DECOMMISSIONING IN GERMANY

Experience, Current Status and Upcoming Challenges

TÜV NORD

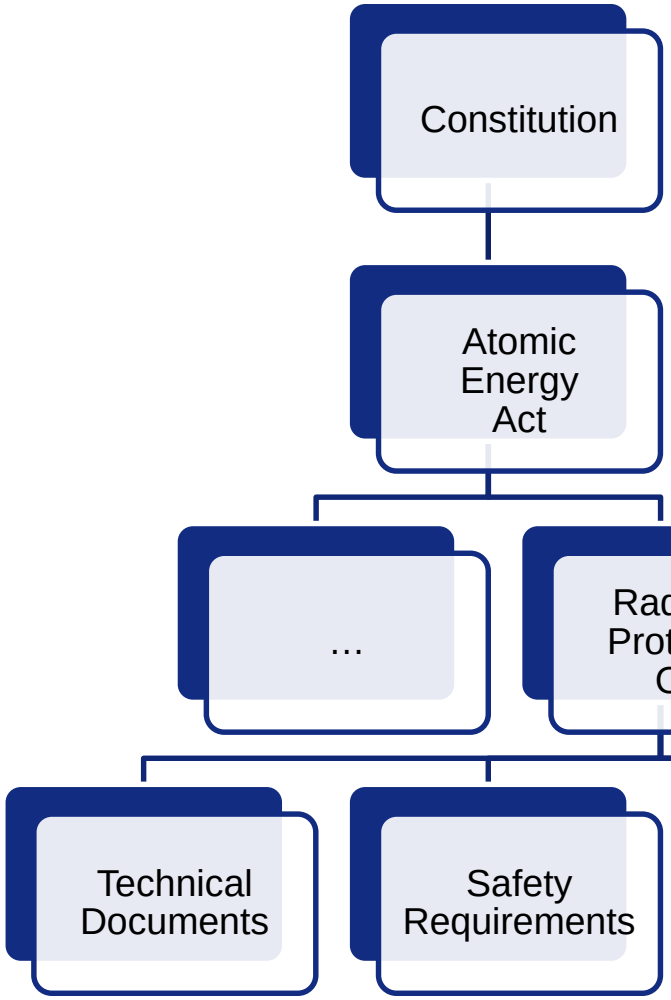
TÜV NORD NUCLEAR: WHO WE ARE

- TÜV NORD Nuclear is a network of entities operating in the nuclear market, total nuclear staff ±500

- Contracted expert for ministries/regulatory bodies in Germany
- Assessment of licence applications, technical expertise
- Consultants to regulators, operators, and vendors outside Germany covering all relevant aspects in licensing and inspection.
- Tailor-made solutions for training and knowledge transfer.

LEGISLATION: THE GERMAN WAY

NUCLEAR REGULATION: THE GERMAN WAY



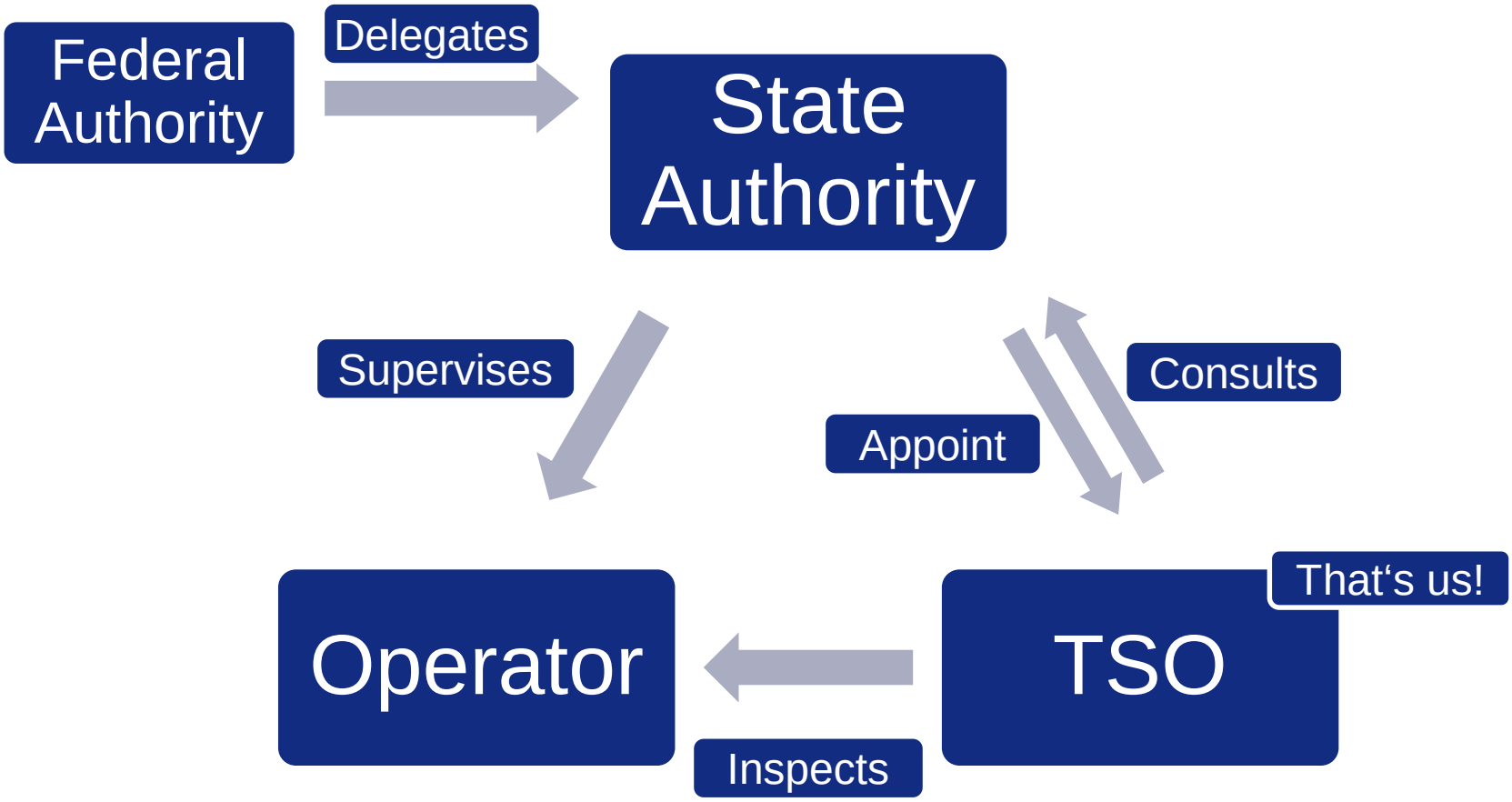
- **Right to physical integrity**
- **Protection of Property**
- **Protection of natural foundations of life and animals**
- **Nuclear energy to be regulated by federal law**
- **But: Regulation can be delegated**

- **Demands for decommissioning license**
- **Regulates supervision and delegation**

Regulates boundary conditions
e.g. dose limitations, waste declaration, clearance, etc…

Specific rules and directives
(official guidelines, ISO, specifications, etc…)

NUCLEAR SUPERVISION: THE GERMAN WAY



THE PATH TO A LICENSE FOR DECOMMISSIONING

Prelimi-nary Work

- Environmental Impact Study
- Characterization
- Preparation (e.g. Defuelling)

Initial Appli-cation

- Application
- Safety Report
- Summary

Public Hearing

- Public concerns

Detailed Regu-lations

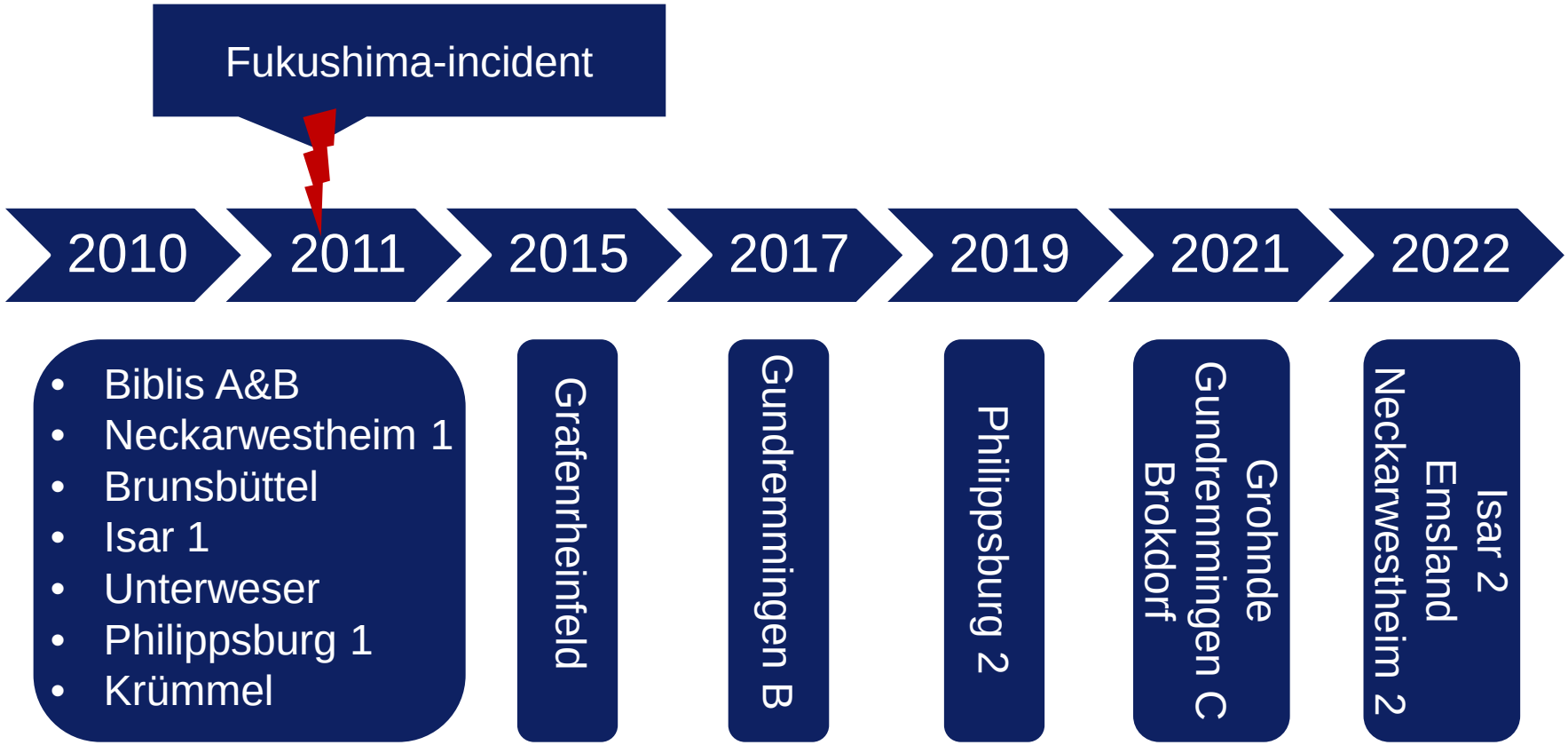
- RP
- Waste
- Methods
- Manual
- Etc…

License

- State Authority drafts license
- Federal Authority reviews
- Issued after Review
- State authority supervises execution

DECOMMISSIONING IN GERMANY: THE STATE OF AFFAIRS

GERMANY NUCLEAR PHASE OUT TIMELINE



CURRENT STATE IN GERMANY

	Shutdown	D&D License
Rheinsberg	1990	1995
Greifswald	1990	1995
Stade	2003	2005
Würgassen	1994	1997
***Lingen**	1979	2015
Unterweser	2011	2017
Biblis A+B	2011	2017
Brunsbüttel	2007	Licensing
Krümmel	2009	Licensing
Emsland	2022	Licensing
Brokdorf	2021	Licensing
Grohnde	2021	Licensing

Power-plants under TN EnSys-inspection
*): Safe enclosure

Wikipedia

PreussenElektra, NPP Würgassen

NPP Würgassen (BWR) & NPP Stade (PWR)

- Components and pipings removed
- To be done:
  Mainly decontamination & clearance for conventional demolishing and site release
- Stade: Unexpected contamination found inside containment
  - Still more decontamination to be done

NPP Rheinsberg (WWER 210), NPP Greifswald (5 units WWER 440)

- Most components removed from all units
  - Steam generators and reactor pressure vessels in interim storage
- Decontamination and clearance
- But: Still some decommissioning work done in auxiliary buildings
- Turbine-hall cleared for conventional use

NPP Lingen (BWR with oil-heater)

- Just woke up from safe enclosure (1988-2015)
- VERY unfavourable nuclide-vector (due to ^{60}Co-decay)
- Preliminary work

NPPs Unterweser & Biblis (PWR, moratorium)

- Licenses issued in 2017
- FSD done, defuelling mostly completed
- Currently removal of components, reactor internals and „smaller items“
- In licensing for dismantling of reactor pressure vessel and biological shield

NPPs Krümmel & Brunsbüttel (BWR, moratorium)

- In licensing
  - License expected by end of 2018
  - Public hearing pending
- Post-operation
  - Defuelled
  - Construction of interim storage facilities
  - Preliminary work

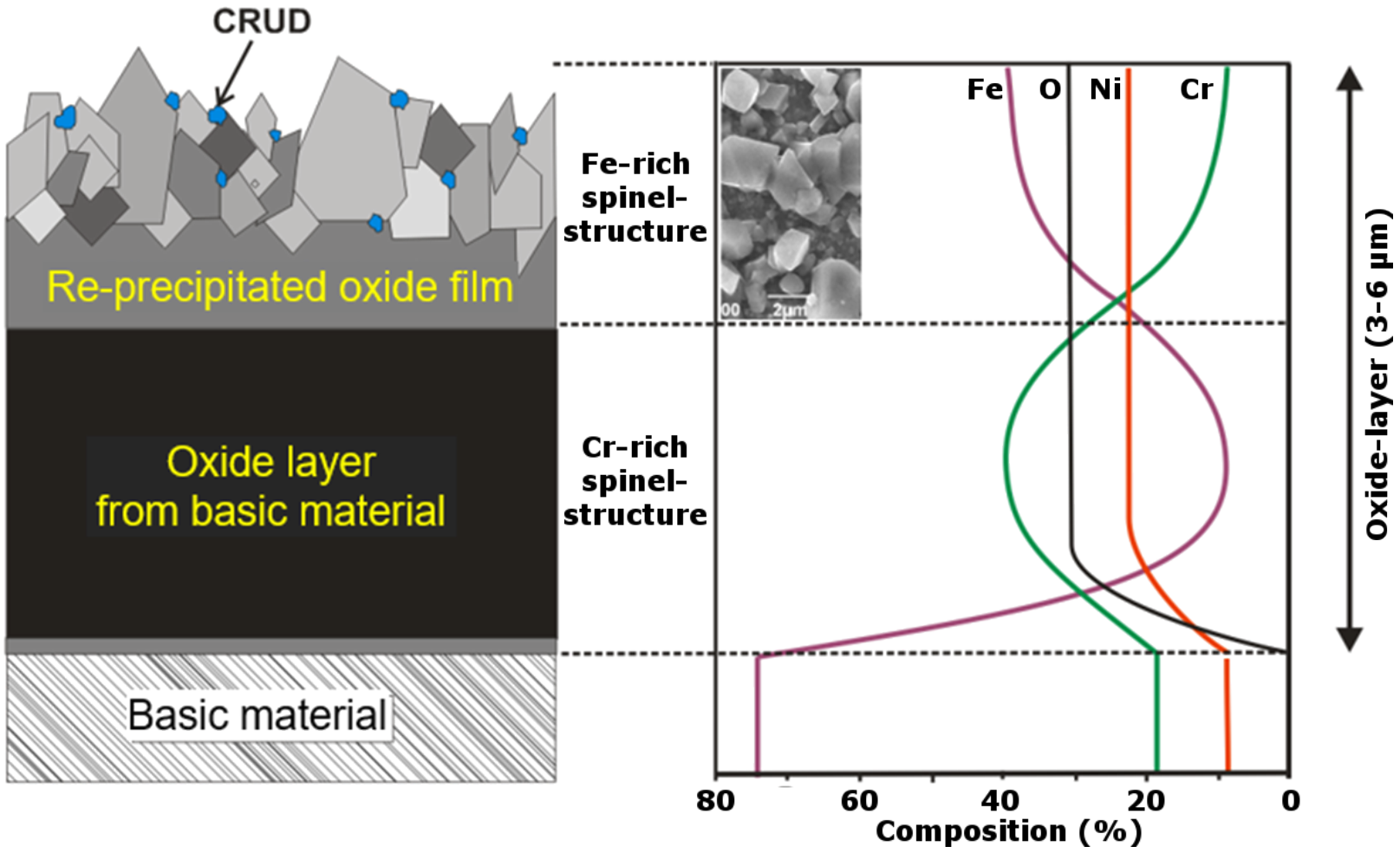
NPPs Emsland, Brokdorf, Grohnde (PWR, 2021-2022)

- Still in operation
- Applied for licenses
  - Ideally, the licenses will be issued before shutdown

DECOMMISSIONING PRAXIS

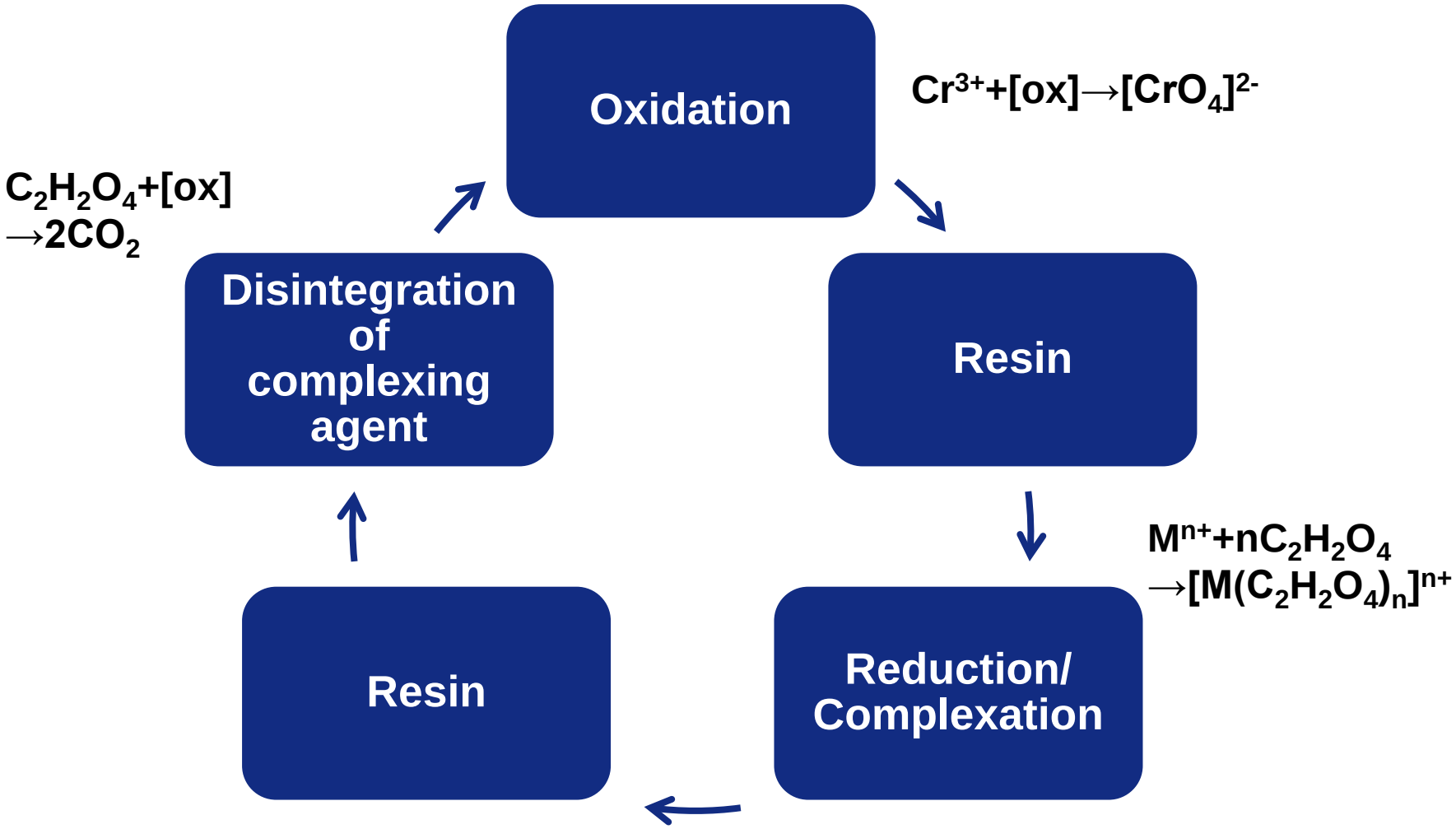
- Full-System Decontamination
- Removal of Large Components
- Free-Release of a Generator

FULL-SYSTEM DECONTAMINATION

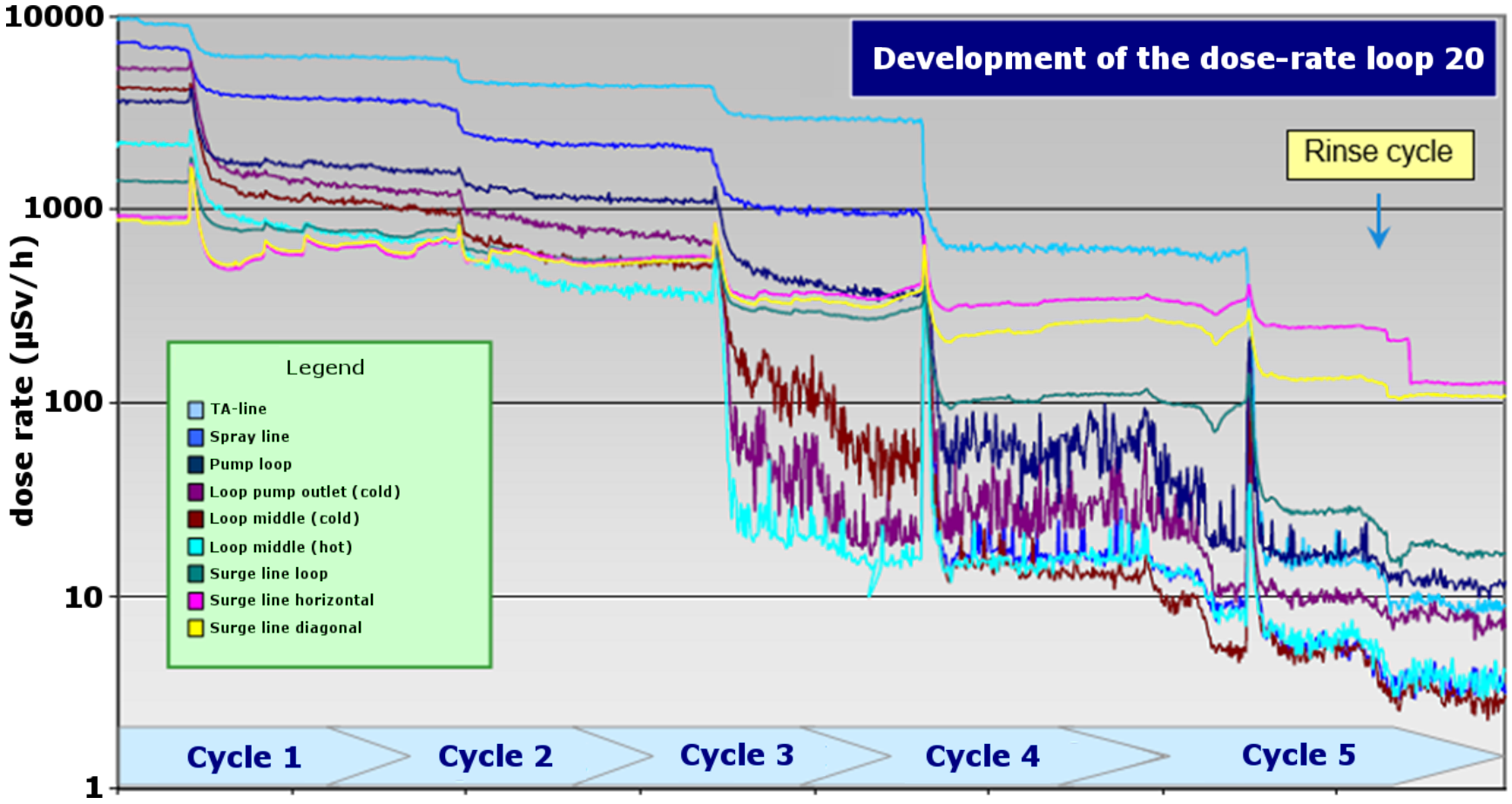


PreussenElektra, NPP Unterweser

FULL-SYSTEM DECONTAMINATION: PRINCIPLE

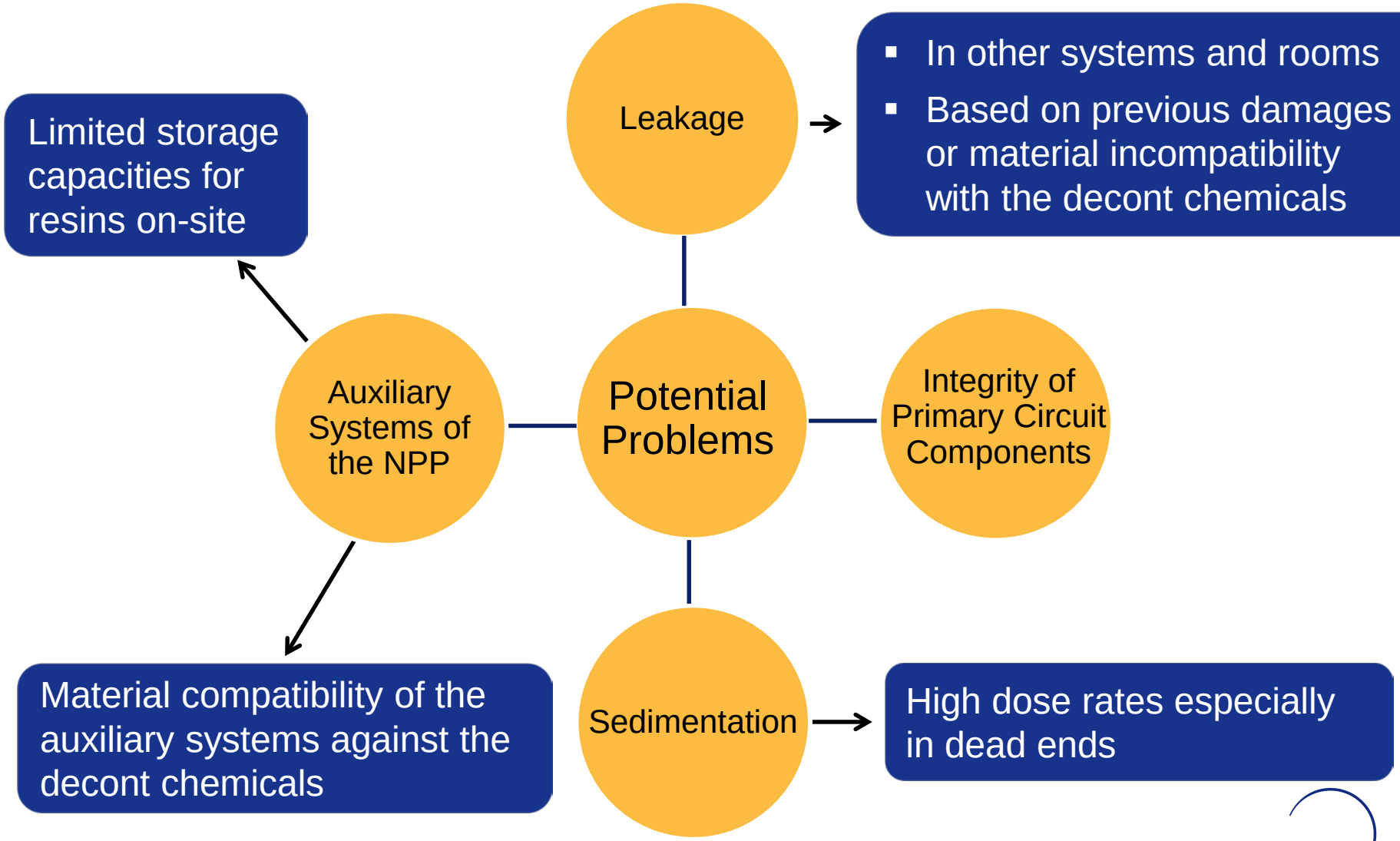


FULL-SYSTEM DECONTAMINATION: RESULTS



PreussenElektra, NPP Unterweser

FULL-SYSTEM DECONTAMINATION: PITFALLS



FULL-SYSTEM DECONTAMINATION: PITFALLS

EWN, NPP Greifswald

Removal of a steam generator in one piece for interim storage on site

- Radiation-Protection
- Crane
- Statics
- Contamination

REMOVAL OF A STEAM GENERATOR: FOR INTERIM STORAGE ON SITE

EWN, NPP Greifswald

PreussenElektra, NPP Stade

Removal of a steam generator in one piece for off-site processing

- Transport to a facility outside of Germany
- Decontamination by melting
- Partial clearance of the resulting metal
  - Authority required proof that German conditions are met

FREE RELEASE OF A GENERATOR: TASK

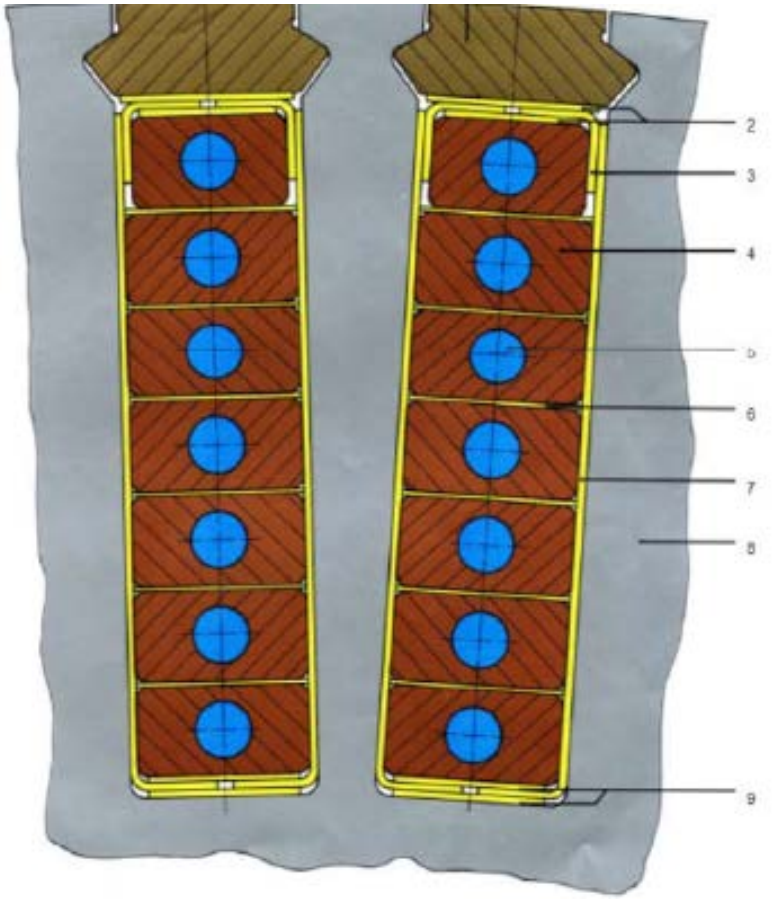
- Non-destructive methods
- Unconditional clearance of all components
- 100 % prove
- Complicated geometries and unreachable cavities
- Cooling system
- Stator:
  Center & end caps
- Rotor
- Auxiliary units

Vattenfall, NPP Brunsbüttel

FREE RELEASE OF A GENERATOR: THE COOLING-SYSTEM

- Highly integrated closed-cycle-system
- Branched channels
- Active electronic elements
- Windings, rotor shaft, feedthroughs

- Holistic approach (rotor and stator)
- Sampling of replaceable systems (e.g. PTFE lines, coolant tank, coolant residues)
- Direct measurements at flanges and feedthroughs
- Swipe tests



Vattenfall, NPP Brunsbüttel

FREE RELEASE OF A GENERATOR: RESULT

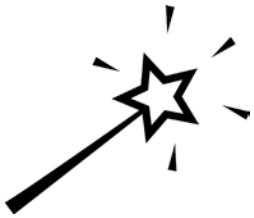
- ✓ Potential re-use
- ✓ Reversible Process
- ✓ Non-destructive

Vattenfall, NPP Brunsbüttel

- ✓ 100 % prove
  either by measurement or
  alternative methods
- ✓ Testing and qualifying procedures for decommissioning
- ✓ Documentation

DECOMMISSIONING: UPCOMING CHALLENGES

- Licensing of moratorium-plants in (long)progress
  - Original staff leaves or retires, diminishing knowledge of the site
- Final disposal and on-site interim-storage
  - No final repository for LAW until at least 2027. For HAW, who knows?
- Conventional waste-streams
  - No public acceptance for released waste on conventional landfills



- Experience in decommissioning is growing in Germany, we are entering a „routine“
- But: Challenges lie ahead
  - No operating final repository yet, thus need for interim storage capacities
  - Many simultaneous projects with limited staff
  - Waning personnel in nuclear
- TÜV NORD EnSys supports a number of D&D-projects, from the initial licensing to the final site-release