FACT SHEET

REDUCING ENERGY WASTE WITH **HEAT RECOVERY**

This fact sheet explores various passive heat recovery systems and provides high level descriptions of how to improve their operational and energy efficiencies. The goal is to help building owners and operators develop an understanding of heat recovery systems and how they can be optimized to improve energy performance.

What Is Passive Heat Recovery?

Heat recovery is the principle of reclaiming heat which would otherwise be lost from a system and, instead, capturing and using it elsewhere to reduce energy consumption. It requires a waste heat stream as a “source”, and a place to utilize the waste heat as a “sink”. Recovering heat offsets heating loads that would otherwise be provided by conventional heating methods, thereby improving energy performance, reducing emissions, and providing utility cost savings.

Passive heat recovery is a term describing a variety of heat recovery methods which require the input of little or no additional energy to facilitate the heat recovery process. Typically, these will include the use of heat exchanger (HEX) systems or other transfer mediums to facilitate the flow of heat. Examples of heat recovery systems that are *not* considered passive include: mechanical heat recovery chillers and distributed heat pump systems.

Energy can be recovered in the form of sensible or latent heat or a combination of the two. Sensible heat refers to the change in temperature of a substance. Latent heat refers to the energy contained in a substance in the form of vapor and is released when that substance condenses, meaning it transitions to a liquid state. Common examples of latent heat recovery applications include the condensation of the water vapor contained in combustion gases and in the exhaust air from a building. Systems which recover both sensible and latent heat will often be referred to as *energy* or *enthalpy* recovery systems to distinguish them from those working exclusively with sensible heat. For example, a heat recovery ventilator (HRV) denotes sensible heat transfer only while an energy recovery ventilator (ERV) recovers both sensible and latent heat. Recovering latent heat typically results in higher heat recovery effectiveness than just recovery of sensible heat.

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In buildings, heat recovery can be considered for any streams of energy that are leaving the boundaries of the facility. This may include building exhaust air streams, boiler flue gas, heat rejected from chilled water, condensate from a steam system, or warm drain water from domestic use. Energy recovered from these sources can be used to offset heating requirements elsewhere in the building. Common uses for recovered heat include the preconditioning of a ventilation air stream or the preheating of domestic hot water. Other opportunities may exist in commercial or industrial applications where there may be a range of more unique sources and applications of recovered heat.

In any heat recovery application, there are several key concepts which must be considered to ensure that the system operates effectively. These include:

- **Waste heat source quality** – What is the temperature, flow rate and availability of the fluid stream used as a heat source? Heat recovery effectiveness is improved when recovering from a source with a high temperature and consistently high flow rate.
- **Heat demand** – Heat recovery is only effective if there is a demand for the recovered energy. Will the demand for recovered heat fluctuate due to seasonal operation changes or other factors?
- **Time coincidence** – In an ideal heat recovery application, waste heat supply (source) and demand (sink) exist simultaneously. If supply and demand are not synchronized, then options such as thermal storage could be explored.
- **Location** – Heat recovery can be implemented most effectively when the heat source and sink are located physically close together.
- **Other site-specific considerations** – Are there concerns with cross-stream contamination (i.e. air mixing from exhaust to supply)? What are the flow rates of the source and demand fluid streams? How will condensation as a result of airstream cooling be managed? Are there humidification considerations? Is there potential for system fouling or corrosion due to fluid stream contents, etc.?

The following sections present different types and technologies for heat recovery from either air, water, or combustion gas streams. Different sources of heat and methods of heat recovery suit various applications and involve unique considerations which will be discussed for each at a high level.

Summary of Heat Recovery Types

Heat Recovery Option:		**Key Attributes:**	**Limitations/Considerations:**
Air-side heat recovery	Plate heat exchanger	› Cross-flow (or counterflow) heat exchangers using fixed plates separated to allow airflow › Most commonly used in heat recovery ventilator (HRV) applications › Flexible in application and lower cost › Minimal moving parts › Total heat recovery effectiveness: 20% to 70%	› Large heat exchanger dimensions needed to accommodate higher flow rates › Typically, only recovers sensible heat › Requires frost mitigation measures › Airstreams are separated but leakage is possible
	Rotary heat exchanger	› Use a wheel-shaped exchanger positioned perpendicular to two air currents, where the rotating effect enables the recovery of energy from one current and its transmission to the other. Air from both the supply and exhaust streams flow through the heat exchanger core in a counterflow or parallel flow configuration › Allows for the transfer of both sensible and latent heat in energy recovery ventilator (ERV) applications › More compact than other options when sized for high flow rates › Total heat recovery effectiveness: 25% to 90%	› Exhaust and supply air streams will mix as the heat exchanger core rotates. Unsuitable for applications where cross-stream contamination must be avoided, such as healthcare › Defrosting cycles may be required in extremely cold conditions, reducing system efficiency
	Runaround heat recovery	› Places heat transfer coils in each airstream connected by pipes circulating a heat transfer media, typically a glycol antifreeze solution › Allows recovery from air streams which may be far apart, increasing flexibility › Air streams are completely separated, eliminating risk of cross-contamination (i.e. can be used in health care settings) › Compact components are often easier to add in existing buildings	› Freeze protection required in runaround loop › Higher static pressure drop in the airstreams due to added coils (increases fan energy) › Reduced heat recovery effectiveness (45% to 65%) due to use of an intermediate heat transfer media
	Heat pipe	› Permanently sealed tubes containing a refrigerant with one end located in the exhaust and another in the make-up air streams. They are designed so the refrigerant vaporizes in the higher temperature end and flows to the other, colder side where it condenses, thus transferring heat › No moving parts, relies on refrigerant phase change to maintain flow of heat › Compact, sealed system	› Lower heat recovery effectiveness of 15% to 60% › Heat transfer capacity limits of heat pipes can be dictated by pipe length, surface area, construction and, in some cases, pipe slope

Heat Recovery Option:		Key Attributes:	Limitations/Considerations:
Boiler stack heat recovery	Economizer	› Specialized air-to-water heat recovery from high temperature flue gas › Useful in applications where condensing boilers and/or low return water temperatures cannot be used	› Heat recovery availability varies with boiler system use › Must be designed to withstand corrosive flue gas condensate on heat exchanger components (such as with a titanium or stainless-steel heat exchanger)
Water-side heat recovery	Refrigeration heat recovery	› Opportunity to recover heat from refrigeration equipment if using a water-cooled condenser system › Heat is available year-round so long as refrigeration equipment is running	› Works best when there is a large refrigeration capacity, such as a restaurant or grocery store
	Wastewater heat recovery	› Recovers waste heat from warm drain water to preheat make-up domestic water › Can be set up using gravity-film heat exchanger (GFX) or thermal storage tanks › Useful in buildings/applications with large hot water loads, whether in the form of peak periods (such as multi-unit residential buildings) or as more consistent use (such as ongoing industrial processes)	› Ideally implemented when demand for hot water coincides with warm water being drained › May require additional space for installation of storage tanks

Recommissioning (RCx) of Heat Recovery Systems

Best Practices

- **Verify fundamental conditions** – The design considerations outlined previously are necessary to facilitate heat recovery. Before undergoing detailed recommissioning, it is necessary to verify that conditions such as heat source quality, time coincidence, and heat demand are in place. If these conditions are satisfied and system performance is lacking, then detailed recommissioning may be warranted.
- **Compare original design with current operation** – Review the original design parameters of the heat recovery system and compare it with the current operation of the system. Have operational changes, building renovations, equipment replacement, occupancy changes, or other factors affected some of the conditions upon which the original system was designed?
- **Obtain robust system information** – The basis of effective recommissioning is accurate and relevant information on system operations. A well designed DDC system can provide information including fluid stream temperatures, flow rates, pump/fan operation, system trend logging, fault warnings, etc. When recommissioning a heat recovery system, review its operation under conditions such as peak winter heating load, shoulder season, morning start up, unoccupied periods, etc. to test it under a range of conditions, exposing potential faults, issues, or opportunities for improvement.

Heat Recovery Controls

- **Verify change in temperature across heat recovery system** – Check the difference in fluid stream temperature (delta T) across heat recovery coils or heat exchangers to verify design conditions are being met. Reduced temperature change across the system could indicate inefficiency due to heat exchanger fouling, flow imbalance, or other issues. This can be verified using temperature sensors and controls system trend logging.

- **Align system operation with heat availability and demand** – Energy consumption can be reduced by shutting down heat recovery system fans/pumps when conditions for effective heat recovery are not present. These could include periods when other equipment is shut down, if heat source stream temperatures are low, etc.
- **Monitor defrost cycle operation** – Air-side heat recovery systems in cold climates generally need to implement defrosting sequences into their operation using reversing cycles, preheat coils, or bypass dampers. These cycles reduce heat recovery efficiency and should be monitored. Some systems may be factory programmed to initiate defrost sequences below a certain temperature, without considering humidity. Some preheating systems may excessively overheat incoming air. Adjusting the defrosting or preheating system parameters can improve system performance by eliminating unnecessary defrosting cycles or improving heat recovery effectiveness.
- **Rotary heat exchanger motor operation** – Rotary heat exchanger operation including rate of heat transfer is controlled by varying the rotational speed of the heat exchanger core. Implementing monitoring and control sequences can optimize heat transfer effectiveness and reduce motor energy consumption. Motor monitoring can also be used for fault diagnostics. For example, if the motor is running, but the airstream temperature sensors indicate poor heat transfer, then there may be other issues present such as a failed drive belt.
- **Implement alarm systems** – Controls system alarms/warnings can be used to alert operators to conditions which compromise heat recovery system operation. These could include heat source temperatures lower than heat sink temperatures, reduced or reversed delta T, frost warnings, etc.

System Maintenance

- **Heat transfer surface cleaning** – Heat transfer effectiveness of any system can be compromised if heat exchanger or coil surfaces become fouled. Cleaning of these surfaces maximizes effective area for heat recovery and improves system performance and flow.
- **Filter maintenance** – Installation and regular replacement of prefilters in outdoor air streams reduces system fouling, improving heat recovery effectiveness and airflow rates. High efficiency filters can also be installed to reduce fan energy consumption and improve airflow.
- **Heat transfer fluid maintenance** – In runaround heat recovery systems it is important that the heat transfer fluid be maintained. Maintenance may include ensuring sufficient glycol concentrations, checking for leaks, fluid top up, and maintaining any filters present.
- **Visual inspections** – Implementing standard operating procedures, which involve inspection of heat recovery systems, can identify issues such as runaround coil leaks, heat pipe seal failure, dirty coils, etc.

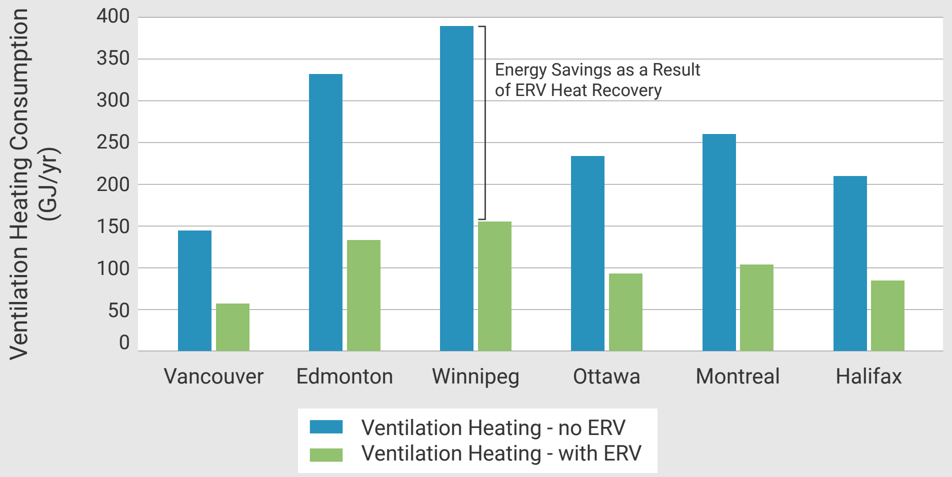

Figure 1: Ventilation Heating Savings with ERV for Office Building

CASE STUDY: ERV Installation

To demonstrate the savings potential of heat recovery in different locations across Canada, an example scenario was developed. This scenario considers an office building with a floor area of 10,000 m^2 heated by a mid-efficiency natural gas boiler system. Per ASHRAE 62.1 guidelines, the recommended ventilation rate for this building is approximately 4,300 l/s of outdoor air. The heating energy required to condition this air represents a significant portion of the building's annual energy use, particularly in cold climates. Figure 1 shows the ventilation heating energy required for this building in six major cities across Canada.

In this scenario, the building looks to reduce its ventilation heating load by installing an ERV unit to recover heat from building exhaust and precondition the incoming outdoor air stream. Modelled energy savings consider an energy recovery wheel with an average total heat recovery effectiveness of 60%. This exercise demonstrates a reduction in annual natural gas use of 85 to 230 GJ, depending on building location. Resultant cost savings could range between $1,100 and $3,100, depending on utility rates. This also represents greenhouse gas emissions reduction of between 4 and 12 tonnes of CO_2 equivalent per year.

Key Takeaways

The recommissioning of heat recovery systems is an opportunity to ensure that existing equipment is providing the energy savings and emissions reduction as designed. A high-level summary of key considerations during recommissioning includes:

- Verify that fundamental conditions for heat recovery are in place and whether the original design considerations are appropriate for current system operation.
- Examine fluid stream temperatures, flow rates, pump/fan operation, system trend logging, and fault warnings under different operating conditions.
- Verify that effective heat recovery is occurring by comparing fluid stream temperatures before and after passing through the heat recovery system.
- Conduct regular maintenance on the heat recovery system to ensure maximum effectiveness and prevent potential issues.

For further information on EBCx resources and support, please CLICK HERE.

Cat.: M154-174/2024E-PDF | ISBN: 978-0-660-71078-5

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