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Title 24, Part 11 (CALGreen) Proposal for Nonresidential Air Leakage Verification

Additional submitted attachment is included below.

To:	California Energy Commission
From:	Maureen Guttman, Energy Solutions on behalf of the California Statewide Utility Codes and Standards Enhancement (CASE) Team
Date:	June 27, 2024
Subject:	**Title 24, Part 11 (CALGreen) Proposal for Nonresidential Air Leakage Verification**

1. Background

The building envelope (exterior walls, windows, doors, roof, and slab) is the thermal, water, and weather barrier between the indoor and outdoor environments. When wind loads and temperature gradients cause air pressure differences, air leaks in or out of the building through unintended openings resulting in higher and longer demands on the HVAC system.

Reducing air leakage is an effective way to reduce energy use and energy costs associated with heating, cooling, and ventilation even in mild and dry climate zones. In addition to energy losses, air leakage may cause moisture problems such as mold growth or condensation issues, which may lead to wooden decay of structural components. Air leakage may also negatively impact indoor air quality if the outdoor air is contaminated, such as in the event of wildfires.

2. Proposal Description

2.1 Proposed Code Change

This proposal for 2025 Title 24, Part 11 would make continuous air barriers mandatory and would add air leakage verification (testing) to CALGreen Appendix A5, which is voluntary statewide but local jurisdictions could adopt as a mandatory provision in local ordinances.

For CALGreen Appendix A5, the prerequisite option for air leakage testing would have a first target maximum leakage rate of 0.35 cfm/ft^2 at 75 Pa. If the first target is not met a visual inspection and diagnostic evaluation would be performed, and all observed leaks would be sealed where possible without destroying any existing components. If the initial test results exceeded a second target of 0.55 cfm/ft^2, the building would have to be re-tested and obtain leakage measurements below this second target. For jurisdictions adopting CALGreen Tier 1, the first and second targets would be 0.30 and 0.5 cfm/ft^2, respectively, and for Tier 2 they would be 0.2 and 0.4 cfm/ft^2.

The proposed air leakage testing requirements would affect nonresidential new construction and additions for all building types and all climate zones. The proposed requirement for continuous air barriers would apply to buildings of any size, but air leakage testing requirements would only apply to buildings up to 25,000 square feet, where Appendix A5 is adopted.

Before adopting either set of air leakage testing requirements, jurisdictions would need to establish what qualifications are needed to perform the testing and ensure there will be sufficient qualified resources to meet demand.

The proposal includes updates to the compliance software to add the value of 0.35 cfm/ft^2. It does not add requirements for any technology not regulated previously.

2.2 Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of standards, reference appendices, and compliance software that would be modified as a result of the proposed change(s).

Table 1: Scope of Code Change Proposal

Proposal Name	**Details**
Type of Requirement	The following requirements would appear in the voluntary chapter of CALGreen: • Mandatory requirement for continuous air barrier • Voluntary requirements for air leakage testing.
Applicable Climate Zones	All
Modified Section(s) of Title 24, Part 11	Appendix A5 Nonresidential Voluntary Measures • Division A5.2 Energy Efficiency
Would Compliance Software Be Modified	Yes, include infiltration air flow rate of 0.35 cfm/sq.ft

2.3 Proposed Code Language

The proposed changes to the voluntary requirements in Appendix A5 are provided below. Changes to the 2022 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

APPENDIX A5 NONRESIDENTIAL VOLUNTARY MEASURES

SECTION A5.203 PERFORMANCE APPROACH

A5.203.1 Energy efficiency. Nonresidential, high-rise residential and hotel/motel buildings that include lighting and/or mechanical systems shall comply with Sections A5.203.1.1, A5.203.1.2 and A5.203.1.3.~~A5.203.1.2.~~ Newly constructed buildings and additions are included in the scope of these sections. Buildings permitted without lighting or mechanical systems shall comply with Section A5.203.1.2 ~~A5.203.1.1~~ but are not required to comply with Sections A5.203.1.1 or A5.203.1.3. ~~A5.203.1.2.~~

A5.203.1.1 Air barrier. A continuous air barrier shall be provided throughout the building thermal envelope. The air barrier is permitted to be located at any combination of inside, outside, or within the building thermal envelope. The air barrier shall comply with Title 24, Part 6, Sections 140.3(a)9A and 140.3(a)9B.

A5.203.1.2~~A5.203.1.1~~Tier 1 and Tier 2 prerequisites.

To comply with Tier 1, ONE of the following efficiency measures is required for all applicable components of the building project. To comply with Tier 2, TWO of the following efficiency measures are required.

A5.203.1.2.1~~A5.203.1.1.1~~ Outdoor lighting.

…(renumber following sections)

A5.203.1.2.6 Whole building air leakage testing.

1. Verification of the installed air barrier shall be performed for buildings up to 25,000 ft^2 of gross conditioned floor area. The entire building shall meet an air leakage rate not exceeding 0.35 cfm/ft^2 at a pressure differential of 0.3 in. of water (1.57 psf) (2.0 L/m^2 at 75 Pa) when the entire building is tested after completion of construction, in accordance with Nonresidential Appendix 5.7 (NA5.7) to Title 24, Part 6, or another test method approved by the Commission.
2. If the air leakage requirements of Section A5.203.1.2.6(1) are not met, a visual inspection and diagnostic evaluation shall be completed in accordance with Nonresidential Appendix 5.7 (NA5.7) to Title 24, Part 6, all observed leaks shall be sealed where such sealing can be made without destruction of existing building components, and buildings where the tested leakage rate exceeded 0.55 cfm/ft^2 of building shell area at 75 Pa have been retested to confirm leakage is below 0.55 cfm/ft^2 of building shell at 75 Pa.

A5.203.1.3A5.203.1.2 Performance standard.

Comply with one of the advanced efficiency levels indicated below.

A5.203.1.3.1A5.203.1.2.1 Tier 1.

Buildings complying with the first level of advanced energy efficiency shall have an Energy Budget that is no greater than indicated below, depending on building type and the type of energy systems included in the building project. If the newly constructed building or addition does not include indoor lighting or mechanical systems, then no additional performance requirements above Title 24, Part 6 are required.

1. For nonresidential building projects that include indoor lighting or mechanical systems, but not both: No greater than 95 percent of the Title 24, Part 6, Energy Budget for the Standard Design Building as calculated by compliance software certified by the Energy Commission.

…

4. Base case Title 24 Part 6, Energy Budget includes verified air barrier as follows:

a. Verification of the installed air barrier shall be performed for buildings up to 25,000 ft^2 of gross conditioned floor area. The entire building shall meet an air leakage rate not exceeding 0.30 cfm/ft^2 in accordance with Section A5.203.1.2.6.

b. If the air leakage requirements of Section A5.203.1.2.6 are not met, a visual inspection and diagnostic evaluation shall be completed in accordance with NA5.7 to Title 24, Part 6, all observed leaks shall be sealed where such sealing can be made without destruction of existing building components, and buildings where the tested leakage rate exceeded 0.5 cfm/ft^2 of building shell area at 75 Pa have been retested to confirm leakage is below 0.5 cfm/ft^2 of building shell at 75 Pa.

A5.203.1.3.2 A5.203.1.2.2 Tier 2.

Buildings complying with the second level of advanced energy efficiency shall have an Energy Budget that is no greater than indicated below, depending on building type and the type of energy systems included in the building project. If the newly constructed building or addition does not include indoor lighting or mechanical systems, then no additional performance requirements above Title 24, Part 6 are required.

1. For nonresidential building projects that include indoor lighting or mechanical systems, but not both: No greater than 90 percent of the Title 24, Part 6, Energy

Budget for the Standard Design Building as calculated by compliance software certified by the Energy Commission.

…

4. Base case Title 24 Part 6, Energy Budget includes verified air barrier as follows:

a. Verification of the installed air barrier shall be performed for buildings up to 25,000 ft^2 of gross conditioned floor area. The entire building shall meet an air leakage rate not exceeding 0.20 cfm/ft^2 in accordance with Section A5.203.1.2.6.

b. If the air leakage requirements of Section A5.203.1.2.6 are not met, a visual inspection and diagnostic evaluation shall be completed in accordance with NA5.7 to Title 24, Part 6, all observed leaks shall be sealed where such sealing can be made without destruction of existing building components, and buildings where the tested leakage rate exceeded 0.4 cfm/ft^2 of building shell area at 75 Pa have been retested to confirm leakage is below 0.4 cfm/ft^2 of building shell at 75 Pa.

2.4 Justification

As found in recent literature and in the analysis conducted for the 2022 CASE Report on Reduced Infiltration, more effective air barriers would result in significant cost-effective energy savings throughout California (Statewide CASE Team 2022). A 2017 National Renewable Energy Laboratory (NREL) study found that "excessive infiltration through the building envelope" was the top fault to be addressed in small commercial buildings to save energy and money (Janghyun, Jie and Braun 2018). Stakeholders have stated that reducing building infiltration is an important aspect of improving the energy efficiency of California's building stock and would help achieve California's ambitious energy and climate goals and would be consistent with California's loading order (California Public Utilities Commission 2012).

As California moves towards electrification for decarbonization, reducing air leakage will be increasingly valuable for creating more grid capacity and managing peak demand, especially in cooling-dominated, high population areas (Facade Techtonics 2021). Relatedly, investing in air leakage testing would be very well aligned with California's heavy investment in heat pumps. High leakage rates cause heat pumps to operate under higher loads, significantly decreasing their efficiency.

Looking at other implications of electrification, the heating and cooling loads in California are on track for continued increases, regardless of the efficiency of the equipment. As shown in Figure 1 and Figure 2, data from the Title 24 Weather File

Statistics show decreases in heating degree days and increases in cooling degree days from 2013 to 2025 in almost every climate zone.

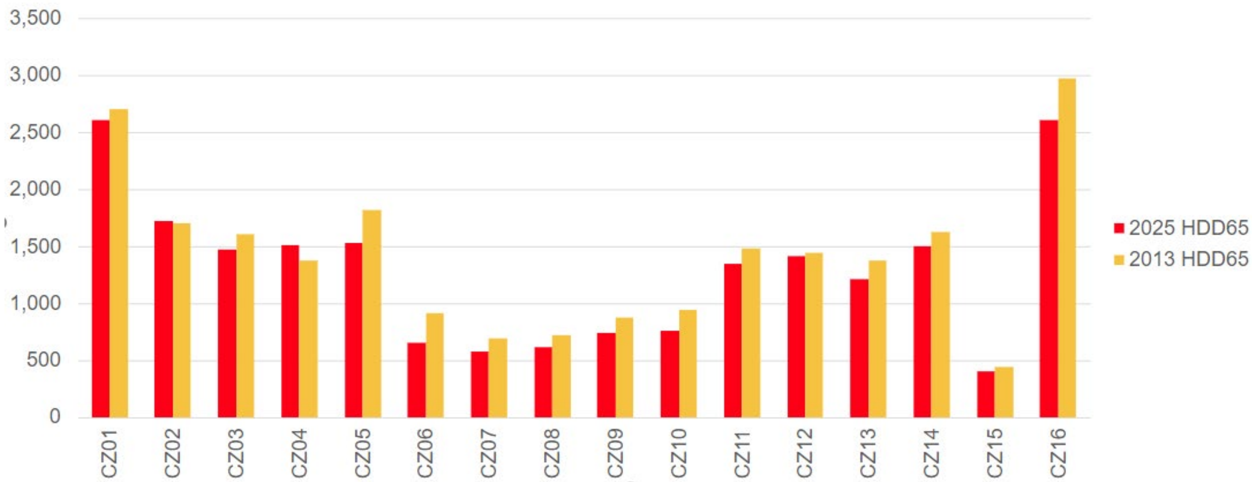

Figure 1: Heating Degree Day per Title 24 Weather File Statistics, 2013 and 2025

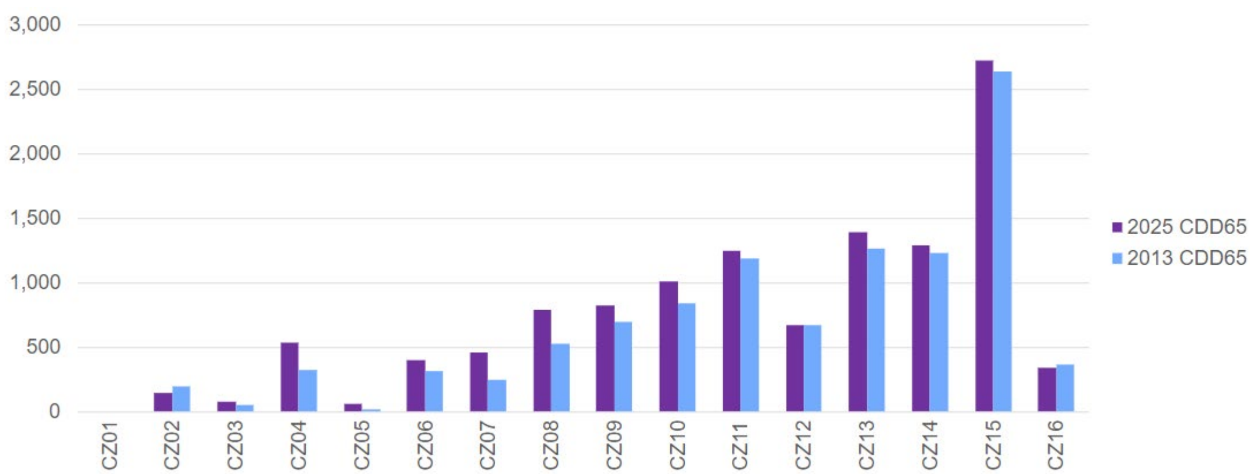

Figure 2: Cooling Degree Day per Title 24 Weather File Statistics, 2013 and 2025

Making air leaking testing more common in the market is essential. If air barriers are required, they should be tested to ensure the expected energy savings are captured. Studies show improper sealing at the junctures of different assemblies is a major source of leakage, which is an assembly issue more than a design issue. The best way to reduce leakage is to signal to builders it will be measured.

2.5 Regulatory Context

Air barrier verification by whole building air leakage testing is required in ASHRAE 90.1-2022 for new buildings up to 10,000 ft^2, and the 2024 International Energy Conservation Code (IECC) will require whole building testing for buildings up to 25,000 ft^2 in the climate zones that correlate with California climate zones. Whole building air leakage testing has been required for nonresidential buildings by the Seattle Energy Code and Washington State Energy Code (WSEC) for a decade. WSEC-2018 limits infiltration to 0.25 cfm/ft^2 at 75 Pa and provides performance credit if buildings do not exceed 0.17 cfm/ft^2 at 75 Pa (Washington State Building Code Council 2018). In addition, whole building air leakage testing has been incorporated into the British Columbia Step Code and the New York Stretch Code.

California first included air leakage requirements for single family homes in 2013 Title 24, Part 6 and currently has a performance option in all climate zones that use verified building air leakage testing. The main barriers to higher stringency are related to testing. For the 2022 code cycle, the Statewide CASE Team recommended adding air barrier verification for nonresidential buildings as a prescriptive requirement in Title 24, Part 6 (Statewide CASE Team 2022). However, the adopted language only says "Verification of the installed air barrier may be performed" (emphasis added).[1] The Statewide CASE Team intends to continue its efforts with a nonresidential proposal for mandatory air barriers and prescriptive air leakage verification for the 2028 Title 24, Part 6 code cycle. This proposal for 2025 Title 24, Part 11 voluntary provisions would help prepare the entire industry but especially architects, builders, testers, and regulators.

2.6 Current Practices, Feasibility and Market Impact

2.6.1 Current Practices

This proposal would not cause a significant change to building design and construction practices. Many building codes currently require air barriers, and the building industry has improved its approach to air barrier construction. There is a growing number of building envelope consultants to support designers. General contractors are now more aware of air barrier material coordination and installation, and project teams often include a building envelope engineer. Envelope construction materials such as continuous insulation and pre-cast concrete are rated as air barrier materials and are used even when there is not an explicit air barrier requirement.

Since requirements for whole building air leakage testing have been implemented, the industry has responded with more training resources and qualified testers. For example, Washington state adopted this requirement over a decade ago and found that industry stakeholders were willing to make training accessible to contractors and testing agencies. Consulting firms and testing agencies alike have grown their departments by either training staff members or by hiring those with experience. Designers and contractors have also put an emphasis on air barrier design and construction by designating envelope quality control personnel involved on projects. IECC 2024 will

[1] See Title 24 Part 6 Section 140.3(a)9C

expand the climate zones in which air barrier testing is required, which will continue driving these trends.

2.6.2 Technical Feasibility

Many studies show that an air leakage rate of 0.40 cfm/ft^2 at 75 Pa is highly feasible. This rate was first introduced in the 2013 version of Title 24, Part 6. This proposal of 0.35 cfm/ft^2 as the first target for the prerequisite option in Section A5.203.1.1.6 would be slightly more stringent, as appropriate for Part 11, and help the industry gain further experience and confidence. For context, the Washington State Code goes further: WSCEC-2018 Section C402.5.1.2 limits infiltration to 0.25 cfm/ft^2. The maximum leakage rate for Passive House designation is 0.06 cfm75/ft^2.

This target is typically met by standard designs properly installed. According to an American Society for Testing and Materials (ASTM) paper on the lessons learned after ten years of mandatory testing in Seattle, Washington, leakage is most likely to occur where the work of different trades intersects. Therefore, the keys to success are improved coordination, oversight, and education (RDH Building Science, Inc 2015).

To select air barrier testing among other energy efficiency measures, builders must be confident their building will pass because by test time the corrective opportunities are limited. This requires confidence that testing is reliable. While training on how to perform air leakage testing is important, it is not complex. All intentional openings must be sealed, the building must be empty, and the test cannot be run during windy conditions.

2.6.3 Market Impacts

Impacts on architects and builders from this proposal would be relatively small once it gains traction. In its paper on lessons learned after ten years of air barrier testing in Seattle, the ASTM concluded that air barrier testing “initially is difficult for all of the industry players but soon becomes routine.”

The impact on HVAC design practices could be more significant and highly positive. Mechanical engineers tend to size equipment for worst-case air leakage, but as they gain confidence in lower leakage rates, they may be able to specify smaller systems. This would especially lower loads in cooling-dominated, highly populated areas, helping buildings manage their demand during peak periods to help the grid. It would also facilitate the adoption of heat pumps. Since these are higher cost, it is particularly important that they not be oversized.

3. Energy Savings

Using its standard methodology, the Statewide CASE Team compared the modeled energy performances of prototype buildings with air leakages of 0.35 cfm75/ft^2 and the baseline. The baseline was 0.7 cfm/ft^2 in all climate zones, to reflect air barriers being prescriptively required for all nonresidential conditioned buildings in all climate zones.[2]

The Statewide CASE Team modeled four building types and assumed 100 percent adoption by the portion of buildings under 25,000 ft^2, as shown in Table 2. It was assumed that schools would be highly likely to select air leakage testing, since indoor air quality is of high importance to them. Savings results are shown in through Table 7. The negative values in Table 3 represent loss of "free cooling" from unfiltered unconditioned air leakage. This leakage actually decreases occupant comfort and should be minimized.

Table 2: Newly Constructed Floorspace Impacted by Proposed Measure

Prototype Codename	Portion of 2024 New Construction Forecast under 25,000 ft^2
OfficeSmall	100%
RetailMedium	25%
SchoolSmall	75%
RestaurantFastFood	100%

[2] Title 24, Part 6, 2022. Section 140.3(a)9A&B.

Table 3: First Year Electricity Savings (kWh) Per Square Foot, by Climate Zone

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15
Medium Retail	0.04	0.02	0.05	0.06	0.06	0.01	0.02	0.03	0.01	0.03	0.11	0.03	0.05	0.13	0.09
Restaurant	0	0	-0.01	0	-0.01	-0.01	-0.01	0	0	0.01	0.01	0	0.01	0.01	0.04
Small Office	0.04	0.01	-0.01	0.02	0	-0.03	-0.02	0	-0.01	0.01	0.06	0.02	0.03	0.06	0.05
Small School	0.02	0.01	0.01	0.02	0.01	0	0	0	0	0.01	0.04	0.02	0.02	0.03	0.04

Table 4: First Year Peak Demand Reduction (kW) Per Square Foot, by Climate Zone

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15
Medium Retail	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.01
Restaurant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small Office	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.01
Small School	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00

Table 5: First Year Natural Gas Savings (kBtu) Per Square Foot, by Climate Zone

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15
Medium Retail	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	1.43	0.64	1.12	0.80	0.82	0.50	0.31	0.23	0.36	0.36	1.14	0.79	0.59	1.10	0.25
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small School	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6: First Year Source Energy Savings (kBtu) Per Square Foot, by Climate Zone

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15
Medium Retail	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restaurant	1.29	0.58	1.02	0.72	0.74	0.45	0.28	0.20	0.33	0.33	1.04	0.72	0.54	0.99	0.22
Small Office	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Small School	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7: First Year Long-term Systemwide Cost Savings (2026 PV$) Per Square Foot, by Climate Zone

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15
Medium Retail	1.08	0.40	0.80	0.68	0.75	0.19	0.38	0.33	0.06	0.39	1.52	0.46	0.54	1.78	1.04
Restaurant	2.01	0.91	1.52	1.24	1.11	0.61	0.38	0.36	0.56	0.65	1.84	1.17	1.06	1.82	0.88
Small Office	0.71	0.24	0.12	0.41	0.09	-0.24	-0.22	0.03	-0.02	0.21	1.11	0.47	0.50	0.96	0.72
Small School	0.47	0.21	0.27	0.25	0.17	0.04	0.05	-0.01	0.10	0.10	0.73	0.35	0.34	0.50	0.53

4. Cost Effectiveness

This cost-effectiveness analysis is for testing only. The cost effectiveness of mandatory air barriers was evaluated during the 2022 code cycle.

The Statewide CASE Team contacted multiple stakeholders to obtain cost estimates for whole-building air leakage testing for buildings up to 25,000 ft^2. It found the main cost drivers to be:

- Number of fans, which depends on the number of spaces not connected.
- Extent of prep work required. Nonresidential buildings especially require a lot of time for sealing intentional openings which could nearly double the fee.
- Location. Costs are lower near larger cities where testing firms are typically located, and along freeway corridors. The fans and other equipment are heavy and bulky.

Table 8 through Table 10 present the results of three different surveys.

Table 8: Testing Fees per Square Foot for 20,000-25,000 ft^2 Commercial Buildings in Seattle Area, February 2024

Criteria	Firm #1	Firm #2	Firm #3
Estimated Fee per Square Foot	$0.30-$0.50	$0.22	$0.20-$0.30
Assumptions	• Two stations with 2 – 4 fans each. • Already working on the project as envelope consultants. Otherwise, add $.04/ft^2. • Project located where general contractors are already familiar with testing. Otherwise, add $0.04-$0.08/ft2		• Local job • Cost would be $0.50-$0.62 if traveled to CA

Source: Poll of Seattle-area firms by Duane Jonlin, Energy Code and Energy Conservation Advisor for the City of Seattle, February 2024.

Table 9: Results of Informal Industry Provider Survey, May 2020

Respondent	Average Estimate for 25,000 ft^2	Cost/ft^2
1	$4,500	$0.18
2	$6,000	$0.24
3	$6,000	$0.24
4	$20,000	$0.80
5	$5,500	$0.22
6	$7,200	$0.29
Average	-	$0.33
Average without outlier #4, (over 3 standard deviations)	-	$0.23

Table 10: Cost Estimates from 2022 CASE Report

Building Prototype	Conditioned Floor Area	Cost of Whole-Building Air Leakage Testing	Testing Cost / ft^2
RestaurantFast Food	2,501	$600.00	$0.24
OfficeSmall	5,502	$500.00	$0.09
RetailMixedUse	9,375	$3,000	$0.32
RetailStripMall	9,375	$800.00	$0.09
SchoolPrimary	24,413	$8,792.41	$0.36
RetailStandAlone	24,563	$8,745.13	$0.36
-	-	**Average**	**$0.24**

Source: 2022 Energy Code CASE Report: Reduced Infiltration

The data in the tables above converges to a cost for air leakage testing of about $0.24/ft^2 for buildings around 25,000 ft^2. However, there is wide consensus this cost will continue to decrease as testing becomes more common. The PNNL report mentions that "*as demand for air leakage testing in commercial buildings increases, more companies will enter the market to provide these services. Therefore, a gradual decrease in cost is expected as more companies are available to do the testing.*" (Pacific Northwest National Laboratory 2018) For example, since prep work is a big driver of cost and test quality, some general contractors in the Seattle area have begun using their painting crews to do the prep work, due to their experience with taping and tape removal. According to a local official and author of an ASTM paper on Seattle's decade of experience with air barrier testing, once everyone starts paying attention to leakage, it becomes relatively easy to meet the standard. Builders tend to strive to pass with room to spare, since failing is expensive. Therefore, compliance can exceed the minimum - unlike for insulation, where everyone just installs the minimum allowable.[3]

Table 11 presents the benefit-to-cost ratios in all climate zones for costs of $0.40/ ft^2 and $0.15/ ft^2. A benefit-to-cost ratio over 1.0 indicates cost effectiveness over the period of analysis.

[3] Email correspondence with Duane Jonlin on March 1, 2024, Energy Code and Energy Conservation Advisor, City of Seattle

Table 11: 30-Year Cost Effectiveness Summary Per Square Foot - New Construction & Additions

Climate Zone	LSC[4] Savings + Other PV Cost Savings (2026 PV$/square foot)	Benefit-to-Cost Ratio Assuming cost of $0.40/ft^2$	Benefit-to-Cost Ratio Assuming Cost of $0.15/ft^2$
1	0.35	0.89	2.36
2	0.14	0.34	0.91
3	0.3	0.75	2.01
4	0.29	0.74	1.96
5	0.14	0.36	0.96
6	0.09	0.23	0.62
7	0.03	0.08	0.22
8	0.09	0.23	0.60
9	0.1	0.26	0.69
10	0.15	0.38	1.00
11	0.53	1.33	3.56
12	0.24	0.60	1.59
13	0.24	0.60	1.60
14	0.54	1.35	3.60
15	0.34	0.85	2.28
16	0.73	1.83	4.87

5. Conclusion

The cost effectiveness of air barrier leakage testing is a chicken-and-egg problem between cost and demand. When deciding whether air barrier testing should be adopted in Title 24, Part 11 the following should also be considered:

- Because testing would be voluntary, the testing option would most likely be selected only for easy projects. Therefore, as the industry gains experience a cost close to $0.15/ft^2$ could become realistic in the field. Documenting such a cost trend would be a valuable step when considering air barrier testing in the future for Title 24, Part 6.

[4] Long-term Systemwide Cost (LSC) savings are calculated using hourly energy cost metrics for electricity and natural gas, projected over the 30-year life of the building.

- Investing in air leakage testing would be very well aligned with California's heavy investment in heat pumps. High leakage rates cause heat pumps to operate under higher loads, significantly decreasing their efficiency.
- HVAC designers currently tend to assume high leakage rates. If they had evidence of lower air leakage, they could downsize their designs. The resulting energy savings would likely more than cover testing costs. (Jonlin 2019)

In further consideration of the benefits of air barrier verification, this requirement would provide a measurable improvement in indoor air quality. In addition to California's air quality issues due to fossil fuel combustion, a study by the National Integrated Drought Information System (NIDIS) finds that wildfire burned areas in California have increased fivefold during 1996 to 2021 compared to 1971 to 1995. And in the coming decades, a further increase in annual forest burned area is expected, ranging from 3 to 52 percent. (National Integrated Drought Information System 2023) According to the World Health Organization, wildfire smoke is a mixture of hazardous toxic pollutants of which particulate matter is the principal public health threat. (World Health Organization n.d.) This fine inhalable particulate matter can travel deep into the lungs and may even enter the bloodstream.

While these health considerations do not factor into the cost-effectiveness methodology, the impact on the state's economy cannot be ignored. The California Air Resources Board (CARB) 2022 Scoping Plan for Achieving Carbon Neutrality estimates that reduced exposure to wildfire smoke between 2024 and 2045 could save the state over $3 billion in health care costs. (California Air Resources Board 2022)

6. References

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