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.
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<sub>th</sub> 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

- 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 1,800 h.

- Low creep strength, suitable for non-pressurised components, or possibly as weld-overlay on SS316, or surface alloy on 15-15Ti.

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