# Summary of RED-IMPACT results on the Impact of P&T on the High Level Waste Management

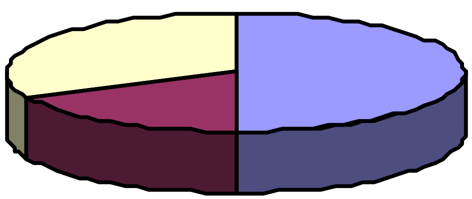
***E.M. Gonzalez (CIEMAT),***
***on behalf of the RED-IMPACT collaboration***

**10th International Exchange Meeting on Partitioning and Transmutation, IEMPT10**
**Mito (Japan) 6-10 October 2008**

# RED-IMPACT

## Impact of Partitioning, Transmutation and Waste Reduction Technologies on the Final Nuclear Waste Disposal

23 partners + 2 subcontractors




**KTH-Sweden: Coordinator**
**FZJ-Germany: Co-Coordinator**
**Belgium: BN; SCK-CEN**
**Czech Republic: NRI; RAWRA**
**EC: ITU-Karlsruhe**
**France: Areva ANP, CEA; COGEMA**
**Germany:FANP; GRS; IER; KKP**
**Netherlands: NRG**
**Romania: CITON**
**Slovakia: DECOM, VUJE**
**Spain: CIEMAT; EA; ENRESA**
**UK: NexiaSolutions; NIREX; UC**

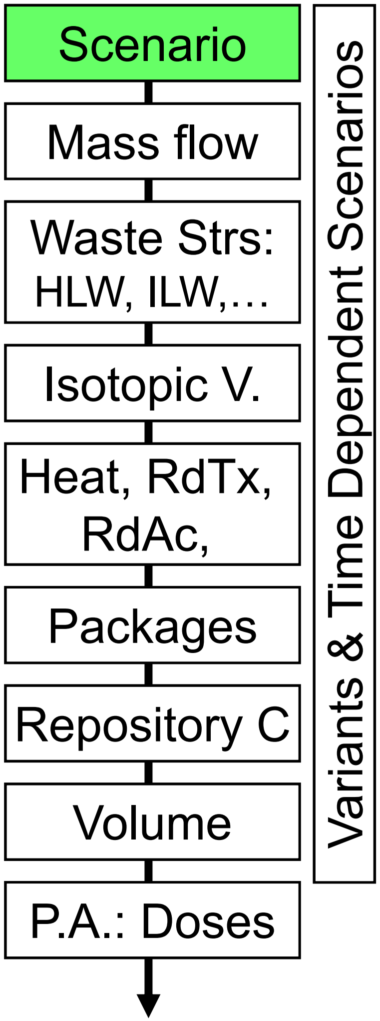

***EC CONTRACT NO. FI6W-CT-2004-002408***
**Duration: March 2004 – September 2007**

# RED-IMPACT

After a comprehensive inventory of existing and foreseen nuclear fuel cycle facilities in Europe, including a review of worldwide ongoing R&D programs on P&T, and assuming the potential evolution of P&T technologies and advanced fuel cycles (including Gen III & Gen IV reactors and ADS), the project has estimated the effect of P&T on waste management when using existing deep geological repository designs.

- **WP1**: Review of waste management and transmutation strategies, selection of fuel cycles scenarios
- **WP2**: Feasibility of the industrial deployment of selected scenarios and their impact on waste management
- **WP3**: Assessment of waste streams, waste features, leach resistance, heat generation, reprocessing capability etc. for selected fuel cycles.
- **WP4**: Assessment of the benefits of P&T/C in advanced fuel cycles for waste management and geological disposal.
- **WP5: **Economic, environmental and societal assessment of fuel cycle strategies
- **WP6: **Synthesis and dissemination of results

# Scenarios for Fuel Cycles

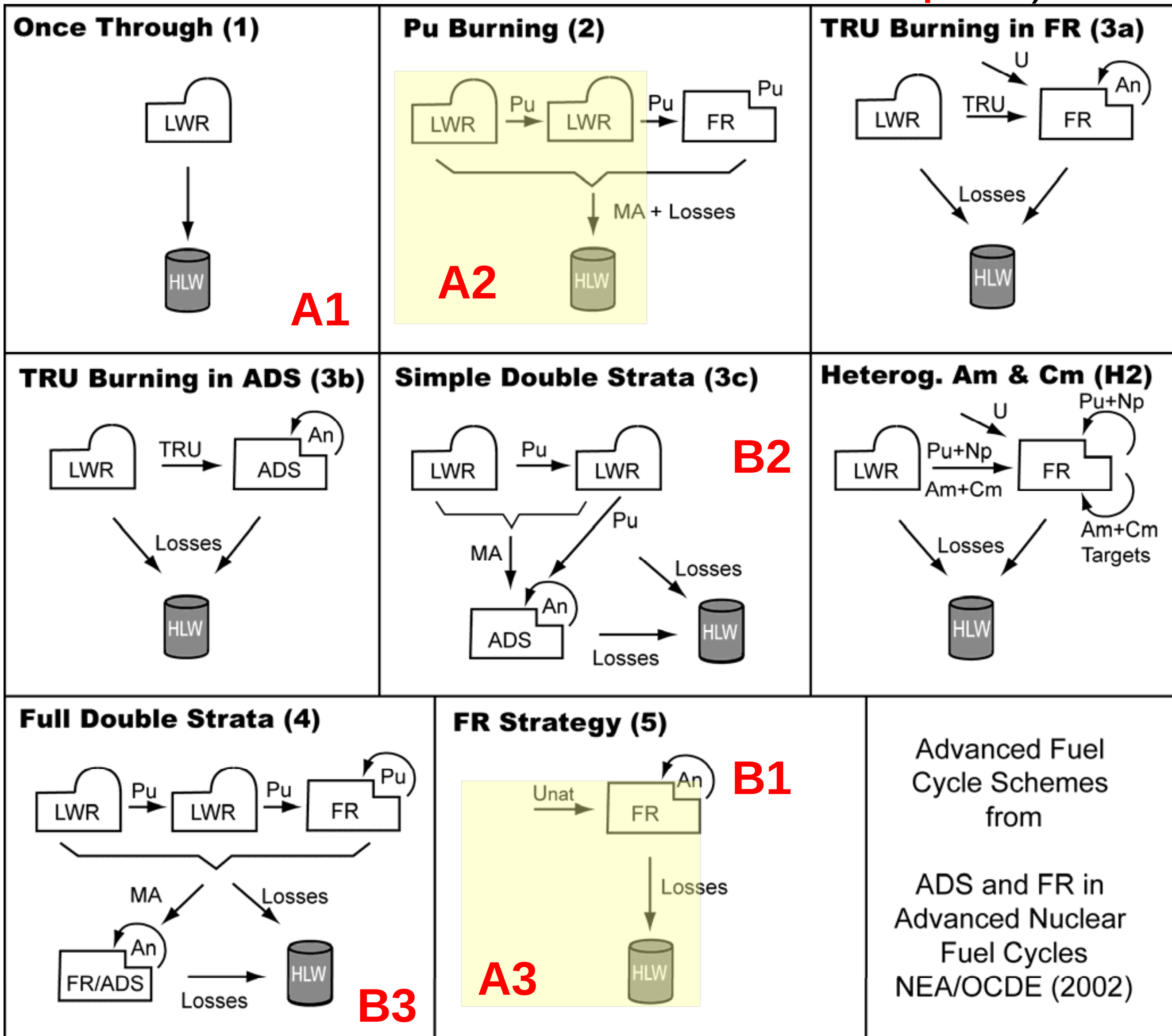



- **Industrial scenarios @ equilibrium**
  - **Scenario A1: (reference) : once through open cycle with Gen-II / III reactors**
  - **Scenario A2 : mono-recycling of plutonium in Gen-III reactors (+ variants)**
  - **Scenario A3 : Multirecycling of Pu (only) in Sodium Fast Reactors (EFR)**
- **Innovative scenarios @ equilibrium**
  - **Scenario B1 : Multi-recycling of Pu & MA in Sodium Fast Reactors (EFR) plus advanced PUREX**
  - **Scenario B2 : mono-recycling of plutonium in Gen-III reactors and burning of Minor Actinides in ADS plus advanced PUREX & PYRO**
  - **Scenario B3 : mono-recycling of plutonium in Gen-III reactors + burning of plutonium in Gen-IV fast reactors + burning of Minor Actinides in ADS including advanced PUREX and PYRO *(reduced efforts)***
- **Transition Scenarios**

# Scenarios for Fuel Cycles (NEA / Red-Impact)

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- Heat, RdTx, RdAc,
- Packages
- Repository C
- Volume
- P.A.: Doses

Variants & Time Dependent Scenarios



# Scenarios for Fuel Cycles

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
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Variants & Time Dependent Scenarios

Pu reprocessing in LWR (single)

The reference cooling time is 50 years

UO2 Initial enrichment in $^{235}$U = 4.20% / MOX 8.5% Pu

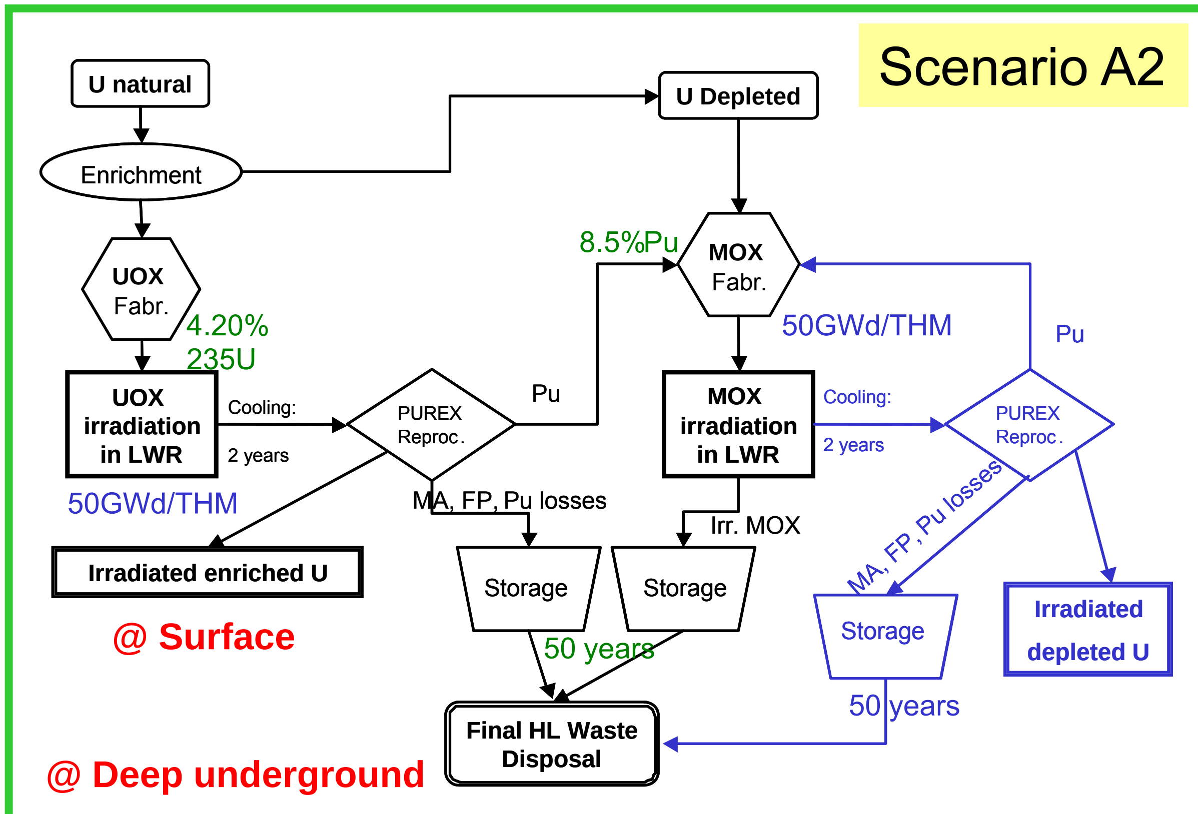
Variants:

- Multiple recycling of Pu in LWR
- Different reactors and fuels for Pu recycling
- Different fuel burnup for Pu recycling

Only presently deployed actinide (Pu) recycle

HLW Waste Streams:

- Irradiated U (enriched)
- MOX Spent fuel
- Purex HLW:
  - FF, 100% MA
  - U & Pu losses



# Scenarios for Fuel Cycles

Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
Repository C
Volume
P.A.: Doses

Variants & Time Dependent Scenarios

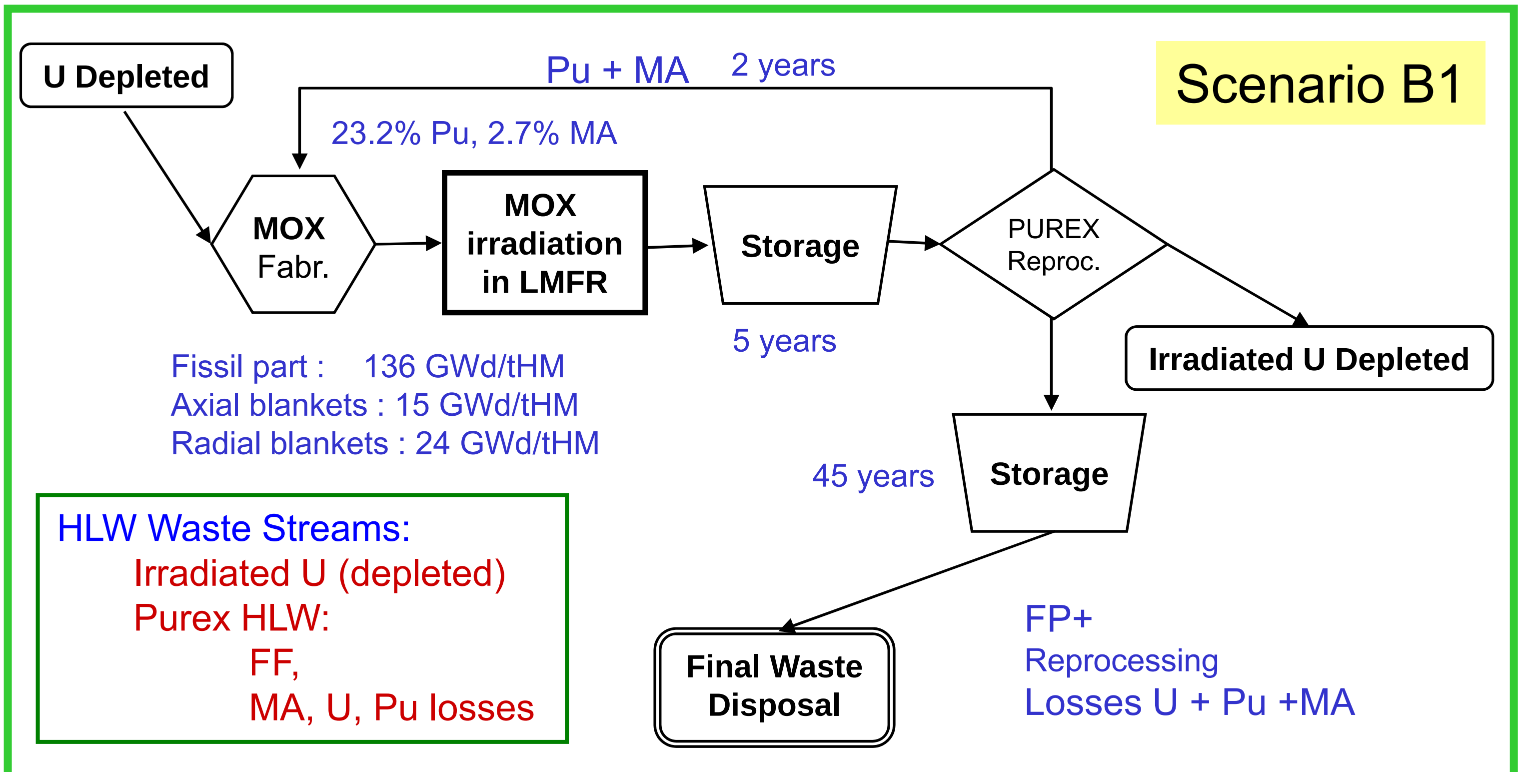
Generation IV fast reactor

EFR CD9/91, Core, Axial and Radial Blankets

23.2% Pu and 2.7% MA in “MOX”

Variants: Separate handling of FP heat sources (Cs+Sr)

- 99% Cs & Sr separated from HLW
- 99% Sr separated from HLW
- Increased FF loading of Univ. Canister (40 → 60 kg)
- Increased FF loading + 99% Cs & Sr separated from HLW
- Increased FF loading + 99% Sr separated from HLW



# Scenarios for Fuel Cycles

Simplified double strata: with LWR UOX, Mono-recycling of PU in LWR and multi-recycling of Pu+MA in fast spectrun ADS (no Fast reactor)

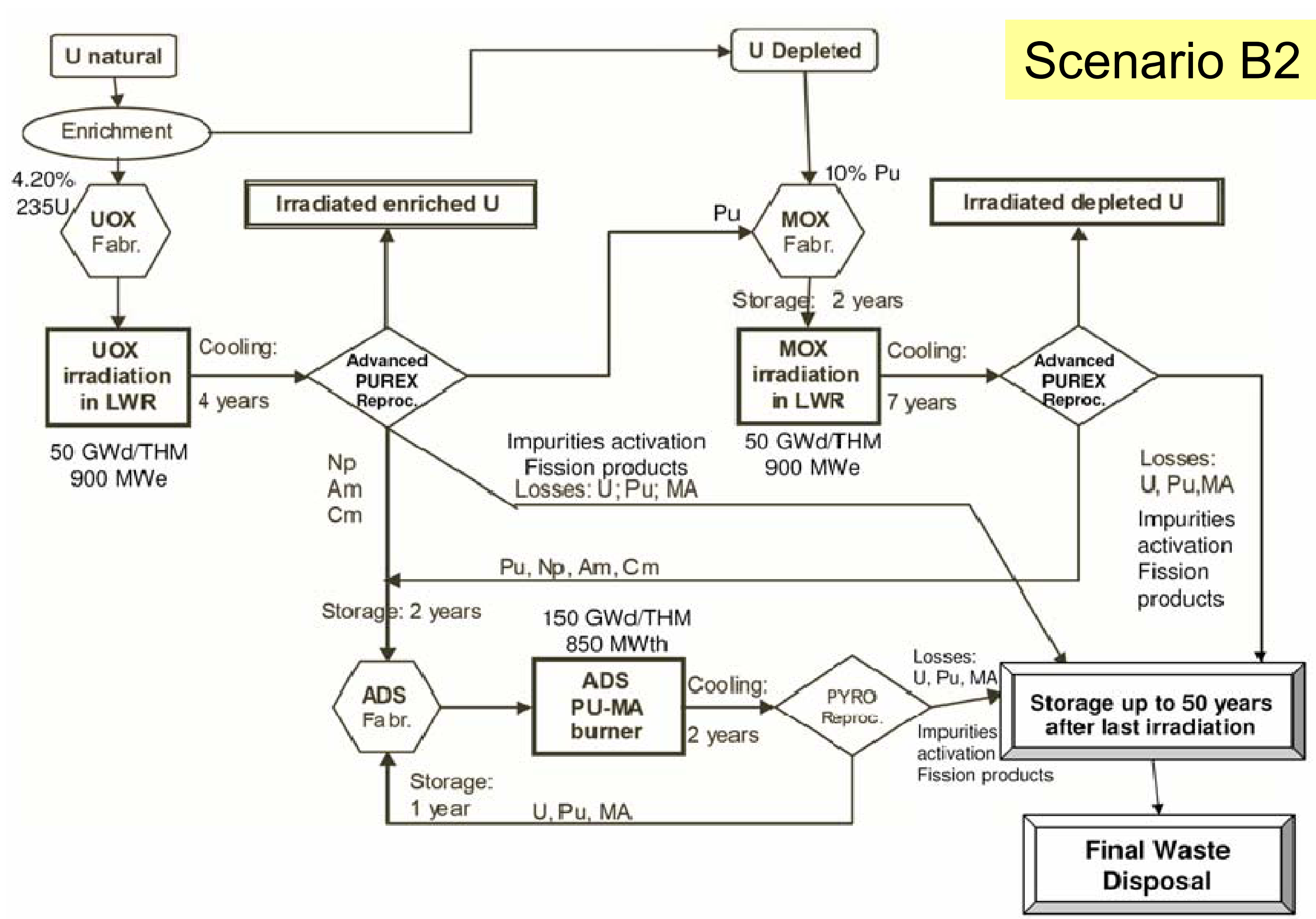
Variants: ADS with TRU Oxide fuel in $ZrO_2$ inert matrix

(+ 8.5% Pu content in MOX and 5 years LWR UOX spent fuel cooling time)

**Separate handling of FP heat sources (Cs+Sr) (studied in B1)**

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- Heat, RdTx, RdAc,
- Packages
- Repository C
- Volume
- P.A.: Doses

Variants & Time Dependent Scenarios



# Packages

Scenario

Mass flow

Waste Strs: HLW, ILW,…

Isotopic V.

Heat, RdTx, RdAc,

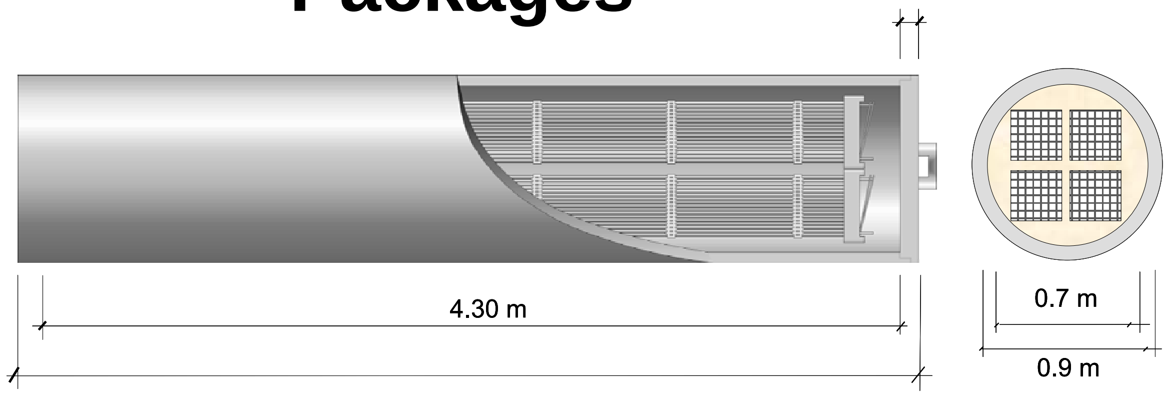
**Packages**

Repository C

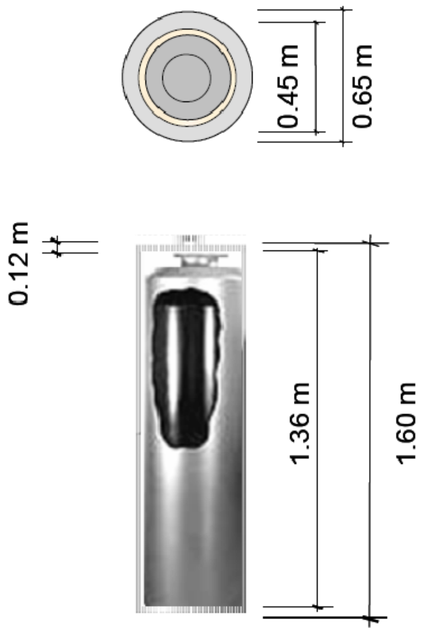
Volume

P.A.: Doses

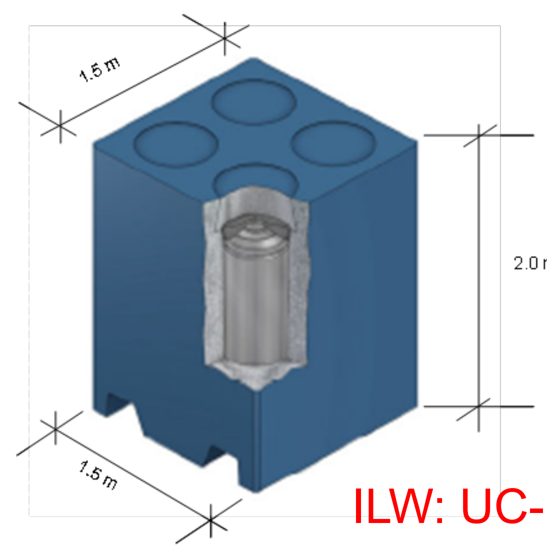
Variants & Time Dependent Scenarios




Spent Fuel: SPA




HLW: UC-V



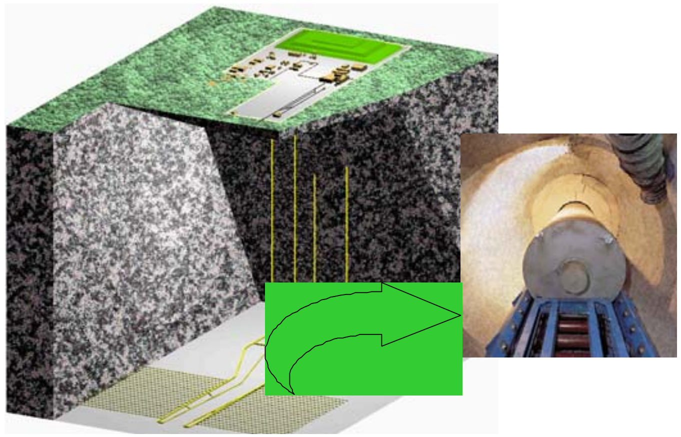

ILW: UC-C

Number of packages, volume and gallery length, heat and radiation levels (n, $\gamma$)

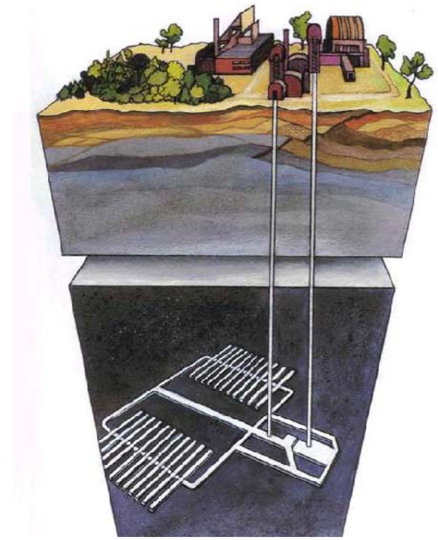
# Deep Geological Repositories

Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
Repository C
Volume
P.A.: Doses

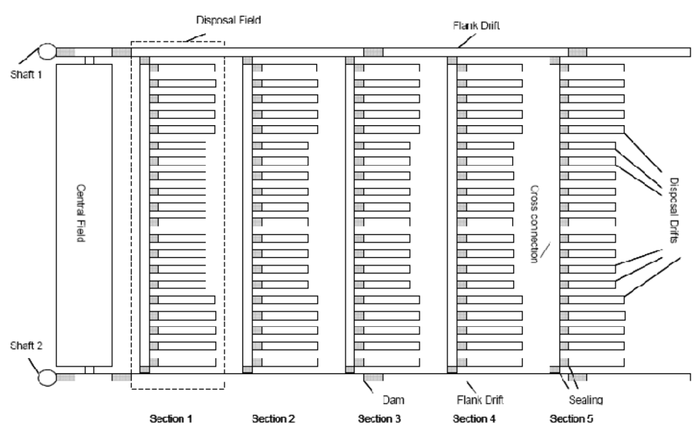
Variants & Time Dependent Scenarios



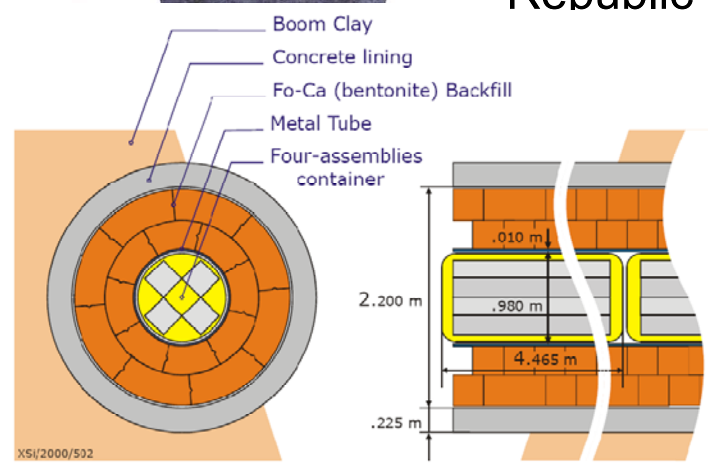
Granite Spain



Granite Czech Republic




Salt Germany




Boom Clay Belgium

# HLW: Waste Streams and Isotopic v.

Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
Repository C
Volume
P.A.: Doses

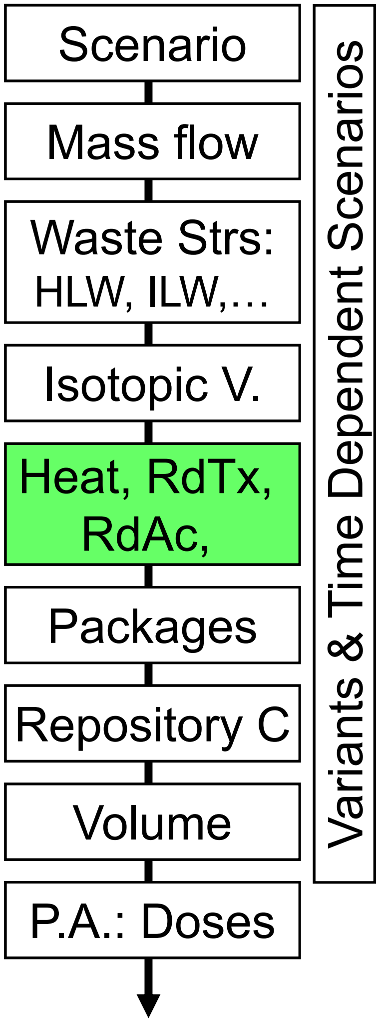
Variants & Time Dependent Scenarios

## Red-Impact- HLW hypothesis

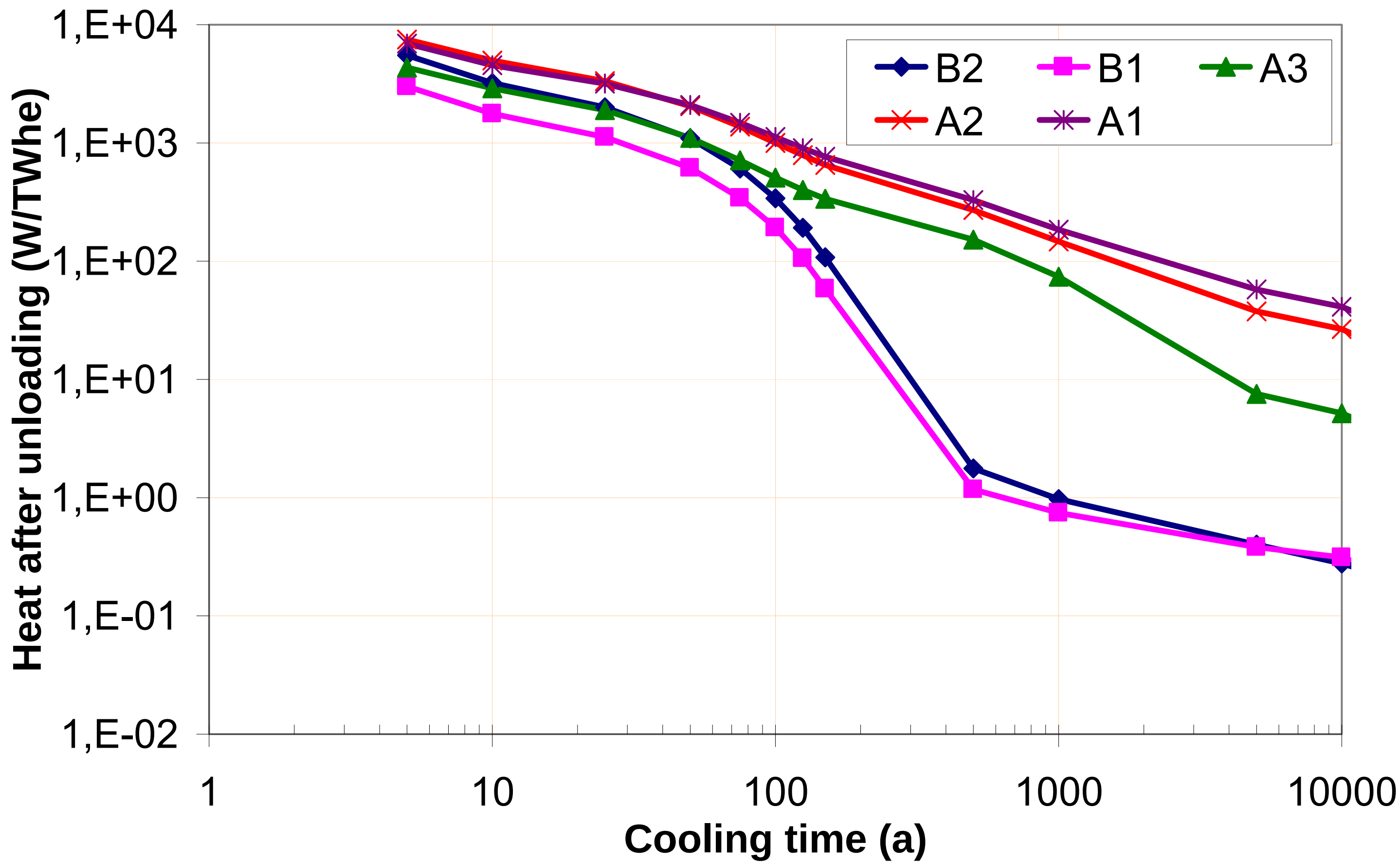
**Fractions of main chemical elements incorporated into the vitrified HLW (%)**

| SCENARIO | | A2 | A3 | B1 | B2 | | |
|---|---|---|---|---|---|---|---|
| REPROCESSING TYPE | | Standard PUREX | Standard PUREX | Extended PUREX | Extended PUREX | Extended PUREX | PYRO |
| REPROCESSED FUEL | | UOX (PWR) | Blankets + Core (FR) | Blankets + Core (FR) | UOX (PWR) | MOX (PWR) | ZrN +TRUN (ADS) |
| ACTINIDES (An) | U and Pu | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | MA | 100 | 100 | 0.1 | 0.1 | 0.1 | 0.1 |
| FISSION PRODUCTS (FP) | Noble Gases | 0 | 0 | 0 | 0 | 0 | 0 |
| | Iodine | 1 | 1 | 1 | 1 | 1 | 1 |
| | Noble Metals | 100 | 100 | 100 | 100 | 100 | 0 |
| | Others | 100 | 100 | 100 | 100 | 100 | 100 |
| LIGHT ELEMENTS (Fuel Impurities) | H | 0 | 0 | 0 | 0 | 0 | 0 |
| | Carbon | 10 | 10 | 10 | 10 | 10 | 10 |
| | Chlorine | 1 | 1 | 1 | 1 | 1 | 1 |
| | Others | 100 | 100 | 100 | 100 | 100 | 100 |
| Fuel Assembly Structurals (particles) | | 0 | 0 | 0 | 0 | 0 | 0 |
| Zr of the ADS fuel matrix (also for the Zr-fission product) | | - | - | - | - | - | 1 |

# Derived magnitudes: Heat Load



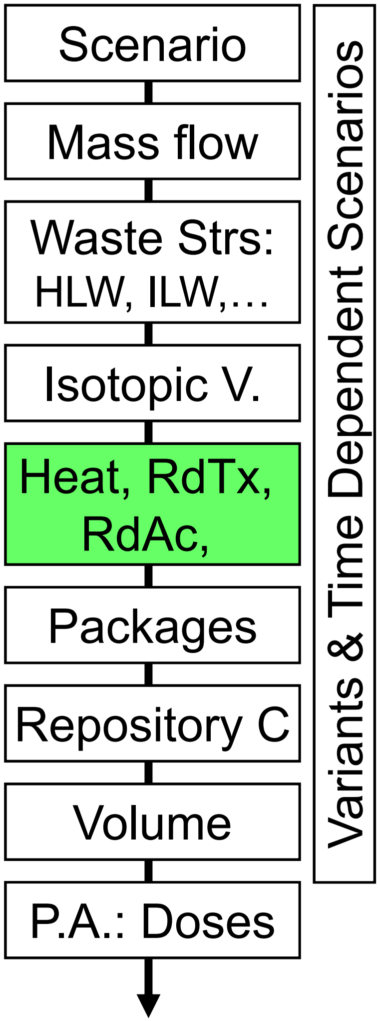

Red-Impact HLWs (total) thermal power evolution with time

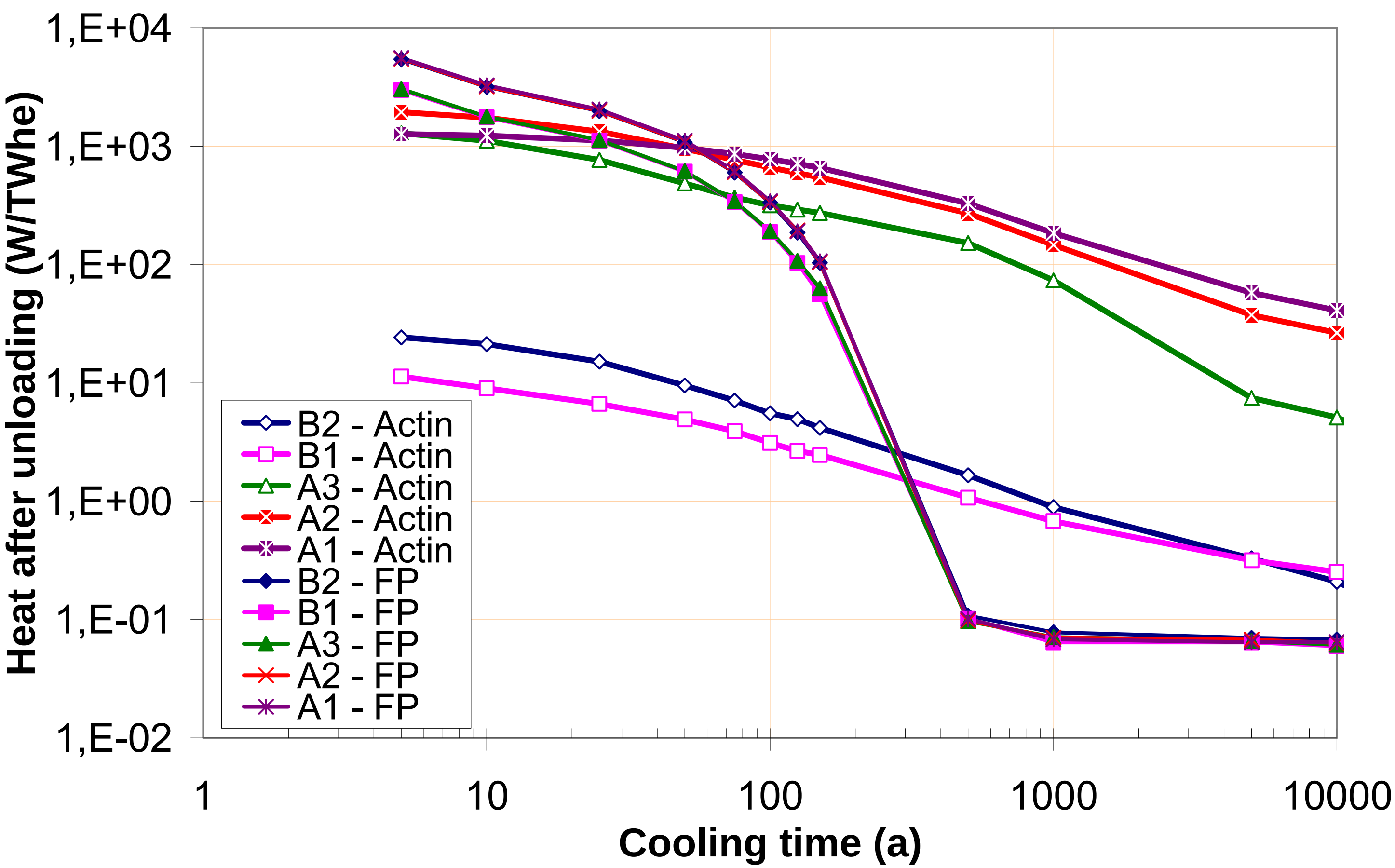


# Derived magnitudes: Heat Load

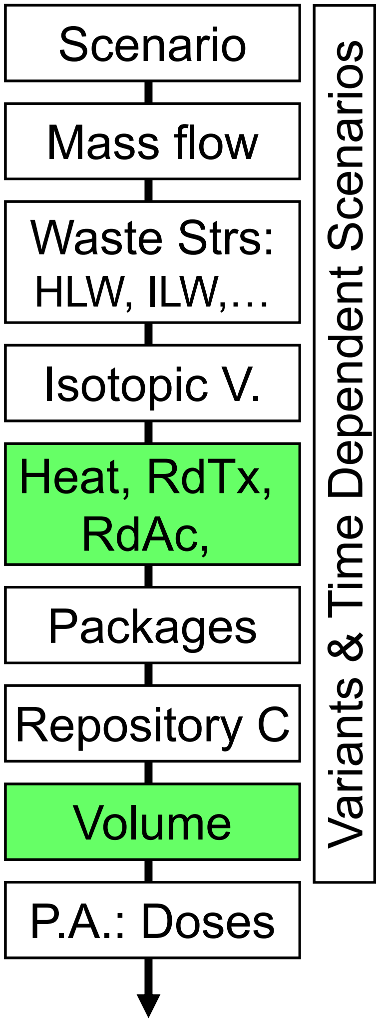
Red-Impact HLWs (total) thermal power evolution with time

(Actinides and Fission Fragments contributions)



# Derived magnitudes: Heat Load

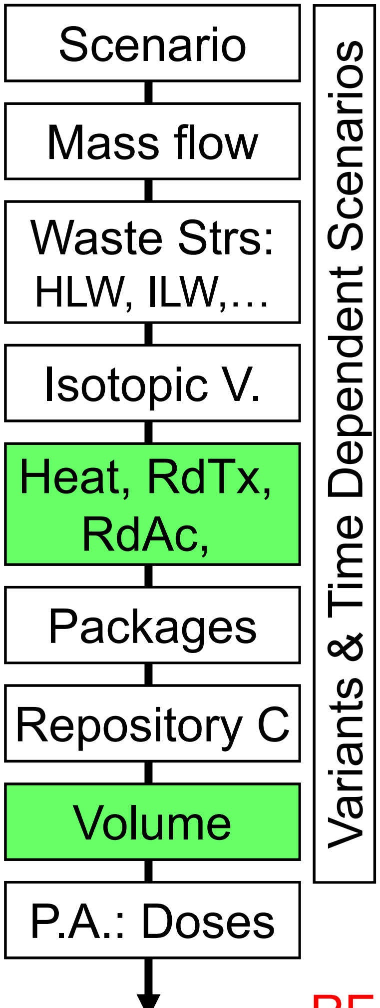



## Red-Impact HLWs thermal power (total per waste stream)

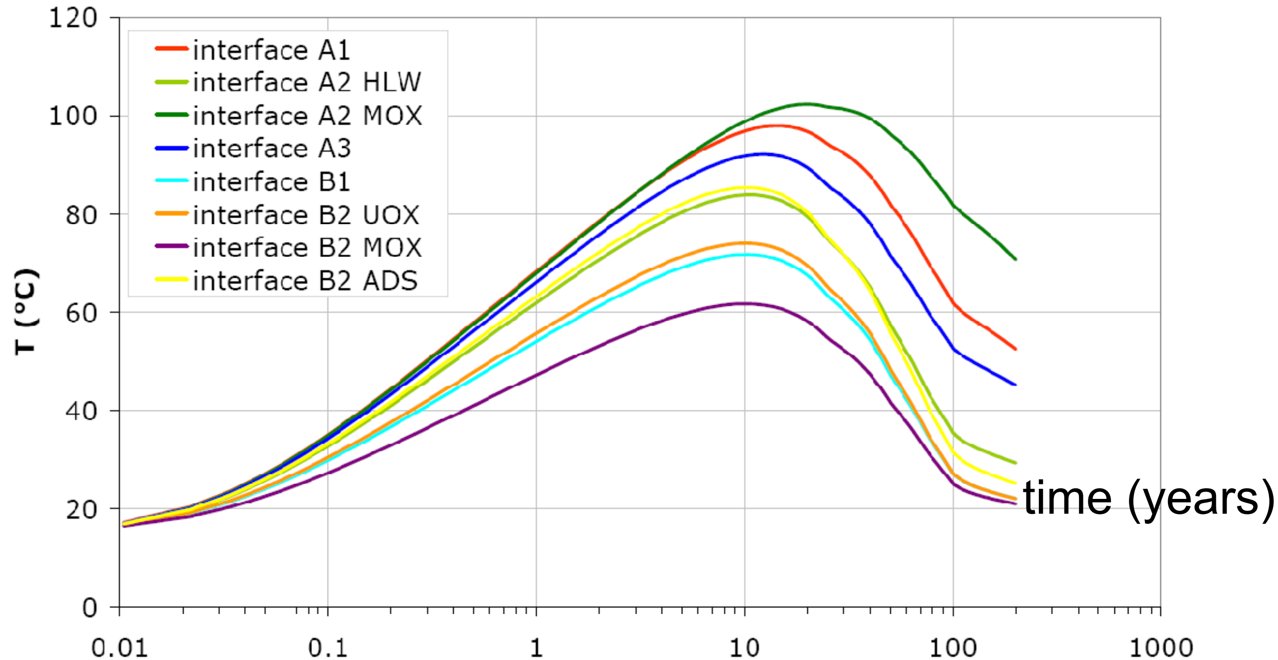
**HLW total thermal power per TWeh in the scenarios**

| Scenario | A1 | A2 | | | A3 | B1 | B2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fuel Type | LWR-UOx | LWR-MOx | LWR-UOx (reproc.) | Total A2 | FR-MOx (reproc.) | FR-MOx (reproc.) | LWR-UOx (reproc.) | LWR-MOx (reproc.) | ADS-TRU-Nitride | Total B2 |
| Thermal Power (W) after 50 years (emplacement time) | 2096 | 836 | 1205 | 2042 | 1270 | 713 | 869 | 86 | 145 | 1100 |
| Thermal Power (W) after 150 years | 766 | 457 | 275 | 732 | 384 | 73 | 83 | 9 | 17 | 108 |
| Thermal Power (W) after 1000 years | 185 | 117 | 27 | 144 | 82 | 2 | 0 | 0 | 1 | 1 |
| Thermal Power (W) after 10000 years | 43 | 24 | 2 | 26 | 7 | 2 | 0 | 0 | 0 | 1 |

# HLW Heat Load -> Capacity




The main thermal limitation for the repository concept is that the maximum temperature at the gallery lining / Boom Clay interface has to remain below 100 °C. For granite repositories the temperature in the bentonite buffer has to remain lower than 100 °C



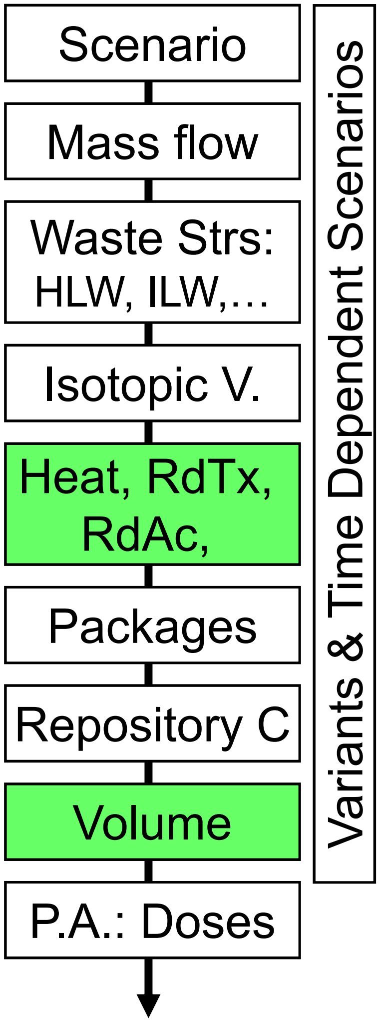

*Red-Impact temperature at the interface between the gallery lining and the Boom Clay (Belgian repository concept for disposal in clay)*

Length of the needed HLW disposal galleries B1/A1 reduced by 3

RED-Impact cases for different Granite/Clay repositories 1.6 < B1/A1 < 6

# HLW Heat Load -> Capacity

Cs & Sr separation from HLW




- Two variant scenarios of B1 in which it is assumed that only Sr or both Cs and Sr are separated from the HLW prior to vitrification studied.
- Separating Sr only, results in a further reduction of the needed gallery length with a factor 1.5, or about a factor 5 in comparison with the "once through" reference fuel cycle A1.
- Separating Cs and Sr makes that the thermal output of the vitrified HLW is so low that cooling times are not longer needed, or that other repository concepts can be used.
- However, for the estimation of the needed gallery length one should not forget that the separated Cs has to be disposed of in a geological repository also, because it contains the long-lived $^{135}Cs$ isotope (half-life 2.3 million years).
- Separating Cs and Sr, if it is assumed that the conditioned Cs-waste is disposed after a cooling time of 100 years (50 more than normal), the needed gallery length can be reduced with a factor 4 in comparison with scenario B1 and with a **factor 13** in comparison with scenario A1.
- Longer cooling times would increase the reduction factors.

# ILW: Waste Streams and Isotopic v.

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- Heat, RdTx, RdAc,
- Packages
- Repository C
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- P.A.: Doses

Variants & Time Dependent Scenarios

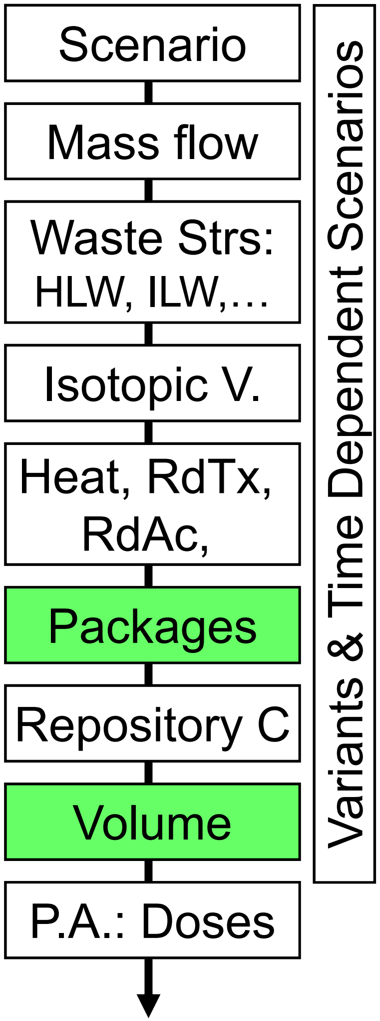
Large amounts of ILW can compromise the capacity improvements from the HLW heat reductions

## Red-Impact – ILW hypothesis

**Fractions of main chemical elements incorporated into the compacted ILW (%)**

| SCENARIO | | A2 | A3 | B1 | B2 | | |
|---|---|---|---|---|---|---|---|
| **REPROCESSING TYPE** | | Standard PUREX | Standard PUREX | Extended PUREX | Extended PUREX | Extended PUREX | PYRO |
| **REPROCESSED FUEL** | | UOX (PWR) | Blankets + Core (FR) | Blankets + Core (FR) | UOX (PWR) | MOX (PWR) | ZrN +TRUN (ADS) |
| **ACTINIDES (An)** | **U and Pu** | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | **MA** | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| **FISSION PRODUCTS (FP)** | **Noble Gases** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Iodine** | 1 | 1 | 1 | 1 | 1 | 1 |
| | **Noble Metals** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 100 |
| | **Others** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **LIGHT ELEMENTS (Fuel Impurities)** | **H** | 40 | 40 | 40 | 40 | 40 | 40 |
| | **Carbon** | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Chlorine** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | **Others** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Fuel Assembly Structurals** | | 100 | 100 | 100 | 100 | 100 | 100 |
| **Zr of the ADS fuel matrix (also for the Zr-fission product)** | | - | - | - | - | - | 100 |

# Number of Waste Packages




## Red-Impact- HLW waste packages

**HLW forms and packages production per scenario**

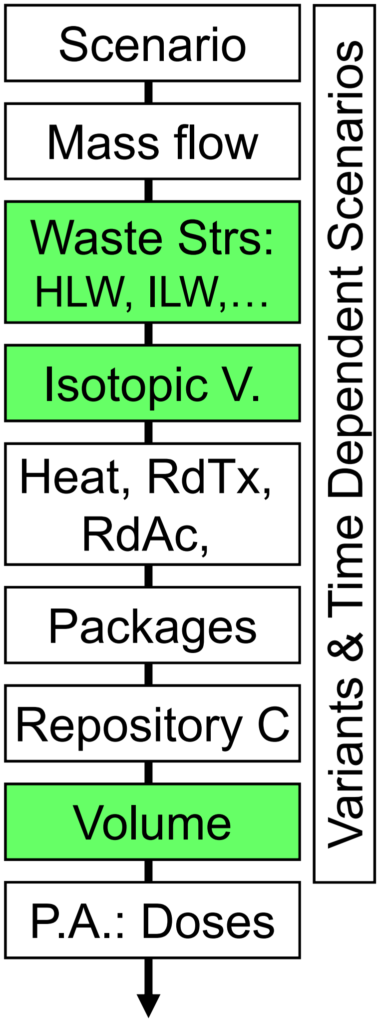
| Scenario | A1 | A2 | | A3 | B1 | B2 | | |
|---|---|---|---|---|---|---|---|---|
| **Fuel Type** | LWR-UOx | LWR-MOx | LWR-UOx (reproc.) | FR-MOx (reproc.) | FR-MOx (reproc.) | LWR-UOx (reproc.) | LWR-MOx (reproc.) | ADS TRU-Nitride (reproc.) |
| **Waste Forms per tHM** | 2.18 | 2.21 | 1.12 | 2.09 | 1.98 | 1.08 | 1.07 | 2.61 |
| **tHM / TWeh** | 2.46 | 0.25 | 2.21 | 1.15 | 1.15 | 1.91 | 0.24 | 0.12 |
| **Waste Forms per TWe/h** | 5.35 SFA | 0.54 SFA | 2.48 UC-V | 2.40 UC-V | 2.27 UC-V | 2.07 UC-V | 0.26 UC-V | 0.33 UC-V |
| **Waste Forms per HLW Package** | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Waste Packages per TWeh** | 1.34 | 0.54 | 2.48 | 2.40 | 2.27 | 2.07 | 0.26 | 0.33 |
| **Package Volume ($m^3$)** | 2.89 | 1.51 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 |
| **HLWs Volume ($m^3$/TWeh)** | 3.87 | 0.82 | 1.32 | 1.27 | 1.21 | 1.10 | 0.14 | 0.17 |
| **HLWs TOTAL Volume ($m^3$/TWeh)** | **3.87** | **2.14** | | **1.27** | **1.21** | **1.41** | | |

## Red-Impact- ILW waste packages

**ILW forms and packages production per scenario**

| Scenario | A1 | A2 | | A3 | B1 | B2 | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fuel Type** | LWR -UOx | LWR-MOx | LWR-UOx (reproc.) | FR-MOx (reproc.) | FR-MOx (reproc.) | LWR-UOx (reproc.) | LWR-MOx (reproc.) | ADS-TRU Nitride (reproc.) | ADS (operation) |
| **Waste Forms per tHM** | - | - | 1.00 | 4.10 | 4.10 | 1.00 | 1.01 | 6.22 | 0.27 |
| **tHM / TWeh** | 2.46 | 0.25 | 2.21 | 1.15 | 1.15 | 1.91 | 0.24 | 0.12 | 0.12 |
| **Waste Forms per TWe/h** | - | - | 2.21 | 4.71 | 4.71 | 1.91 | 0.24 | 0.78 | 0.03 |
| **Waste Forms per ILW Package** | - | - | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Waste Packages per TWeh** | - | - | 0.55 | 1.18 | 1.18 | 0.48 | 0.06 | 0.19 | 0.01 |
| **Package Volume ($m^3$)** | - | - | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| **ILWs Volume ($m^3$/TWeh)** | - | - | 2.49 | 5.31 | 5.31 | 2.15 | 0.27 | 0.87 | 0.04 |
| **ILWs TOTAL Volume ($m^3$/TWeh)** | **-** | **2.49** | | **5.31** | **5.31** | **3.33** | | | |

# ILW: Waste Streams and Isotopic v.




Red-Impact relevant fission and activation products in the solid wastes (HLWs + ILWs)

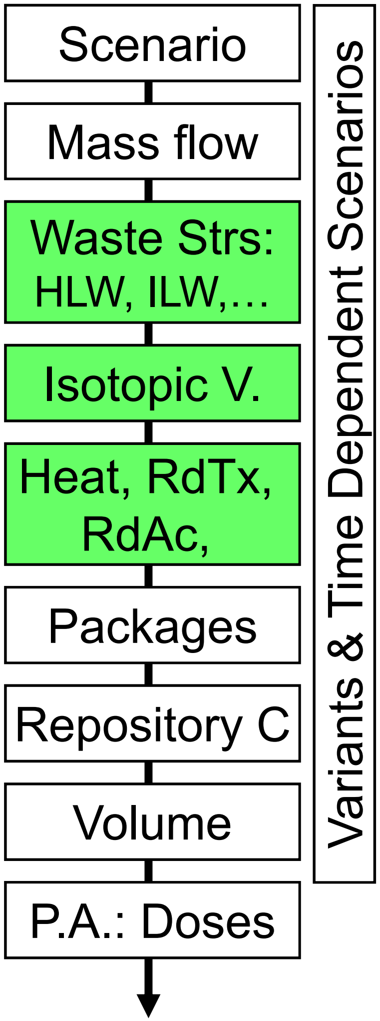
| | Nuclides | Mass of main Fission and Activation Products in Solid Wastes (g/TWeh) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1 | | A2 | | A3 | | B1 | | B2 | |
| | | HLW | ILW | HLW | ILW | HLW | ILW | HLW | ILW | HLW | ILW |
| | Fission Prod. | 125810 | - | 106110 | 195 | 89723 | 189 | 89936 | 189 | 103868 | 191622(*) |
| AI | C-14 | 0.3 | - | 0.03 | 0.01 | 0.2 | 2.3 | 0.2 | 2.3 | 3.1 | 0.1 |
| AI | Cl-36 | 6.0 | - | 0.3 | 0.5 | 0.002 | 0.0004 | 0.002 | 0.0004 | 0.04 | 0.6 |
| | Se-79 | 17 | - | 17 | 0.03 | 16 | 0.03 | 16 | 0.03 | 17 | 0.1 |
| | Sr-90 | 571 | - | 542 | 1.0 | 249 | 0.5 | 250 | 0.5 | 513 | 1.2 |
| | Nb-94 | 18 | - | 2.5 | 15 | 0 | 79 | 0 | 78.6 | 0.7 | 21 |
| | Tc-99 | 2931 | - | 2920 | 6.5 | 2298 | 209 | 2317 | 208 | 2969 | 10.9 |
| | Pd-107 | 837 | - | 937 | 1.5 | 1207 | 2.4 | 1217 | 2.4 | 828 | 296 |
| | Sn-126 | 80 | - | 85 | 0.1 | 108 | 0.2 | 109 | 0.2 | 93 | 0.3 |
| | I-129 | 634 | - | 82 | 5.7 | 6.7 | 6.6 | 6.7 | 6.7 | 6.9 | 9.3 |
| | Cs-135 | 1633 | - | 1750 | 2.9 | 4270 | 8.5 | 4270 | 8.5 | 2336 | 6.5 |
| | Cs-137 | 1405 | - | 1405 | 2.5 | 1137 | 2.3 | 1133 | 2.3 | 1455 | 3.8 |

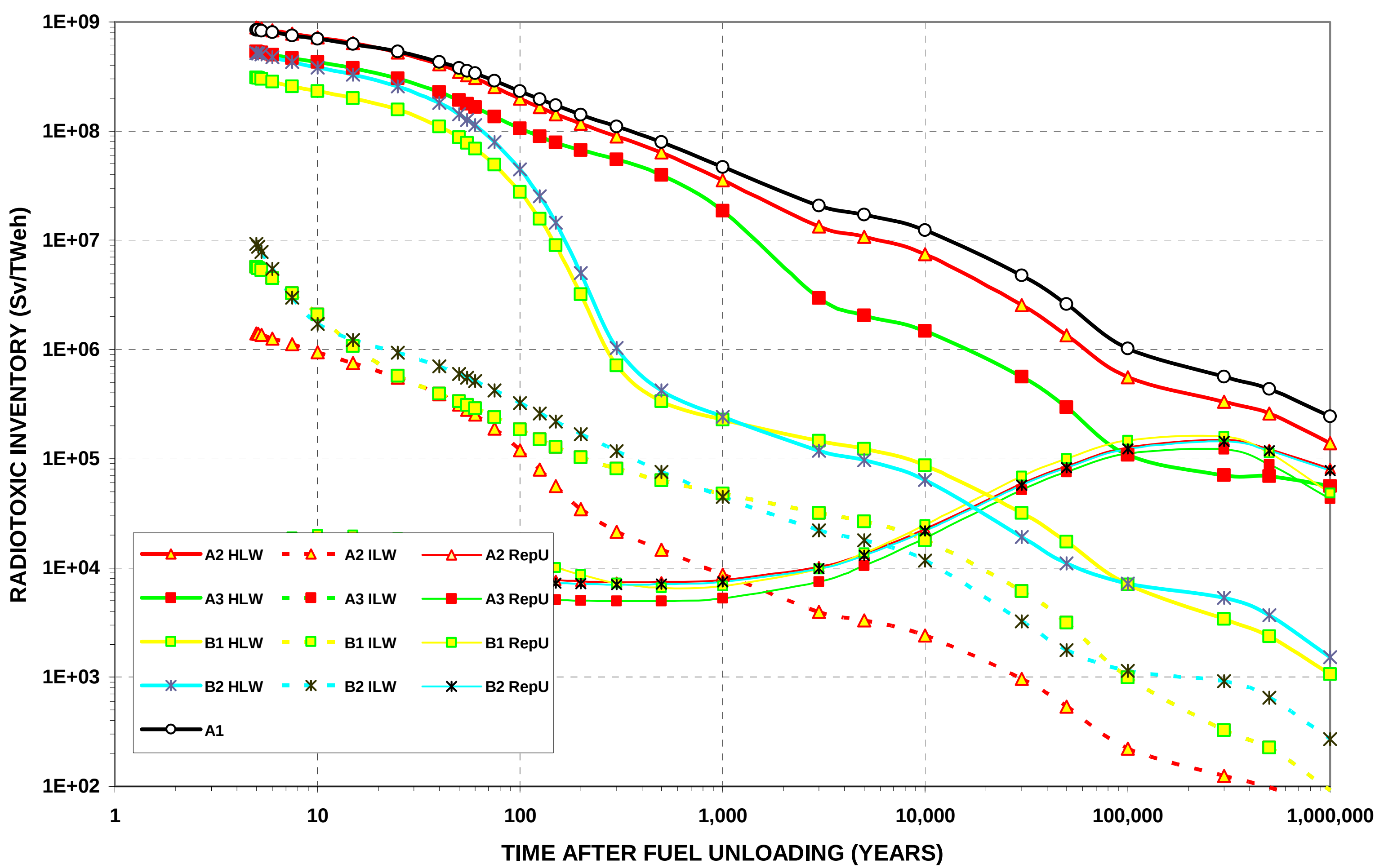
(*) Zr of the ADS fuel matrix included.

AI = Activation of impurities in fuel or structural materials

# HLW + ILW: Radiotoxicity

Red-Impact HLWs and ILWs radiotoxicity evolution with time

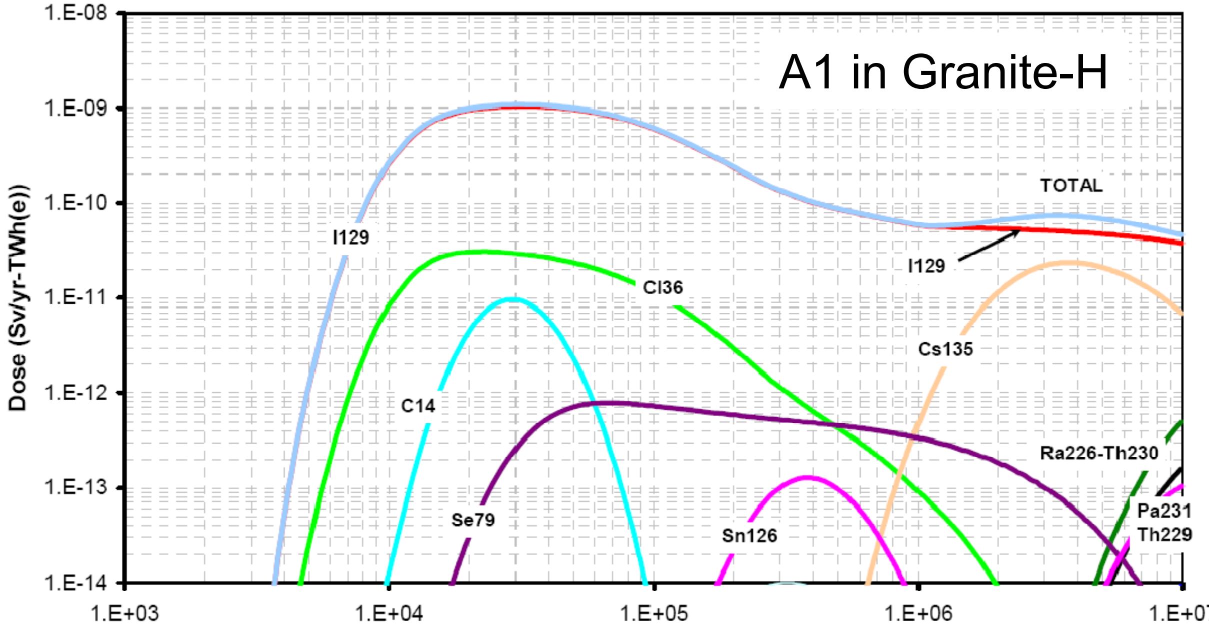


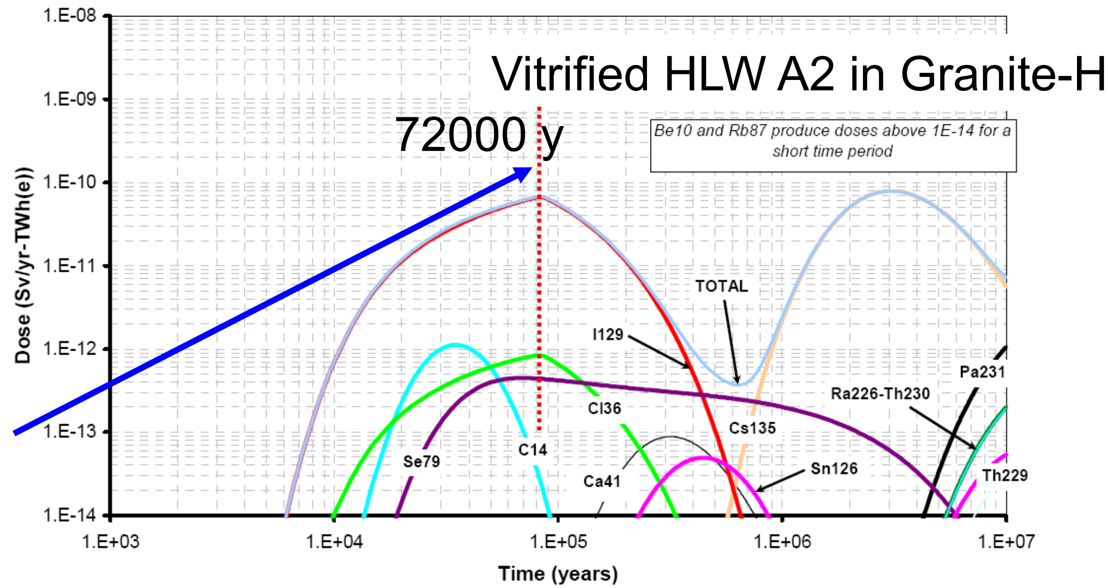
# Individual Dose from repository: HLW

Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
Repository C
Volume
P.A.: Doses

Variants & Time Dependent Scenarios




glass is assumed to dissolve completely in 72000 years

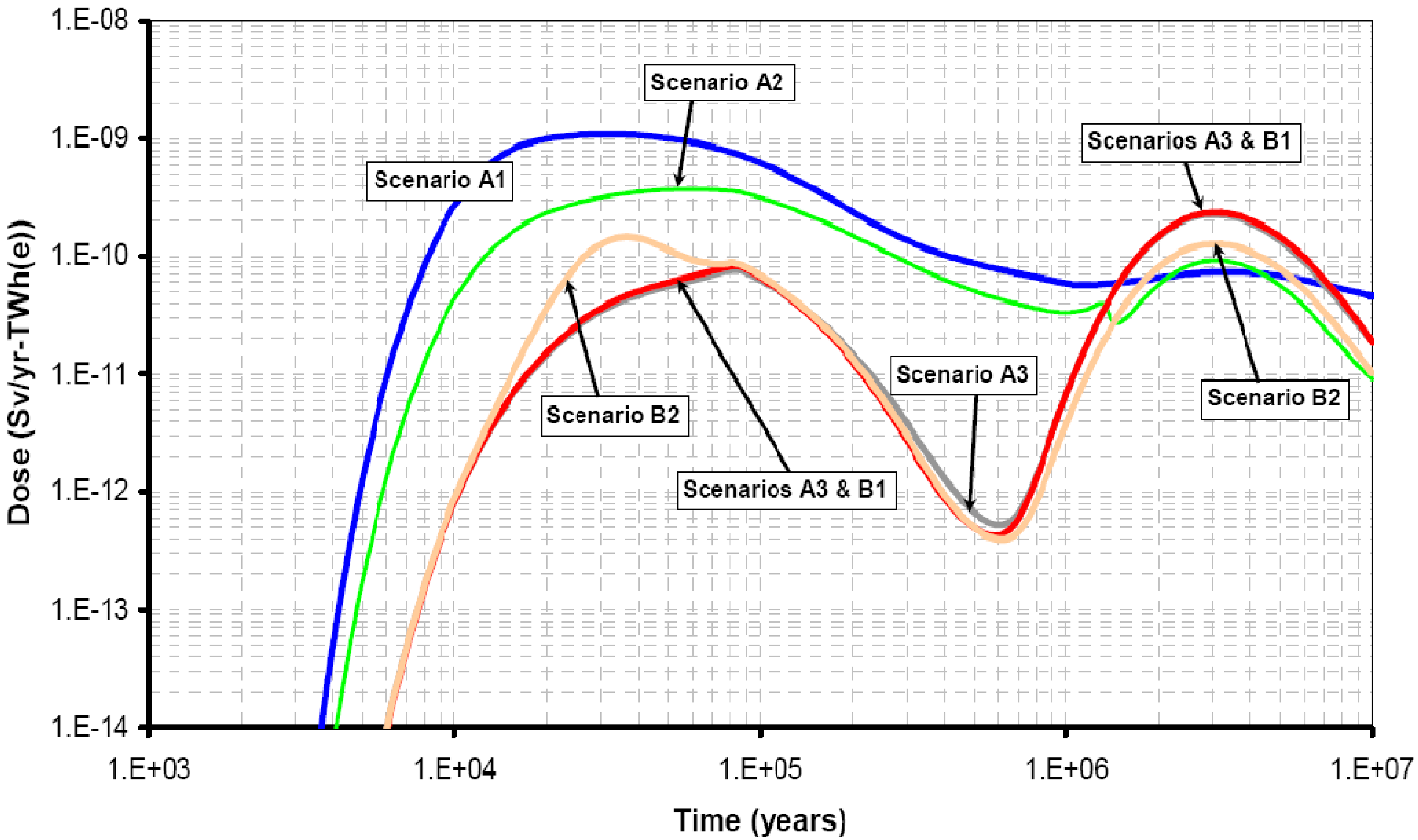


# Individual Dose from repository: HLW

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- Heat, RdTx, RdAc,
- Packages
- Repository C
- Volume
- **P.A.: Doses**

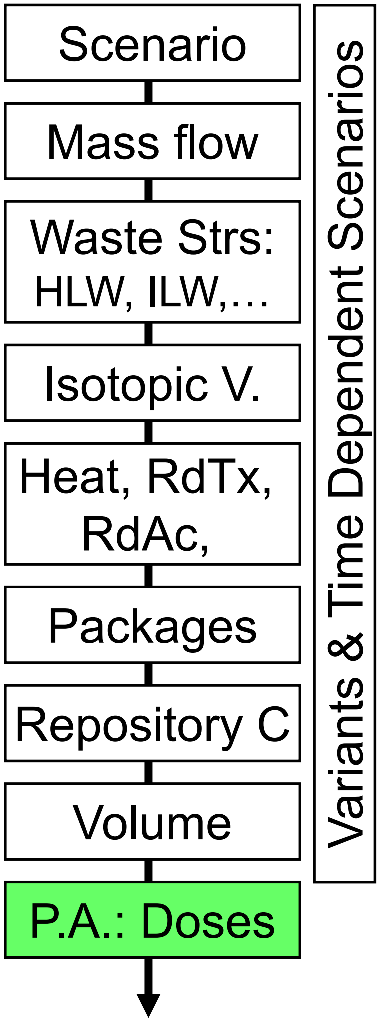
Variants & Time Dependent Scenarios

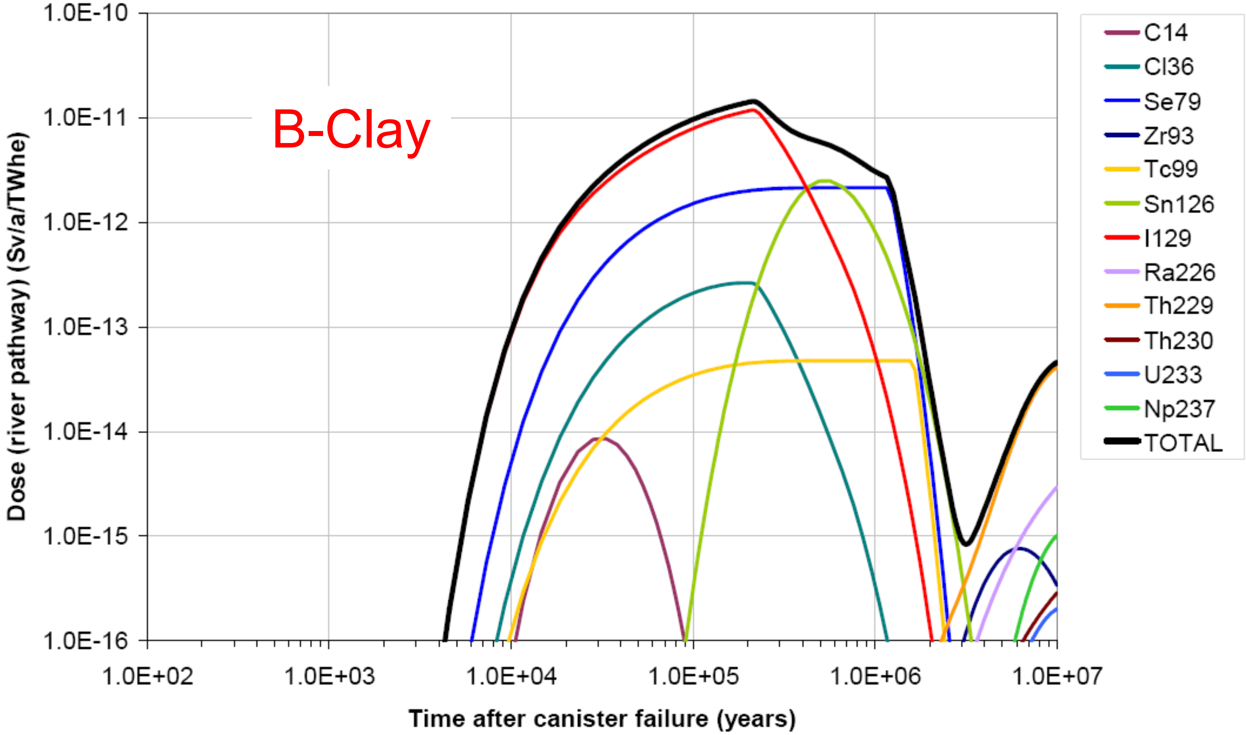
Granite-H

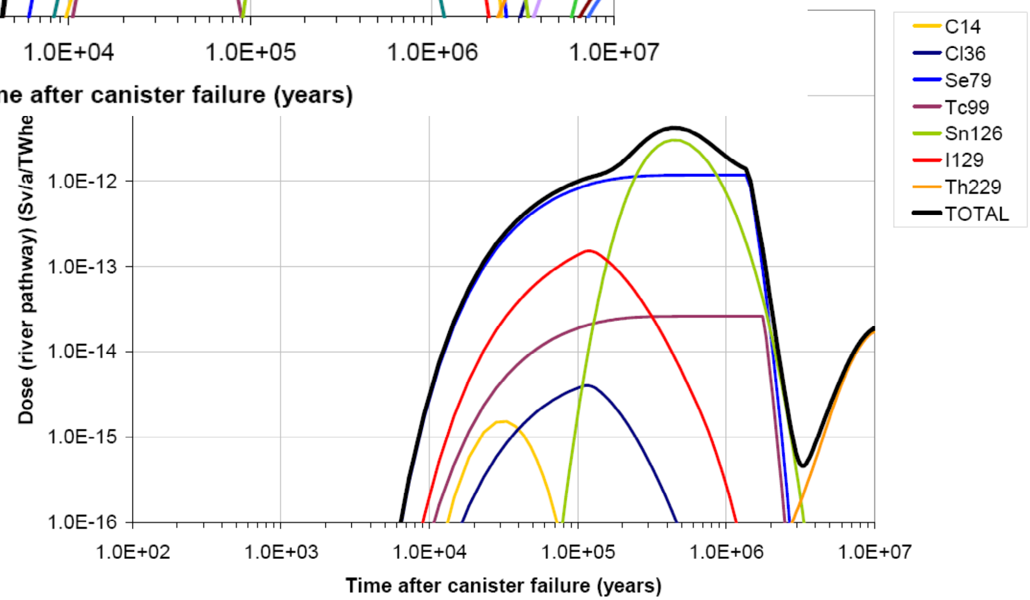



Note that the matrix lifetime has a strong effect on doses due to the mobile fission and activation products such as $^{129}I$, $^{14}C$ and $^{36}Cl$

# Individual Dose from repository: HLW



# Individual Dose from repository: HLW

Scenario

Mass flow

Waste Strs: HLW, ILW,…

Isotopic V.

Heat, RdTx, RdAc,

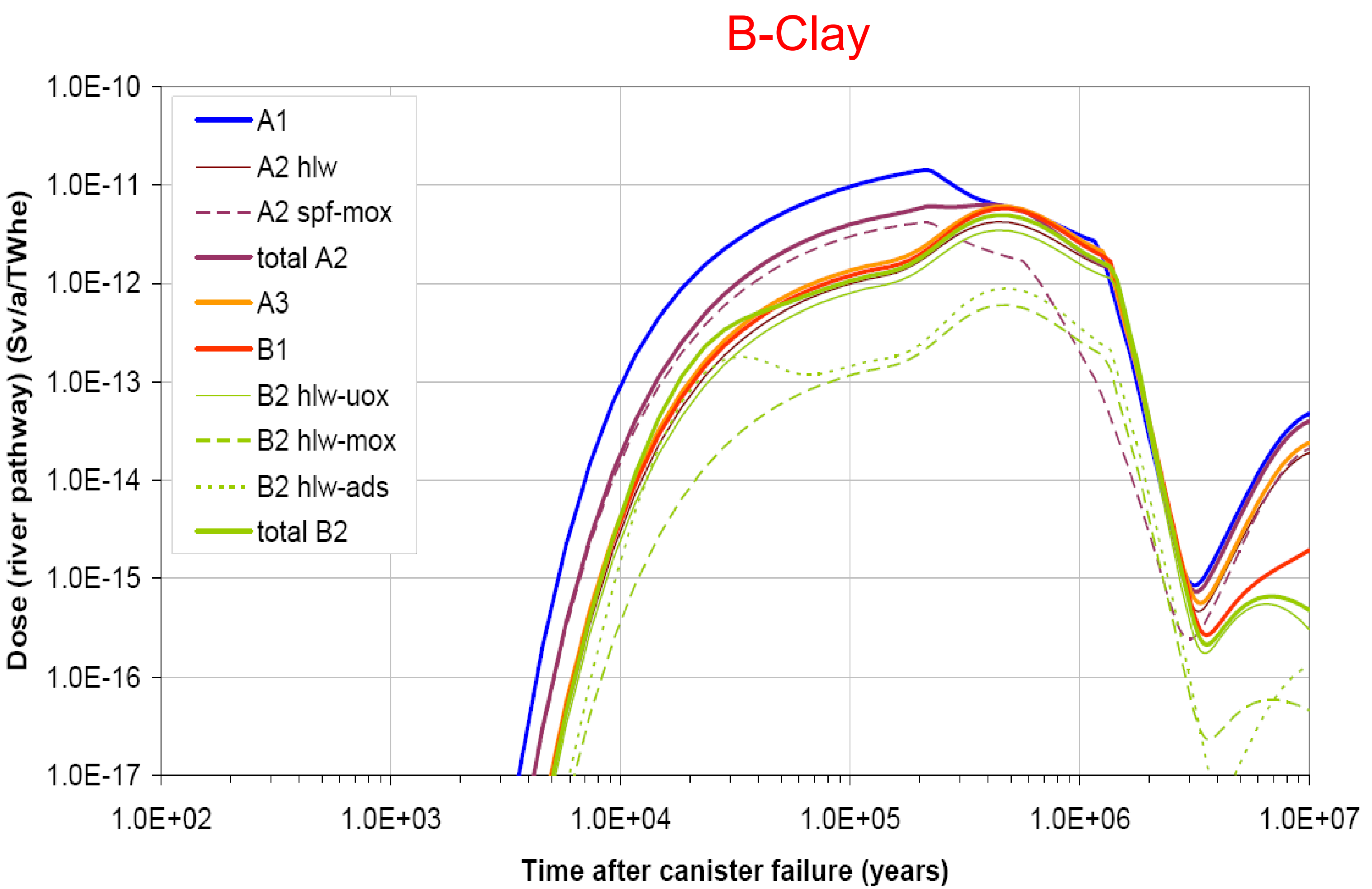
Packages

Repository C

Volume

P.A.: Doses

Variants & Time Dependent Scenarios

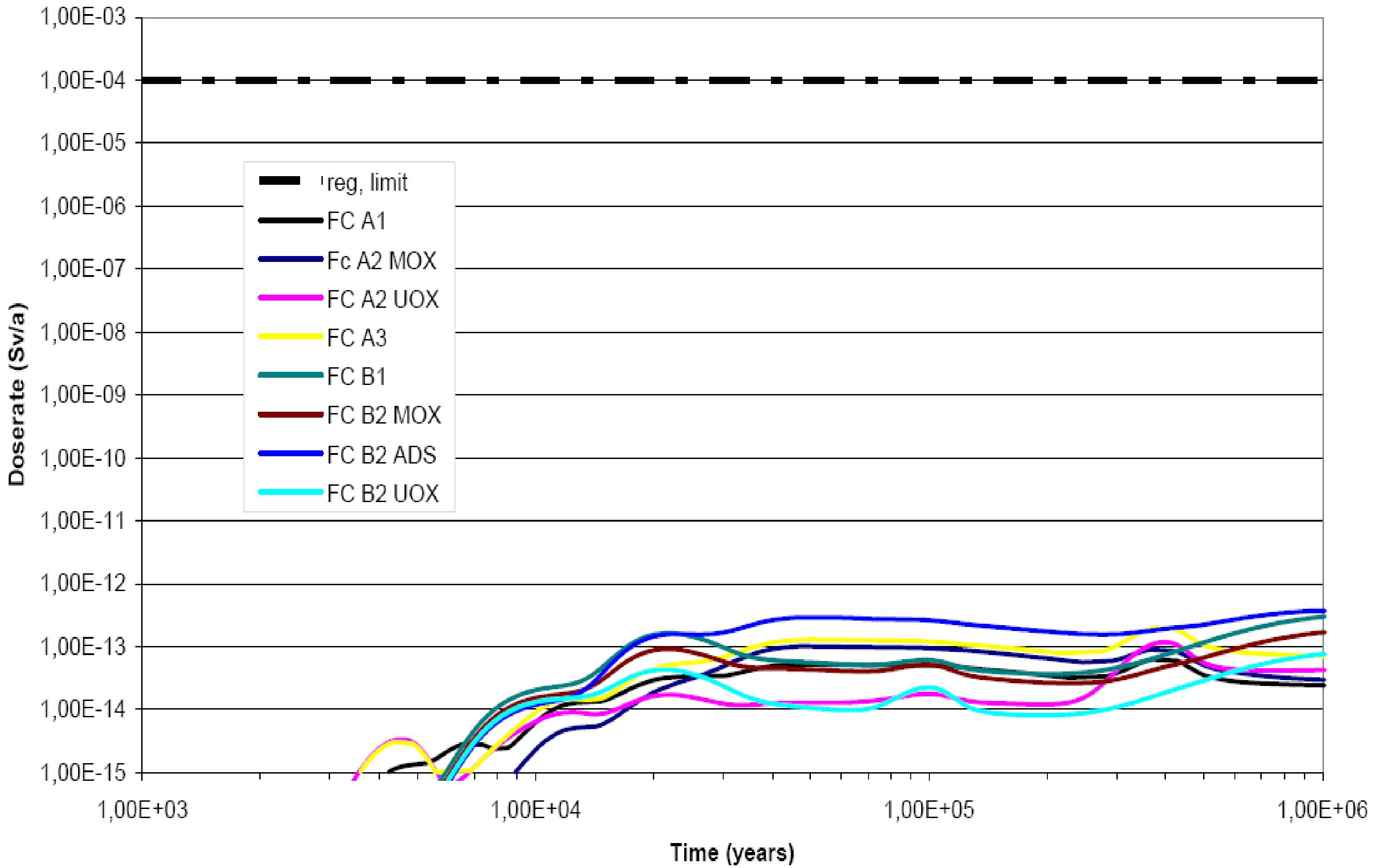


# Individual Dose from repository: HLW

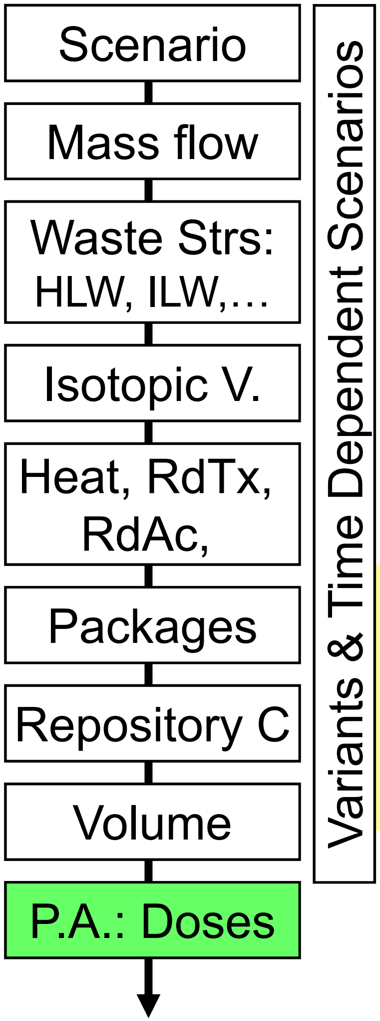
Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
Repository C
Volume
P.A.: Doses

Variants & Time Dependent Scenarios

## Salt (altered evolution)



# Individual Dose from repository: HLW

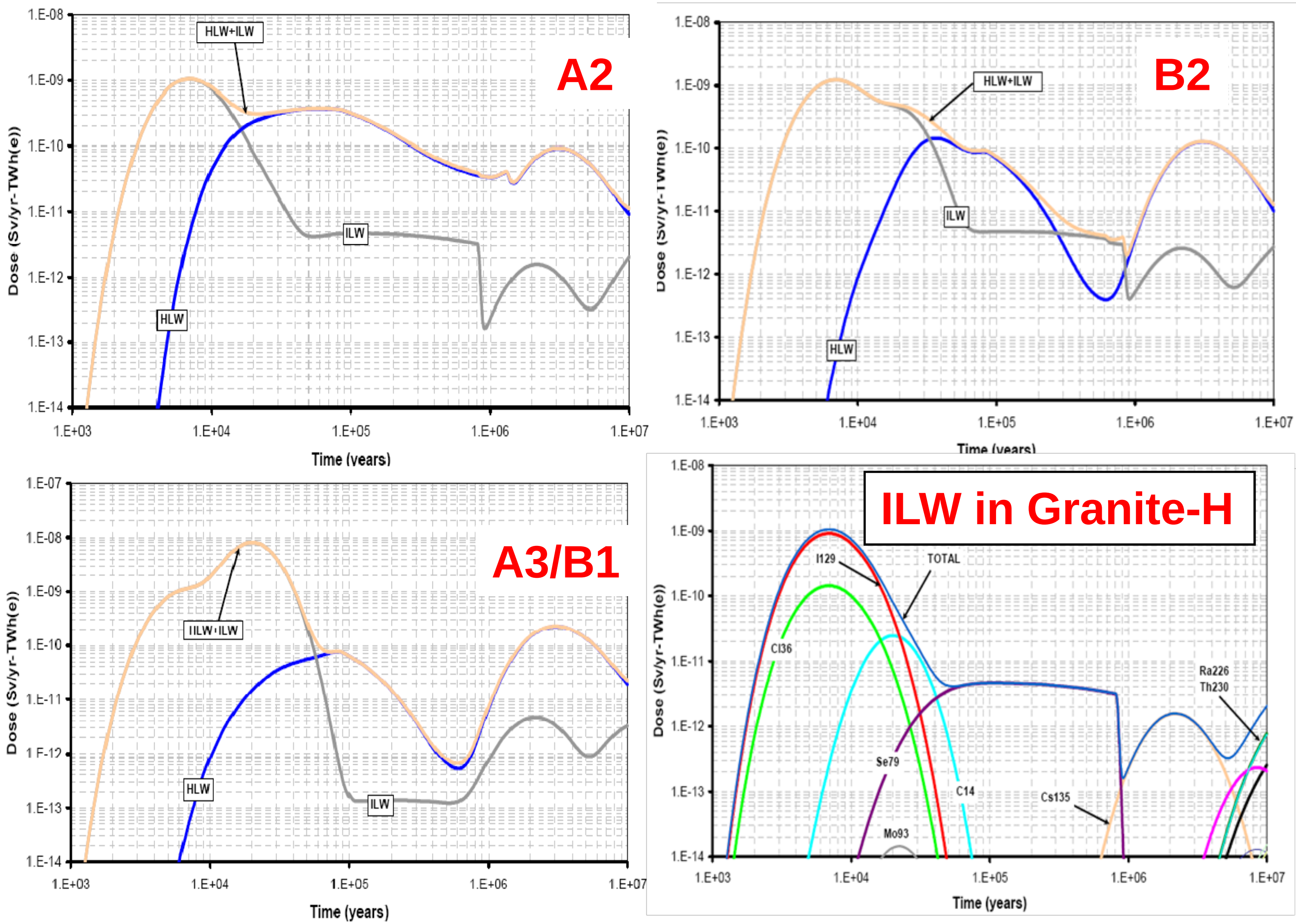



- For all considered host formations, the impact of P&T on the maximum dose is limited, because the maximum dose is essentially due to long-lived fission products.
- One of the most important contributors to the total dose is 129I. The amount of 129I going into the repository as HLW very strongly depends on the fraction of spent fuel that is reprocessed.
- For those long-lived fission products that pass to the HLW during reprocessing (79Se, 126Sn and 135Cs) doses arising from the different scenarios are quite similar.
- For 129I and 14C and 36Cl (activation products) the inventories in the HLW are much smaller than in the original fuel, because large fractions of those elements have been released as effluents.
- The decrease in doses due to 129I, 14C and 36Cl in the scenarios with reprocessing is a consequence of the reduced inventory in the HLW.
- The transmutation of most actinides in fast reactors or accelerator-driven systems in case of advanced fuel cycle scenarios has little impact on the resulting doses, because the low solubility of the actinides in reducing conditions and the strong sorption on minerals present in the buffer and host formation .
- When the waste disposal configuration is adapted to the thermal output of the disposed waste, the higher disposal density in case of advanced fuel cycles can result in a decrease of the release rate of solubility limited radionuclides (79Se, 99Tc and 126Sn,) in case of disposal.

# Individual Dose from repository: ILW

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- Heat, RdTx, RdAc,
- Packages
- Repository C
- Volume
- **P.A.: Doses**

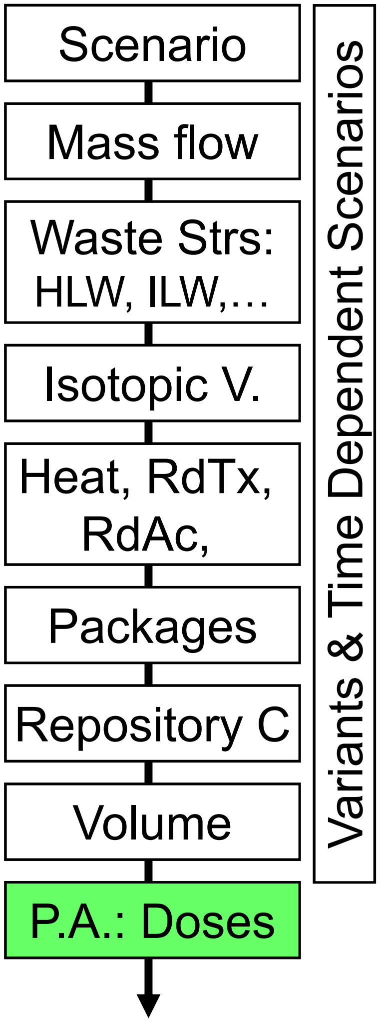
Variants & Time Dependent Scenarios



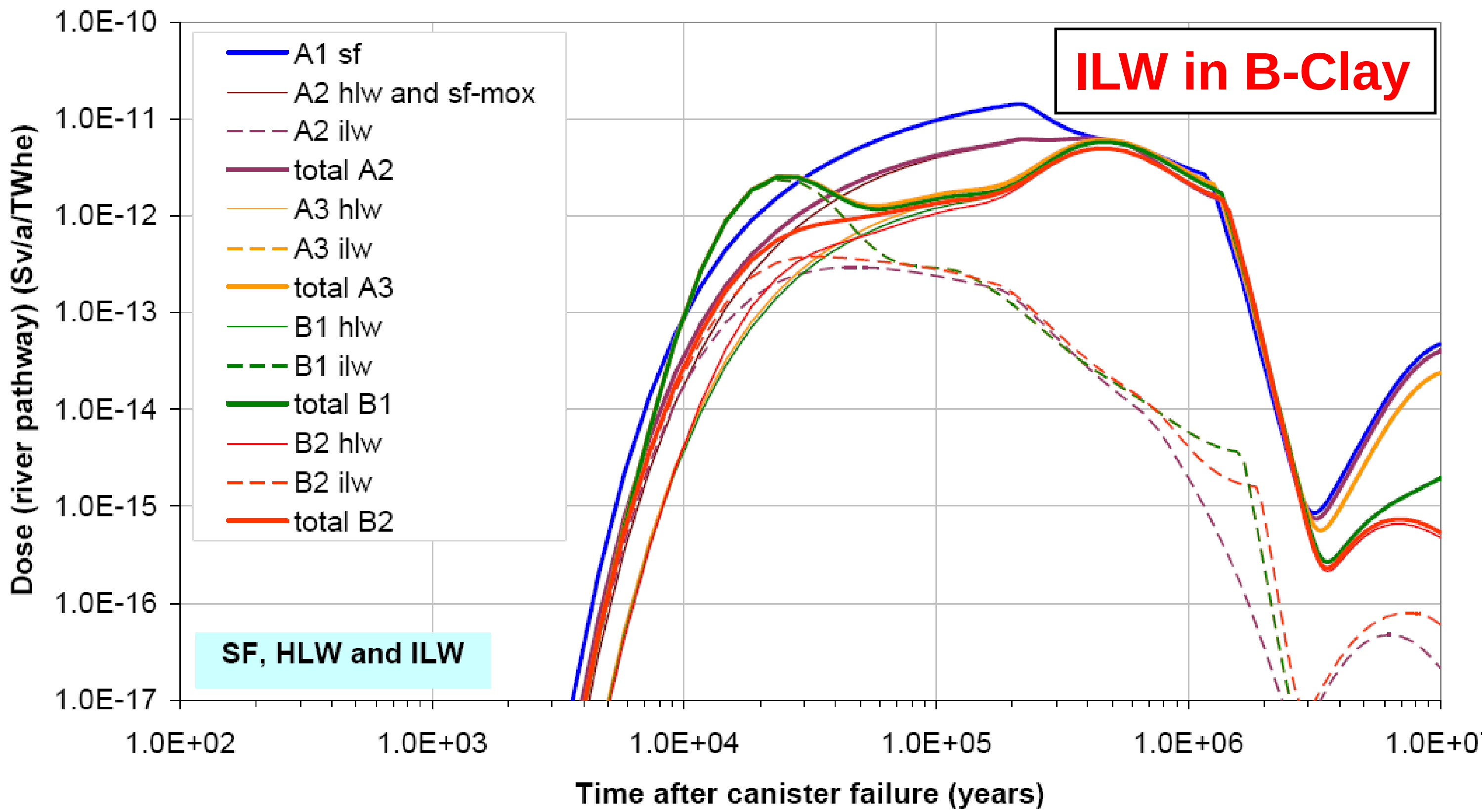

Dose from ILW dominated by I129, Cl36, C14, Cs135.

It was assumed that the waste matrix does not provide any isolation

# Individual Dose from repository: ILW

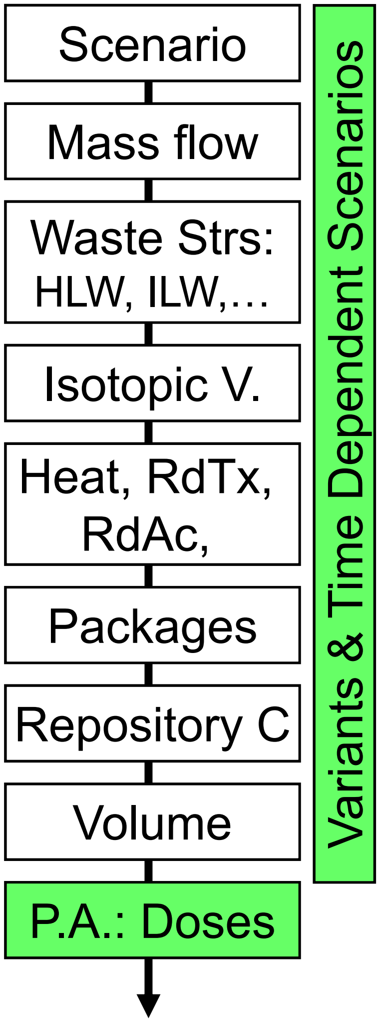


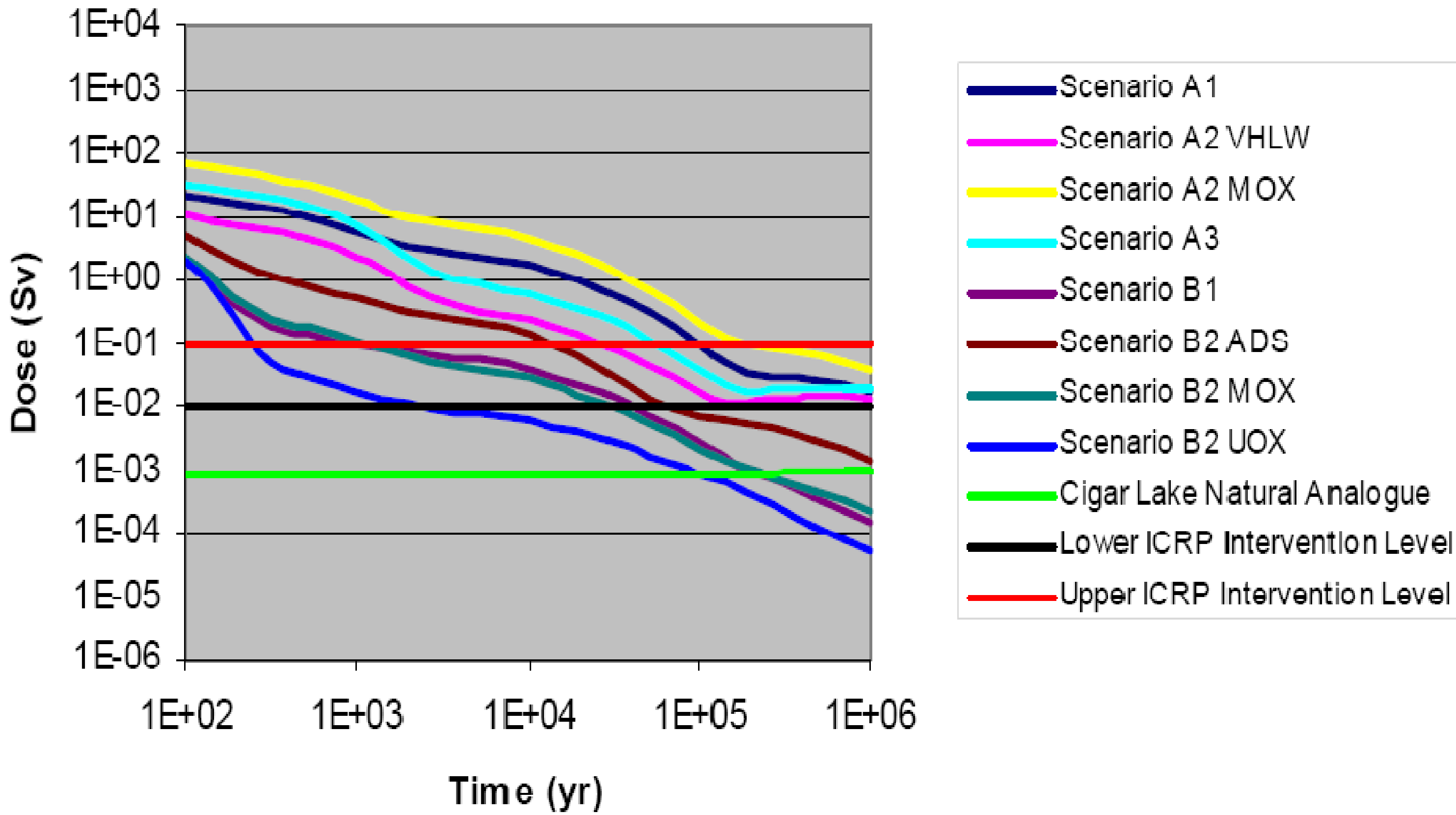

In B-Clay, the about 50-m thick clay barrier spreads the release of mobile fission and activation products from the host clay formation into the surrounding aquifer layers over several tens of thousands of years, minimizing their radiotoxicity at release time.




The the main contributors to the total dose are 129I, 36Cl and 79Se.
The matrix lifetime was taken equal to 1000 years.

# Dose Human intrusion




Annual dose in the geotechnical worker scenario, for 8 HLW and SF types vs Cigar Lake Uranium ore body and ICRP intervention levels

# Time dependent Scenarios

Scenario
Mass flow
Waste Strs: HLW, ILW,…
Isotopic V.
Heat, RdTx, RdAc,
Packages
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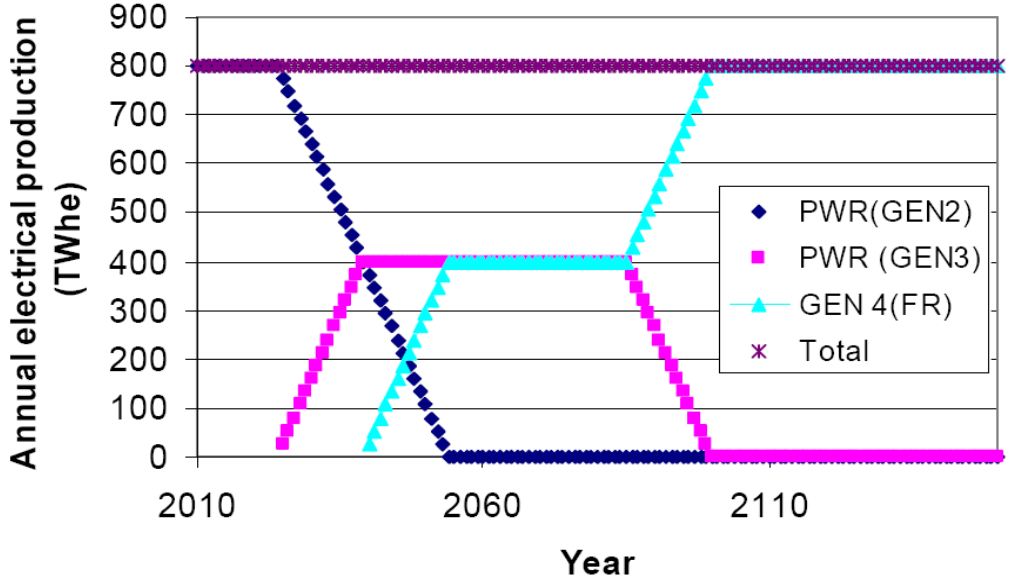
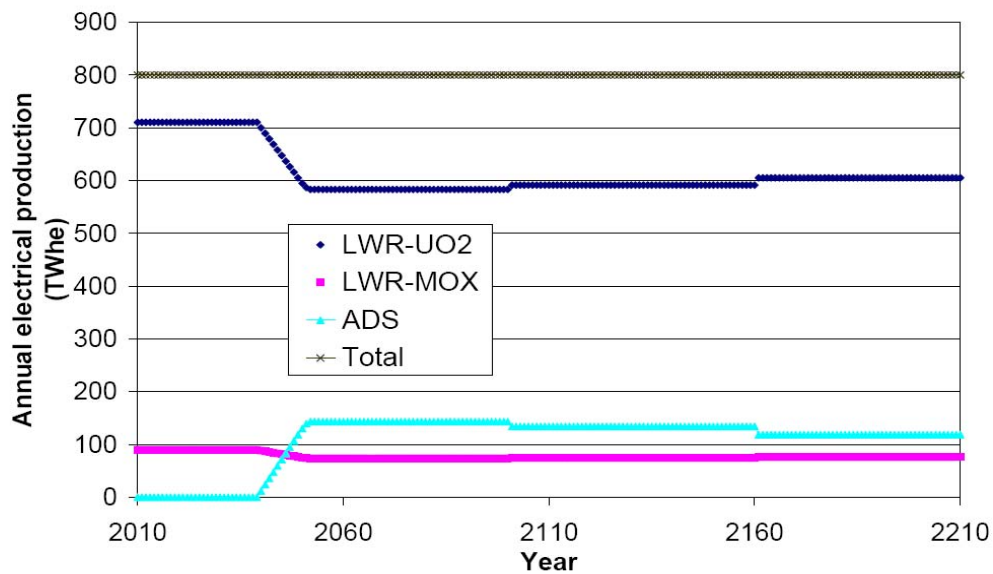
P.A.: Doses

Variants & Time Dependent Scenarios

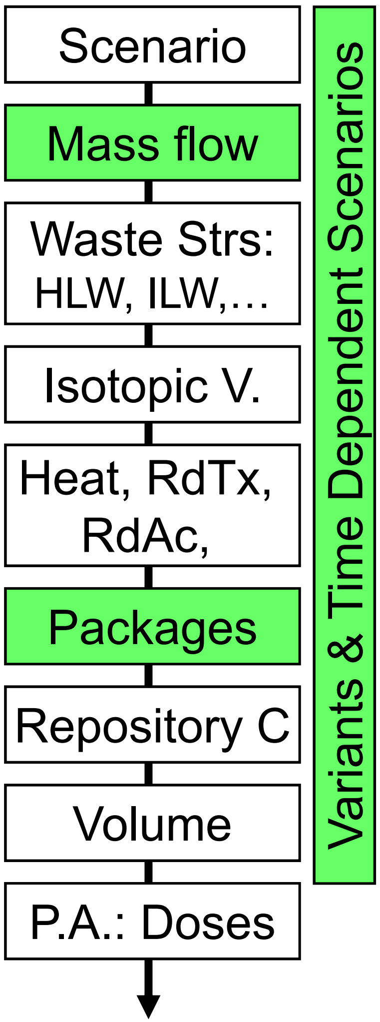
Transition Scenarios: A1 to A3 or B1



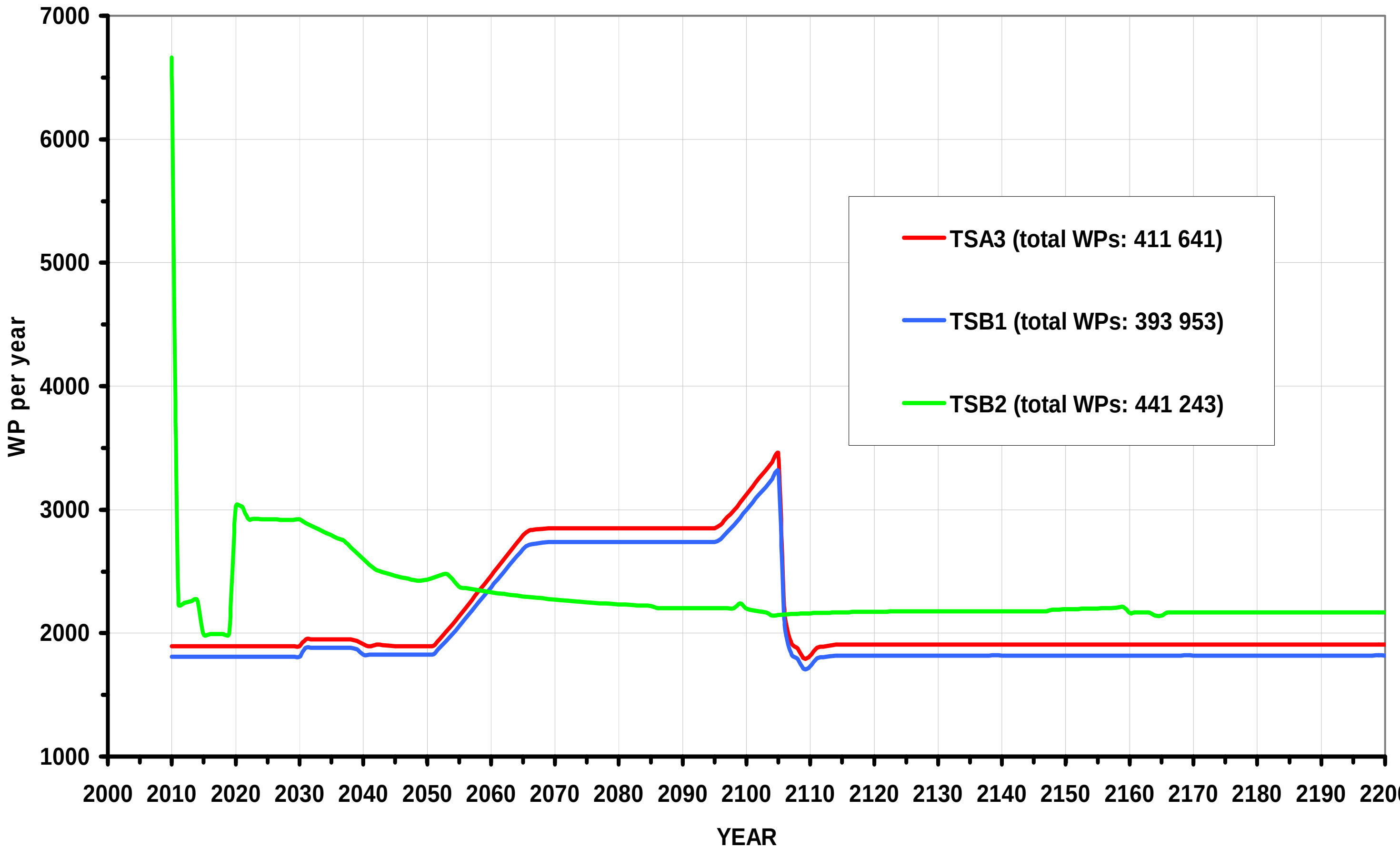

Transition Scenarios: A1 to B2



# Time dependent Scenarios




## Annual production of HLW packages in Transition Scenarios




Detailed and well anticipated planning is needed to achieve equilibrated and optimized facilities and resources utilization.

# Time dependent Scenarios

- Scenario
- Mass flow
- Waste Strs: HLW, ILW,…
- Isotopic V.
- **Heat, RdTx, RdAc,**
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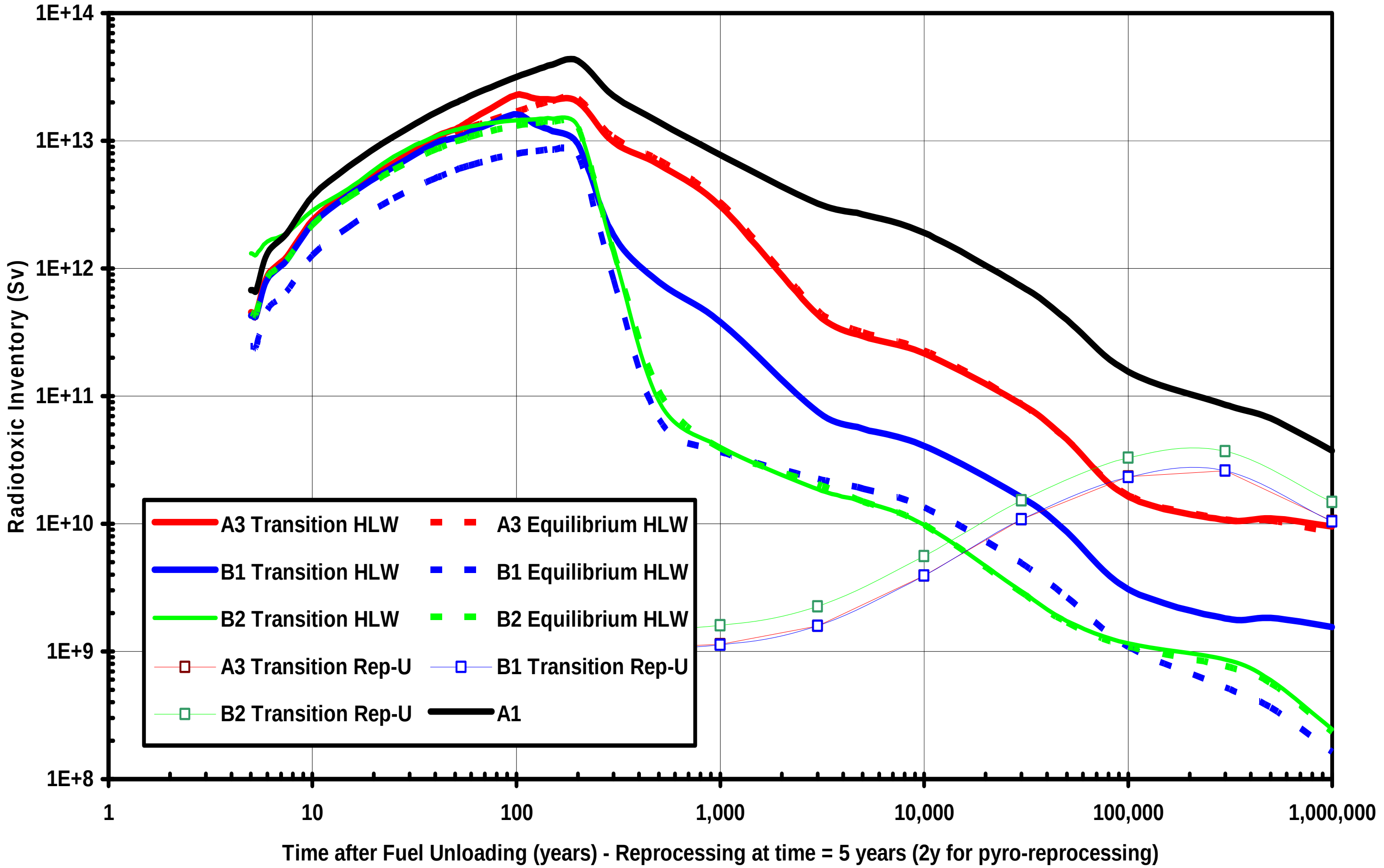
Variants & Time Dependent Scenarios

## Radiotoxicity inventories for transition scenarios




Optimized program of reprocessing as a function of technology maturity to achieve maximum improvements on radiotoxicity inventory and capacity of the repository.

# Red-Impact main conclusions

FP6 RED-IMPACT project has extended the 2002 & 2006 NEA/OCDE studies on P&T adding improvements on:

- A more complete evaluation of wastes:
  - intermediate level wastes, ILW,
  - more detailed structural materials and fuel impurities activation
  - the activation of all the specific components of the ADS (spallation target structural materials and coolant activation, spallation products activation,…).
- More details in the Cs & Sr separate handling scenarios,
- The performance assessment, including in this case the handling of the ILW, has been improved,
- A large effort to evaluate the transition process from the present European situation to hypothetical future scenarios.
- A first methodology to include indicators for all aspects related to waste management (technical, economical, social, environmental,…) in a single evaluation mechanism

# Red-Impact main conclusions

- P&T reduces the final waste Radiotoxicity and its Thermal Load from the wastes to the repository, and strongly accelerates the Thermal load decay after 100 years.
- This will allow to reduce the gallery length required for HLW in granite and clay repositories, increasing their capacity (factor 1.6-6). The effect is enhanced by delaying disposal to >100y from discharge, separating Sr &Cs handling or both.
- There is  small or no advantage from P&T on the dose to the average member of the critical group from the normal evolution scenarios. But significant advantage for improvable human intrusion scenarios.
- ILW could compromise the advantages if prevention is not taken:
  - Large volume of ILW (where to store then, compacted packages?, …)
  - Dose to average individual larger than from HLW (how to isolate then?)
- Transition scenarios show the importance of long term planning of resources and infrastructure availability for the feasibility and performance of P&T.
- Transition scenarios indicates that using early P&T technology before is fully functional (MA handling) might limit the final performance for scenarios mainly oriented to reduction of wastes (like reduction of nuclear park).
- Independently of the minimization technologies used, there will be always need of highly isolated final repository for the residual (losses,…) HLW.