Solar boilers
Evolving issues with an evolving technology

May 14, 2012
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Risk Engineering
Introduction

- How is Concentrated Solar Power (CSP) used today
- What are the newest advances in CSP
- What are the emerging operational and code compliance issues associated with CSP
Introduction to CSP

Concentrated solar power

- Heliostats concentrate solar thermal energy onto a relatively small area
  - Parabolic trough
  - Linear reflector
  - Parabolic dish
  - Power tower

Power tower

- Higher output capacities
- Higher peak operating temperature
- Greater efficiency
A typical power tower arrangement consists of:
- Field(s) of heliostats
- Tower mounted receiver (adaptation of water tube boiler design)
- Steam turbine, for power producers
Design

- A typical power tower arrangement consists of
  - Field(s) of heliostats
    - Arrangement of mirrors automatically controlled to track the sun and focus the thermal energy on a point in space
A typical power tower arrangement consists of:

- Field(s) of heliostats
  - Arrangement of mirrors automatically controlled to track the sun and focus the thermal energy on a point in space
- Tower mounted receiver
  - Weight: 65 tons; height: 165 feet or higher
  - Adaptation of typical water tube boiler design
Return on investment

- Start-up capital is three times that of conventional power plant
- Operating costs are roughly equal
- No fuel costs
Operating conditions

- Desert climate
  - Advantages
    - Maximum availability of solar thermal energy
    - Minimum attenuation of solar thermal energy
  - Disadvantages
    - Wind conditions
    - Rapid loss of stored energy
    - Heliostat maintenance
Typical solar energy curve
Typical solar energy curve

Solar Energy

Generation of superheated steam
Sustainability concerns

- Heat-up/cool-down rate
  - Rapid heat-up during initial hours of sunlight risk exceeding allowable stress levels
  - Rapid cool-down due to convective heat loss

- Water chemistry
  - Experienced issues with
    - Heavy scaling on waterside
    - Oxygen corrosion

- Deaerator inefficiency
  - Unable to maintain operating temperature
  - Oxygen content of feedwater
  - Use of secondary gas-fired boiler may affect renewable energy status
Evaluation concerns

- Inspection and maintenance
  - Receiver (boiler) located on top of 200-foot or higher tower
  - Design may not be conducive to internal inspection
    - Internal critical due to water chemistry concerns
    - Use of Boroscopic examination for thorough internal inspection
  - Environmental factors may prohibit entrance into tower
  - Lockout/tagout procedure must include repositioning and de-energizing heliostat servo motors
    - Control often times at alternate location
Cloud & wind effect

Solar Energy

Cloud transient

Wind effect
Operational concerns

- Overcast skies render unit inoperable
- Cloud transient
  - Supplement loss of energy by additional heliostat focus
  - End of transient with numerous heliostats in view
  - Detection algorithm needed to prevent rapid overheating of receiver material at end of transient
- Heliostat control failure
  - Damage to structural surfaces
  - Trip position critical
Operational concerns

- Efficiency and maximum output
  - Cleanliness of heliostat surface
    - Maximize transfer of solar thermal energy
  - Minimizing the loss of stored energy
  - Molten salt to store thermal energy
    - Aid in maintaining DA operating temperature
    - Allow for longer daily production periods
Typical solar energy curve

Solar Energy

Solar Thermal Energy (w/m²), in thousands
Possible thermal energy curve (molten salt)

- Peak electrical demand
- Generation of superheated steam
Thank you

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