DE-FE0032386: The Midwest Nuclear Regional Direct Air Capture Hub (MINDAC)

Kickoff with Department of Energy

July 19, 2024

Northwestern SUSTAINABILITY AND ENERGY

MINDAC TEAM

Paula M. Trienens Institute for Sustainability and Energy

- Top 10 US research institution
- \$1 billion in annual research expenditures
- MINDAC is housed within the Paula M. Trienens Institute for Sustainability and Energy.
- The project is also supported by the Northwestern-Argonne Institute of Science and Engineering (NAISE)
- Together, Trienens and NAISE have managed over \$14 million in large-scale, multi-institutional projects in the past five years

Northwestern University



Jennifer B. Dunn Principal Investigator Dept. of Chemical and Biological Engineering Assoc. Director and Senior Fellow of NAISE Expertise: TEA, LCA of emerging decarbonization technologies



Ted H. Sargent

Co-Principal Investigator Depts. of Chemistry and Electrical and Computer Engineering Co-Executive Director of Trienens Institute Expertise: CO₂ conversion technologies, electrochemistry



Omar Farha Co-Principal Investigator Dept. of Chemistry Expertise: Nanoporous materials, gas capture, separation, and storage



Ke Xie Project Management Depts. of Chemistry Expertise: CO₂ conversion technologies, electrochemistry



Brad Sageman Senior Personnel Dept. of Earth and Planetary Sciences Expertise: Geological subsurface exploration and production



Mar Reguant Senior Personnel Dept. of Economics Expertise: Economic modeling and policy issues of energy markets



Sarina McBride Research Administrator Paula M. Trienens Institute for Sustainability and Energy

Organizational Chart



Northwestern SUSTAINABILITY AND ENERGY

TECHNOLOGY

Paula M. Trienens Institute for Sustainability and Energy



COMPANY INTRODUCTION

AVNOS, INC.

AVNOS EXECUTIVE SUMMARY

Hybrid Direct Air Capture (HDAC) Technology Captures Water and CO2

HDAC IS A TRANSFORMATIONAL ADVANCE IN THE DAC LANDSCAPE



Produces Water

• Inverts DAC Water Paradigm



Proprietary Technology

• Exclusive Intellectual Property



Moisture Swing CO2 Adsorption

• Eliminates Heat Input



Lowest Cost in DAC

• ~\$95/ton Nth Plant Levelized Cost of Capture

THE HDAC PROCESS





FIRST FIELD-DEPLOYED PILOT SYSTEM

DOE SPONSORED \$3.2M, 30TPA UNIT

Bakersfield, CA

TRL-6

	Avnos	Solid Adsorption Adsorption	Liquid Absorption				
Adsorb / Desorb Technology	Moisture Swing + + Vacuum	Temperature + Vacuum Swing	Liquid Absorb + Central Thermal Desorb				
Energy Consumption Consumption Electrical Thermal	<1,000 kWh/ton <1,000 kWh/ton 0	~2,200 kWh/ton ~400 kWh/ton ~1,800 kWh/ton	~3,000 kWh/ton ~1,200 kWh/ton ~1,800 kWh/ton				
Water P	Produces 5-10 tons	Consumes ~5 tons	Consumes 5-10 tons				
Thermodynamic Efficiency	20%	7-10%	~5%				
LCOC Gen1 LCOC Nth	~\$220/ton ~\$95/ton	\$600-1,000/ton \$200-300/ton	~\$350/ton ~\$200/ton				
Scalability	Modular	Modular	Large-only >500kta				

COMPETITIVE COMPARISON

OUR TEAM

LEADERSHIP



Will Kain Founder & CEO NanoH2O Rusheen Capital



Ben McCool, PhD SVP Technology ExxonMobil Algenol Biofuels



Ben Stone VP Corp Dev 1PointFive US Renewables Group



Jen Hebert Chief of Staff, VP Ops Meta Twitter



JR Johnson, PhD VP R&D ExxonMobil SABIC



Neel Rangnekar, PhD Director, Process Tech ExxonMobil Praxair

24 total team members; 10 PhDs; 10 with prior DAC experience



U.S. Department of Energy

30 tons-CO2 per year pilot unit First field deployment \$3.2M DOE Sponsorship Operating Bakersfield, CA





U.S. Office of Naval Research

450 tons-CO2 per year demo unit Commercial "Module" \$4.8M ONR Sponsorship Commissioning 1Q25 Bakersfield, CA

Commercial Reference Unit

4,500 tons-CO2 demo system 10 Modules \$20M Commercial Sponsorship Target Commissioning: 1H26 Bakersfield **OR** Louisiana

Efficient. Scalable. Affordable.

Carbon Capture

Amir Shiner, Co-Founder & CEO Jean-Philippe Hiegel, Head of Strategy & Growth

RepAir

1. LOWEST ENERGY CONSUMPTION REGARDLESS OF ENERGY SOURCE

Conventional DACs consume up to 4x the energy.

RepAir:

- Lowest energy consumption <600 kWh/t demonstrated by 5,000 hours of continuous data
- We can deploy **today** regardless of the energy source, maintaining carbon net-negativity





Total Energy Target for 1 ton Net CO2 Removed

2. OPTIMAL APPROACH TO REACH SCALE

Standardized StackDAC Modules

• Seamlessly stacked interlocking modules

Mass Manufacturability

- Simplistic, novel design for mass manufacturing
- Build giga factories inspired by battery technology

Easy Deployment

- StackDAC approach for quickest, most efficient, cost-effective and safe deployment
- No solvents, no liquids, no heat (ambient temp.)

Quick ramp-up/shutdown

- Operates at a flip of a switch
- Fast response to intermittencies





PATENTED, EFFICIENT ELECTROCHEMICAL TECHNOLOGY

How it works

Two identical electrodes & a selective separator

Humidified air flows on the surface of the cathode

Electric current is applied, triggering an electrochemical reaction

CO2 molecules are transferred selectively from one side of the cell to the other

Pure CO2 gas at 98%+ purity is drawn out while depleted air goes back into the atmosphere

BINDING OH-CO2

AIR IN



RepAir

Capture capacity: 50 - 70 tons of CO2 per year

Number of cells: 200 - 300

Cell active area: 0.8 - 1.2 m2

Cell hardware material: recycled polymers

Dimensions: 2.8m x 1.4m x 1.4m for a 300 cell stack





ESTABLISHING MASS PRODUCTION CAPABILITIES WHILE LEVERAGING EXISTING, SCALED TECHNOLOGIES

Cell architecture inspired by alkaline exchange membrane fuel cells

Nickel electrodes already commercialized at the giga scale (battery industry)

Widely used plastic injection molding for cell hardware





FIELD PILOT - TRL 6 VALIDATED TECHNOLOGY



GLOBAL COMMERCIAL GROWTH



Repurposed Saline Aquifer Storage \rightarrow 3Mtpa Kavala, Greece ENEARTH

• Mineralization Storage \rightarrow 20-50ktpa

RAISED BUILT GRANTED **\$12M** TRL6 **\$2M & 5 Patents**

AWARD WINNING JOURNEY











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RepAir

REPAIR'S CO-FOUNDERS: SAVVY & SEASONED EXECUTIVES



CEO & CO-FOUNDER

Amir Shiner

A leader with over 25 years of executive industry experience leading companies through diverse growth stages and driving the commercialization of innovative technological solutions.





CHAIR & CO-FOUNDER

Yehuda Borenstein

A serial entrepreneur specializing in climate technology, and an experienced leader with extensive expertise in establishing and scaling technology ventures.



CTO & CO-FOUNDER

Ben Achrai PhD

A PhD in Chemistry & Material Science from the the Weizmann Institute and over 10 years experience focused on advancing electrochemical systems, including extensive involvement in project management.



CO-FOUNDER

Prof. Yushan Yan PhD

Professor at the Henry Belin Du Pont of Chemical & Biomolecular Engineering - Univ. of Delaware. Director at the Center for Clean Hydrogen, furthering research and innovation in sustainable energy.

REPAIR'S TEAM: A TRACK RECORD OF EXECUTION



HEAD OF STRATEGY

Jean-Philippe Hiegel

Over 15 years of experience in upstream O&G industry, including large-scale project development, operations and 7 years heading business development units in Carbon Capture and Storage projects. MEng degree in Electrical Engineering and MSc degree in Energy Economics.



HEAD OF MARKETING

Debra Emanuel

Over 20 years of marketing experience across a spectrum of innovative technologies, spanning from dynamic startups to firmly established companies.



HEAD OF ENGINEERING

Asaf Asherov

Over 15 years of industry expertise spanning R&D, multidisciplinary product development, engineering, project management, and leadership roles within teams. Holds a BSc in Mechanical Engineering.



MATERIALS TEAM LEAD

Naama Gluz PhD

PhD in Chemistry from the Technion – Israel Institute of Technology. Nearly 10 years of industry experience in developing electrochemical products and processes.



R&D TEAM LEADER

Shaked Rosenne, PhD

PhD in Chemistry from the Weizmann Institute and nearly 10 years of experience in R&D of batteries and other electrochemical systems.



UNIQUELY POSITIONED TO REACH THE MEGATON SCALE



*Schematic representation of a DAC Facility at 100 ktpa

Thank you!

Amir Shiner, Co-Founder & CEO, amir@repair-carbon.com Jean-Philippe Hiegel, Head of Strategy & Growth, jp@repair-carbon.com

RepAir

LanzaTech Nasdag: LNZA

MINDAC Kickoff meeting DATE

John Holladay Government Programs

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LANZATECH CAPTURES & TRANSFORMS CARBON

Background and Summary

LanzaTech's role in MINDAC

- In MINDAC LanzaTech is a utilizer of CO₂
- The LanzaFlex[™] biomanufacturing process converts CO₂ into ethanol using a proprietary organism and reactor system.
- CarbonSmart[™] ethanol is a building block for high value sustainable materials and fuels.
- Recycling CO₂ displaces the need for fossil carbon allowing it to stay in the ground.

The Science Behind LanzaTech

How the LanzaFlex[™] process works

- The LanzaFlex[™] biomanufacturing process converts CO₂ into ethanol using a proprietary organism and reactor system (next slide).
- Since CO_2 doesn't contain energy, low carbon intensity hydrogen such as green H_2 —is used to provide energy to the organism.
- The process operates under mild conditions.
- The process is continuous and robust.

A NOVEL CIRCULAR SOLUTION, RECYCLING WASTE CARBON INTO VALUABLE PRODUCTS



Advantages

LanzaTech biomanufacturing creates value from CO₂

- Using gas fermentation to recycle CO₂ adds value in two ways.
- CarbonSmart[™] products create a revenue stream.
 - Meeting a growing demand for sustainable products.
- Fossil carbon stays in the ground.
 - Production of fossil ethylene is GHG intensive.



Being CarbonSmart™



¹ LanzaTech management, ² Per Grand View Research (2019), Allied Market Research (2018), The Business Research Company (2019), Technavio (2019), Fortune Business insights (2019) and Knowledge Sourcing Intelligence (2020).

LanzaTech

In a CarbonSmart[™] world, carbon waste is transformed to nearly everything we use in our daily lives

LanzaTech generates profitable ROIs for partners, accelerating adoption of CarbonSmart[™]

Products with CarbonSmart™

\$1T Addressable Market²

Potential for >1 billion tons/year of product from waste feedstocks

13

https://ir.lanzatech.com/static-files/21eb4d1f-3e47-4224-9957-03bfb658aeab

- Green hydrogen is an emerging field.
- CarbonSmart[™] products have a green premium.
- Policy for products is not developed in the way it is for fuels.

RECYCLE CARBON WITH BIOLOGY

ADDITIONAL PARTNERS

Paula M. Trienens Institute for Sustainability and Energy

Argonne

Northwestern SUSTAINABILITY AND ENERGY

Siemens

Northwestern SUSTAINABILITY AND ENERGY

Comments about 3M's role in MINDAC

- Authors: Sumeet Thete, Ruth Schlitz
- Team: Kevin Eberman, Howard Creel

July 3, 2024

Topic: Background on the technology and the scientific/technical merit of the project

- 1. 3M's role in Midwest Nuclear Powered Direct Air Capture (MINDAC) hub is that of a consultant to validate the Techno-economic analysis and scale-up plans
- 2. Given 3M's history of work in Direct Air Capture (DAC) space [3M and Svante announce joint development agreement to **develop and produce carbon dioxide removal products** May 16, 2023], 3M team will assist in the evaluation of different technologies brought to the table by other MINDAC partners
 - a. 3M has a prior experience as a global manufacturer in air filtration and carbon capture space
 - b. 3M has also experience with supply-chain requirements of large chemical plants
 - c. The PI from 3M has a prior experience working with large chemical plants
 - d. All these skillsets will be utilized to evaluate the new technologies
- 3. The evaluation method will be objective and will use metrics focused on the comparison of economics of the technologies involved and the ease of technology scale up for different technologies presented in the MINDAC hub
 - a. 3M team will model the economics and scaling up for different technologies using experience mentioned in point 2 above
- 4. At the end of the objective evaluation, 3M will submit the recommendations to the PI from Northwestern University

Topic: Describe fundamental science driving the technology (chemistry, thermodynamics, etc.)

- 3M researchers have developed advanced modeling tools that can simulate the behavior of CO2 capture processes not only at micro-scale (at adsorbent particle scale of 1 to 100 micron) but also at macro-scale (over several meters) that allows us to predict how adsorbent particles will behave in a large chemical process plant
- 2. 3M has successfully leveraged these computational toolkits including certain commercial packages such as Aspen and certain internal tools, for product development purposes across respiratory protection portfolio as well as internal processing and manufacturing facilities
- 3. As a part of MINDAC team, 3M researchers will appropriately revise these rigorous models to account for new assumptions from new technologies and use the results of the model to objectively evaluate diverse set of technologies being brought to the table by other MINDAC partners

Topic: Describe how the technology is envisioned to work in operation, including a simple schematic labeled with preferred operating pressures and temperatures, and any other requirements

and

Topic: List and briefly describe the technical and/or economic advantages this technology has for new and existing target markets.

- 1. As a consultant, 3M is not advocating for any given technology or a method of operation
- 2. 3M modeling capabilities are uniquely developed to analyze the micro as well as macro scale CO2 capture dynamics thus assisting the manufacturing scale up for sorbent materials specifically for DAC technologies
- 3. Since the goal of MINDAC is to eventually put together a proposal for a technology that can be scaled up and is economically viable, 3M with its tools is uniquely positioned to objectively evaluate different MINDAC technologies

Topic: List and briefly describe the technical and economic challenges of applying the technology to existing markets

- 3M modeling capabilities have been used before to analyze the adsorption kinematics and hydrodynamics for DAC technologies, but these tools have not been used for electrochemical approaches or CO2 sequestration or in exploration of CO2 to chemicals pathways
- 2. 3M modeling tools in these areas will need to be adapted from their original purposes

Constellation

Northwestern SUSTAINABILITY AND ENERGY

Introductory Summary

July 2024

Executive Summary

Highly Unique Fund

- + The <u>only</u> early-stage VC fund focused on the resilience, sustainability and digital transformation of the natural gas industry
- + Established the category defining thesis of Green Molecules[™] capturing the decarbonization, sustainability and digitization of natural gas value chain
- + Customized engagement and deep integration with corporate Limited Partners to deliver strategic value and outsized financial returns
- + Authentic focus on Green Molecules[™] makes ECV the partner of choice for entrepreneurs innovating in the natural gas value chain

Strategic Value

- + Set the innovation agenda for the natural gas industry
- + Direct the narrative on Green Molecules™ and the future of the industry
- + Influence start-up company development
- + Gain proprietary access to pilots and early partnerships
- + Enhance sustainability and investor relations synergies
- + Evaluated over 2,300 Green Molecules[™] companies, completed and presented numerous deep dives with curated exposure to 100s of companies
- + Acquire outsourced/ off-balance sheet R&D capabilities
- + Mitigate operational and third-party risk through due diligence and insights
- + Leverage ECV fintech and insurtech expertise, synergies safety, climate, IoT, cybersecurity, lending/credit, billing/collecting, insurance, warranty, etc.
- + Attend private forums to collaborate with peers for knowledge sharing on critical industry issues

LP Engagement

- + Quarterly, in-person "deep dives" of key industry trends and Green Molecules™ technologies with proprietary analysis and exceptional insights
- + Annual ECV Summit with hundreds of key industry participants, exciting panels and key notes. Separate LP-only discussions, reporting and reception.
- + Industry event gatherings (AGA, CERA Week, Rice Alliance, Utility Week, etc.)
- + Forum and opportunities to socialize with other natural gas leaders and industry stakeholders, including in-person roundtable discussions
- + Personal attention to individual LP strategic priorities

Fund I

- + Final closing July 2022, \$61M from 7 publicly traded utilities and 1 UHNW
- + Seed+ / Series A lead investor, \$2M to \$5M initial investment with reserve for follow-on dependent on entry stage and company performance
- + LP co-invest opportunities and later stage pro rata syndication
- Investment geography: 70% North America, up to 30% International
- + Led or co-led 8 investments in Green Molecules™ companies as of March 2024
- + Current portfolio of early-stage technology companies tracking well
- + 10-year fund life, plus optional extensions
- 2% management fee, 20% carried interest

Fund II

- + Same strategy and structure as Fund I, the Green Molecules™ venture fund
- + Intent to add 3-5 new LPs to preserve customized/ customer-centric service model
- + \$100M fund target
- Larger capital base to exploit enormous market opportunity and enhance portfolio economics
- \$40M closed Apr 2024 with 3 existing investors, including 2 increasing their commitment by 50% from Fund I

Track Record & Experience

- ← 55.3% IRR (gross) average, 9.3x MOIC for Managing Partner Vic Pascucci III (as of October 2023)
- ▶ 30+ combined years of venture capital experience, including 15+ investing on behalf of Corporations
- + Strong track record of delivering strategic value and financial returns
- + 70+ combined years of leading investment banking experience in the energy sector, \$100B+ in transactional strategic advisory work
- + Prestigious advisory board senior utility executives, experienced regulators, R&D/ technical leaders, private equity management, entrepreneurs and global head of energy consulting practice

Current Professional Service Providers

- + Legal: Reitler Kailas & Rosenblatt LLC; *Edward Reitler and Nate Richman*
- + Tax and Audit: Plante Moran; *Brad Walters, Ken Buczkowski*
- + Fund Administration and Accounting: Standish Management; *Derek Woznicki*

ENERGY CAPITAL VENTURES[®]

Experienced Team, Dedicated to Green Molecules™

55.3% IRR, 9.3x MOIC VC Track Record*, 70+ Years of Investment Banking Experience, Prestigious Advisory Board

FCV Team

VIC PASCUCCI MANAGING GENERAL PARTNER 10+ YEARS OF STRATEGIC CORPORATE VENTURE CAPITAL + Managing Partner, Lightbank VC

+ Head USAA Ventures/ Corp Dev + Strategy/ Transformation

RICK VITON

GENERAL PARTNER

10+ YEARS IA CAPITAL

STRATEGIC INVESTING & 30+

YEARS ADVISORY

+ Hispanic diversity initiatives

and Hispanic market

Partner, IA Capital

+ MD. Credit Suisse

MD. Ramirez

specialist

- Lead + General Counsel
- + Director, Munich Re Ventures

JEFF YINGLING GENERAL PARTNER 35+ YEARS LEADING POWER/ ENERGY INVESTMENT BANKER + Head of Midwest Investment Banking, JP Morgan

- + MD, Morgan Stanley, Power & Utilities
- + Sr Advisor, Guggenheim Securities

RAY O'CONNOR GENERAL PARTNER **30+ YEARS INVESTMENT** BANKING IN POWER, UTILITY

- + MD, Ramirez
- + VP. JP Morgan Chase
- + VP. Banc of America Securities

SECTOR

+ Board Member Advisory Council, ISEN

STEFANO GALIASSO VICE PRESIDENT **10 YEARS OF ENERGY** ENGINEERING EXPERIENCE

- + Associate, New Stack Ventures, George Shultz Innovation Fund + Principal Engineer, ERC
- + MBA University of Chicago (Booth); MS Mechanical Eng., Politecnico di Torino

JULIE GRECO SENIOR ASSOCIATE CORPORATE STRATEGY AND UTILITY EXPERIENCE + Corporate Strategy Associate,

- SUEZ Water + Performance and Strategy
 - Lead
 - + Head of North America Sustainability Program
- + MBA in Sustainability Management

Strategic Advisors

Paul Addison, former Board Member and Finance Committee, First Energy Corp David Carroll, former President & CEO, Gas Technology Institute (GTI); former President, International Gas Union Paul Dabbar, former Undersecretary for Science, Department of Energy; CEO, Bohr Quantum Computing Nelson Diaz, former Member of the Board of Directors, Exelon its operating company, PECO Stuart Frankel, former CEO, Narrative Science (acquired by Salesforce) Gary Gardner, former Vice President, Corporate Affairs, Secretary, American Gas Association Rod Goldstein, former Chairman and Managing Partner, Frontenac Chris Gould, EVP & Chief Sustainability Officer, California Resources Corporation Joe Hamrock, former President & CEO, NiSource Brad Henderson, Chief Executive Officer, P33 Chicago; Board Member, Nicor Gas **Mike Huebsch**, former Commissioner, Wisconsin PUC and former State of Wisconsin, State Representative Rich Kinzley, former CFO, Black Hills Energy Phil Lembo, former CFO, Eversource Andy Lerner, Founder and Managing Partner, IA Capital Allen Leverett, former CEO, WEC Energy Group Margaret MacLean, former President, International, MacLean Power Systems Samuel A. Ramirez Jr, President & CEO, Ramirez Asset Management Bill Rogers, former EVP & CFO, CenterPoint Energy Bob Rowe, former CEO, Northwestern Energy Timothy Simon, former Chairperson NARUC Gas Committee, Chair LNG NARUC/DOE partnership Tony Somma, former SVP, CFO and Treasurer at Westar Energy, Former ECV and CFO at Evergy Steve Trauber, Chairman and Global Head of Energy and Clean Technology, Moelis Jan Vrins, former Managing Director/ Global Energy Practice Leader, Guidehouse Mahvash Yazdi, former SVP and Chief Information Officer, Edison International & So. California Edison

ENERGY CAPITAL VENTURES

Strategic Value

ENERGY CAPITAL VENTURES[®]

Dedicated to LP Engagement

Access to Innovation	 + 2,300+ Green Molecules[™] companies screened + Investor-only digital access to proprietary deal flow database + More than 250 initial due diligence efforts on promising companies + More than 50 extensive due diligence efforts + 50+ introductions made for pilot and commercial relationships as of February 2024
Insights Provided	 ↓ Quarterly Deep Dives on Green Molecules[™] technologies with comprehensive technology market map ↓ Customized assessments particular to LP strategic priorities ↓ Market trend analyses ↓ Disruptive technology spotlights including proprietary ECV insights ↓ Enabling capabilities research ↓ Access to international innovation and global utility practices
Exposure to New Technology	 + Hydrogen, Renewable Natural Gas, e-Methane, synthetic methane, methane leak detection, carbon capture / sequestration / utilization, differentiated natural gas procurement, predictive maintenance, augmented / virtual reality, gas heat pumps, climate risk forecasting, capital planning for sustainability, gas separation + Fund II portfolio size to be determined by final fund size. + Anticipated 10 - 15 portfolio investments in Green Molecules[™] for \$100M AUM.
Partner "Influence"	 ◆ Strategic input on key endeavors in the technology ecosystem and portfolio ◆ ECV Board of Directors representation ◆ LP co-invest opportunities into Green Molecules[™] portfolio companies
ECV Meetings & Events	 Annual ECV Summit, including LP-only updates, reporting and reception Demo days of innovative technology companies Industry event receptions Investor-only roundtable discussions, private forums to collaborate with peers and stakeholders In person meetings coordinated to LP-specific availability

Strategic Value

Strong Engagement with our LPs

LP-only event with industry speakers

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 Grid view ALL Grid view Avista 	721	Loam Bio	https://www.loambio.com/	Loam Bio is developing tech that allows for crops to be inoculated with symbiotic micro-organisms that capture CO2 in the roots of agricultural crops	Request More Information	ESG - Carbon Capture	Biotechnology	2019 0
Grid view Black Hills Energy Hydrogen for Black Hills Energy RNG for Black Hills Energy	722	Locbit	ww.locbit.com	Developer of a platform to unify connected devices in buildings and analyze decision making. Locbit provides the platform to automatically adjust building appliance and energy usage bas	Request More Information	DT - IoT DT - Automation	Software	2012 5
Grid view NiSource Grid view Spire Grid view SW Gas	723	Loci Controls	httes://www.locicontrols.com L	Loci Controls develops wireless sensor and actor network devices for optimizing the extraction of methane from landfills.	Request More Information	ESG - RNG ESG - Methane Capture DT - IoT	Sensor	2012 F
Automation / ML Hydrogen Methane Leak Detection	724	longpathtech.com	longpathtech.com	LongPath Technologies is an methane leak monitoring service company that provides laser- based natural gas infrastructure monitoring systems optimized for stationary applications	Request More Information	ESG - Methane Detection	Deep Tech	2017 E
Carbon Offset ESG Accounting	725	Lotic Labs	httes://loticlabs.com/	Financial services platform designed to understand climate risk and cash flow variation for water utilities	Request More Information	DT - Climate	Data Water	2016 0
Climate Data Carbon Capture Water	726	LuxWall Inc.	https://www.lue-wall.com/	Manufacturer of vacuum-insulated glass designed to improve the energy efficiency of buildings. The company's ptoduct prevents thermal pass- through thereby reducing the energy demand of	Request More Information	(ESG - Energy Ethiciency)	Hardware	2020
🗄 Data 🖽 RNG 🔁 Form	727	Lydian Labs	https://greentcomlabs.com/ members/lydian-labs/	Lydian Labs aims to accelerate the decarbonization of the chemical industry by electrifying the chemical production process through printed catalyst technology	Request More Information	(ESG - Sustainability)	Deep Tech	2021 5
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LP-only access to ECV pipeline

2023 Engagement Metrics

1600+	150+	55+
Total LP Interactions	Hours in LP Meetings	LP Meetings (Zooms & In-person)
93	31	10
Technology Spotlights	New Capabilities Exposed	Market Research Reports
30+	50+	18
Pilot / Commercial Engagements with ECV Network	Introductions Made to Startups	Public Speaking Engagements

Innovation and Investment Areas

July 24

Sustainability, Resilience & Digital Transformation

Methane Leak Detection	Climate Technology	Fintech / Insurtech Convergence	Low-Carbon Molecules	Carbon Management	Workforce	Process Automation	Energy Efficiency
Satellite Imagery & Analytics Plane & UAV Sensors Vehicular Sensors Continuous fixed sensors Fiber Optic Cables	Climate Risk Modeling Weather Forecasting Climate Data Gas Demand Forecasting Price Hedging Tools	ESG Accounting Carbon Offset Marketplaces Carbon Offset Insurance Cybersecurity Utility/ Industry of the Future	Methane Pyrolysis Hydrogen RNG Low CI / Synthetic Fuels Power to Gas Gas Sensing	Point Source Carbon Capture Carbon Utilization Carbon Storage Carbon Offsets Carbon Marketplace Sequestration	Workforce Safety Employee Engagement Injury Prevention Supply Chain Route Optimization Field Operations	Decision Analytics Customer Engagement Machine Learning Digital Twins O&M Tools Robotics	Gas Heat Pumps Energy Management Software + Sensors HVAC Improvements Demand Side Management
		Demo	onstrative Start-up	Companies, Sample	e Set*		
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ENERGY CAPITAL VENTURES[®]

ECV Fund I Portfolio

Rewriting the narrative of natural gas

CEMVITA	O S I <mark>A O S E S</mark>	O ACTUAL	FUCNO
Investment Thesis: Synthetic biology will create the next generation of carbon negative fuels and materials across multiple industries for a net-zero future.	Investment Thesis: Gas separations will become critical to meet customer needs in a future where the gas industry blends molecules to achieve sustainability targets. Membranes simplicity and cost-effectiveness makes them prime candidates to capture this market.	Investment Thesis: Corporations need technology purpose-built for enterprise transformation which integrates all sustainability efforts and stakeholders. Existing ERP solutions and management consulting services are ineffective at enterprise transformation.	Investment Thesis: New forms of ultra-efficient, modular reactors will be required to decarbonize the commodities industries. Industry adoption requires cost effective solutions. Built-world technologies present great opportunities for Green Molecules [™] .
Green Molecules [™] Use Case: Cemvita can produce both biomethane (RNG), bio-hydrogen as well as biofuels such as SAF. Cemvita's bio-methanation process converts CO2 and water into Renewable Natural Gas (RNG), using CO2 or waste biomass as a feedstock while increasing the availability of RNG beyond existing biosolid resources. The CO2 can be taken directly from a flue stack.	Green Molecules [™] Use Case: Osmoses is developing several gas separations critical to the sustainability goals of natural gas: their membranes make biogas upgrading 40-60% cheaper, can be used for upstream natural gas conditioning, for separation of hydrogen blended in gas pipelines, and even point source carbon capture.	Green Molecules [™] Use Case: Actual enables enterprises to plan large-scale sustainability projects across business units, roles, time scales and sustainability topics, within the constraints of regulations and climate-related rules and incentives Pilot project for state-level utility regulations and IRA incentives.	Green Molecules [™] Use Case: Furno is developing a modular, small scale cement kiln that uses natural gas (distribution pipe) instead of coal to decarbonize cement. The kiln maintains and improves the cement cost-effectiveness through a dramatically more efficient production process. Furno can displace large, centralized cement manufacturers similar to how minimills displaced the large, centralized steel manufacturers.
	Vertus energy.	GOLD H2	
Investment Thesis: The gas industry needs practical, cost-effective solutions to address its Scope 1 and Scope 2 emissions. The best applications will leverage existing assets at scale.	Vertus energy.	Investment Thesis: Geologic hydrogen will be the lowest cost hydrogen available, by leveraging existing gas infrastructure to deliver high volume, low carbon hydrogen to large energy users.	Investment Thesis: The natural gas industry needs a software solution to manage methane emissions, whose mitigation is an urgent priority across the value chain. Expertise and thought leadership are key differentiators in the early days of emission management.

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TotalEnergies

Northwestern SUSTAINABILITY AND ENERGY

PROJECT OBJECTIVES

Paula M. Trienens Institute for Sustainability and Energy

Objective

Explore the feasibility of a nuclear-powered DAC hub in the Midwest and develop an ownership structure and business model.

Evaluate, and develop a model for how we can integrate the efforts of: (1) capture technology solutions providers, including for the frontend (e.g. contacting), concentrated point source CO₂ release, and water/humidity management; (2) access to CO₂ pipelines and to eventual sequestration sites; (3) storage/utilization technology providers; (4) expertise in DAC site assessment and development; (5) expertise in scaling/manufacturing at scale; (6) financing providers (including parties equipped to monetize carbon credits); and (7) partners bringing experience in community, labor, and diversity, equity, and inclusion (DEI) engagement.

Achieving our objective will address challenges

- Technology and Markets
 - Core unit life time
 - Electrode manufacture and stack assembly in the short term
 - Long-term scale up and global supply chain
 - Cost of key inputs (green H2)
 - Green premium effect
 - Costs of key materials
- Site Feasibility
- Scale up and financial viability

PROJECT PLAN AND SCOPE

Paula M. Trienens Institute for Sustainability and Energy

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C Part of continuation report

Milestones

M1. [12/17/2024]: Submit Continuation Application that includes the following elements:

- Description of the selected DAC Hub owner and team, site location, CO₂ transport routes, CO₂ storage sites, and CO₂ conversion technologies (if applicable) for the pre-FEED study to be completed in Phase 0b.
- Discuss the current status of the CO₂ storage site(s), including development, characterization, and permitting activities conducted to date.
- Discuss the current status of, and plans for submitting, the UIC Class VI permit to construct application. Recipients must provide an initial design for the DAC Hub BOP.
- Selection of the anchoring DAC technology(ies) (i.e., minimum capacity of at least 50,000 tonnes CO₂ captured from the atmosphere (50 KTA)) for the pre-FEED study to be completed in Phase 0b.
- Conceptual design for the initial DAC Hub capacity (minimum 50 KTA CO₂) integrated with required CO₂ storage and/or CO₂ conversion (if applicable).
- If applicable, selection of the CO₂ conversion technology(ies) for the pre-FEED study to be completed in Phase 0b.
- Data tables with preliminary estimates for the DAC Hub, and the selected DAC and CO₂ conversion (if applicable) technologies.
- Description of safety culture, discussion of security considerations, a permitting workflow overview.
- DAC and CO₂ conversion (if applicable) Technology Maturation Plan(s)
- Preliminary Life Cycle Analysis
- CBP Development Proposal (CBPDP)
- Budget and supporting justification for Phase Ob
- Description of plans for Phase Ob

M2. [4/30/2026]: Submit final data table for each technology in the hub along with the overall hub.

Deliverables Table from SOPO

Deliverables Table

Deliverable	In Task	Due
Project Management Plan	1.1	5/31/24
Presentation to NETL manager upon kickoff	1.0	7/30/24
Continuation report	1.0	12/17/24
Technology Maturation Plan	1.4	12/17/24
CBP Development Proposal	1.5	12/17/24
Preliminary LCA	10	12/17/24
Business Plan	1.2	1/30/26
Financial Plan	1.3	1/30/26
Final Technology Maturation Plan	1.4	1/30/26
Community Benefits Plan	1.5	1/30/26
Integrated DAC pre-FEED	14	1/30/26
Life Cycle Assessment Results	15	1/30/26
DAC Hub BOP Conceptual Design	13	1/30/26
EHS Risk Analysis	16	1/30/26
Integrated Project Schedule	18	1/30/26
Storage Field Devel Plan	17	1/30/26
Pre-FEED Study	14	1/30/26
DAC Hub Data Tables	6.14	4/30/26

All plans will follow specifications from the FOA and Statement of Project Objectives.

Appendices of SOPO include requirements for each plan (e.g., business plan)

Updated template for Community Benefits plan received from DOE to replace CBPDP and CBP.

We will treat CBPDP as a preliminary draft of the final CBP using the template.

PROJECT BUDGET

Paula M. Trienens Institute for Sustainability and Energy

Project Budget

Total Project Budget: \$3,829,387

	Federal Budget	Cost Share
Budget Period 1: <i>May 2024 - Jan 2025</i>	\$1,098,165	\$309 <i>,</i> 658
Budget Period 2: Feb 2025 – April 2026	\$1,871,312	\$550,252
Total Project	\$2,969,477	\$859,910

FUTURE PLANS

Paula M. Trienens Institute for Sustainability and Energy

Forward Thinking

Phase 0 is centered on forward thinking about strategic design of the hub.

In particular, Task 2 emphasizes forming the DAC hub concept including the hub owner and team.

As we progress with our assessment of hub feasibility, our thinking and strategy will continue to evolve.

Northwestern PAULA M. TRIENENS INSTITUTE FOR SUSTAINABILITY AND ENERGY