February 23, 2021

ALL ELECTRIC NEW HOMES: HIGH PERFORMANCE PATHWAYS

2021 Duluth Energy Design Conference

Phil Anderson, Tony Beres, & Jake Selstad

CEE's nonprofit mission

The Center for Energy and Environment promotes energy efficiency to strengthen the economy while improving the environment.

We provide practical energy solutions for homes, businesses, and communities.

WE STAND FOR

- ✓ Collaboration
- ✓ Community
- ✓ Science
- ✓ Expertise
- ✓ Integrity

At our core

PROGRAMS

We cut energy waste while improving comfort in homes, commercial buildings, and communities.

CONSULTING

We help building owners and entire communities achieve long-term, energy-saving solutions.

RESEARCH

We identify and explore cost-effective, efficient technologies and ideas through field analysis, modeling, and stakeholder engagement.

POLICY

We strive for high-impact, pragmatic solutions guided by a public interest ethic.

LENDING

We empower people to make upgrades on energy efficiency and comfort in homes or businesses.

Who We Are

Phil Anderson

- QA & New Homes Manager

Tony Beres

- Senior Energy Rater

Jake Selstad

- Senior Energy Rater

Topics for Today

- Envelope details that lower heating and cooling loads
- High performance heating and cooling options for optimum performance
- Ventilation needs to ensure good indoor air quality
- Appliances
- Helpful certifications to ensure a good quality control process
- Available incentives through utilities
- Case Studies

Reasons

- Cost $

- Fuel availability/scarcity

- De-carbonization and Renewable energy

- Off grid w/storage

Photo courtesy of Sustainable Nine Design + Build

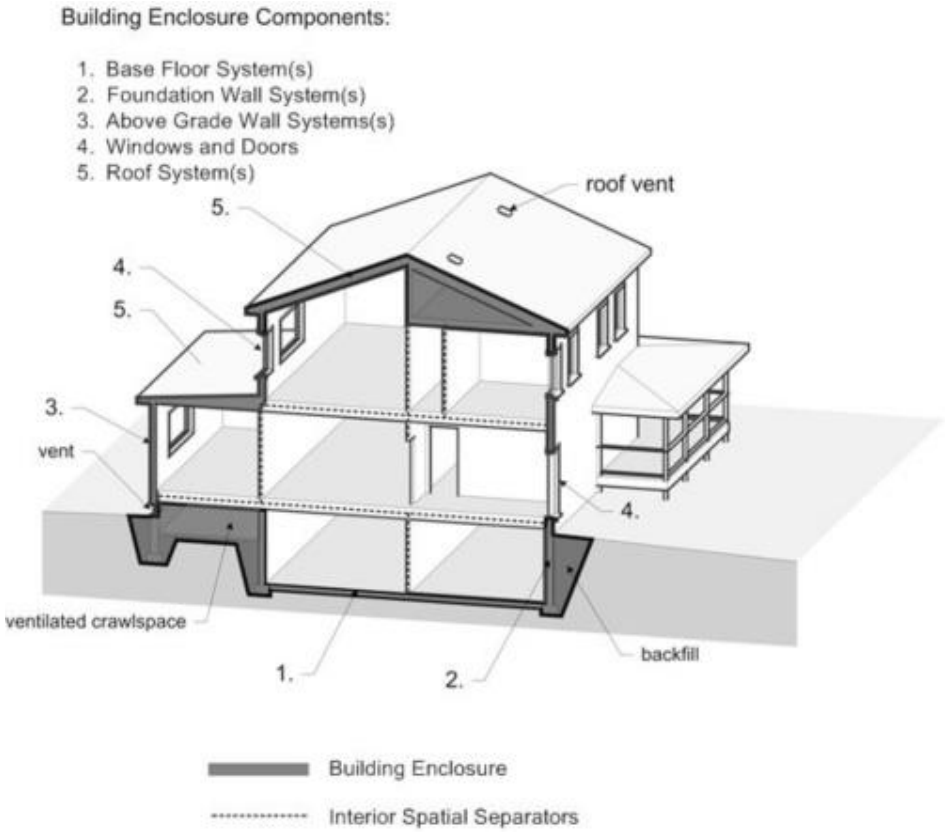
ENVELOPE DETAILS THAT LOWER HEATING AND COOLING LOADS

Tony Beres

Envelope Details

- The overall goal beyond traditional envelope construction is to bring load down as much as possible, to minimize the responsibility of the mechanical systems to condition the home
  - Special considerations in design should be taken for preventing overheating via solar gain

- Basic principals for all envelope aspects
  - High R Value
  - Low Infiltration
    - Minimize Penetrations
    - Focus on indoor air quality
    - Integrate spot ventilation with HRV/ERV
  - Minimize Thermal Bridges



Building Science Corporation

Current Minnesota Energy Code

Insulation levels:

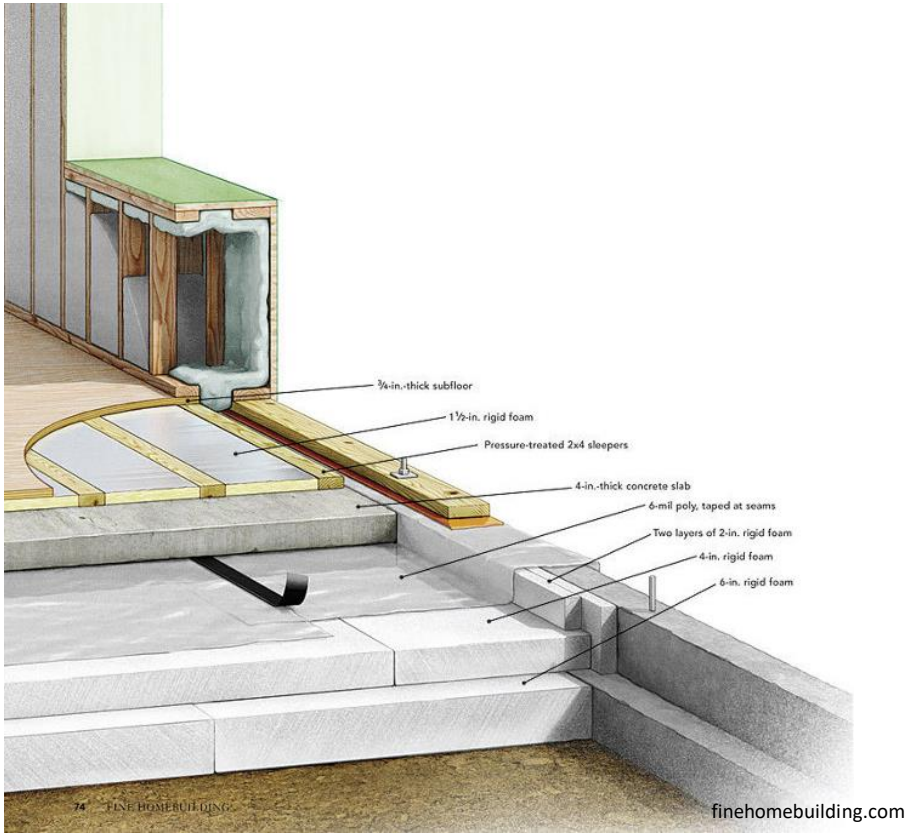
TABLE R402.1.1 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

Climate Zone	Fenestration U-factor[b]	Skylight[b] U-factor	Glazed Fenestration Shgc[b,e]	Ceiling R-value	Wood Frame Wall R-value[f]	Mass Wall R-value[i,g,h]	Floor R-value	Basement Wall R-value[c,i]	Slab R-value And Depth[d]	Crawl Space Wall R-value[c,i]
6	0.32	0.55	NR	49	20, 13+5	15/20	30e	15	10, 3.5 ft	15
7	0.32	0.55	NR	49	21	19/21	38e	15	10, 5 ft	15

Source: http://codes.iccsafe.org/app/book/toc/2015/Minnesota/2015%20Minnesota%20Energy%20Code%20with%20ASHRAE/index.html

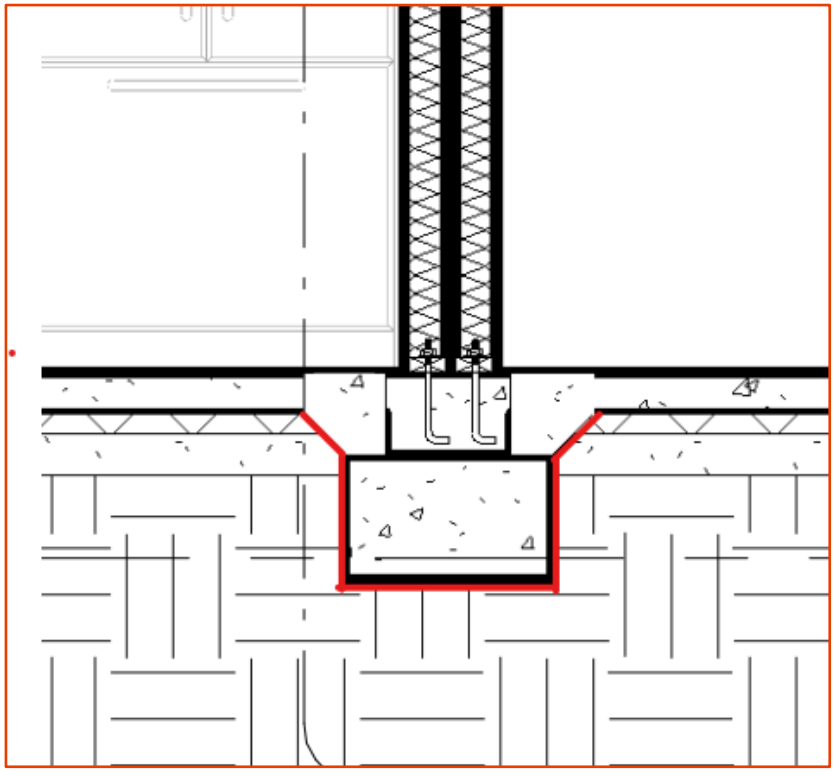
Slab

- High Sub Slab R-Value
  - Increase insulation under slab
  - Integrate with vapor barrier and radon system
- Thermally Broken Slab Edge
  - Slab wrapped insulation, disconnected from contact with footings



Slab

- High Sub Slab R-Value
- Thermally Broken Slab Edge
- Insulated Footings
  - Thermal Bridge at common wall footing



Slab

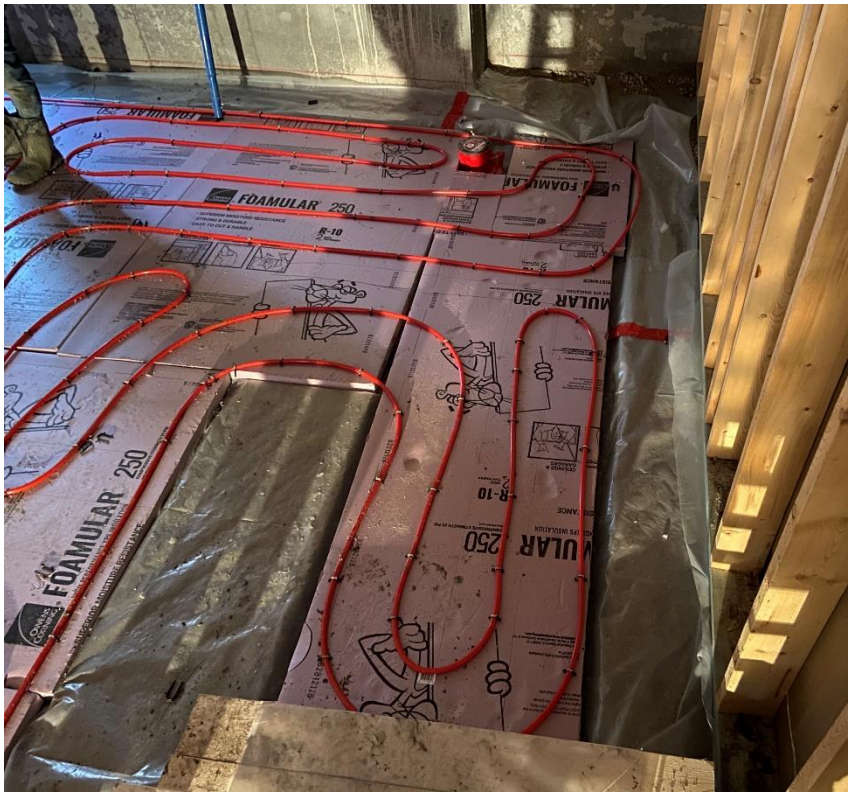
- High Sub Slab R-Value
- Thermally Broken Slab Edge
- Insulated Footings
  - Footings wrapped in rigid insulation

Slab

- High Sub Slab R-Value
- Thermally Broken Slab Edge
- Insulated Footings
  - Footings wrapped in rigid insulation

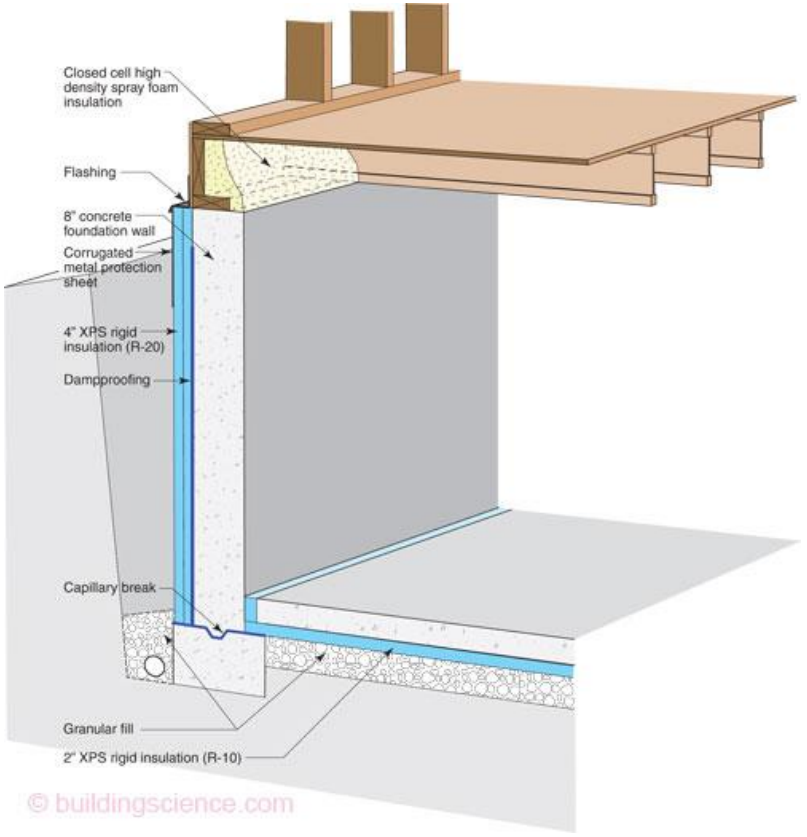
Slab

- High Sub Slab R-Value
- Thermally Broken Slab Edge
- Insulated Footings
- Considerations taken for in slab heat and finished floor coverings



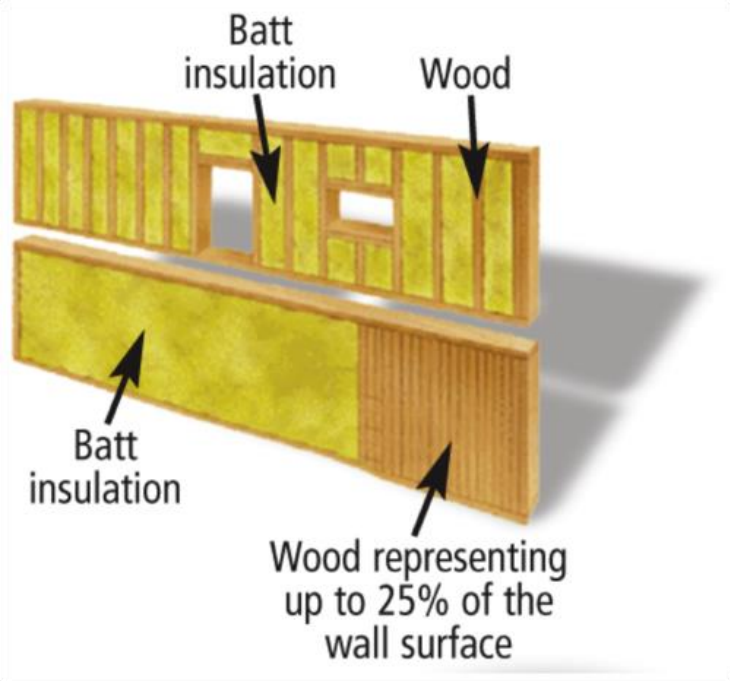
Foundation

- Above Code R-Value
- Moisture control layer on exterior side of insulation
- Insulation extends below slab
- Capillary breaks to prevent moisture wicking through capillary action



Wall Insulation

- Grade 1 instead of Grade 2 wall insulation will result in **2-4%** energy savings
- Adding R5 exterior insulation along with Grade 1 insulation would improve by **5-8%**



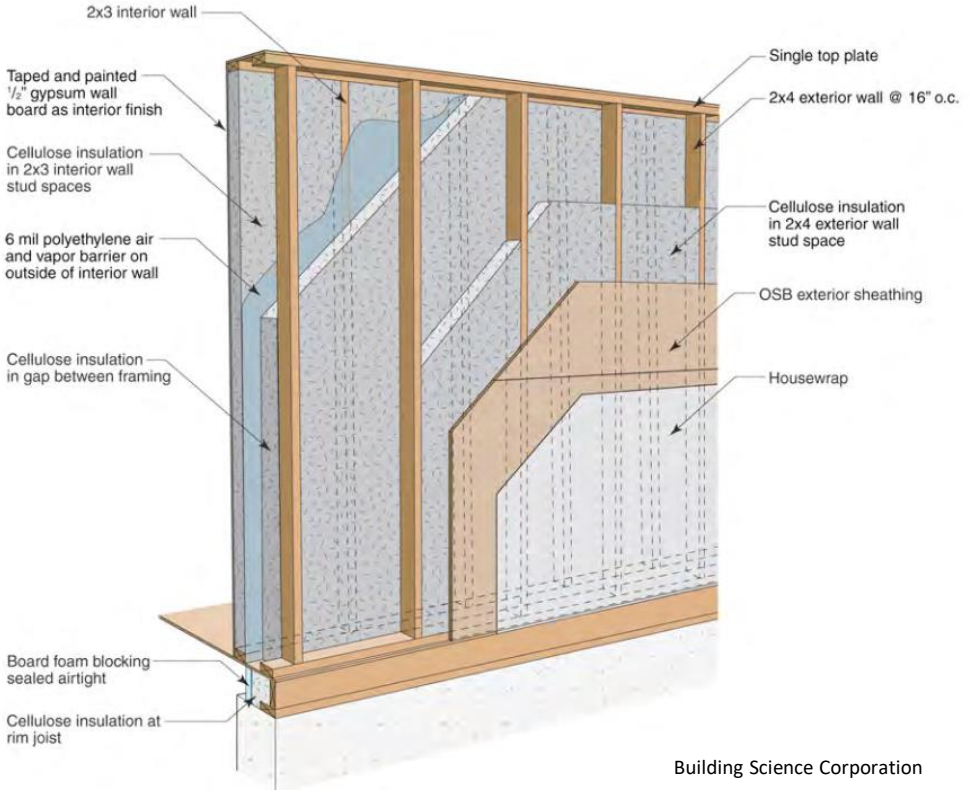
Sam Hagerman

Above (and beyond) Grade Walls

- Exterior insulation
  - Greatly reduces thermal bridging through building walls
  - Exterior details can be difficult for trades unfamiliar with method

Above (and beyond) Grade Walls

- Double stud wall
  - Eliminates thermal bridging by allowing continuous insulation between framing members
  - Easy to modify design for climate and insulation type (Blown cellulose or fiberglass, open or closed spray foam)



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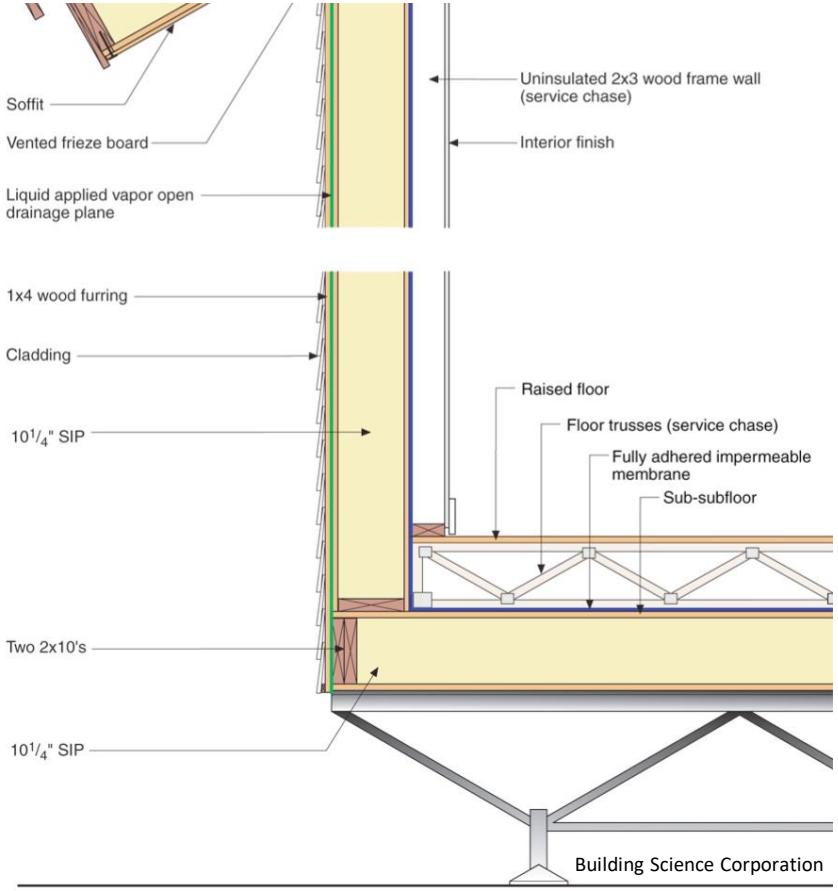
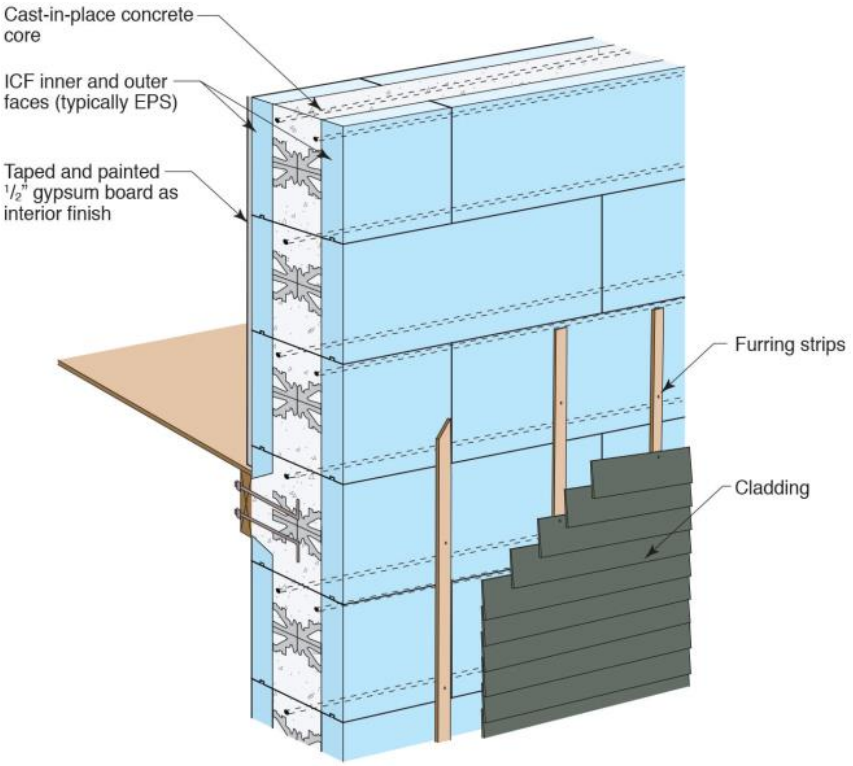
Above (and beyond) Grade Walls

- Structural Insulated Panel
  - Greatly minimize penetrations with framed “service channel” wall for plumbing and electrical
  - Reduced on site construction times
  - Difficult to change initial designs after panels ordered
  - Higher potential for moisture damage if not detailed properly for moisture and infiltration



Above (and beyond) Grade Walls

- Insulated Concrete Forms
  - Low Infiltration-Air barriers created by both the concrete and the rigid foam
  - Durable-Strong and resistant to moisture/vapor drive
  - Relatively easy to assemble
  - Thermal mass benefits lessen in colder climates
  - Remodeling and modifications are difficult



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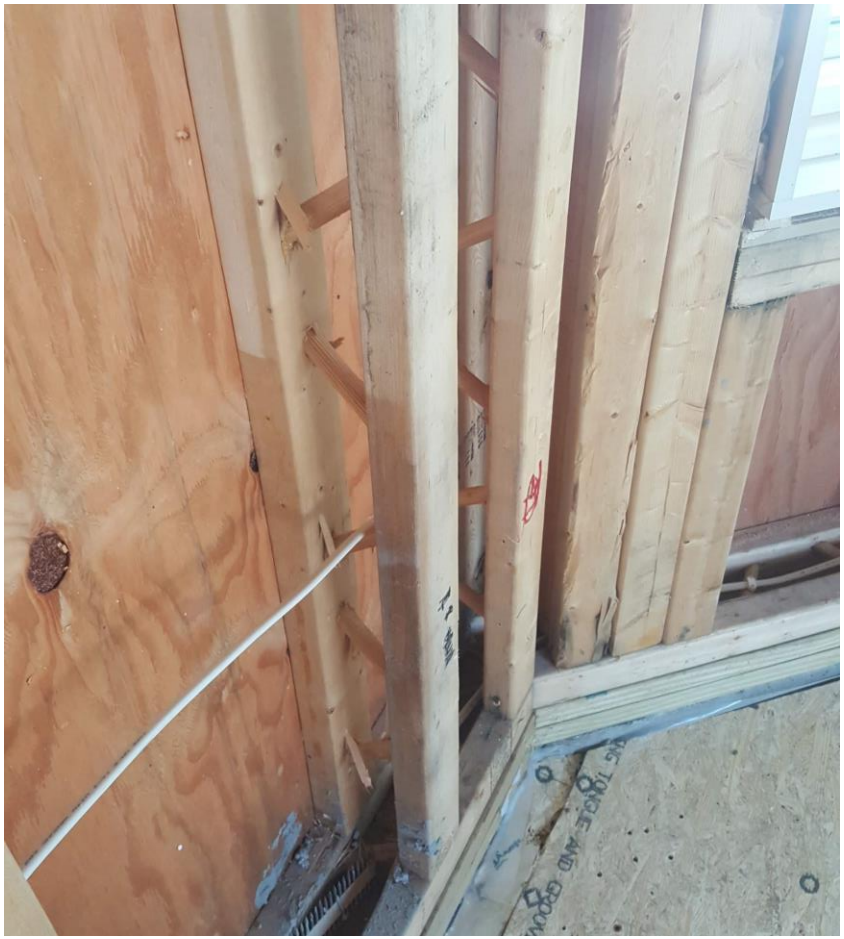
Above (and beyond) Grade Walls

- Thermally Broken Stud
  - Pre insulated with foam for batt insulation or open for blown insulation applications

finehomebuilding.com

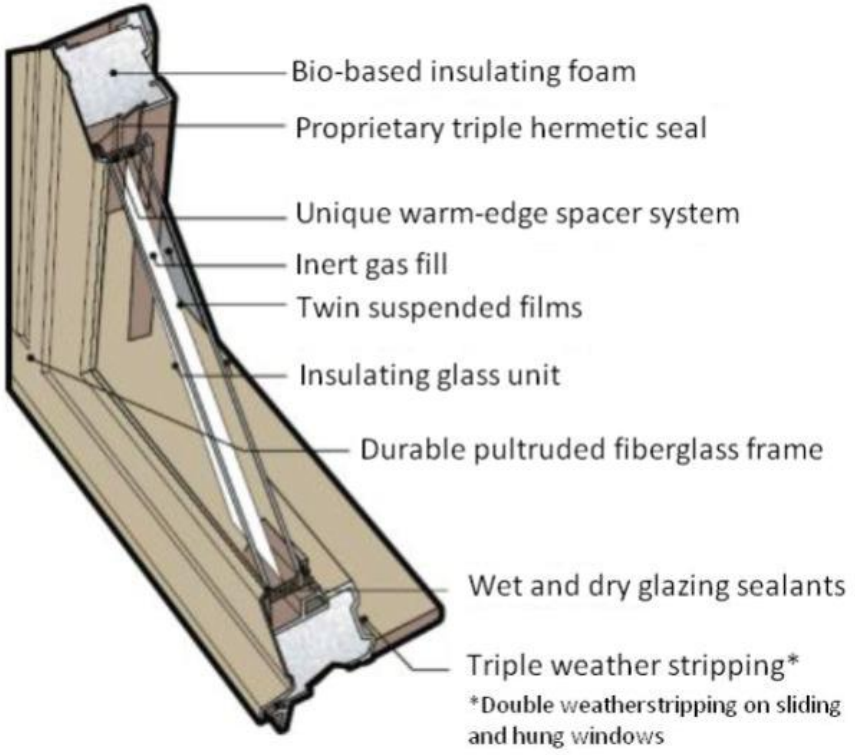
Above (and beyond) Grade Walls

- Thermally Broken Stud
  - Pre insulated with foam for batt insulation or open for blown insulation applications
  - Few changes for trades as dimensions match traditional lumber
  - Increased overall strength allows for framing 24” on center



Windows

- Production/technology advancements are bringing cost down for high performance windows



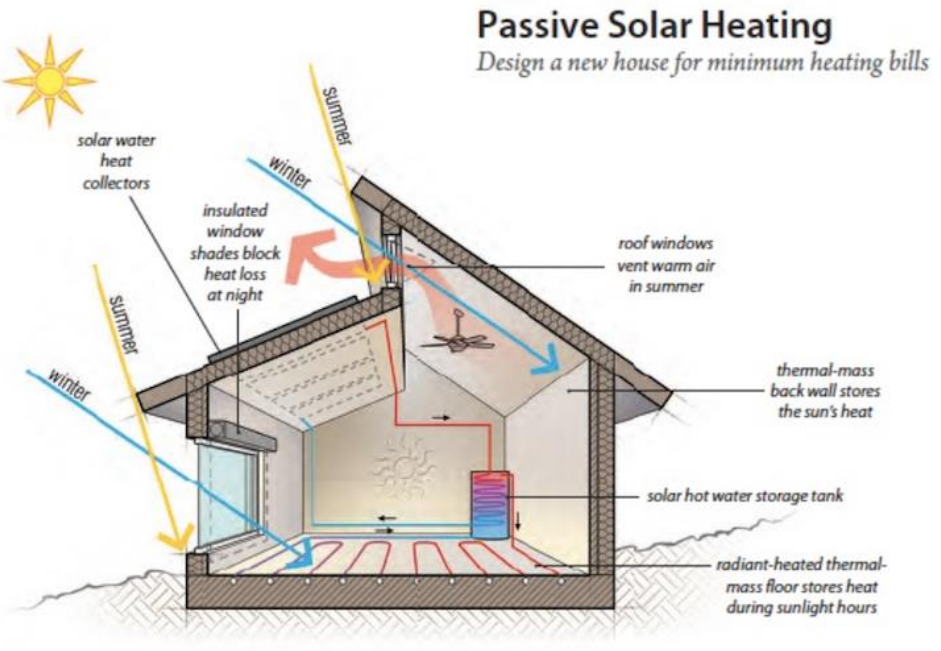
Alpen 925 Series Windows Datasheet

Windows

- Production/technology advancements are bringing cost down for high performance windows
- Increased considerations for window framing due to deeper, high insulation walls

Windows

- Production/technology advancements are bringing cost down for high performance windows
- Increased considerations for window framing due to deeper, high insulation walls
- Window orientation and shading must be considered to prevent overheating with solar gains



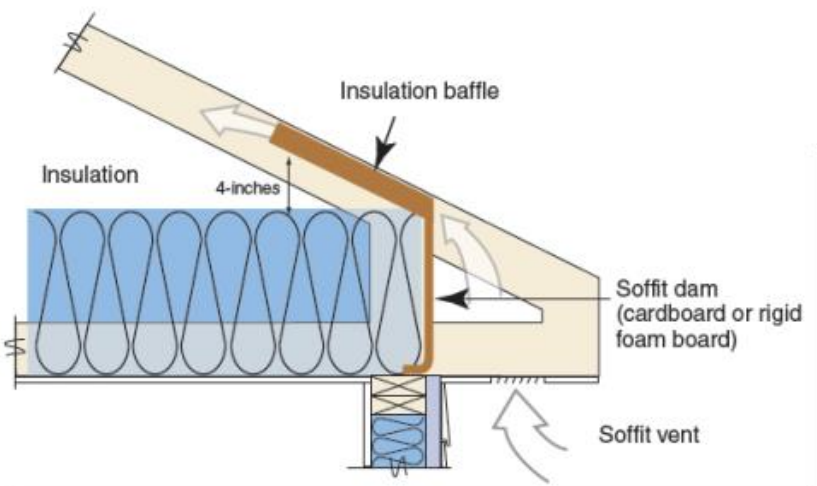
ases.org/passive-solar-heating

Attic/Ceiling

- Penetrations and gaps must be sealed before adding insulation in unconditioned attics
  - Entire ceiling flashed with 1.5”+ Closed Cell foam before blowing loose insulation

Attic/Ceiling

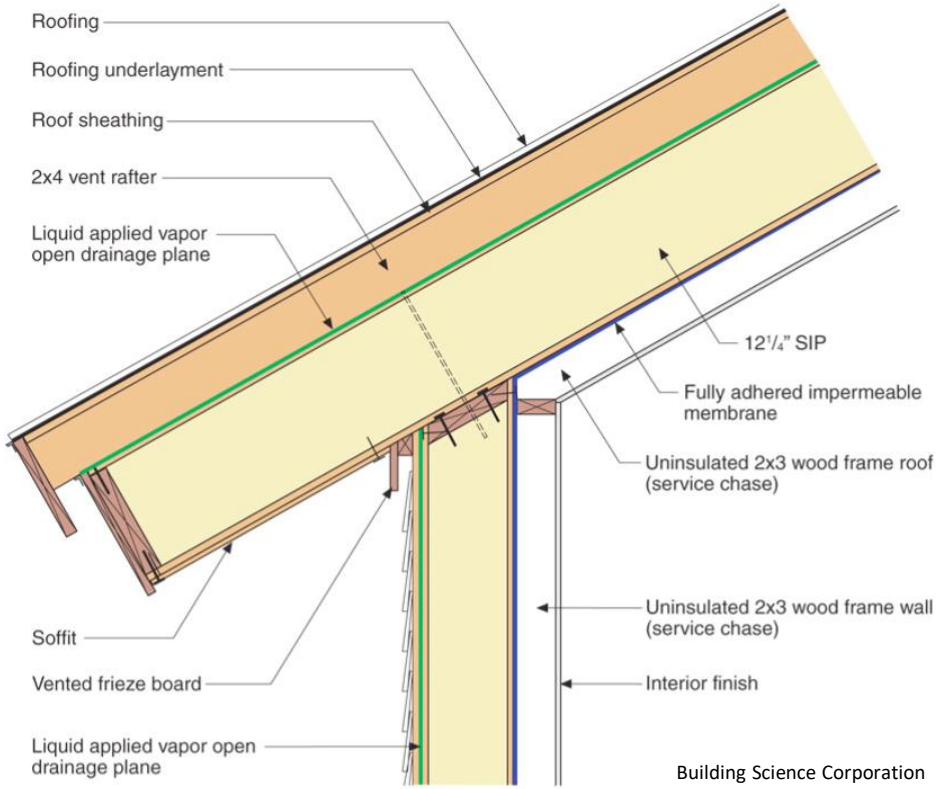
- Penetrations and gaps must be sealed before adding insulation in unconditioned attics
- Raised Heel Energy Truss
  - Full height insulation extends all the way over exterior wall top plate



GA International Energy Conservation Code Supplements and Amendments 2011

Attic/Ceiling

- Penetrations and gaps must be sealed before adding insulation in unconditioned attics
- Raised Heel Energy Truss
- Structural Insulated Panels also possible for roof system



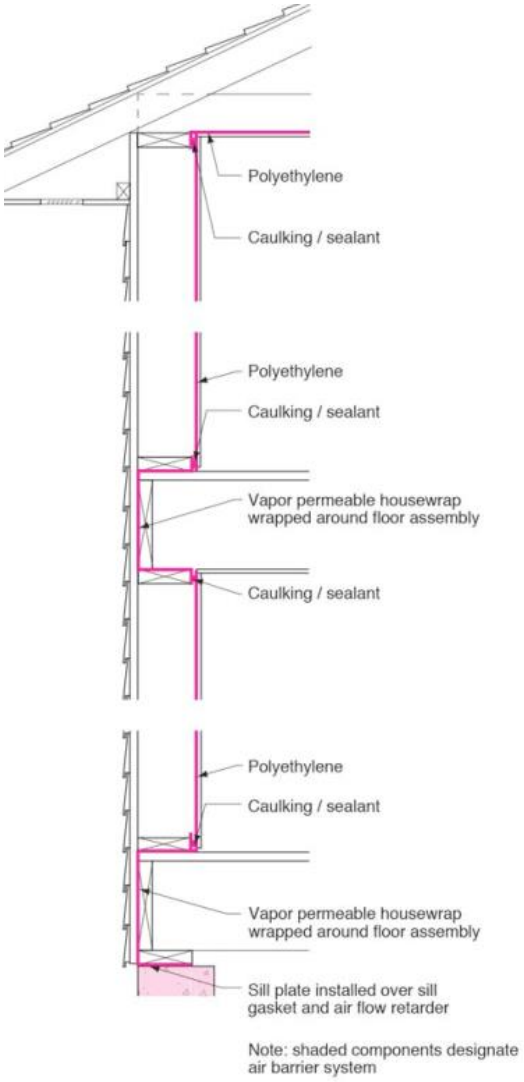
Air Leakage Improvement

- Go from tight to super tight
- 1.5 ACH50 (or better) instead of 3 ACH50 (MN Code) will result in a **6-10%** energy savings
- Most cost effective way to reduce energy usage in home

Home Improvement –Season 7 Ep. 17

Penetrations (Know Your Holes)

- Can you define your air barrier at all points of the building envelope?

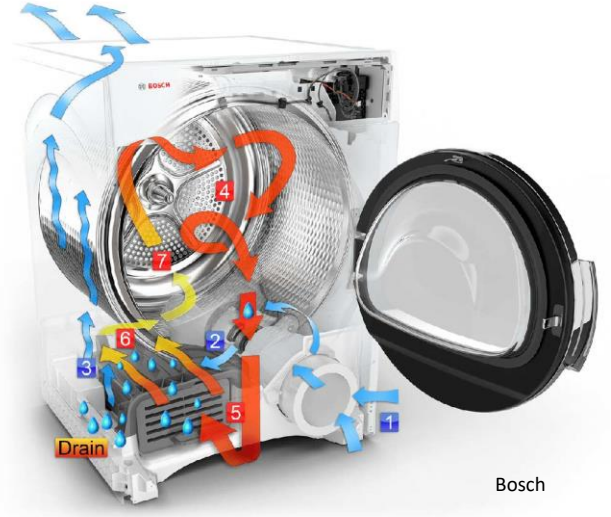


Penetrations (Know Your Holes)

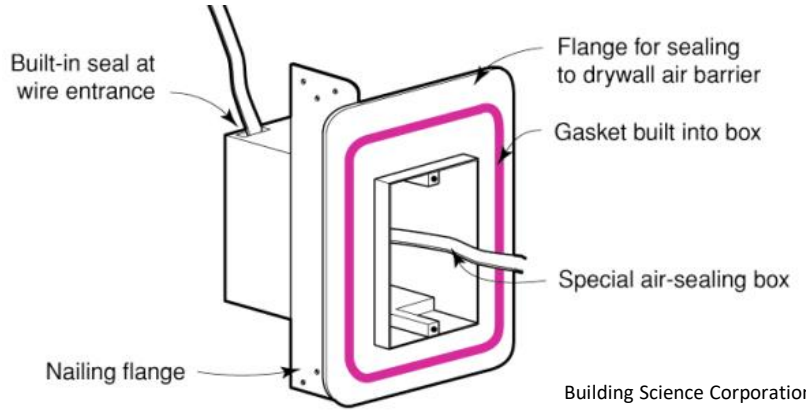
- Can you define your air barrier at all points of the building envelope?
- Exhaust fans
  - Eliminate exhaust only point ventilation by designing point ventilation into whole home system.

Penetrations (Know Your Holes)

- Can you define your air barrier at all points of the building envelope?
- Exhaust fans
- Heat Pump dryer
- Gasketed boxes



Bosch



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Penetrations (Know Your Holes)

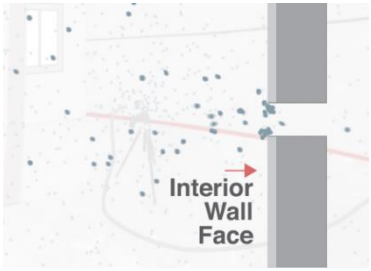
- Can you define your air barrier at all points of the building envelope?
- Exhaust fans
- Heat Pump dryer
- Gasketed boxes
- Elastomeric liquid flashing
- High performance tapes
- Trades communication
  - All holes should be planned and approved
- No combustion means no make up air

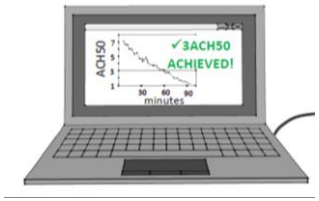
Photograph 11: Window Opening—Origami is not a necessary skill with fluid applied flashing systems.

greeninghomes.com

AeroBarrier - Aerosol Envelope Sealing

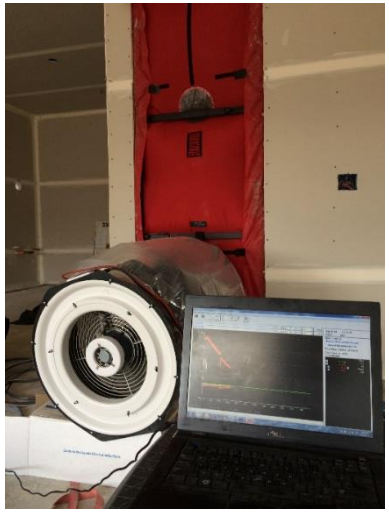
- Blower Door creates and maintains positive pressure
- Spray “fog” of sealant particles into the house
- Particles carried to leaks by escaping air flow
- Process is tracked and displayed in real time and documented electronically
- Finds and seals leaks missed or inaccessible by manual trial-and-error methods





Curtis Harrington, PE UC Davis, Western Cooling Efficiency Center

Basic Concept



Blower door setup for pressurization

Seal formed between gap in foam

Curtis Harrington, PE UC Davis, Western Cooling Efficiency Center

HIGH PERFORMANCE HEATING AND COOLING OPTIONS FOR OPTIMUM PERFORMANCE

Phil Anderson

Available Electric Heating Options

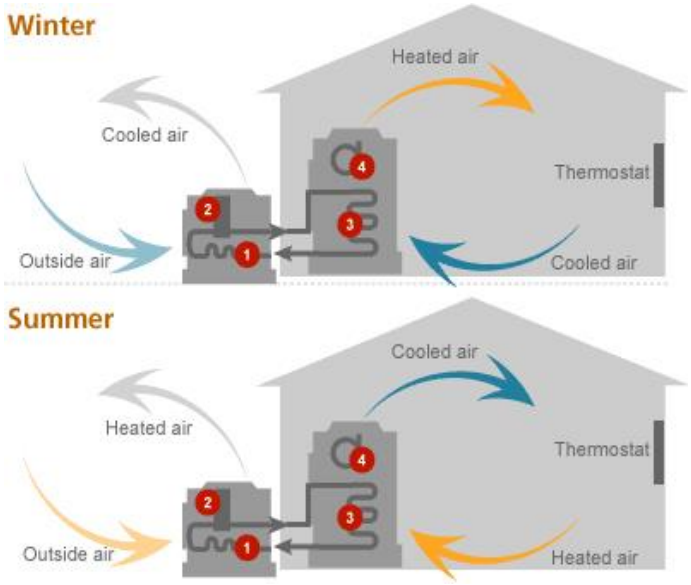
- Electric Resistance
  - Baseboard
  - Storage/off peak
  - Air handler coil
  - Boiler
- Heat Pumps
  - Air to Air
  - Air to Water
  - Geothermal

Available High-Performance Options

- Cold Climate Air Source Heat Pumps
  - Air to Air
  - Air to Water
- Geothermal

Air Source Heat Pump Technology

- Uses a refrigerant system involving a compressor, condenser, and evaporator to absorb heat at one place and release it at another.
- Delivery of both heating and cooling via forced air distribution
- Technology has advanced considerably since 2013.
- New generation systems can operate as low as -13 °F



Inverter Technology

- Much more efficient, with operation at lower temperatures
- Produces heat as low as -13 to -20 degrees F
- ECM drive
- Modulates to building loads
- Very quiet operation, inside and out

Recommended Performance Spec's

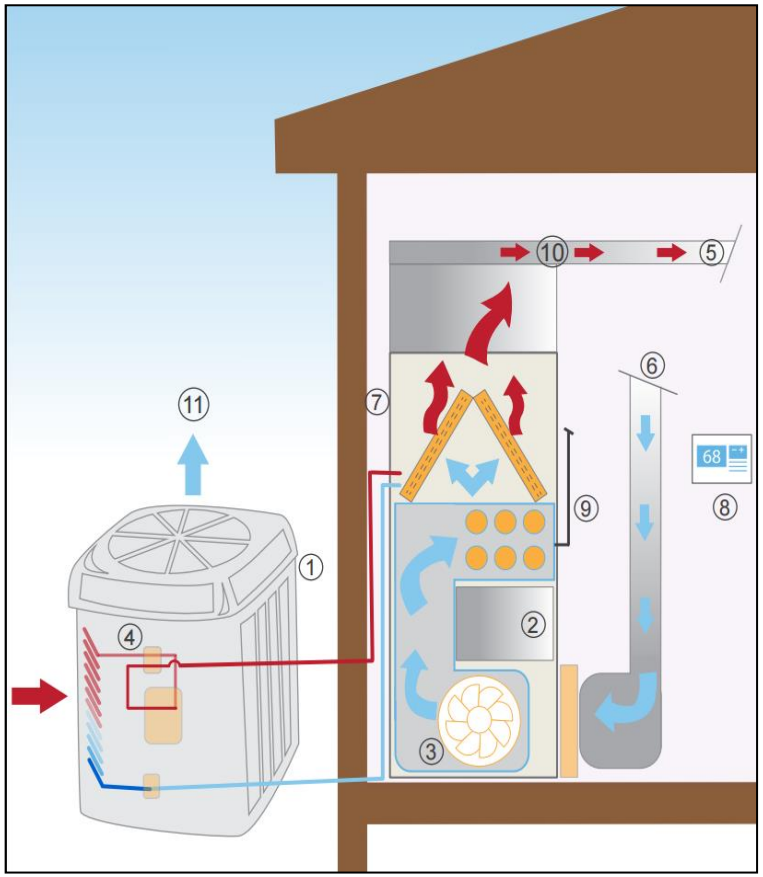
- NEEP List (Northeast Energy Efficiency Partnerships)
- Inverter-driven
- COP ≥1.75 at 5° F (at maximum capacity operation)
- HSPF
  - ≥10 for Non-Ducted systems
  - ≥9 for Ducted systems
- SEER ≥15

- Another resource:
  - Minnesota ASHP Collaborative - www.mnashp.org

New Construction Applications

- Efficient Air-Conditioning – 15+ SEER
- Outside natural gas territory
- Low electric rates – electric heat, dual-fuel, or off-peak
  - ~ 6 cents per kWh
- No ductwork – house, ADU, renovation
- Reduce carbon footprint
  - Energy efficient home, on-site solar, etc.
- Multiple backup heat options for coldest temps

Air to Air – Outdoor Condenser



Air to Air – Indoor Ductless vs. Ducted

Ductless

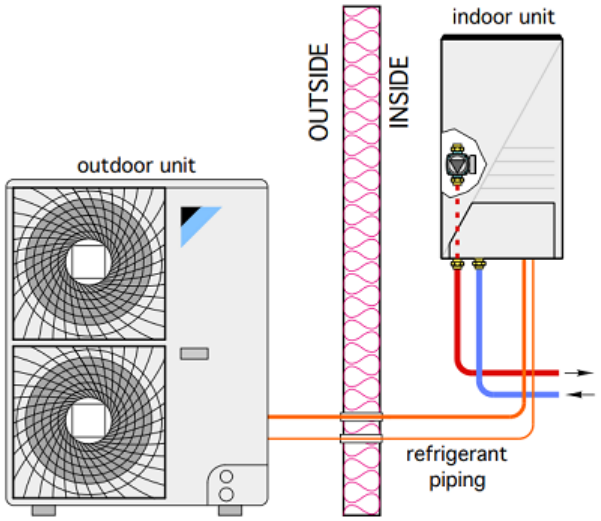
Ducted

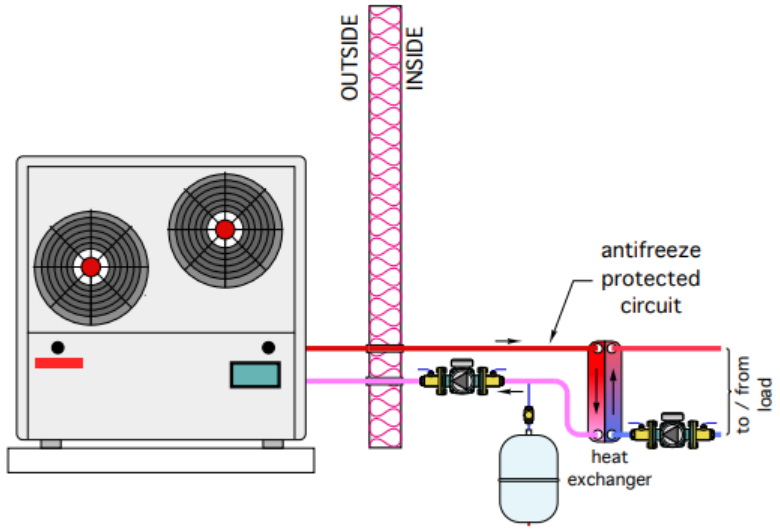
Air to Air - Zoning, sizing options, and VRF

- Many zones can be set up in homes
  - No more cold or hot spots
- Varying BTU sizing of ducted or ductless heads
  - Continuous operation for sustained temperature
- Many options for residential through commercial sizing for outdoor units
- Variable Refrigerant Flow (VRF) allows simultaneous heating and cooling of different zones

Air to water heat pump (AWHP)

- Integrated heat pump (IHP)
- Air Source Heat Pump Chiller (ASHPc)



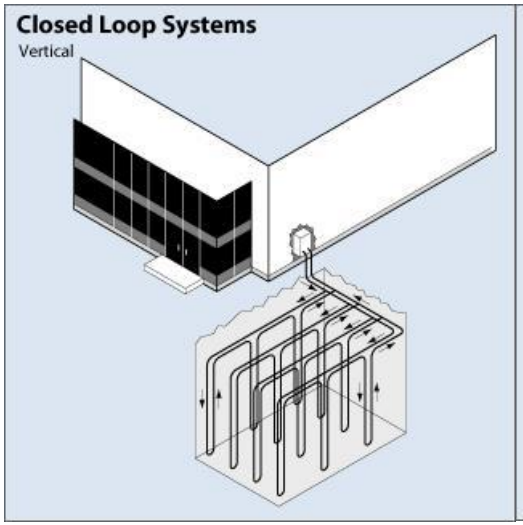


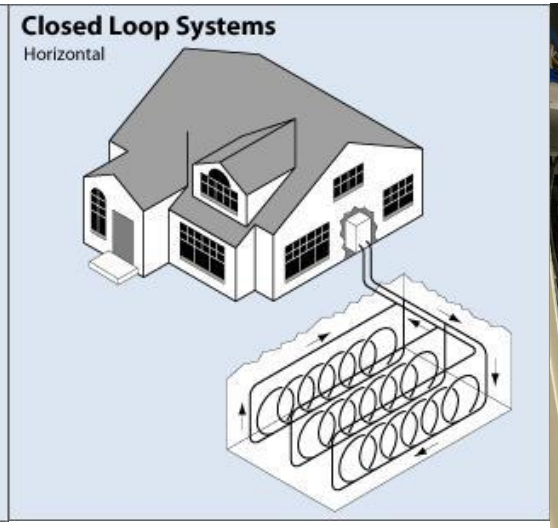
Air to water heat pump (AWHP)

- Similar to an ASHP with outdoor unit, but moves heat through an air to water heat exchanger
- Some systems allow for all heat pump parts to be in a single outdoor unit, called a monobloc, only plumbing into the home, no refrigerant
- Inside unit very flexible for heat/cool delivery options
  - Radiant floors and ceilings
  - Radiators
  - Hydronic air handlers
  - Minisplit cassettes
  - DHW storage tank

Geothermal

- Efficiently uses the earth to heat, cool, and provide domestic hot water
- Different underground well options and inside conditioned air options of forced air and hot water
- Highest upfront cost for install, good long-term payback





Graphics courtesy of the Department of Energy

VENTILATION NEEDS TO ENSURE GOOD INDOOR AIR QUALITY

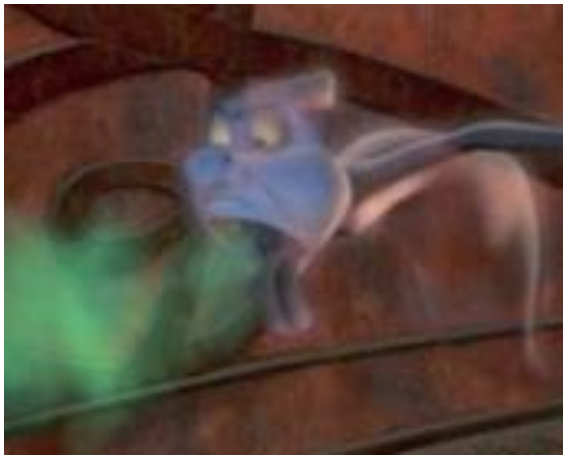
Jake Selstad

High Performance Ventilation

- Crucial for increasingly airtight homes, and people are becoming more aware of the need and benefits.
  - Airborne viruses get people thinking about ventilation
- Can you have too much fresh air?
- Lots of equipment, controls and installation options
- Good design can help maintain air tightness and keep loads low
- Can help distribute conditioned air through increased mixing, and potentially improve comfort

Indoor Air Quality

- Efficient airtight homes have less natural air exchanges, so more mechanical ventilation is needed.
- This is a feature, not a flaw.
- Mechanical ventilation allows for
  - Heat and moisture recovery
  - Controllable rates
  - Point source removal
  - Fresh air to living spaces
  - Filtration



Casper, 1995

Lisa Haney

https://foobot.io/resources/off-gassing/

All Fresh Air is Not Created Equally

- **Supply** - not suitable for cold climates
- **Exhaust** - common for spot ventilation, but can sometimes be used for continuous/whole home
  - Exhaust only is not ideal for airtight/low load homes.
- **Balanced** - can be separate fans or single appliance, should maintain = +/- pressure (this is MN code)
- **HRV & ERV** – best options, but a lot of variables
  - Rated for our climate HRV vs ERV
  - How much ventilation is really needed?
  - Sizing for continuous? Optimal to have a boost function
  - If not continuous, how is it controlled?
  - Common installations and best practices

HRV vs ERV in Cold Climate

- HRV does not transfer moisture
  - This can be helpful in reducing excess humidity in super tight homes during winter
  - Can also dry out a house during winter if moisture load is low
- ERV does transfer moisture
  - Moisture transferred from outgoing to incoming cold air has potential to freeze the core, lowering air flow and heat/energy transfer.
  - Some ERVs have a “defrost” strategy to prevent frozen cores
  - Typically, some form of temporary exhaust only approach which lowers the effective heat and energy transfer of the unit.
  - ERV’s should be rated/tested for cold climate (this is in MN code)

lodel	Temp Mode	°C	°F	Net Airflow (L/s)
/180	HEATING	0	32	38
/180	HEATING	0	32	53
/180	HEATING	0	32	77
/180	HEATING	-25	-13	33
/180	COOLING	35	95	39

HVI.org

lodel	Temp Mode	°C	°F	Net Airflow (L/s)
200	HEATING	0	32	85
200	COOLING	35	95	85

HVI.org

Balancing Efficiency with IAQ, How Much Does A Home Really Need?

- Replacing conditioned air with unconditioned outside air is inherently going to increase energy use.
  - If we didn't care about air quality, we wouldn't ventilate
  - If efficiency didn't mater, we would just over ventilate
- The honest and unfortunate answer is, it depends…
  - Building occupancy (primary reason to ventilate) is also the largest variable, both in quantity and behaviors.
  - Size (and shape), air tightness, location, and presence of interior/exterior pollutant sources should all be considered.
- Certifications often have specific ventilation requirements
- Municipal/State codes & National standards are a good(required) starting point.

MN State Code

- "The mechanical ventilation system shall provide sufficient outdoor air to equal the total ventilation rate average for each 1-hour period in accordance with Table R403.5.2, or Equation R403.5.2, based on the number of bedrooms and square footage of conditioned space, including the basement and conditioned crawl spaces"

a. **Equation R403.5.2 Total ventilation rate:** Total ventilation rate (cfm) = (0.02 X square ft of conditioned space) + (15 X (number of bedrooms + 1).

b. **Equation R403.5.2.1 Continuous ventilation rate:** Continuous ventilation rate (cfm) = Total ventilation rate divided by 2

Table R403.5.2 - Minnesota Ventilation Rate Chart (High/Low)

Cond. Space	1 Bedroom	2 Bedrooms	3 Bedrooms	4 Bedrooms	5 Bedrooms	6 Bedrooms
1000-1500	60/40	75/40	90/45	105/53	120/60	135/68
1501-2000	70/40	85/43	100/50	115/68	130/65	145/68
2001-2500	80/40	95/48	110/55	125/63	140/70	155/78
2501-3000	90/45	105/53	120/60	135/68	150/75	165/83
3001-3500	100/50	115/68	130/65	145/68	160/80	175/88
3501-4000	110/55	125/63	140/70	155/78	170/85	185/93
4001-4500	120/60	135/68	150/75	165/83	180/90	195/98
4501-5000	130/65	145/73	160/80	175/88	190/95	205/108
5001-5500	140/70	155/78	170/85	185/93	200/100	215/108
5501-6000	150/75	165/83	180/90	195/98	210/105	225/113

Meets the current Minnesota Ventilation Code Requirements (Continuous & Total Rate) and IECC 2012 requirements

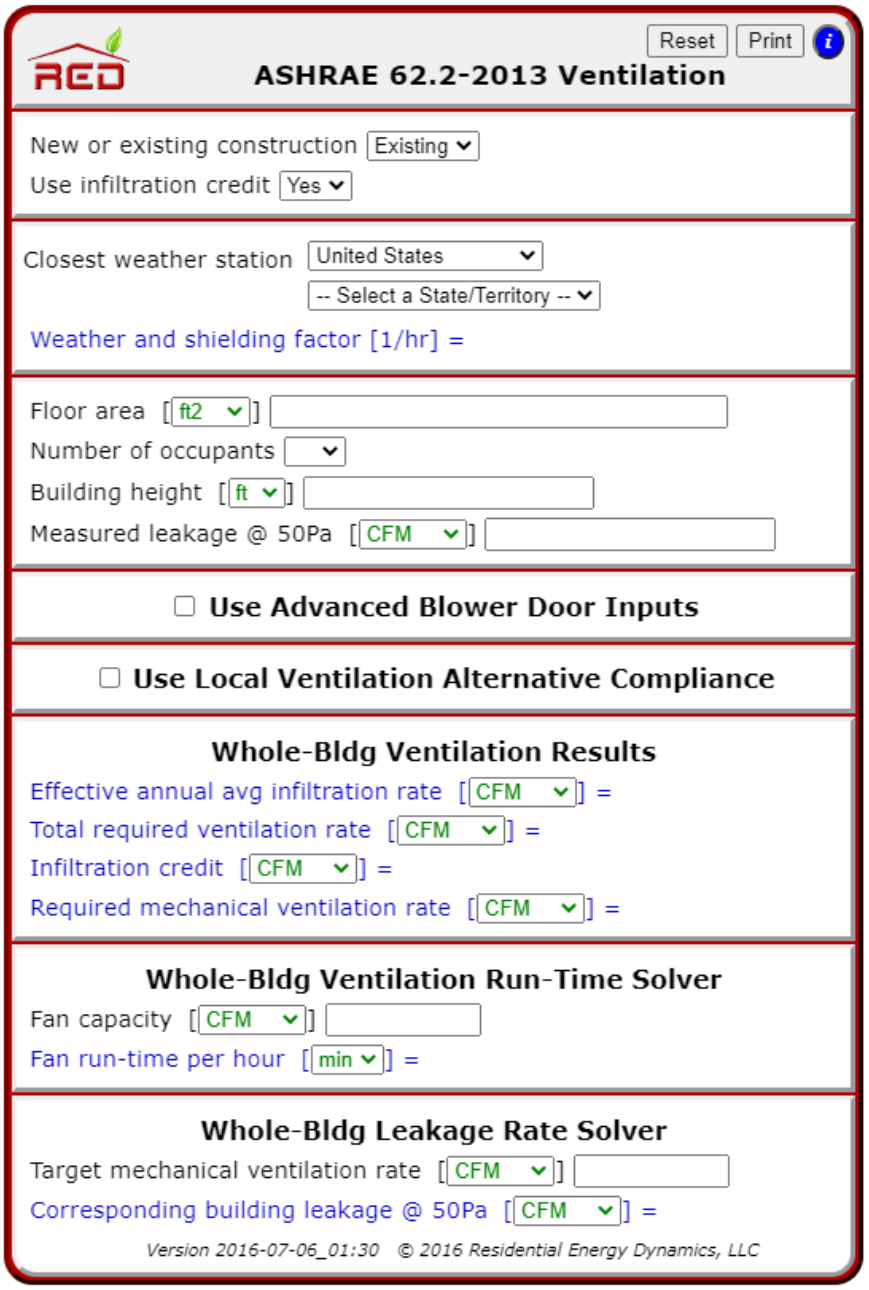
Ventilation Sizing Example:

1. **Size of the House, Total Square Footage, Bedrooms**
   a. **2640 Sq Ft**
   b. **3 Bedroom**

Answer - 120/60 CFM - (TVR = 120 cfm /CVR = 60 cfm)

ASHRAE 62.2

- ASHRAE 62.2 includes a few more inputs
  - Location for weather
  - Height for stack effect
  - Measured leakage
- Proprietary calculators make the process easy and offer other helpful tools
- This is still just best practice guidelines but a good starting point.



https://www.redcalc.com/ashrae-62-2-2013/

“Continuous” vs Whole Home

- A lot of systems are not actually operated as “continuous”
- Multi speed unit can be sized for low speed to meet minimum requirements, while still having the capacity for spot ventilation and times of increased pollutants
- Lower air flows through HRV/ERV core typically means a more efficient heat/energy transfer.

Temp Mode	°C	°F	Net Airflow (L/s)	Net Airflow (cfm)	Power Consumed (Watts)	SRE	ASRE	Latent Recovery / Moisture Transfer
HEATING	0	32	24	51	52	76	84	0.69
HEATING	0	32	38	81	62	72	78	0.66
HEATING	0	32	56	119	106	67	73	0.60
HEATING	-25	-13	35	74	89	60	63	0.63
COOLING	35	95	38	81	62			0.55

HVI.org

Controls for Intermittent

- Percent time or minutes per hour (20 on/40 off)
- Occupant controlled (plug-in/un-plug) Not recommended
- Continuous with a boost for demand might be the best current option
- Imagine trying to set your heat/ac on a timer? For an entire year

Just unplug it in the summer…

The Future is ~~Now!~~ Coming Soon?

- Why not run ventilation based on measured inputs? Like a t-stat for heating/cooling?
- Air Quality inputs: humidty, CO2, VOC, fine particulates (PM2.5)
- Other inputs: occupancy, open windows, exterior air quality

www.trutechtools.com/Indoor-Air-Quality

www.trutechtools.com/Indoor-Air-Quality

www.trutechtools.com/Indoor-Air-Quality

Issues with Intermittent

- What happens when not in operation, is the system open to outside? This is critical depending on installation.
- "Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating."

-R403.5 Mechanical Ventilation, 2015 MN Energy Code

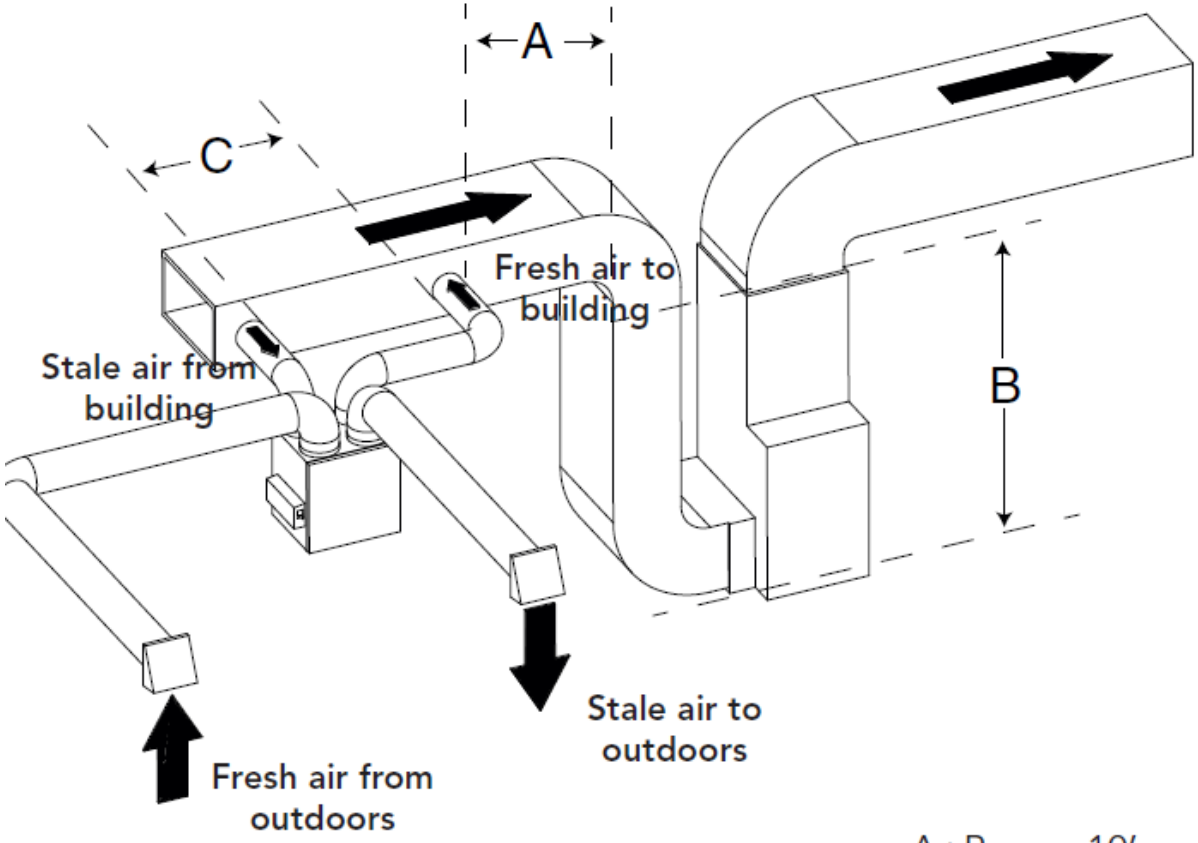
Return/Return, Common Install

Pros:

- Easy to install.
- Secondary filtration

Cons:

- Requires interlock with air handler, which increases electric use
- Does not provide local spot ventilation
- Can result in having uncontrolled supply ventilation.



Broan Install Manual

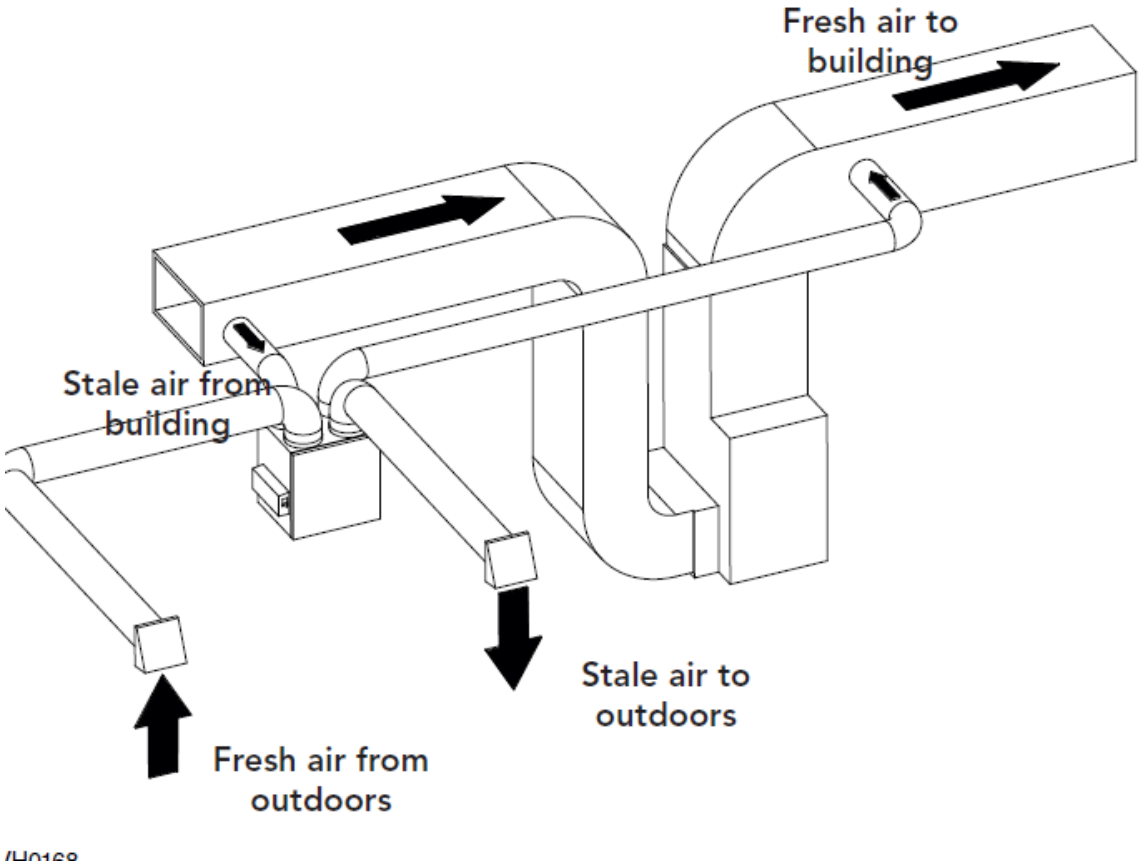
Return/Supply

Pros

- Easy to install.
- Allows for gravity dampers to work on intake and exhaust

Cons:

- May still require interlock with air handler, which increases electric use
- Does not provide local spot ventilation



Broan Install Manual

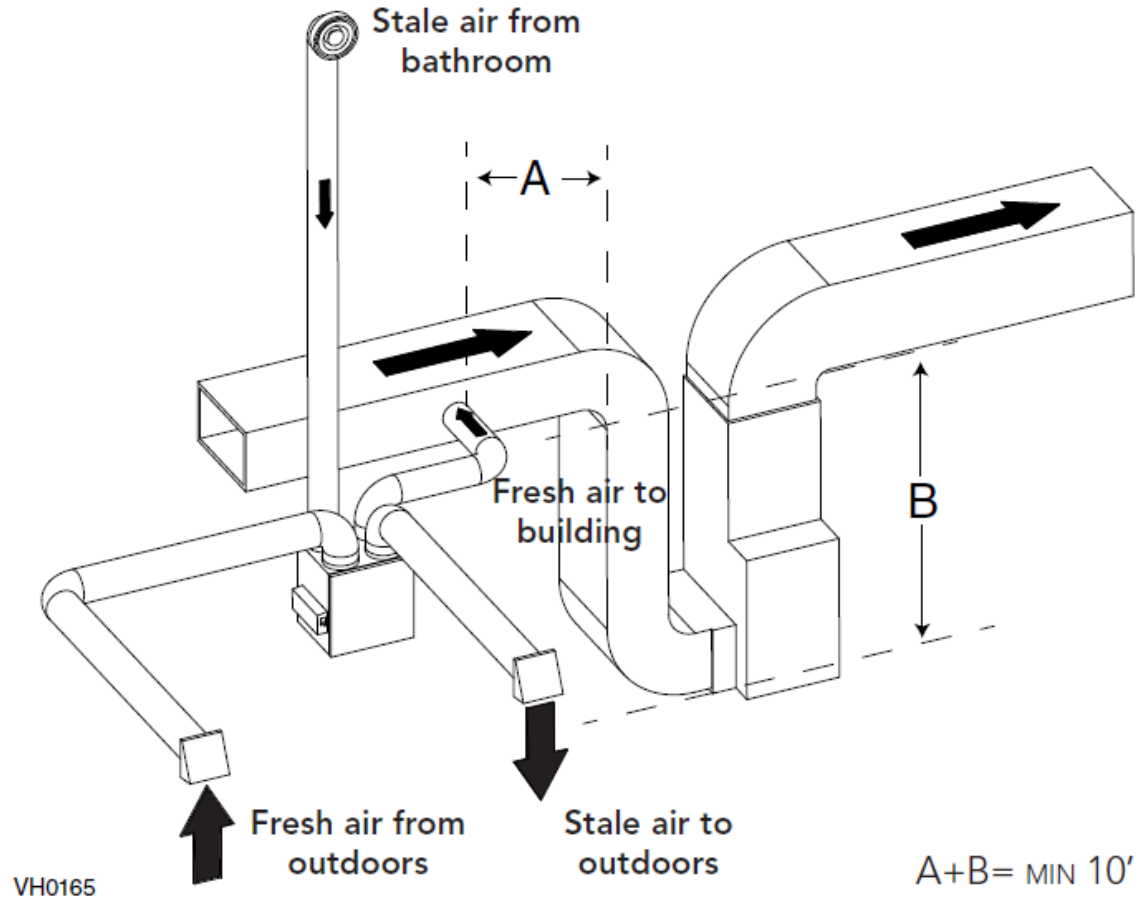
ERV/HRV Spot Ventilation

Pros

- Can replace or supplement point source exhaust fans.
- Recover heat/energy from exhausted air

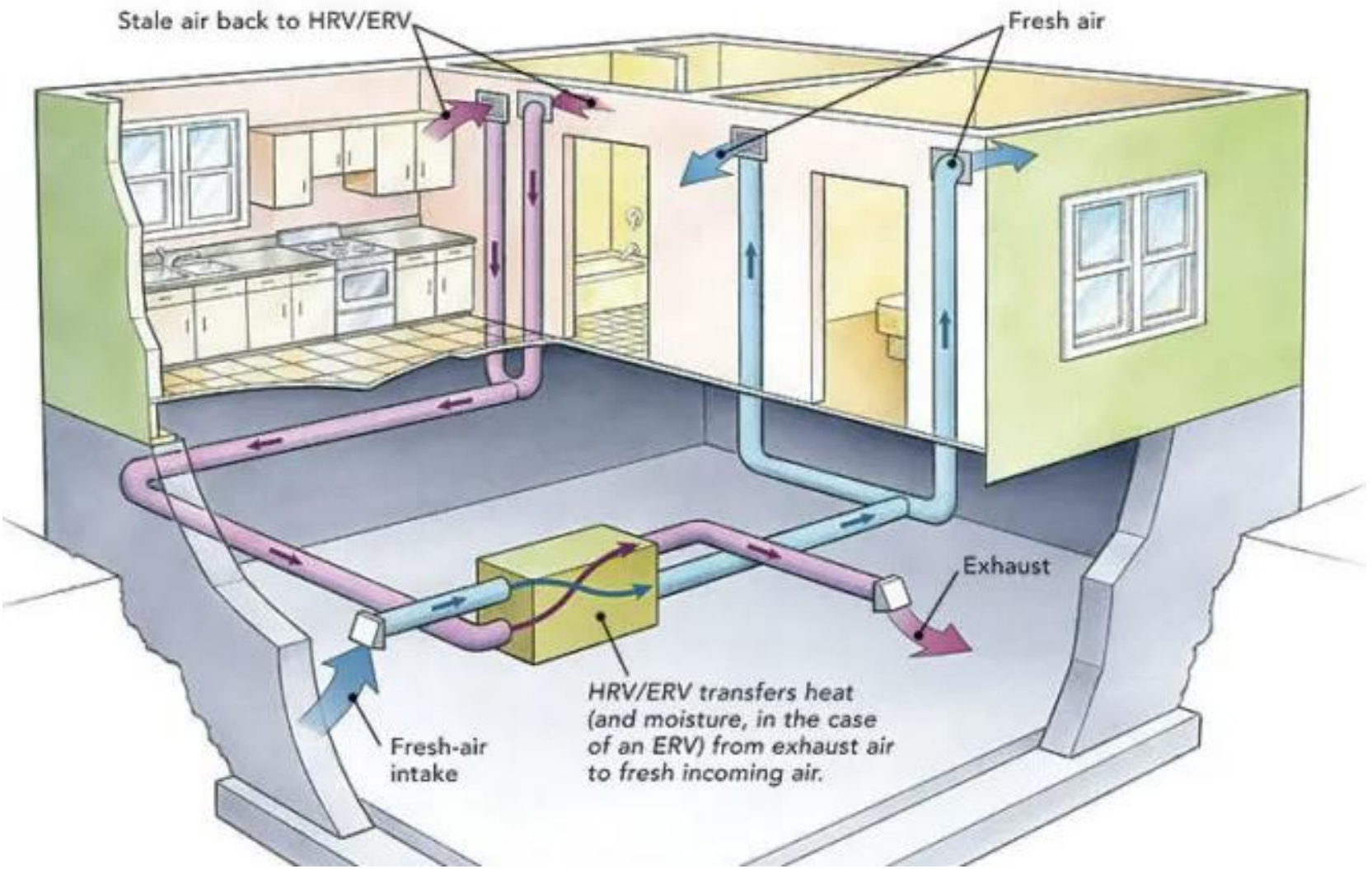
Cons

- May not provide as high of flow during “pollution” events
- When replacing a range hood, you lose “capture efficiency”
- Additional ducting



Broan Install Manual

Fully Ducted is Optimal for IAQ



www.greenbuildingadvisor.com

Whole Home & Spot Ventilation

- Generally, requires a multi speed ventilator
- Controls at exhaust locations that will boost the entire system.
  - Common approach but may not increase exhaust rates where needed the most.
- "Zone Register Terminal" offers ability to increase ventilation rate at a single location.
  - Basically, an adjustable and operable car damper.

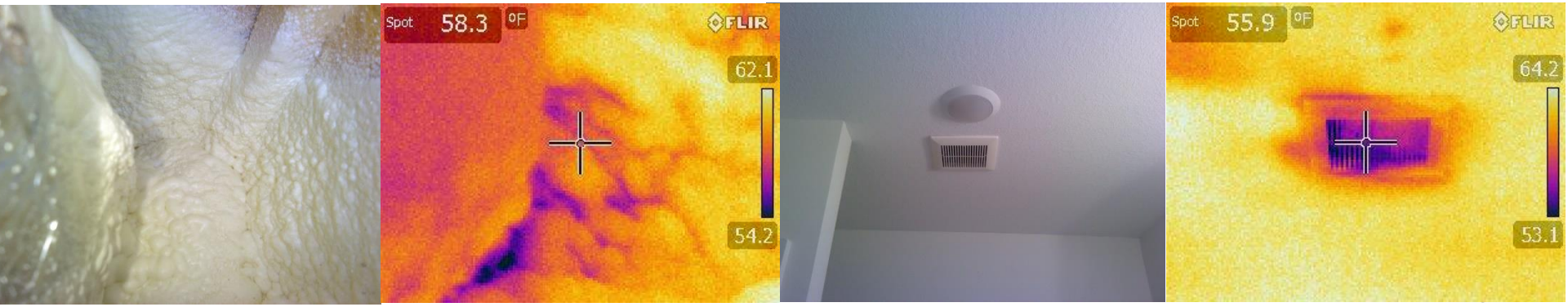
Aldes.com

Commissioning and Education

- Most certifications have quality control
- Flows should be measured, controls should be tested
- Common failures that might go unnoticed
  - Stuck, missing, or incorrect dampers
  - Incorrect ducting connections
  - Imbalanced flows on ERV/HRV and low flows on exhaust
- Occupant education is as important as testing
  - Understanding the importance of ventilation
  - Knowing how the system and controls operate
  - Maintaining the equipment, both occupant responsibilities and professional servicing.

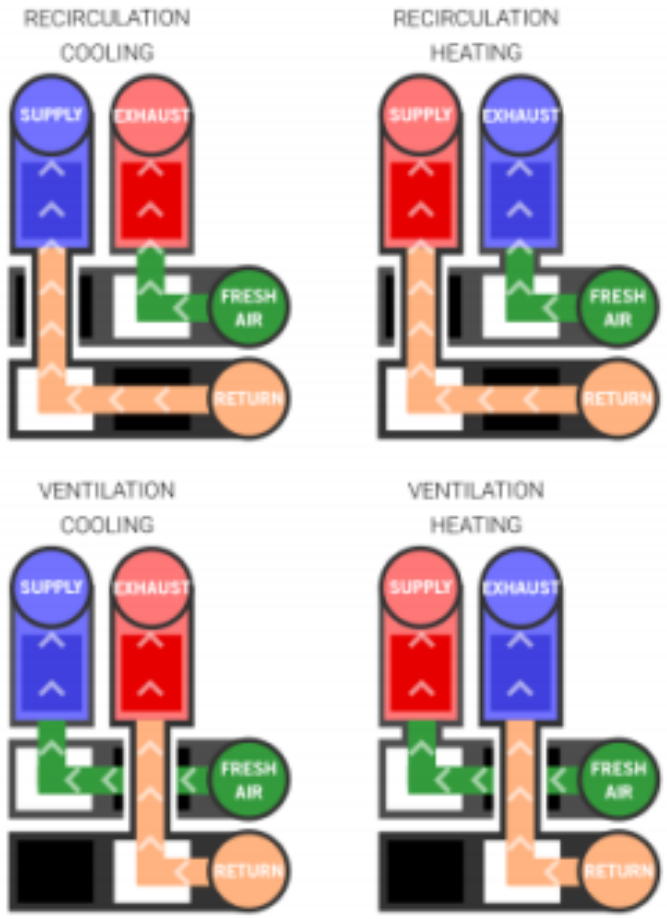
Maintaining Low Loads

- High heat and/or energy transfer of HRV/ERV's mean you get adequate fresh air transfer without sacrificing as much of the energy it took to condition that air.
  - ERV aids low dehumidification of high seer ac
- Fully or partially ducted ventilation system can help lower a buildings air leakage by reducing holes in the envelope. Both intentional and un-intentional.



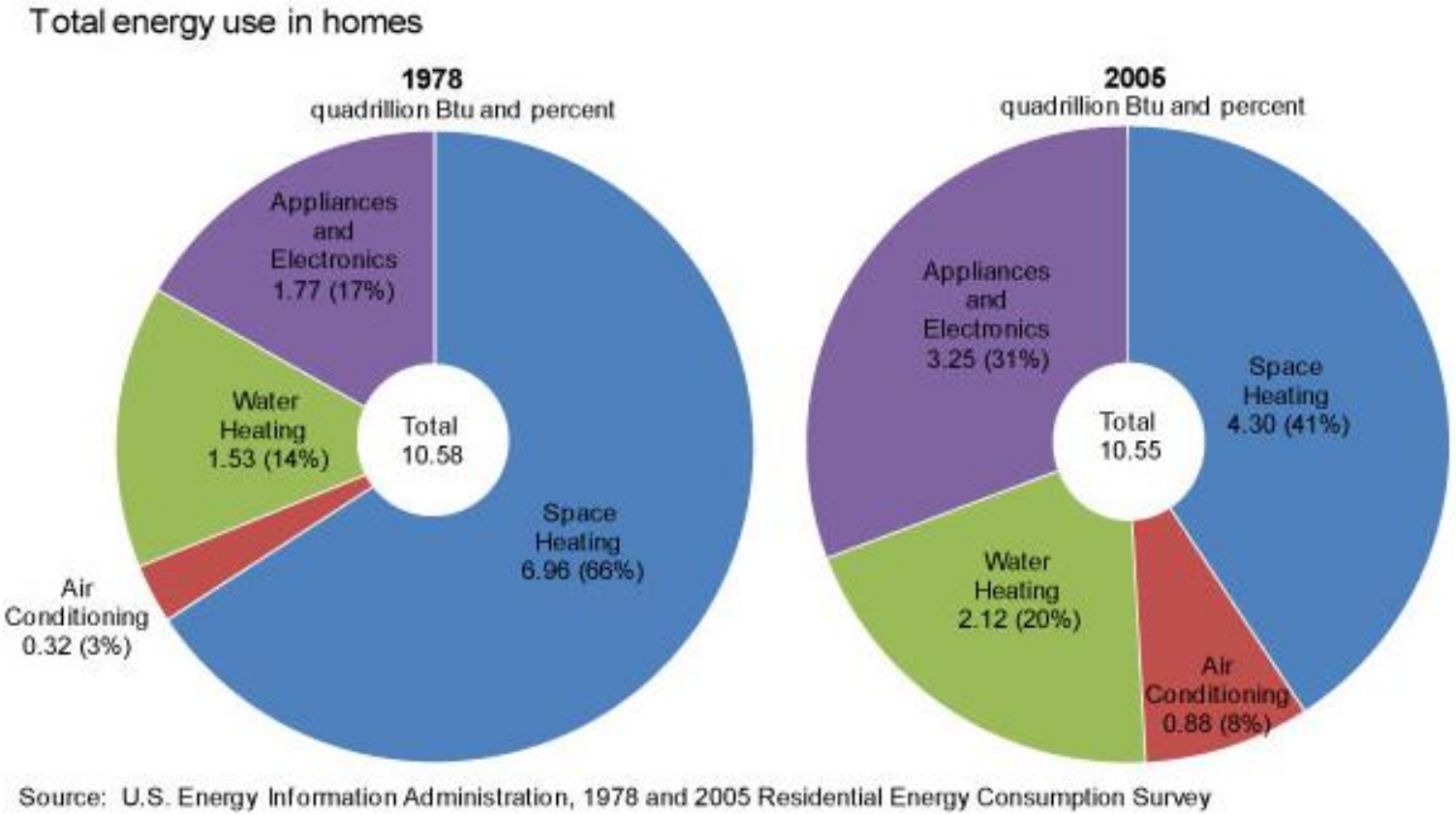
Fully Ducted for Improved Comfort

- Increased air mixing
  - With out running large air handler 24/7
  - Lower air flows decrease chill effect in heating climates
- Code (and best practice) requires fresh air to all bedrooms/habitable space
  - Single or double head mini split
  - Slab heating only
- Shoulder season redistribution & ***conditioning?***
  - A new form of ventilation system uses a heat pump
  - The heat pump is what exchanges heat, not a core like in HRV/ERV
  - This also allows for its own conditioning



https://buildequinox.com/

Appliances for High Performance Electric Homes



ASHP DHW

- Energy Factor “EF” is the ratio of energy output to energy input.
- HPWH’s EF is 2.20 to 2.75, while ERWH EF are .88 to .95
- A lot of research and debate comparing costs of gas WH to HPWH, but for all electric homes the choice is clear.

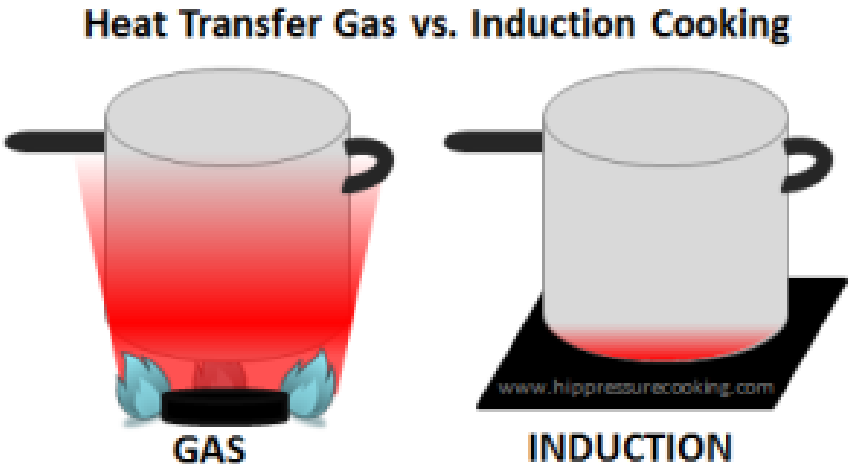
Table 2: Estimated Annual Cost and Performance of HPWH vs ERWH

Water Heater	Daily Hot Water Usage Gallons	Energy Factor	Annual Energy Use KWh	Annual Energy Costs $/year	Install Cost $
Electric Resistance	64	0.93	4721	$567	$650
Heat Pump	64	2.40	1830	$220	$2,000

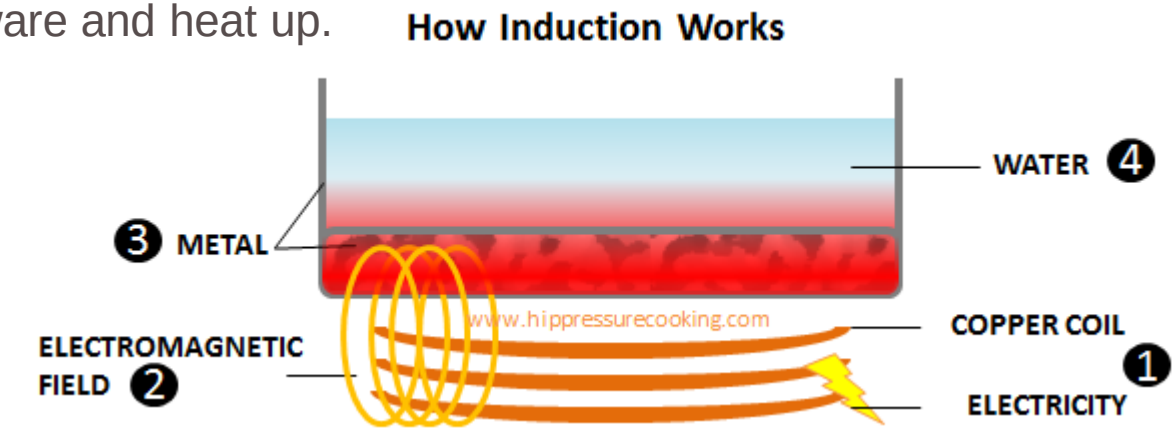
Heat Pump Water Heaters: Savings Potential in Minnesota

Induction: Now we're *not* cooking with gas

1. There is an ***electric current*** that runs through a copper coil which is wound underneath the surface of cooking.
2. An electromagnetic field is generated from the coil in ***a short distance*** from the surface of cooking, which is enough to reach the pot's base.
3. An electric current is induced by the magnetic field and creates forces into the cookware's base within this field. The flow of this current is resisted in the metal of cookware and heat up.



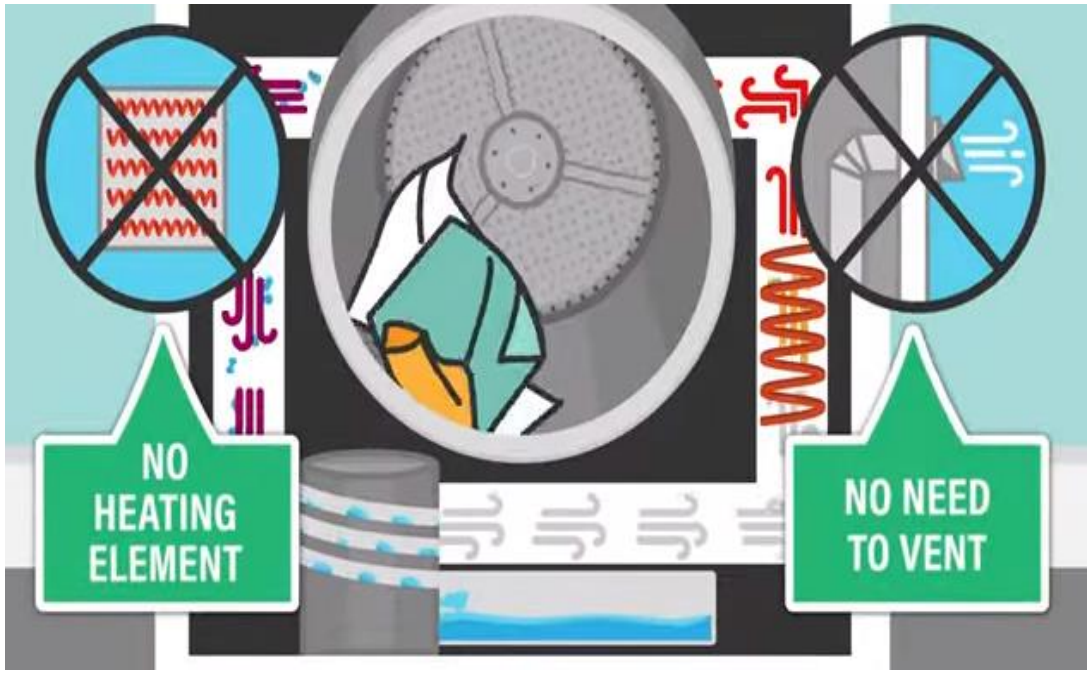
https://www.hippressurecooking.com/



https://www.hippressurecooking.com/

Heat Pump Dryer

- Combined Energy Factor or CEF of ventless heat pump dryer is 5-10
- CEF for the best EnergyStar vented electric resistance is 4.3
- Uses less electricity and does not require an additional envelope penetration
- *HP dryer = ventless, but ventless ≠ HP



Energystar.gov

Energy Star – Choose Wisely

ENERGY STAR

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Home » Certified Products » Product Finder

ENERGY STAR Product Finder

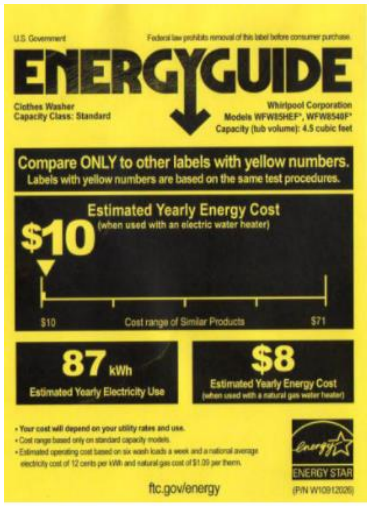
Languages: En

Find all the information you need to start shopping for ENERGY STAR certified products, including product details, rebates, and retailers near you. Products that earn the ENERGY STAR label meet strict energy-efficiency specifications set by the U.S. EPA helping you save energy and money while protecting the environment.

https://www.energystar.gov/productfinder/

Appliances

- Air Purifiers (Cleaners)
- Dehumidifiers
- Residential Clothes Dryers
- Residential Clothes Washers
- Residential Dishwashers
- Residential Freezers
- Residential Laundry Sets
- Residential Refrigerators



Choose Oncely?

HELPFUL CERTIFICATIONS TO ENSURE A GOOD QUALITY CONTROL PROCESS

Phil Anderson

Energy Ratings and Certifications

- Quality Control
  - Pre-design review can catch missed opportunities
  - Multiple onsite visits to verify proper installation of energy efficiency measures
  - Onsite testing of building shell and HVAC systems help ensure targets are hit and systems function as designed
- Pathways to help achieve energy efficiency
  - Certifications have built in guidance to help with:
    - Building shell efficiency
    - HVAC equipment, proper sizing, and quality design
    - Indoor air quality

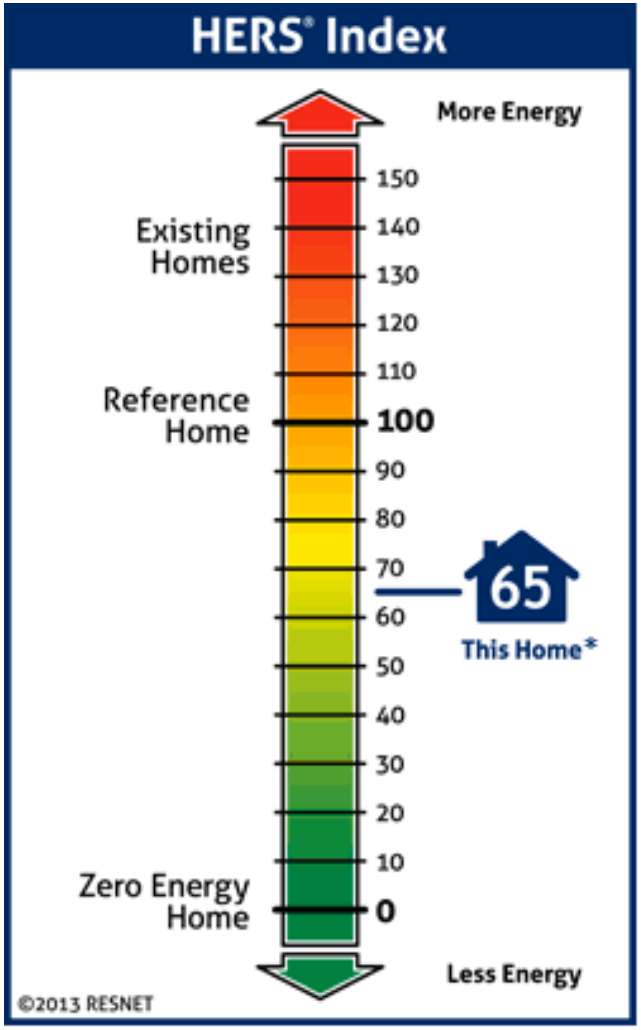
Energy Ratings and Certifications

Four common energy rating types

- RESNET - HERS Index Rating
- ENERGY STAR New Homes
- DOE Zero Energy Ready Homes
- PHIUS+

RESNET Energy Rating - HERS Index

- RESNET certified energy rater makes 1-3 visits to home during construction
  - Framing
  - Insulation – Pre-drywall
  - Final – Blower door, duct test, document appliances
- Home is modeled through software to get HERS Index
  - RemRate
  - Ekotrope



*Sample rating representation.

RESNET Energy Rating - HERS Index

- Way to compare homes energy usage between homes
- HERS Index of 100 is a reference home, which is equivalent to a home built to 2004 IECC
- HERS Index 0 uses no energy
- Typical home built today in Minnesota can score between 45 and 55, very efficient ones in the 30's
- Of the 8,678 MN homes rated in 2020, the average score was 50
- More info at www.resnet.us

RESNET®
RESIDENTIAL ENERGY SERVICES NETWORK

ENERGY STAR New Homes

- EPA sponsored new home program
- Typically use 15-30% less energy
- ENERGY STAR certified energy rater makes 2-3 visits
- Builder and HVAC contractor go through training program
- HVAC contractor required to properly size systems, resulting in better comfort

ENERGY STAR New Homes

- 3 key checklists followed:
  - Thermal Enclosure
  - HVAC Design and Quality Installation
  - Water Management
- ENERGY STAR has excellent brand recognition and good way for builder to set themselves apart from other builders
- More info at: www.energystar.gov/newhomes

DOE Zero Energy Ready Homes

- Follows ENERGY STAR New Homes checklists
- Are at least 40-50% more efficient than new homes
- ENERGY STAR qualified appliances and fixtures
- Use high performance windows
- Meet IECC 2015 code levels for insulation
- Ductwork inside the envelope

DOE Zero Energy Ready Homes

- Hot water distribution system that provides rapid hot water to the homeowner
- Indoor air quality certification through EPA's Indoor airPlus program
- Make home PV-ready if climate has significant solar insolation
- More info at: http://energy.gov/eere/buildings/zero-energy-ready-home

PHIUS Certification

- Greater shell insulation levels
- Tighter construction
- Continuous ventilation key
- Follows and earns ENERGY STAR, Indoor airPLUS, and DOE Zero Energy Ready Home certifications
- Home modeled through HERS rating software and a Certified Passive House Consultant (CPHC) does WUFI hygrothermal modeling also
- More info can be found here: www.phius.org

PHIUS Certification

IECC 2009	IECC 2012	ENERGY STAR v3	ENERGY STAR v3.1	ZERH	PHIUS+	PHIUS+ SourceZero
						Source Zero Renew-able Energy System
					Balanced Ventilation HRV/ERV	Balanced Ventilation HRV/ERV
				SOLAR READY Depends on climate	SOLAR READY **ALWAYS**	SOLAR READY **ALWAYS**
				Eff. Comps. & H2O Distrib	Eff. Comps. & H_2O Distrib	Eff. Comps. & H_2O Distrib
				EPA Indoor airPLUS	EPA Indoor airPLUS	EPA Indoor airPLUS
				Ducts in Condit. Space	Ducts in Condit. Space	Ducts in Condit. Space
		HVAC QI w/WHV	HVAC QI w/WHV	HVAC QI w/WHV	Micro-load HVAC QI	Micro-load HVAC QI
		Water Management	Water Management	Water Management	Water Management	Water Management
		Independent Verification	Independent Verification	Independent Verification	Independent Verification	Independent Verification
IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2009 Enclosure	IECC 2012 Enclosure	IECC 2012/15 Encl./ES Win.	Ultra-Efficient Enclosure	Ultra-Efficient Enclosure
HERS **85-90**	HERS **70-80**	HERS **65-75**	HERS **55-65**	HERS **48-55**	HERS **35-45**	HERS **< 0**

Image from:
https://www.phius.org/media/W1siZiIsIjIwMTcvMDMvMDkvcnp5eDcxbmNuX1BlSVVTX1N0YWlyY2FzZV9GaW5hbC5naWYiXV0?sha=0b997e91

AVAILABLE INCENTIVES THROUGH UTILITIES

Phil Anderson

Utility Rebates

- All electric new homes comprehensive rebates
  - Minnesota Power – Up to $4000 per home, plus free plan review and on-site visits
- Other new home comprehensive rebates
  - Xcel Energy – Up to $2,000 per home
- Minnesota ASHP Collaborative
  - Has listings of all the electric utility ASHP rebates available in MN
  - www.mnashp.org/utility-rebates

MN Power New Construction Energy Efficiency Program

- Minimum Requirements to Participate:
  - Home will be heated primarily with electric heat.
  - Installing an Energy/Heat Recovery Ventilator (ERV/HRV) with a minimum sensible recovery efficiency (SRE) of 60%
- Free Program Offers:
  - A plan review prior to construction
  - On-site inspection during construction to help identify energy efficiency opportunities
  - A final home performance inspection that includes a building air-tightness (blower door) test and infrared thermal scan (if temperature difference allows)

Utility Rebate Examples

Utility	ASHP Rebate	Requirements
Minnesota Power	Ductless ccASHP - $1,000 Ducted ccASHP - $1,000	SEER 15 and HSPF 9 SEER 15 and HSPF 10
Otter Tail Power	ASHP - $400 per ton ccASHP-$500-900 per ton	SEER 15 and HSPF 8.5 SEER 15 and HSPF 10
Connexus Energy	Ducted ASHP $480-$630 Ductless ASHP $300	SEER 14.5-16 SEER 16+
Xcel Energy	Ducted - $150-$450 Ductless - $200 per condensing unit	SEER 14-16 SEER 16+

CASE STUDIES

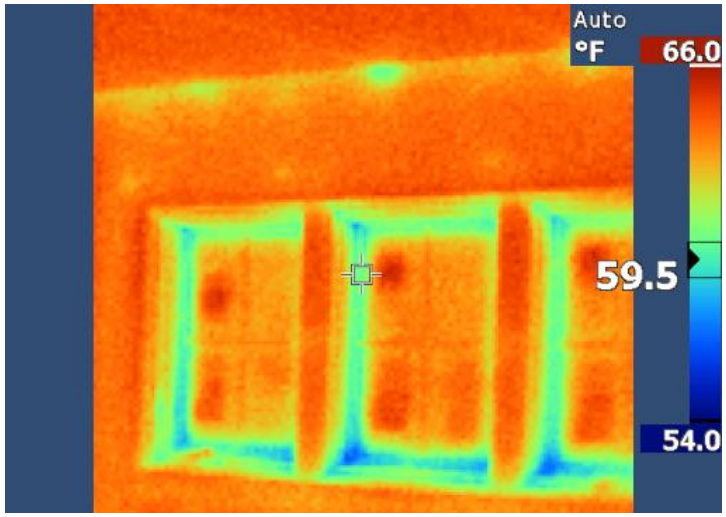
Real world examples of high performance electrically heated homes

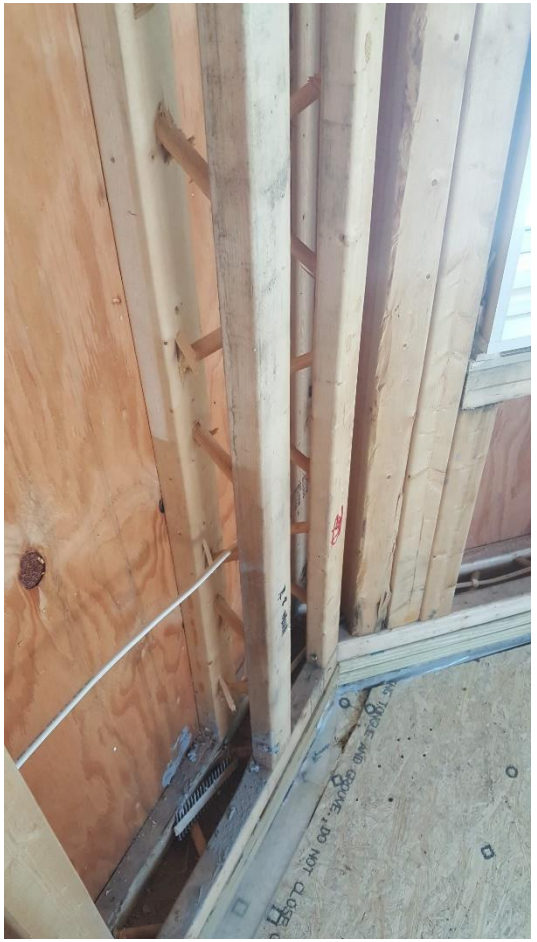
Phil Anderson

Single Family Electric Home

- Description – Walls R-32, triple pane windows, .66 ACH50
- Size – 4,795 sq. ft., 3 bedroom, HERS 29, -8 with solar
- HVAC System
  - Geothermal heat and cool – 3.1 COP
  - Heat pump H2O heater - 3.61 EF
  - ERV with ducted pickups
- DOE ZERH 2020 Housing Innovation Award Winner

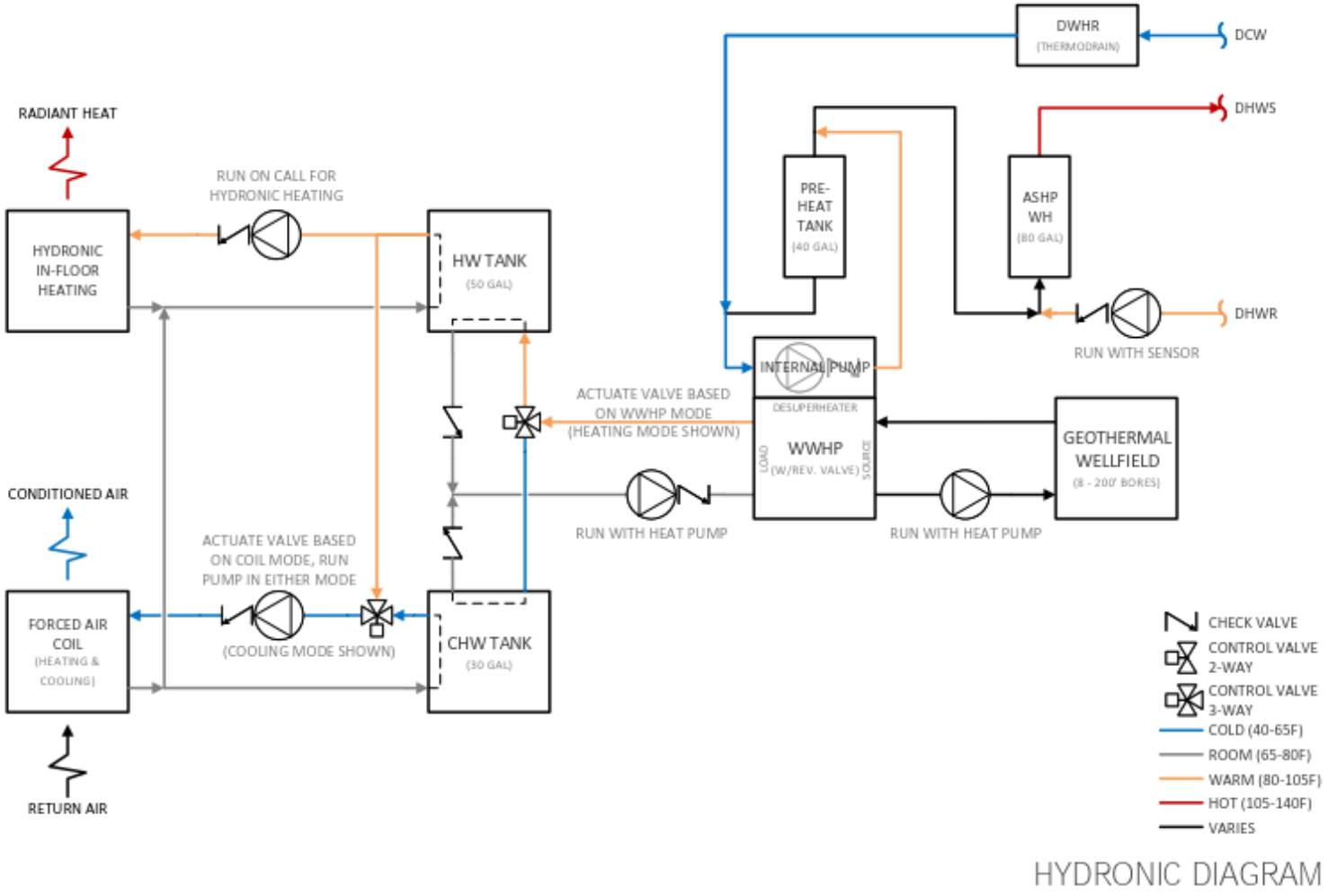
Single Family Electric Home





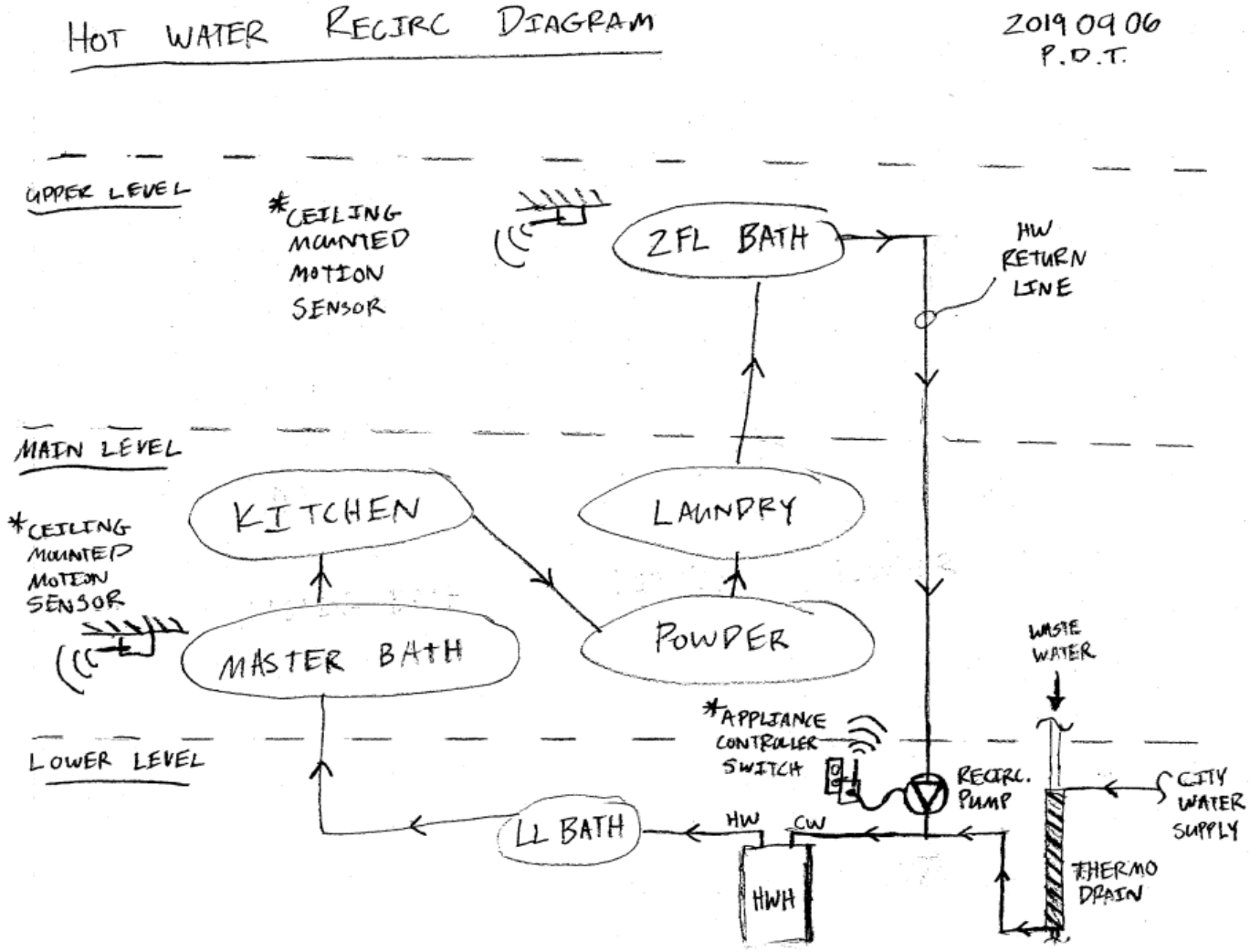
Single Family Electric Home

Single Family Electric Home



HYDRONIC DIAGRAM

Single Family Electric Home



Single Family Electric Home

- Description – Walls R-55 double stud wall, ICF foundation R-38, R-80 Ceiling, R-30 slab, Triple pane windows, .2 ACH50
- HERS 28 pre-solar, 7 with solar
- Size – 5,833 Sq. Ft., 3 level with 11 kW solar array
- HVAC System –
  - 1 Electric Forced Air (Heat Pumps 11 HSPF and 17.8 SEER)
  - Electric plenum and wood pellet stove for backup
  - Heat pump water heater 3.7 UEF
  - Fully ducted ERV

Single Family Electric Home

Single Family Electric Home

Very Large Family Home

- Description – Walls R21 cavity w/R10 continuous, Triple pane windows, 1.1 ACH50
- HERS 41 pre-solar, 24 with solar, DOE ZERH cert
- Size – 8,200 Sq. Ft., 4 level with 12 kW solar array
- System – 3 Dual Fuel Forced Air (Heat Pumps ~10 HSPF and 17 SEER with Natural Gas 97.3 AFUE), 1 Minisplit on upper lookout room

Very Large Family Home

- Owner/Builder feedback
  - Was able to meet the homeowner's goals of efficient electric heat
  - Multiple systems of variable heating cooling allow for even comfort
  - Smart t-stats allow HVAC contractor to monitor system remotely
  - Cost of electric heat priority cost shocked client in cold winter

Smaller Retirement Home

- Description – All electric, super insulated, passive house designed, 19,000 lbs of cellulose insulation, air tight, slab on grade, 10kw solar array, HERS 34 w/o solar, HERS -6 with solar,
- Size – 2052 Sq. Ft.
- System – 2 outdoor units, 2 heads-one up/one down, electric off peak backup heaters, sealed combustion wood stove

Smaller Retirement Home

Client feedback

- Been using heat pumps for 5 years, working well no complaints.
- Use off peak heaters for much of load and wood stove for backup heat.
- Passive solar design of home keeps quite warm during the day, no need for much heat on sunny days.
- When heat pump on, typically using less than 1,000 watts, very low load, only puts out what needed. On 0 degree day, getting 85 degree air from wall head.
- 9 of 12 months, utility pays them.

Small Duplex

- Description – Side by Side slab on grade Duplex, 1 bed, 1 bath each side, exterior insulation
- DOE's Zero Energy Ready Home rating, HERS 43
- Size – 530 Sq. Ft. each side
- System – 1 outdoor 1 ton unit per side, ducted system integrated with HRV
- 2 small wall mounted electric heaters as backup

Accessory Dwelling Unit (ADU)

- Description – 650 Sq. Ft., 1 bed/1 bath ADU built above garage in back of city lot
- System – 2.5 ton, 2 wall unit heads in unit, 1 head in garage below.

Accessory Dwelling Unit (ADU)

- Client feedback
  - Estimated heating cost of $500-$600 last October-April
  - Remotes for heads are finicky and not user friendly, looking to replace with hardwired thermostat
  - Thinks sizing for code insulated building for heating led to some oversizing for AC. Had some dehumidification issues
  - Went with electric baseboard for backup heat, only needed once during the polar vortex winter.

THANK YOU!

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