Molten Salt Sourdough and Full core Analysis

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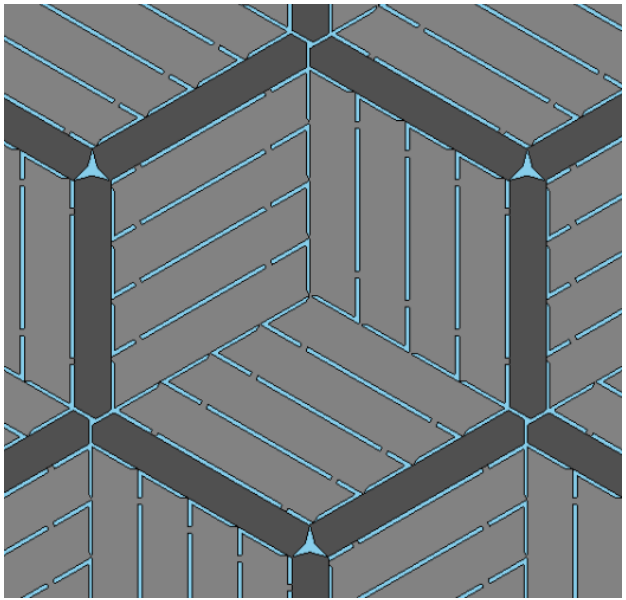

OUTLINE

- **Background**
- **Burnup and Refueling in MSRs**
- **Sourdough Refueling Strategy**
- **Methodology for Thermal MSR**
- **Results**
- **3-D core results**
- **Pros and Cons**
- **Future research**

Acknowledgments

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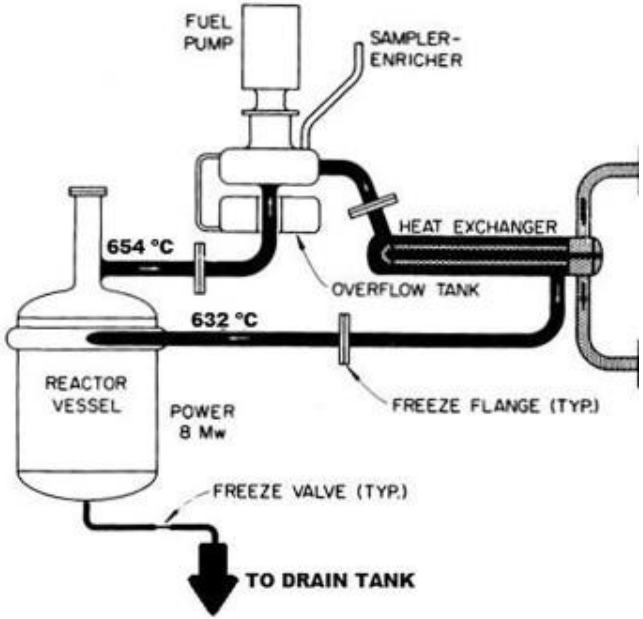
Molten Salt Reactor History

- Most research from MSR research at ORNL in 50s/60s
- Goal of developing of a thorium breeder reactor
- More Uranium reserves discovered since mid century



Source: Singh et al., “Nonlinear dynamic model of Molten-Salt Reactor Experiment – Validation and operational analysis,” Annals of Nuclear Energy (2018)

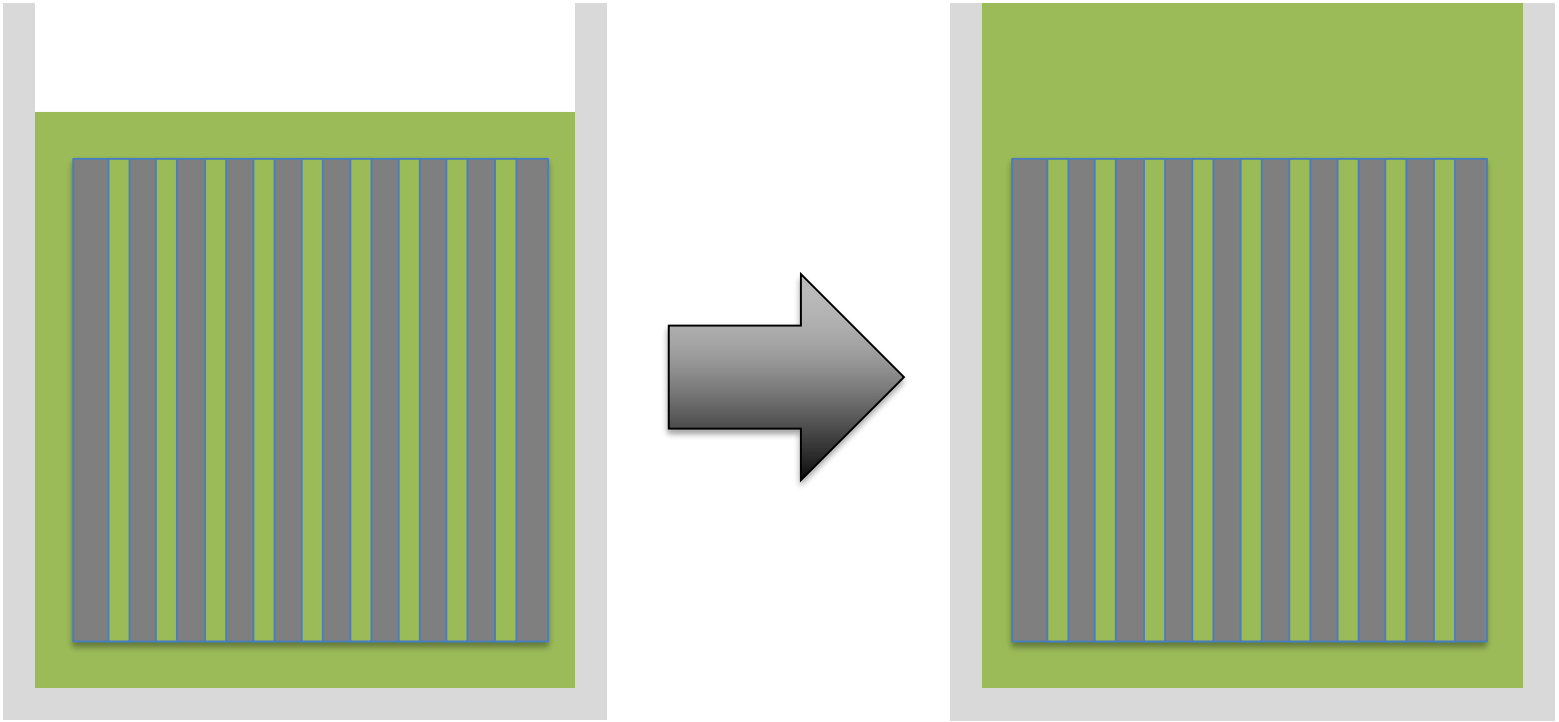
MSRs Going Forward

- Several Entities pursing MSR technology
- Large design space
- Various designs enable many different fuel cycles
  - Many do not include thorium or breeding
- Early deployment likely not include reprocessing to minimize cost

Burnup and Refueling in MSRs

- Molten salt is different from solid fuels
  - Minimal radiation damage
  - Well mixed
- Burnup no longer tied to a single fuel pin
- Refueling affect the entirety of the fuel salt
- Burnup and refueling result in volume growth

Fuel Volume Growth

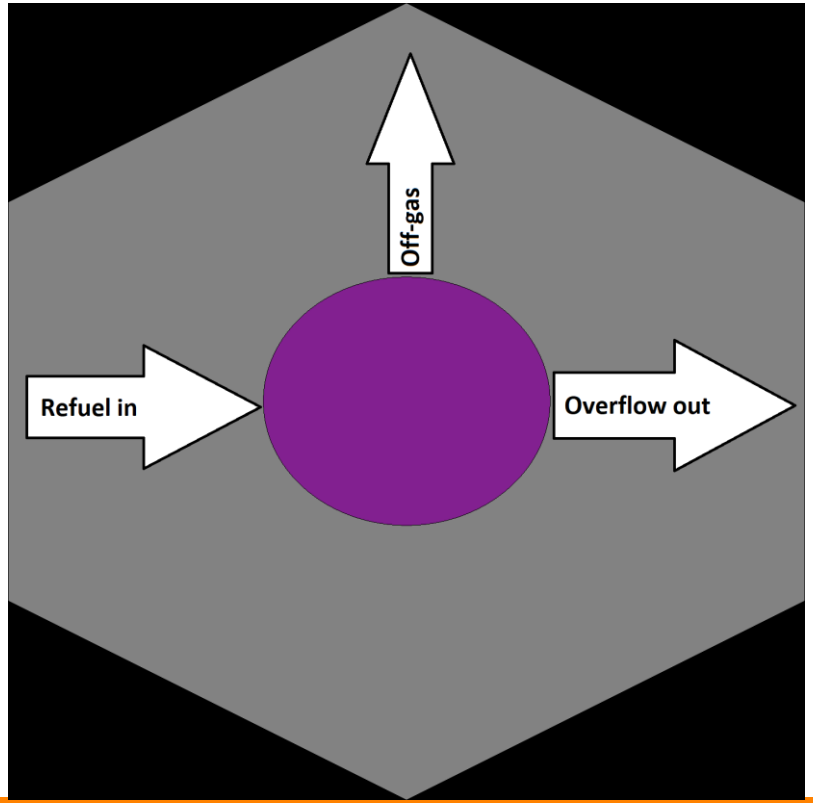


Sourdough Fuel Cycle

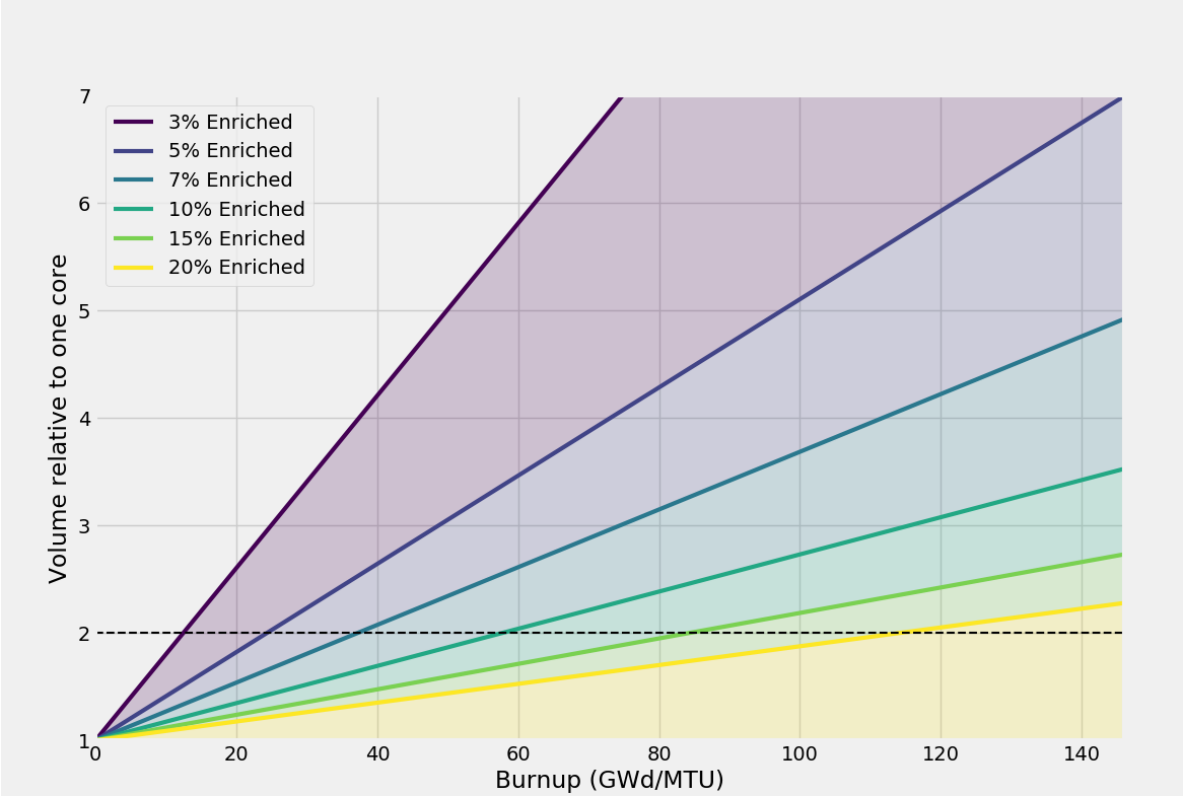
- With no reprocessing, refueling cause volume growth
- Refueling rate vary for different refuel enrichment
- Over reactor lifetime, a significant excess can be produced depending on refuel enrichment
- Used fuel is moved to new reactor of the same design
- Excess fuel not considered waste
- Creates a quasi doubling time

Sourdough Calculations

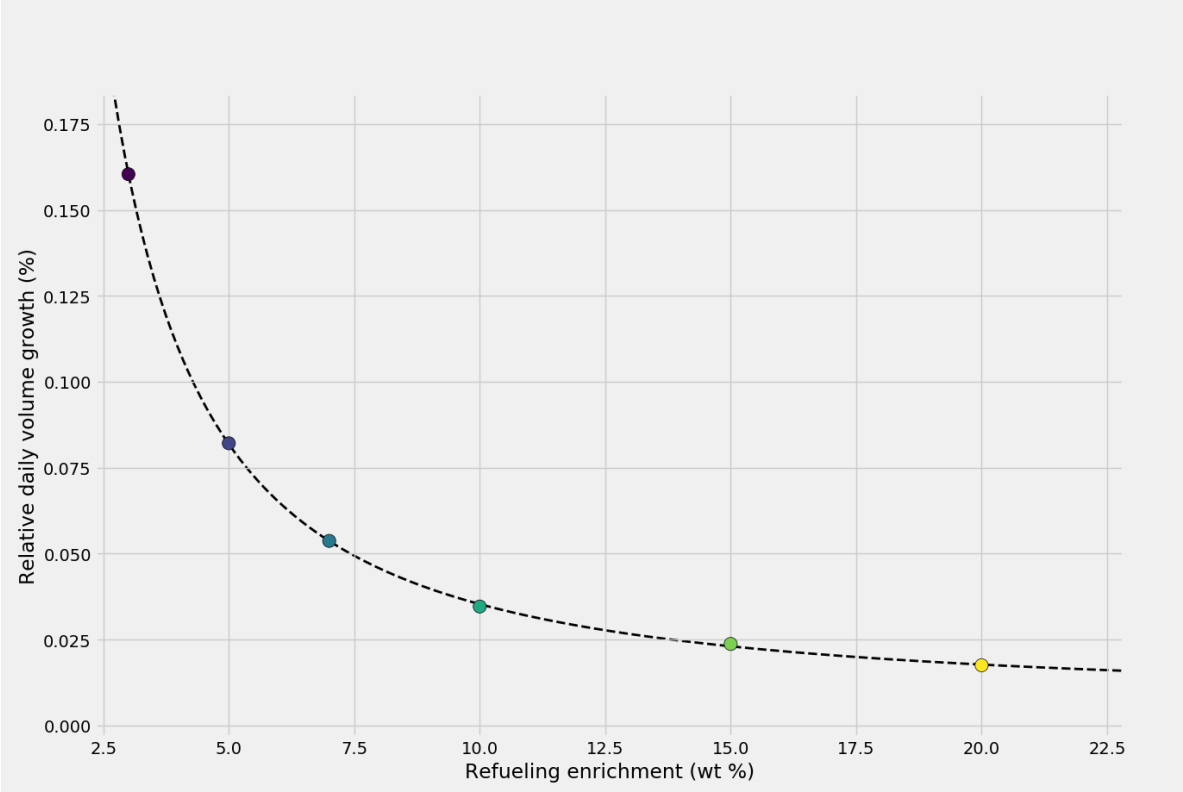
- Infinite lattice
- 3.353 g/cm^3 LiF-BeF_2 – UF_4 (72-16-12 mole%, 99.998% Li-7, 1.3% U-235)
- Thermal spectrum, LEU Uranium
- Modeled in Serpent 2



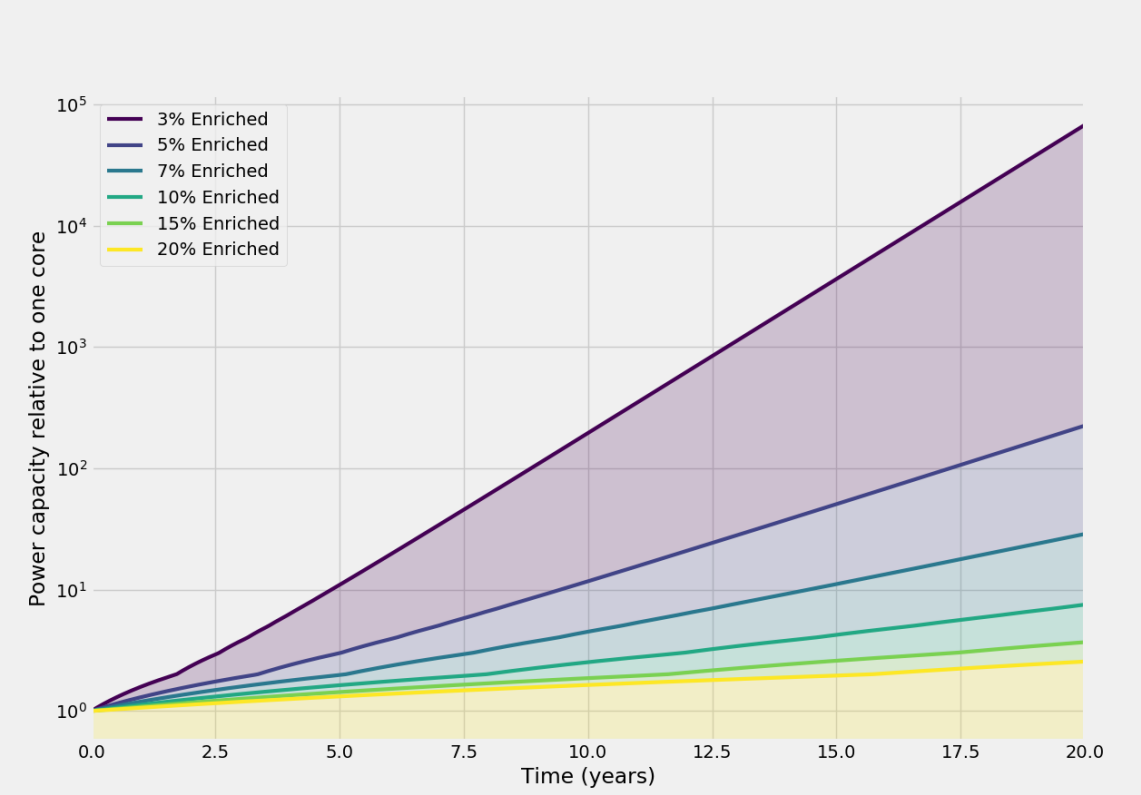
Doubling time



Refueling Enrichment

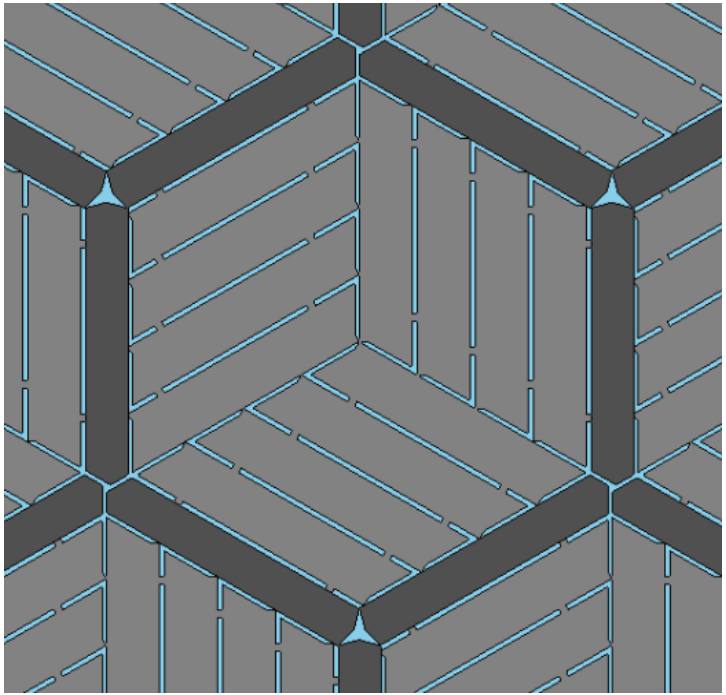


Power Capacity

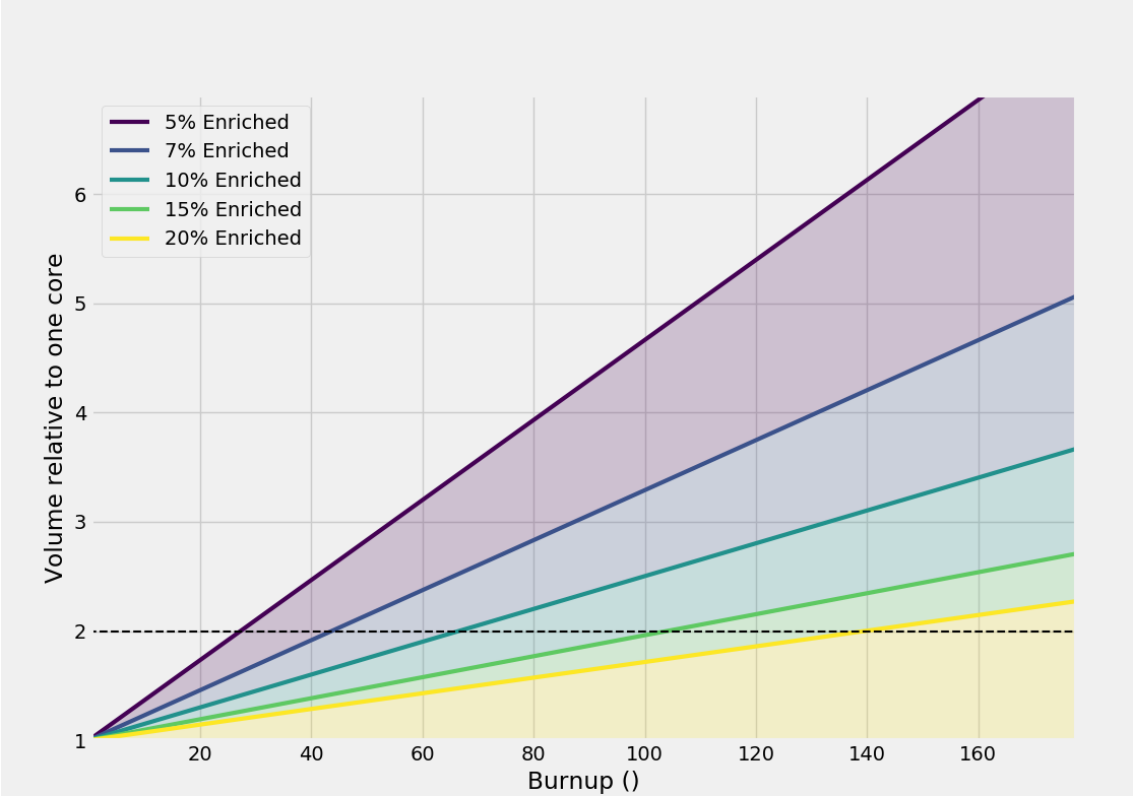


Thorcon-like reactor

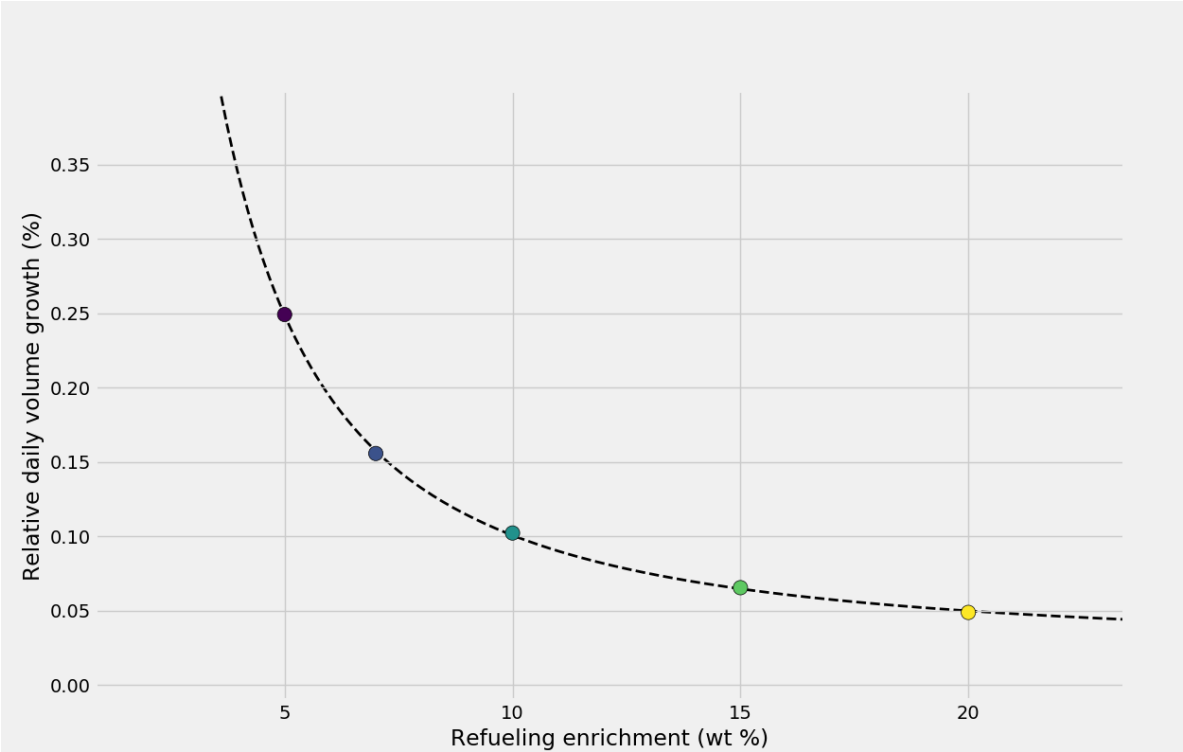
- 5.5 m^3 initial fuel salt
- 3.353 g/cm3 LiF-BeF2 –UF4 (72-16-12 mole%, 99.998% Li-7, 1.3% U-235)
- 557 MWth



Doubling time



Refueling Enrichment



Benefits of Sourdough Fuel Cycle

- Minimizes reprocessing
- Spreads upfront fuel cost of new reactor over previous unit's operation
- Spent fuel is contained in operating reactors
  - novel partitioning chemistry allowing economic FP reuse
  - accelerator-driven waste transmutation
  - fusion-fission hybrid reactors

Drawbacks of Sourdough Fuel Cycle

- Not a VERY long-term waste solution
- Relies on expansion of MSR fleet and steady demand
- Need for transport of radioactive fuel salt
- Excess fuel volume storage
- Modeling limitations

Conclusion and Future work

- Many positive benefits
- Possibly ease public concern over spent nuclear fuel
- Need to add volume expansion in modeling codes
- Apply methodology to specific Reactor design
- Calculate Cost and resource usage

Thank you