A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

National Renewable Energy Laboratory

Innovation for Our Energy Future

Renewable Energy Overview, Global Energy, Climate, and the Challenge of Community-based Solutions

Renewable Energy for Tribal Community Survival

Roger Taylor
Tribal Energy Program Manager
National Renewable Energy Laboratory

EPA Region 9
10/23/08

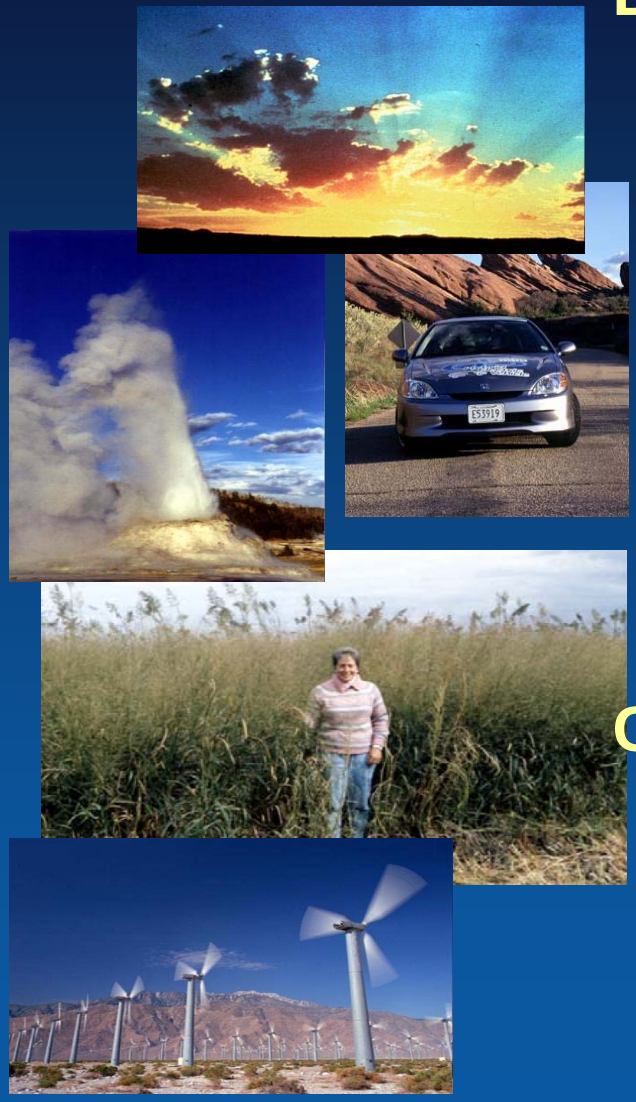
NREL is operated by Midwest Research Institute • Battelle

Major DOE National Laboratories

Major NREL Technology Thrusts

Supply Side

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



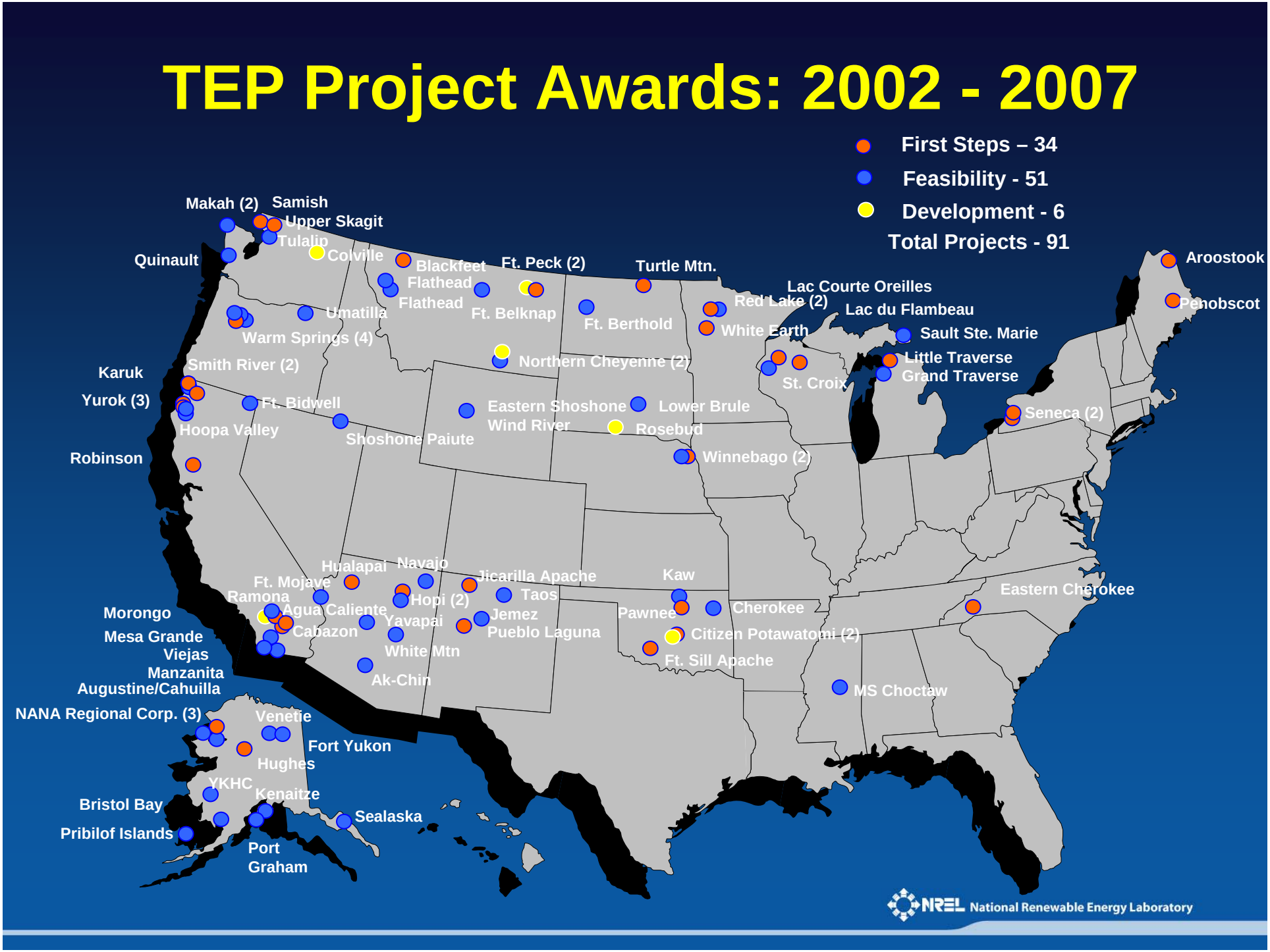
Demand Side

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

Cross Cutting

- Basic Energy Science
- Analytical Studies
- International Programs
- **Tribal Energy Program**

TEP Project Awards: 2002 - 2007



DOE's Tribal Energy Program

Website

- Features
- Program Brochure
- Upcoming Workshops
- Financial Opportunities
- Projects on Tribal Lands
  - Project Overviews
  - Status and Reports
  - Contacts
- Information Resources
- Contacts

www.eere.energy.gov/tribalenergy

DOE's Tribal Energy Program

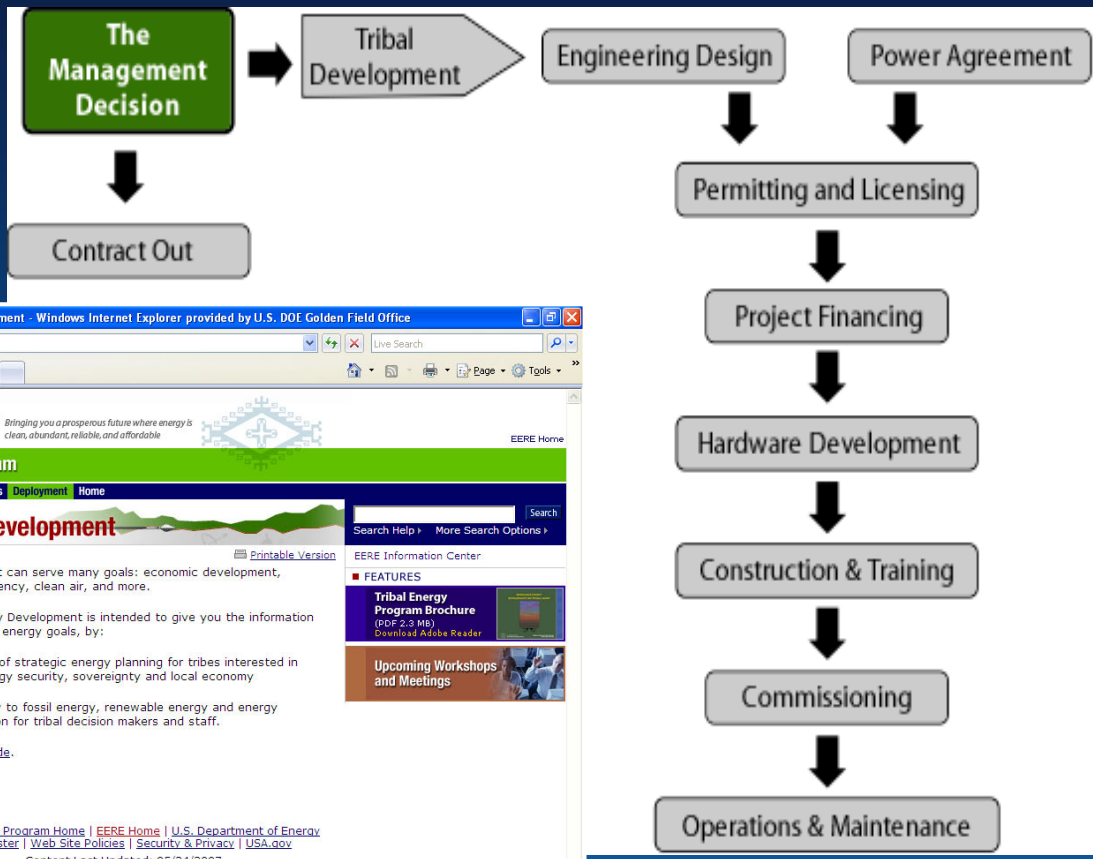
Guide to Tribal Energy Development

Development Processes

- Strategic Planning
- Options Analysis
- Organizational Development
- Project Development

Resource Library

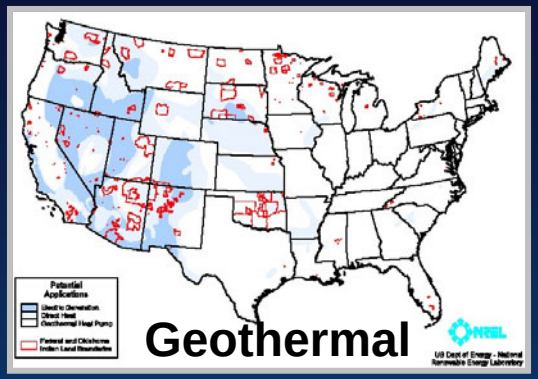
- Energy Resources
- Technologies
- Costs
- Risk Factors
- Legal Issues
- Financing Options
- Contacts

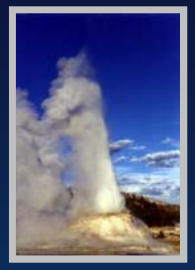


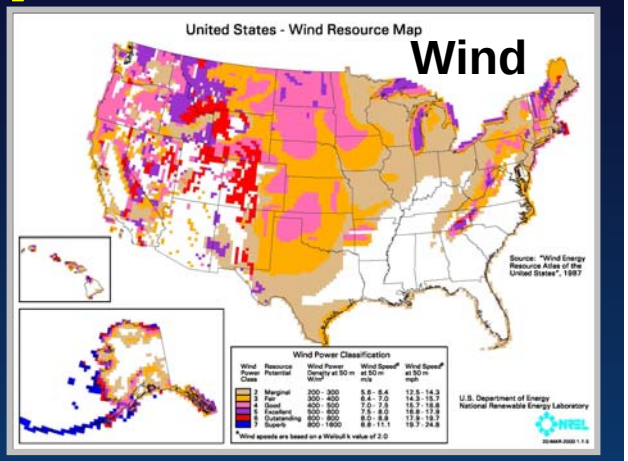
www.eere.energy.gov/tribalenergy/guide

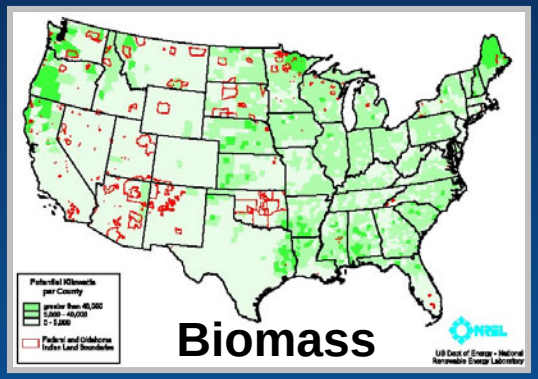
NREL National Renewable Energy Laboratory

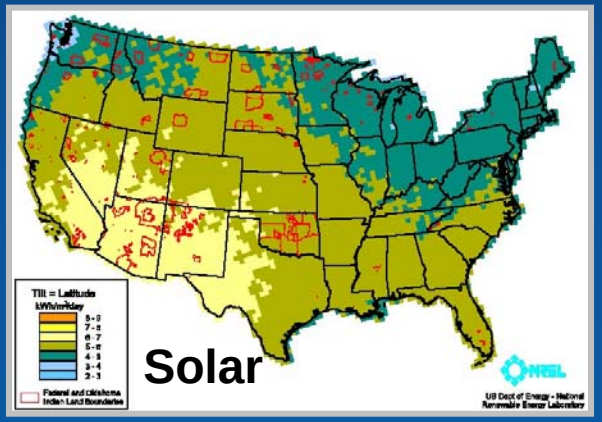
Renewable Resource Options

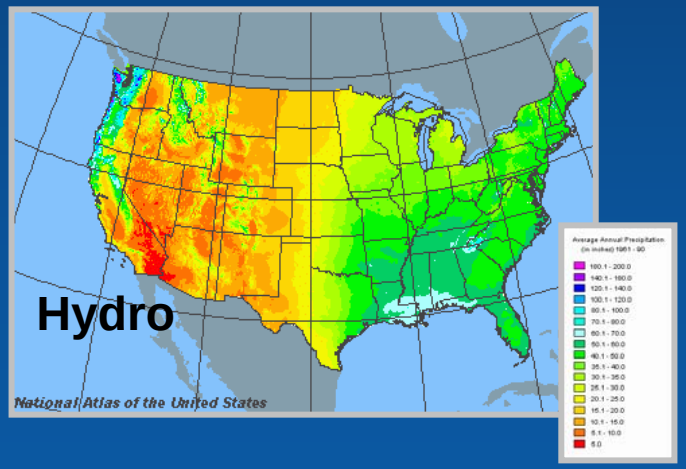




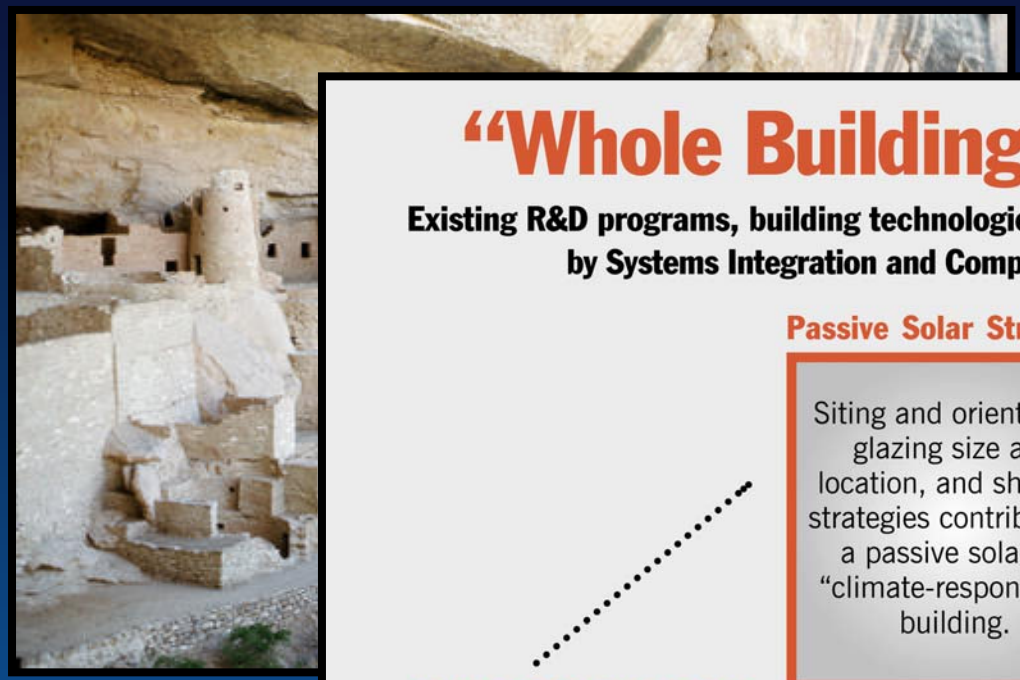








Building Design



"Whole Buildings" Strategy:

Existing R&D programs, building technologies, and components tied together by Systems Integration and Computerized Design Tools.

Passive Solar Strategies

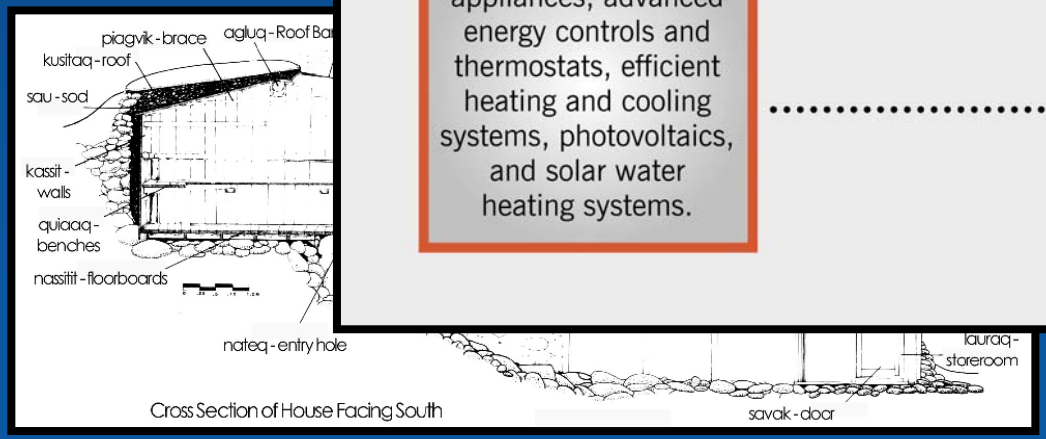
Siting and orientation, glazing size and location, and shading strategies contribute to a passive solar, or "climate-responsive," building.

Advanced Technologies

Energy-saving appliances, advanced energy controls and thermostats, efficient heating and cooling systems, photovoltaics, and solar water heating systems.

Energy-Efficient Materials

Superior building materials, including high-efficiency windows, insulation, brick, concrete masonry, and interior finish products.



Cross Section of House Facing South

Energy Efficiency Options

Energy Star Appliances

Refrigerators – Half as much energy

Clothes Washers – Save up to $110 per year

Oil & Gas Boilers – Save up to 10%

Programmable Thermostats – Save up to $100 per year

Efficient Lighting

If every American changed out 5 lights, we'd save $6 billion/year and the equivalent of 21 power plants.

Weatherization Options

Insulation

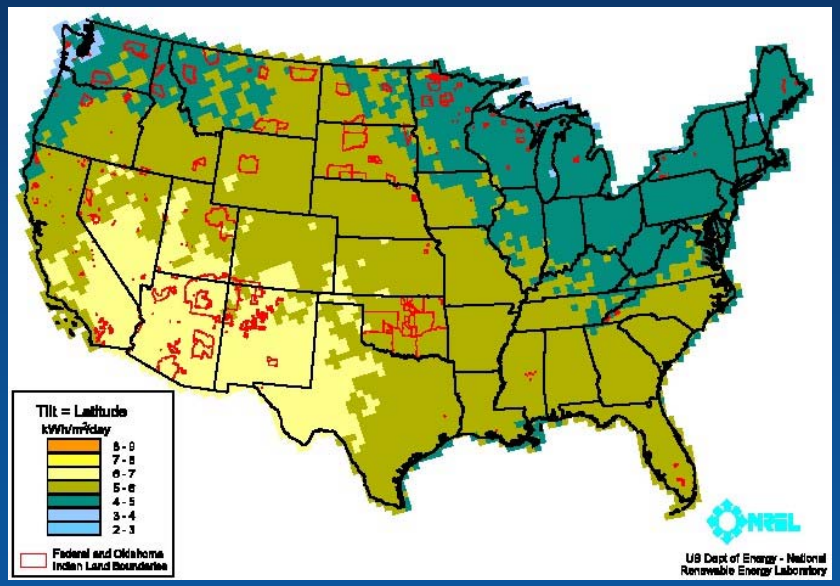
Infiltration

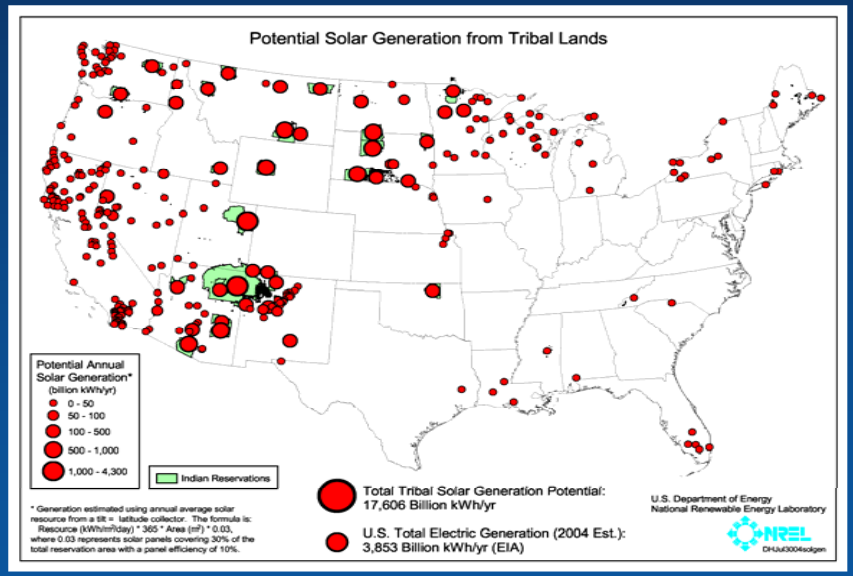
Controls

Maintenance

DOE's Tribal Energy Program

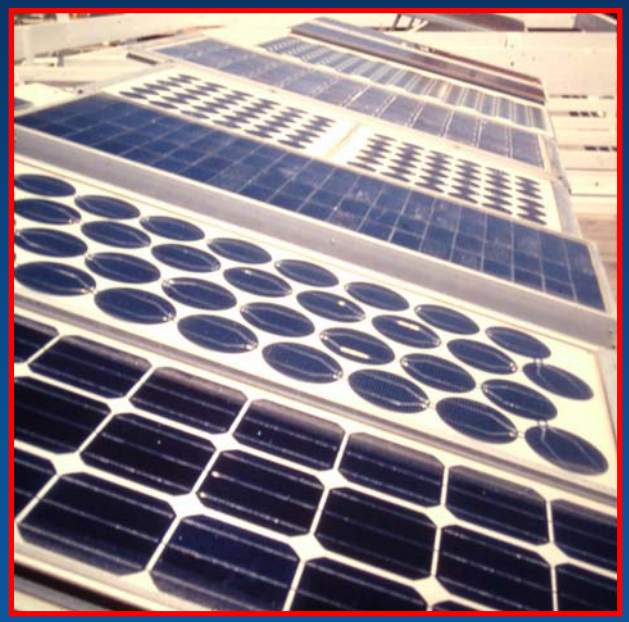
Solar Electric Potential on Tribal Lands ~4.5 times the Total U.S. Electric Generation in 2004



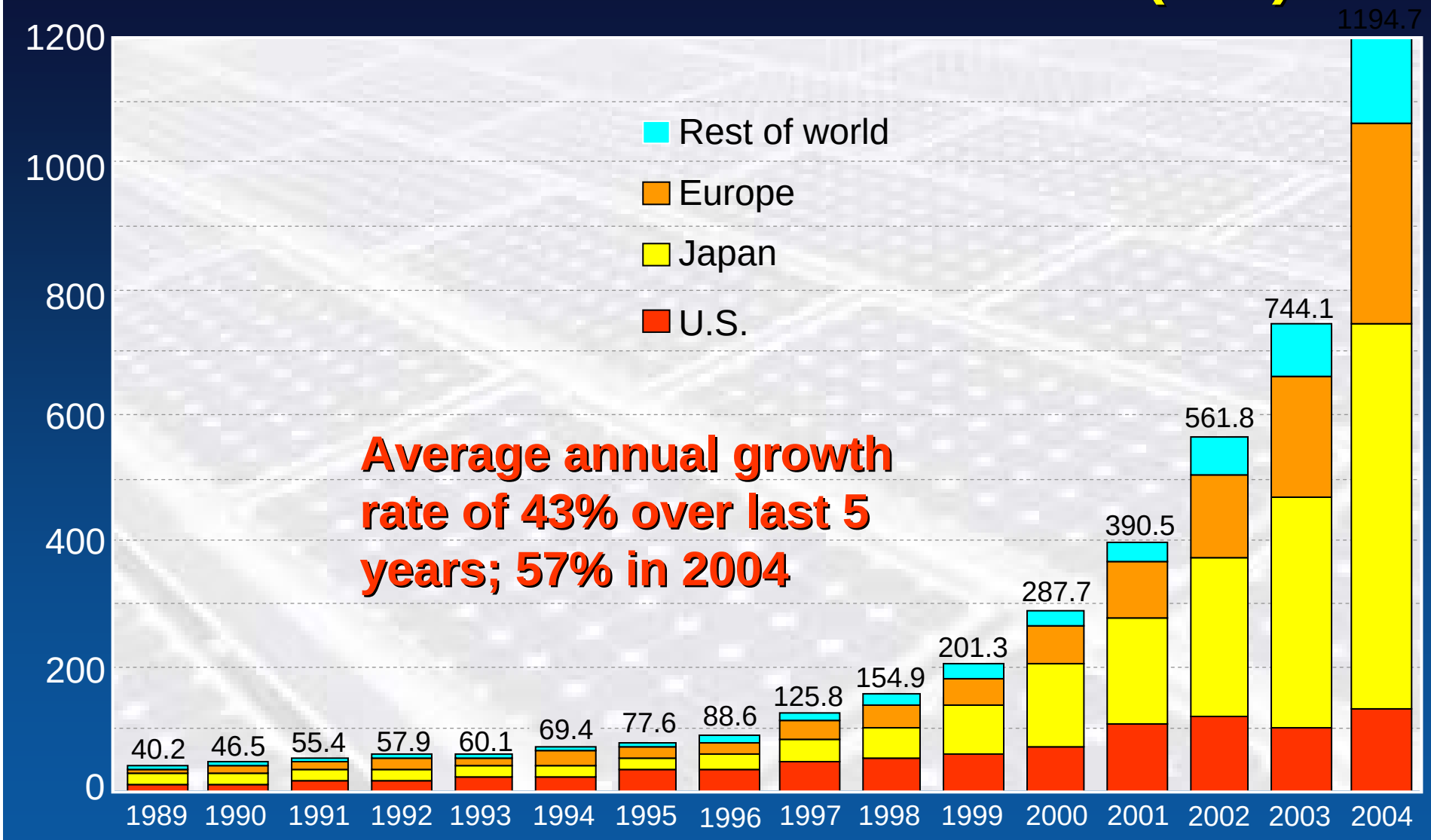


Solar Electric Potential of 17,600 Billion kWh/yr on Indian Lands

Individual cells are connected in series (increases the voltage) and in parallel (increases the current) into a module.



World PV Cell/Module Production (MW)



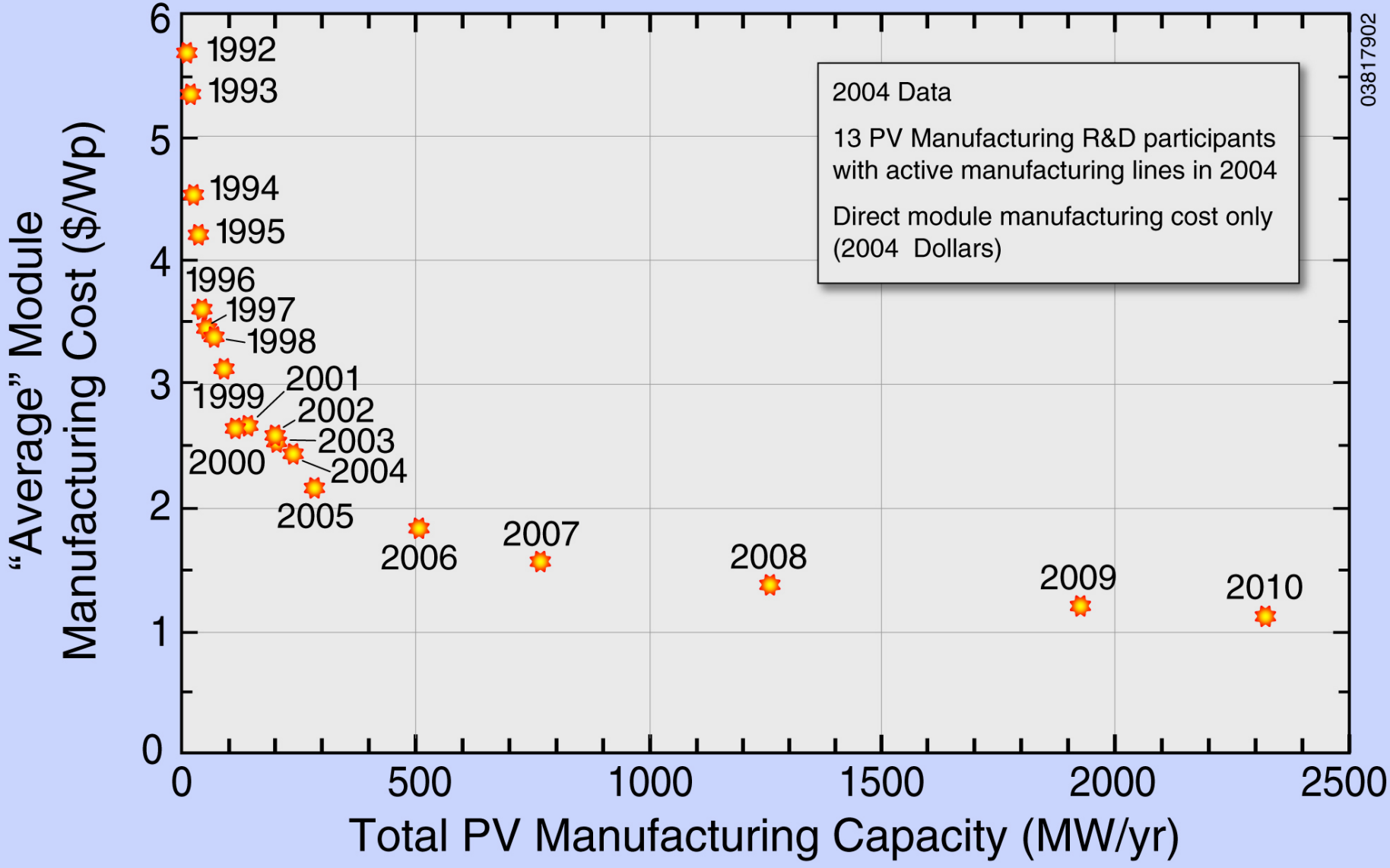
Source: Paul Maycock, *PV News*, February 2005

026587210

Crystalline Silicon, Thin-Films, and Concentrators

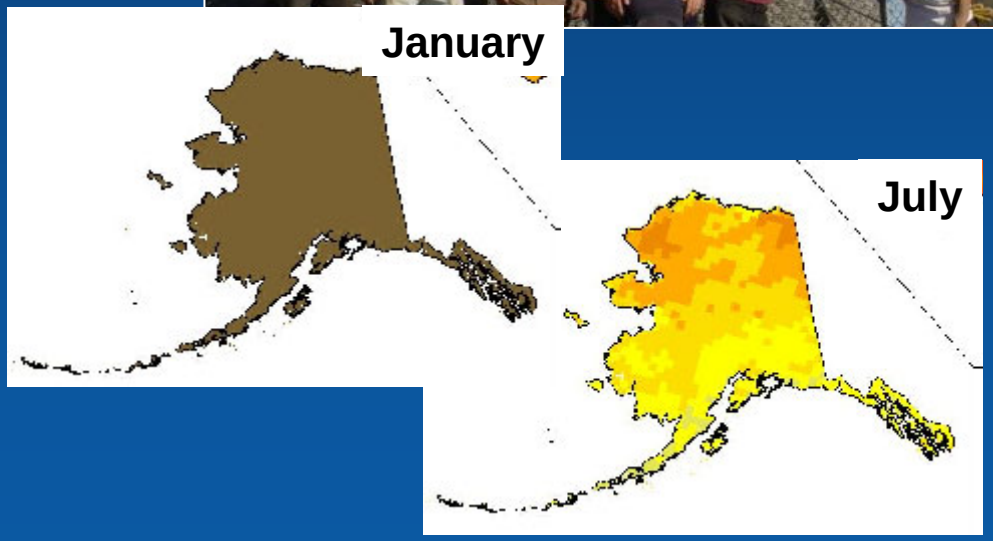
PV Industry Cost/Capacity

(DOE/US Industry Partnership)

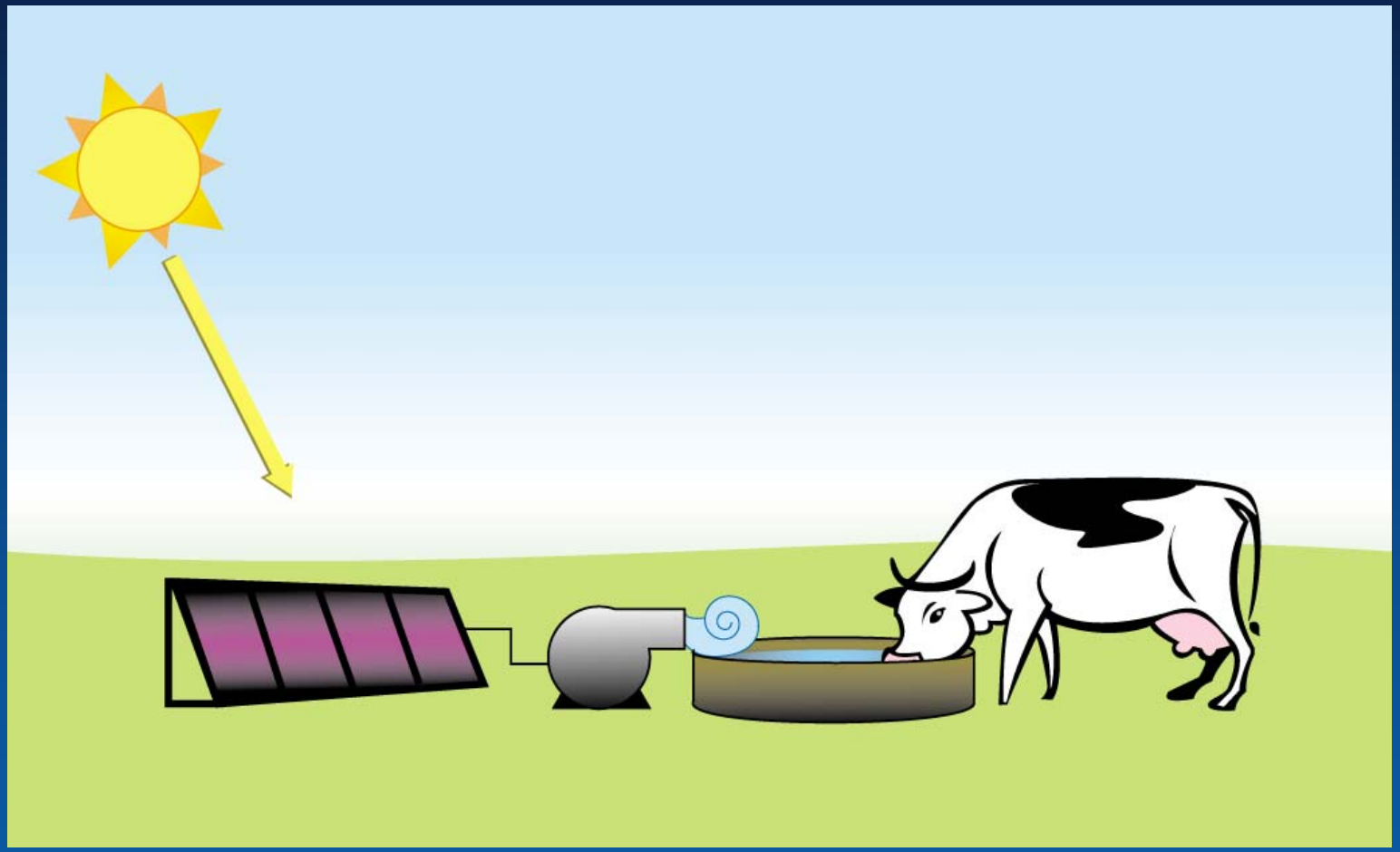


Solar Options

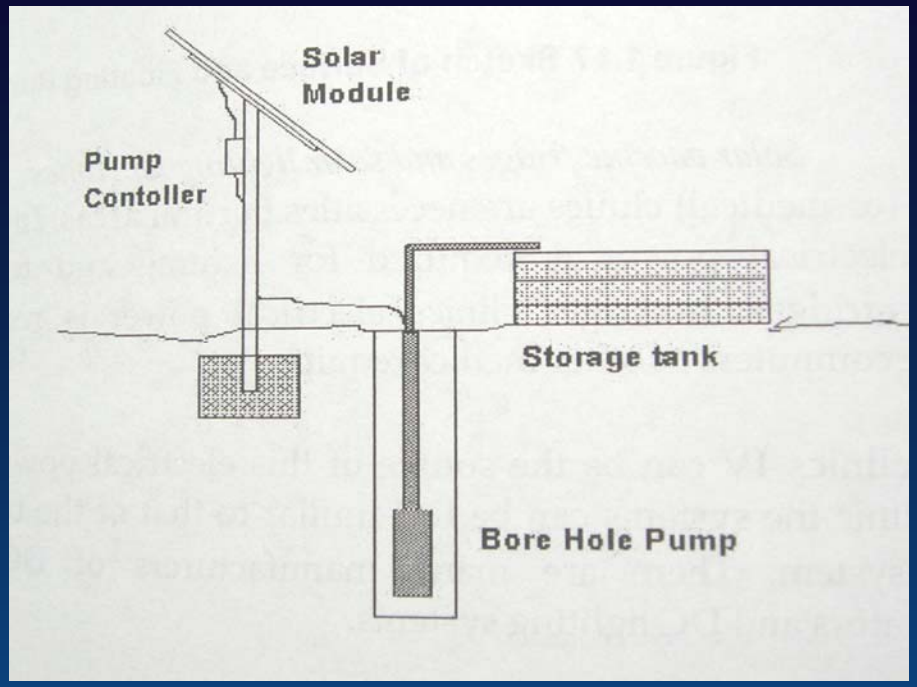
Arctic Village
Venetie

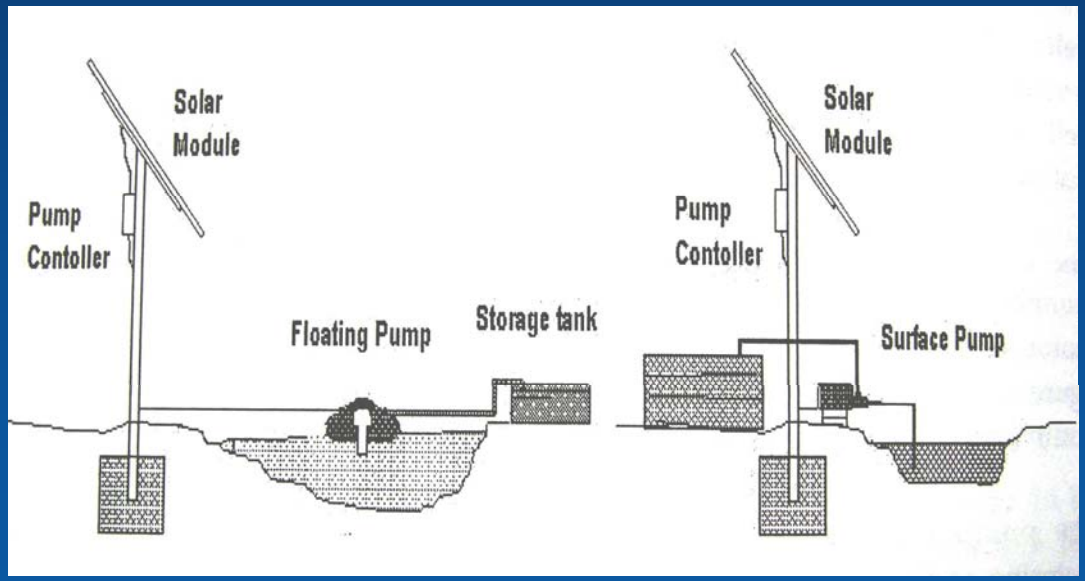


Simple Direct Drive PV System



Water Pumping Designs

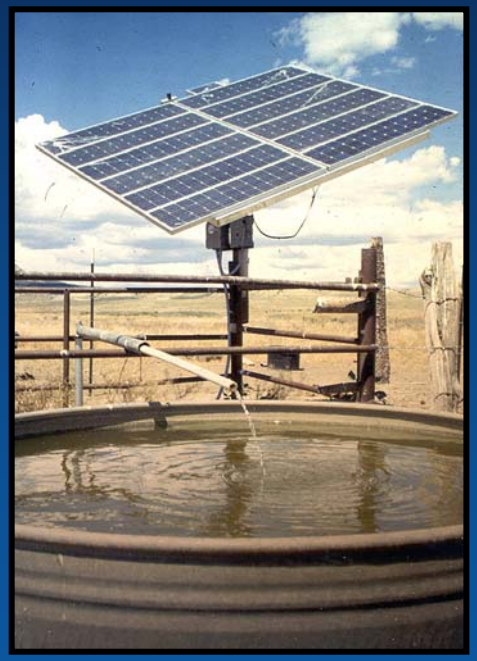




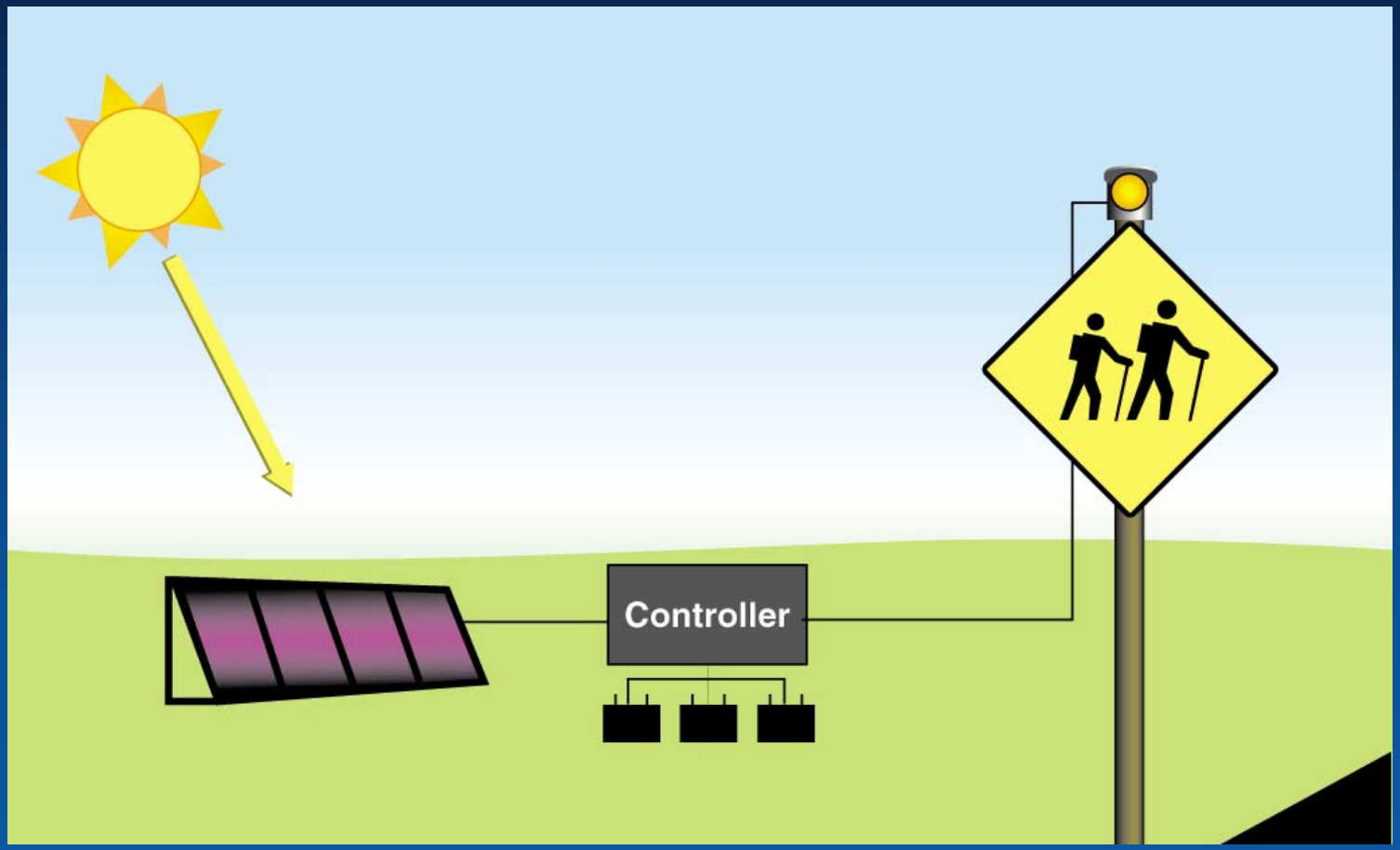
Solar Water Pumping

Ute Mt. Ute Tribe , CO

Inadequate Wind & High Maintenance Costs



Simple DC PV System with Battery Storage



Typical PV - Battery Systems

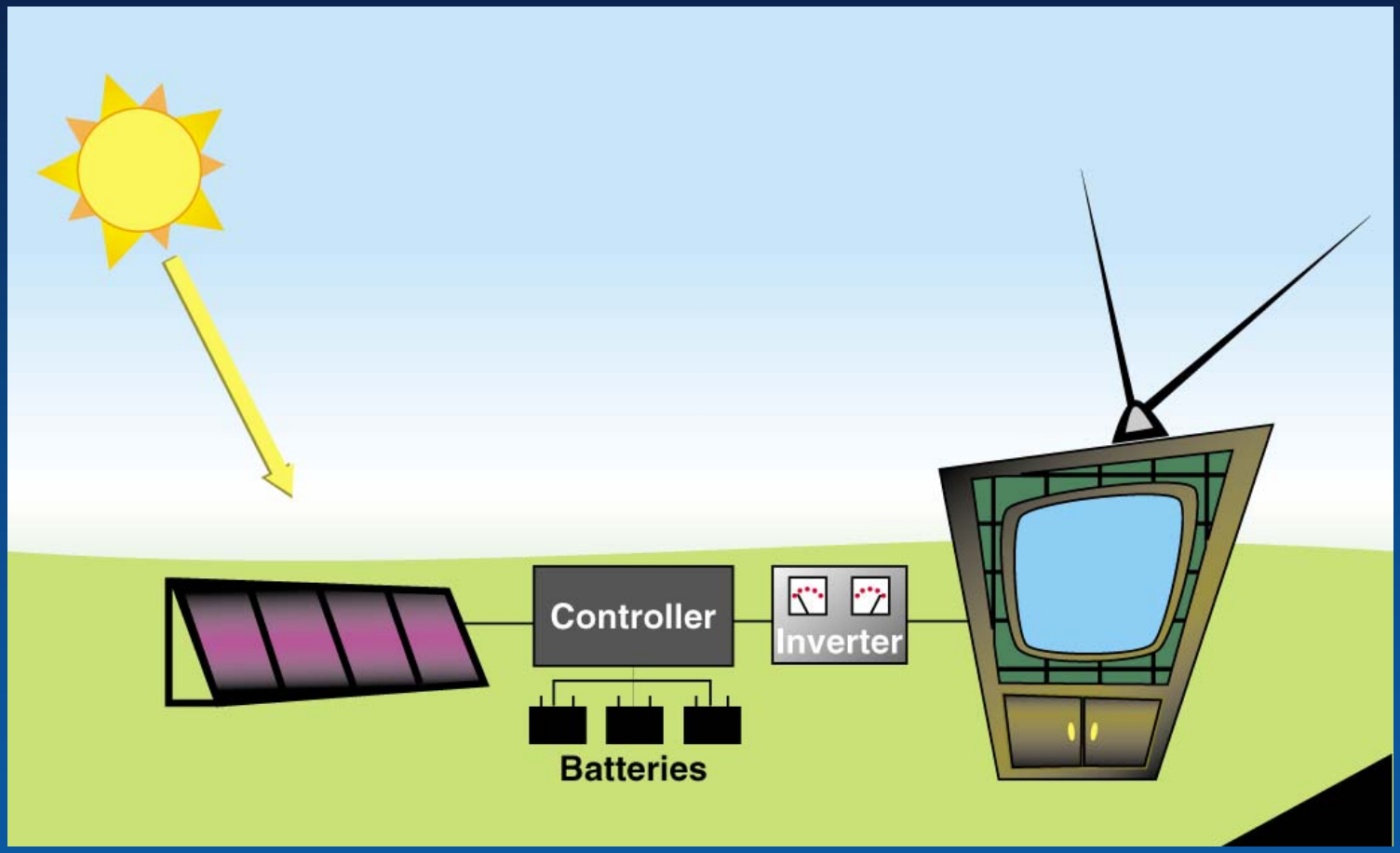
DC PV System Example: PJKK Federal Building, HI

- 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

Department of Interior

National Park Service

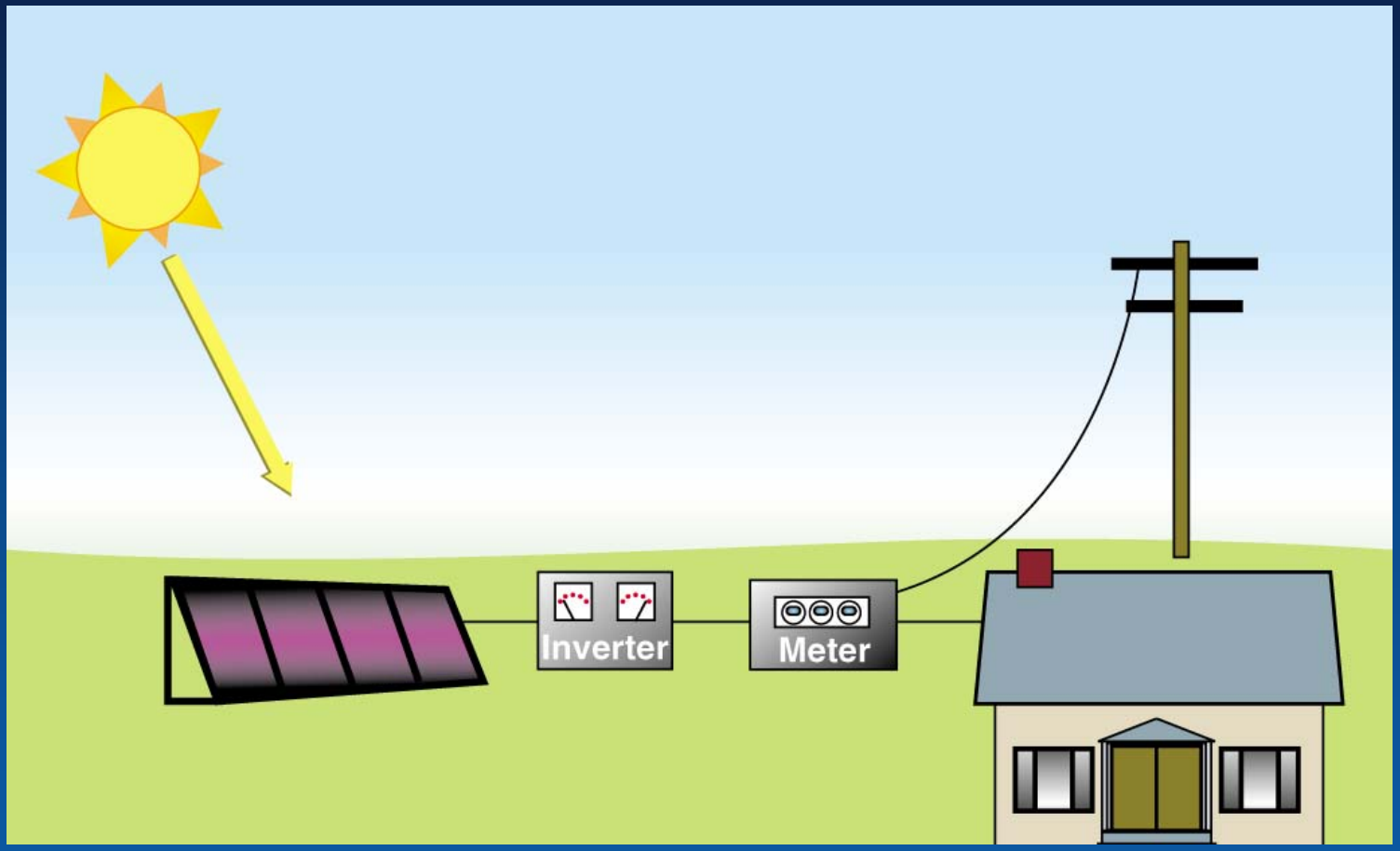
AC PV System with Inverter



5kW Inverter

Converts Direct Current (DC) to Alternating Current (AC)

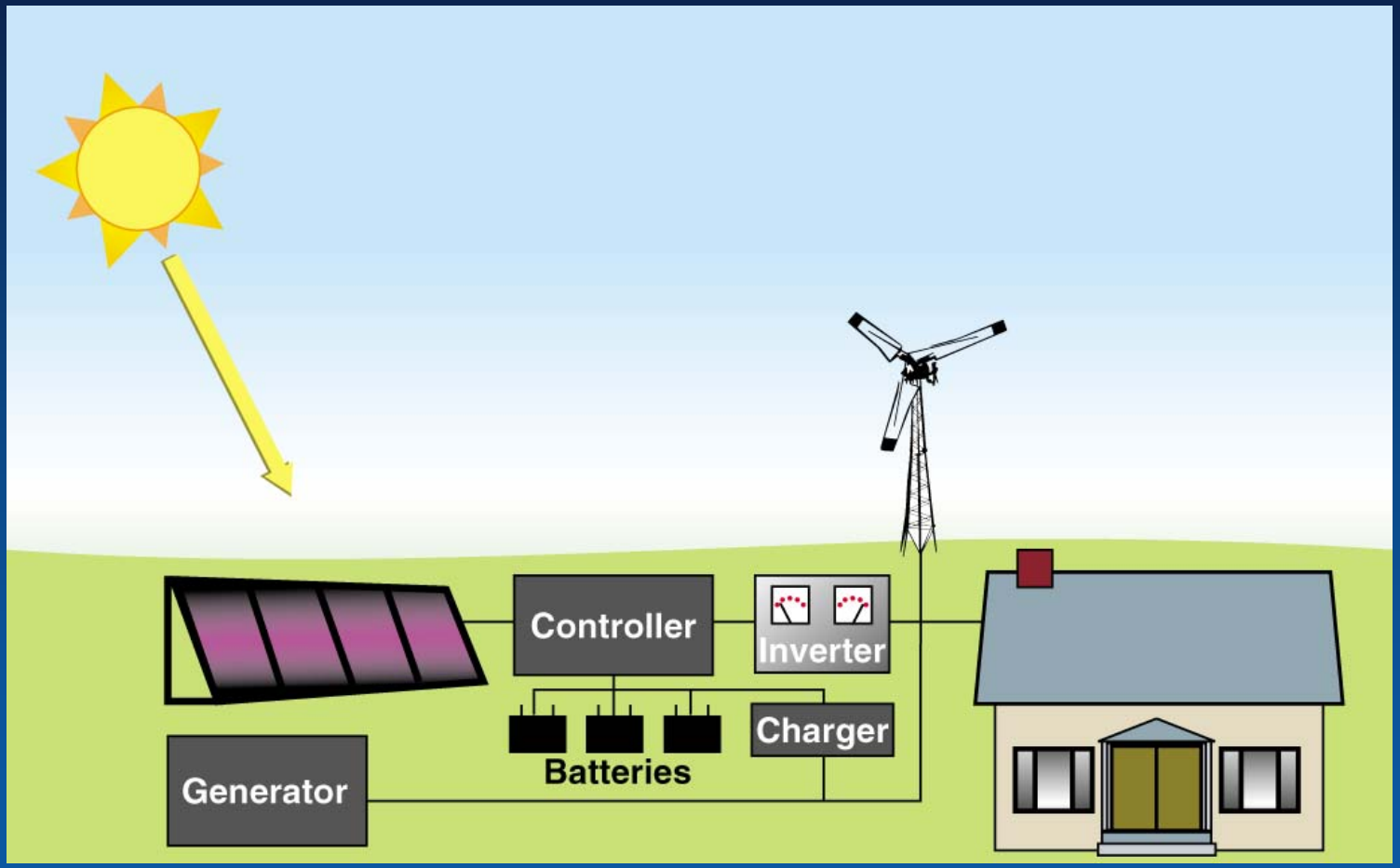
Utility-Connected (Line-Tie) PV System




Jicarilla, Apache, NM
2.4 kW Grid Connected
Dulce High School

Building-Integrated PV (BIPV)

Hybrid PV/Generator System



Stock Watering

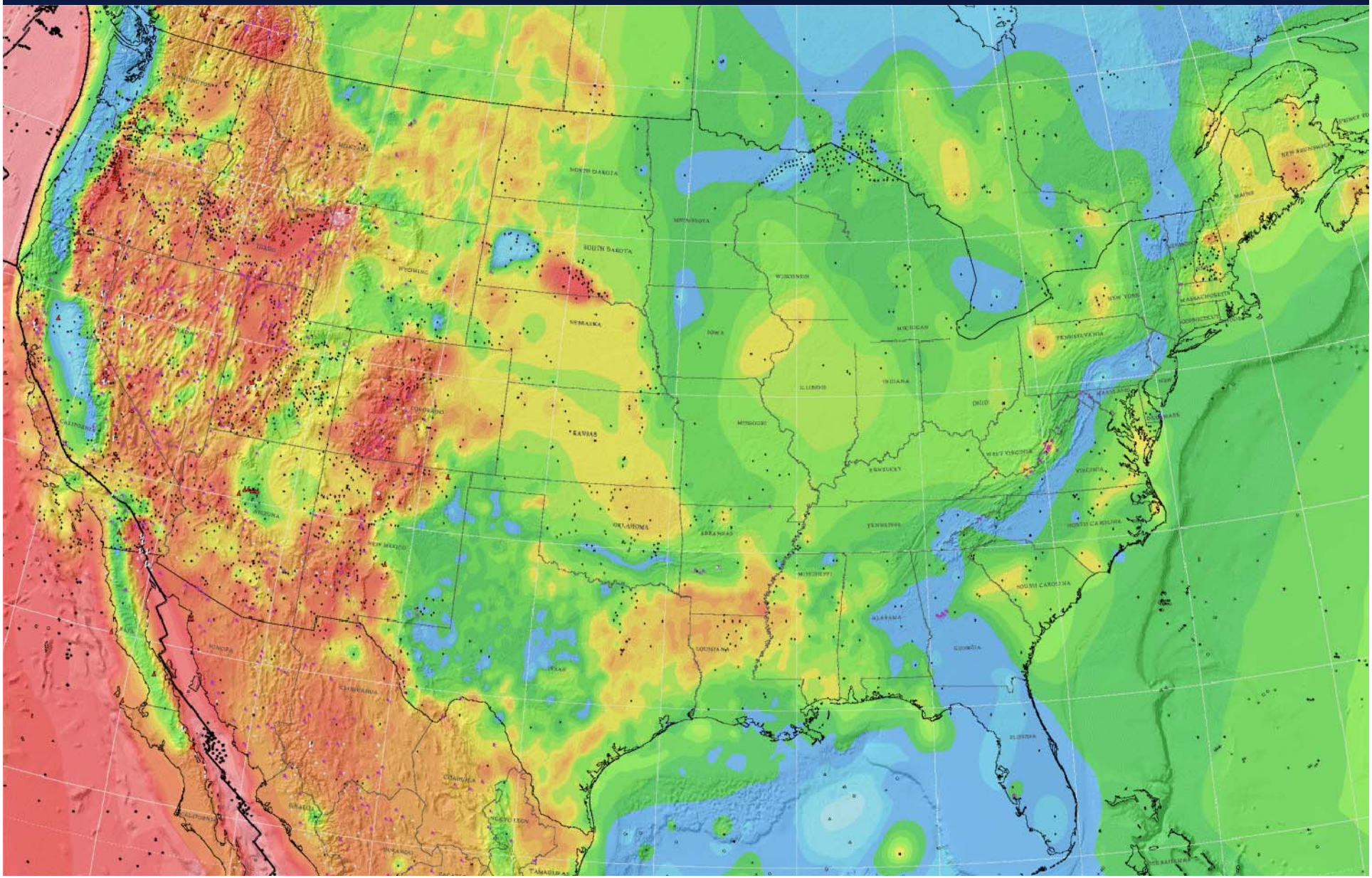
- Livestock watering at the Bledsoe Ranch Colorado, USA

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

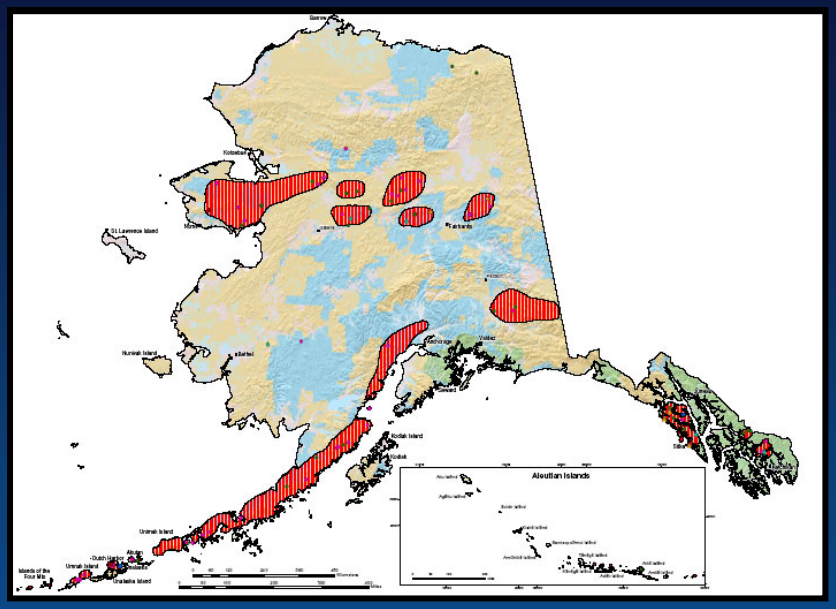
NEOS Corporation

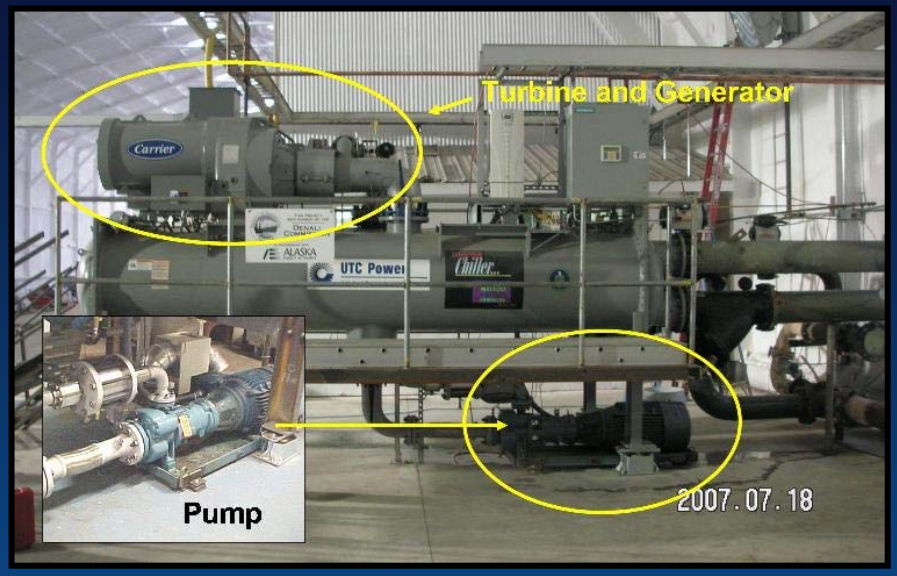
NTUA Home-Scale Hybrid

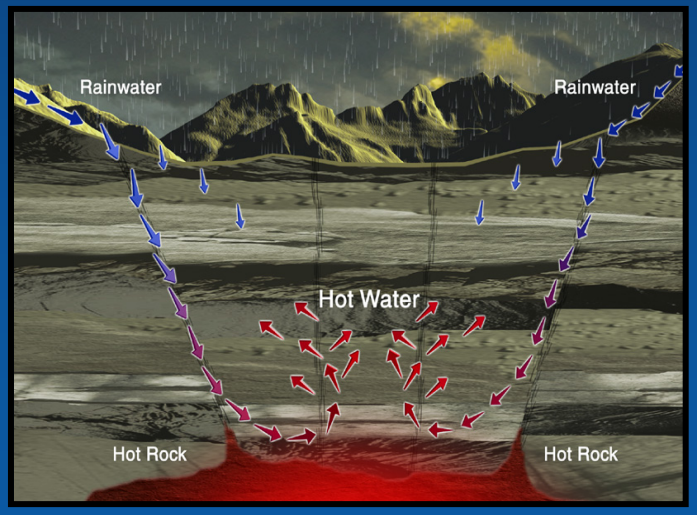
Geothermal Resource Potential

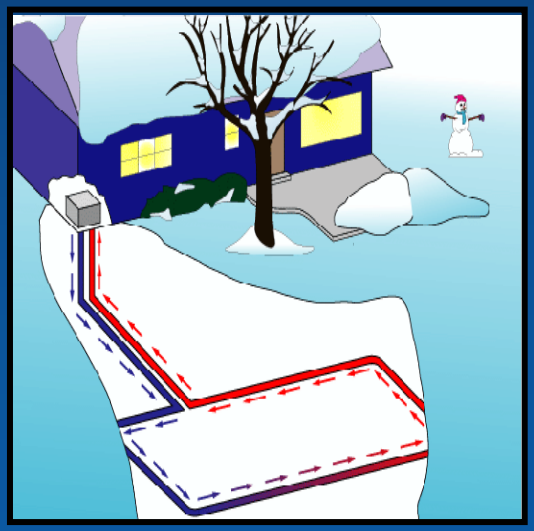


Geothermal Options





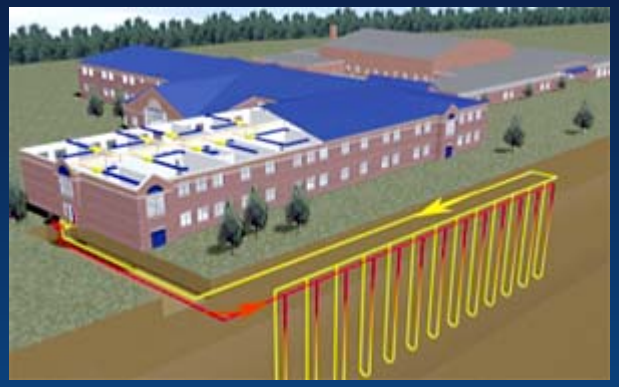




History of Geothermal Electricity

- Experiments began in Lardarello, Italy in 1904
- First U.S. plant at The Geysers in 1920s; first commercial plant in 1960

Geothermal Heat Pump Characteristics
"Using Mother Nature Effectively"



- Highly energy efficient
- High level of comfort
- Typically ~70% renewable energy
- Suitable for residential, commercial or industrial
- Typically 15-25 year life
- Environmentally beneficial with no combustion
- Higher first costs, but lower life cycle costs
- Multiple ways to install, with suitability for almost all geographic locations
- Proven technology

Geo-Thermal Pond

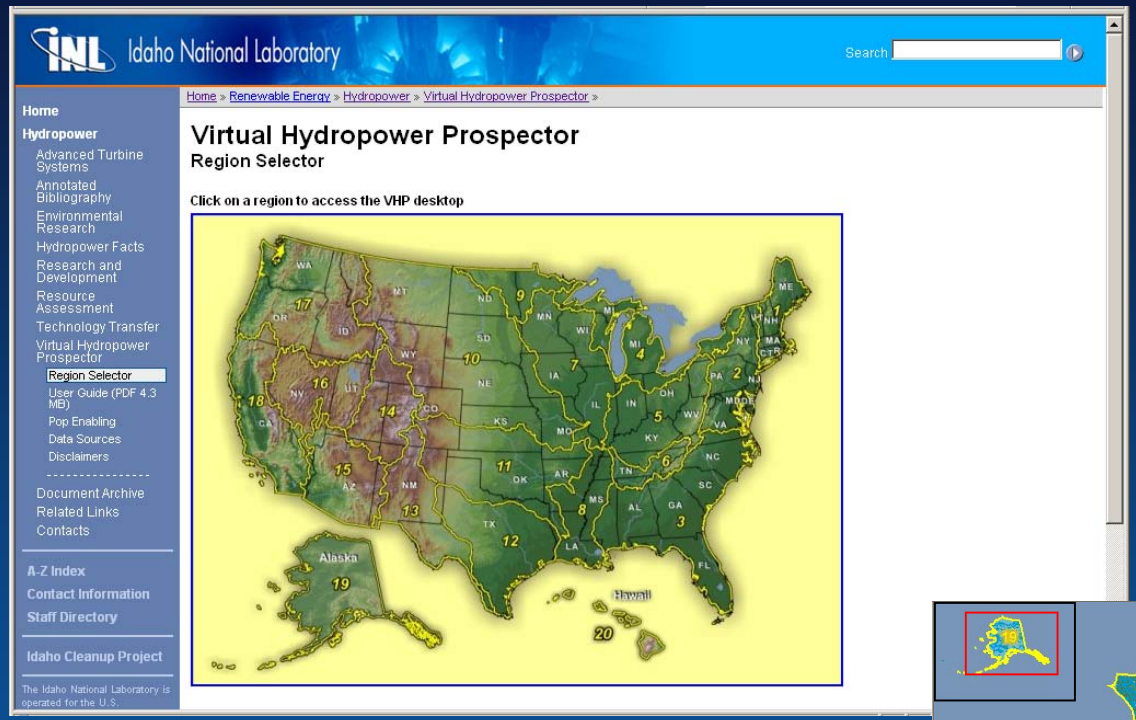
Geo-Thermal Pond

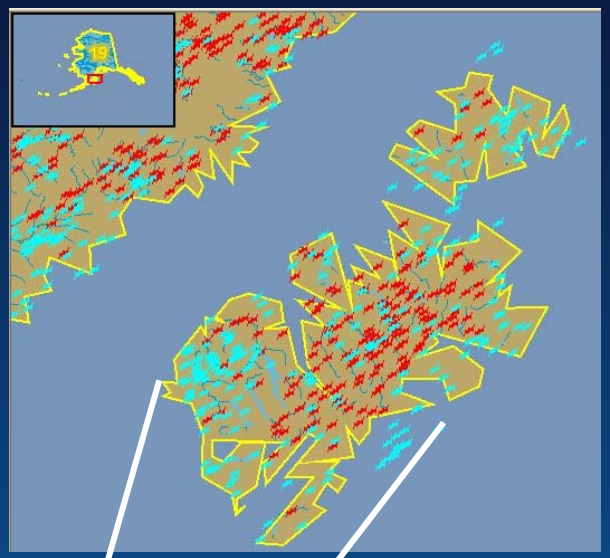
Cultural & Heritage Center

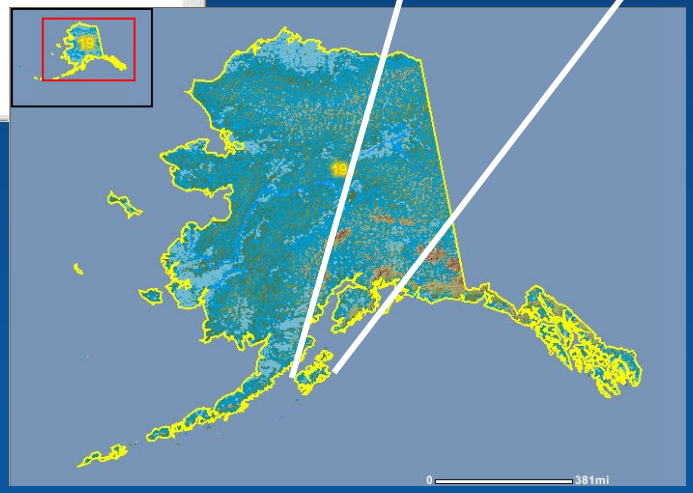
Firelake Discount Foods

- 84,000 Square Feet

Small Hydro Power Options

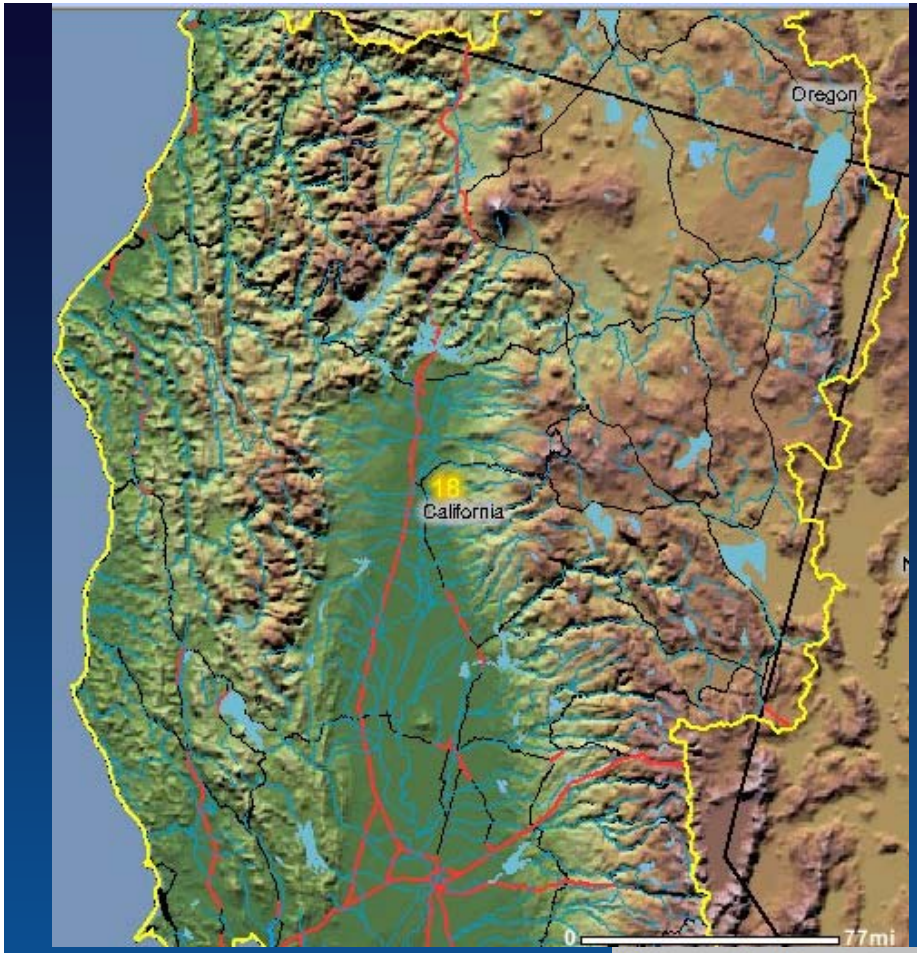


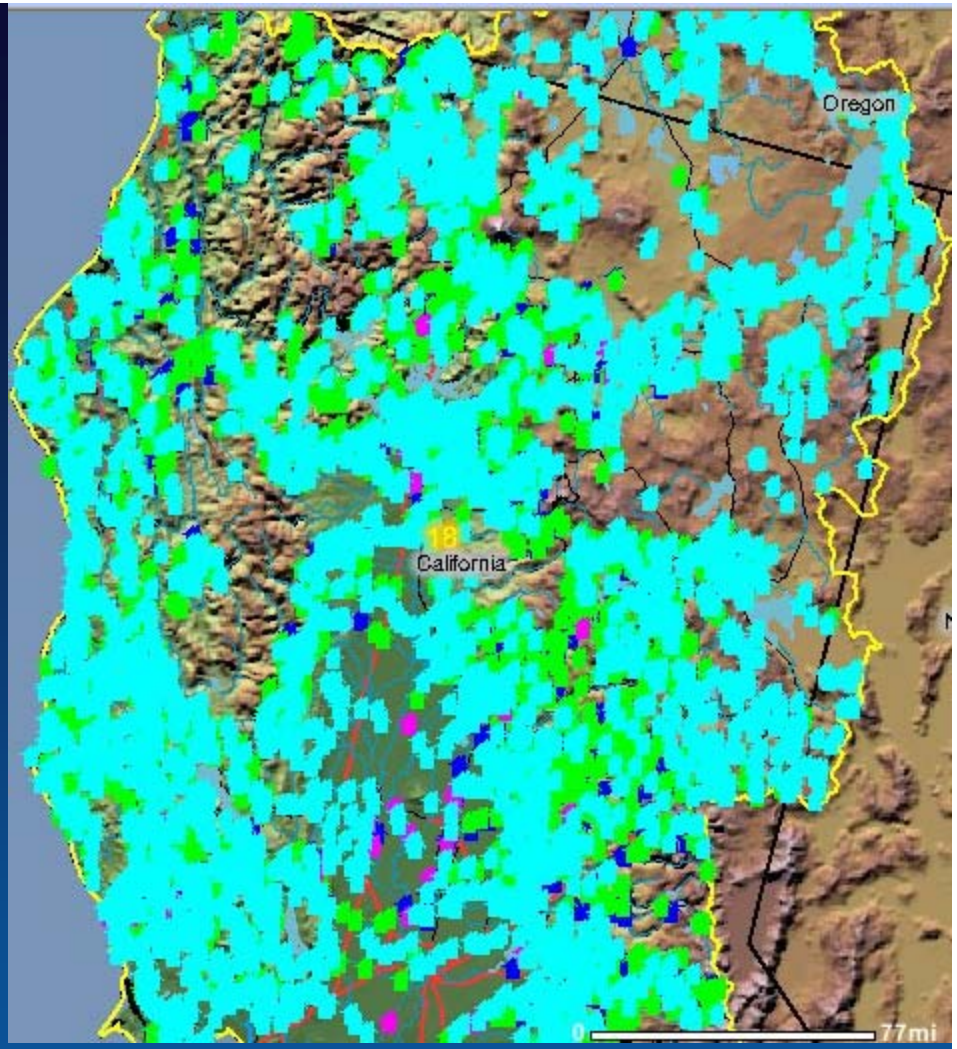




http://hydropower.inl.gov/prospector/


Small Hydropower Opportunities in California
Montana
Oregon
Idaho
Wyomin
Nevada
Utah
California
Arizona
New Mexico
0
234mi

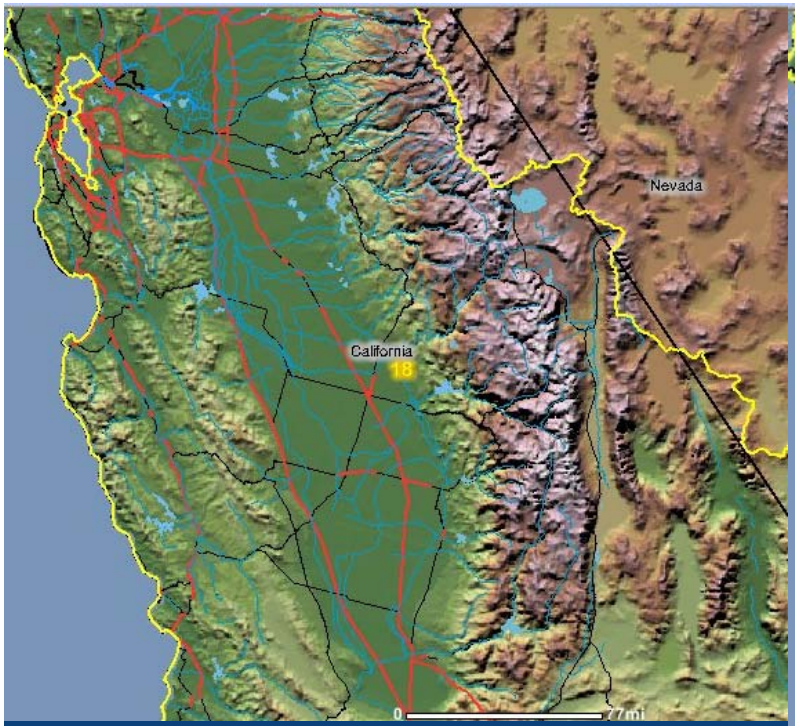


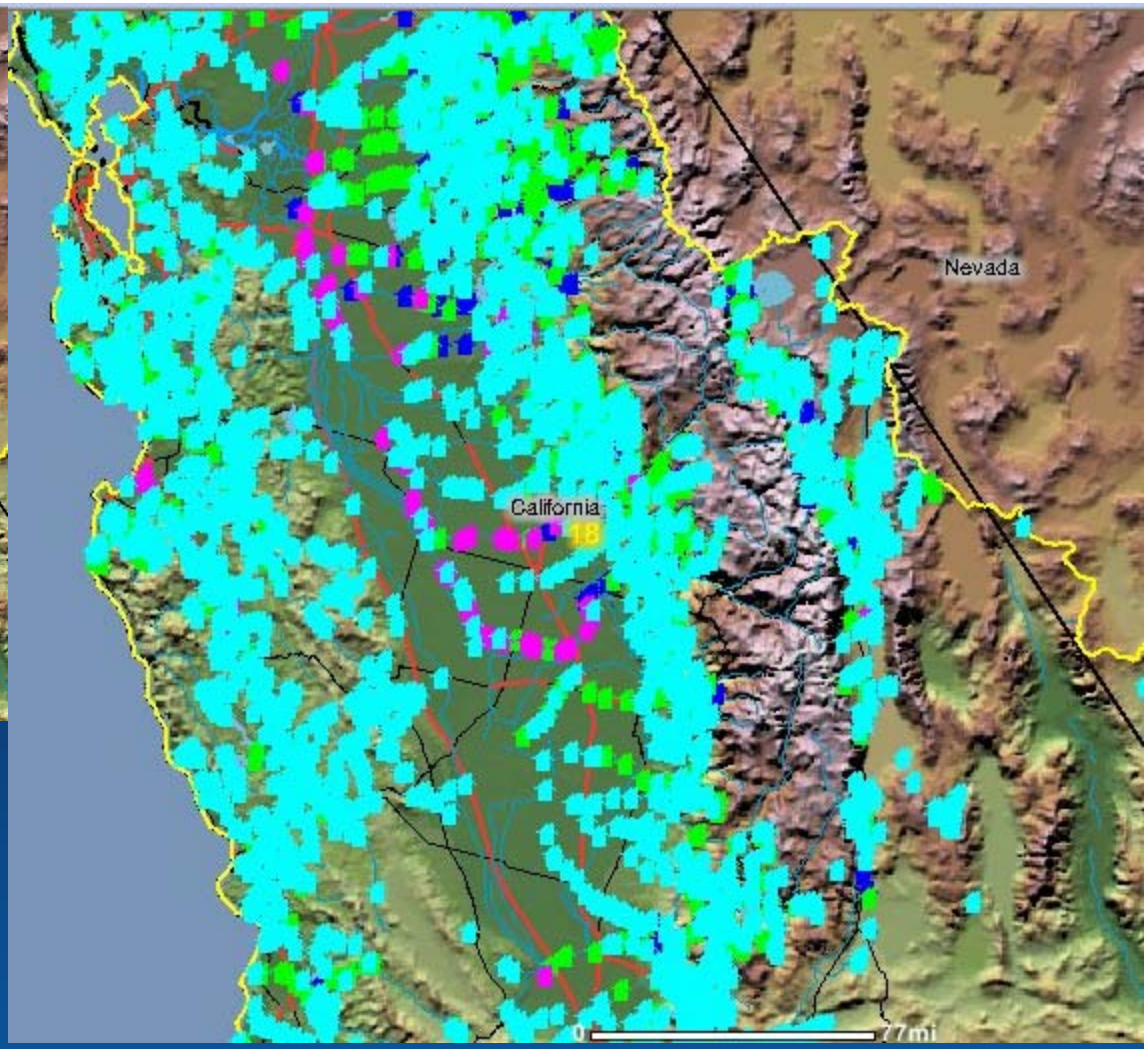


Potential Projects

Feature Select	Active Feature	
☑	○	Small Hydro
☑	○	Low Power Conventional
☑	○	Low Power Unconventional
☑	○	Microhydro

Northern California

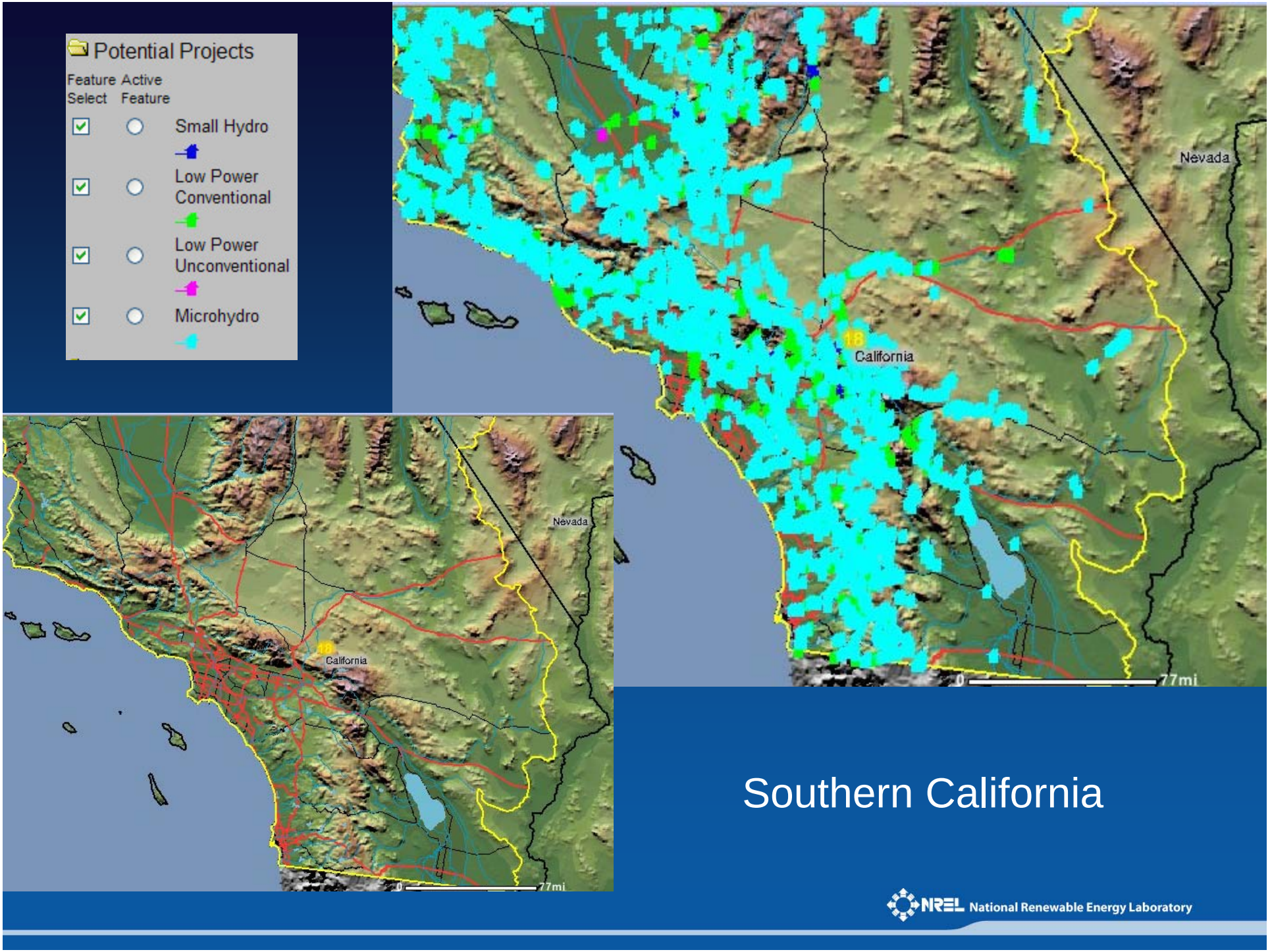




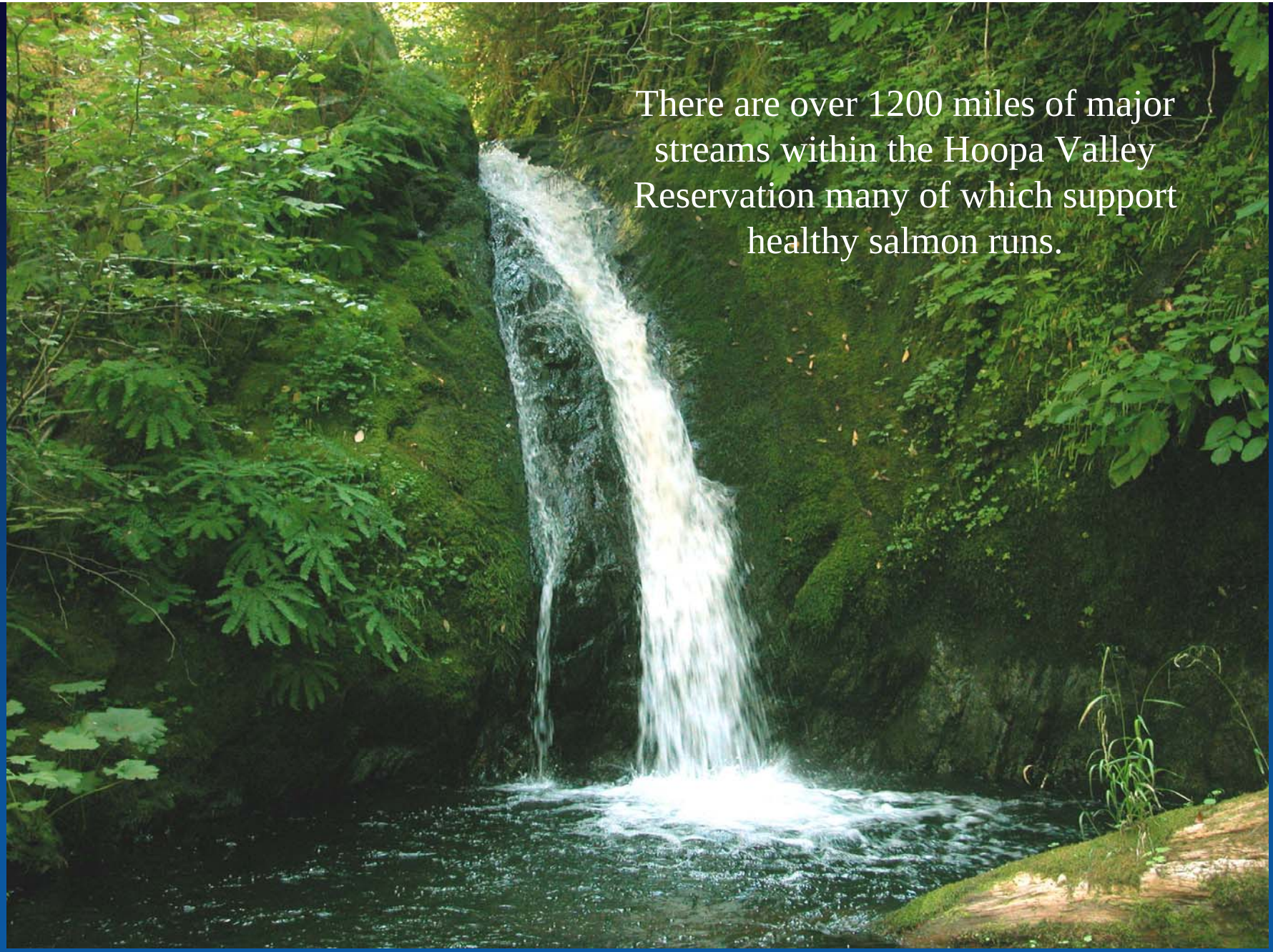
Potential Projects

Feature Select	Active Feature	
☑	○	Small Hydro
☑	○	Low Power Conventional
☑	○	Low Power Unconventional
☑	○	Microhydro

Central California

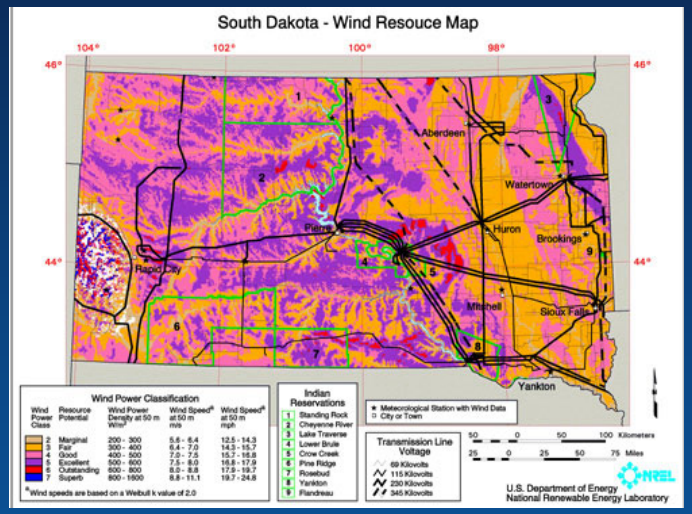


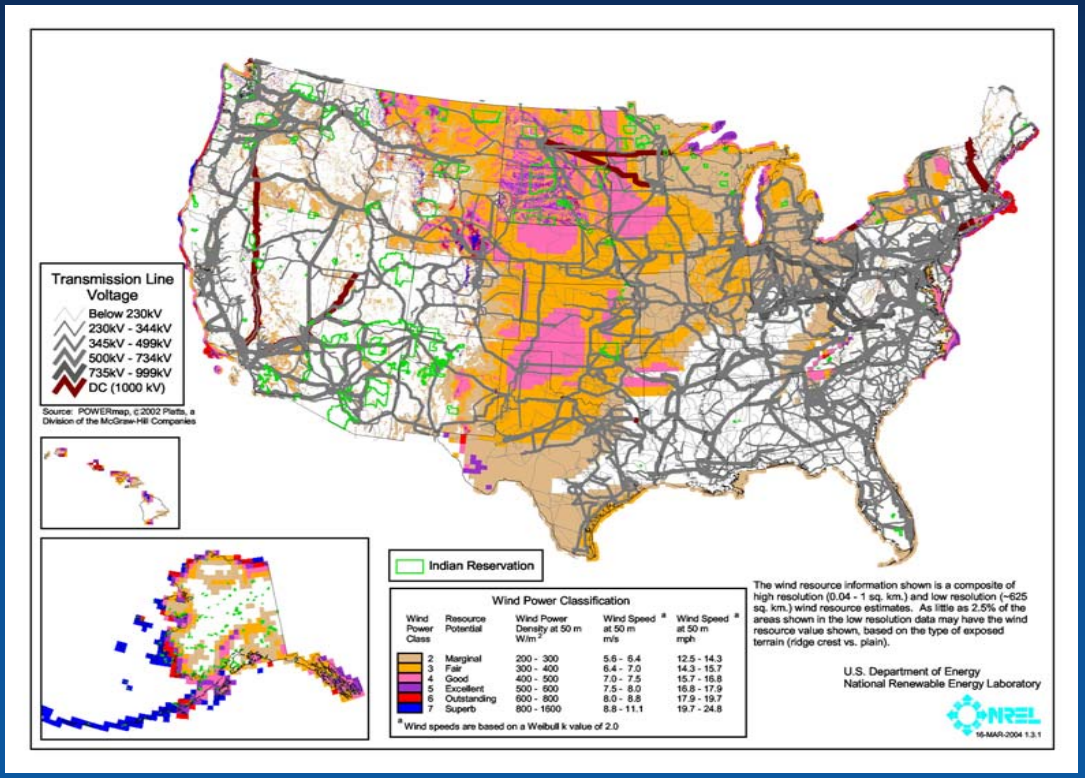
Southern California


There are over 1200 miles of major streams within the Hoopa Valley Reservation many of which support healthy salmon runs.

DOE's Tribal Energy Program

Wind Potential on Tribal Lands about 14% of U.S. Annual Electric Generation (~ 3,853 Billion kWh/year)





Wind potential of about 535 Billion kWh/yr on Indian Lands in Lower 48 States

Wind Turbine Sizes and Applications

Small (≤10 kW)

- Homes
- Farms
- Remote Applications (e.g. water pumping, telecom sites, icemaking)

Kotzebue

Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Distributed Power

Large (250 kW – 2+ MW)

- Central Station Wind Farms
- Distributed Power

St. Paul

Biomass & Bioenergy Flows

Biomass

Fiber

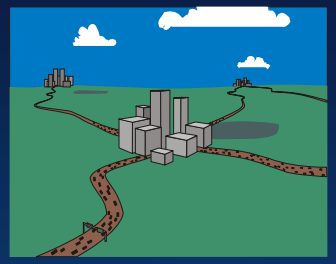
pulp
paper
lumber
plywood
cotton

Materials

Process Residues
black liquor
sawdust
bark

Crops, Animals

Food



Consumers

MSW clean fraction
yard trimmings
constr. & demolition wood
non-recyclable organics

Process Residues
dung
bagasse

stalks & straws
harvest residues
forest slash
forest harvest for energy plantations

Bioenergy

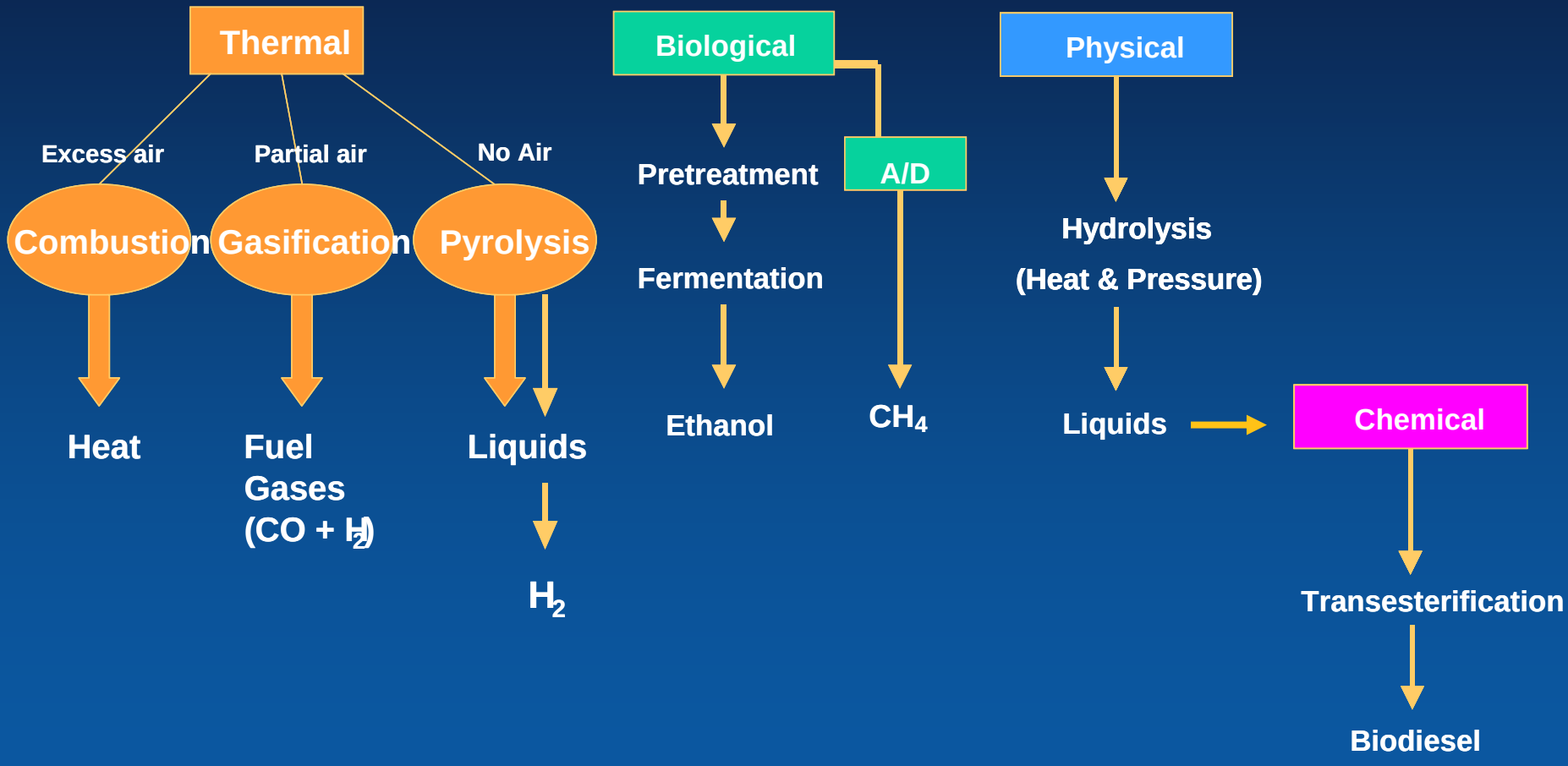
Energy Services

heat
CHP
electricity

charcoal
biogas
ethanol

Biofuels

Biomass Energy Pathways



Thermal

Combustion
Excess air

Heat

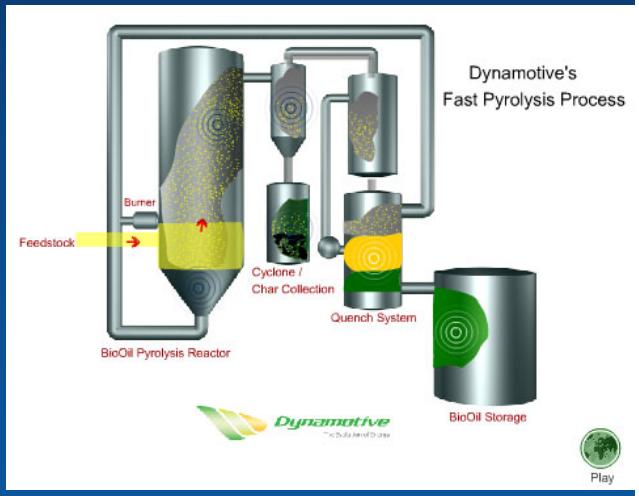
Gasification
Partial air

Fuel Gases

$(CO + H_2)$

Pyrolysis
No Air

Liquids



Wood Stove Heating

Seasoned firewood (20% moisture) @ $300/cord (~$150/ton)

~20 MBTU/cord → high efficiency wood stove @ 77% efficiency

~ $20/MBTU delivered to home
~$2.50/gal heating oil

Commercial-Scale Wood Heating

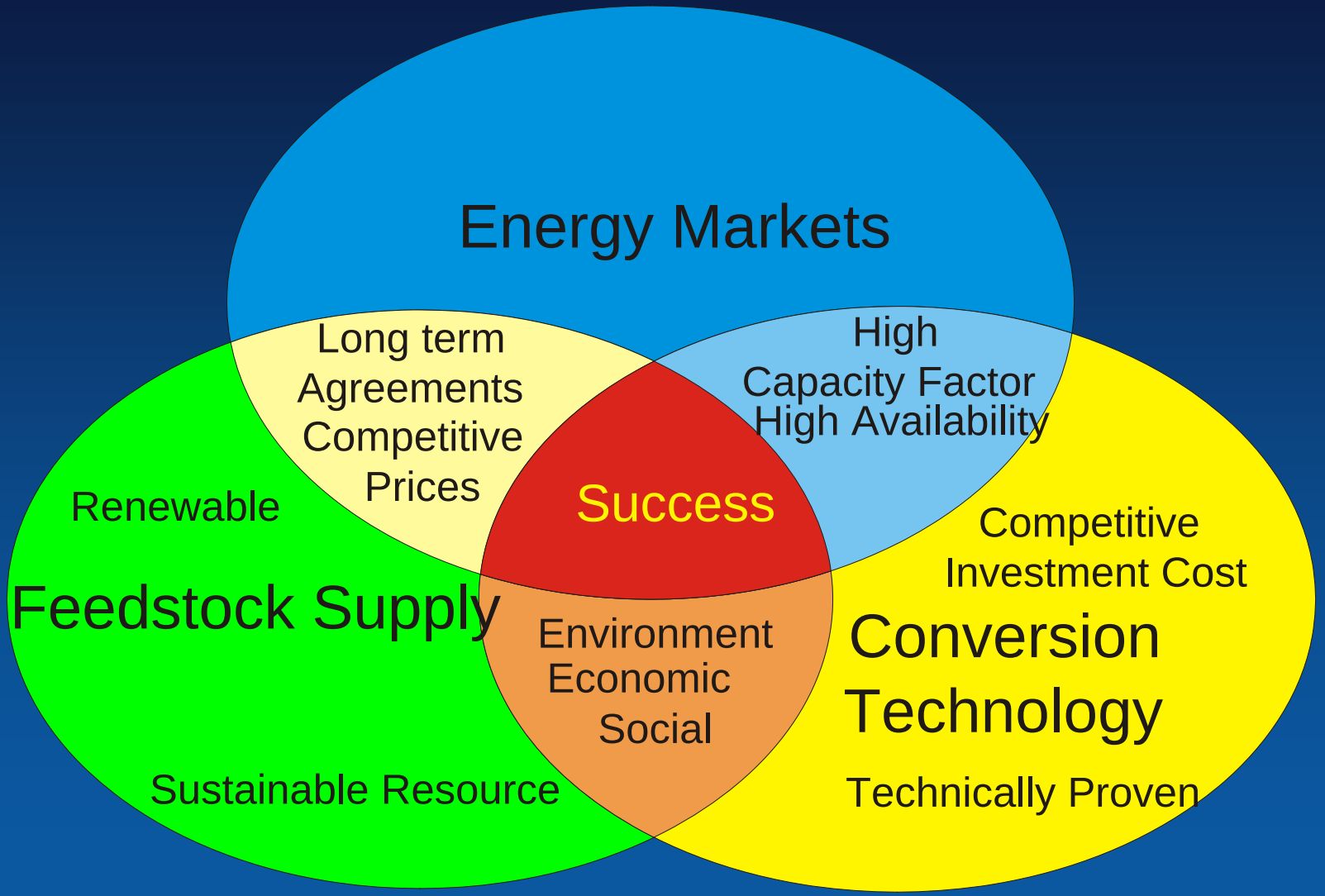
Green wood chips (50% moisture) @ $50/ton
~8.6 MBTU/ton in a
high efficiency wood boiler @ 85% efficiency

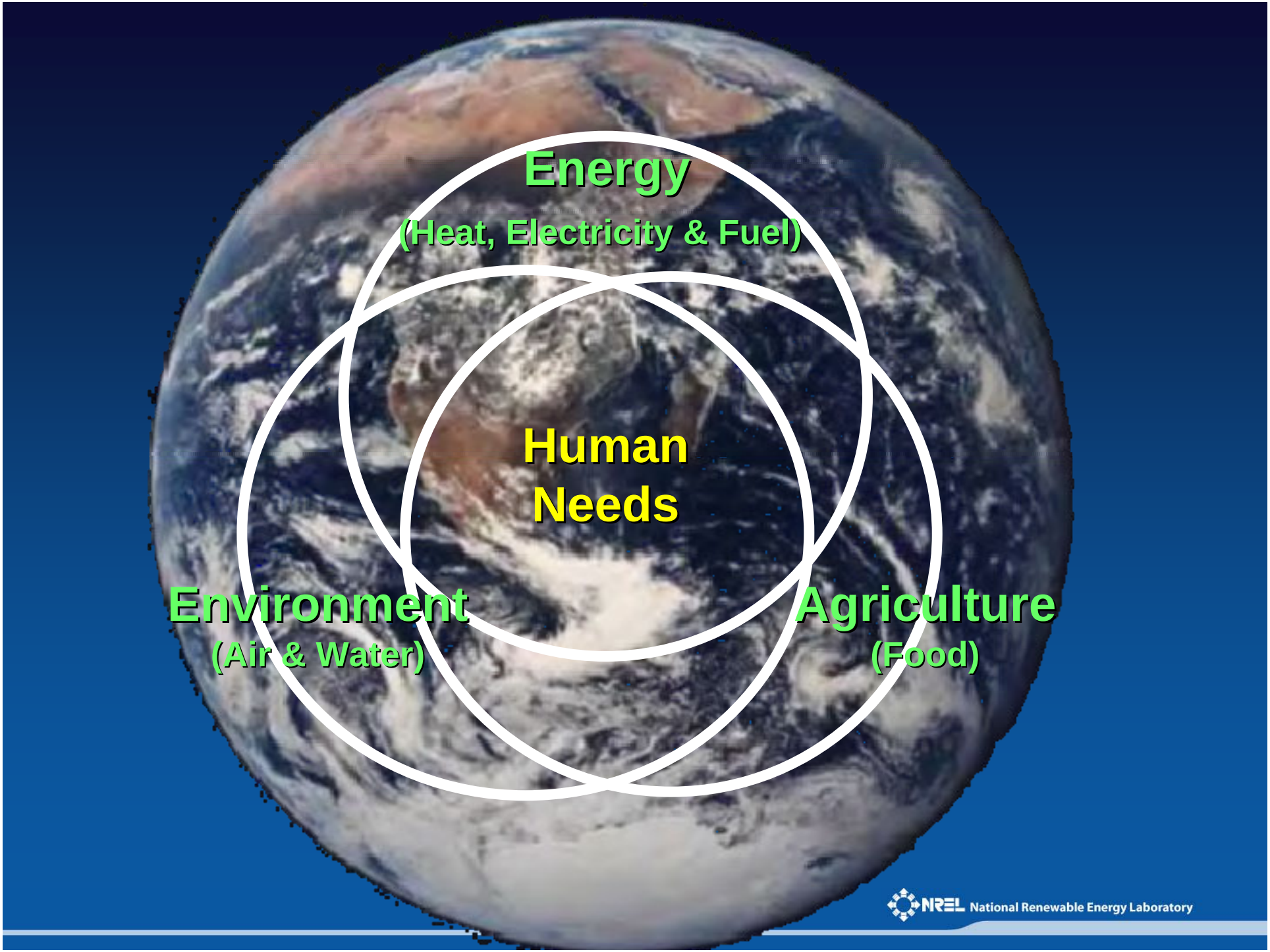
BIOMASS ENERGY RESOURCE CENTER

~ $7.00/MBTU delivered to building

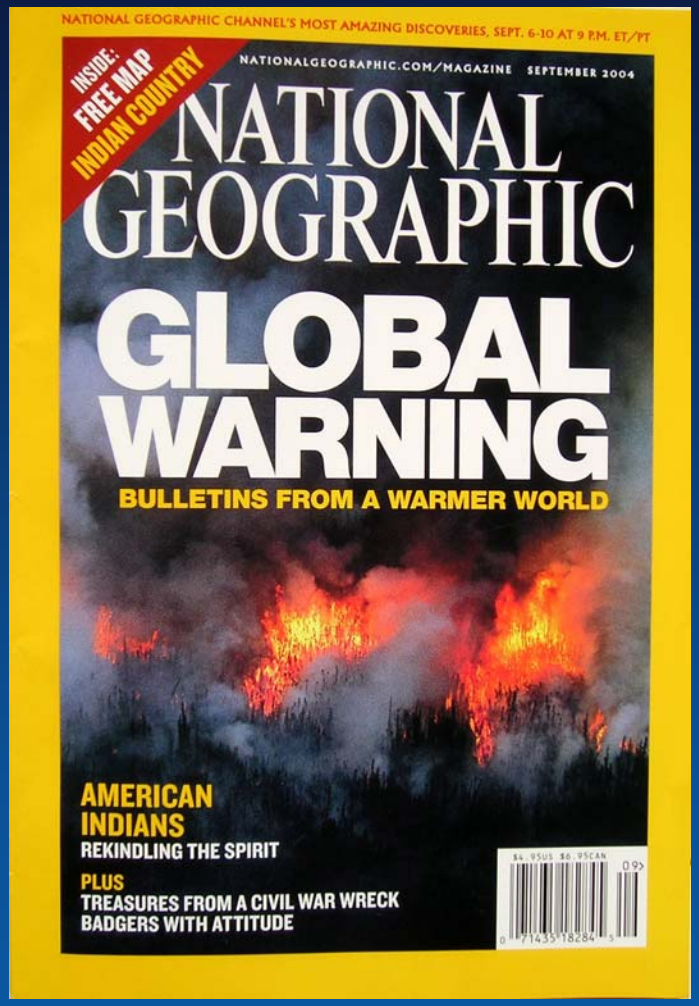
Energy Price Comparison

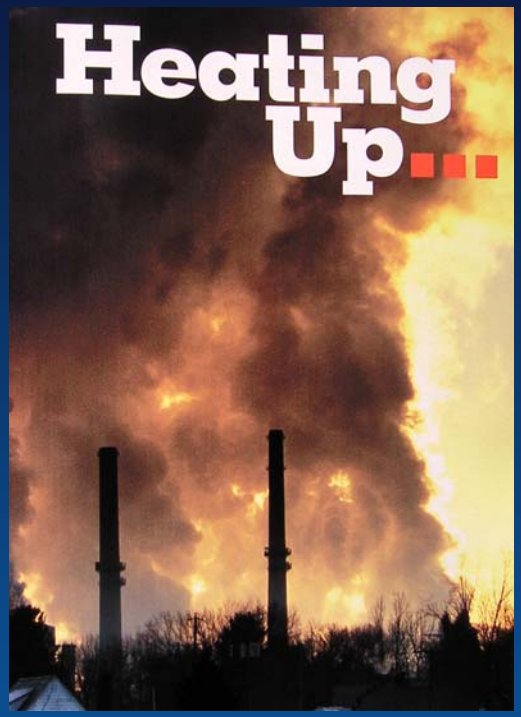
Bioenergy Project Requirements

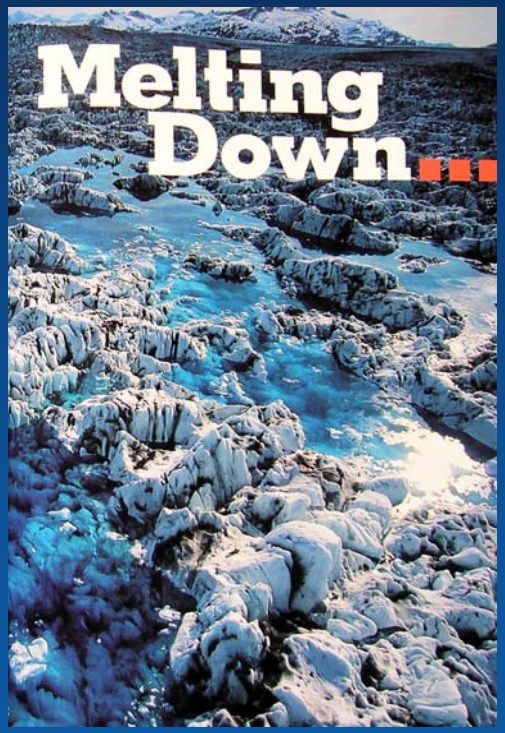



Energy
(Heat, Electricity & Fuel)
Human
Needs
Environment
(Air & Water)
Agriculture
(Food)

We Live in a Changing World

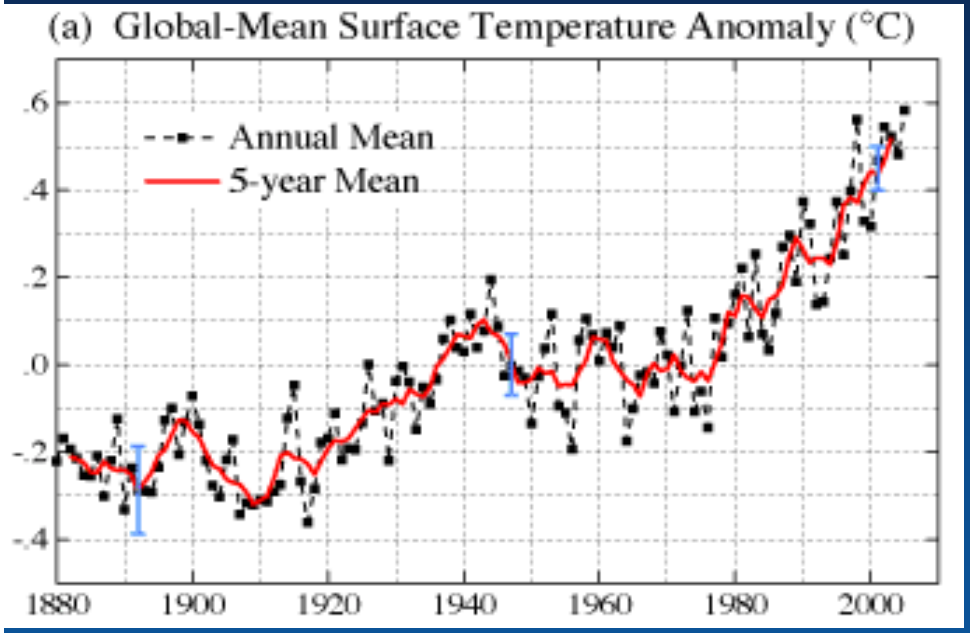


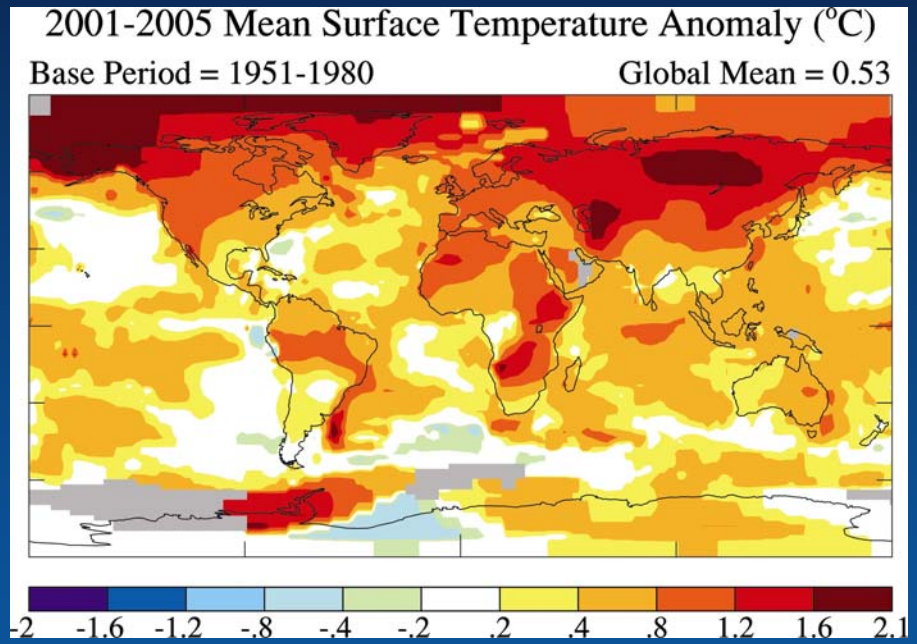




Where Carbon Reduction is a Requirement

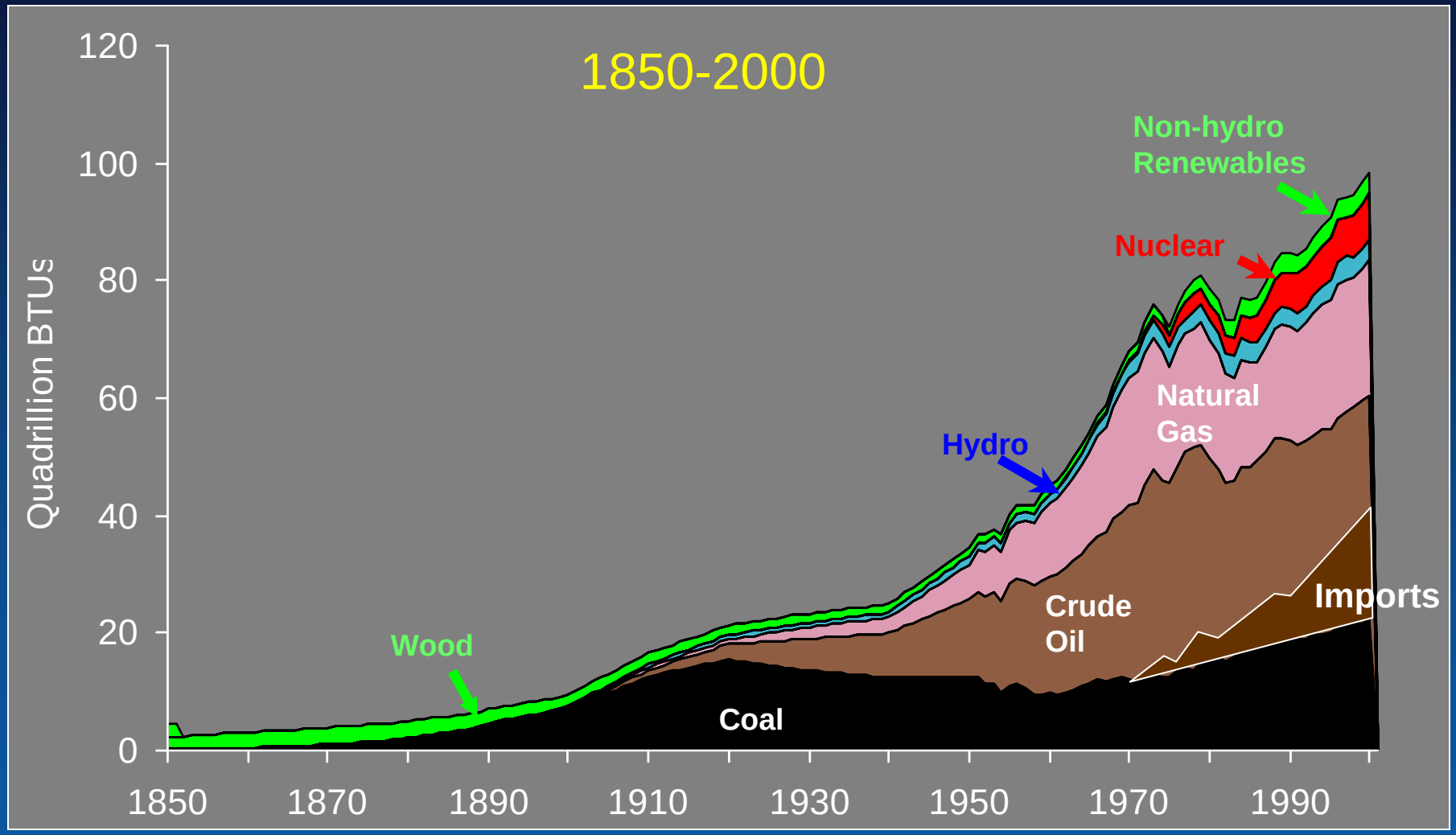
2005 Warmest Year on Record





Warming of 0.2°C/decade over last 30 years

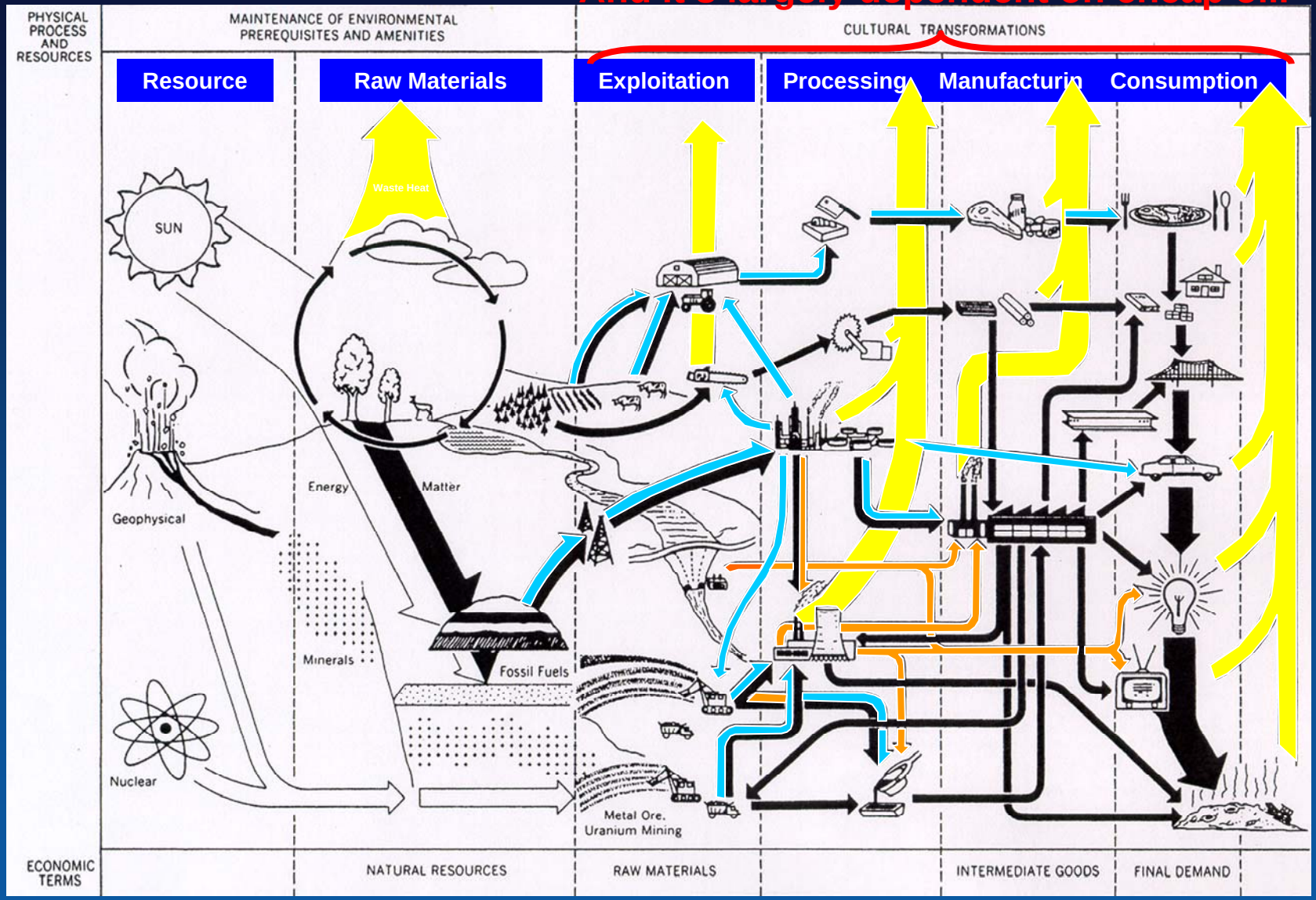
Where U.S. Energy Consumption Continues to Grow



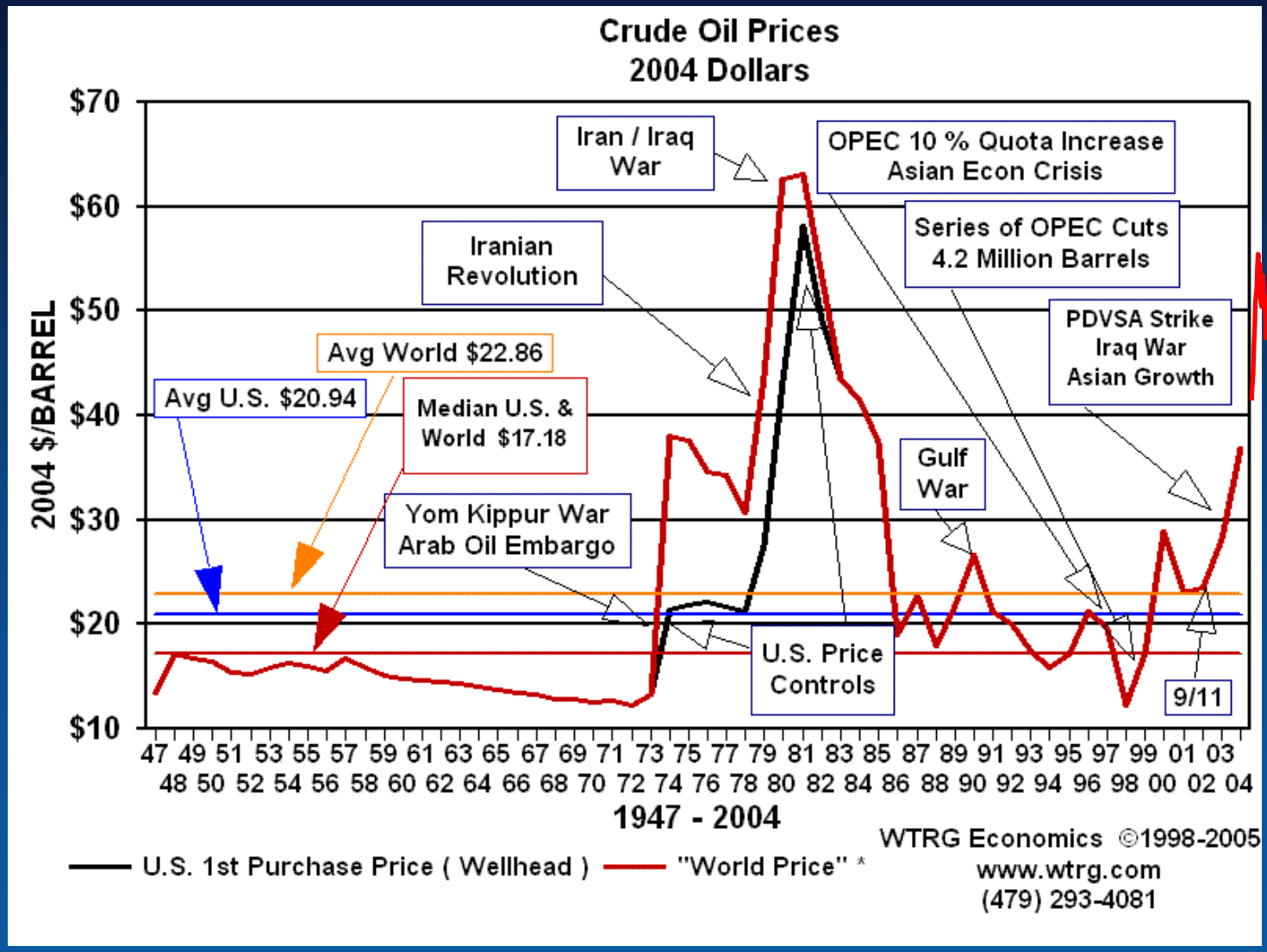
Source: 1850-1949, Energy Perspectives: A Presentation of Major Energy and Energy-Related Data, U.S. Department of the Interior, 1975; 1950-2000, Annual Energy Review 2000, Table 1.3

Where the global economy is very complex

And it's largely dependent on cheap oil.



Increasingly volatile, increasingly upward

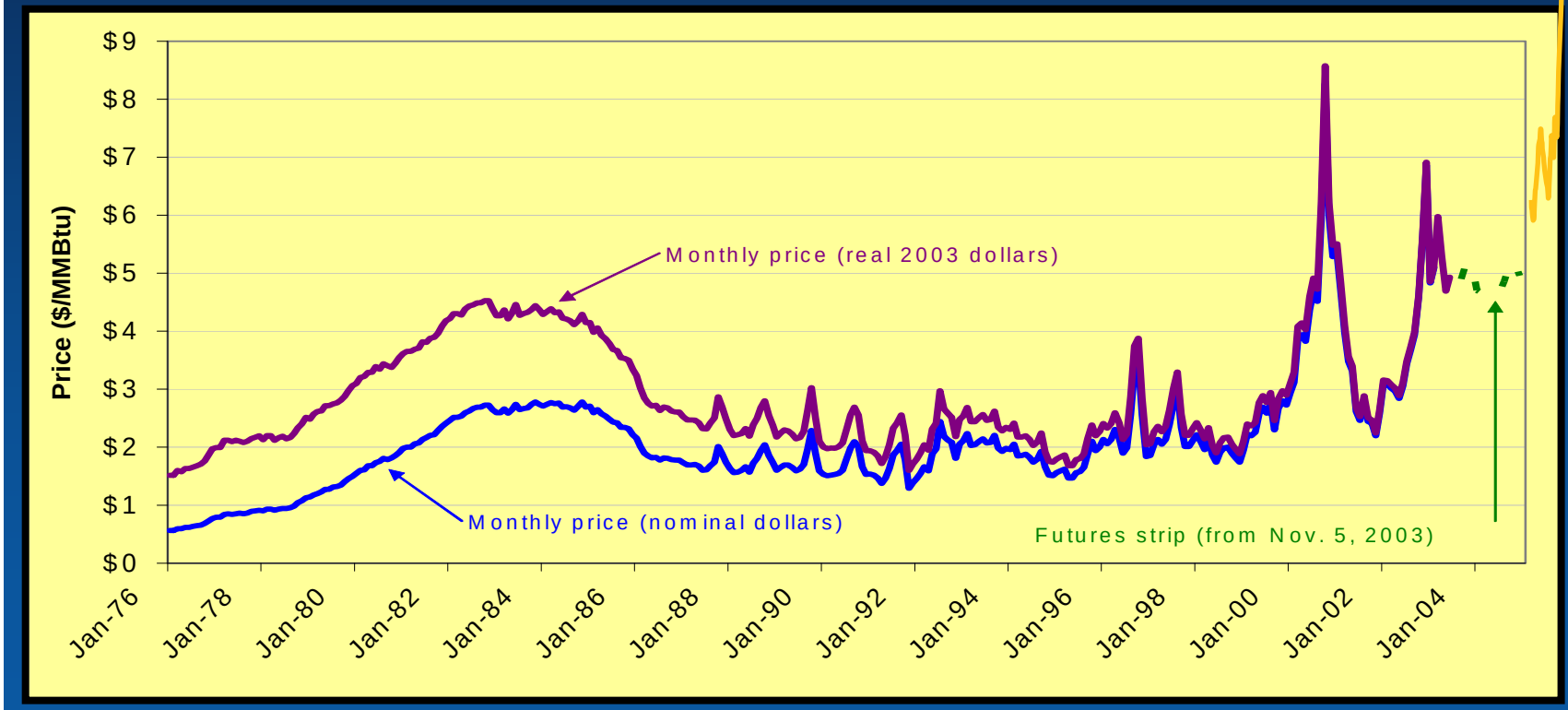


~$140/bbl

~$77/bbl

~$60/bbl

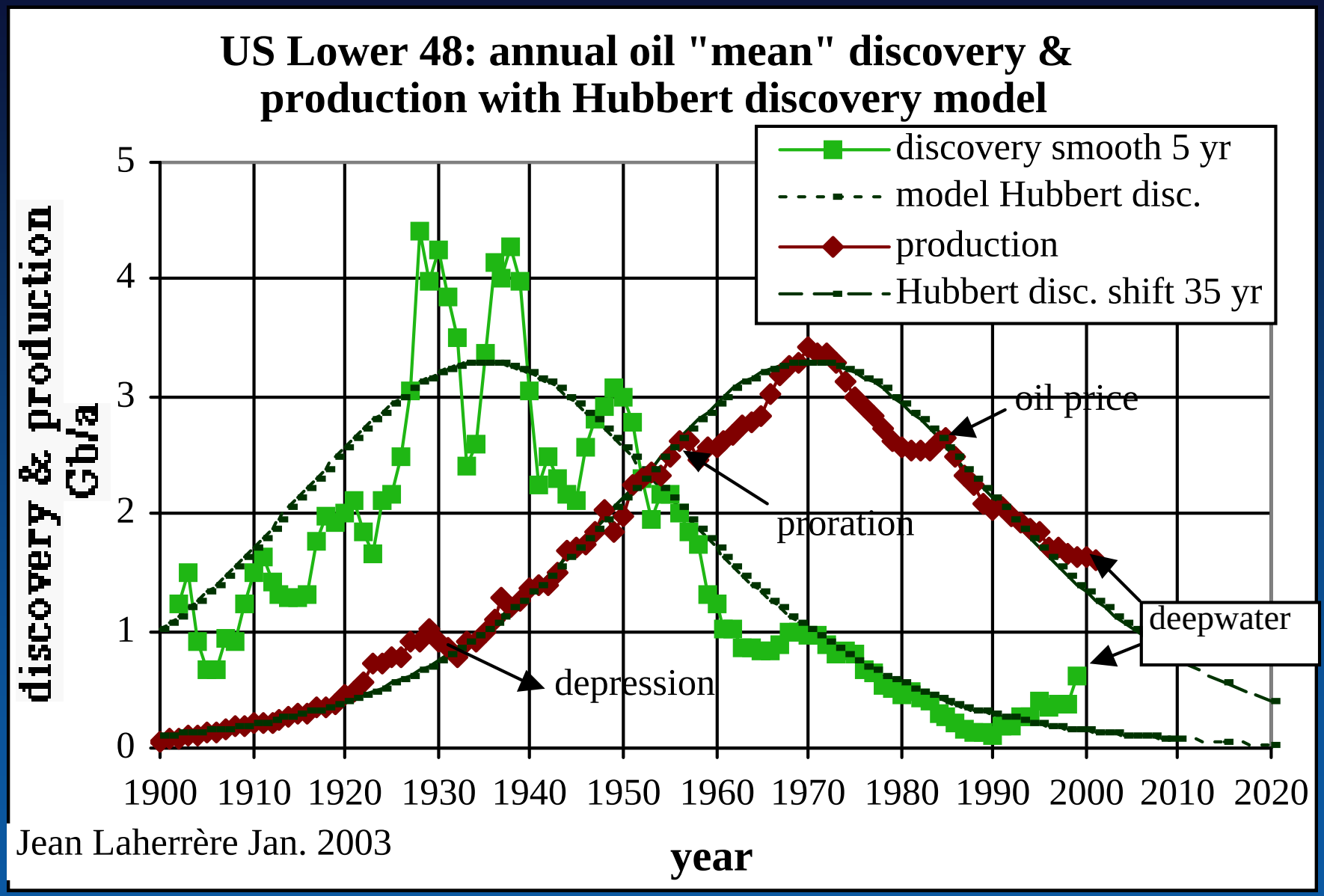
After a decade of low prices, natural gas prices are now more volatile at a higher level.



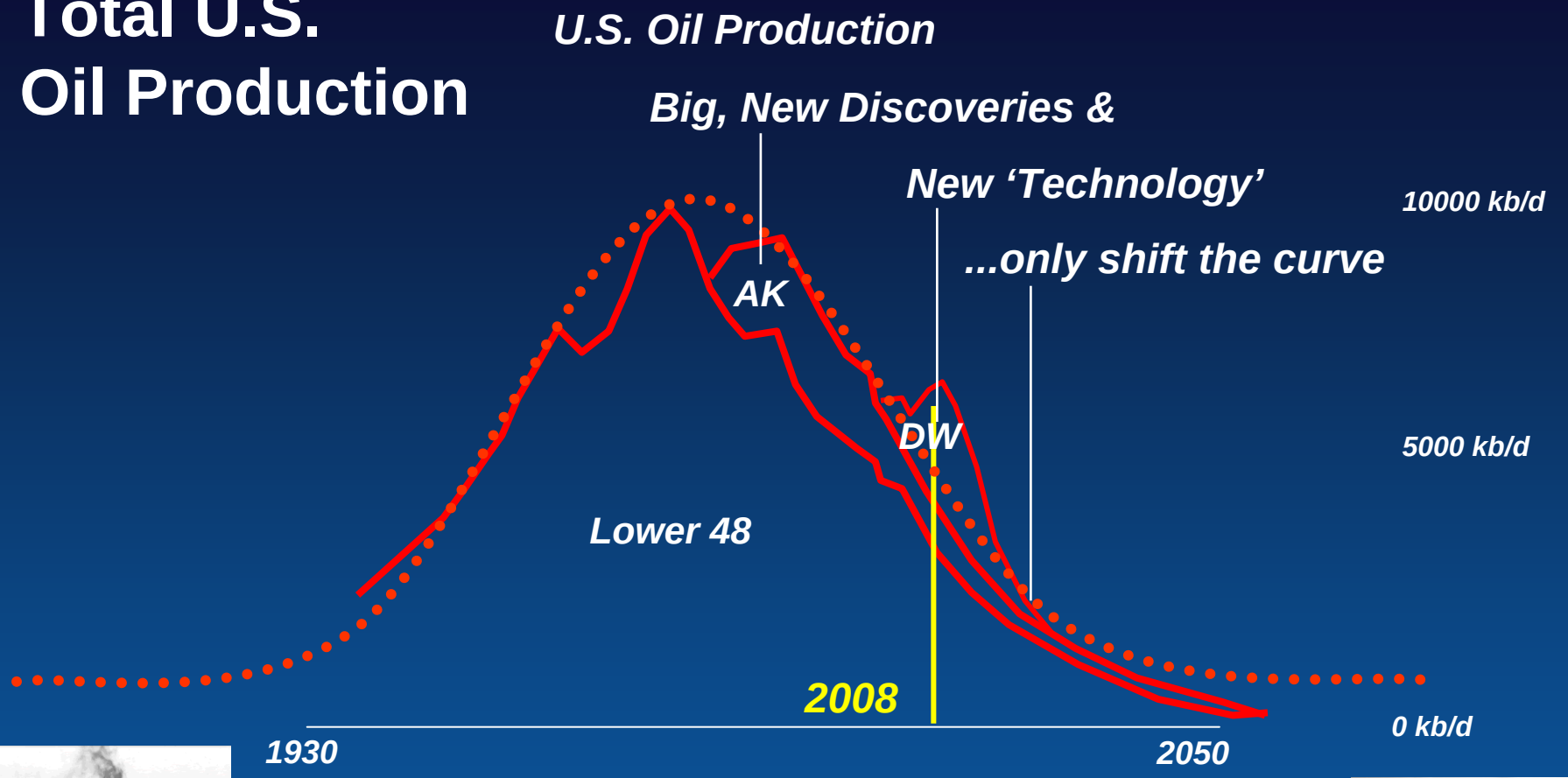
~$15 MMBTU Henry Hub

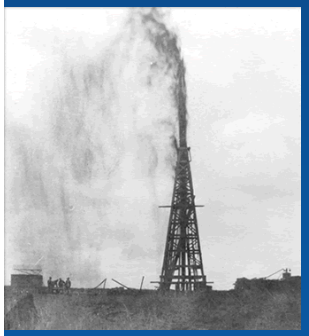
~$8.00 MMBTU

US Lower 48 Oil Discovery & Production



Total U.S. Oil Production





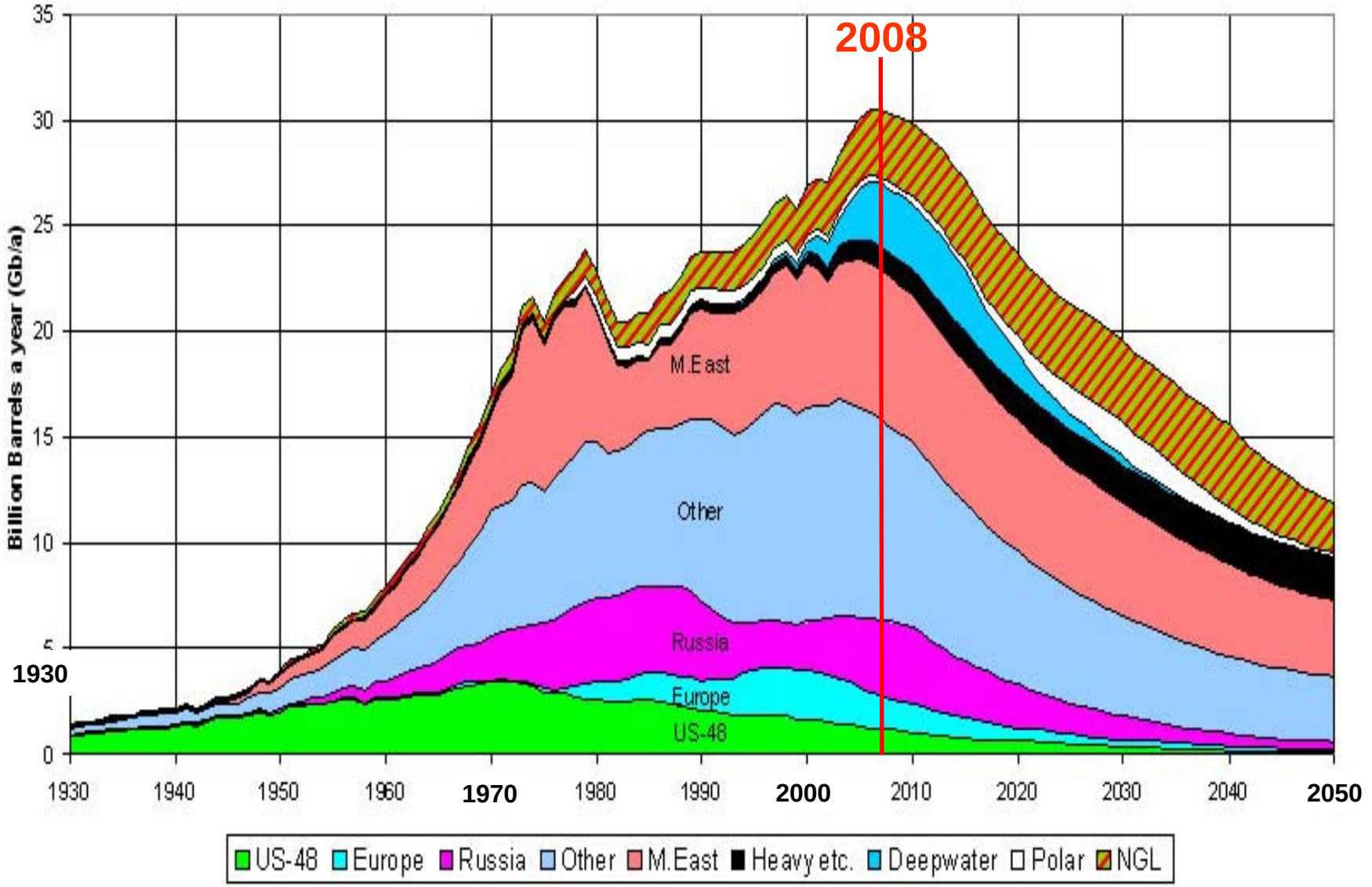
Lower 48

Alaska

Deepwater

Source: Tom Petrie at Denver World Oil Conference

The Age of Oil



7 Generations Span The Age of Oil

Our Great Grand Parents

Our Grand Parents

Our Parents

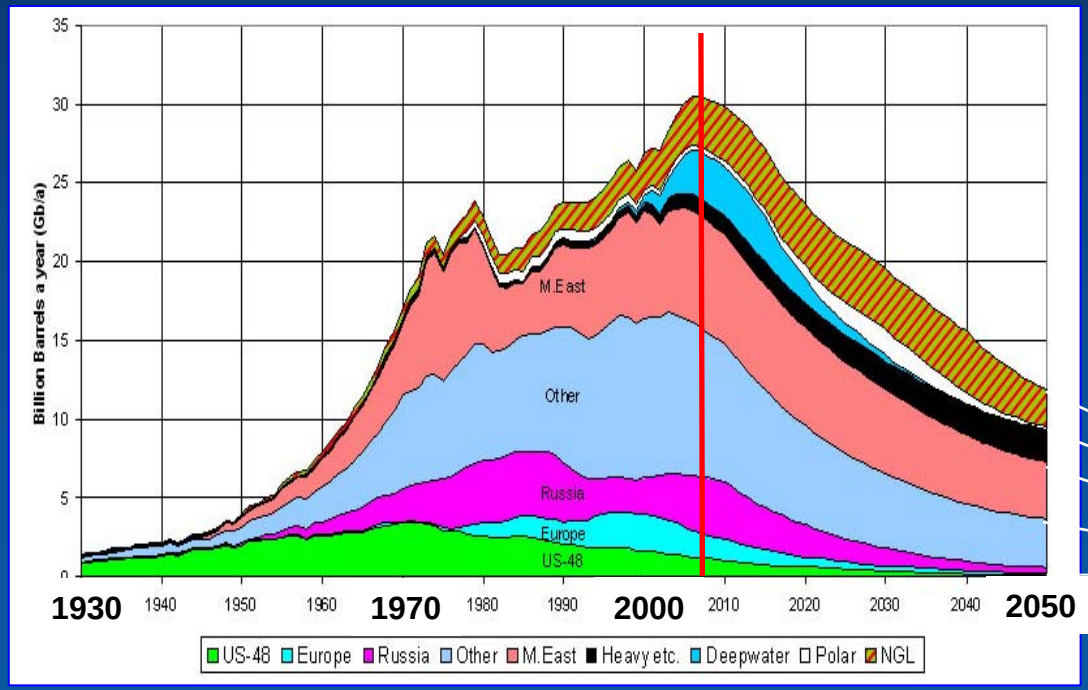
Our Generation

20 80

Our Children

Our Grand Children

Our Great Grand Children

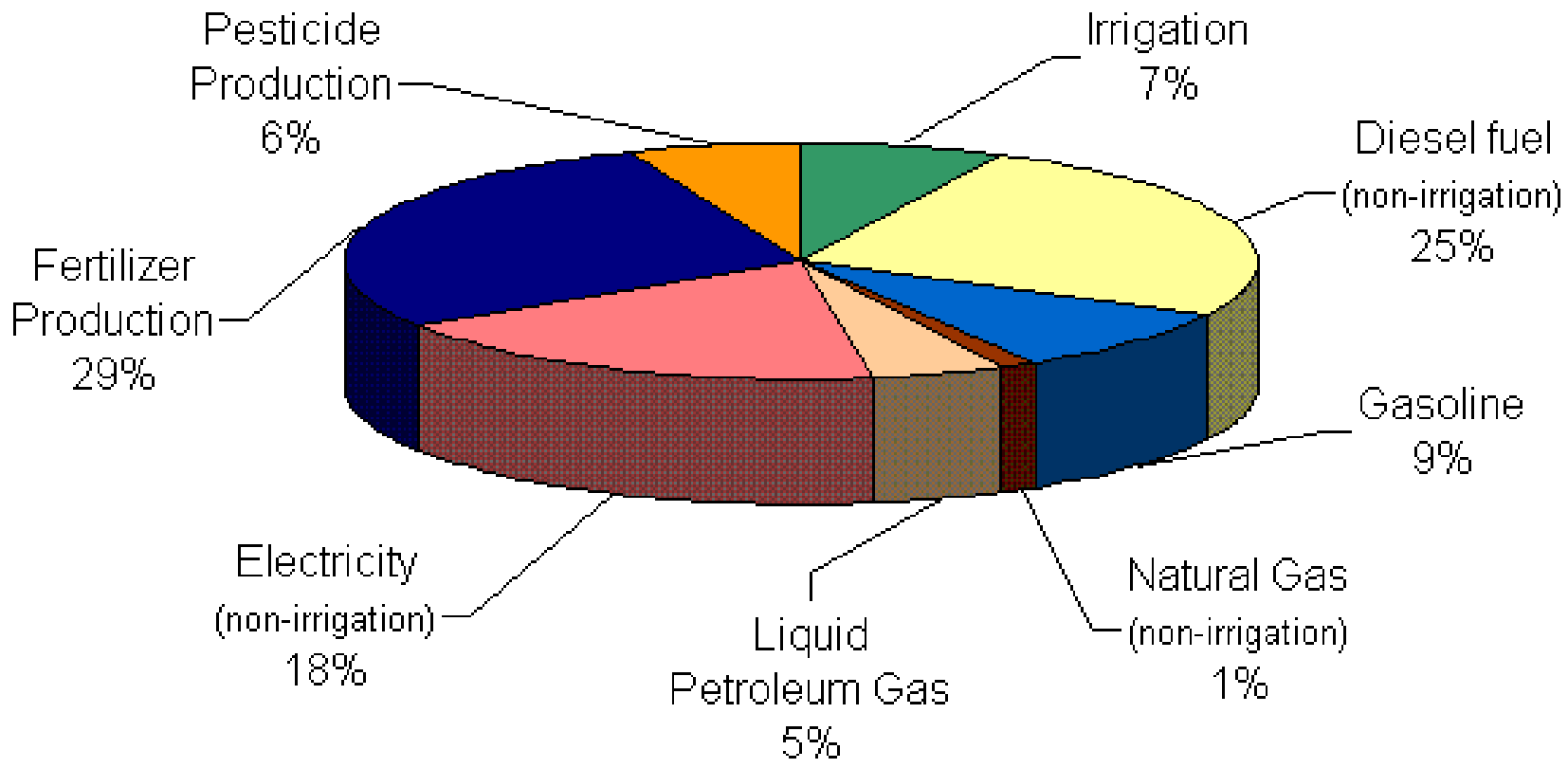


2100

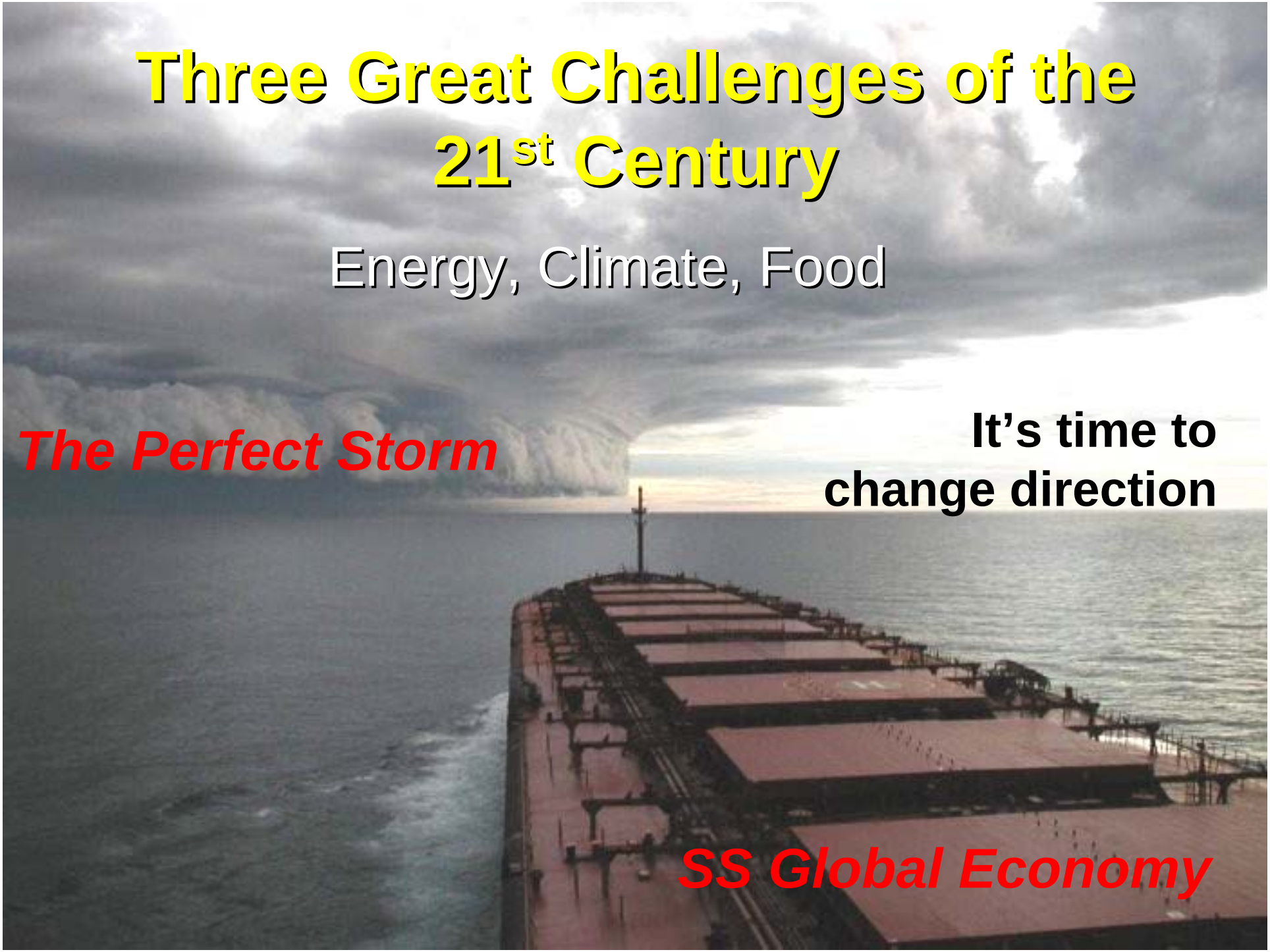
Peak Oil Graph from: ASPO.com - Colin Campbell 2004

U.S. Farm Energy Use, 2002

~75% Petroleum (assuming electric Irrigation)



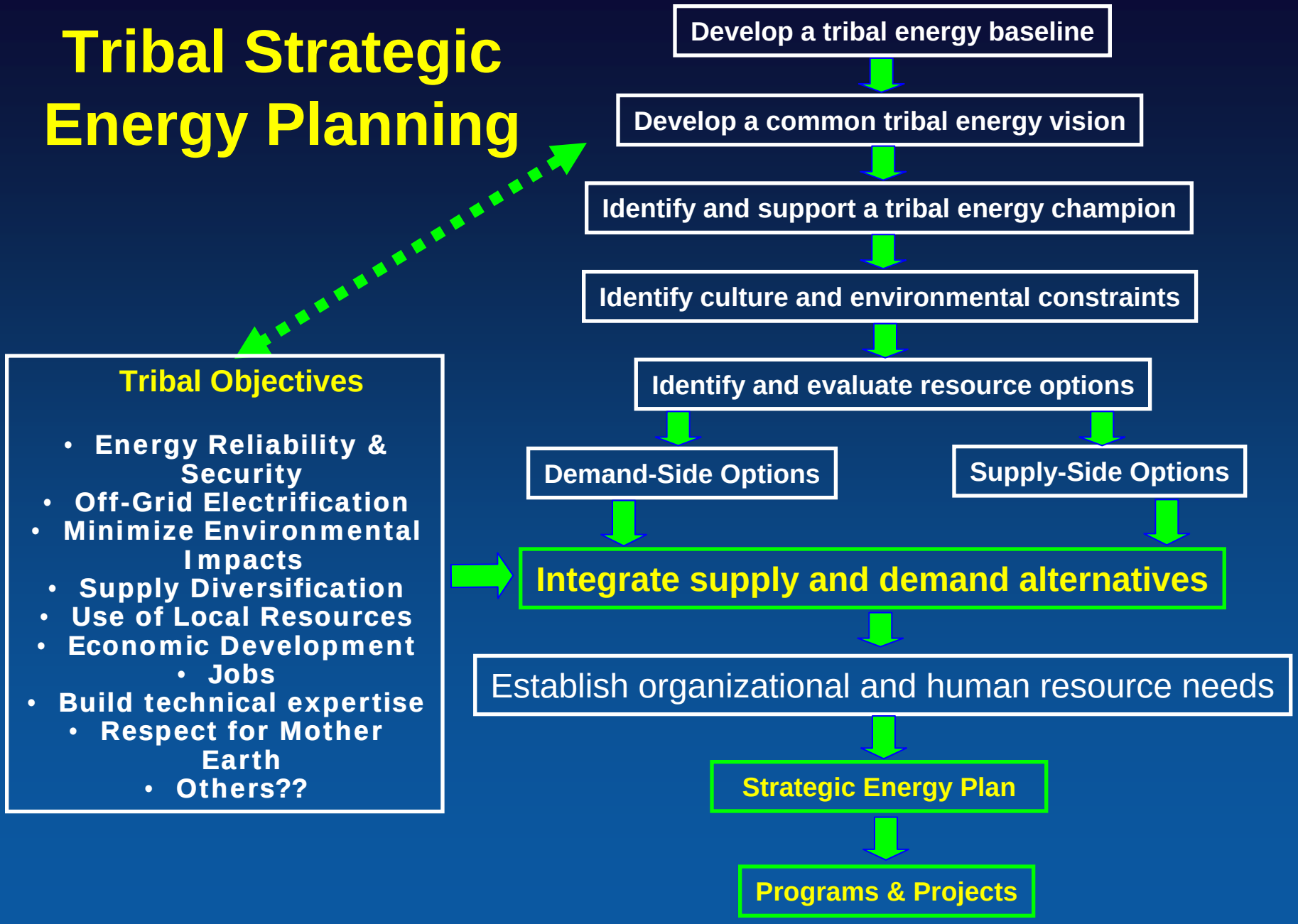
Earth Policy Institute from USDA & DOE data


Three Great Challenges of the 21st Century
Energy, Climate, Food
The Perfect Storm
It's time to change direction
SS Global Economy

Strategic Energy Planning

Defining where you are,
Where you want to go,
What are your energy options, and
Developing a plan to get there.

Tribal Strategic Energy Planning



Establish organizational and human resource needs

How do you want to make it happen?