Research, Development and Demonstration Success Stories for New and Renewable Energy Technologies in the US

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Excellent to Good Resources Everywhere
Major Research Programs

Renewable Resources
- Wind
- Solar
- Biomass
- Geothermal

Efficient Energy Use
- Vehicle Technologies
- Building Technologies

Energy Delivery & Storage
- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage
Technology Management Programs

Federal Energy Management

Intergovernmental

Village Power Project

State & Local

State Technical Assistance Program

Governmental

Small Business

Small Business Growth Programs

Analysis

Forecast Years

National Capacity (GW)

- Wind
- Coal-clean
- Coal-conventional
- Coal-w/scrub
- Gas-CT
- Hydro
- Nuclear
- Gas-CC
- Oil-gas-steam

Pentagon

Zion National Park

NREL Enterprise Growth Programs
Research Focus in Solar

- Photovoltaics
  - Device design
  - Advanced manufacturing
  - Measurement and characterization
  - Nanomaterials and applications
  - Predictive solid state theory
- Concentrating Solar Power
  - Reflective materials
  - Trough system analysis & testing
- Solar Heating
  - Polymer water heater analysis & testing
- Solar Resource Assessment

Collaborations between NREL and Sandia, BNL
2004 R&D 100 Award
Lightweight, Flexible, Thin-Film CIGS PV Modules

The deposition technology enables the manufacture of highly efficient, lightweight, flexible photovoltaic modules using copper indium gallium diselenide thin-film materials.

These modules have the ability to mold to an irregular surface and have a compact, foldable design that allows for easy deployment, transport, and storage.

They meet the needs of military applications (portable power for advance troops and transportable AC power), and civilians (portable power for recharging batteries, signs, and bus shelters).

Research Focus in Wind

- Aerodynamic modeling
- Structures and fatigue research and structural design codes
- Advanced component development
- Wind resource characterization
- Field validation and certification testing

Collaboration between NREL and Sandia
Research Focus in Bioenergy

- Biotechnology (enzyme development)
- Thermochemical and biochemical conversion technologies
- Chemometrics
  - Characterization of biomass
  - On-line process measurement
  - Product quality measurement
- Process modeling and life cycle analysis

Collaborations between NREL and ANL, INEEL, PNNL, ORNL
The anchor of the leading lignocellulose biomass biorefinery concept is the transportation fuel ethanol. Enzymes to produce sugars from biomass has been one of the biggest cost challenges.

The partners were able to increase cellulose conversion yield to more than 90%, increase the performance of the enzymes 2- to 3-fold, and decrease enzyme production costs by 5- to 6-fold.

The impact of the combined advances decreases the effective cost of enzymes by as much as 20 times.

NREL, Genencor International, Novozymes Biotech, Inc.
Research Focus in Geothermal

- Advanced thermal conversion systems
- Corrosion resistant components
- Plant design and testing

Collaborations between NREL and INEEL, Sandia
Research Focus in Distributed Energy Systems

- Distribution system integration (micro-grids, control systems, modeling)
- Interconnection standards & testing
- Hybrid systems optimization

Prior collaborations between NREL and Nevada Test Site, INEEL
Research Focus in Hydrogen

- Renewable H2 Production
- H2 Storage - Carbon Storage Center
- Technical Support
  - Codes & Standards
  - Technology Validation
- Fuel Cells
  - Systems analysis
  - Materials
- Systems Integration

Collaborations between NREL and ORNL, LANL, PNNL, LBNL

Hydrogen Power Systems Test Facilities
Renewable Energy-Based Hydrogen Production
Photobiological Algal Hydrogen Production

- A set of bio-reactors used for photobiological hydrogen production by the green alga, Chlamydomonas Reinhardtii
- The algae are grown photosynthetically and accumulate cell material.
- Then, critical nutrients are removed from the growth medium and, in the light, the cells gradually inactivate their photosynthetic oxygen evolution and remove all residual oxygen.
- Subsequently, they will produce hydrogen for several days.

Photo credit: Warren Gretz
Hydrogen Storage

• How to store hydrogen is one of the most challenging scientific hurdles to a hydrogen-based economy. Better hydrogen storage is particularly crucial for fuel-cell powered vehicles, where weight and the size and shape of hydrogen tanks is critical. Carbon nanotubes are one possibility.

• At NREL, researchers are looking into reversible chemical storage materials, including carbon-containing materials such as carbon nanotubes—tiny, lightweight carbon cylinders, each having a diameter equal to several hydrogen molecules. Heben, and other NREL scientists have shown that hydrogen may be drawn up into these carbon tubes just as water is drawn up into a drinking straw. So, they are working on fabricating bundles of aligned nanotubes. These would essentially be lightweight hydrogen "sponges," ideal for a vehicular hydrogen storage system.
Research Focus in Vehicles

- Systems modeling (digital functional vehicle)
- Renewable fuels and lubricants
- Auxiliary load reduction
  - Air conditioning/heating
  - Power electronics

Collaborations between NREL and ORNL, ANL
NREL Buildings Research

- Whole building design and simulation
- Building systems integration, validation and testing
  - Zero-energy homes
  - High-performance commercial buildings
- Emerging technologies
  - Solid state lighting, prismatic lenses
  - Electrochromic windows
  - Desiccant system testing

Collaborations between NREL and PNNL, ORNL, LBNL

Thermal Test Facility

HVAC Test Loop
Zero Energy Buildings

- Fuel cells integrated into buildings
- Building-integrated PV
- Smart energy management systems
- Electrochromic windows
- Precise building energy modeling
- Energy independent homeowners
Zion National Park: Visitor Complex in Springdale, UT

- The Zion National Park Visitor Center and Comfort Station is one of the National Park Service's (NPS) most efficient complexes.

**Features:**
- 7,600-ft² (706-m²) Visitor Center and 1,100-ft² (102-m²) Comfort Station
- Daylighting, Trombe walls for passive solar heating, downdraft cooltowers for natural ventilation cooling, energy-efficient lighting, and advanced building controls. Features result in estimated 10 kW of electrical demand savings.
- A roof-mounted photovoltaic (PV) system provides electrical power. The PV system reduces the amount of power purchased from the utility and it supplies backup power when grid power is not available.
- Transportation inside the park is part of the redesign. Clean-running propane buses shuttle visitors to nine stops in Zion Canyon and six stops in the nearby town of Springdale, dramatically reducing the number of vehicles inside the park and improving the visitor's experience.
More High Performance Buildings Case Studies

Resources