Insertion of „MOX-(island)-FA“ in the first german BWR „Kahl“ (VAK)

VAK : 88 FA, 16 MW_{el}

RWE Started with MOX-Recycling in BWR in the Year 1966 (1st worldwide)

decommissioning of the plant started 1985

1st MOX insertion (1 FA)

fraction of MOX-FA in the core

100 % !
Development of Core Composition
Gundremmingen Unit B

Number of FA

1996 first MOX FAs

300 MOX FA

1984 first MOX FAs

Cycle No

8x8 Uranium
9x9 Uranium
9x9 MOX
10x10 MOX
10x10 Uranium
10x10 Repu

RWE Power - MOX Gundremmingen, PNN-KB, M.Schrader 2008
Development of Core Composition
Gundremmingen Unit C

1995 first MOX FAs

Number of FA

Cycle No

8x8 Uranium
9x9 Uranium
9x9 MOX
10x10 MOX
10x10 Uranium
10x10 Repu

RWE Power - MOX Gundremmingen, PNN-KB, M.Schrader 2008
# MOX Gundremmingen Licensing Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/1989</td>
<td>Application for license (9x9 MOX, equivalent to 3.14 w/o U235 9x9 FAs)</td>
</tr>
<tr>
<td>03/1991</td>
<td>40,000 objectors against MOX in Gundremmingen</td>
</tr>
<tr>
<td>06/1991</td>
<td>Planned public hearing in Gundremmingen (shifted to indefinite future)</td>
</tr>
<tr>
<td>01/1993</td>
<td>Public hearing at the Augsburg fairground finally</td>
</tr>
<tr>
<td>01/1994</td>
<td>9x9 MOX-License</td>
</tr>
<tr>
<td>03/1994</td>
<td>Claims against license</td>
</tr>
<tr>
<td>03/1995</td>
<td>Court procedure (3 days, refusal of claims)</td>
</tr>
<tr>
<td>06/1995</td>
<td>First MOX insertion (unit C, 16 9x9 MOX FAs)</td>
</tr>
<tr>
<td>07/1996</td>
<td>Application for license (10x10 MOX, equivalent to 3.75 w/o U235 10x10 FAs)</td>
</tr>
<tr>
<td>01/1998</td>
<td>10x10 MOX-License (02/98 claim against license, 03/98 withdrawal of claim)</td>
</tr>
<tr>
<td>06/2000</td>
<td>First 10x10 MOX insertion (unit B, 68 10x10 MOX FAs)</td>
</tr>
<tr>
<td>10/2005</td>
<td>Application for license (10x10 MOX, equivalent to 4.60 w/o U235 10x10 FAs)</td>
</tr>
<tr>
<td>02/2006</td>
<td>Extended 10x10 MOX-License</td>
</tr>
<tr>
<td>07/2008</td>
<td>Planned MOX insertion with Pu_{fiss} \approx 4.5 w/o</td>
</tr>
</tbody>
</table>

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MOX Gundremmingen, PNN-KB, M. Schrader 2008
Todays MOX-License (Licence from February 2006)

10x10 MOX-FA Boundary Conditions

Gundremmingen Units B and C

- number of fresh MOX-FA per reload ≤ 68
- number of MOX-FA in core ≤ 300 (38.3%)

\[ P_{\text{fiss}} \text{ content} \leq 5.49 \text{ w/o} \]
\[ \text{average FA } P_{\text{fiss}} \text{ content} \leq 5.49 \text{ w/o} \]
\[ \text{rod } P_{\text{fiss}} \text{ content} \leq 8.00 \text{ w/o} \]

and some restrictions in the Pu-isotopic composition
Range of „Pu-Vectors“ Included in Today's MOX-License

The proofs in the licensing reports cover every theoretically thinkable Pu-composition within the ranges given in the figure below!
MOX-Core-Management at licensing-limit
Gundremmingen, Unit B

21. Cycle
2005

300 MOX-FA
in core
**GERONIMO / TOP GUN**  Ended in 2006

<table>
<thead>
<tr>
<th>BELGIUM</th>
<th>BELGONUCLEAIRE SCK · CEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRANCE</td>
<td>AREVA NC</td>
</tr>
<tr>
<td>GERMANY</td>
<td>RWE Power / E.ON AREVA NP</td>
</tr>
</tbody>
</table>
| JAPAN         | NFI GNF-J
                | Japanese Utilities       |
                | TEPCO TOHOKU CHUBU HOKURIKU |
                | CHUGOKU JAPC EPDC        |

### Non destructive tests
- Rod by rod FA $\gamma$-scanning
- Visual inspections
- Eddy current tests
- Oxide thickness
- Rod diameter & length
- Axial gross $\gamma$-scanning
- Axial $\gamma$-spectrometry
- X-radiography

### Destructive tests
- Puncture tests
- Ceramo-metallography + $\alpha$ auto-radiography
- EPMA / SEM
- Density
- Radiochemical burnup + special isotopes
- Thermal diffusity

### Ramp tests
- Peak power up to 465 W/cm
- Fission gas release during ramps

**Example of an axial burnup distribution,** 6-cycle rod, 5.5 w/o Pu$_{fiss}$
Fabrication of Gundremmingen MOX-FA
(BWR specialities compared to PWR)

More $\text{Pu}_{\text{fiss}}$ „enrichments“

Spare rods after change of FA-type
(i.e. 9x9 → 10x10)

Higher demands upon pellet quality
(PCI-risk)
Dose During Handling of Fresh MOX FAs in Gundremmingen

mSievert / MOX-FA

- theoretical projection in 1993
- first experience in 1995
- last years (with higher Pu-content)

RWE Power - MOX Gundremmingen, PNN-KB, M. Schrader 2008
How much $\text{Pu}_{\text{fiss}}$ did we recycle in GUN?