Nuclear Fuels – Past, Present, and Future

Present and Near term of Nuclear Fuels

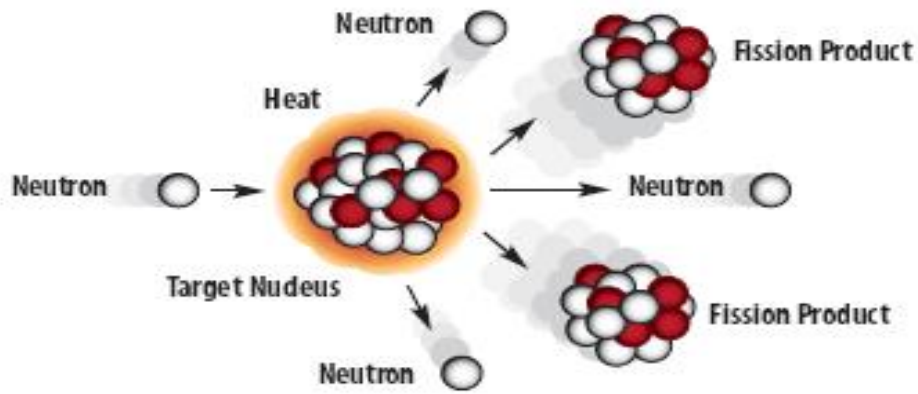
Presented by
Mick Mastilovic
Women in Nuclear Region II Conference
Oak Ridge, Tennessee

TVA Nuclear

Women In Nuclear
OAK RIDGE

Nuclear energy basics

- In the nuclear reactor, nuclear fission of uranium and plutonium atoms produces energy to heat water and create steam that powers generators to produce electricity



(*) Thorium fuel uses Uranium-233 for fission

MOX - A Mixture of Plutonium and Uranium Oxide

TVA Nuclear

- Commercial fuel is uranium oxide
  - Fissionable isotope is uranium-235
  - Plutonium is a byproduct of the uranium fission process in all commercial nuclear power plants.
    - Plutonium remains in fuel pellets producing ~40% of the core's heat energy
    - Over 50% of the energy in individual fuel assemblies in their third cycle
- MOX fuel is a mixture of plutonium and uranium
  - Fissionable isotope is plutonium-239
  - Weapons MOX has a higher concentration of Pu-239 and fewer impurities than commercial MOX
- Fuel hardware is the same for both
- Fuel form is a ceramic pellet for both

Differences in Uranium and MOX Fuel Isotopic Inventories

TVA Nuclear

Isotope	Fresh Uranium Fuel	Irradiated Uranium Fuel	Recycled Fuel MOX	Weapons MOX
U-238	96%	93%	91%	95%
U-235	4%	1%	<1%	<1%
Fission products	0%	5%	0%	0%
Avg assembly Pu	0%	1%	9%	4.3%
Pu-238	0%	1%	1%	0%
Pu-239	0%	57%	57%	94%
Pu-240	0%	27%	27%	5%
Pu-241	0%	8%	8%	<1%
Pu-242	0%	7%	7%	<<1%

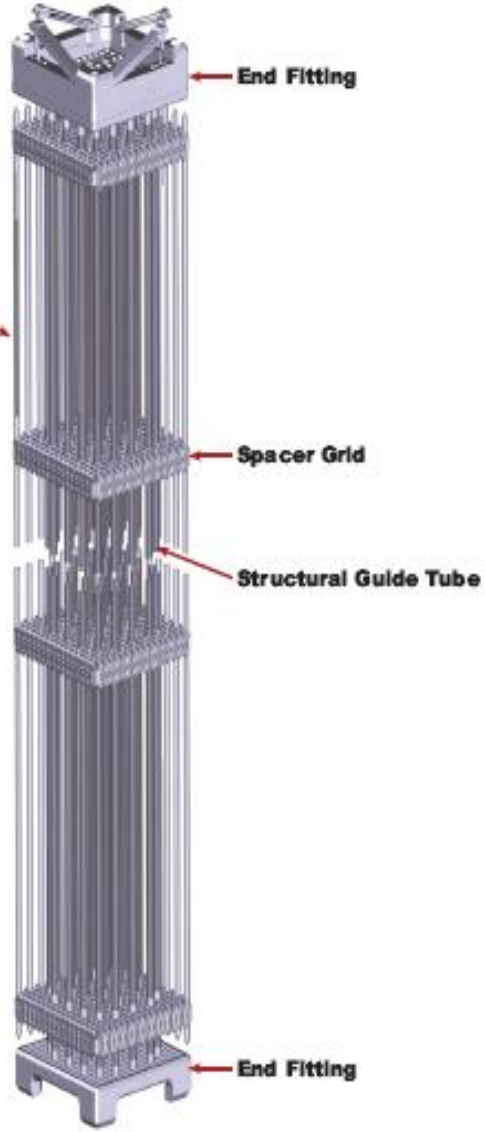
Four irradiated fuel assemblies needed for about one recycled MOX assembly

PWR Fuel Assembly

The PWR 17x17 assembly is approximately 160 inches long (13.3 feet), 8 inches across, and weighs 1,500 lbs.

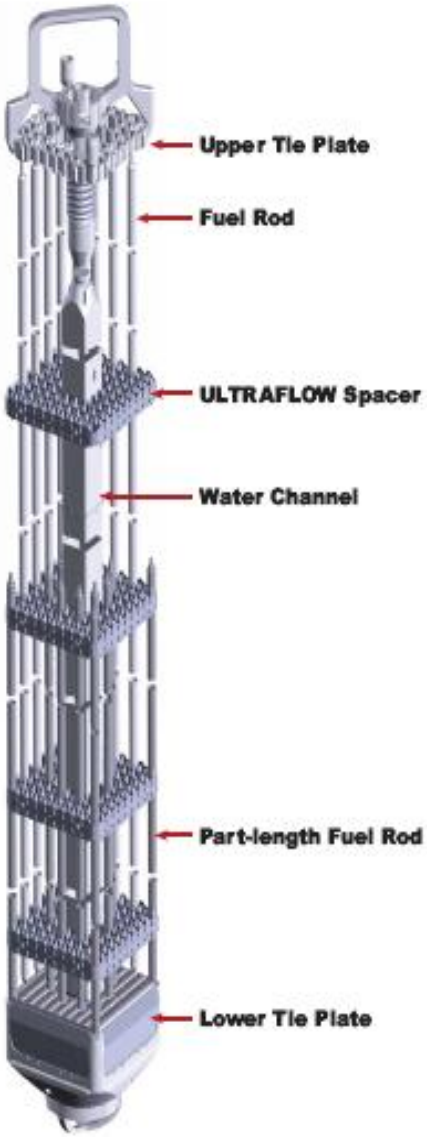
Ceramic Fuel Pellet

Sealed Fuel Rod



BWR Fuel Assembly

The BWR 10x10 assembly is approximately 174 inches long (14.5 feet), 5 inches across, and weighs about 500 lbs.



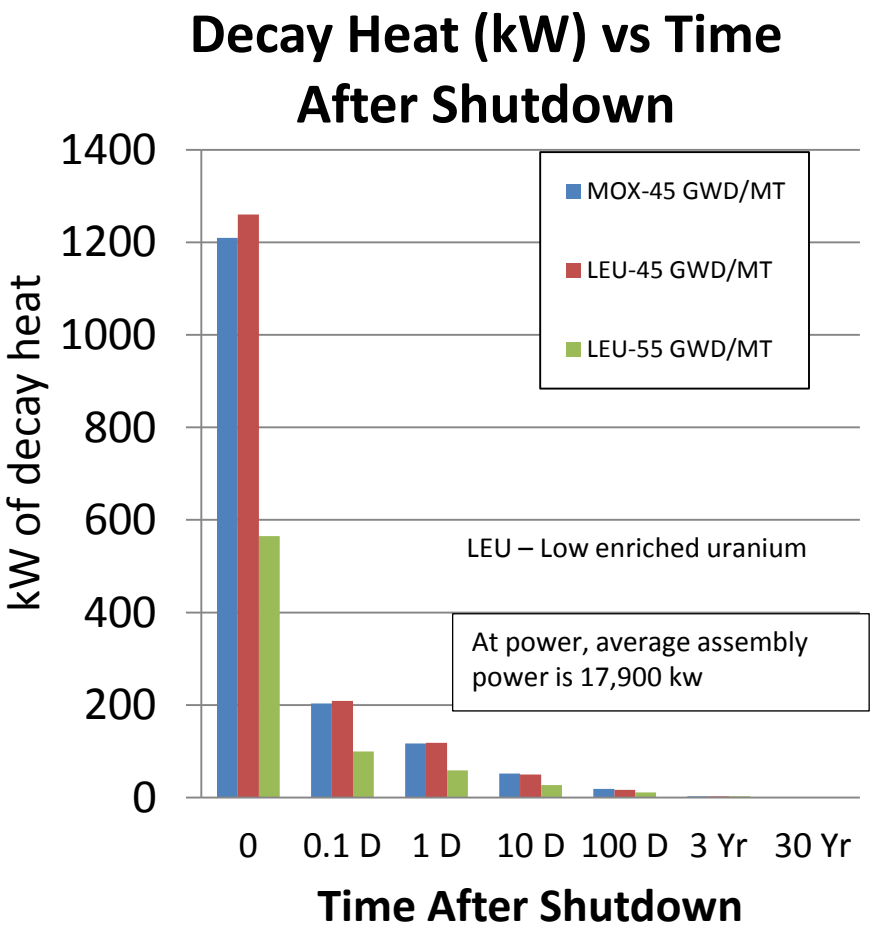
MOX fuel pellets and assemblies are physically identical to uranium fuel

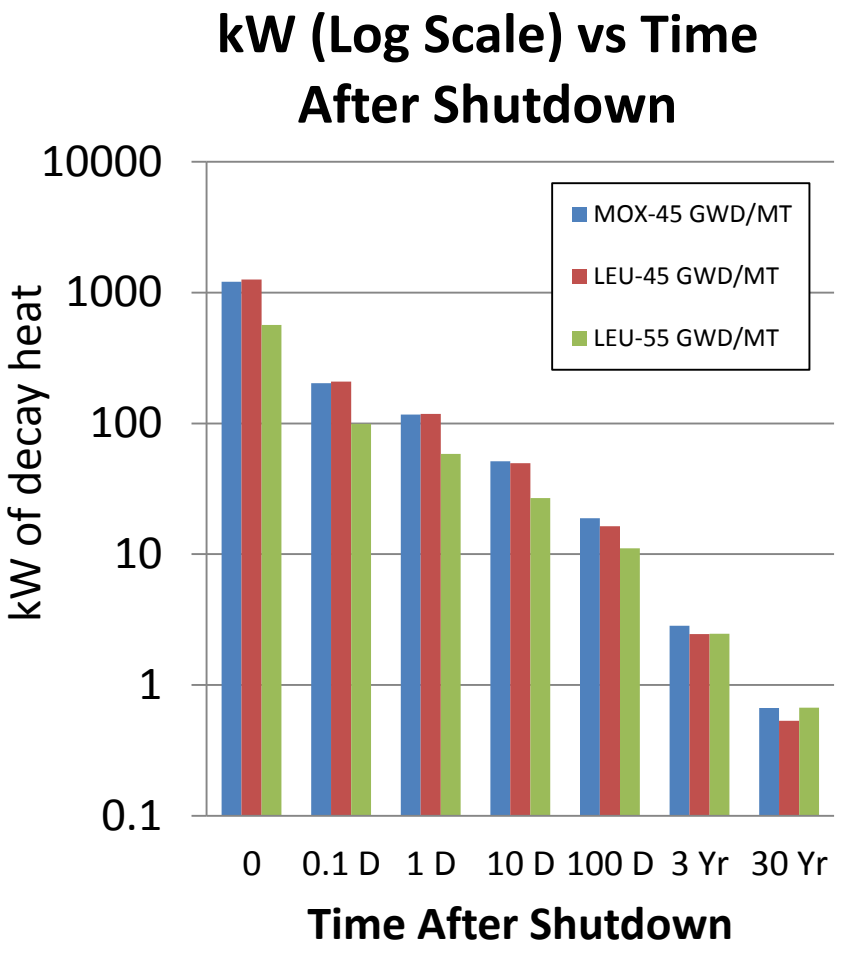
Is MOX fuel hotter than uranium fuel?

TVA Nuclear

- Not while in the reactor
  - Reactor will produce the same amount of heat while operating no matter what fuel is used.
  - Licenses from the NRC limit heat output of reactors
    - 3455 MWt at SQN
    - 3458 MWt at BFN
- After shutdown
  - MOX fuel is cooler for the first day
  - Slightly hotter years later but able to use existing
    - Spent fuel pool
    - Dry casks

Decay Heat Plots

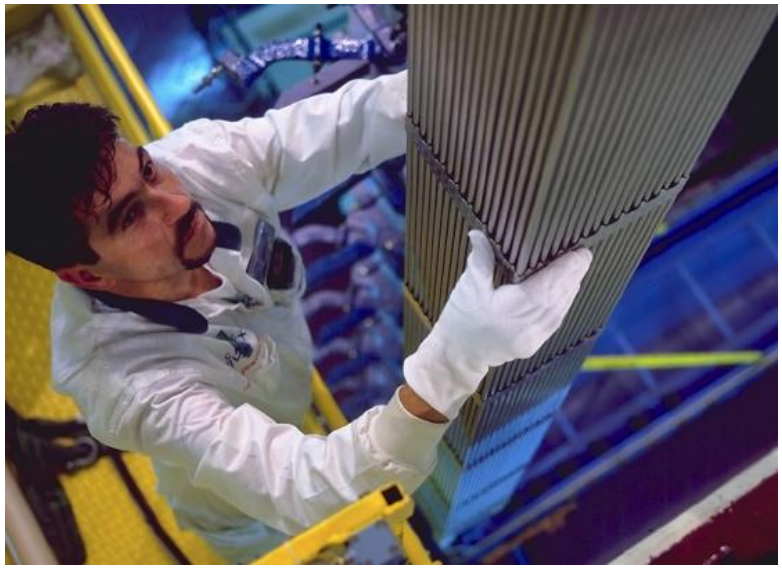


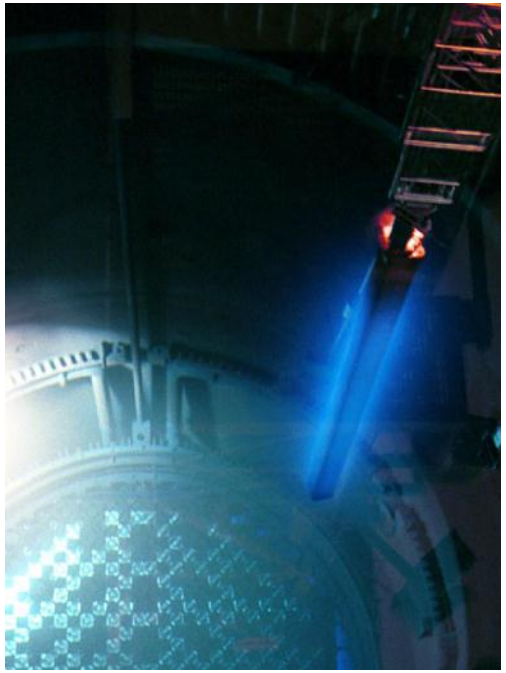


Handling Nuclear Fuel

TVA Nuclear

- Fresh nuclear fuel can be “contact handled,” whether uranium or MOX
- Once irradiated, it is handled remotely underwater





Dry Cask Storage

- Fuel moved from wet pool to dry casks after 8-10 years
- Casks are steel cylinders that are welded closed and placed into a concrete and steel overpack
- Used MOX fuel stored in dry casks just like used uranium fuel

Dry cask storage at Sequoyah Nuclear Plant

Final thoughts

If it can be beneficially used for power production without undue risk and at an attractive cost, it is good for everyone