




Carbon Capture & Reuse

Embedding Circular Practices

 zerowastescotland.org.uk

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**ZERO
WASTE
SCOTLAND**



ABOUT US

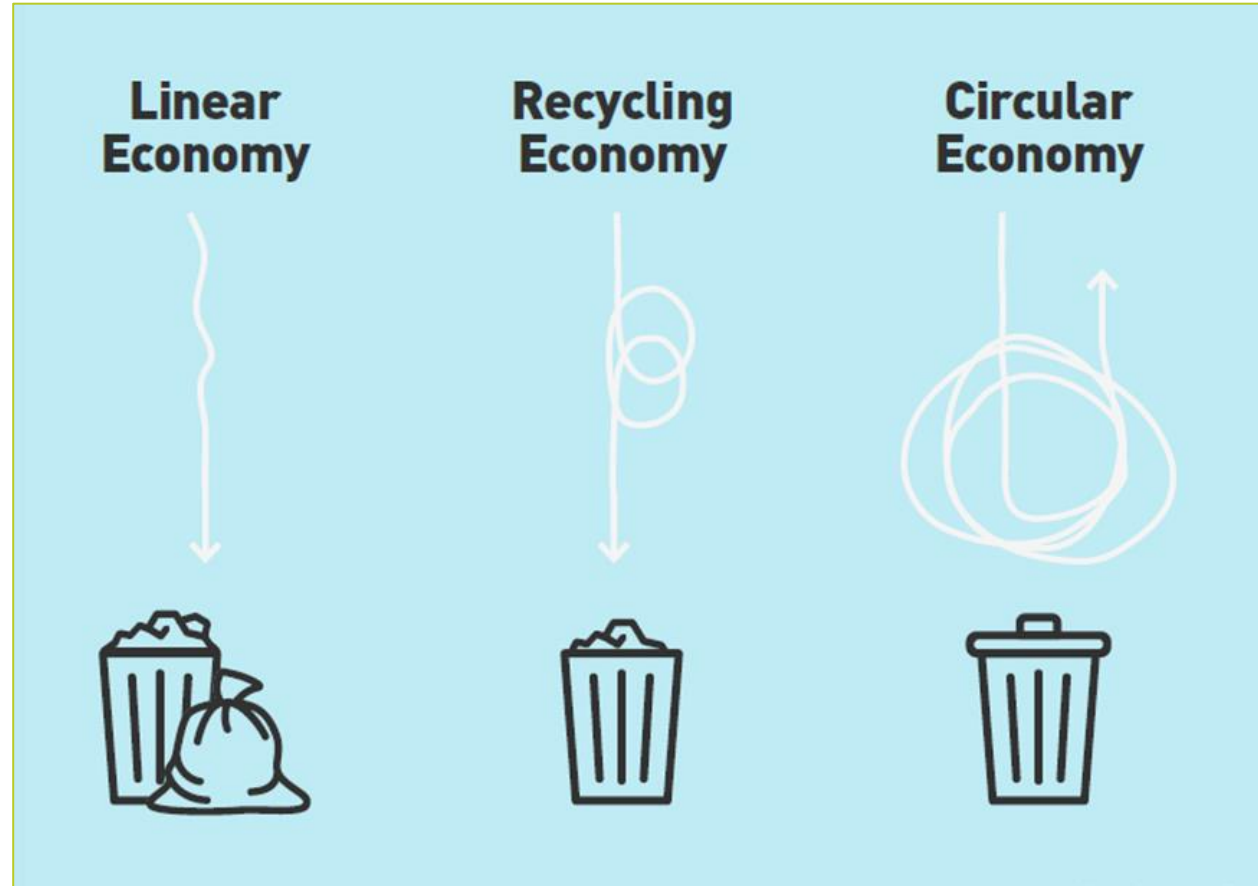
Zero Waste Scotland exists to lead Scotland to use products and resources responsibly, focusing on where we can have the greatest impact on climate change.

**ZERO
WASTE
SCOTLAND**

What is a circular economy?

A systemic shift in the way we think and design products, based on three principles:

1. Design out waste and pollution
2. Keep products and materials in use
3. Regenerate natural systems



Agenda

1. Steve Livens, Policy Manager, British Beer & Pub Association
2. Amy George, President, Earthly Labs (Chart Industries)
3. Steve Stewart, Founder & Managing Director, Stewart Brewing
4. Martin Doogan, Group Engineering Manager, Tennent's
5. Q&A





Use of **CO₂** in the Brewing Sector

24.10.2024



British Beer & Pub Association

Formed in 1904, the BBPA is the leading trade body for brewers and pubs, representing companies across the UK, which between them own around 20,000 pubs and brew over 90% of beer sold in the UK.

Member companies have many different ownership structures, including UK PLCs, privately-owned companies, independent family-owned brewers and UK divisions of international brewers.

The brewing and pub industry in the UK makes a major contribution to the local and national economy. 85% of pubs in the UK are run as SMEs.

Use of CO₂ across the UK

- CO₂ is a vital commodity across a range of UK industries – overlooked in the past both in terms of price and availability.
- Widespread use:
 - Farming & agriculture – animal welfare
 - Food and drink manufacturing
 - Food packaging
 - Nuclear
 - Medical
 - Research
- Brewing sector use:
 - Processing, packaging and ingredient
 - Beer dispense

Where does our CO₂ come from?

- Main sources:
 - Ammonia production (fertilisers) – CF Industries, *both UK sites now closed*
 - Bioethanol production – Ensus, Wilton, majority producer of domestic CO₂
 - Anaerobic digestion – some small scale, localised supply
- A small number of principle gas suppliers – bulk or bottles
- Very little competition in the market
- Domestic supply constraints happen quickly and frequently:
 - Combination of planned and unplanned site shutdown – longer re-start time for bio-ethanol plants vs ammonia plant
 - Mis-matched production schedules – traditionally aligned with the agricultural calendar
 - Very little overcapacity in domestic supply – heavily reliant on EU for shortfalls

Constraints in Supply

- Three main incidents of supply constraint/failure in recent years:
 - 2015
 - 2018
 - 2022
- 2018 most severe shortage:
 - Caused by combination of planned and unplanned plant shutdown across the EU
 - All domestic suppliers operating under Force Majeure
 - Shortage coincided with summer and the FIFA World Cup
 - Beer shortages in on and off-trade because of production interruptions
- 2022 no actual constraint - but did cause some of the worst impacts of any recent event

2022 CO₂ Crisis

- Late 2021 - announcement of imminent, temporary closure of both CF industries plants (Billingham and Ince) citing high energy costs
- Early government intervention resulted in funding to support operations at Billingham
 - Funding on the proviso that an industry solution could be found
- Early 2022 - CO₂ suppliers introduced a CO₂ 'surcharge' on top of supply - accommodated for fluctuations in energy and production costs as well as potential need for alternative source where local supply was unavailable
- Surcharge resulted in CO₂ costs increasing - as much as 600% at the height of the crisis:
 - Annual cost predicted to increase from £150k to nearly £4m!
- No actual shortage but at least one supplier under Force Majeure (for over a year!)
- CF Industries finally closed Billingham in 2023 despite Government intervention and the industry surcharge which remains in place today.

Outcome of the 2018 & 2022 Crisis

- BBPA has been lobbying government since 2018 to take steps to ensure a more resilient and transparent domestic supply chain
- Defra official lead on activities and coordination in the event of future supply interruptions:
 - Broad UK industry engagement but to date no joint supplier and user forum.
- Ongoing high costs and the spectre of future supply constraints and interruptions has prompted the brewing sector to review opportunities for greater self-reliance:
 - Greater efficiencies and prioritisation of use
 - Opportunities for recovery and re-use
 - Re-purpose emissions from other industries as a dedicated, alternative sector supply
 - Sharing of recovered CO₂ within the industry

Potential Solutions

- Work on improving efficiency of CO₂ use since 2018 has lead to reduced demand by brewers - *limited opportunities here for pubs.*
- Unlikely to achieve dedicated sectoral solution at present:
 - No infrastructure for sharing recovered CO₂
 - Cost of generating required quantity of food grade CO₂
 - Origin of CO₂ repurposed from other sectors and risk of negative consumer perception
- Focus remains on own recovery and reuse:
 - Equipment already available for larger producers and now more accessible to smaller producers
 - Gap remains for medium sized, regional brewers - older equipment and plant
 - Potential CO₂ recovery volume increasing but remains rare to exceed 100%



THANK YOU

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Earthly Labs™ CO₂ Recovery

A Chart Industries Company



Earthly Labs CO2 Capture History

Small Scale Carbon Capture



Founded company
Selected 38 out of
140 global entries

2016



“Turning Carbon
Dioxide into Liquid
Gold”

2020



Wine Spectator

First Small-scale CC Wine
Solution Opened in World,
with marketplace of CO2
partners

2022



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

2018



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

2021



Chart acquires Howden,
expanding its Global footprint
and product portfolio across
customer processes.

2023

Small Scale Carbon Capture Drivers for Craft Brewing



Reduce CO₂ supply chain volatility



Reduce CO₂ and VOC emissions



Reduce total CO₂ costs



Improve worker safety with reduced CO₂ in facility



Realize additional revenue through sale of waste and brokering

Elevate brand among consumers

Enhance beer quality



Maine Beer Case Study

Installation Reduces CO2 Demand

Maine Beer Company

Do what's right.



Maine Beer Case Study

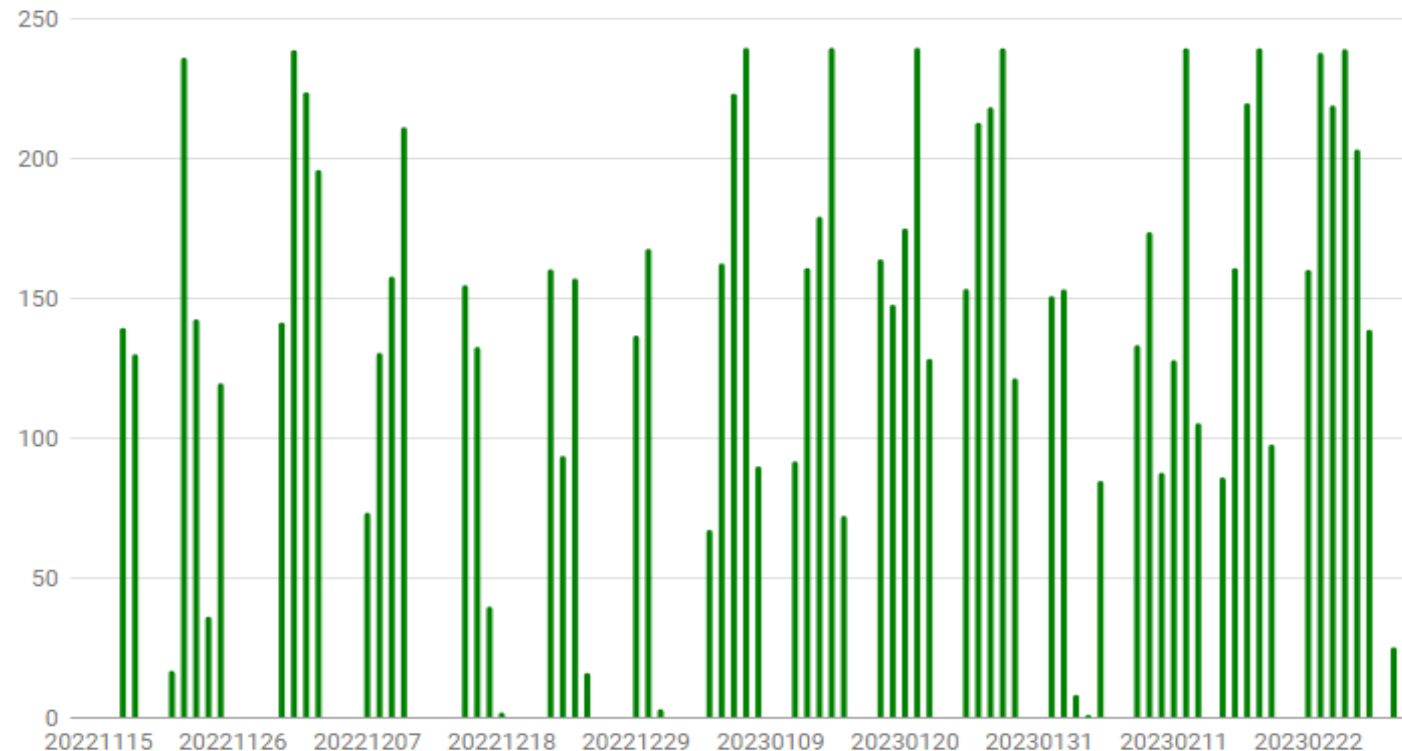
Powering High-quality Beers

Maine Beer Company



Do what's right.

Carbon Dioxide Captured



YearMoDa
Total Pounds co2 this chart = 9871

- Capturing CO2 most days of the week
- CO2 capture improves with use
- Quality measurements weekly
- Meets or beats sensory and bulk gas

“This investment will reduce greenhouse emissions created by CO2 deliveries, but most importantly, it reduces our carbon footprint.”
- Steve Mills CEO

The Alchemist Case Study

Driving Business & Sustainability Goals



- **Recovering CO2 Emissions, Reusing Waste Every Week**
- **Use CO2 Weekly to Carb Beer / Purge, estimate 1.8 M Cans of CO2**
- **Meets most needs with recovered CO2**
- **Expanded to Waterbury**
- **2 CiCi units running weekly**
- **Vermont Carbon reduction team audited and validated carbon positive results**



Pure Madness Group Background

First Wyoming CO2 Capture Site



HISTORY

2012 - Roadhouse founded by Colby Cox, Home Brewer & Entrepreneur, and Gavin Fine, Noted Chef & Restaurateur

2017 - Roadhouse opened a 30 BBL production brewery and

2018 - Roadhouse opened the Pub and Eatery pushing our total annual production to 10kbbls

2022 - Roadhouse Acquired Melvin Brewing Company, a 35,000 BBL Brewery in neighboring Alpine, Wyoming, Creating Pure Madness Brewery Group.



Roadhouse Installation

CO2 Enters Back of Unit



Melvin Installation

CO2 Capture and Repurposed Vessel

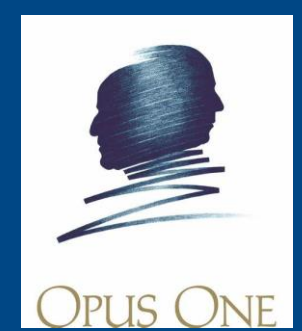


Repurposed holding tank for increased recapture with the potential to sell excess production to local greenhouse



CO2 Capture Winery Case Study

Opus One – Three Year Progress



- Founded in 1979 as a joint venture between Baron Phillipe de Rothschild and Robert Mondavi
- Focus on producing Napa Valley Cabernet Sauvignon
- Deep commitment to sustainability with Napa Green
- Second winery install Earthly Labs
- Third harvest deployed CiCi (Oak) + Winery
- Identified use cases of CO2 on site at the winery



“We have continued to expand Chart’s Earthly Labs carbon capture solution, reducing our climate impact and ensuring the enjoyment of each new vintage for generations to come.”

Michael Silacci, Winemaker - Opus One



CiCi® CO2 Capture Product Portfolio

Standard Technology Sized to Market Needs

CiCi® (Teak)



BREW PUBS

2k-6k hL annual production

Capture rate of 9 – 27 tonnes of CO₂

D125cm x W97cm x H197cm

CiCi® (Oak)



PRODUCTION CRAFT BREWERIES

6k-60k hL annual production

Capture rate of 27 – 135 tonnes of CO₂

D125cm x W97cm x H197cm

CiCi® (Elm)



LARGE CRAFT BREWERIES

30k-200k+ hL annual production

Capture rate of 135 – 900+ tonnes of CO₂

Modular system to fit 60-80m²

CiCi® (Oak) or CiCi(R) (Teak) Full Solution

Turn-Key Deployment from Tank to Use



CiCi Oak Lab Unit
(77.5" H x 38.11" W x 61" deep)

1 x CiCi



Foam Traps
(23.5" W x 32" H)
3' FV Blow off Arm

2 x Foam Trap



Foam trap / HX
(23.5" W & 72" H)
Distance from CiCi – 6'

1 x Smart Foam Trap



Dewar / Scale
(33" W x 33" L x 68" H)
Max Distance of Line -6'

1 x 1,000 lb

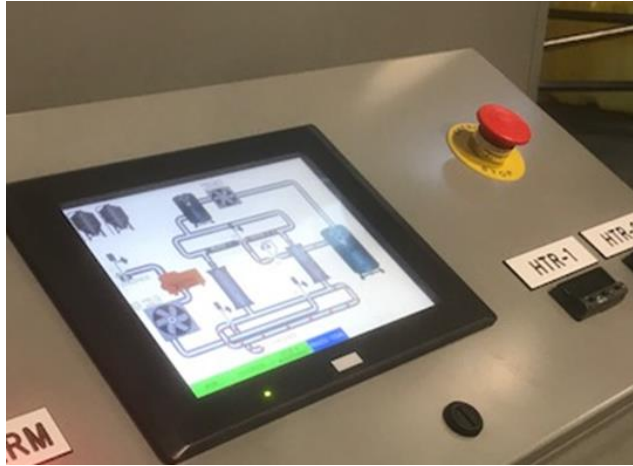


Vaporman
(30" W x 30" L x 48" H)
Max Distance of Line -6'

1 x Vaporman



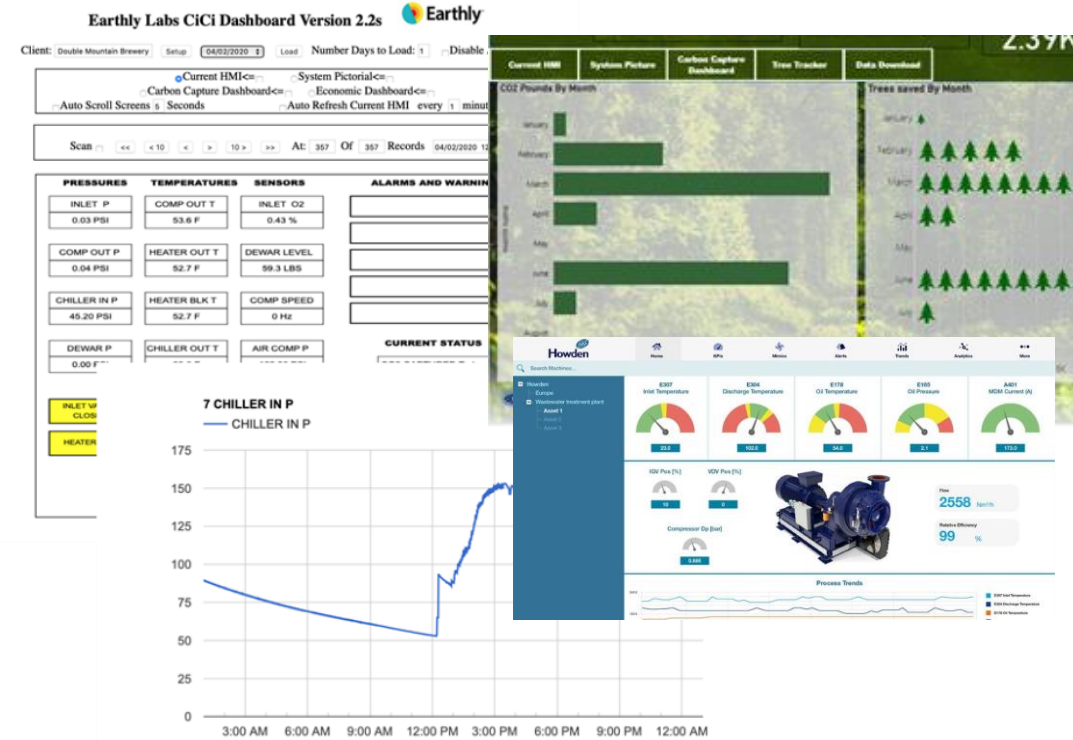
CiCi® CO2 Capture Software for GHG Monitoring & Reporting



At-a-Glance Monitoring
 Real-time Oxygen Levels
 Pressures & Temperature
 Dewar Full Levels
 CO₂ Capture Volume
 Alarms & Alerts



Mobile Dashboard
 Check Status from Phone
 Alerts & Notices Team



Remote Dashboard
 Trends
 Maintenance
 Troubleshooting

Chart Provides CO2 Capture Solution Value Chain

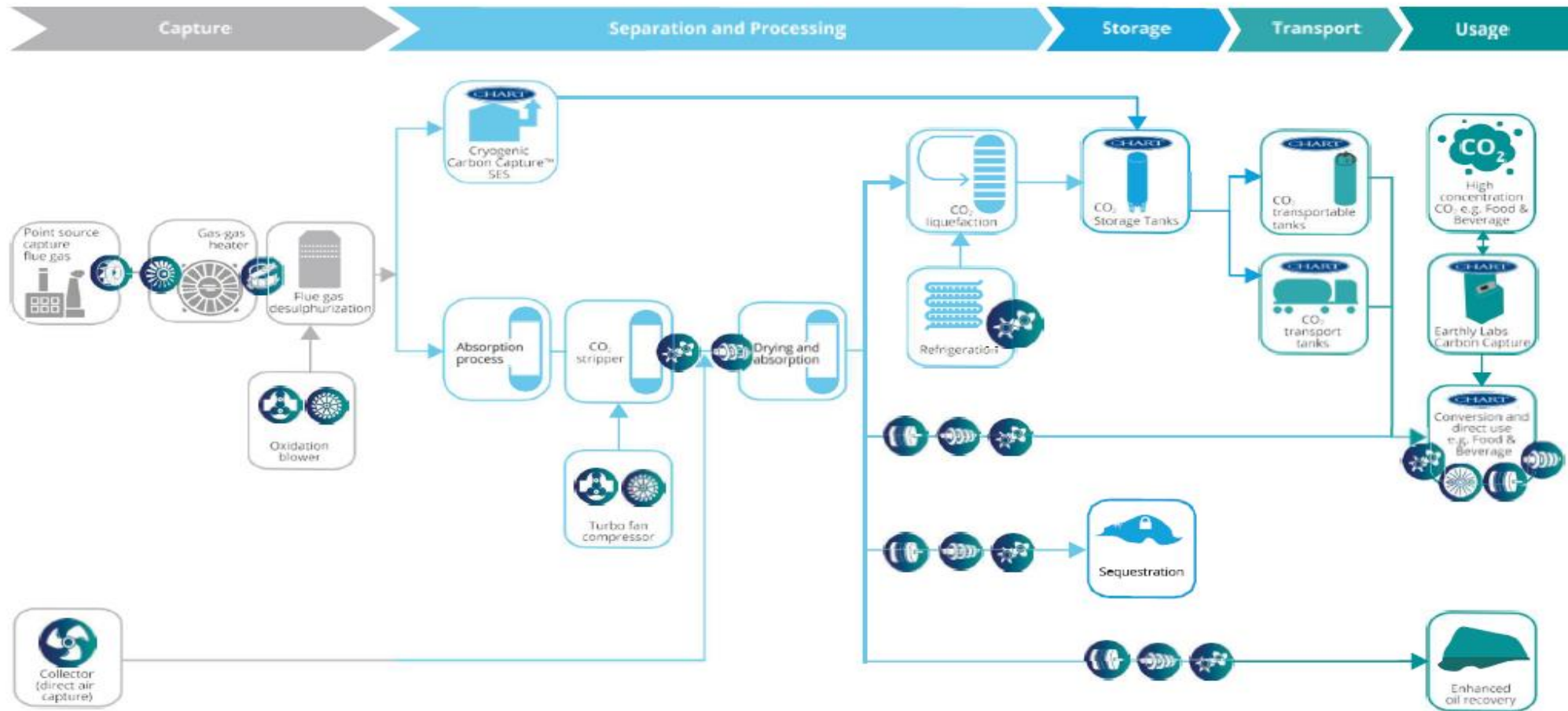


Chart Industries - Global Network, Local Presence

11,637

Experts

165+

Years of Innovation

169

Countries where Assets are Installed

50+

Service Centers

64

Manufacturing Sites

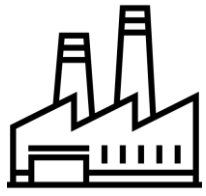


Earthly Labs Europe

Serving the European Region



Scotland
Head
Office



German
Manufacturing



15
Service
Centres



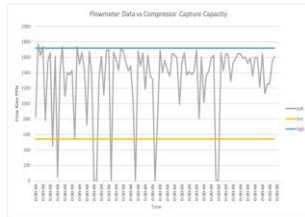
CO₂ Capture Roadmap

Accelerating Value and Reducing Risk

2.8 TO 1 Conversion Assumed			
Month	Dry Ice Production (LBS/Month)	Liquid CO ₂ Demand (LBS / Month)	Available Exhaust Gas (LBS / Month)
January	480,000	1,440,000	960,000
February	480,000	1,440,000	960,000
March	480,000	1,440,000	960,000
April	480,000	1,440,000	960,000
May	480,000	1,440,000	960,000
June	480,000	1,440,000	960,000
July	480,000	1,440,000	960,000
August	480,000	1,440,000	960,000
September	480,000	1,440,000	960,000
October	480,000	1,440,000	960,000
November	480,000	1,440,000	960,000
December	480,000	1,440,000	960,000
Total	5,760,000	17,280,000	11,520,000
Value		\$	892,800.00 (\$155 per ton)

Per Unit	
# of Units	1
DI Capacity (lbs)	3,000
Liquid to Solid Conversion Rate	2.8
Liquid CO ₂ (lb/M)	8,400
GCCO ₂ Exhaust (lb/M)	5,400

[Total Value] CO ₂ Value Increase 10% Per Year	
Year 1	\$ 892,800.00
Year 2	\$ 982,080.00
Year 3	\$ 1,079,288.00
Year 4	\$ 1,185,217.00
Total	\$ 4,139,385.00



FREE CO₂ Assessment

Feasibility Study

Grant & Incentives

Install CO₂ Capture

How much CO₂ available?
Estimated ROI
CO₂ Usages

Validate CO₂ Volume
Identify Grants and Incentives

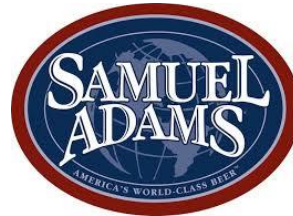
Apply for applicable grants

Full Scale Purchase

Serving Customers Powering a Better World



VENTURE GLOBAL LNG



Thank You

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Forbes

The New York Times





Sustainable Carbon Capture Project

Steve Stewart & Sam Russell



**STEWART
BREWING**



BACKGROUND

- Long interest in Brewery Carbon Capture
- CO2 Use at Brewery – c. **20,000HI** of production, (3.5M pints)
 - Tank Purging – remove O2
 - DO2 Control across brewery processes, (shield gas)
 - Tank to Tank transfers, (pressure operations)
 - Can Line / Bottle Line Operations
 - Dispense Gas, (for refillable growlers)



**STEWART
BREWING**



PURCHASED CO2

- Use of CO2 – **34.5T per year**
 - Cost of supply increased from £350/T to £930/T since 2016
 - Delivered in 34 kg cylinders, (over 1000 cylinders manually handled)
 - **£32,000** cost pa
 - “Interruptible” supply – 2020 & 2021 country ran out of CO2
 - Large Shift from Largepack to smallpack due to covid pandemic
 - Can supply in shortage
 - CO2 supply in shortage
 - Business resilience issue



**STEWART
BREWING**



CO2 EMISSIONS

- CO2 released by Fermentation is “short cycle Carbon”
 - “Captured” in the previous year through barley growth
 - Natural product from the fermentation process, (fizz & sparkle)
 - We release c. **70Tonnes** per year from Fermentation of Barley Malt
- How much of this released CO2 can be captured to offset purchase of purchased CO2?



**STEWART
BREWING**



PROPOSAL 2022

- Introduction of technology that:-
 - Fit with the values of the business, (Ambition Net Zero)
 - Cost effective with acceptable payback times
 - 2 x 15kg per hour Dalum CC machines to allow for
 - Both small and large tank fermentation
 - Increasing potential capture from 43% to 66%
 - 30.5T to 46.3T available Liquid CO2
 - Provide excess CO2 availability
- Fringe Benefits
 - Reduce Manual handling and improve safety and efficiency
 - Higher level of Job Satisfaction
 - Introduce bulk system for efficient operations
 - Improve business resilience



**STEWART
BREWING**



TECHNOLOGY

- Widely available for macro breweries for a long time
- Recently made cost effective for smaller scale producers
 - Collect CO2 from fermentation
 - Wash out any impurities
 - Condense & remove out unwanted gases / liquids, (Oxygen & Water)
 - Liquify & pump into cryogenic storage tank for re-use
 - Produces 99.99% purity, odorless & tasteless CO2
- Dalum – European Based Company that understood our needs and developed solutions that worked



**STEWART
BREWING**



FINANCIALS

- £150K investment Total
 - 2 x Dalum 15kg per hour machines
 - Bulk handling tank
 - Collection and distribution systems
 - Allows for 45T per year productive capacity, (at current Beer production rate)
- Ongoing electrical cost to operate units c. £6912 pa (electrical)
 - 28,800 kwh annual load
 - Subsidised by Excess Solar PV production, (especially at weekends)
 - “Cost” per Tonne = £177, (compared to £963)
 - Annual Savings on purchased CO2 = £26K pa
 - RSA grant awarded by SE of £72K
 - 3 Year Payback, (accounting for grant award)
- Phase II
 - Cylinder Population & Cylinder Filling operation
 - 10 – 15T “spare” CO2 per year
 - Potential “earnings” of £35 - £50K dependent upon price / supply route
- Allows for Investments of savings in further Sustainable projects, (steam injection, heat pumps, water re-use)



**STEWART
BREWING**



ENVIRONMENTAL CONSIDERATIONS

- Operation of Dalum Carbon Capture prevents the release of c. 46 Tonnes of CO₂ to atmosphere per year
- 1 Tonne CO₂ captured reduces estimated carbon footprint by 2 Tonnes of non-sustainably produced CO₂ by industrial processes
 - (eg as by-product of ammonia production as part of fertiliser manufacturing process involving high energy consumption)
- Stewart Brewing Total Reduction of CO₂ footprint by 252 Tonnes over 3 years from this project



**STEWART
BREWING**



FRINGE BENEFITS/LEARNINGS

- Cask heavy Brewery
 - Large production of cask ale is a net positive contributor of CO2
 - Largely uncarbonated product
 - Produces excess available for other requirements
- Larger Vaporiser required, (ambient Scottish temperatures)!
- Can “recapture” from process tanks that have been emptied & use infinitely



**STEWART
BREWING**



DALUM

- Exceptional supplier to work with and have recommended several times to other SIBA members
- 60 plants installed in 16 countries
- Problems Solving, Maintenance support, technology, utilisation of the machines etc

DALUM
Beverage Equipment







**STEWART
BREWING**

MANY THANKS





Tennents Brewery, CO 2 Recovery Project

Martin Doogan, Head of Engineering and Technical, C&C Group

Tennents Wellpark Brewery (CO2 Background)

- Brewing history, since 1556.
- 2 m hl brewery – packaging in can, bottle and keg formats.
- City centre location
- Home and single source of our iconic brand – Tennents Lager
- Before we recovered our Co2, we typically sourced 4,000 tonnes per annum, with associated tanker movements.
- Increasing frequency of supply shortages from 2016.

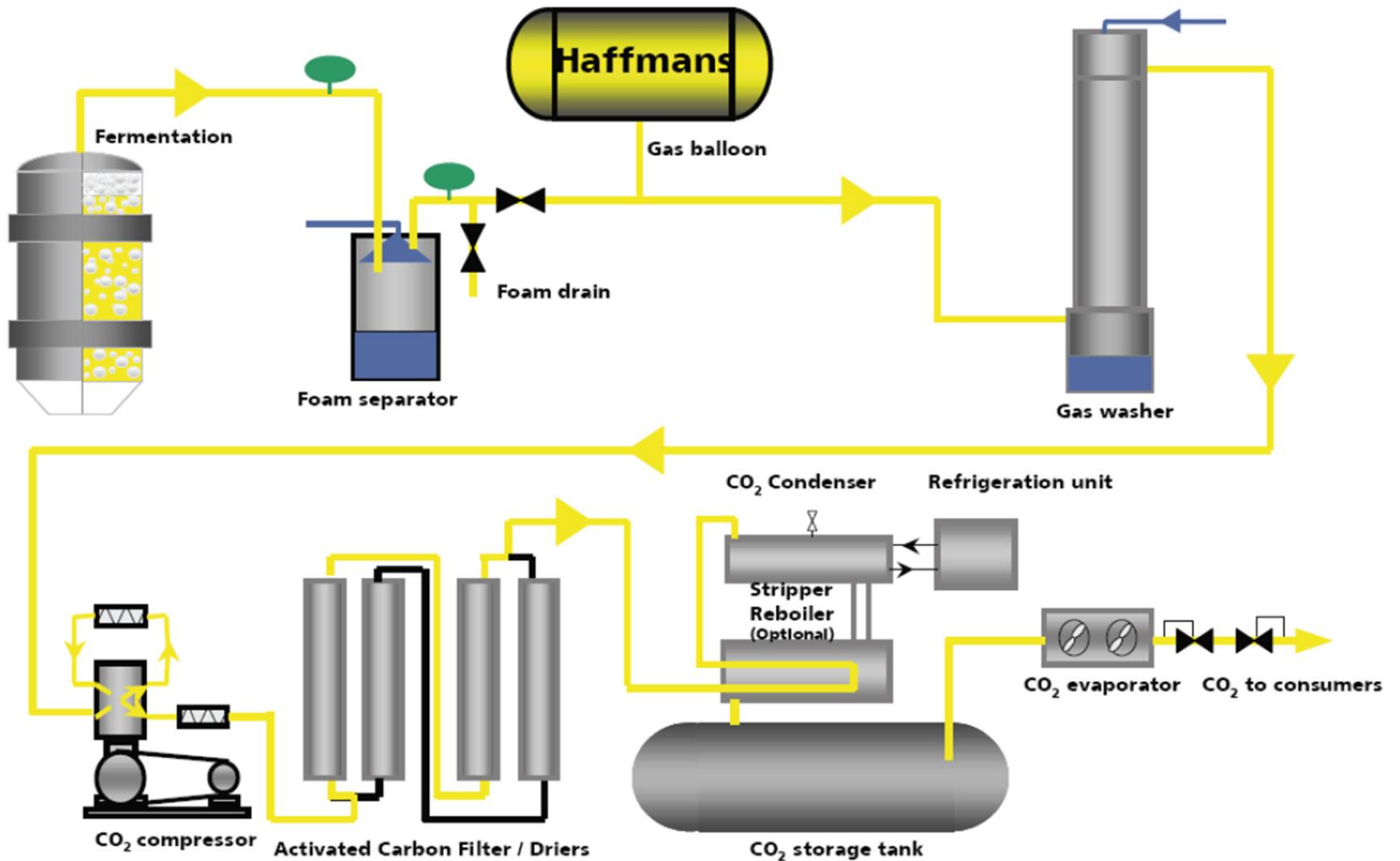




CO2 Recovery Project – Scope & Timeline

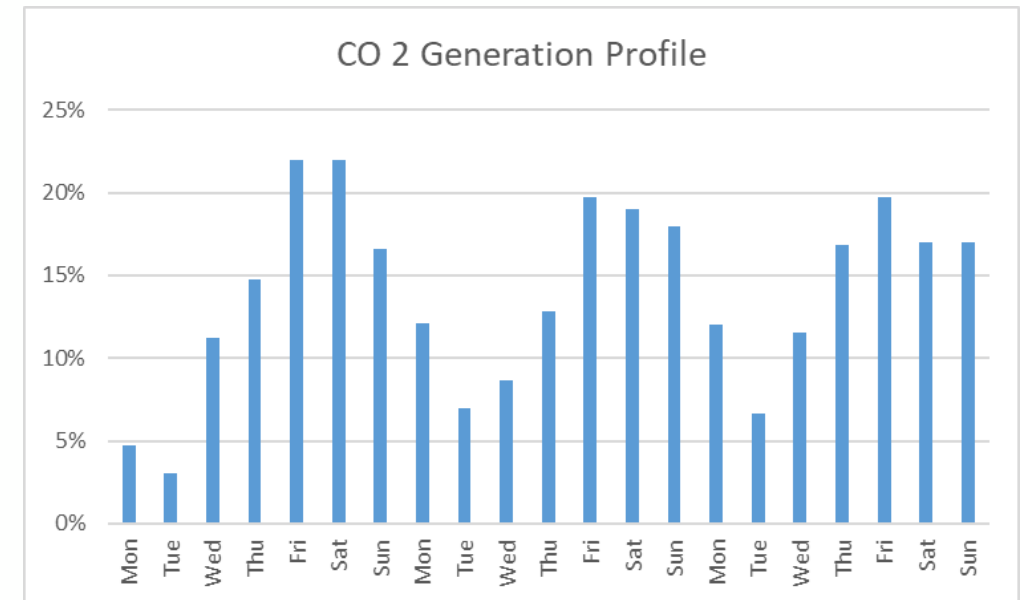
- CO2 recovery plant installed and commissioned in 2020.
- Main plant supplied by Pentair (Haffmans).
- Modifications made to FVs by Tennents.
- Plant and Storage Tanks installed by Tennents.
- Electrical power, civils and associated services installed by Tennents.
- Works covered under the CDM Regulations
- Brewery as a PPC permitted site – variation raised and approved by SEPA.





Co2 – Practical Considerations

- Safety
- Production and usage cycle
- Storage capacity
- Gas Quality in
- Plant Hygiene
- Gas Quality out
- Pressure Systems
- Ambient vapourisation
- Scope 2 carbon increase
- On-going Maintenance Support



CO2 Recovery - Outcomes

- Plant reliability good
- CO2 quality as specified
- Fully circular use for recovered CO2 in our final product.
- Recovering more CO2, than we previously sourced so have extend use to replace nitrogen-based pressure systems in our process areas.
- In last 3 years, we have externally sourced 2 tankers of CO2.
- We have a service and support contract in place with Pentair.
- Our laboratory regularly sample the CO2 to assure the quality.





- <https://candcgroupplc.com/esg/>
- <https://foodandbeverage.pentair.com/en/products/application-co2-recovery-for-beverage-producers>

Funding

SME Loan Scheme · Business Energy Scotland

Loans up to £100k are available to help you pay for energy and carbon-saving upgrades in your business. All loans are interest-free. The repayment term for all loans is 8 years.

Local Authority Development Grants

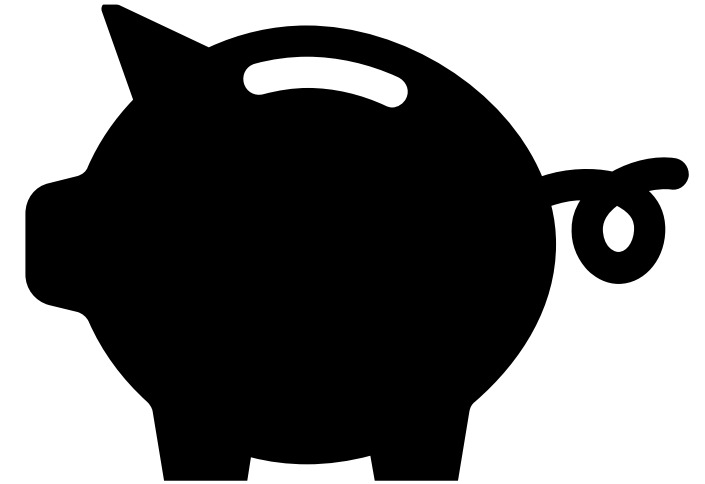
- Green Business Grant - Glasgow City Council
- Green Recovery Capital Development Grant - Perth & Kinross Council
- Dundee SME Development Grant

Scottish Enterprise Support

Contact your account manager or a sustainability specialist

Annual Investment Allowance

You can deduct the full value of an item that qualifies for annual investment allowance (AIA) from your profits before tax.



www.findbusinesssupport.gov.scot



Questions?

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
Thank You

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