



Carbyon Business plan 2H23-2030

Teaser document

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Carbyon was founded in 2019 and is focused on developing a cost-leading DAC technology for mass scale deployment

Introduction to Carbyon



About Carbyon

- Dutch company **founded in 2019**
- **Spin-off** from the Dutch **Research Institute on Applied Science** (TNO)
- **Supported** by the main **Dutch machine manufacturers**, world-leaders in deep-tech machinery
- Targets to become a **mass-producer** of **Direct Air Capture machines**
- **Unique technology** from the semiconductor world to lower the costs of Direct Air Capture to **< EUR 100/tCO₂**

Carbyon aims to mitigate climate change by providing a solution that captures carbon dioxide directly out of ambient air

Value proposition

Challenge I: Realizing a net-zero world in 2050

- Humans emit 40 billion ton of CO₂/year
- The concentration of CO₂ in the atmosphere has risen from 280ppm to approximately 420ppm in 2022, driving climate change
- Global targets have been set to bring the level of global CO₂ emissions to zero by around 2050
- To realize this target the world needs:
 - Deep emission cuts across industries
 - A portfolio of carbon capture solutions



carbyon

Unique Value Proposition

- Carbyon is developing a **unique DAC technology** characterized by a **low machine size and low CAPEX**
- Carbyon demonstrated a **reactor density¹⁾** of 140 ton per year per m³ which is around **10 times higher** than any **other technology** so far
- The **next step** is to optimize the energy budget and further optimize the DAC machine
- Carbyon **targets a DAC cost** well below **EUR 100/tCO₂** and is well positioned to become one of the first companies to reach this threshold

Challenge II: Cost of DAC lower than EUR 100/tCO₂

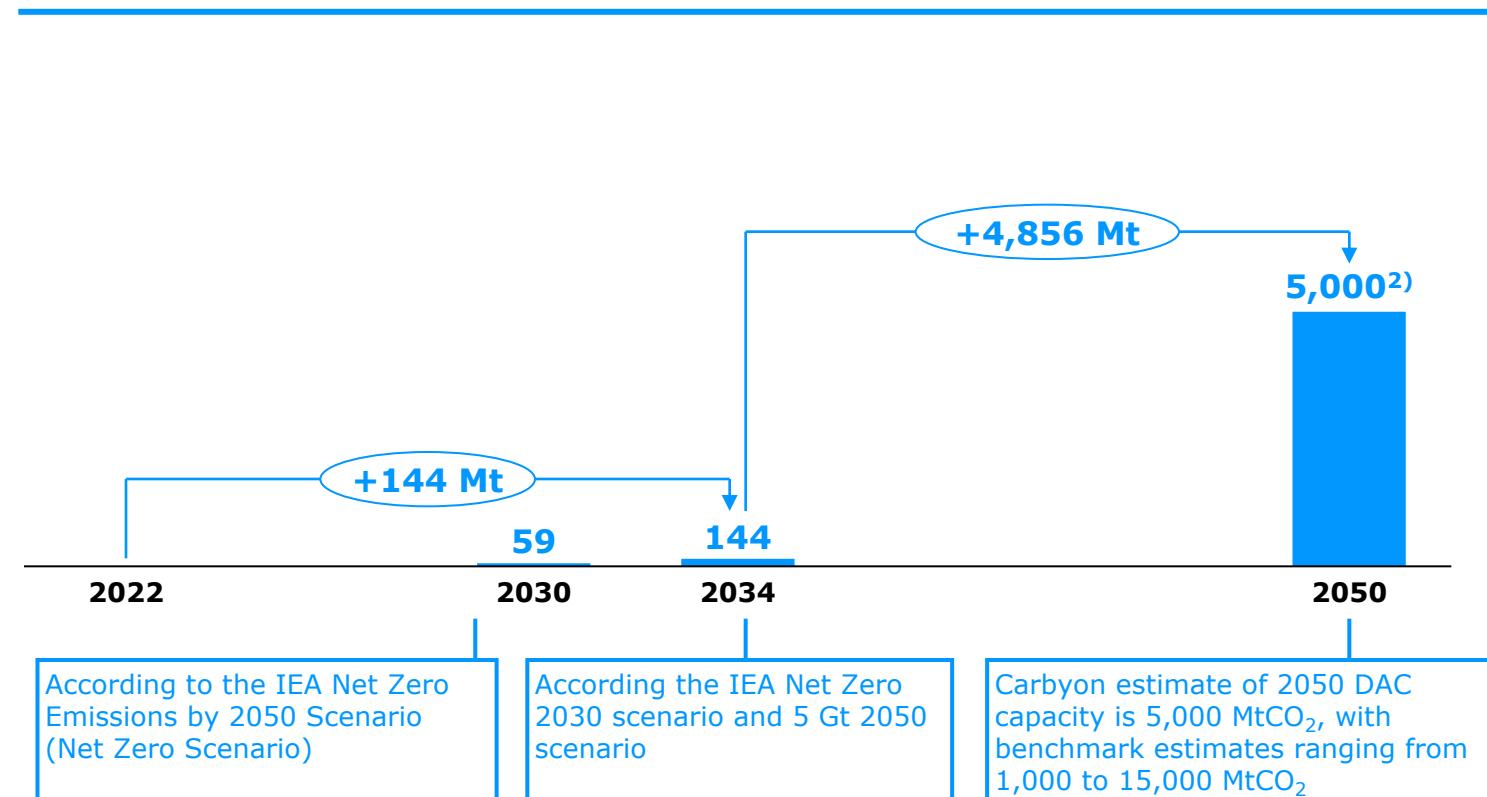
- Within the portfolio of carbon capture solutions, DAC is increasingly seen as one of the most promising technologies for large scale future deployment, due to its
 - Scalability
 - Permanence
 - Verifiability
- The main challenge for DAC is to further reduce the cost related to capturing CO₂ from the air
- A cost of DAC below EUR 100/tCO₂ will make it a gigaton-scale solution by 2050 to help tackle climate change

¹⁾ The CAPEX costs of DAC are determined by the “reactor density”, a measure for the amount of CO₂ that can be produced from air during 1 year with 1 m³ of reactor

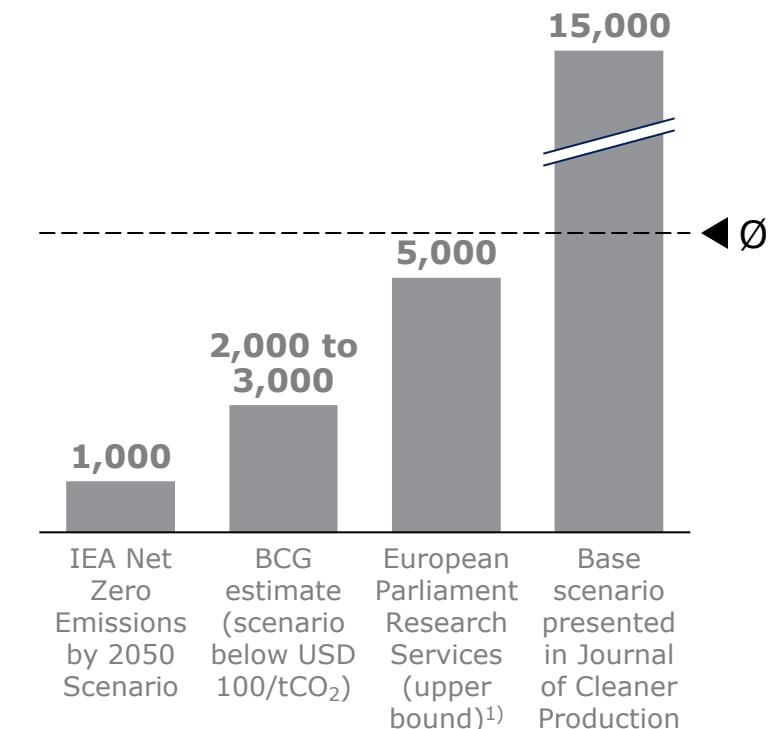
The DAC market is forecasted to accelerate rapidly in the coming decade(s), increasing to an expected capacity of 5 GtCO₂ in 2050

Forecast of global DAC operating capacity (2022-2050)

Carbyon forecast of DAC operating capacity (2022-2050) [MtCO₂/year]



Benchmark forecasts (2050) [MtCO₂/year]



1) Scenario provided by the European Parliament Research Service, based on the Fuss et al. DAC assessment; 2) Forecast of installed DAC capacity is largely dependent on cost development of DAC. If technology costs come down in line with forecasts, DAC can increasingly replace other CDR technologies, such as BECCs

Carbyon has a unique approach to DAC: It is the only company developing a fast-swing sorbent based on thin film technology

Description of Carbyon's technology

Here is what Carbyon does!

- Carbyon's technology is based on a **fast-swing thin film technology** used in the world of microelectronics
- This approach is unique: **Carbyon is the only DAC company** developing a fast-swing sorbent material and has filed a PCT patent application
- A **demonstration reactor** with capacity of 6t CO₂/year is in place to further test the sorbent material and the energy budget



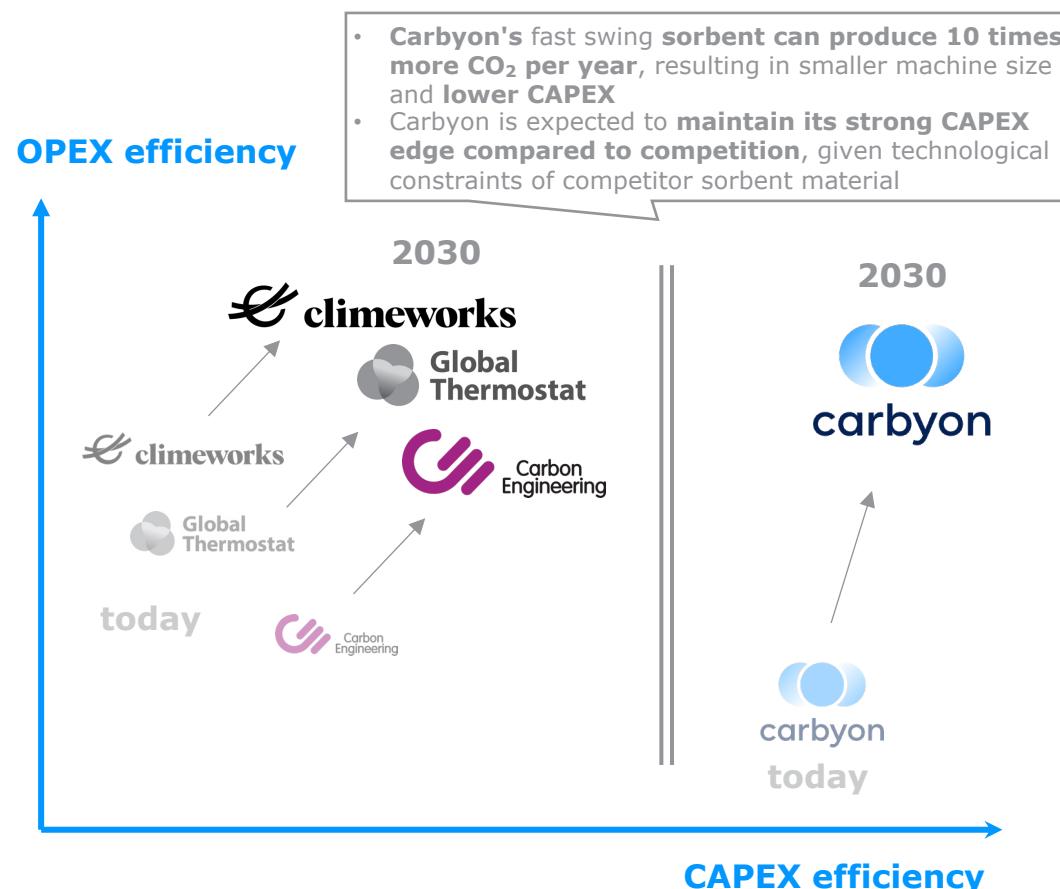
Key technology advantages

- **High absorption surface area:** 3,000 m² surface area per gram of sorbent material
- **Fast cycles:** sorbent saturation takes minutes and only seconds to de-gas vs. 6-hour cycles of key competitors like Climeworks
- **Low machine CAPEX:** Carbyon's fast swing sorbent can produce 10 times more CO₂ per year, resulting in smaller machine size and lower CAPEX

Carbyon's technology allows for a low CAPEX, which provides a strong edge compared to competition

Carbyon technology compared to competition

Comparison of selected players [illustrative]

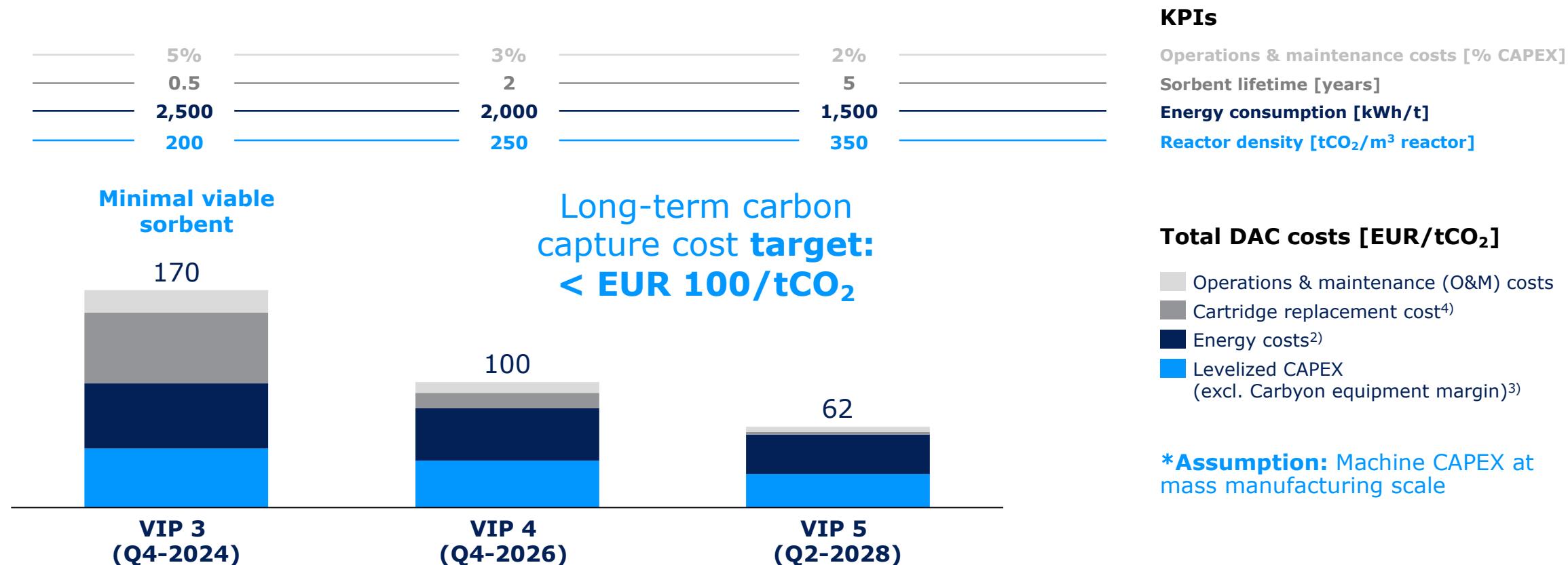


DAC technology comparison (selection)

	Liquid state absorption	Solid state adsorption	Fast swing solid state adsorption
Approach	CO ₂ dissolves in a liquid volume	Adhesion of CO ₂ to a solid surface based on solid state diffusion	CO ₂ dissolves to a solid surface based on gas phase diffusion
Key player	 Carbon Engineering	 climeworks	 carbyon
Advantage	> Good air contactor, leading to efficient CO ₂ absorption	> Limited water uptake resulting in an efficient energetic process	> High reactor density resulting in low CAPEX > Cost effective at small scale and with intermittent energy source
Challenge	> Only cost effective at large (Mt) scale > Requires high temperatures to recover CO ₂	> Cycle is lengthy, leading to low reactor density and high CAPEX > Lifetime challenges of sorbent material	> The porous sorbent tends to adsorb a lot of H ₂ O

Planned developments on the sorbent material will bring Carbyon's carbon capture costs well below EUR 100/tCO₂*

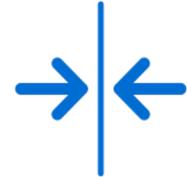
Target carbon capture costs¹⁾ [EUR/tCO₂]



1) Carbon capture cost is defined as the costs to capture CO₂ up to a purity-level of ~40% at the customer level. Capture costs exclude post-DAC treatment costs such as purification, buffering, compression and drying. Carbon capture cost calculations are model-based and will be further refined as technology matures; 2) Energy cost is based on an energy price of EUR 0.02/kWh; 3) Levelized CAPEX is based on production cost at mass volume manufacturing of units, a capital recovery factor of 0.13 (machine lifetime of 15 years and WACC of 10%) and excludes a customer margin on Carbyon's products; 4) Excludes a margin on cartridge replacement

Carbyon can build on unique selling points of its technology to help customers bring down their total cost of ownership

Carbyon's unique selling points



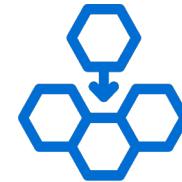
Thin film technology

Carbyon's thin film technology with low sorbent and machine volume per captured CO₂ leading to low capex costs and reduction of CO₂-footprint



All-electric

Carbyon's all-electric technology does not require (use case specific) piping, like for the use of residual heat. Residual heat can be used when available.



Modular design

Modular design enables scalability, size-ability to the specific use case, shape-ability to the customer's need, ship-ability and switch-on and off ability of individual units



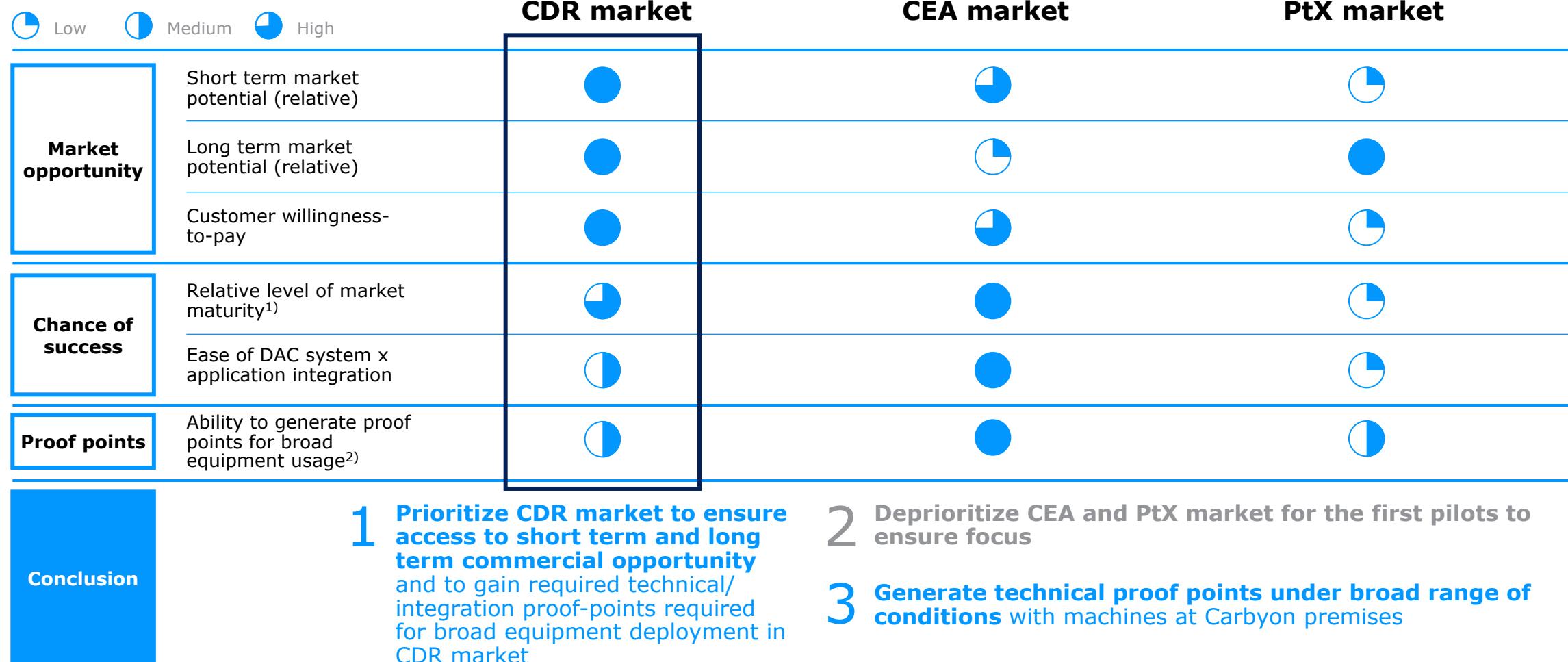
No need for water

No use of water and even production of demineralized water as a by-product with added value in dry areas (e.g. for production of hydrogen and drinking water)

All of these aspects will lead to a low total cost of ownership for the customer per net captured CO₂

Commercial efforts will be prioritized on the CDR market – CDR represents the largest opportunity in the short and long term

Commercial focus



1) Measured as the degree to which the market is proven to function with CO2 as a feedstock; 2) Proof points in various environmental and technical conditions (e.g. intermittent use)
 Source: Carbyon analysis

First pilot is envisioned with Deep Sky – This will help to build strong a position in the CDR market

Pilot partner assessment (selected partners¹⁾)

		CDR market		
		DEEP SKY	Paebbl™	44.01
Partner description & business model	Partner description	A CCS company based in Canada in an area with high supply of low-cost hydropower energy – Gt project ambition	Company focused on re-storing captured carbon into industrial raw materials	Storage company based in Oman, focused on storage of CO2 in an as-a-service model
	Business model Carbyon	Sale of equipment	Sale of equipment	Sale of credits
Commercial criteria	Customer representativeness for broader market Carbyon	High	Medium	Low
	Commercial opportunity (relative) through partner	High	Medium	High
Technical criteria	Degrees of freedom to test & generate technical proof points	Medium	Medium	Medium
	Location suitability for technical proof-points ²⁾	Medium	Medium	Medium
Timing	Time to get first pilot running	High	High	Medium
Conclusion	Prioritize Deep Sky for first CDR pilot – Partnership will enable Carbyon to learn and build commercial proof-points required for broad access to the CDR market opportunity			

1) Pending partner discussions and negotiations

2) Including access to various environments

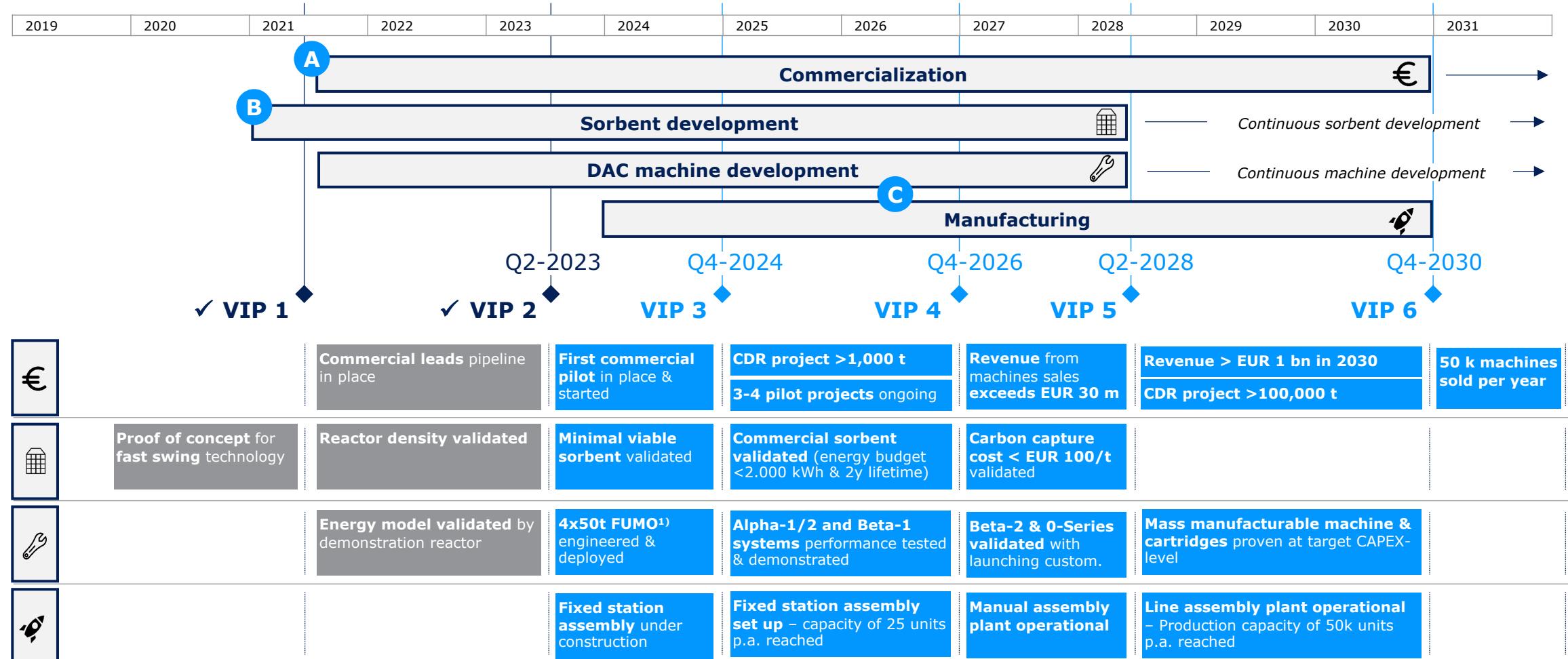
Source: Carbyon analysis

Deep Sky partnership benefits

- Partnership gives access to a large commercial opportunity:** Partnership has a high ambition level and envisions a joint project capacity >1 Mt
- Deep Sky is located in an area with abundant low-cost hydropower:** This plays into Carbyon's DAC economics, with low CAPEX as a key competitive edge (also at first, when Carbyon's energy budget is still above target)
- Partnership targets a joint development project** where there is sufficient space/time for testing and improving the system at the start of the roadmap
- Carbyon is well positioned to start this project on the short term:** Carbyon is shortlisted by Deep Sky as one of the high potential partners with envisioned start in 2024 (LoI is already in place)
- Partnership will be on a non-exclusive basis** enabling Carbyon to pursue other (CDR) opportunities as it sees fit

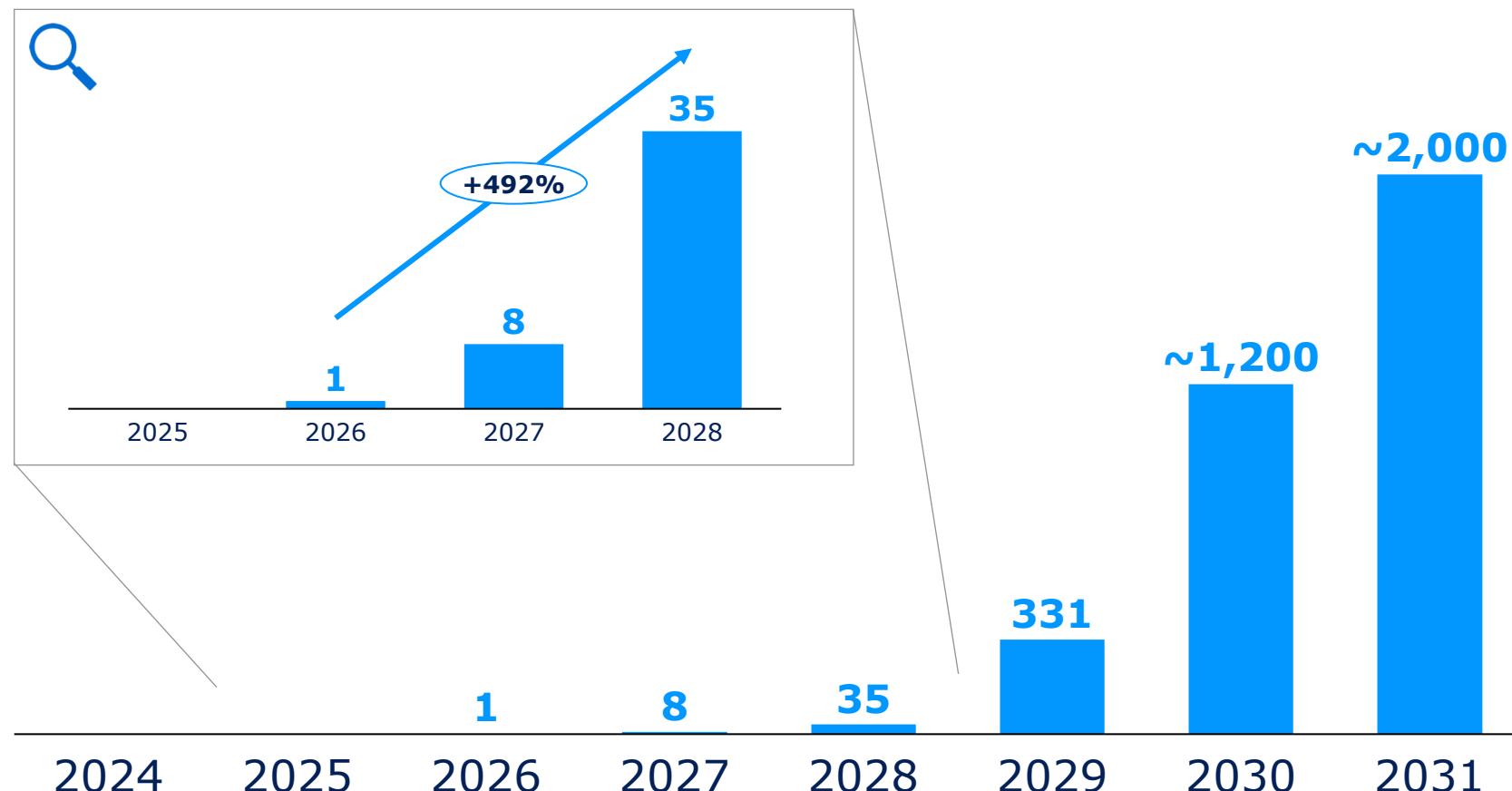
An accelerated roadmap has been defined, targeting the first pilot to start in 2024 and targeting mass production in 2030

Accelerated phased-approach roadmap and value inflection points (VIPs)



The business plan targets a revenue > EUR 1 bn in 2030 at an EBIT margin of 25%

Revenue forecast and target financials (2024-2031)¹⁾ [EUR m]



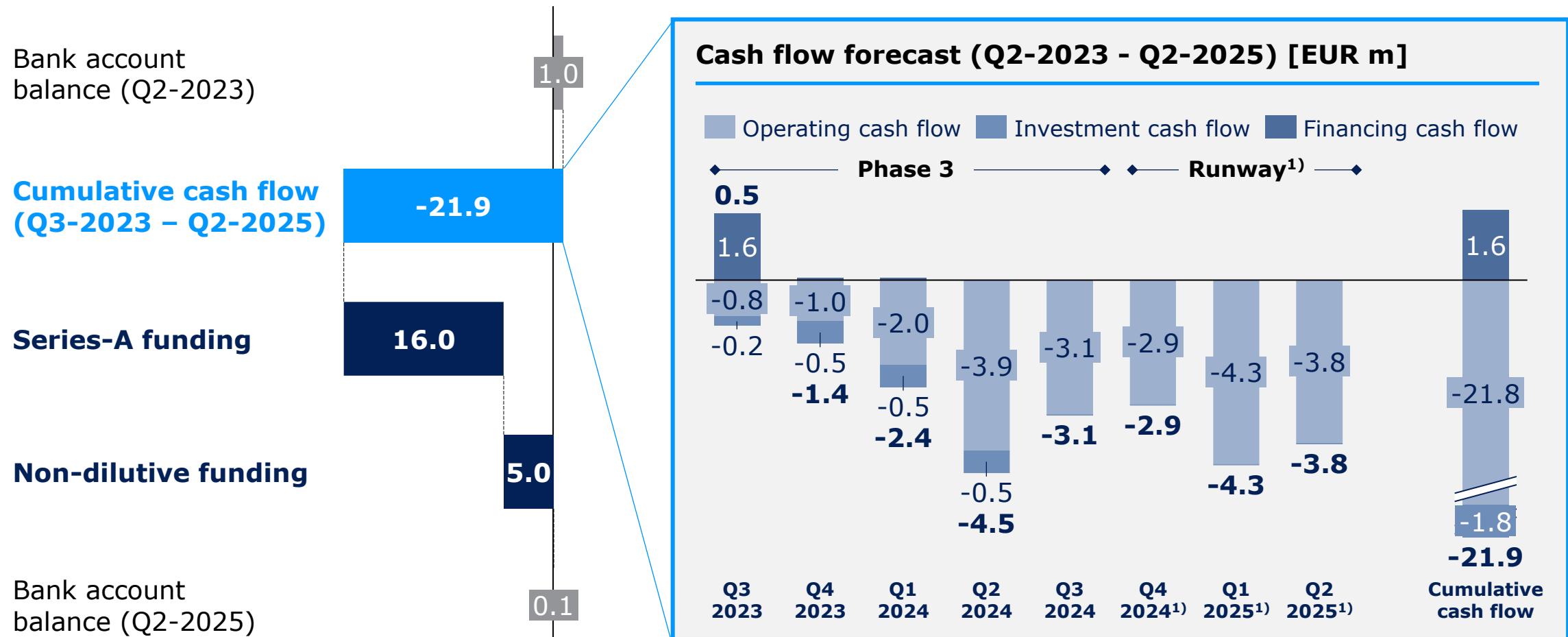
Remarks:

- Revenue is forecasted to exceed EUR 1 bn in 2030
- Carbyon targets an EBIT margin of 25% at the end of the roadmap
- Main revenue source is sales of DAC equipment
- Other revenue sources include recurring revenue from cartridge replacements and revenue from equipment maintenance activities

¹⁾ Revenue is based on i) equipment sales in line with planned production capacity, ii) an assumed gross margin of 50% in the period 2027-2031 for Beta-2 machines, 0-series and mass manufacturable machines; Revenue forecast excludes sales from sorbent/cartridge replacements and maintenance activity

By October 2023 Carbyon wants to close a Series A round of EUR 16m to reach the next milestone by Q3-2024

Cash flow forecast¹⁾ & Series A funding (Q3-2023 - Q2-2025) [EUR m]



1) Forecast period includes runway for the series B funding

Carbyon has a strong and motivated team in place to deliver on the next milestone of the business plan ...

Organization & values

Organization

- Team of ~30 highly motivated researchers, engineers and managers (22 FTE on payroll)
- Core activities currently revolve around R&D projects
- In the next years Carbyon will transition to a product-oriented organization, with more focus on commercialization and manufacturing

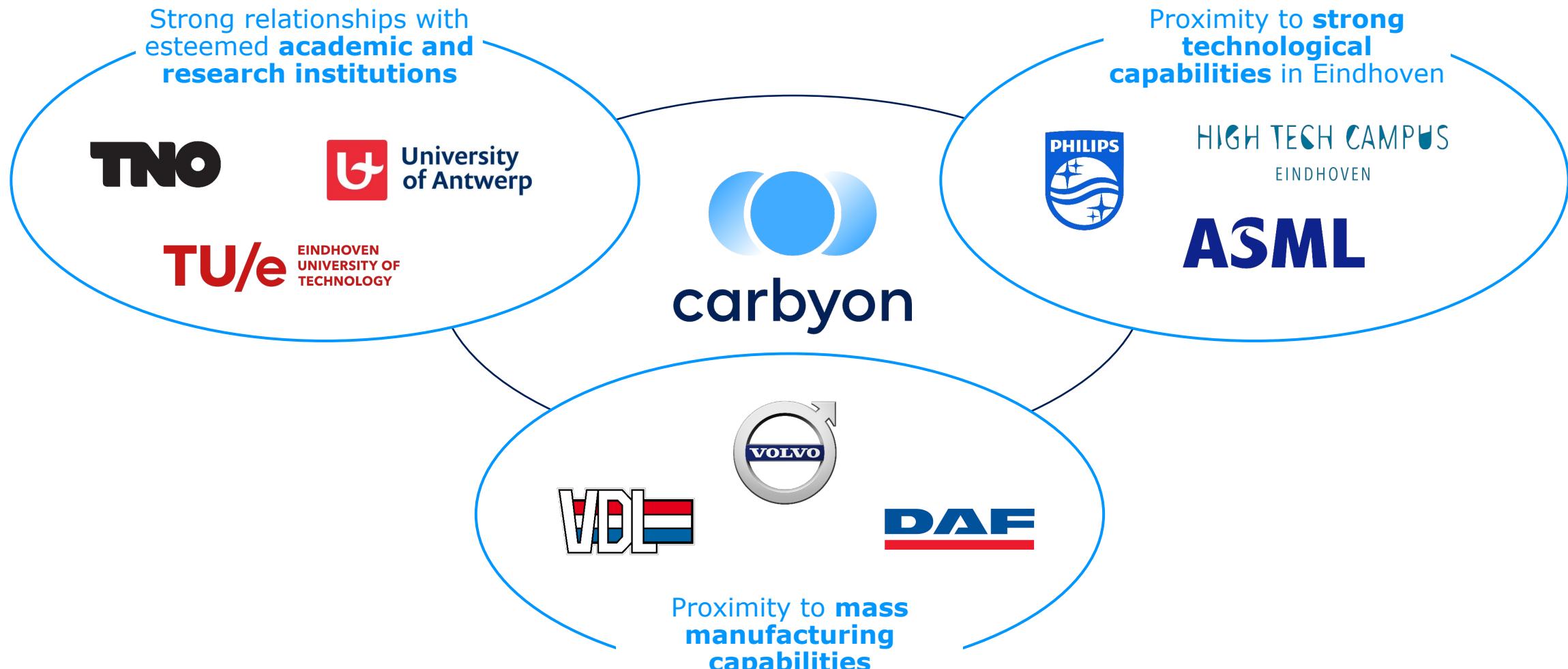


Values

- Carbyon was founded as a purpose-driven enterprise with a steadfast commitment to address climate change and preserve the environment
- Our purpose and ethical charter guide our decisions, actions, and interactions, ensuring alignment with our core values and goals.

... and is well positioned to leverage technological & manufacturing capabilities in its environment

Carbyon's ecosystem



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