Nuclear Power is NOT CO_2-free

Nuclear Power: the Energy Balance

by Jan-Willem Storm van Leeuwen and Philip Smith

The use of nuclear power causes, at the end of the road and under the most favourable conditions, approximately one-third as much CO_2-emission as gas-fired electricity production. The rich uranium ores required to achieve this reduction are, however, so limited that if the entire present world electricity demand were to be provided by nuclear power, these ores would be exhausted within three years.

Use of the remaining poorer ores in nuclear reactors would produce more CO_2 emission than burning fossil fuels directly. The energy balance is barely positive!

Possible sources of CO_2-free Power

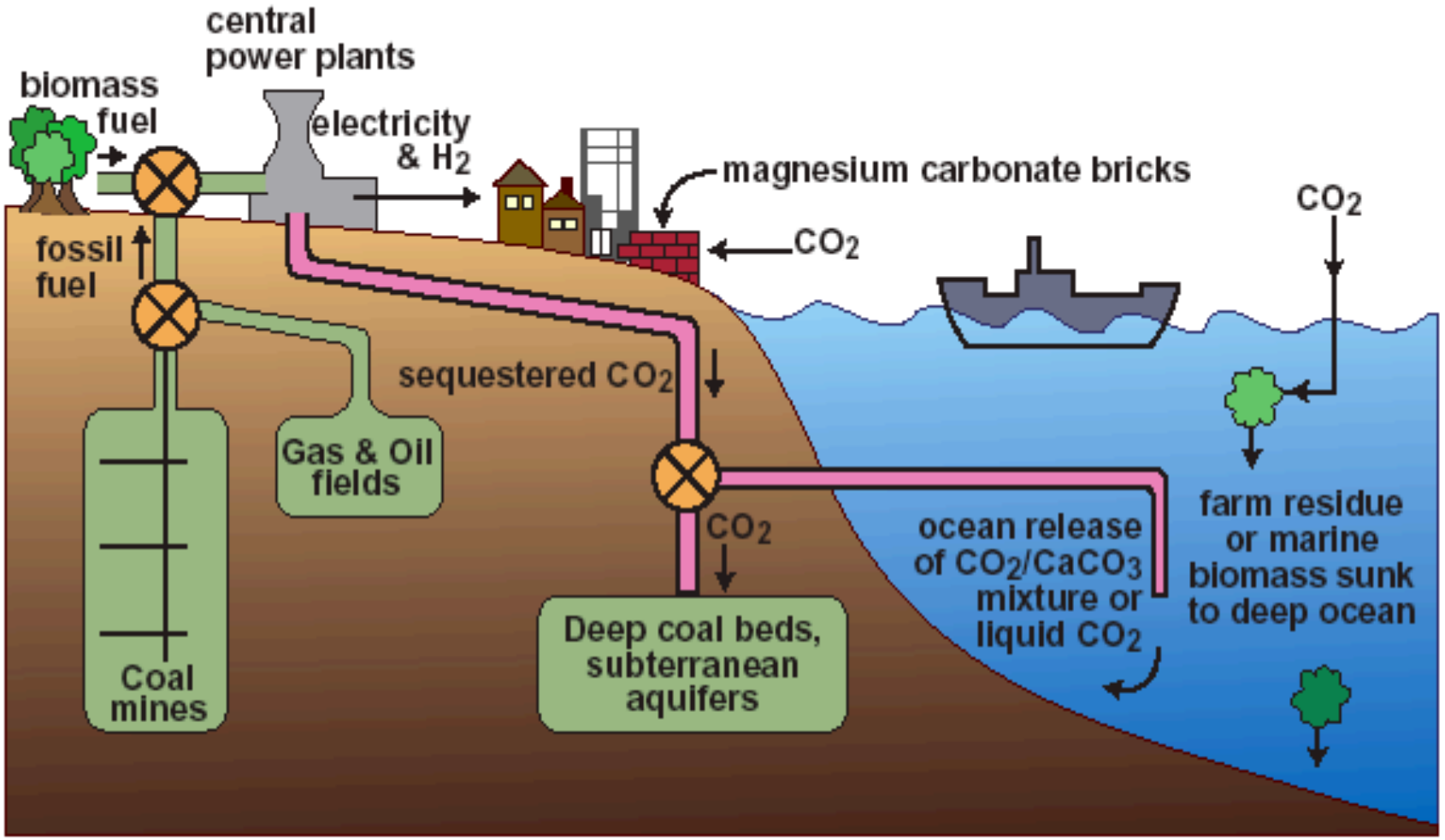
- ~~Nuclear (fission and fusion)~~

Nuclear Fusion:

Even most optimistic proponents of nuclear fusion do not see a commercial reactor before 2050

- **Carbon Capture and Sequestration**
- **Renewables**

Carbon Sequestration



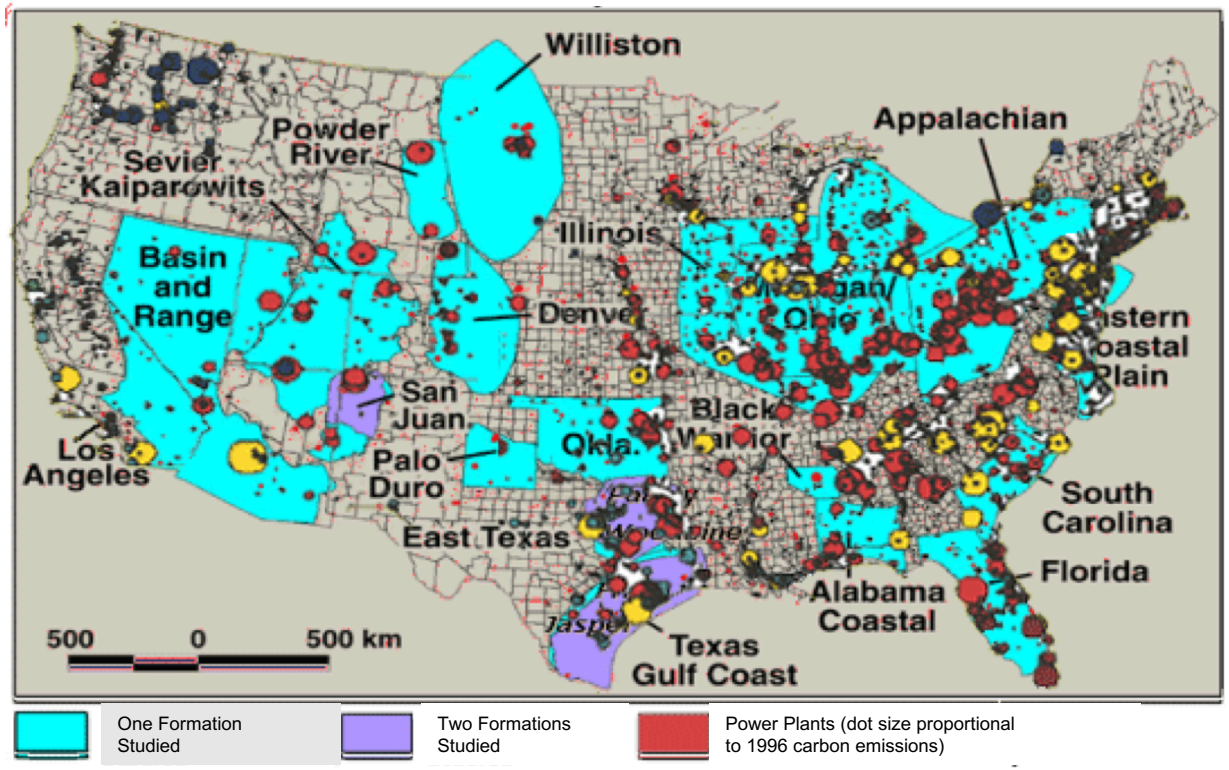
N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

CO_2 Burial: Saline Reservoirs

130 Gt total U.S. sequestration potential
Global emissions 6 Gt/yr in 2002 Test sequestration projects 2002-2004

- **Near sources (power plants, refineries, coal fields)**
- **Distribute only H_2 or electricity**
- **Must not leak**

Study Areas



DOE Vision & Goal:
1 Gt storage by 2025, 4 Gt by 2050

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

4

The Only Carbon Capture Coal Plant in the U.S. Just Closed

In 2020 the Trump administration's Department of Energy celebrated a special birthday. "Happy Third Operating Anniversary, Petra Nova!". *The release boasted of a coal-fired power plant in Texas that seemed to have done the impossible: It successfully removed carbon dioxide from the plant's emissions for three years, safely storing them*.

Middle January 2021 NRG Energy, which owns the project, announced that it would be shut down indefinitely.

Decades of research has made CCS technically feasible, but it's both incredibly complex and wildly expensive.

The CCS technology at Petra Nova required so much energy that NRG made an entirely separate natural gas power plant—the emissions of which were not offset by the Petra Nova technology—just to power the scrubber.

And ironically, the CO_2 pulled from the plant's emissions was actually used to make more fossil fuels. Petra Nova got the permission to transport the carbon dioxide scrubbed from burning coal to a separate oil field, where it was injected underground to help release more oil.

In a twist of fate, this oil was what ultimately killed Petra Nova. After the crash in oil prices at the start of the pandemic last spring, NRG took the CCS project offline, stating that the price of the oil it could get with the extracted carbon dioxide wasn't worth the cost of actually doing the extracting.

Possible sources of CO_2-free Power

- ~~Nuclear (fission and fusion)~~

  ~~Even most optimistic proponents of nuclear fusion do not see a commercial reactor before 2050~~

- ~~Carbon Capture and Sequestration~~

- Renewables

7

Renewables

- Hydroelectric
- Geothermal
- Ocean/Tides
- Wind
- Biomass
- Solar

8

Hydroelectric Power Potential

Globally

- Gross theoretical potential 4.6 TW
- Technically feasible potential 1.5 TW
- Economically feasible potential 0.9 TW
- Installed capacity in 1997 0.6 TW
- Production in 1997 0.3 TW

(can get to 80% capacity in some cases)

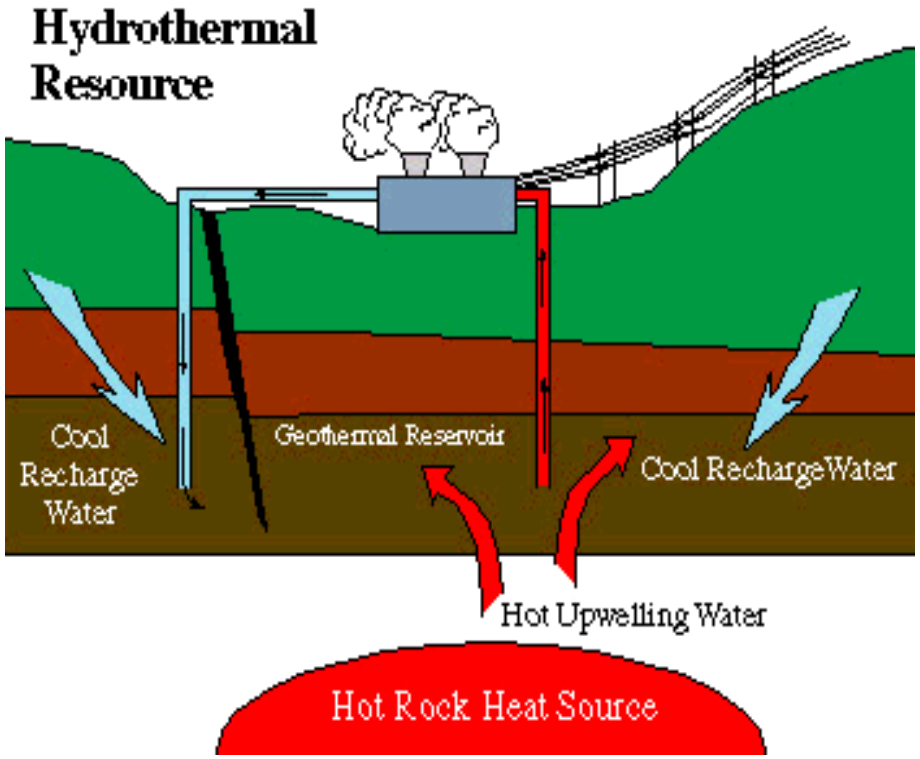
Source: WEA 2000

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

9

Geothermal Energy

1.3 GW capacity in 1985



Hydrothermal systems
Hot dry rock (igneous systems)
Normal geothermal heat (200 C at 10 km depth)

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

Geothermal Energy

- Mean terrestrial geothermal flux at earth's surface **0.057 W/m²**
- Total continental geothermal energy potential 11.6 TW
- Oceanic geothermal energy potential 30 TW

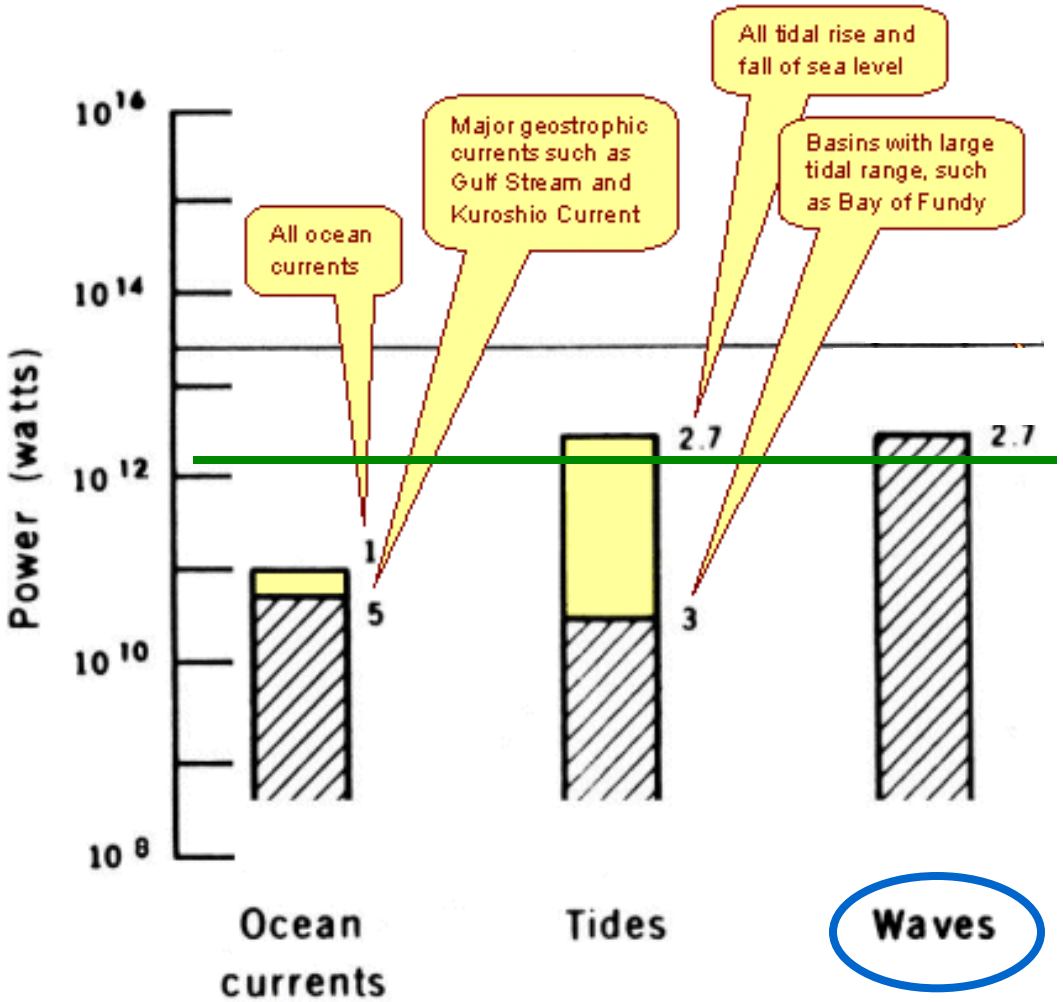
- Wells "run out of steam" in 5 years
- Power from a good geothermal well (pair) 5 MW
- Power from typical Saudi oil well 500 MW
- Needs drilling technology breakthrough

  (from exponential $/m to linear $/m) to become economical

N. S. Lewis: „Global Energy Perspective", http://nsl.caltech.edu/energy.html

11

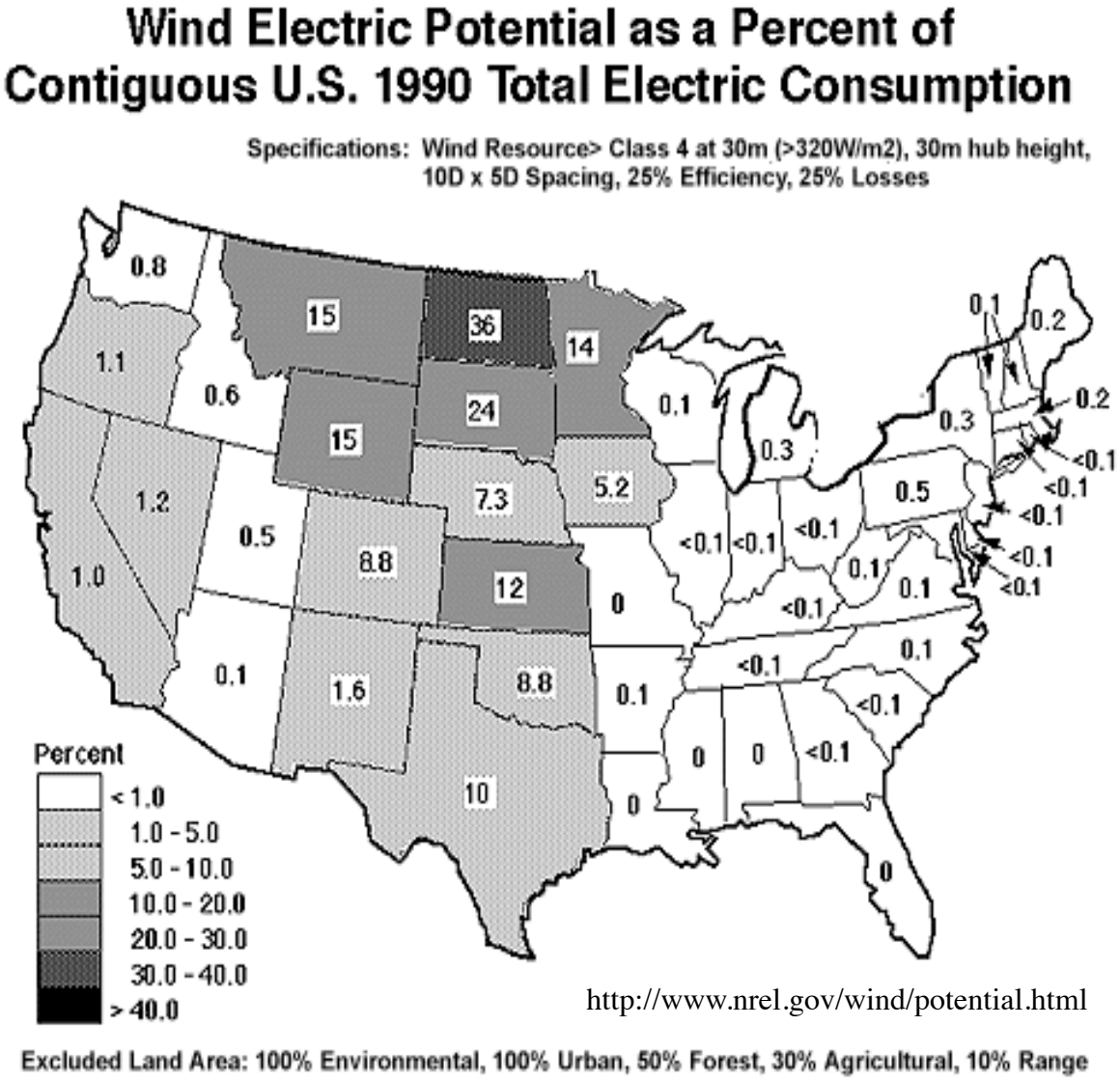
Ocean Power



Isaacs, J.D., and W.R. Schmitt, 1980. "Ocean Energy: Forms ar

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

U.S. Electric Potential of Wind Power



In 1999, U.S consumed

3.45 trillion kW-hr of

Electricity = 0.39 TW

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

13

Electric Potential of Wind Power

- **Significant potential in US Great Plains, inner Mongolia and northwest China**
- **U.S.:**

  Use 6% of land suitable for wind energy development; practical electrical generation potential of ≈ 0.5 TW
- **Globally:**

  Theoretical: 27% of earth's land surface is class 3 (250-300 W/m^2 at 50 m) or greater

  If use entire area, electricity generation potential of 50 TW

  Practical: 2 TW electrical generation potential (4% utilization of ≥class 3 land area)
- **Off-shore potential is larger but must be close to grid to be interesting; (no installation > 20 km offshore now)**

N. S. Lewis: „Global Energy Perspective", http://nsl.caltech.edu/energy.html

14

Electric Potential of Wind Power

- Relatively mature technology, not much impacted by chemical sciences
- Intermittent source; storage system could assist in converting to baseload power
- Distribution system not now suitable for balancing sources vs. end use demand sites
- Inherently produces electricity, not heat; perhaps cheapest stored using compressed air ($0.01 kW-hr)

N. S. Lewis: „Global Energy Perspective“, http://nsl.caltech.edu/energy.html

15