Leopoldina
Nationale Akademie
der Wissenschaften

acatech
DEUTSCHE AKADEMIE DER
TECHNIKWISSENSCHAFTEN

UNION
DER DEUTSCHEN AKADEMIEN
DER WISSENSCHAFTEN

Fact sheet / November 2024

Can Nuclear Fusion Contribute to a Net-Zero Energy Supply?

What is nuclear fusion?

In nuclear fusion, **light atomic nuclei merge** to form new elements with a higher number of particles in their nucleus. For example, two hydrogen nuclei can fuse together to form a helium nucleus. Depending on which chemical elements are used, the fusion reaction releases energy.

The aim of fusion research is to harness this process that takes place continuously in the Sun in order to produce electricity here on Earth. But doing so poses major technological challenges, since **very high temperatures and in some cases high pressures are needed to achieve a nuclear fusion reaction**.

What's so interesting about nuclear fusion?

The goal of nuclear fusion research is a climate-friendly, **continuously available energy source** that requires less space and is powered by fuels that can be produced on site.

There have been high hopes that we are close to a breakthrough enabling a new, climate-friendly means of energy production ever since late 2022, when researchers at the National Ignition Facility in California achieved the first nuclear fusion reaction in the lab to produce more energy than the energy input into the plasma chamber to start the reaction.

We know the physics, but several practical challenges remain

The **physical processes** underlying nuclear fusion are understood. But solutions to various **practical challenges** must be found before a fully operational power plant can be built. These include:

- the supply of the **tritium fuel**
- a better **energy balance** – there is still a big discrepancy between the energy input and output
- **materials** capable of withstanding the high temperatures and neutron bombardment inside the reactor over long periods
- high-power **lasers** and efficient **high field magnetic coils**

First power plants unlikely before 2045

Nuclear fusion research is still **at the basic or in some cases applied research stage**. As yet, there is no definitive power plant design for either of the two fusion concepts (magnetic confinement fusion and inertial confinement fusion).

Given the amount of development work that still needs to be done, the **first fusion power plant is unlikely to be built until 2045 at the earliest**, and there is no guarantee of successful implementation at all. To make it happen, all the unresolved research and development questions will need to be addressed intensively and in parallel.

Keep researching nuclear fusion, but not at the expense of the energy transition

If successfully implemented, nuclear fusion could contribute to a climate-friendly energy supply in the longer term. However, it is unlikely to help Germany and Europe meet their **2045/50 climate targets**.

While there is good reason to continue researching nuclear fusion, this should not be at the expense of efforts to develop and build a climate-friendly energy system centred on renewable energy.