A parametric study on the impact of integrating solar cell panel at building envelope on its power, energy consumption, comfort conditions and CO_2 emissions

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Abstract

This paper presents a parametric study on the impact of solar cell at building envelope and roof on the cell generated power, energy consumption and comfort conditions (interior temperature, relative humidity, discomfort hours and lighting), and amount of CO2 emission within a building. It considers the cell position on the facade (cell between two window parts, two cells have the same total area beside the window, cell locates on the right of the window and cell locates on the left), direction (east, south, north, and west) and location (façade and roof). The study is performed under the meteorological conditions of New Borg El-Arab city, Alexandria, Egypt. The numerical solution of the physical model is solved by using Design-Builder software and is validated by using an experimental setup. The results reveal that the cell at the façade and roof decreases the annual energy consumption inside the facility by about 15% and 40%, respectively compared to the facility without cell. Installed the cell at roof facing south has the highest annual generated power. For the solar cell at the envelope, the cell at south produces the maximum annual generated power and the cell at north produces the minimum. The temperature inside the facility in case of using cell is smaller than the facility temperature without using the cell. Cell at south direction has the comfortable interior conditions for all studied cases. Cell locating inside the window has the minimum light intensity and cell facing the north produces the minimum CO_2 emissions.

Keywords: Solar cell; Energy; Comfort conditions; Roof; façade; CO_2 emissions

Conclusions

This paper presented a parametric study on the impact of solar cell positions, directions and locations on the cell generated power, energy consumption, interior temperature and lighting and CO_2 emissions within a facility. The study is carried out under the climate conditions of New Borg El-Arab city, Alexandria, Egypt. The numerical solution of the physical model is solved by using Design-Builder software. The results show that the position of the solar cell with respect to the window hasn't a sensible effect on the solar cell generated power. cell at roof facing south (reference case) has the maximum annual power generation and the cell at north has the minimum power generation, The solar cell at facade produced 25.3% for north wall, 57.9% for east wall, 81.6% for south wall, and 58% for west wall of the cell power generation at the reference case. The minimum annual energy consumption in the facility occurs at reference case and the basecase (without using cell) has the maximum energy consumption in the facility with respect to the same direction of the studied cases of the solar cell. The maximum effect of the cell direction on the façade on the energy consumption in the facility is about 5.8, 9 and 8% for north, east, south, and west respectively. The maximum temperature in summer inside the facility occurs in case of basecase and window in the center. The maximum annual change of the power required for lighting is about 9.2% for different locations, directions, and positions. The south direction has the lower relative humidity and the relative humidity inside the building for PV different positions, direction and locations is relatively greater than the comfortable range of the relative humidity except for the solar cell at south direction. The annual cell power generation covered the annual consumed power for lighting except for solar cell at facade for north direction. The solar cell at north produces the minimum annual CO_2 emissions compared to other positions and directions of the cell at the wall.

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