SF-management in Switzerland:
a regulator‘s perspective

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Why look at Switzerland ???
It’s so unique!! It’s so diverse!

- 2 BWR, 3 PWR
- Different designs, different generations
- Reprocessing and direct disposal
- All reprocessing waste returned to Switzerland
- Wet and dry storage
- On-site and central storage
- High to very high burnup (53 – 70 GWd/t)
- Specific problems of small countries/customers

Nearly any problem you may get, we already know it!
The country
Switzerland:
Area 41,285 km²
Population 8.5 million
Swiss nuclear facilities
### Nuclear power plants

**Map of Switzerland showing locations of nuclear power plants:**

- **Leibstadt**
- **Beznau I & II**
- **Gösgen**
- **Mühleberg**

**Table:**

<table>
<thead>
<tr>
<th>KKW</th>
<th>Type</th>
<th>Year</th>
<th>$\text{MW}_e$</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beznau I</td>
<td>PWR</td>
<td>1969</td>
<td>365</td>
<td>Westinghouse</td>
</tr>
<tr>
<td>Beznau II</td>
<td>PWR</td>
<td>1971</td>
<td>365</td>
<td>Westinghouse</td>
</tr>
<tr>
<td>Mühleberg</td>
<td>BWR</td>
<td>1971</td>
<td>373</td>
<td>General Electric</td>
</tr>
<tr>
<td>Gösgen</td>
<td>PWR</td>
<td>1979</td>
<td>985</td>
<td>Siemens-KWU</td>
</tr>
<tr>
<td>Leibstadt</td>
<td>BWR</td>
<td>1984</td>
<td>1165</td>
<td>General Electric</td>
</tr>
</tbody>
</table>
Policy
(nuclear phase-out)
- 2011: Electricity production
  Hydro(60%) / Nuclear(40%)
Switzerland: Nuclear Phase-Out
After 2011: Energy strategy 2050

New Builds Suspended
Measures taken since Fukushima
Part of the licensees

<table>
<thead>
<tr>
<th>Measure</th>
<th>Date</th>
<th>KKB</th>
<th>KKG</th>
<th>KKL</th>
<th>KKM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back-fitting of accident-proof level and temperature instrumentation for the SFPs</td>
<td>2014</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Back-fitting of a new SFP cooling system</td>
<td>2015</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Improvement of earthquake resistance of the SFP storage building</td>
<td>2014</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back-fitting of a venting duct to remove heat from the SFP storage building</td>
<td>2014</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back-fitting of a diversified heat sink</td>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

KKM-decision: shut-down and dismantle Dec. 2019
SF management strategy
Final destination

Deep geological repository

• 3-phased site selection process

• SF/HAW-repository operational 2055-2060

• Operational period: 15 a

• Welded steel canisters, 4(PWR)/9(BWR) elements

• Storage time: up to 70 a
Strategy of Swiss SF management

- until June 2006:

  export for reprocessing: reprocessing residues, MOX and RepU fuel

- since July 2006:

  KKB: dry storage in on-site facility
  KKM, KKL, KKG: dry storage in central storage ZZL
  KKG: wet storage in dedicated on-site facility

  why KKG different? very high burn-up / MOX
Regulatory environment of predisposal

- Operating licenses of storage facilities: no expiry date! (but periodical update of SAR)
- Regulatory guide B05: *Conditioning of radioactive waste* addressing waste products and packages (reprocessing waste but not SF)
- Regulatory guide G04: *Design and operation of storage facilities* addressing storage facilities (also for SF)
- Regulatory guide G05: *Dual purpose casks for transport and storage* explicitely addressing design and manufacturing of dual purpose casks for SF and HAW
Phase 1
Reprocessing of Swiss spent fuel
Reprocessing of CH-SF: summary

- Export of 1139 t_{HM} to La Hague and to Sellafield
- Completely processed
- All allocated Pu reused as MOX-fuel
- U in the process of reuse in U_{repOX}-fuel
- HAW from La Hague (CSD-V)
- MAW from La Hague (CSD-C and CSD-B)
- HAW from Sellafield (VR)
- Return from La Hague finished 2016 ✓
- Return from Sellafield finished in 2016 ✓
Return of reprocessing waste
Some pros and cons: reprocessing

**PRO**

- Better use of fissile material
- Larger part of TU-elements and FP in inert waste form
- Less waste volume (only for utilities)
- Dedicated waste treatment

- Low investment today (only for utilities)

**CONTRA**

- Today only one cycle: rep. waste and spent MOX-fuel
- Release of 100% of Kr and Xe
- Total waste balance may even be negative
- High specific heat load of HAW disadvantage for disposal
- More transports
- Long time scale of contracts
- International affair

**Note:**

- **Bold:** safety/technical issues
- **Italic:** economic/political issues
Phase 2: Maximum Exploitation of nuclear fuel in 1 cycle
Towards very high burnup

- Since 1. July 2006: no export for reprocessing
- Storage of all new SF in Switzerland
- SF = waste !!!
- => direct storage and disposal
- Consequently decision for modified fuel-designs with increased burn-up at KKB, KKL and –especially- KKG (up to 70 GWd/t)
Some pros and cons: high burn-up

**PRO**

- Less volume of SF
- **Better use of fissile material**

**CONTRA**

- Very limited number of yet licensed cask designs
- Very long cooling times in ponds
- Limited experience of long term behavior of structural materials
- No reprocessing option
  - not acceptable at rep. facility
  - n-ysical properties of HM call for 2nd recycling in fast reactors

**bold: safety/technical issues**  **italic: economic/political issues**
Phase 2:
Spent fuel storage
Storage facilities: KKG “Nasslager”

“extension of on site sf-pool”
wet storage in separate autonomous building

capacity: 1008 fuel elements
racks for 504 installed

status: 360 SF-elements

demand: 44 SF-elements annually

on-site transfer: no ADR-transport
KKG wet storage, on site
Storage facilities: ZWIBEZ

SF-Storage as part of combined facility onsite KKB and only for KKB

transport and storage casks in storage hall;
capacity: 36 positions (12 optional)
status: 8 casks (eq. 296 fuel elements)

on-site transfer: no ADR-transport, capacity sufficient for 50a operation of both units
ZWIBEZ: dry storage, on site
Storage facilities: ZWILAG

SF and HAW-Storage as part of combined facility transport and storage casks in storage hall

capacity: 200 positions
status: 38 casks with sf
23 casks with CSD-V

For all SF from KKM, KKG and KKL after moratorium on reprocessing as well as all reprocessing waste; ADR-transports;
contains hot cell facility for routine transfer of SF
ZWILAG: dry storage, off site
Casks in dry storage facilities

Dual purpose all metal casks: cast iron or steel
except for n-moderator: PE or epoxy-resin

Bolted double lid system
with continuous leak-tightness surveillance

Additional anti-aircraft cover (safe for aircraft crash)
to replace shock absorbers of transport configuration

Inert gas filling under reduced pressure

Up to now only TN and CASTOR® type casks licensed

Pending for HOLTEC Histar 180 (DPC, bolted lids)
Pending for TN-NOVA-system (non DPC, welded)
Casks in dry storage facilities

Dual licensing regime:
ADR (transport), validity 10a
NEA (storage), validity: unlimited
but: subject to PSR of the corresponding storage

Foreseen storage time: 40-70 years

Repository startup foreseen in 2055

Consequently: Ageing management programmes

• Ageing of cask / cask components
• Ageing of cask loads (fuel elements, canisters)
• Institutional Ageing (license, SAR, documentation)
Preparing for subsequent steps

• Site selection process for geological repository is under way *Operational phase not expected before 2055*

• Responsible Agency (NAGRA) is a utility joint venture! > Clear licensee vs. regulator situation

• Funding is acquired during the foreseen operational period of the NPPs in real, state controlled funds

• NAGRA’s planning is based on a full access to the unified database of all Swiss nuclear waste and spent fuel and the Swiss national waste management program, established since 2008 and updated every 5 years.
Key features of future SF-management

• At time of disposal SF will be extracted from DPCs in a hot cell canister facility, where

• SF will be repackaged in smaller, welded dedicated disposal canisters

• The location of the canister facility is not yet decided. It could be either at the disposal site or the storage site.

• There is no requirement for a continuous revalidation of the transport certificate for any DPC-design but

• Transportability of any loaded DPC is mandatory part of the PSR for the NPPs storage facilities.
Major regulatory issues

- Many different cask designs with small numbers
- High specific workload for licensing and manufacturing control
- Long term behaviour of payloads (SF, cladding)
- Long term behaviour of key-components (baskets)
- Non standardized materials (B/Al-composite)
- Subsequent steps after storage:
  - ADR-transport after long term storage
  - transfer into disposal canister
  - management of emptied DPC
Thank you for your kind attention