# Decarb Lunch Series

zebx

## Heat Pumps for Step 5 Homes in Northern BC

Fri Jan 27, 2023,
from 12- 1pm PST
Free Webinar I zebx.org

ecolighten

NORTHERN HOMECRAFT

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**The ZEBx Podcast is now on Spotify, Apple & Google**

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- [ ] Decarb Lunch
- [ ] Deep Emissions Retrofit Dialogue
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- [ ] Tech Demonstration

Systems:

- [ ] Building Enclosure
- [ ] Domestic Hot Water Heat Pump
- [ ] Geothermal
- [ ] Mechanical

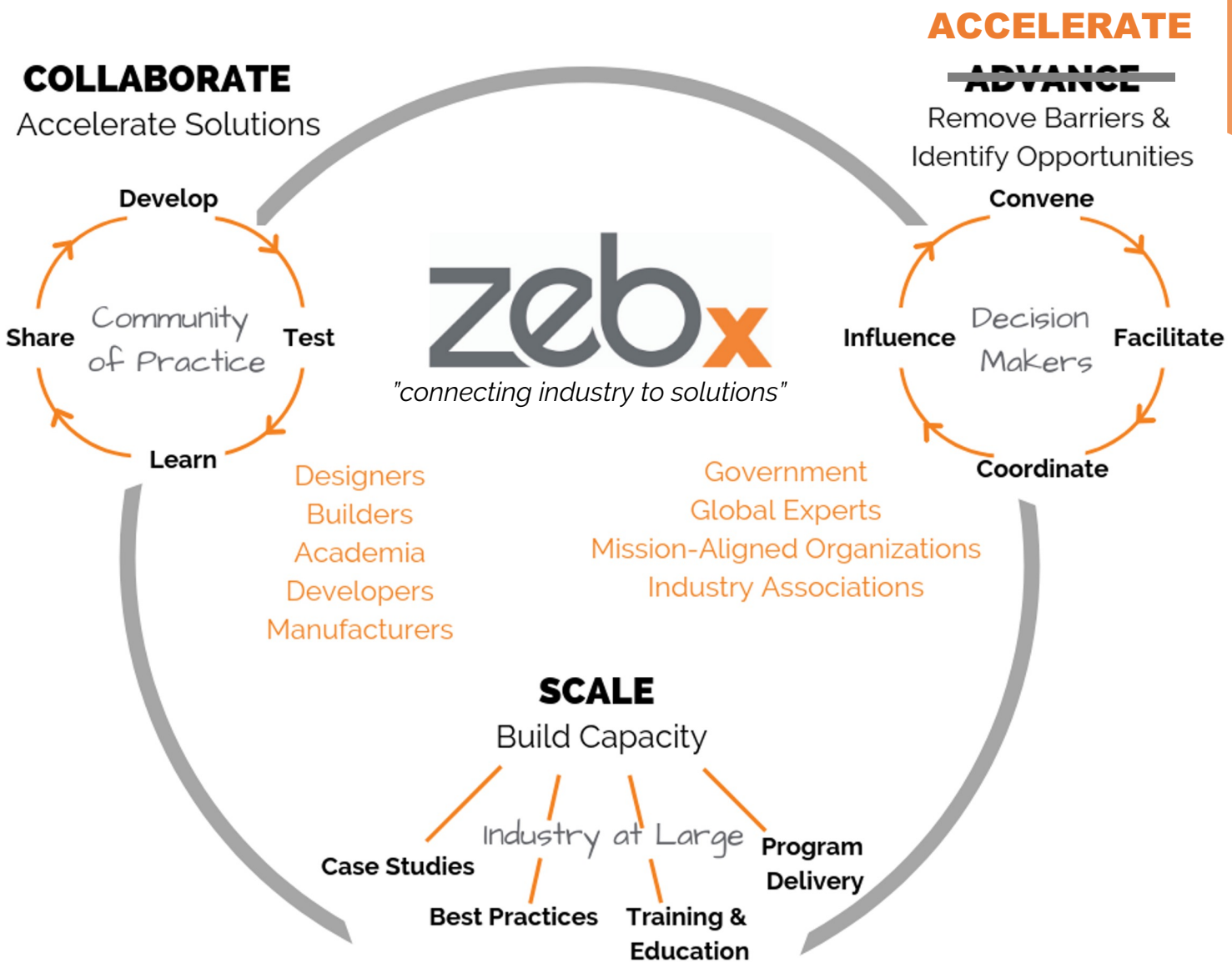

The ZEBx Podcast Decarb Lunch Jan 2022: Reducing Embodied Carbon for Step Code Homes


The ZEBx Podcast Decarb Lunch Oct 2021: From Net-Zero Energy to Near-Zero Emissions


The ZEBx Podcast Decarb Lunch Jul 2021: Developer/Builder Recipes for Low-Cost, All-Electric, Step 4 Residential Construction



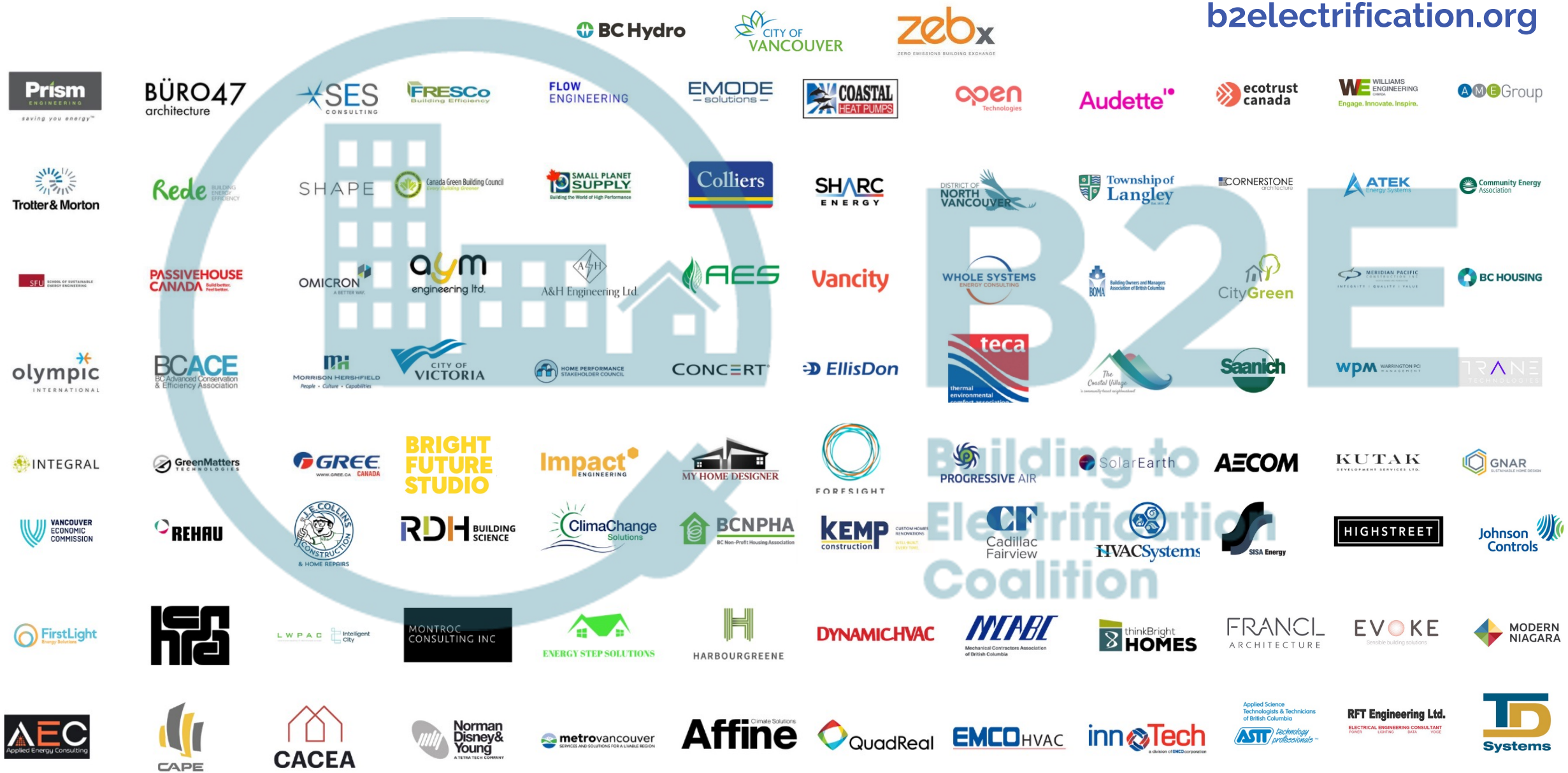
This is a climate **emergency**!




zebx.org

We are a broad coalition working together to electrify buildings in British Columbia in order to reduce their climate impacts and reliance on fossil fuels.

b2electrification.org



CLF Carbon Leadership Forum Vancouver

joins

ZEBx

ZEBx is proud to announce the **Carbon Leadership Forum, Vancouver** has joined our organization.

clfvancouver.com

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# Is Using a Heat Pump in the North Feasible?

June 2022

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Learn from the Leading Edge: Clean BC Net-Zero


Marketing the High-Performance Home




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# Tell us about yourself!

Three-part anonymous poll

BC Hydro

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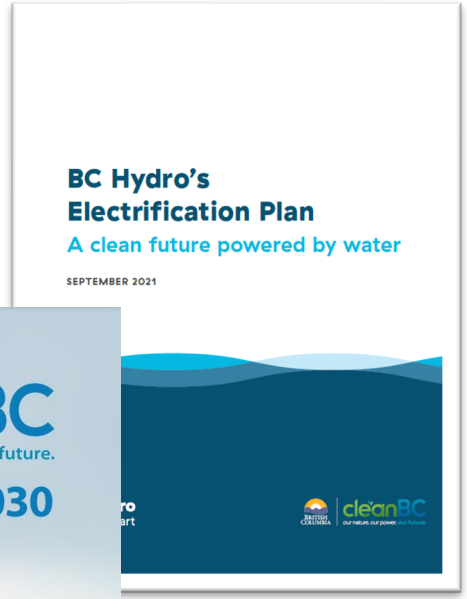
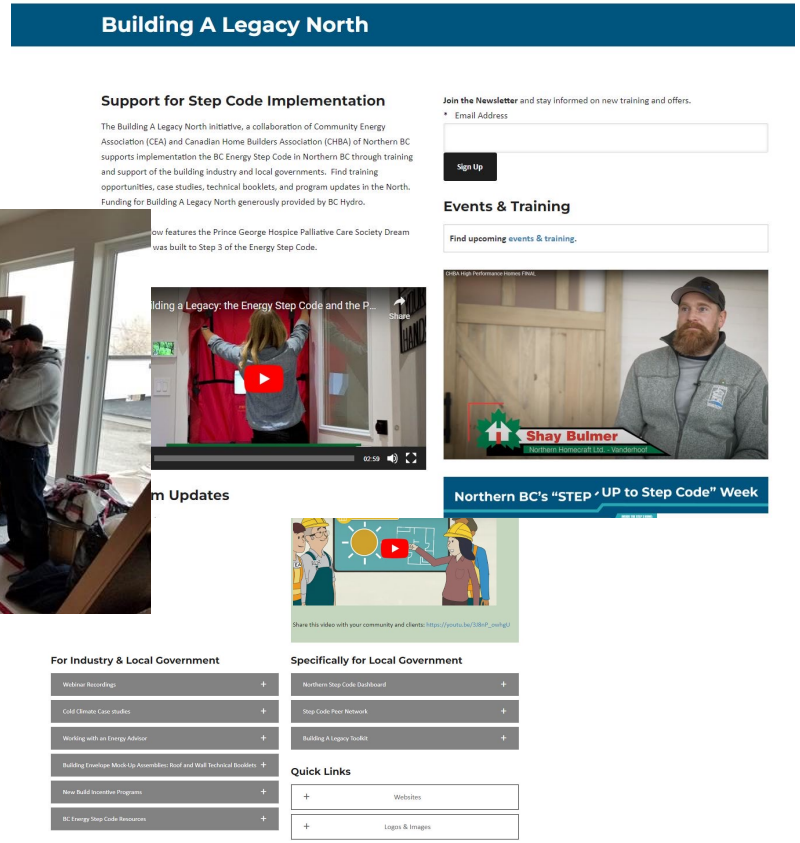
# Market Transformation Support






https://www.communityenergy.ca/bal-north/

BC Hydro
Power smart

# Heat Pumps for Step 5 Homes in Northern BC

Shay Bulmer, Co-Owner

**Northern Homecraft**

NORTHERN HOMECRAFT

# Northern Homecraft

About Shay:

- Building custom homes for 16+ years
- Started Northern Homecraft in 2012
- 2018: First Net Zero Ready home built
  - 1/year since then
- President of CHBA Northern BC

# The Northern Context

Unique regional climate and market considerations:

- Budget
  - “Upside down housing economy”
  - Financing
  - Technical factors
- Labour
  - Need for more specialized trades

# Building All-Electric



- Homeowner motivation
- Rebates
  - Offsetting performance upgrades $$$
- Step-Code-built homes are possible on smaller budgets
  - Design for simplicity
  - Non-complex mechanical systems
  - Use locally available materials

# A Northern Recipe for Success

- Supplemental heating
  - Climate Zone 7A
- Bolstered envelope
  - Insulation
  - Air tightness
  - Triple pane windows
- Adequate planning:
  - Scaled to home
  - Energy Advisor is critical
- Mid-construction testing

# Future-Proofing:
## More Than Marketing

- Upcoming codes, standards, and regulations
  - Meeting future requirements
- Documented labels – recorded and validated
  - Buyer consideration
- Maximized investment retention
- Comfort
  - Economic
  - Physical
  - Environmental

# IS USING A HEAT PUMP IN THE NORTH FEASIBLE?

## Electrification of the North

*Prepared by:*

Ecolighten Energy Solutions

*Prepared for:*

ZEBx: The Zero Emissions Building Exchange

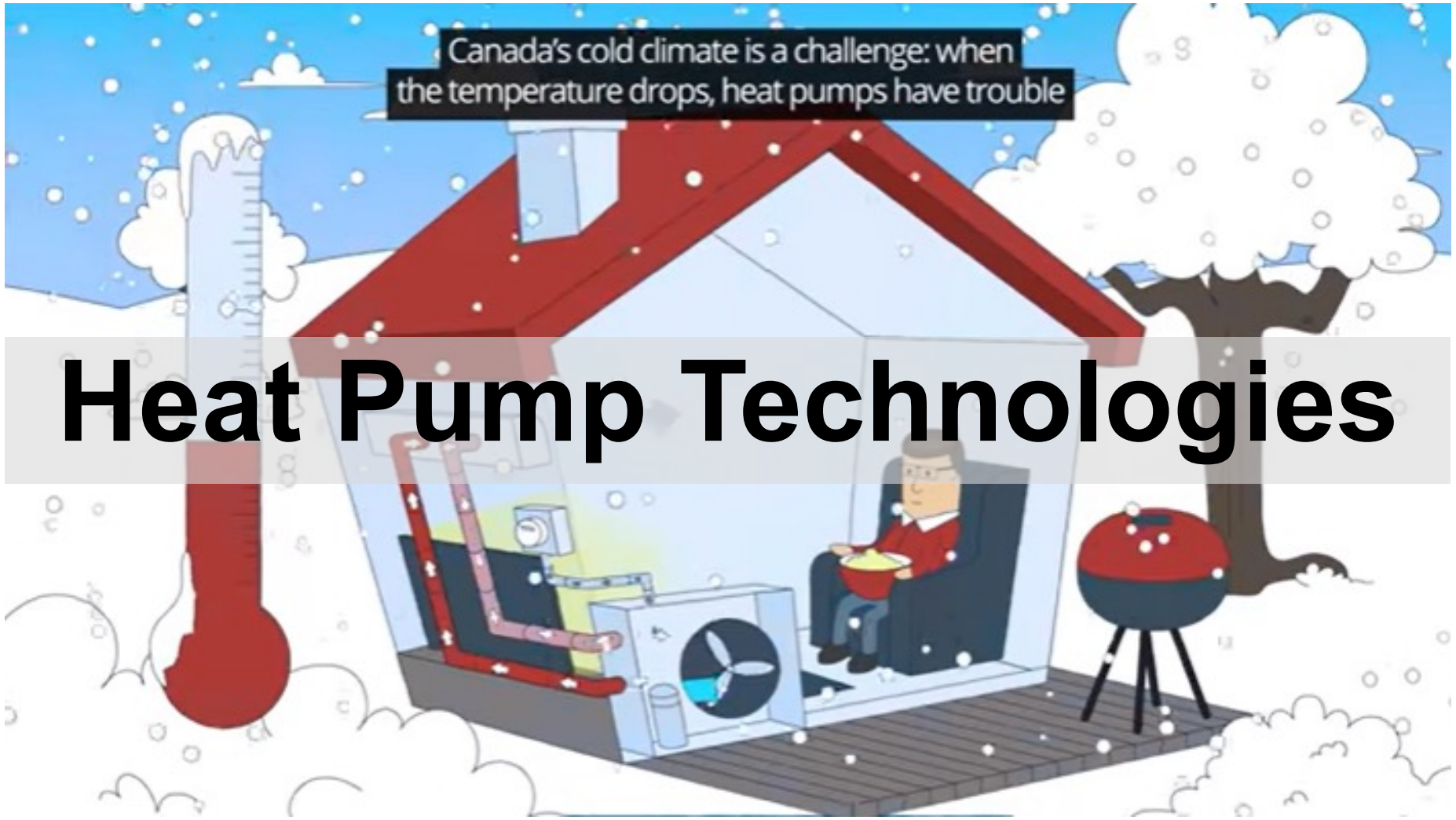
# Why are we talking about HEAT PUMPS in the North?

## Misconceptions about Heat Pump Technology:

- Heat pumps can only perform for a small part of the winter
- Heat pumps cost more than Natural Gas to operate

## Lack of effective mechanical systems design process:

- Upfront Integrated Design including mechanical designer
- Compliant F280-12 Load Calculations
- Design coordinated and articulated in detailed Drawings
- Quality Assurance – i.e. site reviews & inspections

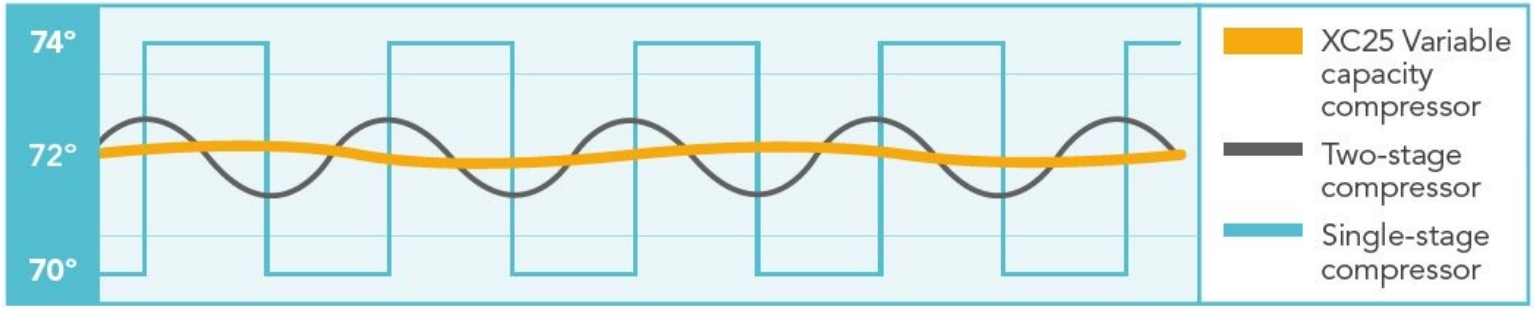



# Heat Pump Technologies

Source: NRCan Adapting heat pumps to our Canadian climate

# HEAT PUMP TECHNOLOGIES

- Conventional Equipment




**Single-Stage:**

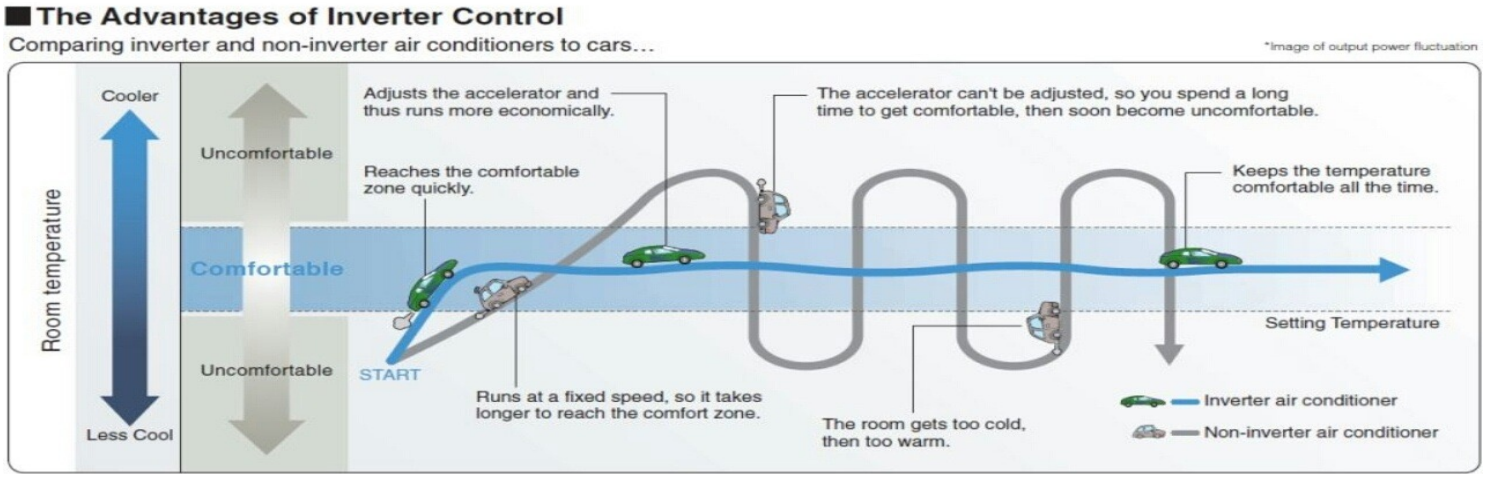
- Operates on a full-on or full-off schedule and works at 100% capacity all the time.
- Most affordable option but efficiency is the lowest.

**Two-Stage:**

- Offers better control and performance with higher efficiency than single-stage equipment.
- Works at 60% – 65% capacity for 80% of the time.

# HEAT PUMP TECHNOLOGIES

- High-Performance Equipment

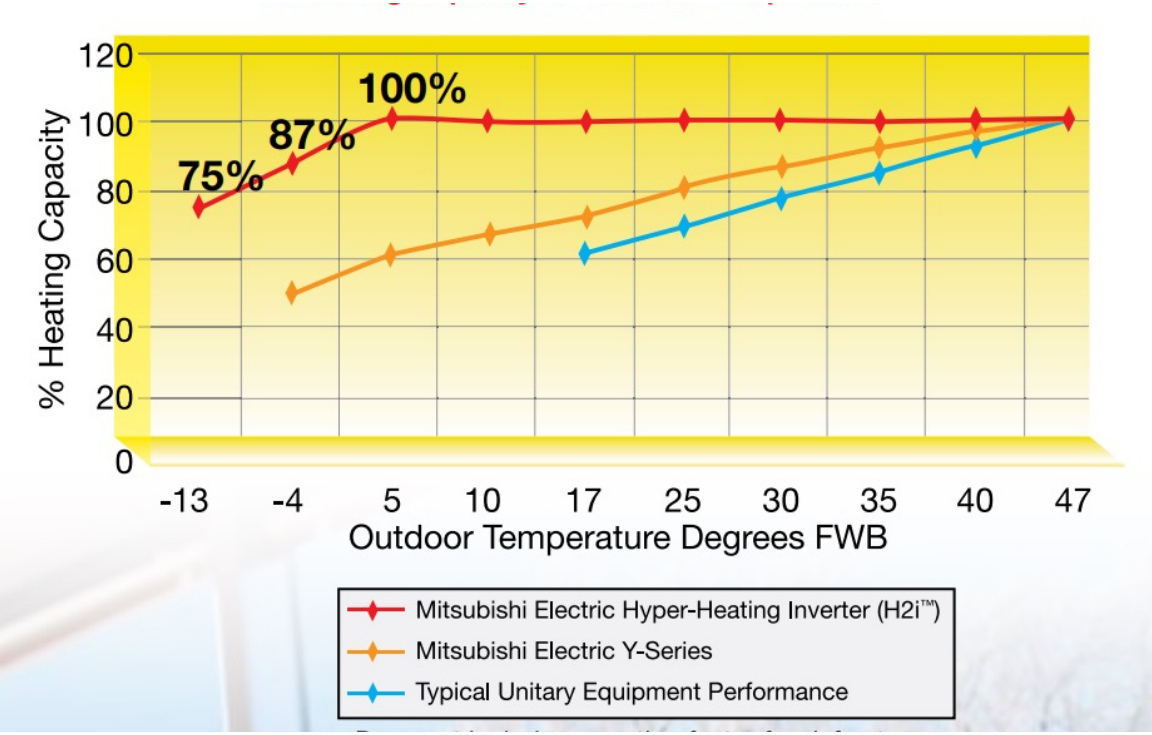



**Variable Refrigerant Flow (VRF)/Variable Refrigerant Volume (VRV):**

- Can modulate and operates at the speed necessary to meet demand.
- 40% - 50%  higher efficiency than conventional equipment.
- Capable of serving multiple zones with a single outdoor unit.

# HEAT PUMP TECHNOLOGIES

- High-Performance Equipment




**Cold Climate Heat Pump (CCHP):**

- Combines inverter-driven variable-speed compressor with newer technologies.
- CCHPs can operate down to -15°C or even as low as -30°C without significantly losing its capacity.
- CCHPs can meet higher heating demand, but they also come with higher installation costs.

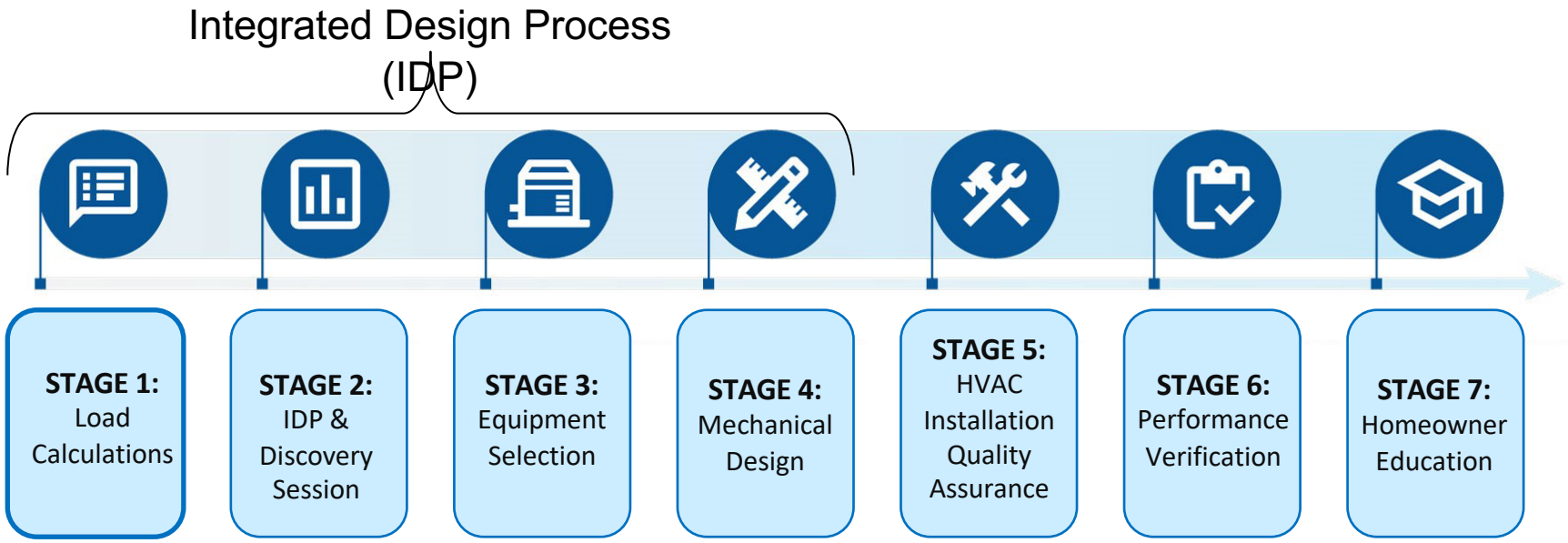
# HEAT PUMP TECHNOLOGIES

- For a modest newly built 3,000 sq. ft. house in Climate Zone 7A built to Energy Step Code 5, builders can expect a peak heat load of approximately 12.9 kilowatt (44,014 Btu/h).
- Consider one hour of heating costs with table below demonstrating an operating cost difference between a standard condensing gas boiler and a heat pump operating within the winter efficiency range typical of most.

| HEATING SOURCE | EFFICIENCY | COST PER kWh |
|---|---|---|
| Electric Baseboard | C.O.P. = 1.0 | $1.64 |
| Heat Pump (Standard) | C.O.P. = 2.O | $0.82 |
| Heat Pump (Cold Climate) | C.O.P. = 2.5 | $0.66 |
| Heat Pump (Geothermal) | C.O.P. = 3.0 | $0.55 |
| Natural Gas Boiler/Furnace | 92% Efficient | $0.62 |

**NOTE**: A blended electricity rate of $0.13 per kWh was used. A natural gas rate of $12.78 per GJ was used as of July 1st. 2022April 1st, 2022.

# MECHANICAL DESIGN PROCESS

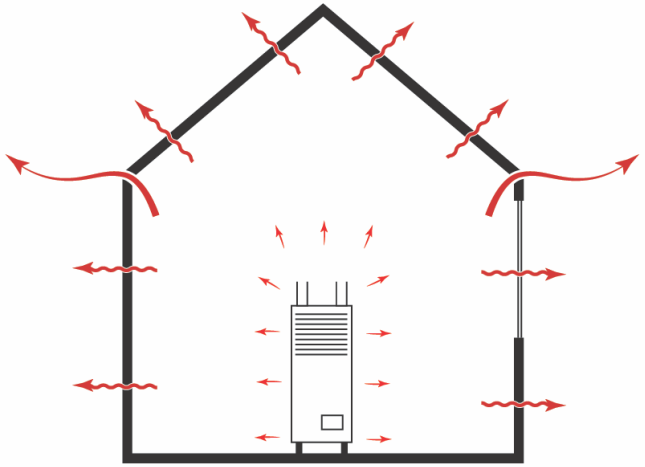


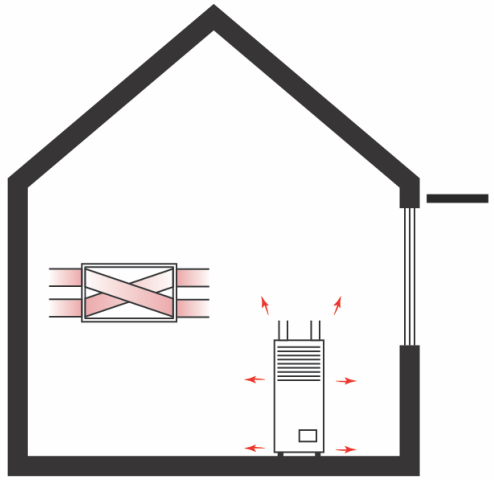
# MECHANICAL DESIGN PROCESS

## Envelope First

A well-insulated, airtight home will have smaller heating and cooling loads, smaller equipment requirements, smaller upfront & operating cost, and be more comfortable.

From the perspective of a mechanical designer, the level of energy performance of the home is the most significant design criteria that allows a simple heat pump as the primary heating source.



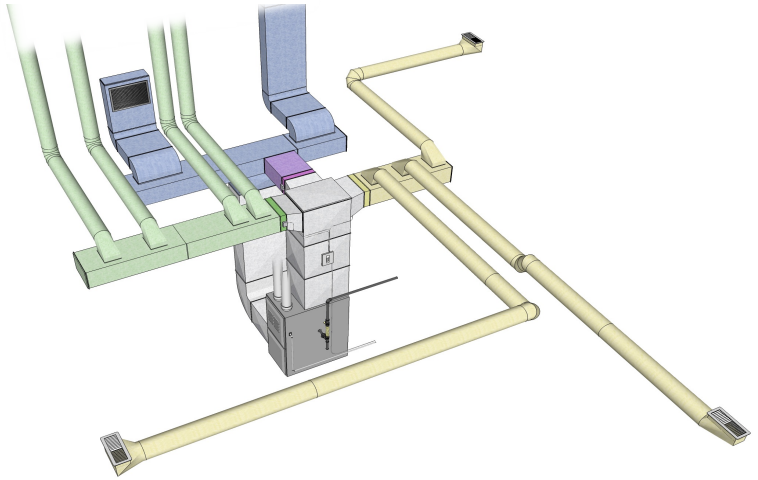


# MECHANICAL DESIGN PROCESS

## Existing Landscape

Ultimate performance of a mechanical HVAC system depends on three general Standards of Practice:

- **Proper Sizing & Design**
- **Proper Installation**
- **Proper Commissioning**



# MECHANICAL DESIGN PROCESS

## Current Practices

- Typical home design does not include adequate consideration of the mechanical system upfront. This often leads to:
  - Limited design choices
  - Additional costs for mechanicals
  - Inadequate performance
  - And frustration for builders and homeowners

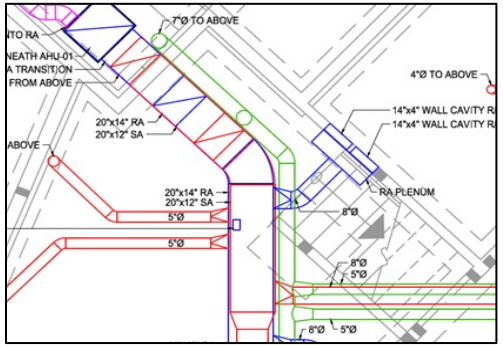
- As homes become more energy-efficient, oversized HVAC equipment is emerging as one of the more serious issues in residential construction.

# MECHANICAL DESIGN PROCESS

## Better Practices

- Start with F280-12 load calculations as the foundation
- Integrate and coordinate design between team members to optimize the system performance.
- Commission and verify after installation.


**Load Calculations:**
CSA F280-12 compliant

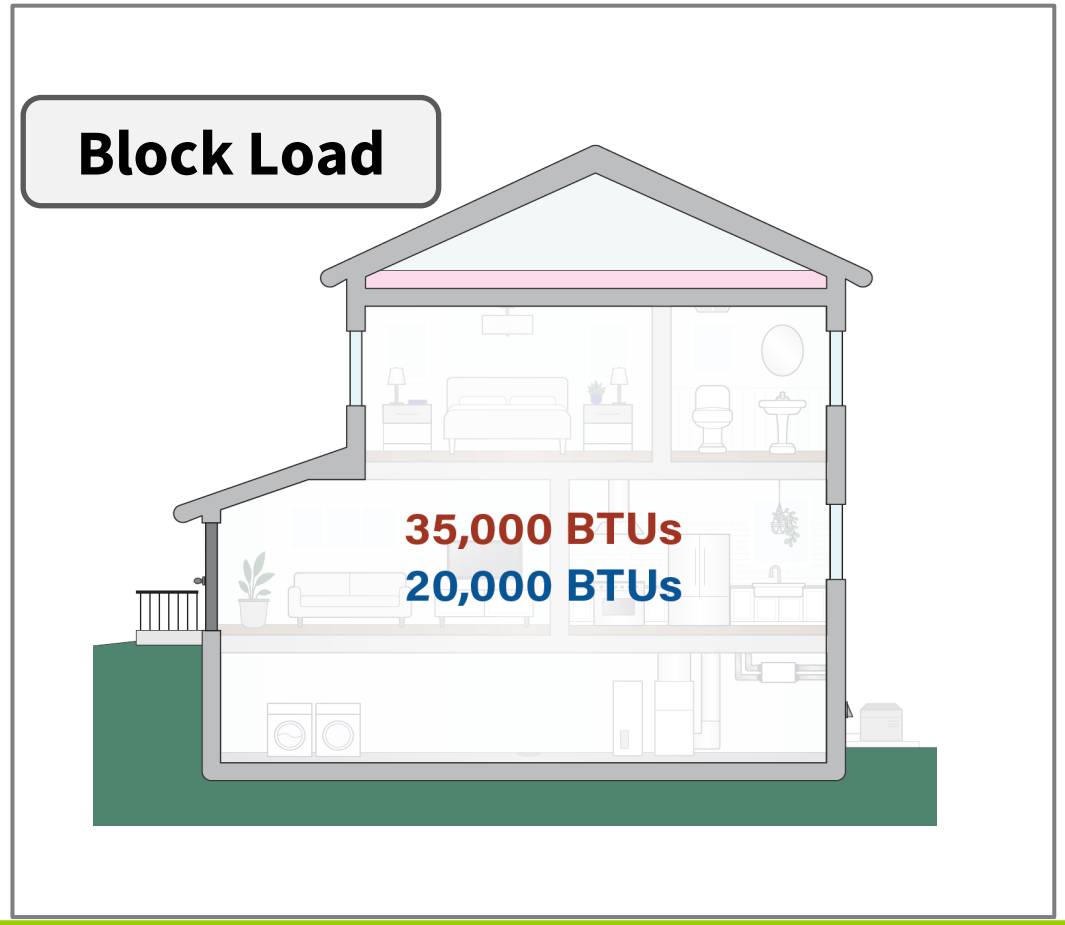


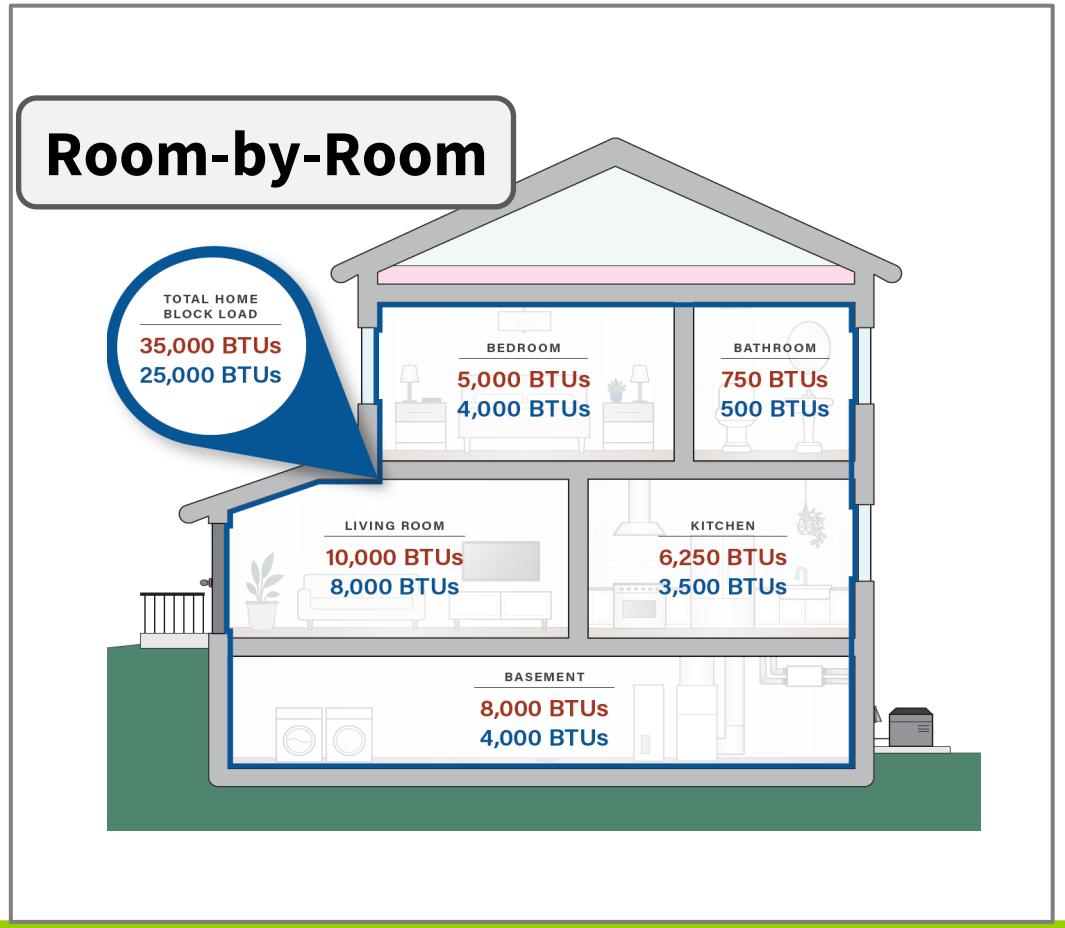

**Design:**
Integrated design practices

**Verification:**
Start-up performance documented

# LOAD CALCULATIONS

## Block Load vs. Room-by-Room Calculations



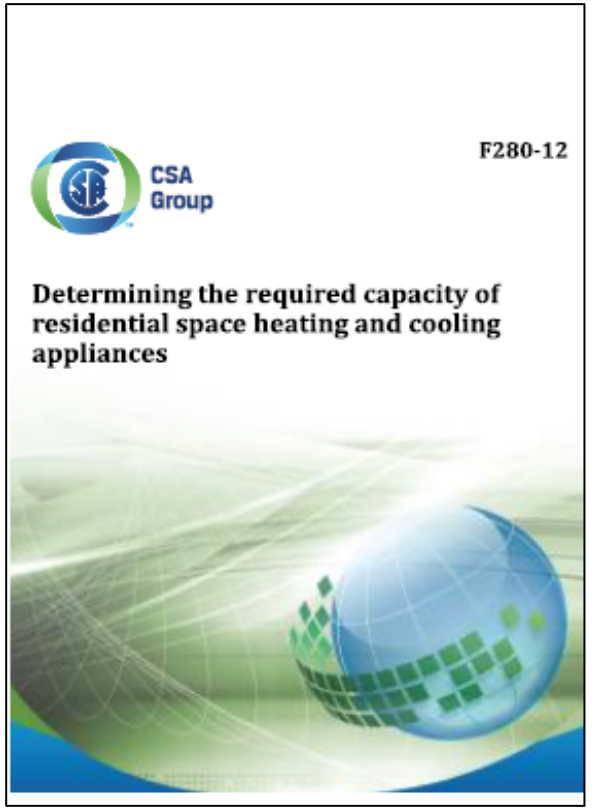



# LOAD CALCULATIONS

## Right Sizing Equipment

- **CAN/CSA F280 (Room-by-Room):**
  Canadian Standards Association (CSA) standard on how to properly size residential space heating and cooling equipment, recognized, referenced and **required** by BCBC (Section 9.33.5).

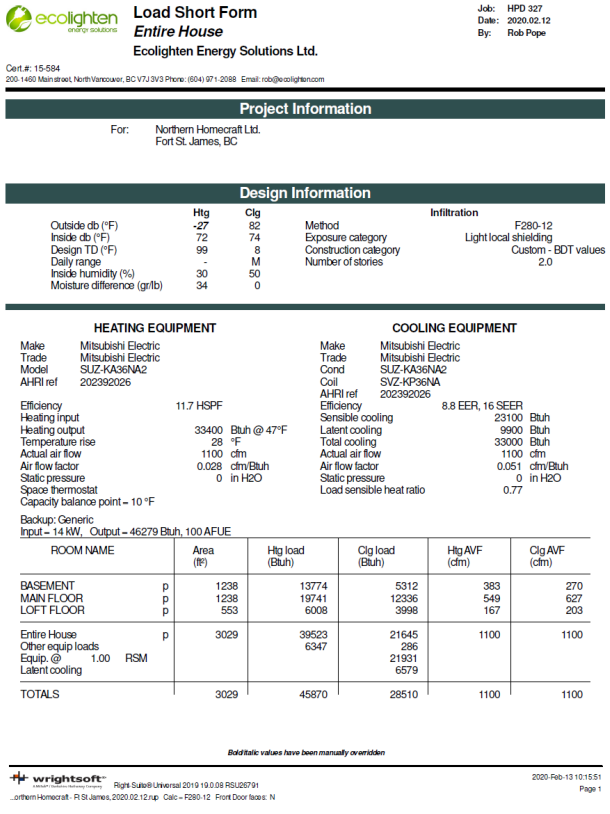
- **HOT2000 (Block Load)**
  Most common Step Code energy modelling software. Not designed as an HVAC design tool. NRCan suggests that HOT2000 should be used to confirm the approximate results of an F280 calculation.



# LOAD CALCULATIONS

## Hodder Residence – Ft St James

Armed with the Energy Model (HOT 2000) results including several iterations, and proper Load Calculations (CSA F280-12), we were equipped to provide the team with accurate analysis and cost/benefit scenarios for consideration.



ecolighten energy solutions

**Load Short Form**
***Entire House***
**Ecolighten Energy Solutions Ltd.**

Job: HPD 327
Date: 2020.02.12
By: Rob Pope

Cert.#: 15-584
200-1460 Main street, North Vancouver, BC V7J 3V3 Phone: (604) 971-2088 Email: rob@ecolighten.com

**Project Information**

For: Northern Homecraft Ltd.
Fort St. James, BC

**Design Information**

| | Htg | Clg | | |
|---|---|---|---|---|
| Outside db (°F) | -27 | 82 | Infiltration | |
| Inside db (°F) | 72 | 74 | Method | F280-12 |
| Design TD (°F) | 99 | 8 | Exposure category | Light local shielding |
| Daily range | - | M | Construction category | Custom - BDT values |
| Inside humidity (%) | 30 | 50 | Number of stories | 2.0 |
| Moisture difference (gr/lb) | 34 | 0 | | |

**HEATING EQUIPMENT**

Make Mitsubishi Electric
Trade Mitsubishi Electric
Model SUZ-KA36NA2
AHRI ref 202392026

Efficiency 11.7 HSPF
Heating input
Heating output 33400 Btuh @ 47°F
Temperature rise 28 °F
Actual air flow 1100 cfm
Air flow factor 0.028 cfm/Btuh
Static pressure 0 in H2O
Space thermostat
Capacity balance point – 10 °F

Backup: Generic
Input – 14 kW, Output – 46279 Btuh, 100 AFUE

**COOLING EQUIPMENT**

Make Mitsubishi Electric
Trade Mitsubishi Electric
Cond SUZ-KA36NA2
Coil SVZ-KP36NA
AHRI ref 202392026
Efficiency 8.8 EER, 16 SEER
Sensible cooling 23100 Btuh
Latent cooling 9900 Btuh
Total cooling 33000 Btuh
Actual air flow 1100 cfm
Air flow factor 0.051 cfm/Btuh
Static pressure 0 in H2O
Load sensible heat ratio 0.77

| ROOM NAME | | Area (ft²) | Htg load (Btuh) | Clg load (Btuh) | Htg AVF (cfm) | Clg AVF (cfm) |
|---|---|---|---|---|---|---|
| BASEMENT | p | 1238 | 13774 | 5312 | 383 | 270 |
| MAIN FLOOR | p | 1238 | 19741 | 12336 | 549 | 627 |
| LOFT FLOOR | p | 553 | 6008 | 3998 | 167 | 203 |
| Entire House | p | 3029 | 39523 | 21645 | 1100 | 1100 |
| Other equip loads | | | 6347 | 286 | | |
| Equip. @ 1.00 RSM | | | | 21931 | | |
| Latent cooling | | | | 6579 | | |
| TOTALS | | 3029 | 45870 | 28510 | 1100 | 1100 |

*Bold/italic values have been manually overridden*

wrightsoft Right-Suite® Universal 2019 19.0.08 RSU26791
...orthern Homecraft - Ft St James, 2020.02.12.rup Calc – F280-12 Front Door faces: N
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ecolighten energy solutions

**Building Analysis**
***Entire House***
**Ecolighten Energy Solutions Ltd.**

Job: HPD 327
Date: 2020.02.12
By: Rob Pope

Cert.#: 15-584
200-1460 Main street, North Vancouver, BC V7J 3V3 Phone: (604) 971-2088 Email: rob@ecolighten.com

**Project Information**

For: Northern Homecraft Ltd.
Fort St. James, BC

**Design Conditions**

**Location:**
Prince George, BC, CA
Elevation: 2267 ft
Latitude: 54°N

| Outdoor: | Heating | Cooling |
|---|---|---|
| Dry bulb (°F) | -27 | 82 |
| Daily range (°F) | - | 22 ( M ) |
| Wet bulb (°F) | - | 65 |
| Wind speed (mph) | 6.2 | 5.0 |

| Indoor: | Heating | Cooling |
|---|---|---|
| Indoor temperature (°F) | 72 | 74 |
| Design TD (°F) | 99 | 8 |
| Relative humidity (%) | 30 | 50 |
| Moisture difference (gr/lb) | 34.0 | 0.0 |

**Infiltration:**
Method F280-12
Exposure category Light local shielding
Construction category Custom - BDT values
Number of stories 2.0

**Heating**

| Component | Btuh/ft² | Btuh | % of load |
|---|---|---|---|
| Walls | 0.9 | 6571 | 15.3 |
| Glazing | 21.8 | 14829 | 34.6 |
| Doors | 0 | 0 | 0 |
| Ceilings | 2.2 | 2733 | 6.4 |
| Floors | 3.4 | 4220 | 9.8 |
| Infiltration | 12.0 | 8192 | 19.1 |
| Ducts | | 0 | 0 |
| Hydronic | | 2979 | 6.9 |
| Humidification | | 0 | 0 |
| Ventilation | | 3368 | 7.9 |
| Adjustments | | 0 | |
| **Total** | | **42891** | **100.0** |



**Cooling**

| Component | Btuh/ft² | Btuh | % of load |
|---|---|---|---|
| Walls | 0.1 | 964 | 4.4 |
| Glazing | 21.3 | 14529 | 66.2 |
| Doors | 0 | 0 | 0 |
| Ceilings | 0.8 | 977 | 4.5 |
| Floors | 0.0 | 0 | 0.0 |
| Infiltration | 0.2 | 139 | 0.6 |
| Ducts | | 0 | 0 |
| Ventilation | | 286 | 1.3 |
| Internal gains | | 5035 | 23.0 |
| Blower | | 0 | 0 |
| Adjustments | | 0 | |
| **Total** | | **21931** | **100.0** |



Latent Cooling Load = 6579 Btuh
Overall U-value = 0.053 Btuh/ft²-°F

Data entries checked.

*Bold/italic values have been manually overridden*

wrightsoft Right-Suite® Universal 2019 19.0.08 RSU26791
...orthern Homecraft - Ft St James, 2020.02.12.rup Calc – F280-12 Front Door faces: N
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# DISCOVERY

**Discovery is the foundation of a successful mechanical system outcome**

- Establish a roadmap for disciplined delivery and success.
- Avoid cost overruns from lack of planning.
- Drive project efficiency by aligning goals and objectives.
- Reduce construction surprises and project disappointment.
- Improve communication and coordination.

**What to Discover:**

- ✓ Existing expectations – are they realistic, achievable?
- ✓ Aesthetics – can drops and chases be avoided or minimized in feature areas?
- ✓ Primary motivation factor – cost savings/rebates, GHG reduction, minimum compliance?
- ✓ Budget – upfront and operational cost expectations
- ✓ Comfort & Health – what is comfortable (forced air vs. radiant heat), what temperatures, are there health issues, allergies, other sensitivities including noise?

# DISCOVERY

## Hodder Residence Integrated Design Process (IDP)

The energy performance target of this home was determined through an Integrated Design Process (IDP), where the critical decisions and design strategies are coordinated early in the project while all options are still available. The team in this case included the homeowner, builder, house designer, energy advisor, mechanical designer, and mechanical installer.

The team met online before construction to discuss and consult on the key parameters that will influence the successful outcome of the project, including the optimization of:

- Energy Performance
- Budget
- Occupant Comfort
- Aesthetics
- Resilience

# EQUIPMENT SELECTION

**Supply Chain**

- Is the equipment and its replacement parts available locally?
- Is there local technical support

**Trades Product Knowledge and Experience**

- Are there contractors available who are familiar and experienced with the proposed equipment?
- Will it be necessary to hire contractors from other communities and incur extra travel costs and scheduling disruptions?
- Will there be a quick response time in case of system breakdowns?

**Electrical Service Capacity**

- All electric homes, in combination with EV's, lead to greater power demand and a potential need for larger electrical panels.
- How much electrical load the Heat Pump requires to run the compressor and fans is one part of the equation. Electrical back-up will typically be a greater load on the panel than the heat pump.

# SYSTEM DESIGN

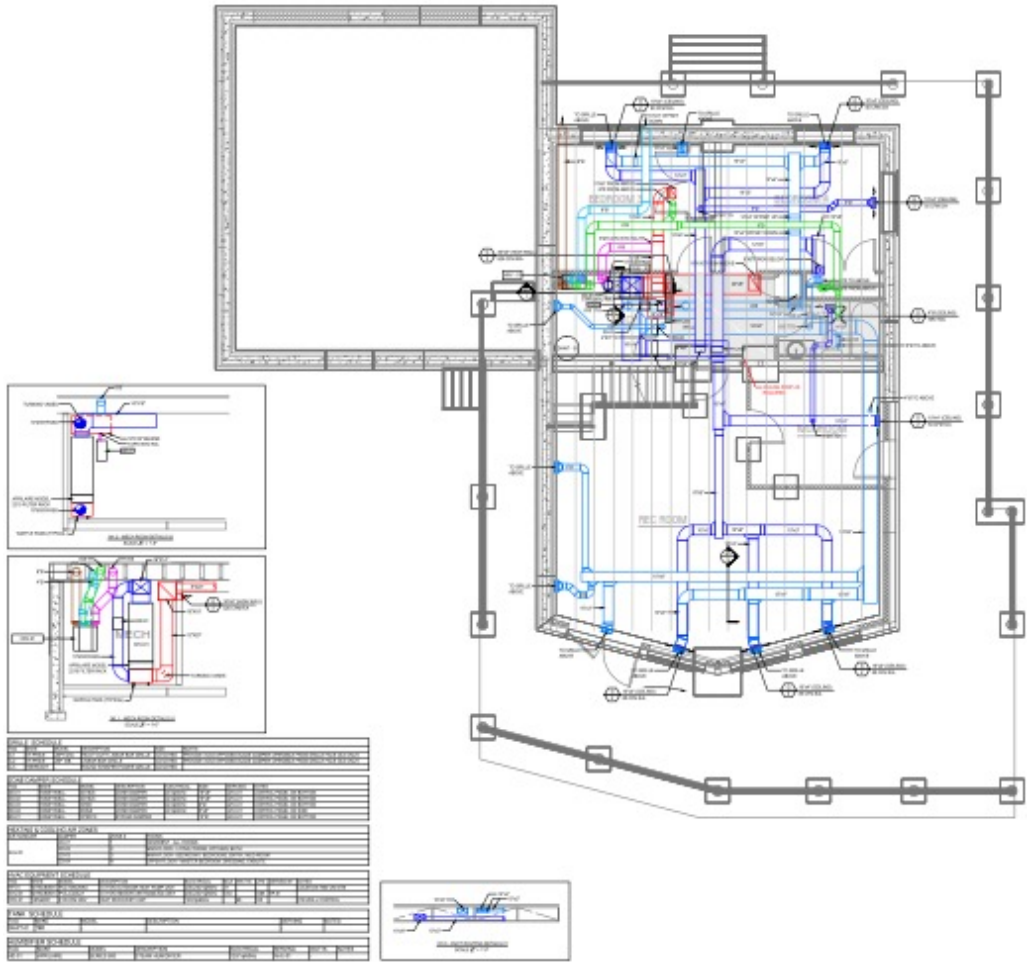
**Hodder Residence HVAC Design**

Ultimately the mechanical equipment package consisted of a:

- Mitsubishi P-Series H2i Cold Climate heat pump with a rated 48,000 Btu/hr (14Kw) capacity at -15°C (5°F), which consists of a PUZ-HA42NKA outdoor unit combined with a PVA-A42AA7 indoor unit.

- Venmar ERV E15 140cfm and 67% Sensible Recovery Efficiency

- The ventilation system was integrated into the forced-air system thereby combining the Mitsubishi with the Venmar ERV

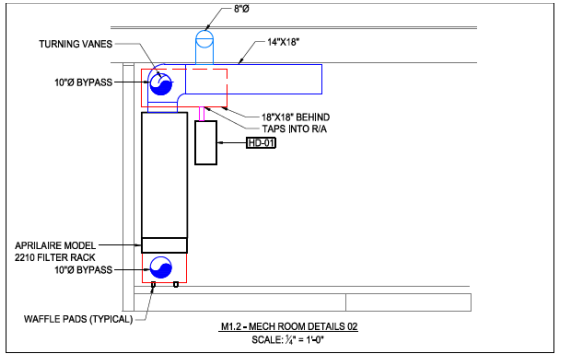


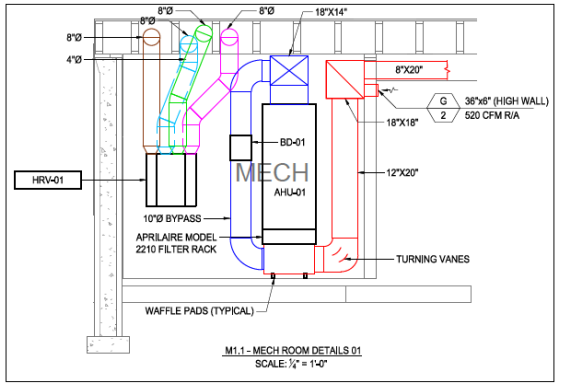
# SYSTEM DESIGN

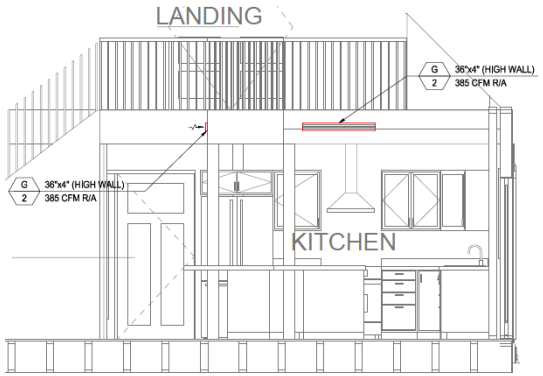
## Hodder Residence HVAC Design

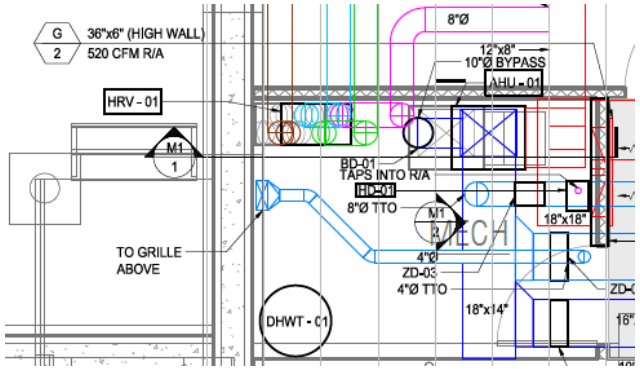
The HVAC system was divided into four 4 independent zones, each with a thermostat controlling a damper in the ducting.

To minimize envelope penetrations, the ERV system was adapted to a Posh™ system (boost function), to allow the ERV to act effectively as bathroom exhaust, removing the need for dedicated bathroom fans.




GRILLE SCHEDULE

| TAG | MAKE | MODEL | DESCRIPTION | SIZE | NOTES |
|---|---|---|---|---|---|
| G-1 | EH PRICE | LBPH 25C | HEAVY DUTY LINEAR BAR GRILLE | AS NOTED | PROVIDE VCS3 OPPOSED BLADE DAMPER OPERABLE FROM GRILLE FACE (S/A ONLY) |
| G-2 | EH PRICE | LBP 16B | LINEAR BAR GRILLE | AS NOTED | PROVIDE VCS3 OPPOSED BLADE DAMPER OPERABLE FROM GRILLE FACE (S/A ONLY) |
| G-3 | ENEREADY | - | ROUND WHISPER POWER GRILLE | AS NOTED | |

ZONE DAMPER SCHEDULE

| TAG | MAKE | MODEL | DESCRIPTION | ELECTRICAL | SIZE | SERVING | NOTES |
|---|---|---|---|---|---|---|---|
| ZD-01 | HONEYWELL | ZD16x8 | ZONE DAMPER | 24/1ϕ/60Hz | 16"x8" | AHU-01 | CONTROL PANEL ON BOTTOM |
| ZD-02 | HONEYWELL | ZD16x8 | ZONE DAMPER | 24/1ϕ/60Hz | 16"x8" | AHU-01 | CONTROL PANEL ON BOTTOM |
| ZD-03 | HONEYWELL | ARD8 | ZONE DAMPER | 24/1ϕ/60Hz | 8"Ø | AHU-01 | CONTROL PANEL ON BOTTOM |
| ZD-04 | HONEYWELL | ZD8x8 | ZONE DAMPER | 24/1ϕ/60Hz | 8"x8" | AHU-01 | CONTROL PANEL ON SIDE |
| BD-01 | HONEYWELL | CPRD10 | BYPASS DAMPER | - | 10"Ø | AHU-01 | CONTROL PANEL ON BOTTOM |

HEATING & COOLING AIR ZONES

| AIR HANDLER | DAMPER | ZONE # | ROOMS |
|---|---|---|---|
| AHU-01 | ZD-01 | 1 | BASEMENT - ALL ROOMS |
| | ZD-02 | 2 | MAIN FLOOR - LIVING, DINING, KITCHEN, BATH |
| | ZD-03 | 3 | MAIN FLOOR - BEDROOM1, BEDROOM2, ENTRY, MUD ROOM |
| | ZD-04 | 4 | UPPER FLOOR - MASTER BEDROOM, DRESSING, ENSUITE |

# QUALITY ASSURANCE

## Field Reviews

- Field inspections should be completed prior to cover-up and before occupancy – key check points including duct sizing and routing, workmanship, proper sealing and insulating.
- Any field deviations should be coordinated with designer to ensure performance of the system will still be maintained.
- Performance verification at occupancy should including system balancing, verification of performance, review of controls and full documentation.
- If well coordinated, field reviews can be done virtually for remote locations

# QUALITY ASSURANCE

## Hodder Residence Field Reviews

Throughout construction, the mechanical installation was reviewed for quality of work and consistency with the design intent.

During construction, several changes to the design were coordinated and implemented by design and the construction teams.

When construction was completed, a final review was done of all components. They were also commissioned to ensure that their actual performance matched the design targets.

All warranty, service, and maintenance, as-builts, all manuals, and all start-up procedures and tests documentation were reviewed.

# THE HAND-OVER

One of the biggest factors in a homeowner satisfaction with their new HVAC system is their understanding of how to operate and maintain the system.

The key components for contractors to focus on includes heat pump operation, maintenance, controls and warranties.

## CONTRACTOR TIP:

Documentation should be stored in a tabbed binder including original drawings, equipment specifications and cut sheets, warrantee documents submitted, as-built drawings, maintenance schedules and user manuals.

### CONTRACTOR CHECKLIST

- ✓ Warranty coverage of the heat pump system and control system including servicing requirements for compliance with warranty policy.
- ✓ Copy of installation record and commissioning checklist.
- ✓ Proper labeling of switches.

# Thank You!

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