Gen3CSP

BraytonEnergy

Bringing together *the* *people* *and the* *pieces* *for an* INTEGRATED CSP SYSTEM

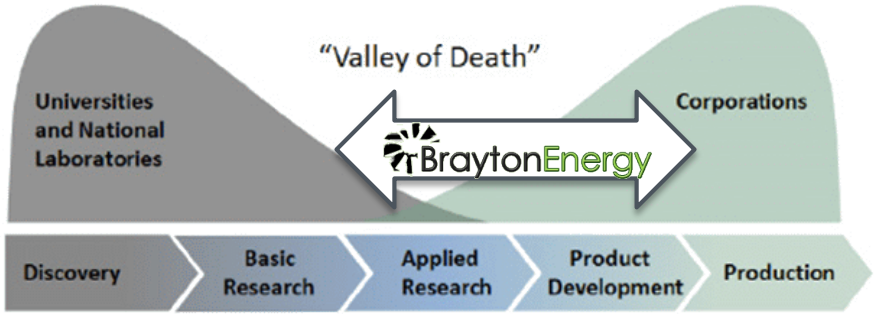
Innovations Enabling *a* Gen3 Gas-Phase Receiver

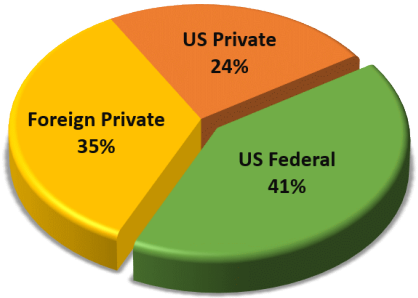
29 October 2020

Shaun Sullivan
Principal Investigator, Gen3 Gas Phase Renewables R&D Program Manager
sullivan@braytonenergy.com

Introduction • Receiver Tour • Flux Profiling • Emerging Materials • System Optimization

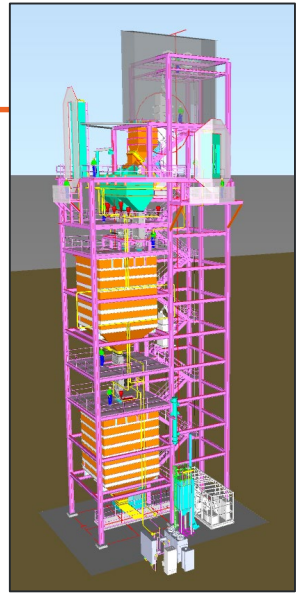
- Turbomachinery
- Compact Heat Exchangers
- Distributed Generation/CHP
- Concentrating Solar
- Alternative Fuels
- Energy Storage
- Hybrid Vehicles
- Nuclear
- Combustion
- UAVs





2019-2020

Gen3 Gas Phase System



- Develop a 100 MW_e commercial system that can absorb, store, and dispatch concentrated solar energy to a working fluid at conditions commensurate with an sCO_2 power cycle (700 °C, 25 MPa)
- Design a Megawatt-scale test facility to demonstrate and de-risk the technology innovations embodied in the commercial design

✓ Phase 1 (October 2018-December 2019)
  - System specification, design, modeling, analysis
- Phase 2 (January 2020-March 2021)
  - Component-level testing
  - Test facility design
- Phase 3 (October 2021-October 2024)
  - Test facility final design, construction, commissioning, operation, and testing

BraytonEnergy

BraytonEnergy

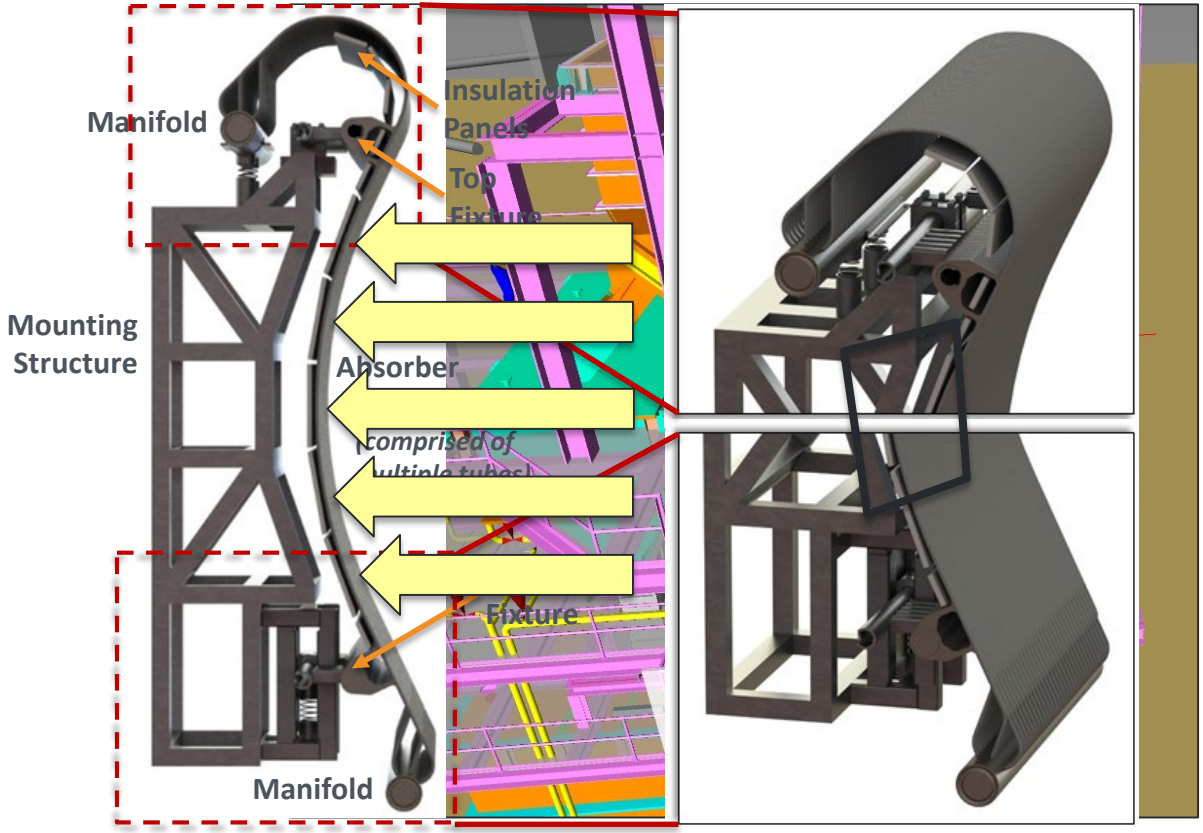
NREL NATIONAL RENEWABLE ENERGY LABORATORY · Worley energy | chemicals | resources · Advisian Worley Group

BrightSource · Colorado School of Mines · DLR · ECHOGEN power systems · EPRI

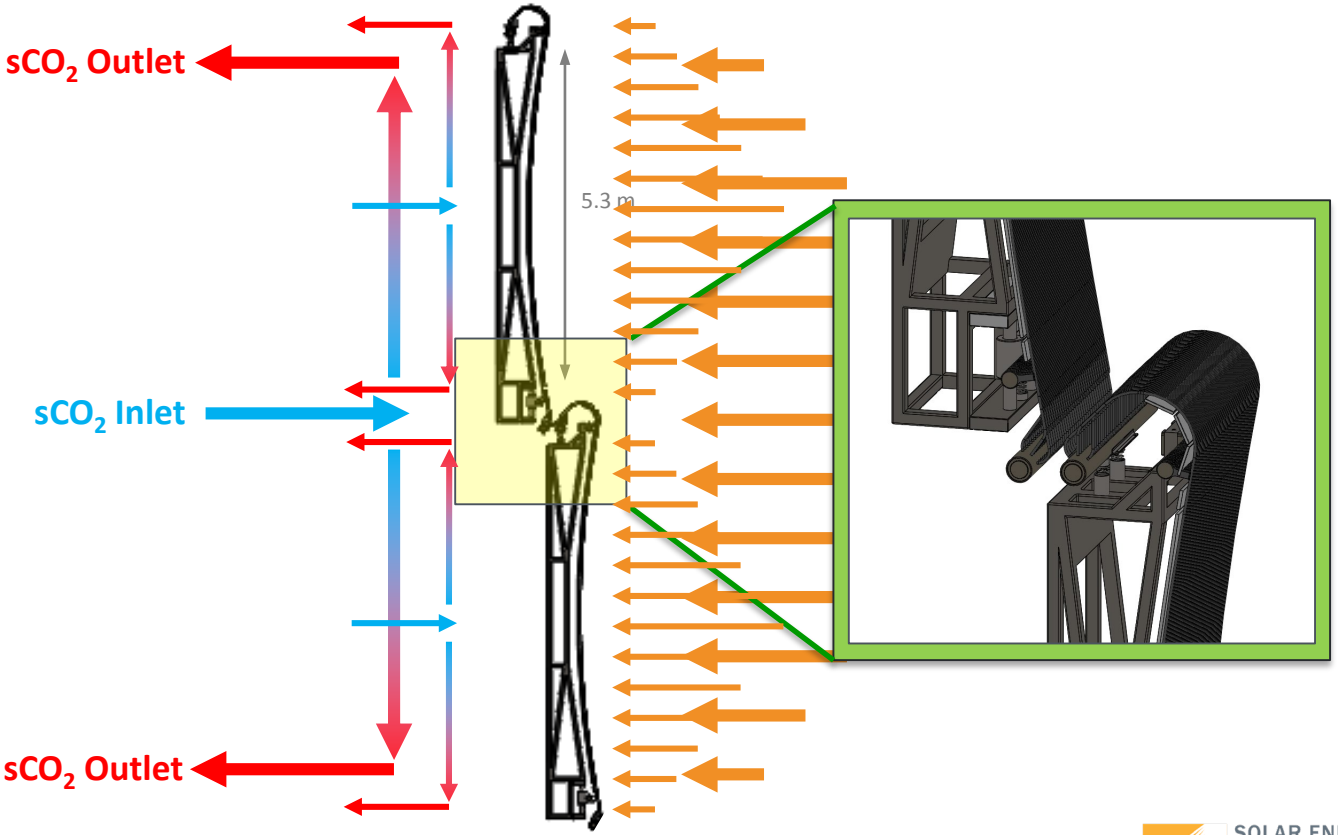
Greg Mehos Ph.D., P.E. · Heliogen · SolarDynamics · SolarTAC Technology Acceleration Center

SOLEX THERMAL SCIENCE · Southwest Solar Technology LLC · WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

A Quick Tour: Gen3 Gas Phase Receiver



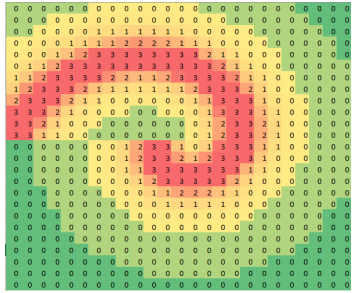
Maximizing the Utilization of Materials



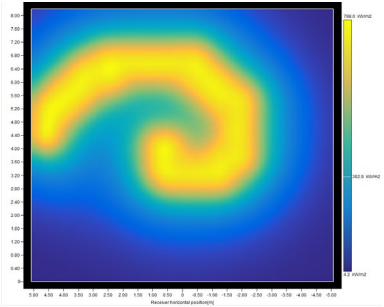
BraytonEnergy

Flux Profiling

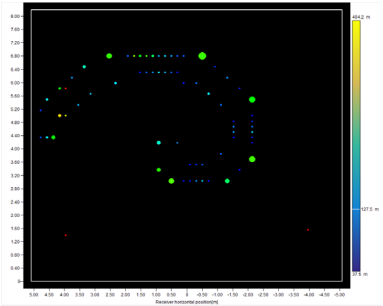
Desired (Prescribed) Flux

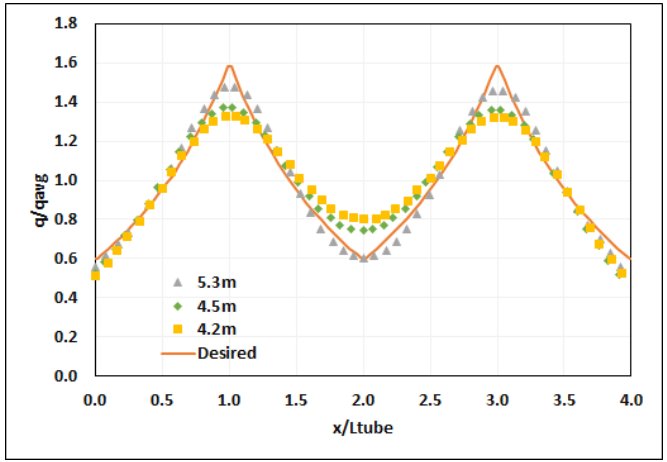


Simulated Flux



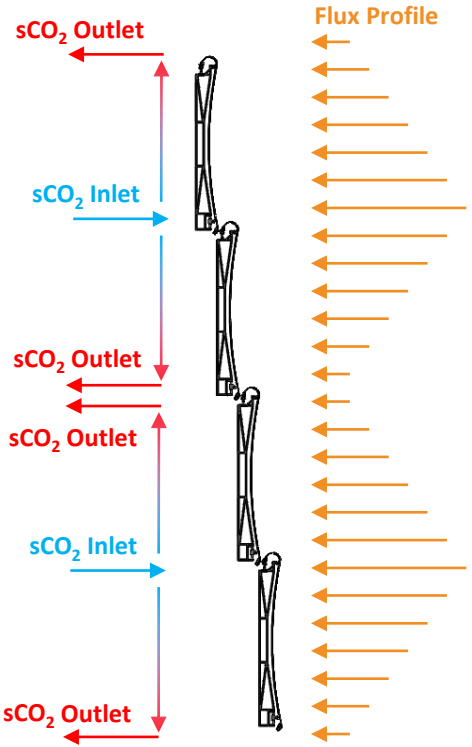
Aimpoints

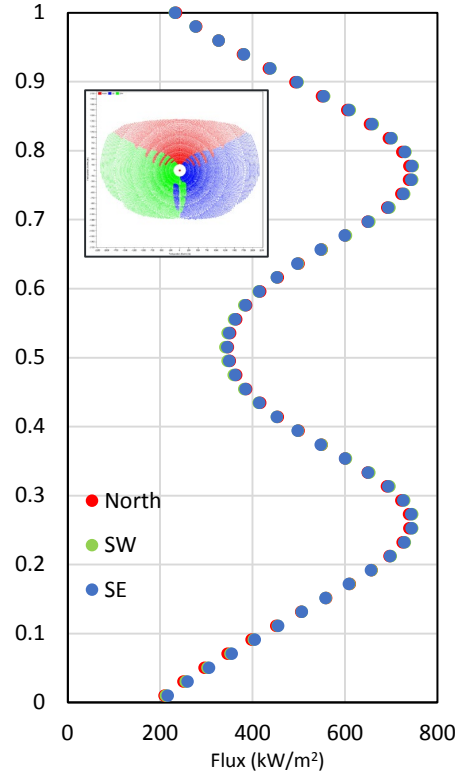


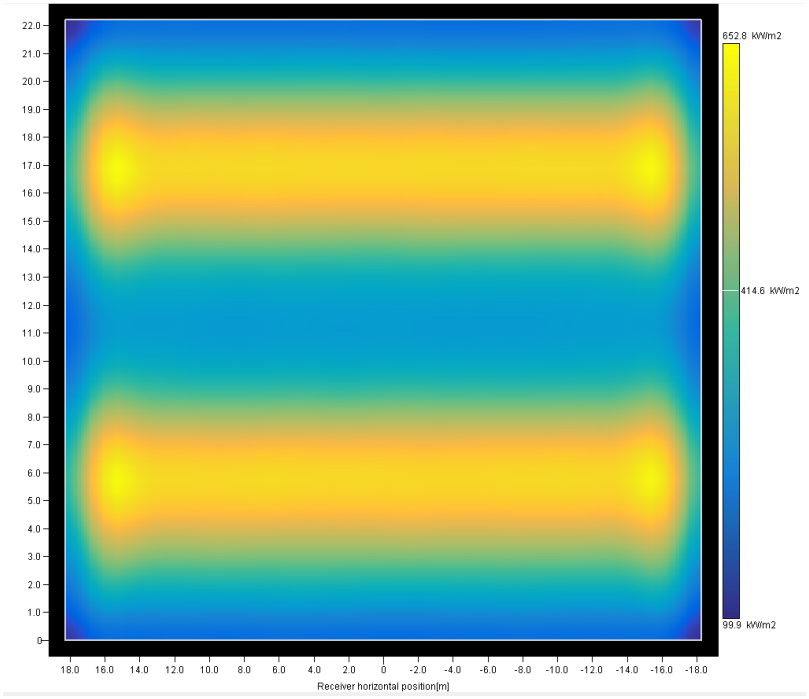


- Aim point selection incorporated into GEN3 system
  - Selection based on matching a prescribed user flux profile
- Ability to achieve desired flux profile depends on complexity of desired profile for:
  - Given heliostats (optical errors)
  - Receiver geometry
  - Field size

Innovative Heliostat Field Control

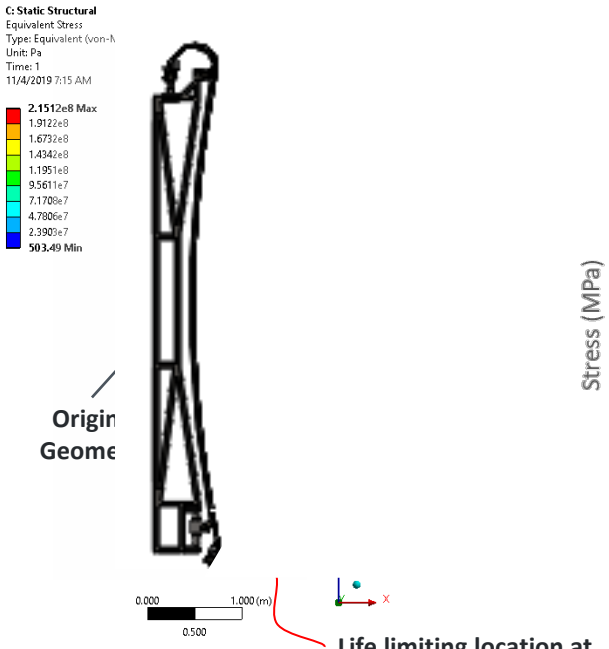


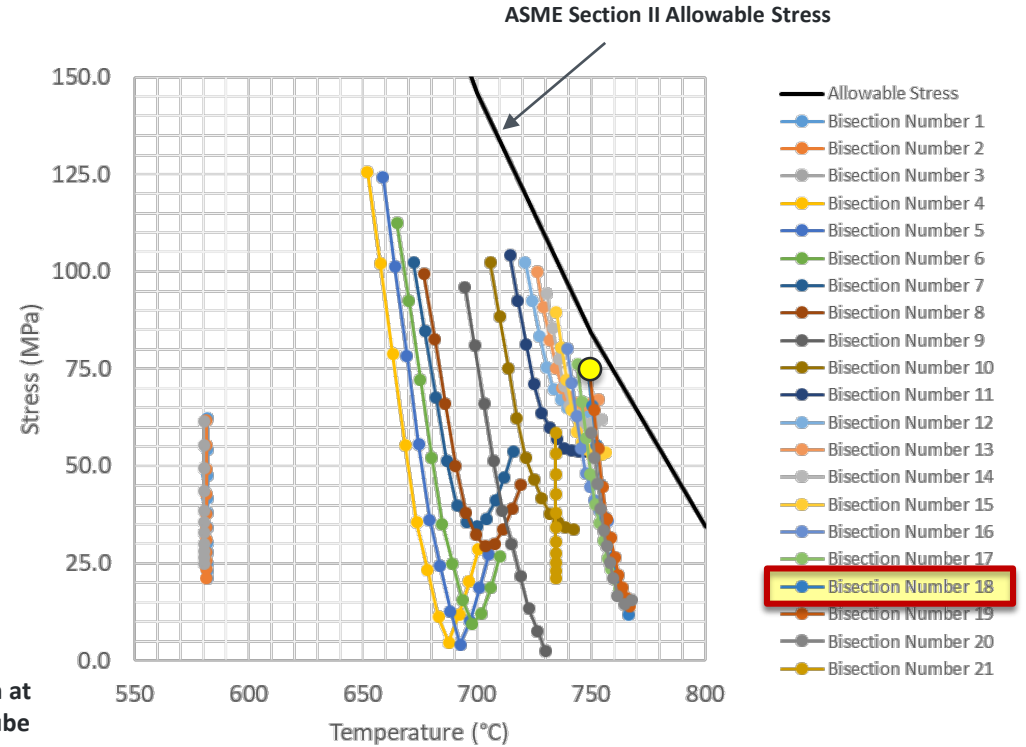




BraytonEnergy

Single Tube Structural Model Results

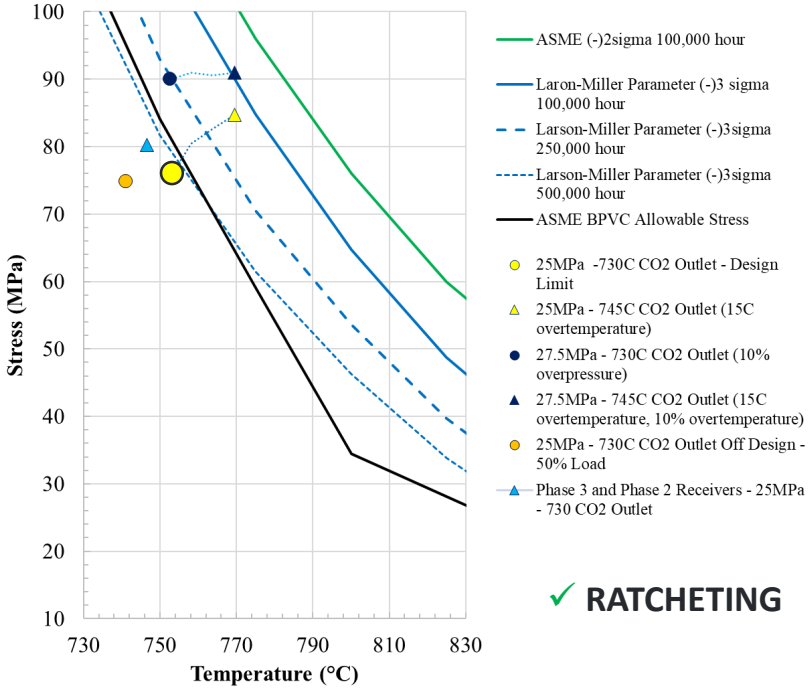




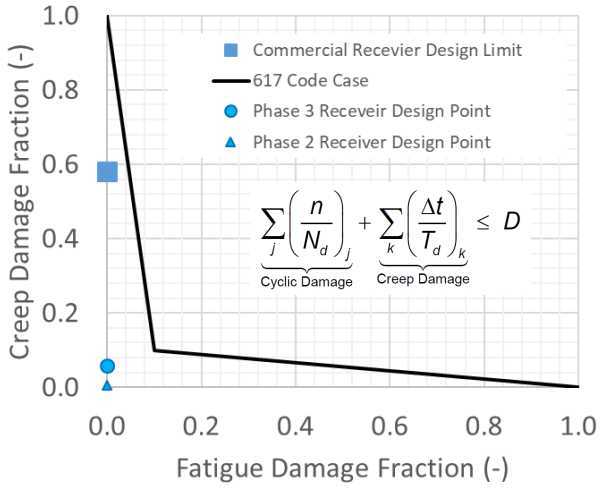
Receiver Life Results

✓ **PRIMARY LOAD** - Stress versus temperature

- *life limiting case*



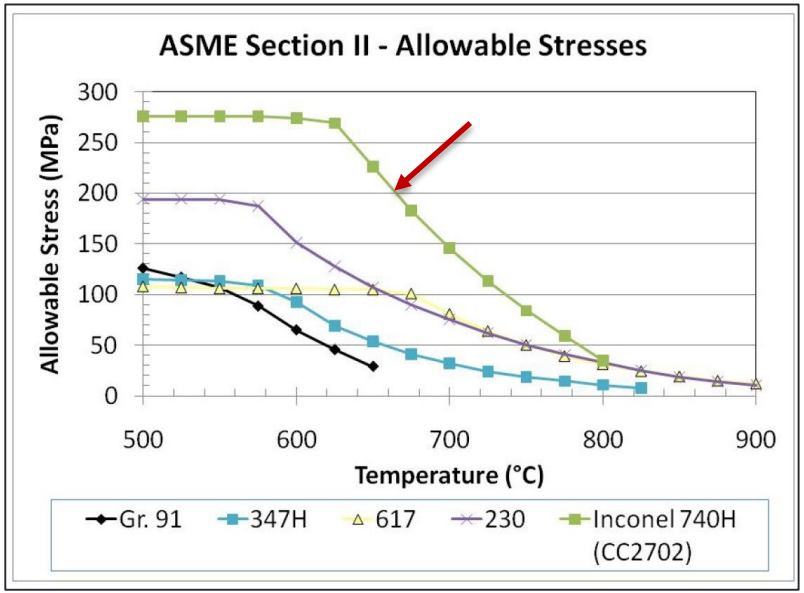
✓ **RATCHETING**

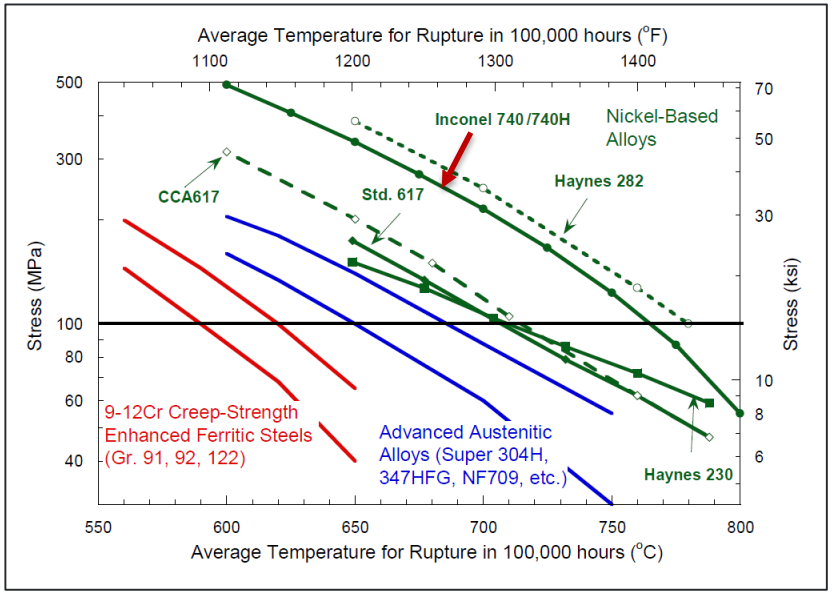


Parameter	Cycle Type 1 Start-up/ Shut-down	Cycle Type 2 Cloud Event
Elastic strain range, Δεe	0.000375	0.00019
Creep strain per cycle, Δεc	1.72987E-07	0
Total strain range, $\Delta\varepsilon_T$	0.00061	0.00002
Design Allowable Cycles, Nd	5.22E+13	2.10E+15
Design Cycles, n	10950	109500
Cycle Damage Fraction	2.10E-10	5.22E-11
Total Fatigue Damage Fraction	2.6198E-10	

✓ **CREEP-FATIGUE**

Special Metals In740H

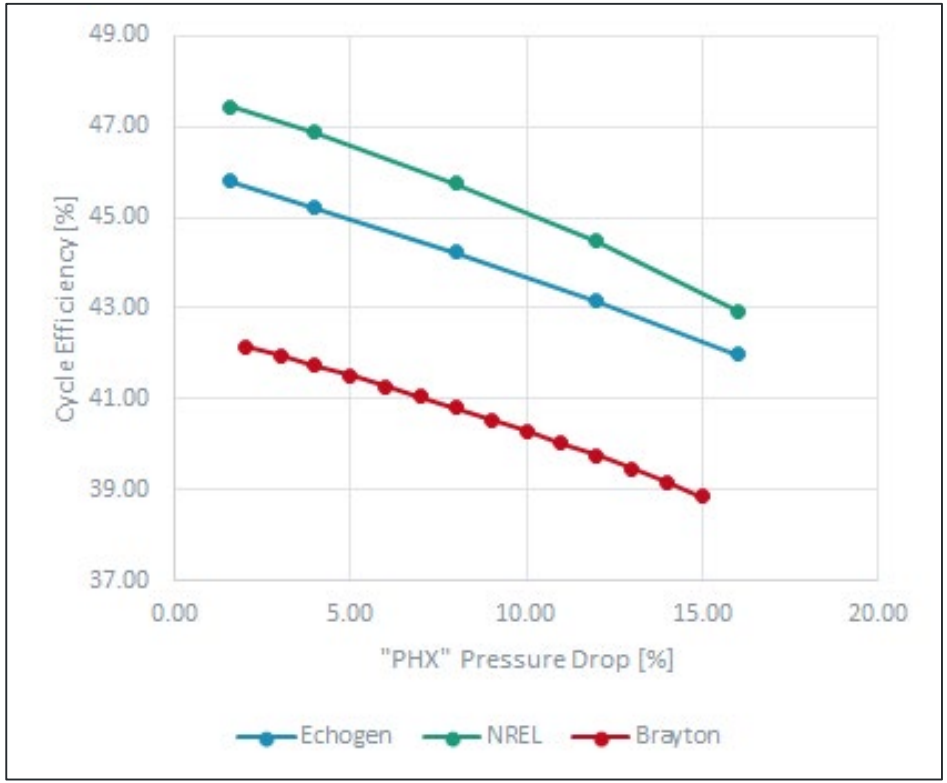




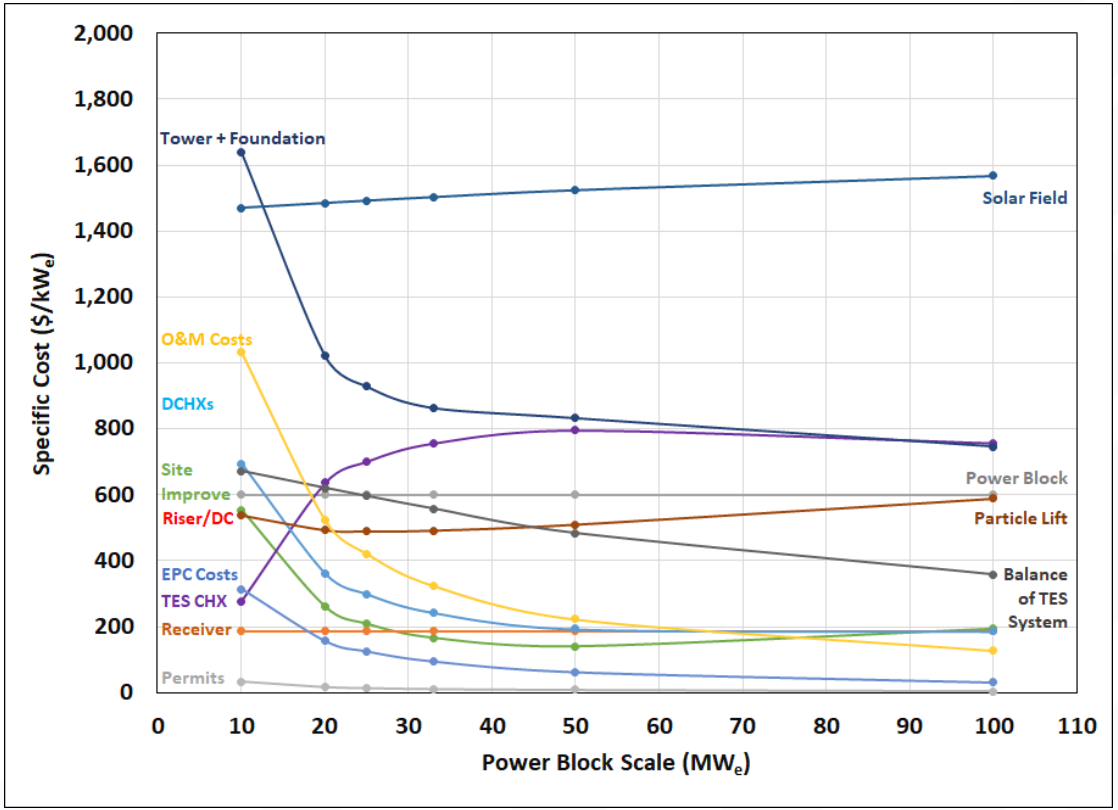
- *Receiver design entirely enabled by the advent of In740H*
  - *H282 is an even more promising prospect with active AM development, but is not yet code qualified*

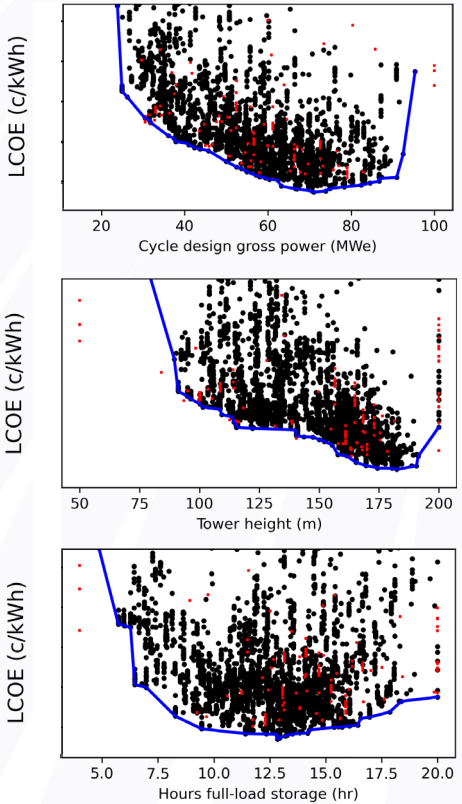
Integrated System Modeling

- The Gen3 Gas Phase leverages the baseload power block as the heat transfer fluid circulator during TES charging operation
  - Minimizes capital costs
  - Imposes a pressure drop penalty during on-sun operations
- Independent studies evaluated the impact of this pressure drop



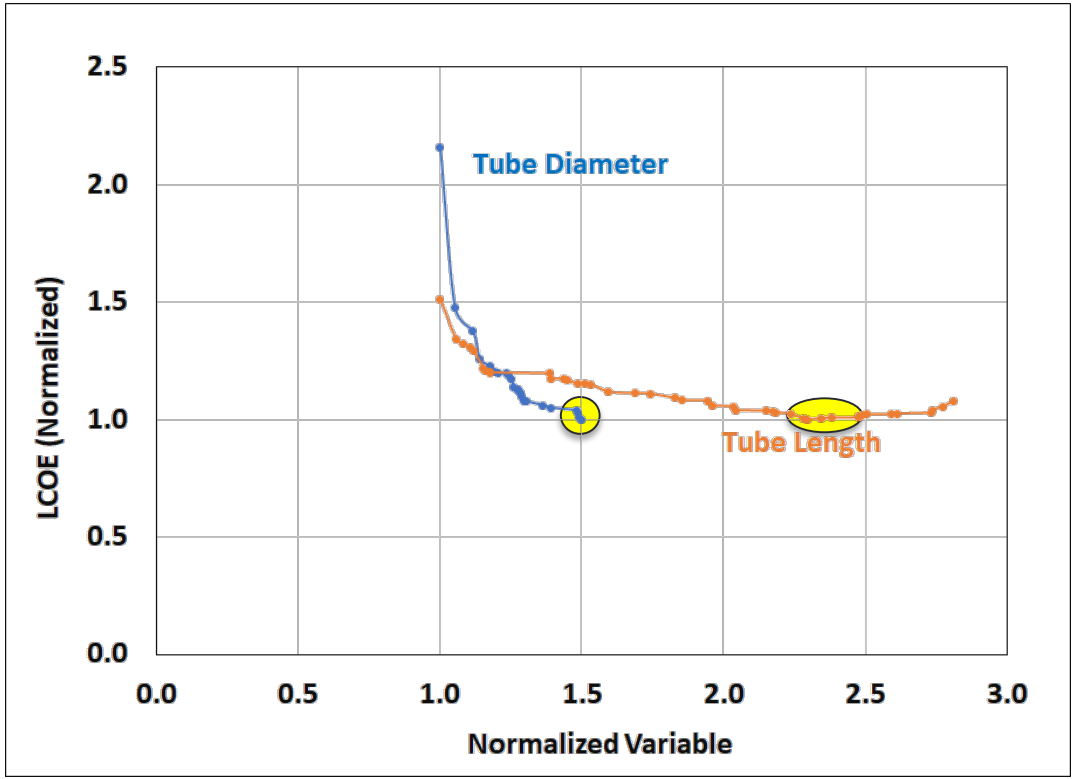
LCOE Optimization and Specific Cost Functions





Optimal *System* Design Accepts Elevated DP

- An integrated analysis that does not presuppose “foregone conclusions” can lead to non-intuitive results
  - i.e. LCOE is minimized by optimizing the power block around a high on-sun PHX DP/P, and allowing it to operate at low DP/P during off-sun hours
  - This strategy also enables system integration with AUSCS cycles, which are significantly less sensitive to PHX DP/P
- System stability demonstrated via detailed turbomachinery mapping and cycle analysis



BraytonEnergy

Shaun Sullivan
Principal Investigator, Gen3 Gas Phase
Renewables R&D Program Manager
sullivan@braytonenergy.com

Gen3CSP

Bringing together *the* *people* *and the* *pieces* *for an* INTEGRATED CSP SYSTEM

Thank You

We gratefully acknowledge the support and funding of the United States Department of Energy Office (via DE-EE0008368) without which this work would not have happened.