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Docket Number: 19-DECARB-01

Aeroseal, LLC

Provide recommendations of building technologies (e.g., devices, appliances, and equipment) that advance or facilitate building decarbonization, electrification, and EV charging that should be included on CECâ€™s informational website. Where applicable, please address the following in the response:
â€¢ Explain how the technology facilitates the installation of EV chargers and reduces GHG emissions in buildings.
- EV Chargers: N/A
- GHG emissions reduction: See included Energy Savings Calculations in attached CEC folder

â€¢ Explain how the technology information would assist building owners, local governments, or the construction industry.
- Aerosealâ€™s groundbreaking aerosolized sealant technologies and a simple, proven process optimizes HVAC efficiencies throughout buildings. According to studies by ASHRAE, the DOE, Berkley Labs, the California Energy Commission, the Florida Solar Energy Center, and Building Commissioning: A Golden Case for Reducing Energy Costs by E Mills (7/09) â€“ HVAC duct leakage is a top building fault. Light commercial duct leakage is typically 30% or more, with typical ductwork losing up to 40% of heating & A/C energy. Even newly installed systems experience commercial HVAC ductwork experiences up to 30% of leakage, and commercial duct leakage costs about 2.9 billion annually.

The DOE now ranks duct sealing as one of the most effective strategies for reducing energy costs. Aerosealâ€™s patented technology addresses this top energy-saving measure by sealing ducts from the inside out with no need for the labor-intensive, cost-inhibitive, and invasive process of tearing down walls and ceilings associated with traditional duct efficiency measures. Further, there is minimal disruption to a buildingâ€™s regular functioning, which allows businesses and institutions to continue operating in a normal or near-normal fashion. Aeroseal reduces duct leakage by 90% or more. Aeroseal does not coat ductwork, only sticks to holes and gaps in ducts, and spans holes up to 5/8â€□ in diameter or seams 5/8â€□ wide. The results are tracked in real-time, and the work is verified with a certificate of completion and is guaranteed. Return on investment is usually 2-7 years. With operations in 29 countries and all 50 states, our technology has already completed nearly 200,000 seals, saving nearly $2 billion in energy waste globally.

Aeroseal can also quickly and efficiently solve airflow, exhaust, pressure, and performance audit issues on new construction projects when the building does not comply to standards or codes and run the risk of being put behind schedule, over budget, and restricting or prohibiting occupancy. Code compliance can be certified in real-time using the Aeroseal Certificate of Completion, which is generated instantly at the completion of each Aeroseal duct sealing project showing pre-seal and post-seal duct leakage (CFM).

Aeroseal also offers other air-side HVAC efficiency services that further improve energy efficiencies and HVAC performance such as duct cleaning, Shield by Aeroseal - a package of services that includes restorative coating that is applied to heat exchangers, casing refurbishment, and refrigerant upgrade/replacement work, and Generate by Aeroseal â€“ a solution integrates the efficiency of a permanent magnet motor with the efficiency of a variable-speed rooftop package control system.

Visit https://aeroseal.com/ for more information
â€¢ Does the technology offer additional benefits, such as improve energy efficiency, reduce energy burden, automate shifting of energy usage to nonpeak hours, or improve indoor air quality?
- In addition to energy efficiency gains, Aeroseal's technology helps increase indoor air quality and comfort in everything from homes, hospitals, hotels, and universities to municipal buildings, military facilities, and offices. Leaky ventilation ducts severely limit the effectiveness of the exhaust system. This, in turn, promotes the growth of mold and mildew and limits the elimination of smoke, odors, and other air contaminants throughout offices, hospitals, and apartment buildings; causing health issues and making the environment less than desirable for the inhabitants. The Center for Disease Control (CDC) estimates that 2 out of 3 indoor air quality problems involve the HVAC system â€“ both the heating and air conditioning side of the equation as well as the more obvious component involving ventilation. The American College of Allergy, Asthma & Immunology estimates that 50% of all illnesses are caused by poor indoor air quality (IAQ). The EPA lists indoor pollution as one of the top five environmental risks to public health, causing 8.5 million deaths each year.
Using Aeroseal to address leaky ductwork results in greater humidity control (reducing mold, mildew, and odors), improved airflow (reducing dust and other particulates), even temperatures, and greater comfort in every room. Additionally, Aeroseal exhibits minimal VOC off-gassing and its non-toxic properties afford it no OSHA maximum exposure limitations.
â€¢ Is the technology capable of providing energy storage to power appliances, buildings, or the grid?
- N/A
â€¢ Is the technology market-available? Please include the manufacturer(s) name and website(s).
- Yes, this technology is available directly through Aeroseal, LLC. and is also available through a wide network of HVAC contractors that have been trained and certified using Aerosealâ€™s technologies.
- Manufacturer name: Aeroseal, LLC. Website: www.aeroseal.com
â€¢ What is the average retail cost point or cost range? Is the technology cost-effective? Please include references.
- The average cost point for Aerosealâ€™s duct sealing technology is $1.00/square foot for most commercial, educational, municipal, and multi-family buildings. The technology is cost-effective and offers a payback/return on investment after 2-7 years. We have

included a complete package of case studies/references with this submission for the CECâ€™s review.

â€¢ What is the useful life of the technology?

- The useful lifespan of Aerosealâ€™s duct-sealing technology has been proven to last over 30 years.

â€¢ What is the expected maintenance and service frequency?

- There is no maintenance or service requirement for Aerosealâ€™s duct-sealing technology.

â€¢ Does the technology require licensed contractor installation and labor? If so, please specify the trade(s) required and estimated installation and labor costs.

- The technology does require Aerosealâ€™s direct installation crew or a trained and certified HVAC contractor to install it. Installation and labor costs are included in the approximate $1.00/square foot price.

â€¢ Does the technology require electrical upgrades to an existing building with a service panel of 30-amp fuse panel/120 volts? 60-amp fuse panel/240 volts?

- N/A

â€¢ Specify average annual energy consumption, if applicable.

- N/A

â€¢ Specify the BTU capacity by tonnage, if applicable.

- N/A

â€¢ Specify the type of refrigerant used, including its global warming potential (GWP), if applicable.

- N/A.
- Aeroseal does not require refrigerant. However, Aeroseal does offer a refrigerant upgrade/replacement service that includes the evacuation of existing R22 refrigerant and reclaim per regulations - changing the refrigerant filter and recharge the system with R438a refrigerant, creating a service report showing the units are operating per manufacturers requirements and returning to the site 35 to 45 days following the exchange to change the refrigerant filter.

â€¢ Specify the applicable building type(s) (i.e, single-family, commercial, or multifamily).

- Aerosealâ€™s technologies can be used in any building that has ductwork including single and multi-family housing and practically all commercial buildings.

â€¢ Does the technology contain â€œsmartâ€� functionality? If so, please detail the â€œsmartâ€� capabilities or protocols.

- N/A

Additional submitted attachment is included below.

Aeroseal Audit Process

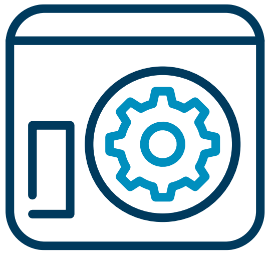
Duct Leakage Energy Audit Methodology

Our Process

AEROSEAL

Due diligence, proposal, installation, measurement and verification provided as a turnkey solution

1. Remote & At-risk Audits



2. Proposal with Guaranteed Reduction & Energy Models

3. Construction, Repair, Clean, Seal, Coat, Retrofit

4. Measurement & Verification

Preliminary Project Information

INFORMATION REQUEST

General information

Known Facts

1. Occupancy hours
2. Energy costs, including demand charge
3. Summer and winter design conditions
4. Location

From Drawings and mechanical schedule

5. Fan design flow & external static pressure
6. Heating and cooling efficiency
7. Outside air percentage

Also provide list of air handling and exhaust systems

Unknown Variable

8. Duct leakage

Aeroseal's Audit Process has 4 Components

1. Verify accuracy of mechanical drawings and schedules versus existing conditions
2. Visually inspect and evaluate accessible ductwork
3. Inspection of HVAC system – coils, housing, and motor
4. Measure duct leakage and static pressure
5. Create audit report to document findings

Findings recorded real-time using customized web-based software

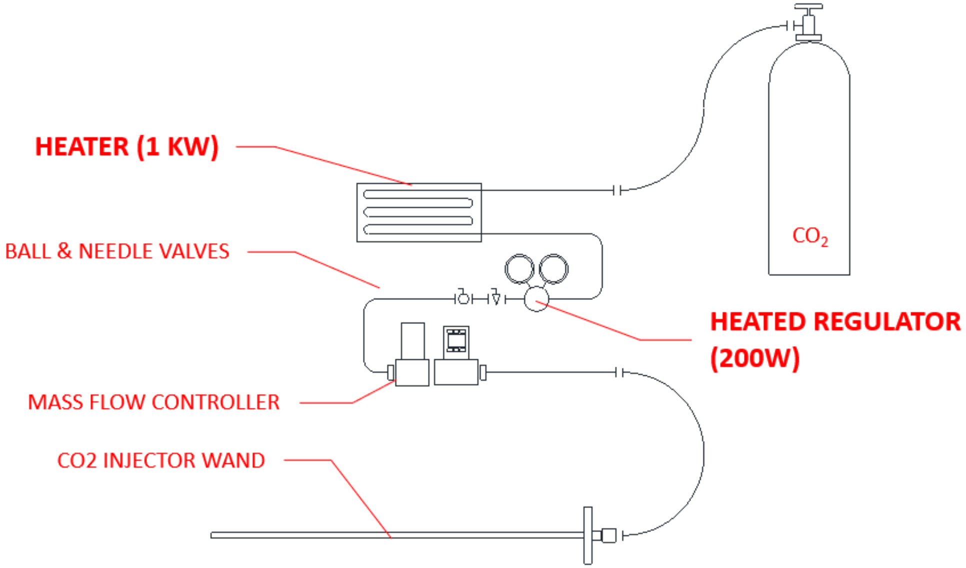
New Leak Detection Audit Advantages

- More precise measurement of duct leakage within commercial buildings with highly accurate results
- Minimally invasive process that removes the requirement of a duct blaster and does not require the duct system to be shut off
- Little amount of equipment and time needed for completion

CO2 sensor

Mass Flow Controller

CO2 Injection Kit



Energy Savings Calculations

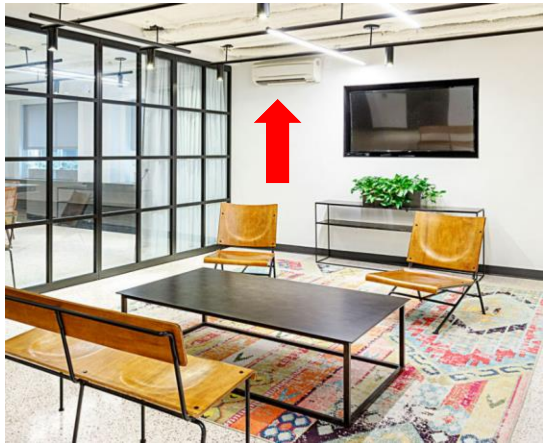
Duct Sealing Energy Savings Methodology

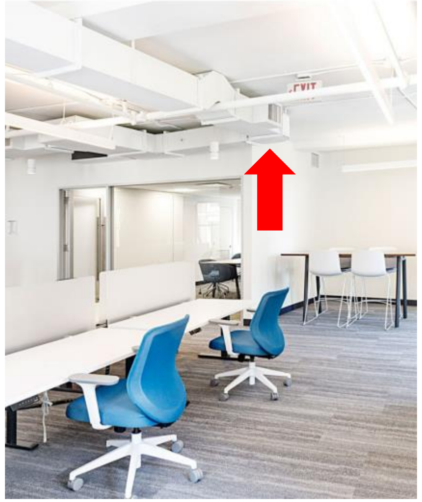
Energy Savings Components

- Detail Aeroseal's Duct Sealing Energy Savings Methodology
  - AHU Supply/Exhaust Fan Selection for Good Energy Savings Payback
  - Energy Savings Model Approach
  - Energy Savings Models
  - Savings Categories and Calculations

AHU Supply/Exhaust Fan Selection for Good Energy Savings Payback

- Fan connected to supply/exhaust duct
  - Excludes chiller fan coil units
  - Excludes refrigerant cassettes
  - Return duct excluded - small energy savings
- AHU supply fan connected to supply duct in **plenum space**
  - Exposed supply duct excluded - small energy savings
- For AHU VAV systems, supply duct upstream of VAV box only
  - Must seal downstream duct separately to protect VAV box
    - Poor payback from high sealing cost
- 5 HP supply fan rating or greater
  - Small energy savings <5 HP

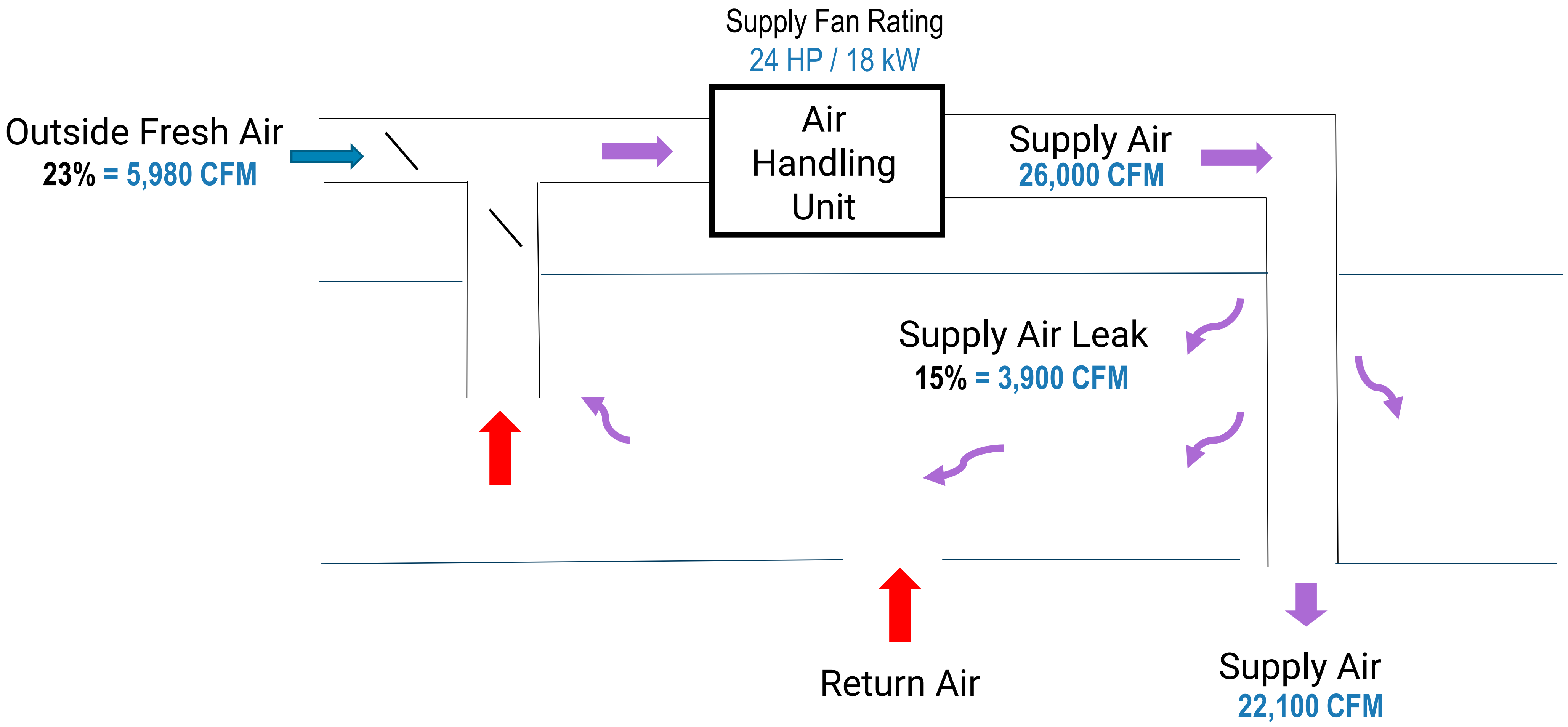




Aeroseal Calculates Energy Savings for All Fans Meeting These Criteria

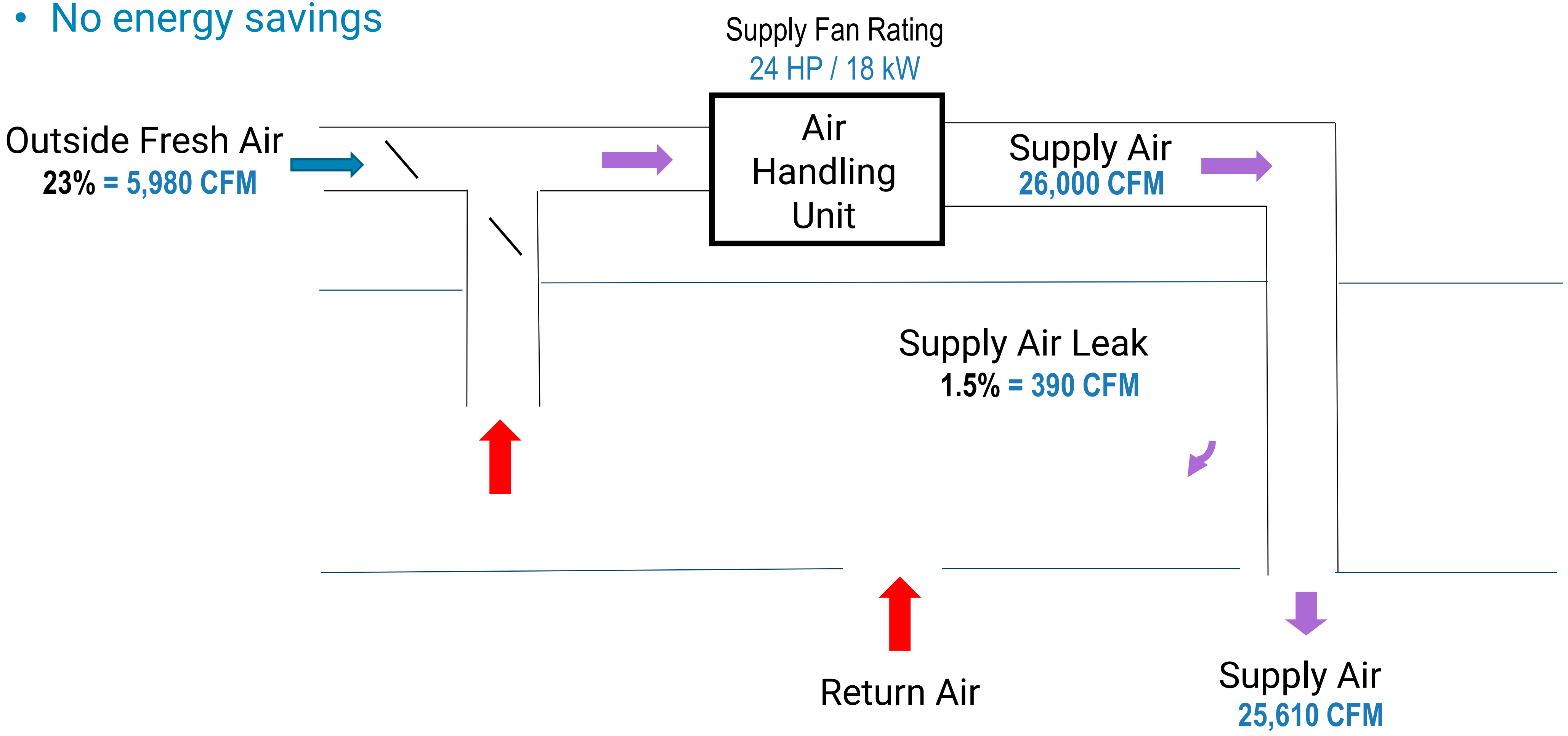
AHU Energy Savings Model Approach: Pre-Seal

- AHU supply fan: 26,000 CFM; 3,900 CFM leakage – 22,100 CFM to occupied space



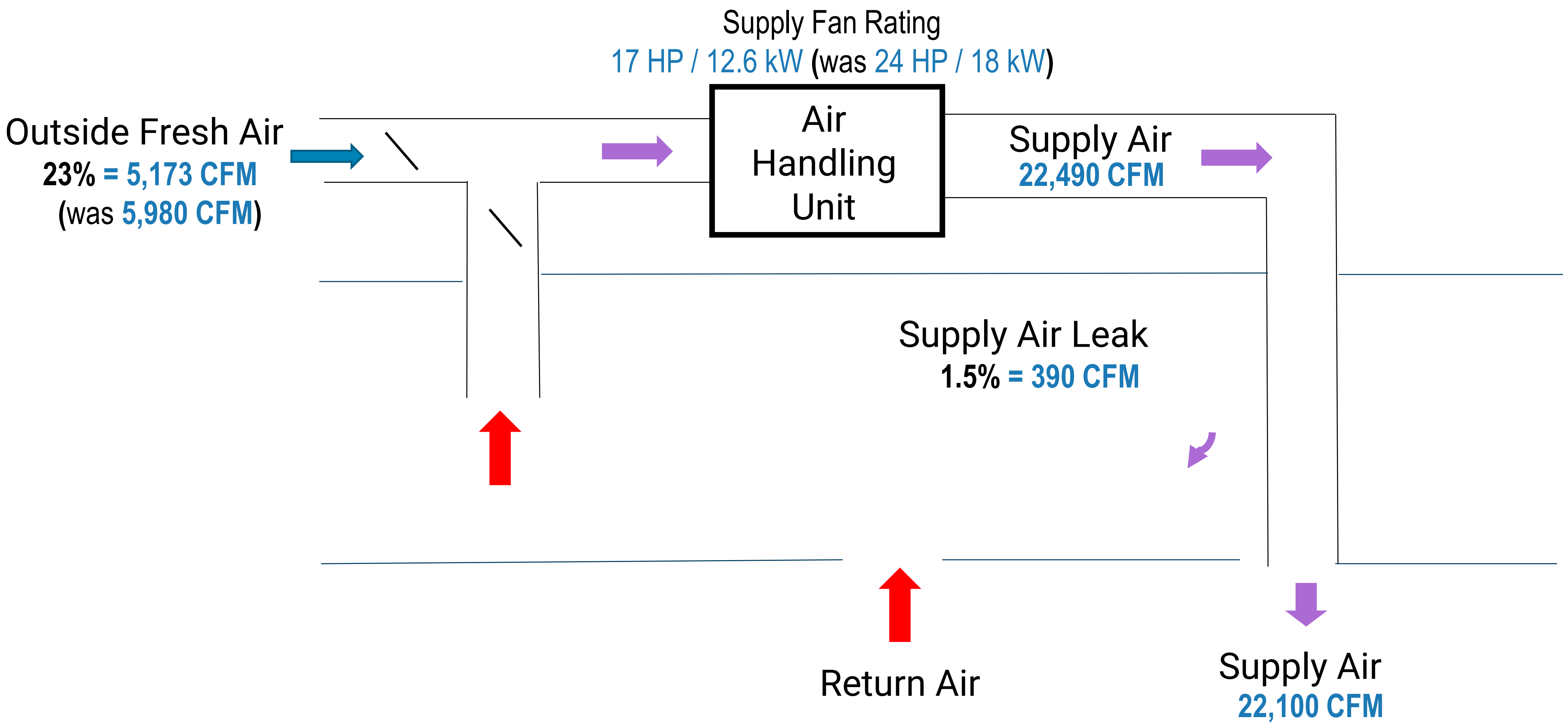
AHU Energy Savings Model Approach
Post-Seal and No Fan Speed Change

- Seal 90% of the leak – 15% leak to 1.5% leak
- AHU supply fan: 26,000 CFM; 390 CFM leakage – 25,610 CFM to occupied space; OA unchanged
- No energy savings



Energy Savings Model Approach: Post-Seal to 90% and AHU Fan Speed Reduction

- Reduce AHU supply fan speed 13.5% to match pre-seal AHU supply fan CFM of 22,100
- AHU supply fan energy savings from reduced fan power – **13.5% speed reduction = 30% power reduction**
- Outside fresh air heating/cooling reduction of **807 CFM** (assumes fixed damper)



Energy Savings Components

- Detail Aeroseal’s Duct Sealing Energy Savings Methodology
  - ✓AHU Supply/Exhaust Fan Selection for Good Energy Savings Payback
  - ✓Energy Savings Model Approach
  - Energy Savings Models
  - Savings Categories and Calculations

Four Energy Savings Models

HVAC System Type	Comment
• Constant Air Volume (CAV) with Changeover	• Heating or Cooling Mode Only • Assumes constant fan speed
• Variable Air Volume (VAV) with Changeover	• Heating or Cooling Mode Only • Assumes variable fan speed • Accommodates CAV fans
• Variable Air Volume (VAV) without Changeover	• Simultaneous Heating and Cooling • Interior VAV boxes with cooling • Exterior VAV boxes with heat
• Constant Volume Exhaust	• Parking garage, bathroom, lab, …

VAV with Changeover Most Common

Four Savings Categories from Fan Speed Reduction

Category	Savings $
Reduced fan speed from reduced supply air short-circuiting	Peak Power (kW) and Electric Energy (kWh)
Reduced outside air cooling from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)
Reduced outside air heating from reduced fan speed	Electric heat: Peak Power (kW) and Electric Energy (kWh) Gas Heat: Gas Energy (therm)
Reduced motor heat from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)

Calculated For Every Selected Fan

Four Savings Categories from Fan Speed Reduction

Category	Savings $
Reduced fan speed from reduced supply air short-circuiting	Peak Power (kW) and Electric Energy (kWh)
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Reduced motor heat from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)

Calculated For Every Selected Fan

AHU Supply Fan Power Savings Calculation

- Fan power is the product of (1) fan flow, (2) total pressure rise across the fan divided by the fan & fan motor & fan motor drive efficiency

- Fan power reduction scales to the exponent of 2.4 to reduction in fan speed
  - Small reduction in fan speed = large reduction in fan power!
- Fan power post-sealing is calculated as:

$$kW_{fan-post} = kW_{fan-pre}\ x\ \left(\frac{\dot{V}_{fan-post}}{\dot{V}_{fan-pre}}\right)^{2.4}$$

  - The exponent of 2.4 is based on tests of supply fans in commercial duct systems
  - $\dot{V}_{fan-post}$ = fan volume flow rate post-sealing
  - $\dot{V}_{fan-pre}$ = fan volume flow rate pre-sealing

AHU Supply Fan Energy Savings Calculation

- Fan energy is the product of (1) fan flow, (2) total pressure rise across the fan and (3) the annual fan hours of operation divided by the fan & fan motor & fan motor drive efficiency
- Fan motor energy reduction scales to the exponent of 2.4 to reduction in fan motor speed
  - Small reduction in fan motor speed = large reduction in fan motor energy!
- Fan energy post-sealing is calculated as:

$$kWh_{fan-post} = kWh_{fan-pre}\ x\ \left(\frac{\dot{V}_{fan-post}}{\dot{V}_{fan-pre}}\right)^{2.4}$$

  - The exponent of 2.4 is based on tests of fans in commercial duct systems
  - $\dot{V}_{fan-post}$ = fan volume flow rate post-sealing
  - $\dot{V}_{fan-pre}$ = fan volume flow rate pre-sealing

Four Savings Categories from Fan Speed Reduction

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Reduced outside air heating from reduced fan speed	Electric heat: Peak Power (kW) and Electric Energy (kWh) Gas Heat: Gas Energy (therm)
Reduced motor cooling from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)

Calculated For Every Selected Fan

Outside Air Heat and Cool Power Savings Calculation

- Duct leakage increases the amount of outside air being drawn into the building by the supply fan for AHUs with fixed outdoor air dampers
- When outside air enthalpy is greater (less) than room enthalpy, additional cooling (heating) energy is required to condition the added outside air
- The power reduction from reduced outside heating and cooling is calculated as:

$$\Delta kW_{heat-OA} \; OR \; \Delta kW_{cool-OA} = \frac{\left(\Delta h \; peak_{(OA-RA)} * \rho * \Delta \dot{V}_{fan \; (pre-post)} \;\; * 60 \frac{min}{hr} * \%OA \right)}{Cooling: EER * 1{,}000 \frac{Wh}{kWh} \; OR \; Heating: Efficiency \; \% * 1{,}000 \frac{Wh}{kWh}}$$

- $\Delta h \; peak_{(OA-RA)}$ is the maximum change in enthalpy (post-sealing – pre-sealing) during the season. The enthalpy change is the difference between the outside air and return air enthalpy during the occupied time (*Btu-h/lb*)
- ρ - density of air at 70˚F at site elevation in *lb/ ft³* (ρ at sea level is .075 *lb/ ft³*) - converts enthalpy from *Btu-h/lb to Btu-h/ft³*
- $\Delta \dot{V}_{fan \; (post-pre)}$ is the reduction in fan volume flow rate
- $60 \frac{min}{hr}$ converts the fan volume flow units ($\Delta \dot{V}_{fan \; (pre-post)}$) from *ft³/min to ft³/hr*
- $\%OA$ is the percentage of outside air to total fan design volume flow
- EER (Energy Efficiency Ratio) is cooling system efficiency (*Btu/Wh*)
- Efficiency % is an estimate of the overall electric heating system efficiency (%)

Outside Air Heat and Cool Energy Savings Calculation

- Duct leakage increases the amount of outside air being drawn into the building by the supply fan for AHUs with fixed outdoor air dampers
- When outside air enthalpy is greater (less) than room enthalpy, additional cooling (heating) energy is required to condition the added outside air
- The energy reduction from reduced outside air heating and cooling is calculated as:

$$\textit{Electric:}\ \Delta kW_{heat-OA}\ OR\ \Delta kW_{cool-OA} = \frac{\left(\sum \Delta h_{(OA-RA)} * \rho * \Delta\dot{V}_{fan\ (pre-post)} * 60\frac{min}{hr} * \%OA\right)}{Cooling: EER * 1{,}000\frac{Wh}{kWh}\ OR\ Heating: Efficiency\ \% * 1{,}000\frac{Wh}{kWh}}$$

$$\textit{Gas:}\ \Delta Therm_{heat-OA} = \frac{\left(\sum \Delta h_{(OA-RA)} * \rho * \Delta\dot{V}_{fan\ (pre-post)} * 60\frac{min}{hr} * \%OA\right)}{Efficiency\ \% * 1{,}000\frac{Wh}{Therm}}$$

- $\sum \Delta \mathrm{h}_{(\mathrm{OA-RA})}$ is the sum of the difference between the outside air and return air enthalpy during the occupied time (*Btu-h/lb*)
- ρ - density of air at 70˚F at site elevation in *lb/ ft³* (ρ at sea level is .075 *lb/ ft³*) - converts enthalpy from *Btu-h/lb to Btu-h/ft³*
- $\Delta\dot{V}_{fan\ (pre-post)}$ is the reduction in fan volume flow rate
- $60\frac{min}{hr}$ converts the fan volume flow units ($\Delta\dot{V}_{fan\ (pre-post)}$) from *ft³/min to ft³/hr*
- $\%OA$ is the fraction of outside air to total fan design volume flow
- EER (Energy Efficiency Ratio) is cooling system efficiency (*Btu/Wh*)
- Efficiency % is an estimate of the overall electric or gas heating system efficiency (%)

Four Savings Categories from Fan Speed Reduction

Category	Savings $
Reduced fan speed from reduced supply air short-circuiting	Peak Power (kW) and Electric Energy (kWh)
Reduced outside air cooling from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)
Reduced outside air heating from reduced fan speed	Electric heat: Peak Power (kW) and Electric Energy (kWh) Gas Heat: Gas Energy (therm)
Reduced motor heat from reduced fan speed	Peak Power (kW) and Electric Energy (kWh)

Calculated For Every Selected Fan

Fan Heat Cooling Power Reduction Calculation

- Fan motor heat increases the supply air temperature
  - Draw-through configuration: increases the air volume required to meet a given space load
  - Blow-through configuration: fan motor heat is absorbed directly by the coil

- The power reduction from reduced fan motor heat is calculated as:

$$\Delta kW_{fan\ heat} = \frac{\Delta kW_{fan}}{\frac{EER}{3.41}}$$

- $\Delta kW_{fan\ heat}$ is the reduction on fan kWh due to post-sealing fan motor speed reduction
- EER (Energy Efficiency Ratio, in Btu/h per W) is for the cooling system including compressor
- 3.41 is a constant that converts BTU/h to Watts

Fan Motor Heat Energy Savings $ Calculation

- Fan motor heat increases the supply air temperature
  - Draw-through configuration: increases the air volume required to meet a given space load
  - Blow-through configuration: fan motor heat is absorbed directly by the coil

- The energy reduction from reduced fan motor heat is calculated as:

$$\Delta kWh_{fan\ heat} = \frac{\Delta kWh_{fan}}{\frac{EER}{3.41}}$$

- ΔkWh_{fan} is the reduction on fan kWh due to post-sealing fan motor speed reduction
- EER (Energy Efficiency Ratio, in Btu/h per W) is for the cooling system including compressor
- 3.41 is a constant that converts BTU/h to Watts

Customer Provided Inputs to Energy Savings Model

Table 1

$\%\dot{V}_{design}$	100%	85%	70%	55%
$\%h_{fan}$	5%	30%	45%	20%

Inputs for Each Building		Source	Default
Fan annual operating hours	h_{fan}	Daily operating hours * annual operating days	10 hr * 240 days = 2,400 hr
Building address			
Indoor summer design conditions: Dry bulb temp (deg F) / Rel. humidity (%)	Δh_{RAS}	Mechanical drawings	74 F / 45%
Indoor winter design conditions: Dry bulb temp (deg F) / Rel. humidity (%)	Δh_{RAW}	Mechanical drawings	70 F / 45%
Electric rate ($/kWh)	R_{ele}	Utility bill	
Peak electric rate ($/kW)	$R_{ele-peak}$	Utility bill	
Natural gas rate ($/therm)	R_{ng}	Utility bill	
Inputs for Each AHU/Exhaust Fan		**Source**	**Default**
Design volume flow rate (CFM)	$\dot{V}_{design}$	Mechanical drawings / T&B reports	
% Design volume flow rate	$\%\dot{V}_{design}$	Fan speed trend data from BMS	CAV systems: 100% VAV: Table 1
% Fan annual operating hours	$\%h_{fan}$	Fan speed trend data from BMS	CAV systems: 100% VAV: Table 1
External static pressure (wg)	ΔP	Mechanical drawings	2
Fan efficiency (%)	Eff_{fan}	Fan submittal or calculated	45% - 65%
Fan motor efficiency (%)	Eff_{motor}	Mechanical drawings or equipment nameplate	85%
Fan motor drive efficiency (%)	Eff_{drive}	Mechanical drawings or equipment nameplate	95%
Fraction of outside to supply air (%)	$\%OA$	Mechanical drawings	20%
Cooling efficiency (EER, Btu/Wh)	Eff_{cool}	Mechanical drawings or equipment nameplate	Electric chillers: 17.1 RTUs: 12
Heating efficiency (%)	Eff_{heat}	Mechanical drawings or equipment nameplate	80% gas; 100% electric

Case Studies Show Diversity and Value of Aeroseal ECM

Building	Partner Type	Leakage CFM Before/After	Annual Energy Cost Savings
Global Policy Organization **Office**	Facility Manager	15,414 / 1,600 90% reduction	$102,000
Federal Bureau of **Prisons** San Diego, CA	ESCO	49,147 / 5,731 89% reduction	$140,000
Northgate II **Apartments** New Jersey	Owner	971 / 166 83% reduction	$37,000
Capital Plaza **Hotel/Convention Ctr.** Frankfort, KY	Owner	6,270 / 771 88% reduction	$110,000
New York State **Medical Facility** NY, NY	ESCO	29,836 / 870 97% reduction	$22,964
West Texas A&M Cornette **Library** Canyon, TX	ESCO	17,413 / 1,271 93% reduction	$30,000

Aeroseal Projects, Certifications, and Partners

Installation Examples

AEROSEAL

- Federal /Military
- Healthcare
- Higher Ed
- Multi-Family / Hospitality
- Critical Applications
- Light Commercial

Certifications & Requirements

ASHRAE Standard 152
ASTM E2342-10
FEMP Top Strategy

GBI Climate Impact Reduction
NFPA 90A Standards
NGBS Certified Product

CEC Title 24 Standards
UL 1381 Sealant Durability
USGBC Eco-Friendly, LEED

EXISTING AEROSEAL PARTNERS

AEROSEAL

ABM
AMERESCO
aramark
Constellation
esG energy systems group
YEAROUT ENERGY

ENGIE
iconergy
Honeywell
Johnson Controls
McKinstry For The Life Of Your Building

Schneider Electric
sodexo
TRANE
wendel
WILLDAN