Simulation and Predictive Performance Modeling of Utility-Scale Central Receiver System Power Plants

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System components

Heliostat field
- Sun-tracking mirrors, reflect radiation to central receiver
- Current designs use 620 to 2,500 two-axis heliostats per tower
- Sizes range from 2m$^2$ to 120m$^2$
- Significant heliostat cost a limiting factor in plant size

Central receiver
- 115-150m (375-505ft) tall
- Operates under nearly 900 times the local solar flux
- Several possible configurations

*Top: A single heliostat at Solar II [2].
Right: The heliostat field is shown surrounding the central receiver tower at the Solar II plant in Barstow, CA [3]*

*The central receiver where radiation is absorbed. [1]*
Power Conversion

Power cycle
- Can be a Rankine or Brayton cycle
- Different designs operate anywhere from 250-800°C
- Interest in fossil-fuel hybridization to reduce investment risk
- Projection of 50-100 MWe per tower
- 10 MWe plants currently in operation

Thermal Storage
- Heat transfer fluid stored in insulated tanks
  - Generally molten salt, oil
- Available on demand during cloud cover, after sunset
- More storage means larger capacity factor
- With storage, Power Towers are an ideal candidate to supply electricity during peak use hours in the afternoon and just after sunset
Project Goals

- Develop an analytical simulation tool for TRNSYS
  - Simulate tower receiver behavior for multiple tower configurations
  - Maximize heliostat performance and optimize layout
  - Evaluate potential power cycles, operating conditions
  - Aid in assessing system performance based on local climate data
  - Determine potential economic viability of this technology on utility scale

- Project tools
  - Initial models constructed using EES
  - Implementation planned as a TRNSYS Type
  - Programming done using Fortran language

References
- Images retrieved from http://www.energylan.sandia.gov/photo/phsear2n.cfm?first=yes&programu=1:
  - [2] Photo ID: 909
  - [3] Photo ID: 2897
  - [4] Photo ID: 820