

# Energy Diversity

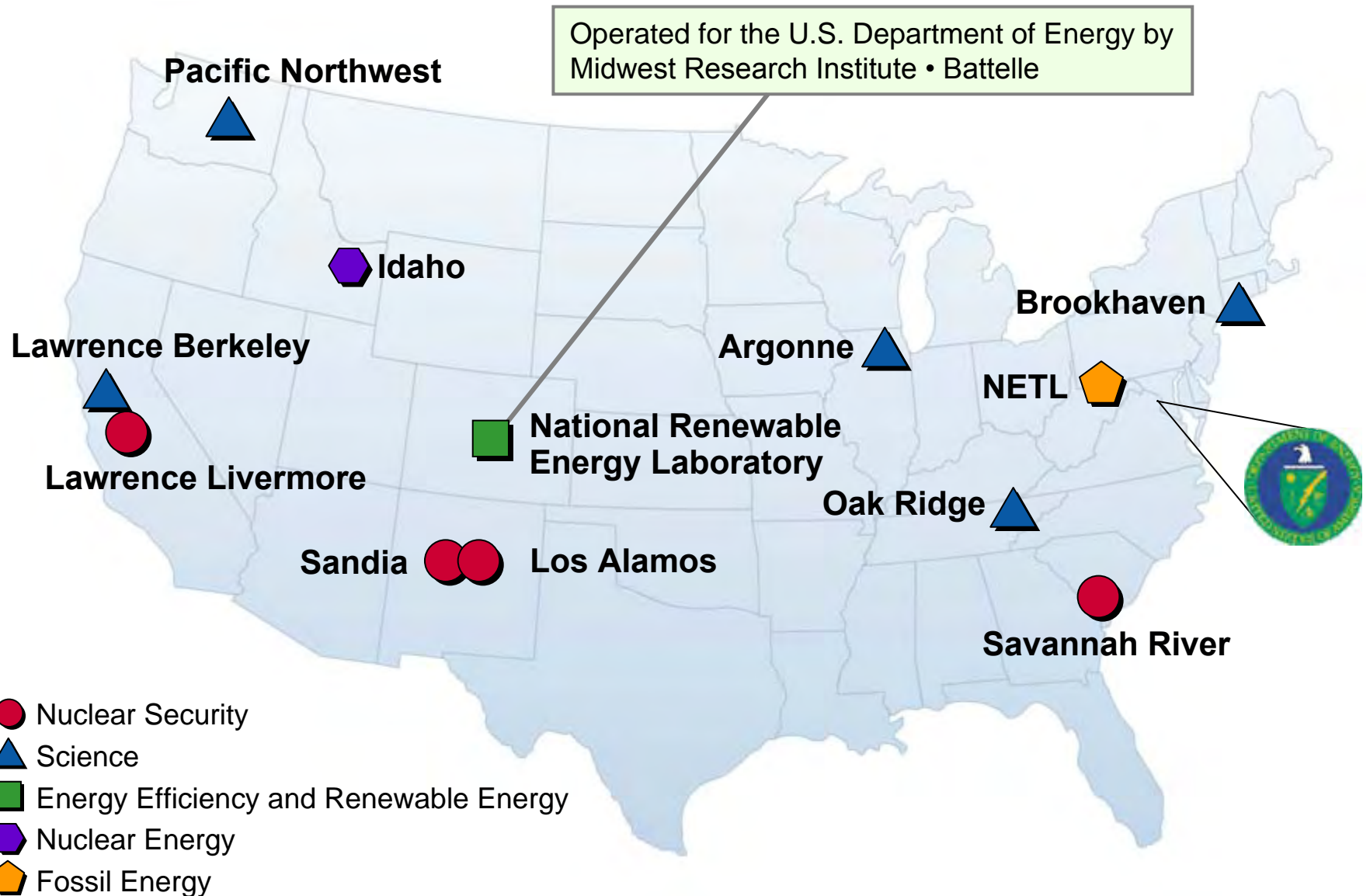


**The 26th Pacific Islands  
Environmental  
Conference**

**Misty Dawn Conrad**  
Technical Assistance Program  
Manager

**June 2009**

# Major DOE National Laboratories



# What Makes NREL Unique?

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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

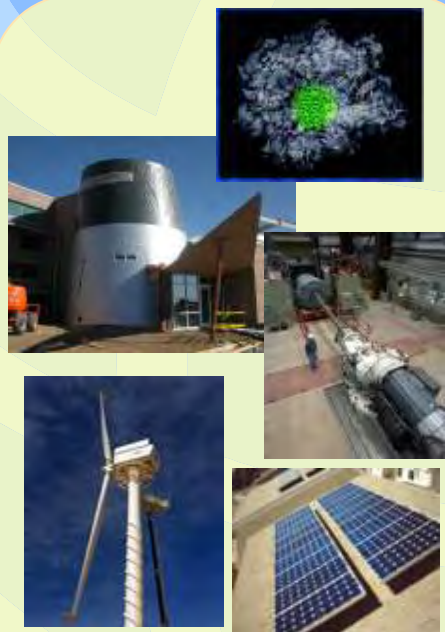
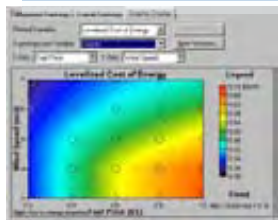
Research conducted with a systems and market perspective



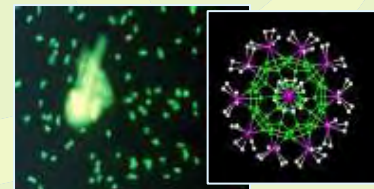
# World-Class Competencies in Key Areas

## *Integrated Energy System Engineering & Testing*

## **Strategic Energy Analysis**



## **Renewable Electricity Science & Technology**



## **Renewable Fuels Science & Technology**

## **Foundational Science**

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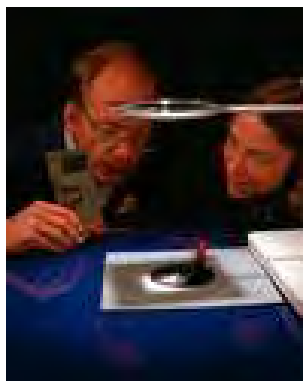
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are needed to see this picture.

# Strategic Energy Applications

Supplier



Co-Development

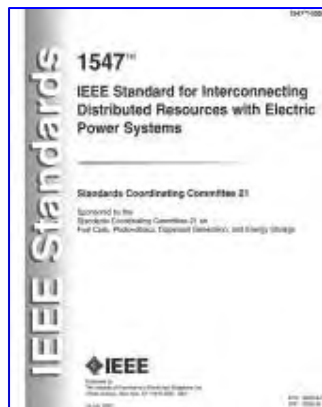


Technology Transfer/  
Technology Maturation

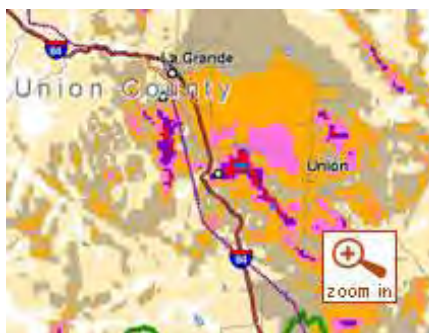


Catalyzing  
Investment

End User



Removing Barriers



Informing Technology  
or Policy Decisions



Facilitating Energy  
Projects

# Technology Thrusts

## Supply Side

Wind Energy

Solar Photovoltaics

Concentrating Solar  
Power

Solar Buildings

Biomass Power

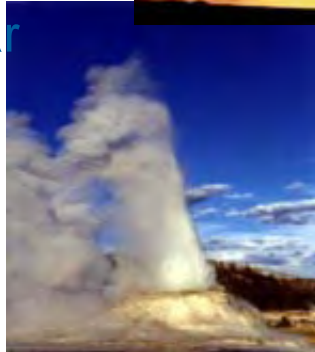
Biofuels

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

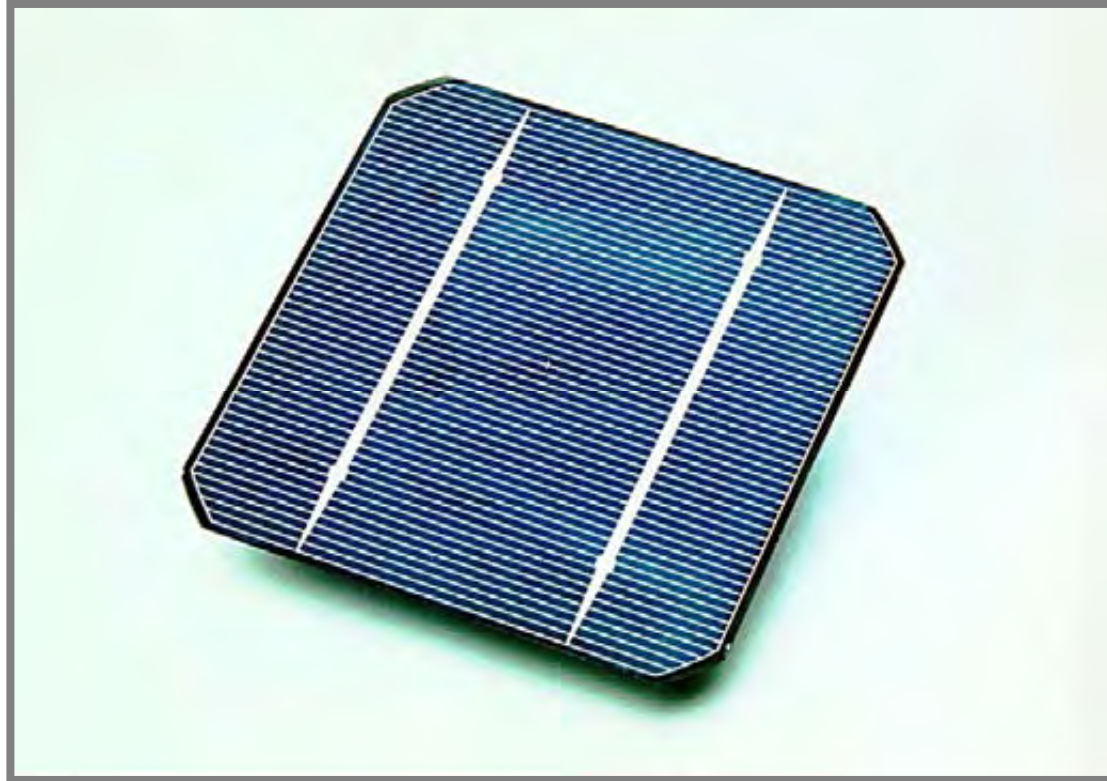
State, Local & Tribal

# Role of Analysis



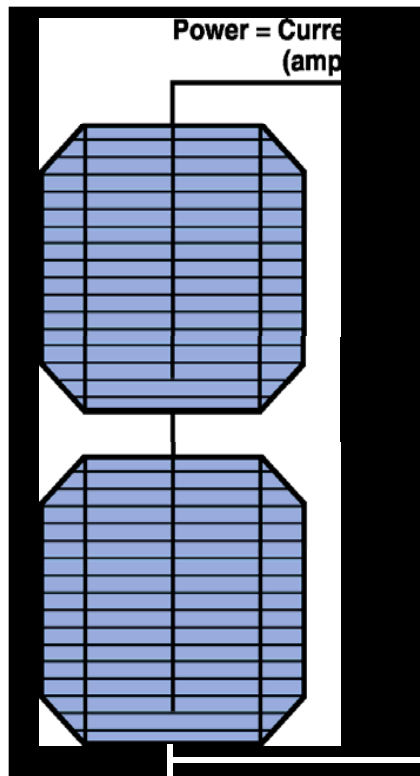
Investing for impact along the concept to commercialization pathway

**A typical solar cell (10cm x 10cm)  
generates about 1W at about 0.5V.**

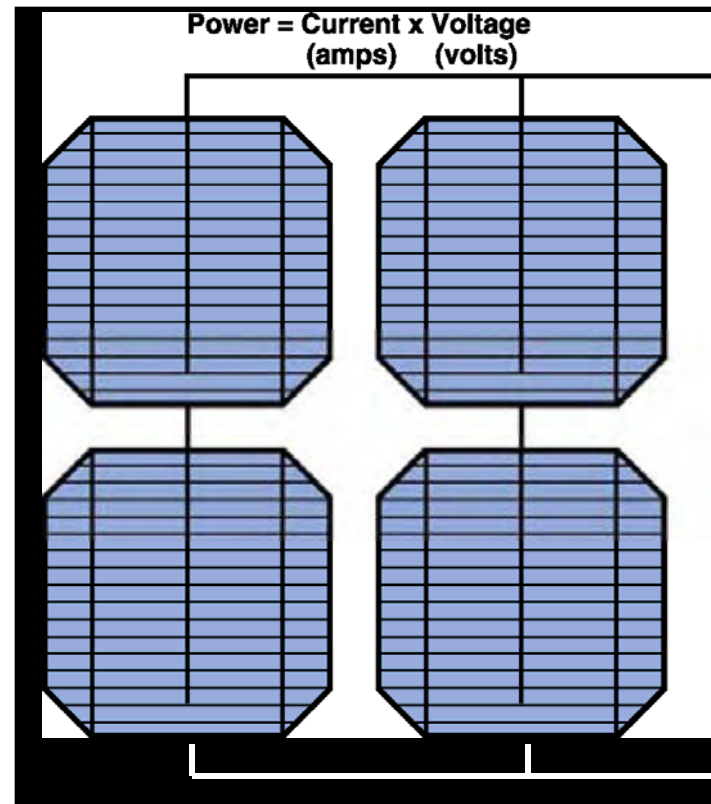


# PV Cells

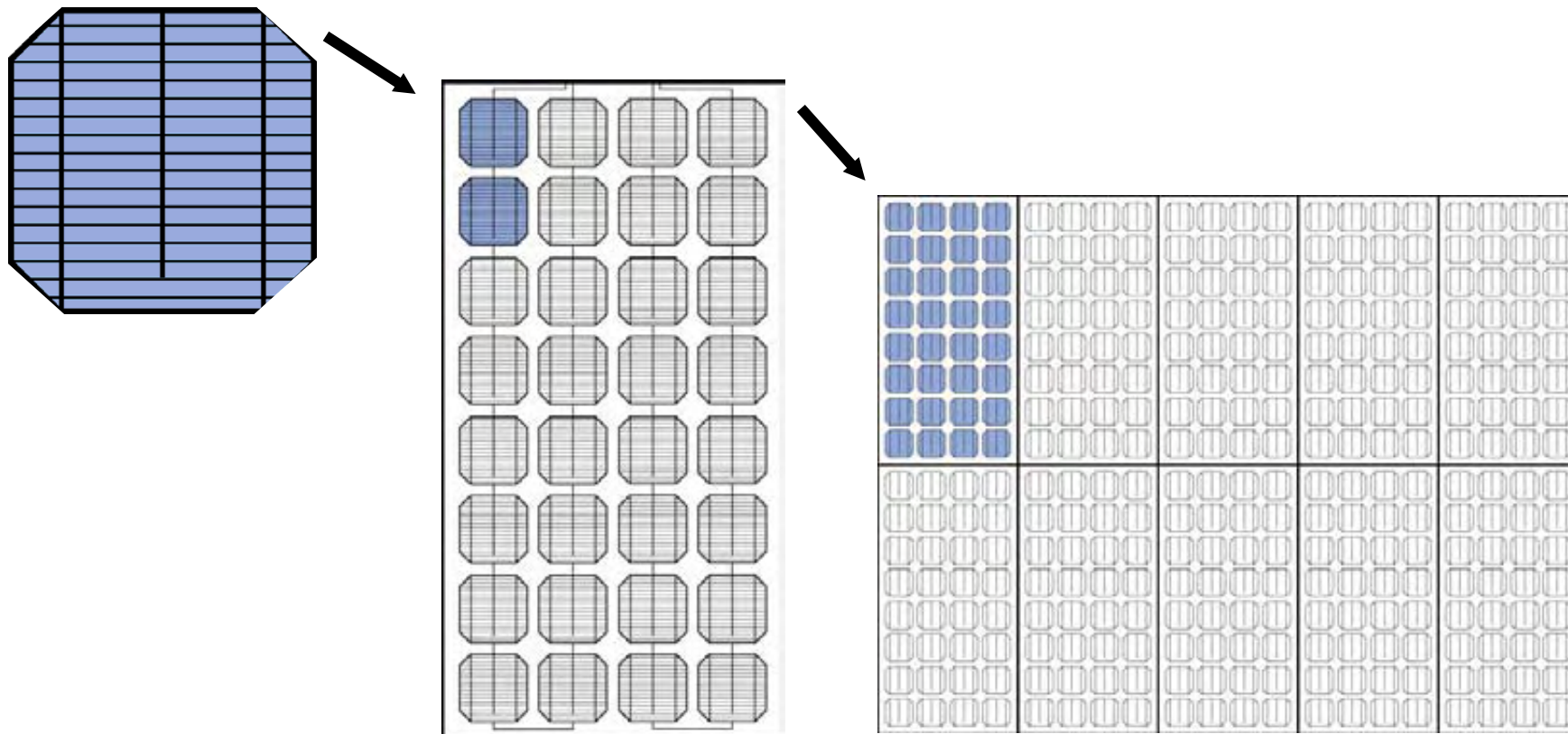
*PV Cells are wired in series to increase voltage...*



*and in parallel to increase current*



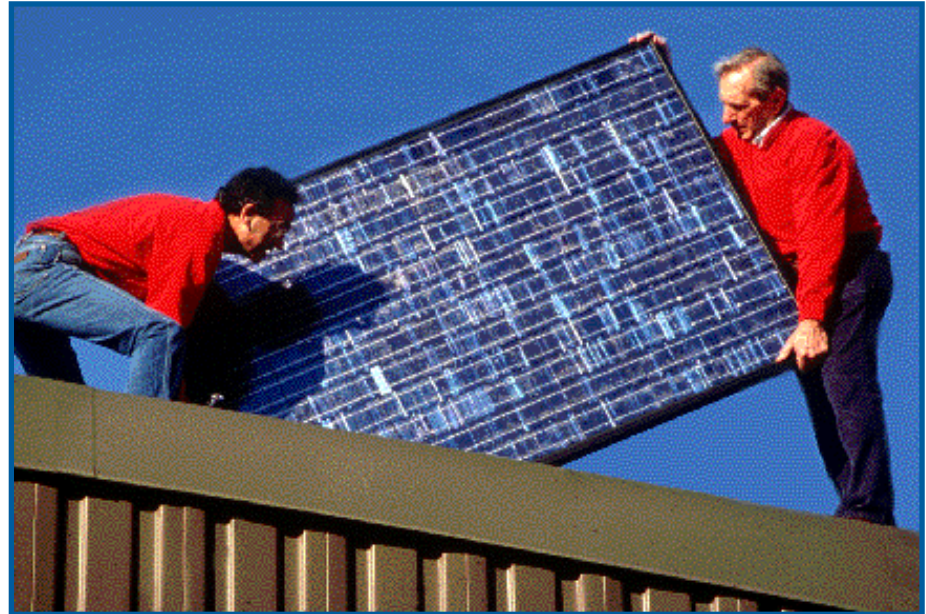
# PV is Modular



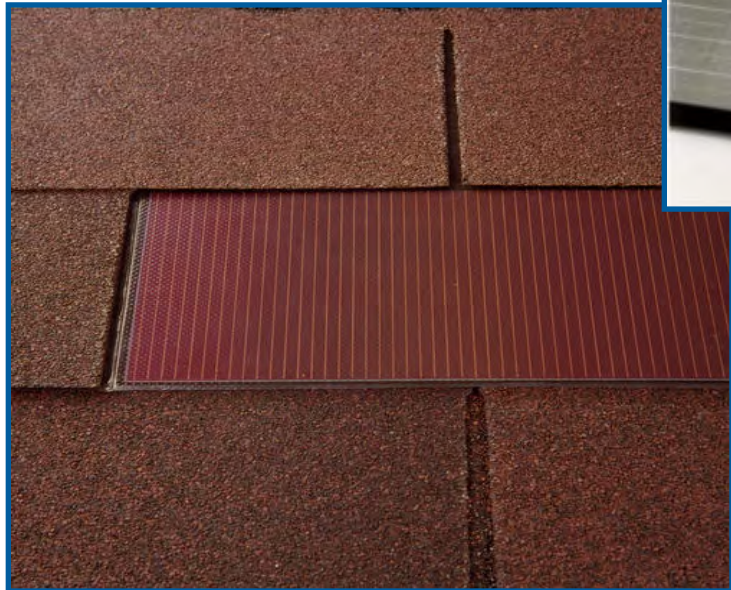
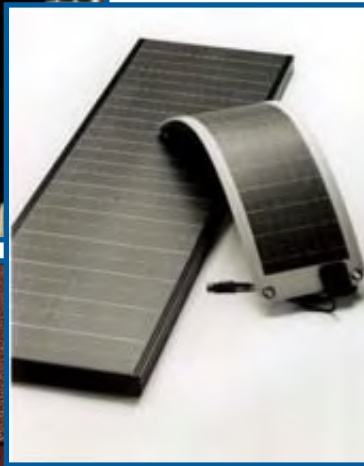
Cells are assembled into modules, and modules into arrays.

# 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

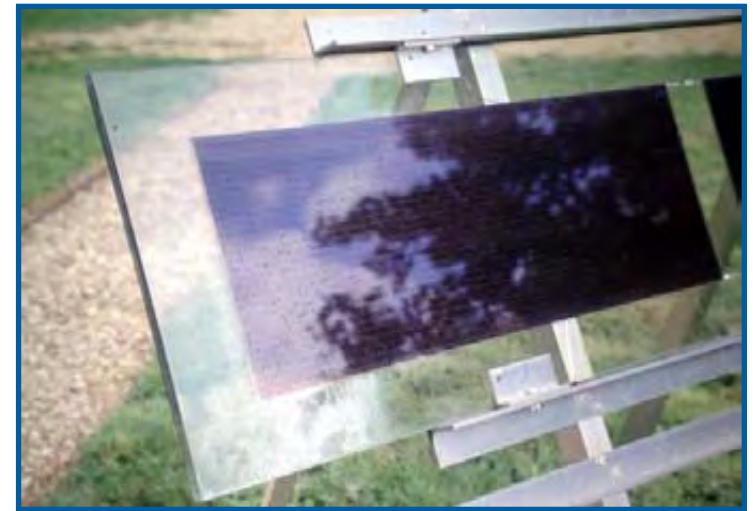


# Military Field Applications



## USDA Forest Service

# Thin Film Technologies On Glass

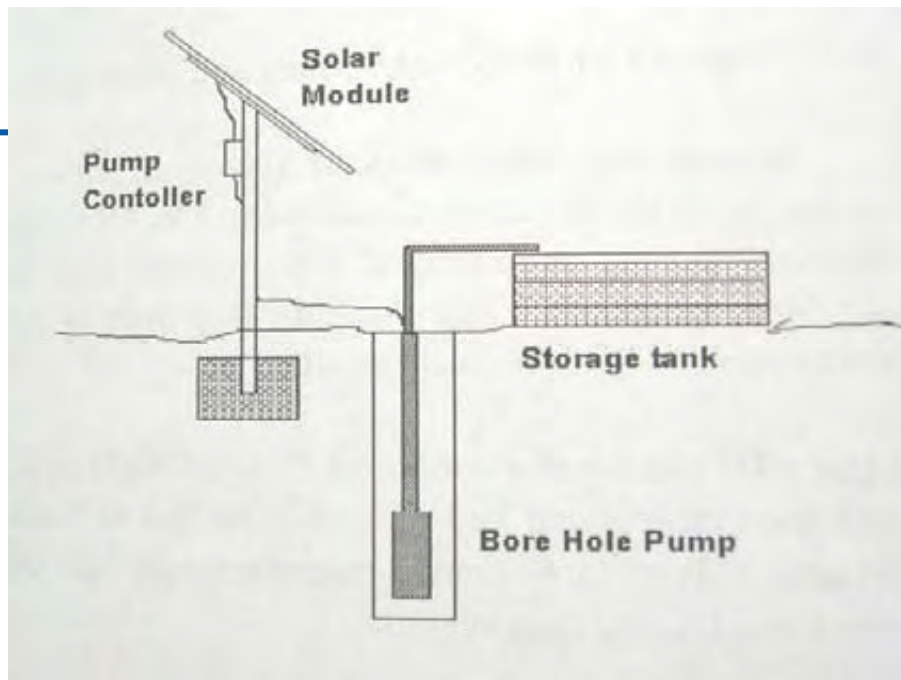


# Rural Electrification: Classics

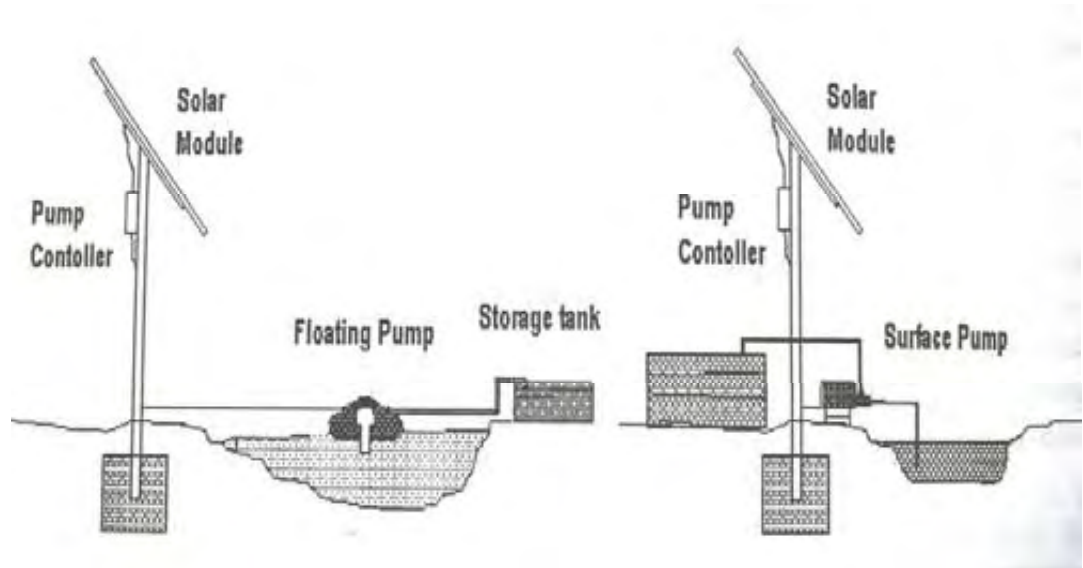
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Historically, the primary means of providing power have been through grid extension and diesel generators.

- **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.



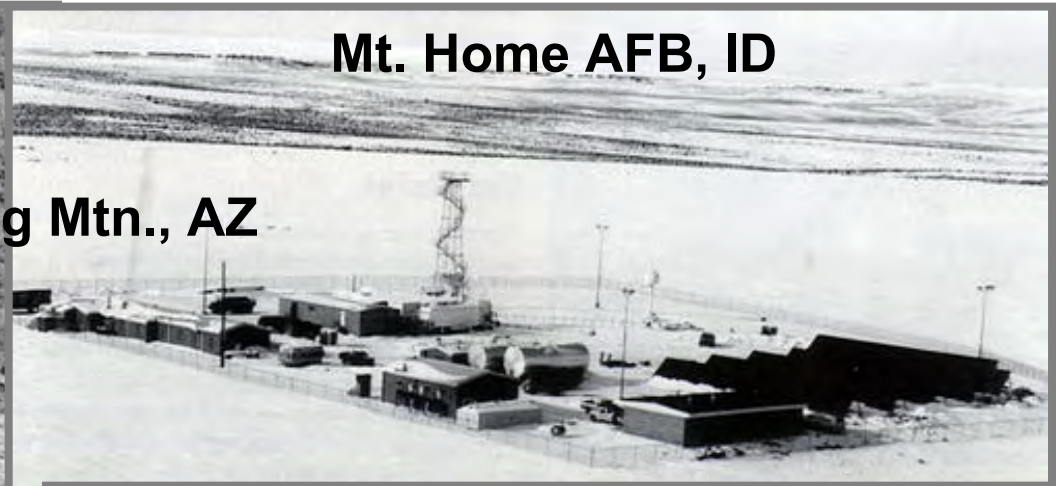
# Water Pumping Designs



# Hybrid Power Systems are Not New



**Carol Spring Mtn., AZ**



**Mt. Home AFB, ID**

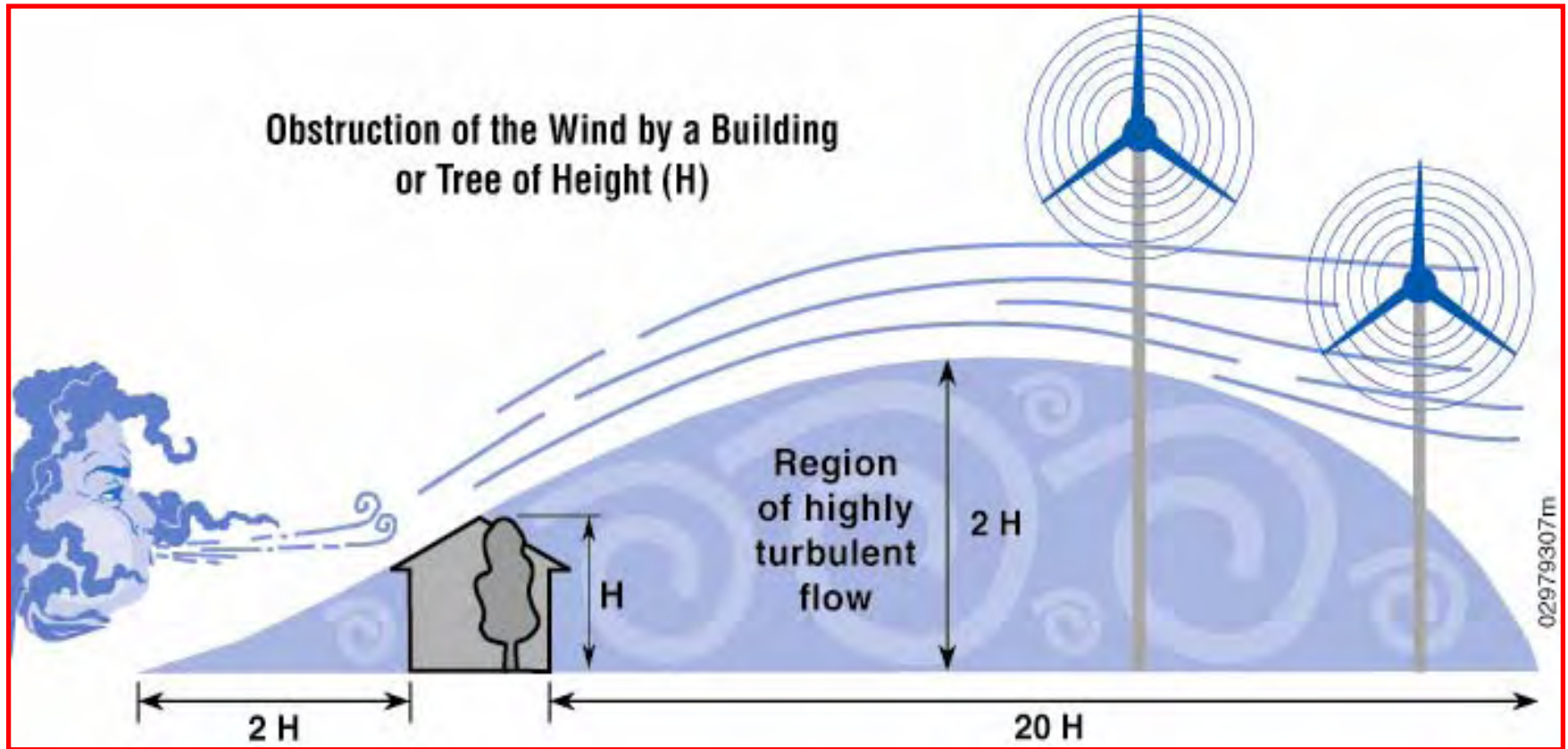


**Test Ban Treaty Monitoring,  
Antarctica**

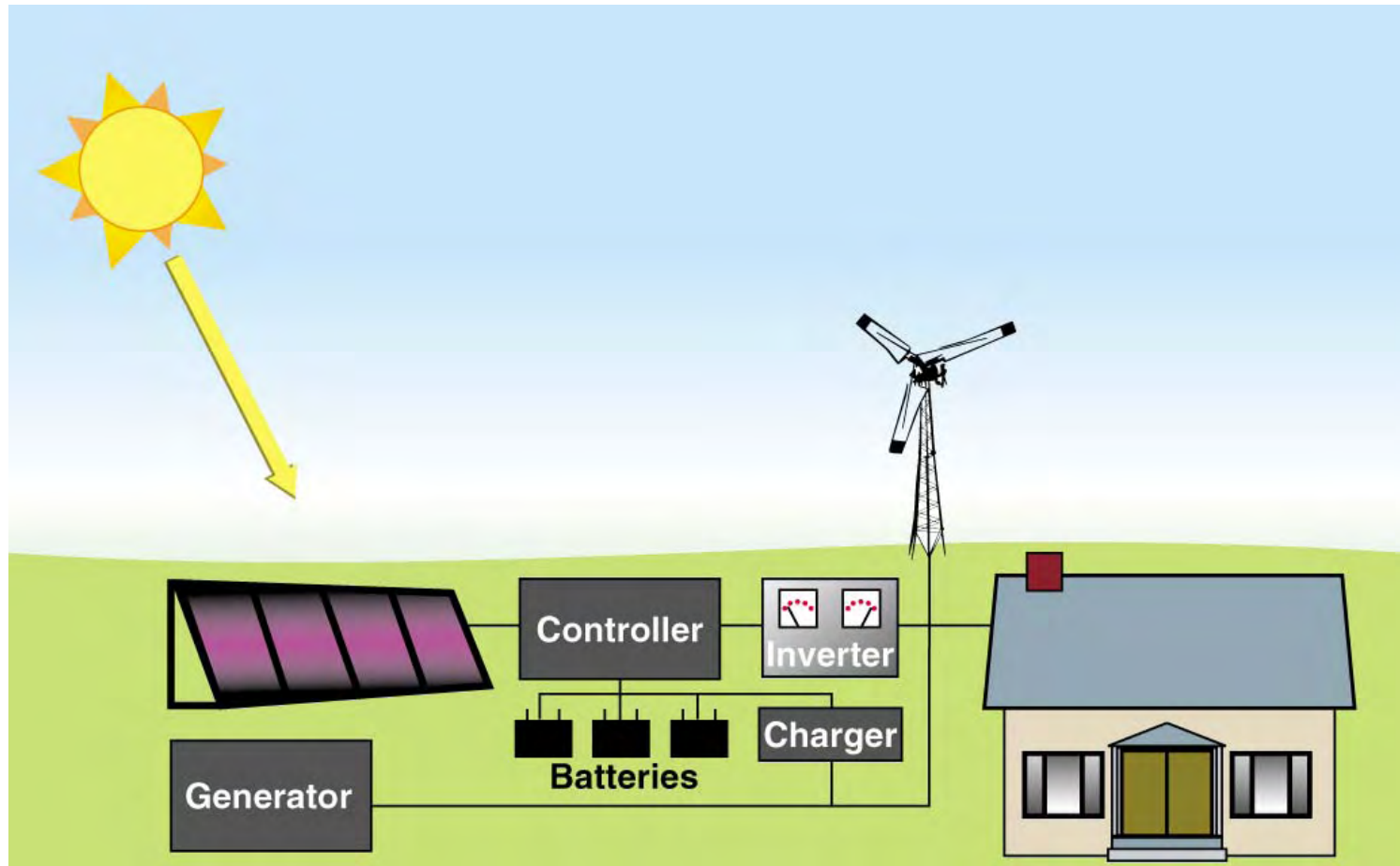


**McMurdo Station, Antarctica**

# Importance of “Micro-Siting”



# Hybrid PV/Generator System



# Hybrid Power Systems

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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

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**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

# Santa Cruz Island, California, USA

## 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



Northern Power Systems

Power system used to support local grid

# Wind-Diesel Power Systems

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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



Four NEG-Micon 225 kW turbines installed in 1996.

U.S. Air Force installation on British island in mid-Atlantic ocean.

Prime diesel generation with rotary interconnect to British 50 hertz system

# Conclusions

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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



Models



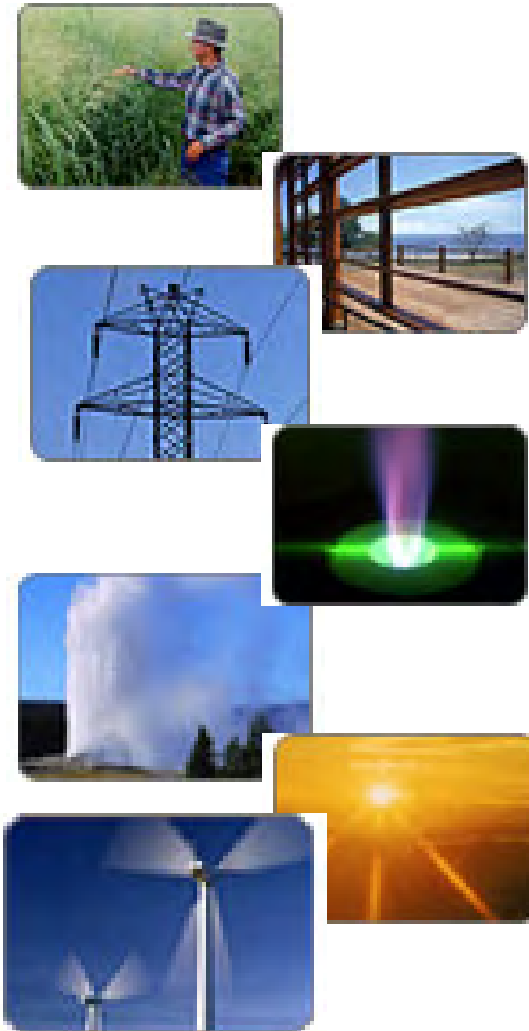
Climate  
Summaries



Databases



Real-Time  
Data



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decompressor  
are needed to see this picture.

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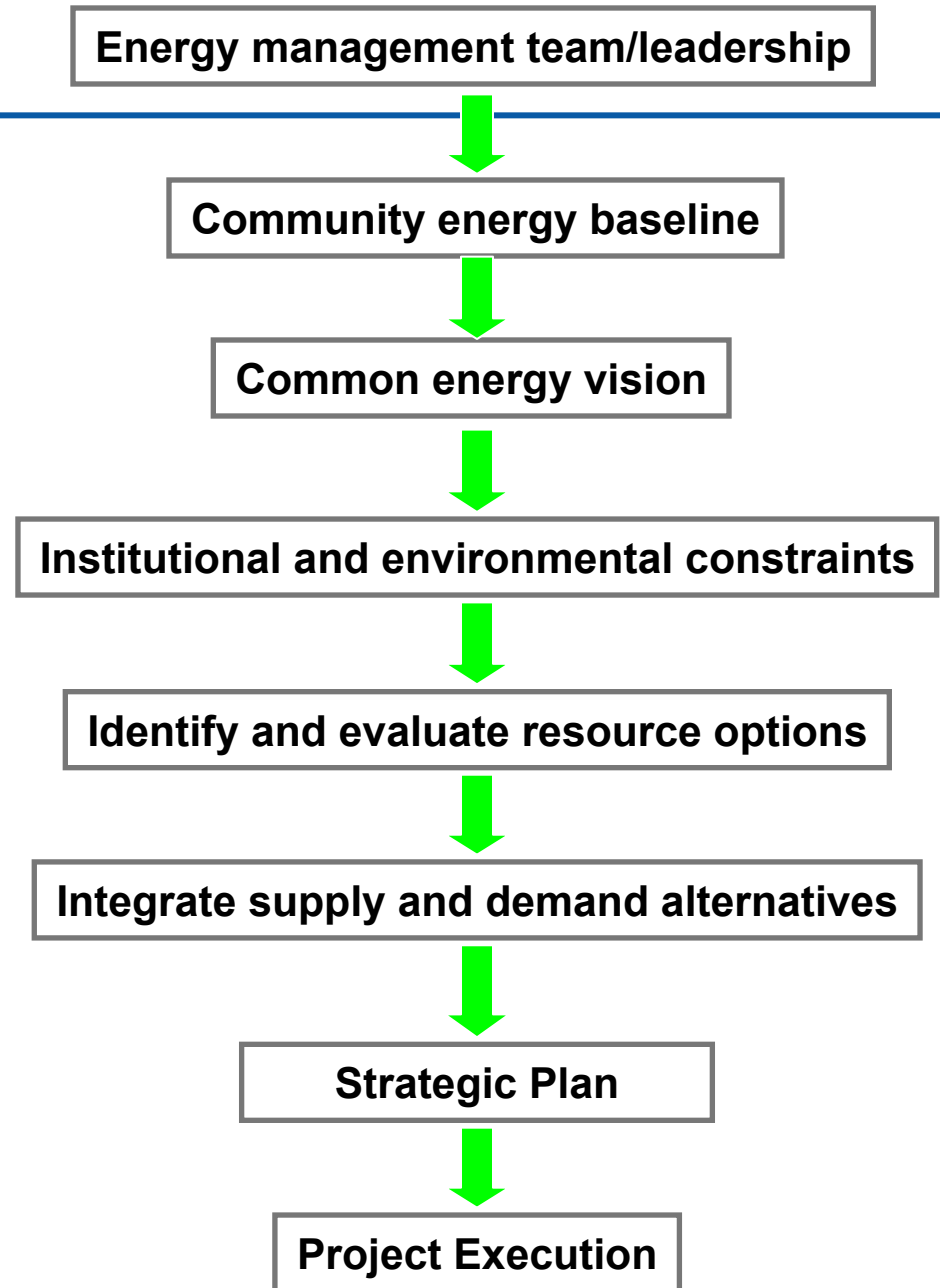


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# Strategic Energy Planning

## Objectives

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



# TAP Our Resources

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- Renewable Energy Resource Supply Assessment
- Policy Options and Analysis
- Economic Development
- Sustainable Facility and Community Planning
- Transportation Planning and Alternative-Fuel Options
- Crosscutting Resources

[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

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