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Innovative Fabric Integrated Thermal Storage Systems and Applications

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Abstract : In northern European climates, domestic space heating and hot water represents a significant proportion of total primary total primary energy use and meeting these demands from a national electricity grid network supplied by renewable energy sources provides an opportunity for a significant reduction in EU CO₂ emissions. However, in order to adapt to the intermittent nature of renewable energy generation and to avoid co-incident peak electricity usage from consumers that may exceed current capacity, the demand for heat must be decoupled from its generation. Storage of heat within the fabric of dwellings for use some hours, or days, later provides a route to complete decoupling of demand from supply and facilitates the greatly increased use of renewable energy generation into a local or national electricity network. The integration of thermal energy storage into the building fabric for retrieval at a later time requires much evaluation of the many competing thermal, physical, and practical considerations such as the profile and magnitude of heat demand, the duration of storage, charging and discharging rate, storage media, space allocation, etc. In this paper, the authors report investigations of thermal storage in building fabric using concrete material and present an evaluation of several factors that impact upon performance including heating pipe layout, heating fluid flow velocity, storage geometry, thermo-physical material properties, and also present an investigation of alternative storage materials and alternative heat transfer fluids. Reducing the heating pipe spacing from 200 mm to 100 mm enhances the stored energy by 25% and high-performance Vacuum Insulation results in heat loss flux of less than 3 W/m², compared to 22 W/m² for the more conventional EPS insulation. Dense concrete achieved the greatest storage capacity, relative to medium and light-weight alternatives, although a material thickness of 100 mm required more than 5 hours to charge fully. Layers of 25 mm and 50 mm thickness can be charged in 2 hours, or less, facilitating a fast response that could, aggregated across multiple dwellings, provide significant and valuable reduction in demand from grid-generated electricity in expected periods of high demand and potentially eliminate the need for additional new generating capacity from conventional sources such as gas, coal, or nuclear.

Keywords : fabric integrated thermal storage, FITS, demand side management, energy storage, load shifting, renewable energy integration
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