Nuclear Power Fact Sheet

Overview
- Nuclear power provides almost 15 percent of the world’s electricity
- Produce and control the release of energy from the splitting of atoms by fission (shown below)
- Fissile atomic nucleus such as uranium-235 \( (^{235}\text{U} \) ) or plutonium-239

Current Use of Nuclear Power
- Breakdown of electricity production in Easton PA.
- Status of U.S. Nuclear energy outages

Traditional Reactor Design
- Fission is a run away reaction which produces a large amount of heat.
- Uses large amount of water for cooling.
- A kg of \( ^{235}\text{U} \) produces 3 million more energy than a kg of coal.
- Complications due to waste storage and disposal.
- Moderator: water, ‘heavy’ water, graphite
  - Slow down neutrons
  - Allows for sustained reaction
  - Control Rods: rods composed of boron, silver, indium, or cadmium
  - Absorb neutrons,
  - Must be regularly replaced
- Resulted in a number of catastrophes
  - Three Mile Island 1979
  - Chernobyl 1986
  - Fukushima 2011
- Public opinion generally opposes nuclear power due nuclear meltdown
- Decline in nuclear use domestically and abroad

Design of Pebble Bed Reactors
- Energy production is governed by same principles as traditional reactor
- Pebbles contained in reactor
  - Circulate about 5 times a year
  - Inert (helium, etc.) gas cooling
  - Gas circulated through vessel
  - Heated gas runs a turbine
  - Temperature controlled
- Pebbles are made of pyrolytic graphite (which acts as the moderator), and contain thousands of micro-fuel particles called TRISO particles.

Criticsms
- Combustible graphite
  - If graphite of pebbles were to burn, fuel material could be released in smoke
- Lack of containment building
  - More vulnerable to outside attack
- Radioactive waste
  - Takes up larger volume in already limited storage areas
- Radioactive dust from pebbles rubbing together

Pebble Design
- Figure of pebble and composition shown below. \( ^{235}\text{U} \) surrounded by a coated ceramic layer of silicon carbide
- Produces 1000 times less radioactive gas than US equivalents

Benefits
- High temperature leads to higher efficiency than conventional nuclear plants
- Continuous fuel replacement
  - No month-long shutdown
- Considered passively safe and removes the need for redundant safety systems
- No risk of meltdown
  - Proximity and geometry of fuel causes a strong Doppler Effect
  - Negative feedback: as nuclear fuel heats up, uranium atoms move faster (harder to absorb neutrons & split), reduces reactor power
- Low fuel density of pebbles magnify negative feedback
- Fuel spheres remain intact and undamaged
- No radioactive fluids
  - Gasses do not dissolve contaminants or absorb neutrons as water does used in traditional reactors

Current Applications
- Germany, U.S., and South Africa have experimented with the PBMR
  - Technical problems, lack of funding
- China
  - Test pebble-bed reactor operating for over 10 years now (Tsinghua University, north of Beijing)
  - Plan to build 50 nuclear reactors in next 5 years
  - First commercial PBMR under construction in Shandong Province (19 units) (2011-?)

Current outages due to nuclear power
Overview


Current Use of Nuclear Power


Traditional Reactor Design


Design of Pebble Bed Reactors


Criticisms


Pebble Design


Benefits


Current Applications
