

1 ☐ Energy: Nuclear Energy Part 2

EVPP 111 Lecture

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2 ☐ Outline

- Cautionary Tale of Chernobyl
- Nature of nuclear energy
- History of Nuclear Energy
- Nuclear reactors
- Nuclear fuel cycle
- Nuclear weapons
- Concerns about nuclear energy
- Waste disposal

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4 ☐ Energy: Nuclear Energy

- **Nuclear fuel cycle**
 - series of actions/activities involved in using nuclear fuels to generate energy
 - **steps**
 - mining ore
 - milling ore
 - fuel fabrication
 - installing and using fuel rods
 - disposing of waste

5 ☐ Energy: Nuclear Energy

- **Nuclear fuel cycle**
 - **mining ore**
 - low-grade uranium ore
 - contains ~0.7% fissionable U-235

– must be enriched

6 ☐ Energy: Nuclear Energy

- **Nuclear fuel cycle**
 - **milling ore**
 - extracts uranium from ore
 - concentrates the U-235
 - process
 - “yellowcake”

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- **Nuclear fuel cycle**
 - **fuel fabrication**
 - pellets sealed in metal fuel rods ~4m long

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- **Nuclear fuel cycle**
 - **installing and using fuel rods**
 - raised or lowered to control reaction
 - after ~3 years, considered “spent”

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- **Nuclear fuel cycle**
 - **disposing of waste**
 - both low- and high-level waste is generated
 - must be stored

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- **Nuclear fuel cycle**
 - each step
 - involves transport of radioactive materials
 - presents possibility of accident or mishandling
 - poses health and environmental concerns

11 ☐

12 ☐ Outline

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- **Nuclear weapons**
 - nuclear power industry is outgrowth of nuclear weapons industry
 - environmental contamination around facilities

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- **Nuclear weapons**
 - DOE is responsible for 8600 km² of properties
 - contaminated sites
 - underground storage tanks
 - 55-gallon drums of radioactive, hazardous or mixed waste in storage
 - sites where wastes are moving through soil
 - low- and high-level radioactive wastes

15

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- **Nuclear weapons**
 - importance has been reduced
 - disposal of nuclear weapons

17 Outline

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- **Concerns about nuclear energy**
 - human health and environmental impacts related to
 - release of radioactive materials at a power reactor
 - Three Mile Island
 - Chernobyl
 - accidents/mishaps during production and transportation of fuel
 - disposal of waste

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- **Concerns about nuclear energy**
 - text states

- not great cause for concern related to reactor operation
- area of most concern is storage facilities for spent fuel

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- **Concerns about nuclear energy**
 - US Nuclear Regulatory Commission (NRC) estimates
 - 15-45% chance of a complete core meltdown at a US reactor during next 20 years
 - 39 US reactors have an 80% chance of containment shell failure from a
 - meltdown
 - explosion of gases inside containment structures
 - nearly half of US plants failed mock terrorist attacks against them

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- **Concerns about nuclear energy**
 - Three Mile Island
 - near Harrisburg, PA
 - 3/28/79
 - cause of accident
 - valve malfunction
 - human error

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- **Concerns about nuclear energy**
 - Three Mile Island
 - result
 - intense radiation released to interior of containment structure
 - small amount of radiation was released into environment

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- **Concerns about nuclear energy**
 - Three Mile Island
 - **consequence**
 - average radiation exposure in surrounding area
 - » ~ 0.012mSv (~1% of natural background radiation)
 - radiation levels near site
 - » on day 3, 12 mSv/hr was measured at ground level (average American receives about 2 mSv/year)
 - days following Chernobyl accident, ~24,000 people received an average dose of 430 mSv

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- **Concerns about nuclear energy**
 - **thermal pollution**
 - addition of waste heat to environment
 - nuclear power plants
 - 2/3 of heat is waste
 - fossil fuel power plants
 - 1/2 of heat is waste

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- **Concerns about nuclear energy**
 - **thermal pollution**
 - nuclear power plants
 - use water in cooling processes
 - cooling towers
 - water

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- **Concerns about nuclear energy**
 - **decommissioning**
 - power plant life expectancy is 30-40 years (nuclear or otherwise)
 - fossil fuel power plants
 - demolished at end of life
 - nuclear power plants
 - not demolished
 - **decommissioned**

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- **Concerns about nuclear energy**
 - **decommissioning**
 - two-stage process
 - stage 1

28 ☐ Energy: Nuclear Energy

- **Concerns about nuclear energy**
 - **decommissioning**
 - two-stage process
 - stage 2

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- **Concerns about nuclear energy**
 - **decommissioning**
 - utilities have three options
 - decontaminate and dismantle “immediately”
 - wait 20-100 years, then dismantle plant
 - entomb plant

30 ☐ Table 11.4

31 ☐ Outline

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- **Waste disposal**
 - problem was not fully appreciated when world entered atomic age
 - waste produced at each step in nuclear fuel cycle

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- **Waste disposal**
 - **low-level waste**
 - give off small amounts of radiation
 - must be safely stored for 100-500 years
 - sources

34 ☐ Energy: Nuclear Energy

- **Waste disposal**
 - **low-level waste**
 - storage/disposal
 - 1940's-1970, in US
 - » steel drums, dumped in oceans
 - » ~90,000 drums
 - currently
 - » steel drums, buried in approved sites

35 ☐

36 ☐ Energy: Nuclear Energy

- **Waste disposal**
 - **high-level waste**
 - give off
 - large amounts of radiation for short time
 - small amounts of radiation for long time
 - must be stored safely for at least 10,000 years
 - ~240,000 if plutonium-239 is not removed by reprocessing
 - sources

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal
 - is any method safe method for storing these wastes

38  Table 11.1

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - bury it deep underground
 - shoot it into space or the sun
 - bury it under ice sheets
 - dump it into subduction zones in ocean
 - bury it in mud on ocean floor
 - change it into harmless/less harmful isotopes

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - bury it deep underground
 - » favored strategy
 - » under study by all countries producing nuclear waste

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - shoot it into space or into the sun

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - bury it under Antarctic or Greenland ice sheet

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - dump it into subduction zones in deep ocean

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- **Waste disposal**
 - **high-level waste**

- storage/disposal - proposed methods
 - bury it in thick deposits of mud on deep ocean floor in areas that tests show have been geologically stable for 65 million years

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - proposed methods
 - change it into harmless, or less harmful, isotopes

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - US sites
 - current - Waste Isolation Pilot Plant
 - » near Carlsbad, NM
 - » began accepting high-level waste in 1999

47 ☐ Fig. 11.17

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - US sites
 - in development - Yucca Mountain, Nevada
 - » unpopulated region
 - » near Nevada Test Site where several nuclear devices were exploded
 - » very dry area
 - » water table 600m (1968ft) below surface
 - » geologically stable (although seismic activity has been witnessed since its selection as site)

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- **Waste disposal**
 - **high-level waste**
 - storage/disposal - US sites
 - in development - Yucca Mountain, Nevada
 - » work has begun, considered exploratory
 - » complete ~2015
 - » Bush signed resolution in July 2002 to allow construction to proceed

50 ☐

51 ☐ The End