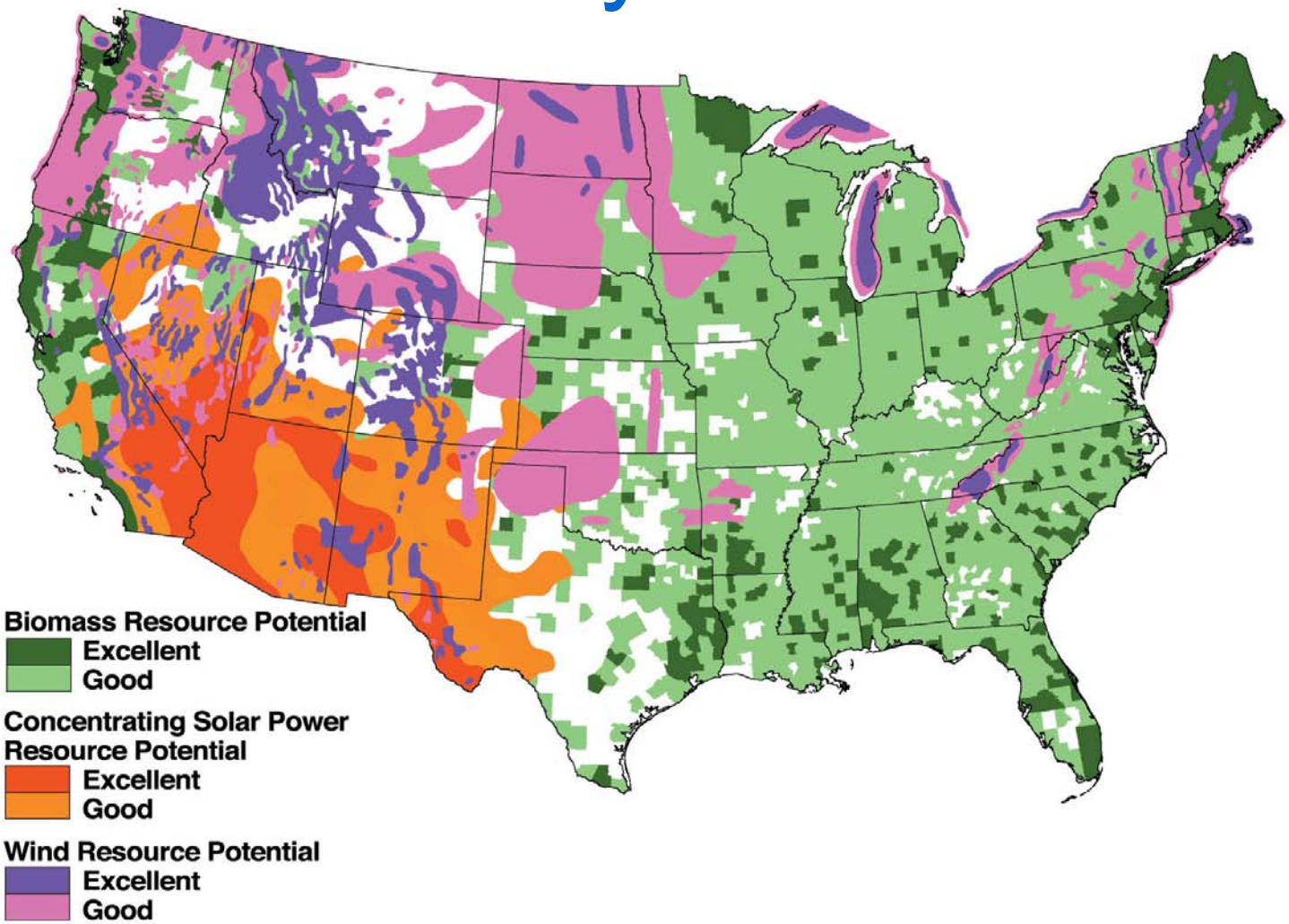
Research, Development and Demonstration Success Stories for New and Renewable Energy Technologies in the US

Harvey Major
US Department of Energy

EGNRET 23 Meeting
Hanmer Springs, New Zealand
November 10, 2004

Excellent to Good Resources Everywhere

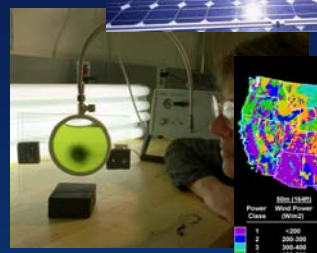
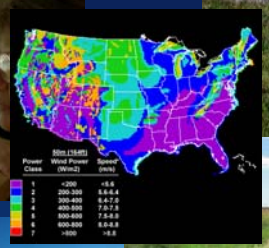


Major Research Programs

Renewable Resources

- Wind
- Solar
- Biomass
- Geothermal



Energy Delivery & Storage

- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage



Efficient Energy Use

- Vehicle Technologies
- Building Technologies

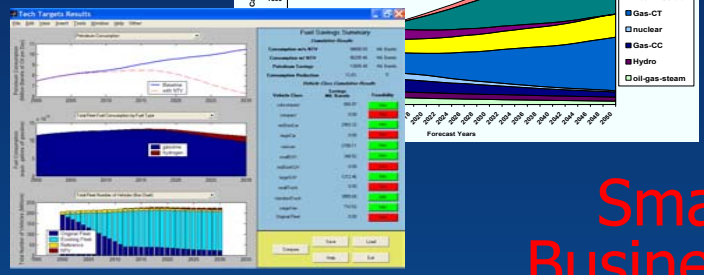
Technology Management Programs

Federal Energy Management

Pentagon

Zion National Park

Analysis



Intergovernmental

Village Power Project

State & Local

Small Business

NREL Enterprise Growth Programs

Major U.S. Department of Energy Laboratories

Research Focus in Solar

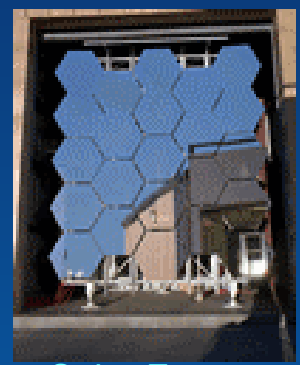
- Photovoltaics
  - Device design
  - Advanced manufacturing
  - Measurement and characterization
  - Nanomaterials and applications
  - Predictive solid state theory
- Concentrating Solar Power
  - Reflective materials
  - Trough system analysis & testing
- Solar Heating
  - Polymer water heater analysis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

Collaborations between NREL and Sandia, BNL

Solar Energy Research Facility

Outdoor Test Facility

Science & Technology Facility



Solar Furnace

Solar Energy Radiation Lab

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).

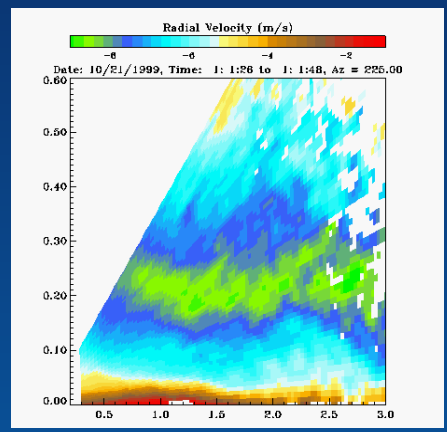
NREL, Global Solar Energy, Inc.,
ITN Energy Systems, Inc.

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

Blade Test Facility

Turbine Test Facility



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

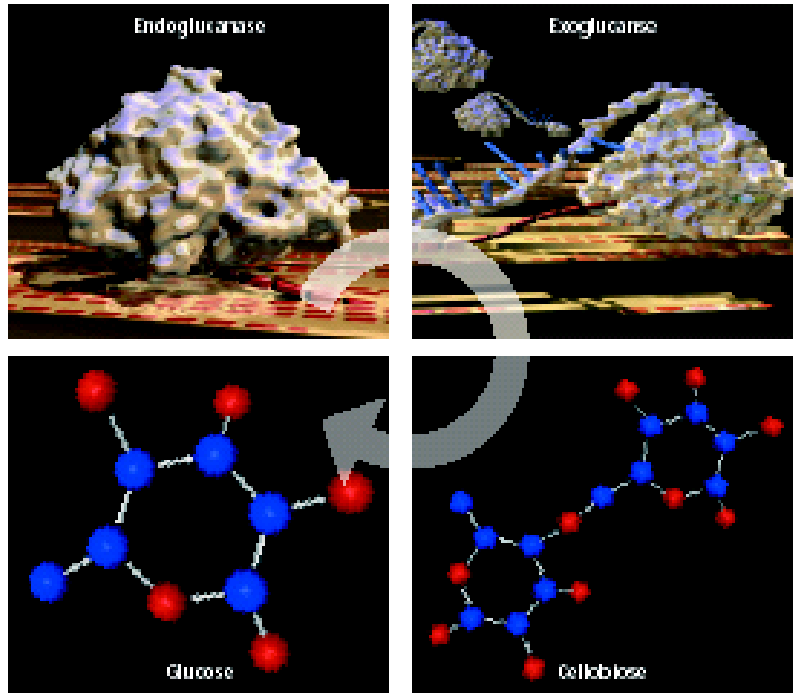
Collaborations between NREL and ANL, INEEL, PNNL, ORNL

2004 R&D 100 Award
Enzymatic Hydrolysis of Biomass Cellulose to Sugars

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

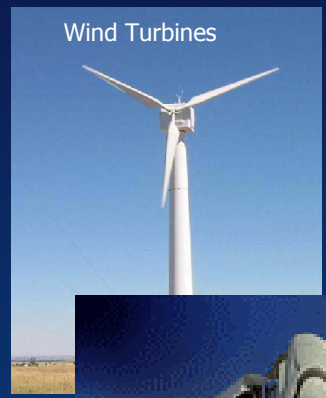
- Advanced thermal conversion systems
- Corrosion resistant components
- Plant design and testing

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

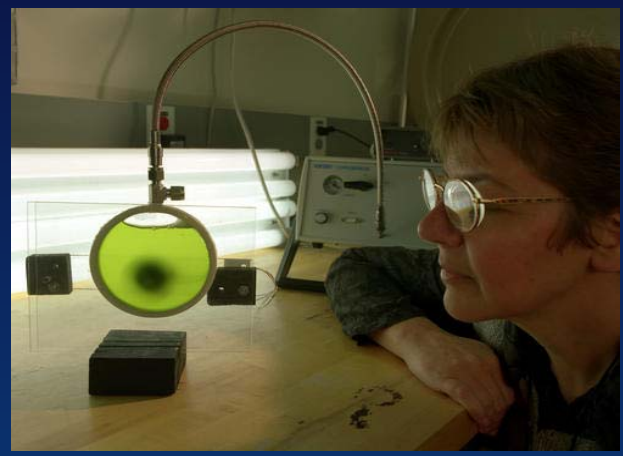
Prior collaborations between NREL and Nevada Test Site, INEEL



Data Acquisition

Research Focus in Hydrogen

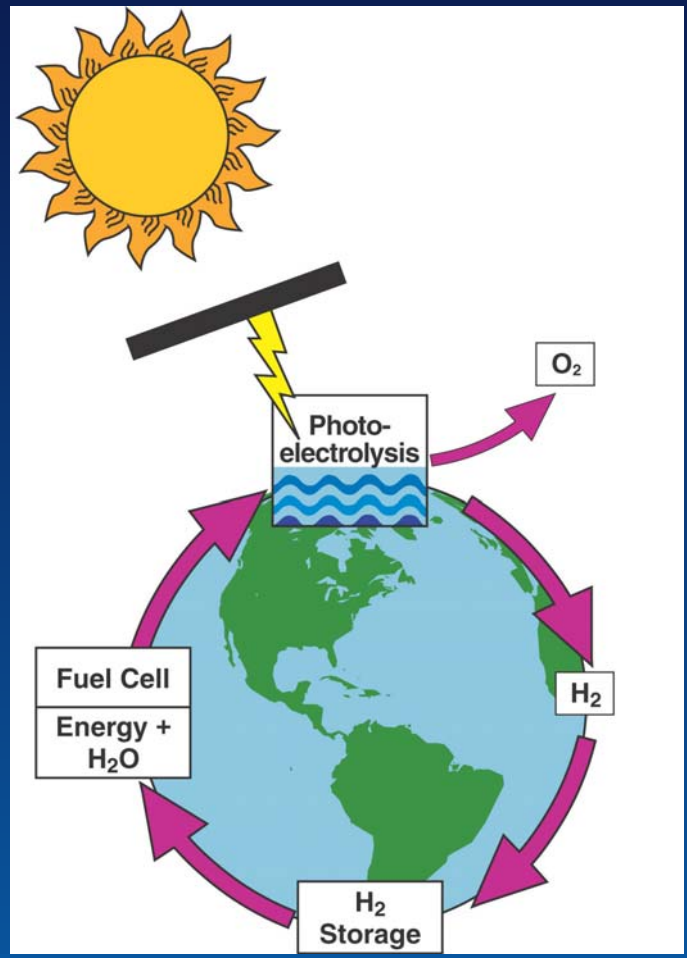
- Renewable H2 Production
- H2 Storage - Carbon Storage Center
- Technical Support
  - Codes & Standards
  - Technology Validation
- Fuel Cells
  - Systems analysis
  - Materials
- Systems Integration



Hydrogen Power Systems Test Facilities

Collaborations between NREL and ORNL, LANL, PNNL, LBNL

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.

Photo credit: Jim Yost

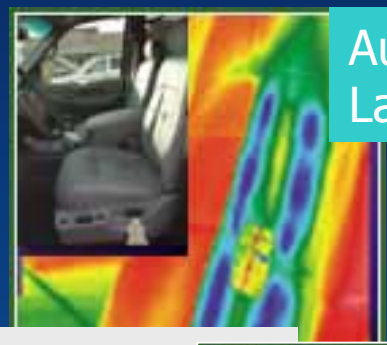
Research Focus in Vehicles

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

Chassis Dynomometer

Refuel Lab

Fuels Chemistry Lab

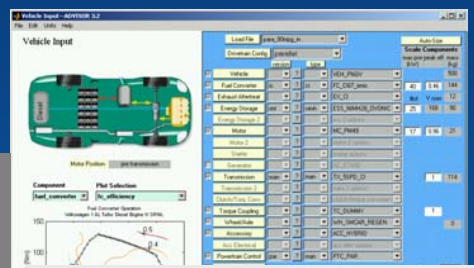


Visualization & Testing

Auxiliary Load Laboratories

Thermal Manikin

Battery Test Lab



Vehicle Systems Models

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

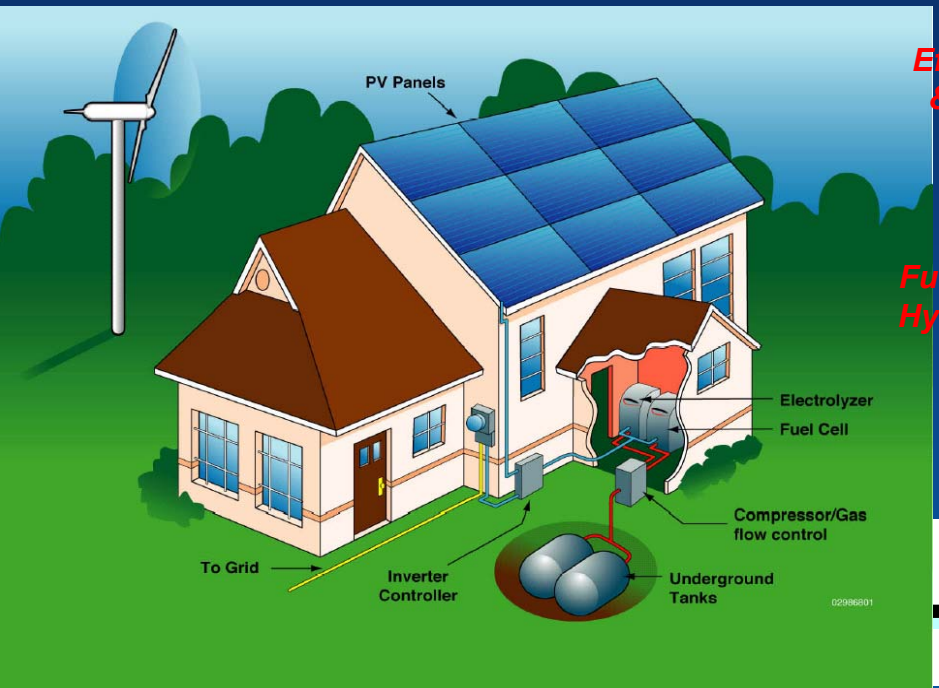
Collaborations between NREL and PNNL, ORNL, LBNL

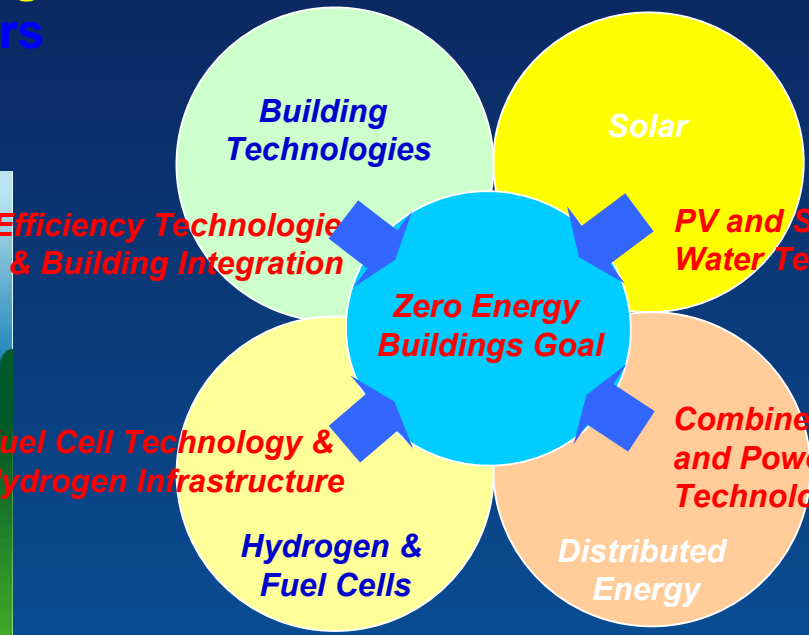

Thermal Test Facility


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

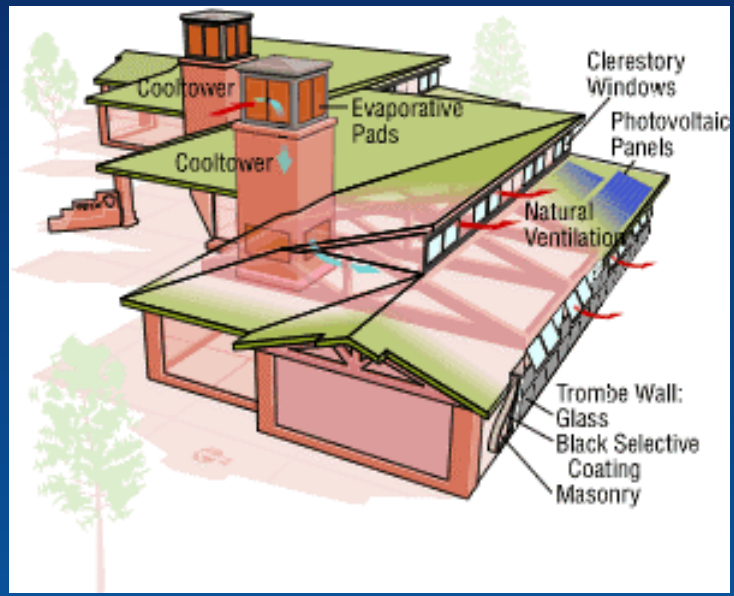
- The Zion National Park Visitor Center and Comfort Station is one of the National Park Service's (NPS) most efficient complexes.

Features:

- 7,600-ft^2 (706-m^2) Visitor Center and 1,100-ft^2 (102-m^2) 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 photovolatic (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

- http://www.eere.energy.gov/buildings/highperformance/case_studies/



Resources

- US Renewable Energy R&D and Market Development: www.nrel.gov
- US DOE Renewable Energy Programs: http://www.eere.energy.gov