Façade Integrated Solar Cooling Systems

PhD candidate: Dan Wu

Supervisors: A/Prof. Lu Aye, Dr Tuan Ngo & Prof. Priyan Mendis

Renewable Energy and Energy Efficiency Group
Melbourne School of Engineering, The University of Melbourne
Aim: to develop an integrated system to enhance the function of façades to utilise solar energy for cooling in office buildings

• To develop façade integrated solar collection systems for cooling generation for commercial office buildings;
• To develop simulation models which can quantify the system performance (e.g. energy gain from solar, cooling load, power output, cooling generation, overall system efficiency);
• To construct an experimental rig for validation of the simulation models for the system developed;
• To optimise the system design and operational parameters for minimum life cycle cost.
Technical and financial analysis

1. Identify possible solar cooling technologies
2. Select feasible solar cooling technologies for façade integration
3. Model cooling systems in TRNSYS
4. Select orientations and configurations
   - Façade integrated solar field
     - Heat gain
6. Office building
   - Solar cooling equipment
     - Cooling output
7. Determine chiller’s capacity
8. Cooling load met?
   - No: Convention cooling system
   - Yes:
     - Solar fraction (SF)
     - Financial analysis (Capital, O&M)
       - Unit cooling cost (UCC)
     - Compare all façade integrated solar cooling technologies with grid connected cooling system
Available options

System overall efficiencies
PV panel (0.15) + VCC (4) = ~0.6
ETSC (0.5) + ORC (0.1) + VCC (4) = ~0.2
ETSC (0.5) + one-stage absorption chiller (0.7) = ~0.35
ETSC (0.5) + adsorption chiller (0.7) = ~0.35
Schematic diagram of the system
Simulations

TRNSYS

• Building, weather data, façade integrated evacuated tube solar collector, pumps and buffer tank;
• Estimating transient cooling load;
• Coupling with GenOpt through interface TRNOPT for optimisation.

Engineering Equation Solver (EES)

• Organic Rankin cycle and vapour compression cycle;
• Thermodynamic model (for working fluid selection);
• Component model (for optimisation studies).
Conclusion: working fluid selection

- To achieve the highest overall efficiency, the optimal hot thermal fluid temperature for ORC is recommended to be 95°C;
- In terms of pressure aspect, R134a and R500 are the best fluids;
- RC318 has the most moderate pressure ratio;
- Expander outlet volume flow rate favours R290 the most;
- From an efficiency point of view, R152a with superheating is the most efficient one.

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<th>Fluid</th>
<th>Superheating (°C)</th>
<th>$\eta_{th}$ (%)</th>
<th>$\eta_{\Pi}$ (%)</th>
<th>$\dot{I}_{tot}$ (kW)</th>
<th>$\dot{V}_4$ (m³/h)</th>
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