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System Analysis on Compact Heat Storage in the Built Environment

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Abstract : An increased share of renewable energy sources in the built environment implies the usage of energy buffers to match supply and demand and to prevent overloads of existing grids. Compact heat storage systems based on thermochemical materials (TCM) are promising to be incorporated in future installations as an alternative for regular thermal buffers. This is due to the high energy density (1 – 2 GJ/m3). In order to determine the feasibility of TCM-based systems on building level several installation configurations are simulated and analyzed for different mixes of renewable energy sources (solar thermal, PV, wind, underground, air) for apartments/multistore-buildings for the Dutch situation. Thereby capacity, volume and financial costs are calculated. The simulation consists of options to include the current and future wind power (sea and land) and local roof-attached PV or solar-thermal systems. Thereby, the compact thermal buffer and optionally an electric battery (typically 10 kWhe) form the local storage elements for energy matching and shaving purposes. Besides, electric-driven heat pumps (air / ground) can be included for efficient heat generation in case of power-to-heat. The total local installation provides both space heating, domestic hot water as well as electricity for a specific case with low-energy apartments (annually 9 GJth + 8 GJe) in the year 2025. The energy balance is completed with grid-supplied non-renewable electricity. Taking into account the grid capacities (permanent 1 kWe/household), spatial requirements for the thermal buffer (< 2.5 m3/household) and a desired minimum of 90% share of renewable energy per household on the total consumption the wind-powered scenario results in acceptable sizes of compact thermal buffers with an energy-capacity of 4 - 5 GJth per household. This buffer is combined with a 10 kWhe battery and air source heat pump system. Compact thermal buffers of less than 1 GJ (typically volumes 0.5 - 1 m3) are possible when the installed wind-power is increased with a factor 5. In case of 15-fold of installed wind power compact heat storage devices compete with 1000 L water buffers. The conclusion is that compact heat storage systems can be of interest in the coming decades in combination with well-retrofitted low energy residences based on the current trends of installed renewable energy power.

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