

Pioneering HTS magnet technology

Our high temperature superconducting (HTS) magnets are an essential part of delivering clean, sustainable, and globally available fusion energy.

Magnetic fields are used in the tokamak to confine and control the 'plasma' – the fusion fuel – allowing it to be heated to a temperature above 100 million degrees Celsius. This is the threshold required for fusion to be a commercially viable energy source. Strong magnets in spherical tokamaks enable more compact confinement, increasing plasma density and power.

Strong magnetic fields are generated by passing large electrical currents around arrays of electromagnet coils that circle the plasma. The magnets are wound from ground-breaking high temperature superconducting (HTS) tapes.

Revolutionary tapes

High Temperature Superconducting (HTS) tapes are innovative high field magnet conductors that make compact fusion possible.

Superconductivity is an ability held by a select group of materials capable of carrying electrical currents with zero electrical resistance. These make for ideal electro-magnet conductors, since they can carry the magnet current without overheating.

For most practical superconductors, this amazing property only works at very low temperatures, around -269°C , with limited magnetic fields. The latest generation 'high temperature' superconducting (HTS) tapes exceed these limitations, operating at elevated temperatures with extremely high magnetic fields.

The fusion magnets still need to be cooled to around -250°C , but this is over five times more energy-efficient than the low temperature predecessors.

HTS tapes are multi-layered conductors made mostly of strong and conductive metals, but with a crucial internal coating of 'rare earth barium copper oxide' (REBCO) superconducting material. The tapes are typically 12mm wide and less than 0.1 mm thick, containing just a 'human hair' of REBCO deposited as a thin coating.

Manufactured commercially by worldwide suppliers in lengths up to 1 km, these incredible conductors can carry 1000s of amperes of electrical current under fusion operational conditions.

When wound into coils, HTS tapes can generate much higher magnetic fields than conventional superconducting magnets, while taking up far less space and requiring far less cooling power.

Pioneering HTS technology

Tokamak Energy has been a pioneer in recognising the opportunity to apply and develop high temperature superconducting (HTS) technology for fusion energy.

HTS magnets enable the construction and operations of spherical tokamaks – a game changer for getting clean, limitless fusion energy on the grid faster.

In February 2023, the company completed building a world-first set of magnet coils using 38 kilometres of HTS tape, which carries currents with zero electrical resistance and requires five times less cooling power than traditional materials.

- 2019: First conduction-cooled all REBCO magnet to exceed 22 Tesla at 20 Kelvin
- 2020: 26.2T HTS magnet tested at CERN – 0.2T off the world record
- 2022: Built world-first set of HTS magnet coils for Demo4 to be assembled and tested in power plant-relevant scenarios
- 2023: Gamma radiation testing at U.S. Department of Energy's Sandia Laboratories to prove HTS magnet lifetime durability
- 2024: Demo4 spherical tokamak magnet device to start operations

Demo4 magnet system

Our ground-breaking Demo4 magnet system is under construction in a purpose-built test facility. It's a complete balanced set of HTS magnets shaped in a tokamak configuration, allowing us to create substantial magnetic forces and test them in fusion power plant-relevant scenarios for the first time.

Demo4 will comprise 14 toroidal field (TF) limbs – which are like segments of an orange – and a pair of poloidal field coils above and below, forming a cage-shaped structure comprised of 44 individual HTS coils. The system will operate in a vacuum at an extremely low temperature of 20 Kelvin. It will have a magnetic field strength of 18 Tesla, nearly a million times stronger than the Earth's magnetic field.

The system assembly will complete and testing begin in 2024. The learnings from Demo4 will push forward our understanding of the technology required to deliver clean, secure and affordable fusion power in the 2030s.

