SolarHybrid Heating and Cooling

NEYER Daniel

With friendly support by:
FH OÖ Forschungs und Entwicklungs GmbH
PinK gmbH
Engie Kältetechnik GmbH
Hilbert Focke
Christian Halmdienst
Jürgen Furtner
Goal

» Reach cost competitive capability by radical reduction of components and optimized control strategies

→ (Solar-) Hybrid Systems
Methodology

» Investigation on component simulation models
  Absorption & vapour compression chiller

» Construction of ACM & VCC
  Vapour compression chiller (VCC)
    Refrigerant ammonia, frequency controlled piston compressor, flooded evaporator, hot gas bypass
  Absorption chiller (ACM developed in DAKTris)
    Ammonia/water, single-/half-effect, high re-cooling temperatures

» Steady state and dynamic laboratory measurements
  Characteristic curves
  Hardware-in-the-Loop
  Solar only & hybrid operation

» Simulation studies
  Realistic case: hotel profile
  Potential study: solar / hybrid potentials

» Assessment and sensitivity analysis with T53E4 Tool
Simulation studies

» **Profile:** heating / cooling / dehum. / domestic hot water / pool

» **HVAC layouts**
   - 7 System Layouts
   - 3 load files / 2 locations

» Validated by measurements; Annually simulation studies
Results simulation studies

» \( f_{\text{sav,NRE}} \) and CR strongly depend only DHW (green), DHW+C (blue), DHW+C+SH (red)
Location (load & solar yield,...)
System configuration

» The higher the savings, the higher the costs

» ST more efficient & less expensive
Laboratory measurements

» **Hardware-in-the-Loop @ UIBK labs**
   TRNSYS & LabView
   System in TRNSYS simulations
   ACM & VCC in real operation

» **Steady state / Large matrix of operation**
   ACM
   LT: 1.5–3, MT: 4.25–6, HT: 3–4.5 m³/h
   VCC
   LT: 2–3.5, MT: 3.5–6 m³/h
   LT: 12–22, MT: 25–45°C

» **Dynamic measurements**
   Daily & weekly profiles
   ACM solar direct
   ACM only
   ACM & VCC hybrid
Measurement results – characteristic curves

» Wide range of operation is possible
» Good performance & optimization Potential
### Measurement results – daily performance

**Hybrid heat pump operation of ACM & VCC**
- Set points: MT: 12/ 40°C; LT: 6/12°C
- Operation if I >200 W/m²
- Location: Innsbruck
- ST: 70m², NO storage
- SPFel.sys: simplified

<table>
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<tr>
<th></th>
<th><strong>Energies ACM</strong> [kWh]</th>
<th><strong>Energies VCC</strong> [kWh]</th>
<th><strong>ACM +VCC</strong> [kWh]</th>
<th><strong>System SPFsys [-]</strong></th>
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<tr>
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<td>$Q_{HT}$</td>
<td>$Q_{LT}$</td>
<td>$Q_{MT}$</td>
<td>$Q_{MT}$</td>
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<td>sunny day</td>
<td>233</td>
<td>125</td>
<td>349</td>
<td>96</td>
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<td>cloudy day</td>
<td>102</td>
<td>57</td>
<td>152</td>
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simulation results – potential study

- **HP system**
  - Set: MT: 12/40°C; LT: 6/12°C
  - Solar thermal direct

- **Annual simulations**
  - Innsbruck & Sevilla
  - w/o VCC

- **f_{sav,NRE} > 80%**

- **CR << 1**

- **Sensitivity analysis**
  - Investment costs
  - Electricity prices
  - Electrical efficiency
  - Thermal efficiency
  - Primary Energy Conversion
**Overview sensitivity**

- **Investment costs**
- **Electricity prices**
- **Electrical efficiency**
- **Thermal efficiency**

**Primary Energy Conversion**

Simulation results – potential study

**Seasonal Performance Factor thermal (SPFth)**

- SF 37.5%
- SF 50%
- SF 100%

**Seasonal Performance Factor electrical (SPFel)**

- SF 37.5%
- SF 50%
- SF 100%

**Seasonal Performance Factor reference (SPFref)**

- SF 37.5%
- SF 50%
- SF 100%
Conclusion

» **Components development**
  Possibility for solar / solar hybrid operation
  Good performance
  Further optimization potential

» **System results**
  ST is more efficient and economic
  Solar direct & hybrid is promising

» **Next step**
  Component optimization & demo project
  System integration → Building & HVAC

» **Solar heating and cooling can become cost competitive**
  designed clever
  simple HVAC layouts,
  advanced control strategies and
  high efficient components.
Thank you for your attention!

Daniel NEYER

Universität Innsbruck
Institut für Konstruktion und Materialwissenschaften
Arbeitsbereich Energieeffizientes Bauen
Technikerstraße 13, 5. Stock, A-6020 Innsbruck

Telefon  +43 512 507-63652
Mobil    +43 512 507-976618
Fax      +43 512 507-63698
E-Mail   daniel.neyer@uibk.ac.at

oberradin 50
6700 bludenz
austria
+43 664 28 26 529
daniel@neyer-brainworks.at
www.neyer-brainworks.at