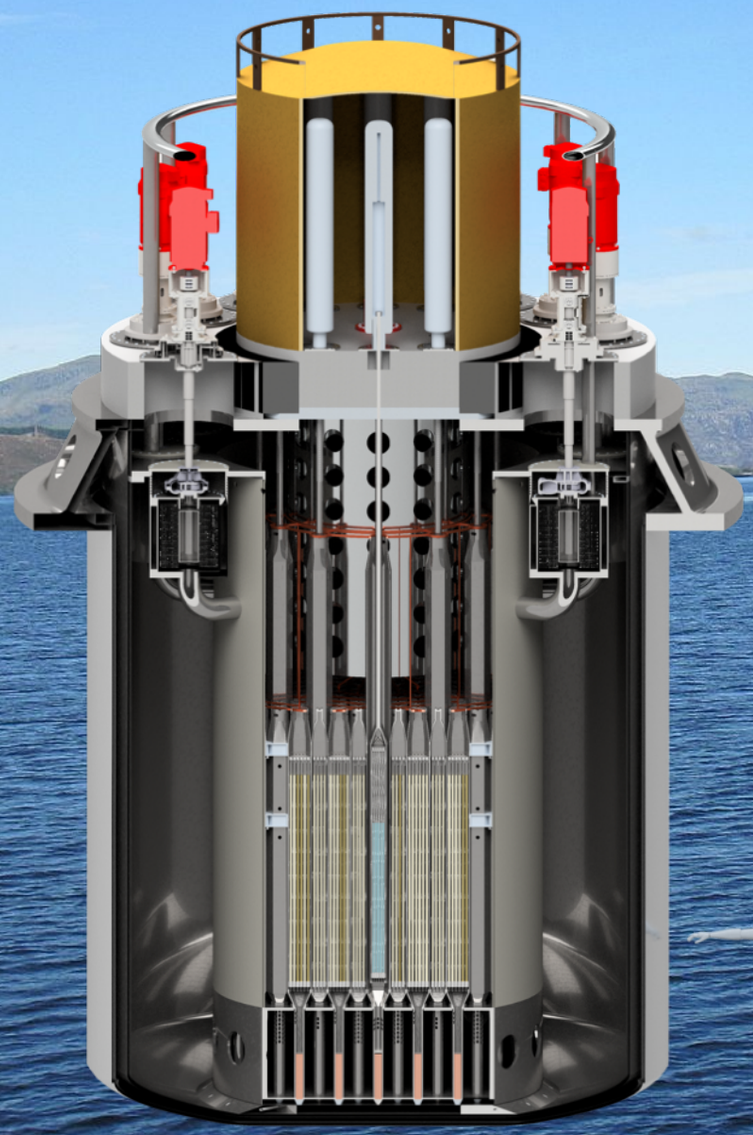
SEALER-UK

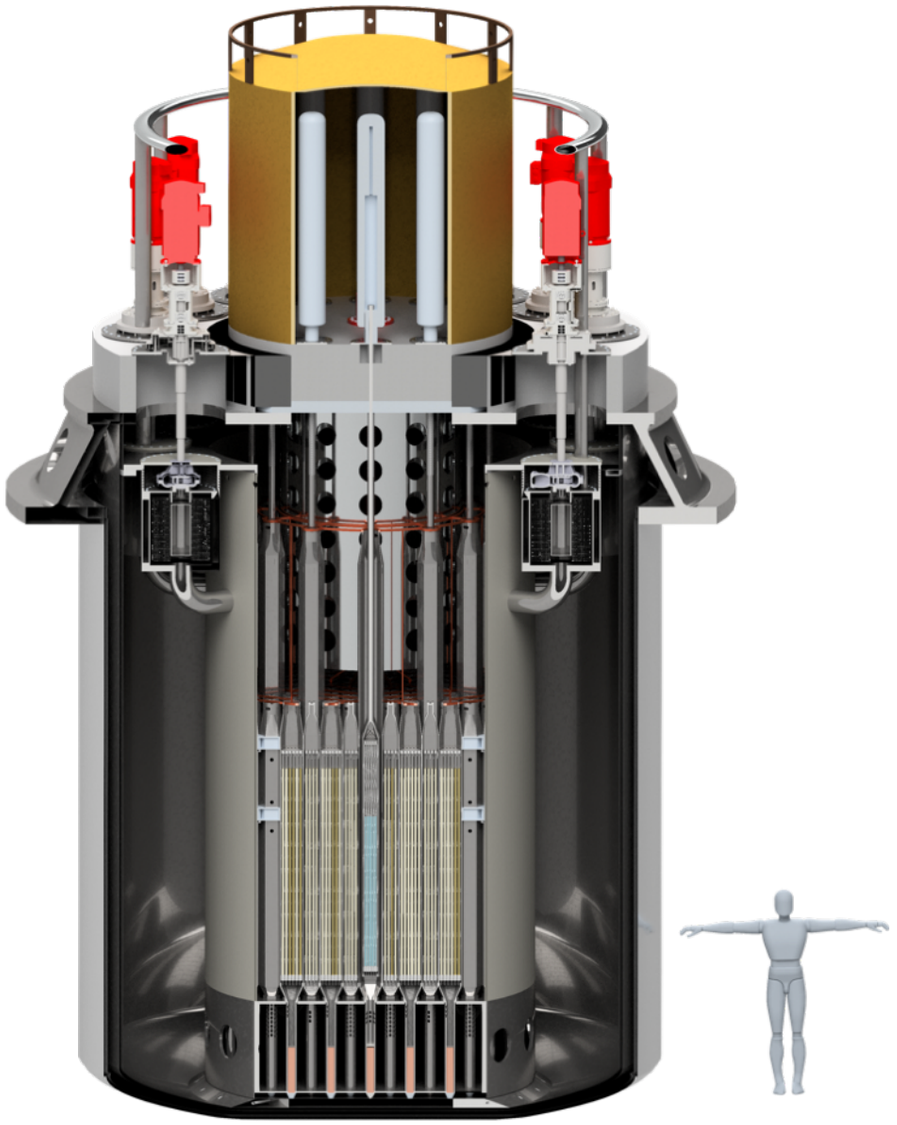
LeadCold



Rationales

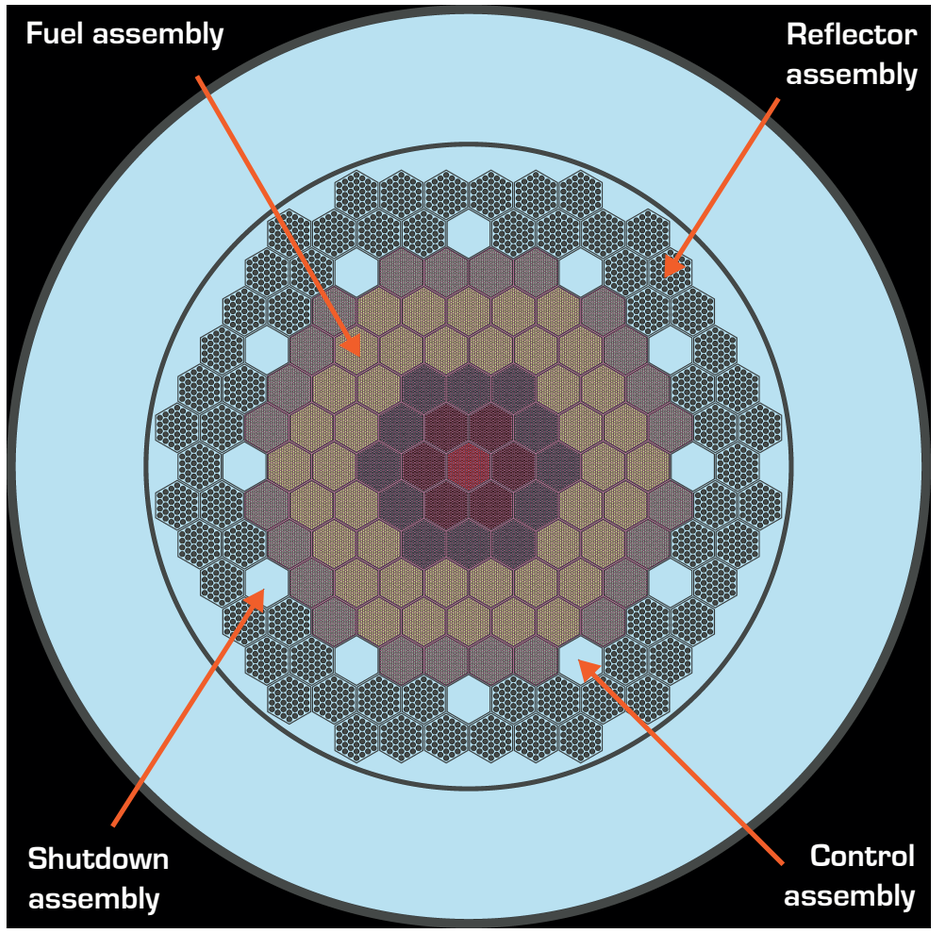
- Nuclear power: only form of base-load capacity that can be deployed to an extent significantly reducing greenhouse gas emissions.
- Large scale LWR projects are facing a number of problems:
  - Investment risk
  - Quality control
  - Construction delay
  - Budget overrun
- Factory production of larger series of smaller units may address all of these issues

SEALER-UK



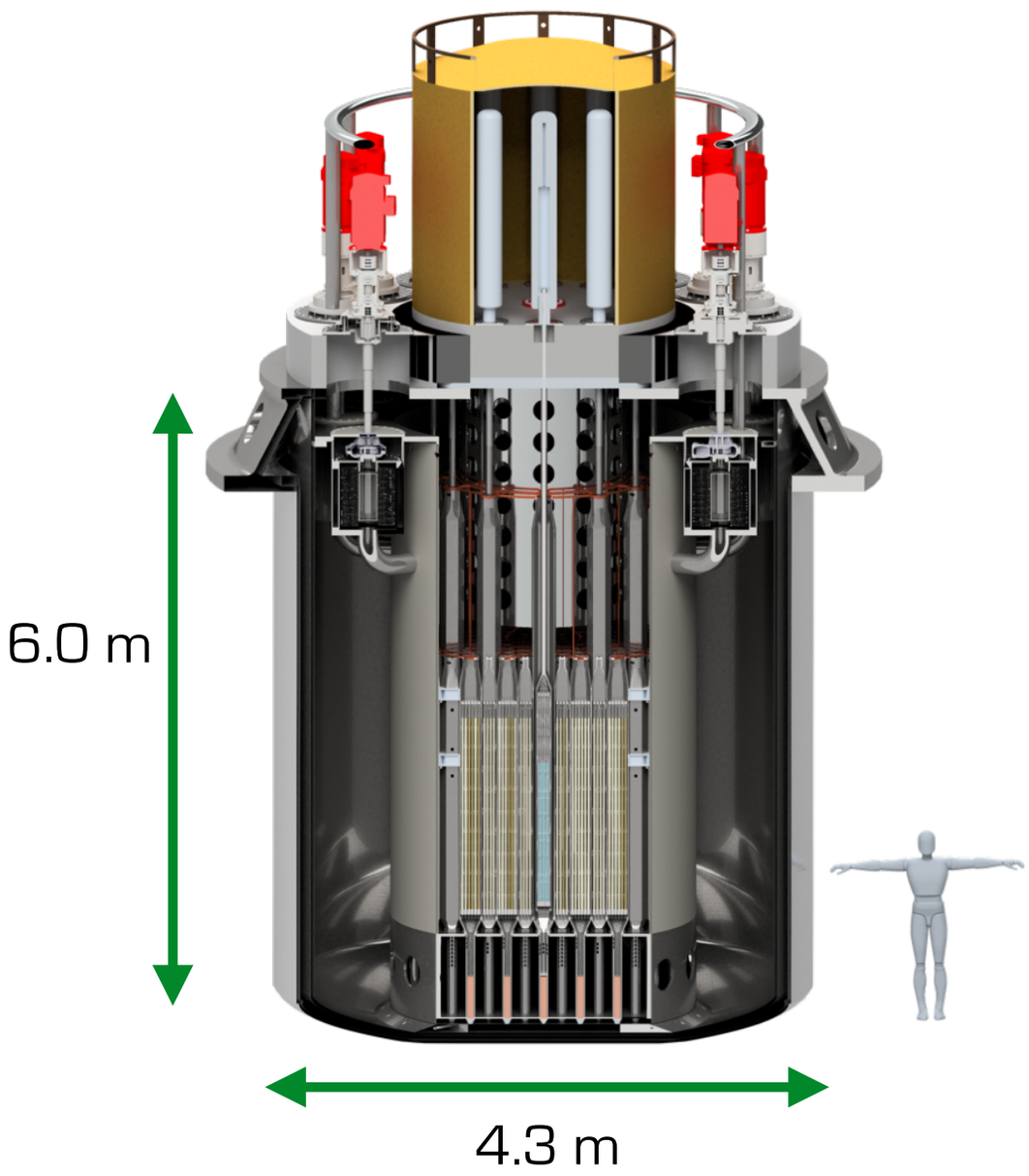
- UK government invited private companies to propose advanced modular reactor concepts that may be manufactured in a factory, in order to reduce construction cost by 30%.
- SEALER-UK designed to be:
- Passively safe, by use of lead coolant
- Economic, by use of uranium nitride fuel
- Compact, and therefore amenable to factory based serial production

Core design



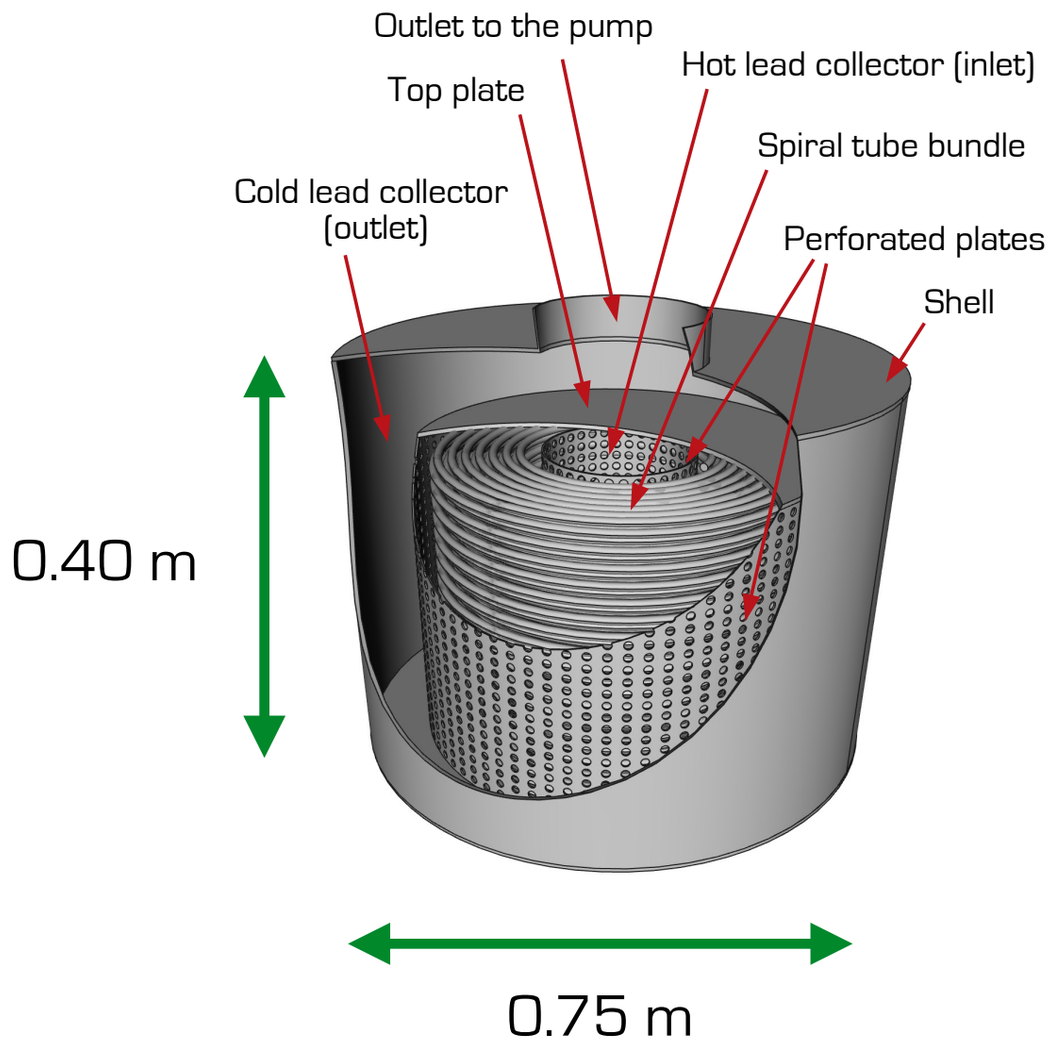
- 85 fuel rod assemblies
- 217 fuel rods per assembly
- 20 tons of 12% enriched UN fuel
- Breeding ratio = 1.0
- 22.5 EFPY of operation
- Six B_4C control rod assemblies
- Six W-(W,Re)$^{10}B_2$ shut-down assemblies
- 72 $(Zr,Y)O_2$ reflector assemblies

Primary system



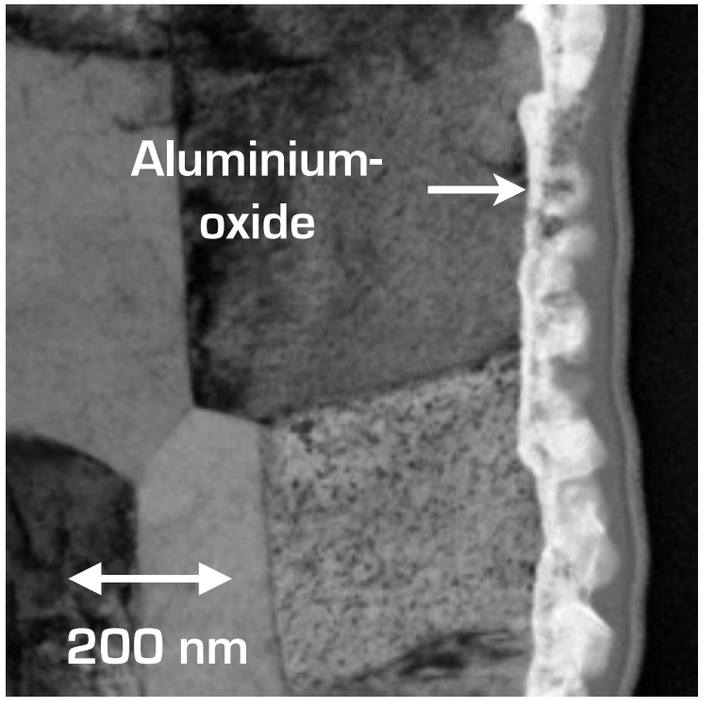
- Thermal power: 140 MW
- 10 x 14 MW steam generators
- 10 pumps, each with capacity 740 kg/s
- Core inlet temperature: 420 C
- Core outlet temperature: 550 C

Steam generator



- **14 MW_{th} spiral layer tube steam generator**
- **25 tubes with 14 turns**
- **Tube length: 18 meters**
- **Tube inner diameter: 11.0 mm**
- **Tube outer diameter: 13.0 mm**
- **Tube P/D: 1.2**
- **Inner coil diameter: 200 mm**
- **Outer coil diameter: 640 mm**
- **Stack height: 350 mm**

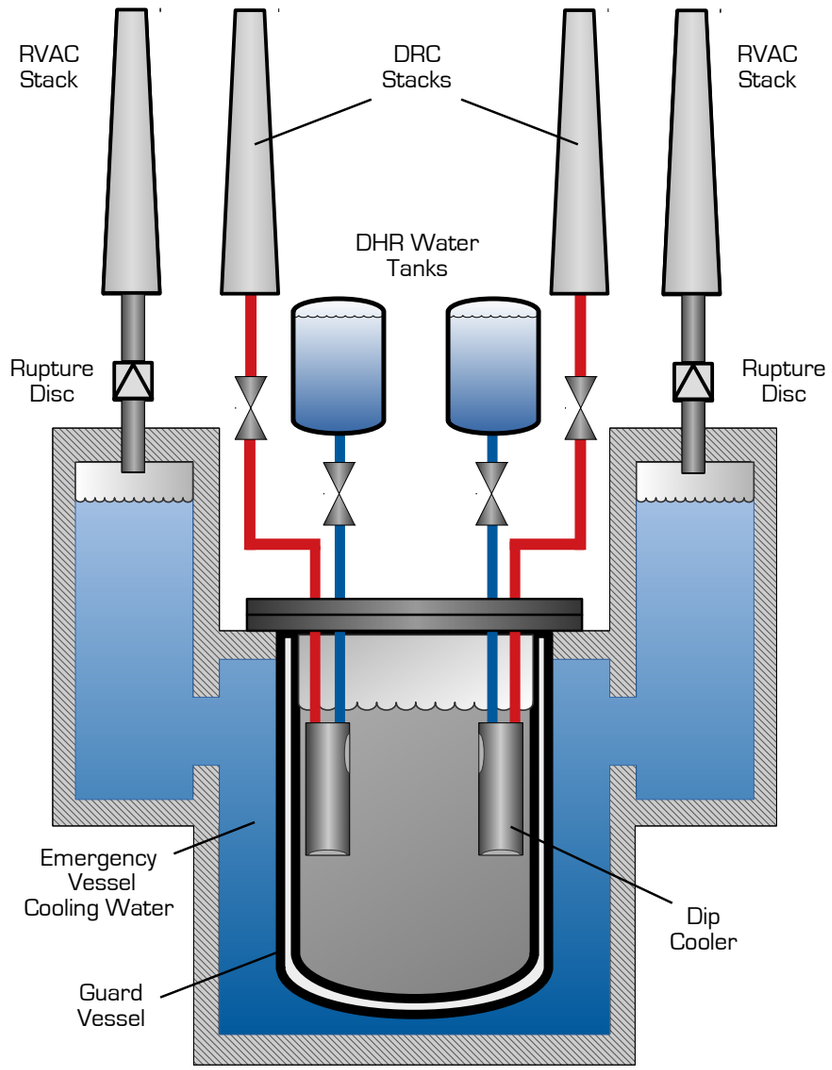
Corrosion protection



10 ton batch of
Fe-10Cr-4Al-RE
produced by SANDVIK

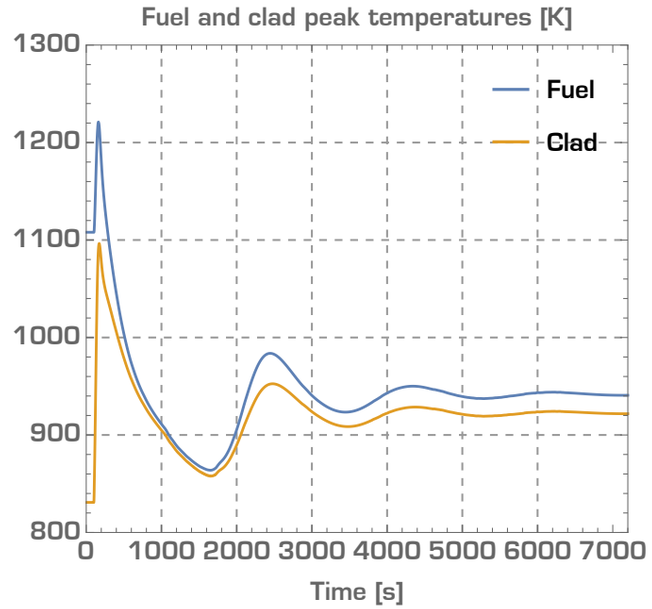
- Chromia scales are not protective above 450 C
- LeadCold's solution: aluminium alloyed steels:
  - Fe-10Cr-4Al-RE (RE = Zr, Ti, Nb, Y)
  - Alumina forming austenitic steels (AFA)
- Form 100 nm thin, ductile and protective alumina film on surfaces exposed to lead with low oxygen content.
- Fe-10Cr-4Al-RE successfully tested at 550 C for 19 000 h & 750 C for 1800 h.
- Low creep strength, suitable for non-pressurised components, or possibly as weld-overlay on SS316, or surface alloy on 15-15Ti

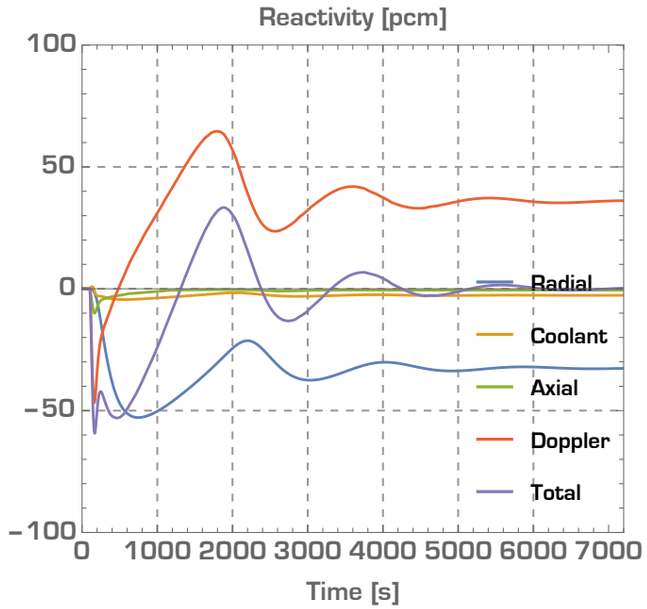
Safety systems

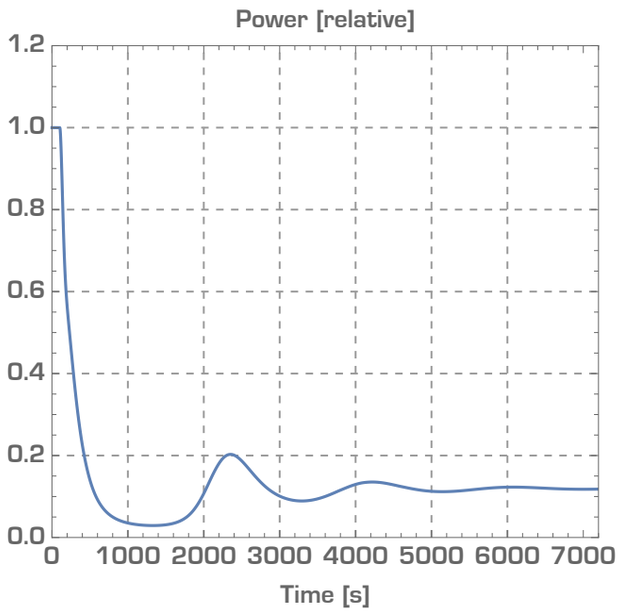


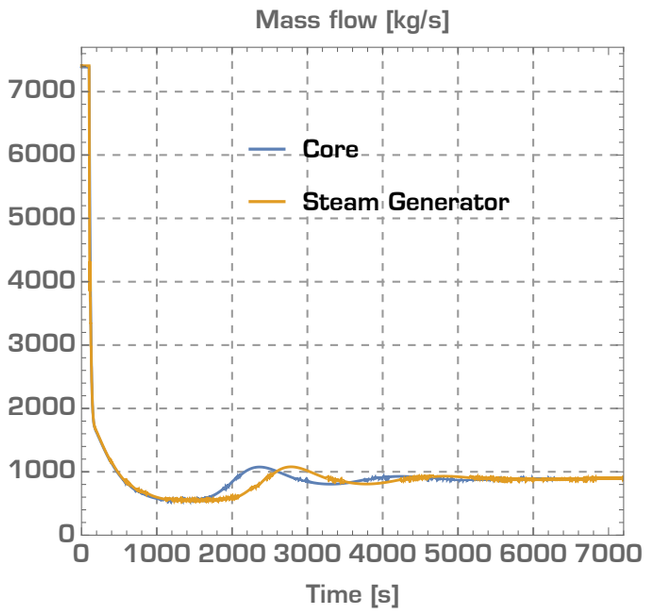
- Decay heat removal is achieved by:
- Passive natural convection from the core to the primary system
- Active actuation of dip coolers, should the secondary side be unavailable.
- Passive radiation from the primary vessel to the guard vessel, if dip coolers are not actuated.
- Guard vessel is immersed in water reservoir, dissipating heat to environment by boiling.

Transient performance: ULOF



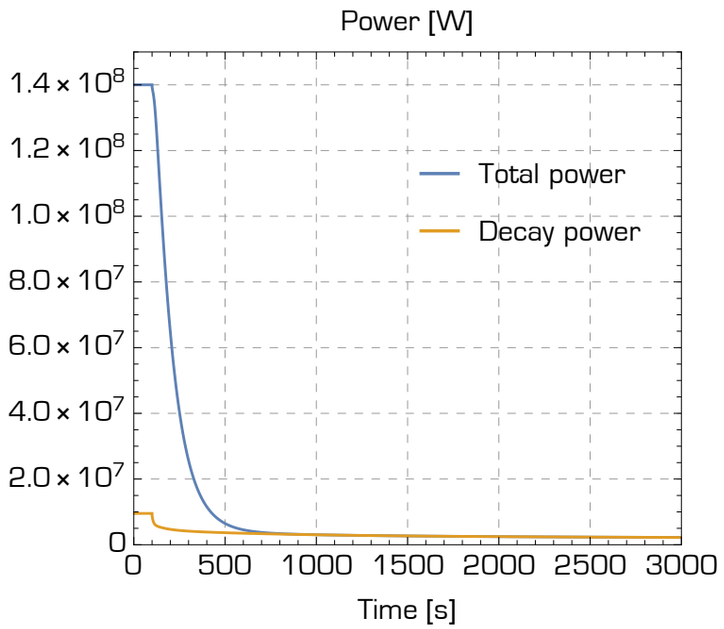


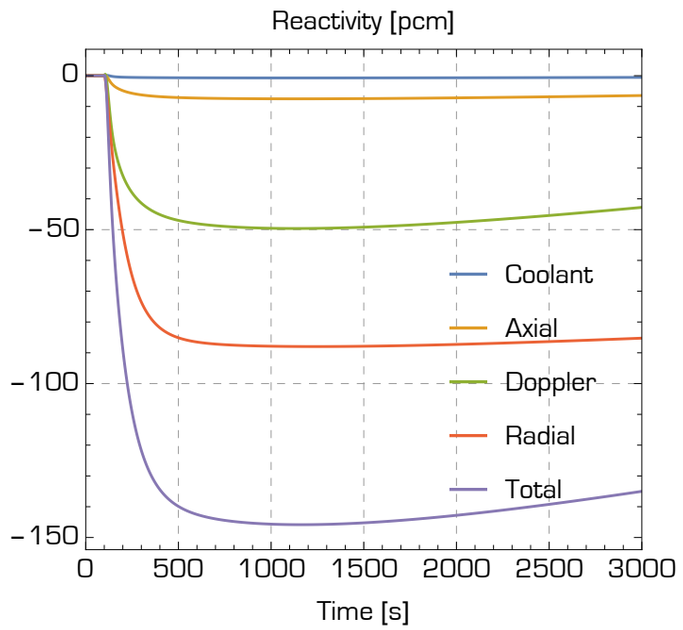


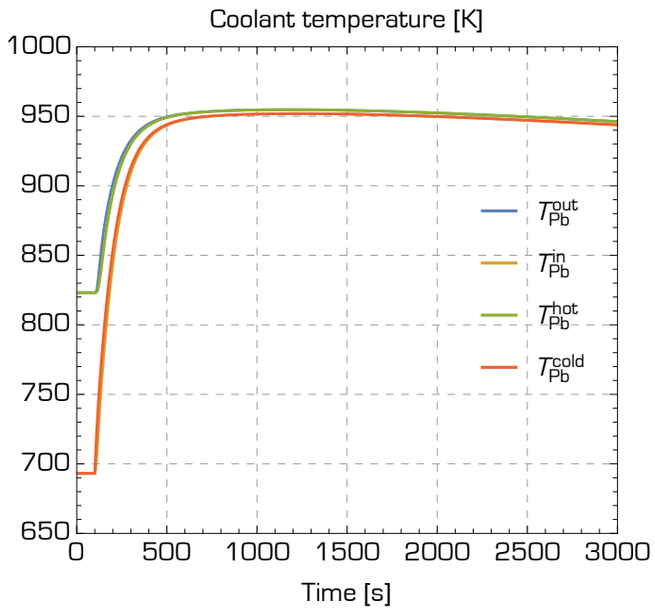


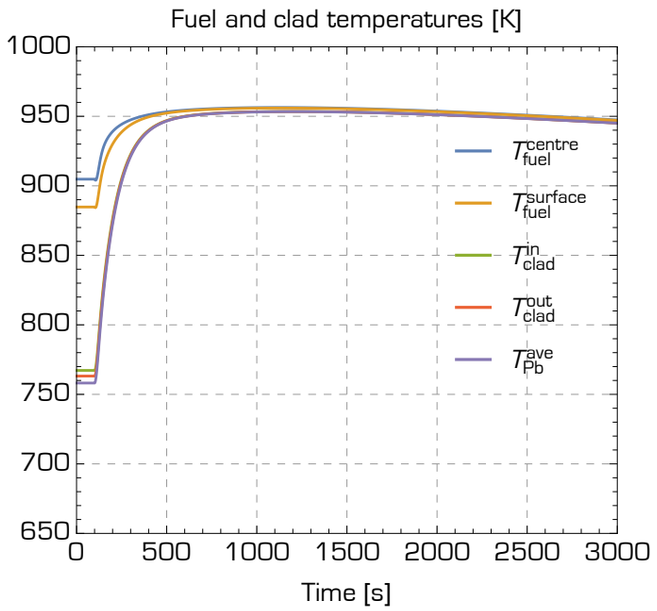
- ULOF at BoL simulated with BELLA

Transient performance: ULOHS





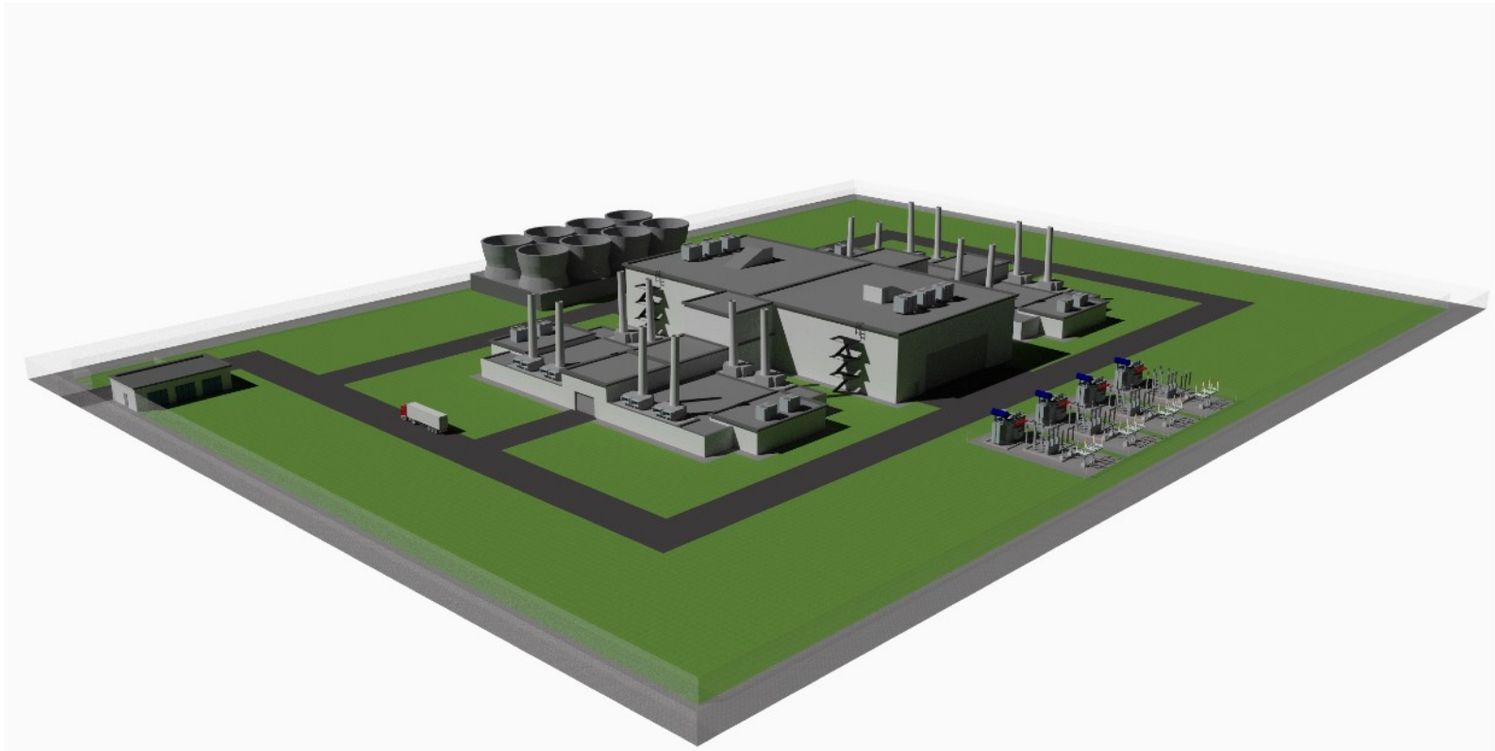




- **ULOHS at BoL simulated with BELLA**

Plant design & economy

- 4 x 55 SEALER/UK units integrated into 220 MWe power plant



- Plant cost: 700 million Euro (24 months from order to operation)
- LCOE: 55-60 Euro/MWh

Benefits and challenges

- Reduced investment risk:
  - 300 million euro for automated factory
  - 175 million euro per 55 MWe capacity increment
  - Time from placing order to commercial operation: 24 months
- Challenges:
  - 22.5 EFPY residence time of fuel - in pile inspection requested
  - Cost for security staff to be verified
  - Common mode design flaw impacts large number of units

Summary & Conclusions

- 55 MWe LFR with UN fuel designed for UK needs
- No refuelling for 25 years of operational life.
- Deployed in clusters of 4 (220 MWe plant)
- Cost competitive on UK market if commissioned 24 months after order.
- Factory production of 200 units (11 GWe capacity)
- Decommissioning of entire primary vessel as single waste package.