Analysis of the UK Nuclear Licensing Framework and Generic Design Assessment (GDA) for SMR Export Strategies

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1. Introduction

The United Kingdom has repositioned nuclear energy as a key low-carbon power source within its long-term Net Zero strategy for 2050 [1][2]. With the phased retirement of Advanced Gas-cooled Reactors (AGR) and the growing need to secure stable baseload generation, Small Modular Reactors (SMRs) have emerged as a strategic alternative alongside large-scale nuclear power plants. Through policy initiatives such as the British Energy Security Strategy (2022) and Powering Up Britain (2023), the UK government has clearly expressed its intention to expand new nuclear capacity and has linked SMR development to industrial competitiveness and export strategies.

The UK nuclear licensing framework is characterized by a multi-agency, multi-stage structure that includes the Generic Design Assessment (GDA) as a pre-licensing design review process [3]. By evaluating the safety and environmental acceptability of a reactor design prior to site selection, the GDA aims to reduce regulatory risks in subsequent site-specific licensing stages.

SMR development in the UK has recently accelerated. A representative example is Rolls-Royce SMR, which has proposed a pressurized water reactor (PWR)-based modular reactor design and is participating in the GDA process [4]. According to publicly available information, Rolls-Royce SMR emphasizes standardized design and factory-based modular construction and has developed an integrated Environment, Safety, Security and Safeguards (E3S) case structure to demonstrate design safety.

This study systematically analyzes the UK nuclear licensing framework, examines the institutional role and evaluation structure of the GDA, and identifies key regulatory considerations for SMR deployment. Based on this analysis, strategic implications for SMR export to the UK market are derived.

2. UK Nuclear Facility Licensing Framework

2.1 Multi-Agency Regulatory Structure

The UK nuclear regulatory system is characterized by the separation of safety, environmental, and planning approval functions across different regulatory bodies.

Nuclear safety regulation is overseen by the Office for Nuclear Regulation (ONR), which issues Nuclear Site Licences under the Nuclear Installations Act 1965 [5][6]. The ONR regulates nuclear installations throughout construction, commissioning, and operation through Licence Conditions.

Environmental regulation is administered by the Environment Agency (EA), which reviews radioactive discharges, waste management practices, and environmental impacts under the Environmental Permitting Regulations [7].

In addition, large-scale energy infrastructure projects require approval through a Development Consent Order (DCO) under the Planning Act 2008 [8]. This reflects the classification of nuclear power plants as nationally significant infrastructure projects.

This multi-agency structure has the following characteristics:

1. Independent review of safety and environmental aspects
2. Procedural separation of design acceptability and site suitability
3. Stepwise approval mechanisms for managing regulatory risk

2.2 Licensing Process

The general licensing pathway for new nuclear facilities in the UK can be summarized as follows:

1. Generic Design Assessment (GDA)
2. Development Consent Order (DCO)
3. Issuance of Nuclear Site Licence
4. Issuance of Environmental Permit
5. Stage-specific approvals during construction
6. Operational authorization and compliance with Licence Conditions

The Nuclear Site Licence does not represent a one-time approval event. It establishes a regulatory control framework consisting of approximately 36 Licence Conditions that govern construction, commissioning, and operational activities [6].

At the site-specific stage, a Site-Specific Safety Case must be submitted, incorporating local conditions such as geology, seismic hazards, flood risk, and population distribution. This ensures that the design can be safely operated at the proposed location.

3. Evaluation Structure of the GDA

The Generic Design Assessment (GDA) is a pre-licensing review process that evaluates the safety and environmental acceptability of a generic reactor design

independently of a specific site [3]. Its objective is to reduce regulatory uncertainty for new nuclear technologies prior to site-specific licensing. Although not legally mandatory, the GDA has become the de facto standard pathway for introducing new reactor designs in the UK. It focuses not only on technical adequacy but also on the structural completeness and logical consistency of the Safety Case.

3.1 Institutional Position and Scope

The GDA adopts an integrated E3S (Environment, Safety, Security and Safeguards) perspective. Since the assessment is conducted prior to site selection, it relies on representative or bounding assumptions rather than site-specific conditions. Therefore, GDA approval does not constitute construction authorization; additional evaluation is required through a Site-Specific Safety Case once a site is determined.

3.2 Process and Phased Review

The GDA follows a phased review structure. In the early stages, the design overview and scope of assessment are defined. Subsequent stages involve increasingly detailed technical review of key safety issues. As the process progresses, greater maturity is required in the claim–argument–evidence structure of the Safety Case. In the final stages, residual issues are identified and regulatory expectations are clarified.

3.3 Documentation Framework

The GDA submission is structured around the Safety Case and consists of multiple interrelated documents. These include design description reports, accident analysis reports, Probabilistic Safety Assessment (PSA), internal and external hazard analyses, digital I&C verification strategies (if applicable), and environmental assessment documentation. Traceability and internal consistency are key evaluation criteria.

3.4 Evaluation Principles

The GDA is conducted in accordance with the ONR's Safety Assessment Principles (SAPs) [9]. The UK regulatory approach is principle-based rather than strictly prescriptive. Designers must demonstrate that risks have been reduced to a level that is As Low As Reasonably Practicable (ALARP). The review process involves iterative question-and-answer interactions between the regulator and the requesting party, leading to progressive refinement of the Safety Case.

3.5 Interface with the Nuclear Site Licence

The GDA provides generic design validation, while the Nuclear Site Licence stage incorporates site-specific considerations through a Site-Specific Safety Case. Therefore, SMR export strategies must consider both early-stage structuring of safety arguments under the GDA and the transition to site-based regulatory requirements.

4. Discussion

The UK licensing framework structurally separates generic design review from site-based authorization, thereby managing design risk and site risk in a staged manner. The GDA evaluates the completeness of safety arguments through a principle-based, Safety Case-centered approach, while the Nuclear Site Licence ensures lifecycle regulatory control through Licence Conditions.

From this analysis, the following strategic implications can be derived:

1. The GDA evaluates not only technical design completeness but also the structure of safety arguments.
2. SMR developers must structure ALARP-based safety justification from the early design phase.
3. Multi-module deployment strategies should be accompanied by integrated site-level safety analysis.
4. Standardization of Safety Case documentation frameworks is essential.
5. Technical communication strategies considering regulatory transparency are necessary.

5. Conclusion

This study analyzed the UK nuclear licensing framework and the structure of the Generic Design Assessment (GDA). The UK adopts a principle-based regulatory approach that emphasizes structured safety argumentation at the design stage. For successful SMR export to the UK, regulatory strategies must incorporate GDA evaluation principles from the earliest design phases.

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