SAND2007-6800C

Fast Reactor Recycle Fuel Thermal Load

Ben Cipiti

JD Smith

Ken Sorenson

Sandia National Laboratories

Brent Dixon

Idaho National Laboratory

William Halsey

Lawrence Livermore National Laboratory

Proceedings of the 15th International Symposium on the

Packaging and Transportation of Radioactive Materials

PATRAM 2007, October 21-26, 2007, Miami, Florida, USA

Work performed by SNL for the U.S. DOE in support of the Global Nuclear Energy Partnership (GNEP). Views that may be expressed herein are those of the authors and are not necessarily representatives of the DOE or GNEP positions.

Overview and Outline

- Overview
  - Objective was to investigate heat load of fast reactor fuel over multiple recycles and evaluate impacts on transportation

- Outline
  - Modeling methodology and assumptions
  - Results
  - Summary/Conclusions

Modeling Methodology

- Utilized ORIGEN 2.2 for all calculations with FFTF cross-sections
- Investigated both metal and oxide fuel as well as startup and equilibrium cores for first recycle
- Due to similarity of results, only metal equilibrium fuel was evaluated for subsequent recycles
- Conversion ratios of 1.0, 0.75, 0.5, 0.25, and 0.0 were run for every recycle
- For all cases, assumed 1,000 MW_{th} core, 175,000 MWD/MT fuel burnup, and fuel residence time of 4.5 years
- Selected representative nominal cask heat rejection limit of 25 kW

Charge Assumptions

- Source of initial fuel composition and isotopic loadings of TRU and uranium: ***Hoffman et al., "Preliminary Core Design Studies for the Advanced Burner Reactor over a Wide Range of Conversion Ratios," ANL-AFCI-177 (September, 2006)***
- Spent LWR source term for all TRU isotopic ratios based on 4.03% initial enrichment, 60,000 MWD/MT burnup, and 5 year decay UO_x fuel
- Assumed reprocessing plant would perfectly extract all TRU together to provide initial fuel charges as a function of conversion ratio

Multi-Recycle Charge Assumptions

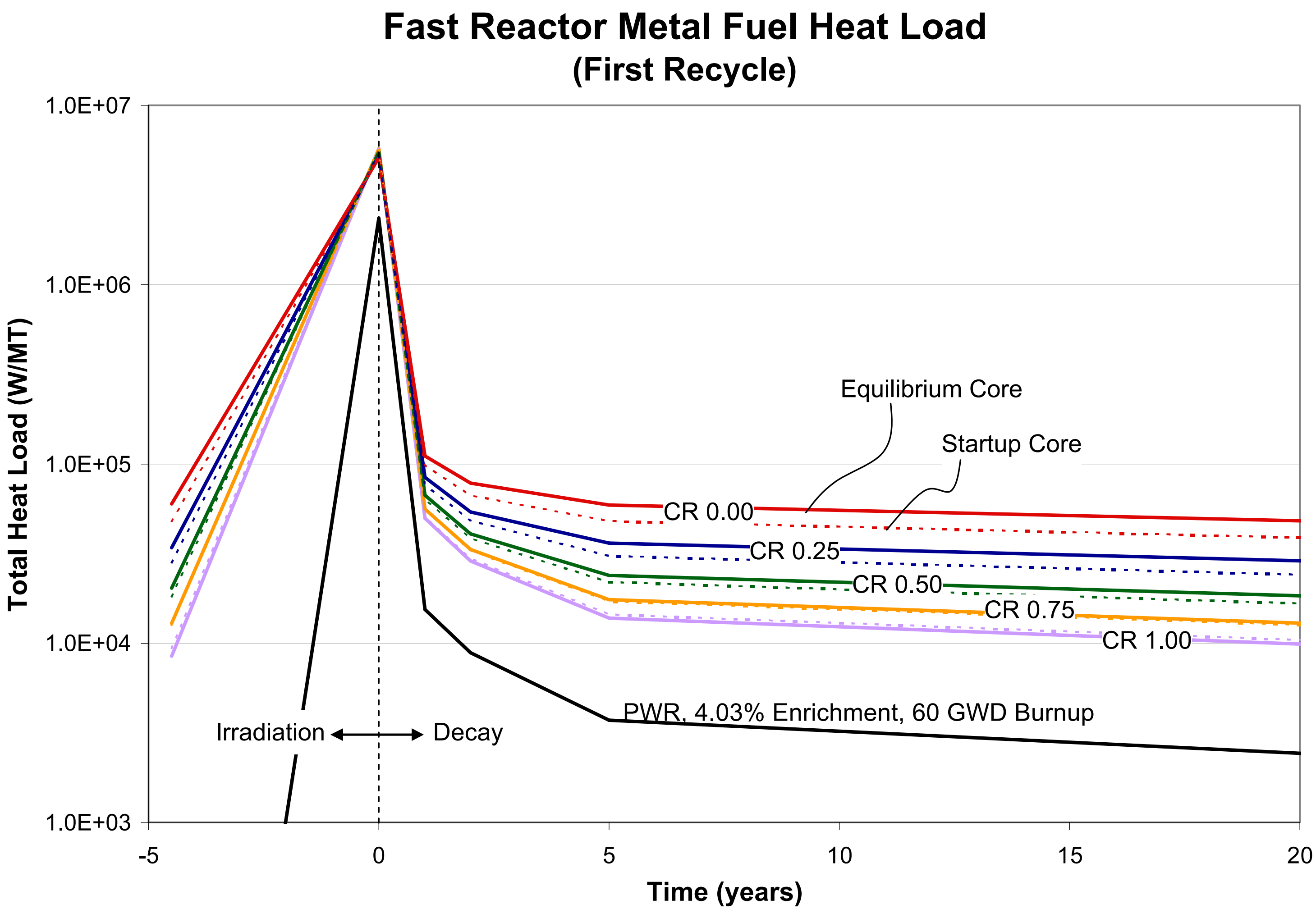
- After first recycle in fast reactor, discharge inventory from equilibrium fuel was used to charge next recycle (5 years cooling assumed between all fast recycles)

- Due to limited availability of data regarding change of TRU/HM enrichment data versus conversion ratio over all five cycles, selected loading percentages from following reference containing data on multi-recycle of a 0.25 CR core: ***Stillman et al., "Follow-Up Analyses for the ANTT Review," ANL-AFCI-132 (September, 2004)***

- Using reference as guide, assumed TRU/HM loading percentage would need to change by the following on each subsequent recycle: CR0.0 and CR1.0 cores - no change, CR0.75 +2%, CR0.5 +4%, and CR0.25 +5%

- Assumed reprocessing of FR fuel would perfectly extract all TRU isotopes, and used ratios obtained following TRU/HM loading adjustment to fuel next recycle

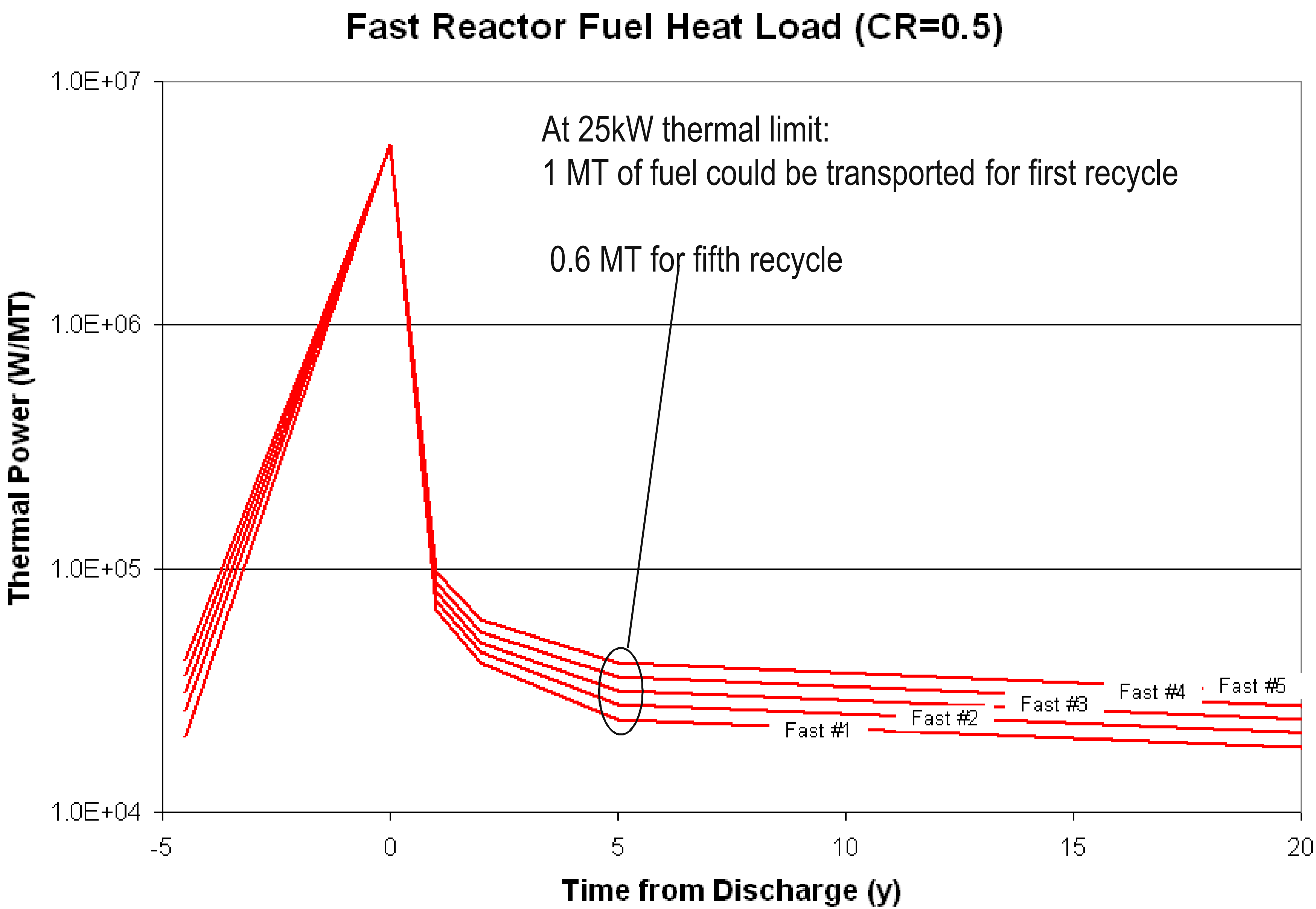
Comparison of Equilibrium to Startup Fuel (First Recycle)



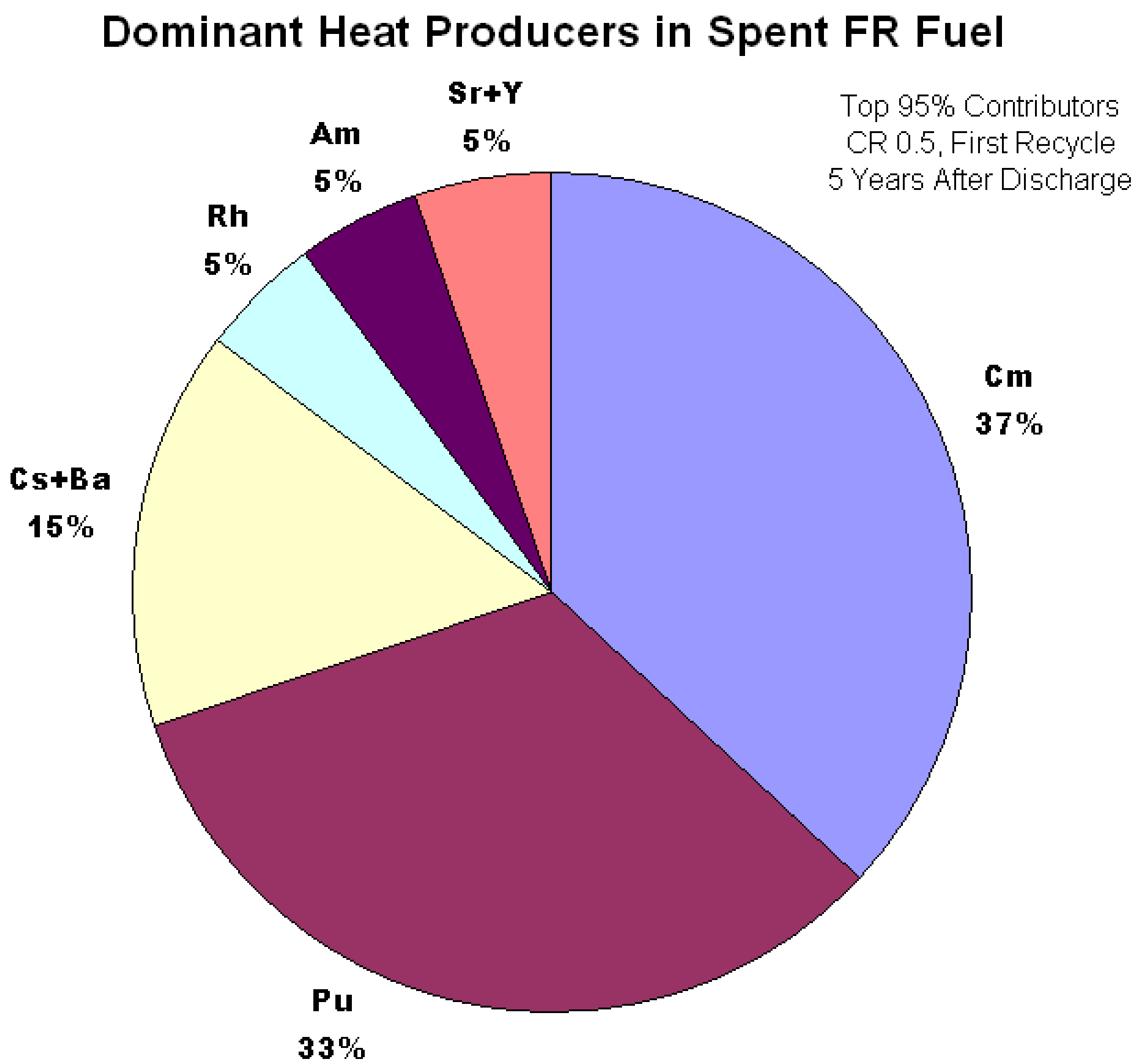
Sandia National Laboratories

Work conducted by SNL for the GNEP

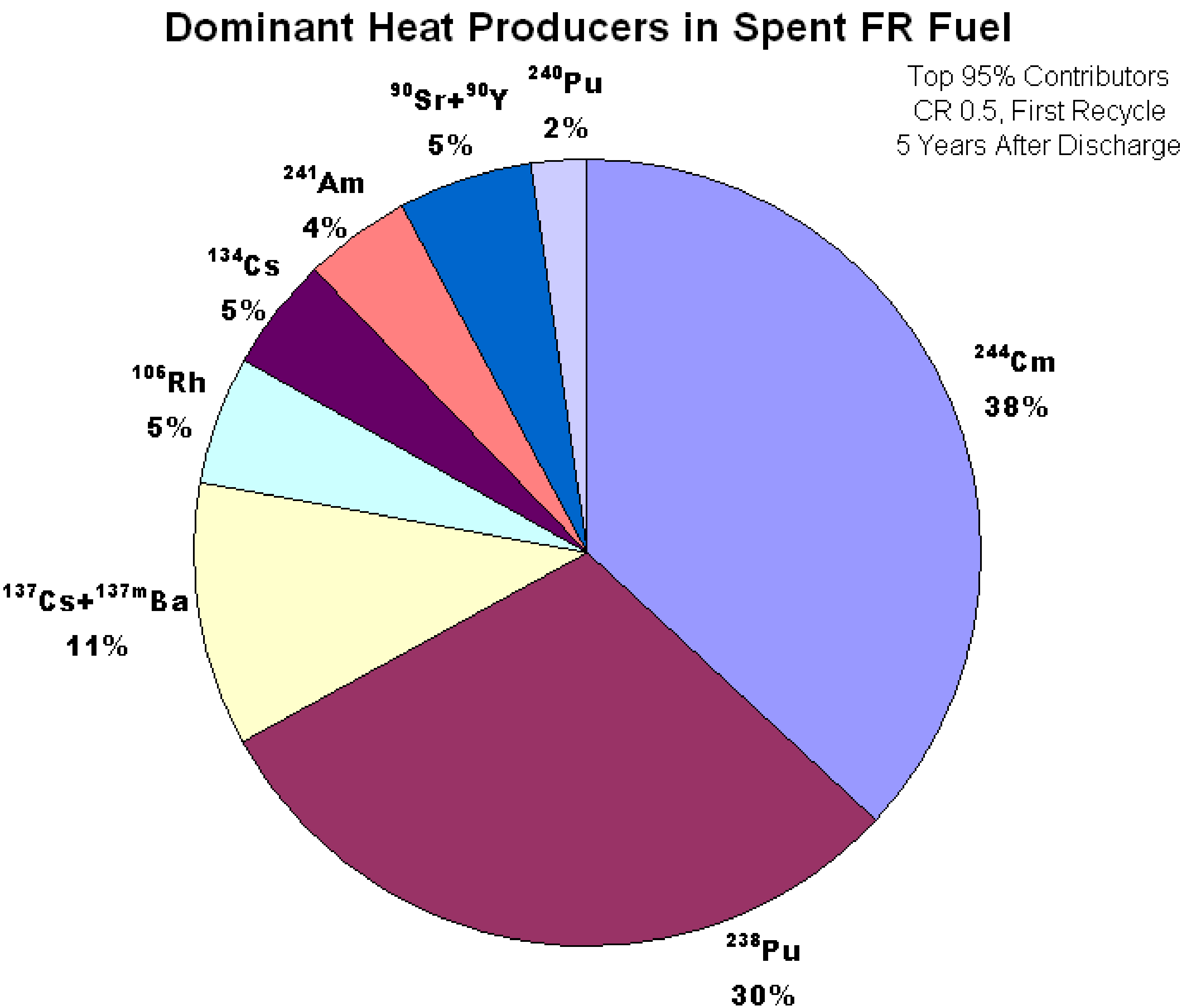
Recycle Successive Heat Load Increase



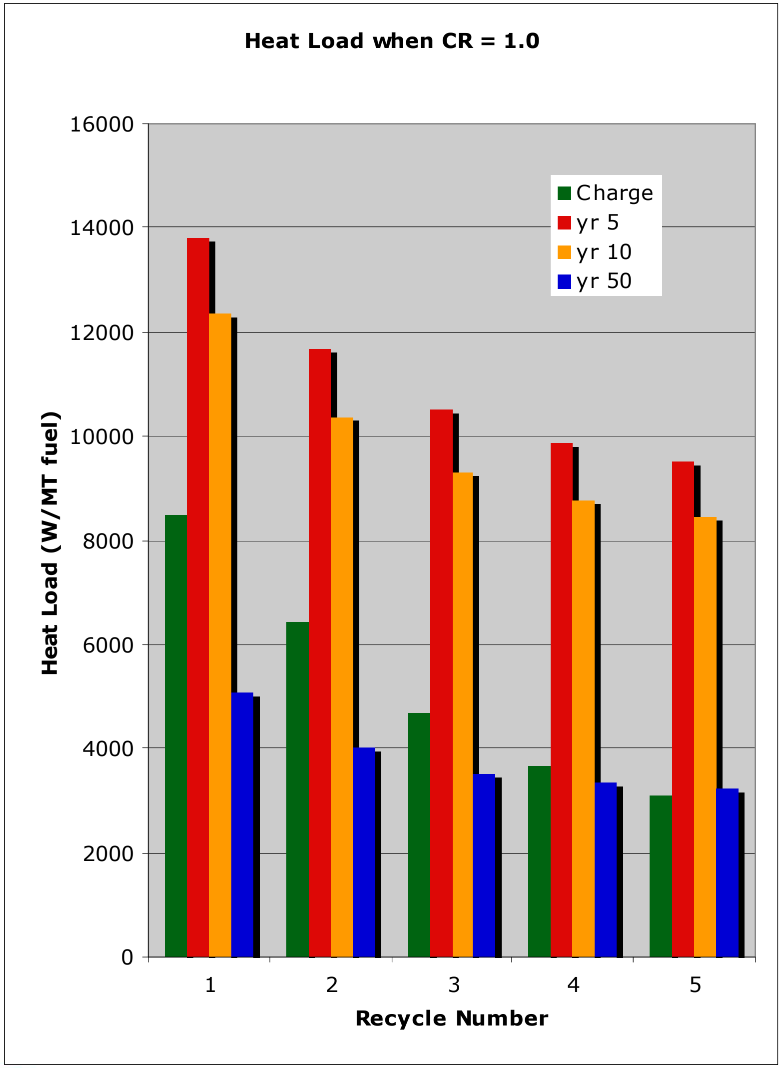
Elemental Contribution

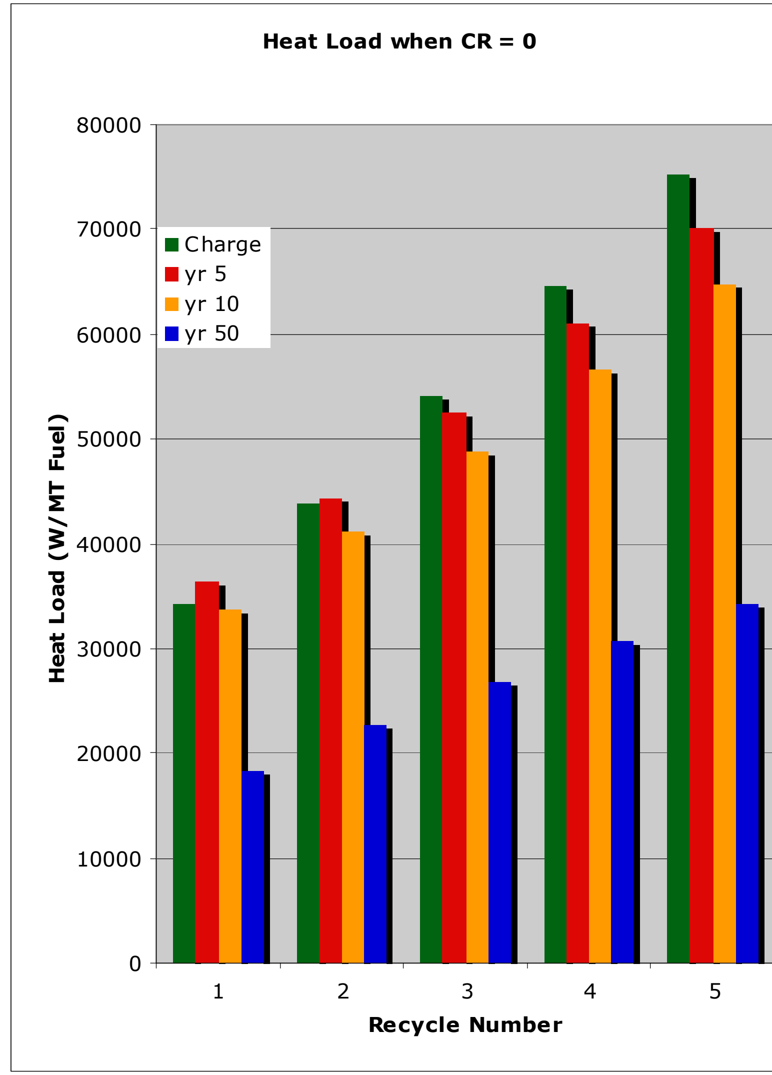


Isotopic Contribution

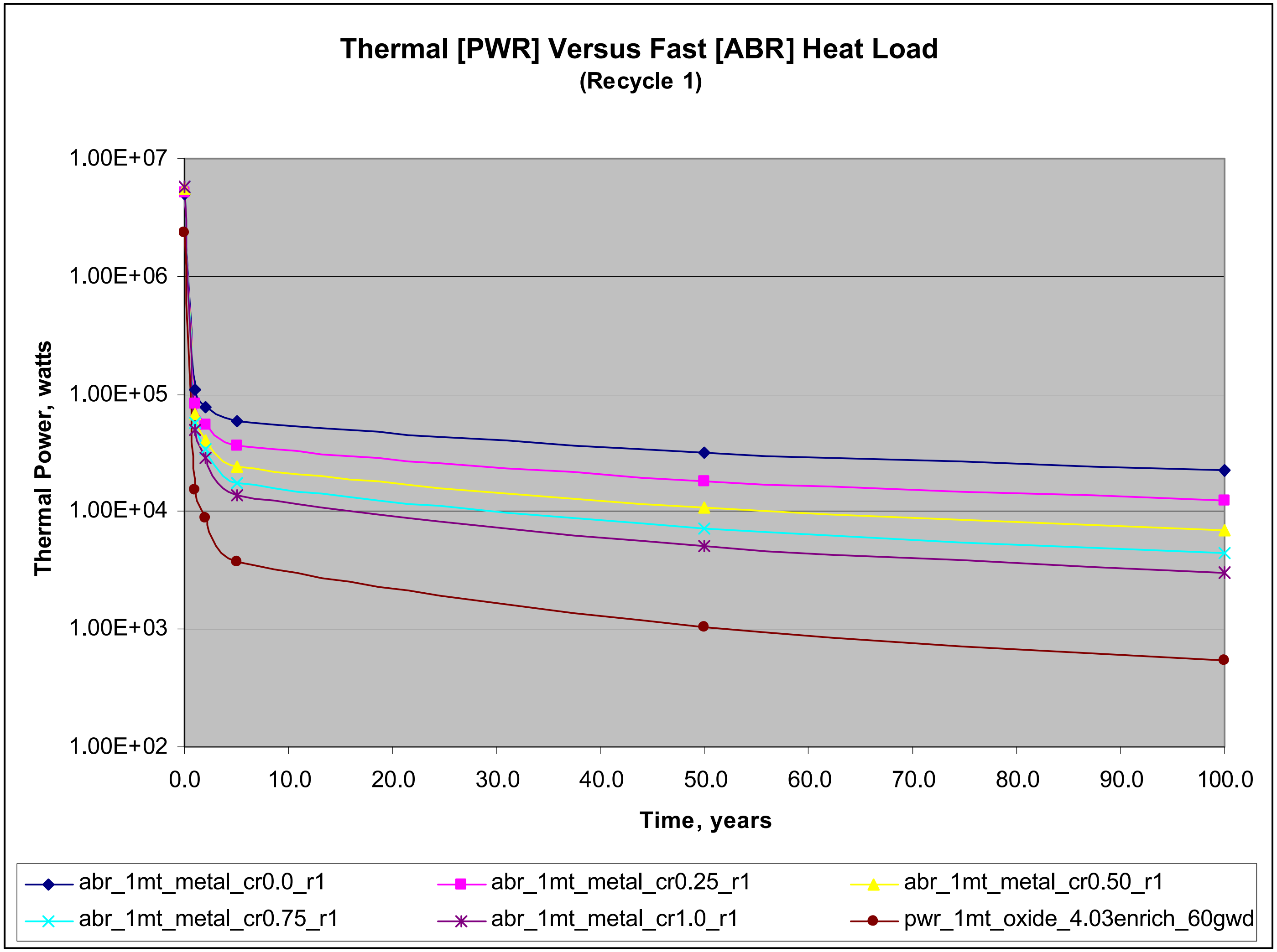


Heat Load Variation By Recycle Number And Conversion Ratio

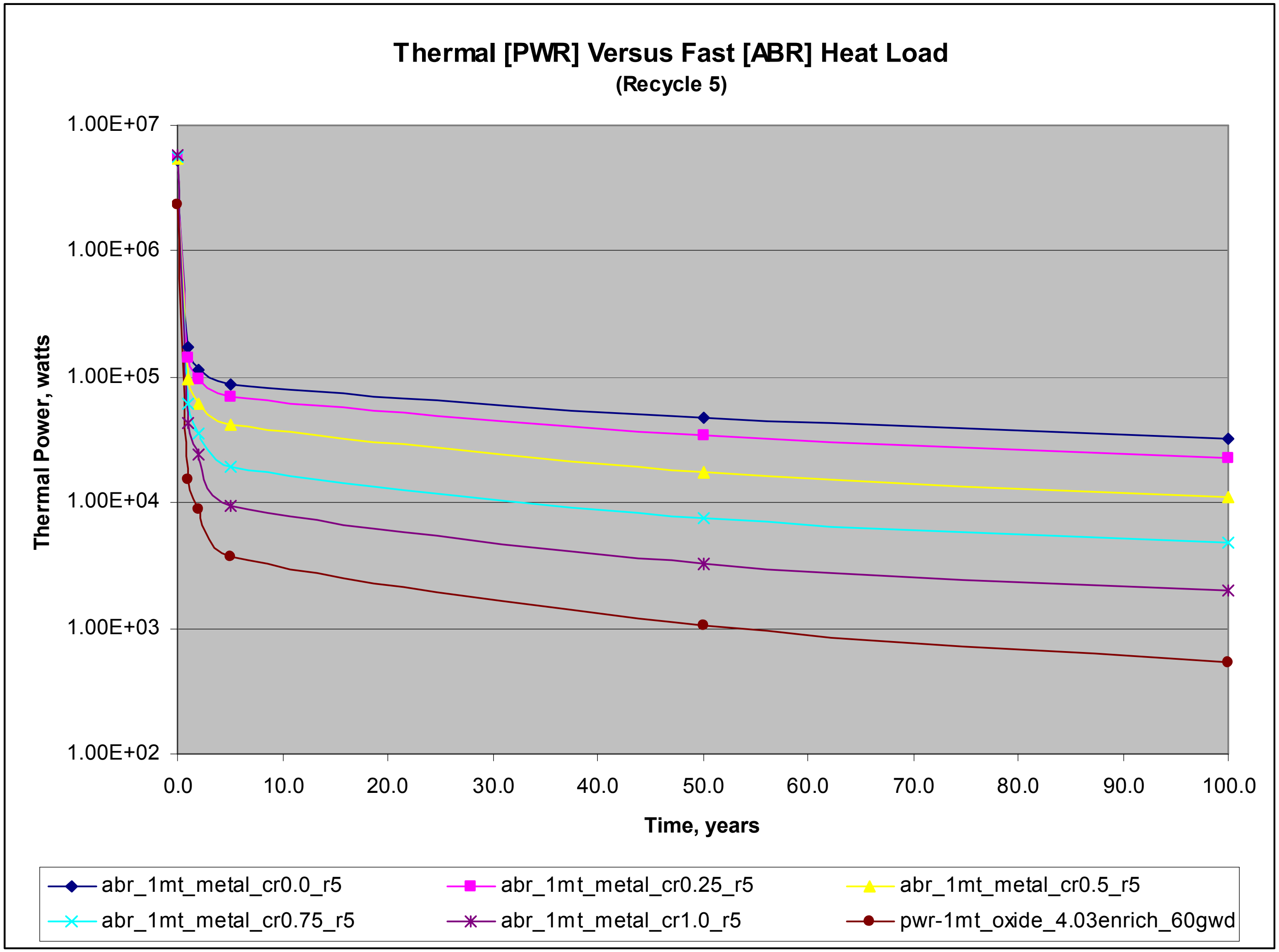




Thermal Versus Fast Reactor Heat Load Comparison – First Recycle



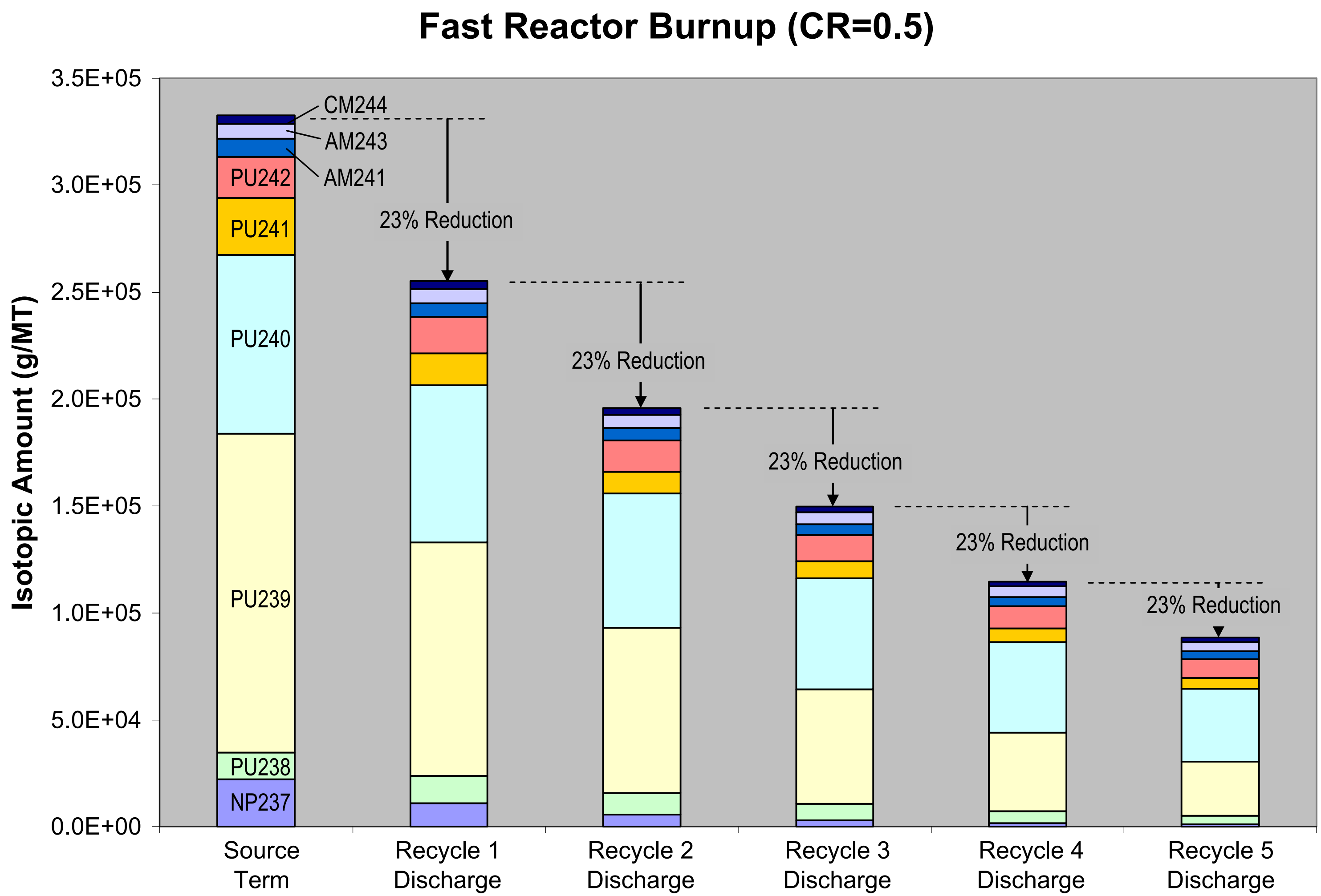
Thermal Versus Fast Reactor Heat Load Comparison – Fifth Recycle



Sandia National Laboratories

Work conducted by SNL for the GNEP

Constant Burnup Percentage With Each Recycle



Sandia National Laboratories

Work conducted by SNL for the GNEP

Summary And Conclusions

- Little difference between startup and equilibrium thermal load
- Heat load increases by less than factor of two out to five recycles
- ^{238}Pu and ^{244}Cm isotopes dominate heat production
- Order of magnitude differential between thermal and fast heat load
- Approximately one quarter of TRU destroyed with each recycle
- Fast reactor spent fuel thermal loads approximately equivalent to initial loading prior to irradiation after 5 years cooling
- Transportation cask loadings are function of assembly design; will be challenging to ship 1 MT of fast reactor fuel at 25kW threshold