SOLAR HEAT IN INDUSTRIAL PROCESSES

Billy de Lange
What if you need more hot water?
Large scale solar thermal systems

What happens if an entire hotel needs hot water? It becomes inefficient to have many small SWH’s. It’s better to have one big integrated system.

Kolymbia beach hotel
Rhodes island, Greece
(144m² of panels, for pool heating)
Large scale solar thermal systems
Large scale solar thermal systems

Solar thermal for district heating
Currently world’s largest system is at Princess Noura Bint Abdul Rahman University near Riyadh in Saudi Arabia:

- 36,305m² of flat-plate collectors
- 25MW thermal

Size is not the issue
Different collector operating temperatures

Collectors and Operating Temperatures

Design Temperature

1  2  20  80

Concentration Factor

70-90 °C  Standard Flat Plate Collectors

< 70 °C  Uncovered Collectors
Most common collectors

Flat-plate

Evacuated tube
Different collector operating temperatures

**Collectors and Operating Temperatures**

- **90-120 °C**
  - Evacuated tube Collectors
  - Advanced Flat Plate Collectors
  - CPC Collectors
- **70-90 °C**
  - Standard Flat Plate Collectors
- **< 70 °C**
  - Uncovered Collectors
Collectors

Compound Parabolic Collector (CPC)
Different collector operating temperatures

Collectors and Operating Temperatures

- **Large** Parabolic Troughs and Fresnel Collectors: 250-450 °C
- **Small** Parabolic Trough and Fresnel Collectors, High Vacuum Flat Plate Collectors, (Advanced) Evacuated Tube Collectors: 120-250 °C
- Evacuated tube Collectors, Advanced Flat Plate Collectors, CPC Collectors: 90-120 °C
- Standard Flat Plate Collectors: 70-90 °C
- Uncovered Collectors: < 70 °C
Collectors

Parabolic trough

- Temperatures from 60°C up to 400°C, some claim even higher
- Only makes use of direct component of solar energy
  - Therefore requires tracking

Linear Fresnel
BBE Linear Fresnel at ERIC
GHI and DNI

diffuse + direct = global
GHI and DNI

South Africa, Lesotho and Swaziland

Annual sum of global horizontal irradiation, average 1994-2010

< 1600 1700 1800 1900 2000 2100 2200 2300 > kW/m²

0 100 200 km

PRETORIA
Johannesburg

Soweto

Welkom

Sihlangu

Richards Bay

Pietermaritzburg

Mbabane

Upington

Kimberley

Bloemfontein

Masutu

Mpumalanga

Durban

Cape Town

Port Elizabeth

George

East London

Solar data - SolarGIS v1.8 © 2012 GeoModel Solar s.r.o.
GHI and DNI

South Africa, Lesotho and Swaziland

Annual sum of direct normal irradiation, average 1994-2010

<1400 1550 1700 1850 2000 2150 2300 2450 2600 2750 2900 > kWh/m²

0 100 200 km

PRETORIA
Johannesburg
Soweto
Welkom
Sihlangi
Persistantzburg
Pietermaritzburg
Pietermaritzburg
Durban

Cape Town
George
Port Elizabeth

Digital map by: SolarGIS
http://solargis.info

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES
### Collectors

#### Non-imaging
- Flat-plate
- Evacuated tube
- Unglazed collectors

- Usually does not need tracking
- Simple, inexpensive
- Lower temperatures

#### Imaging
- Linear Fresnel
- Parabolic trough
- Compound parabolic collector (CPC)

- Many, but not all, need tracking
- Complex, expensive
- Higher temperatures
Typical residential system

- Solar Panel
- Electric Element
- Mains cold water in
- Circulation Pump
- Warm water out
Typical large scale system layout

Typical large scale system layout

Thermal storage

- Store energy for later use
- Add stability to system

- It’s like a battery, but for thermal energy
Thermal Storage
Thermal Storage
System integration

What it is solar process heat?

- **Thermal** energy
- Anything from **hot air** to **hot water**, **steam** and **hot oil**
- Typically larger scale systems
Potential in the industry?

- 1/3 of final energy demand in industry is for heat
- Temperature ranges are suitable for solar
- Can be combined with solar cooling

Potential

It’s important to note that solar cooling should also be considered, especially if used in combination with process heat!

Potential

Global horizontal irradiation

Europe


< 700  |  900  |  1100  |  1300  |  1500  |  1700  |  1900  | > kWh/m²

© 2011 GeoModel Solar s.r.o.
Potential

Global horizontal irradiation

Africa and Middle East

Average annual sum (4/2010 - 3/2010)

< 1600 1800 2000 2200 2400 > kWh/m²

© 2011 GeoModel Solar s.r.o.

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES
Global horizontal irradiation

South Africa

Potential


- 1520 kWh/m²
- 1640 kWh/m²
- 1760 kWh/m²
- 1880 kWh/m²
- 2000 kWh/m²
- 2120 kWh/m²
- 2240 kWh/m²
- 2360 kWh/m²

© 2011 GeoModel Solar s.r.o.
Example: Gösser Brewery in Austria

Study by AEE INTEC on Gösser Brewery in Austria

- 1500m² Flat-plate collectors
- 200m³ Thermal Storage
- Estimated cost: R11,418,750
- Annual GHI 1070kWh/m²
- Expected payback <10 years

If this was in Johannesburg:
- Annual GHI 2200kWh/m²
- Roughly 50% saving in collectors
Example: Gösser Brewery in Austria


Brauerei Göss - Österreich

Solare Wärmeintegration

- 20 – 27 Sude/Woche
  - min. 400 hl/Sud
  - ca. 75 – 90 min/Sud
- Nachrüstung von „dimple plates“

[Diagram of a beer tank with measurements and labels]
Example: Heineken Brewery in Spain

Study by AEE INTEC on Heineken Brewery in Spain

- 2835m² Flat-plate collectors
- 350m³ Thermal Storage
- Estimated cost: R14,139,562
- Annual GHI 1610kWh/m²
- Expected payback <8 years

If this was in Cape Town:
- Annual GHI 2025kWh/m²
- Roughly 26% saving in collectors
Example: Heineken Brewery in Spain


Brauerei Valencia - Spanien

Centre for Renewable and Sustainable Energy Studies
Gatorade PepsiCo – Phoenix

892m²  2,568m²  3,774m²

2008  2009  2010  2011  2012

1,200,000kWh  >3,000,000kWh  >4,200,000kWh

Source: Dr. C. Holter, CEO of S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH, Presented at Gleisdorf SOLAR 2012
• Lowest level in tank cooled down at 8pm already
• Middle and top level satisfy energy demand until 4am
Schulte Paint Shop, Germany

- Operational since **April 2009**
- **136m²** evacuated tube collectors
- Two **5m³** thermal storage tanks
  - One for painting chamber requiring constant temperature of **23°C**
  - Other for drying chamber requiring constant temperature of **70 °C**
- Investment: R1,218,000 including heat recovery
  - Had a 30% investment grant
- Payback expected to be 7 to 8 years

GHI roughly 1000kWh/m²
Galvanizing in Austria

Galvanization Blum, Austria, 2011

**Process heat for galvanization**
(5 working days per week)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperatures</td>
<td>75 / 85 °C</td>
</tr>
<tr>
<td>Gross collector area</td>
<td>459 m²</td>
</tr>
<tr>
<td>Buffer tank volume</td>
<td>8 m³</td>
</tr>
<tr>
<td>Max. continuous power</td>
<td>230 kW</td>
</tr>
<tr>
<td>Yield / Year</td>
<td>150 MWh</td>
</tr>
</tbody>
</table>

Rolf Meißner, r.meissner@ritter-xl-solar.com

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES
Galvanization Zehnder, Switzerland, 2012

**Process heat for galvanization (5 working days per week)**

- Temperatures: 70 / 95 °C
- Gross collector area: 400 m²
- Buffer: 5 m³
ALANOD GmbH & Co., Germany

- 108m² Parabolic trough
- 143°C at 4bar
- Used for oxide coating (anodisation) in finishing process
- Automatic operation since 2010

Source: Solar Steam Supply: Initial operation of a plant, D. Krüger et al., DLR
Dürr/Industrial Solar for automotive paint shops

Pilot system for curing process in convection oven
• 132m² linear Fresnel collector
• 180°C water at 13 bar
• Uses pressurized water to air heat exchanger
• Backed-up with fossil fired boiler

Dairy Industry, Switzerland

Project Example Tête de Moine (Emmi) Saignelégier, Switzerland
627m2 / New PolyTrough 1800 Collector / 125°C / Water-Antifreeze / Cheese Manufacturing
Dairy Industry, Switzerland

Bever, Switzerland
115m² / 190°C / Thermal oil / Indirect Steam Generation / Milk processing
Dairy Industry, Switzerland

LESA Bever Project: Integration

Thermal oil heated to 180°C in solar collector field
What’s happening in SA?
Soltrain II

- Awareness campaigns
- Centres of Competence
- Flagship Demonstration Districts
- Solar Thermal Technology Platforms

financed by

Austrian Development Cooperation

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES
Centre of Competence at Stellenbosch University

Solar Roof Laboratory and Test Facility

Demonstration System

Control Room
Current R&D activities in SA

- Stellenbosch University (SU)
- Tshwane University of Technology (TUT)
- Cape Peninsula University of Technology (CPUT)
- Nelson Mandela Metropolitan University (NMMU)
- North-West University (NWU)
- Durban University of Technology (DUT)
- University of the Witwatersrand (WITS)
- University of Pretoria (UP)
- South African Bureau of Standards (SABS)
- Eskom Research and Innovation Centre (ERIC)/BBEnergy
Areas of Activity

**Thermal Performance Testing**
- Stellenbosch – DIN EN12975
- TUT Systems and components
- SABS – System testing only
- DUT (Planned Technology Station)
- CPUT – For private firms
- NMMU – Systems

**Development**
- TUT – Low cost systems, large scale systems, measurements
- NMMU – Measurement and control
- BBE Energy – Linear Fresnel
- WITS – Selective coatings
- CPUT – Low cost SWH, evacuated tubes

**Training**
- TUT (Installation, maintenance)
- DUT (Planned)
- FET Colleges
- SARETC at CPUT (SWH?)

**Under- and/or postgraduate student projects**
- Stellenbosch
- NWU
- NMMU
- CPUT
- WITS
• Site selection
• Satellite Derived Data
• On-site Solar Measurements
• Bankable Solar Resource Reports
• Bankable Generation Forecast
• Bankable Solar Data for Operating plants
Contact details
Billy de Lange
bdelange@sun.ac.za
(021) 808 3605
crses.sun.ac.za