CENTROGULF
SUSTAINABLE ENERGY

FRESNEL COLLECTORS FOR SOLAR THERMAL COOLING APPLICATIONS

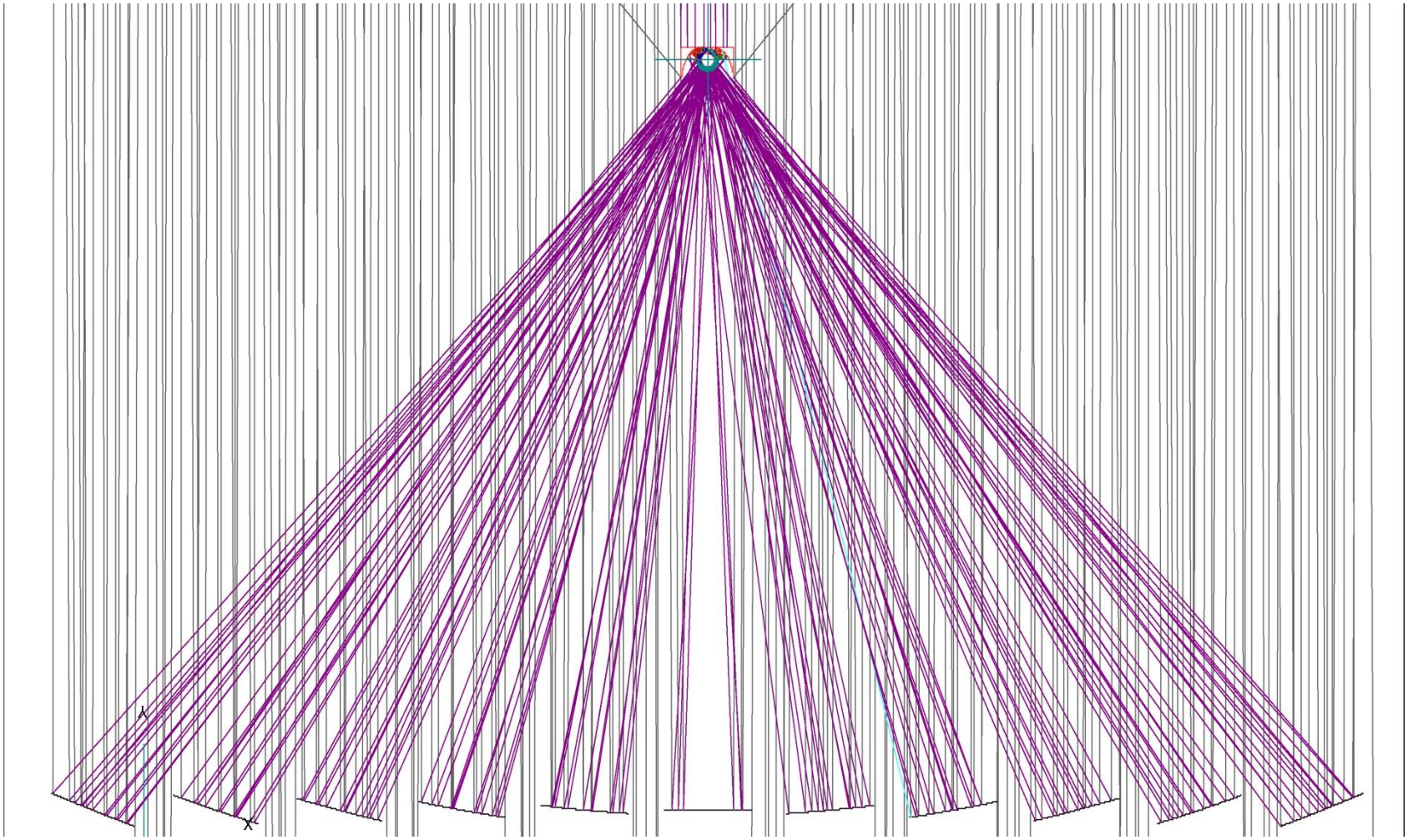
25 % of all daily news are about natural disasters, saving energy and the necessity of reducing our carbon footprint

HOWEVER:
WHAT WE ARE DOING IN REALITY?
DEFINITELY NOT ENOUGH!!!

Industrial Solar Fresnel collectors are designed to generate heat at 130 - 400 ° C

„Process Heat“

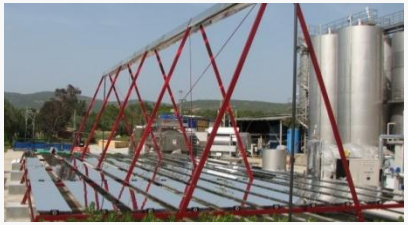
250 - 450 ° C	**Large PTC and Fresnel**	→ Utility scale power generation industrial process heat
130 - 220 ° C	**Small PTC and Fresnel**	→ Industrial process heat solar cooling commercial water heating distributed power generation
90 - 130 ° C	**Vacuum tube CPC collectors**	→ Solar cooling (single stage) Low temperature process heat
40 - 80 ° C	**Flat plate collectors**	→ Domestic water heating, space heating



HISTORY
FROM PSE TO MIROXX

Development since 1999	Pilot-Experience since 2005	Commercialization since 2007



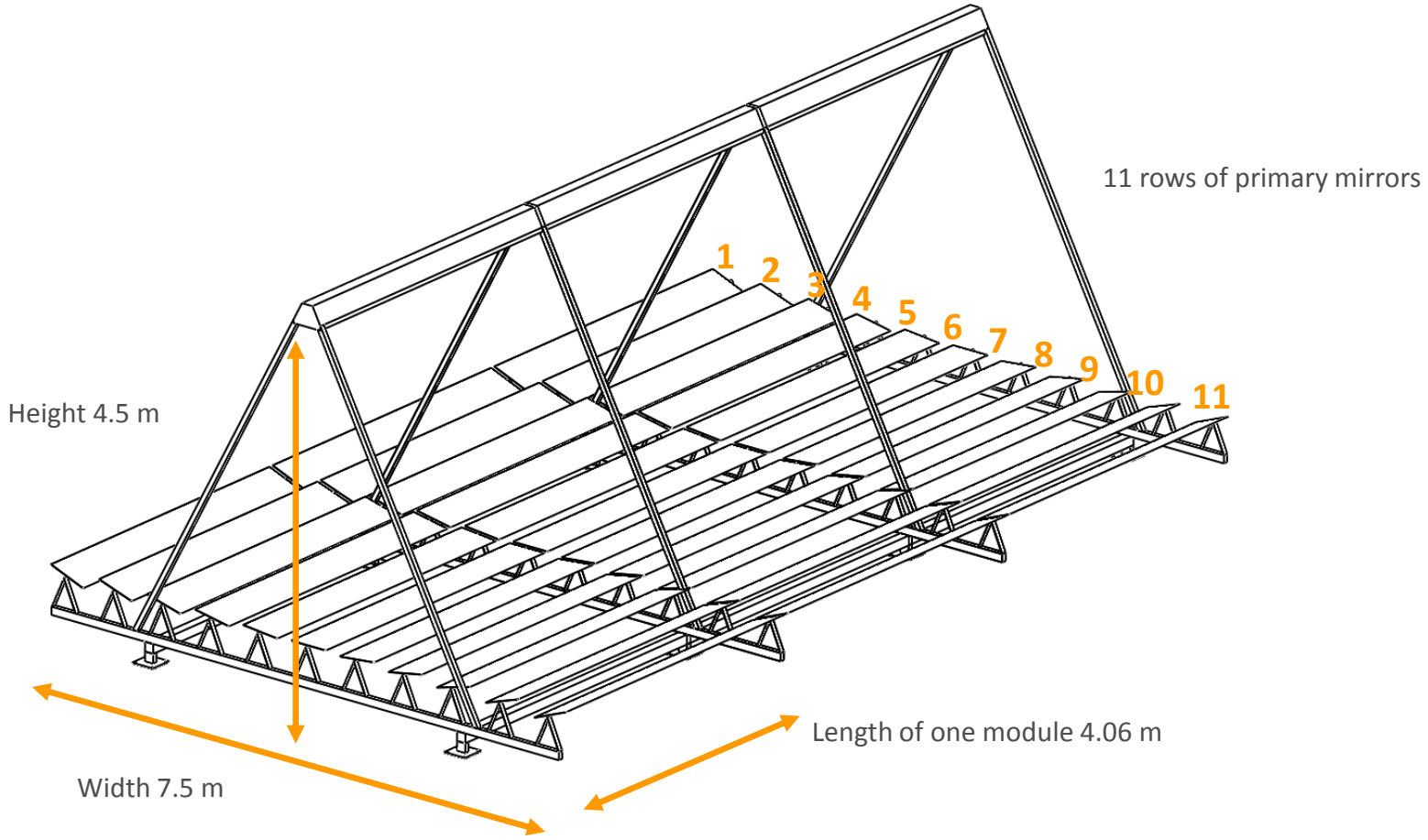



Set up of international subsidiaries, JVs and cooperations for

- Sales
- Installation
- Assembly
- Procurement

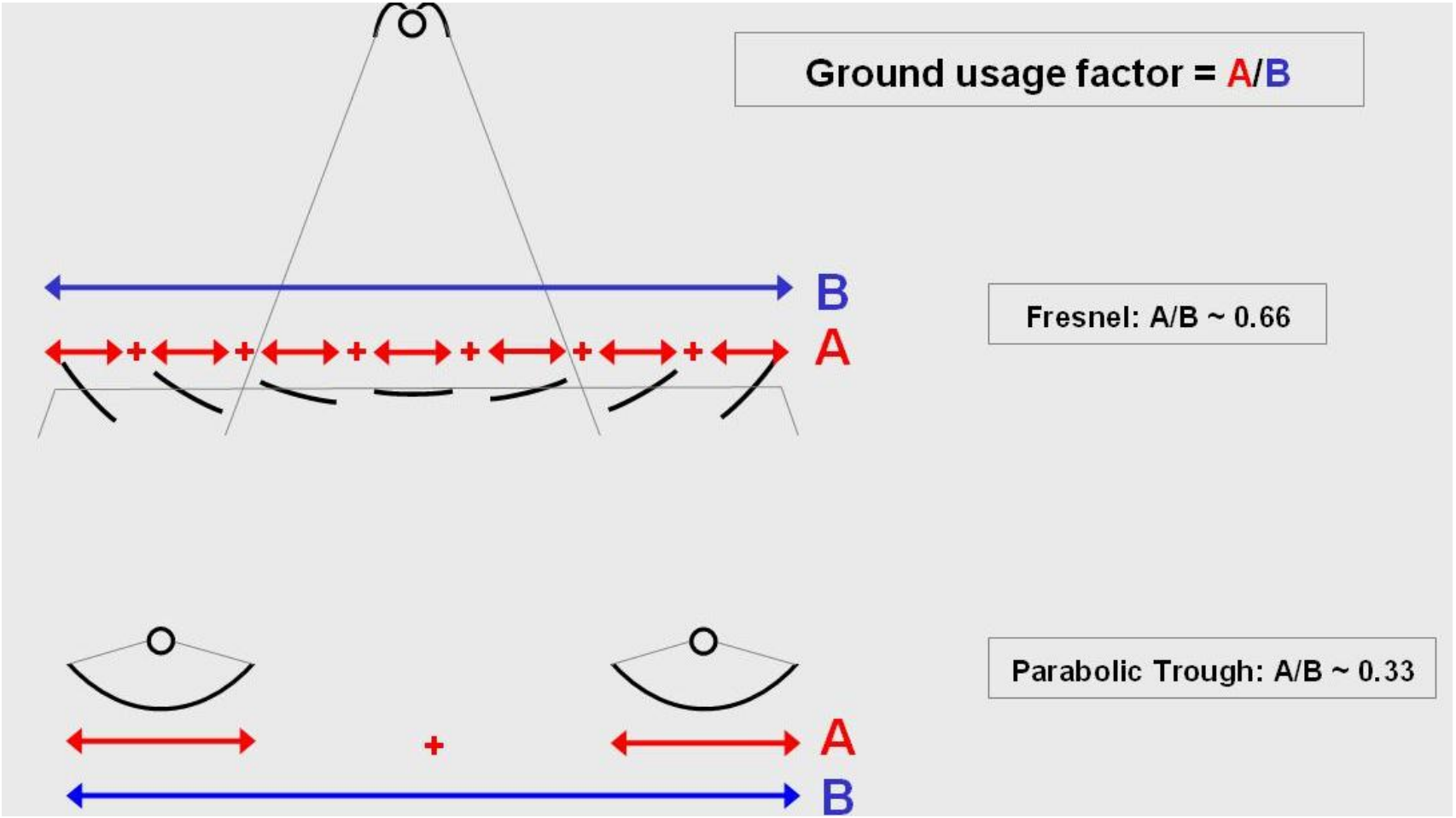
PSE AG

- Spin off from Fraunhofer ISE, Freiburg, founded 1999, staff 68
- CEO Dr. Andreas Häberle, member of ESTTP (European Solar Thermal Technology Panel), DSTTP (German Solar Thermal Technology Platform) and expert for European Commission on CSP related research
- Business units: Solar test stands, solar consulting, solar conferences
- Board: Prof. V. Wittwer, Prof. E. Weber, Prof. J. Luther


11 rows of primary mirrors
1
2
3
4
5
6
7
8
9
10
11
Height 4.5 m
Width 7.5 m
Length of one module 4.06 m

- Low wind load
- Good weight-spread
- High ground usage factor
- No north-south alignment necessary compared to non-concentrating collectors

→Best suited for rooftop installation


Ground usage factor = A/B
B
A
Fresnel: A/B ~ 0.66
A
B
Parabolic Trough: A/B ~ 0.33

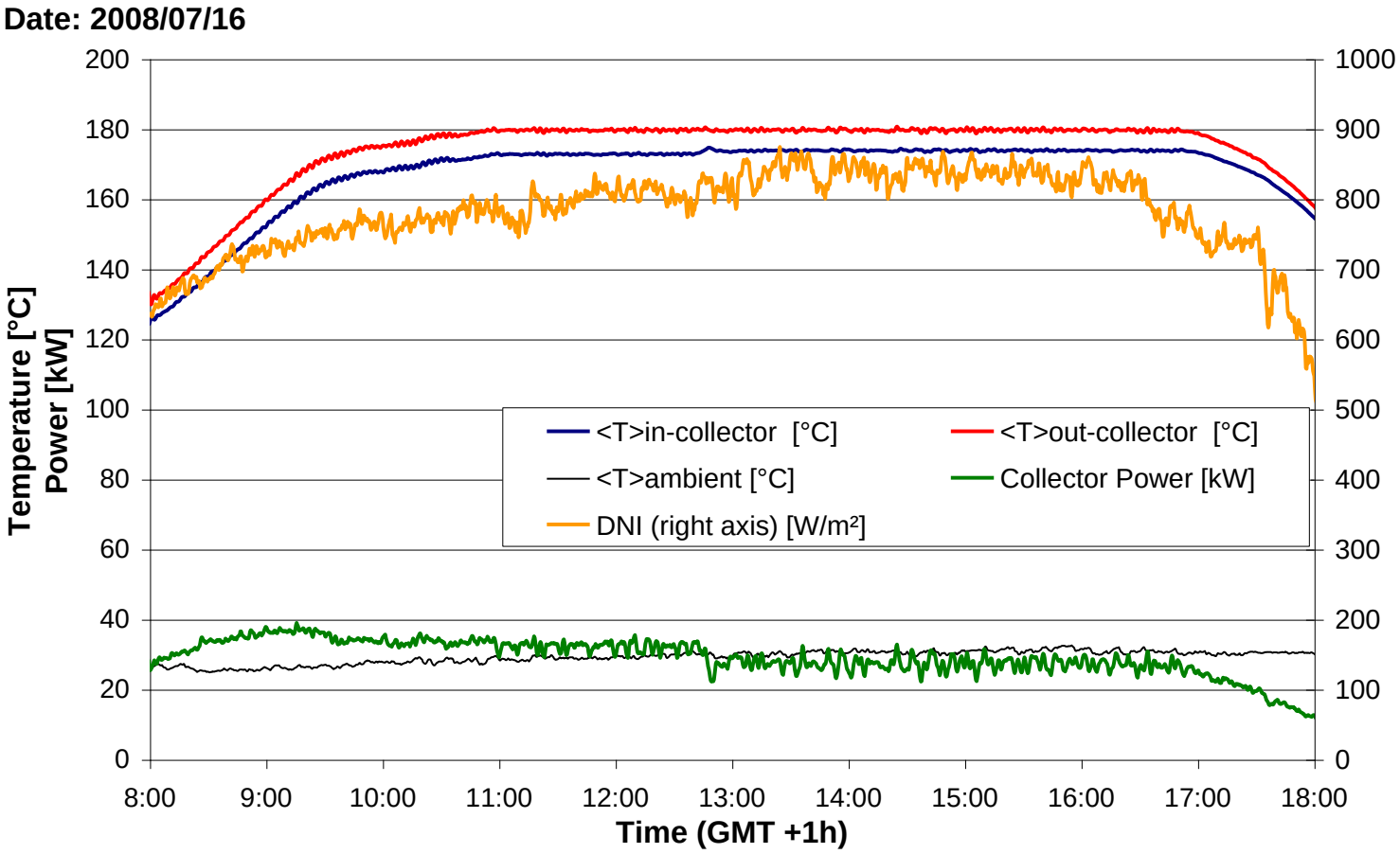
ADVANTAGES I
FRESNEL VS. PARABOLIC SMALL SIZE

THERMAL	FRESNEL	PTC	FRESNEL VS. PTC
PEAK POWER	GROUND AREA	GROUND AREA	GROUND USAGE FACTOR RATIO
88 kW_{th}	264 m^2	458 m^2	1,73
176 kW_{th}	528 m^2	869 m^2	1,65
500 kW_{th}	1.500 m^2	2.462 m^2	1,64
1.0 MW_{th}	3.000 m^2	4.923 m^2	1,64
10.0 MW_{th}	30.000 m^2	48.574 m^2	1,62

ADVANTAGES II

- Primary mirrors made of flat glass vs. aluminum (durability, reflectivity)
- Precise temperature and power control
- Less absorber tube per m² allows high quality 70 mm vacuum absorber tube (industrial standard)
- Remote control and monitoring via
  LAN and internet

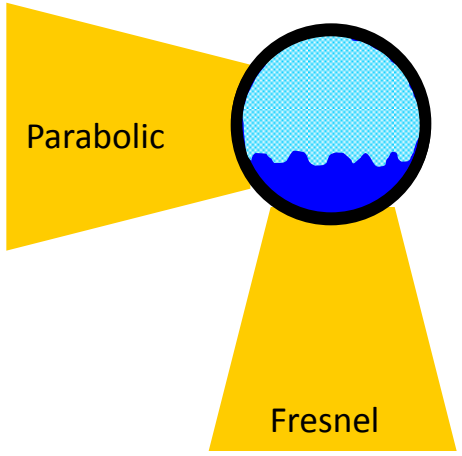
→ Meets industry requirements



→ **Precise temperature control**

ADVANTAGES III

- Stationary receiver, no twisting of flexible connections
- Concentrated sunlight hits absorber tube always from below



→Best suited for direct steam generation

ADVANTAGES IV

- Easy cleaning (flat glass/ good access)
- Low water demand for cleaning
- Reliable components

→Low O&M

SUMMARY ADVANTAGES

- Low wind load
- Good weight-spread
- High ground usage factor
- No north-south alignment necessary

Rooftop installation

- Primary mirrors made of flat glass vs. aluminum (durability, reflectivity)
- Precise temperature and power control
- Less absorber tube per m² allows high quality 70 mm vacuum absorber tube (industrial standard)
- Remote control and monitoring via LAN and internet

Industry

- Stationary receiver, no flexivle connections
- Concentrated sunlight hits absorber tube always from below

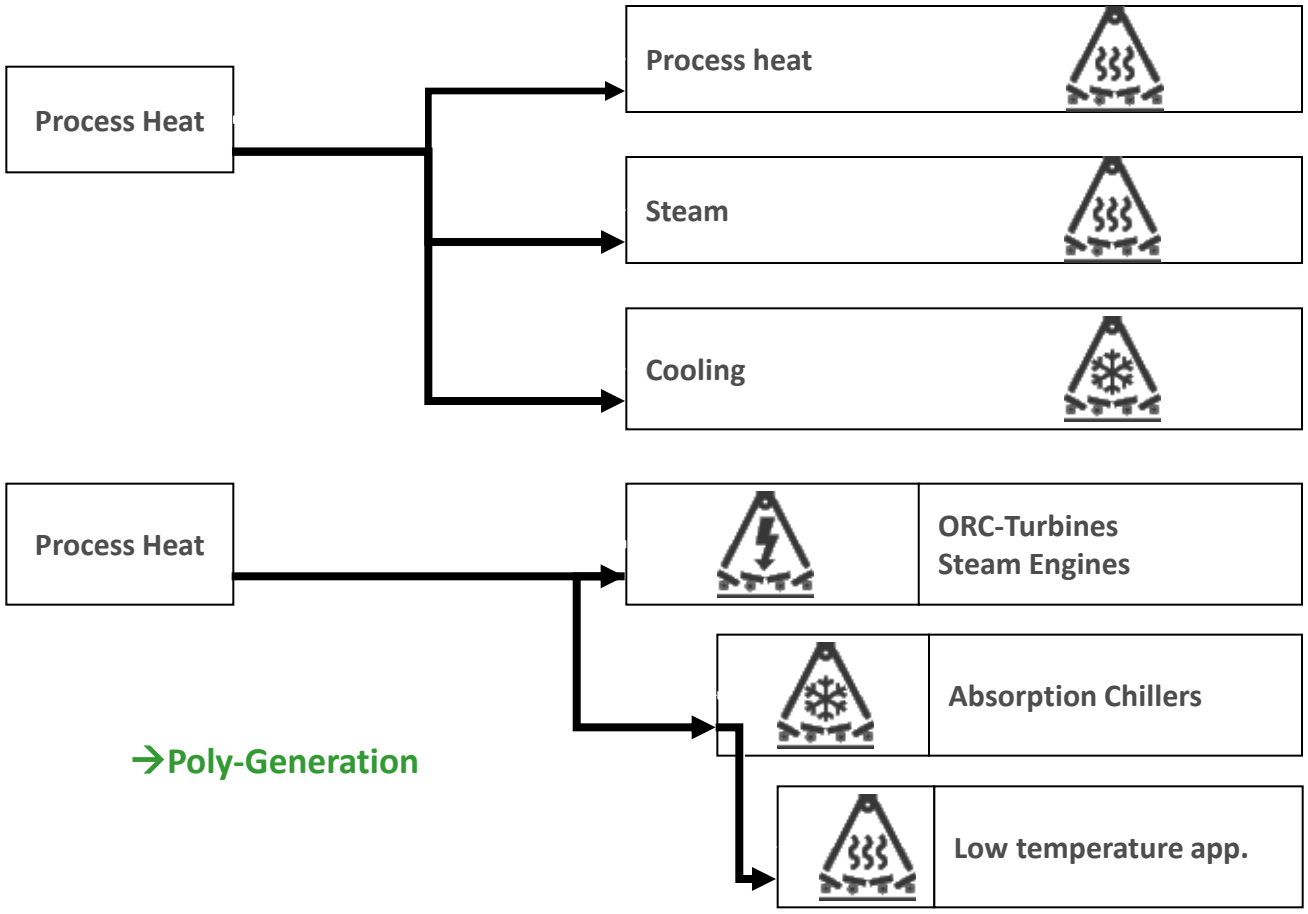
Steam

- Easy cleaning (flat glass / good access)
- Low water demand for cleaning
- Reliable components (mirror/tube/drives)

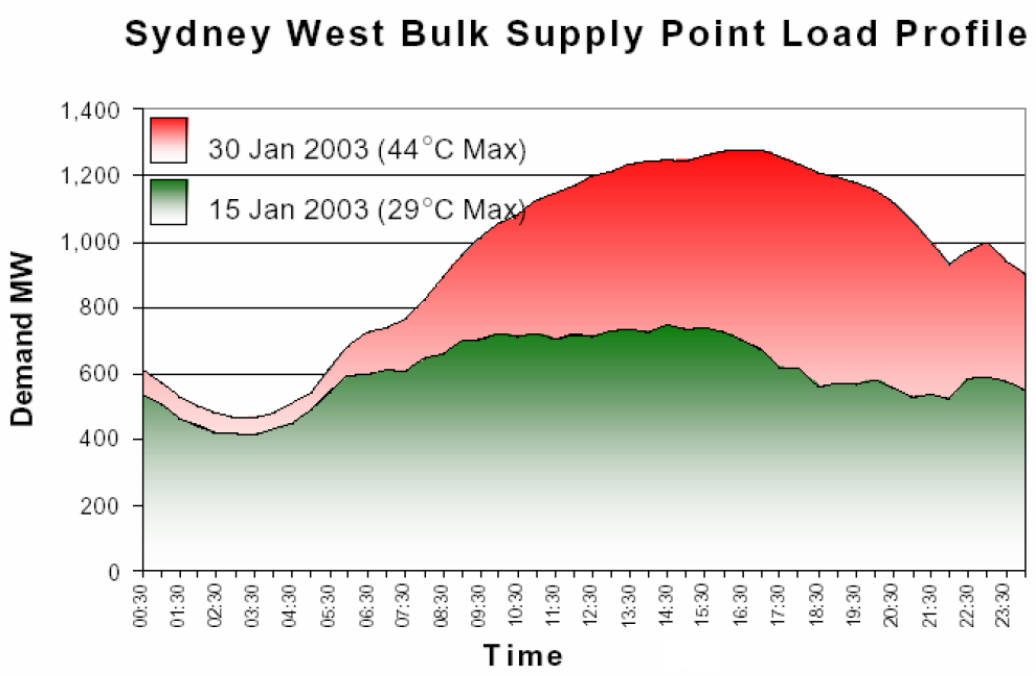
Low O&M

- Heat transfer fluid
  - Pressurized water
  - Steam
  - Thermal oil

- Receiver SCHOTT PTR® 70
  - Maximum pressure
    up to **120 bar** (different versions 40, 60, 120 bar)
  - Maximum temperature
    up to **380 ° C with thermal oil**
    up to **330 ° C with saturated steam or pressurized water**
  - Thermal loss per m² of primary reflector
    u1 = 0.00043 W/(m²K²) (according to DLR)


Process Heat
Process heat
Steam
Cooling
Process Heat
ORC-Turbines
Steam Engines
Absorption Chillers
Low temperature app.
→Poly-Generation

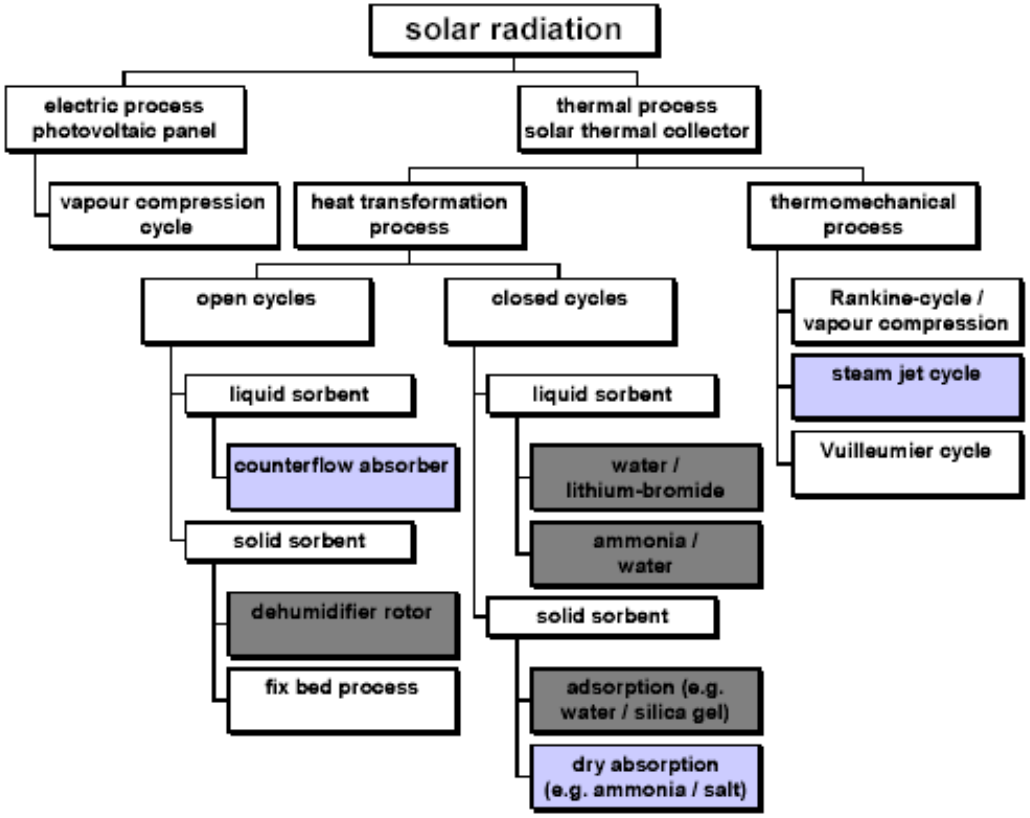
- Peak load of electricity is already determined by air-conditioning demand in some areas
- At the same time, high solar gains may be utilised



Source: Fraunhofer ISE

MOTIVATION FOR SOLAR COOLING

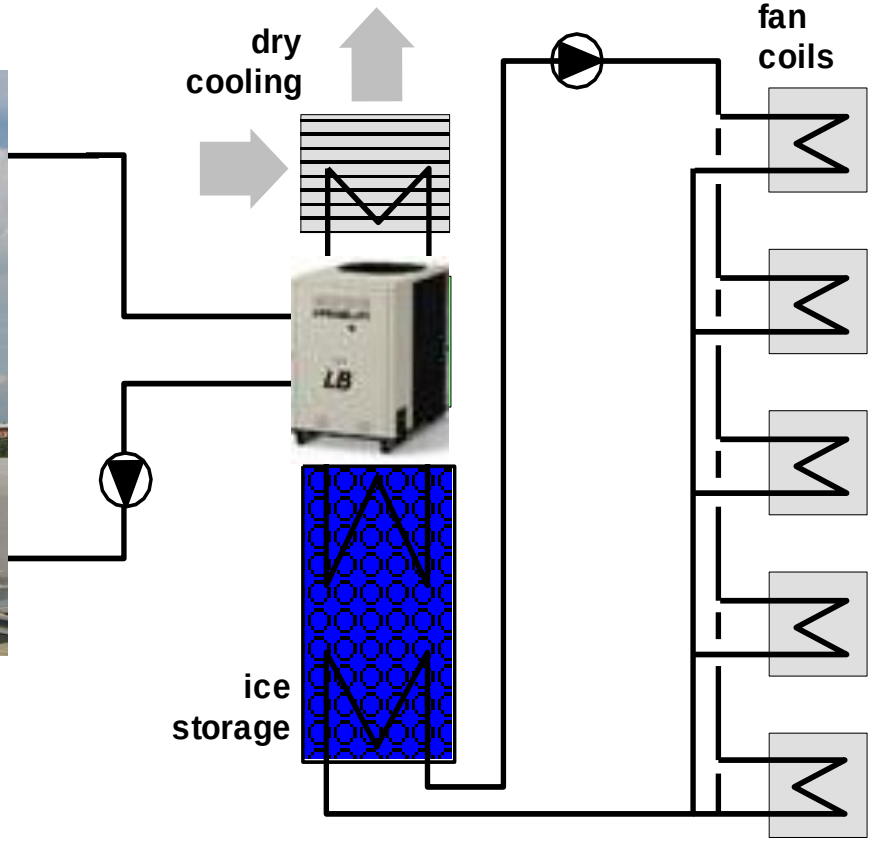
- Savings in primary energy consumption
- Reduction in peak electricity power demand
- Reduction in CO_2 emissions
- Refrigerants without global warming potential; favorable: water
- All-season use of the solar thermal system:
  heating, cooling, domestic hot water



Source: Henning, Fraunhofer ISE

	Double effect H_2O/LiBr	Triple effect H_2O/LiBr	Single effect NH_3/H_2O
Temperature lift (max)	25 K	25 K	55 K
Temperature of Cold	5-20° C	5-20° C	-20° -20° C
Driving temperature	140-180° C	230-270° C	160-180° C
Max. COP	1,1-1,4	1,6-2,1	0,6-0,7

SOLAR COOLING WITH NH_3-H_2O CHILLER



SOLAR COOLING WITH NH_3-H_2O CHILLER

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SOLAR COOLING WITH 2E WATER-LiBr

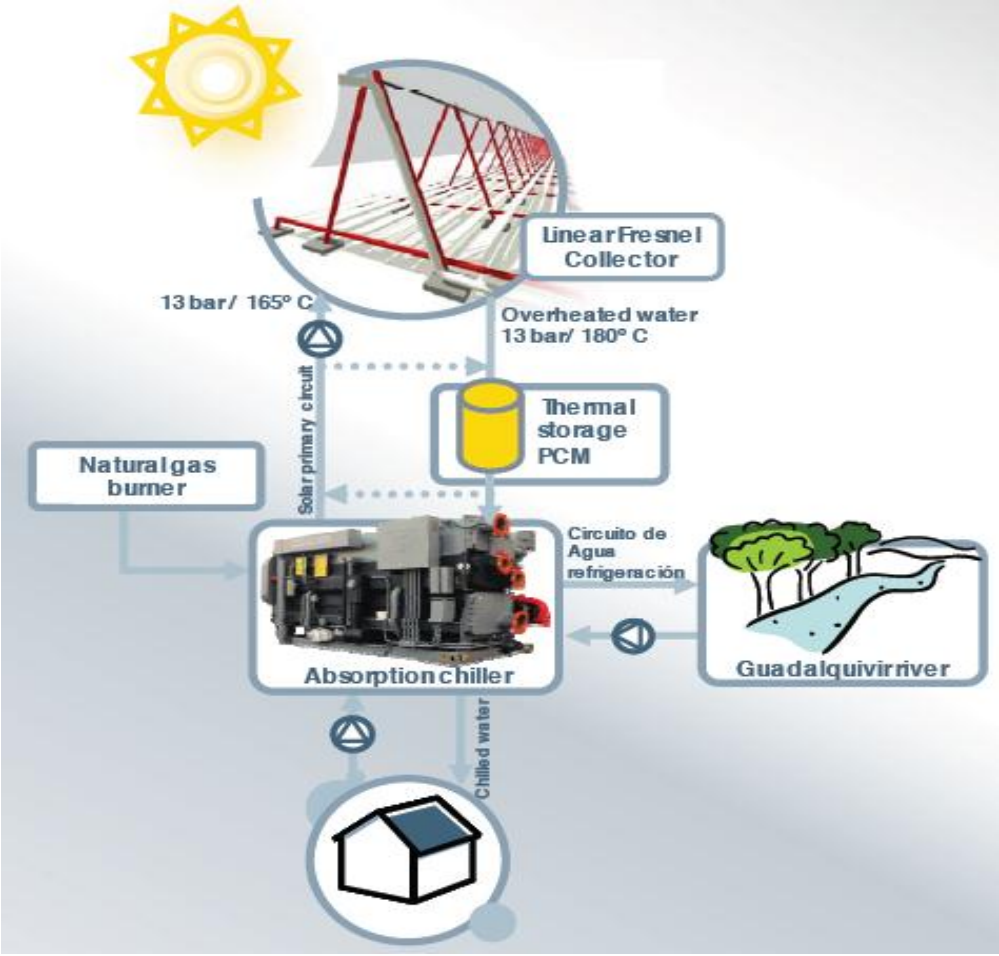
Collector

- 16 modules, 352m² aperture area
- Pressurized water circuit at 16 bar
- Operating temperature 180 ° C

Absorption chiller

- 2E water-LiBr
- Cooling capacity 174 kW

SOLAR COOLING SYSTEM AT ESI IN SEVILLA



- Built in 2007
- Aperture area 352 m²
- Pressurized water circuit at 16 bar
- Outlet temperature 180° C
- Double effect absorption chiller with 50 TR / 174 kW cooling capacity

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SOLAR COOLING WITH 2E WATER-LiBr

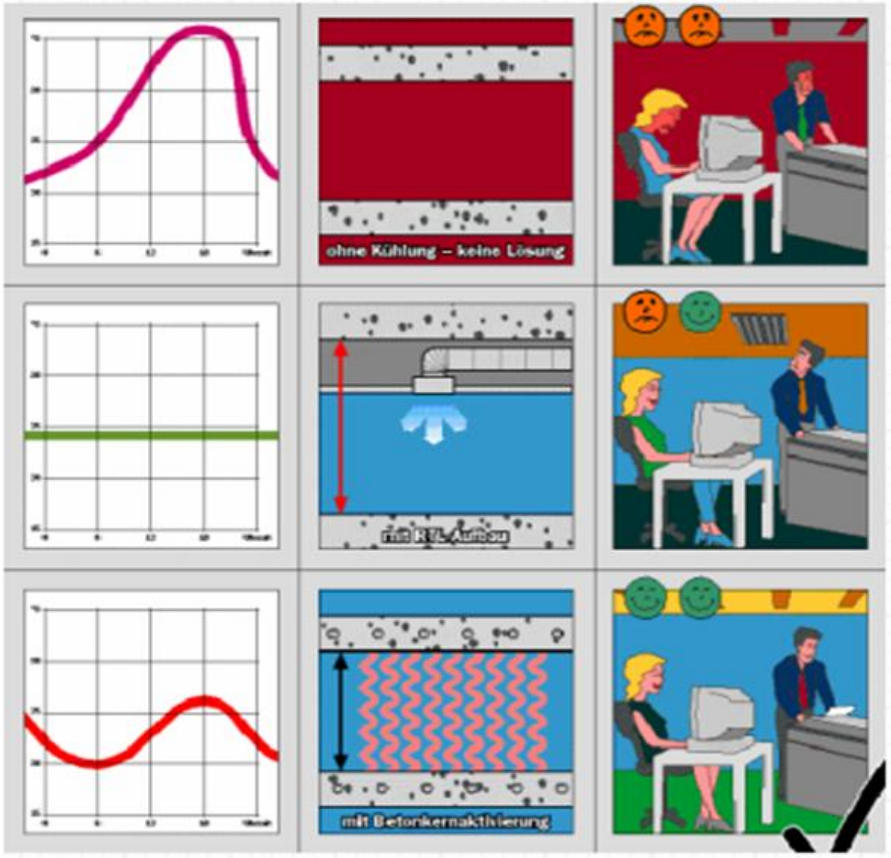
Collector

- 64 modules, 1408m² aperture area
- Pressurized water circuit at 16 bar
- Operating temperature 180 ° C

Absorption chiller

- 2E water-LiBr
- Cooling capacity 650 kW

COMFORT-PERFORMANCE



No cooling – decreased performance

Low energy costs

Low operation costs

Full Air-Conditioning

Constant temperature

Draught, Noise, SBS

High energy costs

High operation costs

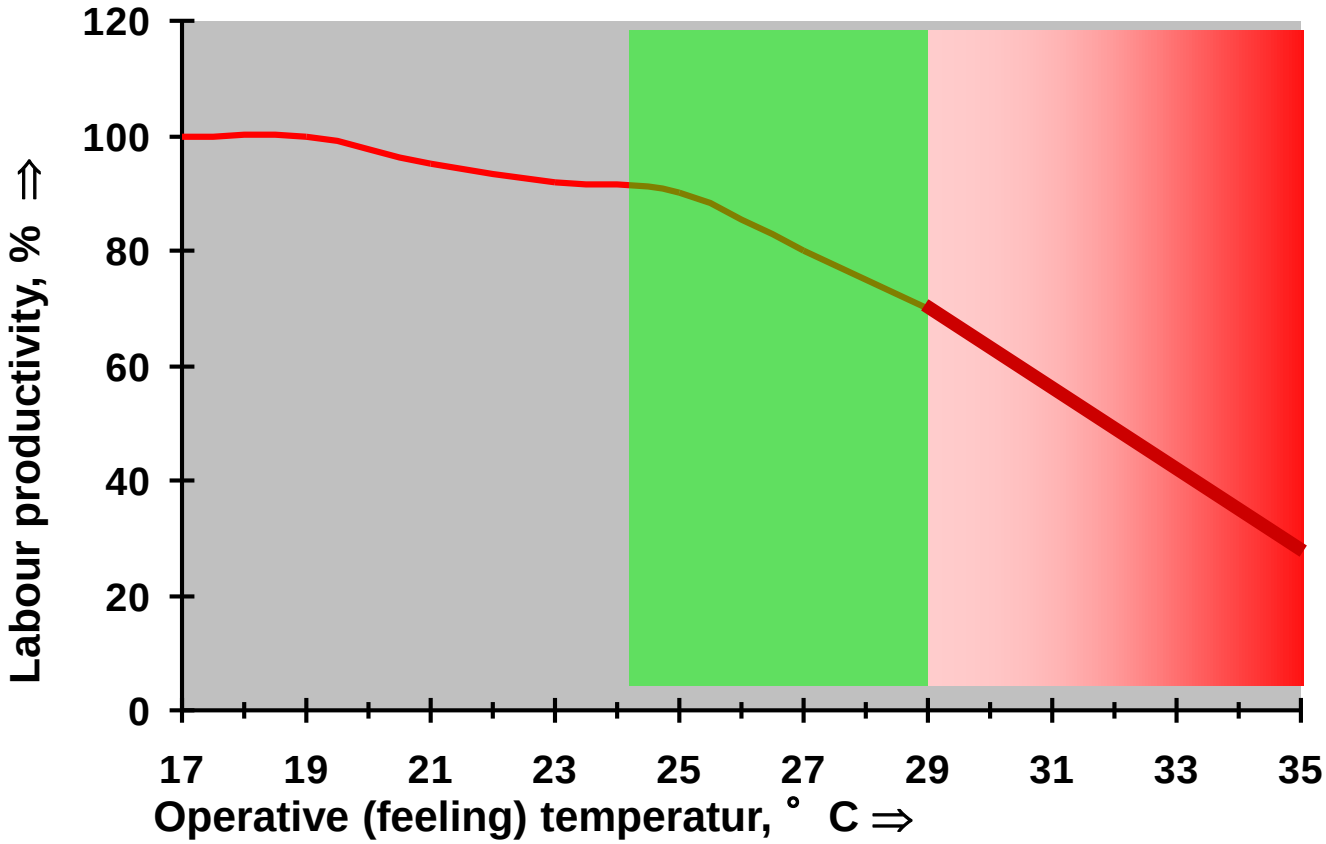
Thermo-Active-Building-Systems

Temperature ramps

Reasonable energy costs

Low operation costs

… which directly influences their labour efficiency



source:
Hettinger, Th.,
Kaminsky, G. ,
Schmale, H.:

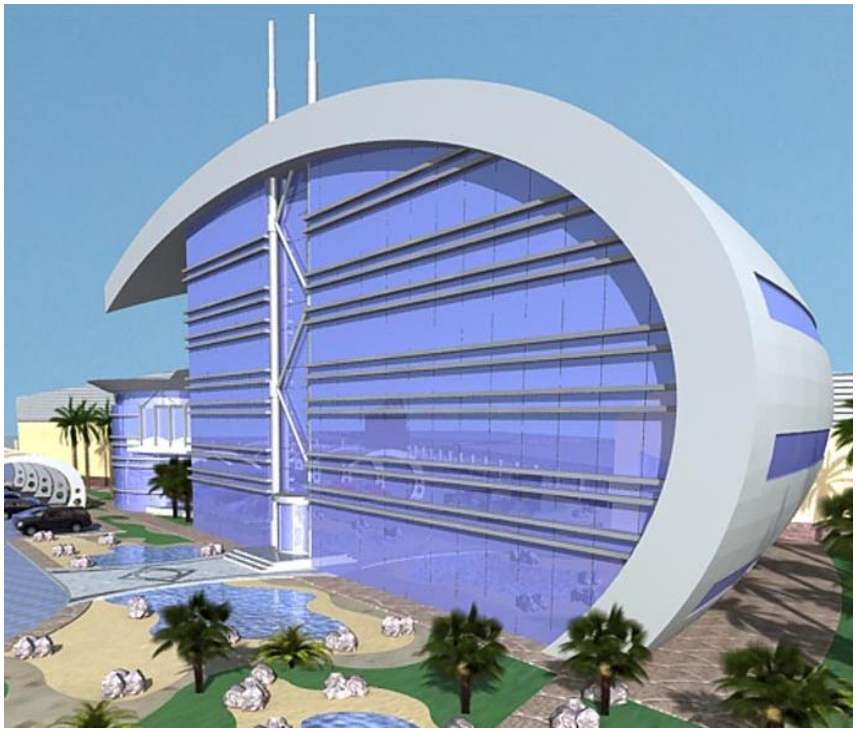
Ergonomy at the work place

Labour productivity as a function of operative (room) temperature

We all spend 90 % of the day time indoors:
at work, commuting and at home

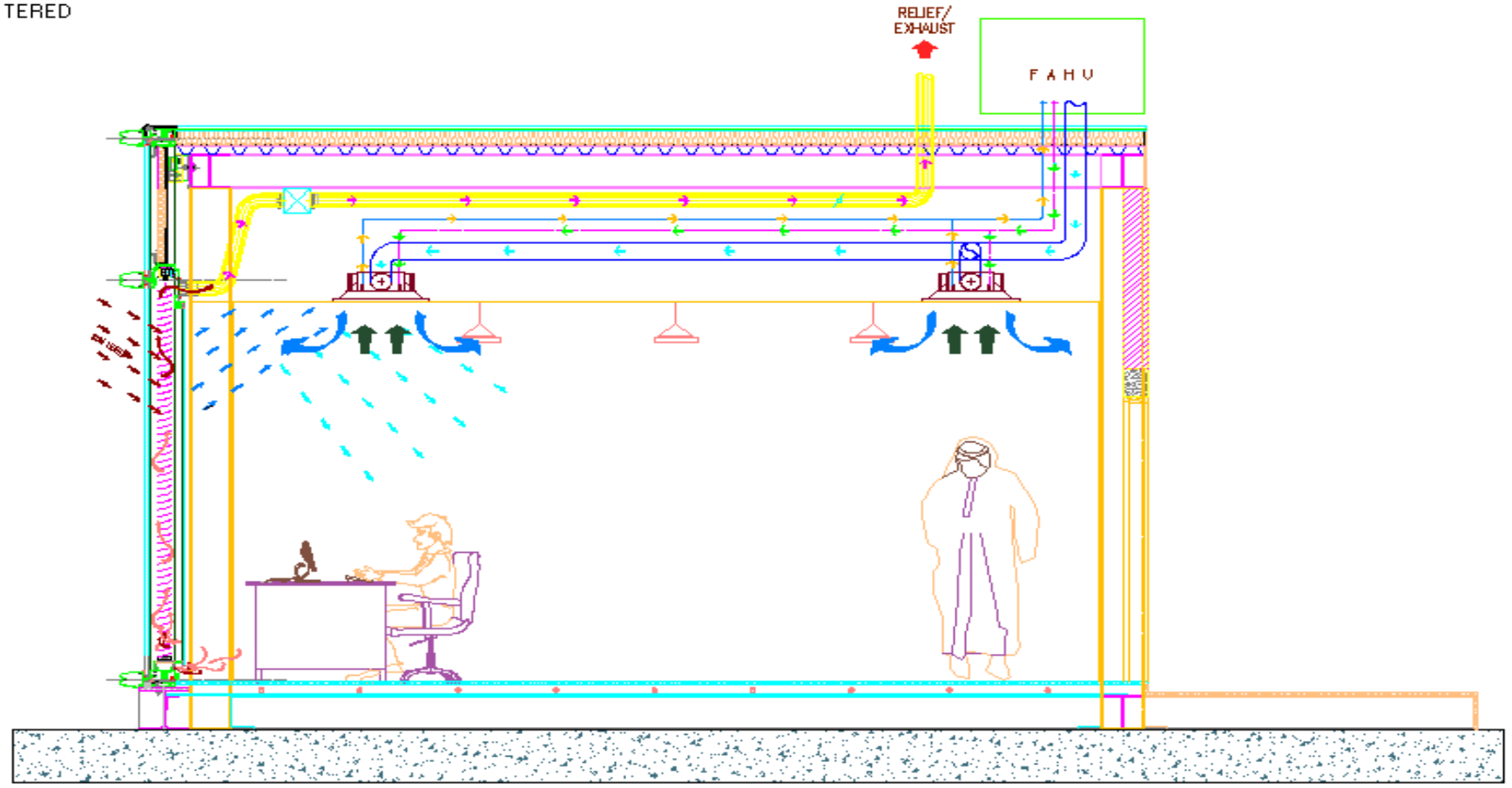
BUT:
WHAT IS COMFORT FOR US?

Reem Emirates Aluminum HQ, Abu Dhabi, UAE



- Radiant floor cooling 5 000m²
- Central Air Handling Unit

COMBINATION WITH RADIANT COOLING



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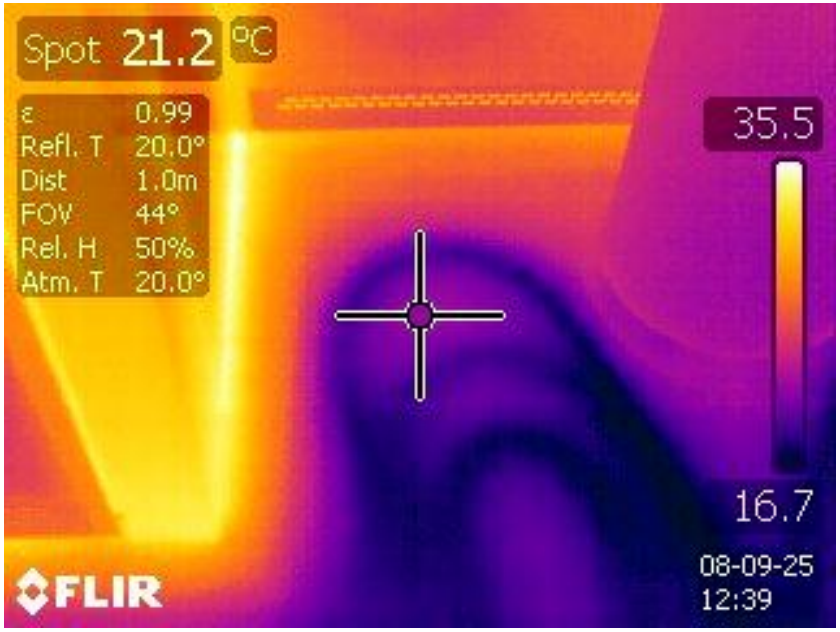
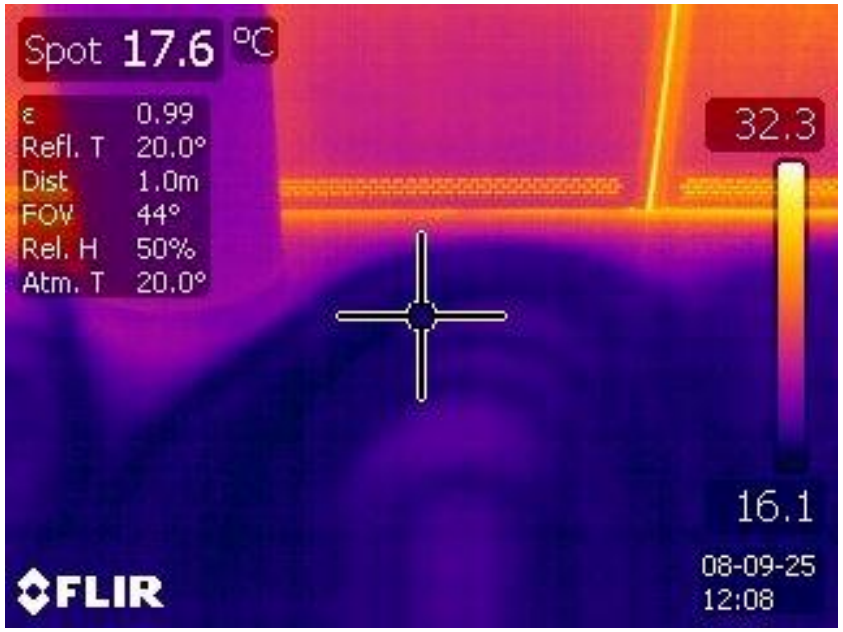
COMBINATION WITH RADIANT COOLING





GARDENS BY THE BAY SINGAPORE

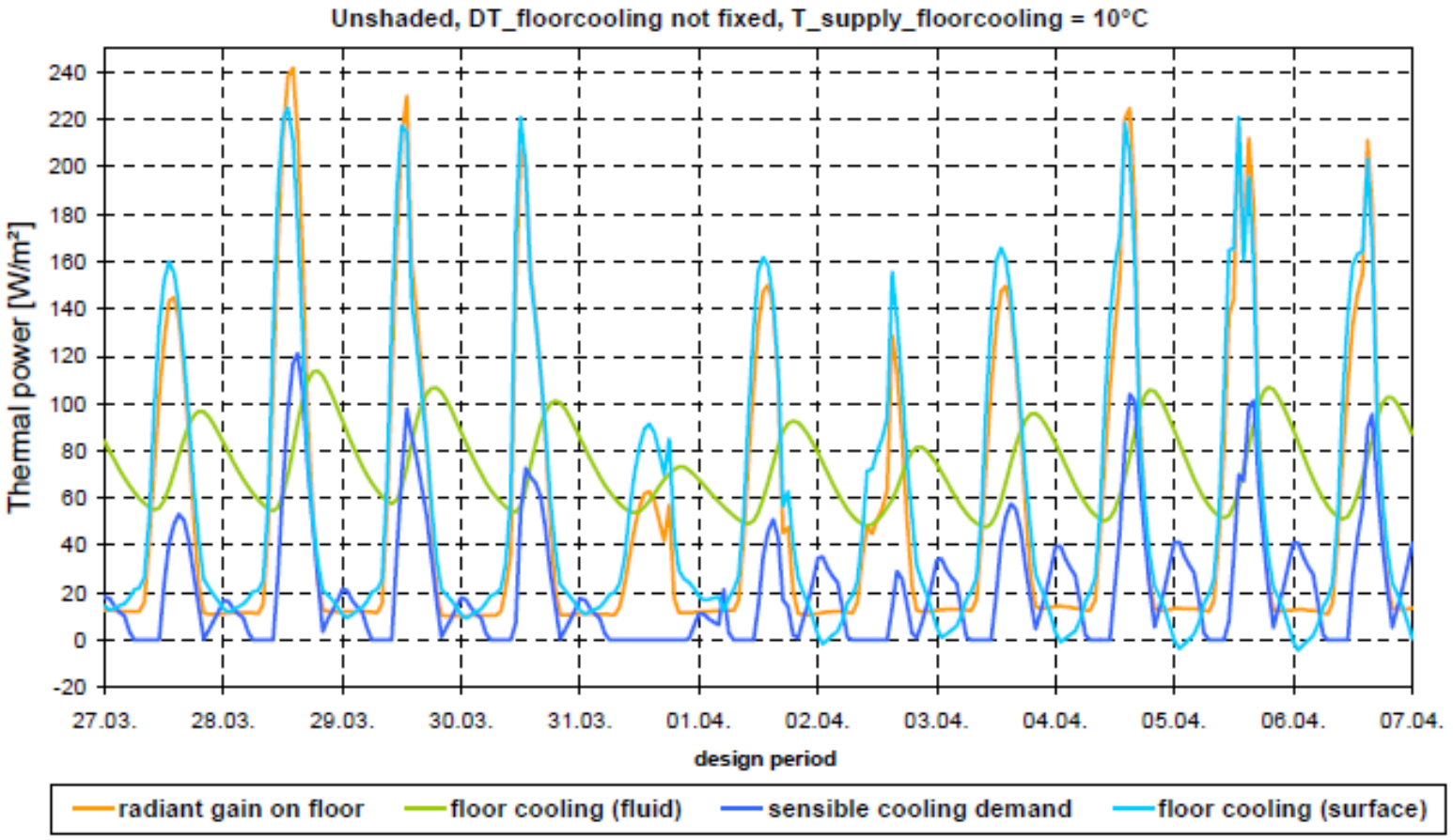
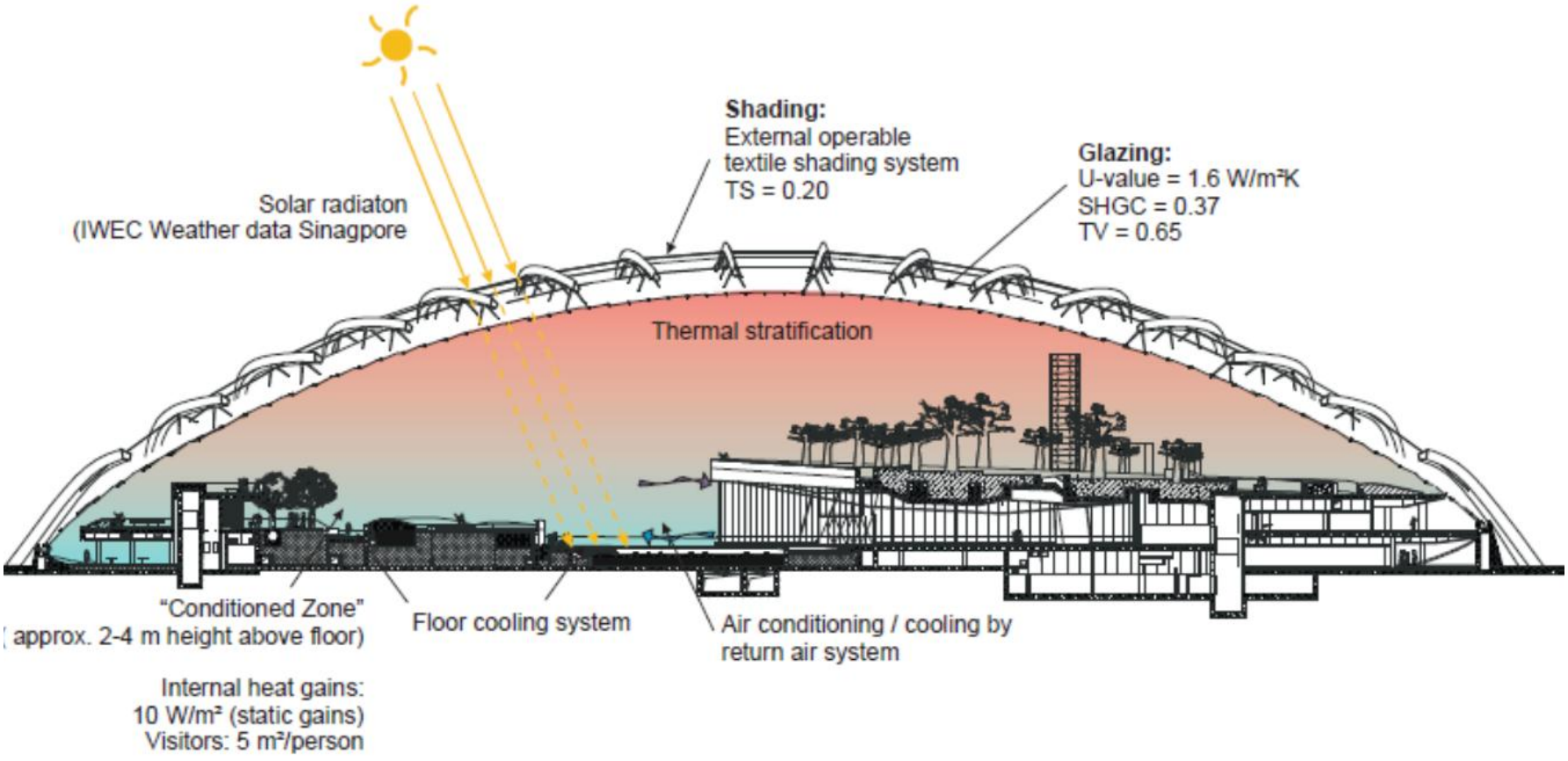


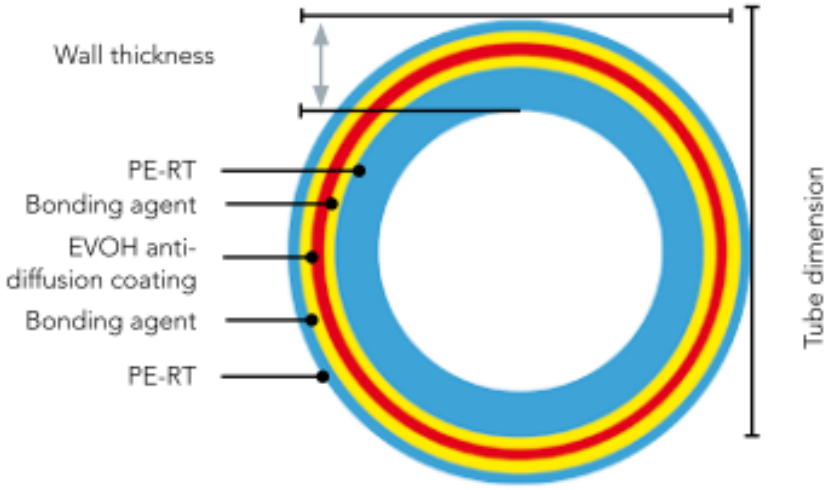
Figure 27: Thermal power in Cool Dry Conservatory for unshaded floor cooling area, maximum floor cooling power (fluid side) not fixed and slab cooling fluid (water) supply temperature 10°C

COMBINATION WITH RADIANT COOLING



Material properties:

- PE-RT plastic tube
- 5 layer technology / 5 layer technology
- High acid resistance and temperature stability
- Co-extruded EVOH layer according to DIN 4724
- Pressure-resistant
- Corrosion-resistant
- Ethylene octene co-polymer / medium density
- High durability and fatigue strength
- Unique molecular structure with linear ethylene main chain and the octene side chains
- Particularly flexible and easy to install (oxygen impermeable according to DIN 4726)
- Extreme acid resistance and resistance to chemicals
- Very low flow resistance in the inner tube
- Extremely good thermal conductivity



Why radiant cooling with solar cooling

- We can use chilled water temperature above 12 ° C
- PERFECT FOR ABSORPTION CHILLERS as the capacity increase with higher chilled water leaving temperature (30 -50 % more capacity)
- Higher comfort, less O&M cost

- **SUNTAINABILITY. LETS TAKE THIS RESPONSIBILITY**.

Table 2B - 2: Primary inputs and outputs of tests varying chilled-water supply temperature

	Measurement values for chiller inputs					Measurement values for chiller outputs				
	Chilled-water flow	Cooling-water flow	Chilled water return temp.	Cooling-water supply temp.	Steam supply temp.	Condensate return temp.	Steam flow	Chilled-water supply temp.	Cooling load	
Test	F1	F6	T20	T32	T22	T23	F2	T21	$Q_{cooling}$	COP
No.	m^3/h	kg/s	°C	°C	°C	°C	kg/h	°C	kW	
1	2.03	1.43	10.93	30.49	165.30	99.14	17.53	5.14	13.66	0.88
2	2.07	1.44	11.11	30.40	165.32	98.99	18.35	5.37	13.86	0.91
3	2.06	1.43	12.22	30.57	165.25	99.16	20.10	6.01	14.87	0.94
4	2.08	1.43	12.22	30.43	165.30	98.92	18.65	6.16	14.66	0.95
5	**2.04**	**1.43**	**13.52**	**30.46**	**165.20**	**99.13**	**19.78**	**6.91**	**15.65**	**1.01**
6	2.08	1.43	14.44	30.59	165.14	99.11	20.88	7.70	16.33	0.99
7	2.07	1.43	15.56	30.68	165.13	99.12	22.90	8.35	17.35	1.02
8	2.07	1.43	16.67	30.66	165.05	99.14	23.28	9.20	17.95	1.07
9	2.10	1.43	17.77	30.61	164.94	99.15	24.03	9.90	19.21	1.09
10	2.10	1.43	18.88	30.53	164.74	99.15	25.47	10.69	19.98	1.11
11	2.13	1.43	22.02	30.50	164.66	99.14	25.85	13.53	21.03	1.14

Thank you for your attention.

Dipl.-Ing. Volker Rühle, Director Centrogulf LLC.

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