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The Generic Feasibility Assessment: An Essential Ingredient in Nuclear Policy making

The UK Government has made a commitment to reduce greenhouse gas emissions by 80% from 1990 levels by 2050. Achieving this goal may demand a significant expansion of nuclear power and the Government has been exploring scenarios with up to 75 GWe capacity beyond 2050.

Various roadmap studies[1] have examined combinations of reactor types and programme sizes, and tools such as NNL's ORION program enable accurate predictions of parameters including uranium usage, plutonium creation and use, spent fuel and waste generation, radiotoxicity and heat generation. However, while providing an excellent view of 'what' will happen for any given scenario, these studies give no information about 'why' any particular scenario should be preferred over another.

The Generic Feasibility Assessment (GFA) seeks to fulfil this requirement, by examining reactor systems and programmes against likely UK energy futures, and seeking to match the reactor system mix with the energy market and the other drivers and barriers to nuclear power deployment. The GFA concept seeks to answer the high level strategic question

> *"What are the attributes of a nuclear energy system which would justify investment in its future development with view to deployment in the UK?"*

If the answer to this question is known, then investment can be focused onto reactors and fuel systems which will meet the energy market need, contribute to decarbonisation of the economy, and benefit the UK in terms of jobs and economic development.

This concept starts from the recognition that, in the UK context, safety, environmental and proliferation/security attributes are all covered by well-developed regulatory regimes – so that reactor system deployment is not about "*how safe, secure, and environmentally benign*" a system is – but rather how much time and effort must be expended to allow the system to conform with this tried and tested regulatory framework.

This leads to five further questions which any system seeking entry into the UK market must answer:

1. *How much time and effort will be required to achieve regulatory approvals to deploy this nuclear energy system?*
2. *Is it likely that the nuclear energy system is capable of being economically competitive with the reference (once-through Pressurised Water Reactor) system?*
3. *If this system was deployed . . . . . ? (covers fuel supply, waste disposal and reactor/fuel cycle siting issues)*
4. *Is there a credible path between state-led R&D investment now and private sector deployment in the future?*
5. *Can it meet market demands (for e.g. flexibility, process heat)*

A schematic of the five key questions is given below. It should be noted, however, that the assessment will be holistic, rather than sequential as implied by the schematic.

[1] For example UK Nuclear Fission Technology Roadmap, Preliminary Report, ERP, February 2012

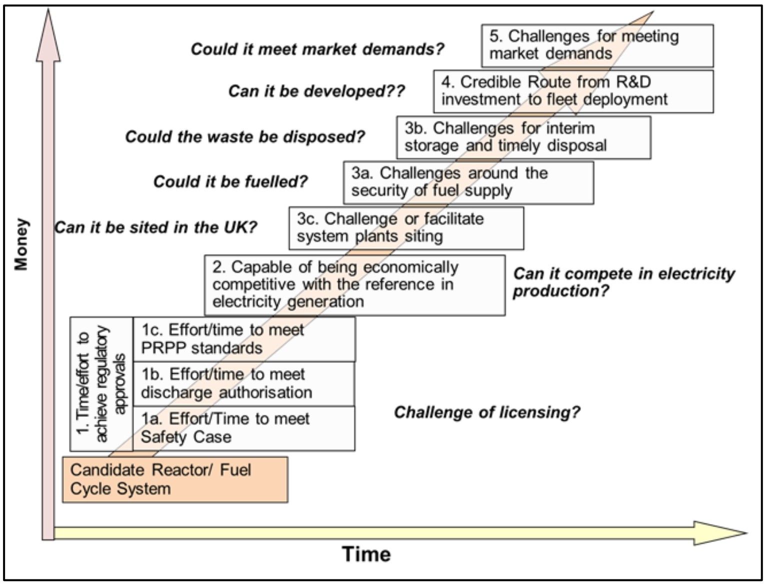

Figure 1 Generic Feasibility Assessment – Schematic Process

The concept is in the early stages of development, but seeks to ensure that any potential future reactor system is assessed against the needs of the UK electricity market, the overall decarbonisation agenda in the international context, and the need to maximise socio-economic impact for the UK, for example:

- Is transport to be decarbonised via batteries or hydrogen? Batteries would increase the need for dispatchable baseload power, while hydrogen could open a market for high temperature process heat
- Will load following be required for nuclear power to compensate for intermittent renewables e.g. wind power?
- Is security of uranium supply an issue in the longer term?
- What proportion of the reactor system can be delivered by the domestic capability?

The linkages between technology options, licensing, competitiveness, credible routes for development, meeting UK-specific constraints and meeting future market needs is illustrated below.

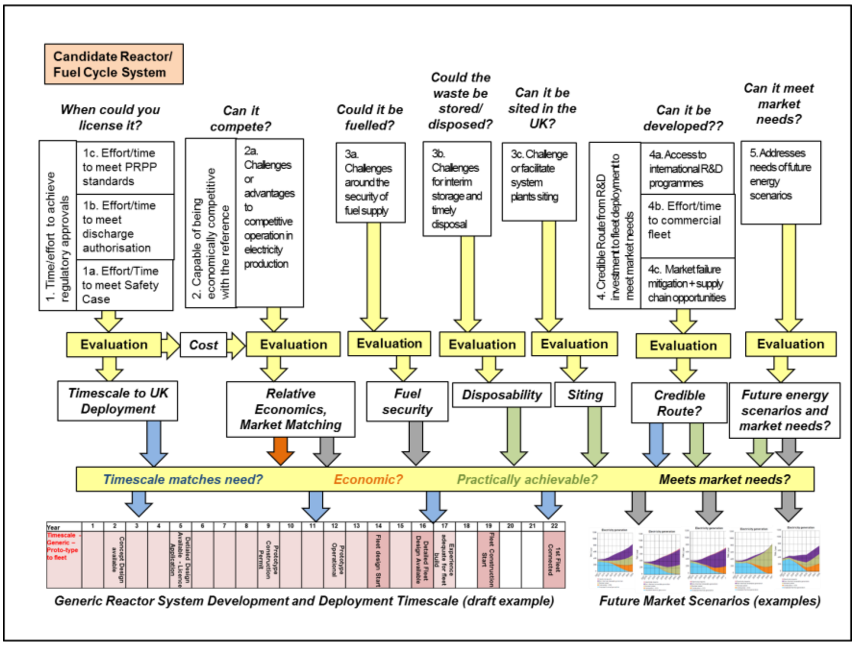

Figure 2: Generic Feasibility Assessment Process Diagram

In most assessment methodologies attempted to date, the desired attributes to describe the systems are derived, data and evidence is gathered, and then benefits and detriments are used in a Multi-Attribute Decision Analysis (MADA), giving 'marks' and 'weights' to each attribute, before combining all the marks and weights to give an "overall system score". Work by NNL provides an illustration of this technique[2]. There are two main disadvantages to this approach:

1. The use of a MADA with a large number of metrics (the study in Reference 2 uses 42) makes the result very difficult to communicate meaningfully, even to committed stakeholders – there is often a shared understanding by 'those that were in the room for the analysis', which fails to be transferable to others.
2. The suitability of a reactor system depends very strongly on 'the world in which it must operate'. For example, high scores for uranium economy (e.g. fast reactors) should be highly weighted in a 'uranium scarce' future, but will not feature in a 'uranium plentiful and cheap' future.

In the selected GFA system, the basic data from the NNL work was utilised[3], but here the attributes listed in the Figure 2 are assessed by comparison to a 'reference system'. This has initially been assumed to be current Pressurised Water Reactor (PWR) with a once-through cycle, for which many of the parameters, for example the time taken to license, uranium usage, load following capability and (in)ability to provide high temperature process heat are already well known. The comparisons made are based on published data which can be referenced, linked, and made publically available. It is expected that as the body of assessments build up, it will provide a significant and easily accessed database on reactor systems and their attributes.

For simplicity and clarity, it has been found effective to compare systems on 12 main attributes using the diagrammatic approach below, noting that each point on the diagram will be referenced to the document(s) and data that support the comparison.

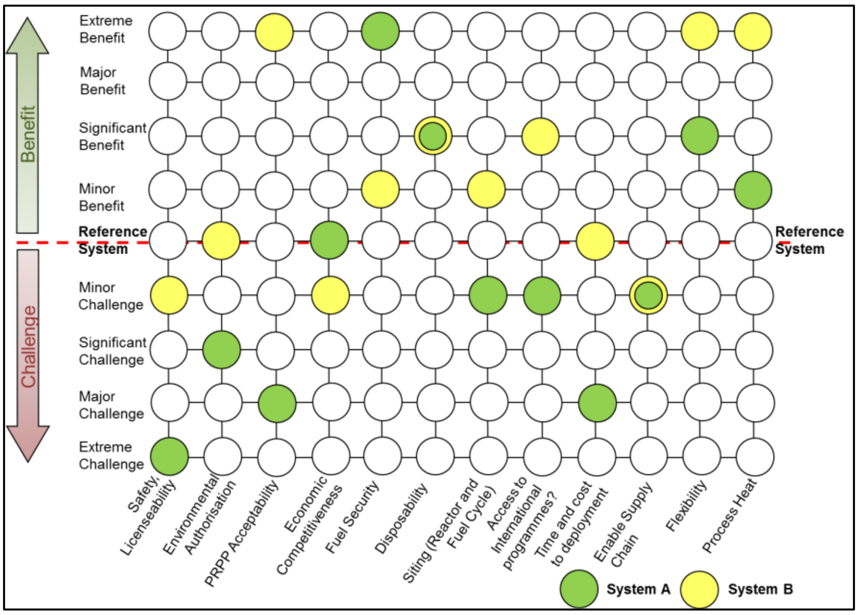

Figure 3. GFA Diagrammatic Presentation

Taking some significant indications from this example, against the once-through PWR reference:

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2 See, for example, Assessment of advanced reactor systems against UK performance metrics, NNL (11)11620 Issue 5, March 2012

3 See also Review of Metrics Relevant to Reactor Systems NNL (11) 11491, Issue 3, January 2012, and Comparison of thorium and uranium fuel cycles, NNL (11) 11593 Issue 5, March 2012, all via DECC website

- System A offers a very challenging safety licensing process, indicating a long timescale to obtain a license, together with very significant technical challenges and correspondingly high costs, and this is mirrored in a challenge to ‘time and cost to deployment’
- However, System A shows benefits in fuel security, indicated low use of a scarce fuel, together with significant advantages in waste disposability

This would indicate that System A is unlikely to be deployable in the short term, but it would have a major advantage in insulation the UK from problems with access to fuel material.

Conversely, System B offers

- Extremely beneficial Proliferation Resistance and Physical Protection (PRPP) properties
- Expected economics expected ultimately to be slightly worse than the PWR reference
- Fuel security on a par with the PWR reference
- An ability to load follow, and to provide high temperature process heat

System A would thus be favoured, in spite of its barriers to deployment, in situations where the security of fuel supply was likely to become paramount.

System B, on the other hand, has no benefit in fuel supply security, but can provide load following and process heat, and would thus be favoured where, for example, nuclear was to provide a high percentage of the electricity supply, and where activities, such as hydrogen generation, provided a market for high temperature process heat.

The Generic Feasibility Assessment concept thus aims at helping to inform the definition of future nuclear programmes from R&D to deployment, aiding the alignment of policy and delivery of systems that will meet the UK market needs, timescales and growth agenda. The answers obtained from the GFA highlight the requirement for a strategic view of UK energy and electricity supply, so that development effort and money is targeted where it will be most effective. This is shown schematically below.

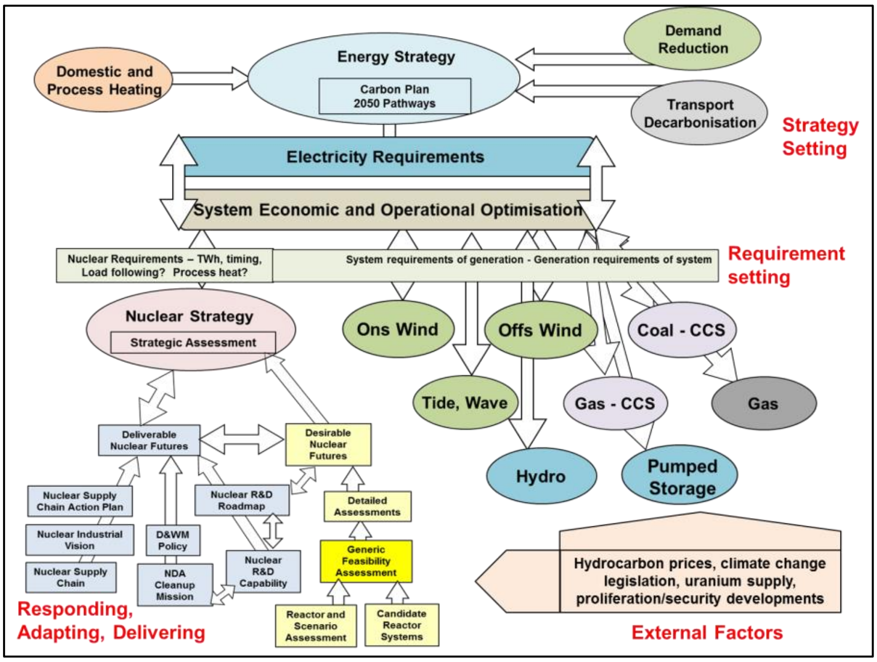

Figure 4. Nuclear within overall Low Carbon Energy Strategy

The GFA concept provides a means of assessing what nuclear ***could*** do in any given UK energy future, but we cannot know what nuclear ***should*** do without scoping an integrated systems approach to UK energy requirements.

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