Task 38
Solar Air-Conditioning and Refrigeration


Solar wine cooling system in Tunisia (Medisco)

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Cape Town, South Africa

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Outline

- Introduction to solar cooling
- Overall status and achievements
- Summary & conclusion

- **Introduction to solar cooling**
- Overall status and achievements
- Summary & conclusion

Stucture of Task 38

Duration: 09/2006 – 12/2010

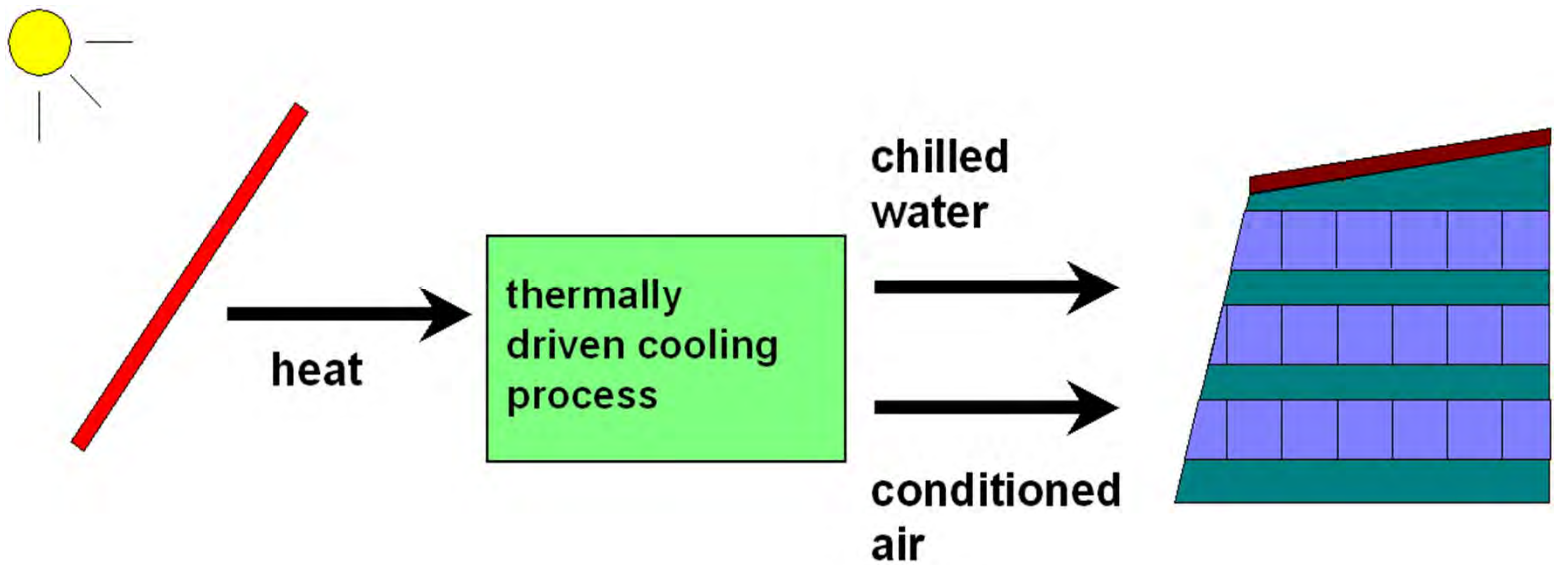
Subtask A Pre-engineered systems for residential and small commercial applications **AEE INTEC (Austria)**	**Subtask B** Custom-made systems for large non-residential buildings and industrial applications **EURAC (Italy)**

Subtask C
Modeling and fundamental analysis
INES (France)

Subtask D
Market transfer activities
POLIMI (Italy)

Operating Agent: Fraunhofer ISE (Germany)

Solar thermal cooling - basic principle



Basic systems categories

- Closed cycles (chillers): chilled water
- Open sorption cycles: direct treatment of fresh air (temperature, humidity)

Open cycles – desiccant air handling units

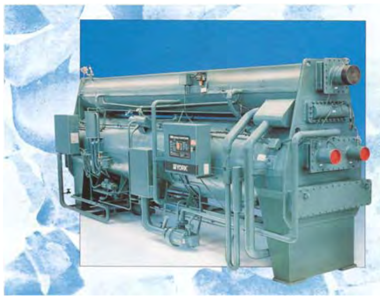
Solid sorption

- Desiccant wheels
- Coated heat exchangers
- Silica gel or LiCl-matrix, future zeolite

Liquid sorption

- Packed bed
- Plate heat exchanger
- LiCl-solution: Thermochemical storage possible

Closed cycles – water chillers or ice production



- Liquid sorption: Ammonia-water or Water-LiBr (single-effect or double-effect)
- Solid sorption: silica gel – water, zeolite-water
- Ejector systems
- Thermo-mechanical systems

Turbo Expander/Compressor
AC-Sun, Denmark in TASK 38

System typology

Driving temperature	Collector type	System type
Low (60-90°C)		***Open cycle:*** direct air treatment
		Closed cycle: high temperature cooling system (e.g. chilled ceiling)

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		Closed cycle: high temperature cooling system (e.g. chilled ceiling)
Medium (80-110°C)		***Closed cycle:*** chilled water for cooling and dehumidification
		Closed cycle: refrigeration, air-conditioning with ice storage

System typology

Driving temperature	Collector type	System type
Low (60-90°C)		***Open cycle:*** direct air treatment
		Closed cycle: high temperature cooling system (e.g. chilled ceiling)
Medium (80-110°C)		***Closed cycle:*** chilled water for cooling and dehumidification
		Closed cycle: refrigeration, air-conditioning with ice storage
High (130-200°C)		***Closed cycle:*** double-effect system with high overall efficiency
		Closed cycle: system with high temperature lift (e.g. ice production with air-cooled cooling tower)

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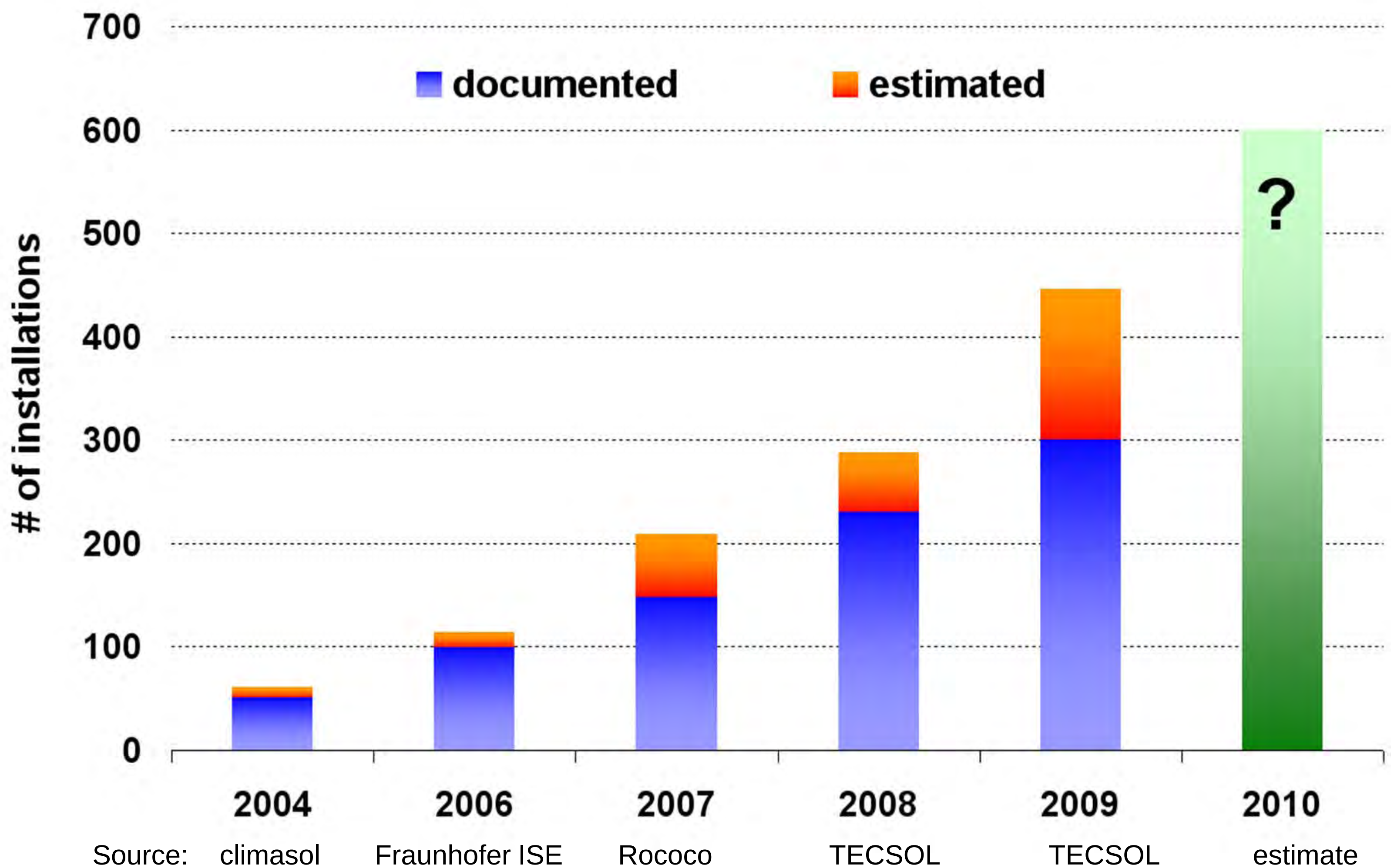
„Market“



700
600
500
400
300
200
100
0
documented
estimated
?
# of installations
2004
2006
2007
2008
2009
2010
Source:
climasol
Fraunhofer ISE
Rococo
TECSOL
TECSOL
estimate

New small capacity chillers

aosol

PINK
ENERGIE- & SPEICHERTECHNIK

invensor

SorTech AG

YAZAKI

EAW Energieanlagenbau Westenfeld GmbH

no claim on completeness

High-temperature applications

Wine cooling in Tunisia (MEDISCO)

Solar cooling for a hotel in Turkey (SOLITEM)

- Increasing number of systems using single-axis concentrating collectors (parabolic trough, Fresnel) in combination with thermally driven chillers (150°C … 200°C)
  - Double-effect chiller with high conversion efficiency (Coefficient of Performance COP 1.1…1.3)
  - Single-effect chiller with high temperature lift for low cooling temperatures (e.g. ice production) and high heat rejection temperatures (dry cooling towers)
- Application in sunny regions for buildings (e.g. hotels) or industrial application (e.g. cooling of food, ice production)

Large and very large installations (examples)

CGD Bank Headquarter

Lisbon, Portugal

1560 m^2 collector area

400 kW absorption chiller

Source: SOLID, Graz/Austria

FESTO Factory

Berkheim, Germany

1218 m^2 collector area

1.05 MW (3 adsorption chillers)

Source: Paradigma, Festo

United World College (UWC) (in planning)

Singapore

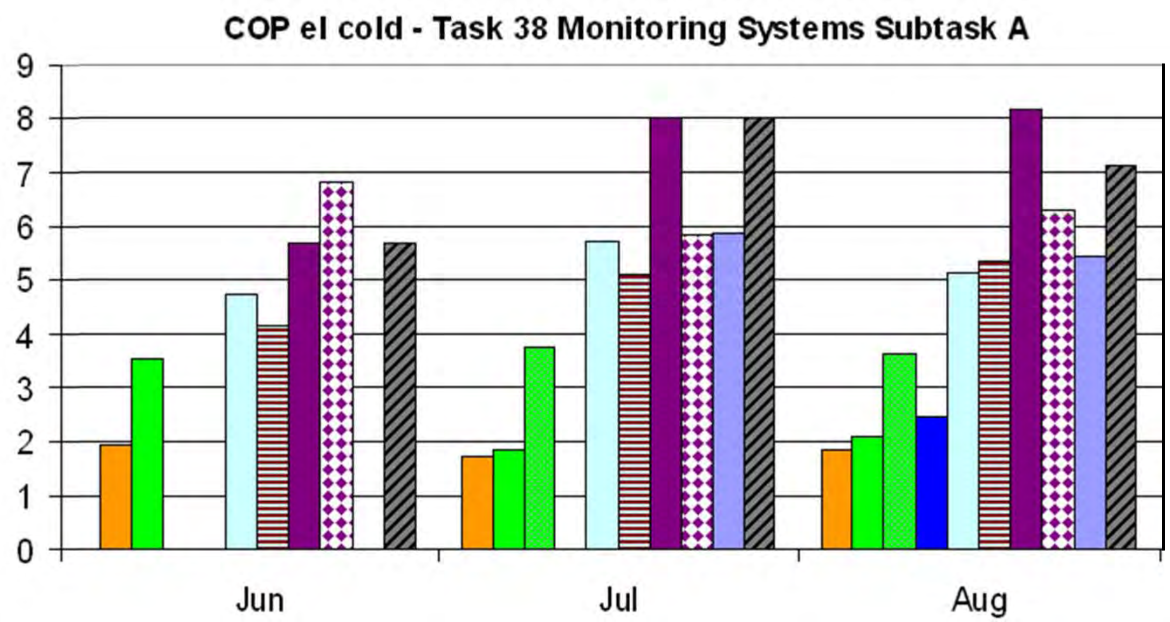
3900 m^2 collector area

1.47 MW absorption chiller

Source: SOLID, Graz/Austria

System performance

- Significant progress in overall system performance
- Electric COP-values up to >8 shown in monitoring of Task 38
  ➔ 8 kWh of cold production per 1 kWh of electricity for solar + cooling equipment (pumps, fans, heat rejection)
- Goal: electric COP > 10



Source: Dagmar Jähnig, AEE INTEC

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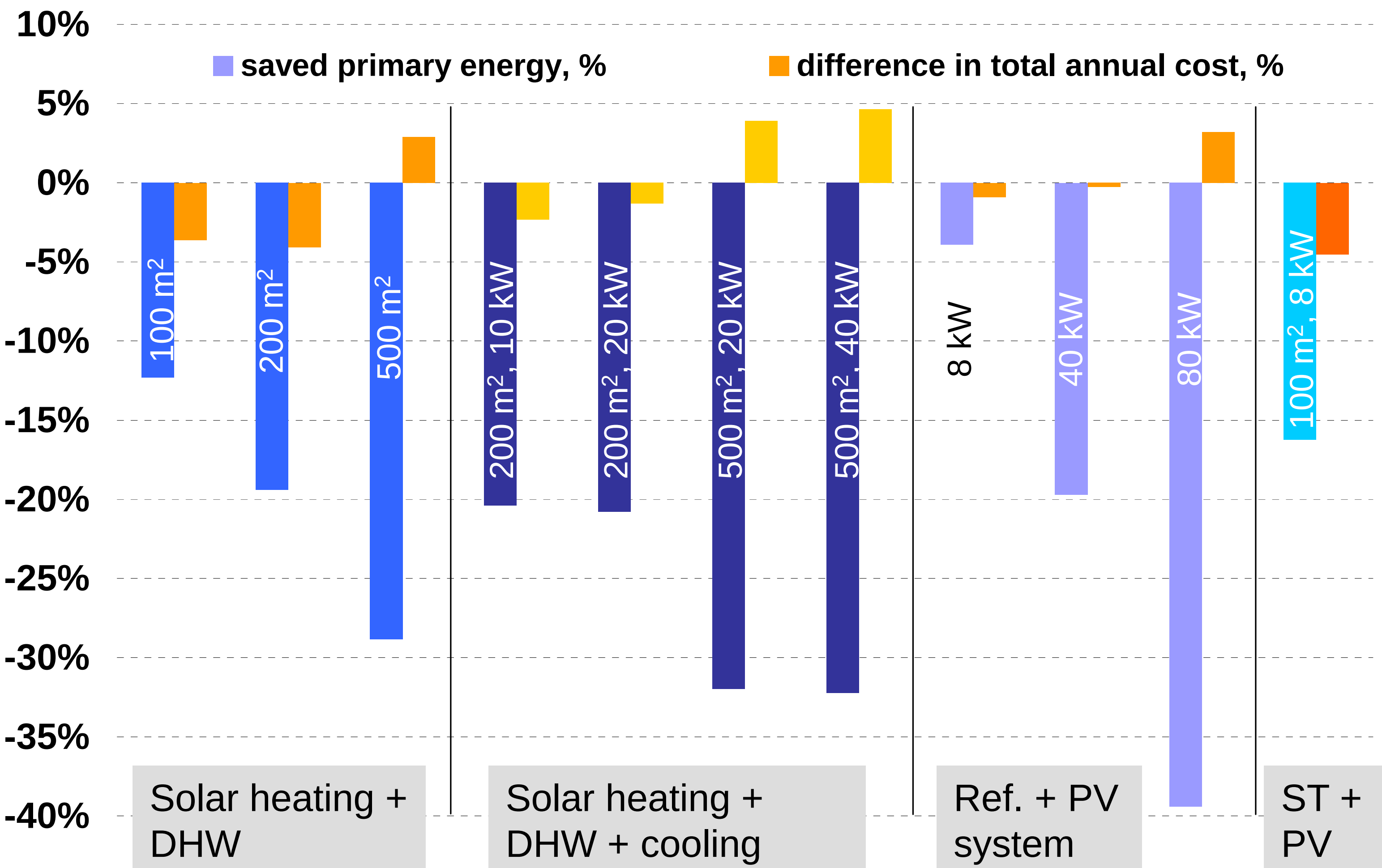
Summary

- Energy saving up to > 50 % achievable compared to conventional reference systems (heating, hot water, cooling)
- Main challenges
  - High quality in all phases of project lifetime: design, installation, commissioning, operation
  - Minimize auxiliary energy demand: heat rejection, pumps & fans, part load behaviour
- Cost issues
  - First cost 2 to 5 times higher than for conventional solutions
  - Under good conditions life cycle cost lower than for conventional solutions

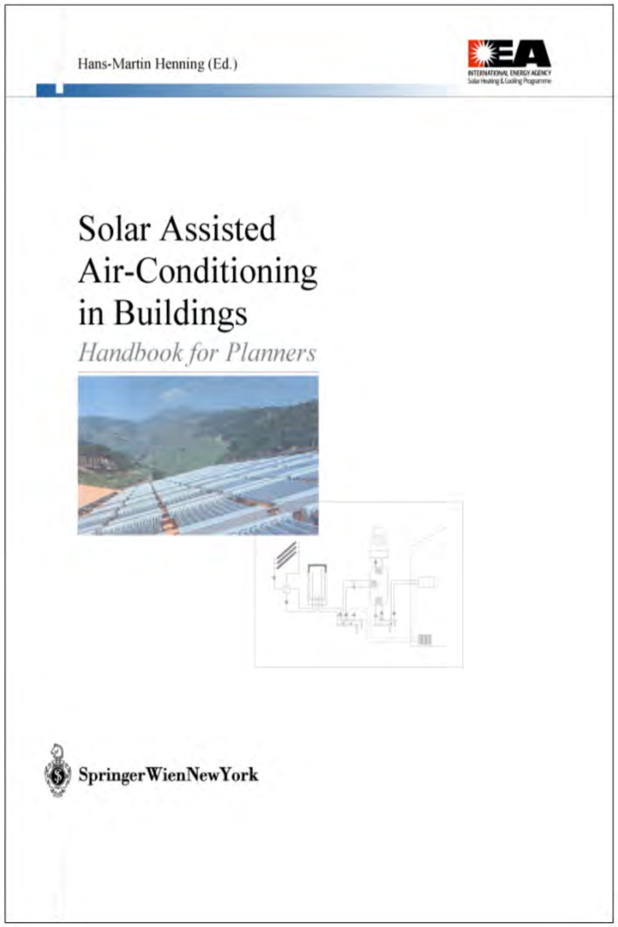
Example: hotel in Spain (simulation study)



Conclusion

- Future buildings have to be highly energy-efficient and make use of locally available renewable energies, mainly solar
- Integrated solutions for heating, cooling and hot water adapted to specific buildings / load profiles / applications and climatic (solar) conditions are needed
- Solar heating and cooling (SHC) systems will play a significant role, since they provide an energy saving solution on the demand side without affecting the electricity grid
- For SHC considerable potentials for further reduction of cost and increase of efficiency exist on both, component and system level
- Main challenge is to assure high quality of installations in broad market
- Development of quality procedures for all phases of projects are essential: Design ➔ Installation ➔ Commissioning ➔ Operation / Maintenance / Monitoring

Task 38 outputs (examples)



- Generic systems analysis
- Monitoring of overall 23 systems
- Tool to assess successful projects in an early phase
- Commissioning guidelines
- Completely revised third edition of a handbook for planners (mid next year)
- Thermodynamic analysis reports (exergy, simulation)
- …

… thank you for your attention

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

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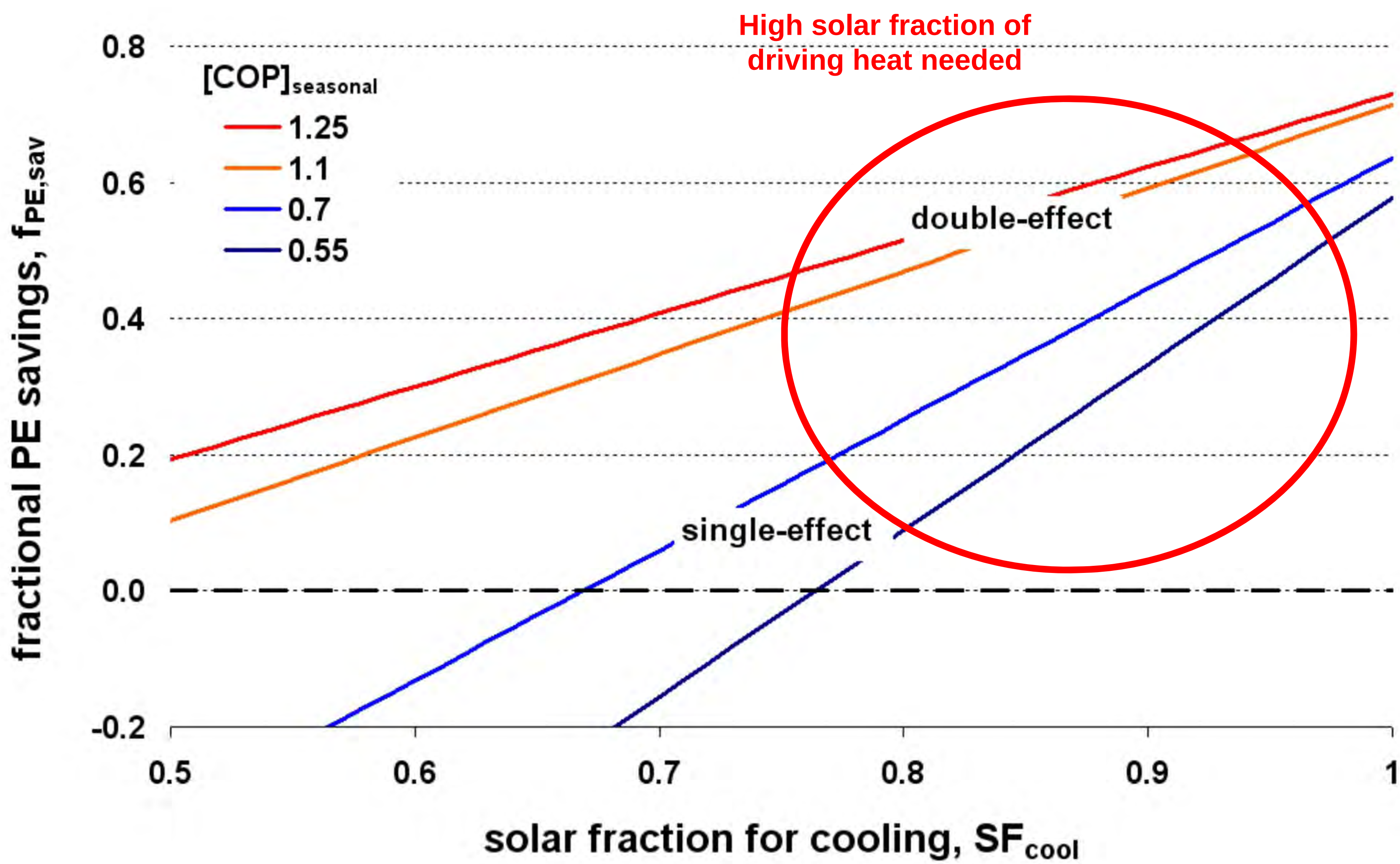
Fraunhofer ISE

Backup

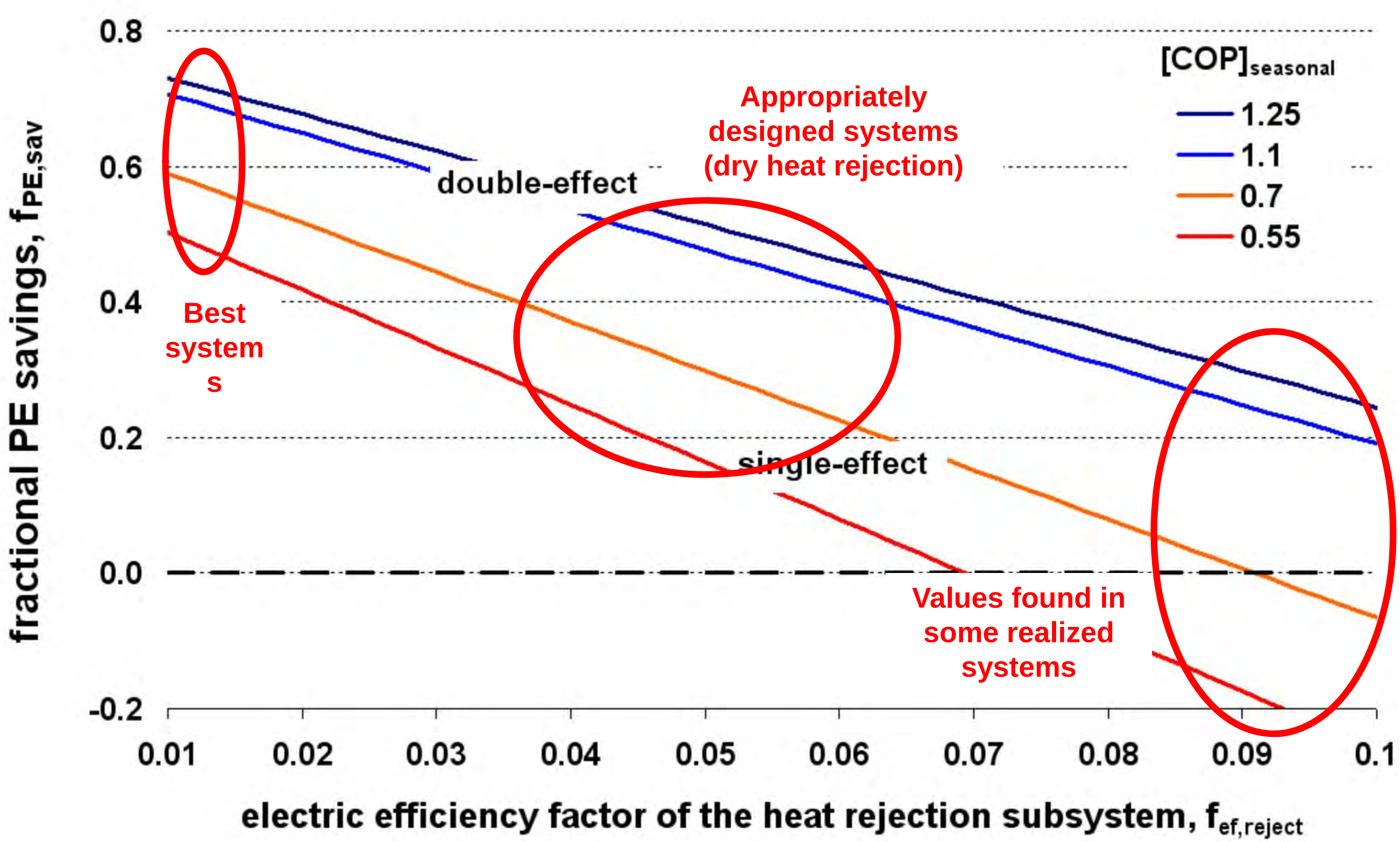
Primary energy saving - solar fraction of driving heat

reference: chapter 7 of the new handbook



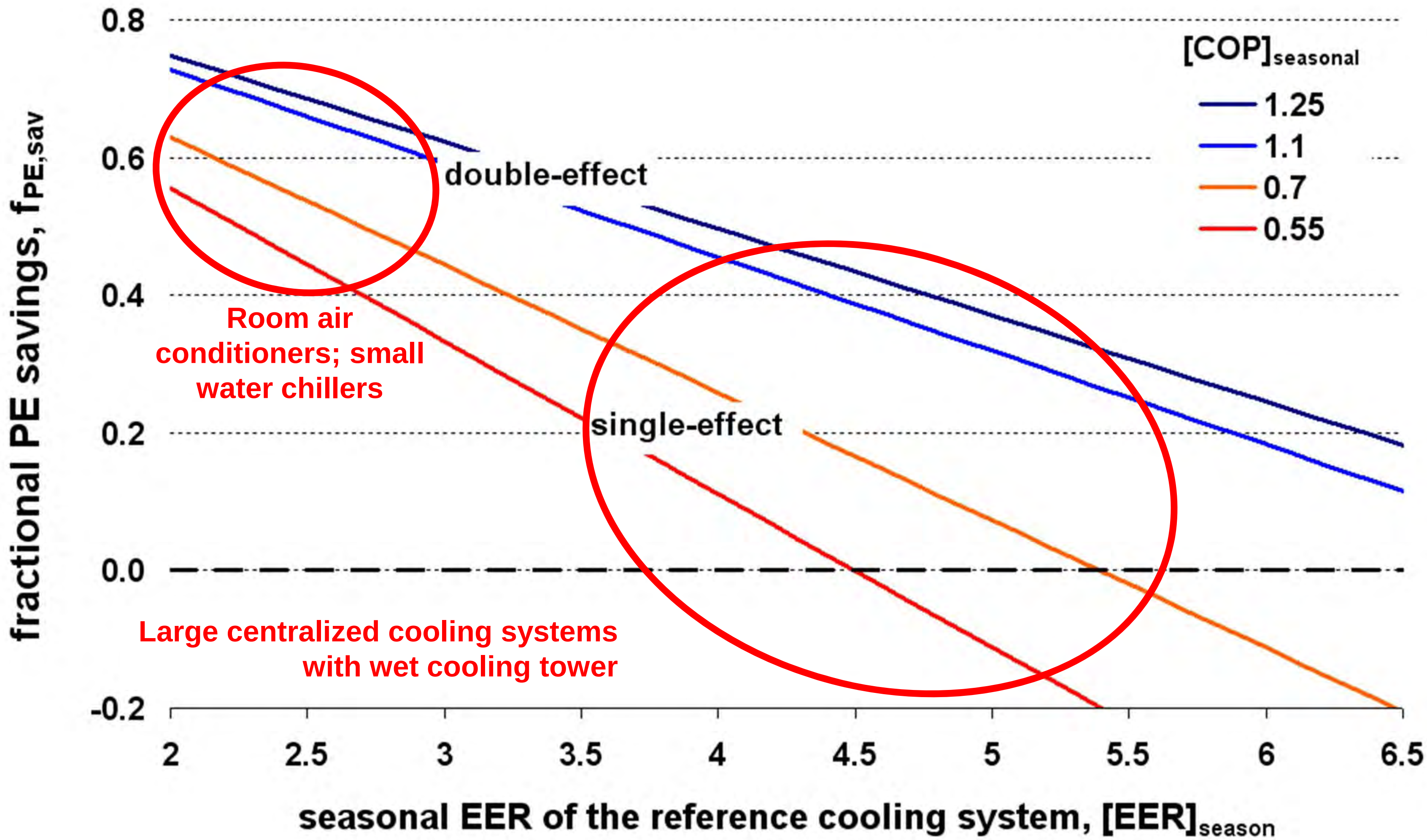
Primary energy saving - electricity consumption of heat rejection

reference: chapter 7 of the new handbook



Primary energy saving - EER of conventional vapour compression chiller

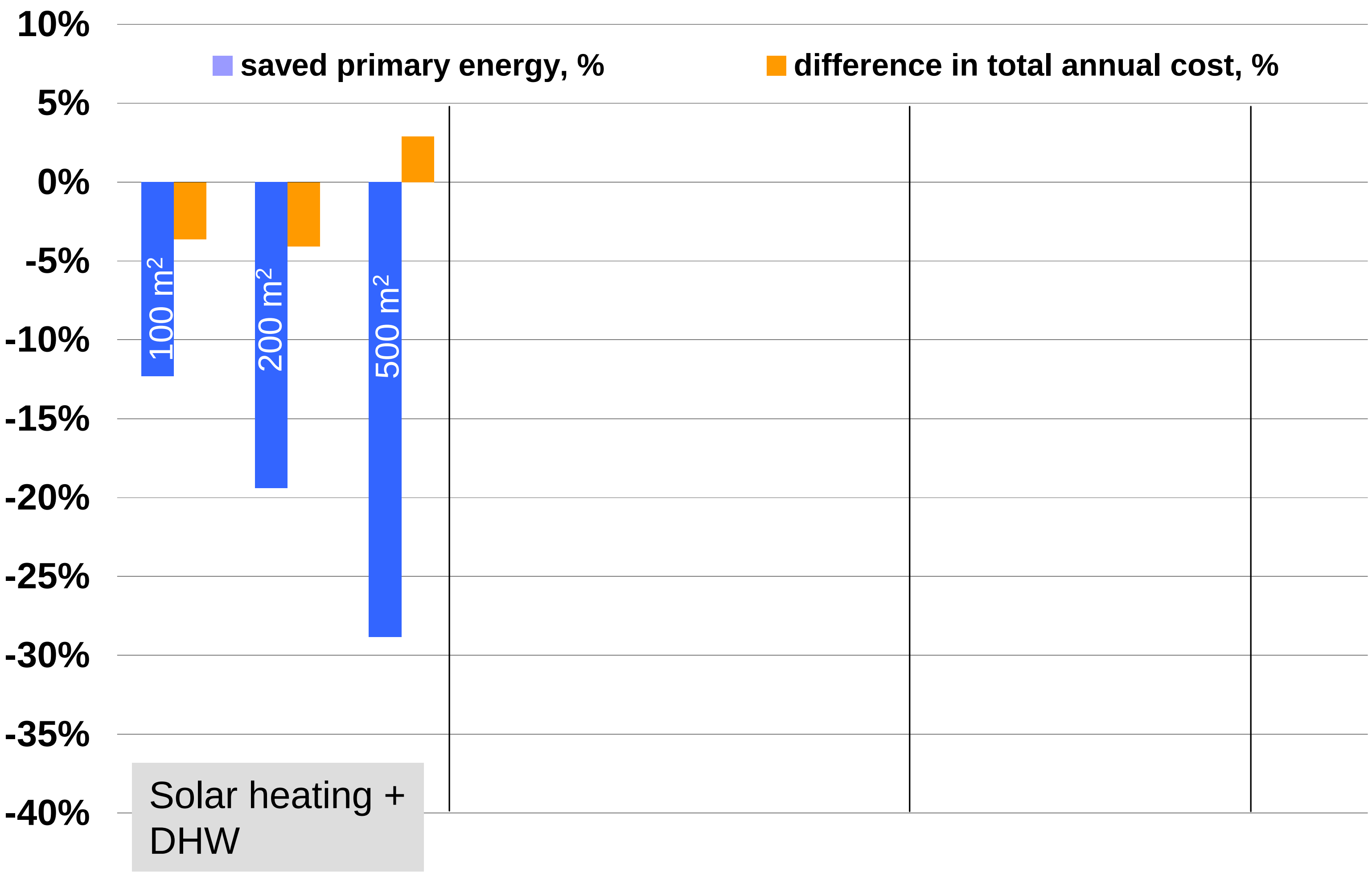
reference: chapter 7 of the new handbook



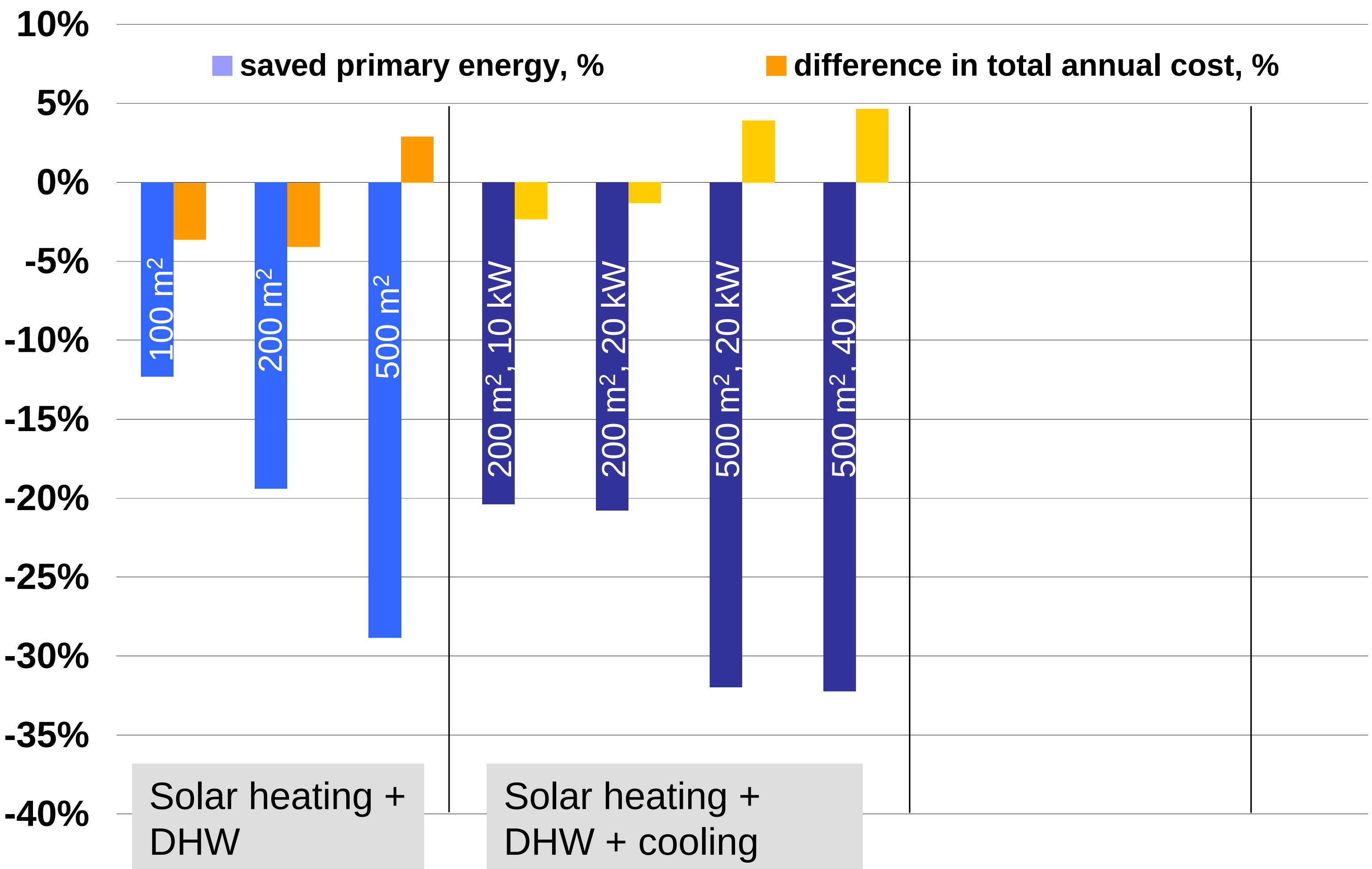
Energy saving and cost – an example (simulation study)

- Comparison of 4 solutions
  - Reference: natural gas + vapour compression chiller
  - Natural gas + solar thermal (heating + hot water) + vapour compression chiller
  - Natural gas + solar thermal (heating + cooling + hot water) + bakcup vapour compression chiller
  - Natural gas + vapor compression chiller + PV system
- Application: Hotel in Madrid (3100 m^2 useful area)
- Analysis of life cycle cost without any funding

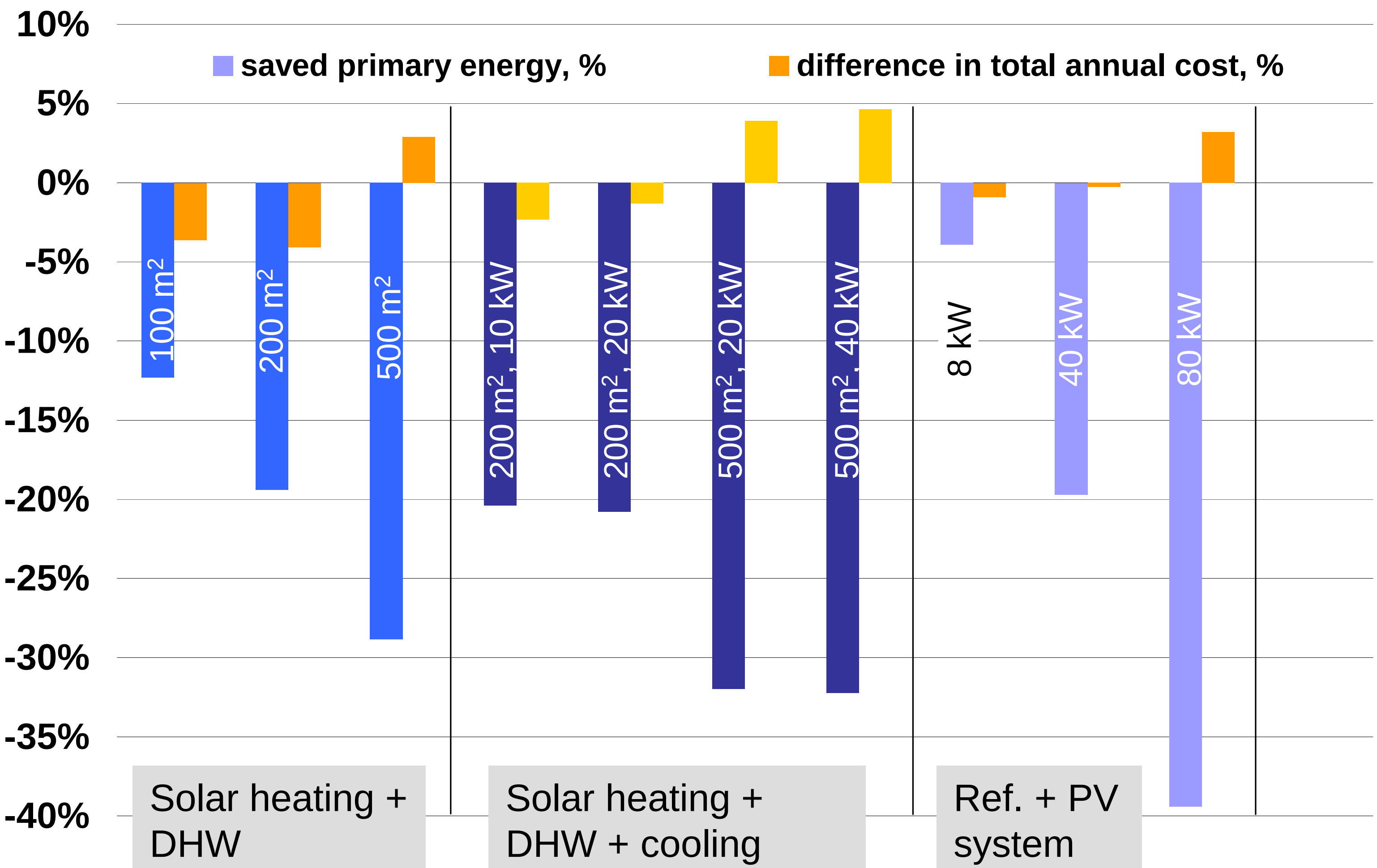
Results


10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
-40%
saved primary energy, %
difference in total annual cost, %
100 m2
200 m2
500 m2
Solar heating +
DHW

Results


10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
-40%
saved primary energy, %
difference in total annual cost, %
100 m²
200 m²
500 m²
200 m², 10 kW
200 m², 20 kW
500 m², 20 kW
500 m², 40 kW
Solar heating + DHW
Solar heating + DHW + cooling

Results



10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
-40%
saved primary energy, %
difference in total annual cost, %
100 m²
200 m²
500 m²
200 m², 10 kW
200 m², 20 kW
500 m², 20 kW
500 m², 40 kW
8 kW
40 kW
80 kW
Solar heating + DHW
Solar heating + DHW + cooling
Ref. + PV system