Investigating decommissioning scenarios of EPR nuclear power plants through MCNP models

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New Nuclear Power in the UK

For the first time in 30 years **two new nuclear power plants** are opening in the UK **Hinkley C & Sizewell C.** The UK government recently announced a **£14.2 billion** investment into Sizewell C. The reactor design is based on the **European Pressurised Water Reactors.** Each Site will be equipped with **2 EPRs** with a Combined Output of **3.2 GW** of electricity.

UK Decommissioning Landscape

- The NDA oversees the strategic clean-up of the UK's nuclear legacy estate.
- 17 nuclear sites are now under decommissioning.
- Annual budget: £4+ billion, with long-term liabilities totalling
 ~£124 billion over 120+ years.
- Many UK sites were never designed with decommissioning in mind.
- The Nuclear Liabilities Fund
 ensures that new reactors, are
 financially equipped for eventual
 decommissioning.
- ~60 Years Expected operational lifetime of new EPRs before decommissioning begins.
- 1,000-2,500 Million € Average cost to decommission a single US PWR reactor.



Figure 1: NDA owned nuclear sites in the UK [1].

Sizewell C Decommissioning Process

Pre-Closure Planning

Schedule development, Environmental Impact Assessment, regulatory consents.

Spent Fuel Management

Fuel cooled in pools, then transferred to on-site dry storage (ISFS).

Site Preparation

Hazardous materials removed; systems made safe for dismantling.

Dismantling

Reactor vessel, turbine hall, and cooling systems dismantled—mostly via remote methods.

Waste Management

Waste classified (LLW, ILW), processed and stored/disposed according to UK policy.

Site Clearance

Radiological surveys and remediation; land released to brownfield status.

MCNP Reactor Design

Define Reactor Geometry

Build **MCNP** model of the plant or sub system.



Perform Criticality Calculations

Run k_{eff} simulations to assess reactivity conditions.



Run Dose & Activation Calculations

Calculate radiation dose rates and material activation.



Interpret Results

Generate dose maps, activity inventories, etc.



Feed into Decommissioning Plans

Use outputs to inform decommissioning strategies.

Decommissioning in the Digital Age

- Virtual reactors before real dismantling Digital models simulate the entire process years ahead.
- Radiation before demolition MCNP predicts radiation hotspots.
- Workflow visualisation Digital Mock-Ups optimise dismantling plans.
- Safer preparation Virtual environments reduce worker exposure.
- Single source of truth All data is captured in unified digital models.

Existing Reactor Modelling using MCNP

Established Use – MCNP has been widely used to model neutron flux, activation, and dose fields in operational and decommissioning reactors.

Beznau PWR Case Study:

- Full-core MCNP modelling supported activation assessments and waste packaging design.
- Demonstrated how spatial flux data informs safe dismantling and shielding strategies.

Relevance to This Work:

- Provides a validated framework for applying MCNP to new reactor types, like the EPR at Sizewell C.
- Shows how dose-informed modelling supports early planning before physical decommissioning begins.

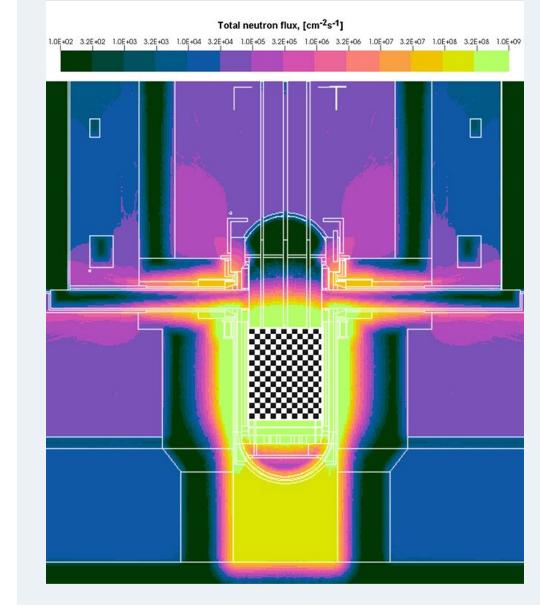


Figure 2: Spatial neutron flux distribution across the reactor pressure vessel and bioshield at the Beznau PWR [2].

References & Acknowledgements

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- 2. Pisano, Paolo Giunio. (2018). Application and Validation of the Nagra Activation Calculation Methodology to the Beznau NPP and Development of a Packaging Concept for RPV and Internals. 10.13140/RG.2.2.24275.53288.

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