U.S. DEPARTMENT OF
ENERGY
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Designing for Supply and Return Air System Interaction in Residential Buildings

This fact sheet summarizes supply and return ductwork strategies and their impact on airflow. Maintaining airflow balance to rooms is critical for home comfort.

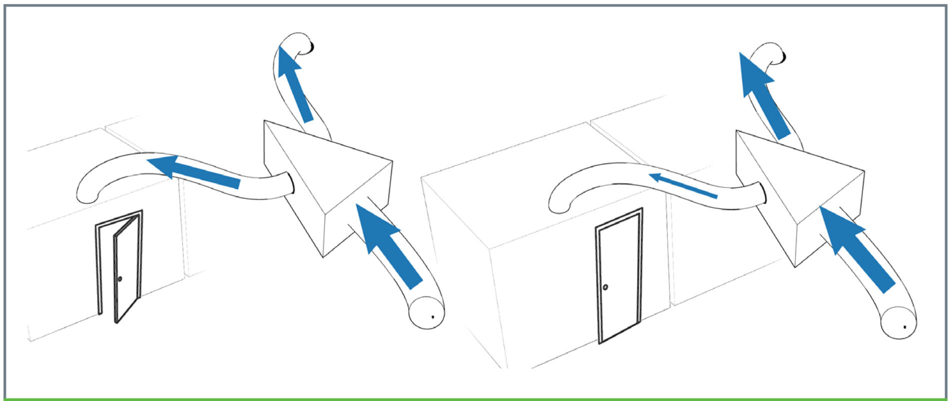

Figure 1. The impact on supply airflow when a bedroom partition door is closed, and an adequate return air pathway is not provided.

Introduction

Optimizing heating, ventilating, and air-conditioning (HVAC) distribution systems and bringing ductwork into conditioned space can help increase energy efficiency in homes. A common issue, however, is when rooms do not have an adequate return air pathway back to the air handler. This leads to rooms receiving too much or too little conditioned air, particularly when doors are closed, and it can become uncomfortable for occupants, as seen in **Figure 1**. Designers must carefully consider the interaction between the supply ductwork and return air pathways when designing a home's HVAC system—different supply and return ductwork strategies have different design, structural integration, installation, and cost implications.

Supply and Return Strategies

Following is a listing of supply and return strategies used in homes:

Supply

Trunk and branch: A primary trunk connects branching ducts to the central air handler.

Radial splitter: Sequential splitter boxes are used to connect ductwork to the central air handler.

Home-run: All ducts connect to a central manifold at the air handler unit with no splits or sequential connections. Ducts are typically all the same diameter with multiple ducts specified based on room load.

Return

Distributed: A dedicated return duct is routed to each room in the home. Ducts must be sized to minimize the return static pressure drop.

Central, per floor: Each floor of the home has a return grille located in a central hallway. Because ductwork is shorter and routing simplified, static pressure drop is typically lower relative to a distributed return.

Central, single: Similar to the central, per floor scenario but with a single return for the entire home, typically located near the air handler; it is common to use this strategy in conjunction with a dedicated return to the master bedroom. The static pressure drop is typically the lowest with this strategy.

Return Ductwork Sensitivity

With a distributed return strategy, the airflow balance to each room is not significantly impacted by the choice in supply strategy when opening and closing bedroom doors; this is because each room has a dedicated return air pathway independent of the partition door. When using central returns (single or per floor), properly sized return air pathways (such as transfer grilles or jump ducts) help to minimize the gain in static pressure from closing bedroom doors, regardless of supply strategy. However, when door undercuts alone are used as return air pathways, the choice of supply strategy will show a marked difference in performance.

Supply Ductwork Sensitivity

The choice of supply ductwork strategy does not show a significant difference in airflow balance when dedicated returns are used, or when central returns are used with transfer grilles or jump ducts providing sufficient return air movement. However, when door undercuts are used with central returns, the choice of supply strategy can noticeably impact the airflow balance to each room when doors are closed.

- With a radial splitter box system, the static pressure is lowest at the final split due to previous splits and high loss components, leading to a drop in supply airflow. Airflow is then redirected to an adjacent duct on the splitter box, exacerbating the imbalance.
- With a trunk and branch system, more adequate supply airflow can be maintained with good design and installation practices that reduce the main trunk diameter to better maintain the static pressure throughout the supply system.
- With a home-run system where all ductwork is connected to a single central manifold, all ducts have the same, higher static pressure available

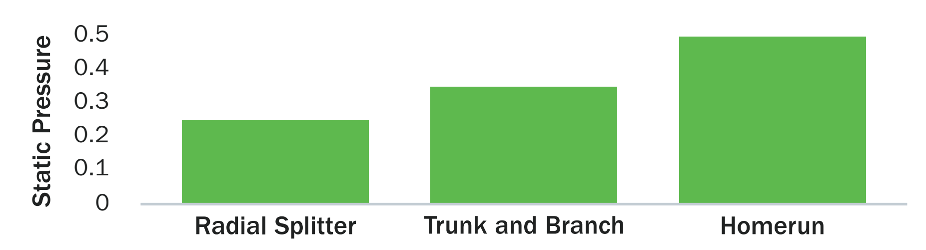

Figure 2. Static pressure available in the final split for the three air supply strategies

that results in superior airflow to rooms. If airflow is reduced to one room, it is equally redistributed to other rooms from the central manifold, minimizing the impact on comfort.

Figure 2 illustrates the relative supply airflow performance to rooms when using a central return strategy with door undercuts, when doors are closed. Greater values indicate more available static pressure to overcome resistance and therefore less likelihood that airflow will be redirected to an adjacent room.

Cost Comparison

Tables 1 and 2 show the estimated cost for each supply and return strategy. All costs are based on the ducts located in conditioned space and were estimated for a 2,800 ft^2 two-story slab-on-grade home and include supply and return duct components, transfer grilles, chase and bulkhead framing, and labor for the duct system installation. Costs are based on general industry data for production homebuilders and may vary by region and local labor rates and material costs.

The supply system costs show the least variation because all systems include ducts to each room. The trunk and branch system is most expensive due to increased labor and unique component count. The home-run system is least expensive due to fewer unique components, easier structural integration with smaller drop ceilings and chases, and reduced installation labor.

The return systems show the most variation in cost. The distributed return strategy is most expensive because of increased materials and labor to install return ducts to every room in the home. The central return options are significantly less expensive due to fewer materials, labor, and easier structural integration.

Conclusions

HVAC system designers have a choice in supply and return strategies to provide needed occupant comfort and meet the required energy codes. Our research shows that a home-run supply duct system can best maintain airflow balance when bedroom doors are closed and door undercuts are used as a return air pathway. Home-run systems are new to the market, however, and have not yet seen significant adoption. Distributed ducted returns and systems with sufficient return air pathways eliminated airflow balance sensitivity regardless of supply system.

Using a central return strategy can lead to significant cost savings, yet is most sensitive to the choice in supply strategy, especially when using door undercuts as a return air pathway from rooms. If using a central return with door undercuts, designers should consider a properly designed and installed trunk and branch or home-run supply strategy to minimize airflow resistance and improve comfort.[1] ■

[1] This work is based on CONTAM building airflow models, using real-world coefficients and factors. Field testing may show that the modeling impact is less than or greater than the real-world impact, but it is expected that the relative sensitivity of each system is accurate. A complete description of the modeling work and results can be found in the companion technical report.

Table 1. Comparative Costs—Supply

Supply Layout	Estimated Cost
Radial	$3,100
Trunk and branch	$3,700
Home-run	$2,700

Table 2. Comparative Costs—Return

Return Layout	Estimated Cost
Distributed	$3,000
Central, per floor	$1,100
Central, single	$600

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Technical Report:
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