DISTRICT HEATING WITH SOLAR THERMAL SYSTEMS
Large Scale Solar Thermal Plants

A PROVEN TECHNOLOGY
252 Plants in Operation
Installed Capacity > 750 MWth
Largest 70,000 m² of collectors and
4.9 MWth
Oldest installed in 1979

Euroheat & Power
Solar District Heating

www.euroheat.org
www.solar-district-heating.eu
Reference Projects of District Energy Installations
District Heating network in Büsingen

Route length of 5 km

107 building connections; residential, commercial and public

Collector Area: 1,090 m² (218 collectors)
Flow temperature: 80..90 °C (176..194 °F)
Solar fraction: ca. 13%
Annual yield: > 520 MWh
Specific yield: 470 kWh/m²a

Total investment in Bioenergy Project – 3.5 Mio. €

Solar heat generation
4,000 MWh/a
Büisingen: Hydraulic Integration

- The solar system is connected directly without heat exchanger – only possible due to Aqua System.
- The solar system is connected just like additional boiler.
- The existing heat storage is sufficient for the solar system.

Oil boiler 730 kW
Wood chip boiler 450 + 900 kW
Buffer tanks 2 * 13,208 gallons
Heating Network Neuerkirch and Külz

- **Route length 6 km**
  - 143 building connections
  - Predominately residential housing

- **Heat generation**
  - Approximately 3,100 MWh / a

- **Investment**
  - 4.8 Mio. €
Heating Network Neuerkirch and Külz

Back-up heating: 1.6 MW oil boiler

Wood Chip Boilers 360 + 900 kW

Buffer Tanks: 2 x 15,850 gallon

Collector area 1,422 m² (290 collectors)
Flow temperature 80 ... 90° C (176..194° F)
Annual solar fraction 20%
Annual yield 625 MWh
Specific Yield 440 kWh / m²
Energiebunker Hamburg

- Innovative conversion of a WW II anti-aircraft bunker into a renewable energy power plant.

- Project idea for the International Building Exhibition (IBA)

- Holistic energy supply into a residential district heating network covering 100 acre

- Large buffer for integrating industrial waste heat, wood chip boilers and solar.

- Implementation by the municipal energy provider Hamburg Energie
### Energiebunker Hamburg

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross collector area</td>
<td>1,348 m²</td>
<td>(275 collectors)</td>
</tr>
<tr>
<td>Flow temperature</td>
<td>85 ... 95° C</td>
<td>(185 ... 203° F)</td>
</tr>
<tr>
<td>Annual yield</td>
<td>&gt; 550 MWh</td>
<td></td>
</tr>
<tr>
<td>Specific yield</td>
<td>410 kWh / m²</td>
<td></td>
</tr>
<tr>
<td>Max. power</td>
<td>750 kW</td>
<td></td>
</tr>
<tr>
<td>Buffer</td>
<td>2,000 m³</td>
<td>(528,000 gallons)</td>
</tr>
<tr>
<td>Solar heat price</td>
<td>&lt;€ 30 / MWh</td>
<td>(&lt;€ 0.88 / therm)</td>
</tr>
</tbody>
</table>
Heating network Wels, Austria

- **Gross collector area:**
  - 3,388 m² / 690 collectors
- **Flow temperature:**
  - 85...100° C / 185...212 °F
- **Commissioned:**
  - 2011
- **Annual yield:**
  - 1,300 MWh

- First decentralized solar field integrated into a district heating network
- First solar district heating system without solar storage
- First solar system with district heating fluid directly in solar collectors.
Germany Accelerates Solar District Heating

Project: Stadtwerke Senftenberg / direct delivery into district heating network

Gross collector area: 8,300 m² / 1,680 CPC collectors

Annual yield: 3.8 GWh  Commissioned: September 2016

The largest solar thermal plant in Germany
Typical Project Workflow

1. Preliminary Design
2. Feasibility study
3. Project proposal
4. Detailed planning / offer / financial model
5. Secure funding
6. Procurement / construction phase
7. Commissioning
8. Monitoring / Service Agreement
Preliminary Design Questions

Load balance analysis

• Solar production in July / August will be 4x December / January, so monthly load balance is necessary for efficient design.

• If summer load is covered by heat from CHP or waste heat capture, look into seasonal storage or absorption cooling.

• Recently developed CPC collectors have high efficiency at high temperatures, which match temperature requirements of single effect absorption chillers.

• Avoid stagnation

• Solar fractions of 20% to 50% are practical
Preliminary Design - Load Balance

Energy

Jan  Mar  Jun  Sept  Dec

HEATING LOAD
SDHW LOAD
SOLAR SUPPLY
COOLING LOAD
Preliminary Design – Collector Mounting

Where to place collectors

- Ground mount – lowest cost for mounting structure and labor
- Roof mount – structural and wind force analysis - ballast system lowest cost
- Wall mount – lower production in summer; higher in winter

• Ground Mount pre-fabricated mounting system - 2, 3, or 4 high with 5 or 6 across

Significant reduction in costs compared to flat roof installation
Preliminary Design Question: Main Line Connection

operation temperature increase  standard feeding  return flow temperature increase
PLANNING DETAILS
COLLECTOR SELECTION
COLLECTOR FIELD PIPING
HEAT TRANSFER FLUID
Efficiency of CPC evacuated tube collector is twice as high as efficiency of flat plate collector at 60 K temperature difference with irradiation of 400 W/m².
Performance Comparison Yearly Collector Yield

Performance of CPC-ETC and FPC
(calculated for Baltimore)

Yearly Collector Yield [kWh/m²/year]

Process temperature [°C]

180 °C, 150 °C, 120 °C, 90 °C, 60 °C

FPC (selct. absorb)
CPC-ETC
CPC-ETC Plasma

0 16 120 335 634
288 414 547 812 905
500 606 711 678 801
Gross collector yield - Solar Keymark

Good, Better, Best – Based on Independent Certification

**Bruttowärmeertrag Solar keymark - 75°C**

- Certificate Solar Keymark
- Yearly sum per m²
- Würzburg
- South, 35° inclination
- Gross collector area
- Temperature 75°C
Solar system annual yields for district heating

CPC Vacuum Collectors Have Highest Yields

*Location Wurzburg, Germany; 30 degree, due south, ScenCoCalc Software (Solar Keymark)

* Based on water systems. Glycol systems would produce 3 % to 5 % less.

Quelle:
Heat Transfer Fluid – Water is Best

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Water</th>
<th>Glycol mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>specific heat capacity</td>
<td>100%</td>
<td>88%</td>
</tr>
<tr>
<td>kinematic viscosity</td>
<td>100%</td>
<td>380%</td>
</tr>
<tr>
<td>heat conductivity</td>
<td>100%</td>
<td>62%</td>
</tr>
<tr>
<td>Reynolds number</td>
<td>100%</td>
<td>25%</td>
</tr>
<tr>
<td>heat transfer coefficient</td>
<td>100%</td>
<td>75%</td>
</tr>
<tr>
<td>pressure loss</td>
<td>100%</td>
<td>142-485 %</td>
</tr>
<tr>
<td>gross price</td>
<td>100%</td>
<td>&gt; 240.000 %</td>
</tr>
<tr>
<td>chemical durability</td>
<td>extreme consistent</td>
<td>oxidation, cracking, cloting, separation</td>
</tr>
<tr>
<td>purchasing</td>
<td>water tap</td>
<td>retail market</td>
</tr>
<tr>
<td>filling</td>
<td>water tap</td>
<td>special devices</td>
</tr>
<tr>
<td>disposal</td>
<td>drainage</td>
<td>dumpsite</td>
</tr>
<tr>
<td>danger of freezing</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>overall comparison</td>
<td>outstanding</td>
<td>problematic</td>
</tr>
</tbody>
</table>

Comparison is valid at temperatures of 40 °C / 104 °F.
The lower the temperatures the worse the properties of the glycol mixture.
Asymmetric XL-piping (no Tichelmann) is highly advantageous with regard to volume flow control, automatic balancing, self-filling, self-deaerating, controlled emptying by extending steam, less piping and minimization of heat losses.
Choice of Heat Transfer Fluid Effects Pipe Design

Typical Glycol Fittings Found on Roof for Heat Pipe and Flat Plate Collectors
- Standard Glycol Filled Collector
- Adapter Fitting
- Flexible Hose Set
- Air Bleeder
- Air Bleeder Shut-off Valve
- T and P Safety Relief Valve
- Copper Main Line
- Shut-off Valve
- Balancing Valve
- Drain Valve

Typical Aqua System Fittings Found on Roof for Ritter CPC Evacuated Tube Collectors
- Corrugated Hose Set with Compression Fittings
- Copper Main Line
Factors influencing the economics

- **Cost of the plant** – $500 to $800 m² gross collector area
  - Collectors 40%, mounting 5%, pipe 10%, mech. room 10% - total mat’l 65%
  - Labor, OHD, Profit 35%

- **Accurate energy modeling**
  - Solar operating temperatures
  - Consumption profile (7 days a week / 5 days a week / ...)
  - System design (surplus in summer, storage, ...)

- **Tax status** – non-profit or taxable entity - PPA
  - Federal and state grants and tax credits
  - Depreciation tax benefit – accelerated write-off

- **Value of solar energy** - intangibles
  - Reduced fossil fuel energy buy – less carbon
  - Energy inflation rate – known and stable energy price for 25 years
Summary – Solar District Heating

- Solar thermal energy can make a major contribution to achieving CO2 reduction goals – Solar thermal reduces 4 times the amount of carbon than solar PV per installed area.
- High solar fractions in summer lead to large load reduction of district heating boilers.
- Simple and effective integration of solar thermal energy into existing networks.
- Solar fields do not have to be near main boiler plant.
- Buffer tanks not necessary.
- Continuous high temperatures possible, even in winter.
- 30 year fixed energy price.
THANK YOU FOR YOUR ATTENTION

Michael DiPaolo, President
Ritter Group USA
mdipaolo@ritter-group-usa.com
570.234.7917