Matthew Simmons

500 MW Coal Plant

- Produces 3.5 billion kilowatt-hours per year, enough to power a city of 140,000
- Burns 1,430,000 tons of coal
- Uses 2.2 billion gallons of water and 146,000 tons of limestone

500 MW Coal Plant

Released each year:

- 10,000 tons of sulfur dioxide - the main cause of acid rain
- 10,200 tons of NOx - a major cause of smog, acid rain
- 3.7 million tons of carbon dioxide - major greenhouse gas
- 500 tons of small particles - health hazard
- 220 tons of hydrocarbons - incomplete combustion
- 720 tons of carbon monoxide - poisonous gas, GHG
- 125,000 tons of ash and 193,000 tons of sludge from the smokestack scrubber - powdered limestone and water used to remove pollution from the plant's exhaust.
- 225 pounds of arsenic, 114 pounds of lead, 4 pounds of cadmium, and many other toxic heavy metals
- Trace amounts of uranium - radioactive emissions are greater than those from nuclear power production.

Electricity from Coal
Superconducting Electrical Transmission

Particulate Control

• Baghouses - Dry particulates are trapped on filters made of cloth, paper or similar materials, then shaken or blown from the filters down into a collection hopper. Used to control air pollutants from steel mills, foundries, and other industrial furnaces - collects > 98% of particulates.

• Cyclones - Dust-laden gas is whirled very rapidly inside a collector shaped like a cylinder, centrifugal forces cause the particles to be thrown against the walls of the cylinder and to drop into a hopper. Used for controlling pollutants from cotton gins, rock crushers, and many other industrial processes - removes up to 95% of solid pollutants.

Power Plant Pollutant Control

• Electrostatic precipitators - static electricity attracts particles to the collection surface, up to 98-99% effective. Used instead of baghouses when the particles are suspended in very hot gases, such as in emissions from power plants, steel and paper mills, smelters, and cement plants.

• Wet scrubbers - Particulates, vapors, and gases are controlled by passing the gas stream through a liquid solution. Used on coal burning power plants, asphalt/concrete plants, and a variety of other facilities that emit sulfur dioxide, hydrogen sulfides, and other gases with a high water solubility. Wet scrubbers are often used for corrosive, acidic, or basic gas streams.

Cost of Electricity

1999 9.2 cents/KWH
2005 12.8 cents/KWH
2006 19.5 cents/KWH

Emission Reduction Benefits far Exceed Costs

Non-Renewable Energy
Nuclear Power

Reliance on Nuclear Power

1990 CAAA: Cleaner Cars, Gasoline & Power Plants

Nuclear Power in US

- Introduction:
  - President Eisenhower's "Atoms for Peace" program (1950s)
  - Atomic Energy Commission and industry created power plants
  - Argonne National laboratory, IL
    - First boiling reactor, 1956
    - Shippingport, PA
  - Pressurized water reactor, 1957
  - By 1974, almost 240 nuclear plants ordered to produce 1,000 MW
  - During 1974-78, just 13 new orders placed
  - No orders placed since 1979 Three mile Island incident
  - Problem with radioactivity released routinely or during accidents
  - Problem with disposal of nuclear waste
**Fuel Rods and Control Rods**

Start Animation >>

**Extraction to Disposal**

Nuclear Energy

- Environmental impacts
  - Uranium mining
  - Large quantities of cooling water
  - Release of radioactivity
    - Nominal operation (<5% background levels)
    - Accidents are more important
  - Processing & disposal of spent fuel rods

- Advantages
  - High energy-density, continuous
  - No pollution gases or particles

Uranium Mining

- Three Mile Island (USA):
  - Partial meltdown in 1979, cost $1 billion
- Chernobyl (Russia), April 1986
  - Explosion blew the roof
  - Cesium$^{137}$ and Iodine$^{131}$
  - Debris transported to Europe and U.S.
  - Deposits on land and food ($^{131}$I) enter human body
  - Radioactivity released equivalent to 300 atomic bombs
  - 10% of the 180 tons of fuel entered the atmosphere
  - 31 deaths; EEC estimates 1,000 deaths
  - 16,000 more will die due to radioactivity
  - Can this happen to U.S. reactors?
Fusion: The power that drives the stars. For several decades, the U.S. and other countries have worked together to harness this power for energy production on earth.

- Fusion has the advantages of:
  - An essentially unlimited fuel supply
  - Enhanced safety
  - No greenhouse gas emissions (global warming)
Plasma Fusion “Z Machine”

Source: Lawrence Livermore National Laboratory

Electrical discharges illuminate the surface of the Z machine, the world’s most powerful X-ray source, during a recent accelerator shot. By early 1998, the Sandia National Laboratories accelerator had achieved temperatures of 1.8 million degrees, close to the 2 to 3 million degrees required for nuclear fusion. In the last 18 months, breakthroughs have enabled the machine to increase its power output roughly seven times.

Alternative Energy Future?

E=mc

The Universe is made of energy.

We do not face an energy crisis.

We face a crisis of imagination.

Alternative Ideas

- Do the Math!
  - Use real costs when comparing alternatives

- Redirect Subsidies to Alternative Energy

- Invest in Basic Energy Research
  - Energy R&D $110 billion over last 50 years
  - $60B Nuclear, $20B Fossil Fuels, $11B Alternative Fuels, $7B Energy Efficiency
  - Military R&D $45B FY 2002

- Conservation 3x Efficiency

- Match Energy Source to End Use

- Cogeneration & Micropower

Energy Research & Development

Alternative Ideas

- Invest in Education
  - More minds on the problem
  - Every field of study will help
  - For the cost of 1 year of occupation in Iraq we could fund 500,000 Ph.D.s

- Telecommuting & Distance Education

- Public Outreach – Get the Facts Out!

- Tax Incentives for Alternatives

- Smart/Green Building Design

- Increased Fuel Economy

- ?
World Energy Consumption by Fuel Type

Peak Oil

$3,196,359,886,853

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