7. Energy production

7.1. CURRENT STATUS

Current patterns of energy usage

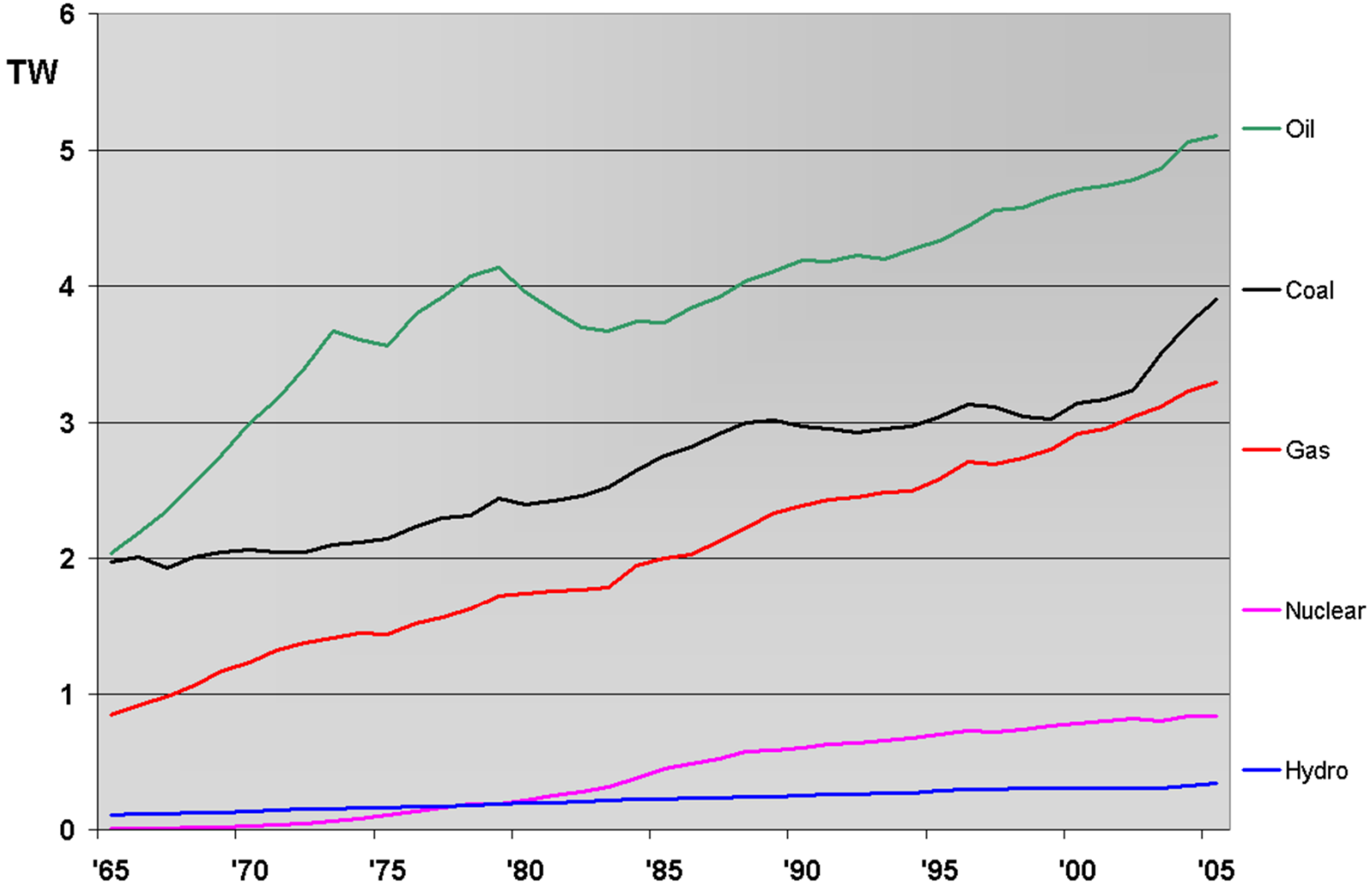
- Dominated by non-sustainable fossil fuels such as petroleum, coal and natural gas.
- Current world energy use is ~500 EJ/yr.
- Industrial/agricultural/commercial energy use makes up over 60% of total in the US.

ENERGY AND POWER

Energy is a resource, measured in joules (J) , that represents the capacity to do work, for example to produce 1 tonne of aluminum. One exajoule (EJ) = 1,000,000,000,000,000,000 J. Another unit is the tonne of oil equivalent (TOE).

Power is the rate at which energy is used, and it is measured in or watts (W). 1 W = 1 J per second. A traditional light bulb uses 60-100 W. One terawatt (TW) = 1,000,000,000,000 W.

Energy production has risen continually



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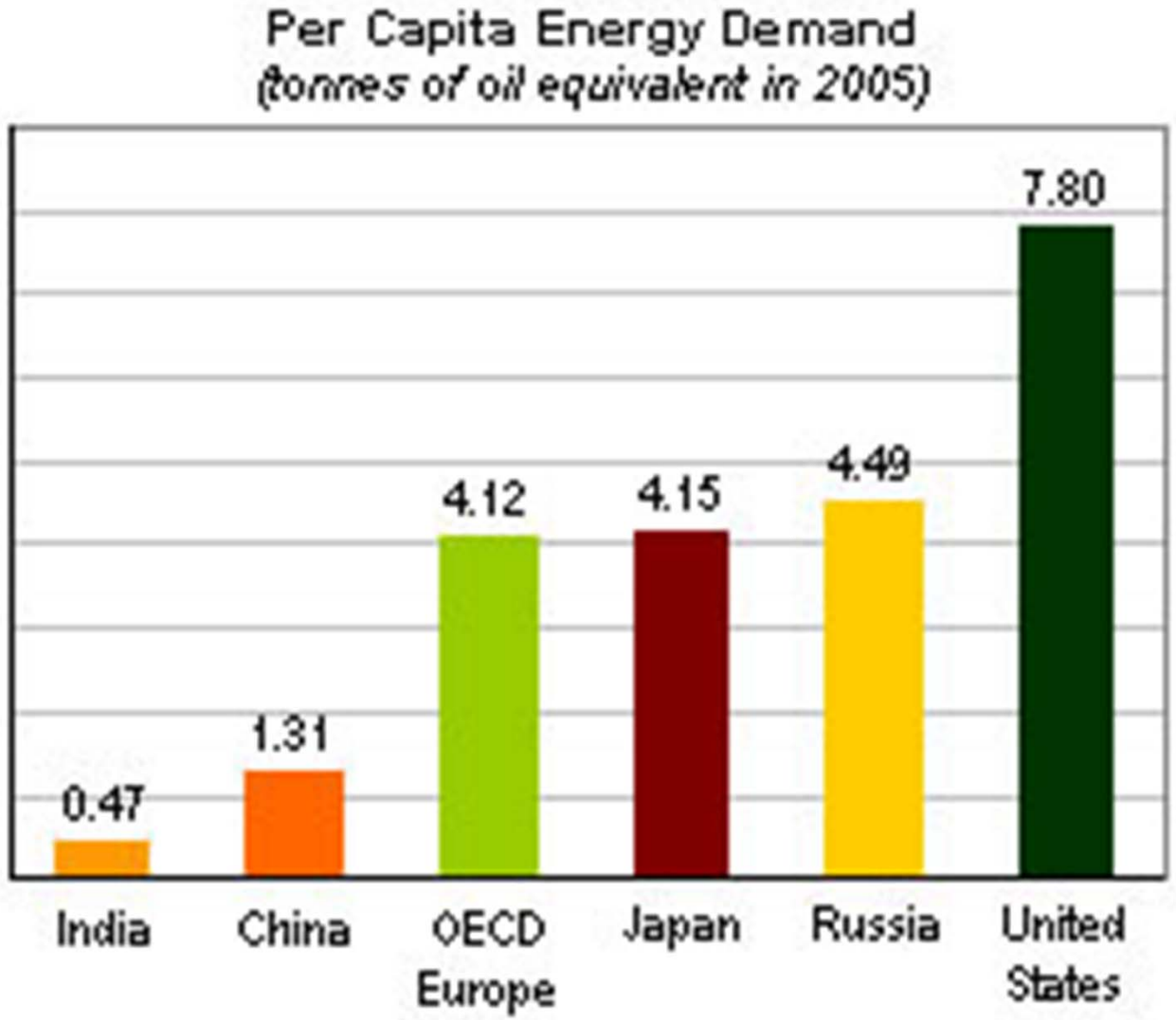
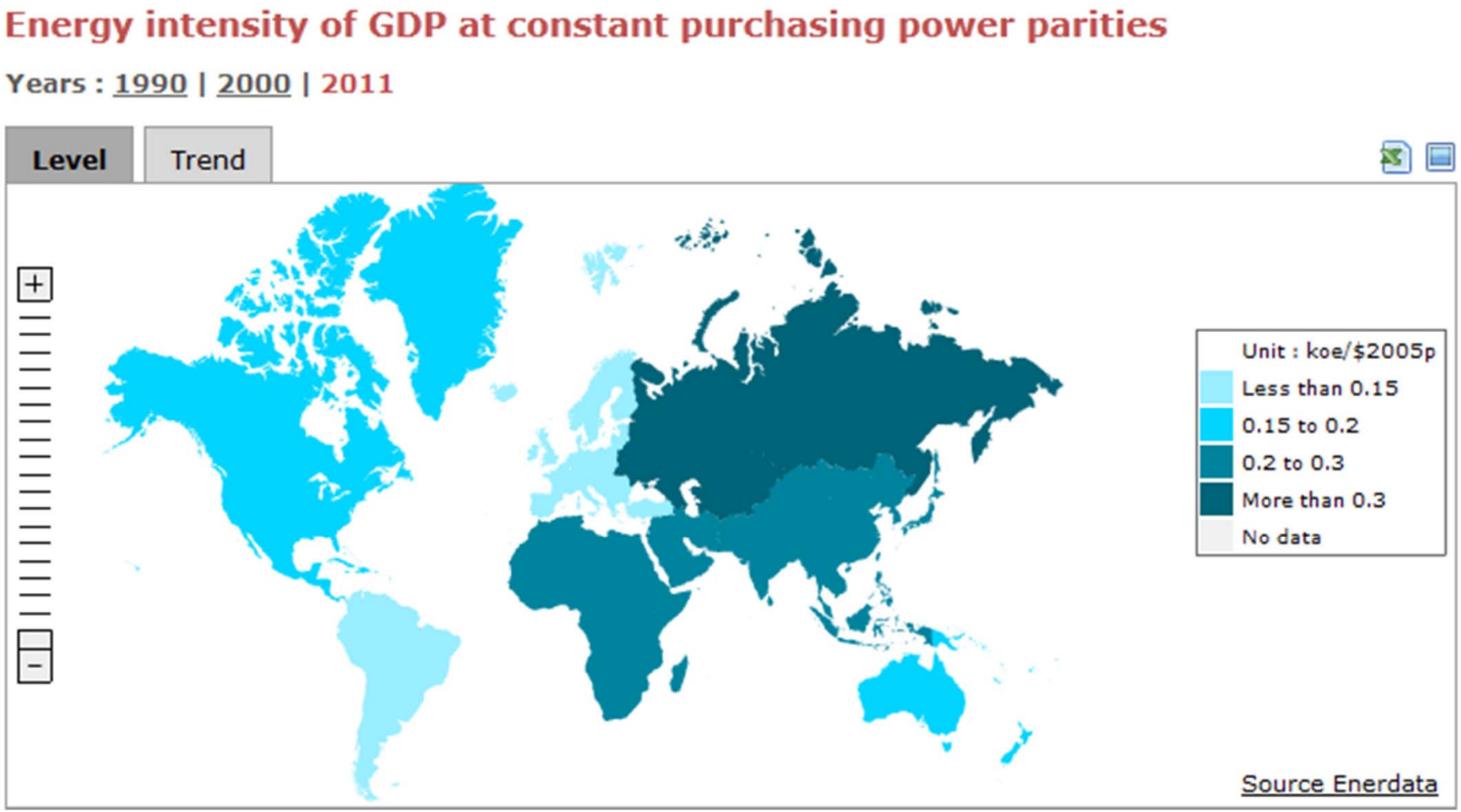
Per capita energy usage (uncorrected for GDP)_



Source: Earthtrends

Energy intensity reflects efficiency of use



Eastern Europe & China appear inefficient at present; Western Europe efficient

Image from Enerdata, **Global Energy Statistical Yearbook 2012**

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Energy usage: Japan

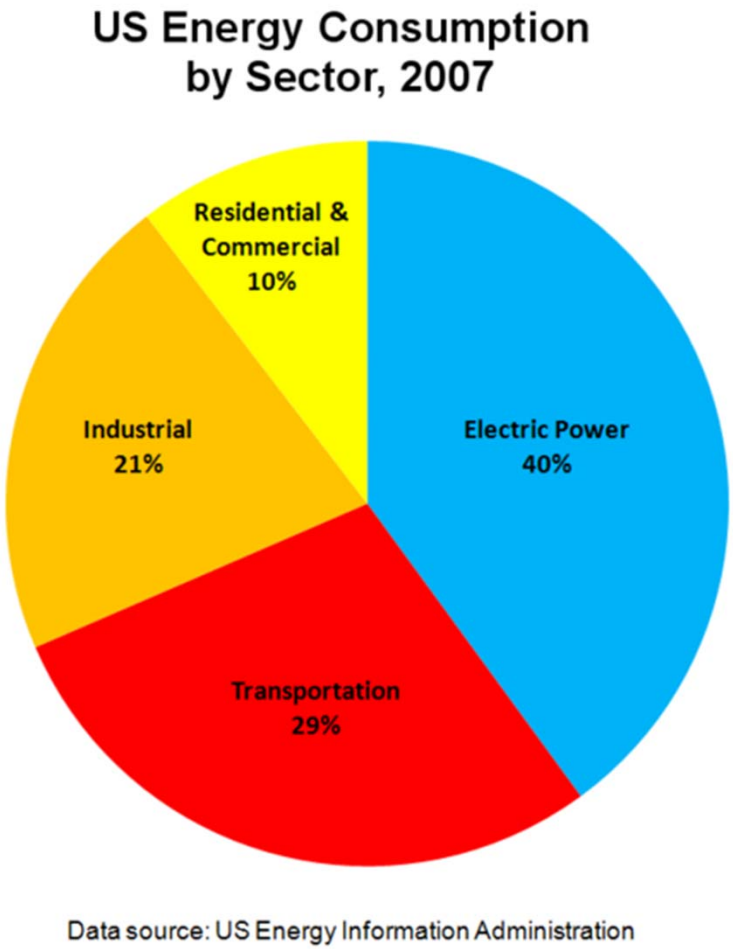
- Total Japanese energy usage is around 20 EJ/year.
- Japan lacks a domestic fossil fuel supply such as coal, oil or gas with 79% of its energy supply imported (1999). Along with environmental concerns, this drives Japanese energy policies.
- Around 50% of this comes from oil, and about 15% each for coal, nuclear and natural gas. Renewables make up the remaining 5%.

Electricity usage (US)

- In 2006, the US used around 104 EJ of energy, of which around 42 EJ was used in the form of electricity.
- Over 50% of this US electricity was generated using coal power. Natural gas has seen the largest rate of increase in recent years. Less than 10% of it came from renewable sources such as hydroelectric or wind power.
- For more information see *http://www.eia.doe.gov/*

US energy consumption, by type

Picture by RockyMtnGuy, Creative Commons License



7.2. ENERGY AND THE ENVIRONMENT

Fossil fuels

- Fossil fuels produce carbon dioxide, which is a greenhouse gas.
- Increasing levels of carbon dioxide are the major factor driving global warming.
- Coal also contains sulfur, which (when burnt) forms sulfur dioxide, which in turn causes acid rain.

Nuclear power

- Nuclear power uses uranium as an energy source, and although this is not renewable supplies of uranium are expected to last well into the future.
- Nuclear power causes very little emission of greenhouse gases, but nuclear waste is highly radioactive and must be contained for a long time to come.

Renewables

- Renewables produce little or no greenhouse gases, and are generally seen as good for the environment.
- However, hydroelectric dams often have a serious environmental impact (flooded land, fish migration, etc.).
- Wind and solar power have little environmental impact, but large scale projects may be seen as eyesores, as with the Nantucket Sound wind farm.

7.2. ENERGY IN THE FUTURE

Energy usage by 2030 (US)

- According to US government predictions, total energy usage in the US is expected to grow from around 104 EJ in 2006 to around 124 EJ in 2030.
- Some of this growth is predicted to be met by biomass and renewable energy, but fossil fuels are still expected to dominate in the US.

Energy usage by 2020 (EU): “20 by 20”

- The EU has set a target of meeting 20% of its supply from renewable sources by 2020 (it was 8.5% in 2005).
- It also aims to cut energy usage by 20% by 2020 through conservation, etc.
- Energy policy in the EU is strongly linked to climate change policy, and planned reductions in greenhouse gas emissions of 20% by 2020 through emissions auctions/trading and conservation efforts.

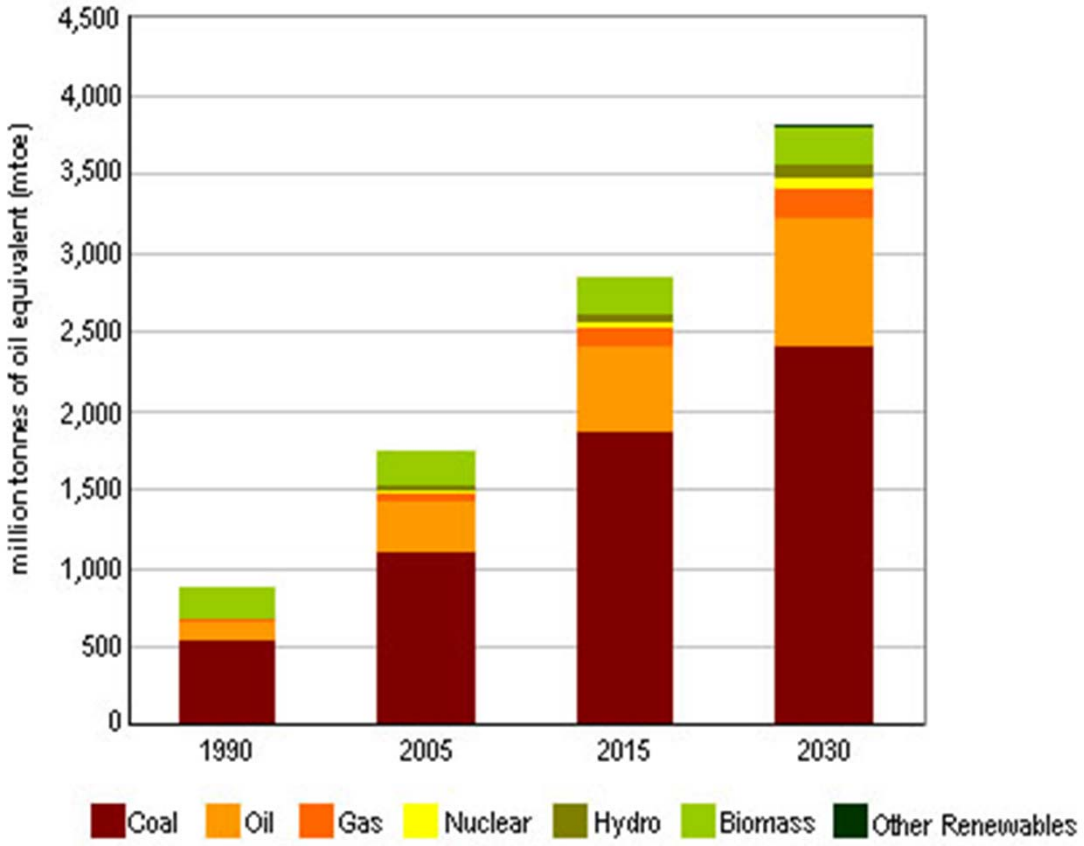
The UK: An example from the EU

- Renewables supplied a mere 1.3% of energy in 2005, but the goal is for 15% renewable by 2020. Much of this growth is planned to come from wind power. Biofuels such as biodiesel receive a 20p per litre tax incentive (~ $1.50 per US gallon).

Energy usage by 2030: China

- Currently most of China's energy is used by industry.
- Most of this energy is supplied from coal, of which China has plentiful supplies.
- China is soon expected to become the world's largest energy user, and it is already the largest producer of carbon dioxide.
- Since 2008, China has moved rapidly towards more sustainable energy production, so the graph on the next page is already out of date!

Expected growth in China's energy usage



Source: Earthtrends

7.3. RENEWABLE ENERGY

Renewable energy

- Hydroelectric power- well established
- Wind power is becoming viable- now popular in Europe
- Solar power also becoming viable- popular in Japan and Germany
- Geothermal power- used in Iceland, New Zealand.
- Biomass- still inefficient, competes with agriculture, but becoming more viable
- Tidal power- useful only in certain locations

Limitations of renewable energy

- Many newer renewable sources of electrical power (solar, wind, waves) are capital-intensive at present, requiring a higher level of investment (per MW) than fossil fuel plants. However, prices may fall as technology improves and products become mass commodities.
- Many of these renewables also provide power only intermittently, which gives problems for reliability of supply (what if the wind isn't blowing when I want to run my washing machine?)

Hydroelectric power

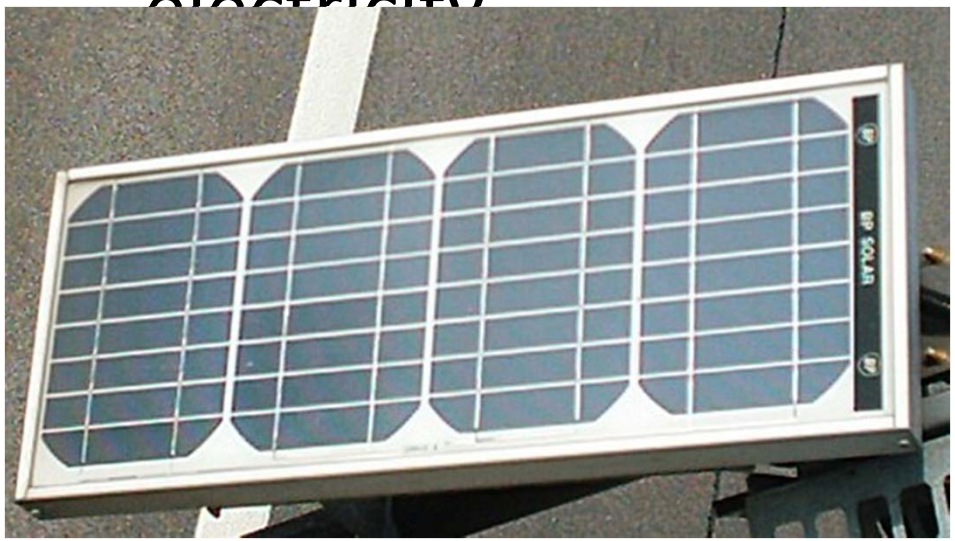
- Currently 10% of US electricity (92 GW currently)
- 25% of the world's electricity
- Still potential in Asia- big dams planned in China (20 GW Three Gorges already in place) & India
- Environmental impacts from flooding may hinder further development.

Three Gorges Dam – world's largest

Picture by Christoph Filnkößl, WM Commons, CC license.

Solar power

- Photovoltaics- convert sunlight to electricity, most established method
- Solar/hot water- convert sunlight to heat
- Solar chimney- convert sunlight to heat to electricity



Picture by Thomas Springer, Wikimedia Commons, CC License.

Wind power

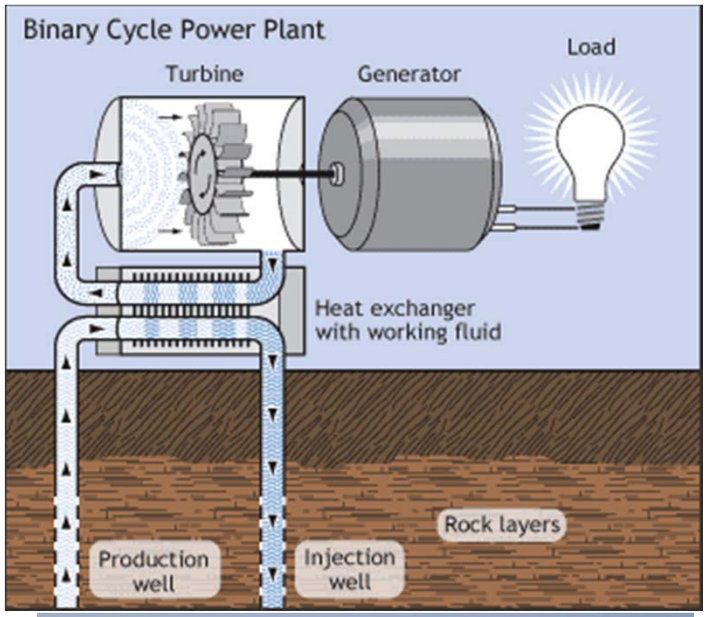
- A turbine extracts energy from the wind and converts it to electrical energy.
- Most are horizontal axis (as in these slides), but some can be vertical axis, as in this example. Three blades is common (for stability), but other numbers of blades are possible too.
- Wind power only works effectively in zones where high winds occur regularly.

- See the video of Prof. Visser, who is studying small turbine for home/farm use.

Other methods

- Geothermal power: "Hot rocks" under the earth- cold water is pumped underground, comes back up hot.

- Wave power – captures energy from ocean waves, such as this scheme in Portugal (projected to reach 70 MW by 2009)



Biomass: Mainly for fuel production

- Plants burned, either directly or after conversion to fuels.
- *Waste* biomass is efficient to use, likely to become very important. Deliberately growing biomass to burn is less viable if it takes away useful arable land for food crops, but may contribute.

- See the video of Prof. Ewy.

Biofuel from Willow
Research at SUNY-ESF