The 8 Issues Model: Insights Since Introduction in 2023

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Three years after introducing the 8 Issues Model, this article takes stock. It does not re-score technologies; it asks what has been learned since 2023 and what this means for applying the model. Developments for large GW plants, SMRs, advanced reactors and fusion confirm the eight Issues as the core structure for assessing readiness to deploy, the model's X-axis. The larger change concerns the yardstick, the Y-axis: the global Net Zero target is increasingly replaced by specific use cases and by questions of geopolitics: energy security and government industrial strategy. A change of yardstick can move a technology's position more than technical progress does. In finance, risk capital for development must be distinguished from capital for construction and industrialisation; the transition between the two is still unresolved but will be critical for the scaling that is needed.



1 Introduction – The 8 Issues Model, three years on

In 2023, in a series of articles in atw, we asked *'What needs to be done to facilitate SMR deployment at scale?'*[1] and whether *fusion in ten years would be 'the real thing' or 'here we go again'* [2]. We were challenged to assess and track the success of these technologies systematically: market players, investors and other stakeholders needed a coherent analytic tool.

To answer this challenge, we developed and published the "8 Issues Model" [3][4]. The model places each technology on two axes (**Figure 1**, reproduced from [4]):

- The Y-axis asks how well suited a technology is, in principle, to the deployment goal. In 2023 that goal was decarbonisation at scale, judged by energy density, availability, efficiency, cost-effectiveness and range of applications.
- The X-axis asks how close the technology is to being deployable at scale, judged against eight Issues: Finance, Supply Chain, Energy Market, Design, Nuclear Regulation, Siting and Local Permitting, Industry Culture and Acceptance, and Competition.
- Three data points indicated where the technologies' scores were coming from and where they were headed.

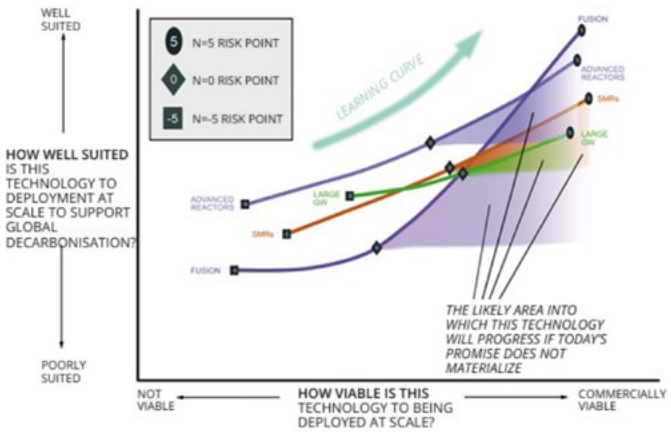


Figure 1
Progress of Technologies mapped against modelled scores of SUITABILITY and VIABILITY.

The model was forward-looking, an assessment and monitoring framework rather than a forecast. The 2023 publication already noted that the Y criteria will vary with the context and objectives of a deployment [3]; our 2025 application to data centers made use of that [5].

This article reviews what has happened since 2023 and what it teaches us about the model. It is not yet a quantitative re-scoring; that belongs to bespoke future efforts:

- Section 2 summarises key developments by technology[1].
- Section 3 reads them against the eight Issues (X-axis).
- Section 4 turns to the yardstick (Y-axis), which as expected should focus on use cases but also geopolitics and the role of governments.
- Section 5 draws conclusions, and
- Section 6 sets out the questions moving forward.

We find that nuclear energy – fission and fusion – are showing signs of great promise, and many positive developments support and further that hopeful "spin". Nevertheless, real breakthrough still seems far away, and unanswered challenges abound.

2 Developments by Technology, 2023–2026

In 2023 we derived the required scale from IEA scenarios: between 358 and 640 GWe of new nuclear capacity by 2050, which at the upper end would mean, for example, around 6,000 SMRs from 20 to 80 vendors [1]. We concluded that the industry, its financiers and its regulators were not yet organised for deployment at that scale. The developments since then are summarised below by technology, each in the same order: evidence from construction and operation, customers and finance, government support, and the risks that remain. The space given to each reflects the volume of activity, not a judgment of importance.

One development cuts across all four. Hyperscale data-center operators (Microsoft, Amazon, Google, Meta) have become direct nuclear customers [6]. Their commitments are of two kinds. Long-term contracts for existing or restarted plants secure firm power now; this is strategic reliance. Agreements with SMR, AMR and fusion developers are mostly options on future capacity, often combined with minority equity, with construction and cost risk left with others; this is a low-risk commercial buy-in. Headline totals of "committed" capacity, above 10 GW by mid-2026, add the two together. So far this customer class is largely a U.S. phenomenon.

2.1 Large GW plants

Vogtle 3 and 4 (2023–2024), Olkiluoto 3 (2023) and Flamanville 3 (2024) were completed years late and far over budget; Vogtle alone cost more than $30 billion. Hinkley Point C, and Sizewell C as its near-replica, seem to have raised long completion timeframes and high costs to a new baseline. These projects tell a story of re-learning and of rebuilding supply chains, including localisation.

Since 2023, large plants have returned to the agenda in two ways:

- **Existing plants** have in some cases found new customers. Microsoft's 20-year PPA supports the restart of Three Mile Island 1 (now Crane) [7], Palisades is returning to service, and Constellation, Vistra and Talen have signed long-term contracts with hyperscalers [6]. Such supply is dedicated either physically, with the data center co-located behind the meter, or contractually, through grid-connected PPAs. Physical dedication avoids grid queues but raises questions of grid cost, grid stability and offsite power. When Talen and Amazon sought to expand behind-the-meter supply at Susquehanna, the U.S. regulator FERC rejected the arrangement in 2024; the parties moved to a grid-connected PPA in 2025 [8].
- New build rests on state instruments. In June 2026 DOE conditionally committed $17.5 billion in loans for long-lead components of ten AP1000 units at five sites, the largest U.S. industrial-policy commitment to nuclear construction since Vogtle [9]. The UK took the final investment decision on Sizewell C in July 2025 under a regulated asset base (RAB) model and with £14.2 billion of government funding for a project estimated at around £38 billion [10]. France plans to build six EPR2 units; Poland and the Czech Republic pursue state-led new-build programmes. In the U.S., Brookfield is evaluating completion of the abandoned V.C. Summer units, with a decision due by 2028 [11], and large-site developers such as Fermi America plan nuclear units alongside gas for data-center campuses [12].

2.2 SMRs (light-water)

The first light-water SMRs in the West are now in construction. Ontario Power Generation received its licence to construct the first of four BWRX-300 units at Darlington in April 2025; the basemat was installed in April 2026 and grid connection is planned for 2030 [13]. In September 2026 the NRC issued TVA a construction permit for a BWRX-300 at Clinch River, the first for a commercial SMR in the U.S., after a review completed four months ahead of schedule [14]. China's Linglong One (125 MWe) is in commissioning, with commercial operation now expected in 2027 [15].

1 In line with our own professional focus, we draw mainly on developments in the U.S., the UK and the EU/Germany. Important progress in Asia and elsewhere should by no means be ignored; it may in fact overtake some of the "Western" efforts.

In the UK, Great British Energy – Nuclear selected Rolls-Royce SMR in June 2025, backed by more than £2.5 billion of public funding. Wylfa was confirmed as the site, and a contract was signed in April 2026, with the National Wealth Fund committing up to £599 million [16]. Rolls-Royce SMR has also won export positions: ČEZ selected the design and took a 20 % stake in the company, and in June 2026 Videberg Kraft chose it for three units in Sweden [17]. The EU's Industrial Alliance on SMRs, launched in 2024, has nearly 400 members and nine project working groups covering light-water and advanced designs; the Commission's SMR Strategy of March 2026 projects 17–53 GW of EU SMR capacity by 2050 [18].

Technology risk for designs derived from licensed large reactors (BWRX-300 from the ESBWR, AP300 from the AP1000) appears limited. Cost, schedule and operating-cost claims remain unproven, and every business case assumes volume production of a stable design, with programmes foreseeing several units per site (four at Darlington, three in Sweden).

2.3 Advanced reactors, including microreactors

Advanced reactors (high-temperature gas, molten salt, liquid metal and fast reactors) have moved towards demonstration, largely in the U.S. The U.S. DOE has opened sites for demonstrations and fuel facilities, and several developers, among them TerraPower[2], Kairos and Oklo, are building or preparing demonstrators. In the UK, Newcleo's lead-cooled fast reactor became the first advanced reactor to enter Generic Design Assessment in 2025 [19]. Microreactors have emerged as a distinct class aimed at remote sites, defence, industry and data centers; they may need and support market and deployment models quite different from current practice.

Most hyperscaler agreements with advanced-reactor developers, such as Google-Kairos and Amazon-X-energy, are options on future capacity rather than commitments that carry completion risk [6].

Fuel is a critical path. Many designs need high-assay low-enriched uranium (HALEU), which until recently was available commercially at scale only from Russia. In January 2026 DOE awarded $2.7 billion to three companies to rebuild domestic enrichment for LEU and HALEU, in response to the U.S. ban on Russian uranium imports that takes full effect in 2028 [9].

The sector is showing early signs of mergers and consolidation: USNC's assets were sold in bankruptcy to Standard Nuclear and NANO Nuclear, and Moltex's technology is being acquired by Nuclea Energy after the company entered administration [20]. Technical risk remains significant, though it is falling; supply chains and fuel are less developed than the designs.

Further designs are appearing, such as NX Atomics and Ampera, which aim to take advantage of recent progress in manufacturing and materials; the accompanying interview with NX Atomics' CTO illustrates how these may perform against the 8 Issues[3].

2.4 Fusion

Physics has advanced. NIF has repeated ignition, reaching a target gain of 4.13 in 2025 [21]; Wendelstein 7-X set a world record for the triple product over long plasma durations [22]; and Helion became the first private company to operate a machine with deuterium-tritium fuel [23]. A power plant has not come closer at the same pace. No device has produced net electricity, and fuel cycle, materials and plant availability remain undemonstrated. The decisive tests, CFS's SPARC and Helion's Orion plant for Microsoft, fall in 2027–2028.

Governments have made fusion a priority. In Germany, the federal and several state governments set the goal that the world's first fusion power plant should be built in Germany and committed more than €2 billion through 2029 [24]; the UK continues to fund its STEP prototype. In the U.S., fusion machines are regulated under the byproduct-material framework, with the rules due by the end of 2027 [25][26].

An important development is industrial interest. Private fusion capital, spread across a large number of commercial developers, reached $11–15 billion by mid-2026 [27], though still less than the cost of a single two-unit fission plant such as Vogtle 3/4. Expectations differ: more than half of the private developers expect a pilot plant by 2035 [27], while a real-options analysis of investor behaviour implies a probability below 20 % for commercial market entry by that date [28]. Significantly, however: spending within the supply chain grows by about a quarter a year [29], developers sell components such as superconducting magnets to each other [30], and utilities offer former nuclear sites and co-investment, as RWE does with Proxima at Gundremmingen and with Focused Energy at Biblis [31]. Magnets, lasers and neutron sources also find markets outside energy [32].

2 In particular, U.S. NRC announced the issuance of the "first construction permit ever issued ... for a commercial non-light-water power reactor" (March 09, 2026 https://www.energy.gov/ne/articles/nrc-issues-construction-permit-terrapowers-natrium-advanced-reactor). At the same time, this project also demonstrates the industrial challenges of deployment: https://www.neimagazine.com/news/bechtel-out-as-natrium-epc/?cf-view (September 24, 2026).

3 In their interview, NX Atomics respond to the 8 Issues based on their own assessment of their own technology and business proposition. In no way is that to be considered an independent evaluation by the authors of this article, as originators of the 8 Issues Model.

2.5 Summary

There is no question that much has developed since 2023, at project and company level as well as in critical details. Importantly, the general perception of nuclear energy has grown more positive, at EU level and in countries such as Switzerland, Italy and Denmark.

We are not yet ready, however, to conclude that these positive developments materially improve the probability of ultimate success, i.e. the scores in the 8 Issues Model. What they do offer are refinements to the model that allow a more 'surgical' analysis moving forward.

3 The X-Axis: The Eight Issues Revisited

Table 1 reads the developments of Section 2 against the eight Issues. The left column summarises the 2023 framing; each entry on the right opens with the direction of change since 2023 and shows examples with cross-references to section 2 above.

Reading across the Issues

Four patterns run across several rows. First, the state has returned as financier and industrial strategist: loans, enrichment awards, RAB models and state-selected designs carry Finance and Supply Chain further than market signals do. Second, the main constraint often lies outside the design: fuel for advanced reactors, forgings and skilled labour for all. Third, progress in one Issue does not carry over to others. Regulation has accelerated within jurisdictions but not across them, and capital for fusion has not yet

Issue and 2023 framing	What changed since 2023
1 Finance – *The scale and profile of financial support for deployments.* Requires easy access to multiple sources of substantial, affordable funds for technology development and deployment programmes.	**Limited progress; the two kinds of finance have moved apart.** Risk capital for development has grown fast, above all for fusion and advanced reactors. It buys an option on a large future market [28] and, for fusion, is partly hedged by markets outside energy. Deployment needs different money: several billion per plant, plus factories and supply chains that first need an order book. Here progress is limited to cases where a state or a large offtaker carries the risk: government loans, RAB models and state equity for GW plants, long-term PPAs for existing plants and restarts, state-backed utilities for the first SMRs. Hyperscaler agreements with developers of new technologies signal demand but rarely carry deployment risk. For SMRs, advanced reactors and fusion alike, the step from development capital to project finance has not yet been made at scale. Measured against the 2023 NZE demand, deployment investment remains far too low.
2 Supply Chain – *The capacity and agility of the Supply Chain.* Requires an extensive, robust, proven global supply chain (equipment, material, labour; nuclear safety-critical and non-nuclear) able to balance localisation demands.	**Limited progress, now with direct state support.** Loans for AP1000 long-lead components and the enrichment awards (2.1, 2.3) make the supply chain a matter of industrial policy and address the "orders before factories" dilemma that the 2023 paper expected the market to solve. Support concentrates on one GW design and on fuel; SMR and advanced-reactor supply chains depend on designs converging. For advanced reactors, HALEU rather than design maturity may become the main constraint. The nuclear workforce has grown (UK: from about 61,000 in 2021 to more than 102,000 in 2026 [33]), yet specialist skills remain scarce and localisation reduces mobility. Constraints persist in large forgings, valves and pumps. Fusion shows an unusual sequence: its supply chain is forming before the design is proven.
3 Energy Market – *Modification to Energy Market Design.* Requires national and global markets structured to encourage nuclear deployment at scale, recognising nuclear's attributes.	**Little change in market design, large changes around it.** No reform since 2023 was designed for nuclear or SMR attributes; the EU market reform (2024) and the UK's REMA aim at price stability and clean power in general. In the U.S., the consequential change bypasses market design: bilateral PPAs with large consumers. Whether such supply is physical or contractual has become a market-design question in its own right: who pays for the grid, and how much firm capacity may leave the system [8]. Elsewhere, nuclear advances through government instruments (CfD, RAB, state offtake) rather than market signals, a shift away from the liberalisation paradigm (Box 1).
4 Design – *Technology implementation risk in designs requires operational experience (> TRL 7) to resolve FOAK risk, and designs deployable across jurisdictions and sites without significant change (NOAK).*	**Uneven progress.** For light-water SMRs derived from licensed large reactors, technology risk appears limited, and the first units are in construction and licensing (2.2). For advanced reactors, technical risk remains significant but is falling as demonstrators proceed (2.3). Fusion has advanced in physics, not yet as a power plant (2.4). Across all technologies, cost, schedule and O&M-cost claims remain unproven, and the benefits of series production depend on keeping designs stable across sites and jurisdictions.

Issue and 2023 framing	What changed since 2023
5 Nuclear Regulation – *Alignment of design and site licensing requirements across jurisdictions.* Requires harmonisation and simplification nationally and globally to reduce redesign risk and realise NOAK benefits.	**Progress at national level.** Reform has accelerated in the U.S. (ADVANCE Act, executive orders, Part 53) [26][34], the UK (GDA progress, first advanced reactor in review) and the EU (SMR Strategy), in parallel rather than in concert. The first U.S. construction permit for a commercial SMR, issued ahead of schedule, shows the effect [14]. International alignment remains largely unresolved: a design cleared in one jurisdiction still needs a largely separate review elsewhere, and emerging nuclear countries rely on the vendor country's reference licence. The role of codes and standards is underestimated; they strongly affect repeatability. Co-location with large consumers raises new safety questions: reliable offsite power, and plant behaviour when a dominant load drops off.
6 Siting and Local Permitting – *Successful deployment will encompass significantly more nuclear sites, requiring new suitable, accessible locations to enable siting at volume with minimal design change.*	**Little progress outside the U.S.** Siting remains governed by jurisdiction-specific rules, which limits replication of one design across sites. Approaching NZE scale requires many more sites, increasingly combined with industrial infrastructure and data-centers. In the U.S., DOE land is being made available and Part 53 revises siting criteria [34]. Former nuclear sites are becoming an asset in their own right, offering grid connection, licensing experience and local acceptance; the fusion projects at Gundremmingen and Biblis are the clearest example (2.4).
7 Industry Culture and Acceptance – *Nuclear industry culture needs to be driven by a more balanced approach and requires an informed, broad cultural acceptance at volume worldwide.*	**Progress in political acceptance.** In the U.S., a concrete industrial customer narrative has partly replaced the abstract climate framing [35]; Germany shows acceptance moving fast for fusion while fission remains excluded. On the 2023 framing, industry culture, regulatory reform and customer-driven timelines are early signs of change, but evidence of a changed culture is still thin. Waste disposal is technically addressed but politically resolved only in Finland and Sweden. The debate about household electricity prices, where large consumers secure firm supply, is a new source of political risk. Public acceptance is favourable but fragile.
8 Competition – *Competition from fusion.* Requires fusion and other technologies not to become a further distractor to the deployment of nuclear technologies.	**A growing threat on several fronts.** (a) Non-nuclear: where time to power decides, gas is built as a bridge, sometimes on the same campus [12]; if nuclear is late, the bridge may become permanent. (b) Fusion: whether it would displace fission depends on timelines that remain uncertain. (c) Intra-nuclear and international, the more consequential competition since 2023: SMR vendors compete for the same export contracts, fusion developers for the same capital. Shared suppliers, such as magnets sold across fusion concepts, work against fragmentation; consolidation among advanced-reactor developers shows that selection has begun (2.3). There is no evidence yet that early movers become eventual winners.

Table 1
The 8 Issues: 2023 view and 2026 observations.

shortened the path to a working plant. Fourth, the step from development capital to deployment finance is where underinvestment can become self-fulfilling, with each class of investor waiting for the other to move first.

One observation leads beyond the table. Several of the largest shifts since 2023 did not come from progress on the Issues themselves. They came from a change in what nuclear is expected to deliver, and for whom: a data-center operator buying firm power, a government pursuing energy security or technology leadership. In these cases the requirement on each Issue changed with the goal. Section 4 therefore turns to the second axis of the model.

4 The Y-Axis: Use Cases, Geopolitics and the Role of Government

4.1 From one benchmark to many

In 2023 we assessed every technology against one goal: contributing to global decarbonisation at scale (see **Table 2**, criteria reproduced from [4]). Deployment is now increasingly driven by specific use cases, each with its own customers, timelines and risk tolerance: grid supply, firm power for data centers, process heat for industry, maritime propulsion, defence, and supply to remote or off-grid sites. Each use case weights the Y criteria differently. For data centers, time to power outweighs most other criteria; this favours existing plants, restarts and gas as a bridge, while new nuclear build serves as the hedge for the next decade. For process heat, temperature and proximity to the consumer matter more than unit size.

A use case also changes the thresholds on the X-axis. In our 2025 application to data centers, six of eight Issue assessments for the same technology changed when only the use case changed [5]. The yardstick therefore affects not only where a technology sits on the Y-axis but also how its readiness is judged on the X-axis.

4.2 Goals beyond NZE

At the same time, the focus on NZE has weakened, particularly in the U.S. Strong growth drivers remain, but they rest increasingly on energy security,

Metric	Definition
High energy density	Confidence in the ability of this technology to provide sufficient quantity of energy when deployed at scale to make a contribution to NZ targets, in as small a land footprint as possible
Always on	Confidence in the ability of this technology to provide reliable energy 100 % of the time (dispatchable = match output to demand)
High efficiency output	Confidence in the output efficiency of this technology
Cost effective	How well does the "commercial benefit" of this technology, when deployed at scale, compare to other energy sources
Multiple applications (grid/non-grid)	Confidence in the ability of this technology to be deployed at scale to support multiple energy source requirements both grid and non-grid

Note: Depending on the context and objectives, the criteria contributing to the Y-axis are to be adjusted.

Table 2
2023: Y-axis – How well suited is this tech to contributing to decarbonisation at scale?

BOX 1 – The role of government

The role of government remains the most important factor in nuclear power development. There are two overall approaches: the market model and the government model.

- Since electricity deregulation, the U.S. nuclear industry has relied on the market model. Recent U.S. government activity focuses on incentives, lower costs and hurdles, and more efficient regulatory oversight, measures that help market-based projects along.
- France and other countries, including China, follow a government approach. It allows multiple identical units (e.g. the French EPR2 programme) and uses government financing, power offtake and even supply-chain components to manage costs.

The government approach has proven effective in several countries; the market approach remains unproven. Since 2023 the dividing line has blurred: the U.S. now uses state loans for supply chains and fuel, and the UK applies the government model to SMRs. For a recent argument that nuclear energy should be treated as sovereign infrastructure, see [36].

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sovereignty and industrial policy. Geopolitics enters the model in two ways. As a goal, security of supply and independence from adversarial suppliers are valued in their own right; they belong to the Y-axis[4]. As a condition, fuel sourcing, vendor origin, export controls and alliance structures change how Finance, Supply Chain, Regulation and Competition play out; they act on the X-axis. The U.S. ban on Russian uranium imports and the EU's concern about the non-EU origin of most advanced SMR designs are examples of both [9][18].

4.3 Governments set the goals

Behind most use cases stands a government strategy, and these strategies differ markedly. The U.S. combines a new private customer class with state loans for supply chains and fuel. The EU treats SMRs as an instrument of industrial competitiveness and energy security, linked to the Net-Zero Industry Act. The UK applies a state-led model to SMRs, selecting design and site and financing the first fleet, and treats the programme as an export industry. Germany, having closed its last fission plants in 2023, has made fusion a goal of technology leadership. Each strategy defines a different yardstick, and the same technology can rank high under one and low under another. Box 1 sets out the underlying choice between market and government models.

4.4 What this means for comparing technologies

A change of yardstick can move a technology's position more than technical progress does. **Figure 2** illustrates this with two examples. Three Mile Island 1 was shut down in 2019 because it could not compete in a merchant power market, an Energy Market failure on the X-axis. With unchanged technology on the same site, it is being restarted under a 20-year PPA with a data-center operator [6]. The use case changed, and with it the market conditions and the value placed on firm power. Fusion shows the opposite movement: Measured against its contribution to NZE by 2050, it ranks low on the Y-axis; measured against technology leadership and industrial capability, the yardstick of the governments that fund it, it ranks high. Its position on the X-axis has hardly moved.

For investors and suppliers, the consequence is that a technology's prospects cannot be judged without naming the use case and the jurisdiction. The model can show a supplier where its design fits; it does not rank individual vendors.

4.5 Back to NZE

The global NZE question is still answered, but as an outcome rather than as the benchmark for each technology. What is built for data centers, industry, security of supply or export adds up to a contribution to NZE. That sum is not simple. Use cases draw on the same scarce resources: enrichment, large forgings, skilled labour and capital. Within each use case, nuclear

4 Because geopolitics changes the yardstick as well as the conditions, we do not treat it as a ninth Issue but as a factor acting on both axes.

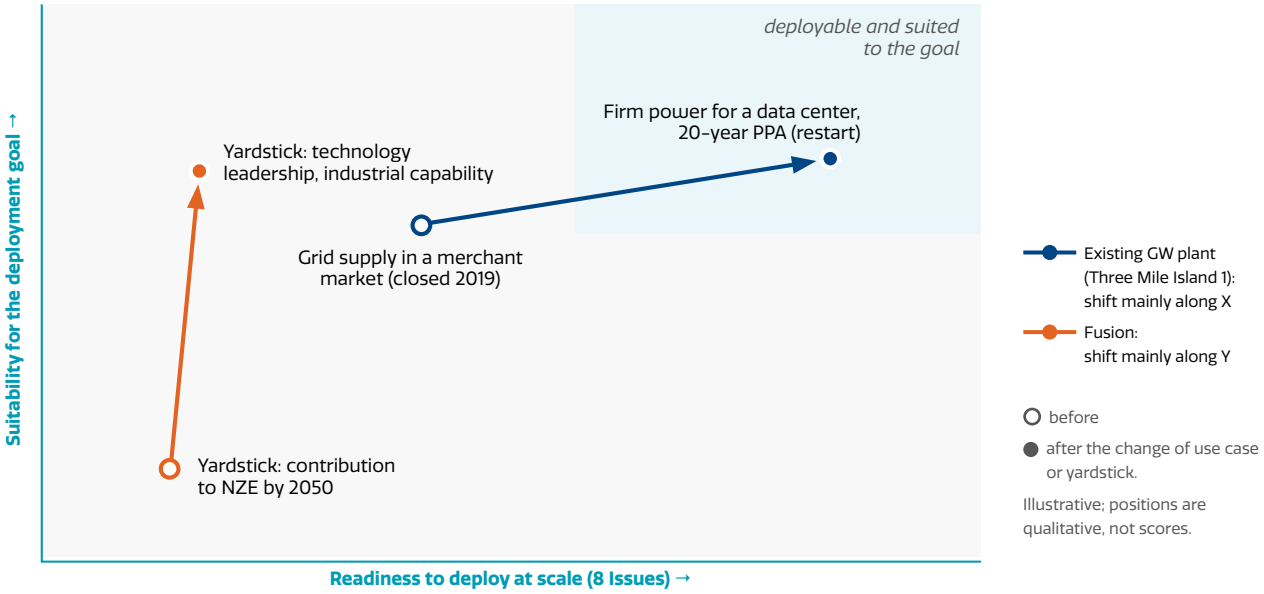


Figure 2
Effect of a change of use case or yardstick on a technology's position in the 8 Issues Model. Illustrative; positions are qualitative, not scores.

competes with non-nuclear alternatives. And supplying data centers from existing plants adds no clean capacity; only restarts and new build do. Where existing supply is physically diverted, the rest of the system may turn to gas. So, when aggregating use-case assessments into an overall NZE verdict, a critical factor is how use cases and technologies and their suppliers compete for limited resources.

5 Synthesis — Our View

The first question to ask is whether the 8-Issue matrix still holds. Our view is that it does. Everything we observed since 2023 maps onto one or more of the eight Issues without a structural change. What has changed is the relative weight of the Issues, their interpretation in specific contexts and, above all, the yardstick against which readiness is judged.

Over time, the driving factors within the Issues will shift. For example, Issue 7 („Acceptance“) was framed in 2023 as an industry culture of excess risk aversion; while this still applies in parts of the established industry, we see significant optimism and political and public acceptance driving a “can do” mentality for other reactor types and for fusion. Issue 8 („Competition“) is becoming multi-dimensional: with competition from within nuclear, from geopolitical preferences, and from non-nuclear bridge solutions. Developers increasingly need to offer mixed energy propositions rather than reactors alone.

Observed progress, the required capability (“goalposts”) and relative position are separate variables:

- A technology can make real progress without its assessment improving, because requirements have become more demanding, competitors have advanced faster or the market need has shifted.
- Conversely, an assessment can improve without technical progress, as Three Mile Island 1 shows. Early commercial success does not prove eventual dominance either.

In 2023 we warned that nobody wants to end up as the Betamax of the SMR renaissance [1]. A PPA or an MoU shows a customer or political relationship, but not which technology will ultimately prevail; the first insolvencies and asset sales among advanced-reactor developers show that selection has begun.

Read across both axes, the four technologies stand as follows:

- **GW plants.** X: strongest evidential position; Finance and Supply Chain (performance) are the main constraints and increasingly carried by the state and, for existing plants, by long-term offtake. Y: highest where large-scale firm supply and energy security are the goal. The trend is positive where the state carries risk.
- **SMRs (light-water).** X: design risk largely retired; Finance, Siting and series production of a stable design together with human resources are serious constraints towards necessary scaling. Y: suited to replacing fossil plants and to industrial sites; export ambitions add an industrial-policy goal. Whether vendor competition converges on a few designs or fragments demand will decide the trend – together with the real-world execution of FOAK projects.
- **Advanced reactors, including microreactors.** X: technical risk significant but falling; fuel and supply chain are binding, and geopolitical exposure through the fuel cycle is highest. Y: strongest where high temperature, small size or remote operation matter; data centers are a leading but not yet committed customer.

- **Fusion.** X: Finance, Supply Chain and Acceptance move fastest, Design slowest; the step from development to deployment finance is still ahead. Y: low against NZE by 2050, high against technology leadership. Timing relative to fission remains the key open question.

A critical, cross-cutting finding remains the investment gap. Development capital has grown, deployment capital has not followed at scale, and the transition between the two is unresolved. This may call for suitable new financial instruments to carry the scaling effort across development and deployment, countries and users. But most importantly, the nuclear industry will have to give the second group of investors the confidence to commit. This in turn will likely require strong guidance by governments, through risk absorption and regulatory improvements.

6 Outlook: What a Future Review Should Address

We intend to apply the 8 Issues Model in full rescoring, next year – technology by technology and Issue by Issue and use case by use case. Several decisive market breakthrough events should fall in that window: the first operation of fusion devices designed for net gain, construction progress on the first SMRs in Canada and the U.S., and investment decisions on new GW units.

This article has raised four questions that need to be addressed as part of any real-world application of the 8 Issues Model. First, which yardstick: the original global NZE goal, specific use cases, or several in parallel, and how should use-case assessments be aggregated into an overall NZE verdict? Second, how should geopolitics be reflected, given that it acts on both axes? Third, how can Finance be assessed separately for development and for deployment? Fourth, how do we distinguish a genuine improvement in technology readiness from a case where the goalposts have moved?

Box 2 summarizes key insights – with a slightly different emphasis - from a peer review.

BOX 2 – Expert Observations to highlight

There has been tremendous activity over the last few years in new reactor technology development, with significant capital being raised to support a plethora of new entrants in the sector. While this is exciting on the one hand, three considerations should be noted:

- Most of these technologies will fail as businesses. Using the U.S. market as an example, the market does not need more than two large reactor designs, two SMR designs, two advanced reactor designs, and maybe two or three microreactor designs. In order to "go fast" and deliver on time and on budget (someday), the nuclear industry – regulators, EPC contractors, supply chain, fuel supply, and operators – need to coalesce around and perfect (through standardization and repetition) the scaling and delivery of reactor fleets.
- While private capital has been flowing into technology development, what is needed now is for money to flow into project delivery. Outside of government funding, that has yet to happen in a meaningful way (with some limited exceptions) across the industry. This latter point emphasizes the need for a "Developer" or "Client" role – someone that puts all the pieces together to create a viable project. That used to be regulated utilities in regulated markets. Now, that role is not prevalent, which, in turn, is impacting project delivery. Ultimately, financing and use cases on the one hand, and project delivery on the other, will drive the industry, not the reactor designs.
- As the "use case" for nuclear reactors expands, that also changes the definition of "Project". The project is now not just the reactor; the project is the integrated facilities – which creates both challenges and opportunities. In turn, the idea of nuclear reactors being the power hub of an energy / industrial hub (possibly with natural gas as a bridge fuel) is a direction of travel for the industry, as it moves forward.

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The authors individually or collectively will be pleased to engage with third parties who may wish to contribute towards further refinement of the 8 Issues Model for various use cases; or apply the 8 Issues Model methodology to their own commercial uses.

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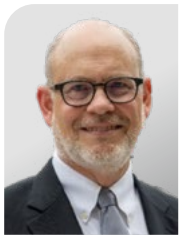
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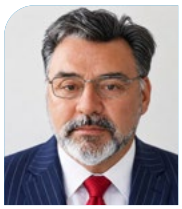


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