Realization of a dynamic society in harmony with the global environment and free from resource constraints, through diverse applications of fusion energy, by 2050.

Fundamental Superconducting Technology to Realize Various Innovative Fusion Reactor Concepts

Project manager

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Summary of the project

"The disruptive innovation of high-field superconducting magnets using high-temperature superconductor will contribute to the compact tokamak fusion reactor, the development of other reactor types, and social implementation in other fields."

By establishing mass production technology for high-performance, high-quality high-temperature superconducting (HTS) wires, we will contribute to supply chain strategy and will grasp the winning strategy of fusion energy with liquid helium-free HTS magnet technology.

By demonstrating a 40-Tesla-class ultra-high magnetic field coil using the HTS wire for the first time in the world, and by developing coil technology that is highly resistant to enormous electromagnetic forces and neutron irradiation, we will open up new possibilities for compact tokamak fusion reactor and new fusion systems.

Through collaboration with liquid hydrogen technology, we aim to realize carbon-free power generation and advanced energy utilization free from resource constraints by the social implementation of liquid helium-free compact fusion reactors, as well as the spread of superconducting applications in fields other than fusion energy, such as medical application, biotechnology, and mobility.

By promoting R&D from superconducting wires to reactor development together with companies, we will establish the advantage of Japan industries by enabling Japan companies to boost technological level, build supply chains, and develop and acquire highly specialized human resources.

Milestone by year 2034

[High-performance REBCO wire mass production technology]

We will establish mass production technology for high-quality rare-earth based HTS (REBCO) wire with high uniformity and realize an advantage in the supply chain.

[Coil design and manufacturing technology]

We will demonstrate technological development for an ultra-high magnetic field coil of 40-Tesla-class magnetic field generation with meter-class outer shape conductor using the HTS wire.

We will establish fabrication and design technology for a real-scall conductors and coils to make it possible for huge electromagnetic force tolerance, neutron irradiation resistance and quench protection.

Milestone by year 2029

[High-performance REBCO wire mass production technology]

We will establish high-performance wire mass production technology using AI-based process informatics.

* We will demonstrate mass production technology for REBCO wires (liquid hydrogen temperature (-253°C) and 20 Tesla conditions) that can be expected to the level to construct one small fusion reactor.
* Technology that can forecast the wire cost about the same as that of current metallic superconducting wires.
* Demonstration of digital factory technology using AI.

[Ultra-high magnetic field magnet]

Establishment of elemental technologies for manufacturing ultra-high magnetic field coils

* Prototype of inorganic insulating coil resistant to neutron irradiation.
* Demonstration of a small-scale ultra-high magnetic field coil of 40 Tesla/300 mm outer diameter using REBCO wires.

[Coil design and manufacturing techniques]

We will demonstrate the design technology of REBCO conductors and coils.

* Fabrication of inorganic insulation, insulation evaluation and verification.
* Mechanical property testing and verification of structural materials.
* Demonstration of quench protection technology.

Project structure