22nd ANNUAL NEW YORK STATE GREEN BUILDING CONFERENCE

COLD AIR RECIRCULATION ASSESSMENT FOR HEAT PUMP OUTDOOR UNITS

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INTRODUCTION

GOAL

To assess the effects of cold air recirculation on heat pump efficiency, with a particular focus on the roles of gravity and fan-generated low-pressure areas.

Might cold air recirculation cause a problem?

Yes, it might,
- Reduce heating capacity
- Increase energy use
- Decrease efficiency (Coefficient of performance)

Literature Survey

A prior study found that for a single outdoor unit (See Figure A) configured in a downflow arrangement, the recirculation rate under long-term average wind conditions was **7.8%**. However, in multifamily installations with multiple outdoor units arranged in a row, the recirculation percentage increased significantly. Recirculation rates ranged from **16.9%** to **52.5%** under typical wind conditions.

REFERENCES: “Analysis of Cold Air Recirculation in the Evaporators of Large-Scale Air-Source Heat Pumps Using CFD Simulations.”

SOURCE: www.mdpi.com/2311-5521/5/4/186

BACKGROUND

How evaporators and air recirculation influence heat pump outdoor units:

Evaporators:
- Evaporators are crucial for heat transfer processes in thermal systems, facilitating cooling or heating by absorbing heat from one medium and transferring it to another.
- They impact system efficiency, performance, and energy consumption by efficiently transferring heat.

Air Recirculation:
- Air recirculation affects thermal systems by altering airflow patterns, temperature distributions, and energy efficiency.

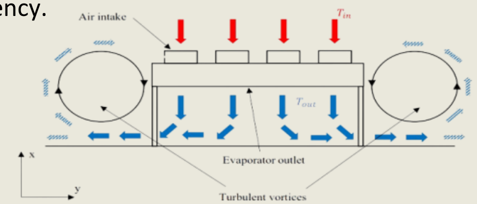


Figure A: Sketch of flow recirculation around the evaporator

IMAGE REFERENCES- Analysis of Cold Air Recirculation in the Evaporators of Large-Scale Air-Source Heat Pumps Using CFD Simulations.

Our approach focuses on investigating airflow patterns around heat pumps.

Figure B: Example CAD model of LG LMU300HHV

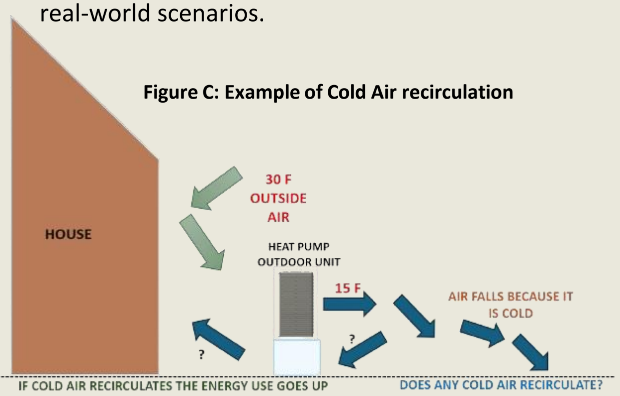
CAD model development for LG LMU300HHV integration into the fluid simulation.

SPECIFICATIONS:
- Rated heating capacity: 28,600 Btu/hr.
- Heating System Performance Factor(HSPF): 11

SIMULATIONS

- Implementing a CAD model and converting it into Fluent simulations.
- Setting up boundary conditions within the simulations.
- Analyzing flow rates and evaluating their impact on real-world scenarios.

Figure C: Example of Cold Air recirculation



Boundary condition specification includes:

- **Outflow Air:** With a maximum airflow rate of 2,295 ft^3/min.
- **Leaving Air Temperature:** The temperature of the air as it exits the heat pump's outdoor unit is set to 15°F.
- **Ambient Air Temperature:** The boundary condition for the ambient air temperature surrounding the outdoor unit is established at 30°F.

Engineering Solutions: To address recirculation concerns, various engineering solutions may be considered, such as optimizing evaporator design, modifying airflow patterns, or introducing baffles or barriers to disrupt recirculating airflows.

We may also try a parametric study using lower airflow rates and varying temperatures.

RESEARCH QUESTIONS

1. What are the potential implications of high recirculation rates on the performance and efficiency of the heat pump system?

High recirculation rates can lead to decreased efficiency and performance of the heat pump system. This may result in reduced heating or cooling capacity, and increased energy consumption impacting the system's overall reliability and longevity.

2. Does recirculation change substantially for temperatures other than 30°F (e.g., 0-60°F), and lower airflow rates?

We expect to find that recirculation rates will indeed vary with temperature changes, as the density and behavior of air change with temperature. Similarly, varying the airflow rates will likely alter the recirculation rate, which we intend to map across different scenarios.

3. If recirculation is of concern, will a baffle reduce it substantially to a level of no concern?

We hypothesize that the introduction of a baffle will disrupt the airflow pattern, thereby reducing the recirculation rate. We aim to quantify this effect and determine the conditions under which a baffle is most effective.

4. Can computational fluid dynamics (CFD) simulations accurately predict recirculation rates under varying conditions?

We will validate the model with the measurements on the same model heat pump, in the field.

The project is being done as part of a project titled **“Reducing Applied Losses in Air Source Heat Pumps,”** under the DOE Building America program, with a contract with the National Renewable Energy Lab.

---JAYAPRAKASH CHANDRAN GOVINDHASAMY SHANKAR