Written evidence from First Light Fusion (NCL0031)

When will fusion power supply electricity to the grid?

- **What are the advantages and disadvantages of developing fusion technologies over other energy sources?**

Introduction to FLF and Inertial Confinement Fusion

Executive Summary

First Light Fusion (First Light) was spun out of the University of Oxford in 2011 to address the urgent need to decarbonise the global energy system. Its approach to fusion energy, which is safe, clean and virtually limitless, has the potential to transform the world's energy system.

First Light is strongly supportive of the work that is being done to support the delivery of commercial fusion energy by Government, for which the appropriate regulatory framework will be essential. Taken together with First Light's work – which includes the world's first demonstration of fusion with a projectile approach, a breakthrough that was achieved faster and cheaper than traditional fusion approaches –will work to accelerate fusion's progress.

First Light is working towards a pilot plant producing ~150 MW of electricity and costing less than $1 billion in the mid-2030s, depending on funding levels.

Solving commercial fusion would represent a huge opportunity to UK in securing its renewable domestic energy supply and positioning the UK as a scientific superpower and technology exporter. Additionally, fusion offers long-term energy security, which is increasingly important in the current geo-political climate, where the UK cannot be beholden to other countries for critical energy resources.

The UK Government must continue to support the development of the broadest possible range of energy technologies and must expand the range of fusion approaches it is supporting to secure a diverse and resilient energy system in the UK whilst ensuring that these technologies can be exploited for the global energy market.

Introduction to First Light Fusion and Inertial Fusion

First Light welcomes the opportunity to respond to the Science and Technology Committee's Call for Evidence on Delivering Nuclear Power, including its specific questions on fusion timelines and its benefits to supplying the UK power grid.

First Light is a University of Oxford spin-out company working towards commercialising a new technology for fusion for electrical power generation. It is part of the well-established field of inertial confinement fusion (ICF, or simply inertial fusion), which is distinct from the magnetic approach (MCF) pursued by other fusion organisations in the UK, including the publicly funded UKAEA and private organisations known to the Government.

This puts First Light in a unique position as the leading organisation in the UK, operating at the cutting edge of a global ICF community. ICF has been demonstrated scientifically in

several labs. This includes First Light Fusion's own laboratory, which in April 2022 achieved a breakthrough result using projectile technology, through the unique targets developed by First Light, which experimentally showed fusion for the first time.

First Light's own technology is unique within the ICF field. Whereas other technologies seek to achieve fusion reactions via lasers, FLF technology uses a shockwave generated by a projectile impact as the driver. We have developed sophisticated 'targets' containing fusion fuel (deuterium and tritium) which are impacted by high-speed projectiles. During impact, the advanced targets amplify the pressure of the shockwave, and they focus it on the fuel. We model our approach to inertial fusion using unique, world-leading simulation tools. This approach has the potential to generate cost-effective fusion energy. This has been demonstrated for less than £45 million, making it considerably lower cost compared to other fusion programmes.

The key result is observation of neutrons produced by fusion and this measurement has been independently validated by UKAEA, the UK's national centre for fusion research. Analysis of the fusion triple product illustrates the company's very rapid progress and the radical nature of the approach, with FLF being able to access record values in some areas.

The ICF approach has also been demonstrated in the United States by the National Ignition Facility (NIF) in California, which achieved a significant milestone in 2021 with 1.3 MJ of fusion energy release.

The fact that we are making major progress in the field towards commercialisation of fusion means that now is the time for the appropriate regulations to be put in place to support the commercialisation of the technology, and ensure the UK remains a world leader in fusion enterprise.

First Light is pleased to see the progress that Government has made in recent years towards supporting the delivery of commercial fusion energy, for which the appropriate regulatory framework and support will be essential.

Given fusion energy can potentially provide near limitless clean energy, it would be a genuine game-changer in decarbonising the UK and global economy and achieve a net-zero economy. It is our belief that realising fusion itself should be the goal of HMG, rather than achieving fusion via a specific mandated approach or route, particularly given there is no consensus in the scientific community as to which method is most likely to succeed.

Responses to the Questions

When will fusion power supply electricity to the grid?

Creating energy from fusion at a commercial scale presents one of the great challenges of our time, but this is closer than ever before.

Fusion as a field has made significant progress in recent times – including First Light's April 2022 breakthrough - and there is considerable interest and investment being made into the sector globally, which means it is only a matter of time before commercial fusion is achieved.

First Light's own plans are advancing at pace. Its gain experiment, which means producing more energy than is put in, will commence upon the commissioning of the new M4 machine, which is targeted for 2027.

Several work streams will be undertaken to ensure that First Light may move to the commercial phase as soon as possible after this is successfully demonstrated. Much of this work is to de-risk the engineering of a reactor plant that will ensure that a conceptual power plant design is delivered as soon as possible after the gain result.

This is the route to achieving our targeted delivery of a first fusion power plant on the grid by the early 2030s.

Working at a lower repetition rate (to manage the engineering risk), this plant will create an excess of tritium such that, despite having a relatively high electricity generation cost, it may be self-funding: the surplus tritium generated shall have substantial value to other end-users. This plant may also be upgraded later to make it more competitive for electricity generation.

With these building blocks in place, the UK and global fusion sector can thrive.

To show true global leadership, and for the UK to be seen as a real science superpower, Government cannot pass up on the opportunity to deliver fusion power to other nations. Additionally, fusion offers long-term energy security, which is increasingly important in the current geo-political climate, where the UK cannot be beholden to other countries for critical energy resources.

The UK Government has an essential role to play in making this possible.

Firstly, providing clarity regarding the regulatory framework provides further assurance and helps to de-risk investment for major investors. This will support the high levels of investment already going into the sector and help to leverage more in the future.

Secondly, Government has outlined its intention to proceed with a Fusion National Policy Statement. FLF would support this. The development of a FOAK fusion plant would be a major piece of infrastructure and subject to much interest from many stakeholders. In our opinion it would neither be feasible nor practical to deliver such a facility without the support of central Government via a NPS, which would both streamline and facilitate deployment, as well as signal Government's support for fusion technology.

We would urge the current government to continue its work on fusion and creating the right environment for companies like First Light Fusion to achieve global success.

What are the advantages and disadvantages of developing fusion technologies over other energy sources?

Fusion power could be, in the UK Government's own words "the ultimate clean power solution", representing a low carbon, safe, continuous, and sustainable source of energy.

There is a pressing need to first decarbonise, and then transition to an energy system in which the world's future energy generating technologies can deliver whatever new demands are placed upon them. Harnessing fusion energy will also hugely improve the UK's energy security, as well as its cleanliness, by reducing reliance on energy imports and price volatility.

It is a source of energy which could provide reliable baseload energy to meet future demands for newly electrified systems, which will be much higher than current levels. Renewables and other energy sources although efficient often rely on environmental factors to produce the energy, causing spikes in energy costs for the supply chain.

Fusion offers the ability to balance the grid in these periods because, unlike other energy sources, nuclear fusion can be turned on by the flick of a switch. The successful realisation of fusion would also present major benefits for the environment by delivering a technology capable of driving the UK's decarbonisation efforts, decoupling emissions from economic growth and helping the UK meet its carbon reduction targets.

The fusion sector also provides considerable wider benefits to the UK scientific community: the equipment used by fusion enterprises is some of the most advanced in the world, and advances in fusion have knock-on impacts in other fields. For example, First Light has designed and built Machine 3, which is the second highest current pulsed power machine in the world. For the subsequent phase of our program, it will build what would be the largest pulsed power machine in the world (Machine 4), alongside other state-of-the-art technical facilities. This equipment will have positive impacts for the wider UK scientific community and would be an extraordinary platform to conduct experiments in areas of fundamental science not possible anywhere else.

This means that First Light, while pursuing fusion, will contribute to the wider UK's scientific capabilities for years to come.

Creating infrastructure for non-fusion nuclear is costly, and a critical consideration as the initial development costs often prove to be large economic barriers. First Light will be able to effectively address these issues using existing supply chains, with the technology requiring less space to operate in.

As we progress towards commercialisation, First Light will address other existing challenges through focused R&D and incremental investment in projects. This includes ensuring the sustained heat levels produced by fusion can be managed and addressing high energy requirements by improving overall efficiencies.

Multiple approaches to fusion exist, but this is not a challenge. Through the work of the UKAEA, the UK is already considered a leader in magnetic fusion. By adopting a technology agnostic approach that backs both magnetic and inertial fusion, the UK effectively doubles its chances of achieving fusion and delivering the key technology breakthroughs. This underlines how we want to work with Government going forward.

Backed by substantial private investment, as we have outlined, First Light has already demonstrated that it is tackling the challenge of delivering the research and development required to commercialise fusion, delivering UK leadership in the field. Plans for Machine 4,

set to be completed in 2027, will reinforce this as First Light begins gain experiments that pave the way for fusion energy on the UK's energy grid. This technology is exportable and will establish an enormous economic opportunity. By addressing fusion's challenge, and continuing to extend the UK's leadership in fusion, we can deliver enormous environmental, economic, and societal benefit.

Furthermore, the ongoing maturing of fusion power technologies will have a clear and direct benefit for the wider nuclear fission supply chain as much of it would benefit from a lot of the manufacturing opportunities, so in the longer-term development of the fusion sector would also bolster growth and opportunities for the nuclear fission supply chain.

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