The Fusion Task Force aims to convene, align, and engage private sector companies in breaking down these strategic barriers to establish the first fusion energy projects in the coming decades.

Sustainable Markets Initiative

Find out more
www.sustainable-markets.org

Link to digital copy

Main contributors:

energy institute

UK Atomic Energy Authority

Fusion Task Force | Sustainable Markets Initiative

e: info@sustainable-markets.org

CPS24.445-SMI

Sustainable Markets Initiative

Fusion Energy 101

A game-changer for future energy supply

Main contributors:

energy institute

UK Atomic Energy Authority

Fusion can help meet the world's rapidly growing demand for energy as a safe, low-carbon source of base load energy supply.

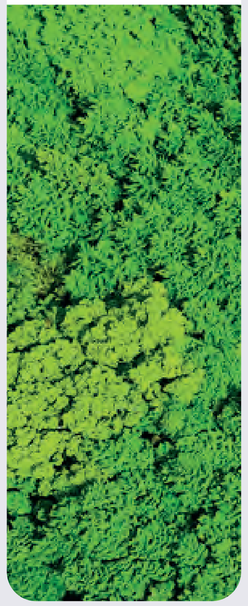
Why do we need fusion energy?

- Fusion could be transformative for energy security and promises to support the fight against climate change.
- The low carbon energy created from fusion will be used to generate electricity in the same way as existing power stations.
- Fusion has the potential to provide 'baseload' power, complementing renewable and other low carbon energy sources as a share of many countries' energy portfolios.

Benefits of fusion

Low carbon

Fusion energy is carbon-free at the point of generation.

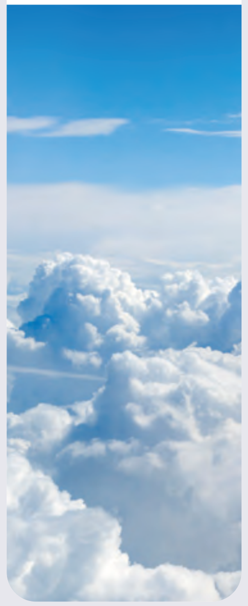


Lower hazard

A chain reaction cannot occur, and the waste produced will be shorter lived, lower level than in fission.

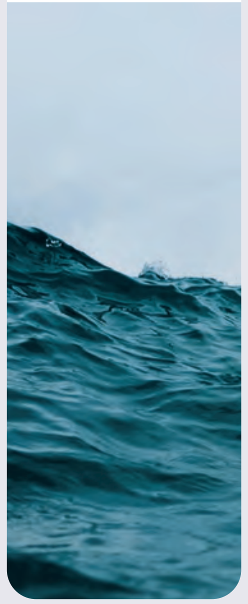
Continuous

Fusion energy is continuously deployable, as it does not depend on external factors such as wind or sun.



Sustainable

Fusion fuel is potentially abundant in our seas and the Earth's crust.

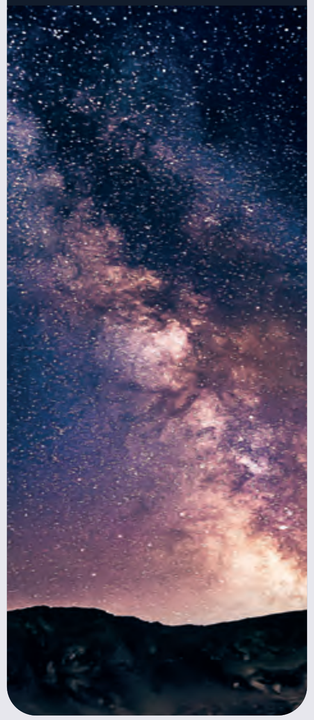


High fuel efficiency

Fusion produces more energy per gram of fuel than any other process that could be achieved on Earth.

What is fusion?

Fusion takes place at the heart of the stars and provides the power that drives the universe.



How does it work?

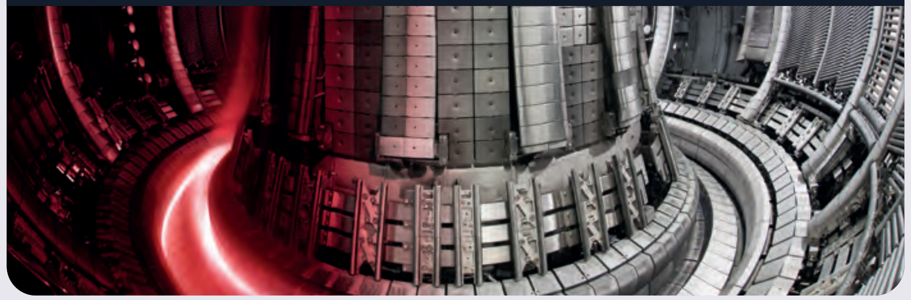
Fusion energy can be thought of as the opposite of nuclear fission – combining lighter atoms rather than splitting heavier ones.

When two forms of hydrogen are heated at extreme temperatures (10 times hotter than the core of the sun) they form a plasma and can fuse together and release energy. When this happens, helium is produced, and huge amounts of carbon-free energy is released.

There is more than one way of achieving this. All require heat, pressure, or both.

Keeping a plasma well confined and stable enough to sustain fusion is hard. If the plasma cools, fusion will instantly cease. This is one reason why fusion is inherently safer than fission.

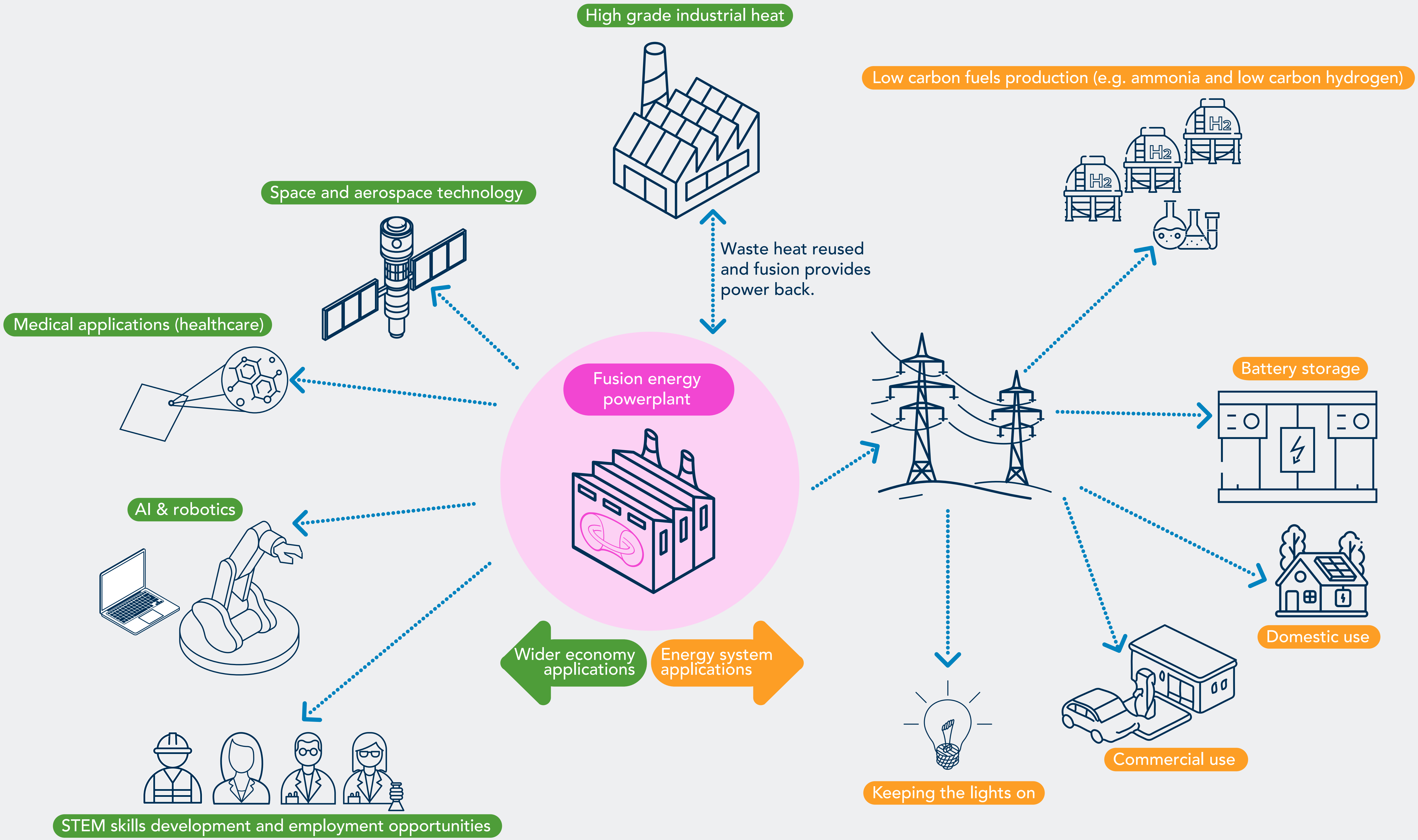
The UKAEA, for example holds this hot plasma using strong magnets in a ring-shaped machine called a 'tokamak'.



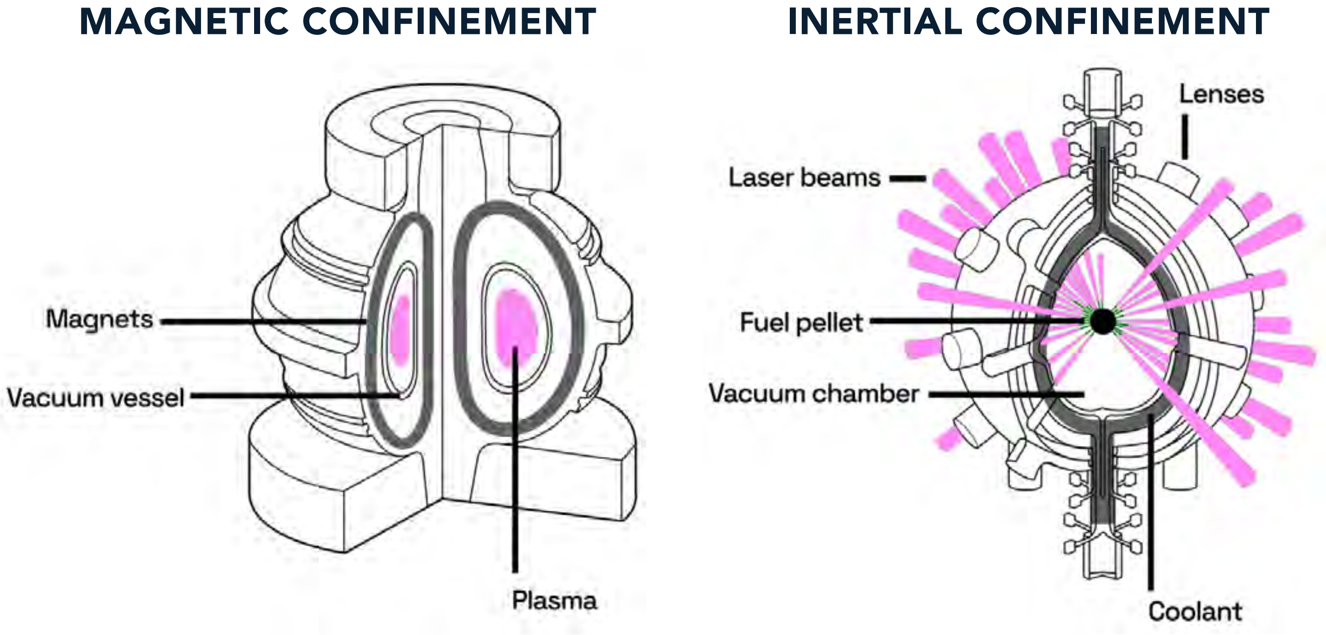
Fusion energy is safe

- Fusion energy production is not based on a chain reaction, meaning there is no risk of a 'runaway' chain reaction that could lead to a melt down (a common concern with fission).
- Fusion produces significantly less radioactive waste than fission, and the waste it does generate has a much shorter half-life.

Potential applications of fusion energy



Types of approaches



Fusion energy generation has several proposed approaches, each with its own methods and technologies. Some key types are:

Magnetic Confinement Fusion (MCF)

In this approach, extreme pressure and heat strip electrons from atomic nuclei, creating a plasma of charged ions. Powerful external magnetic fields are used to confine and control the very hot plasma, preventing it from touching the walls of the machine. The most common approach is the tokamak, which uses a combination of toroidal and poloidal magnetic fields to confine the plasma in a ring-shaped chamber. Another approach is the stellarator, which uses twisted magnetic fields to achieve similar confinement.

Inertial Confinement Fusion (ICF)

This approach to fusion relies on achieving extremely high pressures rather than confining the fuel for extended periods. It is primarily distinguished by how energy is delivered to compress and heat fusion fuel pellets. One method requires a millimetre sized fuel pellet to implode through a rapid delivery of energy. The main existing method to inertial fusion uses large lasers as the energy input to drive the reaction. Facilities like the National Ignition Facility (NIF) in the US are pioneering this approach.

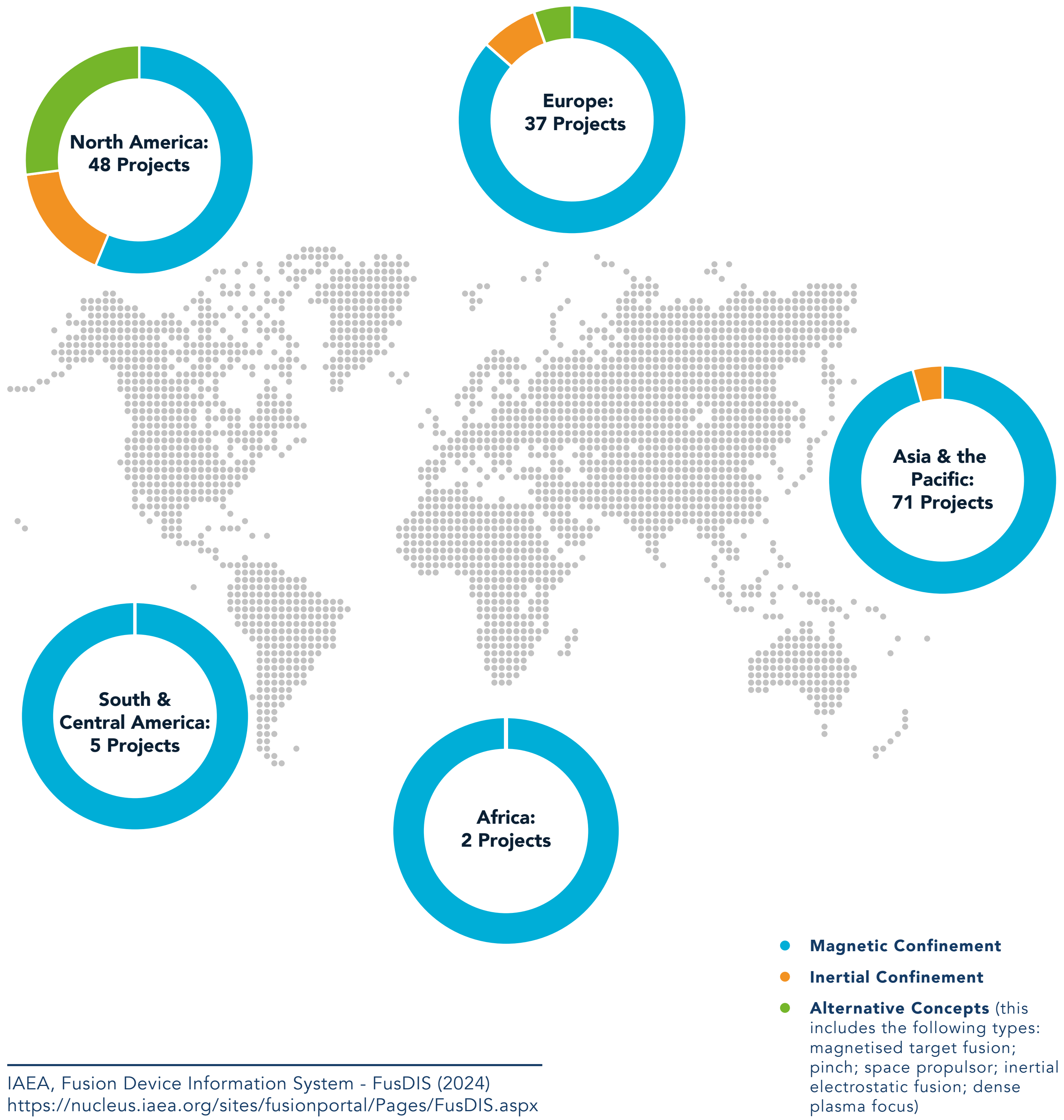
Alternative Methods

Various other methods are also being explored, including (but not limited to):

- Magnetised Target Fusion (a hybrid between inertial confinement and magnetic confinement fusion)
- Inertial Electrostatic Fusion
- Magnetic or Electric pinches

Global Distribution of Fusion Projects

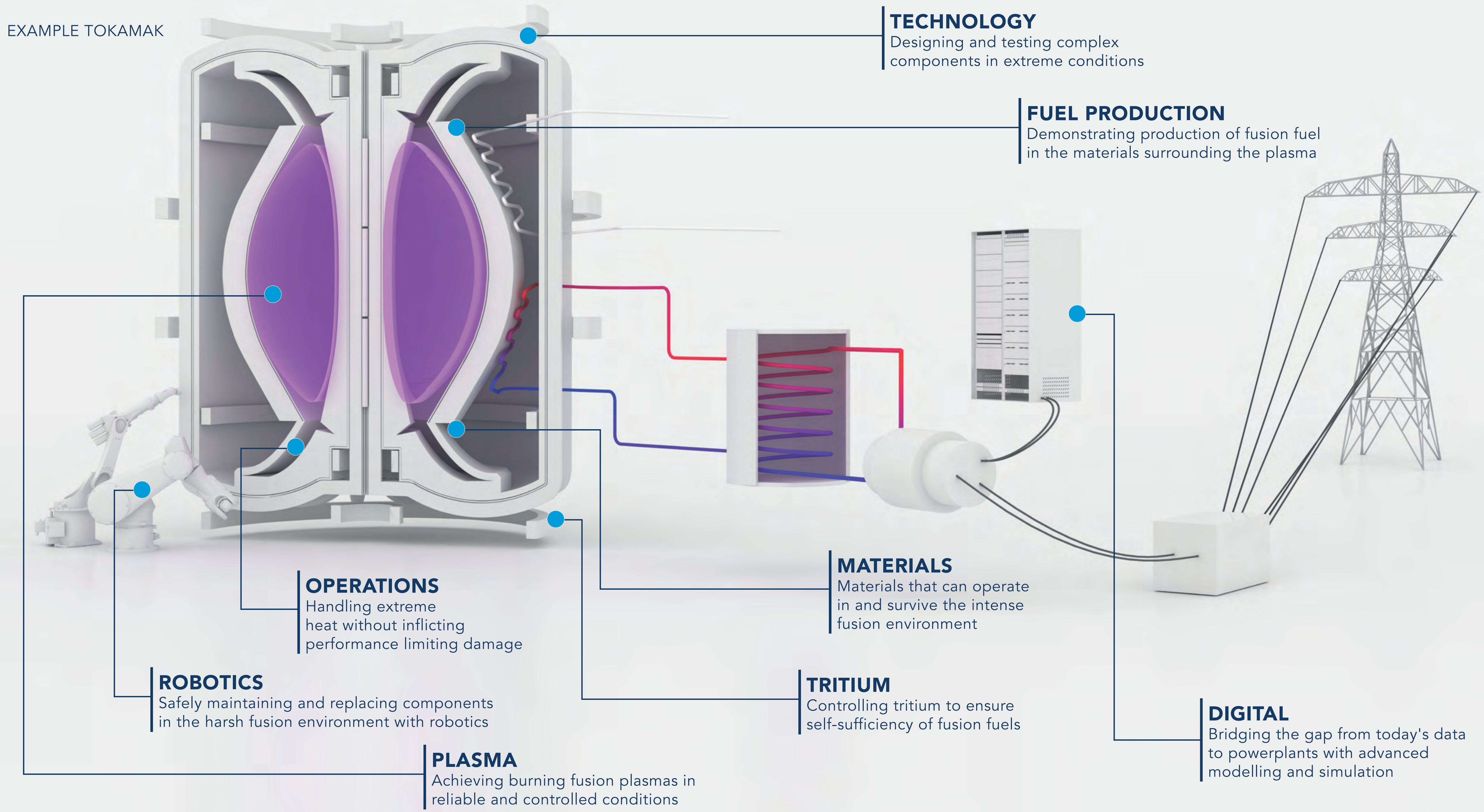
In 2024, there were 163 fusion machines operating, under construction or being planned (up from 136 in 2023), 142 of which are experimental designs. While tokamaks remained the prevalent approach in 2024, the fusion energy sector has experienced significant diversification in recent years with significant growth in alternative machine designs including inertial confinement and stellarators. This diversified approach could significantly enhance the potential for breakthroughs.



IAEA, Fusion Device Information System - FusDIS (2024)
https://nucleus.iaea.org/sites/fusionportal/Pages/FusDIS.aspx

Technical challenges and opportunities

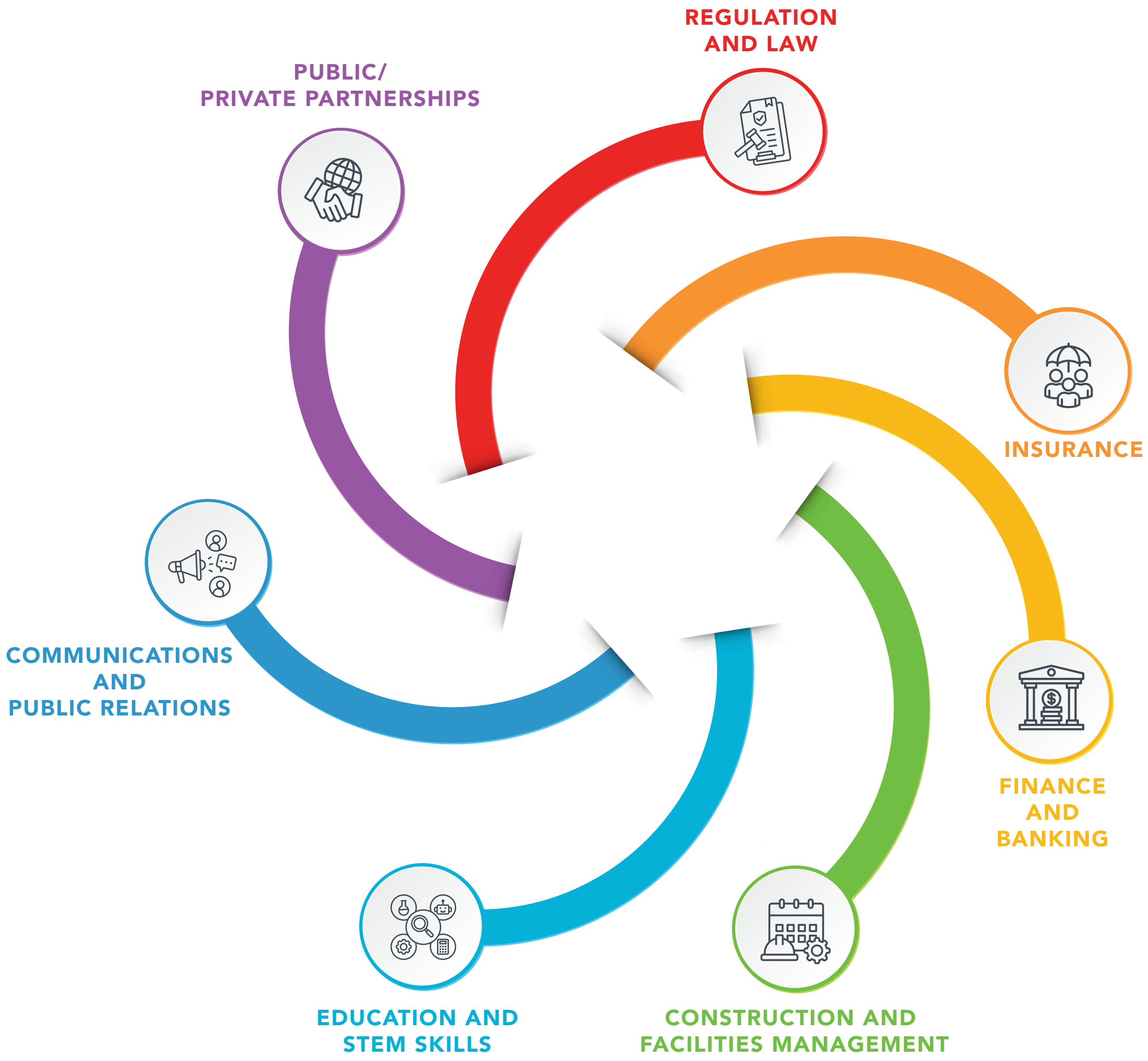
Scientists and engineers from around the world are working collaboratively to solve challenges in materials science, robotics, data and digital, generating new knowledge and innovations. Over 3,500 scientific articles have been published by teams across 15 countries*.



* World Fusion Outlook 2024, International Atomic Energy Agency

Business challenges and opportunities

To date $7.1 billion of private sector investment has been made into fusion energy. At least 45 companies are in operation, targeting markets as diverse as space propulsion, hydrogen production, industrial heat and electricity generation, mostly by the mid-2030s*. But commercialisation of fusion energy requires more than just money to succeed, providing opportunities for the wider fusion ecosystem.



* Global Fusion Industry in 2024, Fusion Industry Association.

How you can help

1

To learn more about the Fusion Task Force

Visit
sustainable-markets.org/taskforces/fusion-task-force

Email
info@sustainable-markets.org

2

Join the Energy Institute's Technical + Innovation programme

Visit
energyinst.org/technical/overview

Email
technical@energyinst.org

3

Organise a viewing of the fusion films, *Star Makers* and *Star Makers 2*.

Star Makers is available on various streaming platforms including Prime Video. *Star Makers 2* will be released in 2025.

For more information about the films please contact
communications@ukaea.uk