Carbon Capture, Utilization, and Storage

Degrees Offered

- Masters in Carbon Capture, Utilization, and Storage
- Carbon Capture, Utilization, and Storage Certificate

Program Description

As global interest in carbon capture, utilization, and storage (CCUS) continues to grow, so does the demand for skilled professionals equipped to tackle its unique challenges. The Mines CCUS graduate certificate program addresses this critical need. By integrating world-renowned expertise in earth sciences, engineering, economics and business, this interdisciplinary program enables students to explore the unique challenges related to CCUS, climate change, and the energy transition while gaining the specialized skills needed to advance their careers.

The Masters in Carbon Capture, Utilization, and Storage (course-based) program is designed to give students a foundation in the technical, business, and community engagement aspects of CCUS to help them further their careers in the CCUS space. This non-thesis, online only program is structured to be of use for both those seeking to expand their career or those just getting started.

The CCUS graduate certificate program is designed for professionals looking to enhance their expertise in carbon capture, utilization, and storage. The courses are fully asynchronous, eight weeks long, and offered online, providing flexibility for working professionals. Students need to complete three courses - two required and one elective - to earn the graduate certificate in CCUS. These courses can also be taken to count towards a graduate degree.

Participants in this program can expect to:

- Assess data on climate change, and the effects of greenhouse gases on climate.
- Develop a solid foundation and proficiency in methods employed for the three aspects of carbon capture, utilization, and storage.
- Learn workflow and practices in the industry. Assess efficiency of CCUS practices.
- Develop skills to better communicate with colleagues in other disciplines in the organization.
- Learn and understand fundamental concepts from well-known, experienced faculty in the field.

Contact

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Program Coordinator: Rachel McDonald
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https://ccus.mines.edu
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Masters in Carbon Capture, Utilization, and Storage

The Masters in Carbon Capture, Utilization, and Storage (course-based) program is designed to give students a foundation in the technical, business, and community engagement aspects of CCUS to help them further their careers in the CCUS space. This non-thesis, online only program is structured to be of use for both those seeking to expand their career or those just getting started.

Program

To receive the MS degree, students will need to complete at least 30 units of online coursework, which includes 9 units in core courses, including a 3-unit capstone course, and 21 credits of electives.

Required Courses

CCUS520	CLIMATE CHANGE AND SUSTAINABILITY	3.0
EBGN502	POLITICAL ECONOMY OF THE ENERGY TRANSITION	3.0
CCUS585	CARBON CAPTURE, UTILIZATION, AND STORAGE CAPSTONE	3.0
Total Semester Hrs		**9.0**

Elective Courses

Choose 21 credits of coursework from those listed below. Other electives can be used with prior approval from the Program Director and your advisor.

CCUS521	GEOLOGICAL CARBON CAPTURE UTILIZATION AND SEQUESTRATION (CCUS)	3.0
CCUS522	NON-GEOLOGIC CARBON CAPTURE AND UTILIZATION	3.0
CCUS525	BIOLOGICAL CARBON CAPTURE AND CONVERSION	3.0
CCUS530	THE KINETICS OF CARBON DIOXIDE REACTIONS	3.0
CCUS598	CLASS VI WELL DESIGN AND PERMITTING	3.0
EDNS501	COMMUNITY-CENTERED APPROACHES TO RESILIENCE	3.0
EDNS502	MANAGING AND LEADING IN MULTISTAKEHOLDER ENVIRONMENTS	3.0
GEOL557	EARTH RESOURCE DATA SCIENCE 1: FUNDAMENTALS	3.0
GPGN519	ADVANCED FORMATION EVALUATION	3.0
GPGN558	SEISMIC DATA INTERPRETATION AND QUANTITATIVE ANALYSIS	3.0

Carbon Capture, Utilization, and Storage Certificate

The Mines graduate certificate in Carbon Capture Utilization and Storage (CCUS) is a three-course, 9-credit, online program that provides graduate-level learning opportunities in climate and societal impacts of elevated levels of atmospheric CO_2, quantitative assessment methods of CO_2 mitigation, as well as economic and policy analysis of a CCUS economy. By bringing salient aspects of CCUS under one umbrella, students gain and develop the knowledge and expertise to make informed decisions on CO_2 mitigation strategies, technologies, and can guide company and/or government policy and economic decisions.

The CCUS certificate program provides students with engaging learning experiences to understand and guide science-based discussions around climate change and how to assess it using environmental data and modeling methods, explore CO_2 capture and utilization technologies, and assess geologic utilization and sub-surface storage options. The program equips students with scientific knowledge about each CCUS topic and various technical CO_2 mitigation solutions and their risks. The program combines the expertise from our world-renowned graduate programs in Earth Sciences, Engineering, and Economics and Business and distills them into a certificate program on CCUS technologies and CCUS economy. This program is designed for professionals and recent graduates who want to acquire new skills for career advancement or get a head start on an advanced graduate degree. Courses in the program focus on real-world and current challenges and progress in CCUS techniques, and CCUS economics. The certificate program requires three 3-credit graduate courses identified below: two required courses and the option to choose an elective in either geologic or non-geologic CCUS.

Required Courses		
CCUS520	CLIMATE CHANGE AND SUSTAINABILITY	3.0
EBGN598	POLTIICAL ECONOMY OF THE ENERGY TRANSITION	3.0
Elective Course Options		
Choose one of the courses listed below.		
CCUS521	GEOLOGICAL CARBON CAPTURE UTILIZATION AND SEQUESTRATION (CCUS)	3.0
SYGN598C	Non-Geologic CCUS	3.0
SYGN598C	CARBON REDUCTION: CAPTURE & UTILIZATION	3.0

Course Modality:

All courses are virtual and asynchronous - so students can listen to the lectures at convenience. All material is online and recorded for offline review. There are timed discussions and deliverables each week where students interact with their peers and with the instructors. The office hours are at specific times, but specific times to meet outside of those hours are often arranged depending on schedule conflicts or on geographic locations.

CCUS520. CLIMATE CHANGE AND SUSTAINABILITY. 3.0 Semester Hrs.
This eight-week online course is intended to introduce students to effects of atmospheric CO2 on climate, CO2 mitigation and avoidance strategies, and aspects of ESG when considering mitigation strategies. The course will provide students with much needed working knowledge about effects of Greenhouse Gases (GHGs) using data, and models. It provides cause and effects of GHGs as well as potential solutions that are equitable and sustainable.
Course Learning Outcomes

- 1) Use professional communication methods; explain in written format to a non-scientific reader (general public or policy maker) the big picture of Climate Change and what is Climate Change
- 2) Use professional communication methods; communicate in written format to a non-scientific reader (general public or policy maker) the big picture of Climate Change considering the role of Carbon in climate change
- 3) Using professional communication methods, explain to a non-scientific reader the big picture of Climate Change considering How can we assess climate change - what's the science (to the level needed to explain to general public) behind understanding the causes, and modeling for predictions
- 4) Explain in written format to a non-scientific reader (general public or policy maker) how scientists and engineers are studying solutions to climate change.
- 5) Analyze and accurately discuss the analysis of data sets related to climate change and CCUS considering data sources, data errors and uncertainties, and selecting accurate and appropriate data
- 6) Balance the atmospheric carbon budget in a proposed CCUS plan; consider CCUS with an ESG perspective
- 7) Discuss, using known scientific and social science perspectives, ethical considerations, societal impacts and issues of Climate Change and CCUS that should be considered as planning CCUS
- 8) Analyze maps of climate vulnerability; discuss climate equity; assess scientific accuracy of climate maps

CCUS521. GEOLOGICAL CARBON CAPTURE UTILIZATION AND SEQUESTRATION (CCUS). 3.0 Semester Hrs.
This course will cover sub-surface aspects of sustainable CCUS projects. Specifically, the topics covered will be geology of the subsurface appropriate for CCUS, how to create sustainable projects, the physics of CO2 transport, injection and storage it's their modeling studies, practical aspects of CO2 flooding, monitoring and verification methods including seismic, gravity and electromagnetic methods, and assessing CO2 capacity and migration. Each week of the course is taught by experts in the area from geology to engineering to geophysics and covers essential topics such as Class VI CCUS wells and EPA permitting, sustainable project development, to detailed physics such as CO2 phase and flow in the subsurface.
Course Learning Outcomes

CCUS525. BIOLOGICAL CARBON CAPTURE AND CONVERSION. 3.0 Semester Hrs.
Plants, bacteria, and algae have evolved over billions of years to efficiently use sunlight to turn carbon dioxide and water into useful chemicals, a potential solution to the very real problem of climate change. How do they do this? How can we take advantage of these processes? And, how can we improve on them to find practical solutions to address climate change? The purpose of this course is to answer these questions by introducing students to bioconversion, nature's ability to convert CO2 into other molecules. In this online, asynchronous course, students will work collaboratively in small teams to discuss current literature on carbon dioxide bioconversion, evaluate the effects of various parameters on bioconversion rates and efficiencies, and design and present case studies on ways to use plants, algae, and bacteria to convert CO2 to useful material. Prerequisite: None Co-requisite: None Prerequisite: Undergraduate introductory biology course (BIOL300 and BIOL301, or equivalent),Undergraduate general chemistry course (CHGN121 and CHGN122, or equivalent).
Course Learning Outcomes

- 1) Analyze how plants, algae, and bacteria contribute to the carbon cycle
- 2) Analyze how plants, algae, and bacteria contribute to the carbon cycle

- 3) Analyze how plants, algae, and bacteria contribute to the carbon cycle
- 4) Evaluate the effect various parameters (such as temperature, pH, salinity, light, etc.) have on the ability of bacteria to convert CO2 via photosynthesis
- 5) Recommend an appropriate biological-based method for capturing CO2 and converting it to a biofuel, based on the needs and available resources of a stakeholder
- 6) Demonstrate the ability to productively contribute to a team evaluating biological methods for CO2 capture and conversion
- 7) Develop and deliver a presentation on biological CO2 capture and conversion catalysts to an audience of postgraduate engineers

CCUS530. THE KINETICS OF CARBON DIOXIDE REACTIONS. 3.0 Semester Hrs.

Carbon dioxide is an extremely stable molecule that stays in the atmosphere for hundreds of years. What makes it so stable? Why does it take so long to convert to something else? How can we, as scientists and engineers, use chemistry to turn carbon dioxide into other, useful things, like fuels and materials? The purpose of this course is to answer these questions by delving into the thermodynamics of carbon dioxide, the kinetics of CO2 reactions, and how electrochemistry, photochemistry, and catalysts can overcome these problems. In this online, asynchronous course, students will work collaboratively in small teams to discuss current literature on CO2 conversion reactions, evaluate the pros and cons of electrochemistry and photochemistry for CO2 conversion, and design and present case studies on ways to use electrocatalysts and photocatalysts to convert CO2 to useful materials. Prerequisite: None Co-requisite: None Prerequisite: Undergraduate introductory chemistry (CHGN121 and CHGN122, or equivalent),Differential equations (MATH225 or equivalent).

Course Learning Outcomes

- 1. Propose electrochemical experiments, and interpret the resulting data, that would allow you to differentiate between CO2 reaction mechanisms
- 2. Propose photochemical experiments, and interpret the resulting data, that would allow you to differentiate between CO2 reaction mechanisms
- 3. Explain the underlying thermodynamic problems associated with converting CO2 into other carbon-based chemicals.
- 4. Evaluate CO2 conversion catalysts, based on various methods such as selectivity, turnover, activity, and cost
- 5. Evaluate CO2 reaction mechanisms based on experimental data
- 6. Develop and deliver a presentation on CO2 conversion catalysts to an audience of postgraduate engineers
- 7. Demonstrate the ability to productively contribute to a team evaluating CO2 conversion catalysts

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EBGN598. POLITICAL ECONOMY OF THE ENERGY TRANSITION. 3.0 Semester Hrs.

This course provides an overview of economics, business, and political topics that are commonly found in the energy transition. Many of the assignments relate back to skills that are needed to interact with economics, business, and policy professionals. The course is designed for students with little, if any, social science or business training. Students will build a basic knowledge of economics, finance, and business issues that are relevant to energy markets and industries.

SYGN598. CARBON REDUCTION: CAPTURE & UTILIZATION. 3.0 Semester Hrs.

This course provides an overview of the technologies used for decarbonization with an introduction to the chemistry of the molecule and the reactive CO2 capture technologies, carbon capture and separation technologies, thermodynamics, and practical applications from a CCUS systems development perspective.

Program Director

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