ENERGY RESOURCES:

CONSUMPTION, SUPPLIES AND IMPORTANT ISSUES

LARRY BELL

It has taken only about 150 years for fossil fuel energy to become the most heavily-traded world commodity.

Most oil and natural gas reserves are likely to be gone within this century.

Oil production may already be peaking, and supply shortages along with increasing costs will require alternatives.

Monash University Australia
Looking Glass Productions Ltd

Freeway Traffic

Tony Boom
Chapel Electrics

Electrical Power

Industry

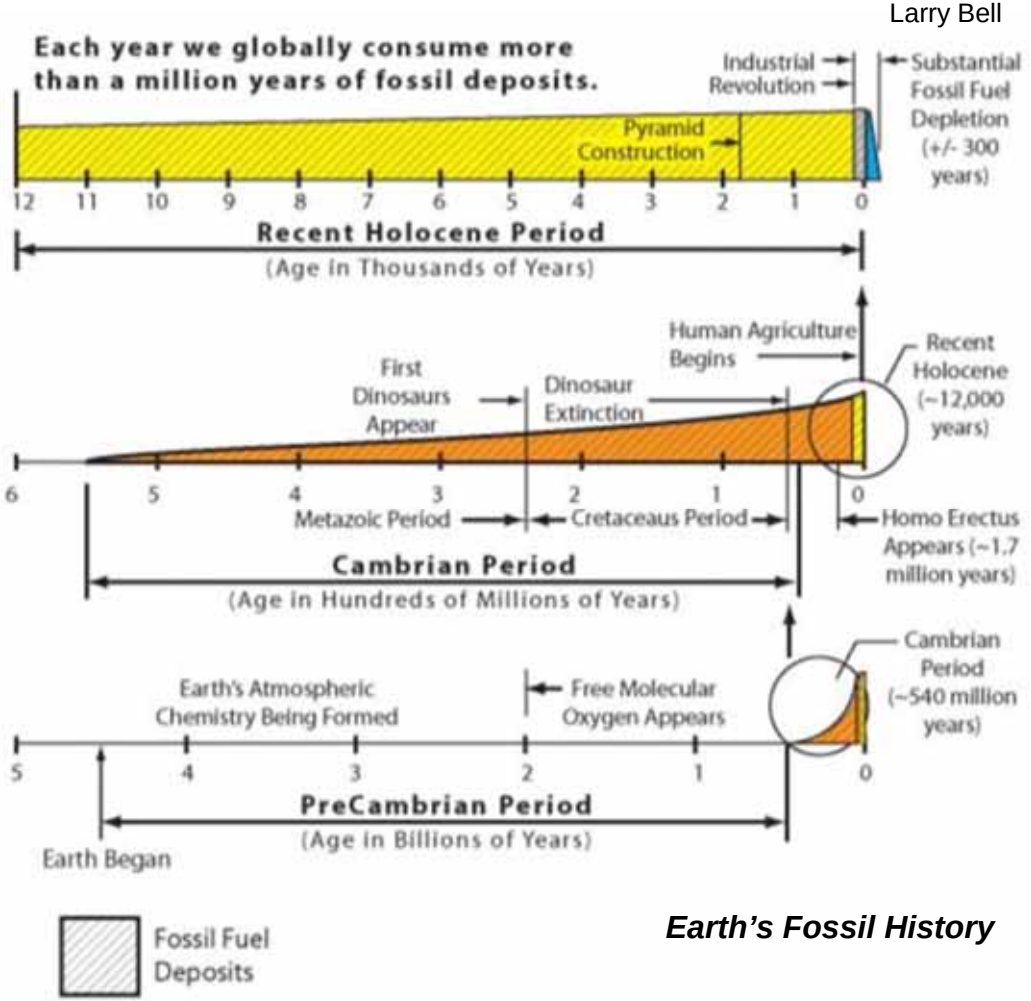
Heating

Fossil energy created over hundreds of millions of years is being depleted in hundreds.

These deposits first began during the Cambrian Period (starting about 150 million years ago).

Our human ancestors, Homo Erectus, appeared about 1.7 million years ago, and human agriculture beginning about 12,000 years ago lead to rapid population growth.

The Industrial Revolution, commencing about 200 years ago, caused the rate of fossil consumption to greatly increase.



Earth's Fossil History

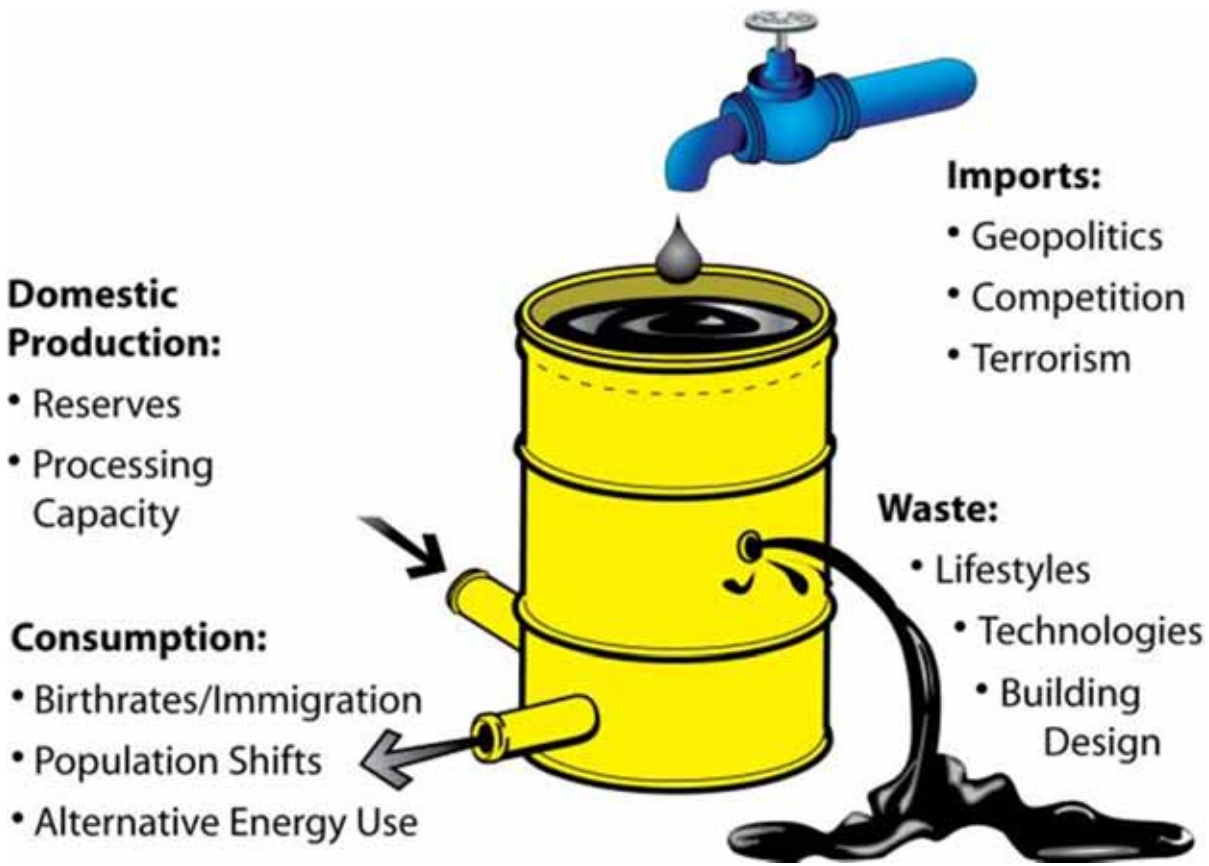
Larry Bell

Human influences upon our planet are producing dramatic impacts.

Influences upon weather and climate, while unclear, are of widespread concern.

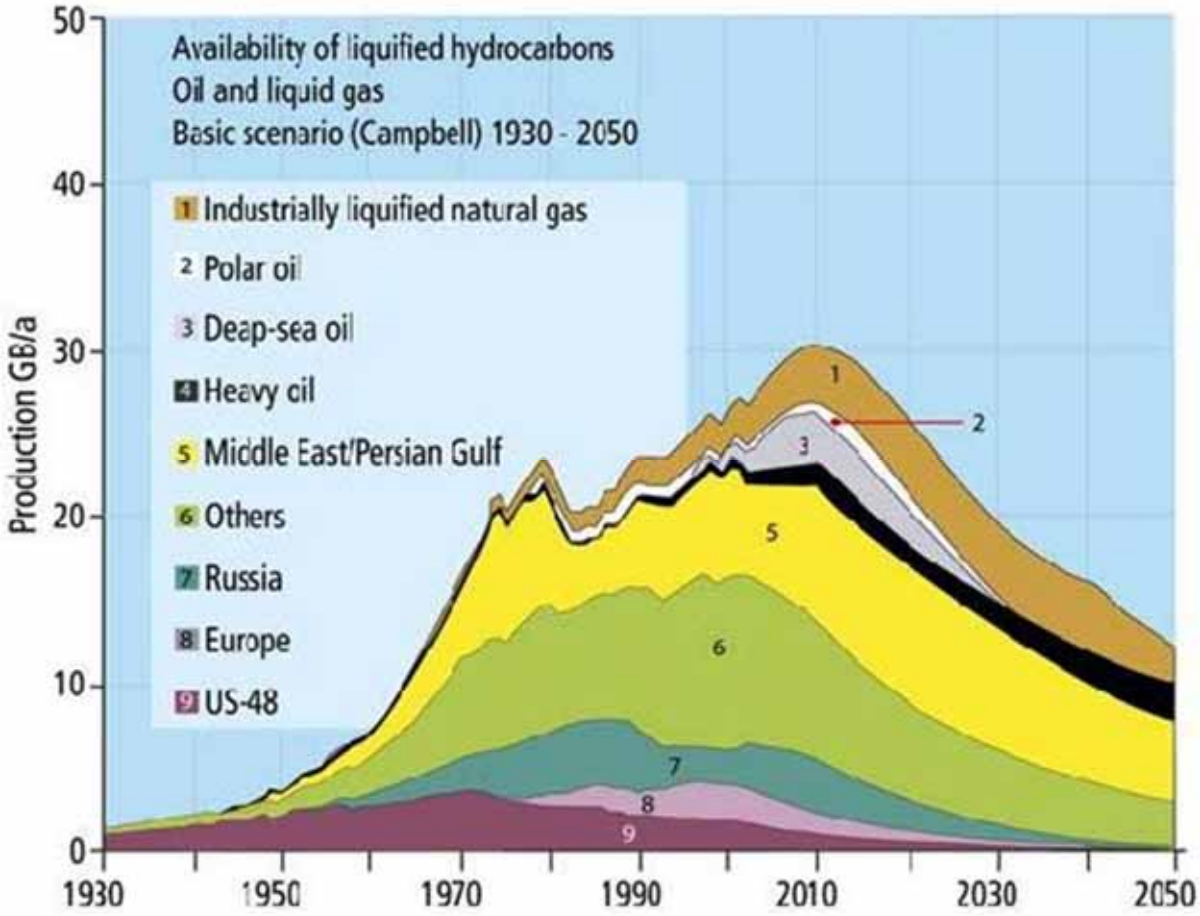
Air and water pollution from fossil burning and other activities affects all life.

It is clear that we must change our ways or experience unacceptable consequences.



Influences and Impacts

The Association for the Study of the Peak Oil and Gas (ASPO), a group of oil geologists, has forecast that oil production will increase roughly until 2010, and then production from new fuels will no longer be able to offset declines from old ones.



ASPO Oil and Liquid Gas Forecast

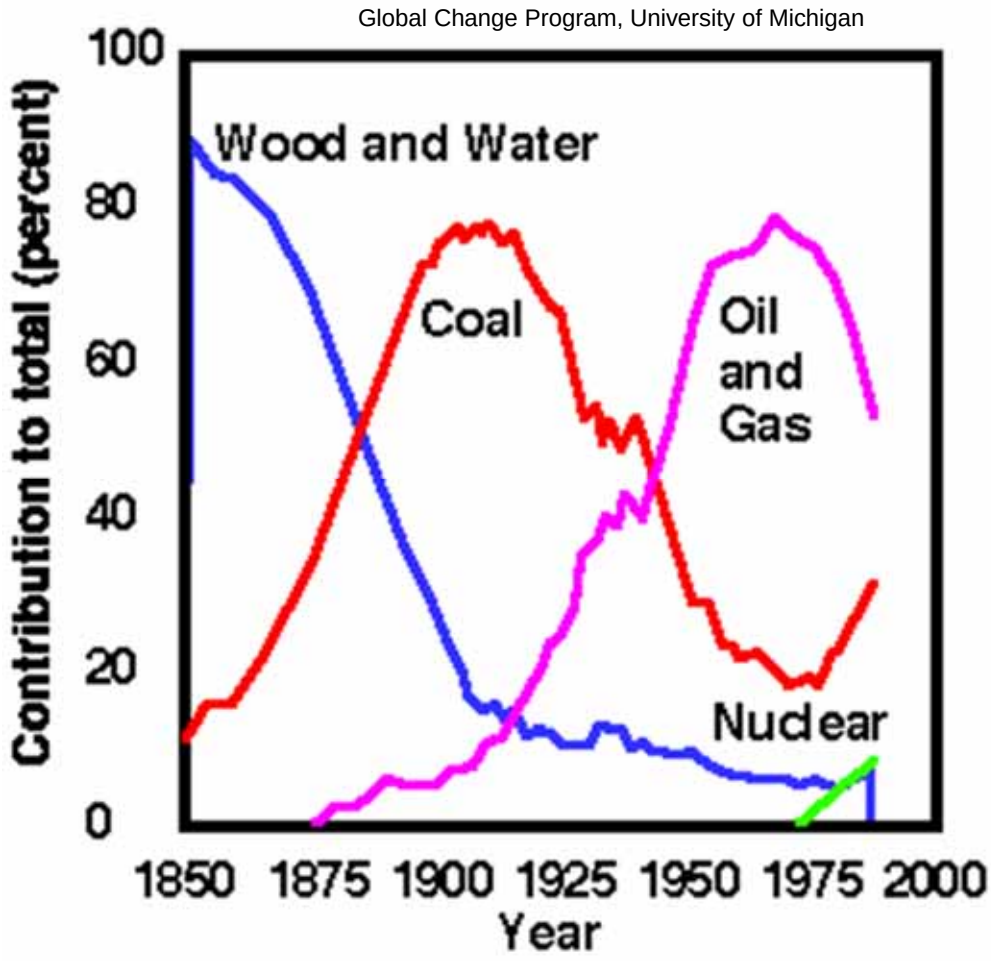
Running on Empty

ENERGY RESOURCES **FOSSIL DEPLETION**

Transitions to alternative fuel and power sources require substantial amounts of time.

It took about 50 years to shift from wood to coal after the mid-1800s as primary US energy, and about the same time to shift from coal to oil and gas after about 1910.

Global Change Program, University of Michigan



Historical US Fuel Use by Percentage

ENERGY RESOURCES **FOSSIL DEPLETION**

The fuel crisis of the 1970s demonstrated that supply disruptions can be costly and painful.

International influences such as import controls and terrorist threats impose supply vulnerabilities.

Brad DeLong

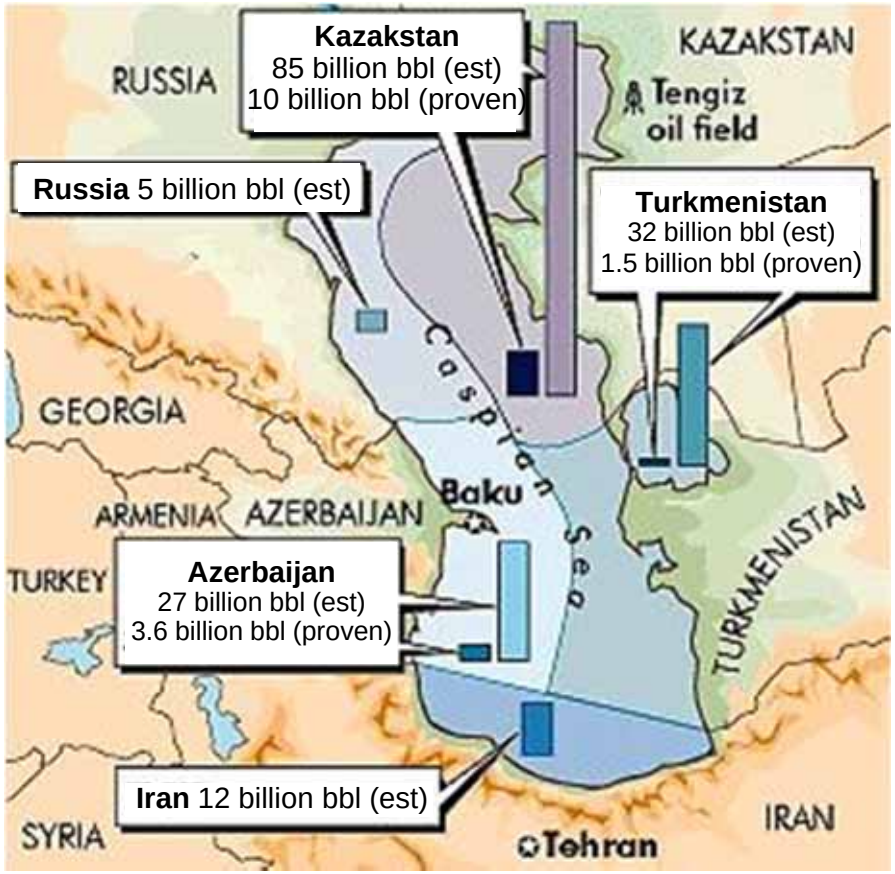
1970s Fuel Crisis

The US currently contains less than 3% of known global oil reserves.

OPEC now produces about 40% of the world's supply (more than half of this from the Persian Gulf).

The Caspian Sea region in Central Asia is another major source, but here many countries have long histories of political instability.

Terrorism presents a growing threat to oil and gas pipeline security.



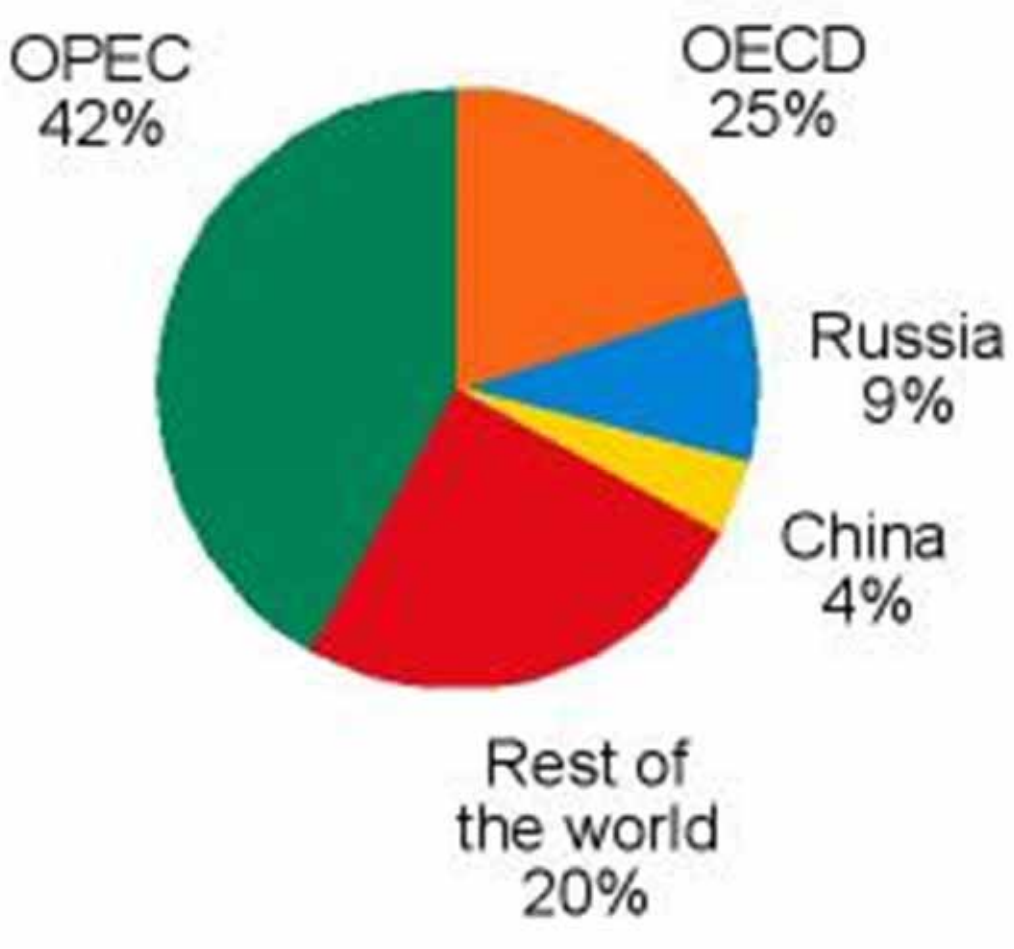
Estimated Caspian Sea Region Oil Reserves

US DOE - EIA

OPEC influence over oil production and prices is motivating many nations to seek ways to lessen dependence upon petroleum.

Exponential consumption growth in China, India, and other countries is a compounding incentive.

Organization of Economic Development (OECD) countries which include the US, European Union, Japan, and South Korea produce only about one-quarter of the global supply keenly share these concerns.



World Crude Oil Production

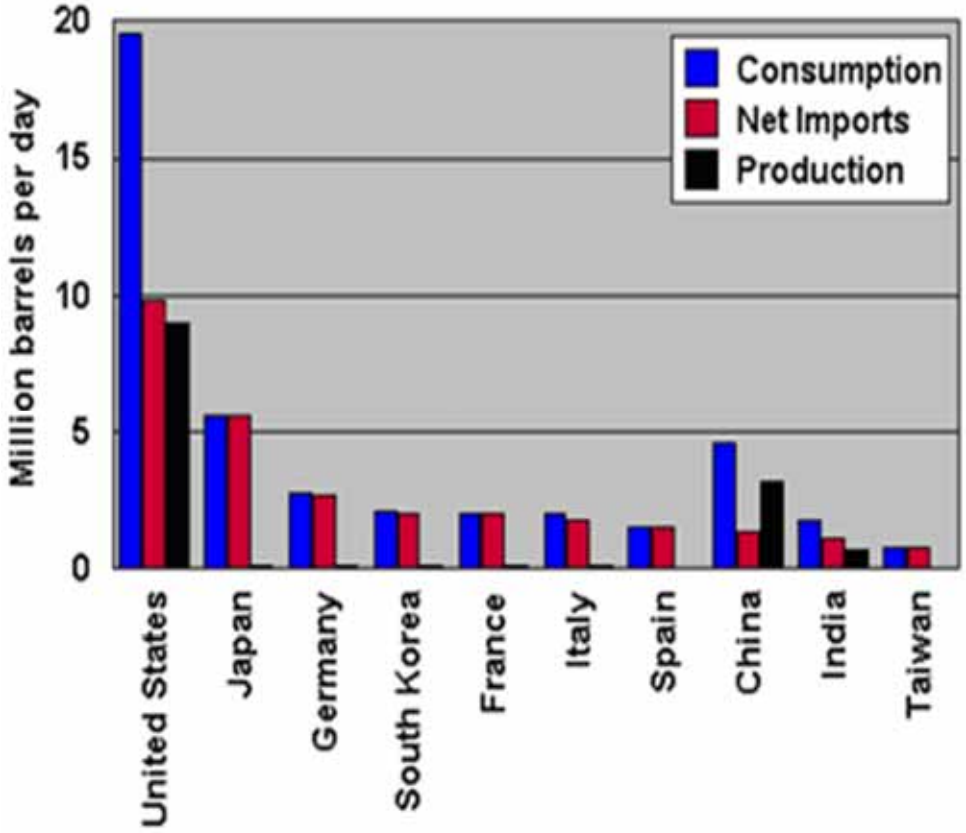
Global competition for oil will become more aggressive as developing nations increase consumption.

Worldwide demand is expected to grow by 60% over the next two decades.

Demand in developing countries may grow by 115% in part due to more automobiles.

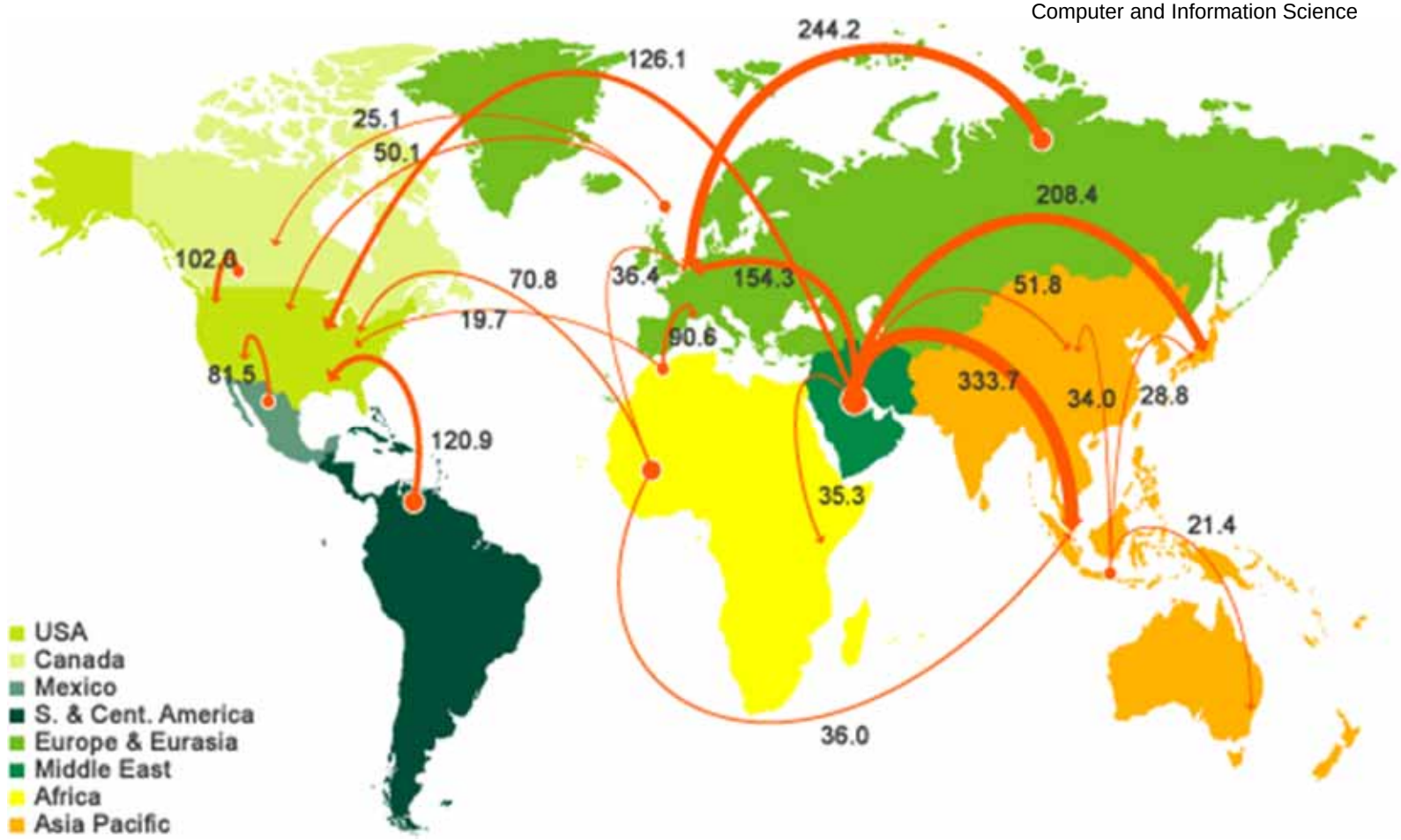
The US now imports about half of its oil, and this may increase about 50% within the next 20 years.

US DOE – EREE



Top Ten Petroleum Importing Countries in 2000.

Northeastern University College of
Computer and Information Science



Oil Trade Flows (Millions of Tons)

ENERGY RESOURCES **US OIL IMPORT DEPENDENCE**

Natural gas currently provides about one-fourth of US energy, and about 20% worldwide.

LNG imports are constrained by deep water harbor options sheltered from wind and waves.

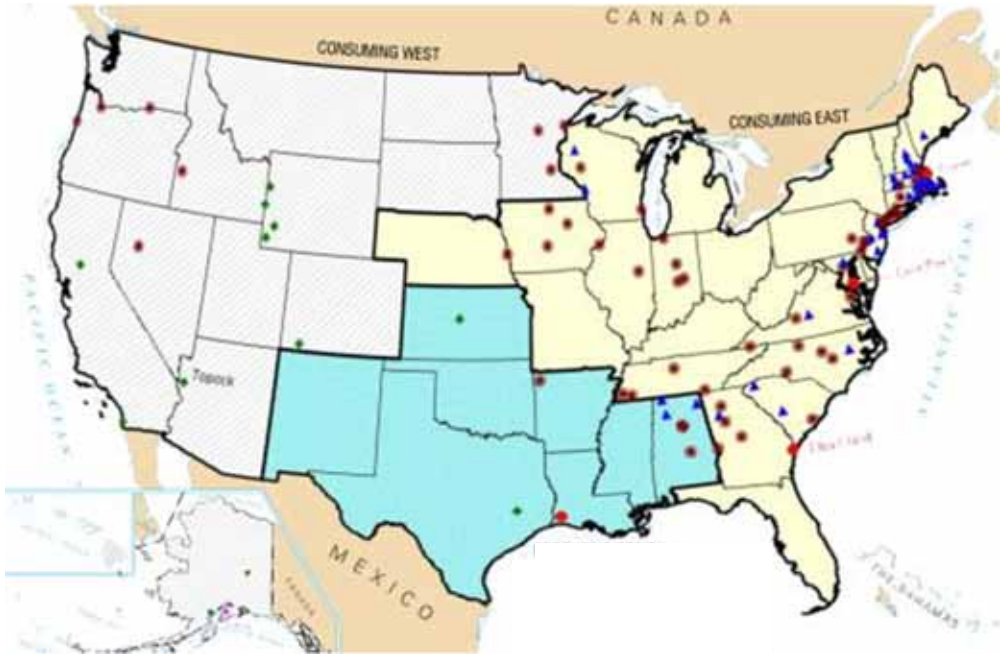
New/expanded LNG terminals are also inhibited by seaport congestion, pipeline right-of-way, conflicts, and limited land near ports and end-users.

The End of an Era

US DOE-EERE

About 99% of US natural gas now comes from domestic and Canadian sources, but LNG imports may provide about 25% by 2021.

Most offshore LNG imports come from Trinidad and Tobago, with lesser amounts from Nigeria, Oman, Indonesia, and the United Arab Emirates.



Active Liquid Natural Gas Facilities

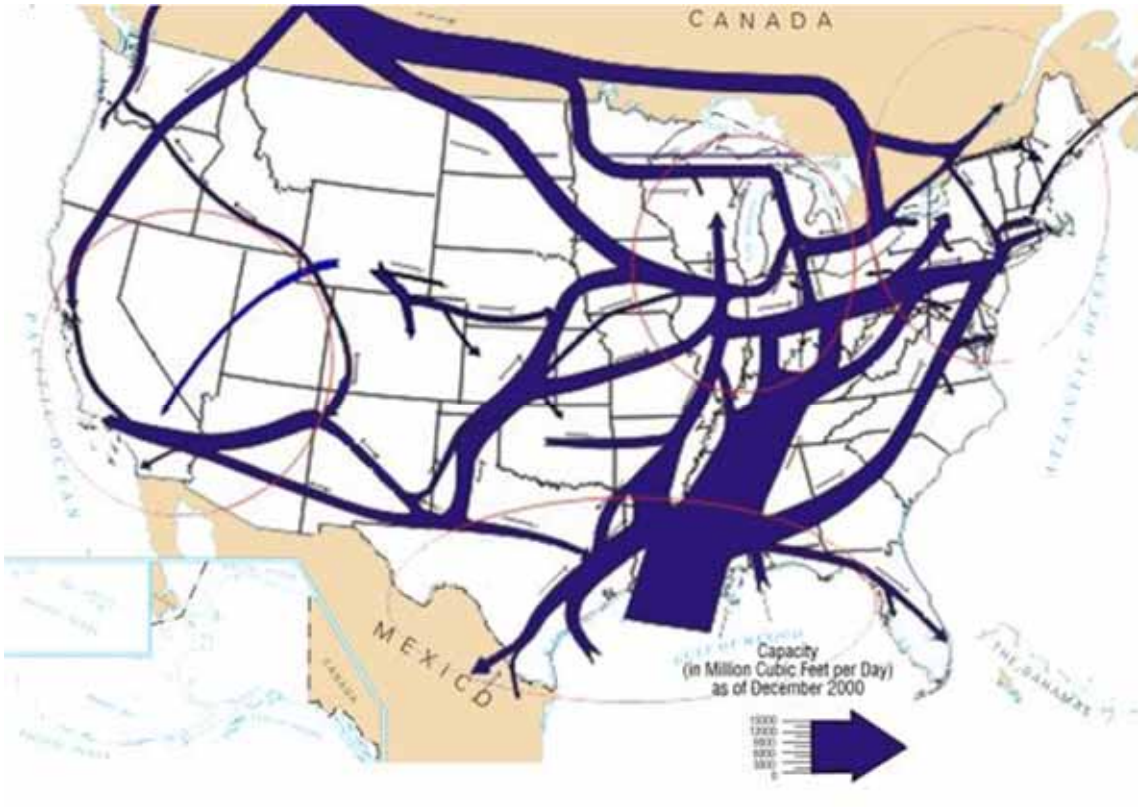
There are currently more than 100 active LNG facilities in the US, including marine terminals, storage and operations.

US DOE-EIA Office of Oil and Gas/NRCAN

The US has a well developed natural gas infrastructure.

Pipelines connect US producers and markets within the US, Canada, and Mexico.

Canadian gas comprises about 95% of US imports, and Mexico now imports more than it exports.



Natural Gas Pipelines

A substantial increase in deepwater and land-based terminal capacity will be required to meet projected needs for LNG imports.

Although many new terminals are proposed, most face strong opposition from local communities and environmental groups.

Of four deepwater LNG ports that presently exist, only the LOOP in Louisiana is in operation.

University of New Orleans

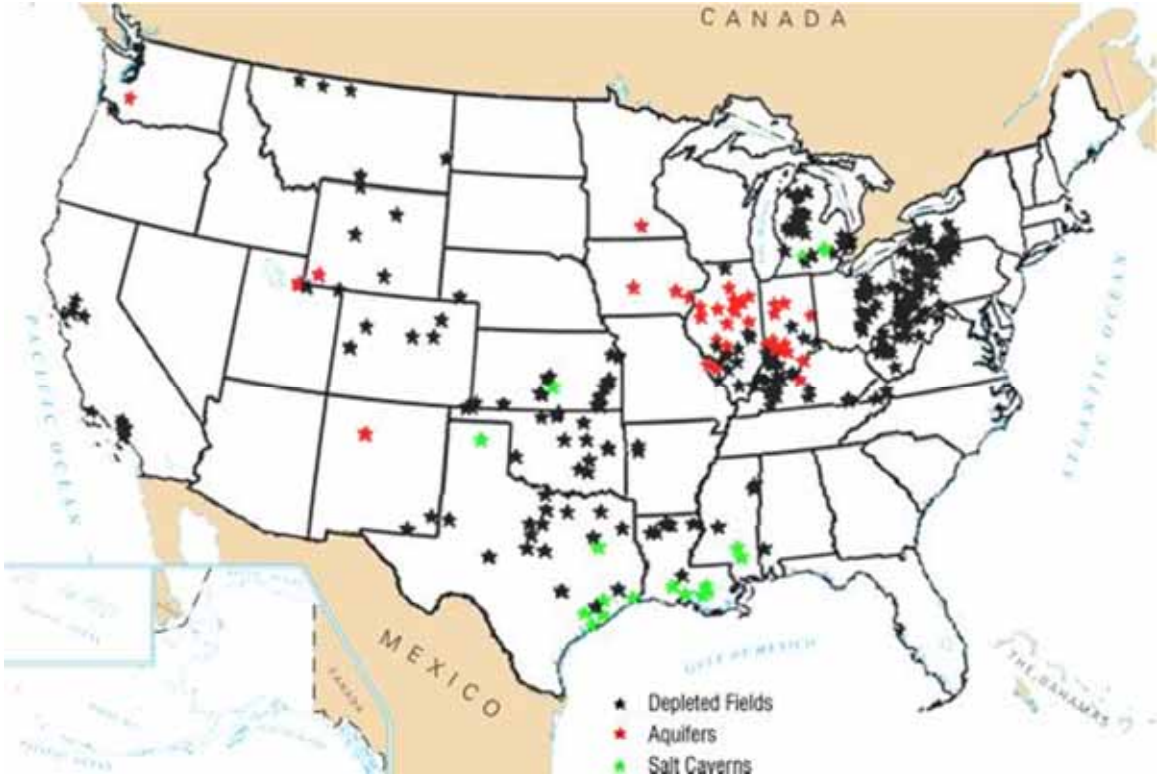
LNG Terminals

ENERGY RESOURCES **INFRASTRUCTURES**

Most natural gas produced in the US requires long-distance transmission to users through the nation's 1.5 million miles of pipelines.

Demographic shifts and predicted regional supply shortages are creating expanding needs to increase storage capacities that can accommodate periodic regional shortfalls.

US DOE Fossil Energy Office



LNG Terminals

ENERGY RESOURCES **INFRASTRUCTURES**

US DOE-EIA

Existing refineries are vulnerable to disruptions due to maintenance and breakdowns caused by accidents and natural disasters that can create supply shortfalls and price hikes.

West Coast and Midwest regions are particularly at risk due to a lack of easy supply accessibility.

Petroleum Refineries

ENERGY RESOURCES **INFRASTRUCTURES**

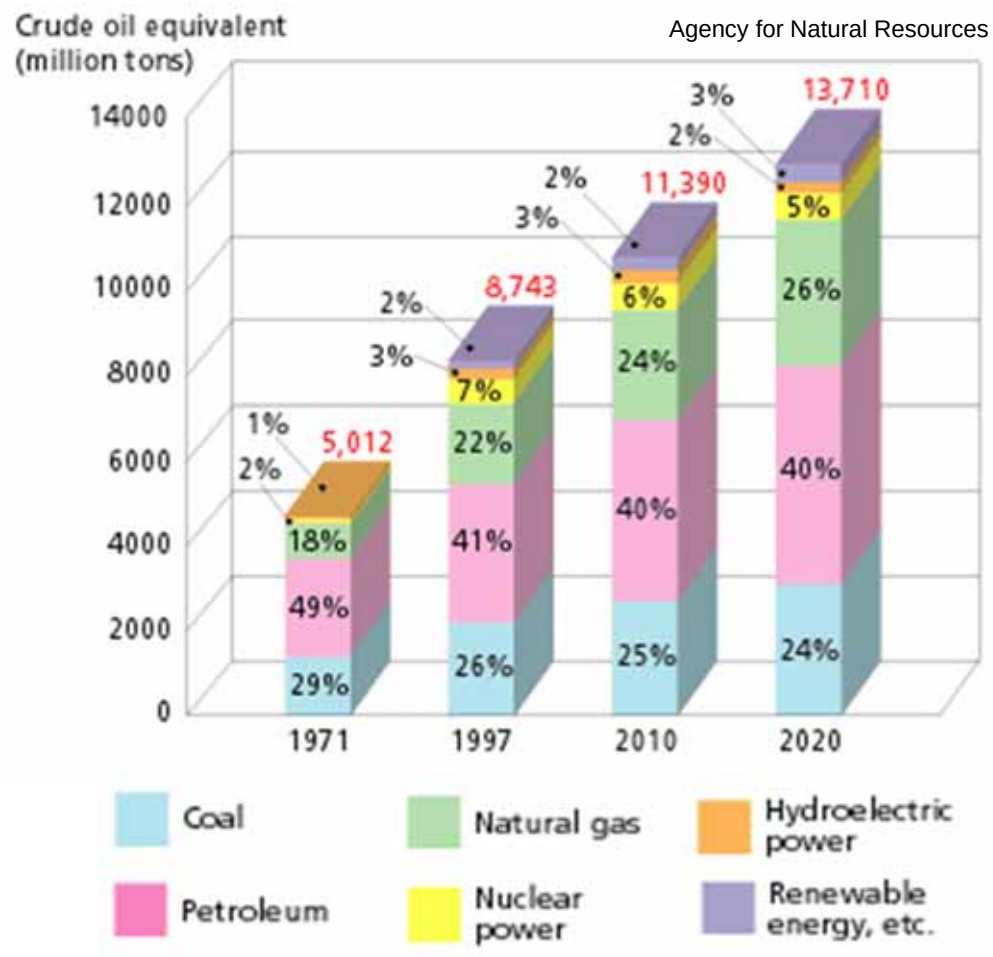
Fossil fuels now provide about 90% of all world energy.

Oil is the largest source, followed by coal and natural gas.

The US trend is shifting even more towards coal which is more abundant than natural gas (an estimated 250 year reserve).

Most global oil reserves may be exhausted in 40-60 years, although extraction from sandy tars may provide some added time.

Agency for Natural Resources



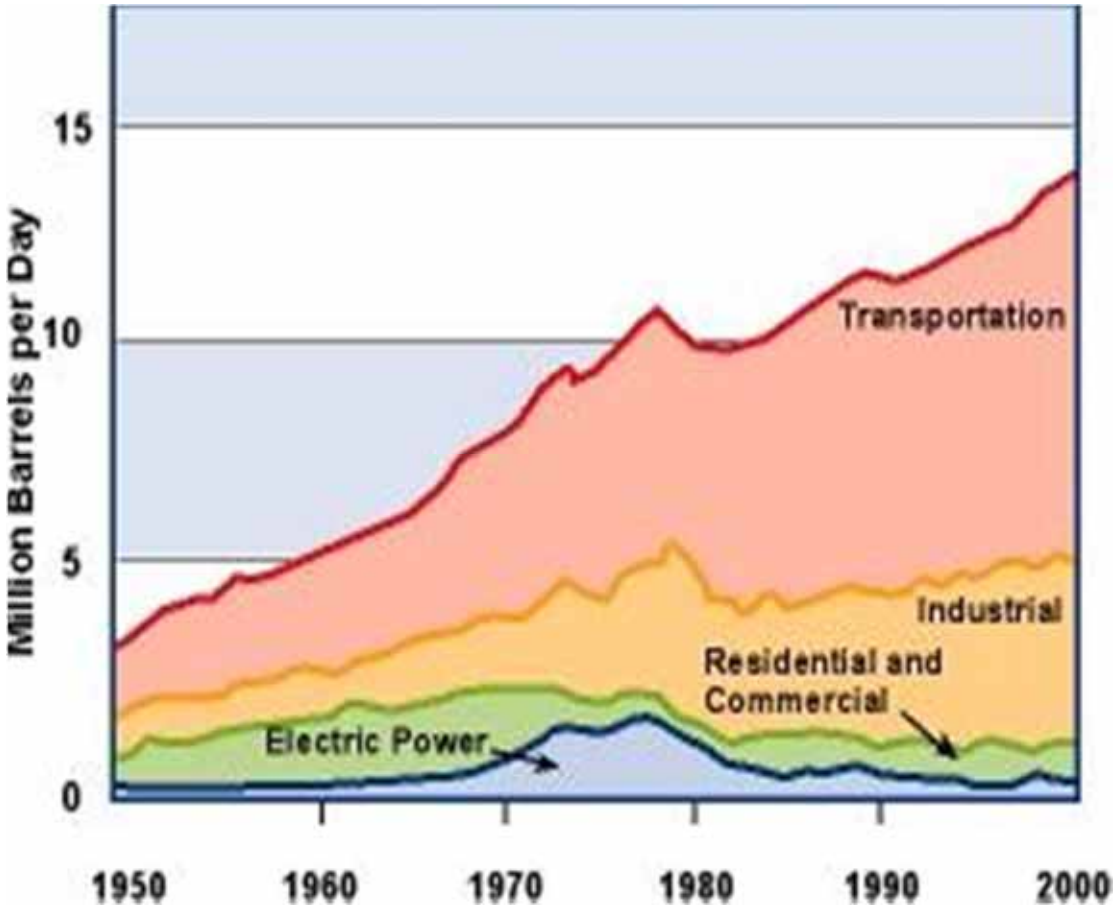
World Energy Demand Trends

The US now consumes more than one-fourth of the world's oil, representing about a quarter of this country's balance-of-trade deficit.

US consumers generally spend a smaller fraction of their incomes on gasoline now than in previous decades.

About 55% of US gasoline costs are for crude oil, 22% for refining, 19% for taxes, and 4% for distribution/ marketing.

US DOE EIA World Energy Outlook 2001



US Petroleum Consumption by Sector

ENERGY RESOURCES **CONSUMPTION TRENDS**

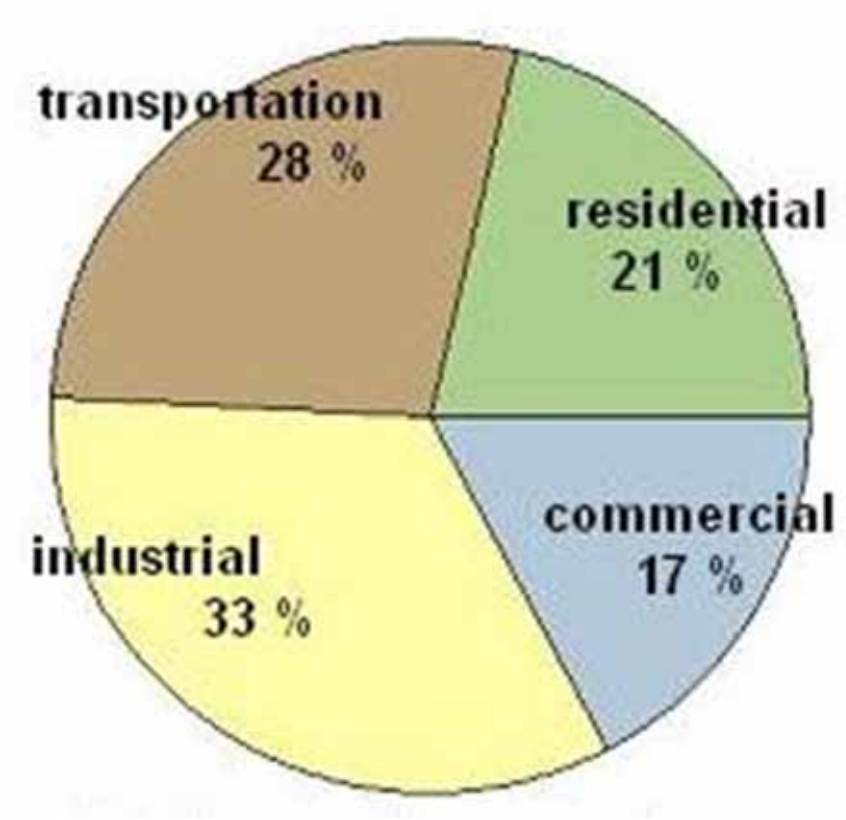
US DOE-EIA

Wealthy nations use the most energy, and the US uses the most per capita.

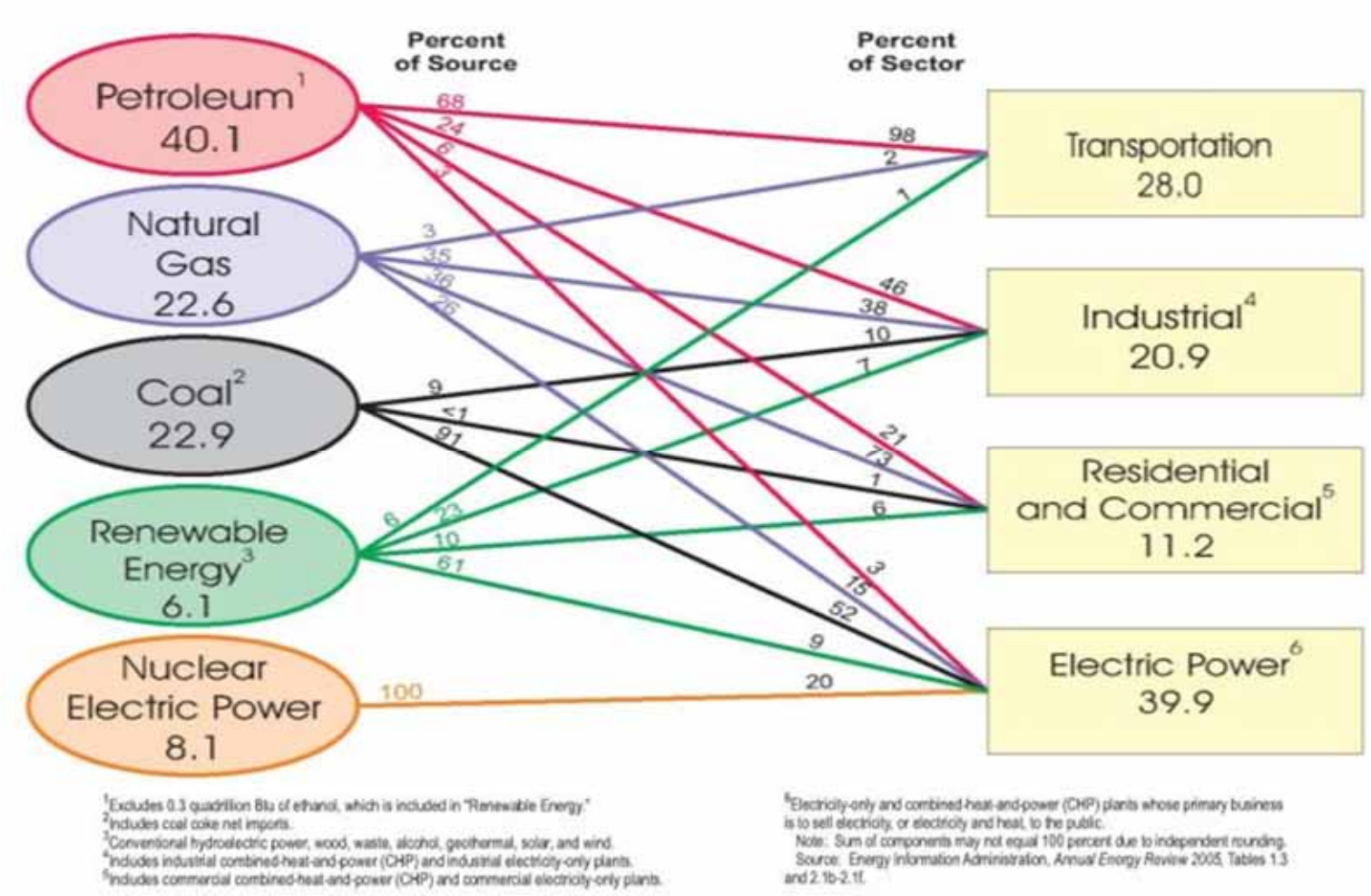
About half of US energy consumption is for transportation and residential sectors largely controlled by individual consumers.

Residential use varies across the country due to regional climate and regulation differences (about half for space conditioning).

Space conditioning is also the largest commercial energy user (about 30%).



US Energy Consumption by Sector (2004)



US Primary Energy Consumption by Source and Sector, 2005 (Quadrillion Btu)

ENERGY RESOURCES **CONSUMPTION TRENDS**

Consequences of global oil and natural gas depletion will be severe.

International relationships and commerce will be impacted, causing geo-political tensions.

Shortages will create competition between various user sectors (military, manufacturing, agriculture, and transportation).

Rising power and heating costs will accelerate population and business relocations to warmer climates, leaving many older/ poorer residents behind.

U of Rochester
Clipmarks

International Trade

LA Review Journal
Age Concern Cymru

Travel and Tourism

Industries and Jobs

Health and Hardships

Future Impacts

ENERGY RESOURCES **CONSUMPTION TRENDS**

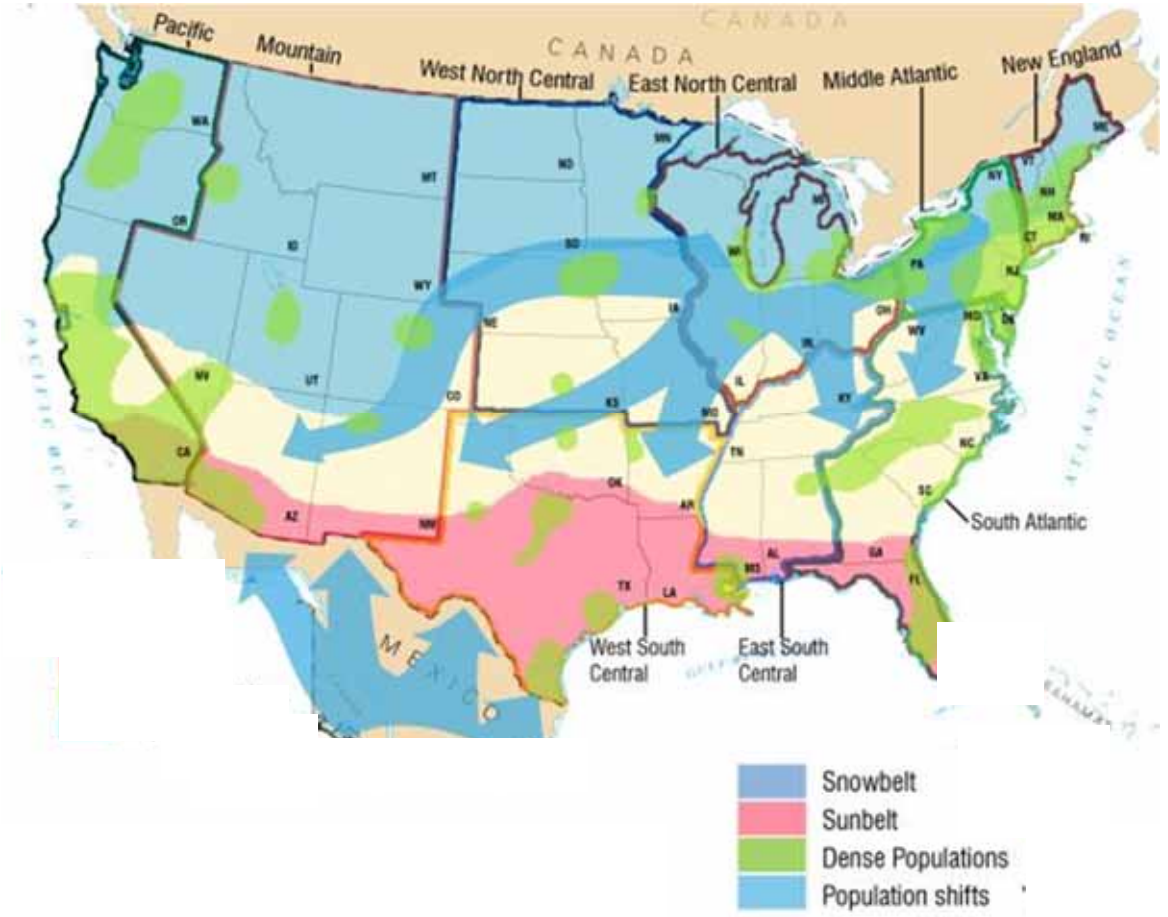
Larry Bell / US DOE - EERE

The US population more than tripled during the 20th century, reaching 300 million in 2006.

It is expected to grow to more than 390 million by 2050.

About 40% of US population growth is from immigration (more than 1 million annually).

People are living longer, and many are residing in larger homes than in the past.



Population and Energy Trends

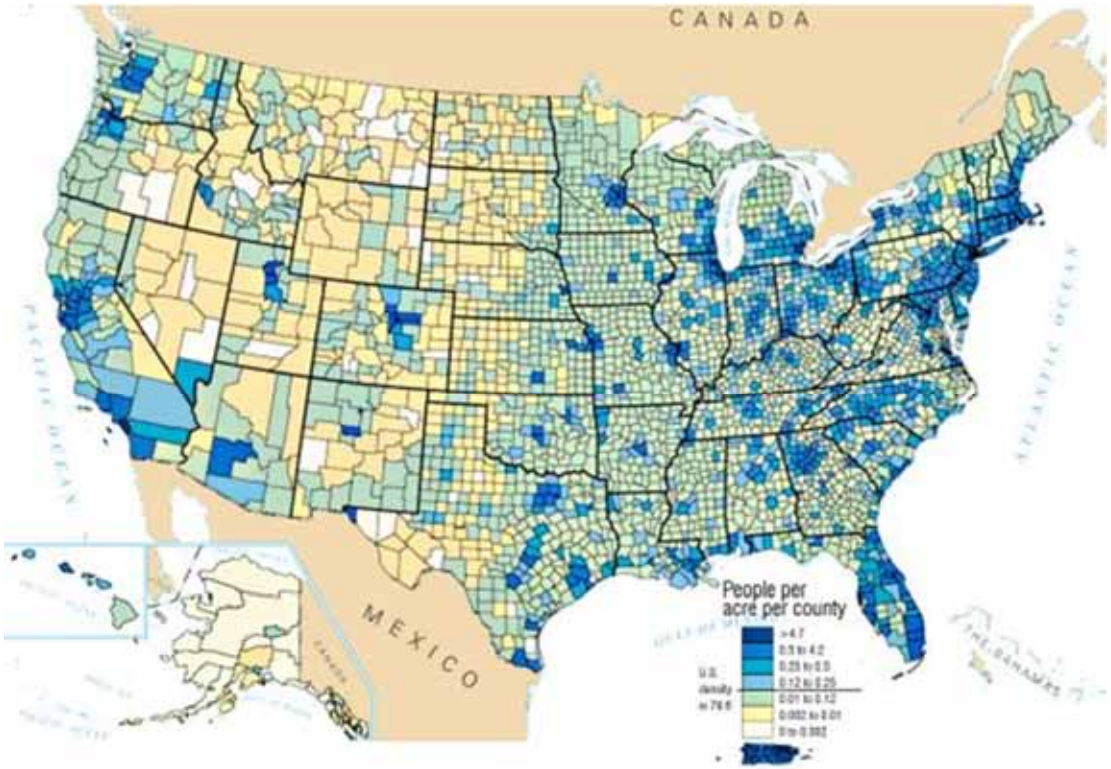
ENERGY RESOURCES **CONSUMPTION TRENDS**

US EPA

The US population is heavily concentrated around large cities in the Northeast, and slightly more than half is clustered in coastal counties.

Rapid shifts are occurring from central cities to suburbs, and from the Northeast and Midwest to Southern and Western states.

Northeastern regions are most densely populated, but are realizing the slowest growth due to Sunbelt migrations.



Population Density by Counties, 2000

Population migrations from colder to warmer regions substitute fuel heating demands for increased electricity use.

Shifts from fossil energy for winter heating to electricity for air conditioning makes better use of centralized power plants which are more efficient than small furnaces and produce fewer CO_2 emissions.

US DOE-EERE

Energy Needs

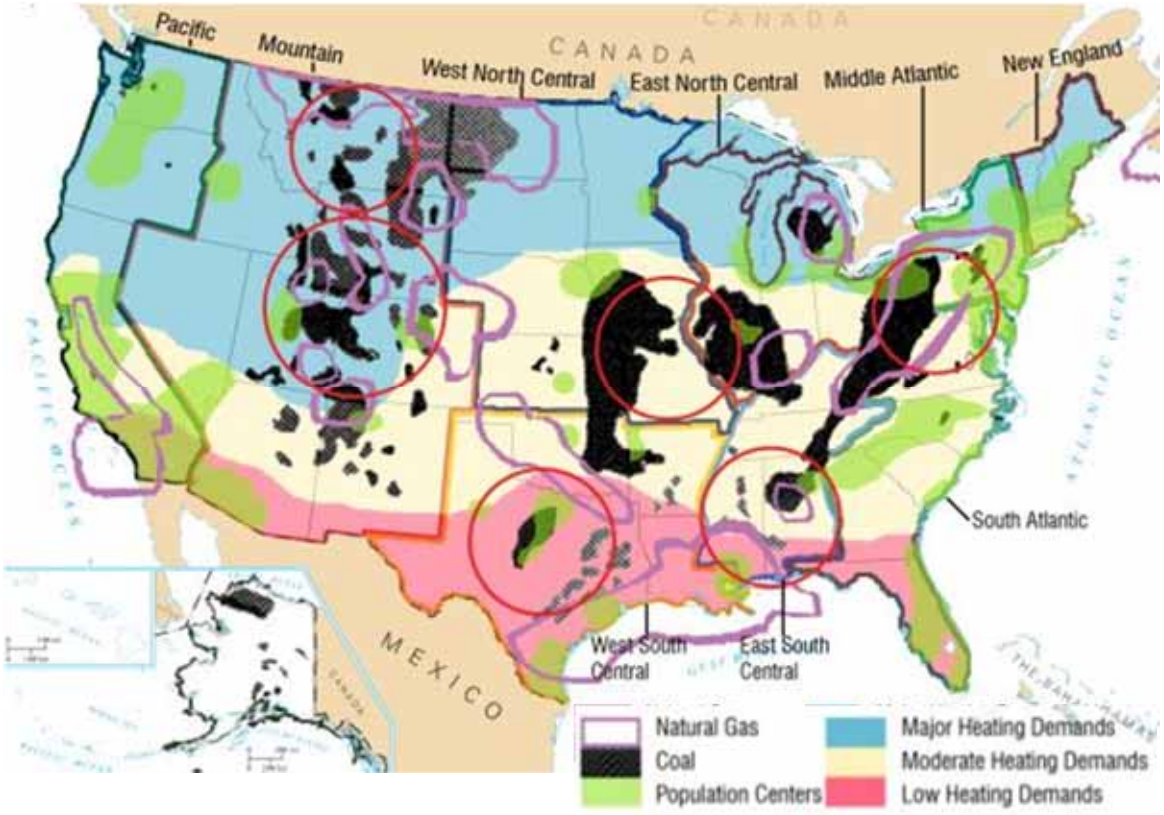
ENERGY RESOURCES **CONSUMPTION TRENDS**

Larry Bell / ACF / US Census / US DOE-EERE

Various regions present different space heating resources.

Cold and moderately cold Mountain, West North Central, East South Central, and Middle Atlantic states have abundant coal and natural gas.

New England, with cold weather and limited fossil supplies must depend upon other regions.



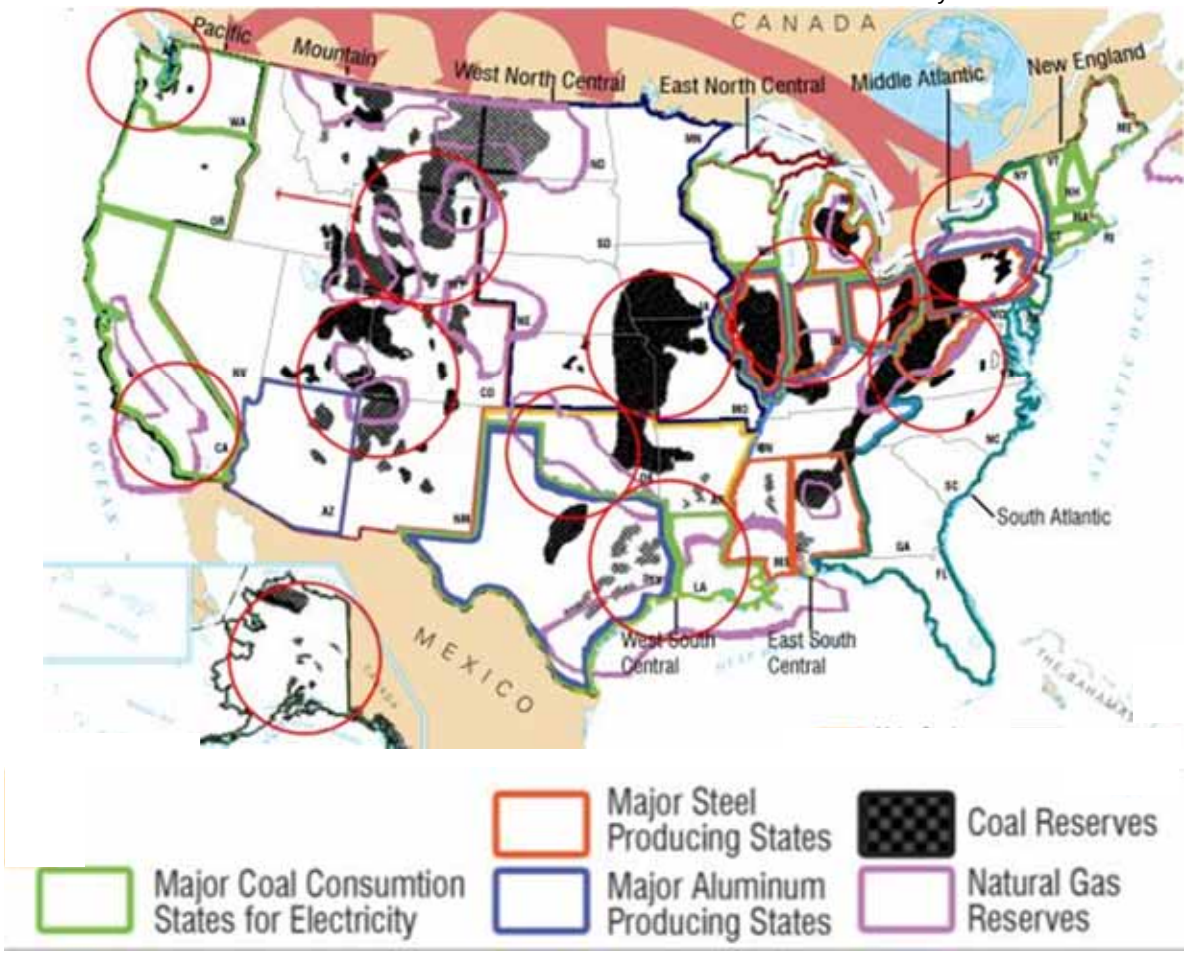
Heating Demands and Fossil Sources

Larry Bell / US DOE-EERE

Industrial plants place large demands upon fossil energy sources.

The three largest coal-producing states are Wyoming, West Virginia, and Kentucky, followed by Texas and Pennsylvania.

Most primary aluminum producers are located in the Pacific Northwest, Ohio River Valley, Great Lakes Region and Southern California.

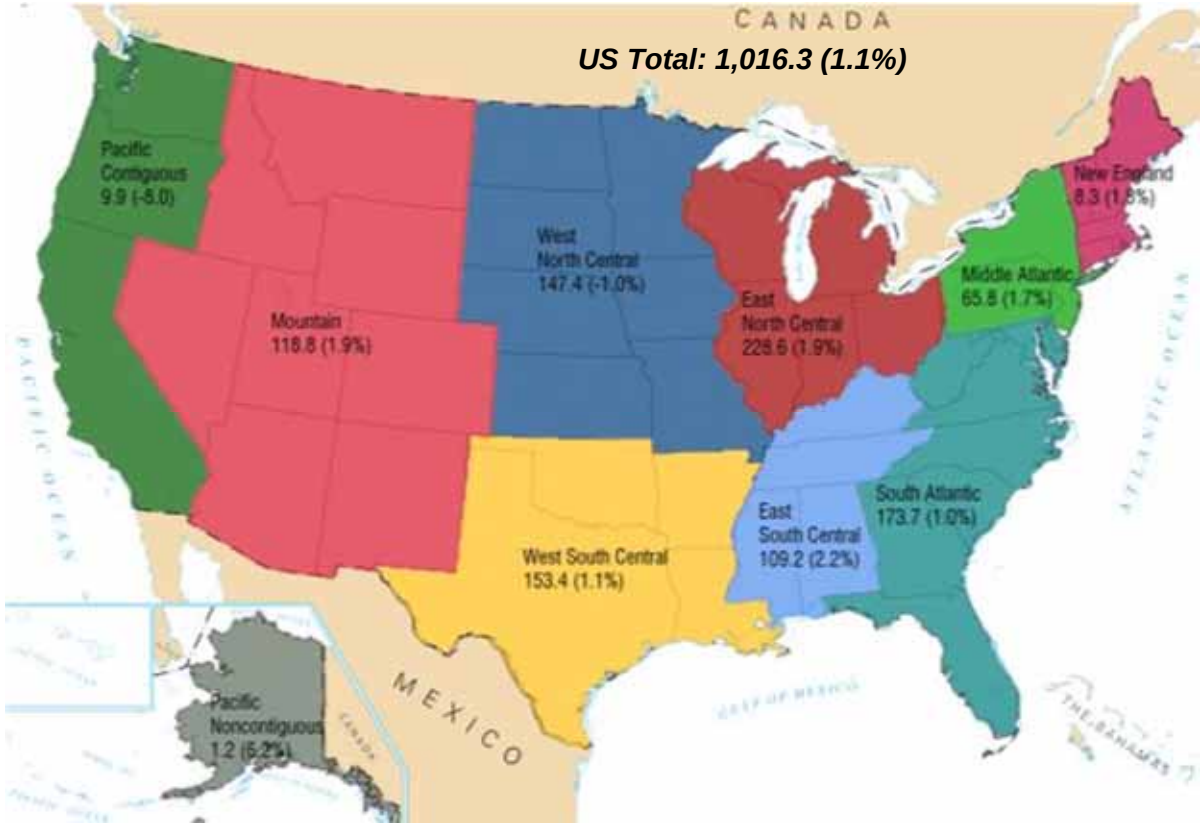


Fossil Fuel Energy Sources and Consumers

US DOE-EIA

In 2005, coal accounted for more than 70% of all electrical power generation in the East North Central Region, making it the largest coal consumer, and accounting for 23% of all electrical power.

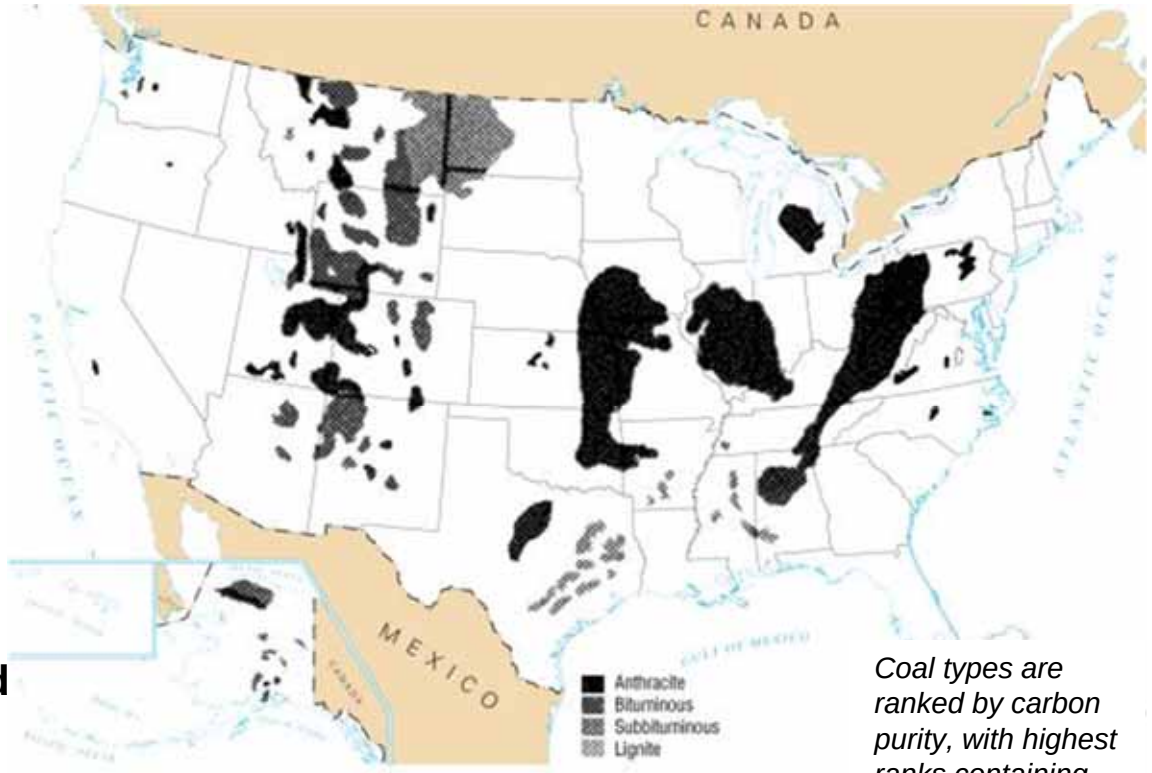
In Mountain and North Central Regions, coal provides more than 60% of the fuel mix for electrical power generation.



Coal Electric Utility Consumption by Census Region (Million Short Tons and Percent Change, 2004 – 2005)

US coal is mined in 27 states, led by Montana:

- **Anthracite (95% purity and above) is primarily used for residential and commercial space heating.**
- **Bituminous (next in rank) is used for steam-electric generation, combined heat and power, and to make coke.**
- **Sub bituminous and lignite (in rank order) are principally used for steam-electric generation.**



Coal types are ranked by carbon purity, with highest ranks containing less hydrogen, oxygen, and nitrogen:

Coal Reserves

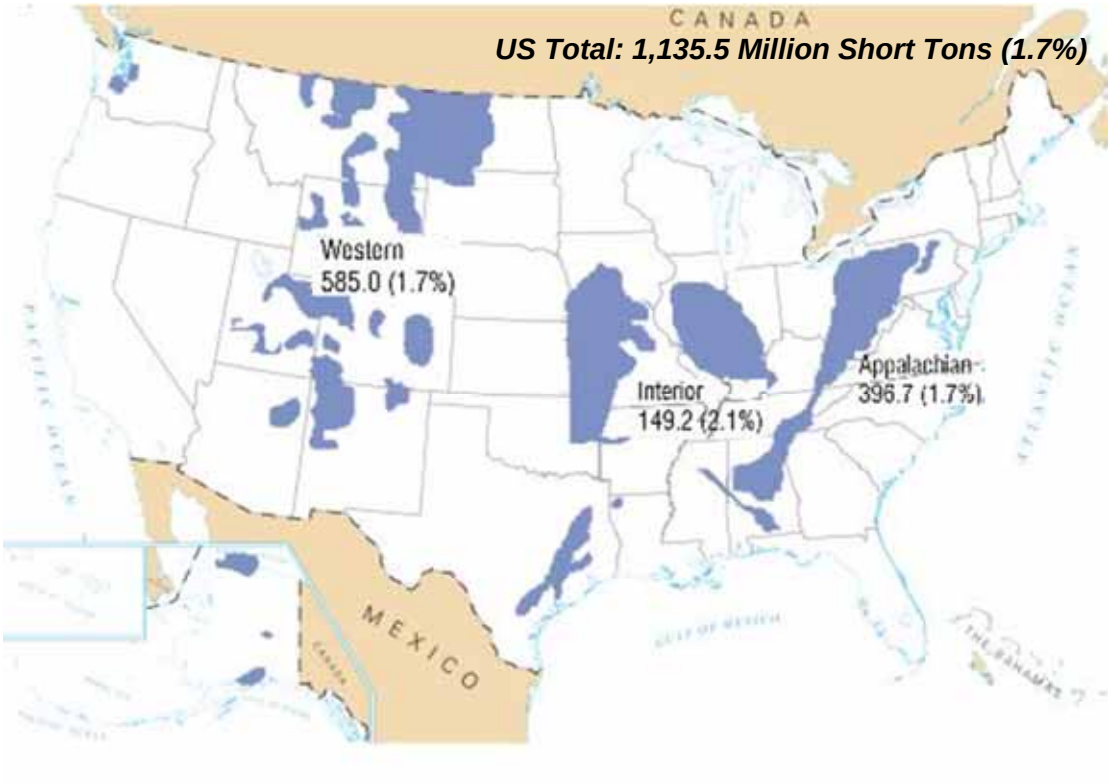
US DOE-EIA

Production in the Appalachian Region in 2005 was hampered by a variety of problems.

Hurricanes and river flooding impacted barge transport.

Lawsuits related to safety problems (roof collapses and high methane gas levels) halted or delayed many mine permits.

The Appalachian Region is led by West Virginia (second largest in the US, followed by Ohio).



Coal Production by Region, 2005 (Million Short Tons and Percent Change from 2004)

Open-pit coal operations are now typically required to post bonds for each acre of land surface to be mined, and later restore soils as nearly as possible to original contours with native vegetation and trees replaced.

Since 1977, more than 2 million acres of coal land have been reclaimed in this manner.

State of South Dakota

Reclaimed Mine Area

Coal Mining Issues

Intertek Petroleum Industry Applications

Synthetic fuels created from coal may extend and eventually replace petroleum produced from oil.

Such coal-derived fuels, including gasoline, diesel, fuel oil, and hydrogen, can potentially be processed in conventional petroleum refineries.

Coal-sourced aviation fuels are also possible.

Coal-Derived Liquid Fuels

The US has large reserves of kerogen-rich oil shale that can be used as a source of liquid and gas petroleum products.

A major economic obstacle for capitalizing upon this resource is the large amount of electricity required for thermal extraction (approximately equivalent one barrel of oil used for every three obtained).

Use of an alternative renewable power source can potentially reduce this disadvantage.

US DOE

Oil Shale Fuel

US oil reserves are largely concentrated in Texas, California, Oklahoma, Alaska and Federal offshore locations.

Intense controversy exists over whether or not a government moratorium should be lifted that prevents drilling for oil in Alaska's Arctic National Wildlife Refuge (ANWR) which is estimated by the US Department of Interior to contain between 9-16 billion barrels of recoverable oil.

US DOE-EIA

Crude Oil Deposits

ENERGY RESOURCES **US FOSSIL SUPPLIES**

A large oil deposit was discovered at a depth of about 4 miles in the Gulf of Mexico in 2006.

Chevron estimated that the 300 square mile region where its test well sits may hold between 3-15 billion barrels of oil and natural gas liquids.

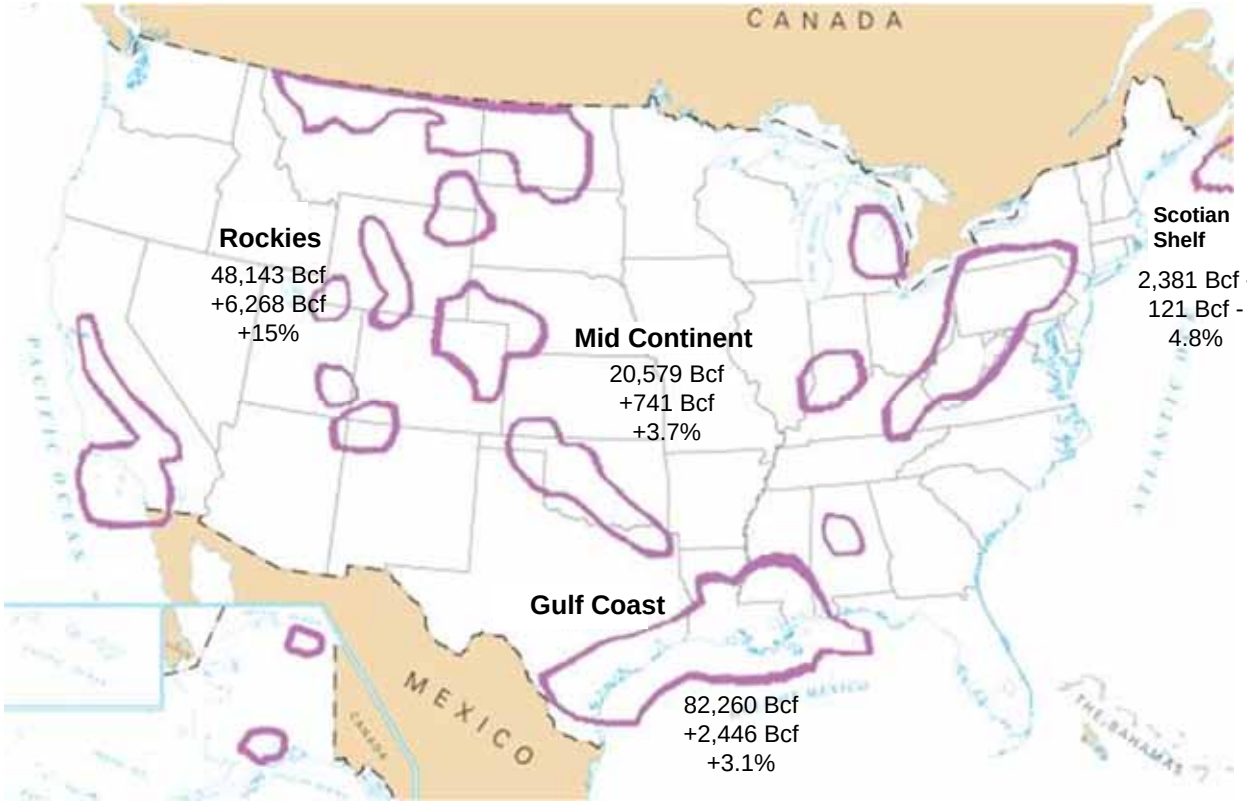
Many years and tens of billions of dollars will be required to tap this supply.

MSNBC

2006 Oil Discovery in the Gulf of Mexico

US DOE EIA / CAPP / NRCan

Most US natural gas reserves are concentrated in Texas, New Mexico, Wyoming, Oklahoma, Colorado and the Gulf of Mexico offshore areas.

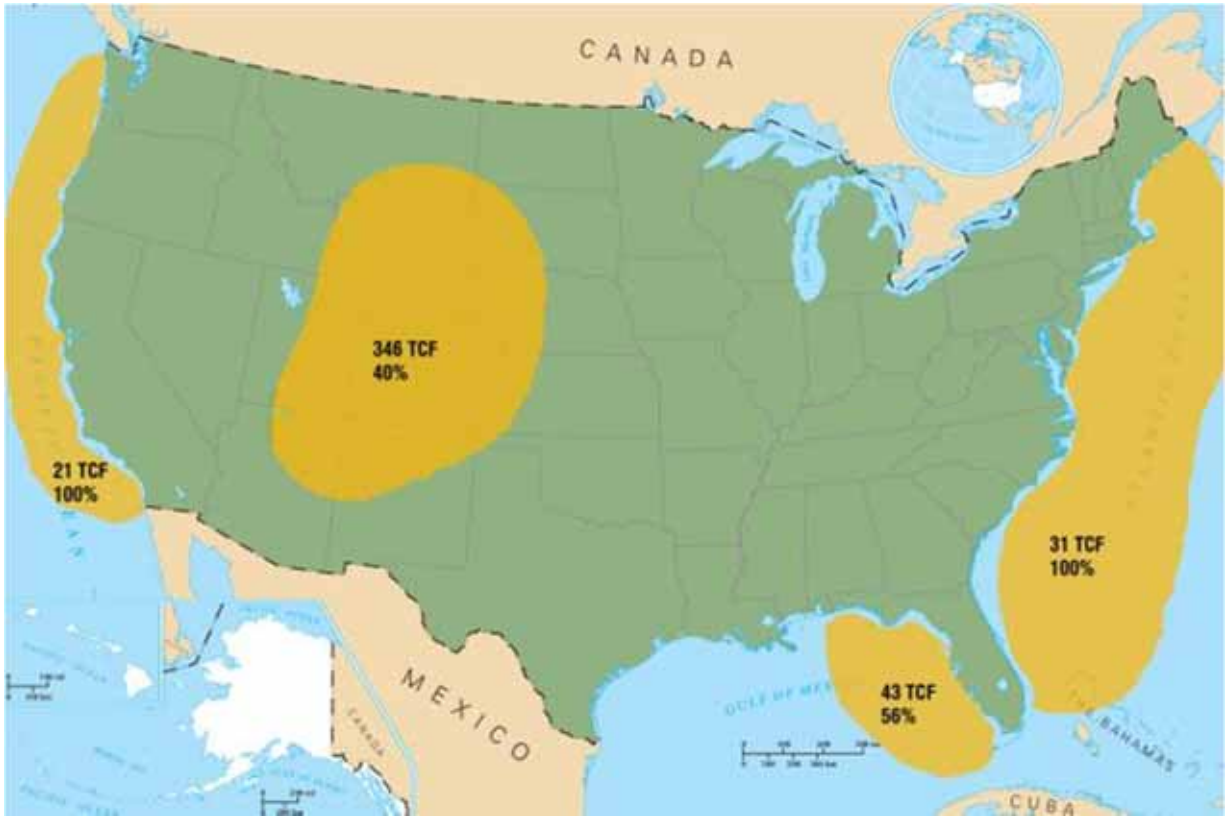


North American Natural Gas Reserves (2001 Estimates)

Independent Petroleum Association of America

Many disputes exist between advocates and opponents of natural gas and oil drilling in public onshore and offshore regions.

A recent US Department of Interior study indicates that 80% of domestic economically-recoverable natural gas reserves are now open for development with certain restrictive stipulations.

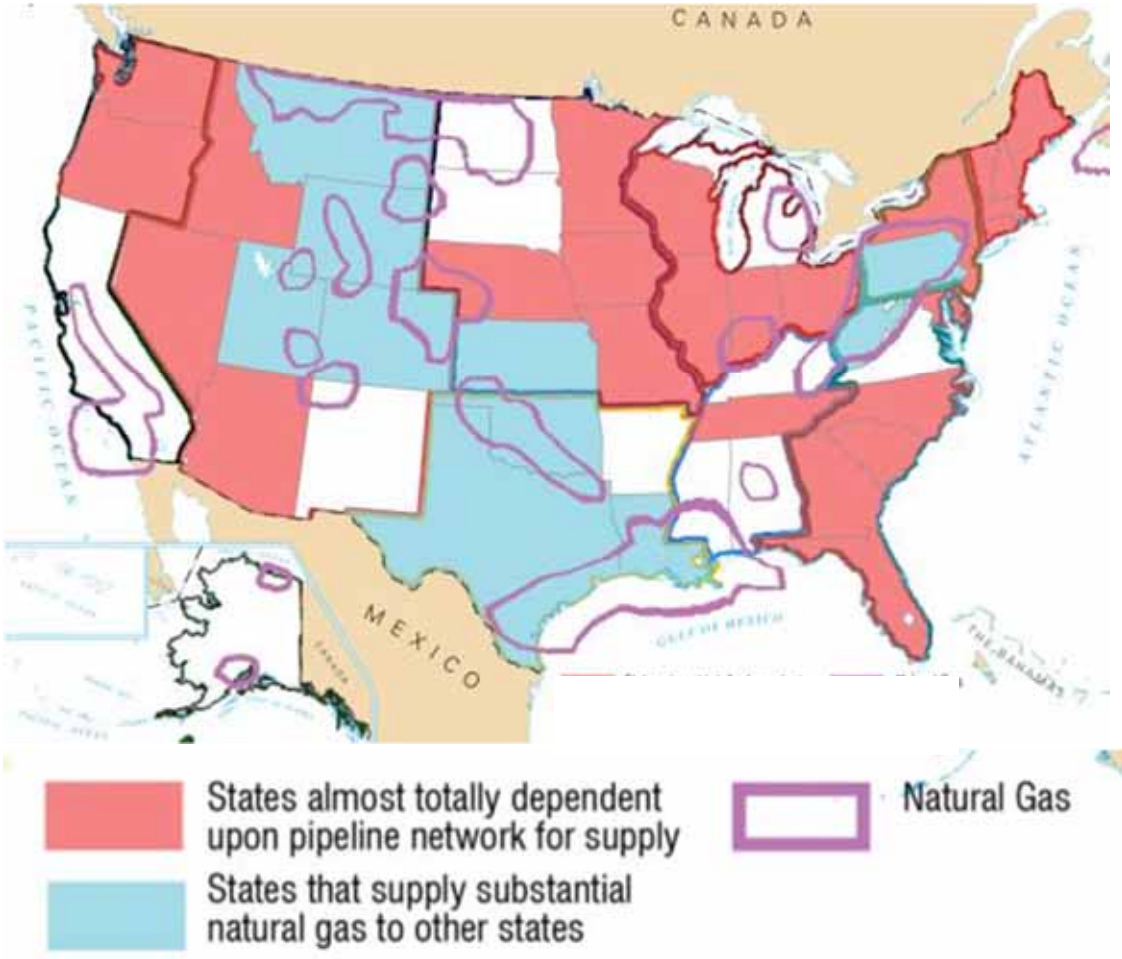


Natural Gas Restricted Reserves
(Trillion Cubic Feet and Percentages)

Larry Bell / US DOE - EIA

An extensive natural gas infrastructure ties regions of the US to Canada and Mexico.

Transport capacity is constantly being added, particularly to supply needs to California from coal bed supply sources in Canada, Montana, Wyoming and Utah.

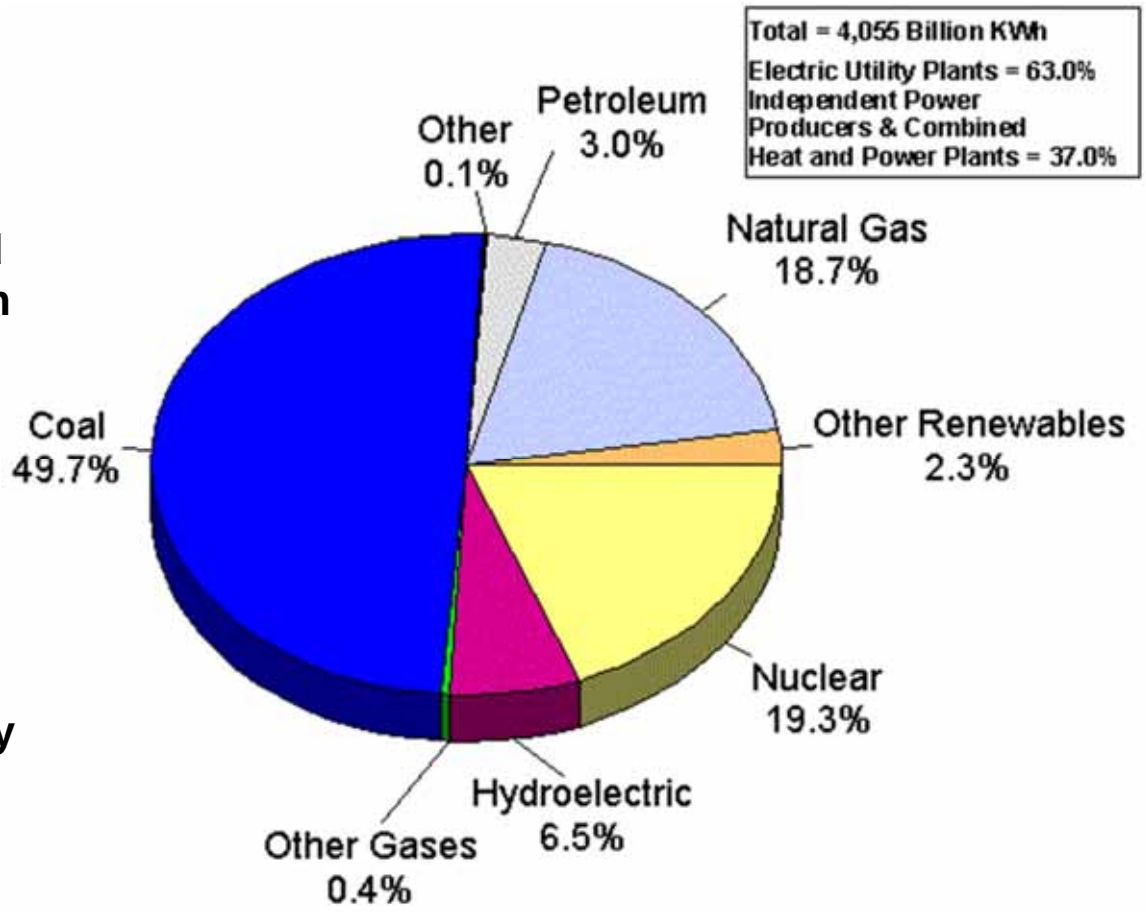


Natural Gas Infrastructure

US DOE - EIA

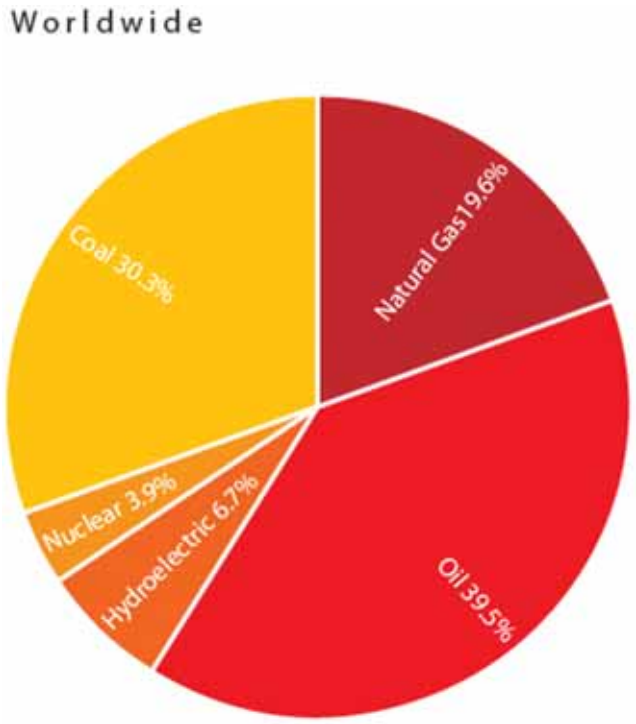
During 2005, more than 71% of all US electricity was produced from fossil fuels and more than 19% from nuclear plants, with less than 10% from hydroelectric and other renewable sources.

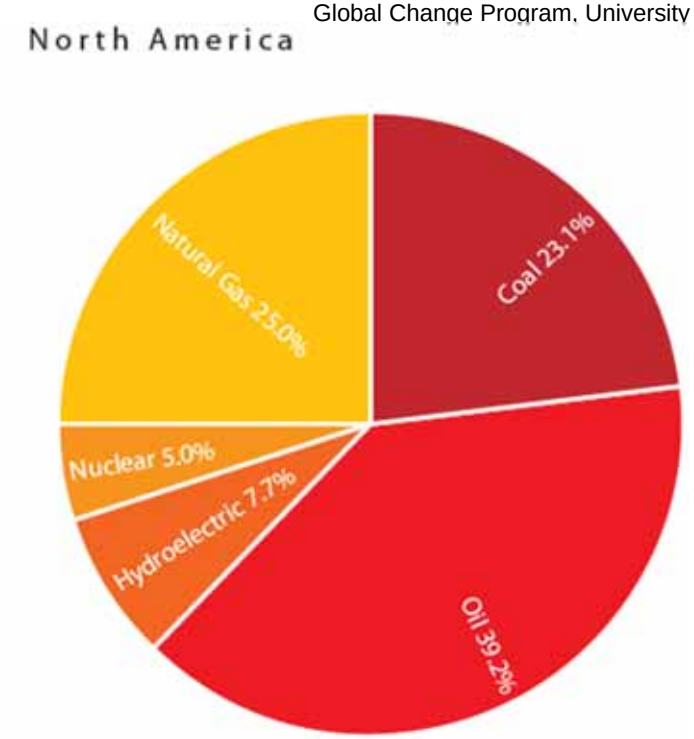
Given that most oil and natural gas reserves will be gone within a few decades, it is essential that non-fossil energy sources rapidly be developed.



US Electrical Power Industry Net Generation, 2005

ENERGY RESOURCES **NON FOSSIL SUPPLIES**





From a total energy production standpoint (all uses), fossils supply about 90% of energy use worldwide, and more than 85% in North America, with hydroelectric and nuclear providing most of the rest.

World and North American Energy Use

ENERGY RESOURCES **NON FOSSIL SUPPLIES**

Flickr/Bill & Vicki Tracey

The US is currently the leading producer of nuclear energy (20% of its electricity) while France produces the largest percentage of power it uses from nuclear (80%).

Renewed international interest in nuclear power is being advanced because reactors don't produce greenhouse emissions (other than water vapor).

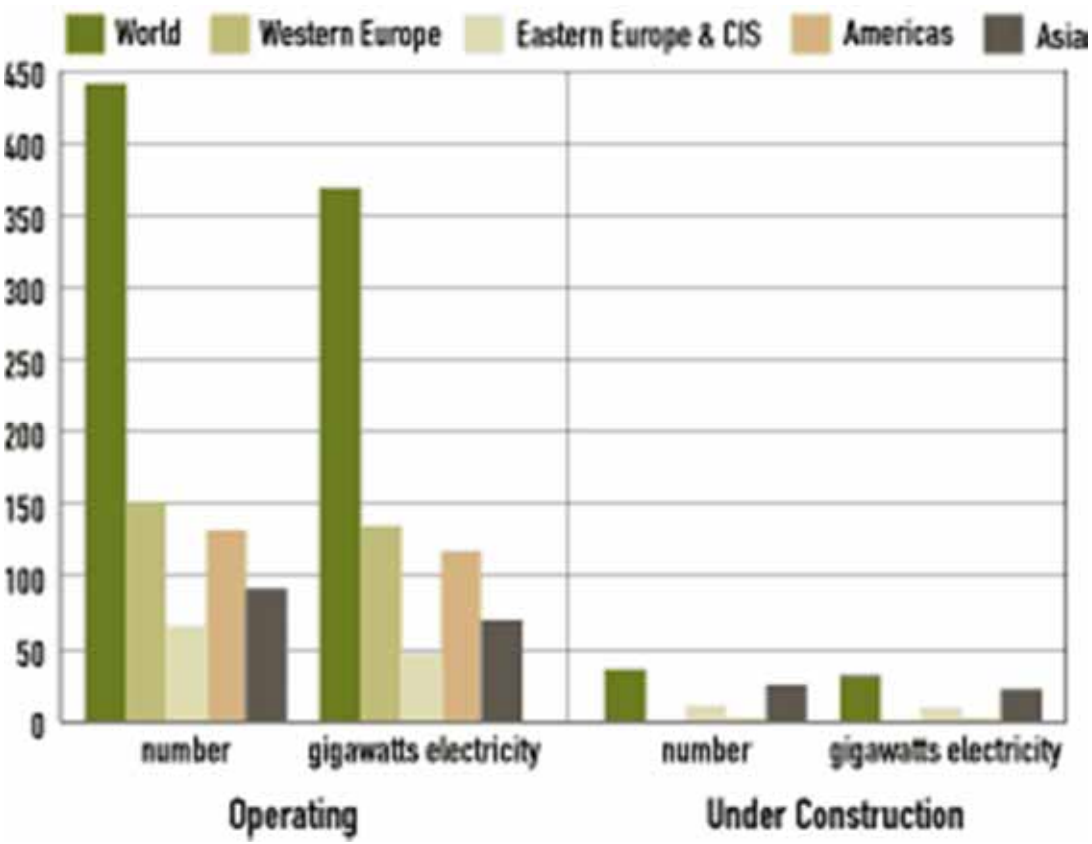
A Substantial Fossil Alternative

Areva Resources Canada

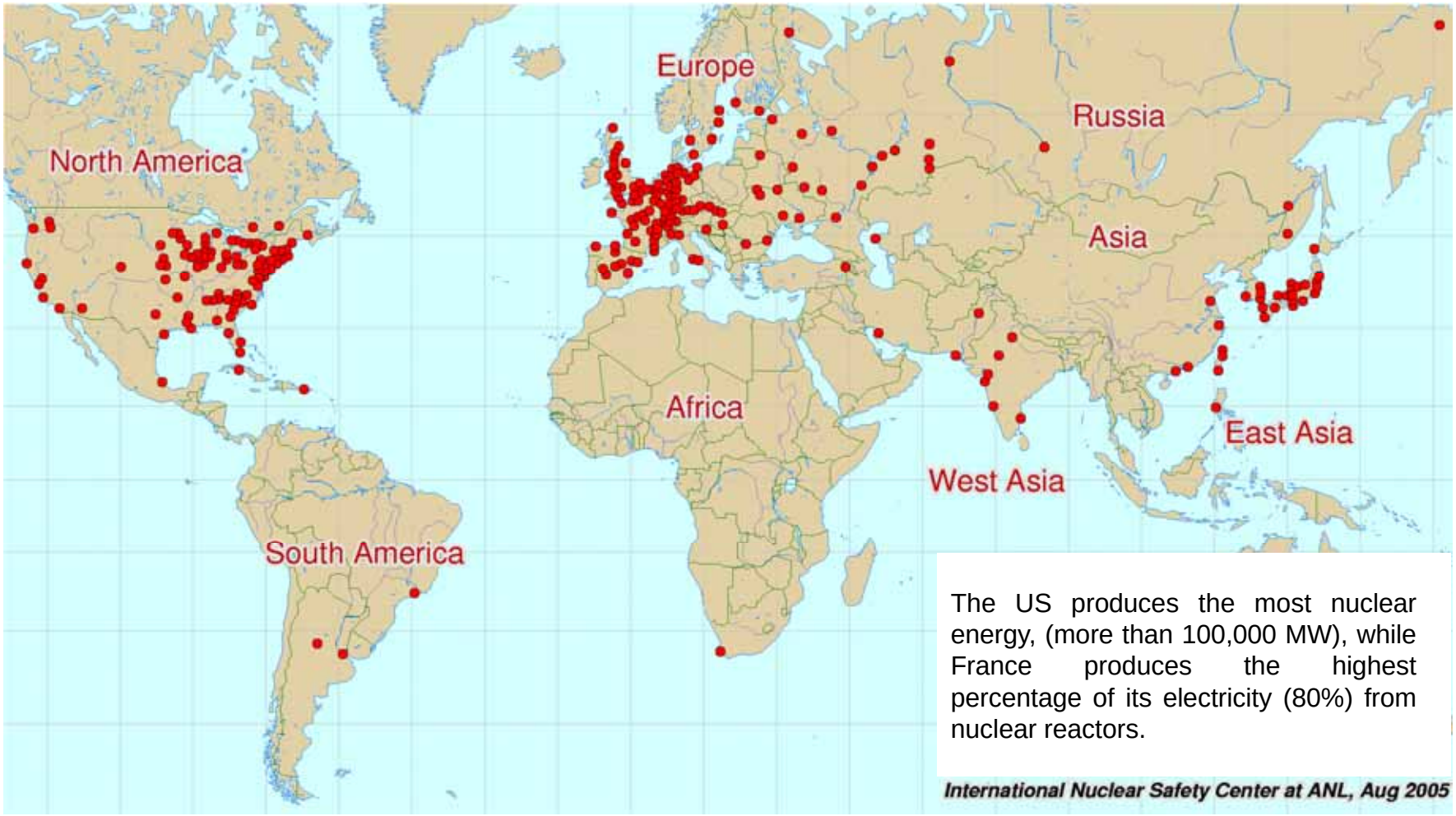
There are currently about 337 nuclear reactors in the world, and at least 60 are likely to be added within the next couple of decades.

India and China are developing nuclear plants at the fastest rate.

A planned 1,600 MW reactor in Finland will be the world's largest.



Operating and Under-Construction Plants



Countries with Nuclear Reactors

ENERGY RESOURCES **NUCLEAR POWER**

Los Alamos National Laboratory

The US currently has 103 nuclear power plants located in 31 states that produce nearly 20% of the nation's electricity and about 8% of total energy.

Although more expensive to build than fossil fuel plants, they release only water emissions, use much less expensive fuels, and may become significant sources of electricity to process hydrogen.

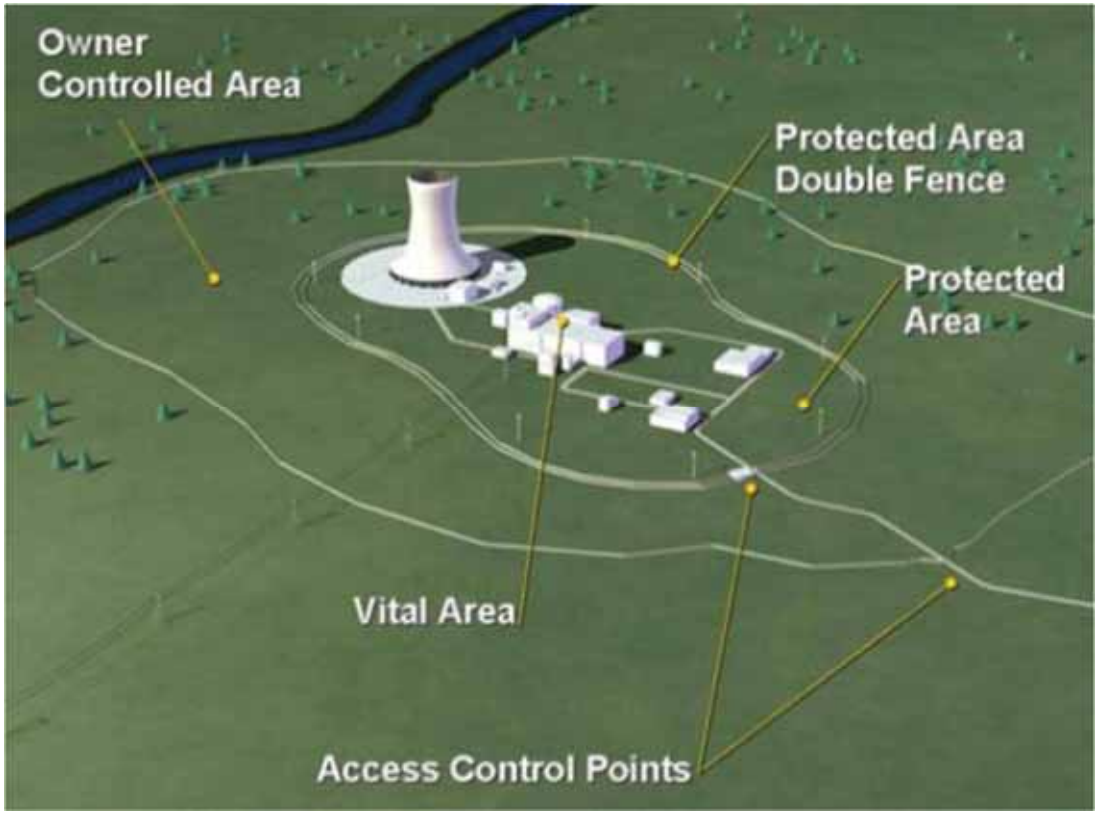
US Plant Locations

Nuclear development is being inhibited by concerns about radioactive waste storage, possible catastrophic accidents and sabotage, and global nuclear weapon proliferation threats.

Security at nuclear power plants is regulated and monitored by the US Nuclear Regulatory Commission (NRC).

Physical barriers and high-tech surveillance devices control access, and reactors are protected by massive reinforced concrete containment buildings.

Nuclear Energy Institute



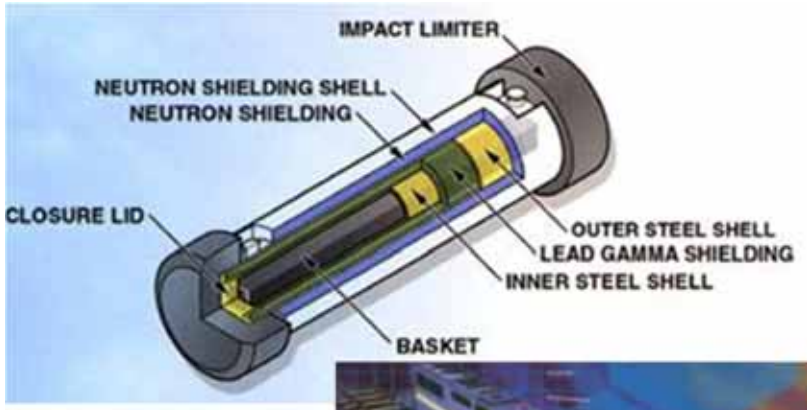
Plant Security

Safe transportation and containment of spent nuclear wastes are vital.

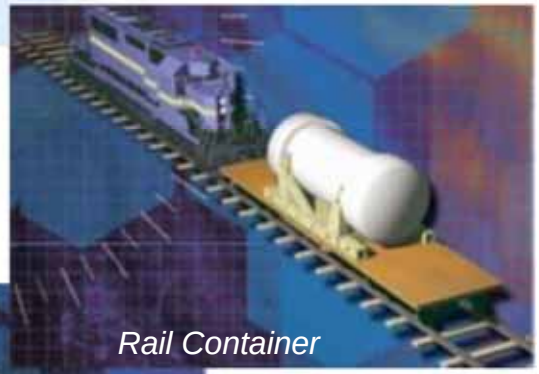
Wastes are currently stored at temporary locations, often near nuclear plants.

Most waste is solid and non-corrosive, but significant amounts of old liquid wastes also exist that can corrode metal tanks.

New, much safer containers and transport systems have been developed for waste relocation to storage sites.



Truck Container Cutaway



Rail Container

Truck Container

Waste Containment and Transport

The US Department of Energy hopes to create a permanent, centralized nuclear waste storage facility at Yucca Mountain in Nevada.

The proposed facility would ultimately contain up to 40,000 metric tons of spent nuclear material, and be licensed under renewable terms of 100 years.

Yucca Mountain Information Office

Proposed Yucca Mountain Nuclear Waste Storage Facility

State of Montana DEQ

There have been no deaths resulting from nuclear power plant accidents for more than 40 years, but lawsuits charging toxic impacts of wastes and uranium mining operations remain as development hurdles.

Contaminated mine sites of past decades are cited as causes of illnesses and deaths, requiring costly cleanup processes.

Groundwater contamination resulting from the leaching of toxic chemicals used in ore recovery is an important issue.

Uranium Mining

Most US uranium deposits are small and low-grade, but supply about 85% of the nation's production.

Modern mining uses in-situ leach (ISL) methods that pump water into sub-surface hydrochemical "cells" to dissolve uranium minerals, leaving the ore where it was naturally formed.

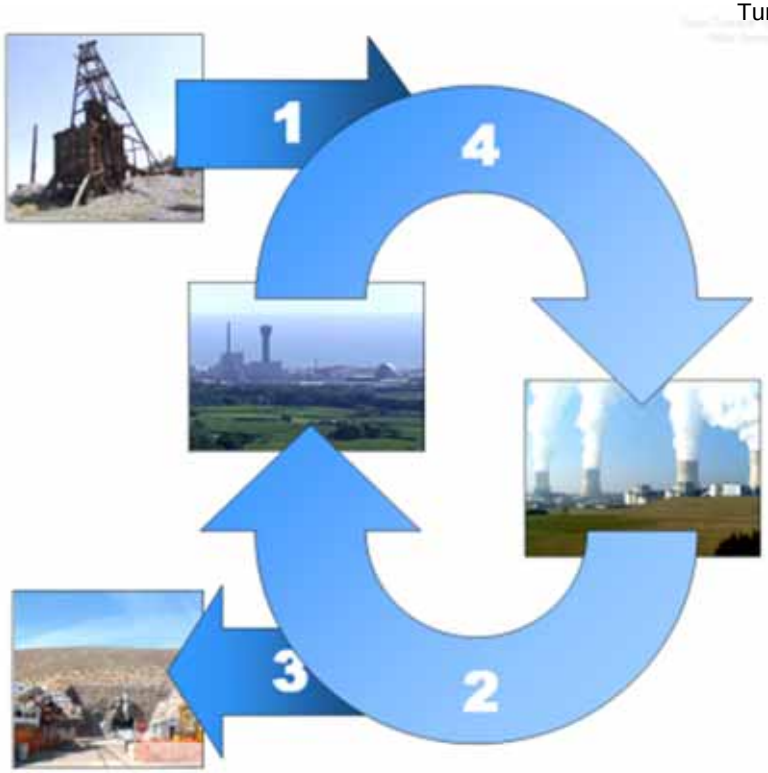
Surface processing of the leached solution produces "yellow cake".

US DOE-EIA Grand Junction Project Office

Major US Uranium Reserves

While breeder reactors can reprocess up to 95% of nuclear fuel, they have been banned in the US due to risks of weapon-grade material proliferation.

A US-sponsored Global Nuclear Partnership initiative is promoting an international effort to enable reprocessing in a matter that will prevent this danger while making nuclear power available to developing countries.



Nuclear fuel can be used many times through reprocessing:

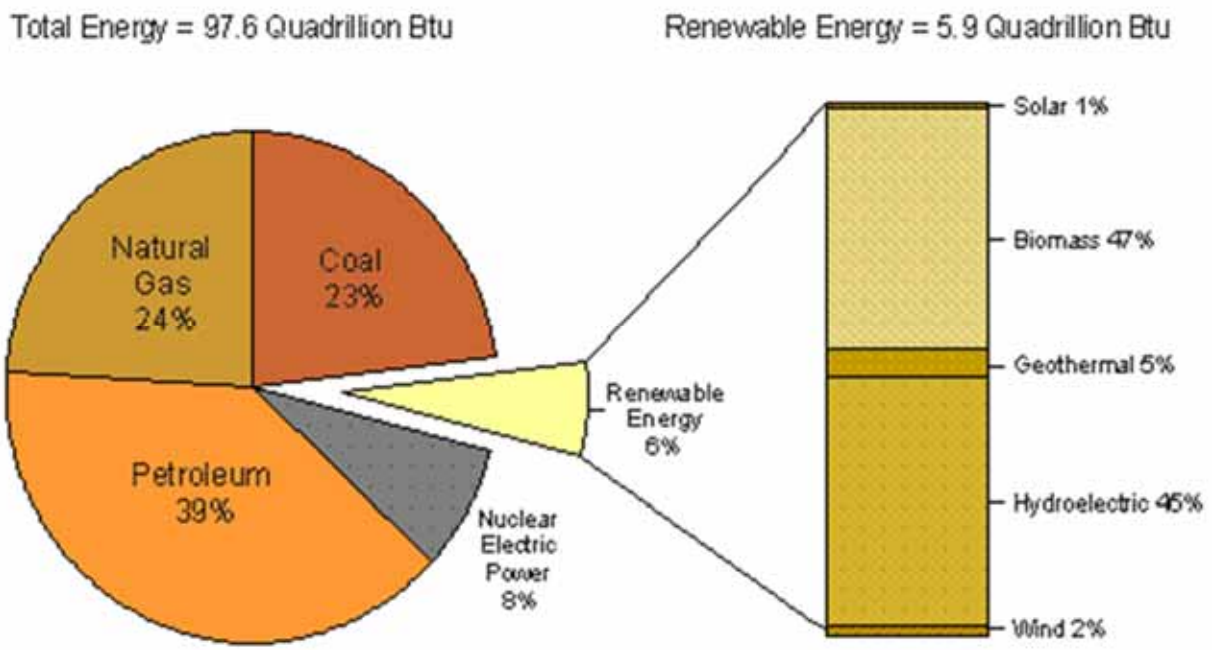
1. Uranium is mined, enriched and delivered to the plant; 2. spent fuel is reprocessed (or 3. stored in a final reposition for geological disposition) and then 4. reprocessed fuel is recycled and reused.

Fuel Recycling

US DOE-EERE

California proposes to attain 20% of its electrical power from renewable sources by 2020, and other states have similar plans.

Recognizing that renewables currently constitute only about 6% of total US energy production, this will be a challenging goal.



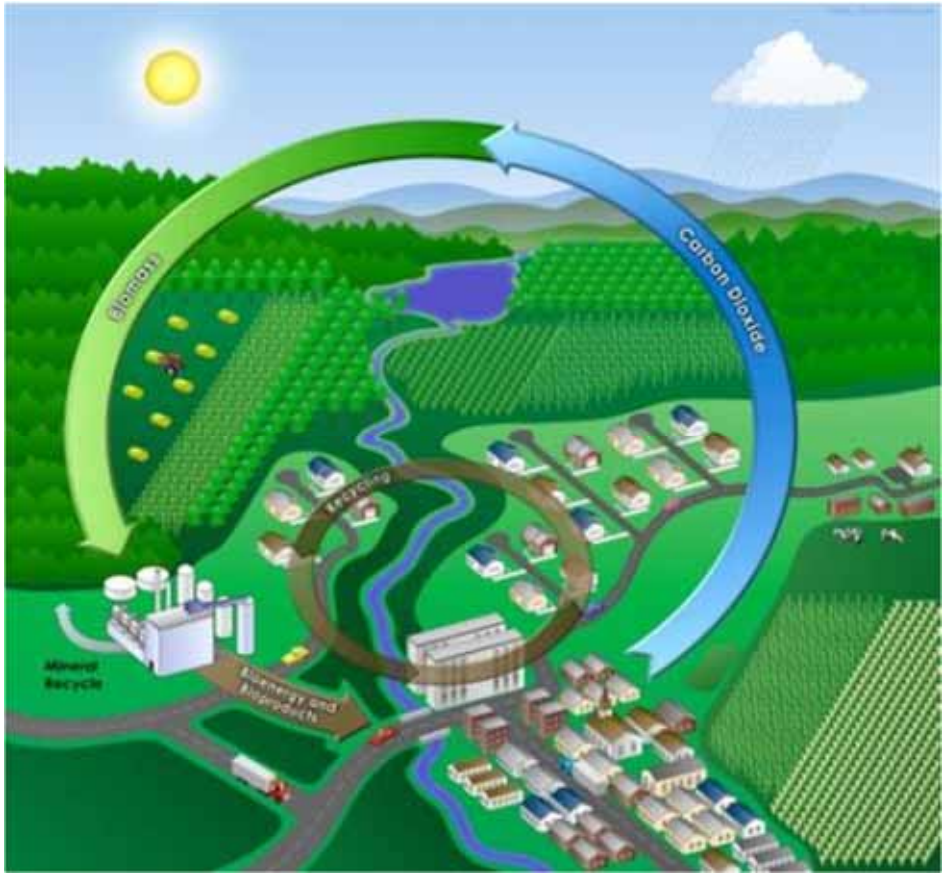
US Renewable Energy as a Percentage of Total (2004 Estimates)

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Many government and industry organizations in the US and abroad are developing biomass resources as alternative energy options.

Current US biomass energy production is comparable to hydroelectric (each nearly half of the renewable total), but is growing rapidly due in large part to government incentives and subsidies.

Biomass now accounts for about 3% of total US energy production.



Biomass Conversion

A variety of products can be created from such biomass sources as dedicated energy crops, plant wastes/residues and animal/municipal wastes.

Biopower technologies now produce more than 10 gigawatts of US electricity, and biofuel R&D is advancing.

Biomass-derived commercial materials include chemicals, plastics, fibers and structural substances.

Ian Smith
EESI

Minnesota Legislature
Marcello Movra

Biomass Products

Wood is the oldest and largest biomass energy source for cooking and heating worldwide.

Other biofuels are food crops (such as corn and various vegetable oils) animal crops (grassy plants), forestry and sawmill materials (woodchips and sawdust), and animal/landfill wastes (methane in particular).

Seeds of Change
Flagstaffotos

Fairfax Co. Pub. Schools
US Fish and Wildlife Service

While often though of as "green energy", burning biomass produces about the same amount of CO_2 as fossil combustion.

Advocates argue that biomass burning produces "new" greenhouse gas (vs. "old" greenhouse gas form fossil sources).

True accounting of biomass emissions must consider pollutants released from crop-growing, harvesting and processing.

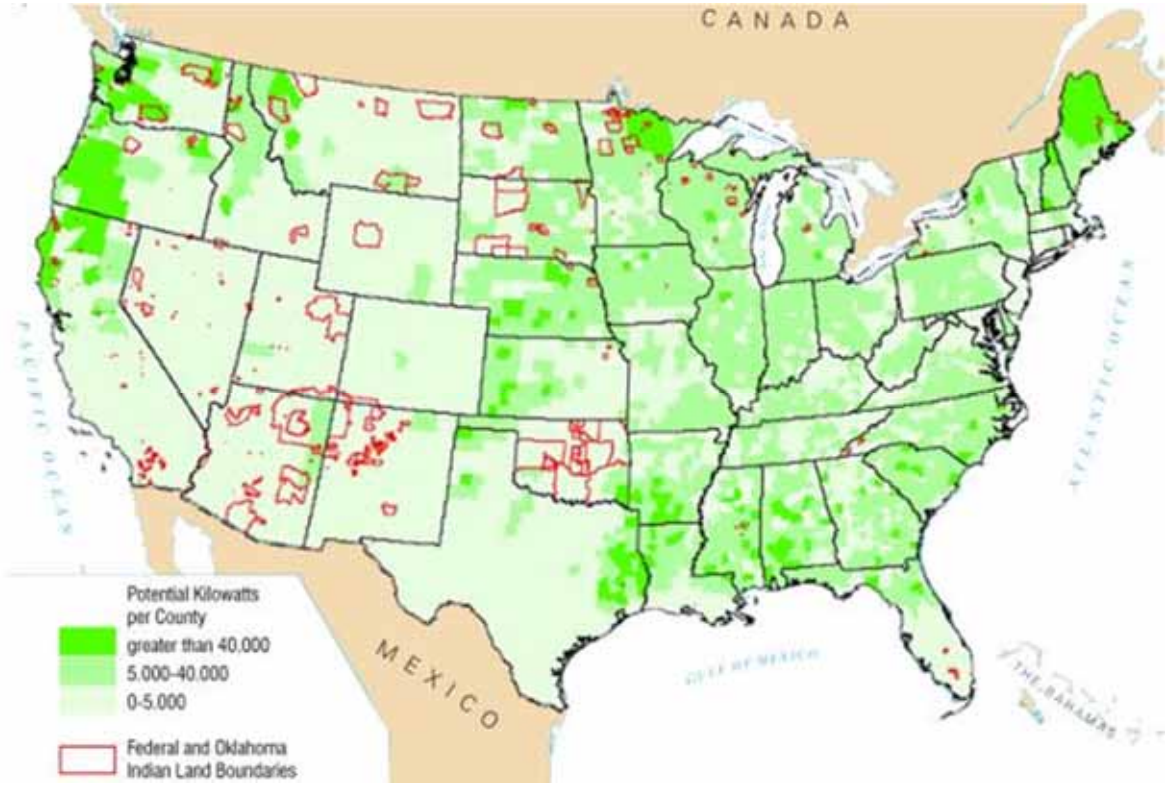
USDA-ARS
Stan Shebs

Bio-Energy Combustion

Biomass energy is considered by some to be nearly carbon-neutral in that it absorbs CO_2 from the atmosphere, during plant growth, approximately equal to the amount emitted in power conversion, producing fewer "new" pollutants than fossil fuels.

Advocates also predict that high-yield energy crops (fast-growing trees and grasses) and more efficient conversion technologies can reduce fossil fuel dependence.

The Global Change Program, University of Michigan



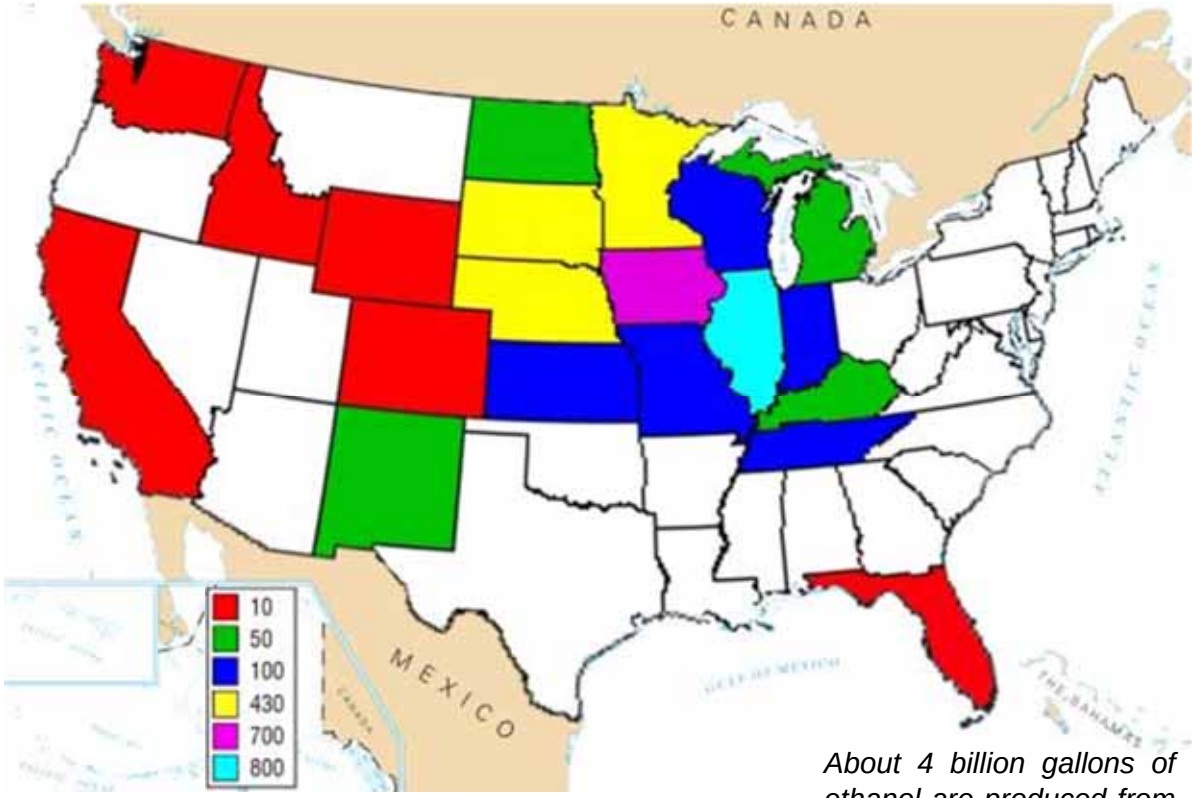
Potential Biomass Kilowatts of Energy per County

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Ethanol and biodiesel can supplement liquid fossil fuels in areas with large agricultural and forestry applications. Ethanol is also nationally-distributed as a gasoline additive to reduce CO_2 emissions.

While at peak demand levels these alternatives might only supply 10%-14% of US transportation needs, many believe it is a step in the right direction.

RunningonAlcohol.com



About 4 billion gallons of ethanol are produced from corn annually.

US Ethanol Production Capacity (Millions of Gallons per Year, 2003).

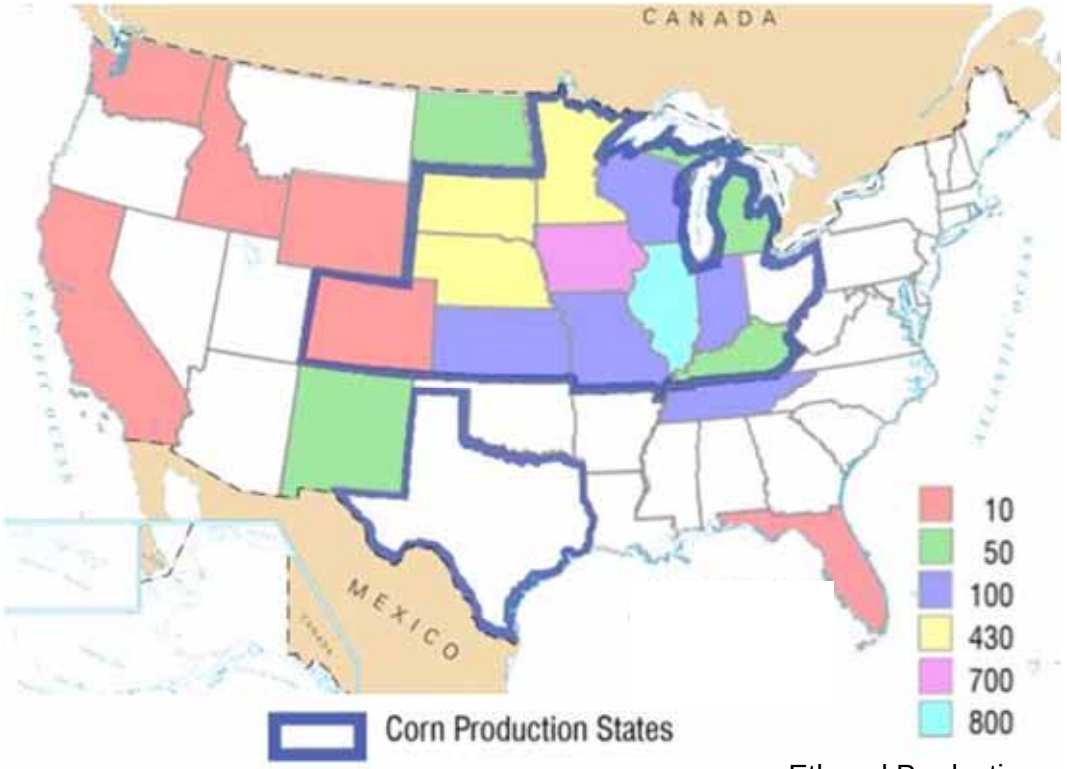
ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Ethanol use is growing rapidly as a gasoline octane enhancer.

More than 80 US ethanol production facilities presently exist (about half farmer-owned), primarily in North Central and West North Central States.

About 30% of all US gasoline is now blended with ethanol, and South Dakota devotes nearly 1/3 of its corn crop for this purpose.

Larry Bell / USDA



Ethanol Production Capacity, Millions of Gallons/Year (2003)

Key Corn and Ethanol States

Tyler Hamilton Foundation

Ethanol produced from plant cellulose is the same product as corn ethanol (ethyl alcohol) but uses waste material (stover) rather than only the plant kernel.

Cellulose ethanol production is accomplished using a variety of biorefinery hydrolysis and fermentation processes to break down fibres into glucose fuel.

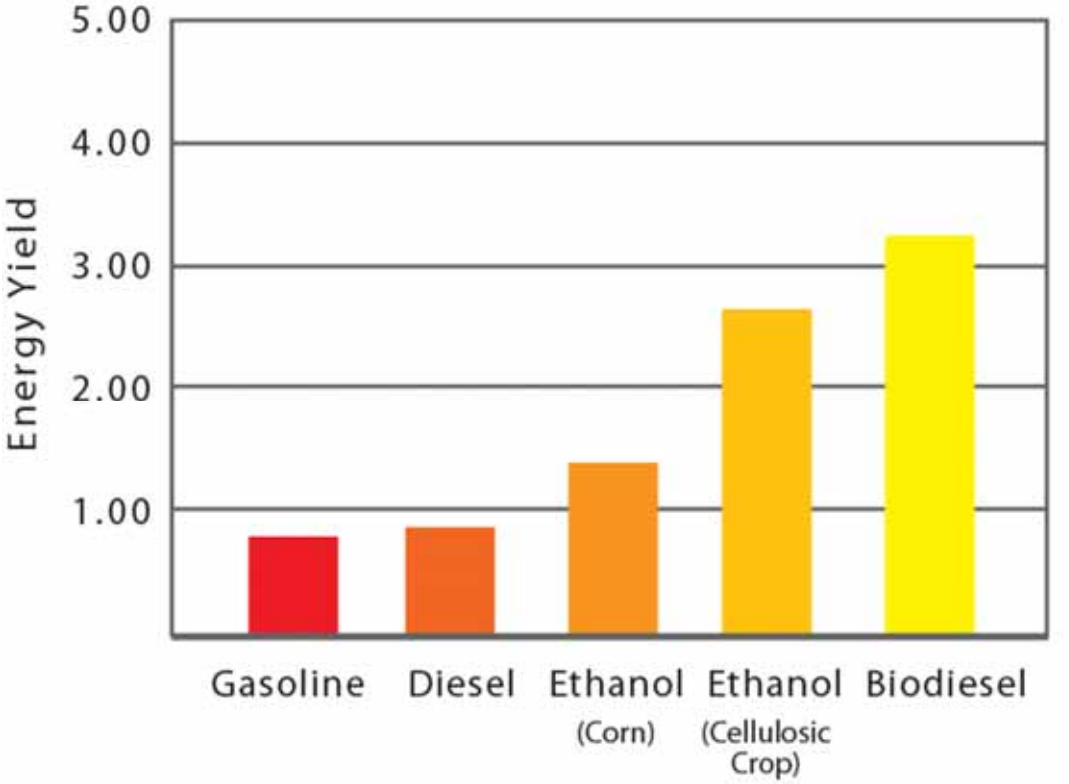
Extensive use of the plant material increases energy yield over corn ethanol but also adds process costs.

Biodiesel produced from plant oil blended with petroleum diesel can reduce fossil fuel consumption along with fossil (old-source) CO_2 emissions per unit of engine work.

This fuel can be used in standard diesel engines with comparable energy efficiencies to petrodiesel (about 80% vs. 83%).

Biodiesel reduces fossil fuel life cycle consumption about proportionately to its blended percentage.

US DOE-EERE



Energy Yield / Unit of Fossil Fuel Consumed on a Life Cycle Basis

Biodiesel

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Hydropower is the second largest US energy source and supplies about 19% of world electricity.

Opportunities to expand its use in developed nations are constrained because prime generating sites are either already exploited or unavailable due to environmental restrictions.

Hydropower is often used to supplement peak load demands and for small-scale off-grid local applications.

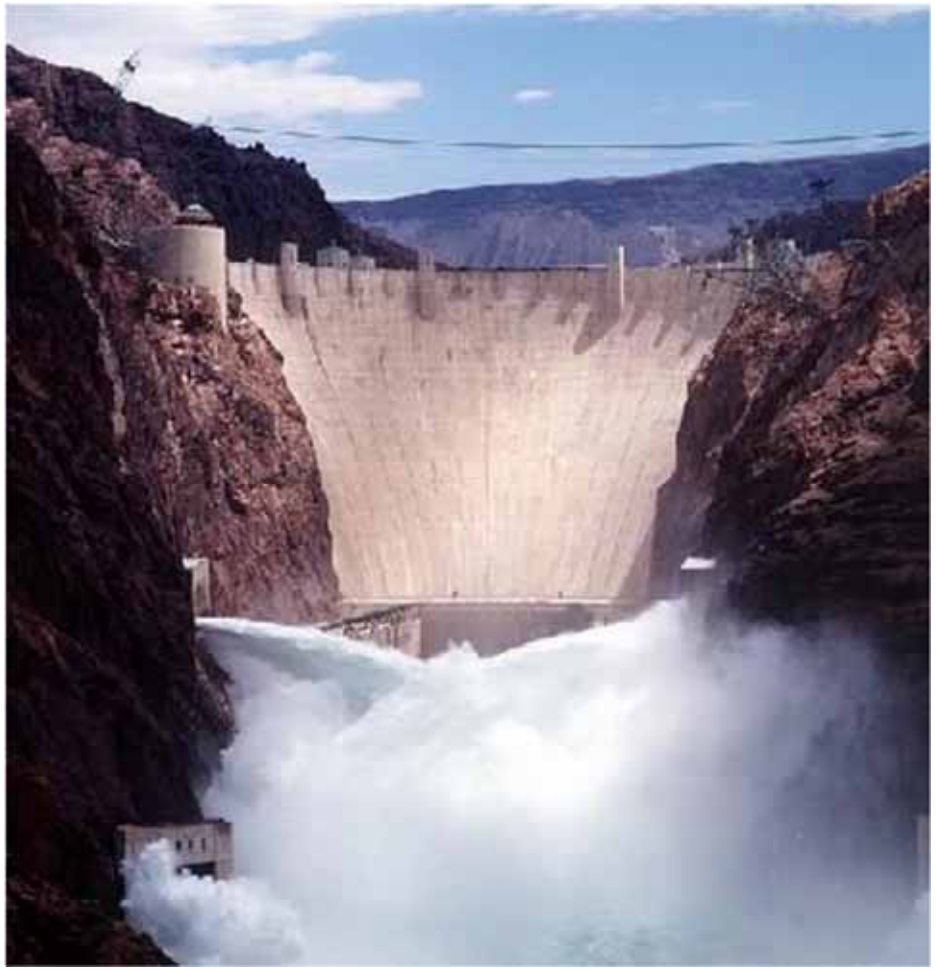
Hydropower

US Bureau of Reclamation

Hydropower now constitutes nearly half of total US renewable energy, and about 3% of total US electrical power.

While conservation of surface reservoirs has slowed considerably since the 1980's, hydropower is the dominant electrical source in Idaho and Washington.

Most US inland sites are already being used or are prohibited for environmental reasons, but new technologies to harness wave and tidal power may open up future resource opportunities.



Expansion Limitations

Hydropower technologies range from large-scale dams/turbines to very small "mini-hydro" and "micro-hydro" devices for domestic and stand-alone industrial applications.

Although the power production doesn't create CO_2 emissions or other pollutants, reservoir construction can cause methane to be released from decaying plant matter exposed in times of drought.

Ancient waterwheel devices for local uses are generally being replaced by highly-efficient small turbine systems that can harness water energy from mountain creeks and other sources.

Large-Scale Dam

Small-Scale Waterwheel

Traditional Applications

Large and medium-scale hydropower systems harness mechanical water energy form major dams, ocean waves and tides, and tidal streams.

Other than dams, most of the technologies used are quite new, and many exist only in prototype stages.

Tidal power, including tidal streams, are rapidly gaining international interest.

Wave power is a potential source of energy for countries with long coastlines and rough sea conditions.

Philip Greenspun
Marine Current Turbines, Ltd.

Dam

Atlantisstrom Germany
Wave Dragon

Tidal Power

Tidal Stream

Wave Power

Many potential hydropower dam sites are restricted form new development to protect fish and other wildlife.

Large numbers of young salmon in the Northwest are killed by turbine blades as they swim downstream towards the ocean, and adult fish attempting to swim upstream to reproduce are blocked by dams.

After salmon populations were dramatically reduced in the Northwest Columbia Basin, many fish ladders and side channels were built.

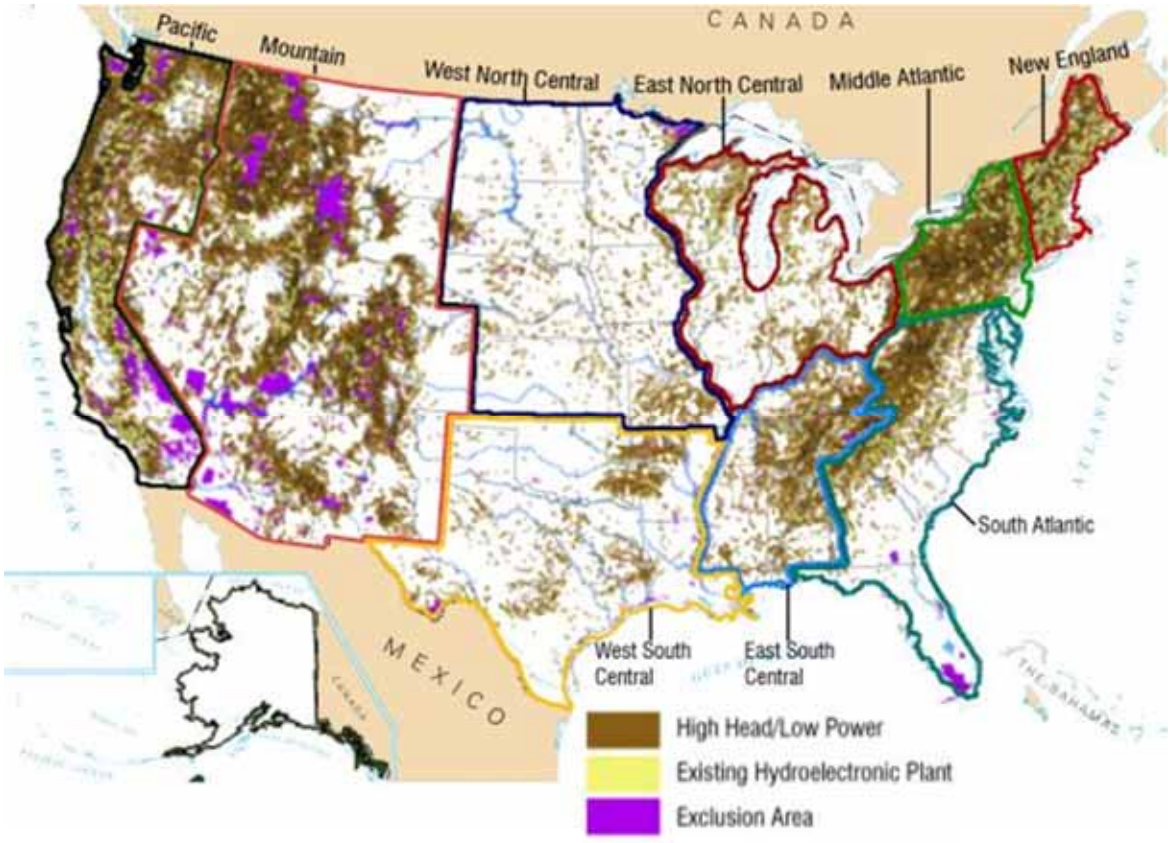
US Geological Service

The Atlas of North America

The Atlas of North America

While most sites for large dams are already used or restricted, there appears to be significant opportunities to expand small installations, particularly in western states.

A 2004 Department of Energy study estimated that US contiguous states might possibly double hydropower production using energy from rivers and streams.



Current and Future Hydropower Capacity

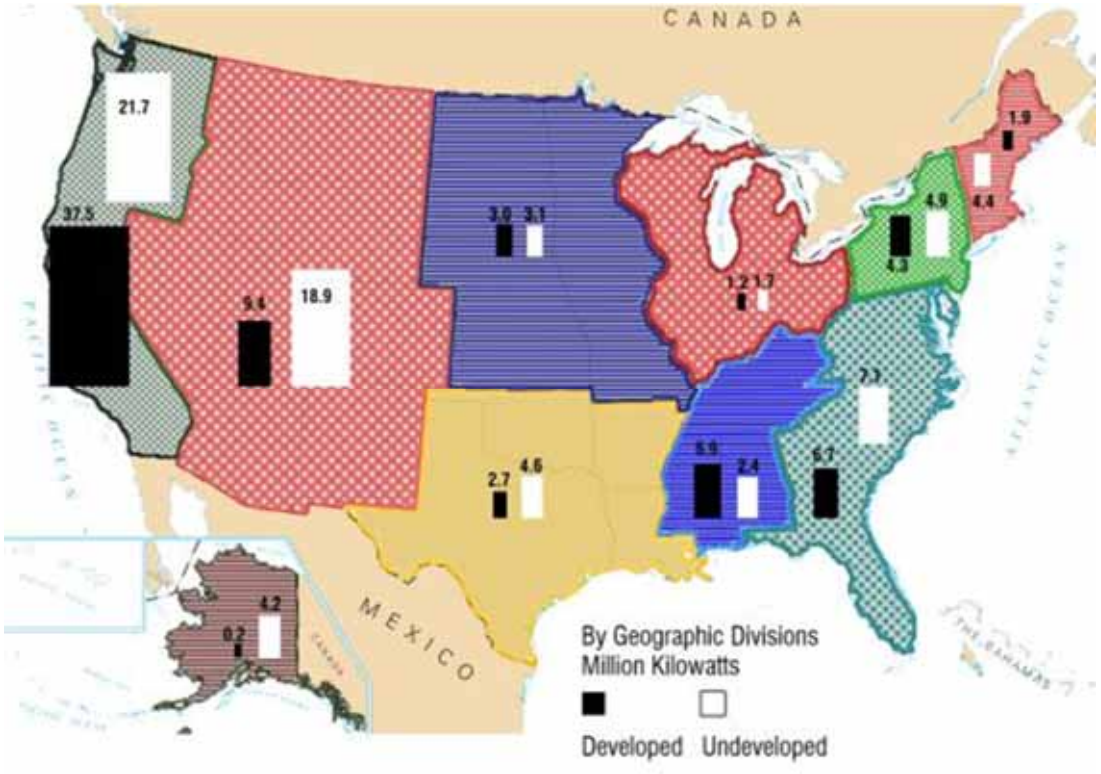
ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Hydropower generates about 2/3 of all electricity in the Pacific Northwest Region with an estimated underdeveloped capacity of about 50% more.

Washington has the highest generating capacity, and Alaska, California, Oregon and Montana have large new potentials.

Hawaii might be able to multiply its hydropower many times.

Nuclear Regulatory Commission



Hydropower Development Potentials

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

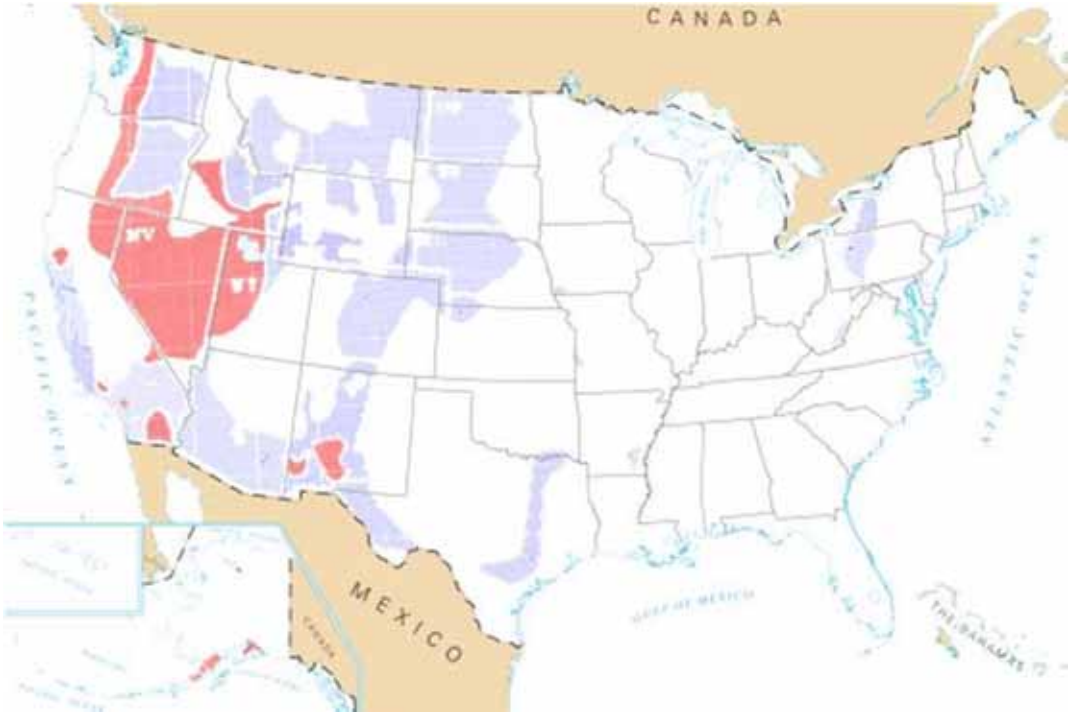
Geothermal power sites are limited, and now less than 1% of US electricity.

Economically-feasible geothermal resources are located mostly west of the Rocky Mountains, and only California, Hawaii, Nevada, and Utah currently have operating plants.

The majority of thermal springs and other surface manifestations of underlying geothermal resources are also located in the West, including Montana, North Dakota, and Wyoming.

Some low-temperature resources also exist in Central Texas.

The Global Change Program, University of Michigan



Los Alamos National Laboratory

In addition to hot water and steam geothermal sources, power can also be generated by tapping deep underground “hot rock” heat.

The Fenton Hill Hot Dry Rock site plant in New Mexico uses a 11,500 ft deep well drilled into rocks in a 430° F environment.

Water pumped into the well at 80° F returns to the surface at 360° F, producing up to 5MW of electrical power.

Geothermal Hot Dry Rock Plant

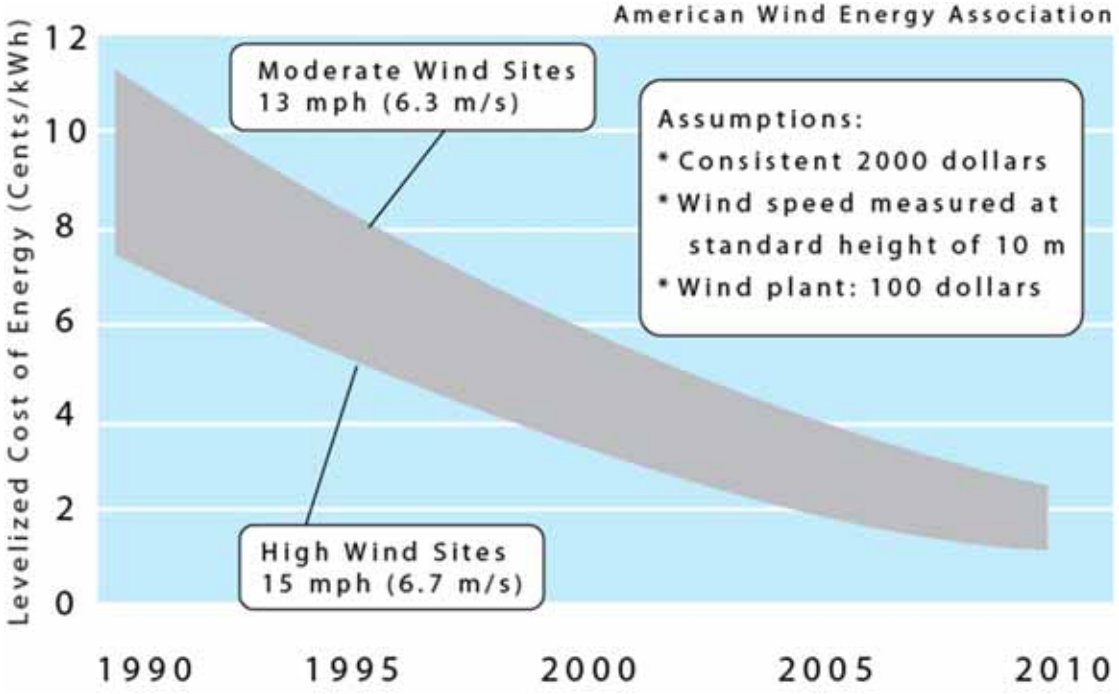
Wind power now provides only about 2% of US renewable energy (0.12% of total electricity) but is rapidly growing.

This growth is strongly supported by new state government energy policies and the success of "green marketing" across the country.

Interest in small stand-alone systems is also growing.

Small units can operate with wind speeds as low as 8 mph, and large ones at 13 mph.

Kaheawa Wind Energy, American Wind Energy Assn.



Energy Production Costs for Large Commercial Wind Projects

Wind Energy

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Wind energy popularity tends to fluctuate with fossil fuel prices, but improvements in turbine technology are spurring new interest.

Wind farms connected to public utility grids have become a significant renewable energy option in the US and Europe, and are the fastest growing global alternative energy source.

Sandia National Laboratories

Offshore Wind Farm

Iowa Energy Center

Worldwide wind capacity more than quadrupled between 1999-2005, with 90% of total installations in the US and Europe (Germany representing 32% of this amount).

Some advocates believe that land and near-shore wind can supply much of the world's power needs, although optimum sites are limited by topographical, land use and seasonal weather conditions.

Wind Sites Can Share Other Uses

While wind is generally characterized as a clean energy source, new wind farm proposals often face public resistance on environmental and aesthetic rounds.

Many developments have been blocked by resident concerns about the influences upon bird migration/nesting patterns and visual impacts upon picturesque vistas.

Seashores are often good wind locations, but also high-value real estate areas.

Offshore turbines encounter less opposition but are more expensive and difficult to maintain.

Research Institute for Sustainable Energy
Greenpeace

Environmental and Visual Objections

Bruce Center for Energy Research and Information

Wind isn't always available when or where needed most.

Daily and seasonal levels can fluctuate considerably.

Regional and local power demand levels also fluctuate on a seasonal and daily basis.

Winter winds tend to be strongest, which can be helpful to enable northwestern states to capture mountain winds during periods of least sunlight to fill cold weather power gaps.

Wind Farms Tend to be Located Far from Power Demand Centers

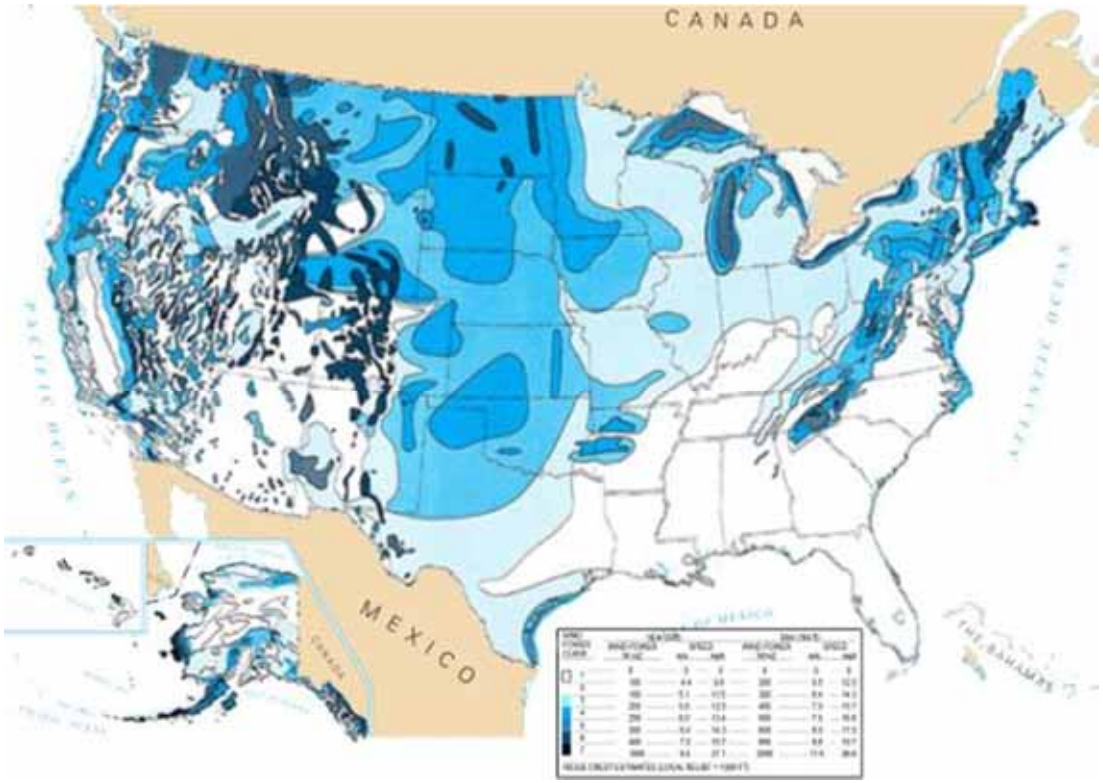
In 2005 the US added 2,431 MW of new wind energy capacity, more than any other country.

American wind farms may save an estimated half billion cubic feet of natural gas a day.

Good wind sources are located in the Great Lakes Region and along eastern, western and southern coasts.

Important inland areas include the Great Plains, mountains of Appalachia and western state mountain wind corridors.

Arizona Solar Center



Annual Wind Power Resources

Advantages

- Wind is renewable, produced by solar heating of the atmosphere.
- It is an abundant US source of energy to reduce dependence on oil imports.
- Wind is one of the lowest-priced renewable energy technologies (about 4-6 cents/kilowatt hour).
- It is a clean source of energy – doesn't pollute like combustion processes.
- Wind turbines don't produce acid rain or greenhouse gases.
- Turbines can be installed on farms or ranches to provide income and local power.
- They can also be combined with other land uses such as livestock.

Disadvantages

- Depending upon site wind conditions, turbines are not always cost-competitive.
- Technology requires higher initial investment than fossil fuel generators.
- Since wind is intermittent, energy is not always available when needed.
- Good wind sites are often remote from areas where electricity demands are high.
- Wind sites can compete with other land uses such as agriculture.
- Noise from blades and visual impacts are sometimes considered to be objectionable.
- Birds are occasionally killed by flying into rotor blades.

Wind Energy Advantages and Disadvantages

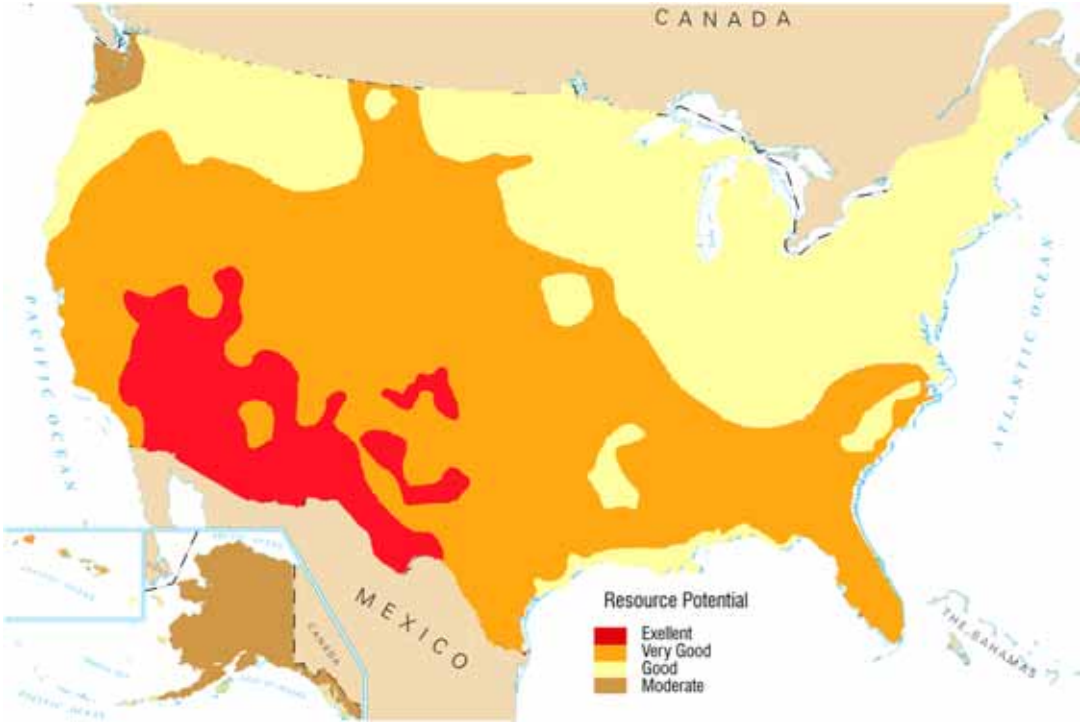
Solar power supplies less than 1% of US energy, but offers substantial expansion possibilities.

Domestic photovoltaic (PV) capacity grew about 20% between 2005-2006.

Many new concentrating solar power systems are planned in sunny southwestern states during the next decade.

Domestic solar water and pool heating is growing most rapidly, increasing about 50% from 2006-2007.

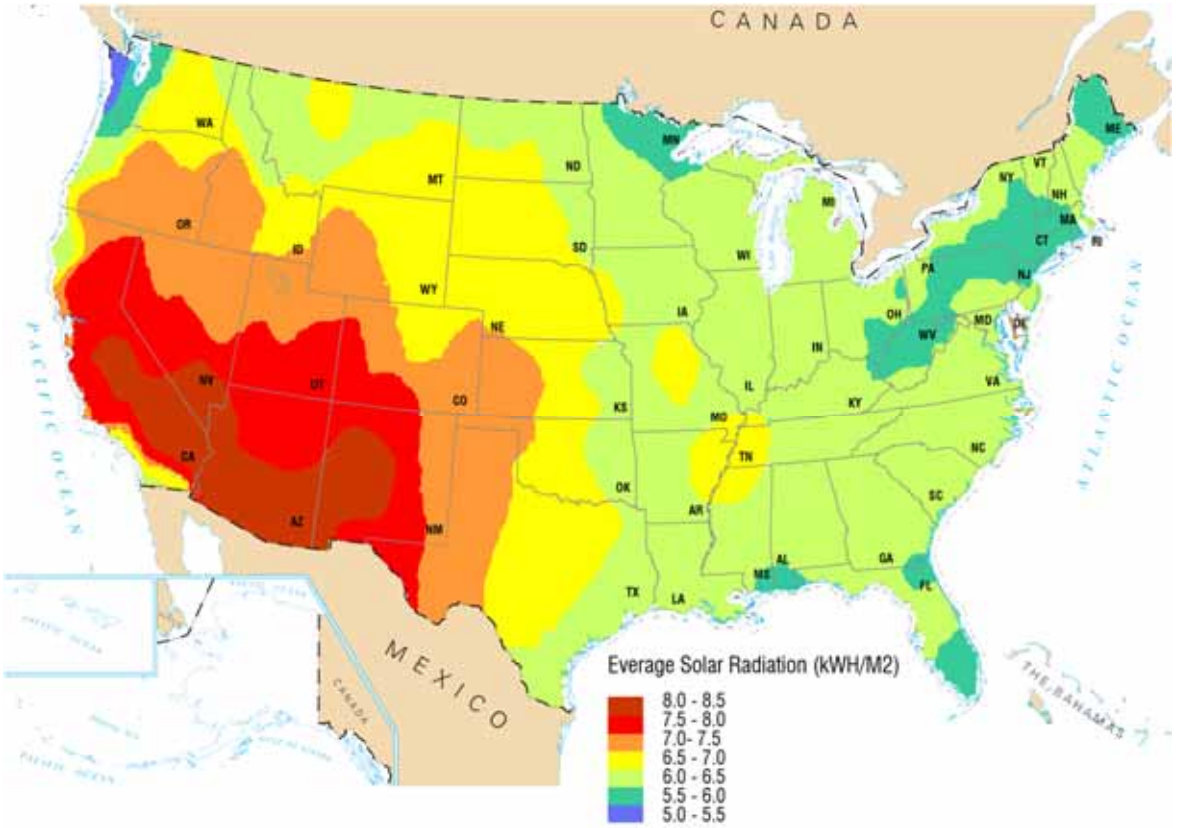
North Carolina Department of Administration



Solar Resource Potentials

Much solar power industry growth has resulted from federal and state government incentives including programs that enable customers to sell excess electricity back to grids.

California leads the US in grid-tied systems (73% of the nation's total), followed by New Jersey.



In many parts of the US, highest PV outputs and demands are on hot sunny summer days.

Solar Worst Case Month (June) Demands

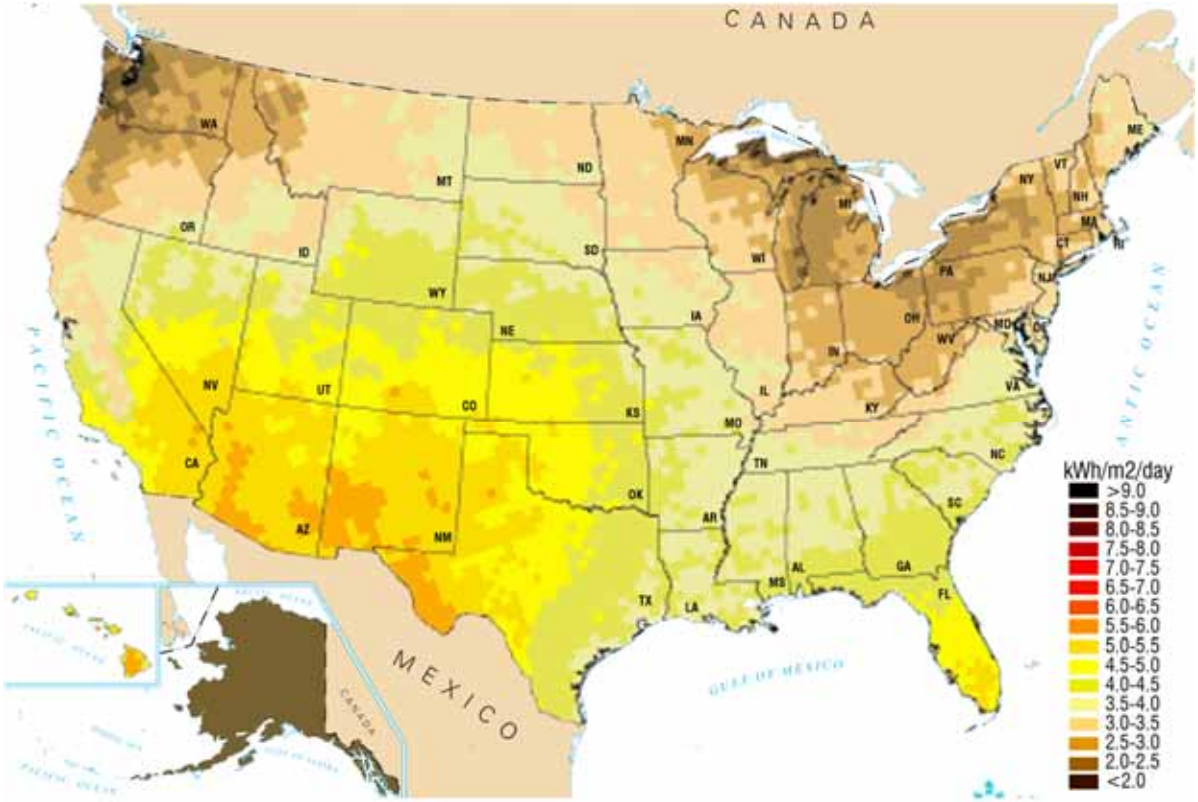
Average Solar Radiation (kW hours/m^2)

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

Several factors inhibit solar power expansion.

Sunlight availability varies considerably according to latitude, seasonal Sun angle influences and prevailing regional weather, sky and atmospheric conditions.

System costs currently require several years for recovery, which discourages investment unless compensated by incentive programs.



This map shows the amount of solar energy in hours received each day on an optimally-tilted surface.

Solar Worst Case Month (January) - Supply

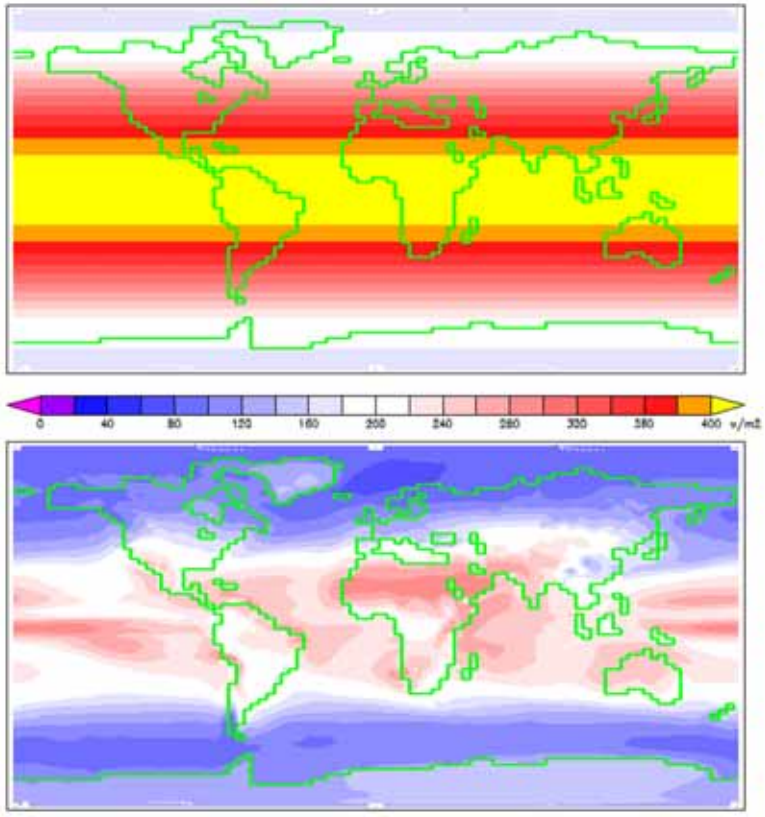
PV Solar Radiation, Flat Plate Facing South Latitude Tilt

Geographic and atmospheric limitations pose constraints on widespread PV utilization.

While traveling through the atmosphere, about 6% of solar energy is reflected back to space and about 60% is absorbed on the surface.

Average atmospheric conditions (clouds, dust and pollution) further reduce incoming amounts by about 20% through reflection, and about 16% through absorption.

Atmospheric conditions also affect the quality of sunlight reaching the surface, diffusing light and altering the spectrum.



Theoretical annual mean insolation, at the top of Earth's atmosphere (top) and at the surface on a horizontal plane.

Solar energy is widely used for a variety of applications, often where other sources are not available.

Many small-scale systems supply electricity for off-grid domestic power, irrigation pumps and other services, and direct solar thermal radiation is used for space heating, hot water and cooking.

Large solar thermal concentrators produce steam or heat gasses to drive electricity-generating turbines, and PV concentrators convert solar energy directly into electricity.

ePrairie, Inc.
National Renewable Energy Laboratory

Off-Grid Electrical Power

Genersys ireland
US DOE-EERE

Water and Space Heating

Solar-Thermal Power Plant

Solar Photovoltaic Power Plant

PV systems that convert sunlight directly into DC electricity are used extensively both on Earth and in space.

Important advantages are lightweight, modular, foldable construction that is simple to transport and install in remote locations.

PV is principally used for supplementary power in locations that afford frequent access to sunshine, often with battery storage and in combination with wind power devices.

Converting Sunlight to Electricity

US DOE-EERE

This 6.5 kilowatt PV array supports an all-purpose general store, restaurant, gas station and public campground near Moab, Utah.

Worldwide sales of small PV systems have recently been increasing at an annual rate of about 60% partly due to manufacturing cost reductions.

US PV markets have greatly benefited from tax and rebate incentives offered by various jurisdictions which enable installation cost recoveries in 5-10 years rather than 20 or more.

These two silicon modules are rated at 50 watts each, and generate power to illuminate a large entry sign.

Small-Scale Commercial Applications

Advantages

- **Sunlight energy is free following initial PV installation costs, and is non-polluting.**
- **Installations can operate with little maintenance after initial setup is accomplished.**
- **Systems are particularly beneficial in remote locations where public utility connections are not available.**
- **Grid-connected systems can displace highest-cost electricity during times of peak demand.**
- **Grid-connected systems can sometimes transfer excess electricity to the grid for energy credits.**
- **PVs can often be combined with wind power and other energy sources to optimize power production.**

Disadvantages

- **Installation and replacement costs may require several years to recover.**
- **Solar panels have limited power density, ranging from only about 7%-17% efficiency.**
- **High-latitude regions and locations with frequent cloud cover and dust limit effectiveness.**
- **Solar power is not available at night or during rainy/cloudy periods when electricity may be needed.**
- **Batter power storage, if needed, imposes large energy penalties, costs and space requirements.**
- **Inverters to convert DC to AC electricity also impose significant energy efficiency penalties.**

PV Installation Advantages and Disadvantages

US DOE-EERE

Concentrating solar photovoltaic power (CSPP) is a cost-effective form of electricity generation in certain sunny locales.

Some systems can provide many MW of power with efficiencies exceeding 35%.

Sophisticated mirrors and tracking devices typically restrict practical uses to electric utility and industrial or large building applications.

Concentrating Solar Photovoltaic Tower

James Fraser

Concentrating solar power (CSP) systems use lenses or mirrors that tract the Sun to focus radiation on thermal collectors or PV cells.

Systems range in size from home-size units of about 10 kW to more than 100 MW for utility-scale applications.

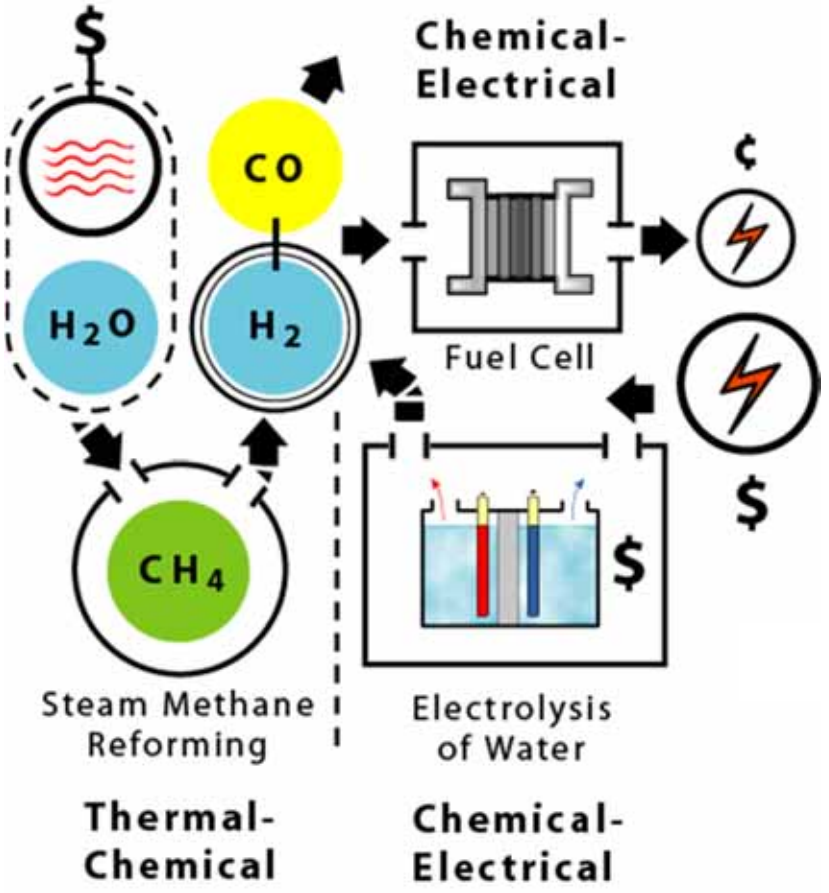
Installations are limited to sunbelt locations, and power storage is often incorporated for nighttime and cloudy periods.

Concentrating Solar Thermal Power

Hydrogen and methanol can be derived from renewable sources (water electrolysis for hydrogen, and biomass for both), but are primarily produced as fossil derivatives.

Most hydrogen is produced from steam methane reforming (SMR) of natural gas, yet the same process can also use biomass methane.

H_2 production using electrolysis of water requires more energy than can be recovered from the gas. (It is an "energy carrier", not an "energy source".)



H_2 Production Economics

Hydrogen not only requires more energy to create than it yields, but also imposes additional energy costs/penalties for compression, liquefaction, transport and bulk storage.

When produced using SMR of natural gas, additional CO_2 pollution penalties result which can exceed emissions caused from burning natural gas directly.

Although SMR itself produces fewer CO_2 emissions than direct burning, twice as much H_2 is needed for equivalent energy because fuel cells are only about 50% efficient.

Geocities

Hydrogen

An offsetting energy advantage of hydrogen fuel cells for some uses is an opportunity to capture heat in addition to produce electricity, but at high energy processing, containment, and transport costs.

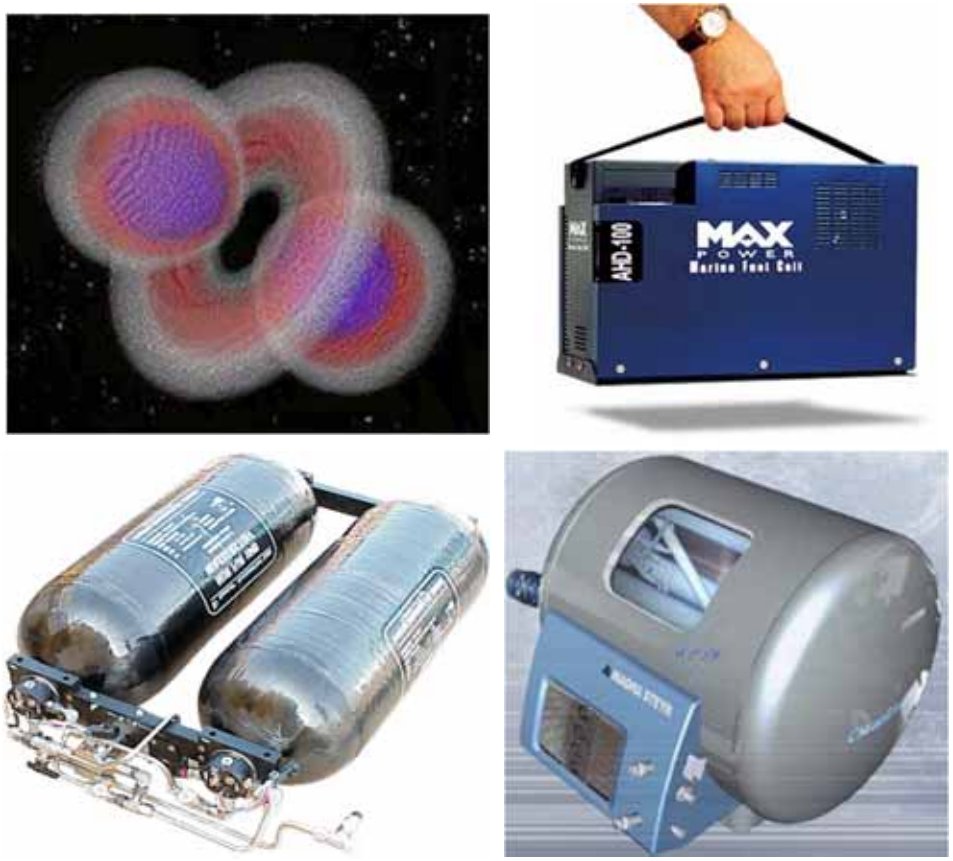
H_2 is highly combustible and difficult to move through pipelines (it leaks out).

When pressurized, strong, heavy tanks are needed to compensate for low energy/volume density, adding expense.

Liquid hydrogen (LH_2) requires heavy tank insulation to prevent boil-off, and liquefaction requires energy.

Purdue University
Micro-vett

E-Marine, Inc.
University of Birmingham



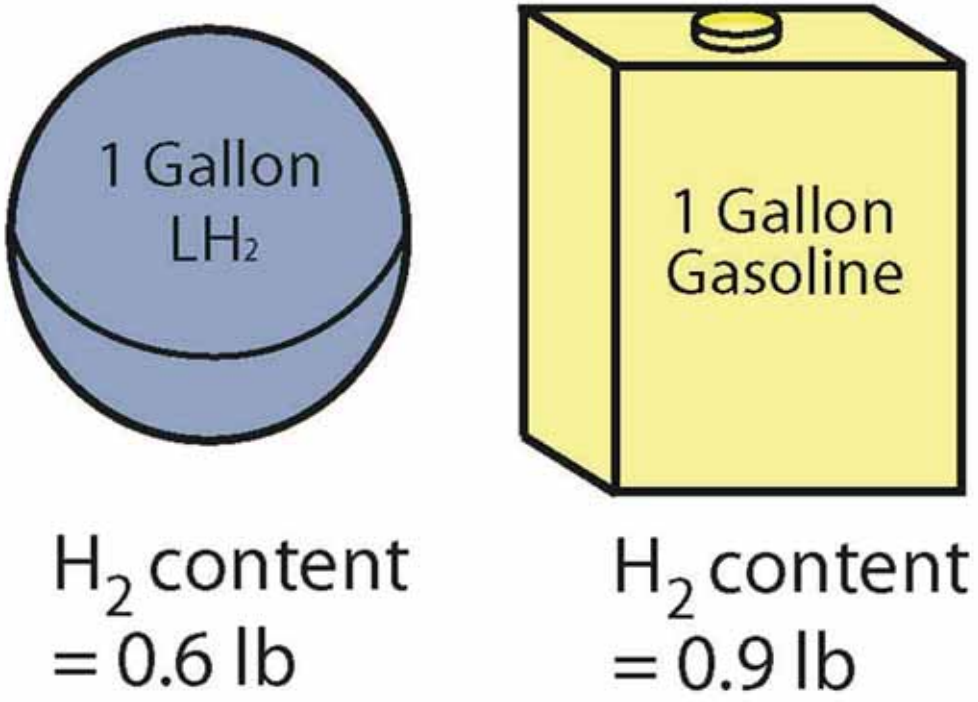
Hydrogen Transit and Containment

Larry Bell

It maybe a long time before hydrogen will have a major place in the automotive energy economy as a substitute for liquid hydrocarbon fuels.

LH_2 has a worse energy density / volume than gasoline by a factor of about four.

There is about 50% more H_2 in a gallon of gasoline weighing 0.9 lb, than in a gallon hydrogen weighing 0.6 lb



Hydrogen Gas (H_2)

- Highly combustible, will burn in concentrations as low as 4% H_2 in air.
- Hydrogen explodes upon ignition when mixed with oxygen.
- Reacts violently in contact with chlorine and fluorine.
- Readily leaks due to small molecular size through porous materials, cracks or bad joints.
- Has good energy density per weight, but poor density per volume (compared with gasoline).

Liquid Hydrogen (H_2)

- Has higher volumetric energy density than gaseous H_2, but requires low temperature storage.
- Has much worse energy density per volume than gasoline.
- Expensive tank insulation is required to prevent boil-off (LH_2 boils at about -423°F [-253°C]).
- LH_2 is cold enough to freeze air, and can cause valves to plug up in automotive fuel applications.
- Production and transportation of LH_2 or H_2 can require more than twice the energy recovered.

Hydrogen Form Characteristics as Energy Carriers

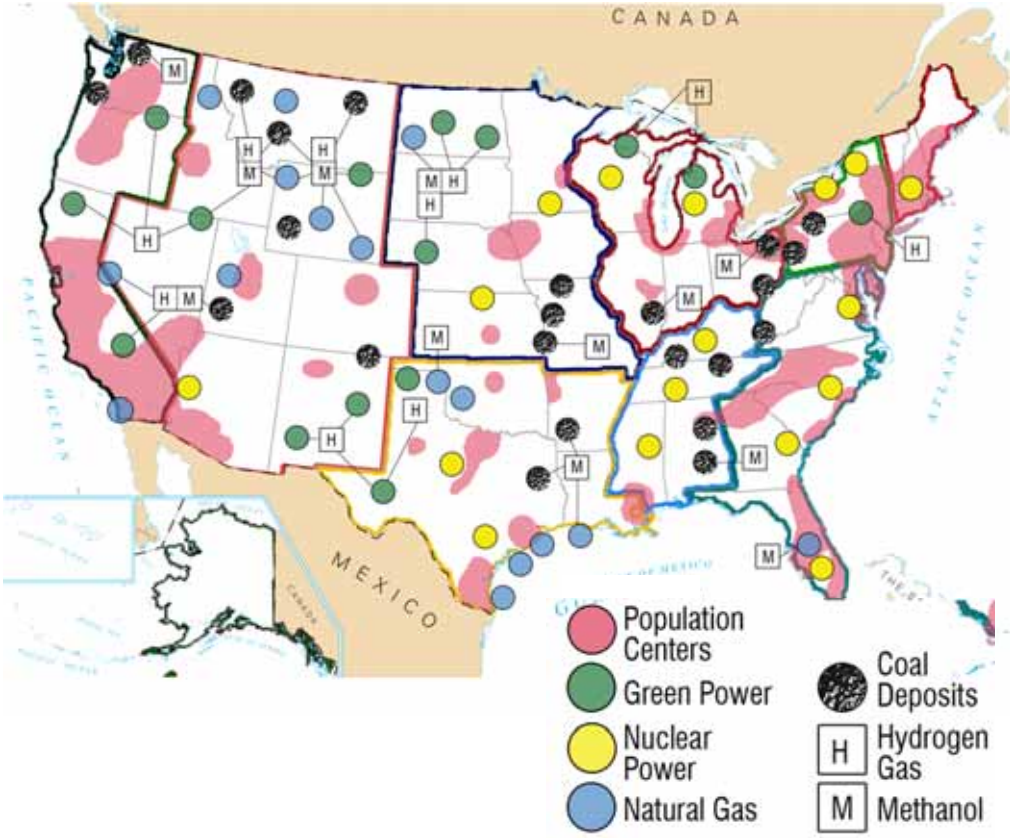
As oil reserves are depleted, hydrogen and methanol may become much more significant transportation fuels.

Methanol has advantages over hydrogen of safer / easier transport and versatility for use in internal combustion engines and in direct methane fuel cells (DMFCs).

Resources both are distributed throughout the US (nuclear power for H_2 electrolysis, and coal, natural gas and biomass for either methanol or H_2).

While hydrogen can be used near production sources to minimize transport, methanol can be distributed long distances using existing petroleum infrastructures.

Larry Bell / GEC / NREL/ US DOE



Potential Hydrogen and Methanol Production Areas

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

National Renewable Energy Laboratories

Hydrogen electrolysis can utilize "free" renewable wind and hydropower resources.

Wind power is a rapidly-expanding energy production segment with significant growth potential.

Hydropower often serves as a source of electricity to fill power gaps, and can be used to produce hydrogen from local water reservoirs between peak demand periods.

The H_2 produced from either source can provide a means for energy storage and/or a fuel product for local applications.

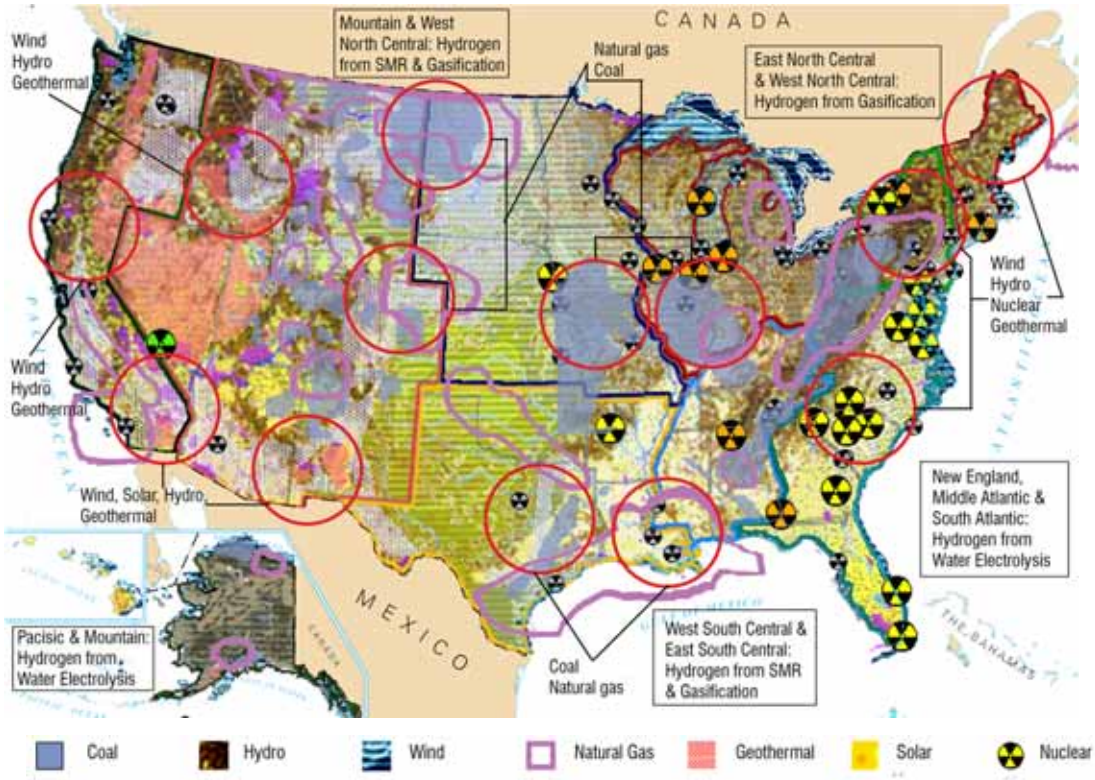
Forces of Nature

Practical hydrogen benefits require regionally-available processing energy and localized use to minimize transport.

Abundant renewable electrical power resources concentrated in Pacific, Mountain, and Atlantic states can serve hydrogen processing for highly-populated western and eastern coastal areas.

Coal and natural gas concentrations in Mountain, West North Central, East North Central, West South Central, and East South Central regions can support production through SMR

Larry Bell / GEC / NREL / AFC



Hydrogen Production

ENERGY RESOURCES **RENEWABLE ALTERNATIVES**

The US is fortunate to have diverse regionally-distributed energy resources that reduce dependence upon singe-source solutions.

This advantage helps to minimize fuel transport and power transmission efficiency losses by providing sources near demand areas.

Coal and nuclear plants concentrated in the upper Midwest and Northeast support regional power-intensive industries and dense population centers.

Hydropower, natural gas, and oil-fueled plants are prevalent in high-density coastal areas.

US DOE / How Stuff Works

US and Regional Diversity

US DOE / How Stuff Works

Power grids of different sizes connect generating plants throughout the country.

Computerized systems at each control area operations (CAO) center monitor power grid activity, balance supplies to meet demands, and prevent overloads.

Population and industry shifts influence demand capacities that must be accommodated.

Electrical Power Grids and Control Centers

Oakridge National Laboratory

Coal, the world's most abundant fossil fuel, will be an essential energy source for many years, and consumption rates will continue to rise.

The US and many other countries are investing heavily in initiatives to minimize environmental impacts of this trend.

Gasification and other "clean coal" technologies are being developed and advanced to remove CO_2 and other pollutants such as sulfur and nitrogen that form droplets of weak sulfuric and nitric acid ("acid rain").

"Clean Coal" Gasification Plant

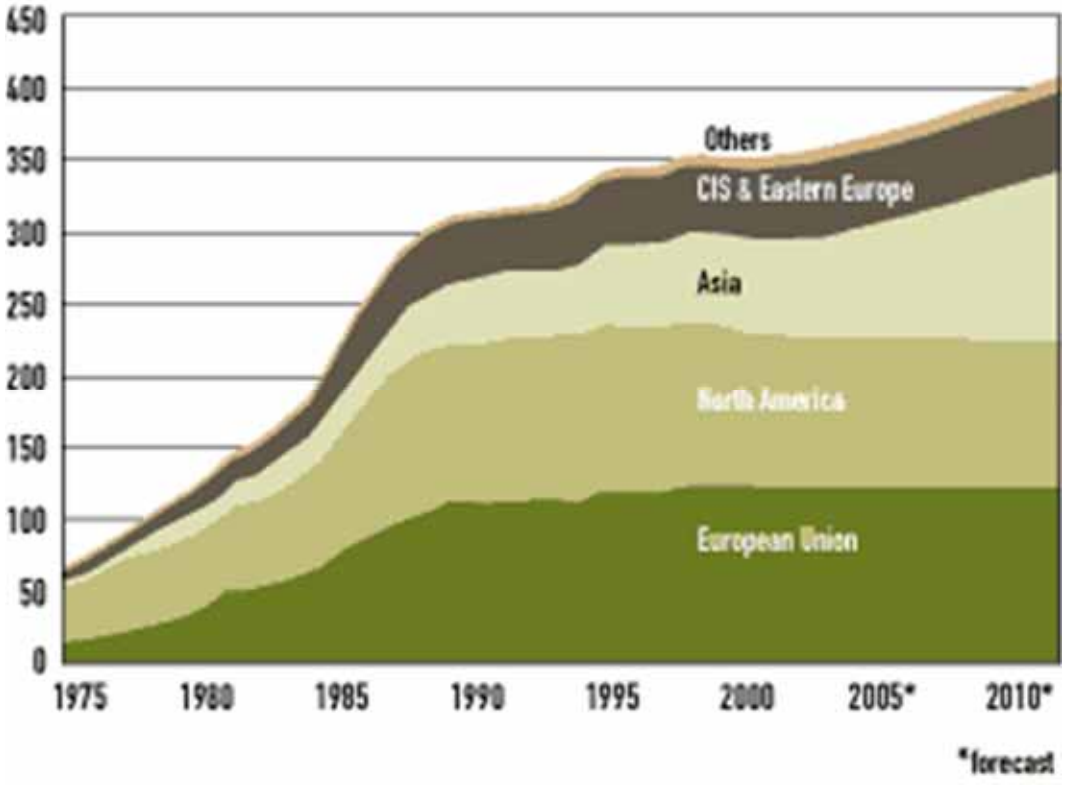
Coal

Coal, nuclear power, and wind are broadly considered to be the only energy sources that can be expanded enough to reduce oil and natural gas dependence after production peaks.

Nuclear reactors are more energy-efficient than coal or natural gas, and do not emit CO_2 or aerosols into the atmosphere.

Surprisingly, nuclear reactors also release less radioactive waste into the atmosphere than coal burning.

Areva Resources Canada, Inc.



Existing and Projected Nuclear Power Output
Gigawatts of Electricity

Following coal, nuclear power is the second largest US electricity source (about 20% of the total).

Nuclear plants are most heavily concentrated in seven Midwestern and Eastern states led by Illinois (6) and Pennsylvania (5).

Nuclear power provides nearly three-fourths of Vermont's electricity; about half of the electricity in Illinois, South Carolina, New Jersey, and Connecticut; about 40% in New Hampshire; and nearly 30% in New York.

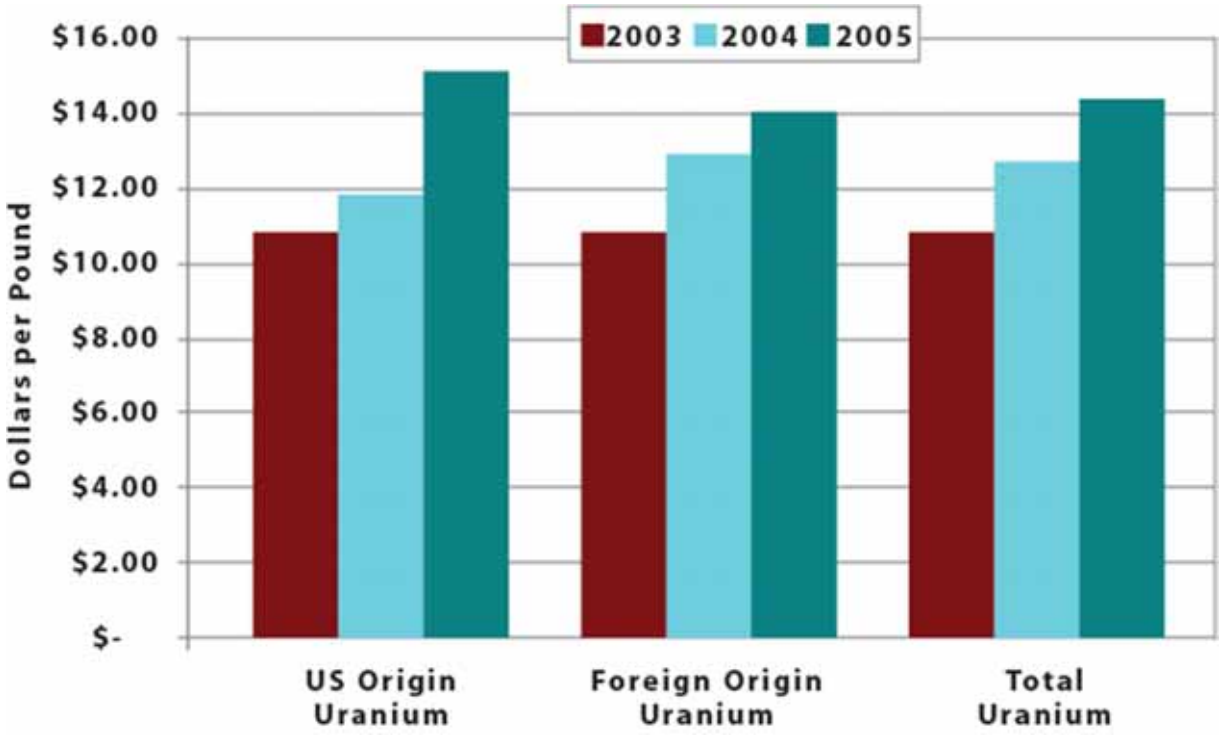
Larry Bell / US DOE - EERE

Although nuclear plants are more costly to build than coal or gas-fired plants, nuclear fuel is cheaper than coal on the basis of energy output, and coal is less expensive than natural gas.

Licensing, inspection and construction of nuclear plants add large implementation costs and delays.

Streamlining and standardization of regulatory processes can offer strong development incentives.

US DOE-EIA



Costs of Uranuim Purchased by Owners and Operators of US Civilian Nuclear Reactors by Origin and Delivery Year, 2003-2005.

“Secondary” wind, solar, hydroelectric and geothermal power options are strongly governed by geographic and sight-specific conditions that constrain expansion.

Mechanical energy from wind and hydropower is limited to locations with satisfactory seasonal climate and prevailing weather conditions.

Wind and solar power are intermittent and somewhat unpredictable.

Hydroelectric and geothermal expansion is severely limited by scarcity of unexploited sites and environmental restrictions.

SKF Group
How Stuff Works

EV World
ACRE

Mechanical and solar power is limited to sites with favorable weather conditions.

Hydroelectric and geothermal expansion is constrained by a scarcity of sites and environmental restrictions.

Expansion Limitations

While wind currently provides only a tiny amount of total US electricity, exploitation of this resource is rapidly increasing.

US growth in this area is being spurred by electricity and natural gas price hikes in combination with passage of Production Tax Credit (PTC) legislation by the Congress in 2004.

It is estimated that about 9,000 MW of wind energy (approximately the 2006 US total) can reduce natural gas consumption by 4% - 5%.

Unlike nuclear plants, coal-fired facilities and LNG terminals, wind farms can be built and permitted in only about 1-2 years.

Greenpeace

Wind Power

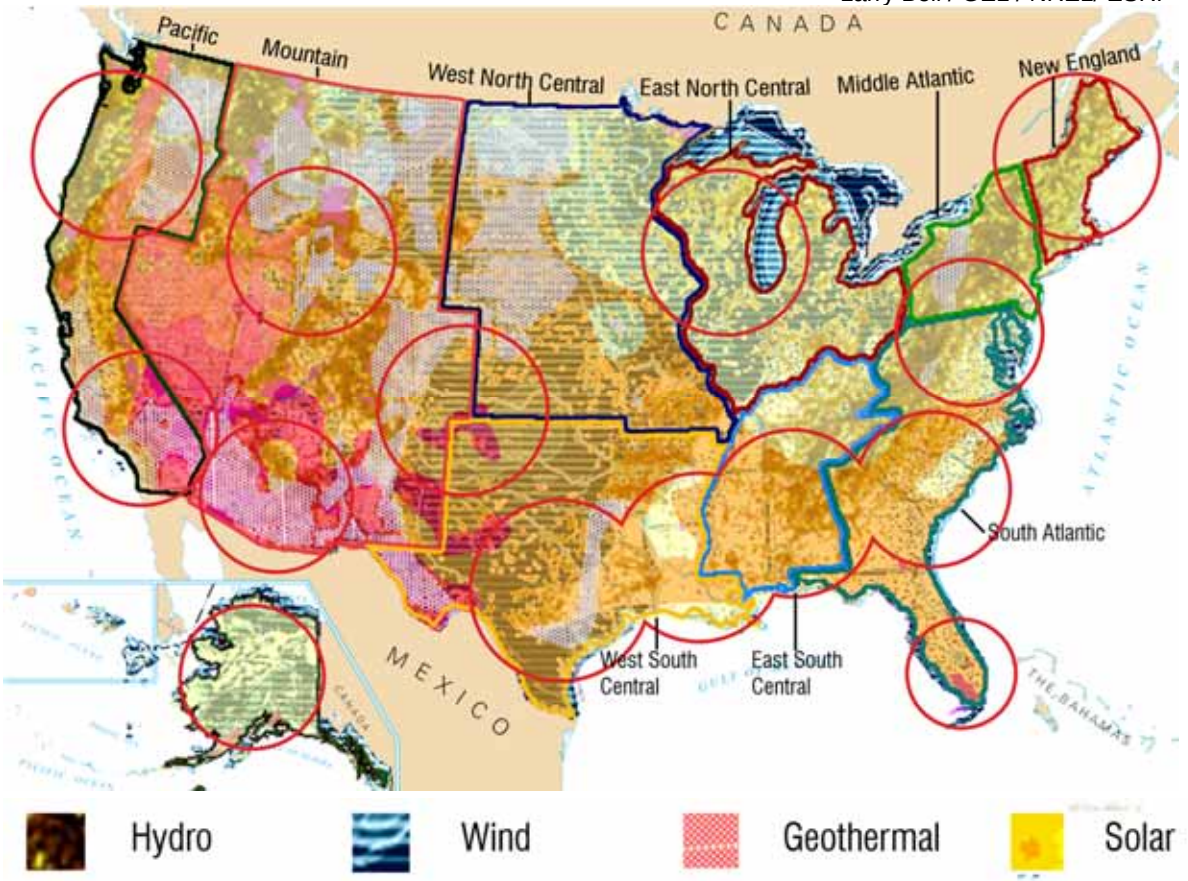
Larry Bell / GEL / NREL/ ESRI

Renewable energy sources aren't always abundant where demands are greatest.

Wind and solar energy conditions are often most ideal in areas remote from population centers.

Geothermal energy is highly localized in the western half of the US, including Alaska and Hawaii.

Hydropower is most abundant in sparsely-populated Pacific and Mountain Regions along with states bordering the Atlantic.



Circles show areas where multiple types converge to expand outputs and benefits.

Renewable Power

National Renewable Energy Laboratory

While very useful as a means to conserve energy use for space and water heating, solar energy is unlikely to become a major source of power to supply national needs.

Expansion of utility-scale solar installations is limited by a scarcity of sites with adequate / dependable sunlight.

Most good locations for utility-scale solar power applications also tend to be remote from population centers.

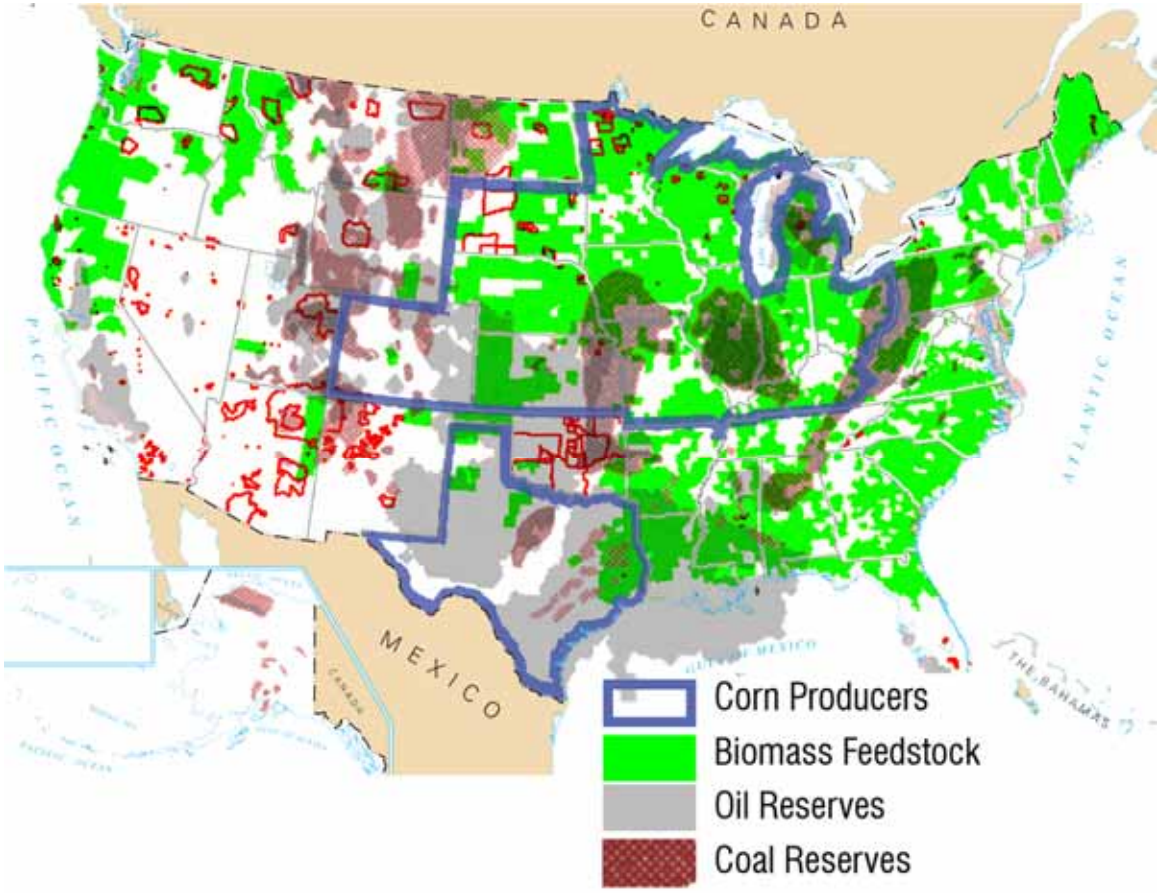
Solar Power

Larry Bell / GEC / NREL/ US DOE

Biomass resources can provide energy fuels to extend diminishing fossil reserves.

Corn ethanol opportunities are most prevalent throughout West and East North Central Regions, and in north central Texas, Kentucky, and Colorado.

Cellulosic ethanol are more broadly distributed, and may become increasingly important as conversion process efficiencies advance.



Liquid Fuel Sources

Although corn ethanol is presently touted as a key bio-fuel contender to extend fossil supplies, the actual net energy gain following production, harvesting, and processing is relatively small (possibly 34%).

It is much more economical to reduce fossil use than to replace excess consumption with bio fuels.

Bob Swihart

Corn Ethanol

Replacing current fossil fuel use with biofuels is unrealistic.

Existing croplands would need to be multiplied many times over and redirected to corn, sugarcane, soybeans and other energy plants.

Crops needed to feed livestock and people would be diverted for vehicles, and food prices would rise dramatically.

Much of the fuel yielded would be consumed for crop planting, harvesting and distilling into alcohol.

USDA

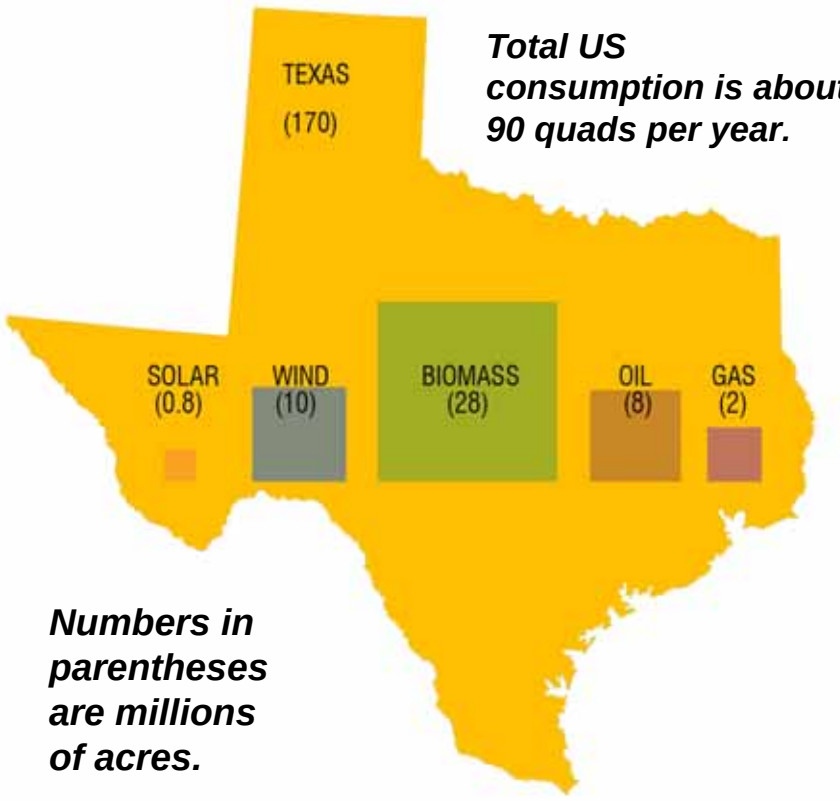
Fuel Balances

Cellulosic ethanol from switchgrass and other fast-growing plants is gaining much interest in the US as an alternative to ethanol from corn and other grain crops.

Ignoring crop rotation requirements, an acre of switchgrass might be expected to yield about 50-100 gallons of fuel annually.

At this rate, about 25 million acres of land (39,000 square miles) would be needed to displace 1 million barrels of crude oil daily.

About 3% of all US crop, range and pasture lands might be required to reduce projected 2050 oil imports 10% (30% to eliminate it).



Total US consumption is about 90 quads per year.

Numbers in parentheses are millions of acres.

One quad (or quadrillion BTUs) equals about 1 TCF of natural gas.

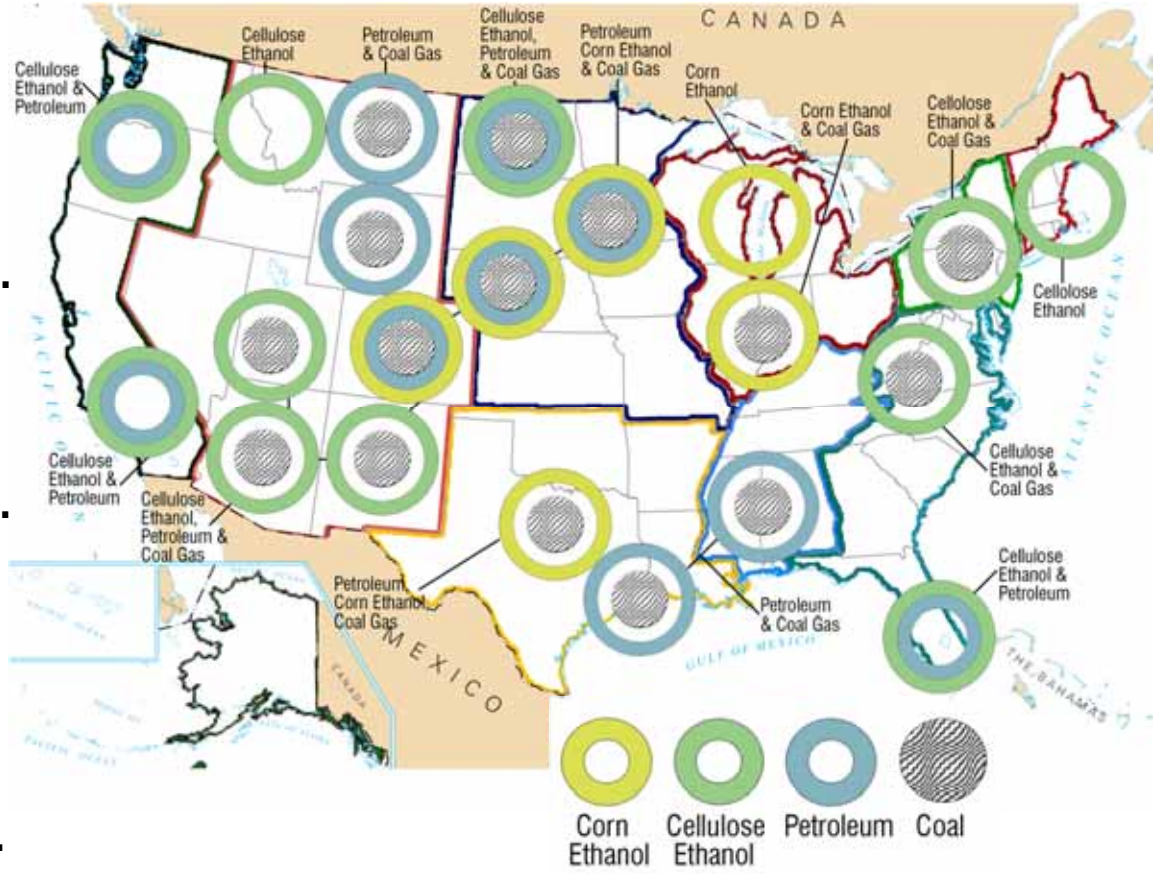
Land Areas Needed to Produce One Quad of Electricity

Larry Bell / GEC / NREL/ US DOE

Opportunities exist to expand small-scale ethanol operations throughout the US by taking advantage of oil refineries and coalgas facilities to produce specially-tailored regional blends.

The Northern Mountain Region can utilize abundant cellulosic biomass and coal reserves to create cold-weather heating fuels.

Northern West and West North Central areas can combine agricultural biowastes with coalgas resources in nearby southern East South Central and northern Middle Atlantic Regions.



Combining Fuel Sources

Elena's Puerto Rico Travel Guide, USA

No single fuel or technology offers a panacea to meet future energy demands or solve environmental problems.

All have distinct disadvantages and limitations that offset benefits they afford.

Nature uses a huge diversity of different mechanisms and organisms to produce energy for life, and it is clear that we must do the same.

A Need for Diversity

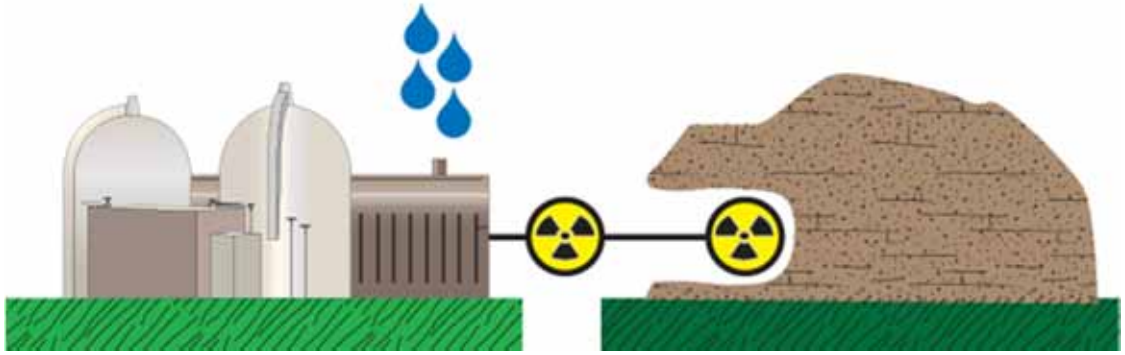
While no fossil-alternative power production option is problem-free, none can be excluded.

Wind, hydropower, solar and geothermal, while constrained, are non-polluting and offer means to produce "free" hydrogen.

Biofuels are renewable, but impose large net lifecycle energy production costs and release combustion contaminates just as fossils do.

Nuclear releases no atmospheric pollutants, but presents waste containment and safety / security challenges.

Fossil and bio-fuels produce atmospheric combustion contaminates



Nuclear plants emit only water, but produce wastes that must be sequestered.

Pollution Tradeoffs

Larry Bell

Oil and Natural Gas **Advantages:** • High energy densities • Many derivative products • Easy to store and transport **Disadvantages:** • Dwindling global supplies • CO_2 and other emissions	**Coal** **Advantages:** • Good energy densities • Many derivative products • Presently relatively abundant • Cleaner technologies available **Disadvantages:** • Mining impacts upon land areas	**Biofuels** **Advantages:** • Resourceful use of biowastes • Can reduce fossil fuel use • Apply current technologies **Disadvantages:** • Compete for land with food crops • Produce CO_2 when burned
Nuclear Power **Advantages:** • Potentially a substantial source • Environmentally-clean energy • Relatively abundant / inexpensive **Disadvantages:** • Possible safety/security risks • Concerns about safe storage	**Hydrogen** **Advantages:** • Derived from multiple sources • Technologies being improved **Disadvantages:** • Low energy density / volume • High costs of production • Difficult to store/transport	**Solar Power** **Advantages:** • Excellent energy supplement • Free energy following installation • Concentrator techs promising **Disadvantages:** • Geographic/weather limitations • High implementation costs
Geothermal Power **Advantages:** • A free energy source • Environmentally-friendly energy **Disadvantages:** • Limited geographic sites • Few high temperature sources • Not currently cost-competitive	**Hydropower** **Advantages:** • Free energy after installation • New technologies developing **Disadvantages:** • Limited geographic sites • Environmental marine impacts • Large systems are costly	**Wind Power** **Advantages:** • Free following installation • Environmentally-friendly energy • Rapidly decreasing costs **Disadvantages:** • Weather-dependent operations • Substantial implementation costs

Key Advantages and Disadvantages of Various Sources

Relative merits of various energy alternatives are issues of hotly-contested disputes between caring people with shared priorities but differing viewpoints regarding choices.

Such disagreements often serve to promote competition for better solutions that advance progress.

However progress is often hampered when advocates for certain solutions work to block development of others that are also vitally important.

ORNL
MYAA Site

Meeting Demands

Western Libraries
The Livingroom

Safety and Security

Protecting Nature

Future Needs

Common Priorities

ENERGY RESOURCES **CONSIDERING THE OPTIONS**

Larry Bell

Advocates →		← Opponents
Is essential to reduce foreign dependence	Expansion of Oil & Natural Gas Drilling	Must protect limited existing supplies
New sources needed for economy / living		Limiting supplies promotes conservation
New development requires years		Improved conservation can solve the problem
Oil / natural gas are energy-efficient		Cleaner alternatives are available / essential
Essential to support growing import needs	New Ports, Terminals & Refineries	They all present major terrorist targets
Technologies are safer / cleaner than in the past		Offshore operations pollute marine life
Necessary to prevent regional power gaps		Don't put them in my region / backyard
Are vulnerable to disasters / breakdowns		Efficiency upgrades have kept pace with demands

Oil and Natural Gas Development

Larry Bell

Advocates →		← Opponents
Coal is our most abundant fuel source	Coal Mining & Power	Cleaner alternatives are available / essential
Clean coal technologies are reducing emissions		Gasification requires large CO_2 containment
Coal is a source of important derivatives		We can obtain them from biomass / biofuels
Coal mining is vital to regional economies / jobs		Mining operations harm people / ecosystems
Nuclear power has large expansion potential	New Nuclear Power Plants	Don't produce it in my region / backyard
Plants produce no CO_2 emissions, only water		Radioactive waste is an environmental hazard
Advanced technologies have proven very safe		Breakdowns / terrorism present large threats
Fuel reprocessing can greatly extend supplies		Breeder reactors can proliferate weapons

Coal and Nuclear Power Development

ENERGY RESOURCES **CONSIDERING THE OPTIONS**

Larry Bell

Advocates →		← Opponents
Produces clean power	Hydrogen Fuel Cells	Production can pollute
Has good power density		Is a net energy user
Usable in different forms		The gas is explosive
A renewable alternative		Is difficult to transport
Are renewable sources	Corn / Cell. Ethanol	Can compete with food
Can reduce fossil use		Reduction may be limited
Releases only "new" CO_2		CO_2 is CO_2,
Cellulose uses biowaste		Processing can be costly
A "free" energy source	Solar PV / Concentrat.	Devices are expensive
Solar Is broadly available		Not always optimum
Can reduce fossil use		Limited energy production
Offer versatile applications		Often requires storage

Hydrogen, Biofuel and Solar Power

Larry Bell

Advocates →		← Opponents
A clean power source	Wind Power	Not in my backyard
An abundant source		Depends upon location
A "free" energy source		Requires large investment
Can reduce fossil use		Intermittant availability
A clean power source	Hydro Power	Can pose ecohazards
An abundant source		Very limited locations
A "free" energy source		Plants can be costly
Can reduce fossil use		Limited growth potential
A clean power source	Geothermal Power	Sites are often restricted
An abundant source		Can deplete heat/pressure
A "free" energy source		Plants can be costly
Can reduce fossil use		Often not very efficient

Wind, Hydropower and Geothermal

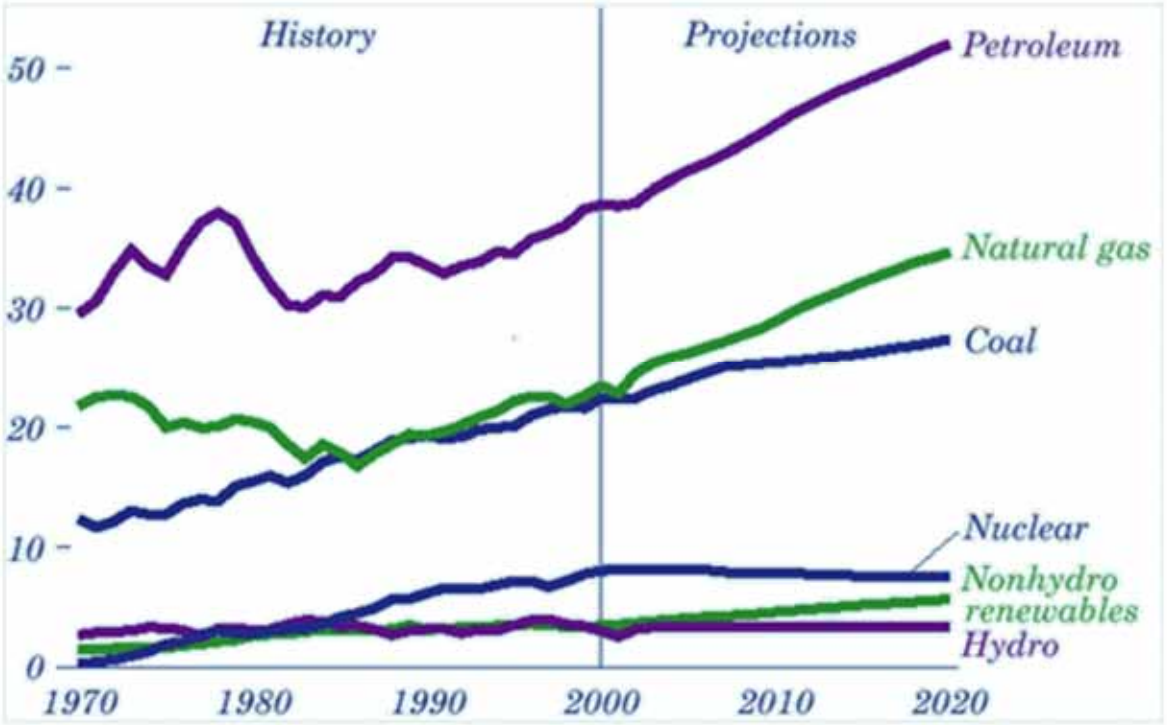
US DOE - EIA

Progressive energy initiatives will require compromises that are unpopular with many.

Nuclear power expansion, opposed by some, is important to reduce fossil fuel dependence and greenhouse emissions.

Biofuels, also important, will raise food prices and are neither clean or energy-efficient.

Subsidies and tax incentives for renewables will be regarded as unwarranted special interest hand-out gifts by many.



Although we may see a continuing rise in use of non-fossil renewables, these fuels are predicted to represent only a small fraction of US energy over the next several years. Petroleum, natural gas and coal will remain to be primary sources.

US Fuel Consumption Projected, 1970 - 2020

US Government

Fossil Fuels:

- Ease restrictions on oil and gas development on public lands.
- Ease permit processes for refinery expansion/construction.
- Offer tax breaks for clean coal technology use.

Nuclear Power:

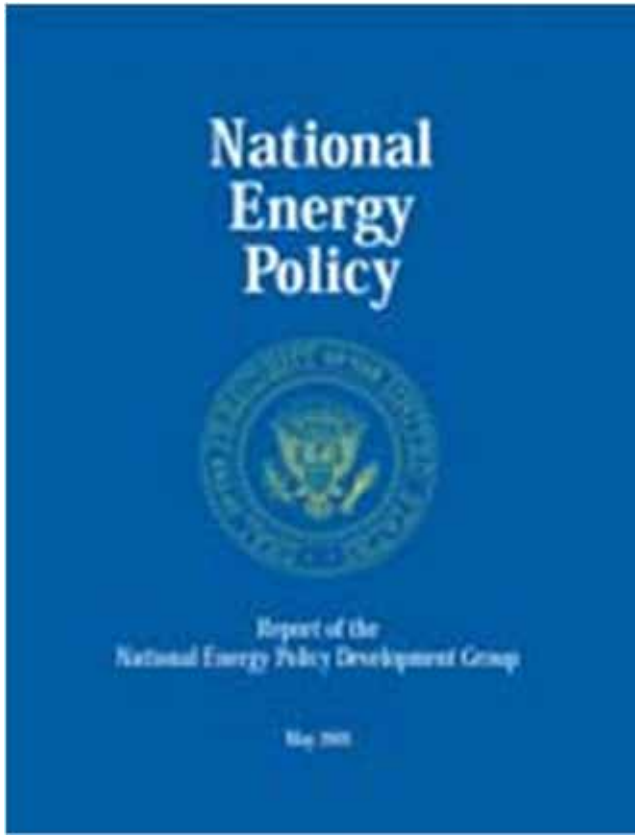
- Speed relicensing of reactors and licensing of new plants.
- Limit industry liabilities from accidents.
- Allow spent fuel to be reused (prohibited since the 1970s).

Power Plants:

- Speed license procedures for new hydroelectric/thermal plants.
- Streamline processes for power plant site permit approvals.
- Ease clean air regulations to make plants more efficient.

Renewable Energy:

- Tax credits for plants that use organic waste/biomass.
- Tax credits for wind energy and household solar panels.
- Tax incentives for alternative fuels and more efficient technologies such as hybrid vehicles.



Representative Recommendations of the National Energy Policy Development Group Report
US National Energy Policy, 2001 Recognize the Importance of All Options

ENERGY RESOURCES **CONSIDERING THE OPTIONS**

Larry Bell

Rather than seek universal national energy solutions, it is more realistic to develop nationally-integrated regional strategies.

Coordination of small utility companies can optimize use of efficient CHP technologies to serve local district needs.

Smaller specialty refiners can provide fuel mixtures tailored for regional weather conditions and regulatory requirements.

State government and regional alliances can promote resource development and use that is most appropriate for unique opportunities and needs.

Priorities	Strategies
Develop appropriate energy supplies and technologies	Provide incentives for energy investments
Create and expand efficient distribution infrastructures	Coordinate state / regional programs and networks
Concentrate supplies / services where needed most	Optimize CHP and other shared-use opportunities
Anticipate demographic trends and future needs	Plan / implement long-term development initiatives
Transition to cleaner / safer energy solutions	Promote / facilitate green energy co-op programs
Encourage conservation in homes and businesses	Establish public information and education programs

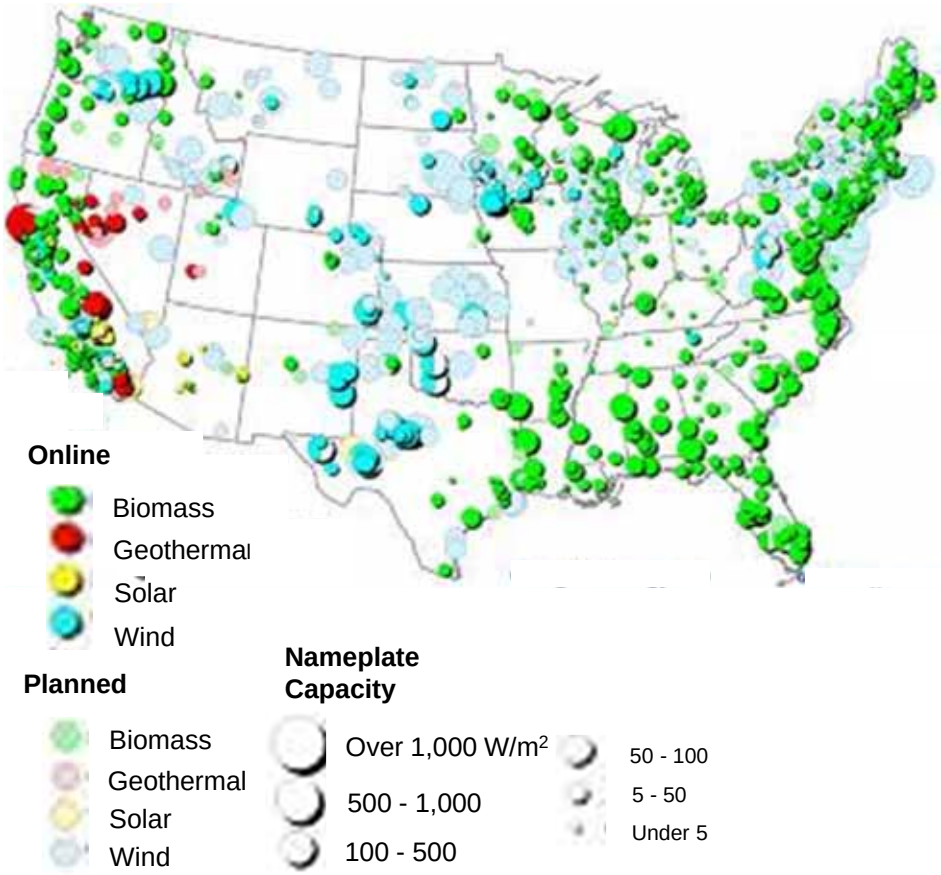
Representative Regional Priorities and Strategies

ENERGY RESOURCES **CONSIDERING THE OPTIONS**

Availability of diverse regional resources and programs provides flexibility in adapting to changing needs and reduces dependence upon single-source uncertainties.

True resourcefulness requires that all options be developed and optimized, including ways to make them more environmentally-friendly and efficient.

Efficiency involves consuming less and putting resources to best use.



Current and Planned Renewable Energy Facility Locations

ENERGY RESOURCES **CONSIDERING THE OPTIONS**

Larry Sherwood, Interstate Renewable Energy Council

Many state and regional government conservation programs are demonstrating progress with public and industry support.

Stricter environmental standards for equipment and building codes are being balanced by tax credits and other benefits.

State educational and financial assistance programs are encouraging broad industry participation.

Most states now allow photovoltaic and other green power consumers to supply excess electricity back to grids for energy credits.

Cumulative US PV Installations by Year

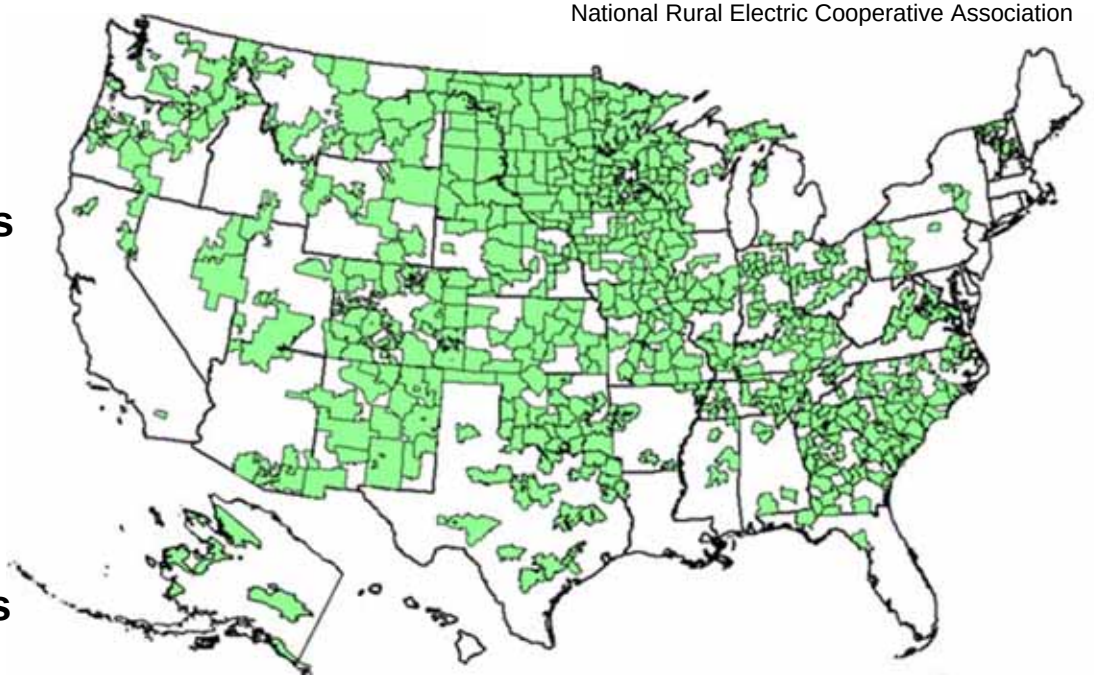
State Government Initiatives

“Green power co-ops” producing electricity from wind, photovoltaics and biomass are a growing trend throughout the US.

More than 550 rural electric providers now offer power through co-op organizations that receive “green tags” that pass on energy credits to their members.

Owners operating “backyard” generating systems can sell excess power back for profit, and sometimes receive low-interest loans to offset installation costs.

National Rural Electric Cooperative Association



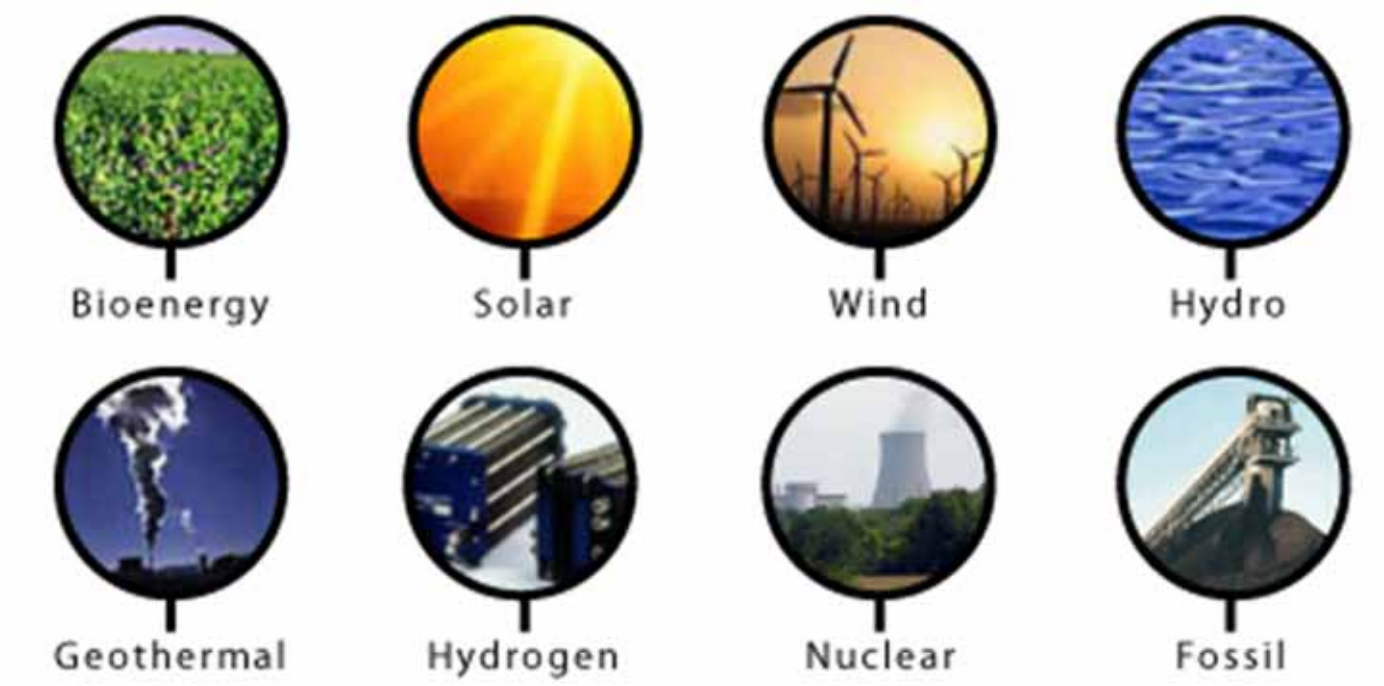
Rural Electric Systems

Terrorist attacks on New York and Washington, DC, brought energy security and independence into the forefront of American consciousness.

The health of the US economy and wellbeing is strongly linked the security of its electricity and fuel infrastructures.

Development of regional energy resources can reduce national vulnerability and impacts of terrorism through decentralization of supplies.

Energy Security



Our Only Real Option is to Resourcefully Optimize All

US DOE EIA / LARRY BELL