



Carbominer

Carbon Dioxide Removal Purchase Application Fall 2022

General Application - Prepurchase

(The General Application applies to everyone; all applicants should complete this)

Company or organization name

Carbominer Ukraine LLC

Company or organization location (we welcome applicants from anywhere in the world)

Kyiv, Ukraine

Name(s) of primary point(s) of contact for this application

Nick Oseyko, Vika Oseyko

Brief company or organization description

Carbominer develops modular DAC solution for different use cases which can benefit from a local capture.

1. Project Overview¹

- a. Describe how the proposed technology removes CO₂ from the atmosphere, including as many details as possible. Discuss location(s) and scale. Please include figures and system schematics. Tell us why your system is best-in-class, and how you're differentiated from any other organization working on a similar technology. (1500)

Carbominer offers a modular solution based on its novel mix of dry and wet capture approaches on capturing stage and a pH-swing based process to release gaseous CO₂ from the enriched solution on the regeneration stage.

¹ We use "project" throughout this template, but note that term is not intended to denote a single facility. The "project" being proposed to Frontier could include multiple facilities/locations or potentially all the CDR activities of your company.

Carbominer has been developing its DAC technology since 2020, verified its first working DAC prototype machine for XPRIIZE competition in late 2021, and delivered the first DAC pilot with an international cement manufacturing company in December 2022.

Carbominer DAC advantages include:

- 1) High modularity, as one or several standard 40 ft capturing units could be combined with one regeneration unit of corresponding capacity.
- 2) Low energy consumption, leading to low full cost of capture - \$750 now and \$90/t at the Mt/y scale.
- 3) Ability to use mostly overproduced electricity from renewable sources, leading to low carbon footprint of the DAC process
- 4) Operation at normal ambient conditions with minor use of water and no use of other liquids or chemicals.
- 5) Minor physical footprint.
- 6) High purity of the captured CO₂ (>99.5%)

Carbominer proposes a 250 t/y CDR collaborating project with one of the largest EU construction companies by mineralizing CO₂ underground. We have signed a pilot agreement with them for a small-scale DAC demonstration in July 2023 and we plan to deliver a pilot of 50 t/y DAC system in Germany before the end of 2023.

CO₂ mineralization underground approach has been successfully demonstrated by several startup companies during the last decade. Our proposal is to dissolve the locally captured CO₂ in water and inject it into the geothermal well, where the carbonated water with low pH will cause a reaction between cations and the dissolved CO₂ to form very stable carbonate minerals to stay in the pore spaces underground.

The project location is at an already developed geothermal well site near Munich (Germany). The region has a lot of renewable generation already installed, making the renewable electricity available for the project.

- b. What is the current technology readiness level (TRL)? Please include performance and stability data that you've already generated (including at what scale) to substantiate the status of your tech.

With DAC technology demonstrated for international partner during a pilot at their construction site

near Kyiv (Ukraine) in December 2022 Carbominer has reached TRL 6.

- c. What are the key performance parameters that differentiate your technology (e.g. energy intensity, reaction kinetics, cycle time, volume per X, quality of Y output)? What is your current measured value and what value are you assuming in your nth-of-a-kind (NOAK) TEA?

Key performance parameter	Current observed value (units)	Value assumed in NOAK TEA (units)	Why is it feasible to reach the NOAK value?
Energy consumption	23 MWh/t	3 MWh/t	Because we have numerous data from open scientific articles and research publications that the energy consumption for the BPM ED process for CO ₂ release is in the range of 1.5 MWh per ton.
Water consumption	27 m ³	5 m ³	Current observed value is clearly high because of the small scale of our first working MVP DAC machine (1.2 t/y). Even with FOAK 50 t/year DAC system our target water consumption of 30 l/h would allow us to reach 5 m ³ /t value.
CO ₂ purity	99.7%	99.8%	Because we already climbed very close to the NOAK target

- d. Who are the key people at your company who will be working on this? What experience do they have with relevant technology and project development? What skills do you not yet have on the team today that you are most urgently looking to recruit? (300)

Nick Oseyko – Founder & CEO.

Has engineering education with two majors in the fields of chemistry and IT.
Inventor. Serial entrepreneur, 6 startup companies started, 1 exit.

Andriy Lavrentiev, CTO.

Has best in class chemical education from Moscow Chemistry Technology institute and three successful launches on novel chemical products.

Volodymyr Oleksenko, Head of Production.

Has 10+ years of experience in production management, managed Metro Cash & Carry in Ukraine prior to joining Carbominer.

Assuming funding for R&D available, we are going to hire at least two more team members as researchers – one for pH-swing BPM ED regeneration tech, another for researching aspects of various CO₂ storage technologies.

- e. Are there other organizations you're partnering with on this project (or need to partner with in order to be successful)? If so, list who they are, what their role in the project is, and their level of commitment (e.g., confirmed project partner, discussing potential collaboration, yet to be approached, etc.).

Partner	Role in the Project	Level of Commitment
Name under NDA (one of the largest cement manufacturing companies in the EU)	Pilot Partner	NDA signed in 2021, LOI signed in August 2022, paid pilot delivered in December 2022
Name under NDA (one of the largest construction companies in the EU)	Storage Partner	NDA signed in June 2022, LOI signed in September 2022, pilot agreement signed in February 2023, first pilot (EU based) scheduled for July 2023.
Mega (leading supplier of BPM ED cells in the EU)	BPM ED cells supplier and R&D partner for pH-swing.	2 BPM ED units supplied (in 2021 and in 2022). LOI signed in December 2022.
Corning Inc. (leading global material science company, developer of Gorilla glass)	Joint R&D Partner. Supplier of high porosity ceramics samples.	NDA signed in 2022, LOI signed in December 2022, first samples for R&D delivered in February 2023.
Brits Energy LLC (leading renewable energy consultants in UK, operator of the first in class Net-Zero strawberry vertical farm project)	Partner for pilot project in the UK in 2024. Consultant on various aspects of renewable electricity applications.	LOI provided in October 2022, UK visa awarded in April 2023, in-person meeting is scheduled for July 2023.

- f. What is the total timeline of your proposal from start of development to end of CDR delivery? If you're building a facility that will be decommissioned, when will that happen? (30)

Q4 2023 – first pilot of a 50 t DAC system
Q1-Q2 2024 – production of five modular 50 t DAC systems to be deployed in the project

- g. When will CDR occur (start and end dates)? If CDR does not occur uniformly over that time period, describe the distribution of CDR over time. Please include the academic publications, field trial data, or other materials you use to substantiate this distribution. **(100)**

July 2024 – June 2026 (2 years), having 500 gross tons distributed by years as:
1. 2024 - 100
2. 2025 – 200
3. 2026 – 200

- h. Please estimate your gross CDR capacity over the coming years (your total capacity, not just for this proposal).

Year	Estimated gross CDR capacity (tonnes)
2023	0
2024	150
2025	600
2026	1,625
2027	7,950
2028	33,800
2029	96,000
2030	222,000

- i. List and describe at least three key milestones for this project (including prior to when CDR starts), that are needed to achieve the amount of CDR over the proposed timeline.

	Milestone description	Target completion date (eg Q4 2024)
1	Demonstration pilot of a 2t Carbominer DAC system in Vienna (Austria)	Q3 2023
2	Demonstration pilot of a 50t Carbominer DAC system in Munich (Germany)	Q4 2023 or Q1 2024
3	Production of 5 50t DAC systems	Q2 2024

- j. What is your IP strategy? Please link to relevant patents, pending or granted, that are available publicly (if applicable). **(200)**

We have filed for our first patent in Ukraine in 2020 (granted in Septemder2022).
 We have filed our core DAC patent application in July 2022 to USPTO, and are doing additional efforts to strengthen this protection by re-applying it
 We also protected Carbominer TM in Ukraine (filed in 2020, granted in 2022) and filed an international application for the key markets in 2023.

- k. How are you going to finance this project **(300)**

- 1) We have secured \$950K from private investors so far (2020-2022).
- 2) We plan to raise \$1.5M via our late-seed round in Q3 2023

3) We have applied to EIC grant of €1.5M in June 2023 to support our R&D

- l. Do you have other CDR buyers for this project? If so, please describe the anticipated purchase volume and level of commitment (e.g., contract signed, in active discussions, to be approached, etc.).

No, however our partner for CO2 storage already indicated their intention to use our DAC technology for earning CDR credits by storing CO2 underground.

- m. What other revenue streams are you expecting from this project (if applicable)? Include the source of revenue and anticipated amount. Examples could include tax credits and co-products. **(200)**

We have an alternative business model of selling locally captured CO2 to greenhouses and are actively looking for first pilots with greenhouses or vertical farms. We assume here that in some countries in some future years market prices of CO2 for greenhouses

- n. Identify risks for this project and how you will mitigate them. Include technical, project execution, ecosystem, financial, and any other risks.

Risk	Mitigation Strategy
<p>1. Technology Risk – if our DAC technology will not work as intended</p> <p>LIKELIHOOD: Low IMPORTANCE: High</p>	<p>We invested significant efforts (time and money) into development of our technology and then we tested our MVP machine internally and then during a pilot with an international company as a partner in December 2022. So we know for sure our DAC tech works, however there is still a probability of not reaching the target low cost of capture before 2030.</p>
<p>2. Market risk - that the DAC systems developed will not be commercially successful due to lack of demand or competition.</p> <p>LIKELIHOOD: Medium IMPORTANCE: High</p>	<p>Even if climate related application of our DAC tech will not be successful, we have a solid plan B as we were targeting a promising CO2 injection market for greenhouses from the very start of Carbominer in 2020.</p> <p>We completed many customer development meetings with greenhouse operators and vertical farmers during 2021-2022 years and feel confident about strong market potential for us in this use case. Our recent participation in StartLife acceleration program in Wageningen fully supports this.</p>
<p>3. Financial risk: the risk that the project will not be completed within the allocated budget, causing financial losses to the company.</p> <p>LIKELIHOOD: Medium IMPORTANCE: High</p>	<p>We gained a valuable experience running Carbominer with private money support during 3+ years, plus Carbominer founder and CEO Nick Oseyko has 10 years of practical experience of working as CFO in several companies from different industries.</p> <p>However, we have experienced problems with raising since the beginning of Russian aggression on Ukraine, as investors are not ready to consider such a high country-related risk. We mitigate this risk by opening a branch company in Poland (planned for July</p>

	2023) and relocating part of our operations from Ukraine to Poland.
<p>4. Intellectual property risk: the risk that the intellectual property rights associated with our DAC project will not be protected adequately, leading to infringement and legal issues.</p> <p>LIKELIHOOD: Low IMPORTANCE: High</p>	<p>We are filing patent applications as the need arises (1 patent already granted in Ukraine). We have protected Carbominer TM in Ukraine (granted in 2022) and filed an international application for the key markets.</p> <p>And we do the competition analysis (including IP review) on a regular basis in-house plus we conducted the formal FTO research with 3rd party experts twice: in 2021 and in June 2023.</p>
<p>5. Regulatory risk: the risk of not being able to meet regulatory requirements for the product, which can lead to delays and additional expenses.</p> <p>LIKELIHOOD: Low IMPORTANCE: High</p>	<p>So far, we observed only a positive trend in regulations, stressing the climate mitigation urgency and providing the favorable conditions and support for climate mitigation projects, with DAC specifically included (EU Green Deal, US IRA).</p> <p>There is a low to no risk that this favorable policy support will be reverted within the project duration frame of 2024-2027</p>
<p>6. Organizational risk: the risk of not having the right resources, skills, and expertise to execute the project successfully, leading to significant delays and other problems.</p> <p>LIKELIHOOD: Medium IMPORTANCE: Medium</p>	<p>We are confident that the prior experience of Carbominer CEO Nick Oseyko as serial entrepreneur and also his 15 years track of record in Human Resources industry mitigates that risk to a significant extent.</p>
<p>7. Ecology risk: the risk that the project will violate ecological norms and regulations in the EU</p> <p>LIKELIHOOD: Low IMPORTANCE: Medium</p>	<p>Ecological regulations in the EU are really strict and we experienced this in our own experience as our first pilot was originally planned for Romania (where our pilot partner operates a cement manufacturing plant), but it was delayed for 4 months and finally moved to Ukraine as our partner failed to obtain a permit from ecological authorities in time.</p>

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