Current Status of Solar Thermal Power in California

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SDSU Energy Discussion Group
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Overview

- Technology Overview
- Previous & Existing Solar Thermal Installations
- State Policy and Regulations
- Environmental & Technical Challenges
- Upcoming & Planned Projects
- Research and Future Projects
Parabolic Trough

- Most common
- Single Axis Tracking
- Distributed Receiver
- Relatively lower concentrations, lower temperatures (350° C)

www.wikipedia.org
Linear Fresnel

- Single Axis Tracking
- Distributed Receiver
- Similar to Trough
  - Withstand higher winds
  - Flat mirrors

www.wikipedia.org
Central Tower Receiver

- Two Axis Tracking
- Central Receiver
- High concentrations, high temperatures
Parabolic Dish

- Two Axis Tracking
- Multiple Single-Point Receivers
- Modular, Scalable

www.stirlingenergy.com
Rankine Cycle

- Phase-Change Cycle
  - Requires condenser
- Closed Loop
Stirling Cycle

- Closed Loop
- Gas Phase
- Highest theoretical thermodynamic efficiency

www.powerfromthesun.net
Stirling Cycle Visualization

Animation of Free Piston Stirling Engine

nasa.gov
Brayton Cycle

- Open or Closed Loop
- Gas Phase
- Highest temperatures

www.powerfromthesun.net
Previous & Existing Solar Thermal in California

- Solar One 10 MW (1982-1986)
- Solar Two 10 MW (1996-1999)
- Sierra Sun Tower - eSolar 5MW (2009)
Existing Capacity

- 411 MW Peak Solar Production (PV?)
- Total Electricity use peak ~15-19h
California Regulations

• SB 1078 – Renewable Electricity Portfolio (2002)
  – 20% from renewable sources by 2010
  – 33% by 2020 (updated 2008)
  – Investor Owned Utilities Only
  – SCE : 17%   PG&E: 14.4%   SDG&E: 6%
  – LA DWP: 20%   SMUD: 23% (targets for 2010)

• AB 32 – Emissions Reductions (2006)
  – Reduce greenhouse gas emissions to 1990 levels by 2020

• Proposition 23
  – Repeals AB 32 (until 4 quarters of 5.5% unemployment)
Environmental Challenges

• Environmental Impact
  – Land use approval
    • State – California Energy Commission
    • Federal – Bureau of Land Management
  – Wildlife (Desert tortoise)

• Water use
  – Dry vs. Wet Thermodynamic cycle condenser
  – Working Fluid
  – Mirror washing
Technical Challenges

• Thermal Storage
  – Shifts production to peak load times
  – Improves stability
• Plant Efficiency
• Proximity to Existing Transmission
Planned Projects

- ~400 MW Existing Capacity
- 2829 MW Approved by CA energy commission
- 1750 MW Waiting Approval
- ~4.5 Million Tons of CO$_2$/yr saved
- Trough, Tower, & Dish Concentrators
- Rankine and Stirling Cycles
Additional Annual Capacity of New Solar Thermal Plants

Year

Power - [MW]
Solar Millennium

- 1000 MW Approved
- 500 & 250 MW Waiting
- Largest solar plant in the world
- Trough
- Dry-cooling
- 2010 – Construction
- 2013 – On-line
- 1.5 million tons of CO$_2$/yr saved

www.solarmillennium.de
Brightsource

- 370 MW Approved
- Central Receiver
- 550° C, 160 bar steam
- 2600 MW of power purchase agreements with PG&E and SCE, 14 plants
- Dry-cooling
- Construction begins now
- 2013 – On-line
- 400 kilotons of CO₂/yr saved

www.brightsourceenergy.com
Solar Reserve

- 150 MW Waiting
- Central Receiver
- Integrated Thermal Storage
- 550° C Molten Salt
- Dry cooling
- Private land

www.solar-reserve.com
Stirling Energy Systems

- 709 MW Approved, 850 MW Waiting
- Parabolic Dish
- 25 kW each
- Hydrogen working fluid
- No Storage
- Minimal water use
- 2010 – Construction
- 2011 – On-line
Abengoa

- 250 MW Approved
- 370° C Steam
- 2013 – On-line
- 431 kilotons of CO₂/yr saved

www.abengoa.com
Timeline of Plant Construction – Brightsource

- 2006 – Brightsource Energy founded
- 9/2007 – Filed Application for Construction w/CA (first since 1989)
- 4/2008 – Power Purchase Agreement w/PG&E
- 10/2008 – Contract with Siemens for Turbine
- 2/2009 – PPA w/SCE
- 12/2009 – Labor agreement for construction
- 2/2010 – Proposed reduced footprint for environmental impact
- 2/2010 – Federal loan guarantees secured
- 8/2010 – CA Energy Commission recommends approval
- 8/2010 – US BLM issues final environmental impact statement
- 9/2010 – CA Energy Commission licenses plant
- 10/2010 – US BLM approves project
Future Research and Projects Impact

- Brayton Cycle, Air-cooled receive
- Direct to steam in parabolic troughs
- Direct to salt in parabolic troughs
- Storage systems
- Costs
  - Currently $5.00-6.50 /Watt installed
- Jobs
  - 500-1000 construction per plant
  - 50-100 operation per plant