sbh4 consulting

Low-hanging fruit for CO2 sourcing

sbh4 GmbH, Stephen B. Harrison

gasworld European CO2 Summit 2026

Rotterdam, 19th March

Low-hanging fruit for CO2 sourcing.
Five questions we will address this morning…

sbh4 consulting

1. Why have we been so keen on ammonia-based CO2 sources in the past?
2. Which other industries offer similarly low-cost CO2 sources?
3. Will refinery hydrogen SMRs be the next low-cost CO2 source for commercial applications?
4. Biogas to biomethane upgrades and biogenic CO2 – running into a price war with CDR?
5. Biogenic CO2 from Waste to Energy – the next big one?

sbh4 consulting

1. Why was ammonia the answer, and what has changed?

Flue gas emissions to air with >90% CO_2

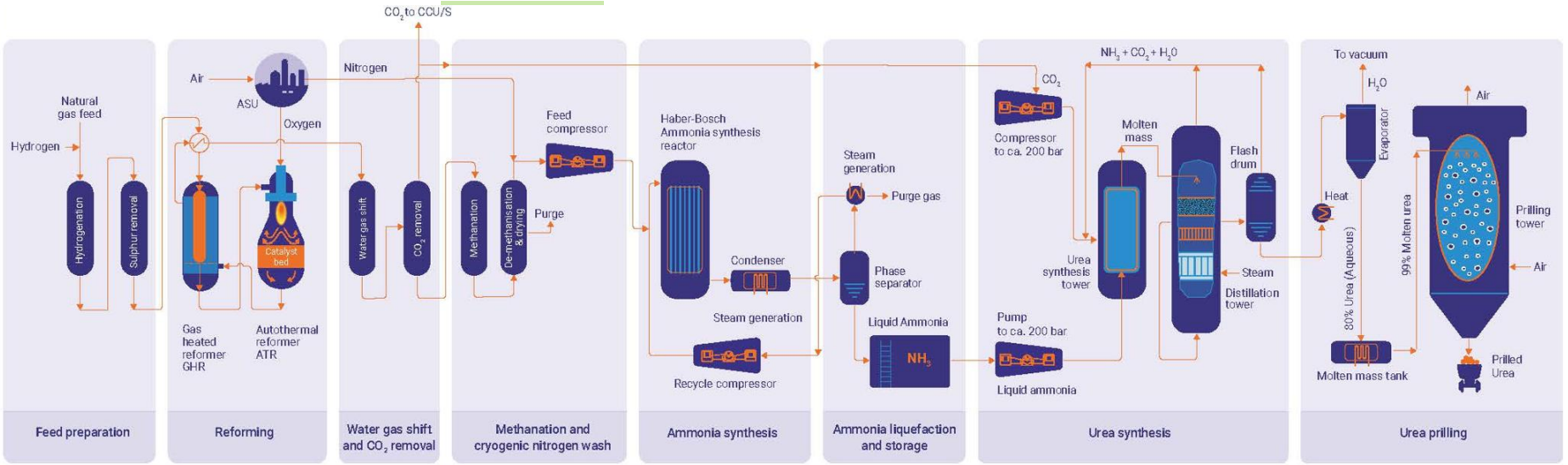
Lowest incremental capex and opex for CO_2 conditioning

CO2 capture is integral to ammonia production.

Image courtesy of KBR. Dyno Nobel, Waggaman, Louisianna.

CO2 must be removed downstream of the reformer during ammonia production. In some sites, a portion of this is used for urea production. In all sites, a large amount of CO2 is available for commercial applications.

sbh4 consulting



But Europe has much higher natural gas prices than USA and the Middle East, how long will ammonia plants remain relevant as CO2 sources in Europe?

sbh4 consulting

Owner	Location	Closure
CF Fertilisers	Ince, UK	2022
CF Industries	Billingham, UK	2023
Yara	Saltend, UK	2025
Yara	Tertre, BE	2024
BASF	Ludwigshafen, DE	2024

https://www.nepic.co.uk/cf-fertilisers-celebrated-as-double-finalists-in-2025-north-east-business-awards/

sbh4 consulting

2. Processes that require no additional energy for CO2 capture

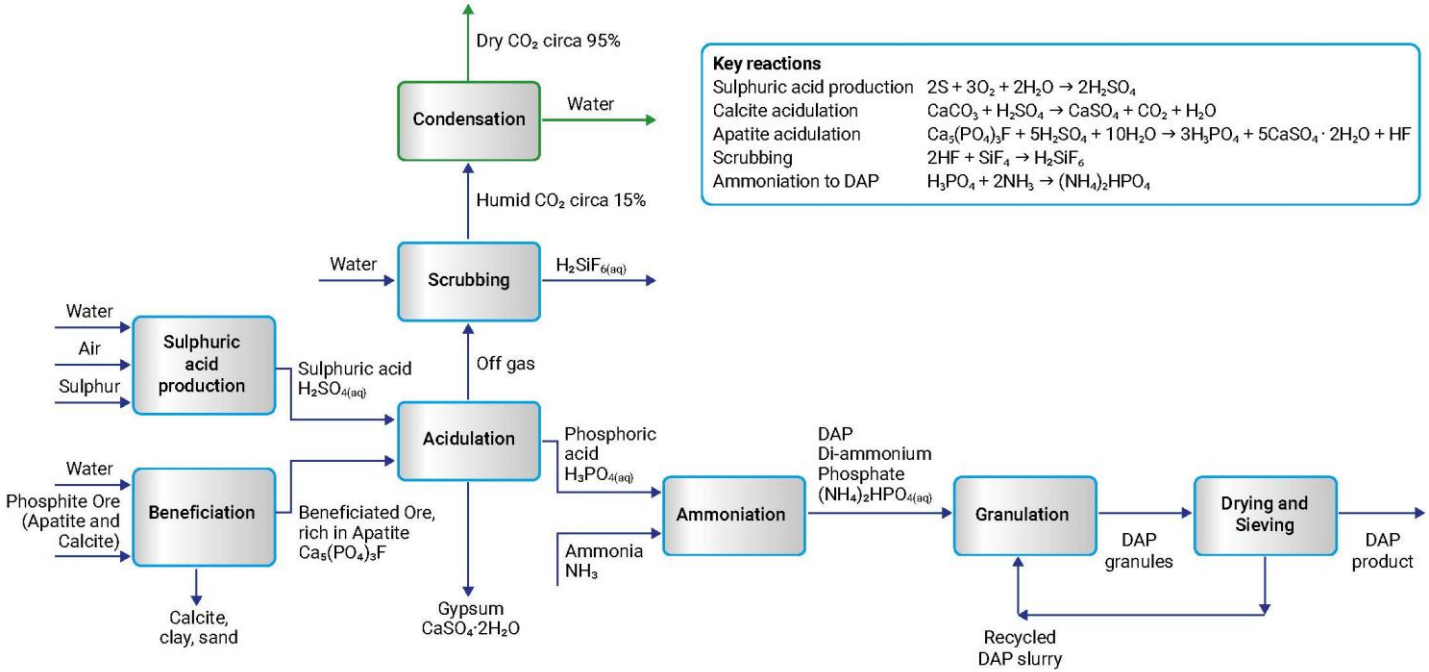
Flue gas emissions to air with >90% CO2

Energy is required for CO2 drying, compression and liquefaction

Lowest incremental capex and opex, brownfield sites, minimal disruption

Geogenic CO2 capture from phosphoric acid and DAP fertilizer production

sbh4 consulting



DAP Fertilizer

- CO_2 is released from the process when calcite rock reacts with sulphuric acid during the acidulation stage
- Several DAP plants operated by OCP in Marocco at the Jorf Lasfar industrial platform will be retro-fitted with CO_2 capture equipment
- The incremental capex and opex to capture CO_2 is purification (drying in this case) and liquefaction.

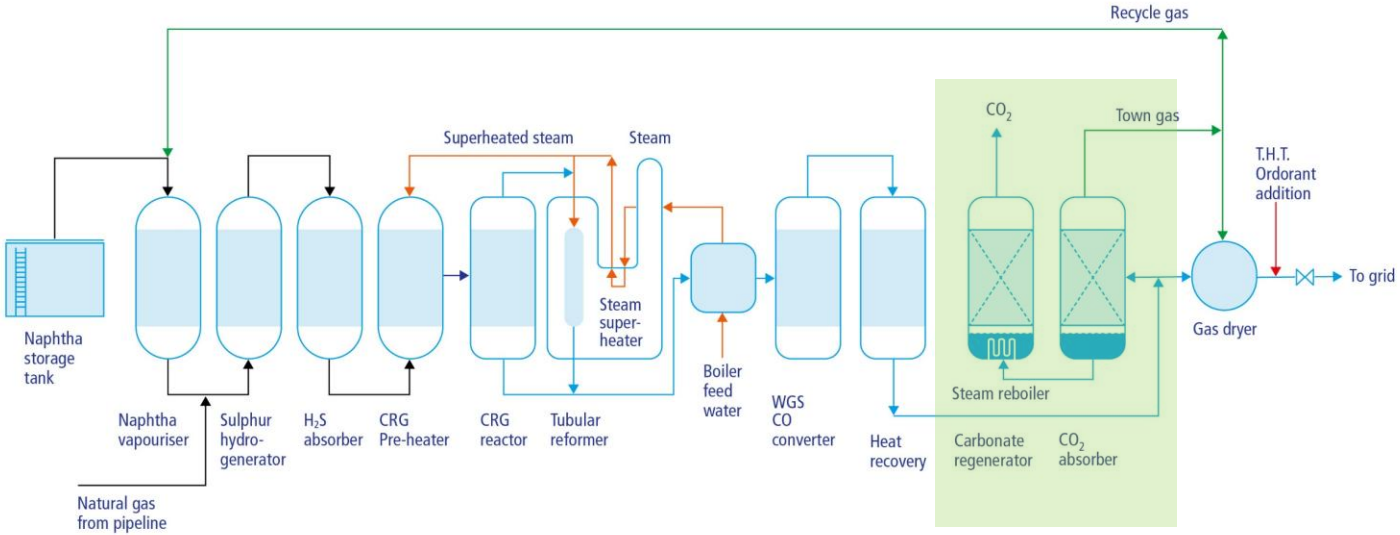
Phosphate fertilizer (DAP) production releases unavoidable geogenic CO2 from the process. Projects are underway to capture and utilise / sequester this CO2.

sbh4 consulting

Towngas – 3,500km of pipelines in Hong Kong for 1.9 million domestic, commercial and industrial customers. CO2 is vented, but could be utilised.

sbh4 consulting

Hong Kong Town Gas – Tai Po Catalytic Rich Gas naphtha / methane reformer and CO_2 capture process



Town gas composition

Carbon Dioxide	16.3% – 19.9%
Carbon Monoxide	1.0% – 3.1%
Methane	28.2% – 30.7%
Hydrogen	46.3% – 51.8%
Nitrogen and Oxygen	0% – 3.3%

Town gas energy value

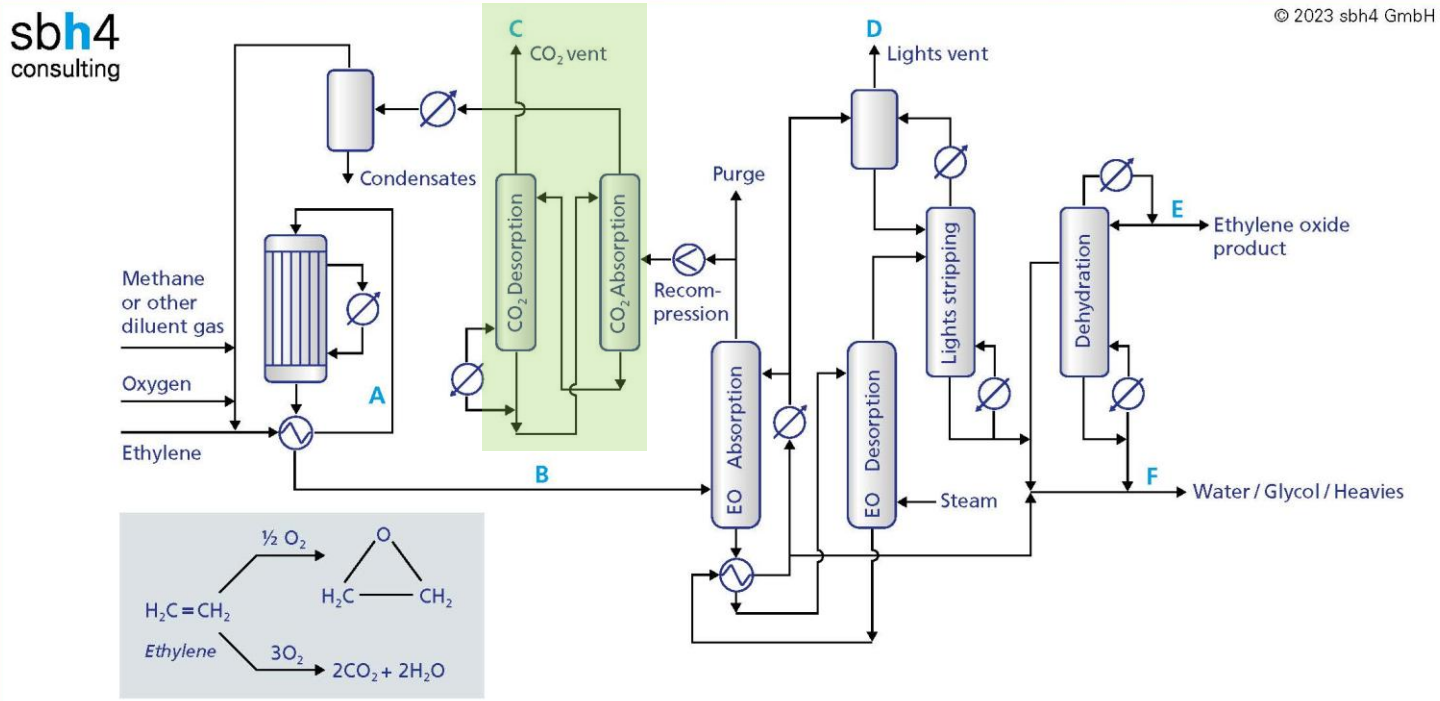
Calorific Value	17.27 MJ/m³
Specific Gravity	0.52
Wobbe Index	24

sbh4 consulting

Town gas

- Naphtha reforming on SMR
- CO2 produced in the SMR is captured to increase the calorific value of the town gas
- High purity (>95%) CO2 vented to atmosphere
- The incremental capex and opex to capture CO2 is purification and liquefaction.

Oxygen-fed Ethylene Oxide Production with Integrated CO_2 Capture



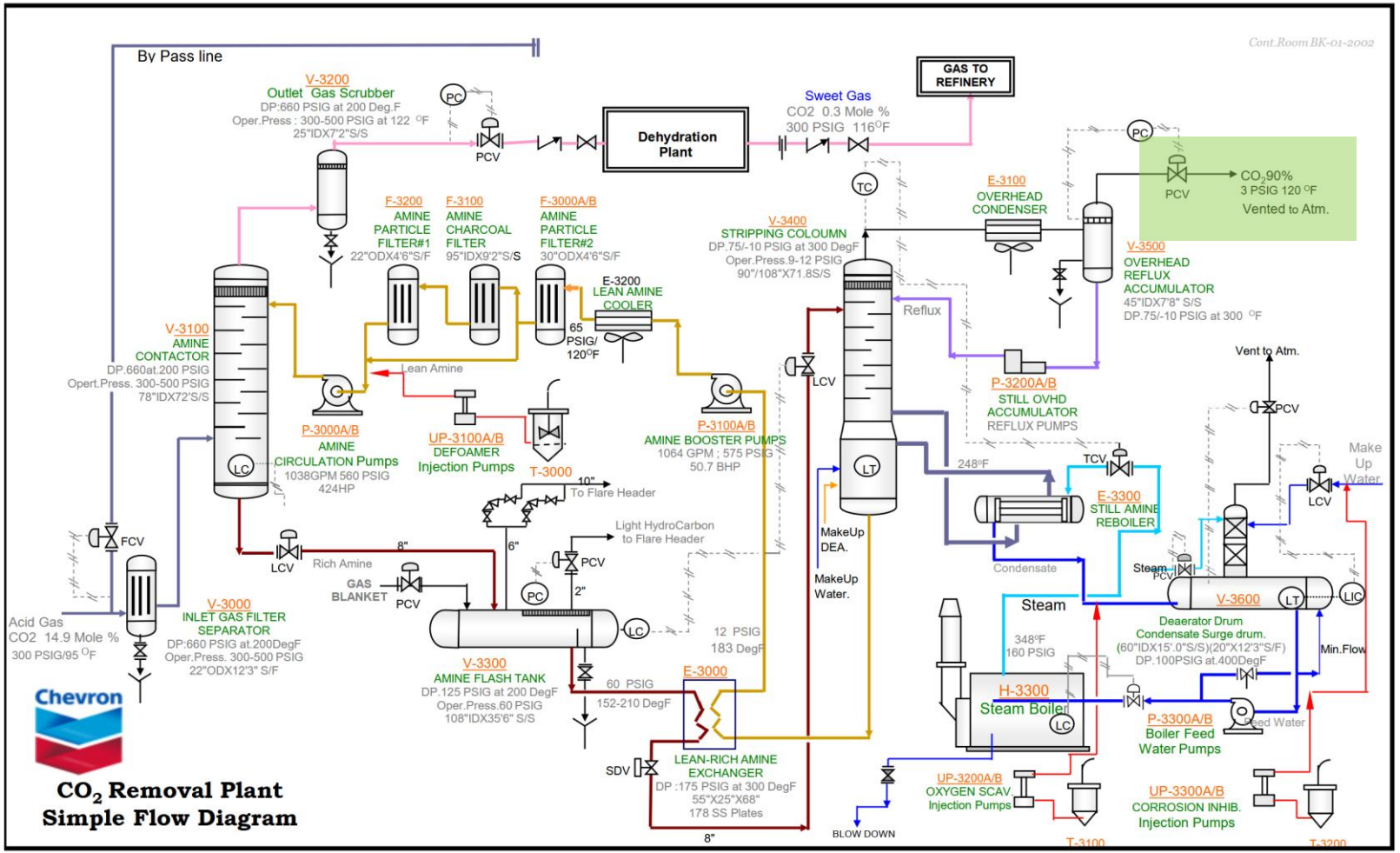
	A: Reactor feed	B: Reactor outlet	C: CO_2 vent	D: Lights vent	E: EO Product	F: Water
Ethylene	34.6 %	25.4 %	0.4 %	64.6 %		
Ethylene oxide (EO)		2.1 %			99.7 %	5.8 %
Oxygen	23.4 %	3.9 %		0.8 %		
Methane	34.6 %	57.2 %	0.4 %	11.0 %		
Water	4.2 %	3.7 %	1.7 %		0.2 %	94.2 %
Carbon Dioxide (CO_2)	3.2 %	7.7 %	97.5 %	23.6 %	0.1 %	

Ethylene oxide

- CO2 is captured within the process to avoid accumulation of CO2 in the reactor gas recycle
- Several EO plants have been accessed as a low-cost source of CO2 for commercial applications
- The CO2 capture costs are taken by the EO product.
- The incremental capex and opex to capture CO2 is purification (drying in this case) and liquefaction.

Equate EO1 plant with CO2 emissions plume Kuwait

Gulf Cryo site with CO2 liquefier and pipeline CO2 supply from Equate EO plant



Natural Gas Processing

- Acid Gas Removal (AGR) captures CO2 and H2S
- The incremental capex and opex to capture CO2 is purification and liquefaction.

Since Q1 2025, BOC operates 60,000 TPA food grade CO2 liquefaction Longford Gas Conditioning Plant.

Air Liquide Australia has also built a food grade CO2 liquefier at Longford. Announced 2021, startup H2 2025.

Wheat fermentation to bioethanol will also be used as a biogenic CO2 source at Air Liquide Australia's new 90,000 tonne per year liquefier at the Shoalhaven Starches site, Bomaderry NSW.

sbh4 consulting

Nippon Gases (Supagas/Coregas) and BOC also have CO2 liquefiers at Bomaderry.

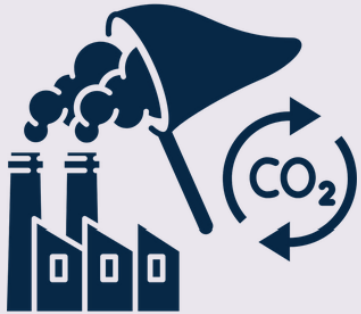
sbh4 consulting

https://www.supagas.com.au/blogs/supanews/2019/Jun/27/Supagas_CO2_project

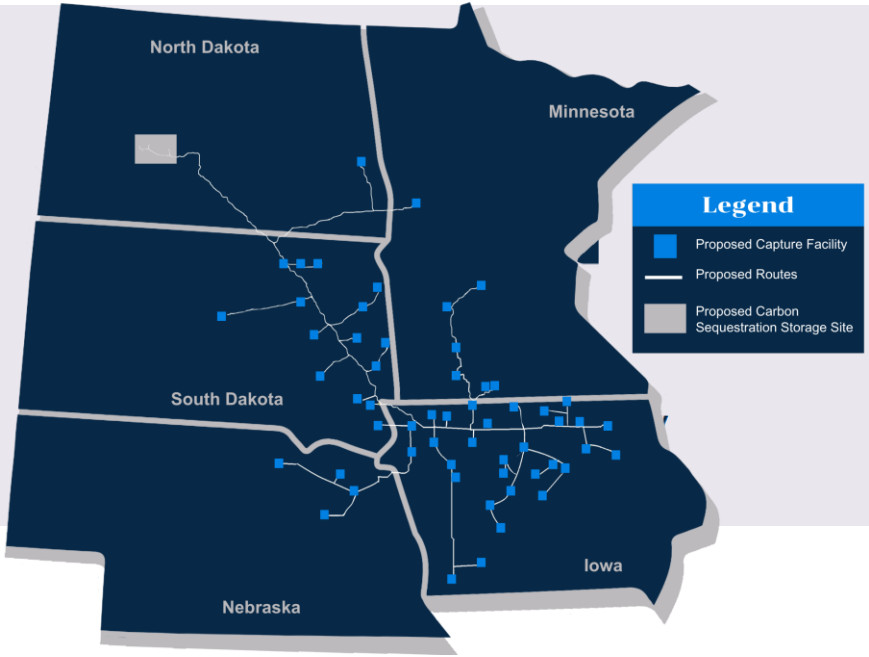
Google Maps

Summit Carbon Solutions is planning CCU/S from >50 corn ethanol plants with pipeline aggregation and geological storage in North Dakota. It supports farmers and rural communities in the mid-west, as crop prices are low.

sbh4 consulting



1. CAPTURE: ETHANOL PLANTS CAPTURE CO2 FROM THE FERMENTATION PROCESS.



3. USE OR STORE: THE CO2 IS SAFELY AND PERMANENTLY STORED IN DEEP ROCK FORMATIONS, OR USED FOR INDUSTRIAL PURPOSES.

https://www.summitcarbonsolutions.com/

https://iowacapitaldispatch.com/2024/08/28/iowa-utilities-commission-issues-pipeline-permit-for-summit-carbon-solutions/

Wheat fermentation to produce ethanol is an ideal source of biogenic CO2 and common source in the USA. Messer France has exploited this source at Vertex Bioenergy at Lacq.

sbh4 consulting

Nippon Gases Europe (VERBIO Zörbing, Germany), and BOC (Cargill Foods, Manchester UK) source biogenic food-grade CO2 from bioethanol derived from wheat fermentation.

sbh4 consulting

https://www.gasworld.com/story/bocs-first-uk-carbon-dioxide-purification-plant-opens-in-manchester/

https://nippongases.com/de-en/news/einweihung-zoerbig-2025

Biogas to biomethane upgrades: CO2 is removed to increase the calorific value of the biogas. Amine solvent and VPSA adsorbent systems are common for CO2 capture.

sbh4 consulting

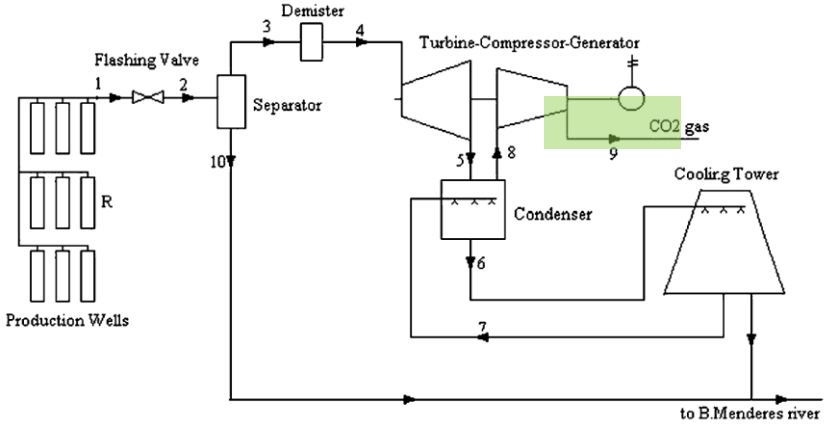
https://sysadvance.com/energy/methagen-ad/?ppc_keyword=biogas%20to%20biomethane&gad_source=1&gad_campaignid=21768948858&gclid=Cj0KCQiAoZDJBhC0ARIsAERP-F9qtgmHwAMOj-NYIfjJir-CJ0ZtrC2GsPWELg_XxWYYeJU3x5WuiEgaAvLgEALw_wcB

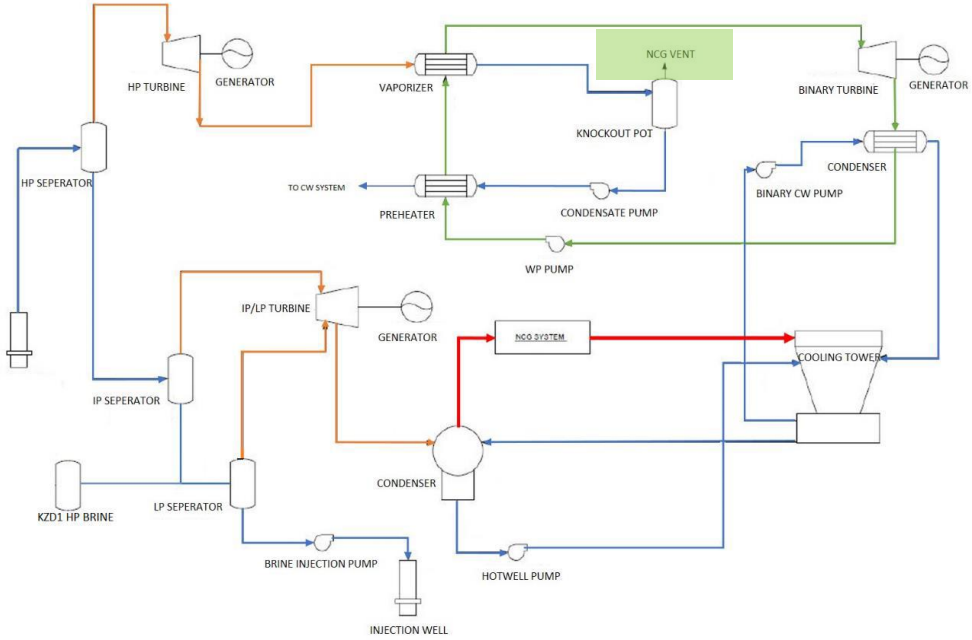
Biogas to biomethane upgrading is an emerging source of commercial CO2. Eg, Bright Renewables food grade CO2 plants at Heek and Brandis, Germany… and many others.

sbh4 consulting

A very pure (>99%) CO2 stream is available from the non-condensable gas (NCG) vent on many geothermal power plants (two configurations from Kizildere in Turkey are shown here). Purification and liquefaction of this CO2 is very low-cost.

sbh4 consulting





https://www.sciencedirect.com/science/article/pii/S0196890404000767

https://publica.fraunhofer.de/bitstreams/333f6c1a-5f18-4693-b837-c5be634371f1/download

Linde Turkey captures circa 120,000 tonnes per year of CO2 from Zorlu Energy's Kizildere II geothermal power plant.

https://www.google.com/maps/place/K%C4%B1z%C4%B1ldere+Geothermal+Power+Plant/
https://www.gasworld.com/story/linde-gaz-turkey-brings-co2-plant-on-stream/2080662.article/
https://maps.app.goo.gl/WezXwm99KRBL72ye8

Nippon Gases Europe & SOL will capture circa 120,000 tonnes per year of CO2 from Enel Green Power's Piancastagnaio geothermal power plants in Siena, Italy. CO2 is captured during geothermal power generation is converted to methanol by CRI in Iceland. Linde (AGA) manages the CO2 supply.

sbh4 consulting

www.greeneuropeanjournal.eu%2Fgeothermal-power-the-future-of-green-energy/
https://www.researchgate.net/publication/327908984_Process_Advantages_of_Direct_CO2_to_Methanol_Synthesis/link/66429ff57091b94e9326bd56/download

And let’s not forget how sparking water got its sparkles before we got involved!

sbh4 consulting

Sol and Nippon Gases Europe source natural CO2 from the wells at Bad Höningen, Germany

https://www.linkedin.com/posts/nippon-gases-deutschland_nippongases-co2-trockeneis-activity-7100798010493648897-_64B/?originalSubdomain=de

CARBO has also sourced CO2 from Bad Höningen's natural wells for more than 100 years

https://www.carbo.de/de/unternehmen

https://www.facebook.com/ortenfahrzeugbaugmbh/posts/mit-carbo-kohlens%C3%A4ure-und-orten-fahrzeugbau-sprudelt-es-sicher-schnell-sensation/2288167414609254/

sbh4 consulting

5. Competing use cases will drive CO2 pricing

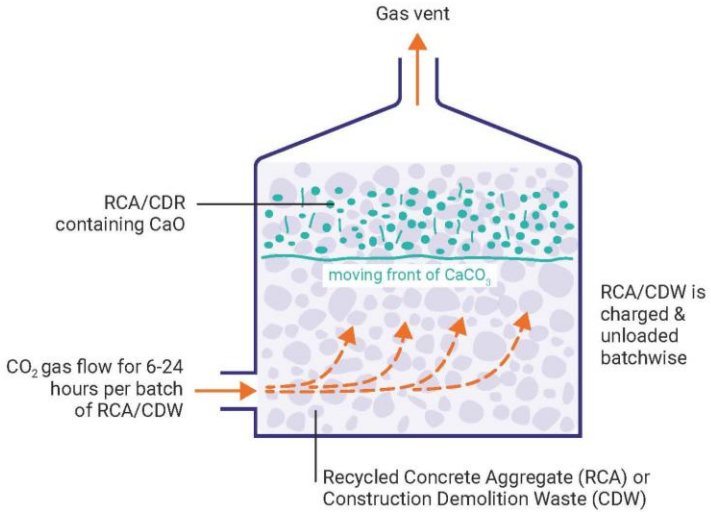
Biogenic CO2 is required for CDR / BECCS and is favoured for e-fuels

Fossil CO2 will be cheaper to source for commercial CO2 applications

Neustark – one of many Carbon Dioxide Removal (CDR) players competing for biogenic CO2 from biogas to biomethane upgrading.

Enhanced weathering CO_2 mineralisation for permanent sequestration of CO_2 and CDR

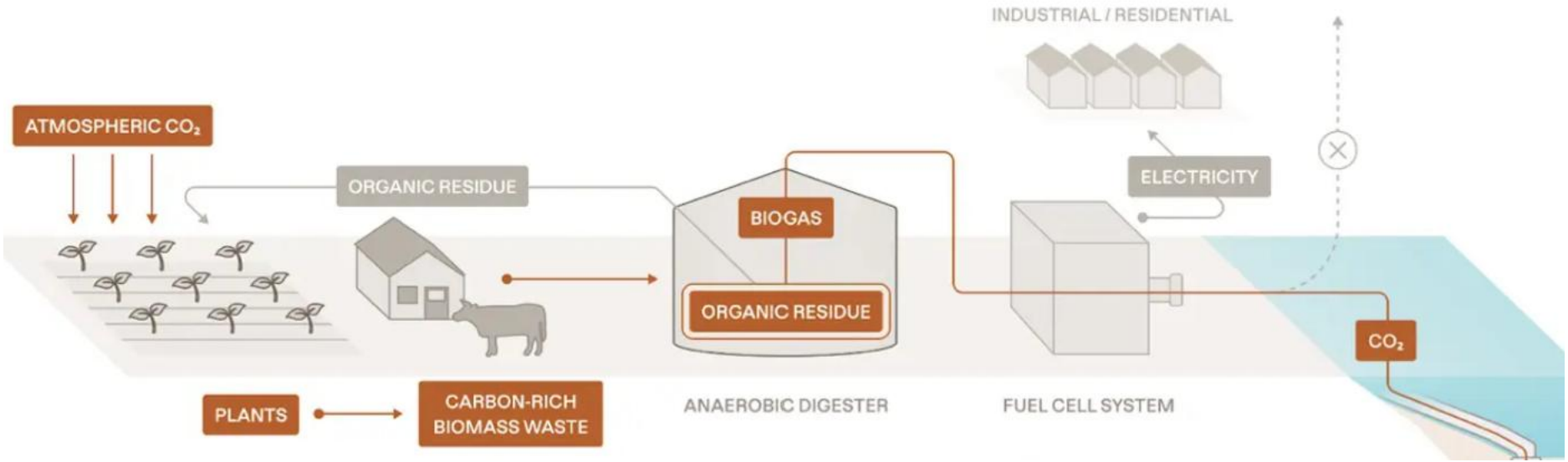
sbh4 consulting



	Enhanced weathering of RCA/CDW
Mitigation principle	CO_2 mineralisation reaction with waste concrete
CO_2 Sequestration method	CO_2 mineralisation to $CaCO_3$
Raw material	CaO from RCA or CDW
Technology maturity level	Early commercial, eg Neustark

Reverion targets biogas to power with direct CO2 capture from an innovative SOFC process, followed by CO2 sequestration. Frontier has purchased 96,000 tonnes of CDR certificates for $41 million: $427 per tonne of CO2.

sbh4 consulting

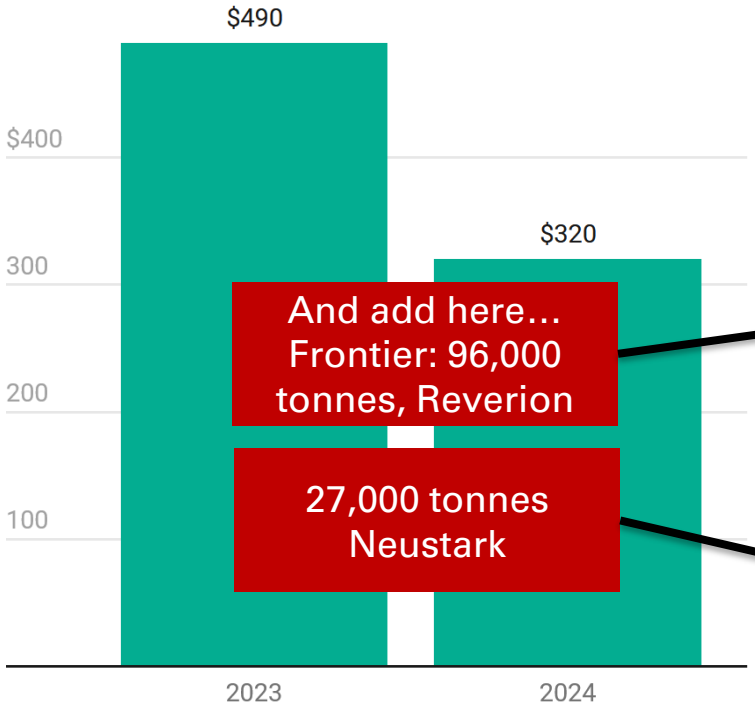


Greensand Future (Ineos) is competing for biogenic CO2 from large biogas digesters in Denmark & northern Europe.

sbh4 consulting

https://www.linkedin.com/posts/greensand-future_greensandfuture-carbonstorage-ccs-activity-7386348443369209856-jj5G/?utm_source=share&utm_medium=member_ios&rcm=ACoAAAa3rdYBqwtNLNxpDPaOIx88MkmHDan5fE0

CDR is setting the price for biogenic CO2

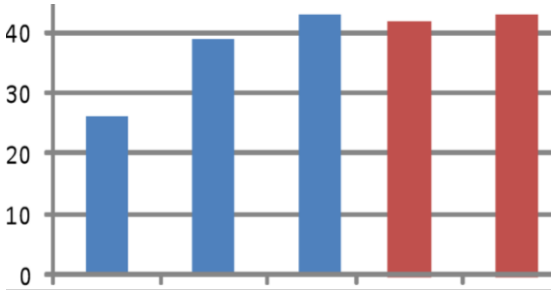


	Purchaser	Tonnes Purchased	Supplier
1	Microsoft	3,330,000	Stockholm Exergi
2	Microsoft	1,000,000	Ørsted
3	Microsoft	500,000	1PointFive
4	Equinor	330,000	Ørsted
5	Google	200,000	Terradot
6	SkiesFifty	200,000	Gigablue
7	Frontier Buyers	224,446	CO280
8	Frontier Buyers	152,480	Vaulted Deep
9	Google	100,000	Holocene
10	Google	100,000	Varaha
11	Google	100,000	Charm Industrial
12	Microsoft	95,000	The Next 150
13	Frontier Buyers	89,998	Terradot
14	Swiss Re	70,000	Exomad Green
15	Frontier Buyers	71,877	CREW
16	Frontier Buyers	61,571	280 Earth
17	Frontier Buyers	55,442	CarbonRun
18	Morgan Stanley	40,000	Climeworks
19	Microsoft	36,000	Carbonity
20	Microsoft	27,000	Neustark

Bio-energy Carbon Capture and Storage (BECCS) will stimulate CO2 capture projects (eg Ørsted Avedøre). Commercial use of fossil CO2 from waste to energy (eg Stockholm Exergi) can leverage the investment in CO2 capture and liquefaction for CDR.

sbh4 consulting

% of biogenic CO2 from WtE plants



https://www.esgtoday.com/microsoft-signs-1-million-tonne-bioenergy-based-carbon-removal-agreement-with-orsted/
https://www.svt.se/nyheter/lokalt/stockholm/vartaverkets-sista-kolpanna-stangs-tidigare-an-planerat
https://www.cewep.eu/wp-content/uploads/2017/10/fossil_carbon_in_waste_2012.pdf

sbh4

consulting

Introduction to Stephen B. Harrison and sbh4 consulting

sbh4 consulting

Stephen B. Harrison is the founder and managing director at sbh4 GmbH in Germany. His work focuses on decarbonisation and GHG emissions reduction. E-fuels, hydrogen, ammonia and CCTUS are fundamental pillars of his consulting practice.

Stephen has extensive M&A and investment due diligence advisory experience in the energy and clean-tech sectors. Private Equity firms, investment fund managers and green-tech start-ups are regular clients. He also supports operating companies in their mission to decarbonise their scope 1, 2 and 3 GHG emissions.

In 2023, Stephen evaluated seven CCTUS, hydrogen and e-fuels submissions to the European Commission's Third Innovation Fund. The fund allocated €2 billion to large-scale decarbonisation projects in Europe. In 2024 he supported the European Commission with venture capital investment due diligence and assessed eight Horizon grant applications. Again in 2025, Stephen is assessing seven Innovation Fund applications related to e- and bio-methanol production.

Stephen has served as the international expert and team leader for three ADB projects related to CCTUS and renewable hydrogen deployment in Pakistan, Palau and Viet Nam. He has also supported the IFC and world bank on e-fuels and green hydrogen strategy development projects in Namibia and Pakistan.

With a background in industrial and specialty gases, including 27 years at BOC Gases, The BOC Group and Linde Gas, Stephen has intimate knowledge of e-fuels, hydrogen, ammonia and carbon dioxide from commercial, technical and operational perspectives. For 14 years, he was a global business leader in these FTSE100 and DAX30 companies.

As a member of the H2 View and **gas**world editorial advisory boards, Stephen advises the direction for the leading hydrogen-focused international publications. Through H2 VIEW, World Hydrogen Leaders and Sustainable Aviation Futures, he has led Masterclasses covering many hydrogen, SAF and hydrogen derivatives themes in virtual and live sessions.

Stephen was session chair for the e-fuels and hydrogen propulsion track at the Bremen Hydrogen Technology Exhibition in September 2023 and chaired the same stream at that conference in Hamburg in 2024. He was also conference chair for the CO2 utilisation Summit in Hamburg in 2023 and the same event in Berlin in 2024 and Antwerp in 2025.