Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Fan System Power

March 29, 2017

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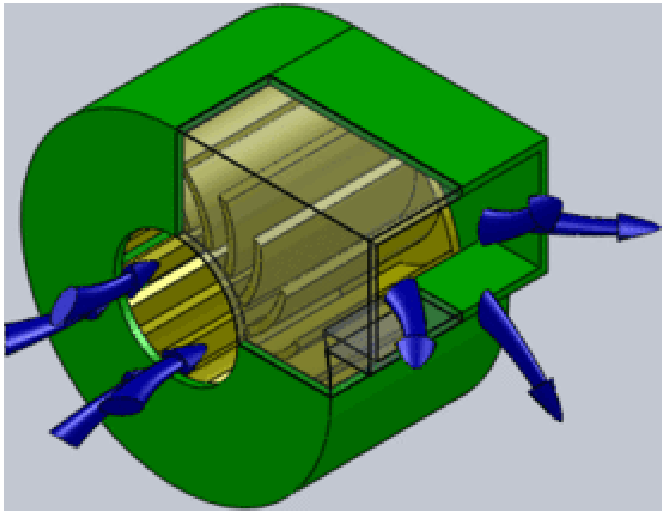
1. Background

Introduction to Technology

- Fan
  - Creates airflow using rotational motion
  - Uses an electric motor to move the fan

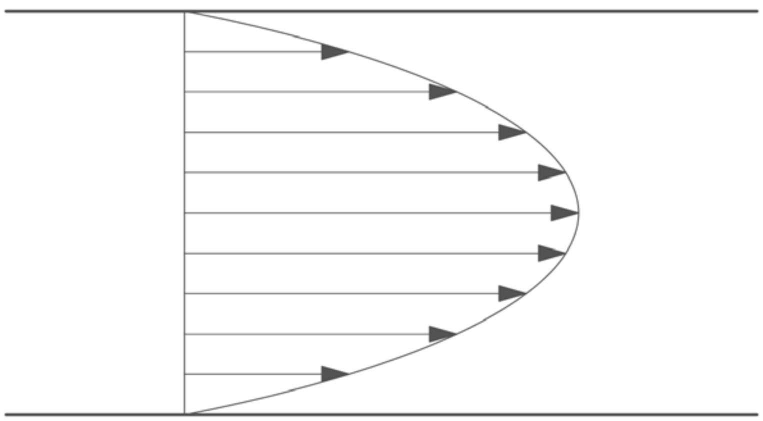


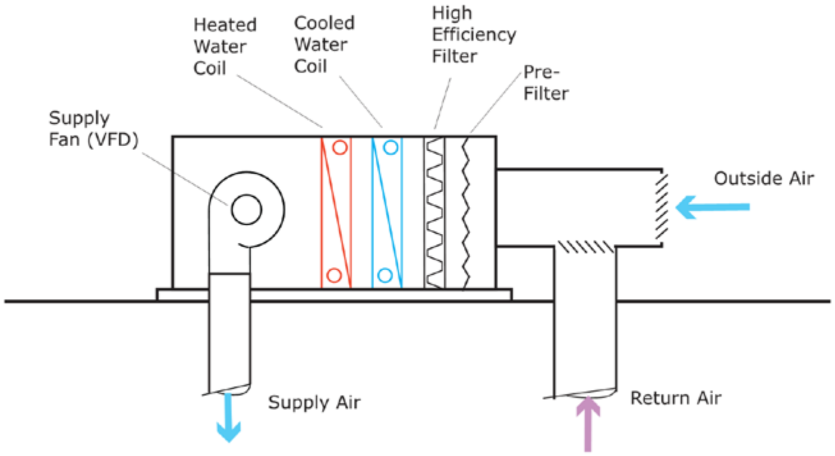
- Power measured in horsepower (hp) or watts (W)

- Amount of airflow measured in cubic feet per minute (CFM)

Introduction to Technology

- Static Pressure is the resistance to air flow
  - Affected by ductwork, filters, coils, or other air-side equipment
  - Units of measurement: inch water column (in. w.c.)
  - Higher static pressure = More fan power
- Proposed measure aims to reduce static pressure allowances

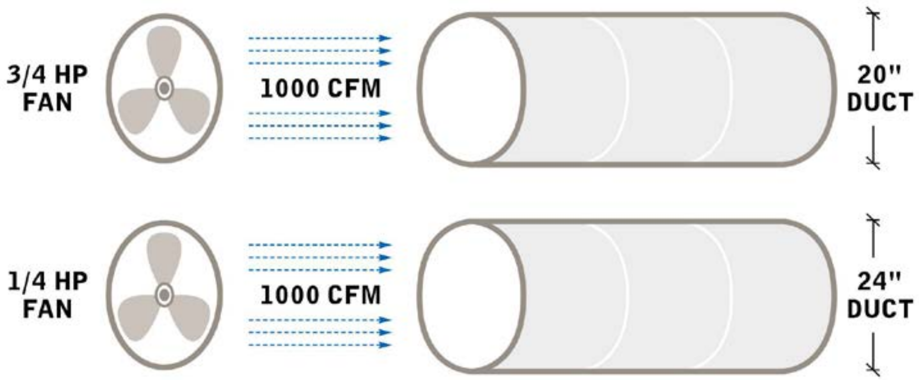




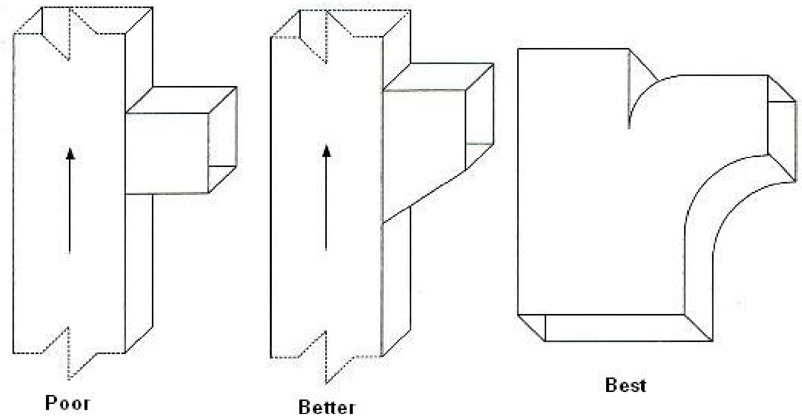
Introduction to Technology

Ways to reduce external static pressure

Larger Ducts



Smoother bends



Relevant Code History

- There are existing requirements in Title 24, Part 6
  - Prescriptive requirement for power consumption of fans (added 1992)
    - 0.8 W/cfm for constant volume systems
    - 1.25 W/cfm for variable volume systems

- Other Relevant Code Requirements
  - Nonresidential Alternate Compliance Method Reference Manual
    - Sets fan power for limit for the baseline for performance compliance
  - ASHRAE 90.1
    - Limits fan horsepower based on airflow
  - DOE 10 CFR 431
    - Establishes motor efficiencies

What do you think? (Discussion)

- Do you understand the technology / building system and how it saves energy?
- Any questions or concerns?

2. Proposed Code Changes

Proposed Code Change

- High-level description of the proposed code change include:
  - Revisions to the existing prescriptive code
  - Affects all building complying under prescriptive compliance path
  - Affects space conditioning fan systems with a total power of 5 hp or greater
    - Sum of fans including supply, return/relief, exhaust, fan-powered boxes.
  - Calculation method based on ASHRAE 90.1 2016 6.5.3.1 and aligning with NR ACM requirements
  - Adopt ASHRAE 90.1 2016 adjustment factors tied to process loads
    - Include filters, air treatment, and heat recovery devices*
    - Exclude sound attenuators, evaporative humidifier/coolers, and return/exhaust systems

**Heat recovery device credit can only be taken when required by code.*

Why Are We Proposing This Code Change

- Update fan power compliance method introduced in 1992
- Regulate more fans (minimum of 5 hp down from 25 hp)
- Keep up with ASHRAE 90.1 as required by federal statues
- Make fan power calculation more transparent to designers
  - Allow designer to calculate based on what is actually designed
- Allow State of California to limit pressure drops through various devices that affect fan power including future devices
- Alignment with NR ACM requirements

Why Are We Proposing This Code Change

Nonresidential Alternate Compliance Method Requirements

- Standard Design in the NR ACM should represent the prescriptive requirements of Title 24, Part 6
  - Allows for proposed design to have tradeoffs between prescriptive codes

- Discrepancy between Title 24, Part 6 and NR ACM
  - NR ACM is much more stringent than prescriptive standard

	Motor Size	Total Static Pressure	W/cfm
Title 24 Part 6	25 hp	6.2”	1.25
NR ACM	25 hp	4.5”	0.91

Proposed Code Change

- Proposed fan system total static pressure.

Total Static Pressure	Constant Volume	Variable Volume
Title 24 Part 6	3.96”	6.18”
ASHRAE 90.1	3.85”	5.35”
Proposed (NR ACM)	3.50”	4.50”

Note: ASHRAE assumes 65% fan efficiency, NR ACM assumes 62% fan efficiency.

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3. Technical and Market Barriers

Technical and Market Barriers

- Lower Static Pressure Duct Design
  - Changes in design practices for duct layout
    - No major changes anticipated. Typical practices don't reach above 6" of total static pressure without additional filter or process equipment.
  - More space taken up by ducts
    - Coordinate early with structural engineers and architects to allocate more space.
  - Increased sheet metal
  - If larger ductwork is not an available option,
    - Specify a more efficient or larger fan
      - less power for same airflow
    - Adjustment factors for process equipment

Feedback on the Proposed Code Change

4. Compliance and Enforcement

Compliance Process

Design Phase

- What happens during design phase
  - Mechanical designer lays out ductwork.
  - Mechanical designer specifies fan system.
  - Coordination with structural engineer and architect to achieve static pressure target.

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - Mechanical designer or energy consultant compares proposed fan brake horsepower with allowed fan brake horsepower
  - Changes to compliance form to reflect new requirements (NRCC-MCH-07-E)

Compliance Process

Construction Phase

- What happens in construction phase?
  - Sheet Metal subcontractor installs ductwork and HVAC system
  - No changes to current practices

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - Inspector check for correct fan installation
  - No changes to current practices
  - No field verification or acceptance test

What do you think? (Discussion)

Since there are no changes to the technology or major changes to design practices, we do not anticipate any compliance and enforcement barriers…

- Do you agree?
- Any questions, concerns, or suggestions?

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - Complaint with prescriptive code
  - 1.25 W/cfm
  - Static pressure varies from 5.9” w.c. to 6.3” w.c. based on motor efficiency
  - 62% fan efficiency

- **Proposed Conditions**
  - Compliant with NR ACM manual
  - 4.5” w.c. of static pressure
  - W/cfm varies from 0.95 W/cfm - 0.88 W/cfm based on motor efficiencies
  - 62% fan efficiency

Cost-Effectiveness Analysis

Incremental Costs

- Incremental First Cost
  - Increased sheet metal ($0.30-$0.48/ft^2 depending on climate zone)
  - **Total Incremental First Cost ($0.30-$0.48/ft^2)**
- Incremental Maintenance Costs over 15-year period of analysis
  - None anticipated ($0)
  - **Total Incremental Maintenance Cost ($0)**

- **Total Incremental Cost over 15/30-year period of analysis = $0.30-$0.48/ft^2**

Cost-Effectiveness Analysis

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of $0.40/ft² to $1.25/ft² depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = $0.40/ft² to $1.25/ft²**

Benefit-to-Cost Ratio

Climate Zone	Benefit to Cost
1	1.15
2	1.45
3	1.29
4	1.45
5	1.33
6	1.66
7	1.68
8	1.72
9	1.76
10	1.55
11	1.53
12	1.50
13	1.46
14	1.69
15	1.81
16	1.18

Cost-Effective in All Climate Zones

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	**4.66**	**$0.41**
2	**6.25**	**$0.56**
3	**5.49**	**$0.49**
4	**6.37**	**$0.57**
5	**5.67**	**$0.50**
6	**7.22**	**$0.64**
7	**7.23**	**$0.64**
8	**7.58**	**$0.67**
9	**7.84**	**$0.70**
10	**7.54**	**$0.67**
11	**6.89**	**$0.61**
12	**6.48**	**$0.58**
13	**6.56**	**$0.58**
14	**7.99**	**$0.71**
15	**8.43**	**$0.75**
16	**6.44**	**$0.57**

Annual Energy Savings per Square Foot

Climate Zone	Annual Electricity Savings (kWh/ft^2-yr)	Annual Natural Gas Savings ($therms/ft^2$-yr)	Peak Electric Demand Reduction (kW/ft^2)
1	0.19	-0.003	0.00002
2	0.22	-0.002	0.00003
3	0.21	-0.002	0.00003
4	0.23	-0.001	0.00003
5	0.22	-0.002	0.00003
6	0.24	-0.001	0.00003
7	0.24	0.000	0.00003
8	0.24	-0.001	0.00003
9	0.25	-0.001	0.00004
10	0.24	-0.001	0.00004
11	0.24	-0.002	0.00004
12	0.23	-0.001	0.00004
13	0.24	-0.001	0.00004
14	0.27	-0.001	0.00004
15	0.28	-0.000	0.00004
16	0.25	-0.003	0.00004

What about costs and energy savings?

Second Stakeholder Meeting for Nonresidential HVAC (2 of 2)

Proposals Based on ASHRAE 90.1-2016: Exhaust Air Heat Recovery

March 29, 2017

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1. Background

Introduction to Technology

Exhaust Air Heat/Energy Recovery

- Type of air heat exchanger that preconditions outdoor ventilation air by coming into indirect contact with the exhaust air

- Can recovery sensible or total energy
  – Wheel type - total and sensible
  – Plate type - total and sensible
    - Typically sensible only
  – Run around coil - sensible only

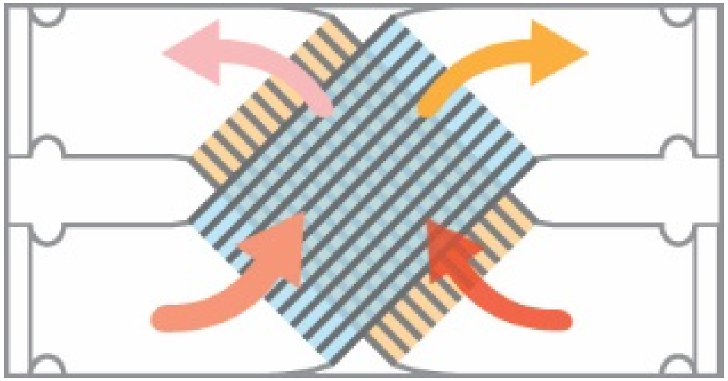
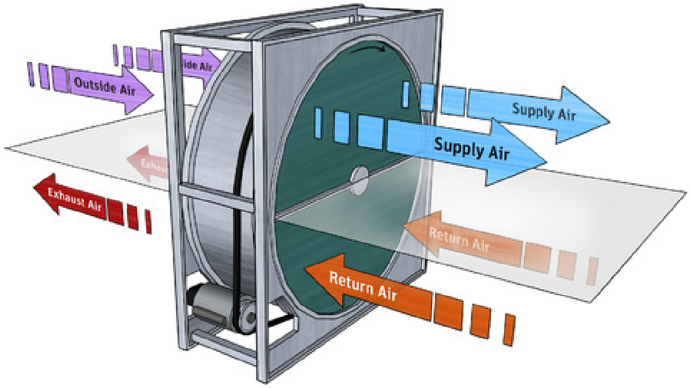


Plate type heat recovery



Wheel type heat recovery

Introduction to Technology

Exhaust Air Heat/Energy Recovery

- Saves energy by reducing the heating/cooling load on the incoming ventilation air.
- Uses the temperate exhaust air that will otherwise be released outside.

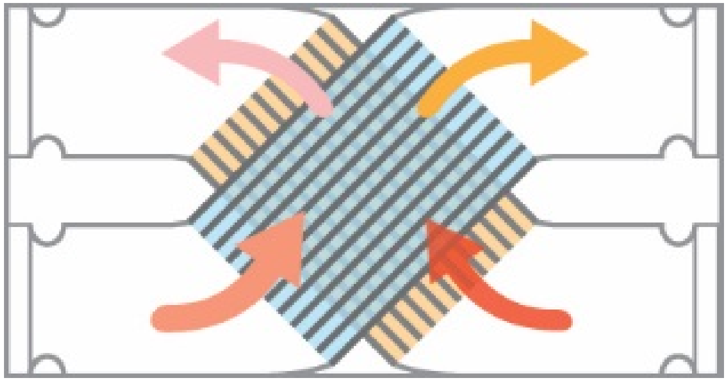
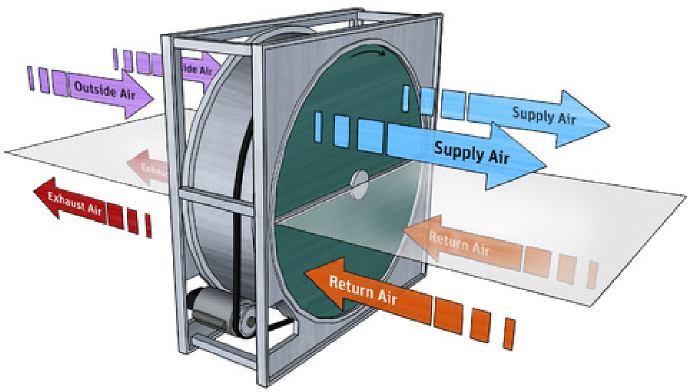


Plate type heat recovery

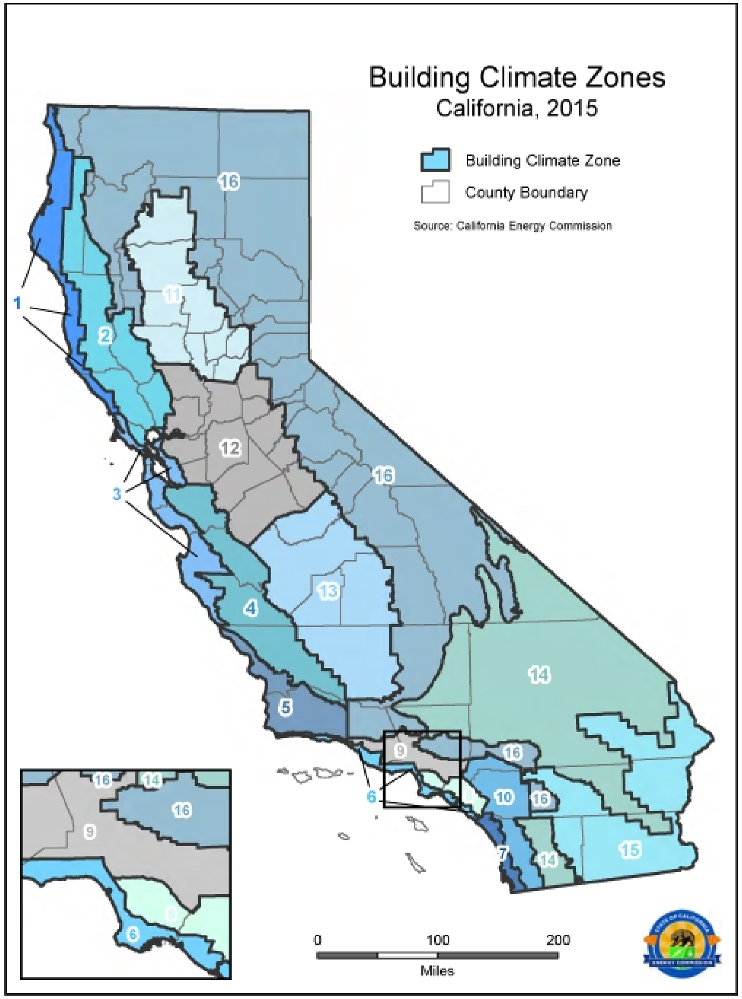
- Economizer bypass
  - When outdoor conditions are more suitable for air side economizers, the outdoor air should bypass the heat exchanger



Wheel type heat recovery

Warning

- Not cost effective in all California climate zones
  - Economizers should have priority over exhaust air heat recovery
- Energy recovered at the penalty of increased static pressure on fan system.
  - Wheel types also have a motor to rotate the wheel.
- Cross contamination
- **Energy savings on heating/cooling must overcome the fan penalty**



Relevant Code History

- There are no existing requirements in Title 24, Part 6

- Other Relevant Code Requirements
  - ASHRAE 90.1 2016 - Requires exhaust air heat recovery systems based on outdoor air fraction, supply airflow rate, hours of operation, and climate zone.

2. Proposed Code Changes

Proposed Code Change

- High-level description of the proposed code change include:
  - – New prescriptive requirement
  - – Affects nonresidential buildings in certain climate zones found to be cost effective
  - – Based on ASHRAE 90.1 2016 requirements
    - Changes to minimum heat recovery effectiveness and climate zones

Why Are We Proposing This Code Change

- Capturing energy savings in certain climates
- Support ZNE goals
- Keep up with ASHRAE 90.1 as required by federal statues
- Prepare for future climate conditions and HVAC systems
  - Most effective in systems with 100% outdoor air supply

What do you think? (Discussion)

- What do you think of the code change proposal?
- Any questions or concerns?

3. Technical and Market Barriers

Technical and Market Barriers

- Economizer Bypass
  - Outdoor ventilation air must bypass heat recovery device when economizer is in operation
    - Recovering heat from exhaust air when outdoor air conditions are more favorable to economize can increase cooling energy.
  - Proper controls and monitoring will allow to maintain the free energy from economizer without compromising the heat recovery

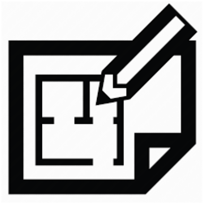
Technical and Market Barriers

- Collocating intake and exhaust airstreams
  - Increased ductwork to reroute the exhaust duct near the intake
  - Most system with return air will have a relief air stream
  - Not all exhaust air must be recovered
    - Cross Contamination
  - Exception 6 in ASHRAE 90.1 Section 6.5.6.1
    - If the sum of airflow rates exhausted and relieved within 20 feet of each other is less than 75% of the design outdoor airflow rates, then exhaust air heat recovery is not required.

What about technical and market barriers?

4. Compliance and Enforcement

Compliance Process



Design Phase

- What happens during design phase
  - Mechanical designer specifies and designs for exhaust air heat recovery.
  - Coordinate with contractor, manufacturer, and architect for technical feasibility of including heat recovery system.
  - Changes to design practice to allow for exhaust air heat recovery to be properly implemented.

Compliance Process

Permit Application Phase

- What happens in permit application phase?
  - Mechanical designer or energy consultant makes sure heat recovery is required for the air system or climate zone.
  - Permit reviewer checks to make sure heat recovery device is required for the air system and climate and is properly designed.
  - Changes to compliance form to reflect new requirements (NRCC-MCH-02-E).

Compliance Process

Construction Phase

- What happens in construction phase?
  - Sheet Metal subcontractor installs heat recovery device.
  - No changes to the current practices of installing heat recovery.

Compliance Process

Inspection Phase

- What happens in permitting phase?
  - Inspector check for correct installation of heat recovery device.
  - Checks to make sure economizer bypass is working properly.

5. Cost-Effectiveness and Energy Impacts

Definition of Baseline and Proposed Conditions

- **Baseline Conditions**
  - School buildings
    - ~30% outdoor air ventilation
    - Operates less than 8000 hours a year
  - Office/Lab mixed use building
    - 100% outdoor air ventilation
    - Operates greater than 8000 hours a year
  - No heat recovery system
  - Supply airstream
    - 4.5” w.c. of static pressure
  - Return/Relief airstream
    - 1.0” w.c. of static pressure
  - Economizer as compliant with 2016 standard

- **Proposed Conditions**
  - 70% sensible effectiveness
  - 1” w.c. of static pressure added per airstream
    - *(2.2" * Effectiveness - 0.5") per air stream (ASHRAE 90.1 2016)*
  - Economizer bypass
    - No fan savings during economizer bypass

Cost-Effectiveness Analysis for Schools

Incremental Costs

- Incremental First Cost
  - Heat recovery device (\$0.89 - \$1.38/ft² depending on climate zone)
  - **Total Incremental First Cost (\$0.99 - \$1.48/ft²)**
- Incremental Maintenance Costs over 15-year period of analysis
  - Cleaning and Annual Maintenance (\$0.10/ft²)
  - **Total Incremental Maintenance Cost (\$0.10/ft²)**

- **Total Incremental Cost over 15/30-year period of analysis = \$0.99 - \$1.48/ft²**

Cost-Effectiveness Analysis for Schools

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of -$0.41/ft² to +$2.01/ft² depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = -$0.41/ft² to +$2.01/ft²**

Benefit-to-Cost Ratio for Schools

Climate Zone	Benefit to Cost
1	-0.34
2	0.40
3	-0.26
4	0.36
5	-0.31
6	-0.10
7	-0.31
8	0.17
9	0.53
10	0.69
11	1.05
12	0.70
13	0.71
14	0.66
15	1.45
16	-0.26

Cost-Effective in Climate Zones 11 and 15

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot for Schools

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	-4.56	-$0.41
2	5.41	$0.48
3	-3.42	-$0.30
4	5.19	$0.46
5	-4.22	-$0.38
6	-1.44	-$0.13
7	-4.21	-$0.37
8	2.37	$0.21
9	7.13	$0.63
10	11.01	$0.98
11	14.85	$1.32
12	9.95	$0.89
13	9.98	$0.89
14	9.79	$0.87
15	22.61	$2.01
16	-4.30	-$0.38

Annual Energy Savings per Square Foot for Schools

Climate Zone	Annual Electricity Savings (kWh/ft²-yr)	Annual Natural Gas Savings (therms/ft²-yr)	Peak Electric Demand Reduction (kW/ft²)
1	-0.16	0.0018	0.0000
2	-0.06	0.0009	0.0003
3	-0.16	0.0010	0.0001
4	-0.07	0.0007	0.0002
5	-0.16	0.0009	0.0001
6	-0.16	0.0004	0.0002
7	-0.18	0.0003	-0.0000
8	-0.10	0.0004	0.0004
9	-0.02	0.0005	0.0003
10	0.06	0.0005	0.0003
11	0.12	0.0007	0.0005
12	0.03	0.0008	0.0004
13	0.11	0.0008	0.0004
14	0.11	0.0007	0.0002
15	0.44	0.0003	0.0007
16	-0.18	0.0011	-0.0000

Cost-Effectiveness Analysis for Office/Lab

Incremental Costs

- Incremental First Cost
  - Heat recovery device ($2.03 - $3.02/ft^2 depending on climate zone)
  - **Total Incremental First Cost ($2.03 - $3.02/ft^2)**
- Incremental Maintenance Costs over 15-year period of analysis
  - Cleaning and Annual Maintenance ($0.30/ft^2)
  - **Total Incremental Maintenance Cost ($0.30/ft^2)**

- **Total Incremental Cost over 15/30-year period of analysis = $2.33 - $3.32/ft^2**

Cost-Effectiveness Analysis for Office/Lab

Incremental Cost Savings (Benefits)

- Energy Cost Savings over 15-year period of analysis
  - **Total Energy Cost Savings = range of -$3.93/ft² to +$22.04/ft² depending on climate zone**
- **Total Incremental Cost Savings (Benefit) over 15-year period of analysis = -$3.93/ft² to +$22.04/ft²**

Benefit-to-Cost Ratio for Office/Lab

Climate Zone	Benefit to Cost
1	2.47
2	3.92
3	0.22
4	2.66
5	0.32
6	-0.37
7	-1.69
8	1.20
9	2.58
10	3.69
11	6.85
12	5.71
13	6.53
14	5.15
15	6.72
16	5.08

Cost-Effective in Climate Zones 1, 2, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16

If Benefit-to-Cost Ratio is over 1, measure is cost-effective.

Annual Energy Savings per Square Foot for Office/Lab

Climate Zone	TDV Energy Savings (TDV kBtu/ft²-yr)	15 Year TDV Energy Cost Savings ($2020)
1	64.94	$5.78
2	114.72	$10.21
3	5.85	$0.52
4	70.26	$6.25
5	8.54	$0.76
6	-9.59	-$0.85
7	-44.21	-$3.93
8	31.90	$2.84
9	82.29	$7.32
10	118.05	$10.51
11	237.79	$21.16
12	173.06	$15.40
13	191.72	$17.06
14	192.33	$17.12
15	247.61	$22.04
16	136.78	$12.17

Annual Energy Savings per Square Foot for Office/Lab

Climate Zone	Annual Electricity Savings (kWh/ft²-yr)	Annual Natural Gas Savings (therms/ft²-yr)	Peak Electric Demand Reduction (kW/ft²)
1	-2.11	0.57	0.0001
2	-0.94	0.44	0.0004
3	-2.10	0.21	0.0010
4	-1.36	0.21	0.0008
5	-2.07	0.25	0.0000
6	-1.96	0.04	0.0004
7	-2.24	-0.04	0.0001
8	-1.11	0.07	0.0013
9	-0.22	0.17	0.0003
10	0.40	0.22	0.0029
11	1.50	0.51	0.0027
12	0.19	0.43	0.0026
13	1.24	0.45	0.0017
14	1.44	0.51	0.0017
15	5.18	0.27	0.0030
16	-1.86	0.87	-0.0000

What about costs and energy savings?

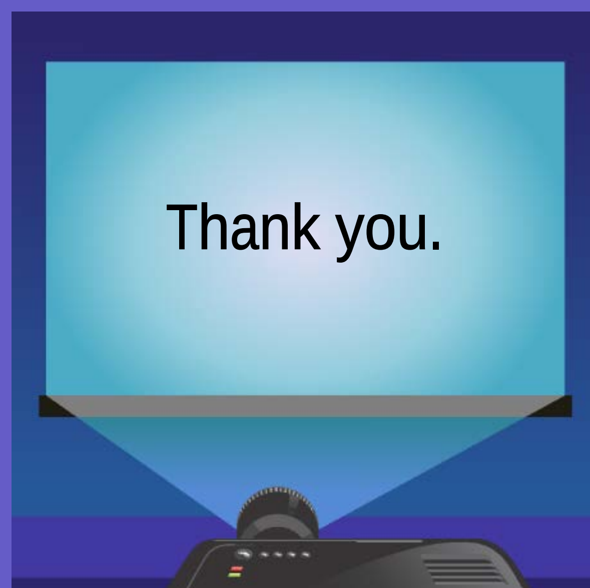
6. Next Steps

Next Steps

- Please send any additional feedback within 2 weeks to:
  - CASE Author (see contact info at end of this presentation)
  - Info@title24stakeholders.com
- Keep an eye on Title24Stakeholders.com for:
  - Presentations from today's meeting
  - Draft Code Change Language
  - Notes from today's meeting
  - Draft CASE Report (will be posted in April)

Let's move on to…

Wrap-up



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