Experimental Study on Performance of Solar Thermal Driven Cooling System Versus a Hybrid Mechanical Compression Refrigeration-Solar Thermal Assisted System in Hot Areas

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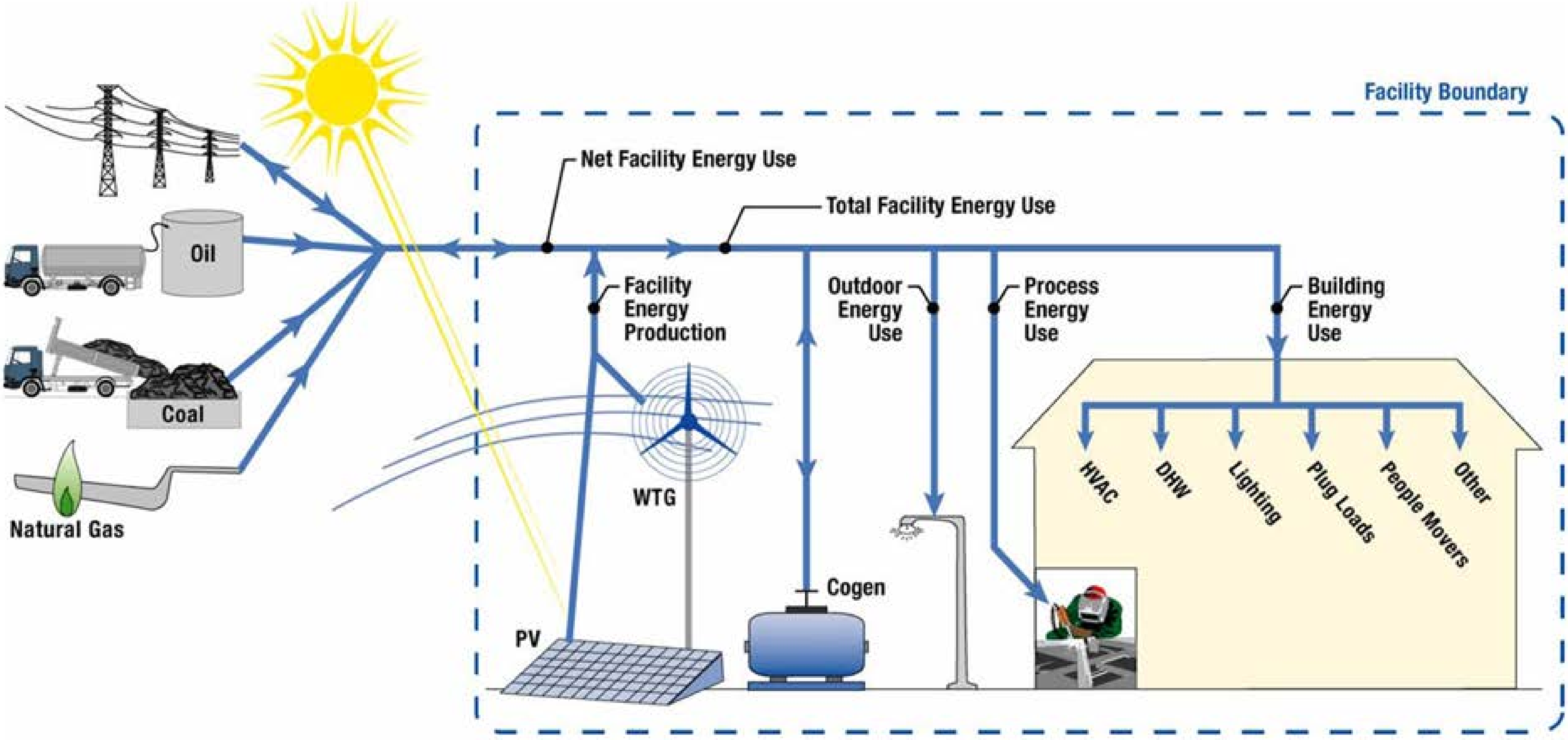

Energy flow diagram providing an overview of this procedure

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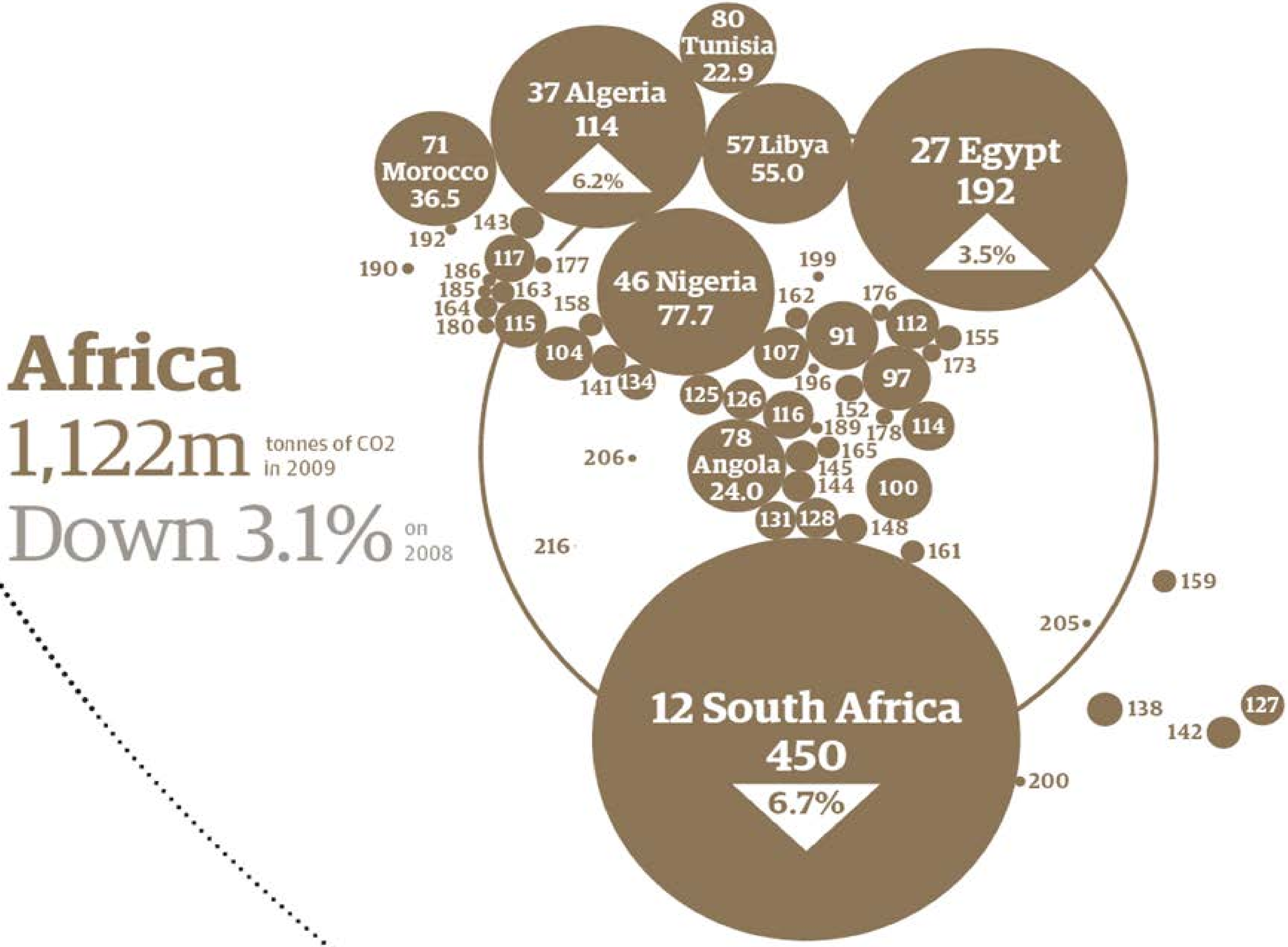

http://www.ecoclimax.com/2017/02/an-atlas-of-pollution-world-in-carbon.html

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Table 3.1 Properties of refrigerants

Refrigerant	Composition	Application	GWP (CO_2 = 1)	Safety class	Boiling point °C	Vapour pressure at 50°C (dew) bar (abs)
HCFC						
R22	$CHClF_2$	HT, MT	1810	A1	−41	19.4
HFCs chlorine free						
R134a	CF_3CH_2F	HT, MT	1430	A1	−26	13.2
R125	CF_3CHF_2	Blends	3500	A1	−48	25.5
R143a	CF_3CHF_3	Blends	4470	A2	−48	23.2
R32	CH_2F_2	HT	675	A2L	−52	31.5
R404A	R143a/125/134a	LT	3922	A1	−47	23.0
R407C	R32/125/134a	HT	1774	A1	−44	19.8
R410A	R32/125	HT	2088	A1	−51	30.5
Other R32 Blends	R32 + HFCs	LT	1770–2280	A1	−46 to −48	21 to 23
Other R125 Blends	R125 + HFCs	HT, MT, LT	1830–3300	A1	−43 to −48	18 to 25
HFOs						
R1234yf	$CH_2 = CFCF_3$	MAC, HT	4	A2L	−29	13.0
R1234ze[E]	CHF = CHCF3	HT	6	A2L	−19	10.0
HFO/HFC Blends	R1234yf/134a, R1234ze[E]/R134a	Various	600–1500	A1	−20 to −50	Various

(Continued)

R290	C_3H_8 Propane	HT, MT	3	A3	−42	17.1
R1270	C_3H_6 Propylene	LT	3	A3	−48	20.6
R600a	C_4H_{10} IsoButane	MT	3	A3	−12	6.8
R290 Blends	R290 + HCs	HT, LT, MT	3	A3	−30 to −48	10 to 18
Other halogen free						
R717	NH_3 Ammonia	LT (MT, HT)	0	B2	−33	20.3
R744	CO_2 Carbon Dioxide	HT, MT, LT	1	A1	−57*	74**

GWP according to IPCC IV, time horizon 100 y
Safety limit classification according to EN378-1
* Triple point (5.2 bar a)

Refrigerants ation, Air Conditioning and Heat Pumps

REFRIGERATION, AIR CONDITIONING AND HEAT PUMPS,
G F HUNDY, A R TROTT and T C WELCH

Fifth edition 2016

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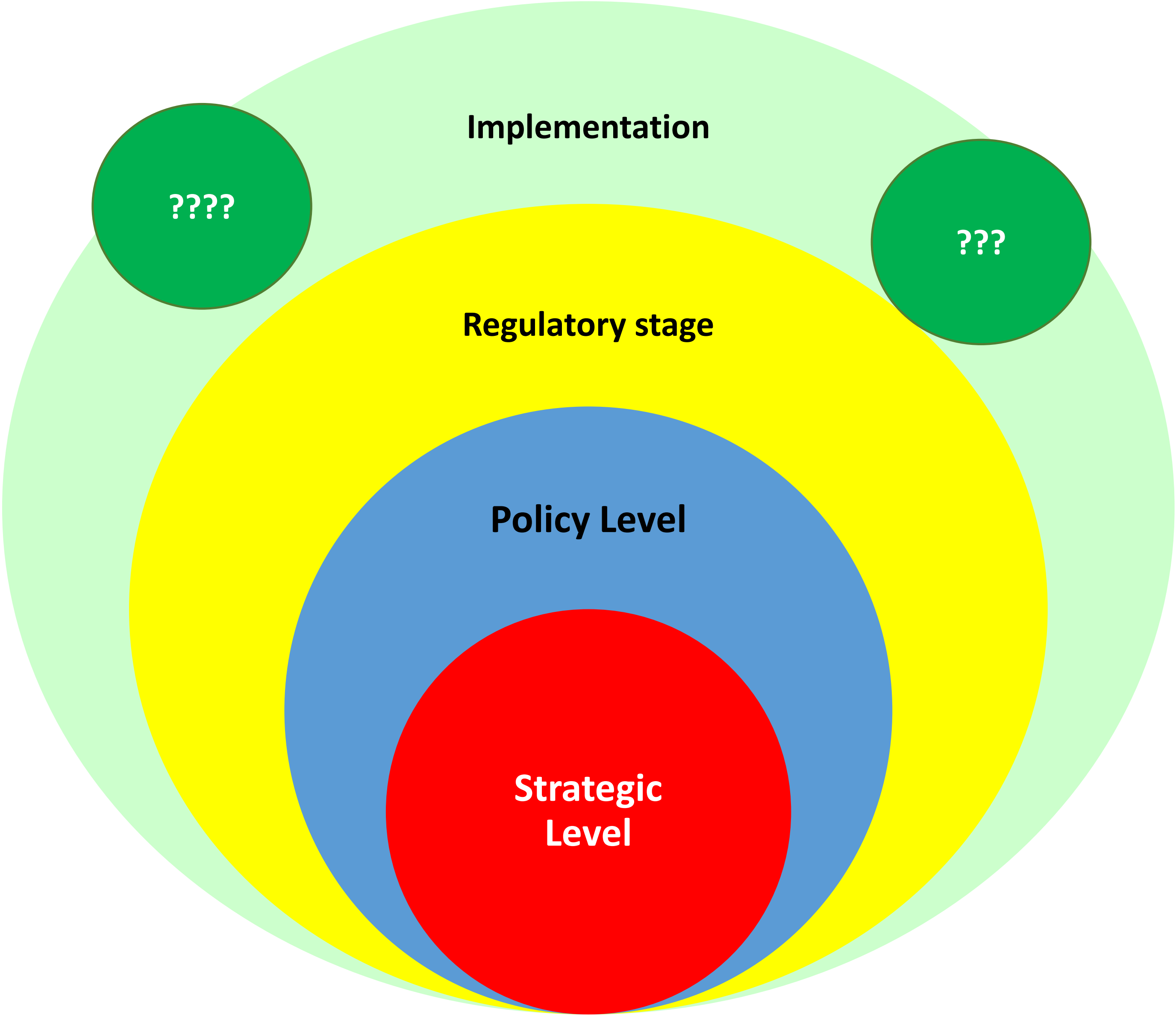
Energy planning with R&D



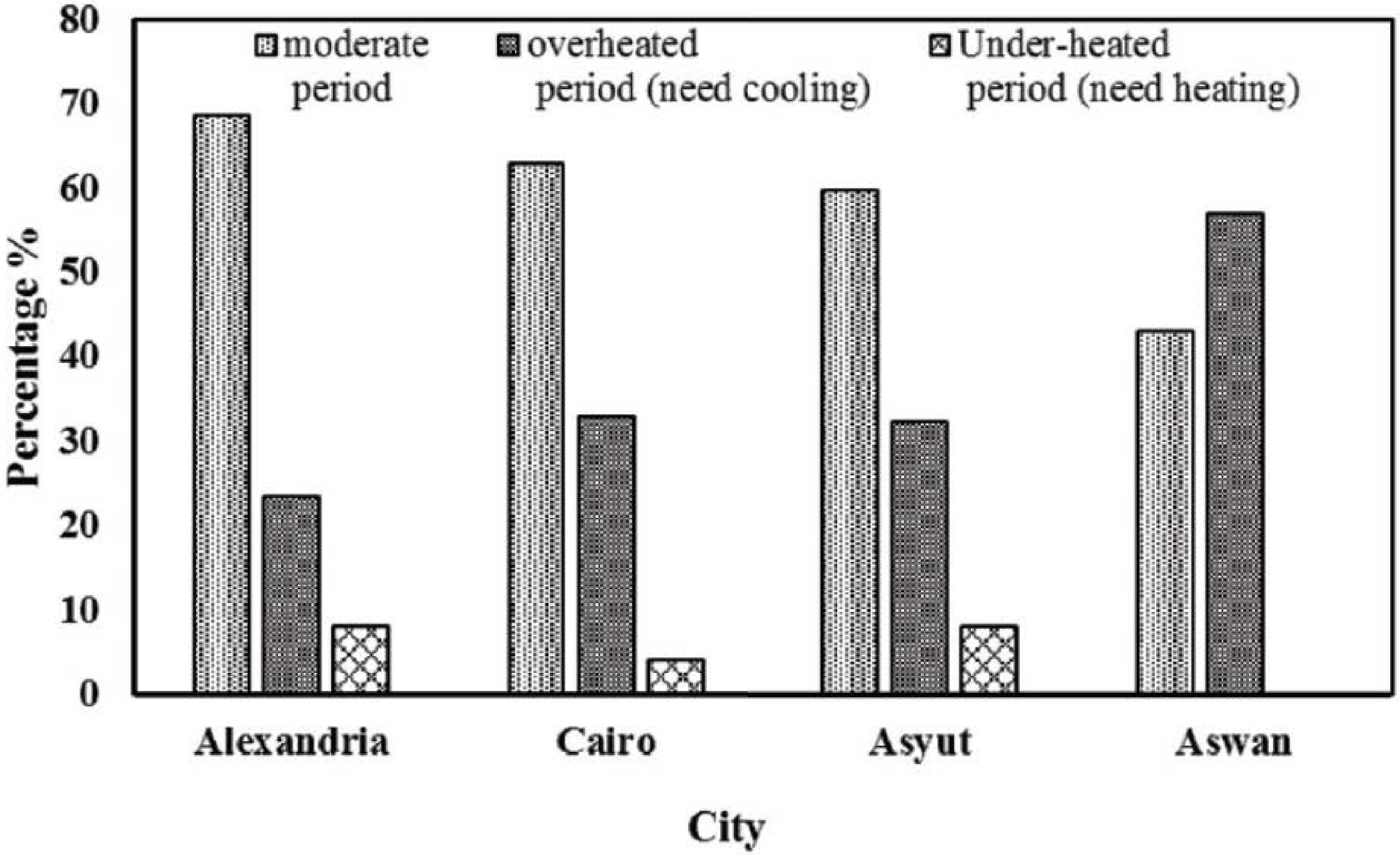


Figure 4-13 The percentages of thermal adaption within different climate regions

T_M = 45°C

High T lift

T_{indoor}= 25 °C

In hot arid countries, indoor cooling during summer time is essential.

Solar Cooling

GERF Project No. 621 (2012)

8 kW cooling capacity, 0.6 therm. COP

Solar panel

72°C in
65°C out

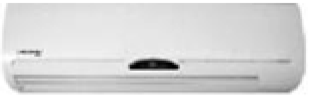
12°C out
14°C in

Residential Cooling

32°C out
27°C in

Heat-Rejection

VS.



Utility AC Power

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Criteria

- performance evaluation
- electrical energy consumption
- environmental benefits
- long-run costs

Residential Scale Solar thermal driven Cooling System in Assiut, Egypt

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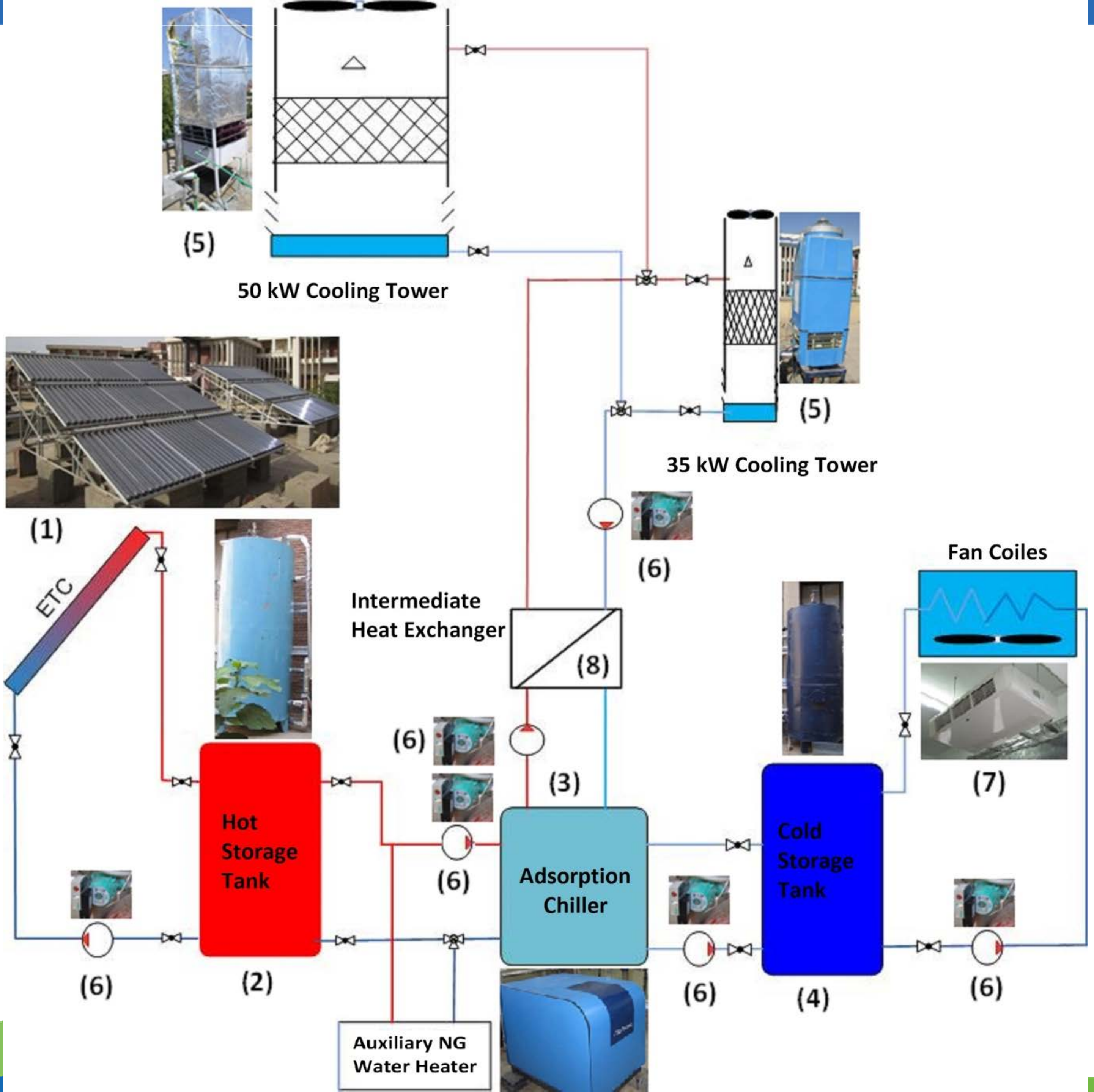
08/10/2011


08/10/2011



Hybrid schematic and photographs diagram of the main components of the solar cooling system: (1) collectors' field (2) hot water storage tank (3) adsorption chiller (4) cold water storage tank (5) cooling tower(s) (6) six-variable speed pumps (7) cooling load- fan coils and (8) intermediate heat exchanger.

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Performance of a small-scale solar-powered adsorption cooling system

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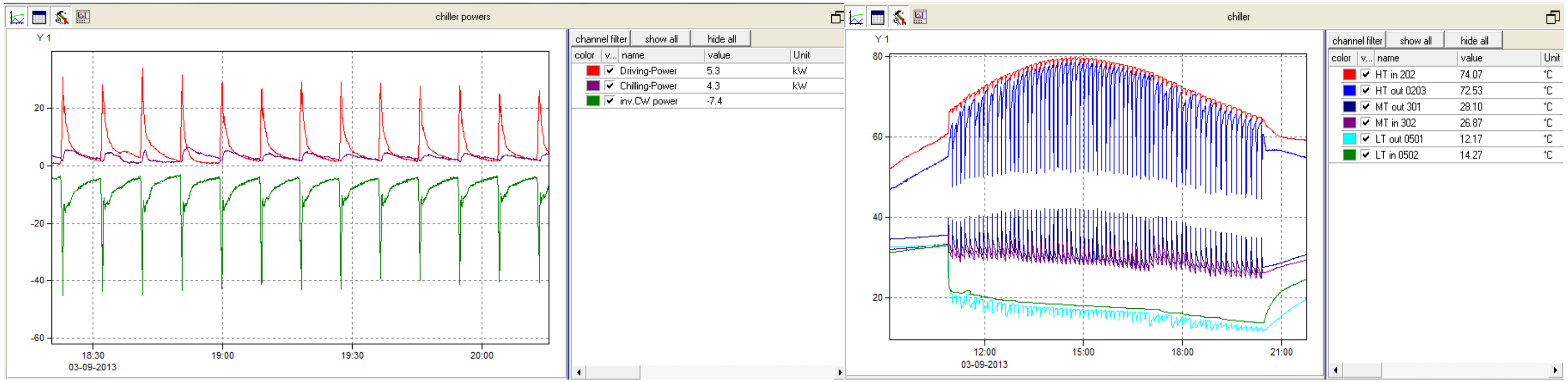

screen shot from the data logger for driving hot water temperature inlet and outlet from the chiller (HT), chiller cooling water temperature inlet and outlet from the chiller (MT) and chilled water temperature outlet and inlet to the chiller and (c) screen shot from the data logger for the chiller driving thermal power, chilling power and heat rejected power (CW power)

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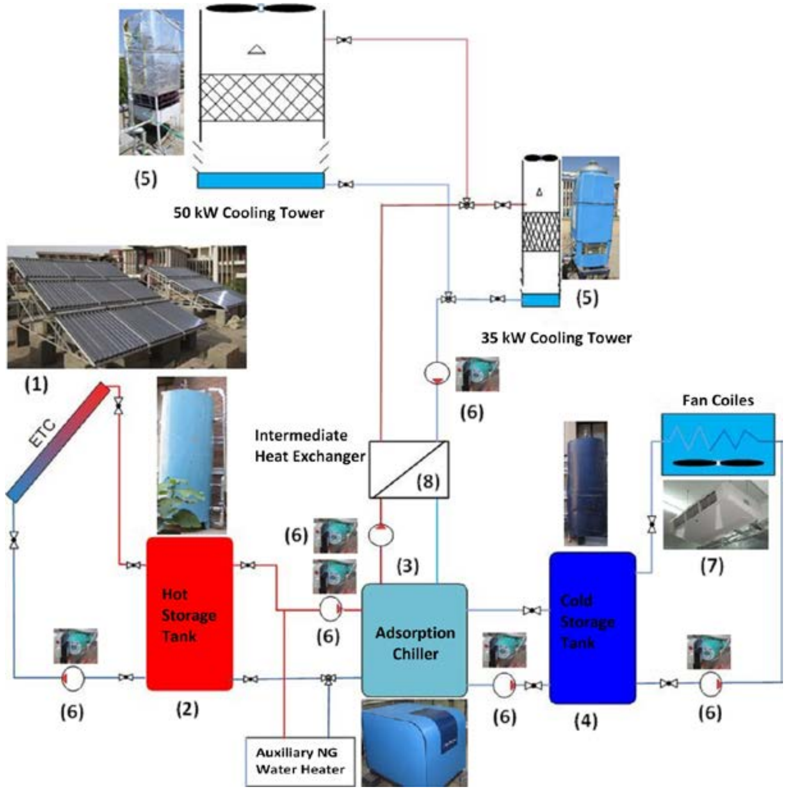
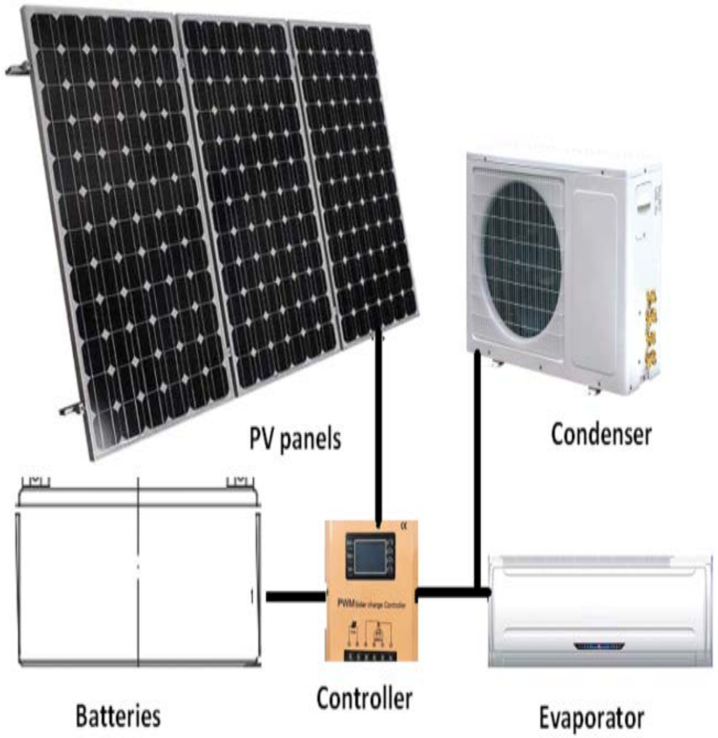


Solar thermal driven cooling system



Off-grid Photovoltaic driven DC air-conditioning system

vs.

Conventional AC driven grid connected air-conditioning system

Analysis between three residential scale A/C in hot arid areas cooling capacity 8 kW and 18 hours daily operation in the cooling session.

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Original article

Performance-cost and global warming assessments of two residential scale solar cooling systems versus a conventional one in hot arid areas

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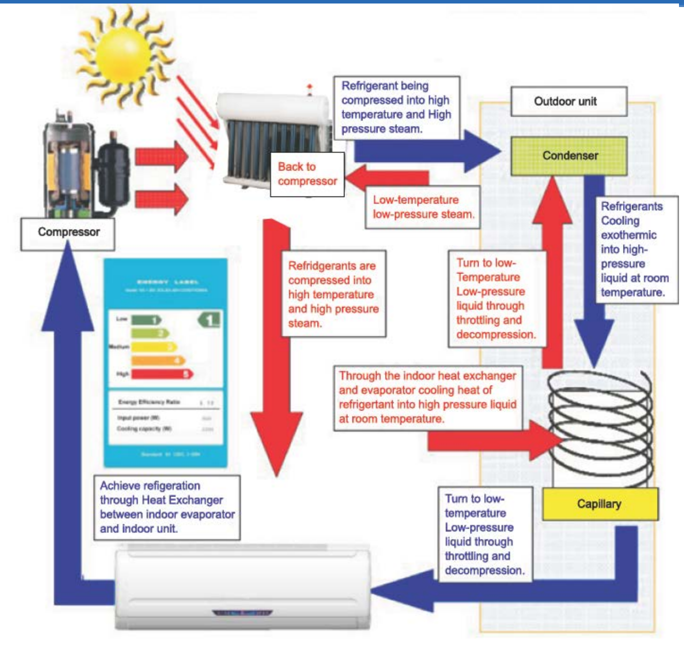
Main finding

System type	Grid required Energy Consumption in MWh	TEWI, equivalent Tons CO_2	Cost per kW cooling in US$
Solar Thermal Cooling System	79.5	45.6	8,790
Off-Grid PV Driven DC Air Conditioning System	0	2.7	1,630
Conventional Air Conditioning System	757.7	416.7	2,970

The results clearly indicate that: **compared with conventional vapor AC driven air-conditioning system,**

- **The solar thermal driven cooling system has an energy consumption of 10.94%, with TEWI of 9.96% and cost per kW cooling higher by 295.96%.**
- **While, the off grid PV driven DC air conditioning system has an energy consumption of 0%, with TEWI of 0.648% and cost per kW cooling less by 54.88%.**



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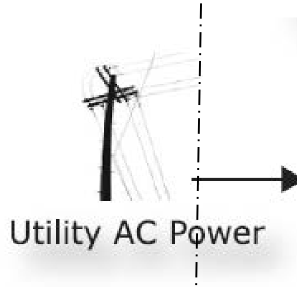

Solar assisted **vapor compression cooling systems**

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Energy Saving

Product	Btu	Cooling	Power	EER	Saving Rate	Electricity	Electricity Saved (KWH)				
		(W)	(W)			(W/H)	1 h	1 Day / 10 h	1 Month	1 Year	5 Year
Normal LG 72GW A/C	24,000	7,200	2,900	2.50	/	2,900					
ULG 72GW Solar A/C	24,000	7,200	1,885	**3.82**	**35.00%**	1,885	1.02	10	305	3,705	18,524

According to the 2017 kWh price of 0. 62LE

Thus, for 1 years of operations the save 2,300 LE and payback period is 3.35 Years

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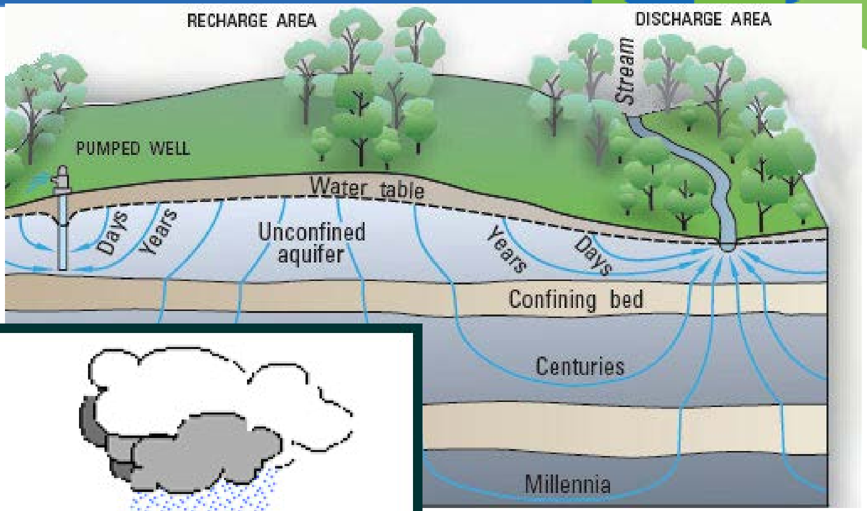
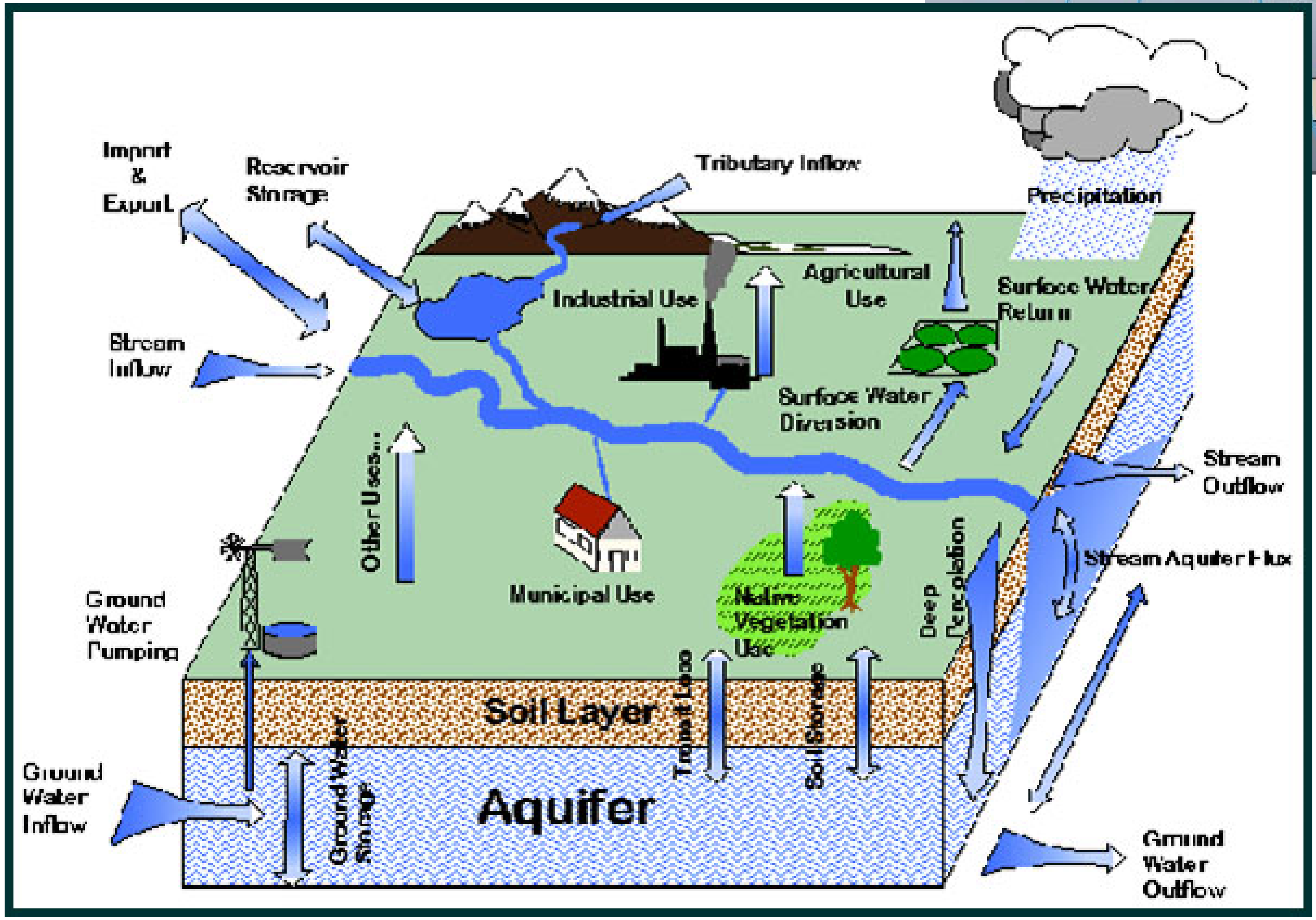
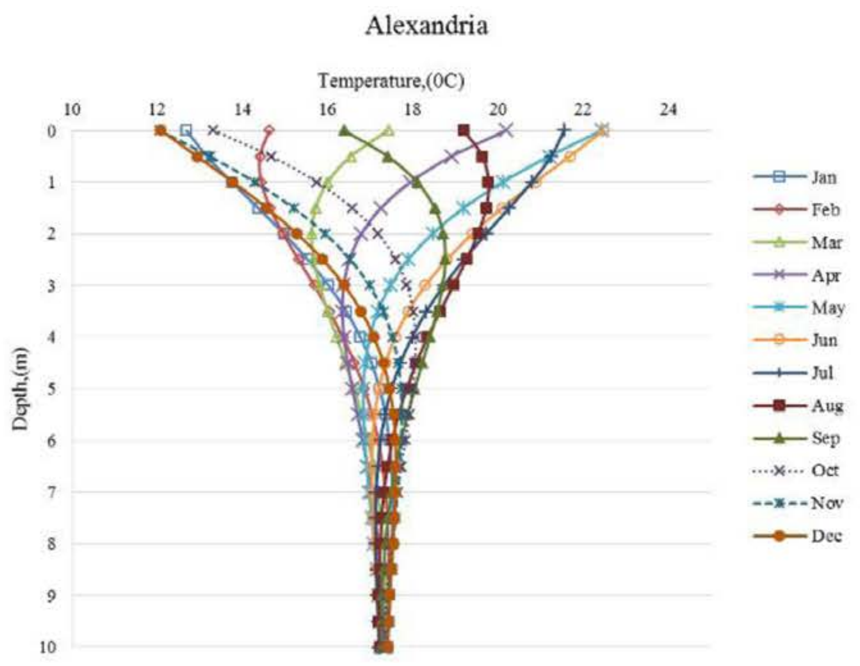
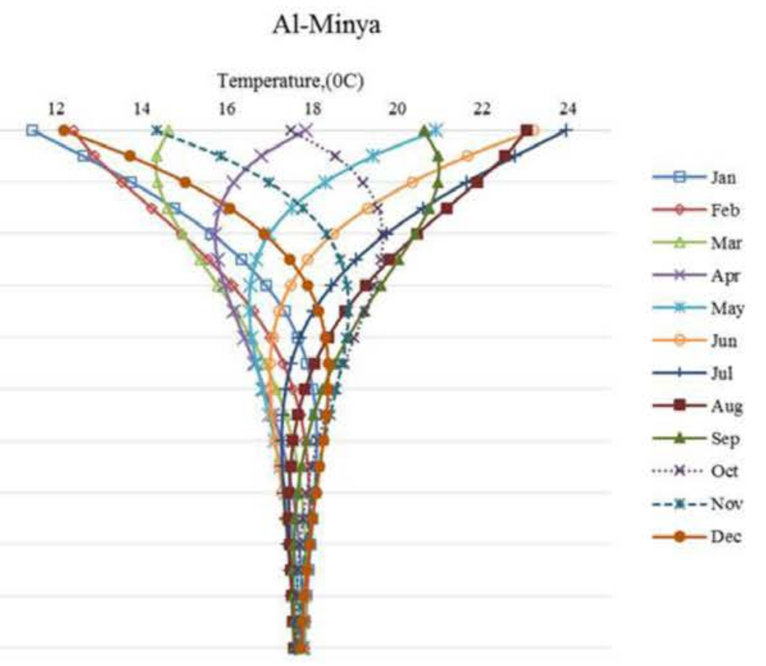
Ground water

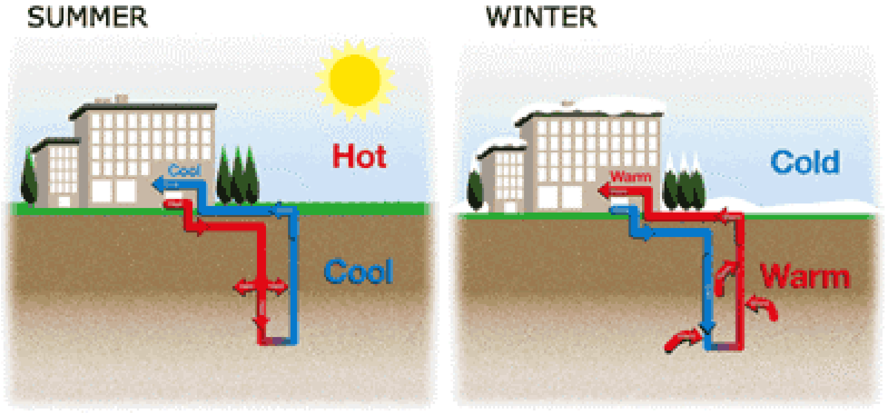


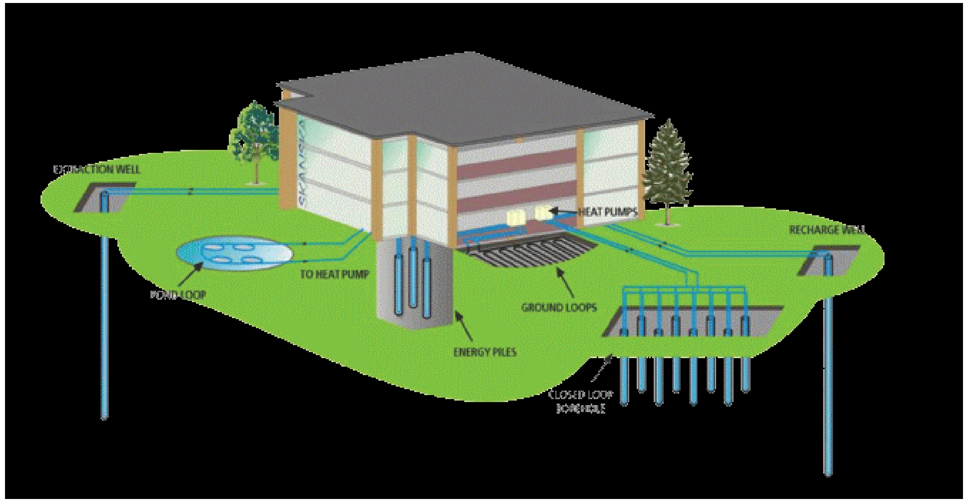


Under Ground Earth Heating and Cooling

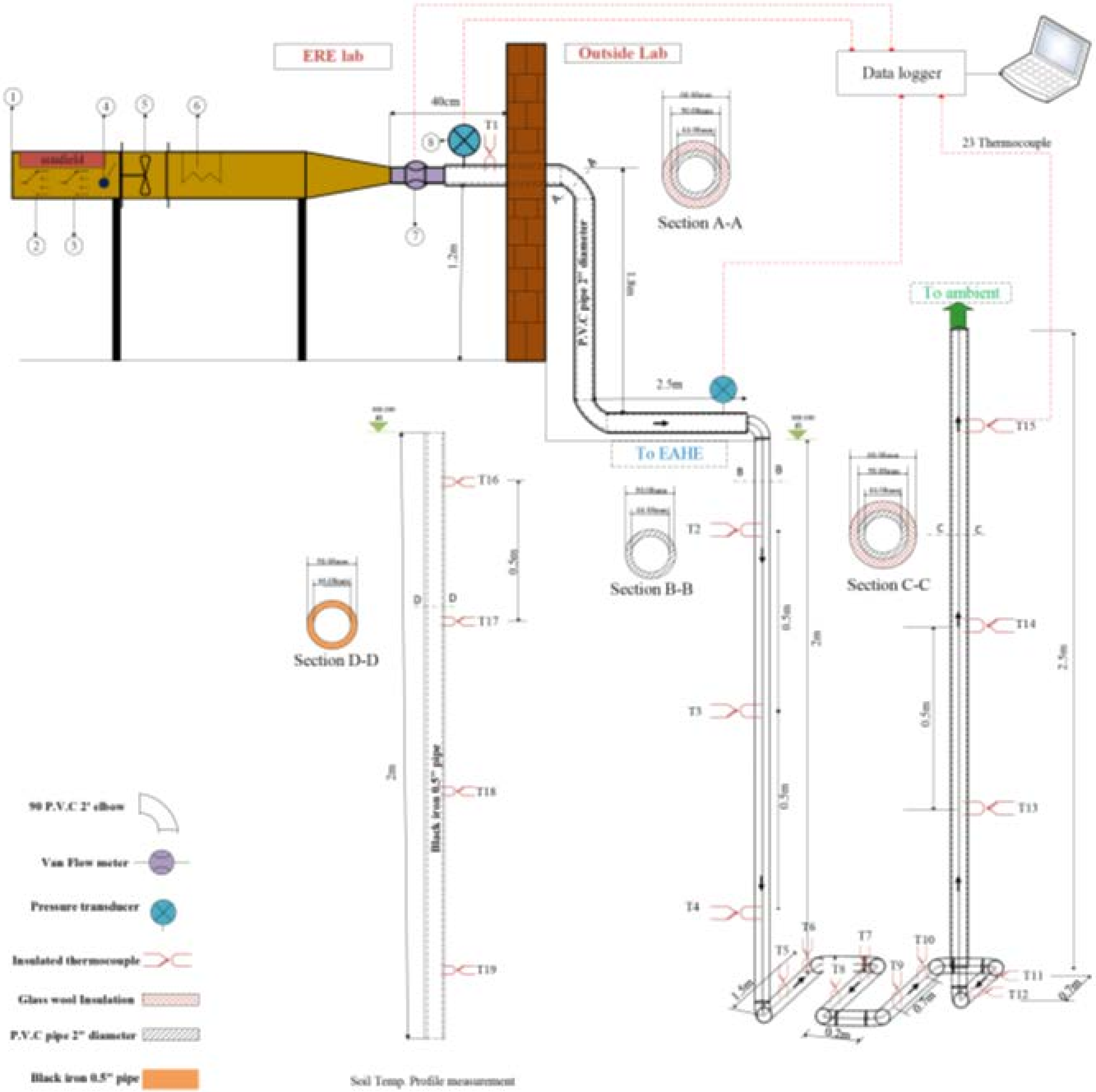








Experiment Setup



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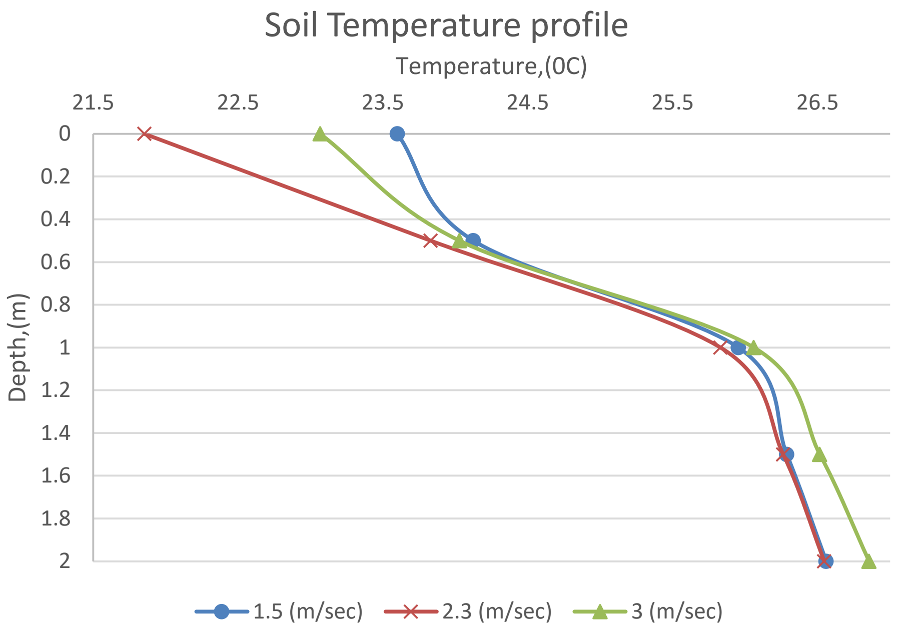
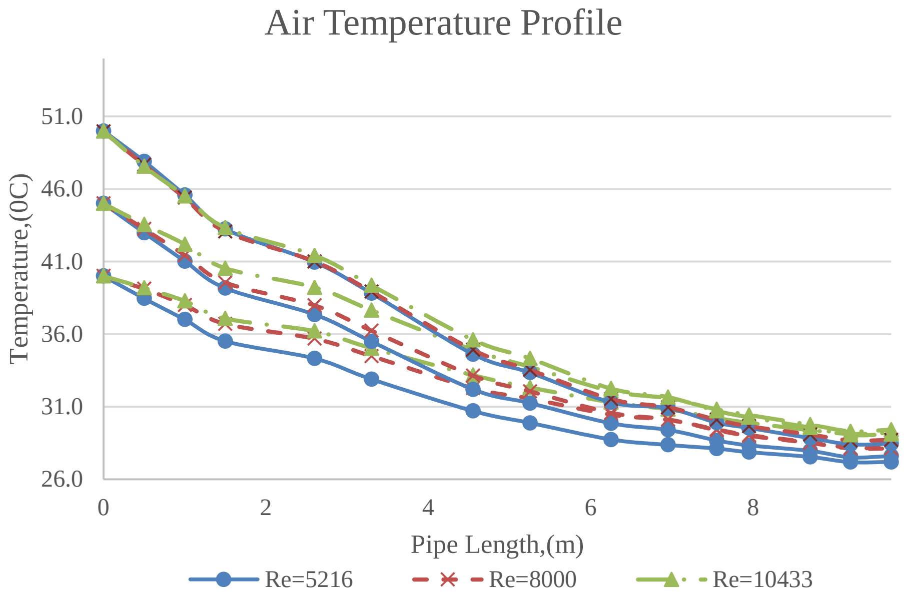
Results



Soil Temperature profile
Temperature,(0C)
21.5
22.5
23.5
24.5
25.5
26.5
Depth,(m)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1.5 (m/sec)
2.3 (m/sec)
3 (m/sec)



Air Temperature Profile
Temperature,(0C)
51.0
46.0
41.0
36.0
31.0
26.0
0
2
4
6
8
Pipe Length,(m)
Re=5216
Re=8000
Re=10433

Conclusions and gained experiences

However, among many others gained experiences the following are the main points to be considered:

- **As the heat rejection from the all system has the higher impact the performance parameters of the chiller in hot arid area, therefore, the re-cooling sub-system should be based on other alternative heat sink recourses techniques than the ambient air whenever is applicable.**

- **Underground earth cooling system is a good alternative heat sink recourses techniques than the ambient air whenever is applicable**

- **Many installed underground earth cooling and heating systems used for schools and other building in EU. Therefore, a joint project need to established and funded for prototyping performance, coast, environmental benefits for long run.**

Thank you

As researchers or practitioners what are the possible interactions/collaboration with practitioners resp. researchers to improve/upscale your activities

What are the potential aspects of the research that can be transformed into practice?

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