SOLARCOOLING WORKSHOP 2014 Brisbane

AIRAH

Venue host

CSIRO

Design and Implementation of a Retrofit Solar-Assisted HVAC System for Residential Applications

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Summary

- Overview of Solar Decathlon Competition
- ‘The Journey to Datong’
- The Team UOW *Illawarra Flame House*
- Photovoltaic Thermal System and Phase Change Energy Storage systems
- Solar Assisted HVAC System
  - Design
  - Modelling
  - Initial results

THE SOLAR DECATHLON

- A competition for University students to design, build and operate sustainable, net-zero energy, attractive and affordable homes.
- Objective: accelerate the development and adoption of advanced building technologies.
- Since 2002:
  - 8 competitions
  - 5 in US
  - 2 in Europe
  - 1 in China
- Total of 164 teams

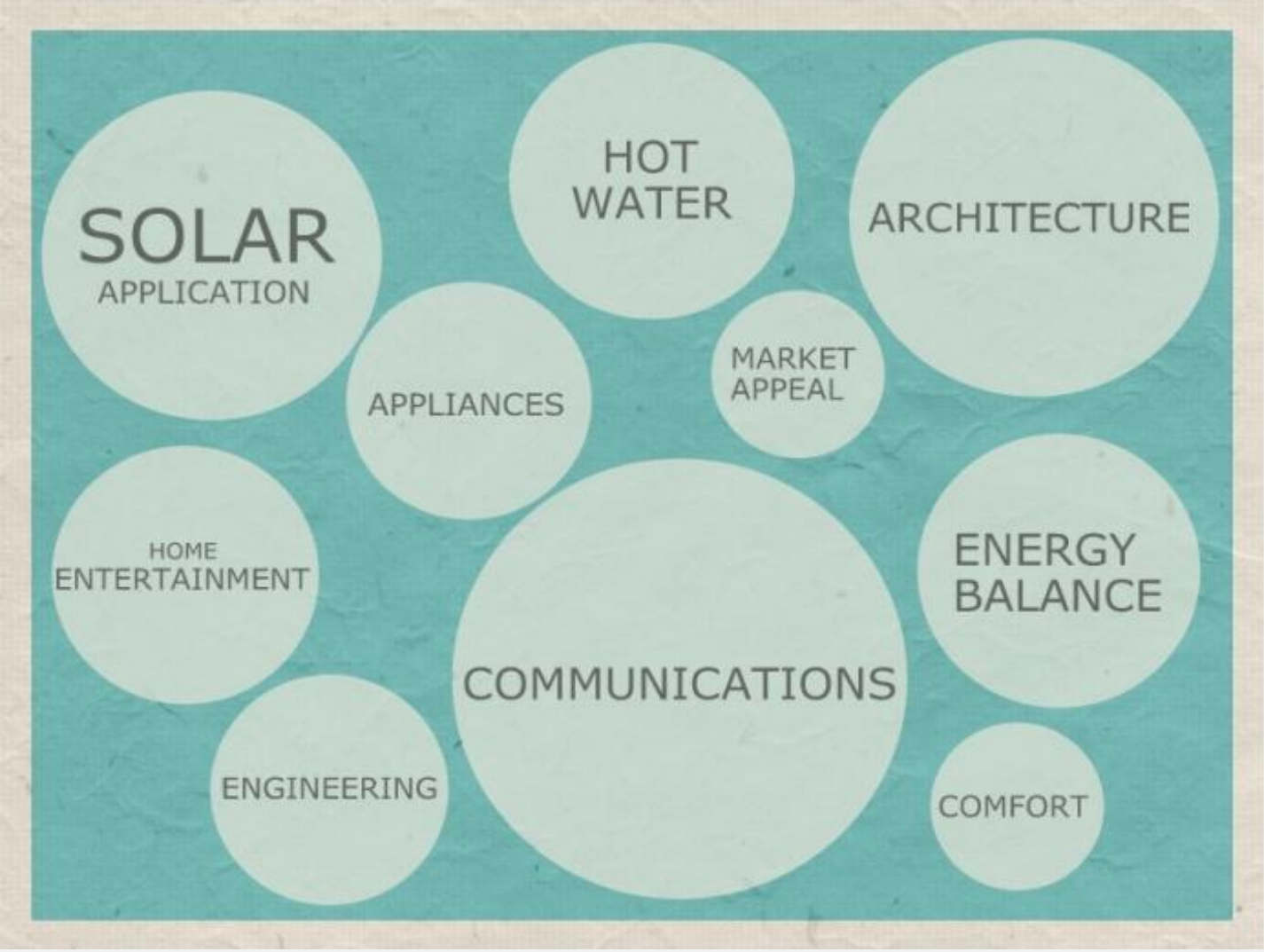
SOLAR DECATHLON 2009 – WASHINGTON MALL

THE SOLAR DECATHLON CHINA 2013 COMPETITION

SOLAR DECATHLON CHINA 2013 – DATONG

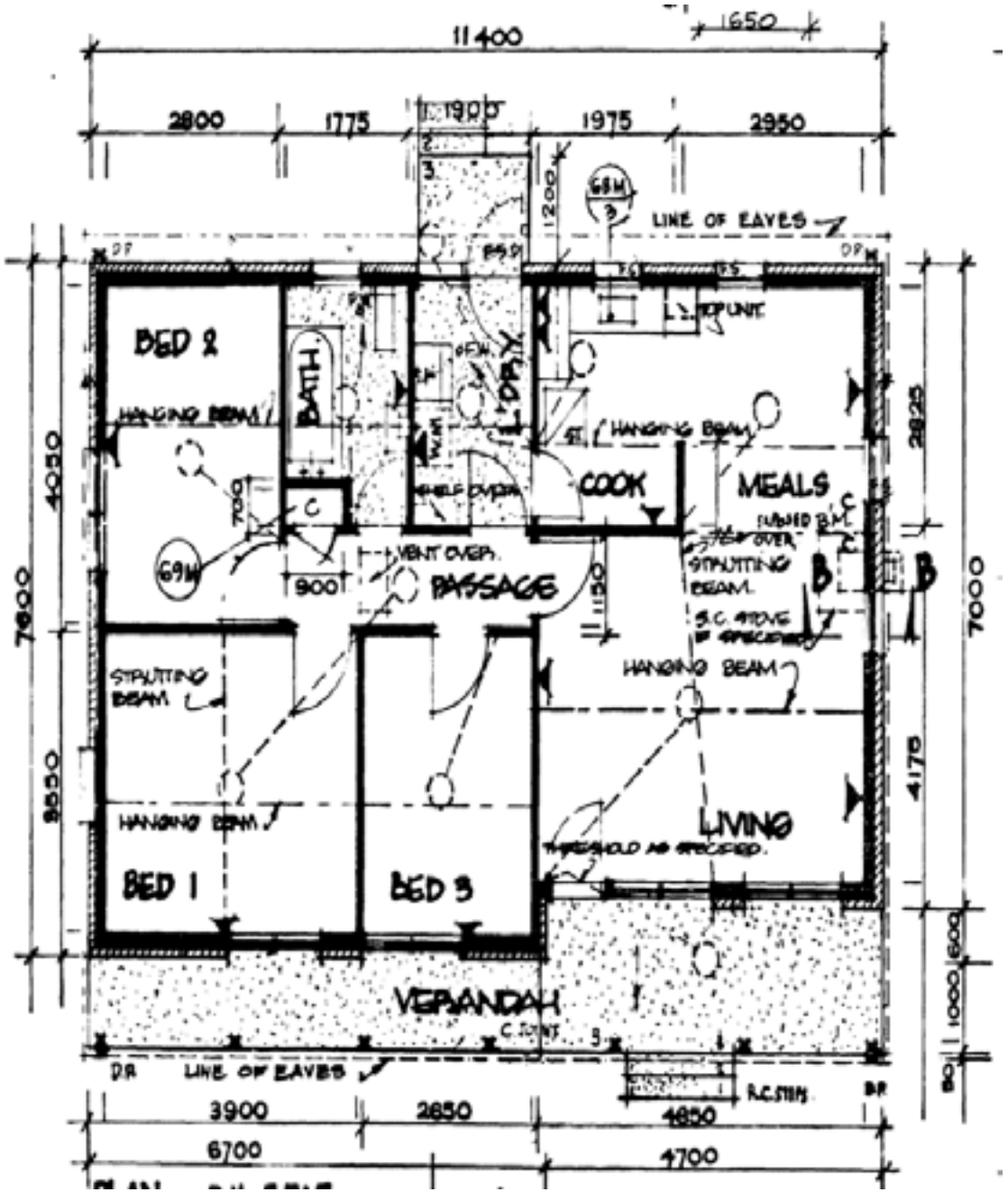
- US Department of Energy and Chinese National Energy Administration held the first SD China in 2013.
- Team UOW was a collaboration between UOW and TAFE NSW Illawarra Institute.
- Team UOW the first ever team from Australia to win entry to a Solar Decathlon.
- 270,000 people attended the competition site.
- 35,000 people were toured through the Illawarra Flame House throughout the competition week – one every 8 seconds!

SUB-COMPETITIONS



TRANSFORMING OUR HOUSES...

The Base Plan



SDRC SUSTAINABLE BUILDINGS RESEARCH CENTRE | UNIVERSITY OF WOLLONGONG

INTO SUSTAINABLE HOMES

SOLARCOOLING WORKSHOP 2014 Brisbane

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SBRC SUSTAINABLE BUILDINGS RESEARCH CENTRE | UNIVERSITY OF WOLLONGONG

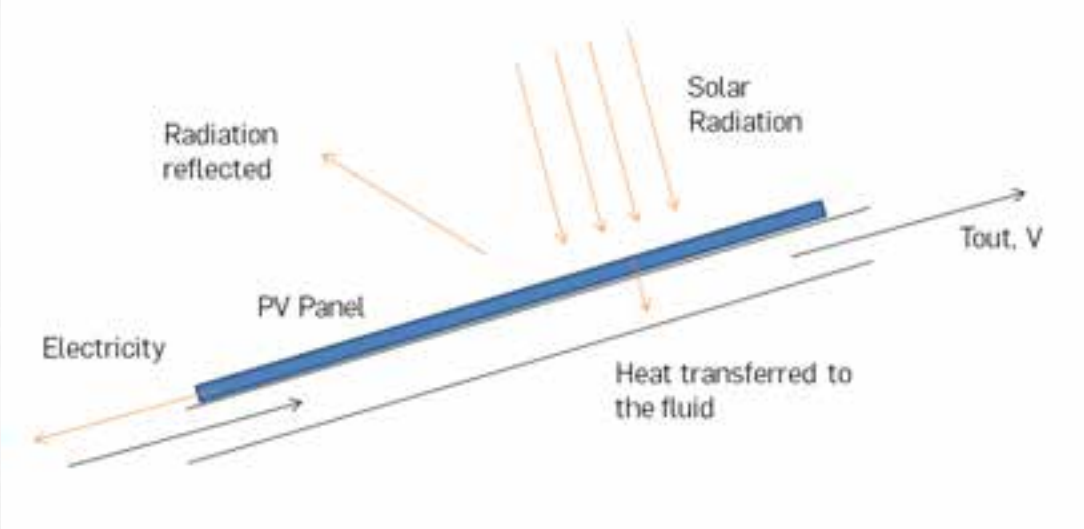
ILLAWARRA FLAME HOUSE FEATURES

- State of the art photovoltaic panels
- Greywater treatment system
- Natural ventilation and automated high level windows
- Innovative HVAC system featuring
  - Photovoltaic-Thermal solar system and
  - Phase Change Material (PCM) Thermal Store
- Innovative Building Management System

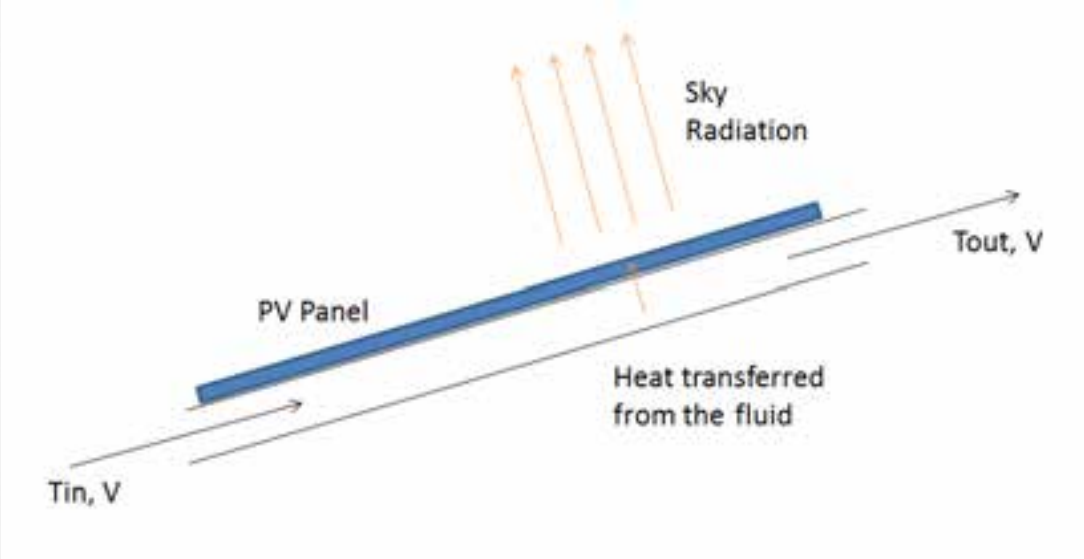
ILLAWARRA FLAME HOUSE IN DATONG 2013

PHOTOVOLTAIC THERMAL SYSTEM

Daytime generation



Night time radiant cooling



PVT AND PCM

PVT ROOF

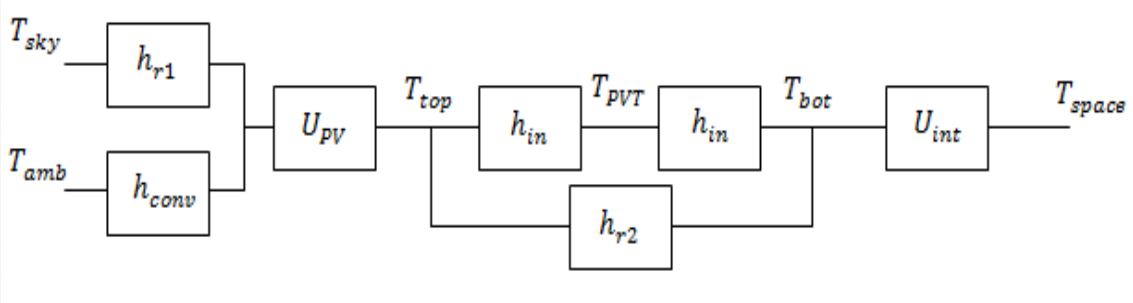
ILLAWARRA FLAME HOUSE – DATONG 2013

BLUESCOPE LYSAGHT TRIMDEK

PVT AND PCM

For optimization it was necessary to develop:

- Thermal Model
- Mechanical Model (Fan Consumption)
- Electrical Model (electrical generation efficiency is a function of PV temperature)

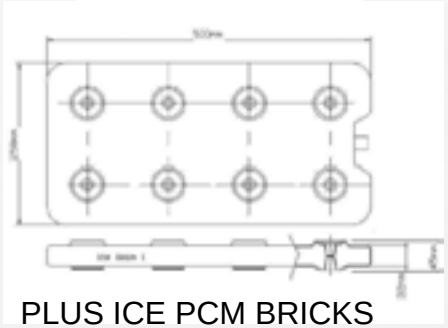


THERMAL NETWORK MODEL

PHASE CHANGE MATERIAL THERMAL STORE

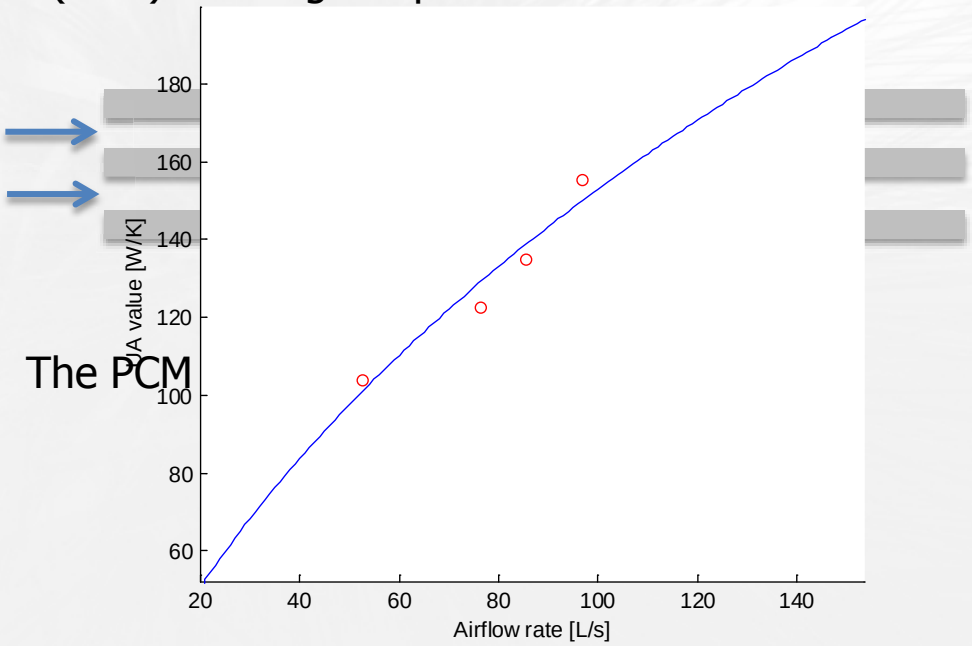
There is generally a significant offset between the thermal generation and the house demand

Thermal energy storage has been included in the design, through the latent heat of Phase Change Material (PCM). Melting temperature has been identified at 22°C

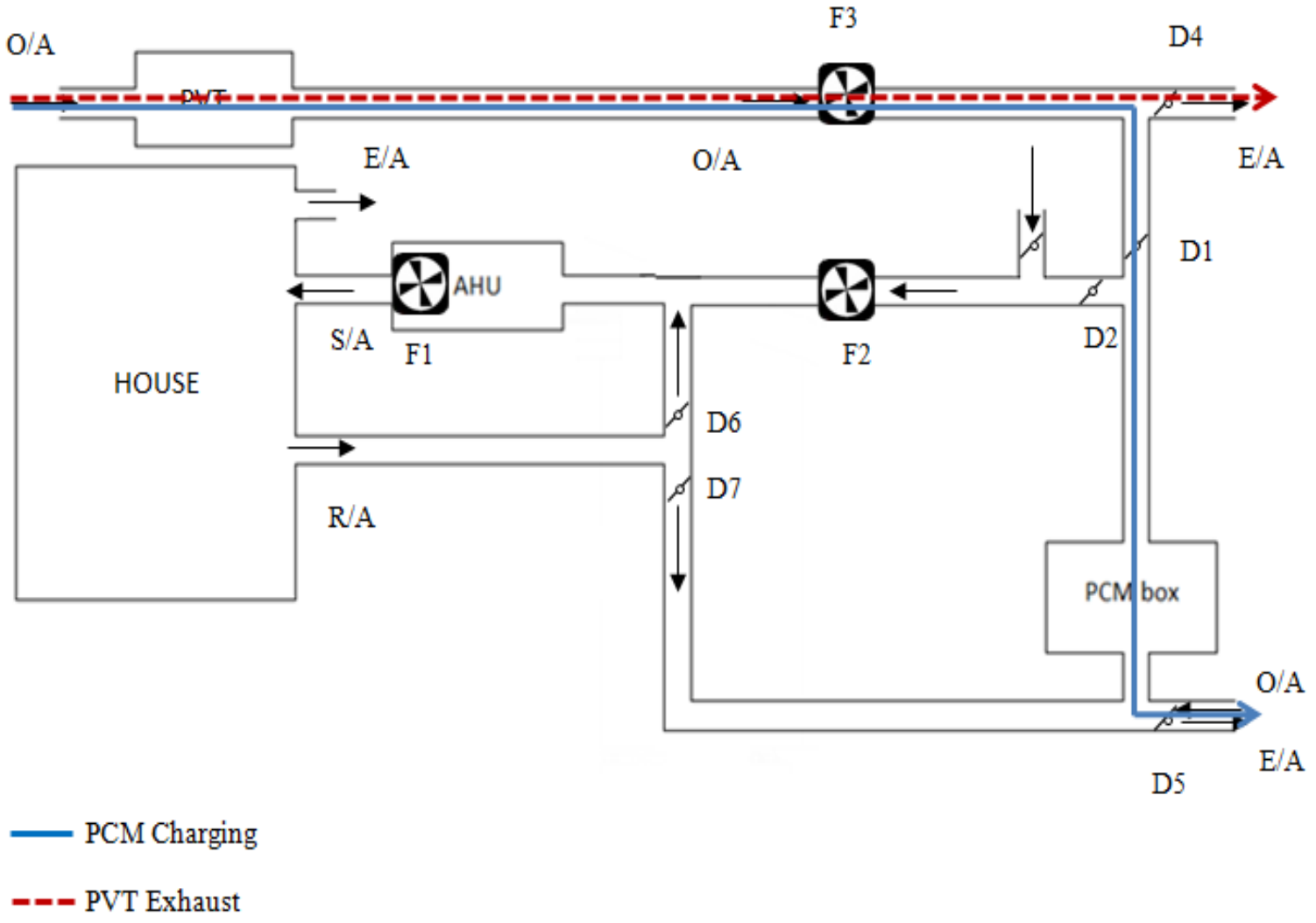


PLUS ICE PCM BRICKS

The PCM



SOLAR ASSISTED HVAC SYSTEM



ILLAWARRA FLAME HOUSE – 4X

First build at TAFE

Dress rehearsal at UOW Innovation Campus

3rd build at competition site

Construction in China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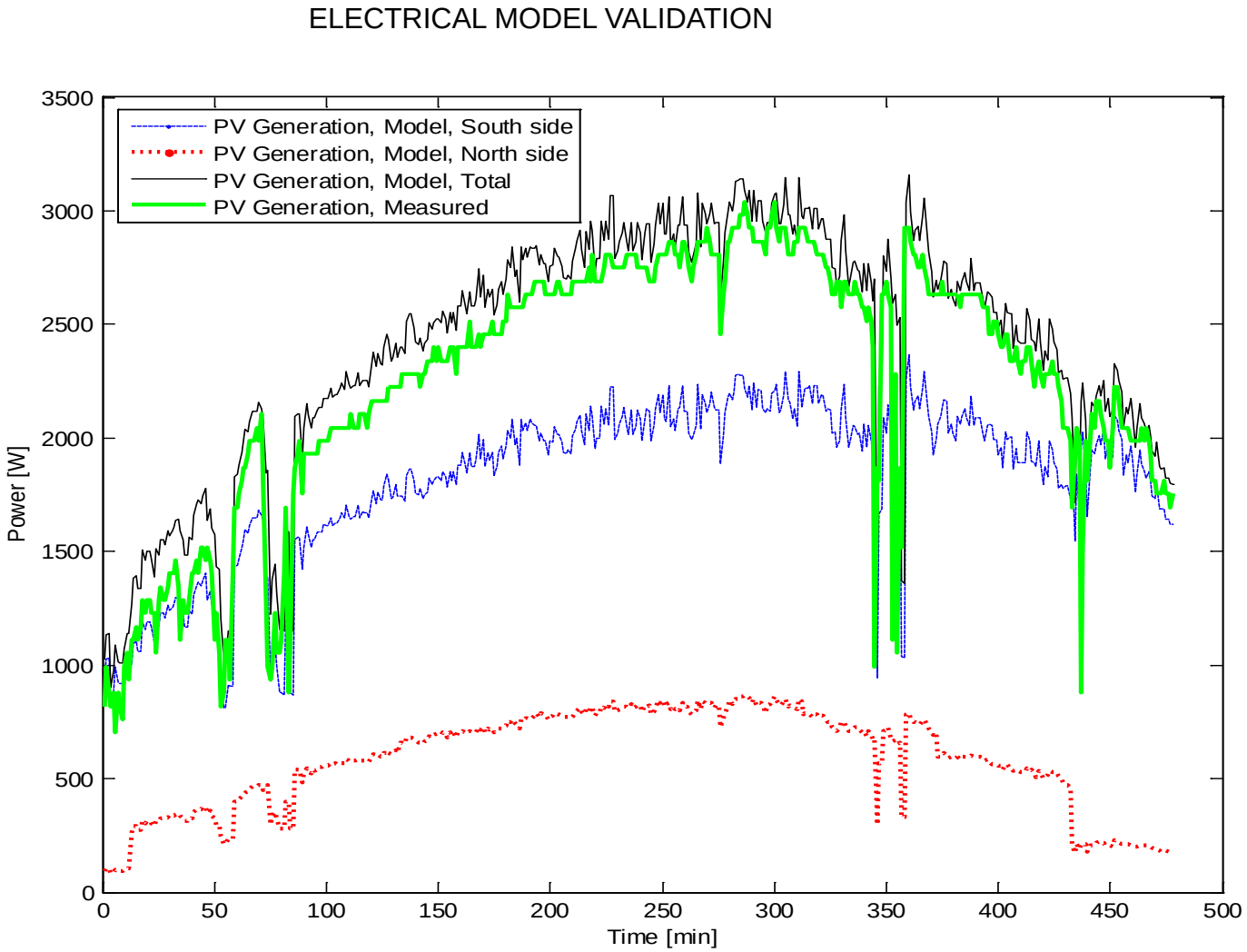
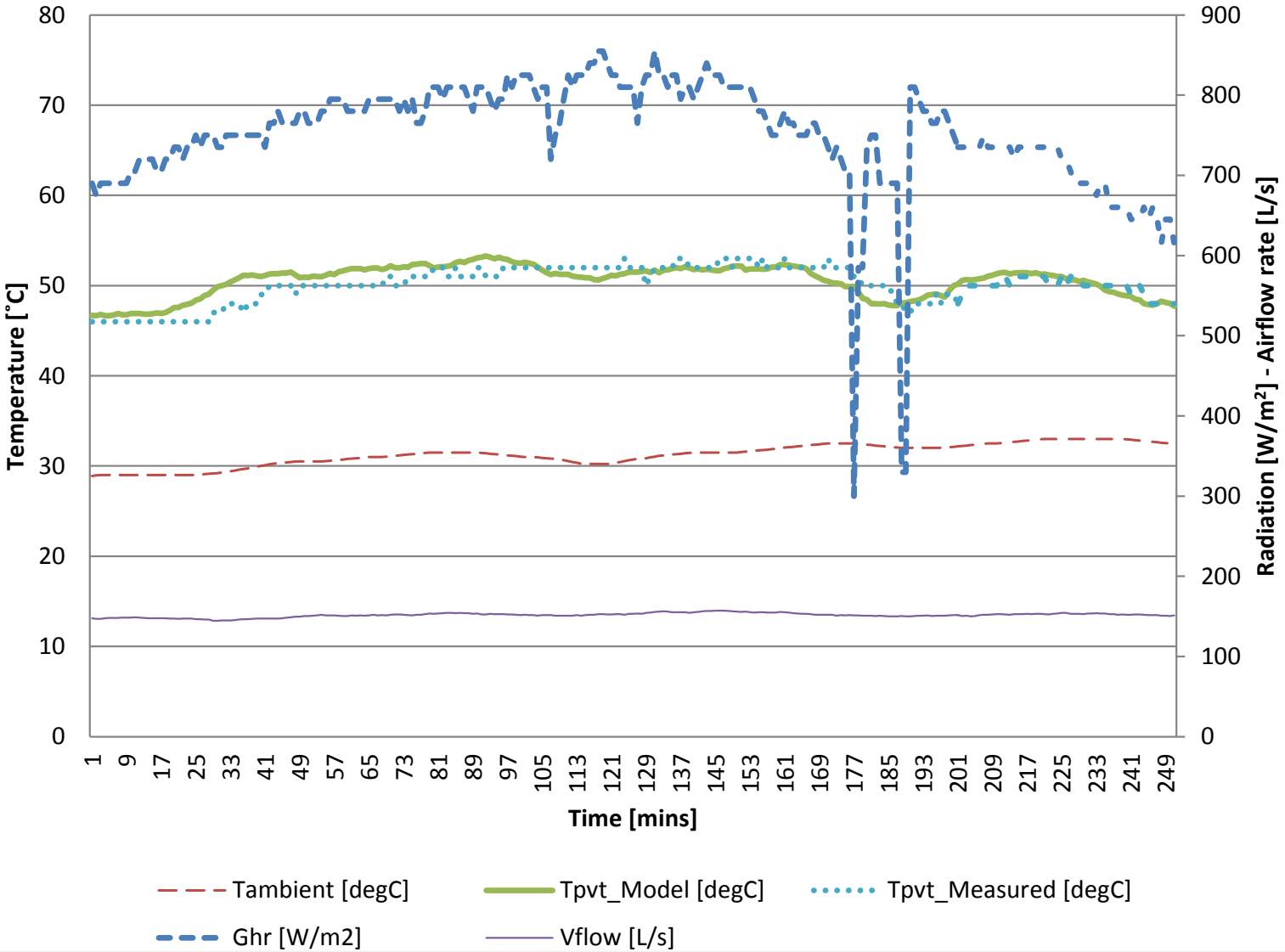
PVT AND PCM – INITIAL RESULTS



PVT AND PCM

THERMAL MODEL VALIDATION



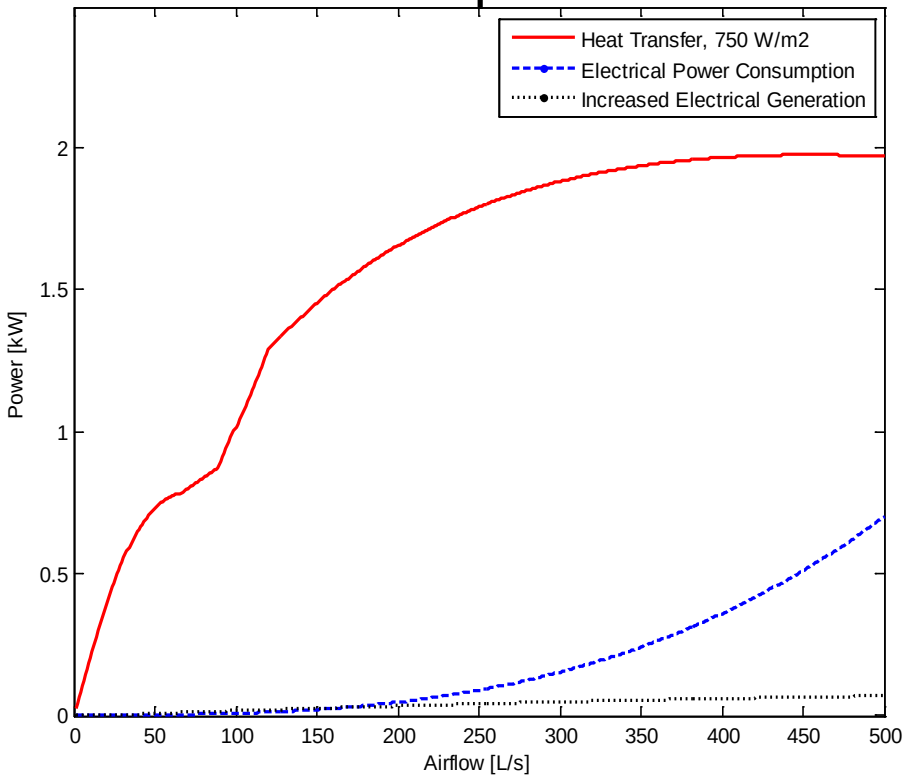
SOLAR ASSISTED HVAC SYSTEM

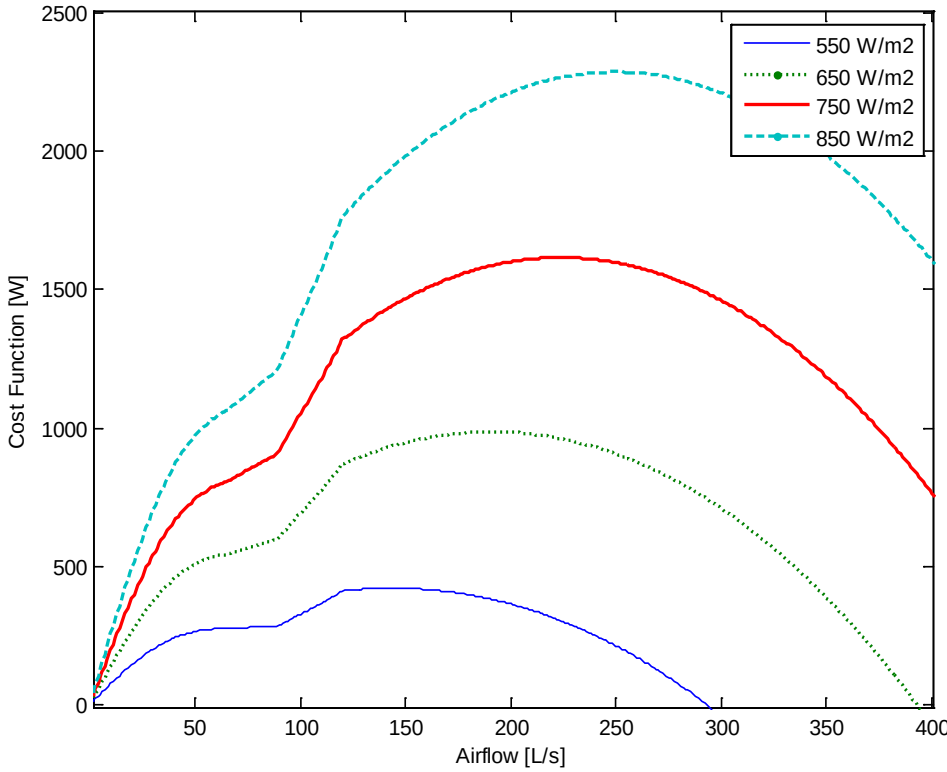
- HVAC System Managed by a Residential type of control system.
- Customized logic and non-standard use of devices to automate the system and control the subcomponents

ILLAWARRA FLAME BMS

SOLAR ASSISTED HVAC SYSTEM

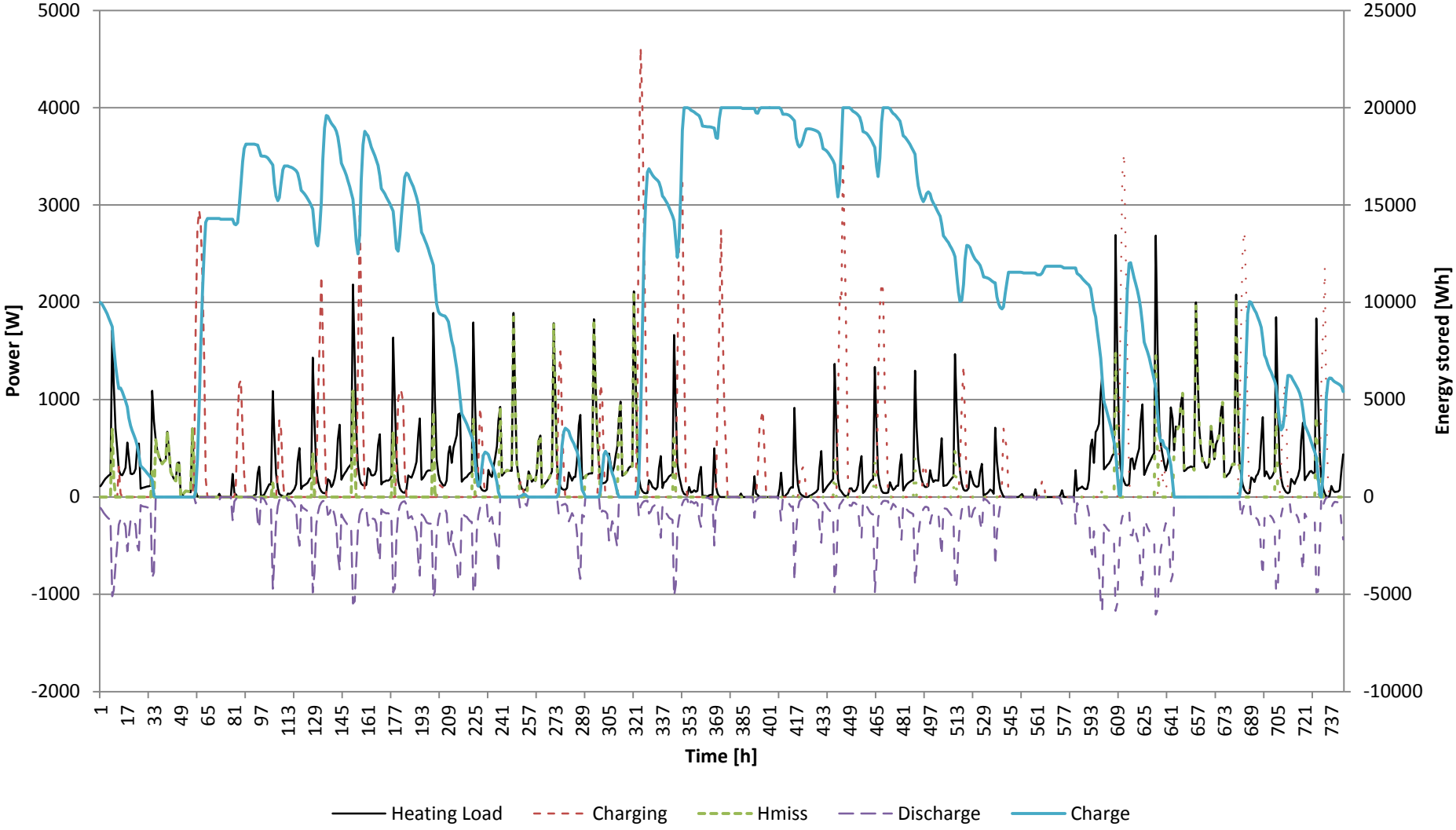
PCM Charging with PVT Optimization Example





$$C = P_{th} + \alpha(\Delta P_{e,gen} - P_{e,cons})$$

SOLAR ASSISTED HVAC SYSTEM



SOLAR ASSISTED HVAC SYSTEM

Simulated Performance Results	Winter July (Heating)	Summer February (Cooling)
Total demand, Thermal (kWh)	206	165
Thermal Energy supplied through PV-T/PCM (kWh)	139	116
Electrical Energy for Discharging (kWh)	6.1	9.6
COP Discharging	22.8	12.1
Thermal Energy Charged (kWh)	131.4	163.6
Electrical Energy for Charging (kWh)	5.0	10.1
COP Charging	26.4	16.2
COP Overall	12.3	6.9

Team UOW Win!

- Overall winner of Solar Decathlon China 2013
- Highest overall score in the history of Solar Decathlon Competitions (957.6/1000)
- Placed first in five out of the 10 competitions:
  - Architecture
  - Engineering
  - Solar Application
  - Hot Water
  - Energy Balances
- Second by one point in:
  - Communications
  - Market Appeal

- >35,000 people toured through house (1 person every 8 seconds!)
- >270,000 members of the public attended competition site

Illawarra Flame and SBRC at UOW

Summary

- Team UOW first:
  - Australian Team to win entry to a Solar Decathlon
  - Team ever to demonstrate a retrofit of an existing building
  - Place at SD China 2013, with highest ever overall score
- Air-based PVT system linked with PCM store and conventional heat pump.
- The Team UOW/BlueScope Solar Assisted HVAC system winner of the 2013 Denis Joseph competition.
- Illawarra Flame house now reconstructed and will be a long-term test bed for solar and HVAC technologies at the SBRC@UOW.

Acknowledgements

- Thank you to all Team UOW members, but especially for key members of the PVT/PCM/HVAC system team:
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