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Overview of Policy and Technical Progress in Fusion Energy Development Around the World

K&L GATES

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Fusion energy is moving towards technological and commercial reality. Fusion involves the release and harnessing of energy by fusing two atomic nuclei to form a heavier nucleus. Fusion reactions differ from nuclear fission, which is the splitting of relatively heavy atoms to release energy. Fusion avoids potential downsides to nuclear fission by leaving behind no long-lived and highly dangerous radioactive waste and creating no risks of a runway chain reaction or meltdown. Fusion also releases substantially more energy, such that it is capable of replacing fission to become baseload power that operates 24/7 and releases no CO2 emissions.

Around the world, public and private efforts are sprinting to realize a commercially viable fusion energy system that demonstrates net energy and the potential to enter the global power generation portfolio. The highest profile international effort, the International Thermonuclear Experimental Reactor (“ITER”), is under construction in France and will use magnetic confinement for fusion experiments when it is scheduled to start operations in 2025.

In light of upcoming fusion events, including a forum at the K&L Gates London office hosted by the Fusion Industry Association on March 4, 2020,[1] and the United States Department of Energy ("DOE") and the U.S. Nuclear Regulatory Commission's ("NRC") public forum on March 18, 2020,[2] this client alert reviews select fusion initiatives worldwide, including in the United States, the United Kingdom, the European Union, China, Canada, and Australia.

Developing fusion technology demands following numerous variables across complex systems. Similarly, private fusion developers, investors, and other stakeholders across the industry should account for critical policy and legal issues as they evaluate where to invest their time and capital, including:

- Government policy towards fusion development
- Regulatory certainty as developers site next generation fusion machines
- Export controls affecting cross-border movement of advanced technology
- Government approaches to health, safety, and environmental protection
- Protection of intellectual property rights
- Network of public and academic institutions to support fusion technology and workforce development

UNITED STATES EFFORTS TO ENABLE FUSION DEVELOPMENT

The U.S. fusion community is approaching fusion research and development from multiple directions. In the private sector, the Fusion Industry Association counts 22 private members, mostly based in the United States (with some in the UK, the EU, and Canada) with each exploring methods to commercialize fusion.[3]

Enabling this private development, the U.S. government is investing more heavily in fusion within new initiatives for technology development funding, as well as initiating discussions about a regulatory framework for the budding industry.[4] In late 2019, Congress directed DOE's Fusion Energy Sciences Advisory Committee to evaluate a cost-share program as part of the Committee's current long-range strategic planning process.[5] Congress also mandated that the DOE prepare a plan for the Congressional Appropriations Committees on a possible fusion public-private partnership cost-share program by June 2020, addressing topics including program objectives, eligibility requirements, and a funding profile.

The DOE's Office of Fusion Energy Sciences' "INFUSE" program also supports fusion research by connecting national laboratories with private fusion industry. The program administers grants of $50,000 to $200,000 for the use of national lab facilities and expertise. In October 2019, twelve projects received the first INFUSE grants. With its FY 2020 funding legislation, Congress appropriated an additional $4 million to the INFUSE program and directed DOE to open the program to foreign companies.

The Advanced Research Projects Agency - Energy ("ARPA-E") is a federal initiative that underwrites cutting-edge energy initiatives, including fusion. ARPA-E's ALPHA program provides $30 million to advance U.S. efforts to develop low-cost fusion.[6] Recently, ARPA-E also introduced the Breakthroughs Enabling Thermonuclear-Fusion Energy ("BETHE") program to build on the ALPHA program's initiative. BETHE offers funding amounts of between $150,000 to $10 million to domestic applicants and U.S. subsidiaries of foreign-owned companies, subject to cost-share requirements of at least 20 percent for most applicants. The first round of applications for BETHE funding were due on January 14, 2020, and ARPA-E expects to announce initial awardees in April 2020.

From a regulatory perspective, in 2009 the NRC reviewed the technological advances and legal issues of fusion, but ultimately decided to wait until a predictable commercial development schedule before establishing a comprehensive regulatory framework.[7] Aside from asserting a general jurisdiction over commercial fusion, the NRC has not taken any further action to establish rules for fusion energy devices in the decade since. The federal Nuclear Energy Innovation and Modernization Act ("NEIMA") that went into effect in January 2019,[8] however, directs the NRC to evaluate the rulemaking and licensing process for certain "advanced reactors," a term that includes fusion reactors as well as advanced fission reactors. As part of this NEIMA-mandated process, the DOE and NRC will discuss the topic and solicit input from the public and industry-at-large at a public meeting scheduled for March 18, 2020. See a draft agenda for the meeting here.[9]

FUSION IN THE UNITED KINGDOM

The United Kingdom was an early mover in fusion energy research and government entities and private industry continue to experiment with fusion. The United Kingdom Atomic Energy Authority ("UKAEA") opened a center to research fusion in 1960 in Culham in Oxfordshire, England. But issues related to Britain's transition out of the European Union create an uncertain future for capturing the innovation already established and maintaining the progress going forward.

The Culham Science Centre houses the Joint European Torus ("JET"), the largest active tokamak (doughnut-shaped) reactor in the world to date. Using magnets to control the plasma inside, the reactor set the record for the first generation of power by nuclear fusion, creating 16.1 megawatts ("MW") of fusion energy, though it required 25 MW to produce the reaction.

Through its membership in the EU, the United Kingdom was a member of the ITER consortium (other members contributing to this megaproject include China, India, Japan, Russia, South Korea, and the United States). While a longtime supporter of ITER, the United Kingdom's membership in ITER was through the European Atomic Energy Community, which the UK Government plans to leave as part of its exit from the EU. The future of the United Kingdom's participation in ITER is not clear, although ITER officials have signaled their intention to negotiate a new relationship with the United Kingdom during the transition period. Furthermore, UK officials stated that participation in JET will not be jeopardized, as their contract to operate ends in 2020 and talks are underway for an extension until 2024.[10]

The UK government, under Prime Minister Boris Johnson, recently announced funding of more than £220 million across the next four years to prepare initial designs for the Spherical Tokamak Experimental Program (or "STEP"), an initiative to construct a fusion power reactor by the 2040s.[11] Once operational, this facility would use a deuterium-tritium reaction to release hundreds more megawatts than needed to trigger the reaction.

Additionally, the United Kingdom hosts private fusion ventures that are members of the Fusion Industry Association, including First Light Fusion and Tokamak Energy.

EUROPEAN UNION'S PUBLIC AND PRIVATE EFFORTS IN FUSION

Outside of the ITER megaproject, multiple private companies and nation initiatives focus on developing fusion technology in the EU. The union's member states and Switzerland created EUROfusion, the European Consortium for Development of Fusion Energy, to support fusion research. In conjunction with ITER, the EUROfusion Power Plant Physics & Technology Work Programme supports ITER's successor, the DEMOnstration power plant that will put concepts developed with ITER into action and produce electricity, though not at commercial plant levels.[12] To support the ITER program, the European Investment Bank is investing €250 million in a Diverter Tokamak Test facility through Italy's National Agency for New Technologies, Energy and Sustainable Economic Development.[13]

Academic and private interest and development in nuclear fusion is occurring across EU member states. In Germany, the Wendelstein 7-X is a stellarator magnetic confinement fusion device created by the Max Planck Institute of Plasma Physics that experiments with fusion to examine aspects for developing future nuclear fusion power plants.[14] In Spain, the start-up group Renaissance Fusion plans to use High-Temperature Superconductors to develop fusion reactors using a magnetic confinement approach, a stellarator, that is similar to a tokamak.[15]

FUSION IN CHINA

China has recently accelerated its efforts in fusion energy development. In addition to contributing to ITER, China, through its National Nuclear Corporation, spent nearly ¥6 billion to develop the Experimental Advanced Superconducting Tokamak ("EAST").[16] Housed at the Institute of Plasma Physics at the Hefei Institute of Physical Science in Hefei, EAST reached more than 100 million degrees Celsius in 2018. Although the reactor is meant to be an experiment, not an ongoing power plant, China recently awarded a second tranche of ¥6 billion in funding for the project.[17]

Additionally, the HL-2M Tokamak, a fusion reactor with advanced magnetic field flexibility that is part of the EAST project, is expected to be complete and operational within the year.[18] China is also funding and developing other fusion initiatives, such as the China Fusion Engineering Test Reactor, a next phase tokamak reactor that would validate the DEMOnstration designs and may commence construction as early as 2035.[19]

CANADA'S EFFORTS IN FUSION

A number of academic efforts are studying fusion energy concepts and system across Canada, including the University of Saskatchewan's Plasma Physics Laboratory, which houses STOR-M, a small-scale tokomak;[20] research at Quebec's *Institut National de la Recherche Scientifique* studying magnetic confinement and other fusion technologies;[21] and research by the Tritium Facility at the Canadian Nuclear Laboratories on tritium and its ability as fusion fuel.[22]

Canadian companies are moving forward with fusion energy development as well, with support from the Canadian government. General Fusion, a British Columbia-based fusion corporation focused on a magnetized target fusion technology, has raised more than $200 million to date and partnered with Hatch, a global engineering firm based in Canada to begin designing and developing a fusion reactor prototype.[23]

FUSION INNOVATION IN AUSTRALIA

Australia is a cooperating member in the ITER consortium, contributing to ITER through diagnostic imaging, fusion theory and modeling, and advanced materials research.[24] In addition to this international effort, a fusion start-up company spun out of the University of New South Wales, HB11, secured patents for a new fusion technology that will use hydrogen, boron, and lasers.[25] Developed at the University of New South Wales, the technology utilizes a chirped pulse laser technology to initiate the fusion reaction.

NAVIGATING A GLOBALIZING FUSION INDUSTRY

The expanding global footprint of the fusion industry presents many opportunities for collaboration, capital investment, and geographic location for fusion devices, especially as national and local governments start to compete for the economic boon that a successful fusion project would ignite. But fusion's growing footprint also creates some risks, ranging from uncertain regulatory frameworks as governments grapple with the implications of fusion energy systems to national security repercussions of cross-border investment in some of the most advanced technologies under development in the energy sector today. Developers and investors active in the fusion energy sector should balance these opportunities and risks carefully as they consider where and how to deploy their resources and capital into the fusion energy sector.

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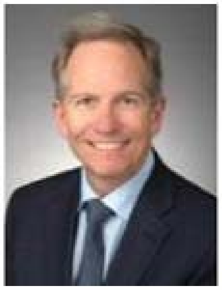

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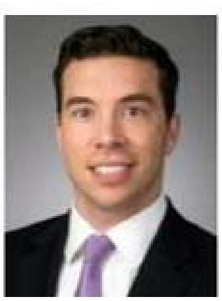

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