

# What does it take to decarbonize the hard-to-abate industries: CCUS perspective

CO<sub>2</sub> Capture, Storage & Reuse  
16-17 May 2023



**RAMBOLL**

Bright ideas.  
Sustainable change.

Burcin Temel Mckenna

Head of Carbon Capture Competency Center

# Who we are





# Ramboll in brief

- Independent architecture, engineering and consultancy company
- Founded 1945 in Denmark
- 17,000 experts
- Present in 35 countries
- Particularly strong presence in the Nordics, the UK, North America, Continental Europe, and Asia Pacific
- Creating sustainable solutions across Buildings, Transport, Energy, Environment & Health, Water, Management Consulting and Architecture & Landscape.
- EUR 1.9 billion revenue
- Owned by Rambøll Fonden – The Ramboll Foundation

Ramboll's +17,000 experts work globally across nearly 300 offices in 35 countries



- Across the world, **Ramboll combines local experience with a global knowledgebase to create sustainable cities and societies**. We combine insights with the power to drive positive change to our clients, in the form of ideas that can be realised and implemented.
- We work multidisciplinary across our seven markets:



**Transport**



**Buildings**



**Environment & Health**



**Energy**



**Management Consulting**



**Water**

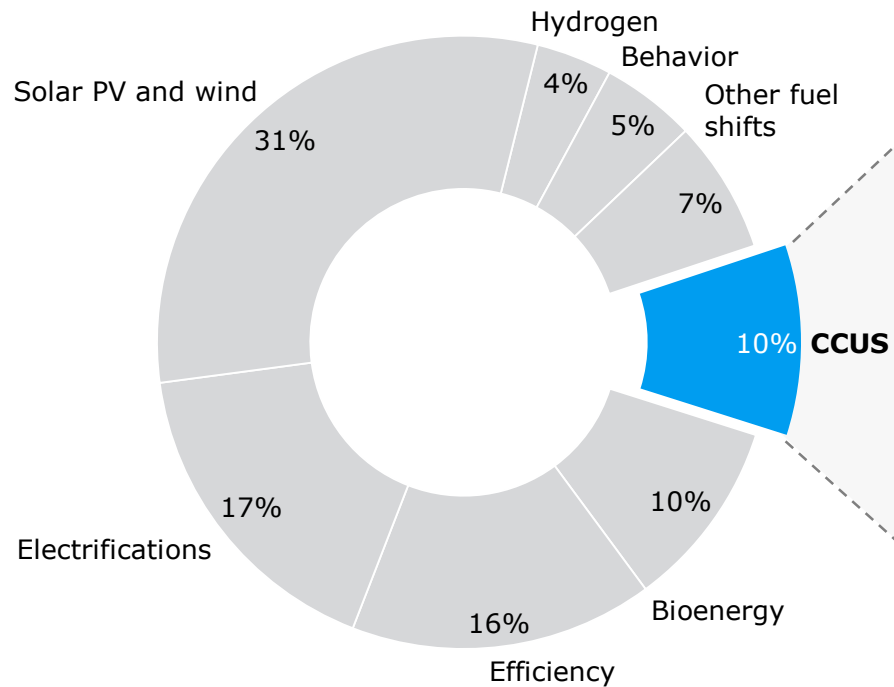


**Architecture & Landscape**

# Carbon capture value chain services

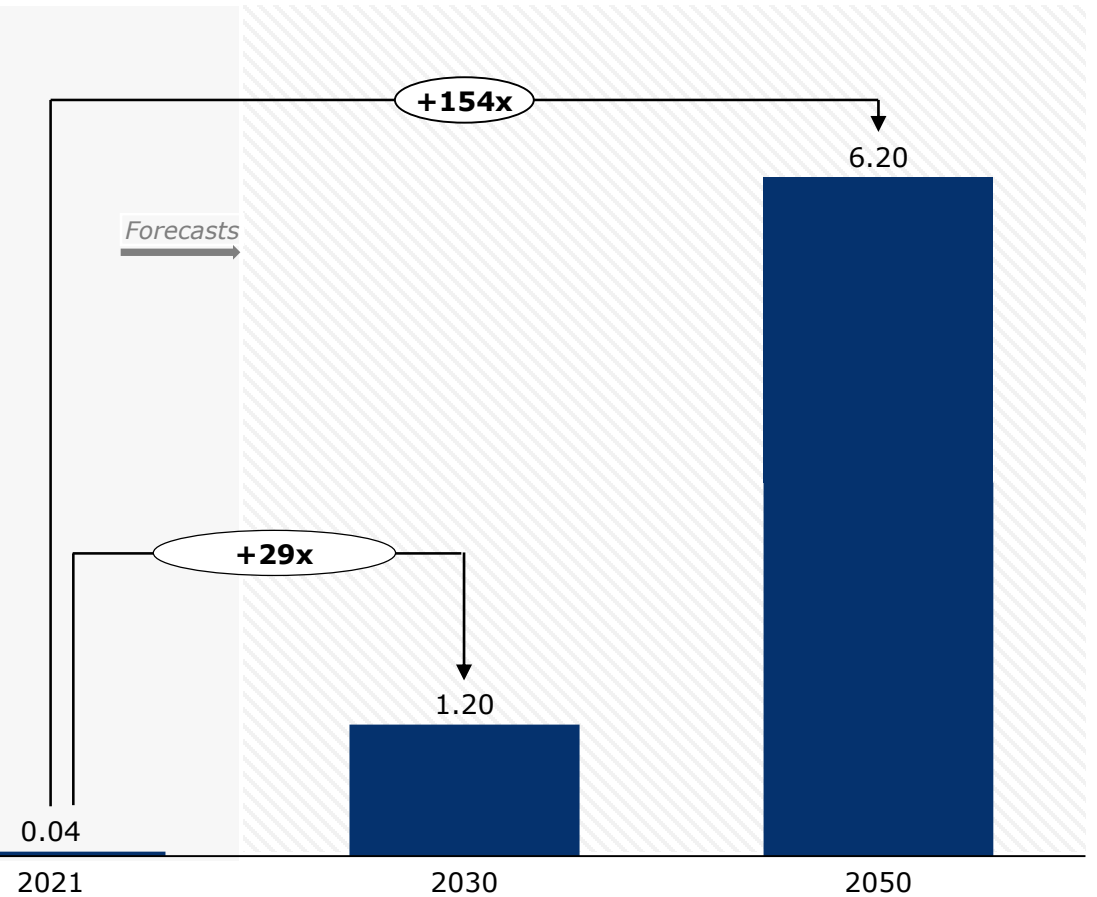
# CCUS is expected to account for 10% of the global cumulative CO<sub>2</sub> reductions in the net zero scenario

Global cumulative energy sector CO<sub>2</sub> emissions reductions by decarbonization pillar 2050, %



CO<sub>2</sub> Capture, Gigatonne (Gt)

Growth



Sources: IEA (2022)

Notes: "Other fuel shifts" include other renewables, nuclear, and switching from coal and oil to natural gas. "Behaviour" includes energy service demand changes from user decisions (e.g., changing heating temperature), as well as avoided demand, which refers to energy service demand changes from technology developments (e.g. digitalisation).

# Carbon capture, utilisation & storage

”

With more than 40 experts and project managers and more than 70 successfully completed assignments within CCUS over the last two years Ramboll is a leading CCUS advisor.

We have a deep understanding of the industry, the technologies and their application and so we can help clients navigate the challenges and pitfalls that projects in this market entail.

”





# Ramboll offers a unique mix of technological, commercial and global expertise and experience within CCUS

We know the technology

Ramboll is a world leading advisor within CCUS and is at the forefront of the development of the technologies used at all phases of CCUS.

Our expertise builds on many years of experience within e.g. capture of CO<sub>2</sub> from power- and Energy-from-Waste plants, on- and offshore handling and transport of gasses, on- and offshore oil- and gas operations and Power-to-X projects.

We have experience with all facets of carbon capture, incl. amine capture, oxyfuel, chilled ammonia, CO<sub>2</sub> compression, etc.



We work across the entire value chain

We embrace work across the entire value chain of CCUS, from carbon capture, to transport, utilisation and /or storage.

Ramboll works as a trusted technical and commercial advisor for clients and has assisted developers, policy makers and technology providers with more than 70 CCU/ CCS projects across the globe and at all project stages.

Consequently, we know and understand the key stakeholders, their needs, concerns and requirements.



We understand all the commercial aspects

Our team of technical CCUS experts, collaborate closely with our experienced management consultants with strong focus and capabilities within CCUS.

We know and understand the carbon and energy markets, hereunder market trends, drivers and challenges, the strengths and weakness of different business models and pre-requisites for operational excellence.

We also have a comprehensive knowledge and understanding of the regulatory environment both globally and locally, and how it impacts projects commercially.

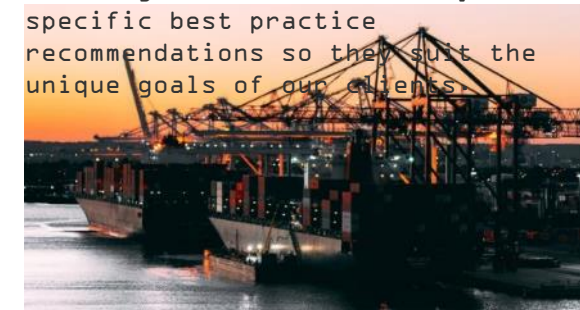


Our experience is global

Ramboll is a large global and multidisciplinary consultancy with global experience combined with in-dept market insights and understanding through our strong local presence.

Our global footprint, gives us in-depth "insider" knowledge about market conditions, sector connections and local industry dynamics and practices (incl. business cultural dimensions).

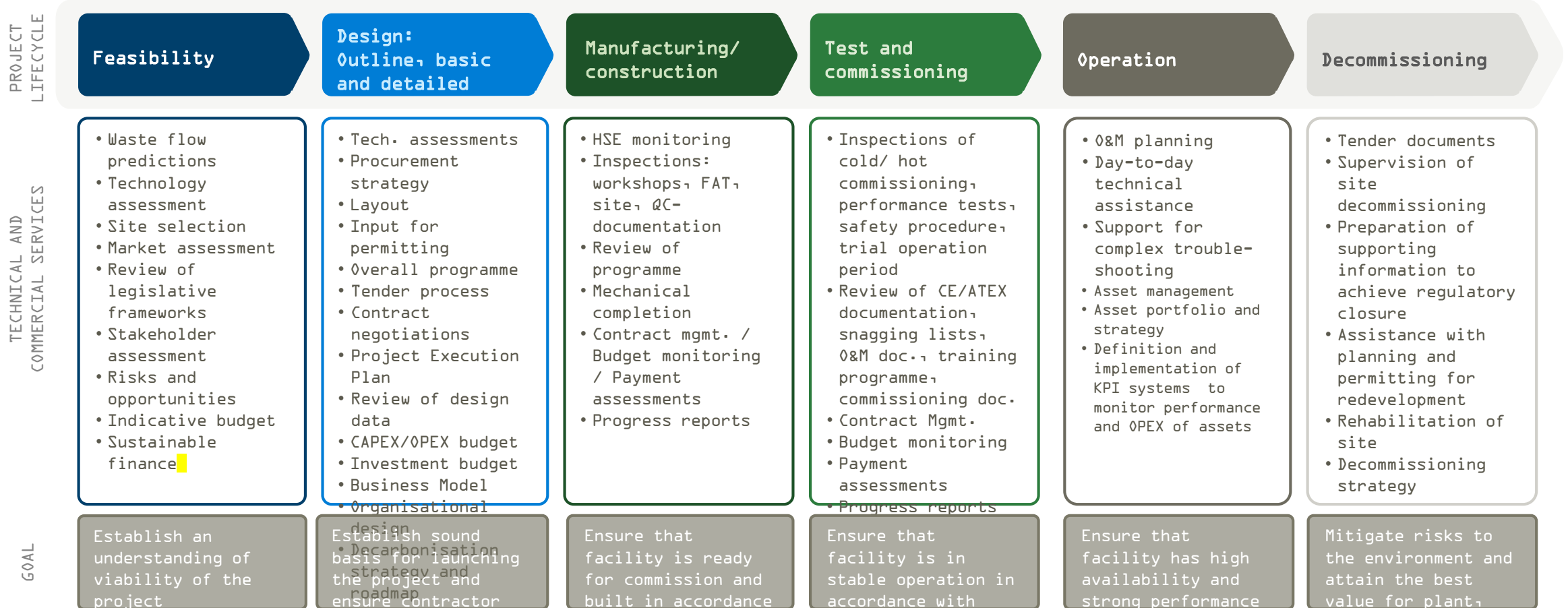
This further strengthens our knowledge-based and industry-specific best practice recommendations so they suit the unique goals of our clients.





# Our services across the full CCUS value chain

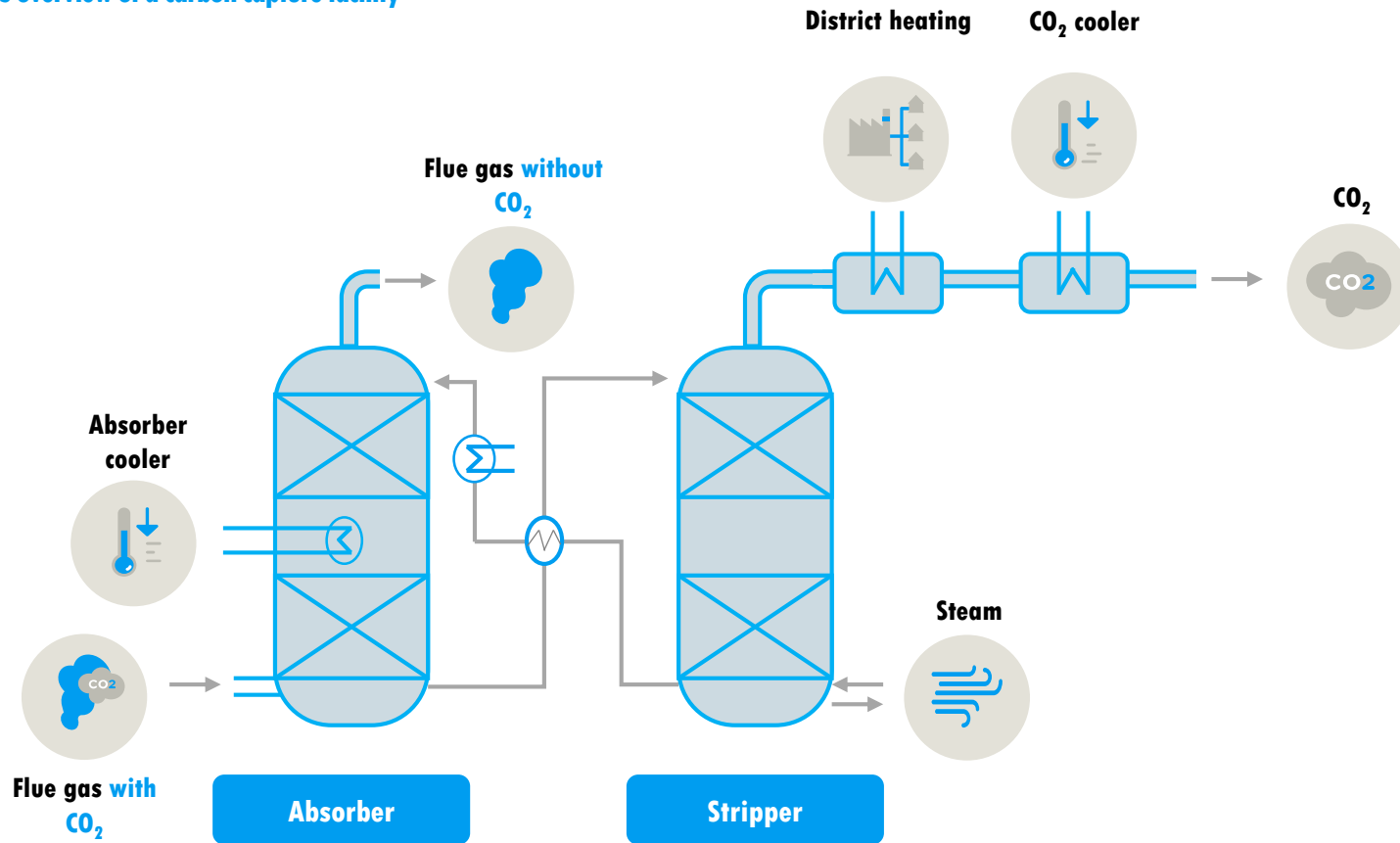
## Owner's engineer



# 1 CO<sub>2</sub> CAPTURE

We have all the skills and experience required to help clients succeed within carbon capture (CC)

Process overview of a carbon capture facility



## Our capabilities

- Ramboll has been involved in CC for many years in fields of research, development, construction, prototype testing as well as integration with power systems
- We have experience with all facets of CC, including amine capture, oxyfuel, chilled ammonia, CO<sub>2</sub> compression, etc.

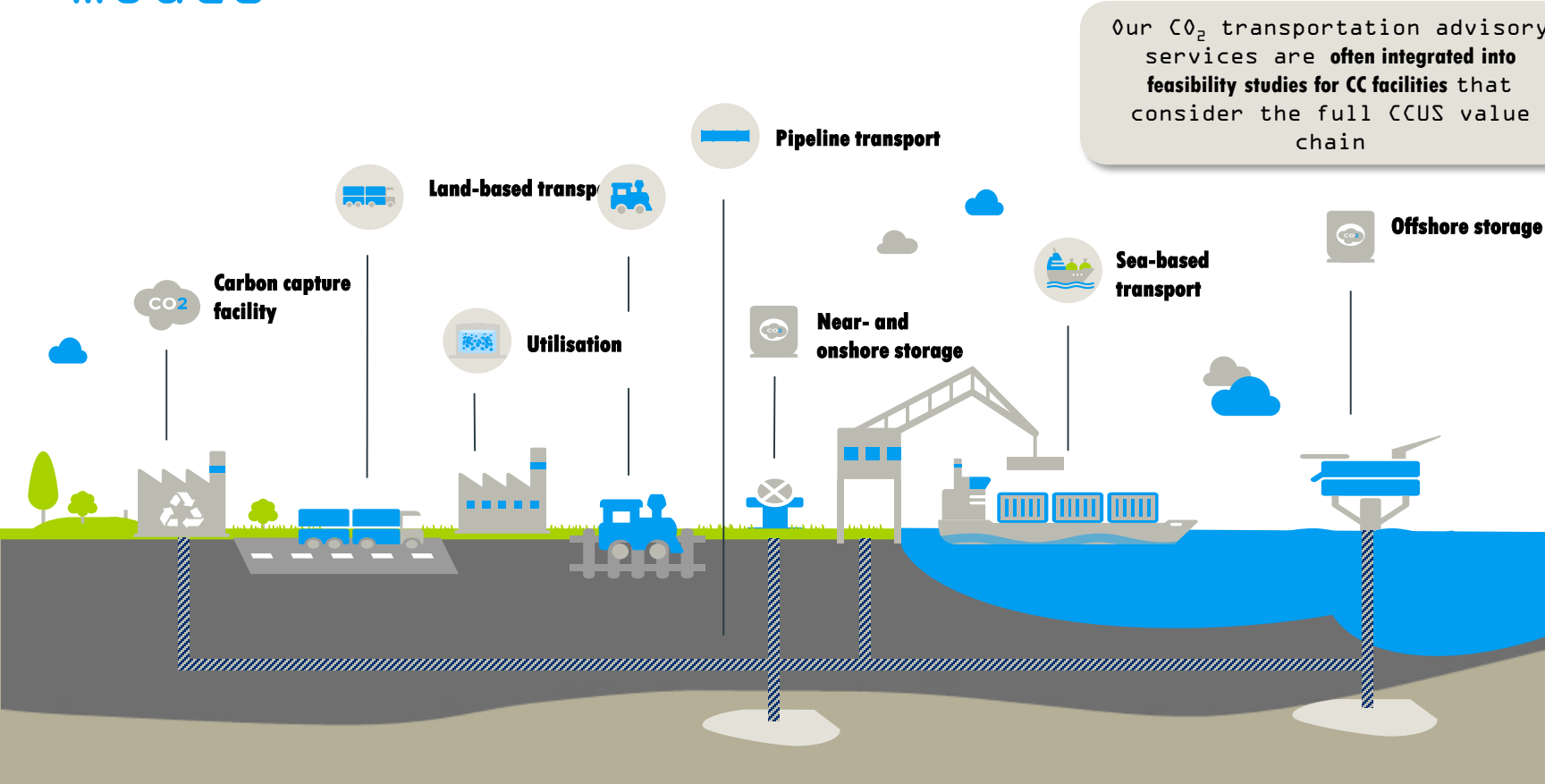
## Services related to carbon capture

- Technical, commercial and environmental assistance to planning, construction, operation and decommissioning of facilities for carbon capture

## Key issues related to CC that we are experienced in dealing with

- Selection of the right CC technology
- Understanding key cost drivers: high CAPEX due to CC immaturity and the "Energy Penalty" often mitigatable
- Issues from lack of CO<sub>2</sub> purity standards

# We leverage our transport expertise when advising on CO<sub>2</sub> transportation modes



## Our capabilities

- We combine our deep transport sector knowledge with commercial and technical expertise to assess CO<sub>2</sub> transport potential
- Our understanding of the possibilities for transporting CO<sub>2</sub> from capture facilities to the location for storage or utilisation enables us to recommend the most technically and economically feasible transport modes and routes for each client

## Services related to CO<sub>2</sub> transportation

- Identification of relevant transport possibilities (pipeline, road, rail, shipping)
- Assessment and cost evaluation of alternative transport solutions
- Technical, regulatory, market and risk assessments

## Key issues related to CO<sub>2</sub> transport that we are experienced in dealing with

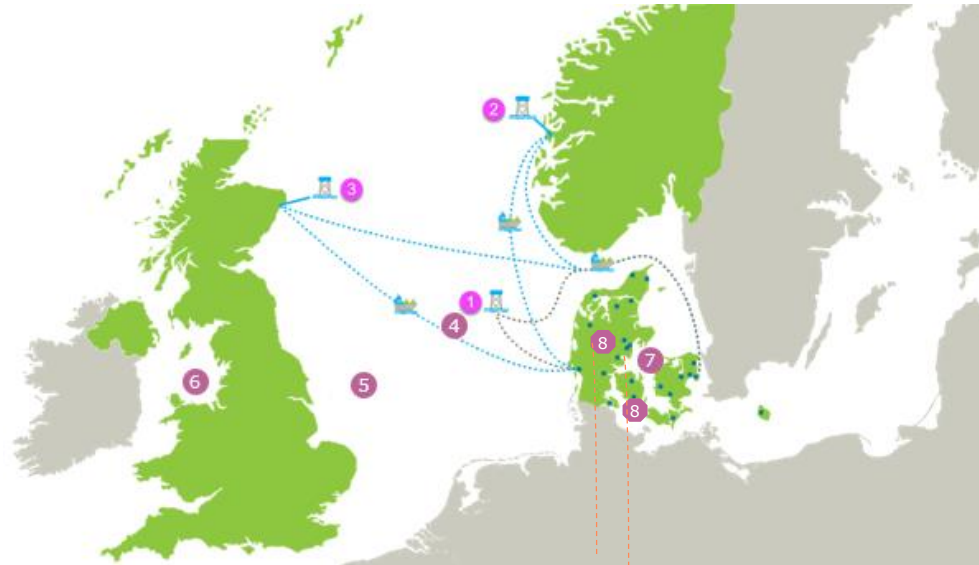
- The importance of access to reliable transport modes and routes

# ... And advise our clients on carbon storage (CCS)

Off-shore transportation by ship or on-shore transportation by pipelines, trucks and rail to CO<sub>2</sub> recipients

Examples in Nordics and UK

- 1) GreenSands (DK)
- 2) Northern Lights (NO)
- 3) Acorn (UK/Scotland)
- 4) Bifrost (DK)
- 5) UK East Coast Cluster (UK)
- 6) Hynet North West (UK)
- 7) Havnsø (DK)
- 8) Danish on-shore storage



## Our capabilities

- We provide deep technical and commercial insight into the selection of potential storage sites for the client, leveraging our knowledge of geographic variations at both local, regional and international level
- Our ongoing experience with CO<sub>2</sub> storage projects ensures that we stay updated on the continuously developing market

## Services related to CCS

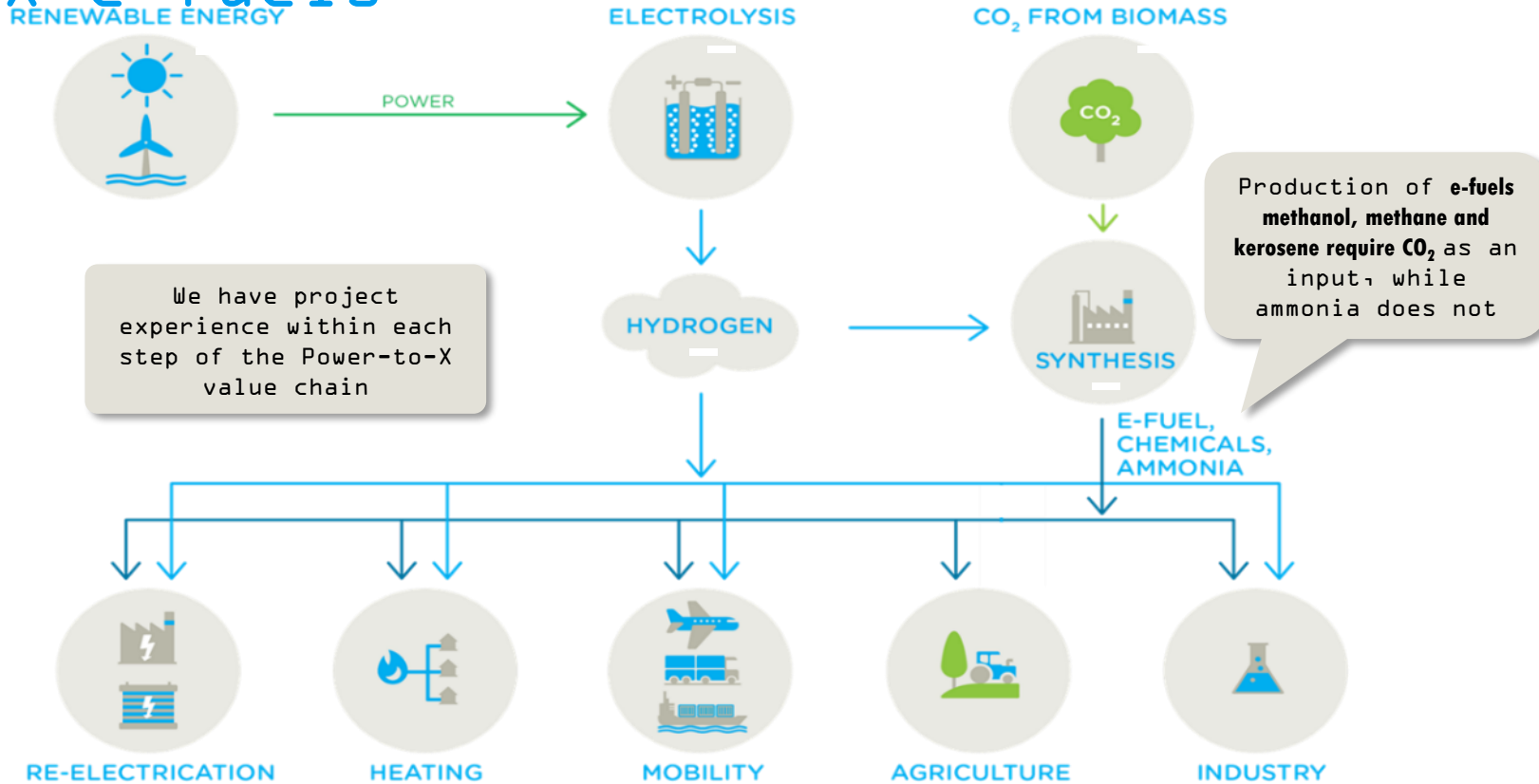
- Assessment of storage potentials
- Cost evaluations of various storage locations and sizes (onshore, nearshore and offshore)
- Technical, regulatory, market and risk assessments

## Key issues related to CCS that we are experienced in dealing with

- Technical and environmental challenges related to storage



# We have broad experience in CCU as a precondition to several Power-to-X e-fuels



## Our capabilities

- We advise both the supply side (i.e., CC) and demand side (i.e., Power-to-X) of the CCU value chain
- We have project experience across the full Power-to-X value chain - including access to captured CO<sub>2</sub> as a precondition for production of e-fuels

## Services across the full CCU project lifecycle

- Technical, economic and market analysis for CC operators and Power-to-X facilities
- CO<sub>2</sub> offtake analysis for CC operators and sourcing analysis for Power-to-X
- Environmental impact assessment
- Consulting and engineering services across all asset phases of Power-to-X
- Access to public funding

## Key issues related to CCU that we are experienced in dealing with

- Potential applications for captured CO<sub>2</sub>
- Barriers for CO<sub>2</sub> offtake caused by preference for biogenic CO<sub>2</sub> in Power-to-X
- Risk of CO<sub>2</sub> supply shortage for

# What makes Ramboll a full value chain service provider?

- Deep technical knowledge on the process design, energy optimization and technology providers: **Owner's engineer**
- 70+ CCS feasibility and engineering design studies with a dedicated team covering **EfW, biomass, refinery, and cement** applications
- **Environmental permitting, risk assessment and HSE** services by local Ramboll experts
- **Layout, piping, electrical and 3D modeling** expertise to optimize space needs of existing industrial plants
- **Off-shore/sub-sea and on-shore** pipelines, transport and storage connection engineering expertise

- **Business case** development, alternative **financing options** advisory, and **regulatory affairs** support

We work across our seven markets:



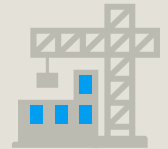
**Transport**



**Environment & Health**



**Management Consulting**



**Buildings**



**Energy**



**Water**



**Architecture & Landscape**

# Hard-to-abate industries

# Hard-to-abate industries' CO<sub>2</sub> footprint

## Focus on Cement and EfW

Cement: 0.9 kg CO <sub>2</sub> /kg cement
EfW: 1.1 kg CO <sub>2</sub> /kg waste
Steel: 1.4 kg CO <sub>2</sub> /kg steel
Aluminium: 2 kg CO <sub>2</sub> /kg aluminium
Glass: 3 kg CO <sub>2</sub> /kg glass

### Challenges

- Access to transport and storage sites
- Funding and available subsidies
- Issues with EU taxonomy
- Cement: missing high temperature steam, complicated site layout, limited footprint
- EfW: balancing the power and district heat requirements together with the CC energy needs

### Opportunities

- Market demand
- Funding and available subsidies
- End user cost
- Social license to operate



# Case study 1: EfW

# EfW offers a unique opportunity to reduce carbon footprint

- **24/7 - operation**

Most EfW facilities operate 8000 h/t.

Operated with constant load

A CC installation will get max operation hr and be in steady operation

- **Fossil and biogenic CO<sub>2</sub>**

Typical EfW facility that treats MSW will have fossil/biogenic CO<sub>2</sub> in 50:50.

With e.g. 90 % capture EfW becomes carbon negative

- **Someone to pay**

Waste suppliers, "green power" customers and possible heat customer pay via gate fee, power purchase and supplied district heating





# Is CC expensive ? Yes/No

## An example from Denmark

- One tonne of waste forms about 1.1 tonne for CO<sub>2</sub>
- Total net cost for carbon capture (complete chain) 200 €/t waste
- “Normal” gate fee is approximately 70 €/t
- Carbon capture may increase gate fee to 270 €/t
- In a liberalized market carbon capture will not happen by itself

## Who pays?

- A large WtE treating 500 ktpy. 200 €/t corresponds to 100 M€/y – will never be feasible
- Annual waste production to incineration is approximately 200 kg per capita.
- Price to make residual waste treatment carbon negative is 40 €/y per capita or 100 €/y per household – This is very feasible!
- Possible contribution from biogenic certificates and saved ETS may reduce cost by 50 % - up to 100 % by increased ETS cost

## How to make it work?

- Strong incentives are needed.
  - Demand
  - Requirement from local waste authority
  - High ETS price







# Cement CCS feasibility

- **Heidelberg Materials: 10 mil tpy CO<sub>2</sub> captured and stored starting 2030**

Slite site plans to capture 1.8 mil tpy by 2030.

Capture, liquefaction, intermediate storage, harbor expansion, transport and storage studies

- **40% fuel and 60% process emissions**

Fuel: RDF (10-20% biogenic), coal, gas

With e.g. 90 % capture cement plant becomes carbon negative

- **Someone to pay**

Green cement is in demand. Additionally, waste suppliers and possible heat customers pay via gate fee and supplied district heating





# Is CC expensive ?

## Yes/No

### A ballpark example (residential)

- Cost of concrete: 1% of the total construction cost
- Cost of cement: 50 €/t (50% of the price of concrete)
- Total net cost for carbon capture (complete chain) 200 €/t cement
- Carbon capture may increase the cement cost to 250 €/t (concrete cost to 300 €/t)
- 3% increase

### How to make it work?

- Strong incentives are needed.
  - Demand
  - High ETS price



# End-customer demand is starting to materialize

## Projects won with Low Carbon Cement

### HS2

- **UK's new high speed rail line HS2** – the largest infrastructure project in Europe – is **committed to sustainability and circular procurement criteria**
- **Cemex's Vertua low carbon concrete** awarded the contract
- In addition to direct reductions, remaining CO2 emissions from using concrete are offset



- **Dublin Airport** is committed to sustainable buildings and infrastructure incl. use of low carbon cement
- Examples include **RFP criteria requesting use of low carbon cement** (CEM II cement) and incorporation of recycled asphalt and concrete in building new pavement for parking of aircrafts



- All building materials for **Paris 2024 Olympics** must have a low-carbon footprint
- All partners awarded construction contracts must comply with international low-carbon requirements
- **Ecocem is set to provide its new ultra-low carbon cement** for construction of The Olympic and Paralympic Village



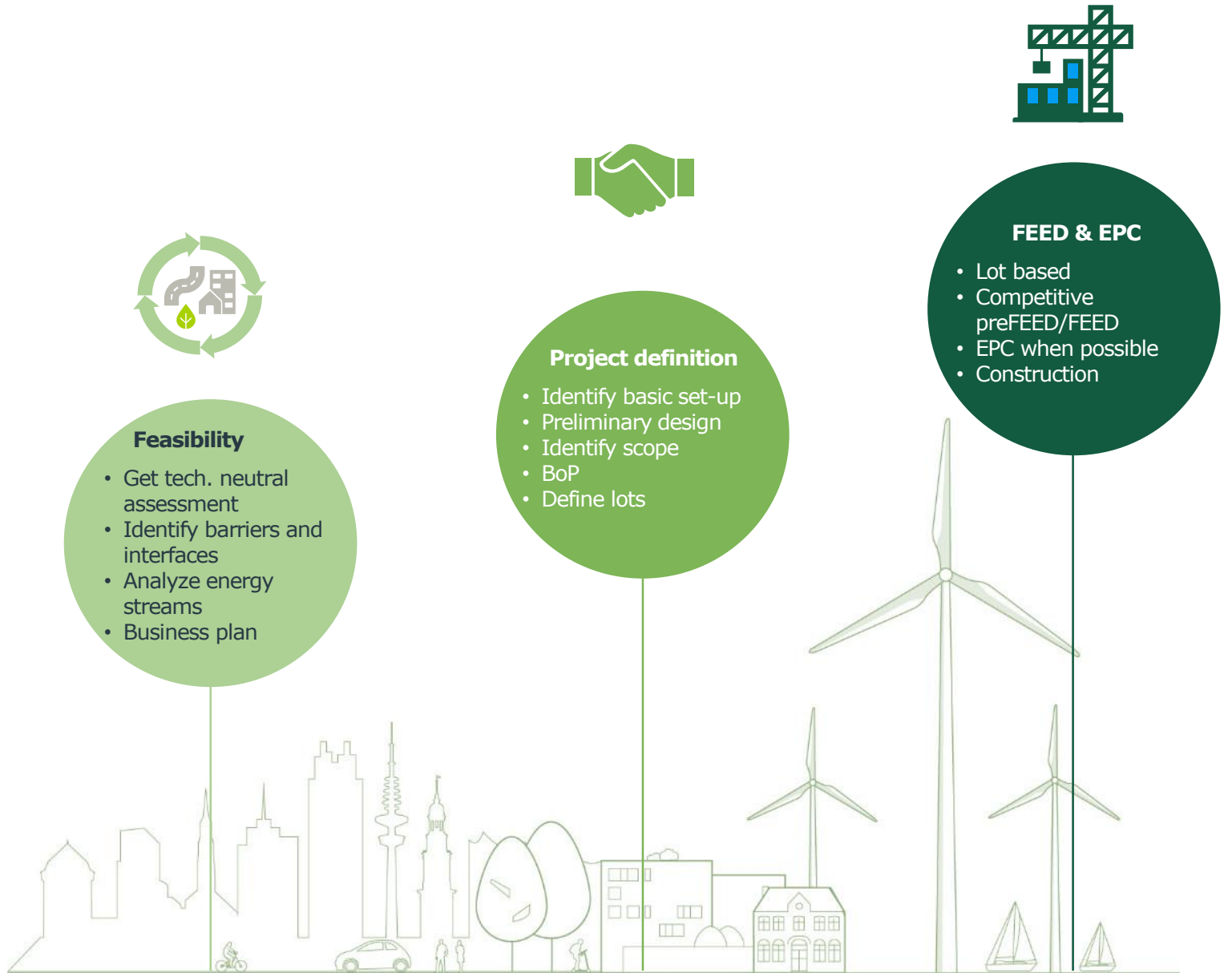
City of Rotterdam

- **The City of Rotterdam** is committed to 40% energy reductions in municipal buildings by 2030 and net-zero buildings by 2050
- **All framework agreements** for construction materials are **awarded based on environmental life cycle costs assessments**

# How to do

## SMART PROJECT DEVELOPMENT:

- Don't waste too early engineering if someone leaves the project
- Before Carbon Capture can be established it is recommended that constructability and project feasibility is assessed.
- CO<sub>2</sub> chain, possible partners and cluster structure ought to be identified
- Energy provision and possible utilisation of excess heat should be assessed
- Minimize risk – well defined scopes





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Sustainable  
change.

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