Energy Diversity

The 26th Pacific Islands Environmental Conference

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June 2009
What Makes NREL Unique?

Only national laboratory whose primary mission is renewable energy and energy efficiency R&D

Roles span from fundamental science to technology application assistance

Collaboration with industry and university partners is a hallmark

Research conducted with a systems and market perspective
World-Class Competencies in Key Areas

Integrated Energy System Engineering & Testing

Strategic Energy Analysis

Renewable Electricity Science & Technology

Foundational Science

Renewable Fuels Science & Technology
QuickTime™ and a decompressor are needed to see this picture.
Strategic Energy Applications

Co-Development

Technology Transfer/Technology Maturation

Catalyzing Investment

Removing Barriers

Informing Technology or Policy Decisions

Facilitating Energy Projects

Supplier

End User

Strategic Energy Applications
Technology Thrusts

Supply Side
- Wind Energy
- Solar Photovoltaics
- Concentrating Solar Power
- Solar Buildings
- Biomass Power
- Biofuels
- Geothermal Energy
- Hydrogen
- Superconductivity
- Distributed Power

Demand Side
- Hybrid Vehicles
- Fuels Utilization
- Buildings Energy Technology
- Federal Energy Management
- Advanced Industrial Technologies

Cross Cutting
- Basic Energy Science
- Analytical Studies
- International
- State, Local & Tribal
Role of Analysis

Investing for impact along the concept to commercialization pathway
A typical solar cell (10cm x 10cm) generates about 1W at about 0.5V.
PV Cells

*PV Cells are wired in series to increase voltage...*  
*and in parallel to increase current*
PV is Modular

Cells are assembled into modules, and modules into arrays.
Modules

Individual cells are connected in series (increases the voltage) and in parallel (increases the current) into a module.
Building Integrated PV & Substrates
DC PV System Example:
PJKK Federal Building, HI

2 solar panels per lamp with peak output of 96 watts
39 Watt fluorescent lamps, 2500 lumens
90 amp-hour battery powers 12 hours per night
~$2500 per light
Military Field Applications

USDA Forest Service
Thin Film Technologies On Glass
Historically, the primary means of providing power have been through grid extension and diesel generators.

- **Grid Extension:** Very high initial cost, poor cost recovery, time intensive (generation, transmission, distribution) and usually must be subsidized. Most often used.

- **Diesel Generators:** Inexpensive installation but expensive to operate, environmental damage/pollution, and subject to volatile fuel costs and availability.
Water Pumping Designs
Hybrid Power Systems are Not New

Carol Spring Mtn., AZ

Mt. Home AFB, ID

Test Ban Treaty Monitoring, Antarctica

McMurdo Station, Antarctica
Importance of “Micro-Siting”
Hybrid PV/Generator System
Hybrid Power Systems

Hybrid power systems use local renewable resources to provide power.

Community hybrid power systems can range in size from small household systems (100 Wh/day) to systems supplying a whole area (10’s MWh/day). They combine many technologies to provide reliable power that is tailored to the local resources and community.

Potential components include: PV, wind, micro-hydro, biomass, batteries, conventional generators, and direct load control.
Agricultural Water Pumping

Livestock watering at the Bledsoe Ranch Colorado, USA

PV, Mechanical wind and diesel backup solves problems with seasonal variations in resource

NEOS Corporation
Home Power Systems

Systems do not have an automated backup generator like most larger hybrids

Very simple architecture:
  – Turbine, PV, Disconnects, Batteries
  – DC Loads or AC power through an inverter

Primarily PV dominated for small loads, wind has potential at larger loads.

In many instances a combination of PV and wind make most sense

Can vary in size, power output
Single Home Systems/mini-grids

Chipepte, Mexico
- Windseeker 503
- 1000Ah, 12V, “No maintenance” Battery Bank
- < 100W DC Loads

Pez Maya, Mexico
- 2 AIR Marine 403 turbines
- 1000Ah, 12V, “No maintenance” Battery Bank
- 1100W inverter
- power to a small mini-grid for homes and cottages

Pez Maya
Remote Telecommunications station

- Power System
  - PV array
  - Two wind turbines
  - No Backup generator
- Vary costly access/site visits
- Remote operation and monitoring of system

Northern Power Systems
San Juanico, Mexico

Remote fishing & tourism community of 400 people

Power System
17 kW PV
70 kW wind
80 kW diesel generator
100 kW power converter/controller
Advanced monitoring system
Inner Mongolia
Remote Village of Joanes, Brazil

Remote village the Island of Marajo

50kW Power System
- PV array
- Four wind turbines
- Backup generator

Power system used to support local grid

Northern Power Systems
Wind-Diesel Power Systems

Larger systems with demands over ~ 100 kW peak loads up to many MW
Based on an AC bus configurations
Batteries, if used, store power to cover short lulls in wind power
Both small and large renewable penetration designs available
Large potential mature with fewer examples
Provide conventional AC power
Ascension Island

U.S. Air Force installation on British island in mid-Atlantic ocean.
Prime diesel generation with rotary interconnect to British 50 hertz system

Four NEG-Micon 225 kW turbines installed in 1996.
Conclusions

Many options for the configuration of hybrid systems -
  Depend on load, resource, and costs.
Medium penetration wind-diesel systems are operating
  in various isolated locations around the world.
  Instantaneous wind penetration levels exceeding
  50% of load are common.
Several high penetration systems, with and without
  energy storage, have been successfully
demonstrated.
High penetration systems are capable of prolonged
diesel-off operation.
Resource Assessment

Resource **DATA** → Technology **INFORMATION**

- Maps
- Databases
- Models
- Climate Summaries
- Real-Time Data
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Strategic Energy Planning

Objectives

- Security
- Reliability
- Off-Grid Power
- Environment
- Supply Diversity
- Local Resources
- Economic Development
- Technical Expertise

Energy management team/leadership

Community energy baseline

Common energy vision

Institutional and environmental constraints

Identify and evaluate resource options

Integrate supply and demand alternatives

Strategic Plan

Project Execution
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[www.eere.energy.gov/wip/resources.cfm](http://www.eere.energy.gov/wip/resources.cfm)
Humanity’s ecological footprint, our impact upon the planet, has more than tripled since 1961. It now exceeds the world’s ability to regenerate by about 25 percent.

The biggest contribution to our footprint is the way in which we generate and use energy.
The Four C’s

• Connect
• Conserve
• Carry Out Energy Efficiency Improvements
• Consider Renewable Energy Systems