Solar Absorption Cooling / Heating System for the Intelligent Workplace

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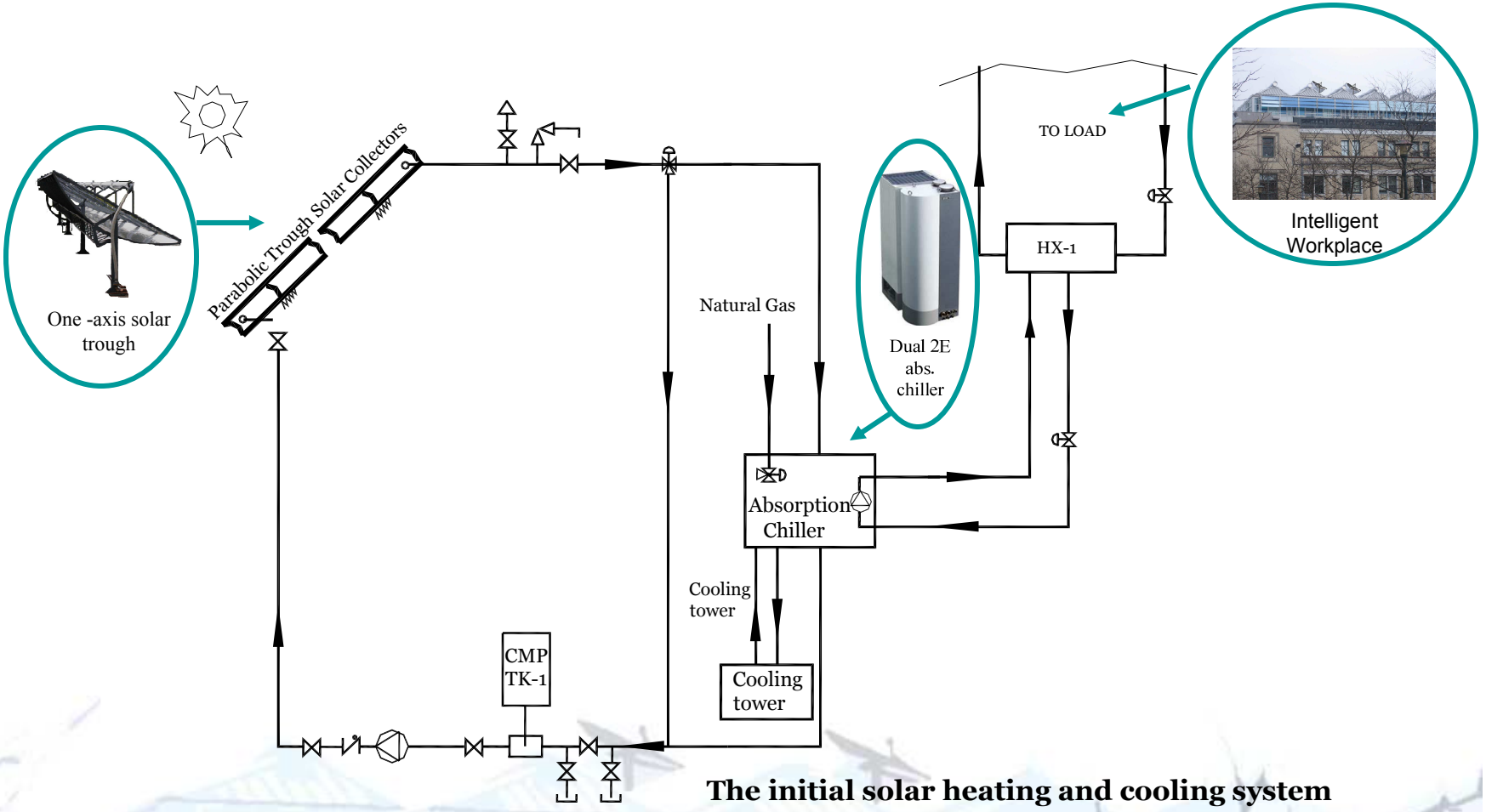
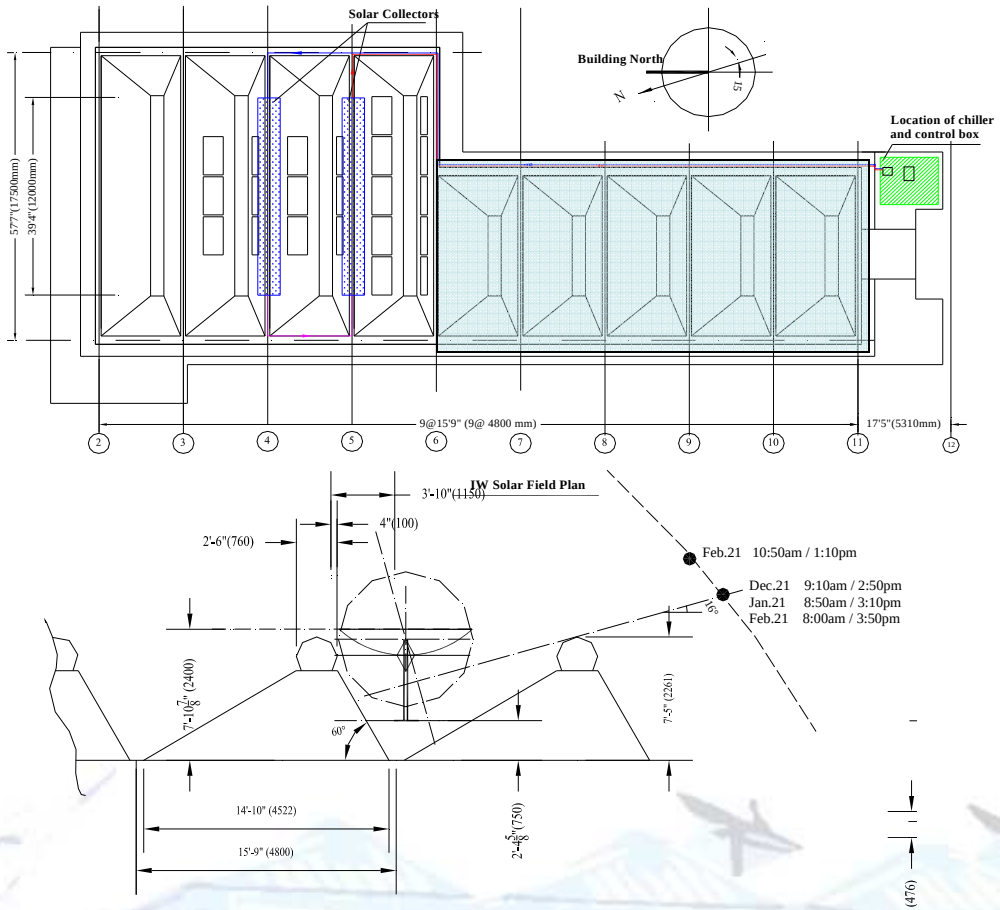
IW solar cooling/heating system



The initial solar heating and cooling system

Intelligent workplace



The Robert L. Preger Intelligent Workplace

- latitude: North 40.26◦
  longitude: –79.56◦
- Orientation: 15 deviation to east from the south
- area:650 m2 (7,000 ft2)

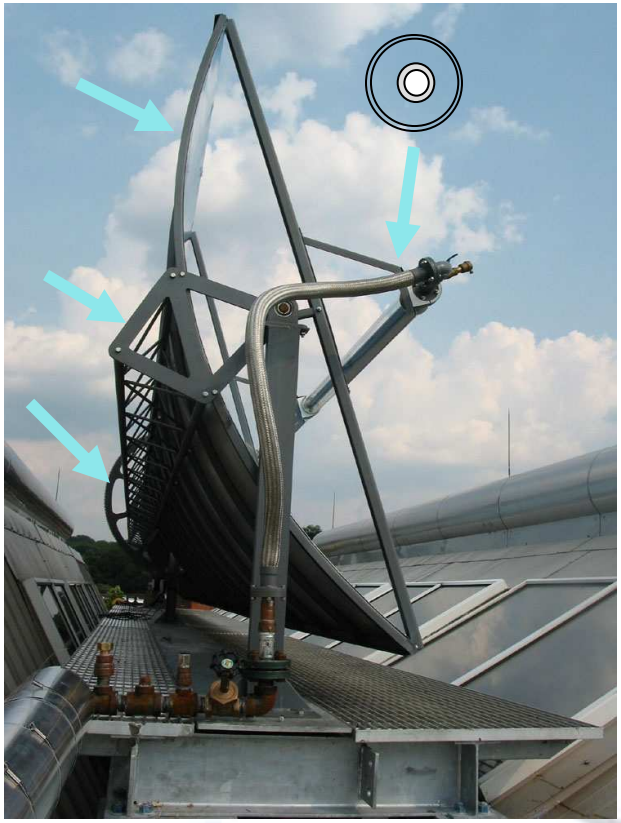
South zone

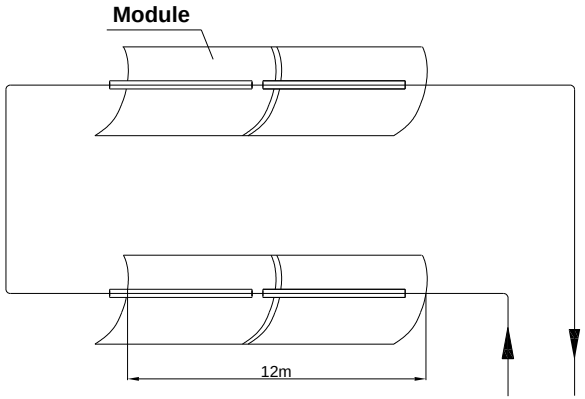
- area: 245 m2 (2,637 ft2)
- 9 offices and 1 conference space
- 30 people

PTSC Orientation

- E-W axis

Parabolic trough solar collector (PTSC)



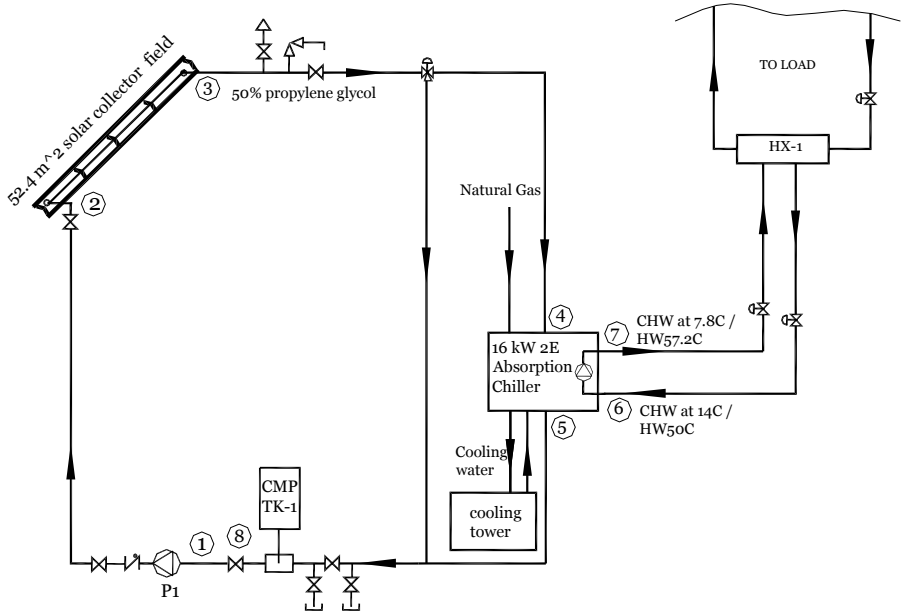


- **Each module includes**
  - parabolic trough reflector
  - receiver pipe, surface treated
  - steel support structure
  - single axis drive
- **4 modules, total 52.44 m2**
- **Installed in series**
- **Piping length:85m**

Dual fired D.E absorption chiller

- 16 kW (4.55 tons)
- hot water driven or natural gas fired
- LiBr/H2O, sorbent; water, refrigerant
- double effect
- COP 1.0~1.2 at the rated condition
- cooling, heating modes
- heating efficiency 0.8~0.95

Solar cooling / heating system



P&ID Diagram of Solar Thermal System
(pressurized aqueous solutions of propylene glycol)

- 50% in volume of propylene glycol
- constant flow

	Cooling	Heating
Solar field pressure	0.85Mpa (123psi)	0.4Mpa (58psi)
Solar field temperature	$>T_{-HTR}$ (155C)	> 130C
CHW/HW supply/return	7C/14C	57C/50C

Design and procurement

Mass & Energy balance cal.

SOLAR THERMAL SUPPLY SYSTEMS
Material and Energy Balance Spread Sheets
(see Figure 4)

SUMMER Pressurized water
WINTER Heat Transfer Fluid

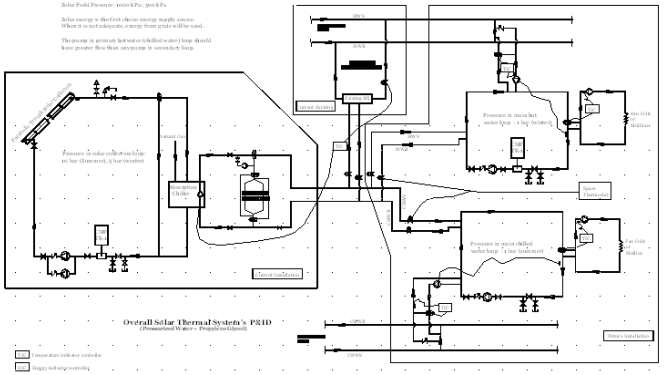
Thermodynamic Properties, Water at 165 °C (Sonntag, Fund of Termo, 6th edition p 674)

H_{sat}, kJ/kg	697.32
H_{satv}, kJ/kg	2763.53
c_{pl}, kJ/kg°C	4.369
c_{pv}, kJ/kg°C	1.054
η, m³/kg	0.001108
μ, kg/m sec	0.00016

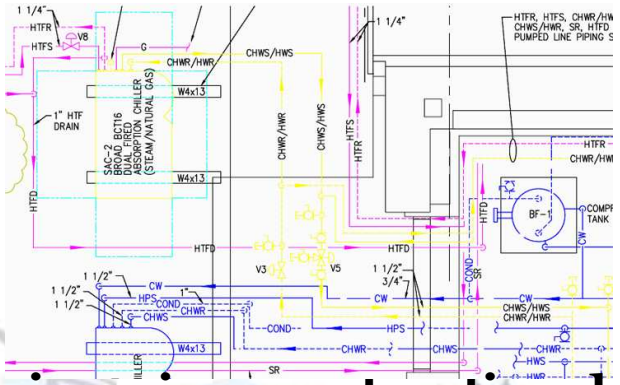
Area solar collectors, m²	52.44
Pump efficiency	0.7
Ambient temperature	20

Stream	Description	Pressure bar	Temperature °C	Flow kg/sec	Enthalpy kJ/sec, kW	Heat kW	Work kW	Solar Radiation W/m²	Absorption Efficiency	Heat kW	Comm
1	Solar collection loop water entering pump	10	165	0.3472	242.125						
2	Water entering solar collectors	8.88	165	0.3472	242.125				(from EES solution) 0.95777778		
						18.53		800	0.5020	21.06	
3	Water leaving soalr collectors	7.98	178.88	0.3472	263.185						
										53.36	
4	water entering chiller	6.84	177.22	0.3472	260.658						
									chiller COP		
									1.00		
5	water leaving chiller	6.04	166.5	0.3472	244.381	by passed					
						2.26					

Preliminary design



Equipment delivery



Engineering construction draw.

System construction and installation






PTSC mathematic model

$$\eta = \eta_{opt} - \frac{\dot{q}'_{thermalloss}}{\dot{q}'_i}$$

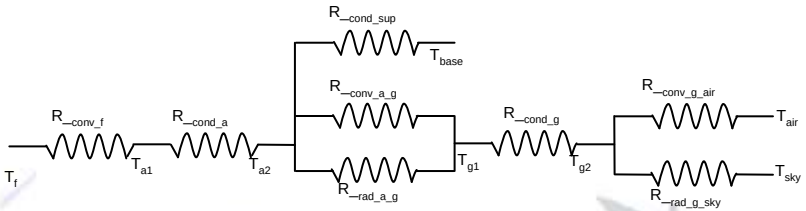
$$\dot{q}'_{thermalloss} = \dot{q}'_{rad\_g\_sky} + \dot{q}'_{conv\_g\_air} + \dot{q}'_{cond\_bracket}$$

$$\dot{q}'_{SolAbs\_g} + \dot{q}'_{cond\_g} = \dot{q}'_{conv\_g\_air} + \dot{q}'_{rad\_g\_sky}$$

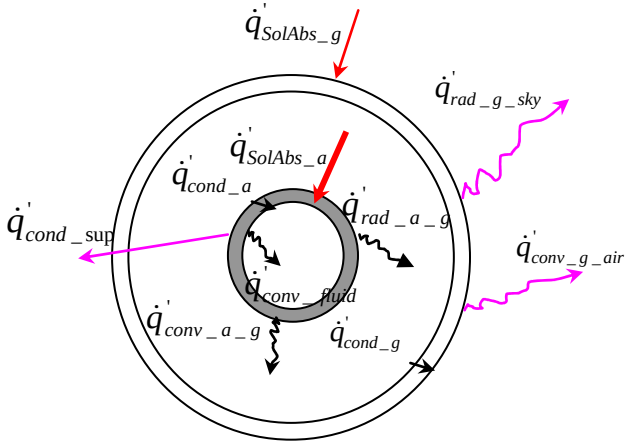
$$\dot{q}'_{cond\_g} = \dot{q}'_{conv\_a} + \dot{q}'_{rad\_a}$$

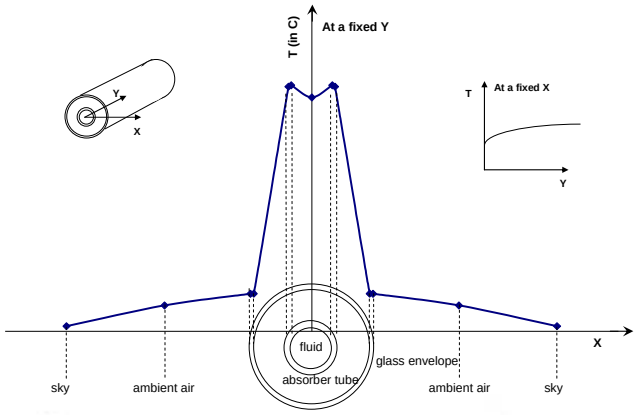
$$\dot{q}'_{SolAbs\_a} = \dot{q}'_{conv\_a} + \dot{q}'_{rad\_a} + \dot{q}'_{cond\_a} + \dot{q}'_{cond\_bracket}$$

$$\dot{q}'_{cond\_a} = \dot{q}'_{conv\_fluid}$$



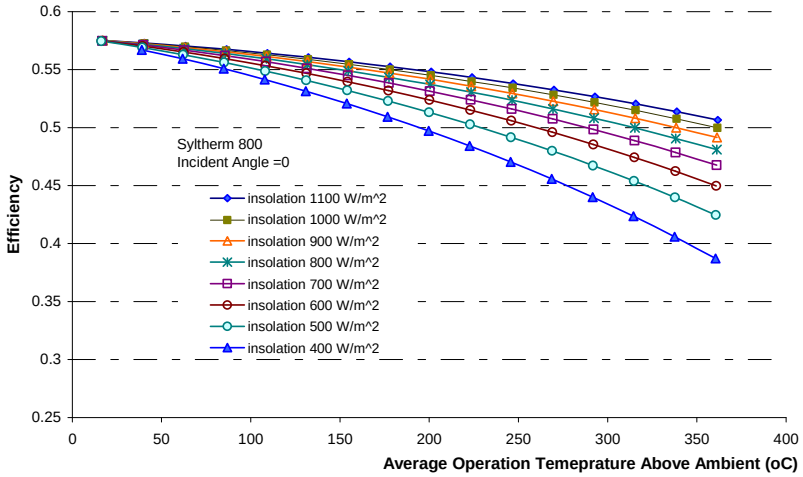
The thermal network



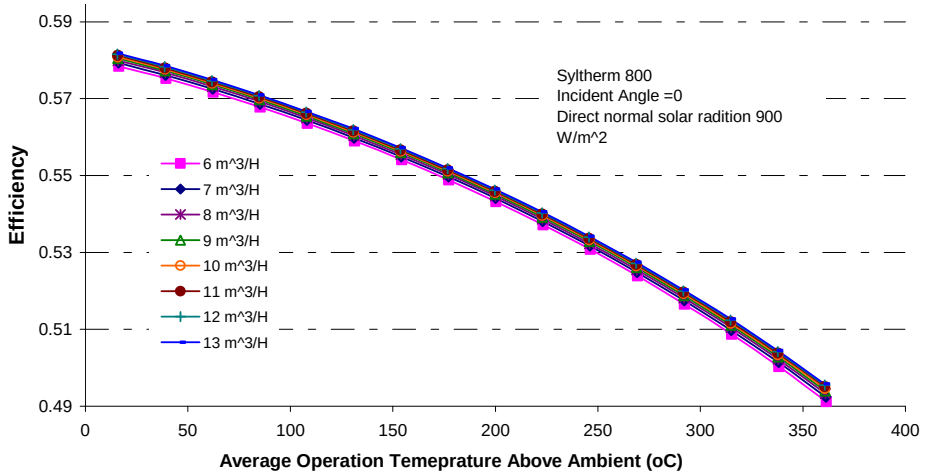


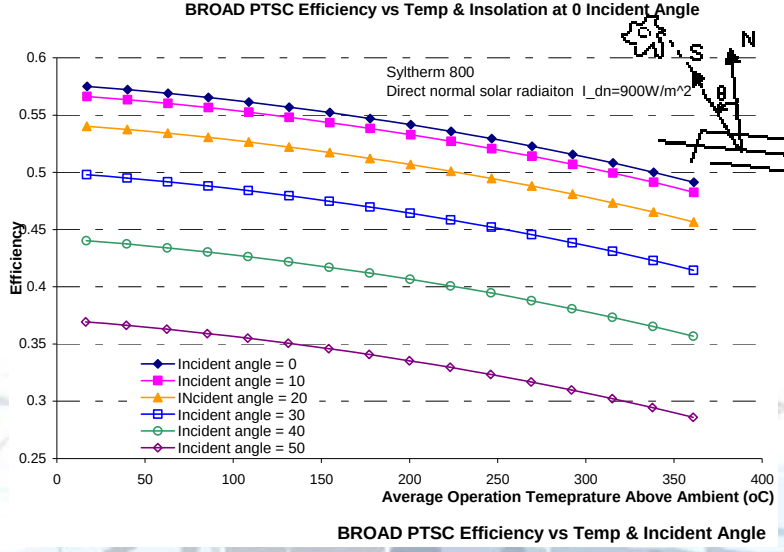
$$T_{a\_out} > T_{a\_in} > T_{fluid} > T_{g\_in} > T_{g\_out} > T_{\infty} > T_{sky}$$

Predicted PTSC performance

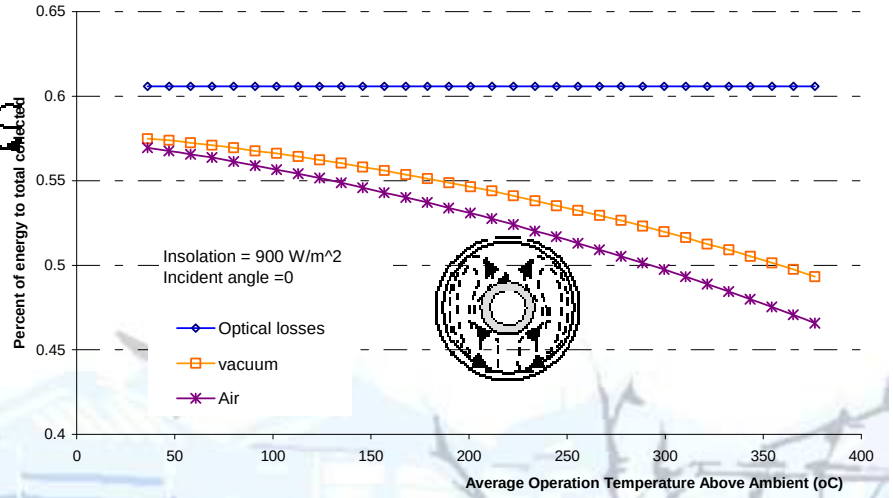


BROAD PTSC Efficiency vs Temp & Insolation at 0 Incident Angle



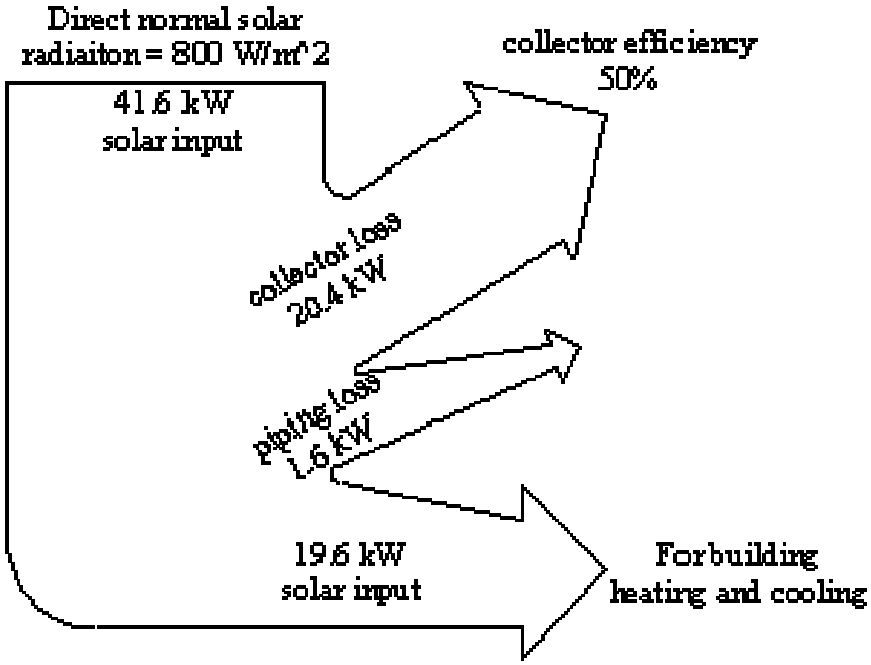


BROAD PTSC Efficiency vs Temp & Incident Angle

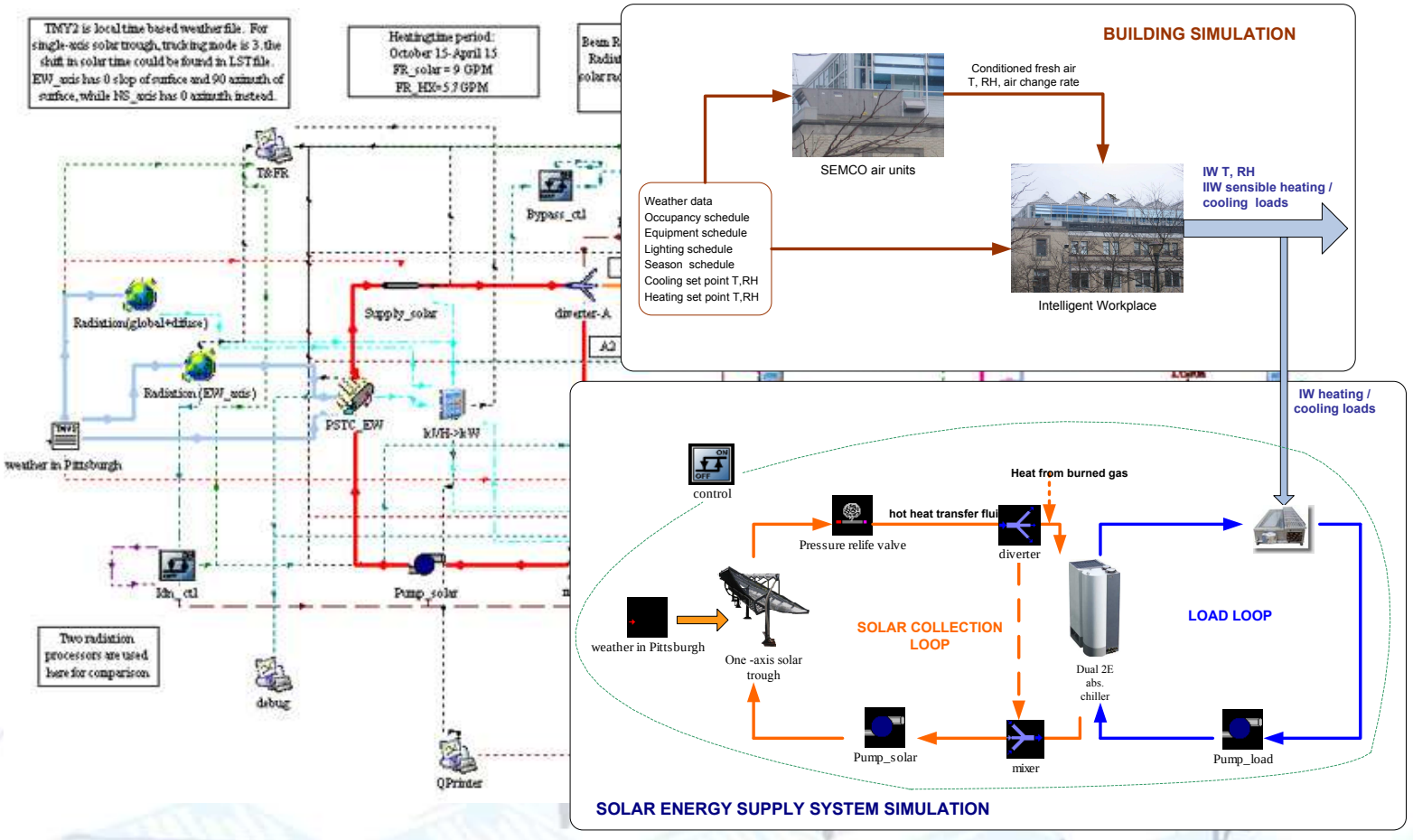


Solar collector efficiency & air in the annular space

Predicted energy accounting by model



Preliminary system simulation

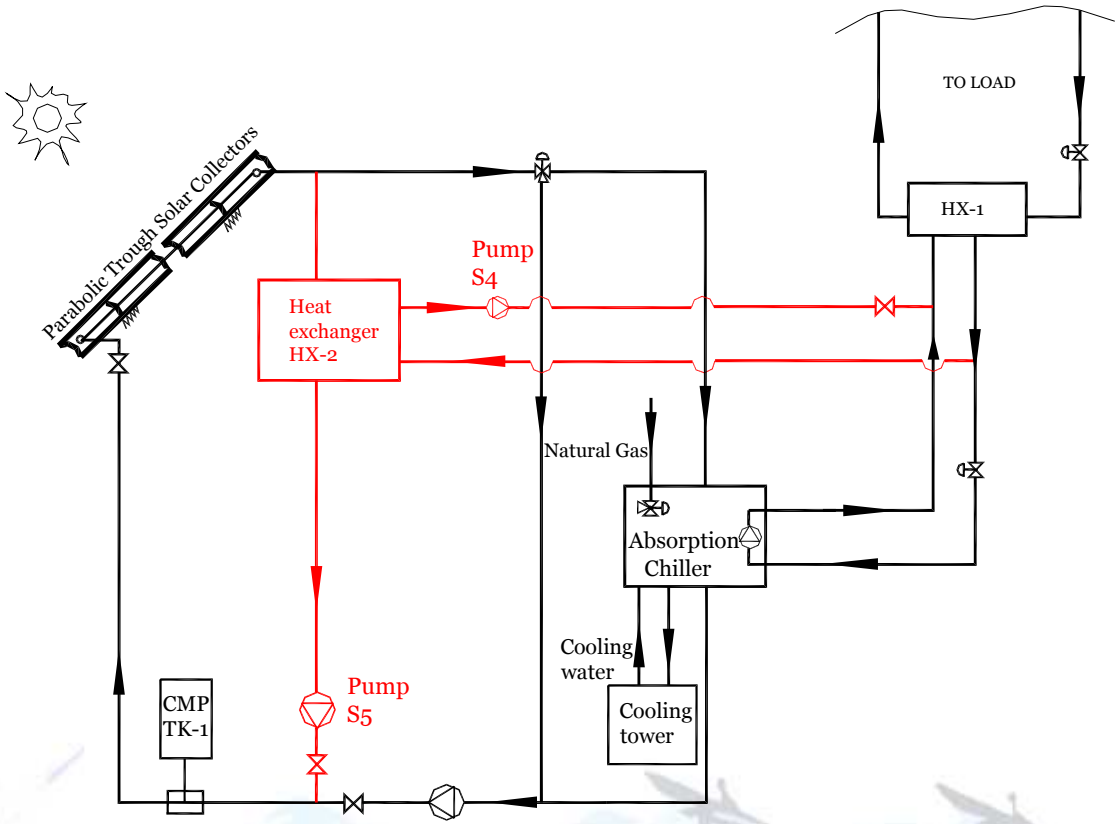


Information flow of TRNSYS simulation

Estimated IW solar system performance by system simulation

IW solar cooling and heating system might cover 39-50% of cooling load and 5-30% heating based on the system simulation.

System also designed for experiments



Installed HX-2 to

- Validate PTSC model
- Evaluate system simulations
- Compare absorption chiller vs HX for space heating

Where are we?

- Completed system installation
- Commissioned the system, solar field has be operated at above 150C driving 16kW D.E absorption chiller.

Where are we going ?

- Integration with cooling and heating devices
- Integration of energy supply systems like solar energy, bio-diesel energy supply system
- System simulation including the integration of various energy supply systems to help design.
- Economic of solar cooling and heating
- System design, evaluation of a given application

Questions?

Experiments to validate PTSC model

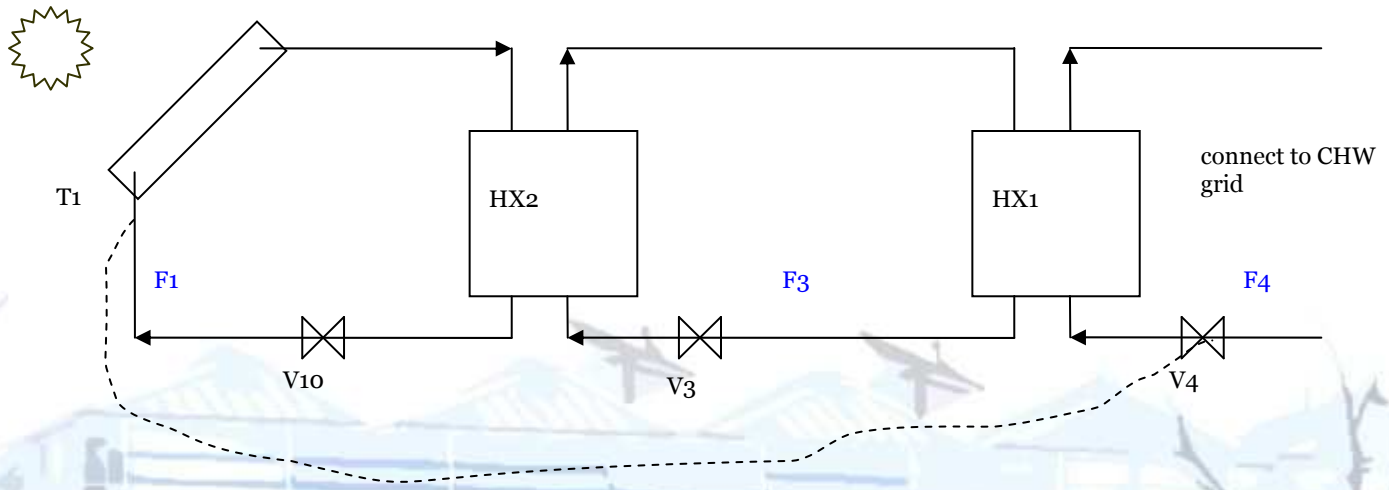
Measure PTSC efficiency

- optical efficiency
- (no thermal loss)
- at various elevated temperature
- at different incidence angle

Thermal loss

- at various elevated temperature
- through piping

Heat capacity



Experiments to evaluate system simulation

Measure system performance for daily or seasonal operation

- Different load profile
- Solar radiation
- control strategy