

# Advanced Energy Systems

# A Transformational Graduate Program



## Mines and NREL Join Forces To Shape the Future of Energy

Colorado School of Mines (Mines) and the National Renewable Energy Laboratory (NREL) are at the forefront of a tectonic shift in the way energy is sourced and consumed worldwide. Concentrated within a 5-mile geographic radius in Golden, Colorado, some of the world's best and brightest scientific minds are leading technological innovation driven by necessity. Developing secure, resilient, and adaptive energy infrastructure that fosters economic growth while reducing environmental impact is among the most pressing challenges—and greatest opportunities—of our time. It will require the next generation of thought leaders to capably and creatively guide this vital energy sector transition.

Through a new interdisciplinary graduate program, Mines and NREL are cultivating the rich opportunity landscape needed to develop these future innovators. The Mines/NREL Advanced Energy Systems (AES) degree program prepares researchers at the doctoral level and energy professionals at the master's level to address the full complexity of tomorrow's infrastructure, economic, and environmental challenges.

*Photos by Dennis Schroeder, NREL 40916 (top); iStock-627777022 (bottom)*



Colorado School of Mines and the National Renewable Energy Laboratory are just 5 miles apart in Golden, Colorado—a hub of energy innovation. *Map courtesy of U.S. Geological Survey*

With a focus on emerging energy technologies, the AES degree program is designed to empower researchers at both institutions to tackle a variety of compelling needs, including:

- Integrating a wide range of energy sources into a flexible, secure grid as power derived from renewables approaches cost parity
- Implementing digitized and optimized energy control and management through artificial intelligence that maintains robust security and resilience
- Addressing economic and policy barriers to development of new clean and high-efficiency technologies for energy conversion and storage
- Advancing the electrification of transportation.

## Collaborations Continue to Build on Successes

Mines and NREL are already engaged in close collaborations in a wide range of research topics. Among them, the Colorado Renewable Energy Collaboratory commercializes technologies, supports economic growth, and educates the workforce. NREL and Mines are also partnering on the joint International Center for Multiscale Characterization, which focuses on critical issues in energy-related materials science while advancing the state of the art in multiscale characterization of materials for photovoltaic, battery, and fuel cell applications. As evidenced by the more than 20 joint appointments between NREL and Mines, the close proximity of laboratory and university creates a diffuse boundary between the two. Researchers at both locations benefit from shared access to resources, facilities, and expertise across multiple lab groups at NREL and departments at Mines.

## Gain Academic Experience in a Professional Setting

Graduates of the AES degree program will be uniquely positioned to enter the workforce in roles supporting advanced energy innovation and research in government, academia, nonprofits, and the private sector.

The Advanced Energy Systems Ph.D. program is structured around three key courses and two rotational assignments at NREL in Year 1. The first year provides researchers with a broad, rigorous background in the energy sector. Year 2 focuses on elective courses required to develop deep expertise in the selected area of focus. Ph.D. candidates will continue with two additional years of dedicated research under the guidance of Mines and NREL advisors. Beyond the core curriculum and rotation, the program design also allows for flexibility to encourage individual student strengths across both campuses. A non-thesis master's degree option, which comprises the same coursework as the doctoral program but excludes the rotations, offers students similar access to joint Mines/NREL seminars, networking, professional development, and recruiting opportunities.

## The Path to Advancing Energy Leadership

The combination of a thriving cleantech market in Colorado, world-class resources and researchers at NREL, and rigorous educational and technical programs at Mines create a truly one-of-a-kind opportunity for advancing fields related to energy systems. These links can uniquely equip top-caliber students to become the scientists and engineers at the forefront of our global energy economy transformation.

### CORE COURSES

#### **Energy Resources and Electric Power Systems**

Introduction to how fossil, renewable, and nuclear energy resources are converted to electric power

#### **Energy for Transportation**

Evaluation of performance and environmental impacts of vehicle and fueling technologies

#### **Energy Systems Integration and Efficiency**

Exploration of the operation and evolution of the electric grid and electricity utilization

SEMESTER	COURSE WORK	RESEARCH
Fall Year 1	<p>ENGY 501: Energy Resources and Electric Power Systems</p> <p>ENGY 502: Energy for Transportation</p> <p>NREL Rotation I – ENGY 691: Analysis of Integrated Energy Systems</p>	Year 1 emphasizes the development of a broad, rigorous background in the energy sector
Spring Year 1	<p>ENGY 503: Energy Systems Integration and Efficiency</p> <p>NREL Rotation II – ENGY 692: Energy Science and Technologies</p> <p>Qualifying Exam</p>	Two NREL rotations—Ph.D. students participate in two rotations, one focused on integrated energy systems, markets, and policy, and the other on energy science and technology research
Fall Year 2		
Spring Year 2	Electives and research	Thesis research will be combined with internship at NREL
Summer Year 2		
Fall Year 3		
Spring Year 3	Electives and research	Thesis research will be combined with internship at NREL
Summer Year 3		
Fall Year 4		Thesis research will be combined with internship at NREL
Spring Year 4	Electives and research	Ph.D. defense

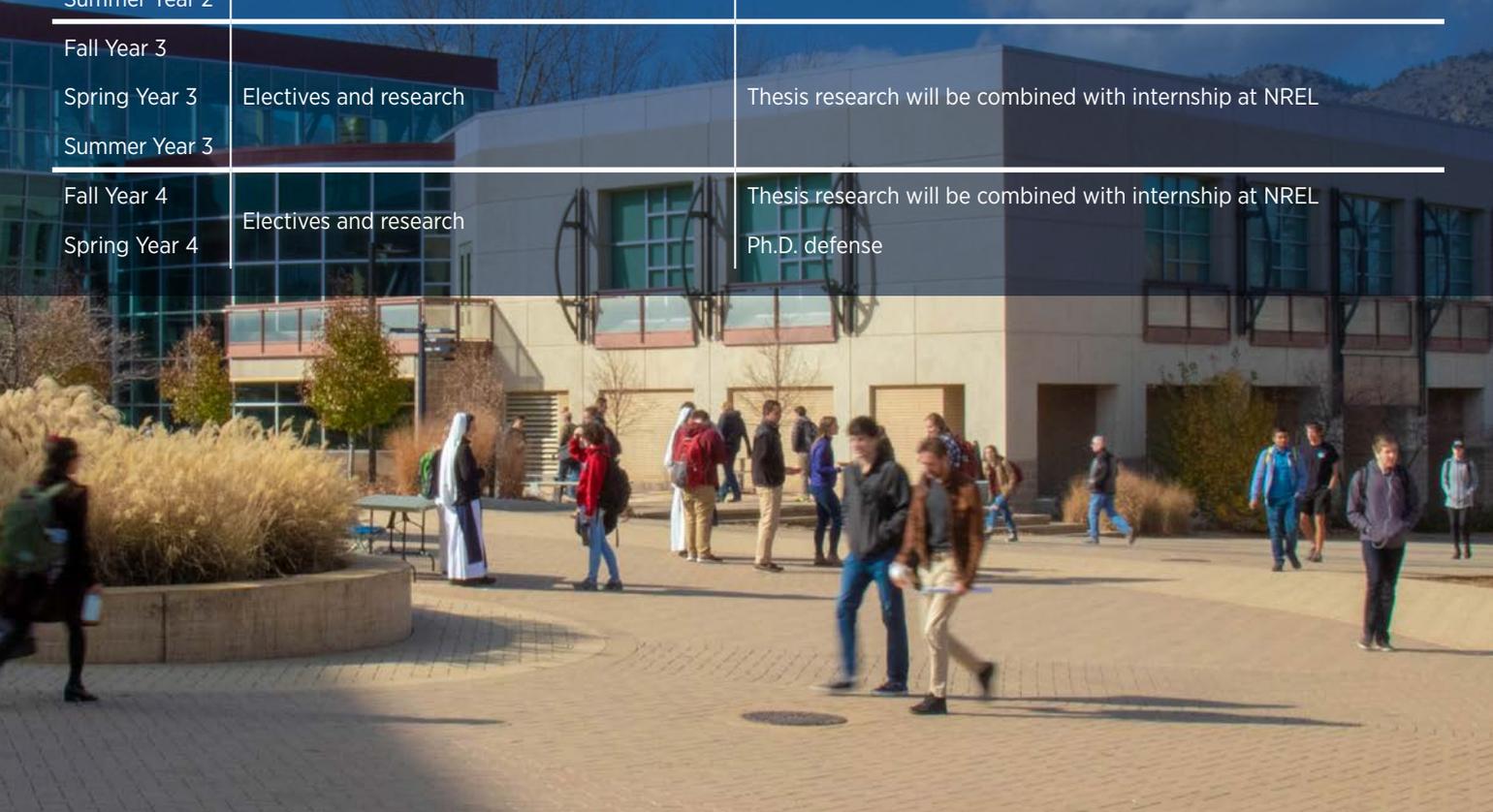


Photo by Joey Lovato, Colorado School of Mines

## Jump-start Your Career in the Energy Sector

Arrive with a bachelor of science in engineering or science and a passion for solving the grand challenges related to:

- Energy transitions
- Transportation system electrification
- Decarbonization
- Energy security and resilience
- Energy policy analysis and decision support.

Leave prepared to take up leadership positions in:

- Government and national labs
- Academia
- Advanced energy companies and suppliers
- Energy development consulting firms
- Nonprofits and NGOs
- Energy providers and utilities.



*Photo from Colorado School of Mines*

## NREL Rotations

The AES Ph.D. program includes two rotations at NREL that provide students with the distinctive professional development experience of working alongside thought leaders and innovators in a world-class laboratory setting.

### Rotation I – ENGY 691: Analysis of Integrated Energy Systems

#### Host NREL Directorates

- Energy Systems Integration
- Scientific Computing and Energy Analysis

### Rotation II – ENGY 692: Energy Science and Technologies

#### Host NREL Directorates

- Bioenergy Science and Technology
- Mechanical and Thermal Engineering Sciences
- Materials and Chemical Science and Technology

### Requirements and Outcomes: Rotations I and II

- Prepare a project plan with quantitative objectives
- Demonstrate appropriate documentation of research progress in laboratory notebooks
- Prepare a technical report in support of a multi-investigator research program

#### Learn More

To learn more about how the Mines/NREL Advanced Energy Systems degree will prepare the next generation of innovators and thought leaders to shape the energy landscape of the future, visit [energysystems.mines.edu](https://energysystems.mines.edu) and follow @CSMEnergy on Twitter.

#### For more information, contact:

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Colorado School of Mines is a public university focused on science and engineering, dedicated to educating and inspiring students, advancing knowledge, and innovating to address the great challenges society faces today—particularly those related to the Earth, energy and the environment.

<https://energysystems.mines.edu>

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Operated by the Alliance for Sustainable Energy, LLC

[www.nrel.gov](http://www.nrel.gov)

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