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INTEGRATION OF ENERGY RECOVERY SYSTEMS INTO RENEWABLE ENERGY COMPLEXES FOR ENHANCING BUILDING ENERGY EFFICIENCY IN UKRAINE

The increasing energy demand, high dependence on fossil fuels, and the urgent need for decarbonization require the implementation of innovative and sustainable energy solutions in buildings. In Ukraine, where energy efficiency remains a major challenge, integrating renewable energy sources (RES) with energy recovery systems (ERS) presents a promising approach to reduce energy losses and improve building performance. This study explores the technical

feasibility and potential benefits of combining photovoltaic (PV) systems, heat pumps, and heat recovery ventilation units within energy complexes designed for residential and public buildings.

Introduction

Buildings account for approximately 40% of total energy consumption in Ukraine, and much of this energy is lost due to outdated infrastructure, poor insulation, and inefficient HVAC systems. In recent years, renewable energy technologies—particularly solar PV and air-source heat pumps—have been actively introduced into building energy systems. However, to maximize the efficiency of these RES, additional strategies such as energy recovery must be employed. Energy recovery systems allow for the reuse of waste heat from exhaust air, greywater, or electronic equipment, reducing overall heating demand. This paper investigates how these systems can be integrated into RES complexes to support the energy transition in Ukraine.

Objectives and Research Tasks

The main objective is to evaluate the potential for improving energy efficiency in Ukrainian buildings through the integration of ERS into RES-based systems. The specific tasks include:

- Analyzing current ERS technologies applicable to buildings.

- Selecting optimal combinations of RES and ERS technologies for Ukrainian climate zones.

- Modeling energy consumption in buildings with and without ERS.

- Estimating the potential for energy savings and CO₂ reduction.

Methodology

A simulation model of a typical Ukrainian residential building (area 120 m²) was developed. The model includes a 5 kW solar PV system, an air-to-water heat pump, and a mechanical ventilation system with a cross-flow heat exchanger for heat recovery. The building was modeled in two scenarios: (1) RES only and (2) RES + ERS. Energy performance metrics, including heating demand, self-consumption ratio, and primary energy use, were analyzed using PV*SOL and RETScreen Expert.

Results and Discussion

Results show that integrating ERS into the RES complex significantly improves building performance. Key findings:

- Heating energy demand was reduced by 28% with the use of heat recovery ventilation.

- Indoor air temperature remained more stable in the RES + ERS scenario.

- Battery storage requirements were reduced by 12%, as more energy was reused internally.

- Total primary energy savings reached 47% compared to a baseline building without RES or ERS.

These improvements are particularly relevant in rural and suburban areas of Ukraine, where centralized heating is not available. Integrating ERS also contributes to decarbonization and energy independence, both critical goals for the national energy strategy.

Conclusions

The integration of energy recovery systems into renewable energy complexes is a technically viable and effective method to enhance the energy efficiency of buildings in Ukraine. The study confirms the potential for significant energy savings and increased system autonomy. Future work will focus on economic assessment and implementation of pilot projects across different climate zones.