sCO$_2$ for WHR

Barriers to Entry and Help Needed
EPS100 & Dual rail WHR cycle

WHR cycle

- EPS100 first commercial-scale sCO₂ engine
- Advanced cycle architecture to deliver high efficiency heat recovery
sCO₂ vs steam

- Normalized to steam power & cost from GT-Pro, “power-optimized” solutions (“cost-optimized” point shown for reference)
- Same exhaust and boundary conditions used for sCO₂
- 10-20% lower cost for same power
- 7-14% higher power for same cost
LCOE comparisons

- Case studies covering 30-800+MW
- Plant LCOE consistently lower with sCO$_2$
Barriers to entry

- Technical risk
- Market driven economics
A simple LCOE analysis

- 2 cases
  - Simple (open) cycle gas turbine (SC)
  - Combined cycle gas turbine, with generic bottoming cycle (BC)
- Calculate an LCOE for SC by itself, and incremental LCOE for BC
LCOE inputs

\[ COE = (\beta \cdot C)/(P \cdot H) + f/\eta + OM/H + \mu \cdot OM(v,b) \]

where
- \(\beta\) = Levelized carrying charge factor or cost of money
- \(C\) = Total plant cost ($)
- \(H\) = Annual operating hours
- \(P\) = Net rated output (kW)
- \(f\) = Levelized fuel cost ($/kWh)
- \(\eta\) = Net rated efficiency of the combined-cycle plant (LHV)
- \(OM\) = Fixed O&M costs ($/kW-yr)
- \(OM(v,b)\) = Variable O&M costs for baseload operation ($/kWh)
- \(\mu\) = Maintenance cost escalation factor (1.0 for baseload operation)

**Assumptions:**
- Ignore O&M costs for now
- SC efficiency of 38% (range is 36-41%)
- 80% utilization
Breakeven LCOE

- SC LCOE has both capex and fuel costs
- BC LCOE has capex contribution only
- Below “breakeven” fuel cost, SC plant produces power at lower LCOE than CC plant

$SC \text{ cost} = \$1000/kW$

$BC \text{ cost} = \$3000/kW$
Current SC and BC costs

- From GTW Handbook & GT-Pro analysis
- 20-50MW class GTs (aeroderivatives) = $1000/$3000 per kW
- 100+MW class GTs (frames) = $550/$1300 per kW
Low natural gas prices, and 20-50MW GT scales make for a difficult value proposition
“Help needed”

- Higher natural gas prices would help... but not much control
- Need to make the jump to larger GT sizes
  - Financial risk mitigation needs reasonable (2-3 years) operation
  - 20-50MW commercial operation will require financial assistance (carbon credits, favorable PPA) to make economic-only value proposition work
  - Emphasize water-free operation, low O&M potential
  - Expand to target markets with either higher gas prices or applications with fundamentally different economics