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Strategies for Sustainable Energy

Lecture 7. Strategies for Sustainability I

ENG2110-01
College of Engineering
Yonsei University
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19. Strategies: BIG

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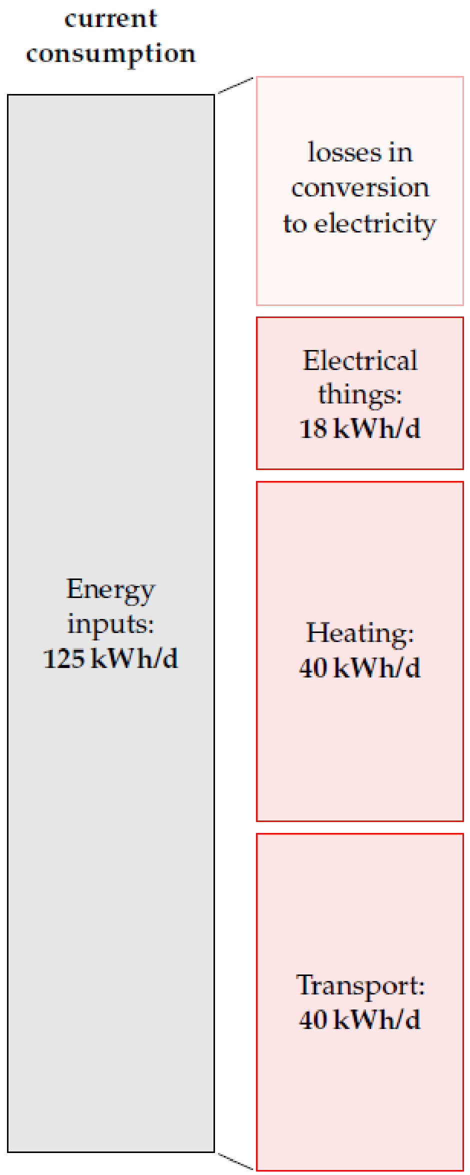
BIG Changes are required

Demand can be reduced
- reduce the population
- change our lifestyle
- keep population & lifestyle, reduce energy intensity through

efficiency and technology

Supply can be increased
- sustainable, clean coal?
- sustainable, nuclear fission?
- buy, beg or steal renewable energy from other countries

Simplify the picture
- transport
- heating
- electricity
- conversion losses



19. Strategies: BIG

Potential Directions

Better Transport (Chapter 20, discussed in Lecture Module 3)

- electrify transportation
- more mass transit
- more bicycles
- advanced design of electric cars

Smarter Heating (Chapter 21, discussed in Lecture Module 4)

- better building design
- heat pumps
- lower thermostat settings

Efficient Electricity Use (Chapter 22)

- turning off idle devices (stand by devices account for 8% of residential electricity use)
- use of energy efficient devices/bulbs
- reduce transmission losses in electrical lines

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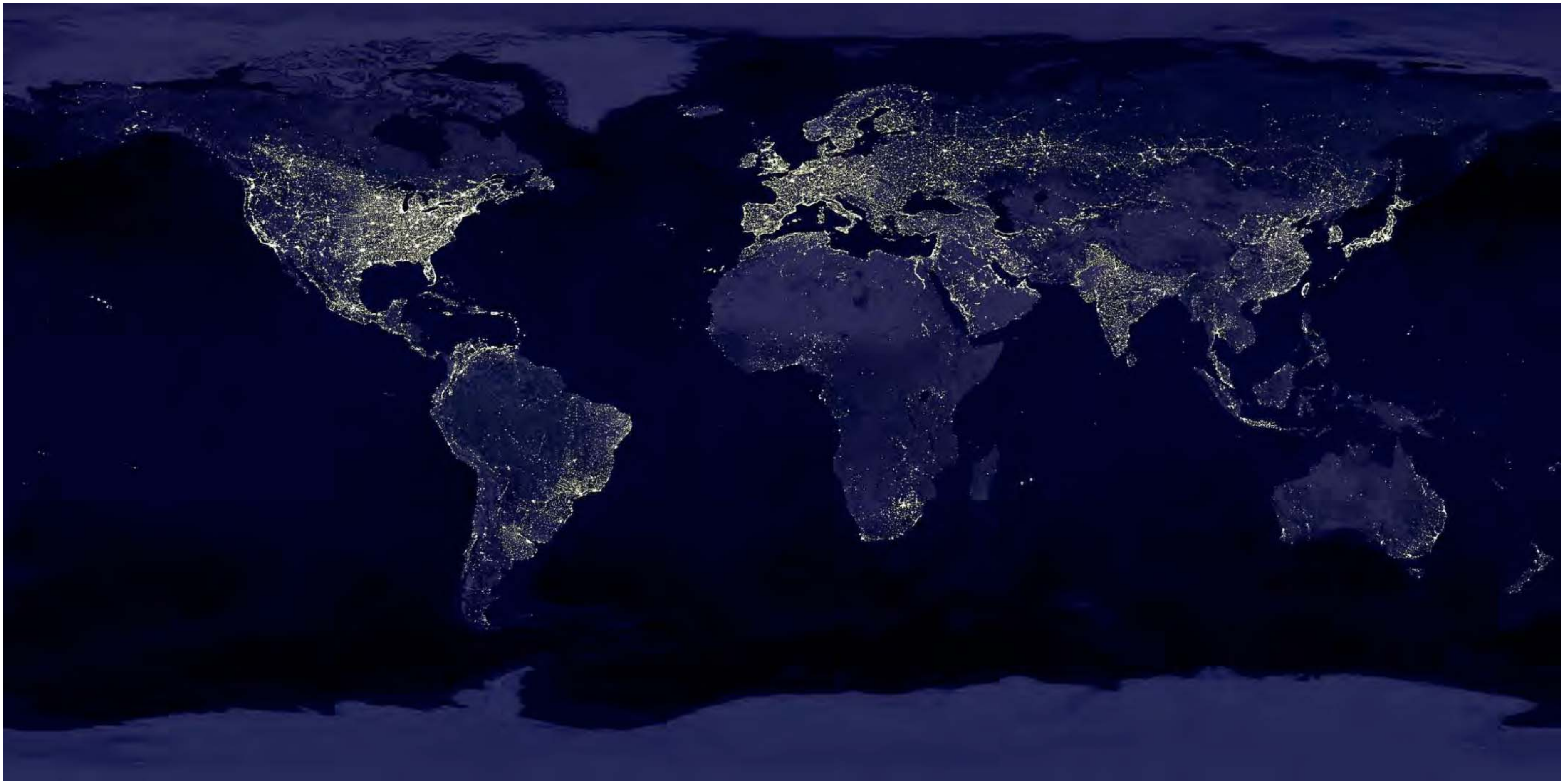

http://www.pppl.gov/colloquia_pres/WC13MAY09_JMinervini2.pdf

Reducing Transmission Losses

Transmission Losses

- Transmitting electricity at high voltage reduces the fraction of energy lost to resistance.
- For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor.
- At extremely high voltages, more than 2 MV between conductor and ground, corona discharge losses are so large that they can offset the lower resistance loss in the line conductors.
- Transmission and distribution losses in the USA were estimated at 6.6% in 1997[13] and 6.5% in 2007.[13]

http://en.wikipedia.org/wiki/Electric_power_transmission

Reducing Transmission Losses

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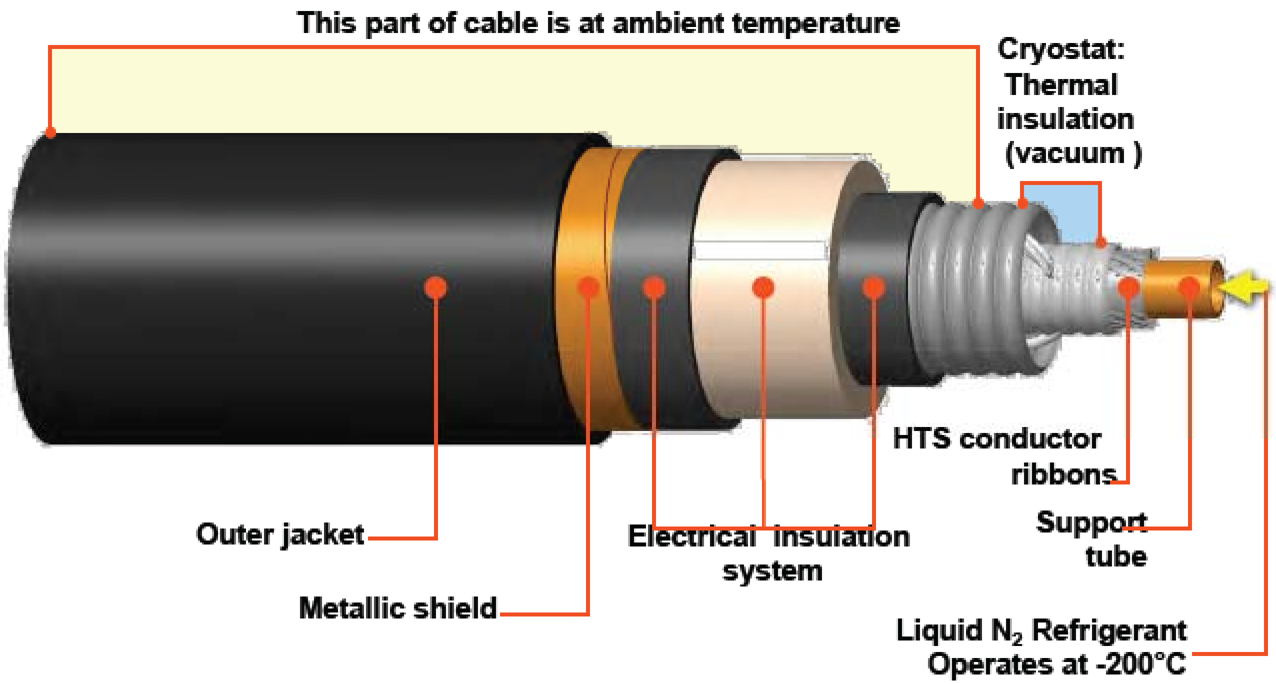
How much can transmission and distribution losses be reduced

High-temperature superconductors promise to revolutionize power distribution by providing lossless transmission of electrical power. The development of superconductors with transition temperatures higher than the boiling point of liquid nitrogen has made the concept of superconducting power lines commercially feasible, at least for high-load applications. It has been estimated that the waste would be halved using this method, since the necessary refrigeration equipment would consume about half the power saved by the elimination of the majority of resistive losses.



http://www.pppl.gov/colloquia_pres/WC13MAY09_JMinervini2.pdf
http://en.wikipedia.org/wiki/Electric_power_transmission

23: Sustainable Fossil Fuels?

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Sustainable Coal

Target: 1000 years

- 1600 Gt of coal
- 6 billion people
- contains 6 kWh/day/person
- due to conversion losses, provides 2.2 kWh/day/person
- with clean coal technology, provides 1.6 kWh/day/person

Conclusion Clean coal is only a temporary solution.

The End of Business as usual: How long will coal last?

- 1600 Gt of coal
- population increase
- coal demand increase at 3.4% per year
- 60 years of coal left ~2070
- the impact will be felt well before 2070.

If Jevons were here today, I am sure he would firmly predict that unless we steer ourselves on a course different from business as usual, there will, by 2050 or 2060, be an end to our happy progressive condition.

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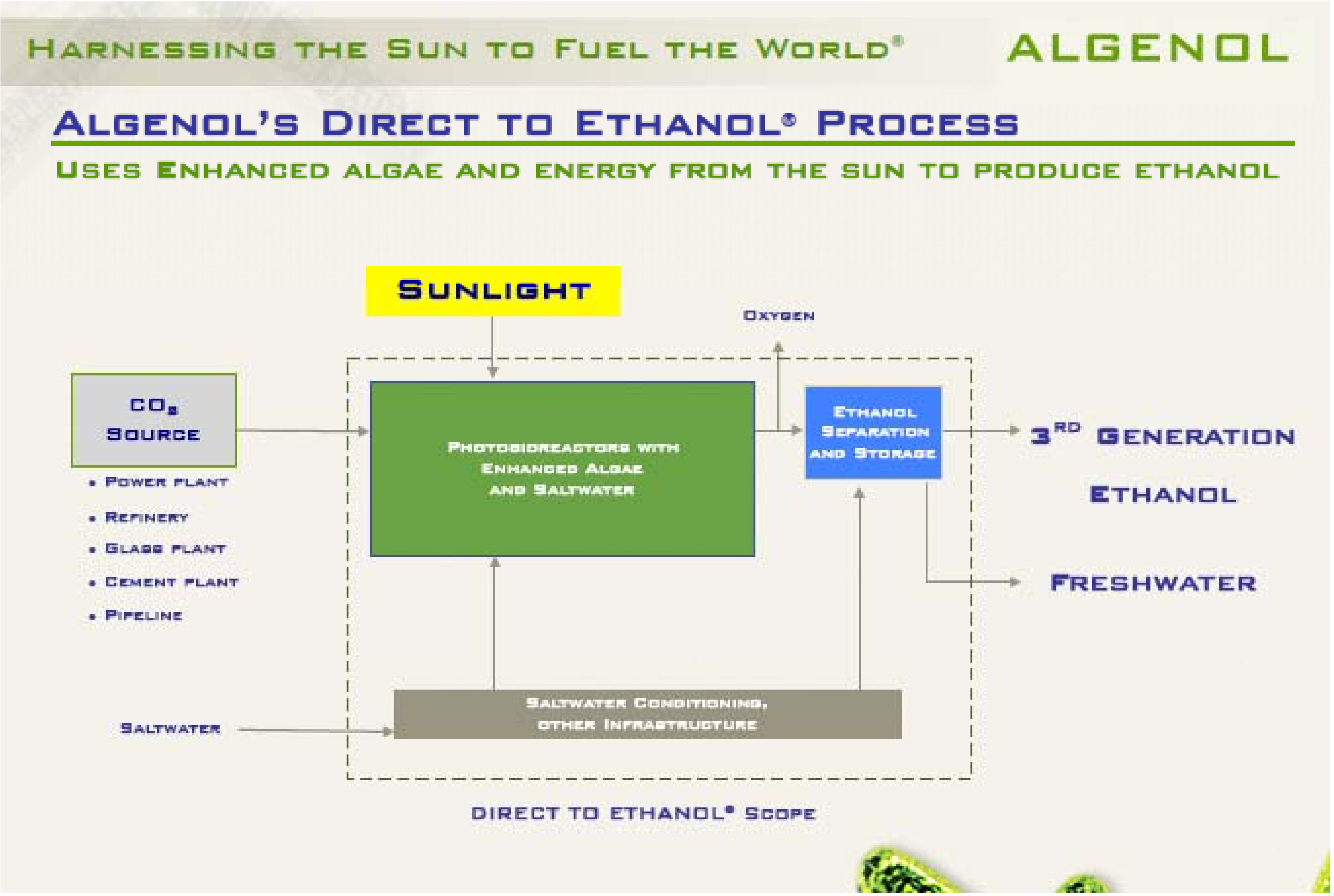
Example of "Clean Coal" or "Carbon Capture" Technology



http://www.algenolbiofuels.com/Algenol_Public_Presentation.pdf

23: Sustainable Nuclear?

Nuclear energy

- fission
  - make small atoms from large atoms
  - currently in use to produce energy
- fusion
  - make large atoms from small atoms
  - currently <u>not</u> in use to produce energy

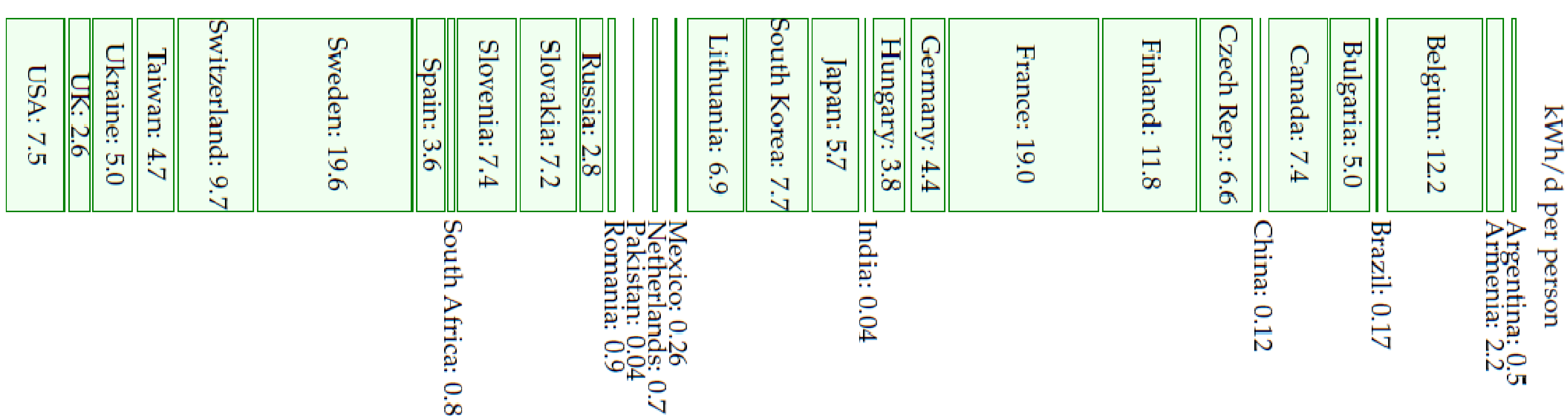


Figure 24.1. Electricity generated per capita from nuclear fission in 2007, in kWh per day per person, in each of the countries with nuclear power.

23: Sustainable Nuclear?

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Nuclear energy

- how much uranium?
  - uranium in the ground 4.7 million tons (currently used)
  - uranium in phosphate deposits 22 million tons
  - uranium in seawater at 3.3 ppm 4500 million tons (currently very expensive to isolate)

- what type of reactor?
  - conventional once-through reactor (uses less than 1% of the Uranium)
  - fast breeder reactors (obtains 60 times the energy of the conventional nuclear reactor)

- sustainable for 1000 years?
  - use uranium in the ground
  - use conventional once-through reactor
  - 0.55 kWh/day/person
  - use fast breeder reactor, 33 kWh/day/person
  - use fast breeder reactor with uranium from the ocean, 420 kWh/day/person

- what about thorium?
  - three times as abundant as uranium in the ground
  - in “energy amplifier” reactor, 24 kWh/day/person
  - don’t know how to recover fissile material from irradiated fuel

http://www.iaea.org/inisnkm/nkm/aws/fnss/fulltext/te_1319_30.pdf

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Nuclear energy safety concerns

Fatality rates in the generation of energy
This includes for example, coal miners dying in a coal mine accident.
This does not include people dying from thyroid cancer caused by enhanced mercury levels in the river fish they eat, due to mercury release from coal-fired power plants.

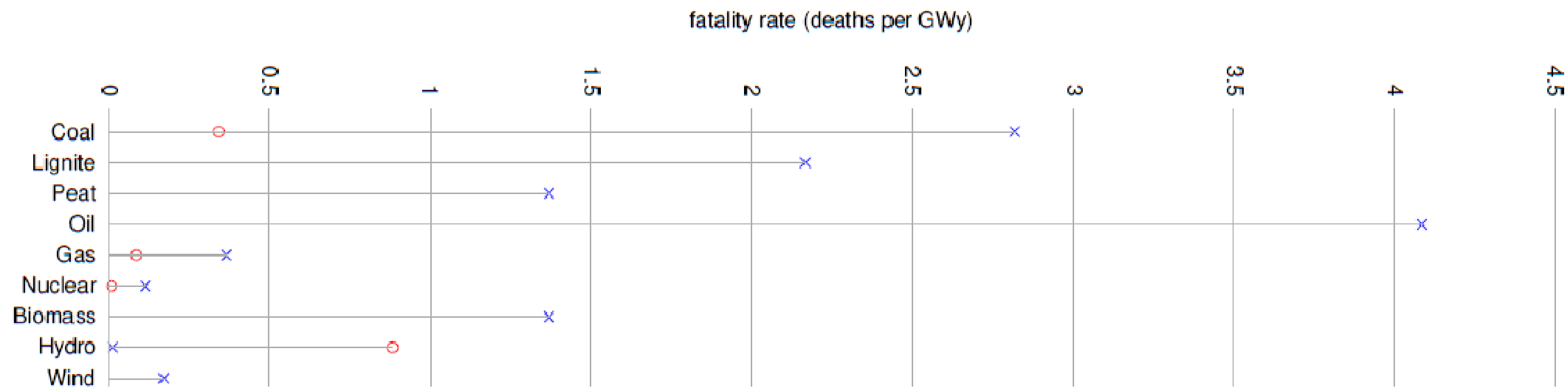

Figure 24.11. Death rates of electricity generation technologies. ×: European Union estimates by the ExternE project. ○: Paul Scherrer Institute.

23: Sustainable Nuclear?

What if fusion of deuterium became a reality?

- 33 grams of deuterium in every ton of ocean water
- 1 gram of deuterium via fusion yields 100,000 kWh
- 230 million tons of ocean water per person

- For a population of 60 billion (not six billion)
- For one million years
- 30,000 kWh/day/person

It is a worthwhile gamble to continue to pursue harnessing nuclear fusion for energy.

Living on other countries' renewables?

Countries that will have renewable energy to export have
- low population density
- large area
- renewable power supply with high power density

Power per unit land or water area	
Wind	2 W/m^2
Offshore wind	3 W/m^2
Tidal pools	3 W/m^2
Tidal stream	6 W/m^2
Solar PV panels	5–20 W/m^2
Plants	0.5 W/m^2
Rain-water (highlands)	0.24 W/m^2
Hydroelectric facility	11 W/m^2
Solar chimney	0.1 W/m^2
Concentrating solar power (desert)	15 W/m^2

Table 25.1. Renewable facilities have to be country-sized because all renewables are so diffuse.

Concentrated Solar Power

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What is Concentrated Solar Power?

Concentrated solar power (CSP) are systems that use lenses or mirrors to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electrical power is produced when the concentrated light is converted to heat which drives a heat engine (usually a steam turbine) connected to an electrical power generator.
CSP should not be confused with photovoltaics, where solar power is directly converted to electricity without the use of steam turbines.

Advantages

- Uses steam turbines (conventional technology)
- No expensive solar PV cells
- 12 to 18 cents per kWh
- needs a desert

Commercial electricity ~ 9 cents/kWh (Knoxville, TN, November, 2010)

http://en.wikipedia.org/wiki/Concentrated_solar_power

Concentrated Solar Power

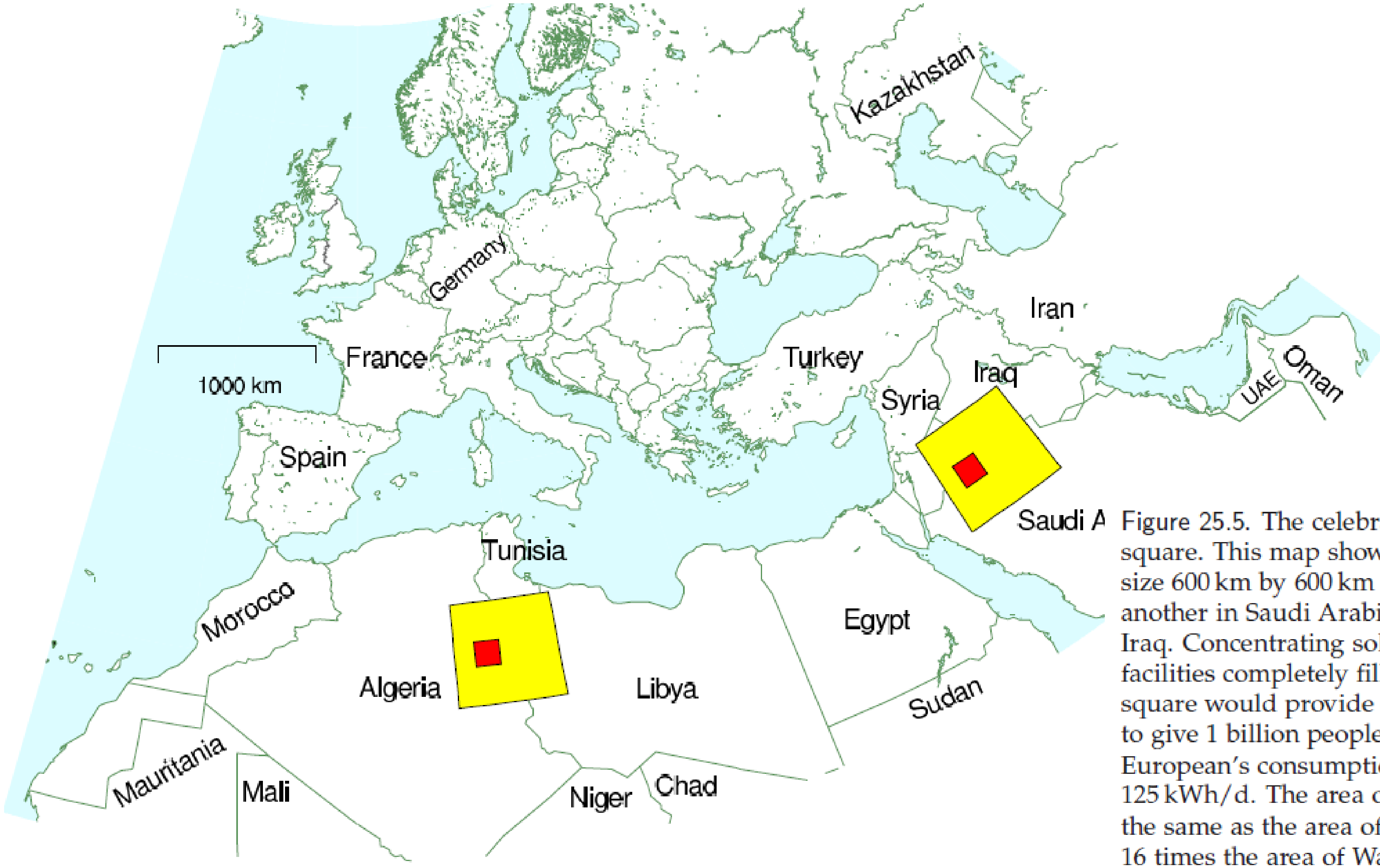

Figure 25.5. The celebrated little square. This map shows a square of size 600 km by 600 km in Africa, and another in Saudi Arabia, Jordan, and Iraq. Concentrating solar power facilities completely filling one such square would provide enough power to give 1 billion people the average European's consumption of 125 kWh/d. The area of one square is the same as the area of Germany, and 16 times the area of Wales. Within each big square is a smaller 145 km by 145 km square showing the area required in the Sahara – one Wales – to supply all British power consumption.

- Each yellow square could provide 125 kWh/day/person for 10^9 people. Place them near water, since they can desalinate water.