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VENTILATION

Evaluating Ventilation in Multifamily Buildings

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The technologies used to ventilate multifamily buildings are not all that complex, yet problems with indoor air quality and high en

While we in the energy conservation business have long been aware of the need for fresh air in a dwelling, we are just beginning to realize how vital it is to a family buildings, blower doors help us quantify air leakage; we have found a wide variation of leakage rates depending on builder, building type and mainte leakage rates per occupied unit appear to be much lower. Since lower leakage levels can cause indoor air quality problems and lead to building system prob multifamily buildings. However, since ventilation systems use energy and cause energy usage through the necessary heating or cooling of the incoming fres ensure that buildings are not over-ventilated. Mechanical ventilation in multifamily buildings varies: some buildings provide centralized air supply and/or others provide small fans in kitchens and bathrooms, some under tenant control and some under building staff control.

The New York State Energy Research Development Authority recently funded a study to assess the types, effectiveness, and energy efficiency of ventilation addition, a procedure and software were developed to audit these systems. Taitem Engineering performed the study using Syracuse Energy Service Compa as subcontractors.[1] We collected detailed information and measurements for ten sites and collected information characterizing ventilation systems on anot many surprising discoveries.

Ventilation and Multifamily Buildings

ASHRAE mandates that if buildings fall below certain criteria for measuring indoor air quality, they must be mechanically ventilated. While the requireme continuous low ventilation of kitchens and baths appear appropriate, the important provision that ventilation for the rest of the building (0.35 air changes for multifamily buildings due to their lower infiltration rates. This was confirmed by air quality problems we observed in many buildings in this project.

These problems are endemic to multifamily buildings because most multifamily units share at least one common wall with another occupied dwelling. This (leakage areas) for fresh exterior air coming directly into the unit. Research recently conducted by Larry Palmiter at Ecotope has shown that air from the ou exiting the building.[2] More people live in multifamily buildings than in single family buildings, which affects indoor air quality as well.

Building Types:

Three buildings we studied in New York City had a similar structure: three- to five-story tenement buildings with a single stairwell, generally of masonry co thirteen and fifteen stories, with interior entrances into corridors (see Table 1).

In upstate New York, the buildings surveyed were "low-rise" (from 2 to 4 stories), all-electric buildings participating in a demand-side management project exterior entrances, and some were apartments with interior entrances from hallways.

Ventilation

In the New York City buildings surveyed, if bathrooms or kitchens did not have operable windows, they were given a central exhaust fan that ran much of t bathrooms and kitchens with operable windows, in which case there was no mechanical exhaust present (82% of the buildings). Corridors in the tenement provided with supply air, but did have ventilation openings (by code) at the top of the stairwell, usually in a skylight. Supply air was provided mechanically surveyed, primarily in larger buildings where the fresh air is provided from a single fan into the corridor on each floor.

Most upstate buildings surveyed (96%) had some form of mechanical exhaust that usually consisted of tenant-controlled small exhaust fans in bathrooms a
from multiple bathrooms/kitchens, was present in 26% of buildings. Supply (fresh) air was provided mechanically in 36% of buildings, usually into corrido
state code.

Fan Operations

In the buildings we inspected, one of every four fans was non-functioning or permanently turned off, usually because of mechanical failures, noise complai
The predominance of occupant-controlled bathroom and kitchen fans in upstate New York buildings led us to question how long tenants actually ran such
minimally used: 28 of 32 tenants in units with kitchen exhaust fans used them for less than one hour per day, and the four remaining tenants reported not
with bathroom exhaust fans used them for less than one hour per day; nine of the remaining tenants reported not using the fan at all; and one tenant said t

We measured airflow on a number of fans in the buildings with a balometer (flow hood) and compared the airflow with design values, either taken from ori
Actual airflows ranged from 6%-254% of rated airflow, averaging 68% (almost one-third less than required). The culprit was usually dirty registers, many o
some dirty filters, but they were not the primary cause of airflow obstruction, because most systems did not have filters. We also found unusual airflow obs
registers, insulation in the ductwork, and even a bee's nest!

Fan power was also measured on several fans. Gross fan and system power-to-airflow ratios ranged from .19 to 1.25 watts per CFM, averaging .63 watts per
airflow ratios (the inverse of efficiency): a variation of up to 600% from the most efficient system.

"Comfort" versus Supply Air

Tenant surveys revealed that mechanical ventilation was associated with complaints about drafts, confirming the separate finding that exhaust airflow is of
shortfall comes from leakage into the building, often through dwelling units. Of eight buildings with supply fans, three had serious comfort complaints in th
severely under-ventilated. Clearly there is a technical challenge to providing comfortable *supply* air into a space when the outdoor temperature varies seaso
on several factors and varies widely. Without changing how supply air is provided, the majority of multifamily buildings will sacrifice either comfort or suff

This problem is not unique to multifamily buildings but is widespread. In large commercial buildings, it is usually addressed through complex controls. Ho
buildings where the complexity and cost can be justified.

Exhaust ventilation is also not without dilemmas. When exhaust fans are tenant-controlled, it is difficult for a building designer to know how to size the sup
other hand, if exhaust fans are centrally controlled, much ventilation is unnecessarily provided, exhausting air even when tenants are not home. Results fro
resulting from tenant control of exhaust fans is only sufficient to control temporary odors in the kitchen or bath. It is clearly not being used to draw in fresh
sources of poor indoor air quality.

Indoor Air Quality

At the time of the initial audits and during follow-up visits, auditors identified pertinent ventilation-interactive issues such as health and safety, comfort, in
done by interviewing building management, building facilities personnel, and tenants. Emphasis was placed on qualitative (descriptive and anecdotal) evid
issues at in the future.

Probably the most striking example of indoor air quality problems was found in a 15-story building in Queens. The 15 residential floors generally had adequ but the basement served as a workshop for sorting, cleaning, and shipping used clothes. Trucks frequently backed up to a loading dock and we found sever throughout the basement, including traces found on exhaust registers in the residential section of the building. Other sources contributing to poor indoor a bathroom use, cleaning fluids, smoke from other apartments, chemical pollutants, car exhaust, garbage room fumes, nearby factories, pigeons, and diapers auditors to look out for anything that requires special ventilation or other measures, such as source reduction to mitigate.

There was a high correlation between the amount of ventilation and the level of air-quality complaints. Two tenants in different apartments in a well-ventil when asked about possible odors. Tenants in an unventilated Brooklyn tenement complained about a wide variety of air quality problems, including pet od tenement where central exhaust fans were not being used complained about smoke and cooking odors, and then reported significant improvements after tv landlord.

Energy Conservation and Ventilation

While the sample size was small, New York City buildings used more energy for mechanical ventilation, on average (12%) than upstate buildings (5%), alth ventilation energy use was upstate (20.6%). Buildings with mechanical ventilation--those which had only tenant-controlled bathroom and/or kitchen fans- averaging only 0.9% of total building energy use. (This calculation assumes each tenant ran each fan for 1/2 hour per day which is representative of respons with central ventilation fans, which were usually run for more hours per day than the tenant-controlled fans, predictably used more mechanical ventilation

We analyzed and compared three options for conserving mechanical ventilation energy with a generic "air sealing" (reduction of natural ventilation) conse isolation, using the existing installation and energy use as a baseline. Each was evaluated according to simple payback and applicability. Could the option b mechanical system and ductwork?

Option 1: Heat Recovery

Heat recovery would be a viable option in three of the five New York City buildings, but would not be applicable in any of the upstate buildings. Heat recove building sector and may also require engineering design, which adds to the cost.

The three candidate buildings in New York City had similar structures: three- to five-story tenement buildings with a single stairwell and rooftop exhaust fa was an ideal location to provide makeup air, as there was only one of these per building (single location to provide air, and so less ductwork), and because t air ductwork from the roof where a heat recovery ventilator could be located. However, paybacks for heat recovery in these three buildings averaged nearly

While two of the upstate buildings had central-supply air provided into the corridors, all buildings relied on tenant-controlled exhaust fans. The widely dist prohibit their use in the central exhaust duct required for heat recovery, and so would require additional duct installation, making this option prohibitively

Option 2: Timer Controls

Overall whole building timer controls for ventilation systems were not an option in the exhaust systems in the upstate buildings, because of the tenant cont already in use on a central supply air fan in one building, and another central fan was turned on and off daily by building staff.

Timers would be appropriate for four of the five New York City buildings, because code requires ventilation 18 hours per day for bathrooms without windov mechanical timer could be installed and immediately save 25% of the thermal and motor energy required. Timers were also found to be appropriate for sev ventilating above the required six air changes per hour. Timers are a simple and low-cost energy conservation measure, consistently providing an attractive

Option 3: High Efficiency Motors/Fans

The economic viability of fan/motor replacement depends strongly on how long the motors run and the cost of electricity. In upstate New York, where elect are not attractive if they run less than an hour each day. Payback is longer than the useful life of the motors. However, in New York City, with electricity arc and 18-hour bathroom exhaust, high-efficiency motors are a more attractive option. Paybacks in New York City for high-efficiency motors averaged 5.4 yea

Option 4: Air Sealing

Air sealing showed higher potential savings than mechanical ventilation in upstate buildings (more than 11%) and lower potential in New York City buildin context that estimating air leakage in multifamily buildings is difficult with current audit techniques. The results may partially reflect the method used to es In the New York City buildings, we predicted air leakage with the EA-QUIP computer program, which uses an analytical method based on the auditor's des the building (see "Confessions of an Addicted Auditor," *HE* May/June '94 p.29). For upstate buildings, we derived air leakage estimates from a combinatio and auditor's experience. Air sealing should only be considered after a thorough investigation to determine the building's natural air change rate. This cann units within the building, since part of the air leakage measured will be leakage from adjacent units. If the building's true air leakage cannot be determined conservation measure. We continually found prohibitively low air leakage in the buildings participating in upstate New York.

Recommendations

Standards for Fan Performance

The wide disparity of fan efficiency points to the potential for energy savings with more efficient fans and motors, and appropriate duct sizing, as well. One through a minimum fan/system efficiency requirement mandated by energy conservation codes, similar to the minimum efficiency requirements for heatin efficiency regulation would need to account for the role of ductwork in a ventilation system, and so might be appropriately applied to the final installed syst static air pressure. This would provide a level playing field for manufacturers and ventilation installation contractors, as well as consumer protection from s energy.

Codes

Codes should provide for dampers in the ventilation system that disallow leakage through the ventilation system due to the stack effect when the system is dampers (motor controlled) are justified for the small kitchen and exhaust fans. Our observations indicated that simple backdraft dampers provide ample a *vertically*. The vertical orientation allows the weight of the damper itself to prevent air leakage due to the stack effect. Spring loading of horizontally orient such dampers can also *prevent flow altogether*, even when the fan is operating.

Manufacturers

More information about fan power consumption, at design and off-design conditions should be provided. Some catalogs provide information on brake hors and system designers is power consumption over the whole performance curve. Providing nominal motor efficiency and power draw (watts) on the motor n heater controls for supply air systems are needed, particularly duct heaters and cabinet heaters (rooftop supply air heaters are less common in multifamily for constant supply air temperature, with setpoint which may be varied.

Architects/Engineers

While architects and engineers clearly have significant control over the ultimate combination of comfort, indoor air quality, and energy consumption ventil understand the shortcomings of existing systems: Current supply air strategies almost always fail. Providing temperature control of corridors independent control of supply air that avoids cold blow into corridors can help avoid this problem. Other design-phase options would include the use of heat recovery ec designs and/or high fuel cost areas and building designs.

Owners and Maintenance Staff

Owners and staff can contribute significantly to building air quality and reduced energy use of ventilation equipment with a few simple preventative measu filters and fans, and inspecting fans for operation and airflow obstructions.

Energy Auditors

Energy auditors should focus on several key issues when examining a ventilation system:

- Check to see if the ventilation system is working at all, (25% of the fans in this study were not)
- check to see if the system design makes sense and does the job as effectively as possible
- Watch out for those systems that are over-ventilating the building
- Be aware of indoor air quality problems associated with poor or improperly designed ventilation systems
- Keep the energy conservation options listed above in mind when exploring those measures which can reduce energy usage, but be aware of possible each
- Bear in mind the impact that improper maintenance of the ventilation system has both on the building and the energy usage of the system

Further Research

Much of the uncertainty surrounding ventilation codes and strategies could be eliminated if an accurate method of quantifying natural air change rates was include optimal ways to provide supply air; optimal ventilation system design for new construction; strategies to control ventilation on the basis of demand backdraft dampers in preventing stack effect airflow out of exhaust systems.

The technologies used in multifamily building ventilation are not complex, yet our observations indicate that there are many shortcomings, relating to both shortcomings can be overcome without developing new technology. However, the number of people involved in providing proper ventilation--from design officials to building staff and tenants themselves--adds a level of complexity that often compromises the ventilation system. Equipment selection, system d to be the keys to overcoming the barriers to healthy, energy-efficient ventilation in new construction. For auditors assessing an existing system, however, o available to increase ventilation efficiency, care must be taken to ensure selected measures are cost-effective and appropriate. Most important is to ensure t that residents enjoy good indoor air quality, which is what ventilation systems are installed to provide.

Notes

1. This article is based on the report, "Evaluation of Ventilation in Multifamily Dwellings" (Report 93-5), published by the New York State Energy Research Plaza, Albany, New York. Tel:(518)465-6251, ext. 272.

2. See "Measured Airflows in a Multifamily Building," ASTM Symposium on the Airflow Performance of Building Envelopes, Components, and Systems, Oc

Table 1. Characteristics of Buildings Used in Multifamily Ventilation Project

Site	Number of apartments	Stories	Central halls	Exhaust local	Exhaust central	Supply local	Supply central	Supply heat	Supply heat fuel	Individual metered
UPSTATE										
Drumlin Heights	18	2	N	Y	N	N	N	N	-	Y
Salina Schools	38	3	Y	Y	Y	N	Y	Y	E	Y
Clarendon Heights	250	3	N	Y	N	N	N	N	-	Y
Sunset Woods	40	4	Y	Y	N	N	Y	Y	E	Y
Country Gardens	83	2	Y	Y	N	N	N	N	-	Y
NEW YORK CITY										
Goodwill Terrace	208	15	Y	N	Y	N	Y	Y	O	N
48th Street	15	5	Y	N	Y	N	N	N	-	N
47th Street	15	5	Y	N	Y	N	N	N	-	N
Putnam Avenue	6	3	Y	N	N	N	N	N	-	N
Holland Avenue	120	13	Y	N	Y	N	Y	Y	O	N

E - electric O - oil G - natural gas local - local ventilation, i.e., kitchen and bath

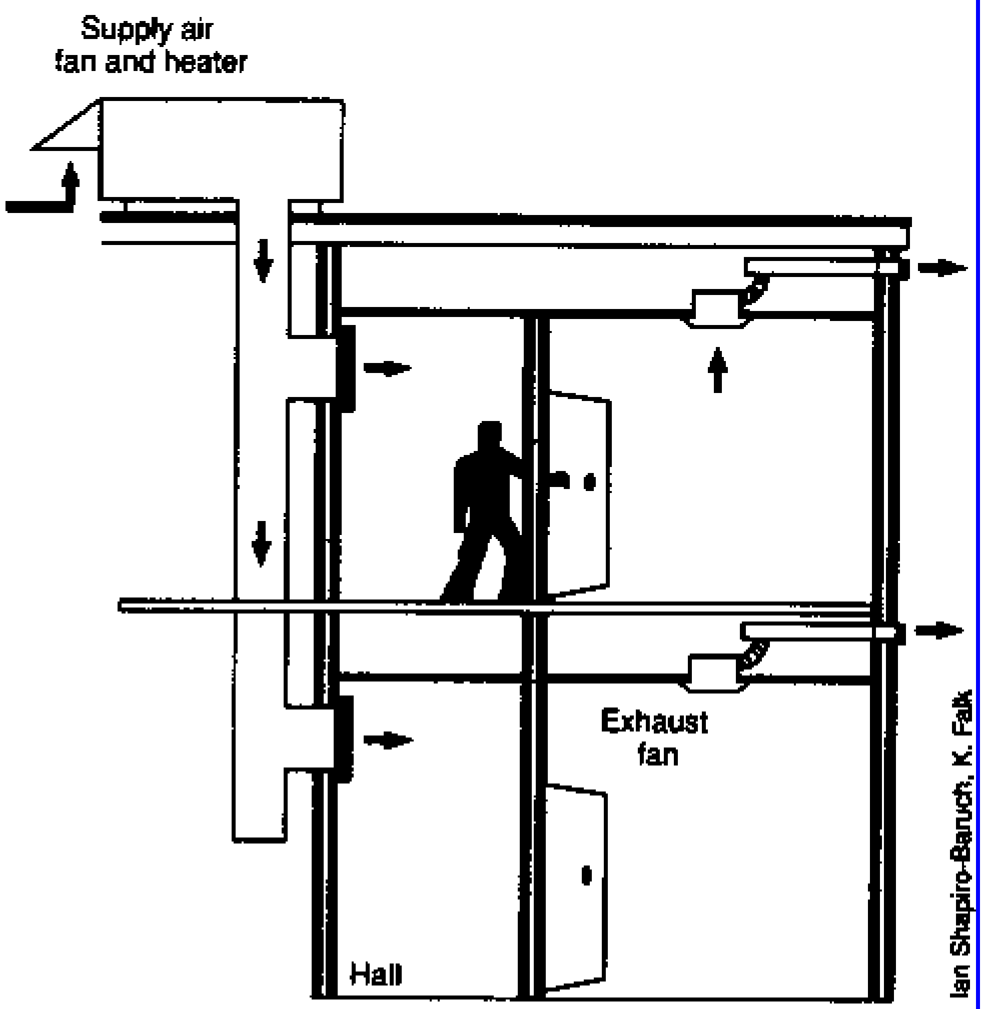

Figure 1. Typical multifamily ventilation system.

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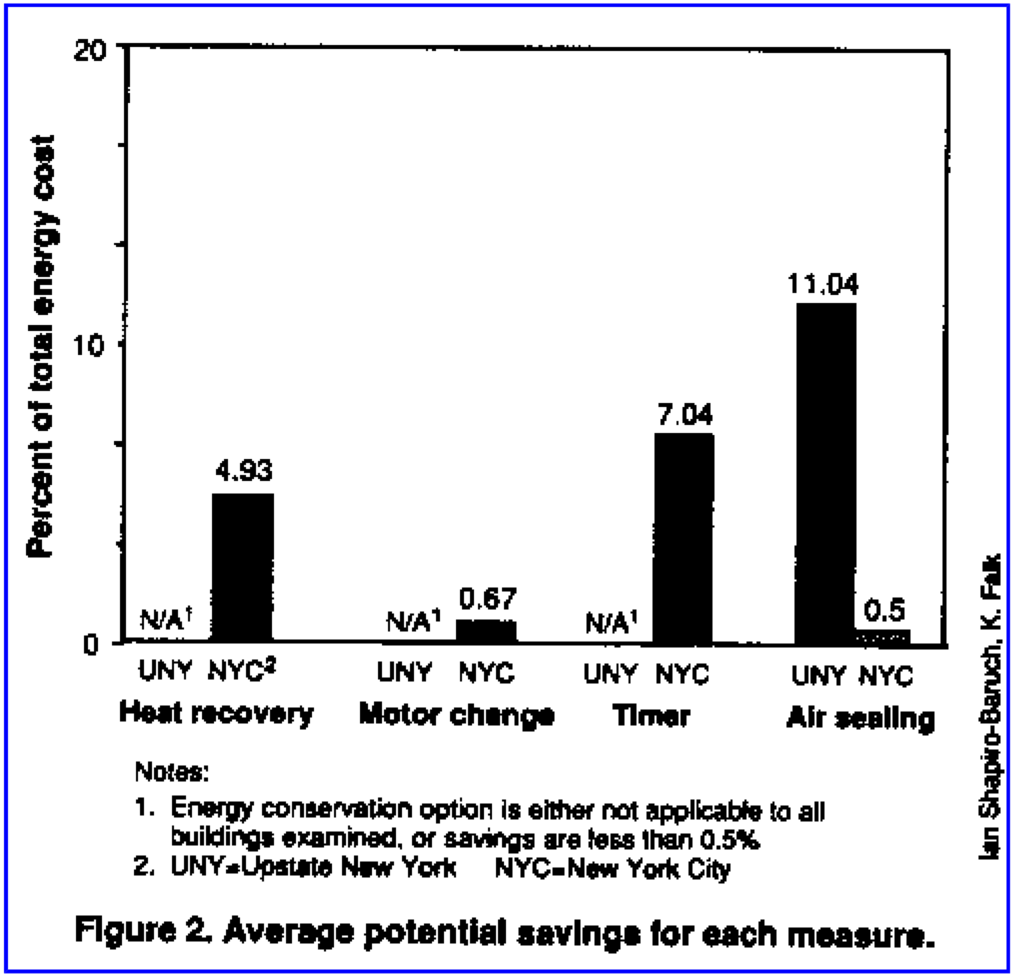

Figure 2. Average potential savings for each measure.

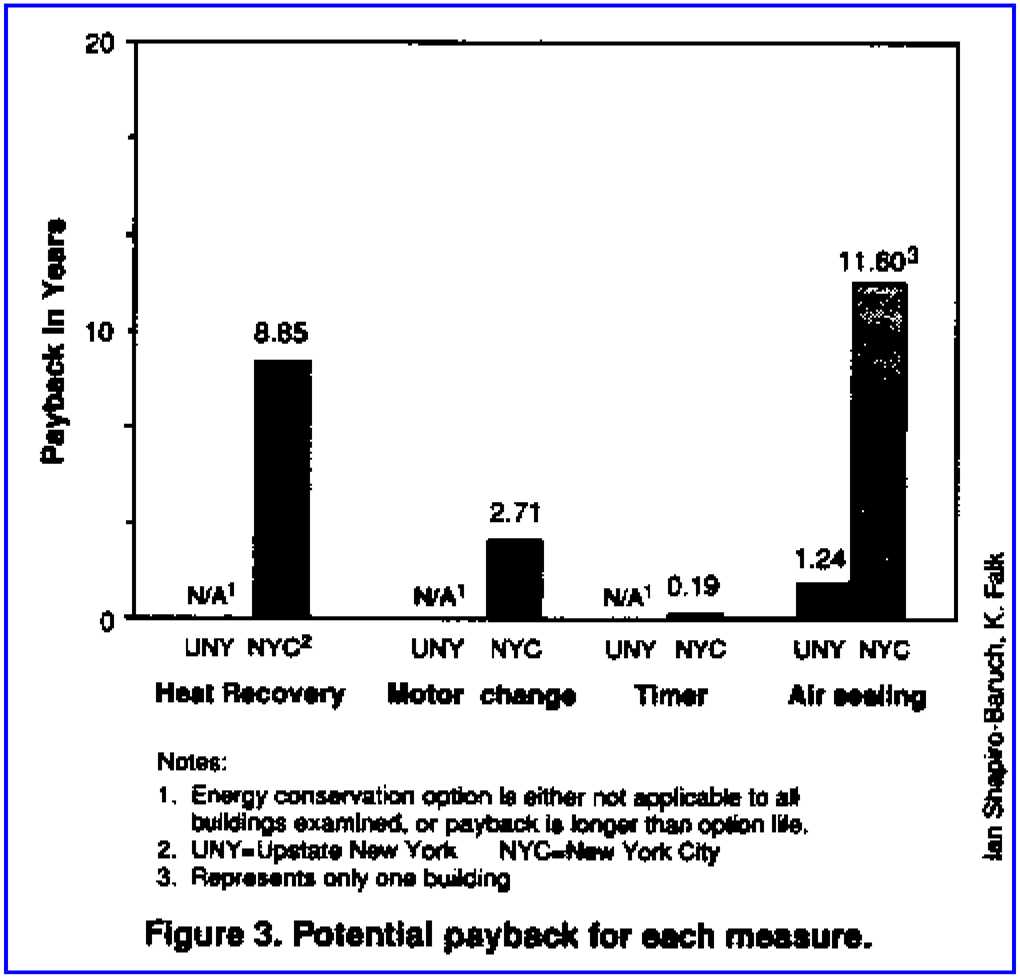

Figure 3. Potential payback for each measure.

Related Articles

["Integrated Heating and Ventilation: Double Duty for Ducts" (Jackson)]
["Ventilating Attics to Minimize Icings at Eaves" (Tobiasson, Buska, and Greatorex)]
["Air Sealing in Low-Rise Buildings" (Hayes)]

"Infiltration: Just ACH50 Divided by 20?" (Meier)
"Introduction to Blower Doors" (Keefe)
"The Best Boiler and Water Heating Retrofits" (Lobenstein and Hewett)
"Bright Prospects for Lighting Retrofits" (Hasterok)
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