Component Technology Maturity & Cost Of Electricity For SCO_2 Brayton Power Cycles In Nuclear, Solar & Fossil Heat Sources: Development Challenges And Mitigation Approaches

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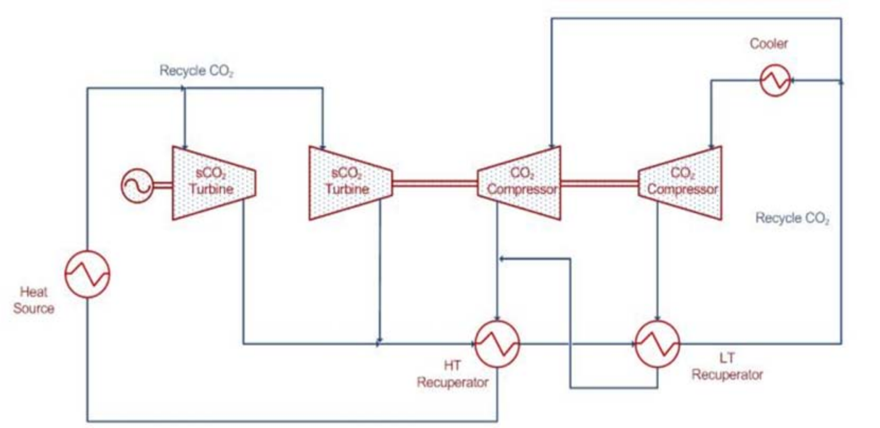
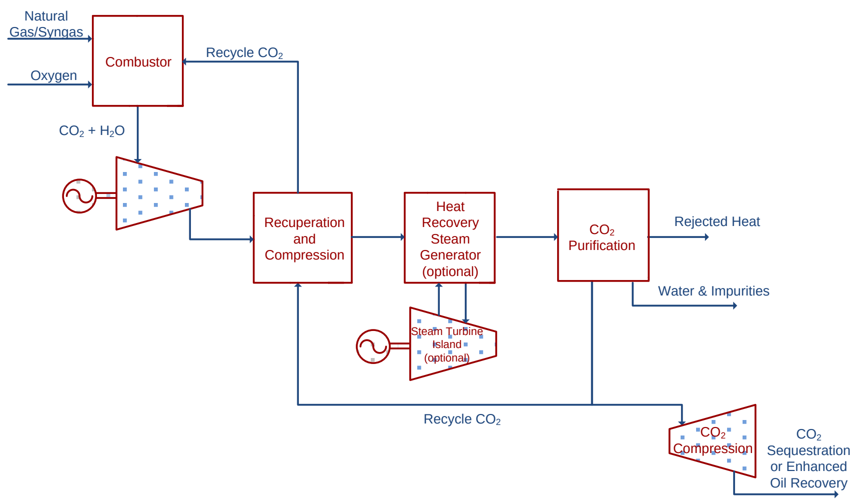
Introduction

- **Indirectly heated and directly heated sCO_2 based Brayton cycles are predicted to offer the potential of lower LCOE than current technologies**
- **Thermodynamic cycle efficiencies increase with peak cycle temperature, but these are limited by material capabilities**
- **Various cycle and component design approaches can be used to overcome these limitations**
- **These approaches decrease the potential efficiency gain of increasing turbine inlet temperature and/or increase the capital cost and complexity**
- **This paper presents predictions of the allowable increase in capital costs to maintain a reduction in LCOE as turbine inlet temperature is increased**

Cycles Evaluated

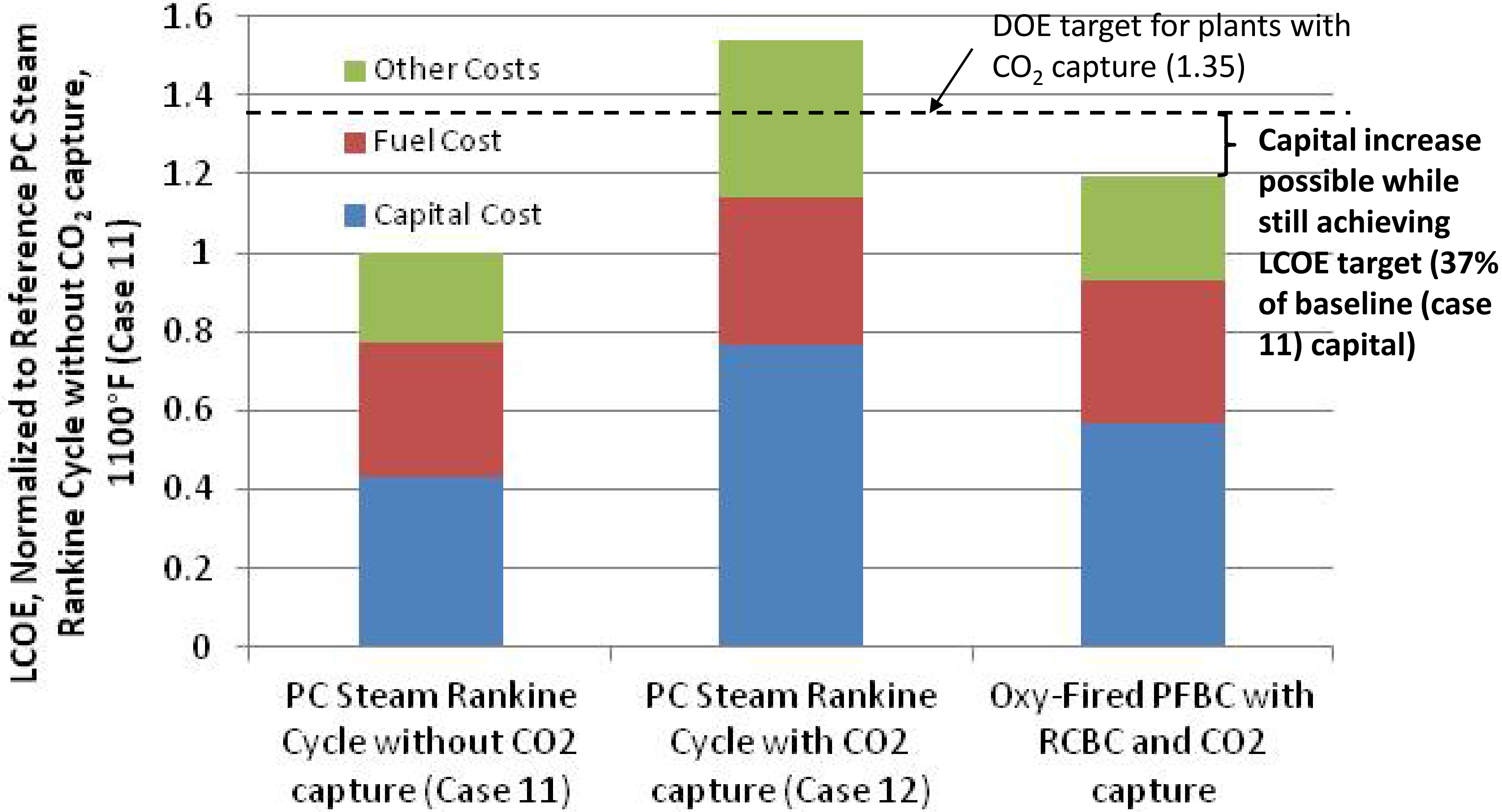


Indirectly Heated Fully Closed Recompression Brayton Cycle

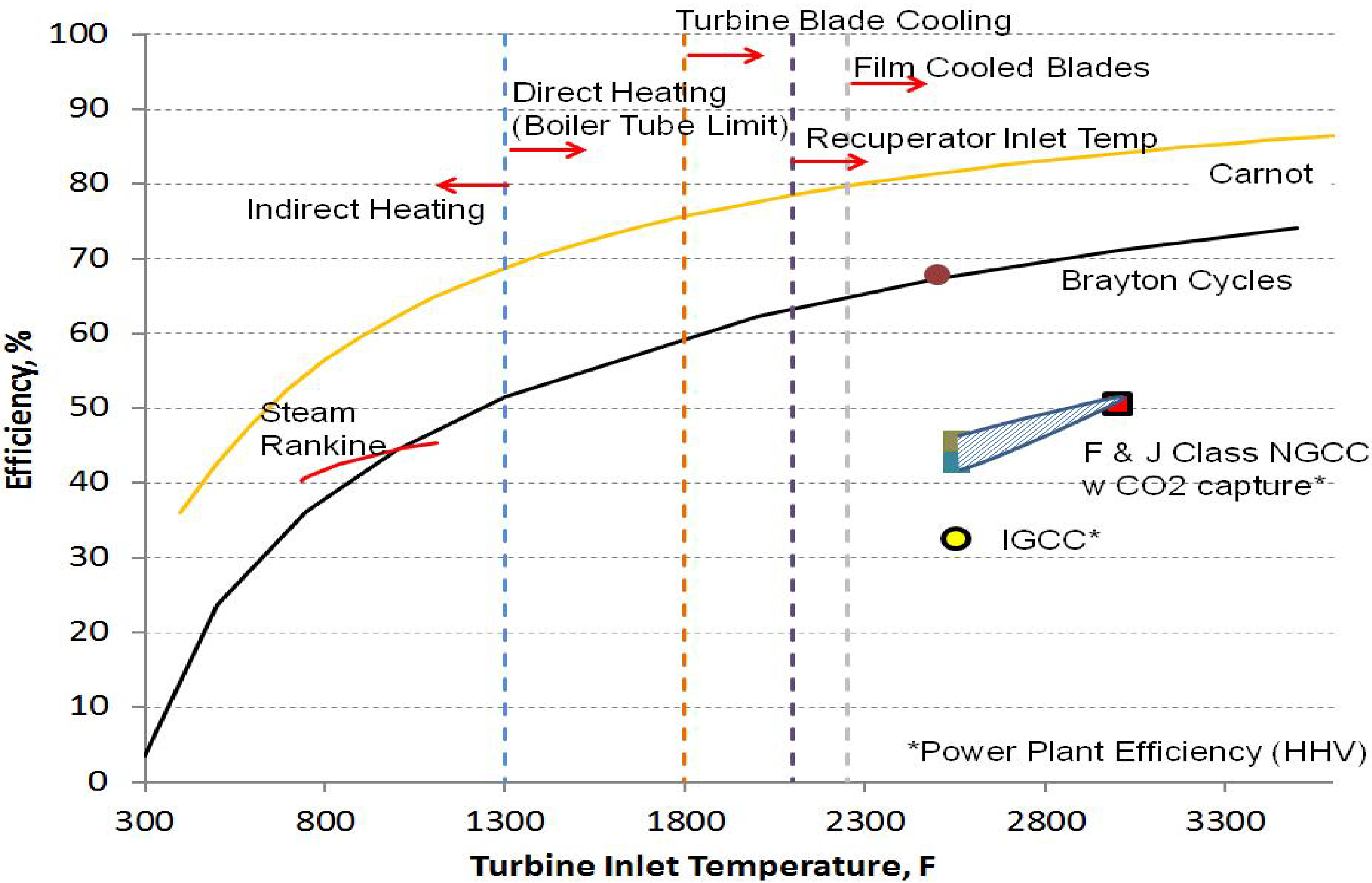


Directly Heated Brayton Cycle

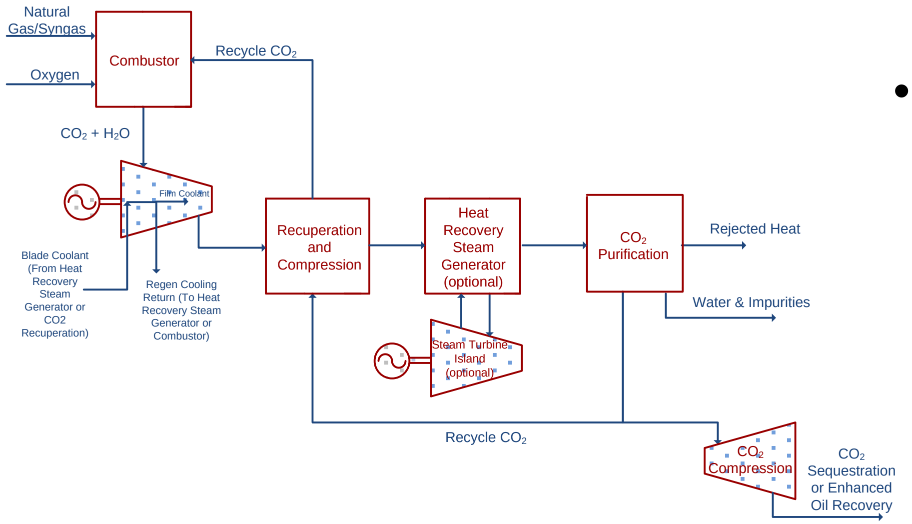
LCOE Predictions for Indirectly Heated Cycle

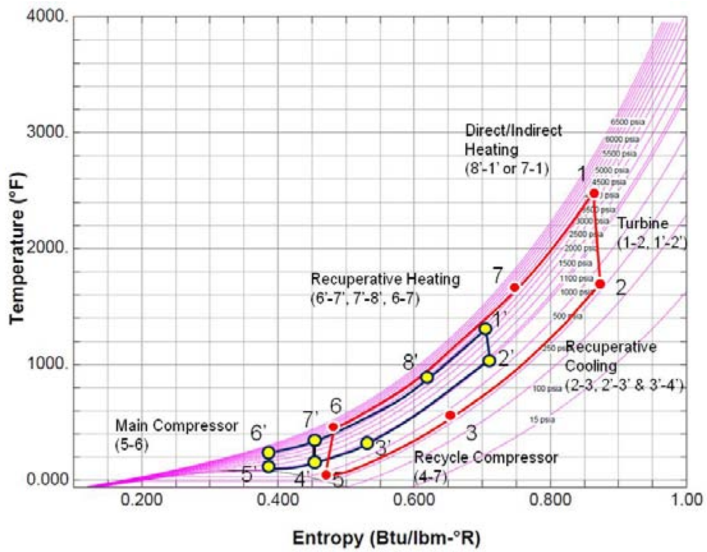


Temperature Limits for SCO_2 Brayton Cycles



Options to Mitigate Material Constraints





- **Turbine Blade Cooling Allows Increased Turbine Temperature**
  - Regenerative cooling provides for heat recovery elsewhere in the cycle
  - Film Cooling extends temperature range

- **Cycle adjustments reduce recuperator inlet temperature**
  - Compression load increases

Efficiency Penalty for the Approaches that Allow Increased Turbine Inlet temperature

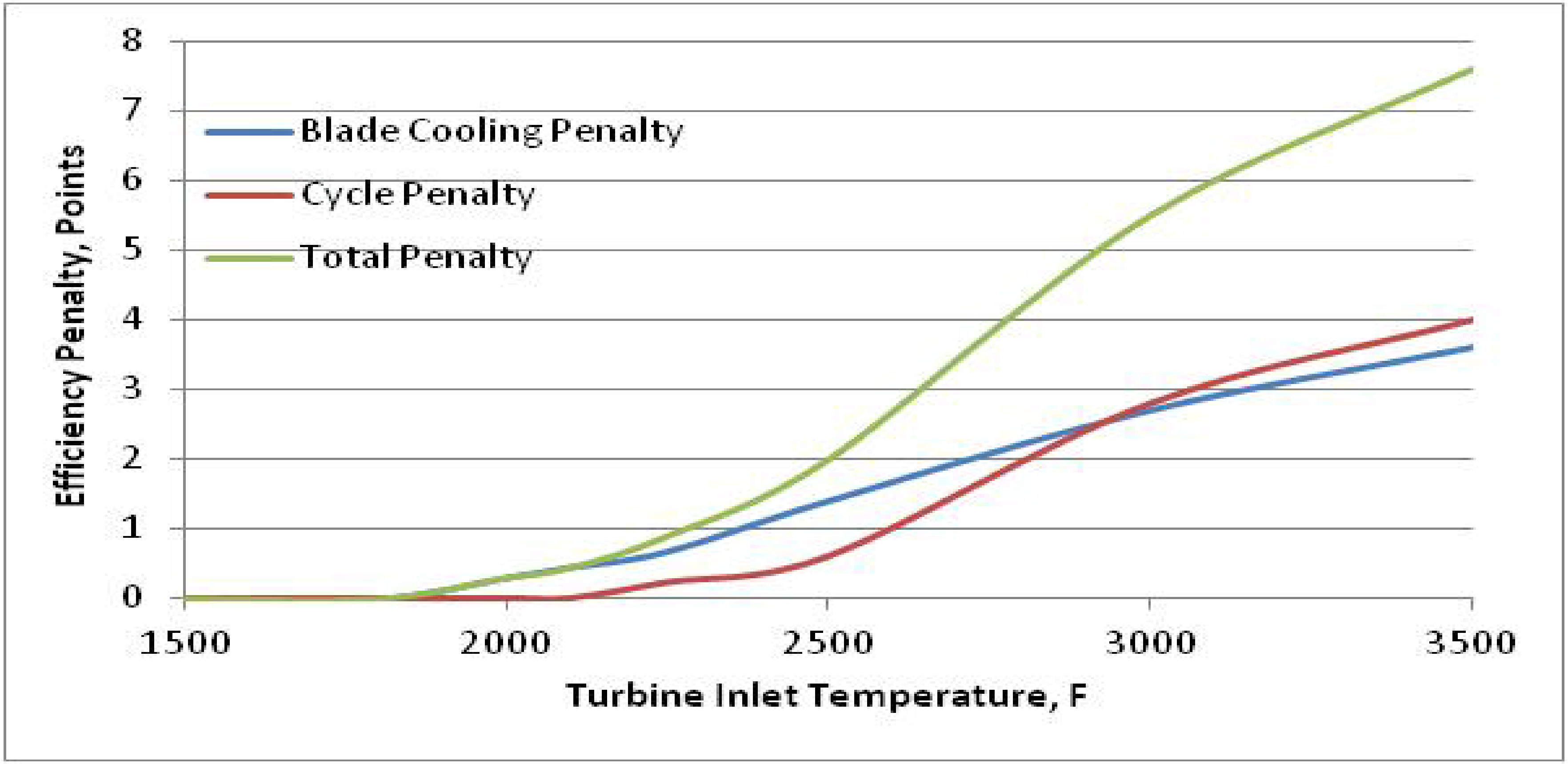
Blade Cooling Penalties

Providing the coolant flow, Heat extracted from the turbine not converted to shaft power

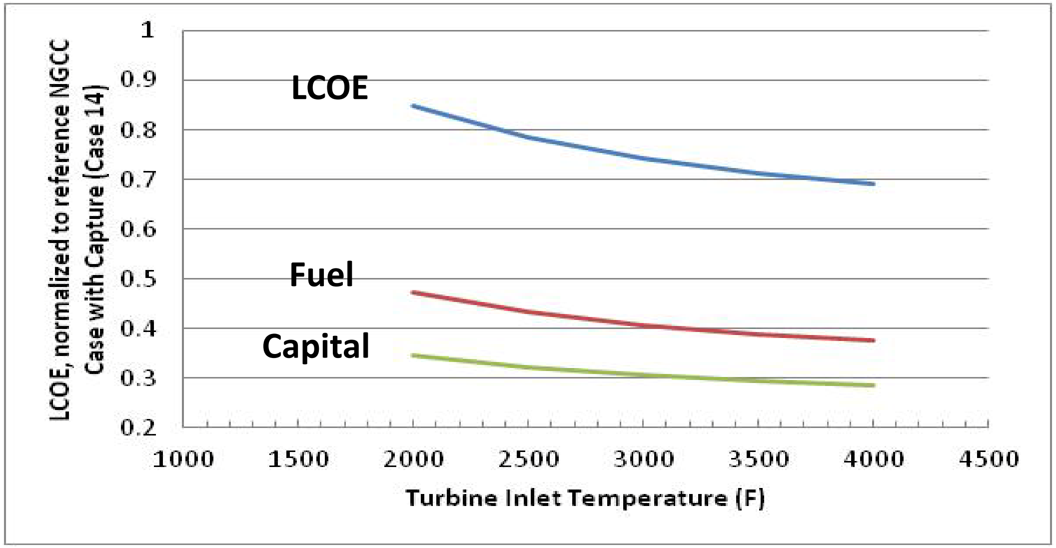
Film cooling – turbine aerodynamic efficiency decreased

Cycle Penalty

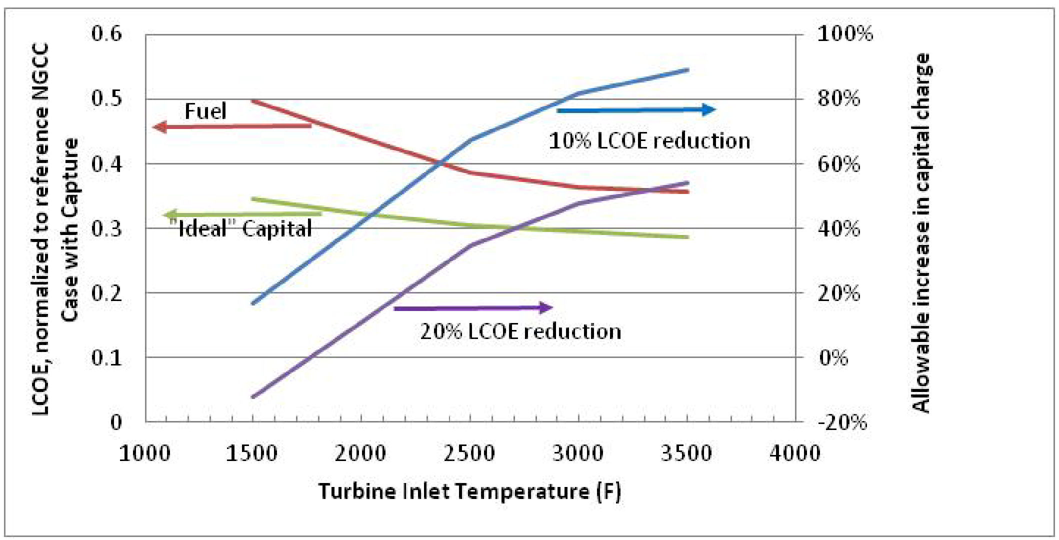
Compression load increased as cycle minimum pressure dropped below critical



LCOE Predictions for Direct Heated Cycles



Idealized LCOE predictions – no accounting made for efficiency penalties resulting from approaches incorporated to allow increased turbine inlet temperature



Allowable increase in capital to achieve target LCOE reductions – accounting for efficiency penalties

Conclusions

- **Brayton cycles are predicted to offer lower LCOE than current technology, especially when CO_2 capture is a consideration**
- **There is also an incentive to develop technologies that allow higher turbine inlet temperatures than those currently targeted for indirectly heated cycles**
  - LCOE reductions are still viable after taking into account the efficiency penalties and associated capital increase of providing methods to keep component metal temperatures within acceptable limits

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Questions ?

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