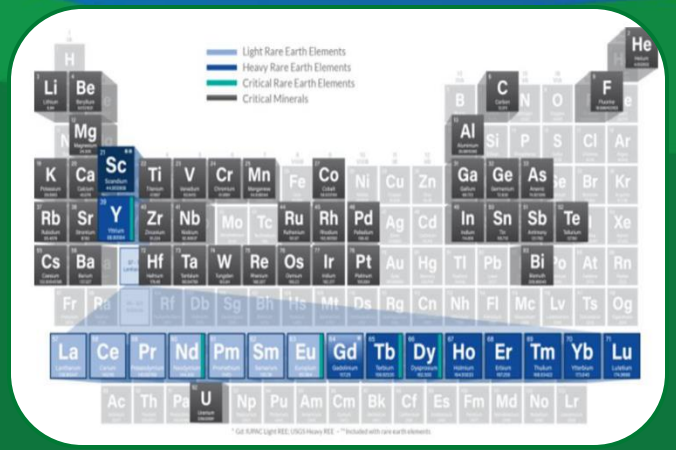
U.S. DEPARTMENT OF ENERGY

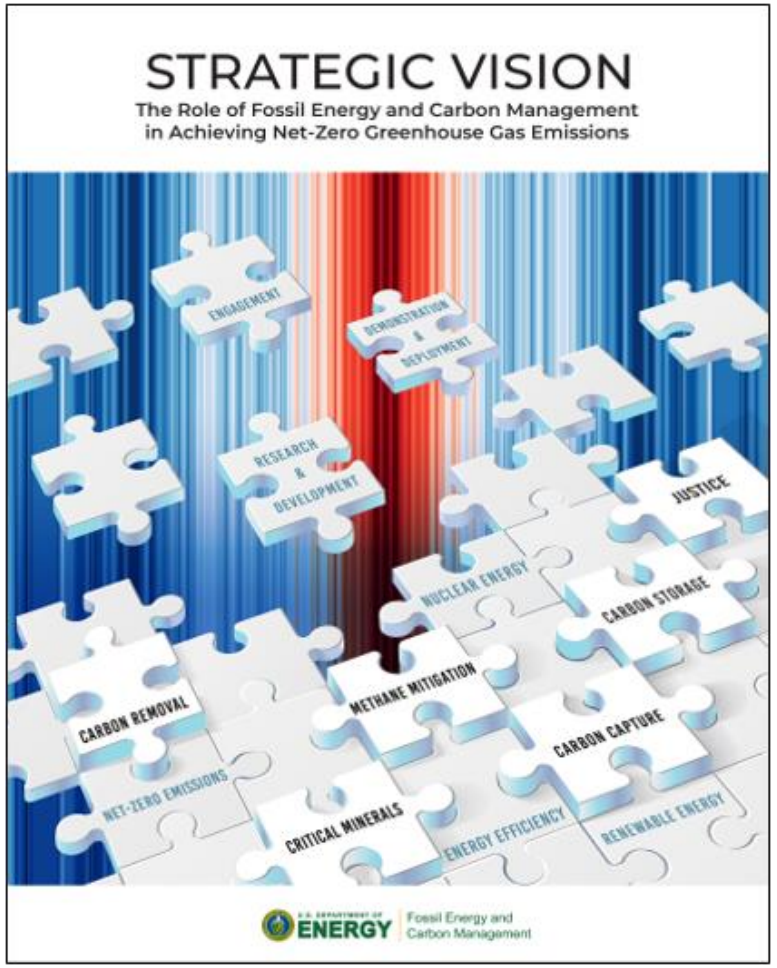
Fossil Energy and Carbon Management

Hydrogen with Carbon Management Ammonia Combustion Activities

May 2, 2023



A Vision for Carbon Management



A carbon management framework that will guide FECM's engagement with offices across the Department, Federal agencies, tribal and international governments, industry, non-governmental organizations, and communities

Advancing Justice, Labor, and Engagement

Priorities: *Justice, labor, and international and domestic partnerships*

Advancing Carbon Management Approaches Toward Deep Decarbonization

Priorities: *Point-source carbon capture (PSC), carbon dioxide conversion, carbon dioxide removal (CDR), and reliable carbon transport and storage*

Advancing Technologies that Lead to Sustainable Energy Resource Utilization

Priorities: *Hydrogen with carbon management, domestic critical minerals (CM) production, and methane mitigation*

Advanced Turbines Program

National Goals

- Carbon-free electricity by 2035
- Net-zero emissions by 2050
- Create new clean energy jobs
- Revitalize communities
- Advance environmental justice

FECM Advanced Turbine Goals

- Use H_2 based fuels while maintaining low NOx and high performance
- Optimization for Carbon Capture and Storage
- Support advanced efficiency
  - Near term 67% (combined cycle) and 50% (simple cycle)
  - Future 70% efficient cycle
  - Pressure gain combustion
- Improve flexible operations
- Additive manufacturing & artificial intelligence

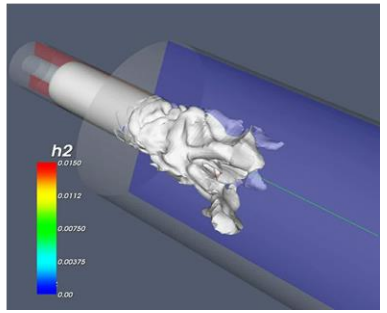
FY21-22 FOAs in Hydrogen R&D

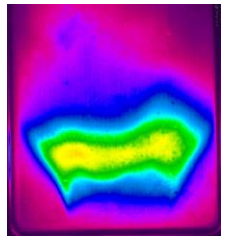
- UTSR FOA FY 21
  - $6.2 M DOE with 20 % cost share
  - Eight university projects awarded
  - **Focus on hydrogen and ammonia combustion R&D**

- FOA 2400—Clean Hydrogen Production, Storage, Transport, and Utilization to Enable a Net-Zero Carbon Economy
  - **H_2 Combustion Systems** for Gas Turbines – applied engineering-scale prototype testing
  - **NH_3 Combustion Systems** – bench-scale
  - Demonstration of a **Rotating Detonation Engine (RDE)**

UTSR
University Turbine Systems Research

LES Simulation of flashback with increasing H_2 content in a NG fuel





FY21 UTSR Advanced Turbine Awards

- Hydrogen /NH_3 Combustion Fundamentals for Gas Turbines
  - *Georgia Tech Research Corporation* *Project page*
  - *University of Central Florida* *Project page*
  - *San Diego State University* *Project page*
- Hydrogen Combustion Applications for Gas Turbines
  - *Purdue University*
  - *The Ohio State University*
  - *University of California, Irvine*
- Hydrogen-Air RDE
  - *The University of Alabama*
  - *Purdue University*

Work being done:

- Explore **chemical kinetics** for H_2/**NH_3 fuels**
- Investigate **NOx** & flame strain rate
- Investigate **ignition delay** times
- Measure **flame speed**
- Evaluate existing fuel injectors
- **Flame structure and combustion dynamics for** H_2 & **NH_3 fuels**
- Assess RDE combustion modes
- Develop design rules for micromixer injectors
- Develop CFD design tools

Recent Industry Advanced Turbine Awards

- Develop combustion modules for F-class, aeroderivative and industrial scale turbines
- Develop retrofit technologies
- Apply to 100% hydrogen & natural gas / hydrogen blends
- **Assess ammonia fuels**
- Advance application of rotating detonation combustion systems for power generation
- Advance hydrogen combustor technology to next stage of testing & demonstration

Performer	Title	Total Funding ($M)
Solar Turbines	Development of a Retrofittable Dry Low Emissions Industrial Gas Turbine Combustion System for 100% Hydrogen and Natural Gas Blends	5.6
GTI	**Investigation of Ammonia Combustion for Turbines (IACT) Project page**	**4.1**
General Electric Company	Advanced Mixed Mode Combustors for Hydrogen F-Class Retrofit	15.0
GE Research	Demonstration of a Gas Turbine-Scale RDC Integrated with Compressor and Turbine Components at 7FA Cycle Conditions	8.7
Raytheon Technologies	Development of Hydrogen Burner for FT4000 Aeroderivative Engine	6.0
Raytheon Technologies	**Low-NOx, Operable Ammonia Combustor Development for Zero-Carbon Power (LOAD-Z) Project page**	**4.2**

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Questions?

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