Additively-manufactured ceramic combustor for dispatchable clean electricity generation

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Existing power plants are dispatchable but emit CO_2

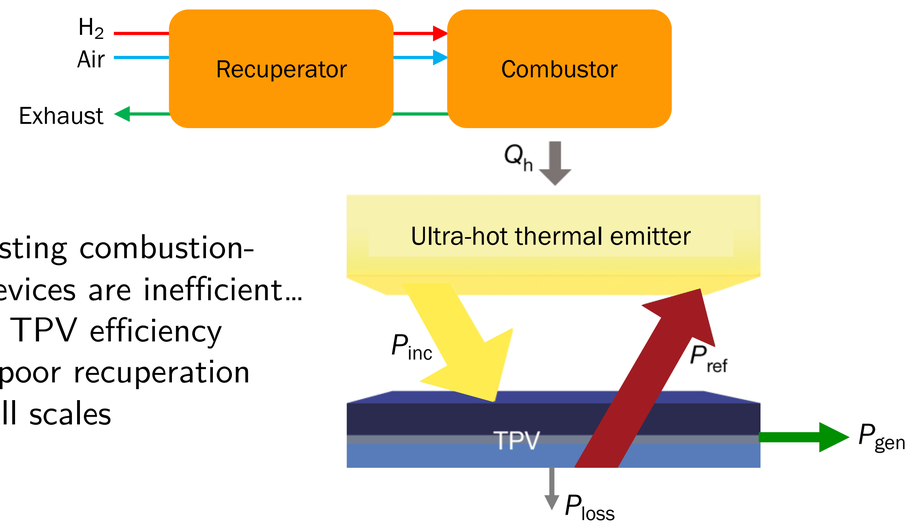
Natural gas power plant

Emits CO_2
Rotating machinery
Dispatchable

Solar PV

Clean
Solid state
Intermittent

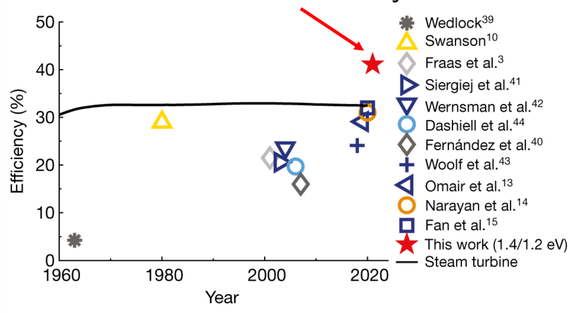
Combustion-powered thermophotovoltaics (c-TPV) is both dispatchable and clean



But existing combustion-TPV devices are inefficient...
1. Low TPV efficiency
2. No/poor recuperation
3. Small scales

How can we create high-efficiency c-TPV?

Our lab set the world record for TPV efficiency

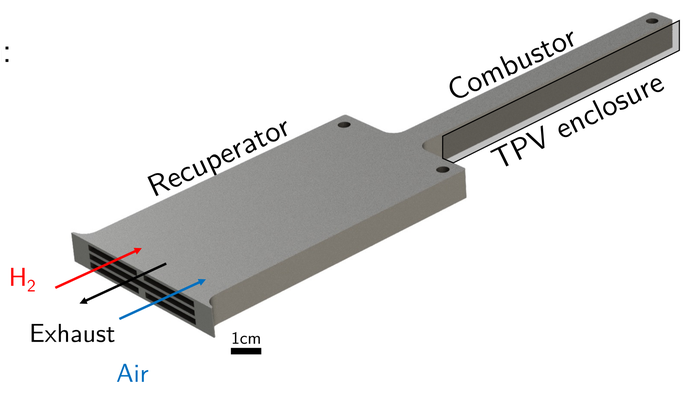


In this work, we design a high efficiency combustor with effective recuperation and low heat loss.

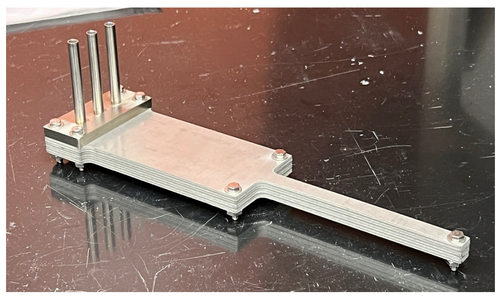
Additive manufacturing enables fabrication of complex internal geometries

Guiding principles:
1. **High surface area combustor** to enable effective extraction of combustion heat
2. **Wide and long recuperator** to enable high-effectiveness heat exchange

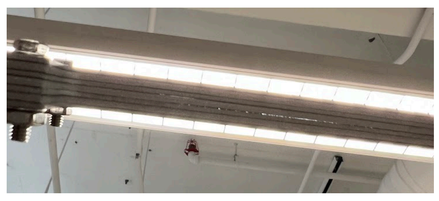
Preliminary design:



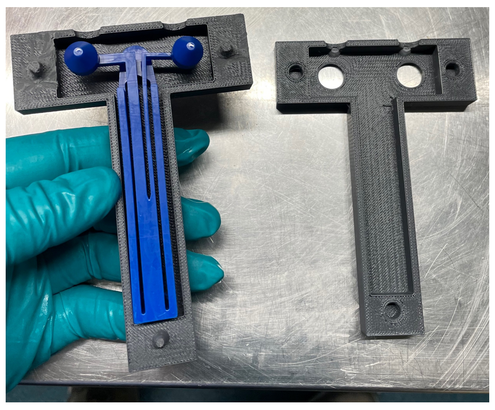
Manufacturing approach 1: stacked slices

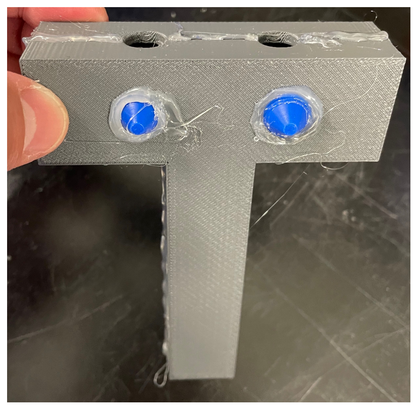


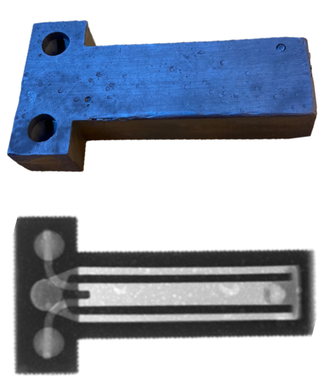
Easy to manufacture but issues with sealing slices



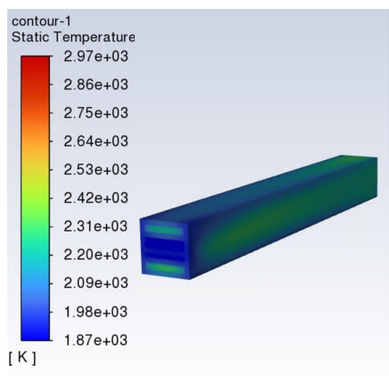
Manufacturing approach 2: SiC casting with 3D printed mold





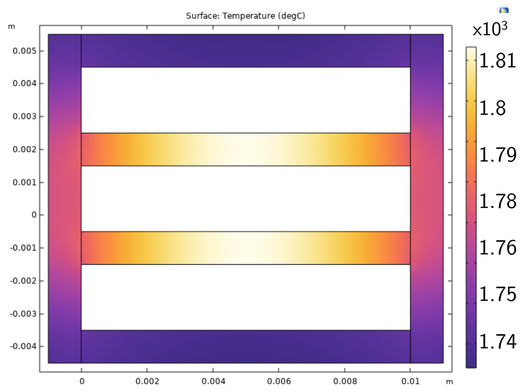


Simulations show the manufactured device has high combustion efficiency

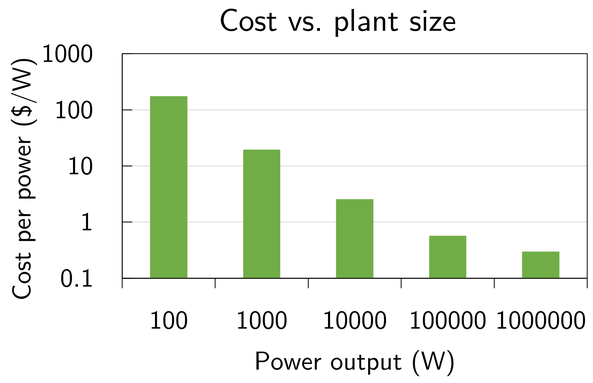


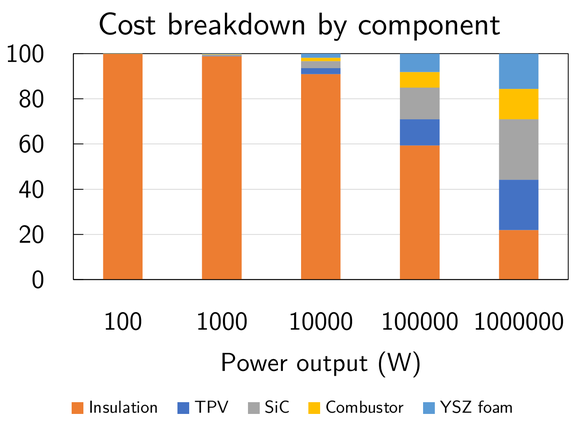
83% combustion efficiency while keeping all SiC surfaces below 1900C

95% recuperator effectiveness

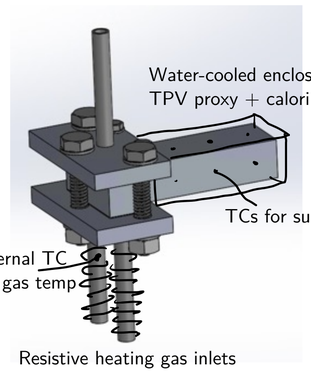


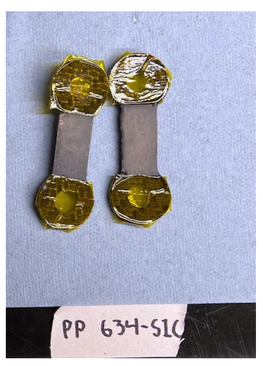
Technoeconomics demonstrate $0.3/W capital cost at large scales





Planned experiments to demonstrate performance





De-coupled combustion and TPV setups to demonstrate both combustion and TPV efficiencies

We have successfully additively manufactured a SiC combustor with high predicted efficiency

- **Existing combustion-TPV devices have low efficiency** because of high heat losses due to poor recuperation and insulation difficulties at small scales.
- **Our combustor** is designed with guiding principles that **maximize efficiency**, but require **intricate internal geometries**.
- **Additive manufacturing provides a cheap methodology** to fabricate these devices, enabling **capital costs less than that of gas turbines** at large scales.
- Our simulations predict a **combustion efficiency of 83%,** with experiments planned to verify this and determine overall efficiency (including TPV efficiency).

Acknowledgements and References

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