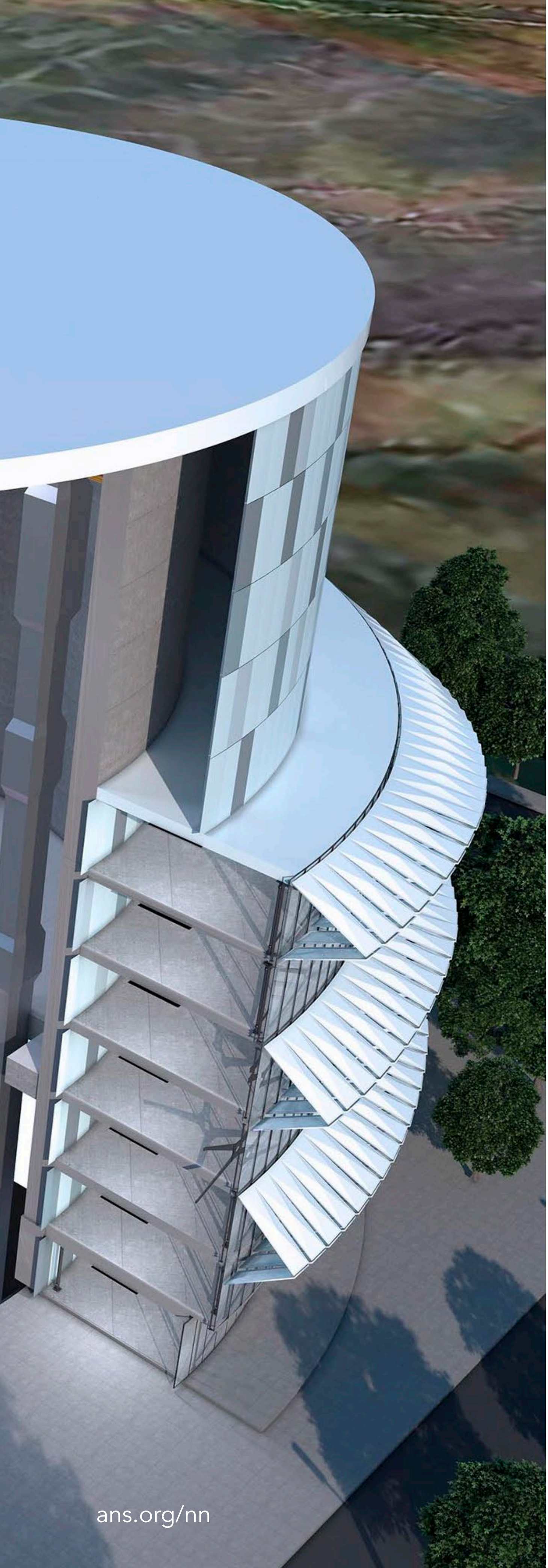
Artist's rendering of the U.K.'s STEP fusion reactor. (Image: U.K. Atomic Energy Authority)



Finding fusion's place

Government policies and innovative technologies are the key to fusion energy economics

By Bart Gordon, Tim Peckinpaugh, Mike O'Neill, and Molly Barker

Fusion energy is attracting significant interest from governments and private capital markets.[1] The deployment of fusion energy on a timeline that will affect climate change and offer another tool for energy security will require support from stakeholders, regulators, and policymakers around the world. Without broad support, fusion may fail to reach its potential as a "game-changing" technology to make a meaningful difference in addressing the twin challenges of climate change and geopolitical energy security.

The process of developing the necessary policy and regulatory support is already underway around the world. Leaders in the United States, the United Kingdom, the European Union, China, and elsewhere are engaging with the key issues and will lead the way in setting the foundation for a global fusion industry.

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What's at stake in this debate?

Fusion energy is a zero-carbon, energy-dense baseload power source that does not depend on geographic location, does not produce any long-lived or highly radioactive waste, and does not present a risk of criticality or a meltdown or weapons proliferation concerns. It is a technology at the scale of the problem of climate change,[2] and because the technology's inputs and fuels are abundant and accessible around the world, fusion technology can decouple energy from geopolitics.

Existing policy and regulatory structures impose heavy economic burdens on new energy technologies. For instance, advanced fission developers, pursuing a technology that is fundamentally distinct from fusion, have invested significant sums in Nuclear Regulatory Commission applications.[3] In France, an international consortium is building the world's largest fusion energy experiment, ITER. The French nuclear regulator, Autorité de Sûreté Nucléaire (ASN), has decided to treat ITER as a nuclear fission installation for permitting purposes and has imposed the same regulatory scrutiny on the ITER experiment that it uses for a fission power plant. ASN has paused the construction of ITER while it conducts additional safety evaluations.[4]

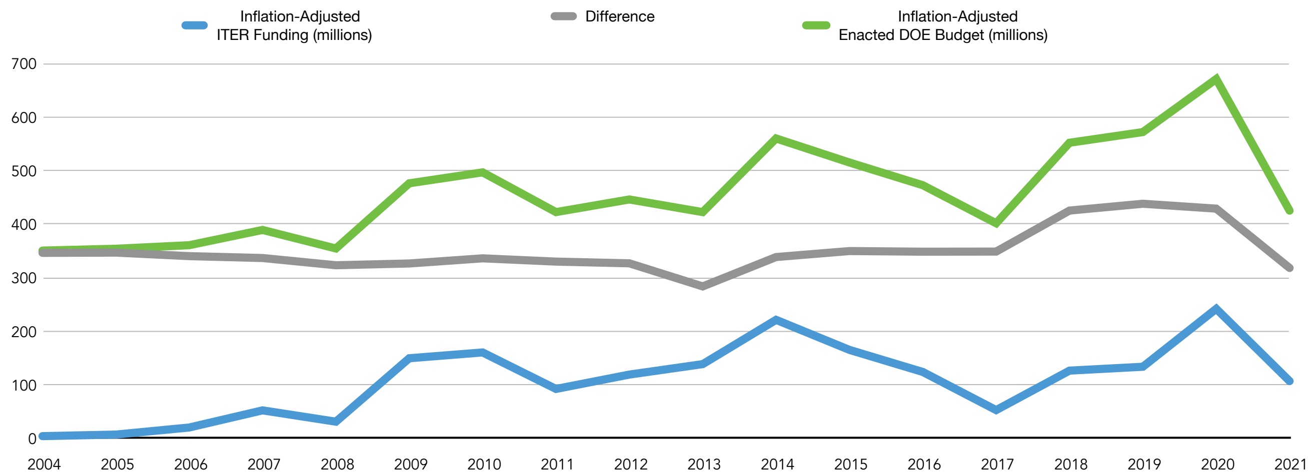
In both examples, American and French regulators are applying regulatory models developed six decades ago for fission generation facilities. Even if there is an argument to be made that advanced fission systems require a regulatory approach similar to that for large light water reactors, there is no basis for treating commercial fusion systems like existing fission power plants.[5] Failure to recognize the fundamental differences between fusion and fission will lead to higher economic costs in the form of lengthier permitting timelines, higher financing costs due to regulatory uncertainty, and increased permitting costs to prepare full fission-style applications, much of which do not apply to fusion systems.

Global conversation around fusion regulation and policy

No government has yet established a firm position on fusion regulation and policy, although the conversation has begun. Stakeholders across the fusion community have significant opportunities to engage and advocate for regulations that reflect the lower risks that fusion poses to public health and safety and that support the adoption of fusion systems.

United Kingdom

In October 2021, the United Kingdom announced its fusion strategy[6] and released a green paper proposing a regulatory approach to fusion energy systems.[7] The pro-



In the late 1980s, the European Union, China, India, Japan, Korea, Russia, and the United States planned for construction of ITER, a large demonstration reactor in France, with costs to be shared by the collaborating countries. The U.S. Congress has occasionally wavered in its funding of ITER. The U.S. has committed to covering 9.1 percent of ITER's construction costs and 13 percent of its operations costs once it begins operation.

The chart above shows the funding of fusion energy in the United States (inflation-adjusted to December 2020 dollars). The green curve shows the total U.S. fusion energy funding, the blue curve shows the U.S. funding for ITER, and the gray curve shows the difference between the two. (Graph created using data from "A Brief History of U.S. Funding of Fusion Energy" by Rachel Margraf, large.stanford.edu/courses/2021/ph241/margraf1/)

Attention to the economics of fusion energy is crucial to ensuring that fusion technology plays a long-term role in mitigating climate change and decarbonizing the global power grid.

posed regulatory approach would treat fusion systems more like particle accelerators than fission power plants, although this policy decision is not final. In addition to hosting several private fusion start-up companies, the United Kingdom is pursuing the public Spherical Tokamak for Energy Production (STEP) demonstration project.[8] With appropriate support for private fusion developers, including those with more aggressive timelines than the STEP project, the United Kingdom is poised to maintain its place as a leader in the global race for fusion energy.

United States

The United States is also taking a lead role in promoting fusion energy. Congress recently approved a record $713 million in annual appropriations for the Department of Energy's Office of Fusion Energy Sciences.[9] Congress also allocated $45 million for a public-private cost-share to support private fusion energy development. The Biden administration expressed interest in fostering the fusion energy industry by hosting a summit meeting on fusion energy at the White House on March 17, 2022,[10] and issuing a "decadal vision to accelerate fusion."[11]

The NRC has asserted general jurisdiction over commercial fusion energy systems, which runs the risk of conflating the risks associated with fission and fusion. At Congress's prompting, however, the agency is developing a regulatory framework for commercial fusion energy systems and has held a number of public meetings to receive comments on the appropriate regulatory methodology. NRC staff is expected to publish a regulatory options paper for consideration by the full commission in the second half of 2022.

China

In addition to participating in the global ITER project, China is developing its own fusion energy industrial base. It operates the Experimental Advanced Superconducting Tokamak[12] and is developing the China Fusion Engineering Testing Reactor to validate the design and operation of a large-scale tokamak power plant.[13] On a parallel track, the ENN Group, a privately owned energy conglomerate based in China, is pursuing both tokamak and field-reversed configuration fusion experiments.[14]

Other global interest

Other governments around the world are engaging in fusion policy and regulatory treatment. The European Union is the largest contributor to ITER, allocating €5.61 billion (about $6 billion) in funding through 2027,[15] and the European Union's long-term plan includes the eventual construction of DEMO, a larger-scale successor to ITER.[16] In addition, Japan,[17] South Korea,[18] and Canada[19] have all indicated interest in developing domestic fusion energy programs. Similar policy and regulatory considerations will affect economic outcomes for fusion technology in every country.

Next steps

Attention to the economics of fusion energy is crucial to ensuring that fusion technology plays a long-term role in mitigating climate change and decarbonizing the global power grid. Adequate government support, like the public-private partnership begun in the United States, and recognizing fusion energy as a zero-carbon or "green" energy source in future energy policies, is critical to building a thriving global fusion industry.

Regulatory certainty aligned with fusion's actual risks—focusing on the material on-site and the hazards that such material could present—further de-risks fusion and makes the economics more attractive. Simply applying legacy fission concepts to fusion places unnecessary economic and regulatory roadblocks toward adopting a promising source of safe, carbon-free power. But if innovative and right-sized government policies can be paired with the increasing pace of technical innovations across the fusion sector, fusion energy can become an important and economic part of the future energy industry.

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