NEEC
NORTHWEST ENERGY EFFICIENCY COUNCIL

Energy Recovery Fact Sheet

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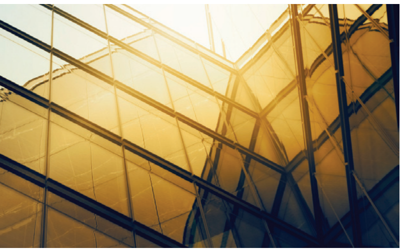
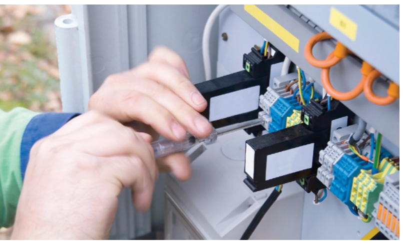
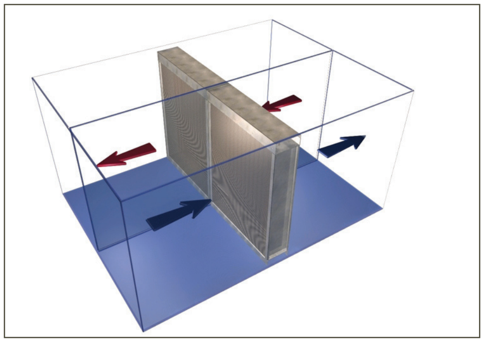




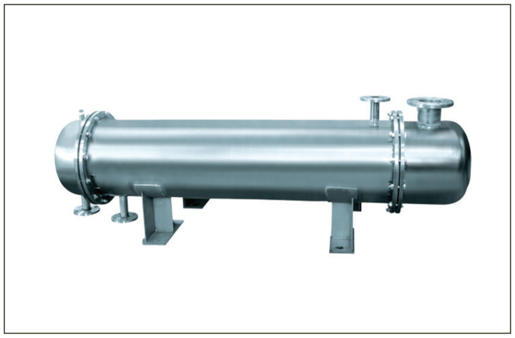
WHAT IS THE PURPOSE OF THIS REQUIREMENT?

Energy recovery strategies can be defined as waste energy sources that are paired with concurrent energy needs. Waste energy sources are opportunities within a system where heat energy of sufficient temperature (or quality) is recovered in a manner where it can be re-used. Similar to water re-use strategies, energy recovery systems provide the capability of re-using energy that would normally be discarded. This in turn reduces the amount of energy needed for various mechanical system operations. Examples of waste energy sources include heated building air that would normally be exhausted, condenser water from various refrigeration cycle systems or electronic equipment to be cooled (e.g. a server or MDF room). Energy from these sources is used to heat or preheat ventilation air, domestic hot water, building hydronic heating water, and other building systems that require heat energy.

There are a variety of system options available for energy recovery. Product efficiencies vary from 40% to as high as 80% depending on the application and waste energy source quality. Some energy recovery systems only capture sensible heat while others are capable of capturing both sensible and latent energy. Air-to-air energy recovery equipment include heat pipes, rotary enthalpy wheels and cross-flow or counter-flow heat exchangers. Liquid based equipment include run-around coils, shell and tube heat exchangers, plate and frame heat exchangers, heat recovery chillers and heat pumps.

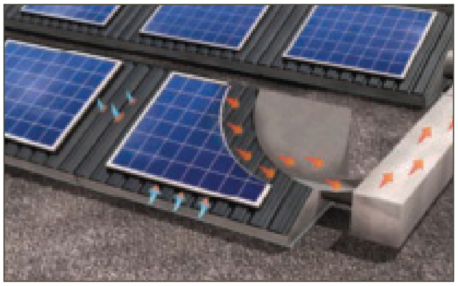


Example of a heat pipe air-to-air energy recovery system.



Example of shell and tube heat exchanger.

In some cases, site-recovered or site solar energy resources may be applied in lieu of energy recovery. Per WSEC definitions, a solar energy resource is a source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation. In the context of energy recovery alternatives, applicable solar energy systems include solar hot water heating systems, solar ventilation air pre-heating systems, and others.



Solar ventilation air pre-heating systems.

In building types where there are multiple sources of waste heat energy, it is feasible to capture nearly 100% of the needed energy for domestic hot water heating.

WHAT DOES THE WSEC REQUIRE?

Energy recovery is required in a variety of mechanical system situations throughout WSEC Chapter 14. These requirements are limited to projects following the Complex Systems compliance path. Projects utilizing the Simple Systems compliance path are not required to have energy recovery.

WSEC requirements focus on waste energy from exhaust air streams, steam condensate, and refrigeration condenser water. Energy recovery equipment is required to have a certain level of recovery effectiveness, meaning that the equipment is capable of capturing a prescribed minimum percentage of the waste energy available.

In many cases the WSEC allows the energy recovery requirements to be met through capture of site solar source energy in lieu of energy recovery from exhaust air, steam condensate, or condenser water systems. Calculations are required to determine the amount of annual energy that would be captured through the required energy recovery system. The site solar source system must then be capable of capturing an equal or greater amount of energy at a similar quality, on an annual basis.

Note that in discussions about energy recovery, the terms heat recovery and energy recovery are often used interchangeably.

Exhaust air systems energy recovery

Heat energy is captured from exhaust air streams and used through a heat exchange system to pre-heat the ventilation air. There are a variety of exhaust air energy recovery approaches available in the market and the option(s) most effective and economical will vary depending on project parameters. The WSEC does not define which method of energy recovery must be used. It only states what minimum energy recovery effectiveness the system must be capable of delivering. Note that for all air systems required to have energy recovery, provisions shall be made to bypass or otherwise control the energy recovery system so that the fan system is also capable of providing full air economizer cooling operation as required per WSEC 1433.

All fan systems except those serving laboratory or indoor heated pool exhaust

WSEC 1436.1 states that all fan systems with a minimum outdoor air capacity of 5,000 cfm or greater shall have an energy recovery system capable of at least 50% recovery effectiveness. In this context, 50% recovery effectiveness means an increase of the outside air supply temperature at design heating conditions of one half the difference between the outdoor design air temperature and 65°F. Where a single room or space is supplied by multiple fan units, the aggregate ventilation (cfm) of those units shall be used in applying this requirement.

There are a variety of exceptions to air system energy recovery requirements. They apply where the process of energy recovery would potentially increase energy use or where an energy recovery system may adversely affect the system it is associated with. Exceptions also allow for alternatives that provide for similar energy savings as the energy recovery requirements. Exceptions only apply to the particular exhaust subsystems described. The remaining cfm of the main supply system is subject to the energy recovery requirements.

Fan system energy recovery exceptions include:

- *Systems serving spaces heated to less than 60°F.*
- *Systems which can be shown to use as much energy with the addition of energy recovery equipment as without it.*
- *Systems exhausting toxic, flammable, paint exhaust or corrosive fumes making the installation of energy recovery equipment impractical.*
- *Type I commercial kitchen hoods.*
- *Systems that only provide cooling.*
- *Air handling units or air conditioning units where the minimum outdoor air is less than 70% of total supply air.*

Example Problem
At outdoor design conditions of 20°F, a counterflow heat exchanger increases the temperature of the incoming outside air to 50°F.

Compliance Result
Target design supply air temperature is 65°F. The increase in outside air temperature through energy recovery is 30°F. The difference between the 20°F outside air and the design supply air is 45°F. Therefore, the heat recovery effectiveness is:

$(50 - 20) / (65 - 20) = 30 / 45 = 0.67$

This exceeds the NREC 50% effectiveness requirement.

Laboratory exhaust fan systems

Systems serving laboratories have unique parameters and limitations, therefore the energy recovery requirements defined in the WSEC for these systems are slightly different. WSEC 1439.2 states that buildings with laboratory exhaust systems having a total exhaust rate greater than 5,000 cfm shall include energy recovery systems to preconditioned makeup air from laboratory exhaust. The energy recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 25°F (13.9°C) in Climate Zone 1 and 35°F (19.4°C) in Climate Zone 2.

There are two laboratory specific exceptions noted in WSEC 1439.2 and 1436.1:

- *Laboratory systems equipped with both variable air volume supply and variable air volume or two-speed exhaust fume hoods. Additional documentation requirements apply.*
- *Variable air volume exhaust and room supply systems capable of reducing exhaust and makeup air volumes combined with an energy recovery system to precondition makeup air from laboratory exhaust. To qualify this combined system shall produce the same energy reduction as achieved by an energy recovery system with 50% sensible recovery effectiveness. This is referred to as the Combined Energy Reduction Method. Calculation procedure is provided in the WSEC.*

Indoor heated pool exhaust fan systems

Heated indoor swimming pools, spas or hot tubs with water surface area greater than 200 square feet shall have an exhaust air energy recovery system that heats ventilation air, pool water or domestic hot water. The heat recovery system shall be capable of decreasing the exhaust air temperature at design heating conditions (80°F indoor) by 36°F (10°C) in Climate Zone 1 and 48°F (26.7°C) in Climate Zone 2.

Exception to this requirement is allowed for pools, spas or hot tubs if they have systems that provide equivalent recovered energy on an annual basis through one of the following methods:

- *Renewable energy*
- *Dehumidification heat recovery*
- *Waste heat recovery*
- *A combination of these methods capable of providing at least 70% of the heating energy required over an operating season.*

Steam condensate and condenser water energy recovery

Waste heat energy is captured from steam condensate or condenser water and used through heat exchangers to pre-heat domestic hot water (or service water) or building hydronic heating water. In building types where there are multiple sources of waste heat energy, it is feasible to capture nearly 100% of the needed energy for domestic hot water heating.

Steam condensate

Per WSEC 1436.2, on-site steam heating systems shall have condensate water recovery. On-site steam systems are those that are located within or adjacent to one or more buildings that are under one ownership. This includes steam generators in laboratories and hospitals and campus steam systems located in a central plant. Buildings using steam generated off-site, such as through a district steam utility, are also required to have condensate water recovery if the off-site source does not. Note that condensate water recovery is not energy recovery and therefore this requirement alone does not meet energy recovery requirements in other sections.

Condenser water applications except those serving grocery and food service

WSEC 1436.3 and WSEC 1445 state that energy recovery is required from condenser water. Process cooling systems are common applications. Waste heat energy from these systems shall be utilized for the heating or preheating of domestic hot water.

This requirement only applies if all three of the following parameters are true:

- *The facility (or its process cooling) operates 24 hours a day.*
- *The total installed heat rejection capacity of the water-cooled systems exceeds 1,500,000 Btu/h of heat rejection.*
- *The capacity of service water heating equipment exceeds 250,000 Btu/h.*

This energy recovery system shall have the capacity to provide one of the following three options, whichever is least:

- *60% of the peak heat rejection load at design conditions*
- *Preheat of the peak service hot water draw to 85°F*
- *50% of the service water heating load*

Exception to this requirement is allowed for facilities that apply condenser heat recovery to space heating (specific parameters apply), or if 60% of domestic water heating energy comes from site solar or site recovered energy or other sources.

Grocery and food service condenser energy recovery

WSEC 1436.4 requires condenser energy recovery for grocery and food service facilities that have system capacities that exceed the following thresholds:

- *Facilities having food service, meat or deli departments and have 500,000 Btu/h or greater of remote refrigeration.*
- *Facilities having a gross conditioned floor area of 40,000 ft2 or greater and 1,000,000 Btu/h or greater of remote refrigeration.*

These systems shall have condenser energy recovery from freezers and coolers. Recovered energy shall be used for domestic water heating, hydronic heating water (for space heating) or for dehumidification reheat used to maintain low space humidity.

Other Applications of Energy Recovery in WSEC

There are various situations where energy recovery or site-recovered energy may be applied in lieu of other WSEC requirements.

> ***WSEC 1412.8 –*** *Demand controlled ventilation (DCV) is required for high-occupancy areas that fall within the prescribed parameters. An energy recovery system that complies with all applicable requirements of WSEC 1436 may be used in lieu of DCV controls.*

> ***WSEC 1432.2.1 –*** *Air systems that supply heated or cooled air to multiple zones are required to include controls that automatically reset supply air temperatures by representative building loads. If 75% of the energy needed for reheating comes from site-recovered or site solar energy sources then this system does not have to have supply air reset controls.*

> ***WSEC 1433 –*** *All new air systems are required to have full economizer capability. If 75% of the energy needed for mechanical cooling comes from site-recovered or site solar energy sources then this system does not have to have full air economizer capability.*

> ***WSEC 1435 –*** *Zone thermostatic and humidistatic controls that are capable of operating, in sequence, the supply of heating and cooling energy to the zone are required. These controls prevent simultaneous heating and cooling. These controls are not required if the zone receives at least 75% of the energy for reheating, or for providing warm air in mixing systems, from a site-recovered or site solar energy source.*

> ***WSEC 1438.3 –*** *Single or multiple fan systems that serve large zones and provide a total airflow over 10,000 cfm are required to have variable speed fan control and zone controls that reduce airflow based on space heating and cooling demand. These components are not required for these fan systems if a dedicated outdoor air supply unit(s) with energy recovery is provided.*

Additional Resources

> ***2009 ASHRAE Handbook of Fundamentals –*** ***http://www.ashrae.org/publications/page/158***

> ***Air-Conditioning, Heating and Refrigeration Institute (AHRI) Guideline V; Calculating the Efficiency of Energy Recovery Ventilation and Its Effect on Efficiency and Sizing of Building HVAC Systems – http://www.ahrinet.org/App_Content/ahri/files/Guidelines/AHRI-Guideline%20V-2003.pdf***

Energy Recovery Strategies

> ***Heat recovery chillers –*** *Buildings such as hospitals and laboratories have substantial requirements for ventilation leading to concurrent heating and cooling needs. Heat recovery chillers provide a means of utilizing waste heat from the refrigeration cycle to pre-heat ventilation air and support other heating needs.*
> ***Resources available through http:/www.ask.com.***
> ***Search: Heat+recovery+chillers.***

> ***Boiler flue gas heat recovery –*** *For buildings with substantial non-condensing boiler equipment (especially steam boilers) or process furnaces, exhaust flue heat exchangers can provide recovered heat to preheat combustion air or the boiler's feedwater.*
> ***Search: boiler+economizers***

> ***Heat recovery from air compressors –*** *In industrial applications, ductwork and dampers can be provided for large air-cooled process air compressors so they can provide supplemental heat during cool weather.*
> ***Search: air+compressor+heat+recovery***

> ***Cogeneration heat recovery –*** *This refers to on-site generation of electric power in such a way that the waste heat is recovered. Building projects that have both hydronic heating and a natural gas generator may be able to incorporate a cogeneration heat recovery system.*
> ***Search: gas+cogeneration+heating***

> ***Heat recovery from wastewater –*** *Coaxial heat exchangers can be placed in vertical domestic drainpipes carrying warm water to preheat makeup water.*
> ***Search: GFX+heat+exchangers***

> ***Computer room air conditioning units used as boilers –*** *In this strategy, buildings heated by condensing boilers that also contain server rooms requiring a redundant cooling method utilize a computer room cooling product intended for summer "dry cooler" applications. This cooling equipment (ACU) is then connected to a variable flow heating water system's return water piping near the boiler. This return water can be cool enough for the computer room ACU to reliably reject heat into, providing supplemental heat to the heating water system that in turn reduces gas energy use at the boilers. This ACU becomes the primary cooling system for the computer room during cool weather, while the other computer room cooling units provide redundancy. When the building doesn't require heat, this ACU piped as a boiler operates as the redundant unit. A failsafe method for summer heat rejection (e.g. a dry cooler) should also be provided.*

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