The *Novo Nordisk Foundation CO_2 Research Center* announces the

2022 Request for Proposals for

Innovative, Interdisciplinary Research on CO_2 Capture and Conversion

Issued: September 6, 2022

Application deadline:

Pre-Proposals: October 14, 2022, at 14:00 CET.

Full proposal (invited applicants only): December 2nd, 2022, at14:00 CET

Applicant notification:

Pre-proposals: October 28th, 2022

Project presentation:

Week 3 (January 16 - 20), 2023

Notification of award:

Week 4 (January 23-27), 2023

Start date:

Earliest possible: March 1, 2023

Latest possible start date September 1, 2023

Further information and link to application system can be found here:
Proposals in specific research areas (au.dk)

Eligibility:
The Principal Investigators must be full time affiliated with a university or non-profit research institution. The location is not restricted to specific countries. Proposed research by interdisciplinary teams is encouraged; however, if sufficiently justified, single PI proposals will also be considered.

Project Funding and Duration:
Projects in Areas 1 -3 should be for up to 3 years and a maximal budget of up to 7.3 million DKK, including bench fee, technical and administrative support. Projects in Area 4 are for up to 1 year and a total budget of 2.5 million DKK, including bench fee, technical and administrative support.

Background
The mission of the *Novo Nordisk Foundation CO_2 Research Center* (CORC) is to generate new science and early technologies for capture of CO_2 as either inert carbon or for use in a circular economy. Core approaches are based on, but not limited to, chemical and life sciences. Mitigating climate change is the most urgent contemporary societal challenge. In order to reach the European, and in particular the Danish climate goal of reducing greenhouse gas emissions in 2030 by 70 % with respect to the level in 1990, new CO_2 capture and conversion technologies are needed. There is general agreement that new CO_2 capture technologies are an essential component for the Green Transition and will be required in the long term at the Gt scale. For example, for 2021, it was estimated that a total of 36.3 Gt CO_2 from anthropogenic sources was net released world-wide, which is equivalent to an annual per person release of CO_2 of $\sim$ 4.6 tons, with large variations between countries. The specific amount of CO_2 that needs to be captured depends on how aggressively society is implementing the transition to fossil carbon-free energy technologies. However, it is at the Gt per year scale, and a new, second generation of scalable CO_2 capture and conversion technologies is urgently needed.

Oxygenic photosynthesis is a natural process of capturing dilute atmospheric CO_2 and converting this CO_2 to biomass carbon that is working at the Gt scale. Annually, about 300 Gt CO_2 are converted to biomass carbon. Such carbon can contribute significantly to a net reduction of atmospheric CO_2 if a fraction of it can be accessed in a sustainable way for carbon storage. How biomass carbon can be converted into new, climate-inert carbonaceous materials (other than biochar) with valuable material properties is a key research frontier and focus of this RFP (Area 1).

Second generation CO_2 technologies produce CO_2-derived, climate-inert carbon materials that are of commercial, e.g., building, value or that will be used in a circular economy. In order to drive a new economy based on CO_2-derived carbon as a valuable material, new fundamental research is highly needed to explore how CO_2 can be converted to climate-inert materials at the Gt scale. Moreover, capture and conversion processes need to be integrated from the outset.

In principle, CO_2 capture at the Gt scale can be envisioned in at least two ways:

- by a limited number of large, centralized plants that operate at an economy of scale with new technologies, where each plant, for example, captures million tons of CO_2; or
- by a large number of small, decentralized household- or community-size units.

A combination of both can also be envisaged.

Both platforms have in common the requirement for renewable energy, as well as electrons (mostly in form of H_2), but differ fundamentally in how the respective scaling can be achieved technically. Thus, there is a need for diverse science and technology options; some are better for large, centralized, and others for small, decentralized platforms, or both.

Second generation CO_2 capture and conversion technologies take advantage of integrating complementary fields such as chemistry and life sciences into new platforms. The energy source is generally electricity from renewable sources (wind, solar, geothermal).

The ***Novo Nordisk Foundation CO_2 Research Center*** announces this broad Request for Proposals in four areas to complement ongoing research at CORC (www.corc.au.dk):

Area 1: Conversion of CO_2-derived carbon to materials with advanced properties

CO_2 carbon can be converted to a valuable material and is, in principle, available at the Gt scale. Pyrolysis of biomass or of biologically produced methane (biogas), for example, has the promise of producing new, climate-inert, carbonaceous materials that can be used in the building and/or infrastructure sector. However, catalyst inactivation and controlling reaction conditions in pyrolysis is variable, and the full potential has not been explored.

Of particular interest in Area 1 is the processing of biomass and CO_2-derived methane into new materials. While biochar, when produced from biomass and introduced into soil, has some potential to store carbon, other forms of inert carbonaceous material need to be developed to take advantage of the Gt scale annual CO_2 capture by photosynthesis.
New chemical sciences for pyrolysis of CO_2-derived methane, such as from biogas or upgraded biogas, to new material are needed. Methane pyrolysis has the advantage of being chemically homogeneous, which can enable formation to homogenous carbonaceous materials, such as carbon fibers or carbon nanoparticles. However, substantial new research on catalysts involved is needed.

In Area 1 of this RFP, new fundamental research on catalytic conversion of CO_2-derived carbon to new, inexpensive materials with useful properties is funded. While the research focus remains on fundamental aspects of catalysis and process integration, scalability to the Mt-to-Gt level of the underlying approach needs to be addressed. Interdisciplinary approaches with significant innovation are encouraged.

Area 2: New approaches of CO_2 capture from dilute sources and conversion for storage or use at scale

New approaches with new science are needed for developing inexpensive, scalable technologies for capturing CO_2 from non-point sources. Innovative inexpensive new chemical conversions and advanced microbial C1 catabolism are highly promising areas.

Because captured CO_2 is converted to new climate-inert materials for storage or use, CO_2 capture needs to be integrated with a conversion process.

In Area 2 of this RFP, proposals on direct capture of CO_2 from air or aqueous systems, such as the oceans or large terrestrial surface waters, are particularly encouraged. Proposed research is based on new chemical and life science-based approaches and/or combinations thereof that have the promise to work at scale. Proposals involving small molecule amines or metal-organic framework (MOF) will not be considered.

Area 3: New approaches for developing CO_2 capture by inexpensive units that work at household/community-level.
A different way to achieve Gt scale CO_2 capture and conversion is by multiplicity of small scale, easy to operate units. For example, small, household-level units could capture amounts of CO_2 equivalent to the CO_2 produced by individuals of a household, in the order of 1 - 4 tons CO_2 per person/year. CO_2 is captured, converted, and disposed of by inexpensive means, taking advantage of local opportunities in terms of energy, carbon storage opportunity as well as low-cost process materials such as waste. Such captured CO_2 could be collected and processed for storage in a de-centralized way.

Area 3 of this RFP seeks low TRL proposals that investigate fundamentals of innovative approaches for CO_2 capture and conversion at a small scale. A key aspect of this approach is in the simplicity in the overall approach and practical handling. Proposals involving small molecule amines or metal-organic framework (MOF) will not be considered.

Area 4: Exploratory or proof-of-concept research
Because of the Gt scale of the CO_2 problem, breakthroughs based on unconventional, out-of-the-box ideas are needed.

For example, H_2 (or electrons in general) plays a key role in reductive transformations of CO_2 for storage and use. Yet, there is a substantial deficit in currently available H_2 if all available hydrogen would be used just for CO_2 capture and reduction alone. Thus, significant innovation is required to develop new sources of electrons/H_2 that are available at scale. Such sources are likely, but not exclusively, geochemically-based and need to be beyond electrolytically -or fermentatively-produced (i.e., organic matter-derived) H_2. The latter two areas will not be considered.

Area 4 of this RFP solicits research to explore new, unconventional ideas on high-risk projects, such as, but not limited to H_2 sources. Proposals in Area 4 are typically for 1 year to explore new ideas and to provide proof of concept data. Collaborative, interdisciplinary teams from chemistry and life sciences are particularly encouraged to apply.