National Renewable Energy Laboratory
*Innovation for Our Energy Future*

# Energy In a Changing World: 2011 Update

**Roger Taylor**

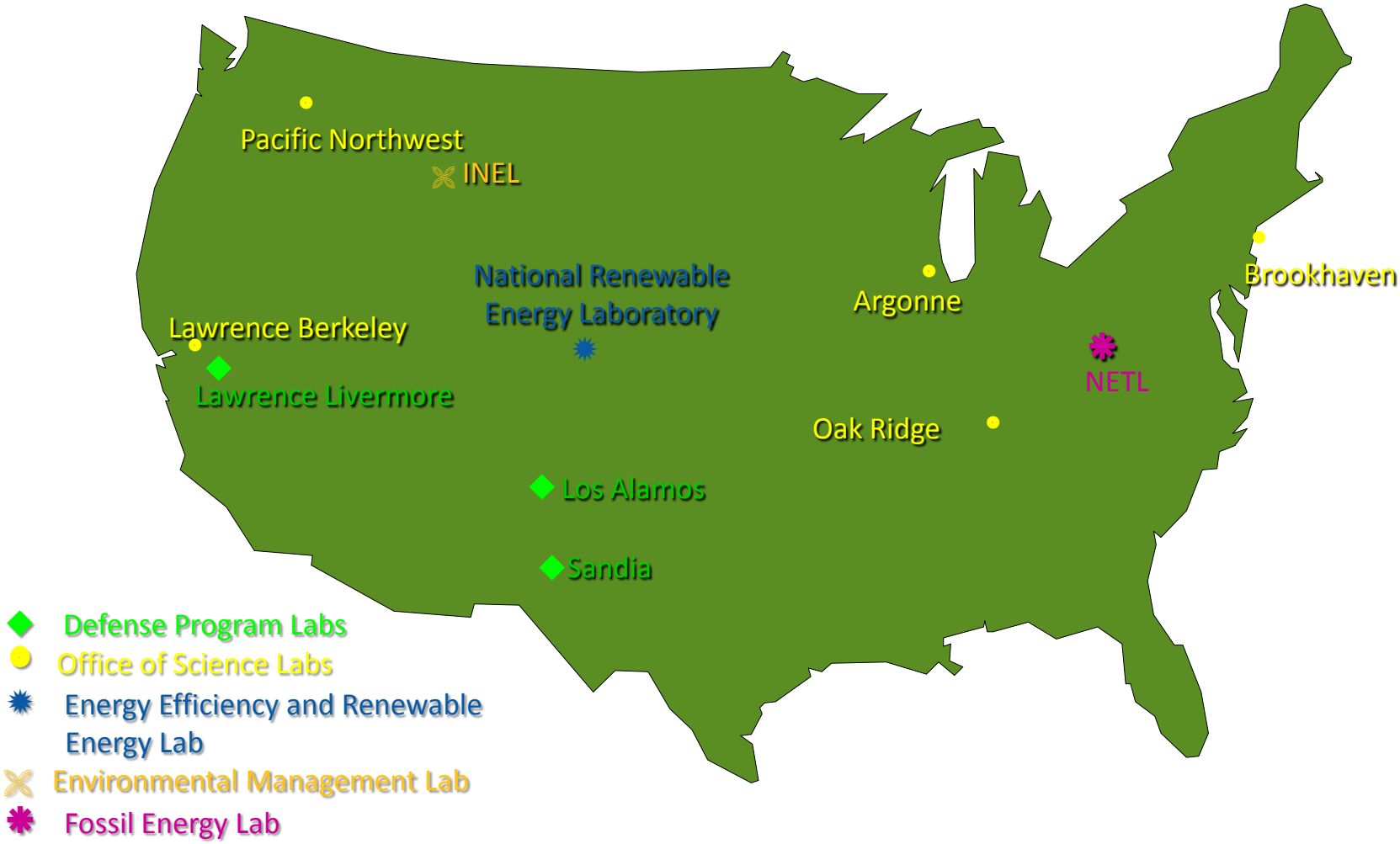
**Principal Engineer**

**Tribal Energy Program**



NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

# 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

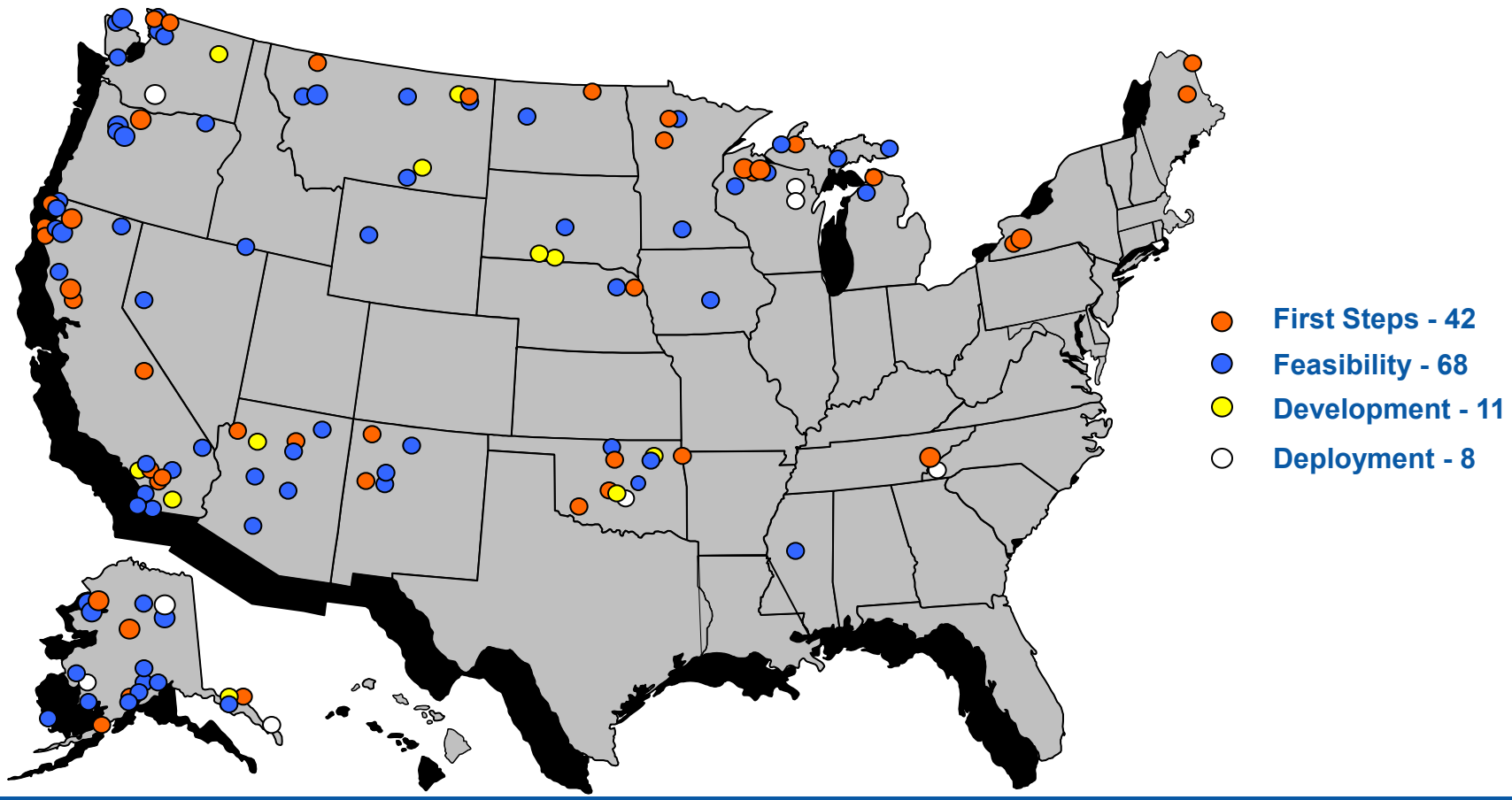
- Hybrid Vehicles
- Fuels Utilization
- Buildings Energy Technology
- Federal Energy Management
- Advanced Industrial Technologies

## Cross Cutting

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

# TEP Project Awards: 2002 - 2010

## DOE has Funded 129 Tribal Energy Projects Totaling $30.4 Million



# *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*

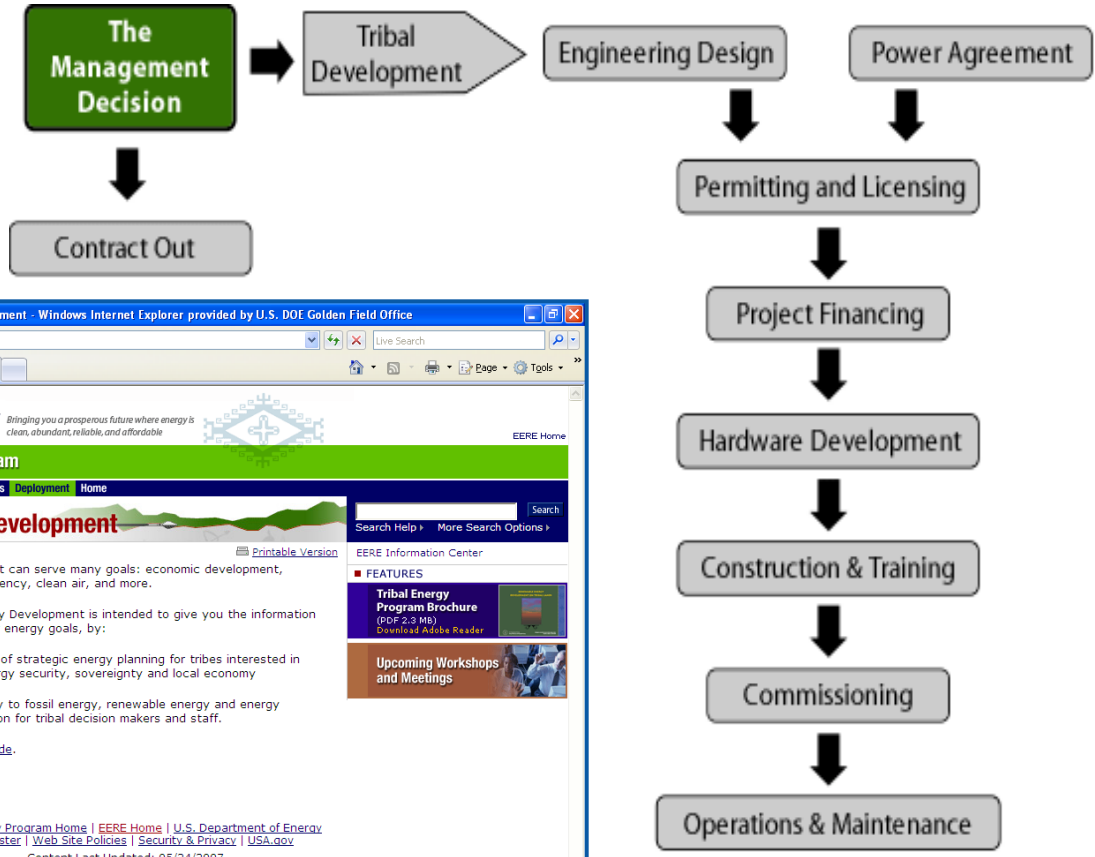
# Guide to Tribal Energy Development

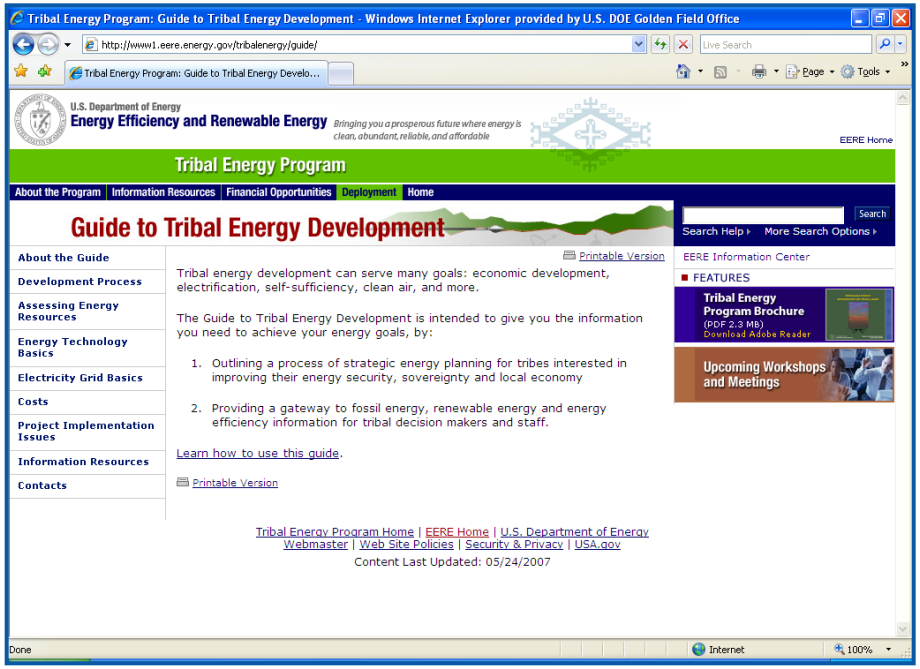
## Development Processes

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

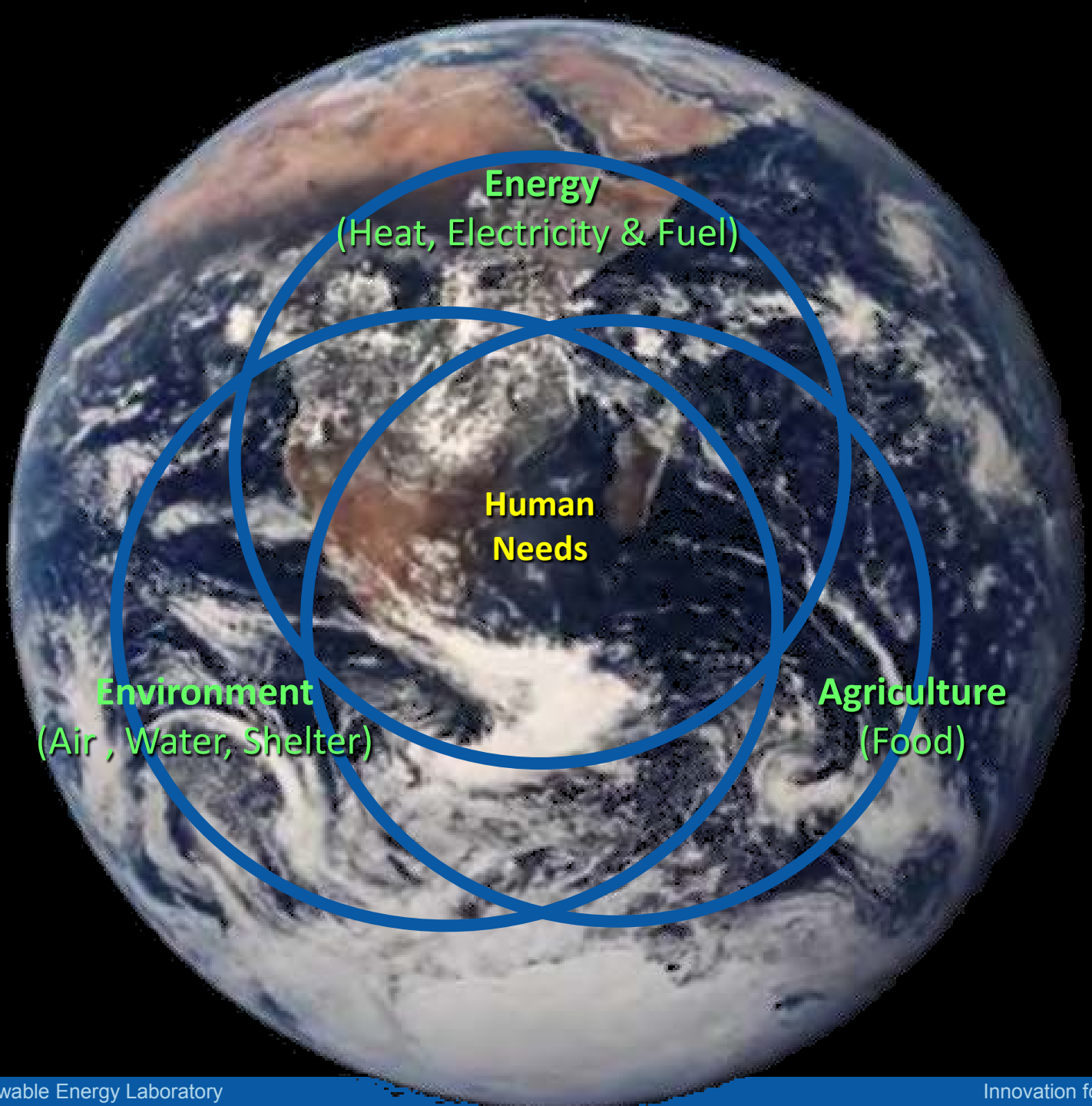
## Resource Library

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

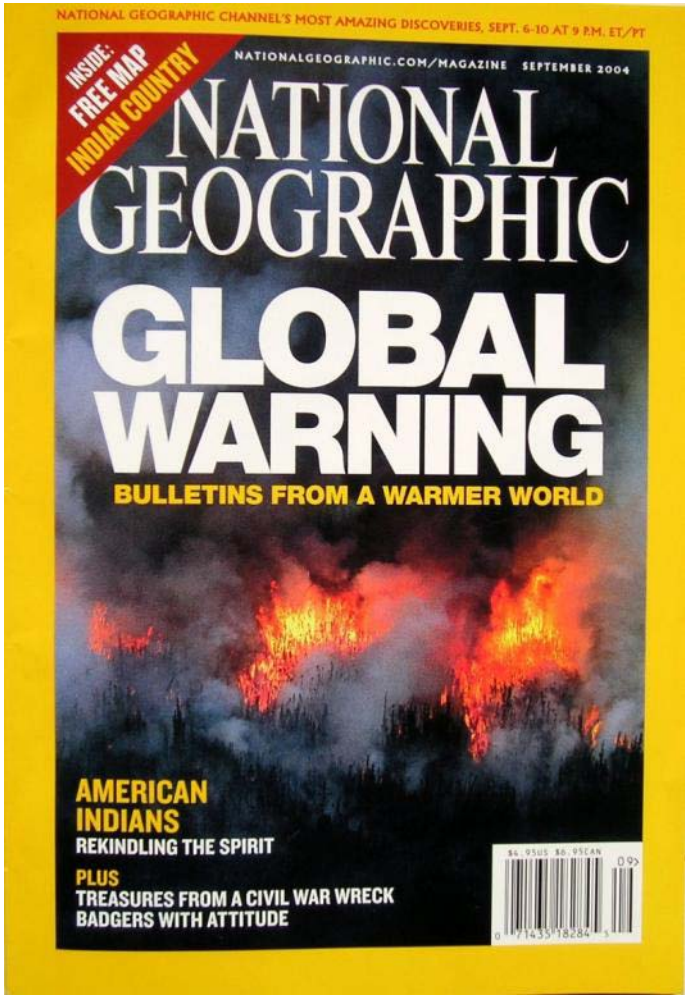


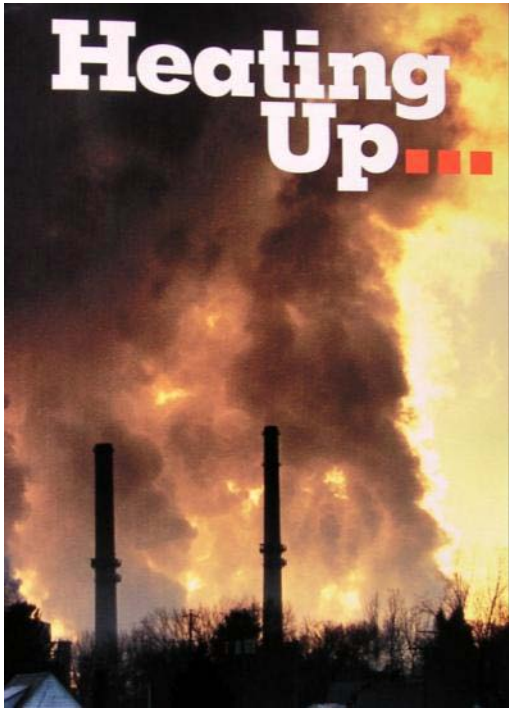



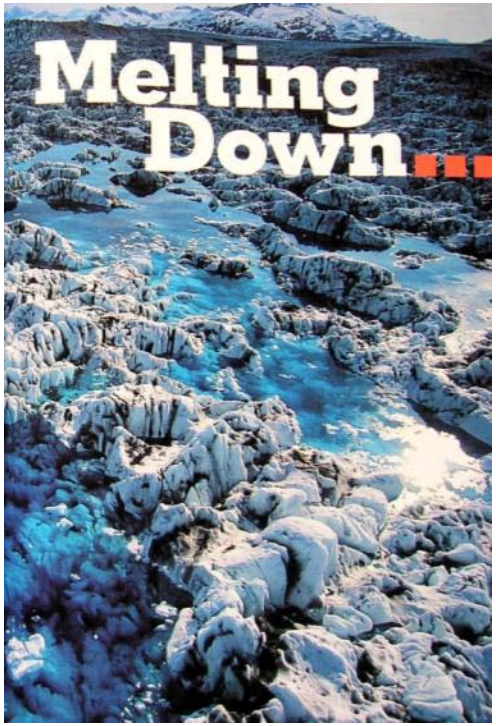

**www.eere.energy.gov/tribalenergy/guide**


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

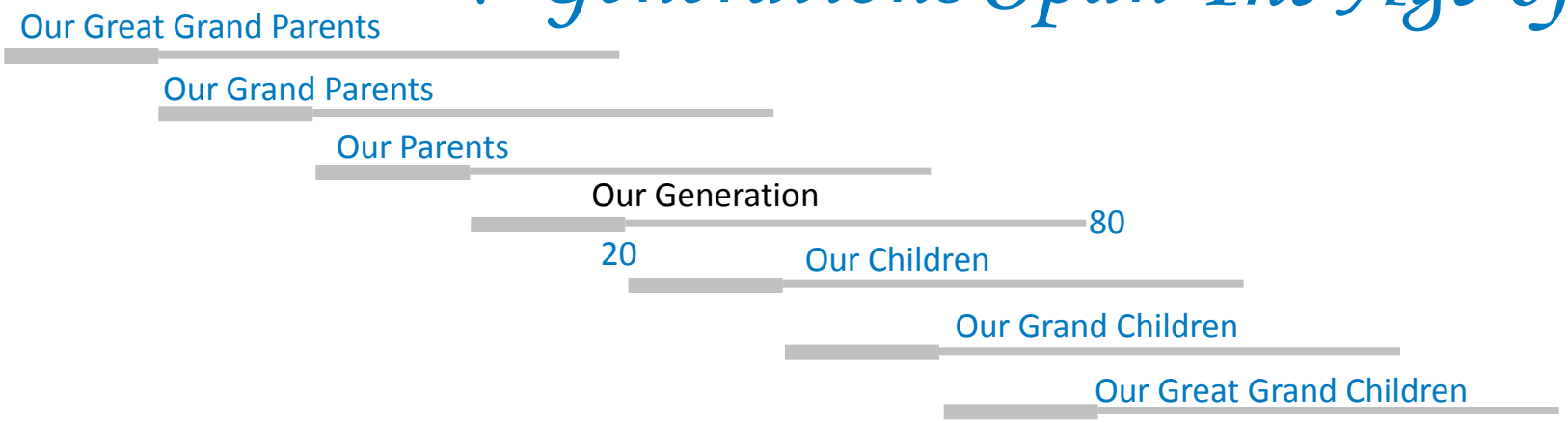
# We Live in a Changing World

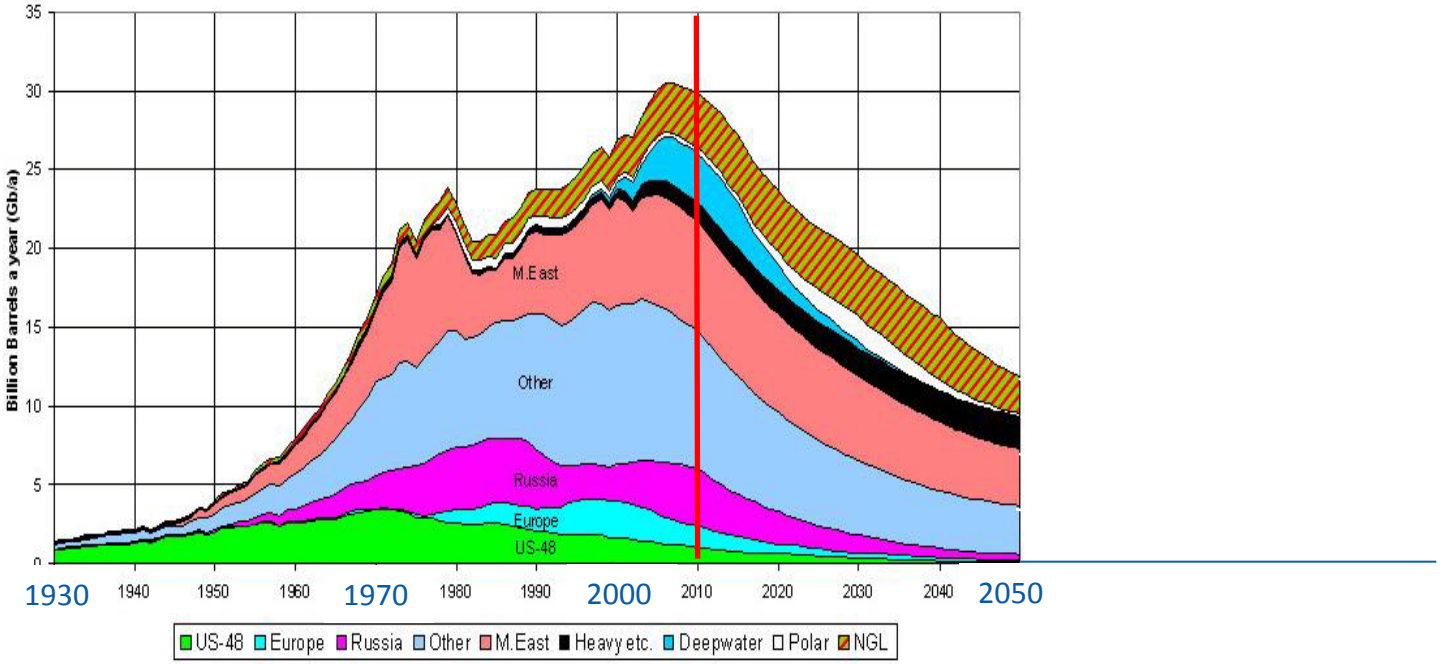


# 7 Generations Span The Age of Oil



http://www.youtube.com/watch?v=RaNz3qS5WAo

12:23

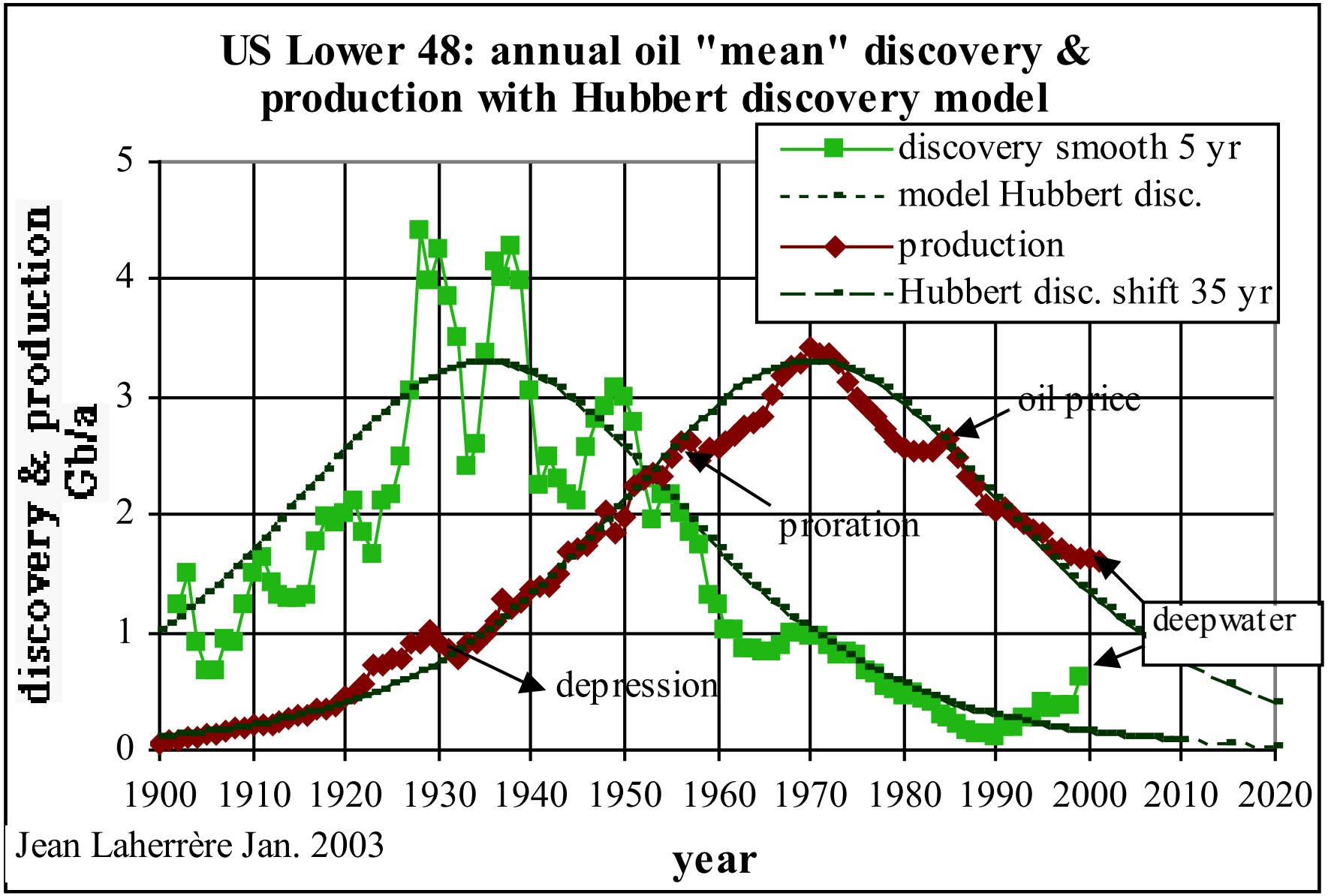
http://www.youtube.com/watch?v=Ulxe1ie-vEY

1:57

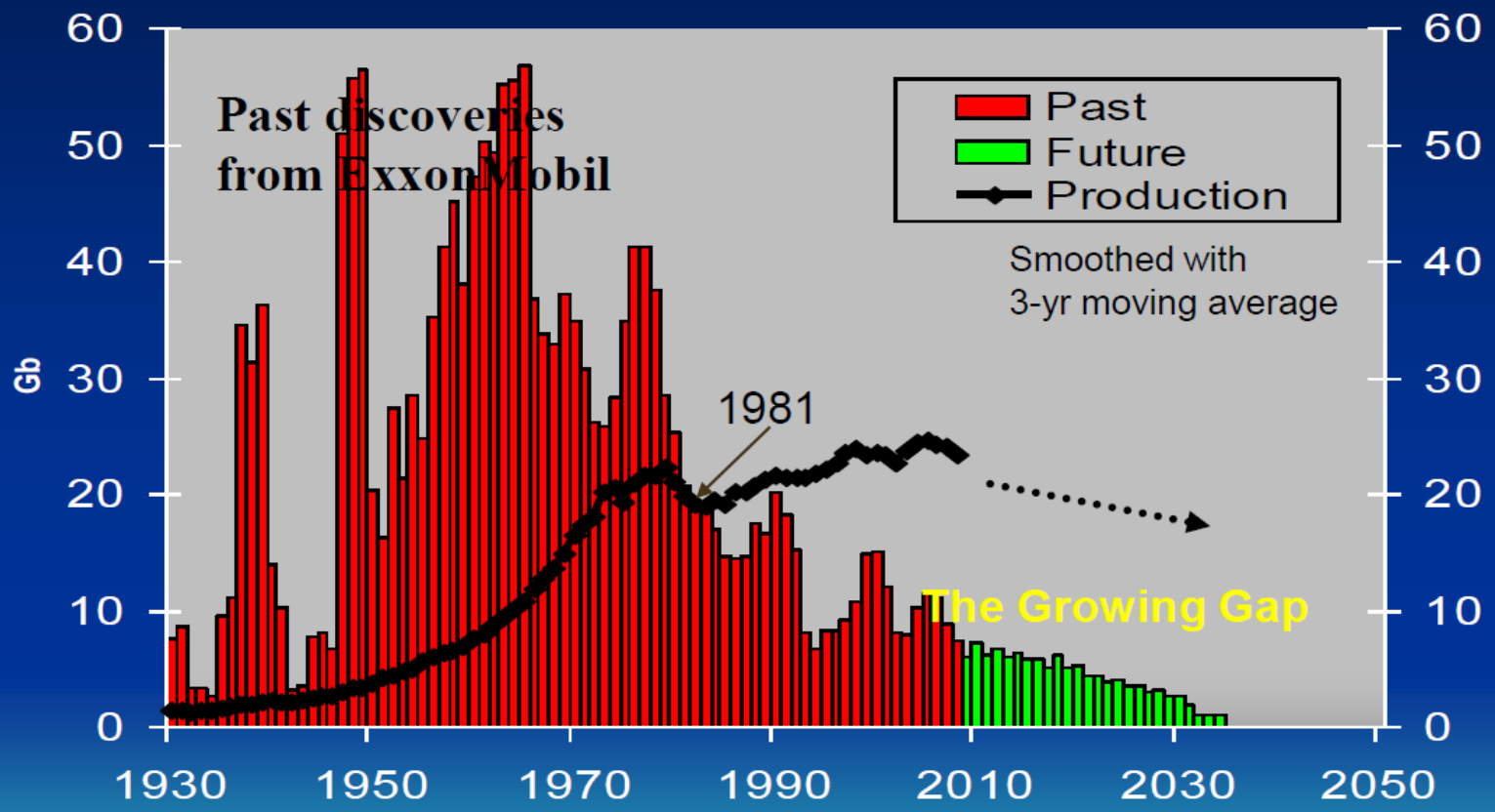
http://www.youtube.com/watch?v=_pje5l7KZDw&feature=player_embedded

3:25

# US Lower 48 Oil Discovery & Production



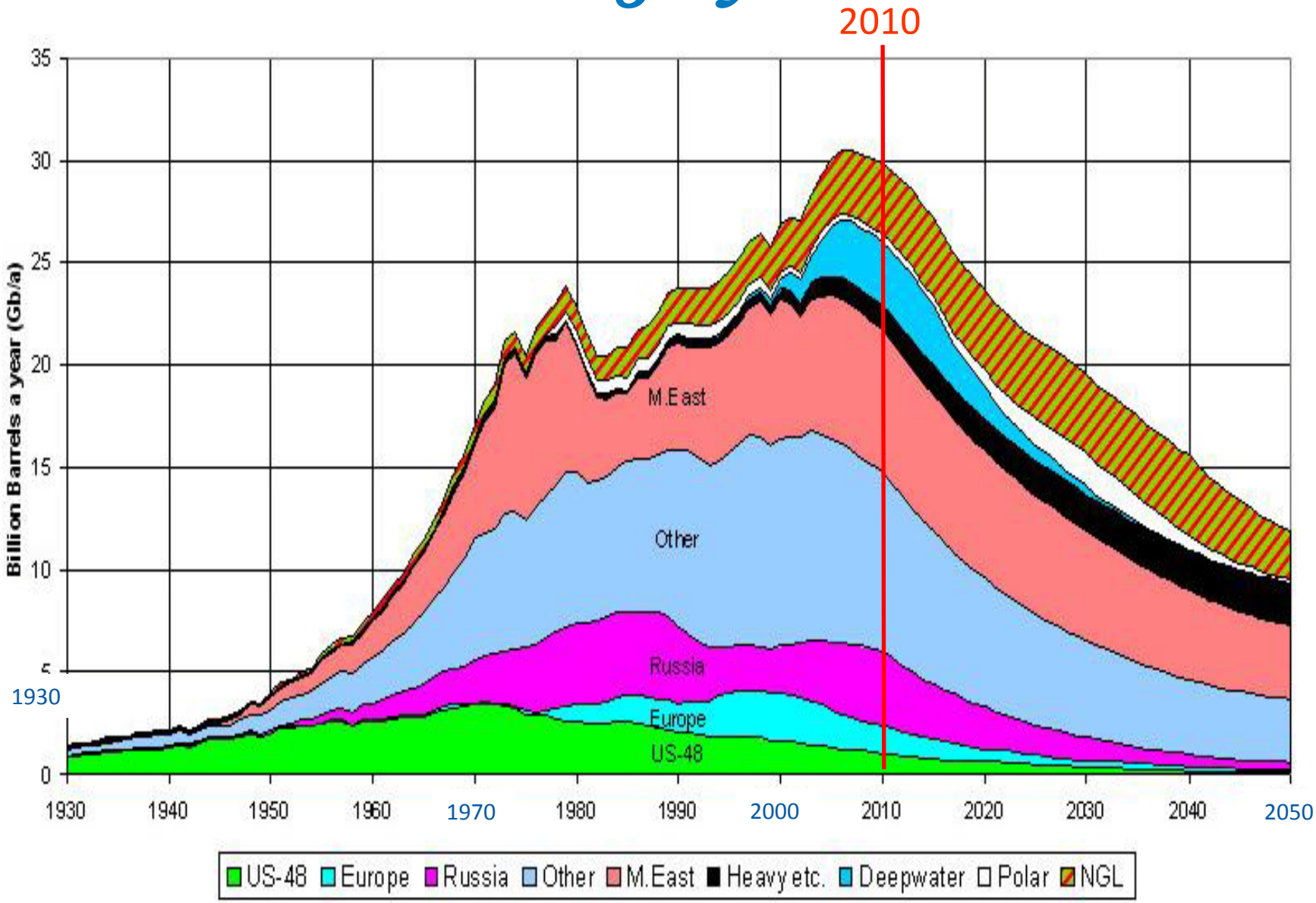
# Discoveries peaked decades ago




**We can't live for ever off the successes of the past**

Jeremy Gilbert ASPO-USA 2010

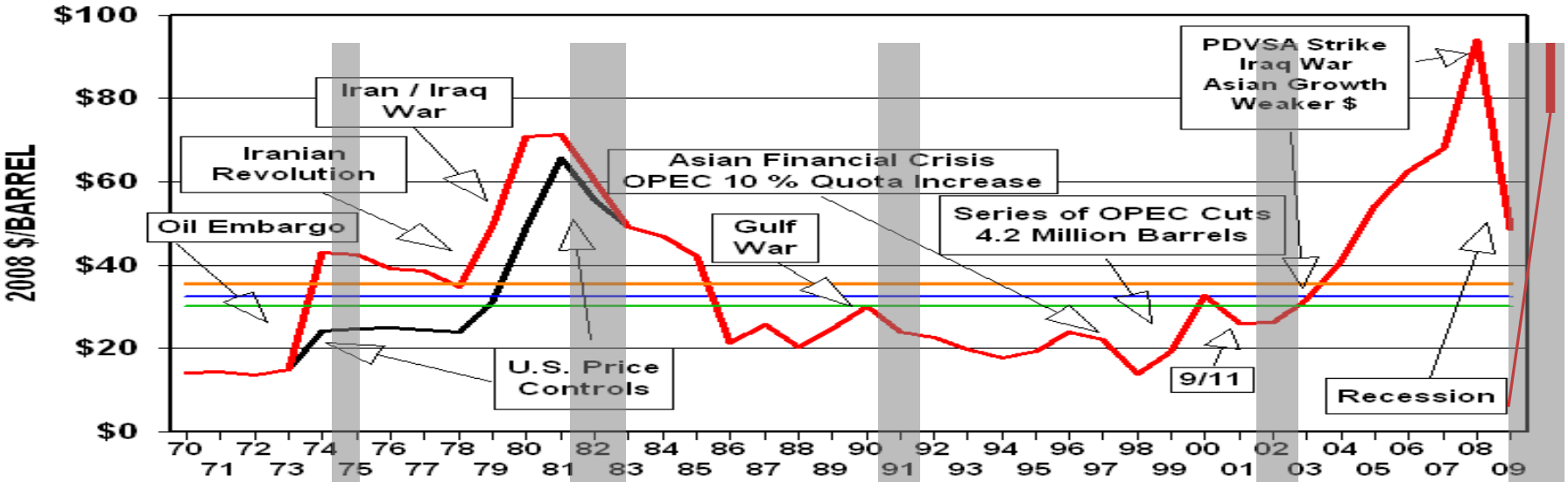
# The Age of Oil

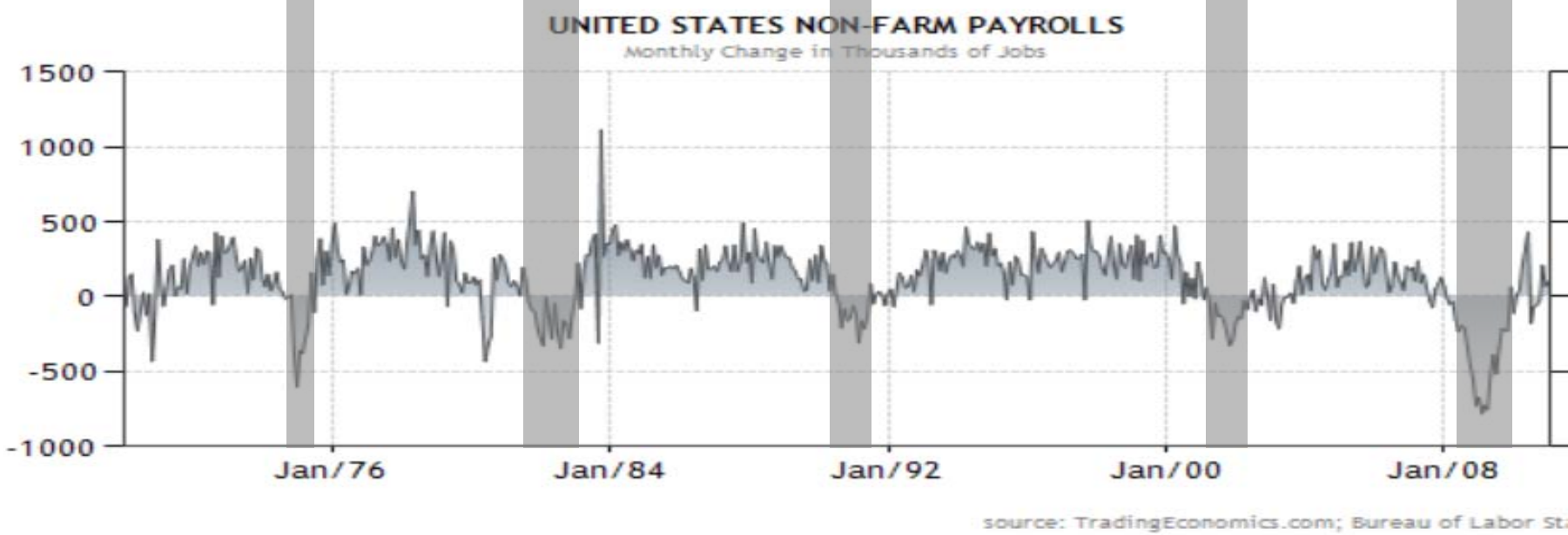


# World Oil Prices – 2008$

NYMEX Prices for February 7, 2011

| | | |
|---|---|---|
| NYMEX Light Sweet Crude | -1.55 | $87.48 |
| ICE Brent | -0.58 | $99.25 |



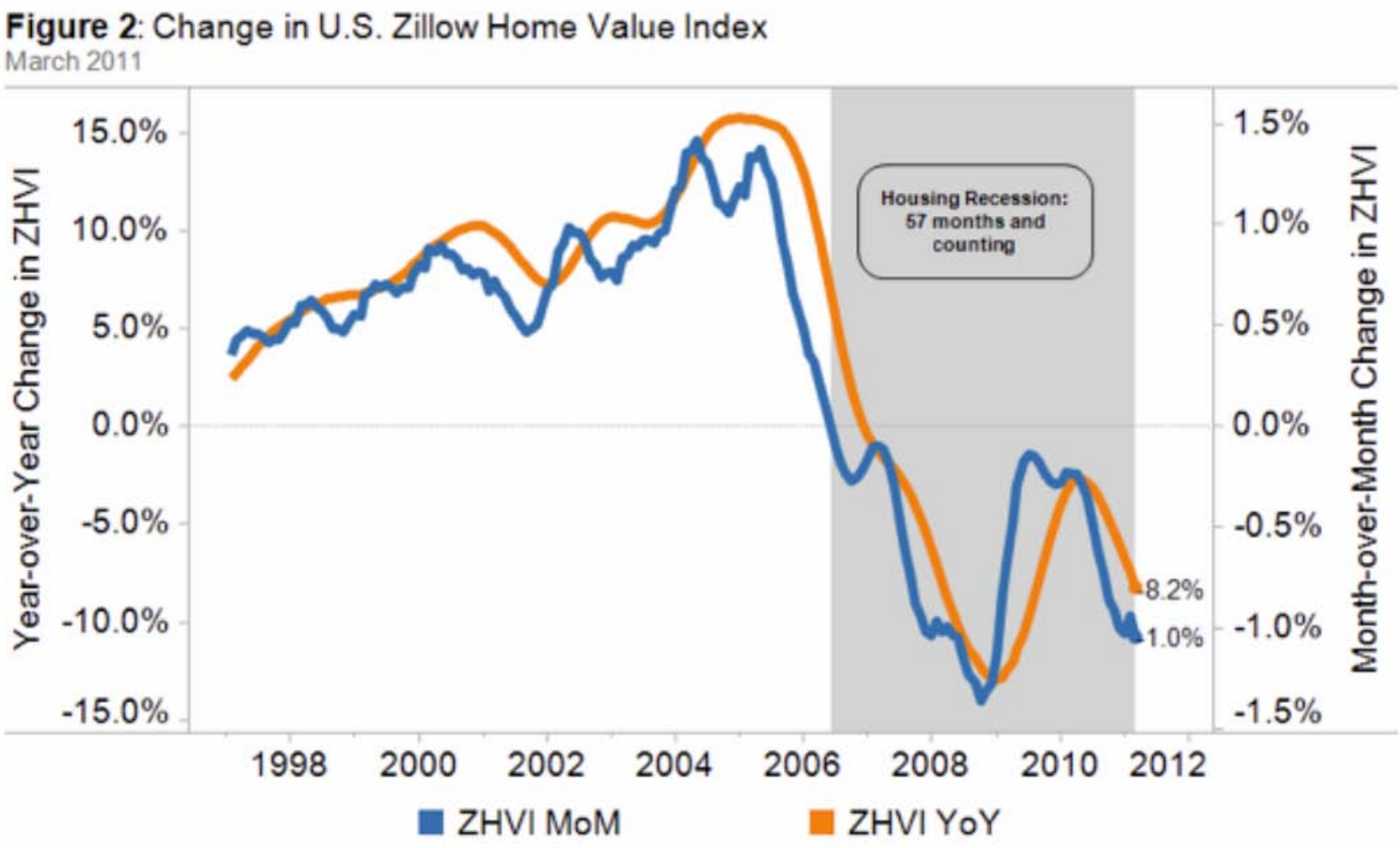



*Image: Zillow.com*

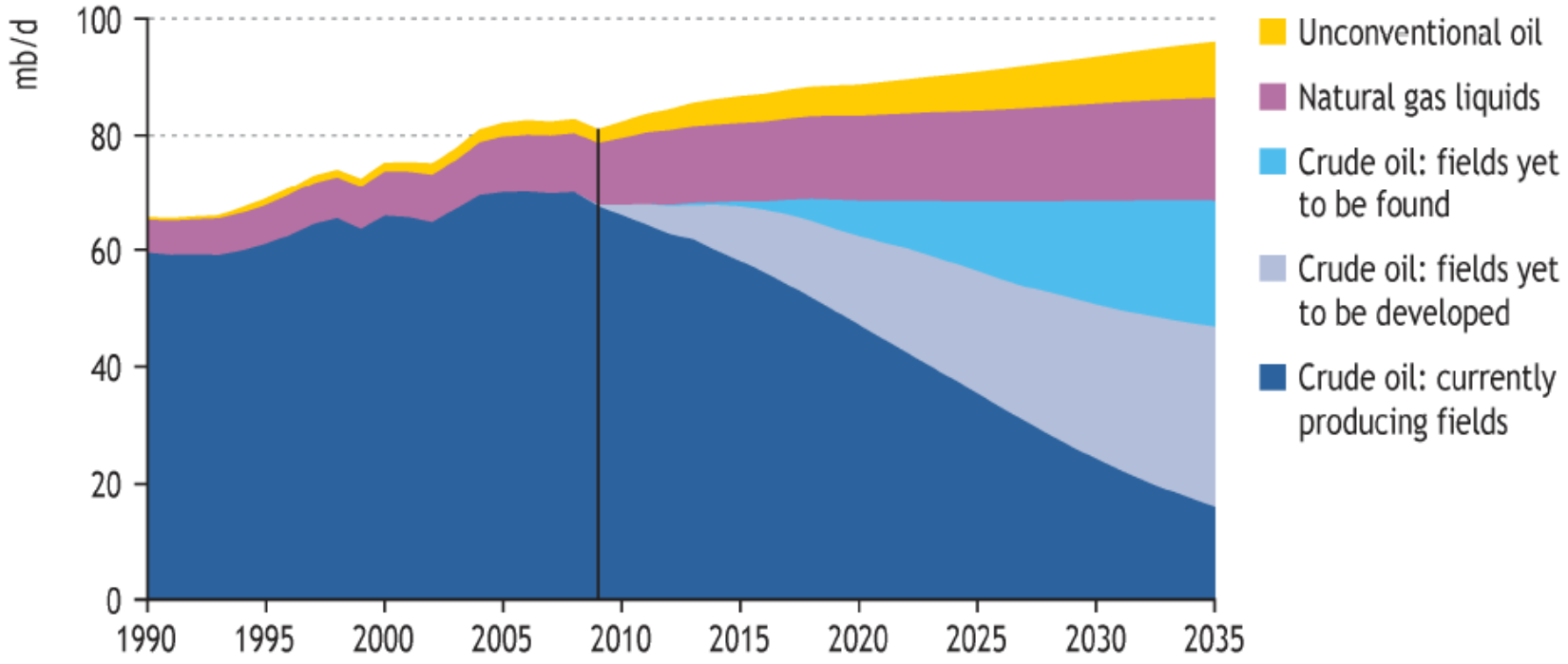
http://www.businessinsider.com/us-housing-has-worst-quarter-since-2008-2011-5?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed:+businessinsider+%28Business+Insider%29

# Oil production becomes less crude

World Energy Outlook 2010

Released November 9, 2010

## World oil production by type in the New Policies Scenario

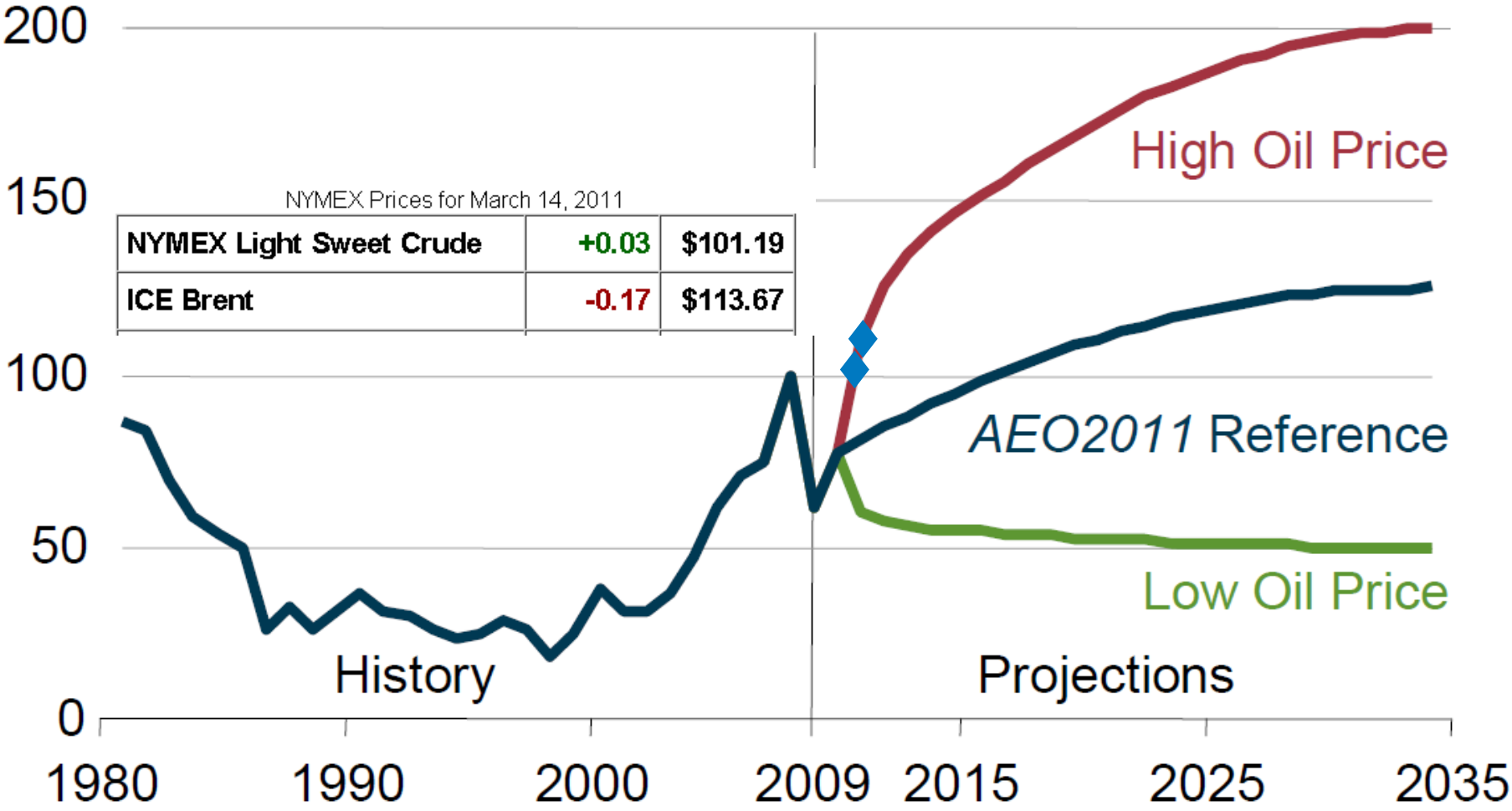



*Global oil production reaches 96 mb/d in 2035 on the back of rising output of natural gas liquids & unconventional oil, as crude oil production plateaus*

© OECD/IEA 2010

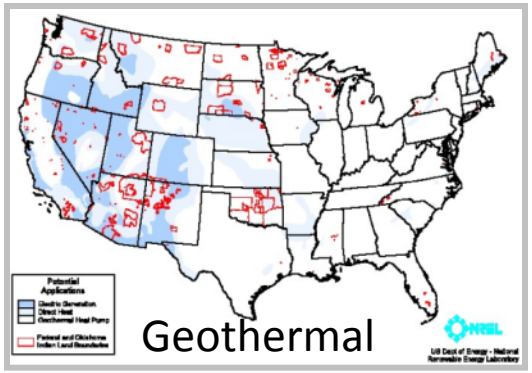
# Figure 4. World crude oil prices, 1980-2035

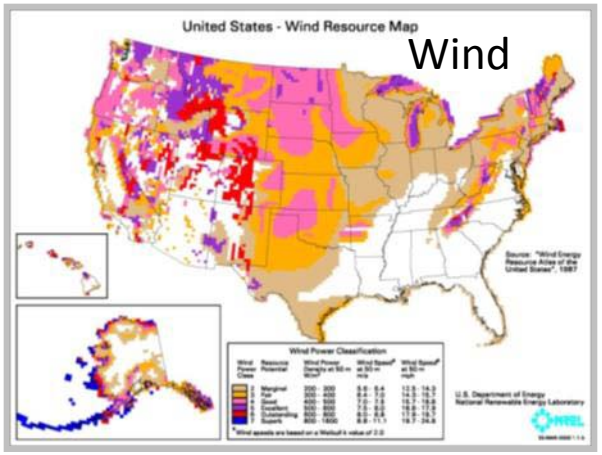
Annual average price of low-sulfur crude oil
(real 2009 dollars per barrel)

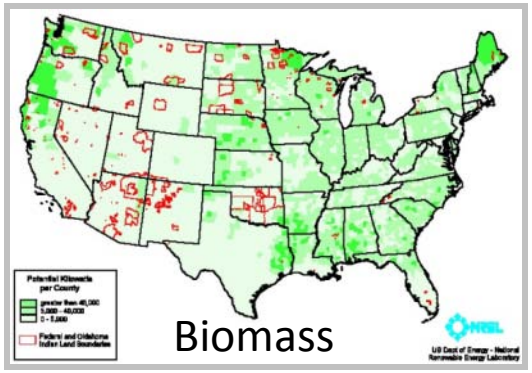


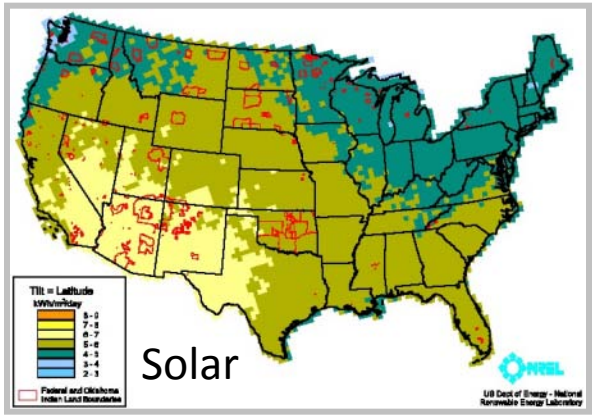

*AEO2011 Early Release Overview*

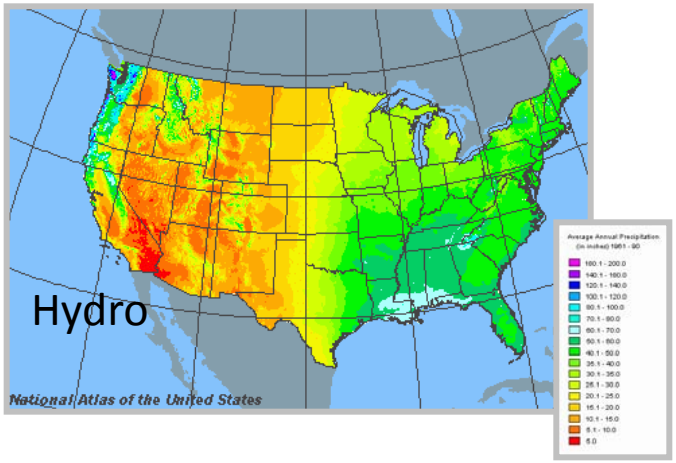
# Renewable Resource Options





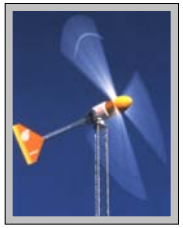


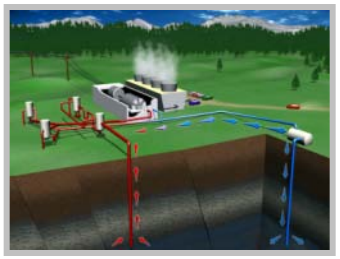
# Renewable Technology Options

Small Modular Power

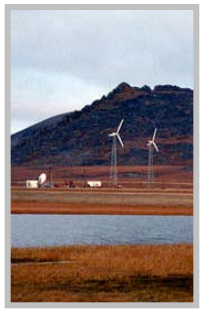
Small Wind



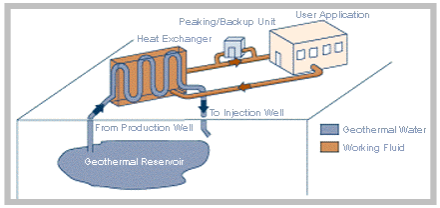
Power



Diesel Hybrids



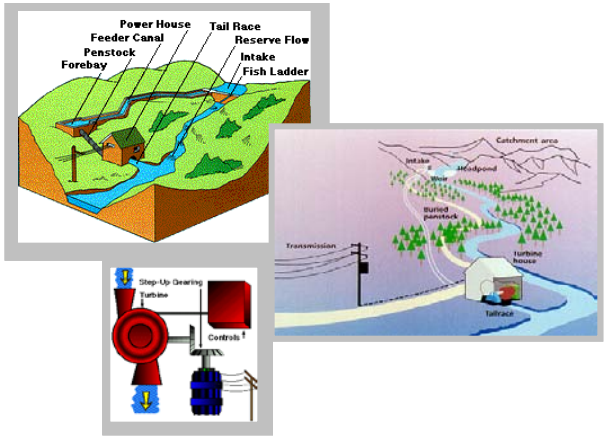
Direct Use



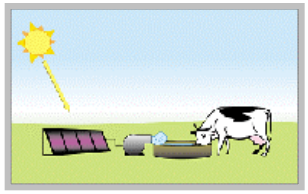
Big Wind

PV - Remote Homes

Small Hydro




Stock Watering



Process Heat

Buildings

# 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

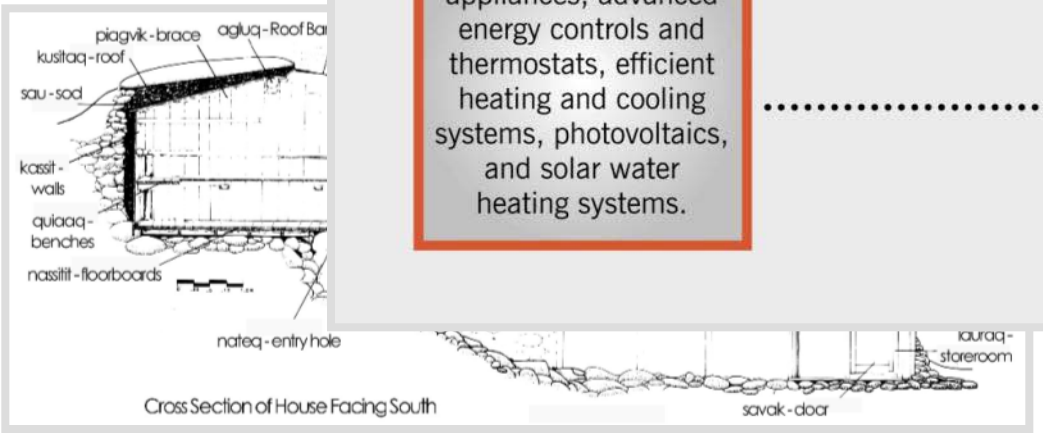
Siting and orientation, glazing size and location, and shading strategies contribute to a passive solar, or "climate-responsive," building.

### Advanced Technologies

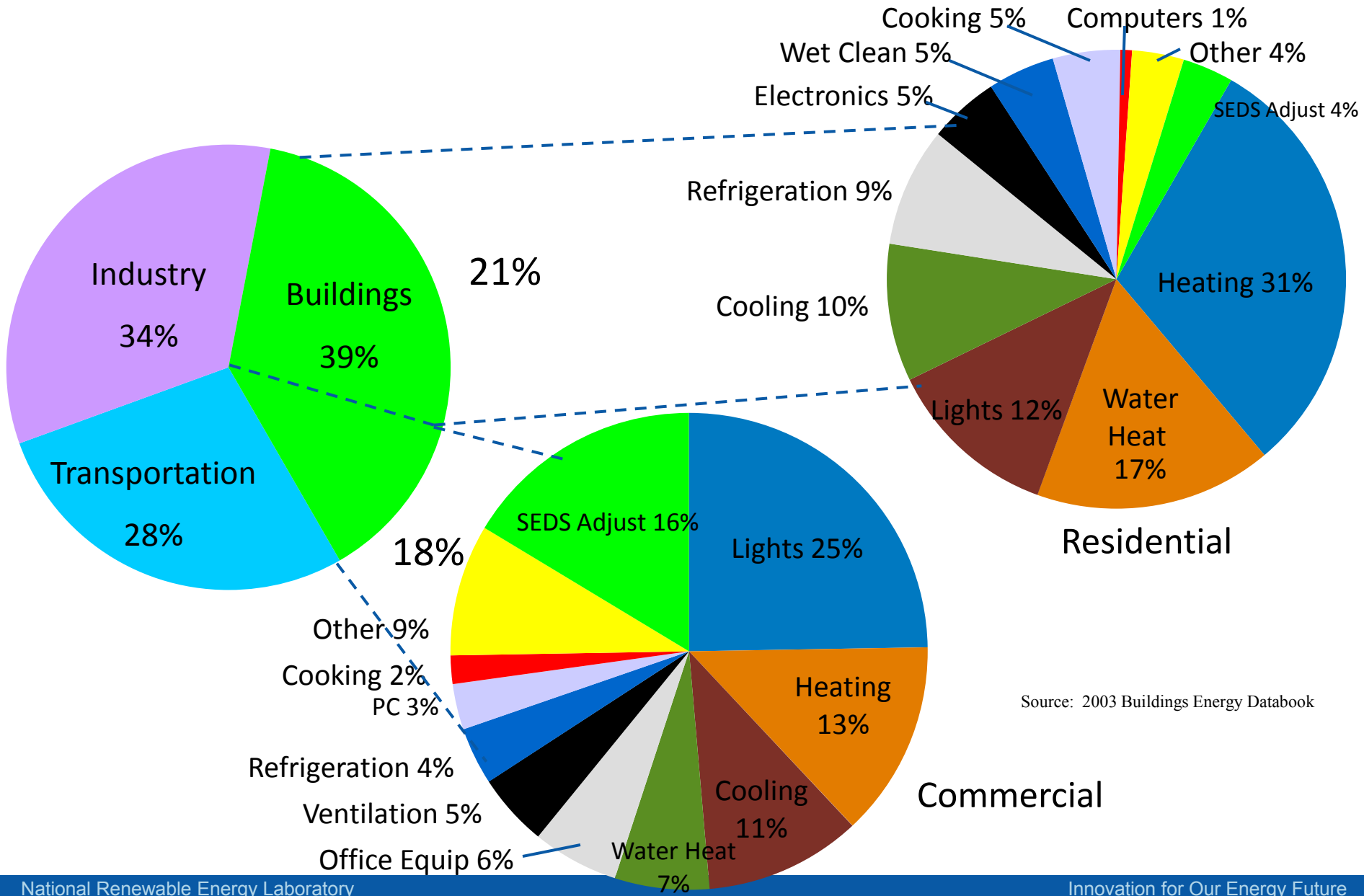
Energy-saving appliances, advanced energy controls and thermostats, efficient heating and cooling systems, photovoltaics, and solar water heating systems.

### Energy-Efficient Materials

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



# Buildings use 70% of electricity generated in the U.S.




Source: 2003 Buildings Energy Databook

# Energy Efficiency

## 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

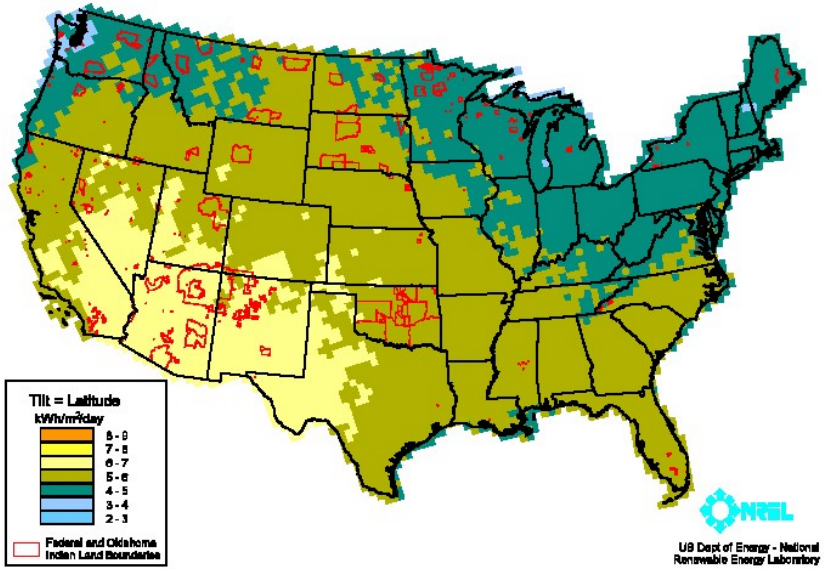
## Infiltration

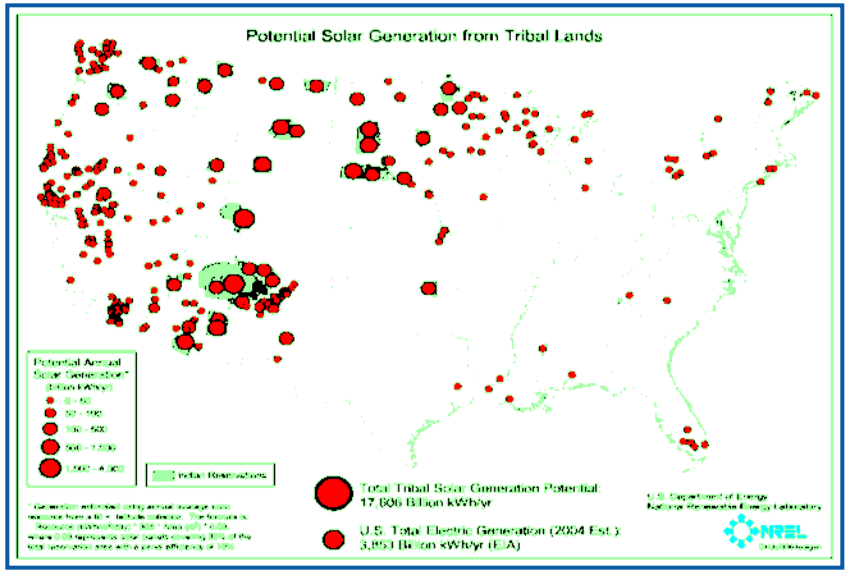
## Controls

## Maintenance

# Solar-Based Technologies

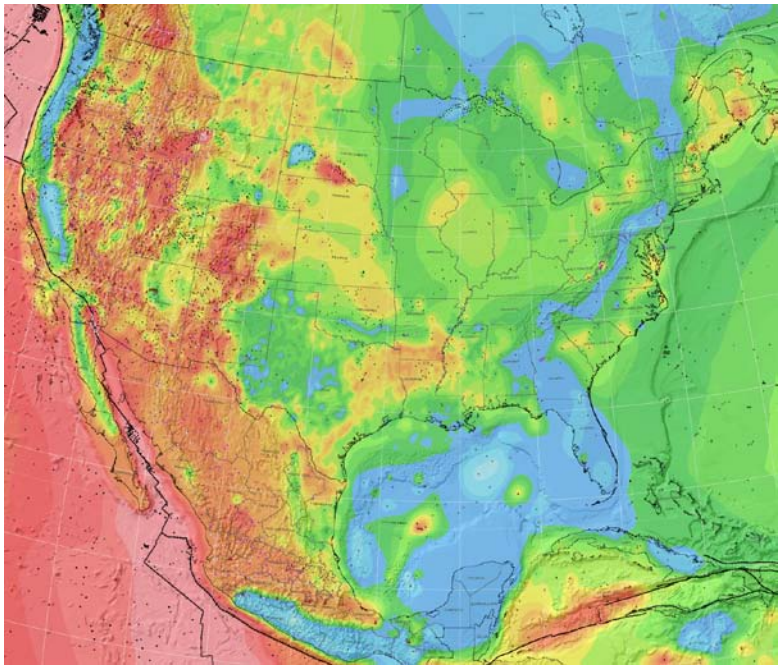
# Solar Electric Potential on Tribal Lands
# Could Provide ~4.5 times the Total U.S. Electric Generation

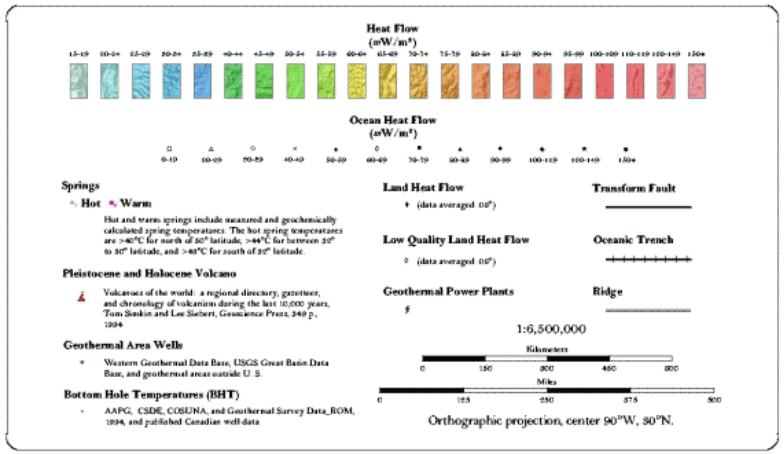


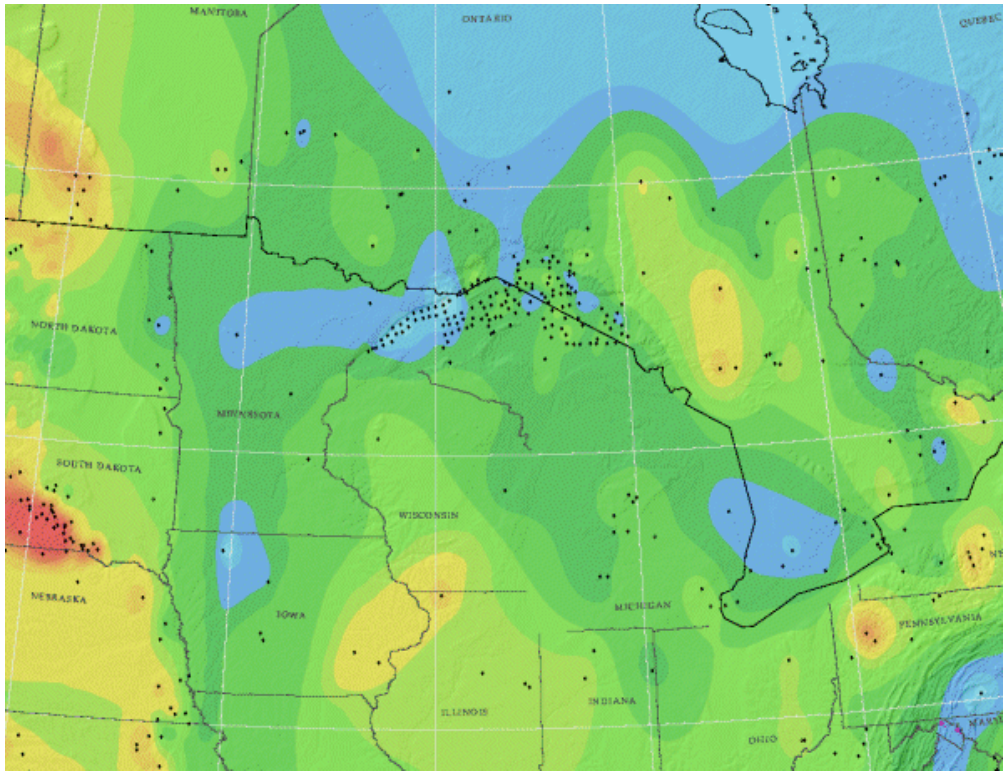




# Solar Electric Potential of 17,600 Billion kWh/yr on Indian Lands

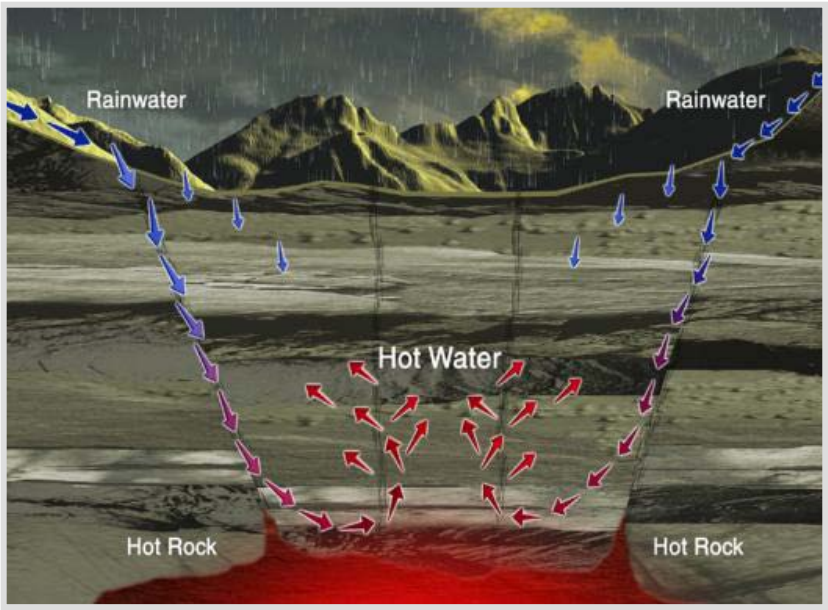
# Geothermal Resource Potential

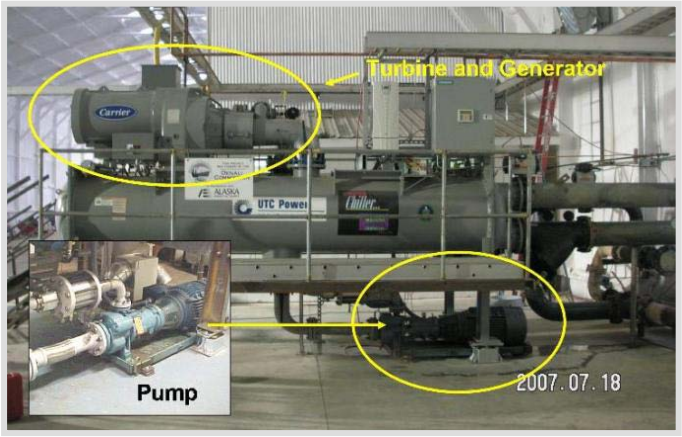


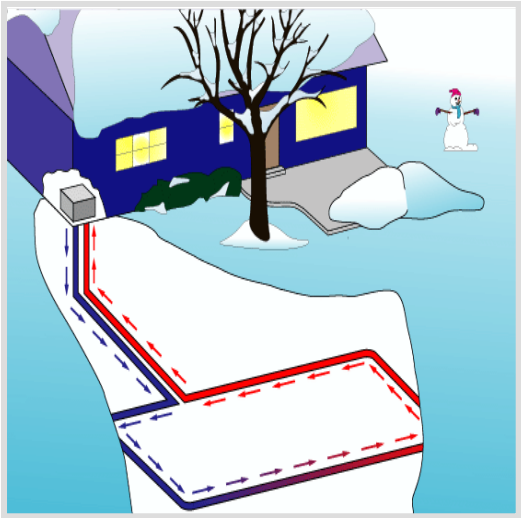


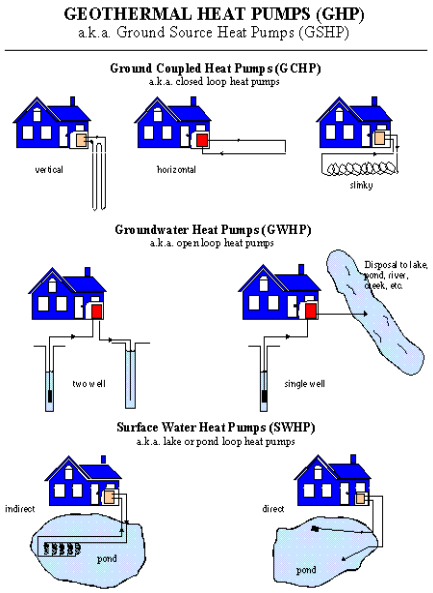



# Geothermal Technology Options

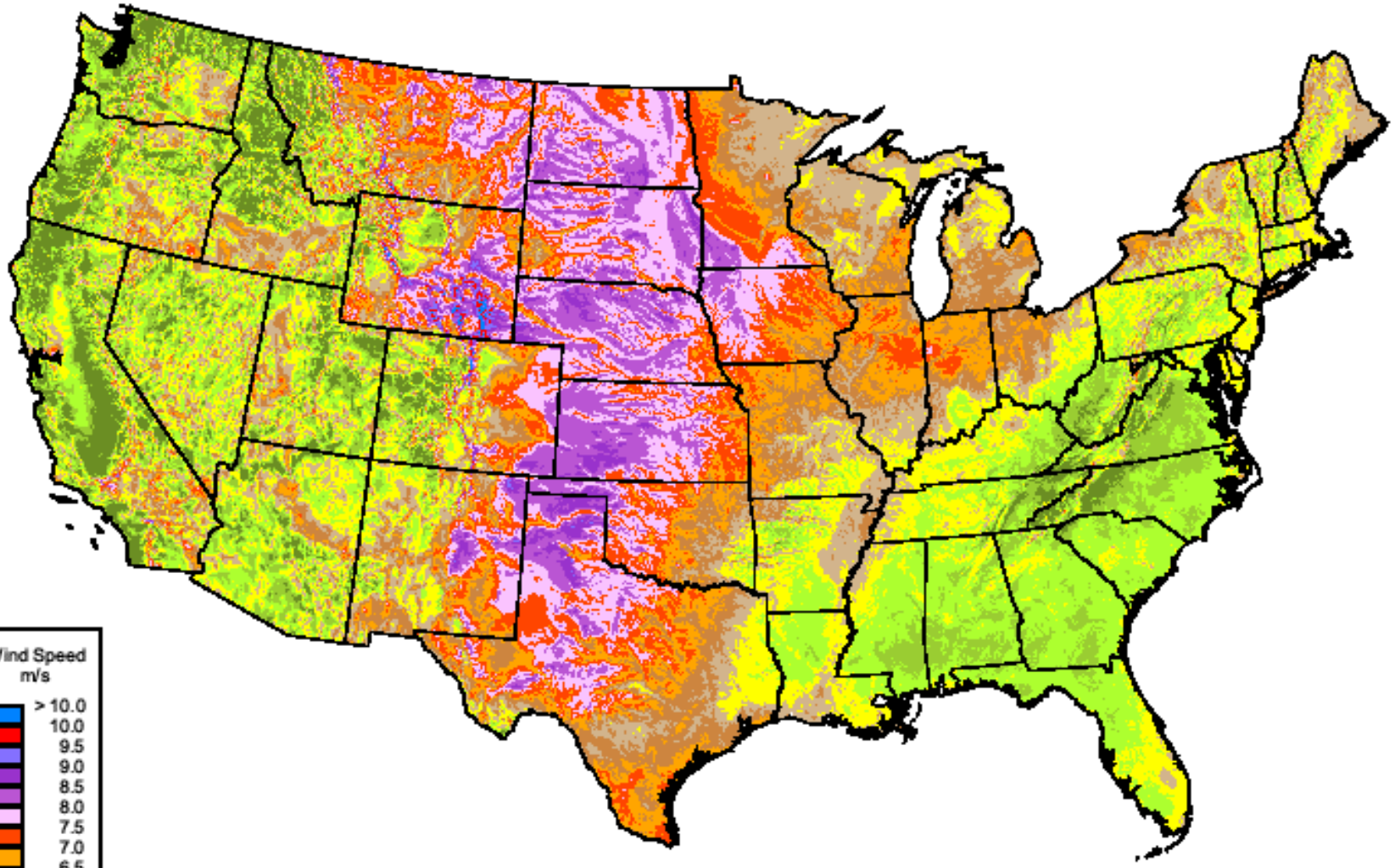






# United States - Annual Average Wind Speed at 80 m



Wind Speed m/s

- > 10.0
- 10.0
- 9.5
- 9.0
- 8.5
- 8.0
- 7.5
- 7.0
- 6.5
- 6.0
- 5.5
- 5.0
- 4.5
- 4.0
- < 4.0

Source: Wind resource estimates developed by AWS Truewind, LLC for windNavigator® Web: http://navigator.awstruewind.com | www.awstruewind.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.

AWS Truewind

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

# Sizes and Applications

Small (≤10 kW)

Homes

Farms

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

Intermediate (10-250 kW)

Village Power

Hybrid Systems

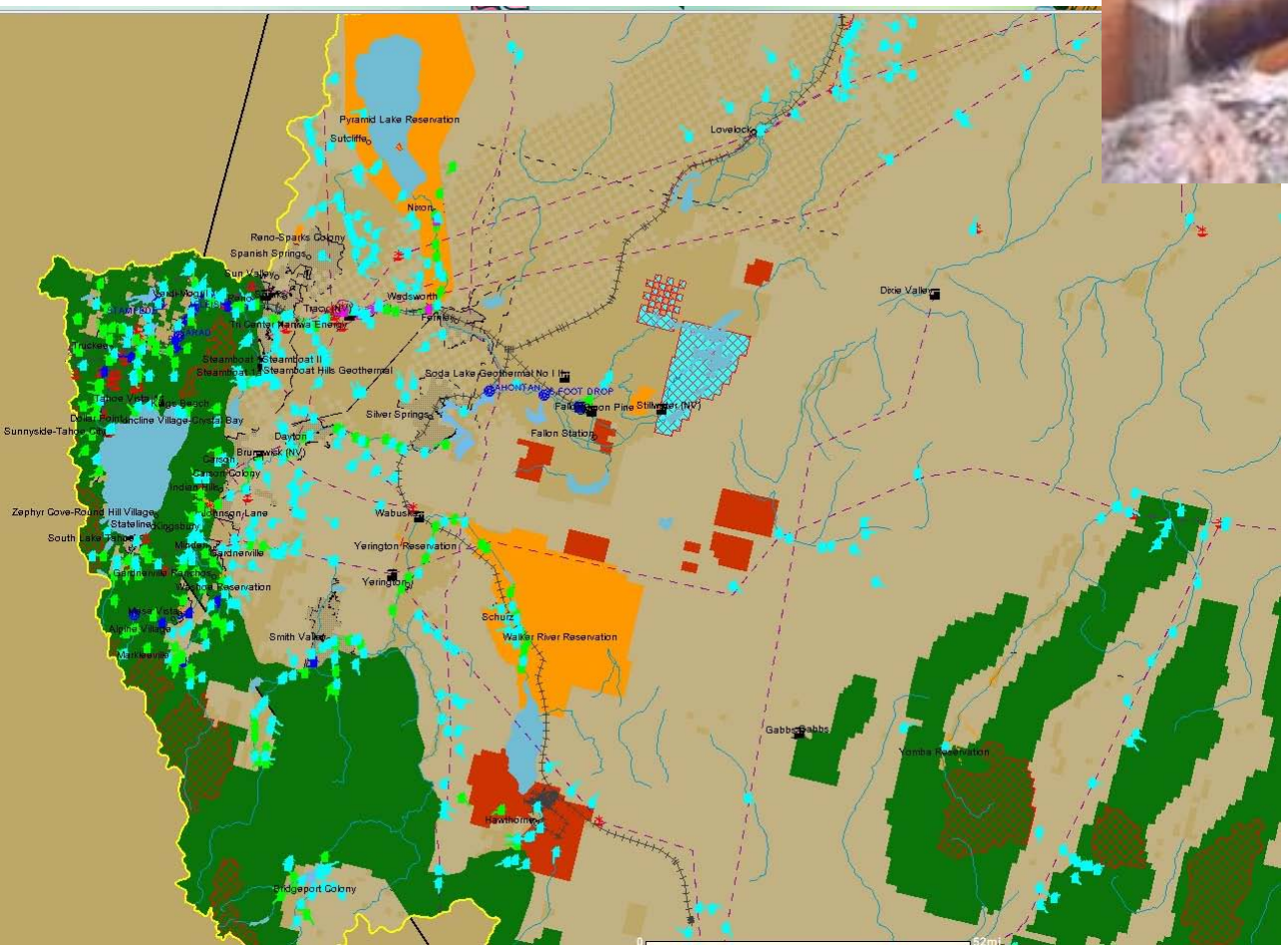
Small Distributed Power

Large (250 kW – 2+ MW)

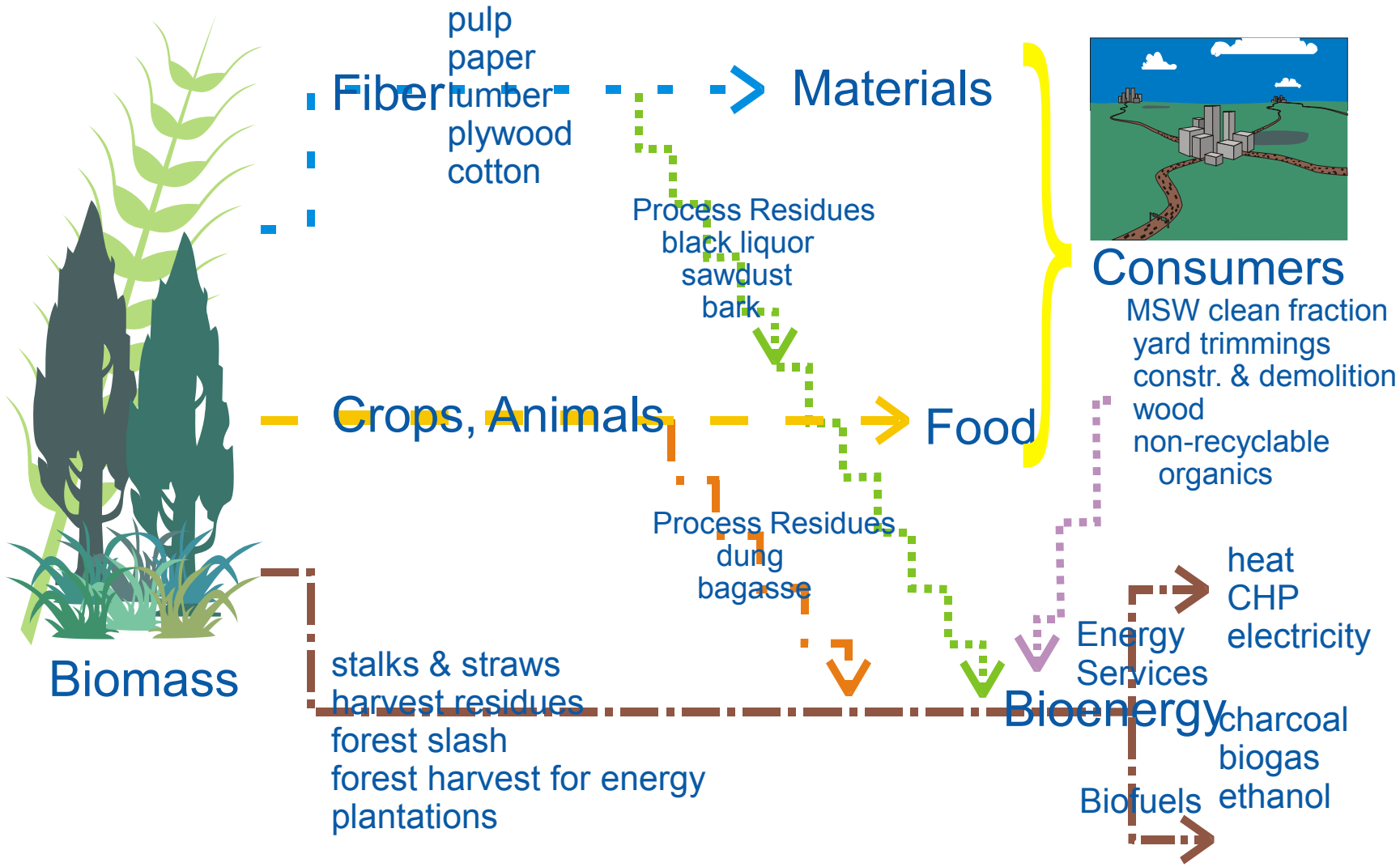
Central Station Wind Farms

Community Distributed Power

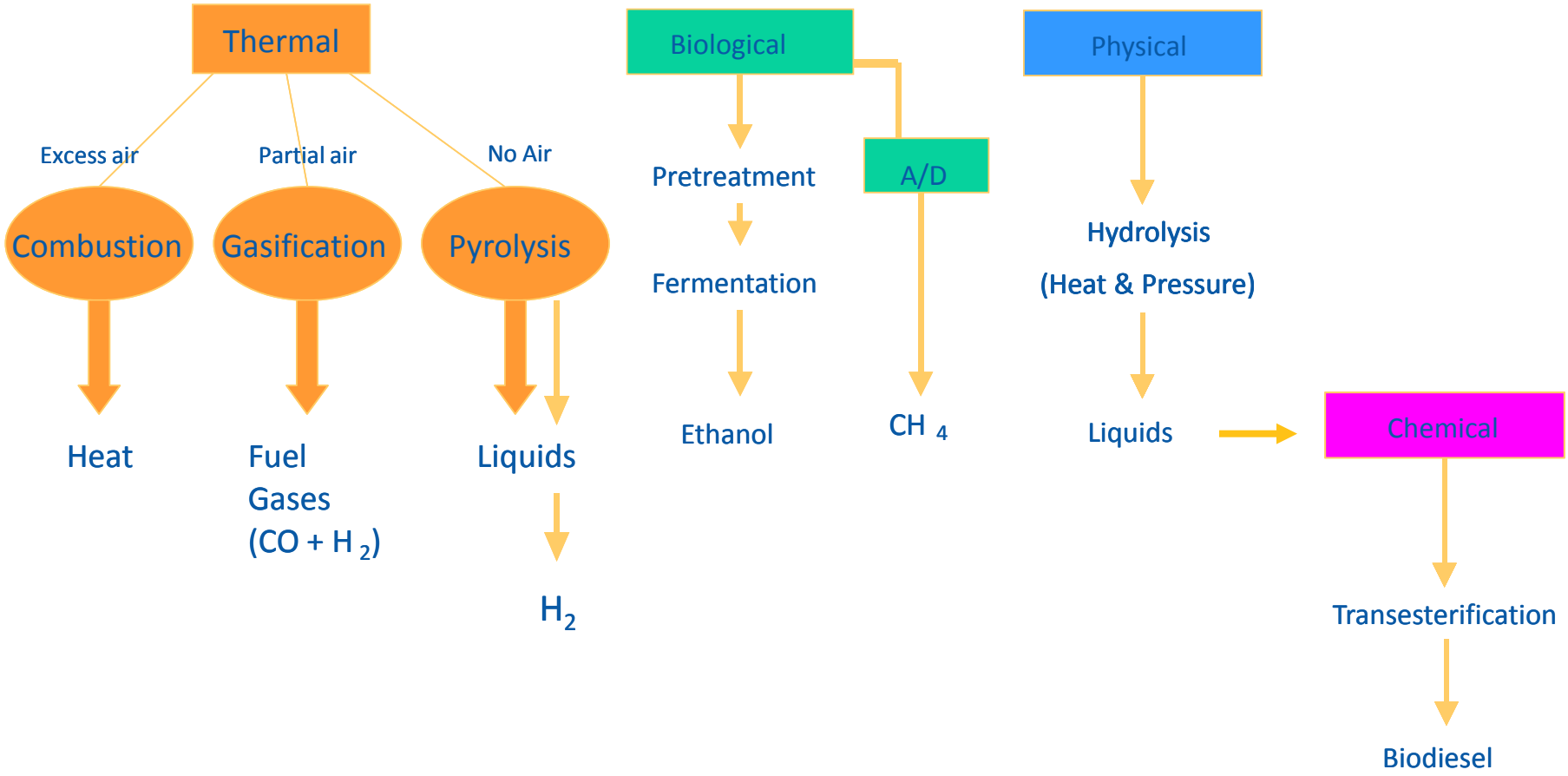
# Small & Micro Hydro Power Options



# Biomass & Bioenergy Flows

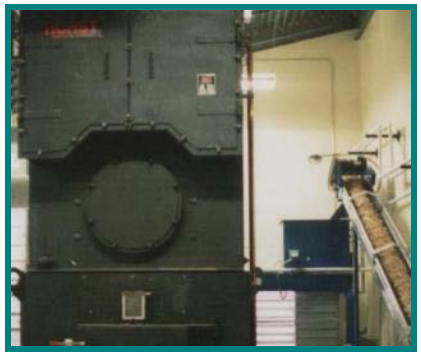


# Biomass Energy Pathways

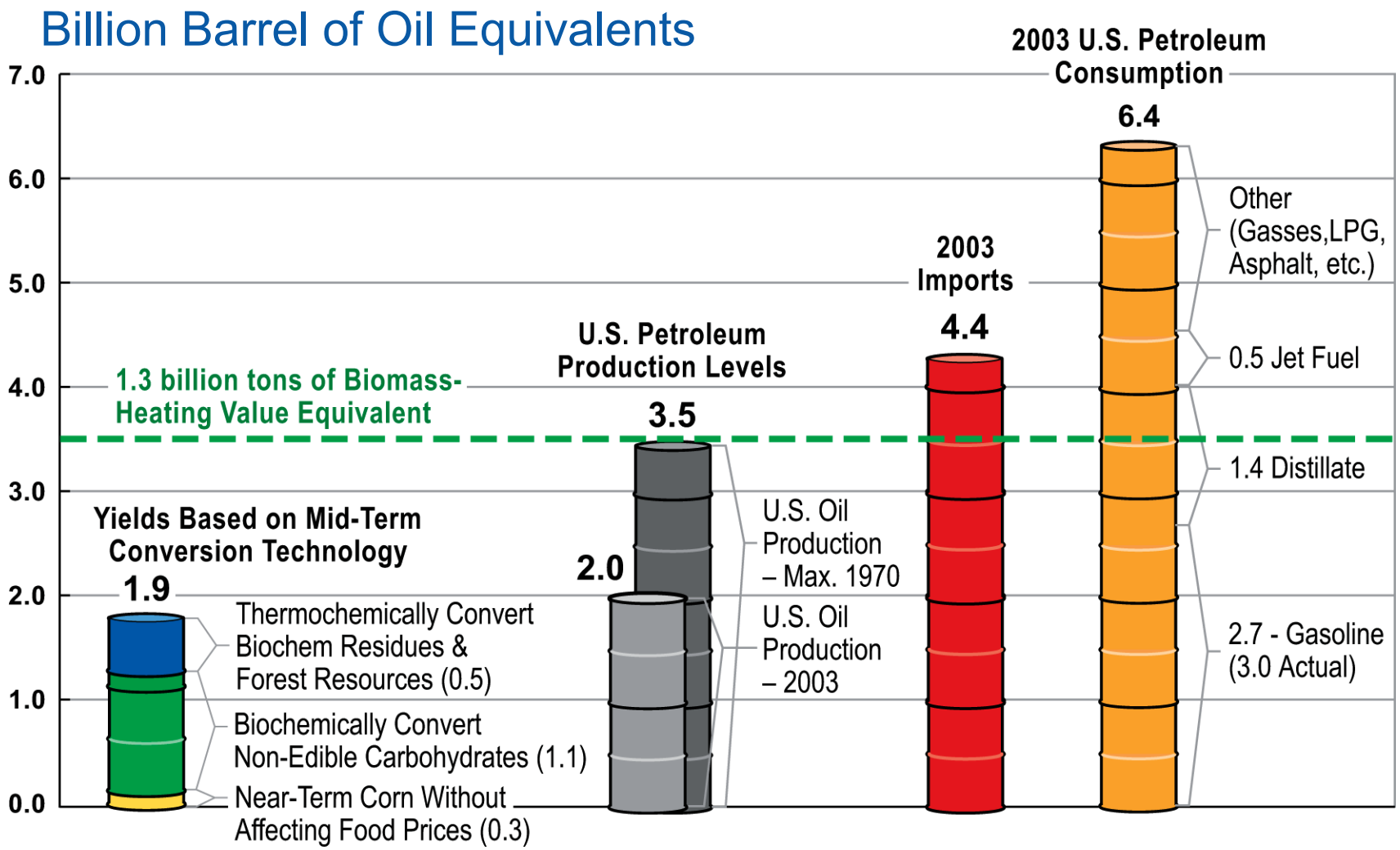


## Residential

## Community

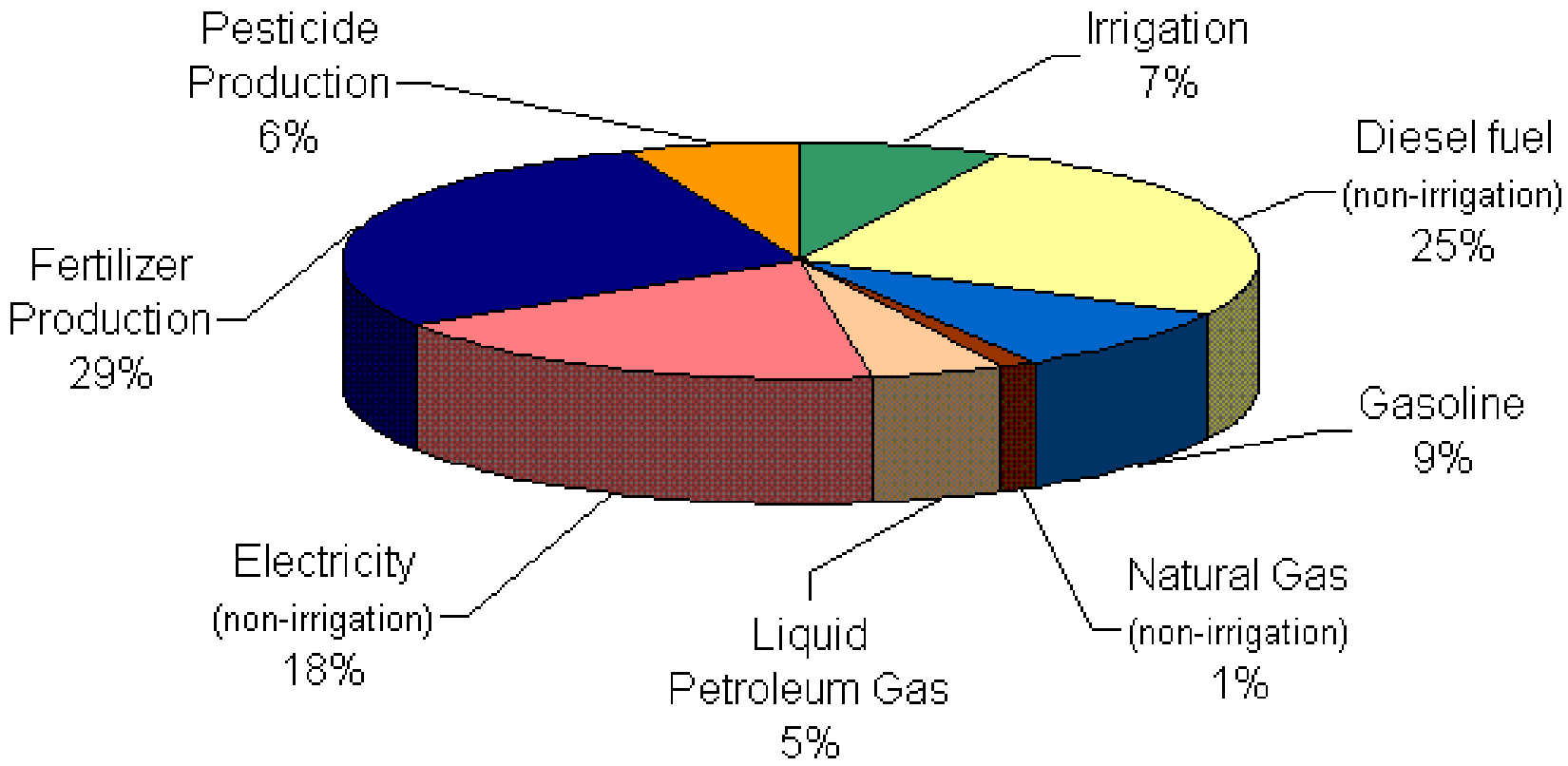


# Significance of the "Billion Ton" Scenario



# U.S. Farm Energy Use, 2002

**~75% Petroleum (assuming electric Irrigation)**

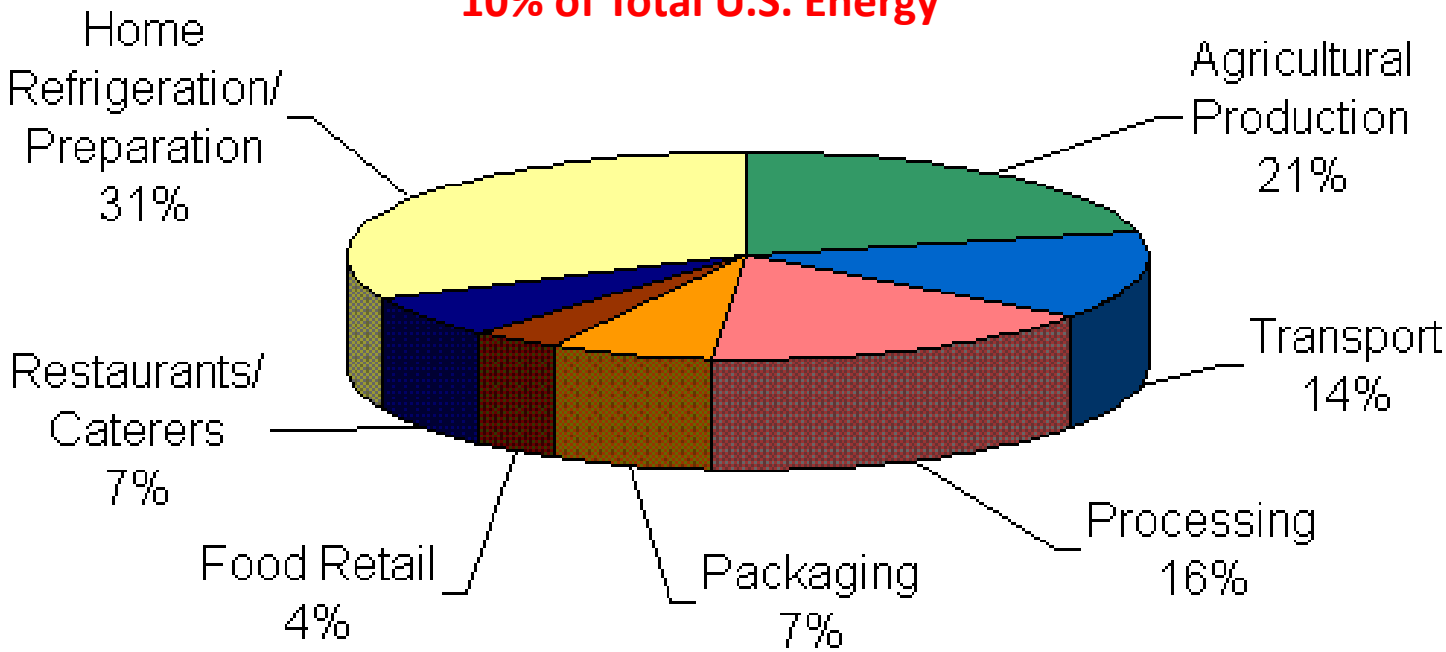



Earth Policy Institute from USDA & DOE data

# United States Food System Energy Use

Total = 10.25 Quadrillion Btu

**~10% of Total U.S. Energy**




*Source: Heller and Keoleian*

Center for Sustainable Systems, University of Michigan, 2000

# Three Great Challenges of the 21st Century

## Energy, Climate, Food

# Strategic Energy Planning

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

DEBT
SOMEDAY, ALL THIS WILL BE YOURS.