Burnup Credit in the Swedish Interim Storage Facility (CLAB)

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Swedish nuclear programme

- In Sweden there are presently 10 reactors in operation

- 7 BWR
- 3 PWR
- 2 BWR-plants have been shut down due to government decision.

- Assuming 50 to 60 years operation time for the reactors this programme will produce around 48 000 BWR-assemblies and around 6100 PWR-assemblies.

SKB

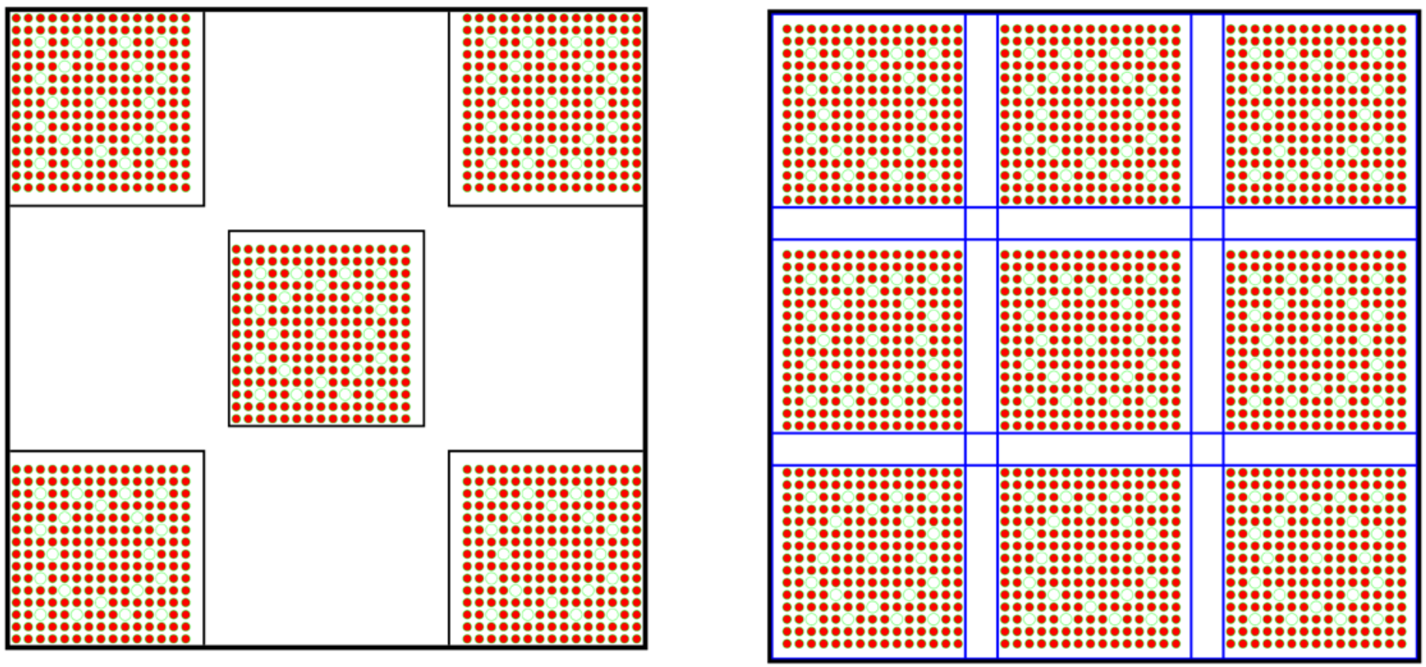
- **Swedish Nuclear Fuel and Waste Management Co is managing the spent nuclear fuel in Sweden**

- **The system consists of**
  - ***Transportation system***
  - ***Interim storage facility* (CLAB)**

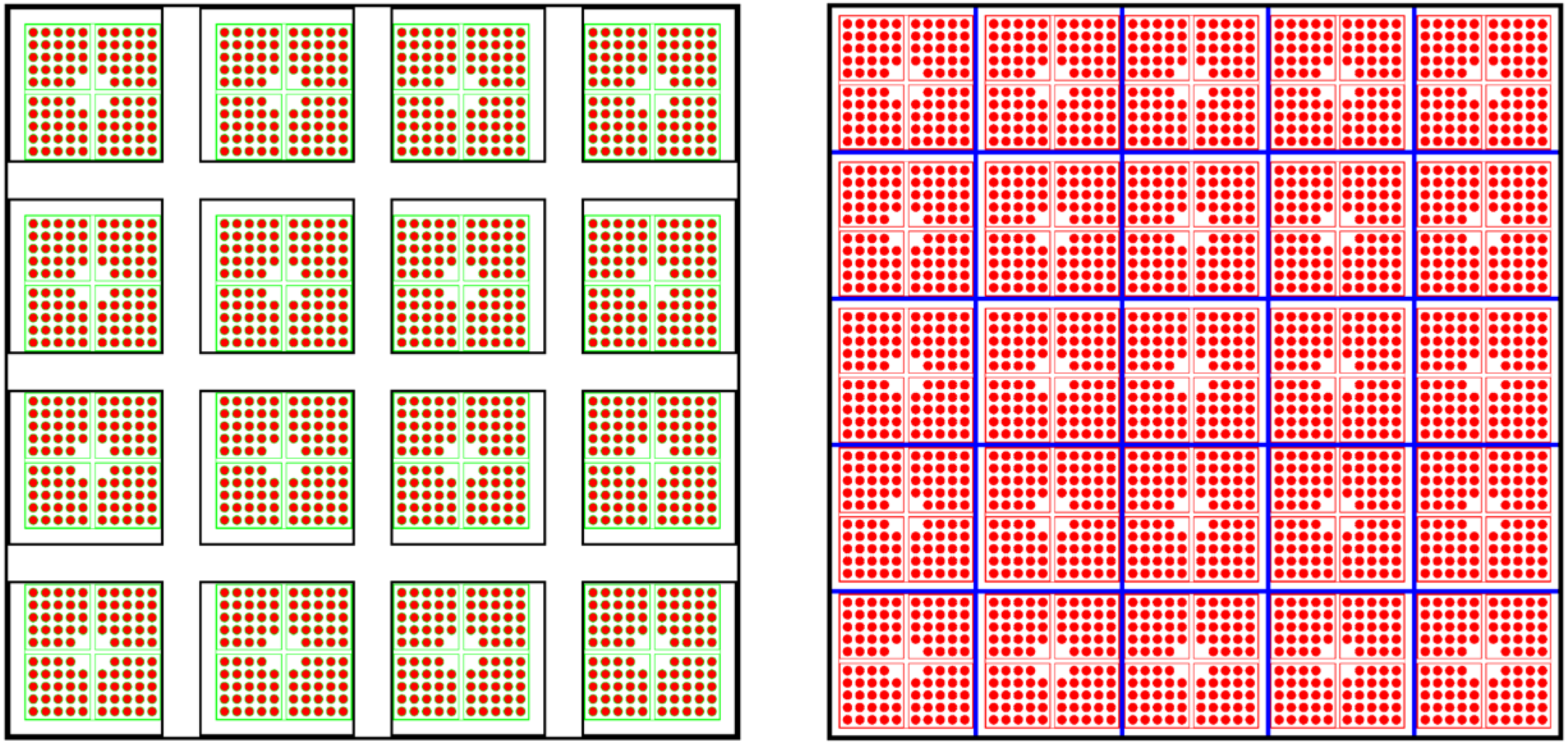
- **There are plans for**
  - ***Encapsulation plant***
  - ***Deep repository***

CLAB and encapsulation plant

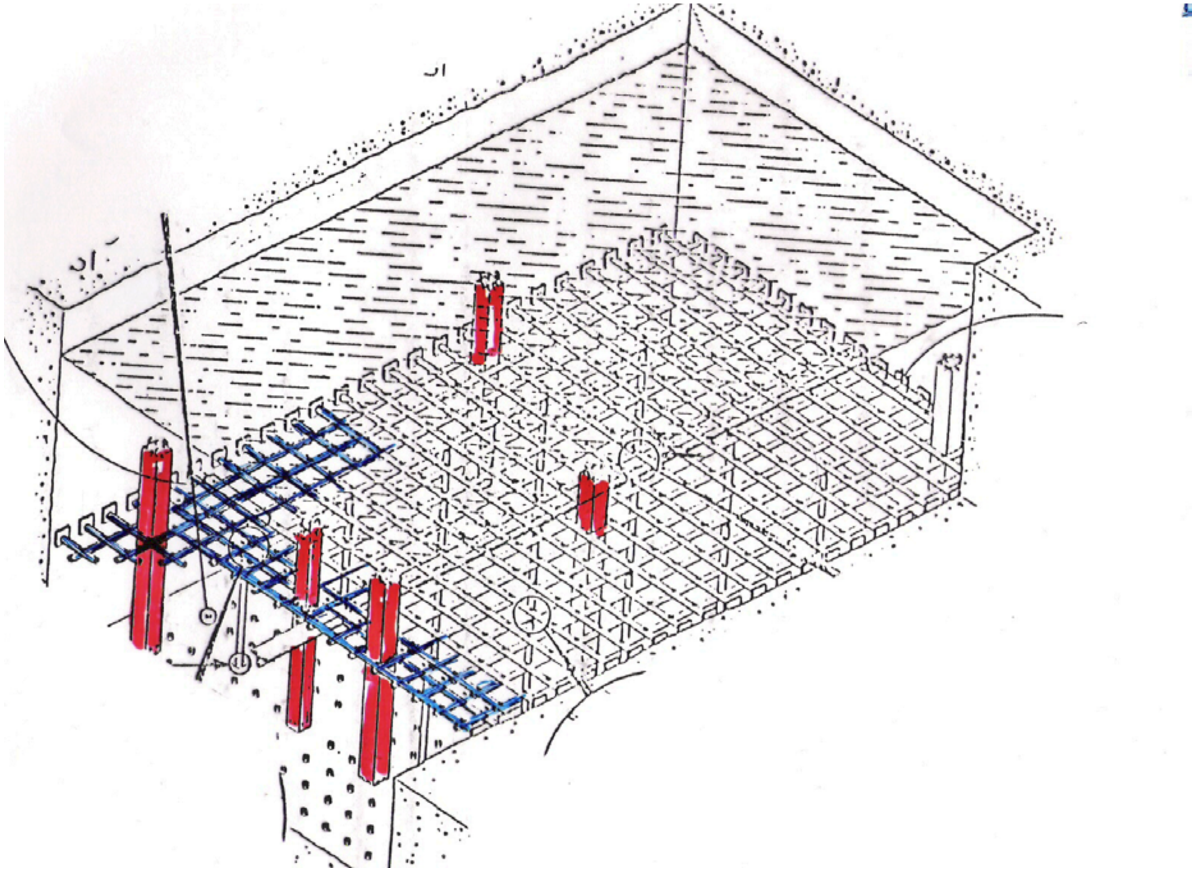
Storage canisters in CLAB



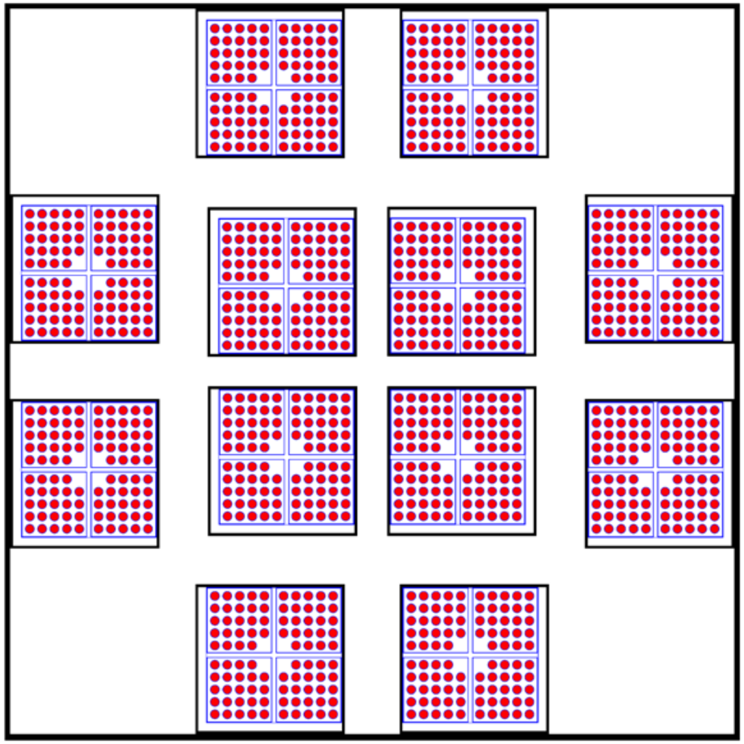
Storage canisters in CLAB

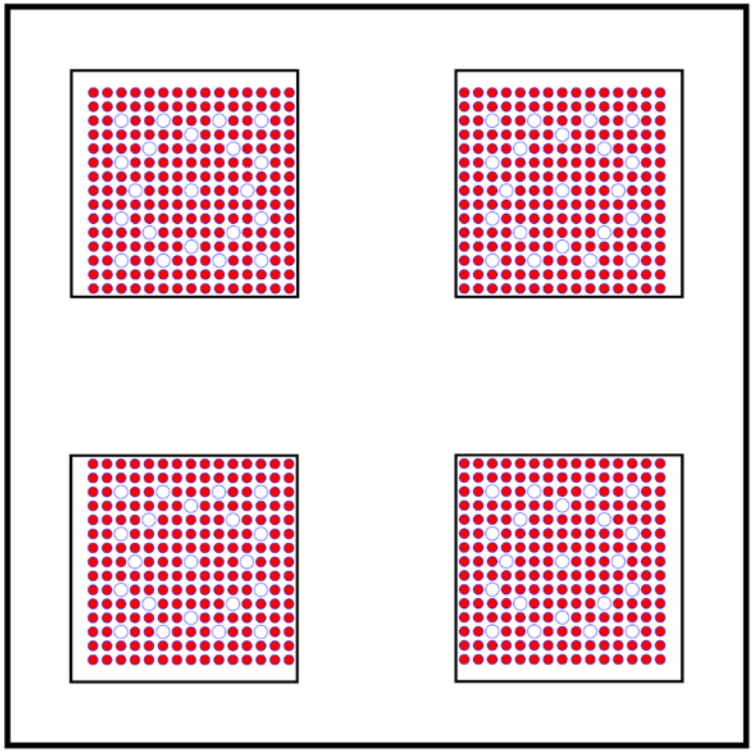


Storage grid for canisters in CLAB



Transfer canisters





Limits in the present system

- **For PWR the limiting enrichment is 4.2% U235 for compact canisters and 3.75 % U235 for normal canisters. Fresh fuel is assumed.**

- **For BWR the limiting enrichment is 4.2% U235 with BA-credit for all BWR-canisters.**

- **There are no margins available to increase the enrichment**

Increase in enrichment

- **The power plants indicate the need for increase in enrichment up to 5 % U235.**

- **To meet this in Clab burnup credit was investigated**

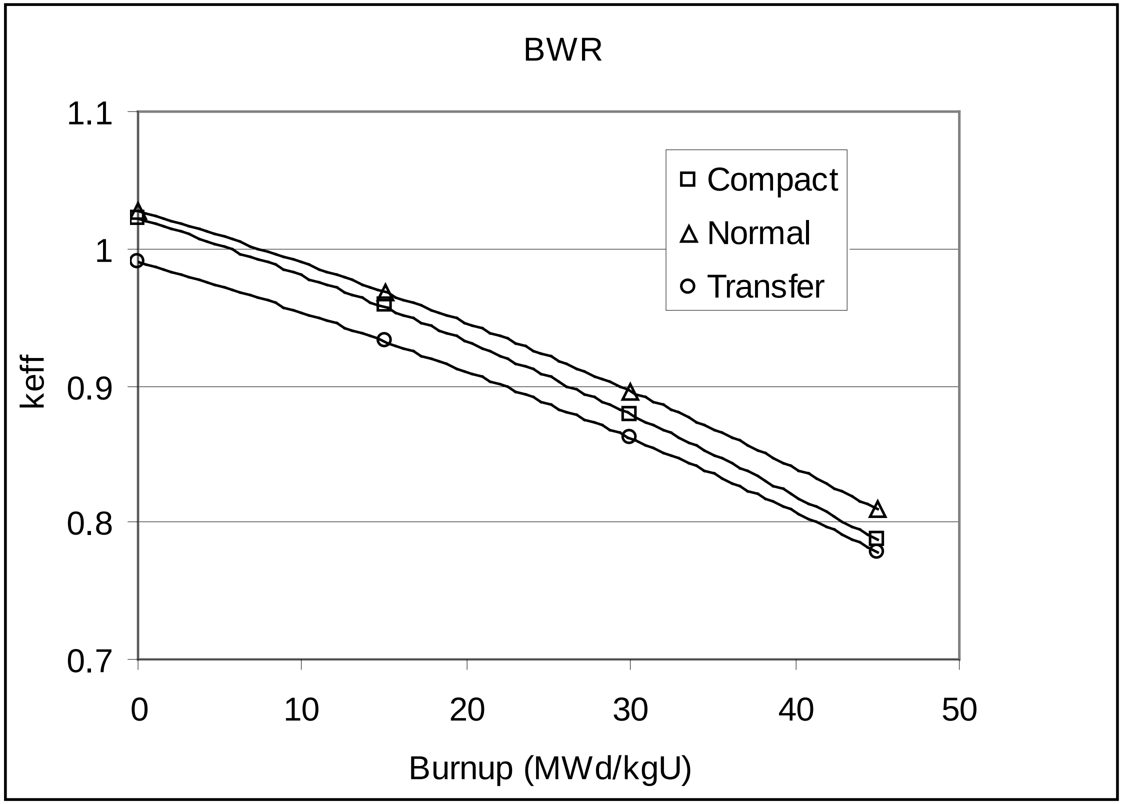
Burnup credit for CLAB

- Calculations were performed using Scale 5.1
- Depletion calculations were performed using SAS2
- Criticality calculations were performed using Scale CSAS25 and Starbucs sequences . Scale 44 – group (ENDF/B-V) library was used.

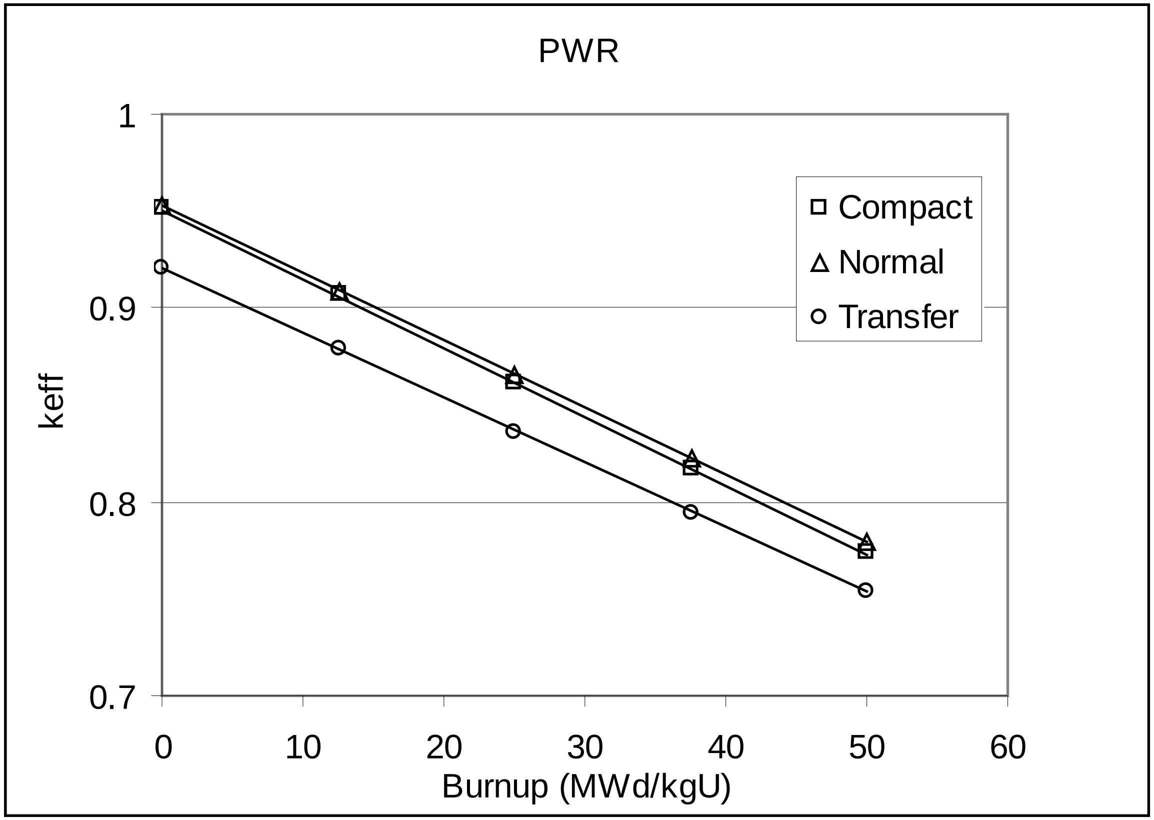
Reference fuel types

- **BWR Svea96 Optima 3**
- **PWR 15x15 AFA3G**

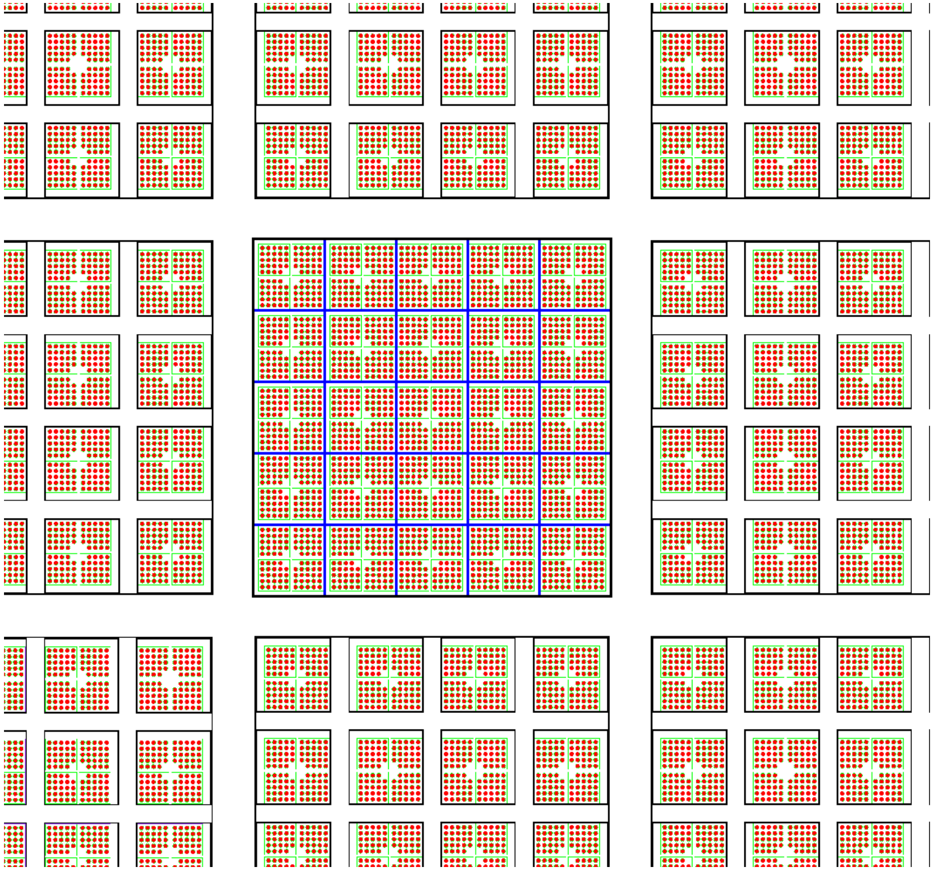
Burnup curves for BWR



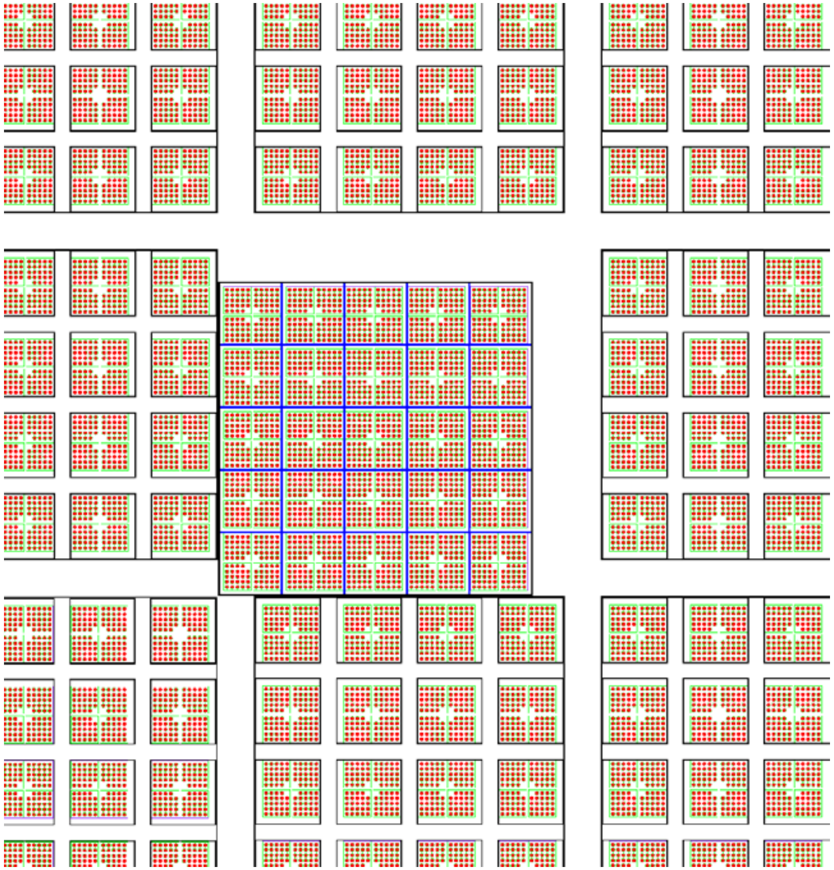
Burnup curves for PWR



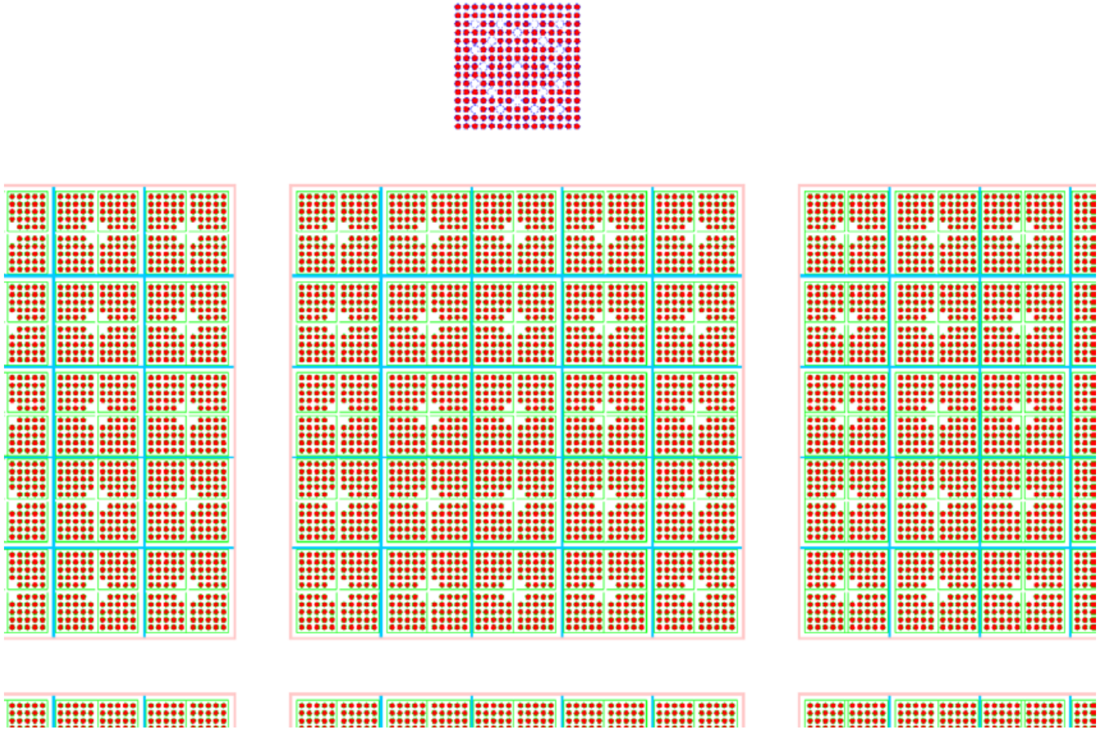
Storage pattern i CLAB



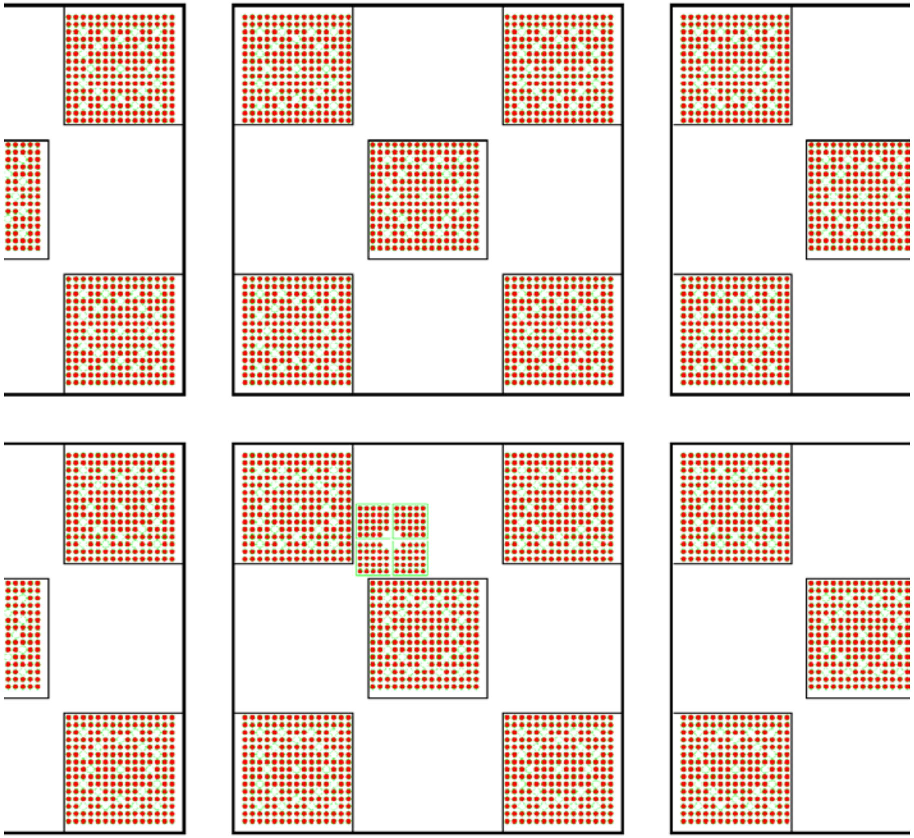
Missplaced canister



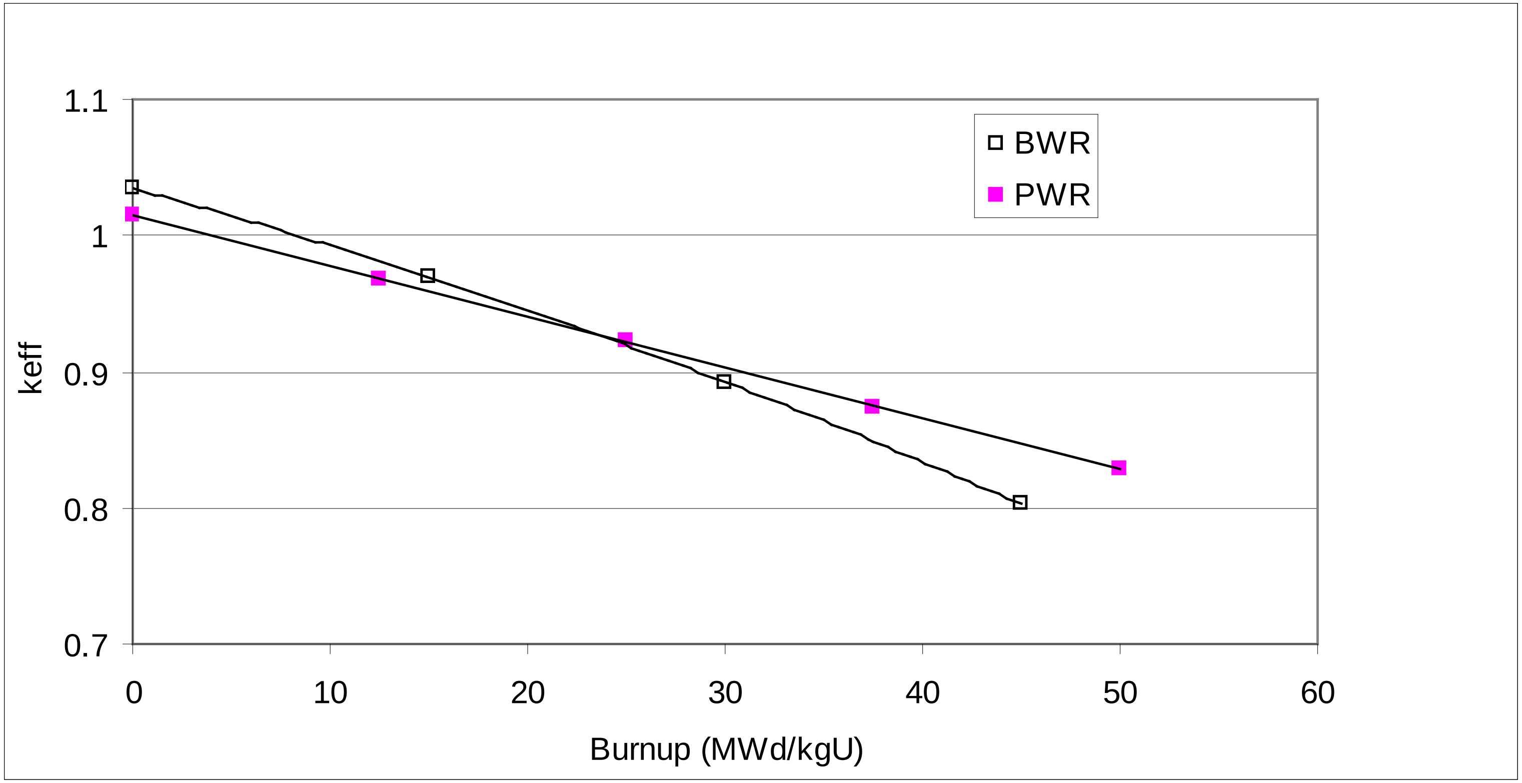
Misplaced PWR-assembly



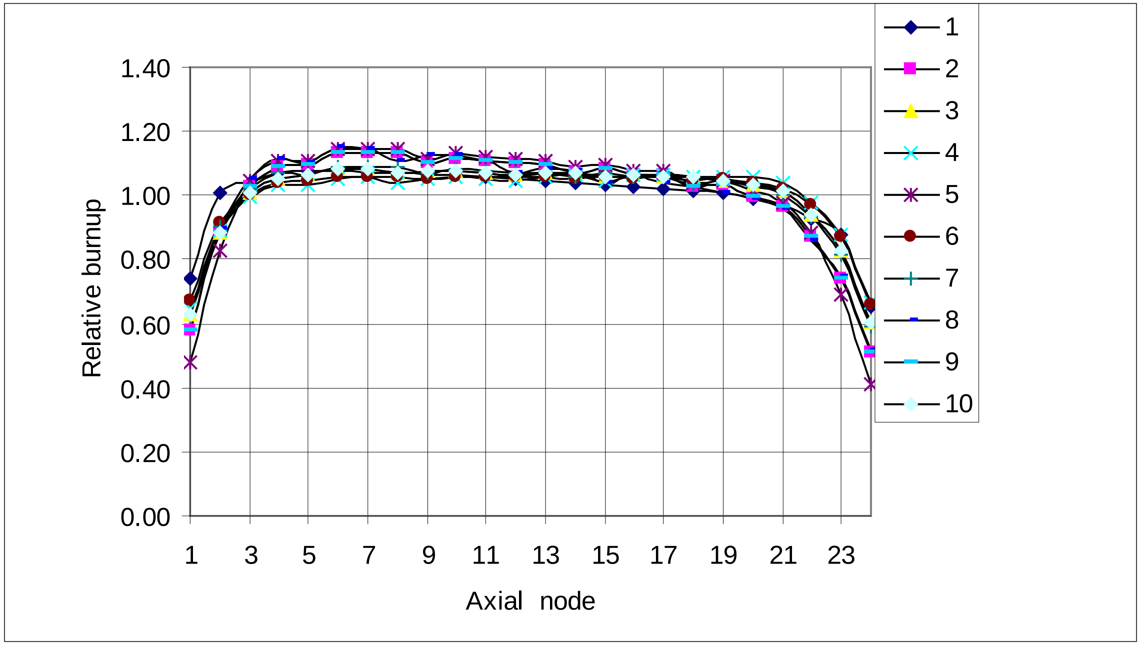
Misplaced BWR-assembly



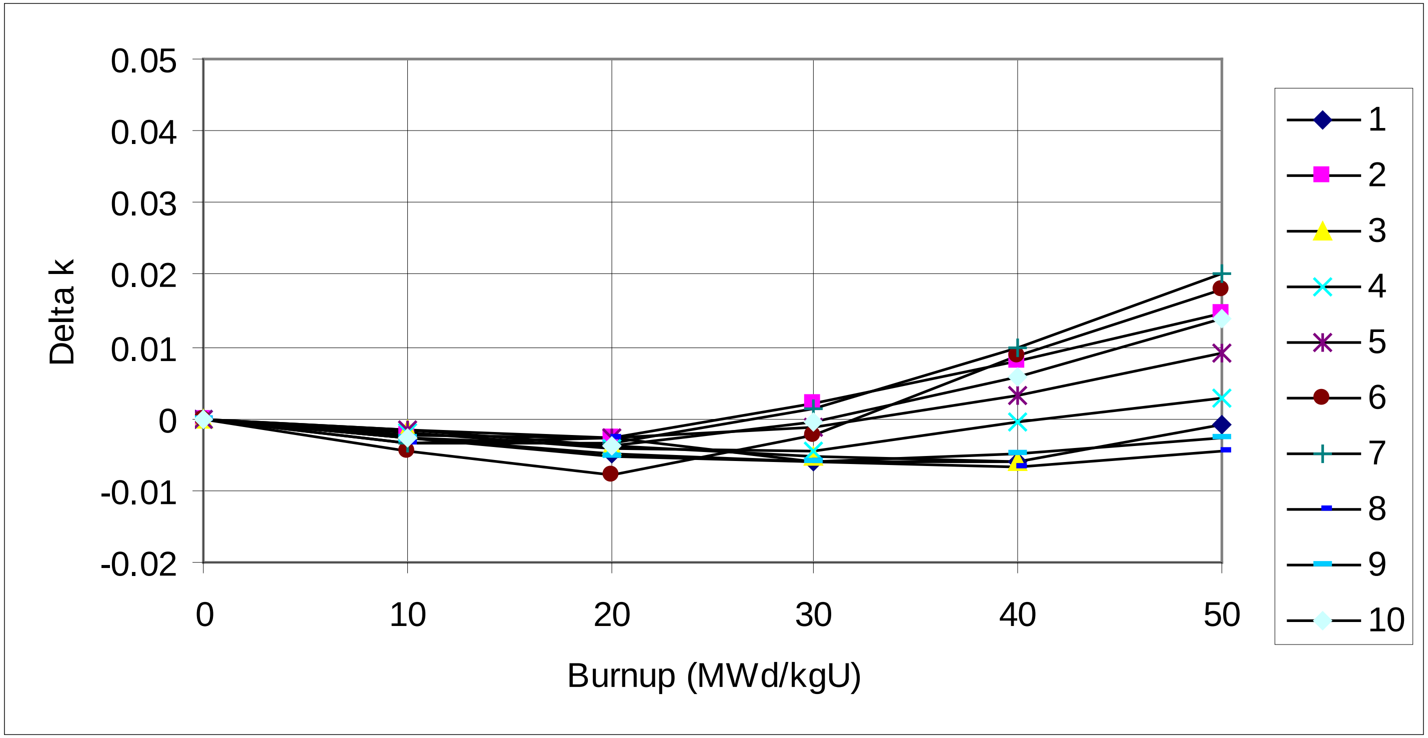
Burnup curves for limiting accident



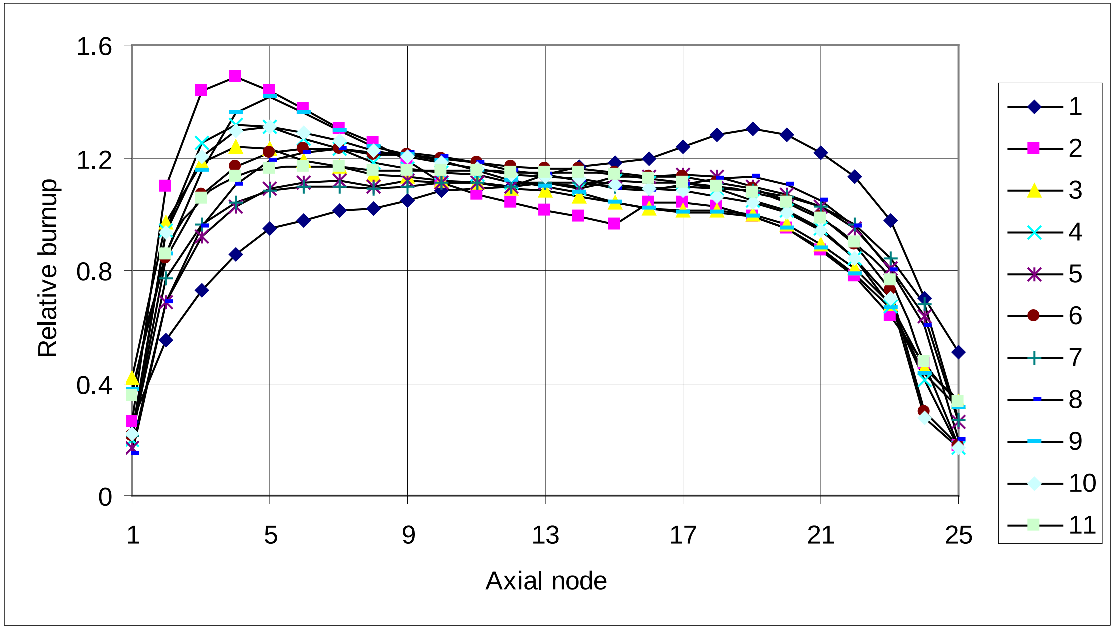
PWR-axial burnup distributions



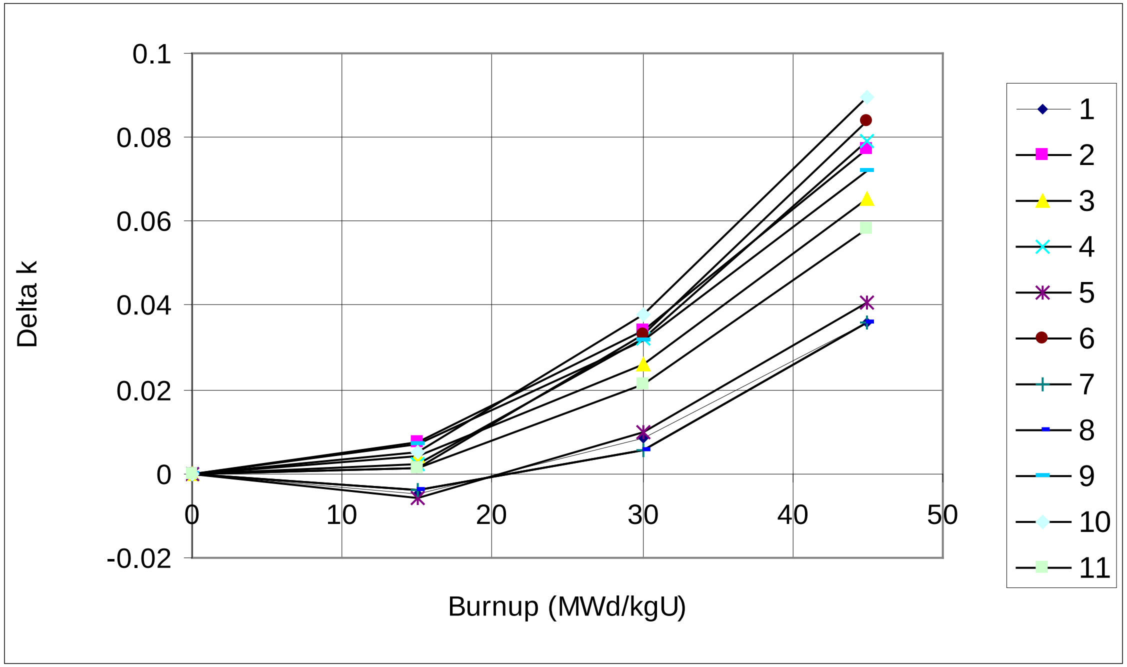
End effect PWR



BWR-axial burnup distributions



End effect BWR



Uncertainties

- Declared burnup
- Axial void- and temperature distribution
- Axial burnup distribution
- Control rods
- Horizontal burnup distribution
- Geometry changes due to irradiation

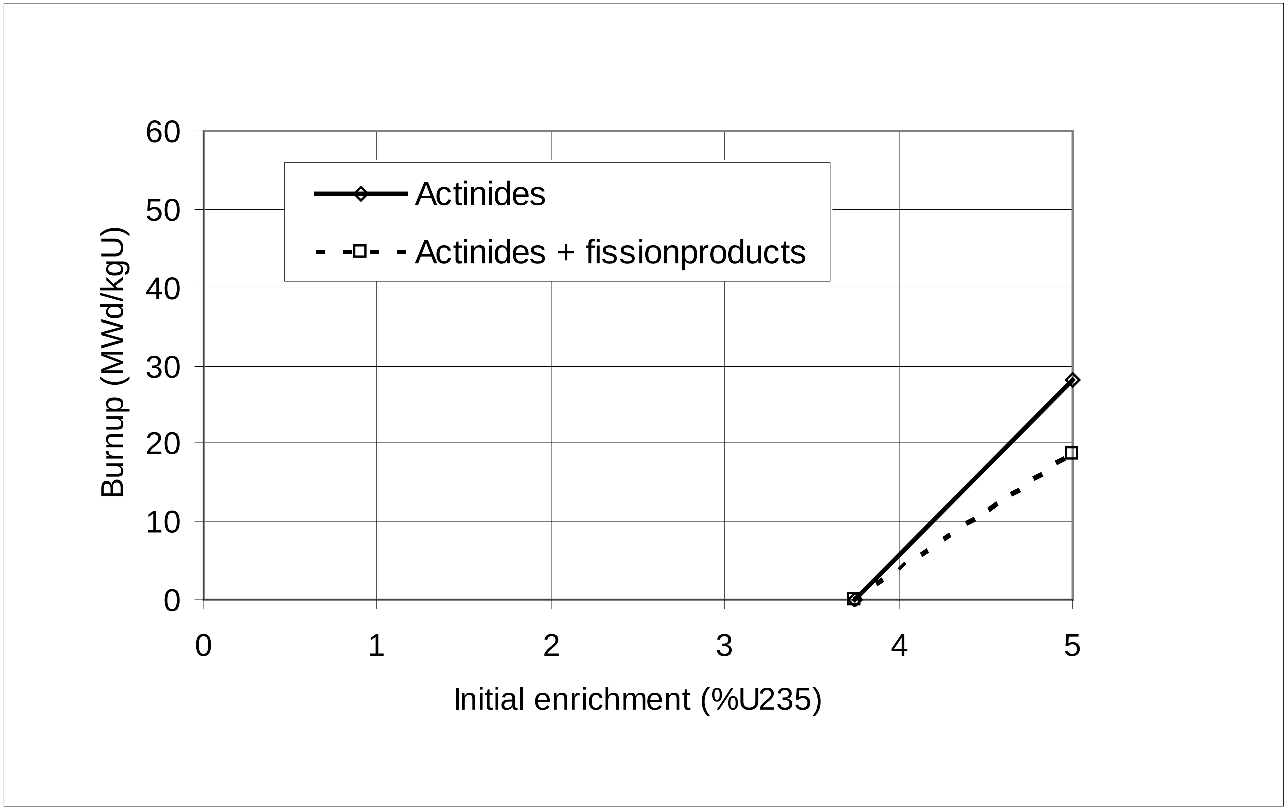
- Calculational uncertainty
- Uncertainty in isotopic prediction

- Manufacturing tolerances in canister and fuel

BU-requirement for PWR

Case	Compact and normal	
	Actinides	**Actinides+ fissions-products**
Uncertainties		
Fuel Data	0.0040	0.0040
Statistcal uncertainty in Keno	0.0009	0.0009
Bias in benchmarking	0.0007	0.0007
Calculational uncertainty	0.0094	0.0094
Uncertainty in isotopic prediction	0.0164	0.0160
Undertainty in burnup	0.0039	0.0037
Horizontal burnup distribution	0.0015	0.0016
End effect	0.0020	0.0000
Geometric change due to irradiation	0.0025	0.0025
Sum	0.0413	0.0347
Keff i basecase	1.0157	1.0157
Sum keff	1.0570	1.0504
Limit	0.9500	0.9500
Need of BU-credit	0.1070	0.1004
Burnup requirement (MWd/kgU)	**28.2**	**18.6**

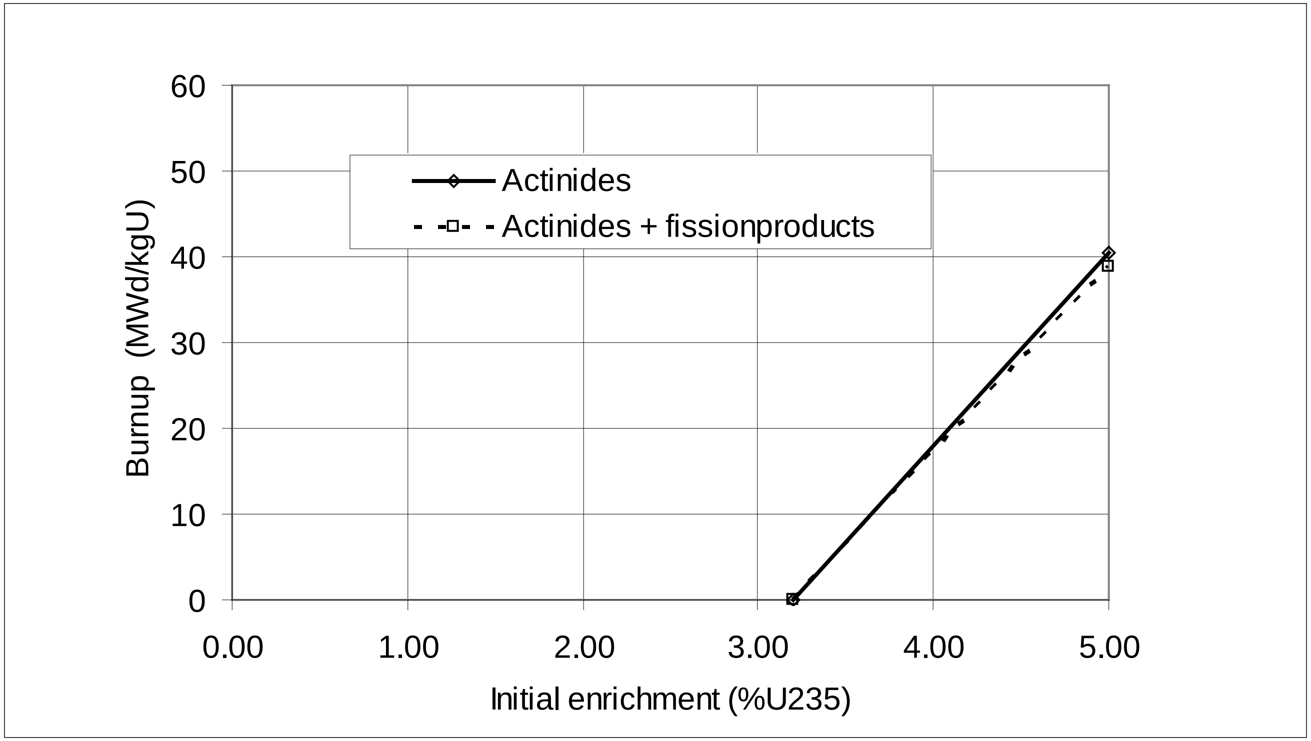
Loading curves for PWR



BU-requirement for BWR

Case	Compact and normal	
	Actinides	Actinides+ fissions-products
Uncertainties		
Fuel Data	0.0033	0.0033
Statistcal uncertainty iin Keno	0.0009	0.0009
Bias in benchmarking	0.0007	0.0007
Calculational uncertainty	0.0094	0.0094
Uncertainty in isotopic prediction	0.0260	0.0520
Undertainty in burnup	0.0083	0.0103
Horizontal burnup distribution	0.0048	0.0051
End effect	0.0720	0.0900
Geometri change due to irradiation	0.0005	0.0000
Sum	0.1259	0.1718
Keff i basecase	1.0344	1.0344
Sum keff	1.1603	1.2062
Limit	0.9500	0.9500
Need of BU-credit	0.2103	0.2562
Burnup requirement (MWd/kgU)	**40.4**	**38.8**

Loading curves for BWR



Conclusion for CLAB

- **Today the enrichment limit in CLAB is 4.2%.**
- **The study shows that with BU-credit enrichments up to 5% could be accepted and the administrative controls significantly reduced.**

Questions

- Validation of codes for BWR
- How to find a limiting axial burnup distribution
- Measurements?