Design of a Heat Pump Assisted Solar Thermal System

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Presentation Overview

- Introduction
- System Design
  - System Operation
- Design Performance
- Design Economics
- Research Applications
- Conclusions
- Questions
Introduction

- Energy costs in the last 10 years have risen ~30% in the U.S.

- United States Environmental Protection Agency plans to cut carbon emissions 30% by 2030.

- Increasingly strict building codes
  - ASHRAE 189.1, High Performance Green Buildings
Large portion of energy use in buildings is from heating and cooling.

The average small building uses electricity or natural gas to condition its space and produce hot water.

Alternative uses to provide hot water:
- Solar thermal
- Heat pump
- Solar thermal and heat pump combination
• Combination solar thermal and heat pumps have been evaluated before.
  • Solar assisted heat pump (SAHP) - water medium
  • SAHP - refrigerant medium for freeze protection
  • Solar thermal with back up heat pump in parallel
System Design

- **Heat pump assisted solar thermal system**
  - Solar collectors in series with the heat pump hot water heater
  - 50/50 propylene glycol mix

- **Main system components**
  - Main circulating pump
  - Solar panel array
  - Heat exchanger
  - Heat pump hot water heater
System Design: Operation

- Solar Mode
  - Only using energy generated by solar array.

- Combination Mode
  - Utilizes both solar and heat pump energy generation.

- Heat Pump Mode
  - Only using the heat pump hot water heater.
**Design Performance**

- **Solar Potential**
  \[
  Q = \text{Insolation} \left( \frac{kWh}{m^2} \right) \times \text{Collector Area}(m^2) \times \text{collector efficiency}
  \]
  - Collector area: 7.7m²
  - Collector efficiency: 60%

- **Heat Pump capabilities**
  - 5000 BTUh (~1.5kW)
  - 12hrs/day, annually 6400kWh produced
Atlanta, GA (33.7° N)
- Total kWh availability: ~8600 kWh
- Daily Average: 23.5 kWh
- Combined annual potential: 15000 kWh

Indianapolis, IN (39.8° N)
- Total kWh availability: ~7700 kWh
- Daily average: 21 kWh
- Combined annual potential: 14100 kWh
Design Economics

- Estimated system cost: $6,000
- Estimated system life: 20 years

Viable Applications
- Year round heating
- Small manufacturing process heat
- Commercial AHU reheat design
A solar heater with heat pump backup will use less than half of the heating energy as compared to traditional electric resistance heating.

A solar heater with heat pump backup is a viable option for solar reheat in a commercial air handler.
Conclusions

• Beneficial for year round production/use

• Rising energy costs, strict emissions, strict codes

• Push towards new energy technologies

• Renewable and sustainable energy for the future