Understanding Best Practices and Key Barriers to Scaling Zero Emissions Homes in Metro Vancouver

EXECUTIVE SUMMARY

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Introduction

The Near Zero Emissions Building Program, launched by ZEBx in 2018, is an incentive scheme that aims to gather data on, and accelerate the construction of, high-performance single-family homes and Part 9 multi-unit residential buildings in Metro Vancouver. The program has collected a wide variety of documented data from over 53 participating projects, including construction/design set drawings, budgets, photos, and questionnaires which were completed over the course of the project at stages of design, post-construction, and occupancy.

This project builds on a trend analysis completed by a previous Sustainability Scholar in 2020, studying key trends and barriers of high-performance homes in the Near Zero Emissions Buildings Program. In this phase of the project, single-family homes in Vancouver were analyzed. This project aimed to distill these resources and organize the data, enabling the ZEBx team to continue sharing and promoting new and relevant content with their audience. The data was compiled into specific datasets, exploring the topics of two different areas: Airtightness, and Low Carbon Mechanical Systems. These datasets were then analyzed in order to identify trends and establish a rough perspective on each topic. The outcome of this research project helps set the foundation for further analytical work, better data collection practices, and well-informed industry discussions.

Background

Airtightness

Buildings require four primary control layers to regulate – in order of importance – water, air, vapor, and temperature inputs (Lstiburek, 2021). The restriction of air flow by an air barrier system is one of the most important functions of a building, as air is a transport mechanism for water, vapor, heat energy, as well as airborne contaminants. The impact of air leakage on building energy use is the primary focus of high-performance building. Uncontrolled air flow increases heating and cooling loads on the mechanical systems (BC Housing. 2017). Thus, controlling air flow is one of the important pillars of high-performance buildings.

Airtightness is quantified through a blower door test that measures how much air changes passes throughout of a defined building boundary by applying a standard pressure (50 pascals for small buildings and 75 pascals for larger buildings) providing a value of Air Changes per Hour (ACH). The blower door test is generally applied twice throughout the project: at mid-construction and at the final test stages of finishing (Building Performance Institute, 2017). The Near Zero program

requires applicants to pursue either Step 4 or 5 of the BC Energy Step Code or the Passive House certification. The Passivhaus standard requires uncontrolled leakage to be smaller less than 0.6 ACH (Passivhaus Institut, 2015), while the BC Energy Step Code requires lower than 1.5 and 1.0 ACH for step 4 and 5 respectively (BC Energy Step Code, 2019).

Low Carbon Energy Systems

According to City of Vancouver (2017), low carbon energy systems are highly efficient systems that depend on renewable sources to provide space heating and conditioned ventilation air for buildings seeking to meet GHG limits. These systems may also provide domestic hot water and cooling., in British Columbia, electricity is considered a low carbon energy source. Approximately 95% of BC's electricity is generated from renewable sources (Canada Energy Regulator, 2016). The Near Zero program requires the use of low-carbon space heating equipment, preferably the use of a heat pump.

Research Approach

Airtightness Strategies

Out the available projects in the program's project list, the data were filtered down to 19 projects that had achieved their final blower door results and are either occupied or ready for occupancy. These projects are presented in the table A1 in Appendix. The projects are sorted from the highest to lowest ACH value.

The intention here was to categorize the installed air barrier system in a holistic perspective including walls and roofs. However, participant's answers rarely provided both information. The design and construction drawing submitted did not make their best communication in showing the air barriers used tracing the whole system in continuum. Reaching out to the participants for clarifications could have been an option, but the timeframe of the project did not allow for that. For simplicity the approach focused only on categorizing above-grade wall air barrier systems.

The categorization began with exploring BC Energy Step Code's definition of air barrier strategies used for walls and divided them between exterior and interior (BC Energy Step Code, 2019). Further, it was also taken into consideration that a double barrier can be used (Building Science Corporation, 2016) Guided by this categorization, a simpler classification was applied with an objective to capture the strategies at a finer resolution:

- Primary Barriers
    A. Exterior

        A.1 Peel and stick membrane

    B. Interior

        B.1 Loose membrane

        B.2 Taped SIP Panels

        B.3 Combination

    C. Double
        - Exterior (E)

            C.E.1 Liquid-applied membrane

            C.E.2 Peel and stick membrane

        - Interior (I)

            C.I.1 Spray polyurethane foam

            C.I.2 Taped SIP panels taped

            C.I.3 Combination of Both

- Secondary Barriers: (uncategorized: will be added in commentary style)

Product data was retrieved from wall assembly plans, design questionnaires, construction photos and follow-up emails. In many cases, the products that were used for the air barrier were not disclosed and following up with contractors or designers to retrieve information was required. In other cases, product information was retrieved from design questionnaires only, and given its uncertainty, it required further inquiry for confirmation. This is partly because of the inherent nature of construction to be different of the design intents. Allowing for this additional fact-checking procedure makes the new dataset more grounded in certainty and useful for the future analysis.

Low-Carbon Energy Systems

Similar to the approach in tabulating the airtightness strategies, the projects here were filtered down to a total of 22 projects. The criteria focused on certainty by selecting only projects that had 6 months before projected completion (would have received a purchase order for the systems). This provided a higher probability that the information used is up to date and matches what was constructed. In cases, where there was the possibility of change, a follow-up email was sent for confirmation. Information was collected focusing on the following three topics:

1. Domestic Hot Water (DHW)
2. Heating
3. Cooling
4. Ventilation

Here, the process of categorizing the data was challenging. That is because of the various ways that the energy systems could be integrated. Even with the initial filtering for certainty, the process was extensive, as the information was not directly laid out. This required a two-way process of checking with the contractor/designer and reaching out for product specifications. It took a long while to categorize the inputs, but was finally shortened to what follows:

A. Domestic Hot Water (DHW)

A.1 Heat Pump

- CO_2 refrigerant
- R134A refrigerant

A.2 Standard Electric Hot Water

A.3 Hybrid Electric Water Heater

A.4 Combo Unit

B. Heating

B.1 Mini split

B.1.1 Ducted

B.1.2 Ductless

B.1.3 Combination of Both

B.2 In-floor Radiant Heating

B.2.1 Electric

B.2.2 Heat Pump

B.4 Combo Unit

B.5 Compact Air Treatment Unit

B.6 Integrated HRV

C. Cooling (uncategorized: will be added in commentary style)

D. Ventilation

D.1: HRV

D.2 ERV

The product information for each was compiled and is shown in Appendix C

Summary

AIRTIGHTNESS:

Out of the 19 projects that had completed their blower door test:

- For the primary air barrier, 21% used an exterior strategy, 53% used an interior strategy, and 26% used a double barrier strategy. The frequency of each category and products used was as follows:

	Location	Strategy	%	Product	%
Single	Exterior	*A.1 Peel and stick membrane*	*100%*	*SIGA Majvest*	*100%*
	Interior	*B.1 Loose membrane:*	*20%*	*SIGA Majrex*	*20%*
		B.2 Taped SIP Panels	*70%*	*SIGA Rissan tapes*	*84%*
				Vapor Tape EX	*16%*
		B.3 Combination of Both	*10%*	*SIGA Majrex*	*50%*
				Henry Bakor VP100	*50%*
Double	Exterior	*C.E.1 Liquid-applied membrane:*	*60%*	*Naturseal*	*50%*
				Adex Hyrdoflex WO-R	*50%*
		C.E.2 Peel and stick membrane	*40%*	*SIGA Majvest*	*50%*
				Delta Vent SA	*50%*
	Interior	*C.I.1 Spray polyurethane foam*	*40%*	*Airmetic Soya*	*50%*
				Insulthane Extreme by Elastochem	*50%*
		C.I.2 Taped SIP panels	*20%*	*MFGR by Premier SIP*	*100%*
		C.I.3 Combination of Both	*20%*	*Prosoco*	*50%*
				SIGA Rissan tapes	*50%*

- As secondary air barrier strategy, 33% of the projects used air sealing (*Aerobarrier* specifically) while the top 5 projects with the highest ACH value did not mention using it.
- 50% of the projects that installed only an interior air barrier also used air sealing as a secondary strategy.
- 50% of the projects that installed only an exterior air barrier also used air sealing as a secondary strategy.
- None of the projects that installed a double air barrier used air sealing as a secondary strategy.
- 5 projects did not disclose whether they conducted a blower door test at mid-construction. Out of the remaining 14 projects, 50% had mid-construction values higher than final test, while the other 50% had values lower than the final test.

LOW CARBON SYSTEMS:

- Following the criteria previously provided in the methodology section, the following was the distribution of each

A. Domestic Hot Water (DHW)

A.1 Heat Pump = 68.19%

- CO2 refrigerant = 92.86%
- R134A refrigerant = 7.14%

A.2 Standard Electric Hot Water = 18.18%

A.3 Hybrid Electric Water Heater = 9.09%

- this is a water heater that includes a built-in mini heat pump on top of it.

A.4 Combo Unit = 4.55%

- this is a heating unit that includes provides domestic hot water, ventilation, heating and cooling

B. Heating

B.1 Mini split = 36.36%

B.2 In-floor Radiant Heating =36.37%

B.2.1 Electric = 18.18%

B.2.2 Heat Pump = 31.82%

B.4 Combo Unit = 4.55%

B.5 Compact Air Treatment Unit = 9.09%

B.6 Integrated HRV = 18.18%

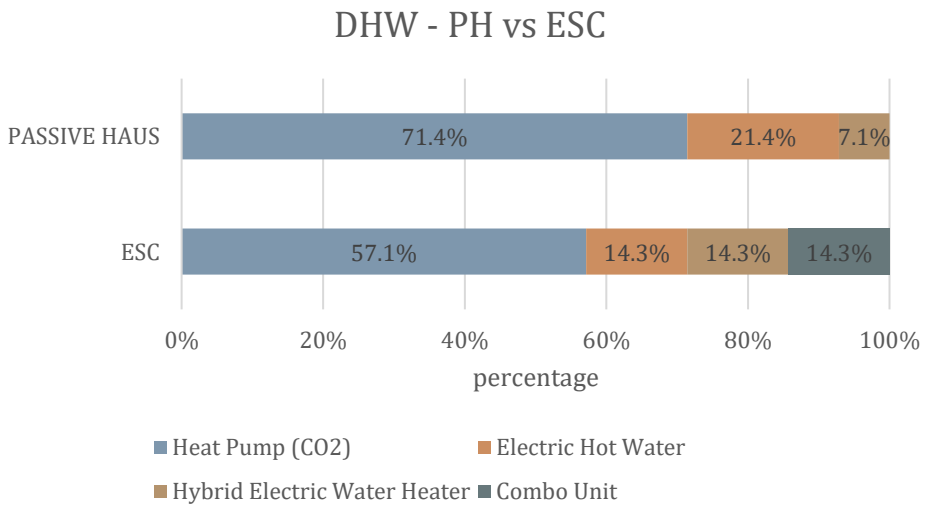
C. Cooling

- 64% of the homes had a system that used active cooling.
- 41% of the homes used same strategy for both cooling and heating

D. Ventilation

- All projects used only HRV (a Combo unit was also used once)
  - *Venmar: 68.18%*
  - *Zehnder: 9.10%*
  - *Combination of two different brands: 9.10%*
    - *Minotiar & Venmar: 50%*
    - *Minotiar & Zehnder: 50%*
  - *Others:*
    - *Lifebreath RNC95: 33%*
    - *Drexel&Weiss, x2 S series: 33%*
    - *Hero Series by Fantech: 33%*

- Comparing between two the Passivhaus and ESC certification



References

BC Energy Step Code. 2019. BC Energy Step Code Handbook for Building Officials Part 9 Residential Buildings. [online] Available at: <http://energystepcode.ca/app/uploads/sites/257/2019/10/BOABC-BCEnergyStepCodeHandbook-2019-10-01.pdf> [Accessed 10 August 2021].

BC Housing. 2017. Illustrated Guide- Achieving Airtight Buildings. [online] Available at: <https://www.bchousing.org/research-centre/library/residential-design-construction/achieving-airtight-buildings> [Accessed 10 August 2021].

Building Performance Institute, Inc. 2017. Technically Speaking: What the Blower Door Test Tells You. [online] Available at: <https://www.bpihomeowner.org/blog/technically-speaking-what-blower-door-test-tells-you> [Accessed 10 August 2021].

Building Science Corporation. 2016. BSI-092: Doubling Down—How Come Double Vapor Barriers Work?. [online] Available at: <https://www.buildingscience.com/documents/building-science-insights-newsletters/bsi-092-doubling-down%E2%80%94how-come-double-vapor-barriers> [Accessed 10 August 2021].

Canada Energy Regulator. 2016. CER – Canada's Renewable Power Landscape 2016- Energy Market Analysis- British Columbia. [online] Available at: <https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/electricity/report/2016-canadian-renewable-power/province/canadas-renewable-power-landscape-2016-energy-market-analysis-british-columbia.html#:~:text=Index%20Next%20Page%20%3E-,British%20Columbia,gas%2C%20wind%2C%20and%20oil.> [Accessed 10 August 2021].

City of Vancouver. 2017. LOW-CARBON ENERGY SYSTEMS POLICY. [online] Available at: <https://vancouver.ca/files/cov/Low-carbon-energy-systems-policy.pdf> [Accessed 10 August 2021].

Passivhaus Institut. 2015. [online] Available at: <https://passiv.de/en/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm> [Accessed 10 August 2021].

Lstiburek, J., 2021. BSI-001: The Perfect Wall. [online] Building Science Corporation. Available at: <https://www.buildingscience.com/documents/insights/bsi-001-the-perfect-wall> [Accessed 10 August 2021].

Appendix A Case Studies

A1: Airtightness Strategies

#	Certification	ACH mid	ACH final	Primary Airtightness Strategy	Air Barrier Membrane Type	Products	Secondary Airtightness Strategy
1	ESC 5	0.25	0.19	Exterior	peel-n-stick membrane	Siga Majvest	
2	PH	0.31	0.285	Exterior	peel-n-stick membrane	SIGA Majvest + Wigluv tape	
3	PH	0.1	0.35	Double	Exterior: liquid membrane Interior: SPF	Exterior: Naturaseal Interior: Insulthane Extreme by Elastochem	
4	PH	0.37	0.35	Double[1]	Exterior: peel-n-stick membrane Interior: 1. SIP panels taped 2. liquid-applied membrane	Exterior: SIGA Majvest Interior: 1. SIGA Rissan tapes 2. Prosoco - liquid applied air and vapour barrier	
5	PH Plus	0.15	0.37	Double	Exterior: liquid membrane Interior: SIP panels taped	Exterior: ADEX Hydroflex WO-R Interior: SIP MFGR (Branded by Premier SIPS)	
6	PH	n.a	0.37	Double	Exterior: peel-n-stick membrane Interior: Spray Polyurethane Foam (SPF)	Exterior: 1. Delta Vent SA with Siga Wigluv tape Interior: Airmetic Soya	
7	PH	0.35	0.4	Interior[2]	1. loose membrane 2. peel-n-stick membrane	1. SIGA Majrex 2. Henry Bakor VP100	Air sealing - (Pacific aerobarrier)
8	ESC 5	n.a	0.44	Double	Exterior: peel-n-stick membrane Interior: loose membrane	Exterior: SIGA Majvest Interior: SIGA Majrex	

[1] Prosoco (in a few locations used)

[2] VP100 was used where the upper wall is set inward from the lower wall and needed to connect the air barrier) Tyvek was used on the exterior as a weather shield on outside

9	PH+	n.a	0.441	Interior	*SIP panels taped*	Siga Rissan tapes	Air sealing - (Pacific aerobarrier)
10	PH Plus	0.85	0.47	Exterior	peel-n-stick membrane	Siga Majvest	Air sealing - (Pacific aerobarrier)
11	ESC 5	0.14	0.48*	Interior	*SIP panels taped*	Vapor Tape EX	1. On the exterior: Henry Bakor VP 100 was used for header) and Tyvek (for sill) 2. NP1 caulking was used in the interior to assist sealing SIP panels
12	PH	0.7	0.499	Interior	*SIP panels taped*	Siga Rissan tapes	1.Air sealing - (Pacific aerobarrier) 2.Spray foam (primary used for vapor barrier, secondary as air barrier) 3. Tyvek was used on the outside
13	PH	n.a	0.501	Interior	*SIP panels taped*	Siga Rissan tapes	1.Air sealing - (Pacific aerobarrier) 2. Tyvek (for all except fenestration) 3. Siga Majvest (for fenestrations)
14	PH	1.1	0.54	Interior	*SIP panels taped*	Siga Rissan tapes	Tyvek was used on the outside
15	PH & CHBA NZE	0.89	0.54	Exterior	peel-n-stick membrane	Siga Majvest with Siga Wigluv Tapes	Air sealing - (Pacific aerobarrier)
16	PH	0.45	0.55	Interior	*loose membrane*	Siga Majrex	Air sealing - (Pacific aerobarrier)
17	PH	0.51	0.7	Interior	*loose membrane*	Siga Majrex + Siga Rissan tapes	Henry Bakor VP 100 (peel-n-stick membrane) was used where the upper floor steps in from the lower floor
18	ESC 5	0.7	0.96	Interior	*SIP panels taped*	Siga Rissan tapes	
19	ESC 4	n.a	1.36	Interior	Siga Rissan tapes	Siga Rissan tapes	

A2: Low Carbon Strategy

#	Certification	DHW	Product	Ventilation	Product	Heating	Product
1	ESC 4	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	lifebreath RNC95	1. Ductless mini split 2. Electric In-floor radiant heating	1. Daiken 17 Series Wall Mount 2. NuHeat
2	ESC 4/NZER	Electric Hot Water	Bradford White 80 gallon	Central HRV	Venmar AVSx24 HRV ECM	1.Ducted mini split 2. Integrated unit HRV – duct heater	1. American Standard air handler & speed Heat Pump 2. HRV - Venmar AVSx24 HRV ECM
3	ESC 5	Combo Unit	Drexel&Weiss, x2 S3	Combo Unit	Drexel&Weiss, x2 S series	Combo Unit	*Drexel&Weiss, x2 S3*
4	ESC 5	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder Comfort Air 350	Ductless mini split	Mitsubishi split heat pump
5	ESC 5	Hybrid Electric Water Heater	Rheem Professional Prestige® Hybrid Electric	Central HRV	Hero Series by Fantech	Ductless mini split	Senville
6	ESC 5	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV (two units)	1.Minotair Pentacare V12 (SFD portion) HRV w/ heatpump 2.VanEE G2400E ECM. (Secondary Suite portion)	Compact air treatment unit	Minotair Pentacare V12 HRV
7	ESC 5	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV (two units)	1. Zehnder Comfoair 200 2. Minotair Pentacare V12 V	1. Mini split 2. Compact air treatment unit 3. Electric In-floor radiant heating. 4. Gas fireplace (for ambient)	1. Daiken VRV IV Heat Pump 2. Minotair HRV 3. n.a 4. n.a
8	LBC/NZER	Heat Pump (r134a refrigerant)	Nordic ATW heat pump	Central HRV	Venmar X30 HRV ECM	1. In-floor radiant heating connected to heat pump 2. Ducted mini split	1. Nordic ATW heat pump 2. n.a
9	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder Comfoair 550	In-floor radiant heating connected to heat pump	Sanden Heat Pump via Taco X-Block
10	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder/Paul Novus 300	In-floor radiant heating connected to heat pump	Sanden Heat Pump via Taco X-Block
11	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder Comfoair 550	1. In-floor radiant heating connected to heat pump 2. Integrated unit HRV - duct heater	1. Sanden Heat Pump via Taco X-Block 2. n.a
12	PH	Electric Hot Water	what is the product?	Central HRV	Zehnder Comfoair 550	1.Electric In-floor radiant heating 2. minisplit	1. n.a 2. n.a
13	PH	Electric Hot Water	expand on it? What kind of products used?	Central HRV	Zehnder Comfoair 550	Ductless mini split	n.a
14	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV (two units)	1. Zehnder/Paul Novus 300 2. ComfoAir 200	EEectric In-floor radiant heating	nu-heat (standard - mats)
15	PH	Hybrid Electric Water Heater	GE Appliances GeoSpring Heat Pump Water Heater Type 4	Central HRV	Zehnder Comfoair 550	Ductless mini split	Mitsubishi Heat Pump with Mitsubishi Mr. Slim Indoor Units
16	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder/Paul Novus 300	1. In-floor radiant heating connected to heat pump 2. Ducted mini split	1. Sanden Heat Pump via Combi 2. Daikin Sky Air 2.5
17	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder/Paul Novus 300	In-floor radiant heating connected to heat pump	Sanden Heat Pump via Taco X-Block
18	PH	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder ComfoAir 550 Exp R lux	Integrated unit HRV	Stelpro SDHR-SDHx
19	PH & CHBA NZE	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	Zehnder ComfoAir 550 HRV	Ductless mini split	Daikin, AHRI 5265840
20	PH Plus	Electric Hot Water	n.a	Central HRV	Zehnder Comfoair 350	Electric In-floor radiant heating	n.a

21	PH Plus	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	1. Zehnder Comfoair 200 2. Zehnder Comfoair 550	1. Integrated unit HRV - duct heater 2. Ducted mini split 3. Electric In-floor radiant heating	1. Stelpro® electric HRV Post-Heater 2. Daikin 3. Schluter: Ditra-Heat
22	PH+	Heat Pump (CO2)	Sanden CO2 Heat Pump	Central HRV	1. Zehnder Comfoair 350 2. Zehnder 200	1. In-floor radiant heating connected to heat pump 2. Ducted mini split	1. n.a 2. Mitsubishi SEZ-KD09NA/SUZ-KA09NA

A3: Domestic Hot Water- Products

Product	Type	Specification
Sanden CO2	Heat Pump	COP dependent on the ambient temperature, it ranges between 2 and above 5. You will see higher efficiencies with warmer ambient air temperatures and colder incoming water. Energy Factor 3.09 COP 5.0
Sanden CO2 Gen 3	Heat Pump	COP 5.2 at 20˚C
Sanden CO2 83 Gallon version along with Gen 4 heat pump unit (GS4).	Heat Pump	Gen4 4.5kw/15,800Btu/h heat pump.
Nordic ATW heat pump	Heat Pump	COP up to 4.23 R134a refrigerant
GeoSpring™ hybrid electric water heate	Hybrid Electric Water Heater	3.25 Energy Factor
Rheem Professional Prestige® Hybrid Electric	Hybrid Electric Water Heater	• High 3.50 EF reduces operating cost • ENERGY STAR® rated
Drexel&Weiss, x2 S3	Combo Unit	COP 4.4

A4: Ventilation- Products

Type	Specification
Zehnder Comfoair 550	Heat recovery: Up to 95%
Zehnder Comfoair 350	Heat recovery with an efficiency of more than 90%
Zehnder Comfoair 200	Heat recovery with an efficiency of up to 95%
Zehnder - Paul Novus 300	Heat recovery with an efficiency of up to 95% Excellent energy efficiency of 0.24 Wh/m³
Venmar AVS - X30HRV ECM	Up to 250 CFM at 0.4 in. w.g. High efficency heat recovery core with a sensible recovery efficiency of 75% at 0°C and 66% at -25°C. Minimal power consumption of 18W and CFM/Watt of 3.6 at 64 CFM
Drexel&Weiss, x2 S series	COP 4.4
Venmar AVSx24 HRV ECM.	Up to 210 CFM at 0.4 in. w.g. High efficency energy recovery core with a sensible recovery efficiency of 84% at 0°C and 65% at -25°C. German made ECM motors. Minimal power consumption of 22W and CFM/Watt of 2.9 at 64 CFM.
Hero Series by Fantech - Hero Series 150H (Product #: 99401)	Up to 160 cfm of fresh air ENERGY STAR® Heat Recovery Rate (SRE) : 82%
Minotair Pentacare V12 (SFD portion) HRV w/ heatpump	ever-highest SRE of the industry at 116% ASE of 178%,
VanEE G2400E ECM. (Secondary Suite portion)	The G2400E ECM is the perfect solution for mid to large size homes in need for the most energy-efficient ventilation solution. Up to 210 CFM at 0.4 in. w.g. High efficency energy recovery core with a sensible recovery efficiency of 84% at 0°C and 65% at -25°C. German made ECM motors. Minimal power consumption of 22W and CFM/Watt of 2.9 at 64 CFM.
lifebreath RNC95	ASE 60CFM (28L/S) 88% ASE 59CFM (28L/S) 75% ASE 70CFM (33L/S) 73% ASE 61CFM (29L/S) 68%

A5: Heating and Cooling- Products

Product	Code	Type	Specification
Mitsubishi Heat Pump with Mitsubishi Mr. Slim Indoor Units	MXZ-2B20NA MSZ-GEO6NA	Ductless Mini Split	
Daiken Heat Pump	VRV IV Heat Pump	Ducted and Ductless Mini Split	Up to 28 IEER Up to 4.20 COP
Stelpro	SDHR-SDHx	Duct Heater	
Daiken Wall Mount	17 Series Indoor Unit Model #: FTXB24AXVJU Outdoor Unit Model #: RXB24AXVJU	Ductless mini-split	17 SEER 9.0 HSPF 11.5 EER 24k BTU 3.68 COP R-410A Refrigerant Compatible
Taco X-Block		water circulation system - water source heating connected to heat pump	
Nordic ATW heat pump		Heat pump connected to in-floor radiant heating	Up to 4.0
Sanden Heat Pump via Combi		Heat pump connected to in-floor radiant heating	
Drexel&Weiss	x2 S3	Combo Combined unit HRV with DHW	COP 4.3 Effective degree of heat provision on the exhaust air side according to PHI 83%
Mitsubishi split heat pump heating system - 20,000 Btu Mitsubishi Multi Zone Ductless Mini Split Heat Pump System -	Model Mxz2c20na	Ductless mini-split	SEER 20 Cooling Btu20,000 Heating Btu22,000

Venmar	AVS X24 HRV ECM	Combo Combined unit ERV without DHW	High efficency heat recovery core with a sensible recovery efficiency of 81% at 0°C and 73% at -25°C.
Venmar	Venmar X30 HRV ECM	Combo Combined unit ERV without DHW	High efficency heat recovery core with a sensible recovery efficiency of 75% at 0°C and 66% at -25°C.
Senville	Outdoor Unit Model Number: SENA/09HF/OZ Indoor Unit Model Number: SENA/09HF/IZ	Ductless mini-split	Cooling Capacity (Btuh): 9000 EER Rating (Cooling): 14.50 SEER Rating (Cooling): 25.00 Heating Capacity(Btuh) @ 47 F: 10900 Region IV HSPF Rating (Heating): 11.20 Heating Capacity(Btuh) @ 17 F: 6900
Minotair	Pentacare V12 HRV	Combo Combined unit ERV without DHW	Up to 3.0 COP
NuHeat	nVent Nuheat Standard Mats	electric In-floor radiant heating	Operating Voltage: 120 V, 208 V, and 240 V Power Output: 12 watts per square foot Maximum Continuous Exposure Temperature: 194°F (90°C)
NuHeat	Raychem	electric In-floor radiant heating	
Schlutar		electric In-floor radiant heating	