Professors Anne White (left) and Dennis Whyte are co-directors of the MIT Fusion and Magnet Research Center.

Photos: Bryce Vickmark (White) and Susan Young (Whyte).

3 Questions: Why fusion research is needed to help the world reduce carbon emissions

Professors Dennis Whyte and Anne White discuss the MIT Energy Initiative's vision for transforming the energy system with a fusion future in mind.

Kathryn M. O'Neill | MIT Energy Initiative
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Advancing research critical to addressing climate change is a key part of the mission of the MIT Energy Initiative (MITEI). Accordingly, MITEI is continuing to grow its eight Low-Carbon Energy Centers, which facilitate interdisciplinary collaboration among MIT researchers, industry, and government on challenges related to mitigating climate change. Here, co-directors of the center focused on fusion and magnet research — Hitachi America Professor of Engineering Dennis G. Whyte and Cecil and Ida Green Associate Professor in Nuclear Engineering Anne White — answer some important questions about MITEI's vision for transforming the energy system.

Q: Why is fusion research needed to help the world reach its goal of reducing carbon emissions?

A: It's hard to imagine a more appealing energy source than fusion, which powers the sun and all the other stars by combining light elements into heavier ones. Fusion energy is carbon free, fundamentally safe, can operate 24/7, produces little waste, and makes few demands on land, water, and other resources. That's why fusion research has enormous potential for catapulting the country — and the world — into a low-carbon future.

- Anne White
- Dennis Whyte
- Low-Carbon Energy Centers
- *Energy Futures* magazine
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- Department of Nuclear Science and Engineering
- School of Engineering

Q: What are the major challenges to tapping fusion's potential, and how will the new Fusion and Magnet Research Center address them?

A: Harnessing fusion power is extremely difficult because it requires the creation and control of extremely hot, charged gases (plasmas) at temperatures above 100 million degrees and confining them within a bottle made of magnetic fields. The industrial maturity of high-temperature superconductors, however, has provided the opportunity for a game-changing breakthrough. Experiments with a high-field copper device at MIT already achieve the temperatures, pressures, and other conditions necessary for practical fusion reactions on a daily basis.

The vision for the Fusion and Magnet Research Center is also to demonstrate the promise of fusion energy sufficiently to place fusion firmly in the national energy plans of the United States. To reach this goal, the center will focus on a mission to design, build, and operate a fusion device called SPARC (which stands for Small, Privately-funded, Affordable, Robust, and Compact) that will carry out the world's first demonstration of net energy from a fusion experiment — making SPARC the first fusion device to make more power than it consumes.

Beyond the operation of the world's first net-power-producing fusion experiment, the center's ultimate goal is to incubate a multi-trillion-dollar, low-carbon fusion industry — something that does not currently exist. To that end, the center will work explicitly with industrial partners toward the development of a high-field pilot plant, which could provide significant net electrical power to the grid.

Q: What research pathway will the Fusion and Magnet Research Center take to accomplish its goals?

A: The center's 3- to 4-year timeline for the initial phase of fusion research and development builds on MIT's extraordinary record of breakthroughs in plasma physics, nuclear science and engineering, magnet technology, instrumentation, materials, reactor design, and many other fields.

High-temperature, high-field superconductors are the breakthrough technology that will make it possible to develop smaller, cheaper magnetic confinement fusion devices. MIT is uniquely positioned to move this area of research forward: The Institute has a long track record of producing record-setting magnets and boasts one of the world's leading groups dedicated to advancing superconducting and conventional magnet technology for large-scale systems.

The next step on the fusion path will involve developing an engineering design for SPARC, with detailed analysis of its mechanics, neutronics, and thermal hydraulics. Safety, regulatory, and siting issues will be addressed along with cost estimates for construction and operation. In parallel, concepts for a fusion electricity pilot plant, the step beyond SPARC, will continue to be developed and improved.

The center is also dedicated to identifying and developing other uses for the new superconductor magnet technology in the energy sector. It's extremely exciting that this breakthrough magnet technology can be developed and applied to near-term improvements in electricity generation, regulation, and storage, while synergistically supporting the ultimate goal of providing energy from fusion.


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New record for fusion


Anne White: A passion for plasma


Dennis Whyte named head of Department of Nuclear Science and Engineering

At the same time, the center will continue its strong collaborations with national and international partners in fusion, plasma science, and magnet science. The center's faculty, scientists, and students participate in a broad range of projects around the world aimed at acquiring a deep understanding of the physics behind controlled fusion and creating validated, predictive models to aid in the development of fusion pilot plants.

Throughout this process, the center will endeavor to become a hub for fusion and magnets — bringing together leading experts in fusion science and technology and key stakeholders to identify the real-world technological and engineering needs that must be addressed to propel fusion into position as a major contributor of carbon-free energy.

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