Task 53

Technical and Economic Assessment
best practice examples of new generation solar thermal and PV driven heating and cooling systems

Daniel NEYER¹,², Rebekka KÖLL³, Daniel MUGNIER⁴
Introduction

- Solar cooling and heating can be complex
  - Solar Thermal or Photovoltaic driven
  - System design & configurations (backups, storages, ...)
  - Demands (domestic hot water, space cooling, ...)
  - ...

→ Assessment in a **common comparable format**
  - energetic, ecological, economic, evaluation
  → **T53E4 Assessment Tool**
  - Assessment based on (monthly) energy balances
  - Measured or simulated (sub) system
  - Data base for Technical and Economic assessment
Introduction

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[Tool download: http://task53.iea-shc.org/]
Final Version to be expected in Autumn 2018
Technical Key Figures

- Non-renewable primary energy ratio ($\text{PER}_{\text{NRE}}$)
  Energy input ($Q_{\text{in}}$) converted in primary energy
  
  \[
  \text{PER}_{\text{NRE}} = \frac{\sum Q_{\text{out}}}{\sum \left( \frac{Q_{\text{el.in}}}{\varepsilon_{\text{el}}} + \frac{Q_{\text{in}}}{\varepsilon_{\text{in}}} \right)}
  \]

- Standardized Task 53 reference system
  Natural gas boiler, air-cooled vapor compression chiller

  \[
  \text{PER}_{\text{NRE.ref}} = \frac{\sum Q_{\text{out}}}{\sum \left( \frac{Q_{\text{out.heat}} + Q_{\text{loss.ref}}}{\varepsilon_{\text{in}} \cdot \eta_{\text{HB.ref}}} + \frac{Q_{\text{out.cold}}}{\text{SPF}_{\text{C.ref}} \cdot \varepsilon_{\text{el}}} + \frac{Q_{\text{el.ref}}}{\varepsilon_{\text{el}}} \right)}
  \]

- Non-renewable primary energy savings ($f_{\text{sav.PER-NRE}}$)

  \[
  f_{\text{sav.PER-NRE}} = 1 - \frac{\text{PER}_{\text{NRE.ref}}}{\text{PER}_{\text{NRE.SHC}}}
  \]
Economic Key figures

- Annuity method & input values based on EN-standards
- Standardized (data base) to calculate annualized costs
  - Investment, replacement & residual value
  - Maintenance & service,
  - Operational costs (energy, water)
  - Solar Heating and Cooling and Reference
  - → Levelized cost of energy

→ CostRatio (CR)

\[
\text{CostRatio(CR)} = \frac{\text{annualized costs SHC}}{\text{annualized cost REF}}
\]
Overview Examples

- Assessment of 28 SHC plants with T53E4 Tool
  - 17 examples (28 configurations)
  - System & Subsystem Analysis
  - Trend analysis
  - Sensitivity analysis

![Technology Pie Chart]

- PV; 12; 41%
- ST+PV; 3; 10%
- ST; 8; 28%
- ST+HP; 6; 21%

![Demand Pie Chart]

- C; 3; 10%
- SH+C; 4; 14%
- DHW; 1; 3%
- DHW+SH; 4; 14%
- DHW+SH+C; 13; 45%
Overview Examples

**Capacity**
- small (<10 kW); 16; 55%
- medium (10-150 kW); 7; 24%
- large (>150 kW); 6; 21%

**Source**
- monitored; 10; 34%

**Design, solar fraction**
- 30-70; 16; 55%
- 70-90; 3; 11%
- >90; 3; 10%
- <30; 7; 24%
- simulation; 19; 66%
Results obtained

- Assessment of 28 SHC plants with T53E4 Tool
  - Technical analysis
    - Energy balance check
    - Comparison to T53 Standard
    - System & Subsystem Analysis
    - $\text{PER}_{\text{NRE}}$, $\text{PER}_{\text{NRE,ref}}$, $f_{\text{sav.NRE}}$, $\text{SPF}_{\text{equ}}$
  - Economic analysis
    - Investment, Replacement & Residual
    - Maintenance, Energy (electricity, natural gas,...)
    - Comparison to T53 Standard
    - Spec. Invest, $\text{LCOE}_{\text{SHC}}$, $\text{LCOE}_{\text{REF}}$, CR

- Trend analysis
- Sensitivity analysis
Summary Result

- Exclude plants with no annual energy balance
Trend analyses

- Many different configurations / boundaries
  - Size / demand / technology / data source / location...

→ Clustering of results
  - south/northern location
  - PV and ST supported systems
Trend analyses

- Many different configurations / boundaries
  - Location & technology
Trend analyses

- Many different configurations / boundaries
  - Location & technology
Sensitivity analyses

- Influence of chosen boundaries
  - Investment, Electricity, Natural Gas price
  - Auxiliary demand, Energy output,
  - Non-renewable primary energy conversion factors

→ Influence shown on trends
Sensitivity analyses

- Influence of chosen boundaries
  - Investment cost

![Graph showing sensitivity analyses](image-url)
Sensitivity analyses

- Influence of chosen boundaries
  - Investment cost
Summary

- **T53E4 Assessment Tool**
  - Simplified analysis of system / subsystem
  - Useful for benchmarking against reference and other RE
  - Focus on
    - non-renewable primary energy (fsav.NRE)
    - Cost Ratio

- **Performance of SHC examples**
  - Non-renewable Primary Energy Savings 40-80%
  - Higher savings lead to higher costs
  - Economics are mainly investment dominated
  
  - Simplification and component reduction !!
Summary

- Sensitivity analysis
  - Effect of changes in boundaries
  - Trend wise comparison of results
  - Large differences for different systems
  → Sensitivity for certain type of systems to follow soon

- Advantage of ST or PV is depending on …
  - Local conditions
  - System design & Application

→ Both technologies can be optimized
→ Cost competitiveness can be reached
Final reports of IEA SHC Task 53 to be expected soon
http://task53.iea-shc.org/

Thank you for your attention!