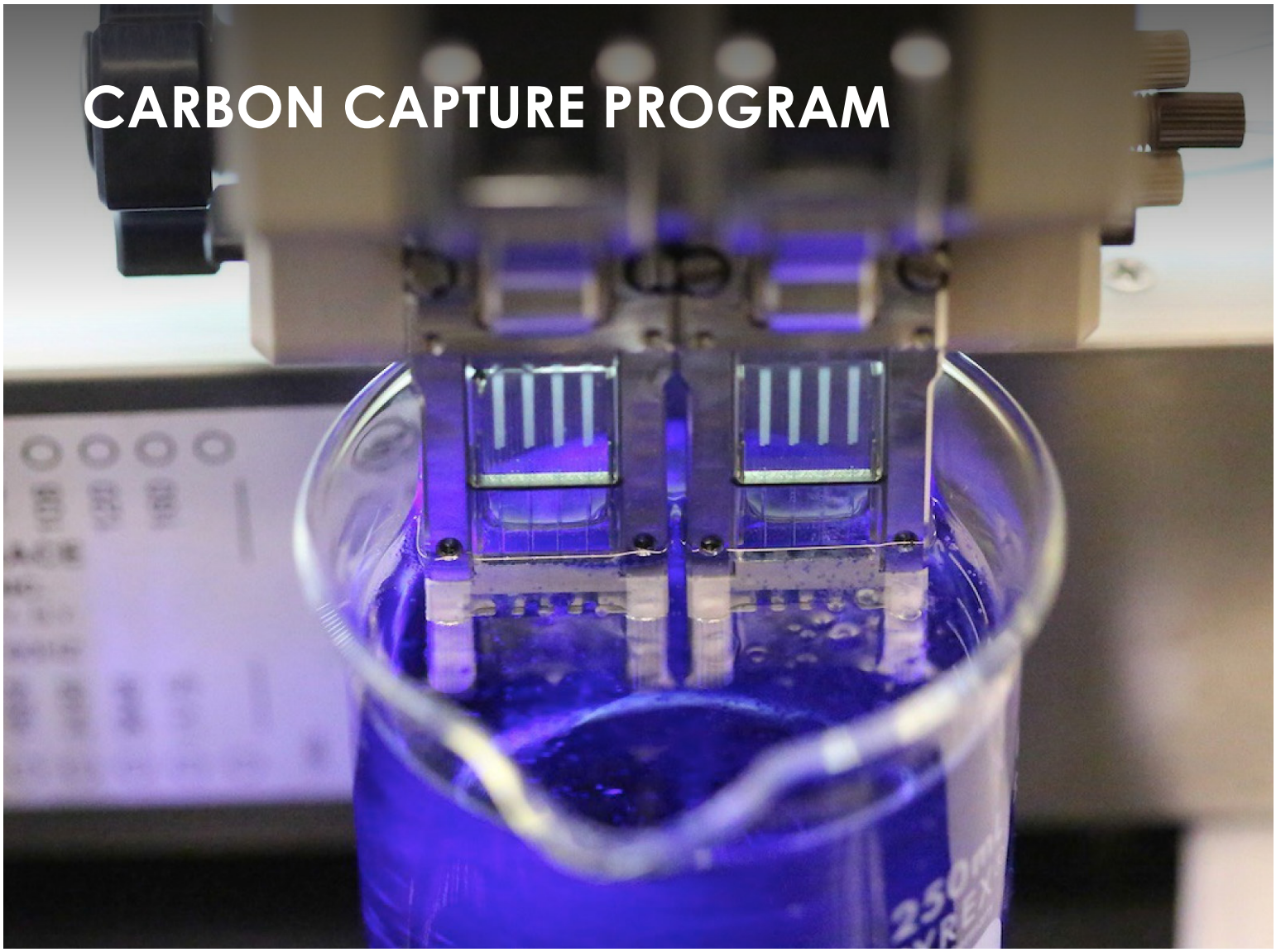
CARBON CAPTURE PROGRAM



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The Carbon Capture Program portfolio is unique in its ability to advance a range of technology solutions aimed at step-change improvement in the economics, efficiency and reliability of carbon capture that are suitable to the unique environments of post-combustion and pre-combustion applications.

Lessons learned from computational simulation, fundamental research, technology development and large-scale testing (in both pre- and post-capture environments) is informing investment in new chemical production methods, novel process equipment designs and new equipment manufacturing methods – with a focus on the seamless integration of new materials, capture processess, equipment, and designs with balance-of-plant operating systems.

Post-combustion capture and pre-combustion capture, the two main carbon capture methodologies being pursued within this program portfolio are briefly discussed below.

POST-COMBUSTION CARBON CAPTURE

Post-combustion capture is applicable to conventional pulverized coal-fired power plants where fuel is burned to generate electric power. CO_2 is captured from flue gas after complete fuel combustion. The principal challenge is separating the CO_2 generated during combustion (12% –15%) from the large amounts of nitrogen (from air) found in the flue gas.

Within the **post-combustion capture** environment, advanced gas separations processes are under investigation in the following four core research areas: **solvents, sorbents, membranes and novel concepts.**

SOLVENTS — Involve chemical or physical absorption of CO_2 from flue gas into a liquid carrier. Research projects focus on the development of durable, low-cost, non-corrosive solvents that can effectively capture CO_2 using as little energy as possible.

SORBENTS — Use physical adsorption by solid sorbents to capture CO_2 from flue gas. Research is focused on developing highly effective CO_2 capture sorbents with low raw material costs, strong thermal and chemical stability and low rates of sorbent losses over time.

MEMBRANES — Use permeable or semi-permeable materials that allow for the selective transport and separation of CO_2 from flue gas. Research focus includes developing low-cost, durable membranes with improved permeability and selectivity, thermal and physical stability and tolerance to contaminants in combustion flue gas.

NOVEL CONCEPTS — Includes hybrid systems that combine attributes from multiple technologies, electrochemical membranes, cryogenic capture, and advanced manufacturing to reduce the cost and improve performance by eliminating conventional manufacturing constraints.

PRE-COMBUSTION CARBON CAPTURE

Pre-combustion capture is applicable to integrated gasification combined cycle (IGCC) power plants, where solid fuel is converted into gaseous fuel – syngas – by applying heat under pressure in the presence of steam and oxygen. CO_2 is captured from the syngas and remaining hydrogen is combusted to generate electric power.

The concentration of CO_2 results in lower cost of carbon capture due to partial pressure, making this initiative more economically feasible.

Within the **pre-combustion capture** environment, advanced gas separations processes are under investigation in the following four core research areas: **solvents, sorbents, membranes and novel concepts.**

SOLVENTS — Involve chemical or physical absorption of CO_2 from syngas into a liquid carrier. Recovering CO_2 at high pressure, improving solvents to reduce H_2 losses, and developing solvents that are effective at higher temperatures improves IGCC cost and efficiency by reducing stages in the process.

SORBENTS — Use physical adsorption by solid sorbents to capture CO_2 from syngas. Research of interest includes sorbents with acceptable performance at the high temperatures encountered in IGCC systems to avoid the need for syngas cooling.

MEMBRANES — Use permeable or semi-permeable materials that allow for the selective transport and separation of CO2 from syngas. Research focus includes developing low-cost, durable membranes with improved permeability and selectivity as well as thermal and physical stability.

NOVEL CONCEPTS — Novel Concepts under investigation include: 1) systems that combine attributes from multiple technologies, and 2) developing or applying process intensification.

POST-COMBUSTION AND PRE-COMBUSTION CARBON CAPTURE ARE DEVELOPING TECHNOLOGIES TO PROVIDE STEP-CHANGE REDUCTIONS IN BOTH COST AND ENERGY PENALTIES COMPARED TO CURRENTLY AVAILABLE TECHNOLOGIES:

- Carbon capture R&D has developed solvents with reduced energy penalty, membrane materials with lower capital costs, process designs that reduce capital costs, and analytical methods to accelerate and de-risk CO_2 capture technology development.
- The National Carbon Capture Center (NCCC) has facilitated maturation of technologies from laboratory- to bench- to pilot-scale testing, allowing the most promising technologies to be tested on actual flue gas or syngas.

NETL is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. Through its world-class scientists, engineers and research facilities, NETL is ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans, advancing environmental justice and revitalizing the economies of disadvantaged communities.

Leveraging the power of workforce inclusivity and diversity, highly skilled innovators at NETL's research laboratories in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania conduct a broad range of research activities that support DOE's mission to ensure America's security and prosperity by addressing its energy and environmental challenges through transformative science and technology solutions.

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