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Nuclear Decommissioning An Emerging Field of Research For Energy Economics

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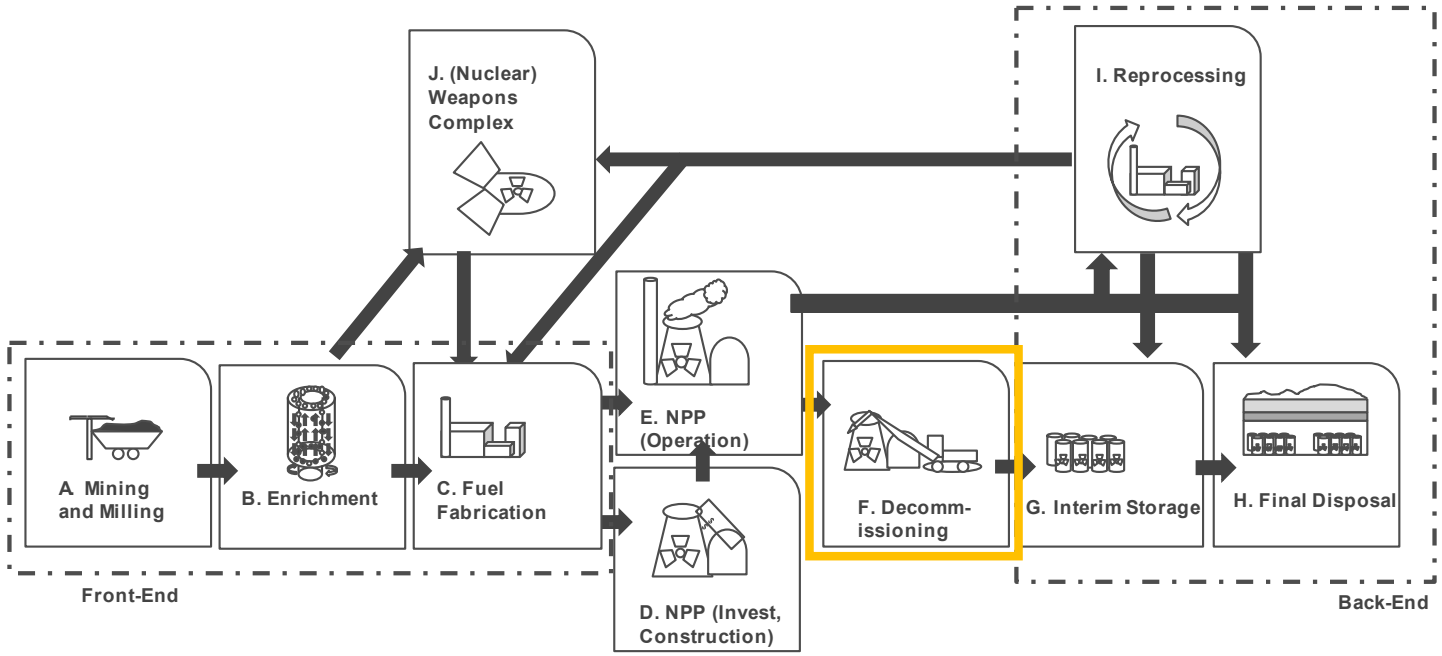
Nuclear Power as a System Good
Stylized Description

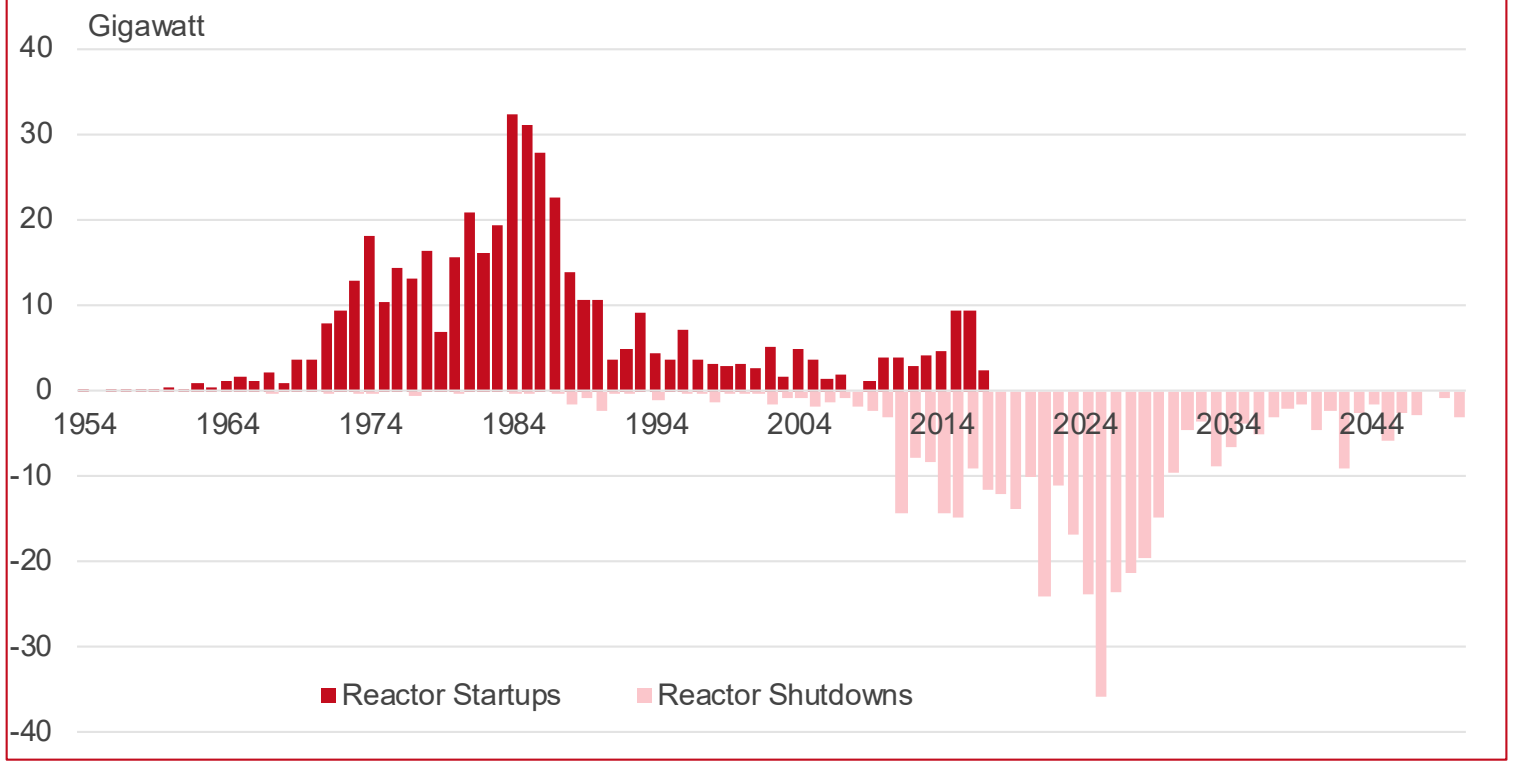


- Nuclear decommissioning is conducted once a nuclear reactor is shut down
- This includes activities from the shutdown itself, the removal of nuclear material and, depending on the target, the environmental restoration of the site
- The process is lengthy and expensive
- From a safety and security view, it is imperative that nuclear reactors are decom. to minimize risk
- Historically, decom. has been neglected as a distant obligation
- In some cases, the combination of inexperience and insufficient planning led to undesired outcomes

Taken from Wealer & von Hirschhausen (2020) Nuclear power as a system good: Organizational models for production along the value-added chain. DIW Discussion Paper 1883. URL: http://hdl.handle.net/10419/222865.

Nuclear Decommissioning
Relevance of Nuclear Decommissioning

Distribution of Global Nuclear Reactor Startups and Shutdowns



- Assuming a 40-year lifetime, many reactors built in the 1980s will begin shutting down in the coming years
- All of these reactors will have to be decom. at some point
- Lifetime extensions (50, 60 or 80 years) can only push this inevitability into the future
- The global decom. industry is still developing and remains largely untested as only around a dozen commercial reactors have been fully decommissioned

Taken from Wealer et al. (2018) Nuclear Power Reactors Worldwide – Technology Developments, Diffusion Patterns, and Country-by-Country Analysis of Implementation (1951–2017). DIW Data Documentation 104. URL: http://hdl.handle.net/10419/179000

Nuclear Decommissioning
Strategies and Technical Process

Decommissioning refers to the administrative and technical actions taken to remove all or some of the regulatory controls from an authorized facility *so the facility and its site can be* ***reused****. Decommissioning includes activities such as* ***planning****,* ***physical*** *and* ***radiological characterization****, facility and site* ***decontamination****,* ***dismantling****, and* ***materials management****.* - IAEA

Decommissioning Strategies	3-Stage-Classification
Immediate Dismantling: Decommissioning is conducted immediately after shutdown	**Warm-up-Stage**: Preparational steps for the hot-zone stage, reactor is defueled
Deferred Dismantling: Reactor is placed into long-term enclosure (LTE) to allow for radiation levels to decline. Decommissioning begins several years to decades after shutdown.	**Hot-zone-Stage**: Removal of reactor pressure vessel & internals and biological shield
Entombment: Reactor is enclosed in safe material (e.g., concrete) for an indefinite period. Method of last resort that was used at Chernobyl.	**Ease-off-Stage**: Removal of operating systems and decontamination of buildings

Sources: Taken from Schneider et al. (2022) World Nuclear Industry Status Report. URL: https://www.worldnuclearreport.org/-World-Nuclear-Industry-Status-Report-2022-.html; IAEA (https://www.iaea.org/topics/decommissioning); Irrek (2019) Financing Nuclear Decommissioning. URL: http://link.springer.com/10.1007/978-3-658-25987-7_12; Park et al. (2022) Sustainable Decommissioning Strategies for Nuclear Power Plants, *Sustainability* Vol. 14 (10), DOI.: 10.3390/su14105947

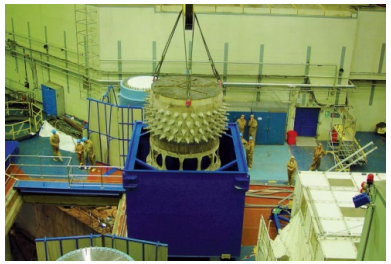
Technical Process
Three-Stage Classification

Warm-Up-Stage

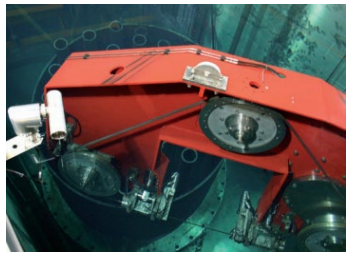
- Removal of spent fuel (“Defueling”)
- Overview of contaminated inventory
- Removal of all machines and components that are not needed for hot-zone dismantling
- Set-up of technical and logistical infrastructure for hot-zone tasks
- Dismantling of contaminated machinery, such as steam generator
- Preparation of dismantling of strongly contaminated components and machinery

Hot-Zone-Stage

- Dismantling of stronlgy contaminated machinery and components, such as reactor pressure vessel or biological shield



Remote underwater cutting



„One piece“ dismantling

Ease-Off-Stage

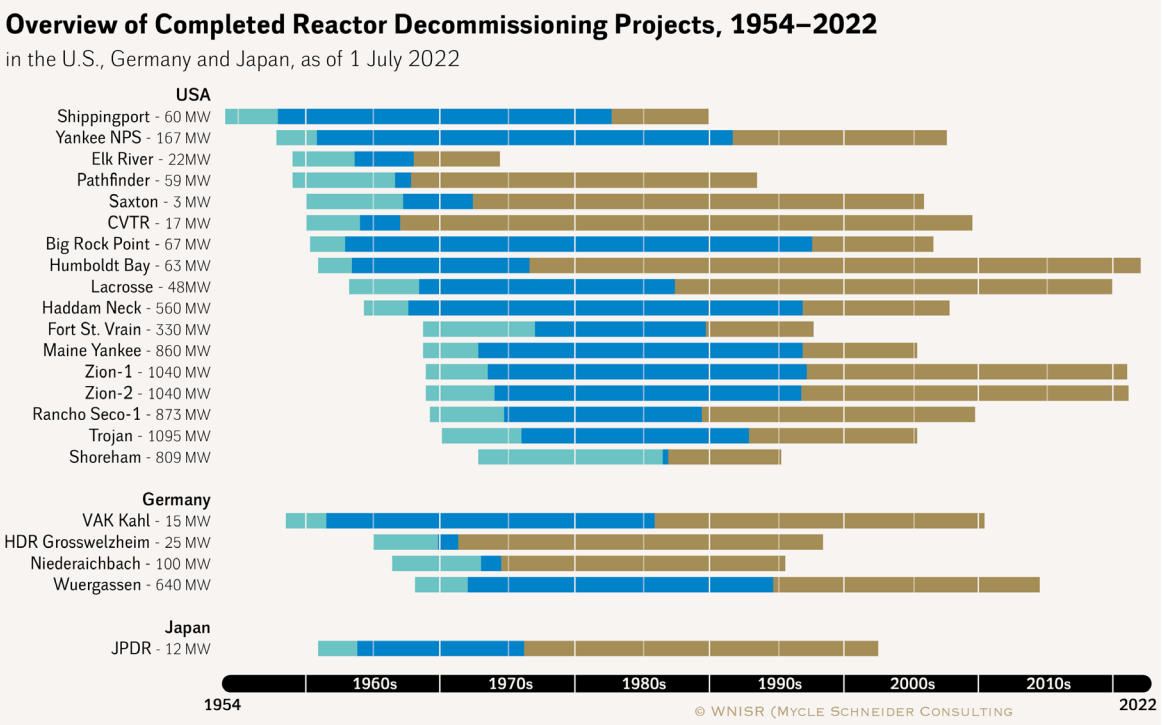
- Dismantling of remaining components and machinery
- Decontamination of buildings
- **Release from regulatory oversight**
- Demolition of buildings
  - **Greenfield**: Site released to be used in non-industrial (and non-nuclear!) context
  - **Brownfield**: Site released for industrial use, e.g., further electricity generation or interim storage facility for nuclear waste.

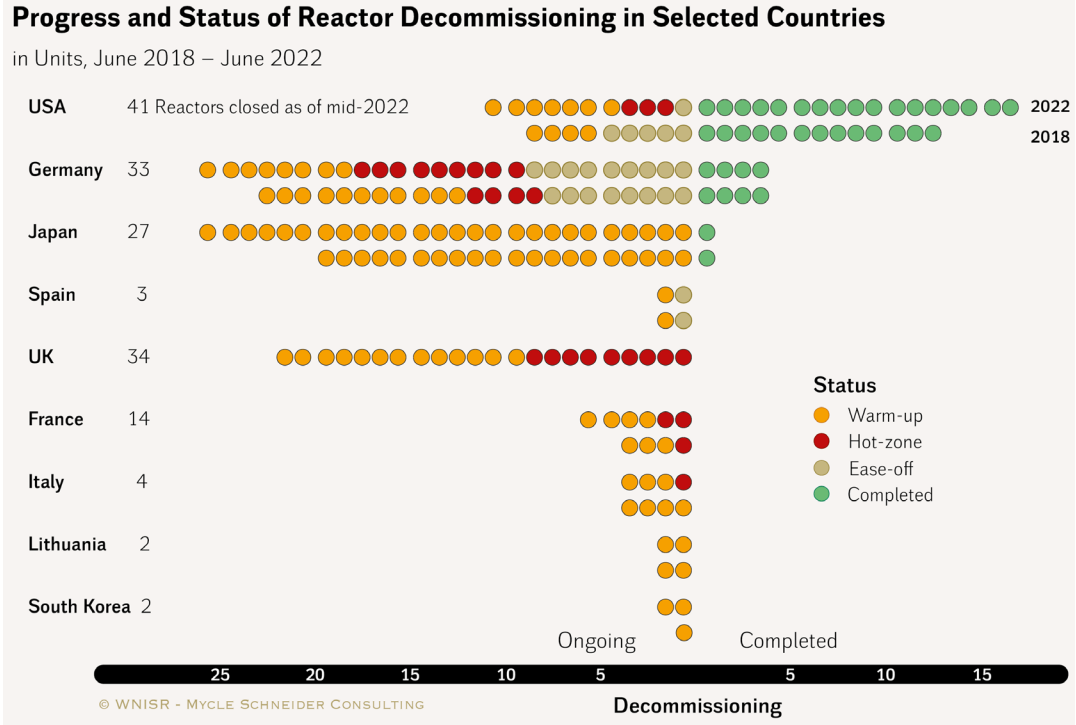
Taken from Schneider et al. (2022) World Nuclear Industry Status Report. URL: https://www.worldnuclearreport.org/-World-Nuclear-Industry-Status-Report-2022-.html;
Images: Brendebach et al. (2017) Decommissioning of Nuclear Facilities, Technical Report, GRS,
URL: https://www.grs.de/sites/default/files/publications/grs-s-58.pdf

Nuclear Decommissioning

Status of Nuclear Decommissioning Projects Worldwide

As of June 2022, 204 nuclear reactors were closed world-wide. Of these, only 22 reactors have been fully decommissioned. 120 are undergoing some form of active decommissioning, while 52 are in so-called “longterm enclosure”.





Taken from Schneider et al. (2022) World Nuclear Industry Status Report. Decommissioning Report, pp. 185-207.
URL: https://www.worldnuclearreport.org/-World-Nuclear-Industry-Status-Report-2022-.html