Solar cooling systems utilizing concentrating solar collectors - An overview

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San Francisco, 9-11/7/2012
Structure

- Concept
- Practical benefits
- Common design issues
- Recent installations:
  - Examples
  - Classification
- Electrical SEER
- Conclusion
Concept

- Increasing driving temperatures \( T_H \) can lead to:
  - Higher thermal COPs \( \frac{Q_L}{Q_H} \)
  - Higher temperature lifts (refrigeration)
  - Higher irreversibilities

\[
COP = f_{Carnot} \frac{T_L}{T_H} \frac{T_H - T_M}{T_M - T_L}
\]
Practical benefits

- Higher COP $\Rightarrow$ Less heat input at generator
  - Less collector area per unit of cooling (kW)
  - Smaller HRD, less parasitic energy
- Decrease in $T_L$ $\Rightarrow$ refrigeration with high temperature lifts
- Decrease in $f_{\text{Carnot}}$ $\Rightarrow$ lower parasitic energy in heat rejection, dry cooling

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HRD
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SCF
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TDC
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1 + \text{COP}^{-1}
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1
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DE
LiBr H2O wet cooled
SE GAX H2O NH3 dry cooled
Common design issues

- Common design issues (besides the selection of a suitable chiller type)
  - Concentrating collectors
  - Heat transfer fluid (HTF)
  - Heat storage Vs direct coupling
  - Hot Vs Cold backup

Collector | HTF | Storage | Backup
--- | --- | --- | ---
stationary or sun tracking reflectors (PTC, Fresnel) | water | pressurized or atmospheric tank or direct coupling cold storage | Hot or cold backup
steam | oil
Recent installations

- First demonstration in 1878
- Prototypes: 1950 ÷ 1990
- New growth starting with 2004...

DE LiBr water

SE water ammonia
Recent installations

- Solar air conditioning (Dalman / Turkey - Hotel)
  - PTC collectors 360 m²
  - Cold backup

- Cooling tower:
  - 27°C to 35°C
  - 7°C to 12°C
  - 140 kW

- Steam generator:
  - 150°C to 170°C

- Double effect LiBr water:
  - 4÷7 bar
  - 7°C

- AC:
Recent installations

- Solar industrial refrigeration (Grombalia / Tunisia - Winery)
  - Fresnel collector 88 m²
  - Driving temperature range: 180 ÷ 160 °C (press. water)
  - Brine temperature range: -10 ÷ -5 °C
  - Air cooled water ammonia GAX chiller (12 kW) + Cold backup
Recent installations

- Classification (based on existing installations)

- Heat transfer fluid: pressurized water in nearly all plants
Electrical SEER

- Expected SEER (theoretical, assuming correct design and control)
Conclusion

- Practical benefits deriving from higher driving temperatures in TDC applications: lower collector area, lower parasitic consumption, refrigeration with high temperature lift, dry instead of wet cooling
- Increasing number of installations using medium temperature collectors, both PTC and Fresnel, growing since 2004
- The concept has been effectively applied: SE dry cooled for AC or R, DE wet cooled for AC only
- Limited choice of market available chillers suitable for the considered applications
- Potentially attractive SEER in all applications, assuming correct design and control
Thank you for your attention!