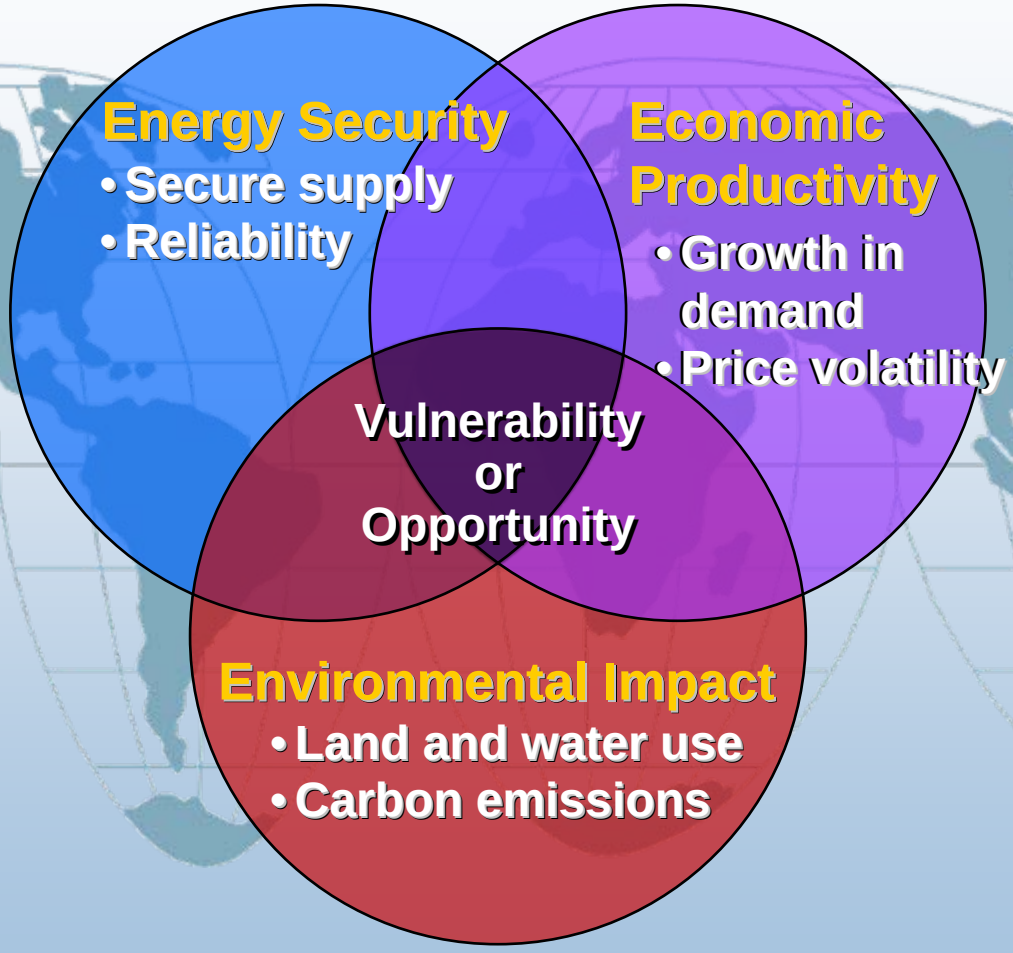
Renewable Energy Opportunities: The Arctic as an Emerging Energy Province

The Arctic Energy Summit
October 15, 2007

Dr. Dan E. Arvizu
Director, National Renewable Energy Laboratory
and
Member, National Science Board

Energy Solutions Are Enormously Challenging



Must address all three imperatives

Today's Energy Infrastructure

Supply & Conversion

Oil

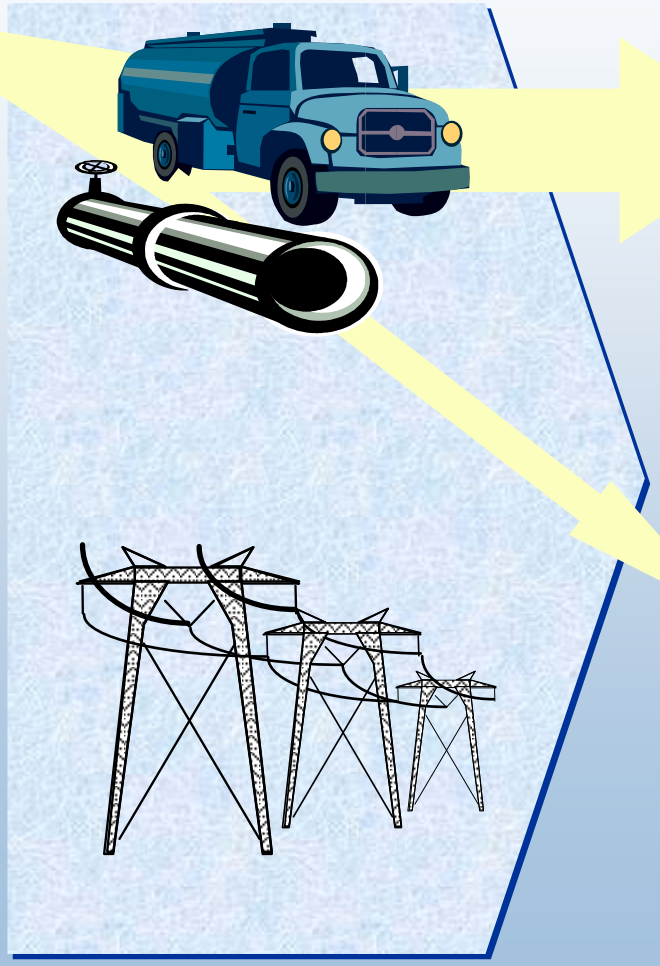
Coal

Natural Gas

Nuclear

Hydro
Wind
Solar
Biomass
Geothermal

Transmission & Distribution



Utilization

…inadequate to meet the needs of the future

A Systems Long View of the Future

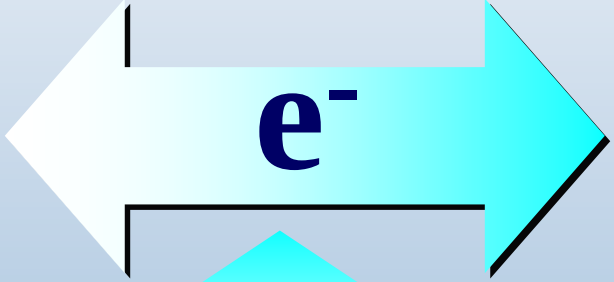
Clean, Diverse & Secure

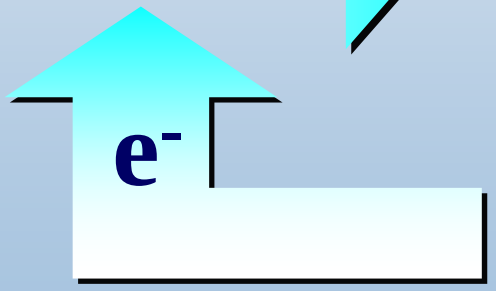
Near-Zero Emission Hydrocarbons

Advanced Nuclear

Renewable Energy

Intelligent, Resilient, Flexible & High Capacity





Efficient & Integrated

Fuel Cell & Hybrid Vehicles

Near-Zero Energy Buildings

Industry

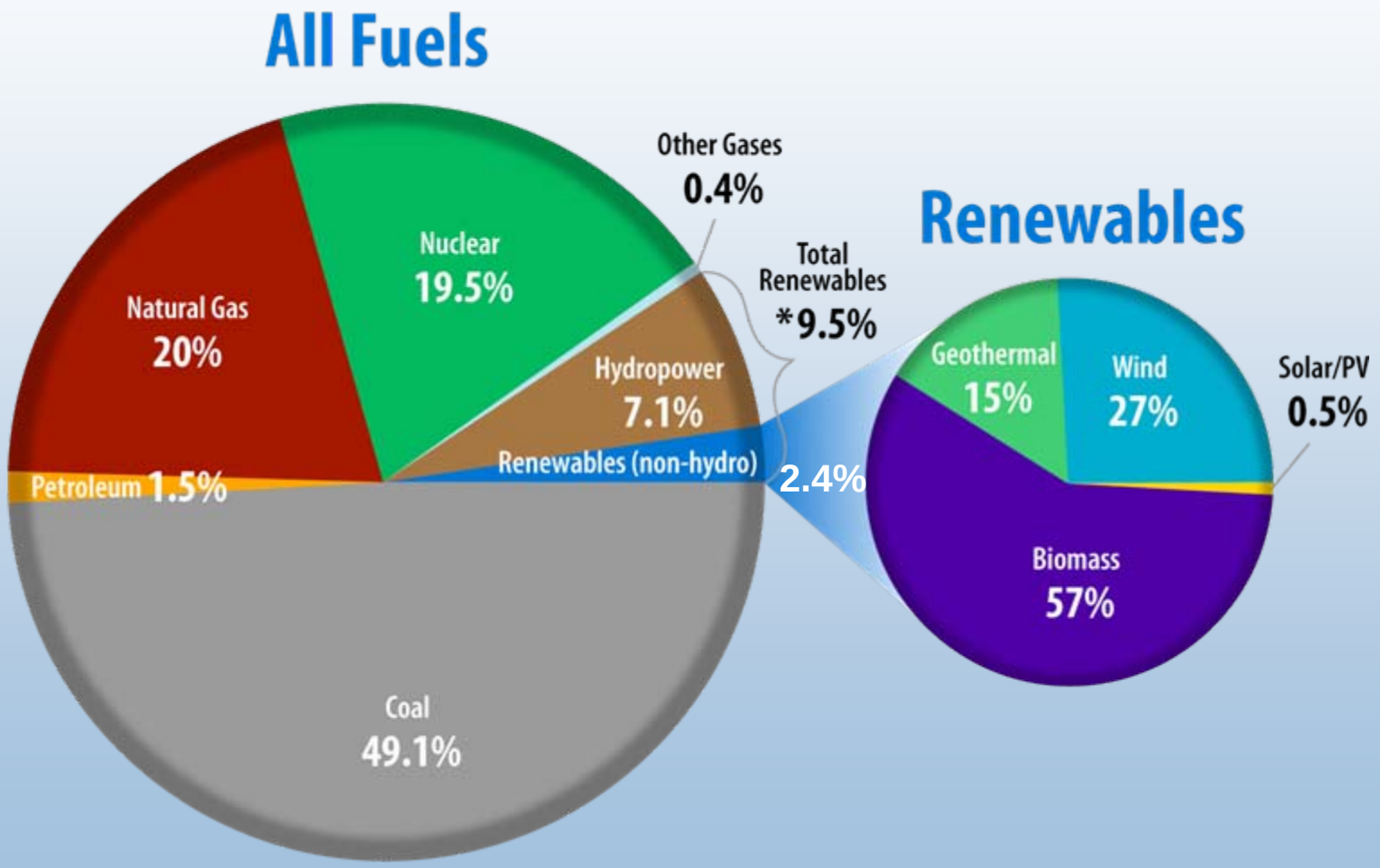
e^-

Distributed Resources

Technology advances are required

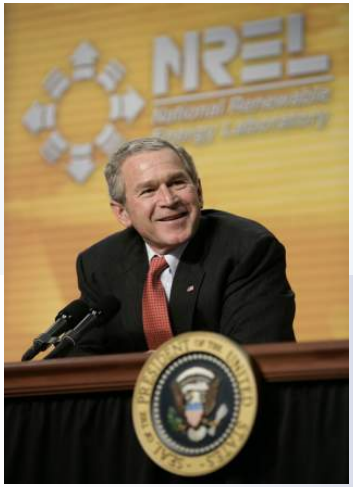
What Are the Major Renewables?

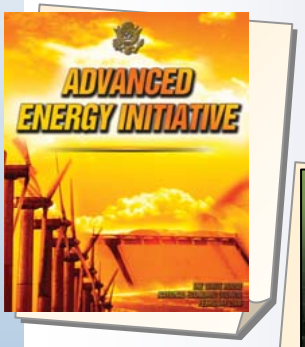
Electricity Net Generation – 2006



* Source: EIA Annual Energy Review 2007

Call for Action





- Supply Diversity
- Environmental Stewardship
- Energy System Reliability
- Energy Productivity

Mission: Develop renewable energy and energy efficiency technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals.

NREL's mission aligns with DOE energy goals

National Renewable Energy Laboratory

What Makes Us Unique?

- Only national laboratory dedicated to renewable energy and energy efficiency R&D
- Research spans fundamental science to technology solutions
- Collaboration with industry and university partners is a hallmark
- Research is market relevant because of a systems focus

Energy Efficiency and Renewable Energy Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

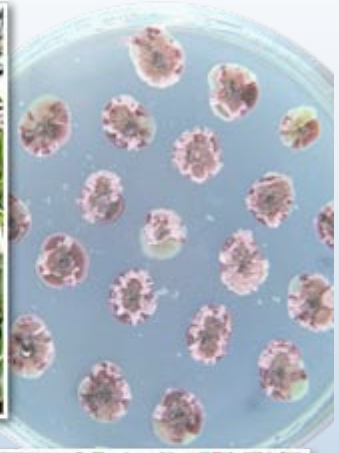
- Wind
- Solar
- Biomass
- Geothermal

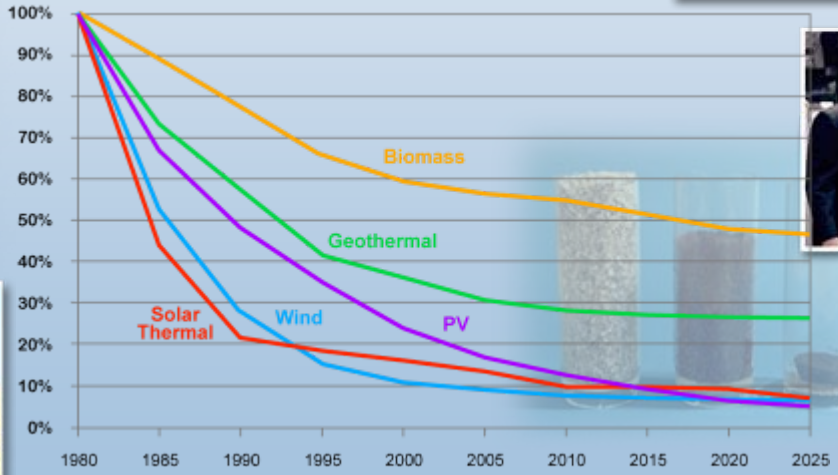
Energy Delivery and Storage

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

Foundational Science and Strategic Analysis

Past Investments Have Yielded Impressive Cost Reductions





Wind

Today's Status in U.S.

- 11,603 MW installed at end of 2006
- Cost 6-9¢/kWh at good wind sites*

DOE Cost Goals

- 3.6¢/kWh, onshore at low wind sites by 2012
- 7¢/kWh, offshore in shallow water by 2014

Long Term Potential

- 20% of the nation's electricity supply

NREL Research Thrusts

- Improved turbine performance and reliability
- Distributed wind technology
- Drivetrain reliability
- Utility grid integration

* With no Production Tax Credit
Updated 1/07, validated 7/07
Source: U.S. Department of Energy, American Wind Energy Association

Wind Power in Remote Environments

Toksook Bay

Selawik

Solar

Photovoltaics and Concentrating Solar Power

Status in U.S.

PV
- 565 MW
- Cost 18-23¢/kWh

CSP
- 420 MW
- Cost 12¢/kWh

Potential:

PV
- 11-18¢/kWh by 2010
- 5-10 ¢/kWh by 2015

CSP
8.5¢/kWh by 2010
5-7¢/kWh by 2020

Source: U.S. Department of Energy, IEA, Solar Energy Technologies Program Multi-Year Plan 2007

Updated July 2007

NREL Research Thrusts:

PV
- Partnering with industry
- Higher efficiency devices
- New nanomaterials applications
- Advanced manufacturing techniques

CSP
- Next generation solar collectors
- High performance storage

PV for Remote Applications

Lime Village

Arctic Village

Geothermal

Today's Status:

- 2,800 MWe installed, 500 MWe new contracts, 3000 MWe under development
- Cost 5-8¢/kWh with no PTC
- Capacity factor typically > 90%, base load power

DOE Cost Goals:

- <5¢/kWh, for typical hydrothermal sites
- 5¢/kWh, for enhanced geothermal systems with mature technology

Long Term Potential:

- Recent MIT Analysis shows potential for 100,000 MW installed Enhanced Geothermal Power systems by 2050, cost-competitive with coal-powered generation

NREL Research Thrusts:

- Analysis to define the technology path to commercialization of Enhanced Geothermal Systems
- Low temperature conversion cycles
- Better performing, lower cost components
- Innovative materials

Source: DOE, NREL, 9/07

Chena Hot Springs Geothermal Power Plant

- Low Temperature -- 165°F
- Village Power: ~225kW
- Water or air cooled

Biopower

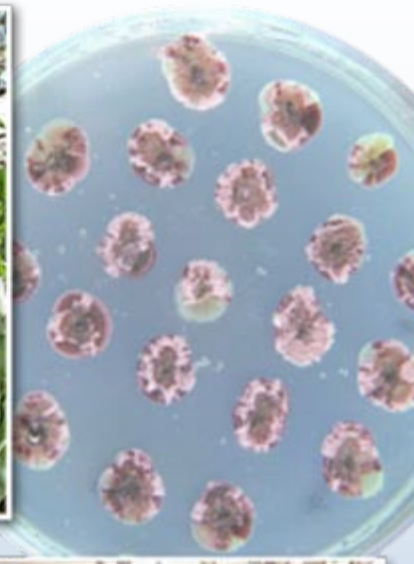
Biopower status

- 2006 Capacity – 10.5 GWe
  - 5 GW Pulp and Paper
  - 2 GW Dedicated Biomass
  - 3 GW MSW and Landfill Gas
  - 0.5 GW Cofiring
- 2004 Generation – 68.5 TWh
- Cost – 0.08 – 0.10 USD/kWh

Potential

- Cost – 0.04-0.06 USD kWh (integrated gasification combined cycle)
- 2030 – 160 TWh (net electricity exported to grid from integrated 60 billion gal/yr biorefinery industry)

Biofuels



Current Biofuels status

- Biodiesel – 1.3 billion gallons/yr capacity[1]
- Corn ethanol
  - 121 commercial plants[2]
  - 6.3 billion gal/yr. capacity[2]
  - Additional 6.2 billion gal/yr planned or under construction
- Cellulosic ethanol (current technology)
  - Projected commercial cost ~$3.50/gge

Key DOE Goals

- 2012 goal: cellulosic ethanol ~$1.62/gge
- 2017 goal : 35 billion gal alternative fuel – President
- 2022 goal: 36 billion gal renewable fuel – Congress/draft
- 2030 goal: 60 billion gal ethanol (30% of 2004 gasoline)

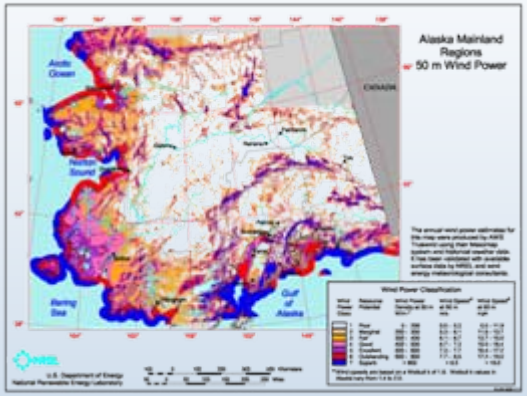
NREL Research Thrusts

- The biorefinery and cellulosic ethanol
- Solutions to under-utilized waste residues
- Energy crops

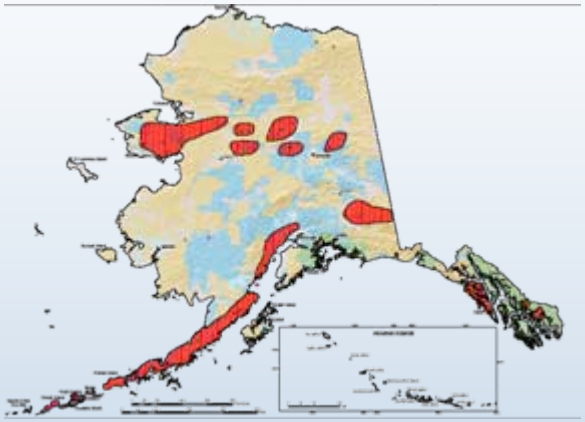
Updated July 2007
Sources: 1- National Biodiesel Board, 2 - Renewable Fuels Association, all other information based on DOE and USDA sources

Indigenous renewable energy resources are key to human survival and future village economies in Alaska…

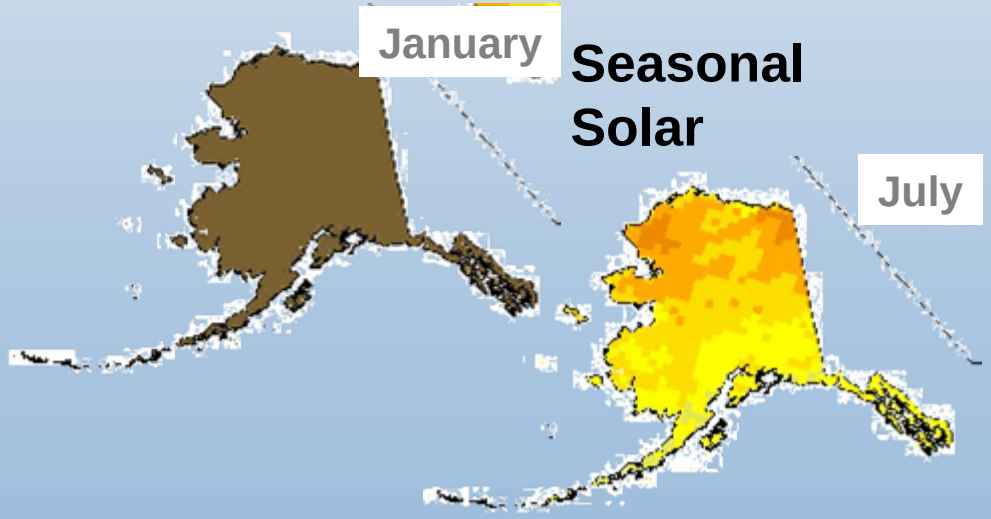
Wind



Geothermal



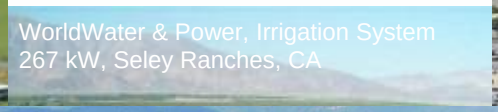
Small Hydro

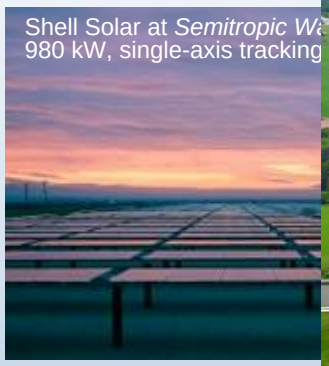


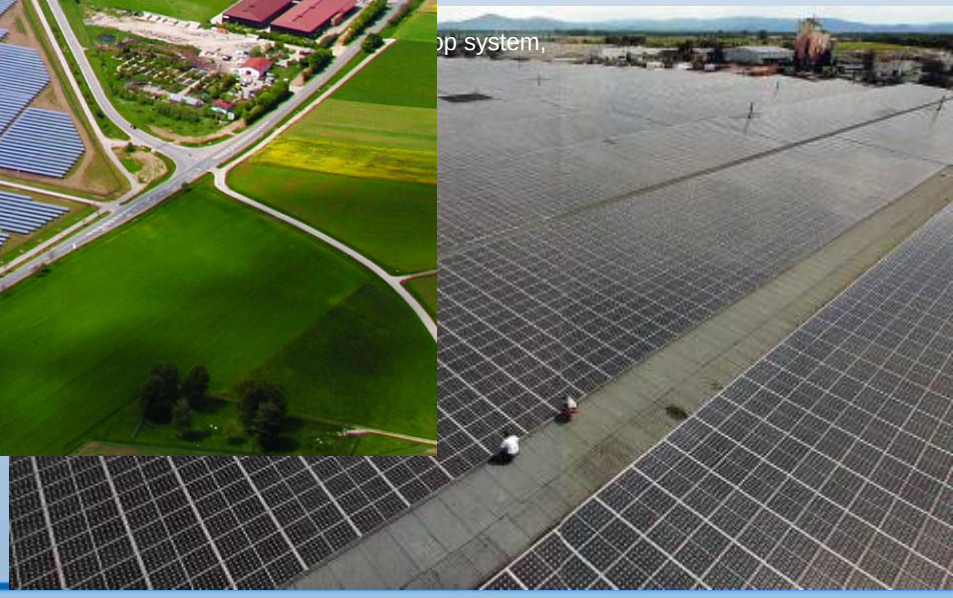
Seasonal Solar

Biomass

Success Story In Germany





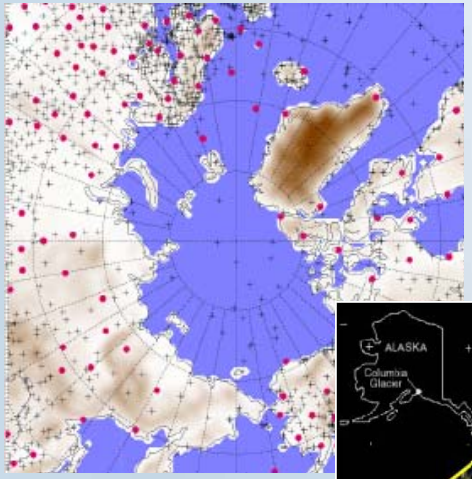


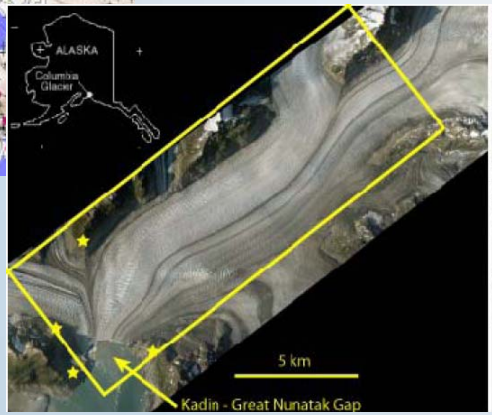
National Science Board
Task Force on Sustainable Energy

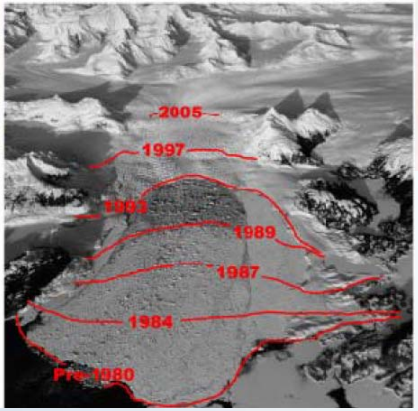
- The Board believes it to be an imperative for the long-term prosperity of this Nation for the government to develop a long-term, coordinated, inter-agency strategy to achieve a stable sustainable U.S. energy future.
- Task Force established October 3, 2007 and charged to:
  - Examine the role of the U.S. Government in addressing the science and engineering challenges related to development of sustainable energy, and
  - Provide recommendations to the President and Congress regarding a nationally coordinated S&E research and education initiative on alternative and sustainable energy, with specific guidance on the role of the National Science Foundation in such an initiative.

National Science Foundation & International Polar Year

- Understanding change
- Human and biotic systems
- Education and outreach







Tiksi, Russia

- NSF is working with NOAA to upgrade facilities at Tiksi

- NSF rebuilt Tiksi Weather Station in 2006 (image right)

- Construction of new research facility is planned to begin in 2007

Our Neighbors as Example

Piteå, Sweden

Reykjavik, Iceland

Promise of renewable energy is profound and can be realized if we…

- Aggressively seek a global sustainable energy economy
- Accelerate investment in technology innovation
- Work with our international partners to learn from each other

It is a matter of national will and leadership

NREL

The U.S. Department of Energy's
National Renewable Energy Laboratory
www.nrel.gov
Golden, Colorado