Nonimaging Optics for Solar Thermal Power
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Roland Winston
Schools of Engineering & Natural Sciences
The University of California, Merced
Can a Stationary Solar Concentrator Exist?

- $C_{\text{parabolic trough}} \leq \frac{1}{\pi \sin 30^0} \ll 1!$ (NO)
- $C_{\text{nature}} = \frac{1}{\sin 30^0} = 2!$ (Yes)
- A factor 2 is significant for thermal conversion permitting $T = 200^0 \text{C}$
- For PV conversion, $C$ is boosted by index of refraction (say, $n=1.5$)
- $C=3-4$ for fixed concentrators
- For tracking concentrators $C$ can be 100,000!
Flat plate collectors are limited to temperatures below 100°C.
Engine 26 Fire House in Chicago
Potential for Concentrating Solar Thermal

- **Viable replacement for electricity & natural gas**
  - *Electricity & natural gas demand increasing*
  - *Natural gas supply and cost increasingly uncertain*

- **Technical innovation promises substantial cost reduction**
  - *Overseas technologies demonstrating cost effectiveness*
  - *Improved fabrication technologies*

- **Flexible & distributed energy source**
  - *Heat (up to 200°C non-tracking)*
  - *Cold*
  - *Power*
Applications for Concentrating Solar Thermal

• **Industrial**
  – *Process industries*
  – *Chemical industry*
  – *Electronics industry*

• **Agricultural**
  – *Food processing & refrigeration*
  – *Water treatment and desalination*

• **Commercial**
  – *Space heating and cooling*
  – *Reliable/renewable/independent power*
Cost Estimate
Concentrating Solar Thermal

• Capital investment: $8/sqft = $86/m²
• Annual solar insolation in CA: 5.5 kWh/(m²*day)
• Conversion efficiency: 50%
• Heat production: 0.094 therm/(m²*day)

► In a 10 years lifetime, the solar system produces heat for a predictable price of 25 cent per therm.

► Industrial heat application: Simple payback time: 3.1 years.

► Commercial heating and cooling application: Simple payback time: 5.0 years
2-Years Research Project

- Industrial partner: SolFocus
- United Technologies
- Sponsor: California Energy Commission
- Budget: $1.4 million
- Scope: Develop a high-temperature non-tracking collector
  - System efficiency of 50% at 180°C
  - Cost goal: $15 per square foot (production cost)
  - Mass manufacturability
  - Easy installation
  - System modularity
  - Market introduction within 2 years
Flat plate collectors are limited to temperatures below 100°C

![Graph showing efficiency vs. temperature for Flat plate collector and Compound Parabolic Concentrator.](image-url)
XCPC Solar Thermal Collector at UC Merced Solar Testing Facility
UC Merced 250C Thermal Test Loop
Glass-to-Metal Seal Tube: Horizontal E/W
Red: With Higher Reflectance CPC + AR Coating
Black: Baseline Design
Identified Application Areas for XCPC

- Water/space heating
- Industrial process heat
- Double-effect absorption cooling
- Distributed Power Generation Using ORC
- Water desalination