



House Energy and Environment Committee Colorado General Assembly

Martin Keller, Director
February 25, 2021

NREL Science Drives Innovation



Renewable Power

Solar
Wind
Water
Geothermal



Sustainable Transportation

Bioenergy
Vehicle Technologies
Hydrogen



Energy Efficiency

Buildings
Advanced
Manufacturing
Government Energy
Management



Energy Systems Integration

Grid Integration
Hybrid Systems

NREL at-a-Glance



2,524

Workforce, including

216 postdoctoral researchers

62 graduate students

103 undergraduate students



World-class

facilities, renowned
technology experts

More than
900

Partnerships

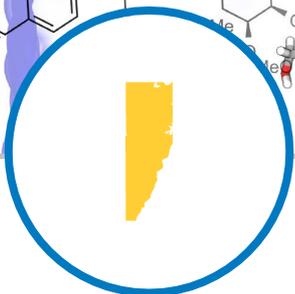
with industry,
academia, and
government



Campus

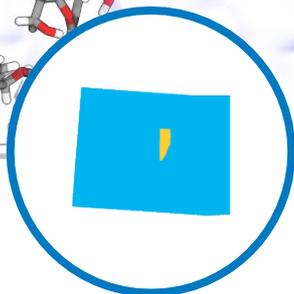
operates as a
living laboratory

NREL FY2019 Economic Impact



\$617M

in Jefferson County.
NREL is the fifth
largest employer.



\$875M

in Colorado, including
4,527 jobs
and an income impact of
\$351M



\$1.4B

in the United States



65

R&D 100 Awards

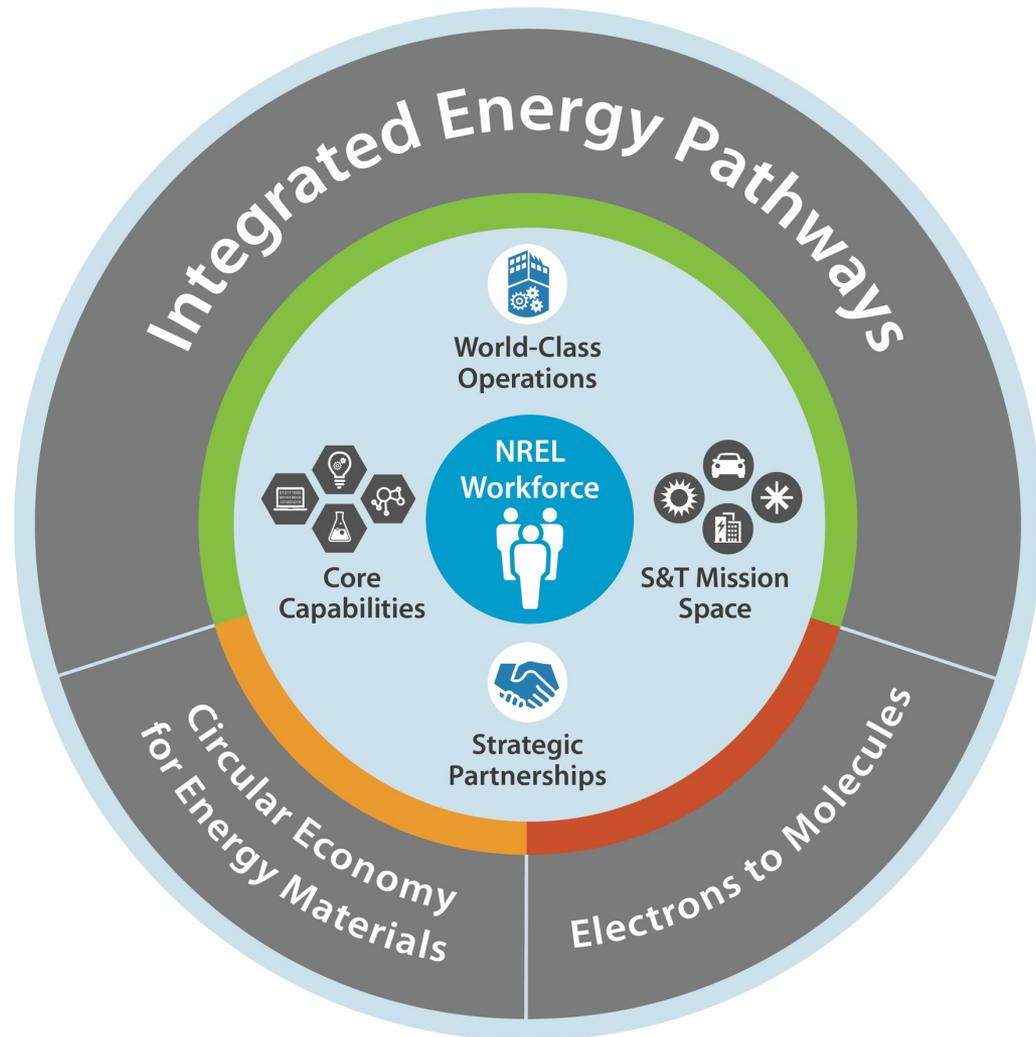
571

patents

43,438

publications to date

Working Toward Our Vision



NREL's Three Critical Objectives



Integrated Energy Pathways

Develop the foundational knowledge and technologies to optimize the integration of renewables, buildings, energy storage, and transportation—modernizing our energy systems and ensuring a secure and resilient grid.



Electrons to Molecules

The conversion of electricity and small waste gases (e.g. CO_2 , H_2O , N_2) into chemical bonds for the purposes of chemical, material, or fuel synthesis and/or energy storage.



Circular Economy for Energy Materials

Establishing the foundational knowledge/technology for design, recycle, reuse, remanufacture, and reliability for energy-relevant materials and processes.



Integrated Energy Pathways

Early Stage

- The number of controllable devices connecting to the grid is skyrocketing. To address this, NREL is developing the concept of autonomous energy systems (AES)
- Focus on basic research in optimization theory, control theory, big data analytics, and complex system theory to develop a flexible planning and operation framework that can keep pace with the complexity of modern energy grids

Mid-Stage

- To meet the needs of future energy systems, NREL's Integrated Energy Systems at Scale (IESS) initiative addresses the fundamental challenges of
 - Scaling the physical size of new energy technologies
 - Controlling large numbers of interconnected devices into larger systems
 - Integrating multiple diverse technologies

Late-Stage

- Demonstrate autonomous energy grids and advanced storage and renewable energy generation



Circular Economy for Energy Materials

Early Stage

- Discovery and genetic improvement of plastics eating enzyme that allows for the degradation of PET to its chemical precursor molecules
- Isolation of biologically derived intermediates and subsequent synthesis of novel, more “recyclable by design” polymers



Mid-Stage

- Exploration of chemical, biological and enzymatic strategies for other plastic degradation (PE, PP, PU, etc)
- Complete synthesis of novel PET-based water bottle with equivalent properties capable of bio-degrading ~100x faster



Late-Stage

- In discussion stage with industrial polymer end users about general plastics upcycling applications



Electrons to Molecules

Early Stage

- Developing electrocatalytic techniques for the reduction of CO_2 (or N_2) into reactive intermediates like CO, formate or methanol (similar to electrolysis of water to H_2 and O_2)
- Development of enabling bipolar membranes for high current gas phase electrocatalysis devices

RUTGERS

TU Delft

Mid-Stage

- Development of gas-diffusion electrode on hollow fiber membranes to generate tunable ratios of CO/H_2 from CO_2
- Genetic engineering of cyanobacteria to maximize production of isopropanol from $\text{CO}/\text{H}_2/\text{CO}_2$ and build integrated system



PRINCETON
UNIVERSITY



Late-Stage

- Demonstrate electrolysis of water (to H_2 and O_2) in combination with biological production of pipeline quality methane (CH_4) from H_2 and CO_2

 SoCalGas
A Sempra Energy utility

 Electrochaeta



Partnering for the Competitive Advantage

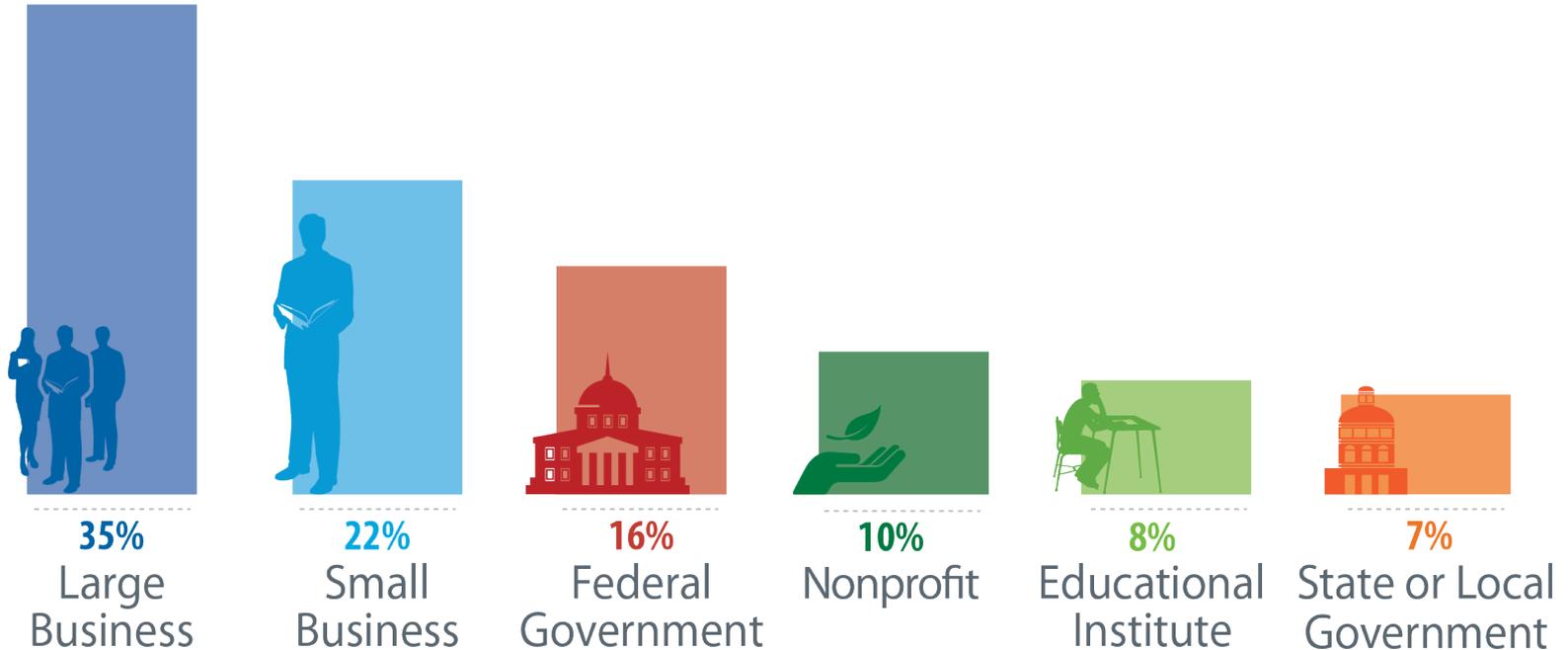
More Than 900 Partnerships

In 2020, NREL's more than 900 partnerships with industry, academia, and government included:

- 274 new partnership agreements
- \$102M value of new partnerships
- 242 unique new partners
- 563 unique active partners



FY20 NREL Partnership Portfolio



FY20 Partnerships



Defense

Emphasize energy security and resiliency at installations.



Federal

Expand access to broader NREL capabilities.



International

Develop initiatives to scale-up markets for advanced energy technologies and systems.



State and Local

Help states and cities meet geographically focused energy goals.



Power

Expand work on PV materials, devices, and reliability research and grid estimation.



Chemicals

Expand current relationships and increase collaborations with industrial partners in chemical, aviation, automotive and other technologies.



Foundations

Partner to support the incubation and maturation of new energy innovations.



Manufacturing

Grow existing partnerships and execute work focused on high-impact and long-term projects.

Partnering for Impact

NYSERDA



Through objective research and analysis, we provide the New York State Energy Research and Development Authority (NYSERDA) with resources needed for effective decision making. Our partnership will advance the use of renewable energy technologies, including options for electrifying its transportation system.

DFW



With Dallas/Fort Worth International Airport, we are using electrification, connectivity, and automation to significantly improve energy-efficient transportation of people and goods.

EATON

Powering Business Worldwide



NREL and Eaton are working in the ESIF on grid intelligence, distributed energy resource management, advanced energy storage systems, virtual modeling and analysis, high-performance computing, and other research.

WELLS FARGO



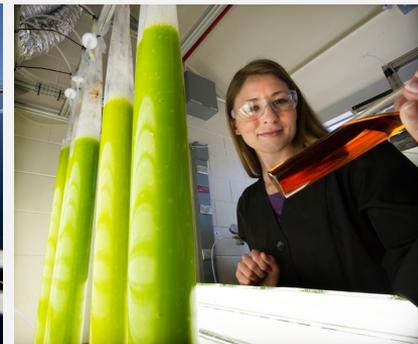
Our Innovation Incubator (IN₂) is expanding this scalable model to other partners and technologies and growing to a multiyear, \$30 million program.

Additional Examples of NREL's New and Enhanced 2020 Partners



Global Clean Energy Center of the Rockies:

the Silicon Valley of Clean Energy



Promoting Economic Recovery in Colorado

- **1000+ New Jobs**
- Rural Project Coordination
- Workforce Development and Training
- Education and Research

Leveraging NREL's Leadership

- Nearly **900** Research Partners Worldwide
- Economic Impact **\$1.4B** in U.S. and in Colorado
\$875M, including **4,527 jobs** statewide
- **573** Patented Technologies
- **65** R&D 100 Awards
- Annually Over **1,700** Scientific and Technical Publications

Expanding Impact Through NREL's Partnerships and Collaborations

- The Broe Group
- Eaton
- Exxon
- Wells Fargo
- Shell
- Colorado School of Mines
- University of Colorado
- Colorado State University
- Innovation and Entrepreneurship Center
- Industry Growth Forum
- Colorado Center for Renewable Economic Development



Global Clean Energy Center of the Rockies
The Silicon Valley of Clean Energy

Global Clean Energy Center of the Rockies:

A Collaborative Partnership for Colorado's Clean Energy Future.



Next Steps

- Establish big picture, long-term concept for Clean Energy Center of the Rockies
- Complete land agreement and conduct local stakeholder engagement
- Develop timeline for initial office building development
- Engage other State of Colorado and NREL partners

An aerial photograph of a large white Siemens wind turbine. The turbine's nacelle and hub are visible, with the word 'SIEMENS' printed in green on the nacelle. The blades extend across the frame. In the background, there is a vast green field, a small industrial or construction site with several buildings, and a range of rugged mountains under a clear blue sky with a few wispy clouds.

Thank you

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

