National Renewable Energy Laboratory
Innovation for Our Energy Future

Renewable Energy R&D – The Laboratory's Role

Nassau, Bahamas

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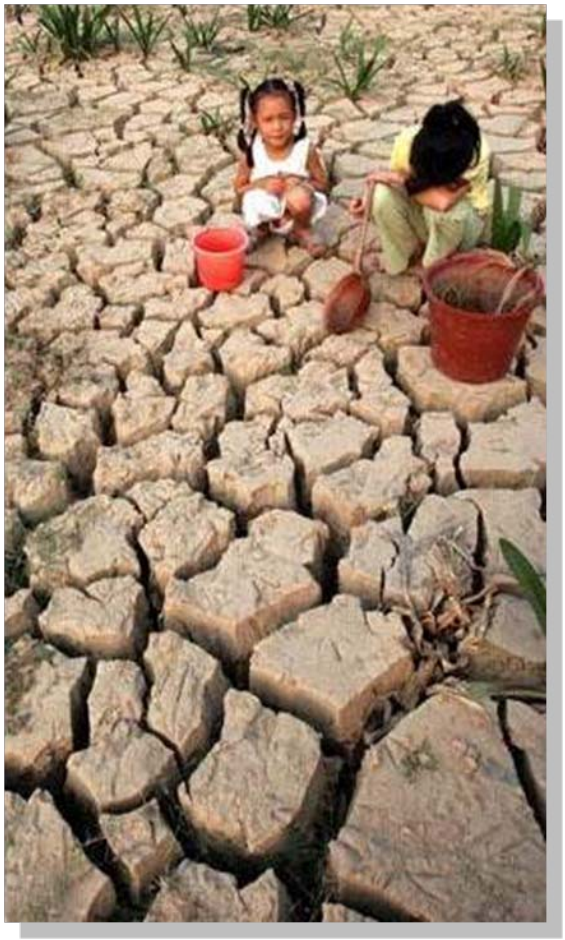
Laboratory Director

July 24, 2008

Energy Challenges are Especially Acute in Some Regions



More Than a Quarter Century of Energy R&D Contributions

Created a commercial nuclear power option

Reduced emissions from coal-fired power plants

Enhanced oil recovery from wells

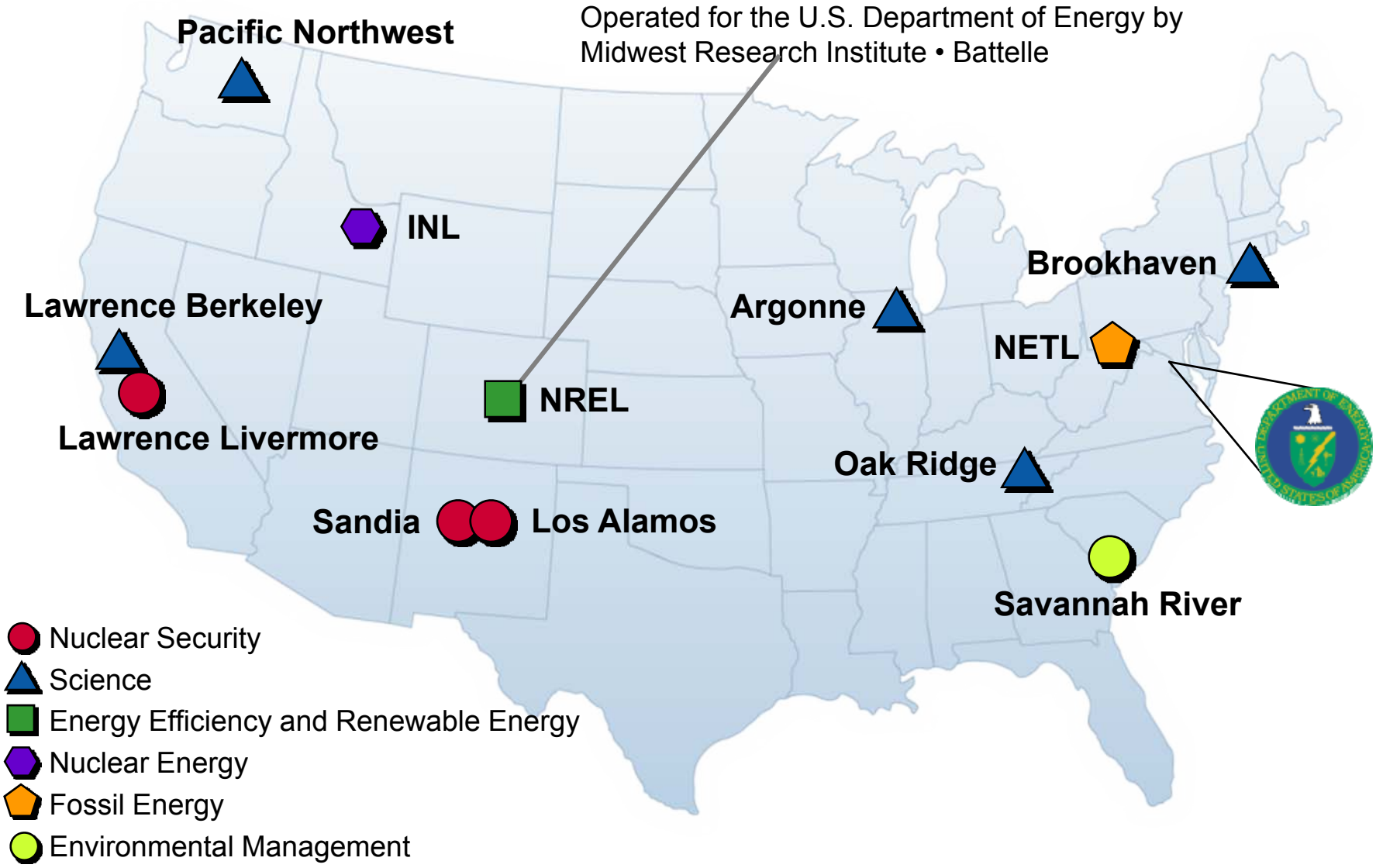
Enabled hybrid vehicles to enter the market

Brought utility-scale wind into our generation mix

Improved energy productivity

Technology innovations have had a significant impact

Major DOE National Laboratories



What Makes NREL Unique?

- Only national laboratory dedicated to renewable energy and energy efficiency R&D
- Collaboration with industry and university partners is a hallmark
- Ability to link scientific discovery and product development to accelerate commercialization

Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

- Wind and water
- Solar
- Biomass
- Geothermal

Energy Delivery and Storage

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

Foundational Science and Advanced Analytics

Efficiency – Low Hanging Fruit

Science at the Leading Edge of Energy Efficiency Research

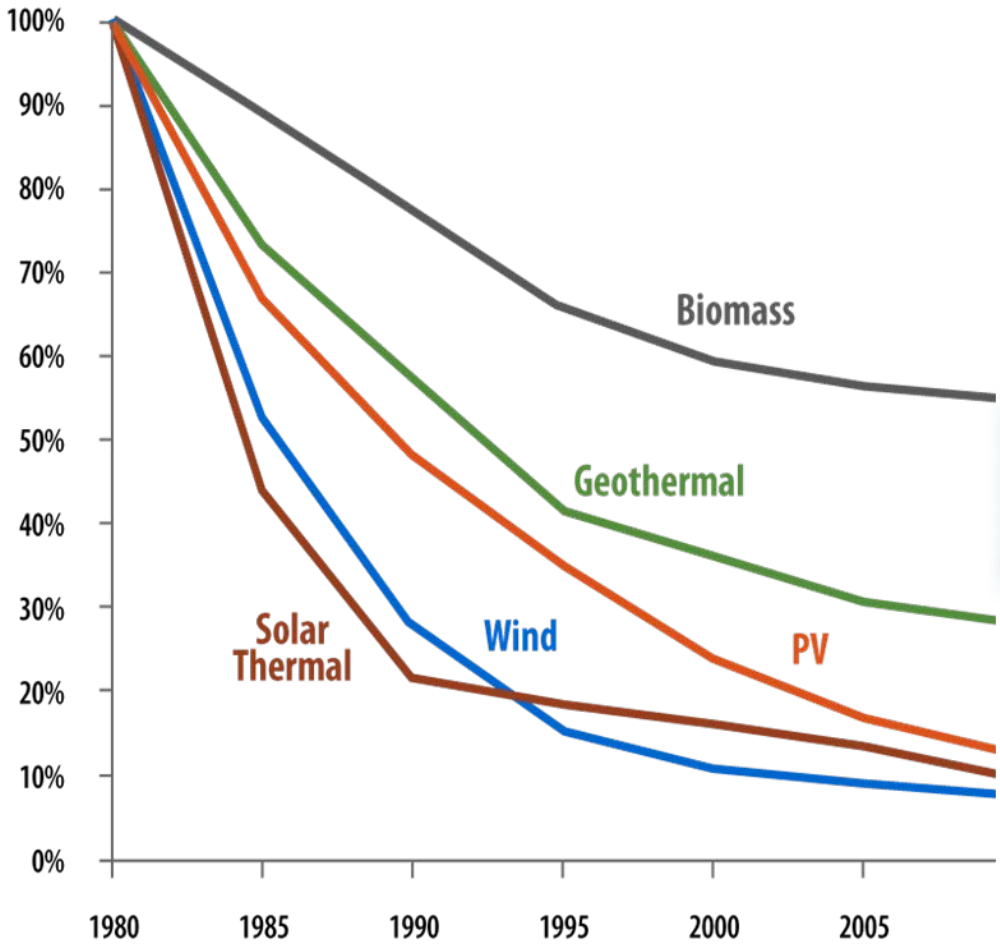
Significant improvements are anticipated through:

- SmartGrids
- Super-strong lightweight materials
- Smart roofs
- Solid state lighting
- Superconducting electric T&D

New discoveries will have broad impact on daily life

Source: Oak Ridge National Laboratory

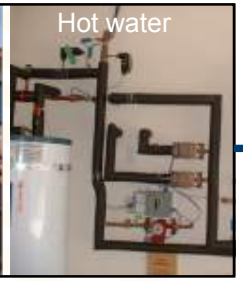
Past Investments Have Dramatically Reduced Renewable Energy Costs



Solar Energy

Applications of Solar Heat and Electricity

Solar Thermal



Photovoltaics (PV)

Concentrating Solar Power (CSP)

Distributed Generation, on-site or near point of use

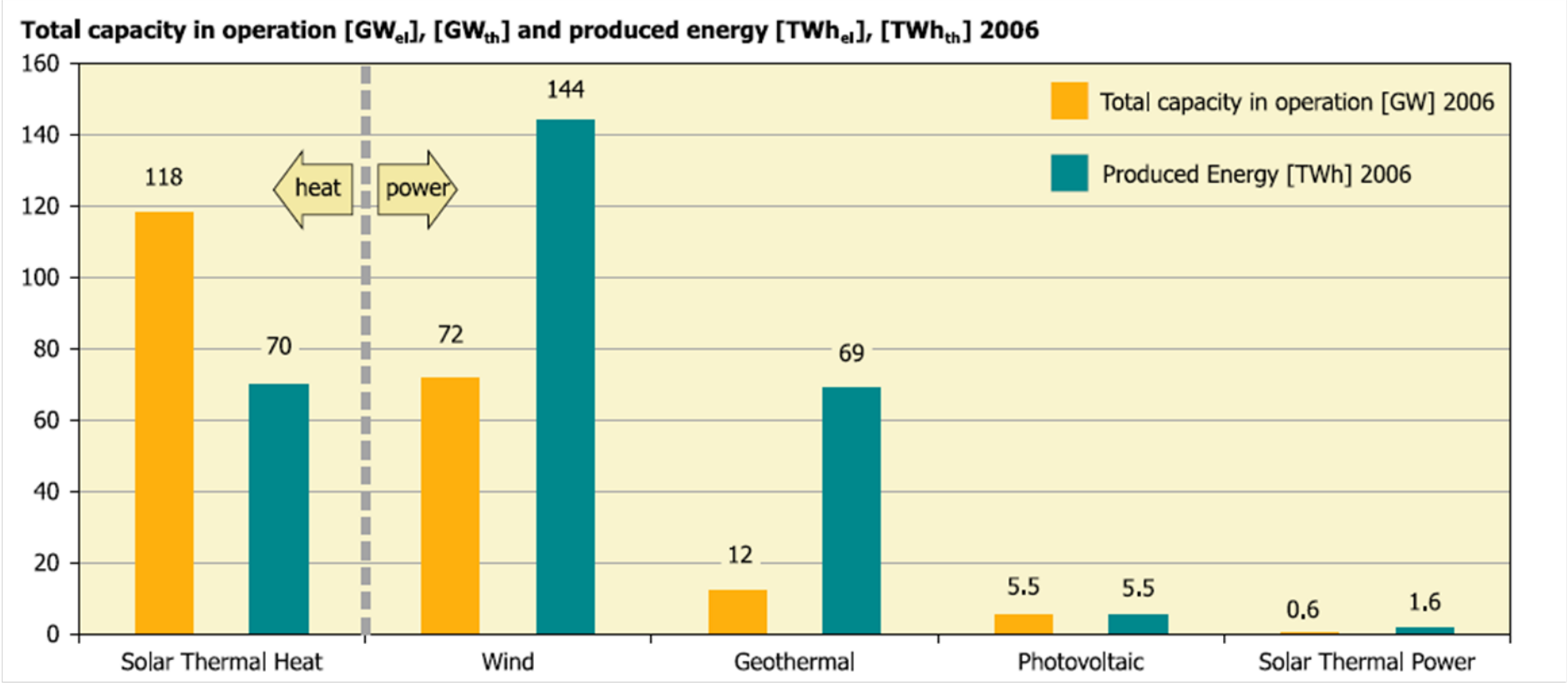
Centralized Generation, large users or utilities

Transportation

Residential & Commercial Buildings

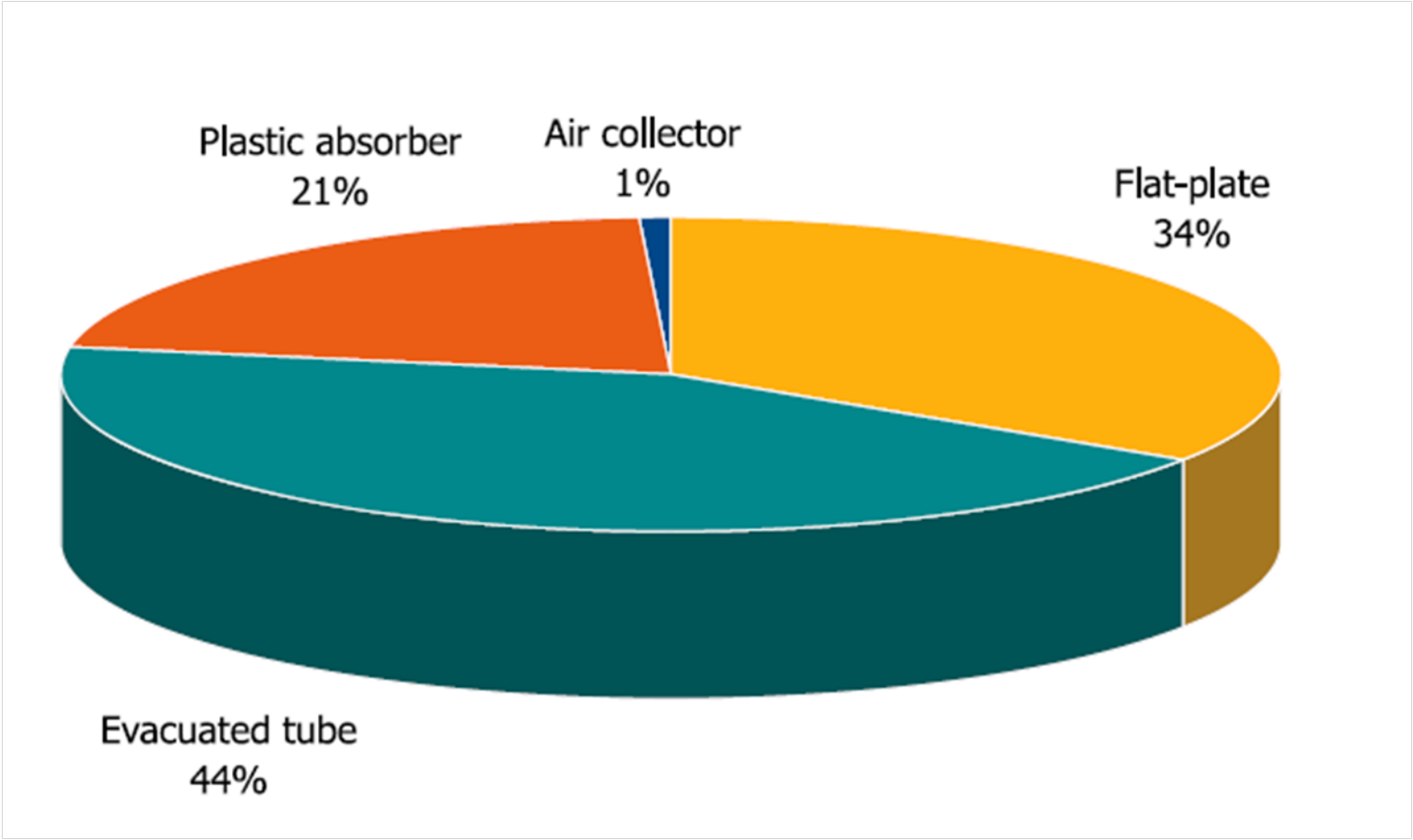
Industrial

Heat & Power Worldwide



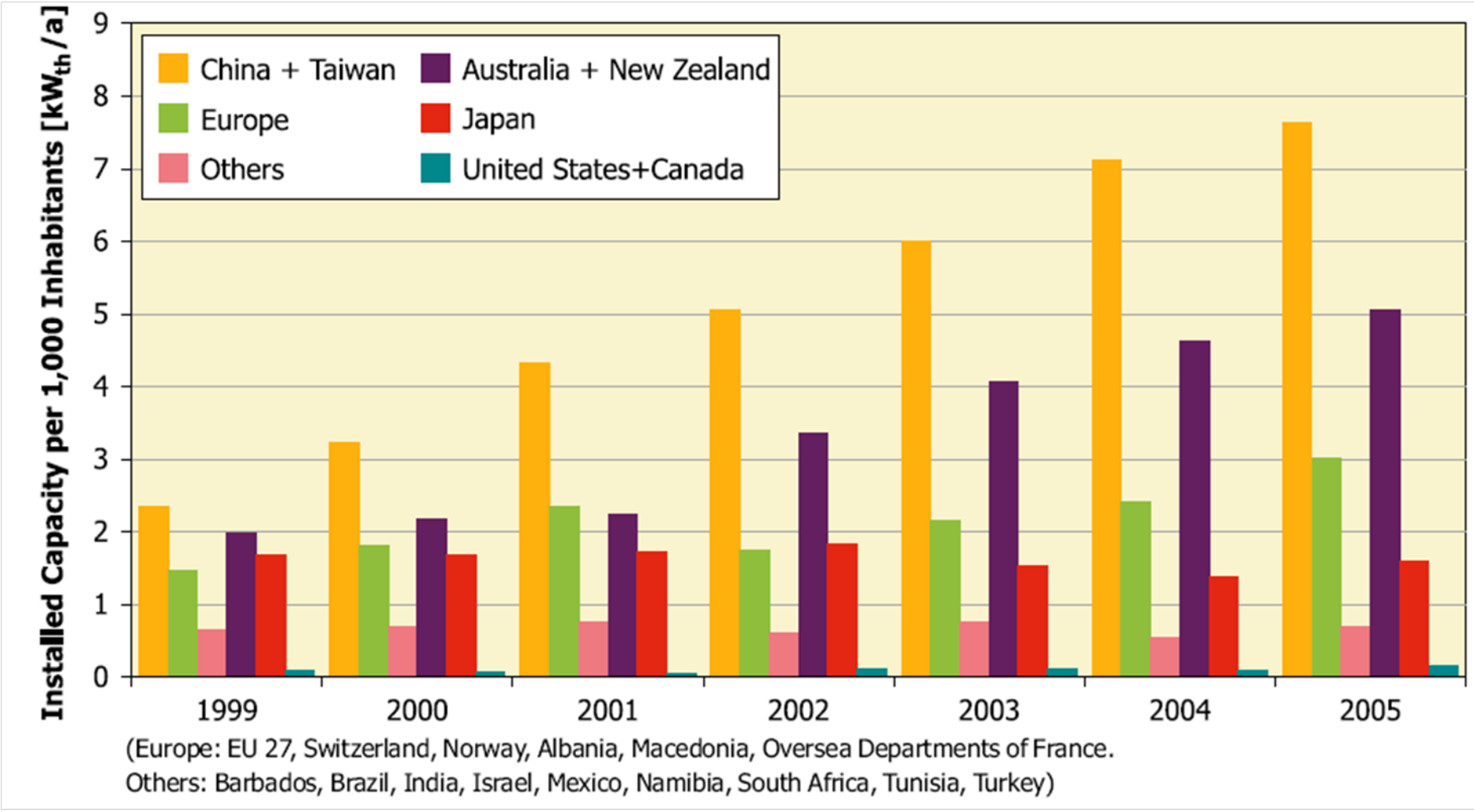
Total capacity in operation [GW$_{el}$], [GW$_{th}$] 2006 and annually energy generated [TWh$_{el}$], [TWh$_{th}$].
Sources: Fawer, M.: Sarasin Sustainability Report 2006 and IEA SHC, 2007.

Distribution of Worldwide Capacity in Operation by Collector Type – 2005



Sources: Fawer, M.: Sarasin Sustainability Report 2006 and IEA SHC, 2007.

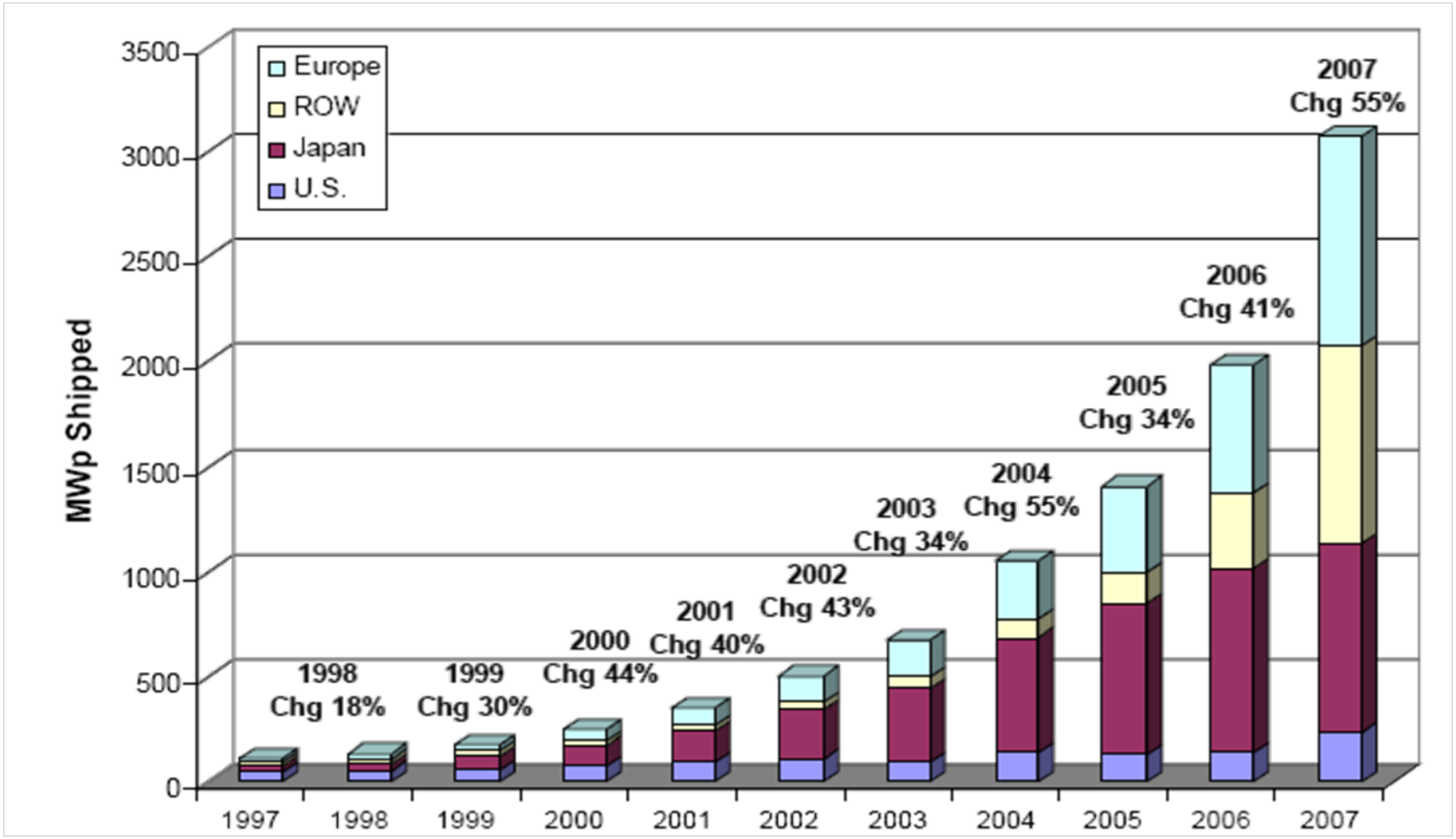
Annual Installed Capacity of Flat Plate and Evacuated Tube Collectors



kWth per 1,000 inhabitants

Sources: Fawer, M.: Sarasin Sustainability Report 2006 and IEA SHC, 2007.

PV Shipment Growth



Source: Navigant Consulting, Report #NPS-Supply 3, April 2008.

NREL Photovoltaics Research

R&D Focused on Technology Roadmaps

- Wafer Silicon
- Film Silicon
- CIGS
- CdTe
- Concentrating PV
- Organic PV
- Sensitized Cells

Next-Generation

- Multiple-Exciton-Generation PV
- Intermediate Band PV
- Nano-architecture PV

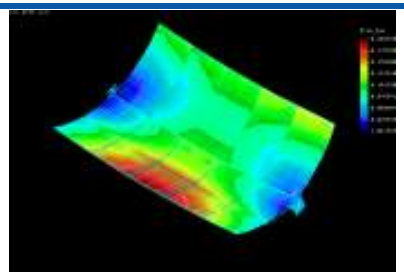
Focus on Key Barriers
Technology Cost and Performance
Reliability
Grid integration
Manufacturing

Process Development Integration Laboratory

Concentrating Solar Power Research

Parabolic Trough R&D

Optimize receiver and concentrator designs, develop next-generation collector design, and create advanced evaluation capabilities.



Thermal Storage R&D

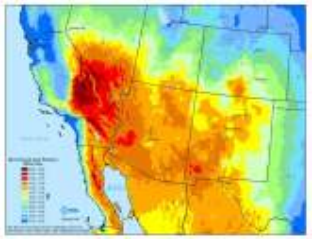
Develop advanced heat transfer fluids for more efficient operation at high temperatures, and test innovative designs for low-cost storage options.

Advanced CSP Concepts

Next generation CSP systems and components

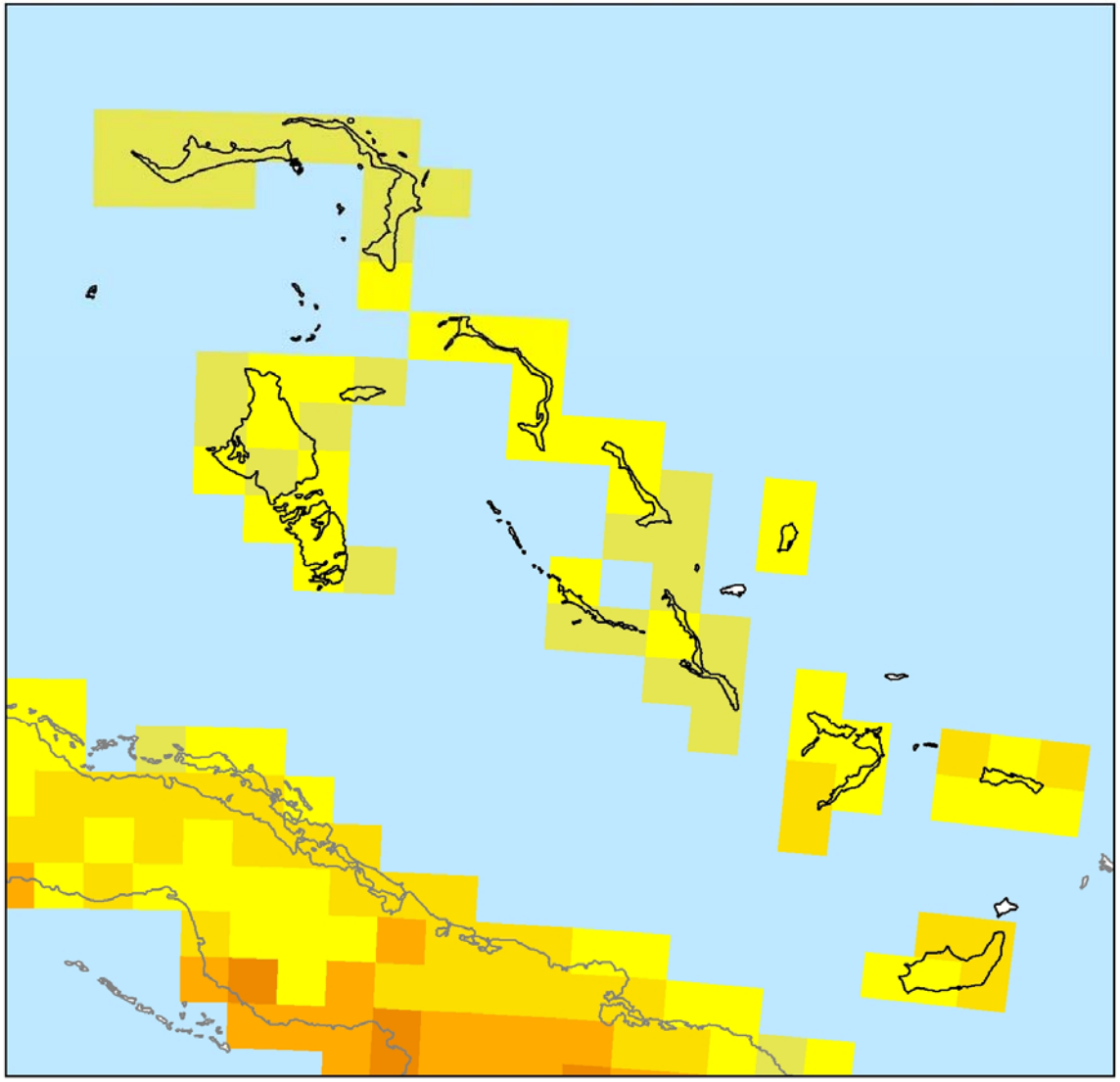
Technology Acceptance

Resource assessment, CSP penetration analysis, grid integration, land use



Focus on Key Barriers
Technology Cost and Performance
Technology Acceptance

Bahamas – Solar Resource



Direct Normal Solar Resource

Annual Solar Resource

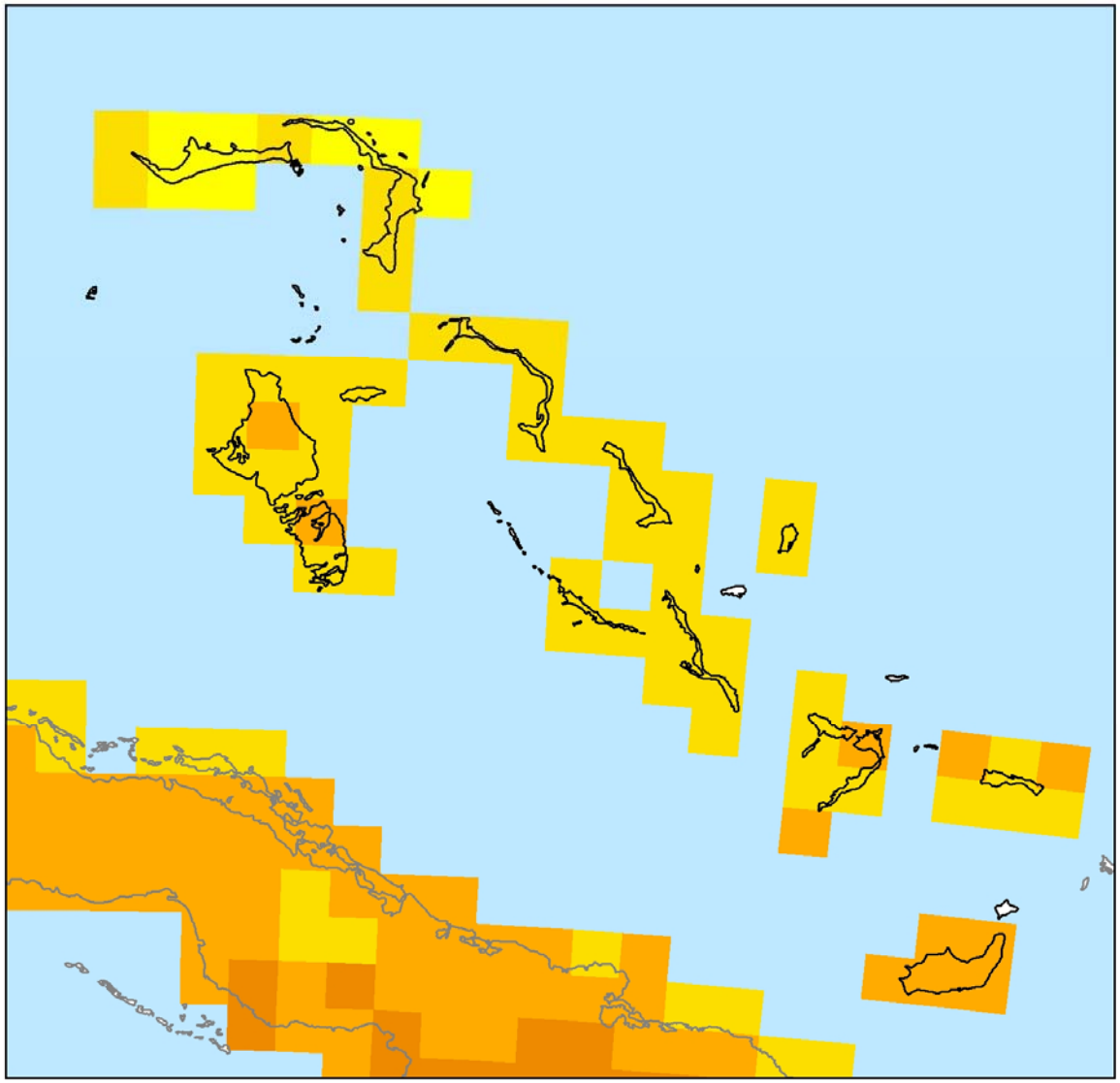
kWh/m^2/day

- > 9
- 8.5 - 9.0
- 8.0 - 8.5
- 7.5 - 8.0
- 7.0 - 7.5
- 6.5 - 7.0
- 6.0 - 6.5
- 5.5 - 6.0
- 5.0 - 5.5
- 4.5 - 5.0
- 4.0 - 4.5
- 3.5 - 4.0
- 3.0 - 3.5
- 2.5 - 3.0
- 2.0 - 2.5
- < 2

Source: National Renewable Energy Laboratory (2003), created for the UNEP Solar and Wind Energy Resource Assessment Program

U.S. Department of Energy
National Renewable Energy Laboratory

Bahamas – Solar PV Resource



Photovoltaic Solar Resource

Annual Solar Resource
kWh/m^2/day

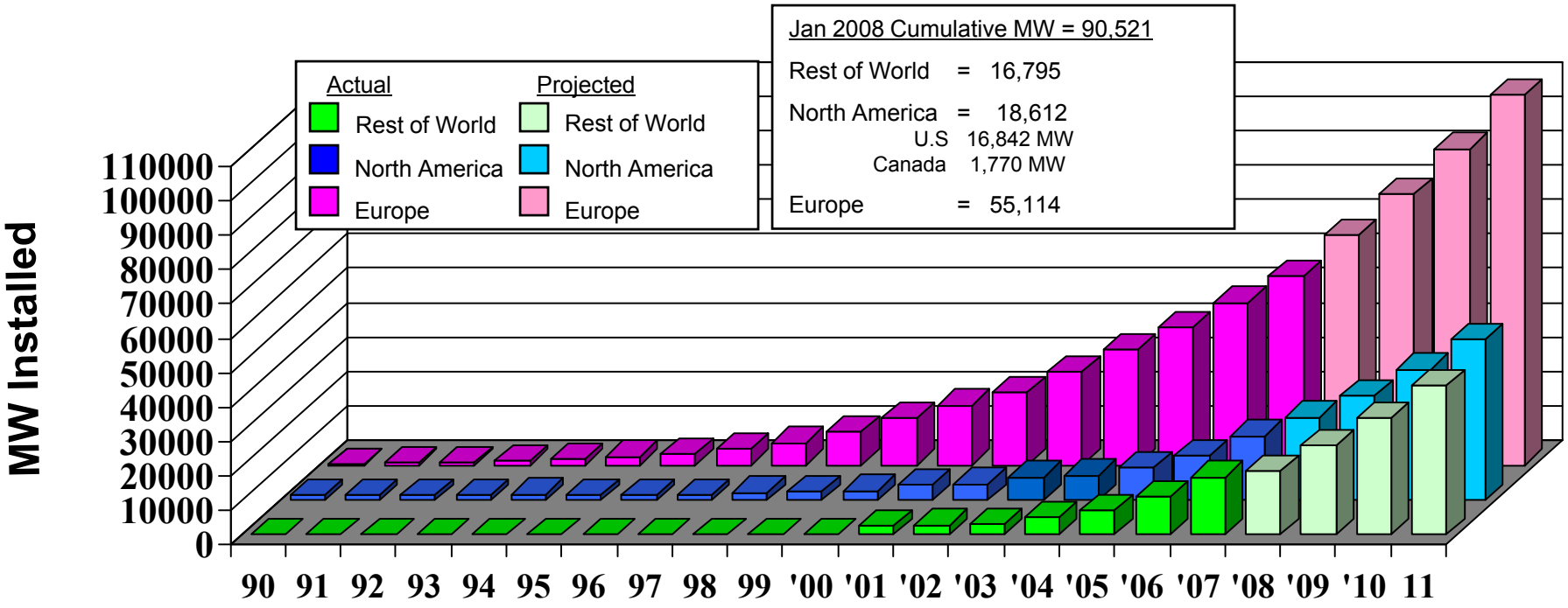
- > 9
- 8.5 - 9.0
- 8.0 - 8.5
- 7.5 - 8.0
- 7.0 - 7.5
- 6.5 - 7.0
- 6.0 - 6.5
- 5.5 - 6.0
- 5.0 - 5.5
- 4.5 - 5.0
- 4.0 - 4.5
- 3.5 - 4.0
- 3.0 - 3.5
- 2.5 - 3.0
- 2.0 - 2.5
- < 2

Source: National Renewable Energy Laboratory (2003), created for the UNEP Solar and Wind Energy Resource Assessment Program

U.S. Department of Energy
National Renewable Energy Laboratory

Wind Energy

Growth of Wind Energy Capacity Worldwide



Sources: BTM Consult Aps, March 2007
Windpower Monthly, January 2008
*NREL Estimate for 2008

NREL Wind Energy Research

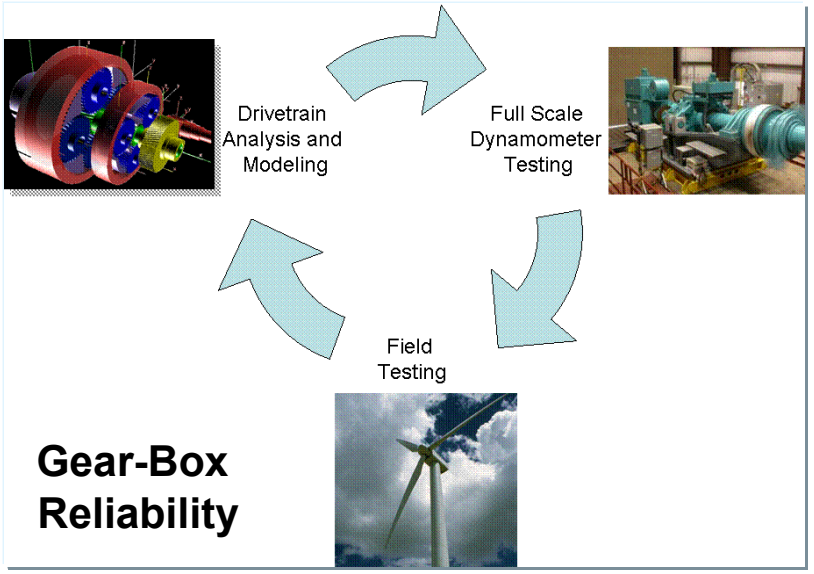
Capabilities

- Design Review and Analysis
- Modeling and Analysis
- Systems and Controls
- Utility Integration
- Wind Resource Assessment

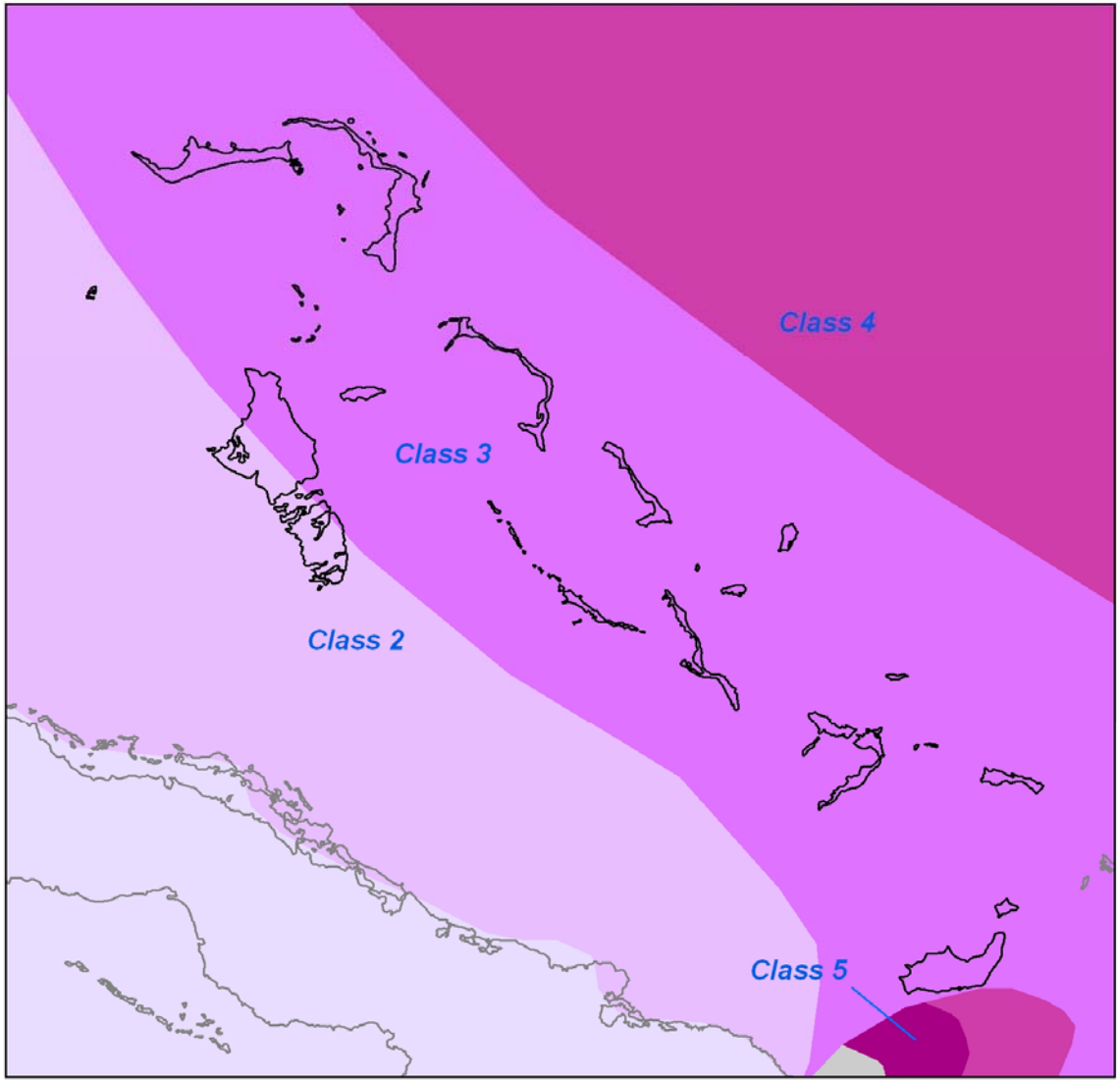
Blade Test

Dynamometer

Focus on Key Barriers
Technology Cost, Performance, and Reliability
Transmission Capacity
Grid integration
Reliable Operation at High Penetration



Bahamas – Wind Resource



Wind Resource at 50 m

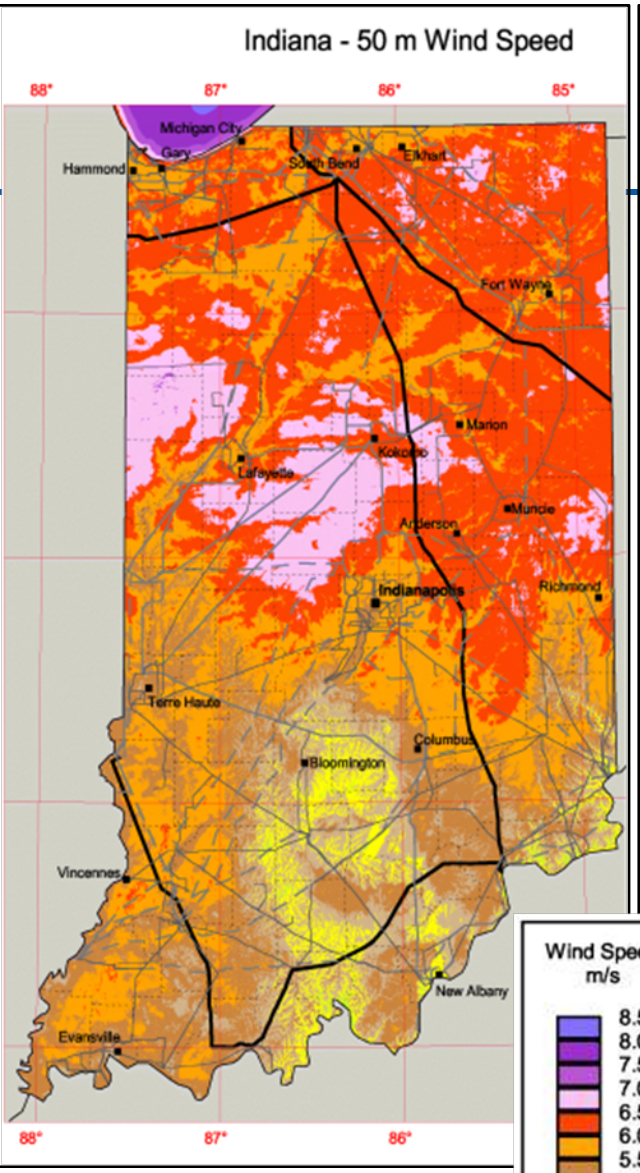
Wind Power Class at 50 m Height

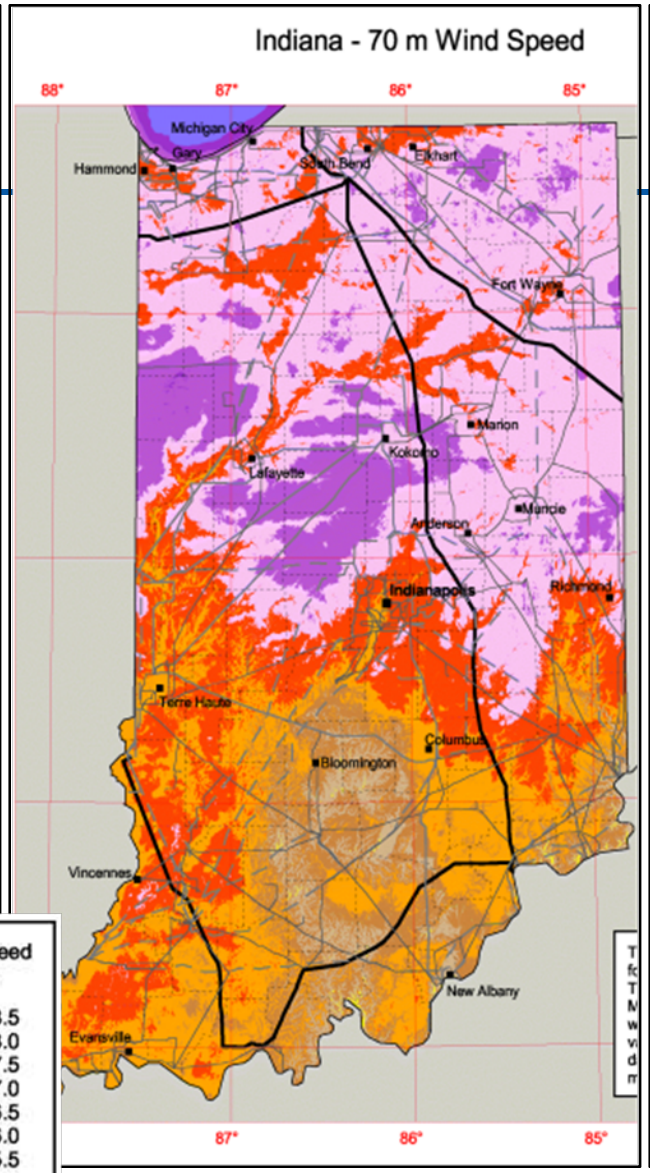
1 2 3 4 5 6 7 Unknow

Low High

Source: Worldwide Wind Map, PNL (1987)

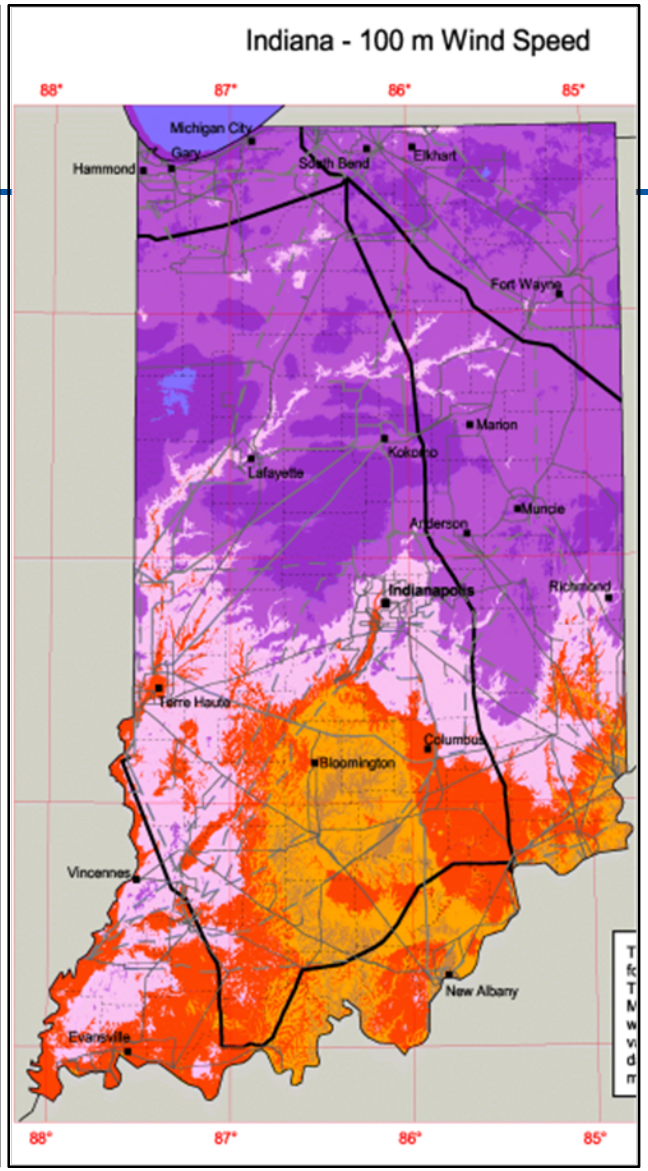
U.S. Department of Energy
National Renewable Energy Laboratory





Wind Potential (12% Losses)
30-36% Capacity Factor: 42 GW

Total: 42 GW



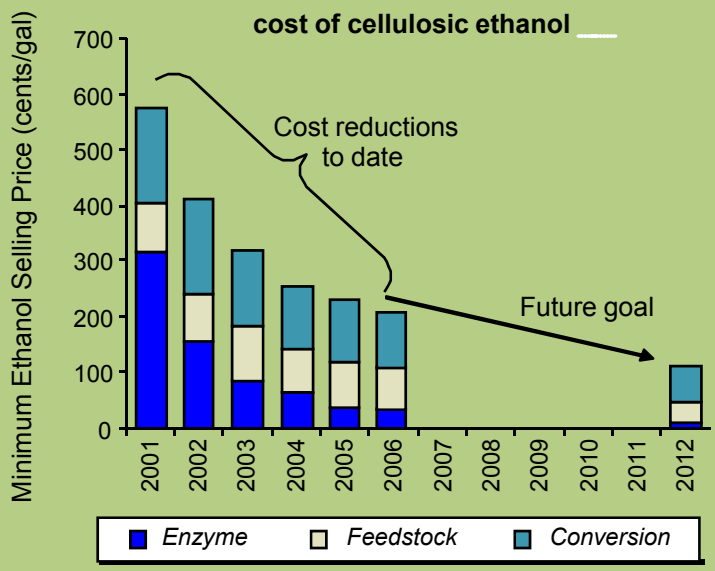
Wind Potential (12% Losses)
30-36% Capacity Factor: 161 GW
36-41% Capacity Factor: 37 GW

Total: 198 GW


Bioenergy

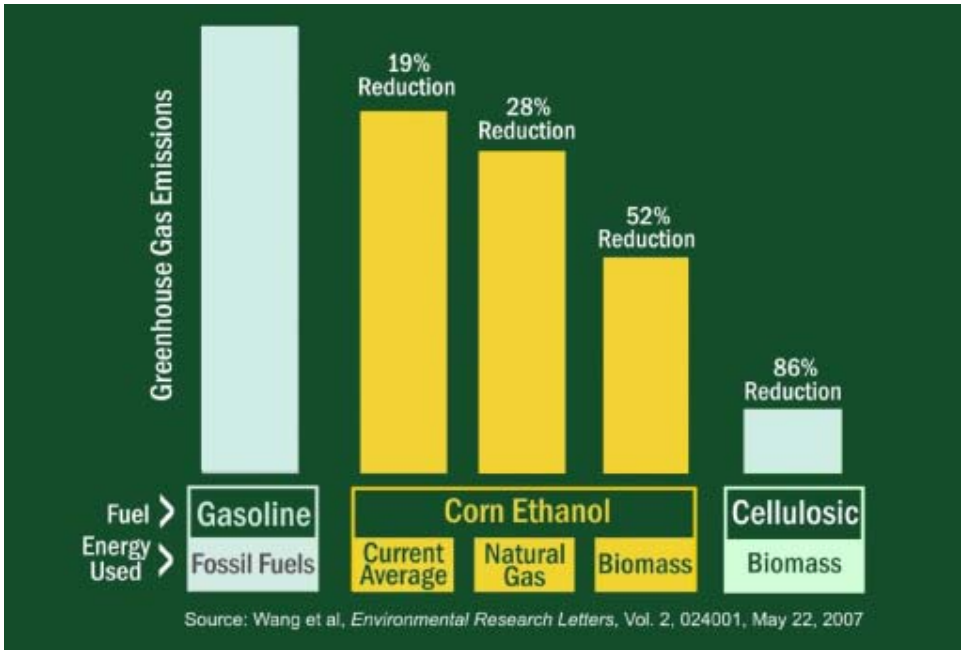
Biofuels Cost and Environmental Potential

Historical and Projected Cellulosic Ethanol Costs

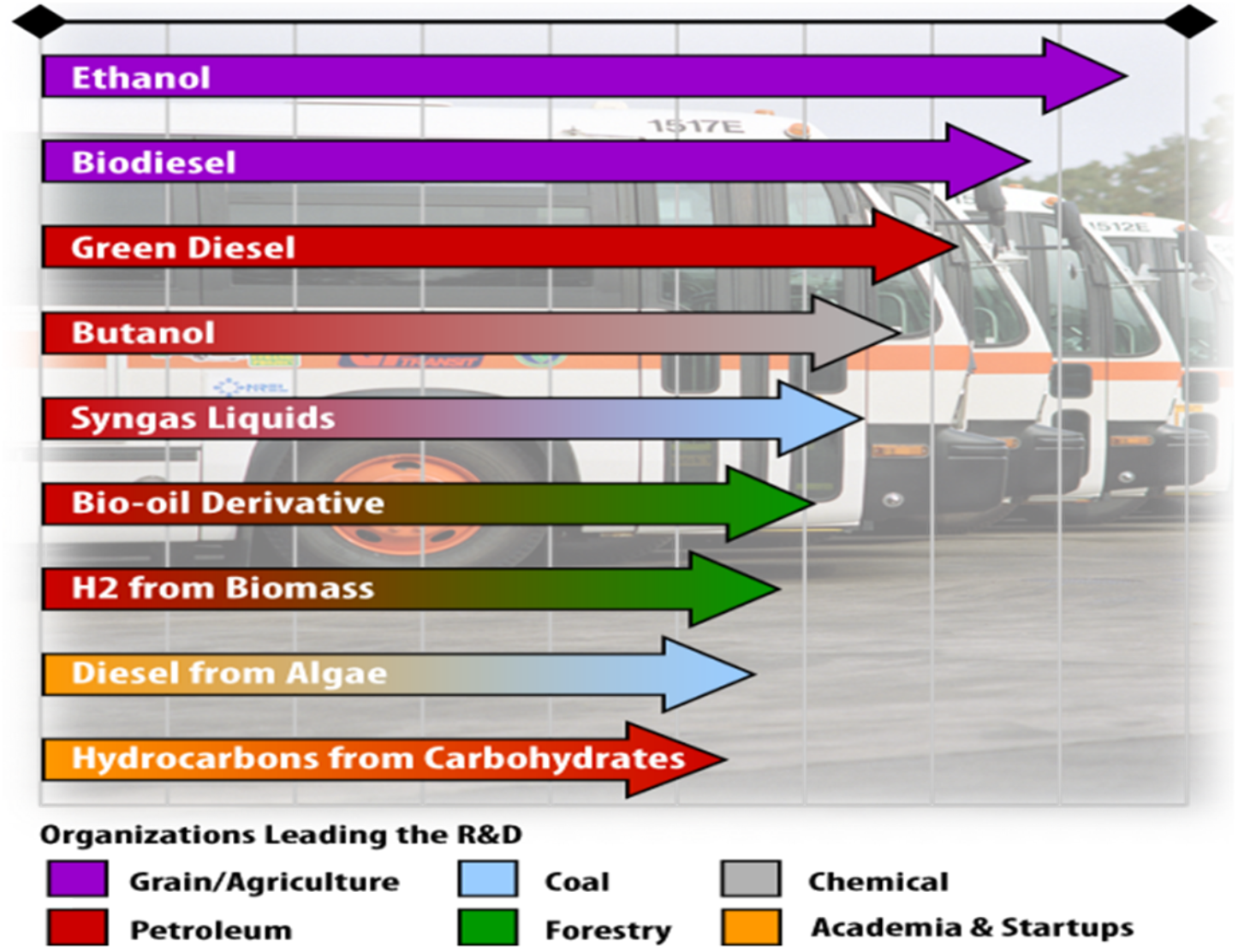


Source: Research Advances: NREL Leads the way: Cellulosic Ethanol. March, 2007. Figures are for biochemical conversion

Federal research has achieved major reductions in the cost of cellulosic ethanol



Range of Biofuels Pathways & Technology Maturity



Small Modular Bioenergy Systems

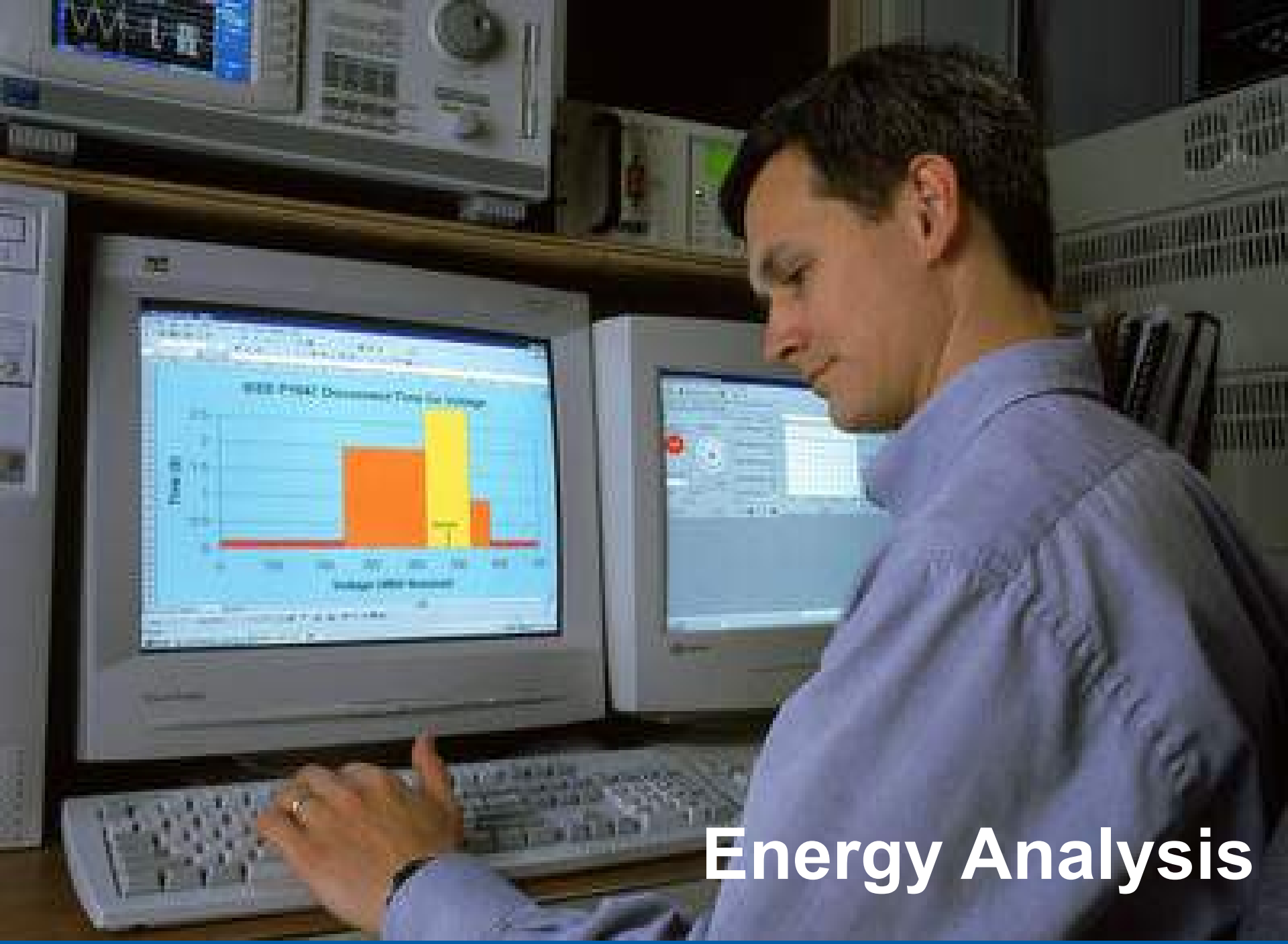
Status

- First generation systems designed for village power (25-100kWe and motive power) to small towns (5MWe combined heat and power)

Future

- Small systems to produce electricity, motive power, heat, and fuel intermediates
- Both gasification and pyrolysis are being investigated

Village Power Philippines, U.S. Indian Reservations, schools

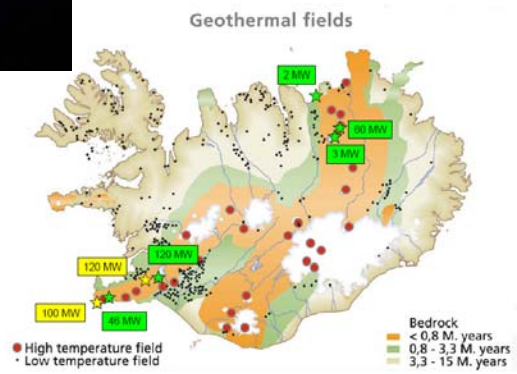


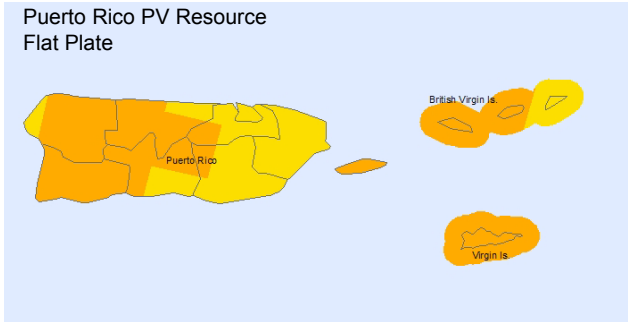
Energy Analysis

Resource, Technology, and Market Information

High-quality and timely data informs RE project decisions and policy development:

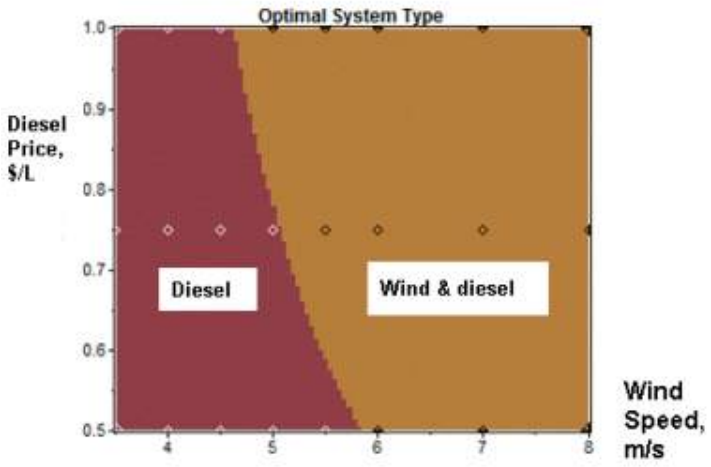
- Provide accurate resource assessment and mapping
- Collaborate on technology R&D
- Contribute timely and definitive analyses on technology, policy, and market issues that govern commercialization



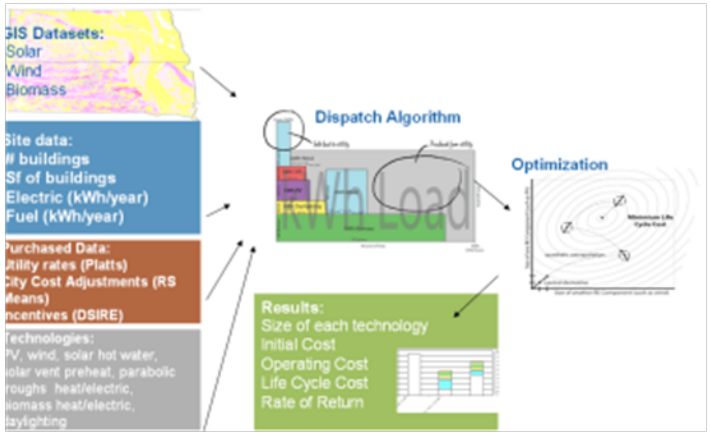


Iceland map courtesy of Iceland Geosurvey

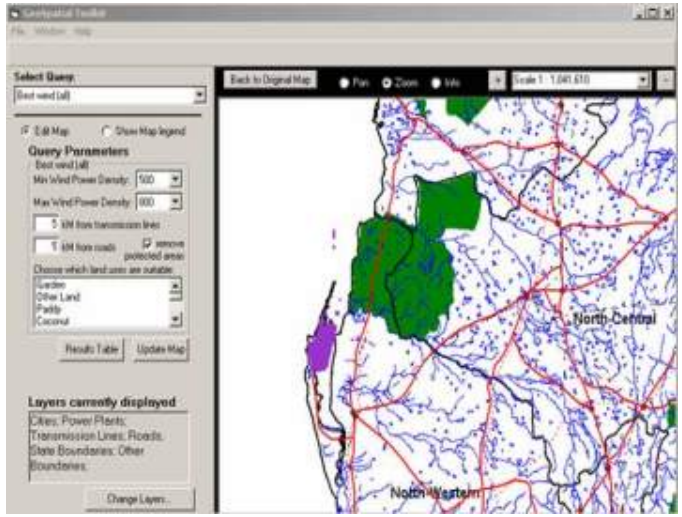
Examples of Analysis Tools and Models



HOMER®
NREL's Hybrid Optimization Model



Renewable Energy Optimization (REO)



GeoSpatial Toolkit

The Laboratory's Role:

- Provision of data, tools, analysis, and information to help facilitate growth
- Evaluation of market opportunities and information exchange with U.S. technology suppliers
- Building R&D capacity in-country

Island Economies Benefit from Renewable Energy and Energy Efficiency R&D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