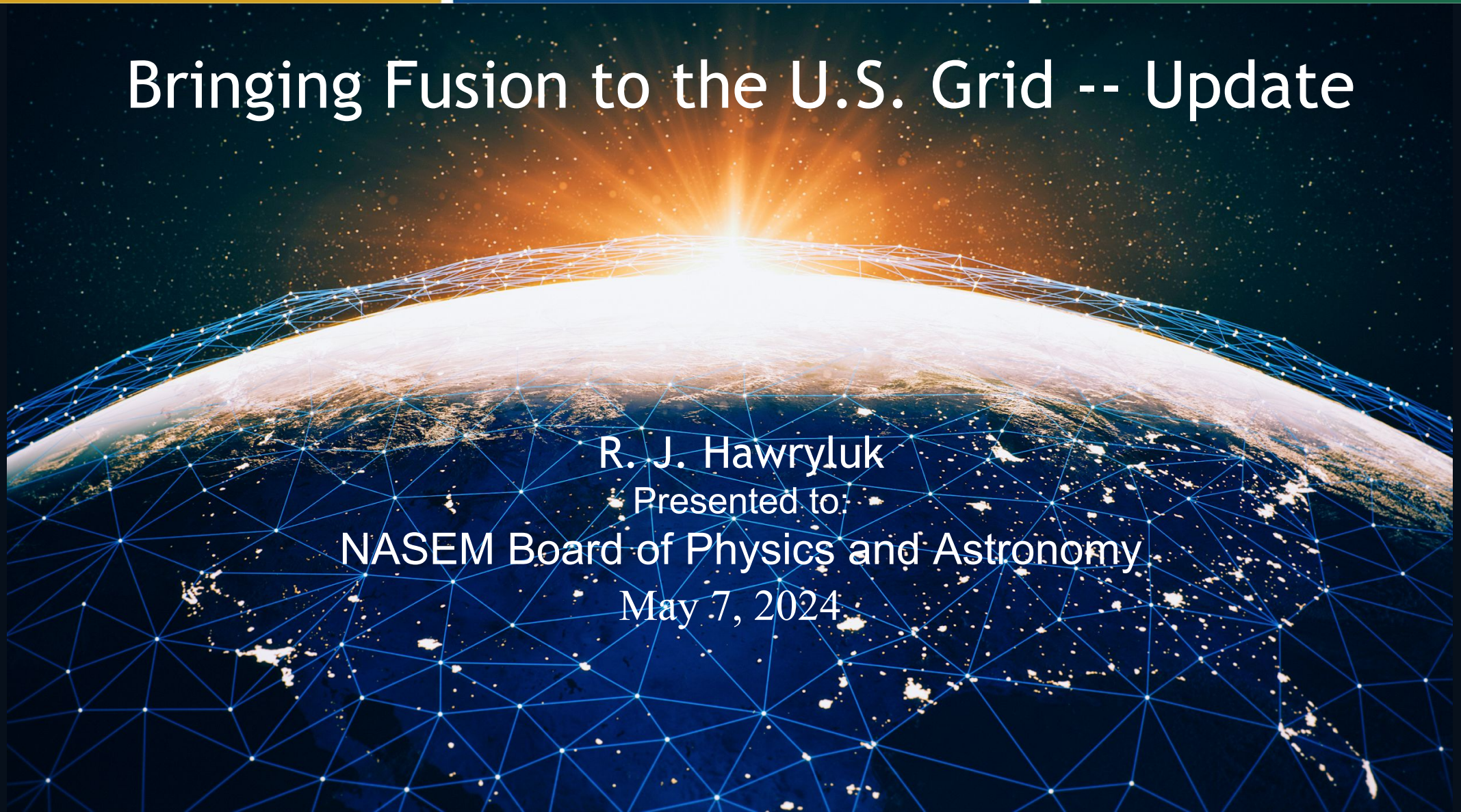
The National Academies of SCIENCES ENGINEERING MEDICINE

Bringing Fusion to the U.S. Grid -- Update



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Presented to:

NASEM Board of Physics and Astronomy

May 7, 2024

Key Takeaways from 2021 Report

Recommendation: For the United States to be a leader in fusion and to make an impact on the transition to a low-carbon emission electrical system by 2050, the Department of Energy and the private sector should produce net electricity in a fusion pilot plant in the United States in the 2035—2040 timeframe.

Recommendation: DOE should move forward now to foster the creation of national teams, including public-private partnerships, that will develop conceptual pilot plant designs and technology roadmaps that will lead to an engineering design of a pilot plant that will bring fusion to commercial viability.

Conclusion: Successful operation of a pilot plant in the 2035—2040 timeframe requires urgent investments by DOE and private industry — both to resolve the remaining technical and scientific issues, and to design, construct, and commission a pilot plant.

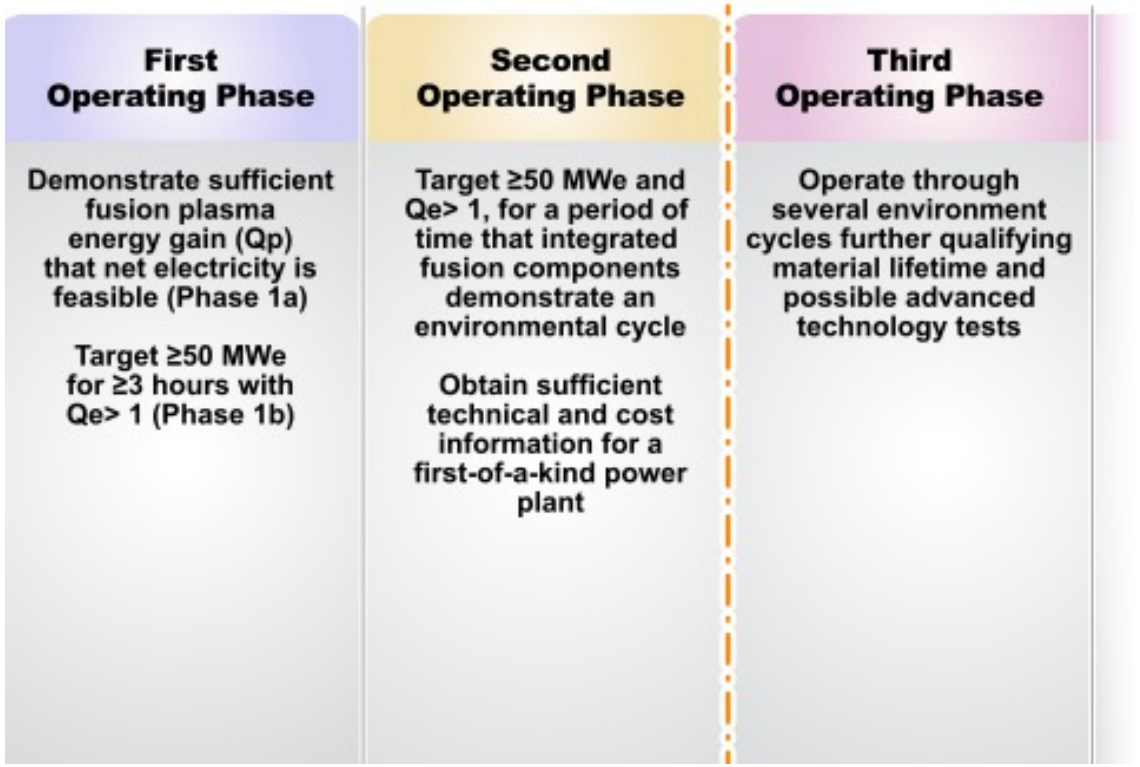
Recommendations, findings and conclusions from the “Bringing Fusion to the U.S. Grid” report are in quotes

Goals for a Fusion Pilot Plant:

"Pilot plants in the U.S. A pilot plant must provide the technical and economic information needed for utilities to operate future plants. It must be a test to ensure public confidence in the technology and the success of the commercial plants that will follow."

- Minimize the investment cost of a pilot plant
- Reduce the cost of a power plant

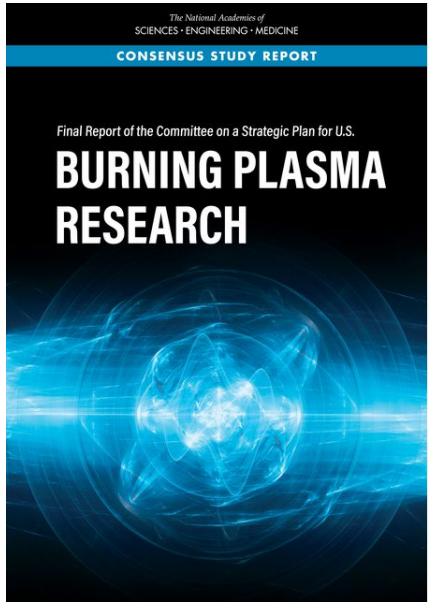
"A pilot must produce an amount of fusion power and energy that is sufficiently representative of the market needs in order to meet the pilot's goal of demonstrated integrated performance and cost, while also demonstrating net electricity gain Qe > 1 and produce peak net electrical power ≥ 50 MWe."

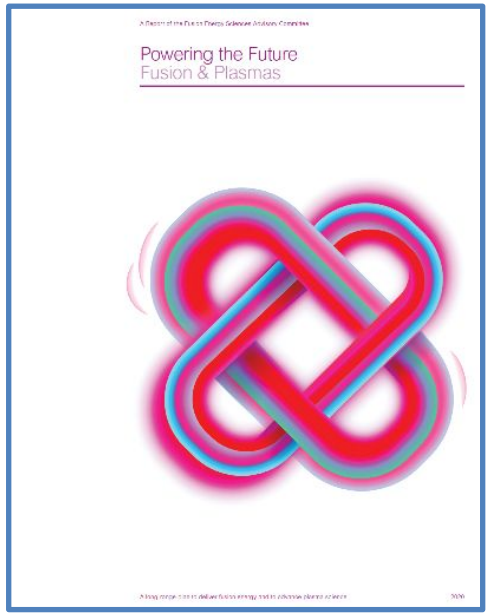


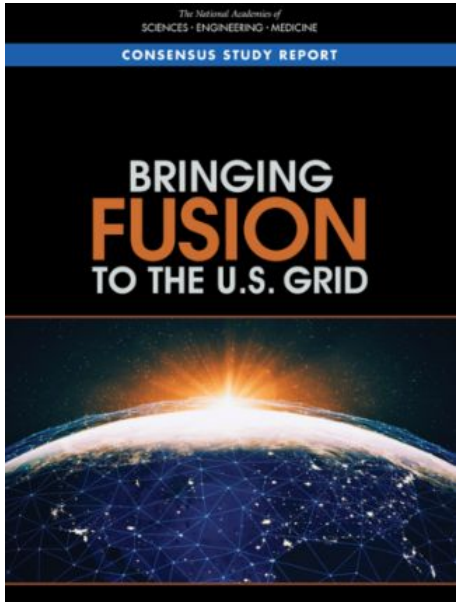
Innovation and Research Investments are Targeted to Meet Technical and Economic Goals

- We need to:
  - "The pilot plant design will need to be based on a vetted, well-established confinement physics basis for achieving net plasma gain well in excess of unity."
  - Improve the economics of a First-of-a-Kind power plant
  - Address regulatory issues to reduce uncertainty
    - Significant progress by the NRC in the last year
- ***Recommendation:*** … "innovations in fusion confinement concepts and technology to extract fusion power and close the fusion fuel cycle should be developed in parallel. This will enable the engineering design of a pilot plant and the construction decisions to be accelerated by a combination of government and private funding."

Series of Workshops and Reports, Briefings to Stakeholders and Technical Progress Together with Investor Interest Has Informed the U.S. Approach







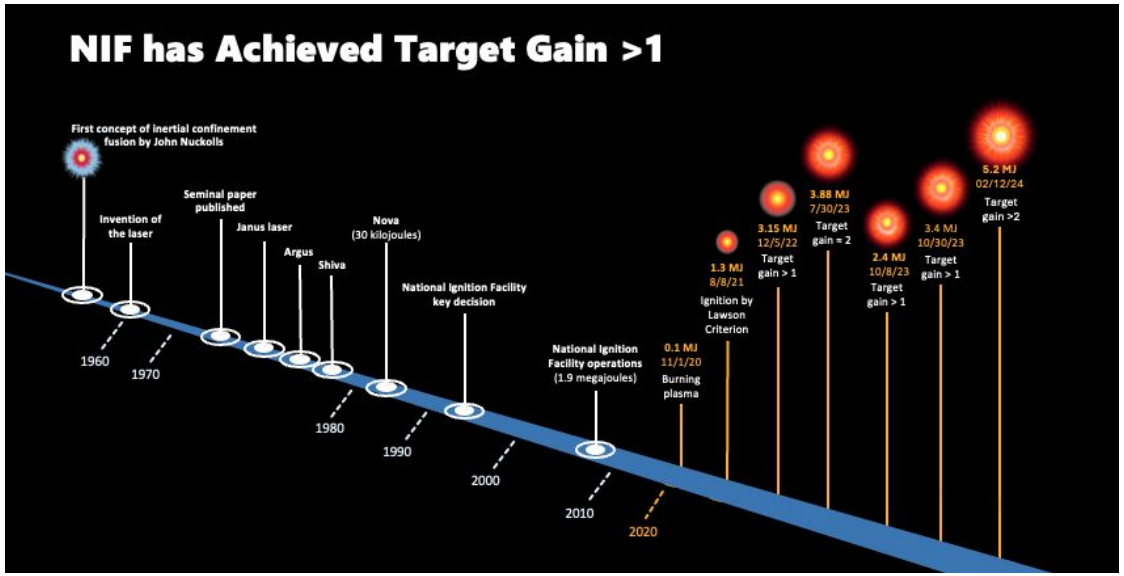
Recommendation: … "the Department of Energy and the private sector should produce net electricity in a fusion pilot plant in the United States in the 2035—2040 timeframe."

White House Summit declared ambition to accelerate this to the early 2030s

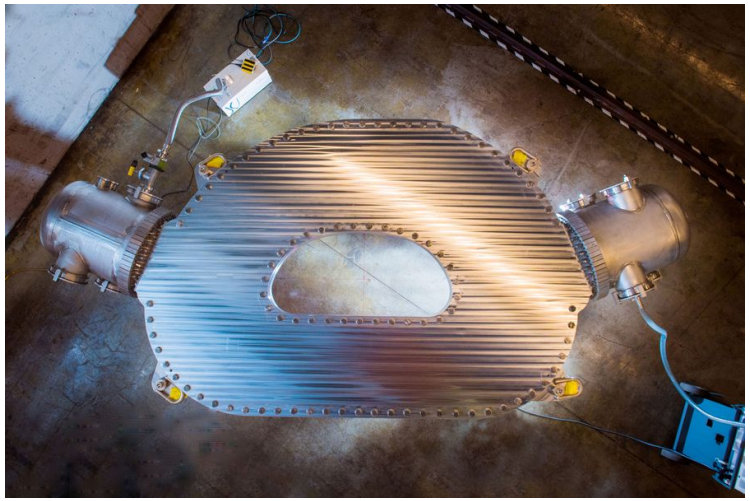
- Bold Decadal Vision

Recent Scientific and Technical Developments Created New Opportunities and Support a New Fusion RD&D Strategy

ITER central-solenoid magnet module constructed by General Atomics (Courtesy of U.S. ITER)

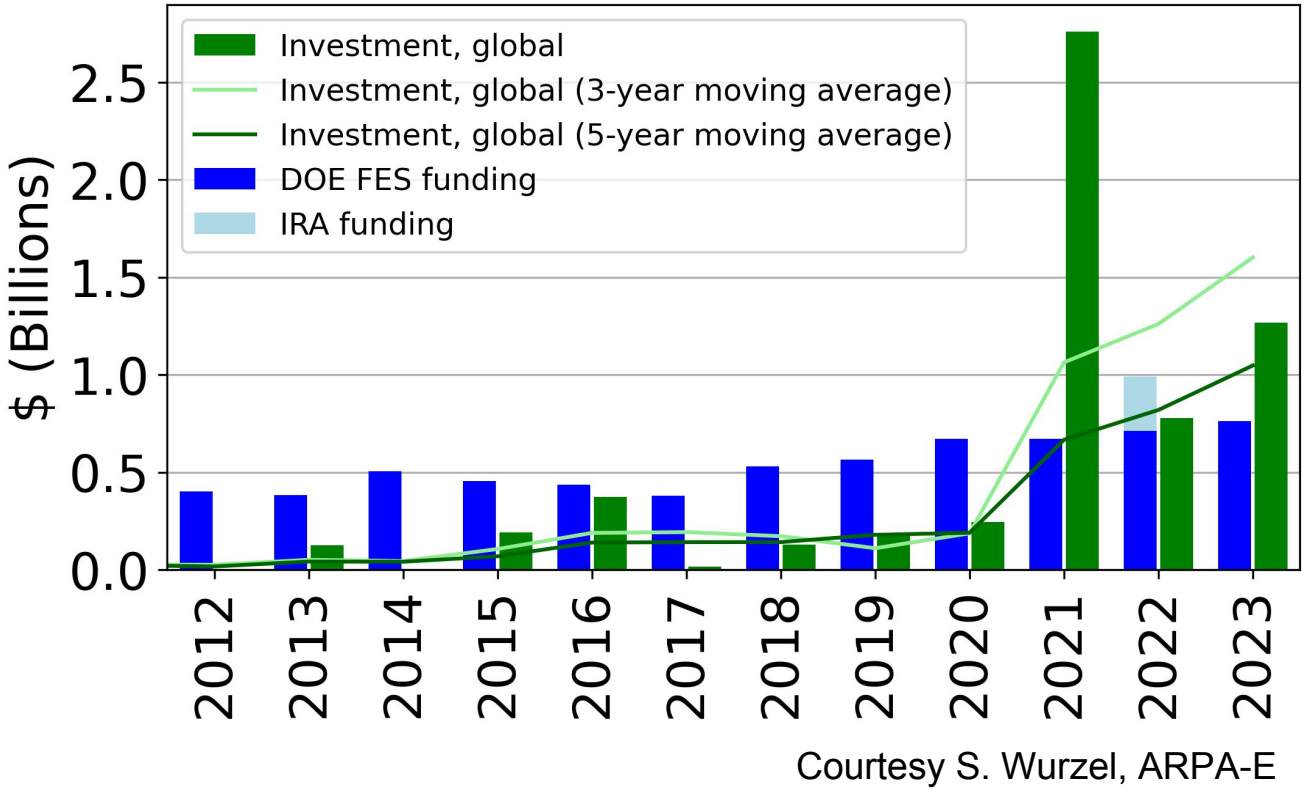


Courtesy of LLNL/NNSA



20-T magnet demonstration
Courtesy of MIT/ Commonwealth Fusion Systems

Fusion Companies Have Raised >$6B in Global Equity Investments



Courtesy S. Wurzel, ARPA-E

- Pursuing diverse number of fusion approaches and fuel cycles
- Growing investment in oversees companies

DOE Launched a Milestone-Based Fusion Development Program

Modeled, in part, after the NASA COTS (commercial space flight) program and Nuclear Energy advanced reactor program

- Private industry takes the lead with strong participation from universities and national laboratories
- Milestone payment occurs upon successful execution
- Greater intellectual property protection for industry
- Reduced procurement and cost-accounting burdens
- Reduced risk to the government

Criteria:

- Scientific and technical viability
- Commercialization viability
- Business and financial viability
- Community Benefits Plan

Deliverables for this phase:

- Pre-conceptual design
- Technology roadmaps
- Achievement of technical milestones

Selected Proposals Span a Wide Range of Plasma Concepts

Impact of recent developments:

High temperature SC coils
- CFS, Tokamak Energy, Realta, Type One, Thea

NIF Achievements:
- Excimer Energy and Focused Energy

High-performance computing:
- Stellarator and IFE Optimization

Increased plasma performance

Tokamaks:

Commonwealth Fusion Systems
Tokamak Energy Inc.

Stellarators:

Type One Energy Group
Thea

Laser Inertial Fusion:

Excimer Energy Inc.
Focused Energy Inc.

Linear Configurations:

Zap Energy Inc.
Realta Fusion Inc.

Technical diversity driven, in part, by industry's assessment of commercial viability
And by reducing the risk of one approach encountering technical or scientific obstacles

The Milestone Program is One Element of Public-Private Partnerships to Bring Fusion to the U.S. Grid

Research funded by FES, NNSA, and ARPA-E is addressing key scientific and technical challenges and critical to close the remaining scientific and technical gaps

- The focus of the next talk

Since the report was issued in 2021, there has been substantial progress both nationally and internationally.