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Safe Management and Effective Utilization
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Research Reactors in Germany: An Overview

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Outline

1. Introduction to the Use of Nuclear Energy in Germany
2. Legislative and Regulatory Framework
 - Participants in the Nuclear Licensing and Supervision Procedures
 - Nuclear Safety Regulations
3. Research Reactor Facilities in Germany
4. Conclusion

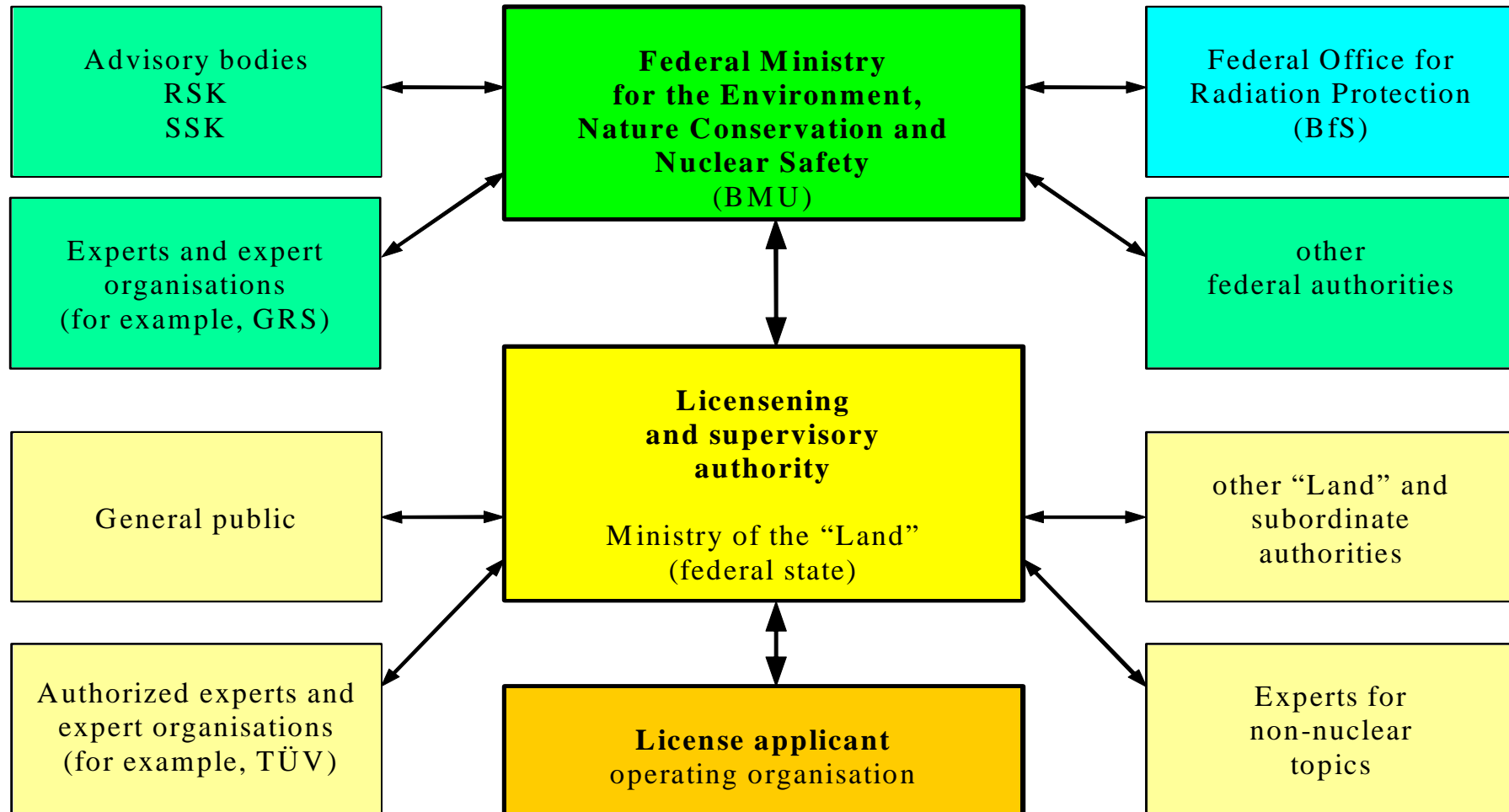
Introduction

- 1955: Civil use of nuclear energy
- Comprehensive legislative and regulatory framework
 - 36 prototype reactors and nuclear power plants (NPP)
 - Several facilities of the nuclear fuel cycle
 - 46 research reactors (RR)
- 1998: After federal election phase out of nuclear power
- 2002: Amendment of the Atomic Energy Act
 - “Phase out the use of nuclear energy for the commercial generation of electricity”

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 - “Phase out the use of nuclear energy for the commercial generation of electricity”
 - **Refers to NPP, not to RR**

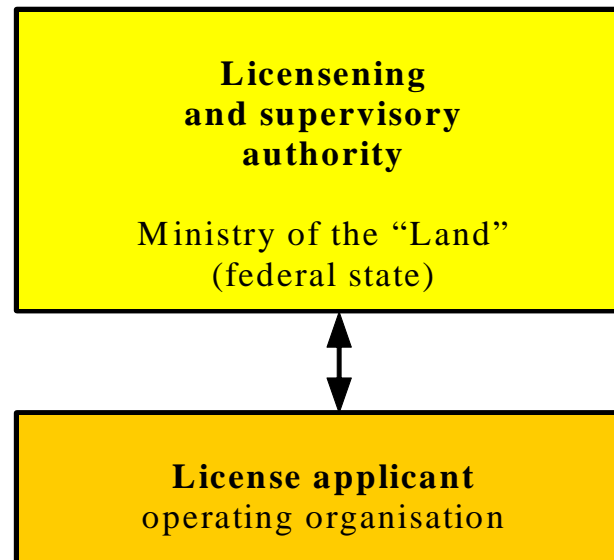
Participants in the Nuclear Licensing and Supervision Procedures



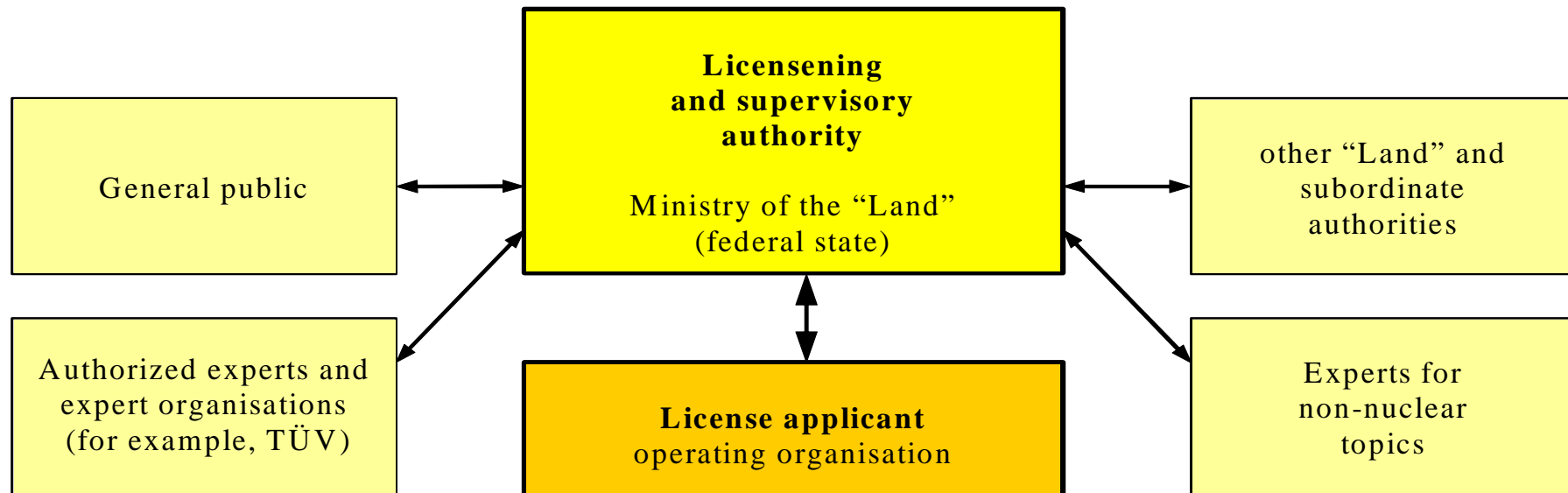
Participants in the Nuclear Licensing and Supervision Procedures

Federal Republic of Germany

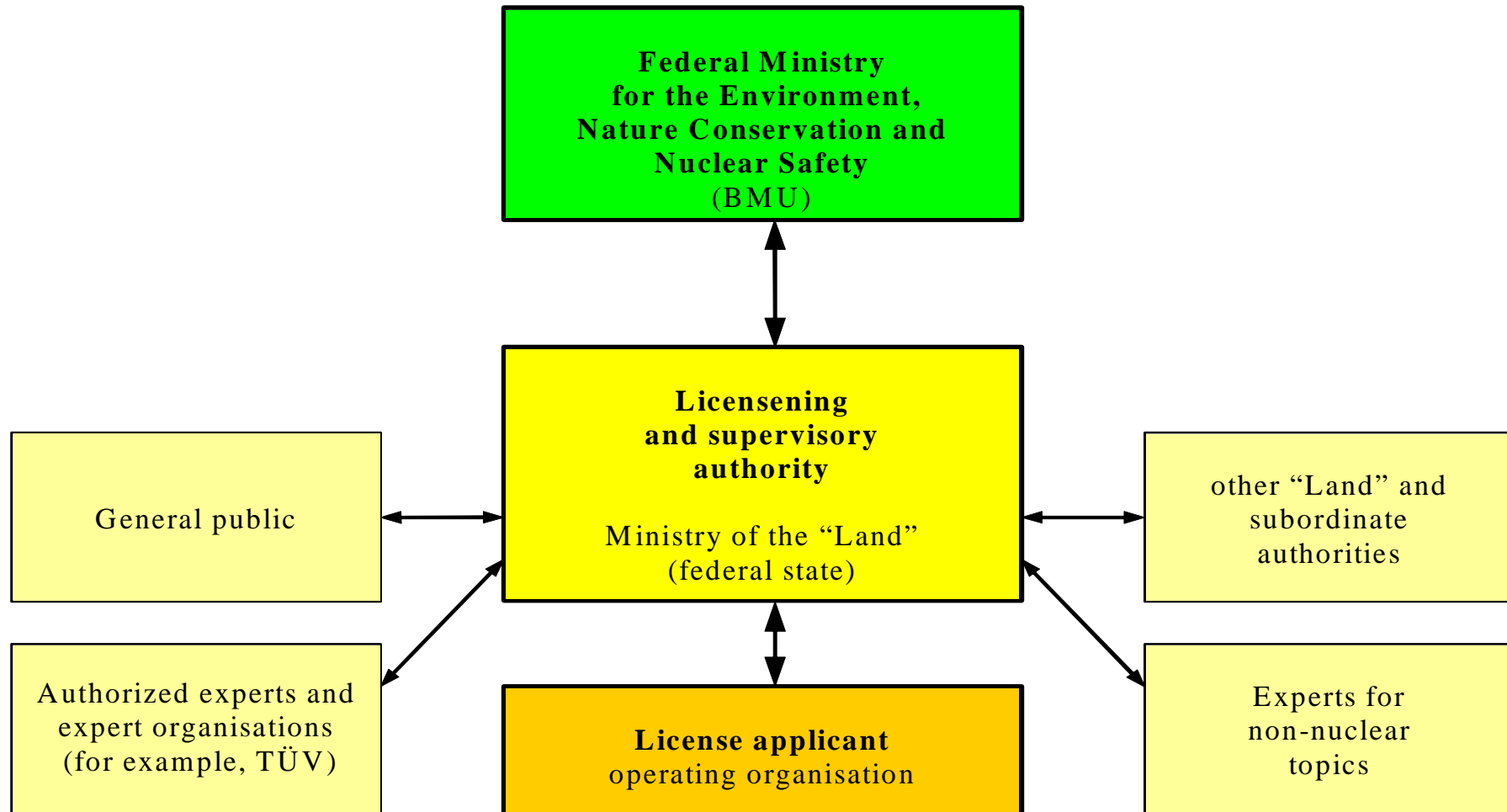
- Federal Government has the legislative competence for the use of nuclear energy
- Atomic Energy Act is mainly executed by the federal states (“Land“ or “Länder“)



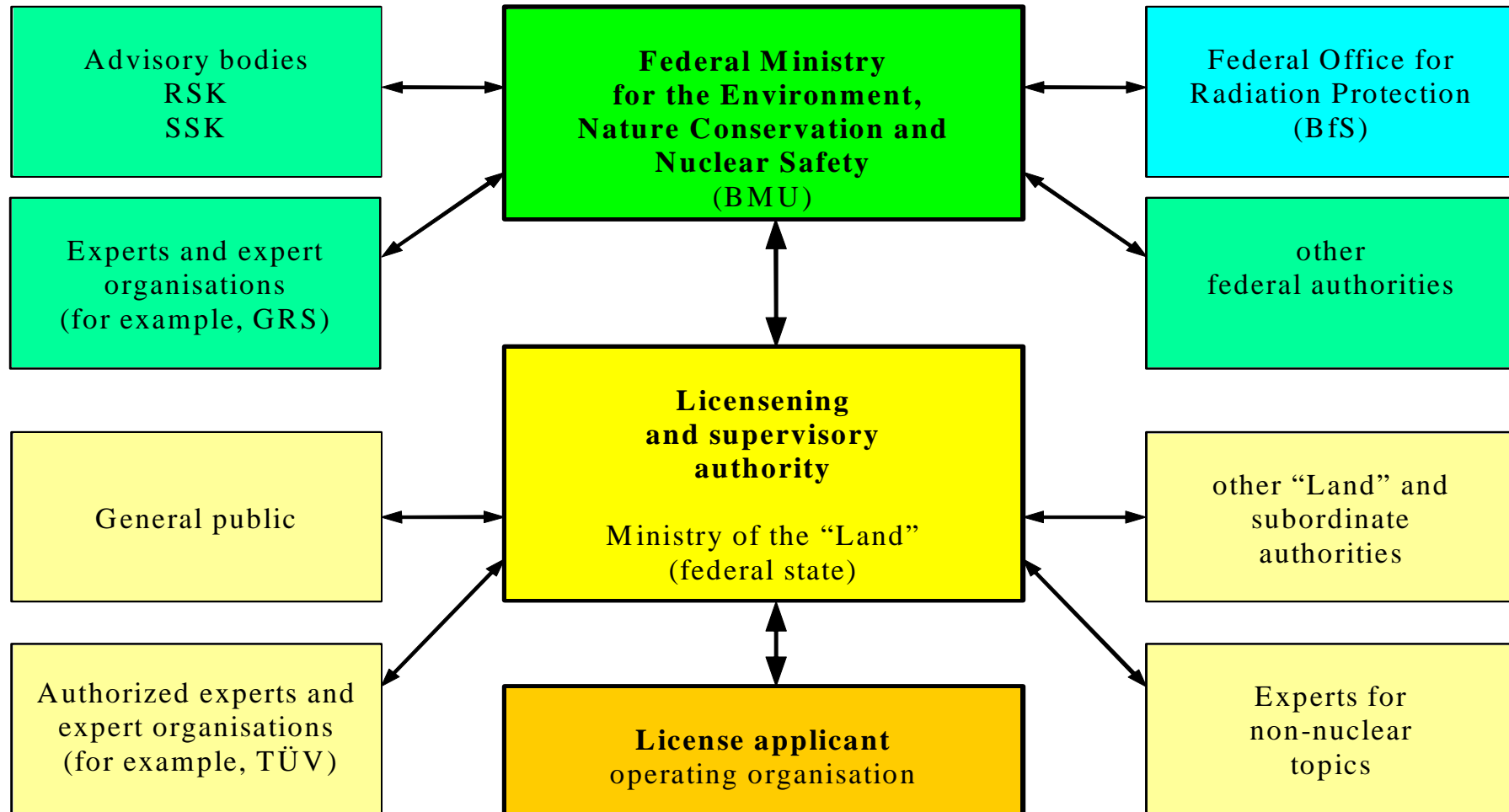
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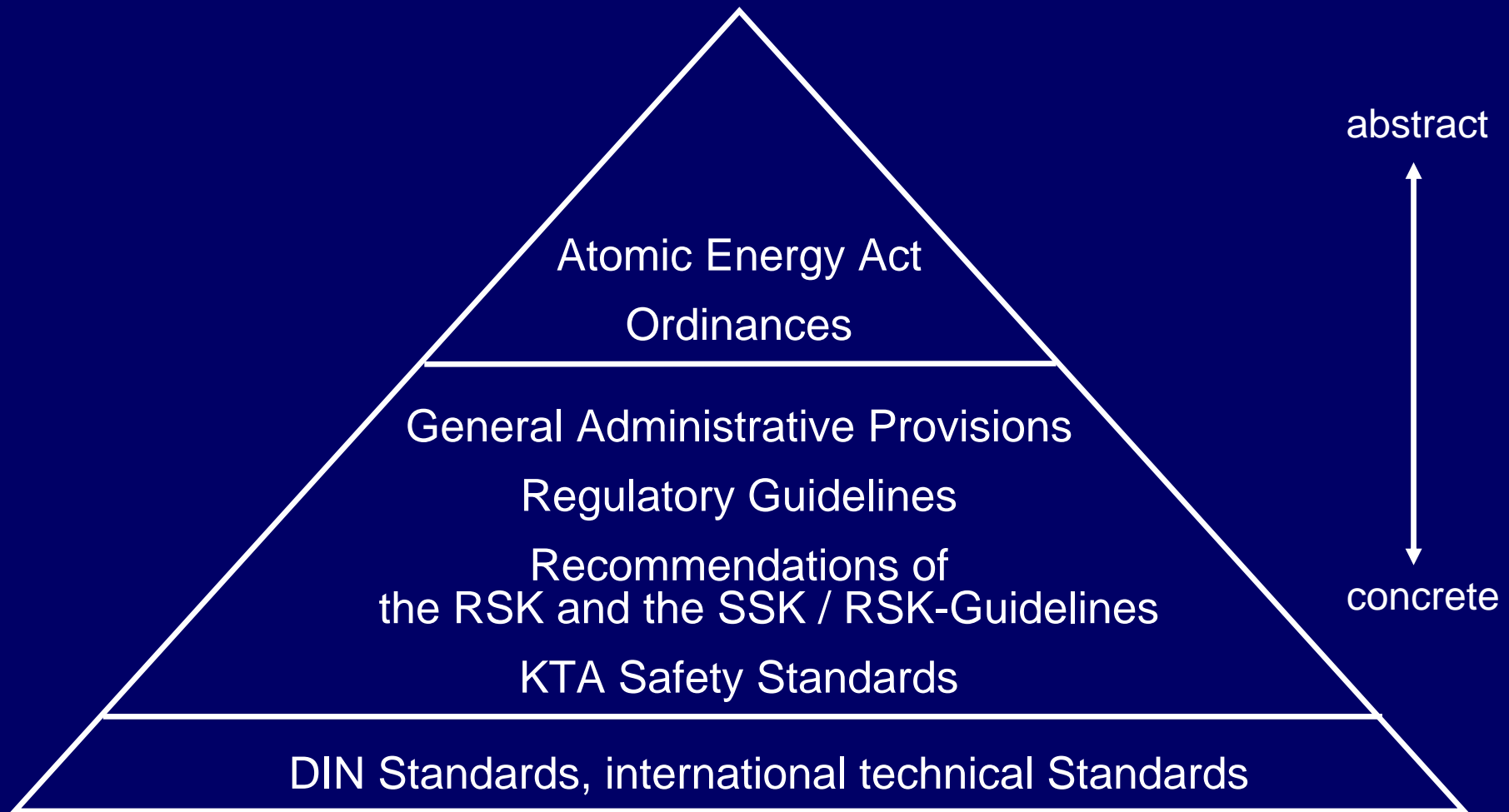
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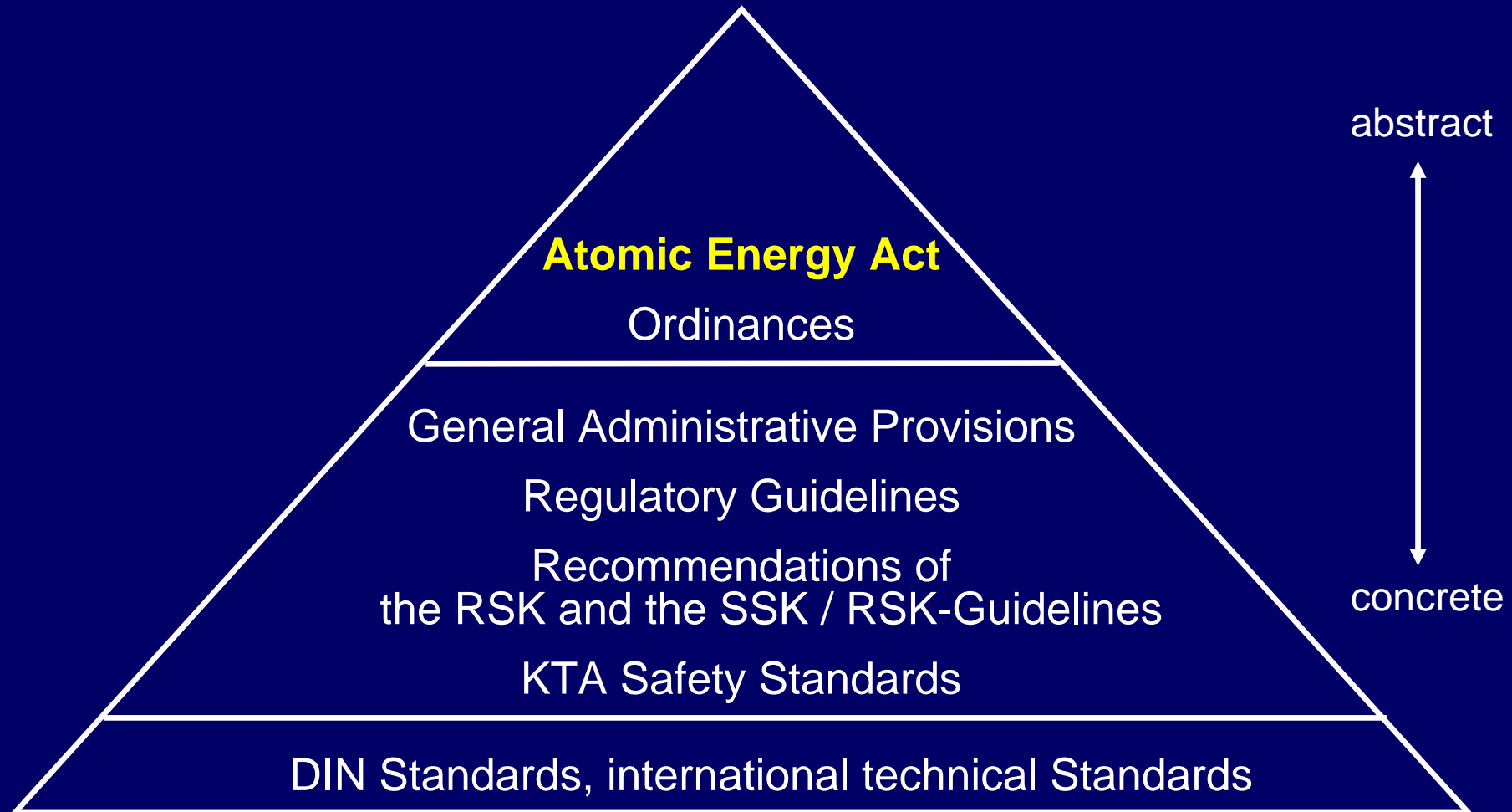
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Nuclear Safety Regulations



Nuclear Safety Regulations



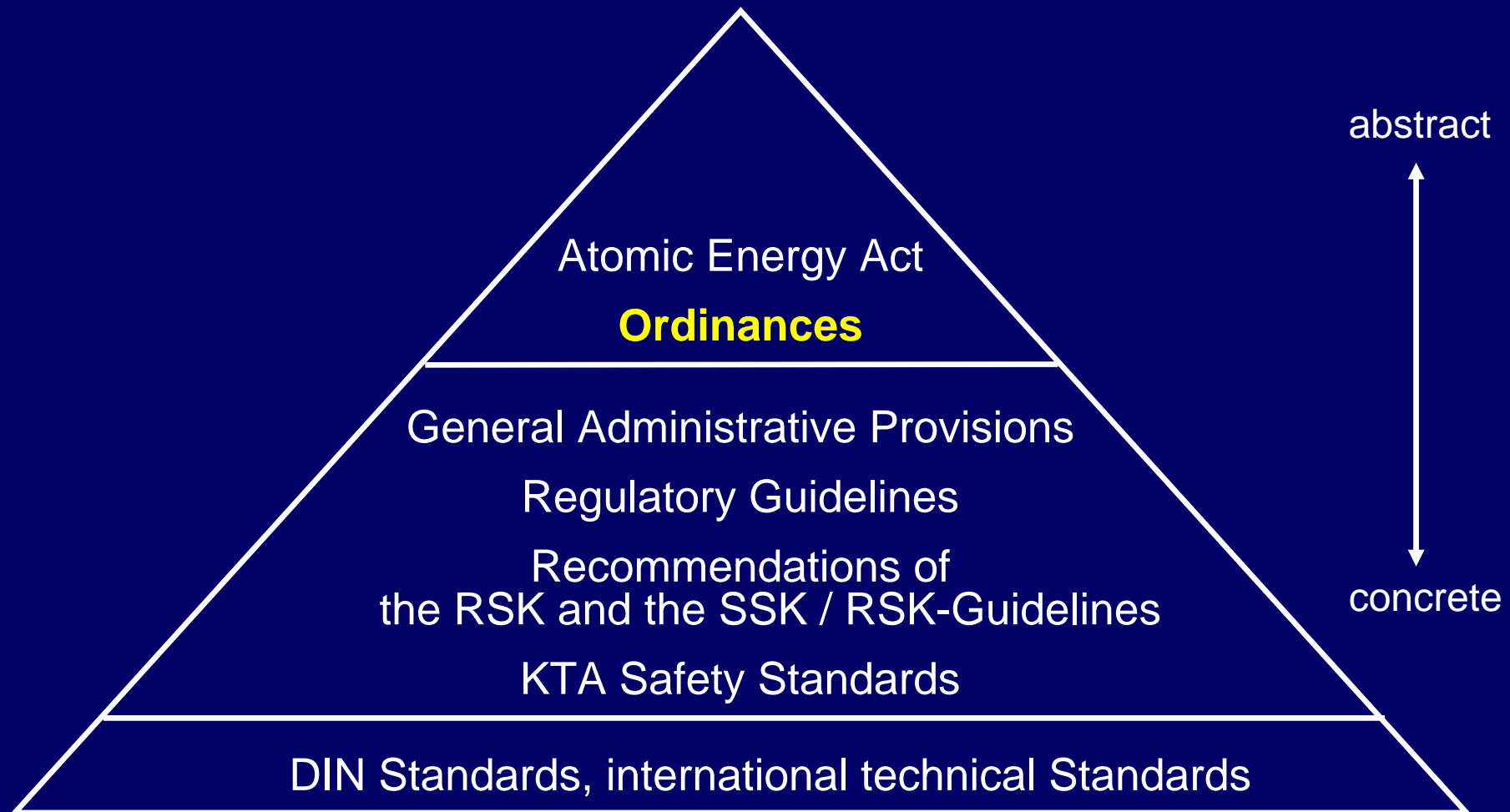
Atomic Energy Act

- First promulgated in 1959
- Updated and amended several times
- Amendment in 2002
 - “Phase out the use of nuclear energy for the commercial generation of electricity” instead of its “promotion”
 - No further licenses for construction and operation
 - Utilisation is limited to an electricity output of approx. 32 years

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Nuclear Safety Regulations



Ordinances (1)

Radiation Protection Ordinance

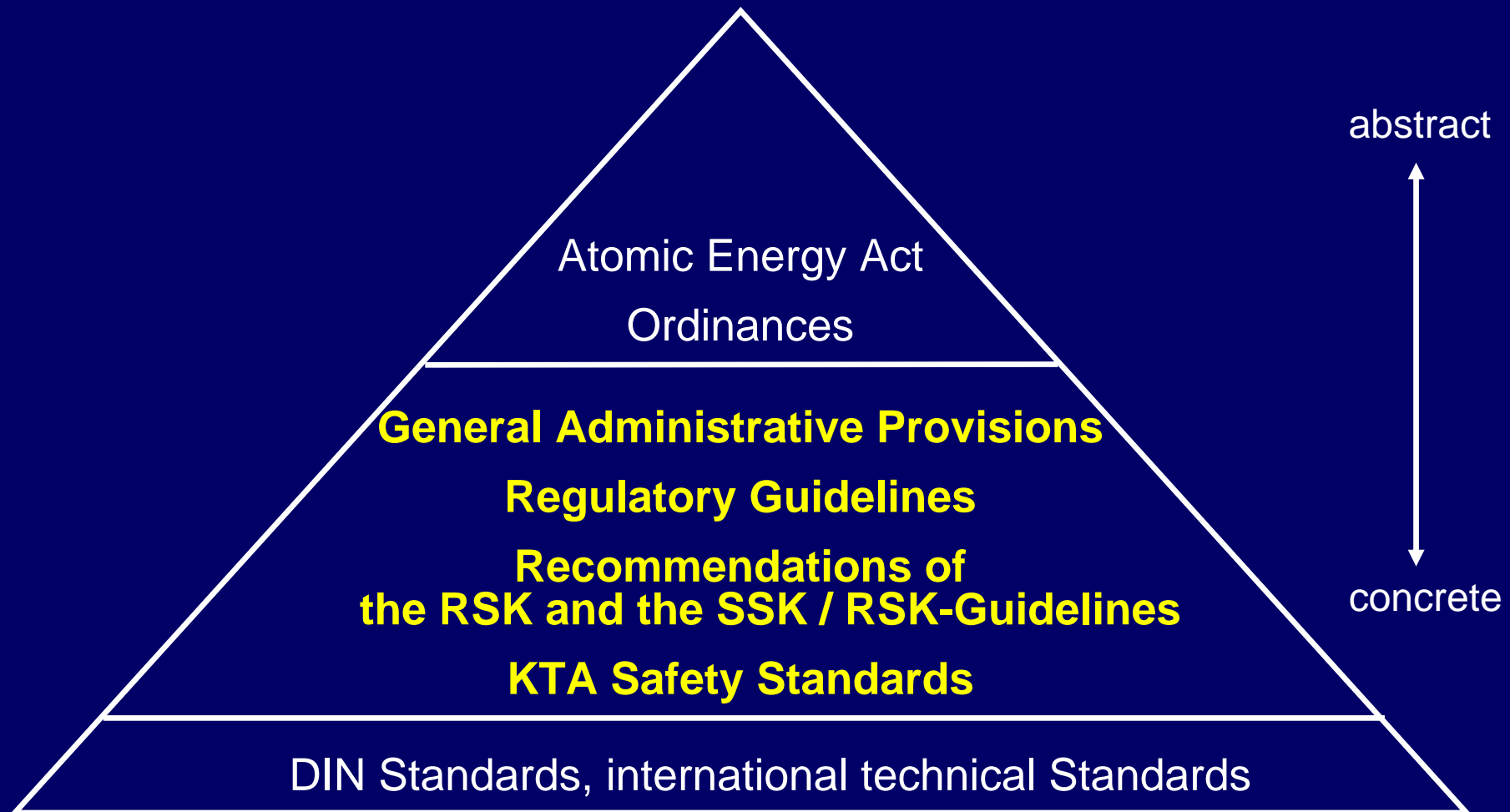
- Legal basis for the handling of radioactive material
- Regulation of the radiation exposure
 - Occupational exposed person: effective dose < 20 mSv/a
 - General public during operating conditions
effective dose < 1 mSv/a by direct radiation,
including 0.3 mSv/a by discharge with air or water
 - General public during design basis accidents
effective dose < 50 mSv (planning value as 50-year
dose commitment)

Ordinances (2)

Nuclear Safety Officer and Reporting Ordinance

- Obligation of the licensee to report “reportable events” to the supervisory authority
- NPP, facilities of the nuclear fuel cycle and **RR with a thermal power output larger than 50 kW**
- Reporting categories: S (without delay), E (24 h), N (5 d)
- Since 1991
 - 228 reportable events in 16 RR ($P_{th} > 50 \text{ kW}$)
 - All category N (low significance to safety), INES 0

Nuclear Safety Regulations



Sublegal Nuclear Safety Regulations (1)

- Mainly developed for NPP
- Applied by analogy to RR
 - Some interpretation
 - Graded approach
 - Potential hazards
- Only few regulations specifically for RR

Sublegal Nuclear Safety Regulations (2)

- Regulatory Guidelines
 - Guideline relating to the proof of the technical qualification of RR personnel
 - Guideline relating to the content of the examination of technical qualification of the responsible shift personnel in RR
- Recommendations of the RSK and the SSK
 - Licensing procedure for upgrading the thermal power of the BER II
 - Licensing procedure for the FRM-II
- KTA Safety Standards
 - KTA 1507: Monitoring and Assessing of the Discharges of Radioactive Substances from RR

International Framework

- Regulations of the European Union
e.g. EURATOM Basic Safety Standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation
- “Safety Fundamentals” of the IAEA
Nuclear safety regulations are in compliance
- “Code of Conduct on the Safety of Research Reactors” approved by IAEA Board of Governors
RR are included in the reports of the Federal Government for the “Convention on Nuclear Safety”

Research Reactor Facilities in Germany

- 1957: FRM reached criticality as first nuclear facility
- In total 46 RR
- Actually
 - 12 in operation
 - 10 in decommissioning
 - 24 dismantled and released from regulatory control
- Broad range of different types
 - Large pool or tank reactors, P_{th} several tens of megawatts
 - Small educational reactors, P_{th} typically hundred milliwatts
- Complete compilation see www.bfs.de

Research Reactors in Operation

- 12 RR in operation
- 4 “larger” facilities with $P_{th} > 50$ kW
 - FRG-1: pool type MTR, 5 MW, first criticality 1958
 - FRMZ: pool type TRIGA, 100 kW, first criticality 1965
 - BER II: pool type MTR, 10 MW, first criticality 1973
 - FRM-II: pool type compact core, 20 MW, first criticality 2004
- 8 “smaller” facilities with $P_{th} \leq 50$ kW
 - Small educational reactors with a thermal power not exceeding 2 W
 - Most of them are foreseen for decommissioning in the near future

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FRM-II



www.frm2.tum.de

FRM-II: Plant Characteristics

- Undisturbed thermal neutron flux: 8×10^{14} n/(cm²·sec)
- Thermal power: 20 MW
- Pool type, light water cooled, heavy water moderated
- Compact core
 - single cylindrical fuel element
 - 8.5 kg HEU in U₃Si₂-Al dispersion fuel
 - cycle length 52 days
- Designed to withstand
 - earthquake
 - high speed military aircraft

FRM-II: Licensing Procedure (1)

- 1980: Start of conceptual design phase
- 1993: Application to competent licensing authority of Bavaria
- 1996: First partial license
 - Suitability of the site and the basic construction features
 - Including a public hearing in 1995
- 1997: Second partial license
 - Construction of mechanical and electrical installations
- 2003: Third partial license
 - Introduction of the fuel element and nuclear operation

FRM-II: Licensing Procedure (2)

- Federal supervision by the BMU
 - Stated its position to each partial license, essentially based on the respective recommendations of the RSK and SSK
 - Binding directive to the licensing authority to impose an obligation in the operation license
 - Reduce the fuel from HEU to uranium with an enrichment of not more than 50 % U 235 until end of 2010
- Operator established international working group
 - Develop new high density fuel on the basis of UMo
 - Goal will obviously not be reached

Research Reactors in Decommissioning

- Decommissioning requires a license
- 10 RR in decommissioning
 - All of them are “larger” facilities with $P_{th} > 50$ kW
 - 2 RR are in a safe enclosure
 - 8 RR are in dismantling
- 24 RR are dismantled and released from regulatory control
 - Most of them were small educational reactors or critical assemblies
 - Supervision under nuclear legislation not necessary any more
 - Sites may be used for other purposes without any restrictions

Conclusion

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- Five decades of safe operation of RR
- In principle, the legislative and regulatory framework is the same for both NPP and RR
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- For further information see
 - the manuscript in the conference proceedings or
 - www.bfs.de or
 - contact m.schneider@bfs.de