WHAT IS THE PURPOSE OF THIS REQUIREMENT?

Economizing refers to the use of outdoor air to provide building cooling. This approach reduces the annual hours of mechanical cooling system operation. There is a choice of economizer methods – air economizer or water economizer. Proper application of these systems can significantly reduce mechanical cooling energy used by air conditioning systems.

Fundamentals of air economizer

An air economizer is an integrated system of outside air and return air dampers, linkages, actuators, sensors and controllers in an air handling system (Figure 1). Operational controls determine when to automatically change the position of outside and return air dampers to provide 100% of the design supply air as outside air to reduce or eliminate the need for mechanical cooling.

There are two methods of enabling air economizer control:

> **Dry Bulb** – Employs standard temperature sensing in both return and outside air streams. If outside air is cooler than return air, and cooling is required, economizer is enabled.

> **Enthalpy** – Operates similarly to dry bulb, but uses more accurate enthalpy sensors to compare energy content of return and outside air streams in order to enable economizer.

There are four operating modes in an air economizer system:

> **Heating mode** – When the air handler is heating during cold weather air economizer is not enabled. The outside air damper remains at its minimum ventilation position to limit the amount of cold outdoor air that is mixed with the return air.

> **Modulated economizer mode** – When the air handler is cooling during cool weather, outdoor air is mixed with return air so the resulting supply air temperature is sufficient to condition the building. This is accomplished without mechanical heating or cooling. This is also referred to as “free cooling.”

> **Integrated economizer mode** – When the air handler is cooling during moderate weather, outdoor air temperature might be between the return air and the supply air temperature. The outside air damper is adjusted to full open position, the return air damper is fully closed, and the mechanical cooling system is then operated simultaneously.

> **Mechanical cooling mode** – When the air handler is cooling during hot weather, air economizer is disabled and the outside air damper remains at the minimum ventilation position. The mechanical cooling system provides all necessary cooling.
It is important that all components of an air economizer system function properly. Outside air sensors must be installed where they can sense the true outdoor air temperature. Dampers, actuators and linkages need to respond correctly when the controller calls for damper position adjustment. At minimum a poorly functioning air economizer represents a loss of opportunity for mechanical cooling energy savings. Worst case, it can significantly increase energy usage by introducing too much outdoor air during very cold and very warm outdoor conditions. Therefore it is important that air economizer systems be tested for proper performance when installed and serviced regularly to ensure all components continue to function optimally.

**Fundamentals of water economizer**

A water economizer is a system by which the return air of a cooling system is cooled directly, indirectly or both, by evaporation of water or by other appropriate fluids such as glycol, to reduce or eliminate the need for mechanical refrigeration. There are two primary types of water economizer – for systems with chillers (Figure 4) and for systems without (Figure 3). In both cases, the economizer enabling sensors determine when to speed up the cooling tower fans in order to reduce its fluid to a temperature below the supply air temperature. When this cold water or glycol is recognized at the air handler (Figure 3) or the heat exchanger (Figure 4), their pre-cooling valves (labeled “A” in each figure) modulate open to maintain air temperature (Figure 3), or the chilled water supply temperature (Figure 4, with additional pumps operating). In integrated economizer mode, a head pressure regulating valve (labeled “B” in each figure) may be required for refrigeration to operate reliably.
WHAT DOES THE WSEC REQUIRE?

The WSEC defines prescriptive application, operational requirements and exceptions for air and water economizer systems. As a general rule, full air economizer capability is required for all new systems. Air economizer requirements and exceptions for Simple Systems (WSEC 1424) are identical to those required for Complex Systems (WSEC 1433). Simple Systems refer to packaged unitary equipment. An alternate compliance path is described in WSEC Figure 14A and Chapter 4 – Systems Analysis. This can be used to demonstrate how certain provisions for energy recovery can save more energy than a prescriptive economizer so these advanced designs may be permitted for Energy Code compliance.

Air Economizers

An air economizer system shall be capable of adjusting both outside air and return air dampers to the 100% outside air position when outdoor conditions are suitable to reduce or eliminate the need for mechanical cooling. This includes appropriate provisions for relief of this excess outside air to prevent building over-pressurization (WSEC 1413.1). Relief air dampers shall be motorized (WSEC 1412.4.1 with exceptions).

Air economizer controls shall be capable of integrated operation where economizer operation and mechanical cooling can occur simultaneously when needed to meet the cooling load. An exception is allowed for direct expansion units with a rated capacity less than 65,000 btu/h. (WSEC 1413.3)

NOTE – Economizer damper and control packages are available for small fan coils and can be controlled from appropriate stand alone thermostats. Building management systems are not required for cost effective and reliable economizer installations on small systems.

If humidification equipment is needed to maintain minimum indoor humidity levels in a system with a requirement for air economizer, then the humidifier shall be the adiabatic type (direct evaporative media or fog atomization type). Exceptions to this requirement apply to: specific health care facilities, 100% outside air systems, stand alone or duct mounted humidifiers serving no more than 10% of the air economizer capacity of all mechanical systems serving the building, or systems with water economizer. (WSEC 1413.4)

There are a variety of exceptions to the air economizer requirements under WSEC 1433. Some exceptions demonstrate alternative options that if applied within the parameters defined will likely provide similar energy savings to an equally sized system with air economizer. A few apply to unique situations where the air economizer would actually increase the energy used by the mechanical system. Many exceptions require that equipment have efficiency ratings that are better than the minimum requirements listed in mechanical equipment efficiency WSEC Tables 14-1A through 14-1G.

The following represents a summary of the available exceptions to WSEC 1433 economizer requirements:

> **Qualifying small equipment – Exception 1**
Capacity of an individual unit can be no greater than 33,000 btu/h. Equipment must have SEER and EER values at least 15% better than the efficiency table values. In addition, the total capacity of all qualifying small systems in a building cannot exceed either 72,000 btu/h or 5% of the air economizer capacity of all mechanical systems serving the building, whichever is greater. This exception does not apply to unitary cooling equipment installed outdoors or located in any room that has an exterior building envelope element, be it wall, floor, or ceiling. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement. It only applies to existing buildings with previous tenant improvement build-outs.

> **Chilled water terminal units – Exception 2**
Applies to chilled water terminal units connected to systems with chilled water generation equipment with IPLV values that are at least 25% better than minimum part load efficiencies listed in WSEC Table 14-1C. The total capacity of all systems in the building that do not comply with air economizer requirements cannot exceed 480,000 btuh/h or 20% of the air economizer capacity of all mechanical systems serving the building, whichever is greater. Additional limitations apply. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement. It only applies to existing buildings with previous tenant improvement build-outs.

> **Onsite energy – Exception 4**
Applies to a system where at least 75% of the annual energy it uses for mechanical cooling is being generated with site-recovered or site-solar energy sources. Recovered energy is defined as energy captured and utilized which would otherwise have been wasted. Solar energy sources are defined as natural daylighting and thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

> **Unusual outdoor air contaminate conditions – Exception 5**
Systems where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes an air economizer infeasible.

> **Dehumidification – Exception 6**
Systems with dehumidification requirements where air economizer would increase overall building energy consumption.
Water source heat pump systems – Exception 7
All required parameters must be met to be eligible. It shall consist of multiple water source heat pumps that are connected to a common loop. Heat pumps shall have a cooling EER and heating COP that are at least 15% better than the WSEC equipment efficiency table values. Air systems shall have at least 60% air economizer and a minimum of 50% heat recovery effectiveness. If provided with a boiler or furnace that is less then 199,000 btu/h, this equipment shall be rated to at least 90% AFUE.

Group R occupancy small system – Exception 8
For equipment installed outdoors or in a room adjacent to the outdoors, cooling capacity of an individual unit can be no greater than 20,000 btu/h. For all other applicable equipment, cooling capacity of an individual unit can be no greater than 54,000 btu/h. For split systems, these limits are based on the cooling capacity of individual fan coils. Cooling systems shall have SEER and EER values at least 15% better than listed in WSEC Tables 14-1A, 14-1B and 14-1D. Chillers with fan coil units or variable refrigerant flow (VRF) systems do not qualify for this exception as they are not covered in WSEC Tables 14-1A, 14-1B, and 14-1D.

Computer and data processing center cooling equipment – Exception 9, parts F and G
Applies to equipment used to cool any dedicated server room, electronic equipment room or telecom switch room provided that they completely comply with Option 9a, 9b, or 9c in the Exception 9 Table below. This applies to equipment subject to the performance requirements of ASHRAE Standard 127-2007 Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners. EER and IPLV values shall be equal to or better than the WSEC equipment efficiency table values.

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Higher Efficiency</th>
<th>Part-Load Control</th>
<th>Economizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 9a</td>
<td>Table 14-1A and 14-1B</td>
<td>+15%</td>
<td>Required Over 85,000 Btu/h</td>
</tr>
<tr>
<td>Option 9b</td>
<td>Table 14-1A and 14-1B</td>
<td>+5%</td>
<td>Required Over 85,000 Btu/h</td>
</tr>
<tr>
<td>Option 9c</td>
<td>ASHRAE Standard 127</td>
<td>+0%</td>
<td>Required Over 85,000 Btu/h</td>
</tr>
</tbody>
</table>

WSEC 1433 - Exception 9 Table

Variable refrigerant flow (VRF) systems – Exception 10
System shall be capable of serving multiple zones in both heating and cooling mode simultaneously by transferring energy from one zone to the other. System shall serve at least 20% internal and 20% perimeter zones for load diversity. Outdoor unit shall be a reverse-cycle heat pump with variable speed compressor and condenser fan with at least 65,000 btu/h in total capacity. This exception is limited to buildings of 60,000 SF or less. It cannot be applied to portions of buildings.

Water Economizers
A water economizer system may be provided in lieu of an air economizer system when allowed under WSEC 1132.2 Exception 1 or WSEC 1433 Exceptions 3 and 9. When selected as an alternative to air economizer, the water economizer system shall be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking air economizer. This concurrent load is calculated based on outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. For this calculation all load factors including solar gain and internal loads (such as occupant and plug loads) shall be based on load peaks, except for the outside temperatures (WSEC 1413.1). Specific documentation requirements for this system type are defined in WSEC 1413.2. System controls shall be capable of integrated operation similarly to air economizer systems. The only exception to the integrated operation requirement is for water-cooled water chillers.

Under WSEC 1433, the two exceptions that allow water economizer systems are:

Chilled beams and chilled ceiling systems – Exception 3
Applies to water-cooled refrigeration equipment serving chilled beams and chilled ceiling (space cooling) systems only, which are provided with a water economizer meeting the requirements of WSEC 1413. Maximum capacity of this system shall not exceed 500 tons. Terminal chilled water units other than chilled beams and chilled ceilings do not qualify under this exception.

Cooling equipment serving dedicated server rooms, electronic equipment rooms or telecom switch rooms - Exception 9, parts A through E
Applies to equipment used to cool any dedicated server room, electronic equipment room or telecom switch room provided that they completely comply with option 9a, 9b, or 9c in the Exception 9 Table. In addition to the water economizer requirements described above, this equipment shall be served by a dedicated condenser water system. A non-dedicated condenser water system may be approved if it can provide appropriate water temperatures during hours when waterside economizer cooling is available. Under this exception the total allowed capacity of cooling systems without economizers shall not exceed 240,000 btu/h or 10% of the air economizer capacity of all mechanical systems serving the building. Additional requirements apply.
Existing Mechanical System Additions, Alternation and Repairs

New mechanical systems installed in an existing building, or existing mechanical systems that are altered or replaced, shall comply with all requirements of WSEC Chapter 14 Mechanical Systems. This includes all economizer performance and integrated operation requirements identified in WSEC 1413, 1423 and 1433. Refer to WSEC 1132.2 Alterations and Repairs, Mechanical Systems for complete requirements.

Alterations to existing mechanical cooling systems cannot decrease the existing economizer capacity unless provisions are included that make the system eligible for an economizer exception. Such systems applying for economizer exceptions have to comply with individual equipment sizing limits and whole building capacity limits based on the air economizer capacity of all mechanical systems serving the building. For existing mechanical cooling systems that do not comply with WSEC 1413 and either WSEC 1424 or 1433, including individual unit size limits and total building capacity limits, the alteration shall then comply with WSEC Table 11-1.

There are three categories per equipment type in WSEC Table 11.1. Under each category unique exceptions to WSEC 1433 requirements are listed.

> Replacement unit of the same type with the same or smaller output capacity

In general, if the replaced unit did not have economizer, economizer will not be required with certain caveats such as high efficiency required for compressorized gear.

> Replacement unit of the same type with a larger output capacity

In general, if the replaced unit did not have economizer, and was originally installed prior to 1991, economizer may not be required with certain caveats. Otherwise, full compliance with WSEC 1433 is required.

> New equipment added to existing system or replacement unit of a different type

If new terminal equipment is added to particular pre-1991 central systems, economizer may not be required with certain caveats. Otherwise, full compliance with WSEC 1433 is required.

Recommendations for optimal long-term economizer performance

Economizer commissioning procedure

> Set up false temperature readings through the building management system or by increasing the temperature at outdoor air temperature sensor (electric hair dryer or similar approach). Compare the response of the economizer damper to the design intent.

> Install temperature data-loggers or use building management system (BMS) trend logging capabilities to measure the outside air, return air, supply air, and mixed air streams. Monitor dataloggers or BMS trending for a minimum period of two weeks.

> If post occupancy, look for large peaks compared to historical billing data in energy use during summer & winter.

Economizer recommended maintenance

> As air flows over the outside-air damper and into the building, dirt and moisture accumulate on the damper and its linkages. Unless regularly cleaned and lubricated, these components can eventually corrode and lock up.

> Check for burned out damper motors.

> Check for actuators that come loose from their mounting position with difficulty transferring torque to the damper.

> Check and calibrate temperature sensors.

> Annually re-commission the economizer. Run a functional performance test to demonstrate proper operation of the physical components of the system.

Additional Resources


> NREC Compliance Forms, MECH-ECO Economizer Flowchart – www.neec.net/energy <http://www.neec.net/energy> codes


Technical content contributed by:

Rushing

McKinsey

For The Life Of Your Building

2009 Washington State Energy Code (WSEC)
Several technical resources are available in support of the 2009 Washington State Non-Residential Energy Code (NREC).

Refer to the NEEC website under the Energy Codes tab – http://www.NEEC.net/energycodes
All of these resources are available for download from our website.

**COMPLIANCE FORMS**
NREC compliance forms have been designed as tools to help designers comply with the Energy Code, and to assist building officials, plans reviewers and inspectors with enforcement of the Energy Code. The following forms are available:

- Building Envelope Compliance Forms
- Lighting Compliance Forms
- Energy Metering Compliance Forms
- Mechanical Systems Compliance Forms

**WEBINARS**
Recorded webinars are available for the following topics:

- NREC Chapter 13 – Building Envelope
- NREC Chapter 14 – Mechanical System
- NREC Chapters 12 & 15 – Lighting and Energy Metering
- NREC Compliance Forms Instructions
- Continuous Insulation

**FACT SHEETS**
Detailed fact sheets are available for several key topics in the NREC that provide context to Code requirements and perspective from industry experts.

- Air Barrier Management
- Continuous Insulation
- Daylighting Controls
- Economizer
- Energy Recovery
- Solar Gain Management

**ADDITIONAL RESOURCES**


- **Classroom Training Presentation** – NEEC presented classroom trainings around the state that provided a summary of updates and additions to the NREC from the 2006 to the 2009 Energy Code edition. Presentation material is available.

- **Air Leakage Test Protocol for Measuring Air Leakage in Buildings** – The 2009 NREC has requirements for air pressurization/depressurization testing for some buildings. The U.S. Army Corps of Engineers has published an air leakage test protocol that may be helpful to those needing more information on this procedure.