



Small Scale CO₂ Capture: 3 Case Studies

#CraftBrewersCon





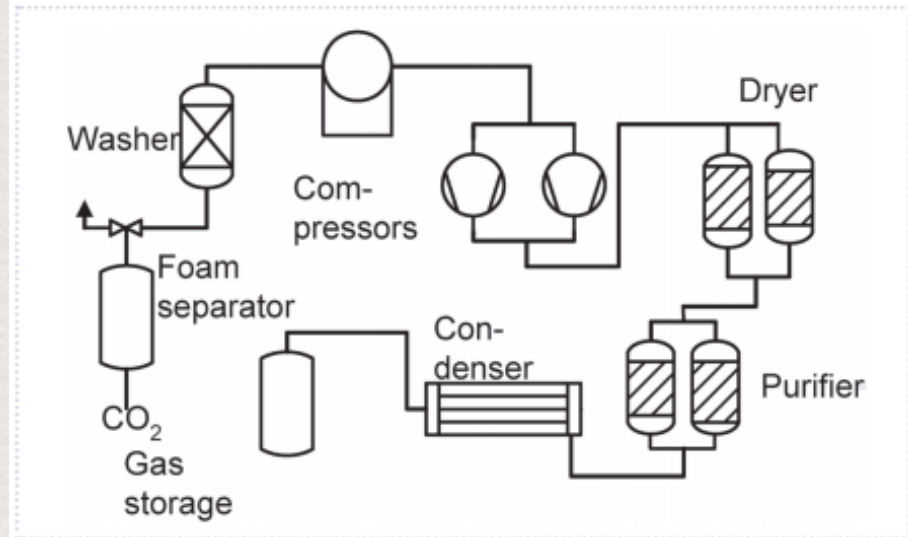
Our Vision: Keep the planet cool.

Mission: Avoid 1 Billion metric tons of CO₂ emissions

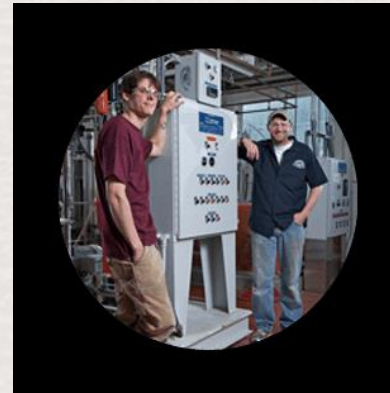
Small Scale CO₂ Recovery Solutions

Advancing Proven Science for Small Craft Brewers

The Standard Method for CO₂ Recovery¹



Featured in Brewer's Association Sustainability Best Practices Manual: *Energy Usage, GHG Reduction, Efficiency and Load Management Manual*



1998 US Craft Brewer
1 MM Lbs CO₂ Reduced



2015-17 Chico & NC Facility
\$1 MM / 2 Year Payback

How Much CO2 Do We Use? CO2 / BBL

CO2 Usage Insights

- National Average 4 – 21 lbs / BBL
- Findings of Survey – 100 Breweries
- Primary Areas of Use:
 1. Fermentation Tanks
 2. Canning
 3. Kegging
 4. Pushing Beer
 5. Cleaning Tanks and Pipes

Ways to Reduce CO2 Usage

- Assess usage vs national average
- Assess Usage Points and compare
- Icing on tanks when not in use suggest leaks
- Allowing tanks to purge overnight drains tanks
- Create best practices and monitor personnel

POLL #1: How much CO2 do you use per BBL?

Go to website:

Sli.do

Enter # D165

Small Scale CO₂ Solution

First Plug-n-Play CO₂ Recovery Solution



CO2 Unit CiCi™
(Patent-pending)

Earthly Labs		
TEMPERATURES	SENSORS	ALARMS AND WARNINGS
COMP OUT T 123.4 F	INLET O2 1234.5 PPM	Unit Shut Down: Check Data Tab
HTR-1 OUT T 123.4 F	DEWAR LEVEL 123.4 %	Chiller Not Cold Enough To Make Liquid CO2
HTR-2 OUT T 123.4 F	COMP SPEED 12 Hz	CO2 Not Cold Enough To Make Liquid CO2
CONDENSE OUT T -1234.5 F	AIR COMP P 123.45 PSI	Activated Carbon Change Required
REFRIGERANT T -1234.5 F		Compressor Maintenance Required
		10L to 20L Liquid CO2 left in Dewar
PROCESS STATUS NOTIFICATION		CO2 RECAPTURED 12345 lbs
CHILLER SYSTEM OFF	DEWAR VALVE OPEN	NOT GENERATING LIQUID CO2
DATA	SETUP & MAINTENANCE	PROCESS VISUAL
		03/27/18 12:49
		RUNTIME HOURS 12345 Hr
		HMI Version 2.5
		PLC Version 12.3

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CO2 Software
(Patent-pending)



Foam Trap



CO2 Storage



CO2 Quality Assurance

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The ABGB Case Study



Brewery History Founded in 2013

- “Best Large Brew Pub” (2016, 2017)
- 1,700 BBL in Austin, Texas
- Brew Pub with To-Go Cans
- Committed to Community & Reducing Waste

CO2 Profile

- Produce More CO2 in Fermentation vs Consume

Key Pilot Goals

- Reduce or Eliminate CO2 Costs
- Reduce Greenhouse Gases
- Advance “Hell Yes” Program Goals



Pilot Experience & Next Steps



Pilot Experience

- Easy Installation in Hours
- 3 Phase 208 Connection
- Deliver on a Forklift
- Flex Tubing (Temporary) Plumb to Tanks
- Refrigerator Size Footprint in Limited Space
- Simple Foam Trap
- Use on fermentation and bright tank
- CO2 Storage can replace “rented” systems

R & D Efforts for Small Brewhouse & Tap Room

- Below 2000 BBL
- Address low flow & low pressure



Beer Quality Test & Results



- Carbonated Same Pale Ale with Recovered CO2 & Commercial CO2
- Brewer Blind Taste Tests to Determine Difference & Preference
- Results: 19, Earthly (11), Commercial (7), Neutral (1)
- Quality Insights – Carbonation Head, Aroma, Lacing

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Celis Brewery - CO₂ Case Study



Brewery History

- Founded in Belgium in 1966 by Pierre Celis
- First Austin brewery opened July 11, 1992
- Reopened in Austin, TX in 2017
- Christine Celis & daughter Daytona
- 24,000 BBL with expansion planned
- #1 Product Celis White, Belgian wit
- Bottles and cans distributed throughout Texas

CO₂ PROFILE

- CO₂ captured ~85% of CO₂ consumed

Driving Force

- Reduce CO₂ waste and costs
- Be an innovator
- Improve safety of facility through reduced CO₂
- Align brand with doing good



Third Party CO₂ Quality Test



RESULT	PARAMETER, CHEMICAL FORMULA (UNITS)			DL	METHOD	ISBT GUIDELINE LIMIT
99.99+	Purity	CO ₂	(% v/v)	5.	ISBT 4.0	99.9% v/v min.
nd	Moisture	H ₂ O	(ppm v/v)	1.	ISBT 3.0	20 ppm v/v max.
nd	Oxygen	O ₂	(ppm v/v)	4.	ISBT 4.0	30 ppm v/v max.
nd	Carbon Monoxide	CO	(ppm v/v)	0.5	ISBT 5.0	10 ppm v/v max.
nd	Ammonia	NH ₃	(ppm v/v)	0.5	ISBT 6.0	2.5 ppm v/v max.
nd	Nitrogen Monoxide	NO	(ppm v/v)	0.5	ISBT 7.0-1	2.5 ppm v/v max.
nd	Nitrogen Dioxide	NO ₂	(ppm v/v)	0.5	ISBT 7.0-1	2.5 ppm v/v max.
--	Non-volatile Residue	NVR	(ppm w/w)	1.	ISBT 8.0	10 ppm w/w max.
--	Non-volatile Organic Residue	NVOR	(ppm w/w)	1.	ISBT 8.0	5 ppm w/w max.
nd	Methanol	MeOH	(ppm v/v)	0.2	ISBT 9.0	10 ppm v/v max.
1.4	Total Volatile Hydrocarbons	THC	(ppm v/v as CH ₄)	0.1	ISBT 10.0-1	50 ppm v/v max.
nd	Total Non-Methane HC's	TNMHC	(ppm v/v as CH ₄)	0.1	ISBT 10.0-1	20 ppm v/v max.
nd	Acetaldehyde	AA	(ppm v/v)	0.05	ISBT 11.0	0.2 ppm v/v max.
nd	Aromatic Hydrocarbon	AHC	(ppb v/v as C ₆ H ₆)	2	ISBT 12.0	20 ppb v/v max.
nd	Total Sulfur Content	TSC	(ppm v/v as S)	0.02	ISBT 13.0	0.1 ppm v/v max. (excl. SO ₂)
nd	Sulfur Dioxide	SO ₂	(ppm v/v)	0.02	ISBT 14.0	1 ppm v/v max.
Sensory Tests						
--	Odor of Solid CO ₂ (Snow Residue)			na	ISBT 15.0	No foreign odor
--	Appearance of Solid CO ₂ (Snow Residue)			na	ISBT 15.0	No foreign appearance
PASS	Odor in Water			na	ISBT 16.0	No foreign odor
PASS	Taste in Water			na	ISBT 16.0	No foreign taste
PASS	Appearance in Water			na	ISBT 16.0	No color or turbidity

CO₂ Sensory Quality Check

Carbonated Water Test for Recovered CO₂



Demonstrate Sensory Quality Checks

- Low levels of VOC going into activated carbon filter
- Low risk of breakthrough of activated carbon filter
- How to test CO₂ for flavor-impacting impurities
- Sensory analysis of carbonated water
- Cheap, easy, little to no additional equipment

Scope Test

- Carbonated with CO₂ in Water over 3 Days
- 2 Corny Kegs in Ice Bath, 30 lbs CO₂
- 11 Taste Testers

Results

- 95% Confidence Level
- Preferred Recovered CO₂ Water
- Commercial Tasted like “Metallic” and “Plastic”

CO₂ Quality Check – Monitoring O₂

Nondetectable Oxygen limits in CO₂



- Recovered CO₂ show nondetectable limits of O₂ in all third-party ISBT tests
- Earthly system has O₂ sensor on inlet
- Periodically monitor O₂ in recovered CO₂
- O₂ meter (gas) is best solution for quality control

(512) Brewing Case Study

(512)
brewing company

Brewery History Founded in 2009

- 12,000 BBL in Austin, Texas
- Organic Beers, Porters
- Distribute Organic Beer Kegs in Texas
- Committed to Sustainability

CO2 Profile

- Fermentation 3X total CO2 needed

Capture Pilot Tests

- ISO 10399 Duo Trio Test
- Great carbonation, visual likeness
- Test revealed no discernible difference
- Oxygen readings 11 ppb – 17 ppb



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**CRAFT
BREWERS**
conference
& BrewExpo America

Hops & Grain: Case Study

Brewery History Founded in 2011

- 8,500 BBL in Austin, Texas, Adding 15,000 BBL in San Marcos
- Tap Room and Distribution in Texas and Colorado
- Committed to Sustainability in all we do

CO2 Profile

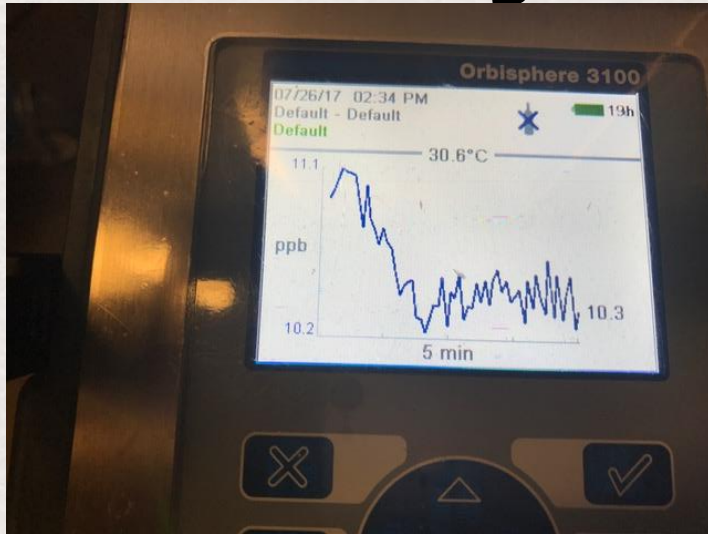
- Fermentation blowoff produces 3X total CO2 needed

Key Benefits

- Reduce CO2 Costs, Capture 1.3x What Purchased
- Reduce Greenhouse Gases 44%
- Advance Sustainability Goals
- ROI – 1 -2 Years
- Transparent consumer engagement opportunity
- Brand building opportunity



CO2 Quality Tests – Internal & Third-party



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nd	Non-volatile Residue NVR (ppm w/w)	1.	ISBT 8.0	10 ppm w/w max.
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nd	Methanol MeOH (ppm v/v)	0.2	ISBT 9.0	10 ppm v/v max.
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- Third-party ISBT Recovered CO2 Test Non-detect in all major impurities
- Yields Very Pure CO2 Better than Commercial PPB – 6 – 13 PPB, vs 30 PPB
- Descriptive Analysis results using the Beer Flavor Map shows more flavor attributes detected in recovered CO2 product sample vs. standard CO2 sample
- Shelf Life Test- True to Target Sensory test shows recovered CO2 product sample retains true to brand attributes approximately 30 days longer than standard CO2 product sample



Commercial Install & Next Steps



Commercial Unit

- 99.99% Pure CO2
- CO2 Capture Rate Improvement
- Digital At-a-glance CO2 monitoring
- Easy to Maintain, Wet Rated

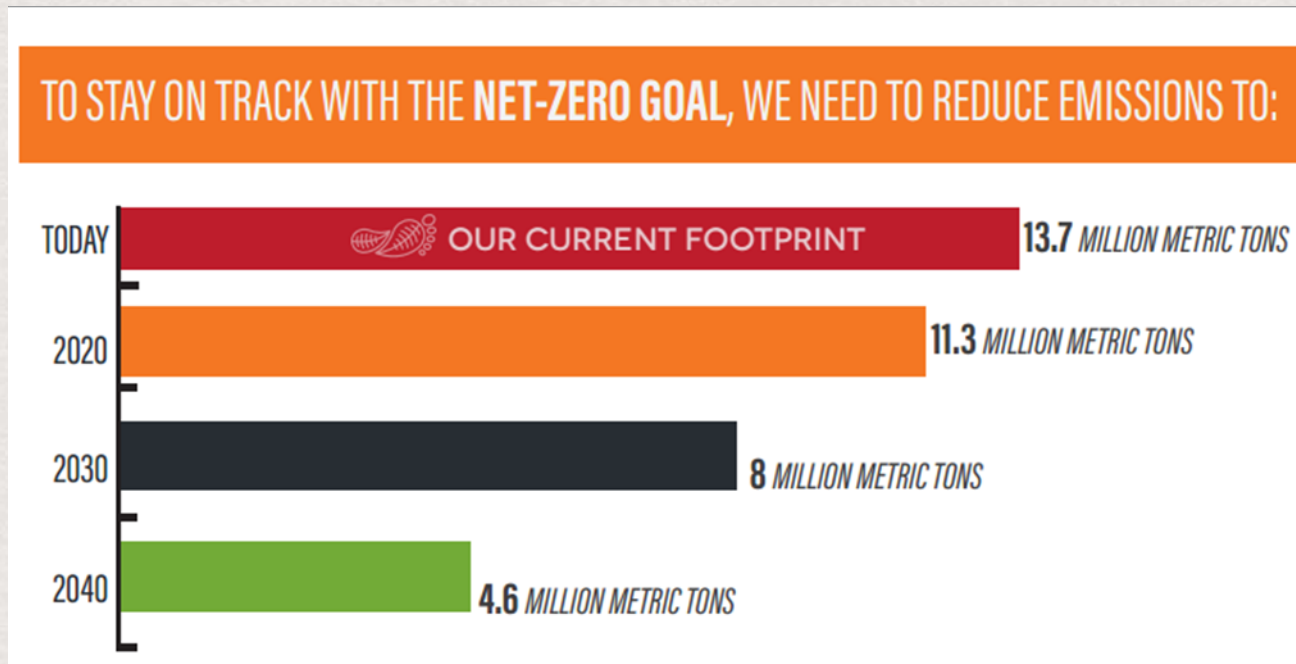
Next Steps

- Market Launch & Storytelling
- Drive Demand and Preference
- Retailer Showcase

Global Climate Goals by 2050

Carbon Capture Solves 13% 60 GT CO₂ Goals

City of Austin Net Zero Example



Brewers can address ~6%

Small Scale CO₂ Recovery Benefits



- ✓ Recovering CO₂ is Possible for Small Brewers
- ✓ Brewers Can Reduce or Eliminate CO₂ Costs
- ✓ Increase Reliability of CO₂
- ✓ Improved CO₂ Purity Can Improve Quality and Shelf Life
- ✓ Simple CO₂ Lab Tests Validate CO₂ Quality
- ✓ Improve Safety in Brewery
- ✓ Recovered CO₂ Can Drive Preference Among Consumers & Retailers
- ✓ Achieve Sustainability and Waste Reduction Goals

Q&A

1. What size do I need to be?
2. How big is the unit?
3. What does maintenance look like?
4. What is the energy use per hour?
5. What is the average ROI?
6. Does this reduce my carbon footprint?

Ask your questions

Go to website:

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Enter # D195

SIGN UP

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CO2 ROI Audit
RSVP Pre-order List

CONTACT

Amy George / Subject: CBC

hello@earthlylabs.com