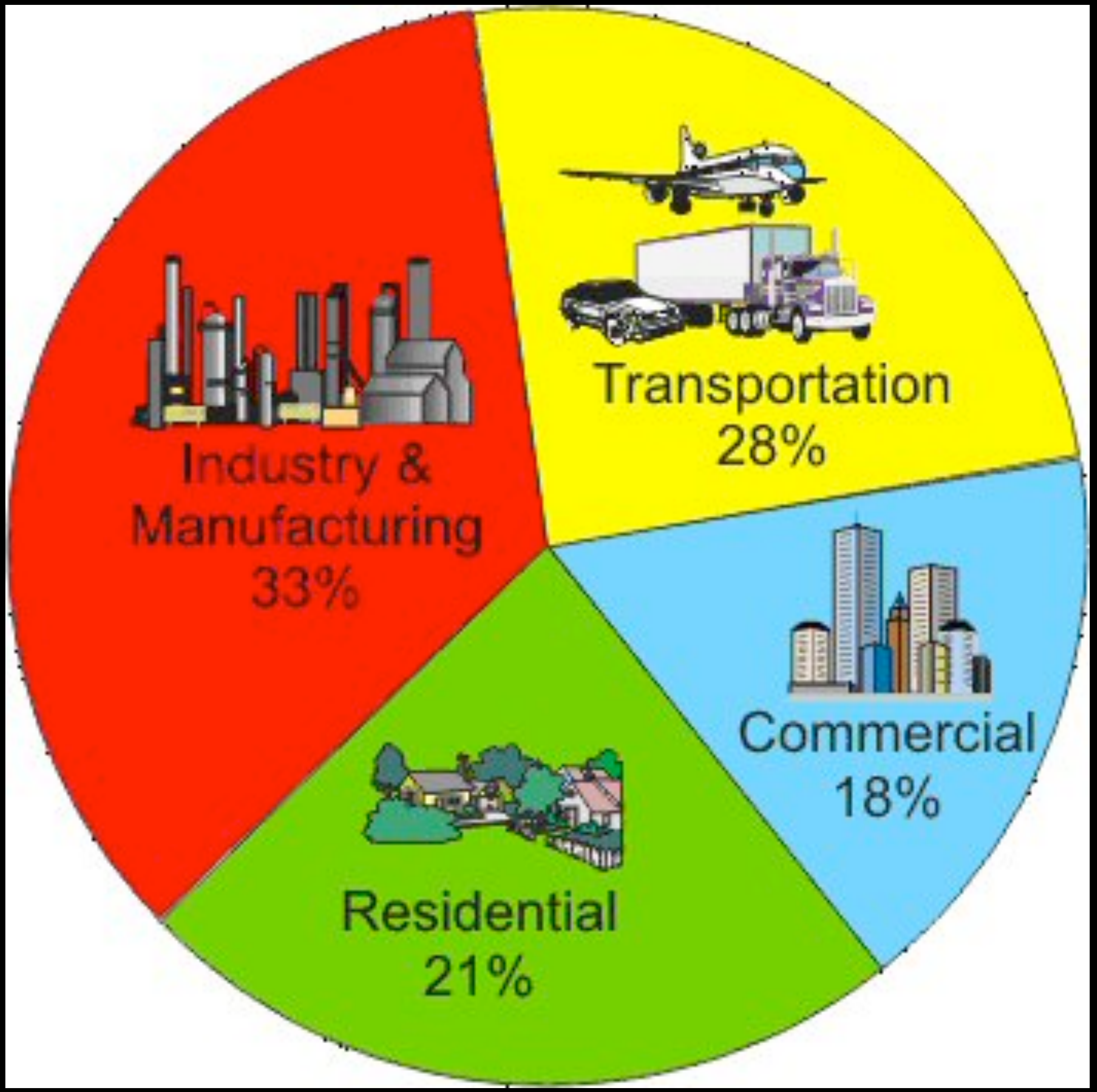
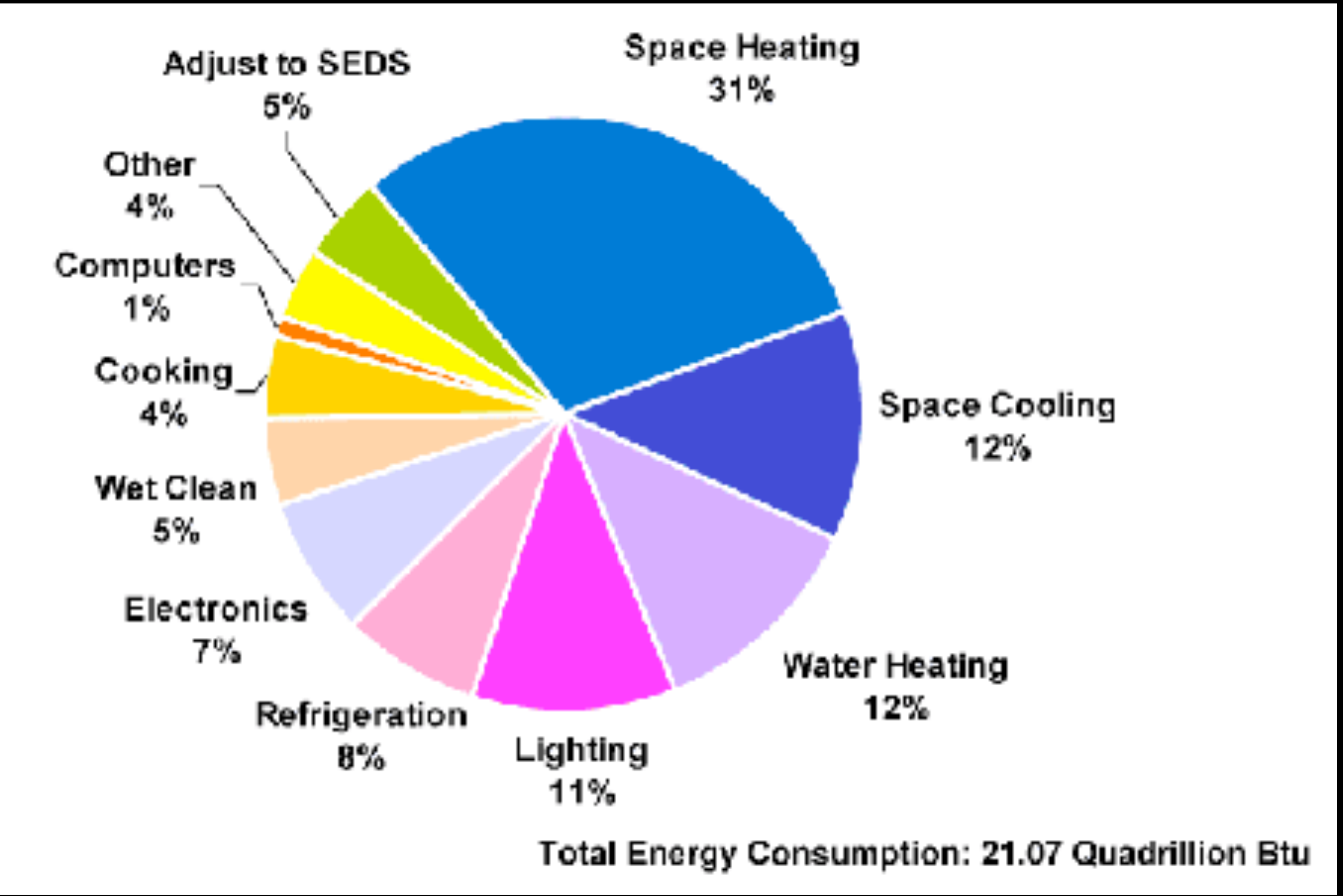
US Energy Use

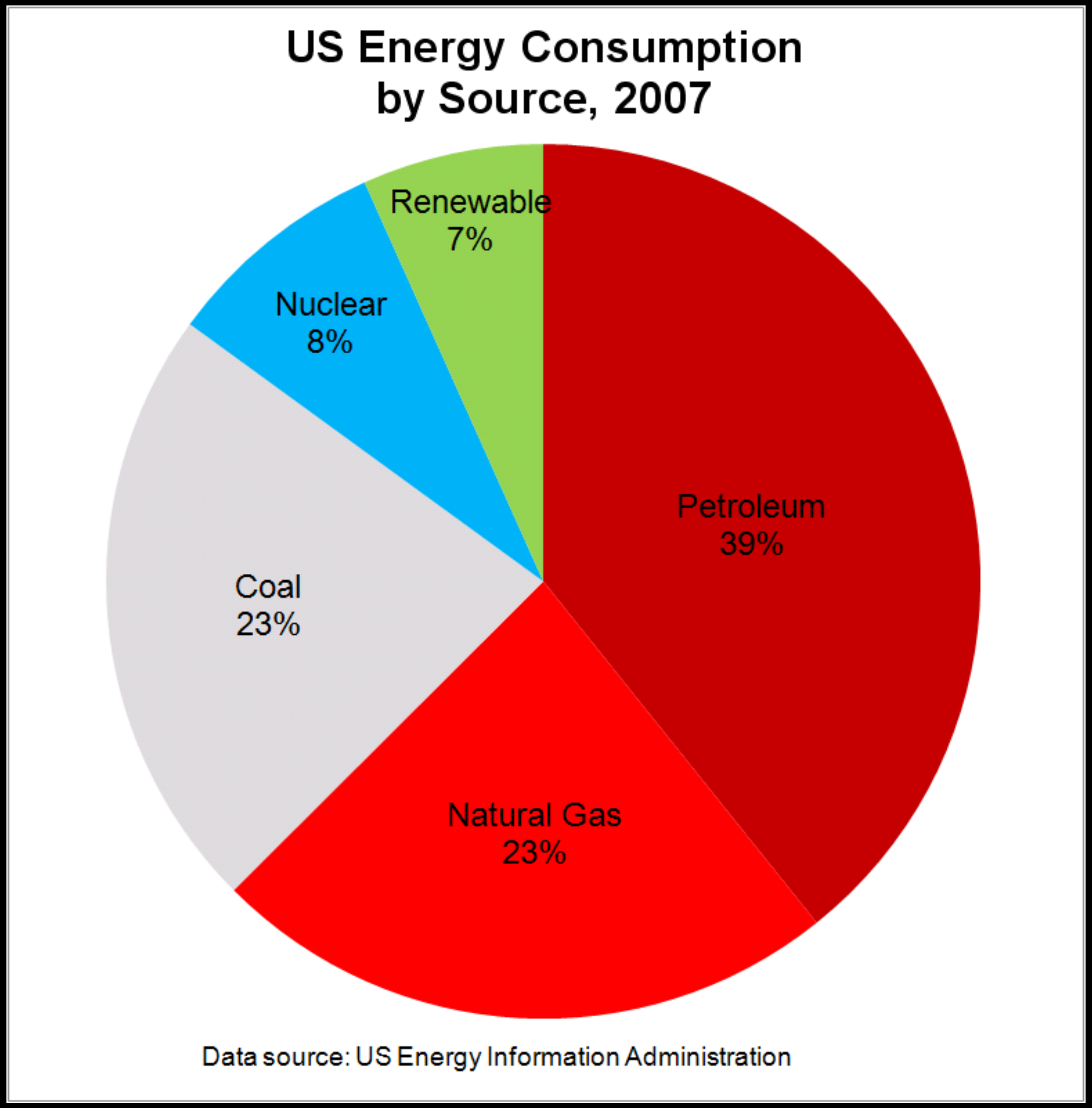


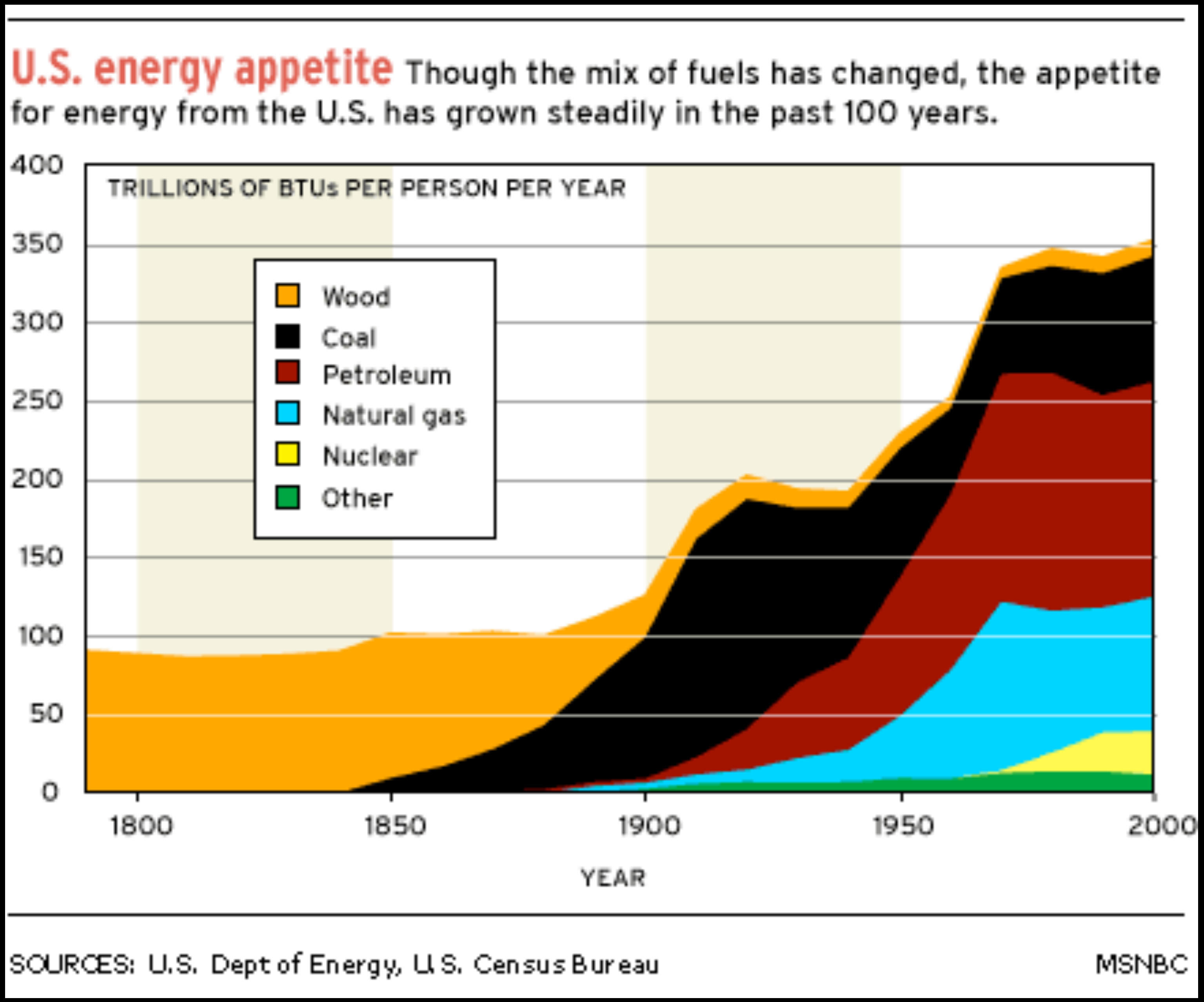
Use by Sector

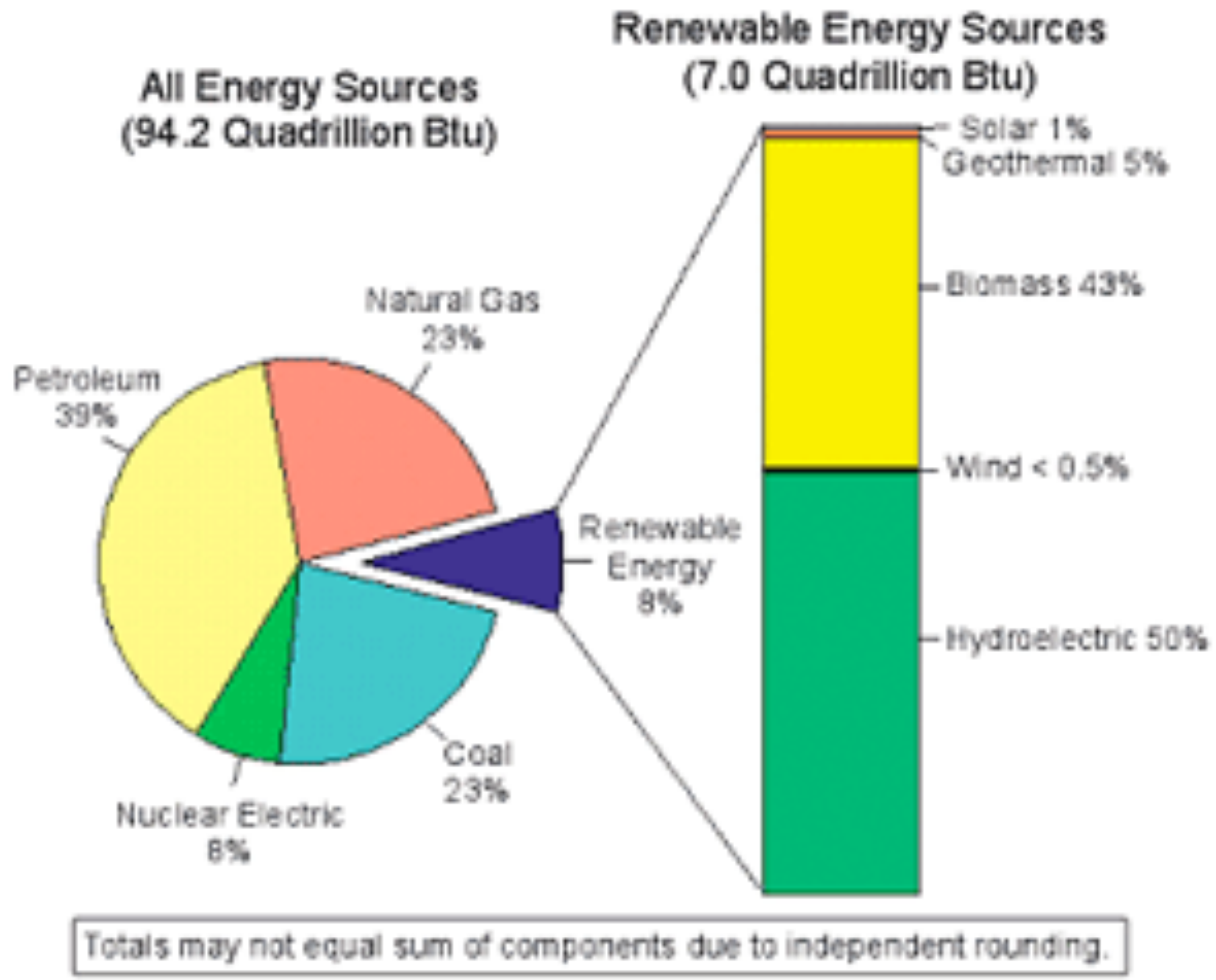
Residential Uses



US Energy Sources

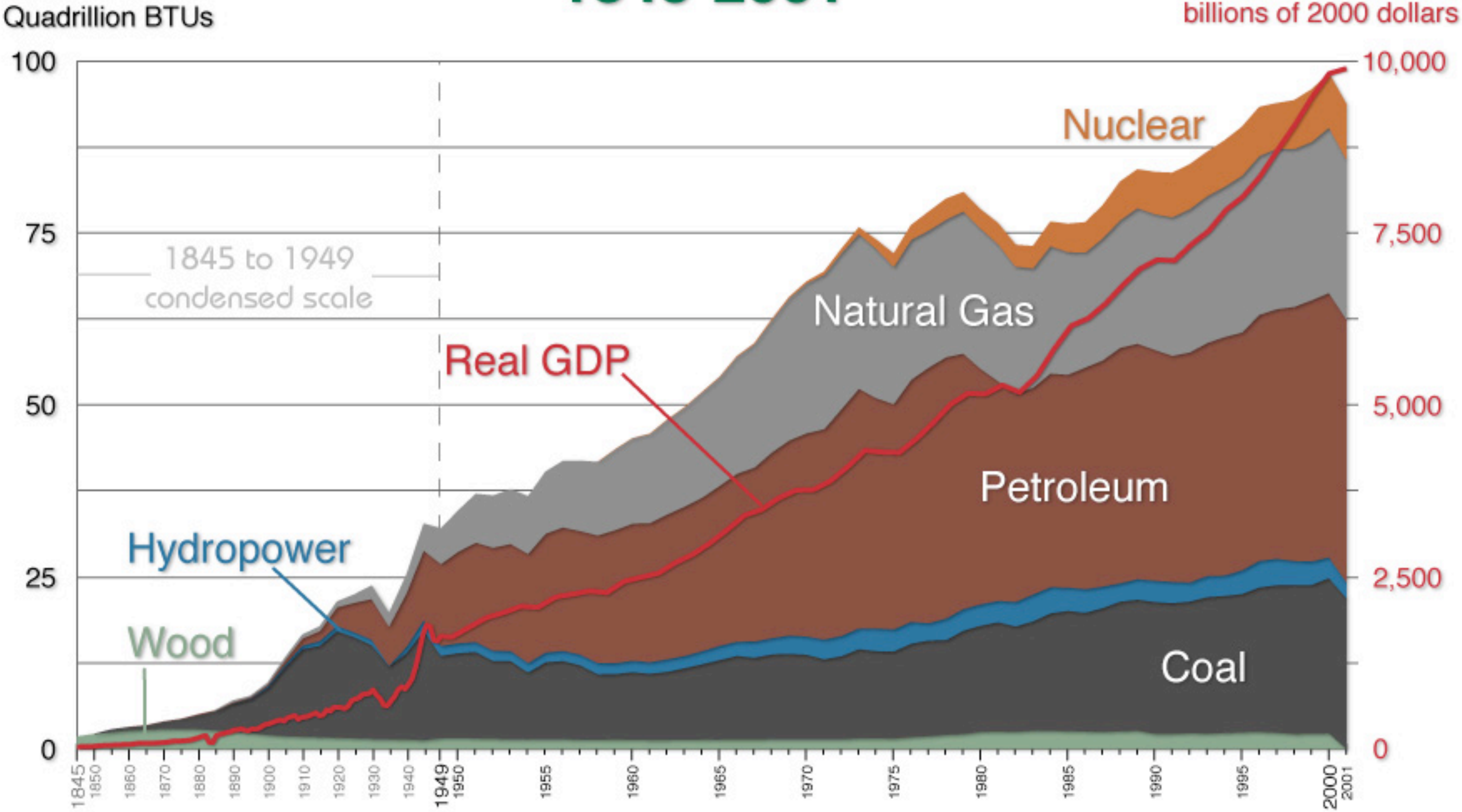





All Energy Sources
(94.2 Quadrillion Btu)
Renewable Energy Sources
(7.0 Quadrillion Btu)
Natural Gas 23%
Petroleum 39%
Renewable Energy 8%
Coal 23%
Nuclear Electric 8%
Solar 1%
Geothermal 5%
Biomass 43%
Wind < 0.5%
Hydroelectric 50%
Totals may not equal sum of components due to independent rounding.

ENERGY

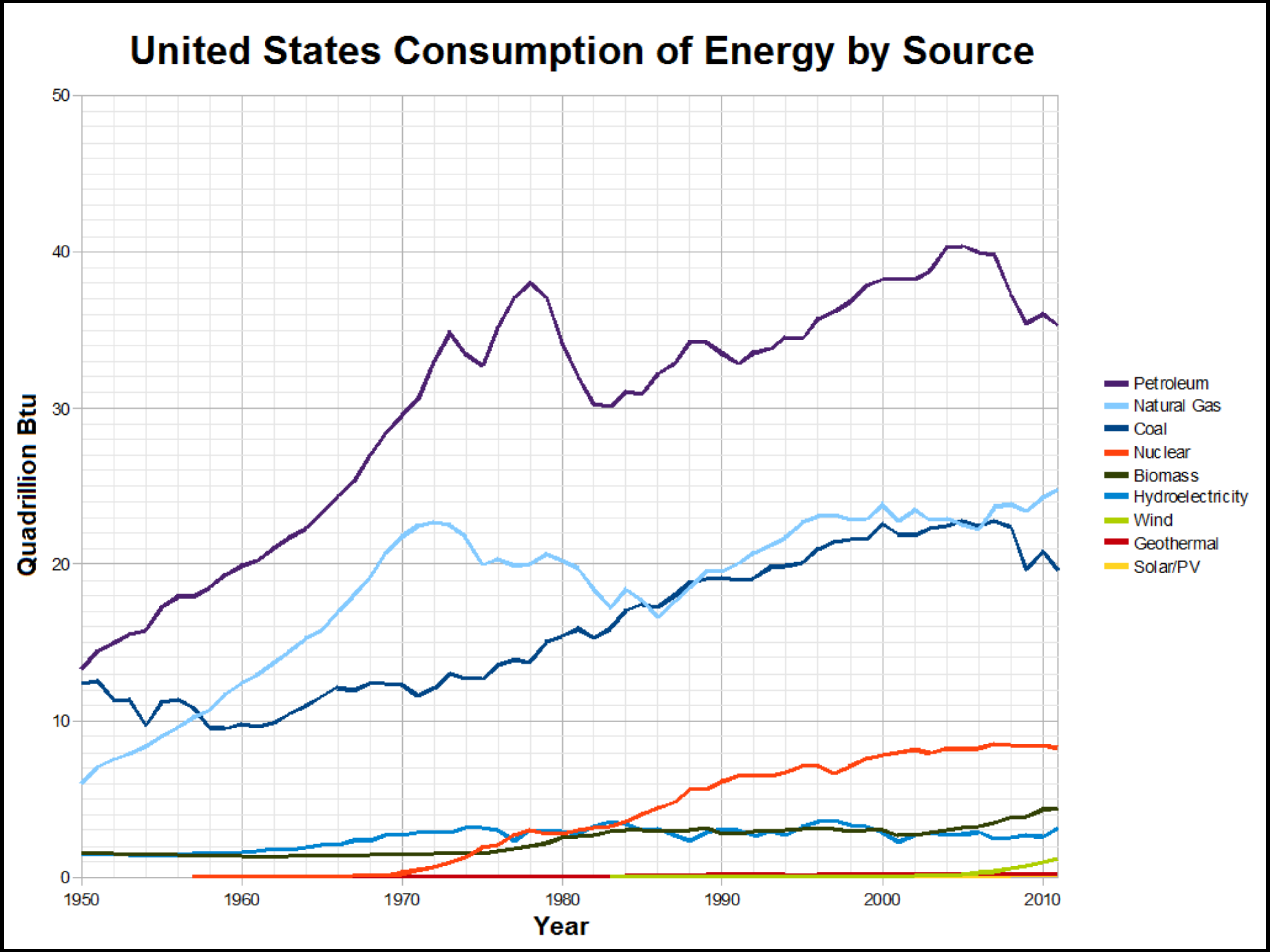
US Consumption by Source v. Real GDP 1845-2001



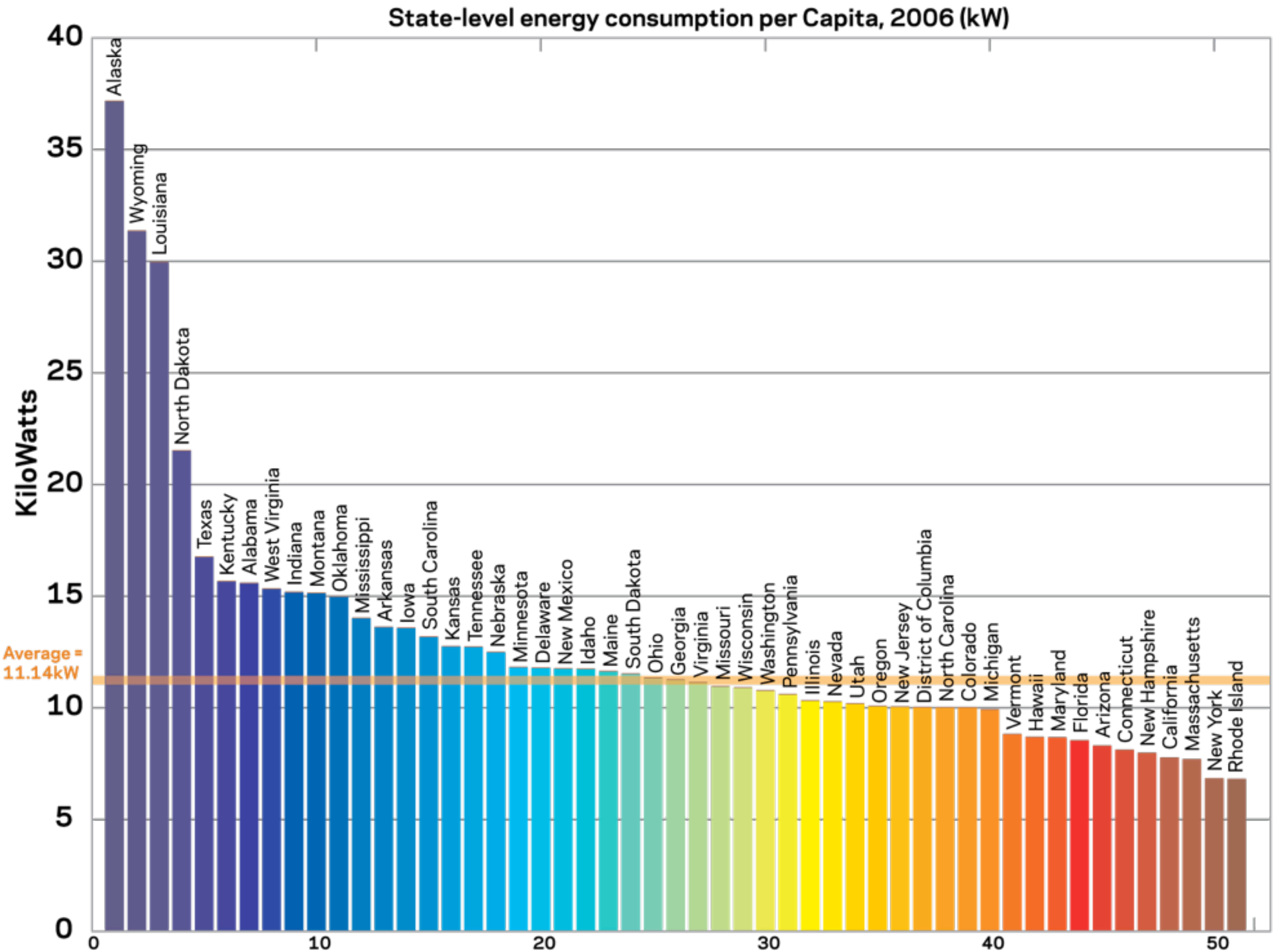
Sources: USDOE, EIA, Annual Energy Review 2001, Table F1a, F1b; and Real GDP data: Louis D. Johnston and Samuel H. Williamson, "The Annual Real and Nominal GDP for the United States,1790-Present" Economic History Services, Oct. 2005, http://www.eh.net/hmit/gdp

US Energy Use

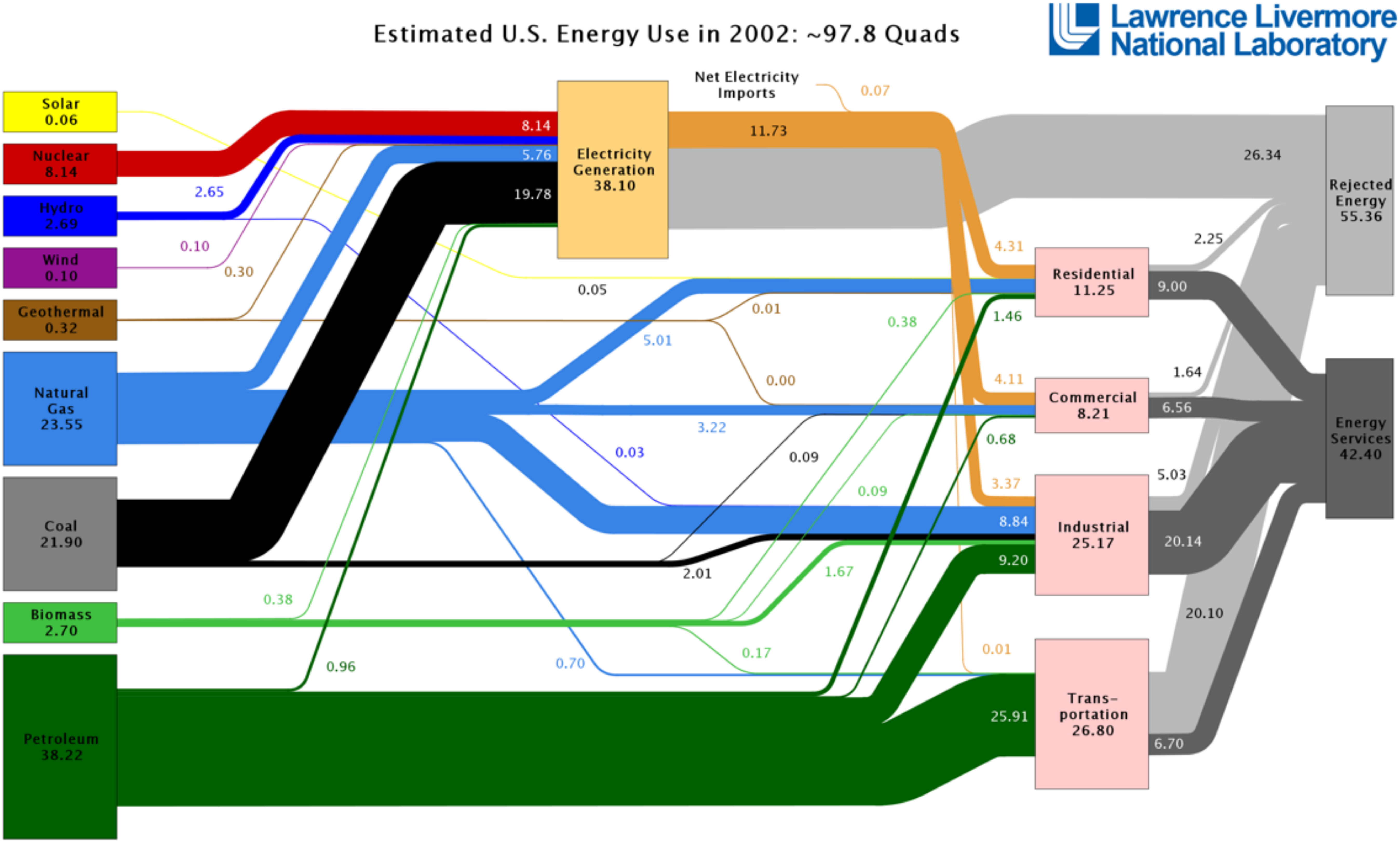
100 quadrillion BTU



10kW per person = 100x a person's energy from food
= 7 microwave ovens running continuously!


State-level energy consumption per Capita, 2006 (kW)
KiloWatts
Average = 11.14kW
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
Alaska
Wyoming
Louisiana
North Dakota
Texas
Kentucky
Alabama
West Virginia
Indiana
Montana
Oklahoma
Mississippi
Arkansas
Iowa
South Carolina
Kansas
Tennessee
Nebraska
Minnesota
Delaware
New Mexico
Idaho
Maine
South Dakota
Ohio
Georgia
Virginia
Missouri
Wisconsin
Washington
Pennsylvania
Illinois
Nevada
Utah
Oregon
New Jersey
District of Columbia
North Carolina
Colorado
Michigan
Vermont
Hawaii
Maryland
Florida
Arizona
Connecticut
New Hampshire
California
Massachusetts
New York
Rhode Island

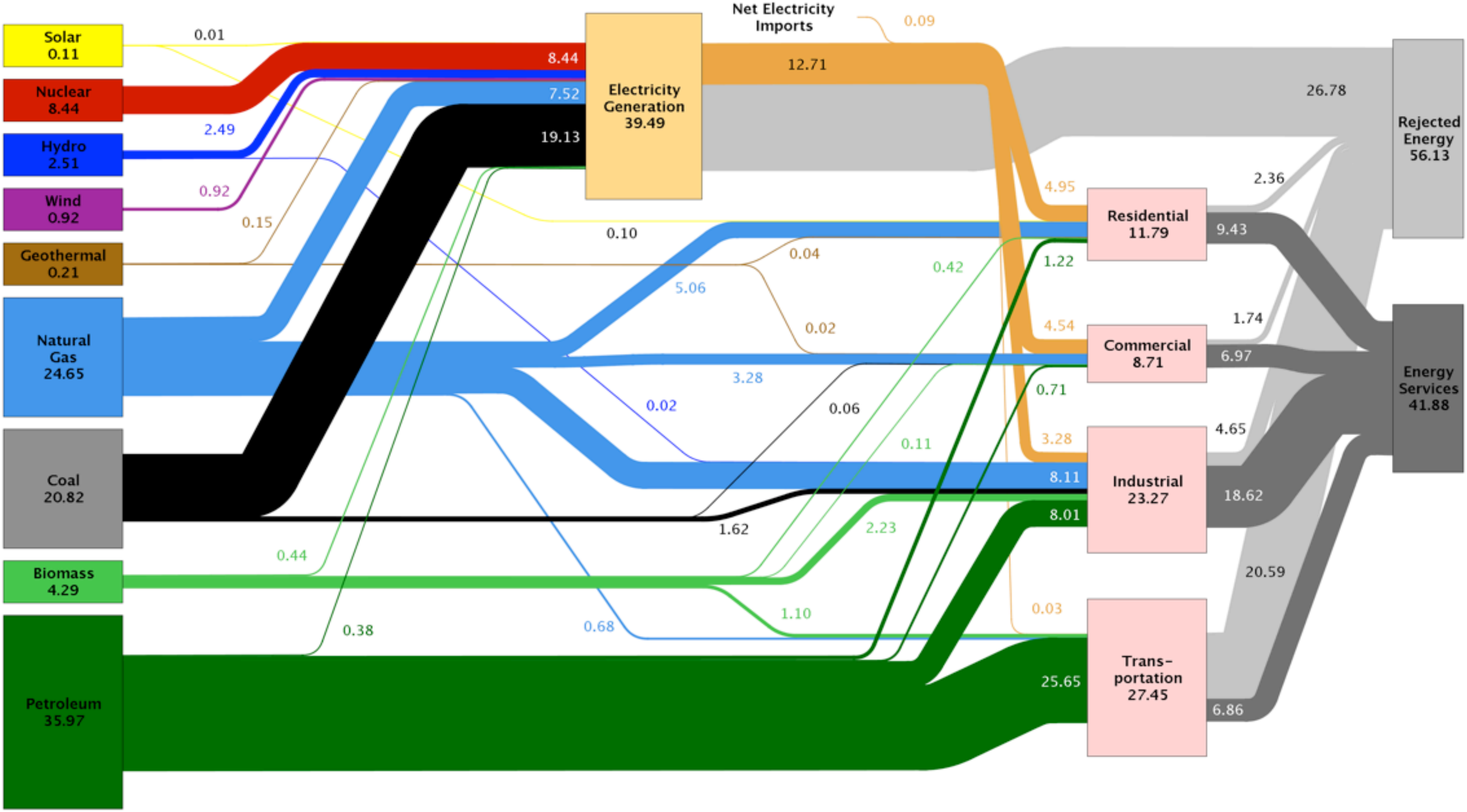
Estimated U.S. Energy Use in 2002: ~97.8 Quads



Source: LLNL 2008. Data is based on DOE/EIA-0384(2007), June 2008. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

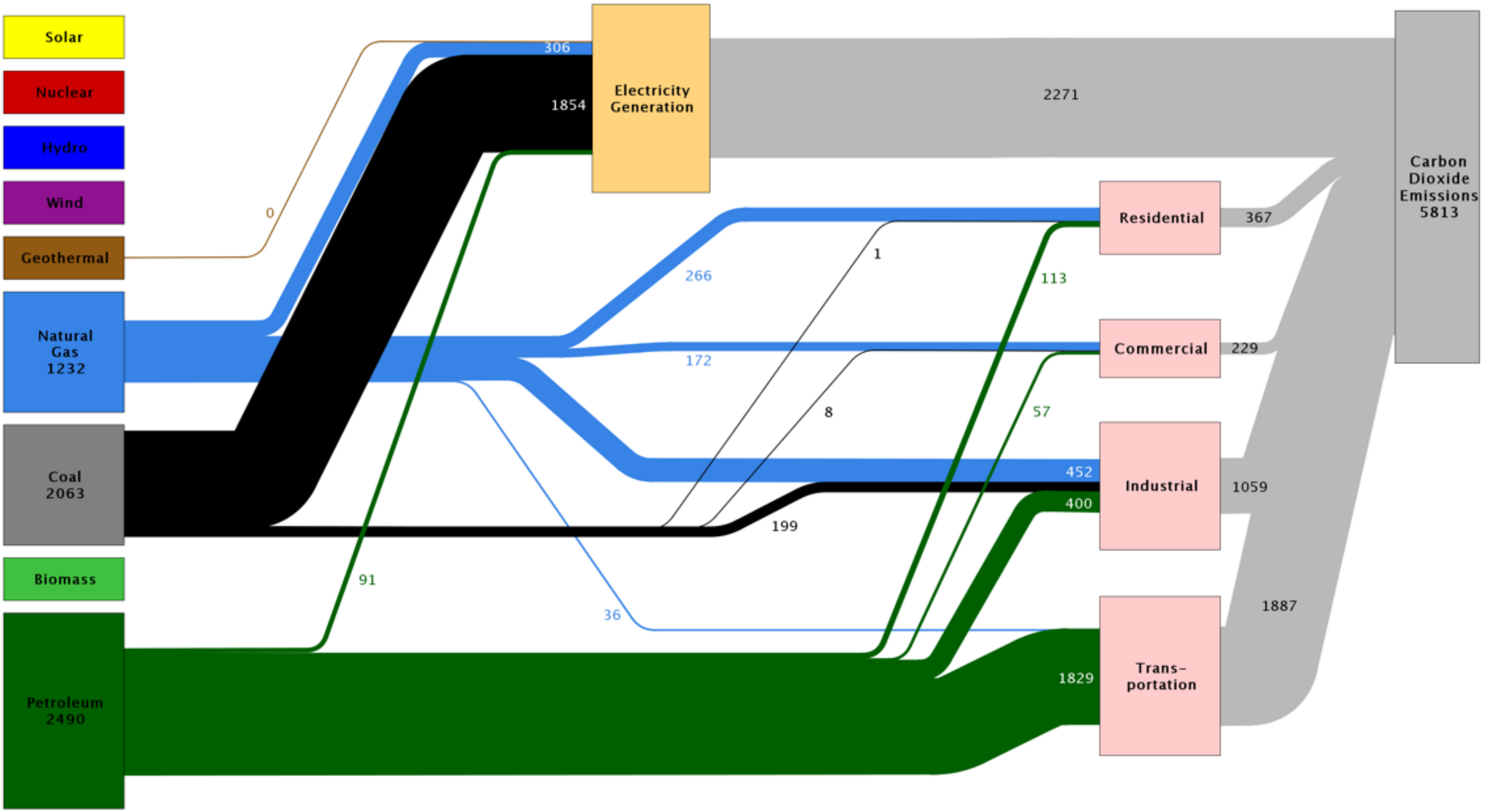
Estimated U.S. Energy Use in 2010: ~98.0 Quads

Lawrence Livermore National Laboratory



Source: LLNL 2011. Data is based on DOE/EIA-0384(2010), October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for hydro, wind, solar and geothermal in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." (see EIA report for explanation of change to geothermal in 2010). The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

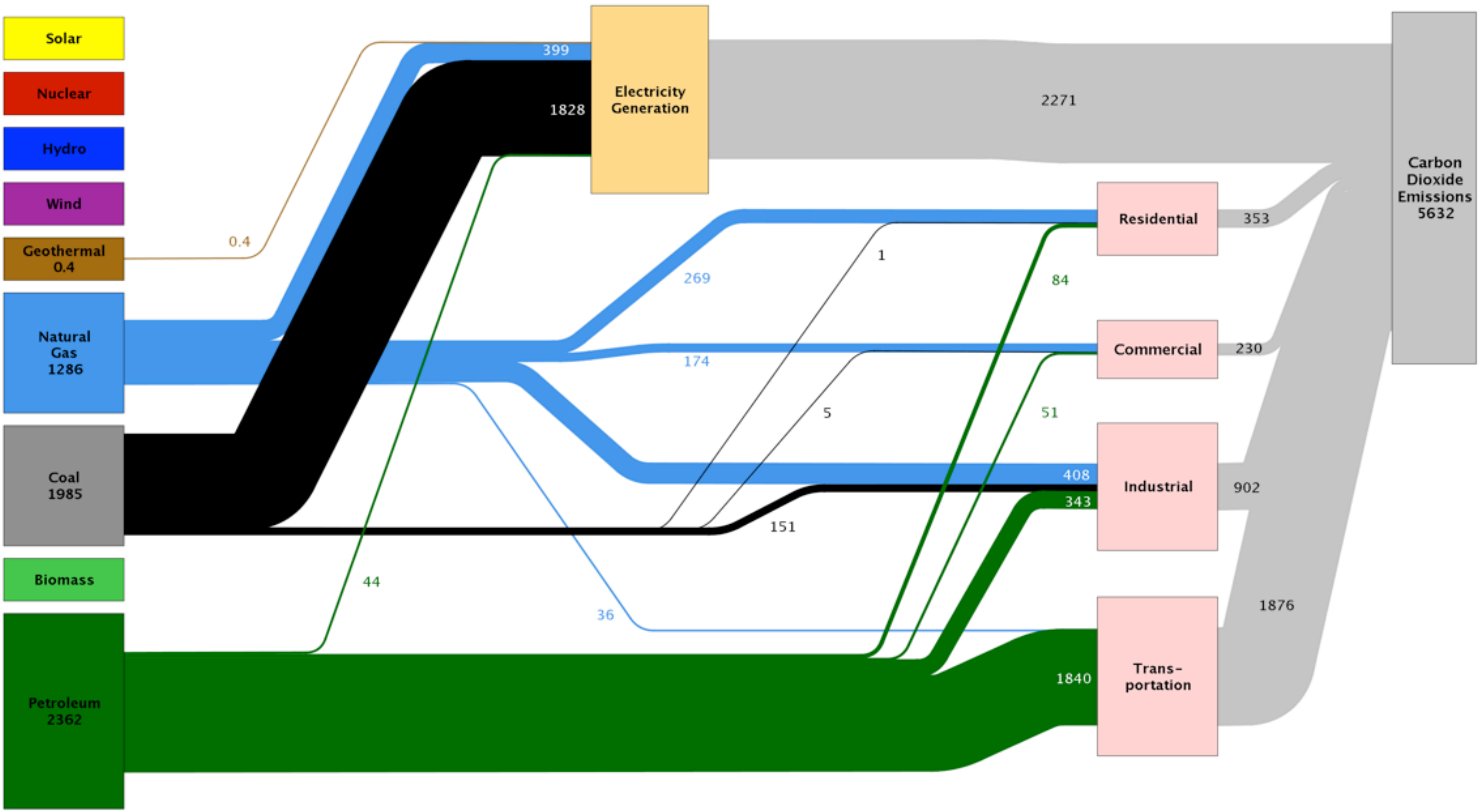
Estimated U.S. Carbon Dioxide Emissions in 2002: ~5813 Million Metric Tons



Source: LLNL 2009. Data is based on DOE/EIA-0384(2007), June 2008. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Carbon embodied in industrial and commercial products such as plastics is not shown. The flow of petroleum to electricity production includes both petroleum fuels and the plastics component of municipal solid waste. The combustion of biologically derived fuels is assumed to have zero net carbon emissions – lifecycle emissions associated with biofuels are accounted for in the Industrial and Commercial sectors. Totals may not equal sum of components due to independent rounding. LLNL-MI-411167

Energy-Related U.S. Carbon Dioxide Emissions in 2010:
~5632 Million Metric Tons

Lawrence Livermore National Laboratory



Source: LLNL 2011. Data is based on DOE/EIA-0384(2010), October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Non-fuel carbon and non-energy CO2 is not shown. The flow of petroleum to electricity production includes both petroleum fuels and the plastics component of municipal solid waste. The combustion of biologically derived fuels is assumed to have zero net carbon emissions – lifecycle emissions associated with biofuels are accounted for in the Industrial and Commercial sectors. Emissions from U.S. Territories and international aviation and marine bunkers are not included. Totals may not equal sum of components due to independent rounding. LLNL-MI-411167

US Energy Use and CO_2 Emission

Year	Energy Use	Carbon Dioxide Emission	Ratio
2002:	97.8 Quads	5813 Million Metric Tons	59.4
2003:	98.1 Quads	5866 Million Metric Tons	59.8
2004:	100.2 Quads	5957 Million Metric Tons	59.5
2005:	100.4 Quads	5982 Million Metric Tons	59.6
2006:	99.8 Quads	5890 Million Metric Tons	59.0
2007:	101.5 Quads	5991 Million Metric Tons	59.0
2008:	99.2 Quads	5814 Million Metric Tons	58.6
2009:	94.6 Quads	5428 Million Metric Tons	57.4
2010:	98.0 Quads	5632 Million Metric Tons	57.5
2011:	97.3 Quads		

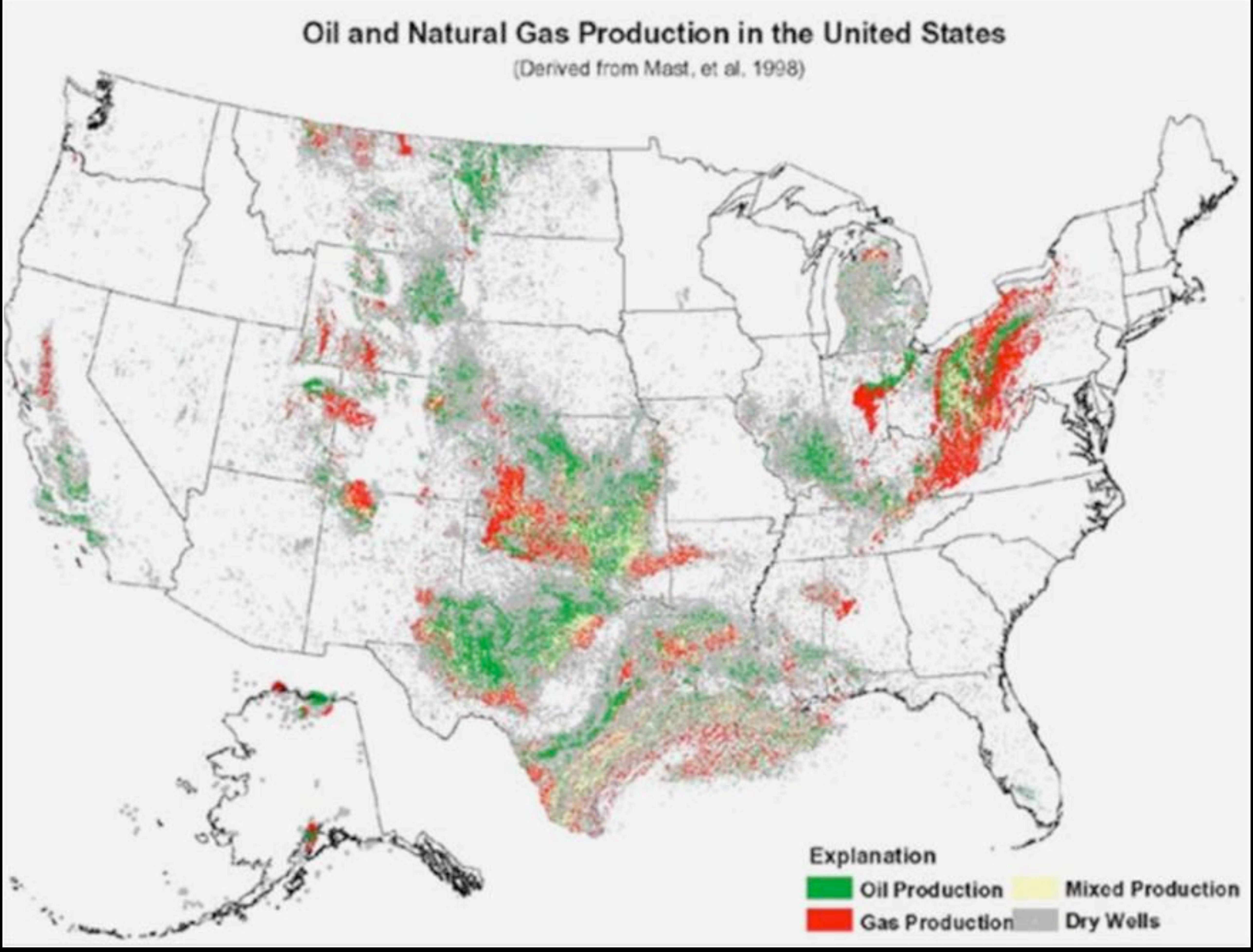
Petroleum

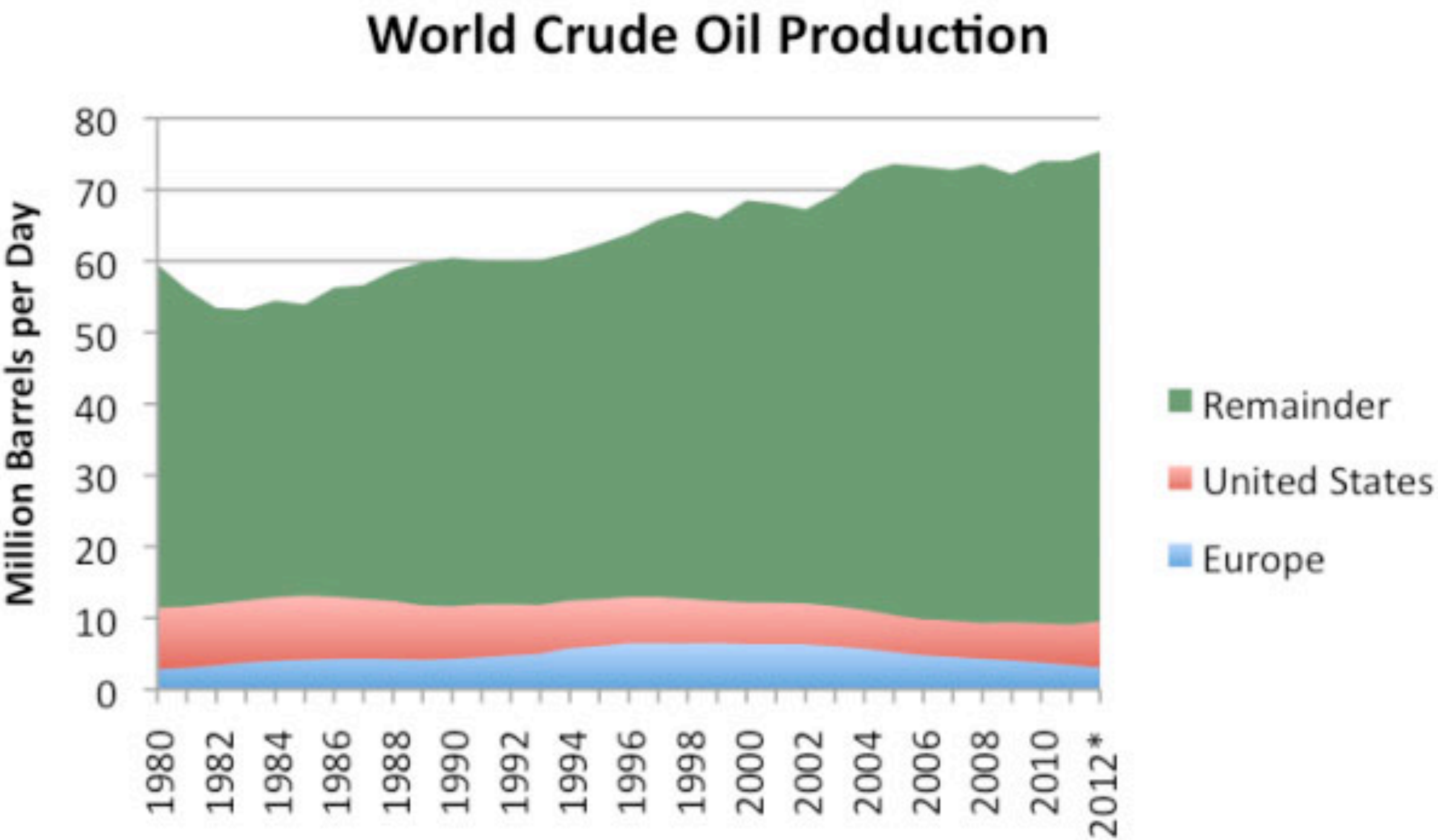
Advantages:

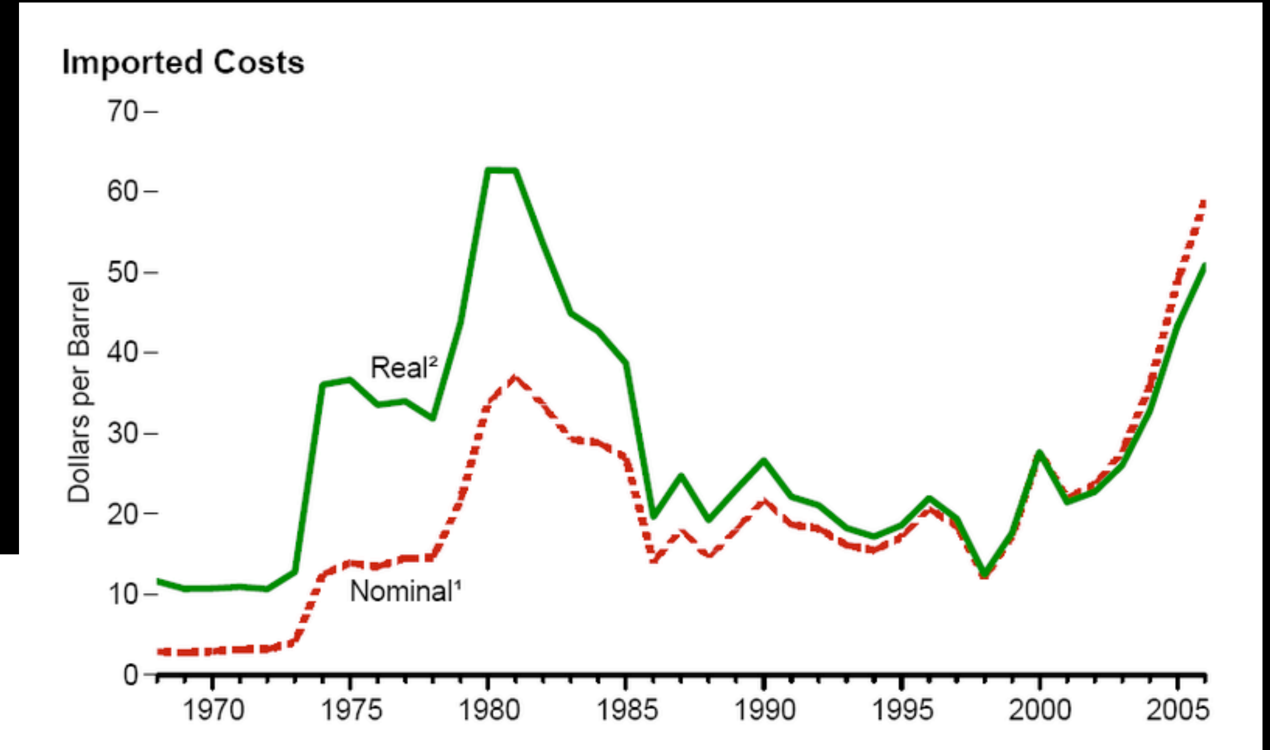
- cheap
- easy to transport

Disadvantages:

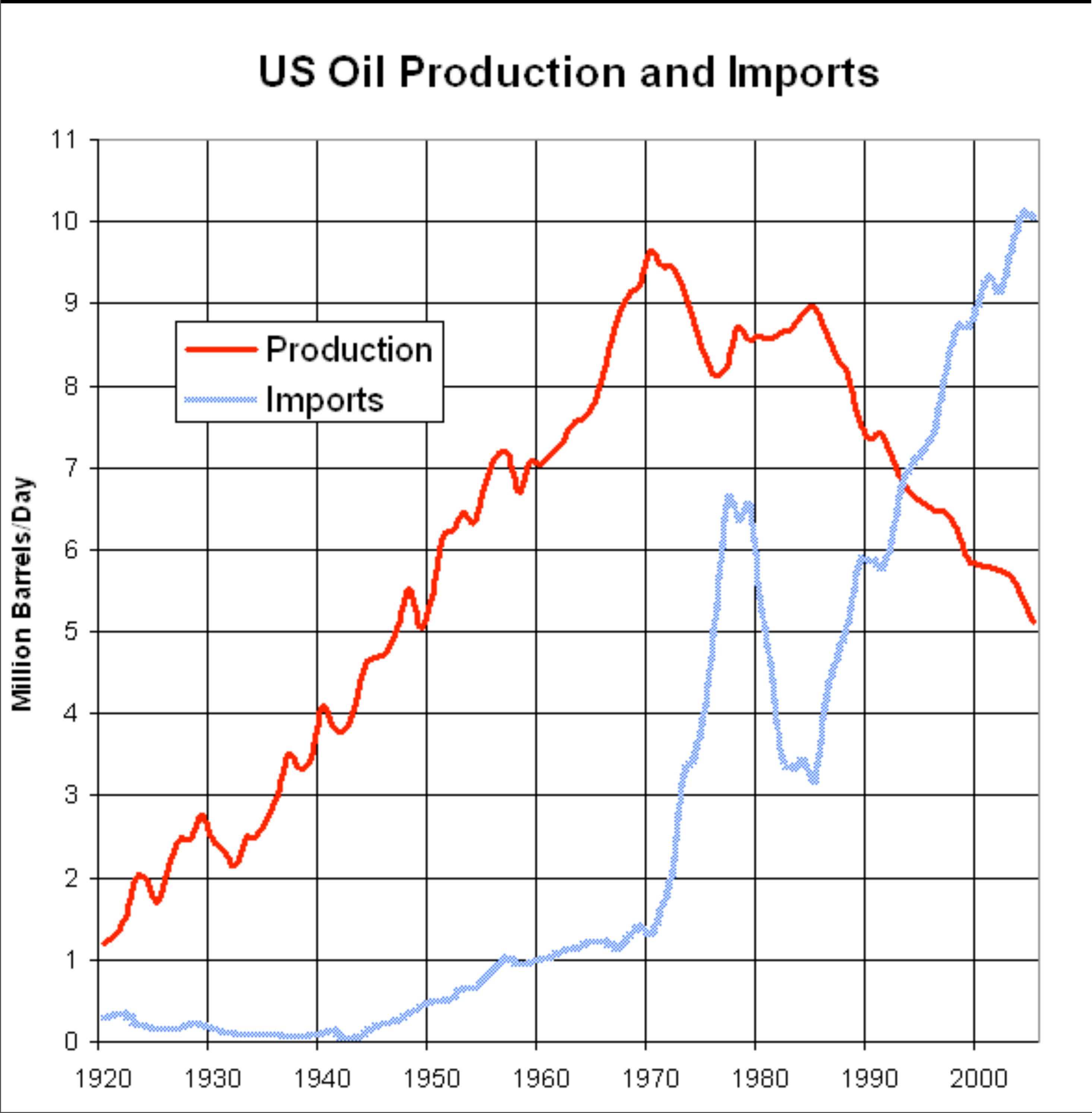
- easy to access stuff is running low
- production of atmospheric CO_2
- not enough local sources


Oil and Natural Gas Production in the United States
(Derived from Mast, et al. 1998)
Explanation
Oil Production
Mixed Production
Gas Production
Dry Wells


World Crude Oil Production
Million Barrels per Day
80
70
60
50
40
30
20
10
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012*
Remainder
United States
Europe

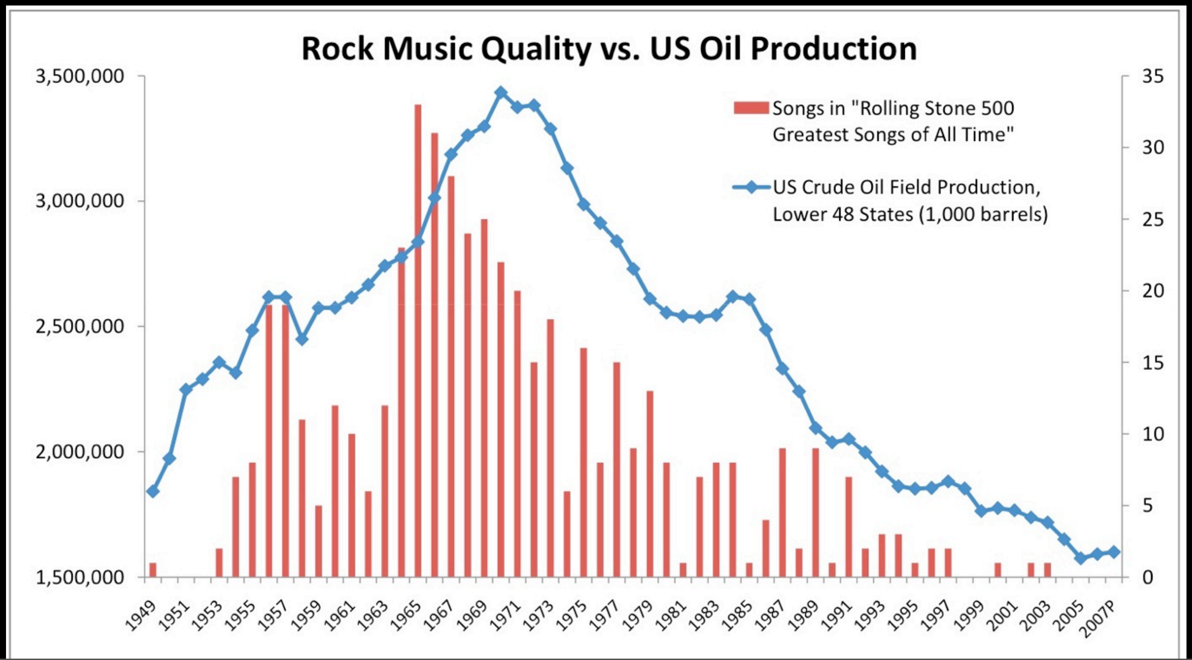


Imported Costs
Dollars per Barrel
70
60
50
40
30
20
10
0
Real²
Nominal¹
1970
1975
1980
1985
1990
1995
2000
2005



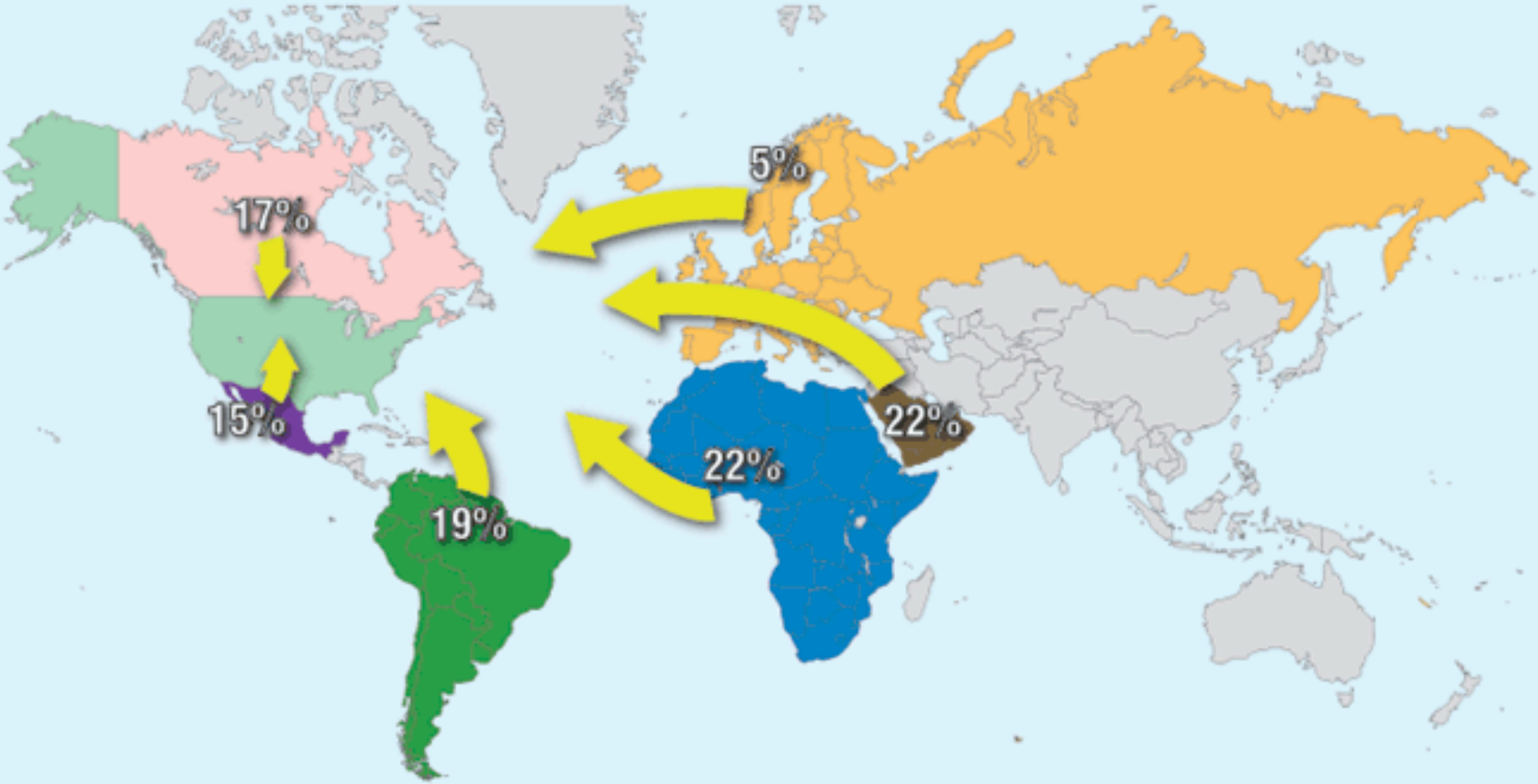
US Oil Production and Imports
Million Barrels/Day
11
10
9
8
7
6
5
4
3
2
1
0
Production
Imports
1920
1930
1940
1950
1960
1970
1980
1990
2000

In 2011,
the US spent
$460 Billion
on imported oil.

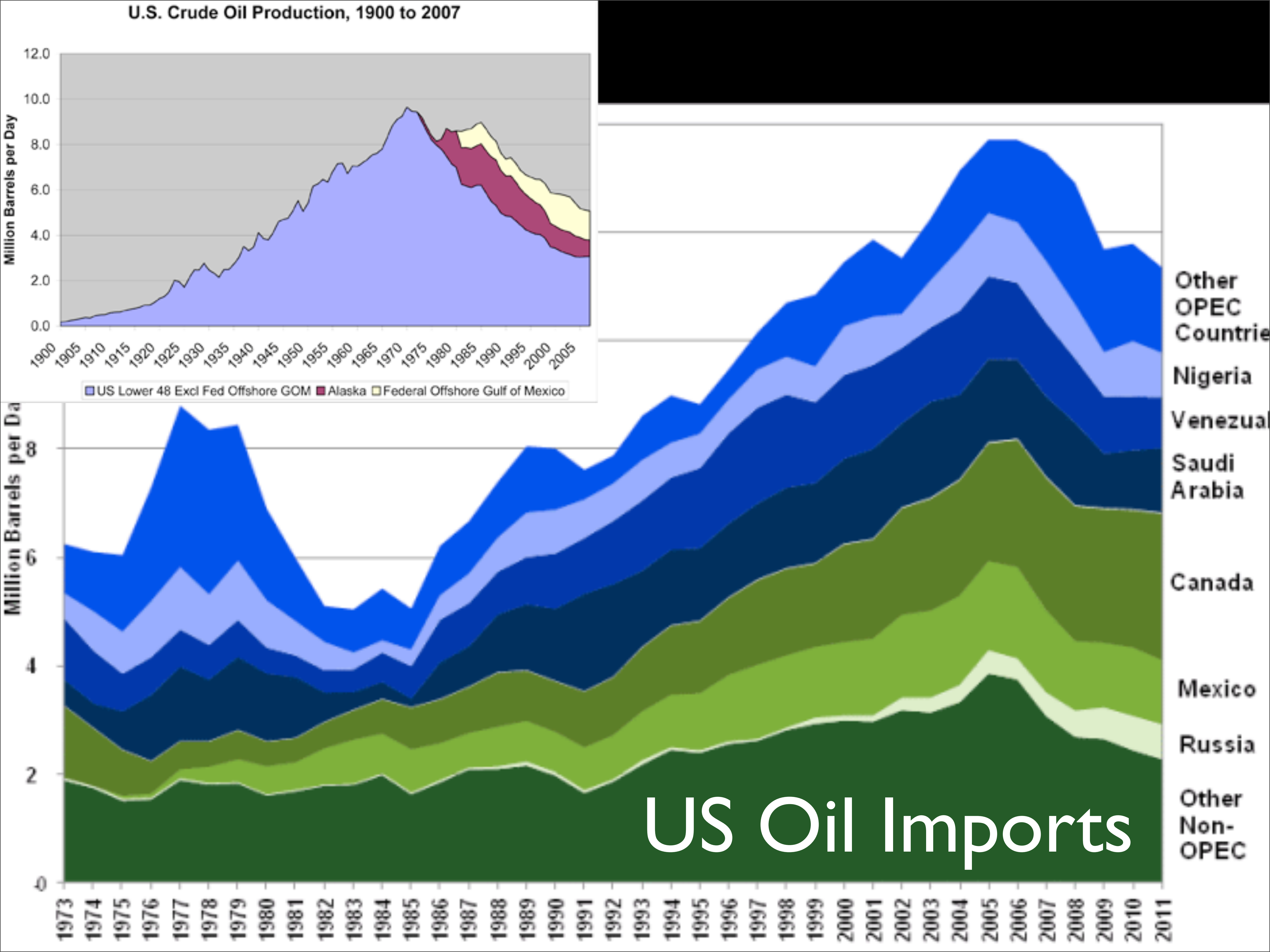


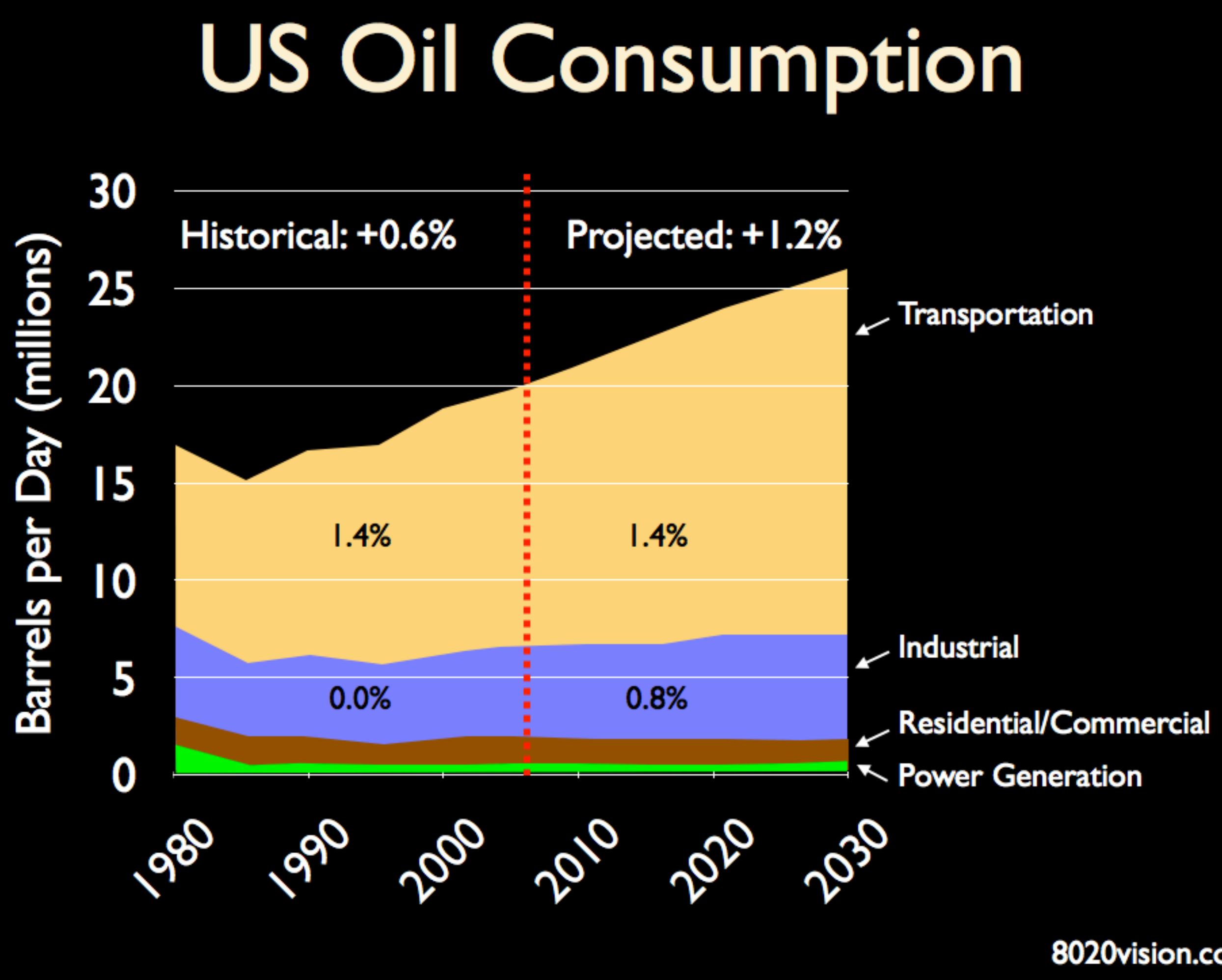
Rock Music Quality vs. US Oil Production
Songs in "Rolling Stone 500 Greatest Songs of All Time"
US Crude Oil Field Production, Lower 48 States (1,000 barrels)
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
35
30
25
20
15
10
5
0

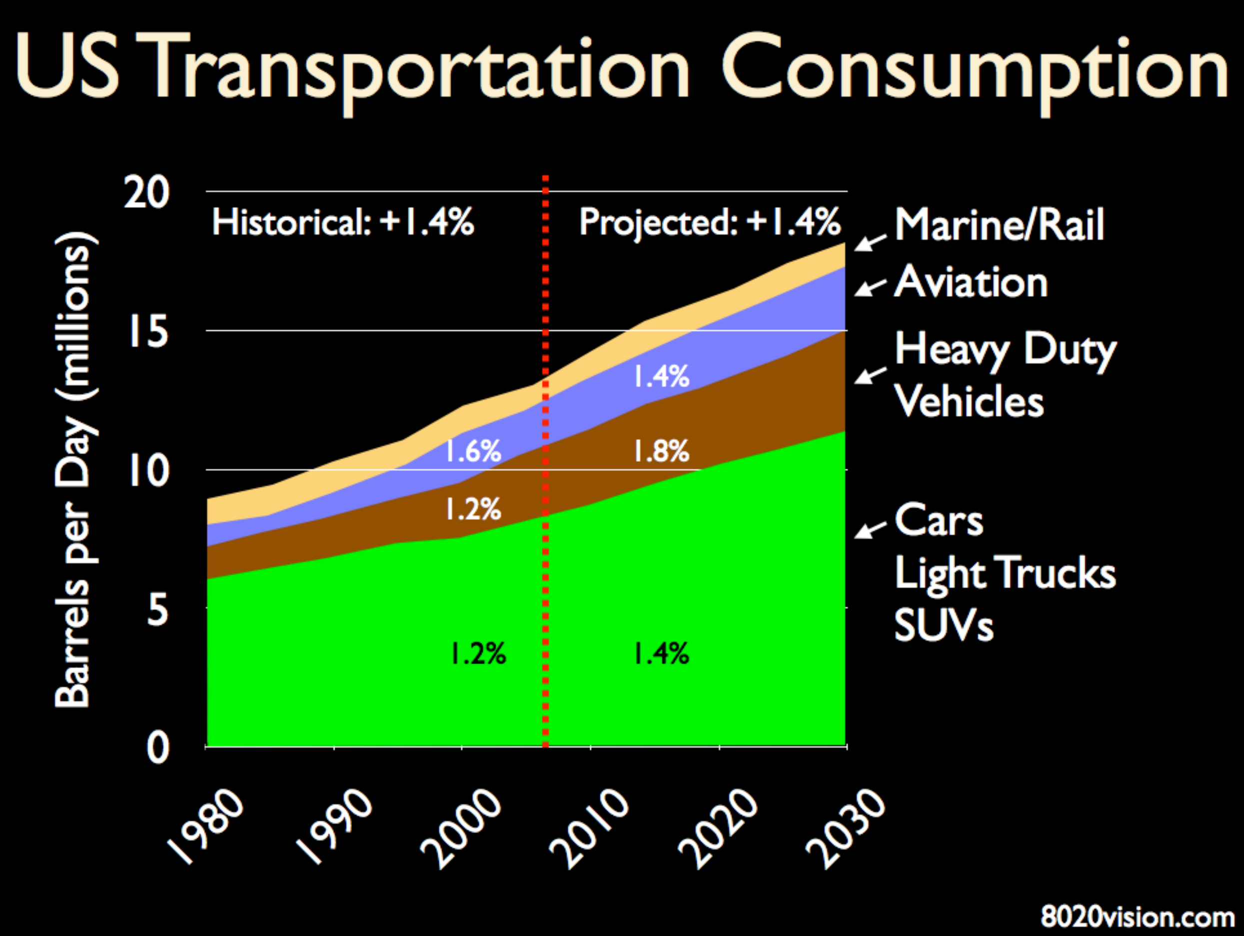
United States Oil Imports

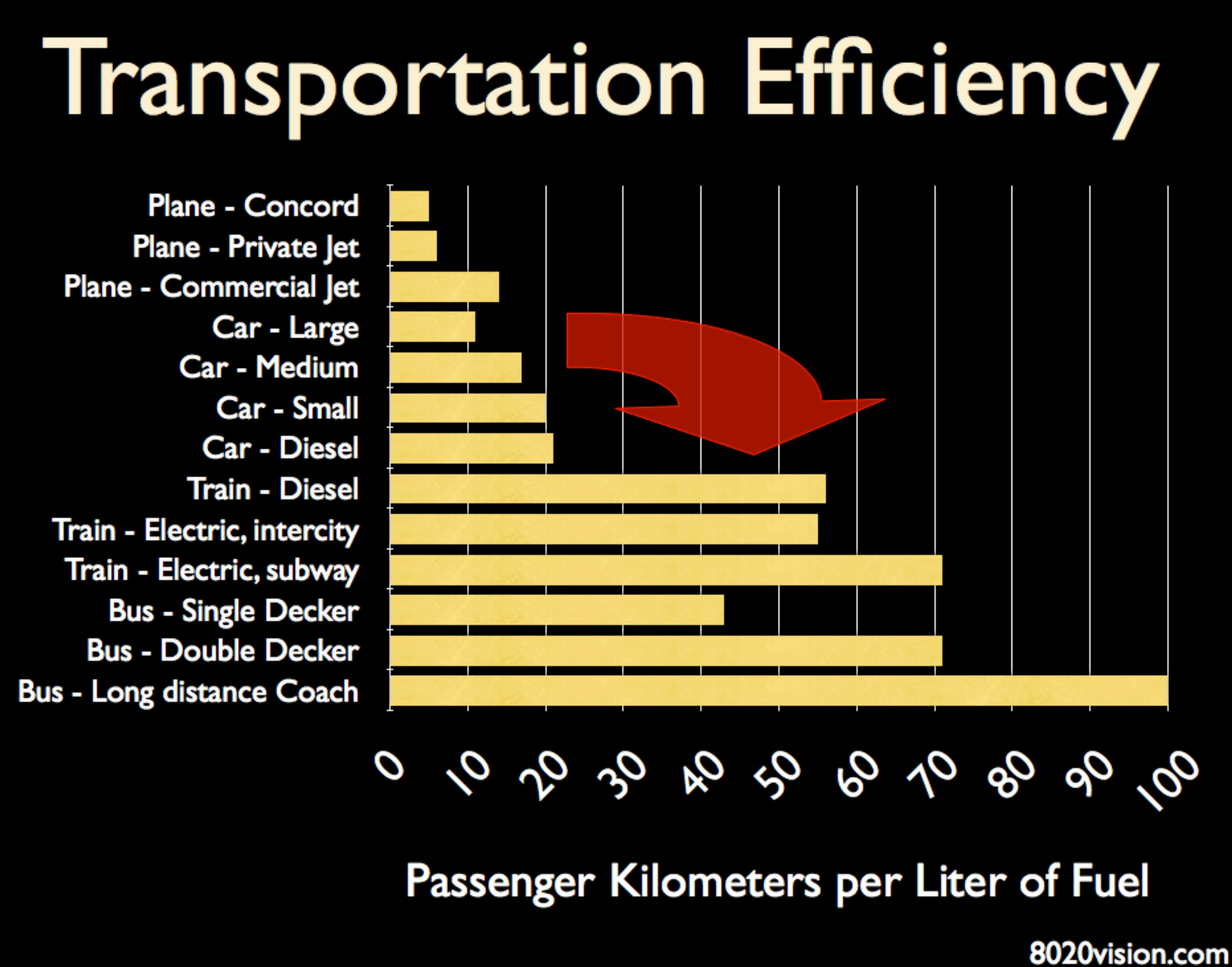


Data are of crude oil imports monthly average between June 2005 - November 2005 where monthly average is greater than one million barrels.
Source: Energy Information Administration, January 2006


U.S. Crude Oil Production, 1900 to 2007
Million Barrels per Day
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005
US Lower 48 Excl Fed Offshore GOM
Alaska
Federal Offshore Gulf of Mexico
Million Barrels per Da
8
6
4
2
0
1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Other OPEC Countrie
Nigeria
Venezual
Saudi Arabia
Canada
Mexico
Russia
Other Non-OPEC
US Oil Imports

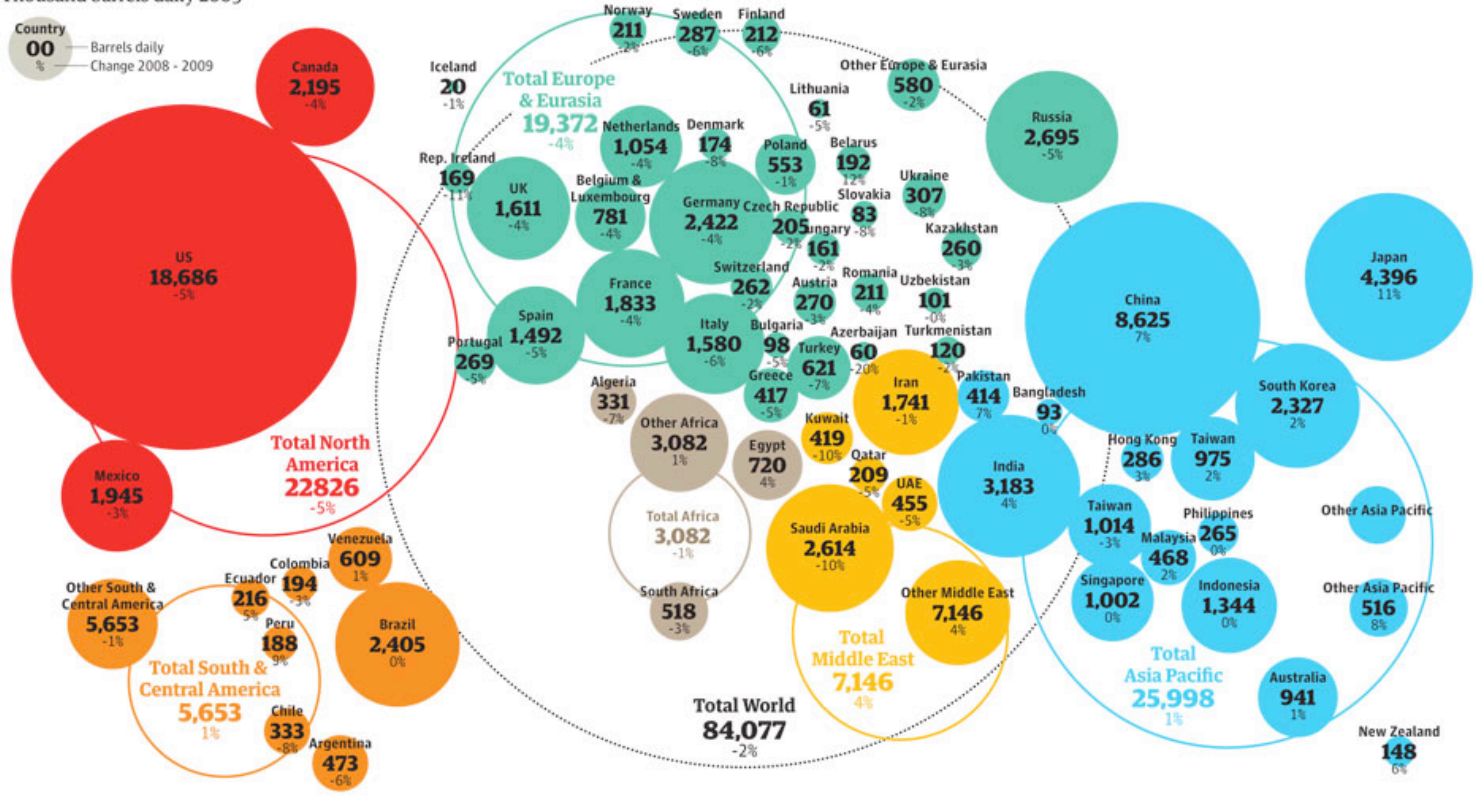

US Oil Consumption
Barrels per Day (millions)
Historical: +0.6%
Projected: +1.2%
1.4%
1.4%
0.0%
0.8%
Transportation
Industrial
Residential/Commercial
Power Generation
0
5
10
15
20
25
30
1980
1990
2000
2010
2020
2030
8020vision.com


US Transportation Consumption
Barrels per Day (millions)
Historical: +1.4%
Projected: +1.4%
1.4%
1.6%
1.8%
1.2%
1.2%
1.4%
Marine/Rail
Aviation
Heavy Duty Vehicles
Cars
Light Trucks
SUVs
0
5
10
15
20
1980
1990
2000
2010
2020
2030
8020vision.com


Transportation Efficiency
Plane - Concord
Plane - Private Jet
Plane - Commercial Jet
Car - Large
Car - Medium
Car - Small
Car - Diesel
Train - Diesel
Train - Electric, intercity
Train - Electric, subway
Bus - Single Decker
Bus - Double Decker
Bus - Long distance Coach
0
10
20
30
40
50
60
70
80
90
100
Passenger Kilometers per Liter of Fuel
8020vision.com

Oil consumption around the world

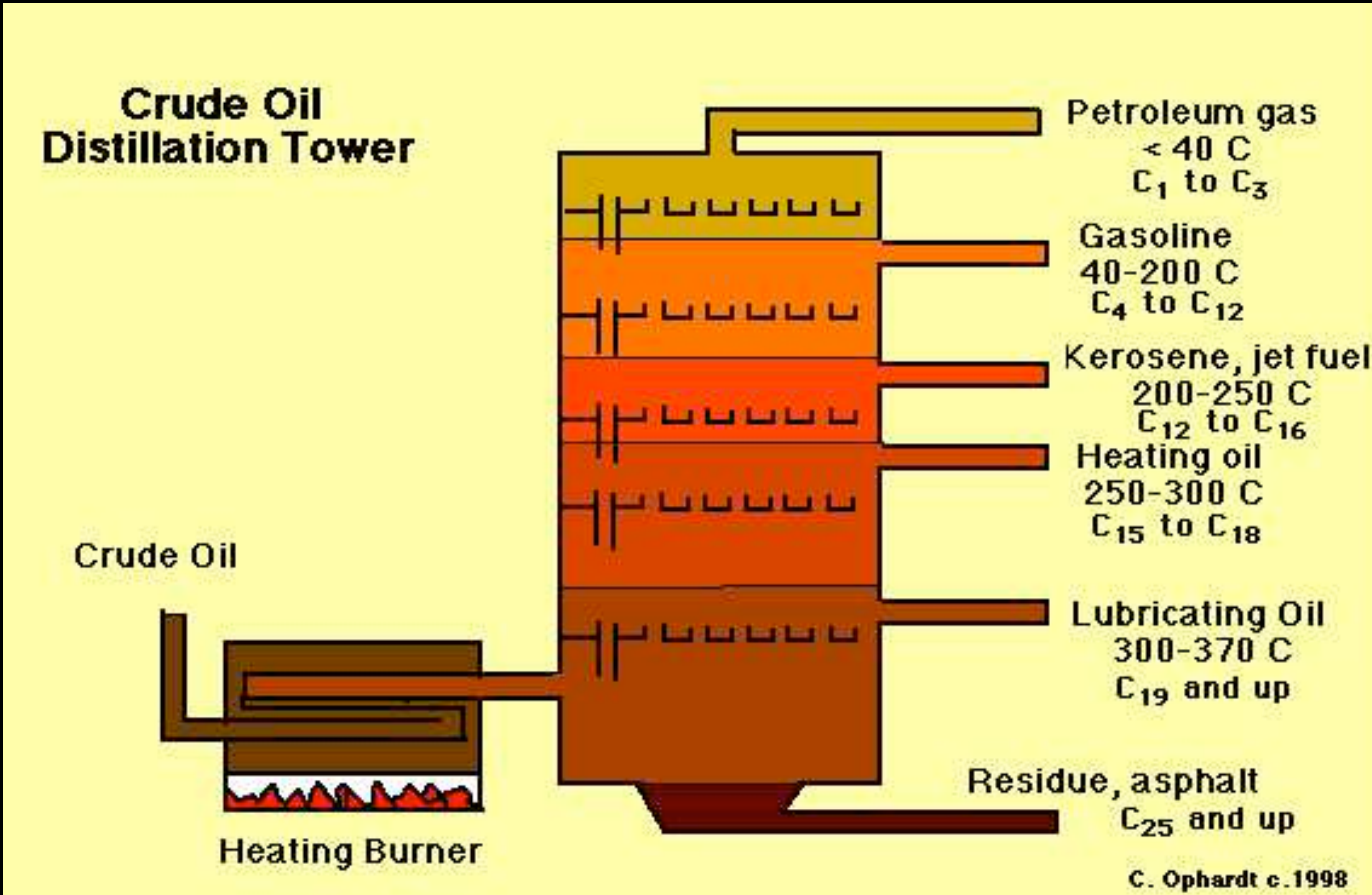
Thousand barrels daily 2009



SOURCE: BP STATISTICAL REVIEW OF WORLD ENERGY

World oil consumption

Thousand barrels daily, 1965 - 2009



Crude Oil
Distillation Tower
Petroleum gas
< 40 C
C_1 to C_3
Gasoline
40-200 C
C_4 to C_{12}
Kerosene, jet fuel
200-250 C
C_{12} to C_{16}
Heating oil
250-300 C
C_{15} to C_{18}
Crude Oil
Lubricating Oil
300-370 C
C_{19} and up
Residue, asphalt
C_{25} and up
Heating Burner
C. Ophardt c.1998

Coal

Advantages:

- plentiful
- domestic sources

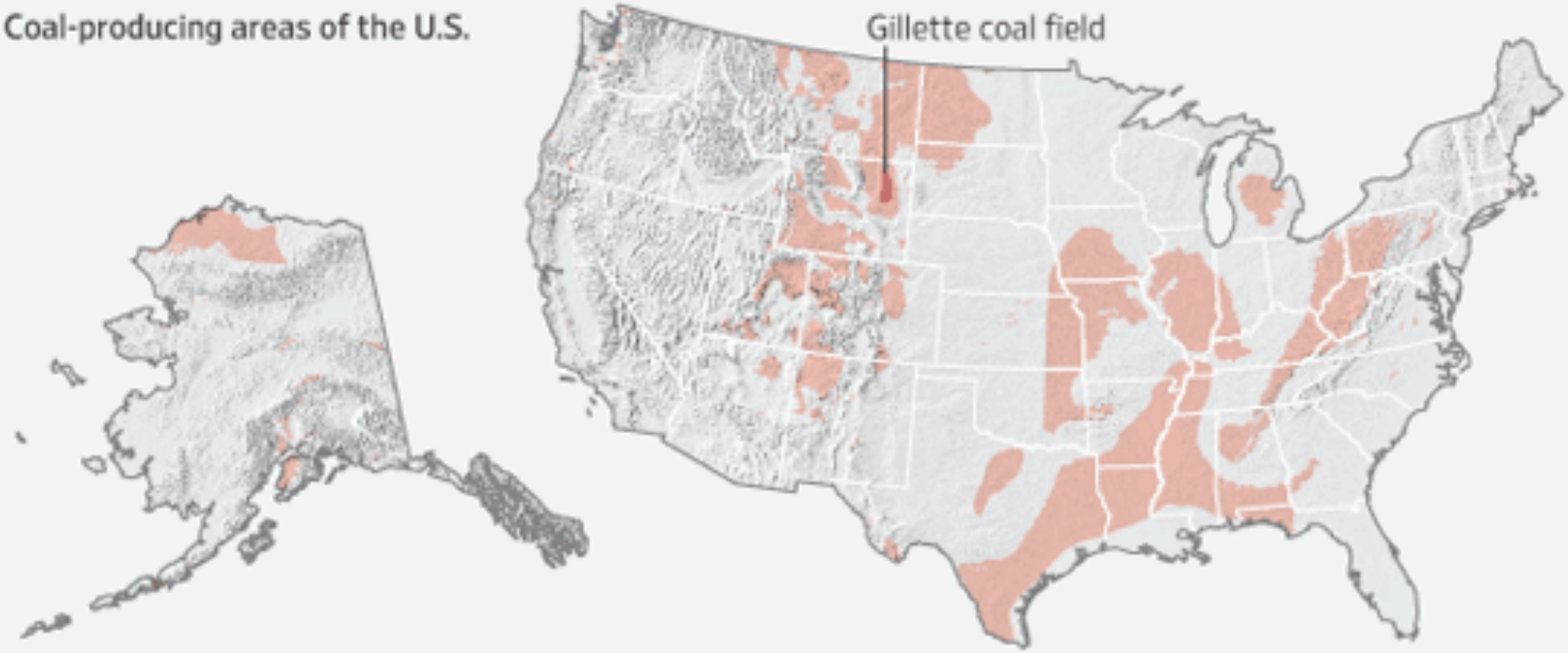
Disadvantages:

- highly polluting (including CO_2)
- releases high levels of radioactivity
- expensive to transport

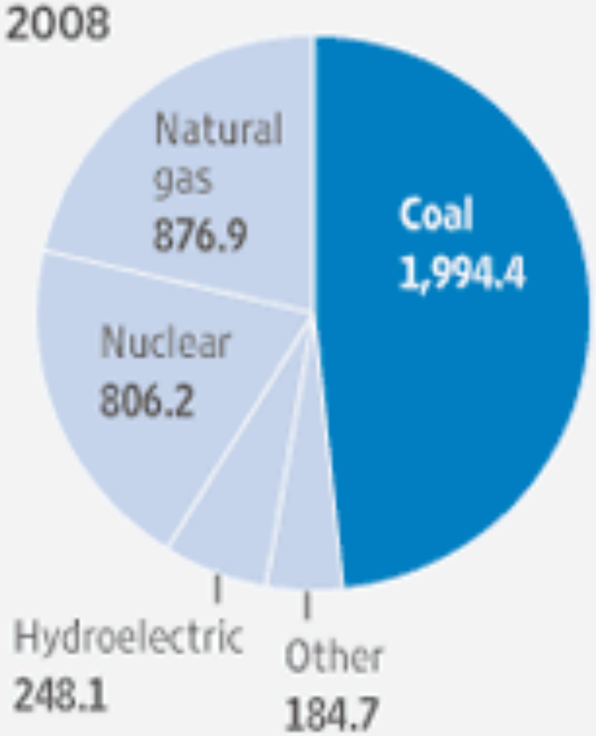
Coal

Power Source | The U.S.'s reliance on coal

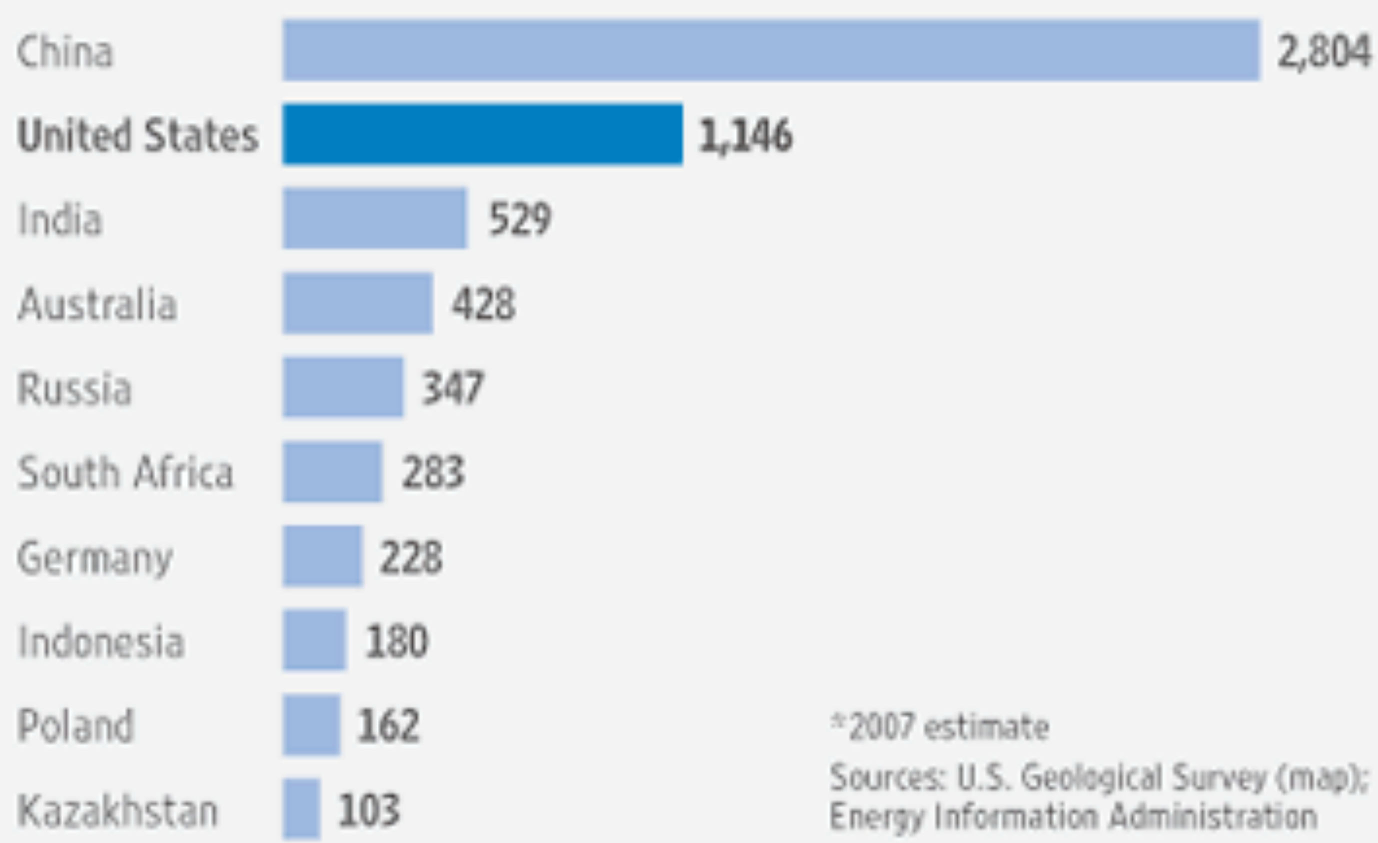
Coal-producing areas of the U.S.



U.S. net electricity generation, in millions of megawatt hours, 2008

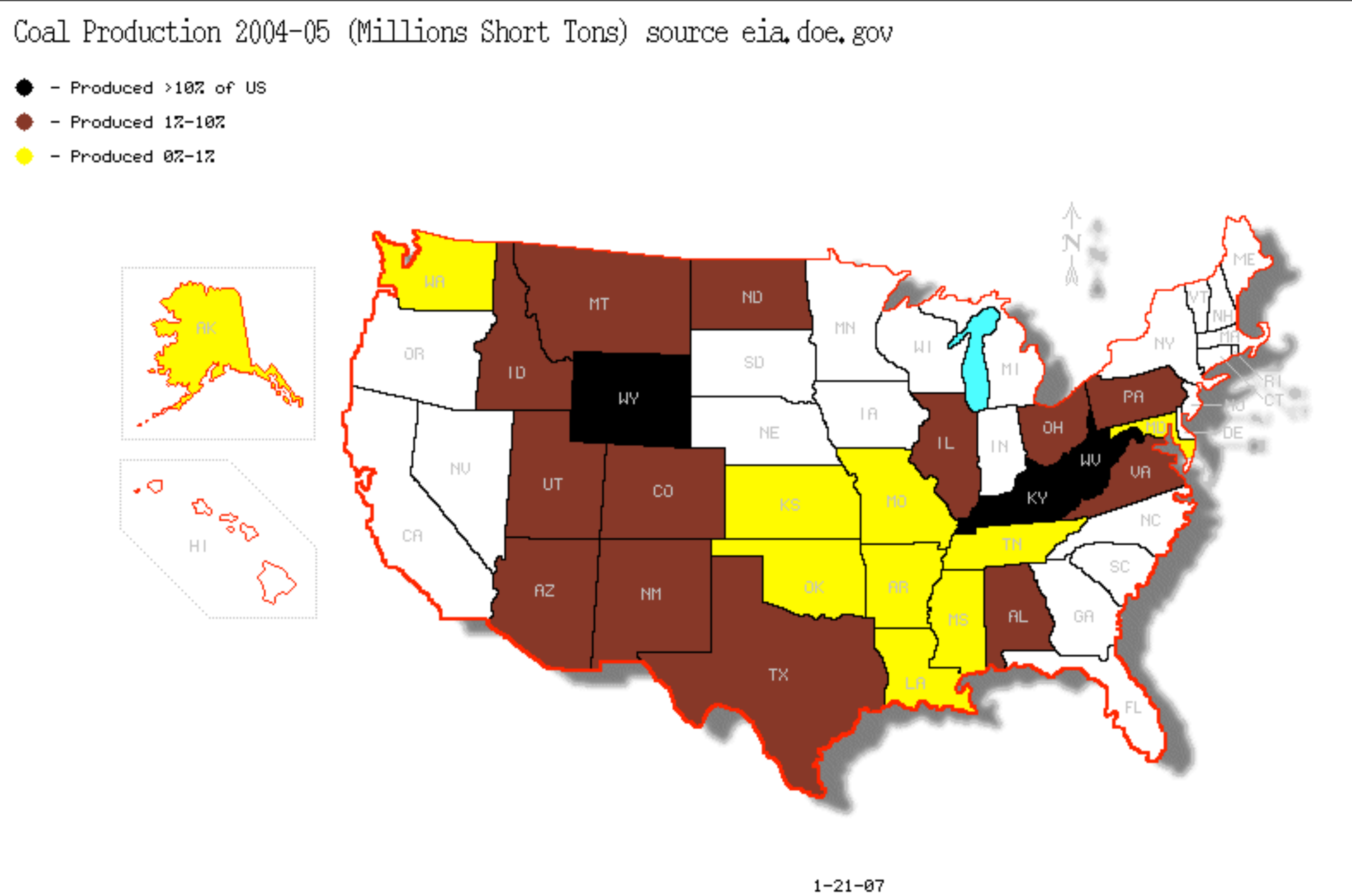


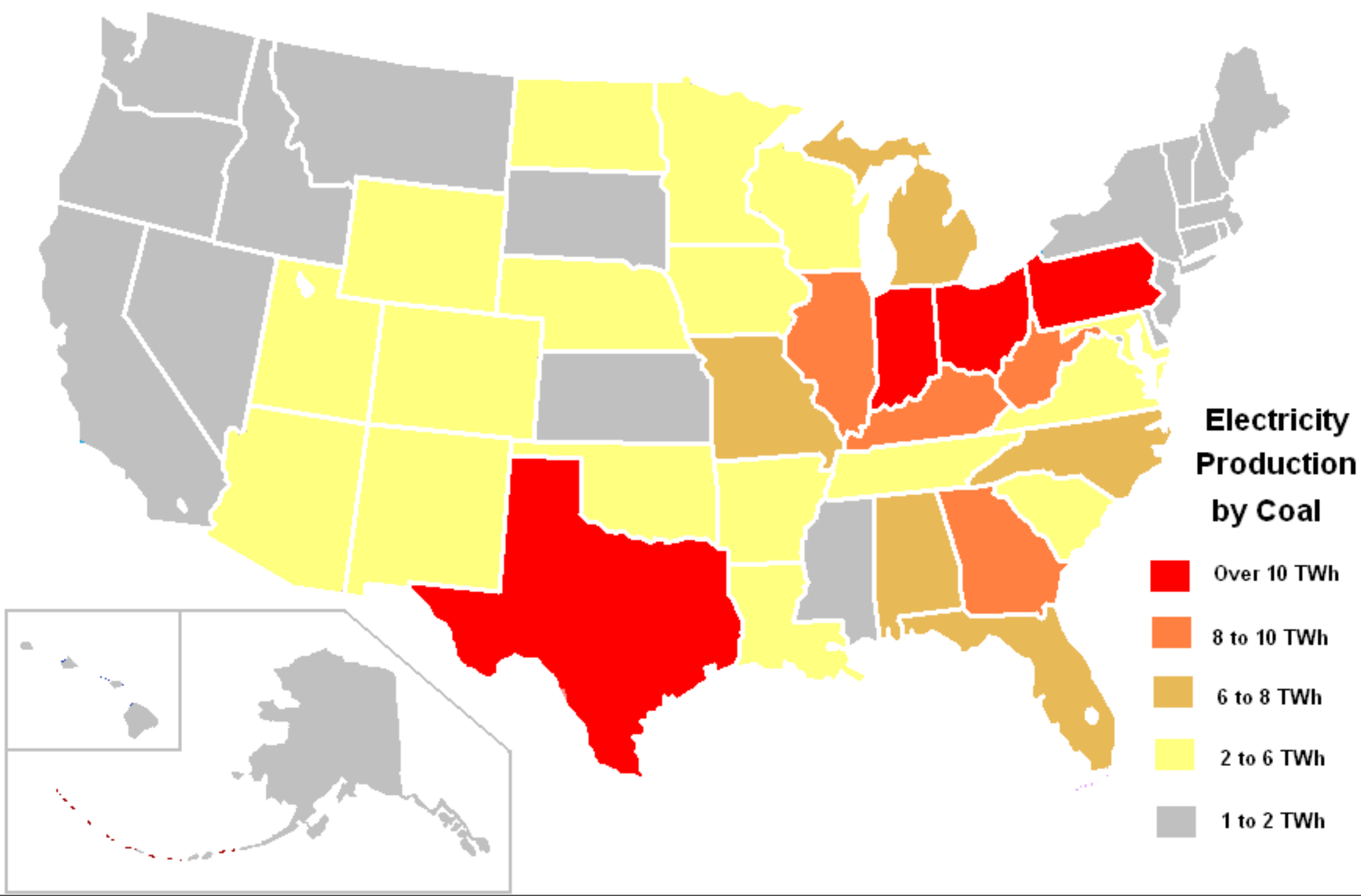
Total estimated coal production, in millions of short tons*



*2007 estimate

Sources: U.S. Geological Survey (map); Energy Information Administration





Wyoming

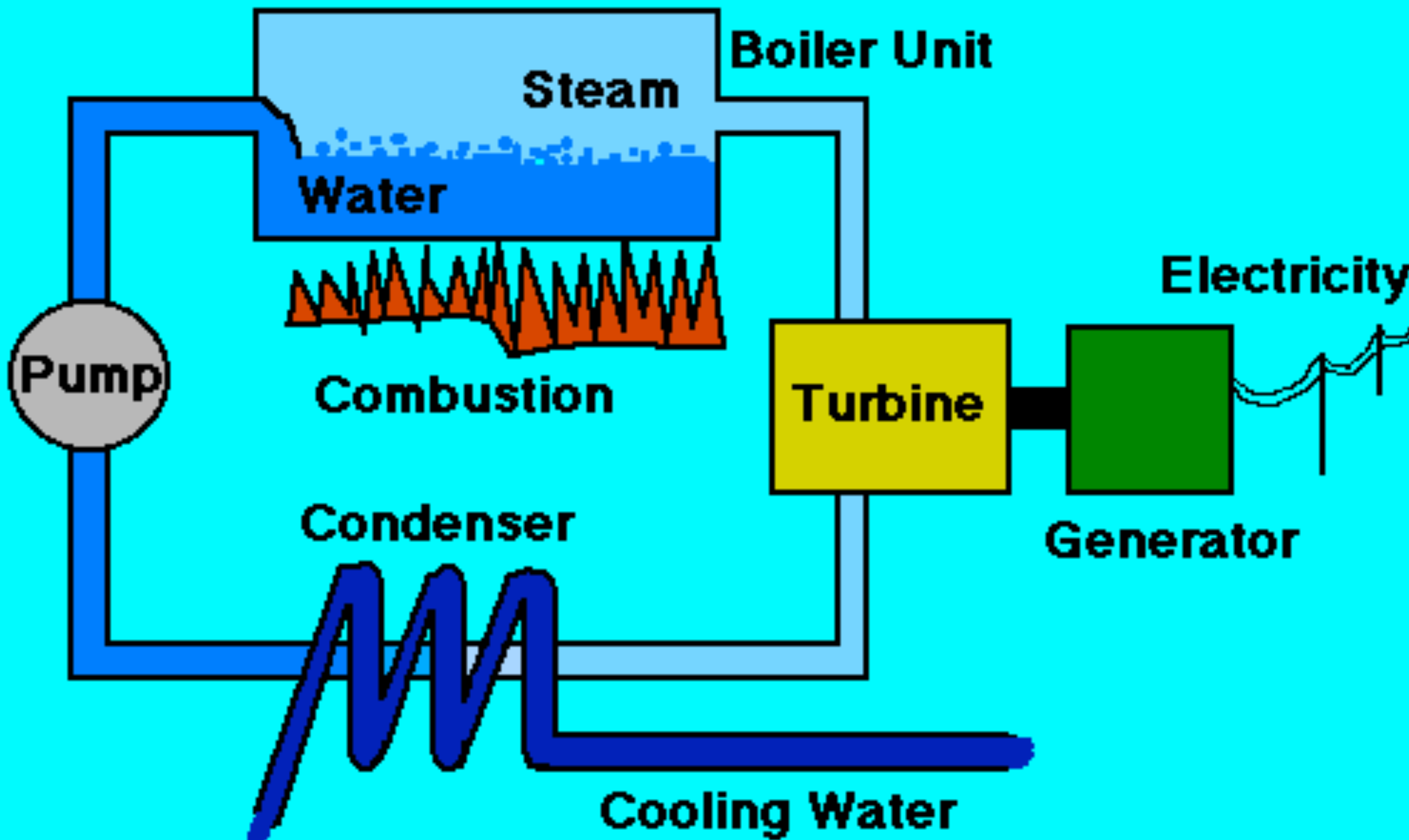
40% of US production transported to 34 states.

438 million tons in 2011

known reserves:
42 billion tons

total resource:
1.4 trillion tons

Fossil Fuel Electric Power Generating Plant

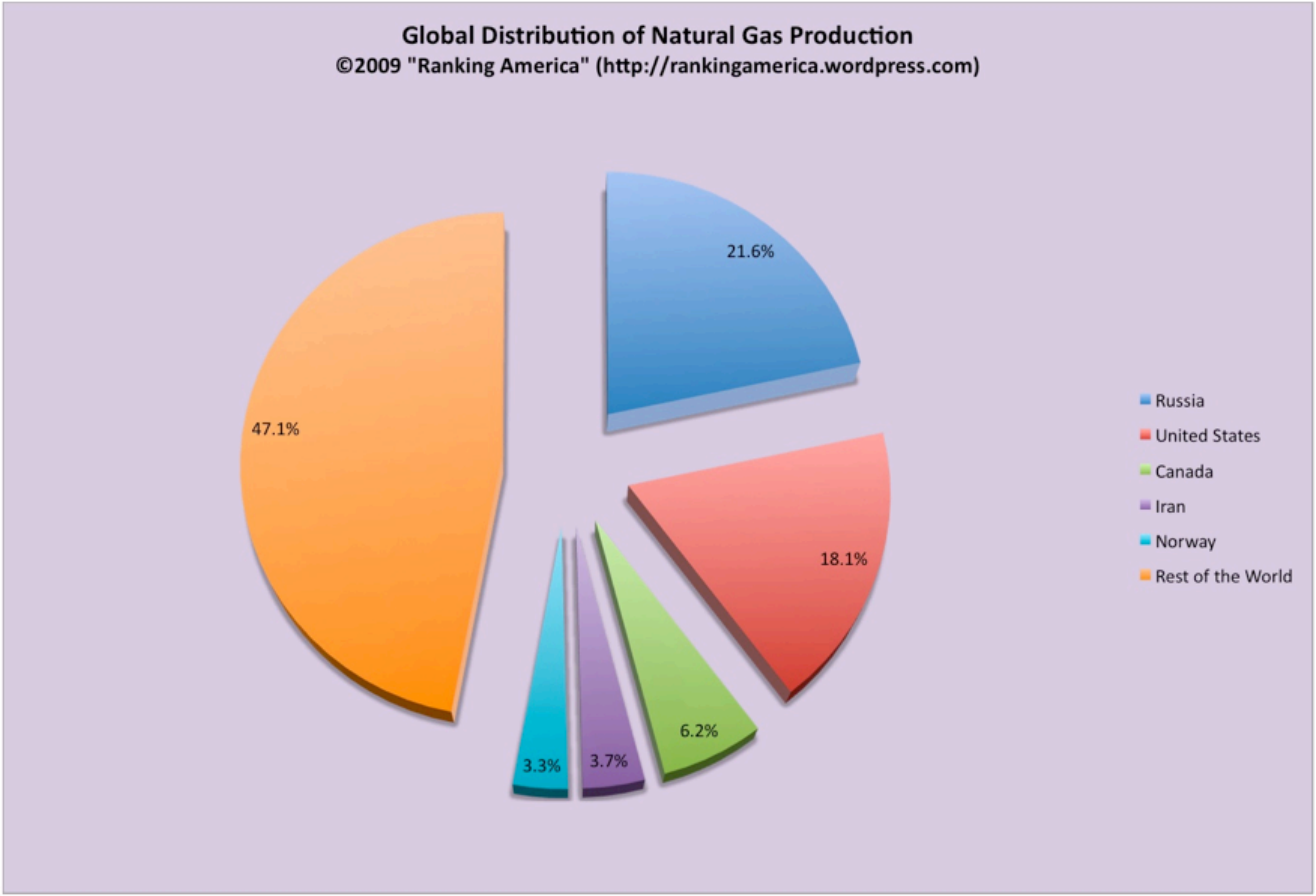


Natural Gas

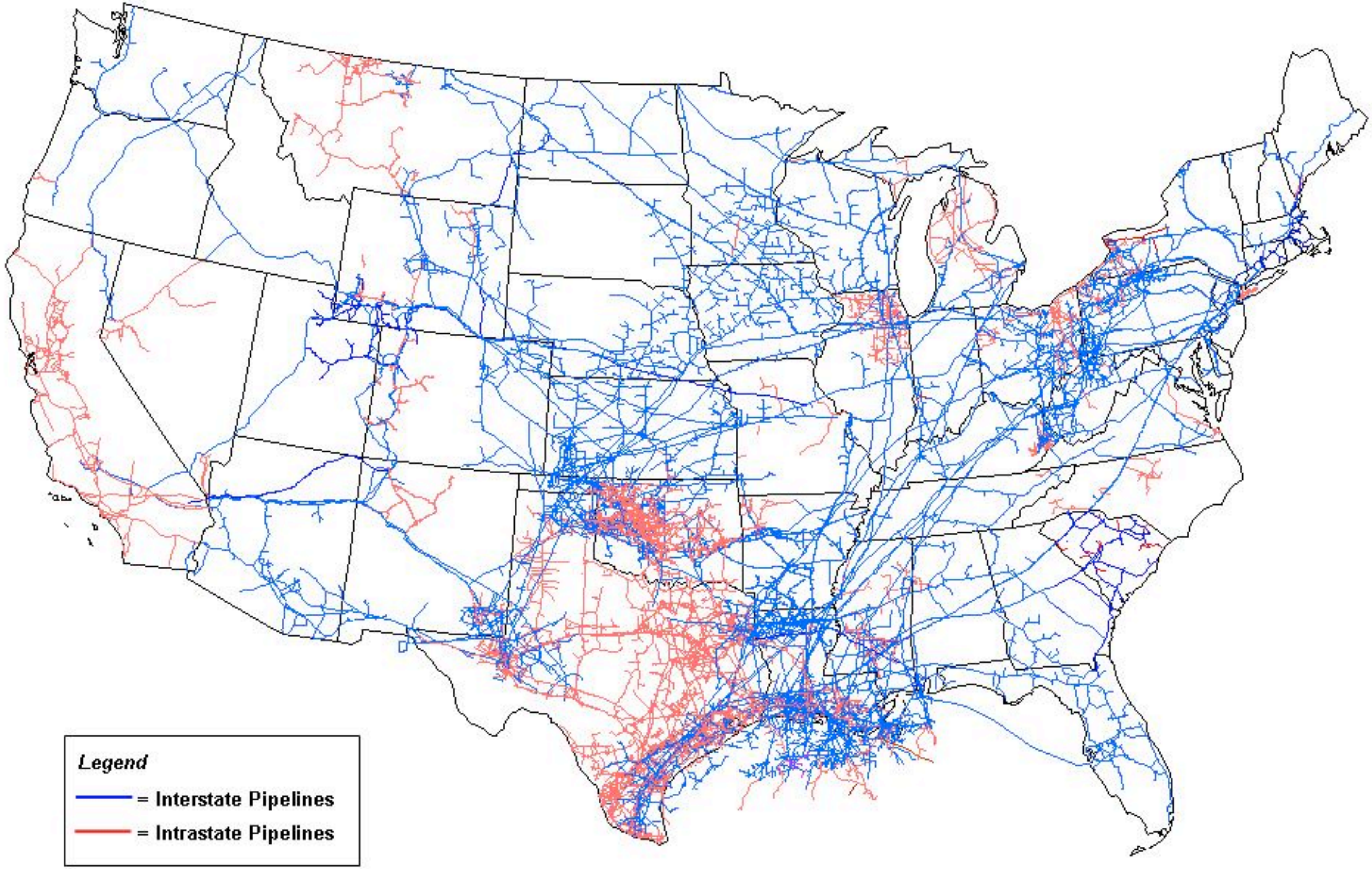
Advantages:
- lowest CO_2 producer
- CH_4 is potent greenhouse gas

Disadvantages:
- running low
- hard to transport internationally
- produces CO_2
- fracking



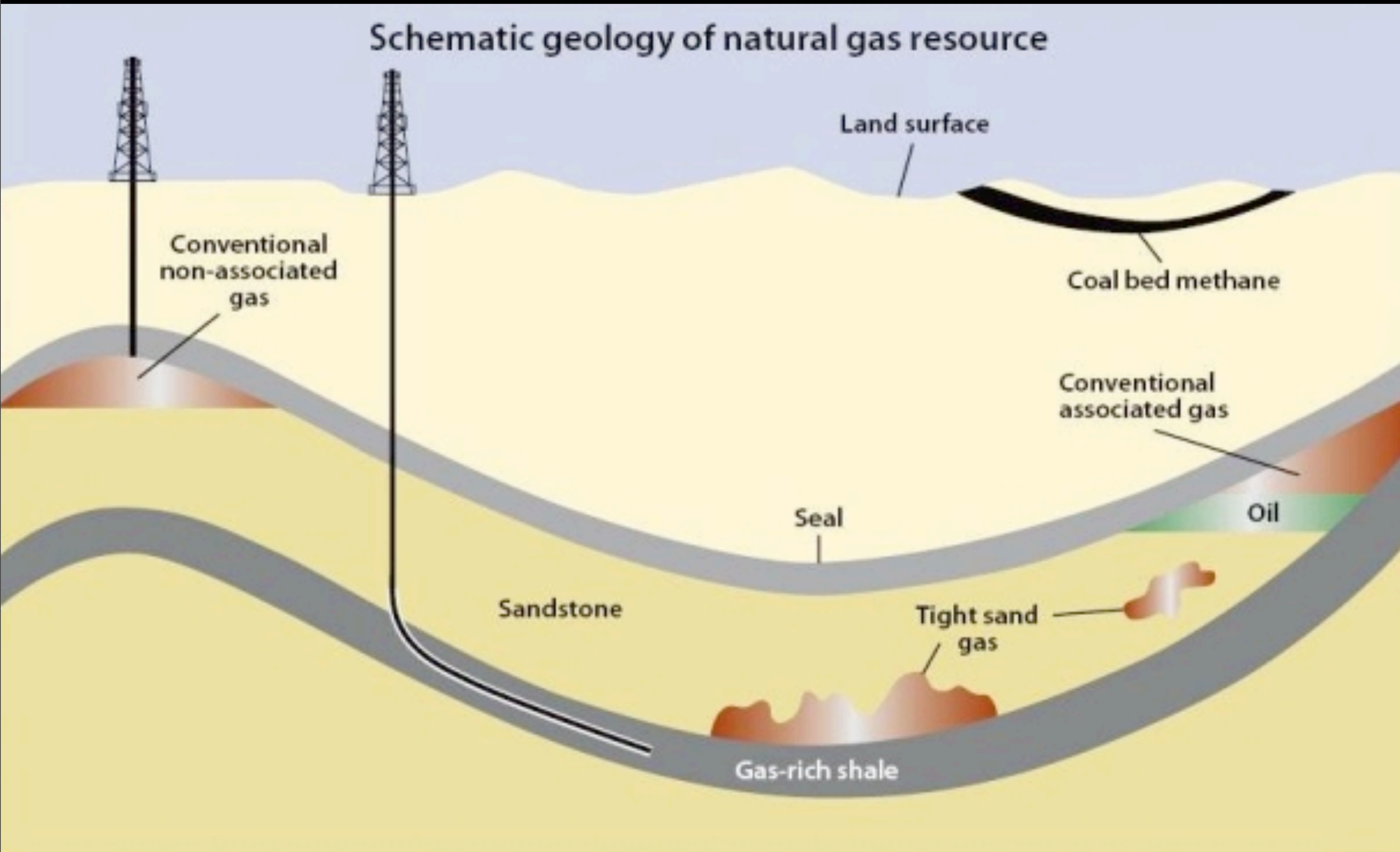


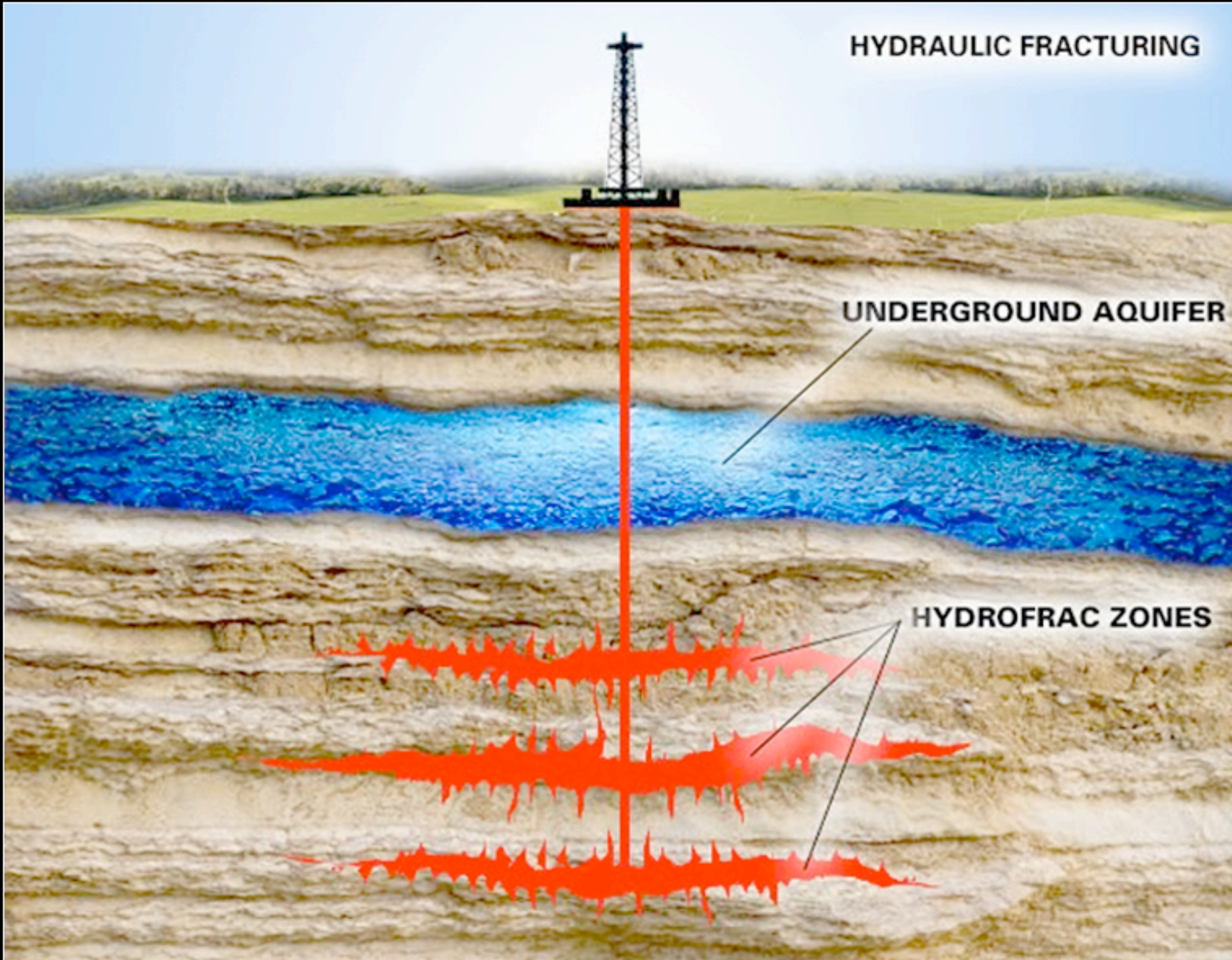
Data from CIA
https://www.cia.gov/library/publications/the-world-factbook/rankorder/2180rank.html



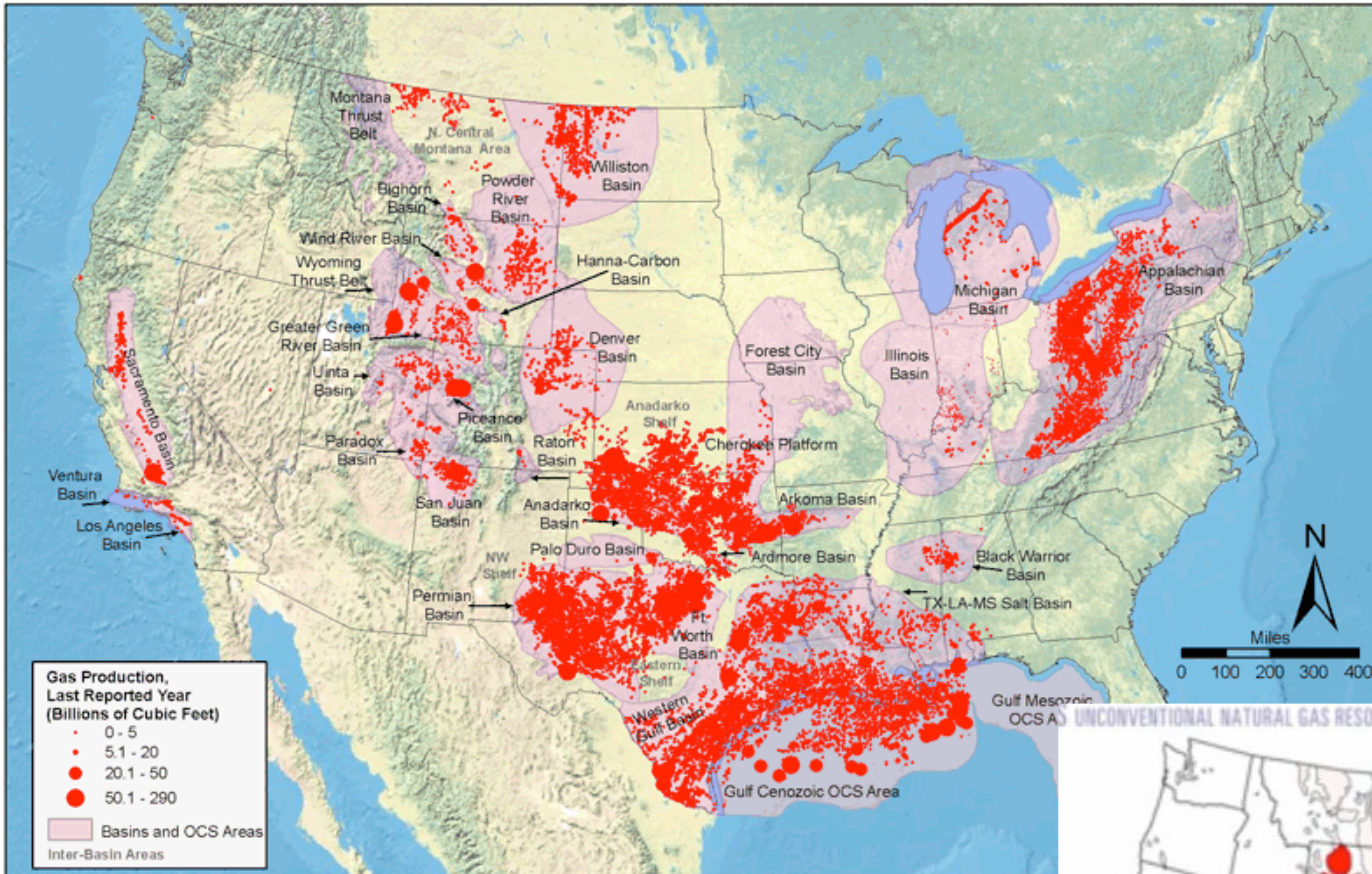
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

PHOTO: STR/AFP/GETTY IMAGES


Schematic geology of natural gas resource
Land surface
Conventional non-associated gas
Coal bed methane
Conventional associated gas
Oil
Seal
Sandstone
Tight sand gas
Gas-rich shale


HYDRAULIC FRACTURING
UNDERGROUND AQUIFER
HYDROFRAC ZONES

Gas Production in Conventional Fields, Lower 48 States

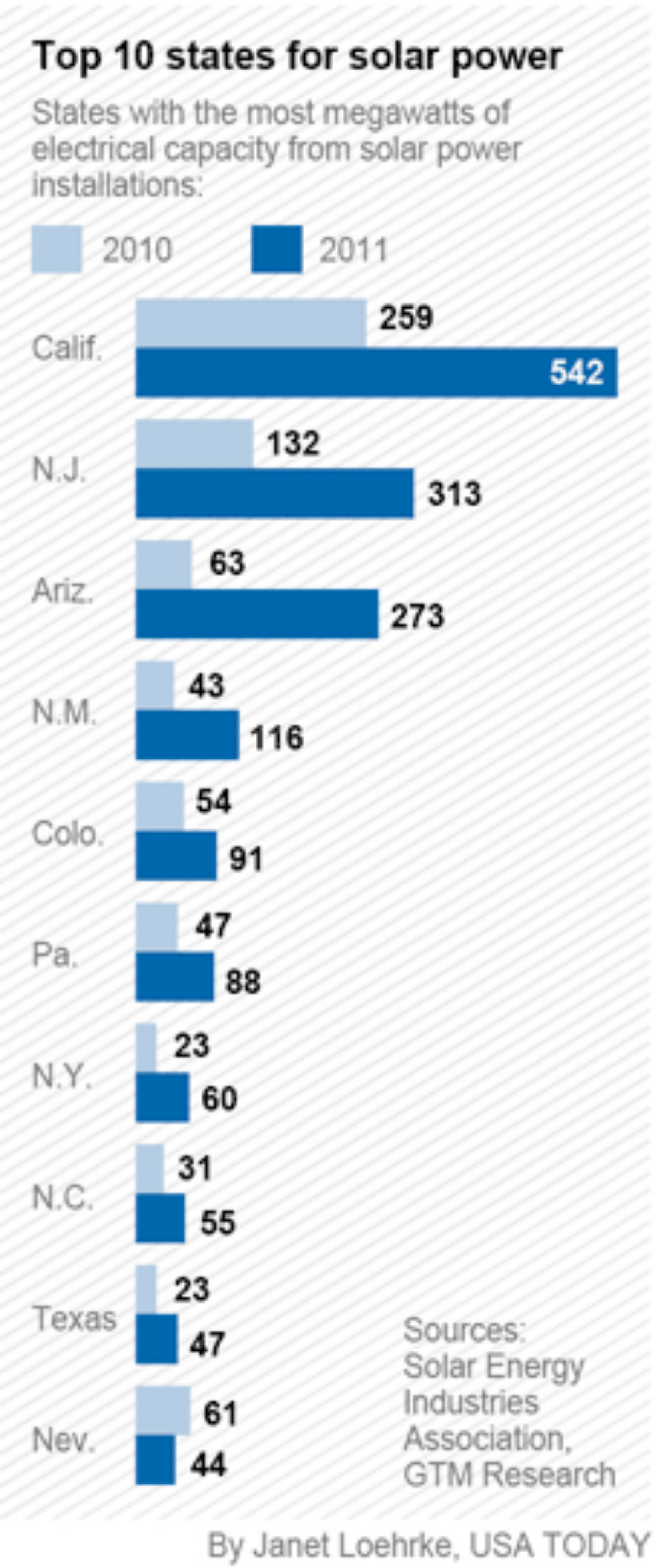


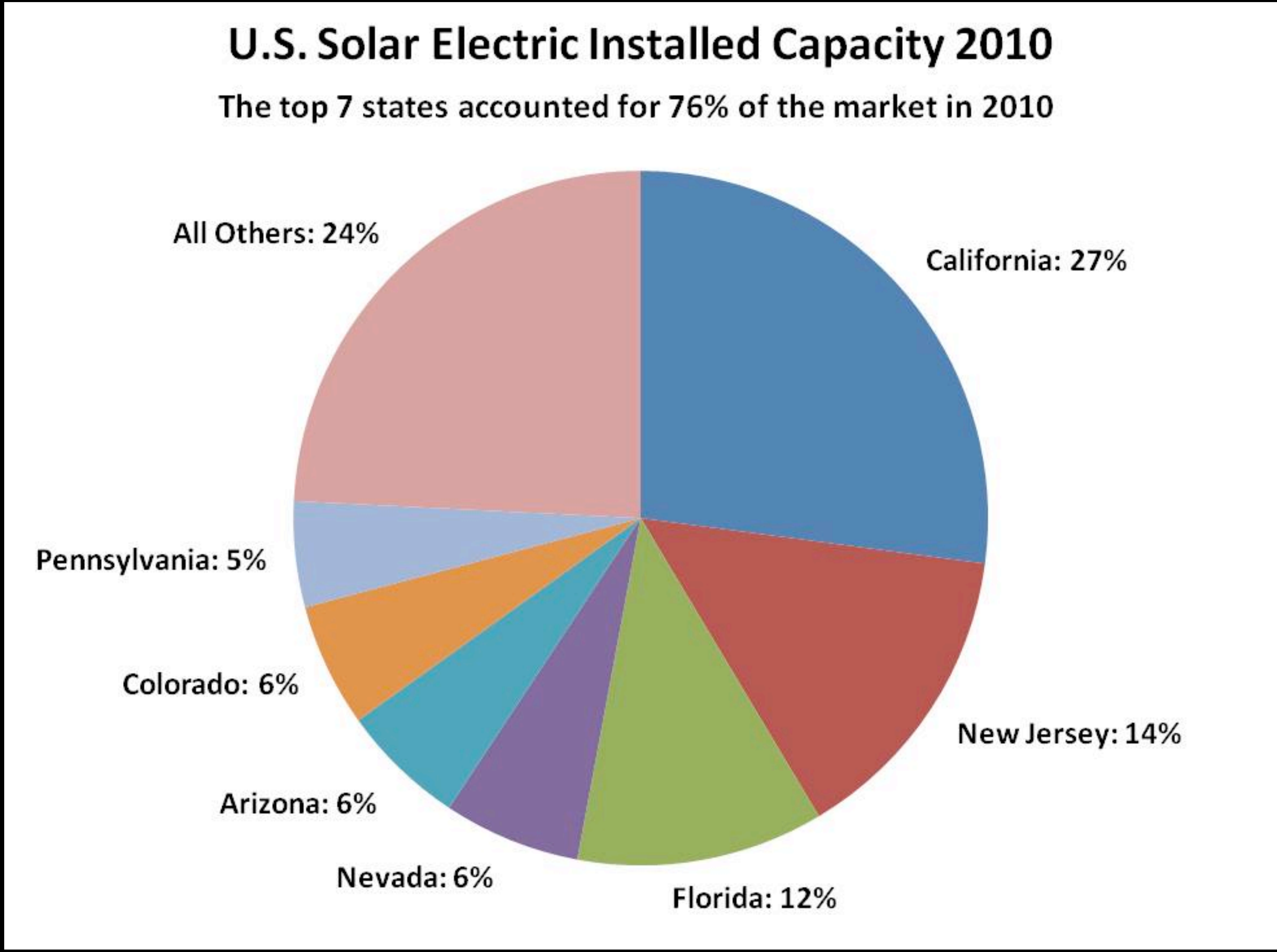
Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

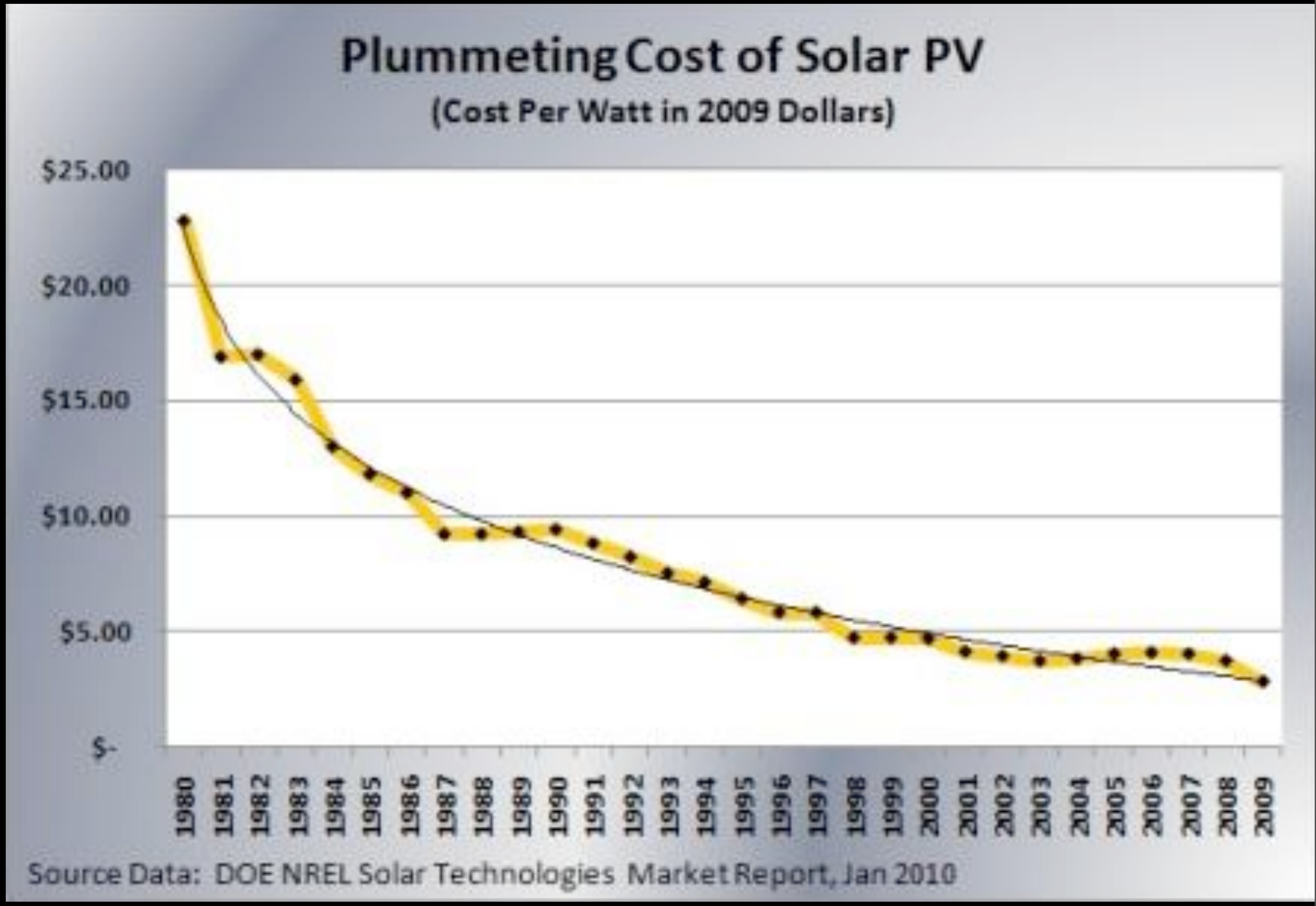
Solar

Advantages:
- clean!
- plentiful
- available worldwide

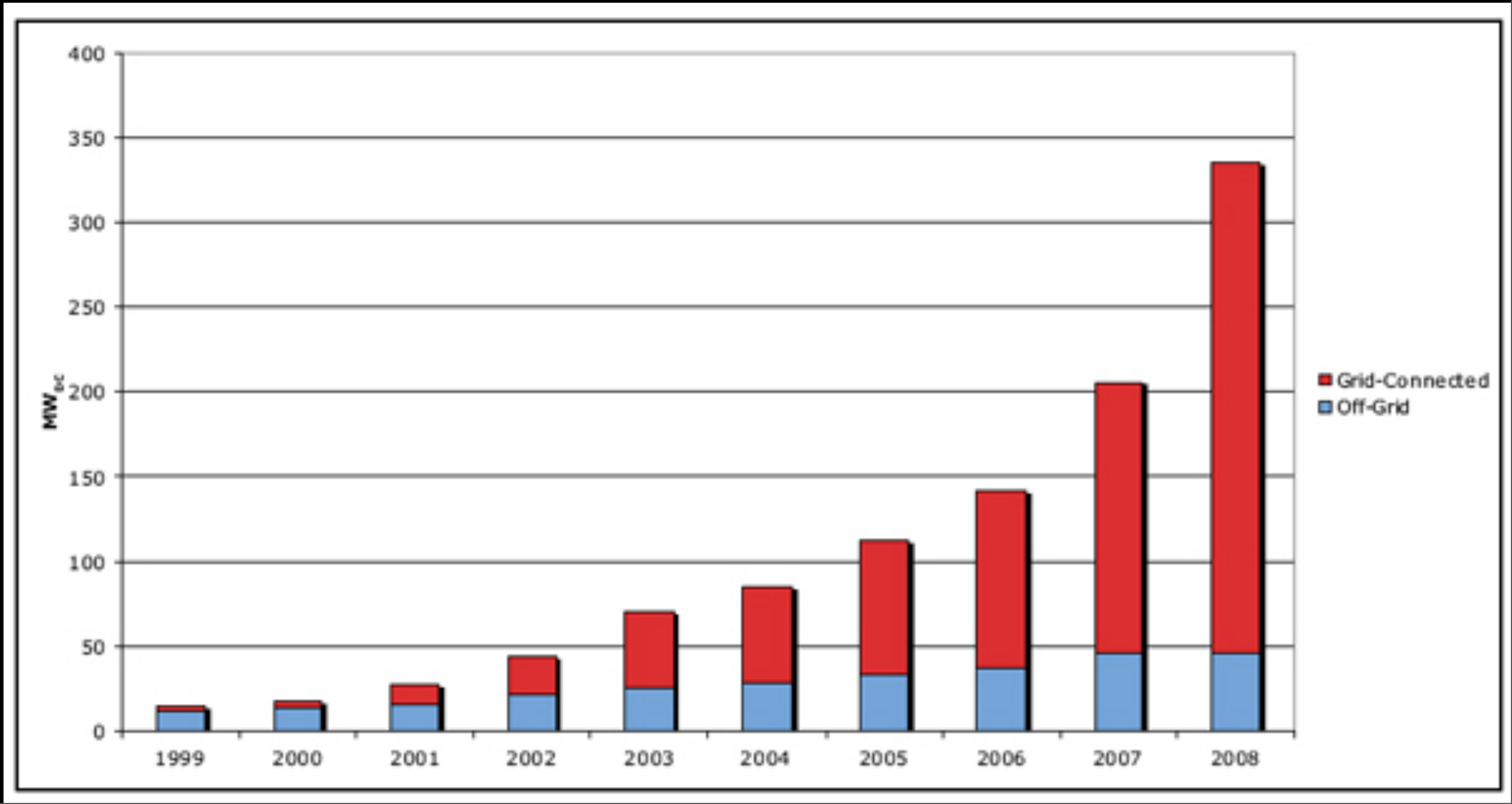
Disadvantages:
- expensive
- not available at night


Top 10 states for solar power
States with the most megawatts of electrical capacity from solar power installations:
2010
2011
Calif.
259
542
N.J.
132
313
Ariz.
63
273
N.M.
43
116
Colo.
54
91
Pa.
47
88
N.Y.
23
60
N.C.
31
55
Texas
23
47
Nev.
61
44
Sources: Solar Energy Industries Association, GTM Research
By Janet Loehrke, USA TODAY


U.S. Solar Electric Installed Capacity 2010
The top 7 states accounted for 76% of the market in 2010
All Others: 24%
California: 27%
Pennsylvania: 5%
Colorado: 6%
New Jersey: 14%
Arizona: 6%
Nevada: 6%
Florida: 12%



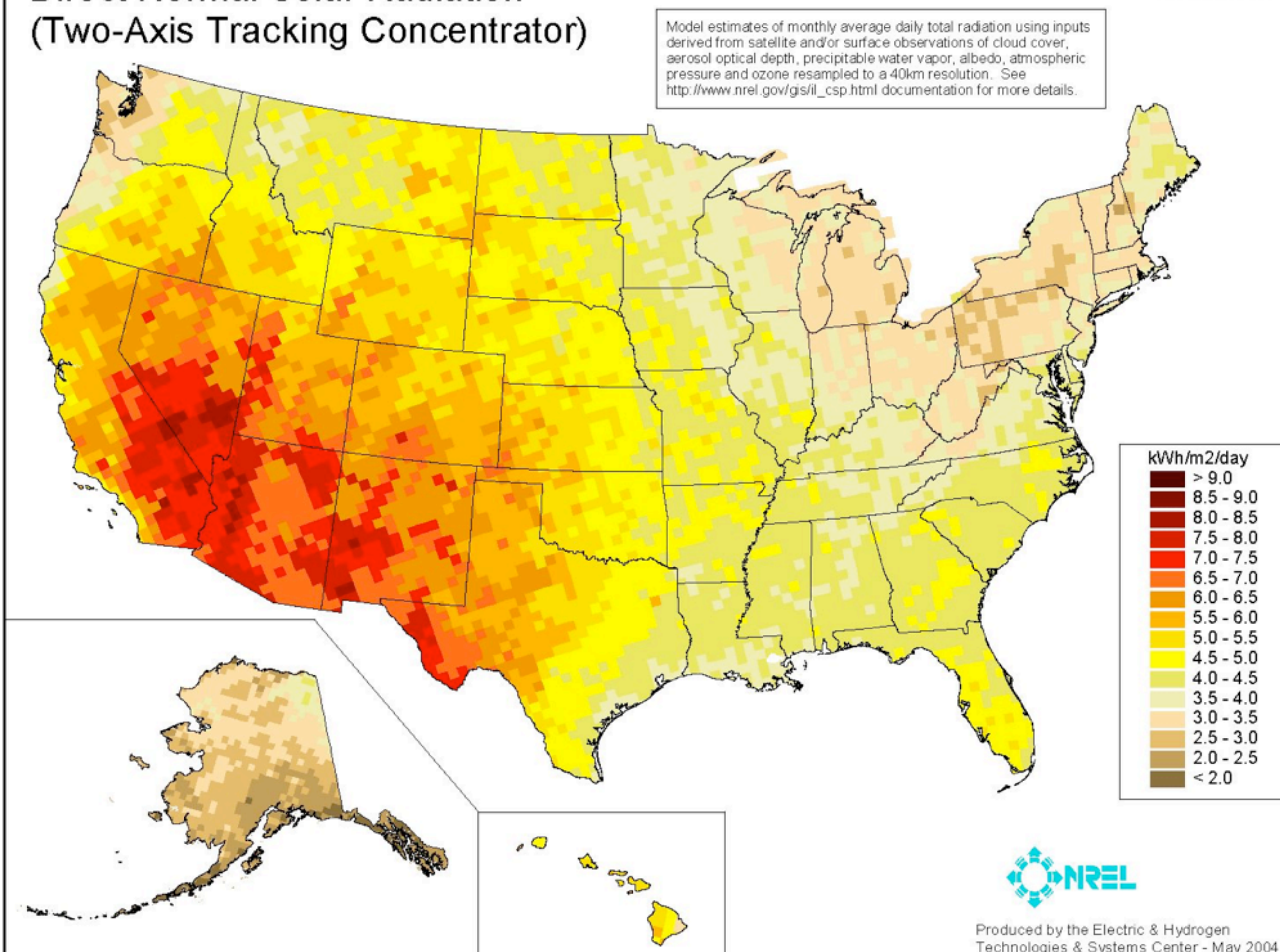
Plummeting Cost of Solar PV
(Cost Per Watt in 2009 Dollars)
$25.00
$20.00
$15.00
$10.00
$5.00
$-
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Source Data: DOE NREL Solar Technologies Market Report, Jan 2010



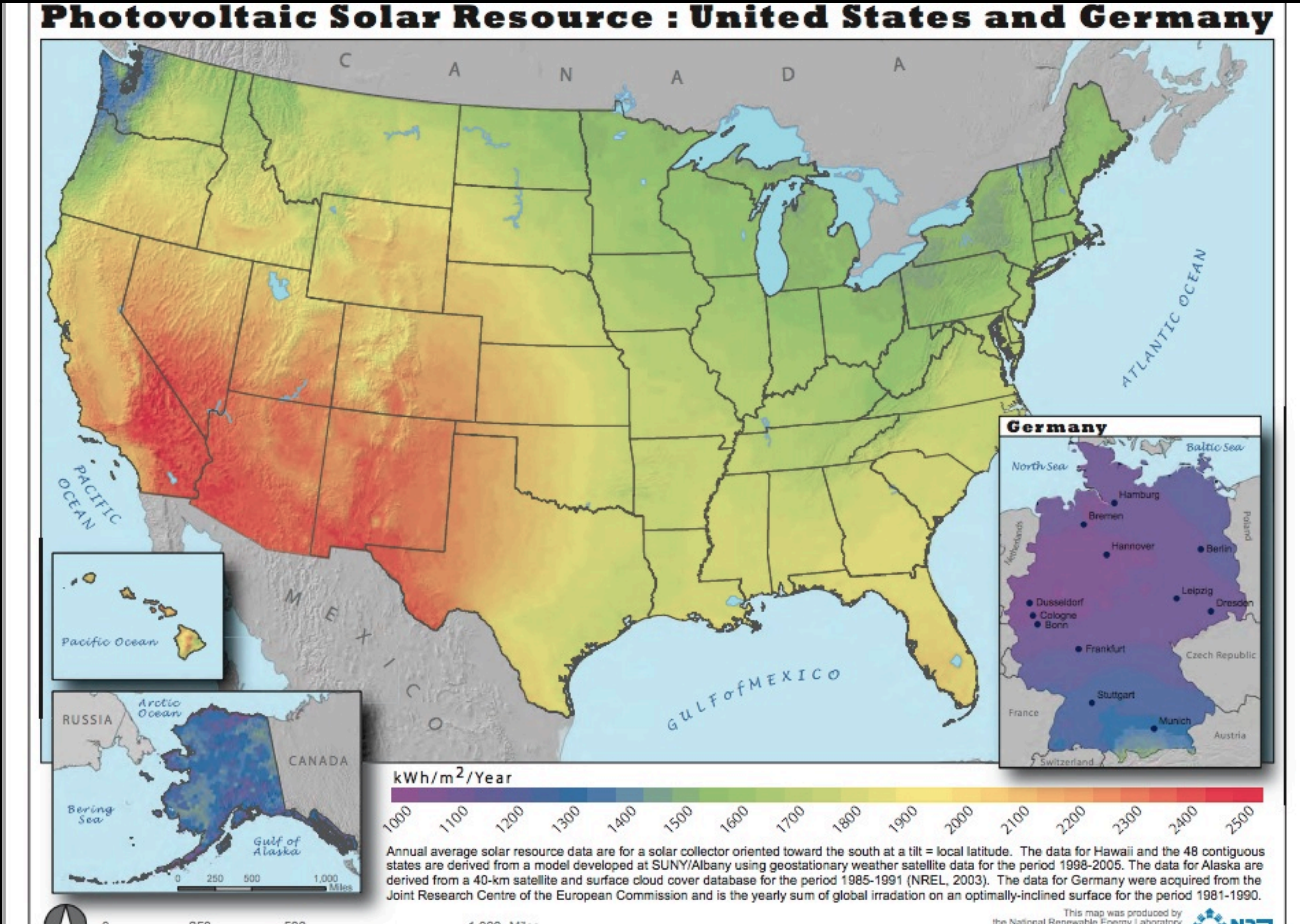
400
350
300
250
200
150
100
50
0
MW_DC
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Grid-Connected
Off-Grid

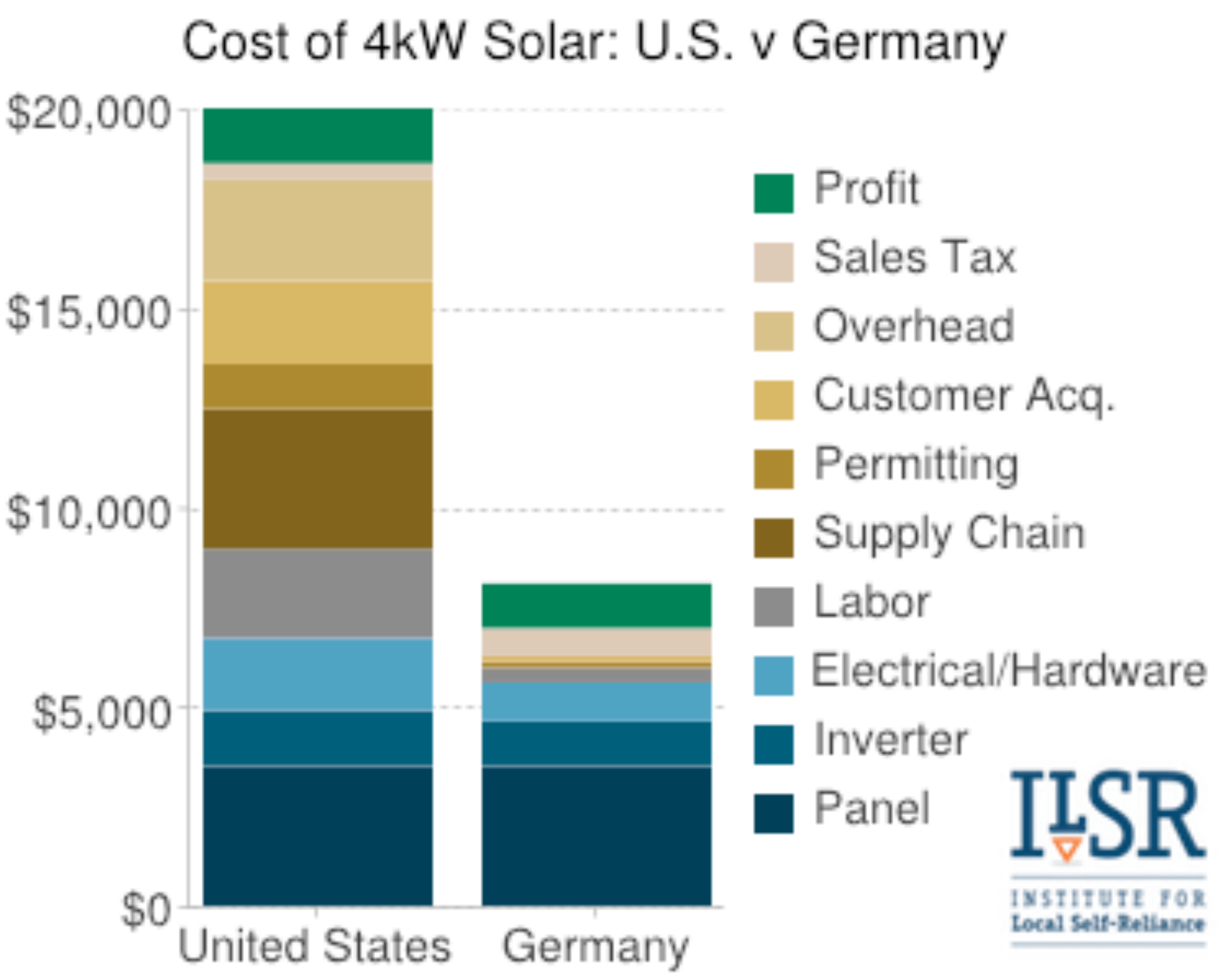
Direct Normal Solar Radiation (Two-Axis Tracking Concentrator)

Annual



Germany has 60x more installed solar

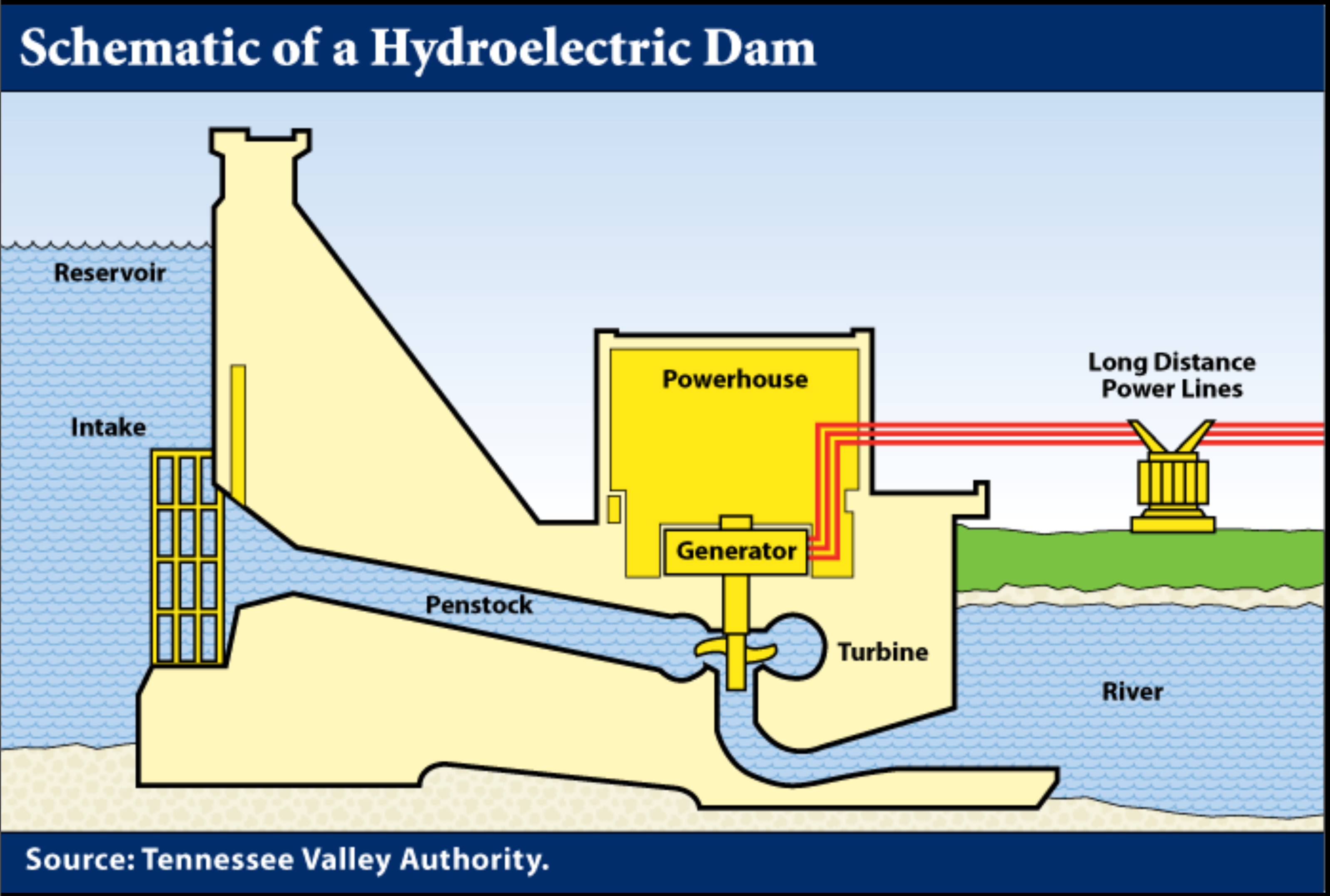



Cost of 4kW Solar: U.S. v Germany
$20,000
$15,000
$10,000
$5,000
$0
United States
Germany
Profit
Sales Tax
Overhead
Customer Acq.
Permitting
Supply Chain
Labor
Electrical/Hardware
Inverter
Panel
ILSR
INSTITUTE FOR
Local Self-Reliance

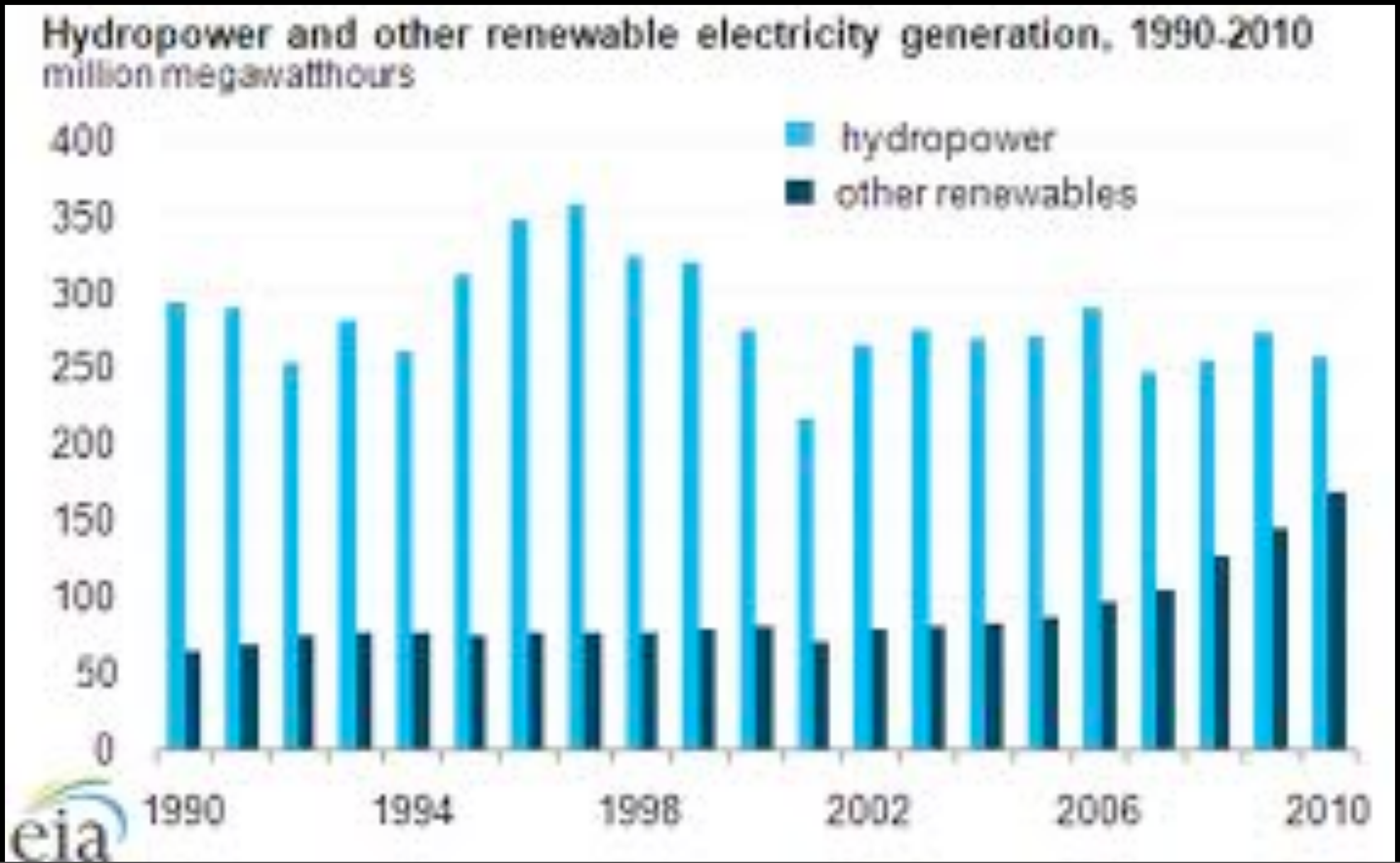
Hydro

Advantages:
- renewable
- on-demand
- can store energy

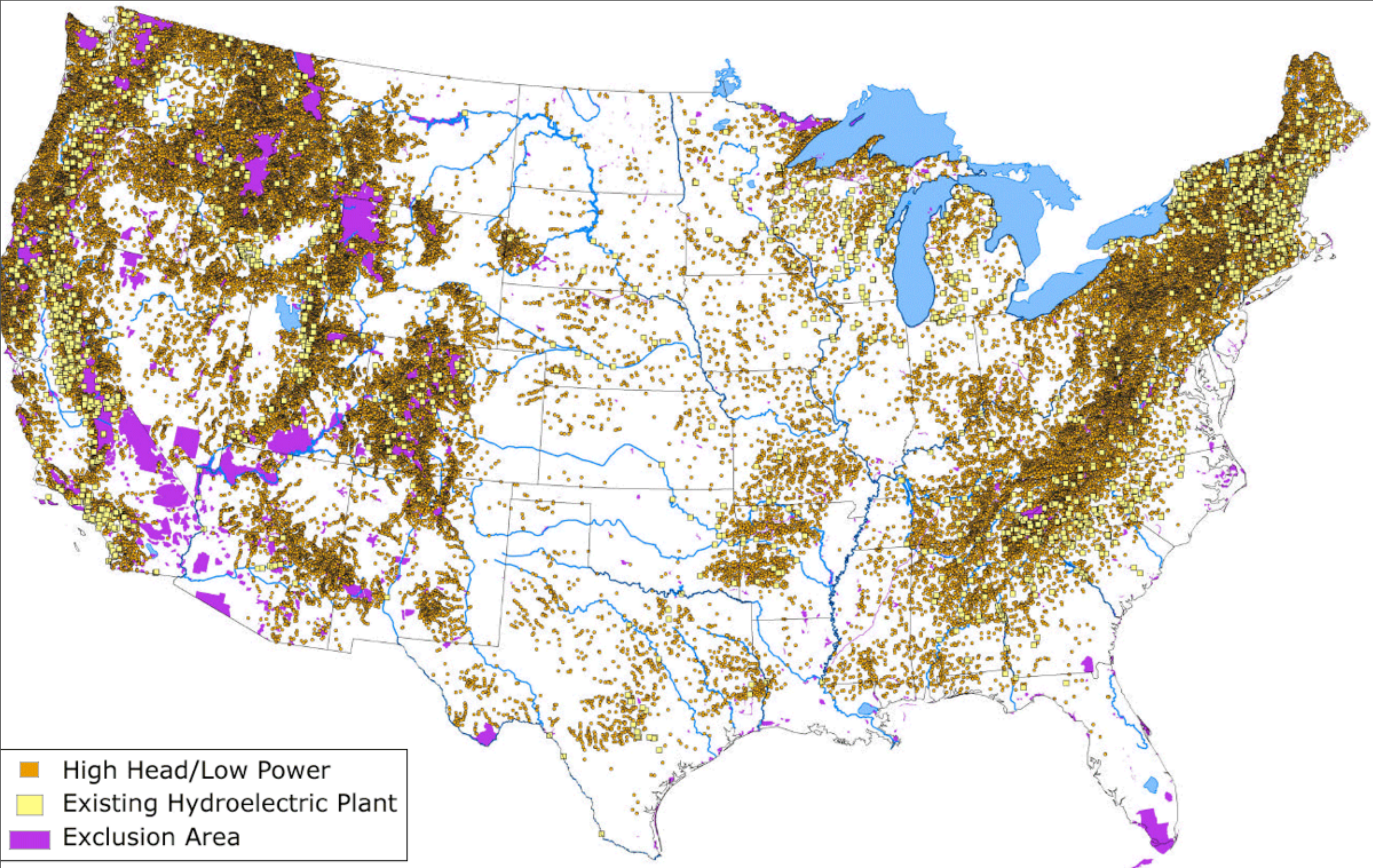
Disadvantages:
- dams bad for fish, river valleys
- nearly fully developed



Schematic of a Hydroelectric Dam
Reservoir
Intake
Powerhouse
Long Distance Power Lines
Generator
Penstock
Turbine
River
Source: Tennessee Valley Authority.



Hydropower and other renewable electricity generation, 1990-2010
million megawatthours
400
350
300
250
200
150
100
50
0
hydropower
other renewables
1990
1994
1998
2002
2006
2010
eia


High Head/Low Power
Existing Hydroelectric Plant
Exclusion Area

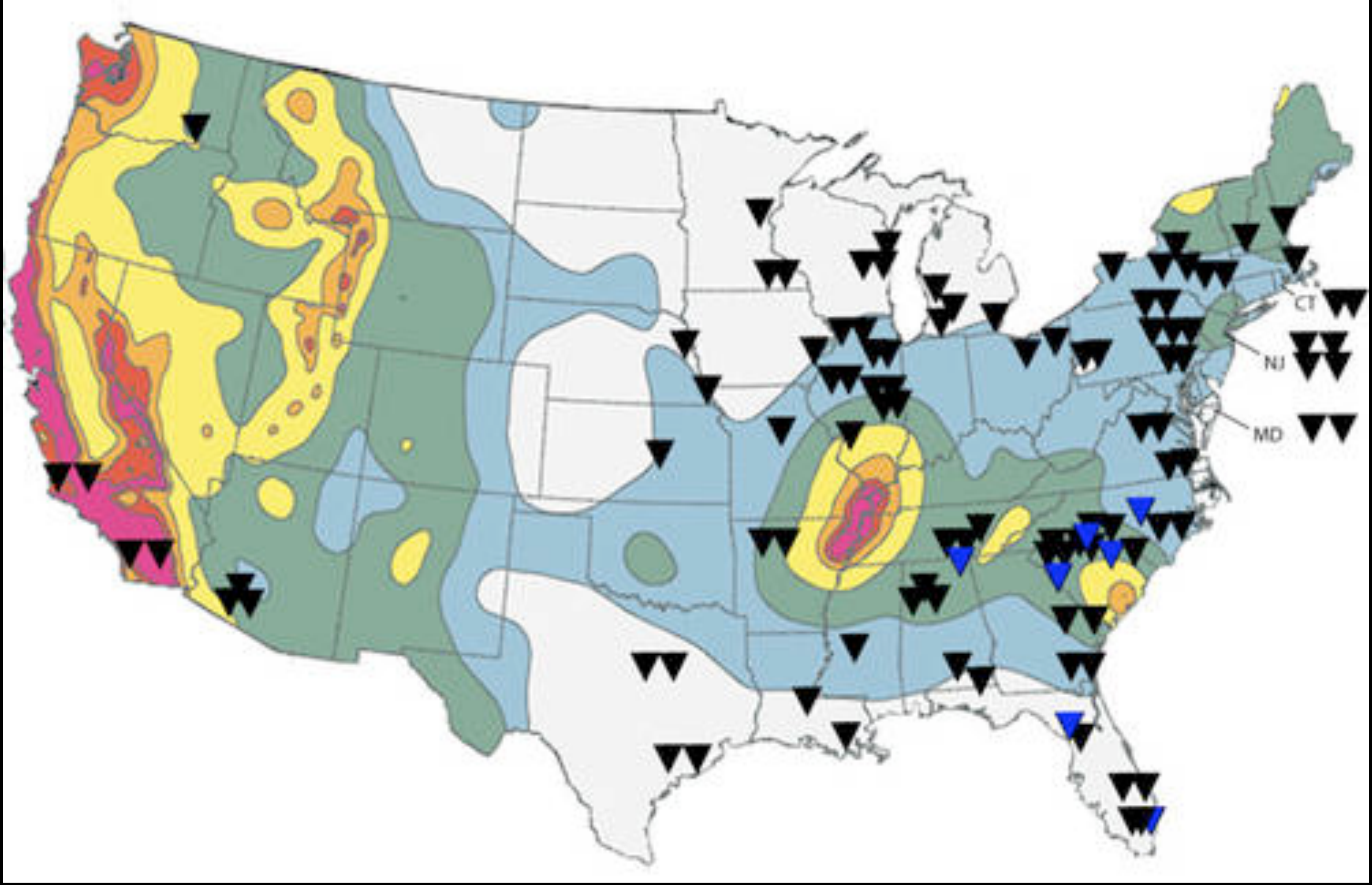
Nuclear

Advantages:

- no CO_2 production
- plentiful Uranium supply?

Disadvantages:

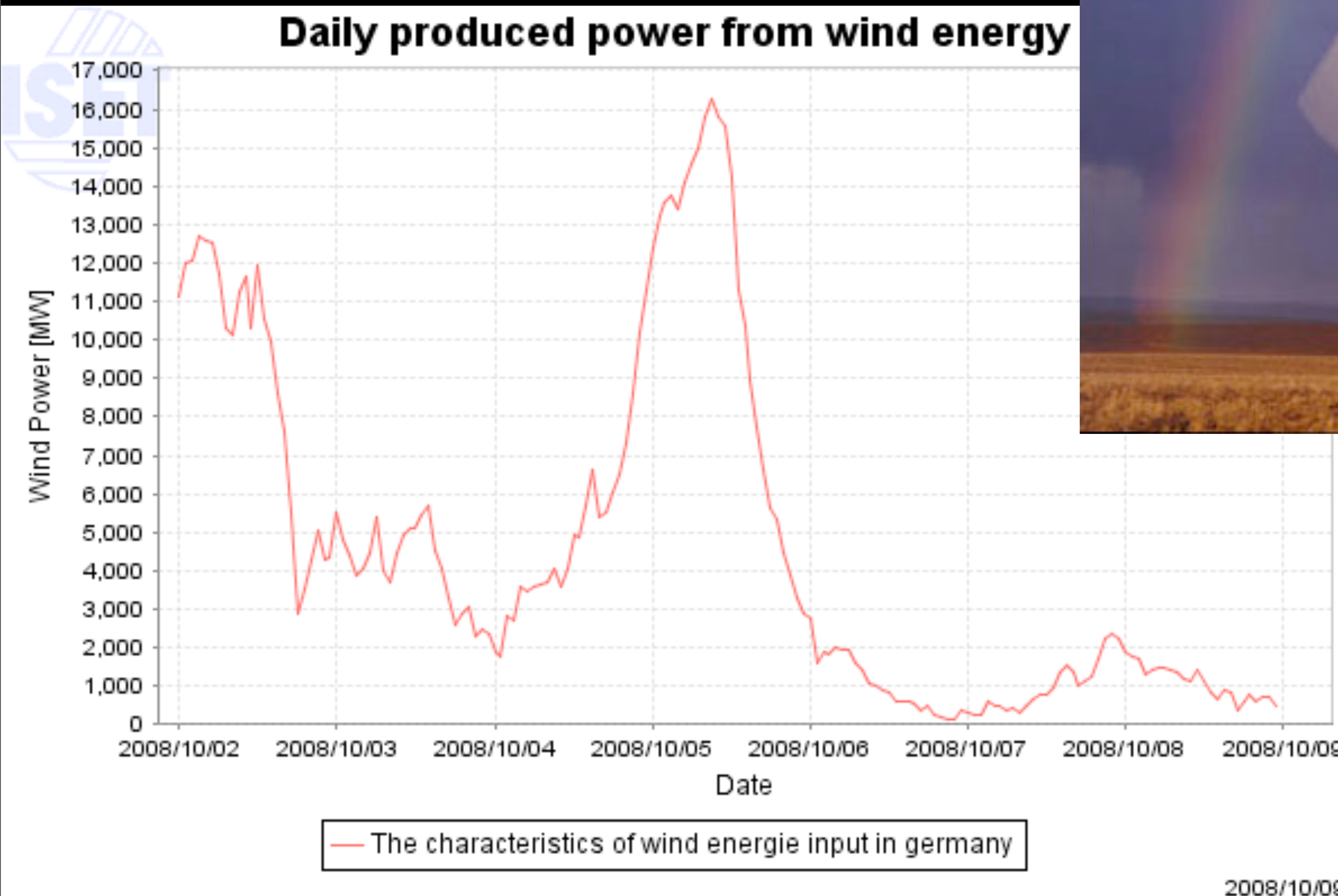
- radioactive waste
- terrorist threat
- proliferation
- natural disasters
- accidents

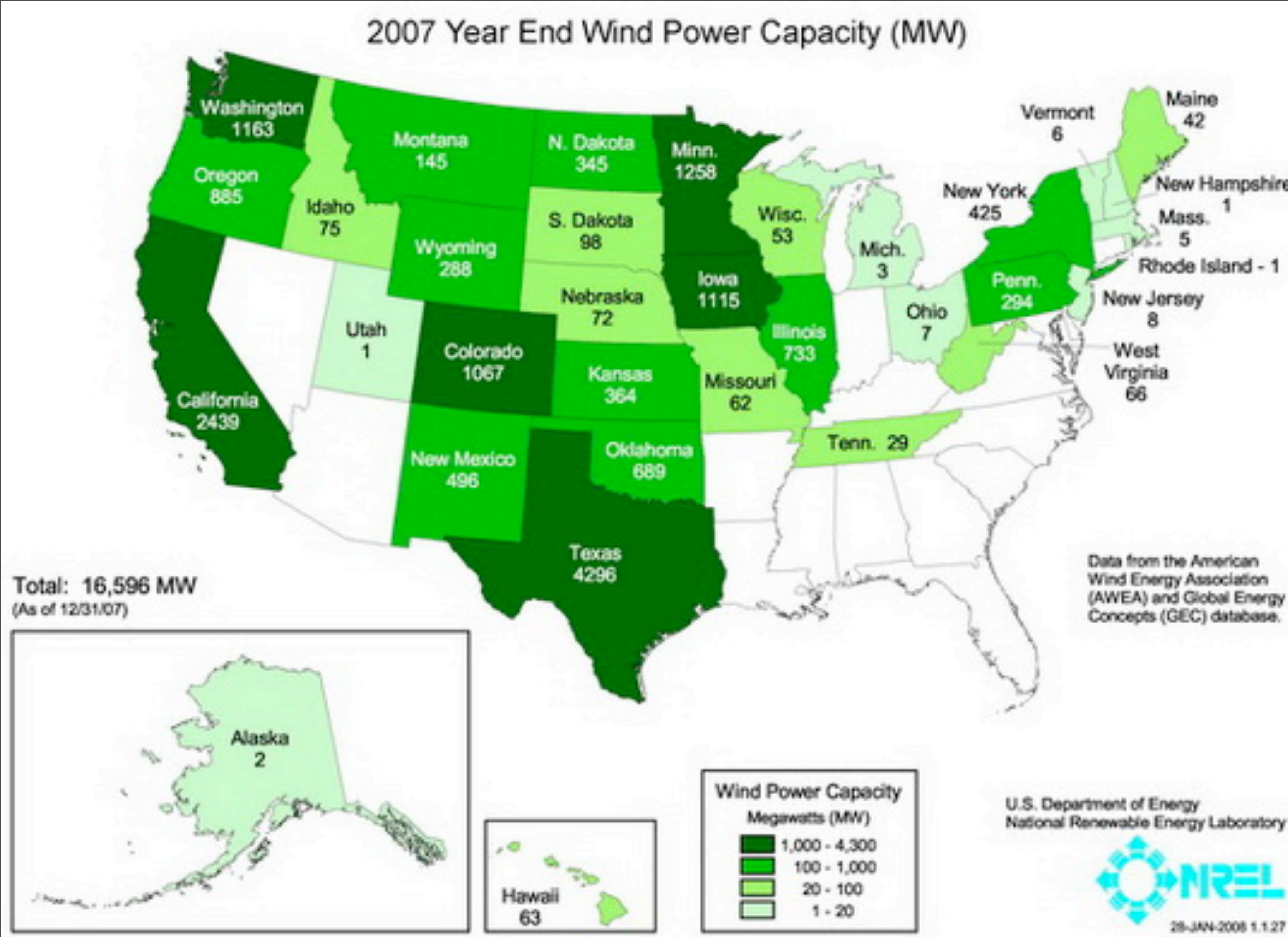

CT
NJ
MD

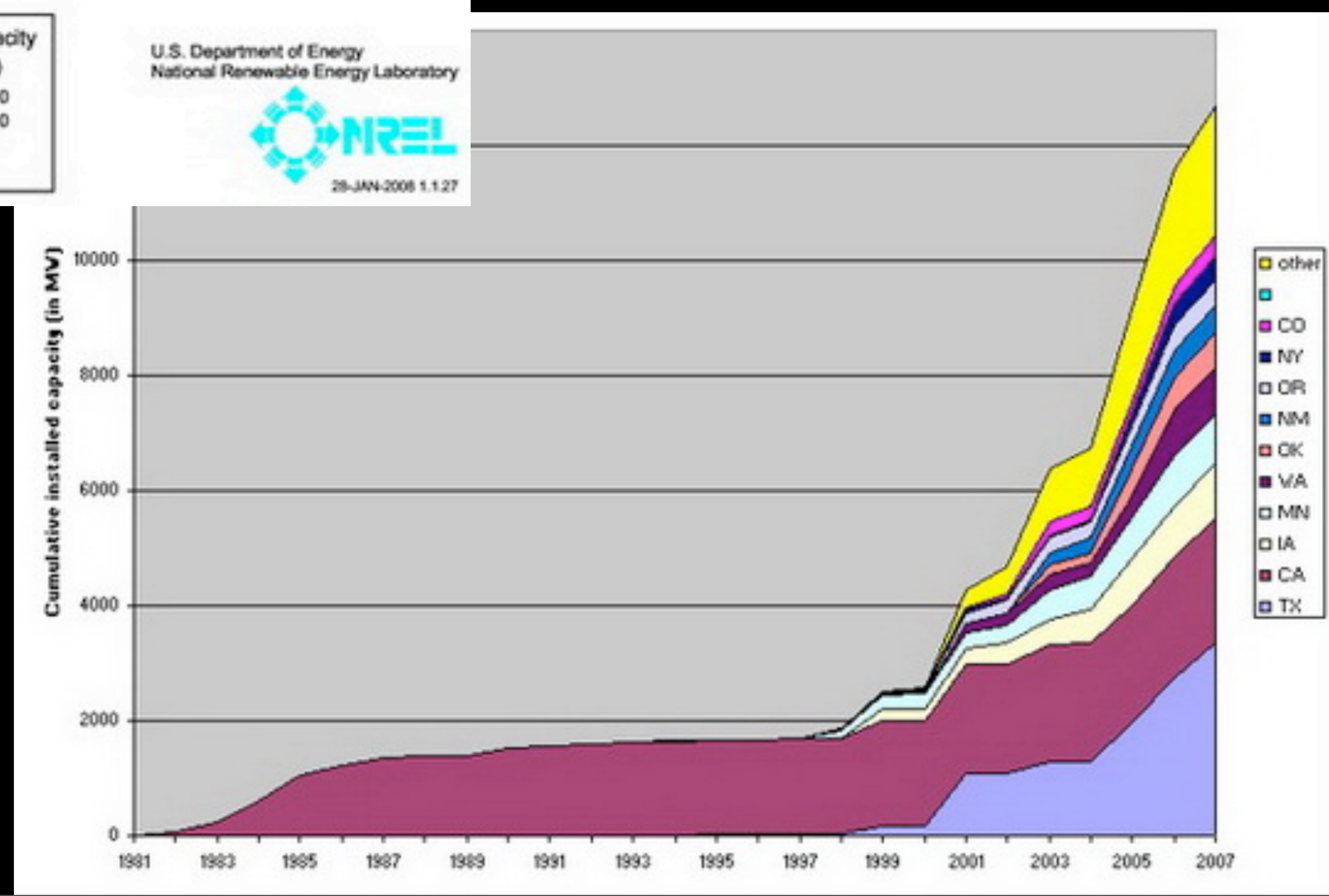
Wind

Disadvantages:
- sporadic
- bird kills?
- limited supply

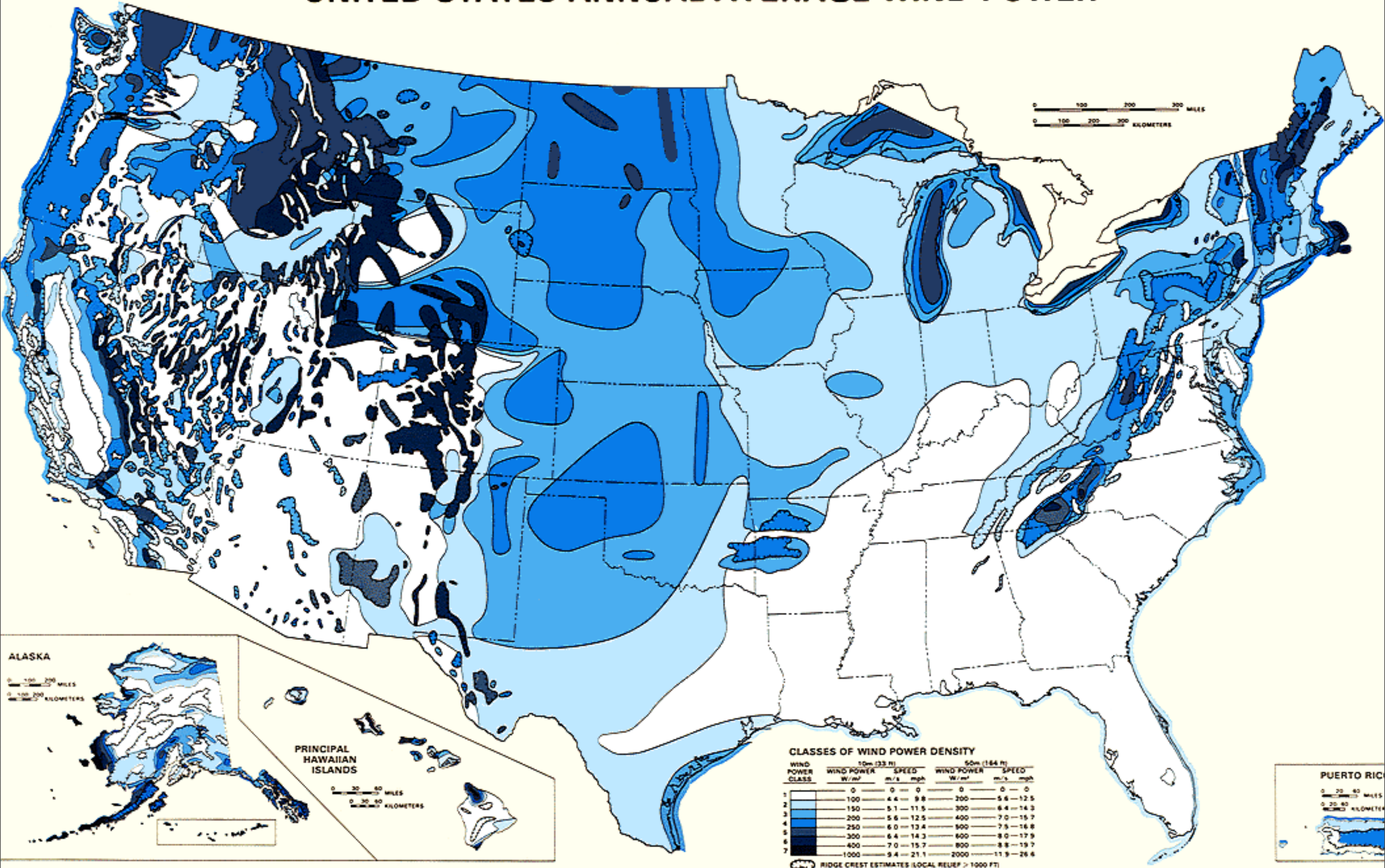
Advantages:
- clean!
- cheap!


Daily produced power from wind energy
Wind Power [MW]
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2008/10/02
2008/10/03
2008/10/04
2008/10/05
2008/10/06
2008/10/07
2008/10/08
2008/10/09
Date
The characteristics of wind energie input in germany
2008/10/09


2007 Year End Wind Power Capacity (MW)
Washington 1163
Oregon 885
California 2439
Idaho 75
Montana 145
Wyoming 288
Utah 1
Colorado 1067
New Mexico 496
N. Dakota 345
S. Dakota 98
Nebraska 72
Kansas 364
Oklahoma 689
Texas 4296
Minn. 1258
Iowa 1115
Missouri 62
Wisc. 53
Illinois 733
Mich. 3
Ohio 7
Tenn. 29
Penn. 294
New York 425
Vermont 6
Maine 42
New Hampshire 1
Mass. 5
Rhode Island - 1
New Jersey 8
West Virginia 66
Alaska 2
Hawaii 63
Total: 16,596 MW
(As of 12/31/07)
Data from the American Wind Energy Association (AWEA) and Global Energy Concepts (GEC) database.
Wind Power Capacity
Megawatts (MW)
1,000 - 4,300
100 - 1,000
20 - 100
1 - 20
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
28-JAN-2008 1.1.27


Cumulative installed capacity (in MW)
0
2000
4000
6000
8000
10000
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
other
CO
NY
OR
NM
OK
WA
MN
IA
CA
TX

UNITED STATES ANNUAL AVERAGE WIND POWER



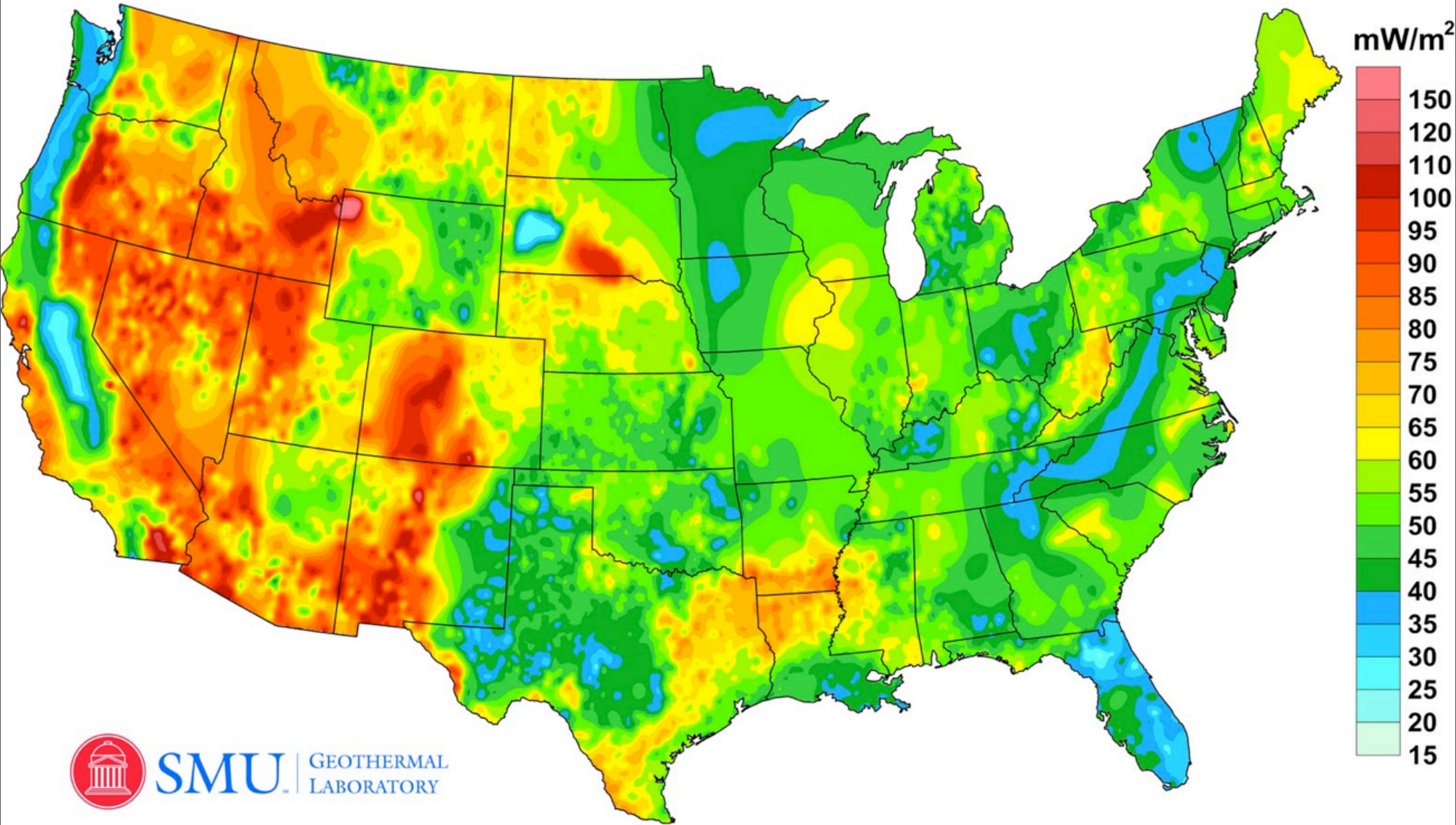
Geothermal

Advantages:

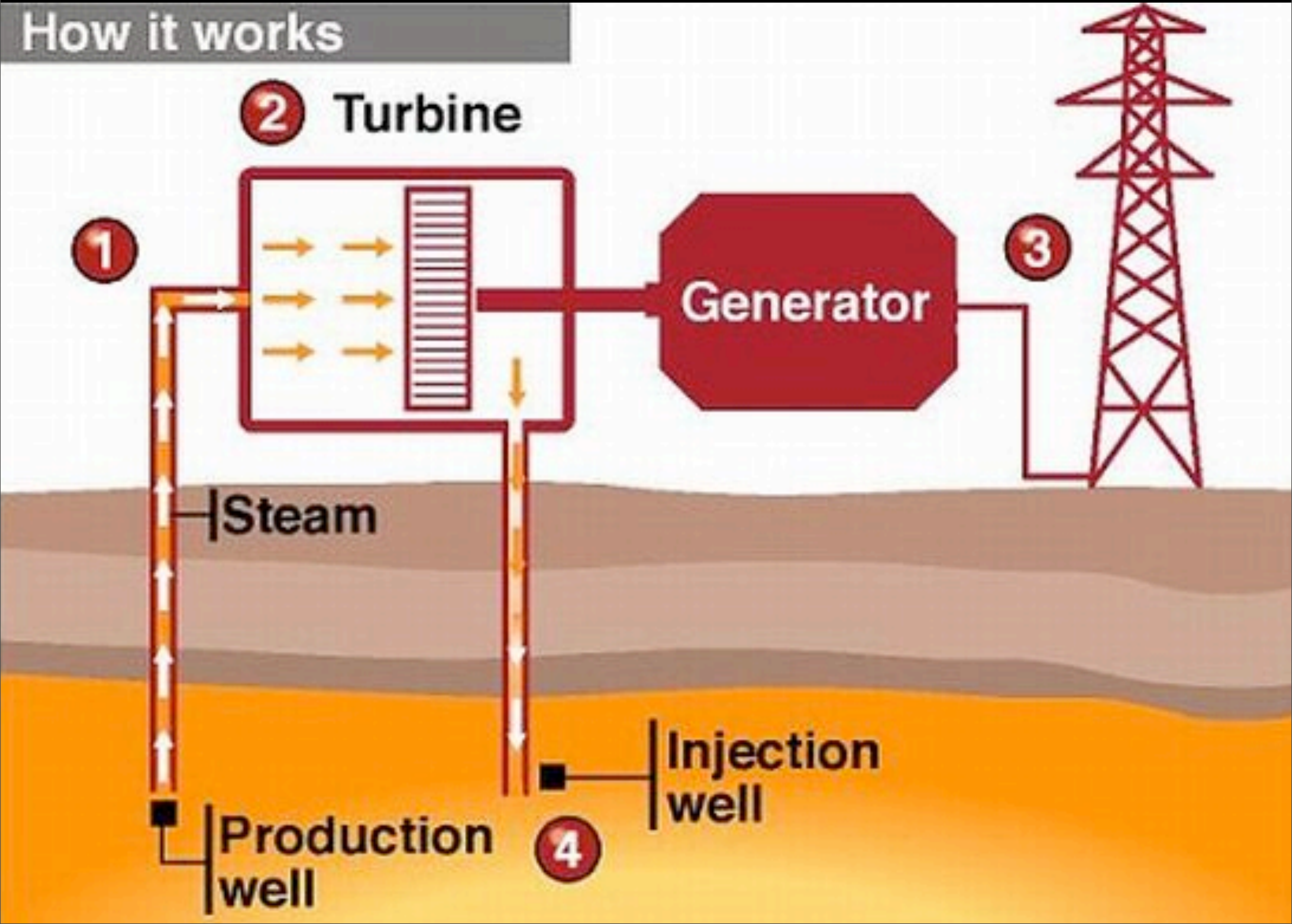
- cost effective
- clean!

Disadvantages:

- not renewable
- not greatly expandable



mW/m²
150
120
110
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
SMU
GEOTHERMAL
LABORATORY

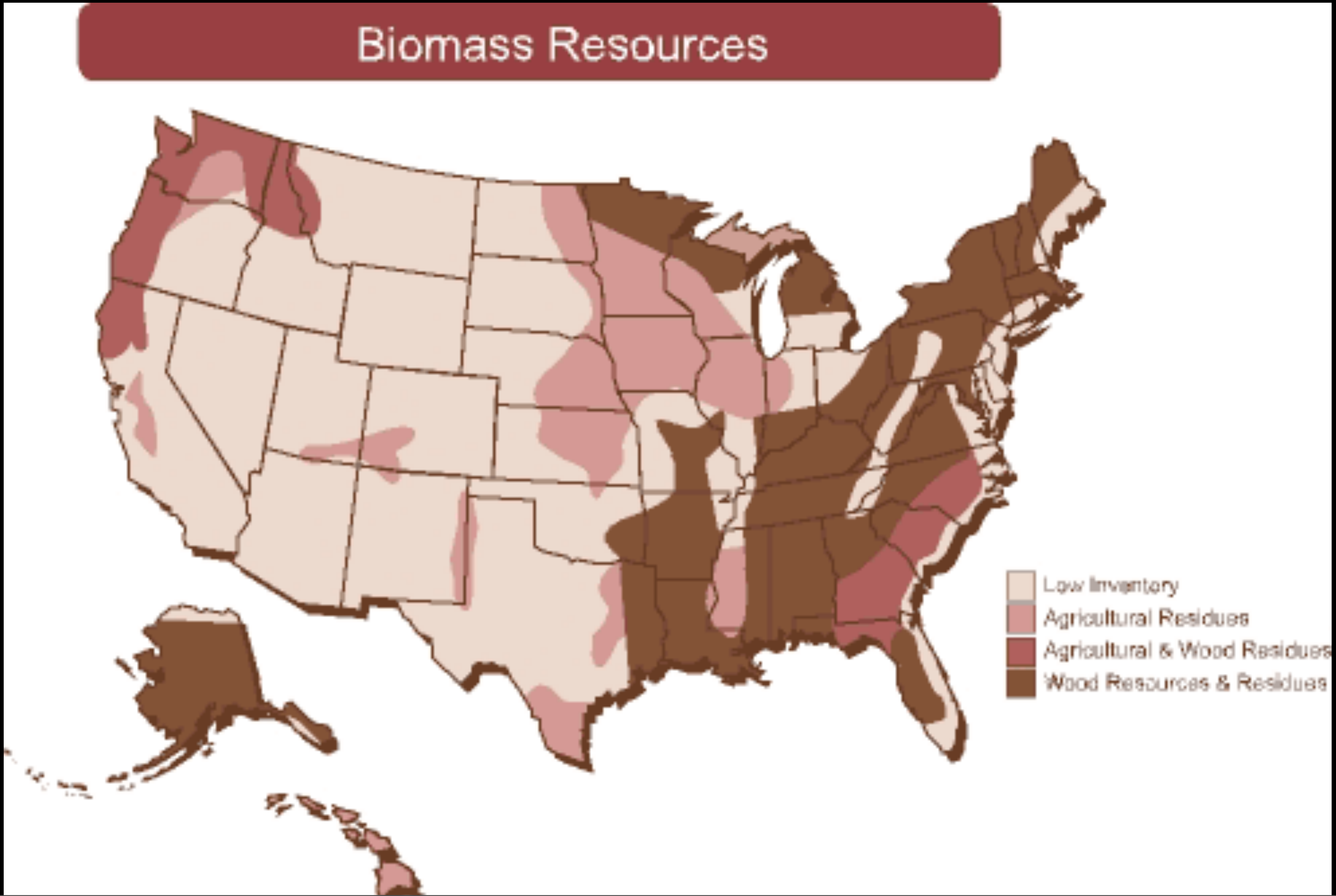


How it works
2 Turbine
1
Generator
3
Steam
Injection
well
Production
well
4

Biomass

Advantages:
- nearly CO_2 neutral
- renewable

Disadvantages:
- competes w/ farming
- land intensive



What the U.S. Should Do

- Develop renewables in regions that make sense
- Invest in new nuclear plants
- Develop CO_2 sequestration to enable use of coal
- Improve efficiency of cars, appliances, energy use