The influence of solar panel roof on urban thermal environment and cooling energy demand during a heat wave event in 2017

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With the rapid development of social economy, China's energy demand has been growing at an alarming rate. The annual cumulative power generation is about 6.8 trillion kilowatts hour in 2017, and 70% of them is provided by fossil fuel resources, so it is important to promote the use of renewable and clean energy, such as solar power generation technology. The advantages of using solar panel roof in urban areas include reduction of the need of land use in the crowded city and less dependence on fossil fuels. However, there is need to understand impacts of solar roof on local climate, on energy supply during heatwaves, and associated economic benefits in China. This study selected a heatwave event in Jiangsu province, China to simulate the impact of solar panel roof on local thermal environment and energy supply. During that time, the cooling energy consumption reached more than half of the total electricity consumption. A new heat transfer scheme of solar panel roof was introduced into WRF/BEP/BEM model, which include layers (glass protective panel, solar panel, bottom plate) and was divided into two types for heat transfer calculation: bracket and non-bracket. The results showed that the urban average 2-m daytime temperature decreased by 0.3°C in non-bracket case which is better than that of bracket case, while its cooling effect on nighttime temperature was small. For the bracket case, its cooling effect on daytime and nighttime air temperature were equal (0.2°C). Both solar panel roofs can reduce indoor daytime air temperature with the maximum cooling effect around 11:00 local time for non-bracket roof and 14:00 for bracket roof. However, bracket roof increased nighttime indoor air temperature and air-conditioning energy consumption. Solar panel roofs also reduce daytime turbulent kinetic energy and constrain the development of boundary layer. Results also show that with solar photoelectric conversion efficiency being 0.14, the photovoltaic power generation can meet 84.1%, 61.3% and 35.9% of the cooling energy consumption for high-density, low-density residential areas and commercial areas, respectively, during this heatwave event.