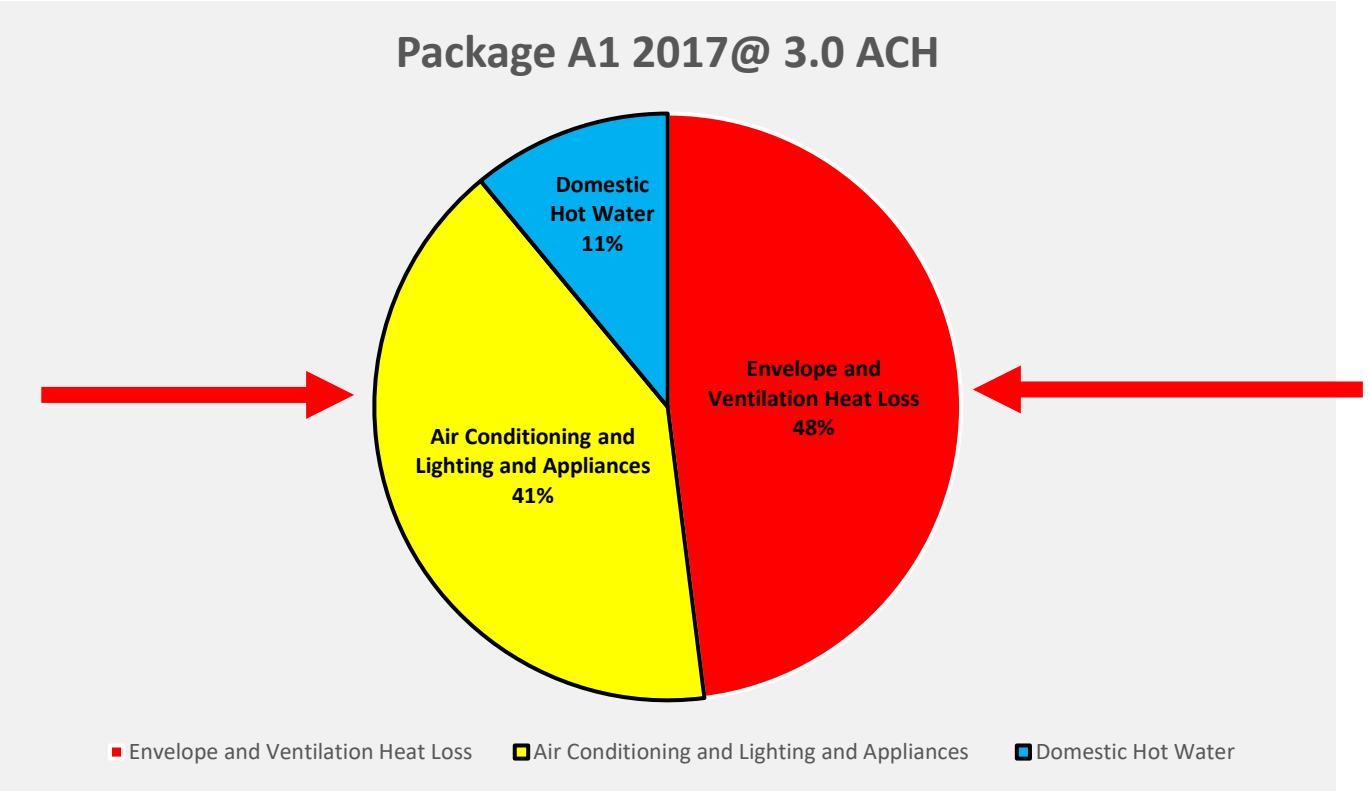
# Combination Heating Systems

*November 18th 2021*

# Agenda

- Introduction of speakers by Frank Buck
- Best practice sustainability checklist – John Godden
- Upcoming seminars - Smart Homes for Sustainability and Resiliency – Dan Murphy
- #1 CSA B214:Installation Code for Hydronic Heating Systems -Brian Jackson, P.Eng
- #2 Combination Heating Systems using Condensing Storage Type Water Heaters – Dave Hammond
- #3 Example of sizing from CSA B214 and Questions

52% of energy use is occupant loads




Diminishing marginal returns from adding more insulation

January 18th 2022

## Smart Homes for Sustainability and Resiliency

In this webinar, we'll help demystify the rapidly evolving "smart" home technology.  By focusing on the right elements, homebuilders can create a whole home ecosystem to allow homeowners to live sustainably.

Our industry panel will discuss

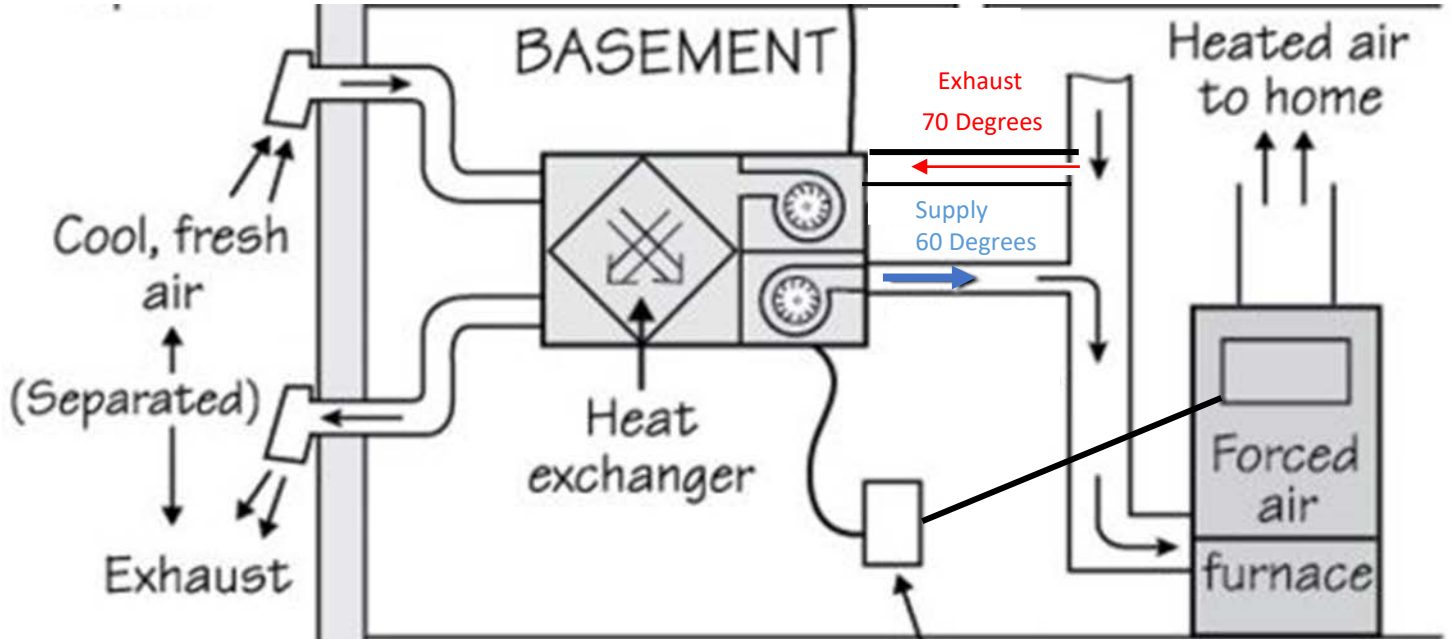
- Leveraging smart technology to enable better occupant load management
- Future proofing homes for the connectivity needed to live and work smartly and efficiently
- Emerging smart technologies to easily enable sustainable lifestyles

## Wiser Energy Monitoring Study

An innovation for modifying occupant behaviour with respect to electricity consumption.

Dan Murphy is looking for builders who would like to be involved in this pilot. Those interested in participating can contact Dan at dan.murphy@se.com

# Simplified HRV with furnace interlock




If furnace is calling for heat, Fresh air is mixed with return air and supplied at 120 Degrees Fahrenheit.

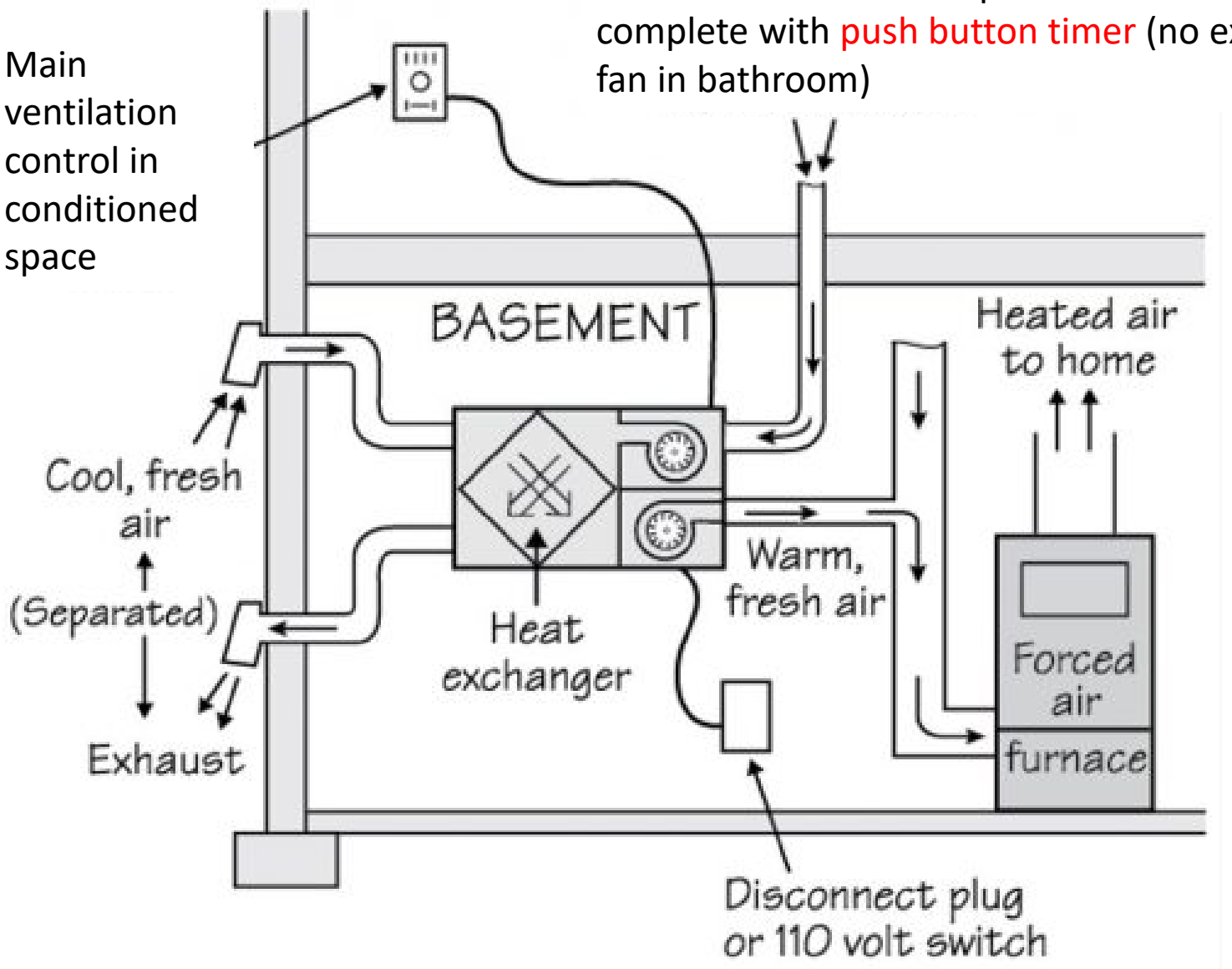
If furnace is **NOT** calling for heat, Fresh air is mixed with return air and supplied at less than 70 Degrees Fahrenheit. This causes discomfort for occupants as circulated air is cooler than occupants core body temperature.

Ventilation furnace interlock – When control calls for ventilation furnace fan relay puts it into highest speed (cooling mode).

Takeaway: We need to stop doing this because it doesn't work well and wastes too much energy

# hybrid ERV installation

# (no interlock with furnace)



**XYZ Furnace Company**

**Model** **60V-14-12**

V - Variable Speed ECM motor

12 - 1200 CFM (cooling 3 tons)

| Item | Speed or Mode | Airflow (CFM) | Power Consumption (Watts) |
|---|---|---|---|
| | | | |
| 1 | Circulation | 540 | 126 |
| | | | |
| 2 | Heating | 875 | 274 |
| | | | |
| 3 | Cooling | 1115 | 496 |
| Difference 3-1 | | | 370 |

Takeaway: Is this a big number?

Furnace interlock consumes 370 watts with intermittence setting
(370w x 8 hrs/day x 365 days/yr)/1000 = 1080 kWh/yr

# Low Carbon Net Zero Cost

A Country Home has a similar annual CO2 footprint as a small 4-cylinder car!

The super-semi is only 3.5 metric tons annually, where package A-1 is 5 metric tons of operational carbon.

clearsphere
training & educating | sustainability consulting | energy rating
building on sustainable opportunities

# Challenges in Ontario with Climate Change

- 40% of the population of Canada and its economic engine (emissions)
- 39.1% of Canadian housing completions in 2020
- Natural gas is primary source for space and hot water heating for homes
- Peak demand issues for electricity and stranded capacity from nuclear power generation at night
- Best strategy is to use electrical power generation for PHEV's and EV's to offset emissions from cars and trucks, not to power houses.
- Myth: existing houses can be easily retrofitted with heat pumps.

*Takeaway: Wise use of natural gas as a bridging energy source until we figure out renewables for ever growing peak demand for electricity.*

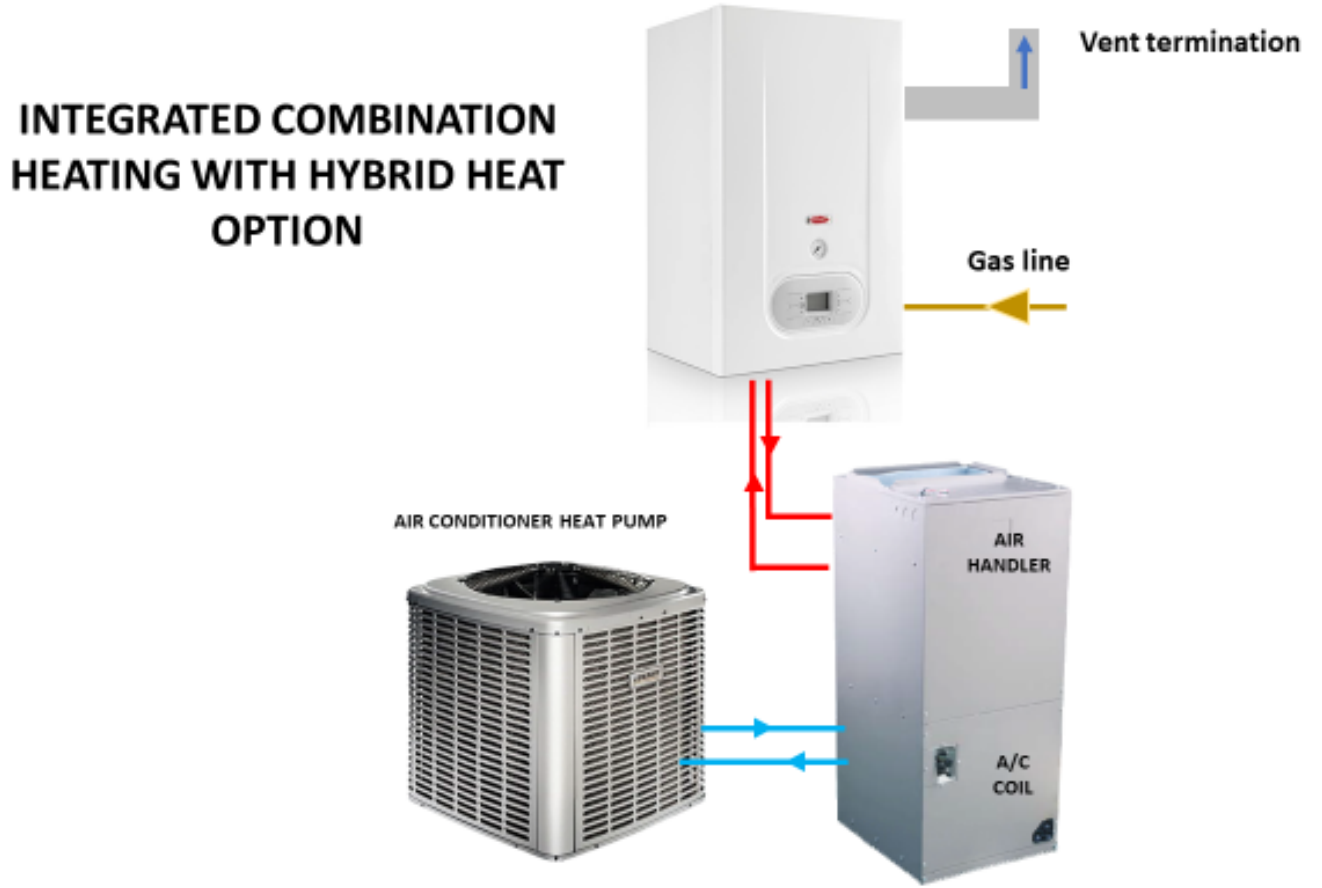
# The Polaris hot water heater used in R2000 houses since early 1990’s

# Enbridge study on Integrated Combo systems

| Lot 15 Gas Consumption Furnace & DHWH vs i-Flow Combo | | | | | |
|---|---|---|---|---|---|
| Year | Heating System | Gas Bills | HDD | m3/HDD | % Difference |
| 2018 - 2019 | Furnace 96% 2 Stage DHWH EF=0.9 | 1804 | 4025 | 0.4482 | / |
| 2019 - 2020 | Iflow Combo CSF = 0.96, WHPF=0.95 | 1678 | 4117 | 0.4076 | 9.1% |

- Comparison is I-Flow to 2-stage furnace. Will have higher efficiency when compared to a single stage furnace

- GTI states that 2 burners are more inefficient. Lot 15 had a 2-stage furnace which can operate at 60% of its output.


## Wise use of Natural Gas

- Integrated combination heating uses 20% less gas than separate furnace and hot water tank.
- Use of air source heat pump can reduce natural gas consumption by a further 40%.

We are here

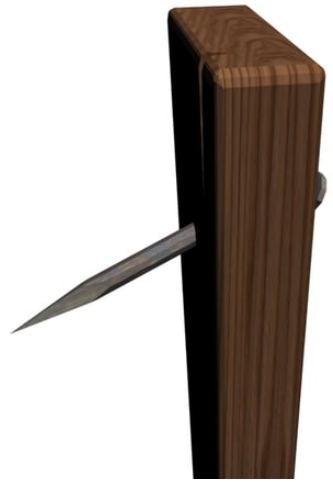
Been there done that

## Averton Village Green -Standard features and Upgrades - Nov 4th 2021

| | Section 1: HIGH PERFORMANCE ENVELOPE | Averton | OTHER BUILDER |
|---|---|---|---|
| 1.1 | Third party performance based energy rating and testing with 20% Better Than Code | ☑ | ☑ |
| 1.2 | Tested air leakage @ 50Pa < 3.0 ACH for detached homes & 4.0 ACH for attached homes | ☑ | ☑ |
| 1.3 | Exterior wood fibre insulated sheathing (BP 1.5) | ☑ | ☑ |
| 1.4 | Air barrier surrounding insulation on six sides | ☑ | ☑ |
| 1.5 | Second Plane of Protection including base flashing for windows | ☑ | ☑ |
| 1.6 | High Performance Windows - Low U-Value, Low Solar Heat Gain | ☑ | ☑ |
| 1.7 | 2x6 @ 16" o.c R22 Batts (high recycled content) with Grade I insulation (see attached) | ☑ | ☑ |
| | **Section 2: HIGH PERFORMANCE HVAC** | **Averton** | **OTHER BUILDER** |
| 2.1 | 95% AFUE heating plant min | ☑ | ☑ |
| 2.1(b) | Combination heating system with hybrid hot water heater, insures maximum air distribution and comfort | ☑ | ☑ |
| 2.2 | 2 Zoned Hi-velocity system for air conditioning including EPC motor technology | ☑ | ☑ |
| 2.3 | Programmable web-based thermostats (2 zones) | ☑ | ☑ |
| 2.4 | Hot Water Heating: Condensing Hybrid (EF=0.90) | ☑ | ☑ |
| 2.5 | Drain water heat recovery on two drains (X2-48) | ☑ | ☑ |
| 2.6 | Hybrid Heat with heat-pump Air conditioner | ☐ | ☐ |
| | **Section 3: INDOOR AIR QUALITY** | **Averton** | **OTHER BUILDER** |
| 3.1 | Min. efficiency ERV 75% SRE vented to laundry and 2-piece bath | ☑ | ☑ |
| 3.1(b) | Best ventilation: Energy recovery ventilation (ERV) reduces need for humidifier | ☑ | ☑ |
| 3.2 | Flow rate verified by third party | ☑ | ☑ |
| 3.3 | Bathroom fans verified at OBC capacities (second floor only) | ☑ | ☑ |
| 3.3 (b) | Best spot ventilation : PANASONIC Ecovent bathroom exhaust (2 speeds) | ☑ | ☑ |
| 3.4 | MERV 8 air filtration | ☑ | ☑ |
| 3.4(b) | Best filter: 4 inches pleated MERV 12 for maximum air filtration | ☐ | ☐ |
| 3.5 | Better air conditioner: Right sized 2 stage, saves 23% of electricity, 16 SEER | ☐ | ☐ |
| 3.6 | Containment control during construction | ☑ | ☑ |
| 3.7 | Pre-occupancy flush (48hrs before) | ☑ | ☑ |
| | **Section 4: REDUCE WATER USAGE** | **Averton** | **OTHER BUILDER** |
| 4.1 | Low Flush toilets (1.1 gpf) and low flow faucets (1.5gpm) and Showerheads (1.75 gpm) | ☑ | ☑ |
| 4.2 | Greywater rough in c/w hot water recirculating pump and HERS H2O label | ☐ | ☐ |
| 4.3 | Greywater system | | ☐ |
| 4.4 | ENERGYSTAR front loading washer and dishwasher | ☑ | ☑ |
| | **Section 5: EFFICIENT LIGHTING AND MATERIAL MANAGEMENT** | **Averton** | **OTHER BUILDER** |
| 5.1 | 90% CFLS or LED lighting | ☑ | ☑ |
| 5.2 | Attic insulation: blown cellulose (40% recycled content) | ☑ | ☑ |
| 5.3 | On site waste management plan (50% divergent rate) | ☑ | ☑ |
| 5.4 | Electric charging station for visitor parking | ☐ | ☐ |
| 5.5 | Choose wood products with 3rd party certification i.e engineered flooring | ☐ | ☐ |
| 5.6 | Wiser Energy monitoring system | ☐ | ☐ |
| 5.7 | Moen Flow water monitoring system | ☐ | ☐ |

Voluntary

Best Practice Resource for builders to manage municipal overreach!



Mandatory

The Inefficiency of 2 burners
on a small load

- Modified Package A1 with a combination heating system has a design heat loss of 28.0 kbtu/hr

CHOOSE 1 BURNER TO DO 2 JOBS

# Combo System Testing



## 3.1.1.2 Energy Efficiency For Building in Zone 1

(7) *Building* designs that utilize combined space heating and domestic water heating systems are permitted to use compliance package A4, provided that

(a) the water heating equipment has a minimum of 0.80 EF, 90% AFUE, or is a condensing type, or,

(b) the combination of equipment has a minimum of 0.85 TPF determined in accordance with CAN/CSA-P.9 "Test Method for Determining the Performance of Combined Space and Water Heating Systems (Combos)."

Takeaway: SB-12 performance allows us to model combination systems without AFUE or TPF with a default of 90% AFUE.

# Uniform Energy Factor (UEF)

| UNIFORM ENERGY FACTOR (UEF) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **BIN** | **BIN Daily Usage** gallons | **First Hour Rating** tank-type water heaters | **Max GPM** tankless water heaters | water heater | **EF** Energy Factor | **UEF** Uniform Energy Factor | **TE** Thermal Efficiency |
| Very small | 10 | Less than 18 gallons | Less than 1.7 | A | x | x | 94% |
| Low | 38 | 18 to 51 gallons | 1.7 to 2.8 | B | 0.80 | x | x |
| Medium | 55 | 51 to 75 gallons | 2.8 to 4 | C | x | 0.88 | x |
| High | 84 | 75 gallons or larger | 4 or more | Combo | **TPF** Thermal Performance Factor | **TPF** Thermal Performance Factor | **TPF** Thermal Performance Factor |

**WATER HEATER SELECTION FACTORS**

- Usage patterns/consumer behaviour
- Installation design constraints
- Total installed costs (installation, capital, maintenance & operating costs etc)
- Depending on building design configuration; will still need to understand equivalency
- UEF – under 75,000 btu
- TE – over 75,000 btu
- May have different spec sheets for USA vs Canada

Four different ways to measure hot water tanks' efficiencies

Which one do we use???

# An Update to CSA B214

Installation Code for Hydronic Heating Systems

Brian Jackson, P.Eng.

# Forward

- In January of this year CSA introduced their updated standard for the installation of hydronic heating systems
- This Standard has some terrific information included and I would suggest all designers have a copy on hand
- One of the systems covered in the standard is Combi Systems which are hydronic based mechanical systems that are designed to provide both Domestic Hot Water (DHW) and space heating

# Combi System Advantages

- Combi Systems can be easily zoned
- If properly selected are 20% more efficient
- Have only 1 fuel burning source
- Can provide better occupant comfort, and will integrate easily into a dual fuel designed system
- For these reasons they have become more popular in new construction and renovation designs.

# Cost Effective Combi Design

- There are many design approaches to Combi Systems but one in particular has been more recently utilized primarily due to capital cost considerations
- The use of a wall hung water heater or fired tank with a heat source, typically a hydronic fan coil
- This is not the best engineering based choice but the cost is low

# Potable Water as a CH fluid

- You are introducing potable water into the heating system and vice versa. You have to safeguard against legionella and contaminants when you mix systems. We'll discuss this later
- A  typical wall hung DHW heater capacity is 199 MBH with a 10:1 turn down which gives you a minimum firing input rate of 19.9 MBH
- Knowing that most attached housing has a heat loss of under 25,000 BTUH and you are operating at less than 40% of this load 90% of the time (CSA P.9-11). So if the space heating is running below 10 MBH 90% of the time it will cause the water heater to cycle. This will make the equipment horribly inefficient and since life cycle is defined in cycles not run time, the life time of the water heater will be reduced.

# Addressing the issues

- Contamination and load imbalance aside, water heaters are used quite often, primarily due to cost and naivety
- The updated B214 gives some clarifications when using potable water
- All components in contact with the potable water must be intended for use in a potable water system.

# All of the following conditions must be met when using potable water as a hydronic heating fluid

- A maximum of one heat source per potable water loop.
- The total length of piping shall not exceed 50ft.
- The total volume of the system shall not exceed 13.1 gal
- The supply water temperature to the heat source must not be lower than 140degF.
- To prevent stagnation an automatic means will be provided to flush the heating system for at least 5 minutes every 24 hour period (there is a calculation to reduce this number based on volume and flow).

**KEY ELEMENTS**

# Exceptions

- Use of a wall hung combination unit or boiler negates all these issues
- Typically gets you an ASME certified unit that requires less service and has a longer life span at a higher space heating operating efficiency
- Be careful when applying water heaters as part of a Combi System. It can be done but make sure your designer is well informed

# Definitions

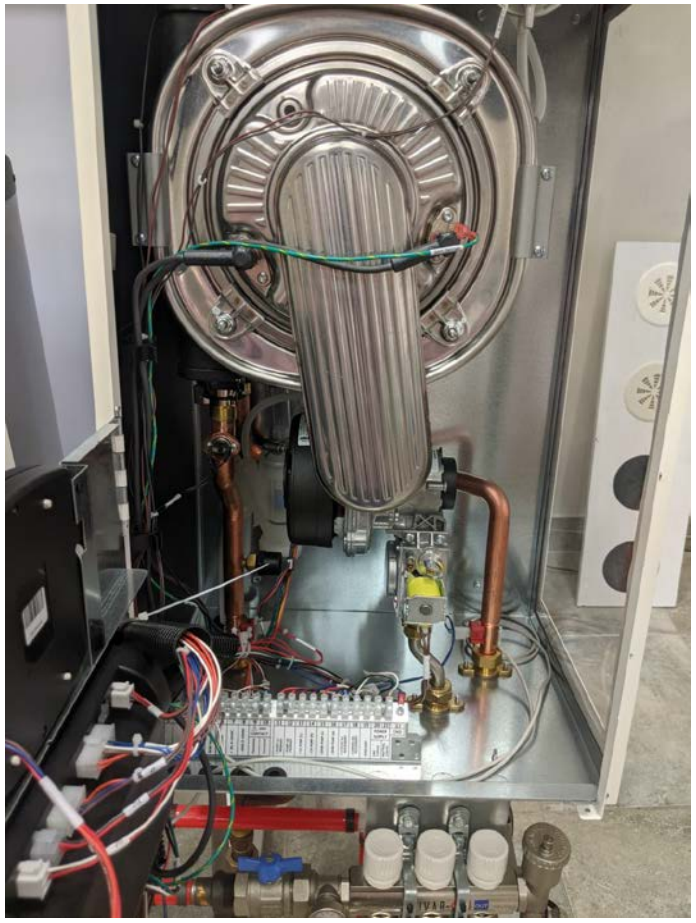
There are 3 types of combi systems hot water sources

- Boilers
- Tankless Water Heaters
- Condensing Storage Type Water Heaters

# Intended Duty

Boiler

- Makes hot water for space heating in a closed loop
- Typically a low pressure circuit (max. 30psig)
- Low temperature rise, high water temperture capability, 180degF
- Performance rating metric AFUE
- Can make DHW using an Indirect Storage Tank



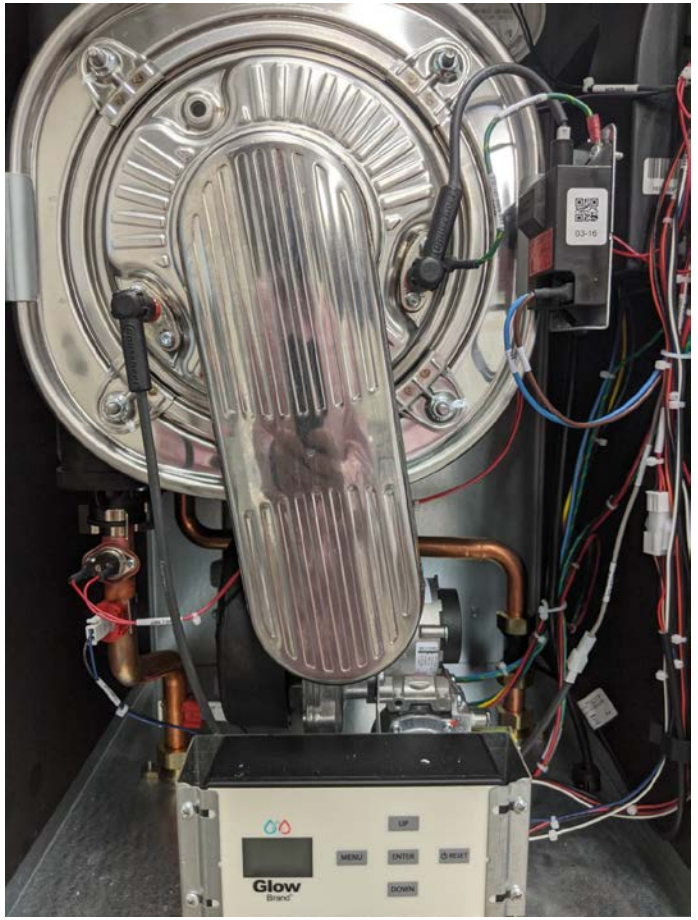
# Intended Duty

- Combination Unit
- Makes hot water for space heating in a closed loop
- Typically a low pressure circuit (max. 30psig)
- Low temperature rise, high temperture capability, 180degF
- Performance rating metric AFUE
- Make’s DHW using an internal plate heat exchanger (separate water streams)

# Intended Duty

Tankless Water Heater

- Makes hot water for DHW in a open loop (can be certified for space heat as well)
- Typically a high pressure circuit (50-100psig)
- High temperature rise, low water temperature capability, 145degF
- Performance rating metric EF, UEF



# Summary

- CSA B214 is a comprehensive standard for sizing and guiding the installation of combi systems with potable water

- Any combi system uses natural gas more wisely than separate function systems i.e furnace and separate water heating.

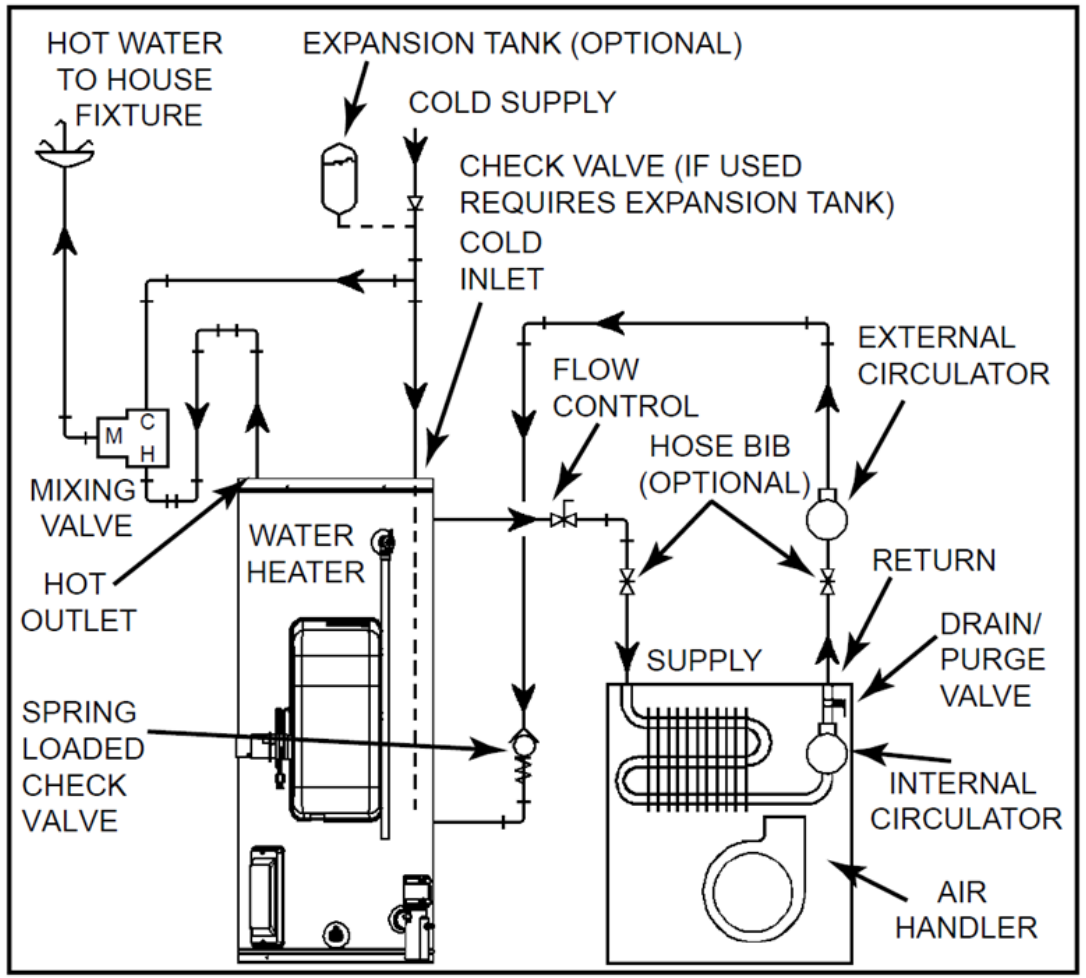
- Any questions about Glow and Airmax combination heating systems please contact me at brianj@airmaxtechnologies.com

# 5 min break

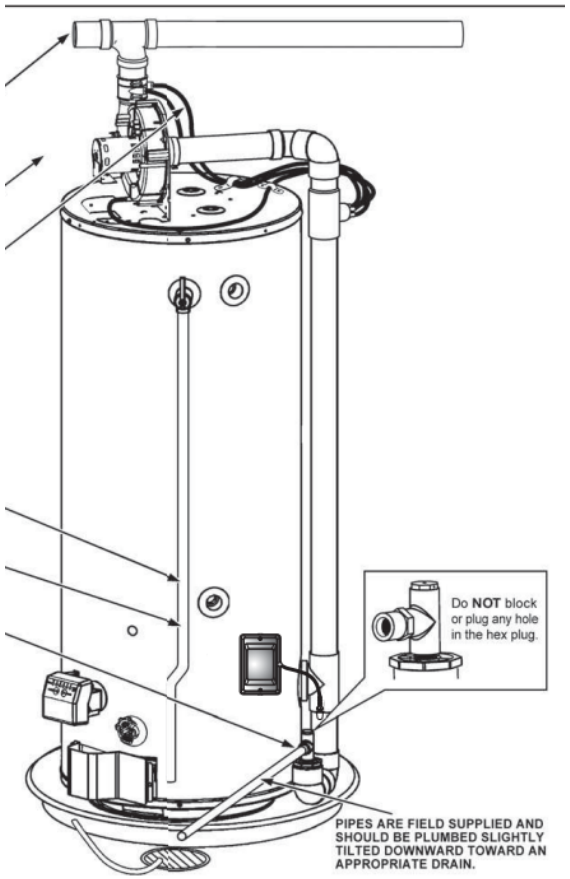
# Combination Heating Systems using Condensing Storage Type Water Heaters

Dave Hammond,
Vice President and General Manager, Canada and Export Markets
A.O. Smith Enterprises Ltd
Contact email: dhammond@hotwater.com

# Schematic of combination heating system



# Residential Condensing Innovation Continues…





2007 — 2017 — 2021 — 2021

# Introducing Envirosense® SF

**Features**

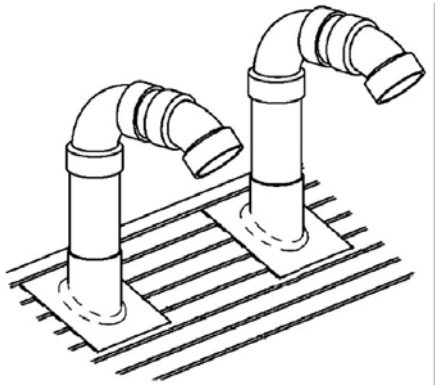
- New design
- New venting capabilities
- PV/PDV convertibility
- 40G and 50G models
- Natural gas only
- 0.90 UEF; 93% Thermal Efficiency
- ENERGY STAR® qualified

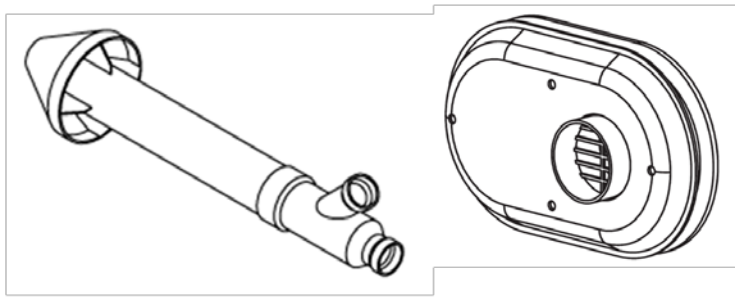
# New Construction Benefits

- Easier handling – smaller, lighter, easy to maneuver
- Easily accessible installation/connection points
- No FV sensor

# Venting simplification

- Industry-standard installation components
- Longer Ø2” vent runs
- Vent termination options





# New Venting Capabilities

| | Maximum Equivalent Vent Length | | |
|---|---|---|---|
| | Ø 2" | Ø 3" | Ø 4" |
| Std. Input PV & PDV | 50' | 125' | 180' |
| Hi-input PV & PDV | N/A | 50' | 125' |
| Hi-input PDV - Concentric | N/A | 30' | N/A |
| Envirosense PV | 25' | 65' | 125' |
| Envirosense SF | 60' | 150' | 180' |
| Envirosense SF - Concentric | 50' | 130' | N/A |

# Hot Water Delivery in a smaller package

| | First Hour Rating | Recovery |
|---|---|---|
| | USG | GPH |
| 40G Envirosense SF | 86 | 65 |
| 50G Hi-input Power Vent | 110 | 69 |
| 50G Hi-input Power Direct Vent | 100 | 73 |
| 75G Power Direct Vent | 154 | 82 |
| 50G Envirosense SF | 118 | 84 |
| Envirosense PV | N/A | 96 |

# Service Considerations

Easily-accessible service points

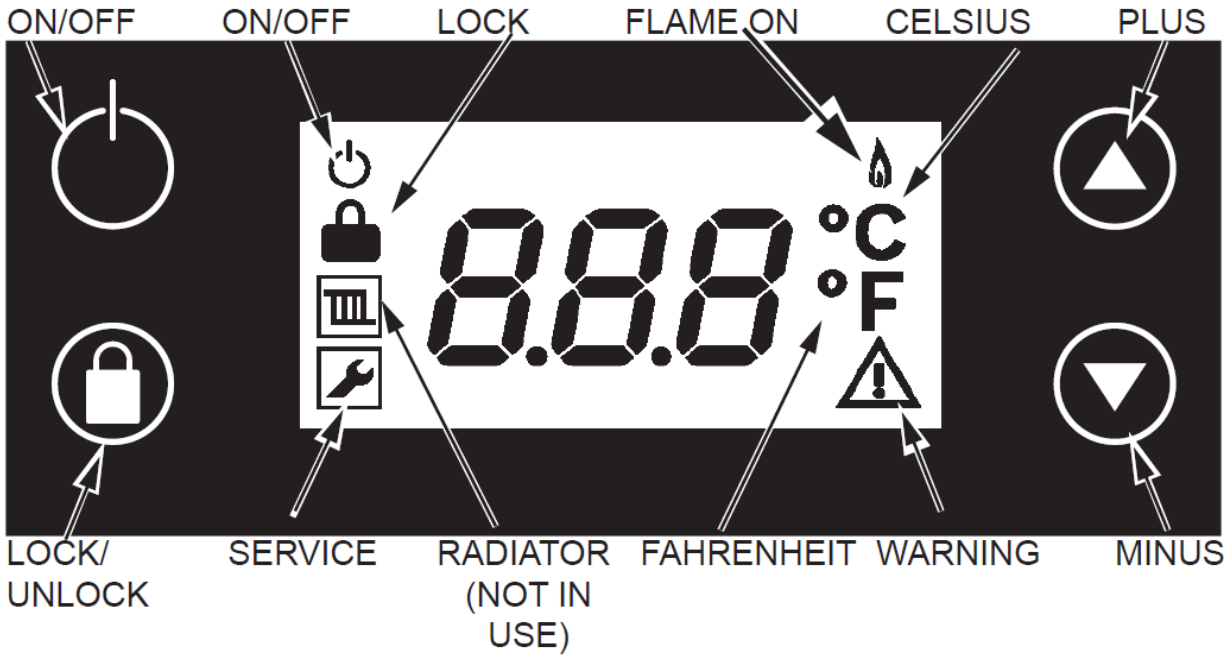
- Front-mounted burner and combustion chamber
- Top water connections
- Top-mounted anode

No FV sensor

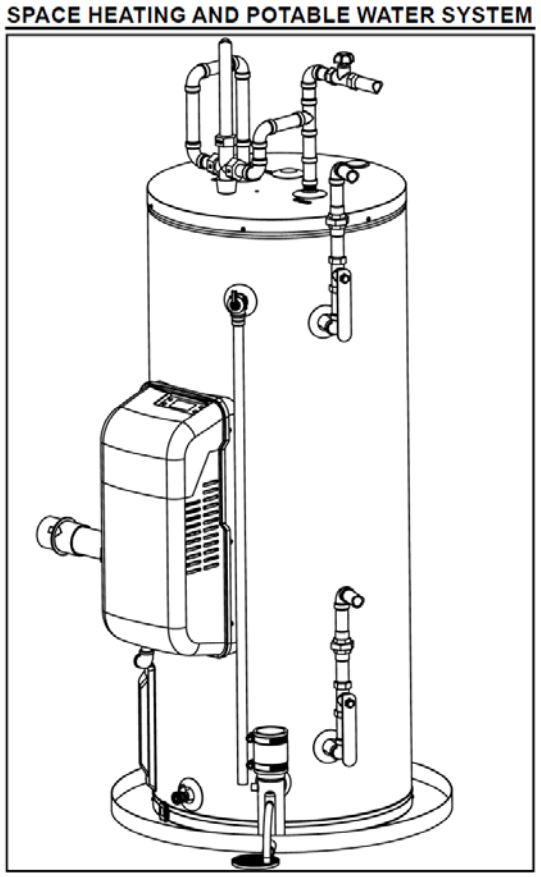
Electronic control with digital display shows operating status, error codes, and fault history

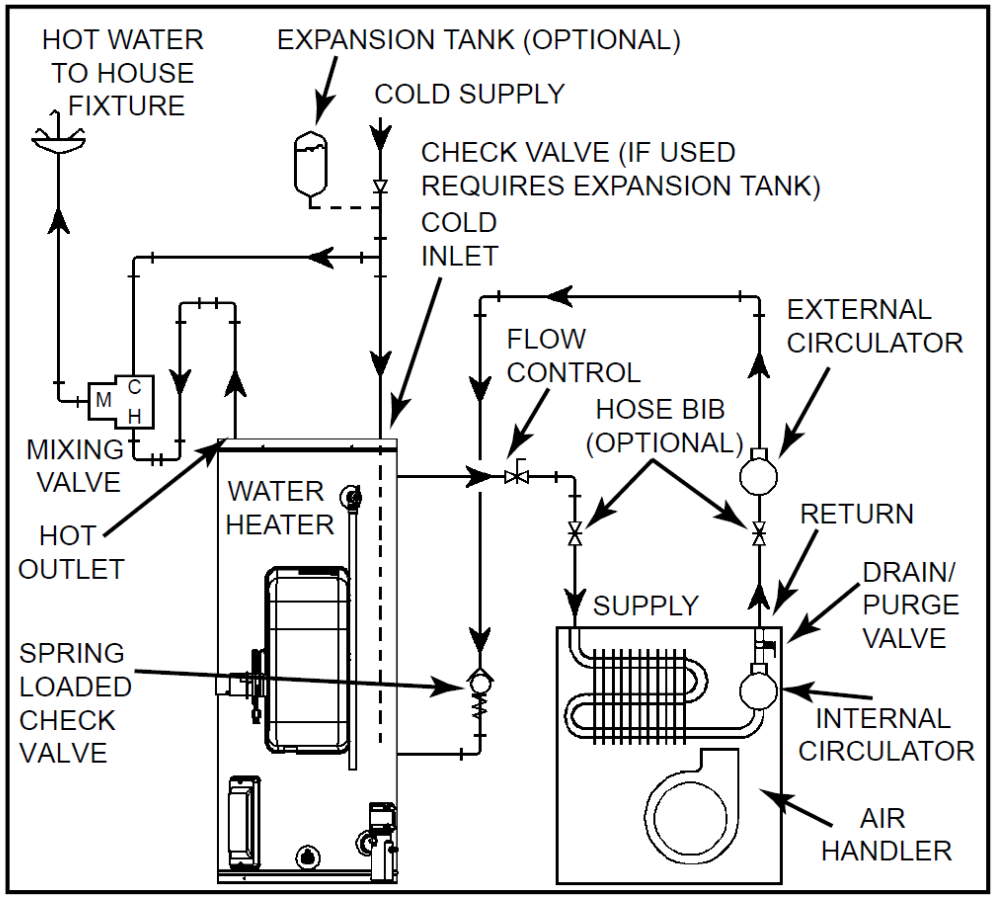
# Integrated Electronic Controls

**Control/UIM**



# Certified for Space Heating Systems




Note: next step will be P9 testing.

# New Home Buyer Benefits

- ENERGY STAR® high-efficiency water heater
- Always available hot water
- Quiet operation
- Electronic control with digital display
- Front and easy access

Envirosense 5076
50 Gallons
(76,000 Btus/hr)
Power Vent
68.5 Inches tall


ENV-50
50 Gallons
(65,000 Btus/hr)
Direct Vent
54 Inches tall


ENV-40
40 Gallons
(50,000 Btus/hr)
Direct Vent
45 Inches tall


| MODEL NUMBER | NOMINAL CAPACITY USG (L) | RATED STORAGE VOLUME USG (L) | FIRST HOUR RATING USG (L) | UEF | THERMAL EFFICIENCY | RECOVERY @ 90° RISE GPH (LPH) | BTU INPUT PER HOUR | APPROX. SHIPPING WEIGHT LB (KG) |
|---|---|---|---|---|---|---|---|---|
| ENV-40 | 40 (151) | 39 (147) | 86 (325) | 0.90 | 93% | 62 (234) | 50,000 | 216 (98.2) |
| ENV-50 | 50 (189) | 48 (181) | 118 (446) | 0.90 | 93% | 81 (306) | 65,000 | 246 (111.8) |

# 1 method for selecting storage type water heaters for dual purpose applications out of *CSA B214:21*

## Example using Table A.2b for stacked townhouses

Table A.2b)

Assumptions

- 2 bedroom
- 2 washroom
- GPCT-40L Tank, 40 usgpm, 50,000 btuh

Table 1 HUD-FHA

- First hour draw 60usgpm
- Recovery 30gph

- Calculations
- Required first-hour recovery 23,240 btuh = (60 usgpm - (40 x 0.8)) x 830
- Water heater output 45000 btuh = 50000 x 0.90
- Output available 21,760 btuh

TAKEAWAY:

So based on the logic provided in the standard the volume/capacity is too small if the heat loss exceeds 21,760 btuh

**Table A.2 b)**
**Alternative dual-purpose water heater selection form (IP)**
(See Clause 4.6.2.)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Dwelling heat loss** | | | | | | |
| Heat loss from an acceptable method [see the HRAI's *Unified Canadian Guideline for Integrated (Combo) Heating Systems*, Section 1] _____ Btu/h | | | | | | [A] |
| **Domestic demand** | | | | | | |
| Minimum domestic demand (use Table 1-HUD-FHA below): | | | | | | |
| Number of bathrooms | = | _____ | Number of bedrooms | = | _____ | |
| Storage, US gal | = | _____ | First-hour draw, US gal | = | _____ | [B] |
| **Water heater first-hour recovery** | | | | | | |
| 1. Domestic first-hour draw [B] minus (selected storage capacity × 0.8) = Domestic recovery required | | | | | | |
| _____ [B] | - | _____ | = | _____ | | [C] |
| First-hour draw | | [selected storage capacity × 0.8] | | Domestic recovery required | | |
| 2. _____ [C] | | × 830 | = | _____ | | [D] |
| Domestic recovery required | | | | Required first-hour Btu/h recovery | | |
| **Water heater capacity for heating use** | | | | | | |
| _____ | × | _____ | = | _____ | | [E] |
| Water heater Btu/h input | | Efficiency | | Water heater Btu/h output | | |
| _____ [E] | - | _____ [D] | = | _____ | | [F] |
| Water heater Btu/h output | | Required first-hour Btu/h recovery | | Btu/h output available Available output [F] must be equal to or greater than [A] above | | |
| **Water heater appliance selection** | | | | | | |
| Manufacturer: | | | | | | |

Model:
Rated Btu/h input:
Rated Btu/h output:
Water heater temperature setting:

Water heater temperature setting should be set 10 °F higher than fan coil's calculated EWT.

Table 1 HUD-FHA: Minimum water heater capacities for one- and two-family living units

| Number of bathrooms | 1–1.5 | | | 2–2.5 | | | | 3–3.5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of bedrooms | 1 | 2 | 3 | 2 | 3 | 4 | 5 | 3 | 4 | 5 | 6 |
| Storage, US gal | 20 | 30 | 30 | 30 | 40 | 40 | 50 | 40 | 50 | 50 | 50 |
| Input, 1000 Btu/h | 27 | 36 | 36 | 36 | 36 | 38 | 47 | 38 | 38 | 47 | 50 |
| First-hour draw, US gal | 43 | 60 | 60 | 60 | 70 | 72 | 90 | 72 | 82 | 90 | 92 |
| Recovery, US gal/h | 23 | 30 | 30 | 30 | 30 | 32 | 40 | 32 | 32 | 40 | 42 |

# Summary

- In airtight houses (>78 sq in) gas code requires direct vent heating systems
- 40 gallon tank with a height of 45” is the perfect equipment for space challenged mechanical rooms in smaller townhouses
- Installation, serviceability and performance

# QUESTIONS?

**Table A.1**
**Dual-purpose water heater selection form**
(See Clause 4.6.2.)

| | |
|---|---|
| Dwelling heat loss | |
| Heat loss = W (Btu/h) | |
| Domestic hot-water demand | |
| Minimum domestic hot-water demand<br>Number of bathrooms = Number of bedrooms =<br>Storage, VT, L (US gal) = First-hour draw, $F_h$, L (US gal) = | |
| Water heater first-hour recovery, $F_{h,N}$ | |
| $F_{h,N} = N \times 64.5$<br>or<br>$F_{h,N} = N \times 833$<br>where<br>$F_{h,N}$ = first-hour recovery, W (Btu/h)<br>$N$ = domestic hot-water recovery, L (US gal)<br>= $F_h$ - 0.8 VT<br>where<br>$F_h$ = first-hour draw, L (US gal)<br>$V_T$ = storage tank volume, L (US gal)<br>64.5 = energy required to raise the temperature of 1 L of water by 55.6 °C, W/L<br>833 = energy required to raise the temperature of 1 US gal of water by 100 °F, Btu/US gal | $F_{h,N}$ = |
| **Available output of the water heater, $O_{Av}$** | |
| $O_{Av} = O - F_{h,N}$<br>where<br>$O_{Av}$ = available output of the water heater, W (Btu/h) | $O_{Av}$ = |
| where<br>$O$ = output of the water heater, W (Btu/h)<br>= I × E<br>where<br>$I$ = Input of the water heater, W (Btu/h)<br>$E$ = efficiency of the water heater, expressed as a number less than 1<br>$F_{h,N}$ = first-hour recovery, W (Btu/h) | |
| **Water heater selection** | |
| Manufacturer:<br>Model:<br>Rated Input, W (Btu/h):<br>Rated output, W (Btu/h):<br>Water heater temperature setting, °C (°F): | |