See-through solar cells in window glazings save energy

T. T. Chow

A naturally ventilated photovoltaic coating system could decrease power consumption for buildings in temperate to tropical climates.

Extensive solar transmission through window glazing affects not only the air-conditioning load in a building, but also thermal and visual comfort. Direct reflection of solar radiation from the glazing back to the outside may lessen the effects but also cause glare for pedestrians and drivers. Glazings with advanced thermal and optical properties for energy conservation and aesthetic purposes, such as low-emissivity glass and switchable glazing, are commercially available. Another product is photovoltaic (PV) glazing, which features solar cells sandwiched between clear glass panes. We can further reduce the solar/heat gain in PV glazings through a multipane window design with airflow in the cavity. Such windows can incorporate various combinations of glass sheets with top and bottom openings.

Traditional opaque PV glazing allows natural light transmission. The use of see-through solar cells is more suitable for places where people spend longer periods of time, however, as they do not cast shadows. Figure 1 compares a PV and normal absorptive glazing. We believe that the combined use of see-through solar cells and a ventilated glazing system can be advantageous.

Figure 2 shows our proposed naturally ventilated PV glazing system. We studied the application of this window system in computer models of identical office buildings in Bangkok, Hong Kong, and Shanghai, which are located in different climate zones. Our computer model of the ventilated PV glazing employed a coupled air-flow network and an energy balance technique. Models of seven other window configurations were also developed for comparison. The computation involved the WINDOW, ESP-r, and RADIANCE software programs, and we verified the numerical models developed using data acquired from an experimental rig. To achieve the daylight control function with a corresponding reduction in space thermal load, ESP-r and RADIANCE were used interactively: RADIANCE calculated the luminance distribution, while ESP-r exercised artificial lighting electricity consumption control according to the indoor luminance distribution. Table 1 summarizes the relative annual electricity consumption for air-conditioning and lighting in buildings using these glazing systems, with the single absorptive glazing system for the office building in Bangkok as the reference case. The PV electricity generated was consumed in the same building.

We found that the electricity consumption in Bangkok was relatively stable throughout the year. In Hong Kong and Shanghai, however, the electricity consumption in summer (especially in August) was almost twice that in winter. In all three cities, the office building consumed the least electricity overall when the D-PV-d glazing (naturally ventilated double-PV glazing with daylight control) system was used, as indicated in Table 1. Compared with their own base cases (single absorptive glazing), the energy-savings potential is 21.9, 17.0, and 17.2% for Bangkok, Hong Kong, and Shanghai, respectively.

Thus, the application of see-through solar cells in a naturally ventilated glazing system is promising from an energy-savings perspective.
Table 1. Comparison of annual electricity consumption (%) with different glazing configurations

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<th>S-AB</th>
<th>S-AB-d</th>
<th>S-PV</th>
<th>S-PV-d</th>
<th>D-PV</th>
<th>D-PV-d</th>
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<td>62.2</td>
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<td>68.4</td>
<td>62.7</td>
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perspective, particularly when combined with daylight control, for climates ranging from tropical to temperate. The lower the latitude, the more solar irradiance can be used as a natural light source, resulting in less electricity being needed for artificial lighting. We hope to begin a demonstration project for this system in the near future.

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References