



U.S. DEPARTMENT OF
ENERGY

Office of the
**UNDER SECRETARY
FOR SCIENCE & INNOVATION**

U.S. Bold Decadal Vision for Commercial Fusion Energy

Dr. Scott C. Hsu

Senior Advisor and Lead Fusion Coordinator

Slides on DOE Fusion Energy Sciences (FES) program courtesy of
Dr. J.P. Allain (Associate Director of Science for FES)

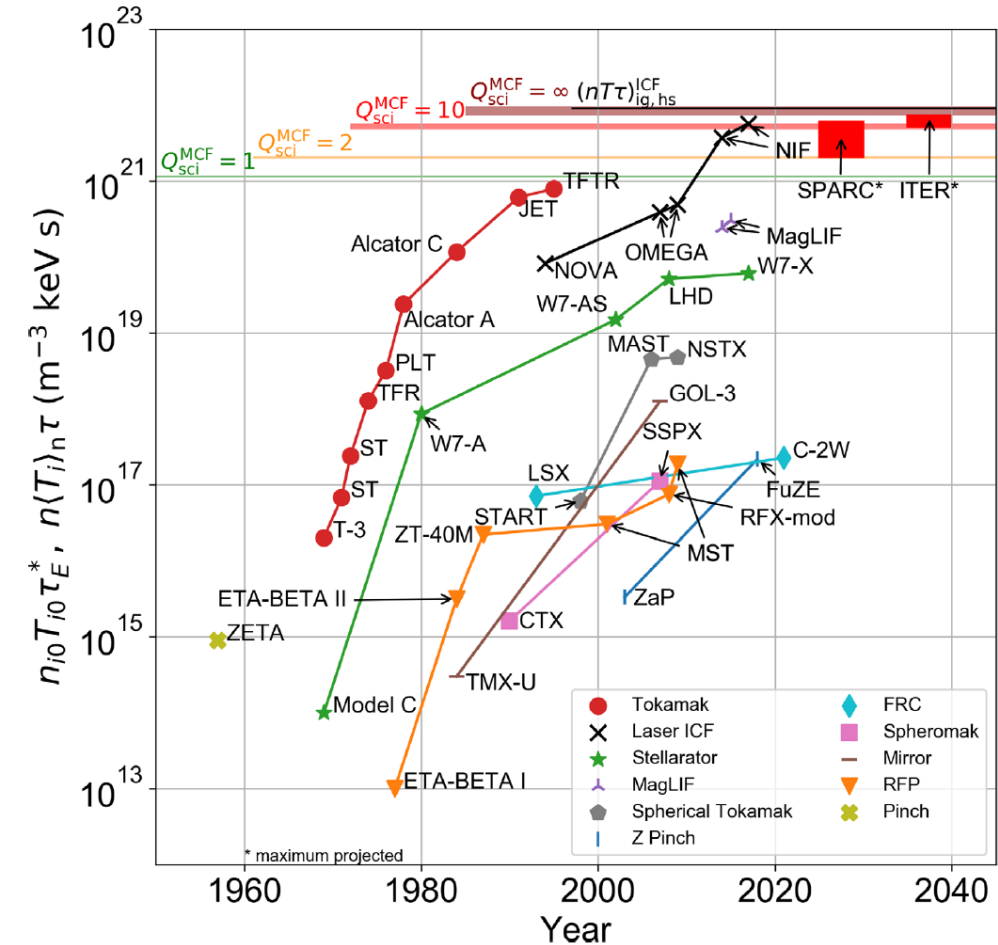
MEXT/JST Moonshot Goal 10:

International Workshop on Fusion Energy

January 31, 2024



Strong technical progress and private investments warrant a new U.S. strategy for fusion research, development, and demonstration



Wurzel & Hsu, *Phys. Plasmas* (2022);
<https://doi.org/10.1063/5.0083990>.

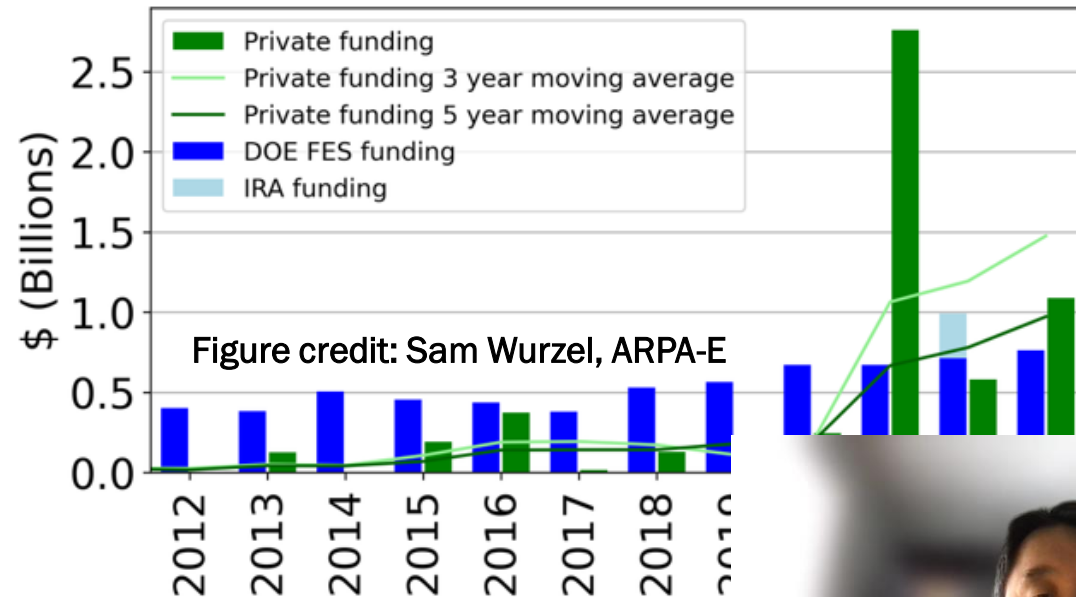
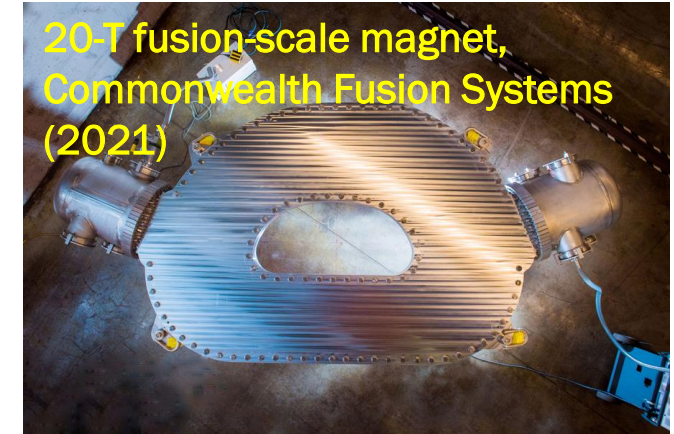


Figure credit: Sam Wurzel, ARPA-E



White House Summit in March 2022 announced the ambition to develop a *Bold Decadal Vision*, building on recent expert consensus reports (hyperlinked images)



WHITE HOUSE SUMMIT:
Developing a Bold Decadal Vision for Commercial Fusion Energy


THURSDAY, MARCH 17, 2022
10:00 AM – 1:00 PM ET

WWW.WHITEHOUSE.GOV/OSTP/EVENTS-WEBINARS/



Powering the Future
Fusion & Plasmas

A long-range plan to deliver fusion energy and to advance plasma science




FESAC “Long-Range Plan” (LRP)

A Report of the Fusion Energy Sciences Advisory Committee 2020

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

CONSENSUS STUDY REPORT

**BRINGING
FUSION
TO THE U.S. GRID**

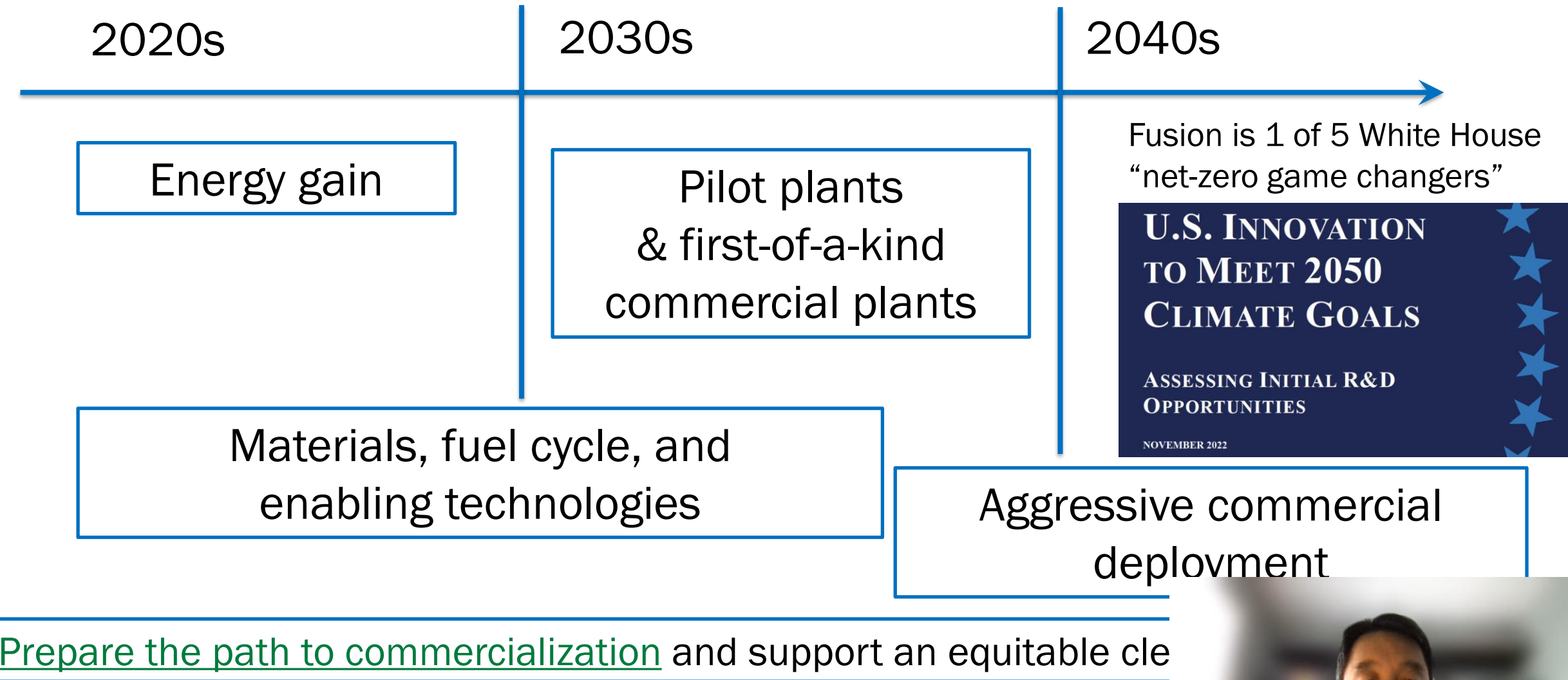


U.S. *Bold Decadal Vision* (BDV) seeks to further accelerate the timeline compared to the FESAC and

3 Additional supporting materials:
<https://www.nationalacademies.org/event/02-16-2023/unlocking-new-possibilities-for-commercial-fusion>;
S. C. Hsu, *J. Fusion Energy* (2023); <https://doi.org/10.1007/s10894-023-00357-9>.



The *Bold Decadal Vision* (BDV) is an element of the White House's innovation agenda to help meet 2050 climate goals



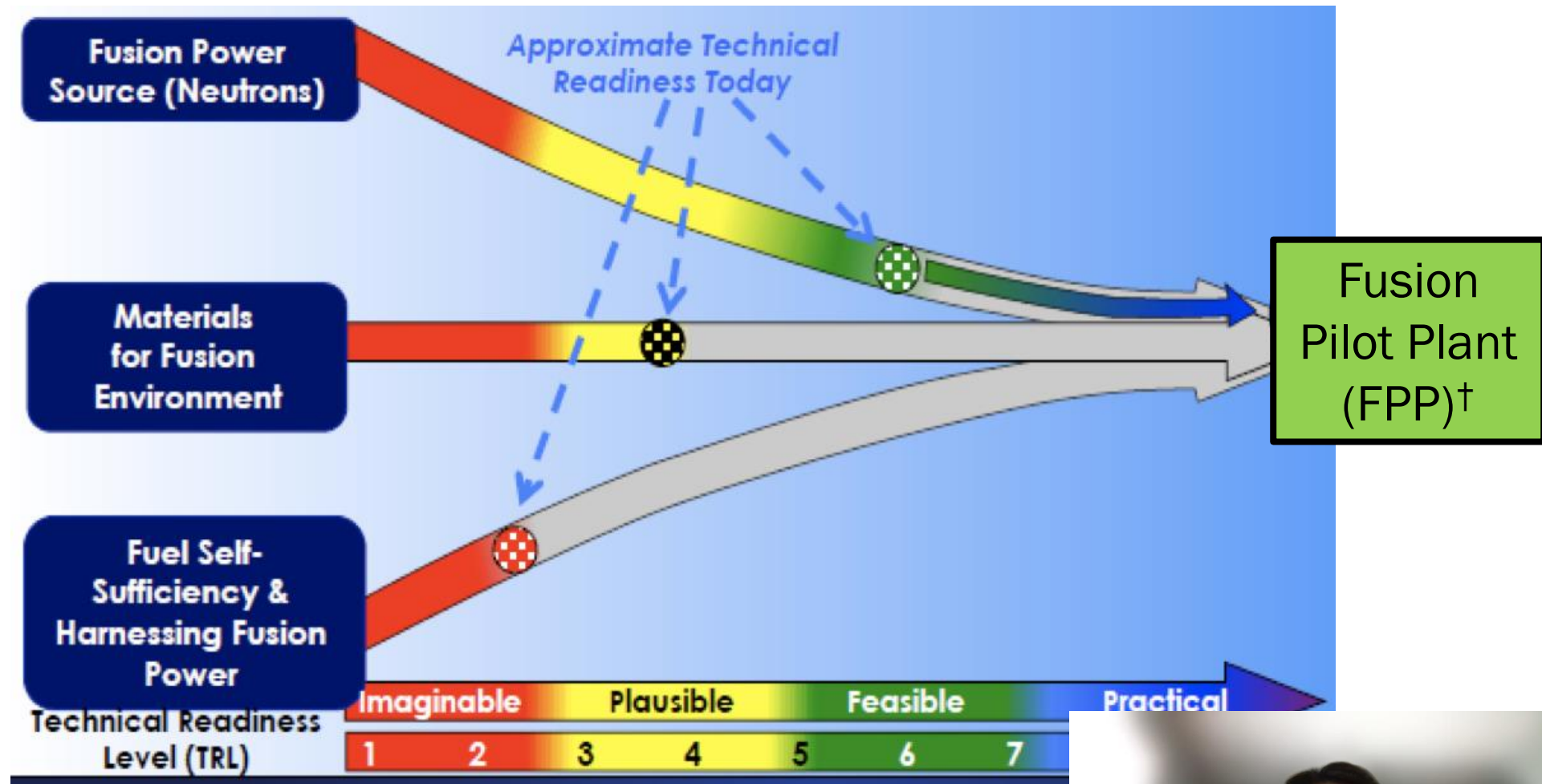
We are at an inflection point between fusion science and fusion-energy development, but significant R&D challenges still remain

Topics/disciplines

Predict, control, sustain a burning plasma

Survive extreme heat and irradiation flux at the first wall

Tritium breeding, processing, containment



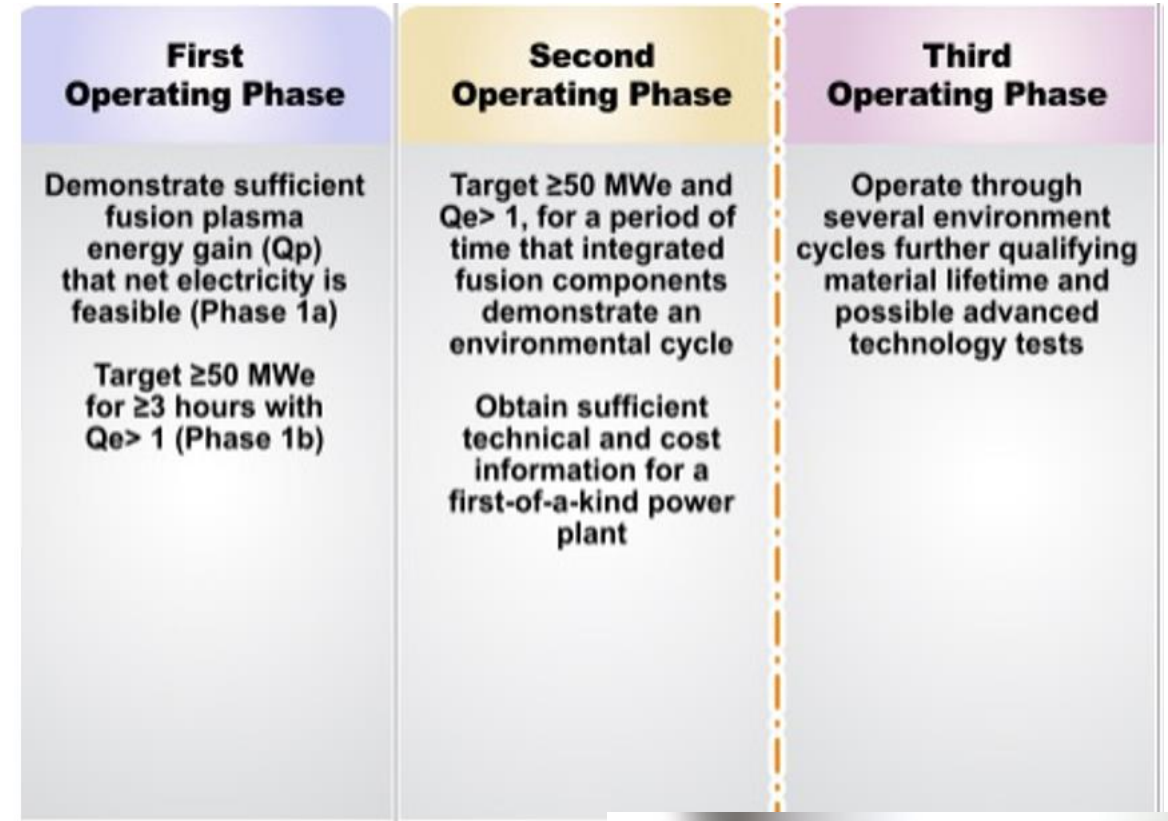
5 †As defined in the 2021 NASEM report [Bringing Fusion to the U.S. Grid](#), i.e., >50 MWe net electricity for >3 continuous hours with timely path to 1 full-power year; on the path to commercial viability. Figure adapted from presentation by M. Wade at APS-DPP [community planning workshop](#) (2019).



A fusion pilot plant must provide technical and economic information for utilities and other plant owners/operators

NASEM report conclusions on FPP requirements:

- Demonstrate $Q_e > 1$, >50 MWe net electricity for 3 continuous hours, progressing to more than 1 full power year
- Demonstrate feasibility of materials and sustainable fuel cycle
- Capital cost that attracts investors and commercialization partners



Decision on
of-a-Kind Pov



Fusion energy development in the U.S. will leverage public-private partnerships (PPPs)

- Greater available financial resources to accelerate timelines
- Stakeholders committed/aligned by sharing cost
- Research/innovation pursued in relevant way for commercialization
- Price signals embedded throughout development path

DOE Workshop on Fusion Energy Development via Public-Private Partnerships

June 1 - 3, 2022

Capital Hilton, 1001 16th Street NW, Washington, DC

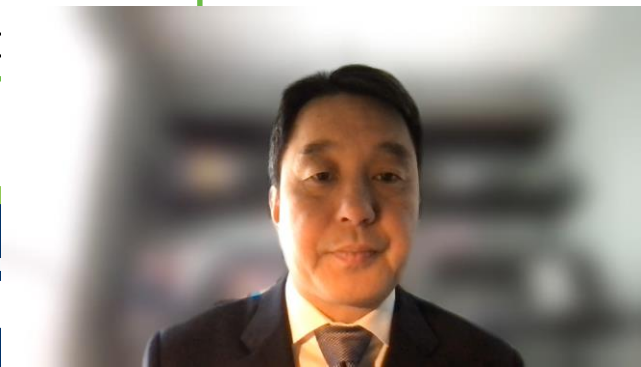
*Hosted by the Office of the Under Secretary
for Science and Innovation*

Sponsored by the Office of Science

Decadal needs
beyond the science
& technology

Aligning public-
and private-
sector R&D

New PPP program
to realize a fusion
pilot p



DOE Milestone-Based Fusion Development Program is a centerpiece and first step of the BDV for realizing an operating fusion pilot plant in the 2030s

Department of Energy

DOE Announces \$46 Million for Commercial Fusion Energy Development

MAY 31, 2023

Awardees will:

- Deliver FPP pre-conceptual designs and technology roadmaps within 18 months
- Pursue R&D to resolve S&T issues, up to delivering FPP preliminary designs within 5 years
- Receive Federal fixed payments upon milestone completion, with significant non-Federal contributions
- Implement Community Benefit Plans in support of community/labor engagement, the American workforce, and DEIA (diversity, equity, inclusion, accessibility)



Diversified portfolio of concepts, and commercial



In conjunction with resolving remaining S&T challenges, DOE and the U.S. Government seek to partner broadly with fusion stakeholders to enable timely fusion commercialization

- Workforce development, training, and retraining
 - Regulatory, licensing, export control
 - Nuclear security and nonproliferation
 - Public engagement and acceptance
 - Energy and environmental justice
 - Supply chains and fuel supplies
 - Manufacturing capabilities and scaleup
 - Waste disposition/recycling
 - Cybersecurity, intellectual-property protection
 - Consent-based siting
 - Demonstration/deployment assistance, facilitating market entry
 - International and interagency coordination/collaboration
- NRC voted to license/regulate fusion systems under the Byproduct Materials Framework (10 CFR 30)
- DOE/NNSA Fusion Energy and Nonproliferation Workshops (Jan. 2023 and Jan. 2024)
- Preliminary DOE assessment of fuel-supply needs has been conducted
- US-UK strategic partnership announced in Nov. 2023; US fusion



New international strategy focuses our R&D collaborations and expands into activities that support eventual fusion commercialization

5 Pillars:

- Identify and pursue collaborative fusion R&D opportunities (including test facilities) focused on enabling timely fusion demonstration and commercialization
- Grow the future global marketplace, including resilient supply chains
- Coordinate on regulatory frameworks that create a safe and secure environment for fusion energy
- Foster and strengthen a diverse and global workforce pipeline
- Improve public education and engagement in fusion energy

SPEC John Kerry announces [U.S. fusion international strategy](#) at COP28 (Dec. 5, 2023)



DOE Dep. Sec. Turk and UK DESNZ Minister Bowie announce [US-UK fusion joint](#)



Fusion Energy Sciences (FES) Mission and Strategic Priorities

MISSION

The mission of the Fusion Energy Sciences (FES) program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundations needed to develop a fusion energy source. This is accomplished by the study of the plasma state and its interactions with its surroundings.

The Energy Act of 2020 **expanded the scientific mission of FES** to support **“the development of a competitive fusion power industry in the U.S.”**

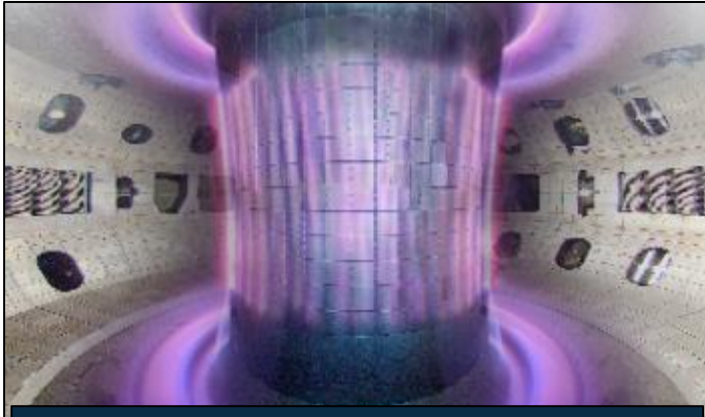
FES PROGRAM PRIORITIES

1. Accelerate fusion development as a carbon-free energy source via public-private partnerships (“bold decadal vision”)
2. Support R&D Fusion Centers (“FIRE” centers) to establish S&T basis of a Fusion Pilot Plant (FPP)
3. U.S. participation in ITER to leverage engineering and study burning plasma science technology at power plant scale while expanding Inertial Fusion Energy (IFE)
4. Support discovery plasma science and technology
5. Broaden participation in fusion and DEIA activities to enable the program

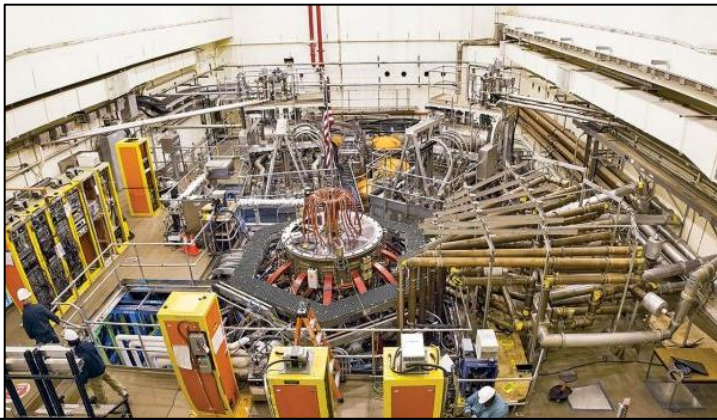


Foundational and Enabling Technology Research in FES

SC User Facilities

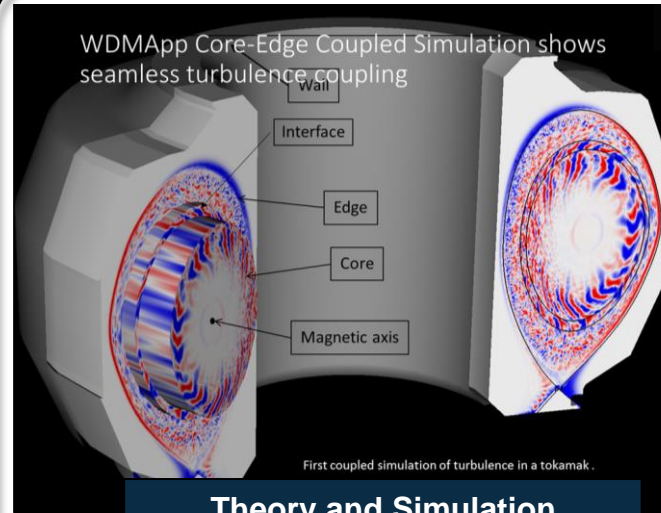


DIII-D National Fusion Facility

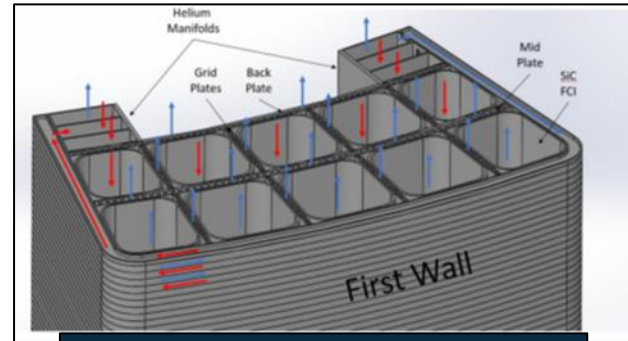


National Spherical Torus Experiment-Upgrade

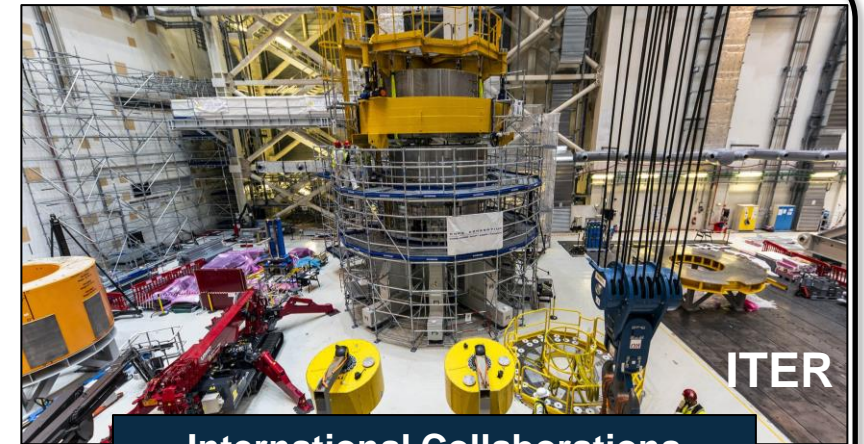
Burning Plasma Science



Theory and Simulation

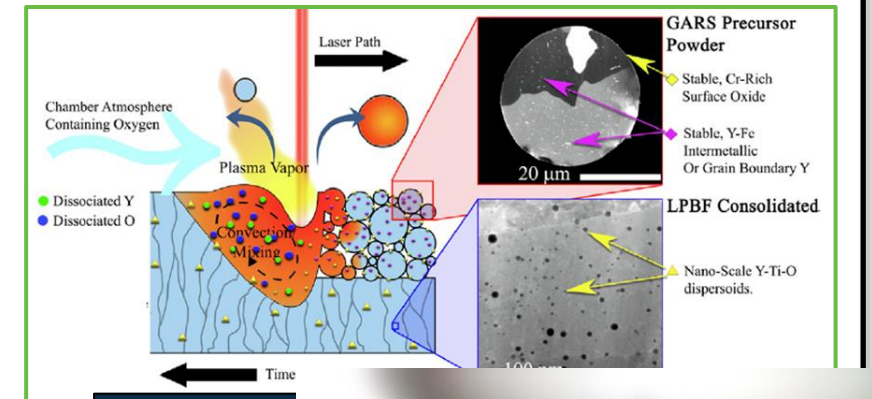


Fusion Nuclear Science



ITER

International Collaborations



Mat

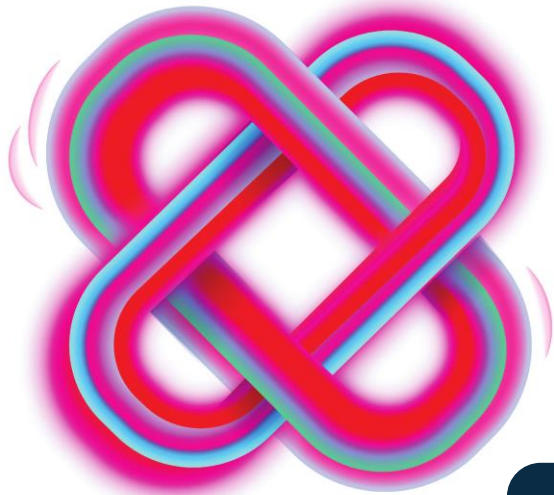
Funding at 61 universities, 14 national laboratories, and 23 private industry partners
> 1,500 FTEs, >300 grad students, >120 postdocs



Vision for a balanced and bold FES program

A Report of the Fusion Energy Sciences Advisory Committee

Powering the Future
Fusion & Plasmas



2020 FESAC
Long-Range Plan (LRP)

A long-range plan to deliver fusion energy and to advance plasma science

"Fulfilling the [fusion] energy mission demands a shift in the balance of research toward FM&T (Fusion Materials and Technology), which connects the three science drivers: Sustain a Burning Plasma, Engineer for Extreme Conditions, and Harness Fusion Energy." pg. 6 FESAC-LRP

- Fusion Science and Technology (S&T) Roadmap
- **Focus:** critical science and technology gaps
- Support public-private partnerships (PPPs)
- Leverage international collaborations



Sustain a Burning
Plasma



Engineer for Extreme
Conditions



Harne
E

LRP Science Drivers



The Fiscal Year 2024 President's Budget Request included an historic 32% increase in Fusion Energy Sciences funding

- **\$130M for Milestone-Based Fusion Development Program**
- **\$120M for Fusion R&D Centers**
 - Fusion materials
 - Fuel-cycle and blanket technologies
 - Enabling technologies (magnets, heating systems, etc.)
 - Advanced simulation for FPP design/optimization
- **\$15M for Inertial Fusion Energy**
- **\$14.67M for Future Facilities Studies**
 - Fusion prototypic neutron source (FPNS)



Summary

- Strong recent technical progress and market interest in fusion have initiated a shift in U.S. strategy for fusion energy development
- White House Summit in March 2022 announced the ambition to develop a *Bold Decadal Vision* to accelerate fusion energy development in order to realize an operating fusion pilot plant (FPP) on a decadal timescale
- Several new initiatives, including the *Milestone-Based Fusion Development Program* and a new strategy for international partnerships, have been launched to advance the BDV

