Task 53

NEW GENERATION SOLAR COOLING AND HEATING

EXPERIENCES FOR SUCCESFULL DESIGN AND OPERATION

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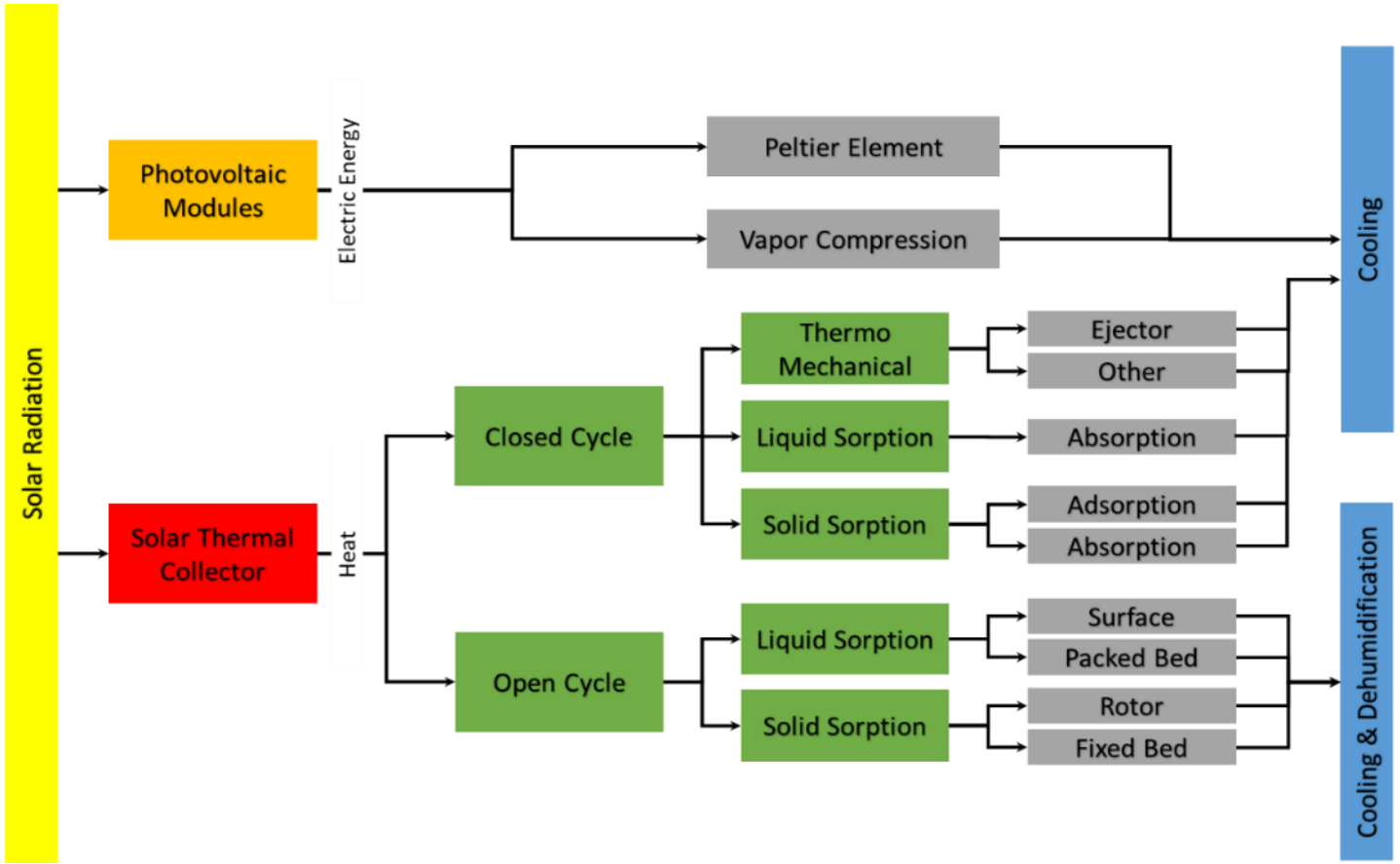
Introduction

- Several **solar supported** solutions are available



Source: Henning et al. (2013) Solar Cooling Handbook

Introduction

- Task 48 (2001-2015)
- **Lack** of
  - **efficient**, **reliable** and **cost** competitive
  - SHC solutions

- Summary of **experiences** / lesson's learned
  - **General findings** → 10 key principles
  - Specific outcomes → 3 examples

- The **Solar Cooling Design Guide**, Case Studies of Successful Solar Air Conditioning Design

Design Guide

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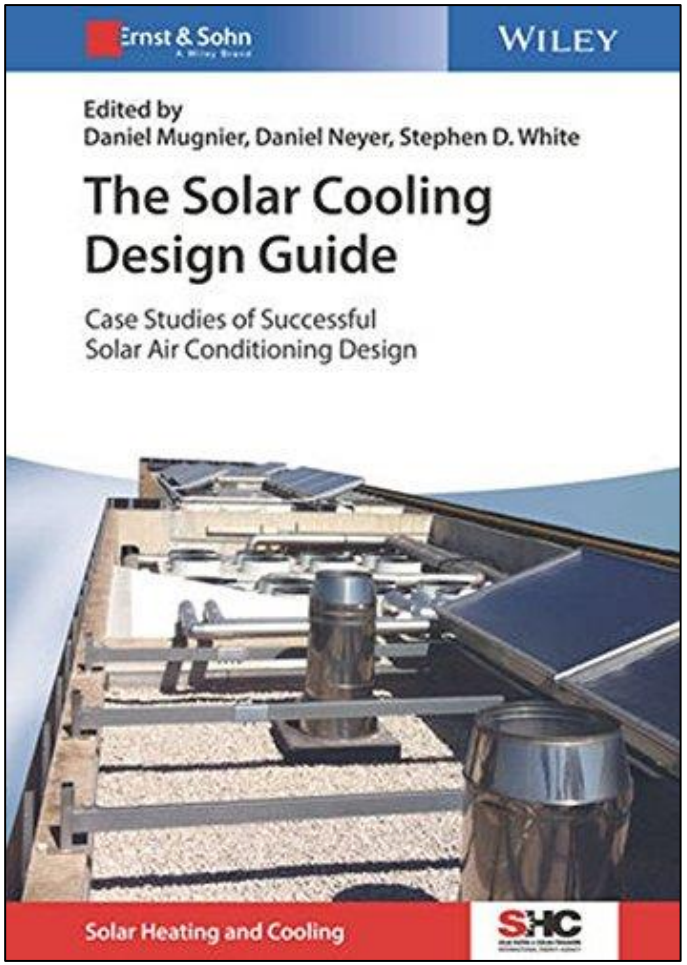
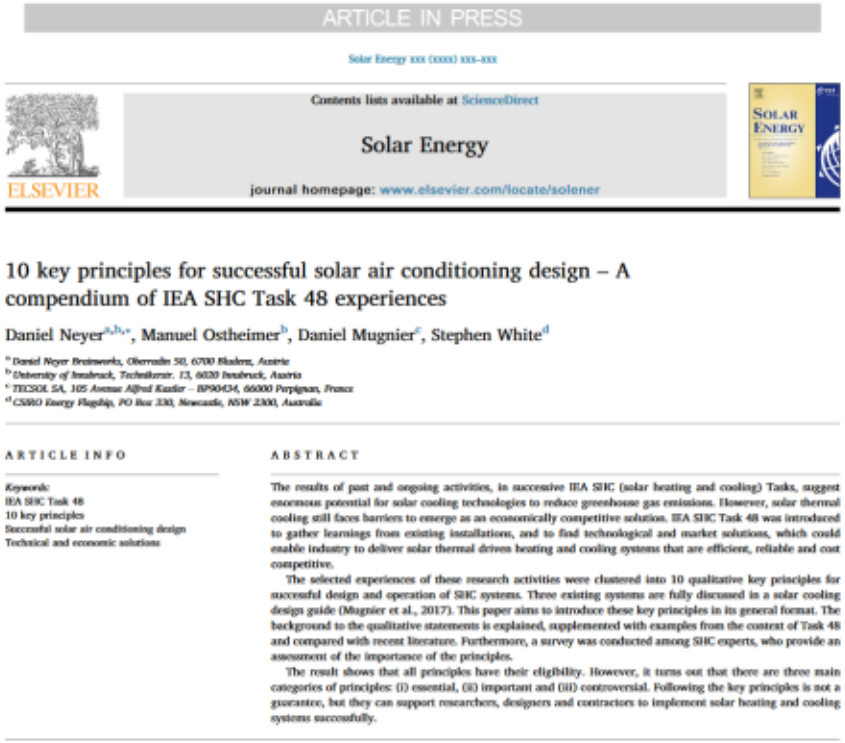
- As **companion** to Solar Cooling **handbook**
- **Specific description** of design for already built and successful SHC examples.

- https://www.amazon.de/Solar-Cooling-Design-Guide-Conditioning/dp/3433031258/ref=sr_1_1?ie=UTF8&qid=1523335059&sr=8-1&keywords=solar+cooling+design+guide



Design Guide

- **Solar Energy** Paper,
  Special Issue: Solar Cooling
- **Scientific background**
  - Literature in context of Task48
  - Recent literature review
  - expert survey
- **Expert Survey**
  - About the 10 key principles
  - Assessment of importance
  - elucidate of expert experiences



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10 key principles for successful solar air conditioning design – A compendium of IEA SHC Task 48 experiences

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ABSTRACT

The results of past and ongoing activities, in successive IEA SHC (solar heating and cooling) Tasks, suggest enormous potential for solar cooling technologies to reduce greenhouse gas emissions. However, solar thermal cooling still faces barriers to emerge as an economically competitive solution. IEA SHC Task 48 was introduced to gather learnings from existing installations, and to find technological and market solutions, which could enable industry to deliver solar thermal driven heating and cooling systems that are efficient, reliable and cost competitive.

The selected experiences of these research activities were clustered into 10 qualitative key principles for successful design and operation of SHC systems. Three existing systems are fully discussed in a solar cooling design guide (Mugnier et al., 2017). This paper aims to introduce these key principles in its general format. The background to the qualitative statements is explained, supplemented with examples from the context of Task 48 and compared with recent literature. Furthermore, a survey was conducted among SHC experts, who provide an assessment of the importance of the principles.

The result shows that all principles have their eligibility. However, it turns out that there are three main categories of principles: (i) essential, (ii) important and (iii) controversial. Following the key principles is not a guarantee, but they can support researchers, designers and contractors to implement solar heating and cooling systems successfully.

https://doi.org/10.1016/j.solener.2018.03.086

Assessment

- 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) en
- Measured or simulated (s
- Data base for Technical ar

Tool download
http://task53.iea-shc.org/
Final Version to be expected in
Autumn 2018

Technical Key Figures

- Non-renewable primary energy ratio (PER_{NRE})

  Energy input (Q_{in}) converted in primary energy

  electricity: ε_{el} = 0.4 $kWh_{Use}/kWh_{PE.NRE}$

  natural gas: ε_{in} = 0.9 $kWh_{Use}/kWh_{PE.NRE}$

$$PER_{NRE} = \frac{\sum Q_{out}}{\sum \left(\frac{Q_{el,in}}{\varepsilon_{el}} + \frac{Q_{in}}{\varepsilon_{in}} \right)}$$

- Standardized Task 53 reference system

  Natural gas boiler, air-cooled vapor compression chiller

$$\mathrm{PER_{NRE.ref}} = \frac{\sum \mathrm{Q_{out}}}{\sum \left(\frac{\mathrm{Q_{out.heat}} + \mathrm{Q_{loss.ref}}}{\varepsilon_{\mathrm{in}} * \eta_{\mathrm{HB.ref}}} + \frac{\mathrm{Q_{out.cold}}}{\mathrm{SPF_{C.ref}} * \varepsilon_{\mathrm{el}}} + \frac{\mathrm{Q_{el,ref}}}{\varepsilon_{\mathrm{el}}} \right)}$$

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

$$f_{sav.PER-NRE} = 1 - \frac{PER_{NRE.ref}}{PER_{NRE.SHC}}$$

Economic Key figures

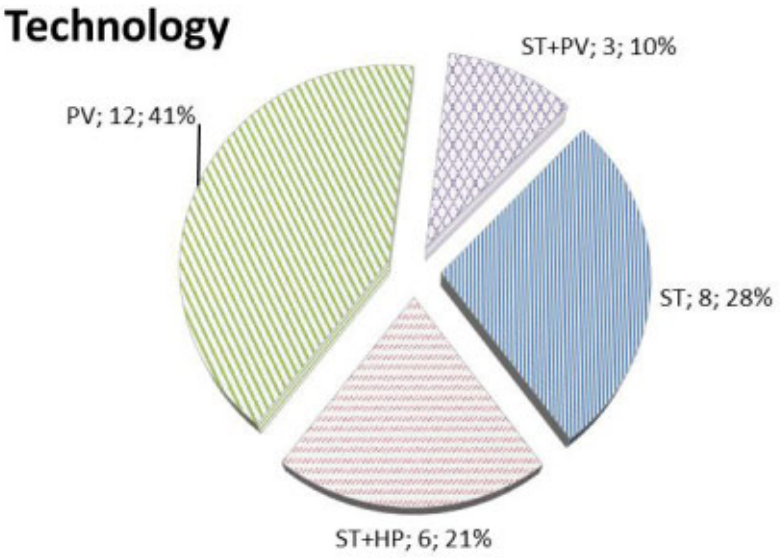
- Annuity method & input values based on EN-standards
- Standardized (data base) to calculate annualized costs
  - Investment, replacement & residual value
  - Maintenance & service,
  - Operational costs (energy, water)
  - Solar Heating and Cooling and Reference
  - → Levelized cost of energy

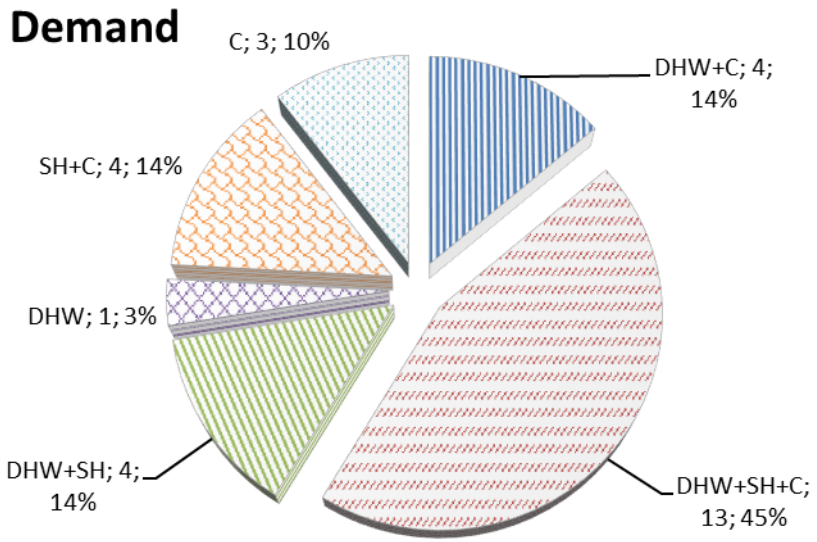
→CostRatio (CR)

$$\text{CostRatio(CR)} = \frac{annualized\ costs\ SHC}{annualized\ cost\ REF}$$

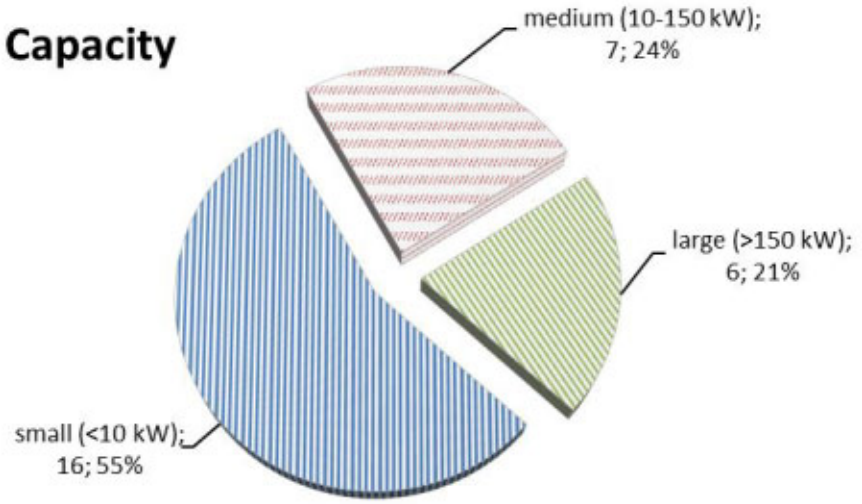
Overview Examples

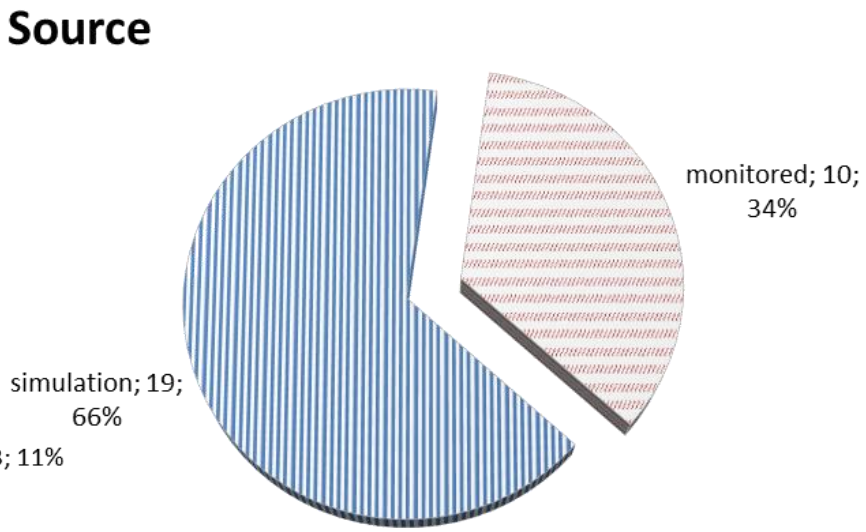
- Assessment of 28 SHC plants with T53E4 Tool
  - 17 examples (28 configurations)
  - System & Subsystem Analysis
  - Trend analysis
  - Sensitivity analysis

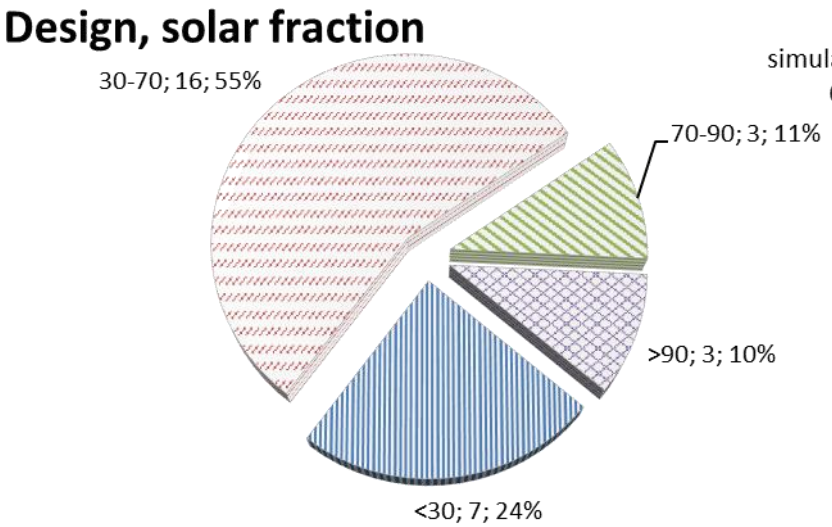




Overview Examples

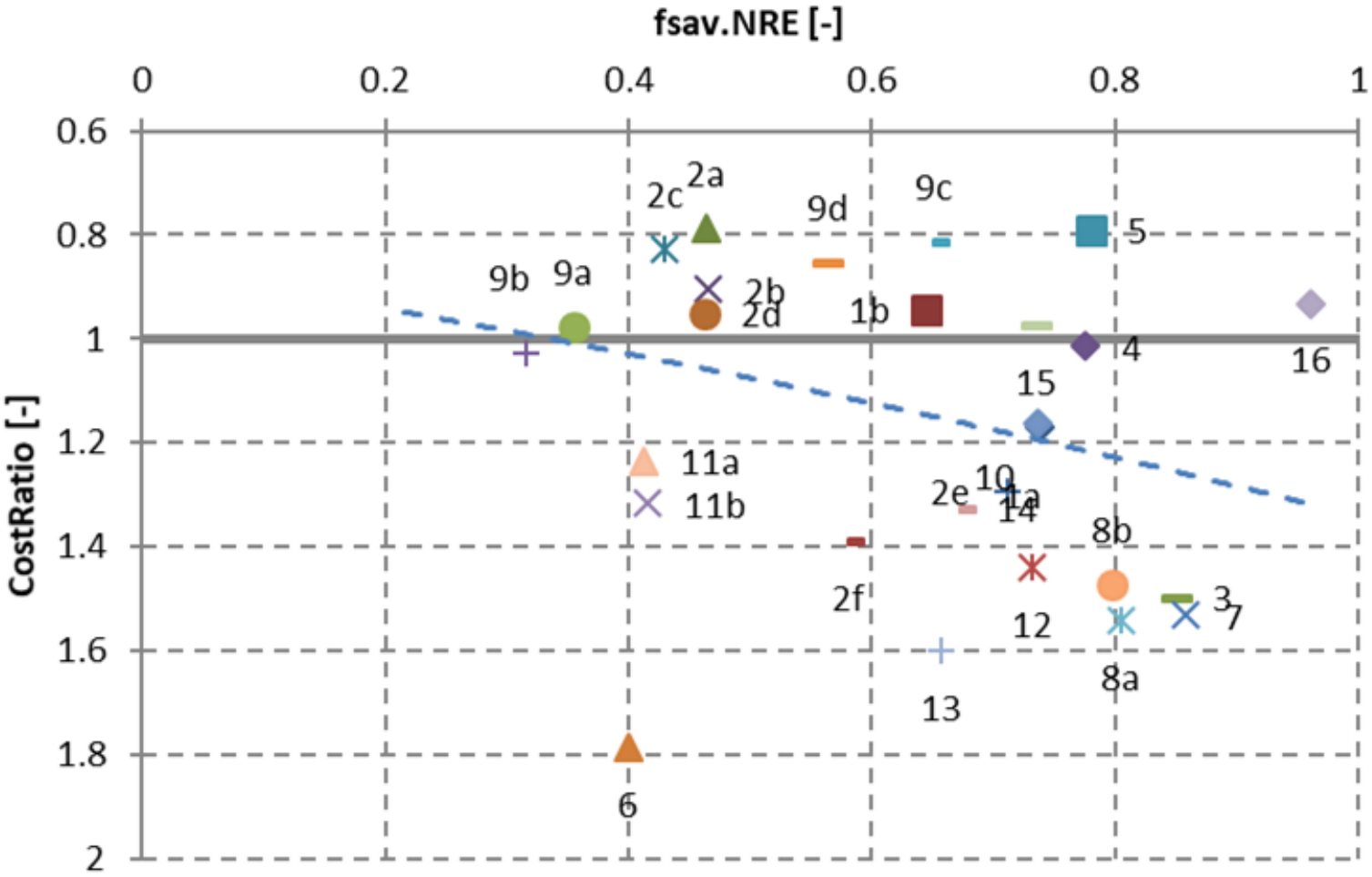






Summary Result

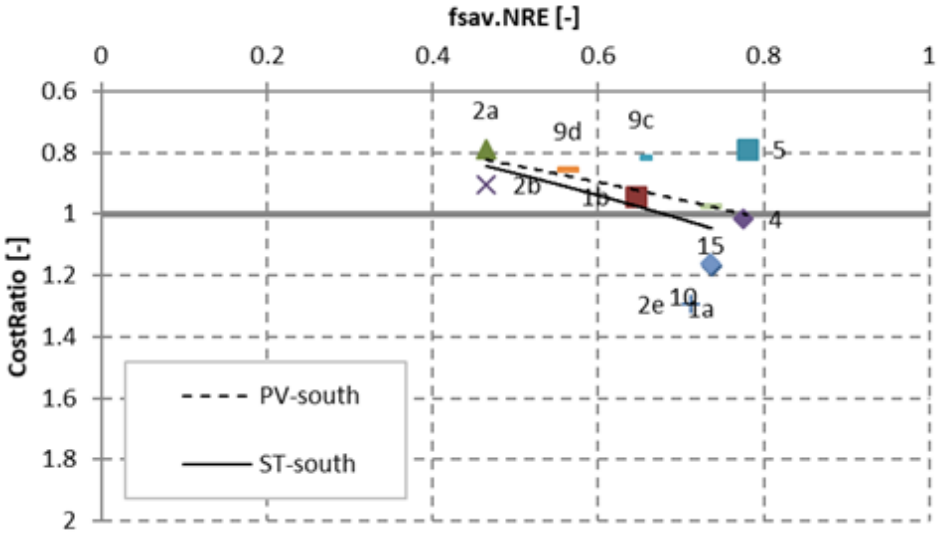
- Exclude plants with no annual energy balance

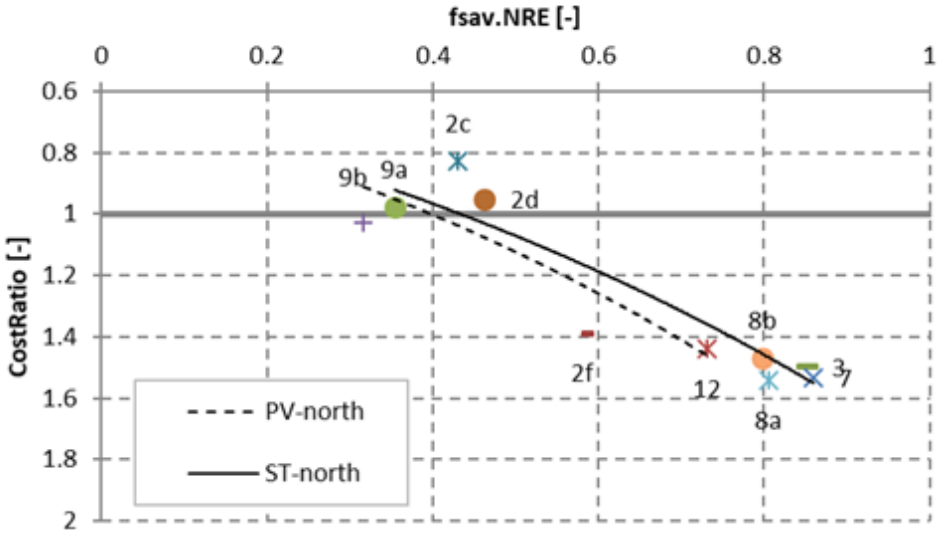


Trend analyses

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

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

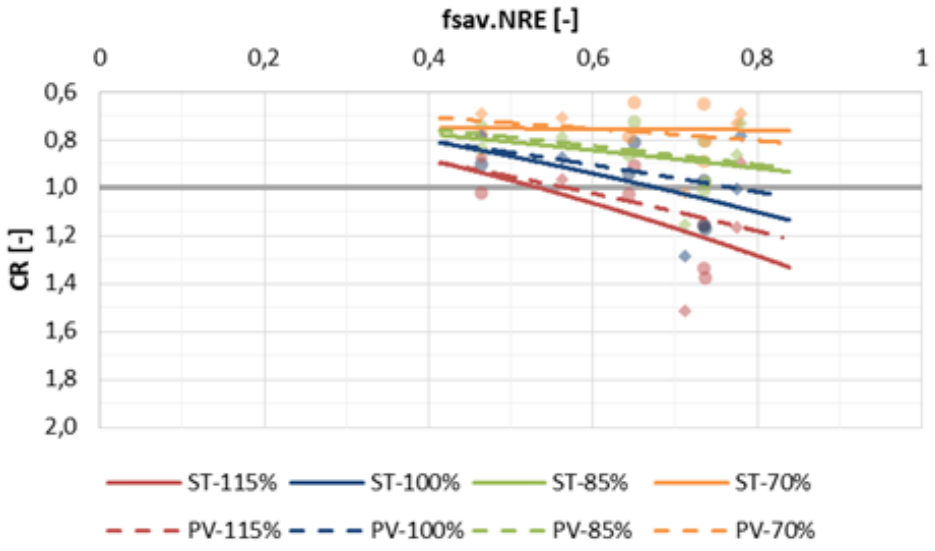


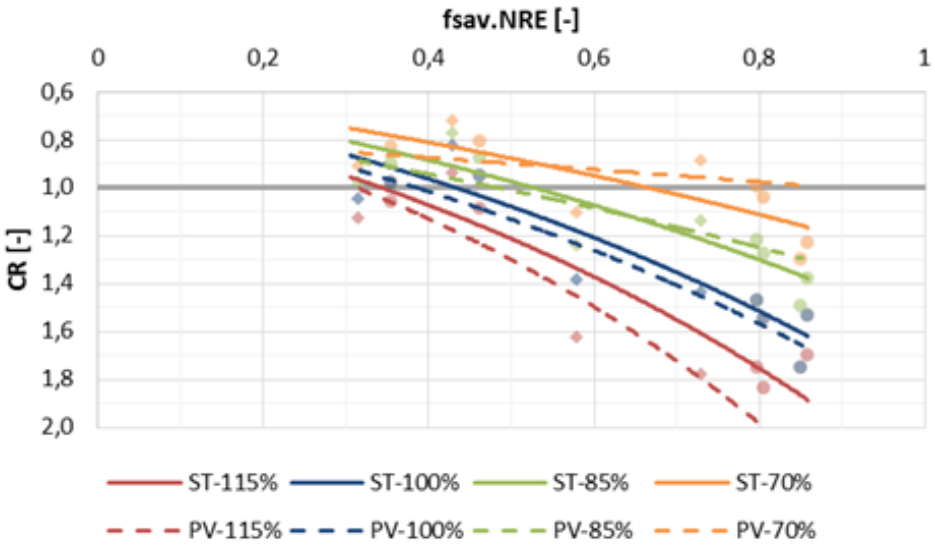


Sensitivity analyses

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

→ Influence shown on trends





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 / Standardization !!**

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/

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