DIRECT AIR CAPTURE - SKYTREE

A Direct Air Capture (DAC) process working with a solid sorbent material subjected to temperature vacuum swing adsorption (TVSA) to release captured CO_2 for different end-uses such as vertical farms, greenhouses, e-fuels, but also storage via mineralization and sequestration. Their solutions come in various modular sizes for different applications. This document shall outline the characteristics of the Skytree Stratus product line, which comes in three versions:

- Skytree Stratus Electric, an all-electric version for operating (sub)systems.
- Skytree Stratus Hybrid, the main feature is that regeneration requires on-site heat from, e.g., geothermal energy or industrial waste heat.
- Skytree Stratus Hybrid Thermo Boost, which is the same as the Hybrid, but it can operate with a lower-grade heat source by using a heat pump.

Direct air capture by Skytree

TECHNICAL ASPECTS (all % are volume-based)

Point sources: Air
CO_2 concentration range: 400 -1200 ppm.
CO_2 capture efficiency: Not applicable
CO_2 purity: 98% (dry basis)
Min. feed gas pressure: 1 bar
Max. feed gas temperature: 30 °C
Standard operating environmental conditions

- *Temperature range: 5 - 30°C*
- *Humidity range: 10 - 80% RH*

Additional options are available for the following environments:

- *Arid climate (30 - 50°C, 10 - 70% RH)*
- *Tropical climate (20 - 50°C, 50 - 90% RH)*
- *Polar climate (-35 - 5°C, 50 - 90% RH)*

Typical scale: Small to Large (Electric - 1 tCO_2/day; Hybrid – 0.8 tCO_2/day).
(*modular technology – upscaling to higher capacity feasible*)
Primary energy source: Electric – only electricity; Hybrid - electricity and (waste) heat.
(Hot water temperature: 99 – 105 °C for hybrid and 50 – 99 °C for Hybrid Thermo Boost)

Impurity tolerance: None – capture material is sensitive to impurities at high concentrations (see next section).

FUNCTION IN CCU VALUE CHAIN

- Capture CO_2 from the air.
- NOx, SOx, and H_2S need to be filtered out before contacting the capture material if a high concentration of these compounds is expected.

LIMITATIONS

- The performance of the unit can be sub-optimal if the ambient air is greater than 40°C, different add-ons are available for operation in these conditions (see technical aspects).

ENERGY

- Electric version: electricity is used for powering all of the components (e.g., heaters, vacuum pumps, fans).
- Hybrid version: electricity is used for powering all of the components except for the CO_2 regeneration from the capture material using hot water. Heat from a geothermal source or waste heat is used.

CONSUMABLES

- For the Hybrid version, hot water for regeneration is needed from a local source, the water temperature dictates whether additional add-ons are needed, such as a heat pump. This water is returned to the source after use and is not consumed during the process.

Energy and Consumables

Parameter	Electric	Hybrid 1	Hybrid 2
Electricity (kWh/tCO_2)	3000	1250	1250
Heat (kWh/tCO_2)	0	1760	700

Hybrid 1 – Standard hybrid; Hybrid 2 – Hybrid Thermo Boost

COSTS

CAPEX: Not available.
OPEX: Not available.
CO_2 capture cost: Not available.
CO_2 avoidance cost: Not applicable.
Stratus product series is priced below the average market price and is evaluated on a project-to-project basis. Please contact Skytree for more information about your specific application.

ENVIRONMENTAL

CO_2 footprint: 80 – 95%[a]
Negative emission technology - carbon capture efficiency of the Stratus product series is expected to be in line with what is found in literature[1], thus approximately 80 - 95%, if renewable or low-carbon energy is used.
*[a]Carbon capture efficiency: for every kg of CO_2 captured and stored, you emit a certain amount of CO_2. Let's say a system emits 100 grams. That makes your efficiency (1000 g of CO_2 stored - 100 g emitted)/1000*100% is 90% carbon capture efficiency.*
Spatial footprint: 22 m^2/tCO_2
Based on individual modules.
Environmental issues: None.

ENGINEERING

Maturity: System Prototype Demonstration (TRL 6-7)
Time to market: 6 months
Retrofittability: Feasible
Only electricity and hot water connections are required.
Scalability: High (modular)
The Stratus unit is modular and can be configured with more than one unit in a DAC hub to increase CO_2 production capacity.
Process type: Solid stationary adsorbent-based without chemical reactions.
Deployment model: Centralized only.
Each column with adsorbent undergoes cyclical CO_2 adsorption and desorption.
Technology flexibility: Hybridization with other capture technologies is not feasible.

TECHNOLOGY PROVIDERS

- DAC by **Skytree**, The Netherlands.

INNOVATIONS

- The unit can operate standalone or with other units in a DAC Hub. It is also decentralized and can use both electricity directly and in the Hybrid versions, both electricity and local heat sources.
- Compared to other DAC technology providers such as Climeworks, our system is modular and can be sized to fit the needs of different customers. The inherently decentralized nature of our technology also helps to accelerate our product development to further optimize our offerings.
- Our system can be rapidly deployed, and issues can be resolved remotely via the cloud thanks to our IoT-enabled units.

BENCHMARK

Direct Air Capture by Climeworks.

CONTACT INFO

Mohammed Khan (mohammednazeer.khan@vito.be)
Miet Van Dael (miet.vandael@vito.be)
Skytree (info@skytree.eu)

ACKNOWLEDGEMENT

This infosheet was prepared as part of the MAP-IT CCU project funded by VLAIO (grant no. HBC.2023.0544).

REFERENCES

1. Deutz S, Bardow A. Life-cycle assessment of an industrial direct air capture process based on temperature–vacuum swing adsorption. *Nat Energy 2021 62*. 2021;6(2):203-213.

PARTNERS

DISCLAIMER

Notwithstanding that this infosheet has been prepared by the developers with the utmost care, using reliable sources, this infosheet is provided on an "AS IS" and "AS AVAILABLE" basis. The developers make no warranties of any kind, express or implied, including but not limited to warranties of merchantability, fitness for a particular purpose or non-infringement of intellectual property rights, with respect to this infosheet. The developers do not accept any responsibility or liability for the use of this infosheet. Use of this infosheet is at the user's own risk. The developers of the infosheet are not responsible for any errors, inaccuracies, or misinterpretations of the information contained herein.