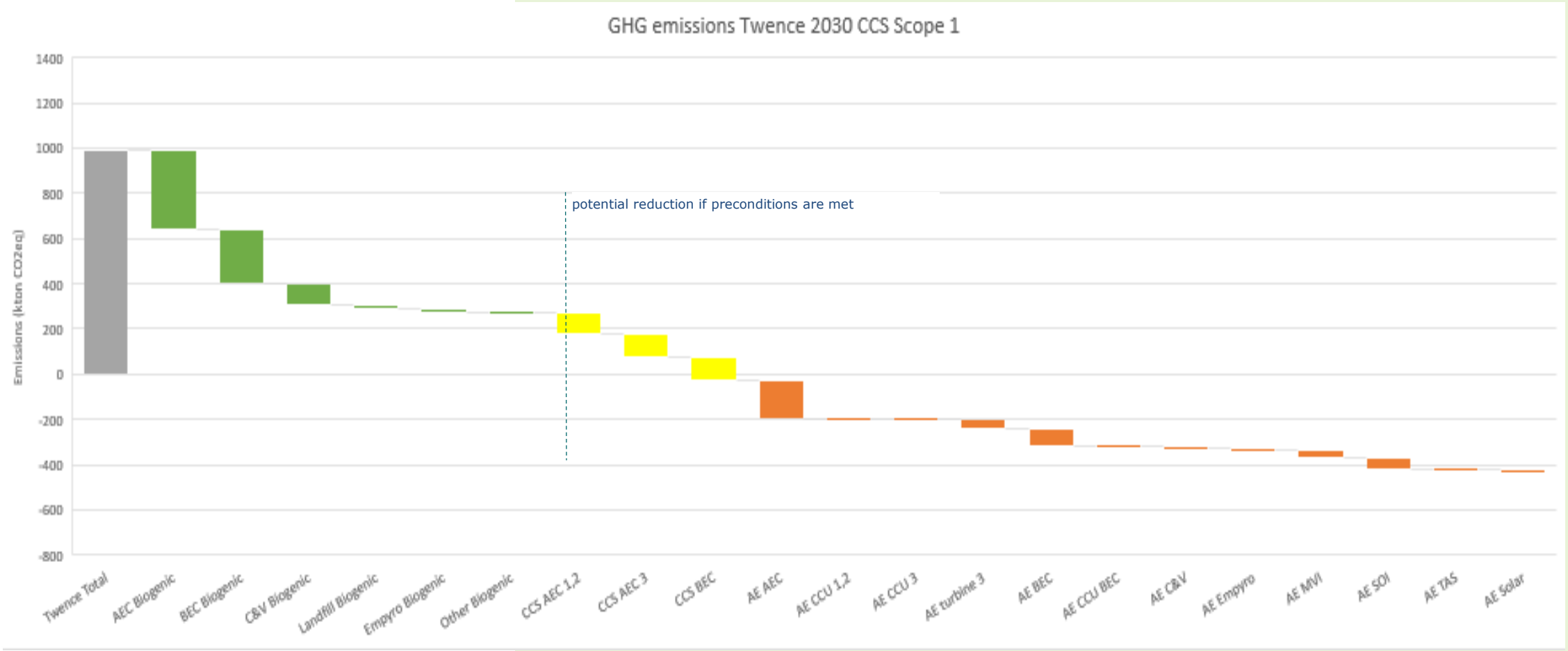
In 2030: goal to achieve net zero CO_2 footprint

CCS routes:

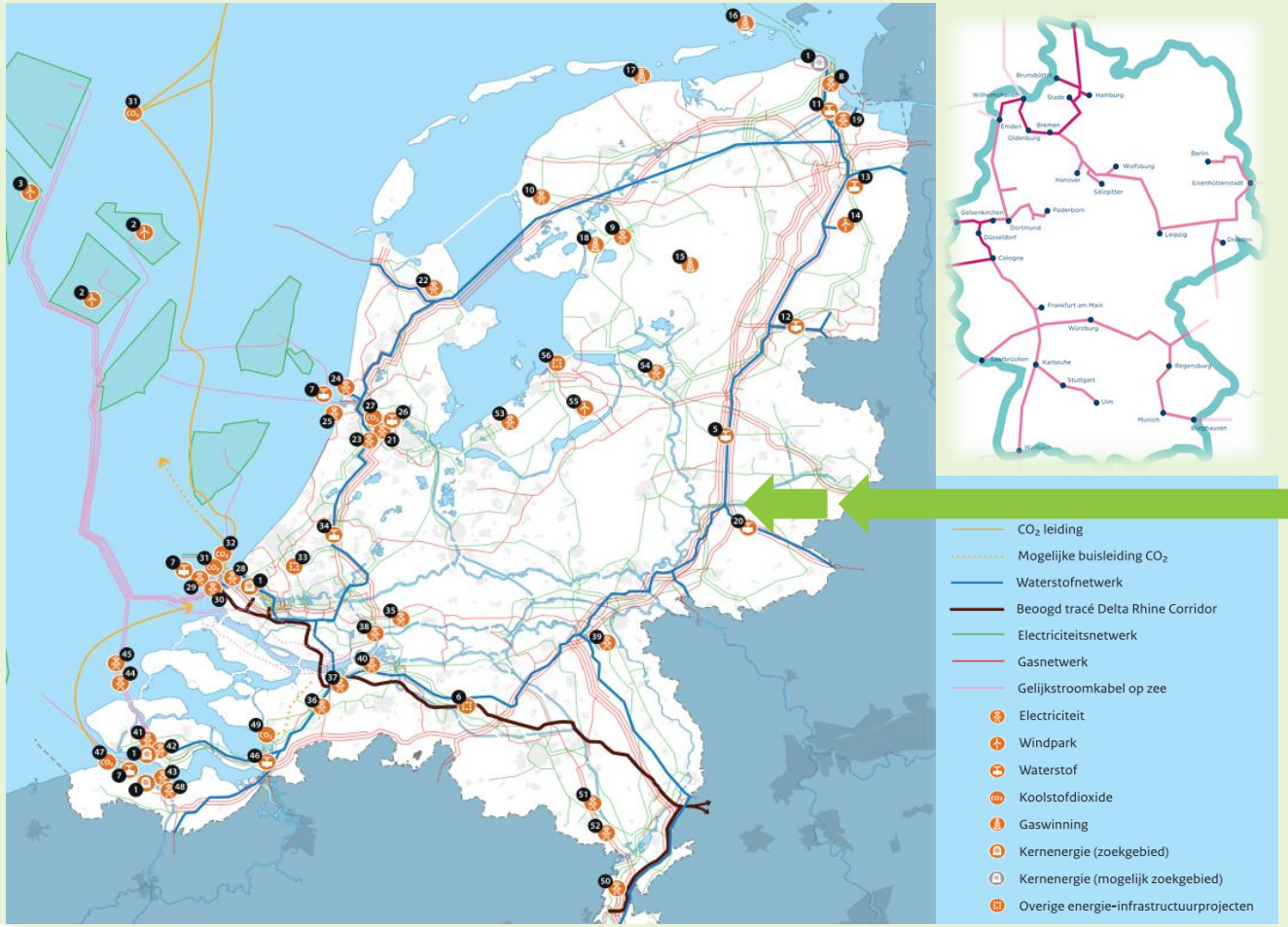
- Required before 2030
- New CCUS Projects



CO_2 Footprint Twence – forecast 2030



CCS infrastructure developments for CO_2 transport



- Aramis and Porthos
- Intended route of Delta Rhine Corridor
- Northern CCS corridor to transport CO_2 (?)
- OGE grid connection to Wilhelmshaven (?)
- Upscaling CCUS requires shipping and connection to a feed-in point of the CO_2 grid

Aramis CCS | Aramis marked as energy project of national importance

CO_2 Grid | OGE | https://oge.net/en/co2/co2-grid

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How to de-risk chain risks for future CCUS projects?

- Cross border CCS infrastructure(s) and grid redundancy / storage capacity / flexibility S&D
- Regulations, support schemes: CAPEX & OPEX
- Equal level playing fields (CO_2 tax systems)
- Affordable levels for CO_2 transport
- Solutions for ‘off-the-grid’ companies
- Synergy between CCS & CCU routes

Climate agreement from Paris (2015)

<2°C

Global warming

49%

less CO_2 emissions in 2030

11 mln. tonnes

less CO_2 emissions waste **incineration sector** in 2030*

Climate goals The Netherlands

55%

less greenhouse gas emissions in 2030*

2050

climate neutral

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How to make future CCUS projects bankable?

.. to enable emitters to connect to future CCS infrastructure?

Risk Mitigation and Protection Measures

- Governmental protection for emitters and T&S providers
- Capital Grants for CCS Grid Infrastructure
- Bioswap for emitters and greenhouses
- EU level playing field for national levies and taxes

Together towards a sustainable future

Thank you for your attention!

Thank you!

Visit us at:
www.twence.nl
capturi.slb.com

Impact at scale

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