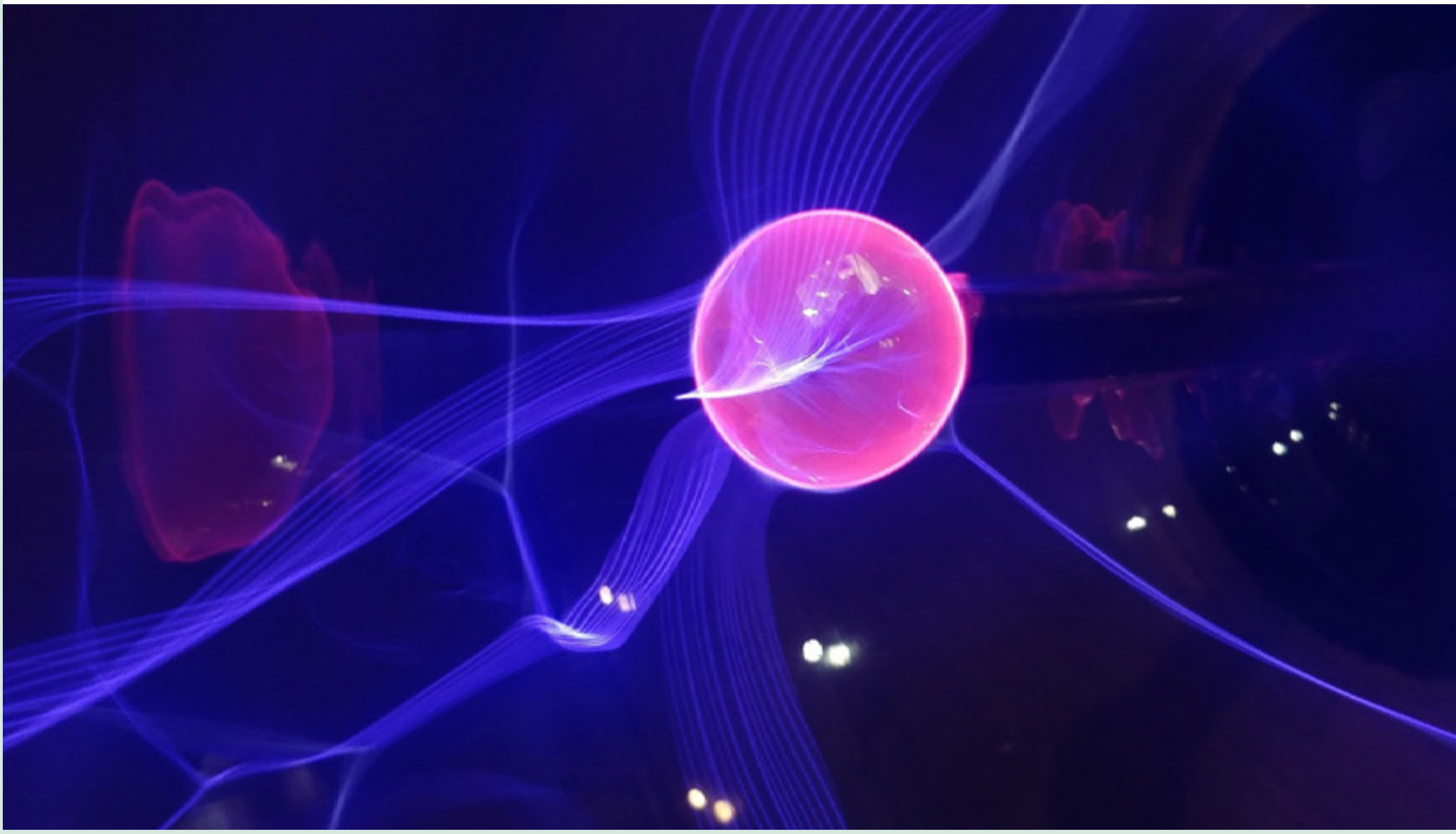
Future for Fusion Roadmap

Commercial Fusion with FLARE

November 2025



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01

Executive Summary

Fusion has long been regarded as a technology with the potential to deliver abundant clean energy.

The UK has long been the world leader in fusion by some distance, from the pioneering days of the ZETA experiment in the 1950s to the ground-breaking achievements of JET at Culham. But, while Magnetic Confinement Fusion (MCF) is progressing, it is facing major physical and engineering challenges, particularly in the field of plasma confinement. Inertial Fusion Energy (IFE) offers a simpler and quicker route to a commercially viable fusion reactor and yet, while it is appreciated in other countries, receives little to no funding or recognition in the UK.

First Light Fusion (FLF) proposes a new IFE reactor concept that avoids the complications of MCF and solves IFE challenges — and can be deployed commercially by 2035. The concept centres on FLFs unique fuel target design, enabling a multitude of market ready technologies (many that are considered technology readiness level 7+) to come together to form a simple and commercially viable fusion reactor. Leveraging FLFs ground-breaking FLARE (Fusion via Low-power Assembly and Rapid Excitation) method of fusion, the reactor can achieve up to 1000x gain.

The fusion race is on. The US and China are deploying their immense resources to cross the finish line to commercial fusion deployment first. By 2035, there will be fusion on the grid in both of these superpowers. The UK cannot compete in a straight race; it must diversify its fusion portfolio if it is to remain a legitimate competitor.

The policy landscape in the UK as it is currently will not allow the timely deployment of commercial fusion, via FLARE or any other method. Vague regulatory frameworks, restrictive regulators that lack expertise and capacity, protracted planning laws and grid connection bottlenecks all mean that the UK risks ceding its position as the fusion world leader to China or the US.

To avoid this catastrophe, we recommend the following policy interventions:

01	Broaden the scope of existing fusion policies, specifically including IFE in the Fusion Strategy alongside MCF and refining the Fusion Prospectus to increase focus on UK unique selling points such as AI and experimental capabilities.
02	Ensure industry policies suit the development and deployment of fusion. Fusion reactors will be no more dangerous than any other form of thermal power plant. Safety regulations should be the same as any other NOAK power plant, and should be overseen by the Health and Safety Executive.
03	Keep fission completely separate from fusion. The ONR should not be involved in regulating fusion.The UKAEA should work with the IEA to publish the first fusion frameworks in the UK, setting an international precedent.

Backing IFE would also stimulate UK supply chains, strengthen sovereign scientific capability, and give Britain a first-mover advantage in a transformative global industry. Furthermore, the regulatory frameworks required for fusion would provide a model for governance of other frontier technologies, reinforcing the UK's reputation as a major force in shaping global norms. The sooner IFE is brought into energy strategy, the sooner the UK can lead the world in delivering commercial fusion and with it, near limitless clean energy.

02
Introduction

For decades, fusion has been recognised as a potential source of near limitless clean power, capable of addressing both the scale and reliability challenges that constrain other renewable technologies.

The science behind fusion has been demonstrated in laboratories around the world, but the step from experimental proof to commercial deployment has not yet been achieved. The difficulties lie in the extreme conditions required - temperatures hotter than the sun, precise confinement or compression of fuel, and the need to breed and handle tritium safely at scale. These challenges have meant that, despite significant investment and fascinating experimental results, fusion is still some way off a commercial plant.

Solving fusion would be transformative for the global energy system. Unlike fission, fusion does not produce large amounts of radioactive waste, and unlike wind or solar, it is not constrained by intermittency. A commercial fusion reactor would provide reliable, sovereign energy at industrial scale, supporting both net zero commitments and energy security.

The race to achieve this is accelerating internationally, with governments and private companies pursuing two main technical routes: Magnetic Confinement Fusion (MCF) and Inertial Fusion Energy (IFE).

Both routes are seen as equal in the worldwide fusion community.

However, in the UK, the national endeavour has decided to pursue only one technology, MCF, where the UK has historically held significant expertise. This is contrary to almost every other country that is pursuing fusion power. Despite this, First Light Fusion, a privately funded IFE sector leader based in the UK, has built on its breakthroughs in IFE to propose a new, simpler route to commercial fusion deployment, built on their ground-breaking FLARE (Fusion via Low-power Assembly and Rapid Excitation) method of fusion.

The proposed reactor leverages their expertise and existing fuel target technology to significantly reduce the energy requirements of ignition, along with an original lithium blanket design that solves many challenges currently faced by the IFE sector.

The UK's current ambition to achieve a commercial fusion reactor by 2040 risks ceding leadership to faster moving competitors, particularly the US and China. China has already committed vast resources to accelerate fusion development and is targeting operational demonstration much earlier than the UK timeline - the BEST programme is targeting 2030 for deployment of its fission-fusion hybrid power plant. If the UK maintains a 2040 horizon, it will likely find itself purchasing foreign technology rather than exporting British expertise, squandering the decades of work by UKAEA and pioneering private firms. FLARE provides a pathway that can yield an operational commercial fusion reactor by 2035, however the policy environment in the UK will prevent this. If the UK is not the easiest place in the world to build the first fusion reactor, it will be built elsewhere.

This paper deconstructs the revolutionary ideas proposed by First Light Fusion that could lead to early commercial deployment of fusion. It then sets out the research and regulatory pathways that will have to be taken to realise commercialisation, along with the wider value chain the development of such a reactor will bring to the UK.

03

A Simpler Fusion Reactor

The deployment of commercial Inertial Fusion Energy is transformative for cheap fusion energy.

IFE is conceptually far simpler than MCF, but up until now, commercial IFE reactors have faced their own barriers. First Light Fusion proposes a new concept of fusion reactor that deploys market ready (predominantly technology readiness level 9) technologies to solve many of the major issues faced by MCF and also current IFE reactor designs.

The reactor concept leverages their ground-breaking FLARE method of fusion, and relies on their unique fuel target design to bring all these existing technologies together into a working fusion reactor. The proposed configuration can be seen in Figure 1.

The proposed configuration has **THREE MAJOR** sections:

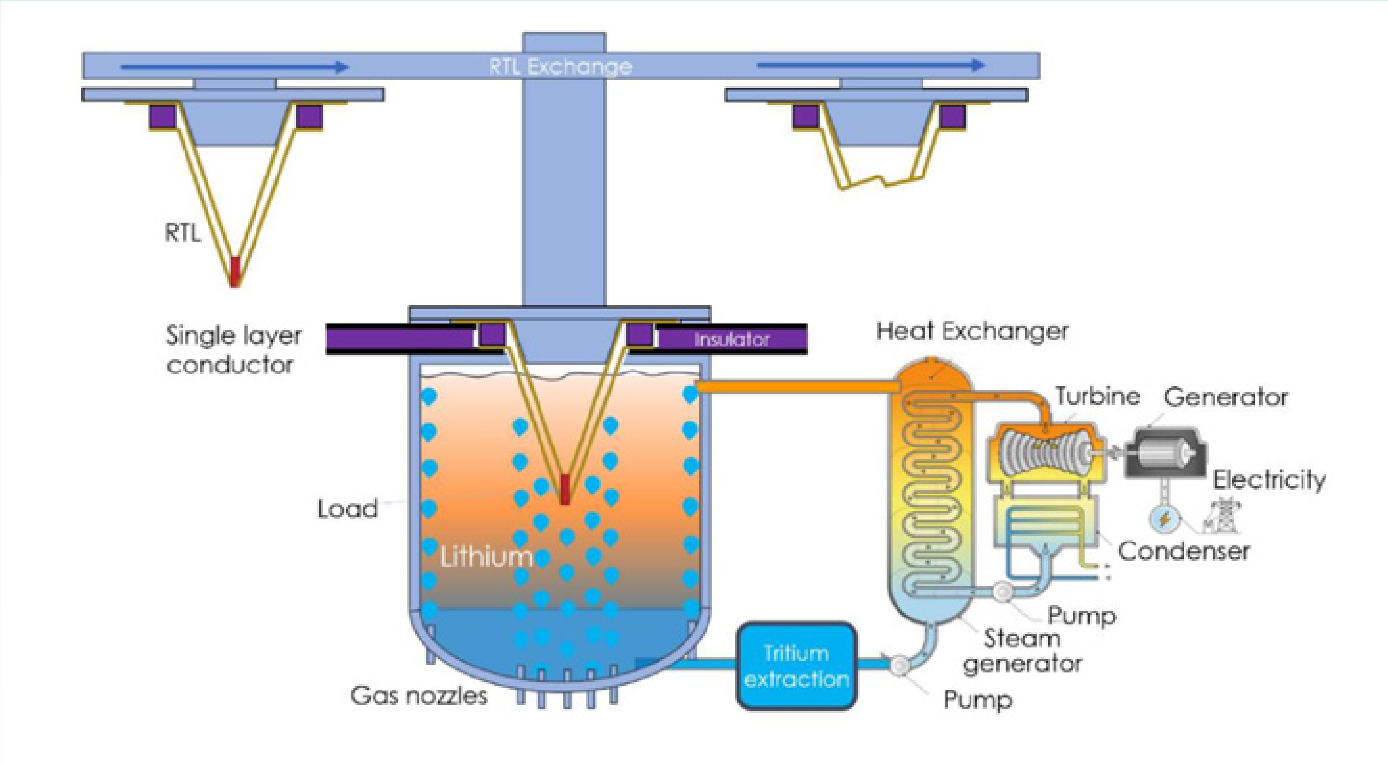
The Recyclable Transmission Line Exchange (RTL) that loads fuel and transmission lines into the reaction chamber.

The Lithium 'pool' which acts as the reaction chamber and as the coolant to harness the heat produced by the fusion reactions.

The Heat Exchanger which extracts the heat from the lithium and generates electricity.

The novel proposed designs of these sections each solve known engineering challenges of building a commercial fusion reactor.

Figure 1 - Schematic of First Light Fusion's Proposed reactor design. Each section is explored in more detail below. Key features that differentiate this design from other proposed designs are the RTL exchange and the configuration of the lithium blanket.



Recyclable Transmission Line (RTL) Exchange

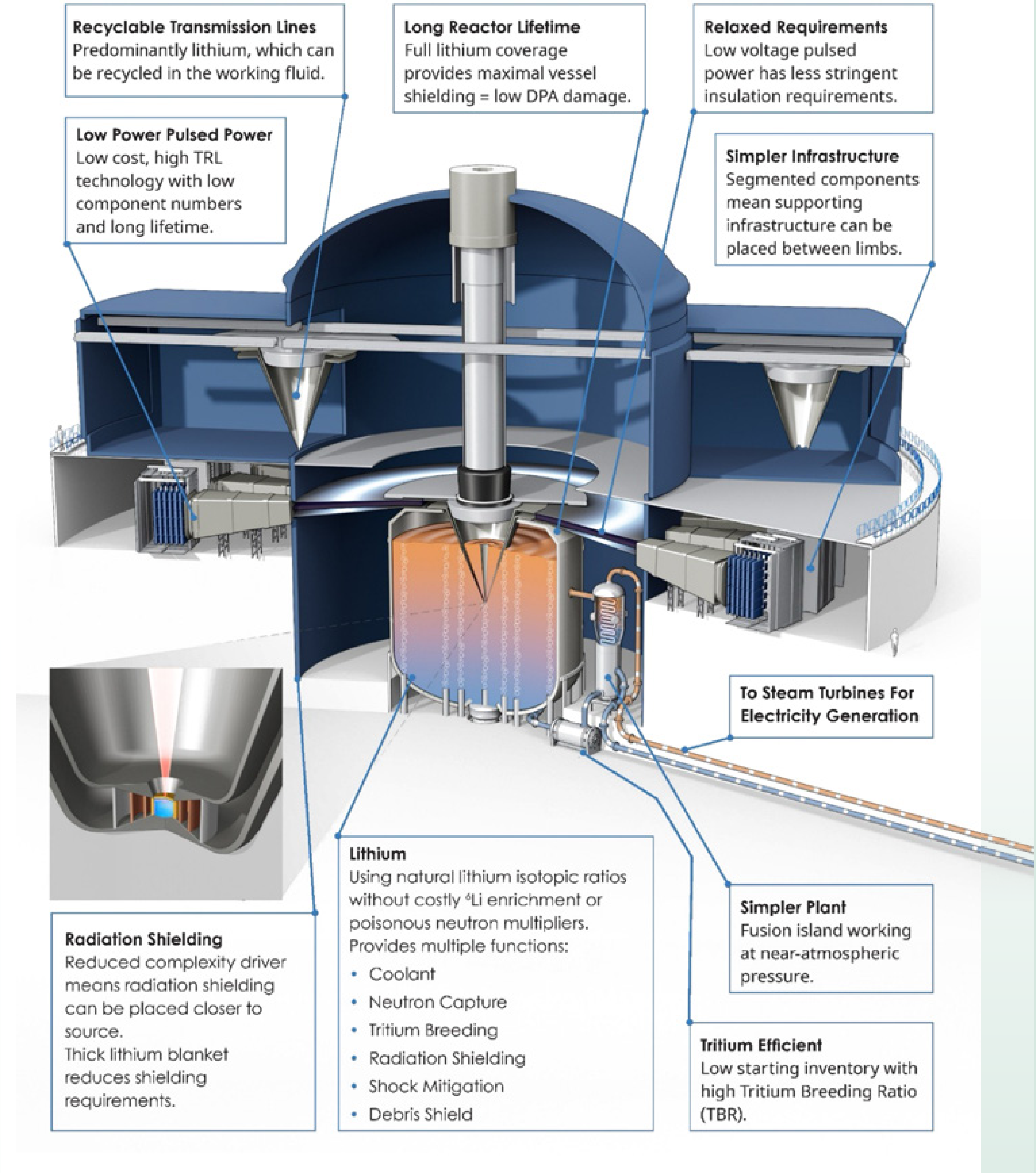
RTLs can be manufactured from low-cost, low-mass materials, co-integrated with the fusion target to streamline alignment processes, and replaced at a rate sufficient to enable operational repetition rates of up to four shots per minute - the required frequency of fusion events to maintain coolant temperature and make the reactor commercially viable.

Furthermore, using a recyclable transmission line - one made out of lithium - mitigates the issue of impurities entering the system and the issue of renewing the lithium pool while simultaneously reducing radiological and waste-handling complexity.

When the shock is delivered to the load, the transmission line will be largely destroyed by the power of the shock. A lithium RTL can be recycled directly into the surrounding lithium pool, eliminating the need for complex separation processes, transport, or off-site disposal, and thereby reducing operational and regulatory burdens.

The most important part of the RTL exchange is the fact that it is curated to maximise the efficacy of FLF's fuel targets. The specifics of the fuel targets are explored in later sections, but it is the target design, along with the use of pulsed power, that makes this reactor concept viable.

Figure 2 - Detailed illustration showing the possible configuration of the reactor and conventional steam and electricity generation. Liquid Lithium flows through the steam generator, and the steam is used to generate electricity in a turbine in the usual manner.



Lithium Pool

It is widely appreciated that some configuration of a lithium ‘blanket’ will have to feature in any commercial fusion reactor, regardless of whether it is based on MCF or IFE. The most common proposed setup is lithium being sprayed out of jets to shroud the fuel load in lithium. The configuration shown in Figure 1 suggests a Lithium ‘pool’ rather than a ‘Blanket’. Configuring the lithium in this way solves many problems faced byIFE and fusion more generally.

A bird’s-eye cross section of the lithium pool setup can be seen in Figure 3.

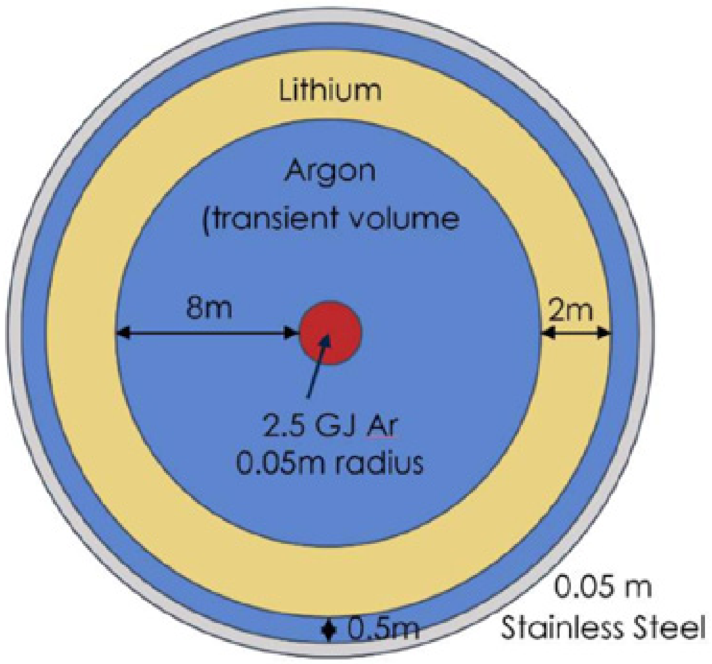


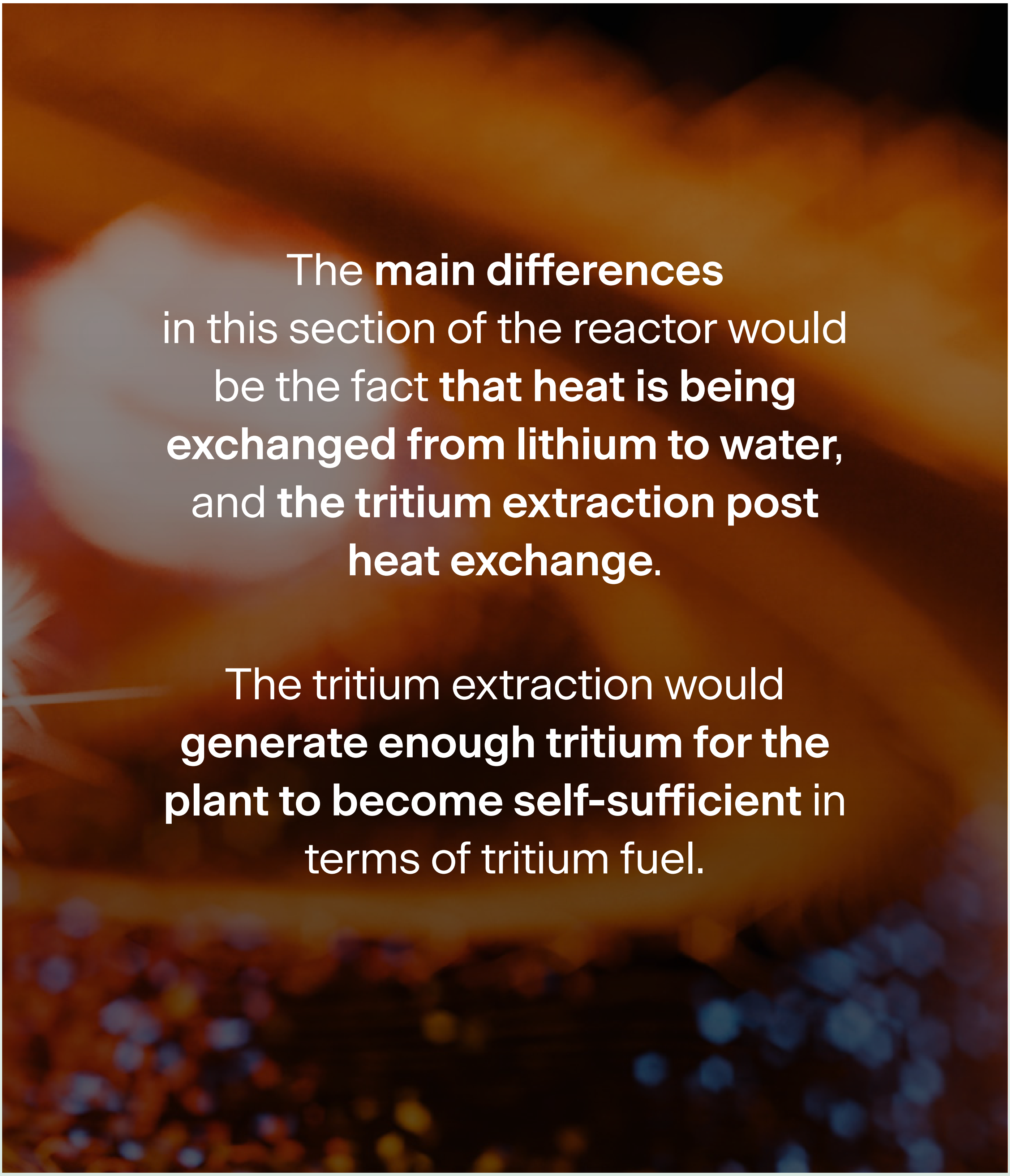
Figure 3 - Birdseye cross-section of the lithium blanket in the ‘pool’ configuration. Configuring the lithium in this manner solves pressurisation, temperature, tritium breeding, component protection and energy capture issues faced by other IFE reactor designs.

The first major issue solved by this configuration is tritium breeding. Low global tritium supplies are a major barrier to commercial fusion deployment generally, so any process that can maximise tritium breeding will alleviate supply chain pressures greatly. By completely surrounding the fuel load with lithium in this fashion, tritium breeding is maximised and greatly increased when compared to alternative configurations. More tritium breeding means more self sufficiency and and therefore lower costs, and could also position the UK as a global supplier of tritium.

Modelling has shown that the 2 metre thick layer of lithium, as shown in Figure 2, results in a primary neutron energy capture efficiency exceeding 99.9%, resulting in maximal heat capture. The low level of neutron leakage shields reactor components, preventing degradation and negating the need for complex solid structures. With this level of neutron capture, the projected operational lifetime of a commercial grade reactor configured in this way, based on four shots per minute, could exceed 180 years.

Heat Exchanger

The heat exchanger is very similar to the very well known kind used in current nuclear fission reactors. In fact, if the operational temperatures and neutron densities are comparable to that of current fission reactors, the components can fit straight in, negating the need for research and innovation in this area.



04

The Game Changing Approach

One of the principal barriers to the commercial deployment of nuclear fusion - whether through MCF or IFE - is the exceptionally high energy input required to create and sustain the extreme conditions necessary for fusion reactions.

Creating the requisite pressure and confinement conditions traditionally demands enormous, high-power driver systems and advanced containment technologies. Using IFE as the power source rather than MCF solves the confinement issue and, using FLFs FLARE approach, can result in up to 1000x gain.

Two changes in the fusion approach proposed by First Light Fusion could alleviate this energy burden to commercially viable levels:

Introducing a new design of high-gain fuel target featuring a high-density pusher and pressure amplifier;

Deploying low-intensity pulsed power in the decoupling of the compression and ignition stages during fusion reactors.

These two approaches reduce the energy requirements of creating fusion conditions, and are explored further in the following sections.

Fuel Target Design

The fuel target is a cylindrical container made up of various components, principally fusion fuel (a mixture of deuterium and tritium, commonly referred to as DT fuel) encased in a high-opacity pusher.

The cylindrical geometry offers many target fabrication benefits. Unlike spherical targets, there is no need to incorporate complicating features such as joint lines or mounting structures. This simplification enhances scalability for mass production.

One effective strategy to reduce the energy and power needed for ignition is to minimize losses from the system. Energy can escape via several channels, especially through radiative losses. As the fuel heats up, it emits radiation, which can escape and carry away energy unless otherwise trapped. This challenge can be addressed by encasing the fuel in a high-opacity pusher that implodes and compresses the fuel. The radiation field from the hot fuel establishes thermal equilibrium with the compressed pusher, recycling a large fraction of the emitted radiation back into the fuel. Recycling the radiation in this way can reduce the ignition energy by as much as 75% when compared to traditional hotspot IFE.

Once ignition occurs, maximizing fusion yield from the compressed fuel is critical. The total fusion yield is limited by expansion and cooling after ignition. Expansion occurs in response to the rapid increase in internal pressure after ignition and can quench the burn prematurely. A high-density pusher can enhance inertial confinement, keeping the fuel compressed for longer. This increases the fraction of fuel that burns and reduces the required fuel mass.

Decoupling Compression and Ignition

A longstanding concept in the Inertial Fusion Energy (IFE) community is the decoupling of fuel compression and ignition. In conventional hotspot ignition, as demonstrated at the National Ignition Facility, compression and heating occur simultaneously. Separating these stages can significantly reduce driver energy requirements and improve system stability. In conventional designs, simultaneous heating during implosion works against compression, demanding precise symmetry and high driver power. Decoupling avoids this penalty: compression energy is delivered first (the Low-power Assembly in FLARE), followed by a separate ignition pulse (the Rapid Excitation in FLARE).

This separation enables “cold” compression - achieving high fuel densities without the destabilising effects of premature heating. By avoiding dissipative processes during compression, the target can reach greater densities at lower energy input. While some heating will inevitably occur due to imperfections, it can be minimised through target design and driver control.

First Light Fusion's approach leverages this principle, enabled by its unique target architecture. Low-intensity pulsed power drivers are particularly well-suited to perform such a compression stage: they offer an efficient, cost-effective means of coupling magnetic pressure to cylindrical targets, without the complexity of multi-beam laser systems. Crucially, sufficient compression for ignition can be achieved with peak currents in the range of 20-40 MA - relatively low electrical requirements that support simpler, modular driver systems, inherently compatible with high-repetition commercial power generation.

Following compression, fuel must be heated to ignition temperature on a timescale shorter than hydrodynamic expansion. To reconcile the need for high burn fraction with efficient radiation recycling, First Light proposes partitioning the fuel: a small, high-opacity ignition cavity is ignited first, driving a burn wave through the remaining dense fuel.

Two ignition methods are under active exploration by First Light:

01	Target-based power amplification - structured pulsed power targets delivering ignition energy directly.
02	Short-pulse laser ignition - ultrafast, high-power lasers, benefiting from the enhanced confinement and reduced losses of the dense, high-opacity pusher.

The laser-based pathway offers a potentially faster, lower-cost route to demonstration but requires line-of-sight through the lithium blanket. The pulsed power approach demands more from the driver, but allows for full blanket coverage, which is an important consideration for tritium breeding and plant efficiency.

05

AI, Defence and Global Competitiveness

The intersection of fusion energy, artificial intelligence, and national defence marks a defining frontier for UK industrial and security policy.

The UK's ability to remain competitive and autonomous in this environment will depend on whether it can supply these digital systems with reliable clean power. FLARE can simultaneously enable the UK to take a leading position in the AI age and provide boosted national security in a time of global political uncertainty.

FLARE will attract data centres to the UK

Data centres are the physical backbone of AI. In a time when industry in the UK is plummeting, demand for data centres is skyrocketing. They are, however, facing an energy crisis. Each hyperscale facility requires hundreds of megawatts - some even gigawatts - of constant power, and the national grid is already straining under demand from electrification and renewables integration. In key development regions such as London and the South East, grid connection delays now stretch beyond a decade, threatening to stall investment in AI capability. Without immediate solutions, the UK risks outsourcing not only its commercial data but also critical national security functions to overseas facilities, placing sensitive data within foreign jurisdictions and exposing it to potential geopolitical risk.

FLARE can provide the solution. It can provide constant baseload power in a compact and modular form. Reactors could be co-located directly with data centres, providing them with a dedicated and secure energy supply independent of grid limitations. By decoupling data centre development from grid connection delays, the UK can accelerate digital infrastructure deployment. Producing this energy domestically strengthens national resilience, allowing critical data to be hosted securely within the UK, rather than relying on foreign powers and infrastructure.

FLARE can defend the UK

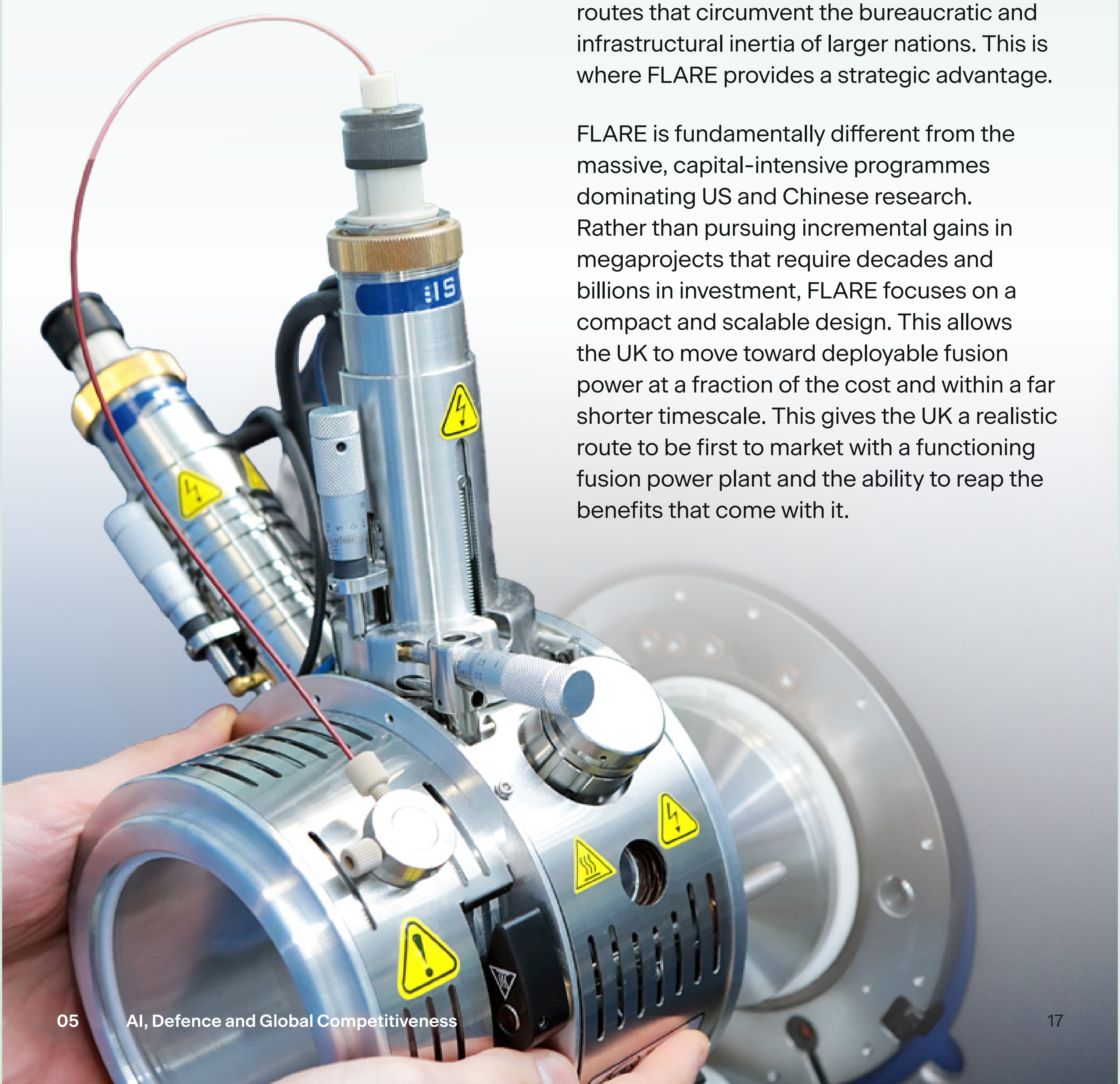
FLARE is a civilian clean energy technology, but its successful deployment would have implications for national security and the strength of the UK's nuclear deterrent. The credibility of any deterrent rests not only on the weapons themselves but also on the resilience and autonomy of the state that sustains them. Fusion energy could play a central role in ensuring that the UK's strategic infrastructure remains secure and independent in the face of global shocks.

The development of the reactor would also necessitate the advancement of domestic research expertise, particularly in shock and high-energy-density physics. Possessing these capabilities within the UK would provide sovereign assurance of performance, enabling domestic validation of key technologies without dependency on foreign laboratories. This is directly relevant to national security as well as to fusion, since shock physics is central to both civil nuclear resilience and defence materials science. Retaining these test capabilities within UK borders ensures both control of sensitive intellectual property and the ability to certify advanced systems independently, strengthening the scientific and industrial autonomy of the UK.

FLARE can allow the UK to compete globally

The global race to commercialise fusion is intensifying, led by the United States and China, whose vast resources and industrial capacity make them formidable competitors. The UK cannot realistically outspend or outbuild these powers through conventional means. Instead, it must compete asymmetrically by innovating faster, operating more efficiently, and taking technological routes that circumvent the bureaucratic and infrastructural inertia of larger nations. This is where FLARE provides a strategic advantage.

FLARE is fundamentally different from the massive, capital-intensive programmes dominating US and Chinese research. Rather than pursuing incremental gains in megaprojects that require decades and billions in investment, FLARE focuses on a compact and scalable design. This allows the UK to move toward deployable fusion power at a fraction of the cost and within a far shorter timescale. This gives the UK a realistic route to be first to market with a functioning fusion power plant and the ability to reap the benefits that come with it.



06

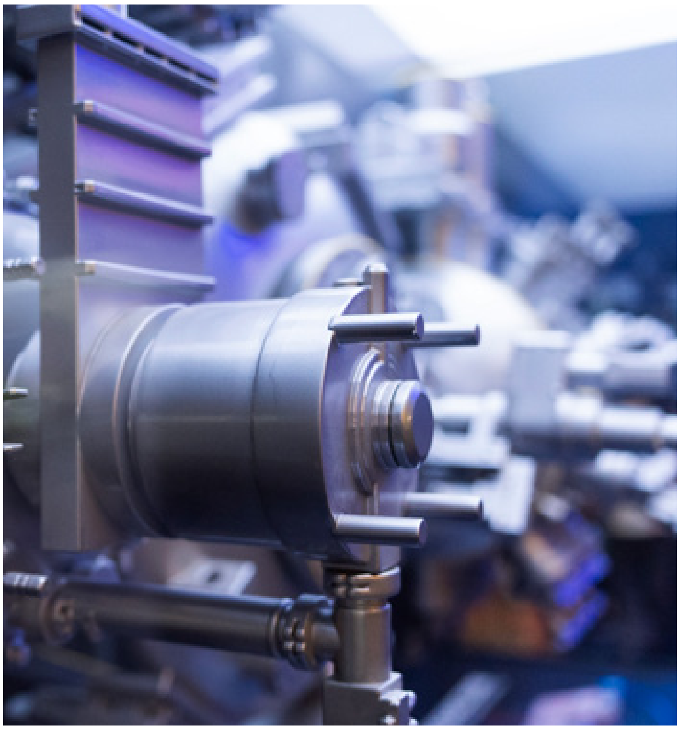
A Roadmap to a Commercial IFE Reactor

The realisation of a commercial fusion reactor of the kind shown in Figure 1 is attainable quicker than any of the current schemes, because it levers off existing technology and concepts.

While this will be built outside of the UK, the UK does need to step in to secure its position in any IFE scheme. There are steps that need to be taken both by the UK government and the sector writ large to make it happen. Further research and innovation along with regulatory and policy preparation is necessary to facilitate this.

Research Pathway

In the near term, research into decoupled compression and ignition IFE configurations must accelerate. With targeted investment, First Light Fusion can rapidly advance its design using a combination of in-house hardware capabilities, AI-driven modelling, and precision experimental platforms. By breaking down the IFE system into discrete components, key physical processes (driver-target coupling, load behaviour, fuel compression etc) can be isolated, tested, and validated under repeatable conditions.



This modular approach reduces technical risk and shortens development timelines. Progress will be fastest where industry, academia, and government work collaboratively. The UK can capitalise on existing research infrastructure, both domestic and international, to investigate and make progress without waiting for fully operational demonstration facilities. Platforms such as Sandia National Laboratories Z Machine, the Omega Laser Facility at the University of Rochester, and the UK's Orion Laser Facility already provide the capability to test high-pressure shock compression, laser-plasma coupling, and material performance at reactor-relevant conditions.

This model mirrors that used in the United States Stockpile Stewardship and UK Warhead Assurance programmes, where system performance is assured through rigorous modelling and sub-scale validation rather than reliance on full-scale trials. Applying this philosophy to fusion enables an evidence-led, confidence-building pathway to commercialisation.

Development of artificial intelligence tools will be transformative. An energy security deal between the UK and US, part of which includes aiming to enhance fusion programmes by combining AI capabilities, has already been announced. FLF are at the forefront of this work having already developed advanced artificial intelligence capabilities, using machine learning to optimise experimental design, analyse high-speed diagnostics, and guide target development. By applying AI to vast datasets of simulations and experimental shots, the company has rapidly refined its understanding of implosion dynamics far beyond traditional modelling alone would allow. This reduces experimental costs and unlocks design innovations that would be impractical to achieve through manual methods. These AI-driven insights help bridge the gap between laboratory experiments and the engineering demands of a commercial power plant. Continuation and funding for this research is vital.

Academic collaboration is critical. Shared research programmes, transparent data, and peer-reviewed results will ensure reproducibility and help secure international credibility. Partnerships should extend beyond the target and driver to encompass all aspects of the reactor system, including recyclable transmission lines, neutron shielding, tritium handling, and liquid lithium technologies. Many of these subsystems can reach higher technology readiness levels faster than the fusion core, but require integration within a complete plant design.

Here, the UK can draw directly on capabilities within the UKAEA and the broader civil nuclear sector. The parallels are strong: advanced materials for extreme thermal and radiative loads, high-integrity engineering, coolant loop design, and safe maintenance are all areas where fission expertise can be leveraged for fusion.

By adopting this strategy, underpinned by open collaboration and targeted use of existing experimental facilities, the UK can derisk IFE development, shorten timelines to demonstration, and position itself as a global leader in the commercialisation of Inertial Fusion Energy. This is a proven approach that aligns with industrial strategy, supports the growth of a highly skilled supply chain, and provides return on public investment.

The Wider Value Chain

The pathway to developing a commercial IFE reactor in the UK would generate value that extends far beyond the core objective of producing clean energy. The research, regulatory reform, and industrial investment required to establish such a system would create a diverse and resilient value chain, supporting high-value sectors and reinforcing sovereign capabilities that are strategically important to the future of the UK.

Current global tritium inventories are extremely limited, with supply largely tied to ageing heavy water fission reactors. Developing tritium breeding capabilities would therefore give the UK a sovereign supply of a scarce and strategically important isotope. Becoming a ‘fusion superpower’ early opens up the potential of becoming a large tritium exporter as the rest of the global community catches up. This in turn creates synergies with the UK’s domestic lithium industry. Companies such as Cornish Lithium are working to establish a secure supply of lithium for batteries, and the parallel demand for lithium in fusion blankets would provide both a technological driver and a commercial market, stimulating regional development in Cornwall while reducing reliance on overseas supply chains.

Beyond these specific technological components, the broader value of IFE development lies in the cross-sectoral innovation it would stimulate. High integrity engineering, extreme materials research, and advanced digital modelling in AI-driven simulation would all benefit from the demands of building a viable IFE reactor. The expertise built in these areas would be transferable to aerospace, defence, pharmaceuticals, and other advanced manufacturing industries. Similarly, the regulatory frameworks required for fusion would provide a model for governance of other frontier technologies, reinforcing the UK’s reputation as a first-mover in shaping global norms.

Not only are there major benefits to be reaped from investing in IFE - there are significant risks of not investing. IFE development is accelerating internationally, with major programmes and private ventures, particularly in the United States and China, moving rapidly. IFE will advance with or without UK involvement, and if the UK hesitates, it risks ceding both industrial opportunities and technical expertise to overseas competitors. Losing first-mover advantage would not only mean forfeiting potential export markets and supply chain growth, but also diminishing the UK’s role in setting global standards and shaping the fusion industry as it emerges. Inaction now could leave the country dependent on foreign technologies in a sector that promises to redefine the global energy system, undermining both economic competitiveness and energy security.

07
The Fusion Policy Landscape

The global race to commercial fusion is being shaped by markedly different policy approaches across leading jurisdictions.

The UK has positioned itself as a research leader, with UKAEA at the centre of experimental facilities and a growing emphasis on public-private collaboration, but risks lagging in deployment timelines without more aggressive policy reform. The US has embraced a market led strategy, mobilising federal support for private companies while ensuring access to national laboratories and experimental platforms. China is pursuing a state driven model, coupling vast capital investment with rapid deployment of facilities, aiming to achieve operational milestones well ahead of western competitors. Europe has moved towards a more coordinated approach, supporting both magnetic and inertial approaches but within a more cautious regulatory culture. The interplay between these approaches means that, while the UK is playing a vital part in global fusion development, the first operational fusion plant will not be built here with the current policy regime.

The Regulatory Environment is Too Vague

The current regulatory framework for fusion in the UK remains ambiguous, with overlapping responsibilities and no dedicated pathway tailored to the technology's unique risk profile. Recent steps such as the Energy Act 2023 and the ongoing consultation on a Fusion National Policy Statement mark progress, but the absence of clear statutory provisions still leaves developers uncertain about licensing timelines and compliance obligations. This vagueness creates investor hesitation and slows project planning, as firms must account for potential regulatory surprises.

By contrast, jurisdictions like the US are moving more decisively towards fusion regulation that is distinct from fission, giving developers and financiers greater certainty. In 2023, the US Nuclear Regulatory Commission made a decision to regulate fusion under the byproduct materials framework rather than under the fission oriented regimes. This effectively treats fusion facilities more like particle accelerators or industrial radiation sources. This was reinforced through the ADVANCE Act and Fusion Energy Act, which created a statutory definition of fusion machines and confirmed that fusion produced radioactive materials fall under the lighter byproduct framework. Furthermore, it was recently announced that Pacific Fusion will be moving to New Mexico due to a nuanced, tax advantaged leasing scheme that will provide hundreds of millions of dollars in incentives. Without our own coherent and transparent UK regime, domestic firms risk being disadvantaged compared to competitors abroad. Publishing guidance specific to fusion would not only provide certainty to innovators but also reduce the risk of costly delays or inconsistent decisions.

Regulators Lack Expertise and Resources

The Environment Agency and other regulators will inevitably play a role in permitting fusion plants, but their current expertise lies primarily in conventional industry oversight. Fusion presents novel challenges that fall outside the agency's established remit. Without targeted capacity building, the EA risks becoming a bottleneck, applying frameworks designed for other industries and slowing down licensing processes.

Compounding this is the chronic underfunding of regulators, which has already stretched their ability to process complex applications at pace to the limit. If fusion applications are added on top of existing pressures without additional resources or training, there is a real risk that licensing could stall projects for months or years. Ensuring that regulators are resourced and trained to handle fusion's distinct challenges is therefore essential if the UK wants to avoid delays in deploying fusion technologies.

The Planning Regime is Too Slow

Commercial fusion deployment will require the rapid construction of FOAK plants, but the UK's current planning system is notoriously slow and procedurally burdensome. Nationally Significant Infrastructure Project processes are very burdensome, requiring years of consultation and ministerial approval. These processes will disallow the UK to win the technology race against the US and China, as they have far more relaxed processes.

A dedicated planning regime for fusion would accelerate build times. Other energy transition sectors have already benefitted from streamlined consenting processes that cut years off project timelines. Applying similar urgency to fusion would demonstrate that government recognises fusion as a strategic priority and is prepared to act accordingly. The publishing of the fusion National Policy Statement, EN-8, represents an opportunity to release fusion from the shackles of crippling protracted planning legislation.

Risk of Falling Under ONR Process

The ONR's licensing regime is designed for fission reactors, with safety case evaluations that last years and compliance structures focused on hazards such as meltdown. Applying this to fusion would be wholly disproportionate to the risks and would impose delays and costs that could derail timelines.

Countries like the US and Germany are moving away from conflating fusion with fission in regulatory terms, recognising that doing so would kill competitiveness. If the UK does not guard against ONR oversight, fusion plants could be stuck in processes designed for a fundamentally different technology, leaving the UK years behind other jurisdictions. A clear separation from ONR processes is essential to maintain momentum and investor confidence in the UK's fusion sector.

Grid Connections Bottleneck Infrastructure

Even if fusion developers can secure planning and regulatory approval, connecting to the UK grid presents a further structural barrier. The current grid connection queue in the UK is one of the longest in the world, with projects facing delays of up to a decade due to limited transmission capacity and outdated planning processes for reinforcement. Fusion plants, which will require substantial and reliable connections, risk being caught in the same bottlenecks as renewables, undermining their ability to come online swiftly.

Other countries are actively addressing these issues. The US is investing heavily in grid modernisation and interconnection reforms, while China's centralised planning allows rapid buildout of transmission capacity to match new generation assets. Unless the UK accelerates grid investment and prioritises strategic technologies like fusion in the queue, developers may face delays even after their plants are ready. Ensuring grid access is therefore a crucial enabler for fusion deployment and should be built into the UK's fusion policy framework.

08

Policy Recommendations

There are specific reforms and regulatory changes can go a long way to breaking down the barriers set out in the previous section.

This section outlines policy recommendations to enable trailblazers like First Light Fusion to keep the UK at the forefront of the energy transition.

Broadening the scope of fusion specific policies

We recommend:

Parity of recognition of IFE alongside MCF in the Fusion Strategy

DESNZ will publish an updated fusion strategy by the end of 2025. This represents an opportunity to embed Inertial Fusion Energy within the UK's overarching energy approach. The updated strategy should emphasise collaboration across the wider UK fusion value chain and with international partners. IFE and MCF bring different but mutually reinforcing strengths - MCF is advancing plasma science and is the current focus of regulatory frameworks, while IFE offers simpler reactor engineering, pulsed operation, and routes to excess tritium production through specially configured lithium blankets. Together, they broaden the scientific and industrial base, reduce technology risk by diversifying pathways, and ensure that UK investment strengthens the entire fusion ecosystem rather than relying on a single approach.

Emphasising the UK’s AI and experimental capabilities in the Fusion Prospectus

DESNZ is developing a Fusion Prospectus to showcase the UK’s fusion value chain to potential investors. The domestic AI and experimental capabilities of the UK should be included in this document to ensure that IFE is represented and its commercial potential made visible to both domestic and international stakeholders. First Light Fusion’s technology directly addresses several of DESNZ’s priority challenges, including tritium breeding. The lithium blanket architecture proposed in Figure 1 can contribute significantly to national tritium self-sufficiency and complement initiatives such as the LIBERTY project.

Integrating IFE with existing fusion programmes and infrastructure

Integration with UKAEA’s capabilities at Culham is important, both symbolically and practically. Opportunities for collaboration on site through joint use of facilities for aspects such as materials testing and lithium blanket development should be explored. The STEP programme also offers a natural point of engagement.

Ensuring industry policies suit the development and deployment of fusion

We recommend:

Fusion plants should be governed by Health and Safety Executive guidance, and the Ionising Radiation Regulations 2017 should make this clear

Regulatory reform will be a central enabler for the commercialisation of both IFE and MCF. Current provisions under the Ionising Radiations Regulations 2017 were designed for fission and are poorly suited to the risk profile of fusion. Rather than applying provisions intended for licensed nuclear installations, the regulations should be updated to make clear that the specific outputs of fusion reactors are to be addressed through tailored guidance issued by the HSE. Compliance with HSE’s guidance should be deemed sufficient to demonstrate compliance with IRR17.

Safety regulations for fusion plants should be the same as any other NOAK power plant

As fusion technologies progress towards FOAK plants and commercial deployment, the safety framework applied must reflect the operational realities. Fusion does not produce dangerous long lasting radioactive waste, nor does it carry catastrophic accident risks. Fusion facilities should be regulated under the same safety regime (e.g The Regulatory Reform (Fire Safety) Order 2005) as other large power plants, such as gas or renewables, rather than through bespoke legislation.

Embedding fusion within a mainstream power plant safety regime will also accelerate deployment by reducing regulatory uncertainty and streamlining compliance. A predictable framework will encourage private capital while ensuring public confidence in safety standards. Over regulating fusion risks slowing innovation, undermining the UK's ambition to lead in the energy transition. Aligning fusion safety requirements with those of other NOAK power plants would strike the right balance between public protection and enabling innovation.

Keeping fission completely separate

We recommend:

The IEA should work with the UKAEA to publish fusion plant compliance regulations. The ONR should not be involved

Positioning the International Energy Agency as the ultimate owner of compliance regulations would provide credibility across jurisdictions. As the UKAEA is currently the global leader in fusion regulation, it can write the rules itself with IEA oversight, enabling rapid deployment into UK policy without losing the benefits of international engagement. By anchoring compliance guidance at the international level, they would ensure that the regulatory environment keeps pace with technological advances. This would not only reinforce the global influence of the UKAEA but also help ensure that its pioneering work directly shapes international norms.

The Nuclear Regulatory Taskforce and the UKAEA are at the forefront of nuclear regulation, and can provide strong support and counsel to the IEA while it builds its fusion framework. Historically, the ONR has set overly constricting restrictions on nuclear endeavours, and involving such a body in the construction of a regulatory framework that must emphasise speed of deployment, as well as provide a considerable amount of leniency for fusion companies to stay agile and adapt, would be counter productive. For this reason, the ONR should not be involved in building the regulatory environment for fusion at all.

An IEA led compliance framework, supported by UKAEA's technical expertise, would allow UK regulators to focus on implementation rather than rule setting, freeing fusion from unnecessarily restrictive oversight such as that provided by the ONR. This would enable a streamlined regime proportionate to the low hazard profile of fusion, while still safeguarding public and environmental safety. By coupling the scientific authority of the UKAEA with the international convening power of the IEA, the UK can deliver a regulatory pathway that accelerates commercial fusion deployment and keeps the country's place as the global leader in the fusion energy transition.

Keep fusion plants excluded from Nuclear Installations Act 1965

Fusion plants were exempted from the highly restrictive siting requirements that apply to nuclear fission facilities, which were designed to address the very different risk profile of fission technologies, in the Energy Act 2023, and must remain so. Applying the same location constraints to fusion would create unnecessary barriers to deployment and limit potential co-location with existing industrial clusters. Unlike fission, fusion does not carry risks of meltdown or significant radiological release, and therefore does not require the same degree of separation from population centres.

Maintaining this regulatory distinction is vital. If fusion is forced into the same siting regime as fission, projects will face higher development costs, longer timelines, and a reduced pool of viable sites, driving investors and developers to countries with more flexible regulations. Government should reaffirm the exclusion of fusion from fission siting rules, providing certainty to developers and showing that the UK recognises and regulates fusion on the basis of its actual risk profile rather than assumptions based on a different technology.

Timeline

Time is of the essence with the implementation of these policy interventions:

01	In the immediate term, the UK must establish the regulatory framework that fosters the environment for commercial fusion deployment. The priority is bringing fusion to the centre of UK energy strategy - the Fusion Strategy and Fusion Prospectus will be published very soon and mark the start of the required shift.
02	From 2026, once strategic recognition is established, attention should shift to deepening collaboration across UK fusion research infrastructure - integrating IFE projects with UKAEA facilities at Culham will be essential to demonstrating feasibility.
03	By the late 2020s, the policy focus must move to regulation and market design. The Ionising Radiations Regulations 2017 should be revised, with compliance overseen by the HSE. By 2030, the first licensing framework for fusion facilities should be complete.
04	With the regulatory framework in place, the UK can begin construction of its FOAK commercial fusion plant by 2031/2032, aiming for operation before 2035.

These policy recommendations, if implemented to these timelines, will allow UK based fusion companies to make significant progress towards a commercial IFE reactor by 2035.

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Conclusion

Commercial nuclear fusion is within reach. By using First Light Fusion's configuration of an IFE reactor, commercial deployment is attainable by 2035.

By bringing IFE into the research and regulatory spotlight alongside MCF, the timelines for fusion development can be greatly condensed. Developing an IFE reactor avoids complex, unsolved plasma confinement challenges that are delaying significant MCF progress.

First Light Fusion's proposed reactor configuration and FLARE fusion method also solve existing issues within the IFE space. The lithium blanket design - more akin to a 'lithium pool' - solves pressurisation, temperature, tritium breeding, component protection and energy capture issues. The reactor design described in this paper can be operated at much lower temperatures and pressures than other designs, can be built using existing and well understood materials, can breed excess tritium and absorb 99.9% of neutron energy emitted by the fusion reactions.

Deploying a low-intensity pulsed driver in the compression phase prevents premature heating, significantly reducing compression energy requirements. Incorporating a pusher into the fuel target design and igniting only a small portion of the fuel directly reduces the ignition energy requirements. The compound effects of these reductions in energy requirements make the proposed reactor far more commercially and physically viable.

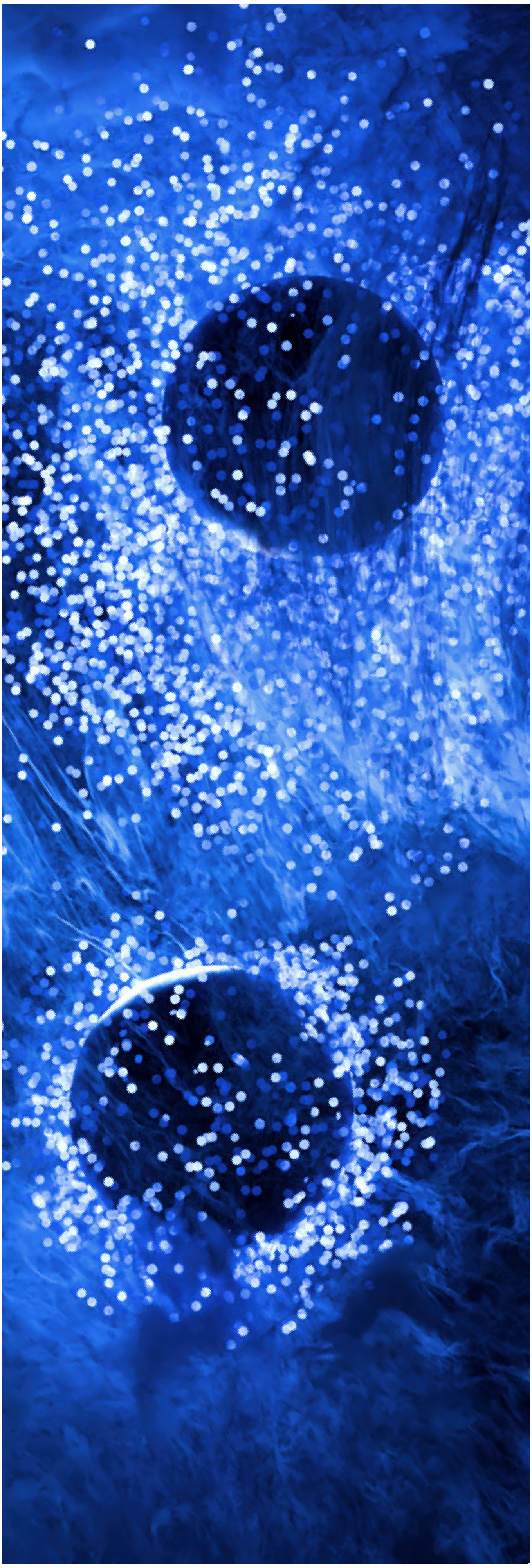
Developing a commercially viable IFE reactor would add significant value across the UK. Domestic lithium supply chains would be stimulated and sovereign capability in the fields of shock and condensation physics bolstered. Furthermore, it would position the UK as a world leader in the field, cementing further the reputation of the country as a scientific superpower.

To realise all these benefits, collaboration between industry, academia and government is vital. Industry brings the capacity to innovate, manufacture, and scale reactor technologies; academia contributes the fundamental research and talent pipeline required to address outstanding scientific and engineering challenges; and government provides the regulatory frameworks, infrastructure investment, and long-term policy certainty necessary to de-risk private capital.

The UK has to move now. The current target of an operational commercial fusion reactor by 2040 leaves the door open for other countries to take the lead in the race for fusion. China and the US are investing heavily, and if the UK does not condense its timelines and make major policy alterations, it will lose its first mover advantage and with it any export opportunities.

Being drawn into a straight race will ensure defeat. An asymmetric approach, by investing in FLARE, will put the UK back in the lead in one of the most important races of the century.

The earlier that IFE is brought to the fore in energy generation debates, the quicker these benefits can be realised and the closer the UK gets to solving the problem of commercial fusion and as such the problem of clean energy.



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Appendix A

A Brief History of Fusion

The Discovery of Fusion (1900-1939)

The chain of events leading to the potential for harnessing the fascinating physical phenomenon of nuclear fusion demonstrates just how sophisticated the concept is. It took some of the greatest scientific minds making Nobel prize-winning breakthroughs to get fusion to where it is today.

Einstein publishes his theory of special relativity (1905)

A seminal moment in the history of the human race, Einstein revolutionized physics by describing how space and time are relative to the motion of an observer, especially at speeds approaching the speed of light. Most significantly to fusion, it introduced the most famous equation in physics, $E=mc^2$, establishing a new understanding of the relationship between energy, mass, and the speed of light. Although this equation is not the reason Einstein won a Nobel prize, it is vital to understanding why fusion releases energy.

Rutherford discovers the atomic nucleus (1911)

Kiwi-born physicist Ernst Rutherford is often described as 'the father of nuclear physics', a title bestowed to him for being the first person to observe that the charge of an atom was concentrated in a small area in its centre - the nucleus. He did so after observing scattering in the gold foil experiment, performed by Hans Geiger (of counter fame) and Ernest Marsden. Made already with one Nobel prize to his name, this observation paved the way for a whole new field of physical study.

Eddington proposes fusion as the source of the Sun's energy (1920)

English astrophysicist Arthur Eddington was the first to propose the Sun was powered by the fusion of hydrogen into helium in 1920, in his paper titled 'The Constitution of the Stars'. Rejecting the leading theory of stellar energy - that it comes from contractions of stars - he reasoned that the energy must come from the only other plausible known source: conversion of matter to energy, described by $E=mc^2$.

F.W. Aston supports Eddington and Einstein (1922)

Francis William Aston developed the mass spectrograph; a device that could measure atomic masses to a precision hitherto unknown (and also won him a Nobel prize in 1922). He found that the mass of a helium atom was less than that of four hydrogen atoms, providing empirical support for Einstein's theory and Eddington's stellar fusion hypothesis. These measurements validated the energy potential of fusion and established a quantitative basis for its feasibility.

The Rise of Quantum Tunneling (1928)

The concept of quantum tunneling - a particle having the ability to overcome an energy barrier even when classical physics would forbid it - was vital to legitimising Eddington's stellar fusion hypothesis. George Gamow proved that tunneling was the mechanism that allowed alpha particles to overcome electrostatic repulsion forces in alpha decays. Explaining how protons would overcome electrostatic repulsion forces in fusion reactions in stars strengthened Eddington's theory.

The Discovery and Isolation of Deuterium (1931)

Harold Urey discovered deuterium spectroscopically at the National Bureau of Standards (now National Institute of Standards and Technology) in 1931. He was also responsible for the nomenclature of both deuterium and tritium. The discovery of the heavy isotope of hydrogen provided one of the most efficient and accessible fuels for controlled nuclear fusion.

The Discovery of the Neutron (1932)

James Chadwick discovered the neutron in 1932 when he studied the products of Beryllium atoms absorbing alpha radiation particles. The resulting products included a very penetrating 'radiation', which Chadwick soon discovered had no charge and was of similar mass to the proton. This particle later became known as the neutron, and allowed a deeper understanding of nuclear structure and reactions, enabling targeted nuclear experiments.

Cockroft and Walton split Lithium (1932)

John Cockcroft and Ernest Walton conducted the first successful artificial splitting of an atom in 1932. They achieved this by accelerating protons to high velocities using a custom-built accelerator and then bombarding lithium nuclei with these protons. This bombardment caused the lithium nuclei to split into two alpha particles, effectively demonstrating the conversion of mass into energy, a key point for fusion. This earned them a Nobel prize in 1951.

Mark Oliphant demonstrates fusion (1934)

Working under Ernst Rutherford and building on his previous work, Mark Oliphant bombarded atomic deuterium with deuterium nuclei and observed that both isotopes of helium and tritium were created, along with neutrons. This was the first instance of induced nuclear fusion in a lab.

Bethe brings it all together (1939)

Hans Bethe built on all this brilliant previous work to mathematically describe the 'proton-proton chain' as the basis of stellar energy production, as well as the CNO (carbon-nitrogen-oxygen) cycle. This work earned Bethe a Nobel prize in 1967.

Modern Fusion (1939-Present)

1939 marked the temporary pause of physics research for the sake of science, especially in Europe, but nuclear research ramped up dramatically during and in the wake of WW2. More attempts to harness the energy of the atom for the gain of society continued to be made worldwide, and technological advancements continued to come.

The Manhattan Project (1939-1945)

The second world war was a pivotal period for nuclear energy, demonstrating that large scale induced nuclear reactions were possible. Although the weapons created utilised fission, the research into nuclear reactions was formative in the field of commercialising nuclear fusion.

TOKAMAK (1950s and 1960s)

The scientists of the Soviet Union were the first to propose the toroidal design of a fusion reactor, and in the two decades after the second world war they made significant advancements. They were able to demonstrate the benefits of confining plasma in this way, and the design they laid out is the basis of a large amount of fusion research and innovation today.

Birth of IFE at Lawrence Livermore National Laboratory (1972)

Much of the focus up until this point had been on Magnetic Confinement Fusion (MCF) of the sort performed in TOKAMAK reactors. In 1972, Lawrence Livermore National Laboratory in the US used lasers to compress and ignite fuel pellets. A new pathway to fusion, Inertial Fusion Energy (IFE), was born.

The Joint European Taurus (JET) achieves first plasma (1983)

A joint effort by the EU and other collaborating European countries, JET was designed to study fusion in conditions approaching those needed for a power plant. It would dominate the fusion research sector for decades, and go on to be the blueprint for many iterations of experimental fusion reactors.

The National Ignition Facility (NIF) is built (2001)

The NIF focuses on laser-based IFE, and is the only IFE facility of its scale. The facility has acted as the focal point for IFE since its construction.

International Thermonuclear Experimental Reactor (ITER) construction commissioned (2006)

The ITER programme was first proposed in 1985, but construction was only signed off in 2006. It is a multi-national collaboration between more than 30 countries, aiming to pave the way to fusion commercialisation. When completed, it is set to become the largest TOKAMAK facility in the world. First plasma is scheduled for 2034.

First Light Fusion demonstrate IFE (2022)

In 2022, UK based company First Light Fusion became the first to demonstrate projectile-driven fusion, using a mechanical shock to create the conditions.

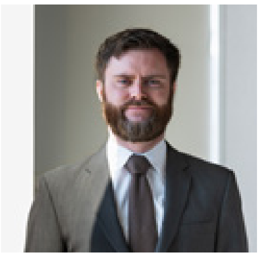
NIF demonstrate net gain (2022)

The only fusion experiment to date to do so, the National Ignition Facility got more energy out of a fusion reaction than they put in, demonstrating the commercial viability of fusion as an energy source.

JET sets fusion energy yield record (2024)

Breaking its own record, the JET reactor produced 69 megajoules of energy in a sustained and controlled fusion reaction. The reaction lasted roughly six seconds, utilising 0.21 milligrams of fuel and achieving the output of burning two kilograms of coal.

ABOUT THE AUTHORS



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