



Advanced Modular Nuclear Reactor Competition

Project brief, v0.91

Project Introduction

Generation 4 Advanced Modular Reactors (AMRs) offer an opportunity to provide firm, carbon-free power to a range of applications such as supplying electricity to grid-independent data centres and remote communities or providing thermal energy for industrial processes.

The aim of this project is to design a megawatt-scale AMR for a regional government. Each team must select one of the two different electrical generation applications listed in Table 1. Then, develop a solution that achieves the solution requirements in Table 1 by completing activities listed in the Project Scope section. Teams are not expected to complete all of the Project Scope to the same level of detail. An ideal team takes a balanced approach and completes work against all of the Project Scope, determining an appropriate level of depth for each scope topic and managing their team's capability, ability to meet project deadlines, and any limitations due to access to appropriate tools.

Before entering a bidding process with the government, your teams technical solution must be reviewed by a third party, who will conduct initial technical due diligence on the government's behalf. This due diligence comes in two phases.

- **Phase 1 (November 2026 to January 2027):** Each team presents an outline of its progress to judges online ([TBC] minutes). Two teams per university are selected to continue into Phase 2; members of teams that are not selected can apply to join the two selected teams for the remainder of the competition. The whole project scope is not expected to be complete by this deadline; this is expected for the finals. During the down selection, teams will be judged based on the quality of work and range of scope delivered to date.
- **Phase 2 (January 2027 to March 2027):** The remaining teams give a 30-minute presentation covering [TBC] and submit a report of no more than 8 pages (title, contents and reference pages excluded; an appendix is permitted but is not scored). The report covers the concept, the method of development, evidence of initial V&V, and key lessons learned, and is due two weeks before the final presentation. We recommend including short snippets of code in the appendix for sections of interest. The report should cover all tasks.

Project Options

Both options are grid-independent electrical systems at the same power level, constrained to the same reactor technology. They differ in what the customer asks of the plant: Option 1 must never stop, Option 2 must be able to move quickly.

TABLE 1 – Project Options and Solution Requirements

	Option 1: Data centre	Option 2: Remote community micro-grid
Customer	A grid-independent data centre campus. Commission date 2040.	A large remote community served by a local micro-grid. Commission date 2040.
Facility Life	60 years	60 years
Electrical demand	20 MWe.	20 MWe.
Facility capacity factor	100%. Critical infrastructure must be continuously powered; there is no planned outage the customer will accept.	95% over 10 years. Some downtime is acceptable (i.e. for maintenance) but must be justified to the customer.
Rate of change of electrical power output	Modest. The plant must manage a step of 10% of rated output (2 MWe) from IT load swings and ramp at 2% of rated output per minute (0.4 MWe/min) without breaching safe operational limits.	The plant must ramp at 10% of rated output per minute (2 MWe/min), sustained anywhere between 20% and 100% of rated output, and manage an instantaneous step of 20% of rated output (4 MWe) holding frequency within ± 1 Hz and recovering to within ± 0.5 Hz in 30 seconds, while remaining within safe operational limits.
Load profile	A practical assumption based on the team's literature review, including steps and ramps featuring the maximum rate of change of electrical power requirement both up and down. It cannot be constant or a flat baseload.	A practical assumption based on the team's literature review, including the community's daily cycle and any intermittent renewable generation on the micro-grid. It cannot be constant or a flat baseload. The load profile must also include steps and ramps featuring the maximum rate of change of electrical power requirement both up and down.
Location	Reachable via roads that lead to deep water ports and airports; next to residential and business buildings; no reliable water source; limited local construction materials.	Reachable via roads that lead to deep water ports; next to residential and business buildings; no reliable water source; limited local construction materials.
Technology constraint	Prismatic high-temperature gas reactor.	Prismatic high-temperature gas reactor.



Project Scope

Develop a concept design for an advanced modular reactor. Teams should fix a power level, duty cycle and refuelling interval early and justify them against their project's specific application, rather than designing to a generic specification. As this solution is for the early bidding process, the minimum design scope for submission is as follows.

- 1) **The nuclear primary circuit** (reactor core, fuel, moderators, RPV, primary coolant, pipework).
 - Select a fuel form and enrichment (e.g. TRISO particle fuel in a compact or monolith, or metallic and oxide fuels) and justify the choice against fuel supply chain availability, sustainability and fuel waste, achievable burn-up, fission product retention, fuel qualification timescales, and the licensing route that choice implies.
 - Core design: geometry, moderator and reflector selection, control and shut-down mechanisms. Produce criticality and burn-up calculations via hand calculation or established codes (e.g. OpenMC, Serpent, or MCNP where licensed) and report the effective multiplication factor over life, not only at beginning of life.
 - Consideration in design and operation for the reduction of through-life operational waste.
 - Demonstrate that the effective multiplication factor stays below unity (reactor is subcritical) whilst the shut-down mechanism (assume fully operational) is inserted during the following accident configurations: reactor core water ingress and flooding, loss of coolant, and finally confirm the reactor remains sub-critical during a partial shut-down mechanism failure (i.e. a one absent rod). Report the calculated reactivity margin in each case rather than asserting the property.
 - Show that thermal runaway is physically precluded rather than merely controlled. Quantify the temperature coefficient of reactivity (fuel Doppler broadening, moderator and expansion feedback) across the whole operating range and show it is negative throughout.
 - Justify transport, installation and decommissioning, including the mass and envelope of the shielding that has to travel with the unit. A core that is neutronically elegant but cannot be fabricated, moved on a standard road or rail load, or handled at end of life is not a good design.
- 2) **A method of power conversion**, transferring thermal energy from the primary circuit into useful work.
 - Select and justify a heat removal route (e.g. heat pipes, gas, or liquid metal) and the power conversion cycle that follows from it.
 - Demonstrate that decay heat can be removed passively, with no operator action, no external power and ideally no moving parts, for the full period over which it matters.
 - Define the thermal storage arrangement and its interfaces with both the primary circuit and the power conversion system, sized as set out above.
- 3) **The method for delivering power to the customer and balancing load**, including the load balancing software, so as to meet the customer's load profile alongside any additional renewables or alternative supplies needed to hit the availability and rate-of-change targets.
 - Set out the control hierarchy and where the boundary sits between automated control and human authorisation, and name the tools or frameworks the team would build on.



- Show the dispatch of the thermal store, the reactor and any other supplies against the load profile over a representative period.
- 4) **Justification for the site location:** below ground, at grade, or in a hardened surface structure. Present this trade-off with evidence rather than asserting a preference; criteria could include shielding, excavation and installation, seismic response, heat rejection, and security.

The design must also be accompanied by a short safety and security case setting out the most important and novel claims made on plant equipment. It should be suitably structured and written, and teams are advised to research the relevant frameworks (e.g. IAEA guidance, and ONR and NRC positions on transportable and factory-fuelled reactors). Consequence, not only prevention, must be assessed. Teams should estimate the source term and off-site dose consequence for only the most significant pathway (that is most likely to result in the largest dose) and use this to argue the exclusion zone and emergency planning zone is suitable for the project's location requirement. The facility must be assessed against a defined range of credible attacks and hostile acts: forced intrusion, vehicle impact, aircraft impact, and cyber intrusion (and its impact on automated processes). Teams should state their design basis threat explicitly and show what physical or inherent feature defeats each case, rather than relying on procedural response alone.

Finally, the design should be accompanied by a short operational summary covering the operating concept, the number of staff required per site, and the degree of automation used, for two lifecycle phases: normal operation (delivering power and load following) and refuelling.

Assessment Criteria

To win the bid, the local government and the third-party reviewer will score each team's technical proposal against the following criteria.

- Delivery against the customer's operating requirement: the availability and rate-of-change figures above, evidenced rather than asserted.
- Safety: Passive safety measures favoured over active safety measures; Evidence of: Reduction in number or significance of hazards (inherent safety) & reduction in reliance on operator action. Overall robustness of any claims, arguments, and evidence.
- Security: Security measures derived from the threat assessment that are practical, simple, limit physical on site security personnel, states residual vulnerabilities, and enable secure remote-control operations.
- Modelling approach: thoroughness, quality, and compliance with good coding practice such as PEP8.
- Consideration and justification of the level of modelling fidelity used. What assumptions have been made, and how have they been captured? This is a powerful skill.
- Depth of research and strength of the design justifications.
- Completeness of the submission against the scope.
- Key points of learning during the task and how they are recorded. We want to see what you discover, how you explore options, what you learnt, and how you then applied it.
- The Phase 1 presentation.
- The final presentation and summary report.
- Novelty of the fuel, core, cooling or energy storage concept.



- Realism of the underlying fabrication, fuel availability, transport and licensing assumptions.
- Project management and process: planning, recording of information, communication, risk capture.
- Evidence of strong team working, cross-functional working, and integration between teams.

Students should use their skills and interests to take on work they think will be useful and interesting even where it is not explicitly listed in the scope, so as to develop the strongest project against the criteria above.

Timeline

- Phase 1 ends: beginning of January 2027 (online presentation and down-selection).
- Phase 2 report due: two weeks before the final presentation.
- Phase 2 ends: March 2027 (final presentation).



Appendix

Key Terminology

- Load Profile - a graph or dataset showing how energy use changes over time.
- Facility Capacity Factor - the ratio of the actual energy output of an electricity-generating device divided by the energy output that would be produced if it operated at its rated power output (Reference Unit Power) for the entire year.
- Subcritical - A subcritical nuclear assembly has an effective neutron multiplication factor (k_{eff}) of less than 1.
- Thermal Runaway -
- Please add further terminology of key terms

Useful Resources & Links

- Heat Exchangers - [How Not to Set Your Pizza on Fire: Crash Course Engineering #15](#)
- Heat Transfer - https://youtu.be/YK7G6l_K6sA?si=n-SlxqQE-m1HR1bE
- Nuclear Chemistry Pt1 - <https://youtu.be/KWAsz59F8gA?si=z19oYf1jXjrlUerT>
- Nuclear Chemistry Pt2 - <https://youtu.be/FU6y1XIADdg?si=XerLQelPmP5dcmr9>
- Please add further links to neutronics calcs (1D calcs etc...)
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