

Solar Absorption Air-Conditioning for a Football Stadium in Qatar

A presentation in Business Administration by SolarICE GmbH:

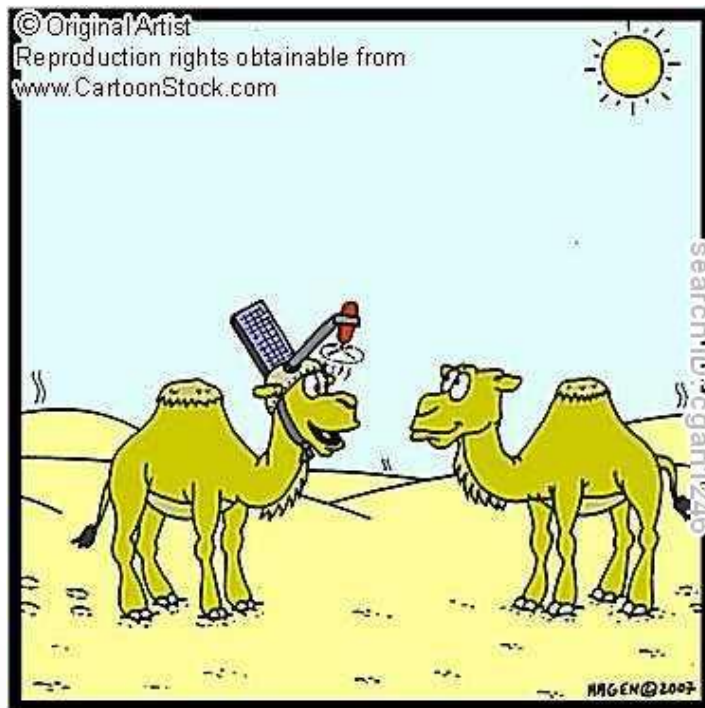
Ali Tabibi

Bhawesh Singh

Tariq Elzubeir

What is Solar Air Conditioning?

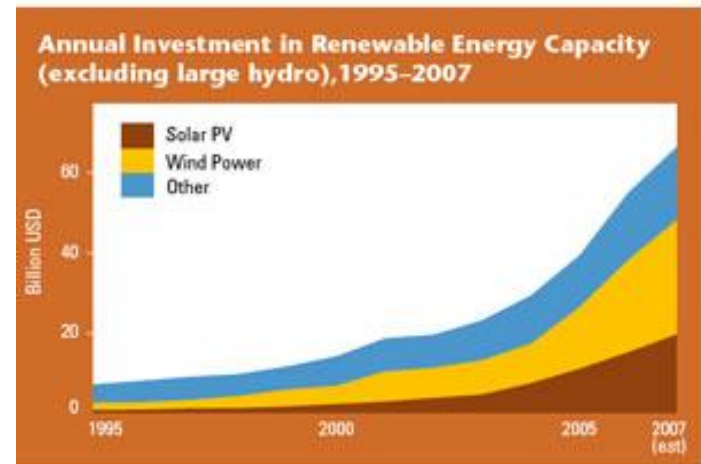
This form of air conditioning or ventilation systems uses heat that is made available by solar collectors. No long-term intermediate storage is necessary in months of high solar energy gain or in southern lands. The sun can, at least seasonally at our latitudes, provide a substantial part of the energy needed for air conditioning.



You know what: These solar-powered fans are great!

The Future

- Vision statement
 - Advanced district cooling
- Goals and Objectives
 - Lowering cooling costs
 - Less CO2 emissions
 - Cooling sport halls and buildings



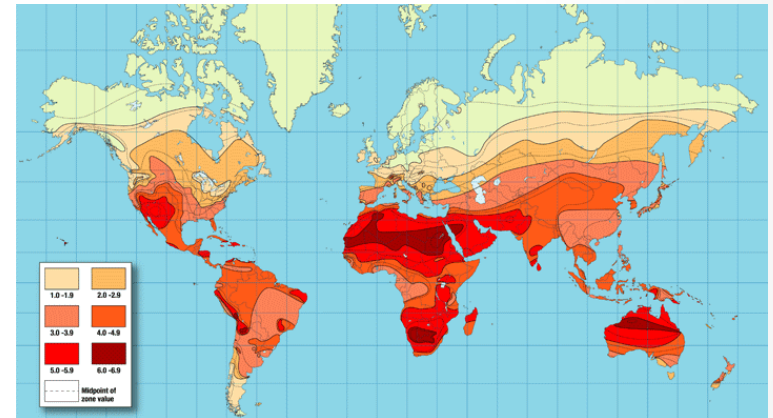
The Business

- Business name
 - SolarICE GmbH
- Business location
 - Qatar
- Business owners
 - Ali Tabibi
 - Bhawesh Singh
 - Tariq Elzubeir
- Products and Services
 - Air-conditioning solutions using solar thermal
 - Installing cooling systems on site
 - Operating and maintaining the system



Why Qatar?

- Has one of the highest irradiation values ($>2200\text{W}/\text{m}^2$)
- Tax-free
- Ease of doing business is highly rated
- Available land for large area demanding projects
- Government's long term vision for renewable energies
- High end infrastructure
- Cost of land is neglectable for industrial projects



Schedule and Plan

ID	Task Name	Start	Finish	Duration	2020		2021				2022				2023				2024				2025				2026				2027				2028				2029	
					Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2			
1	Planning in details	02.03.2020	10.04.2020	30d	[Gantt bar: 02.03.2020 to 10.04.2020]																																			
2	Manufacturing, Development and Engineering of SolarICE System	13.04.2020	27.08.2021	360d	[Gantt bar: 13.04.2020 to 27.08.2021]																																			
3	Registration and Permits in Qatar	30.08.2021	08.10.2021	30d	[Gantt bar: 30.08.2021 to 08.10.2021]																																			
4	Transportation of SolarICE System	11.10.2021	03.12.2021	40d	[Gantt bar: 11.10.2021 to 03.12.2021]																																			
5	Operation of SolarICE System	06.12.2021	13.07.2029	1985d	[Gantt bar: 06.12.2021 to 13.07.2029]																																			
6	Break-even Point	23.01.2023	13.07.2029	1690d	[Gantt bar: 23.01.2023 to 13.07.2029]																																			

The Market

- Target Market

- Football stadiums
- Office buildings
- Housing colonies
- University buildings and hospitals
- Other big building structures

- Market Strategy

- “Free” fuel cooling – sun radiation is for free
 - Increase oil export
 - Decrease electricity costs
- Qatar’s promise to cool their football stadiums
- Multipurpose investment

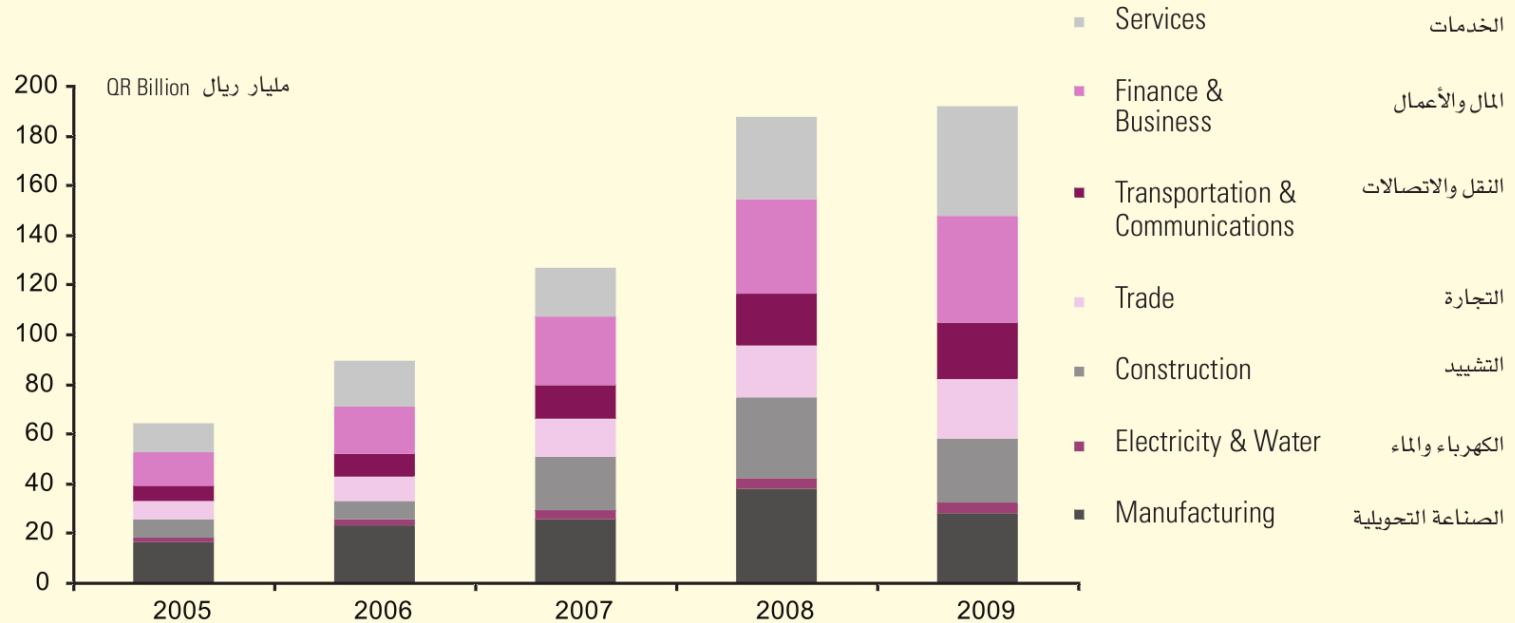


Water and Electricity

- Annual average of €808 million economical activity in the water and electricity sector
- Doubling activity in the Services sector indicating a growing economy

Economic Activity	2007	2008	2009
Agriculture & Fishing	270	305	315
Manufacturing	26,001	37,946	28,363
Water& Electricity	3,179	4,348	3,913
Building& Construction	21,625	32,507	25,781
Trade, Restaurants & Hotels	15,480	20,674	23,946
Transportation & Communication	13,539	21,199	22,696
Finance, Insurance, Real Estate, and Business Services	27,309	38,106	43,374
Services	19,888	32,855	44,147

Growing GDP in Qatar



How does Solar Air conditioning Work?

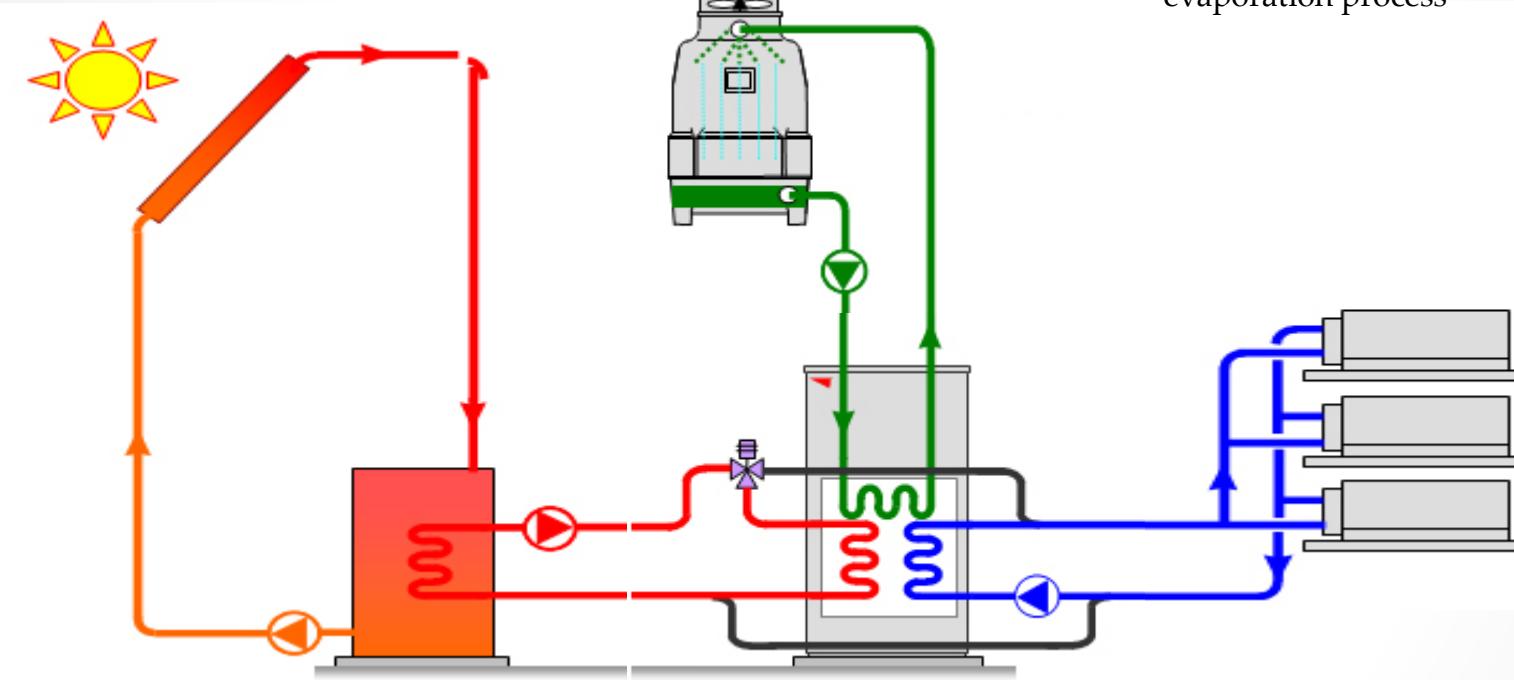
The basic principle behind (solar-) thermal driven cooling is the thermo-chemical process of sorption: a liquid or gaseous substance is either attached to a solid (Silica Gel), porous material (adsorption) or is taken in by a liquid material like lithium bromide or Ammonia (absorption).

The sorbent (i.e. silica gel, a substance with a large inner surface area) is provided with heat (i.e. from a solar heater) and is dehumidified. After this "drying", or desorption, the process can be repeated in the opposite direction. When providing water vapor or steam, it is stored in the porous storage medium (adsorption) and simultaneously heat is released.



How does Solar Air conditioning Work?

Cooling tower: This heat-removal device extracts the heat from absorption chiller through a water-evaporation process



Solar thermal collector

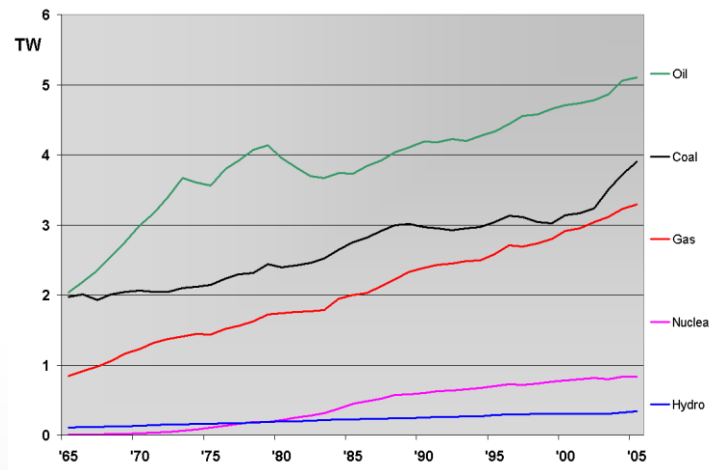
Storage tank: source of heat for cooling/heating at night or when solar collection is inadequate

Double effect absorption chiller

Fan coil units: the air-conditioner devices combine the fan and coil heat-exchanger in one package

Why Solar Cooling?

- Dramatic increase of air conditioning since the early 80s
- Cost of energy
- Issues related to environmental pollution
 - Due to energy production
 - Due to the use of CFC's and HCFC's
- Matches demand with source availability
- Crucial for improving life standards in developing countries

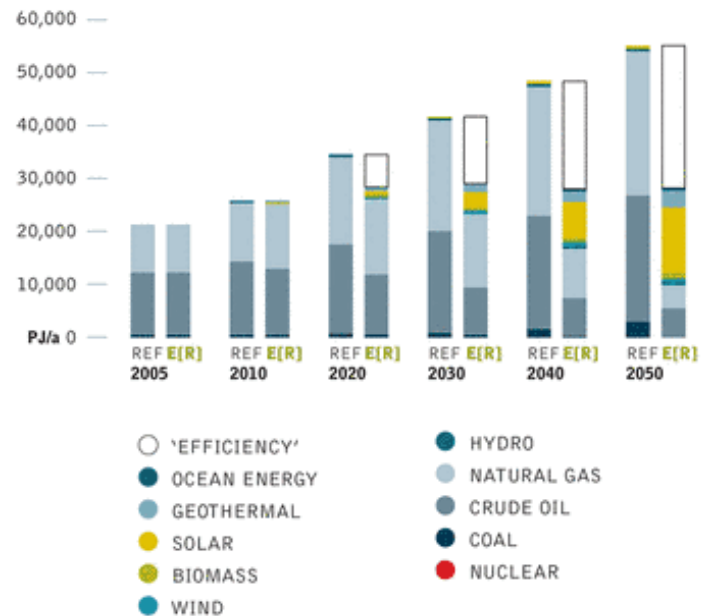


Some important facts

- Cooling consumes 30-60 % of Energy Bill
- Oil prices exceeding 100\$/Barrel in near future
- Gas Prices 5-10 \$/MBtu
- Production of 1 kWh results in 0.4-0.7 Ton CO₂
- Burning 1 kg Natural Gas produces 2.6 kg CO₂

middle east: development of primary energy consumption under the two scenarios

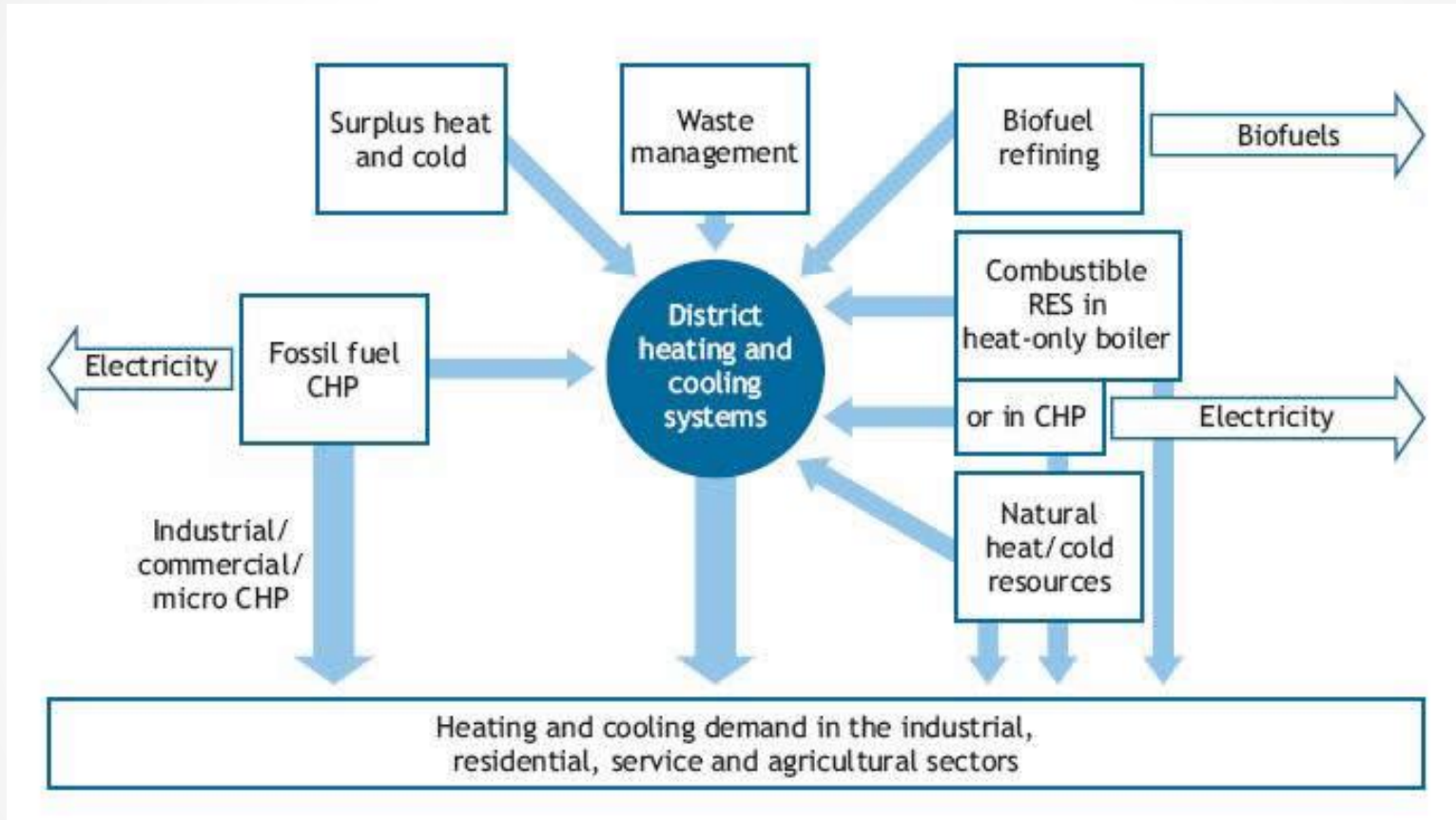
('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



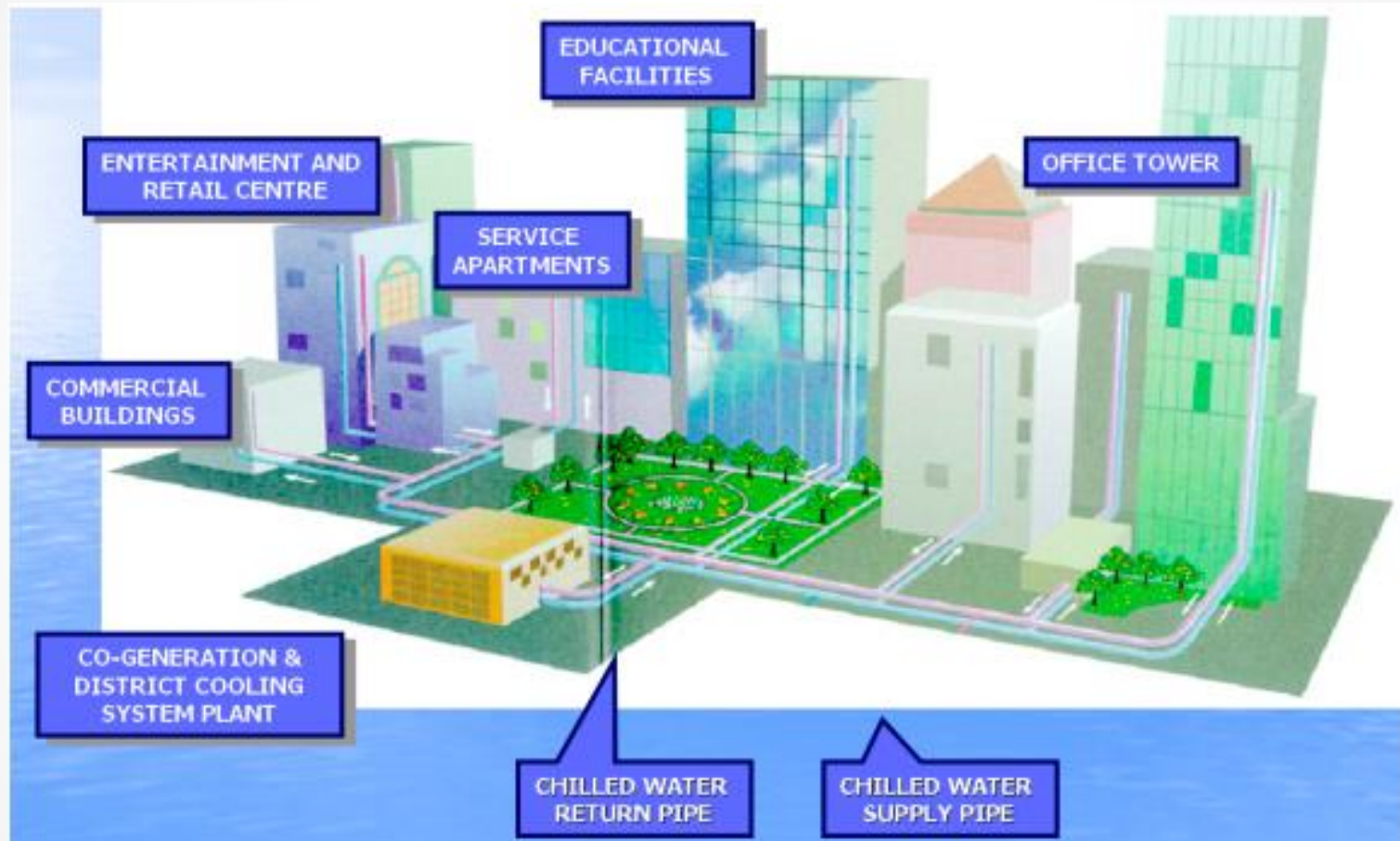
Upcoming Plans in Qatar

- To supply one of the World Cup 2022 football stadiums in Qatar (Qatar University Stadium) completely with Solar absorption Air-Conditioning
- When the game is not being played the chilled water is directed to District Cooling System which provides cooling for 2000 apartments including buildings of Qatar University.
- Yearly around 43000 tons CO₂ is saved which would have been exhausted while burning oil for cooling these apartments.
- The project is more profitable with increase in oil/gas prices.

What is District Cooling System?

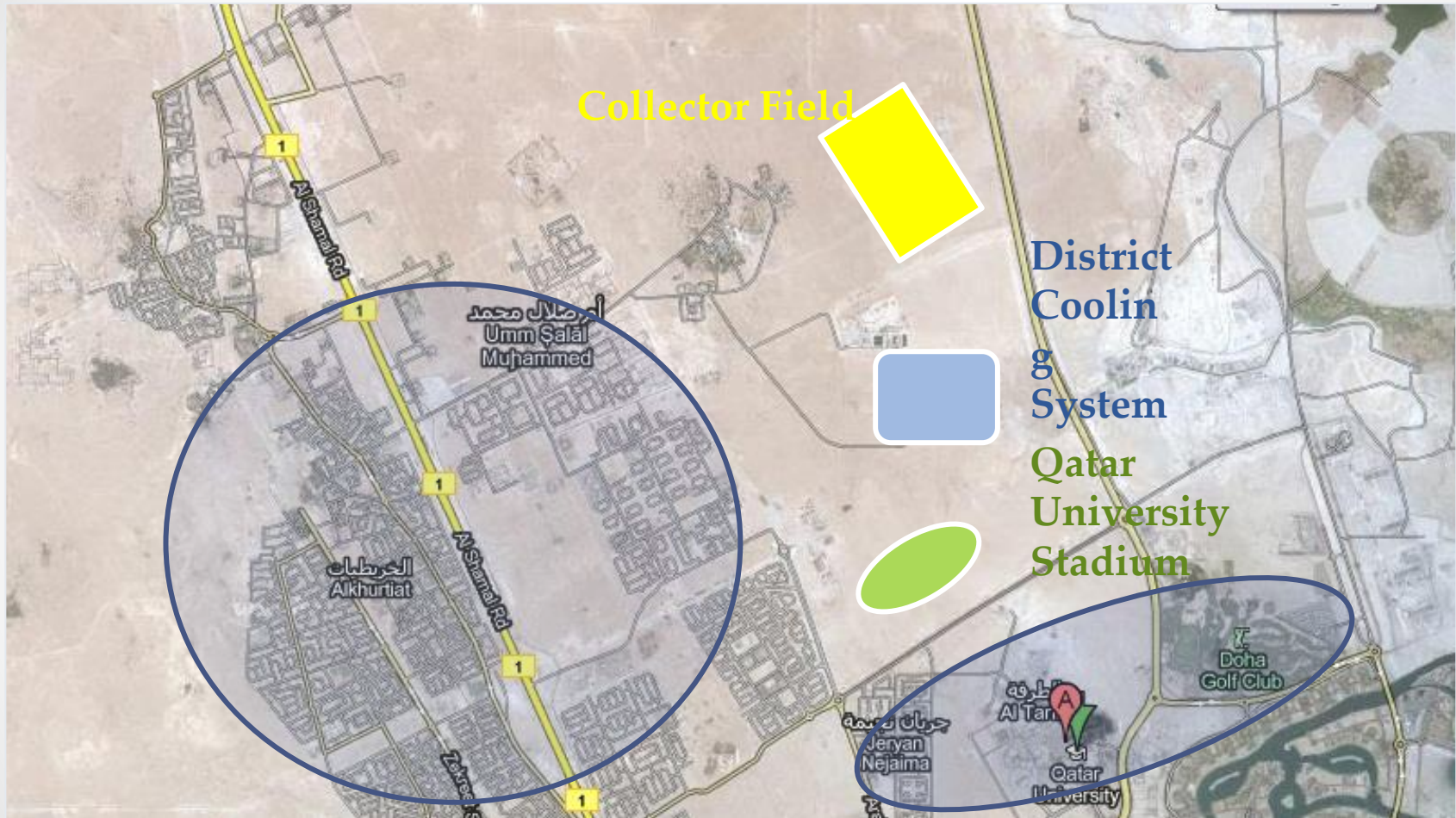


What is District Cooling System?



Source: www.eonmetall.com/DistrictCoolingProd.htm

Construction site



Qatar University Stadium



Investment



Investment and Depreciation Costs

Gross cost for the installation of power producing unit			
Investment goods	Investment (€)	Depreciation (yrs)	Depreciation (€/yr)
Land	0	0	0
On-site control room	50.000	20	2.500
Landscaping	5.000	20	250
Surveying	30.000	20	1.500
Structural foundation	40.000	20	2.000
Safety packing (Collector + Chiller)	100.000	20	5.000
Transport cost of the plant (insured)	100.000	20	5.000
Water tank for hot/cold water (10.000 l)	6.000	20	300
Water tank for cleaning (2000 l)	2.000	20	100
Control valves	2.000	20	100
Water recycle unit	20.000	20	1.000
Lighting (onsight)	5.000	20	250
Protecting property	10.000	20	500
Total goods	370.000	20	18.500

Investment and Depreciation Costs

Power production unit	Euro		Euro
Collectors (9m ² x 16000 pcs)	5.000.000	10	500.000
Chillers (1200 ton x 7)	1.700.000	10	170.000
Cooling Tower + distributor	1.000.000	10	100.000
Pipings + Insultation (seat cooling)	1.000.000	10	100.000
Electronics	5.000	10	500
Pumps (Chillers + Stadium)	70.000	10	7.000
Total Power production unit	8.775.000	10	877.500

Company establishment cost (including Notary, Lawyer and Court fees) : 25.000 €		
Licencing Cost : 20.000 €		
Total Establishment/Licencing	45.000	

Investment and Depreciation Costs

Vehicles	Euro		Euro
Collector cleaning crane	100.000	5	20.000
Off-Road vehicle	50.000	5	10.000
Total Vehicles	150.000	5	30.000
Miscellaneous			
Installation team	400.000	10	40.000
Engineering/Desing/Management team	2.000.000	10	200.000
Unforeseen costs	1.000.000	10	100.000
Total Miscellaneous	3.400.000	10	340.000
Electronics			
Computers/Printers	2.000	4	500
Security electronics	5.000	4	1.250
Total Electronics	7.000	4	1.750
Grand Total	12.747.000		1.267.750

Annual Costs

Annual Costs		
	Number	Cost(€)
Engineer	1	48.000
Technician	2	48.000
Collector cleaner	1	12.000
Watchman	1	12.000
Operation and Maintainance (0,5%)	1	63.000
Total		183.000

Financing



Financing

- 60% Bank of Qatar, 40% Investors
- €12.747.000 Bank of Qatar, €4.989.600 Investors
- The Nationals in Qatar do not have to pay for the electricity
- But the self cost for the government to produce electricity from oil/gas is 3€-Cent/kWh

Chiller size	8000ton
Eq. Chiller size for one apartment (150m ²)	4 ton
Number of apartment that can be cooled	2000
1 Ton cooling (removal of 12.000 BTU/hr)	3,514 kW
Air-conditioning per day	10 hrs (average throughout the year)
Cost / apartment / year	$3,514 \text{ kW} \times 4 \text{ ton} \times 10 \text{ hr} \times 365 \text{ days} \times 0,03 \text{ €} = \text{€ } 1539,13$
Total cost for 2000 apartments	$\text{€ } 3.078.264 = 102,61 \times 10^6 \text{ kWh}$
Calorific value of 1 liter oil	30MJ = 8.3333kWh
Total oil spent in cooling	$102.61 \times 10^6 \text{ kWh} / 8,333 \text{ kWh} = 12.31 \text{ mio liters}$ (104.933,34 barrels)
Total earning (at 80€/barrel)	€ 8,4 mio.

Turnover / Revenue Calculation

Turnover, in this case, for the government is the amount of oil they would have spent if there was no solar cooling system. It can be said that the revenue is the amount of cost (oil + production) they save to cool the apartments.

Year	Output (mio. kWh)	Turnover/Revenue (€)
1	102,61	3.078.264
2	102,61	3.078.264
3	102,61	3.078.264
4	102,61	3.078.264
5	102,61	3.078.264
6	102,61	3.078.264
7	102,61	3.078.264
8	102,61	3.078.264
9	102,61	3.078.264
10	102,61	3.078.264

Interest paid on debt (Financial Costs)

Year	Balance of debt	Interest rate (%)	Interest cost paid	Repayment
1. Year	7.484.400	5,5	411.642	748.440
2. Year	6.735.960	5,5	370.478	748.440
3. Year	5.987.520	5,5	329.314	748.440
4. Year	5.239.080	5,5	288.149	748.440
5. Year	4.490.640	5,5	246.985	748.440
6. Year	3.742.200	5,5	205.821	748.440
7. Year	2.993.760	5,5	164.657	748.440
8. Year	2.245.320	5,5	123.493	748.440
9. Year	1.496.880	5,5	82.328	748.440
10. Year	748.440	5,5	41.164	748.440
Total Interest paid			2.264.031	
Total Repayment				7.484.400

Cash-flow Calculation

	1. Year	2. Year
Turnover/Revenue	3.078.264	3.078.264
Depreciation costs	1.267.750	1.267.750
Annual costs	183.000	183.000
Financial costs	411.642	370.478
Loss carried forward	0	0
Profit before tax	1.215.872	1.257.036
Tax	0	0
Profit after tax	1.215.872	1.257.036
Cash-flow	2.483.622	2.524.786
Repayment Credit	748.440	748.440
Dividend	1.735.182	1.776.346

Cash-flow calculation for 10 years

	1. Year	2. Year	3. Year	4. Year	5. Year	6. Year	7. Year	8. Year	9. Year	10. Year
Turnover/Revenue	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264	3.078.264
Depreciation costs	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750	1.267.750
Annual costs	183.000	183.000	183.000	183.000	183.000	183.000	183.000	183.000	183.000	183.000
Financing costs	411.642	370.478	329.314	288.149	246.985	205.821	164.657	123.493	82.328	41.164
Loss carried forward	0	0	0	0	0	0	0	0	0	0
Profit before tax	1.215.872	1.257.036	1.298.200	1.339.365	1.380.529	1.421.693	1.462.857	1.504.021	1.545.186	1.586.350
Tax	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Profit after tax	1.215.872	1.257.036	1.298.200	1.339.365	1.380.529	1.421.693	1.462.857	1.504.021	1.545.186	1.586.350
Cash-Flow (net profit + depreciation)	2.483.622	2.524.786	2.565.950	2.607.115	2.648.279	2.689.443	2.730.607	2.771.771	2.812.936	2.854.100
Repayment credit	748.440	748.440	748.440	748.440	748.440	748.440	748.440	748.440	748.440	748.440
Dividend	1.735.182	1.776.346	1.817.510	1.858.675	1.899.839	1.941.003	1.982.167	2.023.331	2.064.496	2.105.660
Total Dividend										19.204.209
Equity Profitability	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600	4.989.600
Interest on Equity	34,78%	35,60%	36,43%	37,25%	38,08%	38,90%	39,73%	40,55%	41,38%	42,20%

Break-even Calculator

Investment Costs	
Bank Share of Investment	€4.989.600
Average Annual Dividend over 10 Years	€1.920.420
Total Dividend in the first 3 Years	€5.329.038

Conclusion

- No wastage of produced chilled water due to District Cooling
- Drastically reduces CO2 emissions
- Reduces the consumption of oil/gas
- Break even point before 3 years

Thank you for your attention



References

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- <http://www.oksolar.com/abctech/solar-radiation.htm>
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