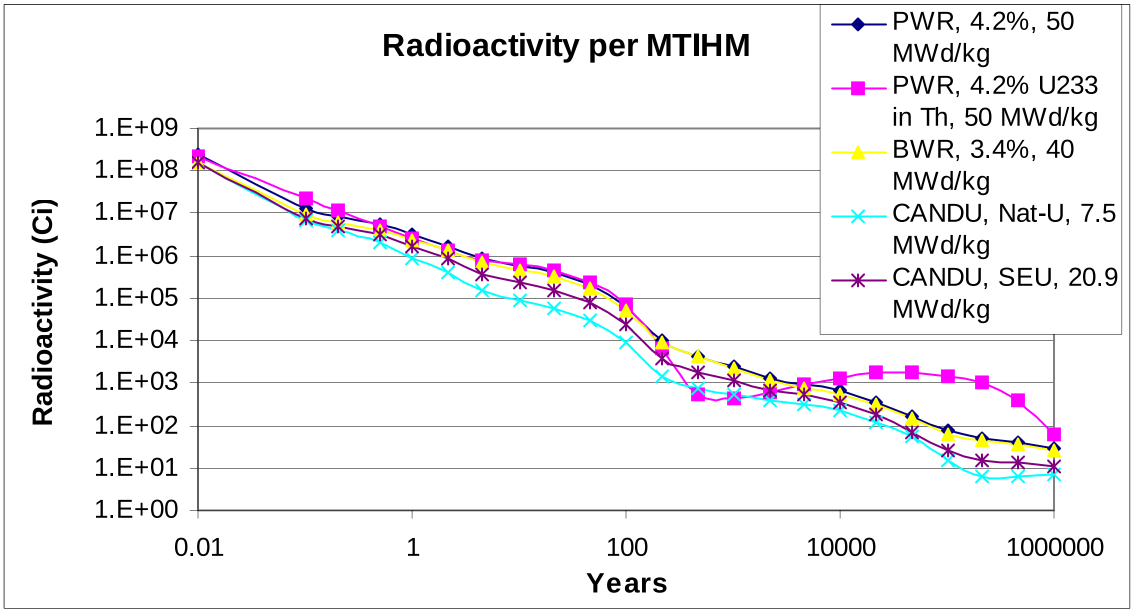
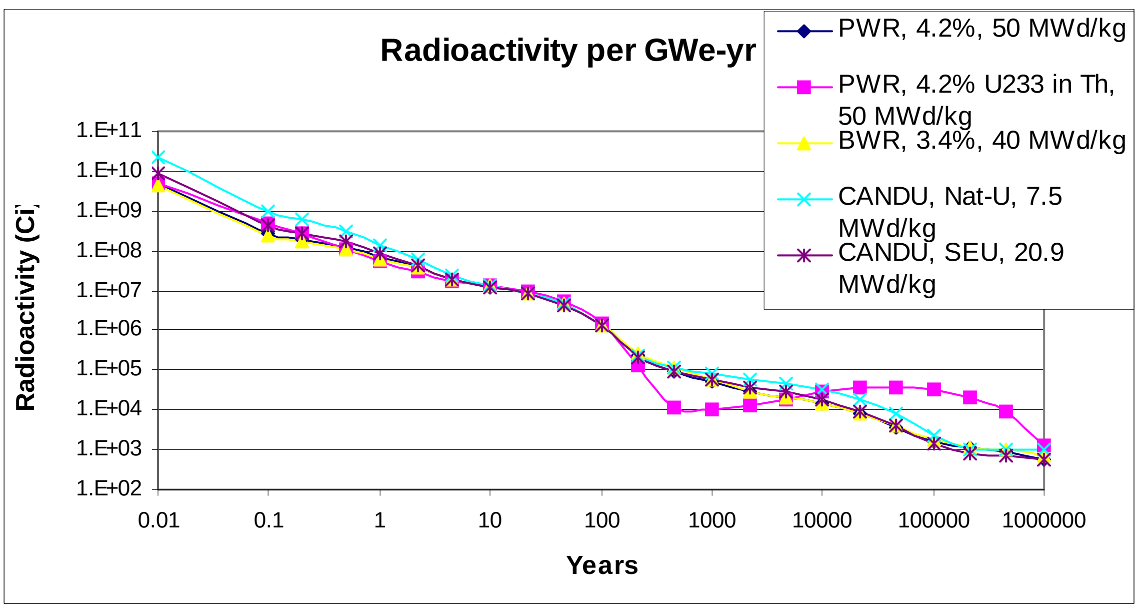
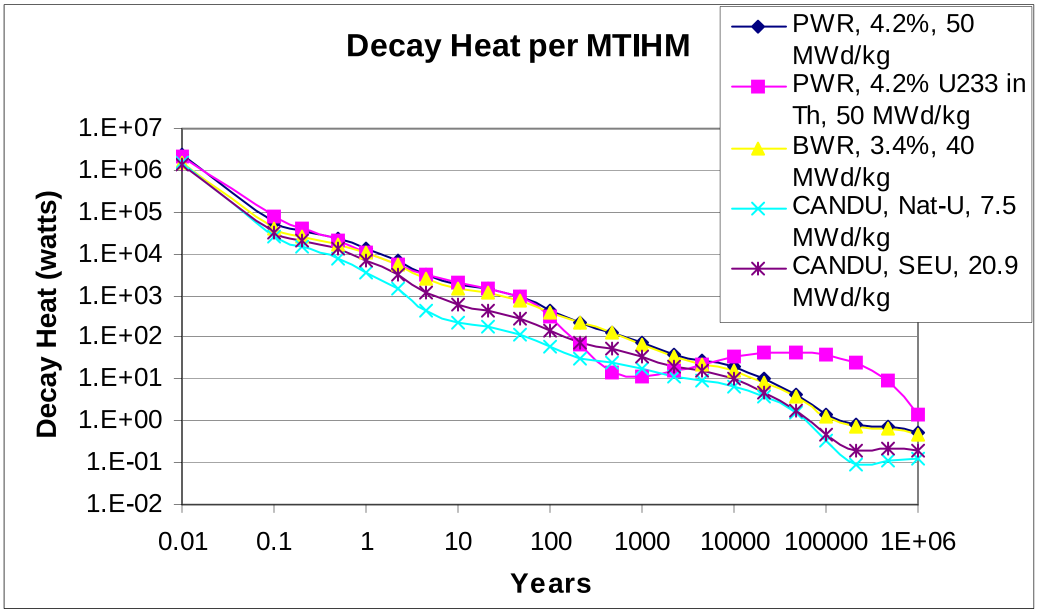
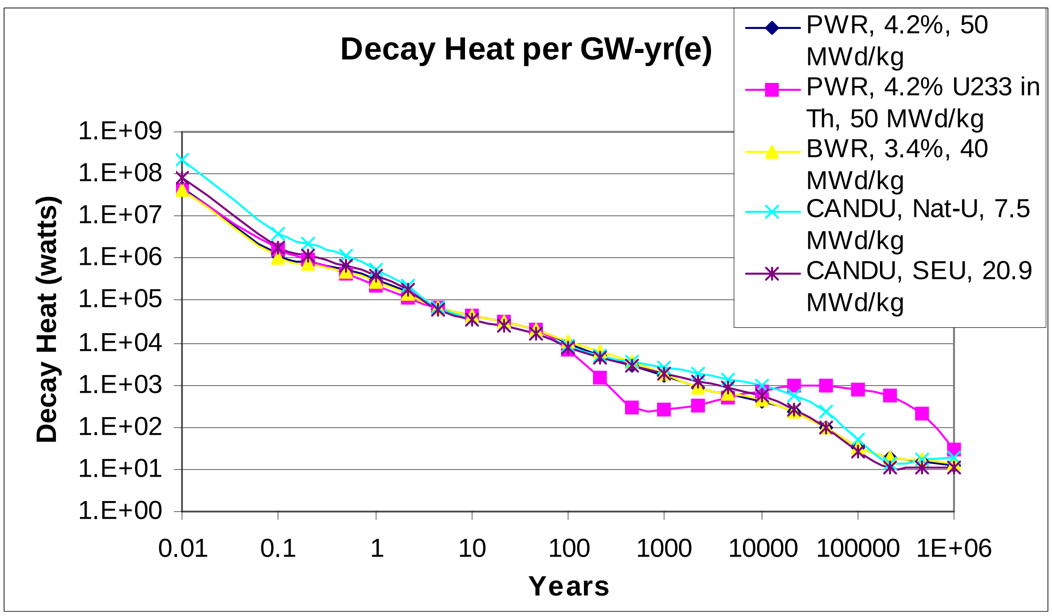
# Lab 2 Solution
# 22.251
# Fall 2005

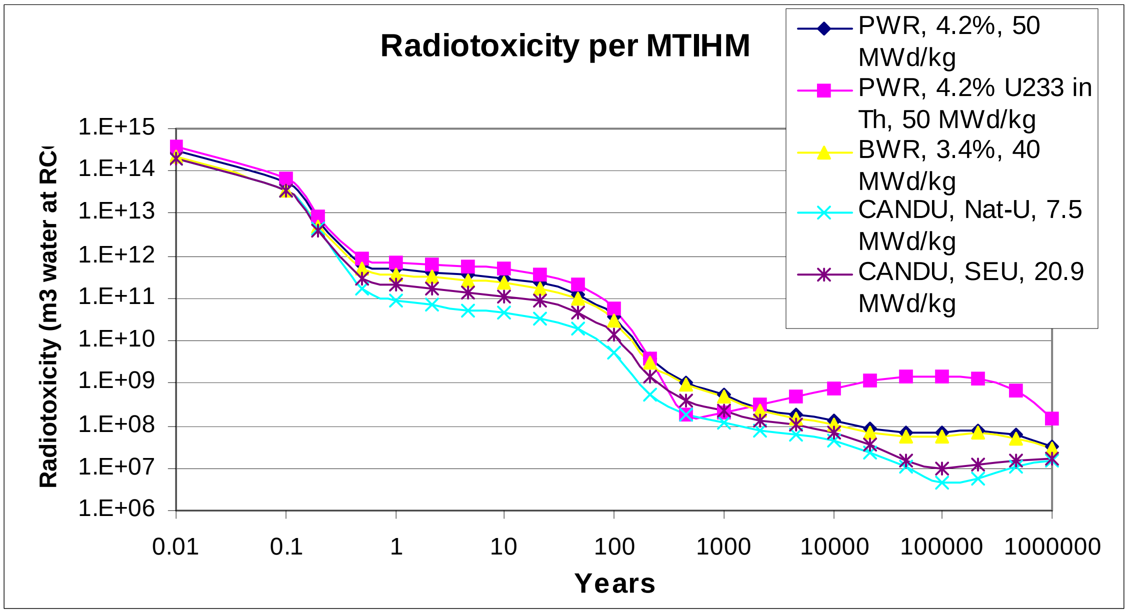
Part 1)

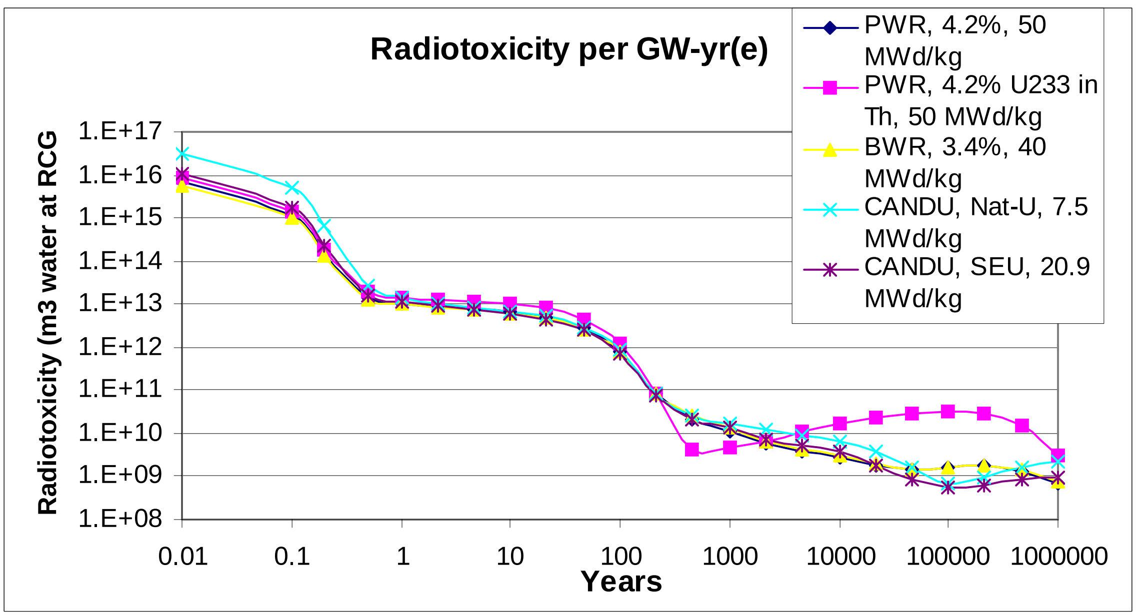



Decay Heat per MTIHM
PWR, 4.2%, 50 MWd/kg
PWR, 4.2% U233 in Th, 50 MWd/kg
BWR, 3.4%, 40 MWd/kg
CANDU, Nat-U, 7.5 MWd/kg
CANDU, SEU, 20.9 MWd/kg
Decay Heat (watts)
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
0.01
0.1
1
10
100
1000
10000
100000
1E+06
Years


Decay Heat per GW-yr(e)
PWR, 4.2%, 50 MWd/kg
PWR, 4.2% U233 in Th, 50 MWd/kg
BWR, 3.4%, 40 MWd/kg
CANDU, Nat-U, 7.5 MWd/kg
CANDU, SEU, 20.9 MWd/kg
Decay Heat (watts)
1.E+09
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
0.01
0.1
1
10
100
1000
10000
100000
1E+06
Years


Radiotoxicity per MTIHM
Radiotoxicity (m3 water at RC
1.E+15
1.E+14
1.E+13
1.E+12
1.E+11
1.E+10
1.E+09
1.E+08
1.E+07
1.E+06
0.01
0.1
1
10
100
1000
10000
100000
1000000
Years
PWR, 4.2%, 50 MWd/kg
PWR, 4.2% U233 in Th, 50 MWd/kg
BWR, 3.4%, 40 MWd/kg
CANDU, Nat-U, 7.5 MWd/kg
CANDU, SEU, 20.9 MWd/kg


Radiotoxicity per GW-yr(e)
Radiotoxicity (m3 water at RCG
1.E+17
1.E+16
1.E+15
1.E+14
1.E+13
1.E+12
1.E+11
1.E+10
1.E+09
1.E+08
0.01
0.1
1
10
100
1000
10000
100000
1000000
Years
PWR, 4.2%, 50 MWd/kg
PWR, 4.2% U233 in Th, 50 MWd/kg
BWR, 3.4%, 40 MWd/kg
CANDU, Nat-U, 7.5 MWd/kg
CANDU, SEU, 20.9 MWd/kg

<u>Part 2)</u> Radionuclides responsible for >90% of radiotoxicity in the 10,000+ year timeframe:

| **Case** | **Total Radiotoxicity (m3 water)** | **Major Nuclides** |
|---|---|---|
| 1 | 1.34E08 | Pu239 – 6.57E07<br>Pu240 – 5.26E07 |
| 2 | 7.89E08 | Ra225 – 2.51E08<br>Th-229 – 3.13E08<br>Rn219, Ra226 – 7.0E07 each |
| 3 | 1.11E08 | Pu239 – 5.73E07<br>Pu240 – 4.06E07 |
| 4 | 4.32E07 | Pu239 – 2.61E07<br>Pu240 – 1.66E07 |
| 5 | 6.80E07 | Pu239 – 2.92E07<br>Pu240 – 3.62E07 |

<u>Part 3)</u> Other factors in evaluating repository performance include:

- Heat Load – This impacts on the flow of groundwater, and hence on the transport of nuclides. This drives the spacing of the drifts (storage tunnels) and ultimately, the overall physical size of the repository.
- Isotope Solubility – How well an isotope dissolves in water.
- Waste volume – This impacts on the size of the drift required, i.e. how much rock must be mined to make space for the waste.
- Modeling Capability – The predictive models used, including their associated uncertainties, determine how the repository and the engineered barriers are designed.

<u>Part 4)</u>

In the 10,000+ year timeframe, the thorium fueled PWR spent fuel has the highest radioactivity, heat load, and radiotoxicity of all the cases. Additionally, one of the key contributors to radiotoxicity is radon, which is a gas that transports easily. However, it contains less fissile plutonium than the other cases. The lower amount of plutonium, along with its higher radiation barrier, makes it a less attractive material for weapons proliferators.

For the same electricity production, comparing a typical PWR, BWR, and CANDU (cases 1, 3, and 4) on a per GW-yr(e) basis.

Lowest Radioactivity: PWR
Lowest Decay Heat: BWR
Lowest Radiotoxicity:PWR