ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F IoT Building Management System in U.S. large offices, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. large offices, both retrofit and new construction. Studied 75F applications include Dynamic Chill Water Balancing (DCWB), Outside Air Optimization (OAO), and Smart VAV With Reheat.

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **22%** in retrofit large offices
- **Total building** energy savings of up to **23%** for new construction large offices
- Energy savings potential is **even across the U.S.**, with the **eastern and southern** portions of the country seeing the highest savings

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The offices analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## LARGE OFFICES

Large office building energy consumption is based on a 12-story building with 498,600 square feet, a gas-fired boiler for heating, a water-source DX cooling coil with fluid cooler for a datacenter in the basement and IT closets in other floors; and two water-cooled centrifugal chillers for the rest of the building. Distribution and terminal units include a VAV terminal box with damper and hot water reheating coil, except for the non-datacenter portion of the basement and IT closets that are served by CAV units.

RESULTS | **Large Offices, Retrofit**

RESULTS | **Large Offices, New Construction**

# 75F® Dynamic Chill Water Balancing™

75F Dynamic Chilled Water Balancing is an end-to-end solution for chilled water systems. 75F sensors in each zone gather millions of data points daily and communicate these points via a 900 MHz wireless mesh network to the 75F® Central Control Unit™ — giving users the ability to monitor the inlet and outlet temperatures, chilled water flow rates, and BTU energy consumption across the line. 75F's system understands, analyzes, and optimizes the overall performance of the HVAC system under various conditions, thereby driving significant energy savings at an AHU level and at the chiller plant.

75F designs and manufactures the world's leading IoT-based Building Management System, an out-of-the-box, vertically integrated solution that is more affordable and easier to deploy than anything on the market today. The company leverages IoT, Cloud Computing and Machine Learning for data-driven, proactive building intelligence and controls for HVAC and lighting optimization. Investors include some of the biggest names in energy and technology. 75F's mission is to improve occupant productivity through enhanced comfort and indoor air quality — all while saving energy.

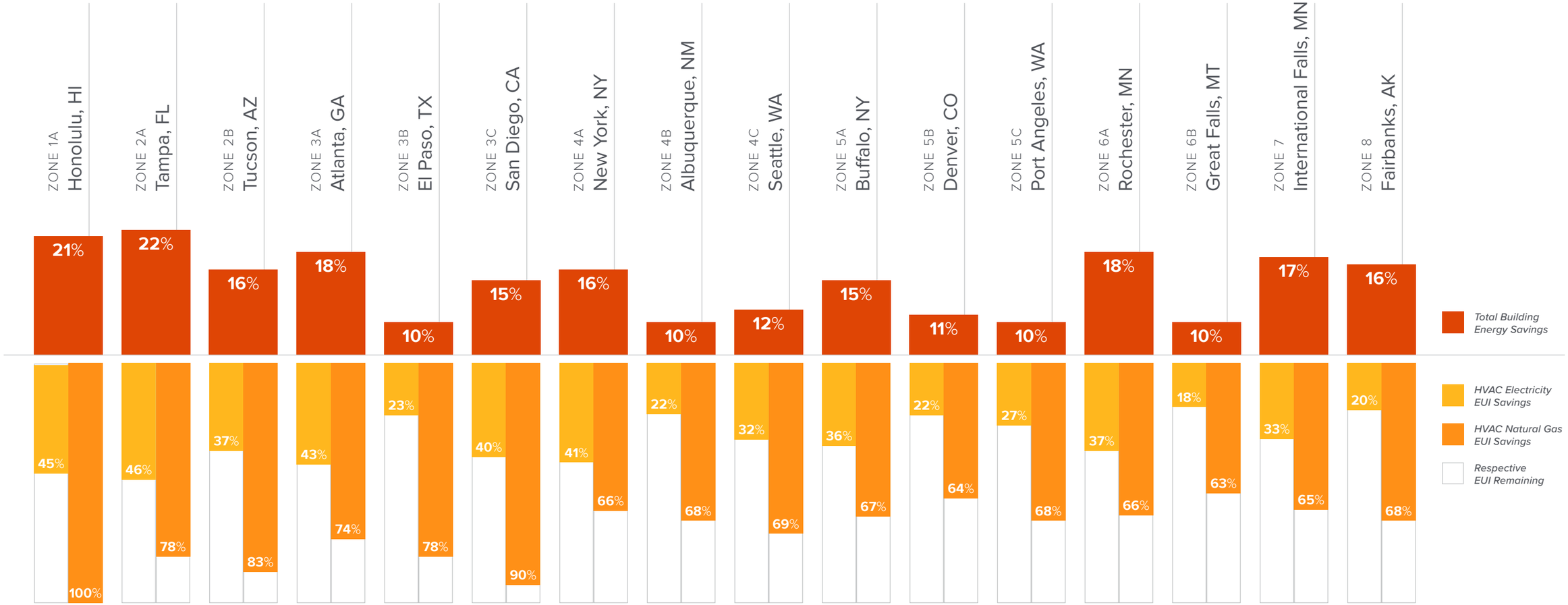
# 75F® Smart VAV With Reheat™

75F® Smart VAV with Reheat™ is a full-stack solution with components that include sensors connecting to 75F's AI for cloud analysis, a 75F® Central Control Unit™ (CCU) as a supervisor with built-in wall interface, 75F® Smart Node™ as terminal equipment controllers, third-party units with actuators or 75F Smart Dampers, and Facilisight, 75F's building intelligence suite of web and mobile apps for secure remote monitoring and control. VAV is an advantageous application for commercial buildings larger than 40,000 square feet with diverse loads or those that require simultaneous exterior heating and interior cooling during winter months. Where common air handling equipment may serve these zones today, VAV with Reheat allows a central RTU or AHU to serve multiple zones. This way, one duct run can provide air for ventilation and cooling while reheat can be used for zones that need heating. Where traditional VAV systems can be costly and inefficient, 75F has encapsulated newer ASHRAE-recommended advanced VAV control sequences. This application modernizes and acknowledges today's fully modulating RTUs and AHUs.

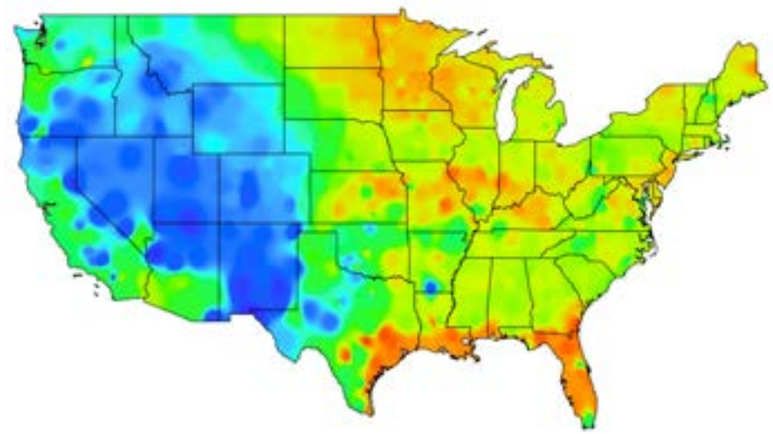
# 75F® Outside Air Optimization™

75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO data, though specific control strategy descriptions are available for all three.

- **OAO** reduces the required ventilation of outdoor air leveraging additional sensors and optimized setpoints.
- **OAO IM** cycles the fan to maintain minimum outdoor air ventilation. Applied in any building with constant-speed fans in the HVAC equipment that provides ventilation to occupants.
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.


ZONE 1A Honolulu, HI
21%
45%
100%
ZONE 2A Tampa, FL
22%
46%
78%
ZONE 2B Tucson, AZ
16%
37%
83%
ZONE 3A Atlanta, GA
18%
43%
74%
ZONE 3B El Paso, TX
10%
23%
78%
ZONE 3C San Diego, CA
15%
40%
90%
ZONE 4A New York, NY
16%
41%
66%
ZONE 4B Albuquerque, NM
10%
22%
68%
ZONE 4C Seattle, WA
12%
32%
69%
ZONE 5A Buffalo, NY
15%
36%
67%
ZONE 5B Denver, CO
11%
22%
64%
ZONE 5C Port Angeles, WA
10%
27%
68%
ZONE 6A Rochester, MN
18%
37%
66%
ZONE 6B Great Falls, MT
10%
18%
63%
ZONE 7 International Falls, MN
17%
33%
65%
ZONE 8 Fairbanks, AK
16%
20%
68%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

15% 20% 25%

ZONE 1A
### Honolulu, HI
45% 100%
**20.9%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
46% 78%
**21.71%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
37% 83%
**16.0%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
43% 74%
**18.3%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
23% 78%
**9.5%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
40% 90%
**14.7%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
41% 66%
**15.5%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
22% 68%
**9.9%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
32% 69%
**11.6%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
36% 67%
**15.3%** *Total Building Energy Savings*

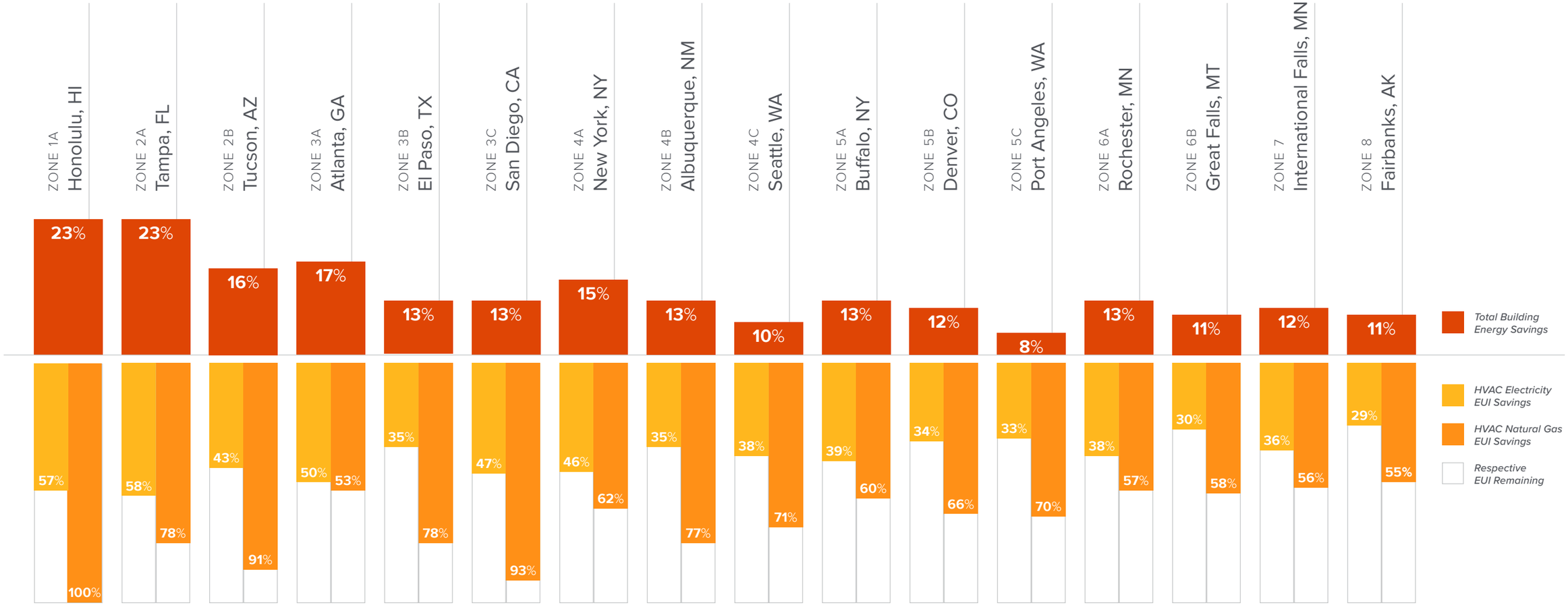
ZONE 5B
### Denver, CO
22% 64%
**10.8%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

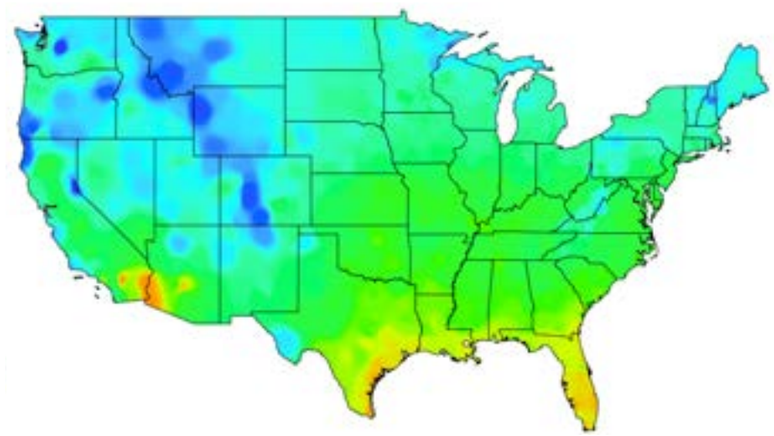
*HVAC Natural Gas EUI Savings*

# RESULTS | LARGE OFFICES, NEW CONSTRUCTION

◀ Methodology



## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

10% 15% 20% 25%

ZONE 1A
### Honolulu, HI
57% 100%
**23.1%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
58% 78%
**22.6%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
43% 91%
**16.4%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
50% 53%
**16.9%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
35% 78%
**12.7%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
47% 93%
**13.4%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
46% 62%
**15.0%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
35% 77%
**13.0%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
38% 71%
**10.3%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
39% 60%
**12.5%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
34% 66%
**12.0%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

# CONCLUSION

This analysis shows significant savings from combined applications Smart VAV With Reheat, Dynamic Chill Water Balancing, and Outside Air Optimization sequences in large offices, particularly in the eastern half of the U.S. for retrofit projects and the southern edge of the country for new construction. New construction large offices have the potential for greatest efficiency improvements in this report with savings of up to 23% total building energy use in representative cities, though retrofit buildings are a close second at 22%. While these high savings are typically located in the southern and eastern portions of the U.S., data in the Rocky Mountains area still hover between 10% and 15% in both vintages, and between 15% and 20% along the California coastline.

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NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

ENERGY SAVINGS

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*An analysis of the unique 75F IoT Building Management System in U.S. medium offices, both new construction and retrofit.*

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NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. medium offices, both retrofit and new construction. Studied 75F applications include Outside Air Optimization (OAO), and Smart VAV With Reheat.

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **28%** in retrofit mid-size offices
- **Total building** energy savings of up to **31%** for new construction mid-size offices
- Energy savings potential is **consistent** across the United States

# METHODOLOGY

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## MEDIUM OFFICES

Medium office building energy consumption is based on a three-story building with 53,600 square feet, a packaged air conditioning unit for cooling and a gas furnace inside the packaged air conditioning unit for heating. Distribution and terminal units include a VAV terminal box with damper and electric reheating coil.

RESULTS | **Medium Offices, Retrofit**

RESULTS | **Medium Offices, New Construction**

# 75F® Outside Air Optimization™

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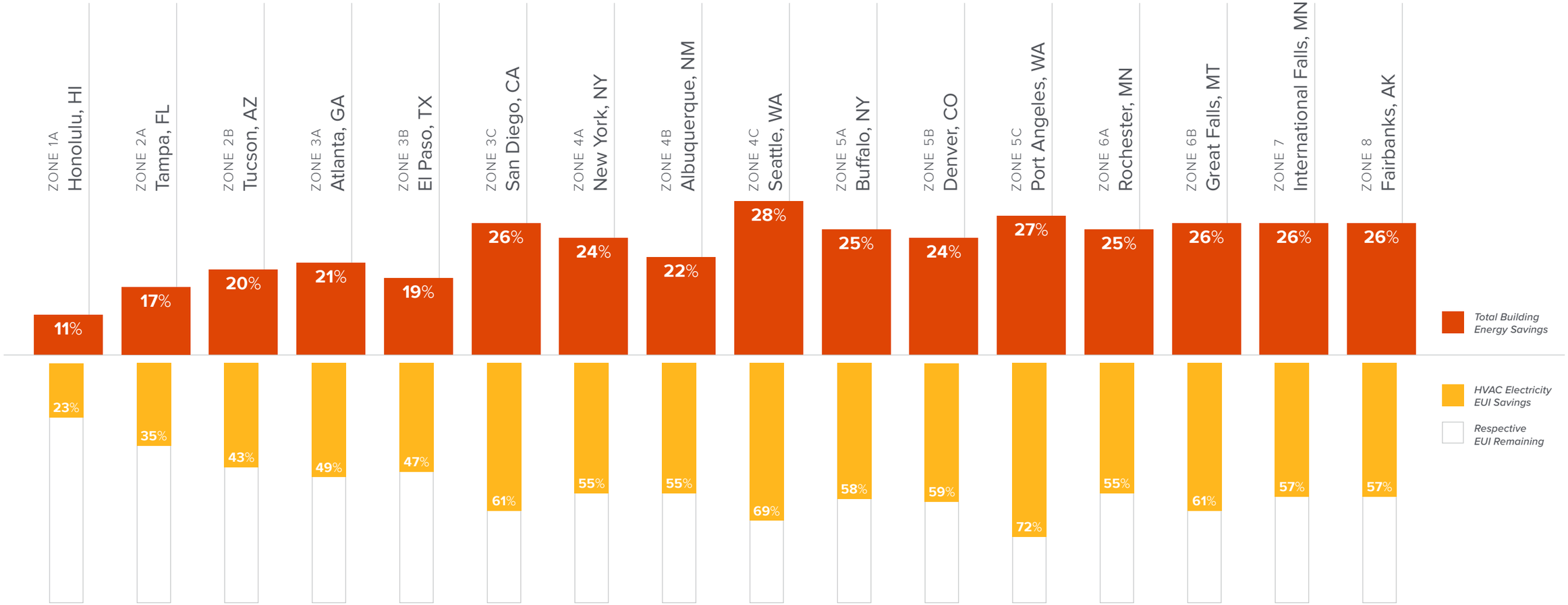
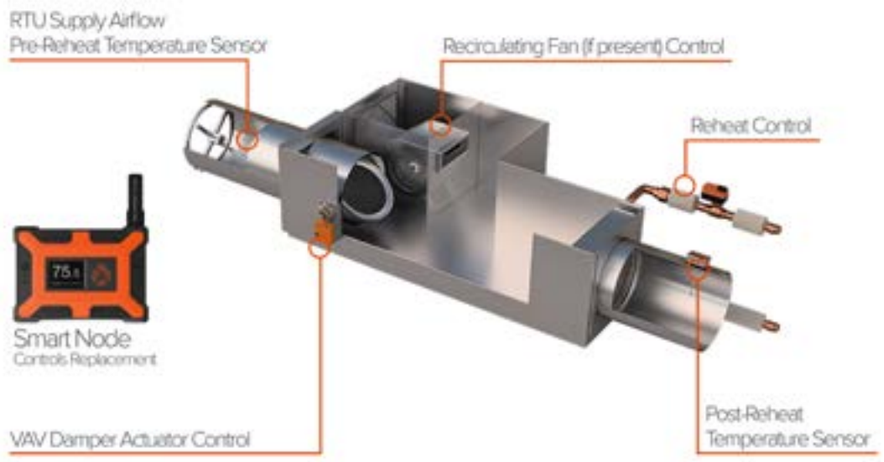
75F® Smart VAV with Reheat™ is a full-stack solution with components that include sensors connecting to 75F's AI for cloud analysis, a 75F® Central Control Unit™ (CCU) as a supervisor with built-in wall interface, 75F® Smart Node™ as terminal equipment controllers, third-party units with actuators or 75F Smart Dampers, and Facilisight, 75F's building intelligence suite of web and mobile apps for secure remote monitoring and control. VAV is an advantageous application for commercial buildings larger than 40,000 square feet with diverse loads or those that require simultaneous exterior heating and interior cooling during winter months. Where common air handling equipment may serve these zones today, VAV with Reheat allows a central RTU or AHU to serve multiple zones. This way, one duct run can provide air for ventilation and cooling while reheat can be used for zones that need heating. Where traditional VAV systems can be costly and inefficient, 75F has encapsulated newer ASHRAE-recommended advanced VAV control sequences. This application modernizes and acknowledges today's fully modulating RTUs and AHUs.




*In this application, natural gas EUI increases due to cost efficiency over electricity.

## 75F SMART VAV WITH REHEAT ILLUSTRATION




ZONE 1A
Honolulu, HI
23%
**11.0%**
*Total Building Energy Savings*

ZONE 2A
Tampa, FL
35%
**17.3%**
*Total Building Energy Savings*

43%
**20.1%**
*Total Building Energy Savings*

*HVAC Electricity EUI Savings*

ZONE 3A
Atlanta, GA
49%
**20.8%**
*Total Building Energy Savings*

ZONE 3B
El Paso, TX
47%
**18.8%**
*Total Building Energy Savings*

ZONE 3C
San Diego, CA
61%
**26.0%**
*Total Building Energy Savings*

ZONE 4A
New York, NY
55%
**24.2%**
*Total Building Energy Savings*

ZONE 4B
Albuquerque, NM
55%
**22.5%**
*Total Building Energy Savings*

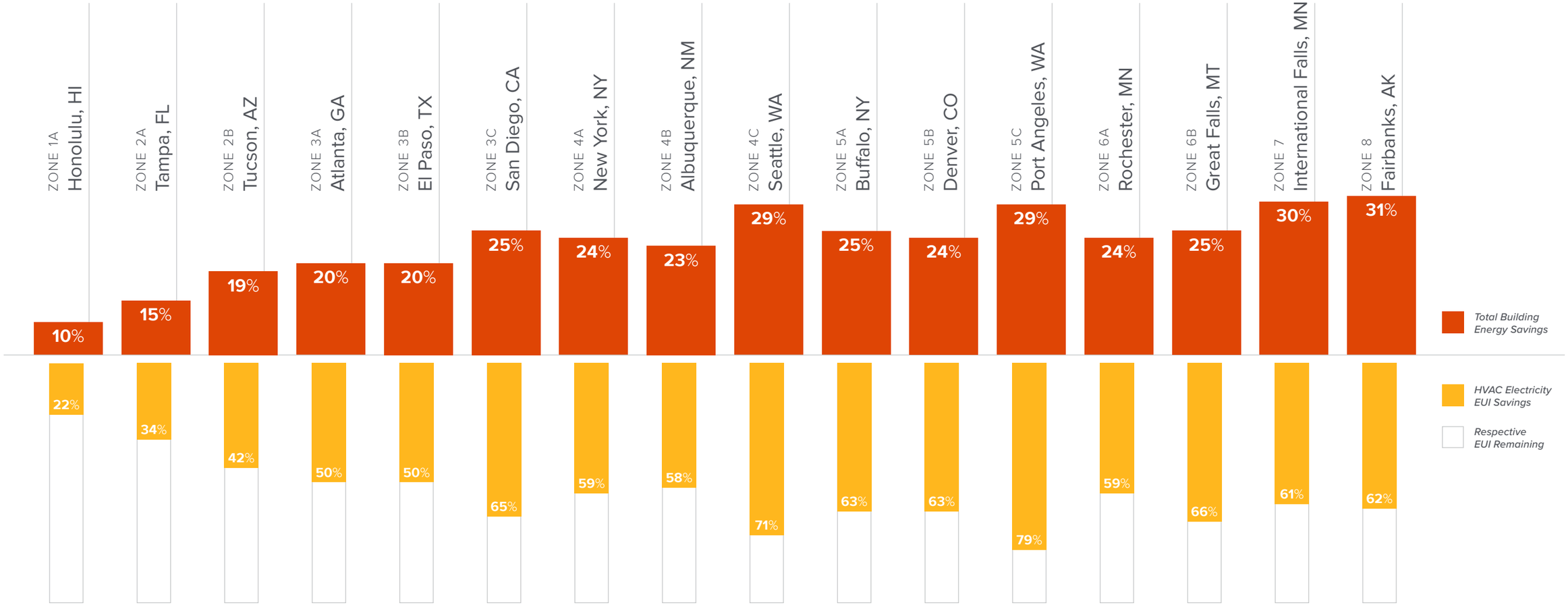
ZONE 4C
Seatlle, WA
69%
**28.5%**
*Total Building Energy Savings*

ZONE 5A
Buffalo, NY
58%
**24.5%**
*Total Building Energy Savings*

ZONE 5B
Denver, CO
59%
**23.8%**
*Total Building Energy Savings*

# RESULTS | MEDIUM OFFICES, NEW CONSTRUCTION

◀ Methodology

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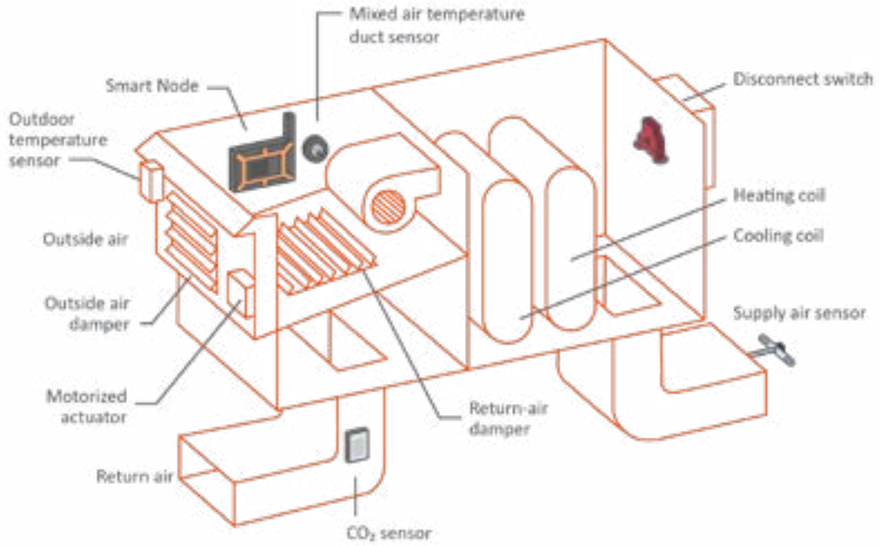
75F OUTSIDE AIR OPTIMIZATION ILLUSTRATION




ZONE 1A
Honolulu, HI

22%

**9.9%**
*Total Building Energy Savings*

ZONE 2A
Tampa, FL

34%

**15.4%**
*Total Building Energy Savings*

ZONE 2B
Tucson, AZ

42%

**18.9%**
*Total Building Energy Savings*

*HVAC Electricity EUI Savings*

ZONE 3A
Atlanta, GA

50%

**20.4%**
*Total Building Energy Savings*

ZONE 3B
El Paso, TX

50%

**20.0%**
*Total Building Energy Savings*

ZONE 3C
San Diego, CA

65%

**24.7%**
*Total Building Energy Savings*

ZONE 4A
New York, NY

59%

**23.6%**
*Total Building Energy Savings*

ZONE 4B
Albuquerque, NM

58%

**22.5%**
*Total Building Energy Savings*

ZONE 4C
Seatlle, WA

71%

**29.5%**
*Total Building Energy Savings*

ZONE 5A
Buffalo, NY

63%

**24.5%**
*Total Building Energy Savings*

ZONE 5B
Denver, CO

63%

**23.5%**
*Total Building Energy Savings*

## CONCLUSION

This analysis shows significant savings from combined applications 75F® Smart VAV With Reheat and 75F® Outside Air Optimization sequences in medium-sized offices, with energy reduction potential across the United States. New construction medium offices have the potential for greatest efficiency improvements in this report with savings of up to 31% total building energy use in representative cities, though retrofit buildings are a close second at 28%. While these high savings are typically located in colder climates such as Minnesota and Alaska, data in warmer climates such as California and Arizona range between 17% and 26% for both retrofits and new construction. In this application, savings stem from reductions in electricity EUI and an increase in natural gas EUI where cost efficiency makes sense.

NREL NATIONAL RENEWABLE ENERGY LABORATORY | 75F | COMFORT SYSTEMS USA

ENERGY SAVINGS

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NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. small offices, both retrofit and new construction. Studied 75F applications include Dynamic Airflow Balancing and Outside Air Optimization (OAO).

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- **Total building** energy savings of up to **23%** in retrofit small offices
- **Total building** energy savings of up to **26%** for new construction small offices
- Energy savings potential is **even across the U.S.**, with the **central and southwestern** portions of the country seeing the highest savings

# METHODOLOGY

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## SMALL OFFICES

Small office building energy consumption is based on a one-story building with 5,500 square feet, an air-source heat pump for cooling and an air-source heat pump with gas furnace as backup for heating. Distribution and terminal units include single-zone, constant air volume air distribution, with one unit per occupied thermal zone.

RESULTS | **Small Offices, Retrofit**

RESULTS | **Small Offices, New Construction**

# 75F® Dynamic Airflow Balancing™

75F® Dynamic Airflow Balancing™ is a proactive zone control system that remotely monitors and controls conditions in individual spaces for superior comfort and efficiency. Predictive machine learning algorithms optimize heating and cooling capacity by redirecting conditioned air to the spaces that need it most, a strategy that multiple third-party, independent tests like the NREL study prove can lower utility cost significantly. Beyond efficiency, the Dynamic Airflow Balancing design is fine grained, so every space gets its own individual temperature control. With these tools, building engineers who implement 75F's Dynamic Airflow Balancing technology can expect vastly improved energy efficiency, occupant comfort, and productivity. These advantages are accessible to a wide variety of commercial buildings thanks to a full-stack solution that works out of the box, scalability across a range of central plant equipment and site footprins, and intuitive and user-friendly tuners like zone prioritization for hassle-free operation. 75F Dynamic Airflow Balancing is ideally suited for multizone airhandling units and packaged rooftop units where zone reheat is not available.

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75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO data, though specific control strategy descriptions are available for all three.

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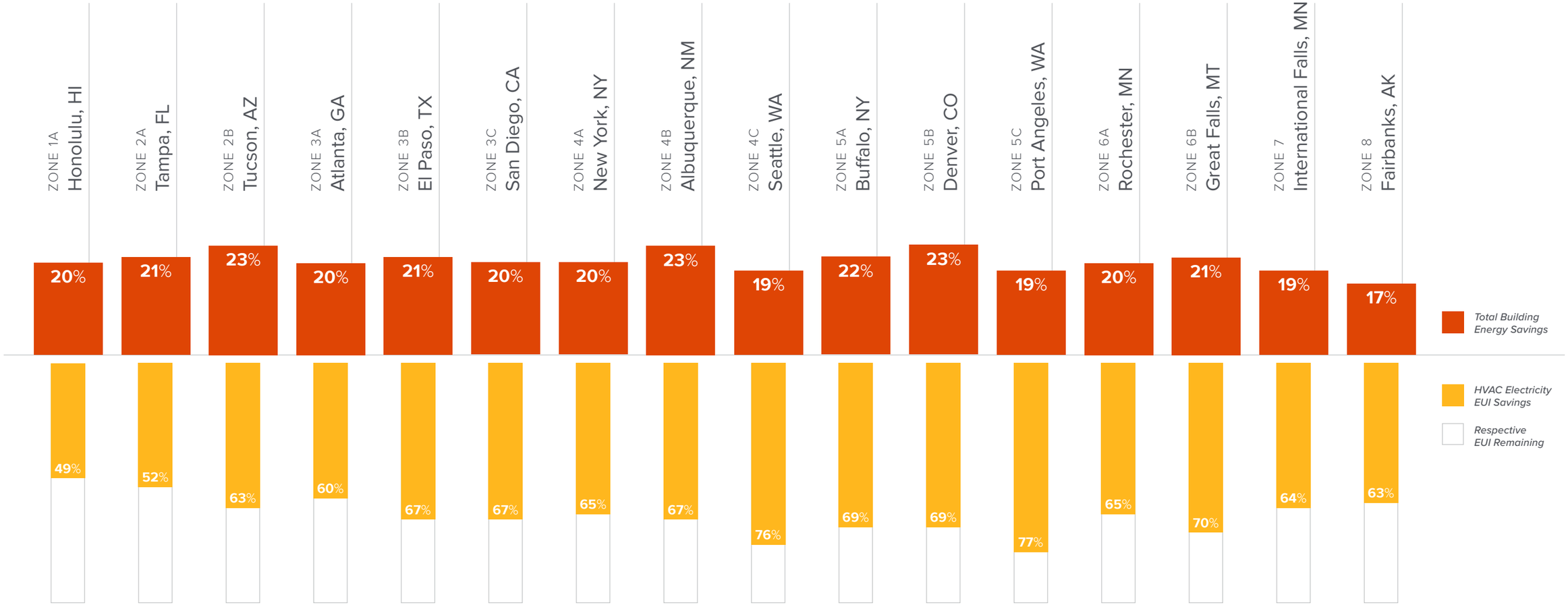
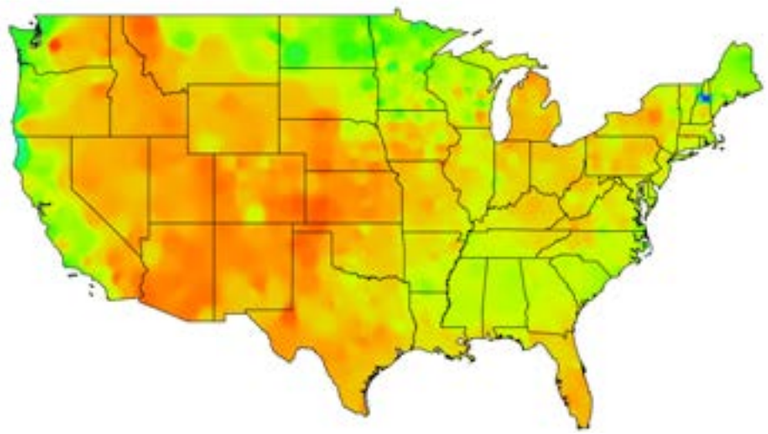



*In this application, natural gas EUI increases due to cost efficiency over electricity.

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

12% 16% 20%

*HVAC Electricity EUI Savings*

ZONE 1A
Honolulu, HI
49%
**20.3%** *Total Building Energy Savings*

ZONE 2A
Tampa, FL
52%
**20.6%** *Total Building Energy Savings*

ZONE 2B
Tucson, AZ
63%
**22.5%** *Total Building Energy Savings*

ZONE 3A
Atlanta, GA
60%
**19.5%** *Total Building Energy Savings*

ZONE 3B
El Paso, TX
67%
**21.0%** *Total Building Energy Savings*

ZONE 3C
San Diego, CA
67%
**19.6%** *Total Building Energy Savings*

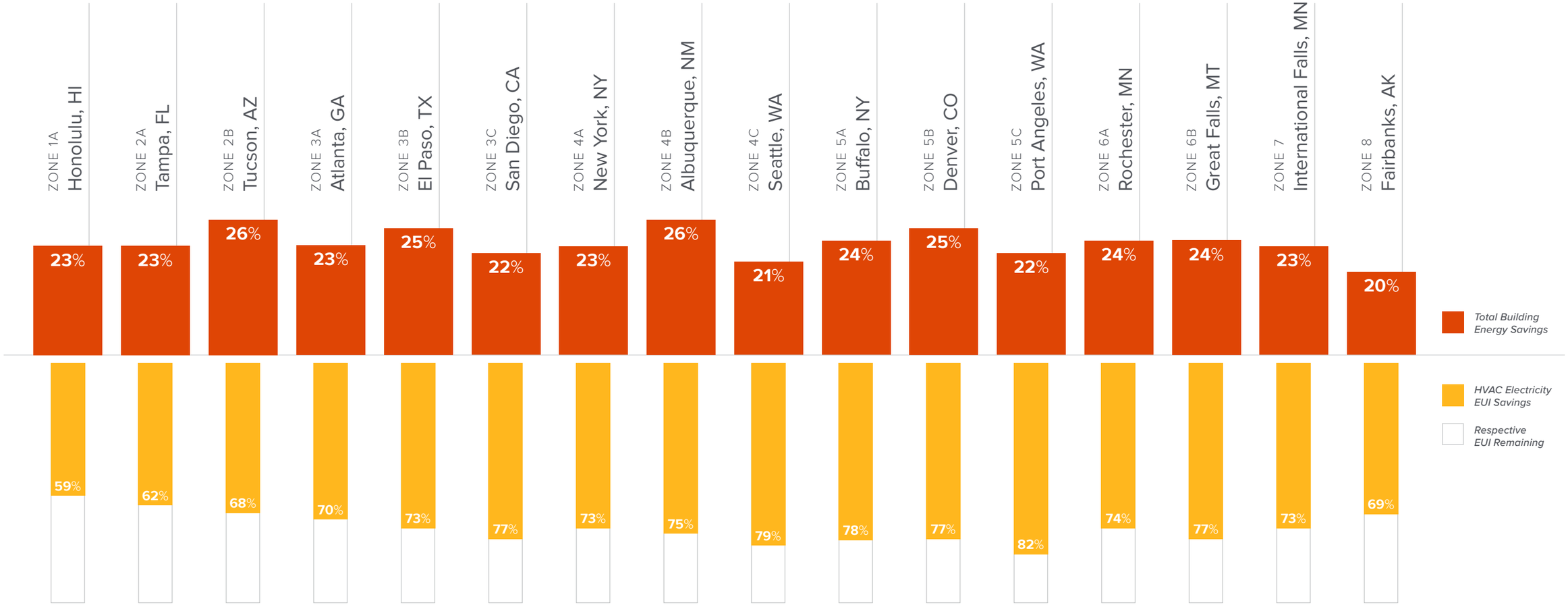
ZONE 4A
New York, NY
65%
**20.1%** *Total Building Energy Savings*

ZONE 4B
Albuquerque, NM
67%
**22.6%** *Total Building Energy Savings*

ZONE 4C
Seatlle, WA
76%
**19.4%** *Total Building Energy Savings*

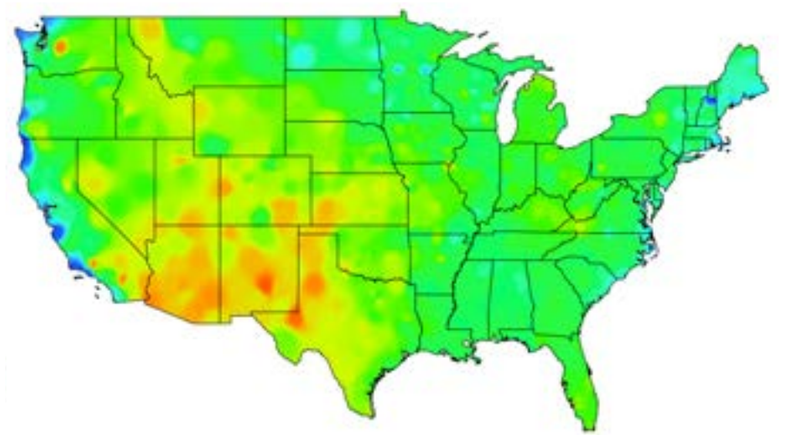
ZONE 5A
Buffalo, NY
69%
**21.7%** *Total Building Energy Savings*

ZONE 5B
Denver, CO
69%
**22.8%** *Total Building Energy Savings*




*In this application, natural gas EUI increases due to cost efficiency over electricity.

## ANNUAL SAVINGS BY CLIMATE ZONE




HVAC Electricity EUI Savings

ZONE 1A
**Honolulu, HI**
59%
**22.6%** *Total Building Energy Savings*

ZONE 2A
**Tampa, FL**
62%
**22.9%** *Total Building Energy Savings*

ZONE 2B
**Tucson, AZ**
68%
**25.8%** *Total Building Energy Savings*

ZONE 3A
**Atlanta, GA**
70%
**23.2%** *Total Building Energy Savings*

ZONE 3B
**El Paso, TX**
73%
**25.5%** *Total Building Energy Savings*

ZONE 3C
**San Diego, CA**
77%
**21.7%** *Total Building Energy Savings*

ZONE 4A
**New York, NY**
73%
**23.0%** *Total Building Energy Savings*

ZONE 4B
**Albuquerque, NM**
75%
**26.0%** *Total Building Energy Savings*

ZONE 4C
**Seatlle, WA**
79%
**20.7%** *Total Building Energy Savings*

ZONE 5A
**Buffalo, NY**
78%
**24.5%** *Total Building Energy Savings*

ZONE 5B
**Denver, CO**
77%
**25.5%** *Total Building Energy Savings*

## CONCLUSION

This analysis shows significant savings from combined applications Dynamic Airflow Balancing and Outside Air Optimization sequences in small offices, particularly in the central and western portions of the U.S. for retrofit projects and the southwest of the U.S. for new construction. New construction large offices have the potential for greatest efficiency improvements in this report with savings of up to 26% total building energy use in representative cities, though retrofit buildings are a close second at 23%. While the highest savings are typically located in the midwest and southwestern portions of the U.S., no particular climate zone demonstrates total building savings below an 18% range in new build scenarios and a 12% range for retrofits. Most circumstances lead to overall savings between 19% and 23%.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F® IoT-based Building Management System in U.S. large hotels, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F®

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. large hotels, both retrofit and new construction. Studied 75F applications include Dynamic Chill Water Balancing (DCWB) and Outside Air Optimization (OAO).

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **26%** in retrofit large hotels
- **Total building** energy savings of up to **20%** for new construction large hotels
- Savings potential is **even across the country**, with highest savings on the west coast and southern U.S.

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The hotels analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## LARGE HOTELS

Large hotel HVAC energy consumption is based on a 122,132 square-foot building with six floors above ground and a basement. It includes one gas-fired boiler for heating and one air-cooled chiller for cooling. Distribution and terminal units include VAV with hot water reheating coils for public spaces on the ground and top floors, and a dedicated outside air system (DOAS) and four-pipe fan coil units for the guest rooms.

RESULTS | **Large Hotels, Retrofit**

RESULTS | **Large Hotels, New Construction**

# 75F® Dynamic Chill Water Balancing™

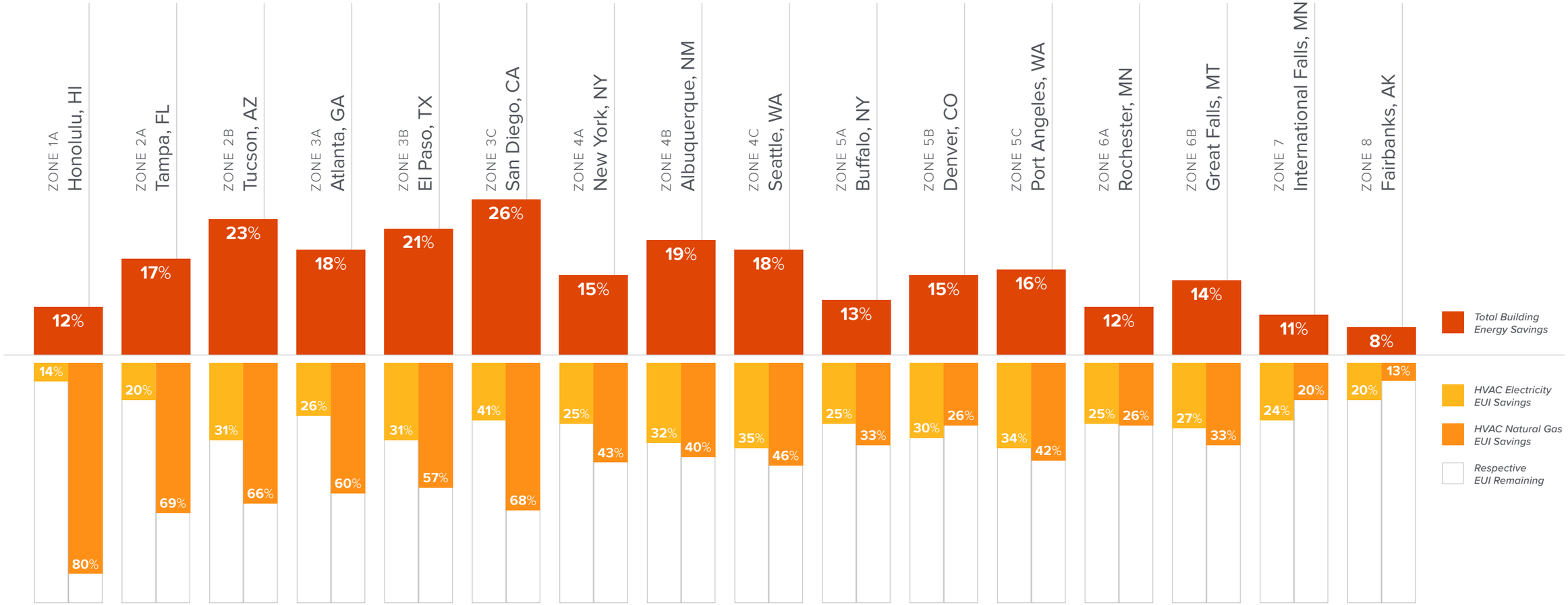
75F Dynamic Chilled Water Balancing is an end-to-end solution for chilled water systems. 75F sensors in each zone gather millions of data points daily and communicate these points via a 900 MHz wireless mesh network to the 75F® Central Control Unit™ — giving users the ability to monitor the inlet and outlet temperatures, chilled water flow rates, and BTU energy consumption across the line. 75F's system understands, analyzes, and optimizes the overall performance of the HVAC system under various conditions, thereby driving significant energy savings at an AHU level and at the chiller plant.

75F designs and manufactures the world's leading IoT-based Building Management System, an out-of-the-box, vertically integrated solution that is more affordable and easier to deploy than anything on the market today. The company leverages IoT, Cloud Computing and Machine Learning for data-driven, proactive building intelligence and controls for HVAC and lighting optimization. Investors include some of the biggest names in energy and technology. 75F's mission is to improve occupant productivity through enhanced comfort and indoor air quality — all while saving energy.

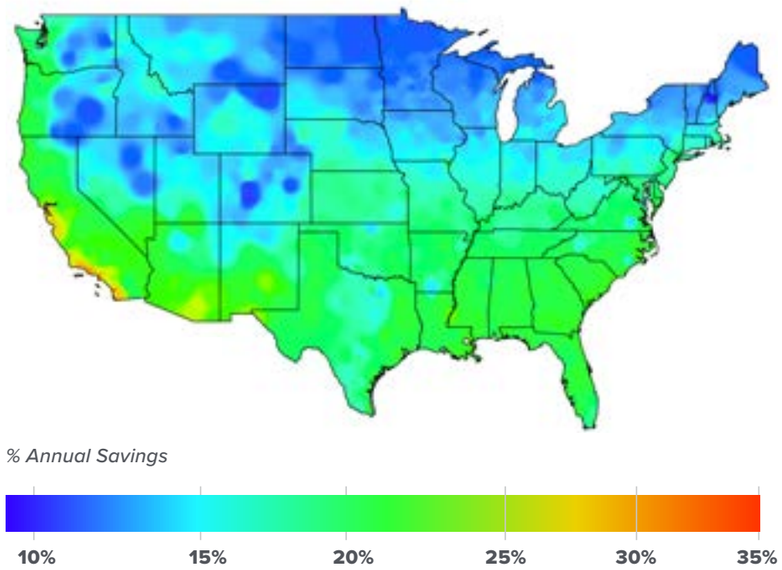
# 75F® Outside Air Optimization™

75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO data, though specific control strategy descriptions are available for all three.

- **OAO** reduces the required ventilation of outdoor air leveraging additional sensors and optimized setpoints.
- **OAO IM** cycles the fan to maintain minimum outdoor air ventilation. Applied in any building with constant-speed fans in the HVAC equipment that provides ventilation to occupants.
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.


ZONE 1A Honolulu, HI
12%
14%
80%
ZONE 2A Tampa, FL
17%
20%
69%
ZONE 2B Tucson, AZ
23%
31%
66%
ZONE 3A Atlanta, GA
18%
26%
60%
ZONE 3B El Paso, TX
21%
31%
57%
ZONE 3C San Diego, CA
26%
41%
68%
ZONE 4A New York, NY
15%
25%
43%
ZONE 4B Albuquerque, NM
19%
32%
40%
ZONE 4C Seattle, WA
18%
35%
46%
ZONE 5A Buffalo, NY
13%
25%
33%
ZONE 5B Denver, CO
15%
30%
26%
ZONE 5C Port Angeles, WA
16%
34%
42%
ZONE 6A Rochester, MN
12%
25%
26%
ZONE 6B Great Falls, MT
14%
27%
33%
ZONE 7 International Falls, MN
11%
24%
20%
ZONE 8 Fairbanks, AK
8%
20%
13%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE




ZONE 1A
### Honolulu, HI
14% | 80%
**12.0%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
20% | 69%
**16.8%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
31% | 66%
**23.2%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
26% | 60%
**18.1%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
31% | 57%
**21.2%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
41% | 68%
**26.1%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
25% | 43%
**15.1%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
32% | 40%
**18.5%** *Total Building Energy Savings*

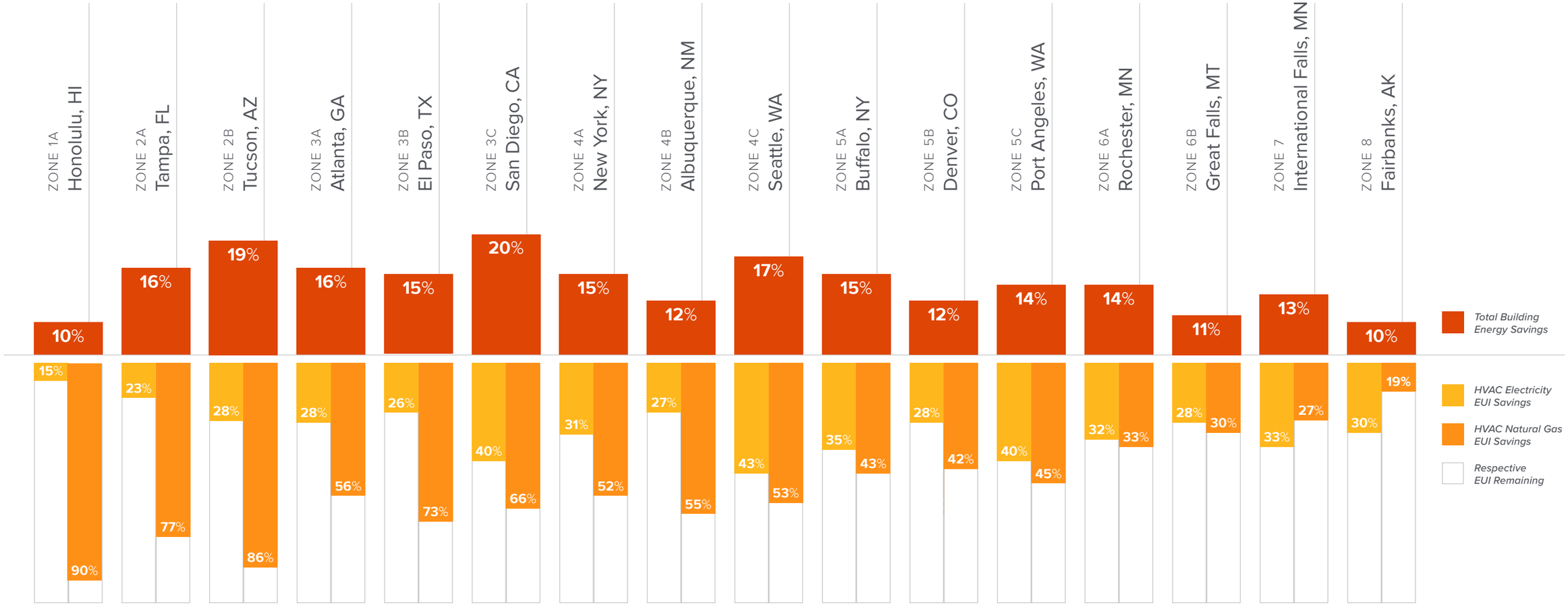
ZONE 4C
### Seatlle, WA
35% | 46%
**18.0%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
25% | 33%
**13.2%** *Total Building Energy Savings*

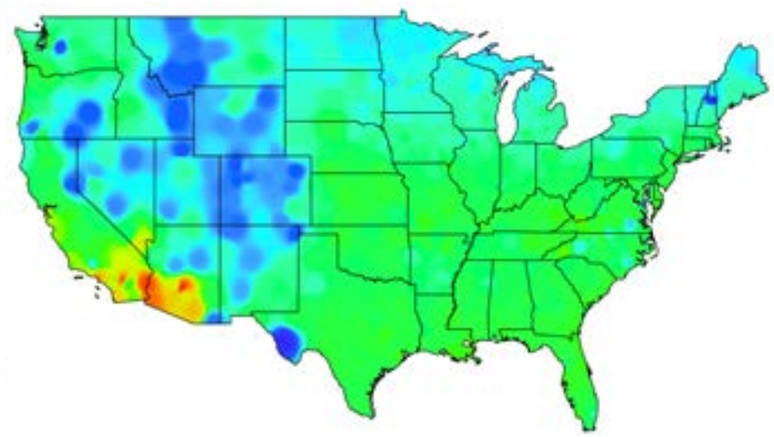
ZONE 5B
### Denver, CO
30% | 26%
**14.6%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*


ZONE 1A Honolulu, HI
10%
15%
90%
ZONE 2A Tampa, FL
16%
23%
77%
ZONE 2B Tucson, AZ
19%
28%
86%
ZONE 3A Atlanta, GA
16%
28%
56%
ZONE 3B El Paso, TX
15%
26%
73%
ZONE 3C San Diego, CA
20%
40%
66%
ZONE 4A New York, NY
15%
31%
52%
ZONE 4B Albuquerque, NM
12%
27%
55%
ZONE 4C Seattle, WA
17%
43%
53%
ZONE 5A Buffalo, NY
15%
35%
43%
ZONE 5B Denver, CO
12%
28%
42%
ZONE 5C Port Angeles, WA
14%
40%
45%
ZONE 6A Rochester, MN
14%
32%
33%
ZONE 6B Great Falls, MT
11%
28%
30%
ZONE 7 International Falls, MN
13%
33%
27%
ZONE 8 Fairbanks, AK
10%
30%
19%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

10% 15% 20% 25%

ZONE 1A
### Honolulu, HI
15% 90%
**10.3%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
23% 77%
**16.0%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
28% 86%
**19.4%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
28% 56%
**15.7%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
26% 73%
**15.1%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
40% 66%
**20.2%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
31% 52%
**15.3%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
27% 55%
**12.3%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
43% 53%
**17.0%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
35% 43%
**14.8%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
28% 42%
**11.7%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

## CONCLUSION

This analysis shows significant savings from 75F® Outside Air Optimization™ and 75F® Dynamic Chill Water Balancing™ sequences in large hotels, particularly on the west coast and the southern half of the country. Retrofit large hotels have the potential for greatest efficiency improvements in this report with savings of up to 26% total building energy use in representative cities compared to 20% in new build use cases. These higher numbers are typically found in the aforementioned areas, though new construction buildings also see strong energy savings in the northeast comparatively. Where energy savings are lowest in the Rocky Mountains area for new builds and the Midwest for retrofits, total building energy savings still tend to be in the 10% range.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F IoT Building Management System in U.S. mid-rise apartments, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F®

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. mid-rise apartments, both retrofit and new construction. The studied 75F application is Outside Air Optimization (OAO).

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **17%** in retrofit mid-rise apartments
- **Total building** energy savings of up to **15%** for new construction mid-rise apartments
- Energy savings potential is **even across the U.S.**, with the **northern and western** portions of the country seeing the highest savings

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The apartments analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## MID-RISE APARTMENTS

Mid-rise apartment building energy consumption is based on a four-story building with 33,700 square feet, a gas furnace for heating, and one split system DX per apartment for cooling. Distribution and terminal units are constant volume.

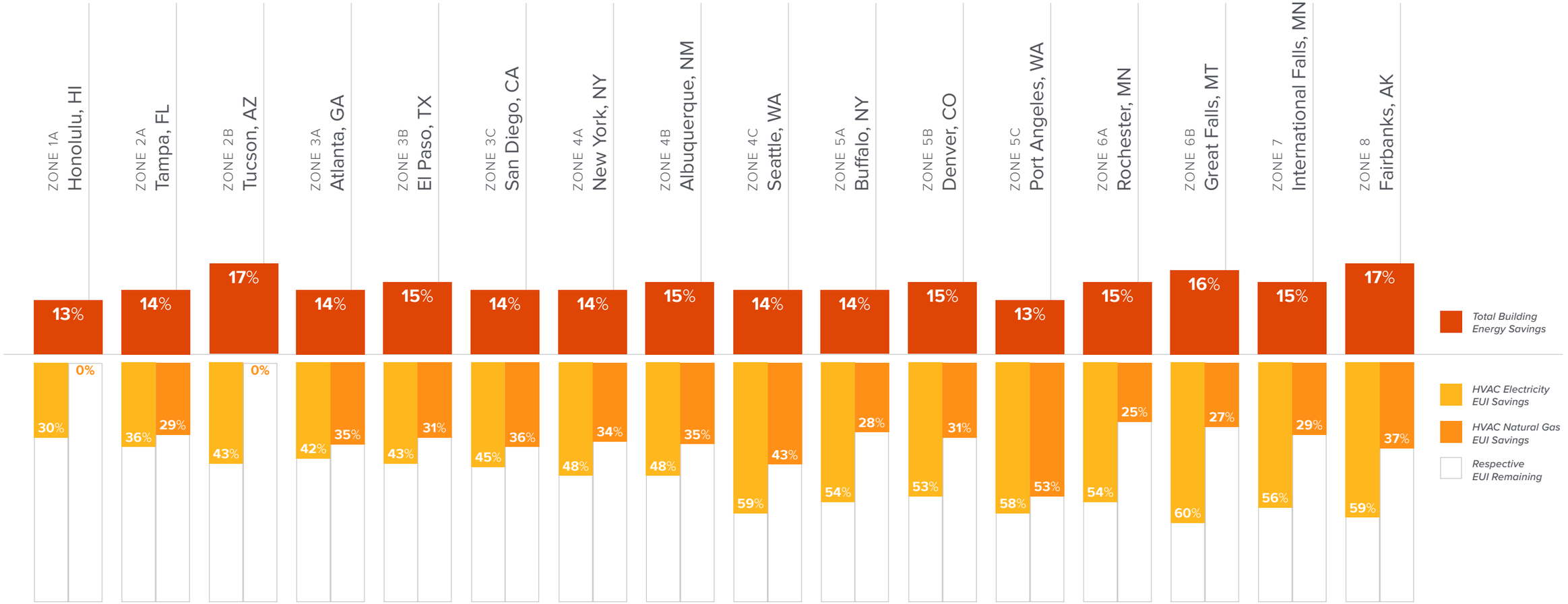
RESULTS | **Mid-rise Apartments, Retrofit**

RESULTS | **Mid-rise Apartments, New Construction**

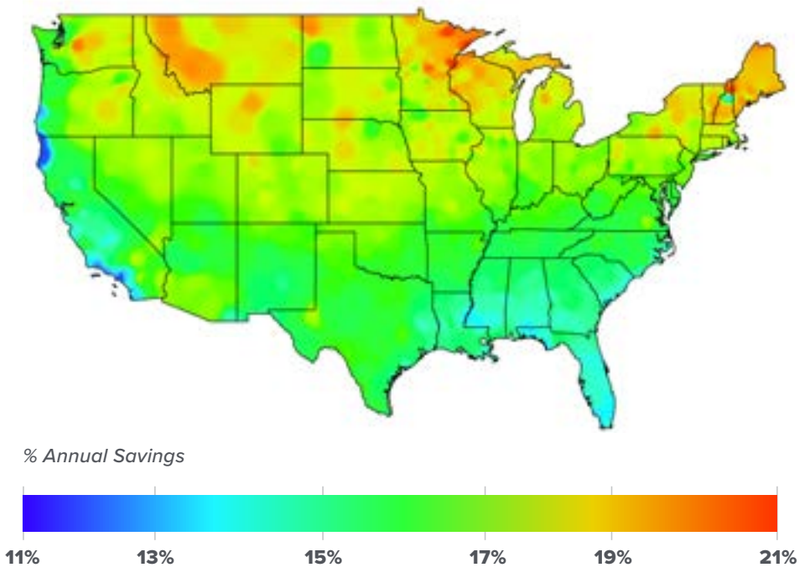
# 75F® Outside Air Optimization™

75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO IM data, though specific control strategy descriptions are available for all three.

- **OAO** reduces required ventilation of outdoor air leveraging additional sensors and optimized setpoints, and provides comparative enthalpy free cooling.
- **OAO IM** cycles the fan to maintain minimum outdoor air ventilation. Applied in any building with constant-speed fans in the HVAC equipment that provides ventilation to occupants.
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.


ZONE 1A Honolulu, HI
13%
30%
0%
ZONE 2A Tampa, FL
14%
36%
29%
ZONE 2B Tucson, AZ
17%
43%
0%
ZONE 3A Atlanta, GA
14%
42%
35%
ZONE 3B El Paso, TX
15%
43%
31%
ZONE 3C San Diego, CA
14%
45%
36%
ZONE 4A New York, NY
14%
48%
34%
ZONE 4B Albuquerque, NM
15%
48%
35%
ZONE 4C Seattle, WA
14%
59%
43%
ZONE 5A Buffalo, NY
14%
54%
28%
ZONE 5B Denver, CO
15%
53%
31%
ZONE 5C Port Angeles, WA
13%
58%
53%
ZONE 6A Rochester, MN
15%
54%
25%
ZONE 6B Great Falls, MT
16%
60%
27%
ZONE 7 International Falls, MN
15%
56%
29%
ZONE 8 Fairbanks, AK
17%
59%
37%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

ANNUAL SAVINGS BY CLIMATE ZONE




ZONE 1A
Honolulu, HI

30% 0%

**12.6%**
*Total Building Energy Savings*

ZONE 2A
Tampa, FL

36% 29%

**14.3%**
*Total Building Energy Savings*

ZONE 2B
Tucson, AZ

43% 0%

**17.4%**
*Total Building Energy Savings*

ZONE 3A
Atlanta, GA

42% 35%

**14.0%**
*Total Building Energy Savings*

ZONE 3B
El Paso, TX

43% 31%

**14.9%**
*Total Building Energy Savings*

ZONE 3C
San Diego, CA

45% 36%

**13.7%**
*Total Building Energy Savings*

ZONE 4A
New York, NY

48% 34%

**14.4%**
*Total Building Energy Savings*

ZONE 4B
Albuquerque, NM

48% 35%

**14.7%**
*Total Building Energy Savings*

ZONE 4C
Seatlle, WA

59% 43%

**14.0%**
*Total Building Energy Savings*

ZONE 5A
Buffalo, NY

54% 28%

**14.1%**
*Total Building Energy Savings*

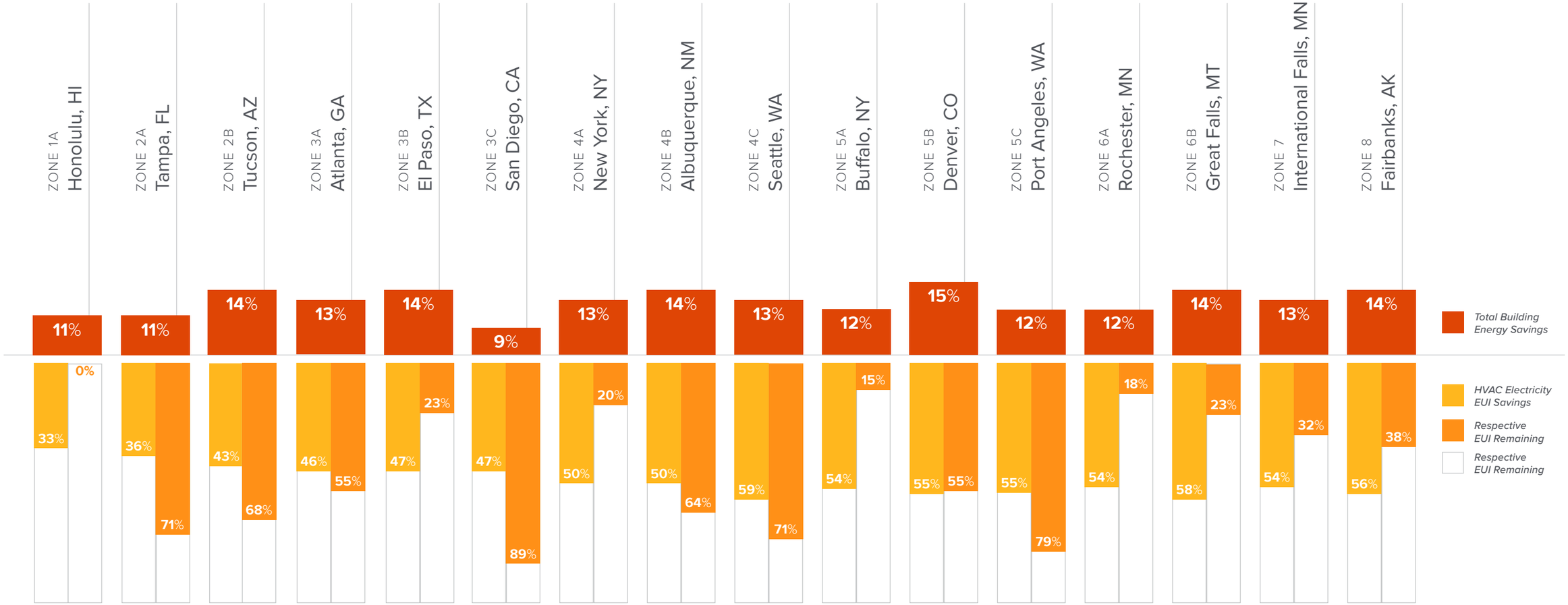
ZONE 5B
Denver, CO

53% 31%

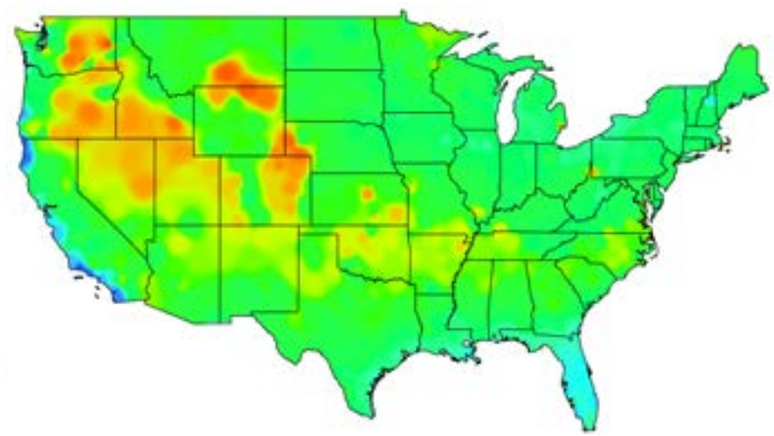
**15.3%**
*Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*


ZONE 1A Honolulu, HI
11%
33%
0%
ZONE 2A Tampa, FL
11%
36%
71%
ZONE 2B Tucson, AZ
14%
43%
68%
ZONE 3A Atlanta, GA
13%
46%
55%
ZONE 3B El Paso, TX
14%
47%
23%
ZONE 3C San Diego, CA
9%
47%
89%
ZONE 4A New York, NY
13%
50%
20%
ZONE 4B Albuquerque, NM
14%
50%
64%
ZONE 4C Seattle, WA
13%
59%
71%
ZONE 5A Buffalo, NY
12%
54%
15%
ZONE 5B Denver, CO
15%
55%
55%
ZONE 5C Port Angeles, WA
12%
55%
79%
ZONE 6A Rochester, MN
12%
54%
18%
ZONE 6B Great Falls, MT
14%
58%
23%
ZONE 7 International Falls, MN
13%
54%
32%
ZONE 8 Fairbanks, AK
14%
56%
38%
Total Building Energy Savings
HVAC Electricity EUI Savings
Respective EUI Remaining
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

8% 12% 16% 20%

*HVAC Electricity EUI Savings*

ZONE 1A
### Honolulu, HI
33% 0%
**11.1%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
36% 71%
**10.9%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
43% 68%
**13.8%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
46% 55%
**12.6%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
47% 23%
**13.7%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
47% 89%
**9.1%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
50% 20%
**13.0%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
50% 64%
**14.0%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
59% 71%
**13.0%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
54% 15%
**12.0%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
55% 55%
**14.5%** *Total Building Energy Savings*

## CONCLUSION

This analysis shows significant savings from Outside Air Optimization sequences in mid-rise apartment buildings, particularly in the northern portions of the U.S. for retrofit projects and the western and northwestern areas for new construction. Retrofit mid-rise apartments have the potential for greatest efficiency improvements in this report with savings of up to 17% total building energy use in representative cities, though retrofit buildings are a close second at 15%. While the highest savings are typically located in the midwest and western portions of the U.S., no particular climate zone demonstrates total building savings below an 8% range in new build scenarios and a 11% range for retrofits. Most circumstances lead to overall savings between 13% and 15%.

NREL NATIONAL RENEWABLE ENERGY LABORATORY | 75F | COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F® IoT-based Building Management System in U.S. outpatient healthcare facilities, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F®

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. outpatient healthcare facilities, both retrofit and new construction. Studied 75F applications include Smart VAV With Reheat and Outside Air Optimization (OAO).

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **21%** in retrofit outpatient healthcare facilities
- **Total building** energy savings of up to **19%** for new construction outpatient healthcare facilities

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The outpatient healthcare facilities analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## OUTPATIENT HEALTHCARE

Outpatient healthcare facility HVAC energy consumption is based on a 40,950 square-foot building with three floors. It includes a gas boiler for heating and a DX cooling coil for cooling. Distribution and terminal units include VAV terminal box with damper, hot water reheating coil, and electric resistance reheat in AHU-2.

RESULTS | **Outpatient Healthcare, Retrofit**

RESULTS | **Outpatient Healthcare, New Construction**

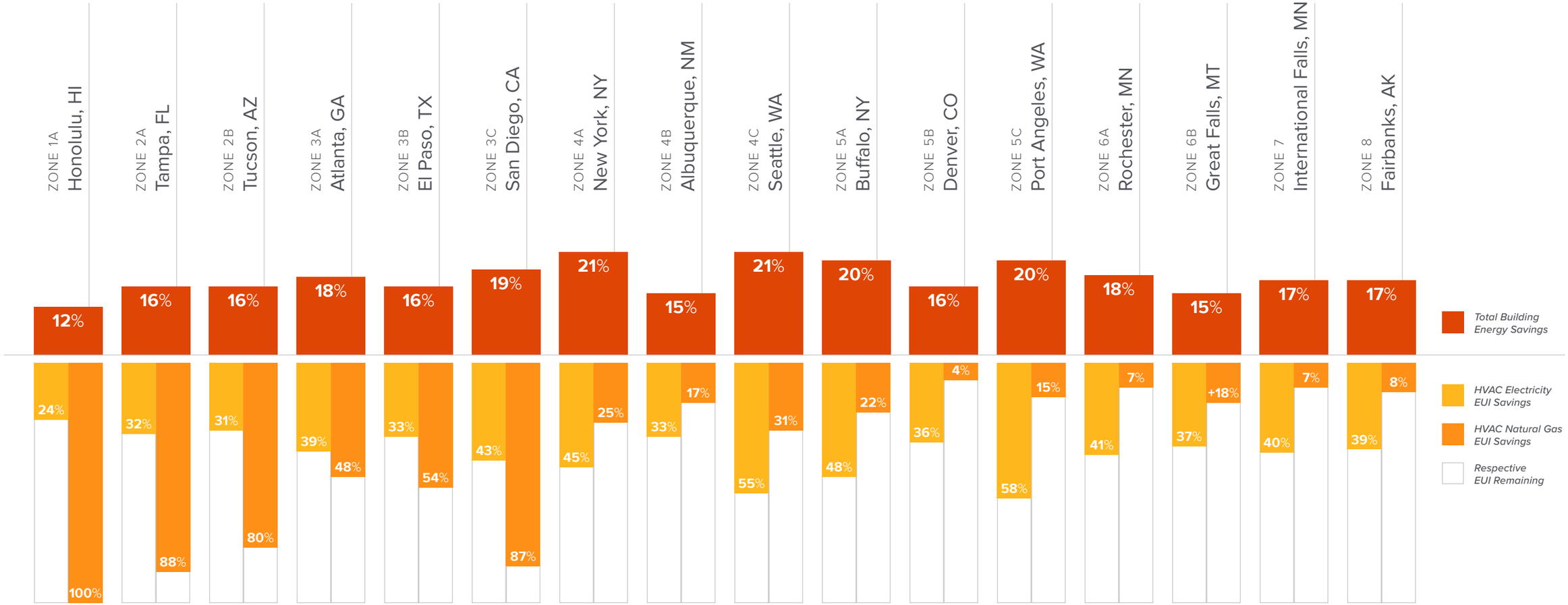
# 75F® Smart VAV With Reheat™

75F® Smart VAV with Reheat™ is a full-stack solution with components that include sensors connecting to 75F's AI for cloud analysis, a 75F® Central Control Unit™ (CCU) as a supervisor with built-in wall interface, 75F® Smart Node™ as terminal equipment controllers, third-party units with actuators or 75F Smart Dampers, and Facilisight, 75F's building intelligence suite of web and mobile apps for secure remote monitoring and control. VAV is an advantageous application for commercial buildings larger than 40,000 square feet with diverse loads or those that require simultaneous exterior heating and interior cooling during winter months. Where common air handling equipment may serve these zones today, VAV with Reheat allows a central RTU or AHU to serve multiple zones. This way, one duct run can provide air for ventilation and cooling while reheat can be used for zones that need heating. Where traditional VAV systems can be costly and inefficient, 75F has encapsulated newer ASHRAE-recommended advanced VAV control sequences. This application modernizes and acknowledges today's fully modulating RTUs and AHUs.

# 75F® Outside Air Optimization™

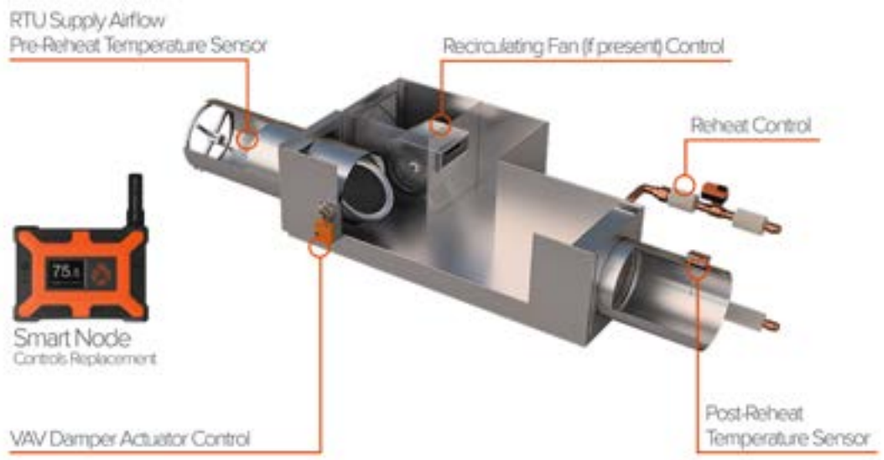
75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO data, though specific control strategy descriptions are available for all three.

- **OAO** reduces the required ventilation of outdoor air leveraging additional sensors and optimized setpoints.
- **OAO IM** cycles the fan to maintain minimum outdoor air ventilation. Applied in any building with constant-speed fans in the HVAC equipment that provides ventilation to occupants.
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.




*In some cases, natural gas EUI increases due to cost efficiency over electricity.

## 75F® SMART VAV WITH REHEAT™ ILLUSTRATION




ZONE 1A
### Honolulu, HI
24% / 100%
**12.4%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
32% / 88%
**16.1%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
31% / 80%
**16.1%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
39% / 48%
**18.1%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
33% / 54%
**15.5%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
43% / 87%
**18.7%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
45% / 25%
**20.6%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
33% / 17%
**15.2%** *Total Building Energy Savings*

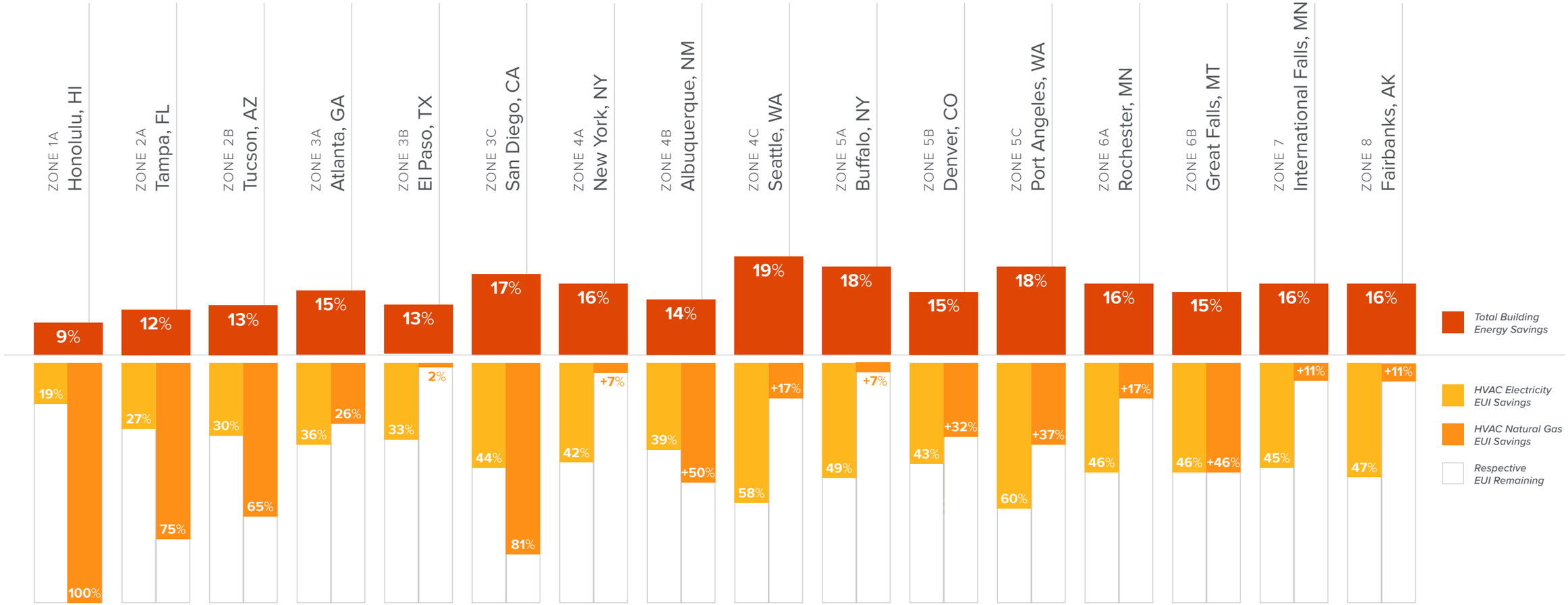
ZONE 4C
### Seatlle, WA
55% / 31%
**21.1%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
48% / 22%
**20.4%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
36% / 4%
**15.8%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

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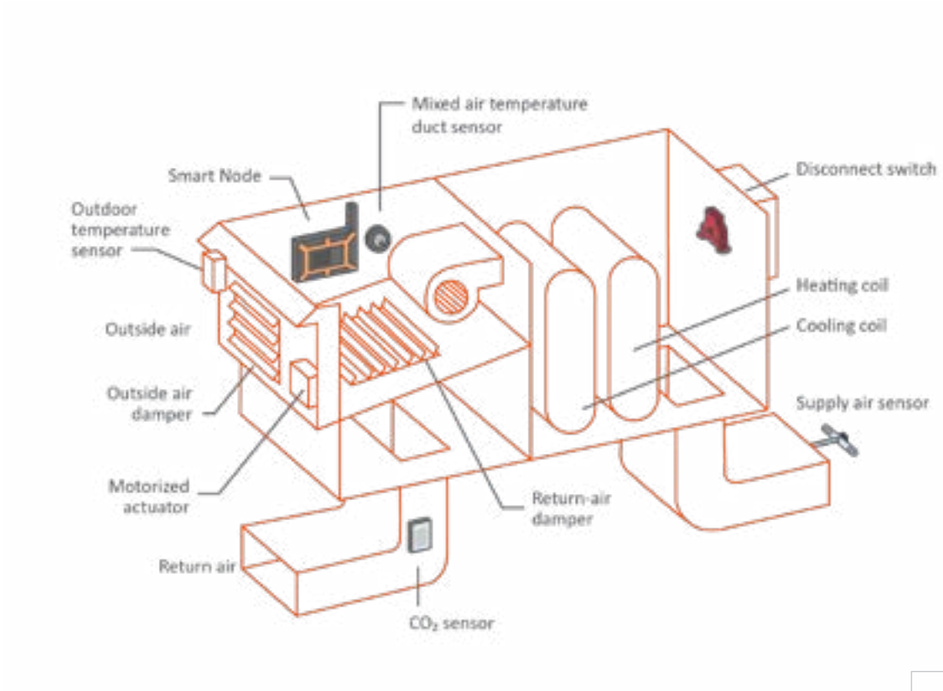
## 75F® OUTSIDE AIR OPTIMIZATION™ ILLUSTRATION




ZONE 1A
### Honolulu, HI

19% / 100%

**9.2%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL

27% / 75%

**12.1%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ

30% / 65%

**13.1%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA

36% / 26%

**14.7%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX

33% / 2%

**13.0%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA

44% / 81%

**16.8%** *Total Building Energy Savings*

ZONE 4A
### New York, NY

42% / +7%

**15.8%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM

39% / +50%

**14.4%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA

58% / +17%

**18.9%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY

49% / +7%

**17.6%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO

43% / +32%

**15.4%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

## CONCLUSION

This analysis shows significant savings from 75F® Outside Air Optimization™ and 75F® Smart VAV With Reheat™ sequences in outpatient healthcare facilities, with energy savings potential consistently found across the United States. Retrofit facilities have the potential for greatest efficiency improvements in this report with savings of up to 21% total building energy use in representative cities compared to a close second of 19% in new build use cases. These higher numbers are typically found in colder climates for both building vintages, though warmer climates such as San Diego, California still demonstrate savings between 17% and 19%, depending on building age. Where energy savings are lowest in places such as Hawaii for new builds and retrofits, total building energy savings still tend to be between 9% and 12%.

NREL NATIONAL RENEWABLE ENERGY LABORATORY | 75F | COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F IoT Building Management System in U.S. primary schools, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. primary schools, both retrofit and new construction. Studied 75F applications include Outside Air Optimization (OAO) and Smart VAV With Reheat.

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **14%** in retrofit primary schools
- **Total building** energy savings of up to **12%** for new construction secondary schools
- Energy savings potential is **even across the U.S.**

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

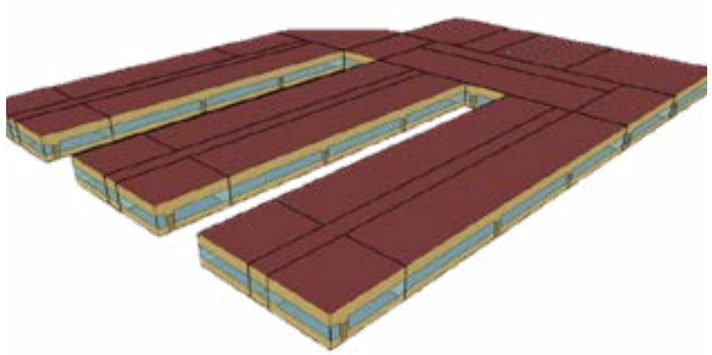
The education facilities analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## PRIMARY SCHOOLS

Primary school building energy consumption is based on a one-story building with 73,960 square feet, gas furnace inside packaged air conditioning unit and hot water from a gas boiler for heating, and packaged air conditioner unit for cooling. Distribution and terminal units include direct air from the packaged unit for the CAV system; VAV terminal box with damper and hot water reheating coil for the VAV system; and minimum supply air at 30% of the zone design peak supply air.

RESULTS | **Primary Schools, Retrofit**

RESULTS | **Primary Schools, New Construction**



# 75F® Smart VAV With Reheat™

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75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO data, though specific control strategy descriptions are available for all three.

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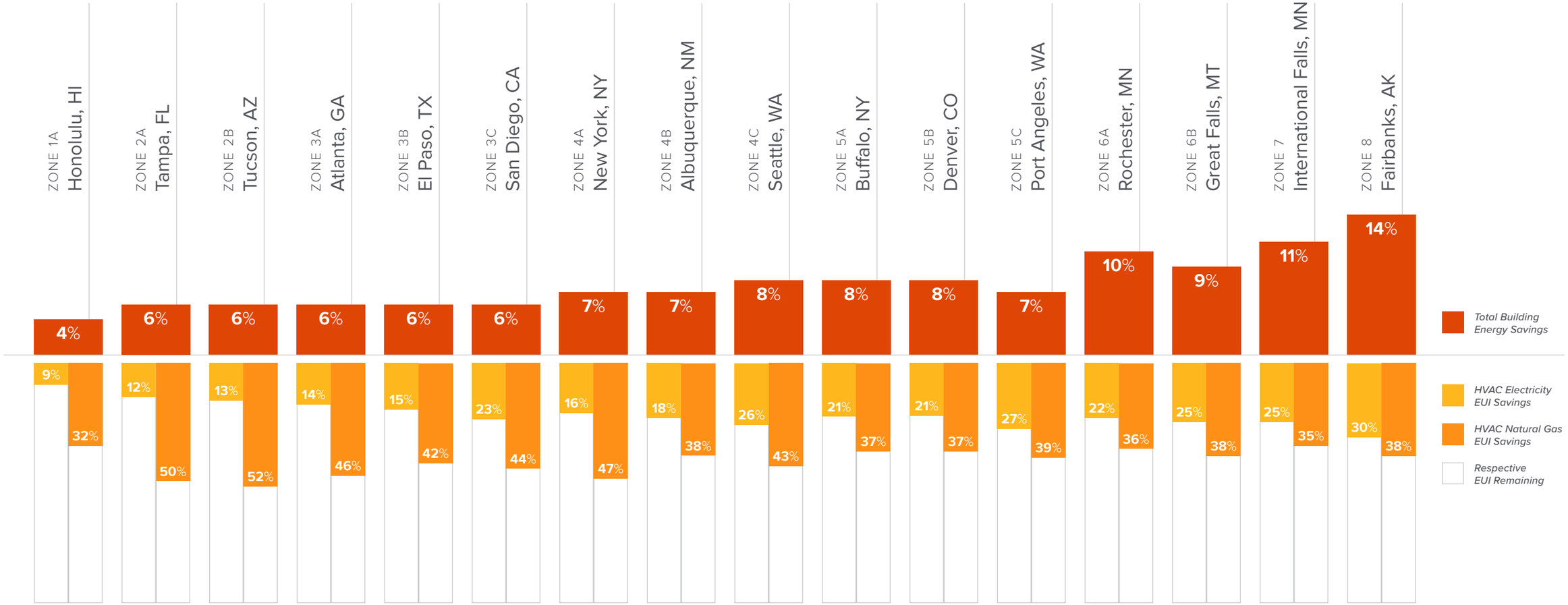
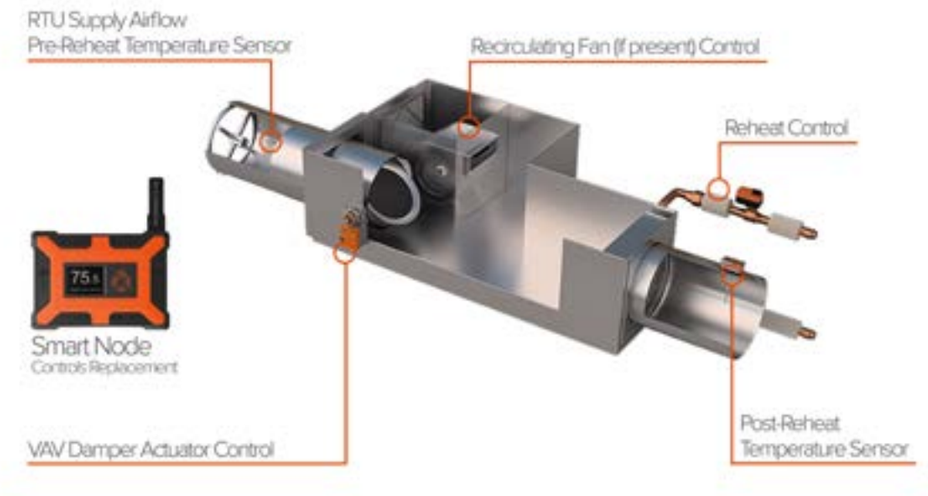

ZONE 1A Honolulu, HI
4%
9%
32%
ZONE 2A Tampa, FL
6%
12%
50%
ZONE 2B Tucson, AZ
6%
13%
52%
ZONE 3A Atlanta, GA
6%
14%
46%
ZONE 3B El Paso, TX
6%
15%
42%
ZONE 3C San Diego, CA
6%
23%
44%
ZONE 4A New York, NY
7%
16%
47%
ZONE 4B Albuquerque, NM
7%
18%
38%
ZONE 4C Seattle, WA
8%
26%
43%
ZONE 5A Buffalo, NY
8%
21%
37%
ZONE 5B Denver, CO
8%
21%
37%
ZONE 5C Port Angeles, WA
7%
27%
39%
ZONE 6A Rochester, MN
10%
22%
36%
ZONE 6B Great Falls, MT
9%
25%
38%
ZONE 7 International Falls, MN
11%
25%
35%
ZONE 8 Fairbanks, AK
14%
30%
38%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## 75F SMART VAV WITH REHEAT ILLUSTRATION




ZONE 1A
### Honolulu, HI
9% | 32% | **4.1%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
12% | 50% | **5.7%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
13% | 52% | **5.8%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
14% | 46% | **5.8%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
15% | 42% | **5.7%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
23% | 44% | **5.6%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
16% | 47% | **7.2%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
18% | 38% | **6.8%** *Total Building Energy Savings*

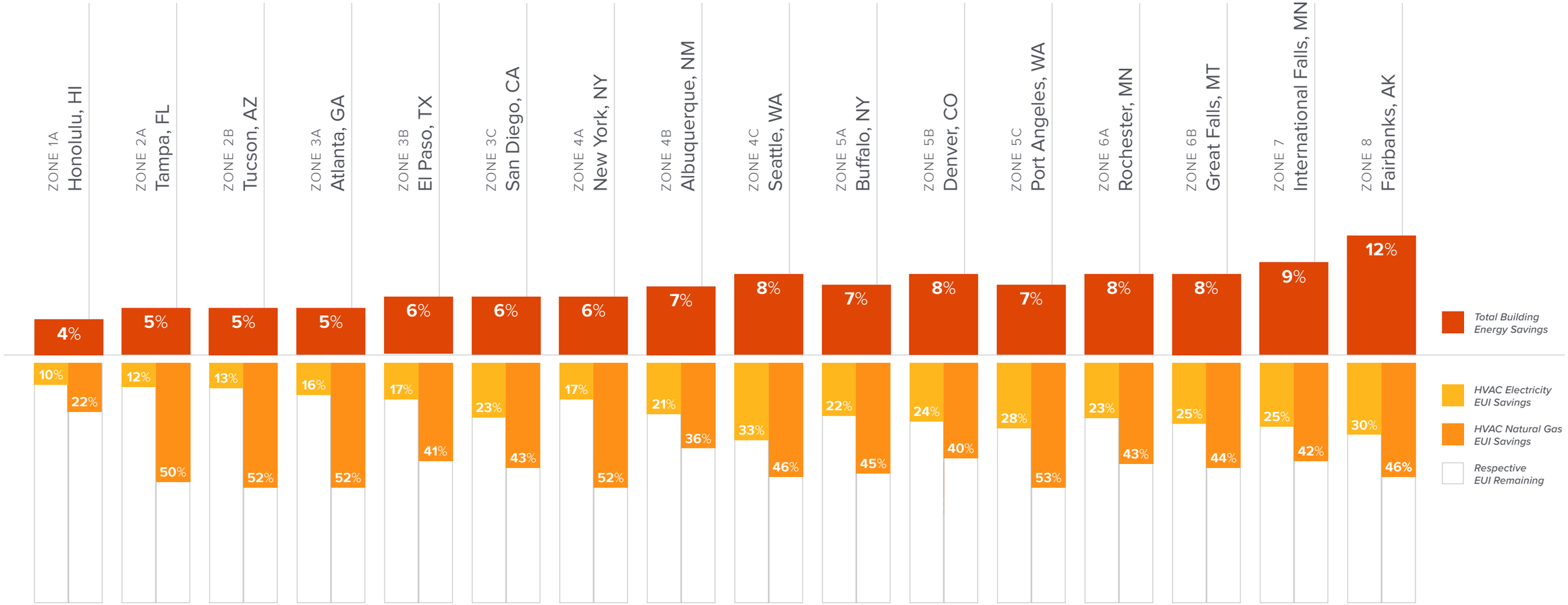
ZONE 4C
### Seatlle, WA
26% | 43% | **7.7%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
21% | 37% | **8.3%** *Total Building Energy Savings*

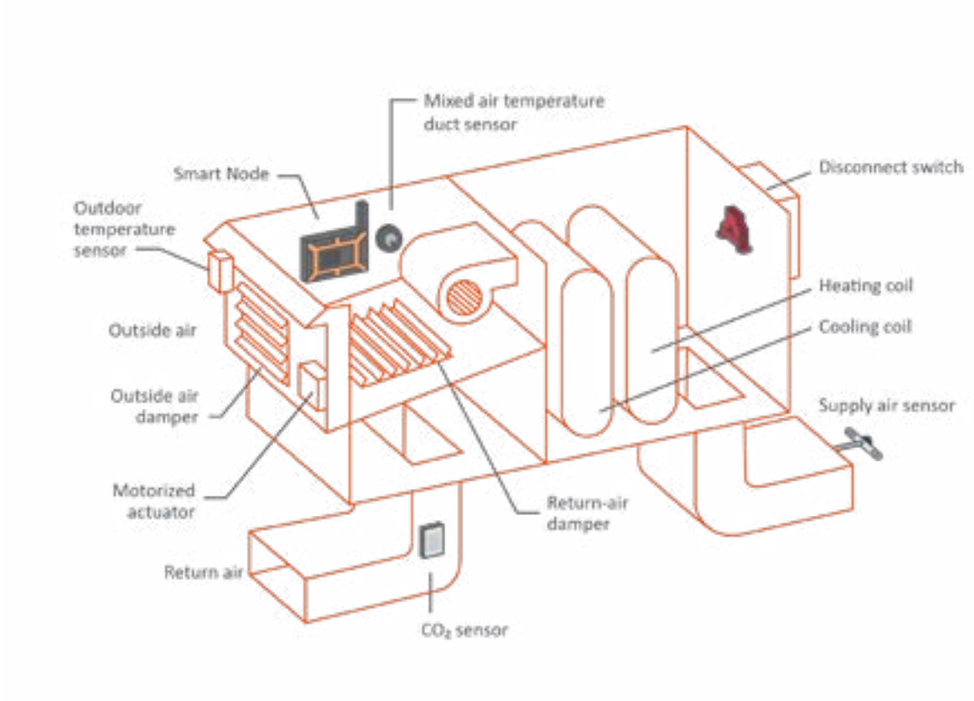
ZONE 5B
### Denver, CO
21% | 37% | **8.2%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*


ZONE 1A Honolulu, HI
4%
10%
22%
ZONE 2A Tampa, FL
5%
12%
50%
ZONE 2B Tucson, AZ
5%
13%
52%
ZONE 3A Atlanta, GA
5%
16%
52%
ZONE 3B El Paso, TX
6%
17%
41%
ZONE 3C San Diego, CA
6%
23%
43%
ZONE 4A New York, NY
6%
17%
52%
ZONE 4B Albuquerque, NM
7%
21%
36%
ZONE 4C Seattle, WA
8%
33%
46%
ZONE 5A Buffalo, NY
7%
22%
45%
ZONE 5B Denver, CO
8%
24%
40%
ZONE 5C Port Angeles, WA
7%
28%
53%
ZONE 6A Rochester, MN
8%
23%
43%
ZONE 6B Great Falls, MT
8%
25%
44%
ZONE 7 International Falls, MN
9%
25%
42%
ZONE 8 Fairbanks, AK
12%
30%
46%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

75F OUTSIDE AIR OPTIMIZATION ILLUSTRATION




ZONE 1A
Honolulu, HI

10% 22% **4.0%** *Total Building Energy Savings*

ZONE 2A
Tampa, FL

12% 50% **4.6%** *Total Building Energy Savings*

ZONE 2B
Tucson, AZ

13% 52% **5.0%** *Total Building Energy Savings*

ZONE 3A
Atlanta, GA

16% 52% **5.3%** *Total Building Energy Savings*

ZONE 3B
El Paso, TX

17% 41% **5.6%** *Total Building Energy Savings*

ZONE 3C
San Diego, CA

23% 43% **5.6%** *Total Building Energy Savings*

ZONE 4A
New York, NY

17% 52% **6.0%** *Total Building Energy Savings*

ZONE 4B
Albuquerque, NM

21% 36% **6.6%** *Total Building Energy Savings*

ZONE 4C
Seatlle, WA

33% 46% **7.6%** *Total Building Energy Savings*

ZONE 5A
Buffalo, NY

22% 45% **6.6%** *Total Building Energy Savings*

ZONE 5B
Denver, CO

24% 40% **8.2%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

## CONCLUSION

This analysis shows significant savings from combined applications Smart VAV With Reheat and Outside Air Optimization sequences in primary education facilities, particularly in climates like those found in Colorado, Minnesota, Washington, and Alaska. Retrofit primary schools have the potential for greatest efficiency improvements in this report with savings of up to 14% total building energy use in representative cities, though new construction buildings are a close second at 12%. While these high savings are typically located in climates that are mountainous and prone to cold winters, data in other areas of the country, such as the southwestern portion, still hover between 5% and 7% total building energy savings in both vintages.

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NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F IoT Building Management System in U.S. secondary schools, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of the 75F IoT Building Management System (BMS) in U.S. secondary education facilities, both retrofit and new construction. Studied 75F applications include Dynamic Chill Water Balancing (DCWB), Outside Air Optimization (OAO), and Smart VAV With Reheat.

The National Renewable Energy Lab (NREL) cultivated the data in this report by leveraging U.S. Department of Energy (DOE) building benchmarks and characteristics across multiple cities, annualized to capture total building energy savings as well as heating, ventilating, and air conditioning (HVAC) electricity and natural gas energy use intensity (EUI) reductions.

- **Total building** energy savings of up to **17%** in retrofit secondary schools
- **Total building** energy savings of up to **13%** for new construction secondary schools
- Energy savings potential is **even across the U.S.**, with the **eastern, southern, and northern** portions of the country seeing the highest savings

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

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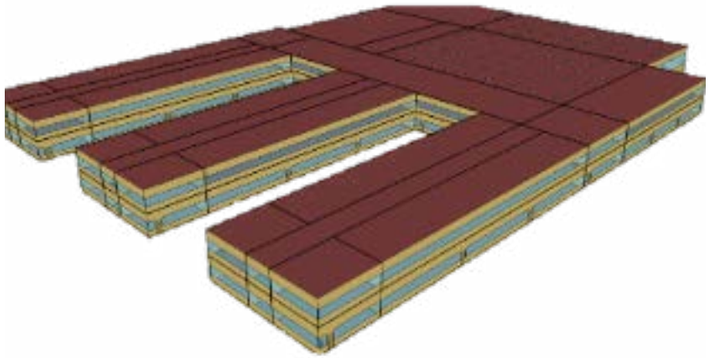
## SECONDARY SCHOOLS

Secondary school building energy consumption is based on a two-story building with 210,900 square feet, gas furnaces inside packaged air conditioning units and a gas-fired boiler for heating, and packaged air conditioner and air-cooled chiller for cooling. Distribution and terminal units include direct air from the packaged unit for the CAV system; VAV terminal box with damper and hot water reheating coil for the VAV system; and minimum supply air at 30% of the zone design peak supply air.

RESULTS | **Secondary Schools, Retrofit**

RESULTS | **Secondary Schools, New Construction**



# 75F® Dynamic Chill Water Balancing™

75F Dynamic Chilled Water Balancing is an end-to-end solution for chilled water systems. 75F sensors in each zone gather millions of data points daily and communicate these points via a 900 MHz wireless mesh network to the 75F® Central Control Unit™ — giving users the ability to monitor the inlet and outlet temperatures, chilled water flow rates, and BTU energy consumption across the line. 75F's system understands, analyzes, and optimizes the overall performance of the HVAC system under various conditions, thereby driving significant energy savings at an AHU level and at the chiller plant.

75F designs and manufactures the world's leading IoT-based Building Management System, an out-of-the-box, vertically integrated solution that is more affordable and easier to deploy than anything on the market today. The company leverages IoT, Cloud Computing and Machine Learning for data-driven, proactive building intelligence and controls for HVAC and lighting optimization. Investors include some of the biggest names in energy and technology. 75F's mission is to improve occupant productivity through enhanced comfort and indoor air quality — all while saving energy.

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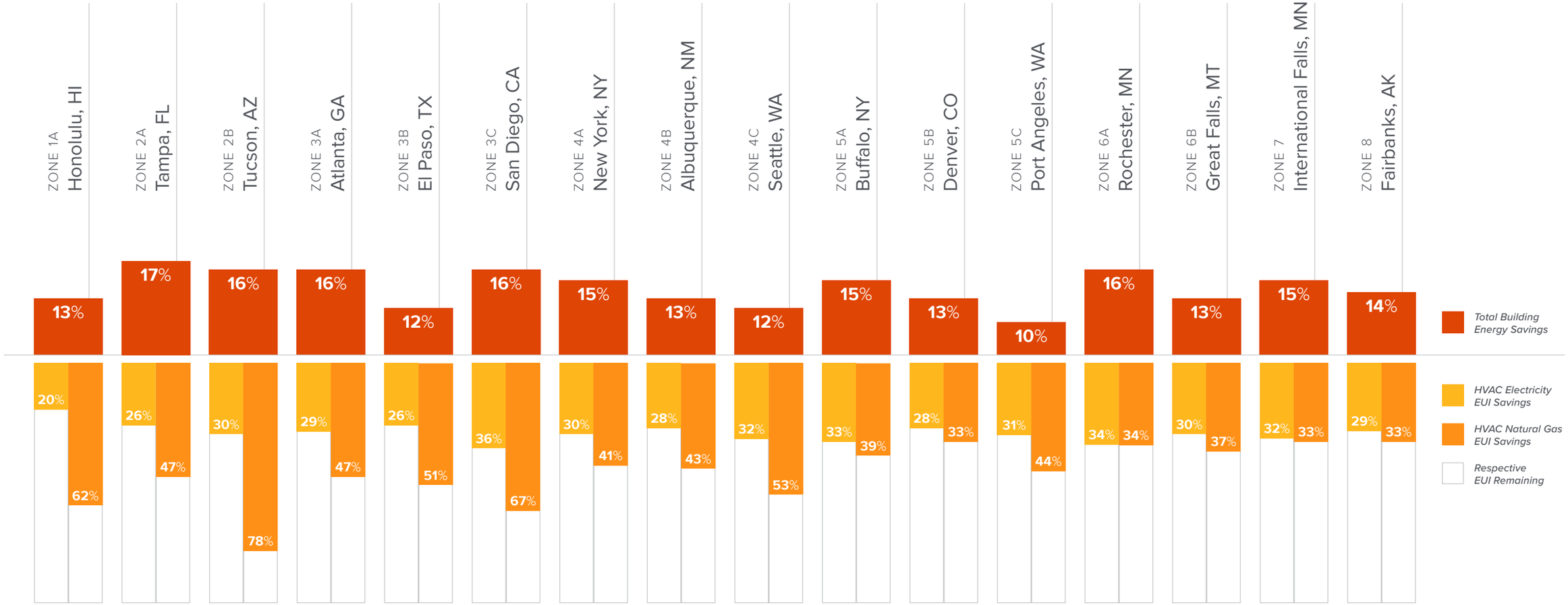
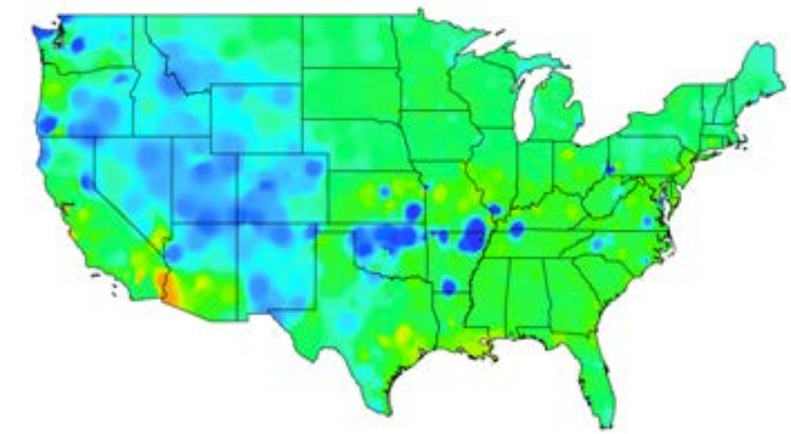

ZONE 1A Honolulu, HI
13%
20%
62%
ZONE 2A Tampa, FL
17%
26%
47%
ZONE 2B Tucson, AZ
16%
30%
78%
ZONE 3A Atlanta, GA
16%
29%
47%
ZONE 3B El Paso, TX
12%
26%
51%
ZONE 3C San Diego, CA
16%
36%
67%
ZONE 4A New York, NY
15%
30%
41%
ZONE 4B Albuquerque, NM
13%
28%
43%
ZONE 4C Seattle, WA
12%
32%
53%
ZONE 5A Buffalo, NY
15%
33%
39%
ZONE 5B Denver, CO
13%
28%
33%
ZONE 5C Port Angeles, WA
10%
31%
44%
ZONE 6A Rochester, MN
16%
34%
34%
ZONE 6B Great Falls, MT
13%
30%
37%
ZONE 7 International Falls, MN
15%
32%
33%
ZONE 8 Fairbanks, AK
14%
29%
33%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE




ZONE 1A
### Honolulu, HI
20% 62%
**12.7%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
26% 47%
**16.7%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
30% 78%
**16.4%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
29% 47%
**16.2%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
26% 51%
**12.3%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
36% 67%
**15.9%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
30% 41%
**15.3%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
28% 43%
**13.0%** *Total Building Energy Savings*

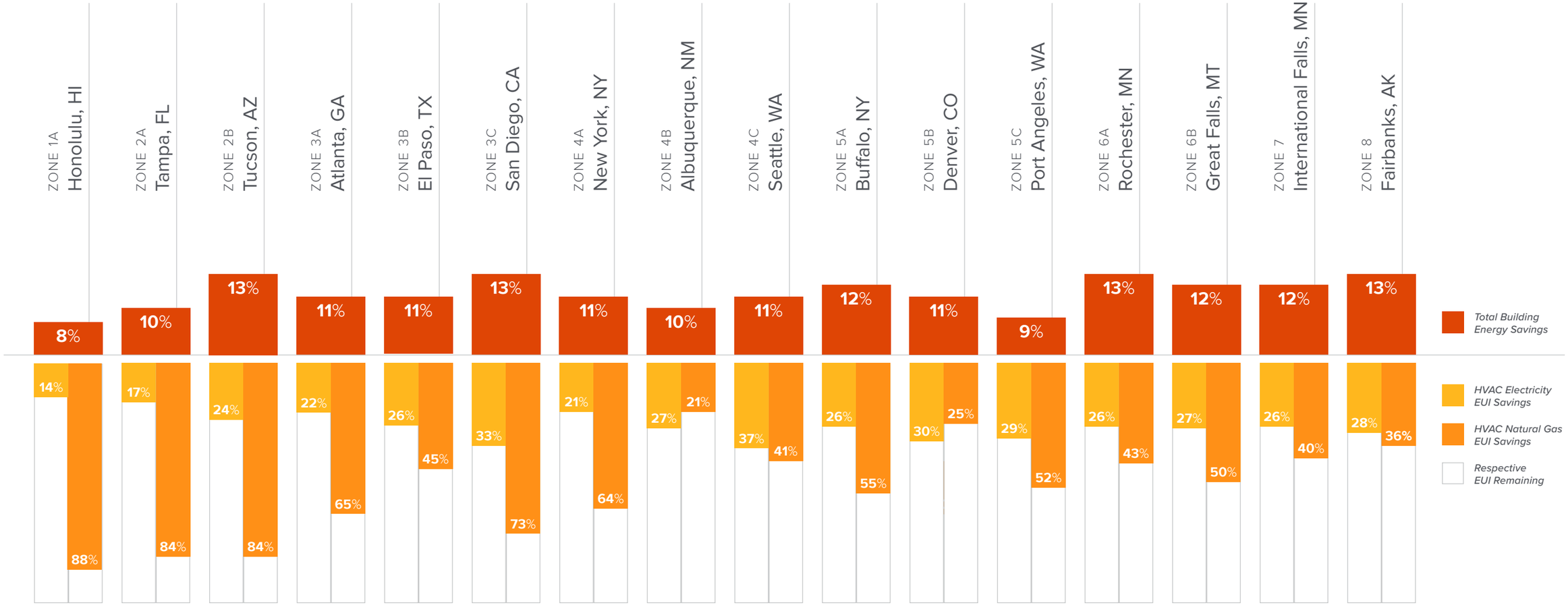
ZONE 4C
### Seatlle, WA
32% 53%
**12.1%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
33% 39%
**15.0%** *Total Building Energy Savings*

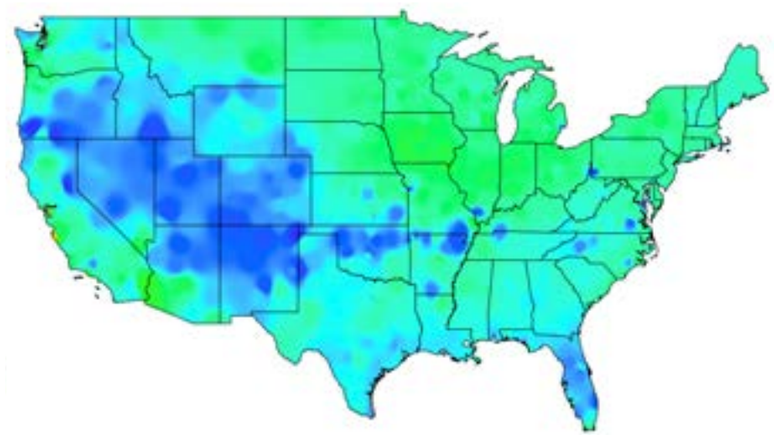
ZONE 5B
### Denver, CO
28% 33%
**12.6%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*


ZONE 1A Honolulu, HI
8%
14%
88%
ZONE 2A Tampa, FL
10%
17%
84%
ZONE 2B Tucson, AZ
13%
24%
84%
ZONE 3A Atlanta, GA
11%
22%
65%
ZONE 3B El Paso, TX
11%
26%
45%
ZONE 3C San Diego, CA
13%
33%
73%
ZONE 4A New York, NY
11%
21%
64%
ZONE 4B Albuquerque, NM
10%
27%
21%
ZONE 4C Seattle, WA
11%
37%
41%
ZONE 5A Buffalo, NY
12%
26%
55%
ZONE 5B Denver, CO
11%
30%
25%
ZONE 5C Port Angeles, WA
9%
29%
52%
ZONE 6A Rochester, MN
13%
26%
43%
ZONE 6B Great Falls, MT
12%
27%
50%
ZONE 7 International Falls, MN
12%
26%
40%
ZONE 8 Fairbanks, AK
13%
28%
36%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

10% 15% 20% 25%

ZONE 1A
### Honolulu, HI
14% 88%
**8.0%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
17% 84%
**9.7%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
24% 84%
**12.7%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
22% 65%
**11.2%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
26% 45%
**11.3%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
33% 73%
**13.0%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
21% 64%
**10.6%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
27% 21%
**10.2%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
37% 41%
**11.4%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
26% 55%
**11.8%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
30% 25%
**10.8%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

## CONCLUSION

This analysis shows significant savings from combined applications Smart VAV With Reheat, Dynamic Chill Water Balancing, and Outside Air Optimization sequences in secondary education facilities, particularly in the midwest and eastern half of the U.S. for retrofit projects and the northern edge of the country for new construction. Retrofit secondary schools have the potential for greatest efficiency improvements in this report with savings of up to 17% total building energy use in representative cities, though new construction buildings are a close second at 13%. While these high savings are typically located in the eastern and northern portions of the U.S., data in other areas of the country, such as the Rocky Mountains area, still hover between 10% and 12% savings in both vintages.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F

COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F® Outside Air Optimization™ solution in U.S. stand-alone retail, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F®

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of 75F® Outside Air Optimization™ in U.S. stand-alone retail buildings. It leverages U.S. Department of Energy (DOE) benchmarks and characteristics and independent research from the National Renewable Energy Lab (NREL) across multiple cities, annualized to capture total building, HVAC electricity, and natural gas EUI reductions across all U.S. climate zones, at multiple utility rates.

The data in this report reflects the current savings potential of 75F's proprietary outside air sequences in retrofit and new construction retail facilities. While 75F's IoT-based applications may be combined in many buildings based on the equipment and needs of the space, this data stands alone for each application type. Buildings with combined application types will have the potential for higher energy savings than those modeled here.

- **Total building** energy savings of up to **19%** in both retrofit and new construction stand-alone retail
- Energy savings potential is **even across the U.S.**, with **15%** total building energy reductions common for the middle and southern regions of the country

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The retail facilities analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## STAND-ALONE RETAIL

Stand-alone retail facility HVAC energy consumption is based on a single-story building with 24,695 square feet; a packaged air conditioning unit for cooling of back spaces, core retail area, point of sale, and front retail area. Front entry does not have cooling. A gas furnace inside the packaged air conditioning unit heats the main building, and a stand-alone gas furnace heats the front entry. Distribution and terminal units include constant air volume air distribution and four single-zone RTUs.

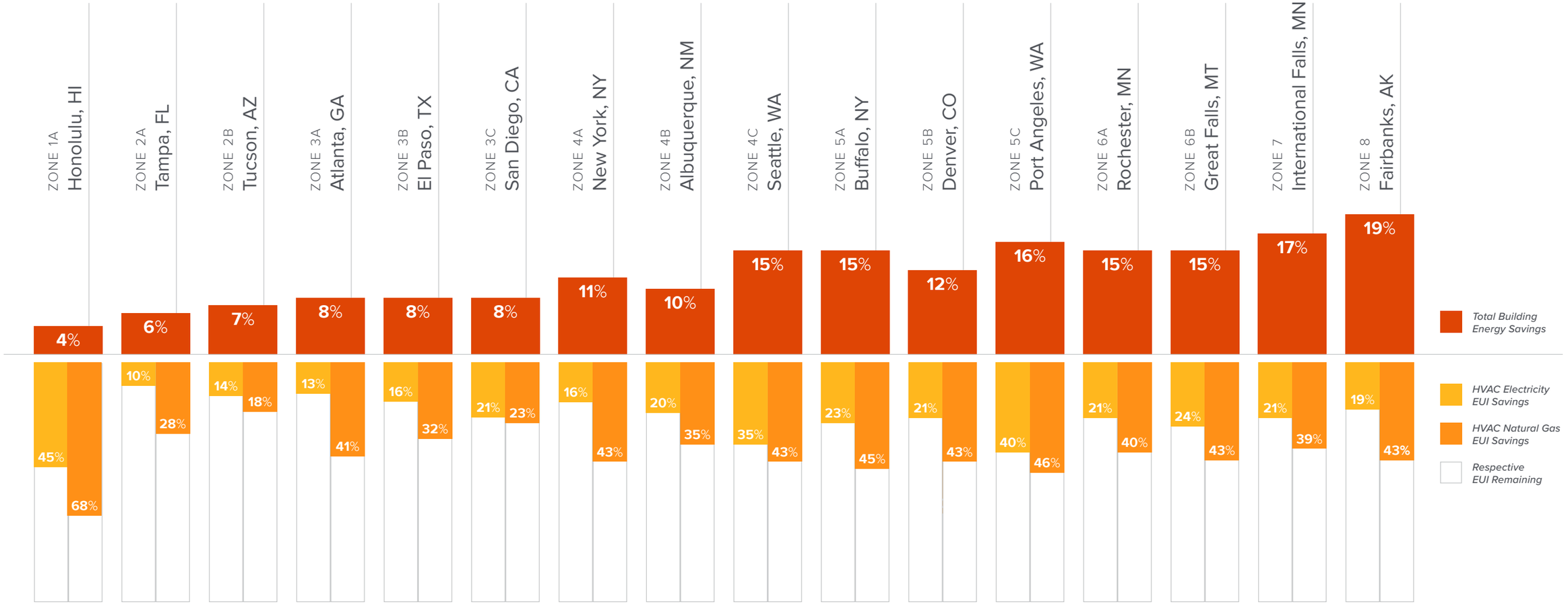
RESULTS | **Stand-Alone Retail, Retrofit**

RESULTS | **Stand-Alone Retail, New Construction**

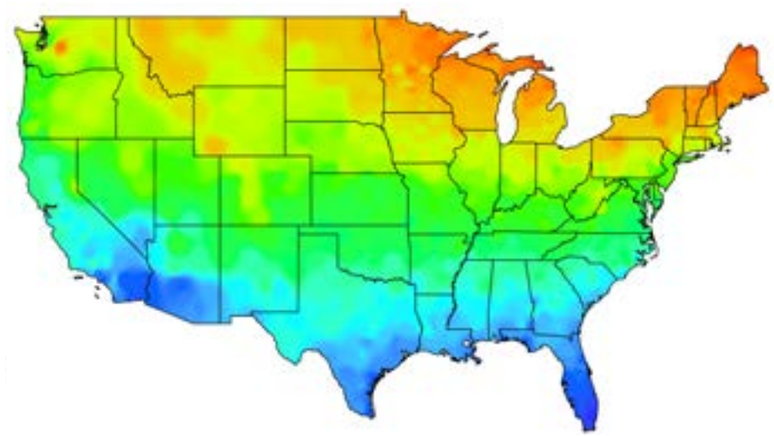
# 75F® Outside Air Optimization™

75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO IM data, though specific control strategy descriptions are available for all three.

- **OAO** reduces the required ventilation outdoor air leveraging additional sensors and optimized setpoints.
- **OAO IM** cycles the fan to maintain minimum outdoor air ventilation. Applied in any building with constant-speed fans in the HVAC equipment that provides ventilation to occupants.
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.


ZONE 1A Honolulu, HI
4%
45%
68%
ZONE 2A Tampa, FL
6%
10%
28%
ZONE 2B Tucson, AZ
7%
14%
18%
ZONE 3A Atlanta, GA
8%
13%
41%
ZONE 3B El Paso, TX
8%
16%
32%
ZONE 3C San Diego, CA
8%
21%
23%
ZONE 4A New York, NY
11%
16%
43%
ZONE 4B Albuquerque, NM
10%
20%
35%
ZONE 4C Seattle, WA
15%
35%
43%
ZONE 5A Buffalo, NY
15%
23%
45%
ZONE 5B Denver, CO
12%
21%
43%
ZONE 5C Port Angeles, WA
16%
40%
46%
ZONE 6A Rochester, MN
15%
21%
40%
ZONE 6B Great Falls, MT
15%
24%
43%
ZONE 7 International Falls, MN
17%
21%
39%
ZONE 8 Fairbanks, AK
19%
19%
43%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

5% 10% 15% 20% 25%

ZONE 1A
**Honolulu, HI**
43% 68% **4.3%** *Total Building Energy Savings*

ZONE 2A
**Tampa, FL**
10% 28% **5.9%** *Total Building Energy Savings*

ZONE 2B
**Tucson, AZ**
14% 18% **7.2%** *Total Building Energy Savings*

ZONE 3A
**Atlanta, GA**
13% 41% **8.1%** *Total Building Energy Savings*

ZONE 3B
**El Paso, TX**
16% 32% **7.8%** *Total Building Energy Savings*

ZONE 3C
**San Diego, CA**
21% 23% **7.8%** *Total Building Energy Savings*

ZONE 4A
**New York, NY**
16% 43% **11.4%** *Total Building Energy Savings*

ZONE 4B
**Albuquerque, NM**
20% 35% **10.0%** *Total Building Energy Savings*

ZONE 4C
**Seatlle, WA**
35% 43% **14.8%** *Total Building Energy Savings*

ZONE 5A
**Buffalo, NY**
23% 45% **15.3%** *Total Building Energy Savings*

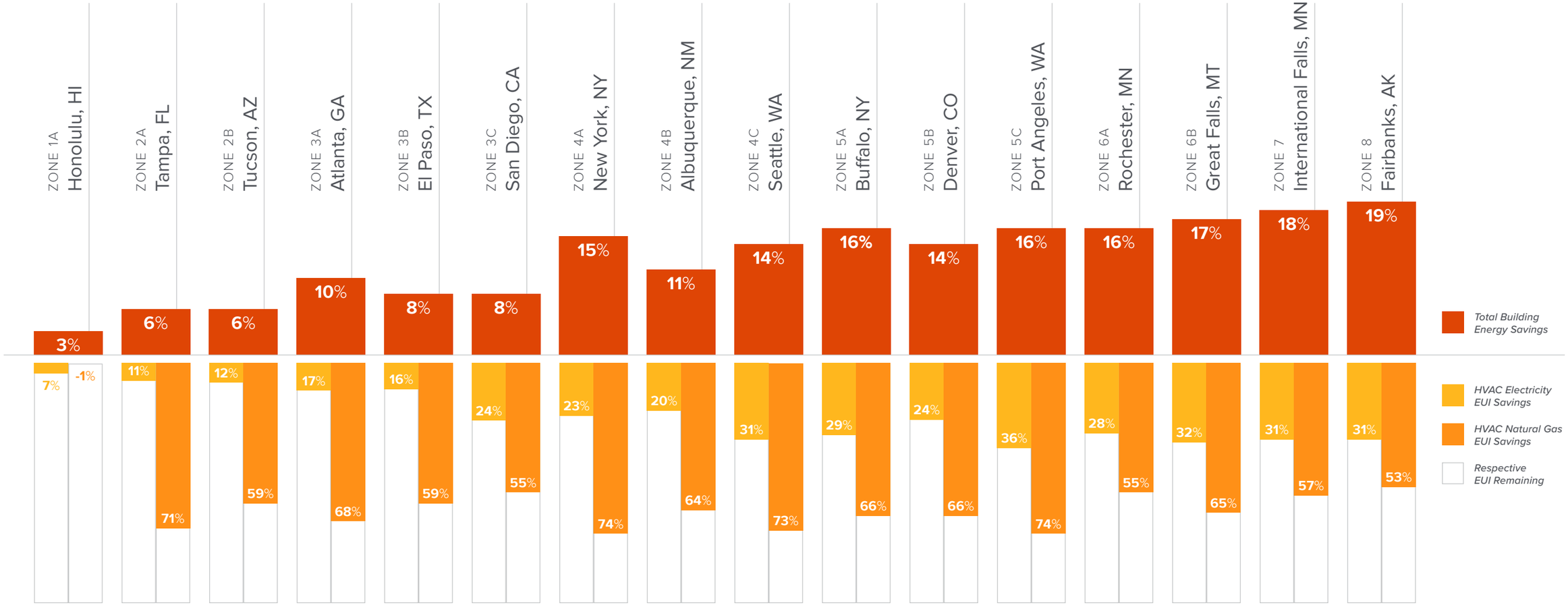
ZONE 5B
**Denver, CO**
21% 43% **12.4%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

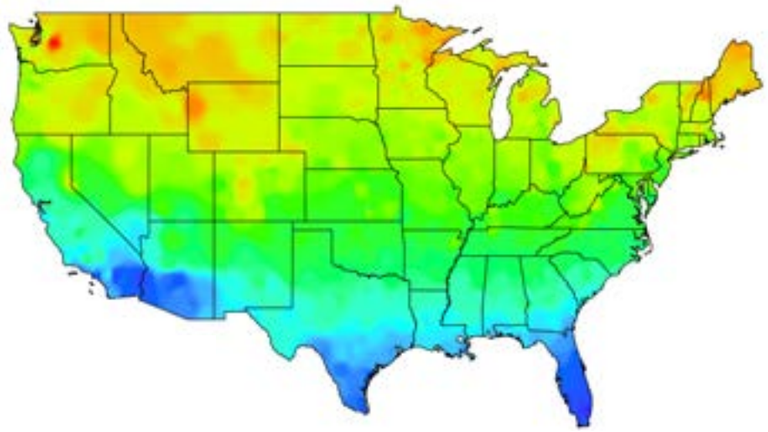
*HVAC Natural Gas EUI Savings*

# RESULTS | STAND-ALONE RETAIL, NEW CONSTRUCTION

◀ Methodology



## ANNUAL SAVINGS BY CLIMATE ZONE



*% Annual Savings*

10% 20% 30%

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

ZONE 1A
### Honolulu, HI
7% -1%
**3.5%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
11% 71%
**5.9%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
12% 59%
**5.9%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
17% 68%
**9.8%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
16% 59%
**8.2%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
24% 55%
**8.4%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
23% 74%
**14.8%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
20% 64%
**10.6%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
31% 73%
**14.2%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
29% 66%
**16.3%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
24% 66%
**14.5%** *Total Building Energy Savings*

## CONCLUSION

This analysis shows significant savings from 75F® Outside Air Optimization™ sequences in stand-alone retail buildings, particularly in the northern portions of the country where savings begin around 15% and climb from there. Both new construction and retrofit retail buildings have the potential for up to 19% total building energy savings in representative cities, though energy reduction is higher in counties not explicitly documented in this report. Both vintages consistently demonstrate savings between 10% and 15% in the middle and lower regions of the U.S. Where savings are the lowest in areas such as Florida, southern California, and southern Texas, the data still evens out around 6% and 10% total building energy reductions.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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COMFORT SYSTEMS USA

ENERGY SAVINGS

# WHITEPAPER

*An analysis of the unique 75F® Outside Air Optimization™ solution in U.S. strip malls, both new construction and retrofit.*

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

75F®

COMFORT SYSTEMS USA

# INTRODUCTION

This report comprehensively quantifies the potential energy savings of 75F® Outside Air Optimization™ in U.S. strip malls. It leverages U.S. Department of Energy (DOE) benchmarks and characteristics and independent research from the National Renewable Energy Lab (NREL) across multiple cities, annualized to capture total building, HVAC electricity, and natural gas EUI reductions across all U.S. climate zones, at multiple utility rates.

The data in this report reflects the current savings potential of 75F's proprietary outside air sequences in retrofit and new construction strip malls. While 75F's IoT-based applications may be combined in many buildings based on the equipment and needs of the space, this data stands alone for each application type. Buildings with combined application types will have the potential for higher energy savings than those modeled here.

- **Total building** energy savings of up to **18%** in retrofit strip malls
- **Total building** energy savings of up to **26%** for new construction strip malls
- Energy savings potential is **even across the U.S.**, with climate zones 4C and 5B seeing the highest savings

# METHODOLOGY

*The U.S. Department of Energy (DOE) is responsible for conducting research about commercial building systems and energy efficiency in coordination with national laboratories, private industry, and universities, with a stated goal of developing more energy efficient buildings and eventually reaching zero energy buildings. This research relies heavily on standardized benchmarks developed and shared by Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL), the nation's primary laboratory for renewable energy and energy efficiency research and development.*

## CLIMATE ZONES

The strip malls analyzed in this report are in 16 cities representing all U.S. climate zones: Honolulu, HI; Tampa, FL; Tucson, AZ; Atlanta, GA; El Paso, TX; San Diego, CA; New York, NY; Albuquerque, NM; Seattle, WA; Buffalo, NY; Denver, CO; Port Angeles, WA; Rochester, MN; Great Falls, MT; International Falls, MN; and Fairbanks, AK. Efficiencies are based on the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 90.1-2016 for new construction buildings, and Standard 90.1-2004 for retrofit buildings. All buildings have varying schedules, occupancy, component efficiency, locations and orientation, lighting loads, plug loads, HVAC sequences and varying ventilation requirements based on zone use.

## STRIP MALLS

Strip mall HVAC energy consumption is based on a single-story building with 22,500 square feet, a packaged air-conditioning unit for back spaces, core retail, point of sale, and front retail for cooling and a gas furnace inside the packaged air-conditioning unit for heating. Distribution and terminal units include 10 single-zone rooftop units with constant-air volume air distribution with one unit serving one store.

RESULTS | **Strip Malls, Retrofit**

RESULTS | **Strip Malls, New Construction**

# 75F® Outside Air Optimization™

75F® Outside Air Optimization™ (OAO) is an application that combines hardware, software, and real-time weather data providing advanced sequences of operation from rooftop economizers to built-up air handlers in a wide range of commercial buildings. While OAO's three primary benefits are improved efficiency, comfort and indoor air quality, this report will focus on OAO's efficiency potential. NREL's study includes three OAO control strategies: OAO, OAO Interval Modulation (IM), and OAO Smart Demand Control Ventilation (DCV). This report focuses exclusively on OAO IM data, though specific control strategy descriptions are available for all three.

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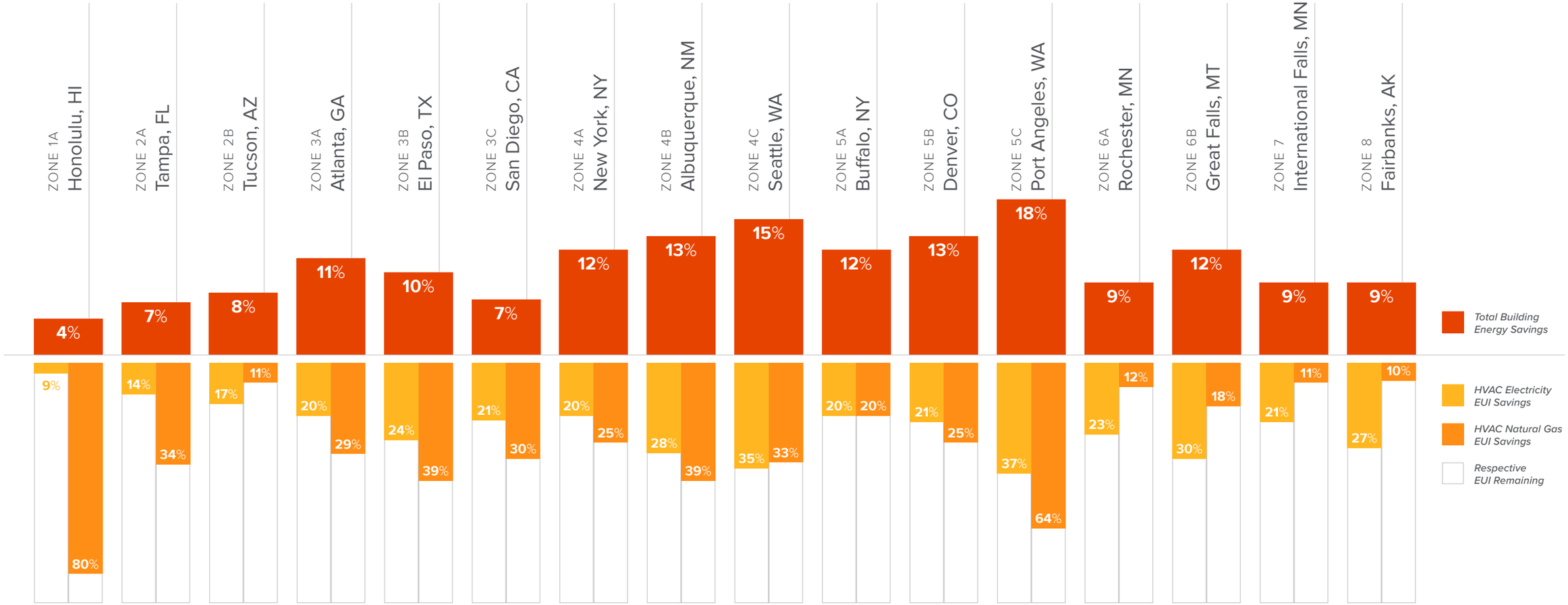
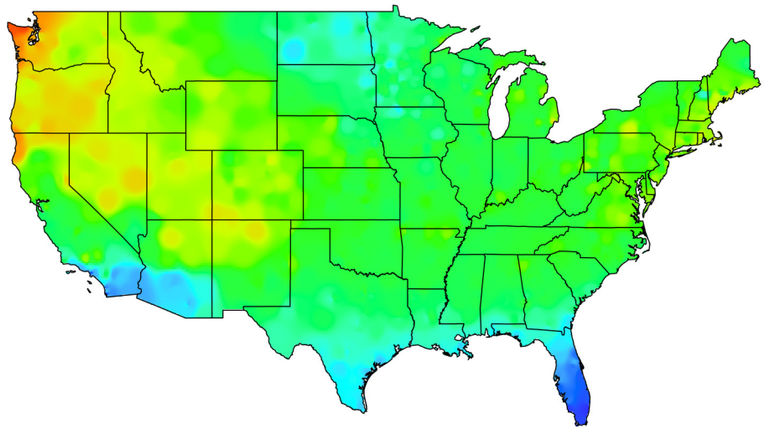
- **OAO Smart DCV** uses CO2 sensors to detect occupancy and adjusts ventilation by room in VAV systems. Applied in buildings with central HVAC systems serving multiple zones leveraging traditional VAV terminal units.


ZONE 1A Honolulu, HI
4%
9%
80%
ZONE 2A Tampa, FL
7%
14%
34%
ZONE 2B Tucson, AZ
8%
17%
11%
ZONE 3A Atlanta, GA
11%
20%
29%
ZONE 3B El Paso, TX
10%
24%
39%
ZONE 3C San Diego, CA
7%
21%
30%
ZONE 4A New York, NY
12%
20%
25%
ZONE 4B Albuquerque, NM
13%
28%
39%
ZONE 4C Seattle, WA
15%
35%
33%
ZONE 5A Buffalo, NY
12%
20%
20%
ZONE 5B Denver, CO
13%
21%
25%
ZONE 5C Port Angeles, WA
18%
37%
64%
ZONE 6A Rochester, MN
9%
23%
12%
ZONE 6B Great Falls, MT
12%
30%
18%
ZONE 7 International Falls, MN
9%
21%
11%
ZONE 8 Fairbanks, AK
9%
27%
10%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

ANNUAL SAVINGS BY CLIMATE ZONE




ZONE 1A
Honolulu, HI
9% 80%
**4.3%**
*Total Building Energy Savings*

ZONE 2A
Tampa, FL
14% 34%
**6.6%**
*Total Building Energy Savings*

ZONE 2B
Tucson, AZ
17% 11%
**9.1%**
*Total Building Energy Savings*

ZONE 3A
Atlanta, GA
20% 29%
**10.7%**
*Total Building Energy Savings*

ZONE 3B
El Paso, TX
24% 39%
**10.1%**
*Total Building Energy Savings*

ZONE 3C
San Diego, CA
21% 30%
**7.3%**
*Total Building Energy Savings*

ZONE 4A
New York, NY
20% 25%
**12.2%**
*Total Building Energy Savings*

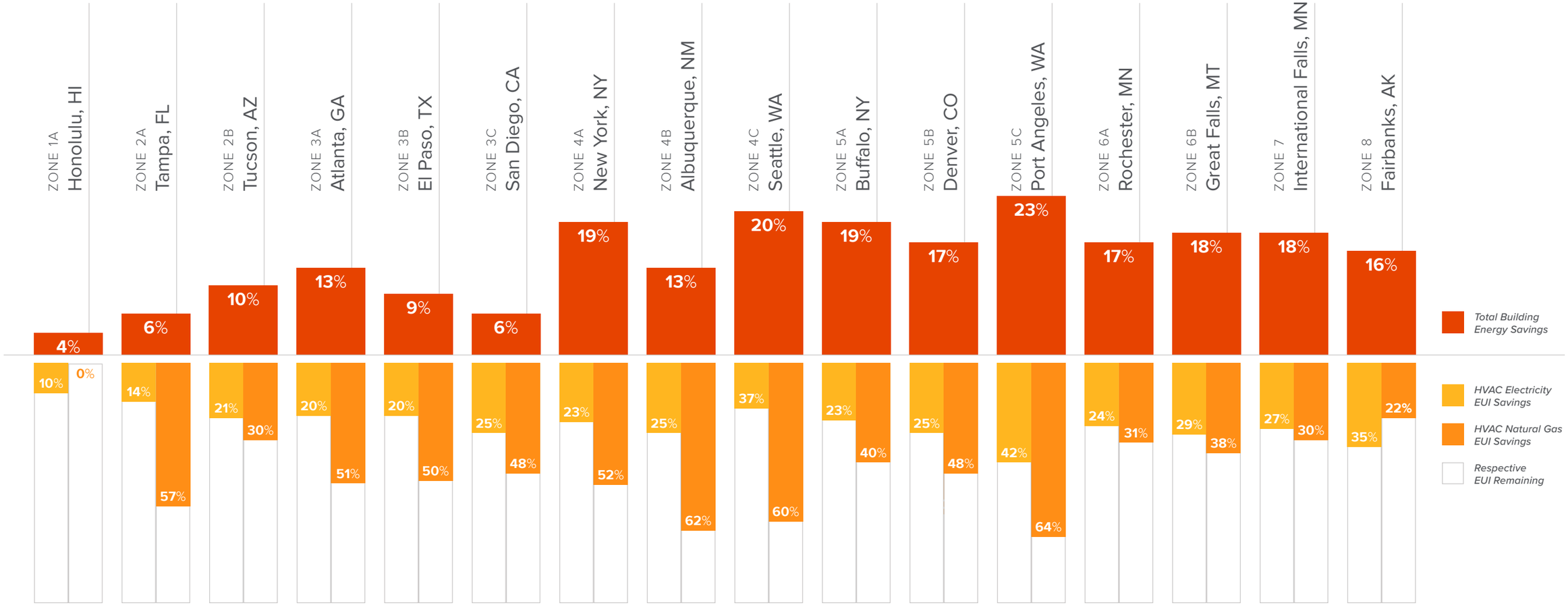
ZONE 4B
Albuquerque, NM
28% 39%
**12.8%**
*Total Building Energy Savings*

ZONE 4C
Seatlle, WA
35% 33%
**14.5%**
*Total Building Energy Savings*

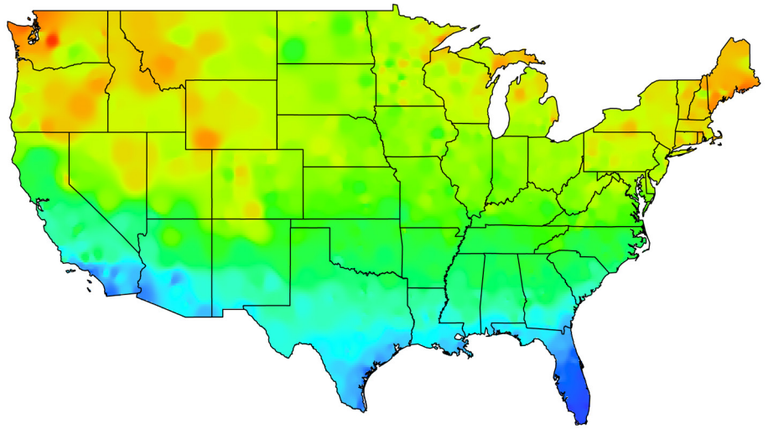
ZONE 5A
Buffalo, NY
20% 20%
**11.6%**
*Total Building Energy Savings*

ZONE 5B
Denver, CO
21% 25%
**13.1%**
*Total Building Energy Savings*

*HVAC Electricity EUI Savings*
*HVAC Natural Gas EUI Savings*


ZONE 1A Honolulu, HI
4%
10%
0%
ZONE 2A Tampa, FL
6%
14%
57%
ZONE 2B Tucson, AZ
10%
21%
30%
ZONE 3A Atlanta, GA
13%
20%
51%
ZONE 3B El Paso, TX
9%
20%
50%
ZONE 3C San Diego, CA
6%
25%
48%
ZONE 4A New York, NY
19%
23%
52%
ZONE 4B Albuquerque, NM
13%
25%
62%
ZONE 4C Seattle, WA
20%
37%
60%
ZONE 5A Buffalo, NY
19%
23%
40%
ZONE 5B Denver, CO
17%
25%
48%
ZONE 5C Port Angeles, WA
23%
42%
64%
ZONE 6A Rochester, MN
17%
24%
31%
ZONE 6B Great Falls, MT
18%
29%
38%
ZONE 7 International Falls, MN
18%
27%
30%
ZONE 8 Fairbanks, AK
16%
35%
22%
Total Building Energy Savings
HVAC Electricity EUI Savings
HVAC Natural Gas EUI Savings
Respective EUI Remaining

## ANNUAL SAVINGS BY CLIMATE ZONE




ZONE 1A
### Honolulu, HI
0%
10%
**3.9%** *Total Building Energy Savings*

ZONE 2A
### Tampa, FL
14%
57%
**6.0%** *Total Building Energy Savings*

ZONE 2B
### Tucson, AZ
21%
30%
**9.6%** *Total Building Energy Savings*

ZONE 3A
### Atlanta, GA
20%
51%
**12.5%** *Total Building Energy Savings*

ZONE 3B
### El Paso, TX
20%
50%
**9.0%** *Total Building Energy Savings*

ZONE 3C
### San Diego, CA
25%
48%
**6.4%** *Total Building Energy Savings*

ZONE 4A
### New York, NY
23%
52%
**19.0%** *Total Building Energy Savings*

ZONE 4B
### Albuquerque, NM
25%
62%
**12.7%** *Total Building Energy Savings*

ZONE 4C
### Seatlle, WA
37%
60%
**19.5%** *Total Building Energy Savings*

ZONE 5A
### Buffalo, NY
23%
40%
**18.6%** *Total Building Energy Savings*

ZONE 5B
### Denver, CO
25%
48%
**16.9%** *Total Building Energy Savings*

*HVAC Electricity EUI Savings*

*HVAC Natural Gas EUI Savings*

## CONCLUSION

This analysis shows significant savings from 75F® Outside Air Optimization™ sequences, particularly in the Pacific northwest (climate zone 4C and parts of 5B) and parts of the Rocky Mountain range in climate zone 5B. New construction strip malls have the potential for greatest efficiency improvements in this report with savings of up to 26% total building energy use compared to 18% in retrofit use cases. These higher numbers are typically found in the aforementioned climate zones, though new builds also see high savings on the upper east coast and midwest. Total building energy savings of 10% to 12% are common across much of the country in retrofits, and 12% to 20% in new construction. Where total building energy savings are below 10%, building operators can still reliably expect reductions in HVAC electricity and natural gas EUIs.

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