RESEARCH REPORT

# Survey of HRV/ERV Performance Issues in Canada's Near North and Far North: Final Report

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# Executive Summary

Effective ventilation is essential to provide acceptable indoor air quality (IAQ) and control moisture in Canadian homes. However, ensuring proper ventilation while minimizing energy costs can be a challenge in housing in Canada's Near North and Far North due to several factors including a harsh climate and frequent overcrowding.

An increasingly common method to provide a healthier indoor environment, control moisture build-up and reduce energy costs is to install a balanced ventilation system that uses a heat or enthalpy recovery ventilator (HRV/ERV). Based on anecdotal reports, there are concerns that HRV/ERV ventilation systems installed in new and existing housing in Canada's Near North and Far North frequently underperform or fail.

This project by John Hockman of J.L. Hockman Consulting Inc. was commissioned by the Canada Mortgage and Housing Corporation (CMHC) to:

- gather insights from key stakeholders about how residential HRV/ERV systems are designed, installed, commissioned, operated and maintained in Canada's Near North and Far North and, for comparison, in Alaska;
- identify and document issues and common problems that affect the performance of these HRV/ERV systems; and
- share the information collected with stakeholders to stimulate discussion and identify future work to improve the performance of HRV/ERV systems in northern housing.

The project began by identifying technical representatives from key northern stakeholders to be included in a telephone survey of HRV/ERV performance issues. These persons were drawn from the three territorial governments (Yukon, NWT and Nunavut) plus Nunavik and Nunatsiavut in Canada; the Cold Climate Housing Research Center in Alaska; and private contractors who design, install and/or service HRV/ERV systems in the North. A subset of these technical representatives, plus representatives from CMHC and Natural Resources Canada, were identified to serve on a Project Steering Committee.

To gain insights about HRV/ERV performance issues in northern housing, Mr. Hockman attended the *2016 Residential Construction Workshop* held in mid-February 2016 in Yellowknife. Organized by Northwest Territories and Nunavut Construction Association (NNCA), the second day of this event focused on 'HRV and Ventilation Issues in the North'. The workshop featured several presentations, including one by Mr. Hockman about design and installation practices for HRV/ERV systems in Manitoba and reasons why they can freeze-up. The workshop concluded with a roundtable discussion of HRV/ERV performance issues in northern housing facilitated by Mr. Hockman.

The roundtable discussion at the NNCA workshop was used to develop a list of issues that participants felt needed to be addressed to ensure that HRV/ERV in northern housing are much more likely to meet their intended level of performance. This list of issues was shared with the members of the Project Steering Committee. A teleconference with the Steering Committee was subsequently held in early March 2016 to gain their input into developing questions for a telephone survey of stakeholders. A separate list of performance issues was compiled by the Nunavut Housing Corporation.

Based on this input, plus issues that emerged from the roundtable discussion at the NNCA workshop, a final set of questions for the survey was developed. The survey was then administered from mid-March to late April 2016 by Mr. Hockman through telephone interviews of 14 individuals from stakeholder groups across the North.

Results of the telephone survey have been compiled and published in a separate companion document to this report. An analysis of responses to the survey yields the following conclusions and recommendations:

- At present, there are no HRVs/ERVs specifically designed and manufactured to meet the rigorous requirements for operation in the Near North and Far North. Notwithstanding, there are actions that can be taken to make it easier to select HVR/ERV units that are appropriate for use in northern housing.
- Many problems that are minor issues for HRV/ERV systems installed in southern Canada become major problems in the North. This can be addressed by:
  - developing additional guidance for designers of HRV/ERV-based ventilation systems for northern housing; and
  - conducting research on system elements such as improved diffuser designs; suitability of ‘home run ducting systems’; optimum options for exterior intake and exhaust openings; and integration of improved air filtration.
- Concerns persist that many HRV/ERV systems did not have all aspects of the systems installed correctly. Although some Northern locations do have access to trained and certified ventilation system designers and installers, many locations have to bring in installers from the South and many of these contract installers are not certified or fully trained in HRV/ERV installation. Expanded efforts to train installers and require the use of installation checklists is recommended.

There is evidence that third-party commissioning/verification system used in Whitehorse results in the fewest problems of all HRV/ERV systems installed in the North. This practice should be used as a model by other jurisdictions.

Many respondents emphasized the importance of having simple and easily understood controls for occupants. This can be supported by developing a standard design for an ‘outdoor temperature reset dehumidistat’. Another action is to source reliable carbon dioxide and VOC sensors /controllers suitable to use as additional indoor air quality controls in homes in the North. This latter measure will address the fact that due to outdoor conditions, many houses in the North can have both low indoor humidity levels and excessive levels of other indoor pollutants due to high occupancy.

Survey respondents suggest that the lack of maintenance of HRV/ERV systems is widespread in the North, resulting in hundreds if not thousands of non-functioning HRV/ERV systems. Maintenance staff at many local community housing authorities feel intimidated due to their lack of knowledge and experience with maintaining HRVs/ERVs. Several actions can be undertaken to lessen this problem including developing:

- a simple seasonal maintenance checklist;
- an online video on how-to set and adjust dehumidistat controllers; and
- a troubleshooting guide for maintenance staff;
- additional training of maintenance staff.

Finally, several survey respondents mentioned that an education campaign is needed to raise awareness of tenants of public housing and owners of private housing in the North about the importance of mechanical ventilation systems in modern, tightly sealed energy-efficient homes.

## Conclusions

The results of the survey activities undertaken for this project reaffirm that ventilation performance in northern housing is influenced by a range of activities including design, installation, commissioning, and operations and maintenance activities. Failure in any of these can result in poor ventilation to complete system failure – potentially leading to indoor air quality issues, mould, and overall poor energy performance.

Achieving high performing, durable northern housing will continue to be difficult until all ventilation issues are resolved.

Additional research into optimal technical designs and information transfer activities that support further education and training of designers, installers, housing maintainers, and tenants is essential to ensuring that HRVs and ERVs perform as needed in Northern housing.

This will require a cross sector commitment amongst builders, installers, designers, manufacturers and operators as well as housing providers to ensure appropriate technologies are selected, installed, and operated effectively.

## Résumé

Une ventilation efficace est essentielle pour fournir une qualité de l'air intérieur acceptable et pour contrôler l'humidité dans les habitations au Canada. Toutefois, il peut être difficile d'assurer une ventilation adéquate tout en réduisant le plus possible les coûts énergétiques dans les logements situés dans le Nord proche et le Grand Nord du pays en raison de plusieurs facteurs, dont la rigueur du climat et le surpeuplement fréquent.

Une méthode de plus en plus utilisée pour assainir l'environnement intérieur, pour contrôler l'accumulation d'humidité et pour réduire les coûts énergétiques consiste à installer un système de ventilation équilibré doté d'un ventilateur récupérateur de chaleur ou d'énergie (VRC/VRE). Selon des rapports anecdotiques, le problème est qu'il arrive souvent que les VRC/VRE installés dans les logements neufs ou existants situés dans le Nord proche et le Grand Nord du Canada aient un rendement insuffisant ou tombent en panne.

Le projet, réalisé par John Hockman de J.L. Hockman Consulting Inc., a été commandé par la Société canadienne d'hypothèques et de logement (SCHL) afin de :

- recueillir les points de vue des intervenants clés concernant la manière dont les VRC/VRE résidentiels sont conçus, installés, mis en service, utilisés et entretenus dans le Nord proche et le Grand Nord canadiens par rapport à l'Alaska;
- relever et consigner les problèmes courants nuisant au rendement de ces VRC/VRE;
- faire part aux intervenants des renseignements recueillis en vue de stimuler la discussion et d'établir les travaux à réaliser pour améliorer le rendement des VRC/VRE des logements dans le Nord.

Le projet a commencé par l'identification des représentants techniques des intervenants clés dans le Nord qui participeraient à une enquête téléphonique sur les problèmes de rendement des VRC/VRE. Il s'agissait de représentants des trois gouvernements territoriaux (Yukon, Territoires du Nord-Ouest et Nunavut), du Nunavik et du Nunatsiavut au Canada, du Cold Climate Housing Research Center, en Alaska, et d'entrepreneurs privés qui conçoivent, installent et/ou entretiennent les VRC/VRE dans le Nord. Certains de ces représentants techniques ont été désignés pour siéger à un comité directeur du projet, en plus de représentants de la SCHL et de Ressources naturelles Canada.

Pour en savoir plus sur les problèmes de rendement des VRC/VRE dans les logements du Nord, M. Hockman a assisté au *2016 Residential Construction Workshop* tenu à la mi-février 2016 à Yellowknife. La deuxième journée de cet événement, organisé par la

Northwest Territories and Nunavut Construction Association (NNCA), était axée sur les VRC et les problèmes de ventilation dans le Nord. Plusieurs présentations y ont été faites, dont celle de M. Hockman au sujet de la conception et des pratiques d'installation des VRC/VRE au Manitoba et des raisons pour lesquelles ils peuvent geler. L'atelier s'est terminé par une table ronde animée par M. Hockman sur les problèmes de rendement des VRC/VRE dans les logements du Nord.

Cette table ronde a servi à établir une liste des problèmes qui, selon les participants, devaient être réglés pour que les VRC/VRE dans les logements du Nord soient plus susceptibles d'atteindre le rendement attendu. Cette liste a été transmise aux membres du comité directeur du projet, qui ont ensuite pris part à une téléconférence au début de mars 2016 afin d'exprimer leur avis sur les questions à utiliser lors d'une enquête téléphonique auprès des intervenants. La Société d'habitation du Nunavut a compilé une liste distincte de problèmes de rendement.

Ces avis et les problèmes qui ont été exprimés lors de la table ronde de l'atelier de la NNCA ont permis de rédiger une série de questions finales pour l'enquête. M. Hockman a mené cette enquête de la mi-mars à la fin d'avril 2016 par le biais d'entrevues téléphoniques auprès de 14 représentants de groupes d'intervenants dans le Nord.

Les résultats de l'enquête téléphonique ont été compilés et publiés dans un document distinct accompagnant le présent rapport. Une analyse des réponses à l'enquête a permis de formuler les conclusions et les recommandations suivantes.

- À l'heure actuelle, aucun VRC/VRE n'est expressément conçu ou fabriqué pour respecter les exigences rigoureuses de fonctionnement dans le Nord proche et le Grand Nord. Néanmoins, des mesures peuvent être prises pour faciliter le choix des VRC/VRE pouvant être utilisés dans le Nord.
- De nombreux problèmes mineurs liés aux VRC/VRE installés dans le Sud du Canada deviennent des problèmes majeurs dans le Nord. Ils peuvent être résolus :
  - en élaborant des directives supplémentaires pour les concepteurs de systèmes de ventilation dotés de VRC/VRE destinés aux logements dans le Nord;
  - en menant des recherches sur les éléments des systèmes, par exemple sur l'amélioration de la conception des diffuseurs, sur la durabilité des réseaux de conduits dans les habitations, sur les options idéales pour les bouches extérieures d'alimentation et d'évacuation et sur l'intégration de filtres d'air améliorés.
- Des doutes persistent quant à la possibilité que des éléments des VRC/VRE soient mal installés. Bien que certaines localités nordiques aient accès à des concepteurs et à des installateurs formés et certifiés en matière de systèmes de ventilation, de nombreuses régions doivent faire appel à des installateurs du Sud, dont bon nombre ne sont pas certifiés ou dûment formés quant à l'installation de VRC/VRE. Il est

recommandé de déployer plus d’efforts pour former des installateurs et d’exiger l’utilisation de listes de vérification de l’installation.

Il ressort que le système de mise en service et de vérification par des tiers utilisé à Whitehorse est celui qui permet de réduire le plus les problèmes liés aux VRC/VRE installés dans le Nord. Cette pratique devrait servir de modèle pour les autres compétences.

Beaucoup de répondants ont souligné l’importance de commandes simples et faciles à comprendre pour les occupants. La normalisation de la conception de la commande de rétablissement du déshumidistat en fonction de la température extérieure en est un exemple. Une autre mesure consiste à se procurer des détecteurs/régulateurs fiables de dioxyde de carbone et de composés organiques volatils (COV) pouvant servir de systèmes de contrôle supplémentaires de la qualité de l’air dans les habitations du Nord. Ainsi seront réglés les problèmes liés au taux d’humidité insuffisant et à la présence excessive de polluants à l’intérieur de nombreuses habitations dans le Nord en raison des conditions extérieures et de la forte occupation.

Les répondants à l’enquête indiquent que l’absence d’entretien des VRC/VRE est courante dans le Nord, d’où les centaines, voire les milliers, de VRC/VRE défectueux. Les employés d’entretien de nombreuses autorités locales en matière de logement se sentent intimidés en raison de leur manque de connaissances et d’expérience quant à l’entretien de VRC/VRE. Plusieurs mesures peuvent être prises pour atténuer ce problème, notamment :

- l’établissement d’une liste simple d’entretien saisonnier;
- la création d’une vidéo en ligne sur le réglage des commandes du déshumidistat;
- l’élaboration d’un guide de dépannage à l’intention du personnel d’entretien;
- l’élargissement de la formation offerte au personnel d’entretien.

Enfin, plusieurs répondants à l’enquête ont mentionné la nécessité de mener une campagne de sensibilisation auprès des locataires de logements publics et des propriétaires de logements privés dans le Nord afin qu’ils saisissent l’importance des systèmes de ventilation mécanique dans les habitations éconergétiques hermétiques modernes.

## Conclusions

Les résultats de l'enquête réalisée dans le cadre de ce projet confirment une fois de plus que le rendement du système de ventilation dans les logements dans le Nord est influencé par diverses activités, notamment la conception, l'installation, le mise en service, le fonctionnement et l'entretien. La défaillance d'une de ces activités peut donner lieu à une mauvaise ventilation, mais aussi à une panne complète du système – d'où des problèmes possibles de qualité de l'air intérieur, de moisissures et de rendement énergétique global.

Tant que tous les problèmes de ventilation ne seront pas résolus, il sera difficile d'offrir des logements durables et à haut rendement dans le Nord.

Il est essentiel de mener d'autres recherches sur les conceptions techniques optimales et sur les activités de diffusion de l'information favorisant la sensibilisation et la formation des concepteurs, des installateurs, du personnel d'entretien des logements et des locataires, afin de s'assurer que les VRC/VRE fonctionnent comme prévu dans les logements du Nord.

Cela nécessitera un engagement intersectoriel de la part des constructeurs, des installateurs, des concepteurs, des fabricants, des promoteurs et des fournisseurs de logements pour s'assurer de choisir, d'installer et d'utiliser efficacement les bonnes technologies.

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# Survey of HRV/ERV Performance Issues In Canada's Near North and Far North: Final Report

**Submitted to:**

Catherine Soroczan, Senior Researcher
Canada Mortgage and Housing Corporation
700 Montreal Road, C2-364, Ottawa, ON K1A 0P7

**Submitted by:**

J.L. Hockman Consulting Inc.

## Acknowledgements

John Hockman of J.L. Hockman Consulting Inc. wishes to acknowledge the important individual and collective contributions to this project by members of the Project Steering Committee and participants in the telephone survey.

## Important Notice

Opinions expressed in this report are those of the author and do not necessarily reflect the official position of Canada Mortgage and Housing Corporation. Comments and inquiries about the content of this report should be directed to John Hockman, B.E.S. at jhockman@mymts.net.

# Contents

**Appendices**

## 1.0 Introduction and Background

Indoor air quality (IAQ) in homes in Canada has been a concern for many decades. Mechanical ventilation for new, low-rise housing was first mentioned in the National Building Code of Canada (NBC) in the mid-1980s. The original concern that prompted this inclusion in the NBC was the potential for the build-up of excessive levels of moisture inside new homes, especially those with no chimney and low levels of natural air change. In Northern Canada and Alaska, frequent high occupancy and a climate that results in people spending much more time inside their homes makes the necessity of an effective mechanical ventilation systems more imperative.

Due to airtight home construction practices, required to minimize the risk of building envelope deterioration or failure and to reduce energy use, balanced ventilation systems with heat recovery have been installed in a high percentage of new homes in the North. The heart of these systems is a heat recovery ventilator (HRV) or, less commonly, an enthalpy recovery ventilator (ERV) which are also sometimes referred to as an ‘energy recovery ventilator’.

Private homes can be built without an HRV or ERV in most jurisdictions in the North. However, in Yellowknife (Northwest Territories) and in Whitehorse (Yukon), both cities have passed construction by-laws that require homes to meet a minimum energy efficiency standard based on Natural Resources Canada’s EnerGuide for New Houses rating system.

In May 2012, Yellowknife City Council passed a by-law requiring a minimum EnerGuide for New Houses (EGH) rating of 80 for new single-family and two-family dwellings. Multi-family buildings were granted a transition period from January 1, 2012 to January 1, 2014 where the EGH 80 requirement was not strictly enforced. After January 1, 2014 these buildings have also been required to achieve an EGH 80 or better rating as well.

The City of Whitehorse has passed an Energy Conservation Bylaw Amendment as part of their new Green Buildings Standards. These amendments are part of the City's ongoing efforts to implement its Sustainability Plan. The effective date for the amendment for heated residential, commercial and industrial buildings was December 31, 2012. The amendment also applies to modular homes and came into effect for mobile homes on June 30, 2015.

There are two options to meet higher levels of building performance. One is to follow a set of prescriptive minimum thermal insulation values. The second option is to use energy modeling software to predict the building’s energy performance. As of April 1, 2014, the City of Whitehorse requires an EnerGuide Rating System label on all new homes with a minimum EGH rating of 82. As part of the Energy Conservation

Amendment there are also specific requirements to meet the ‘Principal Ventilation Fan’ airflow requirements with an HRV or an ERV. The HRV/ERV unit must have a sensible recovery efficiency of 64% or greater at -25$^{0}$C when tested according to CAN/CSA-C439-09 (R2014). The HRV/ERV must also be listed in the Home Ventilating Institute (HVI) Certified Products Directory.

The Government of the Yukon, through the Energy Solutions Centre, offers financial incentives of up to $10,000 for homeowners and builders who construct a new super-insulated home rated at EnerGuide 85 or greater.

Whitehorse has a local building by-law that requires new homes to use a HRV/ERV and have an EnerGuide rating of at least 82 (incentives have been offered for homes that have an EnerGuide rating of 85 or greater). Yellowknife has also passed a local by-law requiring that new homes have an EnerGuide rating better than 80, however, HRVs/ERVs are not specifically mandated. While they are not specifically mandated, it is almost impossible to meet the required energy performance ratings without the use of an HRV or ERV. As a result, all new single and two-family housing in Whitehorse and Yellowknife do have HRV/ERV systems installed. In the remainder of the Yukon and Northwest Territories, private housing can be built without installing an HRV or ERV system.

The Alaska Housing Finance Corporation (AHFC) has offered an Energy Rebate for New Construction for newly built energy-efficient homes. Currently, the program no longer accepts new sign-ups. The AHFC New Home Rebate Program was funded by the Alaska State Legislature. It provided rebates to Alaskan homeowners (regardless of income) who built or purchased a 5 Star Plus Home or 6 Star Home with a rebate of $7,000 USD or $10,000 USD respectively. This performance requirement requires a HRV/ERV in homes built in the colder climate areas of Alaska.

In Nunavut, and Nunatsiavut there are no building code requirements to install an HRV or ERV system in new housing. However, along with Yukon and Northwest Territories, virtually all new public and private housing in Nunavut, and Nunatsiavut are built with HRV/ERV systems. In Nunavik, which falls under the Quebec Building Code, HRVs/ERVs are required in all new dwelling units. In addition, many existing public housing units in all three Territories have been, or will be, retrofitted with HRVs or ERVs.

Thus, across Northern Canada, in the Yukon, Nunavut, Nunavik, Nunatsiavut, Northwest Territories, and also in Alaska, thousands of HRVs and, more recently some ERVs, have been installed. However, there are concerns about how well these HRV/ERV systems perform. Numerous anecdotal reports suggest that many systems fail to provide adequate ventilation or are no longer operational. There is also concern that high occupancy levels common in many homes in Northern Canada, combined with under-performing mechanical ventilation systems, may be contributing to increased respiratory health problems.

## 2.0 Project Objectives

This project by John Hockman of J.L. Hockman Consulting Inc. was commissioned by Canada Mortgage and Housing Corporation (CMHC) to:

- gather insights from key stakeholders about how residential HRV/ERV systems are designed, installed, commissioned, operated and maintained in Canada's Near North and Far North and Alaska;
- identify and document issues and common problems that affect the performance of these HRV/ERV systems through a telephone survey; and
- share the information collected to assist those exploring improved HRV/ERV equipment, systems and training for northern housing.

## 3.0 Approach and Methodology

This section describes the approach and methodology was used to conduct this project.

### Task 1: Identify Northern Stakeholders and Project Steering Committee

The project began by identifying technical representatives from key northern stakeholders to be included in a telephone survey of HRV/ERV performance issues. These persons were drawn from the three territorial governments (Yukon, NWT and Nunavut) plus Nunavik and Nunatsiavut in Canada; the Cold Climate Housing Research Center in Alaska; and private contractors who design, install and/or service HRV/ERV systems in the North. A subset of these technical representatives, plus representatives from CMHC and Natural Resources Canada, were identified to serve on a Project Steering Committee.

Refer to Table A for a listing of the key stakeholders that were identified and individuals who agreed to serve on the Project Steering Committee.

### Task 2: Present at the NNCA 2016 Residential Construction Workshop

To gain insights about HRV/ERV performance issues in northern housing, Mr. Hockman attended the *2016 Residential Construction Workshop* held in February 17 & 18, 2016 in Yellowknife. Organized by Northwest Territories and Nunavut Construction Association (NNCA), the theme of the second day of this event was 'HRV and Ventilation Issues in the North' that featured a series of six presentations. This included a presentation by Mr. Hockman about:

- experience from the design and installation of over 19,000 HRV/ERV systems in Manitoba over the past four years; and
- reasons that can cause HRV/ERV units to freeze-up.

Refer to Appendix B for a copy of Mr. Hockman's presentations. A PDF copy of this presentation, and those of the other presenters, can be downloaded from the NNCA's website at this link: [http://nnca.ca/node/480](http://nnca.ca/node/480)

The workshop concluded with a roundtable discussion of HRV/ERV performance issues facilitated by Mr. Hockman. This discussion included having the audience develop a list of performance issues that they felt needed to be addressed to increase the possibility of HRV/ERV systems meeting their intended performance in northern housing (see Appendix C).

### Task 3: Conduct Steering Committee Teleconference

A Project Steering Committee teleconference was held to gain additional input for the development of the set of questions for a telephone survey. The final questionnaire that was developed was based on the teleconference and feedback from the roundtable discussions at the NNCA workshop in Yellowknife.

### Task 4: Administer Telephone Survey and Compile Results

The telephone survey was administered to representatives from a range of stakeholder group plus other individuals who have had experience as housing managers, designers, installers, commissioning agents and housing maintenance staff. Responses to the survey were compiled by topic areas.

### Task 5: Summarize Conclusions and Recommendations

The responses to the telephone survey were then analyzed. This report presents a compilation of the survey responses and conclusions that can be drawn from the results. Recommendations were also developed for this report for further work that would assist stakeholders to ensure that HRV/ERV systems in new and existing housing in the North operate as intended and provide improved indoor air quality, moisture control and energy savings.

# 4.0 Compilation of Survey Results

The following is a compilation of responses to the telephone survey presented in the order of the survey questions. Some results have been grouped together even though the questions were asked at different times during the telephone survey (e.g., questions on equipment costs, installed systems and individual replacement parts were asked at different points in the survey, but are compiled into one group).

## 4.1 Heat Recovery Ventilators/Enthalpy Recovery Ventilators

### 4.1.1 Popular brands of HRVs/ERVs

The most common makes of HRV/ERV reported to be installed across the North are Venmar, vänEE and Nutech (now named Airia/Lifebreath). Although specific models being used have changed over time, these three brands continue to be the most commonly installed units. Some organizations have tried a few other brands of HRVs/ERVs, but only in limited numbers.

There are some local variations such as the Eneready Products Limited HRV and now ERV, a brand that is popular with some installers in the Yukon. This unit is a low volume, modified version of an older vänEE unit. The manufacturing rights were obtained and modifications made to the controls, motors and other components to give the unit some of the features that installers/homeowners favour. This includes the continued use of PSC motors rather than brushless DC (BLDC or ECM) motors that are thought to be more susceptible to voltage fluctuations and are reported to be much quieter when switching to high speed than some of the early ECM motors. Some Yukon installers have found obtaining parts much quicker for Eneready than other manufacturer’s products in the past (Eneready is based in British Columbia and there is direct air freight to Whitehorse).

Some of the more remote locations tend to prefer specifying older models of some brands to reduce the variation in parts stocking and make it easier for maintenance staff who may be familiar with the older models. Introduction of different brands and newer models, some of which may have performance advantages, are often not accompanied by training to update maintenance personnel.

In Manitoba, where HRV/ERV systems have been mandatory for new low-rise housing since 2012, some builders started using makes and models of HRVs/ERVs that had not had widespread usage in the province. Some of these manufacturers have made modifications, upgrades and retrofit kits to improve the performance of their units in Manitoba’s relatively cold climate. These new models need to be capable of operating in

Thompson, Manitoba, which has a Winter Design Temperature of -44$^0$C (this is similar to Arviat, Nunavut and Yellowknife, NWT).

Further innovations are being explored by manufacturers. One manufacturer has just introduced a 'hybrid' core for their HRV/ERV units. The hybrid core is split – approximately 2/3 of the plates function as an HRV (with no latent moisture transfer between outgoing exhaust and incoming supply airstreams) while the remaining 1/3 of the plates are ERV plates (which allow both sensible and latent heat transfer).

Another manufacturer has introduced a new, higher efficiency HRV and ERV units that use improved European brushless DC (BLDC or ECM) electric motors plus other features that make it one of the most efficient units on the market. This unit also follows another manufacturer's strategy of using individual motors and motor speed controls to permit both high and low airflow requirements to be set individually on each fan motor to improve the balance of fresh air intake and stale air exhaust airflows at various flow rates.

This individual motor speed control at two or more different speeds is an important improvement in the ability to correctly balance airflows in HRVs/ERVs. Where balancing of the airflows relies on balancing dampers in the ductwork, or built-in dampers on the HRV/ERV units and the two fans are powered by a single motor, it is almost impossible to balance the airflows on both high and low airflows as required by Code if the ductwork is not properly designed, sized and installed. If the units are not balanced properly at both the high and low airflow rate requirements there is a much greater probability that the HRV/ERV will freeze-up during the winter and not be able to defrost as intended.

### 4.1.2 Specifiers of HRV/ERV units and ventilation system designers

There are a number of different markets for HRV/ERV specifications and design strategies across the North. The responses from the survey have been divided into groups by market area and type of market.

a) Equipment selection and ventilation system designers for private housing in the Yukon:

   In Whitehorse's private home market, many homes have a preliminary energy analysis completed by an Energy Evaluator who recommends specific makes and models of HRV/ERV which should be used so the home will meet the requirement to achieve at least EGH 82 rating or the new Super Insulated New Homes Program requirement (EGH 85 or better). If a different HRV/ERV unit is installed than that suggested by the Energy Evaluator, the home may not be able to meet the desired energy rating.

The City of Whitehorse requires the design of an HRV system to be completed by a designer certified by the Heating, Refrigeration, and Air Conditioning Institute (HRAI) of Canada. The design is approved by the City upon submission of the initial building plan.

Outside of Whitehorse, the design of ventilation systems is often completed by a plumbing/heating contractor or a builder certified by HRAI in either ‘Residential Mechanical Ventilation Installation’ or ‘Residential Mechanical Ventilation Design’. There are over 70 HRAI certified individuals in Yukon, mostly located in and around Whitehorse. Multi-unit private housing projects in the Yukon most often use a mechanical engineer to provide the design and specifications of an HRV/ERV system.

b) Equipment selection and ventilation system designers for private housing in the Northwest Territories:

In the Northwest Territories private home market the builder or the mechanical contractor typically choses the HRV/ERV unit to be installed. A growing percentage of new homes in southern NWT are modular units shipped from Alberta. In Yellowknife, all new homes must meet a minimum EGH 80, thus the modular home manufacturers, if they provide the ventilation system, are careful in selecting HRVs/ERVs to ensure that the units will have the level of performance to permit the home to meet the required EnerGuide rating.

Ventilation system design, if done for a non-modular, site-built private home, is often completed by a plumbing/heating contractor or builder that has HRAI certification in either ‘Residential Mechanical Ventilation Installation’ or ‘Residential Mechanical Ventilation Design’. There are 33 HRAI certified individuals in the Northwest Territories located in Yellowknife, Hay River, Fort Simpson, Fort Smith and Norman Wells. Multi-unit private housing projects in the NWT typically use a mechanical engineer to provide the design and specifications.

c) Equipment selection and ventilation system designers for public housing in the Yukon, Northwest Territories, Nunavut and Nunavik:

New public housing in the Yukon and the other Territories typically have HRV/ERV ventilation systems designed and specified by mechanical engineers. If the entire house package is tendered for supply and delivery, sometimes it is the supplier of the housing package that chooses the type of HRV/ERV used. In many cases, a Housing Corporation will use past designs and specifications for new tenders and for upgrading and retrofitting of older housing units with HRVs/ERVs.

In Nunavut and Nunavik, most installations of HRV/ERV systems in new homes are completed by plumbing/heating contractors hired by the general contractor. They often come from southern Canada and may or may not have HRAI certification. In most of these cases, a mechanical engineer is responsible for equipment specification and system design, with the general contractor and the mechanical engineer responsible for verifying the installation of the system to the engineered designs.

d) Equipment selection and ventilation system designers for private housing in Alaska:

In the colder regions of Alaska, such as Fairbanks and other interior and northern communities, the builder or the mechanical contractor typically chose the HRV/ERV unit to be installed in the private housing market.

The ventilation system design, if one is done, is often completed by a plumbing/heating contractor or the builder, many of whom have taken training from classes based on the Alaska State Building Energy Efficiency Standard (BEES), or from the manufacturers of the HRV/ERV equipment. Multi-unit private housing projects most often use designs and specifications provided by a mechanical engineer.

### 4.1.3 Suggested key features of HRV/ERV equipment for northern housing

The following is a list of the key features that survey respondents felt are important when selecting an HRV/ERV unit:

- Shut down dampers on both the supply intake and exhaust outlets of the unit as this feature will prevent outdoor air from being drawn through the unit and into the house if the unit is turned off and the house is depressurized by other exhaust devices or when the HRV/ERV is connected to a forced air system and the forced air fan is on creating a negative pressure in the return ductwork that will also draw outside air through the HRV/ERV, most likely freezing the unit and supplying cold air into the living space during cold weather.
- Good efficiency to meet energy targets and reduce operating costs.
- Quiet motors and fans, especially when the unit switches to high-speed defrost.
- Reliability.
- Units that use a neutral pressure defrost strategy so that the unit does not depressurize the home during the defrost cycle (which may be 30% or more of the time in some northern locations).
- Simplicity of control and ease of use, or in another approach some engineers want the unit to be almost totally automatic with little occupant input.
- More effective air filtration.
- Higher delivered supply air temperatures, especially in colder regions.

#### 4.1.4 Should ERVs be used in northern housing?

These units are relatively new to the market and many of the respondents did not know or were unsure at this time if they would work. Some thought that they may be of benefit in low occupancy/low moisture production homes, but many also believed that unless the benefits are dramatic, it is unlikely that they will be adopted.

It should be noted that one of the presentations that was to be made at the Yellowknife NNCA Residential Construction Workshop has examples of the successful use of ERVs in Nunavik.

#### 4.1.5 Are parts for HRVs/ERVs readily available?

In remote communities it was reported that the Local Housing Offices (LHOs) may have some basic parts on hand such as filters, dehumidistat controls, timer switches, etc. However, because there are many different brands and models, most parts have to be ordered from the suppliers and flown in. In some cases parts for the same model of HRV/ERV has to be ordered by serial number and date of manufacture as different components and suppliers were used for a specific part of the HRV/ERV. This makes stocking parts very difficult and frustrating for the LHOs.

In many cases when internal parts such as fans, motors, control boards, dampers or damper motors fail, there is no one in the community that can repair the unit. As a result, the HRV/ERV is often removed and taken to the dump and a new unit installed.

In Whitehorse, installers report that HRV/ERV units are almost always able to be repaired. In most cases, parts are locally available or available within a few weeks.

#### 4.1.6 Average costs of HRV/ERV units and parts

Reported costs for HRV/ERV units, controls and installations vary considerably. The total costs are for Direct Ducted HRV/ERV systems as these account for 90% or more of systems in the North.

a) Average costs in Whitehorse:
   - Newer model units are reported to cost between $1,200 and $1,400. Specialty units are approximately $1,800 with some other lower cost units about $900 (prices are all without controls).
   - Main wall control costs are reported at $120 to $240, depending on type and sophistication of control.
   - Wall timer switches for bathrooms cost approximately $30.
   - Washable foam air filters cost approximately $60 a pair.

- Defrost damper motors cost $30 to $40, but on some newer units the entire damper assembly with motor must be replaced at a cost around $130.
- Total installed costs for an entire HRV/ERV system is reported to be between $5,000 and $7,000 with some specialized designs up to $10,000

b) Average costs in Yellowknife:
   - Newer model units are reported to cost around $4,700 installed with controls but no ducting.
   - Main wall control cost between $120 to $240, again depending on type and sophistication of control.
   - Dehumidistat wall control $60, but some older controls are no longer available.
   - Wall timer switches for bathrooms cost approximately $30.
   - Washable foam air filters cost approximately $40 a pair in bulk.
   - Total installed cost for an HRV/ERV system is reported to be between $5,000 and $8,000.

c) Average costs in Nunavik:
   - Equipment costs in Nunavik are reported to be about 3.5 times the cost in Montreal or Quebec City.
   - Total installed cost for a fully engineered commercial-level design and installation of an HRV/ERV system is reported to be between $10,000 and $15,000.
   - Costs of individual components of the system on new installations are difficult to obtain as the costs are not broken out separately in tenders and are often part of the overall general construction contract.

d) Average costs in Nunavut:
   - Costs for HRV/ERV units (excluding controls, ducting or installation) range from $1,200 to $1,800 depending on model.
   - Costs of individual components of the system on new installations are difficult to obtain as the costs are not broken out separately in tenders and are often part of the overall general construction contract.

e) Average costs in Alaska (U.S. dollars):
   - In Fairbanks and surrounding area, cost is about $1,300 for a new unit model plus $200 to $300 for a main wall control and two bathroom timer switches.
   - Fan motors for the units are $230.
   - ‘Top’ electronic main wall control is $190.
   - Filters are $60 a pair for one model and $40 a pair for another common unit.
   - HRV replacement cores are between $300 and $400.
   - Defrost damper motors cost between $60 and $80.

- Total installed cost for an HRV/ERV system for a three bedroom, two-bathroom home is reported to be approximately $6,000 (this may be for HRV/ERV systems integrated with a forced air heating system as this is more common in Alaska).

## 4.2 Design of HRV/ERV Ventilation Systems

### 4.2.1 Key features for ventilation system designs for northern housing

The following is a list of the key features that survey respondents felt were important in the overall design of a HRV/ERV ventilation system:

- High levels of insulation on exterior of HRV/ERV units to prevent surface condensation.
- Increased thermal resistance for insulated ducts that typically run between HRV/ERV units and the outdoors.
- Accessibility for servicing HRV/ERV units (many maintenance people do not like going into tight crawlspace floor systems common in homes built in permafrost areas).
- Supply air needs to be distributed through high wall supplies with better diffusers that throw the supply air farther into a room along the ceiling where it can mix with the warmer ceiling air and spread out over a wider area so that there are less cold drafts.
- Supply air needs to be warm enough so that people do not feel so uncomfortable that they turn the ventilation unit off.
- HRV/ERV systems must be quiet so people do not feel the need to turn the unit off because it is too noisy.
- Even if home has forced-air heat, the HRV/ERV should be fully ducted to distribute air without using the furnace fan; which will reduce electrical consumption, reduce noise and stop cold air blowing into rooms when ventilation system is on and the furnace blows cold ventilation air when there is no heating demand.
- System should be able to circulate air around the home when not in ventilation mode.
- Ducts should be correctly sized with minimal number of fittings to reduce noise and increase airflows.
- Length of insulated flex duct on the Supply and Exhaust sides of the HRV/ERV should be reduced and kept to a maximum of 5 to 6 feet per side.
- A standard design and specification for pre-heat and post-heat hydronic coils should be developed with good controls for setting the discharge air temperature from the units.
- Controls need to be more intelligent with the best controls having de-humidistats that automatically reduce acceptable relative humidity (RH) levels as the outdoor temperature drops and also has a carbon dioxide ($CO^2$) control that over rides all

other controls to provide ventilation when $CO^2$ levels rise above a set point, even if the RH is low.

### 4.2.2 Are HRV/ERV systems required/mandated for new housing?

In Whitehorse, the Energy Conservation Bylaw Amendment mandates that an HRV/ERV be used as a minimum for the principle or low airflow ventilation rate required by the NBC. Yukon has adopted Section 9.36 section of the NBC with some local amendments. In 9.36, there are options for insulation and other energy performance measures that include an optional HRV/ERV in the home, but HRVs/ERVs are not mandated by 9.36.

In Yellowknife, there is no specific building code requirement that mandate HRVs/ERVs in new homes. However, all new residential dwellings, including multi-family units, must meet an EGH 80 rating. By default, this forces new dwellings to use an HRV/ERV since not using an HRV/ERV makes it very difficult, if not impossible, to meet this EGH requirement. Outside of Yellowknife, the choice of whether to use a HRV/ERV depends on the desire of the builder or homeowner.

Virtually all new public housing projects in Yukon, Northwest Territories, Nunavut use HRV/ERV systems.

Nunavik falls under the requirements of the Quebec Building Code which requires an HRV/ERV in all new dwelling units.

In colder regions of Alaska, the use of an HRV/ERV is the choice of the builder or homeowner. It is increasingly common for HRVs/ERVs to be installed in both private homes and homes built in the remote communities where energy is more expensive.

### 4.2.3 Types of HRV/ERV systems installed in northern homes

There are three common types of HRV/ERV installations:

- Direct-Ducted System – This type of installation features exhaust inlets/pick-ups in wet areas such as bathrooms, the kitchen and sometimes utility or laundry rooms, plus direct supply air distribution to all bedrooms and main living space in the home. There may or may not be a forced-air heating system in the home.

  Survey respondents suggested over 90% to 95%, of the HRV/ERV ventilation systems installed in the North use this type of system, especially because the majority of new and existing homes use hydronic heating and do not have a forced-air heating system. Even if there is a forced-air system, as there may be in Whitehorse, Yellowknife and other more southerly locations, the direct-ducted system may be used as it typically uses much less electricity and often is quieter since the larger forced-air fans are not required to run to distribute the outdoor ventilation supply air.

- Simplified HRV/ERV System – This type of installation integrates the HRV/ERV with a forced-air system and exhausts air from the return air duct upstream of the HRV/ERV supply system that is ducted into the return air duct at least 1 meter downstream of the exhaust connection. This is a whole house ventilation system and the forced-air system fan must run whenever the ventilation system is operated. Because there are no direct pick-ups in the bathrooms and kitchens, these types of systems must have exterior vented exhaust fans in all bathrooms and the kitchen to meet all building codes in Canada. This system type is most often used in retrofits/upgrades in existing homes that have forced-air systems.

  It was reported that very few of these ventilation systems were in use in northern communities.

- Extend Exhaust and Supply to Return-Air – The third common type of HRV/ERV system is one where there are exhaust inlets/pick-ups in the wet areas, such as bathrooms and the kitchen (and sometimes including utility or laundry rooms), and the supply air from the HRV/ERV is ducted into the return air duct of a forced-air furnace. Again, the forced-air furnace fan must run whenever the ventilation system is operated in order to distribute the outdoor ventilation supply air to all rooms in the home.

  In Alaska, if this system type is used, the supply air is often ducted from the HRV/ERV into the forced-air furnace supply duct. The intent is that the supply air may be distributed to the rooms in the home without having to run the forced-air fan.

  It was reported that some of these ventilation systems are being used in homes where there is an existing forced-air furnace and the ventilation systems in the homes have been or will be retrofitted/upgraded.

## 4.3 Installation

### 4.3.1 Who is installing and inspecting HRV/ERV systems in the North?

a) Installation and inspection of HRV/ERV systems in the Yukon:

   In Whitehorse, most private homes have an HRV/ERV system installed by a plumbing/heating contractor, a specialized ventilation contractor, or in some cases, by the builder. In Whitehorse and the rest of the Yukon, if the homeowner/builder is applying for the HRV/ERV rebate from the Energy Solutions Centre, the system must be balanced by a qualified technician. The qualified technician can be an HRAI certified individual or, in the case of Whitehorse, the balancing of the HRV/ERV unit must be checked by a ‘Ventilation System Verifier’ listed by the City of Whitehorse.

City of Whitehorse Building Inspectors complete rough-in inspections and, for the most part, rely on the reports for ventilation systems completed by the City-approved Ventilation System Verifiers. Outside of Whitehorse, if the HRV/ERV is not part of the Yukon Government’s rebate program, inspections are the responsibility of the local building inspectors.

If the HRV/ERV system is being installed in a Yukon Housing project, or a multi-unit residential project, the project’s mechanical engineer is responsible for inspecting the installation by the HVAC contractor. An inspection of the ventilation system may be carried out by the local building inspector.

b) Installation and inspection of HRV/ERV systems in the Northwest Territories:

Similar to the Yukon, most private homes in the NWT have the installation of the HRV/ERV system completed either by the plumbing/heating contractor, a specialized ventilation contractor, or in some cases, by the builder.

Yellowknife, Hay River, Fort Smith, Fort Simpson, Norman Wells and Inuvik have local building inspectors. However, they are not mechanical inspectors. If the HRV/ERV system is being installed in a NWT Housing project, or a multi-unit residential project, the project’s mechanical engineer is responsible for inspecting the installation by the HVAC mechanical contractor. In remote communities, some of the HVAC contractors are brought in from out of the area and, in some cases, from outside of the Territories.

c) Installation and inspection of HRV/ERV systems in the Nunavut

If the HRV/ERV system is being installed in a new housing project in Nunavut Housing, the general contractor, usually the lowest bidder, is responsible for the installation by the HVAC sub-contractor. Ultimately the project’s mechanical engineer is responsible for the installation of the entire mechanical system. In most cases installations, including any ventilation retrofits of existing dwellings, have been tendered and the majority installations completed by mechanical contractors from southern Canada. At the time of this report, Nunavut has not adopted the National Building Code, National Fire Code, National Plumbing Code or the National Energy Code for Buildings Model Codes, therefore Nunavut currently has no building code or building code inspectors, but there are stated intentions to adopt the NBC in 2017 and provide building code inspectors.

d) Installation and inspection of HRV/ERV systems in Nunavik:

If the HRV/ERV system is being installed in a new housing project in a Nunavik Housing project, the general contractor, is responsible for the installation by the HVAC sub-contractor. Ultimately the project's mechanical engineer is responsible for the installation of the entire mechanical system. In most cases installations, including any ventilation retrofits of existing dwellings, have been tendered and the majority installations completed by mechanical contractors from southern Quebec. As Nunavik uses the Quebec Building Code, all residential dwelling units must use a HRV/ERV system for the ventilation system and installers are more likely knowledgeable regarding the installation of HRV/ERV systems.

e) Installation and inspection of HRV/ERV systems in Alaska:

The 2009 International Building Code (IBC) and the 2009 International Mechanical Code (IMC) are mandatory minimums for all buildings except one, two or three-family dwellings, unless otherwise indicated. Plans for all construction (except one, two, or three-family dwellings) are reviewed at the state level except in Anchorage, Juneau, Fairbanks, Kenai, Seward, Kodiak, Sitka, and Soldotna where they are submitted directly to the city.

Installation of HRV/ERV systems is completed either by the plumbing/heating contractor, a ventilation contractor, or in some cases by the builder or homeowner. Inspections may be carried out by local building inspectors in cities where they exist.

### 4.3.2 When are HRV/ERV systems installed in the construction process?

Almost universally, it is reported that the rough-in of HRV/ERV systems are completed with the plumbing and heating rough-in (and, as one installer suggested, hopefully before the electrical rough-in so that the wiring can be threaded around the ducting and not require difficult routing of the ducts to avoid the wiring). As in most construction, each trade like to be the first on-site to claim the wall stud and floor joist spaces to make their installation easier.

The majority of HRV/ERV units are not hung/installed until all or least the majority of the finish work (including painting if possible but for sure any drywall taping) is completed. Specifications for installations in Nunavik also include instructions to cap and seal any ductwork before the finish stages of construction.

### 4.3.3 Most common problems with installations of HRV/ERV systems

This question was intended to determine problems with the overall HRV/ERV system that are caused by poor installation practices. Many of the survey respondents have listed problems that result from poor design of the HRV/ERV system. These “design” issues have been placed at the end of each section and have the word design in brackets at the end of each statement where it applies. It should be noted that in cases where there has been no formal engineered design of the system, it is often the installer that makes “design” decisions at the site during the installation process. Even when a HRV/ERV system has been engineered or designed before the installation process, there are often changes that must be made to the design in the field to accommodate unanticipated site conditions such as framing layouts, site conditions (may impact intake/exhaust hood placement), etc. These on site design changes most often occur during HRV/ERV installations during retrofit or renovation of a dwelling. The following is a list of the most common HRV/ERV ventilation system problems that respondents reported, listed by jurisdiction:

a) Yukon (mostly about installations in Whitehorse):

- Achieving the required airflow from the system as installed.
- Condensation within the insulation of the insulated flex ducting.
- Difficulty finding space for equipment and to run ducting occurs about 20% of the time, which compromises the system installation according to one respondent.
- Difficulty finding an acceptable location for outside intake and exhaust hoods.
- Blowing cold air from supply grilles is a common complaint (poor design/selection/placement of the grille/diffuser).
- Freeze-up of units (may be caused by poor design/selection of HRV/ERV).
- High electrical consumption is an issue where power is costly (design).

Noise from the HRV/ERV unit and sound through ducts are two of the biggest issues (design).

b) Northwest Territories:

- Units have not been properly balanced (leads to freeze-up).
- Getting proper commissioning after system installation.
- Noise and vibration into house framing due to poor unit mounting.
- Blowing cold air from supply grilles (poor design/selection/placement of the grille/diffuser).

Not having the correct duct sizing results in low airflows and more noise (design problem).

c) Nunavut:

- Exhaust dampers on HRVs and clothes dryers freeze or jamb shut (design).
- Outdoor supply air intakes fill with snow (design).

- Sewer odours when water traps, including HRV traps, get sucked dry when sewage tank in the house's crawlspace is pumped-out (design).
- Limited room for mechanical equipment and resulting poor access (cramped crawlspace or tight attics in retrofits in many cases leads to poor installations and lack of maintenance) (design).
- Poor system design and bad duct layout leads to poor airflows (design).
- Noise from unit emanates from ducts and vibration is transmitted to house (design).
- Cold air is blown from supply grilles (poor design/selection/placement of the grille/diffuser).

d) Nunavik:

- Recent fully engineered installations have not had problems meeting airflow requirements.
- Biggest problem is higher cost of items such as special mechanical dampers.

e) Alaska:

- Almost every home has space problems with not enough space to locate the equipment and run ducting.
- Do not usually have problems with exterior hoods as most homes are on crawlspaces and ducts can be run to any side.
  Sometimes have difficulties with airflow on long houses due to undersized ducts (design/installation in the cases where the "design" is being done on site by the installer).

**4.3.4 What can be done to improve the installation of HRVs/ERVs?** The following is a list of survey respondent's suggestions to improve HRV/ERV ventilation system installations:

- Require system design submissions to municipal authorities as part of permission to build process.
- Use of a detailed installation checklist leads to more consistent installations.
- Use of third party verification with a detailed Verification Checklist appears to be working in one or more communities.
- Lack of trained installers is a big problem in many northern areas, therefore education, certification and enforcement of installers would improve things.
- Impliment requirements for HRV/ERV installation to be completed by trained professionals.

- Pre-construction meetings with general contractors, sub-contractors and mechanical engineers helps to reduce installation problems.

### 4.3.5 Are installation checklists used?

Most public housing corporations have some form of commissioning checklist which could be used as an installation checklist. At present, it is usually up to the installing contractor to complete any installation check to ensure that the work has been done correctly. However, there are few checks that this happens other than if a mechanical engineer is involved and they file a completion report with the local housing office (LHO) and territorial Housing Corporation.

In the Yukon, when builders or homeowners have utilized the rebate that is offered for the installation of a HRV/ERV, the ventilation system verification after installation is seen as a form of installation checklist. This verification also occurs in all HRV/ERV installations in the City of Whitehorse.

### 4.3.6 How are airflows measured?

Systems that have been designed and installed under the direction of a mechanical engineer may use commercial type airflow measurement tools to verify airflow rates in installed units. However, the majority of HRV/ERV airflows are measured using pressure gauges and the flow measuring stations that are built into a large percentage of newer models of HRVs and ERVs. For individual exhaust fans, such as bath fans and kitchen fans, flow hoods are often used by engineers or their balancing contractors. Flow hoods are not commonly used by smaller installation contractors or maintenance personnel. One respondent believed that less than 10% of HRV/ERV units in his area have properly balanced airflows.

### 4.3.7 Types of controls used on HRV/ERV systems

Every different type of control has and is being used to control the HRV/ERV ventilation systems. When using an HRV/ERV system, the NBC only requires as a minimum an ON/OFF switch in a central location and switches in every bathroom and kitchen. Typically, the kitchen switch turns the system on to high speed, while the bathroom switches only have to activate the system at the ‘Low Flow Principal Ventilation Rate’. However, most HRV/ERV manufacturers have their units set to run at high speed whenever any switch in the bathrooms or kitchen is activated. This also complies with the NBC.

Some participants in the survey suggested that the simpler the controls the better, suggesting only ON/OFF switches were needed as main controllers; while other participants suggested that fully automatic controllers that allowed minimal occupant inputs was a better approach.

Some locations, notably larger communities such as Whitehorse, Yellowknife and Fairbanks, tend to favour newer automatic controls that two major HRV/ERV manufacturers provide. These main controllers allow more selection of flow rate and timing options such as timed intermittent ventilation, 20- to 30-minutes per hour at different speeds, with either shut down or recirculation during the remainder of the time in the hour.

Some automatic controls do have a ‘set and forget’ function that controls the system to provide relative humidity (RH) control based on the outdoor temperature, which it senses on the incoming supply air stream. If the interior RH is too high relative to the outdoor temperature, the system is run until the RH is lowered. If the RH gets too low, the system does not run.

The majority of the survey participants suggested that 20/40/60-minute timer switches, that allowed the occupants to switch the systems into high speed for those set periods of time, were necessary in the bathrooms and possibly in the kitchen as well.

Most installations include RH controls on the main control switch in the home. However, because these controls require adjustment relative to outdoor temperatures throughout the year, and due to the confusion around how to set the RH switch to the correct levels, they are rarely used as intended. This confusion occurs throughout Canada, not just in the North. If the RH switch is the main control used in the home, unless there are major sources of moisture in the home, there are often very long periods of time when the ventilation system never operates. This is often the case in very cold weather as the outdoor air is so dry that bringing a little outdoor air can dry the house out and then there will not be any ventilation.

### 4.3.8 Types of HRV/ERV defrost strategy used

In Whitehorse, southern Yukon, NWT and in Yellowknife, most HRV/ERV installations use the defrost strategy built into the equipment.

Designers and installers for the most part have switched to makes and models of HRV/ERV equipment that utilize built in damper systems that use neutral pressure defrost. This avoid the problem of a negative pressure defrost which can cause back drafting and spillage problems with any atmospherically-vented combustion appliances such as oil-fired boilers and hot water tanks, or solid fuel appliances. Some manufacturers have additional settings on some HRV/ERV models that lengthens the automatic defrost timing for locations with a colder climate that frequently is colder than - $30^0$C.

In locations where the temperatures are much colder, and in most engineered systems, there are hydronic pre-heat coils added into the incoming supply air ductwork to pre-heat the outdoor supply air prior to it entering the equipment. This is intended to reduce the potential for the HRV/ERV unit to freeze up and to also provide warmer air to the home after it passes through the unit. These hydronic pre-heat coils are engineered to run off the hydronic boilers that heat most homes in the colder regions of Yukon, NWT, Nunavut, Nunavik and Alaska. These are not ‘off-the-shelf’ items, but are often engineered and custom manufactured for each project.

Although common in southern Canada, electric pre- and post-heating coils are rarely seen in the North due to the much higher cost of electricity in most communities. In some new electrically-heated, super-insulated homes in the Yukon where there is hydro generated electricity, there is more use of electric pre- or post-heaters.

## 4.4 Commissioning

### 4.4.1 Cost for Third-Party commissioning

None of the respondents were able to provide a cost for third-party commissioning of an HRV/ERV system. Third-party commissioning is rarely completed as a separate service. It is often tied in as part of the overall services provided by a general contractor, mechanical contractor or engineer.

### 4.4.2 Responsibility for commissioning

In public housing projects across the North (where mechanical engineers were involved), clients expect the engineers to be responsible for the commissioning of the HRV/ERV ventilation system. In cases where a third-party commissioning agent is used, they are often brought in from the south. In many cases, the engineering firms do their own commissioning and may not employ a third party to complete this task.

### 4.4.3 Commissioning reports

Only some clients receive commissioning reports. The Nunavut Housing Corporation has a commissioning checklist on their computerized maintenance system, but reports are that it is not always completed for every housing unit. In some cases, housing corporations have brought in external consultants to complete recommissioning of projects where there were serious problems. However, this recommissioning is a rare occurrence due to the high cost.

In Whitehorse, because of the requirement for both an energy rating and the ventilation system air flow verification, a form has been developed and used by the City of

Whitehorse. This 18-point form functions as a HRV/ERV commissioning report/checklist. The form also includes a calculation of high and low airflow rates required by the building code; a record of the make, model and energy performance of the HRV/ERV; a record of the measured high and low airflow rates; results of depressurization testing; and a list of any make-up air systems installed.

### 4.4.4 Commissioning/balancing labels

Few jurisdictions utilize labels attached to the HRV/ERV to record airflow and balancing information. Some respondents suggested that having a commissioning/balancing label would be a good idea, but others suggested that because many of the labels that are currently used by the housing corporations are removed by the occupants (especially children). As a result, an HRV/ERV balancing label may not last very long.

Some verifiers in Whitehorse reported that separate labels are attached to the equipment with a record of the measured and set air flows. Ventilation System Verifiers have pressure gauges and some basic airflow measuring devices, but rely for the most part on the built-in flow measuring in the HRV/ERV units to accomplish the airflow measuring and balancing. The completed ‘Residential Ventilation, Depressurization, and Air Leakage Verification’ checklist is submitted to the City of Whitehorse Building Inspection Department.

### 4.4.5 Airflow measuring equipment

Many LHOs were provided with some basic air flow measuring equipment years or even decades ago and, in many cases, were provided with some training on the use of that equipment. It has been reported that little of that equipment is still available or functional at this time. Many of the staff who were trained in the past on how to use the equipment and measure the airflows have left for other positions or have moved to do other work.

## 4.5 Operation and Controls

### 4.5.1 Minimum control features that should be used in northern homes

The majority of respondents suggested that the minimum controls that should be installed in homes with an HRV/ERV system is an ON/OFF switch as the main control, with a RH-based controller as an override plus 20/40/60-minute timer switches in bathrooms and the kitchen. Again, some respondents suggested that the simpler the controls the better, while others suggested that fully automatic controllers are a better approach. The simpler approach is preferred for more remote communities as there often is limited ability at present to adjust and set complex controls in these communities.

### 4.5.2 Better or best control features that should be used in northern homes

In some locations there was a desire to at least have the ability to operate the system for timed intervals at either high or low speed. Being able to turn the system OFF or run it only full time at high or low speed was felt to limit the ability to control the system effectively. Because the outside RH is so low for much of the year in the North, and because to be used effectively the RH controller requires resetting to follow the outdoor temperature as it changes from winter to spring and fall and summer, many suggested that RH is not the most suitable proxy for good indoor air quality.

Some of the more recent installations in Nunavik have used a custom-engineered RH controller that automatically adjusts the RH setting used to trigger the HRV/ERV operation based on the outdoor temperature. Newer automatic main controllers from some manufacturers do have a similar adjustment process built in to their controller, but the RH curve that triggers the operation of the HRV/ERV is not adjustable as it is on the custom-built unit. These ‘outdoor temperature reset de-humidistats’ make a RH controller much more useful as a main controller as it does not require monitoring and resetting of the trigger point by the occupant.

It was mentioned many times that even in some high occupancy homes in the winter, the RH may be controlled but there is still a need for additional ventilation to control indoor air quality. There were many suggestions that carbon dioxide based controllers should be used in conjunction with the RH controller.

Many respondents reported that there were problems with electronic controllers and some brushless DC electric motors due to voltage fluctuations and ‘power bumps’ (a short-term electricity outage lasting five minutes or less) in communities with electric power supplied from diesel generators. Installers in Alaska reported that even in diesel-powered communities they have experienced few problems if the HRV/ERV unit is protected by a high capacity, individual electrical outlet with an electronic surge protector. It should be noted that surge protectors have a limited lifetime based on the number of times and extent of the voltage surges, and if not replaced when required do not provide any further protection.

### 4.5.3 Are specific or recommended control settings given to maintenance staff?

Only a few respondents involved with public housing stated that they had a set of specific or recommended control settings that are given to maintenance staff and tenants. If they did have a recommendation, it was to set the RH controller to about 30% during winter.

### 4.5.4 Do installers, maintenance staff and occupants know how to adjust dehumidistat settings based on outdoor temperature?

Installer are assumed to know how to properly set the dehumidistat control for a ventilation system. However, because they typically are only in a home at one period in time, their initial setup does not ensure the correct ongoing operation of the system.

There was a general recognition that in most instances, local maintenance staff do not have the background and training to correctly adjust dehumidistat controls based on the outdoor temperature. Most occupants do not know how to set and periodically adjust dehumidistat controls based on outdoor temperatures. This is why one public housing agency believes that the system should be fully automatic with minimal requirement for LHOs and occupants to adjust settings.

In the NWT, eligibility requirements for public housing require tenants to attend four different Homeowner Workshops, including one on ventilation, prior to occupancy.

### 4.5.5 Do respondents have an HRV/ERV system in their own home?

Some respondents did have an HRV/ERV system in their own dwelling, while others, most often in rental units, did not have a HRV/ERV system.

Many respondents with an HRV/ERV system in their own home were more actively involved with the control of the system, turning it on for set periods when home and turning it off when away from the home. Many of the HRV/ERV systems in respondent's homes were older models with older controls. One person uses an automatic timer control to operate the system 24/7 on low speed with ventilation for 20 minutes and re-circulation for 40 minutes, but they are located in an area with relatively affordable electricity rates.

### 4.5.6 Do HRV/ERV units freeze-up?

The majority of respondents reported that HRV/ERV units freeze in their jurisdictions. In the Whitehorse area, there are fewer reported freeze-ups but it is not clear as to the reason why that is the case. Installers and verifiers in that area suggest that they only see units freezing in cases where there were poor installations or a lack of maintenance.

Locating the HRV/ERV in colder crawlspaces was also reported as a probable cause of some frozen units. One HRV/ERV manufacturer has suggested that locating a unit in cooler locations and having a very low set-back temperature on the homes thermostat can lead to freeze-up because there is not enough energy in the house air to defrost the unit properly within the given timed defrost cycle.

In Nunavut, there are many reports that once the units freeze-up the occupants of the home often simply unplug the unit and it is not used for the remainder of the winter.

### 4.5.7 Does flex duct fill with frost and then water in spring?

There are many reports of the insulated flex duct freezing-up with moisture trapped between the polyethylene vapour barrier and the inner flex duct. Some jurisdictions have tried to eliminate the use of flex duct and switched to more expensive metal duct with commercial-type duct insulation and a high-impact rigid plastic commercial duct vapour barrier and covering.

### 4.5.8 Do HRVs/ERVs over or under-ventilate houses?

There is an even split in the opinion of survey respondents about whether HRV/ERV systems under or over ventilate homes.

Most reports of over-ventilation are likely based on homes being very dry during the winter. However, this dryness may be simply due to the extremely dry outdoor wintertime air in the North. Even if homes are reported to be dry, there may be levels of other pollutants in the home that would require additional ventilation to improve overall air quality. This is a major reason why some respondents have suggested that carbon dioxide controllers may be a better proxy for ventilation needs that relative humidity.

## 4.6 Maintenance

### 4.6.1 Do occupants complain about cold drafts from grilles?

One of the major complaints from occupants of homes in the North, and stated as the number one complaint in some jurisdictions, are cold drafts or air blowing into the rooms from the HRV/ERV supply grilles. This is almost universal unless the HRV/ERV supply air has been heated by a post-heater after the pre-heated supply air leaves the HRV/ERV and before it is supplied to the various rooms in the home. Some survey respondents report that this cold air delivery often results in occupants shutting off the HRV/ERV unit for much of the year.

Another reported reason why occupants turn off HRV/ERV systems is the perceived high operating costs of some units. The majority of older HRV units, and less expensive models of current HRVs/ERVs, use PSC motors that consume more electricity than the newer but more expensive brushless DC motors.

### 4.6.2 Other installation problems that lead to maintenance issues

Some of the other installation problems that were believed to cause maintenance problems of the HRV/ERV systems relate to the poor accessibility of some units; long insulated flex duct runs that reduce airflows; poor duct layout that also reduces airflows; and difficulty in getting spare parts if the units break down.

### 4.6.3 What are the biggest problems maintaining HRVs/ERVs?

The biggest problems with maintaining HRV/ERV systems differ from respondent to respondent, but the most common problems that were reported are:

- Lack of space for maintenance and service. In many new units, the HRV/ERV has been placed in a tight crawlspace with the water and sewage holding tanks or in small semi-conditioned attics over a bathroom or the kitchen. This often means that the maintenance officers do not like to go into these spaces and the HRV/ERV units do not get serviced as often as they should.
- Design and installation problems often create noise in the home, both at the grille due to sound travelling down the ductwork from the HRV/ERV unit, and from unit vibration which sometimes causes the whole house to vibrate. Major maintenance and retrofit work is required to correct these issues
- Dust plugging up the air filters in the Spring/Fall/Summer when road dust is blowing constantly from winds or road traffic. Filters often do not get checked, cleaned or changed on time so the units plug up resulting in insufficient or no ventilation.
- Snow blockage during Winter of intake hoods in Arctic areas in Nunavut, Nunavik and Nunatsiavut; hoar frost blockage of intakes in Winter in Yukon, NWT and parts of Alaska; and Summer plugging of intakes with fireweed and other plant fluff in all areas.
- One of the biggest problems is that unlike heating systems, when the HRV/ERV is not performing properly it may be difficult for occupants to recognize that there is a problem. Problems often do not get reported or dealt with in a timely manner. In some cases this leads to complete unit failure. In private homes it is difficult to get people to realize that they are responsible for what should be at least twice yearly maintenance. In public housing it is reported to be difficult to ensure that the prescribed maintenance schedule is followed and not forgotten while other more pressing matters are dealt with by the LHOs.

### 4.6.4 What would make it easier to maintain currently installed HRVs/ERVs?

While most Northern public housing agencies do have preventative maintenance checklists for ventilation systems, respondents suggested that not all LHOs have staff that are qualified and trained to complete the minimum maintenance that HRV/ERV units require. Problematic is the fact that although there has been an attempt to standardize the installed systems, manufacturers continually change and discontinue models. As a result, there may be many different makes and models of HRVs/ERVs in any one community. To compound the problem, some HRVs/ERVs may have different parts from different suppliers on the same model and parts must be ordered based on the serial number on the unit, not just the make and model.

Almost all respondents suggested that better training of staff or contractors responsible for maintenance would help. Other respondents suggested that there are many HRV/ERV units that are not operating or are not operating properly. They indicated that a troubleshooting guide would help LHO staff more easily diagnose problems with HRV/ERV units, controls and other components giving them more confidence in their capacity to maintain ventilation systems.

### 4.6.5 Does the respondent have a seasonal maintenance checklist and is it in the form of a label attached to the HRV/ERV?

Based on the fact that most of public housing agencies do have preventative maintenance plans (and computerized ones in some cases), the use of a label that can be attached to the HRV/ERV was not viewed as something that would make it easier to ensure units were maintained according to the manufacturer's suggested schedule.

Many private installers in Yukon, NWT and Alaska do have maintenance checklists, but not in the form of a 'stick-on' adhesive label. A stick-on maintenance label was thought to be useful for private homes, but only if the label is placed in a very visible location and not on the unit if it is installed in an out-of-the-way location.

Survey respondents that did agree that a stick-on label would be beneficial rated its importance in the range of 4.0 to 5.0 on a scale of 1.0 to 5.0 (with 5.0 being very important).

### 4.6.6 Would it be helpful to have an online video of basic HRV/ERV maintenance?

The majority of survey respondents suggested that a simple, well-organized 'YouTube-type' video would be beneficial, while one or two other were skeptical that it would be watched by very many people. It was suggested that it should show the basic generic maintenance procedures that should be completed two or three times a year on an HRV/ERV system. One respondent suggested that a link to such a video should be provided on any maintenance label placed in the home.

Respondents that agreed that a 'YouTube-type' maintenance video would be beneficial rated its importance in the 4.0 to 5.0 range (although one sceptic suggested a 1.0) on a scale of 1.0 to 5.0.

A few respondents also suggested that it would be beneficial to produce a document and/or a YouTube video that outlines a troubleshooting procedure to help maintenance staff determine why a new or existing HRV/ERV is not functioning or functioning incorrectly. A document or video of this type would need to be based on the troubleshooting guides produced by the various manufacturers of equipment for HRV/ERV systems.

There were a few respondents that felt that a smartphone app could be a useful tool to encourage and remind homeowners (and perhaps tenants) to be more aware of the operation of their ventilation system and serve as a maintenance reminder throughout the year. A smartphone app could be linked to the manufacturer's maintenance instructions. However, as many of the small communities in the North do not have reliable cell phone or internet service, this would likely be of more use in the built up areas and southern North America.

# 5.0 Conclusions and Recommendations

This section provides conclusions and recommendations for improving the performance HRV/ERV systems in new and existing housing in Canada's Near North and Far North. These conclusions and recommendations are based on the roundtable discussion at the NNCA's 2016 Residential Construction Workshop, feedback from the Project Steering Committee, and an analysis of the results of the telephone survey of stakeholders.

## 5.1 HRV/ERV Equipment

At present, there are no residential HRV/ERV units specifically designed and manufactured to meet the challenging operating environment in Canada's Near North and Far North. However, innovations are happening among Canadian and European heat recovery equipment manufacturers that are improving the likelihood that an HRV/ERV system can perform properly in a harsh northern climate and in dwellings with an above average number of occupants.

New models recently introduced into the market by one of Canada's largest HRV/ERV manufacturers include a unit that is amongst the highest efficiency of any HRV/ERV manufactured in North America. This unit has an individual motor and fan for the supply and exhaust airflows. The fans are powered by integrated BLDC/ECM motors that allow the unit's airflow to be balanced by setting the speed of each fan independently at a number of different speeds.

These new fans also produce higher static air pressures that have allowed the manufacturer to provide the unit with washable MERV 6 filters for greater dust arrestance. HEPA filtration is also available in the unit if the ductwork is designed to accommodate the additional pressure drop of the HEPA filter.

This new model still retains the two shut down dampers that close off both the supply/fresh air and the exhaust/stale air ducts to the exterior when the unit is turned off. This is a desirable and necessary feature in making the HRV/ERV unit less prone to freeze-up (see page 43 of Appendix B – Presentation at NNCA Construction Workshop). The unit is also a neutral pressure/recirculation defrost type, which is important in reducing the potential for house depressurization problems. Virtually all Canadian manufacturers of HRV/ERV units now have models that are neutral pressure defrost type.

Another manufacturer has recently introduced a new model that has an add-on recirculation damper system to now make it also a neutral pressure defrost unit. Like many other units from the different Canadian manufacturers, with the addition of a butterfly backdraft damper in the exhaust/stale air duct right next to the HRV/ERV unit, it can be made into a full shut down unit when the unit is turned off.

This manufacturer has introduced a new model labeled as a ‘HYBRID’ unit. It has a heat exchanger core that is about 1/3 ERV plates and 2/3 HRV plates. This gives the unit the ability to retain some of the interior moisture when the outdoor air is dryer than the indoor air in the winter. This is a new concept in heat exchanger cores and it will be interesting to determine if it proves beneficial and functional after use in the field.

Notwithstanding these and other new product offerings and the research on HRV/ERV equipment that is being pursued at university and other laboratories, there are actions that should be taken to assist in the selection of HRV/ERV equipment suitable for use in the northern cold climate areas of North America.

**Recommendation #1** – Work should be commenced/continued to develop the ability to test HRV/ERV units to at least a -40$^{0}$C temperature condition. Consideration should also be given to determining if testing at this temperature needs to be carried out for a longer period than the current 72-hour testing at a -25$^{0}$C condition.

**Recommendation #2** – Work should be commenced on developing standards to field test HRV/ERV units for the relative levels of sound produced by the units in the space in which they are located. This testing should also be able to determine the relative sound levels that emanate from the grilles of a standard duct configuration at different airflow rates.

**Recommendation #3** – Testing should be undertaken of different configurations and types of supply ducting (e.g., sheet metal, flex duct, smooth interior smaller diameter ducting, etc.) with and without mufflers/silencers to determine optimum configurations that will reduce overall noise levels in a house and in the rooms with supply air grilles.

## 5.2 Design of HRV/ERV Ventilation Systems

Many problems that are minor issues in HRV/ERV systems in southern Canada become major issues that prevent these ventilation systems from providing the performance required from them to protect occupant's health and provide building durability. To reduce the number of design issues that may compromise the proper operation of HRV/ERV ventilation systems, some survey respondents and participants at the NNCA RCW mentioned that there should be a standard document that sets out minimum requirements for selecting equipment and controls, system design, installation, commissioning, operation and maintenance. This document would be an important tool for municipal and territorial governments and housing agencies, private builders, designers, engineers and others to improve the design of HRV/ERV systems in the North.

**Recommendation #4** – Based on the survey results and discussions at the NNCA 2016 Residential Construction Workshop, a guidance document should be prepared for designers of HRV/ERV-based ventilation systems suitable for Canada's North (climates where the Design temperature is below – $30^0$C). This document would set out minimum requirements for:

- Only install HRV/ERV-based ventilation system where twice yearly maintenance can be guaranteed.
- Arctic design for exhaust and intake hoods on exterior of building envelope.
- RSI 1.3 to RSI 1.76 (R-8 to R-10) insulation on all 'cold-side' ducts that connect an HRV/ERV to outside openings.
- Reinforced vapour barrier on insulated flex ducts.
- Keeping flex ducting to less than 6 feet long on each side of the HRV/ERV unless a full duct design is provided showing that the proposed longer flex duct run will still allow the required airflow.
- Detailed installation requirements for flex duct connections to double collars on HRV units and at the exterior envelope.
- Non-metallic flex duct hangers for all insulated and non-insulated flex duct.
- Improved vibration isolation suspension system for machine and duct connections.
- Use of waterless condensate drain trap rather than water-only based trap that are often sucked dry during sewage tank pump out.
- Surge protection on all HRV/ERV equipment and any controls not powered by the HRV/ERV.
- Criteria for selecting HRV/ERV units other than efficiency and power usage,
- Minimum controls and types of controls to be installed for system.
- Installation and temperature settings of pre and post heaters.
- Requirements for duct insulation on the warm side of HRV/ERV.

- Proper connection of HRV/ERV to forced-air system where applicable.
- Specifying the best types of grilles and diffusers for direct-ducted supply systems.
- Detailed instructions for setting and balancing airflows on the HRV/ERV.

**Recommendation #5** – Standardized designs for hydronic pre-heat and post-heat systems should be developed with discharge temperature controls that have a temperature controller to reduce the temperature swings in the discharge temperatures of the coils.

**Recommendation #6** – Research should be conducted to determine the best supply diffuser designs that can throw small volumes (as low as 10 L/s or 20 CFM) of cool air across the ceiling of a room without causing comfort problems for people standing or sitting in the room.

**Recommendation #7** – Research should be conducted to determine if the use of a ‘home run ducting system’ using smaller diameter smooth inside flexible ducting (similar to a Zehnder, Hi-V or Unico high velocity systems) will be more economical in capital, shipping and installation costs than a system designed and installed using sheet metal ducting. It should also be determined if this type of system may offer advantages in situations where homes are to be retrofitted with an HRV/ERV ventilation system.

**Recommendation #8** – Research should be conducted to determine the optimum options for exterior intake and exhaust openings (weather hoods) for use in both below and above the treeline locations.

**Recommendation #9** – Research should be conducted to determine how to better integrate improved filtration systems into the HRV/ERV ventilation system to keep dust out of homes, especially summertime road dust.

**Recommendation #10** – Designers of cold climate HRV/ERV systems should be encouraged to select, design and install systems that reduce the chance of freeze-up that occur because of the reasons given in the list of the five causes in the NNCA Workshop presentation.

## 5.3 Installation

There were many concerns expressed that HRV/ERV systems often do not have all aspects of the systems installed correctly.

**Recommendation #11** – Installers of HRV/ERV systems in the North should be required to have taken training specific to installation of HRV/ERV ventilation systems in the North. This installation training could be a customized version of HRAI Residential Mechanical Ventilation Installation training, specialized courses developed to focus on key installation requirements and issues related to northern HRV/ERV system installation, or courses delivered by the manufacturer of the HRV/ERV equipment with additional subject matter related to the overall installation of these systems in the North.

**Recommendation #12** – Installers of HRV/ERV systems throughout the North should be required to use an installation checklist, possibly similar to the one used by the City of Whitehorse for their code enforcement or one that has been developed for Building Code inspectors in Manitoba.

## 5.4 Commissioning

Many public housing projects in the territories have had the HRV/ERV ventilation systems commissioned, in some cases by third-party independent contractors, after system installation as part of the mechanical engineering contracts. In many cases there are reports of that commissioning on record at the dwelling, at the LHO and at the regional office.

If a ventilation system in a dwelling is not functioning correctly, if a replacement unit is being installed or if a new system is being installed as a retrofit where a consulting engineer is not involved, these systems need to be reviewed, commissioned or recommissioned. The survey results suggested that the third-party commissioning/ verification process, as used in Whitehorse, appears to have produced HRV/ERV systems that many respondents report have the fewest problems of all HRV/ERV systems installed in the North.

**Recommendations #13 –** The process of third-party commissioning as practiced in the City of Whitehorse be used as a model for third-party commissioning in other northern jurisdictions.

**Recommendation #14 –** Any commissioning and airflow measurement reports should be left with each house, any LHO and the city or municipality.

**Recommendation #15** – Consideration should be given to developing a pilot program to supply basic airflow measuring equipment to LHO maintenance staff along with a measurement and balancing training session based on a YouTube-type video of flow measuring and balancing HRV/ERV equipment.

## 5.5 Operation and Controls

Several respondents suggested that it is important to have a simple and easily understood control system in the dwelling. The basic controls, other than the central controller in the main living areas of the home, are the required switches in the bathrooms and the kitchen that must turn on the HRV/ERV ventilation system from these rooms. Research completed in the 1990’s suggests that a bathroom ventilation system must run for at least 45 minutes to remove the majority of the moisture from a typical use of a shower.

**Recommendation #16** – A variable ‘20/40/60 minute’ timer switch should be installed in every bathroom, kitchen and room with an exhaust air intake that occupants can use to trigger the high speed operation of the HRV/ERV system and/or any supplemental exhaust fans in these rooms.

There was also much discussion over the use of dehumidistat switches as a means to control the relative humidity and overall ventilation of a dwelling. As described in sub-section 4.5.2 above, for a dehumidistat switch to function correctly, the set point must be adjusted relative to the outdoor temperature. In cold, northern climates this can probably be set to about 30% RH for most of the winter. If they are not adjusted and set to higher levels or turned off for at least the three or four months of warmer weather, the HRV/ERV will operate at high speed during the entire time of warmer and more humid outdoor air.

As stated in section 4.5.2 above, some public housing units in Nunavik have had a custom made controller that offers an outdoor temperature adjustment of the allowable interior RH and thus automatic adjustment of the dehumidistat switch. At least one manufacturer has a main controller that has an automatic setting that uses a built-in algorithm that resets the allowable interior RH based on the outdoor temperature which is sensed by a thermistor located inside the HRV/ERV unit next to the fresh air from outside duct connection port. Once the lower range of acceptable interior RH has been reached; this controller defaults to a schedule of 10 minutes of low speed ventilation per hour with 50 minutes of “Standby” ventilation setting every hour. The standby mode still allows the HRV/ERV to be activated by switches in the bathrooms and kitchen. This automatic controller only functions on some models of HRVs/ERVs by one manufacturer.

**Recommendation #17** – A standard design for an ‘Outdoor Temperature Reset De-humidistat’ that automatically adjusts internal de-humidistat setting based on outdoor temperature should be developed for use on different makes and models of HRVs/ERVs, especially for retrofit applications. This controller may be able to use some of the work that has been completed by Nunavik for the development of their dehumidistat controller.

As stated in section 4.5.2 above, in high occupancy homes in winter the RH may be controlled but there is still a need for additional ventilation to control indoor air quality. There were many suggestions that carbon dioxide and volatile organic compound (VOC)-based controllers should be used in conjunction with a RH controller.

**Recommendation #18** – Research should be initiated to identify and source reliable carbon dioxide and VOC sensors/controllers that are suitable to use as additional indoor air quality controls in homes in the North that may be very dry due to outdoor conditions but have other indoor pollutants due to high occupancy. The carbon dioxide sensor/controller should be a priority and should be one that does not require frequent re-calibration.

## 5.6 Maintenance

Lack of maintenance of HRV/ERV systems across Canada, not only in the North, has resulted in hundreds if not thousands of non-functioning HRV/ERV systems. In the North it has been reported that some units have never been maintained and they are run until they fail and then they are removed and replaced with a new HRV/ERV.

Many failures could be eliminated if the units were maintained properly. It has been stated that many of the maintenance staff at the LHOs feel intimidated due to their lack of knowledge/experience with maintaining HRVs/ERVs. Also, many of the maintenance staff do not see the importance of maintaining and having a functioning ventilation system until mould or health issues begin to develop in a home.

**Recommendation #19** – It is recommended that a basic/simple ‘Seasonal Maintenance Checklist’ be developed and distributed to all public and private interested parties across the North. This checklist should be able to be installed into a computer based maintenance system, should be able to be printed off as a label that can be attached to HRVs/ERVs, and should be part of a YouTube-type video that walks maintenance staff, contractors and homeowners through the basic seasonal maintenance tasks that should be completed a minimum of two times per year.

**Recommendation #20** – An online ‘YouTube-type’ video should be produced for maintenance staff, contractors and homeowners/tenants to explain the use and adjustment/setting of a dehumidistat controller.

When HRVs/ERVs stop working properly, maintenance staff, many contractors and homeowners/tenants have few resources to try to determine what is wrong with the system. Several respondents suggested that having a troubleshooting guide for HRV/ERV systems would help maintenance staff and others determine the cause of the system problems and what can be done to make it operational correctly again.

**Recommendation #21** – An illustrated 'Troubleshooting Guide for HRV/ERV Systems' and related online video should be developed for training contractors, LHO maintenance staff and homeowners/tenants.

## 5.7 Additional Issues

Several survey respondents mentioned that for both private and public housing, an awareness campaign is needed for homeowners/tenants to educate them about the importance of mechanical ventilation systems in modern, tightly-sealed energy-efficient homes.

**Recommendation #22** – A marketing campaign targeting homeowners/tenants in Canada's Near North and Far North should be developed to boost awareness about the importance of mechanical ventilation systems in modern housing to maintain indoor air quality and avoid the build-up of excess moisture.

# Appendix A:
# Table of Stakeholders and Potential Survey Participants

| **Column A:** Participants in Stakeholder Conference Call<br>**Column B:** Participants that agreed to participate in telephone survey | | | A | B |
|---|---|---|---|---|
| **Nunavut** | | | | |
| Gary Wong | Director Infrastructure,<br>Nunavut Housing Corporation | Iqaluit, NU | **Y** | **Y** |
| John D. Watson | Territorial Maintenance Manager,<br>Nunavut Housing Corporation | Arviat, NU | | **Y** |
| Jim MacEachern | Manager of Economic Development,<br>Communications and IT,<br>Municipality of Cambridge Bay | Cambridge Bay, NU | | |
| Rob Myers | Senior Mechanical Technical Officer,<br>Nunavut Housing Corporation | Iqaluit, NU | **Y** | **Y** |
| Tom Gross | Currently - Arctic Energy Alliance<br>(He was involved with housing in Cambridge Bay, Nunavut for 20+ yrs.) | Hay River, NWT | | |
| Tim MacLeod | Past Nunavut Housing staff, now with private property management in Nunavut | Iqaluit, NU | | **Y** |
| **Nunavik (Northern Quebec)** | | | | |
| Jean-François Gravel | Engineer, Senior Advisor,<br>Société d'habitation du Québec | Quebec City, QC | **Y** | **Y** |
| Julien Bédard | Conseiller en affaires intergouvernementales,<br>Société d'habitation du Québec | Quebec City, QC | | |
| Mr. Michel Savignac | Director of Building Maintenance,<br>Kativik Municipal Housing Bureau | Kuujjuaq, Nunavik | | |
| Pascal Sementilli | Kativik School Board,<br>Material Resources<br>(reports to Daniel Baril) | Kuujjuaq, Nunavik | | **Y** |

| Northwest Territories | | | | |
|---|---|---|---|---|
| Larry Jones | Manager, Construction and Infrastructure Services, Government of NWT | Yellowknife, NWT | **Y** | **Y** |
| Didier (Dee) Bourgois | HOUSEcheck Inspection, Private company in Yellowknife and surrounding areas | Yellowknife, NWT | | **Y** |
| Dwayne Wohlgemuth | Certified Energy Manager, Ko Energy | Yellowknife, NWT | | |
| Irv Perry | Cofly Construction Ltd., Private general contractor | Inuvik, NWT | | |
| Leon Poirier | Private HVAC contractor | Yellowknife, NWT | | |
| Randy Steele | Steeles Mechanical, Private heating and plumbing contractor | Yellowknife, NWT | | |
| **Yukon** | | | | |
| Juergen Korn | R&D Project Manager, Yukon Housing Corporation | Whitehorse, Yukon | **Y** | **Y** |
| Wayne Wilkinson | Frostbusters Energy Consulting, Ventilation & Energy Advisor and Verification Inspector for the City of Whitehorse New Residential Ventilation Bylaw | Whitehorse, Yukon | | **Y** |
| Craig Olsen | Olsen Resource Consulting, Ventilation & Energy Advisor and Verification Inspector for City of Whitehorse New Residential Ventilation Bylaw | Whitehorse, Yukon | | **Y** |
| Cory Sands | Sands Construction, Verification Inspector for the City of Whitehorse New Residential Ventilation Bylaw | Whitehorse, Yukon | | **Y** |
| Theo Stad | Theo's Construction, HVAC contractor | Whitehorse, Yukon | | **Y** |

| | | | | |
|---|---|---|---|---|
| **Alaska** | | | | |
| Bruno Grunau | Research and Testing Engineer,<br>Cold Climate Housing Research Center | Fairbanks,<br>Alaska | **Y** | |
| Colin Craven | Building Science Research Director,<br>Cold Climate Housing Research Center | Fairbanks,<br>Alaska | | |
| Richard Musick | Ventilation Solutions, LLC,<br>Designer/Installer Ventilation Contractor | Fairbanks,<br>Alaska | | **Y** |
| Phil Louden | Private housing and HVAC contractor<br>(retired) | Fairbanks,<br>Alaska | | |
| **Other Participants**<br>(persons not located in North, but have been or are involved<br>with northern housing technical issues) | | | | |
| Jeff Armstrong | DAC International,<br>Private homebuilder and pre-fab housing provider (has provided panelized kits for hundreds of housing units in Nunavut | Ottawa, ON | | **Y** |
| Charles Zaloum | Energy Manager, Hydro Ottawa | Ottawa, ON | | |
| Jeremy Sager | Housing Team Project Officer,<br>CanmetENERGY<br>Natural Resources Canada | Ottawa, ON | **Y** | |
| Julia Purdy | Building Energy Research,<br>Natural Resources Canada | | **Y** | |
| Catherine (Cate) Soroczan | Senior Researcher<br>Canada Mortgage and Housing Corp. | Ottawa, ON | **Y** | |
| Duncan Hill | Manager, Housing Needs Research<br>Canada Mortgage and Housing Corp. | Ottawa, ON | **Y** | |

# Appendix B: Presentation at NNCA 2016 Residential Construction Workshop

**HRV/ERV Installations in Manitoba, and some likely reasons for HRV/ERV freeze-ups**

Presentation at:

NNCA Construction Workshop

Yellowknife, NWT

February 17 & 18, 2016

Slide 1

**My First encounter with an HRV:**

Slide 2

**New Homes in Manitoba**

Typical 2005 New Homes averaged 1.7 Air Changes per Hour @ 50 pascals pressure difference,

- MANY are now more AIRTIGHT.

Many New Home have a maximum air leakage of 1.5 ACH@50Pa (350cfm50).

Two recent Habitat for Humanity Homes were measured at 1.45 & 1.13 ACH@50 Pa and all are 1.5 ACH@50 Pa or less.

Slide 3

**Manitoba Code Amendment (April 1, 2011)**

First requirement:

2 (59) Article 9.32.1.2. is amended by adding the following after Sentence (4):

- 5) Heat or energy recovery ventilators shall be installed in all single- and two-family dwelling units except in a seasonal dwelling.

Slide 4

**Manitoba Code Amendment (April 1, 2011)**

And:

- 6) Heat or energy recovery ventilators shall be designed to provide a minimum 55% sensible heat recovery efficiency when tested to the low temperature thermal and ventilation performance test method set out in CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators", at a test temperature of -25°C at an air flow not less than 28 L/s (or 60 CFM).

Slide 5

**Manitoba HRVs/ERVs since April 1, 2011**

NOTE: Since Dec. 1, 2014, row and apartment type residential units also require HRVs/ERVs to be installed.

- So that is 17,776 single and duplex residential units,
- and 3,222 multi-unit residential units,
- For a total of 19,998 HRVs/ERVs installed in Manitoba since April 2011.
- *SO WE HAVE SEEN ALMOST ALL THE POTENTIAL PROBLEMS IMAGINABLE.*

Slide 6

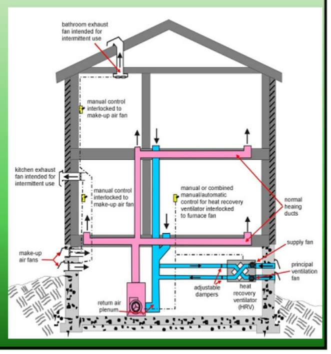
## Typical HRV/ERV Installations

**Simplified System**

- Exhaust from and Supply to forced air return duct (3 ft. / 1m. apart).

***Supplemental kitchen and bathroom exhaust fans are Required.***

*Very few New Homes use this options, but many retrofits do.*

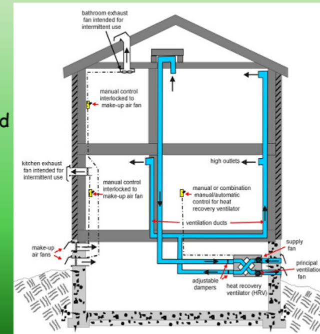



Slide 7

## Typical HRV/ERV Installations

**Stand Alone - Direct Ducted Systems** (no forced air) with

- Exhaust ducting from all bathrooms and kitchen, ***or*** *supplemental exhaust fan in either or both,* and
- Supply air is ducted to required rooms (bedrooms and main living area).




Slide 8

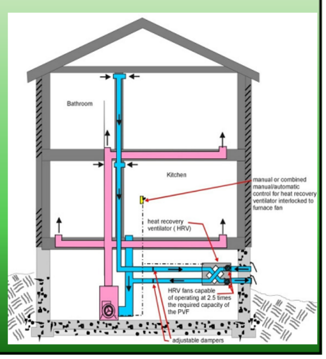
## Typical HRV/ERV installations

**Ducted Exhaust with Supply to Return**

- Exhaust pick-up in bathrooms and kitchen, and
- Supply duct to return of forced air system.

***Optional Supplemental kitchen and bath fans.***

**THIS IS MOST COMMON SYSTEM TYPE WHEN HEATING IS FORCED AIR**




Slide 9

**Canadian Prescriptive Codes (9.32) and Performance Standard (CAN/CSA-F326) both require a High Airflow and a Low Airflow Rate.**

Slide 10

## HRV Airflows – Low Flow Rates NBC 9.32

**NBC states that a Principal Ventilation Fan (PVF) shall be capable of exhausting at the following rate:**

| Normal Operating Exhaust Capacity of Principal Ventilation Fan (PVF) – capable of continuous operation | | | |
|---|---|---|---|
| Number of Bedrooms | PVF Capacity (cfm) | | |
| | Minimum | Maximum | |
| 1 | 34 cfm | 51 cfm | |
| 2 | 38 cfm | 59 cfm | |
| 3 | 47cfm | 68 cfm | |
| 4 | 55 cfm | 81 cfm | |
| 5 | 64 cfm | 95 cfm | |
| More than 5 | System must comply with CSA-F326 | | |

Slide 11

## Required Air Flows – High Flow Rate

- **If the HRV exhaust from kitchen and bathrooms acts as Principal Ventilation Fan (Low Flow Rate),**
- **and if it is capable of 2.5 times the minimum PVF rate (High Flow Rate) and the HRV can be activated at this High Flow Rate from a switch in the kitchen,**
- ***Then no supplemental exhaust fans are required in the kitchen or bathrooms, i.e. the HRV can be the only required ventilation device in the home.***

Slide 12

## HRV Airflows – Low and High Rates

HRV High Airflow capacity required if NO separate kitchen exhaust fan is installed.

| Number of Bedrooms | Normal Operating Exhaust Capacity of Principal Ventilation Fan (PVF) | | |
|---|---|---|---|
| | PVF Capacity (cfm) | | High-Flow Capacity (2.5 times min. PVF) |
| | Minimum | Maximum | Minimum |
| 1 | 34 cfm | 51 cfm | 85 cfm |
| 2 | 38 cfm | 59 cfm | 95 cfm |
| 3 | 47cfm | 68 cfm | 117 cfm |
| 4 | 55 cfm | 81 cfm | 138 cfm |
| 5 | 64 cfm | 95 cfm | 160 cfm |
| More than 5 | System must comply with CSA-F326 | | |

Slide 13

## Comparative Ventilation Rates

EXAMPLE #1 – 93.99 m. sq. (1200 sq. ft.) 3 bedroom home: "occupiable area" equals 1200 sq. ft - 1 bathroom Kitchen, living, dining, laundry room 3 bedrooms. Total = 8 rooms

| Code or Standard | NBC (2010) | CSA-F326 | ASHRAE 62.2 (2012) | ASHRAE 62.2 (2013) |
|---|---|---|---|---|
| **PEF/PVF- Low Flow Rate** (continuous capable) | **22-32 L/s (47-68 CFM)** (Based on bedroom count) | **18 – 27 L/s (38 – 57 CFM)** (40 -60% of MVC) | **18.7 L/s (39.6 CFM)** (*1) + (*2) | **28.1 L/s (59.6 CFM)** (*1) + (*3) |
| **Hi Flow Rate** (continuous central exhaust or HRV system) | **55 L/s** (22 x 2.5) **(117 CFM)** | **45 L/s** (8 rms. X 5 L/s + 5 L/s) **(95.4 CFM) = MVC** | **41.5 L/s** (31.5 +10) (assuming 9.3 m2 kitchen **(88 CFM)** | **41.5 L/s** (31.5 +10) (assuming 9.3 m2 kitchen **(88 CFM)** |
| **Hi Flow Rate** (adding required individual intermittent exhaust fans if used) | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath exhaust Fans) **(212 CFM)** |

***1 = Designed to be operated continuously once dwelling is "occupiable"**
*2 = Rate based on .05 x floor area in sq.m. plus 3.5 L/s x # bedrooms + 1
*3 = Rate based on .15 x floor area in sq.m. plus 3.5 L/s x # bedrooms + 1

Slide 14

## Comparative Ventilation Rates

EXAMPLE #2 – 148.6 m. sq. (1600 sq. ft.) 3 bedroom home: "occupiable area" equals 3200 sq. ft. - 2 bathrooms (main bath + powder room) Kitchen, living, dining, family room, laundry room and finished open basement. Total = 11 rooms

| Code or Standard | NBC (2010) | CSA-F326 | ASHRAE 62.2 (2012) | ASHRAE 62.2 (2013) |
|---|---|---|---|---|
| **PEF/PVF- Low Flow Rate** (continuous capable) | **22-32 L/s (47-68 CFM)** (Based on bedroom count) | **26 – 39 L/s (55 – 83 CFM) (40 -60% of MVC)** | **28.86 L/s (61.1 CFM)** (*1) + (*2) | **58.58 L/s (124.1 CFM)** (*1) + (*3) |
| **Hi Flow Rate** (continuous central exhaust or HRV system) | **55 L/s** (22 x 2.5) **(116.5 CFM)** | **65 L/s** (11 rms. X 5 L/s + 5 L/s + 5 L/s) **(137.7 CFM) = MVC** | **51.5 L/s** (31.5 +10+10) (assuming 9.3 m2 kitchen **(109 CFM)** | **51.5 L/s** (31.5 +10+10) (assuming 9.3 m2 kitchen **(109 CFM)** |
| **Hi Flow Rate** (adding required individual intermittent exhaust fans if used) | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath/WC exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath/WC exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath/WC exhaust Fans) **(212 CFM)** | **100 L/s** (50 + 25 + 25) (intermittent kitchen and bath/WC exhaust Fans) **(212 CFM)** |

***1 = Designed to be operated continuously once dwelling is "occupiable"**
*2 = Rate based on .05 x floor area in sq.m. plus 3.5 L/s x # bedrooms + 1
*3 = Rate based on .15 x floor area in sq.m. plus 3.5 L/s x # bedrooms + 1

Slide 15

**So do we choose an HRV/ERV that can deliver 117 cfm and design the ductwork for 117 cfm?**

**What about the fact that it spends varying amounts of time in defrost, depending on the outdoor temperature.**

Slide 16

## How do we get the 117 cfm Airflow when the unit is in defrost part of the time?

- Back in 1992, E. G. Phillips (**You may recognize his name from**):
- *E. G. Phillips, L. C. Bradley, R. E. Chant, and D. R. Fisher, "Comparison of freezing control strategies for residential air-to-air heat recovery ventilators," ASHRAE Trans., pp. 484-490, 1989. , and*
- *E. G. Phillips, D. R. Fisher, and R. E. Chant, "Freeze-control strategy and air-to-air energy recovery performance," ASHRAE J., pp. 44-49, 1992.*
- (El)Bert developed a procedure and Worksheet (W-4A – HRV Airflow Adjustments) for the HRAI Residential Ventilation Manual and Course.

Slide 17

## HRV/ERV Airflow Adjustments.

- This procedure adjusts the HRV airflow to compensate for:
- Very Low Temperature Ventilation Reduction (defrost time), and
- Cross leakage (Gross Airflow Supply minus the Net Airflow Supply).
- All of the above information is contained in the HVI reporting of the CAN/CSA C-439 testing of HRVs/ERVs
- Sadly this is only done down to -25°C as the test facility can only generate this low a temperature.

Slide 18

## HRV/ERV Airflow Adjustments.

- Very Low Temperature Ventilation Reduction (VLTVR): The percent reduction in airflow rate of the supply and exhaust systems at the end of the 72-hour test compared with operation under non-frosting conditions. The final airflow rate is taken as the average of the last 12 hours of the test. This reduction in airflow results from frost and ice buildup in the exchanger and variation in mechanical ventilation during defrosting.

Slide 19

## How do we get the 117 cfm Airflow when the unit is in defrost part of the time?

Using this procedure for two common HRVs:

- Unit 1 has an adjusted Airflow of 141 cfm
- Unit 2 has an adjusted Airflow of 130.7 cfm
- The difference is because the two units have different reported VLTVR for their Supply and Exhaust Airflows

Slide 20

## How do we get the needed Airflow when the unit is in defrost part of the time?

- The design of the system should use the above HRV Airflow Adjustment Procedure, or
- the ratio of defrost time versus the total cycle time (i.e. one manufacturer's Cold Weather Defrost setting is 10 minutes out of 25 minutes total run time once it goes below -27°C (-17°F)), will require at least:

  117cfm x 25min./15min. = 195 cfm when it is running.
- The HRV/ERV will deliver on average the required 117 cfm every hour, even when in extended cold temperature defrost.

Slide 21

## How do we get the needed Airflow when the unit is in defrost part of the time?

- Based on the timed defrost methods used today, this may over ventilate whenever the weather is warmer than -27°C.
- Also, ducting must be sized based on this adjusted airflow rate, otherwise the airflow will be restricted, not providing the required ventilation rate and in some cases may also affect correct defrosting of the unit.

Slide 22

## *"HOCKMAN'S RULES FOR USING HRVs/ERVs IN COLD CLIMATES"*

**Prime rule: Never ever install HRV/ERV units if you cannot guarantee that they will be maintained.**

**Second rule: If you want to protect buildings in the North from interior moisture (cold & dry outdoor climate in winter) run a ventilation system at between 25 and 30 cfm continuously and warm cold surfaces.**

**Can be balanced (HRV) or exhaust only (if no spillage susceptible equipment).**

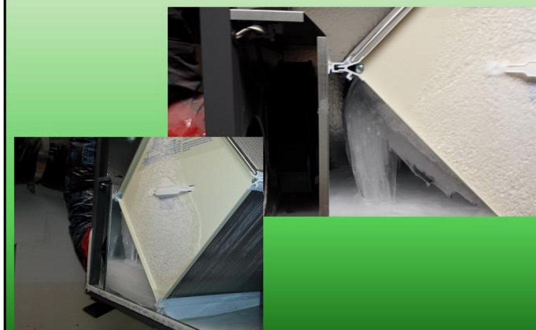
Slide 23

## Likely Causes of HRVs/ERVs Freeze-up During Winter Operation in Manitoba using Current Models of HRVs/ERVs

(In the opinion of JLHockman Consulting Inc.)

Slide 24

## What we want to avoid:



Slide 25

## Summary of 5 Likely Causes of HRV Freeze-up. HRVs freeze when:

1. The HRV is not balanced correctly for cold weather operation.
2. Cold supply air is drawn through the outdoor supply duct on the HRV when HRV is turned OFF and the furnace fan operates to provide house heating – (THIS ONLY OCCURS WHERE HRV/ERV CONNECTED TO FORCED AIR FURNACE OR AIR HANDLER).
3. <u>Cold air is drawn in</u> through the <u>exhaust ducting going to the outside</u> when HRV is turned OFF and the house is depressurized by clothes dryer, kitchen fan or other exhaust device.

Slide 26

## Summary of 5 Likely Causes of HRV Freeze-up. HRVs freeze when: (continued)

4. Additional cold supply air is drawn through HRV when operating, especially in Low Flow (Principal) Rate when house is depressurized by clothes dryer, Kitchen or other exhaust fan(s).
5. One manufacturer also believes that significant temperature setback in the home (to $15^0$ C [59F] or even $17^0$ C [63F]) prevents proper defrost.

Slide 27

## 1. HRV Not Balanced for Cold Climate

In cold and very cold climates especially on the Prairies and in Canada's North:

- It is best to <u>balance the HRV with slightly more exhaust than supply</u> (+/- 10% is permitted by manufacturers and Building Codes [MBC/NBC/OBC]).
- This keeps the core slightly warmer when the unit is operating at both Low and High Flow Rates and helps during defrost cycles.
- This also runs the house at a slight negative pressure (less than 1-2 Pascals) and this helps reduce potential for interior moisture condensing within the building envelope.

Slide 28

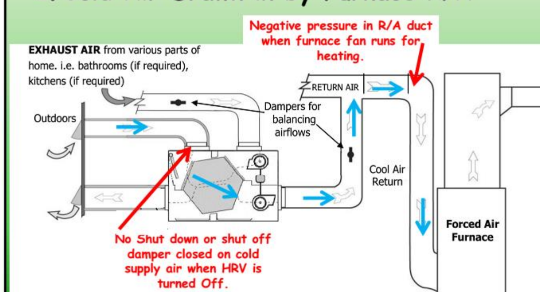
## 2. Cold Air Drawn in by Furnace R/A

Cold supply air is drawn through the HRV when the unit is OFF and furnace fan runs for heating supply.

- If there is no *shut down/shut off damper* on the supply air whenever the HRV is turned off, and a "direct connection" to furnace Return Air exists; when the furnace fan comes on to provide heating distribution the negative pressure in the Return Air duct will draw cold outdoor air through the HRV and chill the core down and cause freeze-up.

Slide 29

## 2. Cold Air Drawn in by Furnace R/A




Slide 30

## 2. Cold Air Drawn in by Furnace R/A (continued)

- Installing an "indirect connection" or locating the connection to R/A duct far from furnace may reduce this problem but often it does not, and
- this "indirect connection" does not solve the next cause of freeze-up problems.

Indirect connection ("breather Tee" fitting)

Slide 31

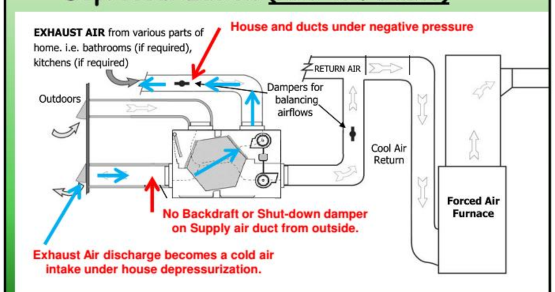
## 3. Cold Air Drawn in by House Depressurization

Cold air is drawn **in through exhaust duct** to outside when the house is depressurized by clothes dryer, kitchen or other exhaust device:

- **If there is no *shut down/shut off damper* or *backdraft damper* in the exhaust air duct to the outside, then if the HRV is turned off and house is depressurized,**
- cold air can be drawn through the exhaust side into the home, chilling the core to the point where it frosts up and the defrost strategy often will never catch up, causing the core to freeze up,
- **Occurs in both furnace connected and direct ducted units.**

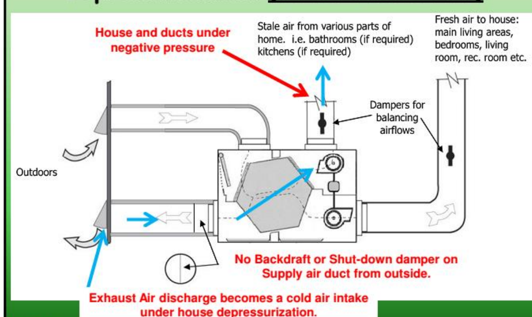
Slide 32

## 3. Cold Air Drawn in by House Depressurization (HRV to Furnace)




Slide 33

## 3. Cold Air Drawn in by House Depressurization (Direct Ducted HRV)




Slide 34

## 3. Cold Air Drawn in by House Depressurization (continued)

- Backdraft damper (butterfly damper) should be installed in the exhaust flex duct as close to the connection to the HRV as possible. **NOTE that exterior backdraft dampers on HRVs will freeze shut in cold climates as shown below.**

Butterfly backdraft damper – hinge should be vertical

Slide 35

## 4. Additional Cold Air Drawn in by House Depressurization

Additional cold air may be drawn in through the supply duct from the outside when the HRV is on Low or High flow and the house is depressurized by clothes dryer, kitchen or other exhaust device.

- In this case even if the HRV has shut down dampers and/or the backdraft damper, the additional cold supply air can be drawn through the HRV core when the house is depressurized (may be additional 5-30 cfm).
- This unbalances the HRV and can cause freeze-up which may not be able to be defrosted by the HRV defrost cycle.

Slide 36

## 5. Significantt Night Set-back of House Temperature Affects Defrost

Severe thermostat temperature set-back reduces the amount of energy in the house air:

- If the amount of energy in the house air is reduced through thermostat set-back, the timed cycle for defrosting the HRV core may not fully defrost the core before the end of each defrost cycle,
- This may leave residual frost within the core that may never be fully defrosted and which may continue to build up frost until it blocks the core.

Slide 37

## Possible Solutions to HRV Freeze-up During Winter Operation

Slide 38

## Possible Solutions to HRV Freeze-up

1. Use an HRV that has "shut down" dampers that completely block both incoming supply and outgoing exhaust ducts when the HRV is in the "off" mode.

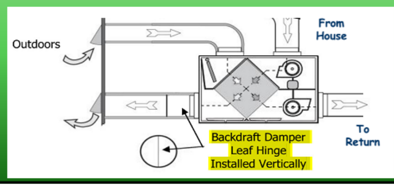
   This prevents the furnace fan and R/A connection from drawing cold outdoor supply air through the unit when the HRV is turned off.

   This also prevents house depressurization from drawing in cold outdoor air through the exhaust side of the HRV when it is turned off.

Slide 39

## Possible Solutions to HRV Freeze-up

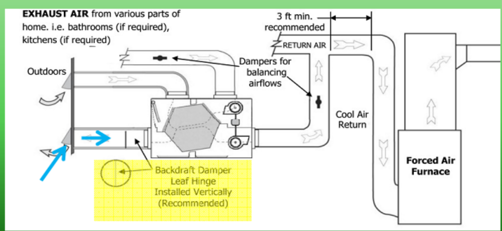
2. Use a HRV that has a "damper defrost" system where the outdoor supply air duct is blocked when the HRV is turned "off". If it does, make sure manufacturer has no objection, and add a "butterfly" backdraft damper in the exhaust duct to the outside as close to HRV as possible (some manufacturers insist on this damper in cold climates as shown below).




Slide 40

## Possible Solutions to HRV Freeze-up

2. This butterfly type backdraft damper prevents the furnace fan and R/A connection from drawing cold outdoor supply air through the unit when the HRV is turned off.




Slide 41

## Possible Solutions to HRV Freeze-up

3. If you must use a HRV that does not have any "dampers" that at least closes off the supply air duct when the HRV is turned "off" (i.e. a HRV with fan shut down defrost), then you could add an after market motorized damper that blocks off the supply duct when the HRV is "off", and add a butterfly backdraft damper in the exhaust duct.

   These added dampers will prevent the furnace fan from drawing cold outdoor supply air through the unit and will **prevent house depressurization from drawing in cold outdoor air through the exhaust side of the HRV when it is turned "off".**

Slide 42

## Possible Solutions to HRV Freeze-up

4. None of the above solutions deal with the situation where the HRV is thrown out of balance (increased cold outdoor supply air) when the HRV is operating and house depressurization draws in additional air through the supply duct and possibly reduces the exhaust airflow at the same time.

This problem will need more study and research to determine how much of a problem this factor is, and what possible solutions (other than Make-Up Air for exhaust devices) may be available.

Slide 43

## Possible Solutions to HRV Freeze-up

5. If the homes night set-back temperature is too low and the HRV is freezing up due to this cause, the set-back should be decreased or on some makes of HRV it may be possible to increase the length of time for each defrost cycle to give the HRV time to fully defrost.

Slide 44

## Consumer Information on HRV Operation and Maintenance

Slide 45

## Consumer Operation of HRV/ERV:

HRAI YOUR ENVIRONMENT OUR EXPERTISE Consumer Information

### Tips on how to operate an HRV and ERV system

**Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV)**

All modern homes need, and are required by Building Codes to have a mechanical ventilation system installed. In your home, the system may include a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV).

**How does an HRV or ERV work?**
This system brings in outside fresh air which, as it enters the home, is preheated by stale air that is exhausted from inside the home. The exhaust air is typically removed from kitchens and bathrooms.

The HRV or ERV system installed in your home allows you to control air quality in winter by exhausting excess moisture and odours when desired. Whenever the HRV or ERV is turned on, it exhausts air from the bathrooms and the kitchen and brings in outdoor "fresh" air to the furnace ducting and this is distributed to all the rooms in the home by the furnace fan which should automatically operate whenever the HRV or ERV is on.

In your home you will see that the HRV and ERV is controlled by an ON/OFF wall switch (Figure 1) or timer switch (Figure 2) installed in the bathrooms and kitchens. These switches may look like a wall light switch, but their purpose is to switch the HRV and ERV fans to high speed and draw exhaust air through the grille normally located high on the wall (you may or may not be able to hear this exhaust air) in the bathrooms or kitchens. This air is ducted to the HRV and ERV where it is used to pre-heat the incoming outdoor air before being exhausted outdoors.

Slide 46

## Consumer Operation of HRV/ERV:

**Operating your HRV/ERV during cold and warm months**
During the coldest weather in winter, most homes need to limit the indoor relative humidity to prevent visible moisture (condensation) from occurring on the inside surface of windows. Depending on the indoor room temperatures, furniture placement and window coverings; the indoor relative humidity may need to be reduced to prevent this window condensation. The relative humidity can be allowed to increase to higher levels as long as there is no visible moisture on the windows or other cold surfaces within the house.

During the winter, the dehumidistat should be set low enough to keep condensation from occurring on your windows. The table below, (provided by Manitoba Hydro), outlines the recommended Maximum Indoor Relative Humidity (RH) levels for double-glazed windows with low E glass. Other glazing types may require different RH levels.

Figure 4 Dehumidistat Exhaust Fan Switch

| Outdoor Temperature | Maximum Relative Humidity | NOTE: |
|---|---|---|
| - 30°C or below | 25% | • This table assumes that airflow across the window glass is adequate and is not restricted by window coverings. • If airflow is restricted or condensation occurs on the window, lower the relative humidity setting until window condensation stops. |
| - 29°C to – 240C | 30% | |
| - 23°C to – 180C | 35% | |
| - 17°C to – 120C | 45% | |
| - 110°C to + 180C | Above 50% | |

If you notice moisture on the windows during cold weather, lower the dehumidistat setting gradually (5% at a time) until there is no moisture on the windows. Setting the furnace fan to run continuously may also help to reduce the amount of condensation that will occur on your windows. The furnace fan should be running whenever the HRV/ERV is operating at either high or low speed, and this should also help to reduce condensation.

Slide 47

## HRV/ERV Installation Inspection Checklist –

## Checklist items are taken directly from the National Building Code.

Slide 48

## Installation Checklist:

Building Inspectors in many Provinces -Territories use this Installation Checklist during site inspections.

### Inspection Checklist - NBC HRV Main Requirements

- ☐ **1.** Outdoor air intake and exhaust openings are protected from weather (they have hoods or weather cowls)?
- ☐ **2.** Exterior fresh air intake hoods are located at least 450 mm (18") or more above finished grade level, any permanent horizontal surface or above expected height of snow to prevent blockage?
- ☐ **3.** Exterior fresh air intake hoods are labeled and are accessible for cleaning?
- ☐ **4.** All fresh-air intake hoods are 900 mm (36") away from sources of stale or polluted air?
- ☐ **5.** Outdoor air intake hoods, and exhaust hoods without backdraft dampers, have corrosion-resistant screen to keep out small animals. If mesh is less than 6mm (1/4"), gross area is 2 to 3 times the duct area?
- ☐ **6.** Exhaust outlets are at least 100 mm (4 inches) above finished grade (more if possible as HRV exhaust may not melt the snow)?
- ☐ **7.** Exhaust hoods located where dripping and icing below hood will not be a problem?
- ☐ **8.** Each exhaust hood for kitchen and bathroom fans has a backdraft damper (not required for HRVs)? Either a backdraft damper or rodent screen [6mm (1/4") metal mesh], is located at the outside wall?
- ☐ **9.** Combustion air has been provided for vented combustion appliances as required by fuel codes?
- ☐ **10.** CO alarm meeting CAN/CSA-6.19 installed in each room with a solid-fuel burning appliance (on or near the ceiling unless manufacturer suggests different location when used for solid fueled appliances), and within 5 m (16') of each bedroom door if any type of combustion appliance or an attached garage is present?
- ☐ **11.** Make-up air provided for exhaust devices if non-solid-fuel burning appliances are vented through a chimney? Make-up air tempered to at least 12°C or delivered to a normally unoccupied area?
- ☐ **12.** HRVs are HVI-certified and meet NBC requirements for airflow capacity. Do HRV/ERV ventilators meet the efficiency requirements specified in section 9.36 Energy Efficiency requirements, if 9.36 was adopted by the Province/Territory.

Slide 49

## Installation Checklist:

Building Inspectors in many Provinces -Territories use this Installation Checklist during site inspections.

- ☐ **13.** HRV vibration isolation mounting used and preferably unit is suspended away from mid-span of joists?
- ☐ **14.** A label been applied to the HRV and the label displays the Code required measured, set and balanced (+/- 10%) Low (PVF) and High airflow rates (2.5 times minimum PVF rate if there is no separate kitchen exhaust, and any balanced high airflow rate if there is a separate vented kitchen exhaust)?
- ☐ **15.** On HRV/ERV units without built-in flow measuring devices, there are indications that a flow measuring station has been able to be installed into the duct or that holes have been drilled in correct locations to permit an insert flow measuring station to be used to provide accurate air flow measurement, setting and balancing.
- ☐ **16.** Air flow through the HRV can be adjusted with dampers built into the HRV, dampers installed in the main exhaust and supply ducts on the dwelling side of the HRV, or with motor speed controls? Indications are that the dampers have been moved and adjusted and then screwed, locked or taped in place to set correct air flows?
- ☐ **17.** Ventilation equipment is accessible for inspection, maintenance, repair, and cleaning?
- ☐ **18.** Ventilation ductwork sized using Section 9.32 tables or detailed design according to Section 9.33. In any case, ductwork not smaller than recommended in manufacturer's literature?
- ☐ **19.** Joints and seams of all ventilation ducts installed throughout the house have been sealed with duct mastic or aluminum foil duct tape as per the code?
- ☐ **20.** Has insulated duct minimum RSI 0.5 (R 3.0) been installed on the "cold-side" between the HRV and where the ducts extend through the exterior wall to hoods?
- ☐ **21.** Has the inner duct and exterior air/vapour barrier on the duct been sealed correctly to the HRV and at the exterior wall and has all flex and metal duct been supported to avoid sagging and compression of the insulation?
- ☐ **22.** Outdoor air supply connection to furnace return is at least 3m (10') upstream of furnace or connected to return drop though an acceptable mixing device?
- ☐ **23.** There is an exhaust intake grille to the HRV, or an outside vented exhaust fan in each bathroom, Water Closet and kitchen?
- ☐ **24.** Are exhaust grilles or fans in bathrooms located 2.0 m (6.5') above the floor or in the ceiling?

Slide 50

## Installation Checklist:

There is a presentation of good and bad photos used to illustrate the 32 point checklist.

- ☐ **25.** Any outside vented kitchen exhaust discharges directly to the outdoors through non-combustible ducting?
- ☐ **26.** All exhaust grilles in the kitchen located within 3 m (10') of the cooktop have a grease-filter in the exhaust grille and is it 2.0 m (6.5') above the floor?
- ☐ **27.** Have fresh-air supply grilles on any direct ducted HRV systems been located in ceiling or high wall 2m (6.5') off the floor to adequately disperse air into a room without leading to occupant discomfort?
- ☐ **28.** In direct ducted ventilation systems is there good cross-flow of air in the bedrooms between supply grille and door undercuts, transfer or return air grilles to adequately flush night-time stale air from the room?
- ☐ **29.** Is there a control switch, labelled "VENTILATION FAN", located in the living area of the dwelling that allows the HRV to be turned on to the PVF airflow rate and which activates any forced air system fan to distribute the supply air?
- ☐ **30.** Are there local switches or timers in any bathroom, WC or kitchen that can activate any exhaust fan in the room or an HRV with an exhaust grille in the room?
- ☐ **31.** Has the clear plastic HRV condensate drain tube been installed on the underside of the HRV; including a minimum 50 mm (2") loop trap that contains water?
- ☐ **32.** Was ventilation system literature supplied to homeowner/occupant or left on HRV?

Slide 51

## Inspection Checklist – NBC Ventilation with HRV/ERV

☐ **1.** Outdoor air intake and exhaust openings are protected from weather (do they have hoods or weather cowls)?

☐ **2.** Exterior fresh air intake hoods are located at least 450 mm (18”) or more above finished grade level, any permanent horizontal surface or above expected height of snow to prevent blockage?

☐ **3.** Exterior fresh air intake hoods are labeled and are accessible for cleaning?

☐ **4.** All fresh-air intake hoods are 900 mm (36”) away from sources of stale or polluted air?

☐ **5.** Outdoor air intake hoods, and exhaust hoods without backdraft dampers, have corrosion-resistant screen to keep out small animals. If mesh is less than 6mm (1/4”), gross area of screen is 2 to 3 times the duct area (6” round = 28.3 $in^2$)?

☐ **6.** Exhaust outlets are at least 100 mm (4 inches) above finished grade (more if possible as HRV exhaust may not melt the snow)?

☐ **7.** Exhaust hoods located where dripping and icing below hood will not be a problem?

☐ **8.** Each exhaust hood for kitchen and bathroom fans has a backdraft damper (not required for HRVs)? Either a backdraft damper or rodent screen [6mm (1/4”) metal mesh] is located at the outside wall?

☐ **9.** Combustion air has been provided for vented combustion appliances as required by fuel codes?

☐ **10.** CO alarm meeting CAN/CSA-6.19 installed in each room with a solid-fuel burning appliance (on or near the ceiling unless alarm manufacturer suggests a different location when used with solid fueled appliances), and within 5 m (16’) of each bedroom door if any type of combustion appliance or an attached garage is present?

☐ **11.** Make-up air provided for exhaust devices if non-solid-fuel burning appliances are vented through a chimney? Make-up air tempered to at least $12^0$C or delivered to a normally unoccupied area?

☐ **12.** HRVs are HVI-certified and meet NBC requirements for airflow capacity? Do HRV/ERV ventilators meet the efficiency requirements specified in section 9.36 Energy Efficiency requirements, if 9.36 was adopted by the Province/Territory?

☐ **13.** HRV vibration isolation mounting used and preferably unit is suspended away from mid-span of joists?

☐ **14.** A label been applied to the HRV and the label displays the Code required measured, set and balanced (+/- 10%) Low (PVF) and High airflow rates (2.5 times minimum PVF rate if there is no separate kitchen exhaust, and any balanced high airflow rate if there is a separate vented kitchen exhaust)?

☐ ☐ **15.** On HRV/ERV units without built-in flow measuring devices, there are indications that a flow measuring station has been able to be installed into the duct or that holes have been drilled in correct locations to permit an insert flow measuring station to be used to provide accurate air flow measurement, setting and balancing?

**16.** Air flow through the HRV can be adjusted with dampers built into the HRV, dampers installed in the main exhaust and supply ducts on the dwelling side of the HRV, or with motor speed controls? Indications are that the dampers have been moved and adjusted and then screwed, locked or taped in place to set correct air flows?

☐ **17.** Ventilation equipment is accessible for inspection, maintenance, repair, and cleaning?

☐ **18.** Ventilation ductwork sized using Section 9.32 tables or detailed design according to Section 9.33? In any case, ductwork not smaller than recommended in manufacturer's literature?

☐ **19.** Joints and seams of all ventilation ducts installed throughout the house have been sealed with duct mastic or aluminum foil duct tape as per the code?

☐ **20.** Has insulated duct, minimum RSI 0.5 (R 3.0), been installed on both "cold-side" ducts between the HRV and through the exterior wall to both hoods?

☐ **21.** Has the inner duct and exterior air/vapour barrier on the duct been sealed correctly to the HRV and at the exterior wall; and has all flex and metal duct been supported to avoid sagging and compression of the insulation?

☐ **22.** Outdoor air supply connection to furnace return is at least 3m (10') upstream of furnace or connected to return drop though an acceptable mixing device?

☐ **23.** There is an exhaust intake grille to the HRV, or an outside vented exhaust fan in each bathroom, Water Closet and kitchen?

☐ **24.** Are exhaust grilles or fans in bathrooms located 2.0 m (6.5') above the floor or in the ceiling?

☐ **25.** Any outside vented kitchen exhaust discharges directly to the outdoors through non-combustible ducting?

☐ **26.** All exhaust grilles in the kitchen located within 3 m (10') of the cooktop have a grease-filter in the exhaust grille and is it 2.0 m (6.5') above the floor?

☐ **27.** Have fresh-air supply grilles on any direct ducted HRV systems been located in ceiling or high wall 2m (6.5') off the floor to adequately disperse air into a room without leading to occupant discomfort?

☐ **28.** In direct ducted ventilation systems, is there good cross-flow of air in the bedrooms between supply grille and door undercuts, transfer or return air grilles to adequately flush stale air from the room?

☐ **29.** Is there a control switch, labelled “VENTILATION FAN”, located in the living area of the dwelling that allows the HRV to be turned on to the PVF airflow rate and which activates any forced-air system fan to distribute the supply air?

☐ **30.** Are there local switches or timers in any bathroom, WC or kitchen that can activate any exhaust fan in the room or an HRV with an exhaust grille in the room?

☐ **31.** Has a 12 mm (1/2”) HRV condensate drain tube been installed on the underside of the HRV; including a minimum 50 mm (2”) trap that contains water?

☐ **32.** Has ventilation system literature been supplied to homeowner/occupant or left on HRV?

# Appendix C: Issues from Roundtable Discussion at NNCA Workshop

Summary of comments at HRV/ERV Workshop NNCA Workshop in Yellowknife

**Design:**

- Consider ventilation without motor(s)
- Consider ERV, not HRV
- Why have such small cores?
- Have motors that can be set at both high and low speeds separately
- Like to see zero to 10 speed control
- Challenge of “dirty” power – brown outs & spikes – durable electrics and electronics
- Arctic specs and Arctic core
- Low-tech/low maintenance solution
- Incorporate accurate sensors in HRV to permit better control
- Docking system to clip unit in and out
- Have efficient and reliable pre-heat module prefabricated to plug in to hydronic system and HRV ducts
- Modular system
- Short payback period

**How to improve installation:**

- Trained installers, good design, adequate space, flex no longer than 3 feet,
- Qualified installers
- Materials used to support flex,
- Account for foundation movement
- Education package – installation

**Commissioning:**

- Installation checklists, start-up and manufacturer’s troubleshooting guide.

**Operation:**

- Control challenges – RH controls have wide dead band (+/- 10%)
- Minimum controls should have hi/low, time on and off, and dehumidistat
- Need better control of pre-heat

- Need $CO_2$ measurements/controls given high # people.
- Remember IAQ considerations
- Control via an app from phone (empowers occupants) include maintenance reminders
- Satisfy health issues at expense of energy/$ - get right balance.

**Maintenance:**

- Multi-unit venting = less O & M work
- Control via an app from phone (empowers occupants) include maintenance reminders
- Education package – operation, maintenance – private and public units
- Design for ease of maintenance
- Self-cleaning models re: maintenance

# Appendix D: List of HRV Issues from Nunavut Maintenance Staff

1. HRV unit being installed in locations that make it very difficult if not impossible to properly service.

2. Housing maintainers reluctant to work on HRVs, intimidated due to their lack of knowledge/experience. Even though we have provided some training, some maintainers are not easily seeing the importance of maintaining the air exchange system, as one would easily see with the heating system, whereby if the heat goes down they have to scramble to do a repair. If an HRV system malfunctions sometimes the system is simply shut off until down the road when mold or health issues begin to surface.

3. Many LHO do not have the proper balancing gauges, and some who do, are confused about how to use them.

4. Some housing units have HRV that are way too large and noisy for the size of the home.

5. Some homes have poorly designed air distribution and exhaust duct locations.

6. Seeing as all arctic HRVs need a preheat coil, and the most economical way to heat the preheat coil is with the boiler, homes that do not have a boiler (have a furnace) are either being equipped with an HRV with no preheat coil, or an electric preheat coil. The electric preheat coil (consumes about 1 KW per hour) was found to be very expensive to run, and for the units without a preheat coil, the tenants shut the HRV off in the winter or tape over the vents due to cold air delivery to the living space.

7. About 50 percent of the time I see incorrect connection of the HRV condensate drain line to the plumbing system.

8. Inadequate education to the tenant of new houses or houses equipped with new HRV on how to use the wall controls.

9. If air exchange system runs when sewage pump out, it creates sewer odor inside the home.

10. The exterior exhaust flapper jamming shut or partially shut, reduces system air moving capability.

11. The air intake, located on outside of building, becoming full of snow.

12. Installers have been installing the units without proper commissioning, leaving systems that are shut off by tenants because of improper operation from day one.

13. Need to keep system design simple to prevent housing maintainers becoming intimidated and/or better education for the maintainers.

14. HRV preheat coil control not accurate enough.

15. Inadequate amount of replacement parts being kept in the LHO.

16. HRV competing with other air moving systems in the house, such as the bathroom fan, range hood, dryer vent and heating appliance. Sometimes causing heating appliance flue gas to be pulled into the home.

17. Exhaust vent grilles being located several feet from the high point in the room of where they are installed.

18. Some systems that run all the time make the living environment too dry.

19. Incorrectly sized duct or too many elbows.

20. Exhaust and fresh air intake hoods being located in areas where they are drifted in with snow, or where the fresh air inlet pulls in contaminants, such as exhaust from dryer, automobile, HRV, bathroom, etc.

21. In some cases, HRV or lack of HRV is being blamed for mold or excessive moisture issues, whereby the real issue lies in the fact that there are undetected water or glycol leaks in the home, or several undetected leaks, that can quickly develop into situations where tenants have to move out.

22. Lack of understanding by maintainers on relative humidity, negative/positive pressures, vapor barrier, due point, C02, etc., which if not fully understood, makes people downplay the need for adequate and proper controlled ventilation. Some Inuk LHO managers are so frustrated with the issue of poor indoor air quality and mold that they think there is a need to poke a hole in the roof (traditional igloo ventilation method), rather than employ state of the art methods, and this is in part due to their maintenance team not understanding the issue.

Gary Wong, CBO B.Arch.

Director Infrastructure
Nunavut Housing Corporation

cmhc.ca