NP4010

STUDIES ON OPTIMAL APPLICATION OF BUILDING INTEGRATED PHOTOVOLTAIC/THERMAL SYSTEM FOR COMMERCIAL BUILDINGS IN AUSTRALIA

RESEARCH QUESTION

How will building-integrated photovoltaic/thermal system in double-skin façade (BIPV/T-DSF) contribute to reduction of energy demand and carbon footprint of commercial buildings as well as the impact of this envelope solution on indoor thermal comfort in Australia?

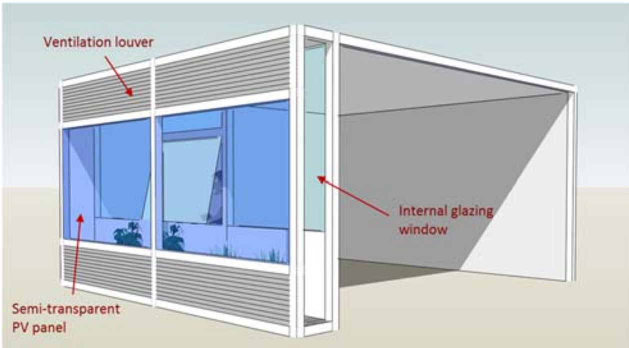

Figure 1: Sample effect picture of the BIPV/T-DSF system in the building.

METHODOLOGY

The research project examines both experimental field measurements [1] and computational simulation for the BIPV/T-DSF system. The computational simulation of the buildings will be conducted using TRNSYS (thermal modelling software). To date, the computational model has basically been validated against the experimental results (Figure 2 shows one of the examples). A long-term system performance and indoor thermal comfort then can be predicted confidently by using the validated computational model. The hourly Mean Bias Error (MBE) and Cumulative Variation of Root Mean Squared Error (CVRMSE) [2] are used as the criteria for assessing the acceptability of the agreement between simulated and experimental data. The MBE and CVRMSE are calculated as:

$$MBE = \frac{\sum_{i=1}^{N_P}(M_i - S_i)}{\sum_{i=1}^{N_P} M_i} \qquad \text{(eq. 1)}$$

$$\overline{M_P} = \frac{\sum_{i=1}^{N_P} M_i}{N_P} \qquad \text{(eq. 2)}$$

$$CVRMSE_{(P)} = \frac{\sqrt{\sum_{i=1}^{N_P}\left((M_i - S_i)^2 / N_P\right)}}{\overline{M_P}} \qquad \text{(eq. 3)}$$

Where M_i and S_i are measured and simulated data at instance "*i*" respectively; *p* is the interval (e.g. monthly, weekly, daily and hourly); N_p is the number of values at interval p and $\overline{M_p}$ is the average of the measured data [3]. The both hourly acceptance thresholds of MBE and CVRMSE are ±10% and ≤30% respectively.

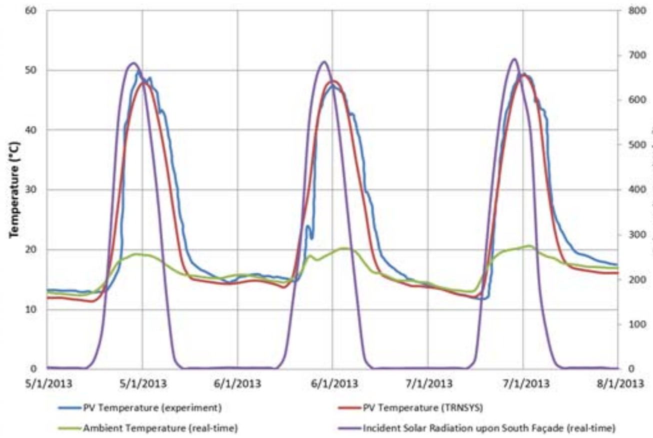

Figure 2: Validation of PV module temperature under buoyancy-driven ventilation (MBE = 4.55%; CVRMSE = 14.48%).

RESULTS

In terms of the validated TRNSYS model, a preliminary numerical simulation model has been developed for investigating the thermal performance of the novel BIPV/T-DSF system and its impact on indoor thermal comfort of a commercial building in summer and winter in Sydney, Australia. As shown in Figure 3 and Figure 4, the building model that utilized the BIPV/T-DSF system has significantly lower indoor air temperature than the building model without a BIPV/T-DSF which indicates the BIPV/T-DSF system can reduce the indoor air temperature and assist in reduce the thermal load on the mechanical cooling system in summer, while the BIPV/T-DSF system brought the thermal buffer benefit that played a passive heating role as well as maintained a comfort indoor air temperature in winter time.

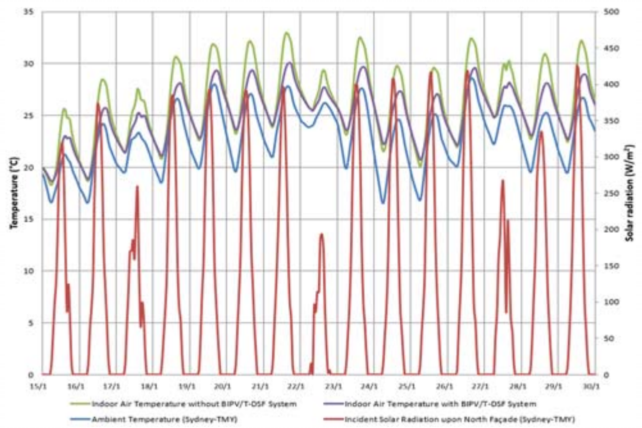

Figure 3: Indoor air temperature with/without BIPV/T-DSF in summer.

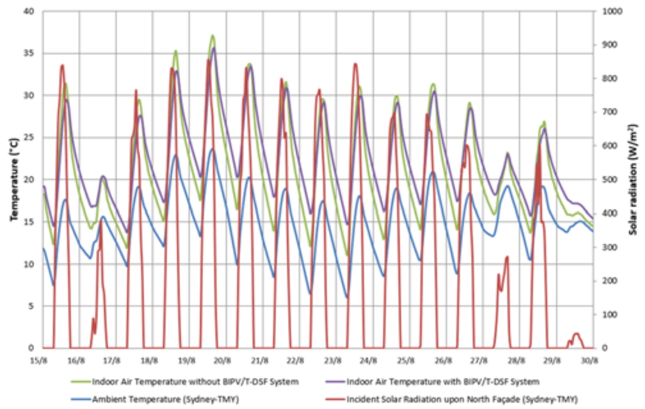

Figure 4: Indoor air temperature with/without BIPV/T-DSF in winter.

CONCLUSIONS

The simulation results show that BIPV/T-DSF system gives not only good thermal performance in terms of buffering the building from summer heat gains, but reduces heat loss as well as overheat of building during winter time in the subtropical climate areas in southern hemisphere like Sydney. Further studies will concentrate on developing the specific strategies for maximizing its thermal and electrical performance and optimizing the long-term indoor comfort using the strategies.

ANTICIPATED IMPACTS

BIPV/T	DSF
• Electrical power production • Thermal energy production	• Energy efficiency enhancement • Indoor thermal comfort improvement

The proposed research project will give the answer on how the performance of the combined BIPV/T-DSF system will be.

REFERENCES

[1] Peng, J., Lu, L., & Yang, H. (2013). An experimental study of the thermal performance of a novel photovoltaic double-skin facade in Hong Kong. Solar Energy, 97, 293-304.

[2] ASHRAE. (2002). Guideline 14-2002 Measurement of Energy and Demand Savings. Atlanta, Georgia: American Society of Heating, Ventilating, and Air Conditioning Engineers.

[3] Raftery, P., M. Keane, and J. O'Donnell, *Calibrating whole building energy models: An evidence-based methodology*. Energy and Buildings, 2011. 43(9): p. 2356-2364.

FURTHER INFORMATION CONTACT:

Siliang Yang (PhD Candidate)

Faculty of Built Environment, UNSW

siliang.yang@unsw.edu.au