Department for
Business, Energy
& Industrial Strategy

Towards Fusion Energy

The UK Government's Fusion Strategy

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Foreword

The challenges of climate change are some of the most urgent and technically demanding the world is facing. For the UK, the Prime Minister's 10 Point Plan[1] sets out the key measures to help us reach our Net Zero target by 2050. However, given rising energy demand globally we also need to look beyond the next 30 years. The world's future energy generating technologies must be capable of delivering whatever new demands we place upon them. We need to work now to deliver solutions for the long term.

Fusion could be the ultimate clean power solution, representing a low carbon, safe, continuous and sustainable source of energy. The UK is widely recognised as a world-leader in the most promising fusion technologies. We have the potential to capitalise on our scientific and technical expertise and lead the commercialisation of fusion energy.

This is not science fiction but science fact. In the UK, fusion research programmes have supported over £1bn of UK economic activity over the last ten years.[2] Building on decades of study at globally unique research facilities, the UK Government has launched the world-leading STEP (Spherical Tokamak for Energy Production) programme, to build a prototype fusion power plant in the UK by 2040. At the same time, private companies in the UK are developing their own fusion power plant designs. UK manufacturers and engineers are beginning to form a fusion supply chain to support these programmes.

This paper sets out the UK Government's strategy to move from a fusion science superpower to a fusion industry superpower. With this plan, the UK hopes to lead the world on the commercialisation and deployment of this potentially world-changing technology.

George Freeman MP

Parliamentary Under Secretary of State, Minister for Science, Research and Innovation

[1] UK Government (2020). The ten-point plan for a green industrial revolution. Available at https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution.
[2] UK Government (2020). Impact of the UK's public investments in UKAEA fusion research. Available at https://www.gov.uk/government/publications/impact-of-the-uks-public-investments-in-ukaea-fusion-research

Background

This paper sets out the UK Government's Fusion Strategy: how the UK will enable the delivery of fusion energy through international, scientific and commercial leadership.

This strategy provides context to the Government's consultation on the future of fusion regulation. This has been published alongside this strategy.[3]

Environmental and energy context

The impacts of climate change are well known. The emerging climate crisis is having an impact around the world. When the Prime Minister launched the UK's Presidency of COP26 in February 2020, he emphasised the link between the carbon-fuelled economy and the hurricanes, bushfires, melting ice caps, and acidification of the oceans. It is well established that we need to decarbonise the global energy system.[4]

Figure 1 – Illustration of climate change as represented by the melting of polar ice caps

[3] UK Government (2021). Toward Fusion Energy: The UK Government's proposals for a regulatory framework for fusion energy. Available at: https://www.gov.uk/government/consultations/towards-fusion-energy-proposals-for-a-regulatory-framework

[4] UK Government (2020). *PM speech at COP 26 Launch*: 4 February 2020. Available at https://www.gov.uk/government/speeches/pm-speech-at-cop-26-launch-4-february-2020

The scale of this challenge cannot be overstated. In 2020 the UK's total generated electricity was 312.8TWh, of which 59% was generated from low-carbon technologies.[5] By 2050, as a result of the rising use of electric vehicles and electric heating, alongside population growth, the UK's total electricity demand is expected to rise to between 570-630TWh[6] – roughly double the current electricity demand. This UK trend will be played out globally owing to the electrification of the world economy. This also does not reflect the anticipated increase in non-electrical future energy requirements, such as industrial heat. As part of its net zero targets, the UK Government is aiming for a fully decarbonised power system in the UK. Ensuring the system is also reliable means that intermittent renewables need to be complemented by technologies which can provide power when the wind is not blowing, or the Sun does not shine.

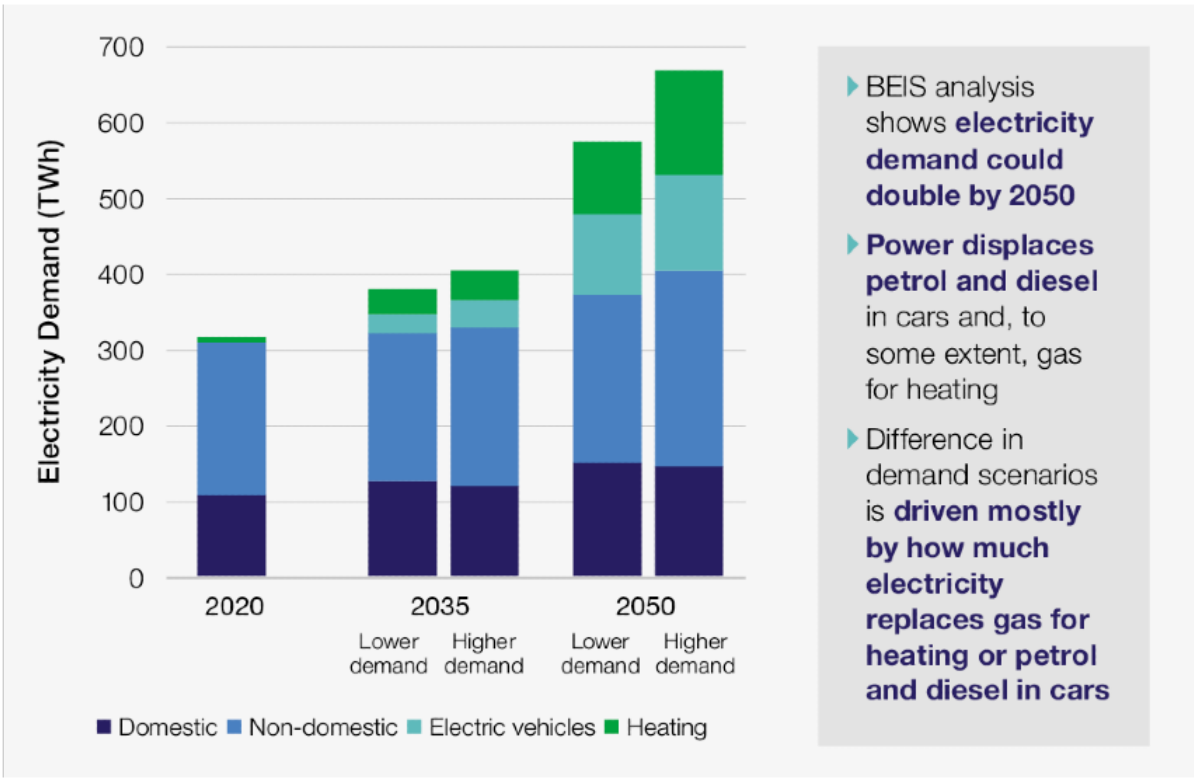

Figure 2 – UK estimated energy requirement for 2050[7]

If it can be successfully demonstrated and commercialised, fusion technology could provide sustainable, low-carbon, baseload power for a future global energy market.

[5] UK Government (2021), Energy Trends March 2021*, Section 5*. Available at https://www.gov.uk/government/statistics/energy-trends-march-2021

[6] UK Government (2020). Energy white paper: Powering our net zero future, Figure 3.2. Available at https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

[7] UK Government (2020). Energy white paper: Powering our net zero future. Available at https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

What is fusion?

Fusion is the process which occurs at the centre of stars. It is the source of light and heat emitted by the Sun. When the nuclei of two light elements are 'fused', they form a heavier element and release excess energy. Fusion energy can be generated in a variety of ways (see Chapter 2 of the fusion regulation green paper[8] for information about the technological approaches to fusion). All methods need to create an environment with sufficient heat and pressure.

The most common fuels considered for fusion power plants are deuterium and tritium, both of which are isotopes of hydrogen. In a deuterium-tritium fusion reaction, the nuclei of a deuterium atom and tritium atom fuse. This creates a helium nucleus and a highly energetic free neutron, whose energy can be harnessed to produce heat and electricity.

[8] UK Government (2021). Toward Fusion Energy: The UK Government's proposals for a regulatory framework for fusion energy. Available at: https://www.gov.uk/government/consultations/towards-fusion-energy-proposals-for-a-regulatory-framework

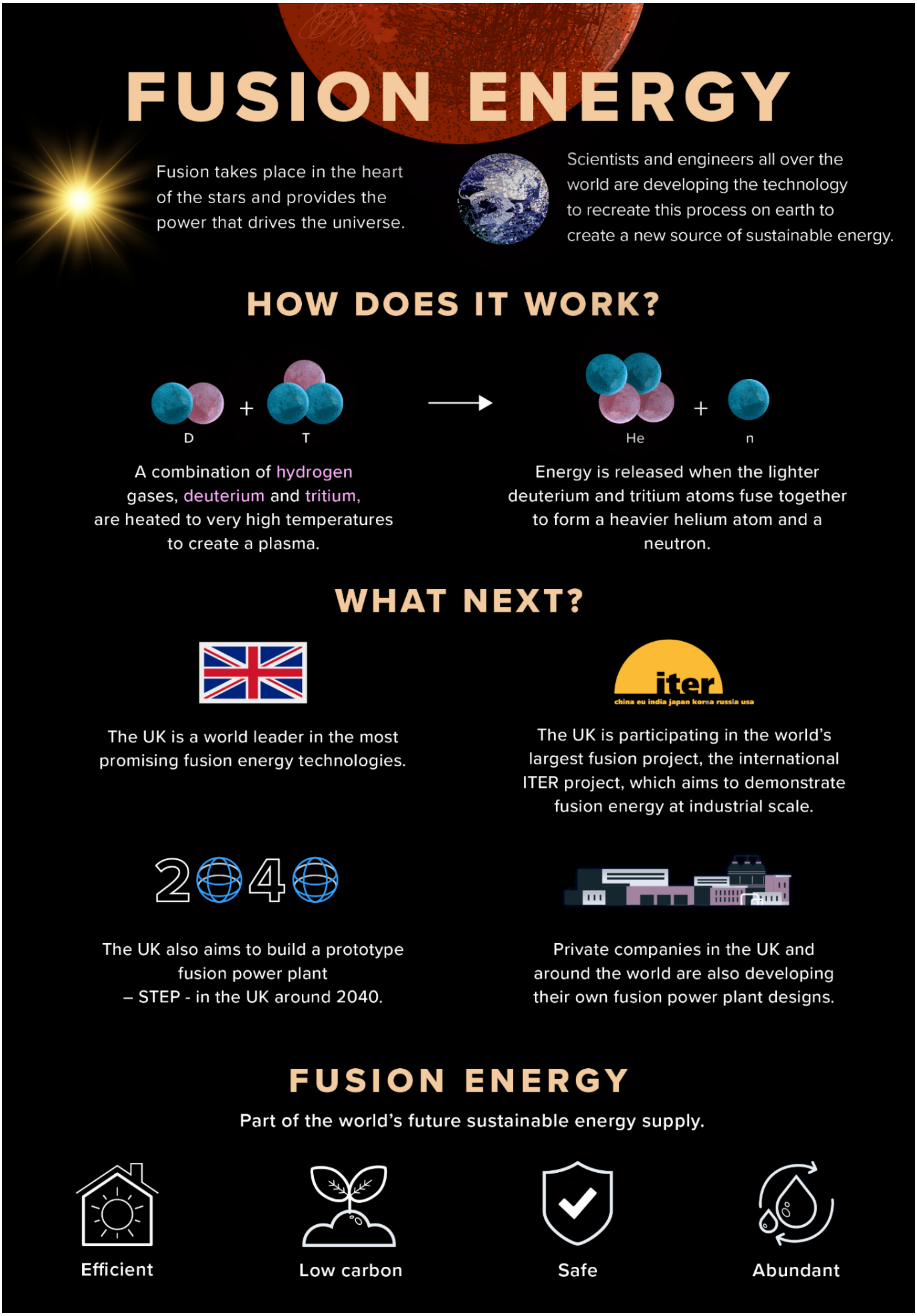

Figure 3 – Summary information about fusion energy

The generation of usable energy using fusion would have six distinct advantages:

1. **Fuel abundance**: the fuels used in fusion reactions are effectively inexhaustible. Deuterium is readily extracted from seawater, and tritium is produced using lithium[9]
2. **Baseload power**: fusion energy does not depend on external factors such as wind or sun, making it continuously deployable at point of need
3. **High fuel efficiency**: fusion produces more energy per gram of fuel than any other process that could be achieved on Earth
4. **Carbon-free**: helium is the product of the fusion process – no carbon or other greenhouse gases are produced in the reaction
5. **No chain reaction:** fusion is not based on a chain reaction; specific conditions of heat and pressure need to be maintained for fusion to occur. Therefore, if there were any technical problems, a fusion facility could be immediately switched off and the process would stop within seconds or less
6. **Shorter lived waste**: fusion power plants are not expected to produce the very long lived, high level radioactive waste associated with nuclear fission

The pathway to fusion energy

While fusion research facilities have been in operation around the world for many decades, no facility has yet demonstrated net energy gain from fusion.[10] The scientific and engineering challenges in delivering fusion energy are considerable. The design and development of the complex components and systems required remains ongoing – and the integration of these into a highly sophisticated facility that can be operated and maintained at commercially viable levels of productivity and availability will be very challenging. However, advances in fusion science and technology over recent years, coupled with advanced manufacturing and computing capabilities now available, mean that fusion energy is closer than ever before.

Fusion energy research is a global endeavour. 35 nations including the UK are collaborating on "ITER" (see page 9), the world's largest fusion project that aims to demonstrate fusion energy generation at industrial scale. Partner nations of ITER represent 50% of the global population and around 90% of the world economy. Alongside ITER, there are a significant number of governments with national initiatives in fusion energy. There are also more than 40 private fusion companies globally which have raised over £2bn in investment to date.

The Government wants the UK – as a leader in fusion science and research – to lead the development of this low carbon energy technology and secure the economic opportunities of a future global fusion energy market. The Government has therefore developed a Fusion Strategy to meet the challenge.

[9] Lithium is abundant in the Earth's crust and so there is a plentiful supply of lithium globally. However, many uses of lithium require a high degree of purity. With the increase in lithium demand due to increasing prominence of electric vehicles, many countries are considering how to increase global capacity to produce high purity lithium. The projected development of fusion energy in the second half of this century will put further pressure on supply. The consideration of the lithium requirements of fusion has already begun including recycling of lithium batteries.

[10] Net energy is when the plasma releases more energy than is needed to heat it. The JET (see page 9) facility currently holds the record for energy release, generating 16 MW from 24 MW of heating (a ratio of 0.67).

The UK Government's Fusion Strategy

The UK's fusion ambitions were set out at a high level in the Ten Point Plan for a Green Industrial Revolution[11] and the 2020 Energy White Paper.[12] The UK Government's Fusion Strategy now sets out these ambitions in further detail. This strategy has two overarching goals:

Overarching goals of the fusion strategy

1. For the UK to demonstrate the commercial viability of fusion by building a prototype fusion power plant in the UK that puts energy on the grid
2. For the UK to build a world-leading fusion industry which can export fusion technology around the world in subsequent decades

The UK Fusion Strategy is focused on achieving these goals by working with the UK Atomic Energy Authority (UKAEA), the UK's research organisation responsible for the development of fusion energy, to secure UK leadership across three 'pillars': international; scientific and commercial.

While the UK Fusion Strategy applies to all technological approaches to fusion, the research programmes described are based on magnetic confinement fusion (MCF), in which strong magnetic fields are used to create the fusion conditions to produce energy and in which the UK is widely recognised as a world-leader.

International leadership

The R&D Roadmap[13] articulated the UK's vision to remain at the forefront of international scientific collaborations. These lead to new advances and discoveries, pushing the frontiers of knowledge faster and further. It has long been the UK's approach to work with partner countries and pool expertise to remain at the forefront of cutting-edge research.

The UK will need to continue to collaborate with the best talent and facilities globally to deliver our fusion energy objectives. The UK already has strong bilateral and multilateral fusion collaboration arrangements. These are structured in a way that maximises the development of fusion science and economic opportunities for UK businesses, whilst protecting the UK's competitive advantage.

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[11] UK Government (2020). *The Ten Point Plan for a Green Industrial Revolution*. Available at: https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title
[12] UK Government (2020). *Energy white paper: Powering our net zero future*. Available at: https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
[13] UK Government (2021). *UK Research and Development Roadmap*. Available at: https://www.gov.uk/government/publications/uk-research-and-development-roadmap

Through international leadership the UK will:

Use international collaborations to accelerate the commercialisation of fusion energy

Reduce the cost and risk of UK fusion programmes through collaboration, while protecting UK intellectual property and competitive advantage

Lead the development of international fusion standards and regulation, to ensure safety and maximise the global potential of fusion whilst creating important market opportunities for the UK

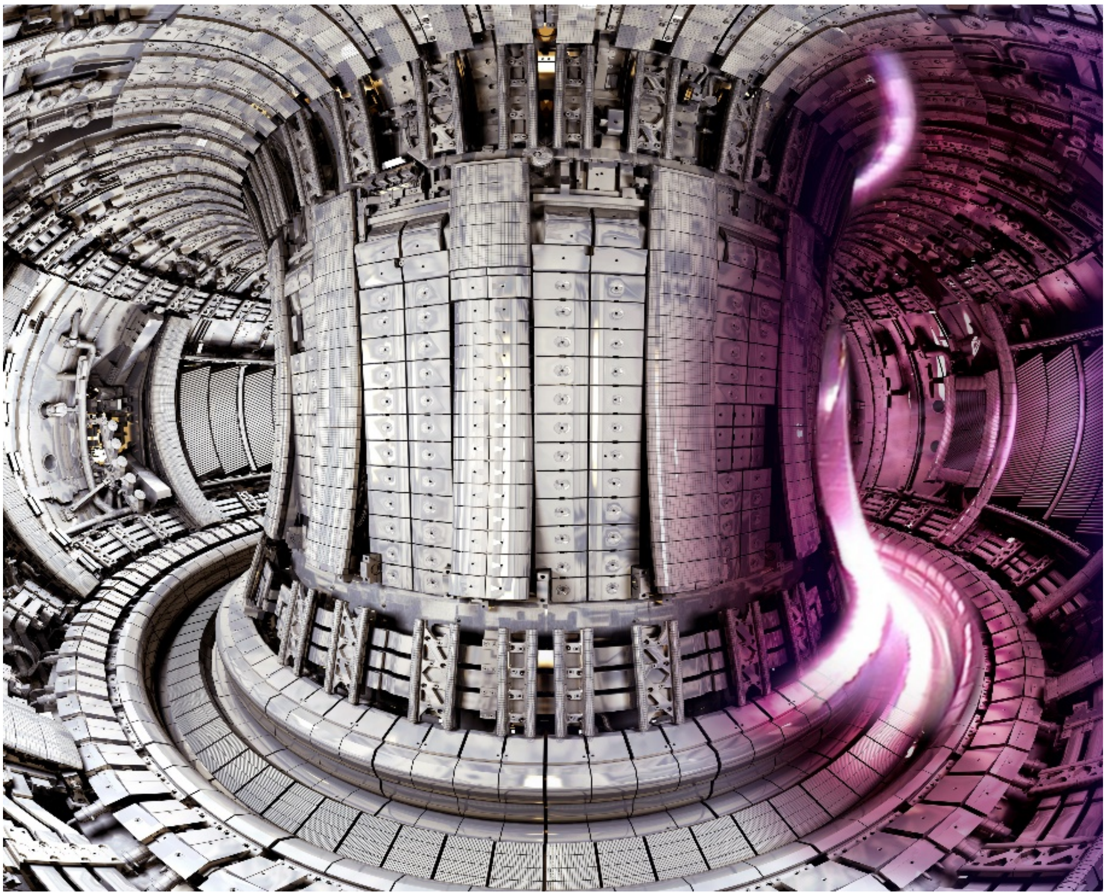

Figure 4 – Internal view of the Joint European Torus[14]

UKAEA hosts the **Joint European Torus (JET)**[15] at the Culham Centre for Fusion Energy (CCFE) in Oxfordshire, UK. JET is the largest and most successful fusion experiment in the world.[16] It is collectively used for fusion research under EUROfusion's[17] management by more than 40 European laboratories. Over 350 scientists and engineers from all over Europe contribute to the JET programme. By hosting JET, the UK has unique experience of operating the world's premier fusion facility.

[14] EUROfusion. Image is available at https://www.euro-fusion.org/media-library/fusion-experiments/ CC BY 4.0
[15] UK Atomic Energy Authority. Further information about JET available at https://ccfe.ukaea.uk/research/joint-european-torus/
[16] More information on JET's successes is available at https://ccfe.ukaea.uk/research/joint-european-torus/
[17] The largest fusion research programme in the world consisting of 28 members.

JET experiments have been fundamental in informing the design and construction of "**ITER"**[18], its international successor, which is being built in France. ITER aims to demonstrate for the first time more power produced from fusion than is required to heat the fuel.

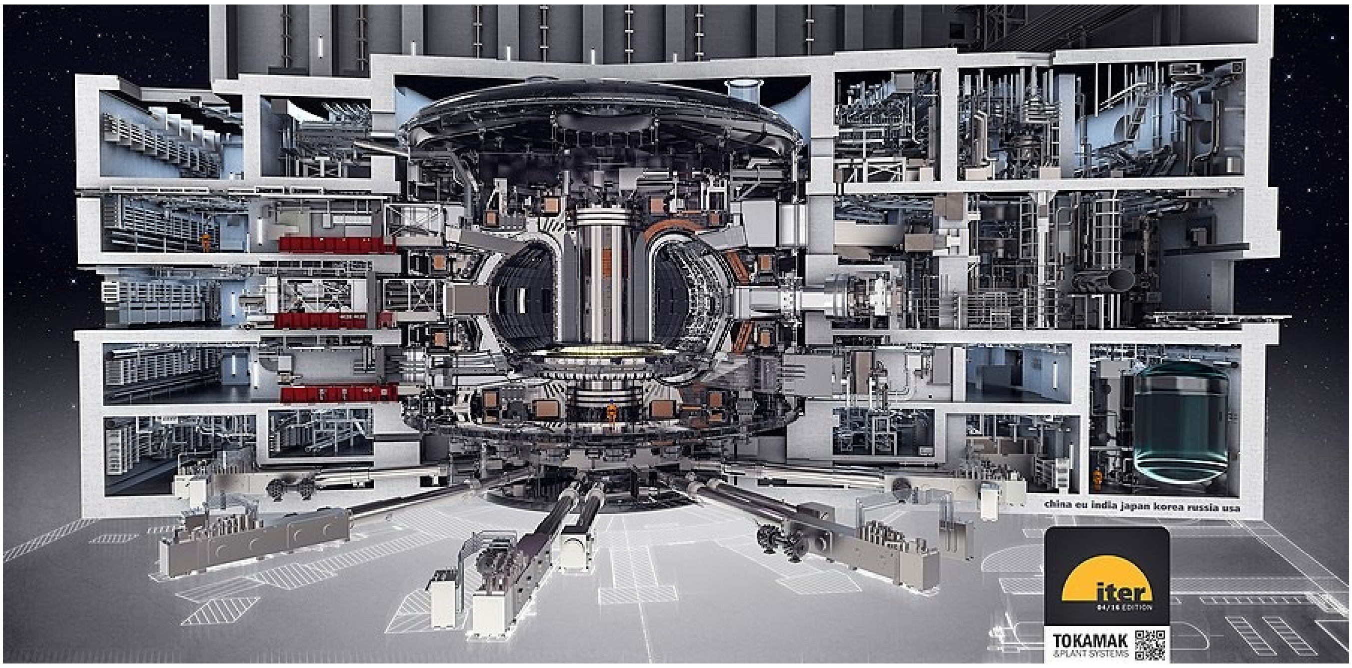

Figure 5 – A illustration of the ITER tokamak and integrated plant systems[19]

Participation in the €20bn project gives the UK access to intellectual property and commercial opportunities which support development of the UK's fusion supply chain and the UK's own domestic fusion programme.

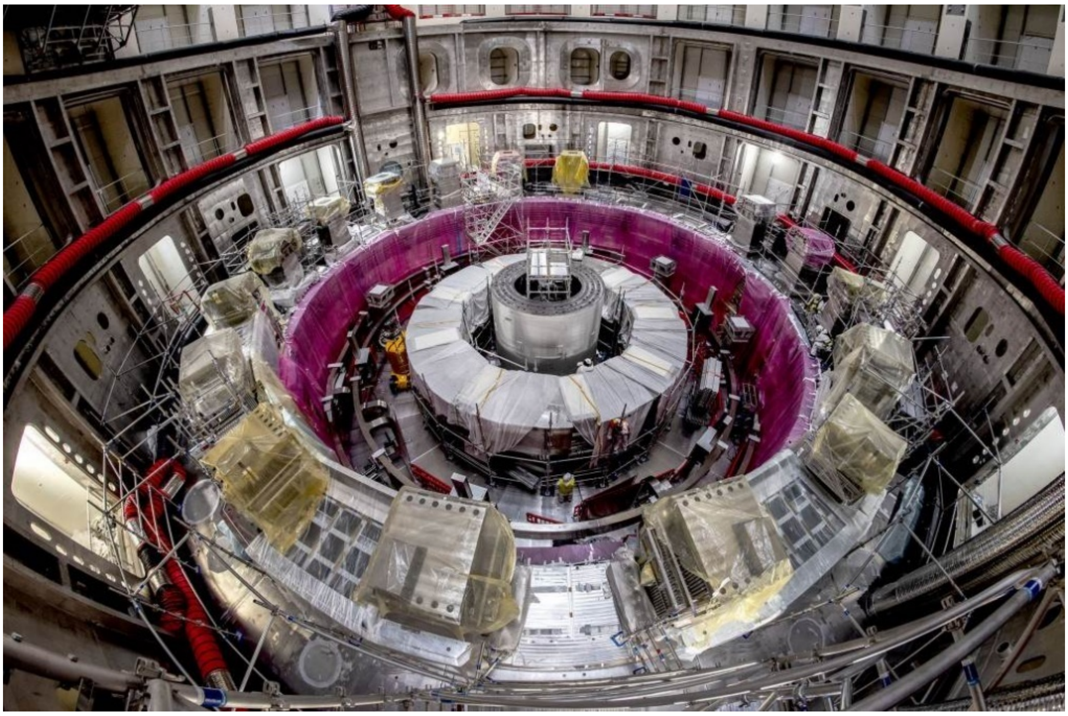

Figure 6 – Inside ITER July 2021[20]

[18] www.iter.org
[19] © ITER
[20] © ITER

In the Trade and Cooperation Agreement (TCA) with the EU agreed at the end of 2020 the UK set out its intention to associate to the **Euratom Research and Training Programme** (Euratom),[21] the EU programme that supports and funds fusion energy research at a European level. The TCA also includes an agreement for UK participation in ITER through membership of Fusion for Energy (F4E). These agreements allow the UK to continue its vital work for ITER, with UK researchers providing essential scientific expertise and UK companies delivering key contracts for ITER's cutting-edge components and technologies.

As well as supporting continued science exploitation of JET and preparation for ITER, the EUROfusion consortium is designing a demonstration fusion power plant called **DEMO** based on the ITER concept. The UK provides many leadership roles and is one of the largest contributors to the DEMO programme. DEMO, whilst a different technological approach to STEP, has many synergies and commonalities in the technical challenges, so the UK's participation is mutually beneficial.

Figure 7 – Illustration of DEMO power plant[22]

As well as working with Euratom and F4E, we are looking at the potential for building other strategic fusion partnerships beyond Europe. It will be necessary to work internationally on both the technical and regulatory challenges that must be overcome to reduce barriers to a thriving global fusion sector.

What's next:

- In Autumn 2021 JET will conclude a programme of experiments using Deuterium-Tritium fuel that will help to pave the way for ITER to achieve net energy.
- The UK will work with countries and organisations around the world to promote international collaboration on fusion.

[21] Euratom Research and Training Programme. Available at https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/euratom-research-and-training-programme_en

[22] ©F4E/EUROfusion

Scientific leadership

The UK has long been a pioneer in fusion science and engineering, with dedicated fusion research facilities since the 1950s.

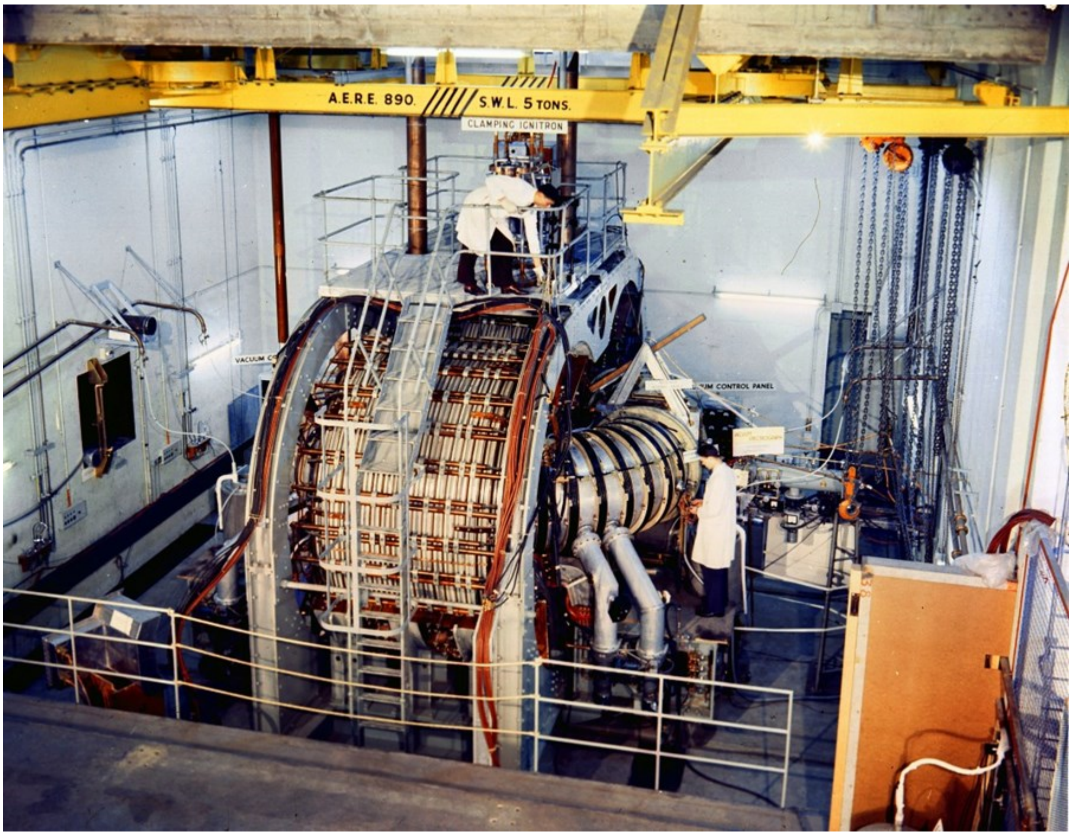

Figure 8 – Image of Zeta project from the 1950s[23] [24]

The UK's leadership in fusion science and engineering needs to be comprehensive across the technical challenges of fusion if we are to lead the world in commercialising fusion energy. Identifying solutions to these challenges and translating them into commercially viable power plant technology is the central scientific mission within this fusion strategy. To do this, we need to continue our innovative and agile R&D programmes, maintain our unique research facilities, and nurture our world-leading fusion scientists, researchers and engineers.

Through scientific leadership the UK will:

Maintain global scientific lead in fusion technologies and facilities

Attract, grow and retain leading fusion talent, including in supporting engineering disciplines

[23] ZETA, short for "Zero Energy Thermonuclear Assembly", was a major experiment in the early history of fusion power research. It was built at the Atomic Energy Research Establishment in the UK in the 1950s. ZETA was larger and more powerful than any fusion machine in the world at that time.
[24] © ITER

UKAEA's **MAST-U (Mega-Amp Spherical Tokamak - Upgrade)**[25] is an innovative type of fusion facility that is designed to investigate the viability of fusion power production at a reduced scale and cost. The original MAST experiment operated from 2000-2013. Its impressive performance led to a major upgrade, which completed in 2020. Based at the Culham Centre for Fusion Energy, MAST-U represents the largest investment in a single scientific experiment in the UK in decades.

In 2021 MAST-U is testing a unique system which minimises exhaust heat from the hot gas of fusion fuels – a key challenge for the first fusion power plants – with early results already demonstrating its effectiveness.

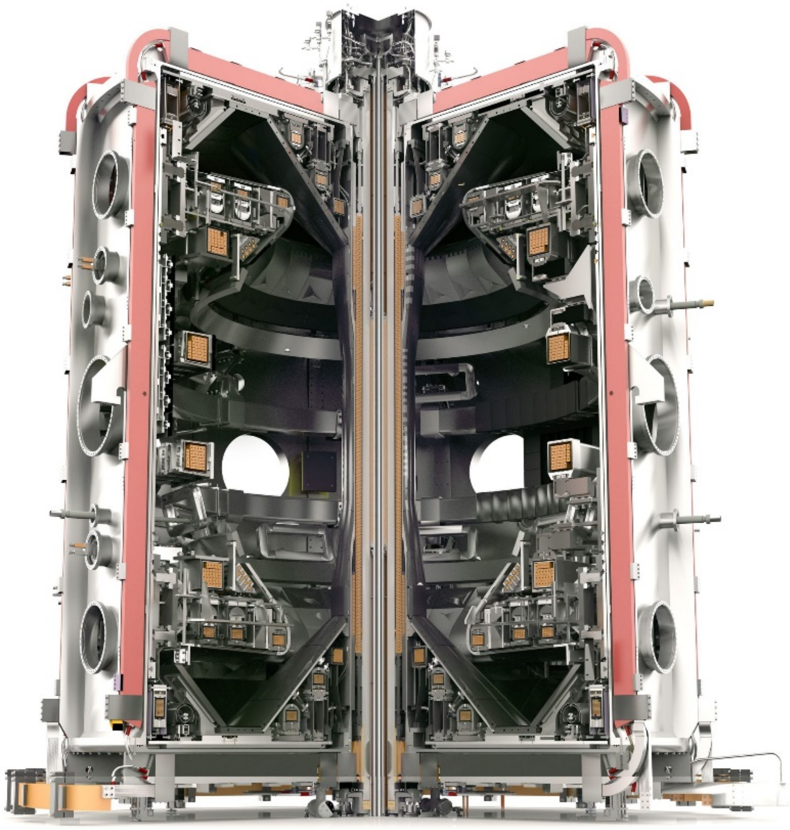

Figure 9 – Illustration of MAST-U[26]

Results from MAST-U will play a key role in the **Spherical Tokamak for Energy Production** (STEP)[27] programme. The STEP Programme will design, develop and build, by 2040, a prototype fusion power plant that puts energy on the grid. STEP will play an important role in demonstrating the commercial viability of fusion by integrating and operating industrial-scale fusion systems in a single, energy-producing facility.

[25] UK Government (2020), First results from UK experiment available at: https://www.gov.uk/government/news/first-results-from-uk-experiment-point-to-a-solution-to-one-of-fusions-hottest-problems
[26] © UKAEA
[27] UKAEA (2020): What is STEP? Available at https://step.ukaea.uk/

The STEP programme complements the work of private fusion companies in the UK by acting as a magnet for global investment, a driver of supply chain innovation and a source of skills and expertise for the growing UK fusion sector.

STEP will not be located in Culham where JET is sited. A formal process is currently underway[28] to inform decisions about a final site for STEP. In this process, in addition to the technical requirements for the facility, the Government will consider the levelling up agenda and the socio-economic opportunities for the local community.

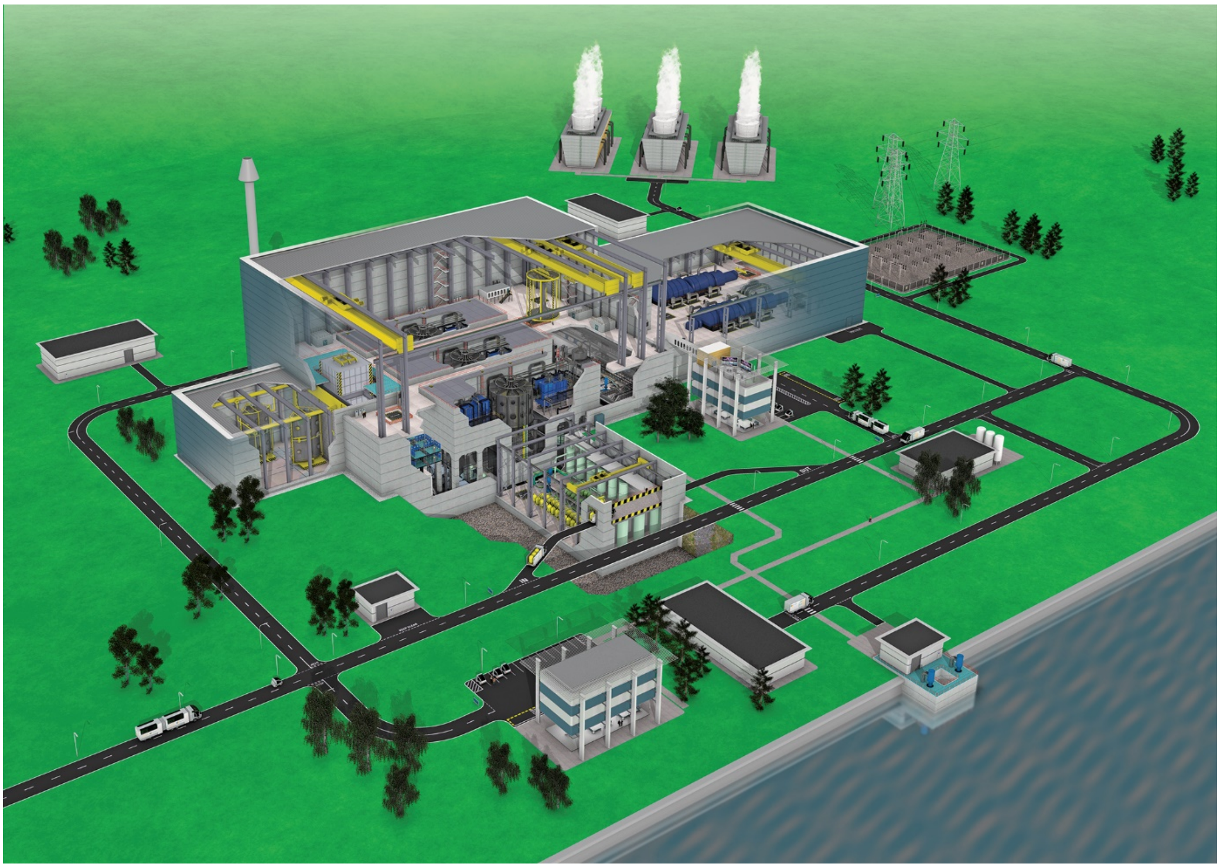

Figure 10 – Illustration of STEP prototype power plant facility[29]

Alongside STEP, UKAEA operates a suite of research facilities that are developing technical solutions to the six main challenges of fusion (based on magnetic confinement). An illustration of these facilities is shown overleaf.

As well as addressing these technical challenges, the UK fusion programme will develop the holistic digital design capabilities to design power plants. UKAEA is also exploring opportunities for repurposing parts of the £Bn-assets needed for JET after operations cease at the end of 2023, as well as undertaking R&D into novel techniques that could result in quicker and more efficient decommissioning of JET and future fusion power plants.

[28] UKAEA (2020), Where will STEP be sited? Available at https://step.ukaea.uk/step-siting/
[29] © UKAEA

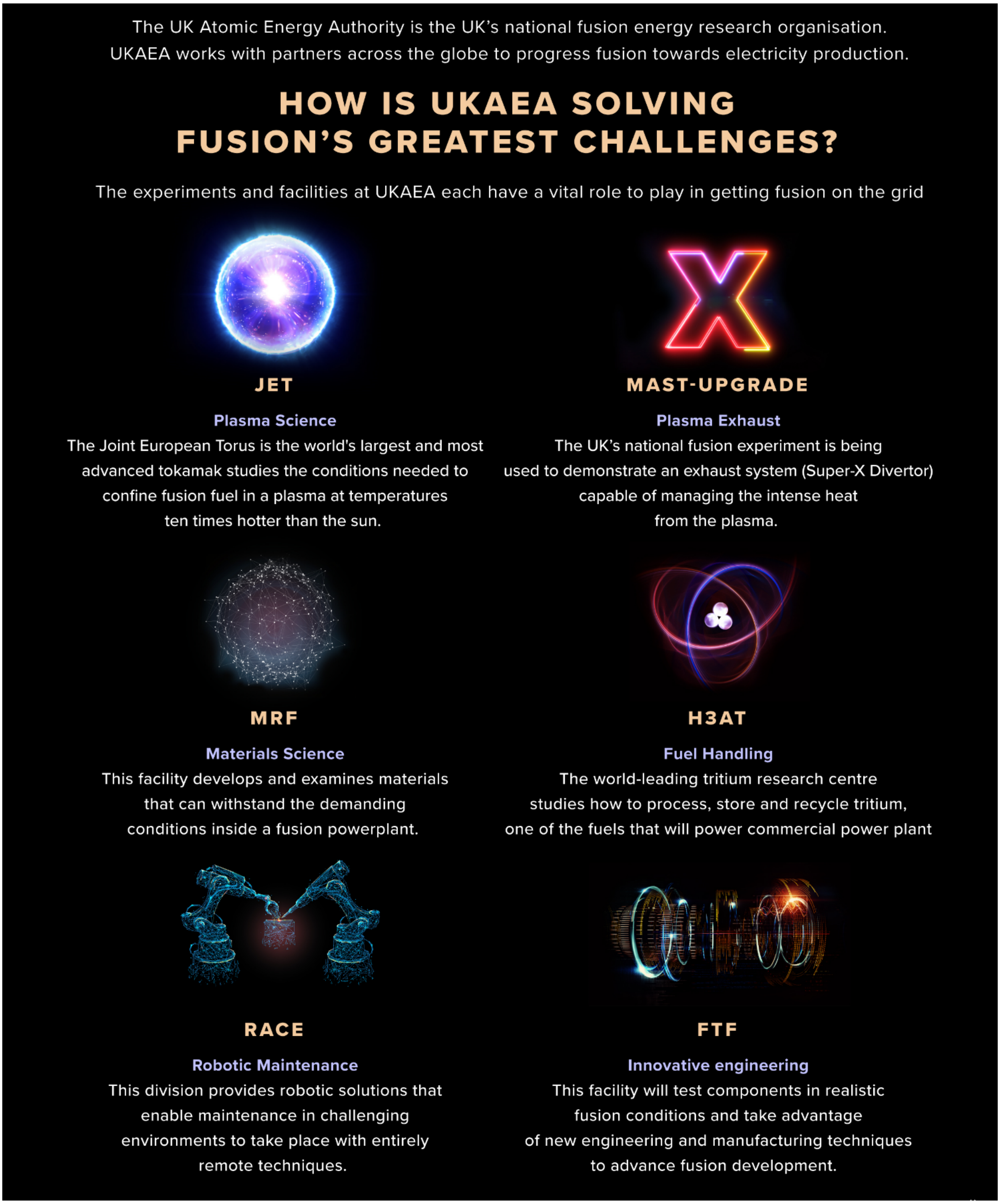

Figure 11 – The six challenges of magnetic confinement fusion and the roles of UK-based facilities and experiments in addressing them[30]

[30] JET – Joint European Torus, operated by UKAEA on behalf of EUROfusion
MAST-U – Mega-Amp Spherical Tokamak-Upgrade
RACE – Remote Applications in Challenging Environments
MRF – Materials Research Facility
H3AT – Hydrogen-3 Advanced Technology
FTF – Fusion Technology Facilities

What's next:

- **MAST-U** will continue its globally unique research programme[31] to inform design choices around future fusion power plants.
- A site for **STEP** will be selected by December 2022 by the Secretary of State for the Department for Business, Energy and Industrial Strategy (BEIS) following an appraisal by UKAEA.
- As part of the **Fusion Technology Facility (FTF)**, the **CHIMERA**[32] machine will become operational in 2022. This will be the only machine in the world able to test components under conditions encountered in large fusion devices.
- UKAEA's **Remote Applications in Challenging Environments (RACE)** facility undertakes research and commercial activities in the field of Robotics and Autonomous Systems. Beginning in 2021, RACE is leading a four-year collaboration between the UK and Japan to develop new robotics and automation techniques for fusion research and nuclear decommissioning.[33]
- UKAEA's **Materials Research Facility (MRF)** enables industrial and academic researchers to analyse the effects of irradiation on materials. In September 2021 the MRF launched a Fusion Materials Roadmap, setting out the pathway of research required to develop the fusion materials and technology necessary for future fusion power plants.[34]
- UKAEA's **Hydrogen-3 Advanced Technology (H3AT)** centre will open in 2023, representing the largest fusion tritium research centre in the world.

Commercial leadership

The Government wants to see a fusion industry in the UK that can export UK-developed fusion technology around the world. The Government has invested in fusion programmes, facilities and infrastructure to boost the capability of the UK supply chain and create new opportunities for fusion companies to locate, collaborate and innovate in the UK. This will help to de-risk commercial investment into UK fusion innovation and accelerate the growth of the sector.

[31] https://ccfe.ukaea.uk/research/mast-upgrade/
[32] https://ccfe.ukaea.uk/fusion-technology/chimera/
[33] https://www.gov.uk/government/news/12m-uk-japan-robotics-deal-for-fusion-energy-and-nuclear-decommissioning-research
[34] https://www.gov.uk/government/news/uk-fusion-materials-roadmap-aims-to-accelerate-progress-in-developing-fusion-power-plants

Through commercial leadership the UK will:

Create a vibrant fusion technology cluster or clusters in the UK

Attract inward investment into fusion and related technologies

Develop the supply chain and skills base to support fusion delivery and equip UK firms to compete successfully in a future global fusion market

As described, the UK's involvement in **ITER** and the construction of **STEP** will galvanise the development of a fusion supply chain in the UK. On top of this, the Government launched the **Fusion Foundations** programme in 2020.[35] This aims to transform UKAEA's Culham fusion campus into a global hub for fusion innovation and enhance Culham's unique fusion research capabilities. This commitment has already resulted in General Fusion[36], a Canadian fusion company, announcing that it would build its own Fusion Demonstration Plant at Culham.[37]

Figure 12 – UKAEA vision of the future Culham Campus

[35] http://www.culham.org.uk/culham_global_fusion_hub/
[36] https://generalfusion.com/
[37] https://www.gov.uk/government/news/general-fusion-to-build-its-fusion-demonstration-plant-at-ukaeas-culham-campus

The Fusion Foundations Programme will also expand UKAEA's award-winning apprenticeships scheme and teaching facilities, increasing opportunities for young people across the UK to gain high-quality engineering skills and qualifications. Combined with ongoing graduate, PhD and post-doctoral training schemes, Fusion Foundations is sowing the seeds of a future fusion workforce. By 2025, 1000 apprentices per year will be training in fusion and related fields in Oxfordshire and beyond. This will benefit both UKAEA and private sector fusion research programmes.

The two largest UK fusion companies, **Tokamak Energy**[38] and **First Light Fusion**,[39] are seeking to accelerate their own fusion technology programmes. Tokamak Energy focuses on magnetic confinement fusion in a spherical tokamak, which is the same technological basis as UKAEA's programmes MAST-U and STEP. First Light Fusion focuses on inertial confinement fusion technology using high velocity projectiles.

Figure 13 – Oxfordshire Advanced Skills apprentices[40]

The UK Atomic Energy Authority (UKAEA) runs the **Oxfordshire Advanced Skills (OAS) Centre** at its Culham Campus, in partnership with the Science and Technology Facilities Council. Since 2019, the expanded OAS Centre trains up to 350 technical apprentices per year for UKAEA and a host of industrial partners, with 80% of apprentices going to local industry. Specialising in areas such as power engineering, AI, robotics and nuclear design, OAS apprentices routinely win local and national awards.

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[38] www.tokamakenergy.co.uk
[39] www.firstlightfusion.com
[40] © UKAEA

Through the Fusion Foundations programme, UKAEA is now creating new OAS centres beyond Culham. UKAEA will also be using OAS to pilot new approaches to attracting and supporting apprentices from underrepresented and/or disadvantaged backgrounds. These initiatives will help to expand skills opportunities across the country.

What's next:

- Supported by the ongoing investment into world-class facilities, UKAEA is welcoming onto its Culham campus global fusion company **General Fusion**. General Fusion will build and operate a new Fusion Demonstration Plant (FDP) at Culham in order to demonstrate their proprietary magnetized target fusion (MTF) technology.
- UKAEA has launched **new collaboration opportunities** centring around specific technical challenges and is exploring how to **increase commercial innovation activity** at the Culham site in future.

The role of the UK Government in delivering our fusion strategy

It is the Government's role to create the right conditions for UKAEA and private fusion companies to enable fusion to flourish in the UK.

Notwithstanding the remaining technical challenges to achieving fusion energy, the Government recognises the need to move quickly if the UK is to commercialise fusion energy at the pace required to help decarbonise global energy generation in the face of rising energy demand. The Government has **enhanced programme governance and policy coordination** on fusion, so that decisions are made in the right way and at sufficient pace.

BEIS' R&D people and culture strategy[41] sets out how the UK will develop the research workforce it needs, ensuring that careers in research and innovation are open to people from all backgrounds, working within environments that nurture and get the best out of them. The Government is specifically looking at how the UK can best **attract the world's top fusion specialists** against increasing international competition.

[41] UK Government (2021). Research and development (R&D) people and culture strategy. Available at https://www.gov.uk/government/publications/research-and-development-rd-people-and-culture-strategy

Figure 14 – Illustration of UKAEA fusion scientists and engineers[42]

It is critical that these programmes deliver good value for money and inform wider science and innovation policymaking. UKAEA is developing new **Monitoring & Evaluation (M&E)** systems for the UK's fusion programmes, with a renewed focus on the socio-economic benefits of these programmes.

A report by London Economics published in 2020[43] on the impact of UK investment in fusion identified a total economic impact to the UK economy of around £1.4bn in relation to £350 million of public investment in UKAEA's fusion research over 10 years, and that this had supported around 36,000 job years over the same period (illustrated in Figure 15 overleaf). This also shows that the impact of fusion research on the supply chain is spread across the country.

[42] © UKAEA

[43] UK Government (2020). Impact of the UK's public investments in UKAEA fusion research. Available at https://www.gov.uk/government/publications/impact-of-the-uks-public-investments-in-ukaea-fusion-research

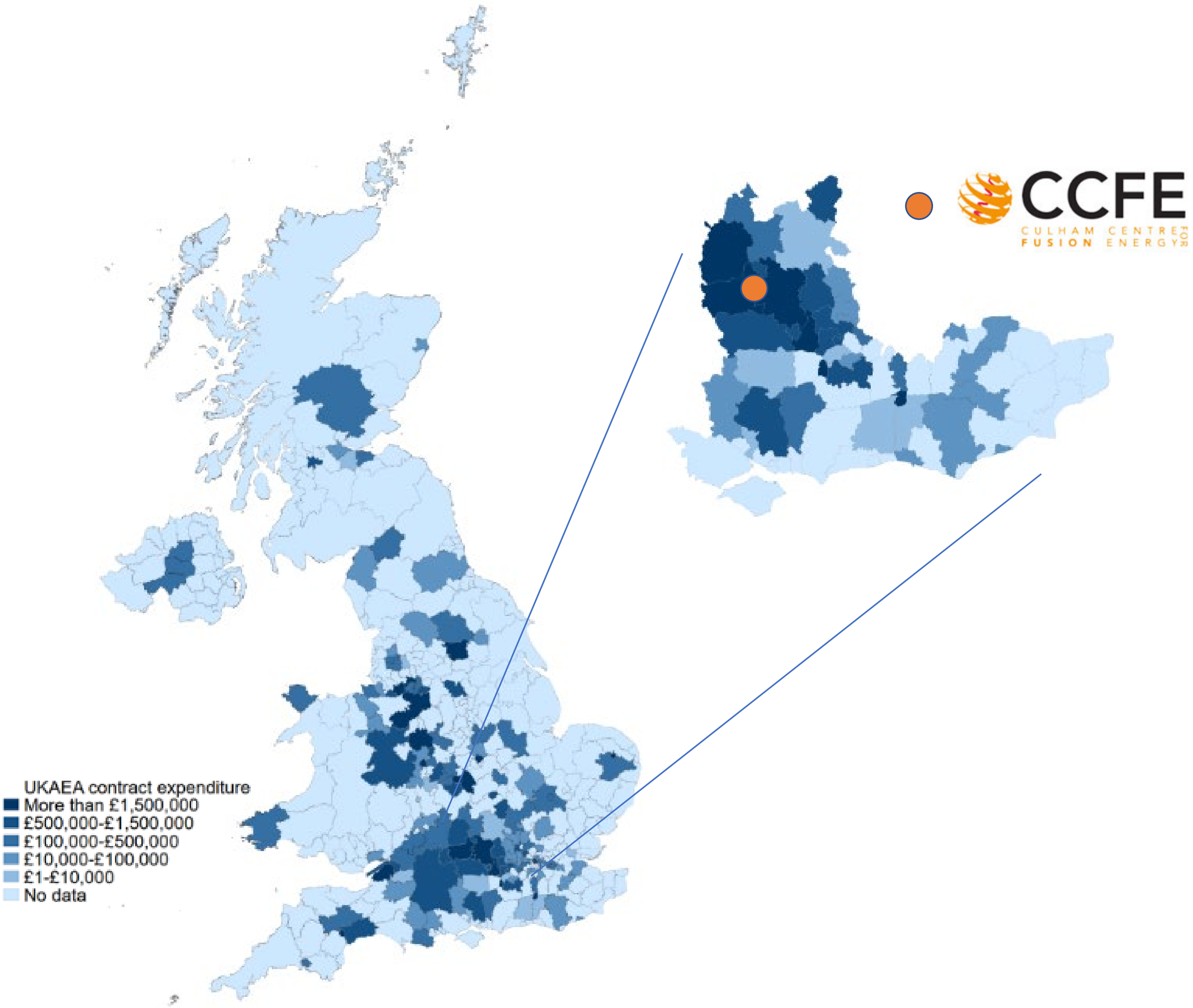

Figure 15 – Distribution of UKAEA contract spending across the UK[44]

Looking ahead, the Government is renewing its **analysis of future market opportunities of fusion** to ensure that the UK's Fusion Strategy is underpinned by robust evidence.

Finally, **proportionate and effective regulation** is a key 'enabler' of the UK's Fusion Strategy. If the UK is to maximise the potential of fusion energy technology both in the UK and around the world, the regulatory framework for fusion needs to enable the safe and rapid deployment of fusion energy power plants, promoting innovation while maintaining human and environmental protections at all times. The Government has published a green paper setting out its proposals on the regulation of fusion energy in the UK and will confirm its plans after a period of consultation on these proposals.

[44] UK Government (2020). The impact of the UK's public investments in UKAEA fusion research. Available at: https://www.gov.uk/government/publications/impact-of-the-uks-public-investments-in-ukaea-fusion-research © London Economics. The enlarged section focuses on the local impact of UKAEA's Culham Centre for Fusion Energy in Oxfordshire.

Conclusion: Towards Fusion Energy

With fusion energy closer than ever, the UK believes that the time is right for decisive and strategic action. This strategy sets out the UK's action plan: collaborating internationally; doubling down on cutting-edge scientific research; and unleashing private sector innovation to achieve the commercialisation of fusion energy.

In the short term, there are important economic benefits to fusion research. The UK Government intends to exploit these to help build back better and level up economic opportunity across the country. However, it is the long term benefits of commercially viable fusion energy that are the real prize. Analysis suggests that the annual fusion energy market (in present values) in 2100 could be worth around £52bn, rising to £167bn if the capital cost of fusion power plants could be reduced by 30%.[45] The wider benefits to the world of a new low carbon, safe and continuous power source are incalculable but significant.

The challenges of fusion energy remain considerable. As with any technically demanding goal, there will be setbacks. However, advances in fusion science and engineering capabilities mean that there is increasing confidence in the fusion sector's ability to overcome these. That confidence, resolve and clarity of purpose must be matched by governments around the world if we are to meet the challenges that climate change poses. This strategy demonstrates the UK's commitment to meeting those challenges head on.

The realisation of fusion energy will require continued collaboration: with other nations and international organisations; with academia and technical experts; and with businesses and industry groups all around the world. So, while this paper sets out the UK's national strategy on fusion, the UK is ready to engage with potential collaborators, from national governments to individual experts in fusion technology, to help deliver a technology that could change the face of global energy production and provide a genuinely long term solution to climate change.

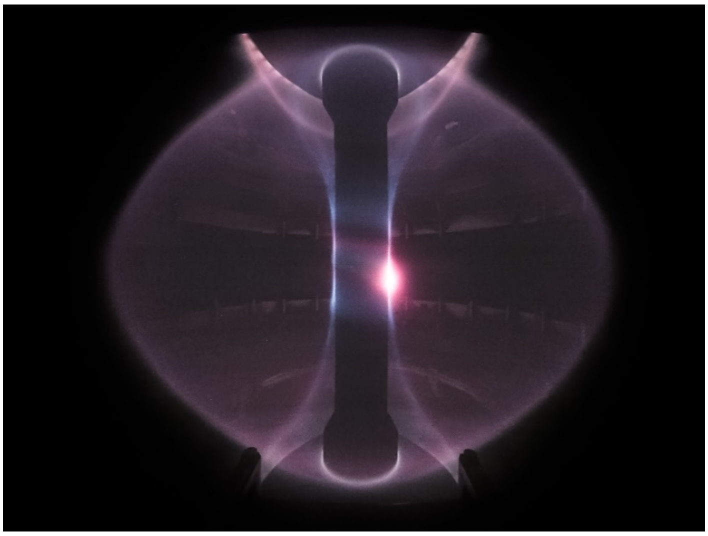

Figure 16 – Plasma in MAST, the UK's pioneering spherical tokamak[46]

[45] Based on findings from Cabal et al. (2017, 2016) and current electricity wholesale price. See exploration of fusion power penetration …. Cabal et al, 2016 and https://www.businesselectricityprices.org.uk/retail-versus-wholesale-prices/.
[46] © UKAEA

List of Figures

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