CCU at Twence
Status from Pilot to Demonstration

Workshop on EU funding opportunities for CCU projects

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Twence®

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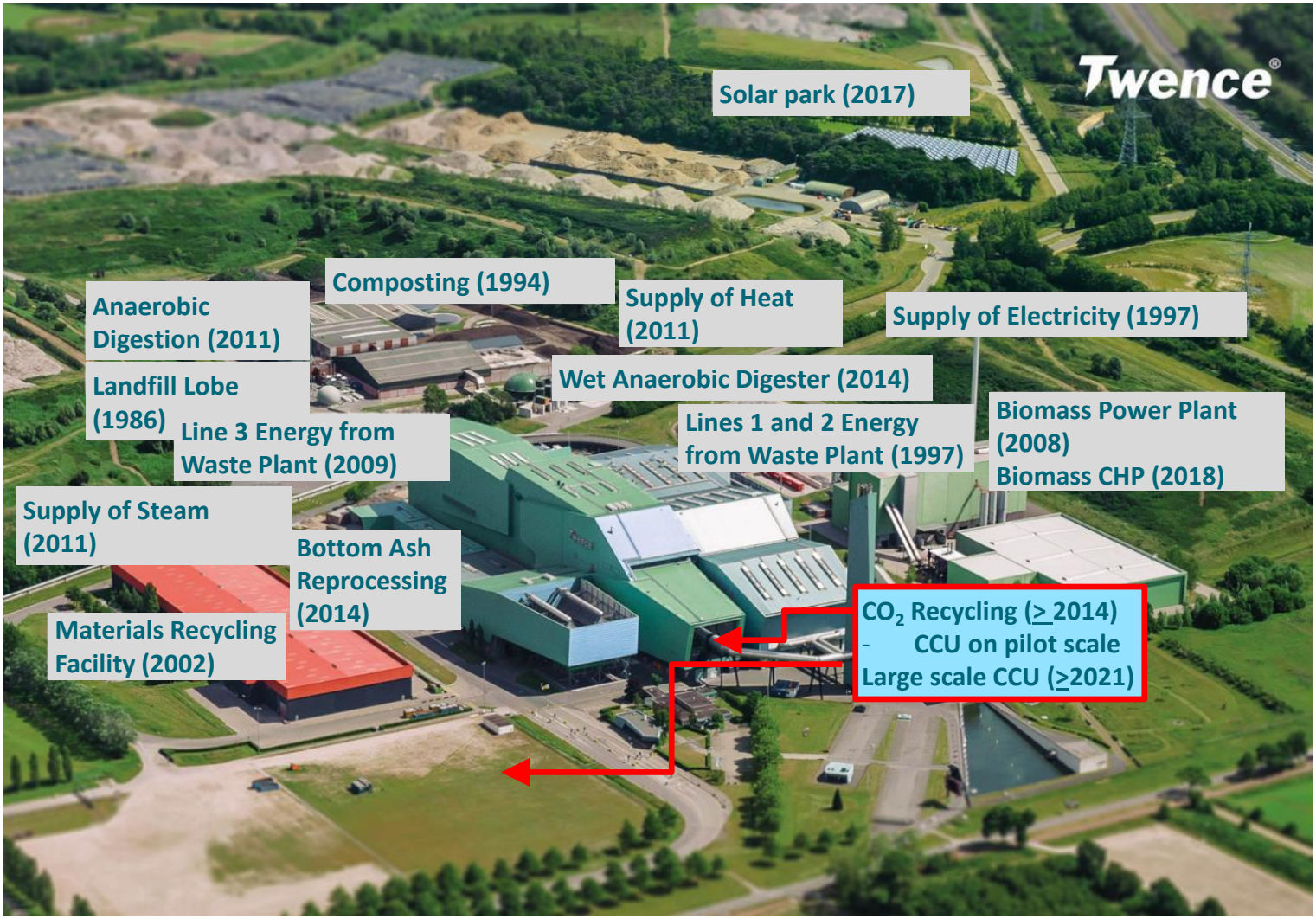
1. Introduction Twence



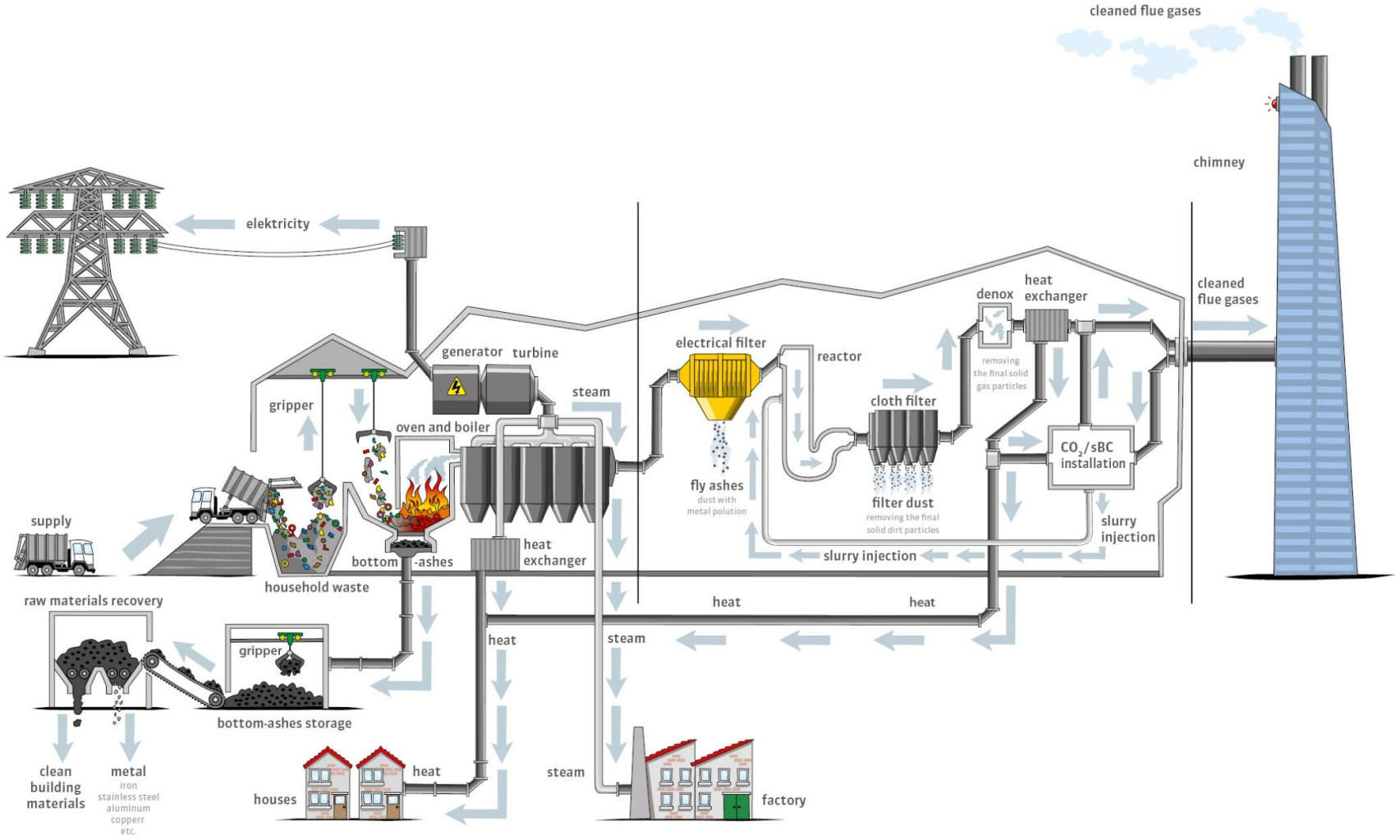
2. CCU roadmap from 2008 onwards

Rationale for CO_2 valorisation	to produce sodium-bicarbonate (SBC) to reduce acid gas emissions (Cl, SO2) towards zero-emission waste treatment
Reaction	$Na_2CO_3 + H_2O + CO_2 \rightarrow 2\ NaHCO_3$
• CO_2 reduction	3,000 tonnes per year
• SBC production	8,000 tonnes per year

Roadmap towards demonstration

• First idea demo on CO_2 capture	Autumn 2007
• Start 3 kton/a Demonstration Plant	July 2011
• Commissioning	October 2014
• Demonstration Programme	2014 onwards and ongoing
• Preparation 100 kton/a Full Scale Plant	2017 onwards and ongoing

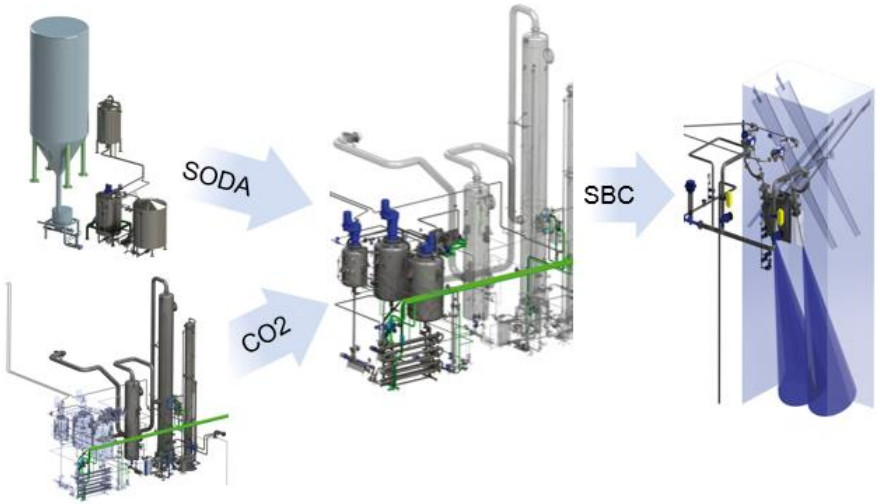
3. Innovative Technology of CCU at EfW Line 3

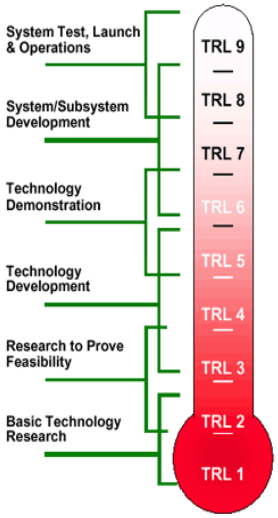


3. How innovative is the CCU Pilot?

Key elements and products

- Amine salt based CO2 capturing
- Mixing process of sodium and CO2 in H_2O
- Production of 8 kton/a $NaHCO_3$
- $NaHCO_3$ suspension injected in FGT
- Savings in transport movements (40 m^3 diesel) and 2 – 3 kton/a CO_2

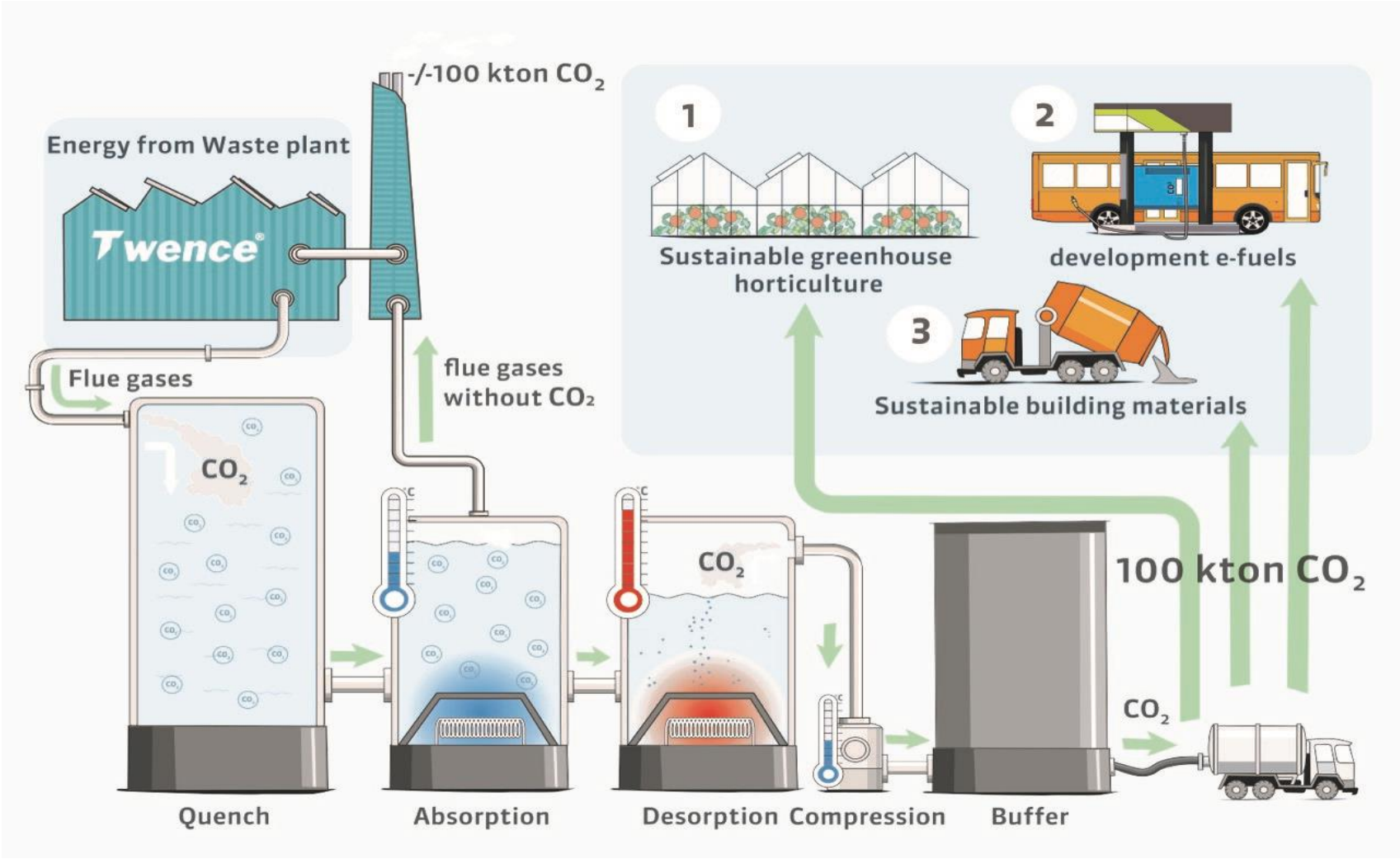




Technology Readyness Level (TRL)

- TRL – 8 system tests (2015) to TRL-9 in past 4 years of operation
- First installation in the world that 'mineralizes' CO_2 for re-use (absorbent) in flue gas scrubbing
- CEWEP Innovation Award on 20th September 2018; Bilbao Spain

3. Project development of large scale CCU



4. Level of uncertainty / Financial Gap / LCA results

- CAPEX and OPEX estimates based on FEED and tender (re-)quotes
- Inaccuracy below 20%; Off-take contracts in preparation
- Mid term strategy focused on x% horticulture and y% mineral materials

CCU route	Profitability gap per ton captured CO_2 stripper gas (€/ton CO_2 stripper gas)	Emission reduction compared to non-capture (kg CO_2-eq./ton CO_2 stripper gas captured)	Cost effectiveness per ton CO_2 emission reduction (€/ton CO_2 emission reduction)
Mix of: 40% Horticulture short 60% Mineralisation	48	Mean value: Approx. 1,200 kg of CO_2-eq.	40
Carbon8 *	NA*	861 kg	NA*
Orbix	38	1,915 kg	20
Sodium bicarbonate	38	787 kg	48
Horticulture short-term (2022)	83	876 kg	95
Horticulture long term (2030)	83	137-475 kg	175-606

Dependency on other projects:

- Eligibility of Innovation Fund (EU) for CCU at EfW facilities (ETS products)
- What if CCS can be combined with CCU in carbon capture projects at EfW?

4. Project development timeline at Twence

Positioning

- WtE line 3
- Dry flue gas cleaning line 3
  - ESP
  - Bag House Filter : activated carbon & sodium bicarbonate injection
  - SCR

Planning

- Start operation Q2 2021

Key Decision Making Hold Points

- Environmental Permit
- Grants for Subsidies
- Financial Closure
- Approval of Supervisory Board
- Contracts for off take and design & construction

4. Market Potential

De-carbonization of EfW facilities in Europe:

- Via CO2 capturing and integration with flue gas treatment process line(s)
- Via synergy of utilities: low-pressure steam supply / condensate return
- Improvement of energy efficiency
- .. 96 Mton/a EU EfW capacity* potentially available for CCS/CCU
  .. 8 Mton/a NL EfW capacity: by 2030 1.1 Mton/a (fossil share of) CO2 capturing in EfW sector

CCU off-take potential – a growing market

- Greenhouse sector in the Netherlands => 1.5 – 2 Mton/a CO2
- Orbix: Bricks via reaction of (5%) CO2, (20%) stainless steel slag and (75%) sand
  - In NL circa 0,5 Mton/a steel slag available => 125 kton/a CO2
- Carbon8:
  - 6% recyclable coarse aggregates in concrete (NL: 282 kton/a)
    - 30% coarse aggregates in concrete
    - 20% of coarse aggregates replaceable by recycled material
  - 40 kg CO2 per ton Carbon8 intake (4% * 282) => 11 kton/a CO2
- In EU concrete production capacity 263 Mton/a (56 times NL production capacity of 4.7 Mton/a)
  - EU market for CO2 potentially (11 * 56) => 616 kton/a CO2

* 2017, CEWEP Data from factsheet ' Waste to energy plants in Europe 2017' by Confederation of European Waste to Energy Plants -CEWEP http://www.cewep.eu/waste-to-energy-plants-in-europe-in-2017/

5. Conclusions and Key Questions

- Development time 10 years from initial idea towards upscaling
- Learning curve (process stability) requires development time
- Uncertainties in upscaling first commercial plant:
  - Inaccuracy operational performance (OPEX)
  - Solvent developments and choices
  - Initially high(er) CAPEX levels required
  - Dependency on (new) subsidy regulations and off take contracts
  - Future policy and financial instruments for CCU

Key Questions

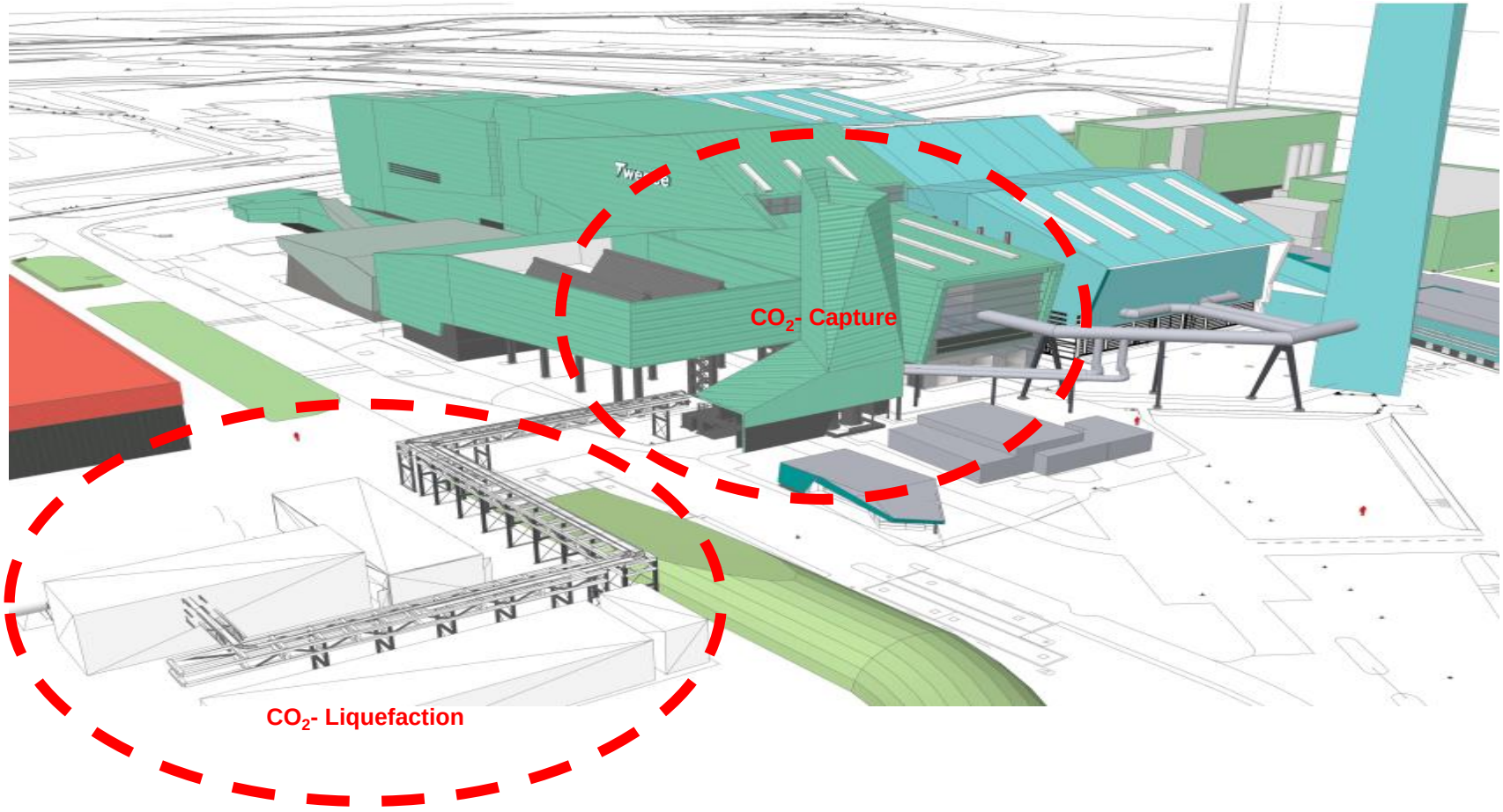
- Can the capturing and supply of CO2 (CCU) at WtE facilities* be considered as an eligible CCU project in the framework of EU - Innovation Fund support scheme?
- Can an LCA analysis provide the objective and transparent criteria to assess eligibility for EU-support?
- What if different CCU options are combined in carbon capture projects at EfW?
  => is a combination with CCS eligible for support ?

* towards horticulture / construction materials / minerals / chemicals be considered as an innovative renewable energy and energy storage technology00

Many thanks for your attention

Any Q&A?

4. CCU – Artist Impression



4. LCA Assumptions and Results

Methodology

The Life Cycle Assessment (LCA) methodology was used to determine the environmental impact of the capturing of 1 tonne of CO_2 and its subsequent utilization of the captured CO_2. The assessment was carried out in line with the ISO 14040 and 14044 standards.

190105 - Environmental and economic analysis of carbon capture at Twence combined with four types of utilisation - June 2019

Four types of CO2 capture and utilization

1. Utilisation of CO_2 as fertilizer in horticultural applications (greenhouses)
2. Mineralisation of CO2 in:
    1. Carbon8: production of aggregates from residual materials and CO2
    2. Orbix: production of bricks from aggregates, residual materials and CO2
3. Production of sodium bicarbonate
4. (Electrical) Production of e-fuels like formic acid (chemicals serving as H2-carriers)

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