Project Title:	Investigation on the thermal and power performance of vacuum BIPV curtain wall technology and its application potential in buildings in Hong Kong
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Objective

To develop and investigate a novel high-efficient energy-saving vacuum building integrated photovoltaic (BIPV) curtain wall, which combines photovoltaic curtain wall and vacuum glazing technologies.

Background

A curtain wall combining the PV technology can convert sunlight into electricity and become an architectural solar power supply system. However, a shortcoming of the current PV curtain walls with common double-glazed PV modules is the poor thermal insulation performance due to high solar heat gain coefficient (SHGC) and U-Value. It is found that vacuum glazing technology could improve thermal insulation performance and sound insulation performance. Hence, a novel energy-saving vacuum PV glazing, which combines the current photovoltaic curtain wall and vacuum glazing techniques, was proposed, to improve the overall energy performance.

Methodology

The research consists of both experimental study and simulation study.

Experimental study

A small scale prototype of the proposed vacuum BIPV curtain wall was manufactured and tested in the Hong Kong Polytechnic University. The dynamic thermal and power performance of the curtain wall was measured under real local environmental conditions. Some other commonly used windows were also tested for a comparative purpose.

Simulation study

A simulation model was developed, which consisted of three key models: model of power output, model of thermal performance and model of building performance. The simulation model was first validated by experimental tests. Then, the model was used to investigate and compare the energy performance of the vacuum PV glazing and other commonly used energy-efficient glazing.

Results and Findings

- The energy performance of the vacuum PV glazing was evaluated by an outdoor field measurement. For the test chamber, the measured average and maximum internal air temperature for the vacuum PV glazing are 39.6°C and 40.3°C, respectively, while the corresponding average and maximum internal air temperatures of the clear glass are 43.6°C and 44.7°C. The test results validate that the vacuum PV glazing has better heat insulation performance.
- SHGCs of the vacuum PV glazing and double-pane PV glazing are much smaller than those of the vacuum glazing and double clear glazing, because the coupled PV module can absorb most of the solar irradiation. The vacuum PV glazing has the lowest SHGC of 0.10 which can act as an excellent thermal insulation.

- East and west facing windows have better solar heat insulation performance to reduce heat gains from outside environment. For electricity generation, the annual electricity generation of single PV, double PV and vacuum PV is similar to each other.
- Based on an average electricity price in Hong Kong, the simple payback period is between 7.5 to 8.8 years depending on the glazing type. Hence, the product could be considered as a cost-effective application in building facades when considering its tremendous saving of air-conditioning energy and corresponding annual expenses.
- A brief technical guideline for the vacuum PV glazing is devised. The guidance mainly focuses on the aspects of design strategy, environmental variables, multi-functionality, installation situation, electrical components, and economic aspects.

Recommendations

- PV glazing is recommended to install on the south facade in order to maximize the electricity output in Hong Kong and it is not recommended to apply PV glazing on north façade due to limited solar radiation available.
- In order to commercialize the vacuum PV curtain wall, the following issues need to be addressed: technical, marketing, building integration, standardizations, financial and training.