Published on *BuildingGreen* (https://www.buildinggreen.com (https://www.buildinggreen.com))

Mind the Gaps: Making Existing Buildings More Airtight

FEATURE ARTICLE

Leaky building enclosures create health hazards, comfort problems, and high energy bills. Fixing them isn't rocket science; but you'd better know your building science.

by Nadav Malin (https://www.buildinggreen.com/author/nadav-malin) [1] and Peter Yost (https://www.buildinggreen.com/author/peter-yost) [2]

July 25, 2017

Sealing air leaks in any building can make it more comfortable and efficient. But owners of existing buildings often resist spending the time and money to address the problem. In fact, addressing air leaks in existing buildings is like the Rodney Dangerfield of Rodney Dangerfields. In the words of the late comedian, "they just don't get no respect."

Even without air leaks, existing buildings don't get no respect unless they are historic or otherwise noteworthy.

And when there are air leaks, most owners don't pay attention until the signs are impossible to ignore: ice dams building up, mold growth, or people near the windows are shivering. At that point an expert might be recruited to scope out the problem and recommend a solution.

Drivers for Air Sealing

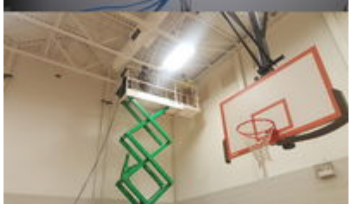
Leaky buildings are often ignored in the face of other problems that are perceived as more critical, reports Jenny Carney of WSP in Chicago. "In larger commercial buildings, even if they know that they have an air leakage problem, it's rare that fixing it rises to the level of capital investment," Carney says. "When it does," she continues, "it's driven by occupant comfort or other issues."

To make things worse, "most people don't even realize that they have a leaky building unless they are getting drafts or have freezing pipes, cluster flies, or icicles coming out of the curtainwall," reports building forensics expert Terry Brennan of Camroden Associates.

In Canada, many architects are aware of the general importance of airtightness in building enclosures thanks to the network of provincial Building Enclosure Councils. Seeking to establish similar councils in the U.S., architect and building enclosure consultant Wagdy Anis of Wiss Janney Elstner Associates connected the American Institute of Architects with the National Institute of Building Science to jointly convene the groups. This model began in Boston, according to Anis, and "there are now thirty around the country."

These councils are mostly focused on designing new buildings, according to Anis, who helped establish the groups. "Consultants get called in for forensic work due to problems in [existing] buildings," he says. "Architects don't typically get called in for that."

Performance problems



Owners don't often seek out air-sealing improvements to save energy. "We would love to convince our clients of the long-term value of our approach based on energy benefits alone, but often the driver is some other problem," says Catherine Muller, president of Air Barrier Solutions, a company dedicated to air sealing and insulating existing buildings.

Air Barrier Solutions is typically called in due one of these common performance problems:

- Ice dams: warm air leaking into roof cavities melts snow on the roof. The water runs down and freezes at the eaves, where it builds up, resulting in puddles behind it and potentially dangerous icicles along the edge.
- Thermal comfort complaints: leaking air makes it hard to keep people near the perimeter comfortable, either because they're getting drafts directly from outdoors or because the whole perimeter zone suffers from cooling and heating systems that can't keep up with the load.
- Humidity control problems: air that leaks in isn't conditioned for appropriate indoor humidity levels.
- Window condensation: cold air leaking in near windows lowers their surface temperature to the dew point of indoor air.
- Mold or mildew: condensation on cool surfaces inside the building or within building cavities supports microbial and fungal growth, which can release allergens or toxins, and damage building materials.
- Noise from outside sources: sound travels via pressure waves in the air, so leaking air means more noise transmission.
- Odors: smells from outdoors bypass a building's filtration systems when they leak in through the walls. In multifamily buildings, compartmentalizing individual units to prevent odor from spreading is a common challenge.

Buildings with tight performance requirements, such as an historic building with old finishes or a museum housing humidity-sensitive art, are especially at risk. "It might be deteriorating plaster now that a historic building is air conditioned or controlling temperature and humidity for museum exhibits—it is amazing how many problems trace back to a defective air barrier," notes Muller.

For more on the problems associated with leaky buildings and strategies for making new buildings tight, see our previous article: Making Air Barriers that Work: Why and How to Tighten Up Buildings (http://www.buildinggreen.com/feature/making-air-barriers-work-why-and-how-tighten-buildings) [3].

Aesthetics

Buildings can also fail—at least in the commercial sense—by not keeping up appearances. In certain markets, owners will invest in reskinning a building to update its look and to keep it competitive with newer peers.

Lorne Ricketts, a building science engineer with RDH Building Science in Vancouver, British Columbia, has studied the drivers for building envelope upgrades. The Belmont is a high rise apartment building he investigated that had enclosure elements wearing out, and was starting to look old and dated. “The building is in a high-end neighborhood and the owners wanted something that reflected a more modern design while also providing needed renewal,” he explains about the building's owners.

Once the owners started looking into upgrading the look of the building, they saw the opportunity to improve it in other ways. Now that the project is completed, the owners are pleased with the energy savings, but even happier with how comfortable and quiet the apartments are.

Energy savings

Saving energy is usually a fringe benefit to a building envelope upgrade that is driven by other factors, but sometimes an audit points to air sealing specifically as a worthwhile energy conservation measure. “For existing buildings, infiltration is often the biggest envelope energy driver,” reports Andrea Love, building science cirector at Payette in Boston. “Unfortunately,” she continues, “very little data exists on large scale commercial buildings infiltration, and it is difficult and expensive to test whole buildings so it very rarely happens.”

Energy audits are one common way that leaky buildings are identified if their other symptoms haven’t already raised air leaks as an issue. Jenny Carney is also founder of the BIT Building program, which aims to encourage and support managers of existing buildings—including underperforming buildings where resources are limited—to improve energy, water, and waste footprints. In BIT, as in LEED, the required energy audit will show strategies that will lead to performance improvement, according to Carney. “The assessment would determine if envelope measures are part of the solution,” she explains.

Even audits tend to undervalue envelope improvements, however, because they’re often done by people whose expertise—and sometimes incentives—are tied to mechanical systems. “If software like Air Barrier Solutions’ $\text{CHIEF}_{\text{Plus}}$ were available to more people doing audits, they might identify air leakage as an opportunity more often,” says Carney.

How big is the energy opportunity?

According to the latest Commercial Buildings Energy Consumption Survey (CBECS), in 2012, the U.S. had more than 5.5 million commercial buildings. These buildings collectively use nearly 7 quads of energy—that’s quadrillion—or 7×10^{15} Btu. Pushing for net-zero energy in new buildings is great, but without addressing this huge energy load in existing buildings we won’t make much of a dent in near-term carbon dioxide emissions.

Only 670,000 of those 5.5 million buildings are over 25,000 ft^2 in floor area, but those larger buildings are responsible for nearly 70% of the energy use. The larger buildings also contain most of the floor area, but that doesn’t explain all of their energy appetite: their average energy use intensity (EUI) is just over 84 $kBtu/ft^2$, compared to 80 for all commercial buildings.

Almost 36% of this energy is used for heating and cooling, for a total of 1.7 quads. Adding in the energy lost during conversion and transmission, that number is 2.8 quads, or about 3% of total U.S. energy consumption.

The handful of studies that have measured air leakage in large buildings find that they vary widely, from quite tight to very leaky. When they were built and where they are located doesn't seem to matter much, but tall buildings do tend to be much tighter than short ones.

A study that modeled the air sealing opportunity in U.S. Army barracks found that tightening them up from 1 CFM75/ft^{2}SA (cubic feet per minute of air leakage at pascals of pressure per square foot of building shell area) to 0.25 would save between 6% and 52% of total energy use. In a military office building those numbers are lower, ranging from less than 1% in a mild climate to 14% in a very cold climate. A 2005 U.S. Department of Energy-funded study of commercial buildings predicted energy cost savings ranging from 3% to 36% by sealing up buildings from typical levels to a high standard of tightness. The low ends of these ranges, in hot humid climates, don't account for the full energy load of dehumidifying outside air—so the actual savings are higher.

Units of Measure: Quantifying Air Leakage or Tightness (https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/1)

[4]

Tests that quantify air leakage yield a building total, expressed in a variety of ways: ...

Read more... (https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/1) [4]

Diagnosing Leakiness

Inputs - Oxford, CT				
HDD (calcs use BINs)	6,375			
CDD (calcs use BINs)	334			
Avg. Wind	7.0			
# Stories	4			
Shielding	3			
Cost/MMBtu	$10.00			
Cost/kWh	$0.10			
Occupied hours	84			
Setbacks - heating	72/65			
Setbacks - cooling	74/78			
Heating System Efficiency	75%			
Outputs				
	H_D	H_U	C_D	C_U
CFM Decreases - 1 door	13	12	7	7
Savings/CFM Decrease	$1.10	$0.89	$0.07	$0.04
Total Savings	$25.68			

Some symptoms are easy to diagnose. If you feel a cold draft coming through a crack between window panes, you know where the problem lies.

Others are a little trickier—general draftiness near the outside wall could indicate problems with the windows themselves, with the window-to-wall connections, or at the junctions between walls and ceilings or floors. If it's cold enough outside, the draft could even be a convection current generated by the cold surface of the window—a sign of poor thermal performance, but not necessarily air leakage.

Some symptoms might be obvious to people who have seen similar problems in other buildings, but not to the casual observer. Icicles forming at the weep holes in a curtainwall, for example, are a tell-tale sign of humid air escaping the building. "You have to look at the whole building as a system," explains air-sealing consultant Henri Fennell of Thetford, Vermont.

As building owners and their tenants get more sophisticated about monitoring indoor air quality, other clues can emerge. In one commercial office, for example, the facilities team noticed an increase in fine particulates when local forest forest fires were active. The higher PM2.5 (particulate matter 2.5 micrometers or smaller) readings were happening in perimeter zones during off hours, when the building was under negative pressure. That gave the clear evidence that air pollution was leaking in through the enclosure, bypassing their filtration systems.

Air tightness testing

All too often, the leakiness of a building is determined by an educated guess. “Most of the time it ends up being a guess based on our professional intuition of a building looking to be leaky or not, to determine if infiltration is a big deal,” reports Love. “There is definitely lots of room for improvement.”

Testing can be time-consuming and expensive, but it’s the best way to figure out what’s really going on. If you’re working on a comprehensive energy audit, for example, testing is the best way to find out how much of the heat lost (or gained) through the enclosure is due to air leakage. “Pre- and post-retrofit testing drives our Quality Assurance program,” says Larry Harmon, co-founder of Air Barrier Solutions.

There are a number of testing protocols—defined by ASTM and other standards—that can be used to guide the process (see sidebar: ASTM Testing Standards Decoded).

The bigger a building is, and the leakier it is, the harder it is to measure, however. The standard technology involves setting up fans—”blower doors”—to pressurize or depressurize the building. By measuring how much air the fans have to move to maintain a certain pressure difference between indoors and out, you can tell how much air is leaking at that pressure.

That works fine for houses and other small buildings, or for very tight buildings, because the fans don’t have to move that much air. But a large, leaky building might require an industrial-scale fan, or array of fans. “The most we’ve used was 22 fans on engineering building in Florida,” reports Brennan.

Fans as diagnostic tools

Blower doors are good for more than just measuring total air leakage. While they’re running it’s easy to walk around with little smoke sticks and see where the air is moving in or out. And by measuring air pressure in different parts of a building you can tell if some areas are more leaky than others.

“We do confidential and proprietary at-risk inspections when people are interested in having us fix their buildings without shopping the job to other contractors,” says Harmon. Air Barrier Solutions’s inspections always include blower door tests to identify leakage sites, and may also include whole-building blower door testing to quantify pre- and post-leakage rates and/or more targeted testing on individual building components, such as windows or doors.

The residential tower under construction on Cornell University’s Roosevelt Island campus in New York City, for example, is being built to Passive House standards. Because it met that high standard, it was easy to test, reports Brennan. “The building tested at 0.04 CFM75/ft^{2}SA—four times better than the Passive House threshold,” Brennan said.

SIDEBAR

ASTM Testing Standards Decoded
(https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/2)

[5]

Stop blowing and listen

An innovation that builds on the sound detection option within ASTM E1186, SonicLQ uses sound to locate and size air leaks in a building’s exterior envelope. The system can be used to test any building, during construction or after the building is completed or occupied, and during any season of the year. Acoustic data are presented to the user in a visual format that identifies where air leaks are located on the building

Architects and particularly specifiers need to be familiar with these terms and the most common standards cited for building air leakage or tightness.

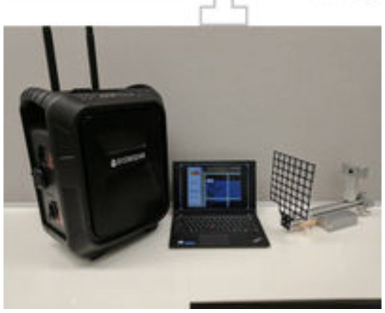
[Read more… (https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/2)](https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/2) [5]

façade—as well as the size of specific leaks—so that informed decisions can be made to seal the largest leaks and realize the greatest energy savings while minimizing assessment and diagnostic costs.

In the SonicLQ system, a low-frequency sound (about 60 decibels or so, roughly the same as conversation in a restaurant or background music) is generated from a speaker inside the building. Sound that leaks out is picked up by the small microphone array just outside the wall. The microphone array is lightweight enough that it can be carried on a drone to track with the speaker location.

The sound data are wirelessly sent to a laptop computer, which translates the data into a visual map of leakage that can be overlaid onto an image of the building. Testing a single 12 foot by 12 foot room within a building would take 2–4 minutes, according to the company.

“Distant” acoustic measurement identifies target areas of air leakage; these measurements currently cover about 100 square feet of exterior enclosure but the goal is to increase this significantly. The near-field acoustic measurements assess 3 foot by 3 foot areas of leakage.



SonicLQ has published its patent application, started testing a field prototype, and procured funding from the Department of Defense to do field testing alongside a conventional blower door, according to Inventor Ralph Muehleisen, principal building scientist at the U.S. Department of Energy’s Argonne National Laboratory, “We will be ready for pilot projects within the next nine months,” he predicts.

Upon learning about this new technology, Brennan was impressed. “This is definitely real,” he said. “The math holds up. I am not sure that this approach will be a real advantage over existing approaches for new, tight, buildings—such as the Cornell University 27-story building, which tested with just one blower door—but for big existing buildings, this has real promise.”

Brennan has some particular questions regarding how well SonicLQ will do with complex, circuitous air leaks—for example, air leaks through steel stud with fiberglass and gypsum sheathing into the cavity behind brick veneer at the top of wall into soffit or coping—but he also says that the SonicLQ might do better than existing pressure techniques for features such as trash chutes.

The real test, according to Brennan, would be to have experienced blower door experts working with SonicLQ on the testing.

How Leaky Are Existing Buildings?

“There is a huge range in air-tightness performance of existing buildings,” reports Ricketts. For example, “a highly glazed commercial building is likely pretty airtight,” he predicts.

Steven Emmerich and Andy Persily at the U.S. Department of Commerce National Institute for Standards and Technology (NIST) collected data on 200 buildings from several sources and concluded that they are, on average, very leaky. How leaky? About 1.5 CFM75/ft^{2}SA. But their average might have been skewed by a bunch of super leaky small commercial buildings in Florida.

Actual measurements of larger buildings found that many of them aren’t so bad. An ASHRAE study of 16 relatively new buildings in the eastern U.S., all built between 2000 and 2010, measured a ten-fold difference in leakage rates from the best to the worst, but even the worst was only half as leaky as the average building from Emmerich and Persily’s study. Most of the buildings tested, including both the tightest and the leakiest, were either LEED or Energy Star certified.

A 2014 International Energy Agency report entitled "Energy Efficient Technologies & Measures for Building Renovation" assumes 1 CFM75/ft^{2}SA as a baseline for existing buildings. This figure doesn't so much represent a "typical" building—because actual air tightness in existing buildings varies so widely—but it may be a reasonable approximation of an average. For the 23,000 ft^2 four-story rectangular office building modeled for that report, this leakage rate translates to about 1 air change per hour (ACH) at normal pressures (4 pascals).

Sealing Up Buildings

Improving very leaky buildings isn't hard

"We've had good success on before and after retrofit infiltration of historic buildings in the range of 50,000 ft^2, even with remarkably simple measures," reports Z Smith of Eskew Dumez & Ripple in New Orleans. Smith reports reducing infiltration levels from about 1.5 CFM75/ft^{2}SA, nearly four times the International Energy Conservation Code new construction limit of 0.40 CFM75/ft^{2}SA, down to compliance with that target.

"In a moderately leaky building, you could get 10%–20% improvement without really invasive retrofits," reports Ricketts. "It depends on how easy it is to find and seal the holes."

SIDEBAR

How Tight is Tight?

(https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/3)

[6]

Less than one cubic foot per minute of air flow may not sound like much, but it adds up quickly as one multiplies that number by the size of the building.

Read more... (https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/3) [6]

There's profit in soffits

Anis has some simple rules of thumb: "You have to go through the whole building starting at the top because the top is most leaky," he suggests. "Then you go into the elevator shafts and stairwells, and look at any penetrations. Then look at exterior walls."

The single best resource for understanding and assessing air barrier continuity is the US ACE Air Barrier Continuity Guide, a 16-page downloadable pdf (https://www.buildinggreen.com/sites/default/files/usace_airbarriercontinuity.pdf) [7]. The guide prioritizes the most common air leakage pathways diagrammatically, and then provides 12 pages of photos of the most common examples of air leakage pathways—for each priority area—and how to air seal them. It's building science or physics that drives the prioritization, but it's identifying and sealing the holes that deliver the results. This guide has both.

Getting tight buildings even tighter is harder

Standard	Whole Building Air Leakage Allowed @ CFM75/ft^{2}SA enclosure
U.S. Army Corps of Engineers (2008)	0.25
Washington State (2010)	0.25
U.S. General Services Administration (2010)	0.25
ASHRAE 189.1-2009	0.40
International Energy Conservation Code (2012)	0.40
International Green Construction Code	0.25
Passive House (U.S)	0.16*

* Approximate value, converted from air changes per hour threshold.

The take-away from air sealing the 26 buildings in Minnesota is that it's expensive to eliminate the last bit of infiltration from buildings that are already tight. The roof-wall junction was responsible for most of the leakage that they found.

Not every company does careful testing to check on its work, but for the most dedicated, it's a matter of principle: "Performance-based work is driven by measurement and verification; this drives every member of our team, from company owners to project managers to the building envelope specialists who install the work," says Harmon.

Challenges with Air Sealing Existing Buildings

Along with all the glamour of crawling into crawl spaces and slithering through mechanical spaces, there is some serious technical know-how involved with a good air-sealing job. The challenges include understanding a building's ventilation strategies to avoid creating problems, justifying the time and cost to building owners, and ensuring good craftsmanship.

Sealing off large holes often involves building and installing some kind of a barrier, often out of plywood or sheet metal. Small cracks are best filled with caulk. And isolated gaps, such as the spaces around pipe or duct penetrations through a wall, can often be filled with one-part polyurethane foam from a small can.

But to create reliable air barriers across large surfaces that lack one, nothing works like two-part spray-foam insulation. Unfortunately, no material is more vulnerable to shortcomings in quality control during installation.

Spray foam debacles

Two-part polyurethane foam is a construction material that is manufactured on the job site. There are two kinds: open-cell, which is less dense, less costly, remains flexible, and is permeable to moisture. And closed-cell, which has a higher R-value and cures into a solid, durable layer. Closed-cell foam is commonly used to spray onto exposed surfaces. Either one can also be injected into closed cavities—with careful controls to prevent rapid expansion that could bust apart the assembly.

Polyurethane foam is highly reactive when it comes out of the spray gun, but—if prepared and sprayed properly—quickly cures to a relatively safe, inert condition. It's far from an ideal material—see BuildingGreen's Spray Foam Insulation Product Guide (http://www.buildinggreen.com/product-guide/spray-foam-insulation) [8] for more info—but nothing else is currently available that does the job. And it's a better choice than the formaldehyde-based foam insulations that are still used in some areas despite serious occupant health concerns.

Installing spray foam well isn't so easy, however. Many installers don't seem to understand that they are creating a sensitive chemical reaction in difficult-to-control conditions. "I have had more failed foam cases in the last five years than in the preceding twenty," says Brennan. "There are so many people installing this stuff who really aren't experienced," he adds. "It could eventually kill a very useful product."

"Most of my work is trouble-shooting problem installations around the country," reports Fennell. There are many ways a spray-foam installation can go wrong. (See Foam-In-Place Insulation: 7 Tips for Getting Injection and Spray Foam Right (http://www.buildinggreen.com/blog/foam-place-insulation-7-tips-getting-injection-and-spray-foam-right) [9] for details.)

The underlying problem, according to Fennell, is that manufacturers provide instructions telling installers what the ideal parameters are, but they don't specify tolerances for their requirements. "The manufacturer doesn't say where the line is between good and bad, so installers don't have any way to verify if they're doing it well enough," Fennell says. "Manufacturers don't want the liability to shift from installers to them," he explains. A good installer will provide submittals before doing the work proving they know what they're doing, and also quality-control samples during and after the installation, according to Fennell.

SIDEBAR

Two Air Barrier Solutions Case Studies

(https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/4)

[10]

Air Barrier Solutions specializes in fixing problem buildings by fixing defects in building enclosures, and air barriers in particular.

Read more... (https://www.buildinggreen.com/feature/mind-gaps-making-existing-buildings-more-airtight/sidebar/4) [10]

Buildings that depend on leakiness for fresh air

Many people have a visceral reaction to the idea of sealing up a building tightly—they're concerned that won't allow in enough fresh air. For buildings with mechanical ventilation systems, the opposite is true—only by preventing uncontrolled air flow can you ensure that fresh air is actually being delivered as intended.

But many older buildings lack mechanical ventilation, so it's essential to plan for ventilation when sealing up the enclosure. "Some buildings rely on leakiness for fresh air—that is how they were engineered," says Brennan. For example, prior to ducted fresh air, it was common to engineer buildings with exhaust-only ventilation fans and provide fresh air via intentional gaps around the windows, Brennan explains. In situations where getting fresh air to occupants depends on a certain amount of leakiness, it's important to install mechanical ventilation when tightening up the enclosure.

Time and money

Air sealing a building may be the most cost-effective energy-saving strategy available for a leaky building, but that doesn't mean the owner will make the investment. Air sealing almost always is done from the interior, so in addition to the cost and hassle of contracting for the work, there is the loss of use of the space while the work is underway.

"Without doing anything invasive, we're always going to be a bit limited in terms of amount of impact that we can have," reports Ricketts. He has found it an easier sell to intervene when they need to replace the windows, or replace cladding, or even upgrade the HVAC system—with an upgraded enclosure the replacement mechanical system can be smaller, and cheaper.

Brennan sometimes gets called in to create a proper air seal between units in a multifamily building, but only when the apartment is changing hands. "Even then the opportunities are limited because the building owner wants a quick turnover. A lot of the time, building owners won't let me take a day to compartmentalize a units—even if they know it would help solve their roach infestation problem," Brennan says. "They don't want to take the day to do that extra sealing."

Fringe Benefits: from Pest Control to Odor Control

Addressing pest infestations is one of the many ancillary benefits of tightening up a building, or the units within it. Increasing comfort, reducing spread of odors, and reducing noise are others. A few other advantages that might come along with a good air sealing job include:

- Improved indoor air quality—when polluted air is leaking in from outdoors, or if the ventilation system can't distribute air reliably because it can't control air pressure due to leaks.
- Doors work better—especially in tall buildings where stack effect pressures together with air infiltration can put a lot of pressure on doors, making them hard to open or close.
- A teaser for deep energy retrofits—once an owner experiences the benefits of reducing air leakage, the possibility of going even further to upgrade building performance becomes intriguing. On the other hand, it can be harder to justify the cost of adding insulation to a building enclosure after the low-hanging fruit of energy savings from air leaks has already been harvested.
- Improves new construction—retrofitting older buildings to solve problems might eventually lead an owner with multiple buildings to get it done right the first time. The Army Corps of Engineers has retrofitted hundreds of buildings to meet its performance standard for air tightness, and now enforces that standard consistently on new buildings. Universities can also learn this lesson, according to Brennan: "Fix enough of their buildings and eventually they say 'let's have these guys involved in design'."

Wrapping Up

Any energy audit should include at least a visual inspection for potential air leakage. This might involve seeing the actual gaps, but more often relies on noticing the tell-tale signs of chronic air leakage, and the high energy bills that go along with that leakage. If the audit indicates that air leakage is a problem, then addressing it as a stand-alone conservation measure might be feasible.

 With today's low energy costs, air sealing an existing building just for the energy benefits is a tough sell. Occupant comfort is valued more highly, at least in some settings. And when safety is at stake it's a no-brainer. The opportunity in that case is to encourage the use of whole-building diagnostic tools, both to ensure that the source of the problem has been addressed, and to leverage the intervention to save energy and address other potential problem areas.

Similarly, any retrofit or renovation that involves the building envelope represents an opportunity to check for air tightness and seal up the enclosure as much as possible.

As building diagnostic tools get better and less intrusive to use, it should become easier and cheaper to test buildings on a routine basis, both for overall airtightness and to locate specific problem areas. For those who don't know where to start, local Building Enclosure Councils are a good place to look for the expertise to help make this happen.

Lots of existing buildings are out there, waiting impatiently, for the attention.

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