Power generation from ammonia combustion enabled by thermophotovoltaics

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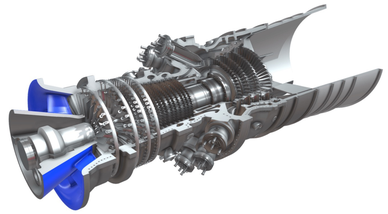
Ammonia can be a clean, dispatchable power source...

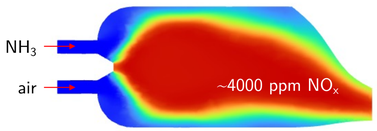


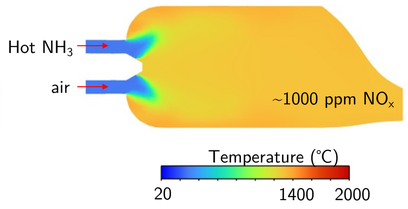
...but ammonia turbines are prone to high NOx production

Challenges with ammonia combustion:

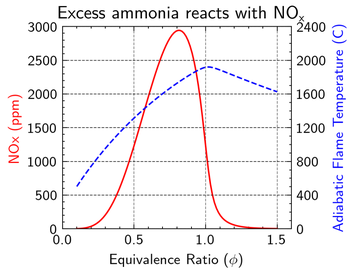
- High-temperature flames (~2000°C): high NO_x production
- Short residence time (~20 ms): no NO_x reduction

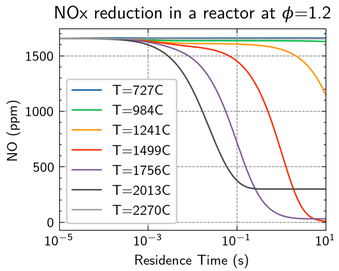
Solution to challenge #1: flameless combustion





Solution to challenge #2: rich + slow exhaust relaxation





These solutions are not suitable for turbines

Turbines rely on:

- Flame stability
- Low pressure drop

Flameless combustion requires:

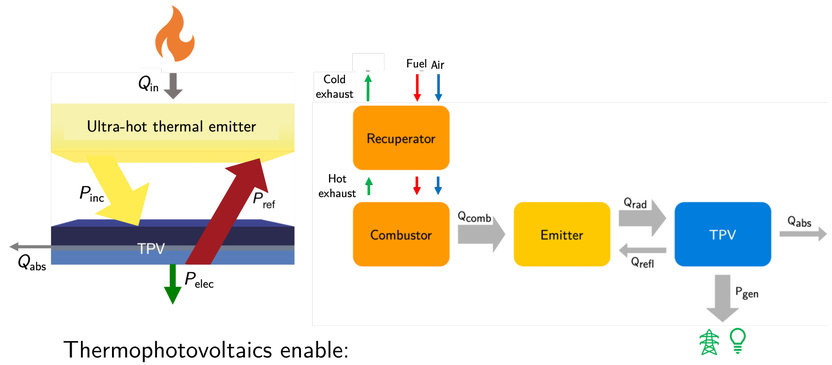
- High reactant preheating
- Rapid mixing
- Larger volumes

Ammonia de-No_x'ing needs:

- Long residence time at high temperatures

Can we design an alternative heat engine that enables low-NOx ammonia combustion?

Thermophotovoltaics convert the light emitted from ammonia combustion to electricity *with low NO_x emissions*

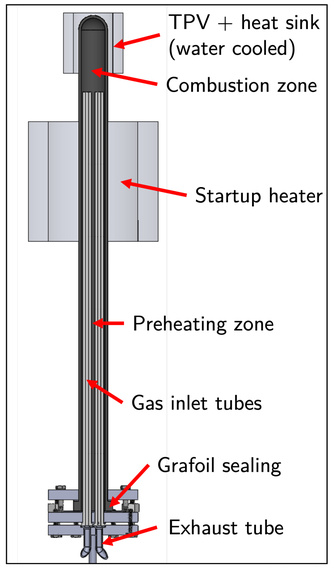


Thermophotovoltaics enable:

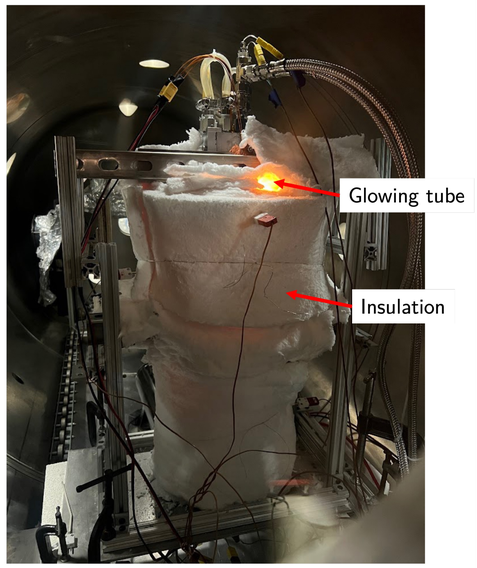
- Well-mixed, volumetric combustion zone with preheated reactants
  → Low NOx production
- Long residence time in recuperation zone
  → Efficient de-No_x'ing
- High efficiency (~45%) and power density (5 W/cm²)

Can we demonstrate a combustion-TPV device experimentally?

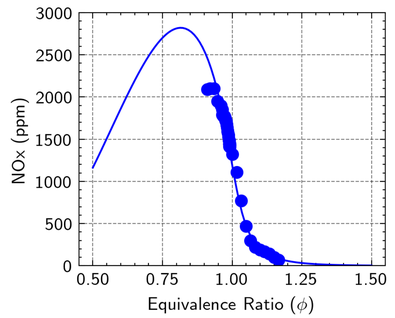
Proof-of-concept prototype of an ammonia combustor coupled with thermophotovoltaics

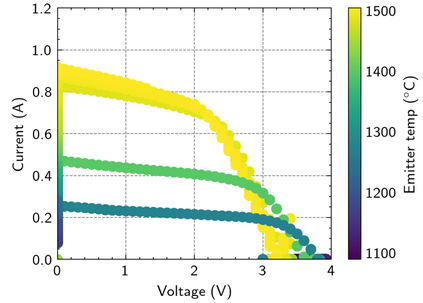


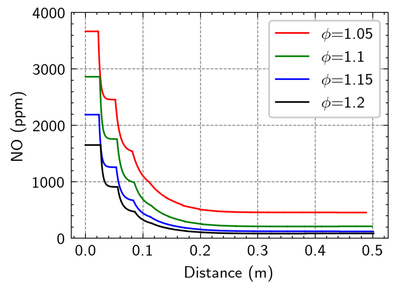
1:3 scale

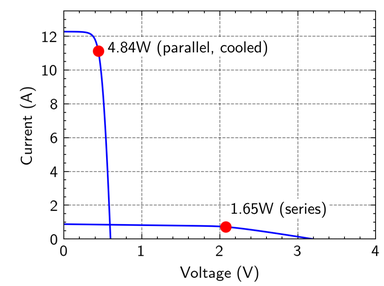


Results indicate prototype combustor enables low-NOx, power dense energy conversion









Rich (excess ammonia) flameless combustion enables **low NO_x emissions** (~20 ppm @ 15% O2) and **high TPV power density** (~1W/cm²) achieved at **high emitter temperatures** (~1400C).

This is the first demonstration of power generation from low-NO_x ammonia combustion.

Previous attempts using turbines have failed to achieve low NO_x (~300ppm @ 15% O2) and have relied on SCR for NO_x control.

Previous low-NOx ammonia combustion demonstrations (down to ~9ppm @ 15% O2) have not included power generation.

This first prototype needs optimization but opens many opportunities, including in long-duration chemical energy storage.

I'm looking for academic collaborators and industrial partners to investigate this further and build it at scale! Reach me at skverma@mit.edu.