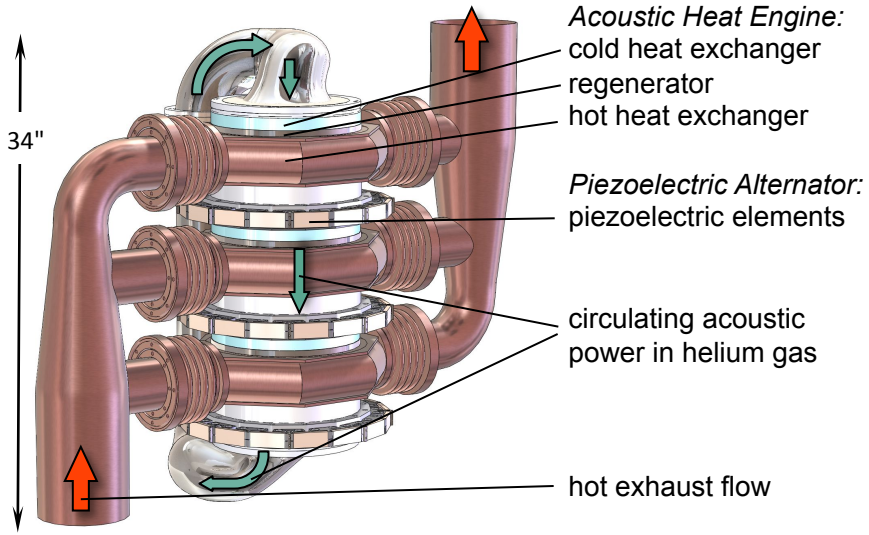
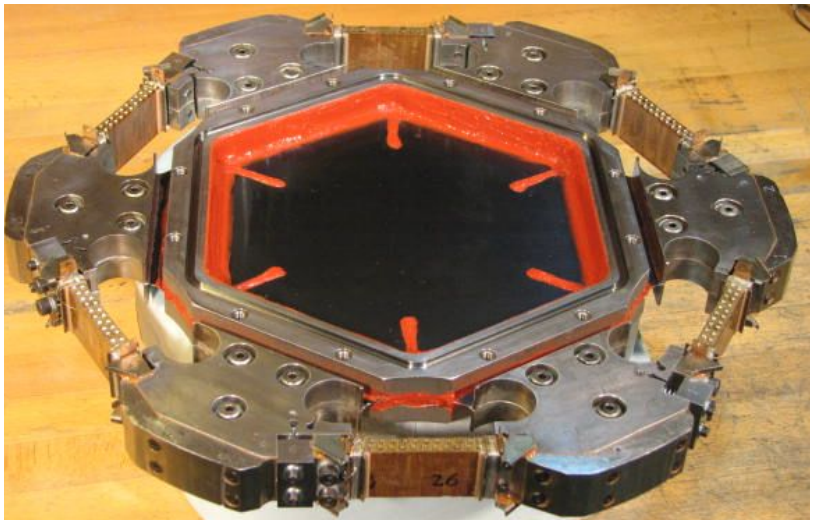
# Penn State Applied Research Lab "Sonic Joule"™




Flexible-diaphragm piezoelectric alternator:

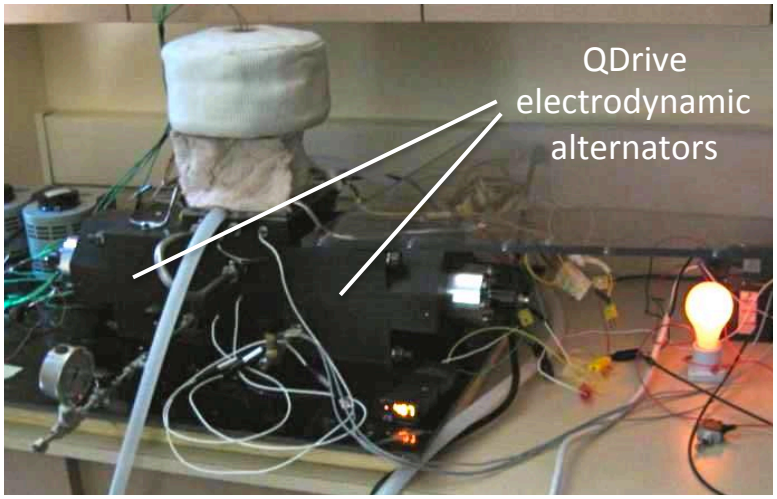


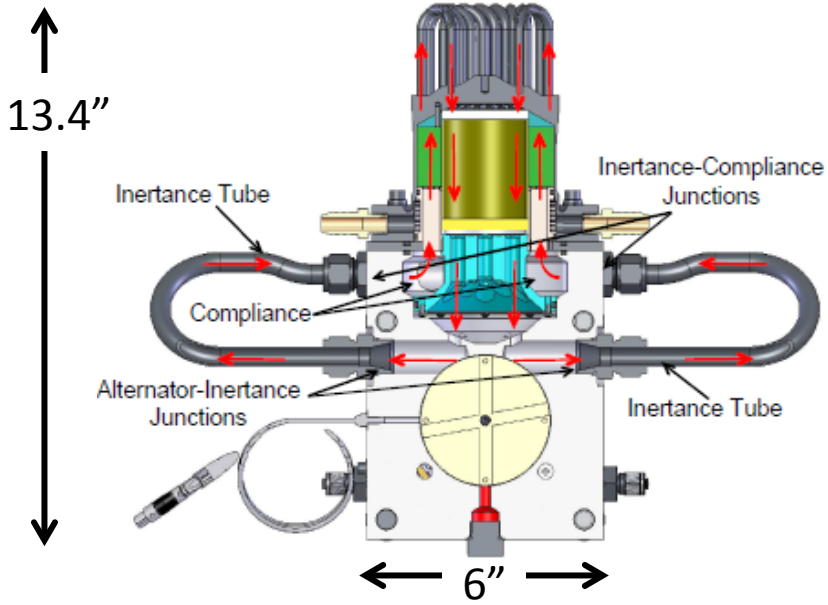
- Thermoacoustic-Stirling piezoelectric generator
- Compact, quiet, low-cost, robust, reliable

## Technical Details

- 1 kW–1 MW elec best range
- 100–350 W/kg (3–10 g/W)
- 30–1000 kW/m$^3$ (1–35 ml/W)
- 12%–22% efficiency (fuel to elec) (30%–45% of Carnot)
- Emissions are that of heat source
- Flexible inlet and exhaust temps, prime or intermediate in CHP
- No pistons, no internal wear—reliability of fans and pumps
- $1/W (less at high power) feasible
- Vibration balanced, nearly silent

# Chart Industries/QDrive "TaSEG"




- Thermoacoustic-Stirling Engine-Generator

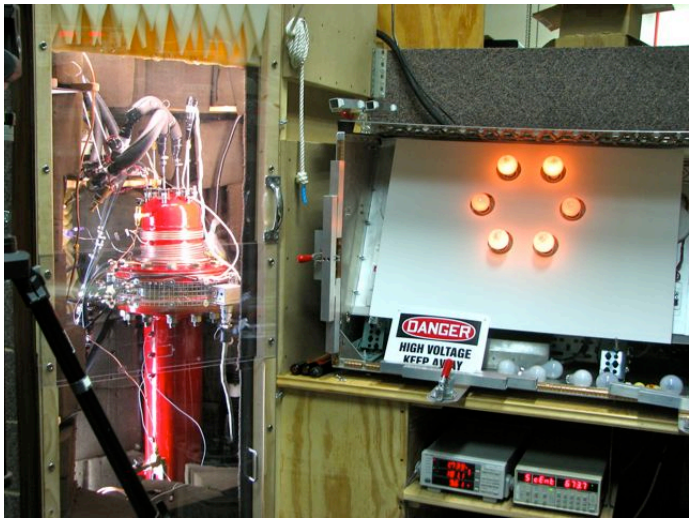
**Achieved Performance Details**

- Functional µCHP prototype
- Achieved 100 $W_{elec}$
- Support from well-known international industry leader
- Powered by external heat source
- 7% thermal to electric efficiency
- Low noise & vibration compared to Free Piston Stirling engine
- Prototype ≈ 80 lbs (3 W/kg)
- Operating temps appropriate for residential heating appliance
- No internal wearing parts
- Single unit labor & parts, $6K

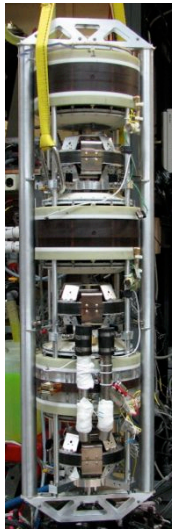
# Thermoacoustic CHP

## Development Needs

- Prototype development needed in 1 to 5 kW range
- Higher efficiency with heat exchanger and regenerator R&D
- Long durability (e.g. 5 years) should not be a problem
- Lower cost with heat exchanger, regen, and transducer R&D
- 1 to 5 kW range is feasible
- Main trade-offs are size vs efficiency, inlet temp vs material cost
- Cost, efficiency, and compactness important for residential use
- R&D for Design for Manufacturability is needed




Sonic Joule
Alpha Prototype
37 W at 110 V



ARPA-E BEETIT
Trillium chiller
3500 W at -29˚C