Abstract

This graduation project investigates the design, simulation, and economic analysis of a solar-assisted hybrid heat pump system for heating the indoor semi-Olympic swimming pool at An-Najah National University. The current system, which primarily depends on diesel-fired boilers, consumes approximately **70,000 liters of diesel annually**, with a total operational cost of **420,000 ILS (~120,000 USD)** per year. This results in high environmental and financial burdens, especially during the winter season when solar radiation is insufficient.

To address these inefficiencies, the proposed system integrates **evacuated tube solar collectors**, an **electric heat pump (30–70 kW)**, and a **thermal storage tank (5,000–10,000 liters)**. The design ensures that solar energy is utilized during periods of high radiation, while the heat pump acts as a backup during cloudy days or high demand periods. Advanced simulation tools, including **MATLAB**, **Excel**, and **RETScreen**, were used to assess technical performance, environmental impact, and financial feasibility.

The MATLAB model allowed for hourly analysis of system performance, accounting for dynamic thermal losses through evaporation, convection, radiation, and conduction. The system was tested under various scenarios including **pipe insulation** and **thermal pool cover use**, which collectively contributed to significant reductions in thermal losses. With both insulation and a pool cover, heat losses were reduced by more than **40%**, optimizing the system's efficiency.

RETScreen was employed to calculate key financial indicators. The proposed hybrid system showed a **Net Present Value (NPV)** greater than zero, a **payback period of approximately 4–6 years**, and an **Internal Rate of Return (IRR)** exceeding **15%**, indicating high financial viability. Environmentally, the system reduced CO_2 emissions by over **60%** compared to the existing diesel-based system, with a potential to save more than **40,000 kg of CO_2 annually**.

In conclusion, the proposed hybrid solution not only offers a sustainable and cost-effective alternative but also aligns with the university's goals for energy efficiency and environmental responsibility. The methodology and results presented in this project can serve as a model for similar institutional heating applications in regions with moderate solar resources.