

# Innovation: Carbon Capture and Storage

29 November 2023

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*The Fuellers' Duke of Edinburgh Future Energy Conference 2023*

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# Agenda

Brief intro to the carbon capture raison d'être, including the myriad of acronyms

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Carbon Capture Technologies: current proven and upcoming new entrants

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Project Economics and Policy Instruments

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Our ongoing carbon capture construction projects

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The future is modularisation, repeatability at scale, CCaaS

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# Aker Carbon Capture in brief

**Pure play** carbon capture company offering modular and configurable capture plants

**Best-in-class HSE** friendly and proprietary patented technology for optimized plant performance

**Proven** market-leading proprietary technology with over 60,000 operating hours and seven carbon capture units being delivered

## Key regions



## Prioritized industries



CEMENT



BIO/WASTE-TO-ENERGY



GAS-TO-POWER

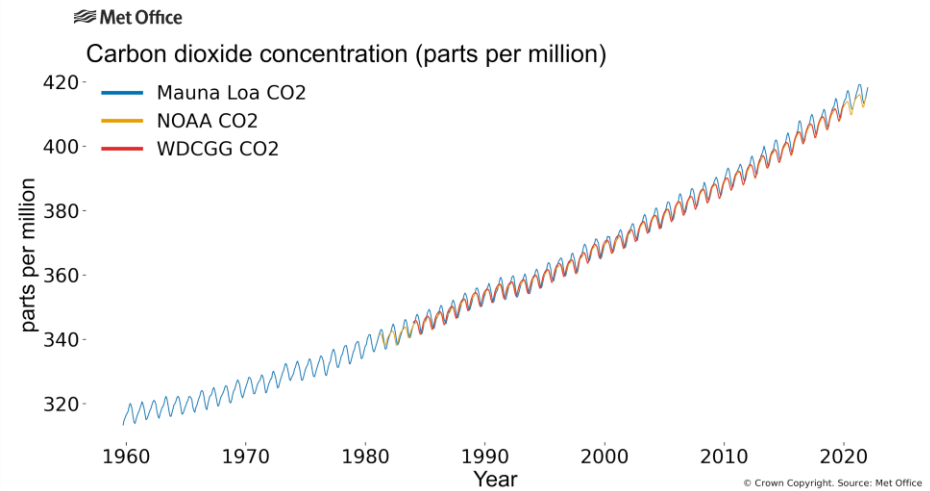
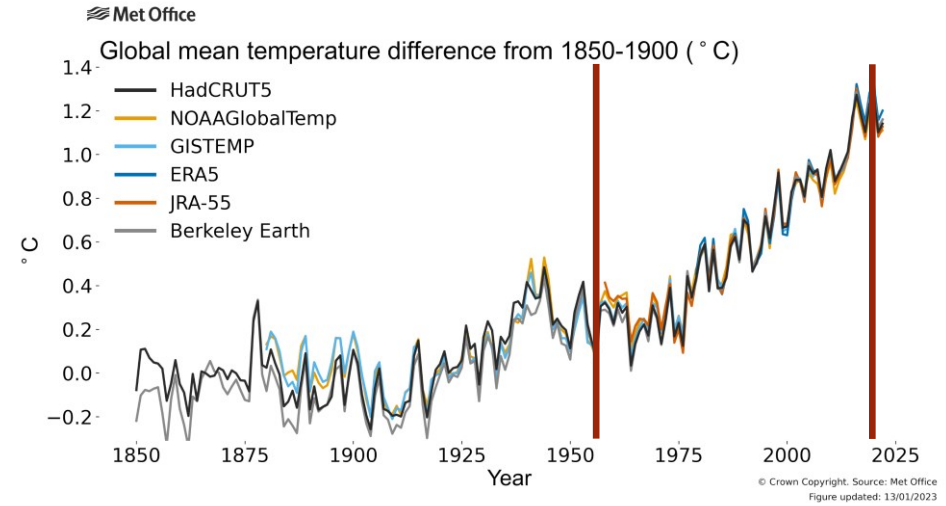


BLUE HYDROGEN

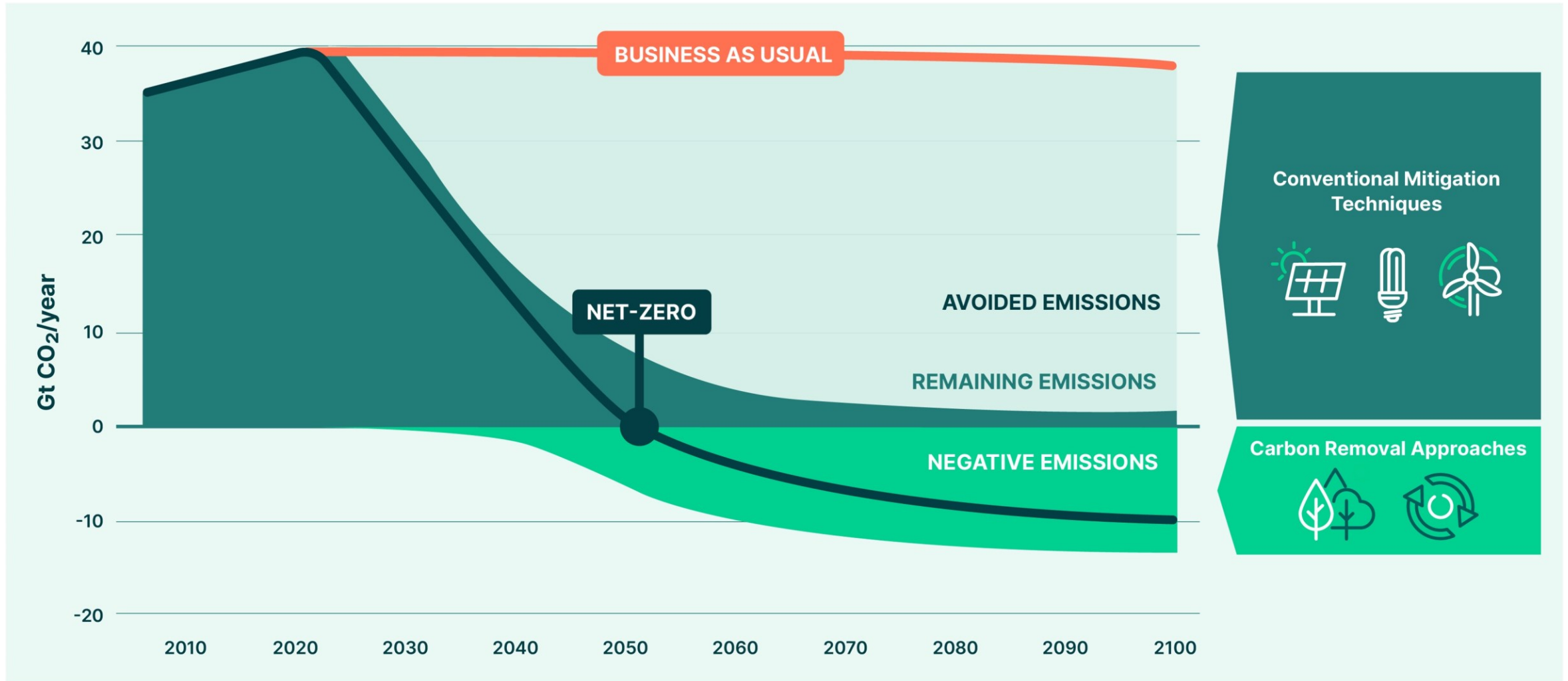
...and engagement with new industry segments like refining and process industries



# Raison d'être - Climate Change



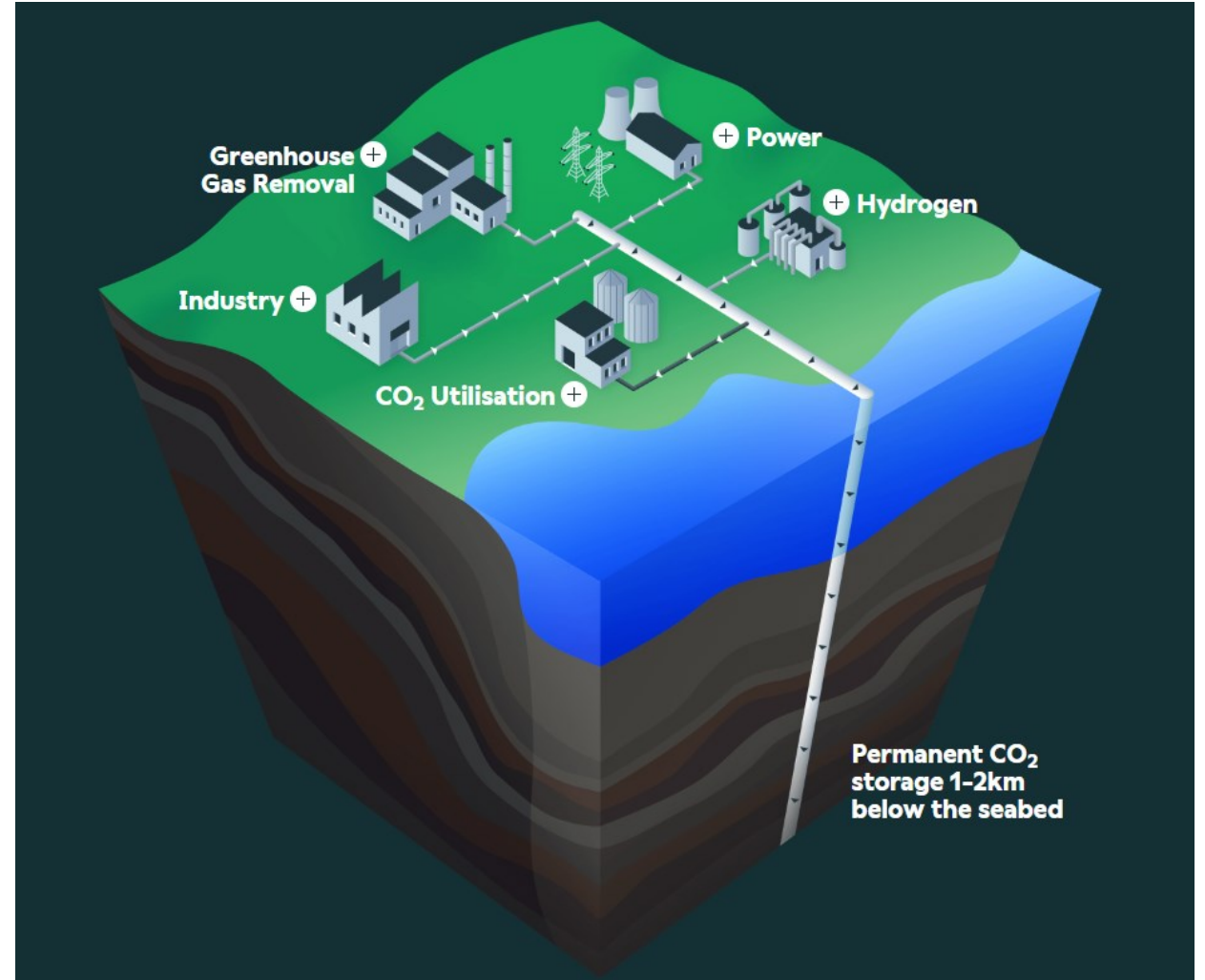
# Staying below 1.5 degrees of global warming



# Carbon capture and its' acronyms: CCS, CCU

Carbon capture and storage (CCS), or its close cousin, carbon capture, use, and storage (CCUS), is a suite of technologies for trapping carbon dioxide, the main gas responsible for climate change, from power stations, industrial facilities, and other sites burning oil, gas, coal, biomass, or solid wastes, or emitting CO<sub>2</sub> during production, such as in cement-making.

The carbon dioxide is then piped to a location to be safely disposed of thousands of meters underground, in depleted oil or gas fields, or within rock formations containing undrinkable saline water. It also can be used (CCU) to make fuels, fertilisers, plastics, enhance plant growth in greenhouses, and even to put the fizz into drinks.



# CDR: Carbon Dioxide Removal

- **Afforestation / reforestation:** Planting new trees or restoring existing forests to increase carbon uptake and storage.
- **Soil carbon sequestration:** Improving agricultural practices to enhance the amount of organic carbon stored in soils.
- **Peatland and coastal wetland restoration:** Preserving or restoring natural ecosystems that store large amounts of carbon in their biomass and soils.
- **Agroforestry, improved forest management:** Integrating trees with crops and livestock, or applying better practices to manage existing forests, to increase carbon sequestration and reduce emissions.
- **Biochar carbon removal (BCR):** Producing charcoal from biomass and applying it to soils to enhance carbon storage and soil fertility.
- **Direct air carbon capture and storage (DACCS):** Using machines to capture CO<sub>2</sub> from ambient air and store it underground or in long-lived products.
- **Bioenergy with carbon capture and storage (BECCS):** Growing biomass for energy and capturing the CO<sub>2</sub> emissions from its combustion or conversion, then storing it underground or in long-lived products.
- **Enhanced weathering (alkalinity enhancement):** Accelerating natural processes that dissolve minerals containing carbon or increase the alkalinity of seawater, thereby increasing the ocean's capacity to absorb CO<sub>2</sub>.
- **Ocean fertilization:** Adding nutrients to the ocean to stimulate the growth of phytoplankton, which can take up CO<sub>2</sub> and export it to the deep ocean.
- **Ocean-based carbon removal:** Using various methods to enhance the biological or physical uptake and storage of CO<sub>2</sub> in the ocean, such as seaweed cultivation, marine permaculture, or artificial upwelling.





# Delivering large-scale carbon removal from 2025

Accelerating planet positive through biogenic carbon capture and storage

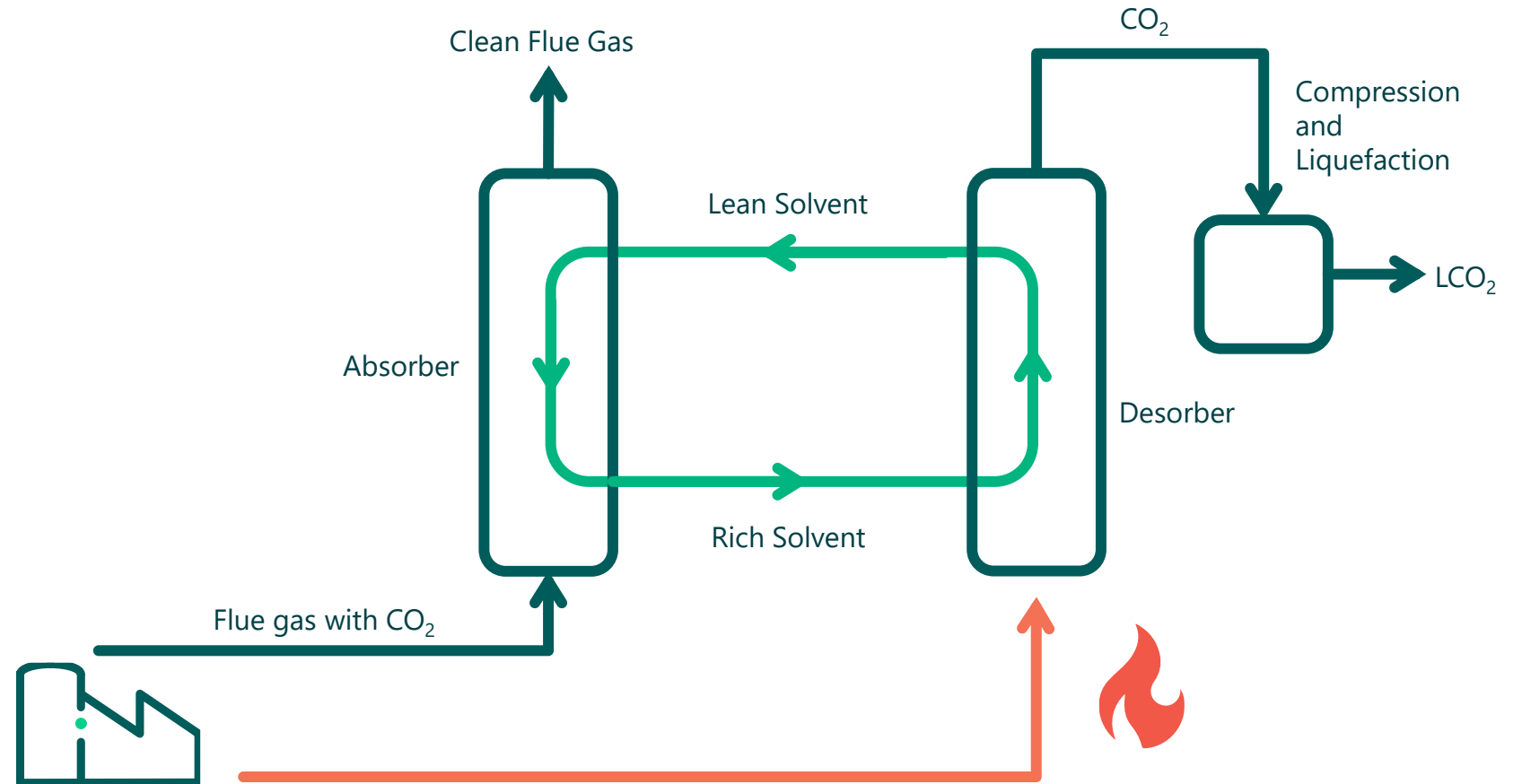


# Carbon Capture Technologies (in varying TRLs)

- **Amine:** Liquid sorbent technology – current state of the art.
- **Oxy Fuel:** Uses pure oxygen instead of air as the oxidant, resulting in a flue gas that is mainly CO<sub>2</sub> and water, which can be separated by condensation.
- **Chemical Looping:** Uses a metal oxide as an oxygen carrier to oxidize the fuel, instead of using air.
- **Non-amine liquid sorbents:** Similar in operation to amine system. May involve enzymes to accelerate reactions.
- **Membrane-based separation:** This is a technique that uses thin and porous materials, such as polymers, ceramics, or metals, to selectively separate CO<sub>2</sub> from the flue gas.
- **Calcium Looping:** Uses calcium oxide (CaO) as a sorbent to capture CO<sub>2</sub> from the flue gas of a point source. The CaO reacts with CO<sub>2</sub> to form calcium carbonate (CaCO<sub>3</sub>), which is then heated in a separate reactor to release CO<sub>2</sub> for storage and regenerate CaO for reuse.
- **Solid sorbent-based separation:** This is a technique that uses solid materials, such as zeolites, or metal-organic frameworks, to adsorb or absorb CO<sub>2</sub> from the flue gas of a point source.

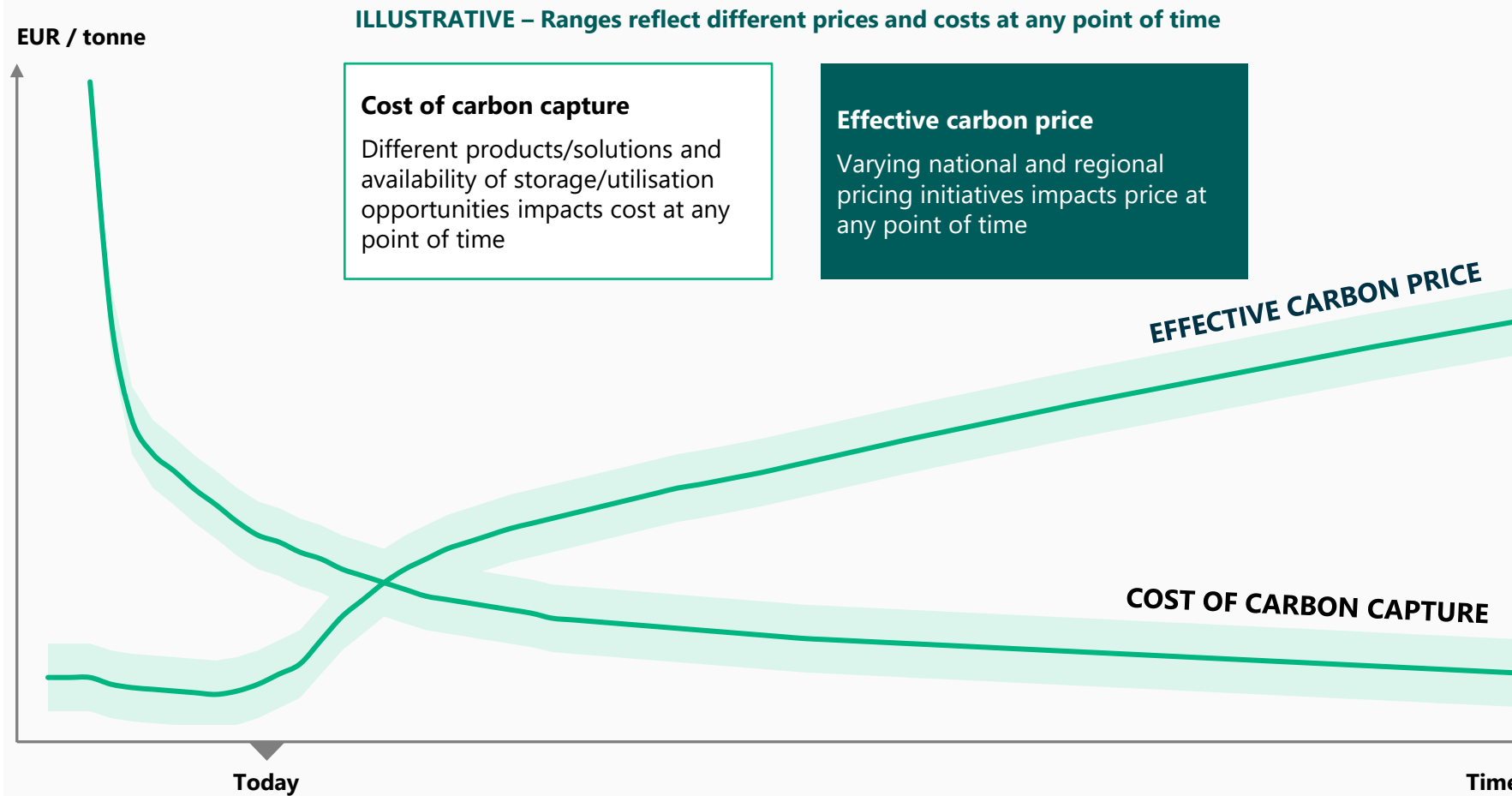
# How does Amine liquid sorbent technology work?

- Flue gas is exposed to solvent in the absorber
- The solvent is regenerated by heating in the desorber
- The CO<sub>2</sub> is conditioned to prepare for transport, storage or use
- CO<sub>2</sub> concentration and capture rate are primary drivers for energy use



# Project economics turning positive

Market trends are leading to a more favourable market dynamic and project economics turning positive



## Continuous cost reductions

- › Standardisations
- › Technology development
- › Competitive supply chains
- › Learning-by-doing

- › Other regulations
- › New carbon taxes
- › CO<sub>2</sub> quota system design
- › Public sentiment

**Favourable price development**

# Policy Instruments

## Government subsidies

e.g., competitions (UK cluster sequencing, EU Innovation Fund),  
tax breaks (45Q),  
government support agreements, (direct procurement of CO2 storage)

## Demand-side policies for carbon storage markets

*driving up demand for CO2 storage from emitters of CO2*

e.g., emission trading schemes (ETS)  
public and private sector low-carbon procurement obligations  
low-carbon product regulations

## Supply-side policies for carbon storage

e.g., producer responsibility frameworks, such as storage mandates (CSO, CTBO).



Twence's waste-to-energy facility in the Netherlands



# Our ongoing carbon capture construction projects

*Beyond PowerPoint...  
Building CCS now!*



Heidelberg Materials cement facility in Norway



Contract signing ceremony at Ørsted's Avedøre Power Station

**May 2023**  
CONTRACT AWARD

**June 2023**  
KEY PURCHASE  
ORDERS PLACED

**End 2025**  
PLANNED DELIVERY

# ØRSTED KALUNDBORG CCS

Denmark

- Design capture capacity of 500,000 tonnes CO<sub>2</sub> per year
- Key purchase orders placed
- Five Just Catch™ units at wood chip-fired Asnæs Power Station and straw-fired Avedøre Power Station
- First full-scale CCS value chain in Denmark, delivered by Ørsted, Aker Carbon Capture, Microsoft and Northern Lights

# Innovation through Modularisation: Just Catch™ benefits



## Big Catch™

Tailormade site-specific design

Highly integrated to host processes

Flexible layout

Field-proven delivery

## Just Catch™

Optimized modular design

Quick integration towards emitter

Predictable footprint

Up to 1-year faster delivery time

Proven and efficient technology





# Just Catch™ 400

## Carbon Capture



**Small  
footprint**



**95%  
capture rate**



**Transportable  
by truck**



**24 - 30 mths  
delivery time**



**Modular  
design**



**Cost efficient  
solutions**

# Innovation through business models

## Carbon Capture as a Service: Carbon capture made easy™

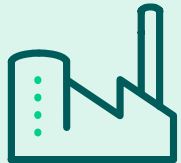
From a complex management of the full CCS value chain...



Interface, contracts and risk across the full CCS life-cycle



Financing



Carbon Capture



Liquefaction



Temporary storage



Transportation



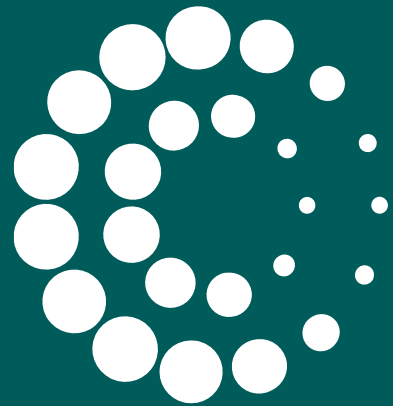
Permanent storage



...to carbon capture made easy



**CARBON CAPTURE AS A SERVICE**  
Carbon capture made easy™



AKER CARBON  
CAPTURE