Ammonia Combustion Technical Working Group Meeting #2

July 11, 2023

Dr. Clinton Bedick
National Energy Technology Laboratory
Research and Innovation Center

ASME Turbo Expo

- Turbo expo was a great success for ammonia combustion!
- (5) ammonia sessions
- Multiple panels
- Thanks to Rob Steele (EPRI) and Vishal Acharya (Georgia Tech) for organizing ammonia discussion
- Themes/points of interest
  - 'RQL' style combustors showing significant promise for ammonia
    - Importance of rich stage heat loss and residence time
  - Liquid ammonia can be burnt
  - Plenty of ~300-1000 ppm NOx data at low P
  - Importance of measuring NO2 and N2O
  - Need for high P experimental data

ASME Turbo Expo

- A few papers of interest
  - [GT2023-103088] THE STRUCTURE AND STABILITY OF PREMIXED CH4, H2, AND NH3/H2 FLAMES IN AN AXIALLY STAGED CAN COMBUSTOR - Anestad et al (Norway)
  - [GT2023-102452] INFLUENCE OF STEAM AND ELEVATED AMBIENT CONDITIONS ON N2O IN A PREMIXED SWIRLING NH3/H2 FLAME - Pugh et al (Cardiff)
  - [GT2023-100880] TECHNO-ECONOMIC ANALYSIS OF HYDROGEN AND AMMONIA AS LOW CARBON FUELS FOR POWER GENERATION - Goldmeer et al (GE)
  - [GT2023-102803] MODELLING AMMONIA-HYDROGEN-AIR COMBUSTION AND EMISSION CHARACTERISTICS OF A GENERIC SWIRL BURNER - Mazzotta et al (Italy)
  - [GT2023-100755] EXPERIMENTAL INVESTIGATION OF THE STABILITY OF LIQUID/GASEOUS AMMONIAFIRED MONO-FUEL GAS TURBINE – Ohtomo et al (Japan)

Ammonia Combustion

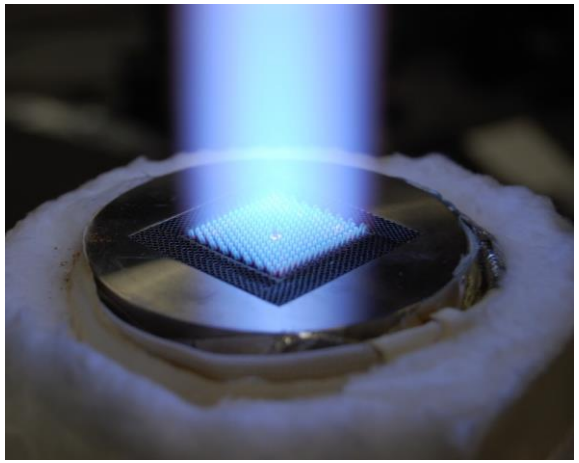
Meeting Schedule

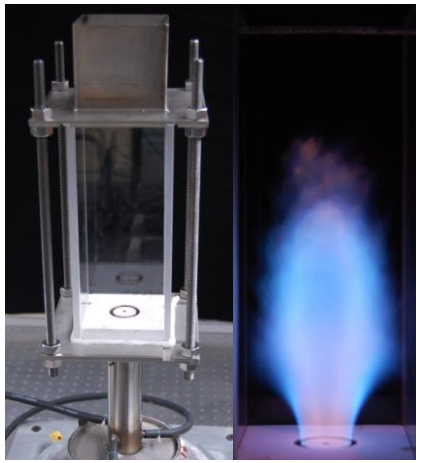
- Introductory remarks (1:00 pm EST)
- CPS Presentation by Hassan Abdulsater (1:10 pm EST)
- CPS Q&A (1:30 pm EST)
- LSU Presentation by Shyam Menon (1:40 pm EST)
- LSU Q&A (2:00 pm EST)
- Open discussion and review of Mendi poll results from May meeting (2:10 pm EST)
- Closing remarks (2:55 pm EST)

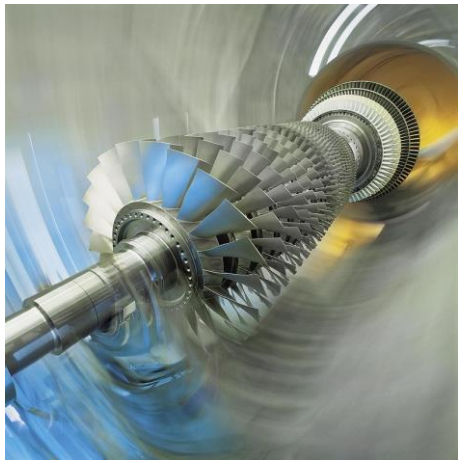
Working Group Objective

Promote a technical understanding, among all, on the subject of ammonia combustion for power and industry.

- Information sharing
- Reduce risk and address technical challenges

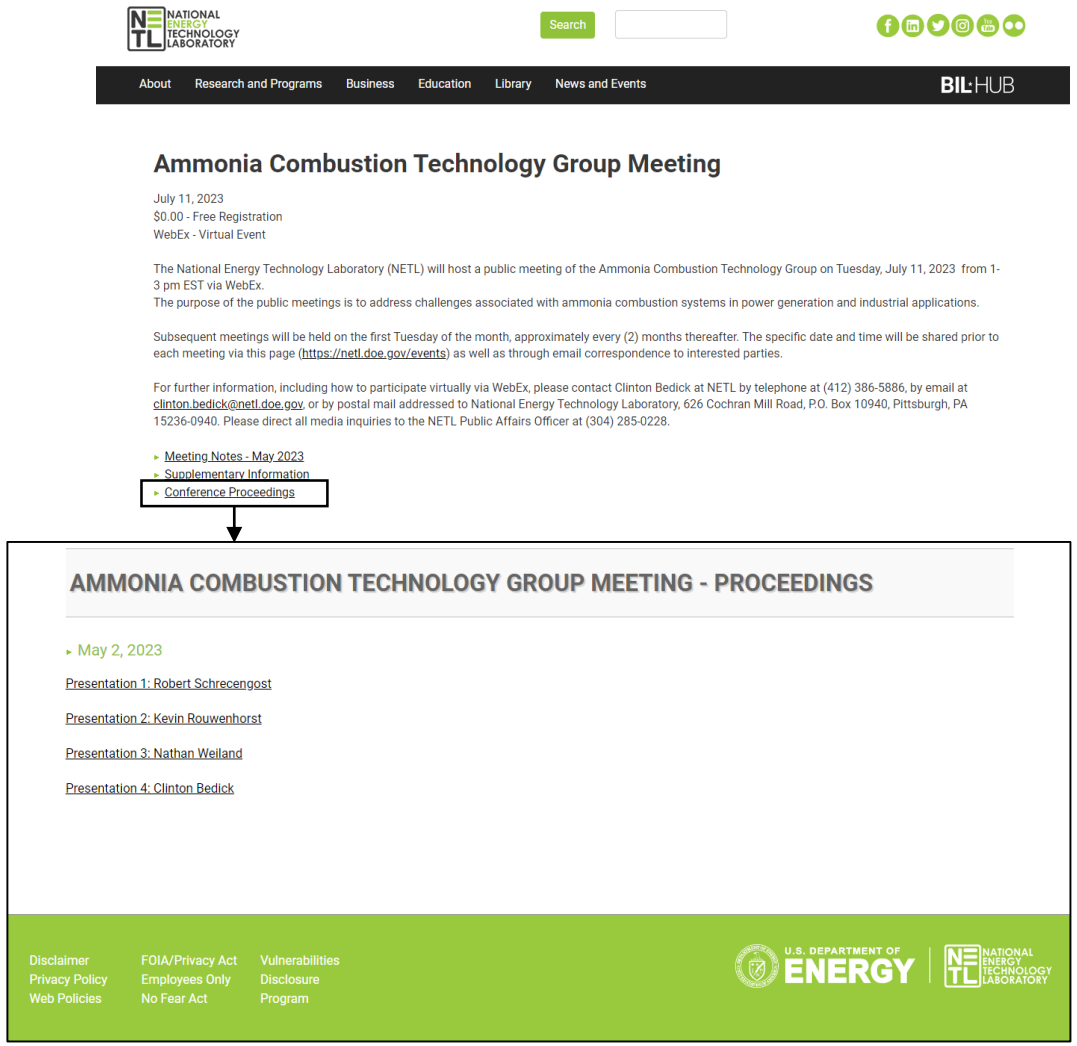






Working Group Format and Participation

- Virtual meetings held every-other month
- Two presenters, with time for Q&A and open discussion
- Focused on technical issues relating to the technology of ammonia combustion, R&D, practical issues, lessons learned, Q&A, etc.
- Informal, everyone welcome to speak
- Anyone can participate (open-to-the-public)
- Minutes and presentations published to NETL proceedings page after each meeting



Disclaimer

The public meetings are considered "open-to-the-public." The purpose of the public meetings has been examined during the planning stages, and NETL management has made specific determinations that affect attendance. All information presented at the public meetings must meet criteria for public sharing or be published and available in the public domain. Participants should not communicate information that is considered official use only, proprietary, sensitive, restricted or protected in any way. Foreign nationals, who may be present, have not been approved for access to Department of Energy information and technologies.

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Next meeting information

The public meetings are held via WebEx. The specific date and time of each meeting will be shared approximately 1 month in advance via the NETL events page (https://netl.doe.gov/events). Interested parties may RSVP, to confirm their participation and receive login instructions, by emailing clinton.bedick@netl.doe.gov.

The next meeting is planned for Tuesday, September 5, 2023 from 1-3 PM EST, with presentations by

- Meyer/Athmanathan (Purdue University)
- TBD

If you did not receive login instructions for the current (7/11/23) meeting directly from me – I may not have you on the distribution list!

Please email me and request to be added.

Mendi Poll Results (May 2023)

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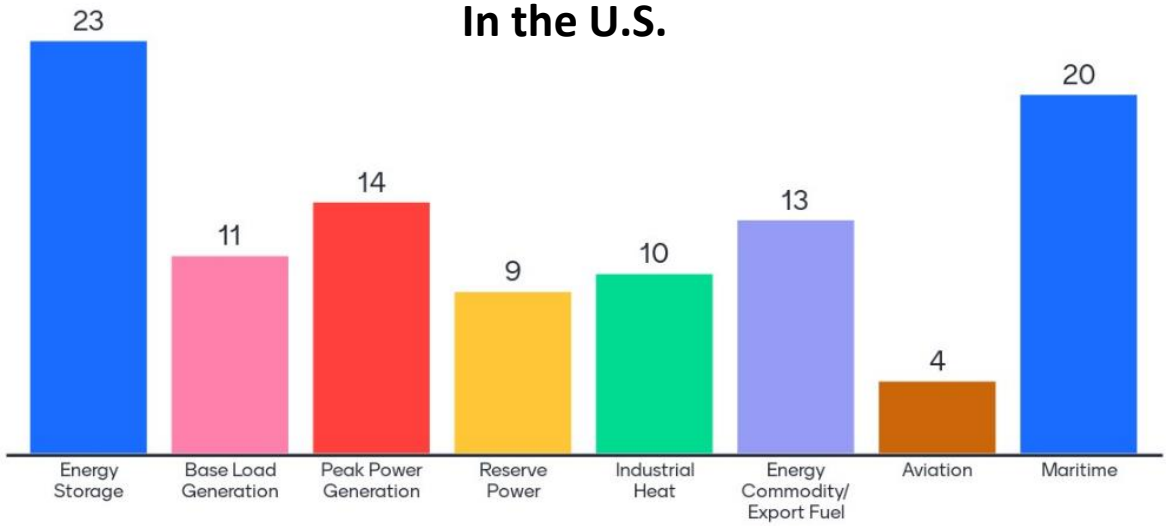
Overall - 36 participants, 506 votes

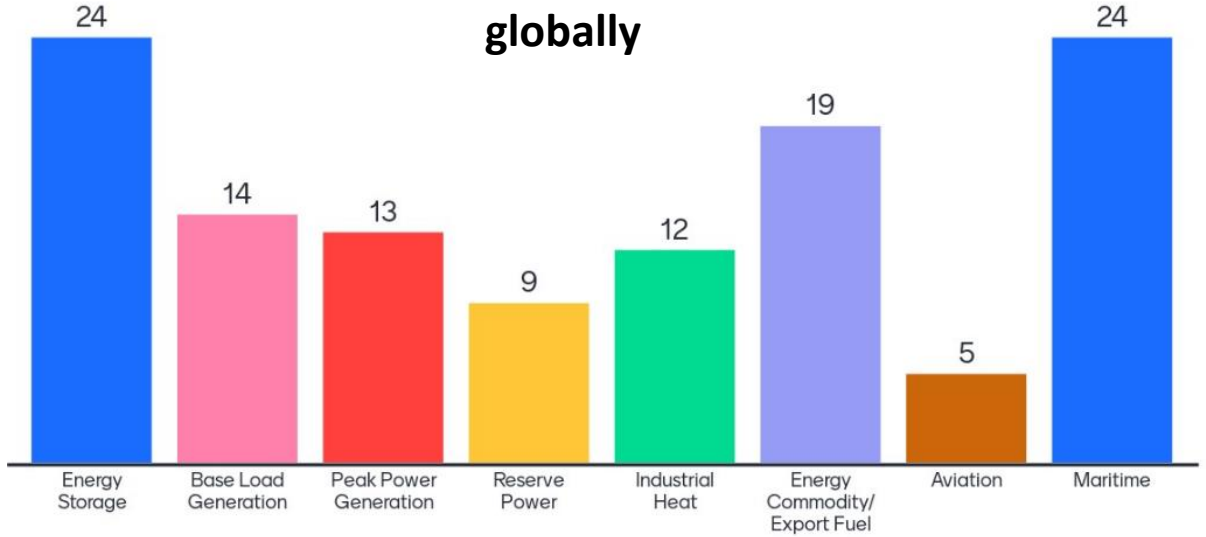
Where do you think clean ammonia will play a role in the future of energy…

In the U.S.



- Energy carrier/transporter
- Agriculture (replace fossil-based NH3 feedstock)
- Refrigeration
- Carbon-free backup/bunker fuel
- Space exploration
- Vehicles/transport/trucking
- High T industrial
- Too soon to predict

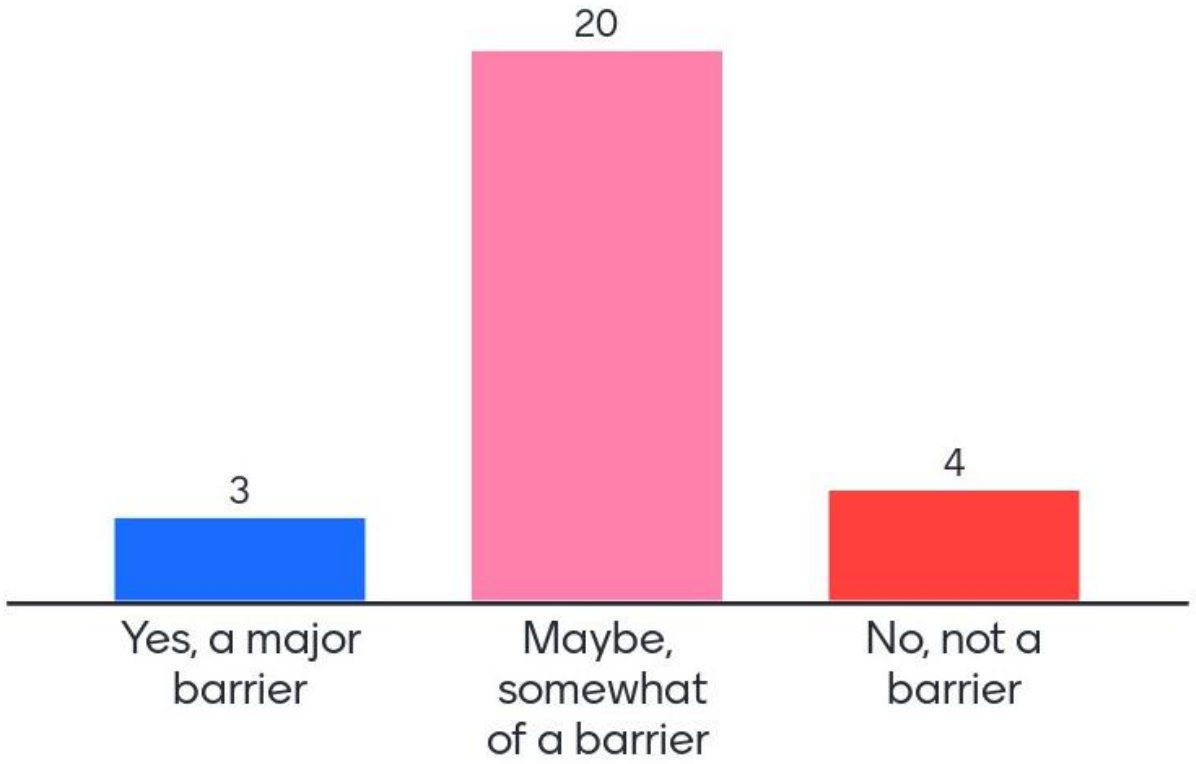
globally



- Transportation
- Energy carrier/transporter

Mendi Poll Results (May 2023)

Is the toxic nature of ammonia a barrier to commercial implementation as a carbon-free fuel?



Mendi Poll Results (May 2023)

What are the largest technical barriers to wide-scale use of NH3 as a carbon-free fuel?

NH3 Synthesis
- Carbon emissions intensity (5)
- Availability at scale (2)
- Cost

Combustion
- Emissions and burning characteristics (3)
- Efficient combustion
- NH3 slip (5)
- Low energy release
- Low flame speed (2)
- NOx (12)
- Plant complexity

Materials/Safety/Economics
- Materials compatibility (3)
- Storage/Handling (2)
- Toxicity/Safety (3)
- Regulations
- Distribution and infrastructure
- Market barriers/minimize fertilizer cost impact (2)
- Gaseous vs. liquid NH3

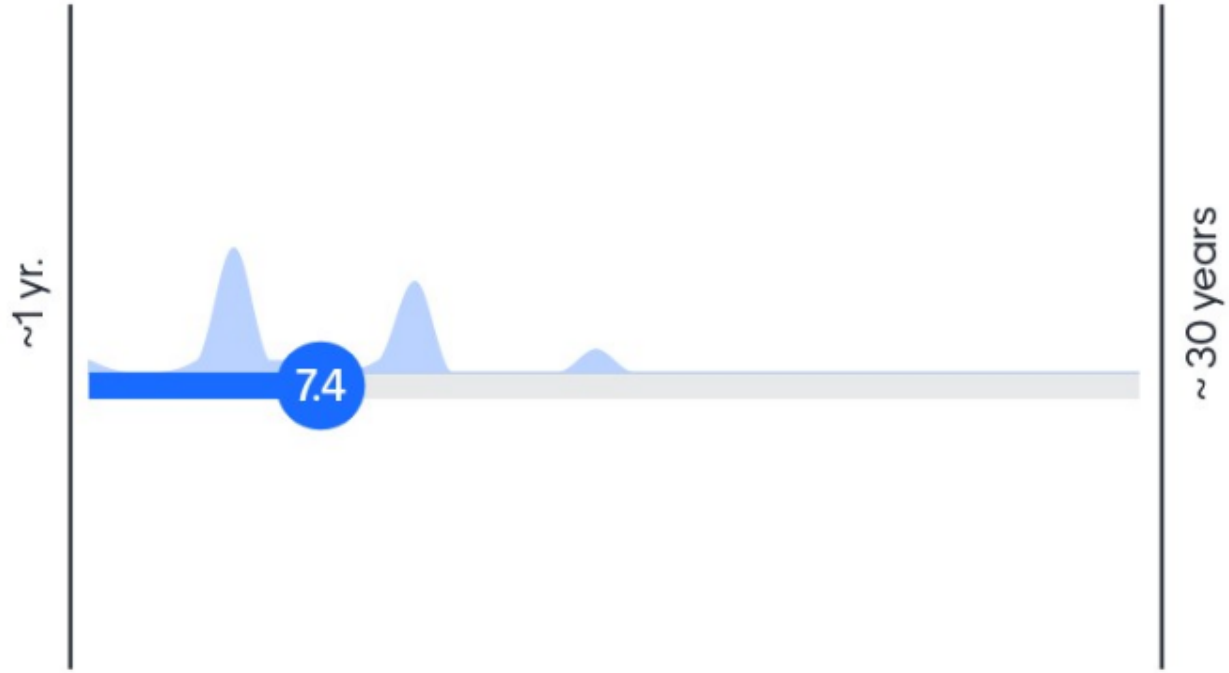
Mendi Poll Results (May 2023)

What are the R&D needs to advance the TRL of NH3 combustion to a practical/commercially viable level?

- High pressure experimental data
  - Various combustor concepts
  - Working can combustor
  - Pilot scale, including DeNOx
- Pilot scale demonstration (2)
- Validated kinetics, esp. high P (3)
- Emissions confidence (NOx, NH3) (2)
- Safety

Mendi Poll Results (May 2023)

In what timeframe do we need to make these advances considering the current push to decarbonize and meet global climate change targets?



Mendi Poll Results (May 2023)

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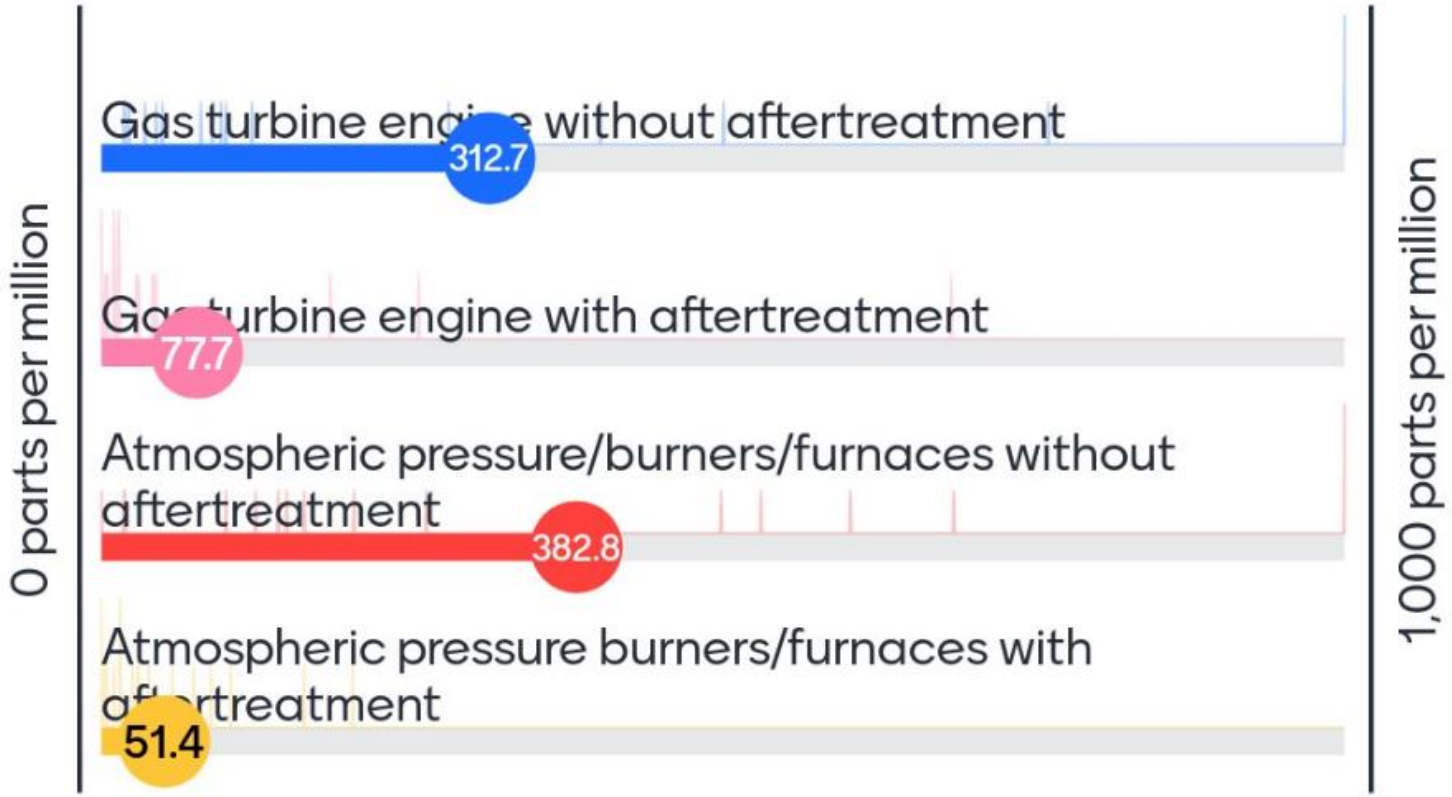
Do you think upfront reforming of NH3 to H2 will be needed for practical implementation in…

gas turbine engines?

atmospheric pressure burners/furnaces?

Mendi Poll Results (May 2023)

What is a reasonable expectation of Nox emissions from a 100% NH3 system?



Closing Remarks

Future meeting will strive to have a common “theme”

Ideas:

1. Modeling
2. Kinetics validation
3. Infrastructure developments
4. Diagnostics
5. Liquid delivery/vaporization systems
6. Model combustors
7. High pressure experiments

If anyone has ideas for other themes, please let me know!

Also – I need volunteers to present during future meetings. Please reach out!

THANK YOU!

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CONTACT:

Clinton Bedick, Ph.D.
Research Engineer – Energy Conversion Engineering
412-386-5886
clinton.bedick@netl.doe.gov