SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Keynote:

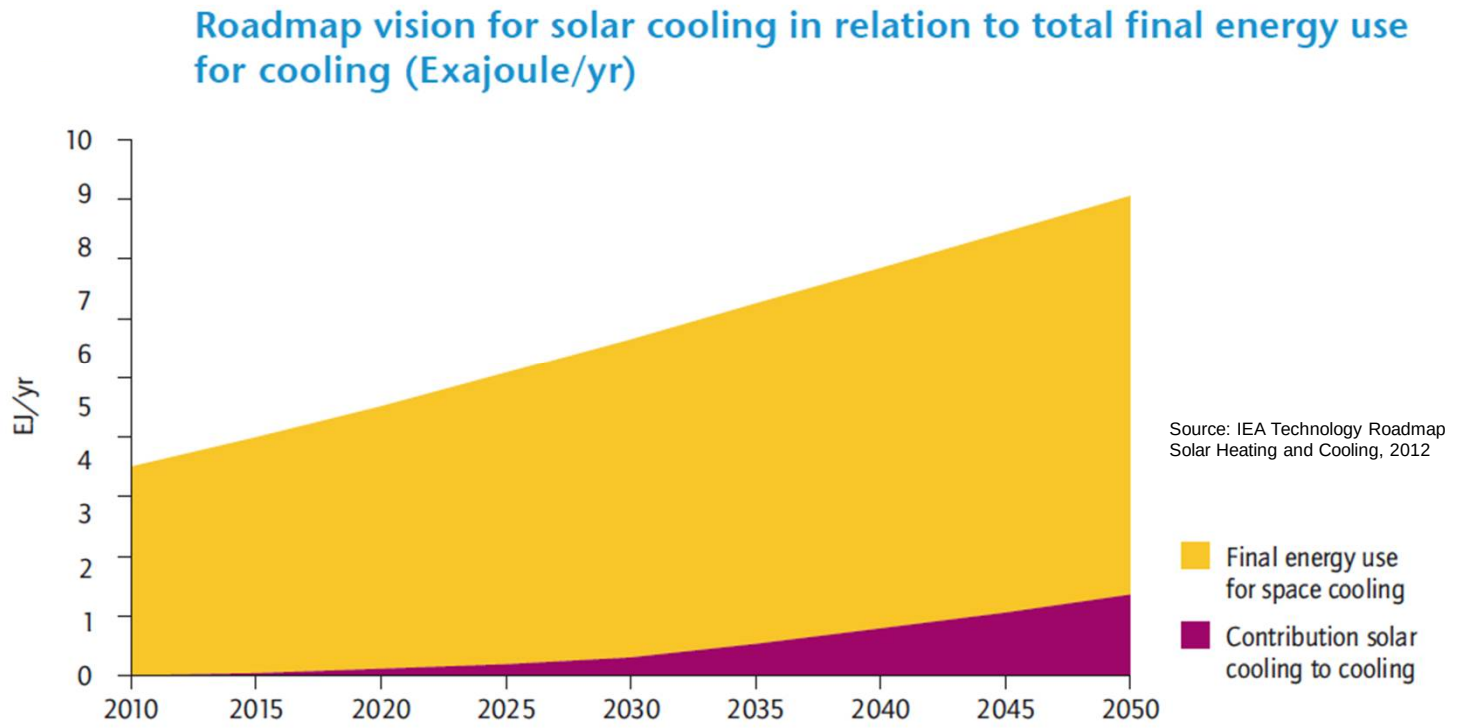
Solar Cooling potential in the MENA Region

Daniel Mugnier, Dr. Ing, TECSOL & IEA SHC Task 53 Opérating Agent
Abu Dhabi, 31/10/2017

Task 53

IEA Technology Roadmap SHC

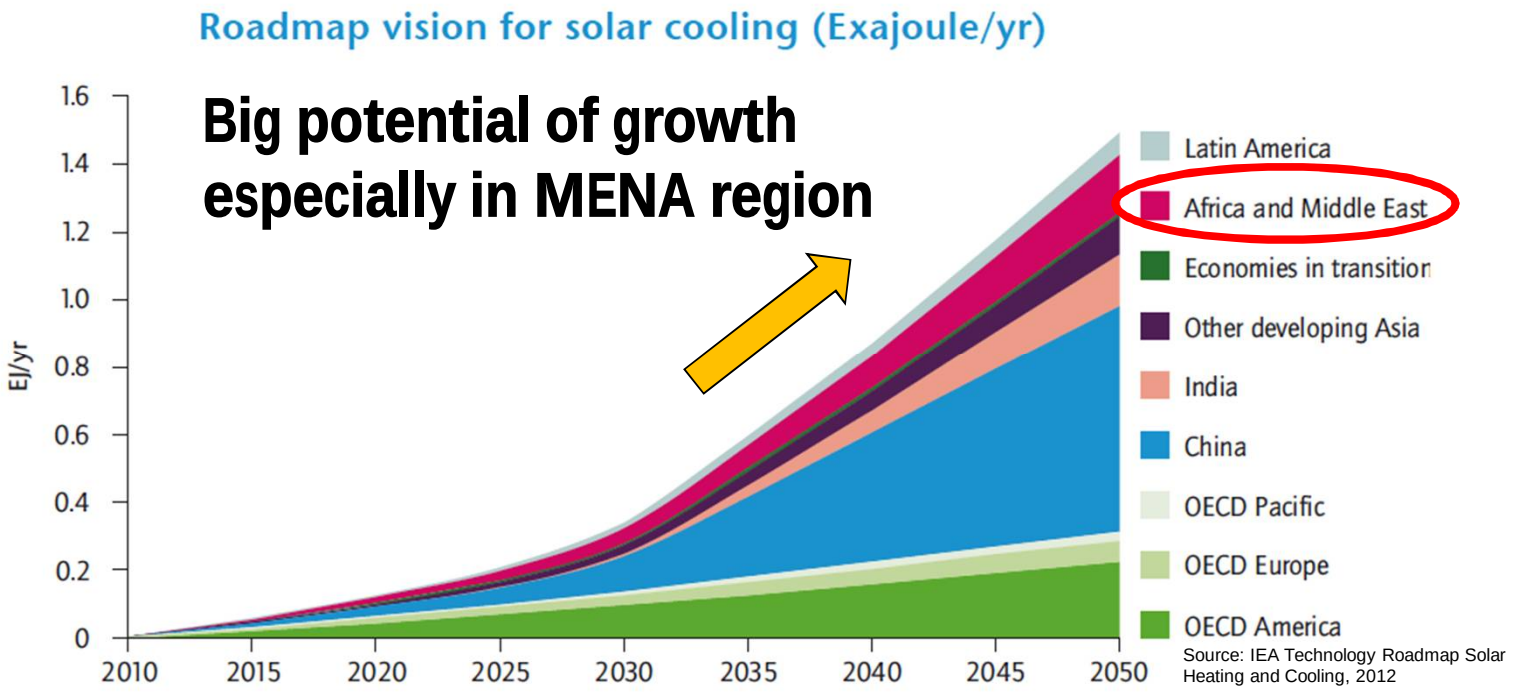
Share of solar cooling by 2050



Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

Solar Cooling nearly 17% of total energy use for cooling!

IEA Technology Roadmap SHC – *Market potential by 2050*



Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

1.5 x 10^{18} J/a = 416.7 TWh/a Solar Cooling by 2050

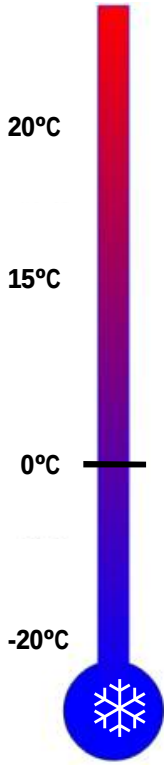
Systems could enter the market between 2015 and 2020

2 main channels in 2016 for Solar Cooling

CHILLER / AIR CONDITIONER

Solar thermal collector technologies & application for solar cooling

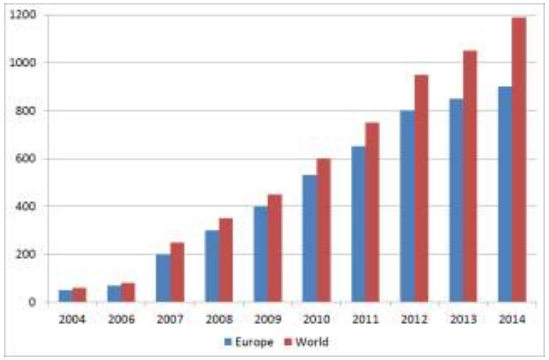
Solar thermal collector	Heat transfer medium	Collector temperature	Application for cooling
Air collector 	Air	40-60°C	**Air-conditioning**
Flat plate collector 	Water, Water-Glycol	70-90°C	**Air-conditioning, slab cooling**
Evacuated tube collector 	Water, Water-Glycol	90-120°C	**Air-conditioning, slab cooling**
Parabolic trough / Fresnel collector 	Thermal oil, Water	120-250°C	**Refrigeration, air-conditioning, slab cooling**



Source : JER

Solar cooling market trends in the World

Still a niche market :
≈ 1,200 systems installed worldwide (2015)



Source: Solem Consulting / TECSOL

A High level of innovation still present :

IEA SHC Task 53

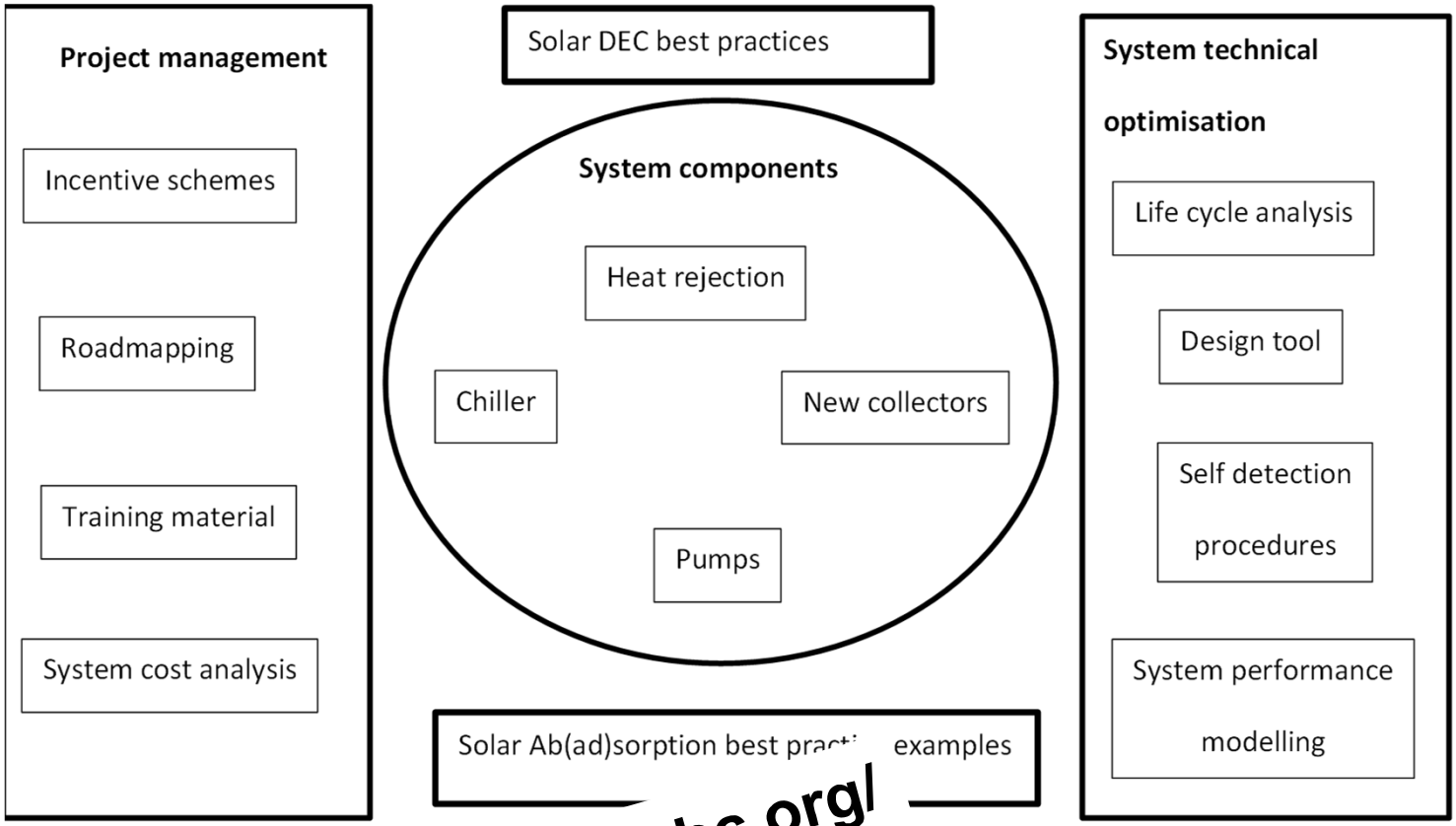
* Heat rejection
* Electric consum[illegible]tion
* kWh coo[illegible] decrease

http://task53.iea-shc.org/

Already very accurate concepts for Arabic countries

* low & medium temperature solar thermal absorption
* small size PV air-conditioning

Task 48 investigation results



Source : IEA SHC Task 48

http://task48.iea-shc.org/

Need of a new Generation solar cooling systems

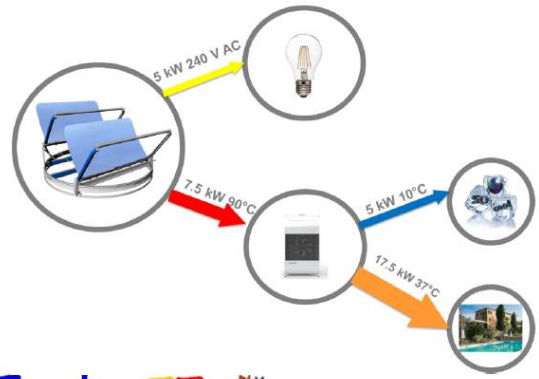
Solar thermal « traditionnal » cooling has **difficulty to emerge as a economically competitive solution**

Main reasons :

- **Technical** : Limit on adaptability due to hydraulics, complexity
- **Economical** : High upfront cost, especially for small systems

⇒ Still need **intensive R&D** for quality improvment and best solution selection (ongoing IEA SHC Task 53)

⇒ Very innovative concepts such…

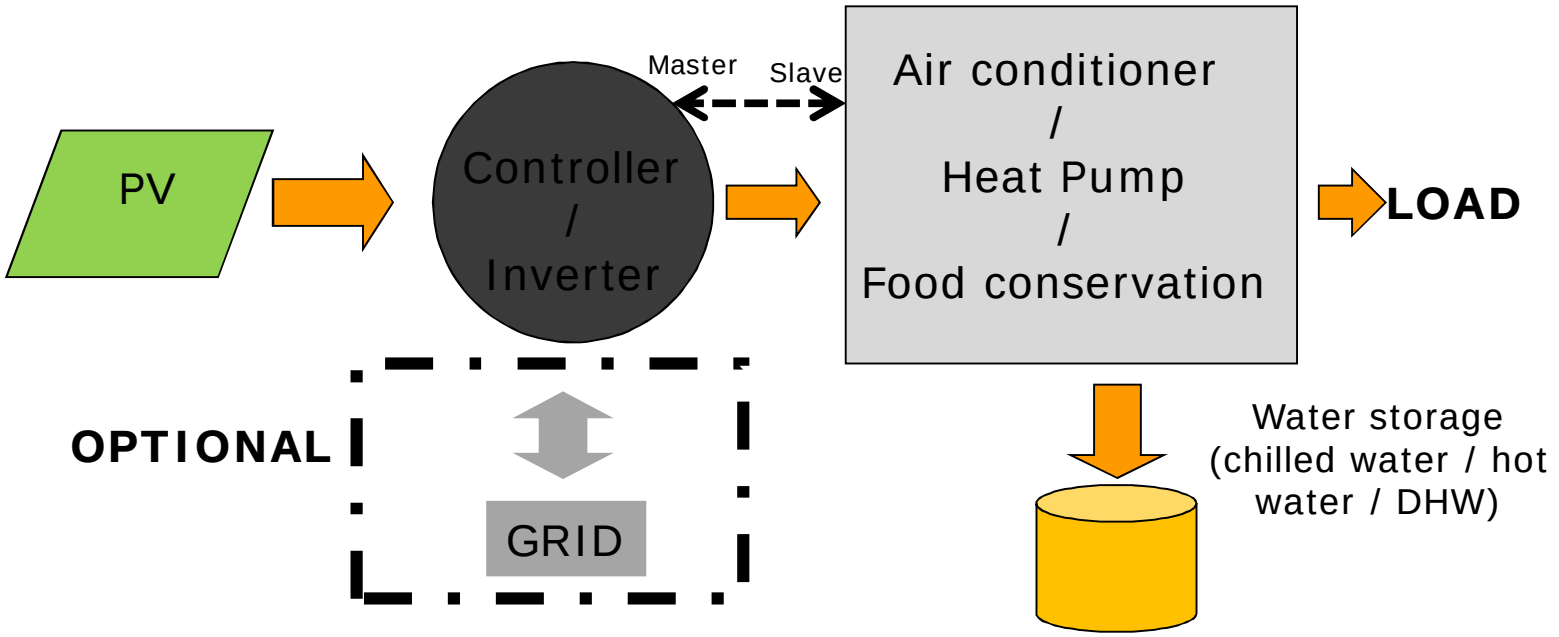


Task 53

Sunoyster®

SOLABCOOL (NL)
4,5 kWc

Example of Basic concept for the PV approach



Main categories of PV cooling systems

Solar air conditioners : Splits

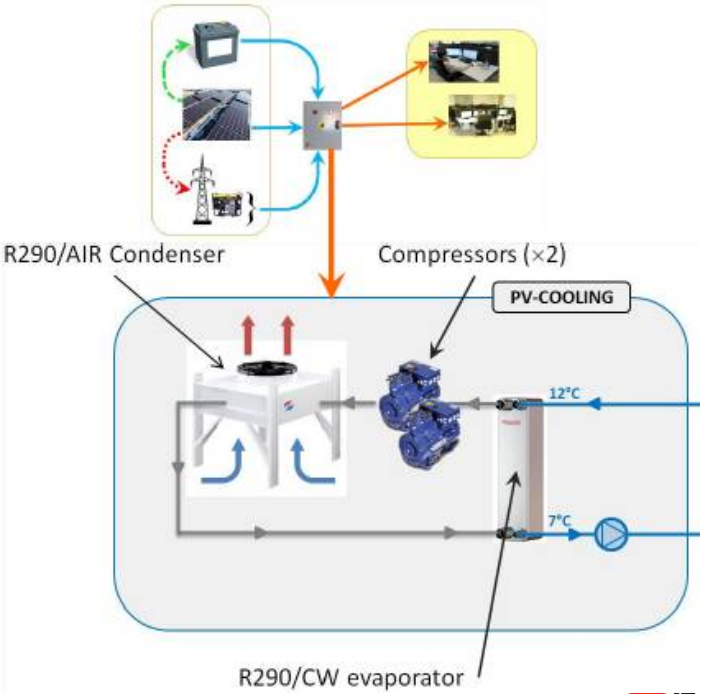
PV+ HP coupling for Office/Commercial

PV COOLING CONCEPT

PV + INVERTER + R290 « clean » chiller

Ready for the market via demos..

ATISYS Concept



Conclusions on the State of the art

Solar cooling **highly needs innovations** : cost reduction, 30 years reliability and performance..

High stimulation from PV to solar thermal for small to medium cooling power range

High priority targets in term of markets :

- **MENA region**
- China
- Sun Belt

Very promising segments for solar thermal cooling with large system concepts

Study on solar cooling potential

Clients :

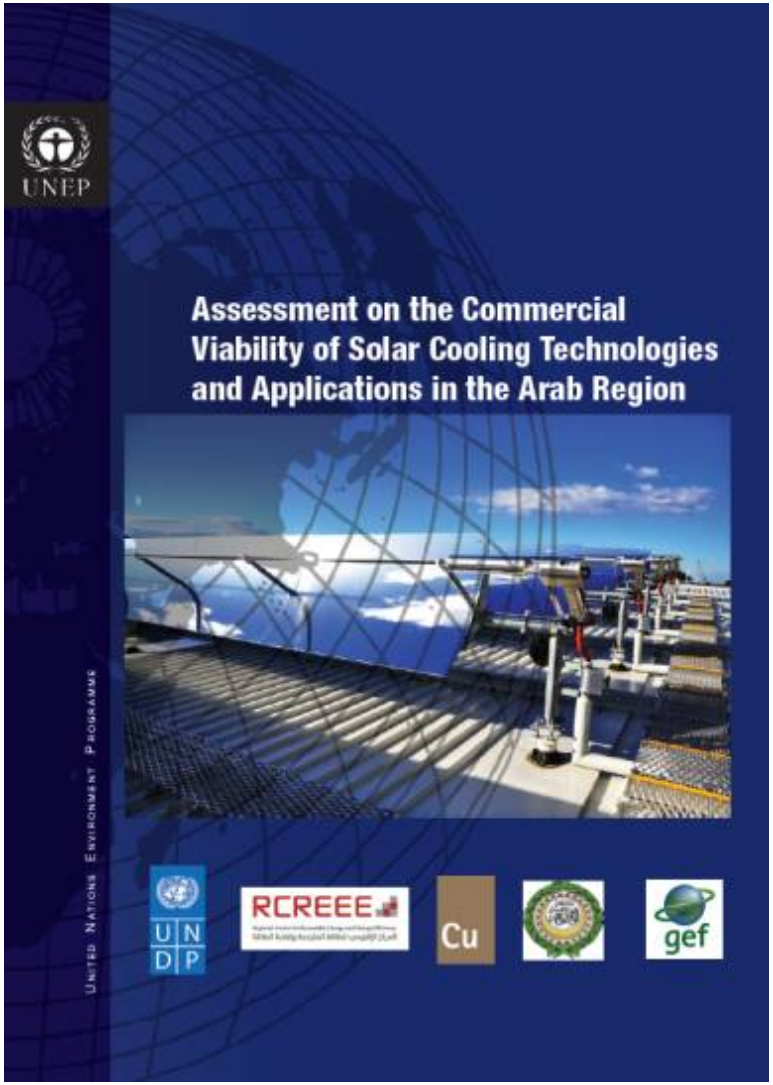
RCREEE
Regional Center for Renewable Energy and Energy Efficiency
المركز الإقليمي للطاقة المتجددة وكفاءة الطاقة

UNEP

Consultants :

SOLEM CONSULTING

TECSOL



Qualitative assessment

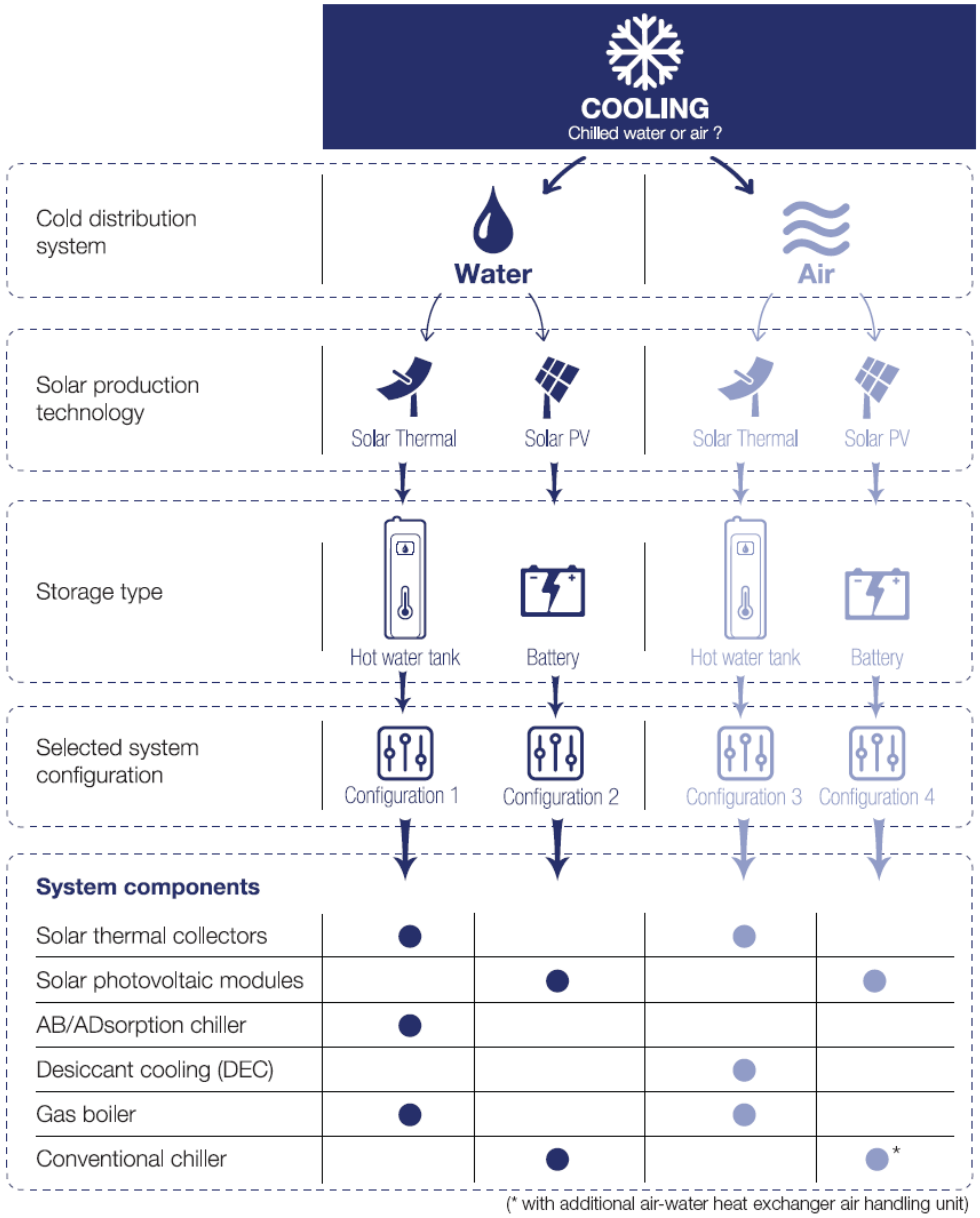
* Target buildings in Arab region where solar cooling accurate
⇒**a predominant daily cooling load.**

* For large spectrum of markets in the Arab region
Solar cooling to be **very robust & simple to maintain**
in harsh hot & arid conditions.

* As solar cooling technology is having high upfront costs,
each produced kWh of cooling to be used in the best efficiency.

* Study **on developing the analysis of 2 driving technologies**:
- Solar thermal absorption cooling
- Vapour compression scroll chiller and PV modules

Solar cooling decision tree

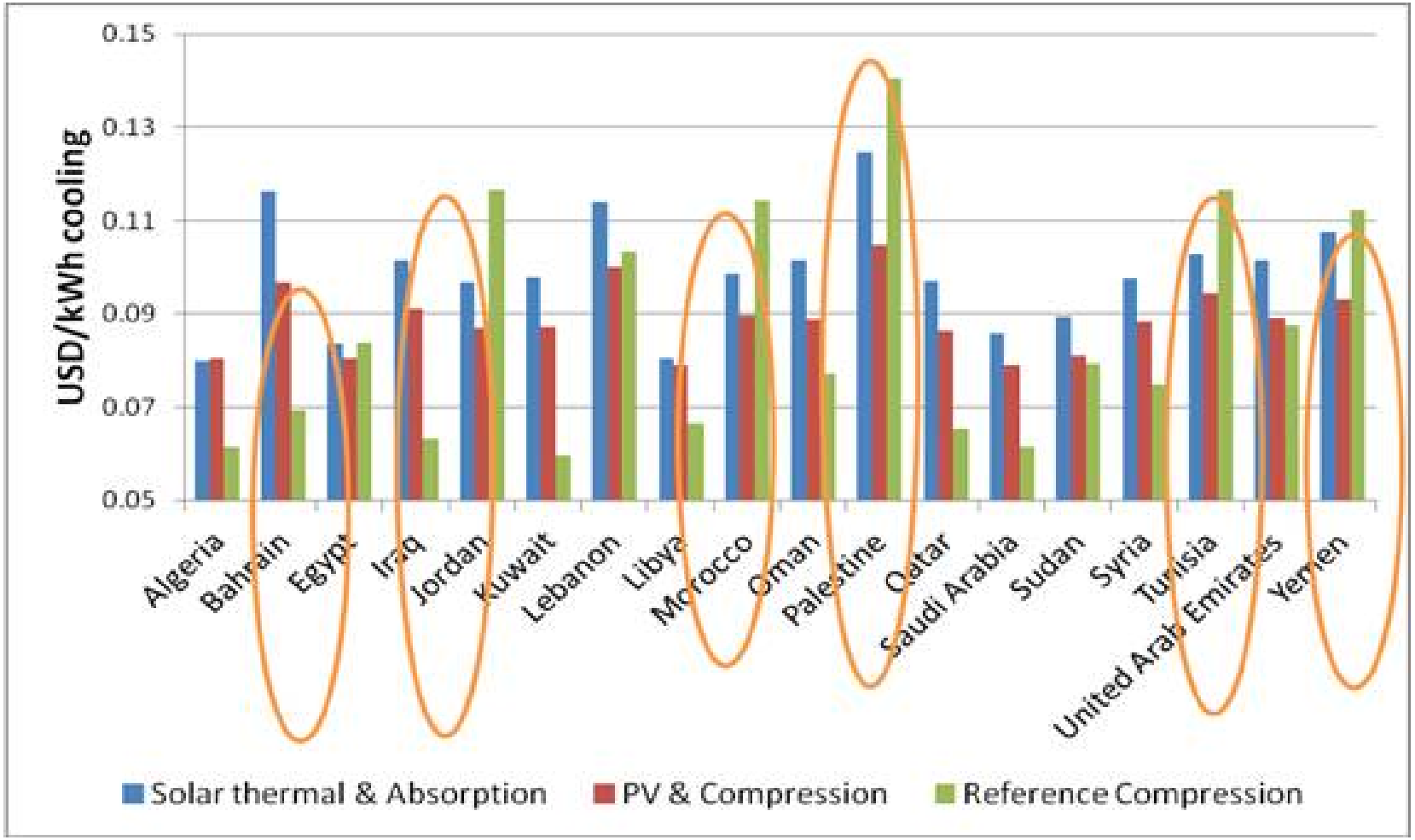


Economic analysis : hypothesis

	Global Horizontal Irradiation	Direct normal Irradiation	PV yield, (°20 tilt ; South)	Electricity cost for commercial	% of subsidy on electricity tariff for commercial	Water cost
	kWh/m².y	kWh/m².y	(kWh/ kWp.y)	(cUSD/ kWh)		(USD/m³)
Algeria	1,970	2,700	1,600	4.2	78%	0.5
Bahrain	2,160	2,050	1,900	0.8	96%	8
Egypt	2,450	2,800	1,730	9.9	49%	0.4
Iraq	2,050	2,000	1,800	1.1	94%	0.05
Jordan	2,320	2,700	1,800	17	12%	1.47
Kuwait	1,900	2,100	1,900	0.7	96%	0.75
Lebanon	1,920	2,000	1,700	10.4	46%	1
Libya	1,940	2,700	1,700	5.5	71%	0.05
Morocco	2,000	2,600	1,700	16.1	16%	1.5
Oman	2,050	2,200	1,900	5.2	73%	2
Palestine	1,920	2,000	1,800	19.2	0%	1.2
Qatar	2,140	2,200	1,900	2.5	87%	1.4
Saudi Arabia	2,130	2,500	1,930	3.2	83%	1
Sudan	2,130	2,500	1,950	7.7	60%	0.3
Syria	2,360	2,200	1,800	5.1	74%	0.3
Tunisia	1,980	2,400	1,600	16	17%	0.6
United Arab Emirates	2,120	2,200	1,900	8	58%	0.6
Yemen	2,250	2,200	1,900	14	27%	0.3

Economical analysis of the 100 kW cooling segment

Levelized cost of cooling energy over 20 years & reference cooling cost for specific 12 countries



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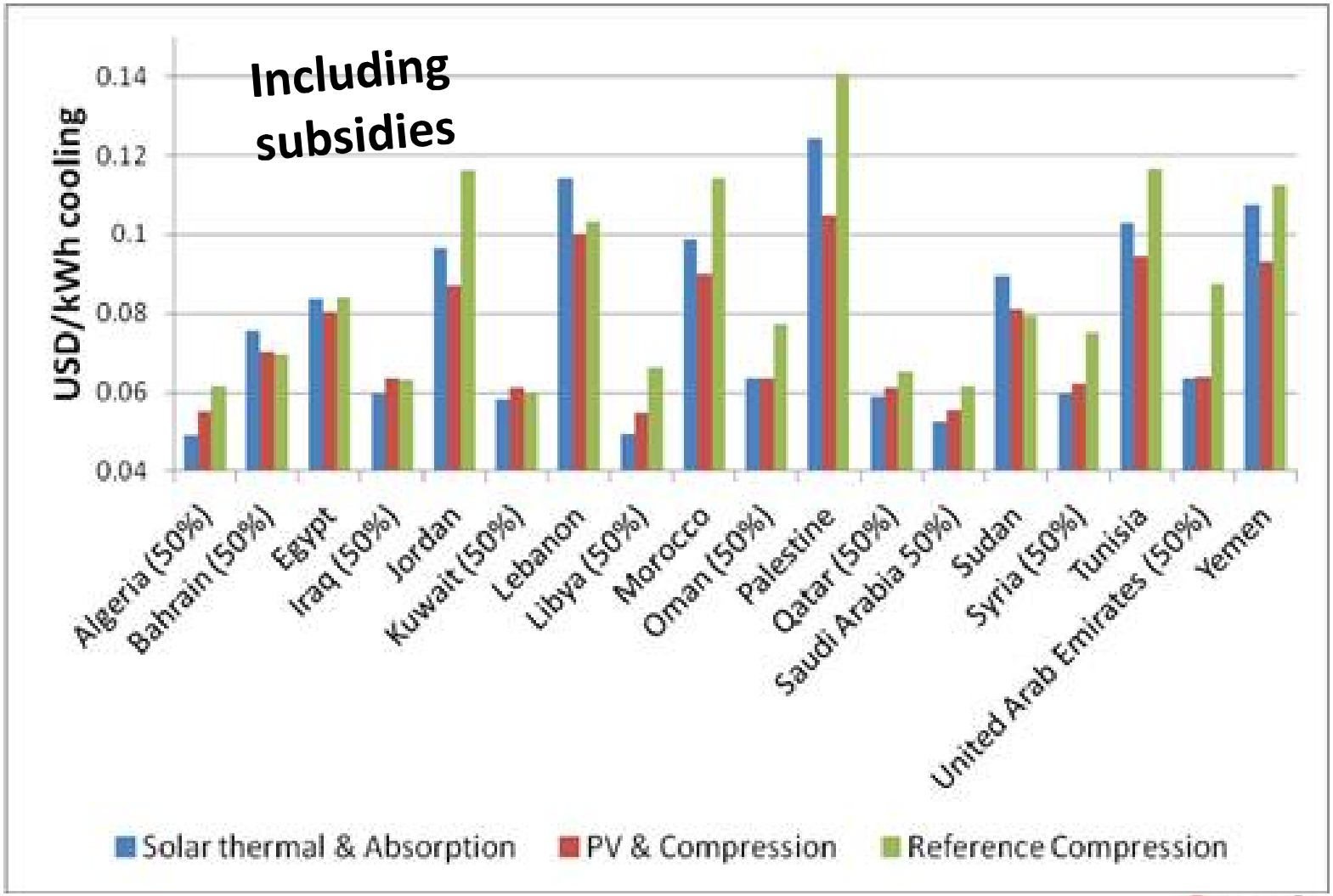
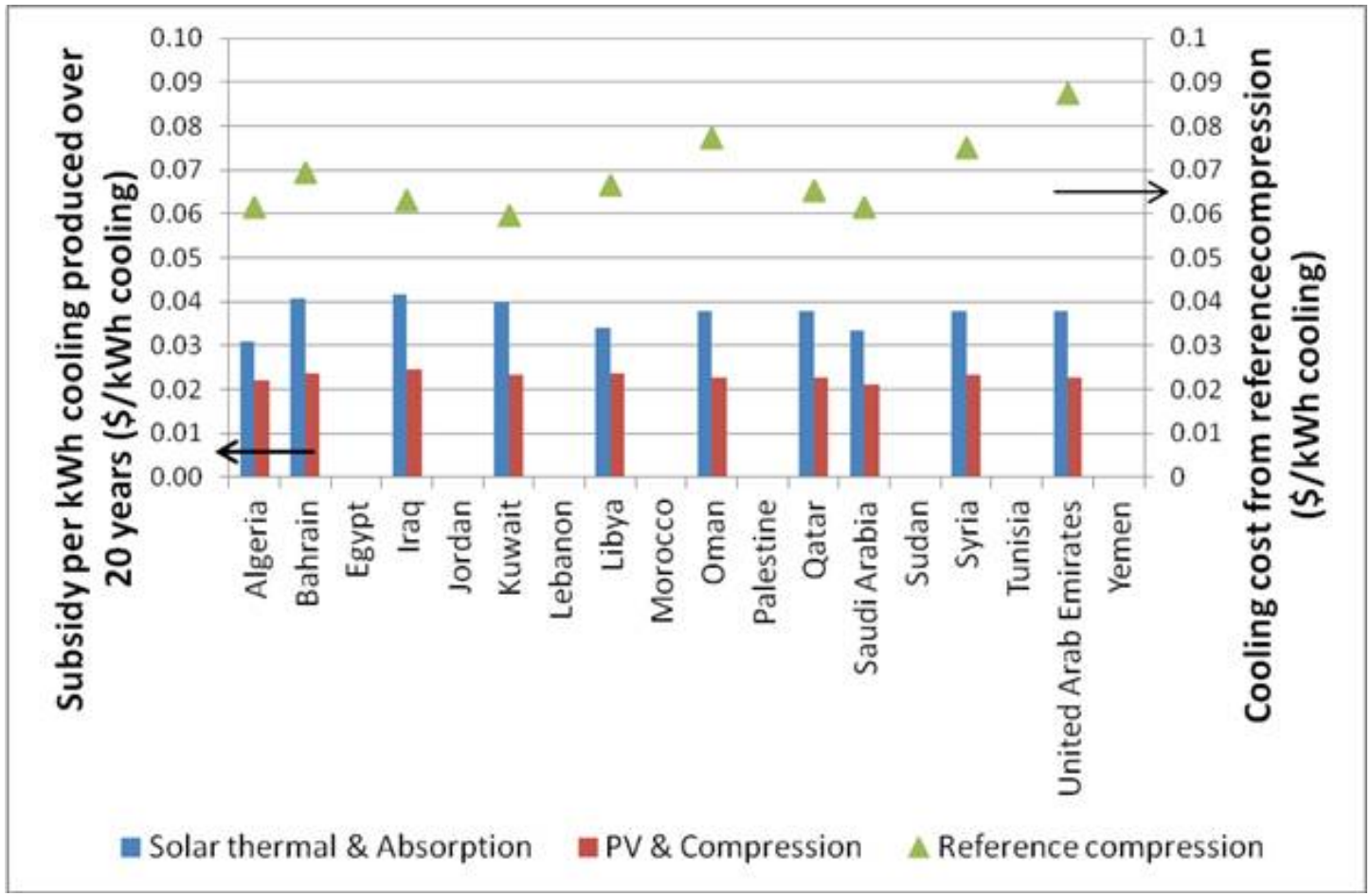


Economical analysis of the 100 kW cooling segment

Level of subsidy per unit of cooling production over 20 years & reference cooling cost for specific 12 countries



It is far cheaper to subsidized solar cooling than oil or gas cooling !

Conclusion for 100 kW cooling segment

Compensation of the **important implied subsidy** by a

≈ equivalent subsidy on the upfront cost of solar cooling.

If **50% grant** on the capital cost **to increase**

the attractiveness of the solar cooling systems

⇒ **In all the countries of Arab Region**

the kWh cooling is lower over 20 years with solar cooling

than with a conventional system.

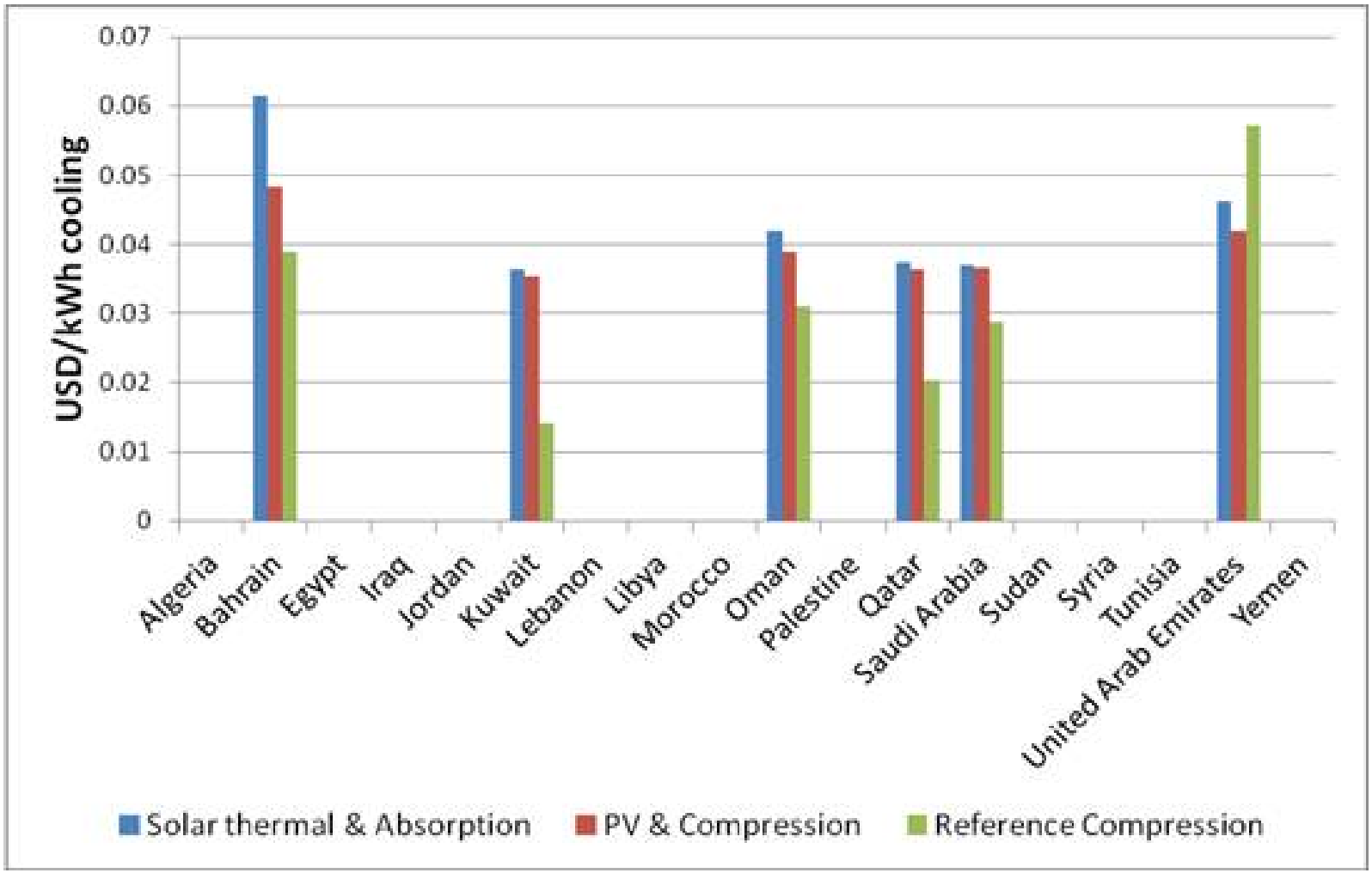
Conclusion for 100 kW cooling segment

Egypt, Jordan, Morocco, Palestine, Tunisia and Yemen, where **the cost of solar cooling energy** is **lower over 20 years than for conventional cooling.**

In all cases, **the PV Cooling solution is more competitive than the solar thermal one**

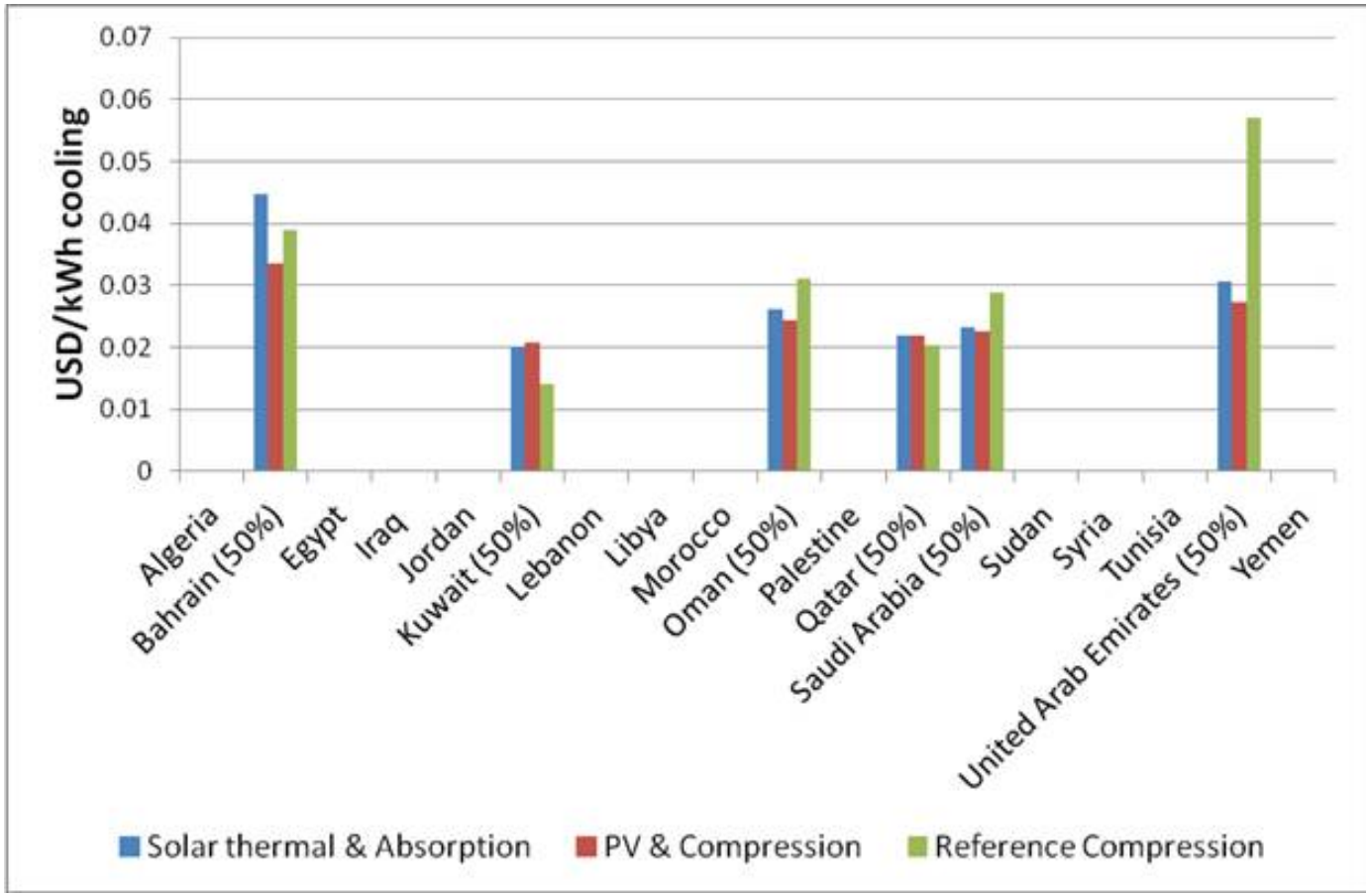
Economical analysis of the 1 MW cooling segment

Levelized cost of cooling energy (without subsidies)



Economical analysis of the 1 MW cooling segment

Levelized cost of cooling energy (including subsidies)



Very Large production of solar thermal cooling is TODAY cost competitive if considered as a long term investment!

Conclusion for 1 MW cooling segment

In the UAE, solar thermal and solar PV Cooling already more interesting than the reference system over 20 years.

In the other countries and especially in **Kuwait, Qatar and Saudi Arabia,** solar thermal and solar PV cooling solutions are very **close** in term of **NPC** and **more interesting** than the **reference system over 20 years if a subsidy of 50%** is applied on the **investment cost** (≈ compensation of high level of implied subsidies of conventional cooling energy)**.**

Cost reduction potentials on solar cooling

(by 2020-2025)

Factor	Key indicator evolution *(difference between initial situation and new one)*	Cost reduction ratio *(reference : 2015, on investment)*
Sales scaling factor	x10 sales volume	15 to 30%
Size scaling factor	x10 system size from 100 kW_c to 1 MW_c	50 to 70%
Packaging factor	Solar cooling prefabrication (kits of less than 30 kW_c)	30 to 40%
Local company manufacturing factor	Manufacturing of the main components locally	5 to 10%
Technical innovations factor	Arab region adapted solar production	10 to 30% on Net Present Cost
	Heat rejection	
	Cooling storage	

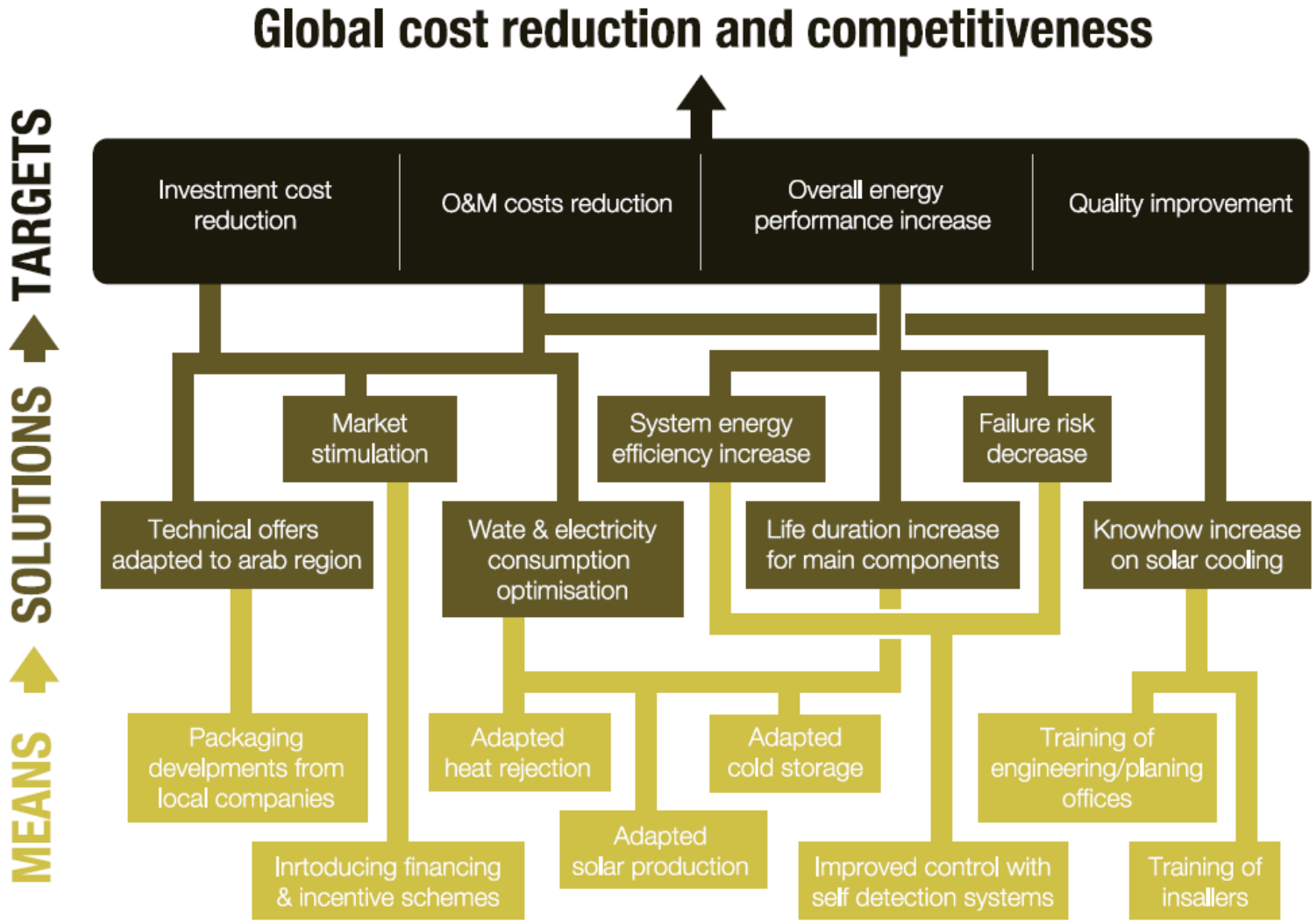
Significant cost reduction potential thanks to R&D !

Budget proposal for R&D and demo program

Total budget required for the proposed R&D and demonstration programs : **≈ 4.5 million USD to develop solar cooling for Arab region**:

- **Adapted heat rejection** (1.0-1.5 million USD R&D program)
- **Adaption of existing products/kits to Arab region** (1.0 million USD R&D program)
- **Adapted storage** (0.5-1.0 million USD R&D program)
- **Two 100 kW PV Cooling demo systems** (approx. 200.000 USD funding for one project)
- **Two 1 MW Solar thermal cooling demo systems** (approx. 600.000 USD funding for one project)

Solar Cooling Roadmap proposal



Conclusions

* It is time for solar cooling !

* Innovation must mix International and arabic countries expertise

* Next steps in 2017-2018 :
  - International collaborations (EU, IEA, UNEP, ..)
  - Mission Innovation?
  - R&D programs
  - Demonstrations projects

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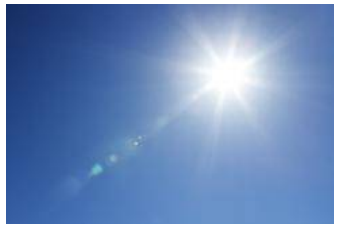
Thanks for your attention !



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