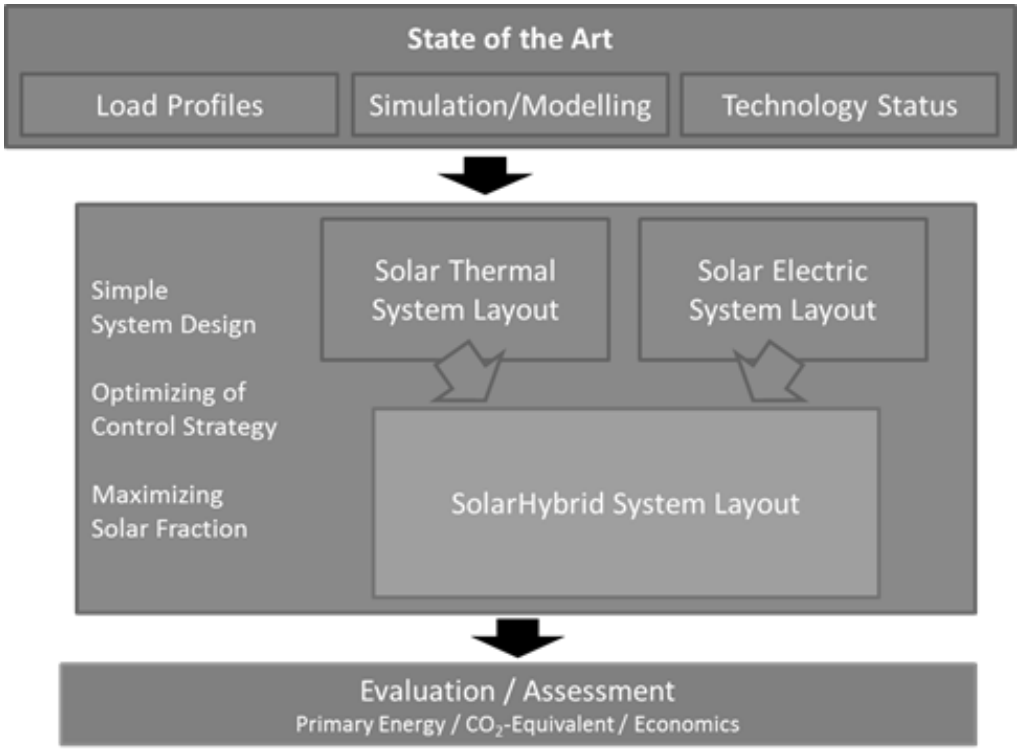
SolarHybrid Heating and Cooling

Daniel NEYER[1,2], Alexander THÜR[2]

Goal

- Simplification & cost competitiveness
- reduction of components, efficient components and optimized control strategies

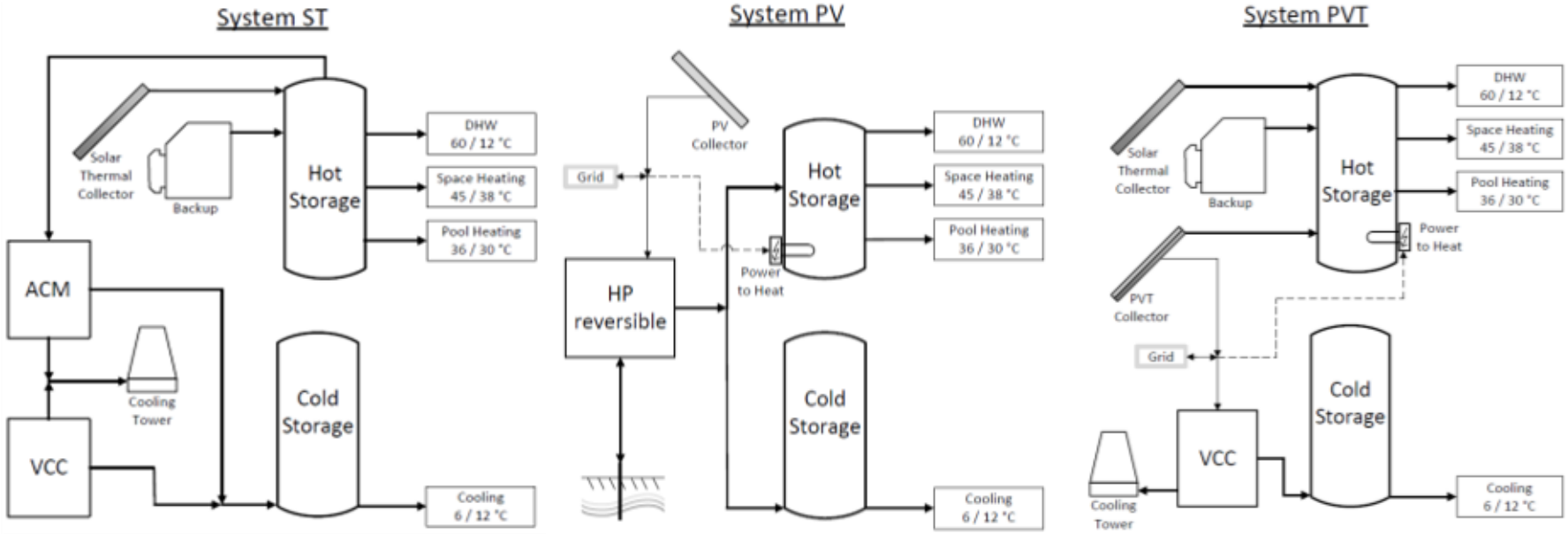


Methodology

- **Prototype** 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
- Investigation on component **simulation models**
- Steady state and **dynamic laboratory** measurements
  - Characteristic curves
  - Hardware-in-the-Loop
- **Simulation studies**
  - Realistic case: hotel & office profile
  - Potential study: solar / hybrid potentials
- **Assessment** and **sensitivity analysis** with T53E4 Tool

Simulation studies

- **Hotel profile**:
  - heating / cooling / dehum. / domestic hot water / pool
- HVAC layouts
  - **7 system** layouts
  - 3 load files / 2 locations

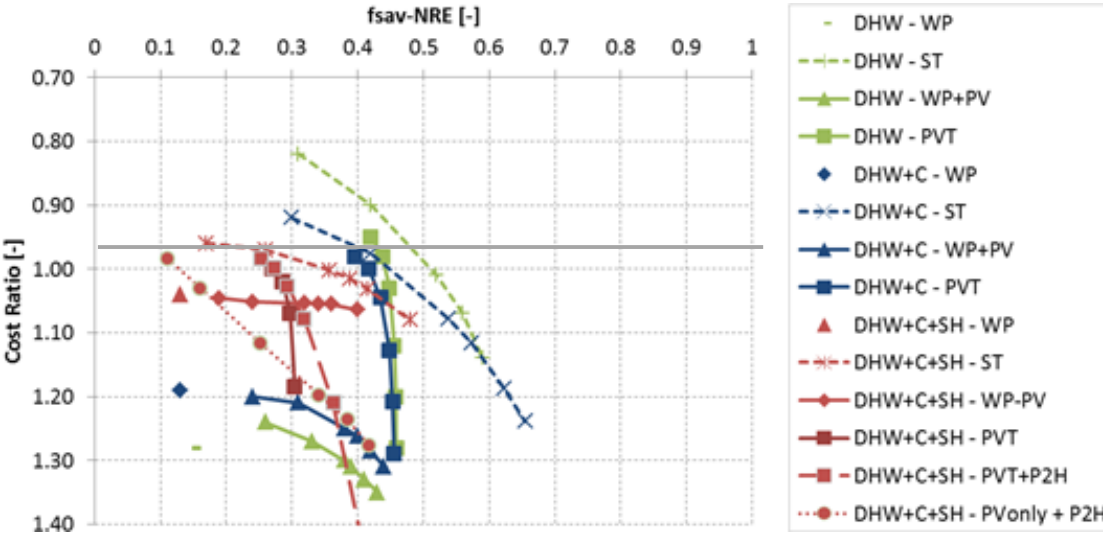


- Component **models validated** by measurements

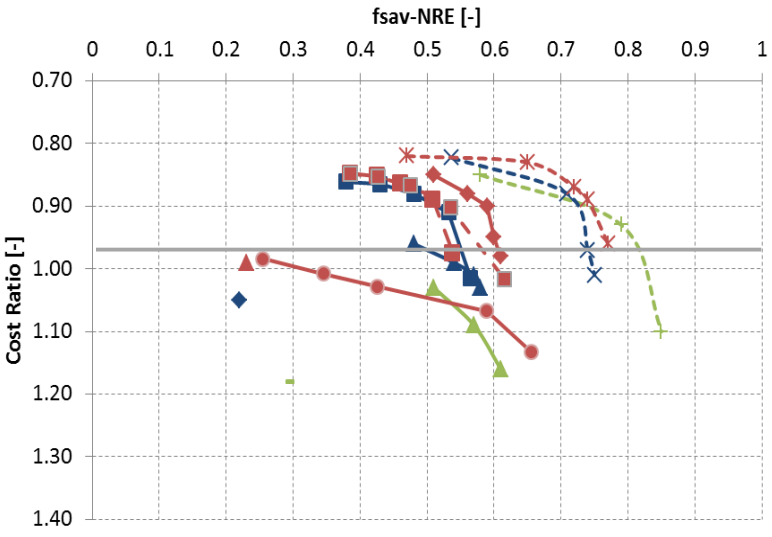
Results simulation studies

- **$f_{sav.NRE}$ 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

Innsbruck



Sevilla



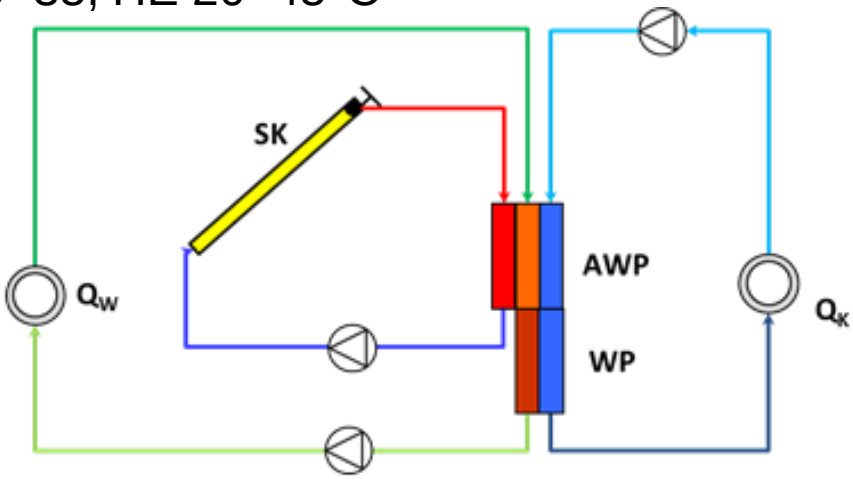
Laboratory measurements

universität innsbruck
Arbeitsbereich für Energieeffizientes Bauen

danielneyer brainworks

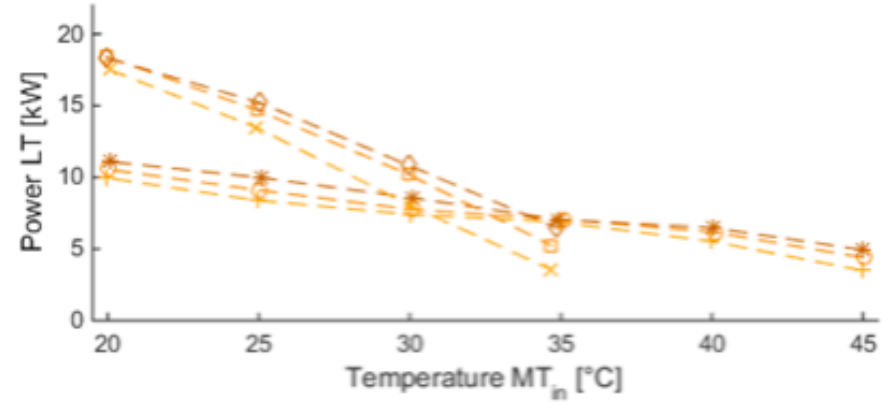
- **Hardware-in-the-Loop** @ UIBK labs
  - TRNSYS & LabView
  - System in TRNSYS simulations
  - ACM & VCC in real operation

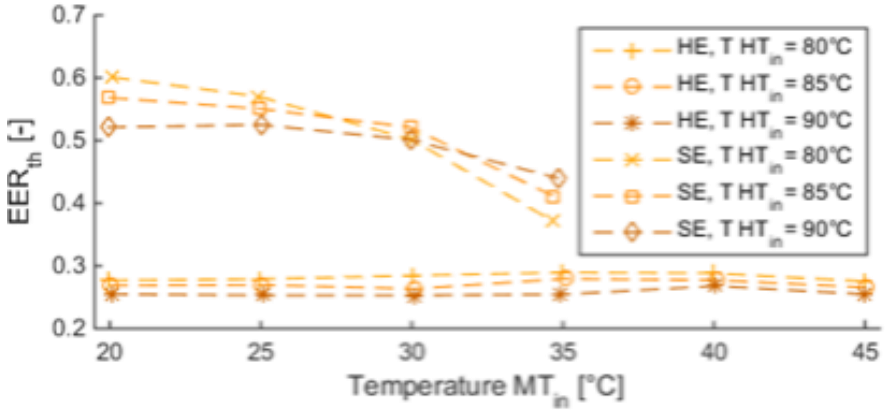
- **Steady state** / Large matrix
  - ACM
    - LT: 1.5–3, MT: 4.25–6, HT: 3–4.5 m³/h
    - LT: 6–22, HT: 80–90, MT: SE 20–35, HE 20–45°C
  - VCC
    - LT: 2–3.5, MT: 3.5–6 m³/h
    - LT: 12–22, MT: 25–45°C
- **Dynamic** measurements
  - Daily & weekly profiles
  - ACM only & solar direct
  - ACM & VCC hybrid

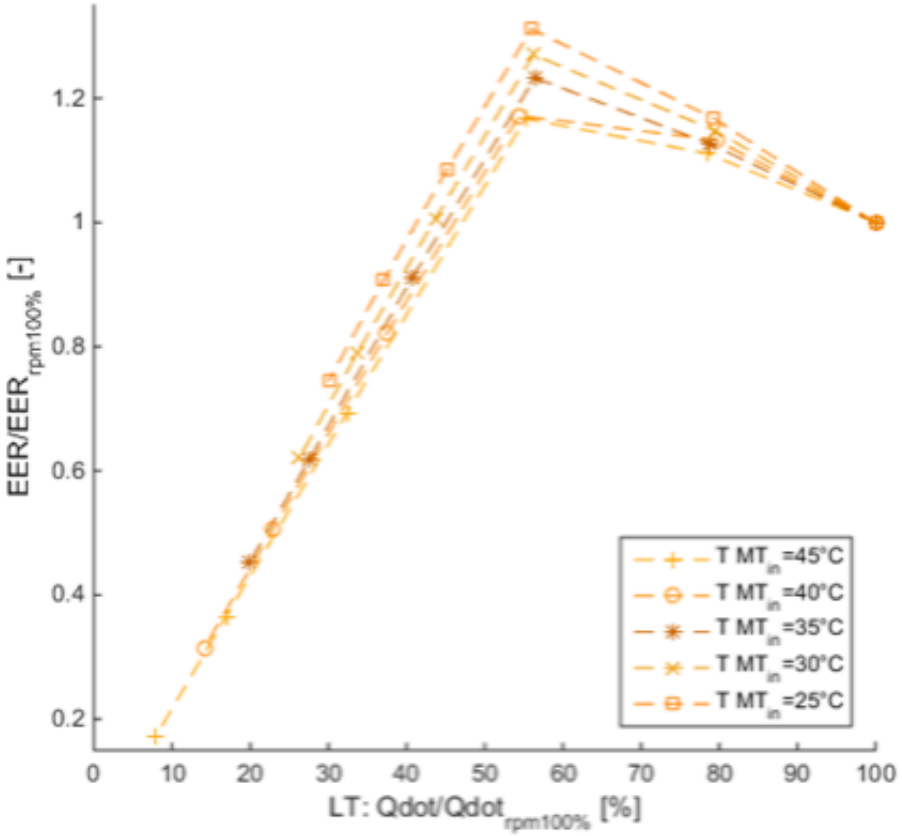


Characteristic curves

- Wide range of operation is possible
- Good performance & optimization Potential







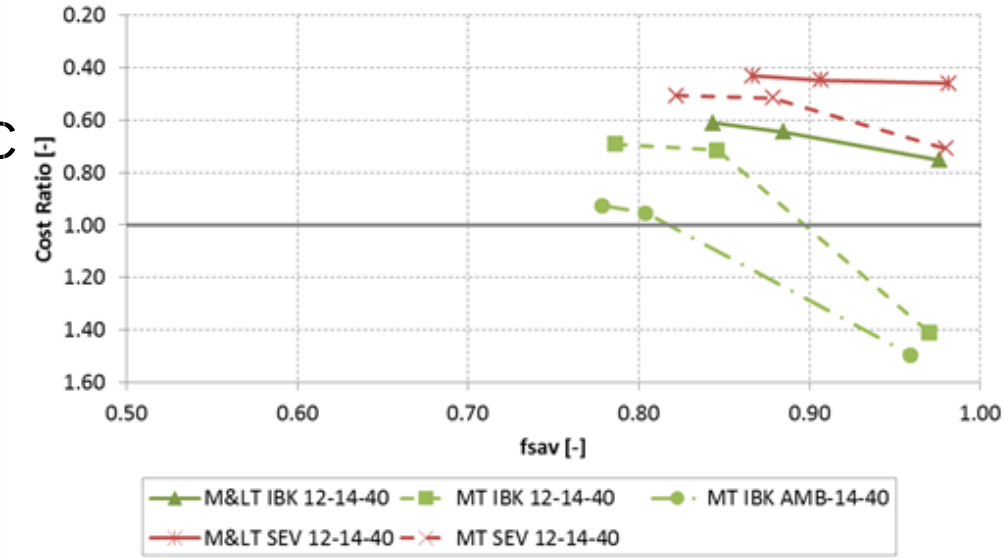
Daily performance

- 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

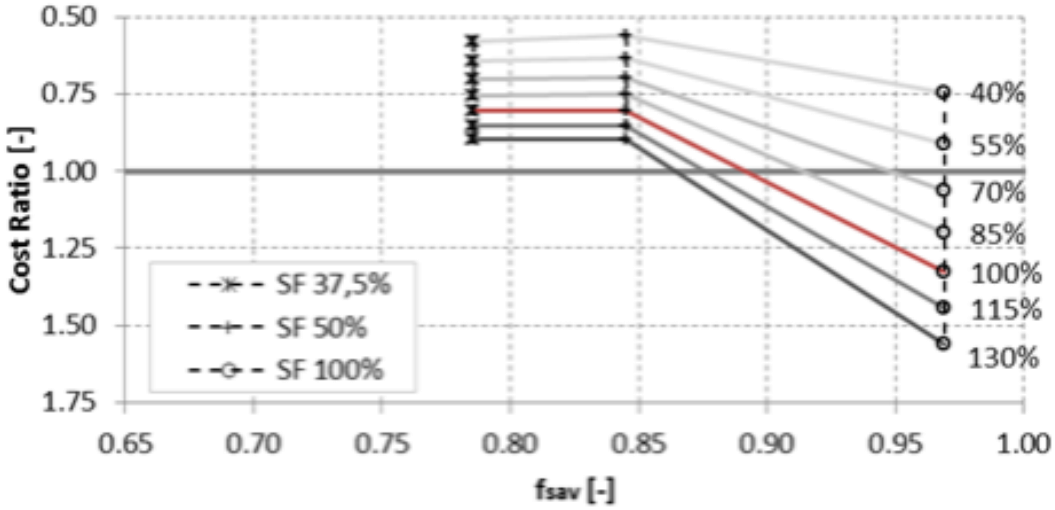
	Energies ACM [kWh]			Energies VCC [kWh]			ACM+VCC [kWh]		System SPFsys [-]			
									MT+LT		MT	
	Q_{HT}	Q_{LT}	Q_{MT}	Q_{MT}	Q_{LT}	Q_{el}	Q_{MT}	Q_{LT}	SPF_{th}	$SPF_{el.sys}$	SPF_{th}	$SPF_{el.sys}$
sunny day	233	125	349	96	80	21	445	205	2,03	20,19	1,50	13,82
cloudy day	102	57	152	102	86	21	254	143	2,04	12,33	1,49	7,89

Potential study

- HP system
  - MT: 12/ 40°C; LT: 6/12°C
  - **Solar thermal direct**
- **Annual** simulations
  - Innsbruck & Sevilla
  - w/o VCC

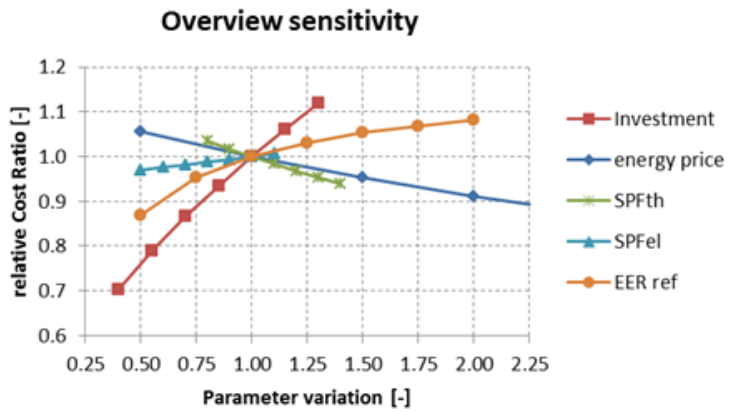


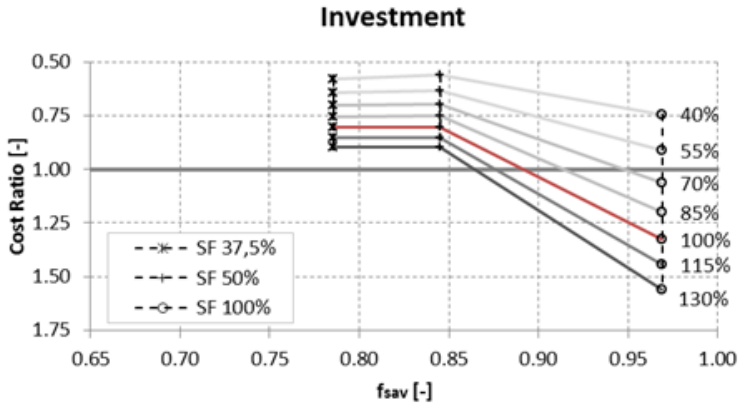
- $f_{sav\ .NRE} > 80\%$
- **CR << 1**

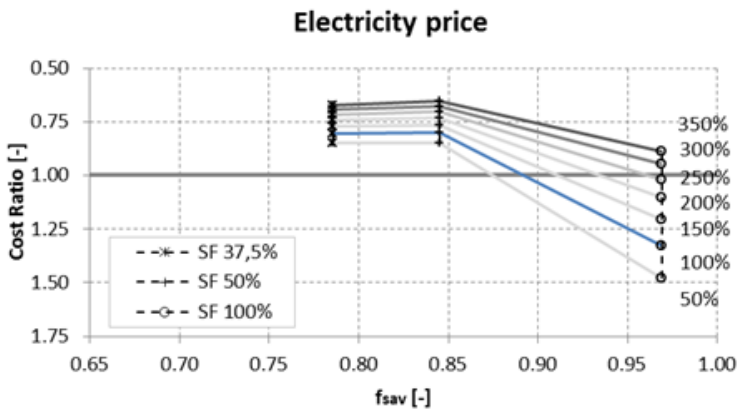


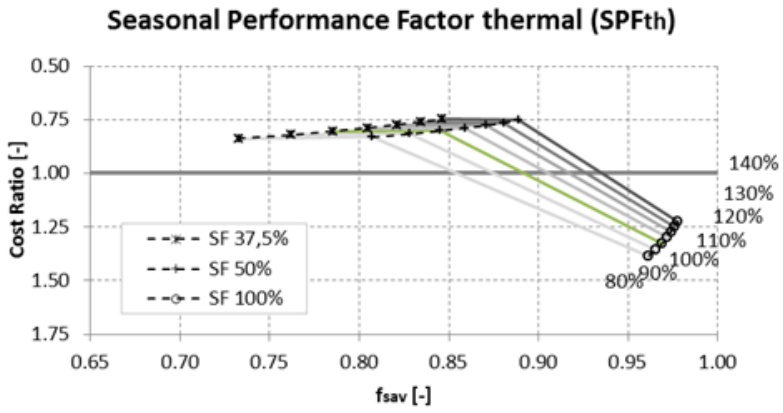
- Sensitivity analysis
  - **Investment costs**
  - Others..

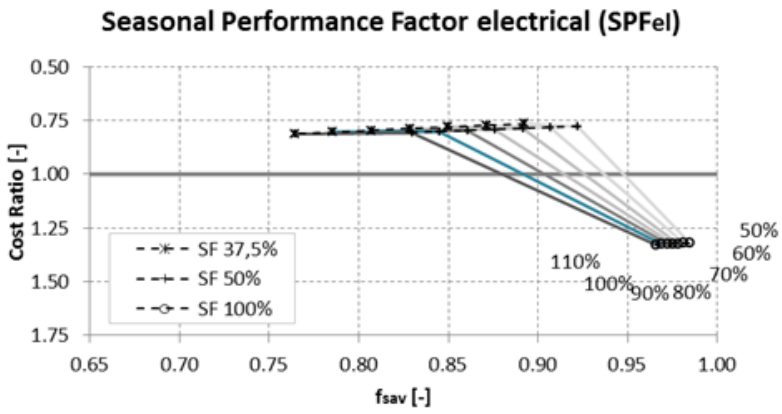
Pc

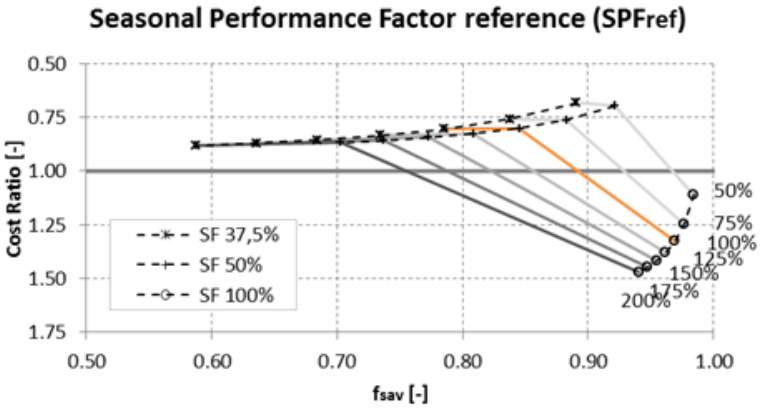

Overview sensitivity
relative Cost Ratio [-]
Parameter variation [-]
Investment
energy price
SPFth
SPFel
EER ref


Investment
Cost Ratio [-]
fsav [-]
SF 37,5%
SF 50%
SF 100%
40%
55%
70%
85%
100%
115%
130%


Electricity price
Cost Ratio [-]
fsav [-]
SF 37,5%
SF 50%
SF 100%
350%
300%
250%
200%
150%
100%
50%


Seasonal Performance Factor thermal (SPFth)
Cost Ratio [-]
fsav [-]
SF 37,5%
SF 50%
SF 100%
140%
130%
120%
110%
100%
90%
80%


Seasonal Performance Factor electrical (SPFel)
Cost Ratio [-]
fsav [-]
SF 37,5%
SF 50%
SF 100%
50%
60%
70%
80%
90%
100%
110%


Seasonal Performance Factor reference (SPFref)
Cost Ratio [-]
fsav [-]
SF 37,5%
SF 50%
SF 100%
50%
75%
100%
125%
150%
175%
200%

Conclusion

- Components development
  - Possibility for solar / **solar hybrid operation**
  - **Good performance** with optimization potential
- System results
  - Solar thermal 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 with simple HVAC layouts,
  - advanced control strategies and
  - high efficient components.

Final report online
https://www.energieforschung.at/projekte/804/solare-hybridsysteme-zum-heizen-und-kuehlen-mit-optimierungen-zu-minimierten-und-kostenguenstigen-systemkonzepten/

danielneyer brainworks

CORE© THE CYBERNETICS OF RENEWABLE ENERGY AND EFFICIENCY.

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

Thank you for your attention!

danielneyer brainworks

universität innsbruck
Arbeitsbereich für Energieeffizientes Bauen

FFG

Danksagung
Dieses Projekt wird aus Mitteln des Klima- und Energiefonds gefördert und im Rahmen des Programms „ENERGY MISSION AUSTRIA“ durchgeführt (FFG-Projekt Nr. 843855)

powered by klima+ energie fonds