ONE Chart – Carbon Capture

1 About ONE Chart

Strong Global Presence

Our Vision – Nexus of Clean™

Chart's vision is to be the global leader in the design and manufacturing of cryogenic process technologies and equipment for clean power, water, food and industrials, regardless of molecule.

The combination of Chart and Howden furthers our global leadership position in highly engineered process technologies and products serving the Nexus of Clean™.

2 Chart in Carbon Capture

We provide critical CCUS solutions and support to various end-use Industries

Oil & Gas

CO_2 can be stored in dedicated storage sites such as depleted oil and gas reservoirs or deep saline formations, or it can be injected underground for Enhanced Oil Recovery (EOR) purposes

Natural Gas Processing and LNG

CCUS is the only solution to address CO_2 emissions from natural gas processing.

CCUS can facilitate the production of clean hydrogen from natural gas

Hydrogen, Ammonia & Biofuel Production

CCS applied with bioenergy processes (bio-CCS schemes), negative CO_2 emissions can be potentially achieved

Chemicals & Petrochemicals

CCUS deployment is critical to chemical subsector decarbonisation.

Cement

CO_2 generated in the cement kiln can be captured through post-combustion capture techniques or purified from kiln flue gases through oxy- fuel capture technologies when oxy-fuel combustion is used.

Fertilizer Production

In ammonia production process, a highly concentrated CO_2 stream is already produced, making it a low hanging fruit for CCS

Iron & Steel

CCUS, coupled with upgraded process technologies for hot metal production that incorporate oxygen-rich conditions, becomes important to meet the emissions reduction targets.

Metal Processing

Primary metal production is highly energy-intensive, with electricity making up a large share of the energy consumed; decarbonising its power sources would help reduce indirect emissions

Power and Low-carbon Power Systems

CCUS can support power system transformation by mitigating emissions from existing coal and gas assets through retrofitting and by generating negative emissions when combined with bioenergy

Maritime

CCUS solutions are already commercially available for onshore projects, while solutions for commercial vessels are being tested.

Commercial & Residential Buildings

CO_2 generated in the construction and buildings can be captured

Food & Beverage

Capture and utilize the CO_2 generated in the food & beverage industry. It is an essential technology driven mitigation option that converts exhaust CO_2 into stored CO_2 or into value added product.

Our existing presence and expertise in diverse hard-to-abate industries
Providing critical operational support with the integration of CCUS technology

We constantly evolve our solutions with the emerging CCUS technologies, our portfolio covers a large range of sub-sectors on various scales.

	High Purity point sources				Low purity point sources				Diffuse/legacy CO2
Sub-sector	**Gas Processing**	**Ethanol**	**Hydrogen**	**Ammonia**	**Power gen: coal**	**Iron & Steel**	**Cement**	**Power gen: natural gas**	**Direct air capture**
									
Emissions, MtCO2e	40	<10	<10	24	677	155	112	245	-
Avg. TPD/plant	-	400	70	-	2-20k	2k	4k	4-10k	60k
Our Portfolio	Earthly Labs — Turnkey Solutions Solid sorbent and cryogenic capture technology				SUSTAINABLE ENERGY SOLUTIONS — Turnkey Solutions Cryogenic capture technology				
	Howden — Technology and Product Solutions Air movement, compression & heat exchanger technology and products								
	CHART Cooler By Design. — Technology and Product Solutions Storage tanks, heat exchangers, cold boxes and solutions								

We handle CO_2 on multiple scales, in different forms, at various temperatures

- Reduce CO_2 supply chain volatility
- Reduce CO_2 and VOC emissions
- Reduce total CO_2 costs
- Improve worker safety with reduced CO_2 in facility
- Realize additional revenue through sale of waste and brokerage
- Elevate brand among consumers
- Enhance beer quality

- Lowest energy and cost retrofit technology
- Easiest retrofit carbon capture technology
- Produces high-purity, liquid CO_2
- Very high capture rates, up to negative emissions (99%+)
- Integrated grid-scale energy storage

- Comprehensive product lines and expertise in compression, air movement, RAM, heaters and MVR.
- Agnostic in serving Capture Technology (i.e. supports cryogenic, amine, solid sorbent and emerging technologies).
- Strong customer base and relationships with deep process knowledge; install base of ~300 CO_2 Compressors globally
- Mechanical Vapor Recompression (MVR) technology

Complete range of solutions for carbon dioxide distribution including ISO containers, transport trailers and Chart's Orca™.

Complete range of vertical and horizontal tanks to suit any size and demand application.

Modular solution

All-metal outer jacket eliminates insulation deterioration from water condensation that is commonly found in foam insulated tanks

We bring value to our customers

Chart Solutions for CCUS

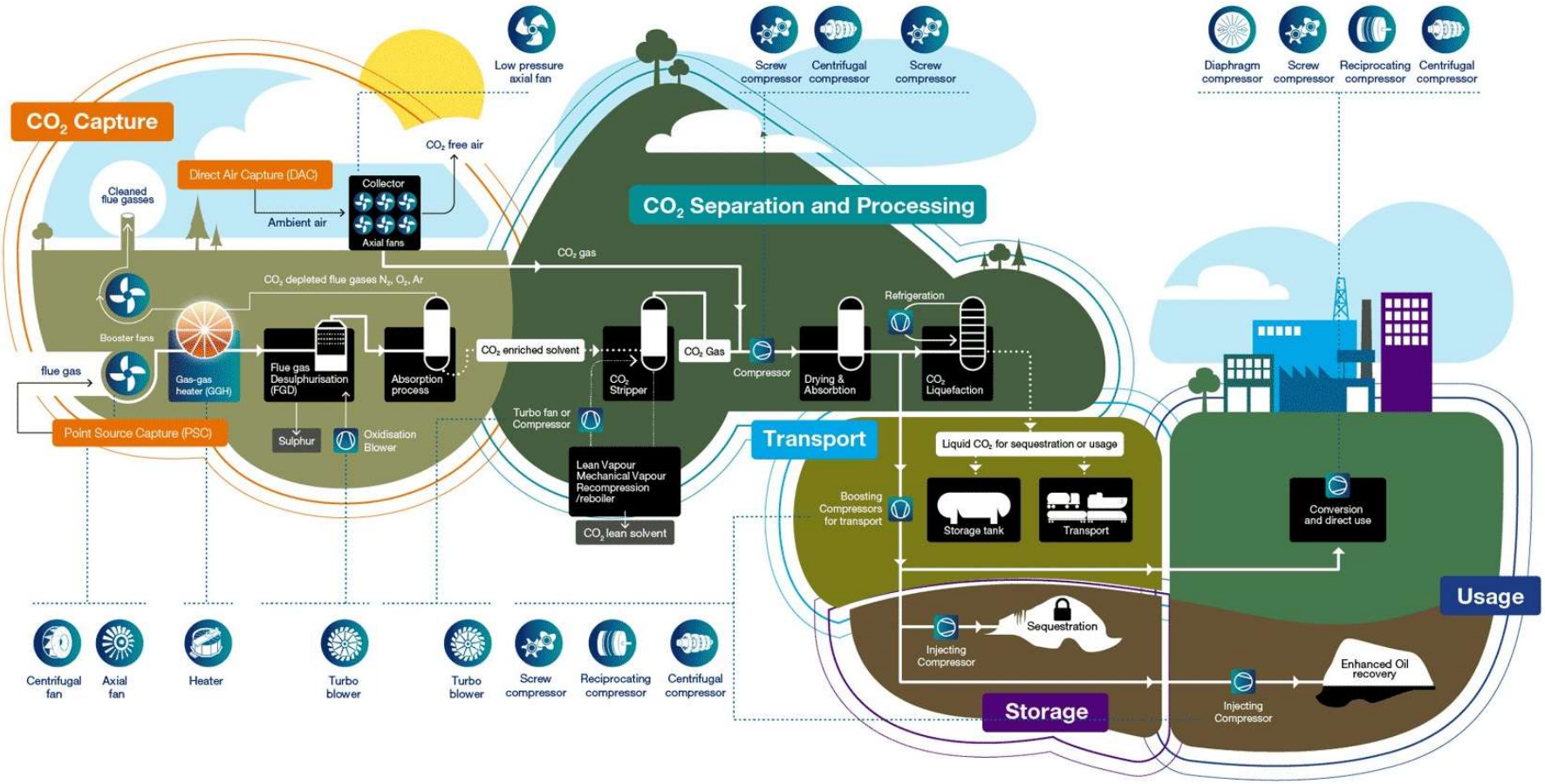
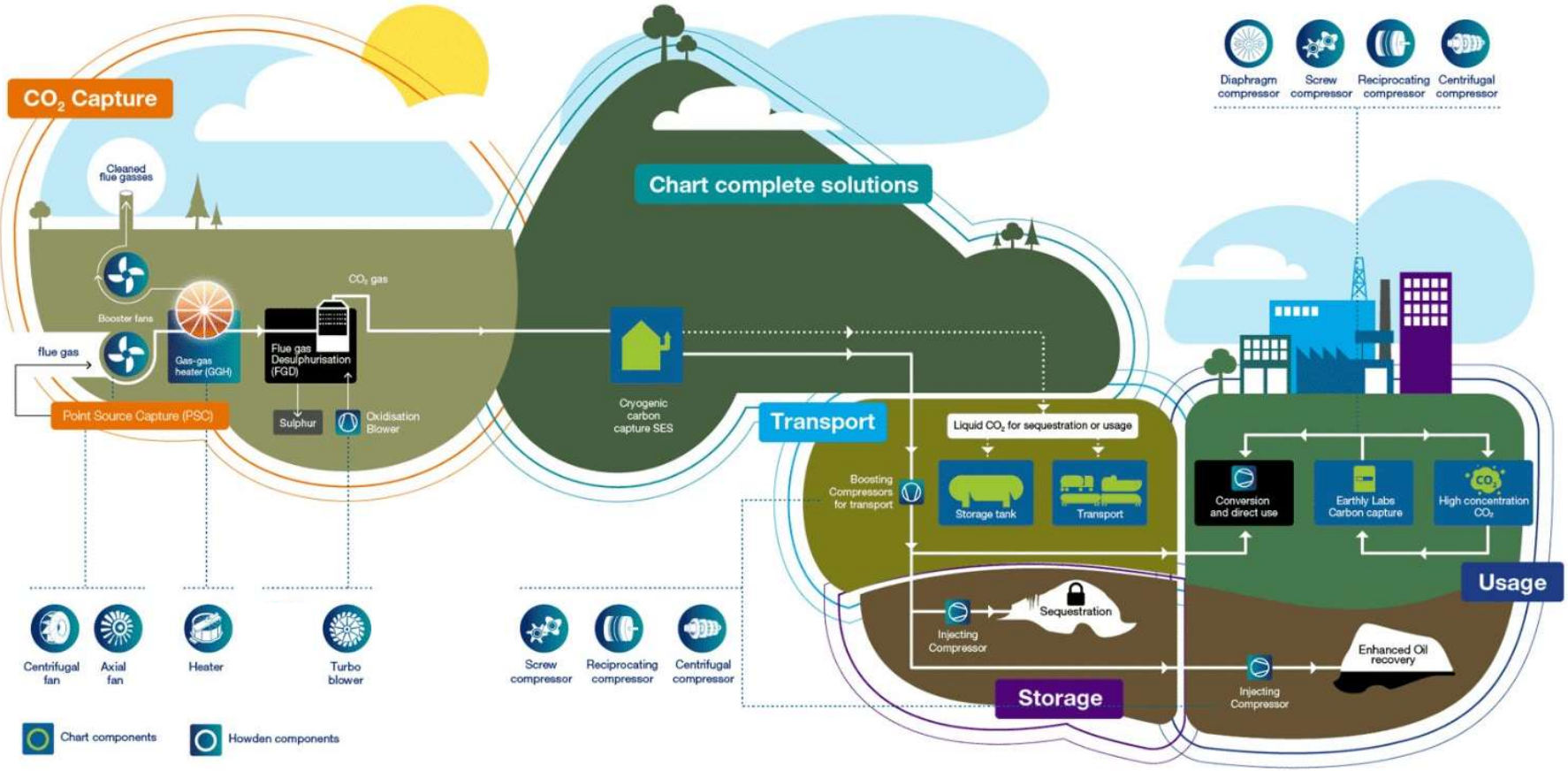


Chart Solutions for CCUS



Carbon Capture – small-scale, high purity point sources

Earthly Labs technology captures carbon dioxide waste from smaller sources that make up more than half of all carbon dioxide emissions.

Earthly Labs

Meet **CiCi** our small-scale carbon capture solution developed specifically for the brewery and carbonated beverage space. CiCi's patented purification technology transforms a mixed gas waste stream from your fermentation and brite tanks into a beverage-grade liquid for instant reuse; all in a box the size of a refrigerator.

Earthly Labs Carbon Capture Technology Offerings

Earthly Labs technology is uniquely designed to capture carbon dioxide waste from smaller sources such as businesses, homes, and transportation that make up more than half of all carbon dioxide emissions.

CiCi® Oak

- Launched 2018
- Production Breweries
- *5K-25K BBL

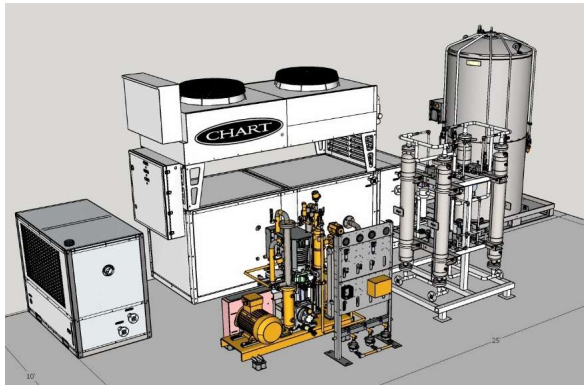
CiCi® Teak

- Launched 2023
- Brew Pubs
- 1K-4K BBL

CiCi® Elm

- Install 2023
- Large Craft Breweries
- 25K – 200K + BBL

CiCi (Oak) system compresses, purifies and liquifies CO2 for reuse



CiCi® (Elm) CO2 Capture Solution – Example Design

Earthly Labs CO_2 Capture – #1 Leader in Small Scale Carbon Capture

Earthly Labs
A Chart Industries Company





nrg | cosia CARBON XPRIZE

Founded company Selected 38 out of 140 global entries

2016

Selected ABINBev 100+ Accelerator 21 out of 300+ global entries

2018

CNN

"Turning Carbon Dioxide into Liquid Gold"

2020

CHART
Cooler By Design.

IOT CCU platform with More Small Scale Systems in World, with marketplace of CO2 partners

2021

Wine Spectator

First SmallScale CC Wine Solution Opened in World, with marketplace of CO2 partners

2022

Innovation in CCUS

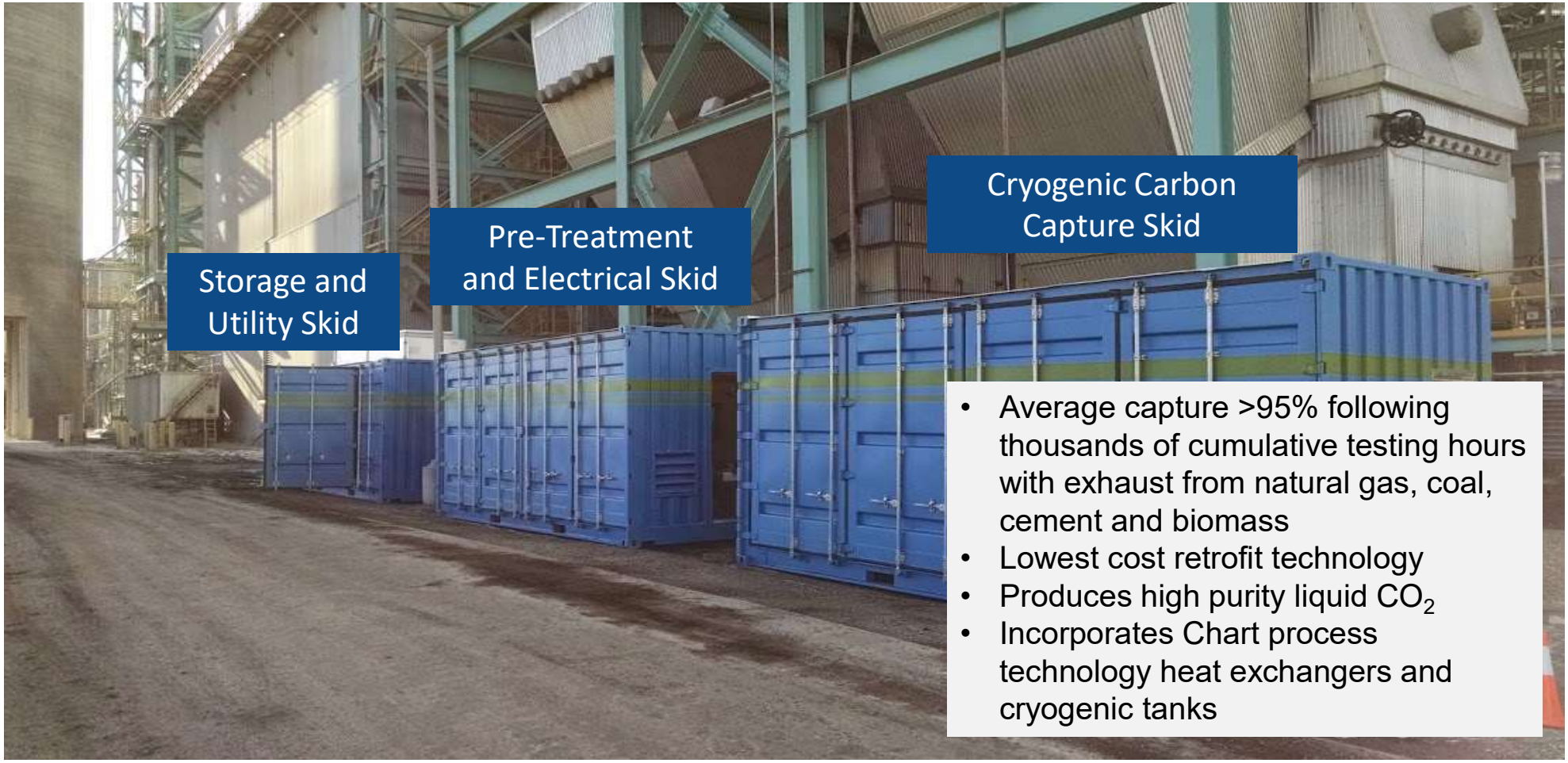
Continue to innovate and Open new CO2 Capture Markets in biogas, distilling, and post-combustion

2022

CHART

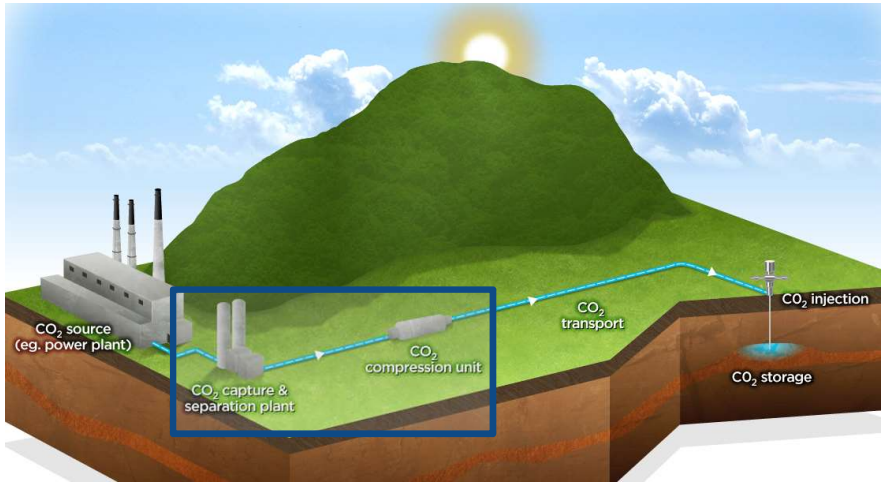
Carbon Capture – medium/large scale, low purity sources

SES INNOVATION
A Chart Industries Company

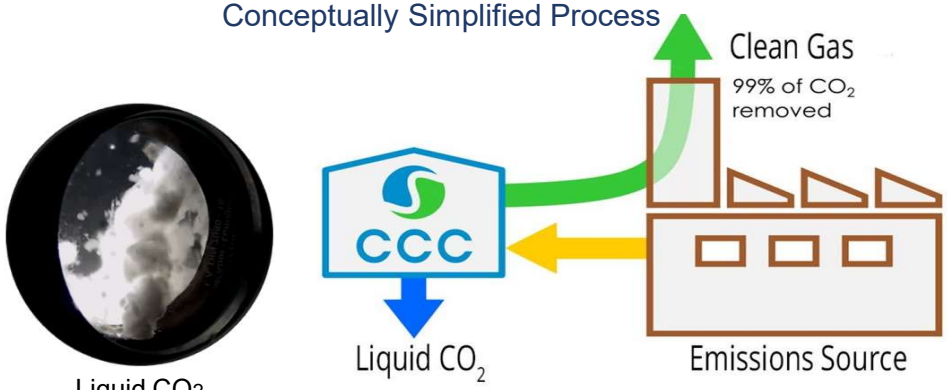


- Average capture >95% following thousands of cumulative testing hours with exhaust from natural gas, coal, cement and biomass
- Lowest cost retrofit technology
- Produces high purity liquid CO_2
- Incorporates Chart process technology heat exchangers and cryogenic tanks

SES Carbon Capture Technology Offerings



Conceptually Simplified Process



Liquid CO_2

Cryogenic Carbon Capture (CCC)

CCC separates CO_2 from plant exhaust and pressurizes it in a single process delivering it as a high-pressure liquid ready for transportation and use.

Cryogenic Carbon Capture™ (CCC) is a post-combustion technology that reduces carbon emissions from fossil energy power stations, cement, pulp and paper, iron and steel facilities as well as certain chemical production plants.

CCC Pilot/Small Commercial-Scale Preliminary Layout

Sustainable Energy Solutions – CO_2 Capture Leadership

SES INNOVATION
A Chart Industries Company




SES INNOVATION — MITei MIT Energy Initiative — Edison Awards Gold

60+ Patents Issued, Bench and Field Pilots Completed, Recognized as top Post-Combustion Carbon Capture Technology

2010-2021

nrg | cosia CARBON XPRIZE

Powered Carbon Cure (Round 1 & 2) to win the Carbon XPRIZE

2019-2020

CHART Cooler By Design.

Chart acquires SES to Accelerate Carbon Capture Scale-Up and Deployment

2020

Central Plains Cement Company

First Small-Commercial Project (30-300 TPD CO2) Near Kansas City, MO

2021

Denbury — OXY — Northern Lights — WOLF

Scale-up to Full-Industrial Carbon Capture

2023-

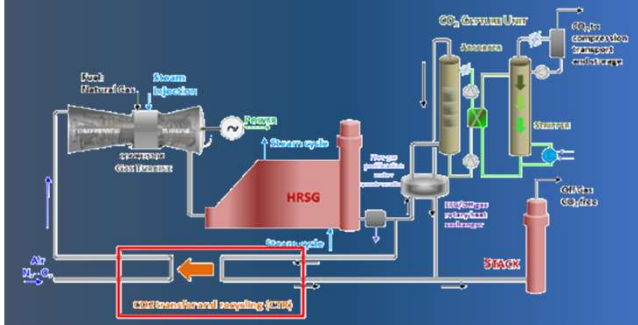
CHART®

Howden – Over 10 years involvement in CCUS technology development

Howden has been involved since the beginning of fundamental CCS research and has provided collaborative support for the associated universities in the development of carbon capture technology, and provided equipment for worldwide CCS demonstration projects

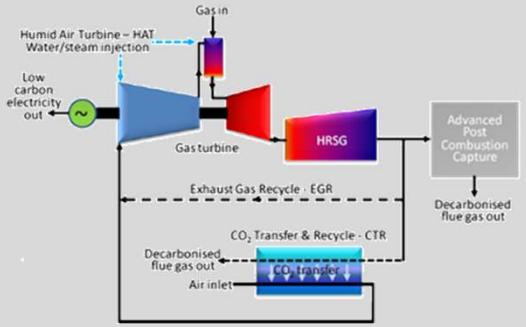
TECRON Project

- Transition Engineering and Capture Ready Options for New-Build NG-Fired Stations
- EPSRC Case Award



UKCCS Research Centre

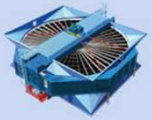
- Gas – FACTS Project
  Advanced Capture Technology Options
- Exhaust Gas and Co2 recirculation for CCS process intensification



Equipment provided for worldwide demonstration projects

Boundary Dam, CFB with PCC	USA
Mikawa, CFB with PCC – GGH	Japan
Karlshamn, Gas Fired CCGT with PCC	Sweden
Ferrybridge, CFB with PCC	UK
Donguaan, IGCC	China
Hua Dian, CFB with PCC	China
Kemper County, IGCC (585MW)	USA
Petrobras, FPSO	Brazil
Xinjiang Oilfield, Periflow Compressor	China

Howden Carbon Capture Product Offerings – agnostic to capture technology

Customer Need	Our Products in the Solution
Point Source capture (<1 Bar)	 Turbo blower  Centrifugal fan  Axial fan  Gas-gas heater
Direct Air Capture (DAC)	 Direct Air Capture Fan  Rotary Adsorption Machine (RAM)
CO_2 Separation (~2 Bar) and Processing (~30 Bar)	 Screw compressor  Centrifugal compressor  Turbo blower / MVR
Transport, storage and usage (>75 Bar for supercritical)	 Diaphragm compressor  Screw compressor  Reciprocating compressor

Scope includes driver, monitoring instrumentation, controls, filters, silencers, inter-coolers, skids, ducting and commissioning support.

Carbon Capture – medium/large scale

Complete range of vertical and horizontal tanks to suit any size and demand application.

- Modular solution
- All-metal outer jacket eliminates insulation deterioration from water condensation that is commonly found in foam insulated tanks

Carbon Capture – medium/large scale

Complete range of solutions for carbon dioxide distribution including ISO containers, transport trailers and Chart's Orca™.

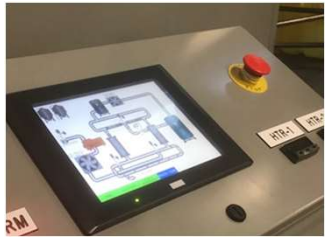
Digital Twin Solutions

CiCi® CO_2 Capture Software for GHG Monitoring & Reporting

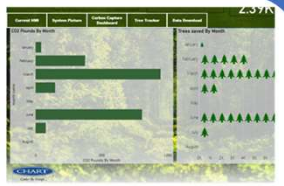
At-a-Glance Monitoring
Real-time Oxygen Levels
Pressures & Temperature
Dewar Full Levels
CO_2 Capture Volume
Alarms & Alerts

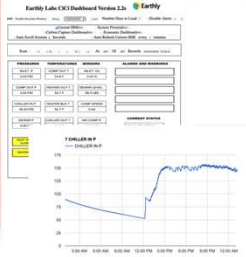
Mobile Dashboard
Check Status from Phone
Alerts & Notices Team

Remote Dashboard
Trends
Maintenance
Troubleshooting



Earthly Labs
A Chart Industries Company





Howden Uptime – The unique digital solution for equipment performance optimization.

- Howden Uptime is a digital platform that seamlessly integrates data related to your rotating equipment.
- We are combining over 160 years of OEM expertise with the most advanced industrial IoT architecture in the world, to provide a purpose built, innovative platform to deliver value to our customers.

CHART

Partnerships – Signed MOU's

- Svante
- B&W
- Kiewit
- Wolf Carbon Solutions
- Teco 2030
- CarbonCure
- Koch Engineered Solutions
- FuelCell Energy
- …

Together We Are Creating the Future

TURNING
CHALLENGES
INTO
SOLUTIONS

CHART
Cooler By Design.

Thank You

NEXUS OF CLEAN™