UNIVERSITY OF CAMBRIDGE IMPERIAL UNIVERSITY OF OXFORD UCL

Novel Fission and CO2 Reduction Project

Project Scope

With the new age of nuclear on the rise and the global initiative for decarbonisation, novel applications of reactors are an exciting and accelerating area of research. This project will provide exciting insight into the possibilities of smaller advanced reactors for working towards this.

The aim is to Design a System for the Application of a High Temperature Gas Reactor (HTGR) for Net Reduction of CO_2 with a Water Independent Heat Rejection System. This is the combination of two tasks that should be completed by sub-teams working closely together.

The following sections will break down the requirements and expectations of each task. However, it is important to remember that although these are outlined as separate tasks, they have significant reliance on information from each other.

Subtask 1 - Application of High Temperature Gas Reactor for CO_2 Reduction

1.1.1 This task will be to develop a concept for an application of a HTGR for CO_2 reduction. The use of nuclear itself results in CO_2 reduction by lessening reliance on fossil fuel combustion. However, the application of the system as a whole can reap further benefits.

1.1.2 An example is the production of synthetic fuels, in which the HTGR is used to produce not only the electricity required for running machinery and electrolysis but also the heat for other processes. In this example the students must find the total CO_2 saved by using nuclear to generate electricity, heat, and the CO_2 extracted from the atmosphere, and then how these balance with the synthetic fuels being combusted – with a net positive effect.

1.1.3 The first part of the task will be a supporting literature review of existing HTGR designs, power extraction cycles, applications, etc. Followed by the outlining of requirements, assumptions, inputs, and outputs.

1.1.4 The main task will require the development of a model of the whole plant - reactor systems, power extraction systems, secondary systems for the application, and some representation of the heat rejection system. This can be created in a tool/language of the teams choosing (python/MATLAB/etc). This will be developed in several stages – to a fidelity suitable for results to present at the end of the first phase, and then developed to a higher fidelity for the finals.

1.1.5 It is proposed that the teams use the High Temperature Test Reactor (HTTR) as the starting geometrical design of the core and power output. It is not expected that teams develop their own designs and concepts (though it is welcomed). Experience and access to the relevant tools is not commonplace, and so teams will not be penalised for not completing this extra work. If a higher power is required, then the teams can use multiple cores in parallel or use literature to find how to scale the core design to accommodate this.

1.1.6 Good practice is to also assess that the core operates in a safe temperature range. In the second phase of the project a two dimensional unit cell assessment should be undertaken. This can be supported with CFD work for comparison.

1.1.7 The working fluids, power extraction cycle, heat rejections system, etc are all free to be chosen by the teams. All designs should have safety at the forefront - a novel design that significantly increases efficiency is excellent, however it should also operate safely. Justification that extra layers of safety have been considered is required.

1.1.8 We would like to see evidence of some verification and validation of models created against data in literature.

1.1.9 The primary figure of merit is the net CO_2 saved. However, there is also significant weighting on other things such as:

a) Modelling approach taken – the thoroughness, quality, and compliance with standards such as PEP8.

b) Project management and process – planning, recording of information, communication, risk capture etc

c) The consideration and justification of the level of modelling fidelity used. What assumptions have been used and how have they been captured? This is a powerful skill.

d) Key points of learning duration task and how this is recorded. We want to see what you discover, how you explore options, what did you learn and how did you then apply this?

e) Novelty of the application.

f) First phase presentation.

g) Final presentation and summary report.

h) Cross-functionality working and integration between teams.

i) Depth of research.

j) Full supply chain definition – for example, if carbon capture is used, how is the carbon then used?

1.1.10 The scope outlined isn't expected to be completed by the first deadline, this is for the finals. The progress up until the first phase is what will be assessed in the initial project down selection. Additional work should also be completed investigating all requirements – material properties and limitations, existing components and operating characteristics, etc. Students should utilise their relevant skills and fields to complete tasks that they think will not only useful but also interesting, even if not listed here.

Subtask 2 – Novel Design of a Water Independent Heat Rejection System

2.1.1 Not all applications of a HTGR are going to be near a water source. If the HTGR is to be installed for an existing plant that is not near a water source, then this is a significant challenge. Therefore, this task explores the possible solutions to heat rejection without a water source. The team should design the required architecture to reject any excess heat from the system in the other task. See the example of Aalo progressing with water independence: (Announcing the Aalo Pod | Aalo Updates).

2.1.2 Water may be used in the system in a contained loop, but replenishing significant amounts of water is not permissible. Use of water for the application of the HTGR (e.g. Hydrogen production through the electrolysis of water) is permissible, but not for this task.

2.1.3 The mandatory assessment is that the design is for steady state conditions – the required heat rejection for the main system. A desirable task is that the architecture is scaled to account for transient behaviours such that a higher load needs to be rejected. The assessment should be completed in environments that are representative of the application and account for the range of temperatures that can occur during the day and year (i.e. demonstrate that it is functional at the hottest day and coldest day).

2.1.4 The key assessment criteria will be the size/footprint and the power required to run this (e.g. motors, fans, etc) as these are considered parasitic loads.

2.1.5 The task requires a literature review of existing concepts be completed and then a model developed (in several steps as before) to demonstrate the functionality and feasibility.

2.1.6 The main scoring criteria for the design is the size and power requirement to operate. However, the other criterion listed for the other subtask are also of importance.

Timeline

This competition has two phases: the first ends at the beginning of January, wherein each team presents their design to judges online; from here, 2 team´s designs are selected from each university for the in-person finals. Members from teams which did get selected can apply to join the two selected teams for the remainder of the competition.

In January a mid-project review will be held, and for this the only deliverable is a presentation outlining the progress completely thus far.

The in-person finals consists of a 30 minute presentation, as well as the submission of a report; this has a limit of 8 pages (title, contents, and reference pages not included, appendix not included but will not be included in the scoring) and should cover the concept, the method of development, evidence of initial V&V, and key lessons learned. This should be delivered 2 weeks before the final presentation. We recommend including short snippets of code in the appendix of sections of interest. The report should cover both tasks.

6 October 2025	Applications Open
17 October 2025	Applications Close
20 October 2025	Teams formed
24-28 November 2025	Mentor Check-In (Feedback given)
12-16 Jan 2026	Phase 1 Presentations (Feedback given)
9-13 February 2026	Mentor Check-In (Feedback given)
20 March 2026	Finals