What's New in Building Energy Research

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Thermal Distribution Technology

DOE looks at cutting energy losses in a building's heating and cooling distribution system

More than 10% of all primary energy consumed in the United States passes through ducts and pipes to heat and cool buildings. In recent years, research has focused on improving the energy performance of the building envelope, heating and cooling equipment, lighting, and appliances inside the building. However, little attention was given to the thermal distribution system.

Although the energy efficiency of forced-air furnaces currently averages about 75% to 85%, the efficiency of distribution systems typically averages about 60% to 70%. This level of efficiency means that thermal distribution systems are wasting some \$15 billion worth of energy each year. Even worse, the lowest efficiency occurs during the hottest days of summer or coldest days of winter—peak demand days.

Besides being inefficient, these systems often produce uneven heating and cooling and sometimes affect the health of building occupants. The systems also increase environmental pollution through additional combustion to make up for the wasted power and fuel.

The Office of Building Technologies (OBT) of the U.S. Department of Energy (DOE) works with industry to improve the energy efficiency of residential and commercial buildings. OBT's program in thermal distribution systems focuses on developing the technology and information base necessary to advance the maximum energy efficiency of thermal distribution systems in residential and small commercial buildings. Program objectives seek to

- Establish a voluntary national consensus standard for measuring the efficiency of thermal distribution systems for use by government- and utility-sponsored programs
- Develop the cost-effective materials, systems, and methods necessary for 100%-efficient thermal distribution and promote their wide application.

Losing Energy Through Distribution Systems

Forced-air furnaces, the most common heating system, waste energy through duct leakage, the system's effects on a building's infiltration rate, and thermal conduction. For example, duct leakage accounts for 10% to 20% of the total air infiltration rate when the furnace blower is off. Total infiltration rates typically increase by 200% when the blower fan is turned on. The total infiltration rate can increase by as much as 500% when the return air paths are impeded, such as when interior doors are closed.

Studies by the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory (LBNL), and the Florida Solar Energy Center show that duct inefficiencies increase a building's heating and cooling load by 30% to 40%.

Forced-air furnaces waste energy through duct leakage, imbalance and system flows, and thermal conduction.

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Photo courtesy of Lawrence Berkeley National Laboratory/PIX#1426

This first prototype of an aerosol-based sealing technology for residential ducts was developed by Lawrence Berkeley National Laboratory.

Conduction through uninsulated or poorly insulated ducts into unconditioned space, such as an attic or crawl space, typically adds 20% to the building's space-conditioning load.

Using existing technologies could save most of the energy wasted in thermal distribution systems. The incremental costs of efficiency improvements range from \$100 to \$200 for a new home and \$300 to \$500 for a retrofit. If only one-half the typical loss of uninsulated and unsealed ducts in attics or crawl spaces were saved, it would cut the total heating and cooling bill in a typical home by \$160. With these savings, the cost to seal and insulate the ducts would most likely be paid for after 3 years. These estimates apply to retrofitting an existing home. For new construction the potential savings would be greater. And with lower cost to install sealant and insulate, the payback would be less than 1 year.

Even with these advantages, however, builders and building owners have not adopted these higher efficiency distribution systems. Reasons include

- A lack of accurate data on thermal distribution performance
- Inadequate tools for evaluating more efficient alternatives
- Lack of incentives that would allow builders and building owners to take credit for improved systems.

Working Toward 100% Efficiency

To help meet DOE's first objective, Brookhaven National Laboratory and LBNL conducted a study in 1991. The analysis found that possible savings would exceed 2 quadrillion Btu

(2 exajoules) of primary energy annually by 2020.

The study identified some incentives and technologies. Incentives include "figures of merit" for thermal distribution systems. These figures of merit would be used in weatherization, utility demand-side-management programs, and home energy ratings.

Technologies for both new construction and retrofits include cost-effective retrofit tech-

niques for duct sealing and insulating and cost-effective new house designs that place ducts within the conditioned space. One technology currently being developed seals ducts from the inside and should seal currently inaccessible leaks to significantly reduce sealing costs.

Developing Figures of Merit

Figures of merit have been successfully used to promote efficient use of heating and air-conditioning equipment. A comparable figure of merit would help promote efficient thermal distribution systems. Examples of figures of merit include

- Annual Fuel Use Efficiency for furnaces and boilers
- Heating Seasonal Performance Factor for heat pumps
- Seasonal Energy Efficiency Ratio for air conditioners.

A proposed framework accounts for interactions between the thermal distribution system and the building envelope and for interactions with the heating and cooling equipment and the weather dependence of thermal distribution efficiency. A figure of merit will allow for comparing forced-air, hydronic, and refrigerant distribution systems, and will apply to the installed heating and cooling system efficiencies. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is developing a standardized figure of merit (SPC 152 P) for homes that includes heating and cooling equipment with forced-air or hydronic systems.

Partnering with Industry

OBT program activities are coordinated with public- and private-sector groups. These groups include the Association of State Energy Research and Technology Transfer Institutions, ASHRAE, the Electric Power Research Institute, the Gas Research Institute, and the National Association of Home Builders.

An example of this coordination was demonstrated at the DOE-Industry Thermal Distribution Conference, held in March 1992, which brought together industry and government representatives. They discussed ways to reduce the energy loss from inefficient heating and cooling air distribution systems in small buildings. Presentations on current research findings and viewpoints were followed by workshop and panel discussions on how DOE can best assist industry in promoting energy efficiency in thermal distribution systems.

Another example is the Thermal Distribution Coalition sponsored by the National Association of Plumbing-Heating-Cooling Contractors. This group of industry associations supports research on duct efficiency and the development of the ASHRAE figure of merit. The consortium also confers with DOE on industry needs.

A brochure entitled *Improving the Efficiency of Your Duct System* is available from the Energy Efficiency and Renewable Energy Clearinghouse.

For More Information

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