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Final Scientific/Technical Report

School of Chemical & Biomolecular Engineering
Georgia Institute of Technology

Final Scientific/Technical Report

Wind-Driven Direct Air Capture System Using 3D Printed, Passive, Amine-Loaded Contactors (WEDAC)

DE-AR0001414

Award:	[DE-AR0001414]
Lead Recipient:	School of Chemical & Biomolecular Engineering, Georgia Institute of Technology
Project Title:	Wind-Driven Direct Air Capture System Using 3D Printed, Passive, Amine-Loaded Contactors (WEDAC)
Program Director:	[Dr. Jungho Kim]
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Contract Administrator:	[Ivey Bell]
Date of Report:	[07/30/2025] Updated: 09/29/2025
Reporting Period:	[05/01/2021 – 03/31/2025]

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Public Executive Summary

This project advanced the development of a novel wind-driven direct air capture (WEDAC) system for removing carbon dioxide (CO_2) from the atmosphere. Our research focused on combining passive air contact with electrothermal desorption using specially designed carbon fiber modules, aiming to provide a scalable, low-cost, and energy-efficient alternative to conventional carbon capture systems.

The work conducted during the funding period contributes to a broader understanding of materials chemistry, contactor design, and energy management in direct air capture (DAC) systems. We successfully developed and optimized a poly(ethylene imine) (PEI)-impregnated sorbent material and investigated a modified PEI with a controlled heat of adsorption (-65 to -70 kJ/mol), which is believed to enable more efficient CO_2 separation. When applied to carbon fiber supports, the sorbent demonstrated enhanced CO_2 uptake and rapid regeneration via Joule heating. A roll-to-roll coating method was established for scalable production, with improvements in coating symmetry and optimization of the coating thickness realized.

To enhance system performance, computational modeling and wind tunnel testing were conducted to optimize airflow and temperature uniformity within the contactor. Computational fluid dynamics (CFD) simulations were used to evaluate module designs with varying fiber densities, arrangements, and mechanical support structures. The analysis indicated that fiber densities between 10–15%, combined with central support structures smaller than 0.02 m in a 0.05 m diameter contactor, provided acceptable velocity distributions around each contactor fiber.

Experimental results confirmed that rapid heating and high-purity CO_2 output (over 95%) can be achieved using vacuum-assisted electrothermal desorption (ETSA) with a breakthrough system. A lab-scale prototype was built and tested under ambient air conditions, demonstrating stable performance over multiple capture and release cycles. This prototype was used to quantify CO_2 capture capacity and cycle time, enabling evaluation of various sorbent coating thicknesses to determine the maximum daily CO_2 capture capacity based on measured cycle times and per-cycle capture amounts. The system's peak daily capture capacity reached up to 990 moles CO_2 produced per cubic meter of contactor volume.

In addition, energy consumption was optimized by reducing heat dissipation during the adsorption process through faster heating rates, resulting in a minimum experimentally measured value of 15 GJ tCO_2^{-1} captured. Further reductions may be possible through optimization of sorbent composition (e.g., PEI loading) and control of moisture during adsorption and desorption.

A large-scale prototype module was designed and constructed during the second phase of the funding, capable of housing 700 fibers, each 14 inches in length. This automatable prototype has been installed in the Carbon Neutral Energy Solutions (CNES) building at Georgia Tech in Atlanta. A techno-economic analysis (TEA) was conducted based on experimentally obtained parameters. Although the current levelized cost of CO_2 capture (LCOC) was estimated at \$231.8 tCO_2^{-1}, further improvements in sorbent stability, cycle time, and contactor design are expected to reduce the cost to around \$191.0 tCO_2^{-1}, approaching long-term cost targets for carbon removal technologies. This project demonstrates the technical viability of an energy-efficient, modular

carbon capture system powered by wind. With continued optimization and commercial partnerships now in place, the WEDAC platform has the potential to scale direct air capture technologies for global deployment.

Acknowledgements

We gratefully acknowledge the support of ARPA-E for funding this work, and we thank Won Hee Lee, Inyoung Jang, Raymond Warner, Xin Zhang, Seo-Yul Kim, Sayan Banerjee, Johnathan W. Bargsten, Shivani Potdar, Agustina Rivata, Matthew J. Realff, and Christopher W. Jones for their valuable contributions to this project.

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Accomplishments and Objectives

The project focused on developing a pre-pilot prototype module of the wind-energy-driven direct air capture (WEDAC) system, based on lab-scale analysis and module design. Its potential for commercialization was further supported by a techno-economic analysis using reliable and more realistic values obtained from the lab-scale studies.

A number of tasks and milestones were laid out in Attachment 3, the Technical Milestones and Deliverables, at the beginning of the project. The actual performance against the stated milestones is summarized here:

Table 1. Key Milestones and Deliverables.

Tasks	Milestones and Deliverables
1.1 Optimized sorbent finalized	**Milestone detail:** Sorbent developed with sorption enthalpy of -65 kJ/mol and projected working capacity and capital cost at scale consistent with \$100/t CO_2 removed—these values reported to ARPA-E. **Actual Performance: (Completed: 07/31/22)** A sorbent synthesized by substituting 10 mol% nitrogen-functionalized epoxy into PEI impregnated in SBA-15 exhibited a CO_2 uptake capacity of 0.8 mmol/g, compared to approximately 1.2 mmol/g for unmodified PEI. Although this represents a 33% reduction in uptake, the heat of adsorption was lowered to –65 to –70 kJ/mol, a range hypothesized to offer optimal separation efficiency in DAC systems. For the development of sorbent-coated carbon fibers, PEI-impregnated CA/C803 sorbent material was used, and an optimal PEI loading of 10 wt% was identified, achieving the highest CO_2 uptake of 1.84 $mmol/g_{(sorbent)}$ compared to both 5 wt% and 20 wt% loadings.
1.2 Sorbent scale up	**Milestone detail:** 20 g of sorbent identified in M1.1 synthesized for integration into the contactor. **Actual Performance: (Completed: 07/31/22)** A roll-to-roll sorbent dip-coating procedure has been developed and demonstrated for the mass production of sorbent-coated carbon fiber. Various coating speeds were tested, and 200 mm min^{-1} speeds resulted in a more uniform and consistent coating layer. More than 20 g of the sorbent was synthesized.
2.1 Resistive heater specs defined	**Milestone detail:** Define optimal carbon material for resistive heating, as well as loading and maximum contactor height. **Actual Performance: (Completed: 10/31/22)** During Q4–Q6, temperature uniformity was improved by incorporating aluminum electrodes into 3D-printed monoliths and using carbon fibers as Joule heating materials. After Q5, carbon fiber was selected as the sorbent support due to its rapid heating and consistent temperature profiles, which enabled efficient CO_2 regeneration. A bundle of six 22.5 cm carbon fibers exhibited a steep temperature rise, reaching the CO_2

Tasks	Milestones and Deliverables
	regeneration range of 90–110 °C within 60 seconds when 7 V was applied.
2.2 Optimized contactor fabricated	**Milestone detail:** Contactor fabricated with wind speed ratio (ratio of wind speed external to system to speed of air in a channel) of 0.15 and geometric surface area > 5,000 m^2/m^3 **Actual Performance: (Completed: 10/31/22)** In Q5-Q6, the porosity and CO_2 adsorption capacity of SiC-based structures were improved using nano-sized powders, and sorbent-coated carbon fiber modules were developed, demonstrating enhanced CO_2 uptake and uniform Joule heating. In Q7, the first-generation WEDAC prototype was designed and tested, resolving sealing issues and yielding key performance data through extended adsorption/desorption cycling and CFD-assisted design validation. Wind speed ratios in excess of 0.15 were observed.
3.1 CO2 purity established	Demonstrate 95% CO_2 purity in the outlet stream using synthetic air with 400 ppm CO_2. **Actual Performance: (Completed: 1/31/23)** Vacuum-assisted electrothermal desorption was conducted by applying a brief vacuum followed by Joule heating, with argon used as a sweep gas to enable accurate measurement of CO_2 and H_2O desorption kinetics via mass spectrometry. The results demonstrated that over 95% of the sorbed CO_2 could be rapidly regenerated at high purity using the ETSA process, with minimal heat loss observed at the module surface, and the scaled-up DAC system is expected to operate using weak vacuum instead of argon.
3.2 Final prototype performance	**Milestone detail:** Provide 2 weeks of operating data using outdoor air. Target productivity is 1.5 kg CO_2 per kg sorbent per day. Target purity is >95 mol% CO2 using real air. Target energy consumption is < 4 GJe/tonne CO2 (with a maximum of 0.5 GJ/tonne attributable to vacuum). Target < 3% swing capacity loss over 2 week cycling period (to be assessed by high precision sorption isotherm measurement). These targets provide a clear pathway to $100/tonne. **Actual Performance:** (**Completed: 4/30/23**) The prototype WEDAC module was designed over Q5-Q8. The completed module, presented in the Q7 report, demonstrated initial WEDAC testing using fan-driven ambient airflow. The CO_2 purity of the gas collected from the prototype WEDAC module increased to 82% with higher fiber density, and this milestone has been extended to Milestone 8.1 in Phase 2.
4.1 Initial TEA	**Milestone detail:** Use initial estimates of fabrication costs, adsorbent capacity and cycle operation to estimate cost of CO_2 capture. Pathway identified to cost of $100/tonne CO_2 removed.

Tasks	Milestones and Deliverables
	Actual Performance: (Completed: 10/31/22) A TEA model is developed by using the initial estimations of the fabrication costs, vacuum pump's properties, optimal swing capacity and cycle operations. By implementing a fiber temperature-controlled Joule heating input mode in a cylindrical contactor with an insulation coat, the desorption performance was further improved with the Joule heating energy consumption dropped from 11.5 GJ $tCO2^{-1}$ to 7 GJ tCO_2^{-1} in dry conditions.
4.2 Final TEA	**Milestone detail:** Use experimentally determined performance to estimate adsorbent capacity and cycle operation and scaled up fabrication cost to estimate cost of CO_2 capture. **Actual Performance: (Completion date: 12/31/24)** This final TEA milestone has been extended to Milestone 9.1 in Phase 2.
5.1 Initial T2M Plan	**Milestone detail:** Provide a two-page plan that describes what product will be "sold" from the technology developed, and how it will be provided (manufacture and sell, licenses). **Actual Performance: (Completed: 10/31/21)** The initial T2M plan has been completed and submitted. Please find the attached file with the title of "WEDAC - Technology to Market Plan DE-AR0001309-10-31-21"
5.2 IP Analysis	**Milestone detail:** Provide a strategy for developing and protecting project IP and ensuring freedom to operate. Analysis will include survey of prior art and any issues that it may present. **Actual Performance: (Completed: 10/31/21)** The initial IP analysis has been completed and submitted. Please find the attached file with the title of "WEDAC - Technology to Market Plan DE-AR0001309-10-31-21"
5.3 Value Chain Analysis	**Milestone detail:** Identification of the value chain necessary to deliver technology to market. Analysis will identify how advancements made fit into this value chain and the partnerships or supply chain relationships necessary to deliver your solution **Actual Performance: (Completed: 10/31/22)** Demand of carbon fiber for DAC system was estimated by assuming 1% of global CO_2 emission to be captured by DAC system. Carbon fiber manufacturers and costs were reported in Q5-Q6 report.
6.1 Refine tasks, milestones and initial T2M plan	**Milestone detail:** Refine tasks and milestones for the work plan. Develop an initial T2M plan with an emphasis on attracting development partners and tasks needed for technology commercialization. **Actual Performance: (Completed: 9/30/23)** The refinement of tasks and milestones for the work plan has been completed, and the initial T2M plan has also been submitted Please find the attached file with the title of "GTRC Comprehensive Post-Renewal Attachment 3 Clean V2"

Tasks	Milestones and Deliverables
6.2 Fabricate necessary number of fibers for WEDAC modules	**Milestone detail:** Sufficient quantity of fibers will need to be fabricated to create at least two 2” WEDAC modules. We estimate at least 0.5-1 km of fiber will be required. **Actual Performance: (Completed: 09/30/24)** Approximately 0.3 km of fibers were successfully fabricated, resulting in a total of 850 sorbent-coated fibers, each 14 inches in length, which was more than enough to create more than two 2” modules. Photos of the fibers are shown in **Figure 1**. All the fibers are connected with metal components at each end for enabling electric connection with the metal plates.
6.3 Optimize headers for fiber distribution in WEDAC module via modeling	**Milestone detail:** • Use CFD modeling to determine the best performing fiber distribution for scaled-up WEDAC module. • Models correlating module dead volume, wind speed ratios, CO_2 purity, and heating/cooling kinetics will be created. **Actual Performance: (Completion date: 03/31/25)** CFD simulations were created to model the wind flow through the device but without the ability to represent the CO_2 adsorption or desorption because of the model complexity. Design optimization was not carried out. Design evaluation was carried out for different fiber densities, arrangements and with different module mechanical support structures. We found fiber densities between 10-15% with central support structures <0.02m in a 0.05m diameter contactor had acceptable velocity distributions around each contactor fiber.
7.1 Design automated WEDAC module	**Milestone detail:** Mechanical engineering design of simple proof of concept but automated WEDAC module to realize minimum capture requirements. Design includes CAD drawings and initial physical prototyping. **Actual Performance: (Completion date: 09/30/24)** The automated WEDAC module has been designed, with schematic illustrations shown in **Figure 2** and **Figure 3**.
7.2 Fabricate WEDAC modules	**Milestone detail:** • Install fibers into simple proof of concept but automated WEDAC module. Experimentally verify the ability of module to hold vacuum, and open/close without mechanical failure. Check out testing of complete system to confirm integration with larger complete system. • System will be design with improved metrology, including temperature and pressure sensors in the WEDAC device. **Actual Performance: (Completion date: 03/31/25)** The fabrication of the large-scale prototype module is complete, with a remaining minor issue related to vacuum leakage. The complete prototype module has been installed in the Carbon Neutral Solutions Laboratory in Atlanta.

Tasks	Milestones and Deliverables
	(https://research.gatech.edu/energy/cnes) as shown in **Figure 4** and **Figure 5**.
8.1 Performance quantification of an automated WEDAC module in step-by-step experiments	**Milestone detail:** Provide baseline experiments on CO_2 adsorption, air removal, Joule heating and CO_2 collection, cooling, and module opening steps to resolve heat and mass transfer kinetics. **Actual Performance: (Completion date: 09/30/24)** CO_2 quantification, cooling/heating rate analysis, adsorption time, and Joule heating studies were all completed over Q10 to Q14 using small lab-scale testing. The experimental data was used for TEA analysis to evaluate the system's economic performance. As reported, through the optimization of the thickness of the sorbent layer and heating element (carbon fiber), the minimum experimentally measured energy consumption was 15 GJ tCO_2^{-1} with a maximum daily CO_2 capture capacity in the range of 800-990 mol $\mathrm{m}_{\mathrm{system}}^{-3}$ day^{-1}. The calculation was conducted based on the quantified cycle time with controlled adsorption time, and CO_2 capture capacity per cycle and study of heat transfer within the module.
8.2 Cyclic performance quantification of an automated WEDAC module in lab air	**Milestone detail:** Program and operate WEDAC module in continuous cycle within lab environment. Target operation of at least 10 cycles and preferably 100 cycles before moving to outdoor air operation. **Actual Performance: (Completion date: 09/30/24)** Cyclic testing was successfully performed over 10 cycles. When comparing the average CO_2 capture capacity of the first three cycles to the last three cycles, the value dropped by only 6.5%, while the corresponding increase in energy consumption was 4.3%, indicating relatively stable operation. This calculation was based on the quantified cycle time with controlled adsorption duration, the CO_2 capture capacity per cycle, and a study of heat transfer within the module.
9.1 Integrated flowsheet design, performance, and technoeconomic cost estimate including CAPEX	**Milestone detail:** • TEA to include variations in performance at different locations based on weather, electricity pricing. Variation in cycle timing and duration to exploit potential electricity price variation. • Improved CAPEX estimates including system utilization factors etc. will be conducted. • Include additional CO_2 capture costs for cleaning up CO_2 to pipeline quality (as a baseline) and compare to CO_2 capture costs for direct capture and injection. **Actual Performance: (Completion date: 25/03/31)** Through the Techno-economic analysis based on the data acquired from section 8.1 and 8.2, the levelized cost of carbon capture (LCOC) for the WEDAC

Tasks	Milestones and Deliverables
	process was estimated at approximately 231.8 US\$ tCO_2^{-1}. When the WEDAC process is fully powered by wind energy, which has one of the lowest carbon footprints, the estimated LCOC was 245.0 US\$ per ton of net CO_2 captured. the overall energy intensity (EI) is relatively high (16.2 GJ tCO_2^{-1}) due to sorbent degradation and uncontrolled water desorption. The sensible heat required for the sorbent bed (which accounts for 24% of the LCOC) was identified as the primary energy cost driver, highlighting the importance of sorbent and contactor working capacity and long-term stability. Sorbent replacement costs ($OPEX_{ads}$, 16%) and the capital investment for sorbent bed ($CAPEX_{bed}$, 16%) were also significant due to sorbent degradation. Various factors that could increase or decrease the LCOC have been explored. With foreseeable improvements in device performance, such as reducing the contactor cost by 20%, shortening the cycle time by 10 minutes, and increasing the CO_2 working capacity by 20%, the LCOC of the WEDAC process is projected to decrease to approximately 191.0 US\$ tCO_2^{-1}. The impact of the various humidity and temperature conditions was explored through measuring the pseudo-equilibrium CO2 adsorption capacity of the sorbent material, assuming various weather conditions and showed improved CO_2 adsorption capacity of 1.3 mmol g^{-1} which possibly allows the reduction of reduced to below 191.0 US\$ tCO_2^{-1}.
10.1 Identify and coordinate commercial partners for scale-up/-out of WEDAC module and process	**Milestone detail:** Recipes developed in M2.1 and M2.2 will be basis for recruiting spinning partners. Scale of spinning required determined in M5.3. Module designs from Task 3 will be shared with potential partners under NDA. **Actual Performance: (Completion date: 25/01/01)** We have secured a commercial partner to support the development of electrothermal DAC systems.
10.2 Final T2M Plan	**Milestone detail:** Complete final T2M plan based upon results of 5.1 - 5.5 **Actual Performance: (Completion date: 25/03/31)** The final T2M plan has been completed and submitted to the system. Please find the attached file titled “T2M Plan - WEDAC_DE-AR0001414-04-30-25”.

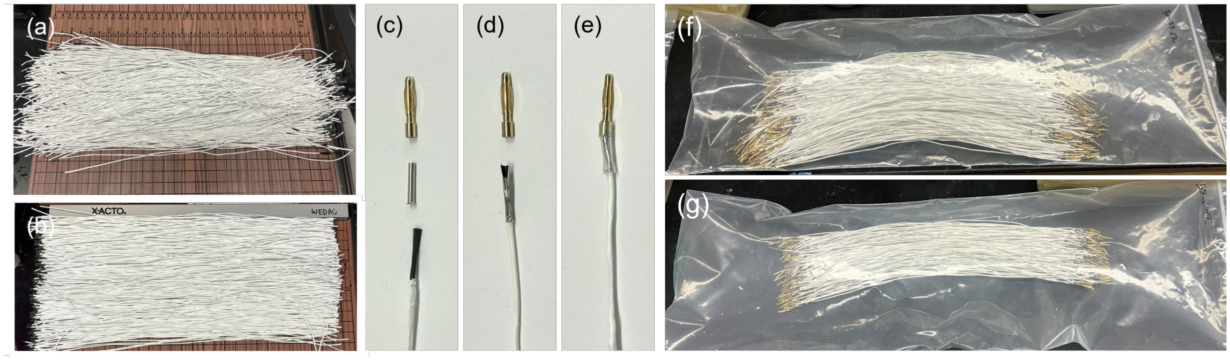

Figure 1 (a) Photo of the fabricated F800 fibers (total ca. 850 fibers), and (b) after being cut to 14 inches. **(c)-(e).** show the fiber edge trimming steps for connecting the fibers to the fiber assembly jig fabricated by GTRI. Photos of fibers soldered with banana plugs at each end that are sorted by the resistance of (f)**.** 50–55 Ω and (g)**.** 55–60 Ω

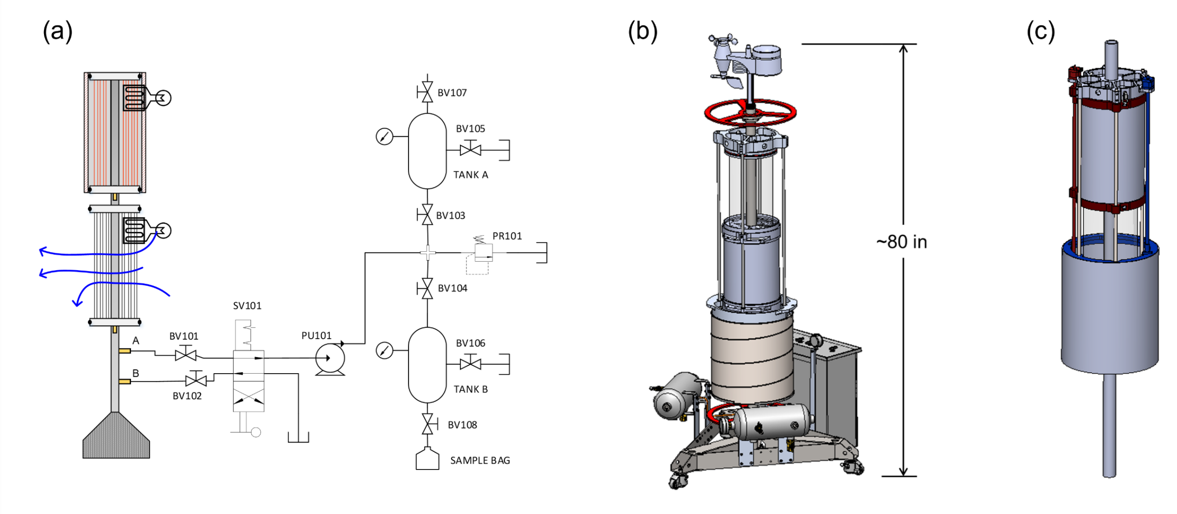

Figure 2 (a) Pneumatic schematic for GT's WEDAC environmental prototype. (b) Isometric rear view of environmental prototype. Height of full prototype is expected to be around 80 inches tall (c) Sleeve assembly concept for environmental prototype. A manual version will be made for this set of funding while incorporating features to make it automatable with future funding.

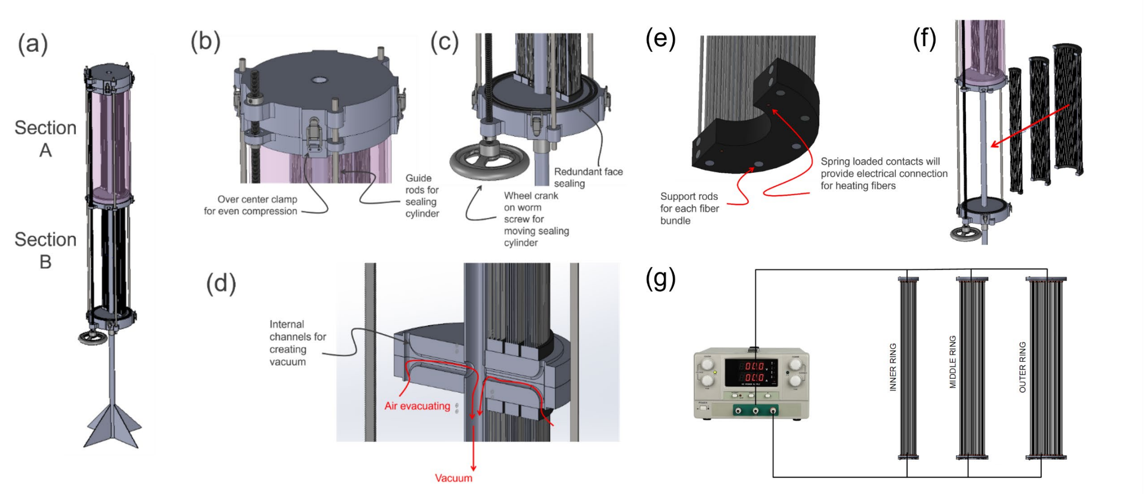

Figure 3 (a) An overview of the 2-stage automated prototype cartridge. (b) clamps and guide rods ensure the sealing chamber obtains a consistent seal during the vacuum stage. (c) redundant face sealing ensures system reliability while the automatable worm screw controls vacuum chamber positioning. Currently shown with a hand crank for early design concepts. (d) Internal vacuum chambers allow the efficient extraction of air during the desorption phase, designed with additive manufacturing techniques. (e) Spring loaded contacts can be used to provide electrical paths for heating fibers while (f) multiple staged fiber bundles allow options for differential heating and efficient bundle packaging. Magnets installed in the c-shaped frame pieces allow proper indexing for vacuum extraction and installation. (g) Electrical loop for heating fibers in each ring. Splitting the power in parallel paths ensures each fiber receives roughly the same amount of current, removing the potential for damage. Temperature is monitored inside vacuum assembly to control durations.

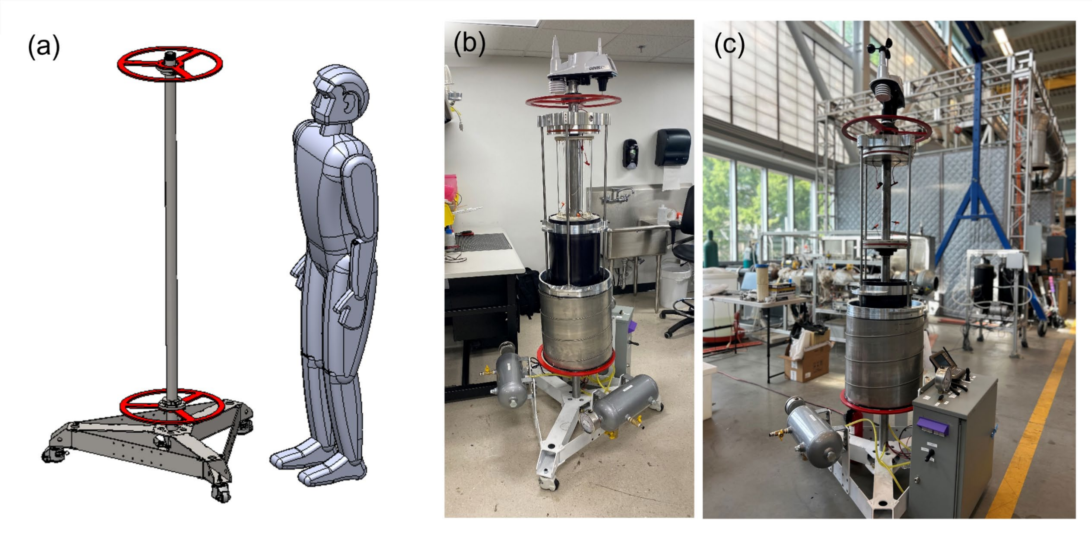

Figure 4 (a) Base and center post of environmental prototype. The long ribs connecting each arm have a generic hole pattern that can be adapted to any piece of equipment that needs to be attached to it. In addition, a 95th percentile male is shown next to the prototype base for scale. The red wheels are designed for easy manipulation and protection. (b) Full prototype build. Shown without fiber assembly for clarity. (c) The photo of WEDAC prototype module installed at CNES building.

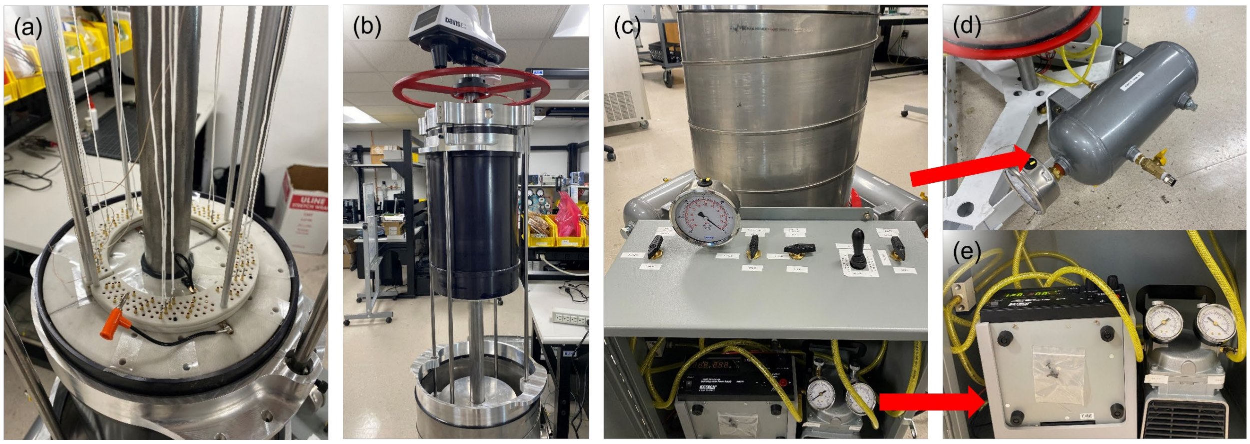

Figure 5 (a) Two-part center puck (red arrow) creates a seal between the vacuum sleeve and the center structural support Vacuum sleeve installed on upper fiber section of direct-air-capture prototype. (b) Vacuum sleeve installed on upper fiber section of direct-air-capture prototype. (c) Control panel for direct air capture prototype. (d) Example of sample tank (1 of 2) for the direct air capture prototype (e) Portion of pneumatic tubing inside the control box. Control valves are located at the top and side of the enclosure.

Project Activities

The program was initiated on 05/01/21 with the aim of developing a simple, scalable system for direct air capture based on CO_2 adsorption in porous solids via passive contactors, utilizing 3D-printed structures with porous supports loaded with poly(ethylenimine) (PEI) during the two-year funding period. During the initial phase, the sorbent design was revised to a sorbent-coated carbon fiber, produced through a roll-to-roll coating process. Its Joule heating kinetics and optimal PEI loading were explored. Additionally, initial Computational fluid dynamics (CFD) modeling of airflow through the carbon fiber-based contactor was conducted to inform the contactor design by estimating the air throughput, pressure drop and optimizing fiber bundle density based on wind speed. The early-stage contactor was designed to analyze CO_2 purity during the desorption mode, which operated via a temperature-vacuum swing adsorption (TVSA) process. Using a breakthrough system, the highest observed CO_2 purity in TVSA mode was approximately 95%. The techno-economic analysis (TEA) indicated an energy intensity of 7.2 GJ per tonne of CO_2 captured.

In the 12-month extension, we have created an automatable large-scale prototype WEDAC module to enable proof of concept. This module is currently installed in Carbon Neutral Energy Solutions Laboratory (CNES) building in Georgia Tech, Atlanta. In addition, to enable more accurate quantification of system performance, we developed an upgraded lab-scale module with improved vacuum capability and the ability to monitor temperature changes during operation. This allowed us to determine the exact cycle time of the system and accurately measure the amount of CO_2 that can be captured using the module, in the lab air environment. the minimum experimentally measured energy consumption was 15 GJ tCO_2^{-1} with a maximum daily CO_2 capture capacity in the range of 800-990 mol $\mathrm{m}_{\mathrm{system}}^{-3}$ day^{-1}. We also explored the optimal fiber array configuration for installation in the WEDAC module through CFD calculations. Lastly, we identified a commercial partner for the scale-up and commercialization of the WEDAC system.

Project Outputs

A. Journal Articles

- Sorbent-coated carbon fibers for direct air capture using electrically driven temperature swing adsorption, W.H. Lee, X. Zhang, S. Banerjee, C.W. Jones, M.J. Realff, R.P. Lively, Joule 7 (2023) 1241–1259. https://doi.org/10.1016/j.joule.2023.05.016
- H. E. Holmes, S. Banerjee, A. Vallace, R. P. Lively, C. W. Jones, M. J. Realff, Tuning sorbent properties to reduce the cost of direct air capture, Energy Environ. Sci. 17 (2024) 4544–4559. https://doi.org/10.1039/D4EE00616J
- Electrically-Operated Sorbent-coated Carbon Fiber Modules for Direct Air Capture, I. Jang, S. Kim, R. Warner, M. Song, S. Potdar, A. Rivata, W.H. Lee, M.J. Realff, R.P. Lively, Chemical Engineering Journal, 2025, Under Revision.

B. Papers

C. Status Reports

D. Media Reports

Inside-Out Heating and Ambient Wind Could Make Direct Air Capture Cheaper and More Efficient, Georgia Tech, College of Engineering:

https://coe.gatech.edu/news/2023/06/inside-out-heating-and-ambient-wind-could-make-direct-air-capture-cheaper-and-more

E. Invention Disclosures

All disclosures have been converted to patent applications, see section F.

F. Patent Applications

- [IP Generated by this project]: SORBENT COATED CARBON FIBERS AND THEIR MODULES FOR REDUCING CARBON DIOXIDE USING ELECTRICALLY DRIVEN TEMPERATURE SWING ADSORPTION SYSTEM, US. Patent Application No. 19/190,141

G. Licensed Technologies

H. Networks/Collaborations Fostered

Attended the ARPA-E Energy Innovation Summit in 2023 (Washington DC) and 2024 (Texas, Dallas).

I. Websites Featuring Project Work Results

J. Other Products (e.g. Databases, Physical Collections, Audio/Video, Software, Models, Educational Aids or Curricula, Equipment or Instruments)

K. Awards, Prizes, and Recognition

Follow-On Funding

Additional funding committed or received from other sources (e.g. private investors, government agencies, nonprofits) after effective date of ARPA-E Award.

Table 2. Follow-On Funding Received.

Source	Funds Committed or Received
ZeoDAC	01/01/2025