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A transient model for optimizing a hybrid nocturnal sky radiation cooling system

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Abstract

Nocturnal sky radiation cooling (NSRC) is a passive, sustainable, cooling method that utilizes the sky as a radiation heat sink. Here, a reliable, hybrid NSRC system including a heat pump is presented and analyzed for the cooling of remote, off-grid data centers. An analytical system model that incorporates thermal and life cycle cost analyses including system control logic has been developed. The thermal analysis was validated by a detailed numerical analysis. In addition, a model for the radiator was developed and a performance curve of an ideal radiator is introduced. The strength of the here developed analytical, transient model lies in its ability to simulate a wide variety of possible system configurations using local, site dependent meteorological conditions over multiple years. The analysis determines the optimal system design based on minimum life cycle costs. The here presented concepts can be used for similar systems encompassing different components.

Keywords: Nocturnal sky radiation cooling, air-conditioning, off-grid data centers, optimal system design

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