Cold Climate Housing Research Center

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Final Report

Zehnder Comfoair 350: Evaluation for Use in a Cold Climate

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Abstract

In Alaska and Canada, the defrost strategies of the dominant brands of heat recovery ventilators (HRVs) involve recirculating return air across the heat exchanger core and back into the supply air for the house. In cold climates, this type of frost protection system can undermine ventilation standards. To overcome this issue, continuous ventilation systems such as the Zehnder HRV address frost protection by preheating air before it enters the HRV core, resulting in increased supply air temperatures and mitigating heat exchanger core freezing. This paper discusses the effectiveness of the technology for frost prevention, the energy use of the system, and the effect of continuous ventilation on indoor air quality in a cold climate home.

Keywords: heat recovery ventilator, HRV, continuous ventilation, frost protection, frost prevention, indoor air quality, energy efficiency

Zehnder Comfoair 350:
Evaluation for Use in a Cold Climate

In North America, heat recovery ventilators (HRVs) are becoming the default solution for providing energy efficient and balanced mechanical ventilation in residential construction. In cold climates, HRVs require a defrost strategy to remove condensation and frost that can form within the air-to-air heat exchanger core. When the core of an HRV accumulates frost, it can impede airflow and result in severe energy efficiency losses. However, the frost protection mechanisms in HRVs can incidentally create an *intermittent ventilation* system that causes cross contamination of exhaust and supply air streams. These shortcomings can undermine the fresh air requirements of ASHRAE 62.2 (ANSI/ASHRAE, 2013), a residential ventilation standard commonly used as a baseline for building codes and programs.

To overcome this issue, the Swiss manufacturer, Zehnder, has created *continuous ventilation* HRVs that address the frost protection concerns by preheating air before it enters the core, thus raising the air temperatures and mitigating core freezing. This strategy has implications for energy efficiency and indoor air quality; for example, continuous ventilation is highly effective in removing household airborne pollutants on a continual basis, though heating the incoming airstream to achieve this goal is more expensive. Two of these HRVs were installed in residences in Fairbanks, Alaska and evaluated over the course of two winters for energy efficiency and their effects on indoor air quality. To that end, this paper explores the advantages and disadvantages of a continuous ventilation HRV that uses the preheating defrost method in cold climates.

Defrost Strategies

Four HRV defrost strategies dominate the market in North America: fan shut-off, damper-based, recirculation, and preheat.

Fan shut-off is the simplest defrost strategy, which monitors the incoming (outdoor) airstream temperature and, when a threshold temperature is reached, shuts off the supply air fan while keeping the exhaust air fan on. During this defrost cycle, the system may increase the exhaust airflow to accelerate warming or thawing of the heat exchange core by the airstream. This method results in low system efficiency (since no heat recovery is occurring) and can remain in this state for longer than other defrost strategies. During the defrost cycle, fresh air is not provided to the dwelling by the HRV, but instead by air leakage through the building envelope as with an exhaust-only ventilation system. Additionally, the unbalanced airflow of this strategy results in the depressurization of the home. This defrost strategy is used in low-priced systems, uncommon in northern climates because of a great need for balanced ventilation in airtight homes.

Damper-based defrost implements a fifth port[1] on the intake airstream. The incoming (outdoor) airstream temperature is monitored and during defrost operation the intake air port is closed and an extra port is opened, moving indoor air across the heat exchange core to warm or thaw the core. The exhaust fan

[1] HRVs typically have 4 ports: The intake, supply, return, and exhaust. The *intake port* brings fresh air from outside into the heat exchange core where the airstream continues to flow to the *supply* port that delivers this fresh air to the home. The *return* port brings stale air from the house to the heat exchange core where the airstream continues to flow to the *exhaust* port that eliminates the air to the outside.

remains on during this time, resulting in unbalanced airflow and depressurization of the home since air is being exhausted without fresh air being supplied to the building by the HRV. Fresh air will be provided during the defrost cycle from air leakage through the building envelope. This method of defrost is faster than the fan shut-off strategy.

Recirculation defrost involves monitoring the incoming airstream and, when a threshold temperature is reached, recirculating warm return air across the heat exchanger and back into the house supply port. Typically, this defrost mode occurs for a timed window (such as 10 minutes) when the intake air temperature is below a temperature set-point (such as 23°F) and overrides current ventilation schedules[2]. During the defrost cycle, the intake and exhaust ports are closed, resulting in neutral pressure in the home. The HRV does not provide fresh air to the dwelling during this time, and air exchange from air leakage is not induced due to the lack of any mechanical air pressures. Recirculation is the most commonly implemented defrost strategy for HRVs used in cold climates.

The *preheat* defrost strategy, which could be considered to be a *frost prevention* strategy, involves monitoring incoming airstream temperatures and heating the intake or return airstreams to increase air temperature entering the core and warming or thawing the core. This system maintains neutral pressure and constant ventilation in the home. Preheating may be accomplished though electric resistance heaters or through other methods such as a ground source heat exchanger (GHE). HRVs using preheating are uncommon in cold climates due to limited commercial availability. Because of the dramatic reduction in efficiency that results from the use of electric pre-heaters, HRVs with electrical heaters are ineligible for ENERGY STAR[3] qualification in Canada, a market disincentive to the two largest North American HRV manufacturers located in Canada.

Zehnder HRVs use a preheating defrost method and are fairly new on the North American market for cold climate applications. They are, to date, the only commercially available HRV in Alaska that is certified to meet *Passivhaus*[4], a specific certification for high-performance, high-efficiency houses. These systems are significant to the building community because the preheating technology may provide additional ventilation options for homeowners in cold climates who value the potential benefits of continuous ventilation.

Operational Behavior of the Zehnder

The Zehnder HRV provides continuous ventilation by using an electric air heater to warm the fresh outdoor airstream before it enters the HRV core if necessary to prevent frost accumulation. The system controller continuously interprets air temperatures of the intake, supply, return, and exhaust airflow streams and uses a proprietary algorithm to determine the conditions when frost accumulation are likely to occur. When these conditions occur at cold temperatures, the controller determines the amount of pre-heating needed in order to prevent frost accumulation (through another algorithm). This process is continuously

[2] Lifebreath® offers a variation of this strategy called *Polar Defrost* which varies the defrost time based on the outdoor air temperature.

[3] See ENERGY STAR is a voluntary program by the U.S. Environmental Protection Agency aimed at energy efficiency of electronically-operated devices. See http://www.energystar.gov for more information about this program.

[4] *Passivhaus* is a rigorous certification process developed by *Passivehaus Institute* in Germany for buildings; the goal of this process is construct buildings that provide a high level of occupant comfort while using very little energy for heating and cooling. See http://passiv.de/en/ for more information about this program.

repeated in order to maximize the efficiency of the system while preventing frost. The benefit of this frost prevention strategy is that the unit is continuously providing ventilation without resorting to recirculation of supply air.

Preheating the incoming air comes with a potential energy penalty. Presumably, the designers at Zehnder intend for pre-heating to keep the incoming air above a certain set point. Several HRVs on the market set the cut-off temperature to about 23°F for activation of a recirculation defrost period. In order to prevent the incoming air temperature from dropping below this temperature, energy needs to be added to the airstream. Consider, for example, that the amount of energy[5] required to preheat air from 0°F to 25°F at 50 CFM air flow is 1,375 BTU/hr (403 W). For comparison, the heaters in the HRV under study (the Zehnder ComfoAir) operated at either 300 W or 600 W, depending on the temperature of the airstreams.

Zehnder has an additional add-on closed loop heat exchange system called the ComfoFond used to preheat the fresh outdoor air using geothermal heat. This system circulates a glycol-water mixture through tubing buried beneath the ground surface and transports heat from the ground to a heat exchanger (GHE), which is then used to preheat incoming air. The GHE preheating system is designed to minimize the amount of electricity required to prevent the core from freezing; however, the integration of the ground loop system has practical implication: the installer must bury approximately 400 ft of plastic tubing in the earth at a depth sufficient to extract useful heat for increasing the temperature of the fresh outdoor airstream. In order to rely on heating the intake airstream using only the GHE, the amount of energy provided to the airstream would have to amount to about 400 W based on the example above. If the GHE cannot provide this amount of heat, then the electric heater must add energy to the airstream.

As part of the frost prevention strategy, if the air preheating systems (electric heater and, if applicable, geothermal heat exchanger) do not provide sufficient heat to achieve the core efficiency necessary to prevent frost accumulation, then the unit will use unbalanced air flow to achieve this goal. When this occurs, the supply airflow is designed to be temporarily reduced or stopped and exhaust airflow remains unchanged, effectively relying on air leakage through the building envelope to temporarily supply fresh air to the residence. This fan shut-off strategy can cause temporary unbalanced airflow and put the house under negative pressure, causing problems such as the backdrafting of carbon monoxide and other dangerous gasses through combustion appliances. Notably, if the electric preheater or GHE is not installed in the unit, the default (fan shut-off) frost-prevention strategy employed is to temporarily reduce (or stop) supply air flow. The installer of a ComfoAir 350 can select defrost settings that shift the reliance more towards pre-heating of intake air or supply flow rate reduction, depending on the preferences for the specific installation.

Case Studies of the Zehnder in Application

Zehnder released a white paper entitled "Heat Recovery Ventilation with Closed-Loop Ground Heat Exchange" (Cremers, n.d.), which describes the performance of a ComfoAir HRV installed in The Netherlands with the GHE. The paper describes the intended effect of the GHE on the performance of the system and summarizes the operation and performance of the complete ventilation system, as reproduced from Cremers (n.d.) in Figure 1.

[5] $Q = 1.1 \times CFM \times \Delta T$, where Q is a rate of heat energy [Btu/hr], CFM is airflow rate [cubic feet per minute], and ΔT is the temperature increase [°F].

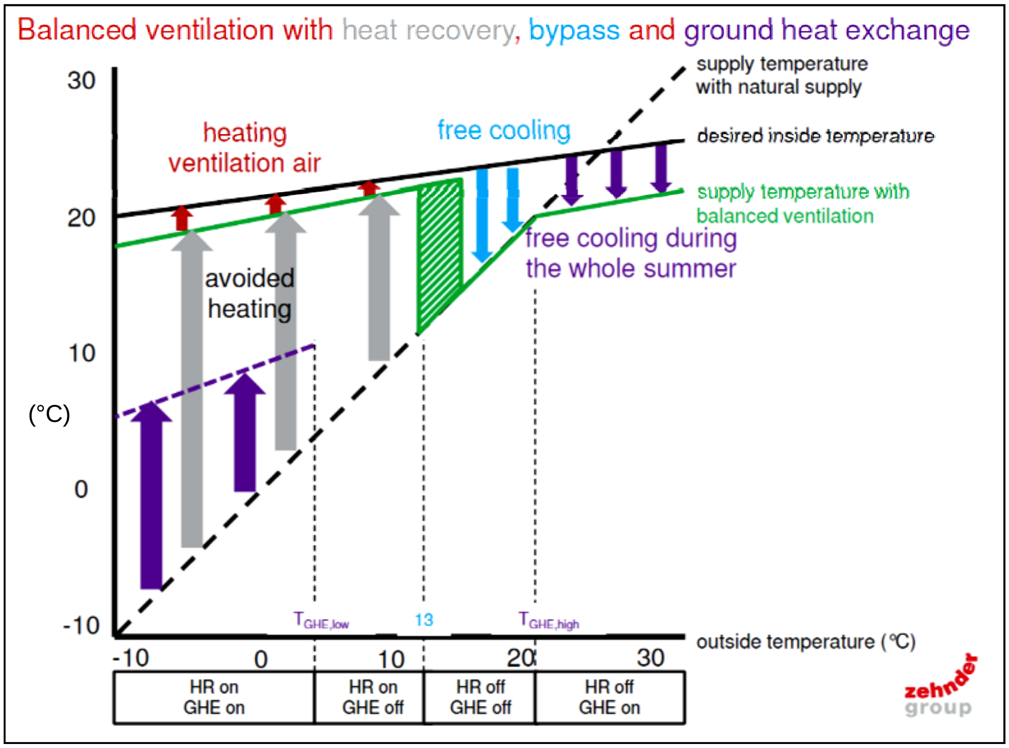

Figure 1. Schematic of the intended effect of the ground loop heat exchanger (GHE), the HRV heat exchanger core (HR), and the cooling bypass functions on the supply temperature. In this case, for fresh outdoor air temperatures less than about 37°F (3°C), the GHE has the ability to reduce the amount of electrical energy required to increase the supply air temperature to the desired inside temperature (shown as the black solid line). The black dashed line describes the resulting supply air temperature if the GHE or HR were not available. The green line represents the effect of the HR on the supply air temperature for the conditions shown. The red arrows describe the amount of temperature rise is necessary (through a post heater in the supply airstream) to achieve the desired supply air temperature. (Graphic from Cremers, n.d.)

The GHE was operational and provided preheating when the outside temperature is below 45°F (7°C) and provided cooling when the outside temperature was above 61°F (16°C). The GHE was effective in increasing the incoming air temperature; for instance, when the outdoor air temperature was 14°F (-10°C), the GHE increased the air temperature by about 20°F (11°C). The incoming air temperature downstream of the GHE was at or above 32°F (0°C), which presumably avoids the need for additional frost protection measures. Figure 2 illustrates the measured effect of the GHE and the heat exchanger core on the supply airstream. The ground temperature ranged from 41°F (5°C) in the winter to 59°F (15°C) in the summer. No electric preheater was used to increase the incoming air temperatures. The paper does not detail whether the fan shut-off mode was used as part of the defrost strategy.

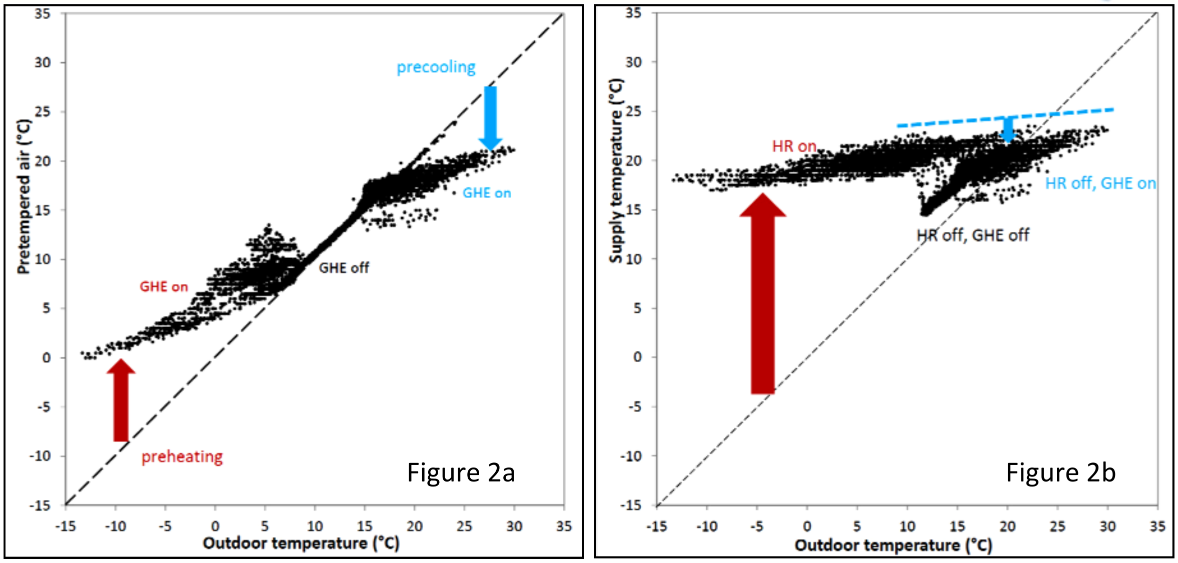

Figure 2. (a) The effects of only the GHE on the fresh intake airstream temperature prior to the heat recovery core (HR) and (b) the effect of both the GHE and the heat recovery core on the supply airstream temperature. The GHE raises the supply airstream by 20°F (11°C) when outdoor temperatures are 14°F (-10°C). The combined effect of the GHE and heat recovery core raises the incoming airstream by about 49°F (27°C) when outdoor temperatures are 14°F (-10°C). (Plot from Cremers, n.d.)

The data presented by Cremers (n.d.) suggests that the avoided total space heating using the GHE and the heat recovery core was 3,899 kWh, while the system consumed 593 kWh operating the GHE pumps and HRV fans for approximately one year. This yields a seasonal performance factor (energy gain divided by the measured energy consumption) of 6.6: the heat energy delivered to the house is *over six times* the electrical energy consumed running the equipment.

A study conducted by the Vermont Energy Investment Corporation compared the performance of the Zehnder ComfoAir 350 in two similar homes; one of the HRVs used an electric resistance heater and the other used a GHE for preheating intake air. As described in Holladay (2015), the electrical energy consumption of the electric preheat HRV during one year of monitoring was 314 kWh, while the electrical energy needed for the GHE preheat HRV was 311 kWh (including the energy needed to run the HRV fans). The electrical energy consumption between the two HRVs was comparable because a similar amount of energy was needed to run both the electric heater and the GHE fluid pump. Holladay (2015) does not report whether the ground loop was used during the summer to cool intake air, which could have provided additional energy savings from avoided cooling that would not be captured by this comparison.

Implications for Energy Efficiency

In North America, ERVs[6] and HRVs are tested using C439, "*Standard Laboratory Methods of Testing for Rating the Performance of Heat/Energy Recovery Ventilators"* , a standard used to determine ventilating capacity, power consumption, and the sensible, total, and latent energy recovery performance for either HRVs

[6] An energy recovery ventilator, or ERV, is similar to an HRV that can recover moisture as well as heat energy from the exhaust airstream.

or ERVs (CSA International, 2000). Performance calculations such as sensible recovery efficiency (SRE)[7] and apparent sensible effectiveness (ASEF)[8] are determined for each unit. The sensible and total energy recovery efficiency calculations in this procedure include terms that account for known energy inputs (that is, fan power and defrost energy) as well as differences in air flows, air leakages, and heat transfer through the cabinet to the surrounding environment.

The standard heating mode testing condition for HRVs tested under C439 is an indoor (return) air temperature of 72°F (22°C) with 40% relative humidity and an intake air temperature 32°F (0°C). The standard provides an optional procedure for a low temperature (less than 32°F, 0°C) performance test. This low temperature test is conducted for 72 hours with the performance ratings determined from measurements recorded during the last 12 hours of the test.

The HRV manufacturer can specify any intake air temperature below 32°F (0°C), but most manufacturers who opt for this test specify -13°F (-25°C) in response to Canadian codes and ENERGY STAR® requirements for those conditions. As a result, testing at -13°F (-25°C) has become the default test for the industry for cold climate applications.

In Europe, HRVs and ERVs are tested using variations of European Standard EN 13141-7 *"Performance testing of components/products for residential ventilation, Part 7: Performance testing of mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings."* This standard tests HRVs & ERVs under different conditions than what is specified under C439, making it difficult to compare performance results of European HRVs and ERVs to North American units based these two standards.

Nuances of the C439 procedure are described in *"Technical advice to Task Force on Northern Mechanical Ventilation Equipment Design and Testing,"* (Zaloum, 2010) a report released in 2010 by the Canada Mortgage and Housing Corporation (CMHC) which investigates ventilation performance and key technical issues specific to HRVs and ERVs in northern climates. This report also addresses current and foreseeable changes in codes, standards and labeling programs relating to mechanical ventilation in Canada. The report discusses the current technology employed by the industry, how it relates to energy efficiency, and its suitability in an extreme cold climate. The report discusses HRVs with preheating defrost operation, but does not specifically mention the Zehnder unit because it was not yet available in North America and also because they are currently excluded from the ENERGY STAR certification due to the electric preheater.

The Home Ventilating Institute (HVI) is an organization established to test and compare the ventilation performance of ventilation products in North America. HVI rates ERVs and HRVs based on the C439 standard

[7] Sensible Recovery Efficiency (SRE) is the net sensible energy recovered by the supply airstream as adjusted by electric consumption, case heat loss or heat gain, air leakage, airflow mass imbalance between the two airstreams and the energy used for defrost, as a percent of the potential sensible energy that could be recovered plus the exhaust fan energy. This value is used to predict and compare heating season performance of the HRV. ERVs (CSA International, 2000)

[8] Apparent Sensible Effectiveness (ASEF) is the measured temperature rise of the supply airstream divided by the difference between the outdoor temperature and entering return air temperature, then multiplied by the ratio of mass flow rate of the supply airflow divided by the mass flow rate of the lower of the supply or exhaust system airflows. Apparent Sensible Effectiveness is useful to predict final delivered air temperature at a given flow rate and should be used for energy modeling when wattage for air movement is separately accounted for in the energy model. ERVs (CSA International, 2000)

and updates its certified products inventory on a near monthly basis. HVI provides a voluntary certification program for HRVs and ERVs in the North American market that provides ratings based on performance tests following the C439 standard. As mentioned above, the heating tests at 32°F (0°C) intake air temperature are required, and lower temperature tests are optional based on the manufacturer's preferences.

Some Zehnder units are listed under the HVI ratings. For instance, in the HVI ratings obtained in April 2012 (HVI-Certified Products Directory), under the normal test conditions, the ComfoAir 350 is listed among the highest performing HRVs, having SRE of 88% and apparent sensible effectiveness (ASEF) of 93% (at the low air speed setting). Under the low temperature test with an inlet temperature of -13°F (-25°C) and using the electric preheater, the SRE drops to 49% and the ASEF increases 99%. The drop in SRE and increase in ASEF under the low temperature test is due to the intake air preheating, which is not necessary for frost control when the intake air temperature is 32°F (0°C).

While the C439 test accounts for total energy use in the calculation of the efficiency calculations, it currently does not provide a means to characterize the performance of a system when a GHE is installed due to the variability inherent to a GHE installation (that is, a buried glycol loop emplaced in soil that vary in temperature based on location, depth, season, amongst other factors). During the heating season, the heat added to the incoming airstream by the GHE reduces the amount of electrical resistance heating necessary to increase the incoming air temperature.

For comparison, the Venmar AVS HRV EKO 1.5, a similarly-sized, commonly installed HRV in Alaska that uses a recirculation defrost strategy, has an SRE of 75% and ASEF of 83% (at the low air speed setting). Under the low temperature test (with an inlet temperature of -13°F, -25°C), the SRE drops to 64% and the ASEF increases to 89%.

Also, the Lifebreath 195ECM, another similar-sized, commonly installed HRV in Alaska that uses a recirculation defrost strategy, has an SRE of 71% and ASEF of 78% (at the low air speed setting). Under the low temperature test (with an inlet temperature of -13°F, -25°C), the SRE drops to 64% and the ASEF increases slightly to 80%.

Of the three HRVs that were compared under low temperature conditions, the SRE is the *lowest* for the Zehnder unit because the electrical consumption to increase the intake airstream temperature is accounted for and lowers the SRE. The preheating of the air using the electric heater to overcome frosting of the core leaves a significant amount of energy unrecovered in the exhaust air. Conversely, since ASEF is based on the measured temperature rise of the supply airstream (which is increased by the electric preheater) divided by the difference between the (unheated) outdoor temperature and entering return air temperature, the ASEF of the Zehnder is highest among the HVI listings.

The two HRVs with the recirculation-type defrost strategies have higher calculated SRE than the Zehnder because no additional energy is added to the incoming airstreams since warm air from the house is being used to warm the core. Conversely, because the change in temperature of the supply airstream is much less without a preheater, the ASEF of these units are lower than the Zehnder unit. This energy efficiency measure is a major reason why HRVs with recirculation defrost strategies dominate the cold climate market.

Implications for Indoor Air Quality

Building professionals often follow the guidelines of ASHRAE 62.2 regarding ventilation. The amount of whole house mechanical ventilation required in this standard is determined using a formula that takes into consideration the size of the building and the potential number of occupants. While the standard is based on the assumption of continuous whole house mechanical ventilation, it provides guidance on how intermittent ventilation strategies can provide an equivalent net ventilation rate. A common implementation strategy for HRVs in cold climates to meet this code involves reducing the airflow of the unit to the minimum required ventilation rate. This strategy accomplishes two things: (1) it reduces the amount of heating energy lost to ventilation and (2) it prevents over-ventilation, a condition which can lead to uncomfortably dry conditions in cold climates.

While the occupant, installer, or system designer may have intended for the HRV to provide continuous ventilation, the defrost mechanism overrides programmed ventilation controls and effectively turns the system into an intermittent ventilation system that can lower the effective ventilation below the ASHRAE standard. To overcome this issue, one option may be to use the HRV controls to increase the ventilation rate during cold periods. Experience has shown, however, that occupants tend to ignore HRVs (unless an apparent problem exists) and the settings remain untouched. As a result, the occupant is faced with either excess mechanical ventilation for much of the year to ensure adequate ventilation during the winter or less mechanical ventilation than called for by ASHRAE 62.2 during the winter due to the recirculation-type defrost mechanism.

A study was conducted on a continuous ventilation ComfoAir 350 HRV installed in a university student residence in Fairbanks, Alaska by researcher Martin Kotol for a three-week period in December 2012. His findings were published in his report *Survey of Indoor Air Quality, University of Alaska Fairbanks Sustainable Village* (Kotol, 2013). No GHE was installed with this unit, though the unit was equipped with an electric preheater. This study focused on the indoor air quality of the home as it related to three other similar homes in the study which had ventilators that used the recirculation-type defrost strategy. One of these three homes employed an ERV, which recovers moisture as well as heat energy from the exhaust airstream.

Kotol (2013) investigated each home to assess whether they meet the ventilation requirements of ASHRAE 62.2 (2013). Table 1 describes the HRV type, location, user settings, recommended fresh air rates, and measured fresh air rates of the four residences. The defrost mechanisms were used during the study period as the average outdoor air temperature in December 2012 was -17°F (-27°C); with a maximum of 41°F (5°C) and minimum of -48°F (-44°C).

Of the three HRVs under study, the two Venmar HRVs that provided intermittent ventilation spent 41% and 67% of their time in recirculation mode due to a combination of users settings that included recirculation and the defrost mechanism. The hourly average fresh air supply to the house for these HRVs was below the recommended rates of two different ventilation standards. Kotol's (2013) findings reveal that the user's control settings of the ComfoAir HRV was set to the lowest fan speed, which resulted in the continuously ventilated home being slightly under ventilated. In other words, none of the homes with HRVs met the ASHRAE 62.2 ventilation rate.

The effect of the time spent in recirculation mode on meeting the ASHRAE ventilation standard can clearly be seen in Table 1. The Venmar ERV and Venmar HRV units in Houses 1 and 4 respectively are identical to each other, except for the core material and the temperature setpoint that triggers the defrost mode. The HRV triggers the defrost mode at 23°F (-5°C), while the ERV triggers the defrost mode for the same time period at 14°F (-10°C). Both units trigger a longer defrost cycle at -17°F (-27°C). The implication of these settings is that when the temperature was warmer than 14°F (and less than 23°F), the HRV spent time in defrost mode while the ERV did not. The result of these differences is that the house with the ERV was in compliance with ASHRAE 62.2 (2013) and the house with the HRV was not.

The home with the ComfoAir was among the two homes with the highest ventilation rates and the lowest indoor concentrations of CO_2. CO_2 is generated by the respiration of occupants and is a general indicator of air exchange relative to occupancy. While the impact of ambient CO_2 on human health is somewhat uncertain, high CO_2 levels are indicative of inadequate air exchange. This can also mean that other known indoor air hazardous (such as mold spores, bacteria, animal dander, carbon monoxide, second-hand smoke, volatile organic compounds, etc.) are not being adequately expelled and replaced with fresh air.

Relative humidity (RH) is another general indicator of air exchange in winter for a cold climate. Similar to CO_2, RH is reduced by higher ventilation rates. RH levels were lowest in the house with ComfoAir (16-25% median RH) compared to the other houses with the Venmar HRVs (22-32% and 29-42% median RH). Notably, occupants from the house with the lowest measured relative humidity (ComfoAir 350) complained about dryness of the air. No occupants from any of the other homes complained about dryness.

Table 1. Summary of Findings from Kotol's Indoor Air Quality Study (adapted from Kotol, 2013). Air flow units in cubic feet per minute (CFM) averaged on an hourly basis.

	House 1 (Tamarak House, Northeast)	House 2 (Birch House, Northwest)	House 3 (Willow House, Southeast)	House 4 (Spruce House, Southwest)
Ventilation Unit	Venmar EKO 1.5 ERV	Zehnder ComfoAir 350 HRV	Venmar EKO 1.5 HRV	Venmar EKO 1.5 HRV
Frost Protection Type	Recirculation	Preheat	Recirculation	Recirculation
Ventilation Settings	Continuous ventilation at minimum fan speed	Continuous ventilation at minimum fan speed	Ventilation at high speed for 20 min/hr, recirculation for 40 min/hr	Continuous ventilation at minimum fan speed
Measured Total Supply Air Flow (delivered to house)	80 CFM	52 CFM	76 CFM	78 CFM
Total portion of the time the unit was in recirculation mode during the monitoring period	27%	0%	67%	41%
Hourly average fresh air supply to the house	**58 CFM**	**52 CFM**	**25 CFM**	**46 CFM**
ASHRAE 62.2 recommended ventilation rate	55 CFM	55 CFM	53 CFM	53 CFM
BEES recommended ventilation rate	67 CFM	67 CFM	65 CFM	65 CFM

Implications of Continuous Ventilation

A ventilation system must be carefully designed to achieve healthy indoor air quality while also maximizing energy efficiency. For instance, system designers need to understand the difference in intermittent versus continuous ventilation systems. One designer may prefer that fresh air be delivered continuously, rather than for only a portion of the time. A different designer may prioritize other aspects of residential ventilation and find intermittent ventilation an acceptable compromise. In both cases, the same whole-house ventilation rate may be met, but only if the designer understands the function of the HRV and the intent behind ventilation standards.

Building Ventilation Standards

Using ASHRAE 62.2 (2013) as a design guide for ventilation may not be sufficient to provide acceptable indoor air quality in many cases. Under this standard, whole-house ventilation compliance can met with an exhaust-only system or a whole house balanced ventilation system. There is a substantial difference between the two mechanical ventilation approaches in terms of known deliver of supply air, heat recovery, potential for filtration, and pressurization of the building. However, these differences are not considered in the 62.2 standard. Furthermore, the current recirculation defrost schemes in place on most HRVs can also undermine ASHRAE 62.2 requirements by reducing the net ventilation rate and causing cross-contamination of the exhaust and supply air streams.

The standard should be considered to be a minimum standard for ventilation, not a best practice standard. A professional or homeowner who wants to meet best practices should also consider the actual number of occupants in the home as well as the strength of pollutant sources. The whole-house ventilation rate in the 62.2 standard assumes one person per bedroom with two in the master bedroom. If a house is anticipated to have a higher occupancy, this should be accounted for in the mechanical ventilation system design. Another consideration is the 62.2 whole-house ventilation rate calculation does not account for the decreased ventilation rate caused by ventilation defrost mechanisms. Furthermore, the standard is not designed to address high-polluting events such as painting, cleaning, smoking, or construction projects. These concentrated pollutant sources require local exhaust ventilation and modification of occupant behavior in order to achieve acceptable indoor air quality.

In Alaska, the Alaska Building Energy Efficiency Standard[9] (BEES) (Alaska Housing Finance Corporation, 2013) adopts ASHRAE 62.2-2010 by reference with a few modifications. One significant modification is the requirement for a higher whole-house ventilation rate per bedroom than the ASHRAE standard because of the assumption for a higher occupancy. The Alaska BEES also prohibits the use of supply-only ventilation and recommends the use of an HRV for whole-house ventilation. However, since BEES adopts ASHRAE 62.2, it contains the same shortcomings mentioned above.

Additional Options to Meet Ventilation Goals

The recirculation defrost method, alone, does not necessarily undermine ASHRAE 62.2 (2013) requirements since several strategies could be employed to achieve the targeted whole-house ventilation rate. For instance, one could over-ventilate to meet ventilation minimums, though the energy lost due to over-ventilation may be unjustifiable by some homeowners or designers. Another option may be to ensure that an HRV with recirculation defrost has sophisticated enough controls to program an intermittent ventilation

[9] BEES was established by the State of Alaska to promote the construction of energy efficient buildings. It sets building energy use standards for thermal resistance, air leakage, moisture protection and ventilation. It is currently comprised of the 2012 International Energy Conservation Code (IECC), ASHRAE 62.2 2010, and Alaska Specific Amendments to both.

- See more at: http://www.ahfc.us/efficiency/research-information-center/bees/#sthash.qsRtJrsk.dpuf schedule per ASHRAE 62.2.

Using the electric heater, the continuous ventilation Zehnder unit in Fairbanks in Kotol's study demonstrates that lower supply air flow rates can be used to achieve the ASHRAE 62.2 whole-house ventilation rate relative to conventional recirculation defrost HRVs. In terms of measured CO_2 levels, the Zehnder unit was able to provide among the best air exchange rate. There is potential to reduce the operating cost by using the GHE, but to date, there isn't sufficient data to support this assertion. Additionally, in a cold climate like Fairbanks, the GHE would not be a complete replacement for the electric preheater; rather, it would be a supplemental heat source to offset the electric heater use, as described by Figure 1.

While Kotol's (2013) study focuses on indoor air quality, he noted that the electric preheater in the ComfoAir activated when the outdoor temperature dropped below 15°F (-9.5°C) and he saw no evidence of frost accumulation at the core. Also, as noted in Kotol's study, improper settings (for example, wrong ventilation speed) could undermine the system's ability to meet appropriate ventilation standards.

The issues associated with low relative humidity levels in homes in cold, arid climates need to be considered. The ERV in Kotol's (2013) study had the highest relative humidity of the four houses. Perhaps the designer would consider the use of ERVs. A recent study by the Cold Climate Housing Research Center shows promise for the performance of ERVs in cold climates (Cold Climate Housing Research Center, 2014). Perhaps an ERV core can replace the unit's ERV core (the Venmar EKO units have this capability) may also be considered used to alleviate this issue by retaining moisture from the house. Additionally, *if the building envelope can handle the additional moisture loading*[10], humidification of the home may also alleviate the dryness issues.

House Pressure Concerns

Of the four defrost mechanisms described at the beginning of this paper, fan shut-off and damper-based strategies result in negative house pressure since they operate in an exhaust-only capacity during defrost. Such a situation can lead to backdrafting of combustion appliances, which can create indoor air quality problems and potentially life-threatening conditions for occupants.

In houses with a moderately leaky building envelope, the negative pressure caused by fan shut-off and damper-based defrost mechanisms discussed earlier may not be enough to cause a dangerous backdrafting scenario. With improvements in building performance of new homes in cold climates, however, building envelope tightness has also increased. In such houses, the effect of HRVs on house pressure is much more significant.

HRVs with recirculation-type defrost modes maintain neutral house pressures, a point worth considering from a combustion safety standpoint. The Zehnder HRV also maintains neutral house pressures, as long as the GHE and/or electric preheater is installed. The default mode without these preheaters, however, is fan shut-off, which can be a dangerous risk in a tight home.

[10] Typical cold climate wall construction does not tolerate high inside humidity levels because it can lead to moisture accumulation within wall systems and cause mold or rot. Humidifiers should only be used if the building envelope were designed to handle the moisture loading or if the humidification can be limited to 40% RH.

Summary

Understanding frost protection is critical to designing an HRV system that conserves energy while protecting indoor air quality. In cold climates, HRV systems that use fan shut-off, damper-based (fifth-port), and recirculation-type defrost strategies could undermine ventilation efforts during extended cold periods. In some cases, preheating the incoming (outdoor) airstream may be necessary to meet ventilation standards while preventing the HRV from freezing up.

An evaluation of Zendher's ComfoAir 350 continuous ventilation HRV provided some insight as to the benefits and costs associated with a preheating defrost strategy in cold climates. In short, providing enough energy to raise the incoming air temperature to prevent core frosting can allow the system to provide continual fresh air and prevent frost buildup all year long. Such a system could dramatically improve indoor air quality in cold climates. The cost, of course, is the additional energy added to the system for frost prevention.

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