THE FUTURE OF NUCLEAR POWER

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BIO

- Andrew Ohrablo
  - Bachelor of Science Nuclear Engineering – University of Wisconsin at Madison
    - Senior Thesis – Design of Liquid Metal Fast Breeder Reactor
  - Perry Nuclear Power Plant, Perry, OH 2014-Present
    - Maintenance Engineering Supervisor – Current Position
    - Maintenance Electrical Engineer
    - Work Week Manager
  - Cooper Nuclear Station, Brownville, NE 1999-2014
    - Shift Technical Engineer
    - Senior Reactor Operator NRC License Number 44337
  - United States Navy Nuclear Electrician – USS Enterprise 1987-1993

REACTOR SIZES

- Three generally recognized reactor sizes:
  - Large Commercial Reactors:
    - >300MWe
    - Largest operating is Grand Gulf ~1400MWe
    - Currently two 1100MWe reactors under construction in Waynesboro Georgia
  - Small Modular Reactors
    - >5Mwe and <300MWe
    - Does not depend on reactor design, pressurized water, boiling water or advanced design
    - NuScale, Terrapower
  - Micro-reactors
    - <5MWe
    - Commonly referred to as a nuclear battery

BENEFITS LARGE COMMERCIAL REACTORS

- Current regulations charge per reactor ($4,749,000)
- Standardized emergency plans for 1, 5, 10 and 50 miles
- NRC experience with light water reactors
- Low cost per MegaWatt

DETRIMENTS OF LARGE COMMERCIAL REACTORS

- Significant risk on one shaft
- Large source term
- Initial cost for construction, long return on investment
- Large part availability

BENEFITS OF SMALL MODULAR REACTORS

- Shorter construction time, earlier return on investment
- Lower source term
- Easy to manufacture the “smaller” parts
- Less risk on each shaft
- Quality control in factory setting

DETRIMENTS OF SMALL MODULAR REACTORS

- Current License fee
- Higher cost per MegaWatt
- Current Emergency Plan requirements

BENFITS/DETRIMENTS NUCLEAR BATTERY

Benefit	Detriment
Dispacthable	Proliferation target
Quality Control	Security requirements
Plug & Play	License cost
No refuel	Higher cost per MegaWatt
30 day install	

SMALL MODULAR REACTORS

- Light water designs include:
  - Nuscale 77MWe
  - SMR-160 Holtec
  - BWXT mPower Babcox and Wilcox 180MWe
  - BWRX-300 GE 300MWe
  - Westinghouse 225Mwe

SMALL MODULAR ADVANCED TECHNOLOGY

- Terrapower:
  - Traveling wave – referred to as the nuclear cigar
  - Natrium – Sodium Cooled Fast Breeder Reactor
  - Molten Chloride
- Hyperion Lead Cooled reactor 75MWe
- Westinghouse Lead Cooled Reactor – 450MWe
- Hermes 140MWe liquid Flouride Salt Reactor
  - Demonstration at Oak Ridge, Tennessee

MICRO-REACTORS

- Oklo 1.5MWe Liquid Sodium Cooled
- eVinci –Westinghouse 1-5Mwe
- BWXT Advanced High Temperature Gas Cooled
- X-energy High Temperature Gas Cooled

CURRENT DEVELOPMENTS

- Infrastructure Bill
  - $6B for assistance to at risk plants
  - $21.5B for carbon capture, direct air capture and new small modular reactor development
- Coal to Nuclear
  - Terrapower Natrium Reactor pilot project to replace coal generating station in Wyoming
  - Repower Commanche power station in Pueblo, CO with nuclear plant

CURRENT DEVELOPMENTS

- Susquehanna developing project to mine bitcoin
- Eielson Air Force Base to pursue micro reactor by 2027
- Hydrogen generation from nuclear
  - DOE demonstration projects at Davis Besse, Nine Mile and Monticello
  - Hydrogen production allows large commercial plants to load follow

INTERNATIONAL DEVELOPMENTS

- Nuscale to build 12 pack reactor in Romania for 706MWe
- Nuscale developing reactors for Bulgaria
- Turkey start construction of Rosatom reactor
- Poland to build 6-9GWe of power by 2030
- Canada plans to build eVinci reactor at Bruce

CONCLUSION

- Three levels of reactor designs based on electric output.
  - Large Commercial >300MWe
  - Small Modular >5MWe and <300MWe
  - Micro-Reactor <5MWe
- Each size has definite benefits and detriments
- New reactors are of multiple designs:
  - Light water
  - Liquid Sodium cooled
  - High temperature gas cooled
  - Lead Cooled

QUESTIONS?

CITATIONS

- * NRC regulations 10CFR20 & https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html
- **BC Campus, College Physics Biological effects of Ionizing Radiation https://opentextbc.ca/physicstestbook2/chapter/biological-effects-of-ionizing-radiation/

TERMS

- Critical – status of nuclear reactor where the number of neutrons in one generation is equal to the number of neutrons in the previous generation – power is remaining constant
- Reactivity – Relative departure from critical for a nuclear reactor
- Sub-Critical – status of nuclear rector where the number of neutrons in one generation is less then the number of neutrons in the previous generation – power is going down
- Super-Critical – status of nuclear rector where the number of neutrons in one generation is more then the number of neutrons in the previous generation – power is going up

TERMS (CONTINUED)

- Barns – measure of cross section of a nucleus for a specific reaction – higher barns means a nucleus is more likely to react
- Absorption – nuclear reaction where an incident particle is absorbed into the nucleus
- Capture – Nuclear reaction where an incident particle remains in the nucleus following absorption
- Fission – nuclear reaction where an incident particle results in the mother nuclear splitting into two or more nuclei
- Beta Decay – where an excited nucleus releases energy in the form of a positron or electron and a nucleon is changed from a proton or neutron to bring the nucleus to a lower energy state
- Alpha decay – where an excited nucleus releases an alpha particle to bring the nucleus to a lower energy state
- Alpha Particle – Essentially a helium atom without the electrons. Two protons and two Neutrons