Picture: SOLEM Consulting

Results from feasibility studies of solar cooling systems in Mexico and the Arab Region

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IEA SHC Task 53 Solar Cooling Workshop
ILK Dresden, Germany

SOLEM CONSULTING

Solar Cooling in Social Housing - Mexico

giz

Technologien zur solaren Kühlung in Wohngebäuden weltweit und in Gebäuden des sozialen Wohnungsbaus in Mexiko

Einführung, Praxisbeispiele und Anwendungspotenziale für Mexiko

Ein Beitrag zum GIZ-internen Wissensmanagement
Oktober 2017

GIZ Study (2017):

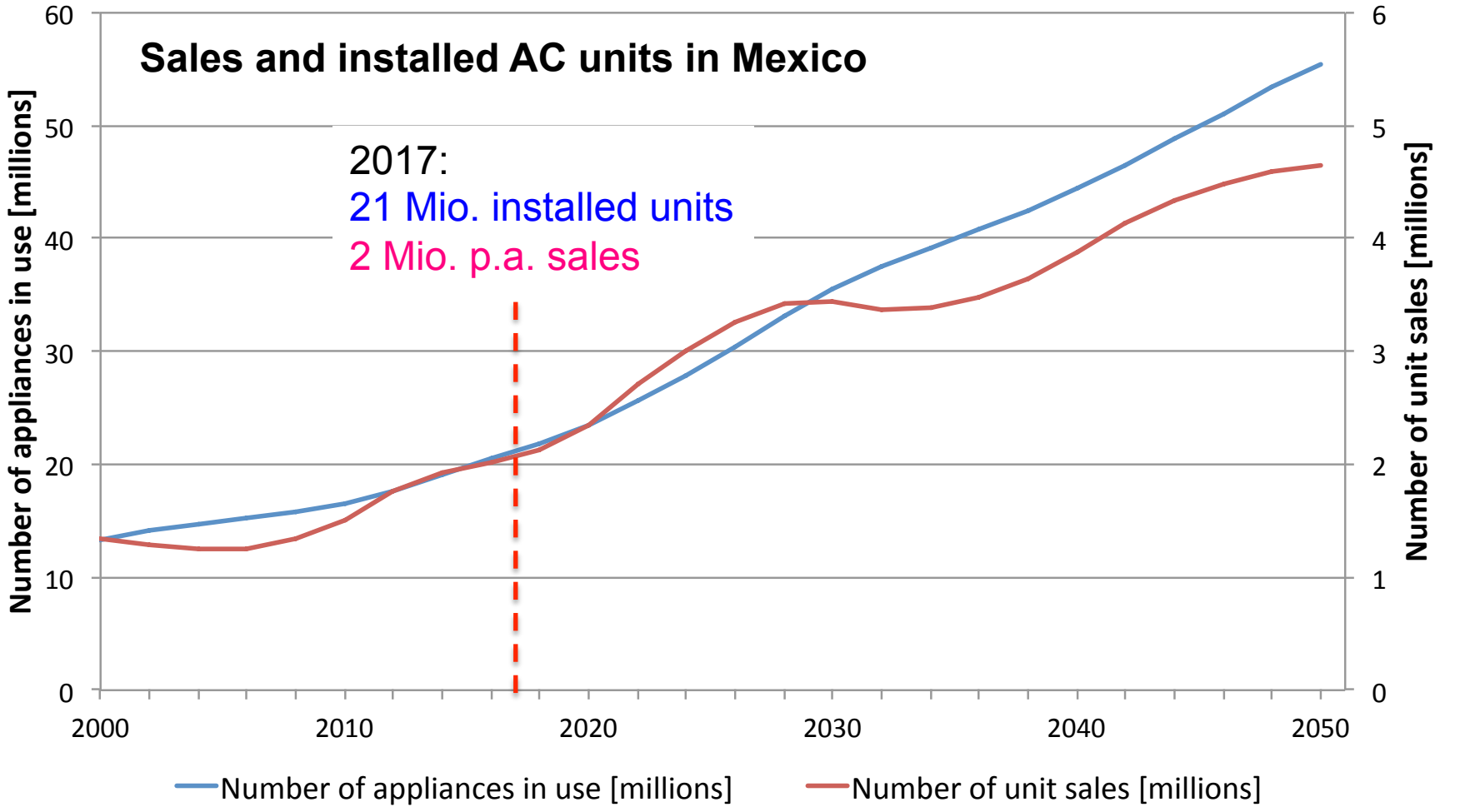
Solar cooling technologies in residential buildings worldwide and in buildings of social housing in Mexico

NAMA Support Project: Implementation of the New Housing NAMA Mexico, Technical Component

Commissioned by:
German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), UK's Department for Business, Energy and Industrial Strategy (BEIS)

Implemented by:
German Development Cooperation GIZ with the Mexican Ministry of Agrarian, Territorial and Urban Development (SEDATU) and the Mexican National Housing Commission (CONAVI)

Market potential - Roadmap

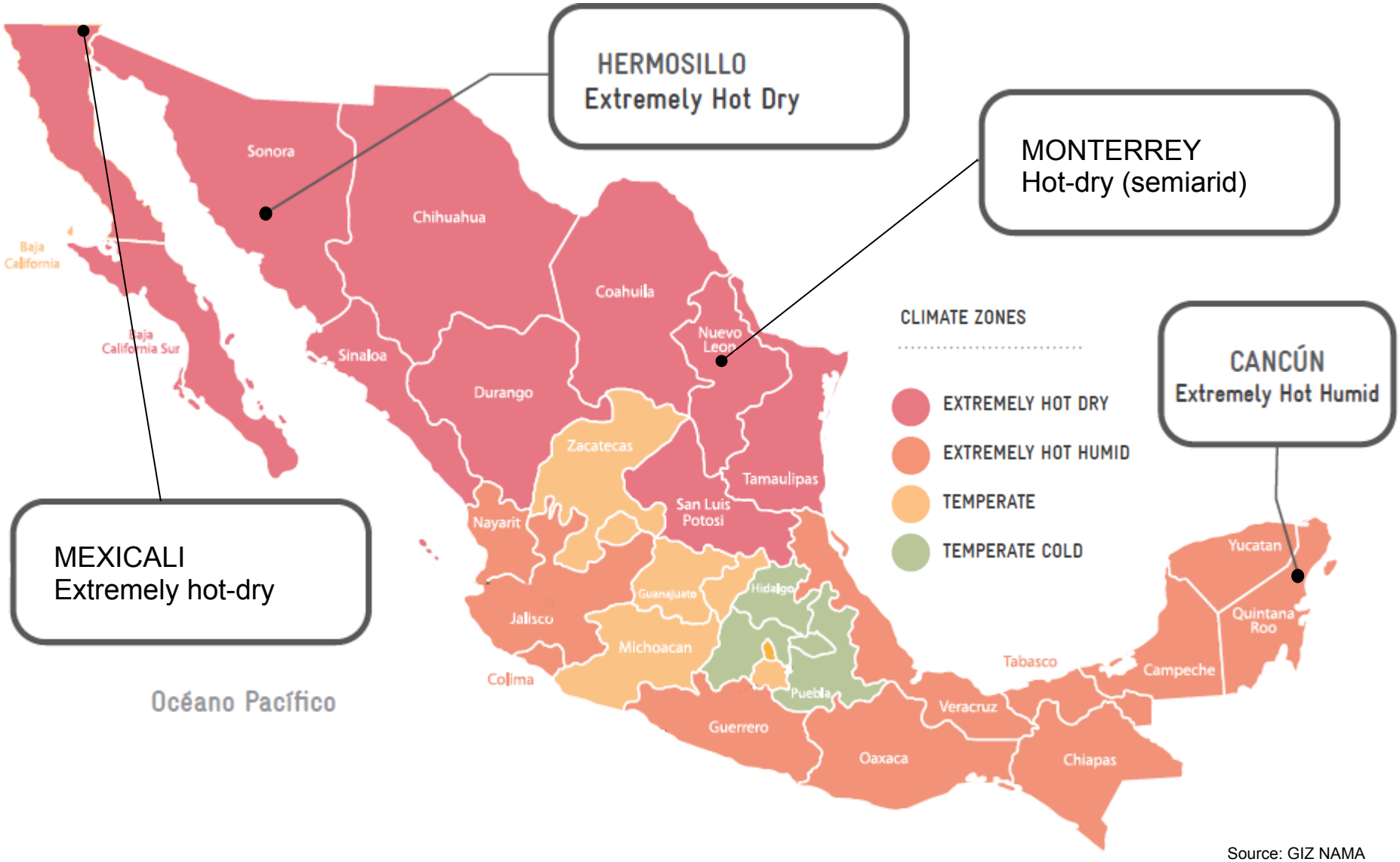


Source: www.green-cooling-initiative.org

Buildings investigated

Type	Single family house	Row house	Multi family house	Housing estate
Example view	 Source: SEMARNAT/CONAVI	 Source: SEMARNAT/CONAVI	 Source: SEMARNAT/CONAVI	 Source: gupovivo
Number of buildings per type	1	1	1	100 of which: 50 row houses, 50 multi family houses
Number of housing units per type	1	1	8	450 of which: 50 in row houses, 400 in multi family houses
Floor space per housing unit	40 m^2	70 m^2	40 m^2	40 m^2 row house 70 m^2 multi family house
Total floor space per type	40 m^2	70 m^2	320 m^2	19,500 m^2 of which: 3,500 m^2 in row houses, 16,000 m^2 in multi family houses
Number of levels per building	1	2	4	2/4

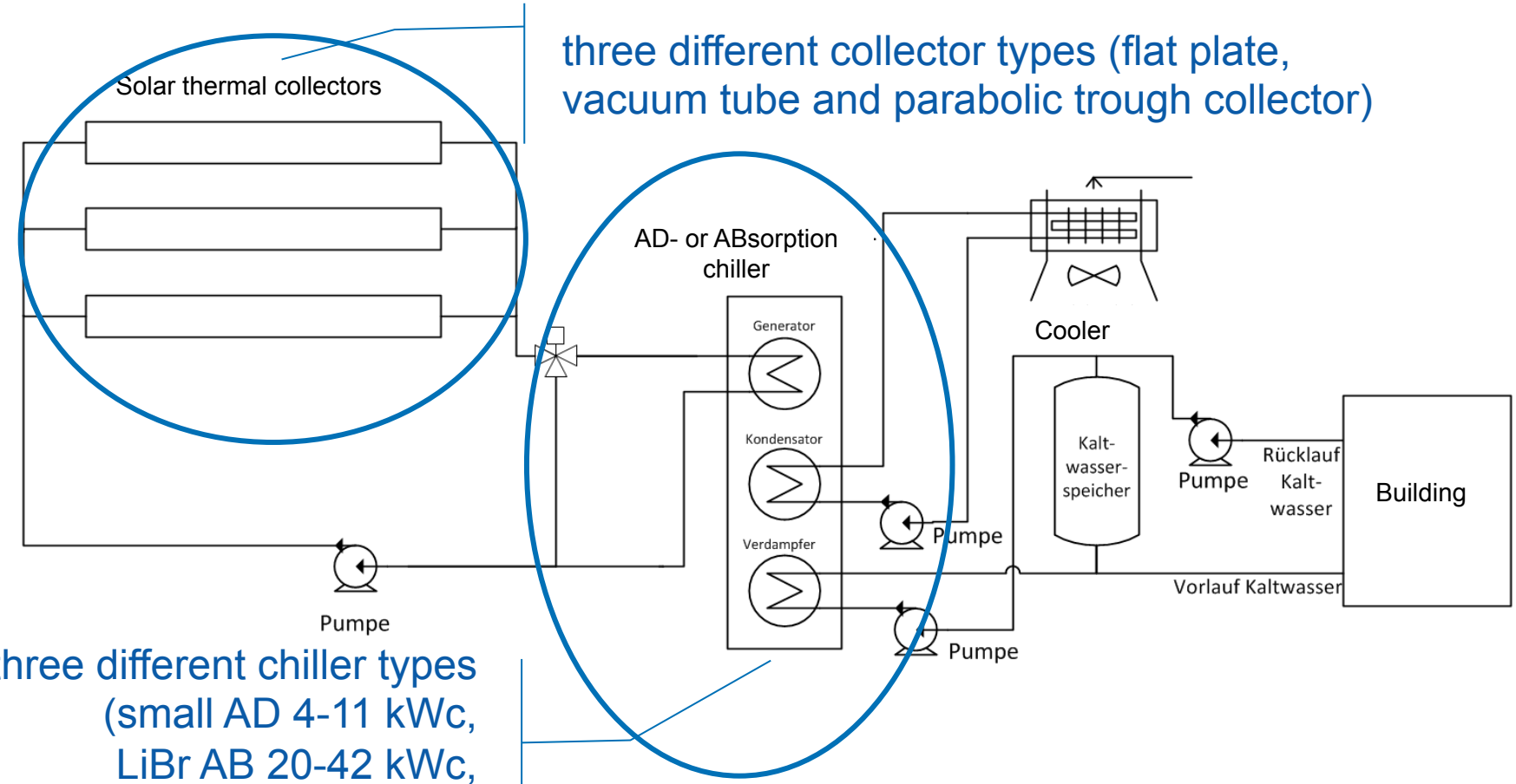
Climate zones and locations investigated



Source: GIZ NAMA

Solar thermal cooling

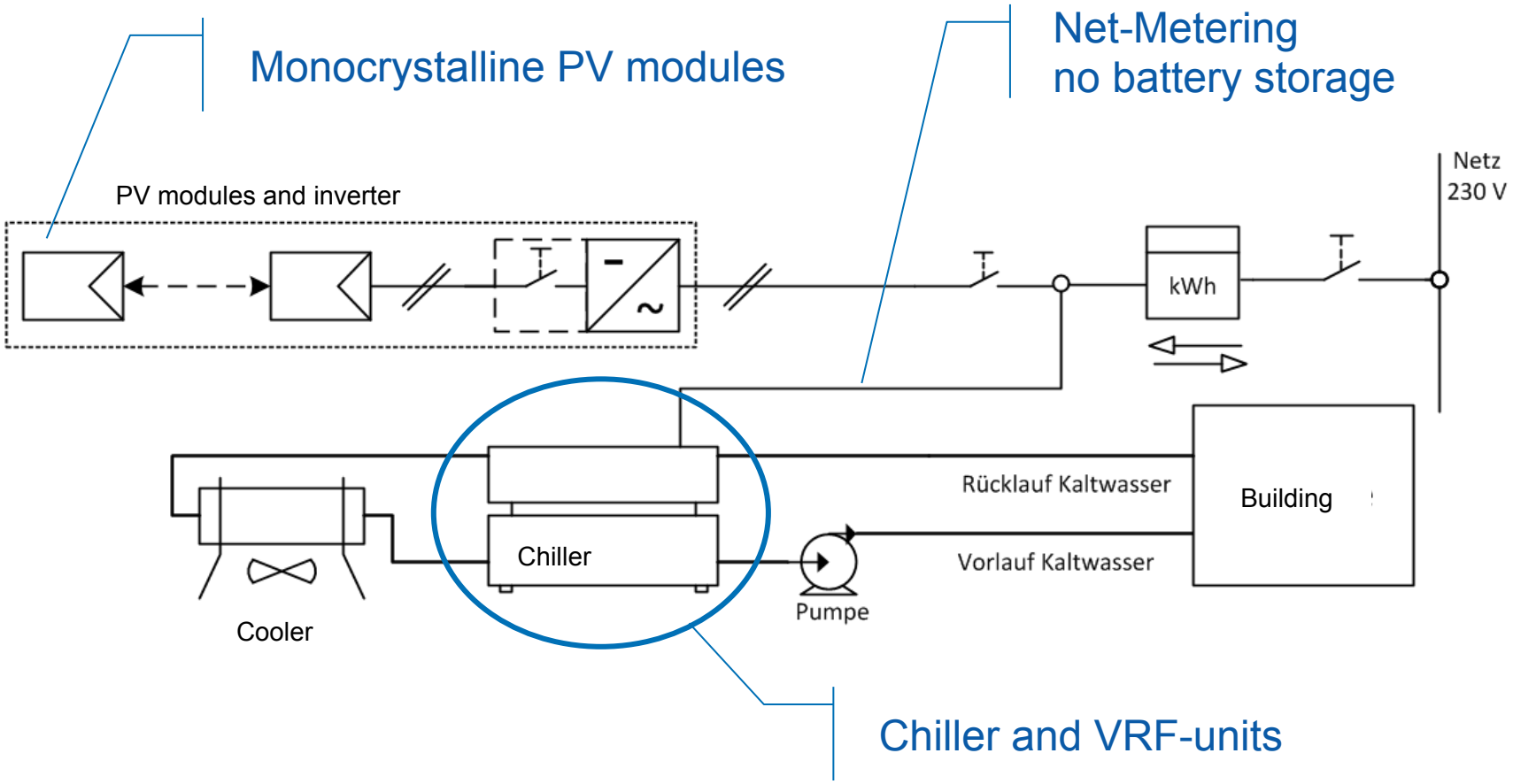
three different collector types (flat plate, vacuum tube and parabolic trough collector)



three different chiller types (small AD 4-11 kWc, LiBr AB 20-42 kWc, DE AB 1.2-2.6 MWc)

Source: SOLEM Consulting

Photovoltaic cooling



Source: SOLEM Consulting

Parameter investigated

$$LCCE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_t}{(1+i)^t}}$$

LCCE **Levelized Cost of Cooling Energy in Euro/kWh**

I_0	Investment cost in Euro
A_t	Total annual O&M cost in Euro in Year t
$M_{t,}$	Cooling energy removed from building per year in kWh
i	Interest rate in %
n	Assumed lifetime of plant in years
t	Year of use (1, 2, ...n)

$$t_{Am} = \frac{I_{0,Solar} - I_{0,\mathrm{Re}f}}{\bar{A}_{\mathrm{Re}f} - \bar{A}_{Solar}}$$

Payback period

compared to reference scenario

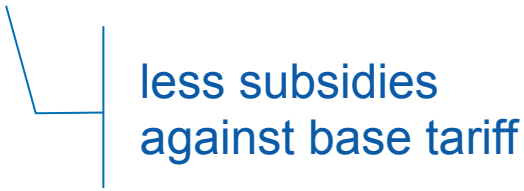
$$\Delta Q_{PE} = \frac{W_{el,ref} - W_{el,Solar}}{\eta_{KW,MX}} - Q_{Gas,Solar}$$

Energy savings potential per year

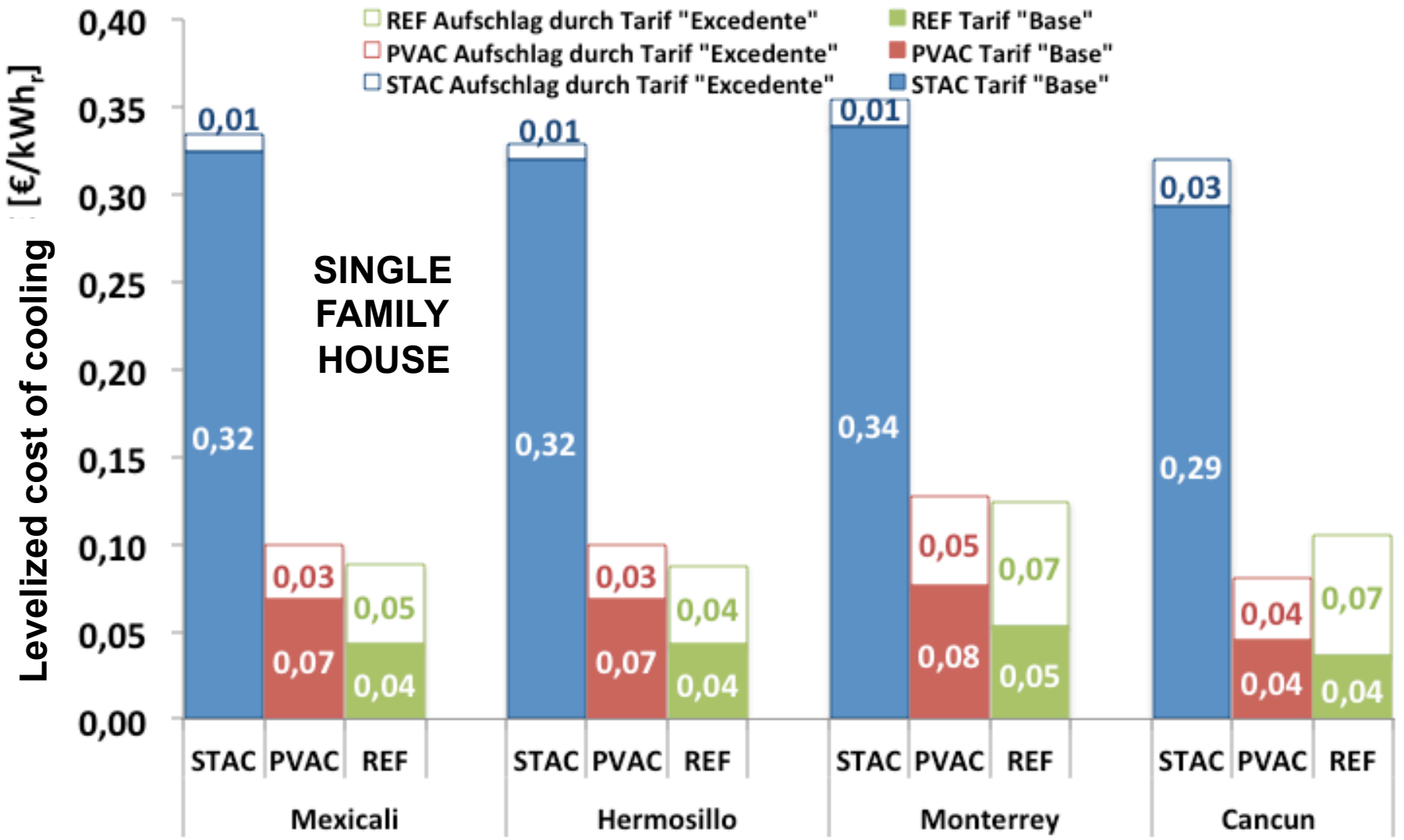
compared to reference scenario, based on primary energy

Main Assumptions

Location	Electricity cost tariff Consumo Base	Electricity cost tariff Consumo Excedente	Subsidy on electricity cost (both tariffs)	Gas cost	Water cost
	€/kWh	€/kWh	%	€/kWh	€/m3
Mexicali	0.037	0.132	-66% during 01.05. to 31.10.	0.053	0.276
Hermosillo	0.036	0.130	-66% during 01.05. to 31.10.	0.053	0.769
Monterrey	0.039	0.137	None	0.051	0.691
Cancun	0.038	0.134	None	0.055	0.864



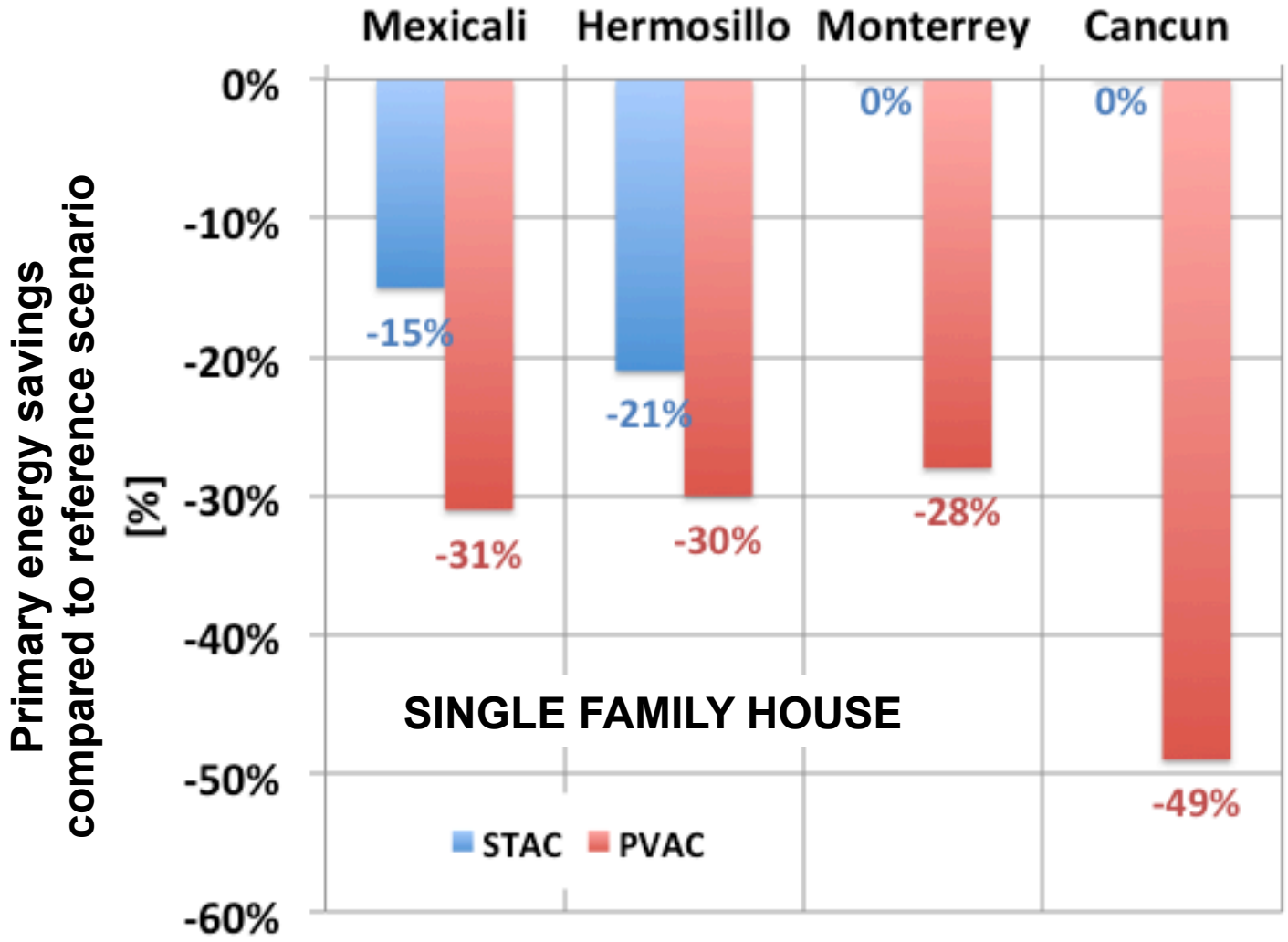
Results – Single family house



Legende:

STAC: Solarthermische Kühlung PVAC: Photovoltaische Kühlung REF: Referenzsystem – 100% Netzbetrieb

Results – Single family house



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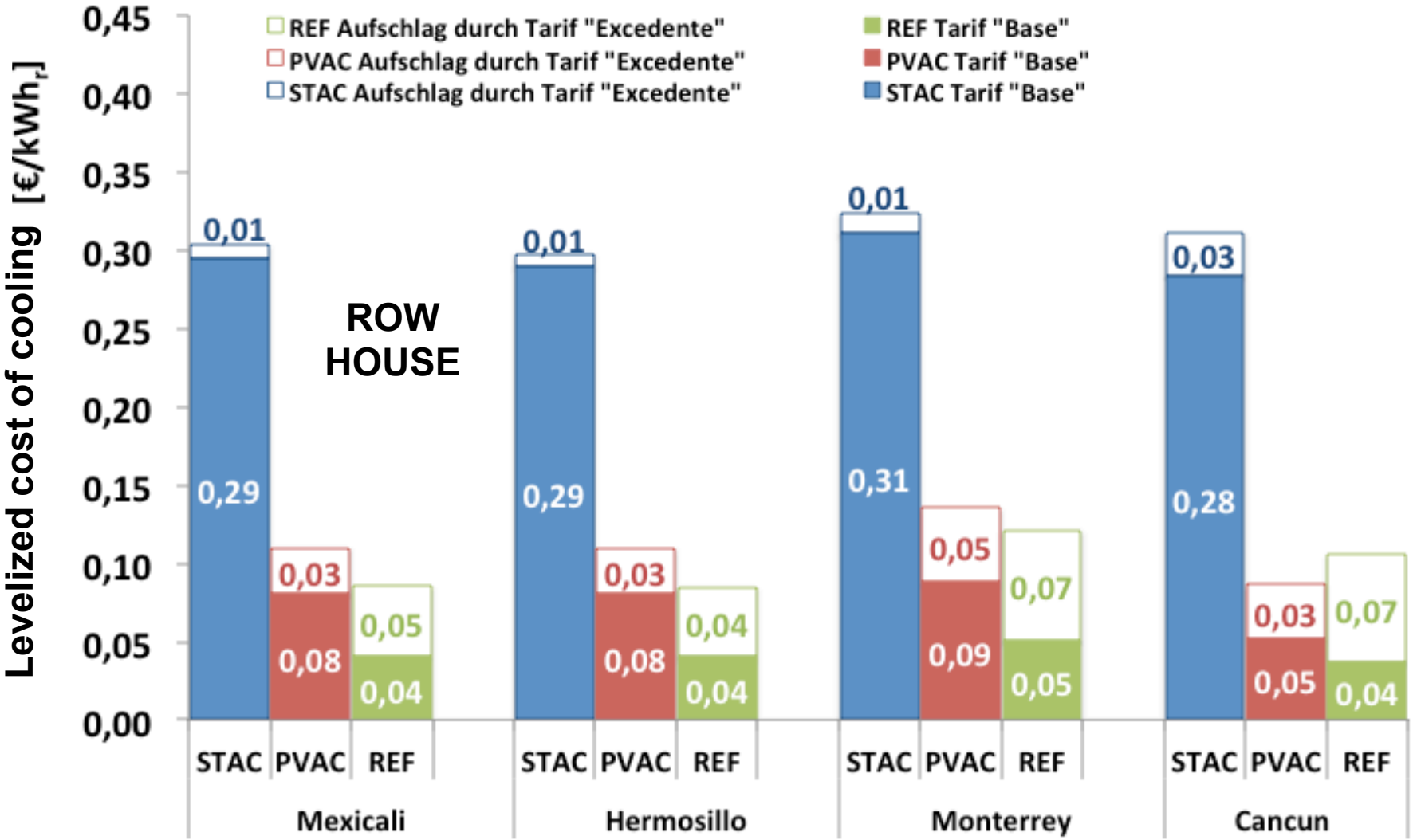
Results – Row house



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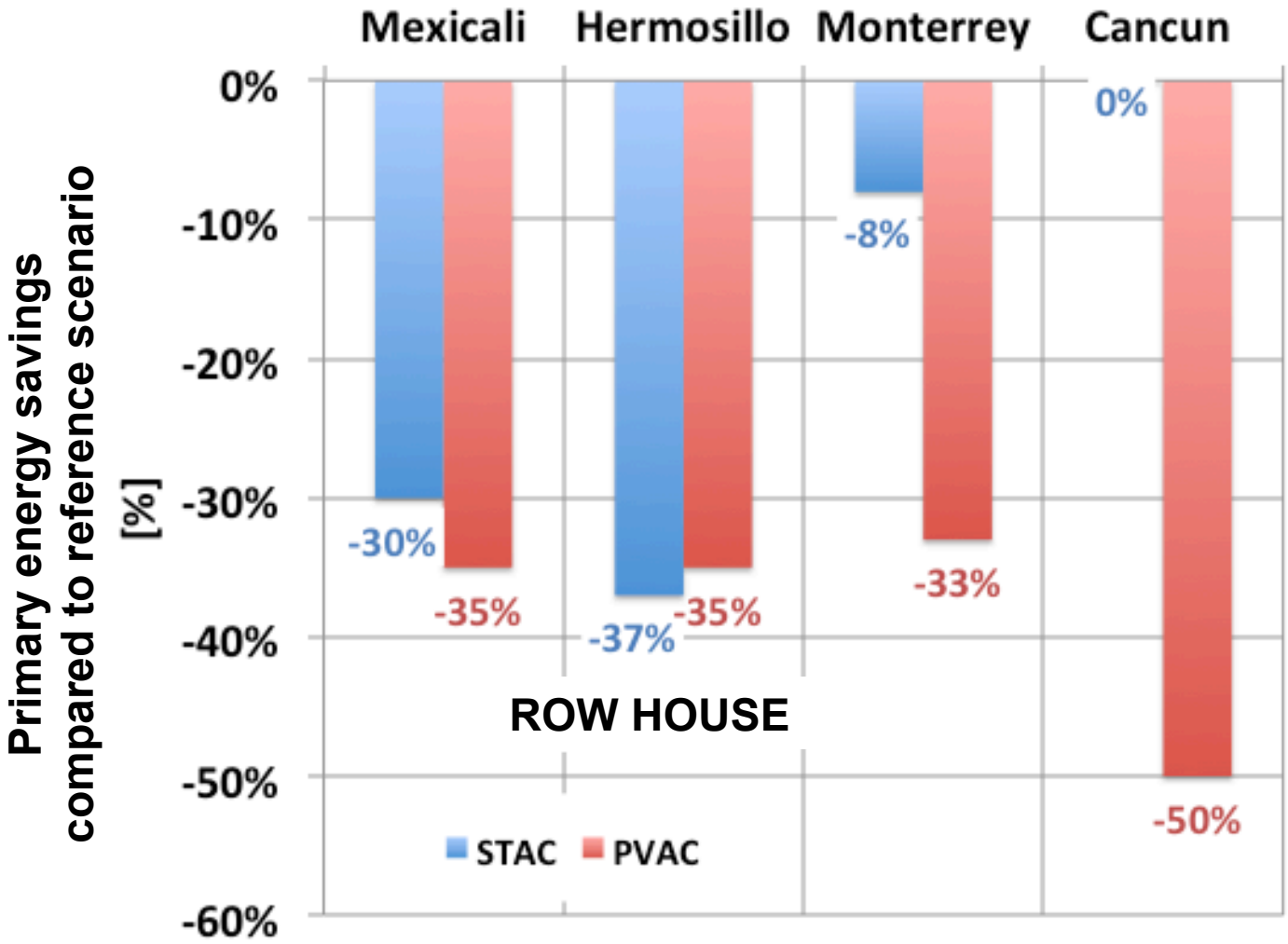
Results – Row house



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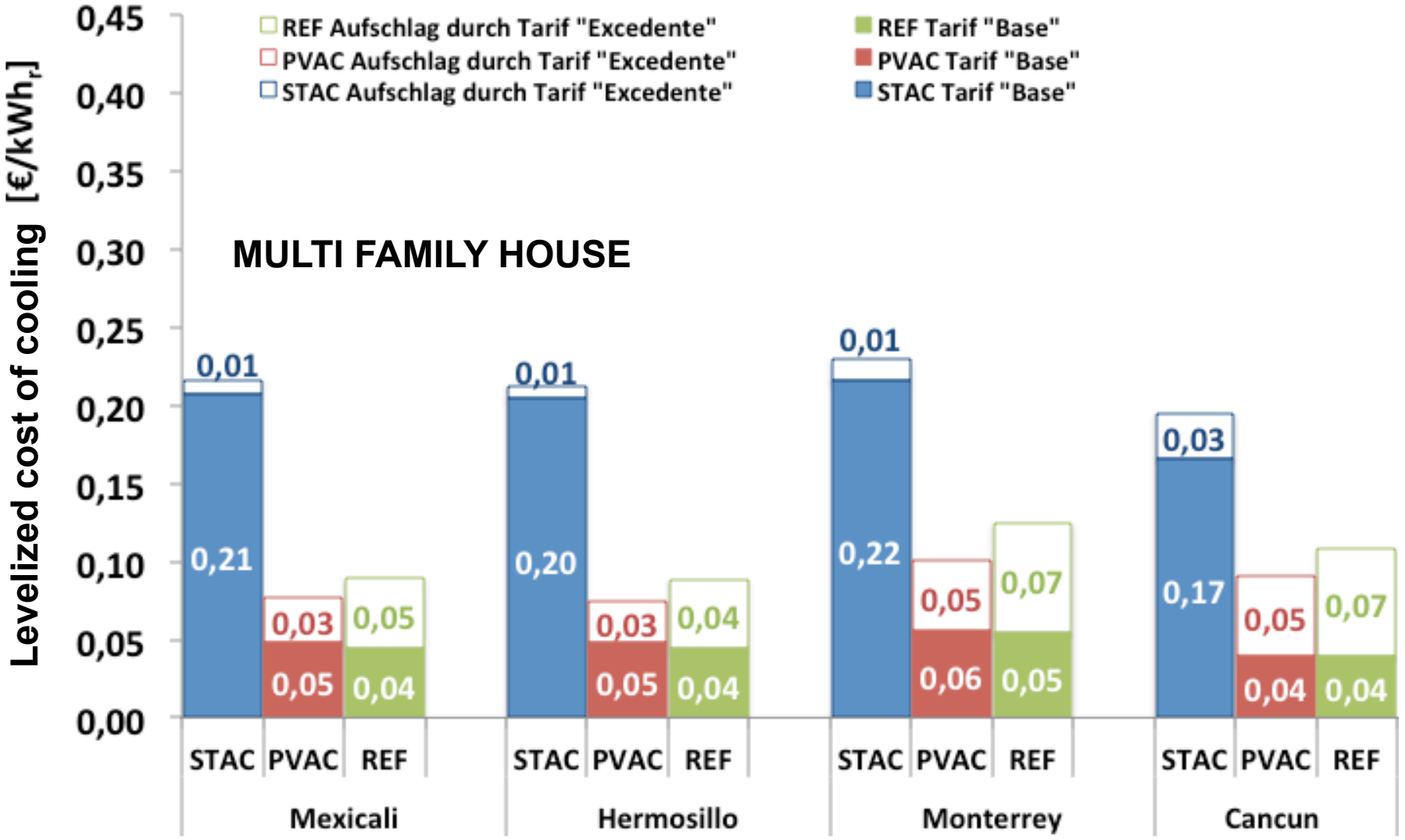
Results – Multi family house



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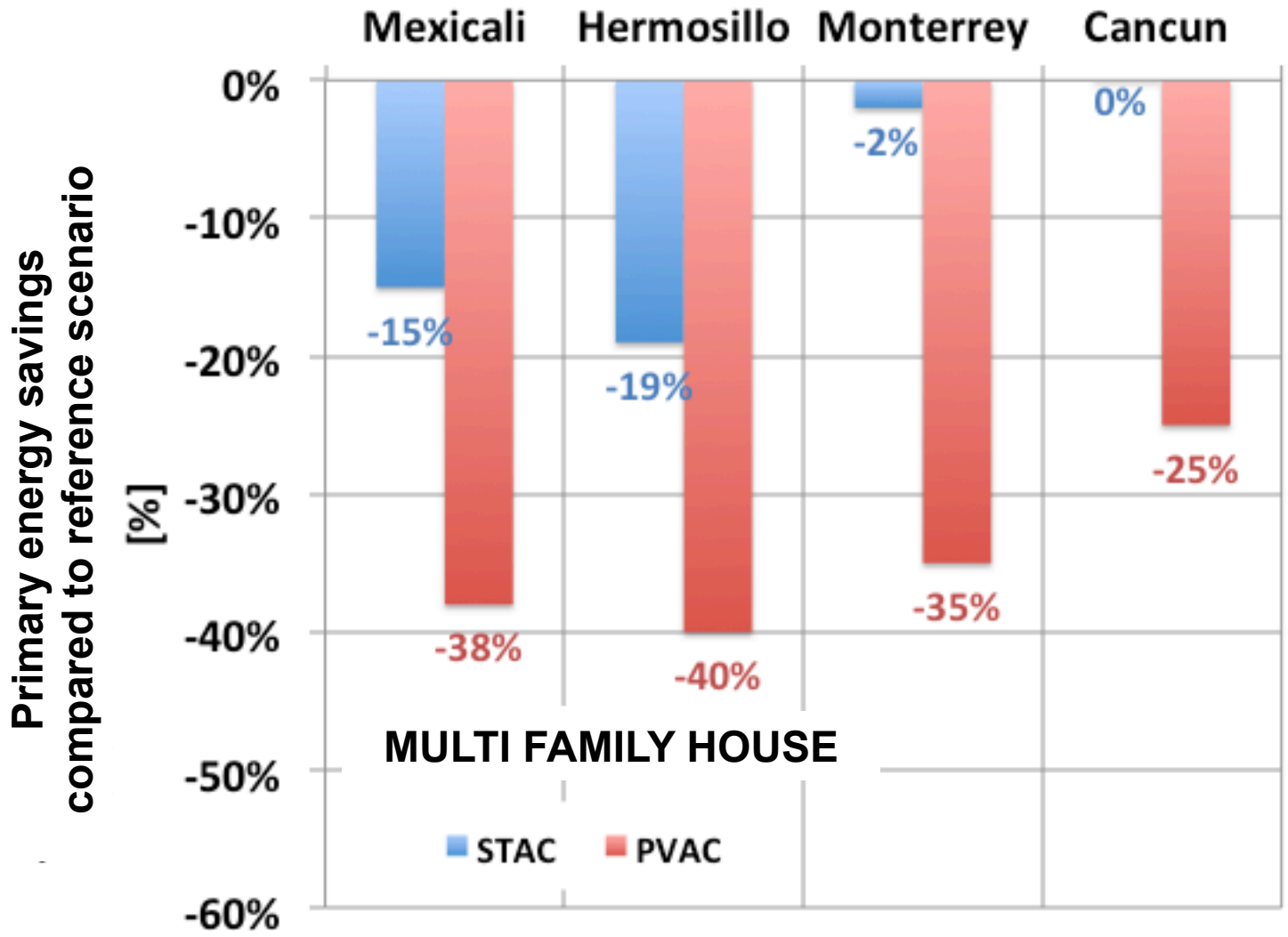
Results – Multi family house



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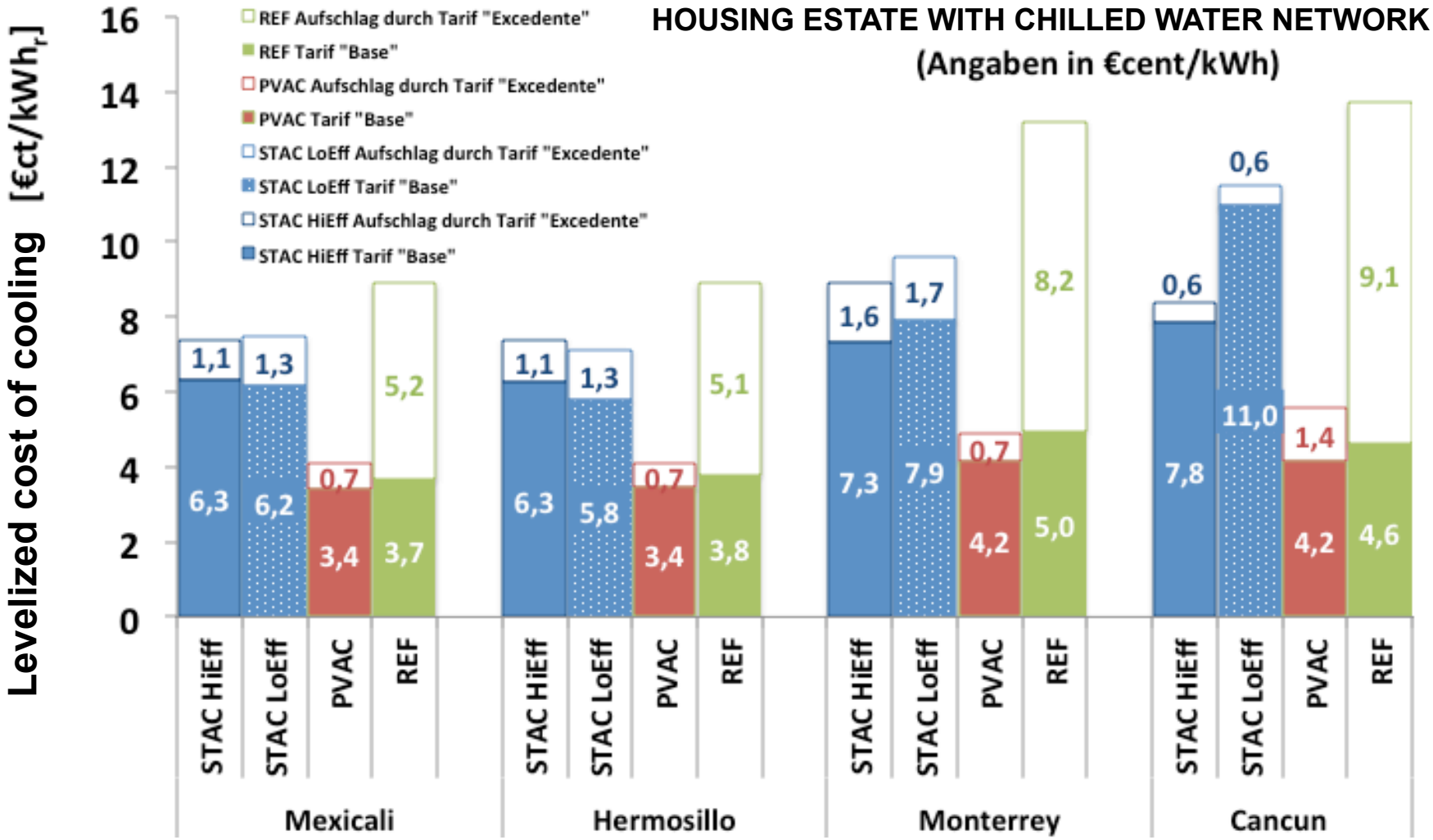
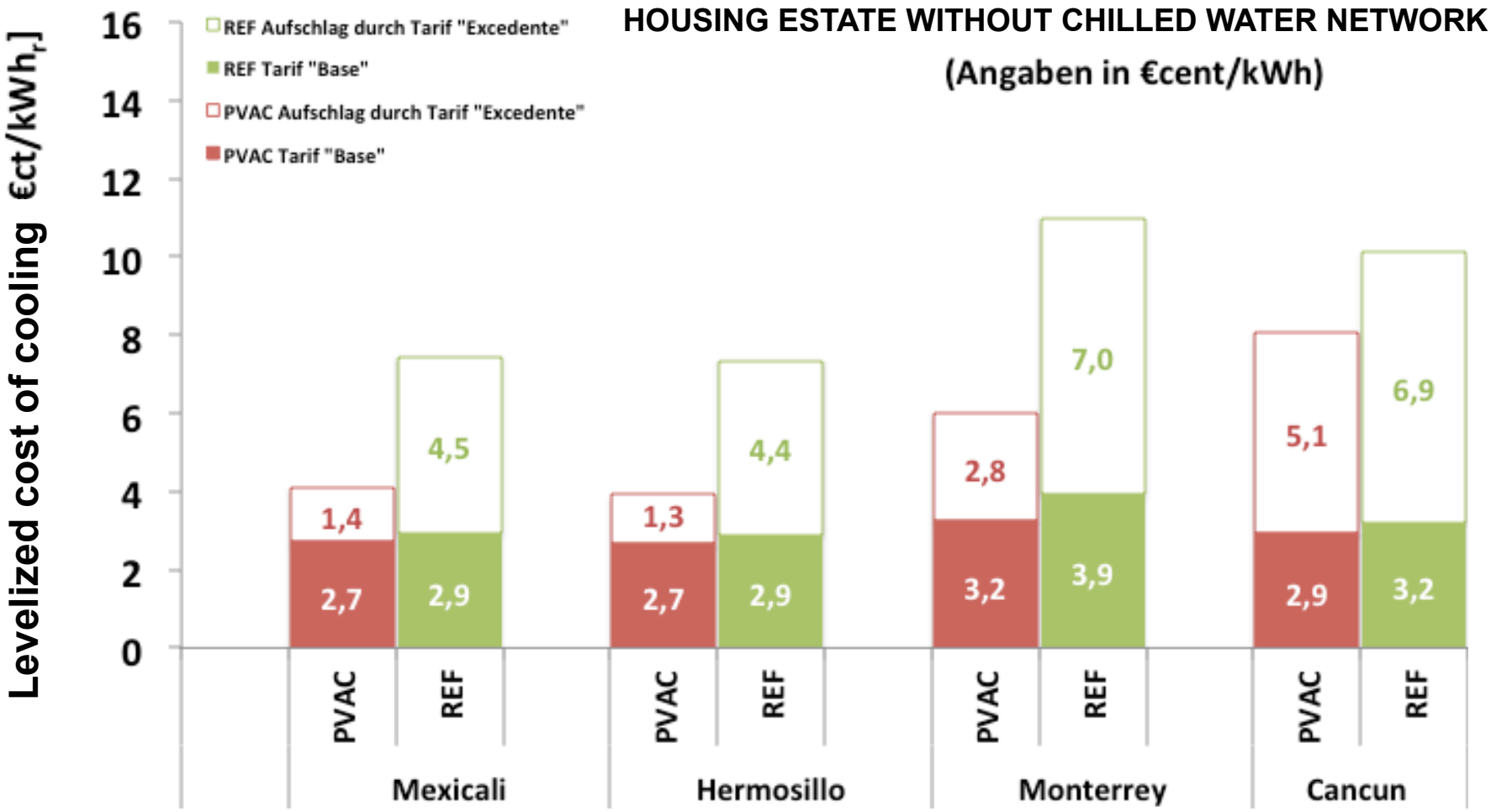
Results – Housing estate with chilled water network



Legende:

STAC: Solarthermische Kühlung PVAC: Photovoltaische Kühlung REF: Referenzsystem – 100% Netzbetrieb
HiEff: Variante mit effizienten Parabolrinnenkollektoren LoEff: Variante mit Standard-Vakuumröhrenkollektoren

Results – Housing estate without chilled water network



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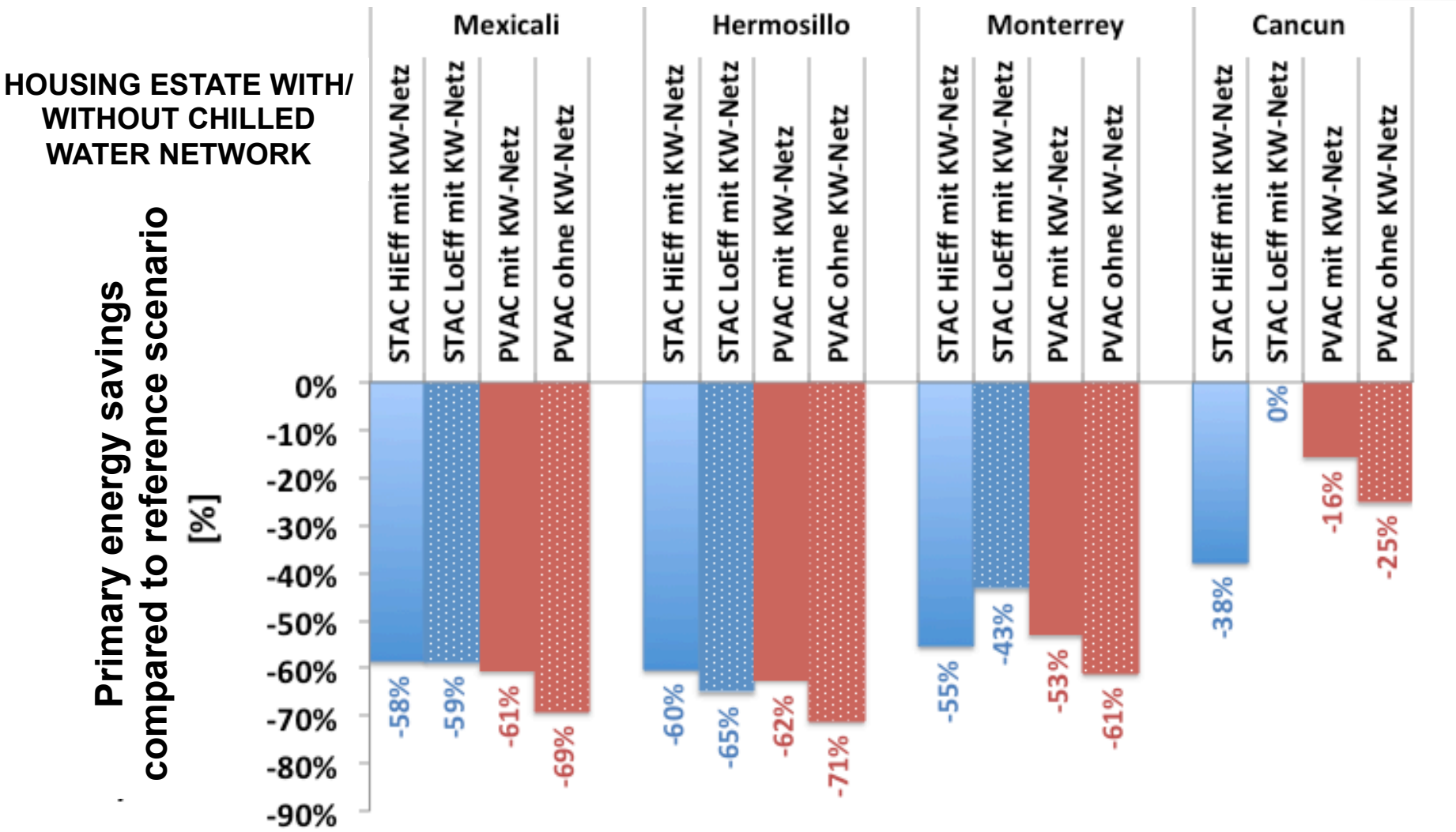
HiEff: Variante mit effizienten Parabolrinnenkollektoren LoEff: Variante mit Standard-Vakuumröhrenkollektoren

Results – Housing estate with/without chilled water network



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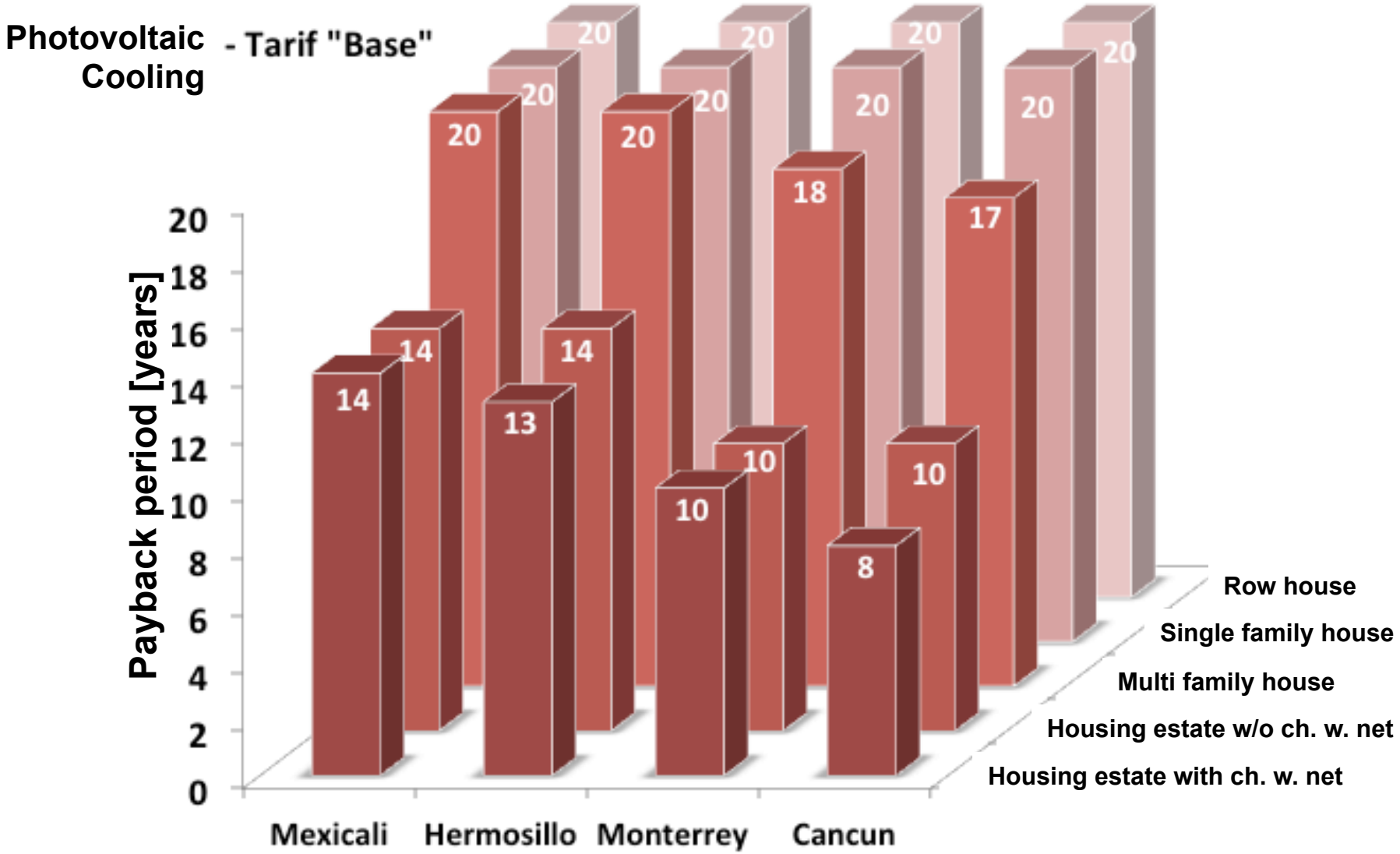
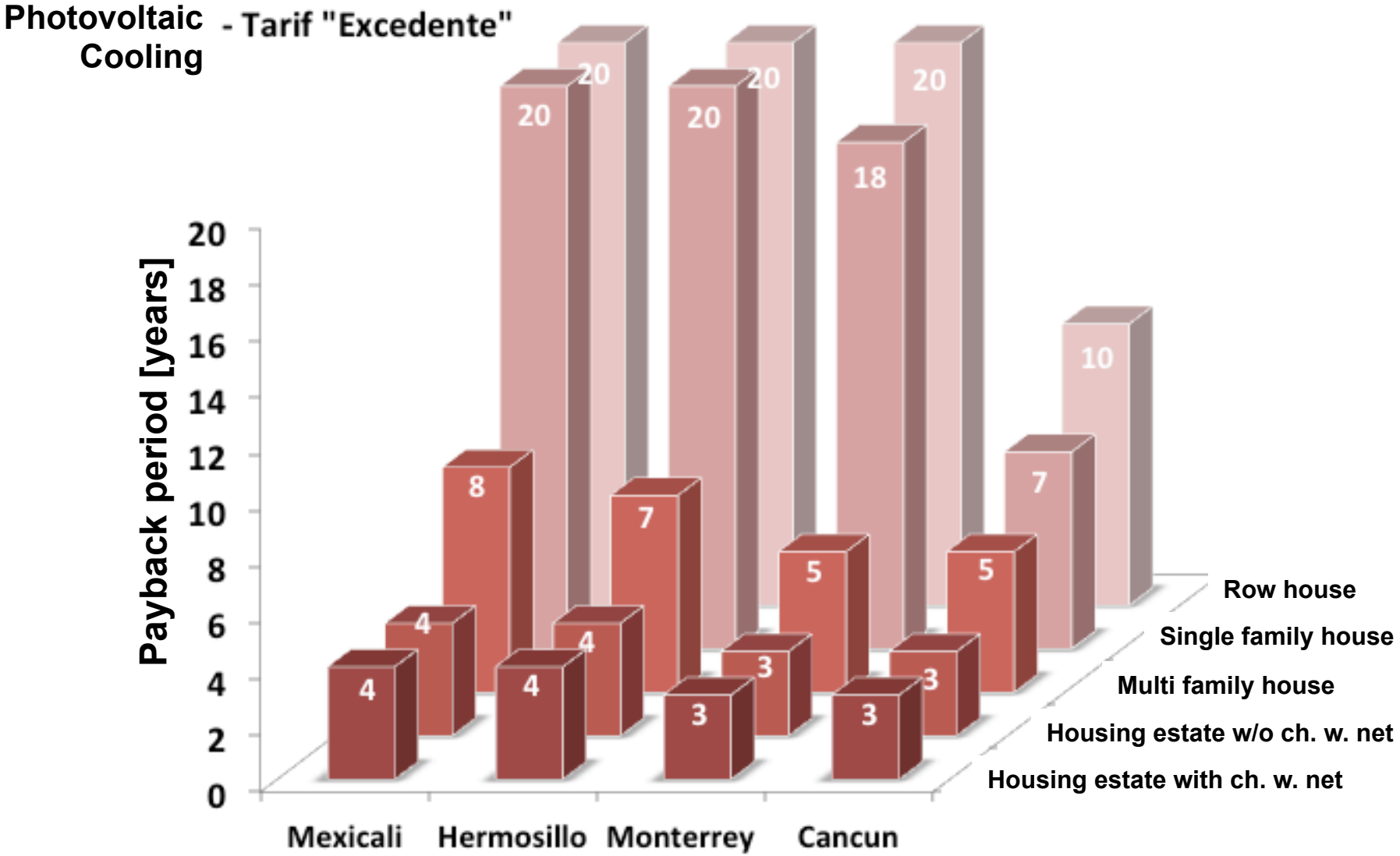
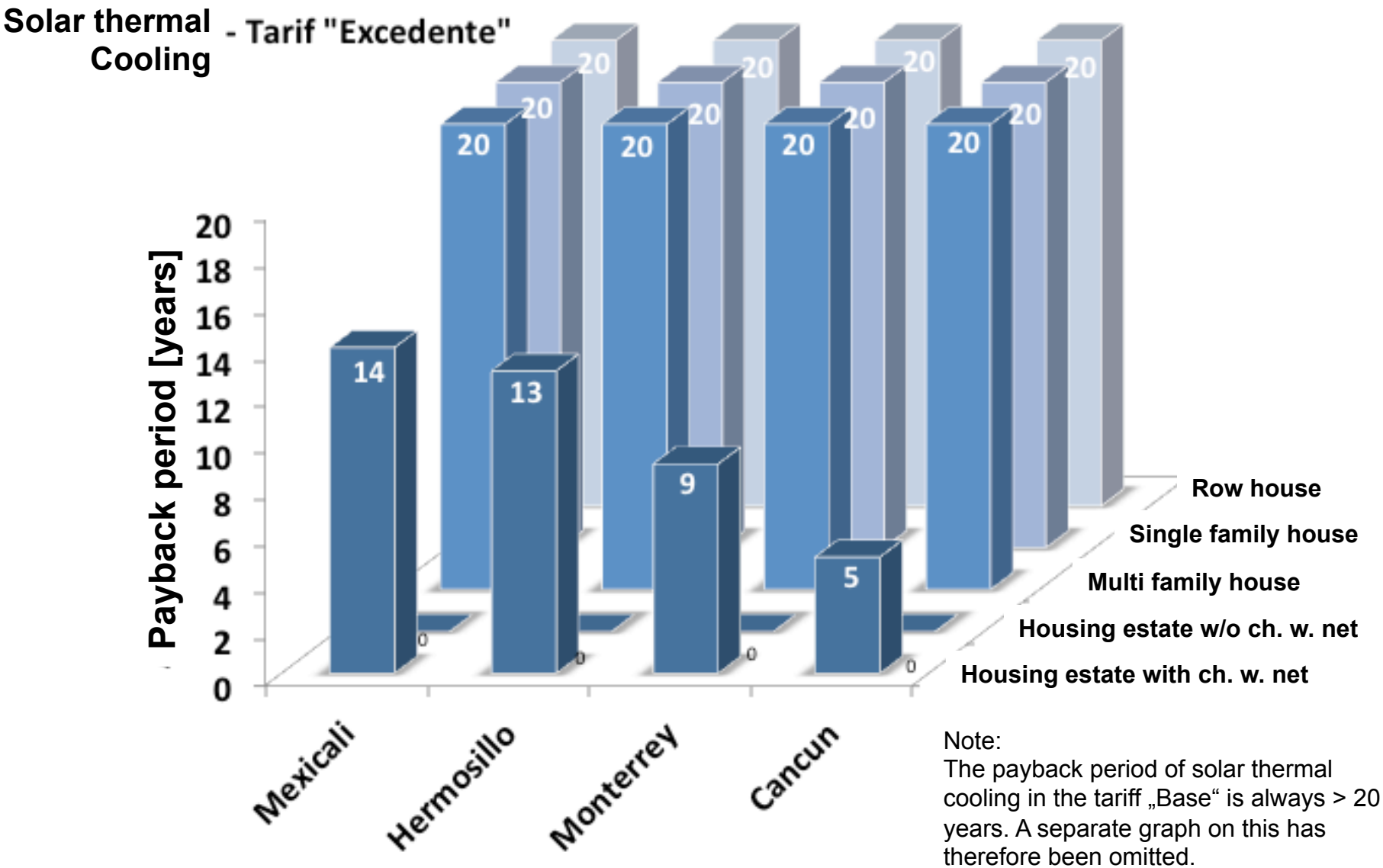
Results – Payback period



Results – Payback period



Results – Payback period



Note:
The payback period of solar thermal cooling in the tariff „Base“ is always > 20 years. A separate graph on this has therefore been omitted.

Summary Mexico

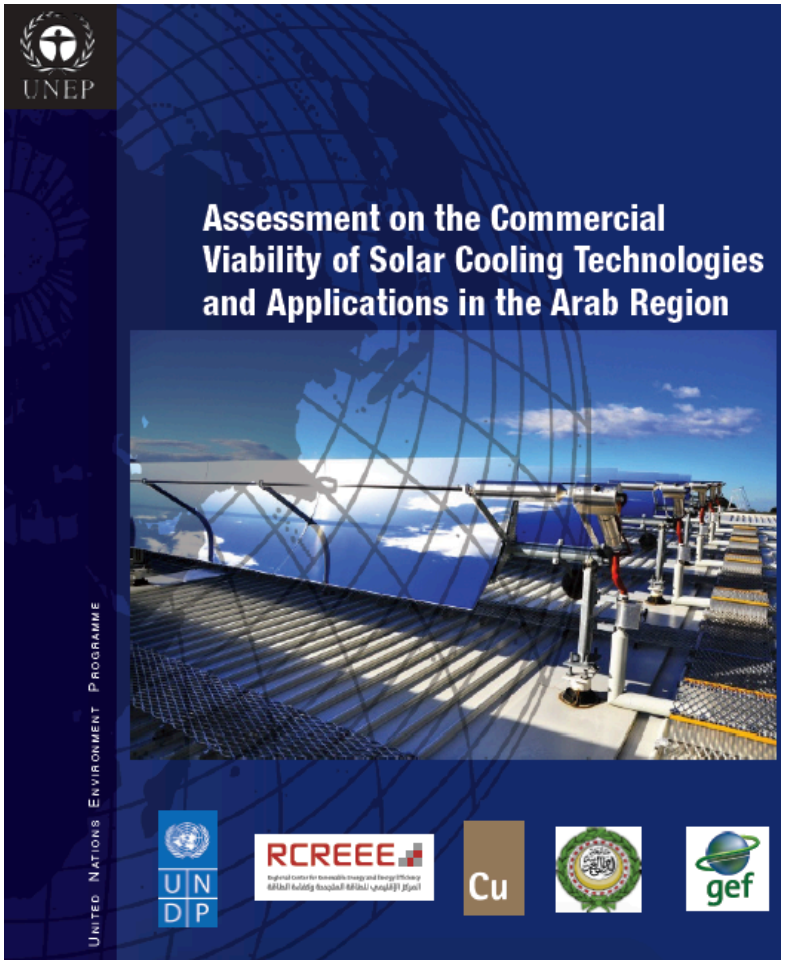
Current conditions (Power tariff „Base“):

- none of the solar options is ecomically viable for single family, row and multi family houses
- **PV cooling** has significant economic advantages if applied in the **housing estate**
- the difference between PV cooling with and without a chilled water network for a housing estate is negligible regarding the payback period

Future conditions (tariff „Excedente“):

- Payback period and LCCE for solar thermal cooling are greater for all buildings and all locations, compared to PV cooling
- PV cooling in single family and row houses is only viable in Cancún.
- **PV cooling** in **multi family houses** is viable at all locations.
- **PV cooling** in **housing estates** has a significant advantage at all locations.
- **Solar thermal cooling** in **housing estates** with chilled water network is a viable alternative at all locations.

Solar Cooling in Commercial Apps – Arab region



UNEP / RCREE Study (2015):

Economics of solar cooling in 18 of 22 arabic countries

Regional Center for Renewable Energy and Energy Efficiency (RCREEE)

Commissioned by:
League of Arab States (LAS), United Nations Environment Programme (UNEP)

Supported by:
German Development Cooperation (GIZ), Danish International Development Agency (DANIDA), Egypt Renewable Energy Authority (NREA)

Arab countries investigated

Source: RCREEE

Buildings / technologies investigated

Target buildings:

- Two building types/sizes with a potentially constant cooling load during the day have been chosen:

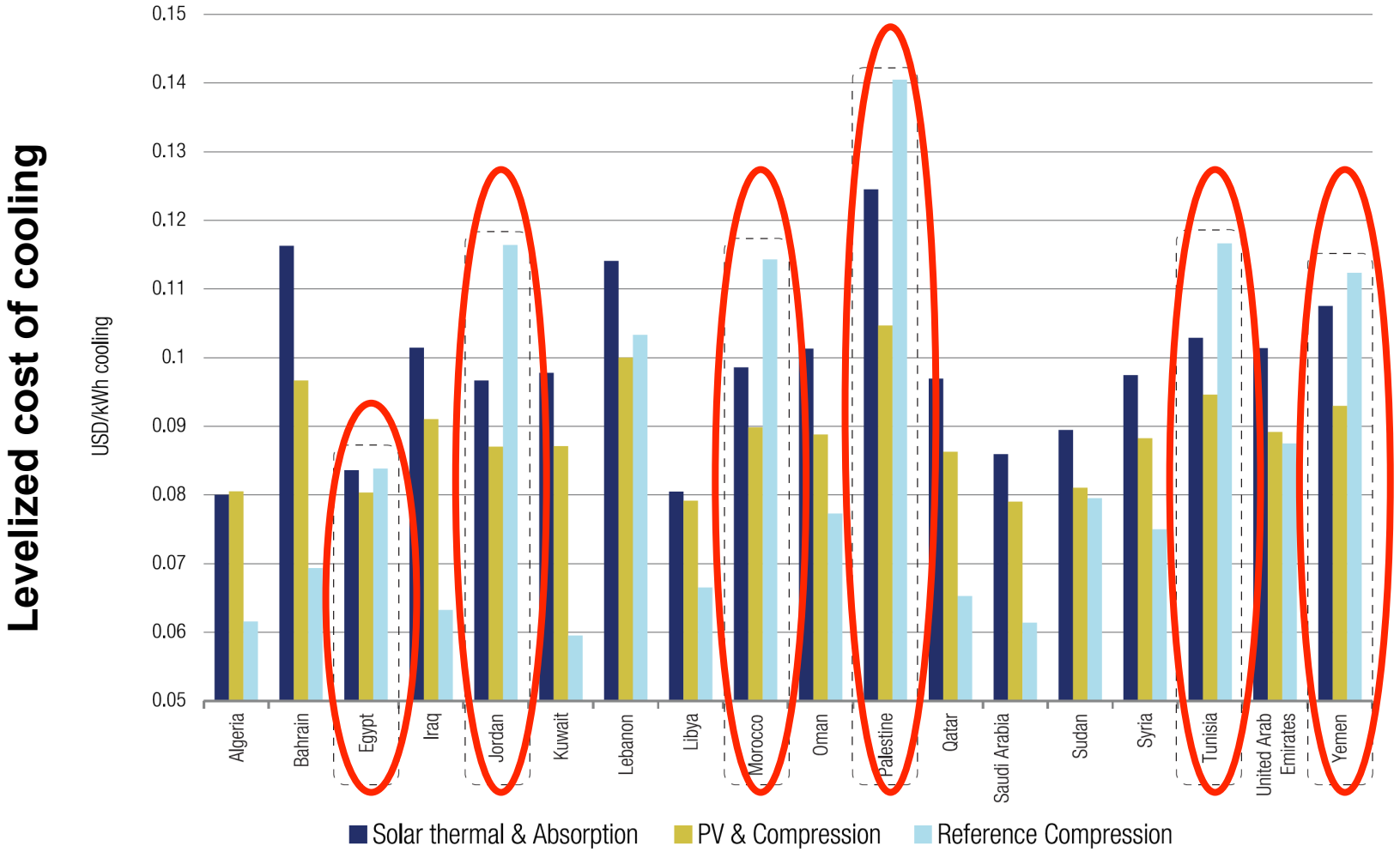
  a) Medium: **Average commercial building of 500 to 1,000 m² air-conditioned area** (depending on the location in Arab region). Cooling capacity approx. 100 kWc

  b) Large: **Group of buildings (using a distributed cooling network) or a large building, air-conditioned area of 5,000 to 10,000 m².** Cooling capacity approx. 1 MWc.

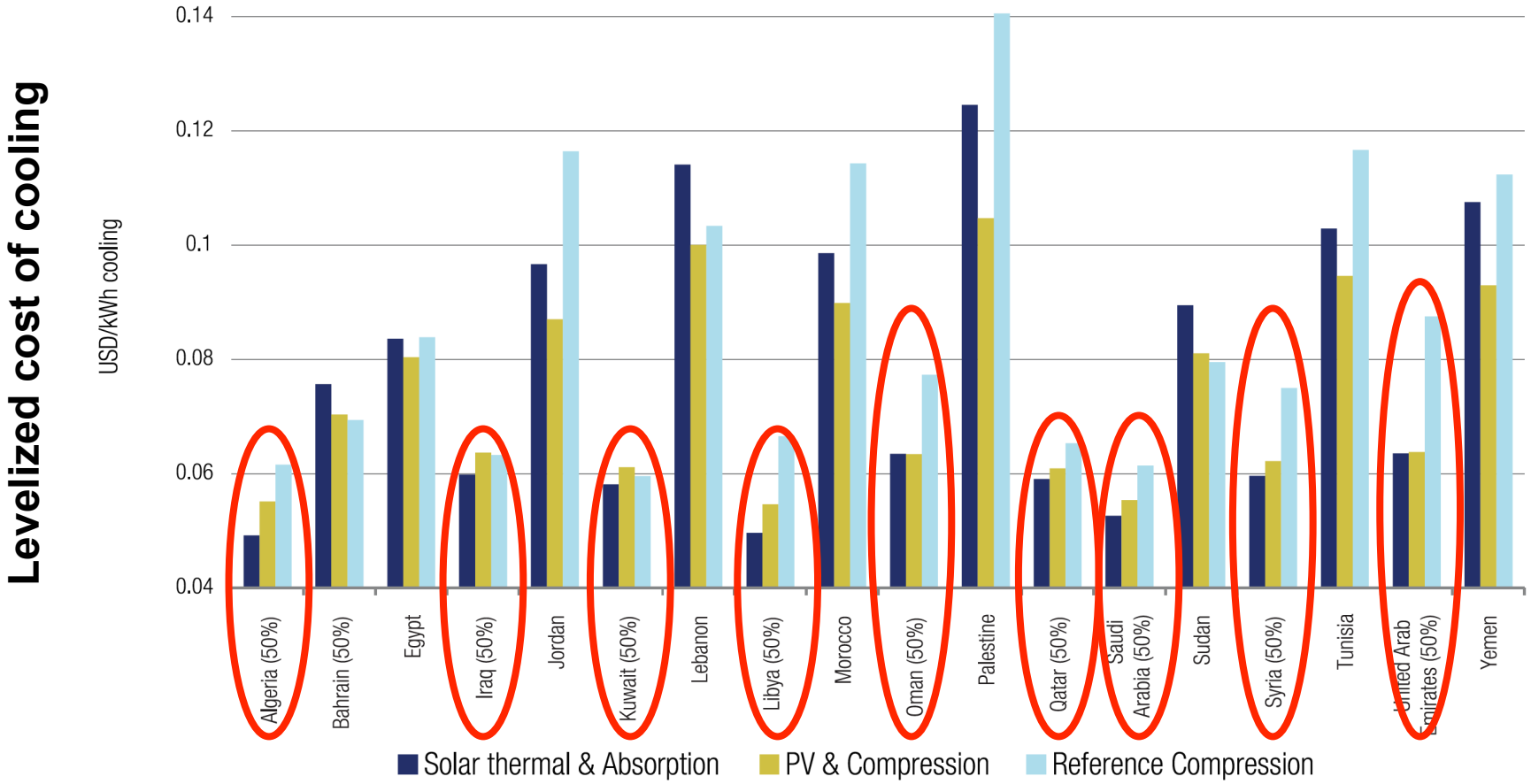
System configuration:

- Double-effect absorption chiller with Parabolic trough/Fresnel collector, a small hot water tank and hybrid cooling tower
- PV Cooling with scroll vapour compression chiller, battery storage and wet cooling tower
- Reference with scroll vapour compression chiller and wet cooling tower

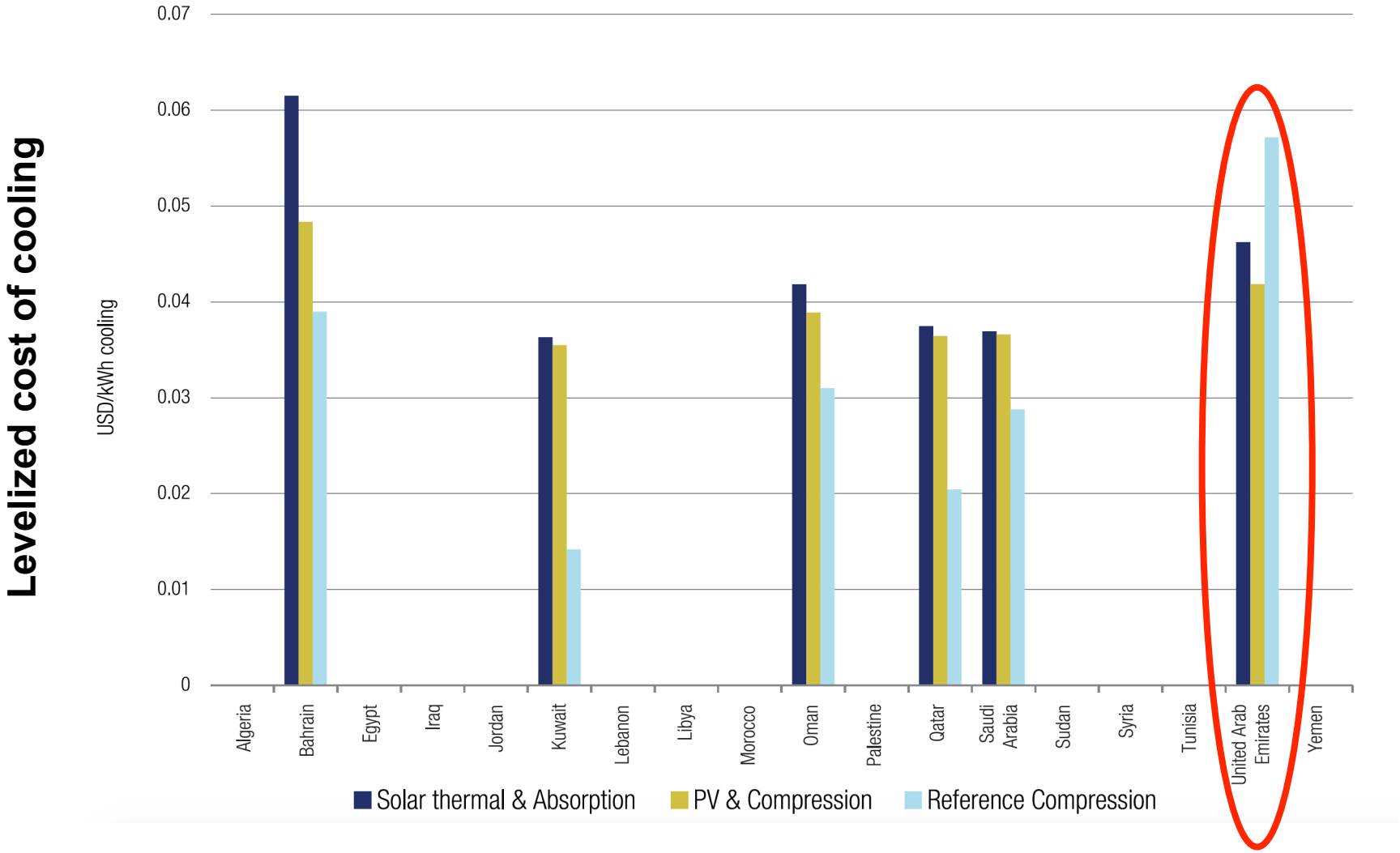
Results – 100 kWc segment



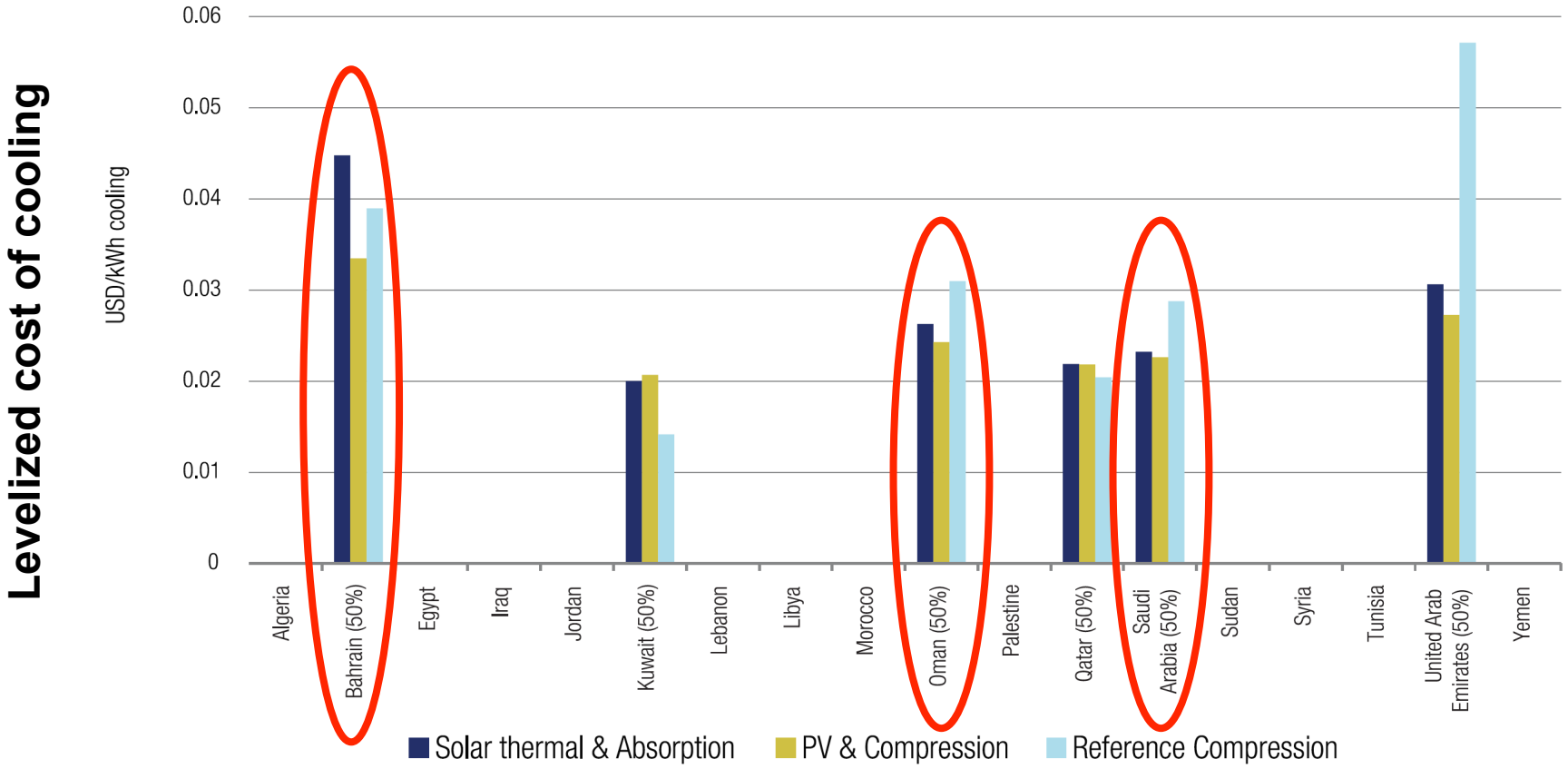
Results – 100 kWc segment
(50% subsidy on investment cost for 12 countries)



Results – 1 MWc segment



Results – 1 MWc segment
(50% subsidy on investment cost for 6 countries)



Summary Arab region

Favorable countries for a 100 kWc solar cooling system:

Egypt, Jordan, Morocco, Palestine, Tunisia, Yemen

- There, the net present cost over 20 years of lifetime is lower for both solar cooling technologies compared to the reference case.
- In all countries above, the PV cooling solution is more competitive than the solar thermal one.

Summary Arab region

Favorable countries for a 1 MWc solar cooling system:

UAE, Kuwait, Qatar, Saudi Arabia

- In the UAE, both solar thermal and solar PV cooling are currently economically viable with lower net present cost than the reference case over 20 years.

- In Kuwait, Qatar and Saudi Arabia, solar thermal and solar PV cooling solutions are very close to each other in terms of net present cost. Both solar cooling technologies, however, are only economically viable compared to the reference system if a subsidy of at least 50% is applied on the investment cost.

Picture: SOLEM Consulting

Thank you for your kind attention !

Stuttgart

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