What's Happening in Our Risky Energy World? What's New Under the Sun?

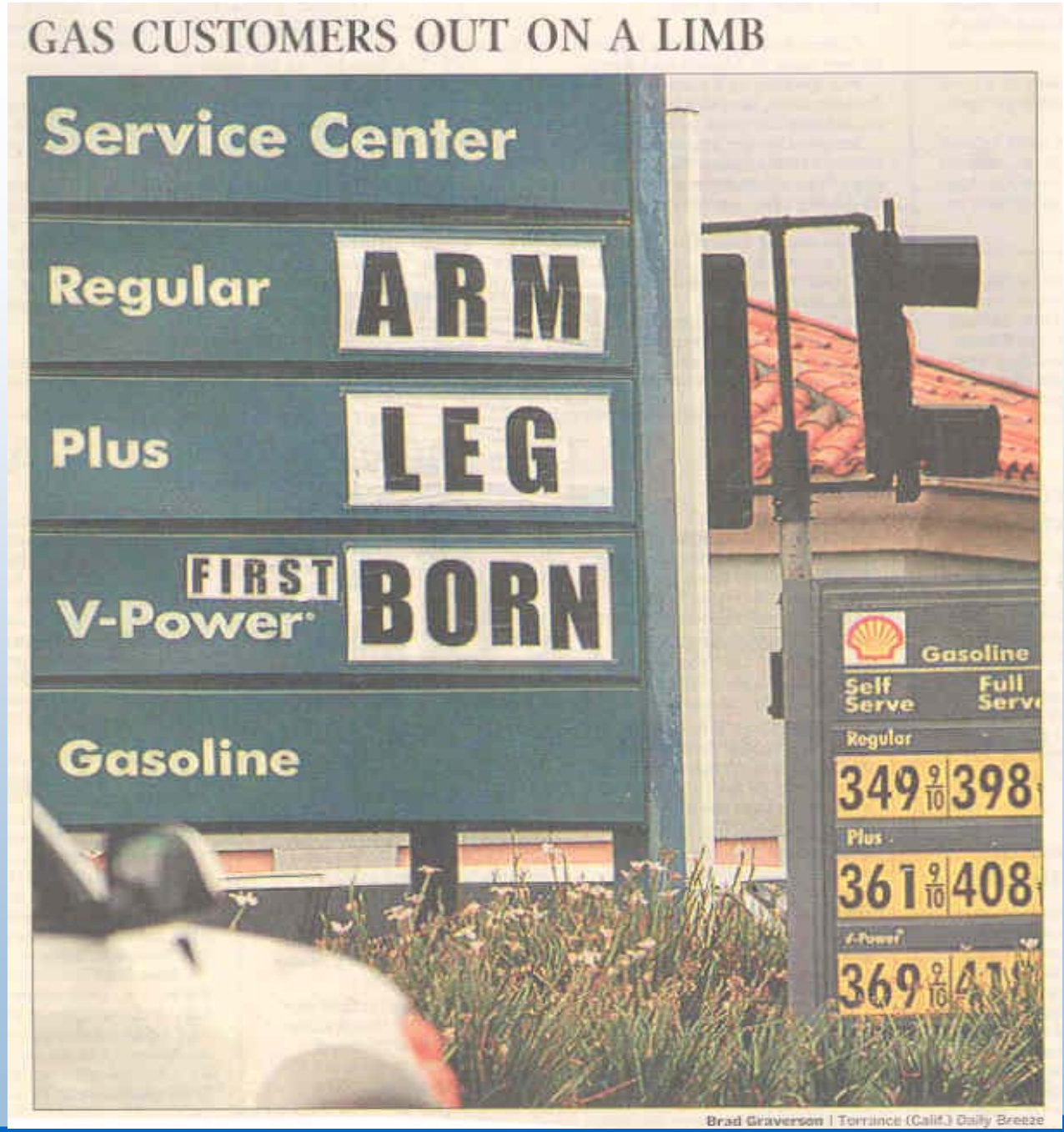
Consumer Power for the 21st Century

February 9, 2008

Carol Tombari

Energy costs are going up.

(duh-h-h….)



Energy Is the Elephant in the Room…

…An operating cost, a cost of doing business

… A vulnerability for businesses that require 99.9999% reliability

… A factor in local environmental conditions and associated human health

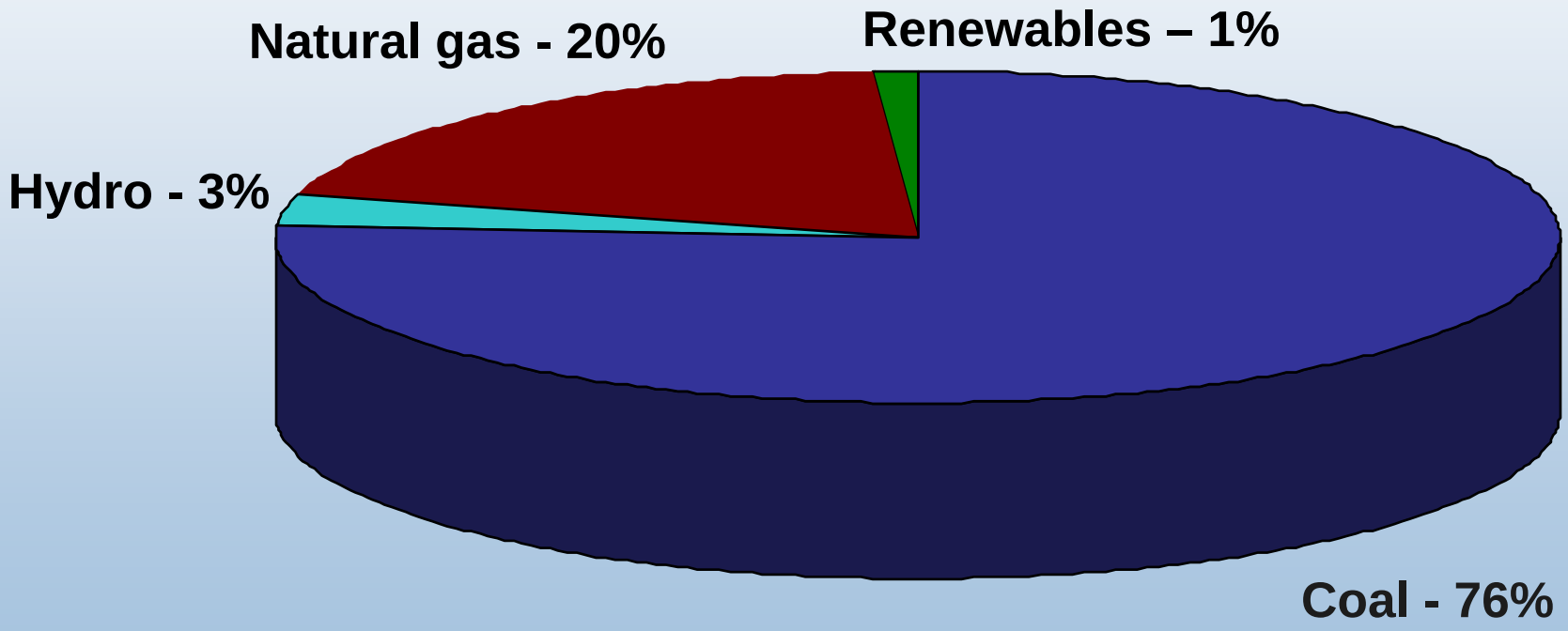
… A factor, for better or worse, in local economies

… A homeland security concern

… A national security concern

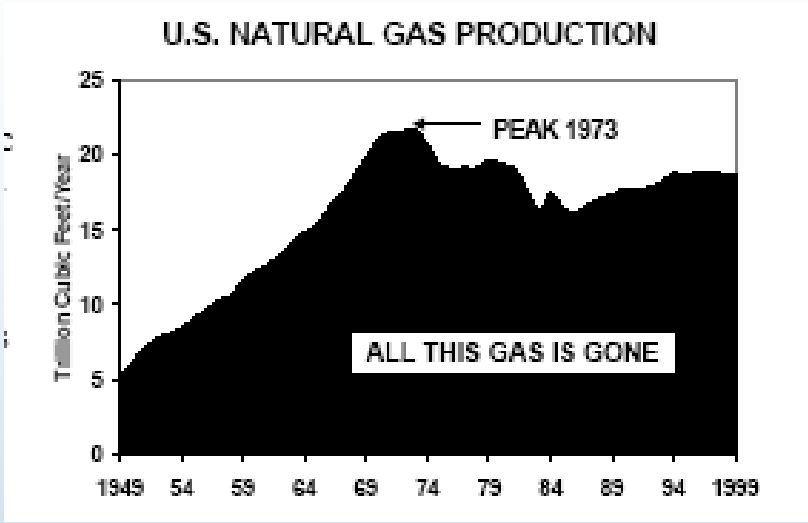
… A behind-the-ticker-tape factor on Wall Street

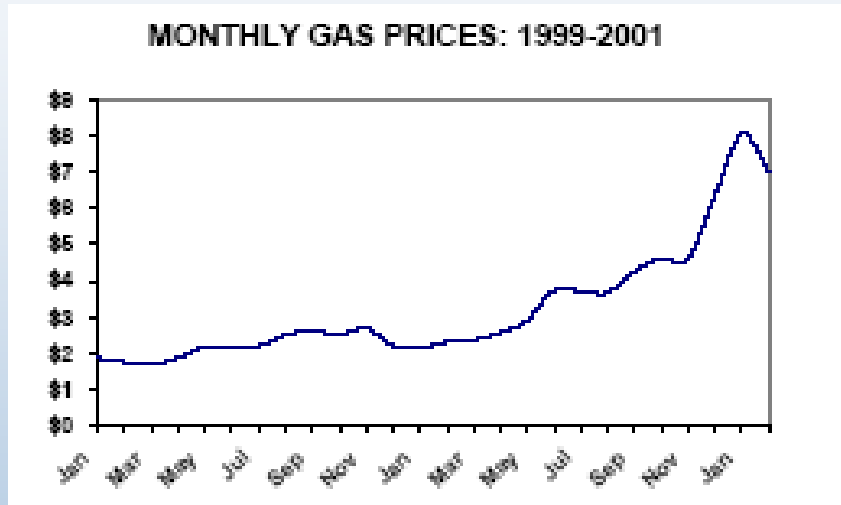
Colorado's Resource Mix
All Electric Utilities

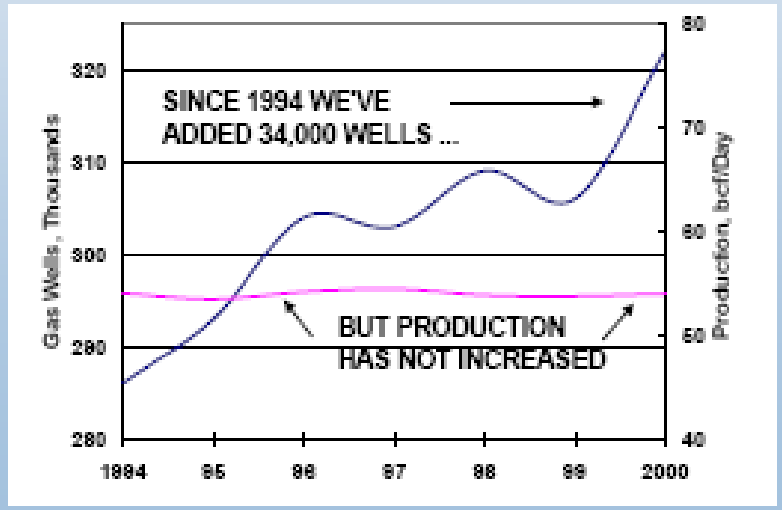


Source: Energy Information Administration, Electric Power Annual, 2003 (published January 2005)

Natural Gas







Source: Community Office of Resource Efficiency

Managing Coal Piles at Power Plant

Central Station Power Plants: Reliable Baseload Capacity

Jobs Creation:

- 40 permanent jobs
- 1,000 temporary construction jobs

Economic Multiplier: $1.61

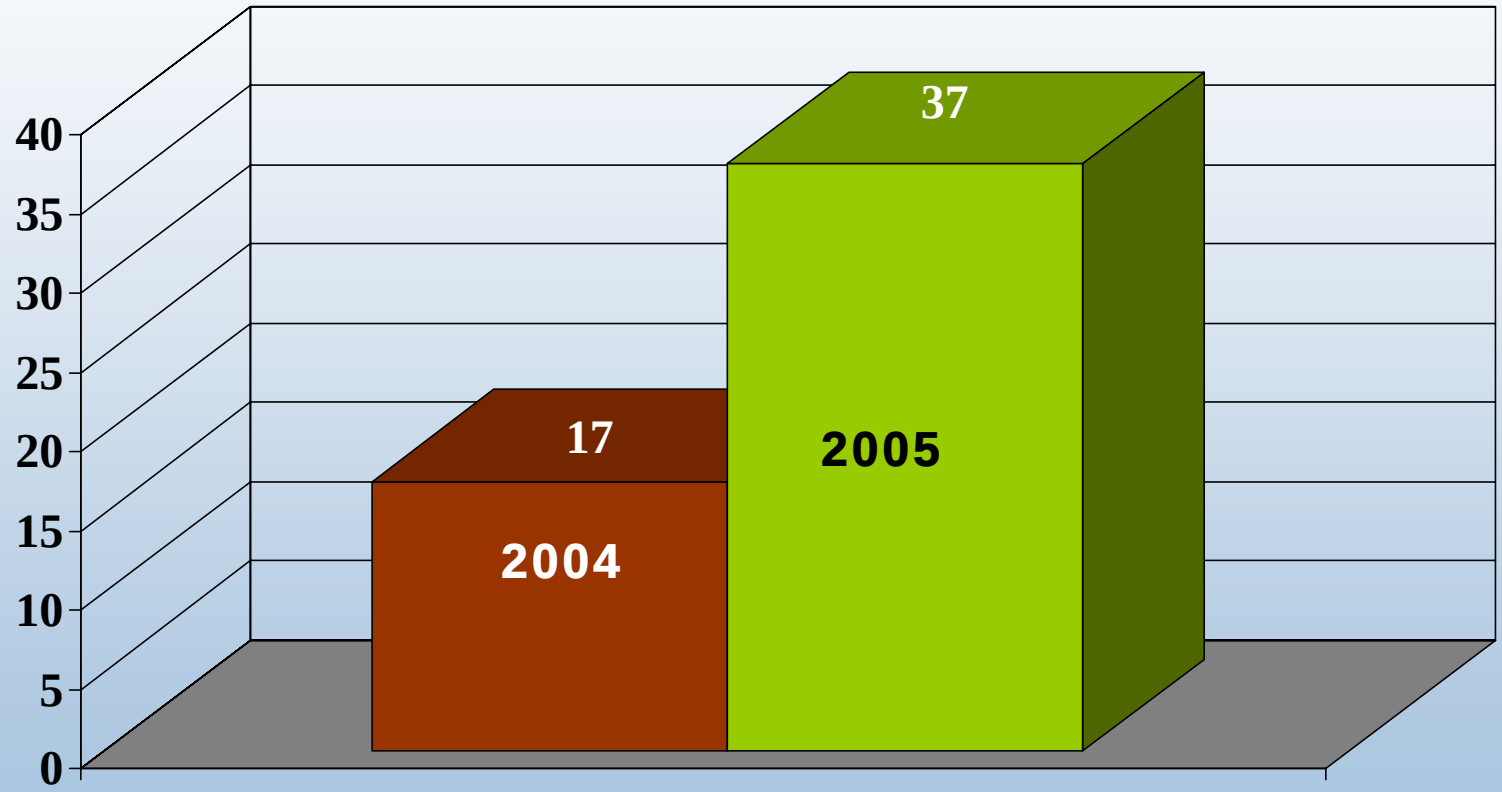
Environmental Impacts:

- Emissions: CO_2, fine particulates, mercury, SO_x
- Cooling water requirements

Land Use Impacts:

- Coal piles
- Generating facility
- Cooling towers
- Railroad tracks

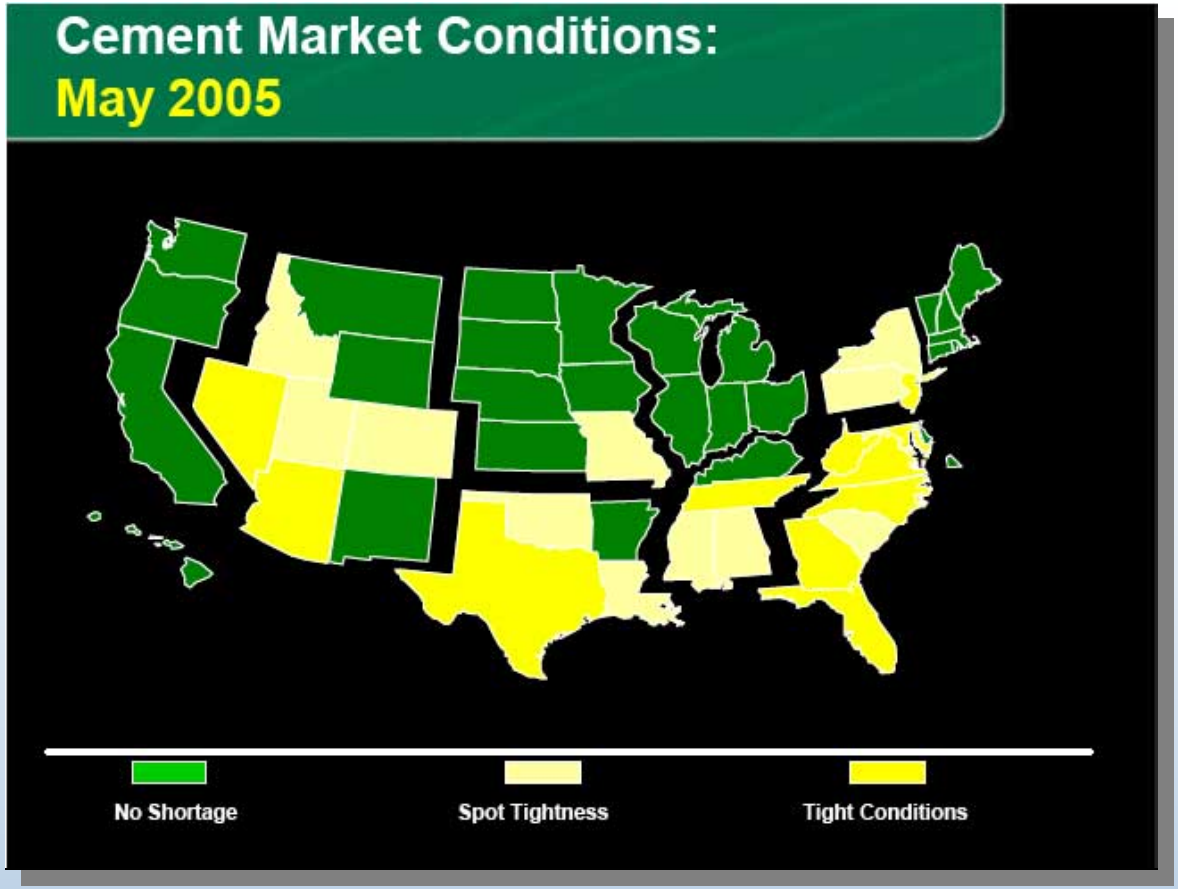
Increase in Coal Spot Price



Cement producers

1. China
2. India
3. U.S.

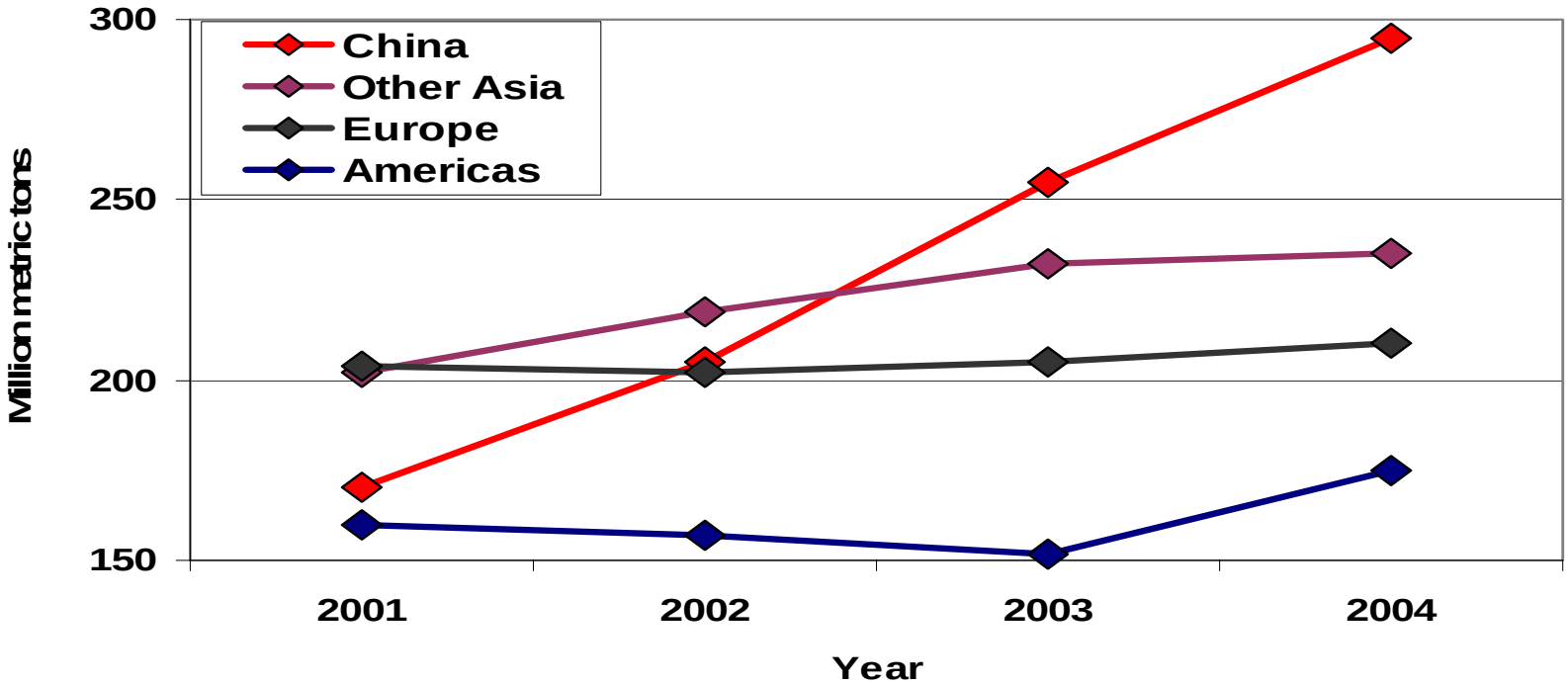
22% Imported



China Consumes ½ of all the concrete in the world

U.S. cement manufacturing is 81% foreign owned

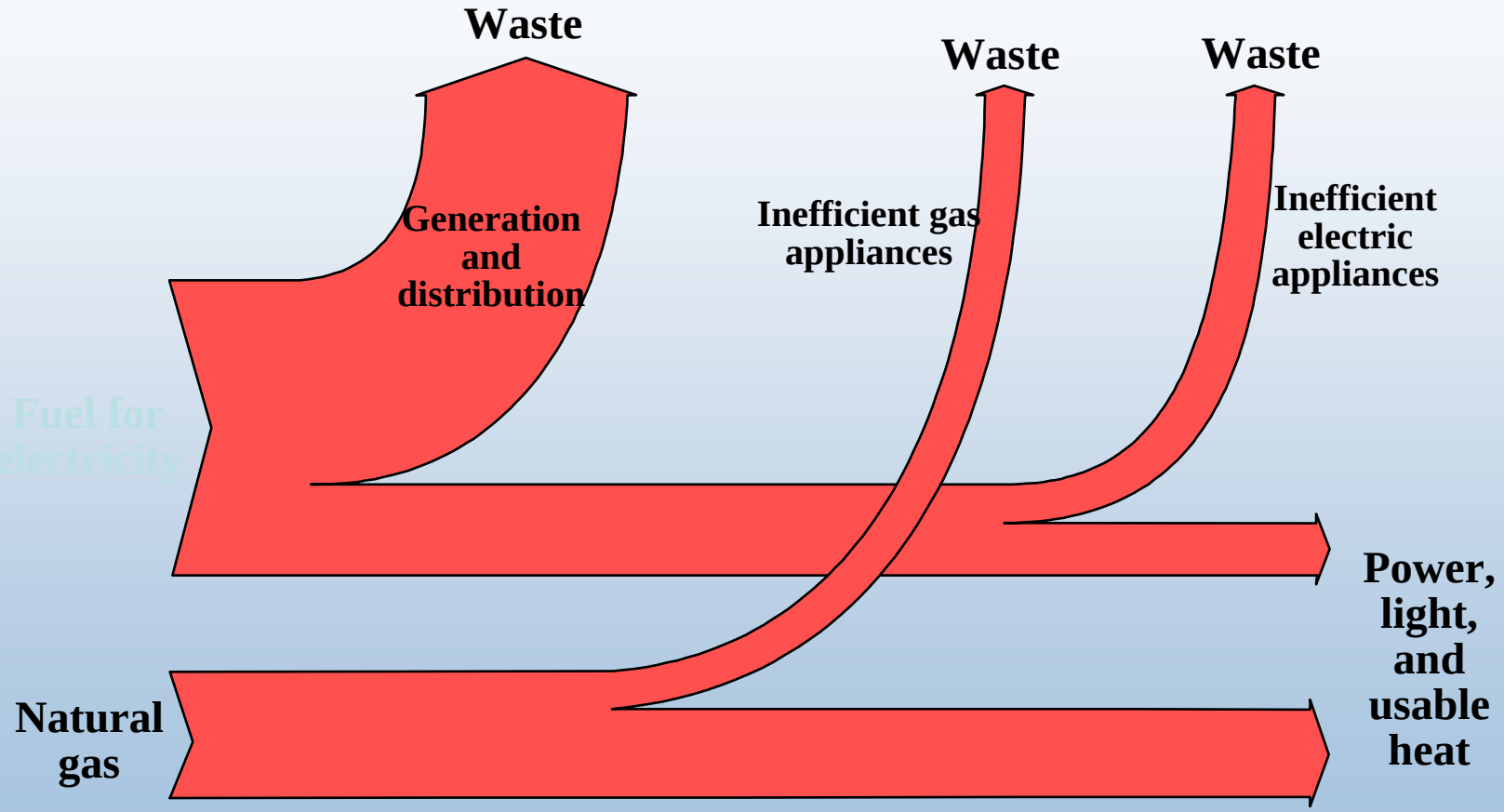
Trends in Demand for Steel



Source: International Iron and Steel Institute.

Where We Are Today

Consumption for Average Residential Customer



Source: A Micro-Grid with PV, Fuel Cells, and Energy Efficiency, Tom Hoff, Clean Power Research.com

Energy Intensity

The American economy is, after Canada's, the most energy-dependent in the advanced industrialized world, requiring the equivalent of a quarter ton of oil to produce $1,000 of gross domestic product. ***We require twice as much energy as Germany -- and three times as much as Japan -- to produce the same amount of GDP.***

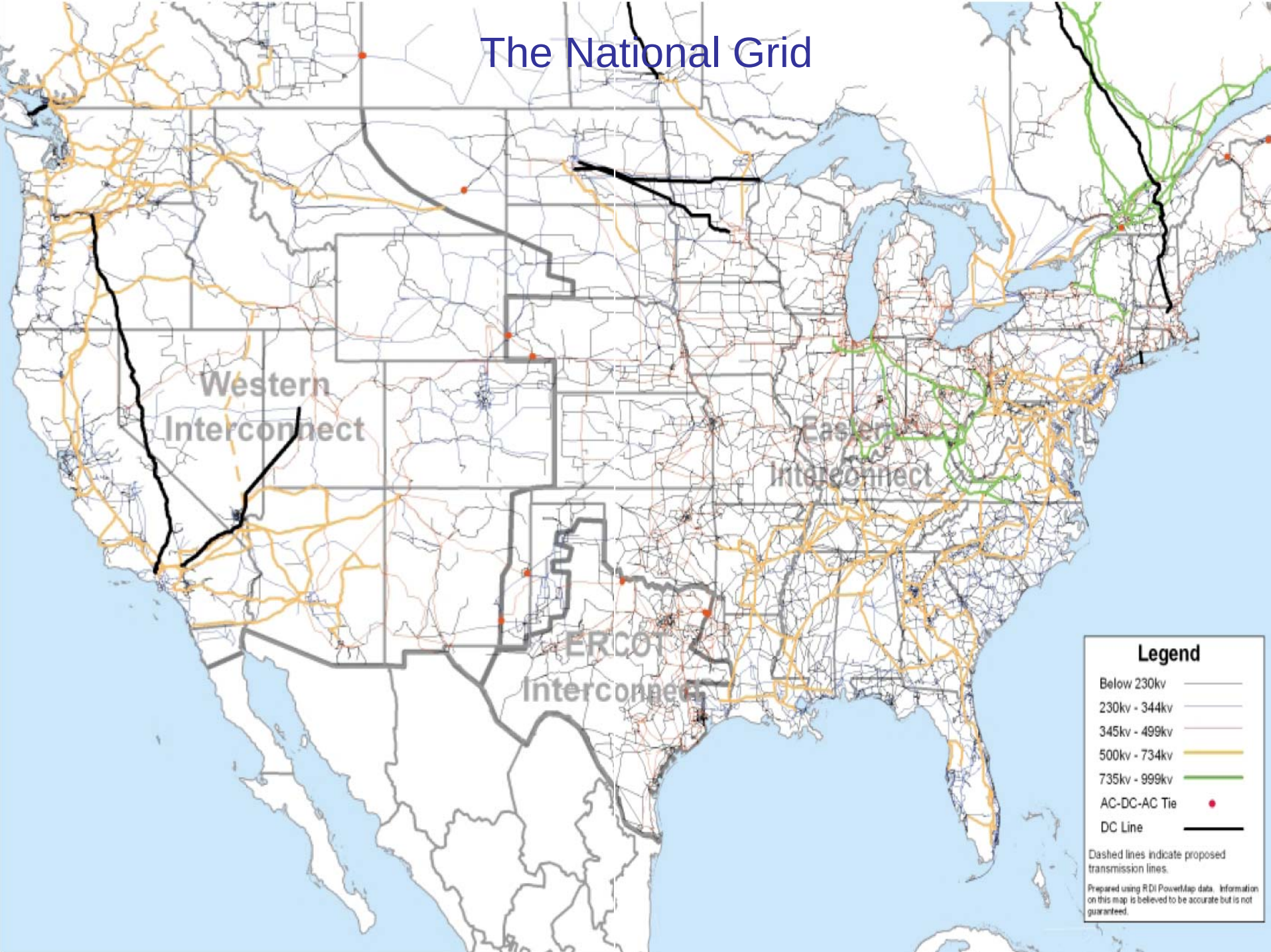
Source: Ricardo Bayon, *The Atlantic Monthly*, Jan/Feb. 2003

The Risk

Rising energy (operating) costs →

- **Lower profit margins**
- **Uncompetitive product pricing in global market place**
- **Lower standard of living**

The National Grid



Homeland Security

Vulnerability of the Electrical Grid to Natural Disasters

High-voltage power line cut by fallen tree limb near Oregon/California border - August 10, 1996

Before

After

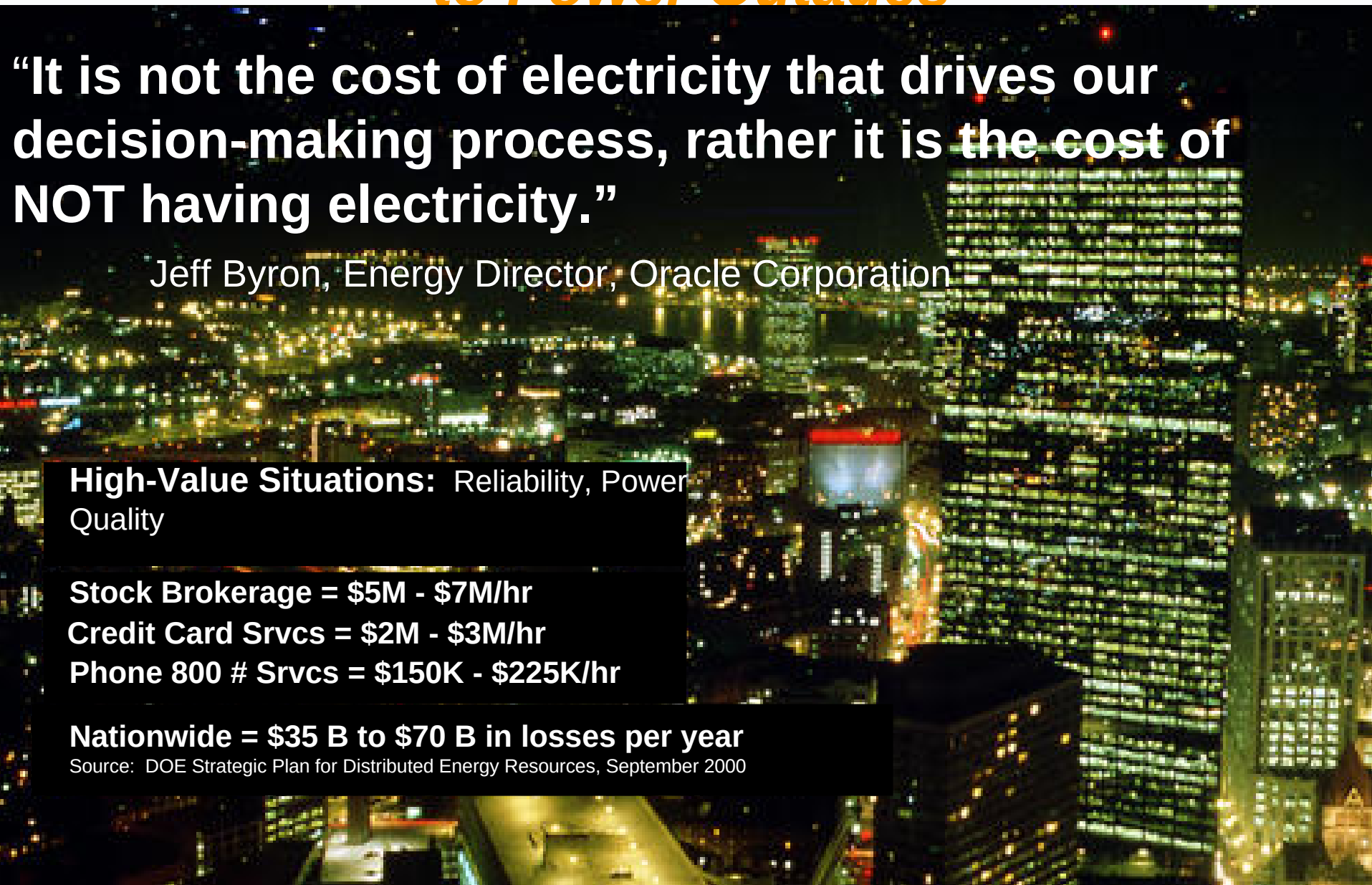
- **Affected a 9-state region**
- **Lasted up to 3 weeks in some areas**
- **Almost 16 million people affected in California alone**

Source: W. Becker, U.S. DOE

Source: W. Becker, U.S. DOE

What is the value of energy if you don't have any?

Vulnerability of Our Economy to Power Outages



"It is not the cost of electricity that drives our decision-making process, rather it is the cost of NOT having electricity."

Jeff Byron, Energy Director, Oracle Corporation

High-Value Situations: Reliability, Power Quality

Stock Brokerage = $5M - $7M/hr
Credit Card Srvcs = $2M - $3M/hr
Phone 800 # Srvcs = $150K - $225K/hr

Nationwide = $35 B to $70 B in losses per year
Source: DOE Strategic Plan for Distributed Energy Resources, September 2000

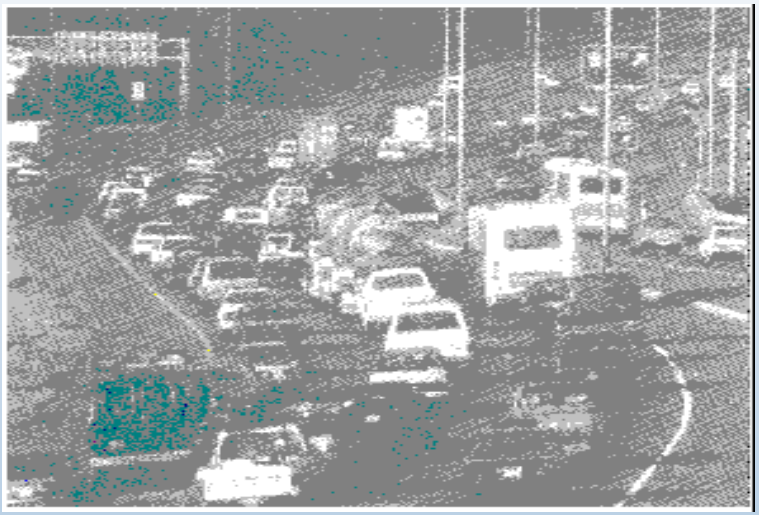
The Risk

Aging, stressed national transmission grids →

- **Reliability of electricity supply**
- **Power quality issues**
- **Resulting business losses**
- **Increased line losses**
- **Stranded renewable energy resources**

Air Emissions & Public Health

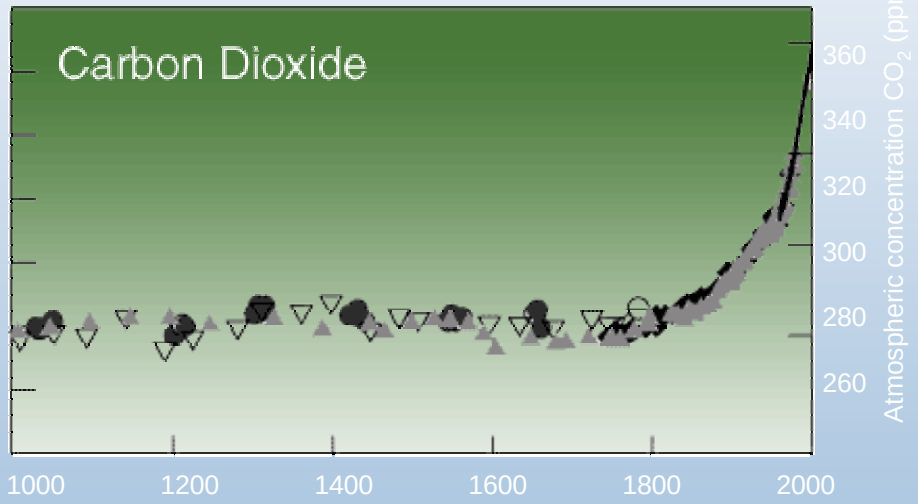
45% of U.S. Population live in non-attainment areas.

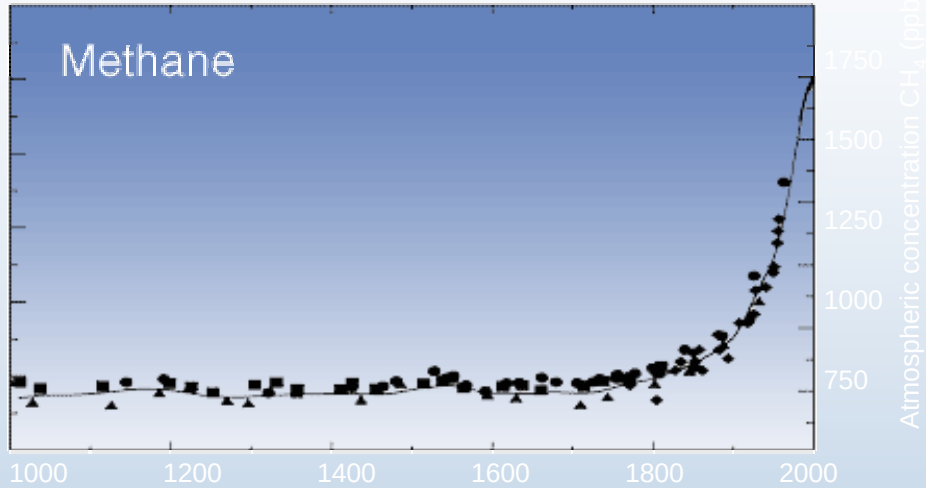


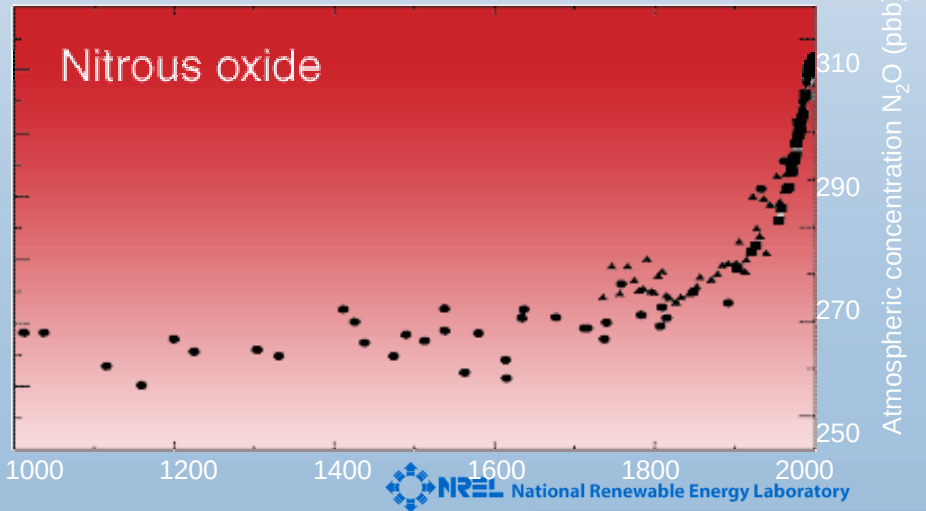
- **121.4 million Americans lived in counties that violated national air quality standards in 2000.**
- **The American Lung Association estimates that Americans spend >$50 billion a year on health care as a result.**

Changes in Atmospheric Concentration

CO_2, CH_4, and N_20 – A Thousand Year History







Source: IPCC Third Assessment Report (2001)


If
Planet
Earth...
were
the size
of an Apple,
Then her life-giving atmosphere
would be thinner than an Apple's peel!

Perennial Sea Ice Cover

- Significant reduction in perennial sea ice cover over the last 25 years (10% per decade)
- Submarine data indicate 40% thinner ice than in the several decades before the mid-1990s

Yellow Line is the 1979-2004 average

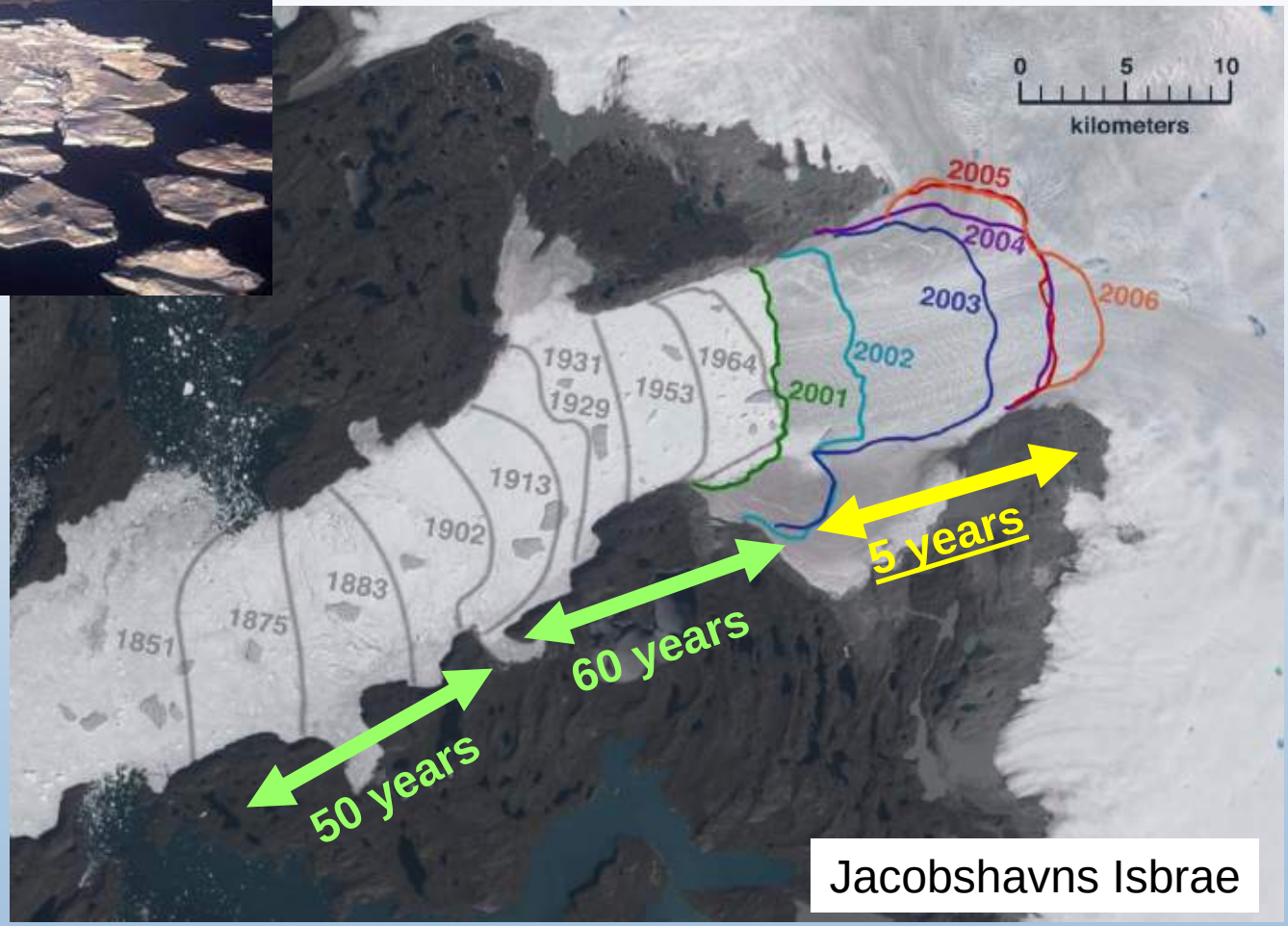
Source: GSFC Scientific Visualization Studio and J. Comiso

Consequences of Global Warming

- Sea level rise, storm surge, flooding of coastlines
- Early runoff, summer droughts/famine, wildfires
- More frequent weather extremes, e.g., heat waves and heavy precipitation events
- Increased hurricane intensity
- Loss of mountain glaciers and drinking water
- Spread of tropical diseases, increased plant and crop disease
- Extinction of plants, corals, and other animal species
- Long-term, sustained drought in American West

Rapid Retreat

5 ft per hour!



Iceberg-choked fjord created by rapid retreat

Courtesy of Robert Bindschadler

The Risks

Emissions from energy production and use →

- **Local/regional environmental impacts on air and water**
- **Diseases, chronic conditions and related health care costs**
- **Climate change**

"I can tell you that nothing has really taken me aback more as Secretary of State than the way that the politics of energy is warping diplomacy around the world."

Secretary of State Condoleeza Rice, Congressional Testimony, as quoted in Roll Call, 6/19/06

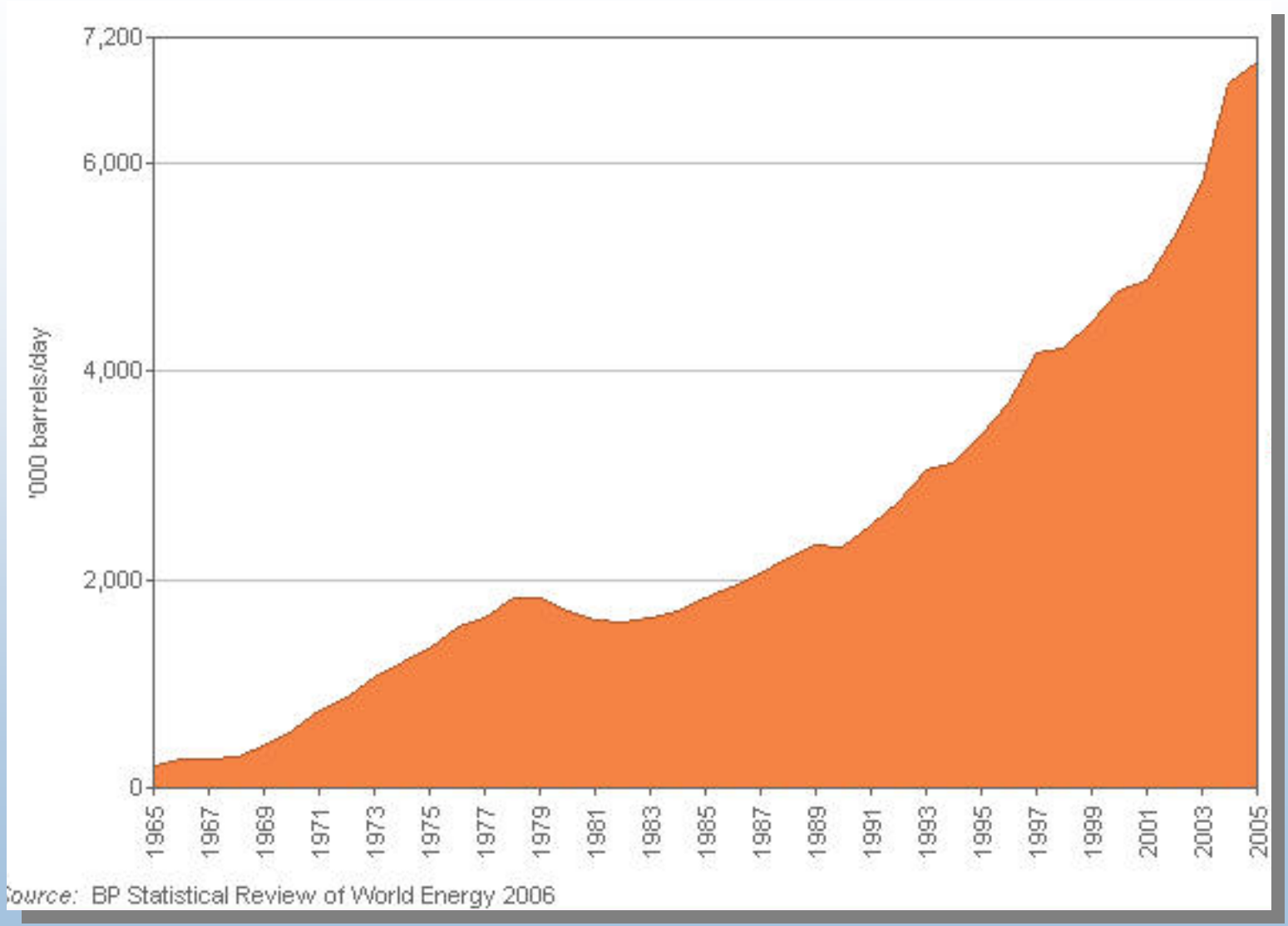
U.S. Dependence on Foreign Oil

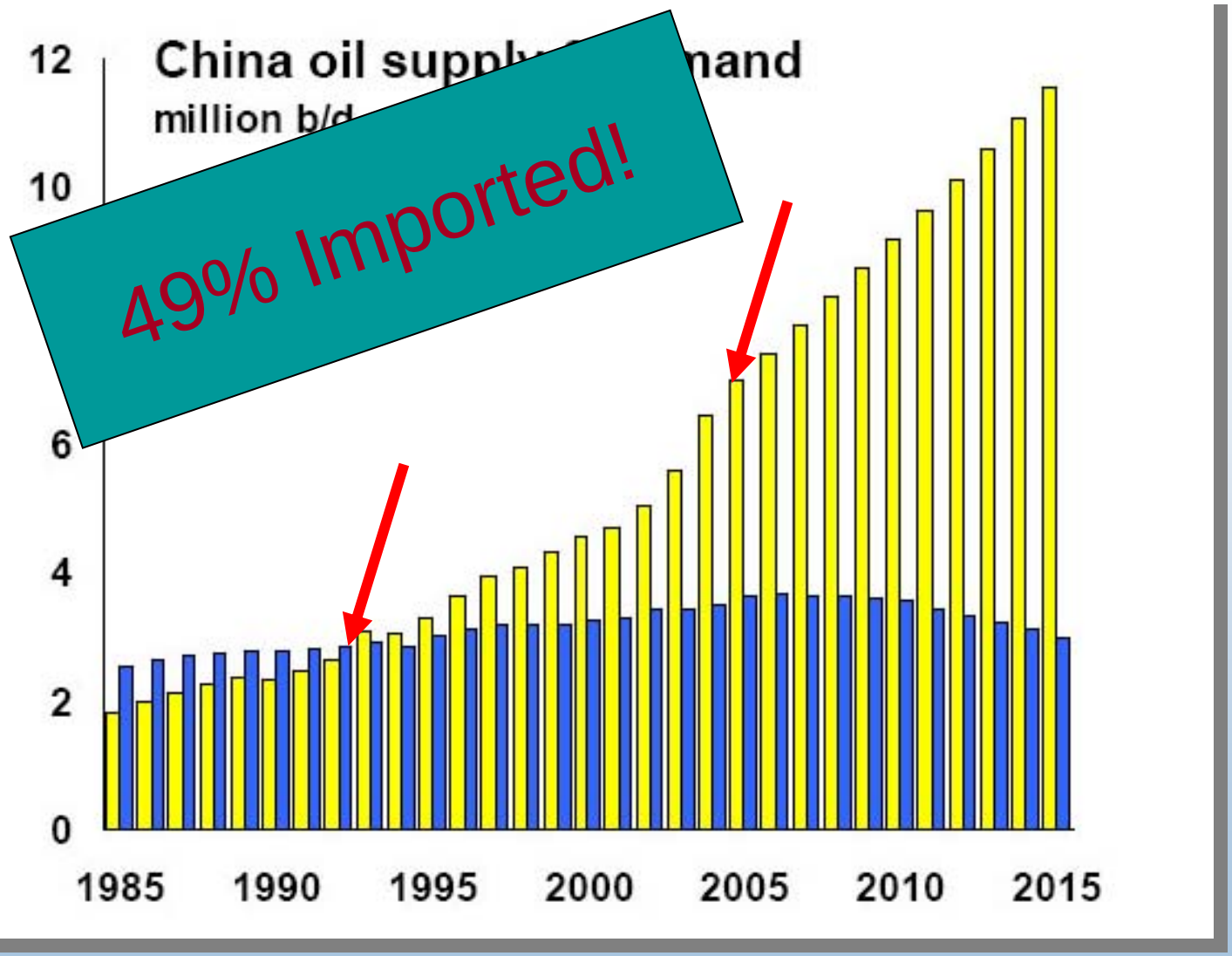
Have Oil		Use Oil	
Saudi Arabia	26%	U.S.	26%
Iraq	11%	Japan	7%
Kuwait	10%	China	6%
Iran	9%	Germany	4%
UAE	8%	Canada	4%
Venezuela	6%	Russia	3%
Russia	5%	Brazil	3%
Libya	3%	S. Korea	3%
Mexico	3%	France	3%
China	3%	India	3%
Nigeria	2%	Mexico	3%
U.S.	2%	Italy	2%

The U.S. uses more than the next 5 highest consuming nations combined.

Updated March 2003. Source: International Energy Annual 2001 (EIA), Tables 11.4 and 11.10.

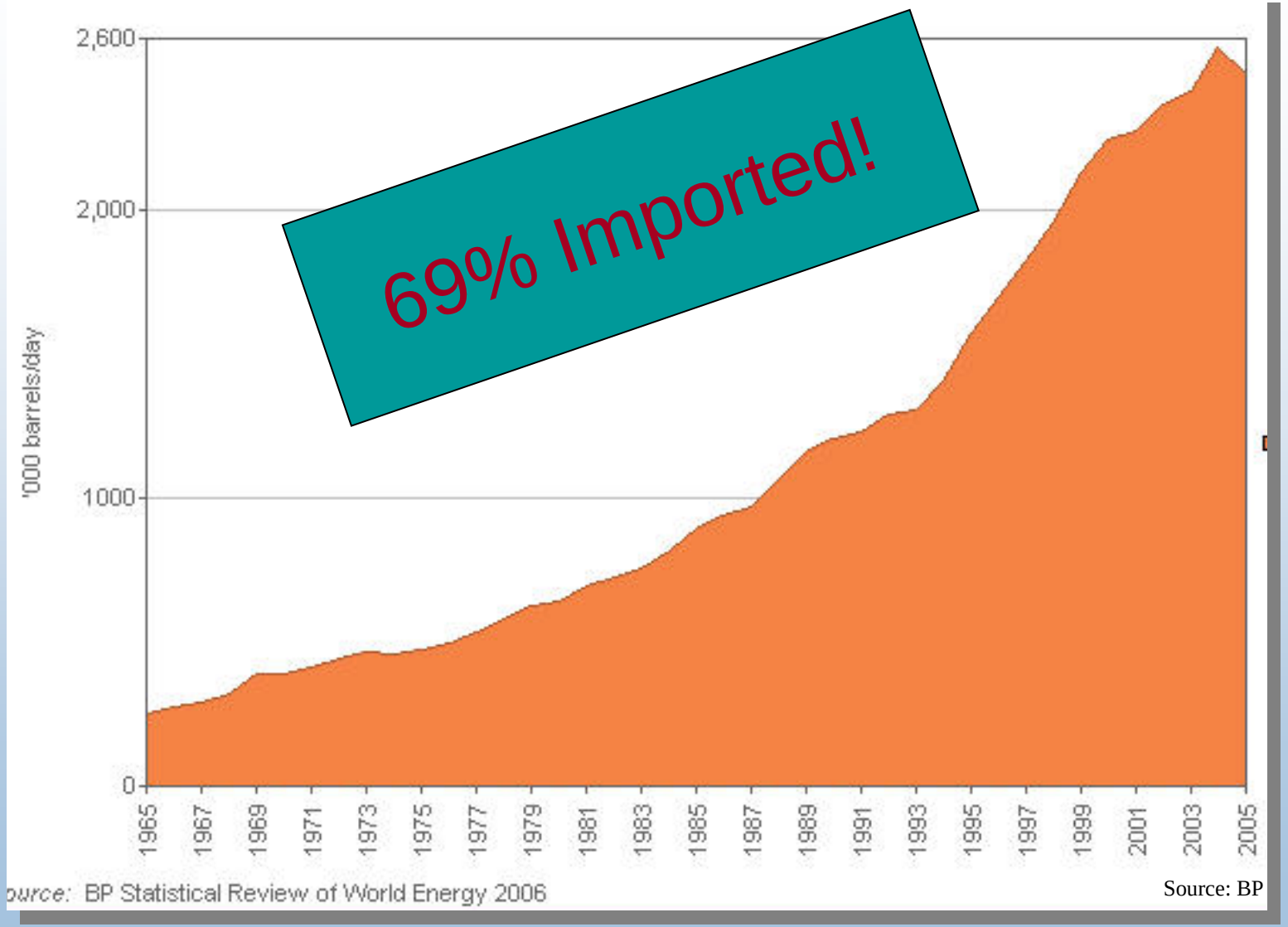
OIL CONSUMPTION- China





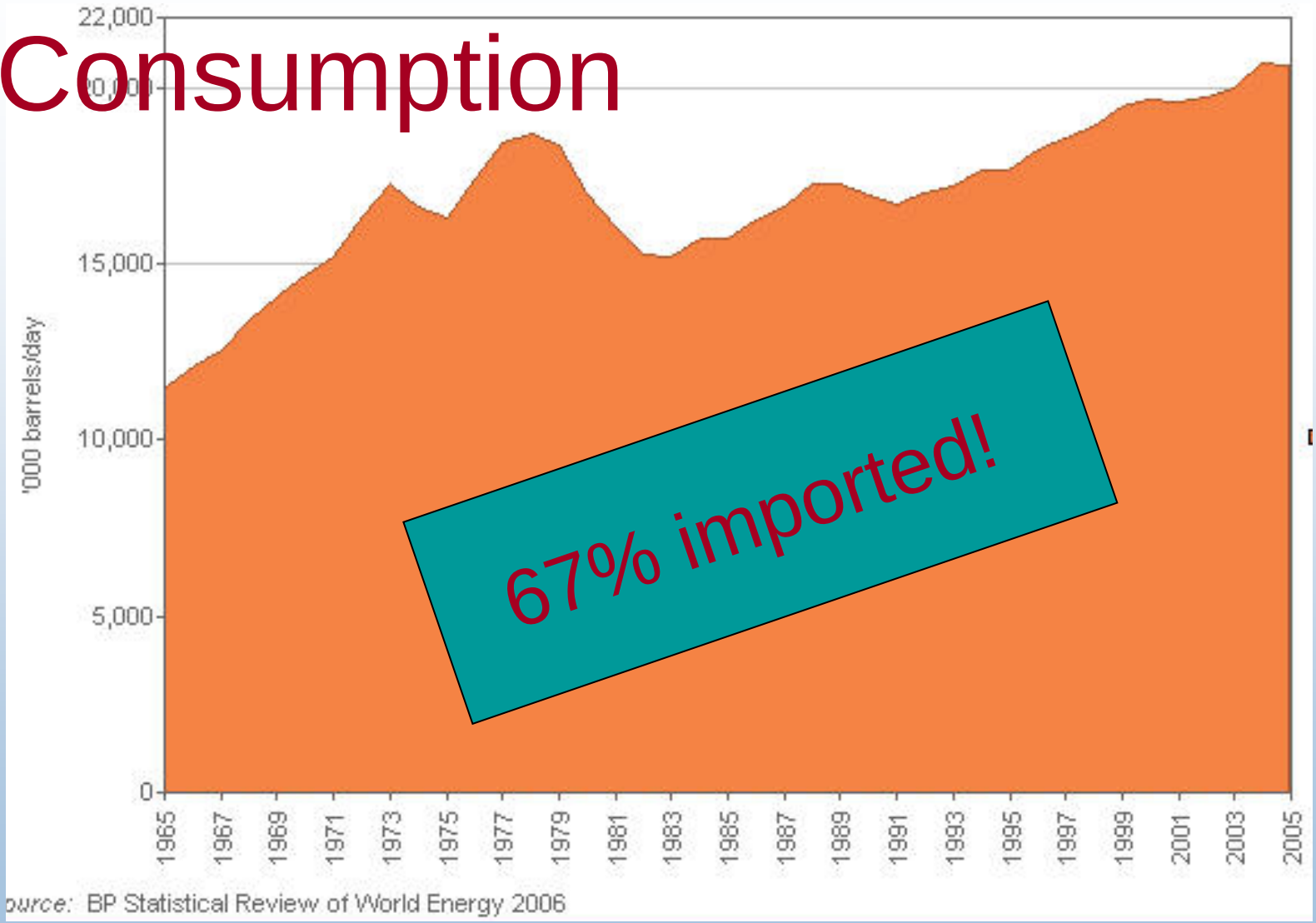
Source: Wood McKenzie

OIL- CONSUMPTION India

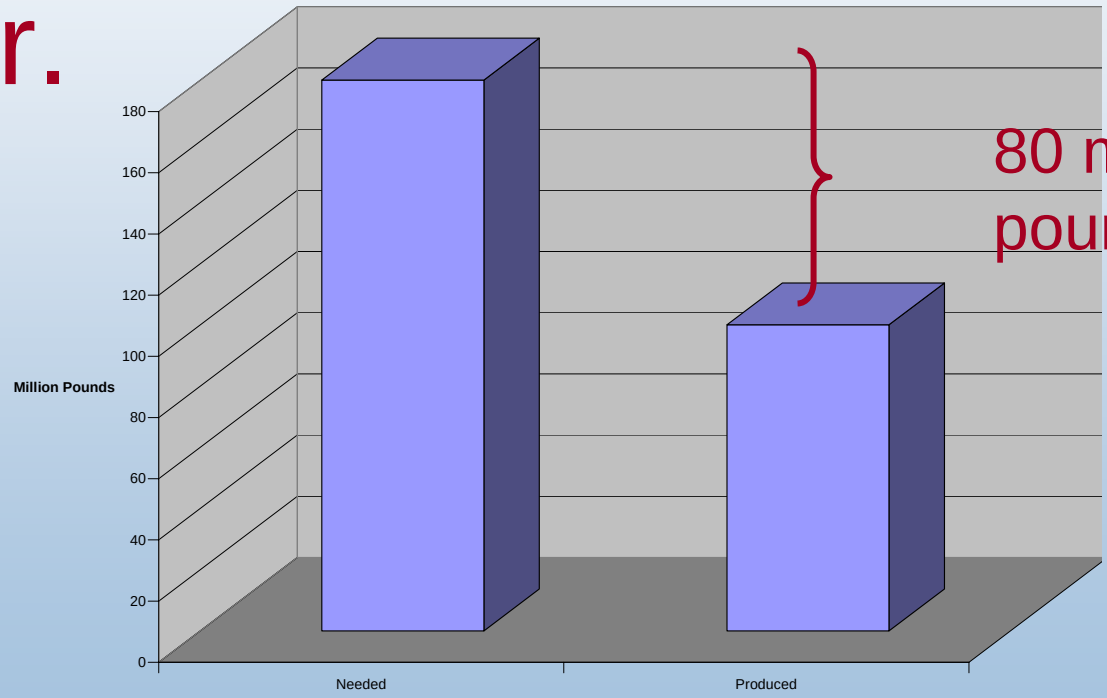


Source: BP

OIL- U.S. Consumption



The world's existing 435 nuclear reactors currently need 180 million pounds of uranium each year.



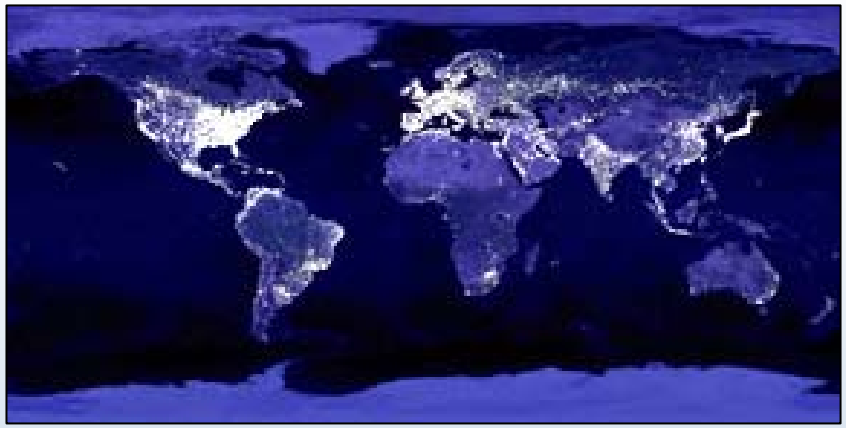
The Risks

Dependence on overseas supplies →

- **Competition for global resources**
- **Rising costs of commodities**
- **War**

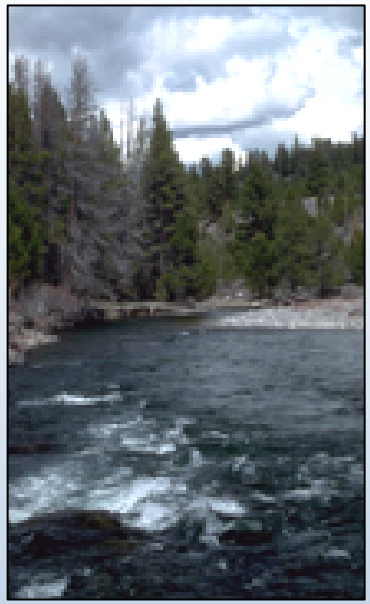
Energy Challenges are Enormous

Energy Security and Reliability



Economic Growth

Natural Disasters



Environmental Impact

Technology-Based Solutions:

There is no single or simple answer.

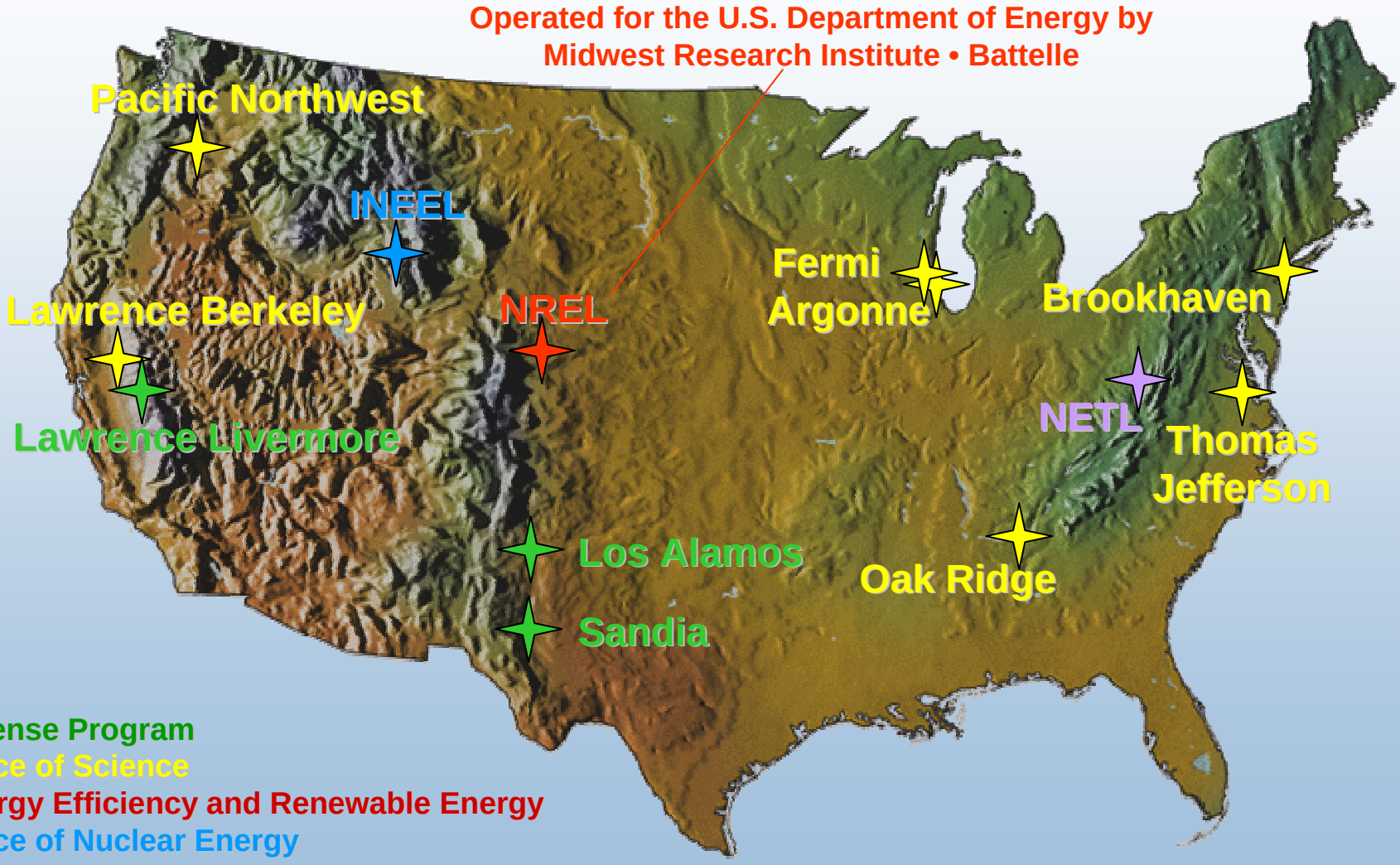
- **Energy efficiency**
- **Renewable energy**
- **Nonpolluting transportation fuels**
- **Transition to smart, resilient, distributed energy systems**

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**

DOE National Laboratories



Energy Efficiency & Renewable Energy Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

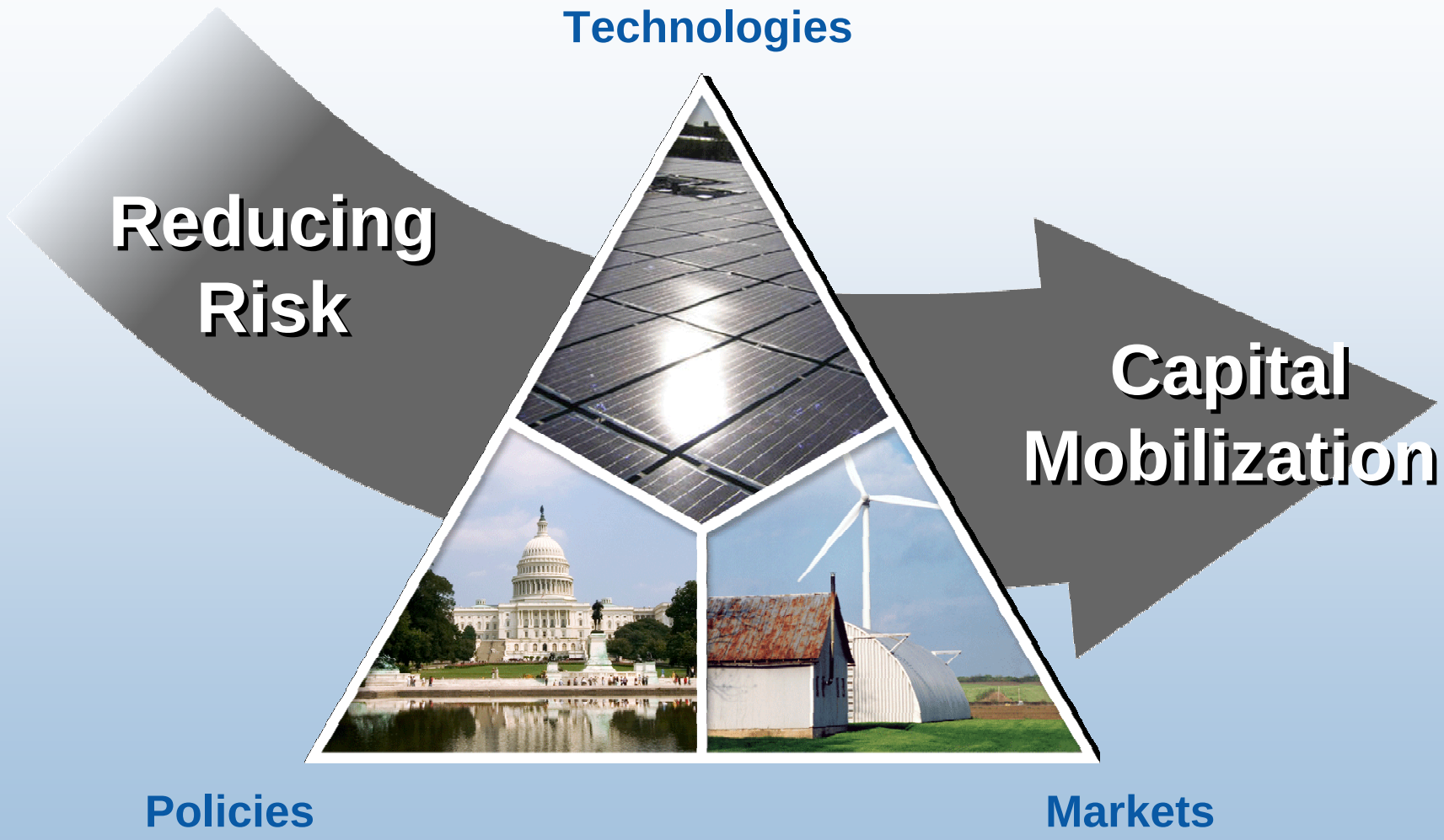
- Wind
- Solar
- Biomass
- Geothermal

Energy Delivery & Storage

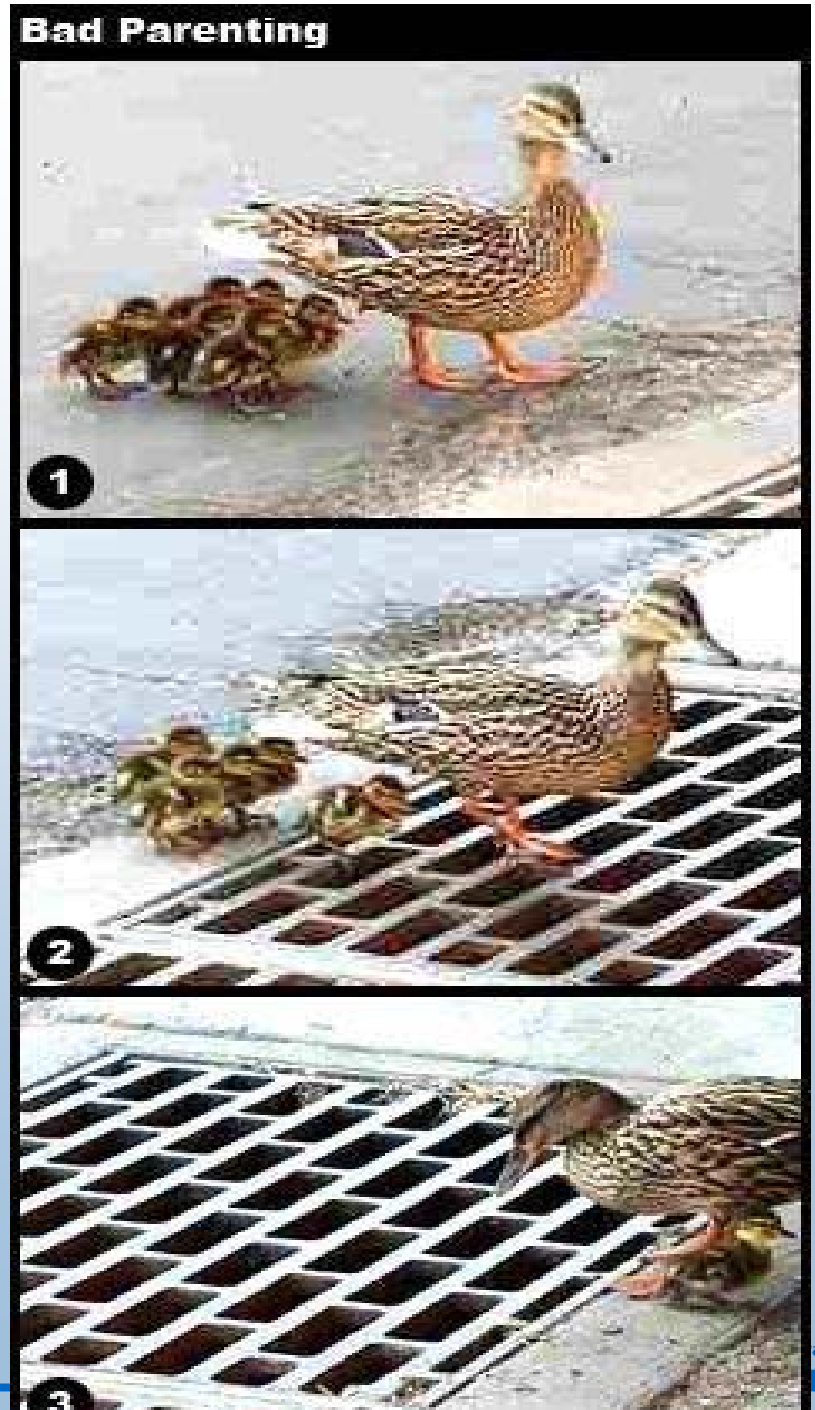
- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage

Foundational Science

Increasing Renewables in the Energy Mix



Consider changing how we define, think about, and approach RISK in our energy choices.



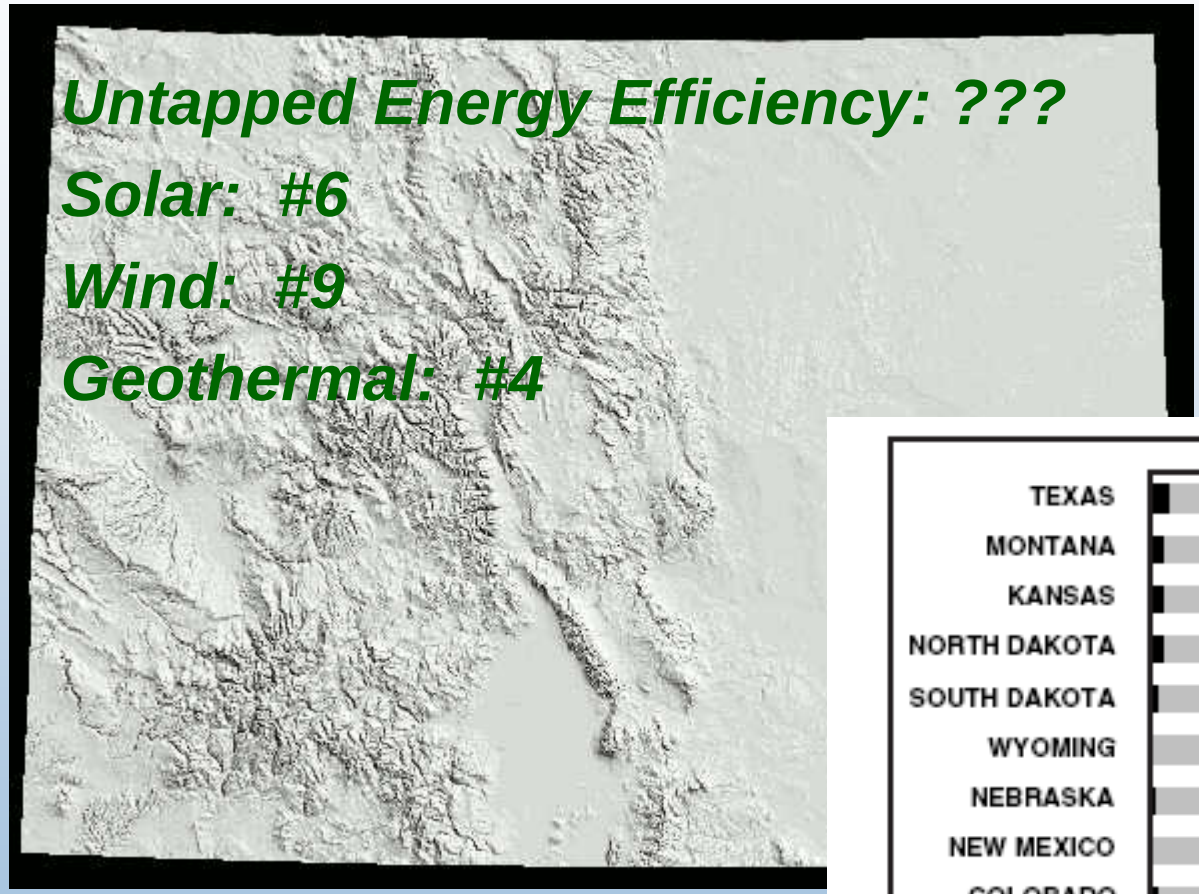
"We cannot know with absolute certainty, so we do nothing... The essential human dilemma is that all our experience is in the past and yet ***all our decisions relate to the future***."

Richard D. Lamm, in Elliott, Ethics for a Finite World

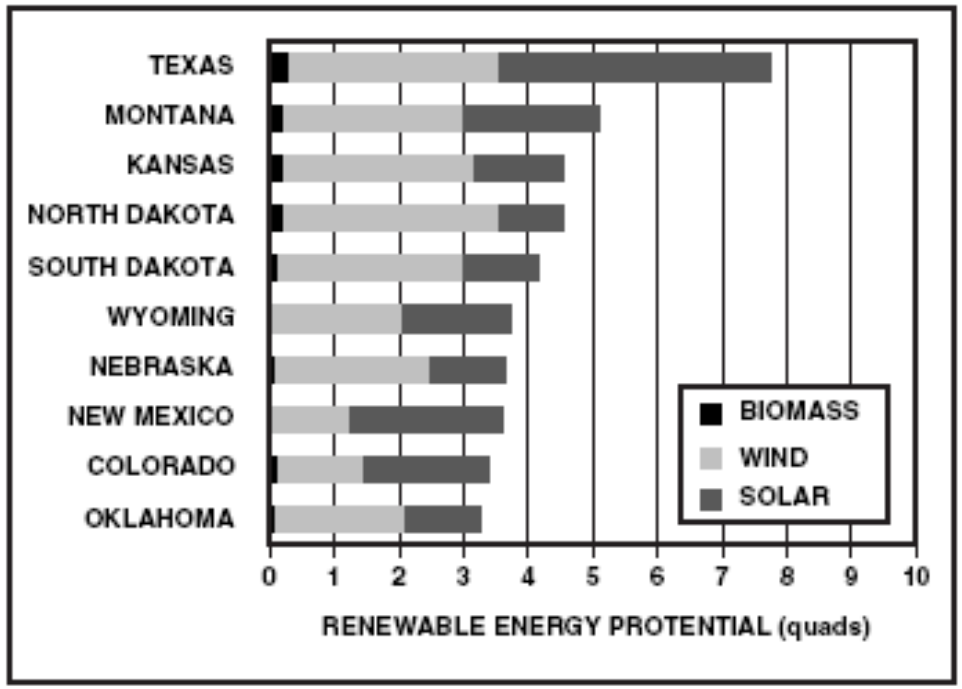
Approach #1:

Tap into cost-effective energy efficiency and renewable energy resources.

Colorado's National Ranking: Renewable Energy Resources

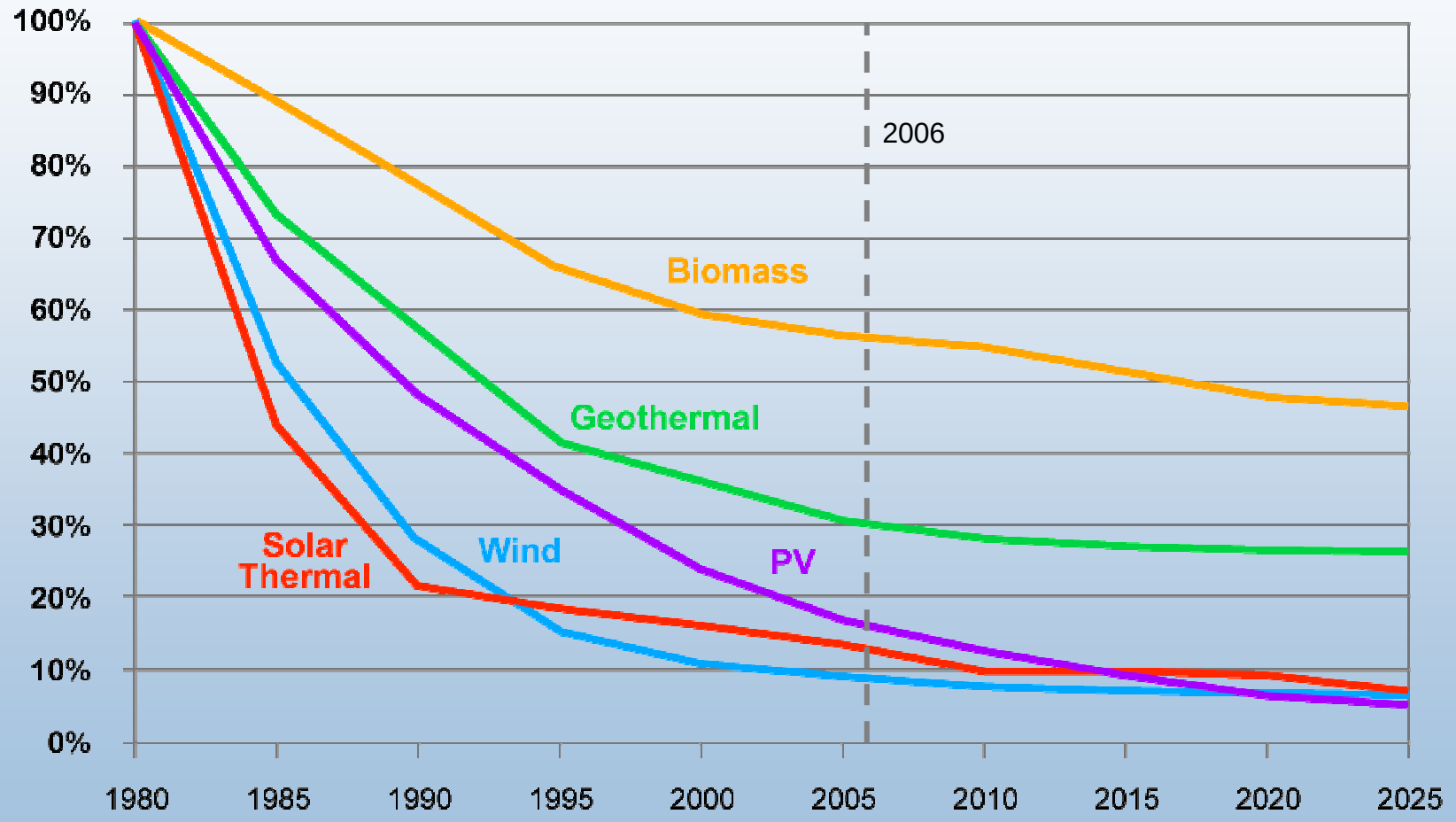


Source: infinitepower.org



Renewable Energy Costs Have Decreased

Historical and Projected



Costs as percentage of 1980 levels

Source: NREL 2005, 2002

What is the value of energy if you don't have any?

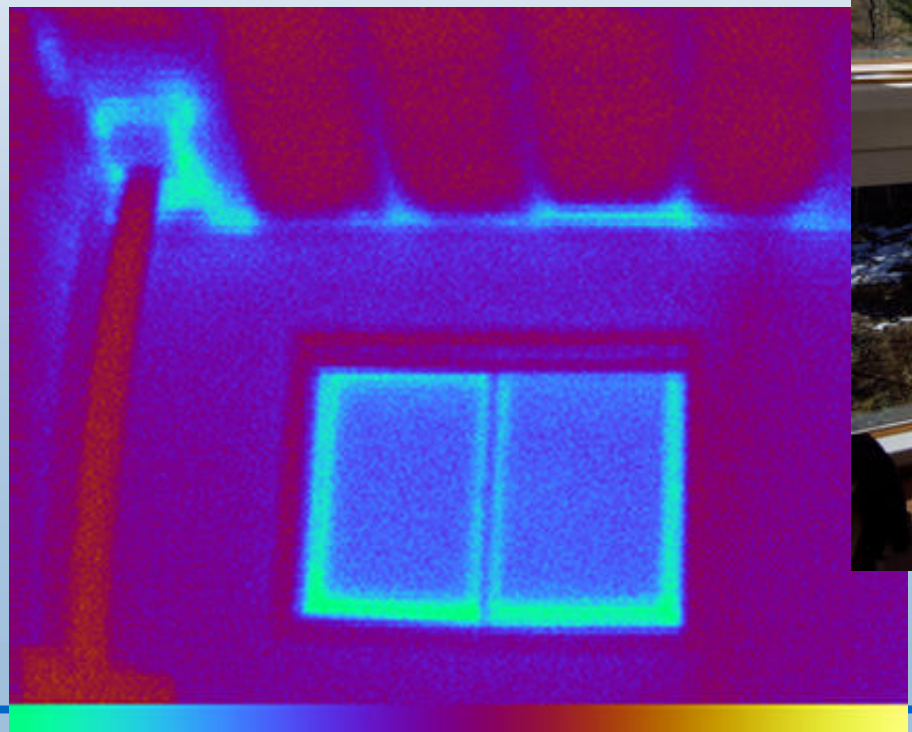
Energy Efficiency

"Every watt not used is a watt that doesn't have to be produced, processed, or stored."

Richard Perez, Homepower Magazine

Energy Efficiency

- Doing more with less
- Technology, not Conservation



Contribution of Efficiency to Energy Mix

Energy is "produced" on the demand side.

- **Properly designed and oriented buildings use *60% less* energy than conventional structures.**
- **Passive solar design can reduce home heating costs by as much as 30%.**
- ***Less than 20%* of energy used by autos actually turns the wheels.**
- **In today's power system, *only 26%* of energy in coal results in usable electricity.**
- **U.S. utilities waste enough energy each year to meet the power needs of Japan.**
- **Only 10% of energy input to conventional light bulbs produces light; *90% is thrown off* as heat – which often must be cooled, requiring more electricity.**

What Makes a Building Energy Efficient?

- **Proper orientation and design of structure**
- **Proper design and installation of HVAC**
- **Proper installation of insulation**
- **Reduced air leakage**
- **Water conservation**
- **Efficient windows**
- **Efficient lighting**
- **Efficient appliances, equipment**

High-Efficiency "T" Light Bulbs: A "Main Vein" of Demand-Side Energy

- **Use 80% less electricity than incandescents**
- **Last longer**
- **Produce higher-quality light**
- **Permit de-lamping**
- **Reduce A/C load**
- **T-8s require ballast change-out**

LED Lights: The "Mother Lode" of Lighting-Produced Demand-Side Energy

- **Use 90% less energy than incandescents.**
- **Investment pays back in weeks.**

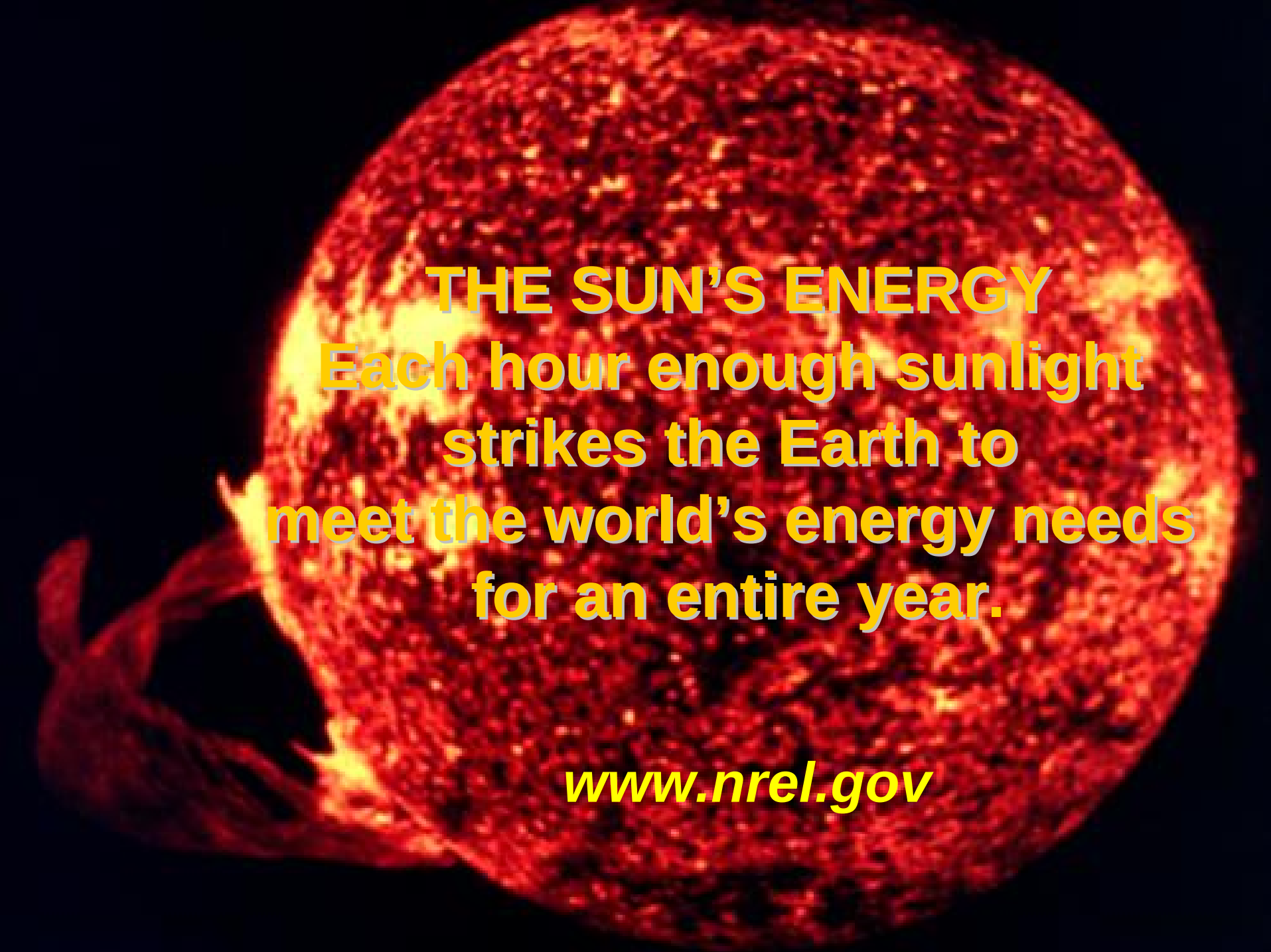
"Conservation Power Plant"

- *Constructed in Austin TX, c. 1987-2001*

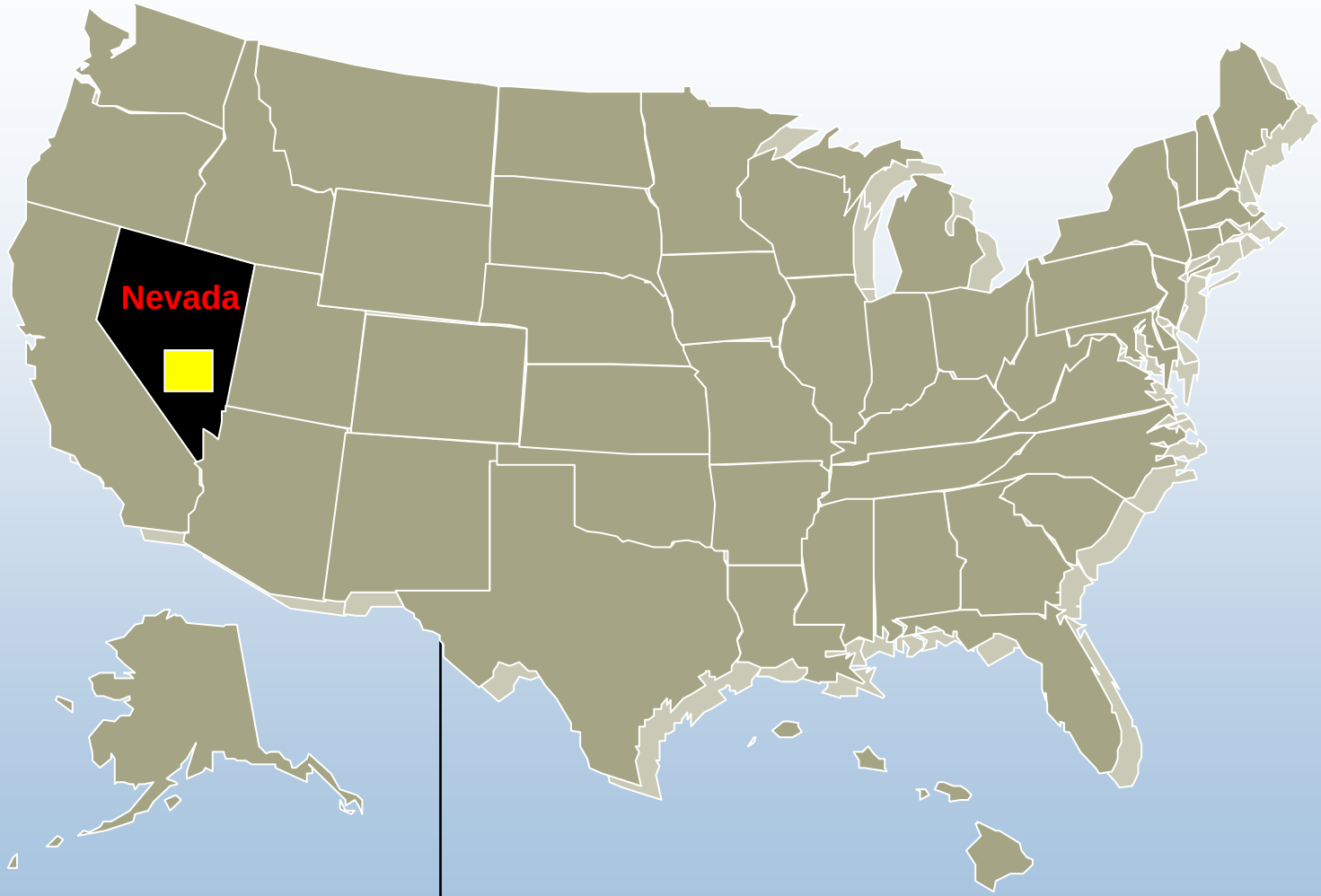
- **Utility substituted programs and policies for bricks and boilers.**
  - **Loan programs for residential efficiency improvements, building code upgrades, rebates for high-efficiency equipment, etc.**
- **Utility achieved 550 megawatts of documented, sustained energy savings.**
- **Utility took planned 450-MW coal-fired plant off its books.**

This occurred during a period when Austin's economy grew by 46 percent and its population doubled!

Renewable Energy


THE SUN'S ENERGY
Each hour enough sunlight strikes the Earth to meet the world's energy needs for an entire year.
www.nrel.gov

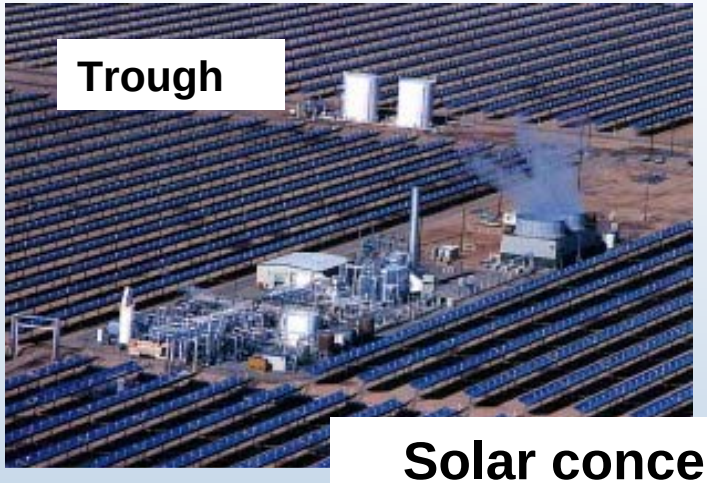
Total Area Required for a Photovoltaic Power Plant to Produce the Total U.S. Annual Electrical Demand



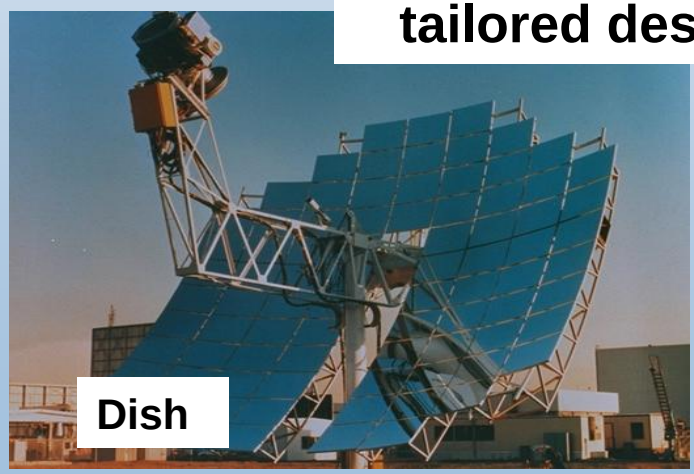
PV/electrolysis area for 200M fuel cell vehicles.

P109-G1055201

Concentrating Solar Power



Solar concentration allows tailored design approaches



Solar Heat

- Solar water heating is commercially available for both domestic and industrial water systems and for swimming pools.

- Solar space heating and preheating are also available.

Photovoltaics

PV roofing shingles

PV panels

Mauna Lani Hotel in Hawaii

4 Times Square, New York City

PV Remote/Stand-Alone Market is Well Established

PV Light

Water Pumping

Water Fountain

Irrigation Control

Remote Home

Lighting in High Density Areas

PV streetlights are sturdy -- able to withstand hurricane winds and provide needed lighting when the electricity grid is down.

After Hurricane Andrew, Picture facing N.W.

Dade County
Florida USA

Shea Homes: San Diego

"Net Zero Energy" Buildings

At the very least, generate as much energy as they consume on an annual basis. ZEBs can be totally self-sustaining (grid-independent), or even net exporters of energy.

Net Zero Energy Habitat for Humanity Home

- ***Superinsulated walls, floors and ceilings***
- ***Efficient appliances***
- ***Solar water heating system***
- ***Compact fluorescent lighting***
- ***Windows coated with thin layers of metallic oxide to help keep heat in during the winter and out during the summer.***
- ***4-kilowatt photovoltaic system***

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 performance and reliability
- Distributed wind technology
- Advanced rotor development
- Utility grid integration

* With no Production Tax Credit
Updated January 23, 2007
Source: U.S. Department of Energy, American Wind Energy Association

Sizes and Applications

Small (≤10 kW)

- Homes
- Farms
- Remote Application

Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Distributed Power

Large (660 kW - 2+MW)

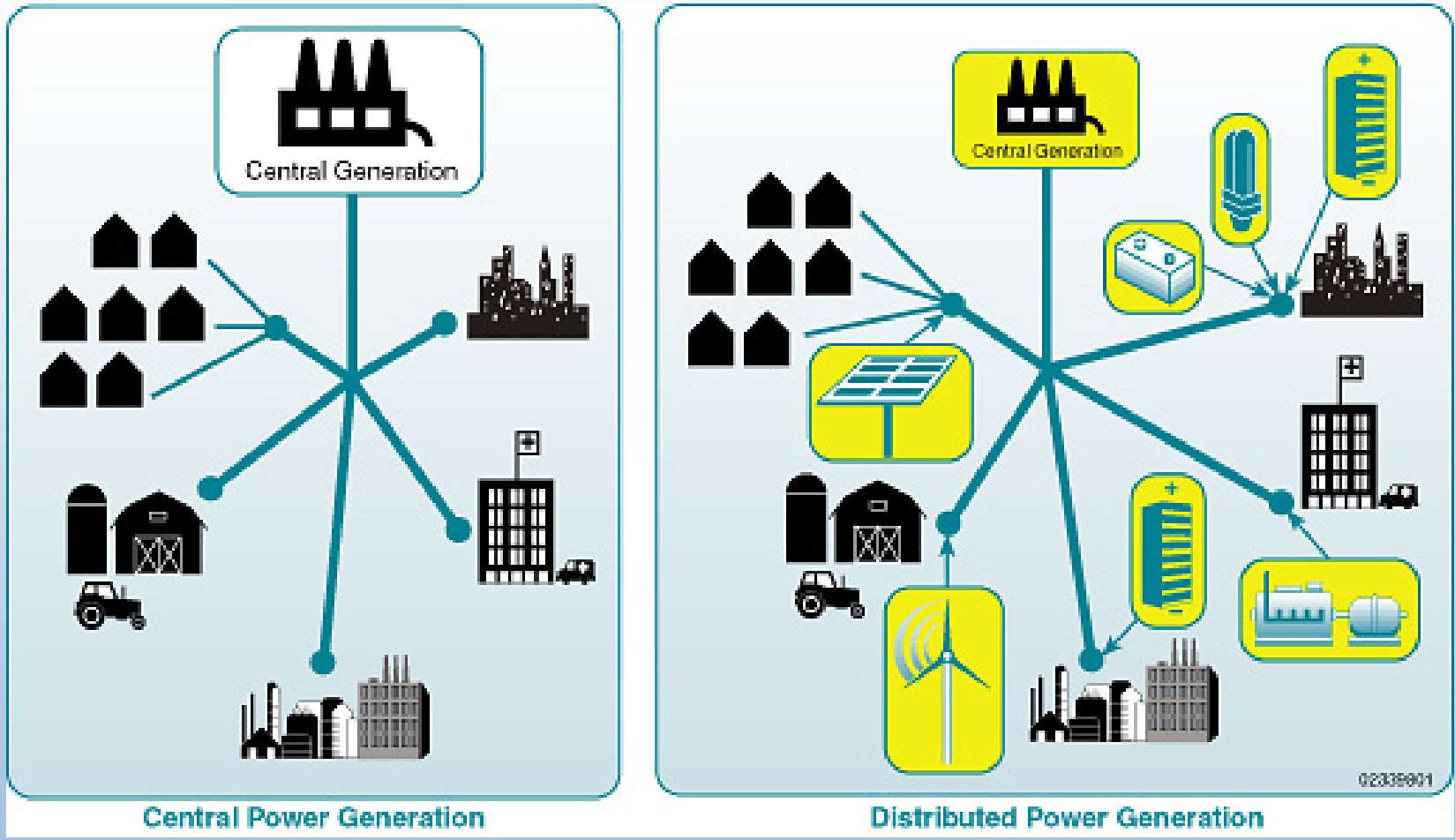
- Central Station Wind Farms
- Distributed Power
- Community Wind


Boeing 747-200

Approach #2:

Supplement today's central station power plants with distributed generation from energy efficiency and renewable energy resources.

Distributed Energy



Distributed generation: Small power source located near the user

Skystream Residential Installation

PV can recharge electric- or hybrid-vehicle batteries, while providing shade and shelter.

How Do You "Build" a Virtual Clean Energy "Power Plant?"

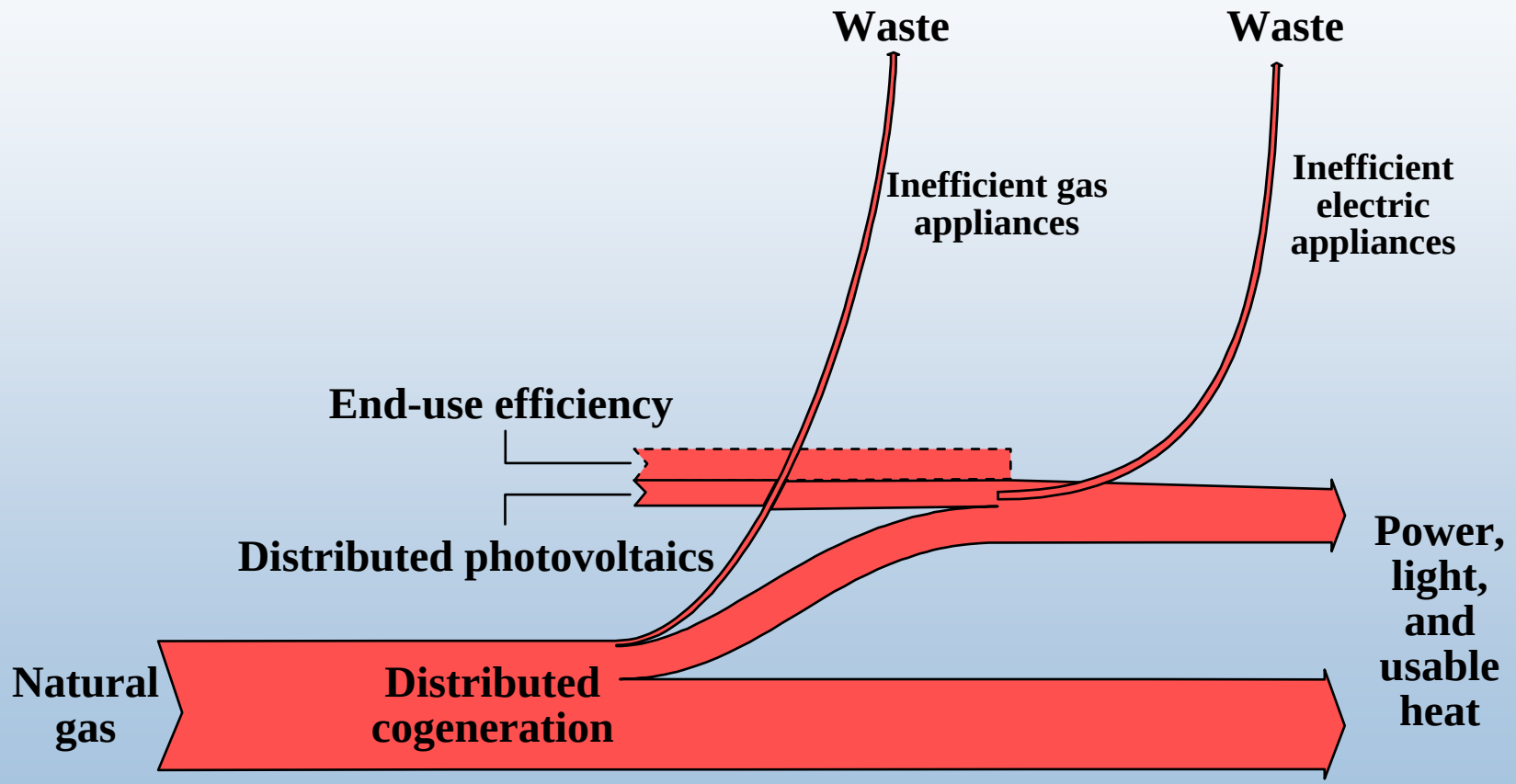
- **Energy Efficiency**
- **Customer-sited renewable energy (solar, small wind)**
- **Utility-scale renewable energy (wind, solar, biomass)**

Intermittent Renewables

- Renewable/Electrolysis
  - Co-producing electricity and hydrogen can address issues that currently face intermittent and season renewable technologies
  - Wind/electrolysis is likely to be the first economical renewable system

Where We Could Be

Consumption with Clean Distributed Resources



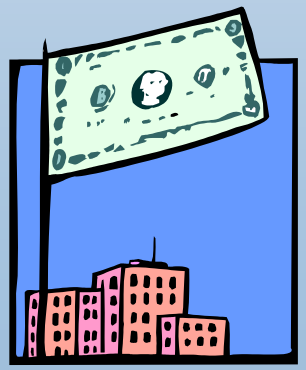
Source: A Micro-Grid with PV, Fuel Cells, and Energy Efficiency, Tom Hoff, Clean Power Research.com

Approach #3:

Develop energy efficiency and renewable energy resources as an *economic development* approach.

Osage, Iowa, Uses Energy Efficiency as Economic Development Strategy

- **Every $1 spent in Osage generates $1.90 of economic activity**
- **Petroleum products → $1.51**
- **Utility services →$1.66**
- ***Energy efficiency →$2.23***
- **By doing energy efficiency, town was able to attract desirable industries due to reduced energy operating costs**



Source: “The Jobs Connection”, US DOE

Correlation Between Windy Rural Areas and Depopulation

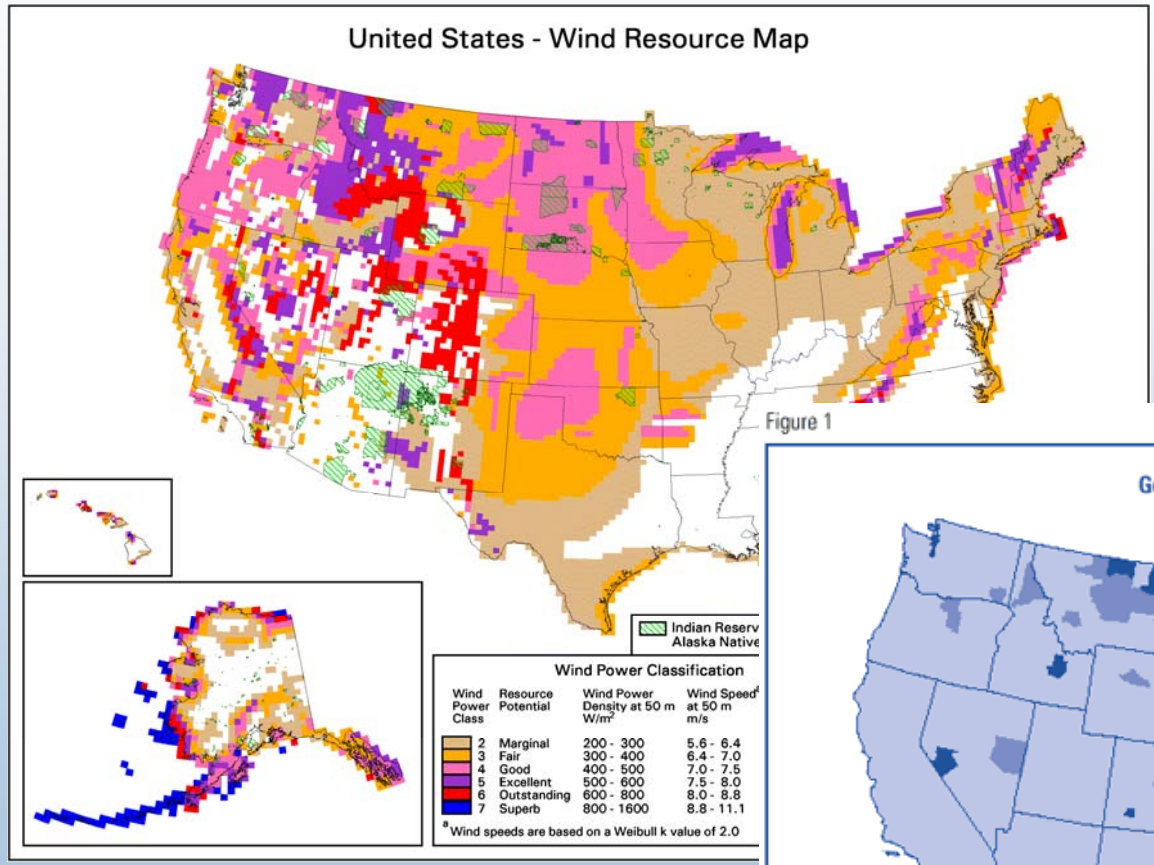
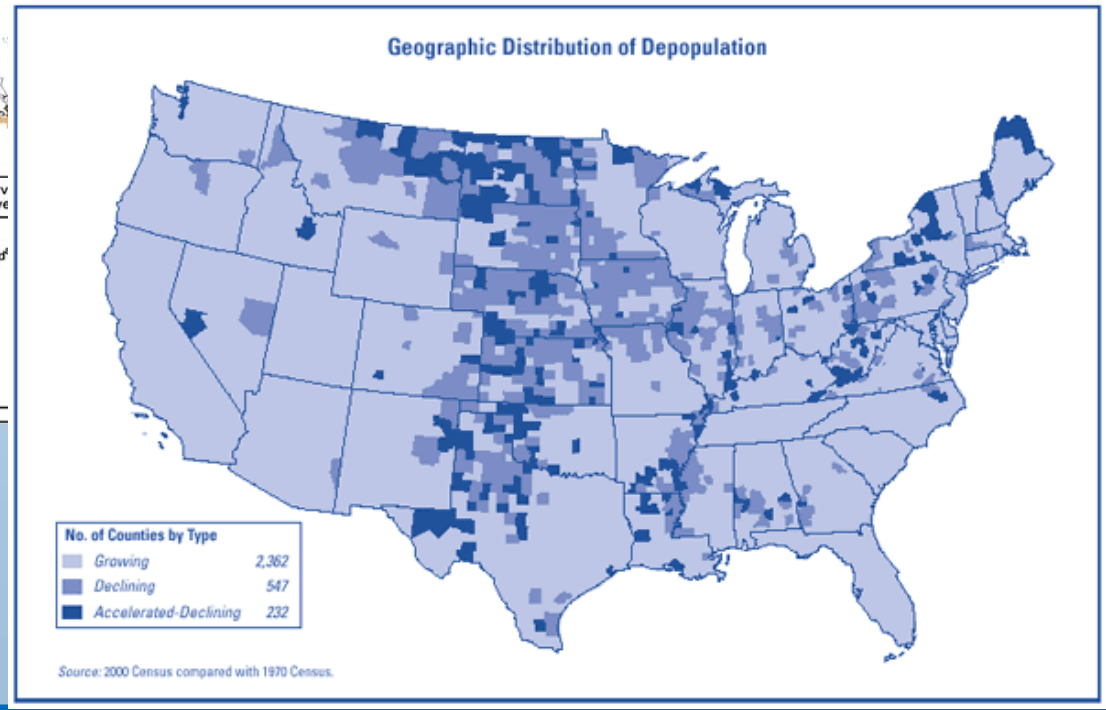


Figure 1



Case Study: Prowers County, Colorado

- 162-MW Colorado Green Wind Farm (108 turbines)
- $200M+ investment
- 400 construction workers
- 14-20 full-time jobs
- Land lease payments $3000-$6000 per turbine
- **Prowers County 2002 assessed value $94M; 2004 assessed value +33% (+$32M)**
- **Local district will receive 12 mil tax reduction**
- Piggyback model

"Converting the wind into a much-needed commodity while providing good jobs, the Colorado Green Wind Farm is a boost to our local economy and tax base."

John Stulp, county commissioner, Prowers County, Colorado

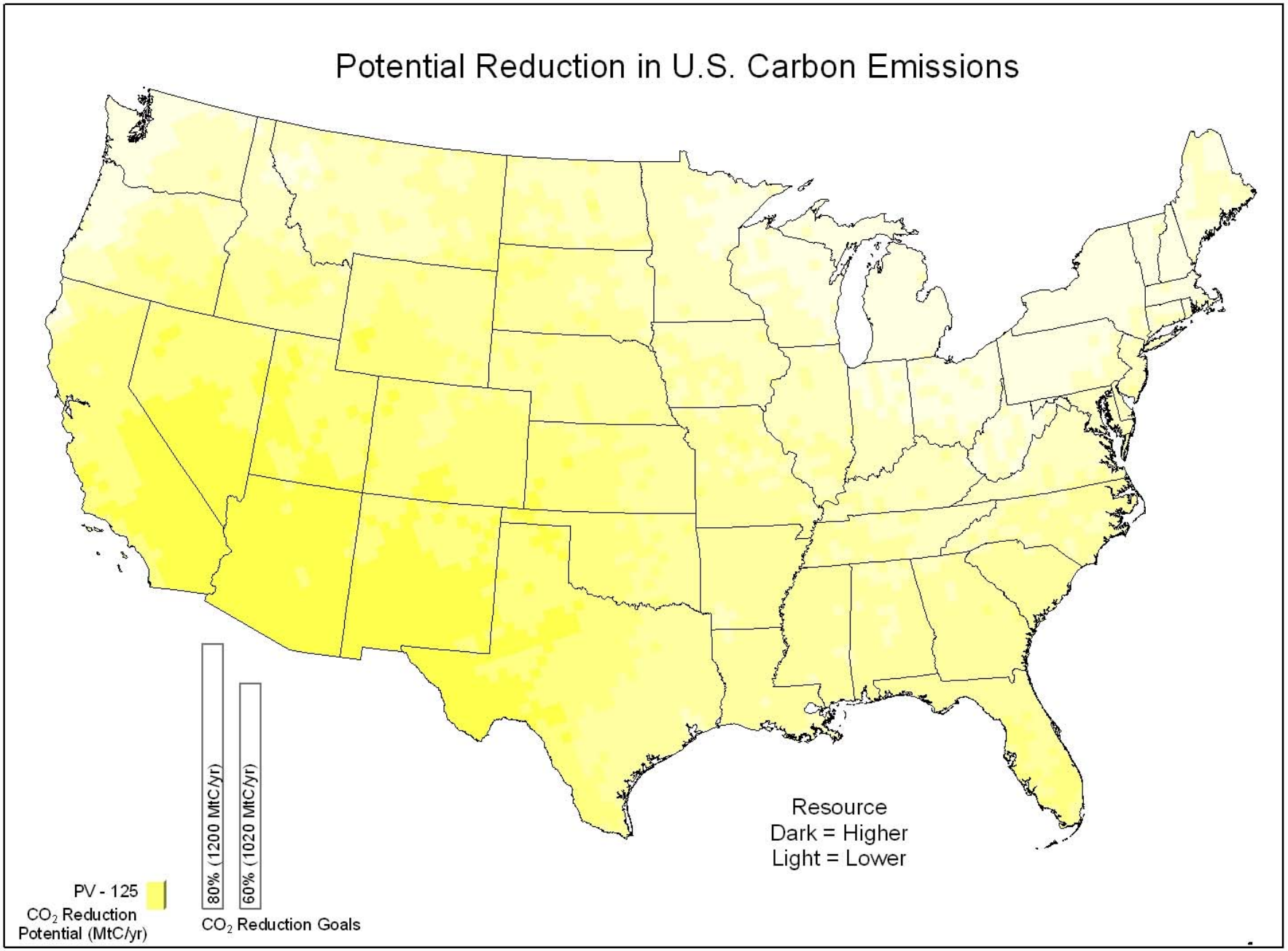
“Shell bought me a root canal.”

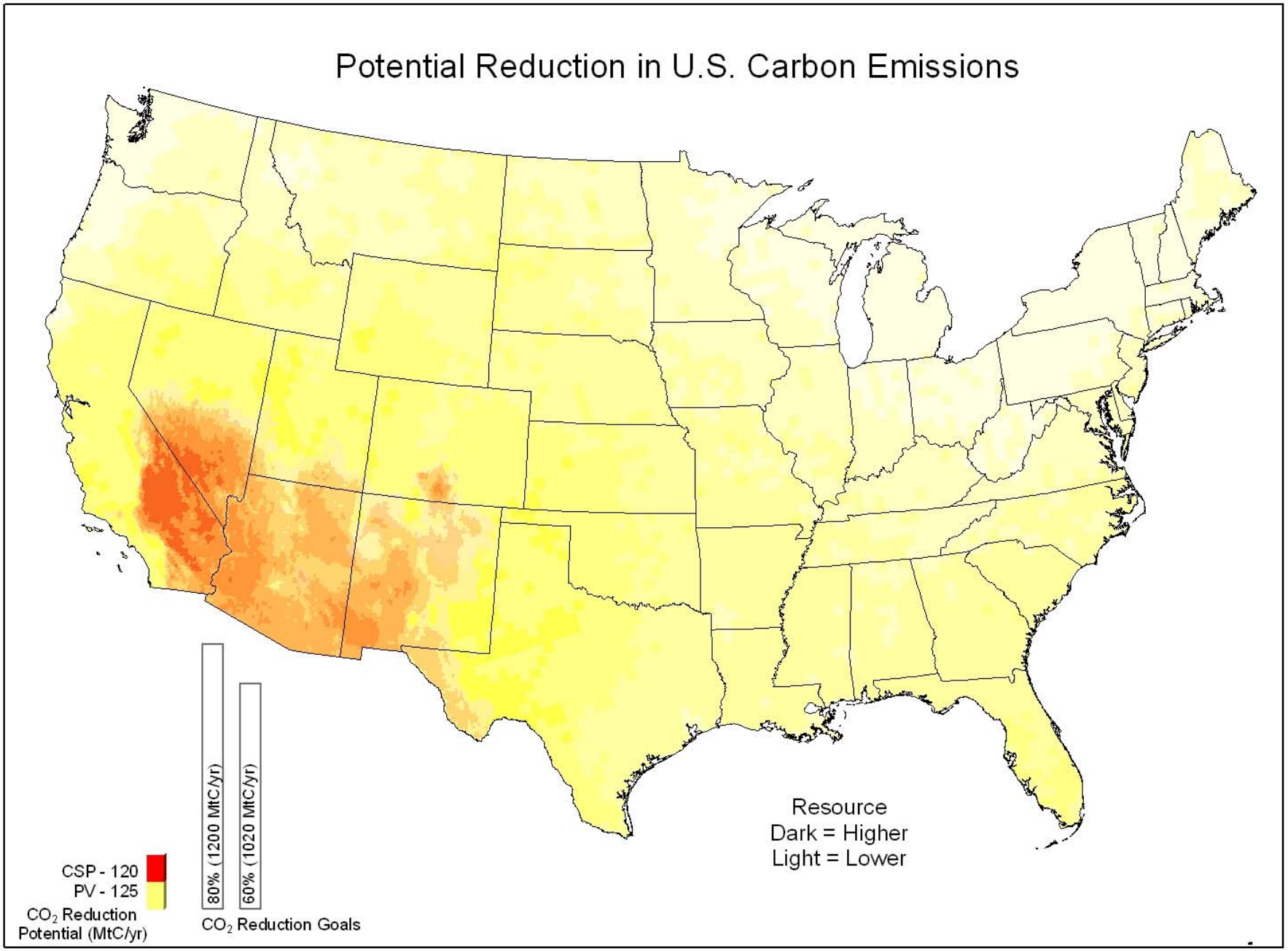
Eddie Rhoderick, rancher

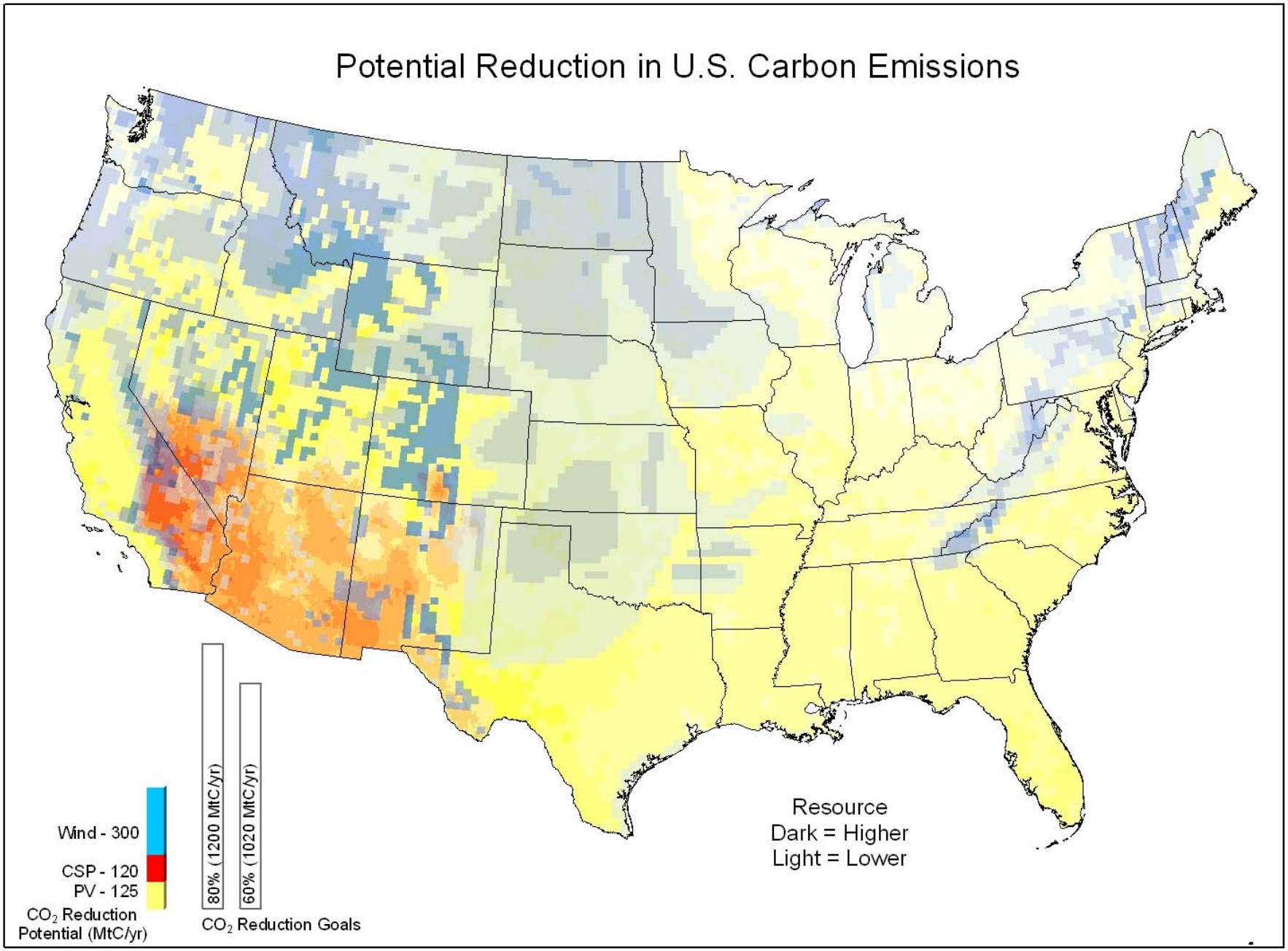
Briscoe County TX

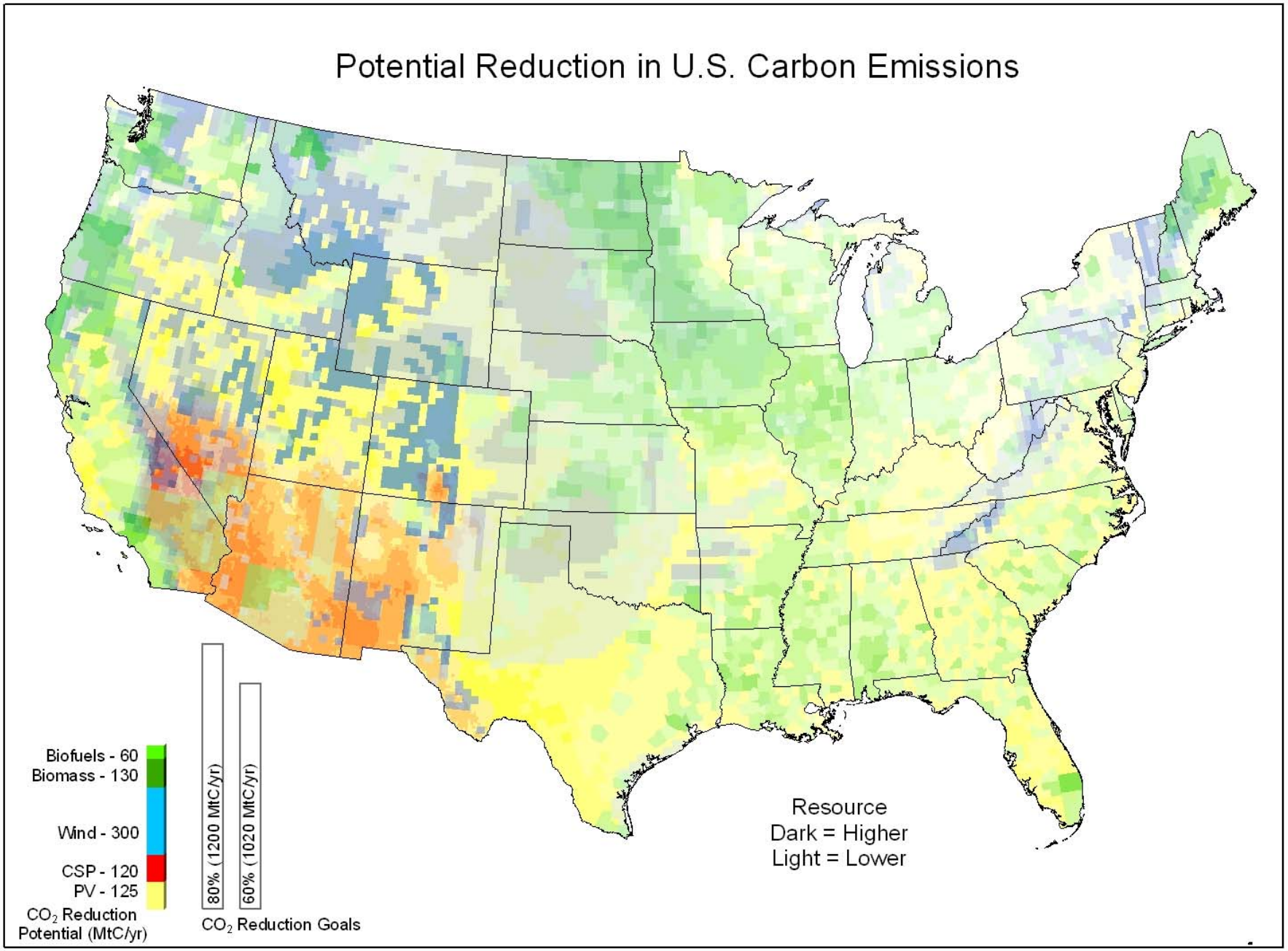
Approach #4:

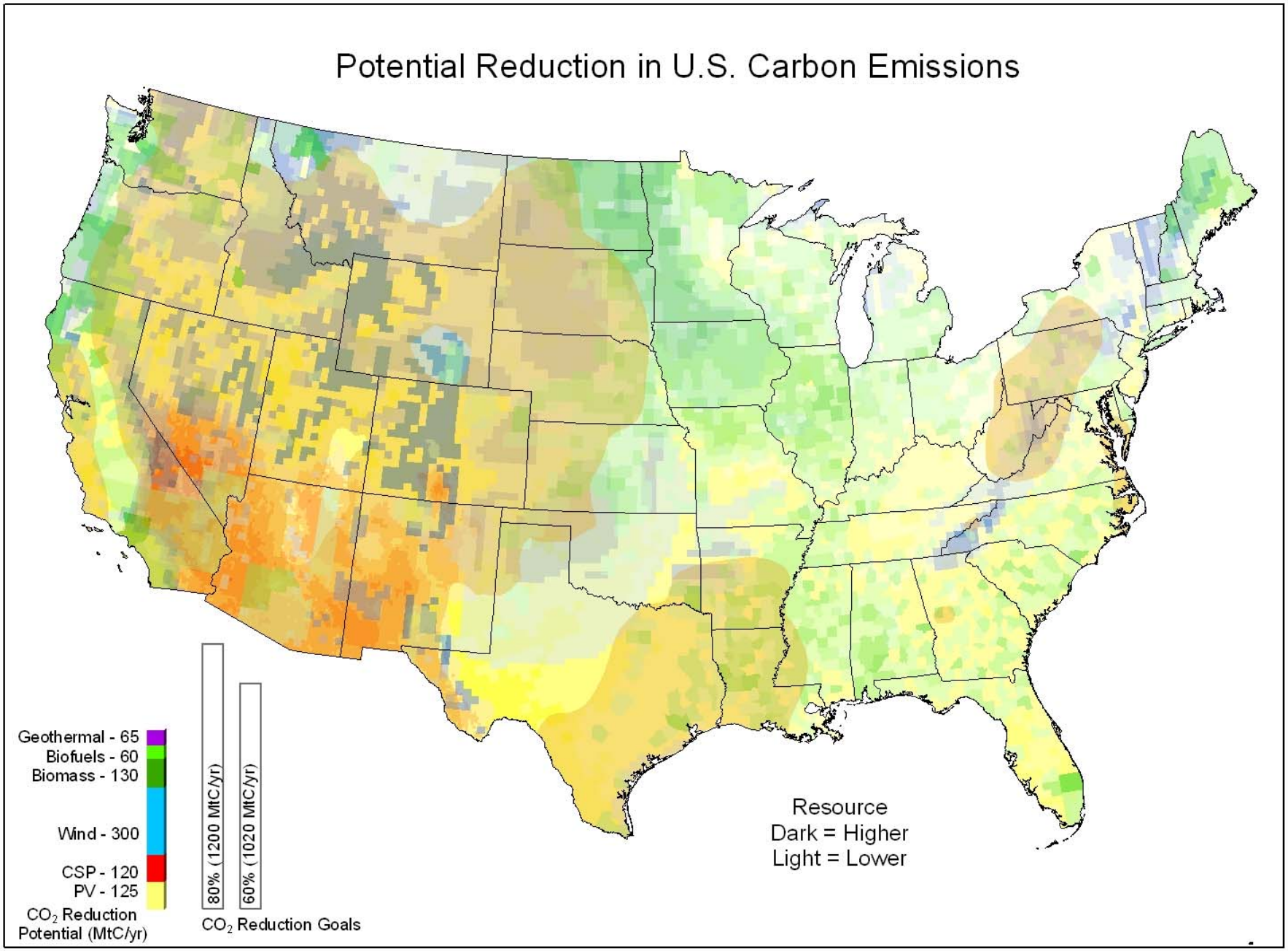
Manage environmental and climate risks with energy efficiency and renewable energy technologies.


Potential Reduction in U.S. Carbon Emissions
Resource
Dark = Higher
Light = Lower
80% (1200 MtC/yr)
60% (1020 MtC/yr)
CO2 Reduction Goals
PV - 125
CO2 Reduction
Potential (MtC/yr)

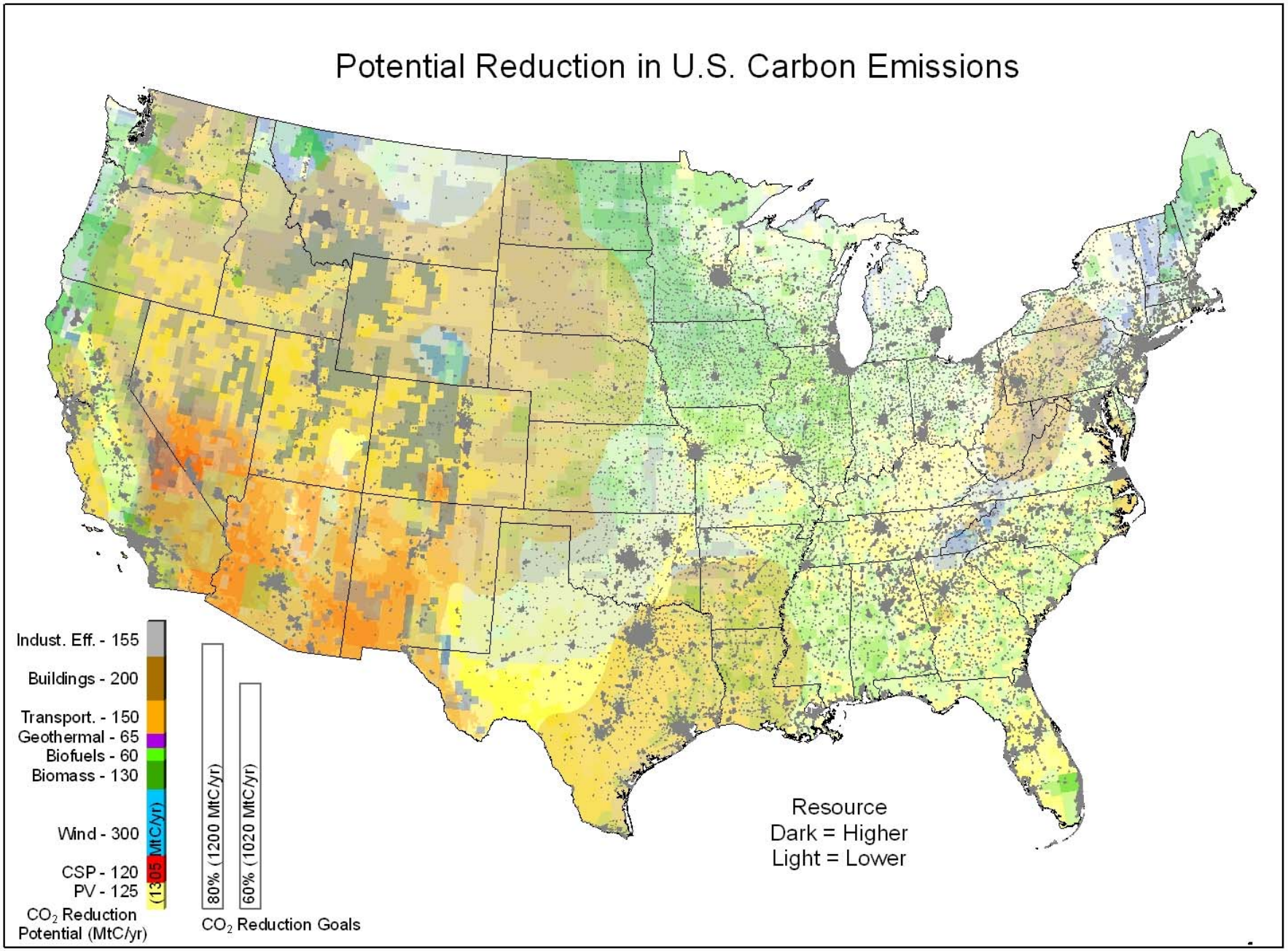

Potential Reduction in U.S. Carbon Emissions
Resource
Dark = Higher
Light = Lower
CSP - 120
PV - 125
CO_2 Reduction Potential (MtC/yr)
80% (1200 MtC/yr)
60% (1020 MtC/yr)
CO_2 Reduction Goals

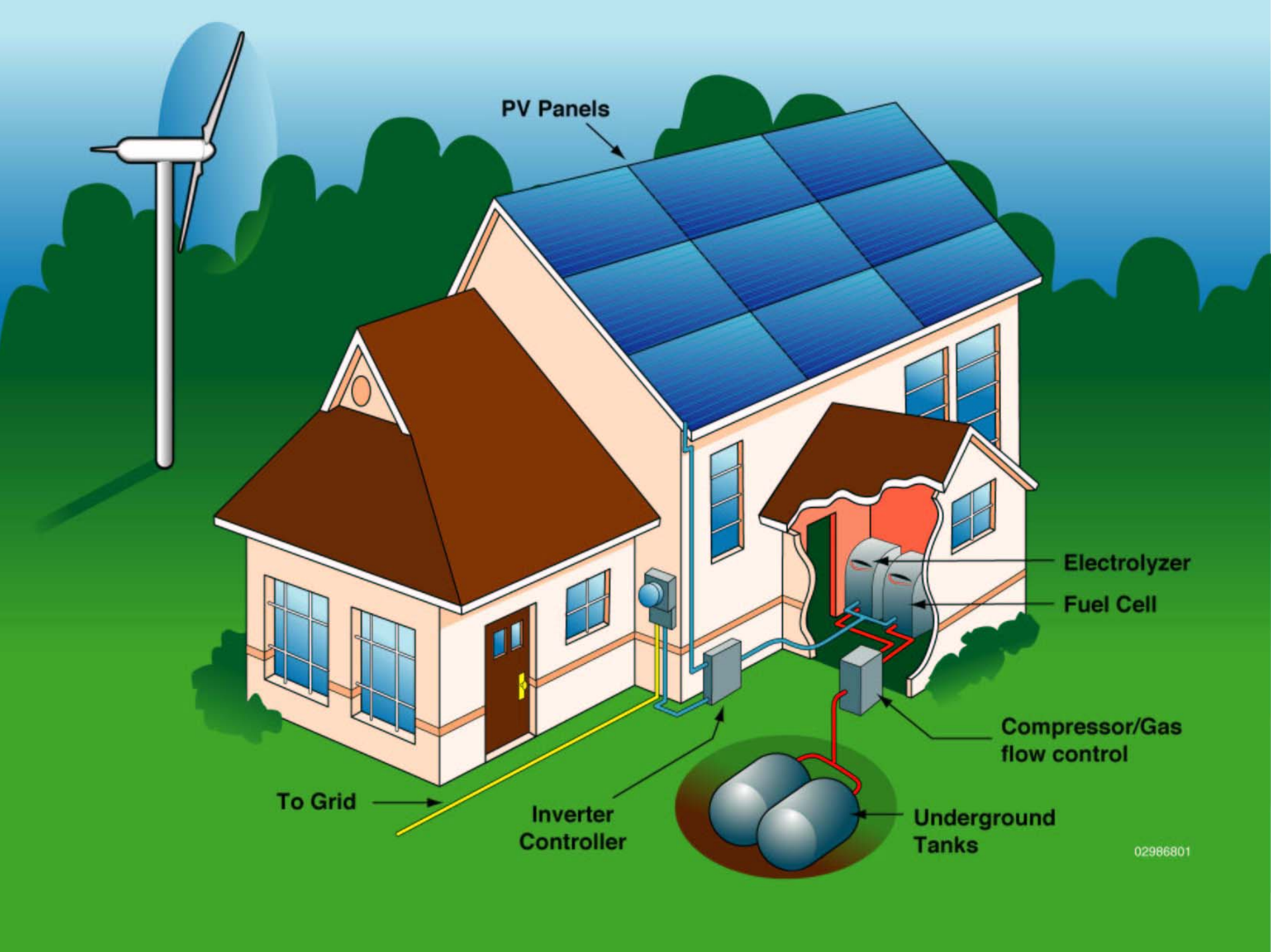

Potential Reduction in U.S. Carbon Emissions
Wind - 300
CSP - 120
PV - 125
CO_2 Reduction Potential (MtC/yr)
80% (1200 MtC/yr)
60% (1020 MtC/yr)
CO_2 Reduction Goals
Resource
Dark = Higher
Light = Lower


Potential Reduction in U.S. Carbon Emissions
Biofuels - 60
Biomass - 130
Wind - 300
CSP - 120
PV - 125
CO_2 Reduction Potential (MtC/yr)
80% (1200 MtC/yr)
60% (1020 MtC/yr)
CO_2 Reduction Goals
Resource
Dark = Higher
Light = Lower


Potential Reduction in U.S. Carbon Emissions
Geothermal - 65
Biofuels - 60
Biomass - 130
Wind - 300
CSP - 120
PV - 125
CO_2 Reduction Potential (MtC/yr)
80% (1200 MtC/yr)
60% (1020 MtC/yr)
CO_2 Reduction Goals
Resource
Dark = Higher
Light = Lower

Potential Reduction in U.S. Carbon Emissions




PV Panels
Electrolyzer
Fuel Cell
Compressor/Gas flow control
To Grid
Inverter Controller
Underground Tanks
02986801

U.S. Department of Energy's
National Renewable Energy Laboratory
www.nrel.gov