Summer Direct Cooling Operation Strategy for a Novel Energy Pile-Building Integrated Photovoltaic/Thermal System (Postprint)

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Abstract

The development of renewable energy utilization technologies, represented by solar energy and shallow geothermal energy, plays a significant role in promoting energy conservation and emission reduction. Among them, the novel energy pile-building integrated photovoltaic-photothermal (BIPV/T) system can not only comprehensively utilize solar energy and shallow geothermal energy for building heating, but also address two critical issues in the comprehensive utilization of solar and shallow geothermal energy: the degradation of photovoltaic power generation efficiency due to temperature rise and soil thermal imbalance caused by excessive heat extraction. In cold and severe cold regions (such as Shenyang), traditional energy pile heat pump systems do not provide cooling to buildings during summer because the cooling load is relatively small for most of the time; however, buildings still have certain cooling load demands, which particularly affect indoor thermal comfort during hot weather. This paper proposes a free cooling operation strategy for the novel energy pile-building integrated photovoltaic-photothermal system. Under this strategy, without activating the heat pump unit in summer, natural cold water extracted from energy piles is utilized for direct cooling through a floor radiant system, where the required inlet water temperature for the floor radiant system can reach 16–18°C. This approach not only satisfies the basic indoor cooling load demand and improves summer thermal environmental comfort, but also achieves heat replenishment to the soil during summer, significantly ameliorating the problem of increased winter heating energy consumption in energy pile systems caused by soil thermal imbalance. Compared with traditional energy pile ground-source heat pumps, the hybrid system operating under this strategy can significantly improve the building' s thermal comfort environment and reduce the system' s annual operating energy consumption.

Full Text

Investigation of Direct Cooling Strategies in Summer for Novel Building Integrated Photovoltaic/Thermal-Energy Pile System

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Abstract

The development of renewable energy utilization technologies, particularly solar and shallow geothermal energy, plays a crucial role in energy conservation and emission reduction. The novel building-integrated photovoltaic/thermal (BIPV/T)-energy pile system offers a comprehensive solution that harnesses both solar and shallow geothermal energy for building heating while addressing two critical challenges: the degradation of photovoltaic power generation efficiency due to elevated temperatures and soil thermal imbalance caused by excessive heat extraction.

In cold and severely cold regions such as Shenyang, conventional energy pile heat pump systems typically do not provide cooling during summer since the cooling load remains relatively small for most of the period. However, buildings still exhibit certain cooling load demands, which can compromise indoor thermal comfort during hot weather. This paper proposes a free cooling operation strategy for the novel BIPV/T-energy pile system during summer. Without activating the heat pump unit, this strategy utilizes naturally cold water extracted from energy piles to deliver direct cooling through a floor radiant system. The required inlet water temperature for the floor radiant system can reach 16–18°C, which not only satisfies the building' s fundamental cooling load requirements and enhances summer thermal comfort but also enables heat replenishment to the soil during summer. This significantly mitigates the issue of increased winter heating energy consumption in energy pile systems stemming from soil thermal imbalance. Compared with traditional ground-source heat pump systems employing energy piles, the hybrid system operating under this proposed strategy can substantially improve the building' s thermal comfort environment while reducing annual system energy consumption.

Keywords: Energy pile; Building integrated photovoltaic/thermal (BIPV/T); Floor radiant system; Thermal comfort

Note: Figure translations are in progress. See original paper for figures.