universität innsbruck
Arbeitsbereich für
Energieeffizientes Bauen

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SolarHybrid Heating and Cooling

NEYER Daniel

With friendly support by:
FH OÖ Forschungs und Entwicklungs GmbH
PinK gmbH
Engie Kältetechnik GmbH

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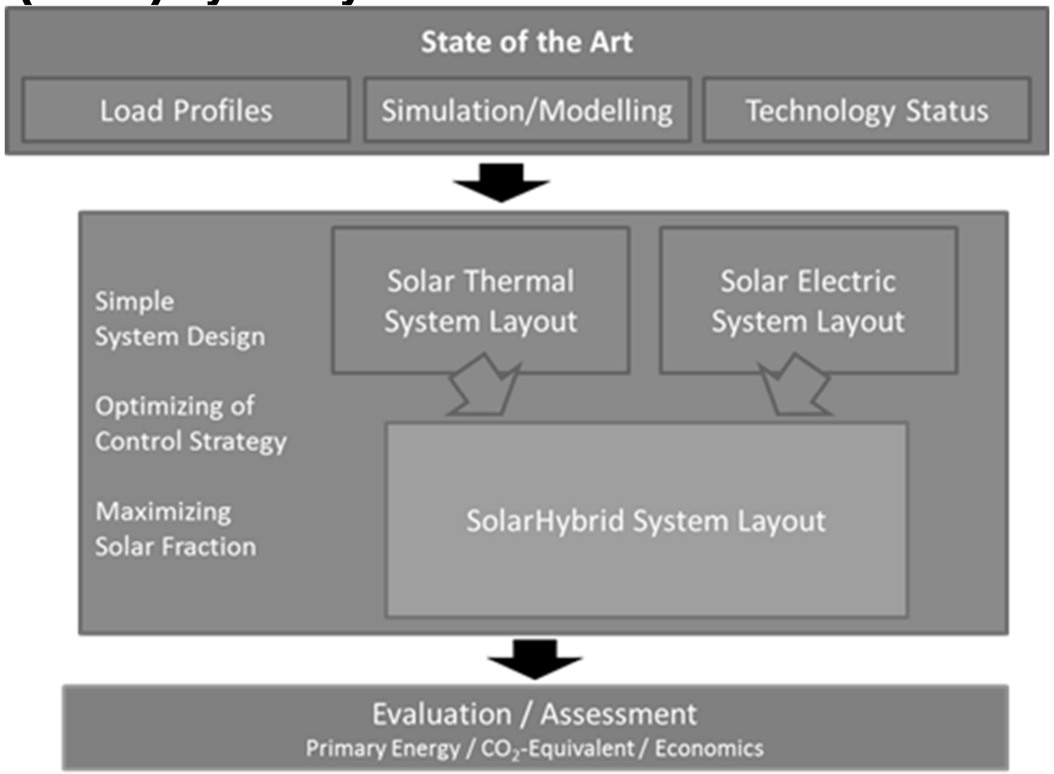
Goal

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

→ **(Solar-) Hybrid Systems**



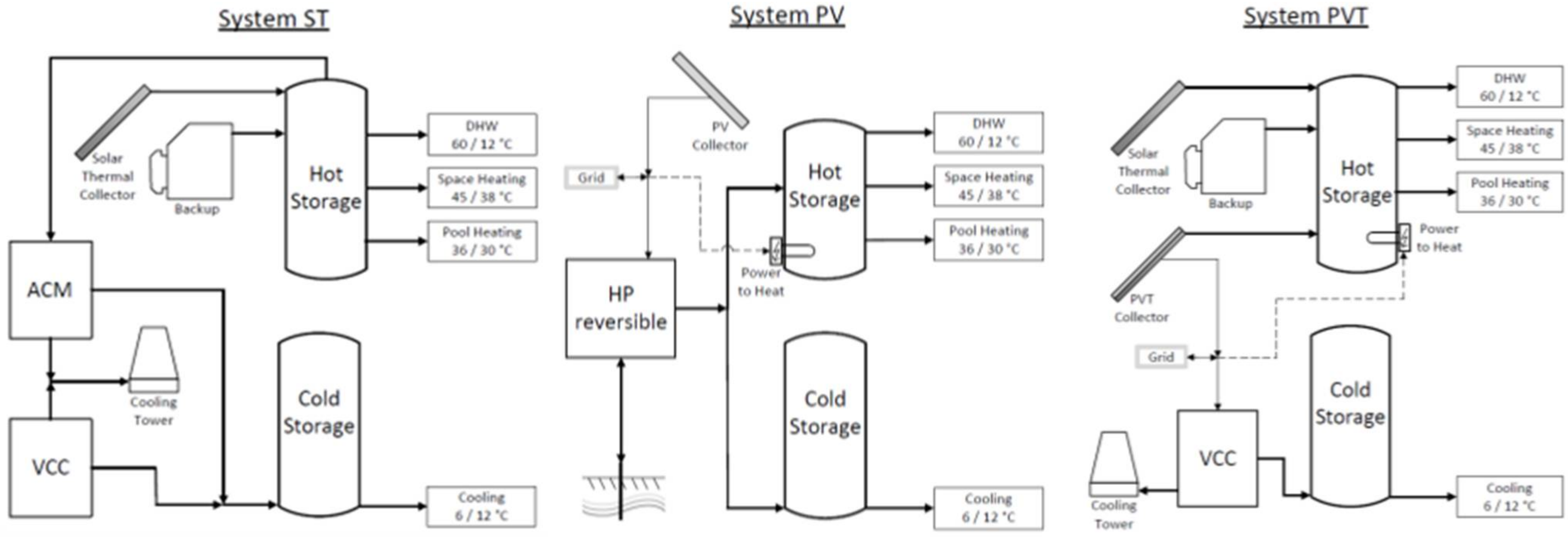
Methodology

- **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

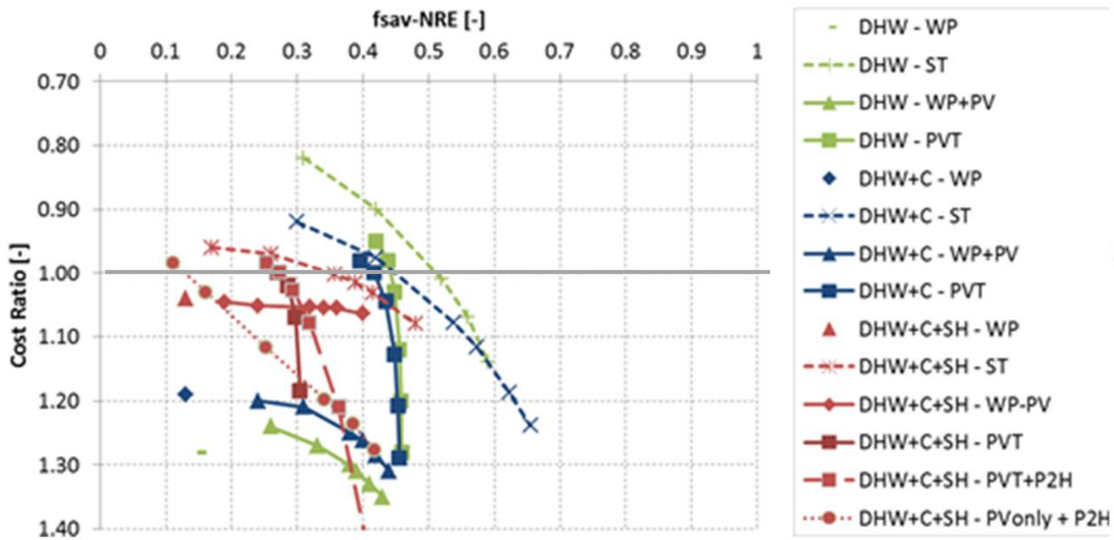


» **Validated by measurements; Annually simulation studies**

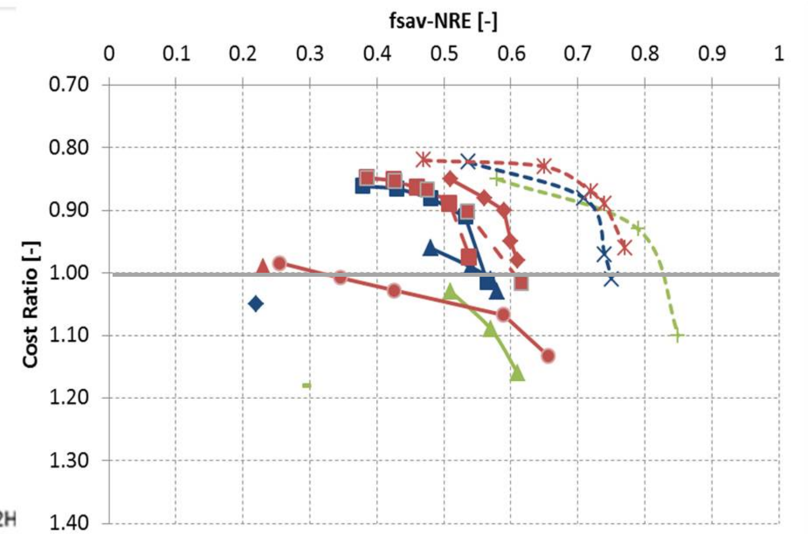
Results simulation studies

- **$f_{sav.NRE}$ 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

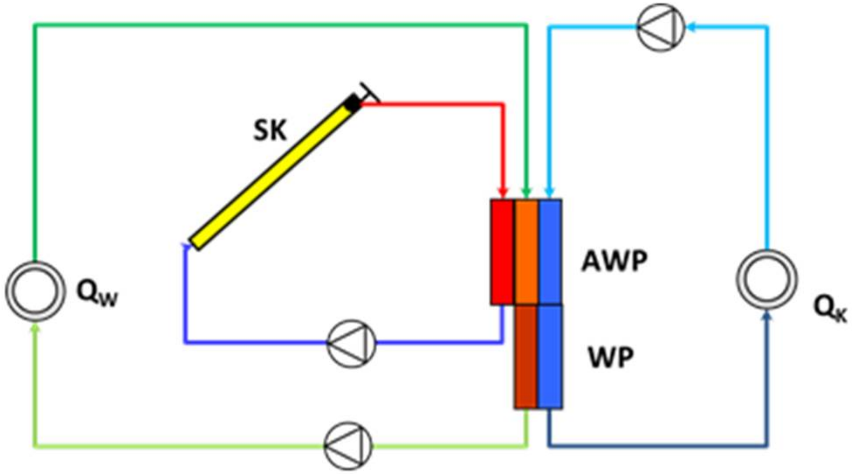


Laboratory measurements

» **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
  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

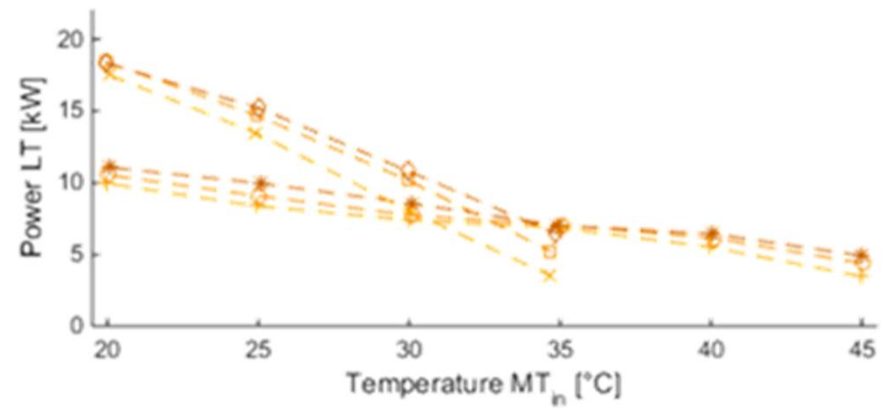
» **Dynamic measurements**
  Daily & weekly profiles
  ACM solar direct
  ACM only
  ACM & VCC hybrid

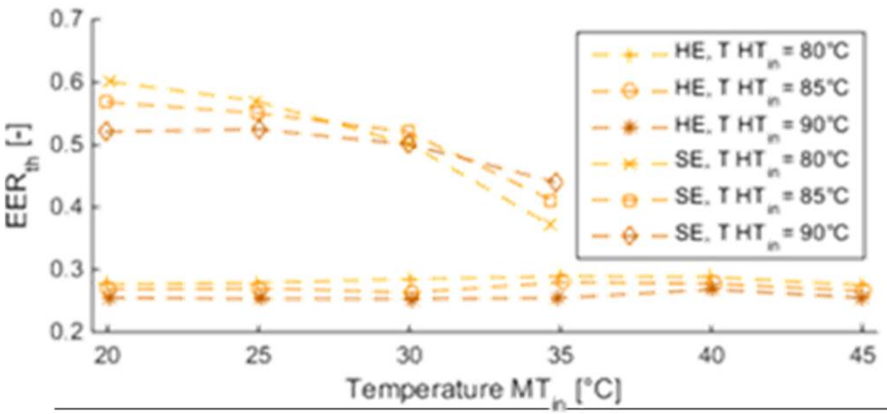


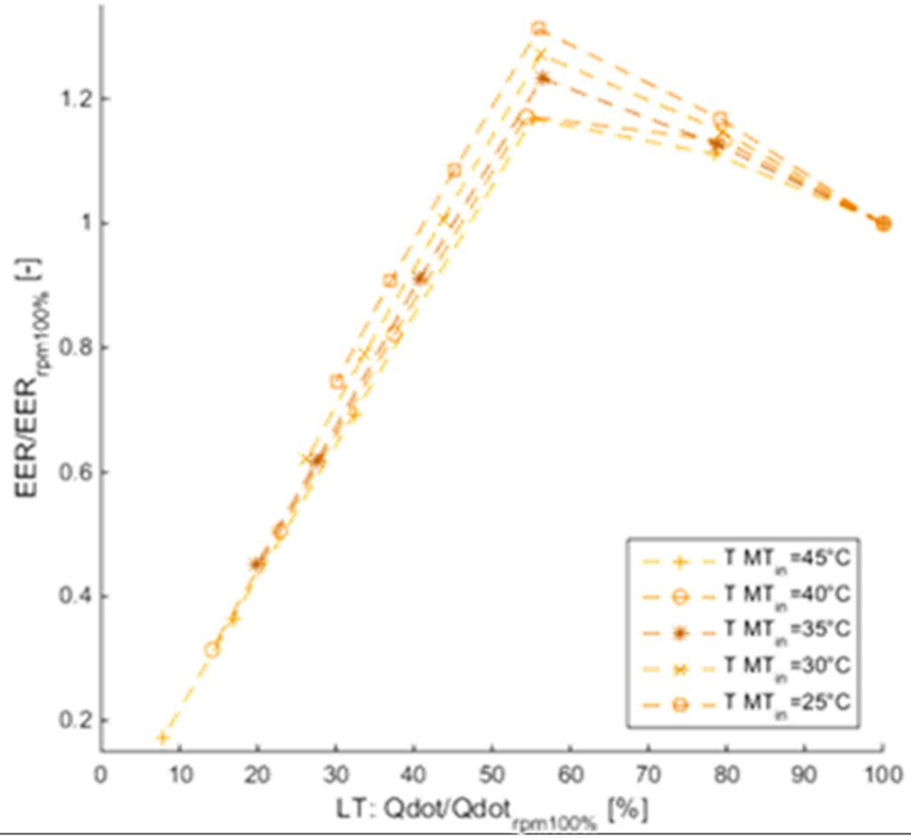
Measurement results – characteristic curves

» **Wide range of operation is possible**

» **Good performance & optimization Potential**







Measurement results – daily performance

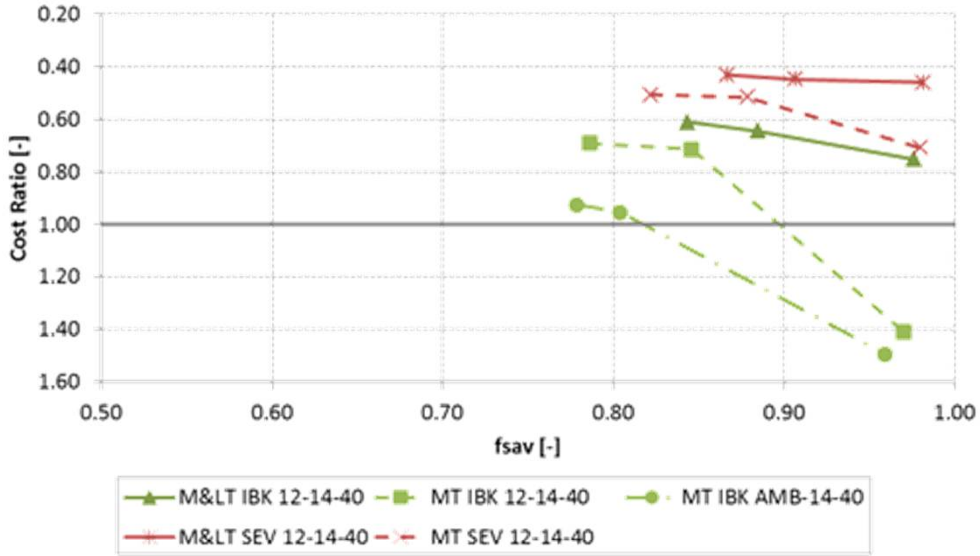
» **Hybrid heat pump operation of ACM & VCC**
Set points: MT: 12/ 40°C; LT: 6/12°C
Operation if I >200 W/m²
Location: Innsbruck
ST: 70m², NO storage
SPFel.sys: simplified

	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

simulation results – potential study

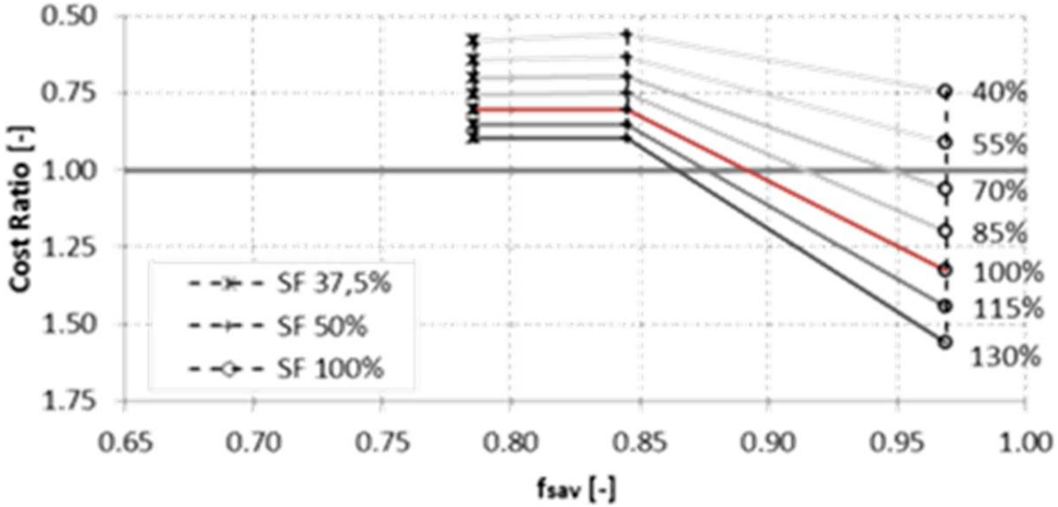
» **HP system**
  Set: MT: 12/ 40°C; LT: 6/12°C
  Solar thermal direct

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

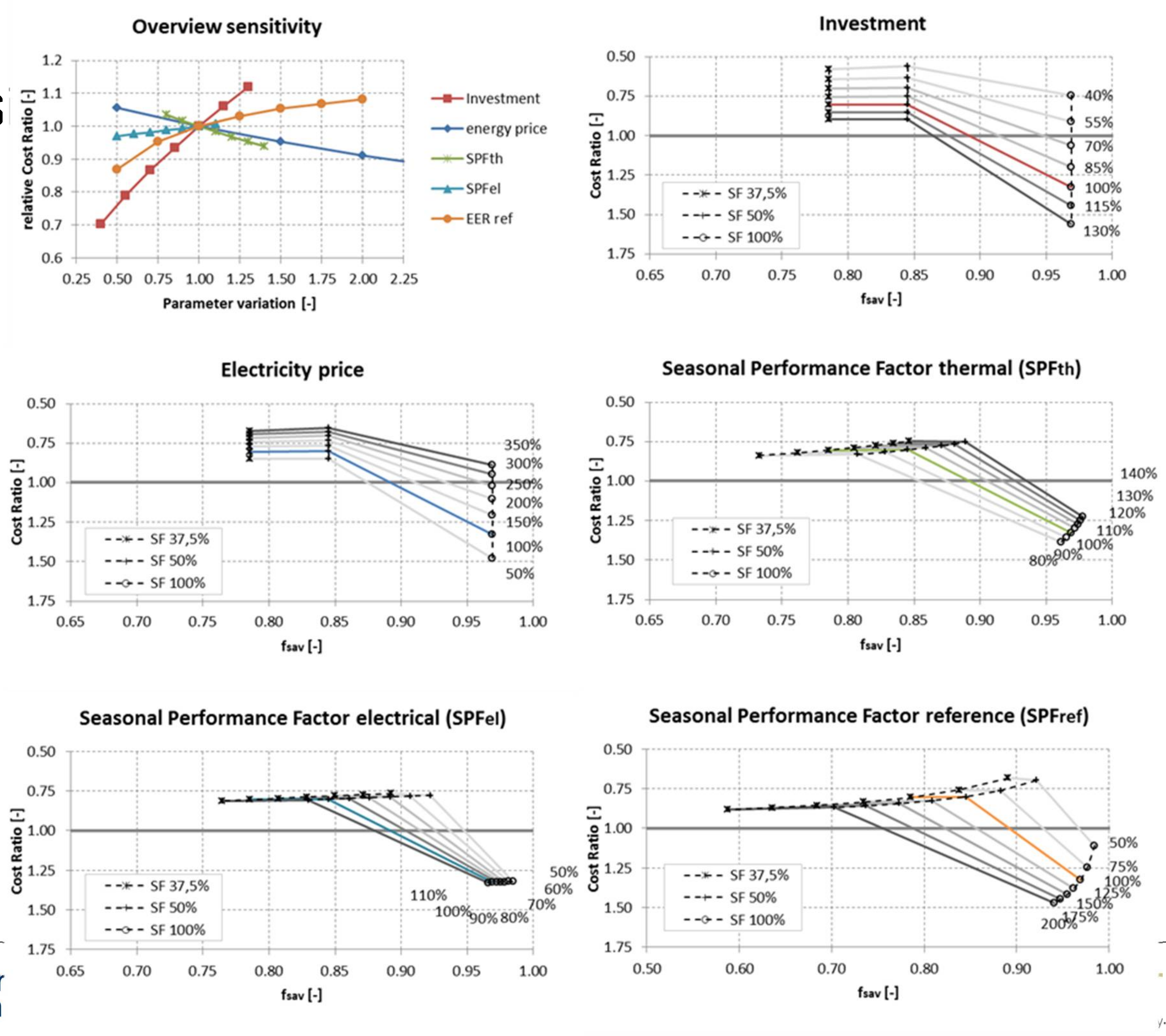


» **$f_{sav\ .NRE}$ > 80%**

» **CR << 1**



» **Sensitivity analysis**
  Investment costs
  Electricity prices
  Electrical efficiency
  Thermal efficiency
  Primary Energy Conversion


Overview sensitivity
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
350%
300%
250%
200%
150%
100%
50%
Seasonal Performance Factor thermal (SPFth)
140%
130%
120%
110%
100%
90%
80%
Seasonal Performance Factor electrical (SPFel)
50%
60%
70%
80%
90%
100%
110%
Seasonal Performance Factor reference (SPFref)
50%
75%
100%
125%
150%
175%
200%

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.

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