Sustainable energy: Opportunities for collaboration

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Collaboration Opportunities

Nuclear power

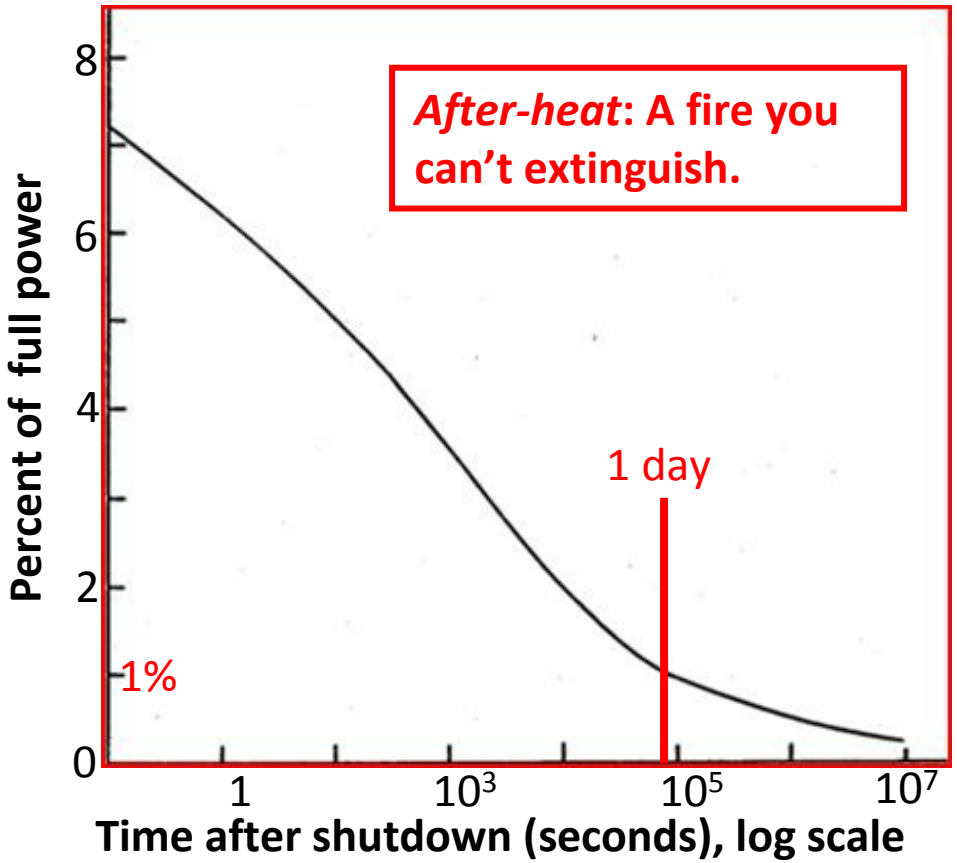
A low-carbon energy system

Nuclear power

Clean-up at Fukushima
Dry casks for storage
Fuel cycle and nuclear weapons

Nuclear power and “after-heat”

Fukushima Daiichi, before the accident



Source: Nautilus Institute for Security and Sustainability, 2011. *After the Deluge: Short and Medium-term Impacts of the Reactor Damage Caused by the Japan Earthquake and Tsunami.*

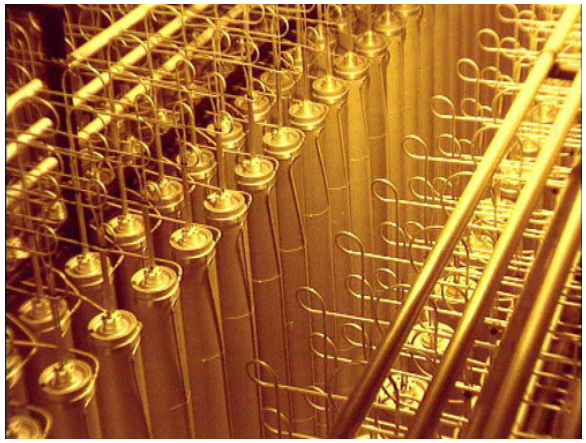
Source: A. Nero. Jr., *The Guidebook to Nuclear Reactors*, p. 54

Nuclear power and dry-cask storage

The nuclear power fuel cycle and nuclear war

Both uranium isotope enrichment (the “front end” of the fuel cycle) and spent-fuel reprocessing to recover plutonium (the “back end” of the fuel cycle) are routes to nuclear weapons.

Nuclear power cannot become a safe global energy source until much stronger international institutions are developed to govern the nuclear power fuel cycle in all countries.



Gas-centrifuges for enrichment

France’s reprocessing plant at La Hague

Opportunities for collaboration

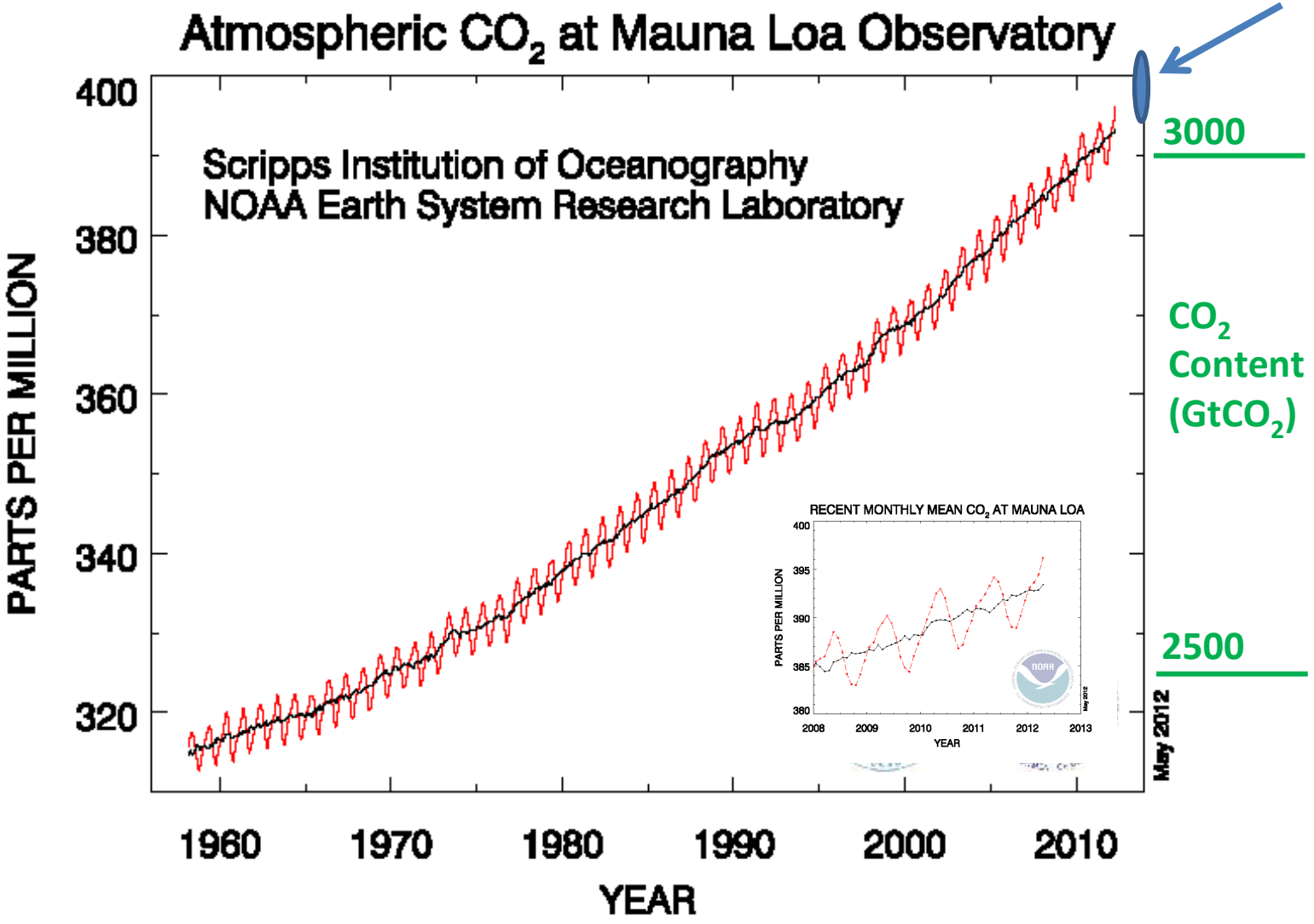
- Risk reduction and clean-up at Fukushima.
- Waste management with dry casks – the new norm?
- The fuel cycle and nuclear weapons proliferation.

A low-carbon energy system

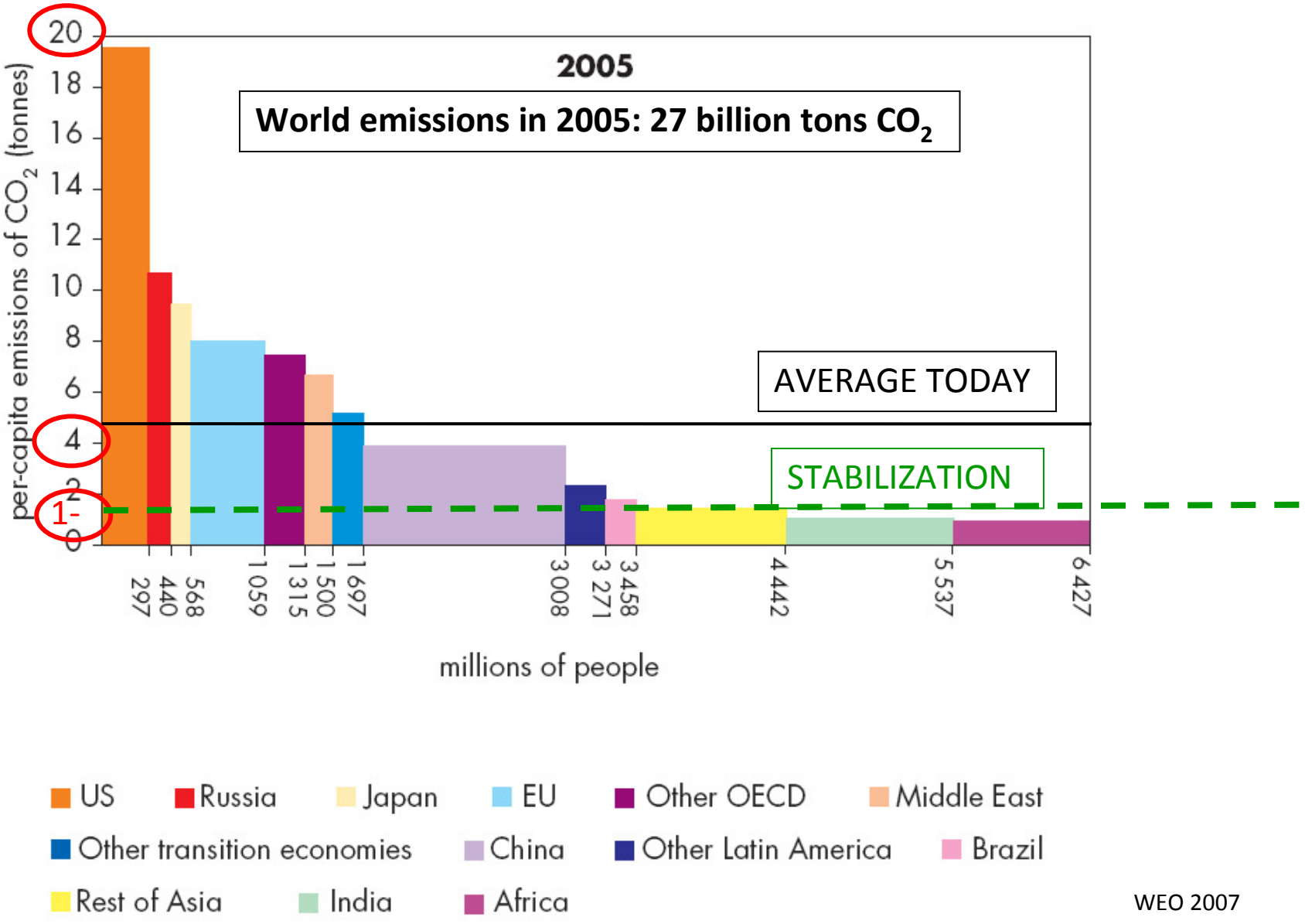
Efficient use
Modern fossil-fuel-based electricity
Renewables

The relentless rise of the CO_2 concentration

Arctic **monthly averages exceeded 400 ppm in April 2012.**



Per-capita fossil-fuel CO_2 emissions, 2005



WEO 2007

Four ways to emit 4 tonCO_2/yr (today's global per capita average)

Activity	**Amount producing 4 ton CO_2/yr emissions**
a) Drive	24,000 km/yr, 5 liters/100km
b) Fly	24,000 km/yr
c) Heat home	Natural gas, average house, average climate
d) Lights	300 kWh/month when all coal-power (600 kWh/month, natural-gas-power)

Efficient Use of Electricity

***Three images*:**

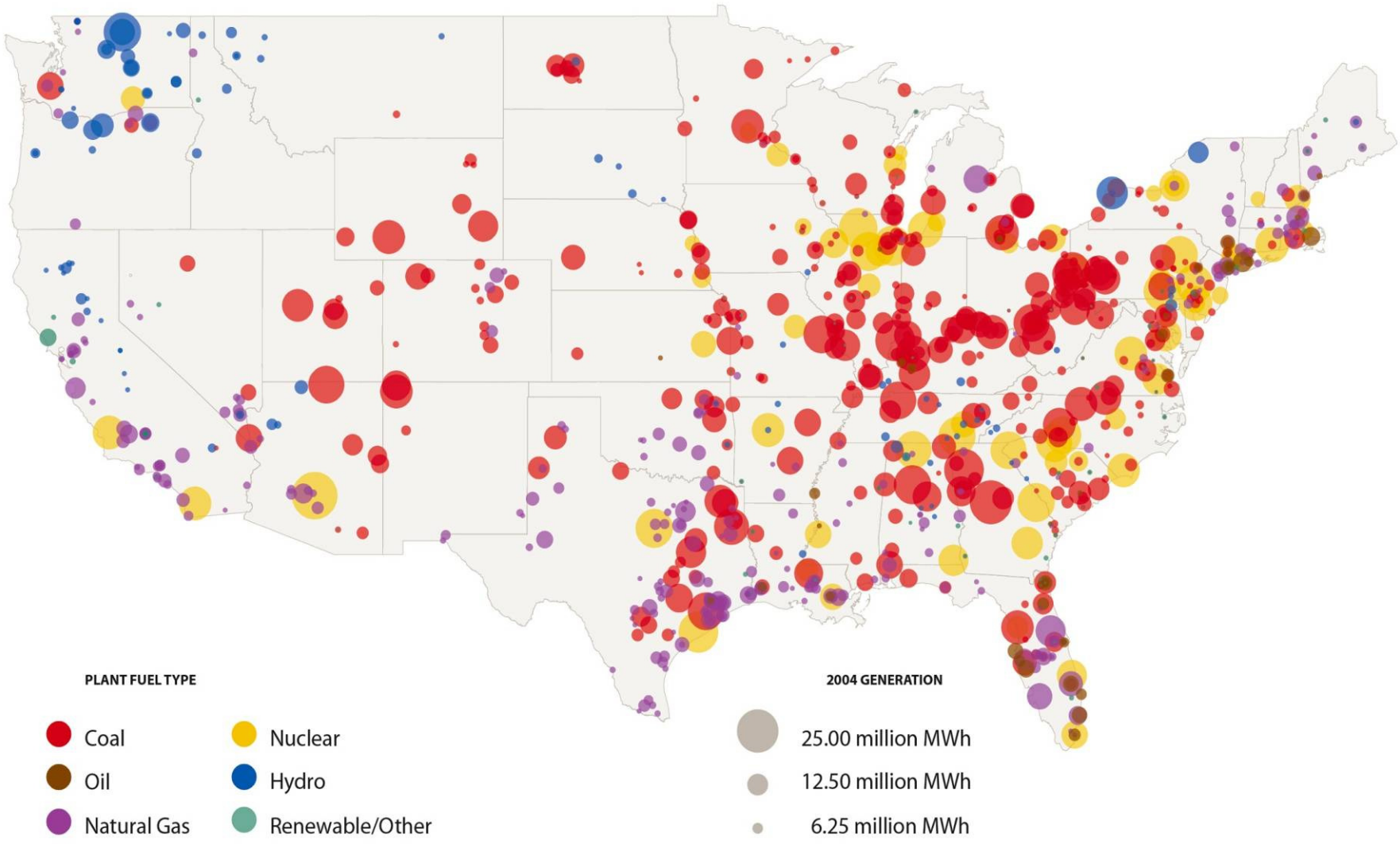
Power electronics for variable-speed-drive motors.

Integration of electricity and thermal energy ("cogeneration").

Can also integrate electricity and fuels/chemicals.

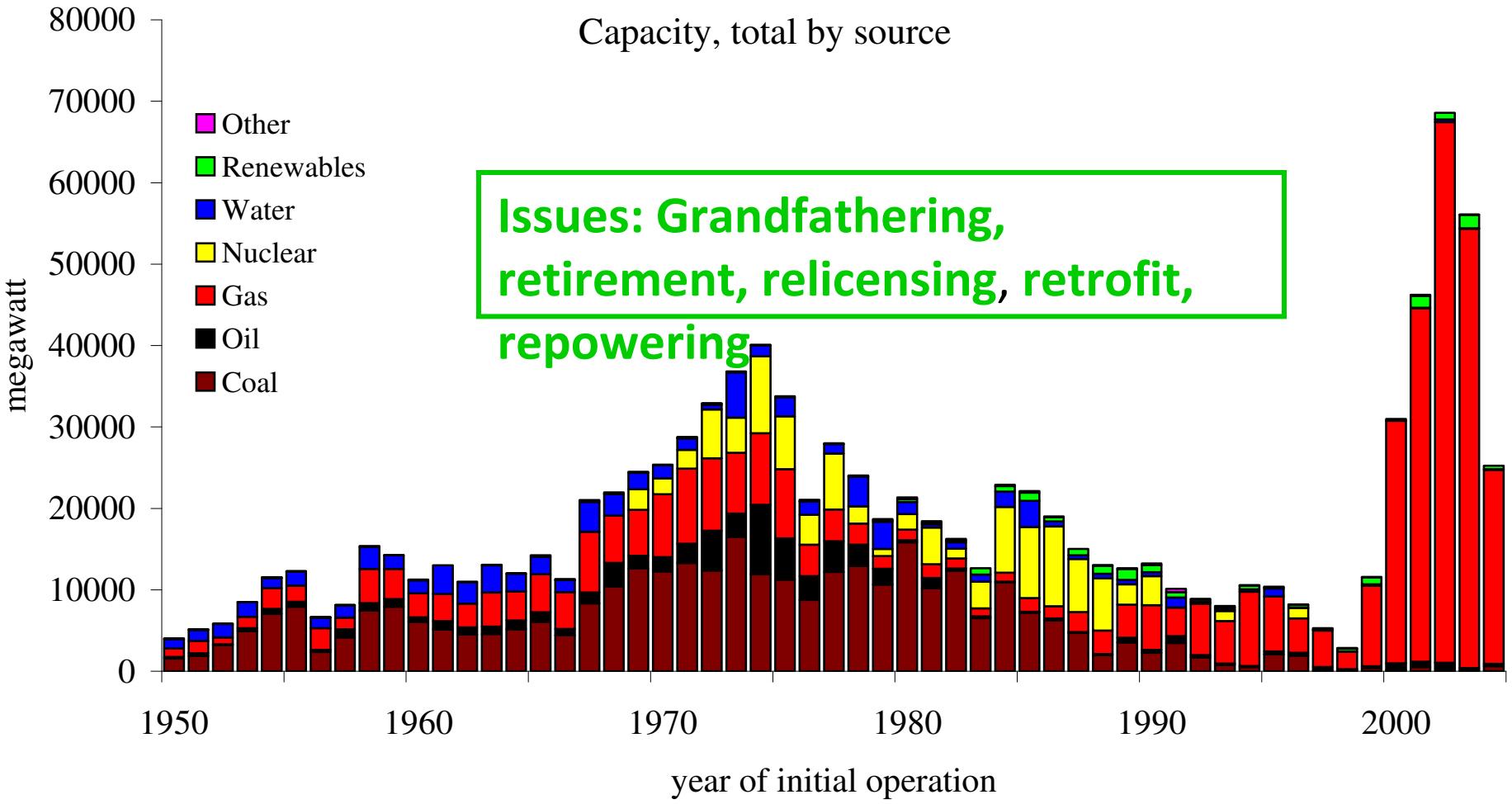
Efficient lighting.

Legacy: U.S. Power Plants



Source: *Benchmarking Air Emissions*, April 2006. The report was co-sponsored by CERES, NRDC and PSEG.

Will U.S. power plants retire?



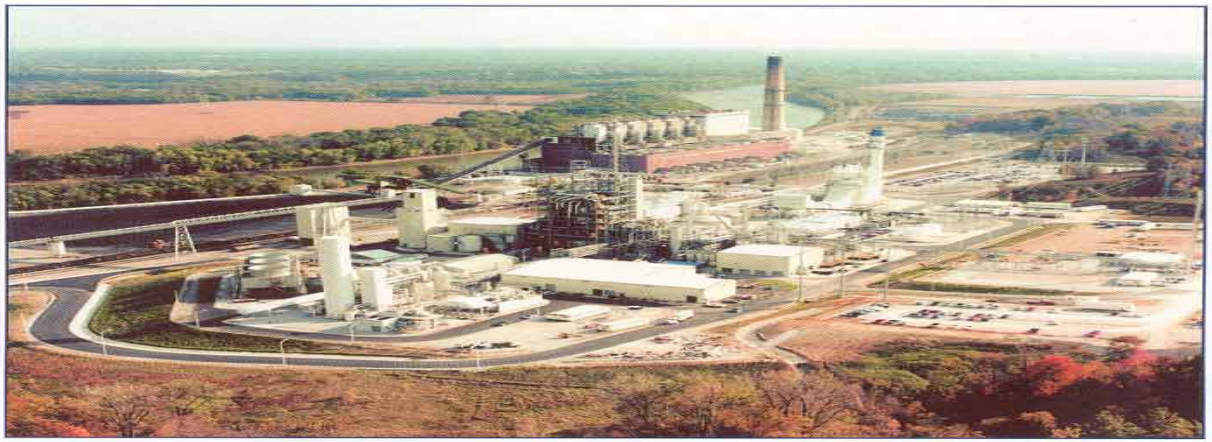
Source: EIA. Joseph.Beamon@eia.doe.gov

Fuel Switching: Coal to gas

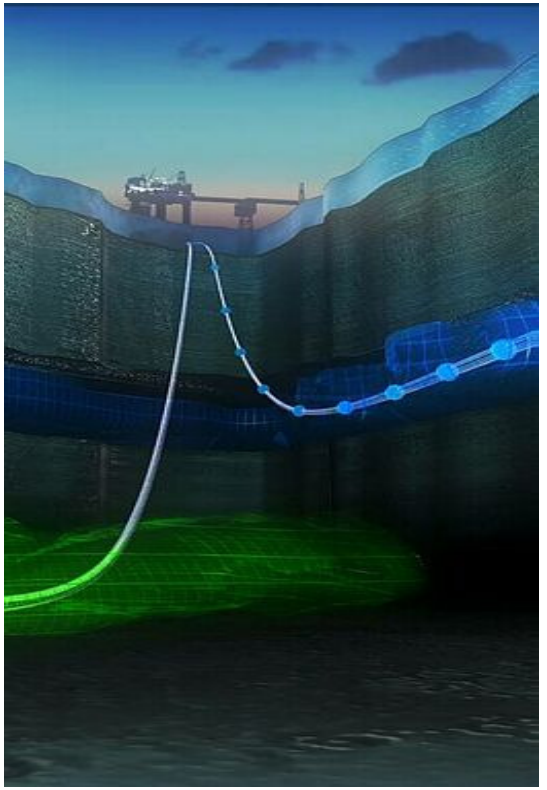
Photo by J.C. Willett (U.S. Geological Survey).

How important is shale gas?

Coal with Carbon Capture and Storage



The Wabash coal gasification reprocessing project



Sleipner field, Norway

Graphics courtesy of DOE Office of Fossil Energy and *Statoil ASA*

The Future Coal or Natural Gas Power Plant

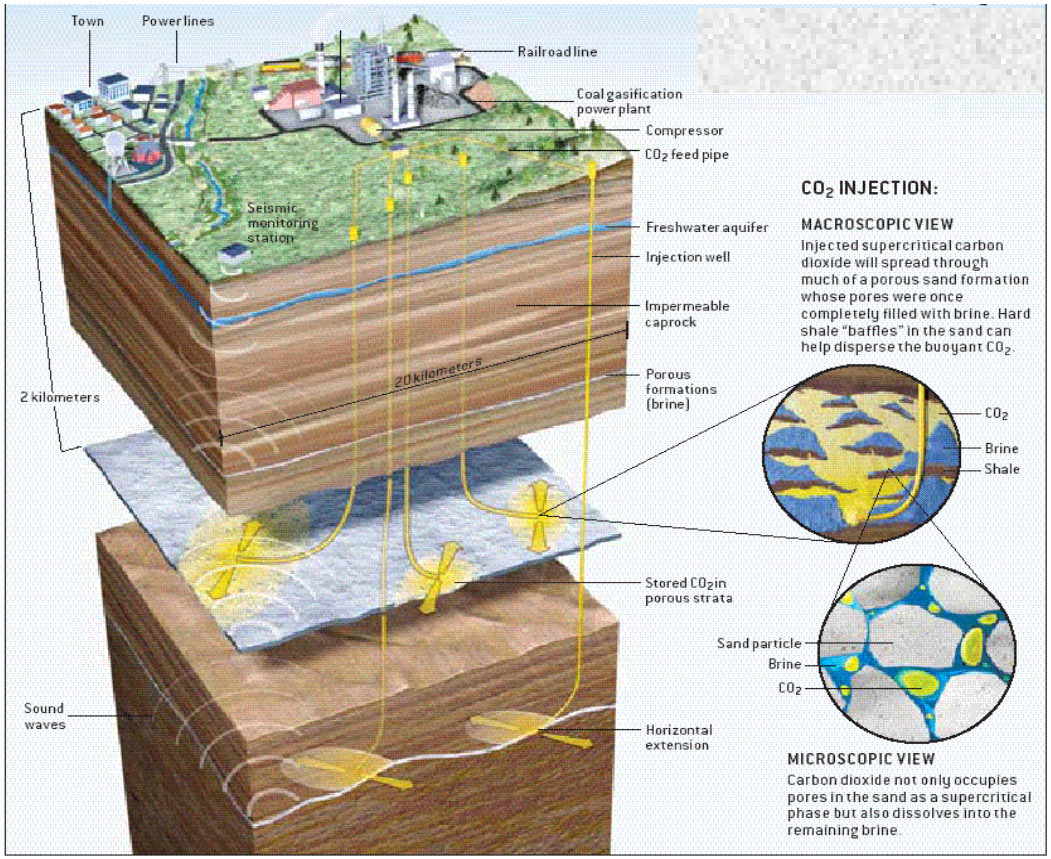


ILLUSTRATION BY DAVID FIERSTEIN, CONCEPT BY JULIO FRIEDMANN Lawrence Livermore National Laboratories

Shown here: After 10 years of operation of a 1000 MW coal plant, 60 Mt (90 Mm^3) of CO_2 have been injected, filling a horizontal area of 40 km^2 in each of two formations.

Assumptions:

- 10% porosity
- **1/3 of pore space accessed**
- 60 m total vertical height for the two formations.

- *Note:* Plant is still young.

Injection rate is 150,000 bbl(CO_2)/day, or 300 million standard cubic feet/day (scfd). That's 3 billion barrels, or 6 trillion standard cubic feet, over 60 years.

Renewable Power

***Installed already, world-wide*:**

Wind:	**240 GW_{peak}**	**(through 2011)**
Photovoltaic:	**40 GW_{peak}**	**(through 2010)**
Concentrators:	**Very little**	

Opportunities for collaboration

- Climate-change science
- Efficient energy use – measure and evaluate
- Power-plant retirement
- Low-carbon fossil energy
- Renewables

“Solutions” can bring serious problems of their own.

Every “solution” has a dark side.

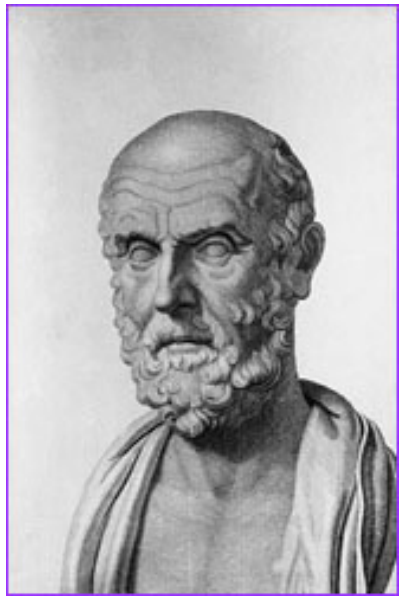
Conservation	Regimentation
Renewables	Competing uses of land
“Clean coal”	Mining: worker and land impacts
Nuclear power	Nuclear war
Geoengineering	Technological hegemony

Risk management: In choosing targets, we must take into account both the risks of disruption from climate change and the risks of disruption from mitigation.

Wisdom from Hippocrates

"I will apply, for the benefit of the sick, all measures that are required, avoiding those twin traps of overtreatment and therapeutic nihilism."

Hippocrates



*** Modern version of the Hippocratic oath, Louis Lasagna, 1964.**
http://www.pbs.org/wgbh/nova/doctors/oath_modern.html