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Photovoltaic-Driven Thermochemical Storage for Cooling Applications to Be Integrated in Polynesian Microgrids: Concept and Efficiency Study

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Abstract : The energy situation in tropical insular regions, as found in the French Polynesian islands, presents a number of challenges, such as high dependence on imported fuel, high transport costs from the mainland and weak electricity grids. Alternatively, these regions have a variety of renewable energy resources, which favor the exploitation of smart microgrids and energy storage technologies. With regards to the electrical energy demand, the high temperatures in these regions during the entire year implies that a large proportion of consumption is used for cooling buildings, even during the evening hours. In this context, this paper presents an air conditioning system driven by photovoltaic (PV) electricity that combines a refrigeration system and a thermochemical storage process. Thermochemical processes are able to store energy in the form of chemical potential with virtually no losses, and this energy can be used to produce cooling during the evening hours without the need to run a compressor (thus no electricity is required). Such storage processes implement thermochemical reactors in which a reversible chemical reaction between a solid compound and a gas takes place. The solid/gas pair used in this study is BaCl2 reacting with ammonia (NH3), which is also the coolant fluid in the refrigeration circuit. In the proposed system, the PV-driven electric compressor is used during the daytime either to run the refrigeration circuit when a cooling demand occurs or to decompose the ammonia-charged salt and remove the gas from thermochemical reactor when no cooling is needed. During the evening, when there is no electricity from solar source, the system changes its configuration and the reactor reabsorbs the ammonia gas from the evaporator and produces the cooling effect. In comparison to classical PV-driven air conditioning units equipped with electrochemical batteries (e.g. Pb, Li-ion), the proposed system has the advantage of having a novel storage technology with a much longer charge/discharge life cycle, and no self-discharge. It also allows a continuous operation of the electric compressor during the daytime, thus avoiding the problems associated with the on-off cycling. This work focuses on the system concept and on the efficiency study of its main components. It also compares the thermochemical with electrochemical storage as well as with other forms of thermal storage, such as latent (ice) and sensible heat (chilled water). The preliminary results show that the system seems to be a promising alternative to simultaneously fulfill cooling and energy storage needs in tropical insular regions.
Keywords : microgrid, solar air-conditioning, solid/gas sorption, thermochemical storage, tropical and insular regions
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