

Lecture 8: Monday, February 18, 2008

HW#2 is due in class WEDNESDAY.

We will have a discussion of the homework at the beginning of class today.

The class web site

<http://www.physics.rutgers.edu/~karin/140>

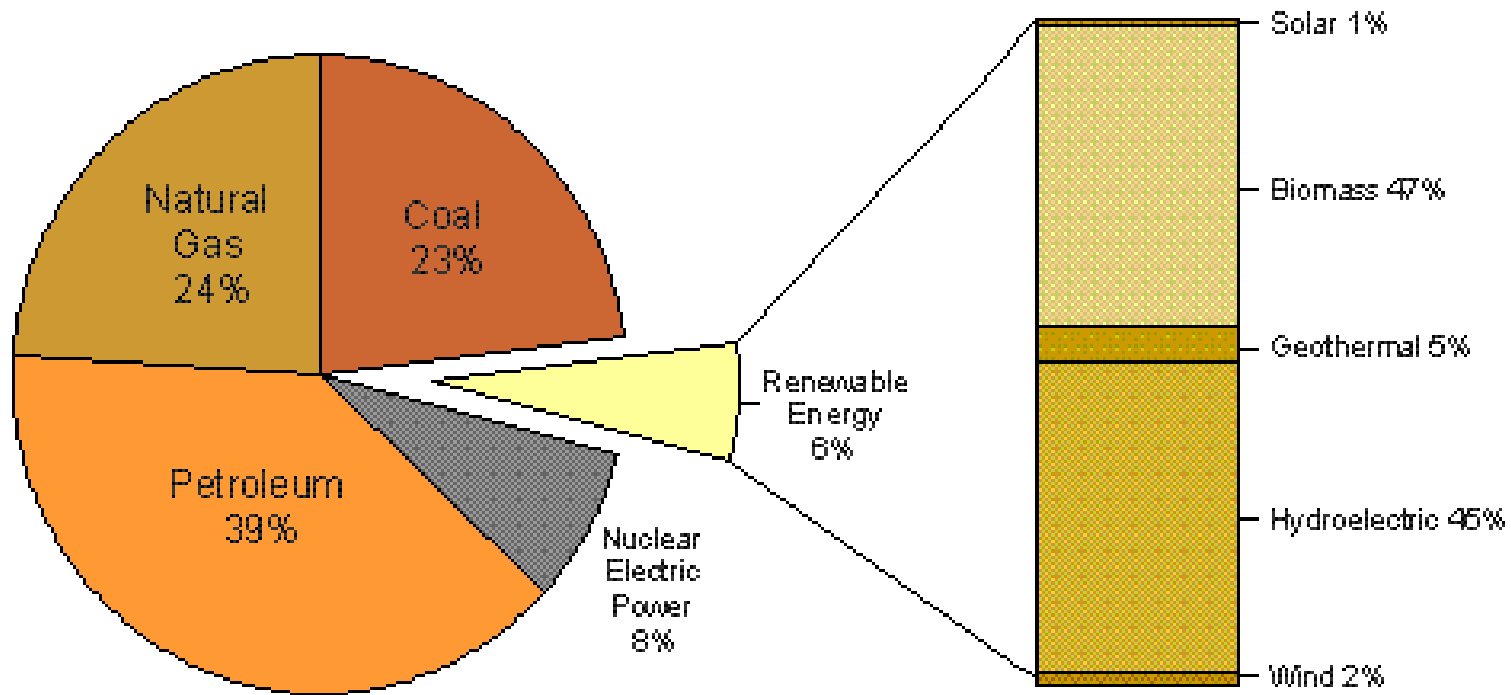
includes required reading (articles and weblinks) and useful course information (including the homeworks)

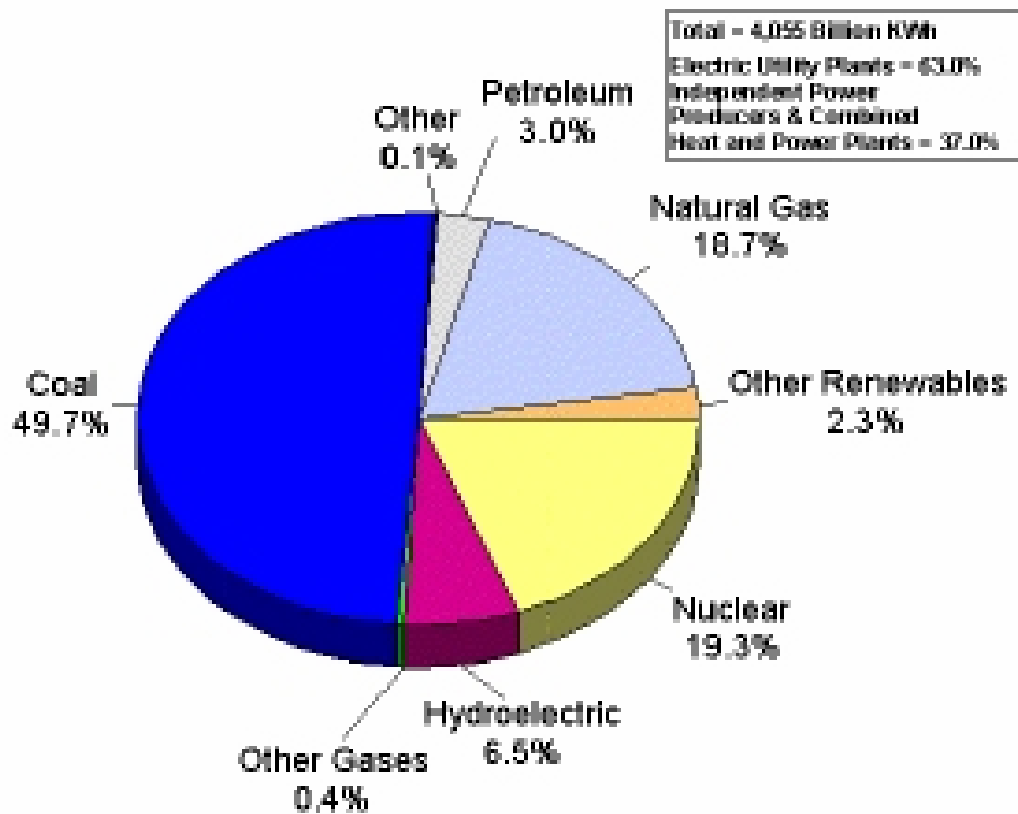
Note: I have added a couple of extra readings for last week's lectures (a few pages from The Rough Guides, and two more DOE–Energy Kids pages)

Overview of renewable energy

Total Energy = 97.6 Quadrillion Btu

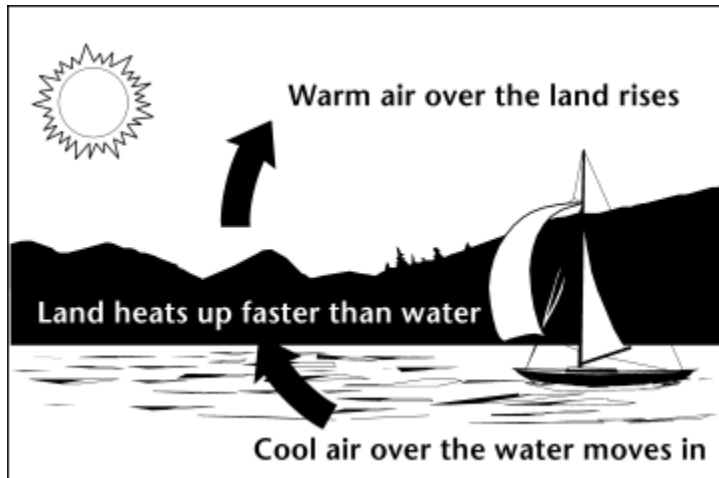
Renewable Energy = 5.9 Quadrillion Btu





US electricity generation 2005
 from www.eia.doe.gov

Wind



Light energy (from the sun) →
Mechanical (kinetic) energy of the
moving air

Windmills

Mechanical energy (wind) → mechanical energy (rotating millstone)
or potential energy (pump water upward)



England: grind corn

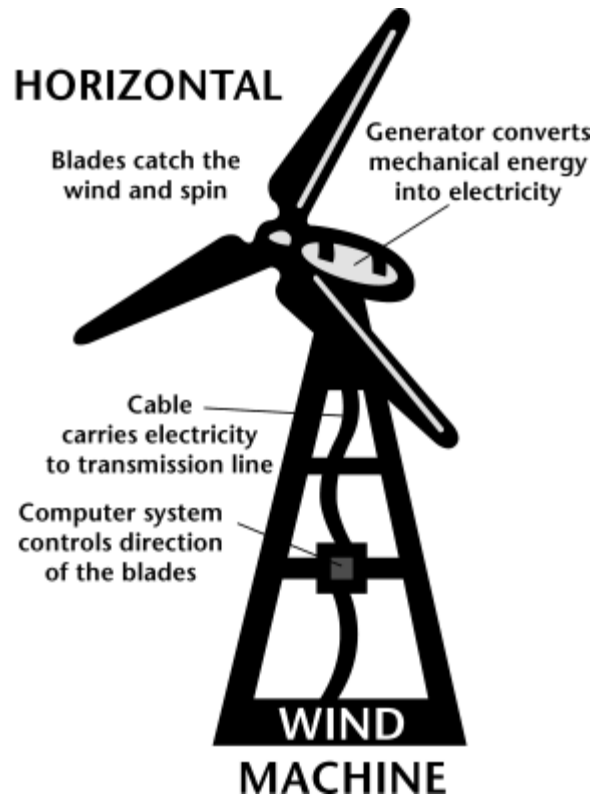


Holland: drainage



US: water from wells

Modern Windmills



horizontal axis



vertical axis



| Product/Rotor diameter (m) | V15 | V17 | V19 | V20 | V25 | V27 | V39 | V44 | V47 | V52 | V66 | V80 | V90 |
|-----------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Year of installation | 1981 | 1984 | 1986 | 1987 | 1988 | 1989 | 1991 | 1995 | 1997 | 2000 | 1999 | 2000 | 2002 |
| Capacity (kW) | 55 | 75 | 90 | 100 | 200 | 225 | 500 | 600 | 660 | 850 | 1750 | 2000 | 3000 |
| MWh/year | 217 | 265 | 301 | 346 | 481 | 647 | 1304 | 1581 | 1947 | 2530 | 4705 | 6768 | 9152 |

Wind farms



Horse Hollow III, Texas
223.5 MW
(149 1.5 MW turbines)



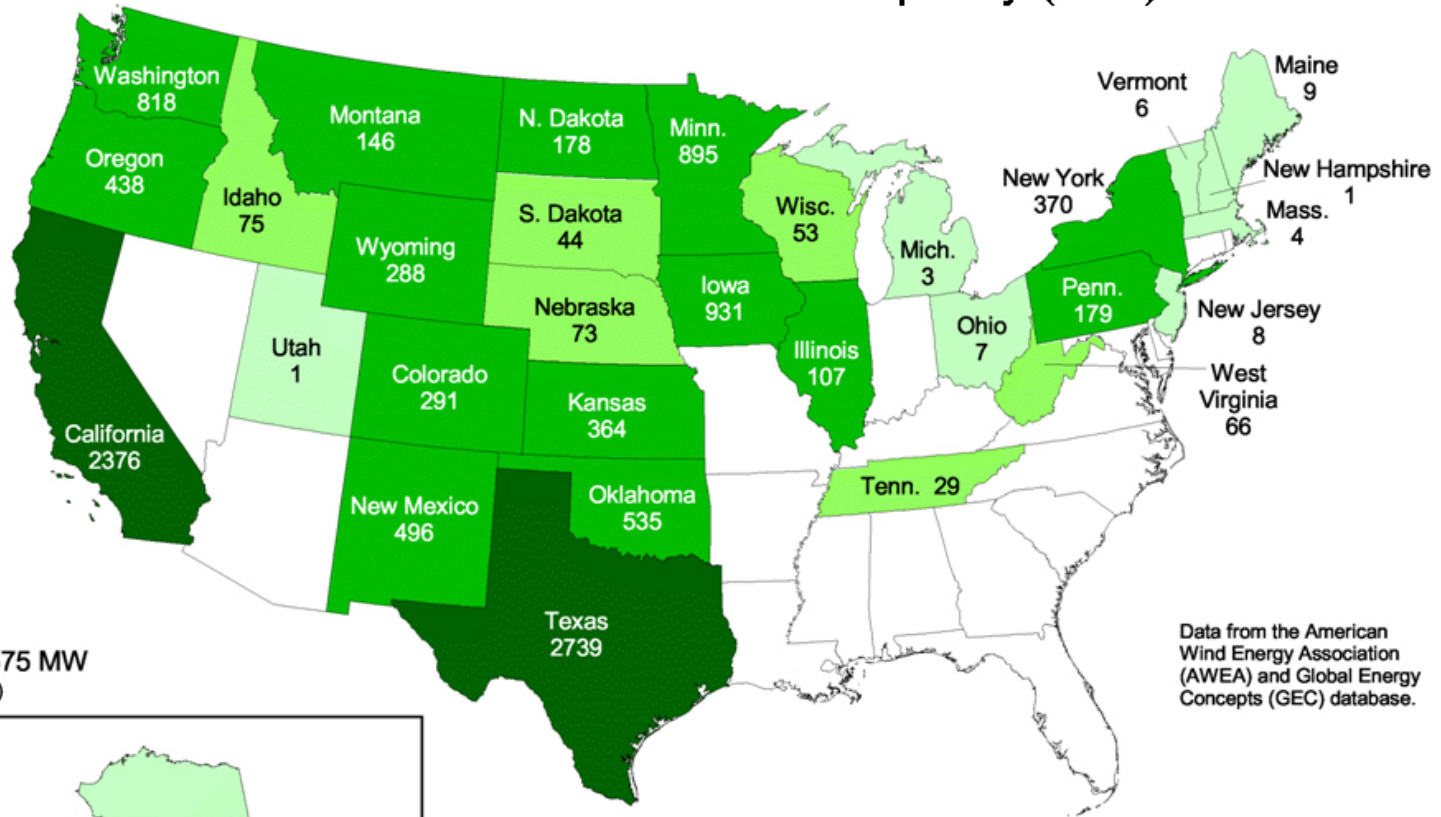
The world's most productive wind farm is Nysted Wind Park in the southern part of the Baltic Sea. Nysted has 72 wind turbines rated at 2.3 MW each. In 2004 it was the world's largest off-shore wind farm in terms of capacity.

Table 12.2 TOP WIND ENERGY MARKETS

| Country | Installed Capacity (MW) | |
|----------------|-------------------------|-------|
| | 1998 | 2004 |
| Germany | 2872 | 16629 |
| United States | 1770 | 6740 |
| Spain | 822 | 8283 |
| Denmark | 1433 | 3110 |
| India | 1015 | 2110 |
| Netherlands | 375 | 938 |
| Italy | 199 | 922 |
| United Kingdom | 334 | 759 |
| Japan | | 758 |
| China | 224 | 568 |

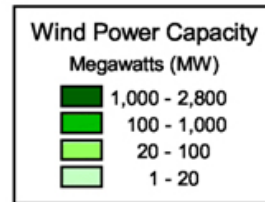
Source: USEIA.

2006 Year End Wind Power Capacity (MW)



Total: 11,575 MW
(As of 12/31/06)

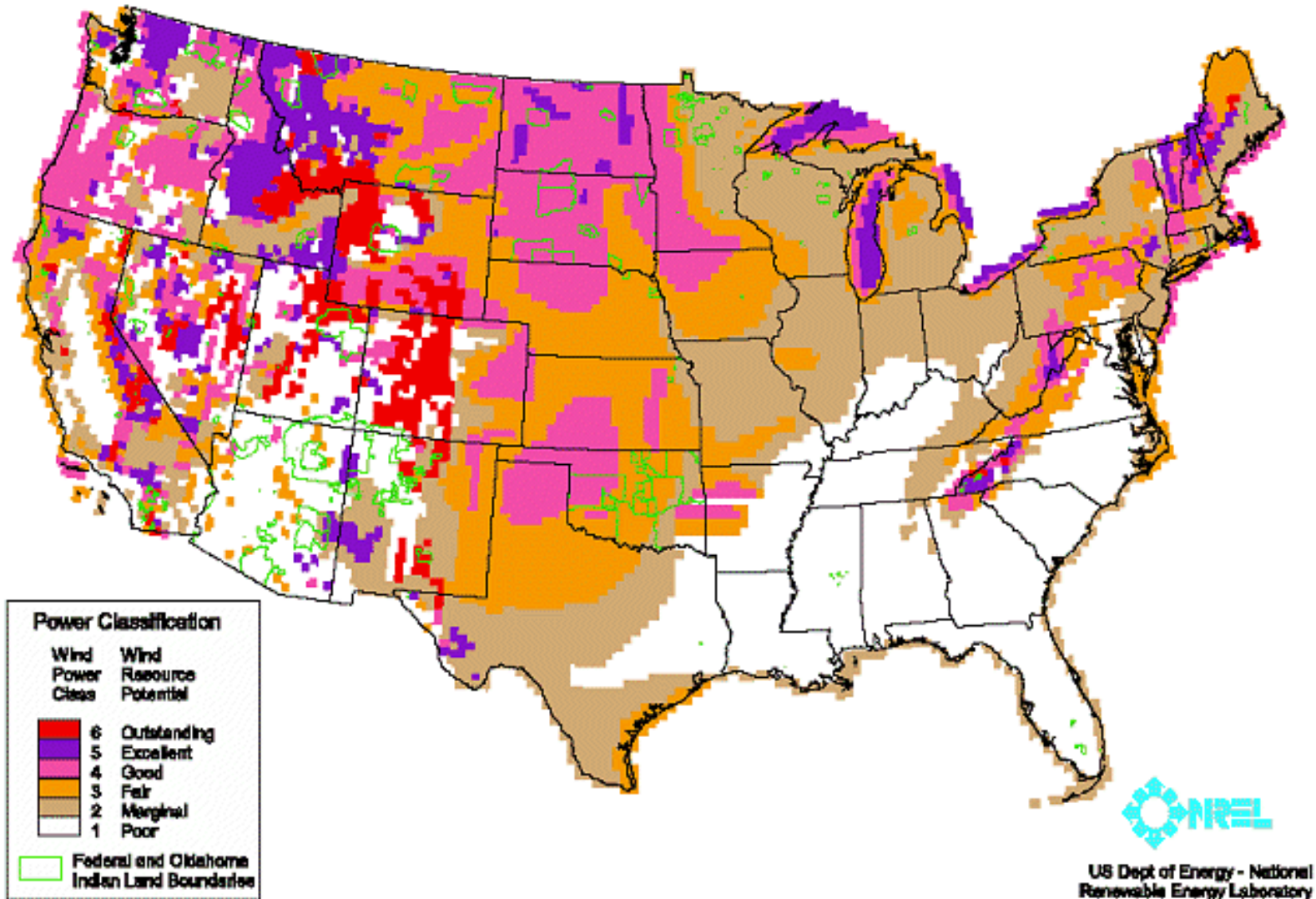
Data from the American Wind Energy Association (AWEA) and Global Energy Concepts (GEC) database.



U.S. Department of Energy
National Renewable Energy Laboratory



Figure 13. Wind Resource Potential



Wind energy production

Wind power: potential

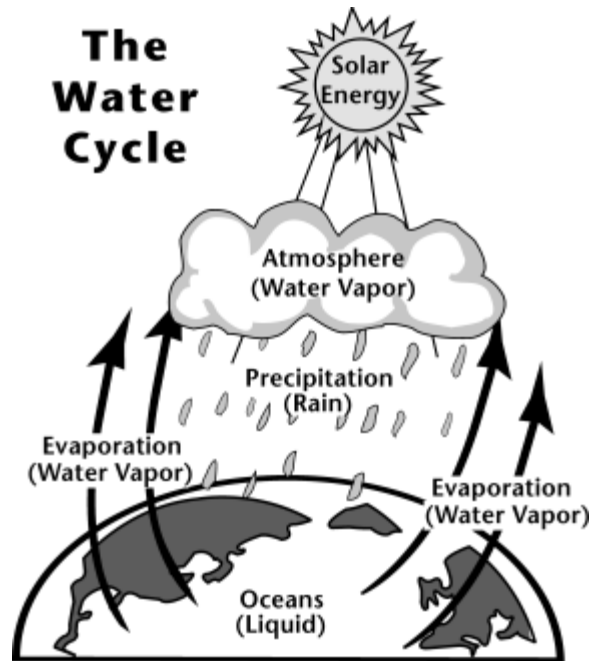
The CleanPower Choice Program from the New Jersey Board of Public Utilities' Office of Clean Energy is a statewide program that allows you to choose clean, renewable sources of energy. When you make the CleanPower Choice, electricity is generated from clean, renewable energy sources located in New Jersey and the mid-Atlantic region. Importantly, the New Jersey Board of Public Utilities' Office of Clean Energy verifies that renewable energy is delivered into the Mid Atlantic power pool that serves your needs. Each household that participates in the CleanPower Choice Program can reduce CO2 emissions by over 10,000 lbs. per year, which is equivalent to planting 1.35 acres of trees!*

| CleanPower Supplier Companies | Resource | Additional Price per Kilowatt Hour | Percent of Monthly Electricity Usage | Additional Monthly Cost* |
|--|---|------------------------------------|--------------------------------------|--------------------------|
| Community Energy, Inc. 1-866-WIND-123 www.newwindenergy.com | 50% Wind 1% NJ Solar 49% Low-Impact Hydro | 1.3¢ | 100% | \$9.10 |
| Green Mountain Energy Co. ** 1-800-810-7300 www.greenmountain.com/nj | 50% Wind 50% Small Hydro | 1.3¢ | 100% | \$9.10 |
| Jersey-Atlantic Wind, LLC 1-877-NJ-WIND1 www.njwind.com | 100% NJ Wind | 5.5¢ | 15% | \$5.78 |
| Sterling Planet, Inc. 1-877-457-2306 www.sterlingplanet.com | 75% Wind 25% Small Hydro | 4.7¢ | 15% | \$4.94 |

New Jersey CleanPower Choice Program charges are in addition to your normal monthly charges. Check your electric bill for your monthly usage to determine your cost. Currently, the average residential customer pays between 14¢ and 16¢ per kilowatt hour.

*For a home using 700 kWh per month. **Serves residential customers only.

Hydropower



Light energy (from the sun) →
Mechanical (potential) energy of
water

Niagara Falls–potential energy & power of falling water

Horseshoe Falls

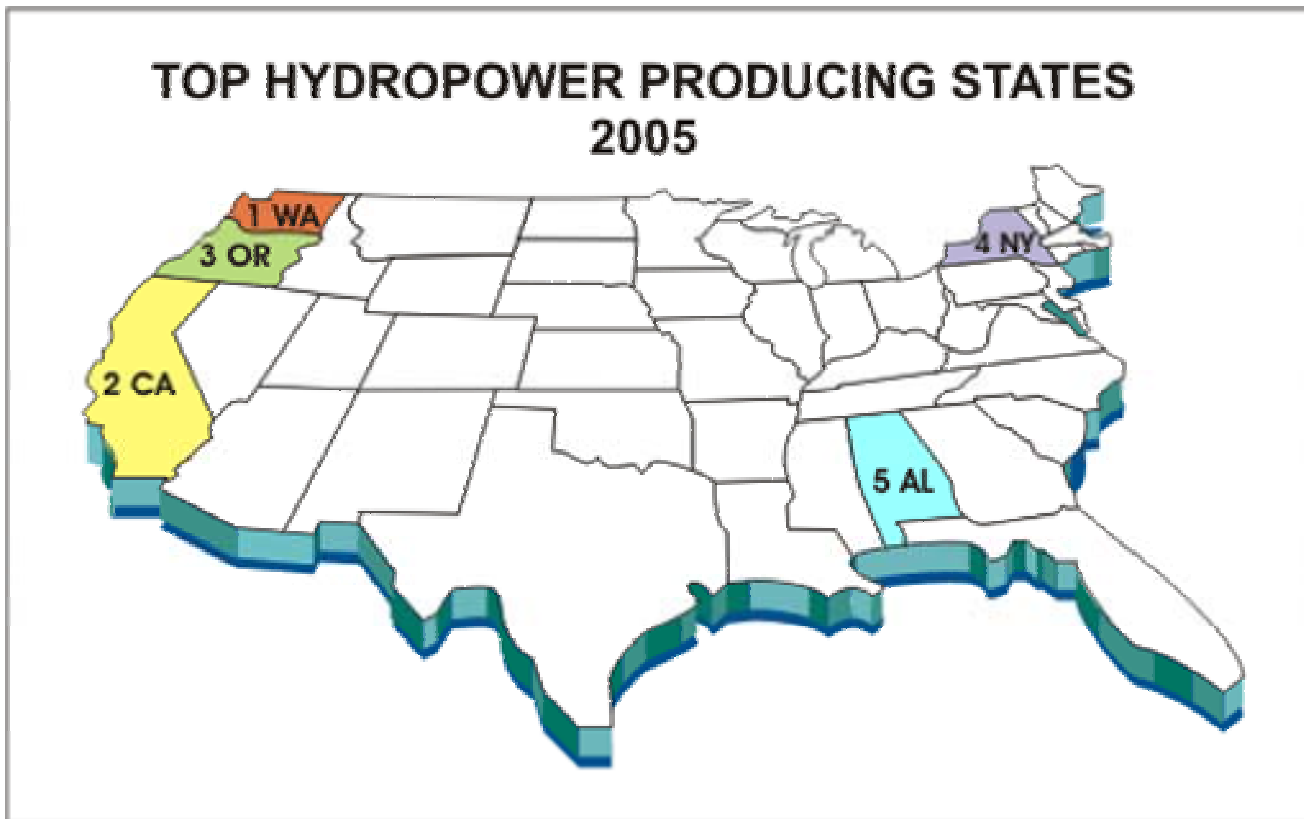


length of brink: 2600 feet
height: 167 feet
volume of water: 600,000
U.S. gallons per second

Table 12.5 HYDROPOWER OUTPUT (2002)

| | Electricity Generated (Billion kWh) | Installed Capacity (Thousand MW) |
|----------------------|--|---|
| Canada | 315 | 67 |
| China | 309 | 83 |
| Brazil | 282 | 63 |
| United States | 255 | 99 |
| Russia | 180 | 45 |
| Norway | 125 | 27 |
| Japan | 81 | 22 |
| India | 68 | 26 |
| Sweden | 66 | 16 |

Source: U.S. Energy Information Administration.



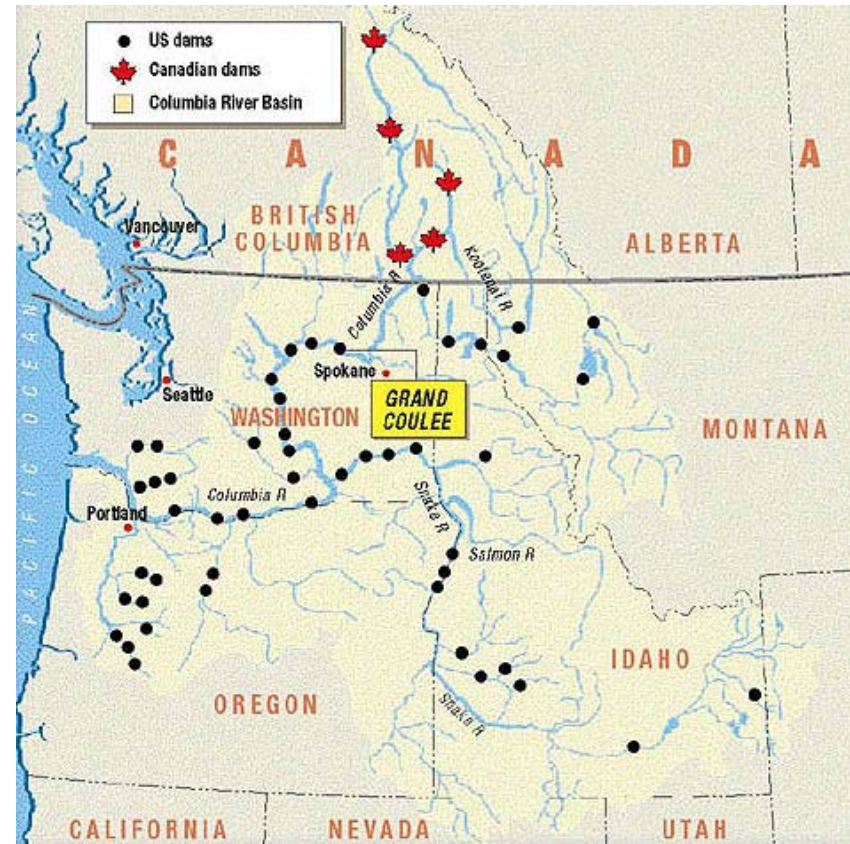
It is important to note that only a small percentage of all dams in the United States produce electricity. Most dams were constructed solely to provide irrigation and flood control.

Hydroelectric power



Grand Coulee Dam

6495 (10,800) MW





Grande Dixence Dam, Switzerland

Three Gorges Dam



Yangtze River, China
18,200 MW, fully operational in 2009