COOLING, DEHUMIDIFICATION AND AIR CONDITIONING POWERED BY SOLAR / LOW GRADE HEAT

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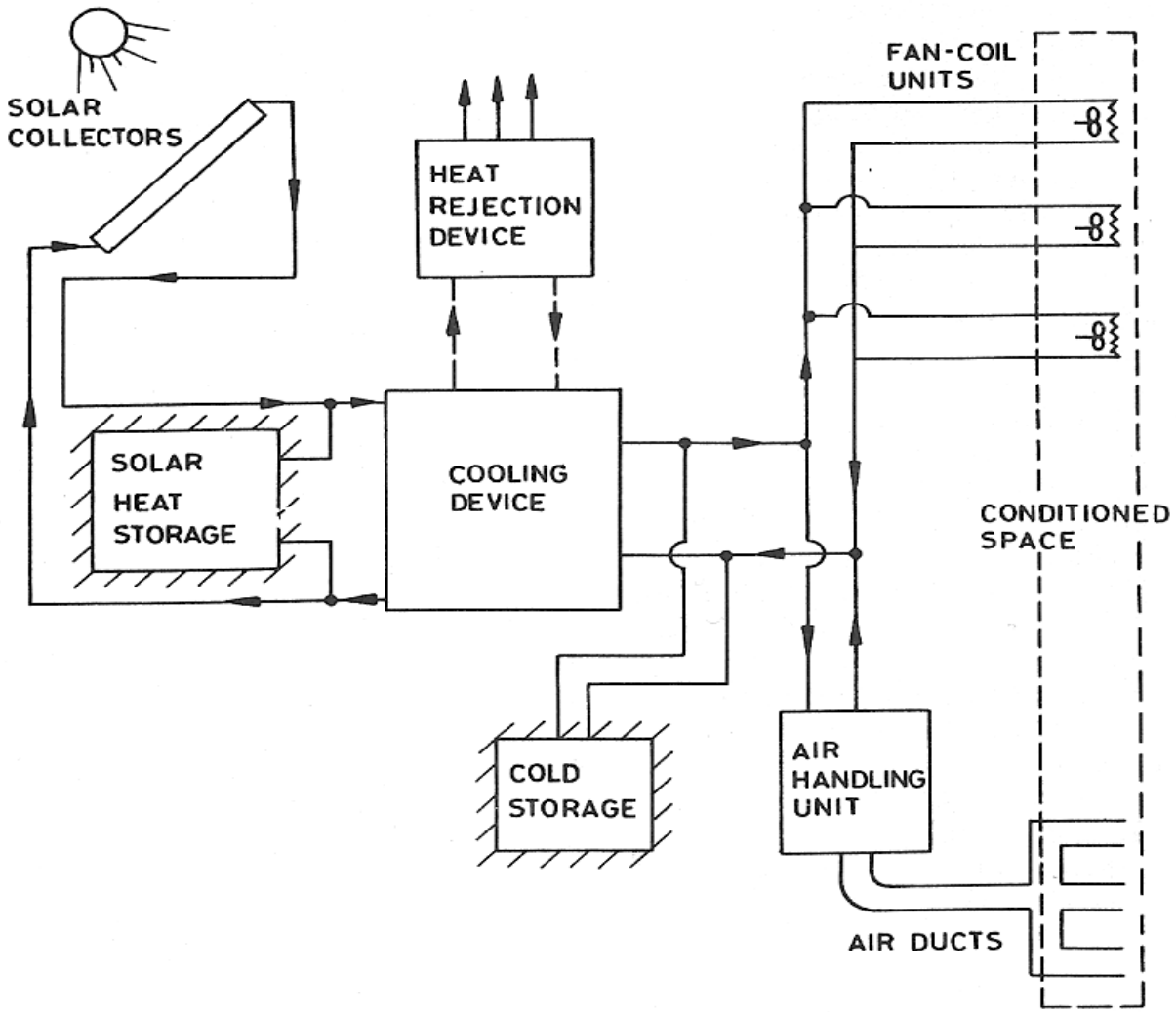
Demand for Air Conditioning in the World is on the rise…

- Climate change and Global Warming
- Increased standard of living + comfort
- A/C essential in modern business
- European countries with no A/C tradition:
  - Air conditioned space increased from in 30M m^2 in 1980 to 150M m^2 in 2000
  - Number of A/C systems larger than 12 kW increased X5 in last 20 years

Demand for A/C associated with increased demand for primary energy…

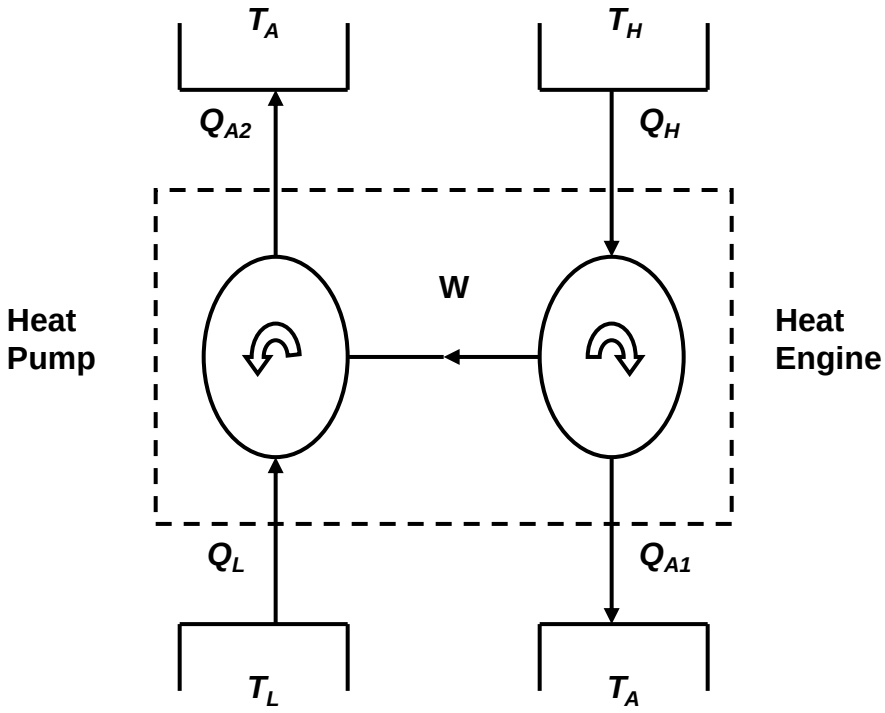
- AC – largest consumer of Electric power; In Israel - 30% of electric power produced is used for A/C
- Highest demand caused by business sector
- Electric utilities faced with peak demands in hot summer months…
- Solar Cooling can alleviate the problem

Solar Cooling System



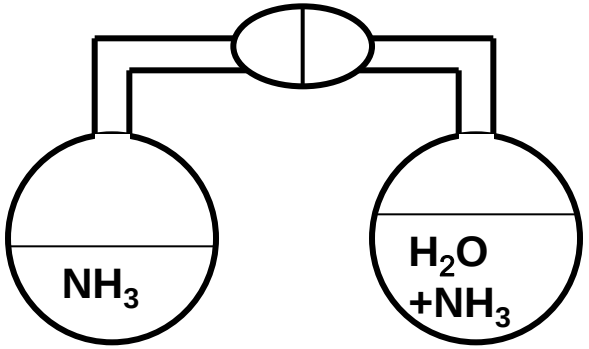
Solar Cooling/ Air Conditioning

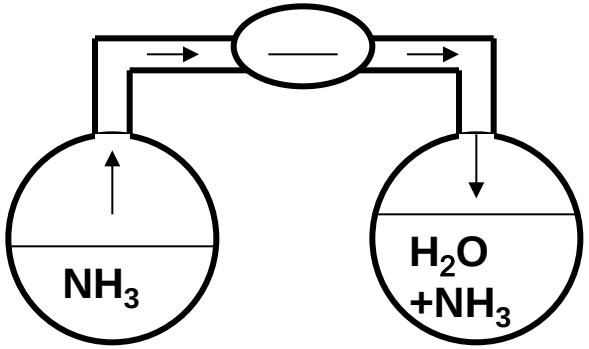
- Closed-cycle systems: Absorption, Adsorption, Jet-cooling….
- Open-cycle systems: Liquid desiccant, Solid sorption



- Heat Pump driven by Heat Engine
- Absorption/Adsorption Heat Pump

Chemical Heat Pump Principle



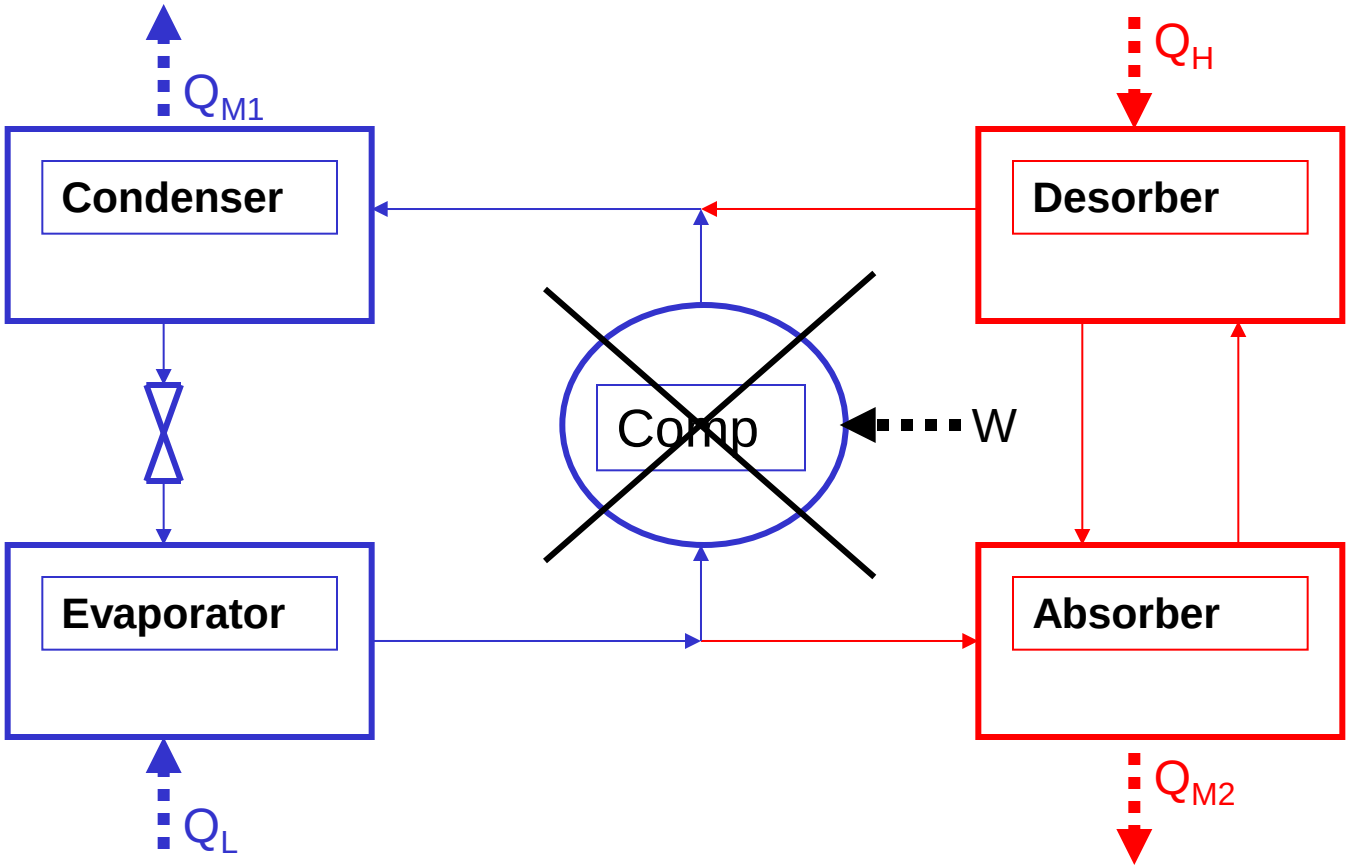


$T_{pure} = T_{solution}$
$P_{pure} > P_{solution}$

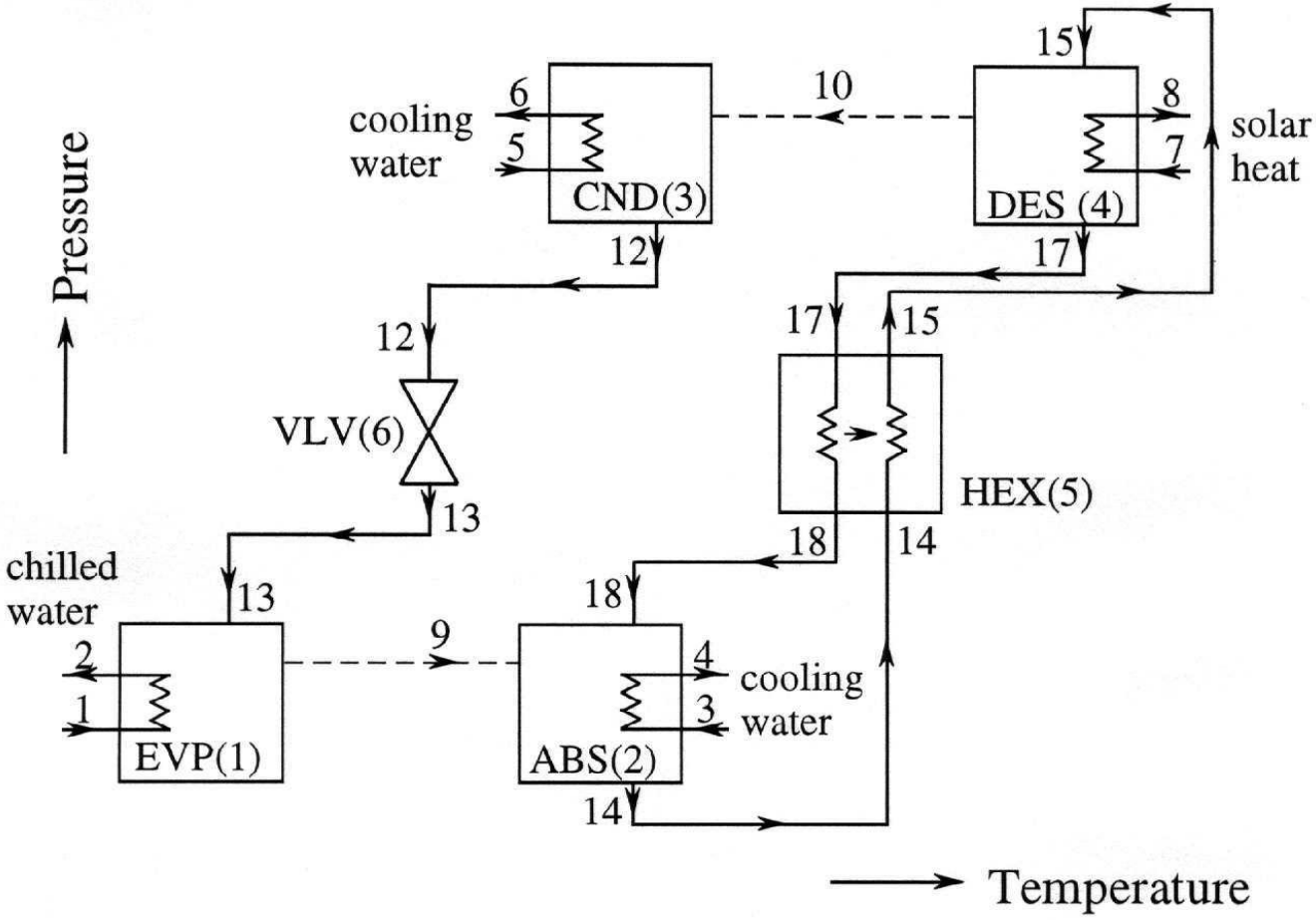
$T_{pure} < T_{solution}$
$P_{pure} = P_{solution}$

$T_{solution}-T_{pure}$=Temperature Lift

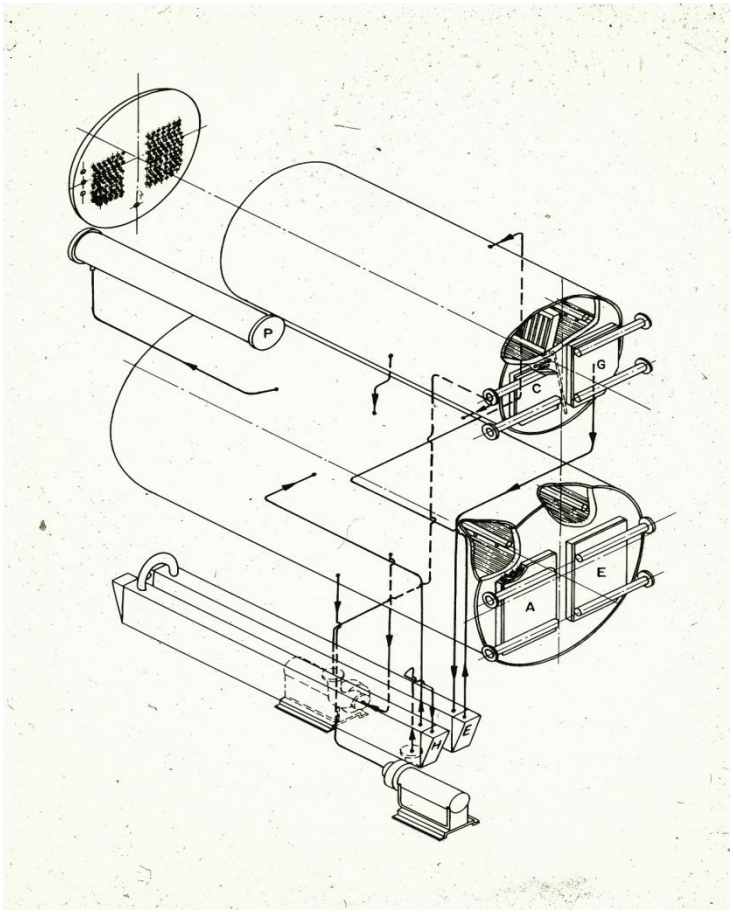
Absorption Heat Pump Principle

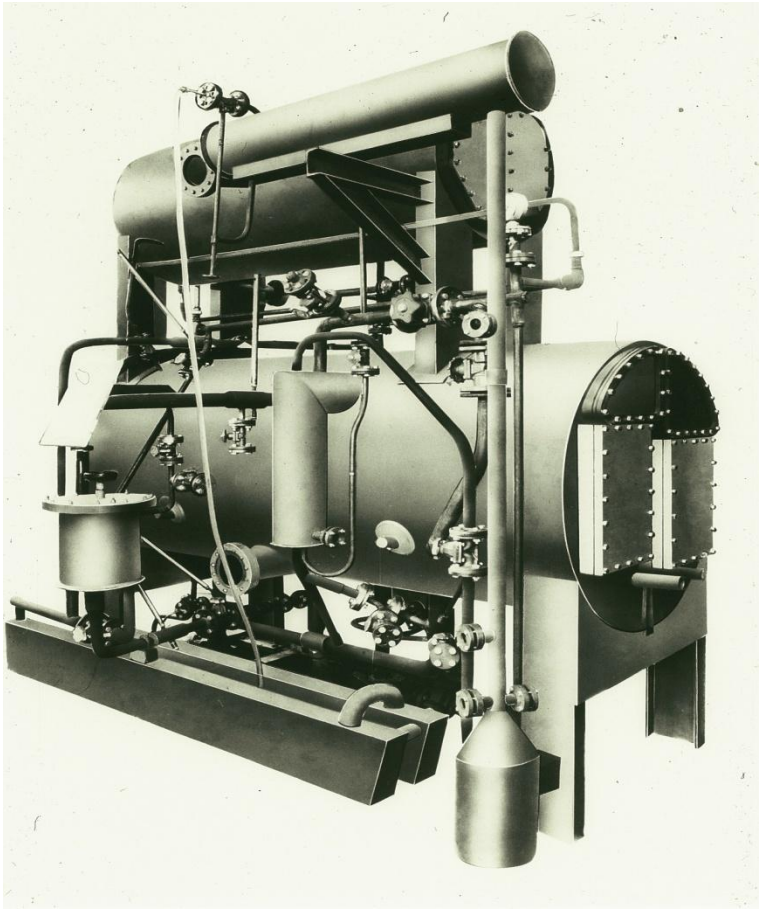


Single-Effect LiBr-H_2O Absorption Chiller



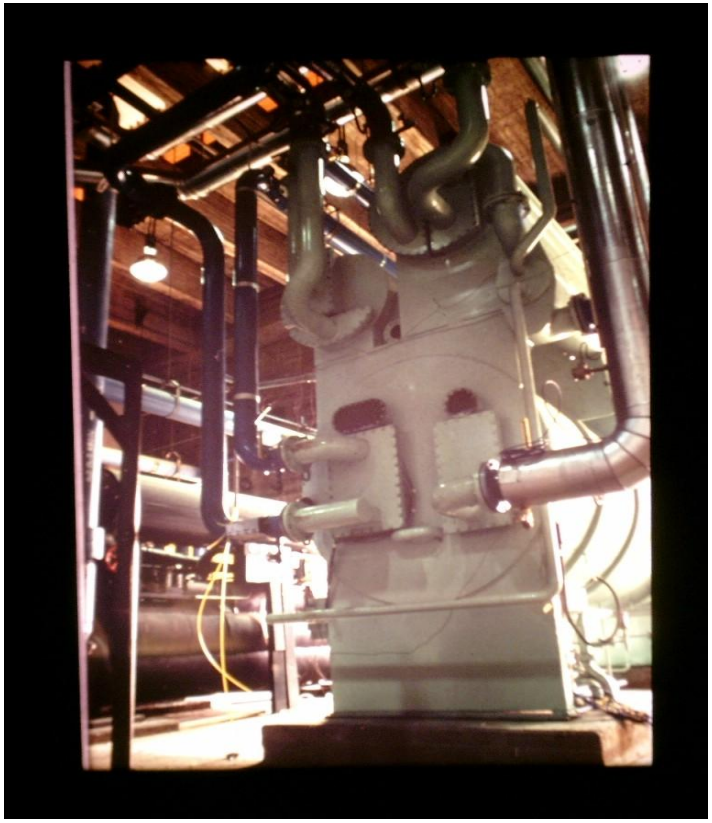
Prototype 50 TR (175 kW) Solar Absorption Cooling System, Tadiran ASD





Tadiran ASD Solar Cooling Project

200 TR (700 kW) Solar Absorption Cooling System at Tel-Hashomer Hospital, Israel



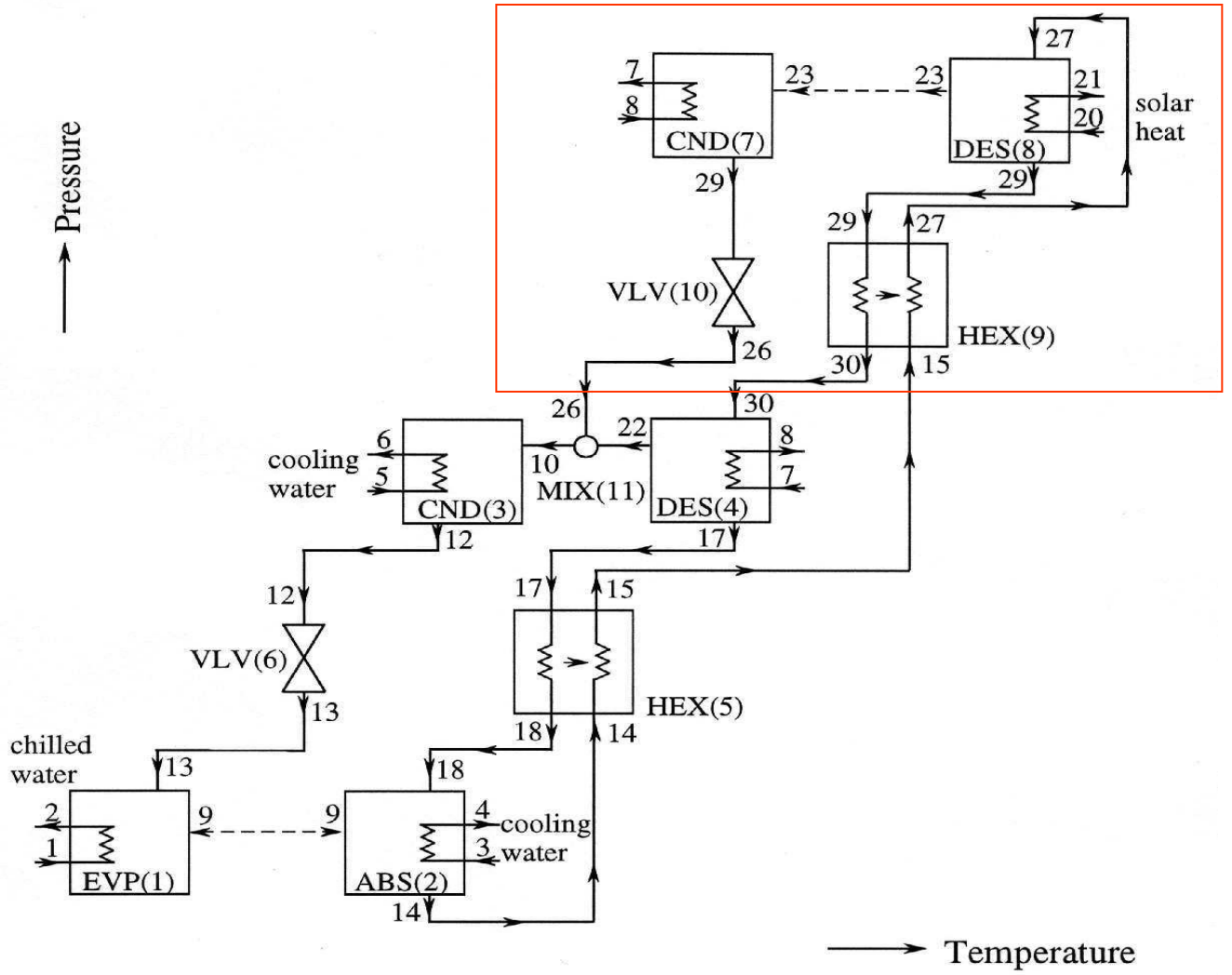
Absorption Systems – first cooling machines in History

- Chemical Heat Pumps – as early as 18th century
- First continuously operating refrigerators – Edmond and Ferdinand Carrè ~1860
- Gas-fired NH_3-H_2O domestic refrigerators up till ww2
- Large-scale H_2O-LiBr chillers powered by waste heat and solar
- Multi-effect gas-fired chillers for A/C ~1980's and on
- Domestic NH_3-H_2O heat pump development

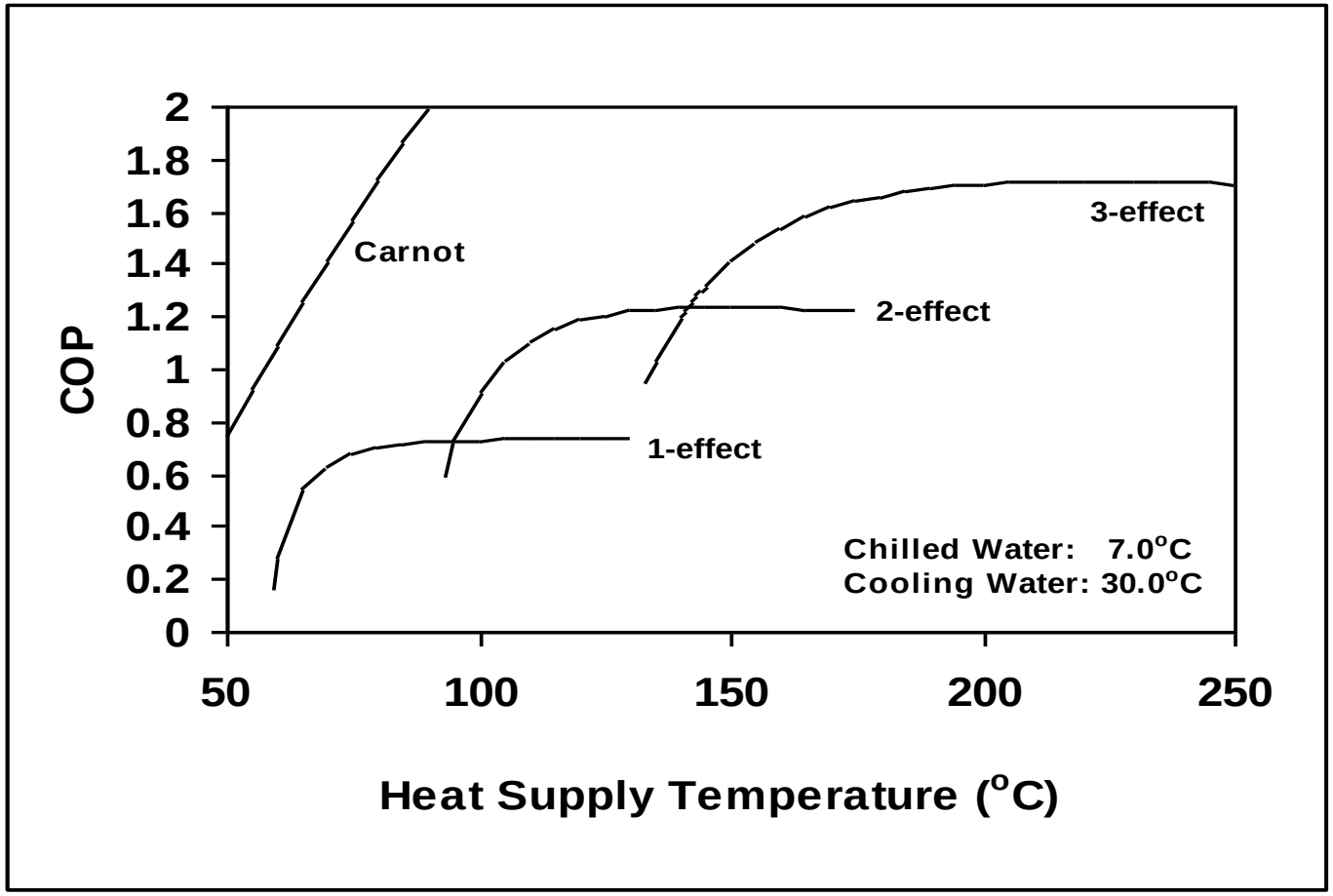
Absorption Multi-Staging

- Staging required to benefit from hi-temp heat source

- Double-effect chillers: Series and parallel connections
- Triple-effect systems
- Cascading



Multi-Staging allows improved performance with high heat source temperatures



Research Needs

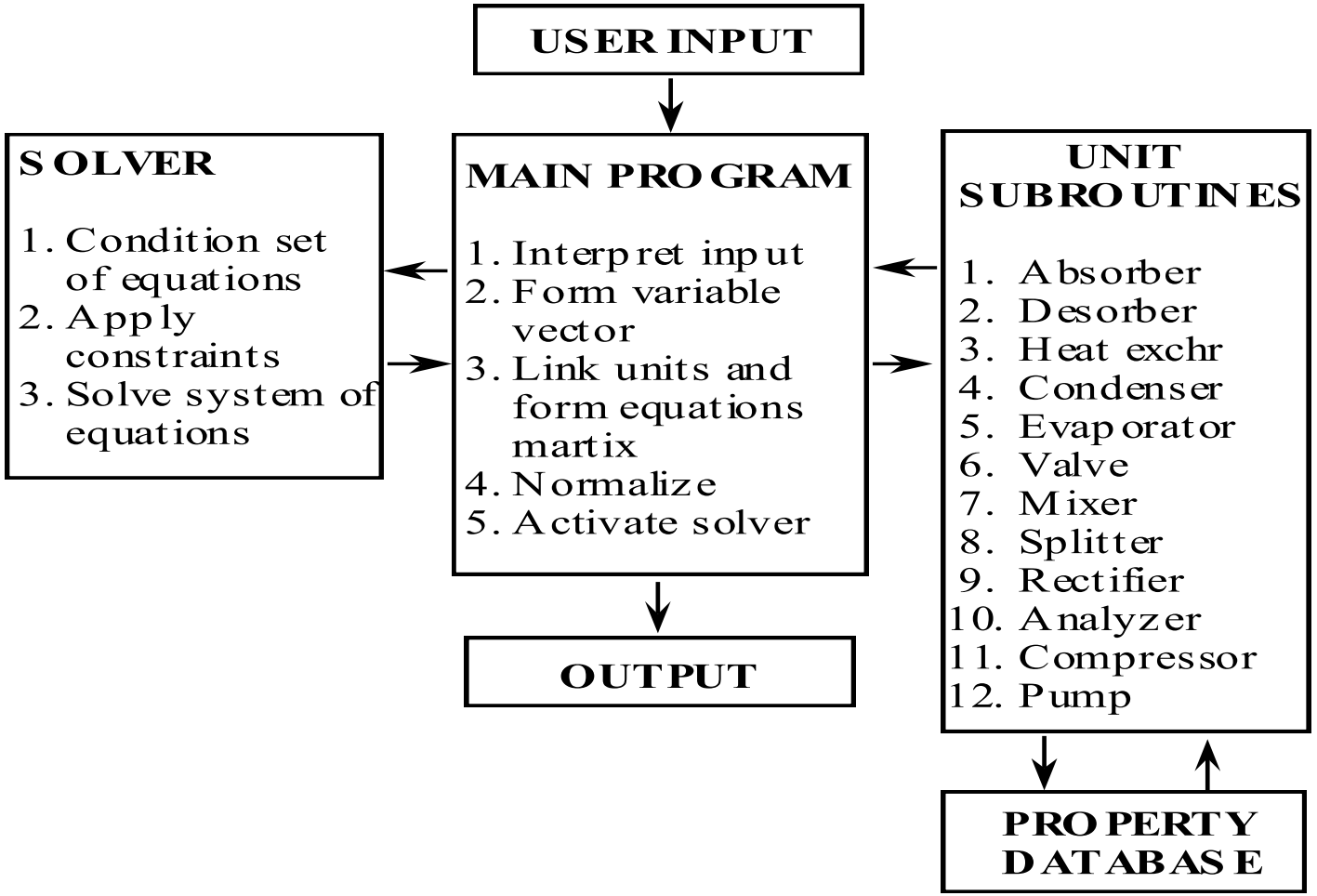
- Advanced cycles
- Advanced fluids
- Heat and mass transfer in absorption/desorption
- System simulation

ABSIM

Modular Simulation Tool for Absorption and other Thermal Systems

- User-oriented, modular and flexible
- Evaluate different cycle configurations and working fluids
- Evaluate system performance in off-design conditions
- Perform preliminary design optimization
- Check control strategies

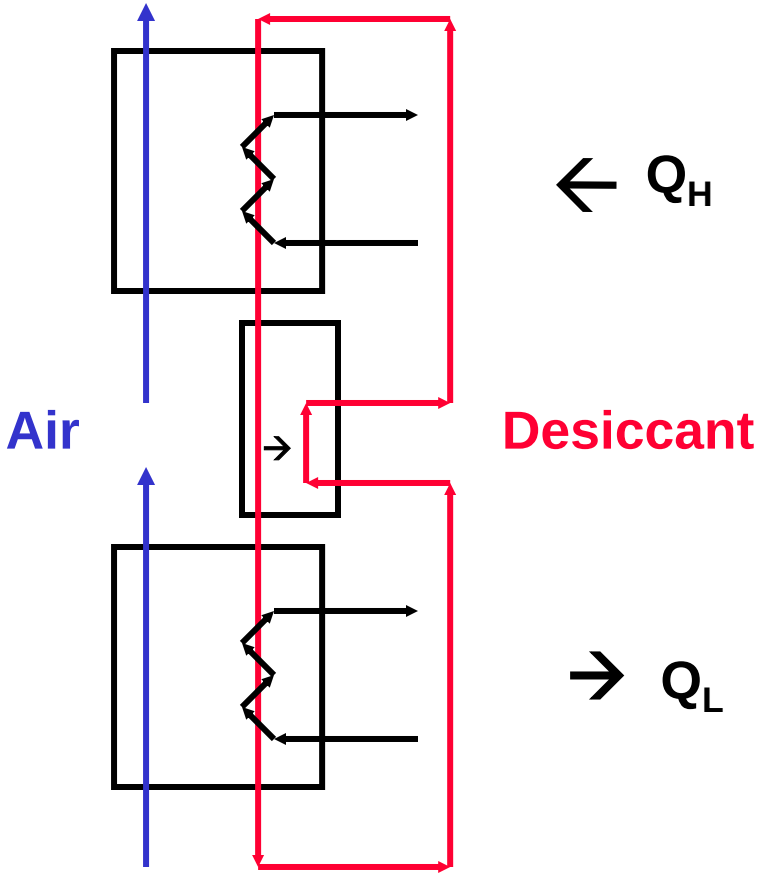
ABSIM - Program Structure



Alternative Approach to A/C

- Roles of Air conditioning: Reduce temperature and humidity
- Hybrid operation possible; independent control of temperature and humidity
- Latent load conventionally treated by cooling process air below its dew point
- Desiccant dehumidification performed at ambient temperature; can be powered by low grade solar or waste heat

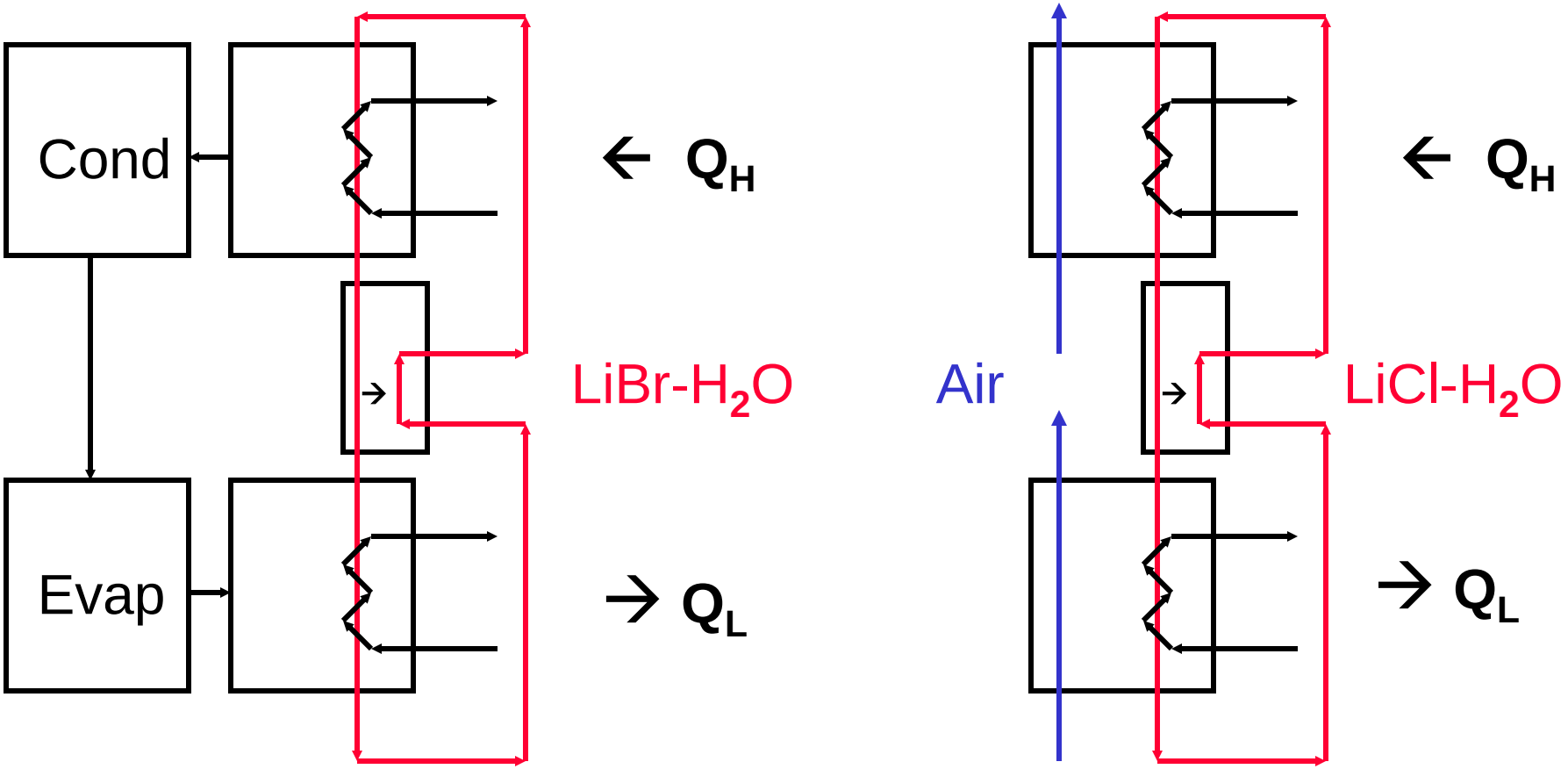
Desiccant System Principle



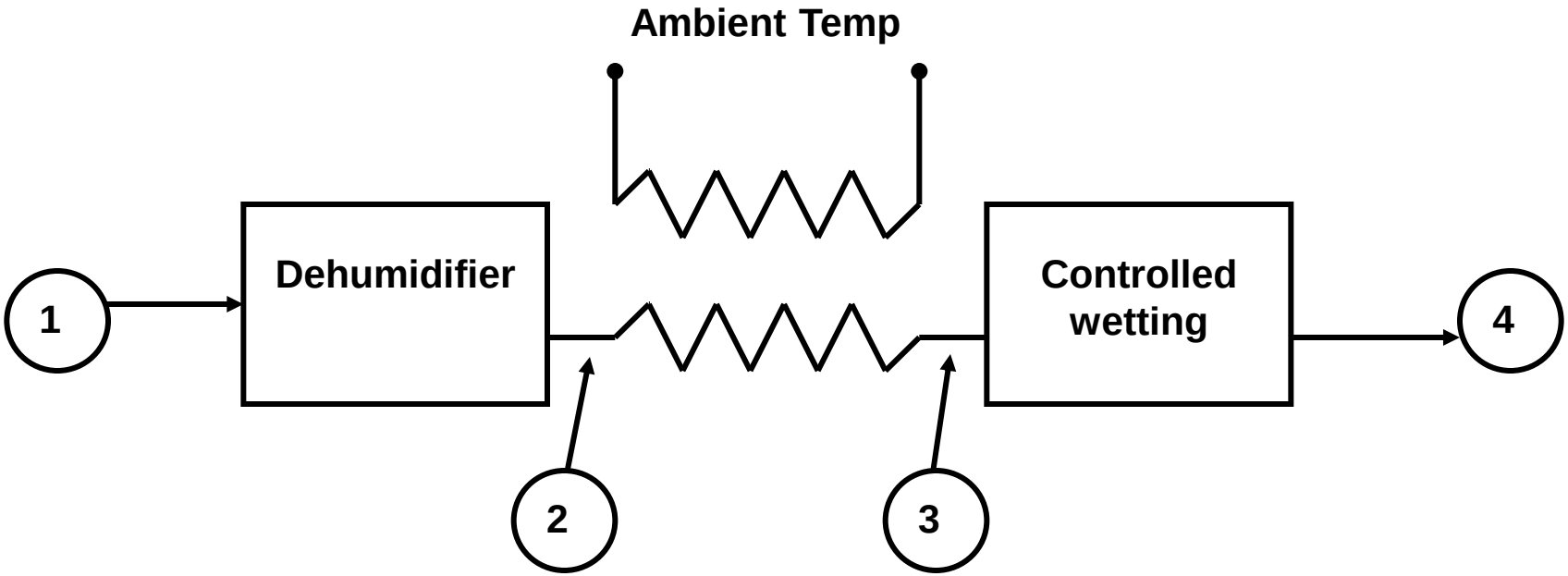
Two types of Desiccants

- Adsorbent
- Absorbent

Liquid Desiccant vs. Absorption



Cooling by controlled drying and wetting



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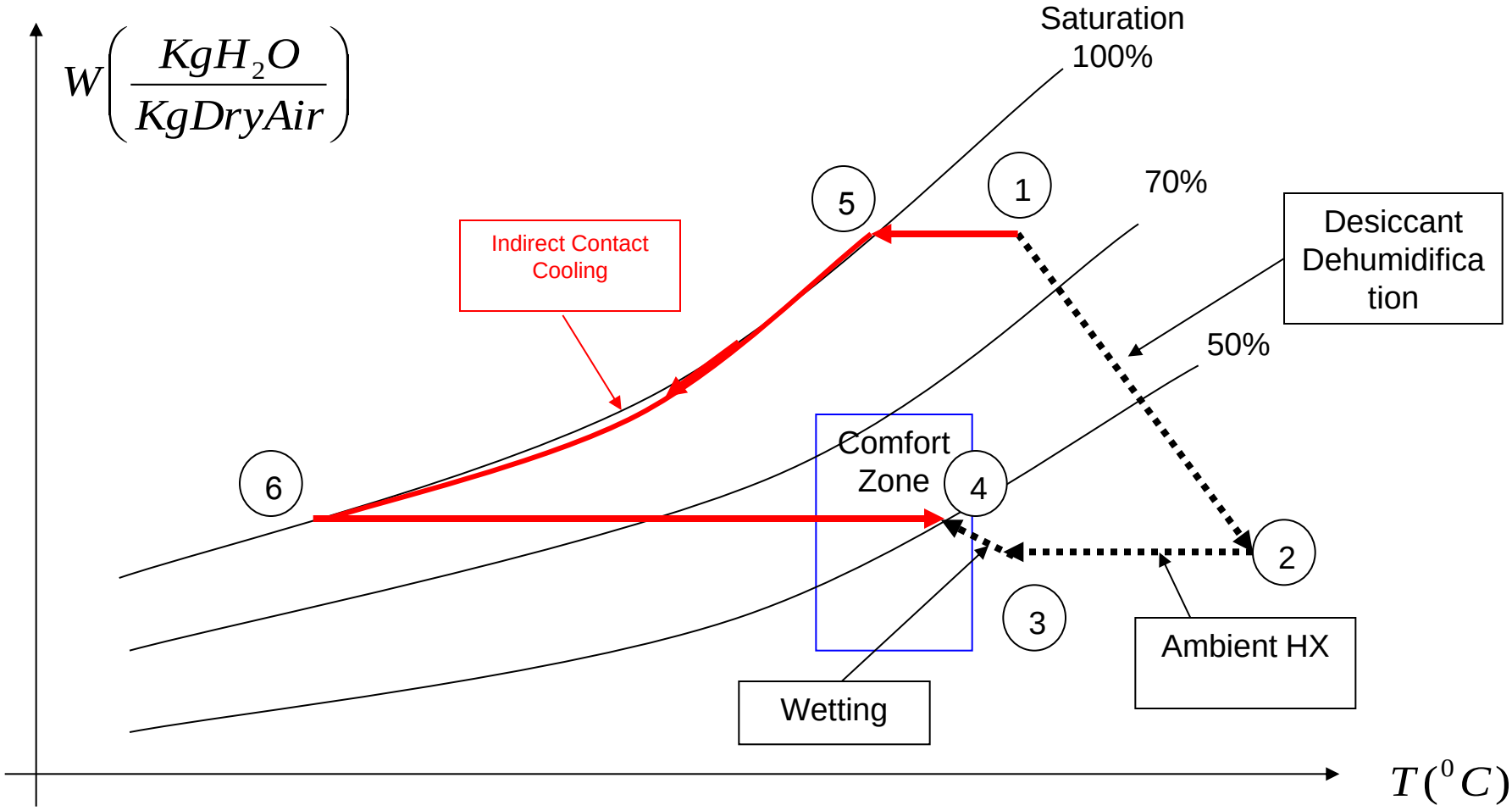
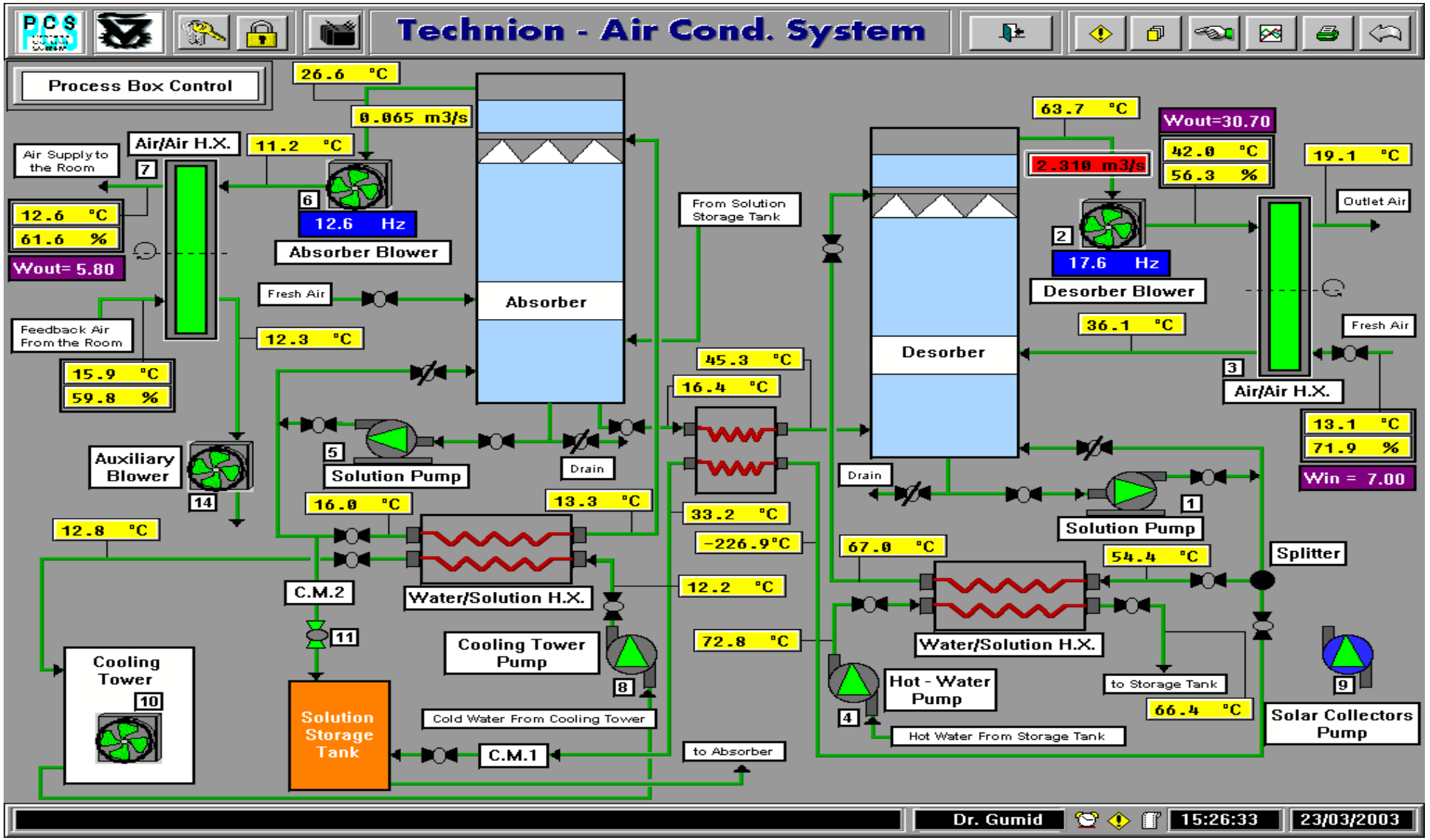


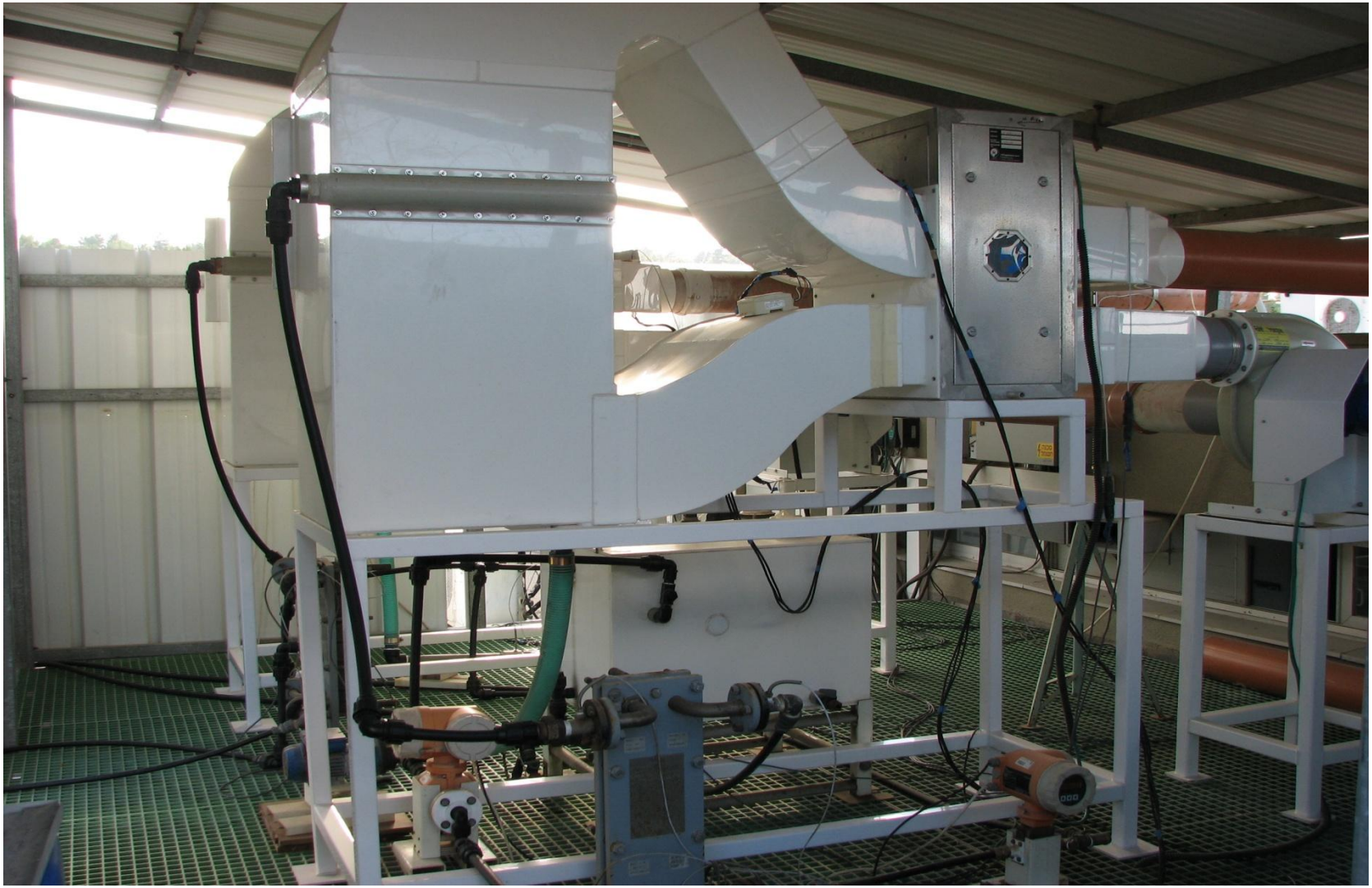
20-kW Solar Liquid Desiccant System at Technion, Haifa, Israel

Control Unit - View of Computer Screen

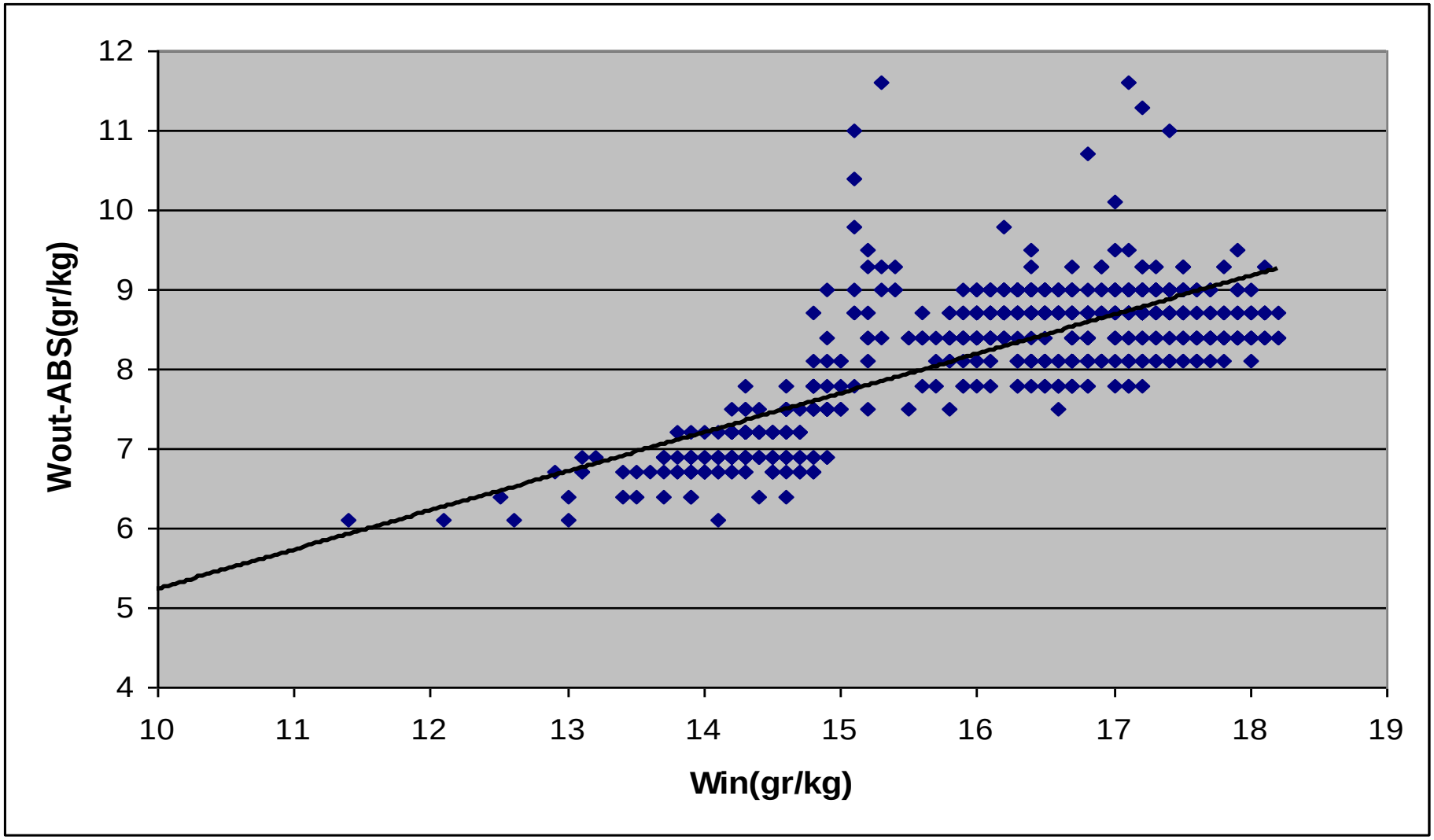


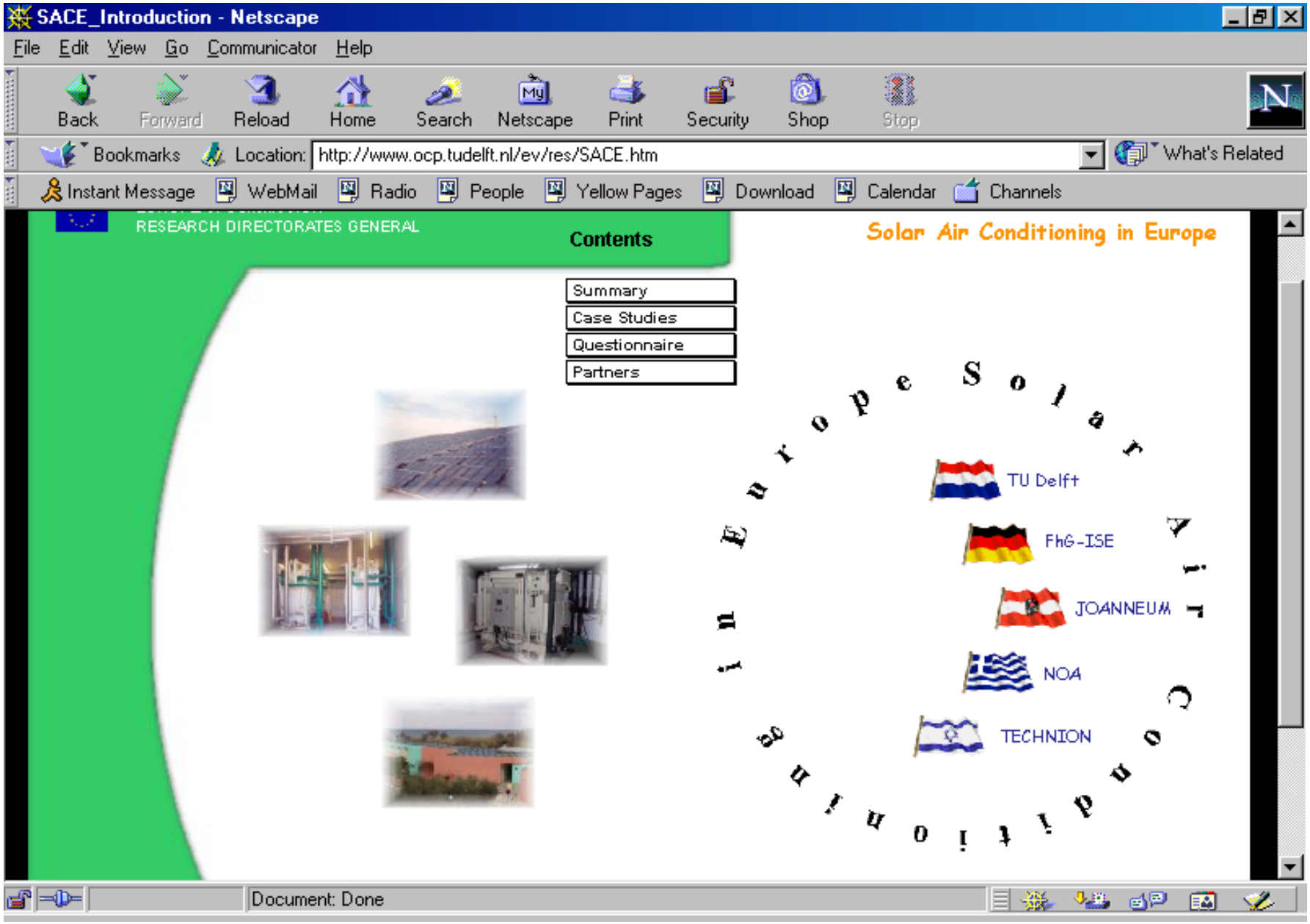
Solar Collector Field

Liquid Desiccant System



Experimental Results – Supply air Humidity

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Application
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Cooling Techniques
Cooling
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Solar Collector Typologies
Collector
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Evaluation
Available Projects in selected Location: ALL COUNTRIES
Short Description
SARANTIS Inofita Viotias HELLAS
ADSORPTION SOLAR AIR-CONDITIONING OF A COSMETICS FACTORY
This is the largest solar cooling installation at a Hellenic cosmetics factory, completed in 1999. The facility includes a total area of 2700 sq. metres flat plate selective surface solar collectors, coupled with two adsorption chillers (350 kW each) for covering 40% of the total cooling load of the factory (total airconditioned area 22000 sq. metres and 130000 cub.metres). The peak cooling load is estimated at 1750 kW. The adsorption chillers were selected since they require a lower heat supply. In summer, the solar collectors supply water at 70-75 deg. Celcius and the adsorption chillers produce water at 10-14 deg. Celcius, which is then supplied to the indoor air handling units (heat exhangers have been oversized to facilitate operation at relatively high chilled water supply temperature). Dehumidification is not a major concern, given the local weather conditions. The backup cooling system consists of three, 350 kW each, compression chillers. Two oil-fired boilers (1200 kW each) are available for back-up heating system, although given the oil prices, the compression chillers are used instead. In winter, the

Additional Reading

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ISRAEL SUSTAINABLE ENERGY SOCIETY | האגודה הישראלית לאנרגיה מתחדשת

ISES

Popular article in Hebrew: www.ises.org.il/solar-ac

Policy issues:
The Samuel Neaman Institute:
www.neaman.org.il

The End

Thank You for Your Attention!