

# Solar Cooling and Heating System in the IW

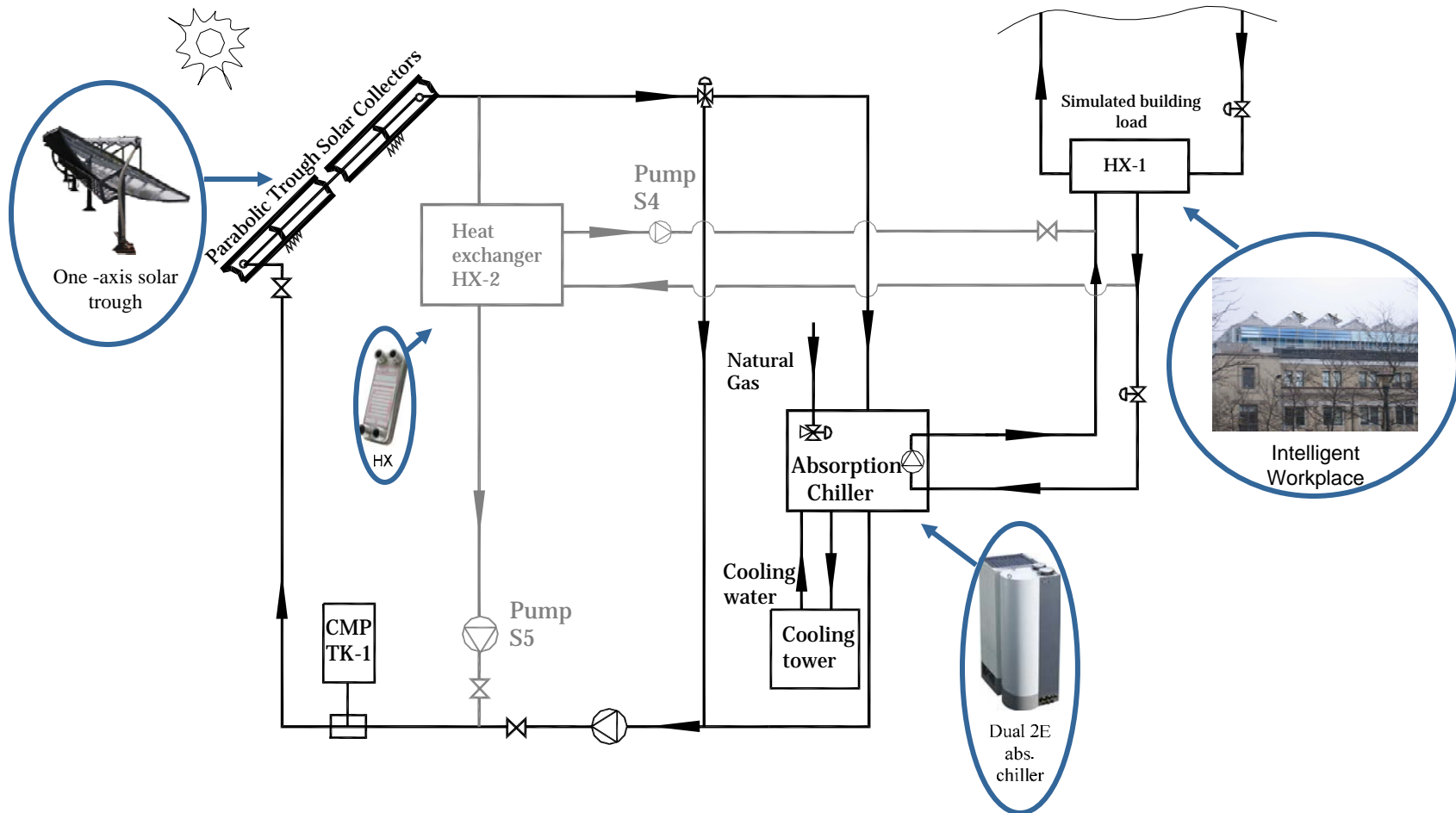
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Ming Qu

Center for Building Performance and Diagnostics

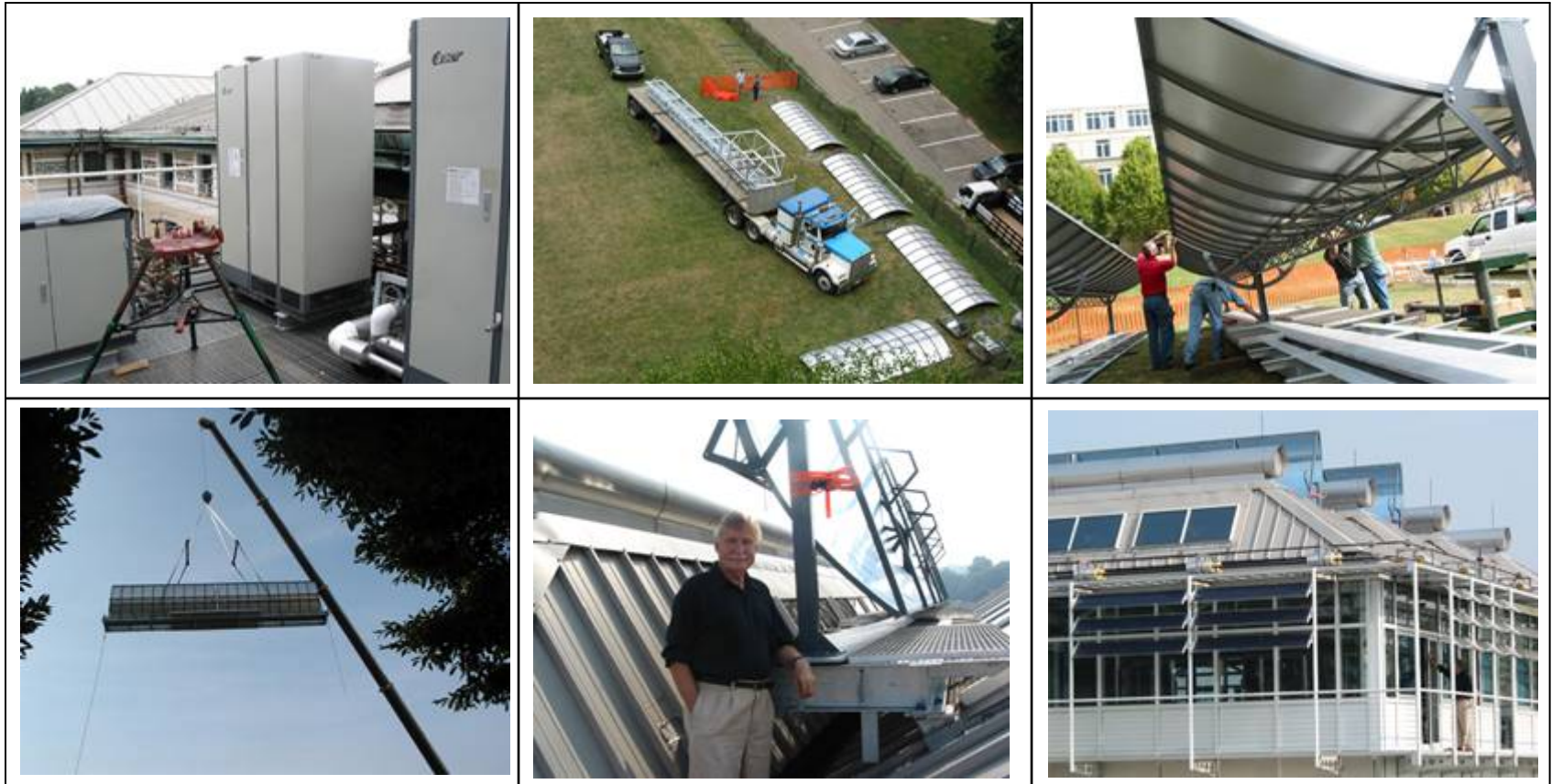
Dec.12,2007

# Solar cooling and heating system installed in IW

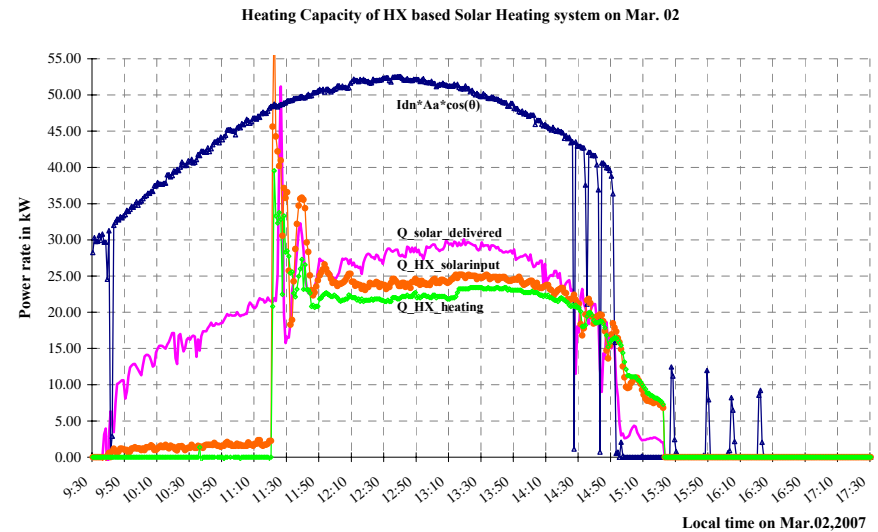
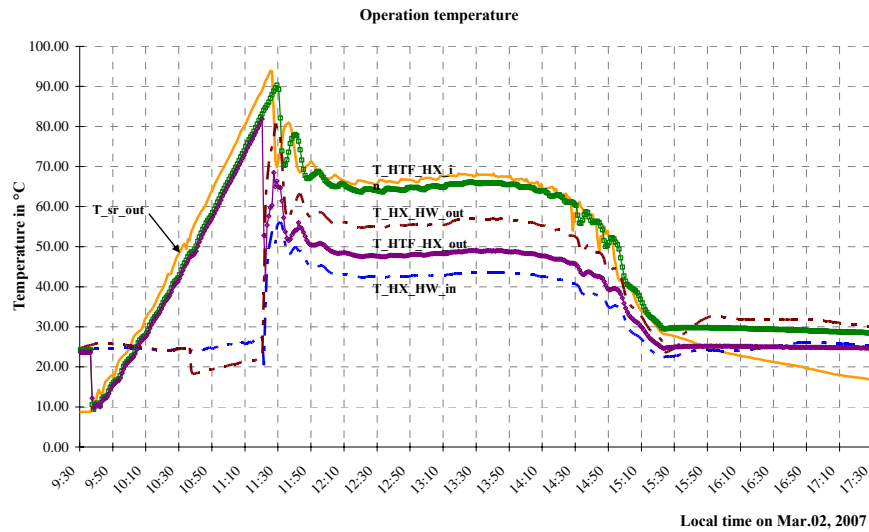


# System installation

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# The results of solar heating daily test by using HX



	Solar + HX heating	Solar + absorption chiller heating
Q_useful (kW)	16 ~29	15~19
Operation hours (hrs/day) in March	5	2
Storage is possible	yes	not quite

# PTSC model

## Energy balance analysis and heat transfer

$$\dot{q}'_{focs} = \frac{I_{DN} * r * R * IAM * A_a}{L}$$

$$\dot{q}'_{abs\_g} = \dot{q}'_{focs} * \alpha_g$$

$$\dot{q}'_{ref\_g} = \dot{q}'_{focs} * R_g$$

$$\dot{q}'_{tra\_g} = \dot{q}'_{focs} * \tau_g$$

$$\dot{q}'_{abs\_a} = \dot{q}'_{tra\_g} * \alpha_a$$

$$\dot{q}'_{Abs} = \dot{q}'_{abs\_a} + \dot{q}'_{abs\_g}$$

**Total absorbed solar energy**

$$\dot{q}'_{Thermoloss} = \dot{q}'_{rad\_g\_sky} + \dot{q}'_{conv\_g\_air} + \dot{q}'_{a\_connection}$$

$$\dot{q}'_u = \dot{q}'_{Abs} - \dot{q}'_{thermoloss}$$

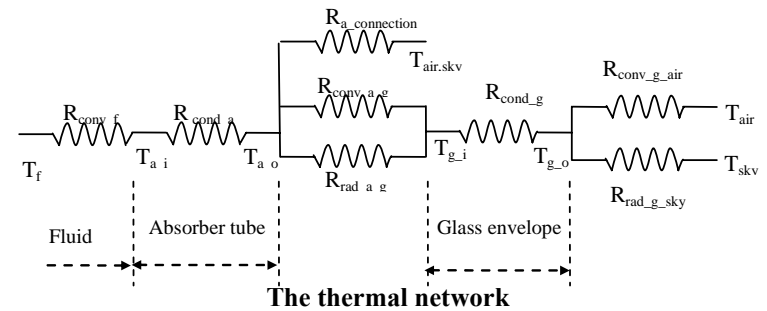
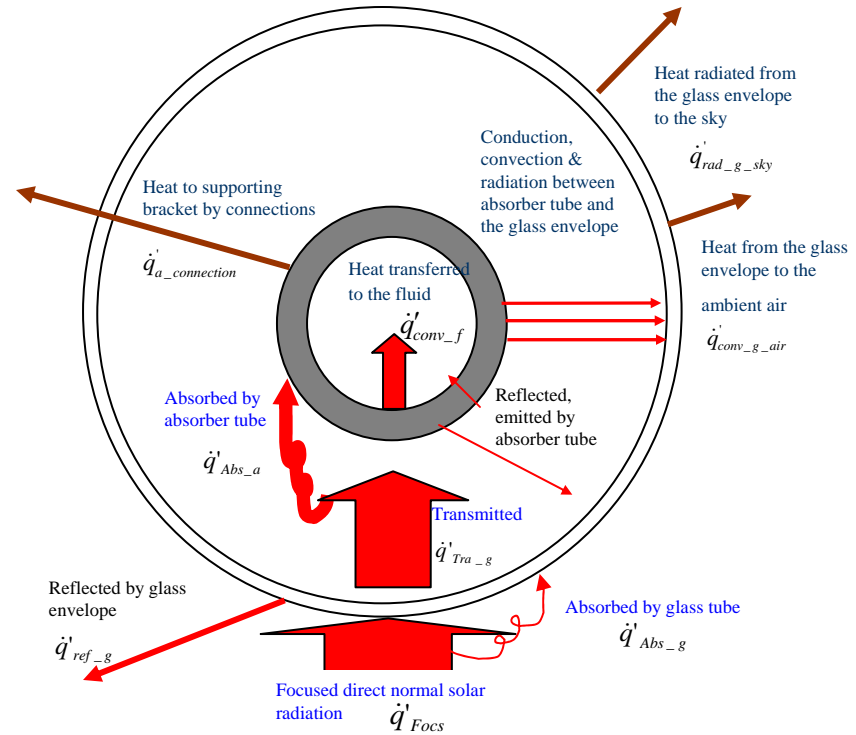
$$\eta = \frac{\int \dot{q}'_u * L * dt}{A_a \int I_{dn} * dt}$$

**PTSC efficiency**

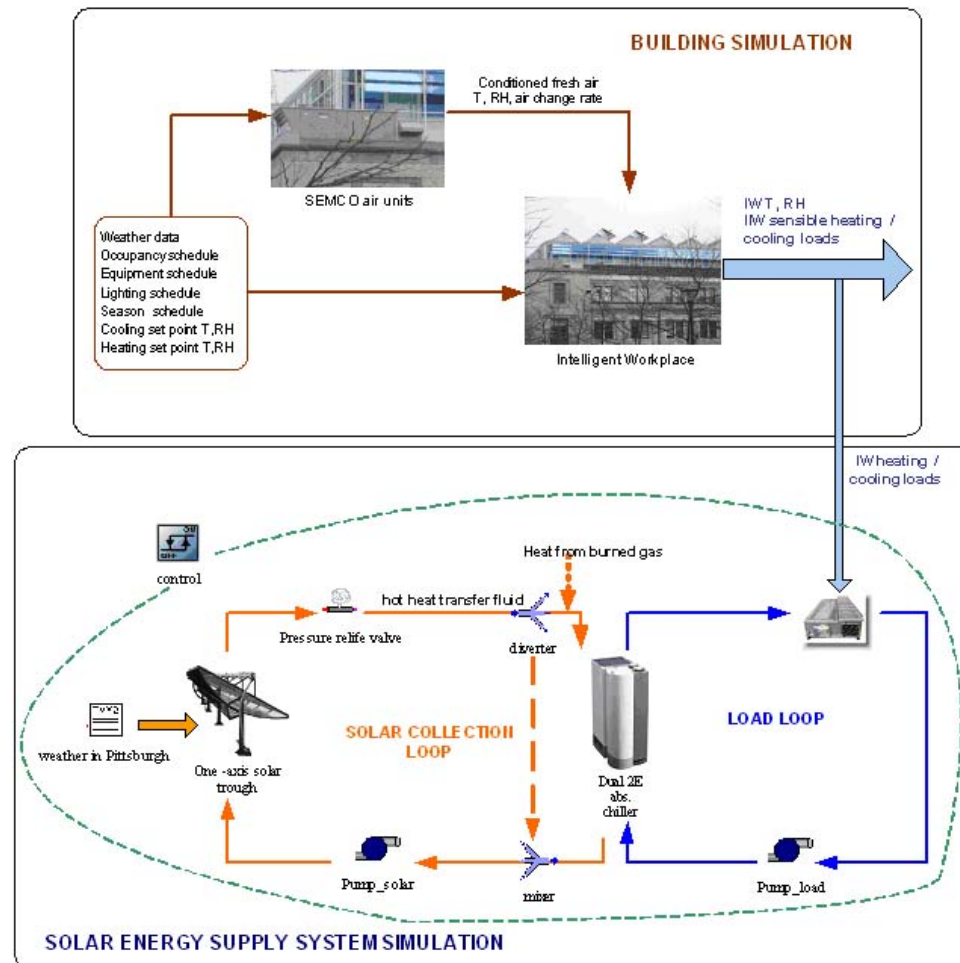
$$\dot{q}'_{abs\_g} + \dot{q}'_{rad\_a\_g} + \dot{q}'_{conv\_a\_g} = \dot{q}'_{rad\_g\_sky} + \dot{q}'_{conv\_g\_air}$$

$$\dot{q}'_{abs\_a} = \dot{q}'_{rad\_a\_g} + \dot{q}'_{conv\_a\_g} + \dot{q}'_{conv\_a\_fluid} + \dot{q}'_{a\_connection}$$

**Energy balance in two independent C.V.**



# TRNSYS system performance model



# Findings in the PTSC

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- the **tracking system** is not completely effective
- the **properties of material** greatly impact on the performance of PTSC, the absorptivity of glass envelope is relative high
- the thermal loss from **connections** between absorber tubes is high, almost the same level as convection or radiation from the glass envelope to the surroundings.
- the **vacuum** in annular space between the absorber pipe and glass envelope improves the efficiency between 3~5%
- the **wind velocity** greatly impacts the thermal loss from the PTSC to the surroundings by convection
- the **glass envelope** plays important a role in improving the PTSC's efficiency when the operating temperature is high.

# Guidelines for design and operation of solar absorption cooling/heating system

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- **Orientation of the solar collectors**
  - Solar cooling dominated system: N/S orientation; Solar heating dominated system: E/W orientation
- **Thermal storage in solar heating and cooling system**
  - It significantly improves the system performance by means of shifting available solar heat for space heating and improves operational stability for cooling
- **Drain back system recommended**
  - It reduces both the night time heat loss from the system and the warm up time the next morning
- **Size and diameter of pipe in the solar collection loop**
  - The length and diameter of the pipe in the solar collection loop should be designed as short and as small as possible
- **System operation and control**
  - Constant-outlet-temperature can effectively shorten the preheating time of system. Its advantage, however, is not as significant if the heat capacity of system is small.
- **HX based solar heating better than absorption chiller based heating**
  - HX based solar heating significantly reduces heat losses and increases the efficiency of solar heating