SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK60
PVT SYSTEMS

PVT Systems
-
Key Performance Indicators

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SPF INSTITUT FÜR SOLARTECHNIK

What's the purpose of key performance indicators ?

- **Compare the performance of a system (or a part of it)**

  ... with its rated, expected or optimal performance

  ... with the performance of another system

  (Values can come from measurement data or simulations)

KPIs defined in Task 60

Energy

Economics

Environment

KPIs defined in Task 60

Energy

- **Thermal and electrical solar yields per m^2**
- **Thermal and electrical utilisation ratios (yield/irradiation)**
- **Power-weighted collector temperature**
- **Solar thermal fraction**
- **Solar electrical fraction**
- **Seasonal performance factor (for heat pump systems)**

Economics

Environment

KPIs defined in Task 60

Energy

- **Thermal and electrical solar yields per m²**
- **Thermal and electrical utilisation ratios (yield/irradiation)**
- **Power-weighted collector temperature**

$$\vartheta_{\mathrm{m,power}} = \frac{\int \left(\vartheta_m \cdot \dot{Q}_{PVT}\right)\, dt}{\int \dot{Q}_{PVT}\, dt}$$

- **Solar thermal fraction**
- **Solar electrical fraction**
- **Seasonal performance factor (for heat pump systems)**

Economics

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Economics

- **Specific investment cost per m^2**
- **Levelized cost of heat and electricity (LCOH, LCOE)**
- **Saved fuel and grid electricity cost**

Environment

KPIs defined in Task 60

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Economics

- **Specific investment cost per m^2**
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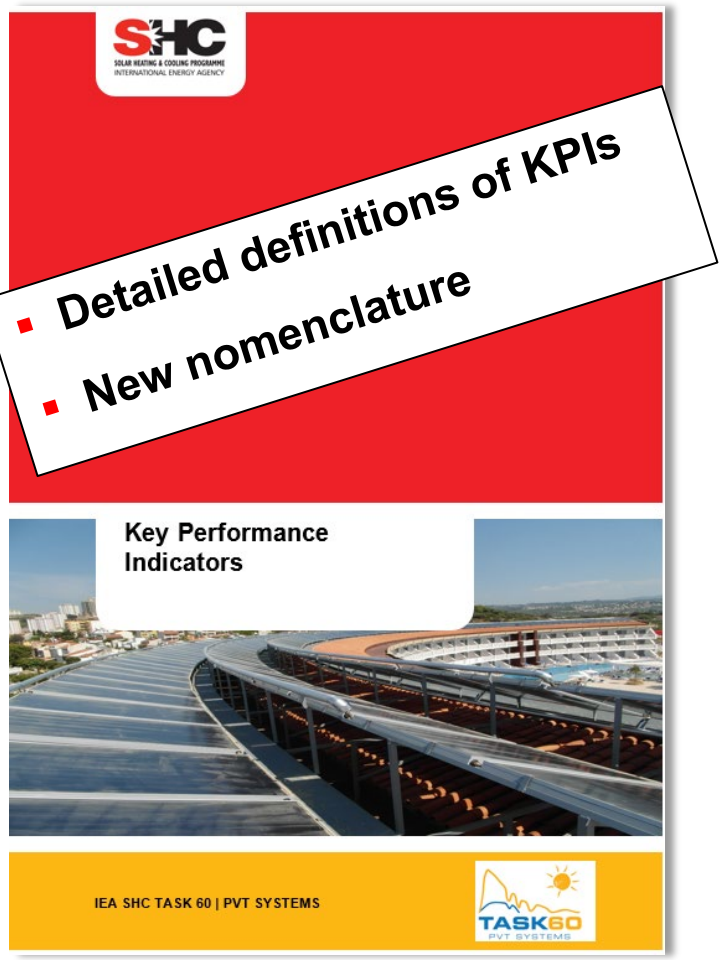
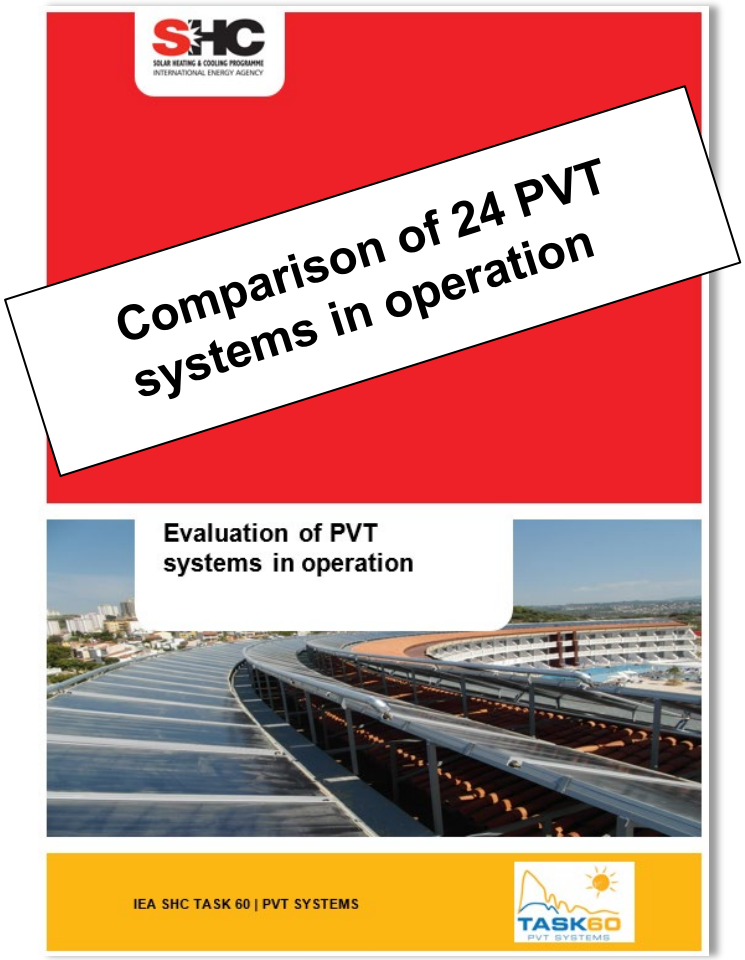
- **Saved fuel and grid electricity cost**

Environment

- **Avoided primary energy depletion [kWh oil-eq/(a*m^2)]**
- **Avoided global warming impact [kg CO2-eq/(a*m^2)]**

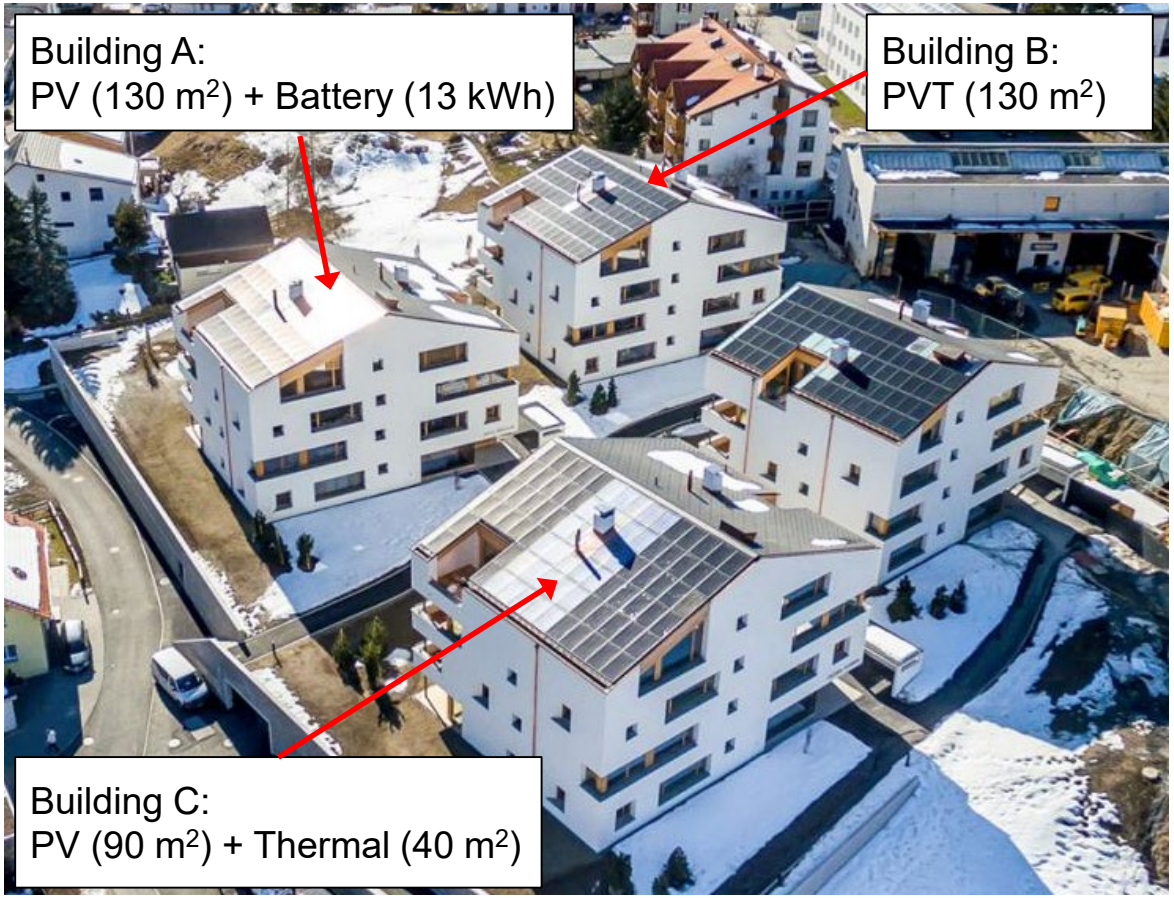
Task 60 reports





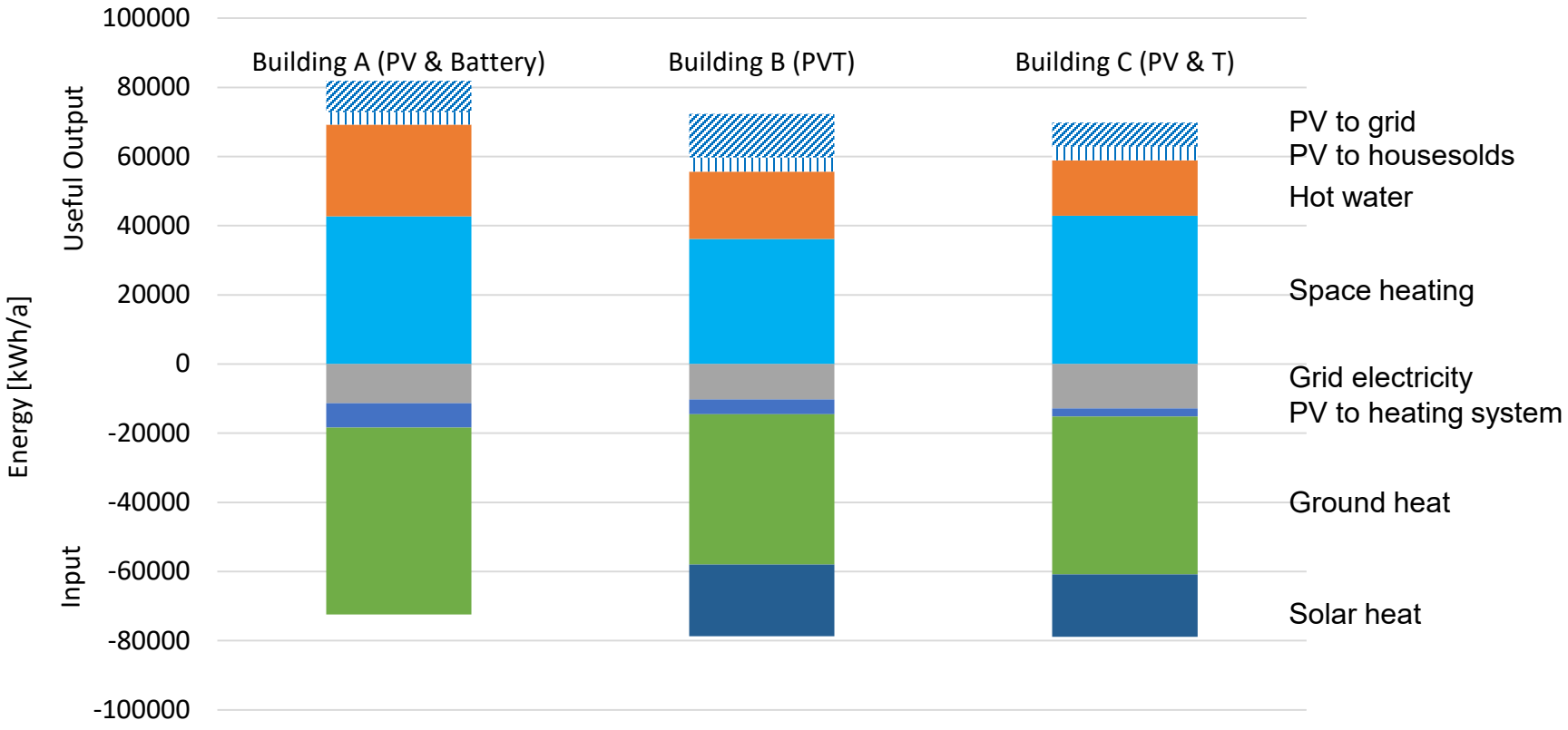
→ Available this spring on task60.iea-shc.org

Building complex «Sotchà» Switzerland



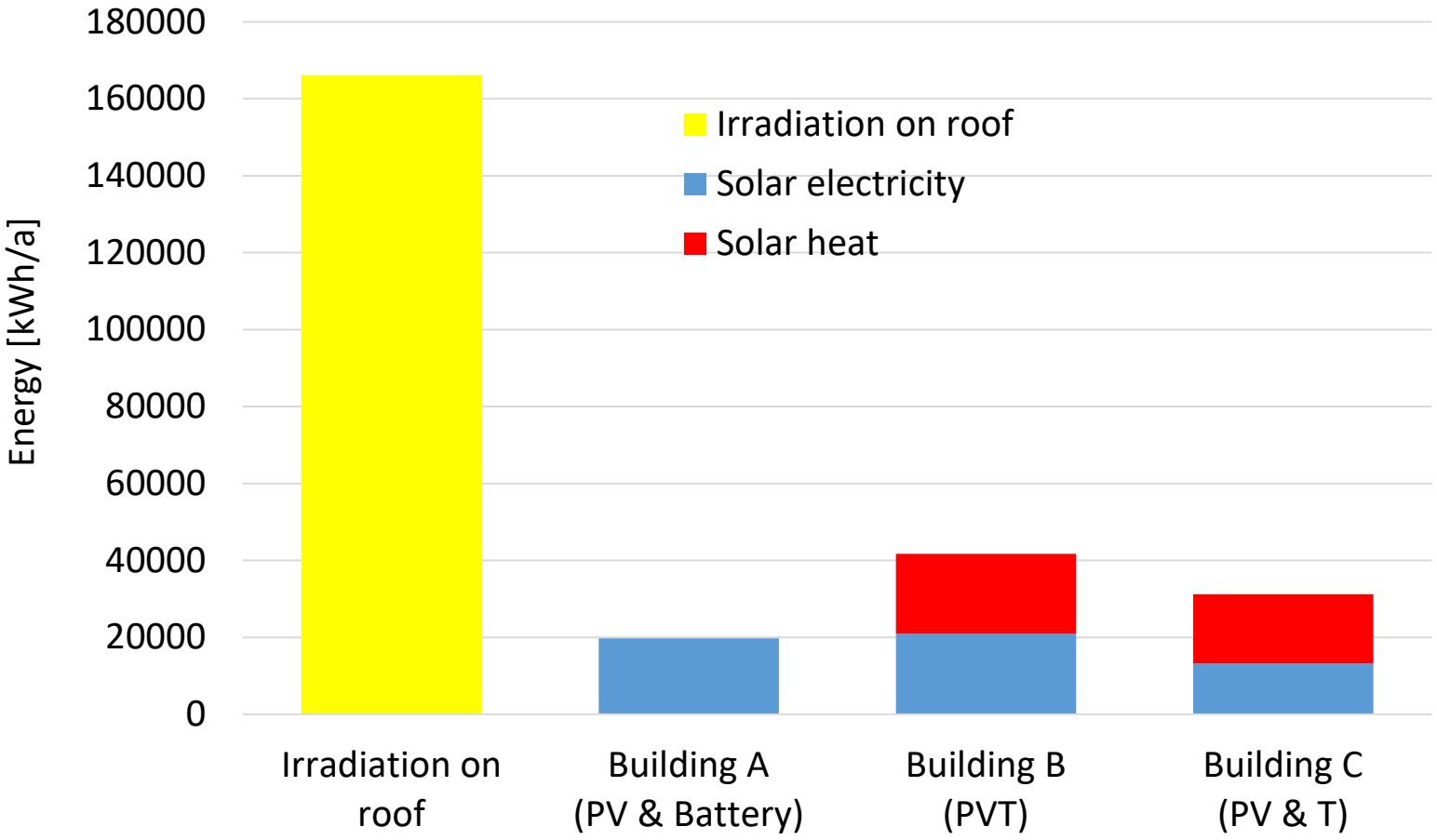
- **Each system with a 30 kW heat pump and 5 x 170 m boreholes**
- **Solar heat in buildings B and C for borehole regeneration DHW and SH**

Sotchà – Energy balance (July 2018 – June 2019)

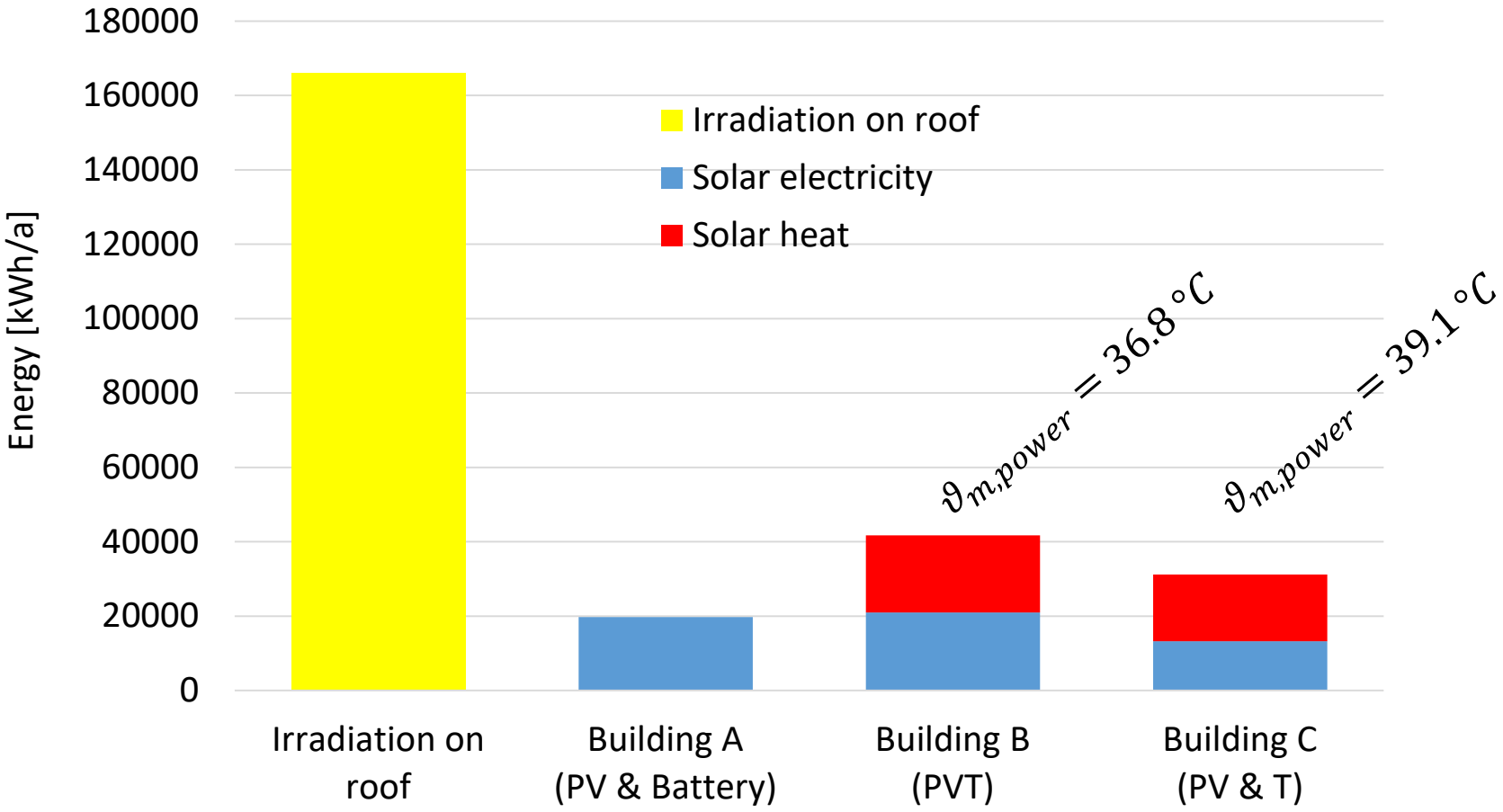


(Building A has high DHW consumption. B has low SH consumption.)

Sotchà – Solar yields and operating temperatures

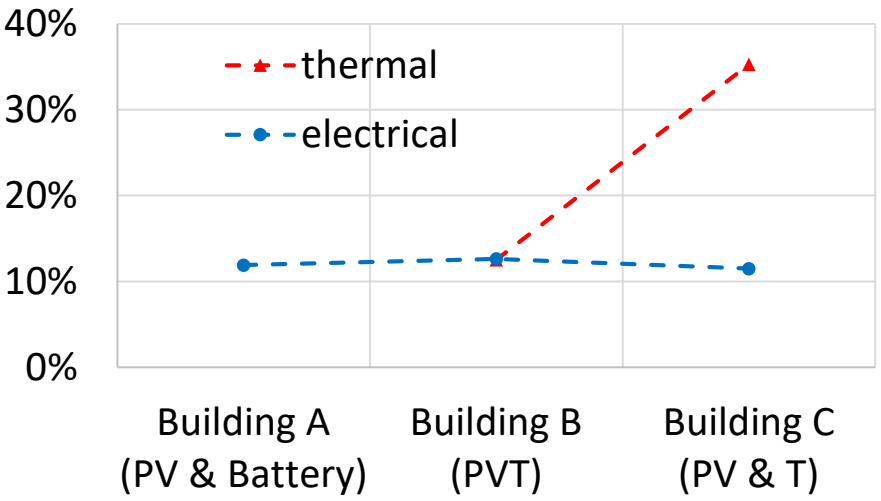


Sotchà – Solar yields and operating temperatures

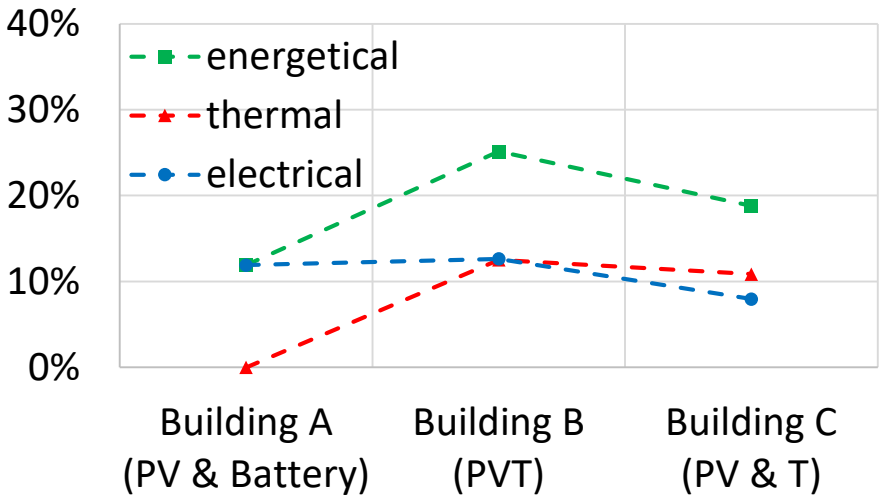


Sotchà – Solar utilization ratios

$$\frac{\text{Yield}}{\text{Irradiation on } \textbf{component} \text{ surface area}}$$



$$\frac{\text{Yield}}{\text{Irradiation on } \textbf{solar installation} \text{ surface area}}$$

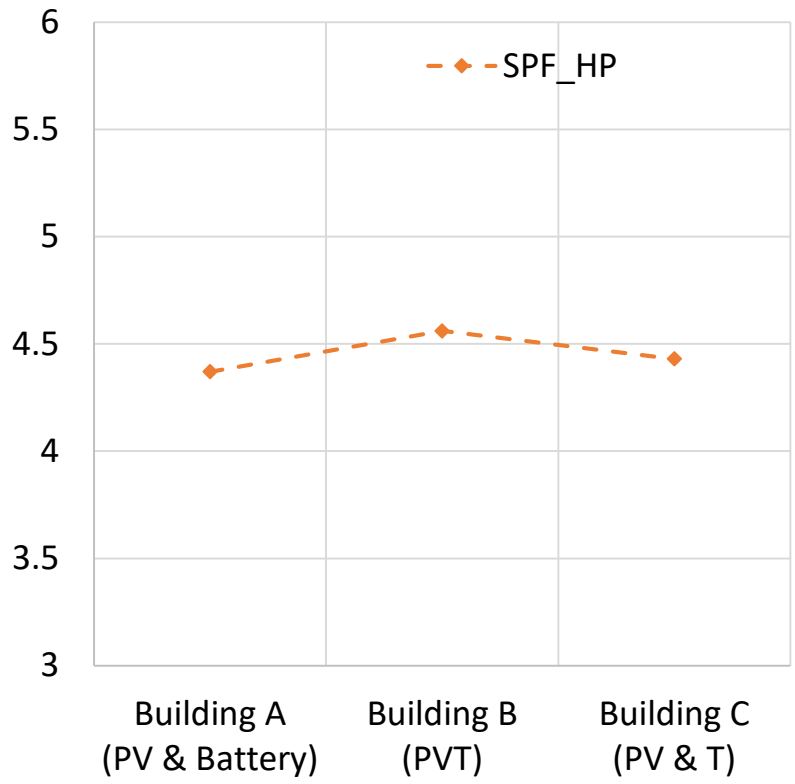


PVT has the highest «energetic solar utilization ratio».

Sotchà – Seasonal Performance Factors

Seasonal Performance Factor of Heat Pump

$$SPF_{HP} = \frac{\text{Heat from HP}}{\text{Electicity to HP}} = \frac{Q_{HP,*}}{E_{*,HP}}$$



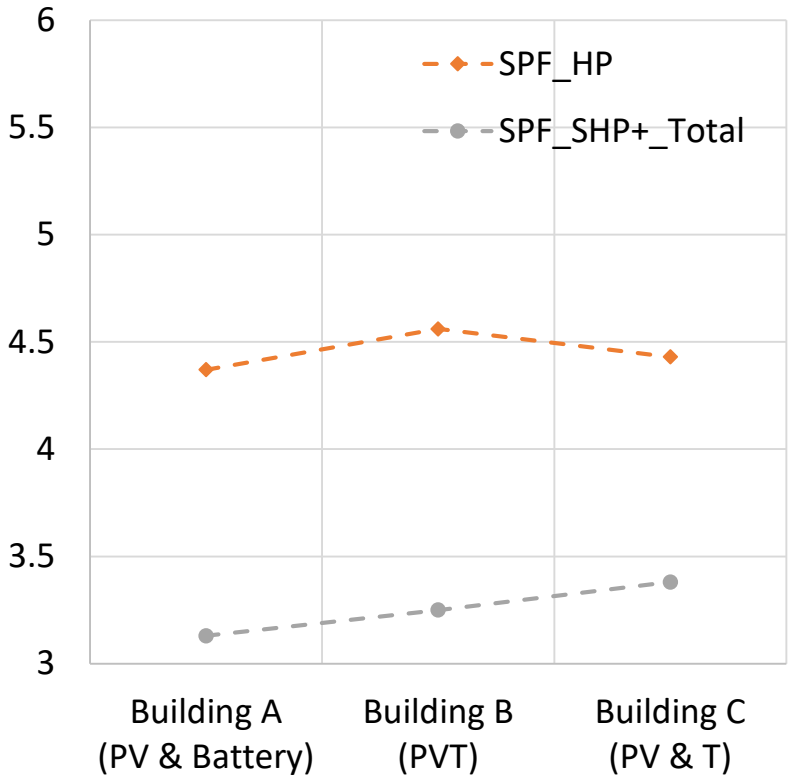
Sotchà – Seasonal Performance Factors

Seasonal Performance Factor of Heat Pump

$$SPF_{HP} = \frac{\text{Heat from HP}}{\text{Electicity to HP}} = \frac{Q_{HP,*}}{E_{*,HP}}$$

Seasonal Performance Factor of System

$$SPF_{SHP+}^{total} = \frac{\text{Useful Heat}}{\text{Electicity to system}} = \left[\frac{Q_{SH} + Q_{DHW}}{E_{*,sys}}\right]_{SHP+}$$



Sotchà – Seasonal Performance Factors

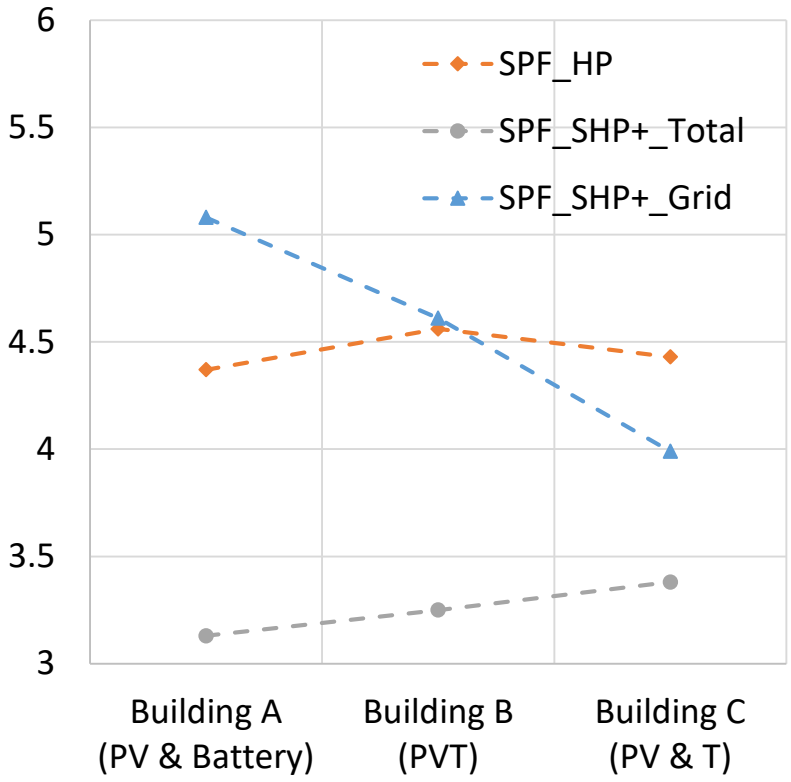
Seasonal Performance Factor of Heat Pump

$$SPF_{HP} = \frac{\text{Heat from HP}}{\text{Electicity to HP}} = \frac{Q_{HP,*}}{E_{*,HP}}$$

Seasonal Performance Factor of System

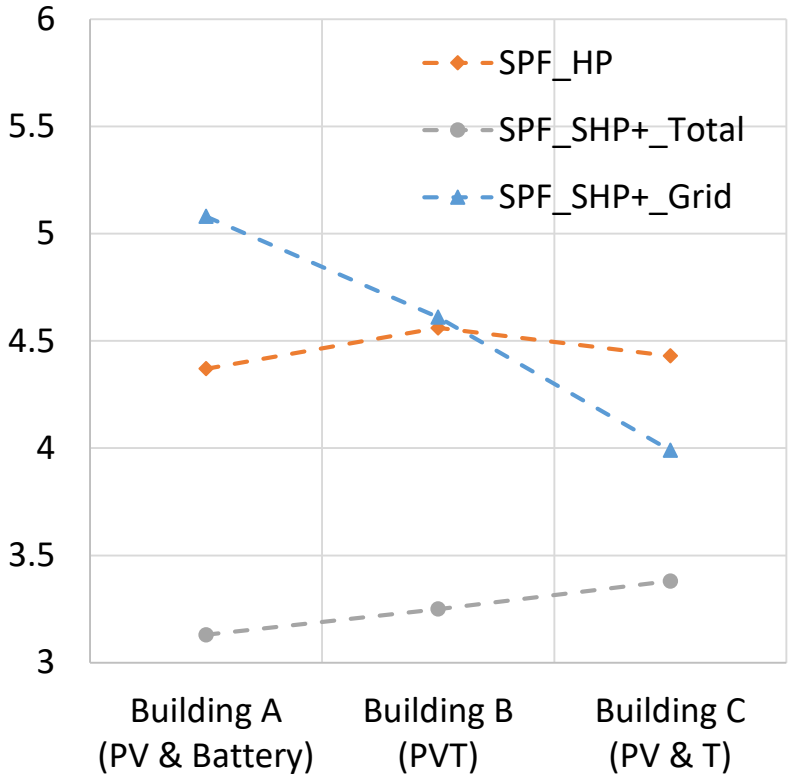
$$SPF_{SHP+}^{total} = \frac{\text{Useful Heat}}{\text{Electicity to system}} = \left[\frac{Q_{SH} + Q_{DHW}}{E_{*,sys}}\right]_{SHP+}$$

$$SPF_{SHP+}^{Grid} = \frac{\text{Useful Heat}}{\text{Grid electricity to system}} = \left[\frac{Q_{SH} + Q_{DHW}}{E_{*,sys} - E_{PV,sys}^{AC}}\right]_{SHP+}$$



Sotchà – Seasonal Performance Factors

- SPF_{HP} **similar for all systems, in the long-term likely to be better for B and C**
- SPF_{SHP+}^{total} **highest for building C, because of highest amount of solar heat to storage**
- SPF_{SHP+}^{Grid} **highest for building A, because of highest amount of slef-consumed PV-electricity**

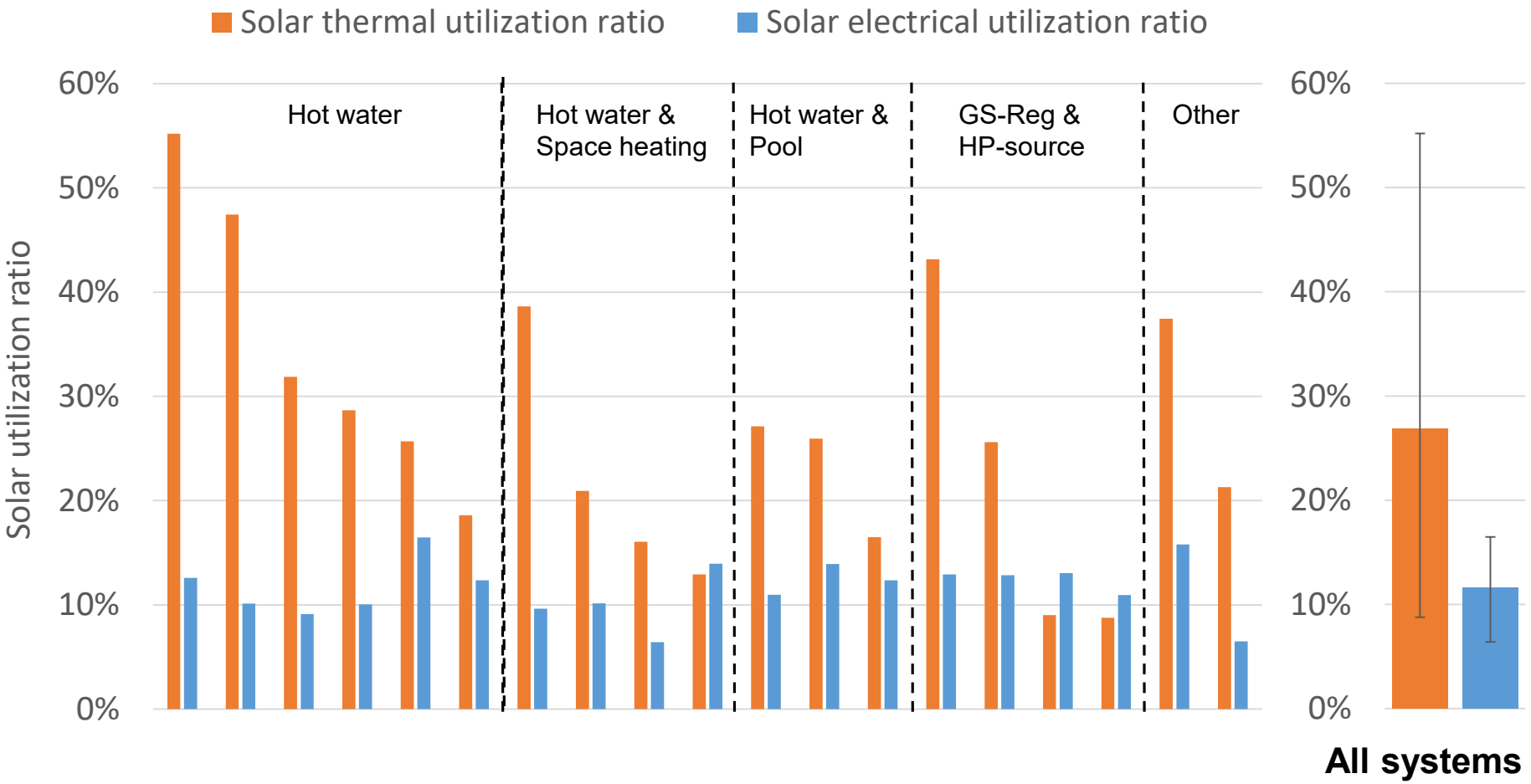


→ Final report this spring on www.spf.ch

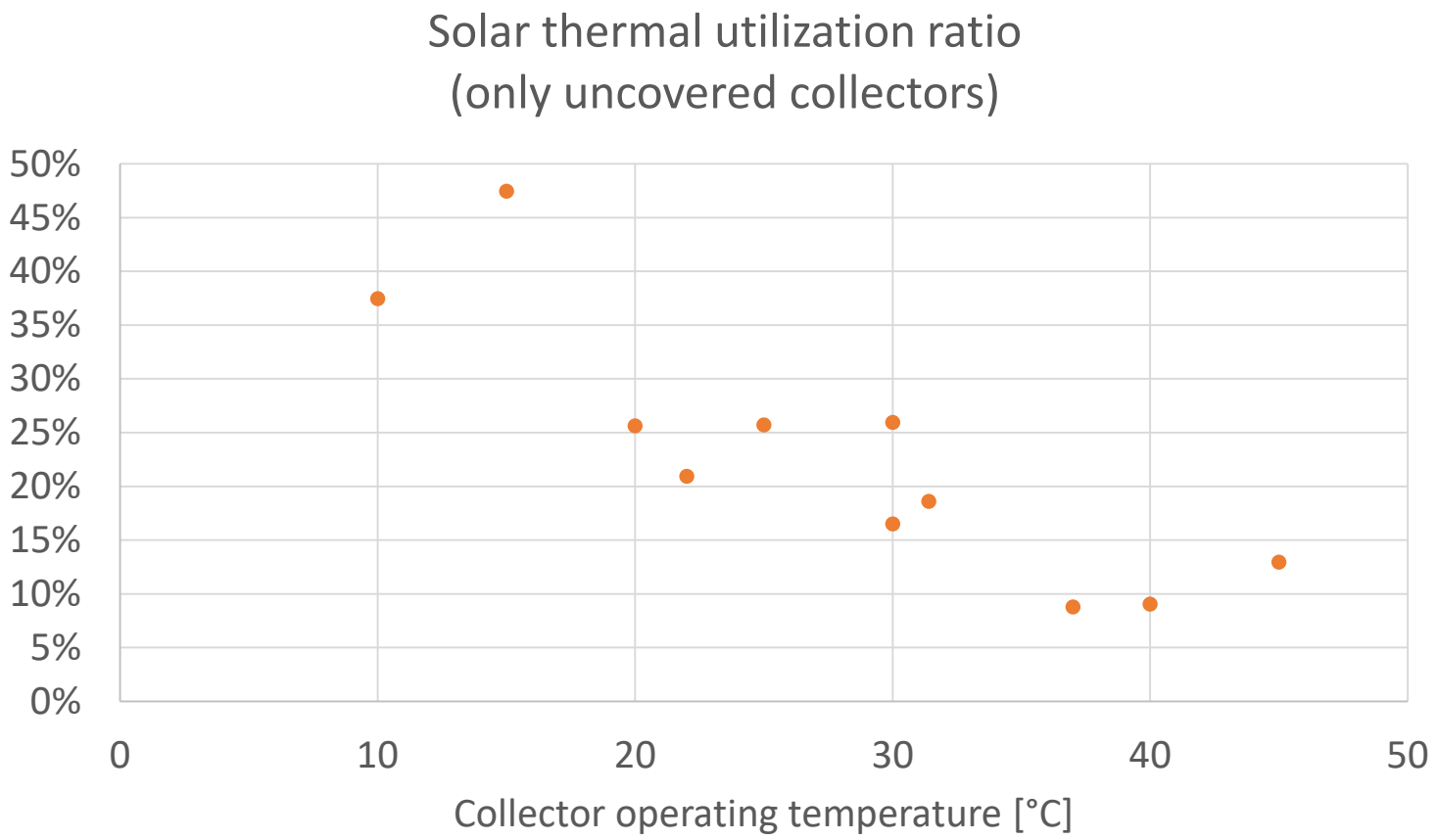
Comparison of systems in operation

System Nr.	Country	Location	Application	Collector Type	Gross area [m²]
1	Spain	Zaragoza	DHW	covered	29.7
2	Spain	Zaragoza	DHW, SH	covered	10
3	Spain	Ibiza	DHW	covered	147.6
4	Spain	Zaragoza	DHW, Pool	covered	46.2
5	Italy	Catania	DHW	uncovered	3.3
6	Switzerland	Näfels	Preheating of ground water source	uncovered	292
7	Denmark	Egedal	DHW, SH	uncovered	80
8	Netherlands	Katwoude	Electricity and Heat for cheese production processes	concentrator	226.2
9	Czech Republic	Prerov	Ground source regeneration, source for heat pump, DHW (test installation)	uncovered	188
10	Italy	Suello	Ground source regeneration, source for heat pump	covered	26.1
11	Germany	Freiburg	DHW (test installation)	covered	48
12	Denmark	Kgs. Lyngby	DHW	uncovered	3.1
13	Switzerland	Wettswil am Albis	DHW, SH	uncovered	45.9
14	Switzerland	Ostermundigen	Ground source regeneration, source for heat pump	uncovered	622
15	Switzerland	Rapperswil	DHW (test installation)	uncovered	9.9
16	Switzerland	Obfelden	Ground source regeneration, source for heat pump, DHW	uncovered	423
17	Switzerland	Scuol	Ground source regeneration, source for heat pump	uncovered	130.3
18	France	Amberieu-En-Bugey	DHW	uncovered	6.4
19	France	St.-Genis-Les-Ollieres	DHW	uncovered	9.6
20	France	Sete	DHW, Pool	uncovered	300
21	France	Perpignan	DHW, Pool	uncovered	300
22	Australia	South Perth	DHW, SH	air heater	7.5
23	UK	Swansea	DHW , SH	evacuated tube	27
24	Germany	Enge-Sande	Heat and Cold (thermal HP) for office	concentrator	34.2

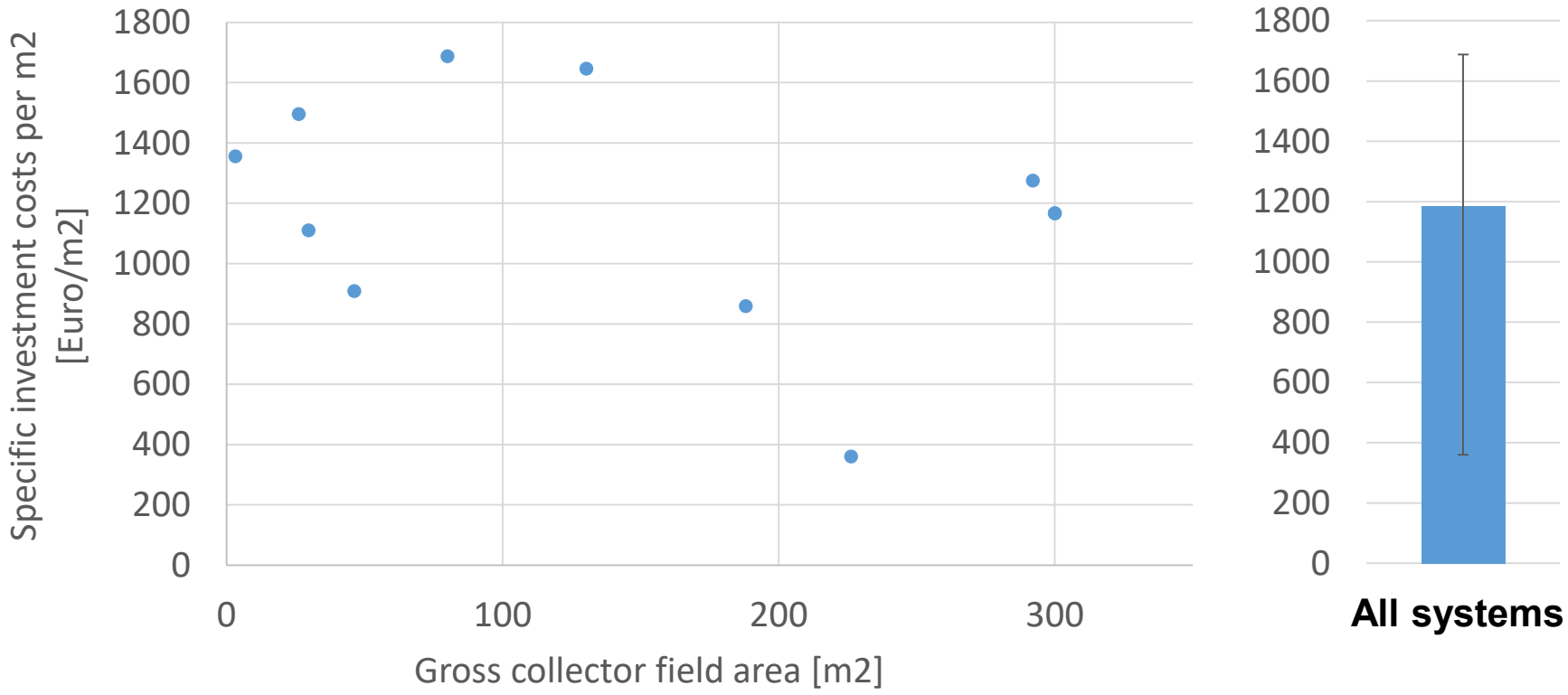
Solar utilization ratios



Solar thermal utilization ratio – temperature dependence



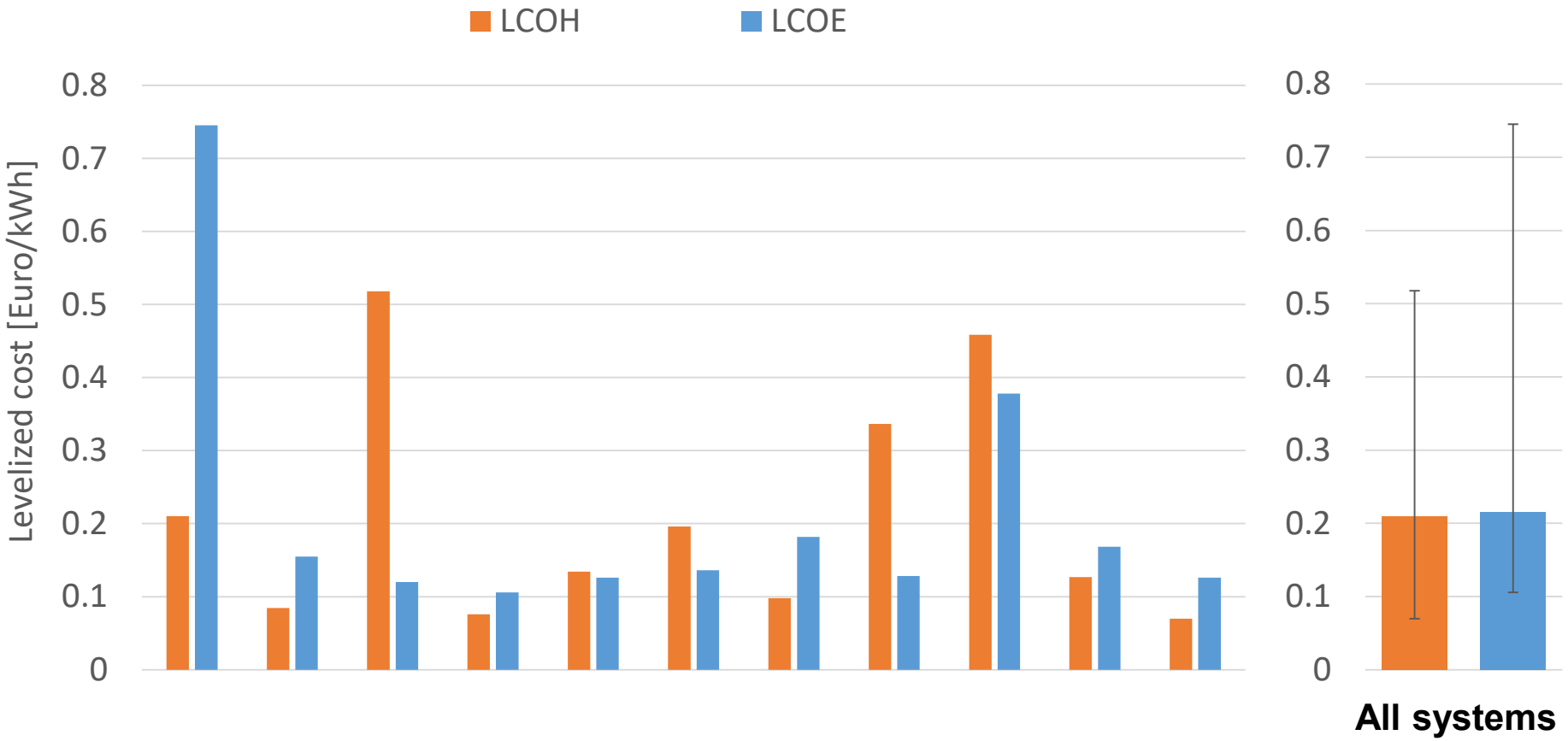
Specific investment cost per m²



Levelized costs of heat and electricity

- Only costs of the solar energy system components (w/o backup)
- Attribution of investment costs to solar heat system (2/3) and solar electricity system (1/3), unless exact number is provided
- Yearly maintenance cost : 1% of investment cost (unless provided)
- System lifetime set to 25 years
- Real discount rate set to 3%

Levelized costs of heat and electricity



The End