# PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

# ASHRAE 90.1-2007 to 2010 to 2013: Changes in Air-To-Air Energy Recovery Requirements and the International Energy Conservation Code (IECC)

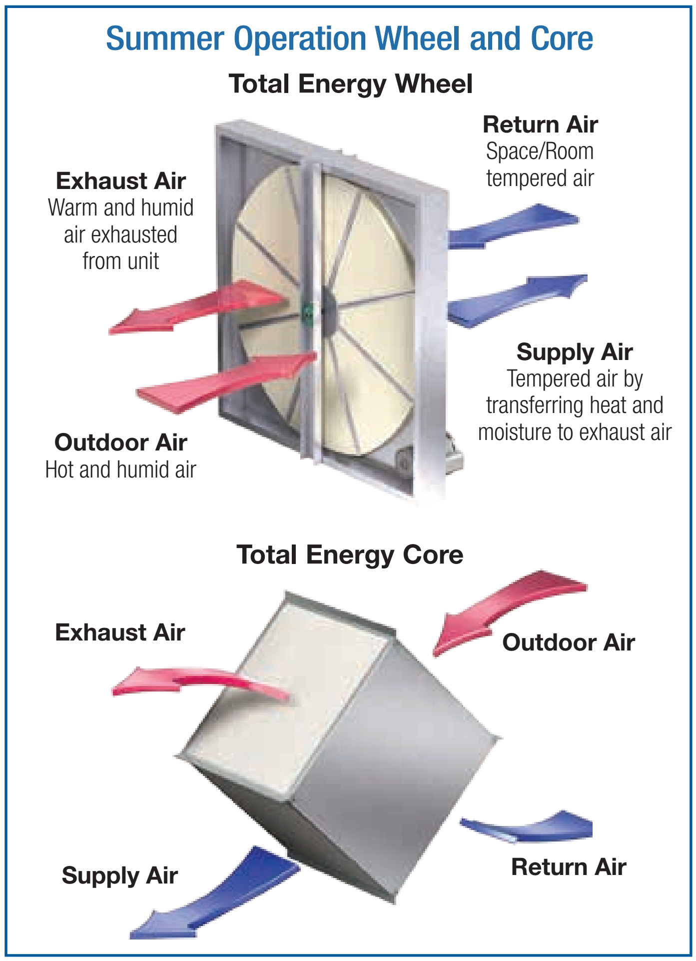
Air-to-air energy recovery devices present several key benefits for commercial buildings. These benefits include lower energy costs due to the reduction in the overall mechanical cooling and heating requirements, lower first costs due to reduced mechanical equipment sizes, and reduced variability in air conditions entering the cooling and heating system. Because energy recovery devices have shown a significant savings in energy consumption, energy standards for commercial buildings have included requirements for air-to-air energy recovery based on system design. ASHRAE Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," defines guidelines for energy efficiency in commercial buildings. The language and guidelines from ASHRAE 90.1 are adopted into the International Energy Conservation Code (IECC), which is often adopted by state and local jurisdictions.

## ASHRAE 90.1-2007/2009 IECC Energy Recovery Requirements

As energy recovery has shown its value, ASHRAE 90.1 has been revised to require air-to-air energy recovery more often and at different criteria. At a minimum, most states follow the requirements of the 2009 IECC which has adopted the guidelines from the ASHRAE 90.1-2007 standard. This version of the standard states an energy recovery device is required if:

1. The supply airflow is ≥ 5,000 cfm
2. **AND** 70% or more of the supply airflow is outdoor air.

The total effectiveness must be greater or equal to 50%, as defined by ASHRAE Standard 90.1. This is the difference in the enthalpy of the outdoor air and supply air equal to 50% or greater of the difference between the outdoor air and return air enthalpies at design conditions.





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## ASHRAE 90.1-2010/2012 IECC Energy Recovery Requirements

While ASHRAE 90.1-2007 drives the use of energy recovery based on airflow and outdoor air percentage, it does not differentiate the use based on geographic locations and climate, both of which can heavily influence the benefits of energy recovery. ASHRAE 90.1-2010 expands the requirements of energy recovery use by separating the United States into different climate zones based on historical weather conditions. These requirements are adopted into the 2012 IECC.

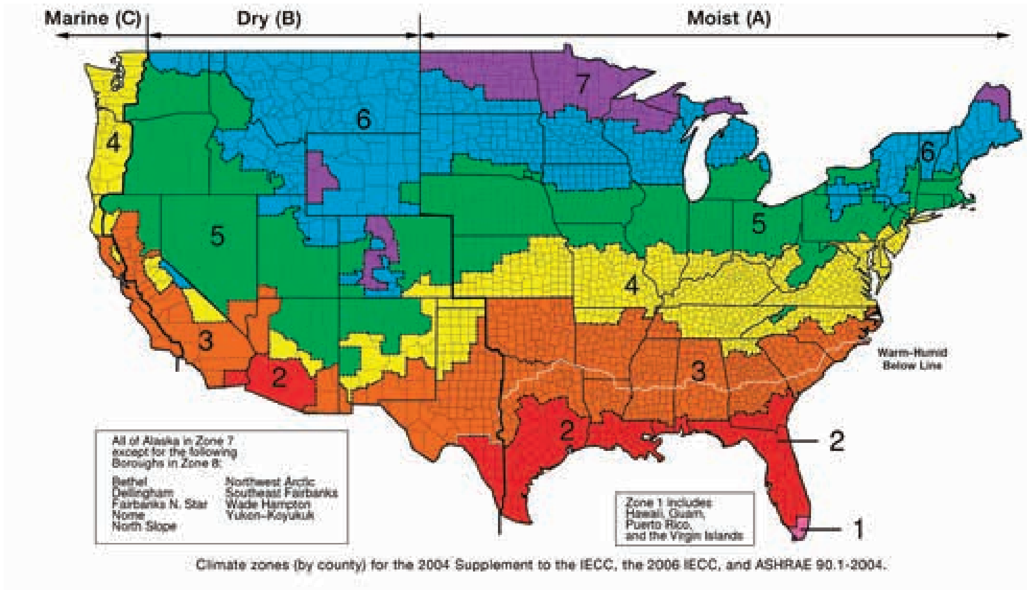



*Figure 1: United States climate zone map based on ASHRAE 90.1-2010 standard. Source: www.ashrae.org*

| Table 6.5.6.1 ASHRAE 90.1 2010 Standard Energy Recovery Requirement | | | | | | |
|---|---|---|---|---|---|---|
| Zone | Percentage of Outdoor Air at Full Design Airflow Rate (cfm) | | | | | |
| | 30% ≤ 40% | 40% ≤ 50% | 50% ≤ 60% | 60% ≤ 70% | 70% ≤ 80% | ≥ 80% |
| | Design Supply Fan Airflow Rate (cfm) | | | | | |
| 3B, 3C, 4B, 4C, 5B | NR | NR | NR | NR | ≥ 5,000 | ≥ 5,000 |
| 1B, 2B, 5C | NR | NR | ≥ 26,000 | ≥ 12,000 | ≥ 5,000 | ≥ 4,000 |
| 6B | ≥ 11,000 | ≥ 5,500 | ≥ 4,500 | ≥ 3,500 | ≥ 2,500 | ≥ 1,500 |
| 1A, 2A, 3A, 4A, 5A, 6A | ≥ 5,500 | ≥ 4,500 | ≥ 3,500 | ≥ 2,000 | ≥ 1,000 | ≥ 0 |
| 7, 8 | ≥ 2,500 | ≥ 1,000 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 |

NR = Not required

As shown on the map in Figure 1, each zone consists of a number and a letter associated with that area. The correlating number of each zone is based on weather bin data, with seven different temperature zones across the map. The letter represents the humidity in each area which is separated into either an A, moist region, B, dry region, or C, marine region. Table 6.5.6.1 in ASHRAE 90.1-2010 dictates the use of energy recovery based on climate zone, supply air volume, and outdoor air percentage at design airflow.

For example, if a unit is being designed for 100% outdoor air in Chicago, Illinois, the map and table can be used to determine the supply cfm when energy recovery is required. Based on the map in Figure 1, Chicago, Illinois is in Zone 5A. Table 6.5.6.1 can be used to determine when energy recovery is required for a 100% outdoor air unit. By following the row that includes Zone 5A to the ≥80% column, energy recovery is required at supply airflow rates ≥ 0 cfm. This means all 100% outdoor air units are required to use energy recovery where ASHRAE 90.1-2010 / 2012 IECC is enforced in Zone 5A. ASHRAE 90.1-2010 requires the energy recovery system to have a total effectiveness of **greater than or equal to 50%**.

If a unit were designed for only 30% outdoor air in the same Zone 5A, energy recovery would be required at a supply cfm of ≥ 5,500 cfm which is determined by using the same Table 6.5.6.1.

## ASHRAE 90.1-2013/2015 IECC Energy Recovery Requirements

When energy recovery is applied to systems in operation for extensive periods of time, such as 24 hour operation 7 days a week, significant energy savings can be achieved. Because of this, the ASHRAE 90.1-2013 standard, which is adopted into the 2015 IECC, takes operating hours into account when defining energy recovery requirements. This version uses a similar climate zone map as Figure 1 to determine the zone where the unit is being applied, but now two tables are referenced. One table is used when the unit is operating less than 8,000 hours per year and the other is for greater than or equal to 8,000 hours per year (equivalent to ≥ 22 hrs. per day.)

**ASHRAE 90.1 2013 Standard For Energy Recovery Requirement Based On Operating Hours Per Year**

**Ventilation Systems Operating Less Than 8,000 Hours Per Year**

| Zone | Percentage of Outdoor Air at Full Design Airflow Rate (cfm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10% ≤ 20% | 20% ≤ 30% | 30% ≤ 40% | 40% ≤ 50% | 50% ≤ 60% | 60% ≤ 70% | 70% ≤ 80% | ≥ 80% |
| | Design Supply Fan Airflow Rate (cfm) | | | | | | | |
| 3B, 3C, 4B, 4C, 5B | NR | NR | NR | NR | NR | NR | NR | NR |
| 1B, 2B, 5C | NR | NR | NR | NR | ≥ 26,000 | ≥ 12,000 | ≥ 5,000 | ≥ 4,000 |
| 6B | ≥ 28,000 | ≥ 26,500 | ≥ 11,000 | ≥ 5,500 | ≥ 4,500 | ≥ 3,500 | ≥ 2,500 | ≥ 1,500 |
| 1A, 2A, 3A, 4A, 5A, 6A | ≥ 26,000 | ≥ 16,000 | ≥ 5,500 | ≥ 4,500 | ≥ 3,500 | ≥ 2,000 | ≥ 1,000 | ≥ 0 |
| 7, 8 | ≥ 4,500 | ≥ 4,000 | ≥ 2,500 | ≥ 1,000 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 |

NR = Not required

**ASHRAE 90.1 2013 Standard For Energy Recovery Requirement Based On Operating Hours Per Year**

**Ventilation Systems Operating Greater Than or Equal To 8,000 Hours Per Year**

| Zone | Percentage of Outdoor Air at Full Design Airflow Rate (cfm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10% ≤ 20% | 20% ≤ 30% | 30% ≤ 40% | 40% ≤ 50% | 50% ≤ 60% | 60% ≤ 70% | 70% ≤ 80% | ≥ 80% |
| | Design Supply Fan Airflow Rate (cfm) | | | | | | | |
| 3C | NR | NR | NR | NR | NR | NR | NR | NR |
| 1B, 2B, 3B, 4C, 5C | NR | ≥ 19,500 | ≥ 9,000 | ≥ 5,000 | ≥ 4,000 | ≥ 3,000 | ≥ 1,500 | ≥ 0 |
| 1A, 2A, 3A, 4B, 5B | ≥ 2,500 | ≥ 2,000 | ≥ 1,000 | ≥ 500 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 |
| 4A, 5A, 6A, 6B, 7, 8 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 | ≥ 0 |

NR = Not required

## Additional Requirements

When the IECC requires energy recovery, certain criteria must be met with the energy recovery system. Per 2012 IECC, Section C403.2.1, "*Heating and cooling loads shall be adjusted to account for load reductions achieved where energy recovery systems are required.*" In other words, the system cannot be oversized to meet the required loads as if the energy recovery device were not present. This makes certain the energy recovery device is used to ensure the most energy savings.

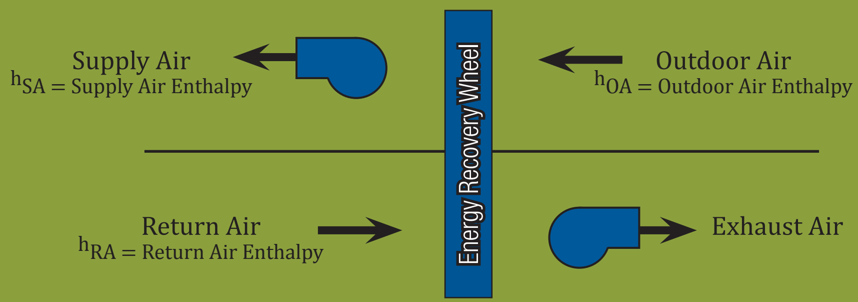
Another requirement of the 2012 IECC found in section C403.2.6 states, "*Where an air economizer is required, the energy recovery device shall include a bypass or controls to permit economizer operation where required.*" Economizer control allows for unconditioned outdoor air to be utilized for free cooling when conditions are within an acceptable range. Using a bypass damper around the energy recovery device, modulating an energy wheel, or stopping an energy wheel reduces the energy transfer between outdoor and exhaust airstreams and allows for free cooling when outdoor air conditions are conducive for an economizer sequence.

## What Does 50% Total Effectiveness Mean?

"Total Effectiveness" being greater or equal to 50%, as defined by ASHRAE Standard 90.1, is the difference in the enthalpy of the outdoor air and supply air equal to 50% or greater of the difference between the outdoor air and return air enthalpies at design conditions. Enthalpy includes both the sensible (heat) and latent (moisture) energy, so it encompasses the dry air temperature and its contained moisture. Sensible devices, which only transfer heat, not moisture, will have a lower total effectiveness than a device that transfers both sensible and latent energy. Below is the equation of how total effectiveness is calculated based on the ASHRAE 90.1 Standard.

**Total effectiveness must be greater than or equal to 50% based on the ASHRAE 90.1 Standard which is calculated based on the enthalpy differences of the airstreams in the equation below.**

$$\text{Total Effectiveness} = \frac{h_{OA} - h_{SA}}{h_{OA} - h_{RA}} \geq 0.50$$




It is important that the total effectiveness is calculated based on ASHRAE 90.1 as it is adopted into the IECC. AHRI 1060 also has an equation for total effectiveness, however it can be misinterpreted at unbalanced airflows and not meet the total effectiveness requirement. It's important that the outdoor air and return airflows are balanced as closely as possible to ensure a high total effectiveness resulting in more energy savings for building owners and further assurance that the 50% total effectiveness code requirement is satisfied.

## Exceptions

There are certain applications that do not require the use of air-to-air energy recovery devices. These include laboratory fume hood exhaust, kitchen exhaust, and make-up air used for process exhaust applications. These applications have exhaust air that cannot re-enter the supply airstream, so no cross leakage through energy recovery devices can occur. Spaces that are heated to less than 60°F also do not require energy recovery devices.

2012 IECC specifies certain climate zones where energy recovery is not required due to relatively mild climactic conditions throughout the year. Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8 do not require energy recovery for cooling applications and Zones 1 and 2 do not require energy recovery for heating.

In these zones, even if energy recovery is not required for cooling mode it may be required for heating mode as it will produce significant energy savings, and vice versa. For example, much of the state of Utah falls in Zone 5B, so energy recovery is not required for cooling due to a relatively mild and dry summer. However, air-to-air energy recovery can greatly reduce the heating capacity required in winter months which will significantly reduce operating costs.

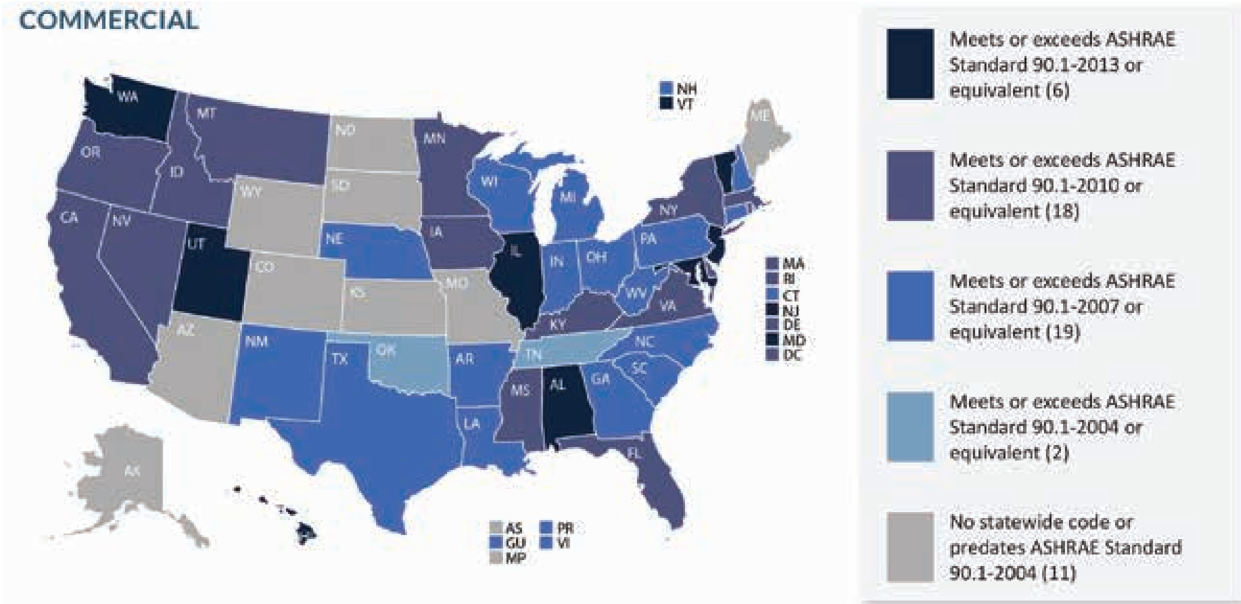



*Figure 2: The commercial state energy code status of ASHRAE 90.1 standard adopted into the IECC building code as of July 2016*
*Source: http://bcap-energy.org/code-status/*

## Commercial State Energy Code Status of ASHRAE Standard 90.1

Many states have adopted the ASHRAE Standard 90.1 requirements into their energy codes. Figure 2 is a map indicating which version of ASHRAE Standard 90.1 has been adopted at the state level. As of July 2016, the majority of states are either on the 2007 or 2010 version of ASHRAE Standard 90.1, while eight states are currently on the 2013 version of ASHRAE Standard 90.1.

Additionally, many states [in gray] have adopted different versions of ASHRAE 90.1 at a city or county level rather than on a state level.

## Summary

With the continuous development and adoption of ASHRAE Standard 90.1 into the IECC at state and local levels, air-to-air energy recovery will be required more often across various applications. ASHRAE 90.1-2010 bases the requirement of energy recovery on the climate zone and percentage of outdoor air. ASHRAE 90.1-2013 expands on the 2010 version of the standard with additional requirements based on annual operational hours. This enables commercial building owners to further reduce operating costs through energy recovery devices with a total effectiveness **greater than or equal to 50%**. As many states and local jurisdictions continue to adopt ASHRAE 90.1-2010 and 2013 into energy codes, building owners will capitalize on the benefits that energy recovery offers, such as:

1. Reducing the cooling and heating capacity required for a system
2. Reduction in energy consumption for a system
3. Reduction in variability in air conditions entering the cooling and heating systems.

Having a clear understanding of the requirements and adoption of ASHRAE Standard 90.1 into the International Energy Conservation Code (IECC) at state and local levels will allow building owners to capture the economic and performance benefits of efficient ventilation systems through the use of air-to-air energy recovery.

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