

Integrating Insulated Concrete Form (ICF) with Solar-Driven Reverse Osmosis Desalination for Building Integrated Energy Storage in Cold Climates

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Abstract : This research addresses the pressing global challenges of clean energy and water supplies, emphasizing the need for sustainable solutions for the building sector. The research centers on integrating Reverse Osmosis (RO) systems with building energy systems, incorporating Solar Thermal Collectors (STC)/Photovoltaic Thermal (PVT), water-to-water heat pumps, and an Insulated Concrete Form (ICF) based building foundation wall thermal energy storage. The study explores an innovative configuration's effectiveness in addressing water and heating demands through clean energy sources while addressing ICF-based thermal storage challenges, which could overheat in the cooling season. Analyzing four configurations—STC-ICF, STC-ICF-RO, PVT-ICF, and PVT-ICF-RO, the study conducts a sensitivity analysis on collector area (25% and 50% increase) and weather data (evaluating five Canadian cities, Winnipeg, Toronto, Edmonton, Halifax and Vancouver). Key outcomes highlight the benefits of integrated RO scenarios, showcasing reduced ICF wall temperature, diminished unwanted heat in the cooling season, reduced RO pump consumption and enhanced solar energy production. The STC-ICF-RO and PVT-ICF-RO systems achieved energy savings of 653 kWh and 131 kWh, respectively, in comparison to their non-integrated RO counterparts. Additionally, both systems successfully contributed to lowering the CO₂ production level of the energy system. The calculated payback period of STC-ICF-RO (2 years) affirms the proposed systems' economic viability. Compared to the base system, which does not benefit from the ICF and RO integration with the building energy system, the STC-ICF-RO and PVT-ICF-RO demonstrate a dramatic energy consumption reduction of 20% and 32%, respectively. The sensitivity analysis suggests potential system improvements under specific conditions, especially when implementing the introduced energy system in communities of buildings.

Keywords : insulated concrete form, thermal energy storage, reverse osmosis, building energy systems, solar thermal collector, photovoltaic thermal, heat pump

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