

Workshop – Energize the CEE Region Focusing Reliable Energy Security

Baker Hughes

Gianluca Di Federico

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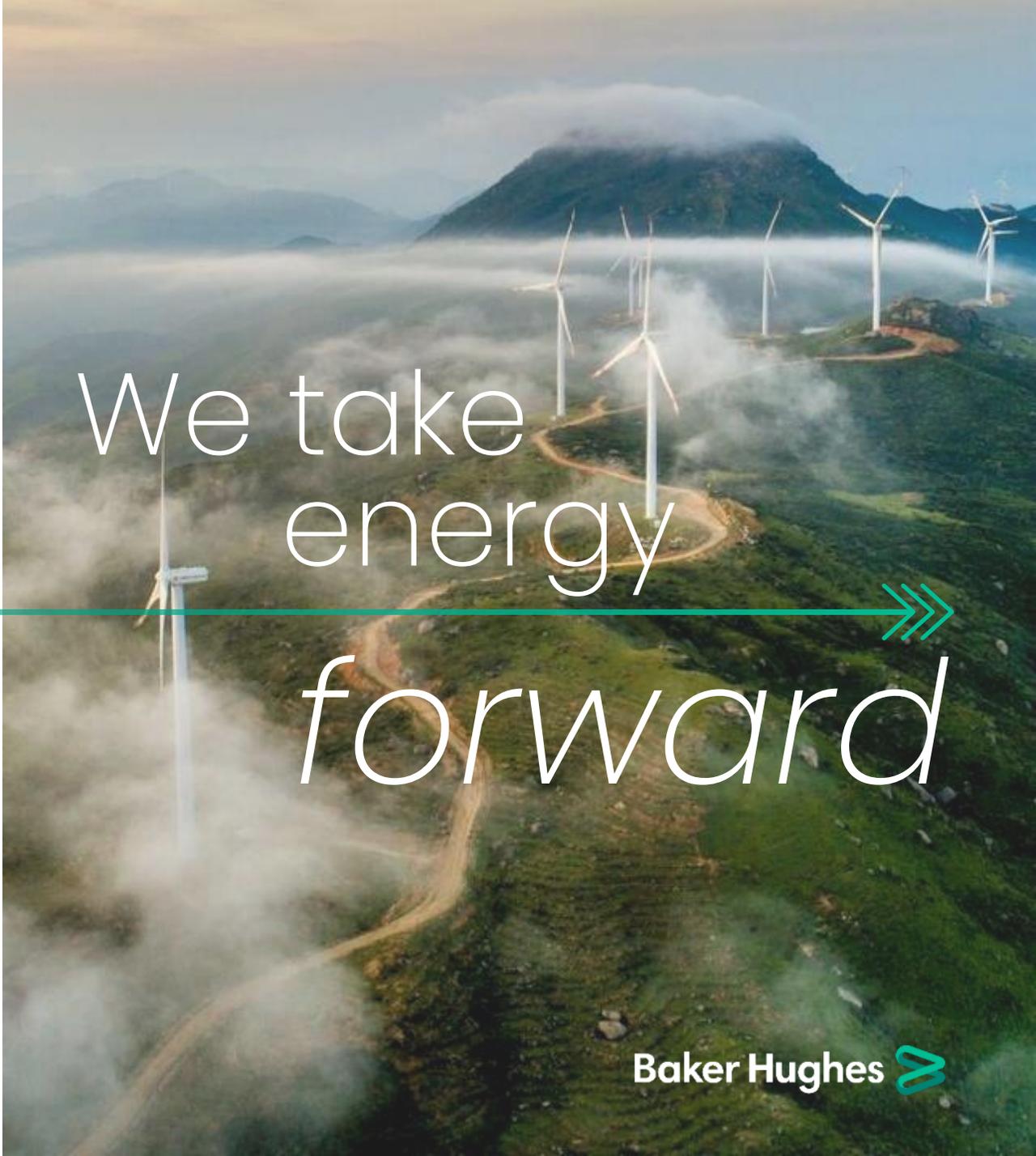
Our mission

We are Baker Hughes, an energy technology company. Together, we're making energy safer, cleaner, and more efficient for people and the planet.

Energy for today and tomorrow.

The energy sector is changing, faster than ever before. The energy trilemma – solving for energy security, sustainability, and affordability – is rebalancing our priorities and creating a new path forward for the industry.

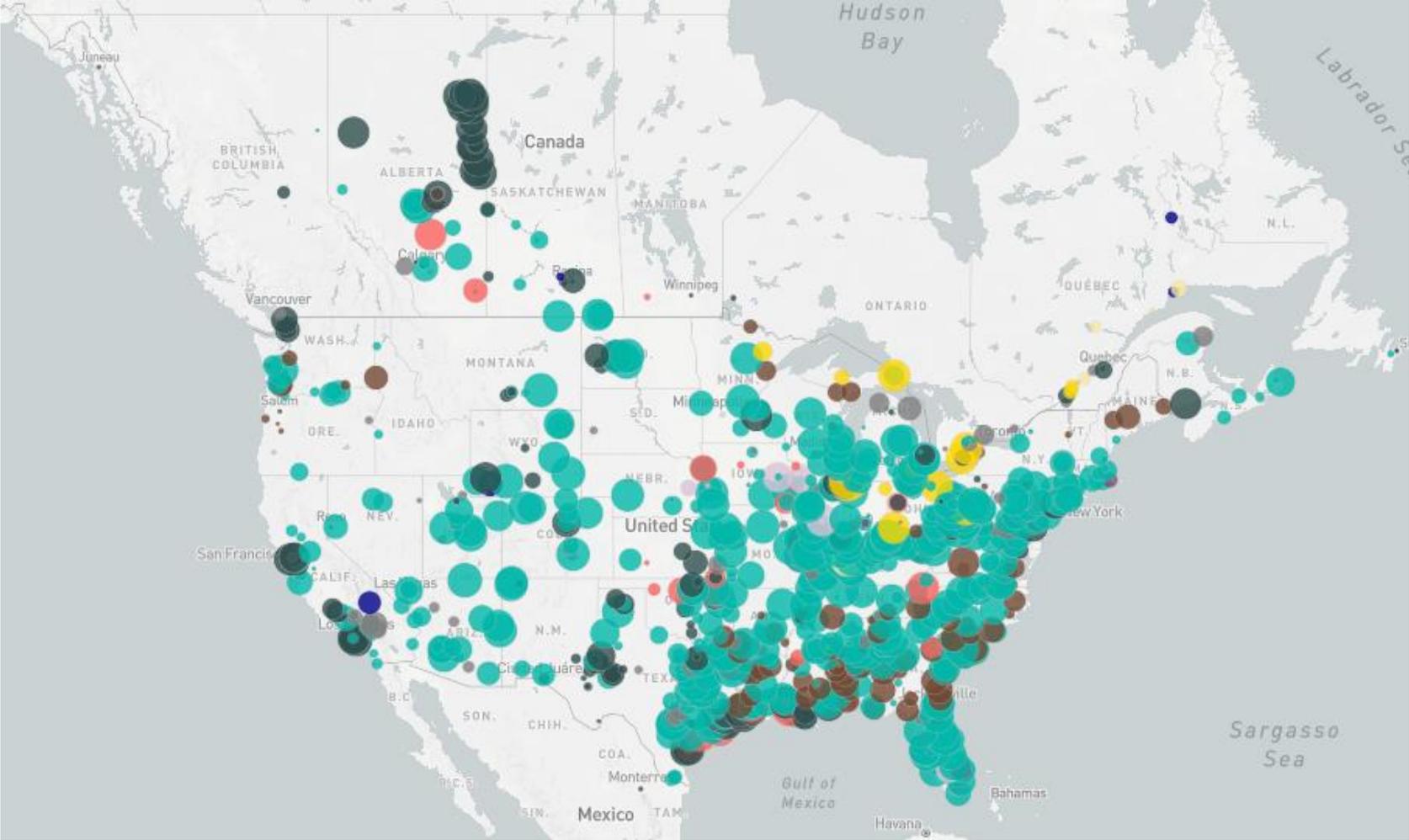
We believe we can meet those objectives together. As demand for energy increases, we're demanding more from energy, making it more sustainable, more reliable, more abundant, and more accessible.



We take
energy
forward

Outlook

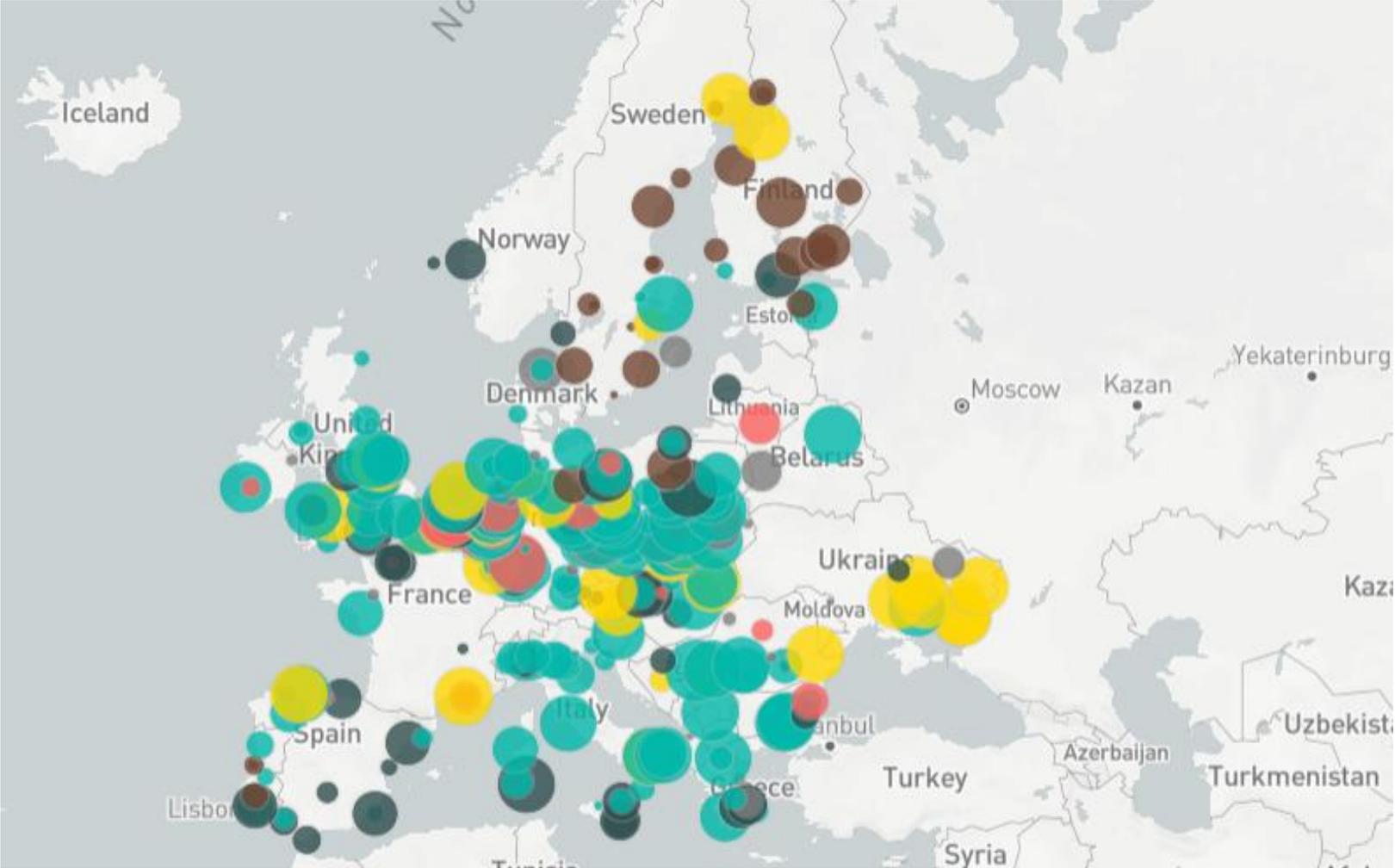
NAM – CO₂ emitters and potential stores



~ 6.7 Gtons
of CO₂ emitted each year

Source: Courtesy of Endrava's CaptureMap (showing 1207 facilities of > 0.5 mtpy capacity as CO₂ emissions).

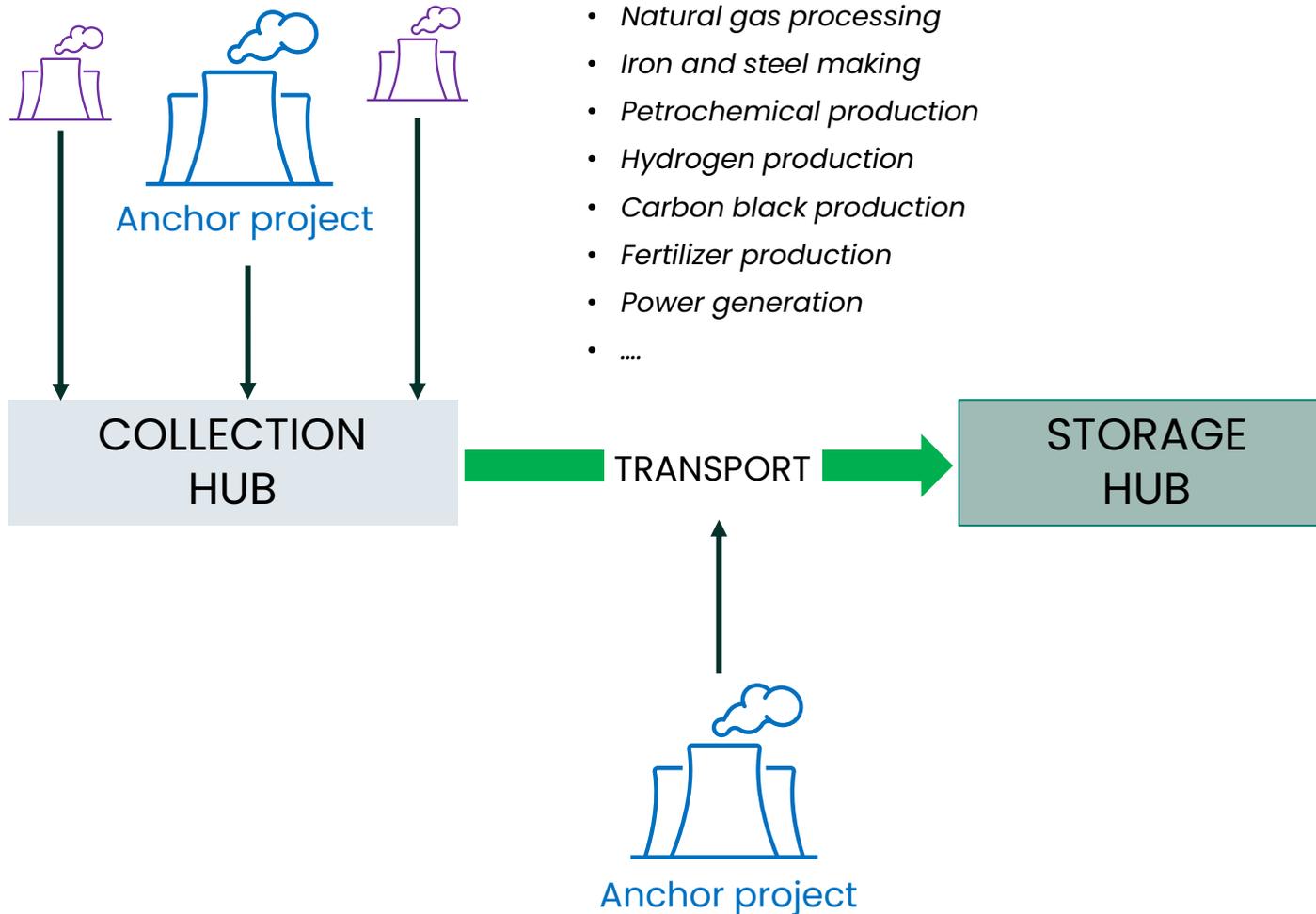
Europe – CO₂ emitters



3.7 Gtons
of CO₂ emitted each year

Source: Endrava's CaptureMap (showing 366 facilities of > 1mtpy capacity as CO₂ emissions)

Connecting emission points to stores



Why we need CCUS infrastructures

- Sharing infrastructures to enjoy economies of scale
- Enabling CCS in regions without access to suitable stores
- Enabling CO₂ capture from small volume sources
- Reducing commercial risks by jointly mitigating them
- Enabling e-fuels production

An example of a cluster project... Borg CO₂



- Offering Carbon Capture as a Service (“CaaS”)
- Includes several industry partners, as well as the Port of Borg, and aims to capture and store emissions from industrial facilities located in the cities of Fredrikstad, Sarpborg and Halden
- The total amount of CO₂ expected to be captured is 630ktpy, with a 70% share being of biogenic nature
- Captured CO₂ will be liquified and temporary stored onshore at the Port of Fredrikstad, shipped and eventually stored
- In April '21, Borg CO₂ announced to have entered into a MoU with Northern Lights
- BH is supporting the project with its portfolio of carbon capture & turbomachinery solutions as well as engineering services for the development of the hub - currently in the Pre-FEED stage
- During Pre-FEED, Borg CO₂ will evaluate the optimal implementation strategy and pursue grant and incentive opportunities both in Norway and Europe



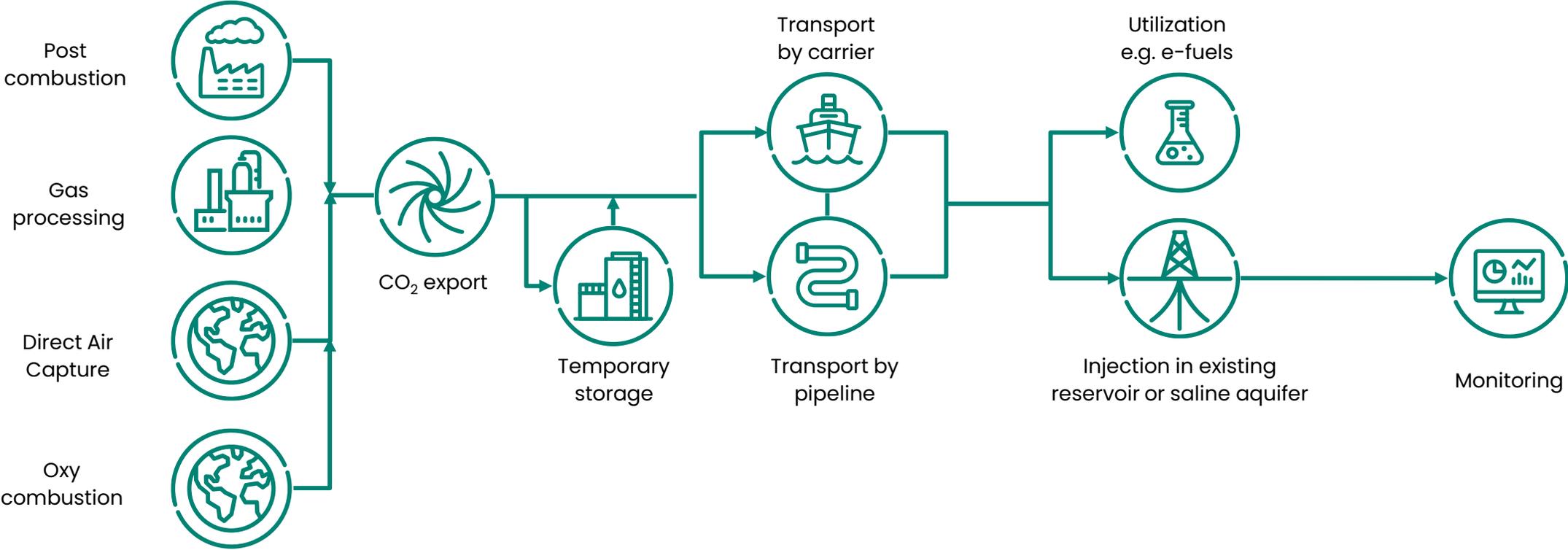
June '21 – BH & Borg CO₂ entered into an MoU to develop a cluster for decarbonization of industrial sites in the Ostfold region

May '22 – BH became shareholder of Borg CO₂

Borg CO₂™ is a trademark of its respective owners, not affiliated with Baker Hughes Company

Baker Hughes portfolio

Our positioning across the CCUS value chain



CO₂ capture technologies

Technology

Chilled Ammonia Process (CAP)

Solvent: ammonia-based



Readiness level

1 2 3 4 5 6 7 8 9

Validated at TCM (80ktpy)

Key features

- Releasing CO₂ at high pressure:
- Reducing compression needs
 - Allows for direct liquefaction

- Sustainable solvent:
- Widely available/commodity
 - No thermal and oxidative degradation
 - Environmentally friendly effluents

Controllable emissions to atmosphere and tolerant to flue-gas contaminants (NO_x, O₂, etc.)

Mixed Salt Process (MSP)

Solvent: potassium-based with ammonia



1 2 3 4 5 6 7 8 9

TRL6 on-going at UIUC (10tpd)

More efficient mass-transfer:

- Reduced column diameter
- Reduced bed depth

Versatile for challenging applications:

- Pre- or Post-combustion capture
- Self-cleaning for high-solids processes
- Capture/scrubbing or 2- or 3-phase reactors

Industrial Climate Solutions (ICS)

Pulsing froth gas-liquid contactor

Compact size with no moving parts



1 2 3 4 5 6 7 8 9

More efficient mass-transfer:

- Shorter absorber columns
- Compact regeneration system

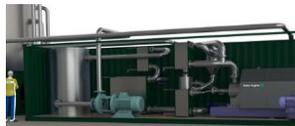
Modular and scalable configuration:

- Reduction in footprint & height
- Retrofittable for brownfield applications

Compact Carbon Capture (CCC)

Solvent agnostic (tested with MEA)

Rotating beds to intensify mass-transfer

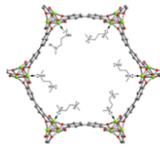


1 2 3 4 5 6 7 8 9

TRL7 on-going

Mosaic

Metal Organic Frameworks for DAC



1 2 3 4 5 6 7 8 9

- The extra step to meet 1.5°C
- Adsorbent w/ higher efficiency & lower costs
- Unique performance achieved thru a proprietary "cooperative binding" process

Flue gas compression

Hot Potassium Carbonate and Cryogenic technologies require to increase the flue gas pressure well above atmospheric to reach an adequate CO₂ partial pressure

Compression technologies suitable for flue gas compression within BH's portfolio

Axial (AN)



Over 30 units installed

- Low suction pressure
- High volume flows
- Up to 7+ pressure ratio

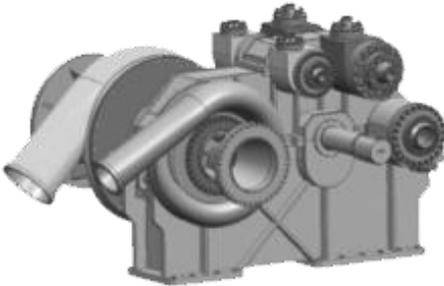
Horizontally Split (MCL)



Over 1,000 units installed

- Large volume flows
- Up to 500 kNm³/h
- Up to 50 bar discharge
- Easy maintenance

Integrally geared (SRL)



Over 200 units installed

- Heavy duty services
- High compression ratio
- Low abs. power (intercooling)
- Maximized flow range (IGVs)

Vertically Split (BCL)

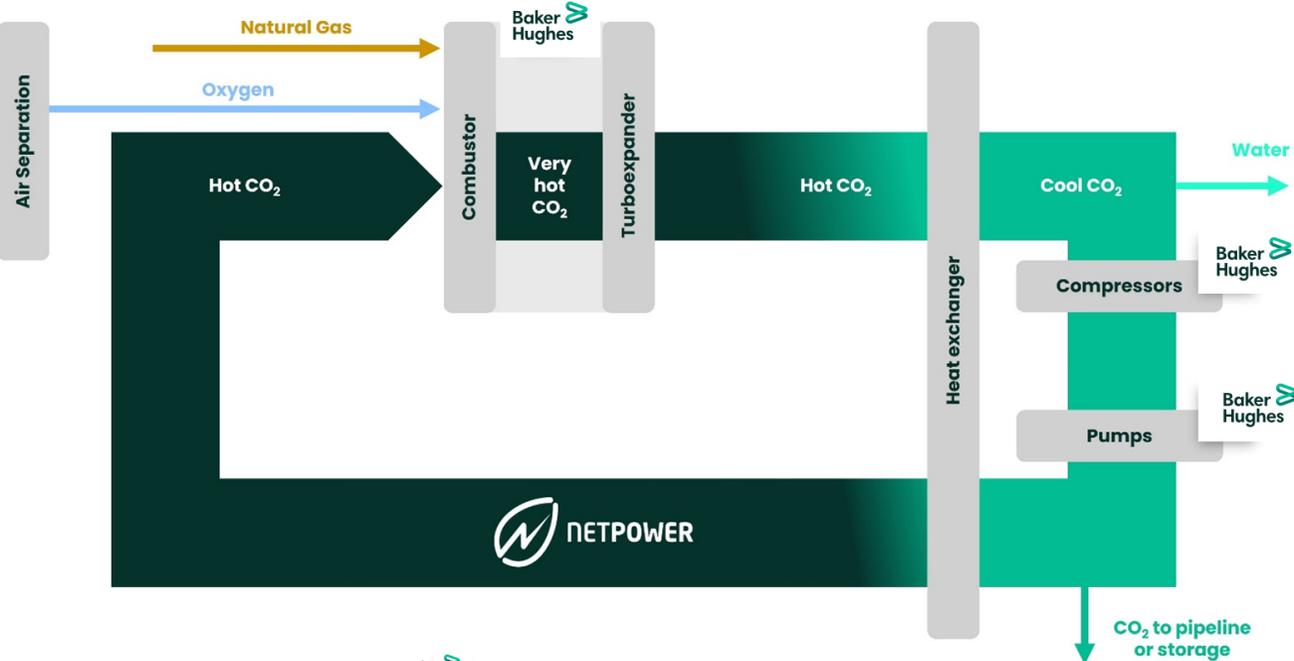


Over 2,400 units installed

- Med to low volume flows
- Up to 800 bar discharge
- Bundle cartridge to ease maintenance

The NET Power solution

- Proprietary process to produce **emission-free, dispatchable** and **low-cost electric power** for utilities, heavy industries, oil & gas applications
- **Uses natural gas and oxygen** to fuel a supercritical CO₂ cycle that **generates electricity**, while also inherently capturing CO₂
- Enables power plants to operate with high efficiency and produce only electricity, water, and sequestration-ready **CO₂ that is then permanently locked away from the atmosphere**



 Key Process Equipment provided by BH

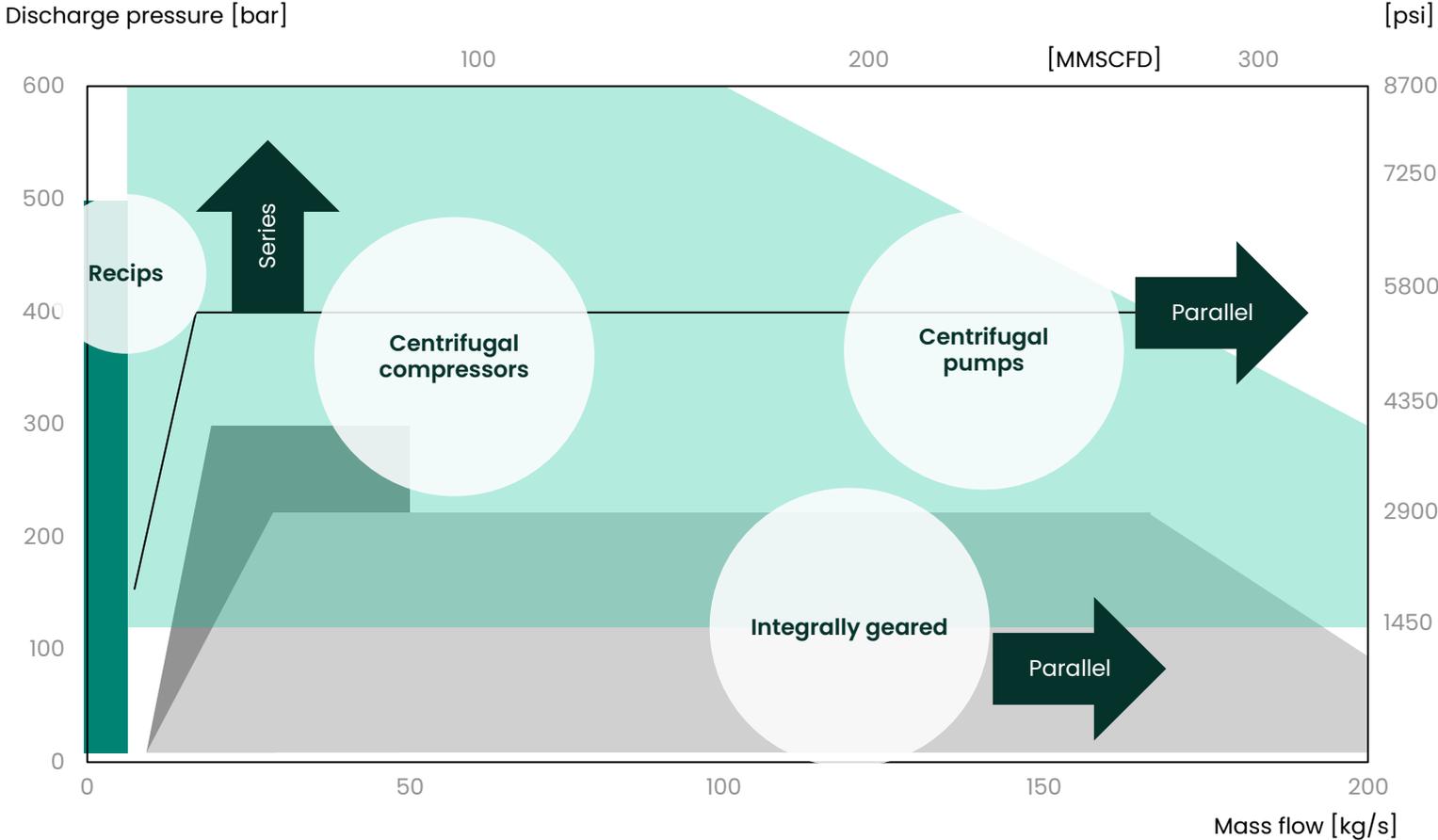
Typical Project Structure


Cycle Technology Licensor


Key Technology Provider

EPC
Engineering, Procurement and Construction

CO₂ transportation – compression and pumping



Centrifugal Pumps

- Design pressure 670bar (API 6A 10000), discharge pressure 540bar
- 10+ kg/s flowrate



Centrifugal Compressors

- Since 1968, 90+ urea plants, 13Mio operating hours
- Discharge pressure up to 280bar and up to 18MW, inlet flow 300,000+ Nm³/h

Over 40 years of experience in compression and high-pressure pumping

CO₂ transportation – non-metallic pipeline

We manufacture spoolable thermoplastic piping, that reduce 'cradle to grave' CO₂ impact by **up to 75%**

Lower Cost of Ownership

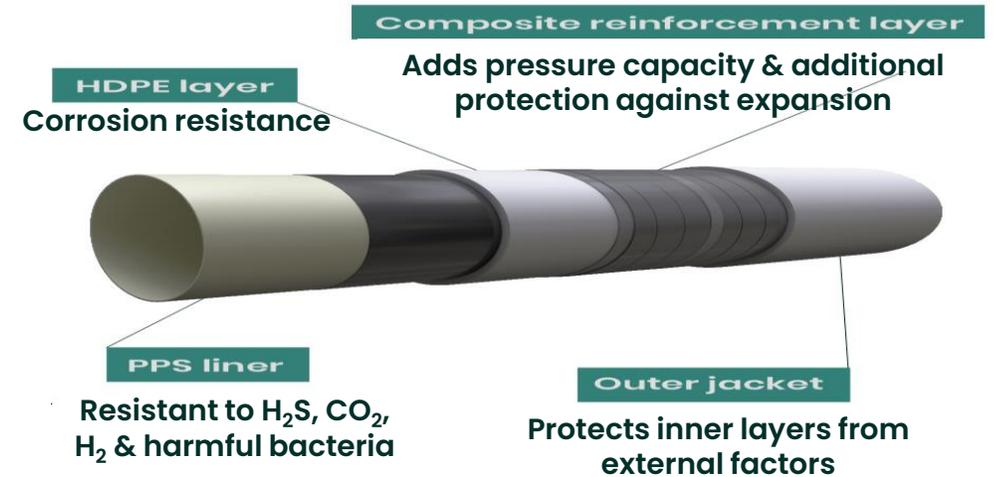


- Lighter and faster to install
- No welding needed
- No cathodic protection/pigging
- Reduced lifetime OPEX

Operational Excellence



- Superior composite products chemically inert
- Can transport H₂ and CO₂
- Re-purposing and rehabilitation of old pipelines



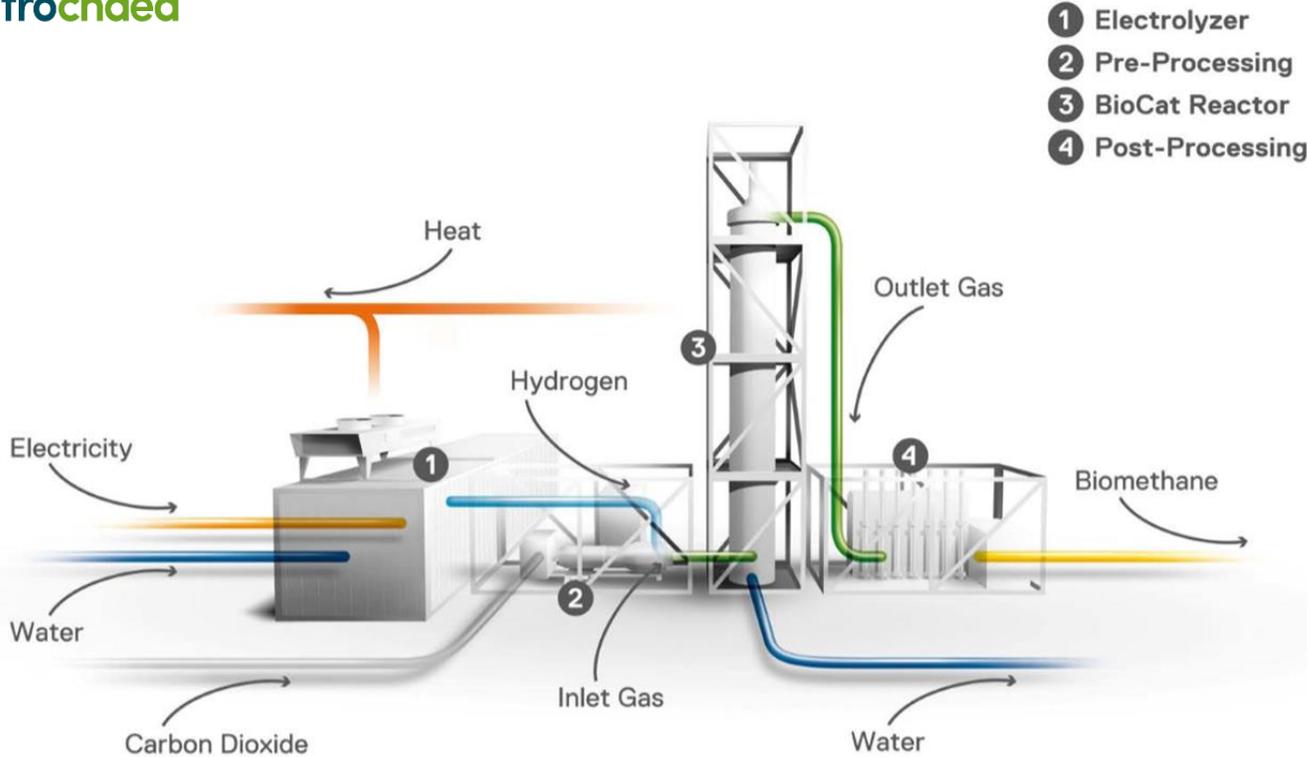
150°F/180°F
(65°C/82°C)



750/1500 psi - unbonded
2250psi fully bonded - in development
(52/103/155bar)



CO₂ utilization – biomethanation



- 1 Electrolyzer
- 2 Pre-Processing
- 3 BioCat Reactor
- 4 Post-Processing

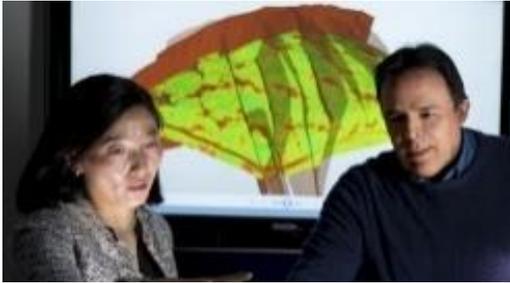
0.7 MWe	
Gas Grid Injection	
Solothurn, Switzerland May 2019	

1 MWe	
Gas Grid Injection	
Avedøre, Denmark April 2016	

Electrochaea’s biomethanation technology is now available at 10MWe, 25MWe and 75MWe scale

CO₂ storage – injection & storage capabilities

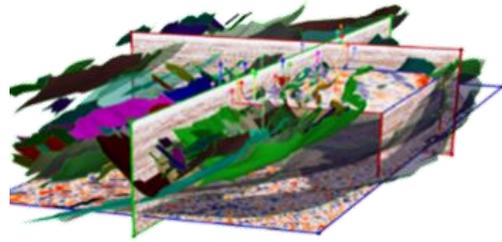
Project development



Storage characterization

- Assess the feasibility of our customer's assets for storage capacity and integrity
- Conduct pre-FEED and FEED studies for storage leveraging our capabilities in geo-mechanical modeling, subsurface engineering and completions design
- Assist with the injection site permit application

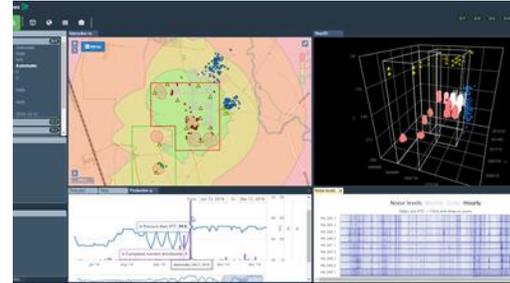
Subsurface storage



Installation optimization

- Provide integrated well services and project management to ensure regulatory compliance, third-party management and timely delivery
- Deliver an optimized injection and monitoring philosophy tailored specifically to project needs
- Customize well designs and service integration to assist each storage project's unique requirements

Asset integrity



Compliance assurance

- Ensure containment across the lifetime of the asset to comply with local and regional regulations
- Provide near-wellbore and formation monitoring services to verify the integrity of the wellbore, the stability of the reservoir and its regional seal
- Real-time monitoring services to reduce risk and number of resources required to manage the long-term injection project

Post-injection care & closure



Long-term asset protection

- Assist with site closure through optimized plug and abandonment operations
- Continue asset monitoring with our robust solutions designed to reduce OPEX spend and additional field-based activities
- Continue to assist our customers with long-term regulatory compliance to reduce overall project risk

Process and Safety Control

- For more than a century Baker Hughes Valves has partnered with process and industrial manufacturers and engineers, providing the most reliable control and pressure relief valves with the widest selection of materials, test standards and fluid control technology to ensure safe and efficient production, transportation and storage of process media like unwanted carbon.
- There are many ways to capture carbon that involve a wide range of operating conditions, pressures and temperatures, like post combustion chemical absorption, pre combustion gasification, oxy fuel flue gas combustion or atmospheric direct air capture (DAC).
- Baker Hughes has valve technology that can operate and control the differing capture process techniques to provide a safe environment for people and equipment together with optimized flow and pressure control.

Rotating Equipment safety

- Compressors require control valves and actuator systems to prevent and control surge, trip and efficiency scenarios.
- Pumps require control valves to prevent mechanical or thermal damage.

Environmental safety

- Meeting environmental emissions standards ISO & API
 - Environmental damage such as air pollution.
 - Long-term health risks to workers and communities.

Plant safety

- Designed to ensure the safety of life, and equipment from unexpected overpressure.
- Pilot Operated Devices reduce emissions, improve efficiency while ensuring “Zero Leakage” even at 98% of set pressure.

Process optimization

- Since the introduction of the SVI (Smart Valve Interface) in 1997, Masoneilan has continued to lead the way in advanced performance control, full suite of valve operation and maintenance software, independent of valve OEM.

Masoneilan

a Baker Hughes business

Becker

a Baker Hughes business



Masoneilan Globe Control Valve

Consolidated

a Baker Hughes business

Mooney

a Baker Hughes business



Pilot Operated Safety Relief Valve

Baker Hughes 