Technical and economical analysis of solar cooling systems

Results of Task 53 (New Generation Solar Cooling)

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Motivation

- **Aim:**
  - comparison of performance of PV and solar-thermal driven SHC systems

- **Challenge:**
  - High complexity (different technologies, configurations, control, storages)
  - Demand (space heating, domestic hot water, cooling)
  - Different capacities
  - Location
  - Boundaries (data available, which quality)

- **T53E4-Tool** developed to make comparison of systems

- 28 different cases of measured and simulated examples were analyzed
Primary energy savings vs. Cost ratio

- **Fsave vs. Cost ratio**

![Graph showingPrimary energy savings vs. Cost ratio](image-url)
Primary energy savings vs. Cost ratio

- $F_{\text{save}}$ vs. Cost ratio

![Graph showing $F_{\text{save}}$ vs. Cost ratio]
Results shown in

- **Trends** (Costs vs. Efficiency)
  - Categorized by boundary conditions
    - Location
    - Technology
    - Capacity
    - Demand

- **Sensitivity Analysis** (Costs vs. Efficiency)
  - Variation of
    - Investment costs
    - electricity price and gas price
    - auxiliary demand
    - energy output
    - PE conversion factor
Trend: Capacity

- Small scale highest costs → designed to achieve high energy savings
- Intermediate scale are cost competitive at energy savings < 50 %
- Large scale cost competitive at higher energy savings
Trend: Technology

- ST + boiler lower increase than ST + HP
- ST + boiler = efficient use of both technologies
- PV systems perform better, because examples are in southern areas
Trend: Location and technology

- Southern SHC systems more cost competitive than northern locations → higher/more constant loads
- PV and ST nearly same performance when considering location
Sensitivity Analysis

▪ Influence of boundaries
  – Investment costs
  – Electricity price
  – Natural gas price
  – Auxiliary demand/energy input
  – Non renewable primary energy factor
Sensitivity Analysis – Investment costs

- Only effects CR
- 100 % indicates standardized investment costs at the moment
- Plants with higher $f_{\text{sav}}$ are more sensitive
- PV systems are more sensitive
Sensitivity Analysis – Natural Gas Price

- Only effect CR
- Standard 5 €ct/kWh
- Effects reference system and ST + natural gas boiler
Sensitivity Analysis – Primary Energy Factor

- Only effects $f_{sav}$
- Electricity based systems more effected
- No significant influence
Summery

- Trends
  - Simplified comparison
  - Indication for Optimization
  - Higher savings result in higher costs
  - Location main influence on efficiency

- Sensitivity
  - Effect of changes in boundaries
  - Main influence: Investment costs & natural gas price (changes when reference system is different)
Limitations of analysis

- Analysis only showing trends no absolute numbers (too little amount of systems for analysis)
- Mainly demo systems – not commercial systems
- Costs standardized – vary on location, planning experience

Detailed analysis in Deliverable C3 of IEA SHC Task 53 „New Generation Solar Cooling“ (including trend, sensitivity and individual system analysis)
Conclusion

- Both solar thermal and PV-driven systems can be cost competitive when well designed.

- No significant difference btw PV and ST – depends on level of optimization / proper design.

- Focus for small system on easy to install and maintain systems.

- PV preferred for small systems since easy to connect to HP.

- ST systems need high investment costs (cooling tower) – only cost effective for large systems.

- Cost competitiveness reached: \( \text{f}_{\text{save}} \) up to ~ 30 %.
Conclusion

- Highest influence factor on CR: Investment costs – further research should focus on reduction

- Decrease of investment costs
  - By 15% $\Rightarrow$ $f_{\text{save}}$ up to ~ 65% at CR 1
  - By 30% $\Rightarrow$ considerably below CR 1

- Gas price also significant influence (mainly influence reference system)
  - Difficult to predict
  - Depend on political, economic and exploration boundary conditions
  - Increase of 50% gas price $\Rightarrow$ CR 1 can be achieved for $f_{\text{save}}$ ~ 60% (instead of 30%)

- Other boundary conditions e.g. auxiliary demand, primary energy factor, ... no significant influence
Thank you for your Attention