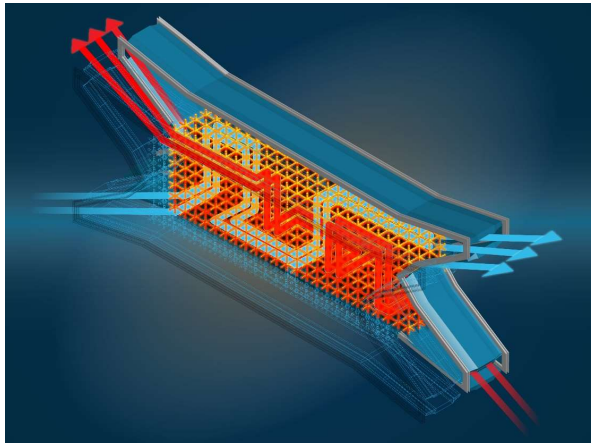
High Intensity Thermal Exchange through Materials and Manufacturing Processes – HITEMMP



Second Annual Program Review Meeting

March 30th, 2022 – Atlanta, GA

HITEMMP – ARPA-E's Team

Program Directors


Zak Fang


David Tew


Philseok Kim

Tech-to-Market Advisers


Rakesh Radhakrishnan


Max Tuttman

TechSETAs


Vivien Lecoustre


Ashok Gidwani


Pankaj Trivedi

Programmatic Support


Brenna Thorpe


Bryant Natsuhara


Max Zeitlin

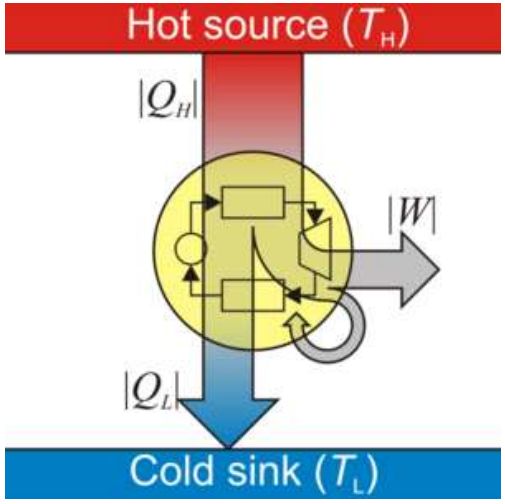
Meeting Planner


Nancy Hicks

arpa·e
CHANGING WHAT'S POSSIBLE

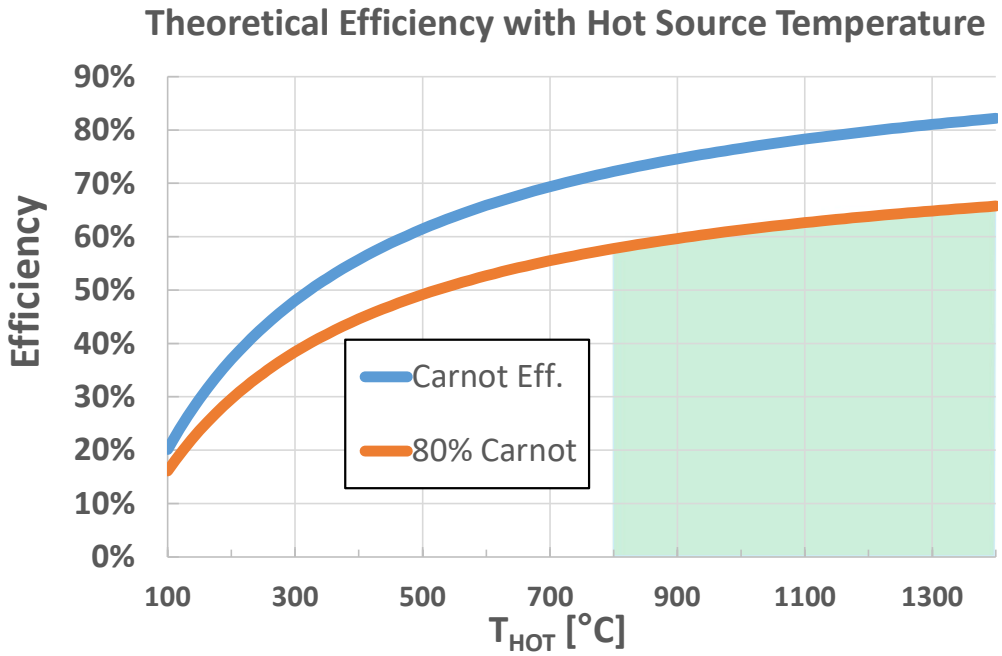
Initial Vision: Program Objectives

- **Compact power systems** (heat engine-based) at 2X the current efficiencies (fuel to power) and reduced footprint
- **High T (≥ 800°C), high P (≥ 100 bar), presently do not exist**



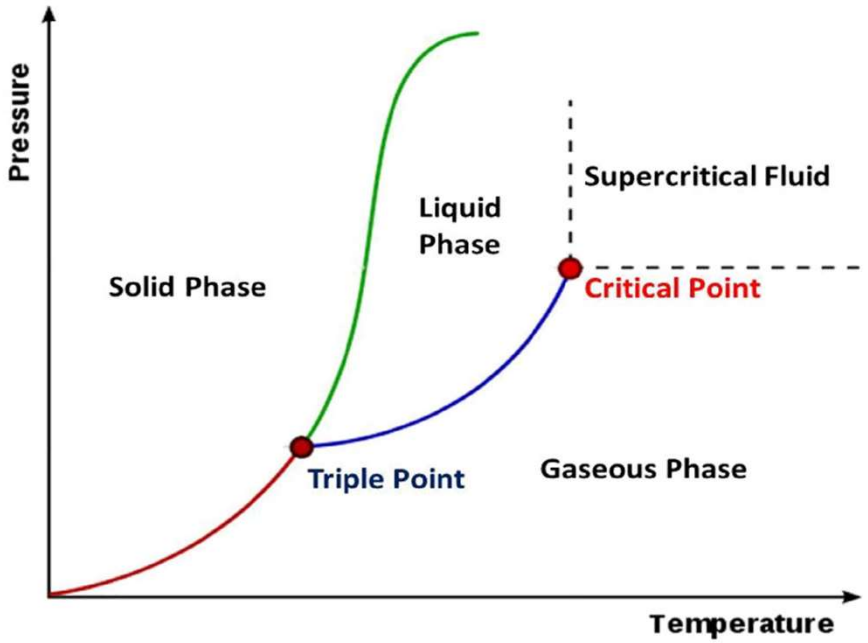
Carnot Efficiency:

$$\eta = 1 - \frac{T_{cold\ sink}}{T_{hot\ source}}$$

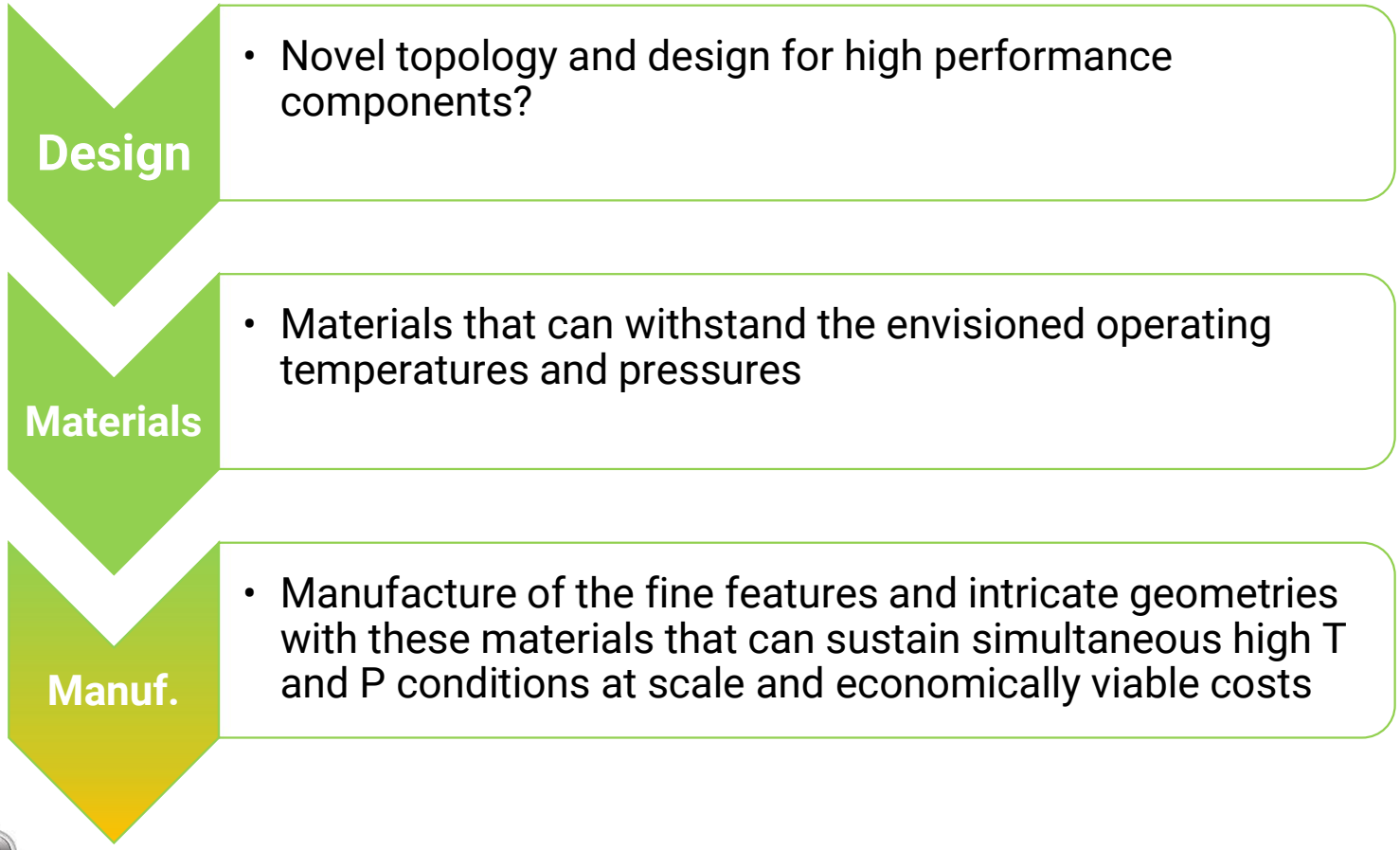


Initial Vision: Why Higher Pressures?

Higher pressures & use of supercritical fluids can substantially reduce component's size



Initial Vision (2022-Updated): Design, Materials, Manufacturing



Metallic-Based (Cat A) Projects

- **Materials used:**
  - *Haynes 282, Mar M247, AM303, IN740H, MHA3300, Haynes 214, Cermet*

- **Manufacturing processes:**
  - *Laser powder bed fusion (LPBF)*
  - *Diffusion Bonding*
  - *Brazing*
  - *Powder Metallurgy*
  - *Laser Welding*

Ceramic Based (Cat B) Projects

- **Materials**:
  - *SiC, ZrB_2, Al_2O_3, Glass fiber ceramic matrix composite*
- **Manufacturing processes:**
  - *Sintering based AM*
    - *Extrusion based 3D printing*
    - *Multiple co-Extrusion*

Preliminary Lessons Learned

- **Power density:** Good values for the power density (model)
- **Pressure drop:** Pressure drop not the main challenge (model)
- **Modeling:** Full simulations of 50 kWth prototypes are more challenging
- **Manufacturability:** Achievable, but at different degrees of maturity, printing speed critical
- **Durability:** Achievable. *Corrosion with sCO_2 is not a showstopper*
- **Cost:** the cost target are hard to meet ($2,000/UA for power generation and $5,000/UA for aviation)

Focus going forward

- **Fabricate prototypes and testing**

Thank you

U.S. DEPARTMENT OF
ENERGY

zak.fang@hq.doe.gov