Heat Pump Ready Manufactured Homes

Breathing new ideas into barely evolving industry

Product Council

December 5, 2023

Presented by

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Outline

- Context & NW Update
  - NW Manufactured Homes
  - HUD, EPA, and DOE – Standards and Specs
  - HPMH and NEEM+
  - Current Market
- HP Ready Manufactured Homes
  - Research
  - Specification
- How does it fit with Federal Tax Credits

Context

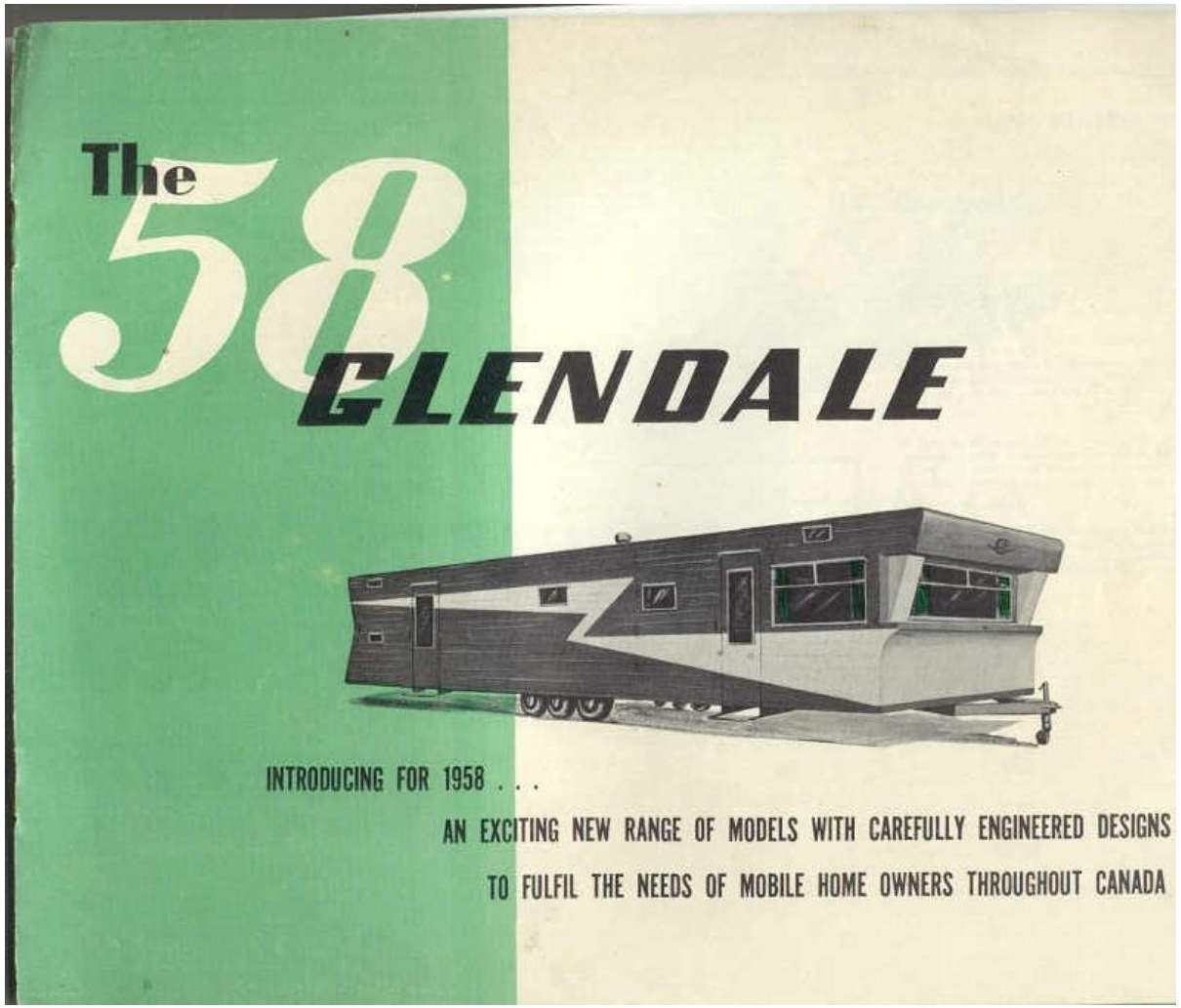
Many People Live in Manufactured Homes

- 6.3% of the nation's housing stock
- 14% of rural housing stock.
- Median income of MH owners is $35k, site-built is $70k.
- 2/3 of MH owners earn less than $50k, compared to 1/3 of site-built owners earning less than $50k

Fannie Mae, Manufactured Housing Landscape 2020

- In some rural counties of the NW, Manufactured homes represent over 30% of the existing housing stock

Origin



HUD Code

Today's Manufactured Home

https://www.bobvila.com/articles/8405-mobile-homes-then-and-now/#.WPuld5V1rTs

Today's Manufactured Home

http://mobilehomeliving.org/5-great-manufactured-home-interior-design-tricks/

History of EE Manufactured Homes

- Model Conservation Standards 1987 - 1991
  - Research Phase, utilities began industry engagement
- MAP – Super Good Cents 1992 - 1995
  - 50,000 homes built under MAP
  - Utility support led to HUD standard change in 1994
- NEEM Housing Program 1996 to present
  - Industry funded
  - Utility incentives promote program uptake
  - Homes branded Super Good Cents and Natural Choice (gas heated), later transitioned to Energy Star and Eco-rated

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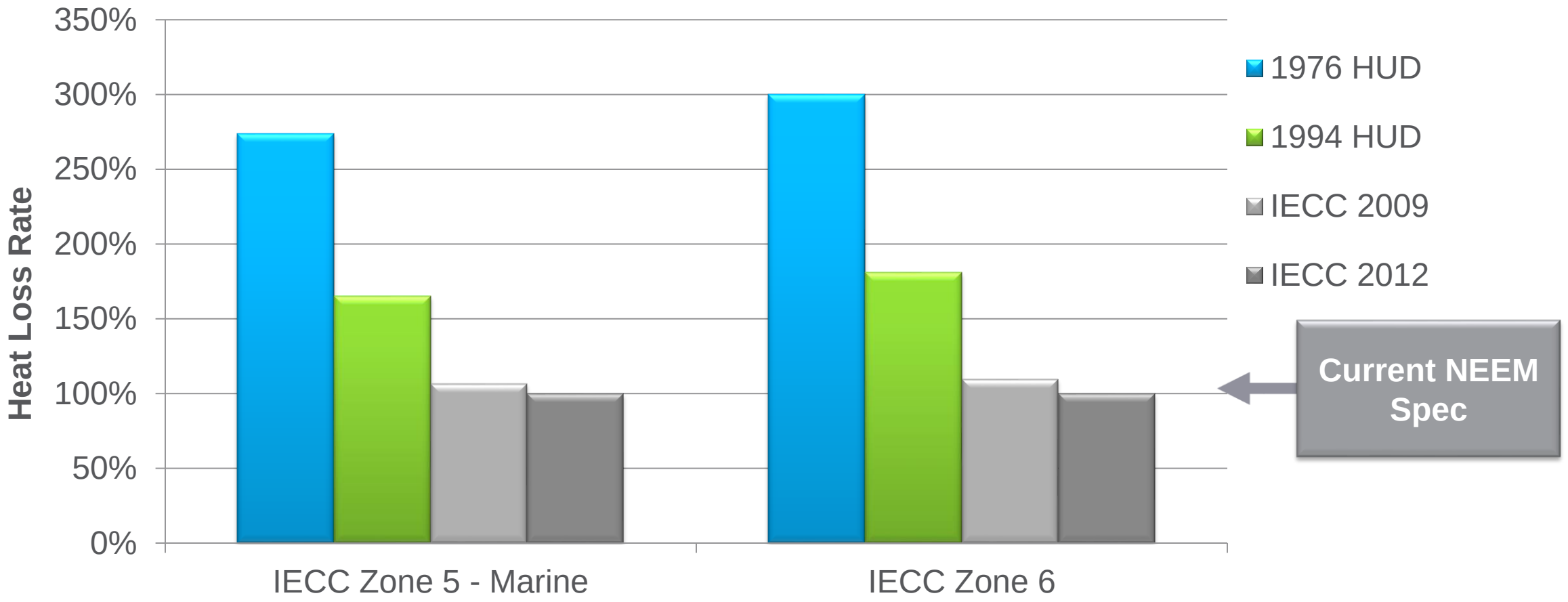
HUD Code has Not Moved in Nearly 30 years



*** Bonneville Power Administration Analysis**

EPA ENERGY STAR Requirements

- Currently version 2.0
- Proposed version 3.0
  - Basis for DOE Zero Energy Ready pilot certification
  - Minimum requirements
  - Points given for different measures, values vary be climate zone

- IRS 45L tax credits require ENERGY STAR certification

2012-2015 BPA Funded
8 High Performance Demos

- Six Factories Participated
- NEEA Provided Monitoring
- Conclusion
  - Zero Energy potential achieved
  - Factories can build them without retooling
  - Considerable additional cost

Maximum Attic Insulation

Exterior
Rigid
Insulation

Having no ducts in floor

allows more insulation

HPWH Decoupled
from home interior

Window Flashing

+

Triple pane windows

DHPs in Manufactured Homes

- Not a new concept
- Limited location where the outdoor unit can be mounted (trailer end)
- Limited volume each is treated as a custom project

R-19 Window Research

- Market Barriers
  - Not transparent
  - Color clashes with shag carpet

Poor Factory Uptake of this *high-performance* measure

Current NEEM Program

NEEM provides verification of factory processes

- 30+ years of field and factory expertise and collaboration
- Detailed drawings and criteria
- Bi-Monthly factory inspections and staff training
- Field Diagnostics and problem resolution

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Detailed Specifications

Floors and Duct Systems

Figure 1
TRANSVERSE AND LONGITUDINAL FLOOR SYSTEM INSULATION

sure floor insulation matches R-value indicated on the unit
der.
oid insulation compression and gaps. Compression reduces the
value of insulation, lowering its resistance to heat loss. Gaps
ovide easy pathways for heat loss and reduce energy efficiency.
sure rim joists are completely insulated around the entire
imeter of the floor. Adequately insulating the floor bays may
uire installation of full-width batts in the front and rear floor bays.
intain loft of insulation around plumbing, mechanical, and
ctrical components.

ction 2.1.5

Figure 27
FLAT CEILING INSULATION, VENTING, AND AIR SEALING

- Cover the top plate of the exterior wall with insulation.
- A vapor retarder of one perm or less must be installed on the warm side of the roof cavity. If kraft-faced insulation is used, ensure that the kraft facing completely covers the ceiling between the trusses and that there are no tears. If a spray-on retarder is used, use a film gauge to measure for correct thickness.
- Seal all ceiling penetrations — around vent pipes, wires, fans, and light cups.

See Technical Specifications section 2.1.3, 2.4.1.3

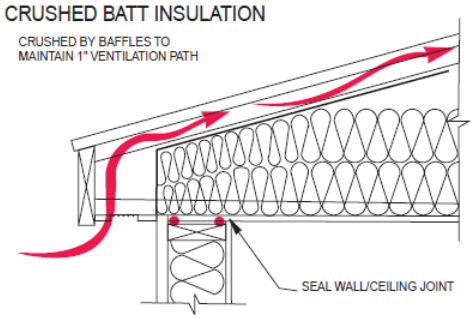


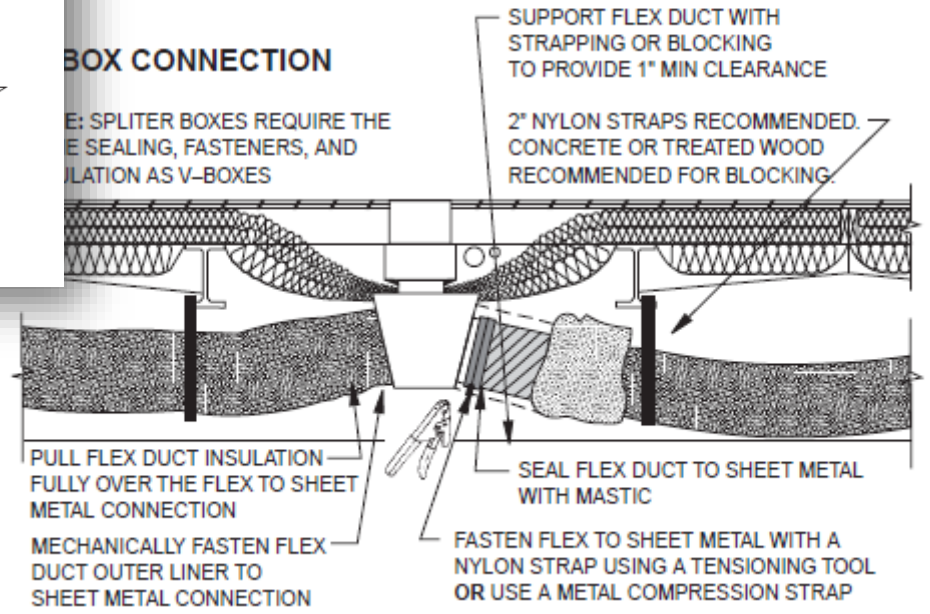
Figure 12
CROSSOVER DUCT CONNECTIONS

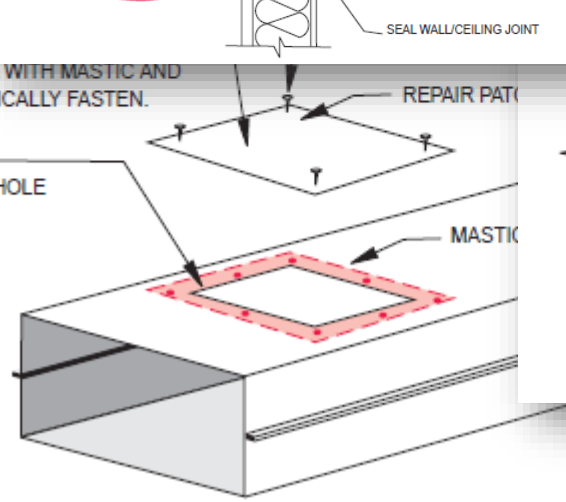
hen the correct crossover duct materials are not shipped with the
me, the crossover connection on site is usually done badly. See
EM specifications section 5.6 for crossover duct materials that
to be shipped with the home.

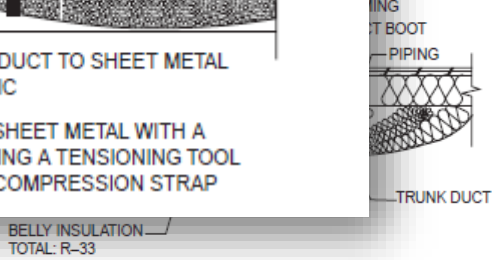
Technical Specifications section 2.1.7, 5.6

BOX CONNECTION

E: SPLITER BOXES REQUIRE THE
E SEALING, FASTENERS, AND
LATION AS V–BOXES





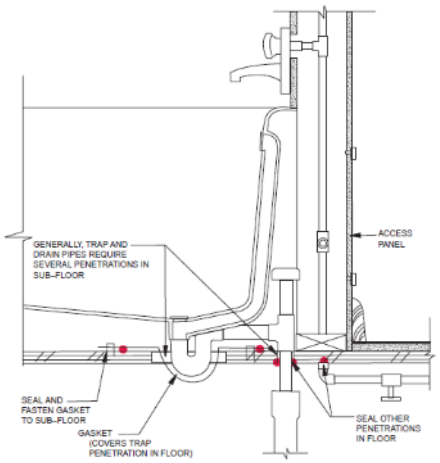


2x6 FLOOR FRAMING

Figure 14
TUB P-TRAP SEALING: TRAP ARM ABOVE FLOOR

- Seal all plumbing, electrical and mechanical penetrations through the floor to reduce heat loss and prevent condensation and moisture damage in floor cavity.
- Floor penetrations for tub trap arms are the most difficult to consistently seal. A well thought-out strategy is required.
- If a gasket is used to seal around the tub drain, seal the gasket to the floor and the drain.
- Consider adding an inspection procedure if the gasket is routinely cut for trap inspection or repair. Tape all cuts before shipping the home.

See Technical Specifications section 2.4.1.3



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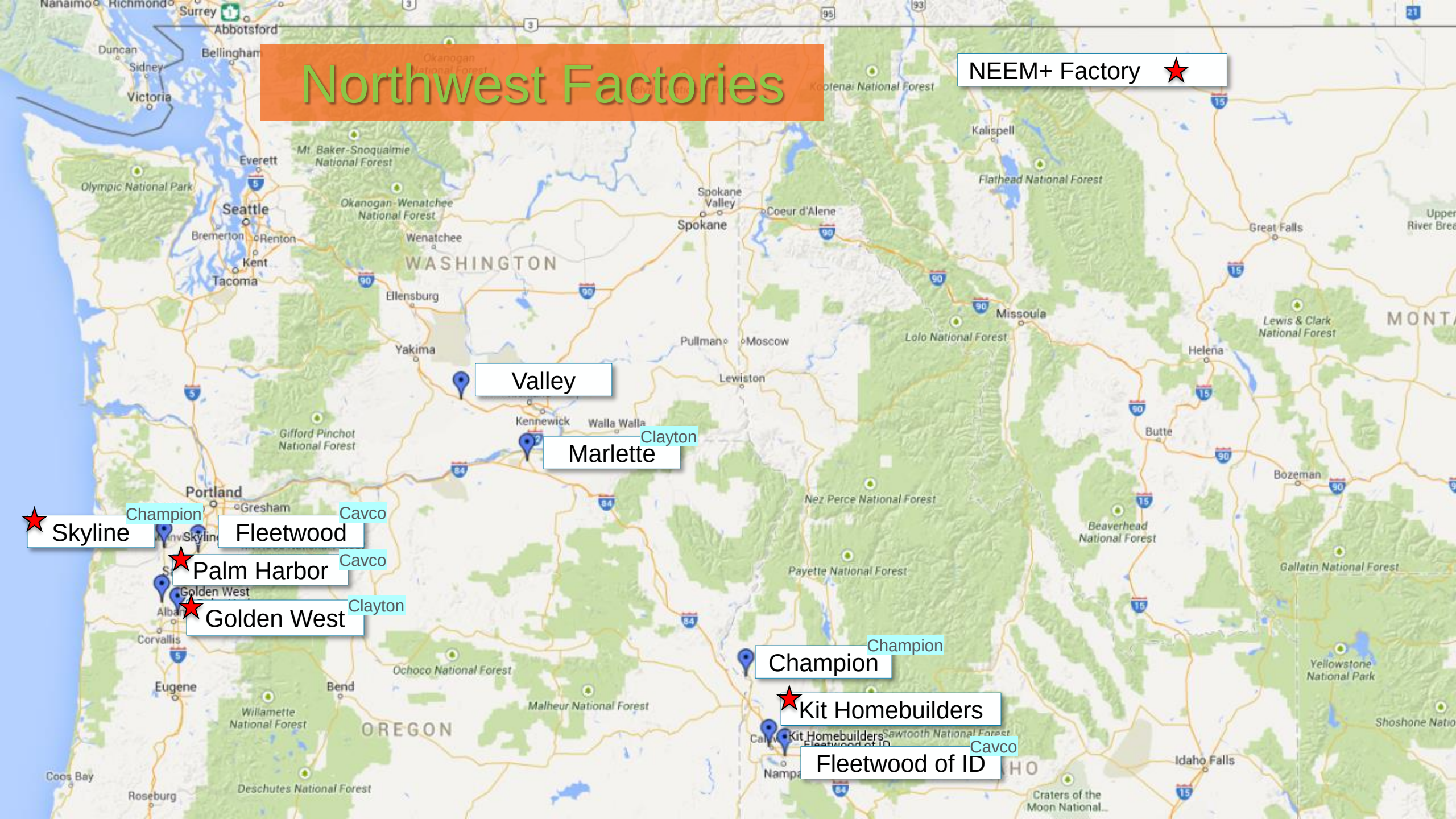

Northwest Factories
NEEM+ Factory
Valley
Marlette
Clayton
Champion
Skyline
Cavco
Fleetwood
Palm Harbor
Cavco
Golden West
Clayton
Champion
Champion
Kit Homebuilders
Kit Homebuilders
Cavco
Fleetwood of ID
WASHINGTON
OREGON
Seattle
Spokane
Portland
Yakima
Kennewick
Walla Walla
Pullman
Moscow
Lewiston
Missoula
Kalispell
Bozeman
Butte
Helena
Great Falls
Idaho Falls
Eugene
Bend
Corvallis
Golden West
Olympic National Park
Mt. Baker-Snoqualmie National Forest
Okanogan-Wenatchee National Forest
Gifford Pinchot National Forest
Ochoco National Forest
Malheur National Forest
Willamette National Forest
Deschutes National Forest
Nez Perce National Forest
Payette National Forest
Beaverhead National Forest
Gallatin National Forest
Lolo National Forest
Flathead National Forest
Kootenai National Forest
Lewis & Clark National Forest
Yellowstone National Park
Sawtooth National Forest
Craters of the Moon National...
Coos Bay
Roseburg

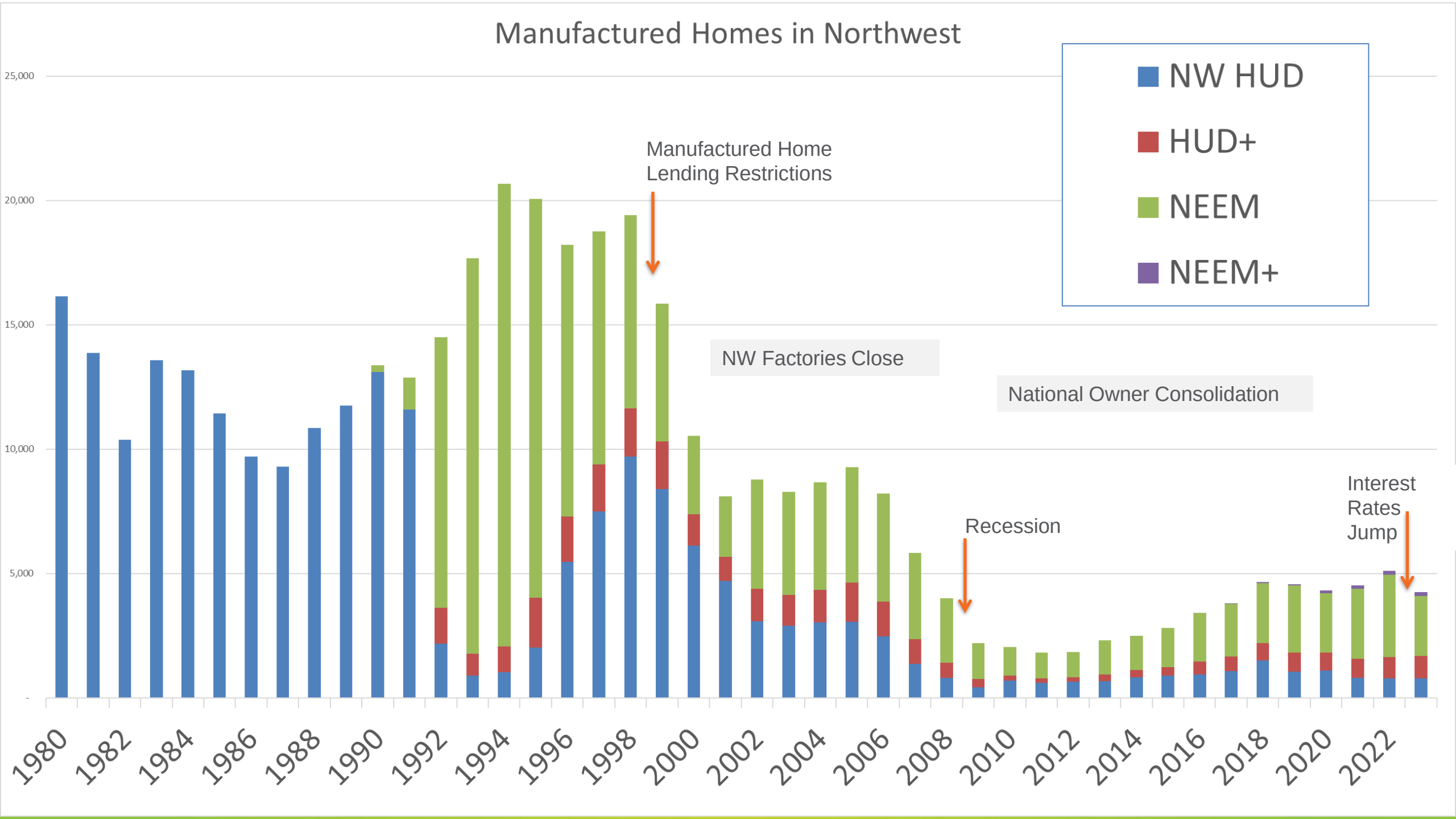
NW Brands

- NEEM 1.1 = ENERGY STAR
- NEEM 2.0 = NEEM+
  - ~ 10% better savings

NORTHWEST ENERGY EFFICIENT MANUFACTURED HOUSING PROGRAM

Technical Specification Comparison between NEEM ver. 1.1 and ver. 2.0

	NEEM ver. 1.1, branded as **ENERGY STAR®**	NEEM ver. 2.0, branded as **ENERGY STAR with NEEM+**
Reference Path Insulation		
Ceiling	R-40	R-44 (or R-40 with improved floor)
Walls	R-21 standard framing	R-21 Intermediate framing w/insulated headers
Floor	R-33	R-33 (or R-33/52 with R-40 ceiling)
Windows	U-0.35	U-0.25 (or U-0.28 w/ added insulation)
Skylights	U-0.50	U-0.50
Entry Doors	U-0.19	U-0.19
Overall Average U-value	0.053	0.049
Building Tightness	5.0 ACH @ 50 Pa, via standard NEEM measures	4.0 ACH @ 50 Pa, via expanded air sealing measures
HVAC Measures		
Duct System	Mastic, 0.06 CFM50/ft3 total	Mastic, 0.06 CFM50/ft3 total
Crossover duct	R-8, elbows, tensioned straps	R-8, elbows, tensioned straps
Thermostat	Programmable	Wi-Fi Connected “Smart”
Whole house ventilation	32 Watts, <1 Sone	17 Watts, <1 Sone
Lighting	Not Specified	LED Throughout
Appliances, ENERGY STAR	Dishwasher	Dishwasher and Refrigerator
Moisture Management	Not Specified	Building wrap & door/window flashing


Manufactured Homes in Northwest
NW HUD
HUD+
NEEM
NEEM+
Manufactured Home Lending Restrictions
NW Factories Close
National Owner Consolidation
Recession
Interest Rates Jump
25,000
20,000
15,000
10,000
5,000
-
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

How NEEM Works

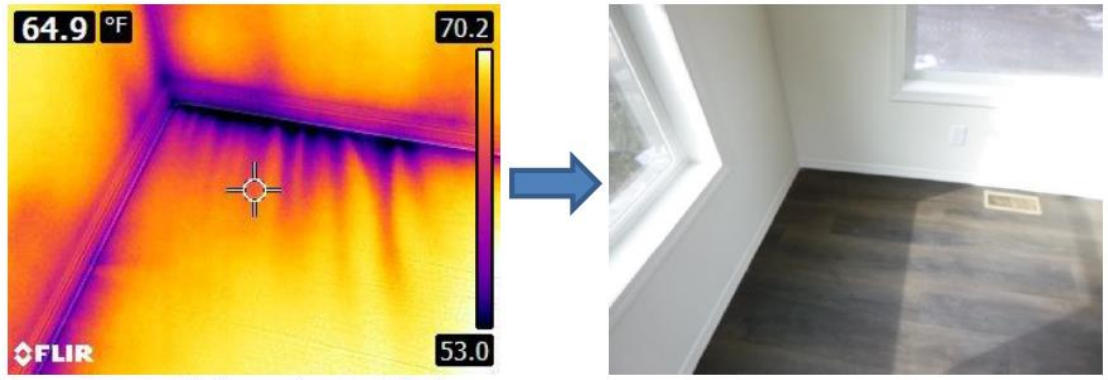
- All participant factories agree to same standard
- Factories pay flat fee per home certified ($100-$150)
- NEEM provides technical support upon request
- NEEM supports dealers with value proposition resources

Training

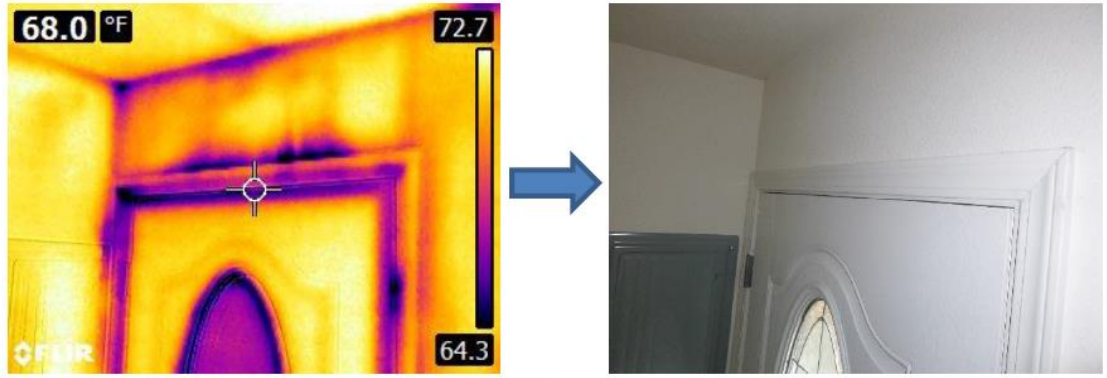
- Duct sealing and testing
- Production crew
- QA/QC staff
- Sales training
  - Factory representatives
  - Retailers

Onsite Evaluations

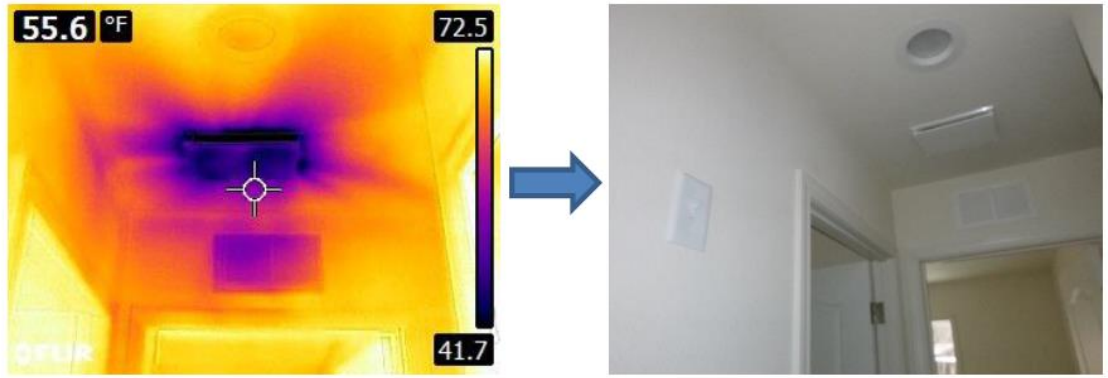
- High bill complaint customer site visits ~ 10 per year
  - Duct leakage
  - Blower door
  - IR camera
- 2% Field QA of all NEEM certified homes



Thermal image with Blower Door – air leakage at bottom plate of wall

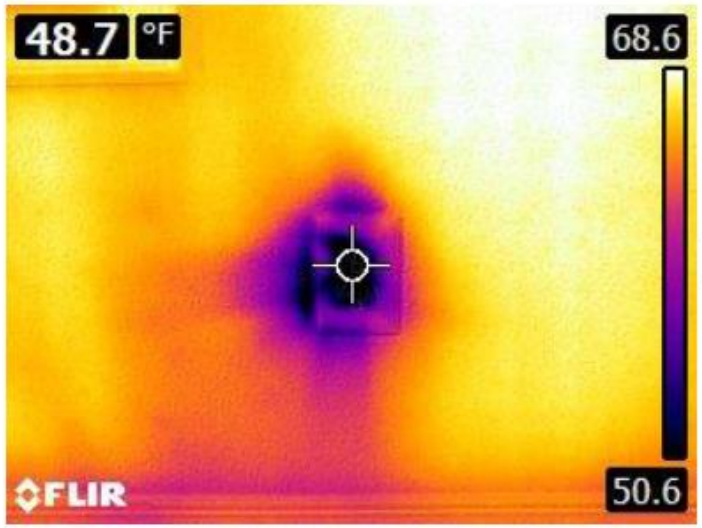


Thermal image with Blower Door – air leakage top trim of exterior door (side trim caulked, top trim not visible not caulked)



Thermal image with Blower Door – air leakage at whole house fan

In Factory Continuous Process Improvement



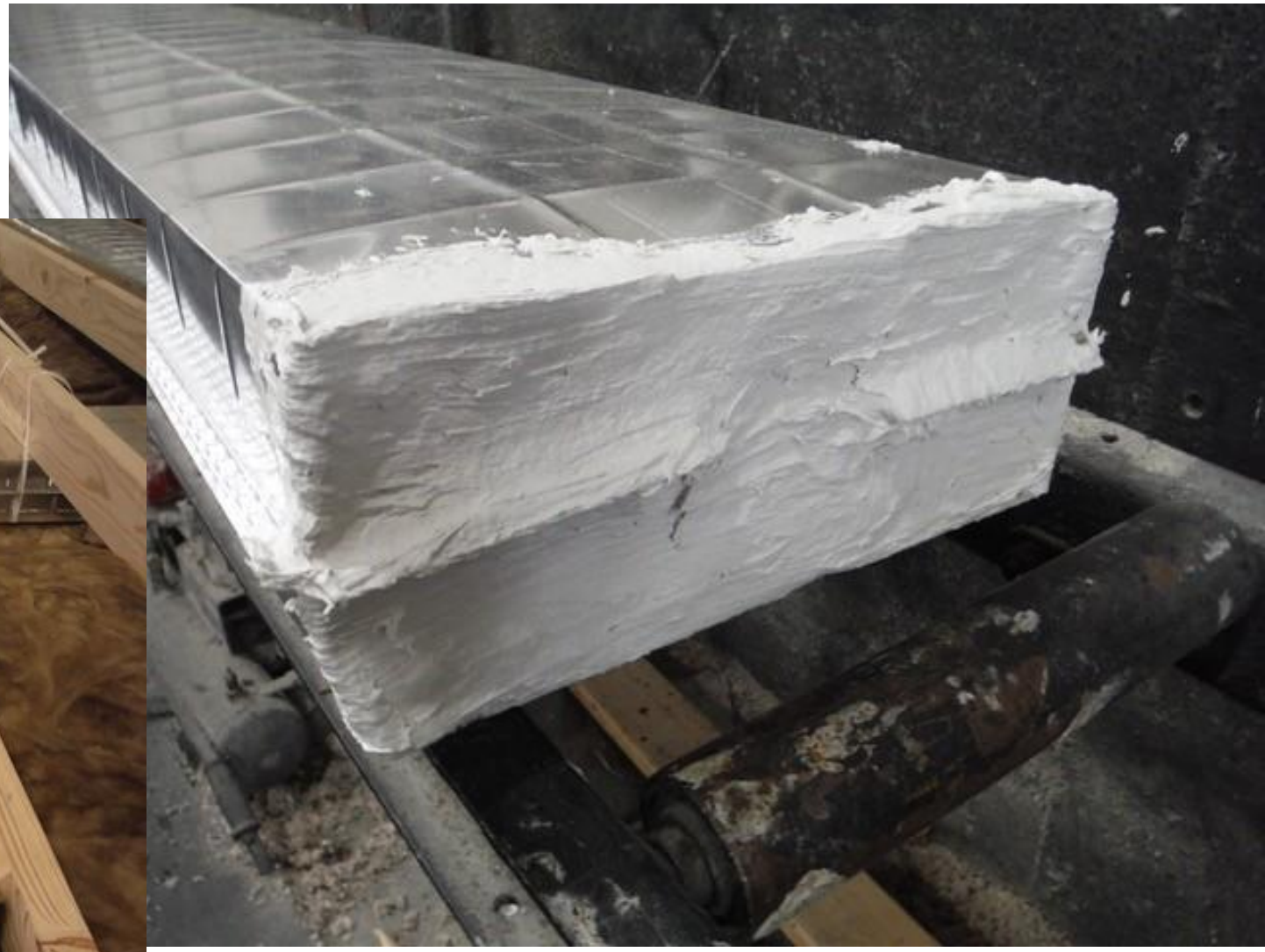
Thermal image with Blower Door – air leakage at exterior wall outlet box

Outlet boxes get foamed in factory and include foam gasket

Broken plumbing penetration seals under sinks

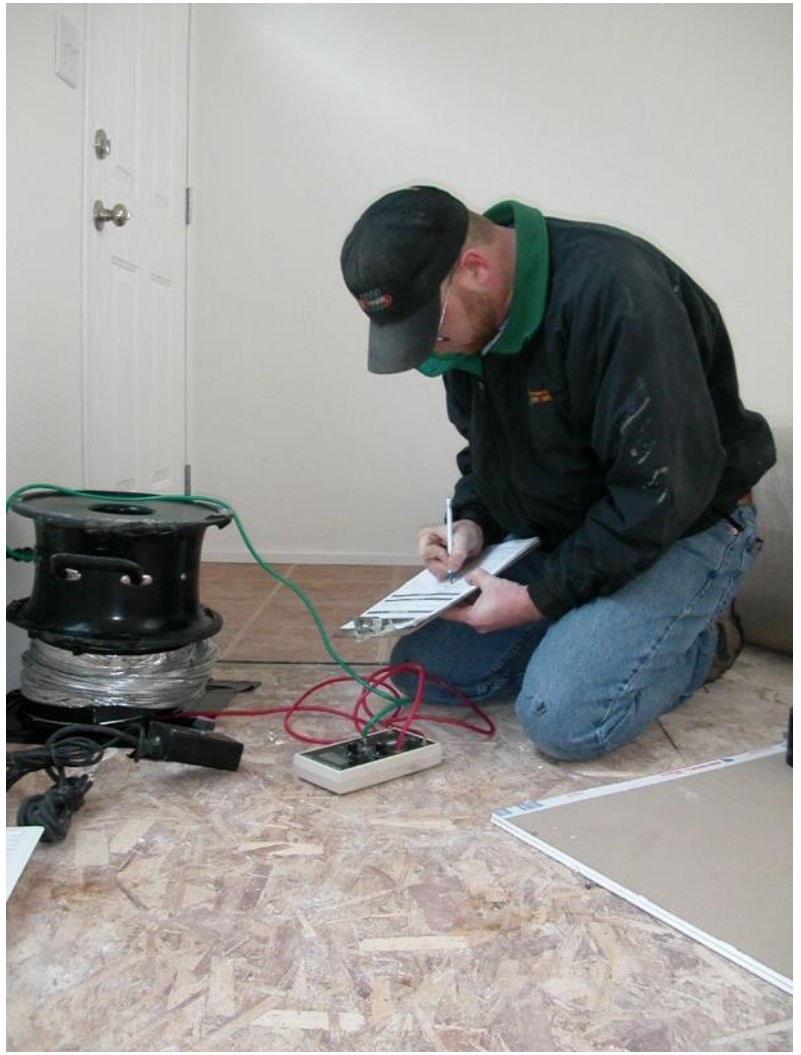
Broken plumbing penetration seals under sinks

All NEEM Homes Have Tested Ducts



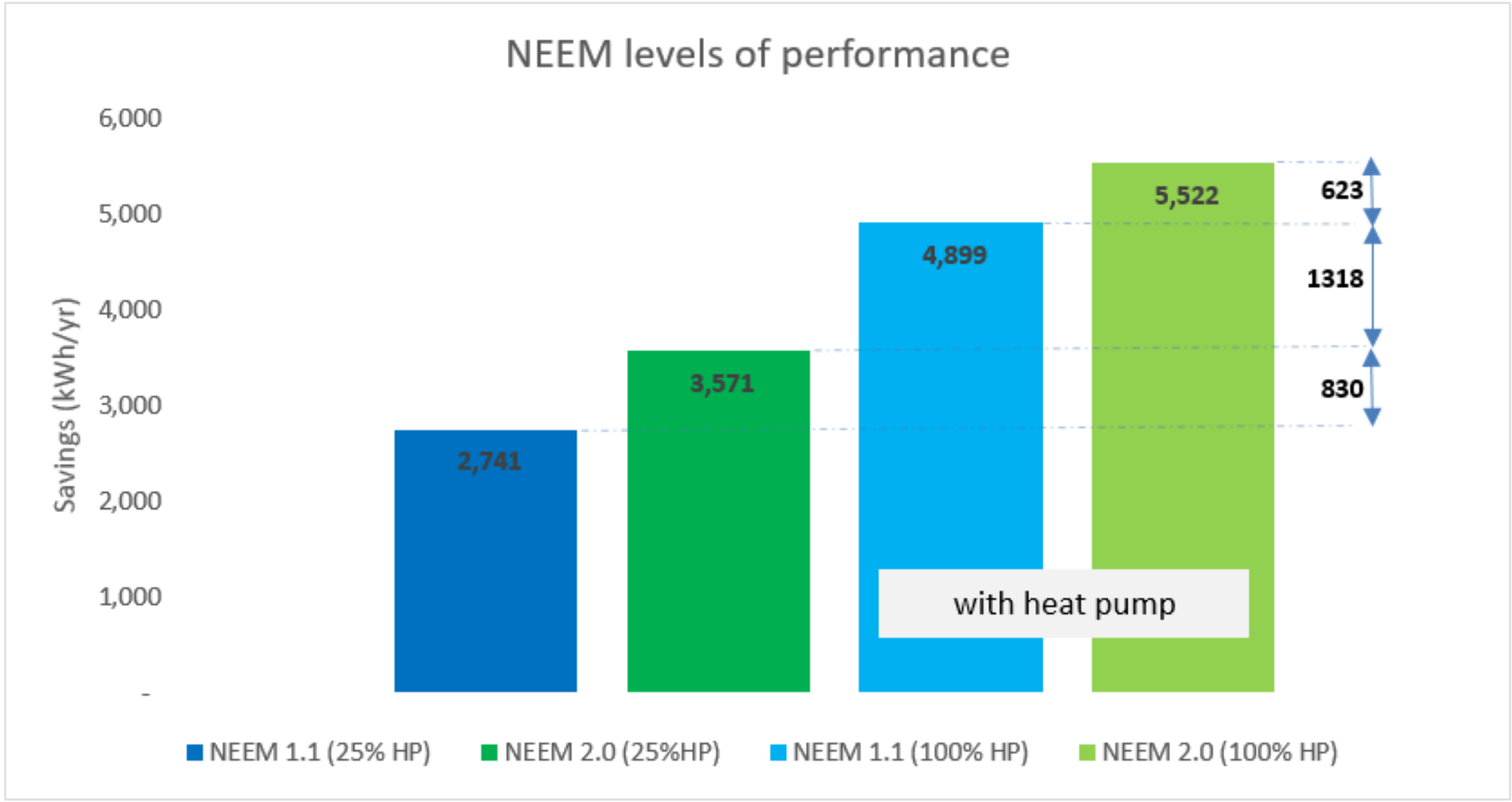
What it looks like

Most loved Duct Blaster in the World



Heat Pump Ready

Heat Pumps are Where Future Savings are Found



Concept

The Big Change to NEEM

- Adding a heat pump means the home does not leave factory fully certified
  - Factories unable to provide this assurance
  - Code officials don’t do this either

What Was Done

- Research to understand challenges and get feedback on potential solutions
  - In-depth interviews of contractors (n = 7)
  - Ongoing discussions with retailers
- Collaborated with factories to develop spec
- Leverage work by Slipstream under US DOE grant

Two Types of HVAC Contactors

- “Typical” Residential HVAC Contractors are contacted by the homeowner
  - Utility lists
  - Word of mouth
  - Marketing
- MH Specialists
  - Contacted by park owners
  - Provided jobs by dealer

Sizing

- Ducts have limited capacity
- Factories provide guidance
- Local contractors that do not follow guidance likely oversize equipment
- Few size with Manual J, most use rules of thumb:
  - 700 to 1000 square feet per ton
  - 1 floor = 2 ton, 2 floors = 2.5 ton, 3 floors= 3 ton
  - 0.7 CFM required per SQ. FT.

Outdoor Unit Location is Important

- Preset location at factory would require close coordination with the dealer and knowledge of the electrical requirements of the heat pump

- Avoid
  - Disconnect located on wrong side of house
  - Walkways
  - Patios
  - Bedroom windows
  - Snow and Ice falling from roof

Least Favorite Part of Installation: Running the Condensate Line

- Hard to get necessary slope due to metal framing members, cross overs, cutting the belly, fitting the units inside of closet were cited reasons.

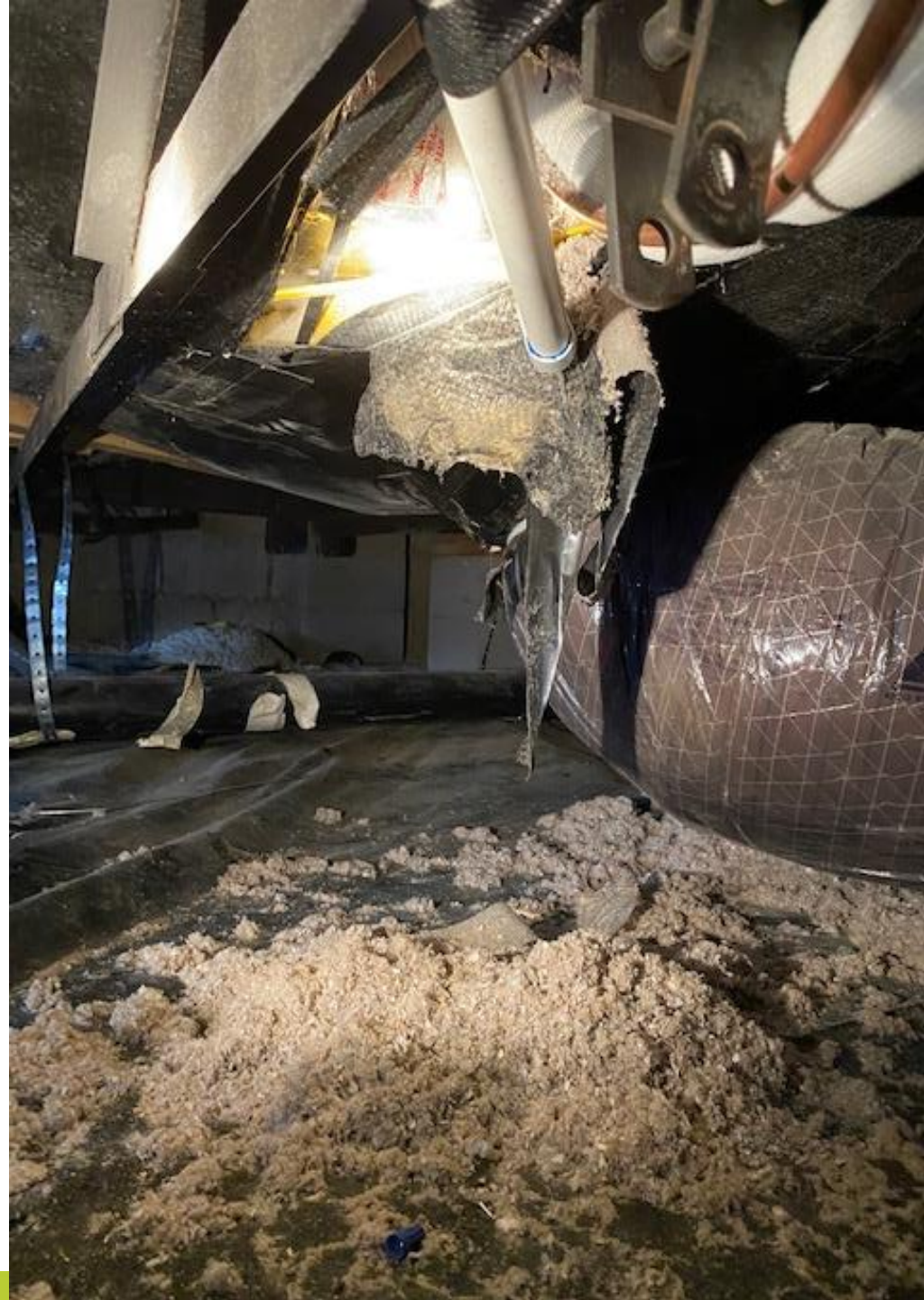
- Many contractors stated that in order achieve the necessary slope they had to dig dry wells by the skirting, install a crawl space vent curb and run the condensate to it

Might need a dry well

Can’t tie into waste line

2nd Least Favorite
Cutting and Repairing Belly

- Insulation falls out
- Tape fails
  - (likely not specified for application)
- Critter entry point



Five Things Contractors Want

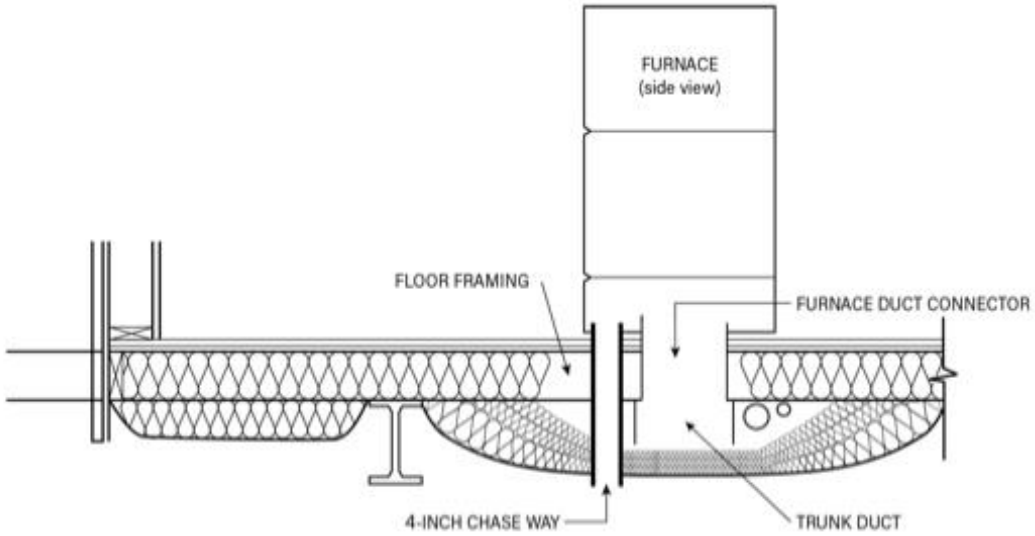
- Wide HVAC Closets
- Refrigerant/electrical chase from HVAC to crawlspace
- Pre-plumbed condensate drain
- Electrical wire chase from Panel to crawlspace
- Standard 8-wire Thermostats

Closet Size

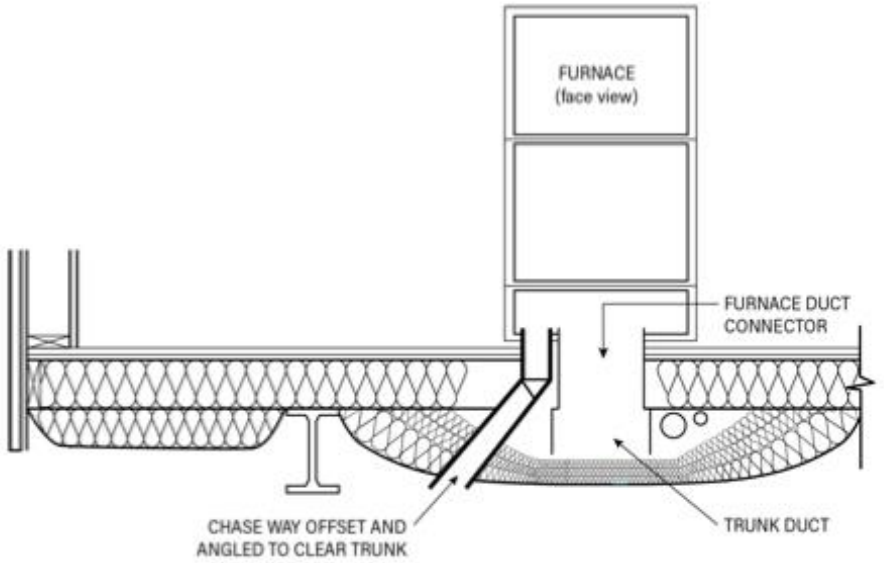
- Closet size is an issue when replacing air handler
- Replacement contractors often reported that closet modifications were needed
- Many replacement air handlers extend beyond the closet
- Want door width of 24+ inches
- Would like to see the plenum connection moved more forward in the closet

Refrigerant Chase

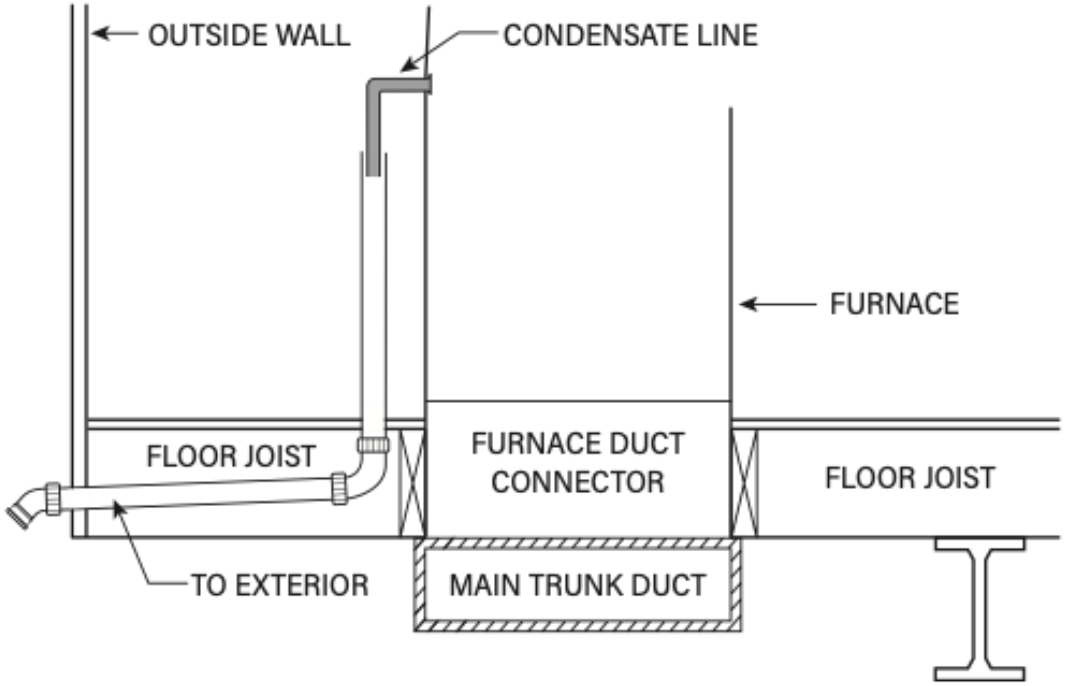
Chase way furnace perpendicular to trunk duct

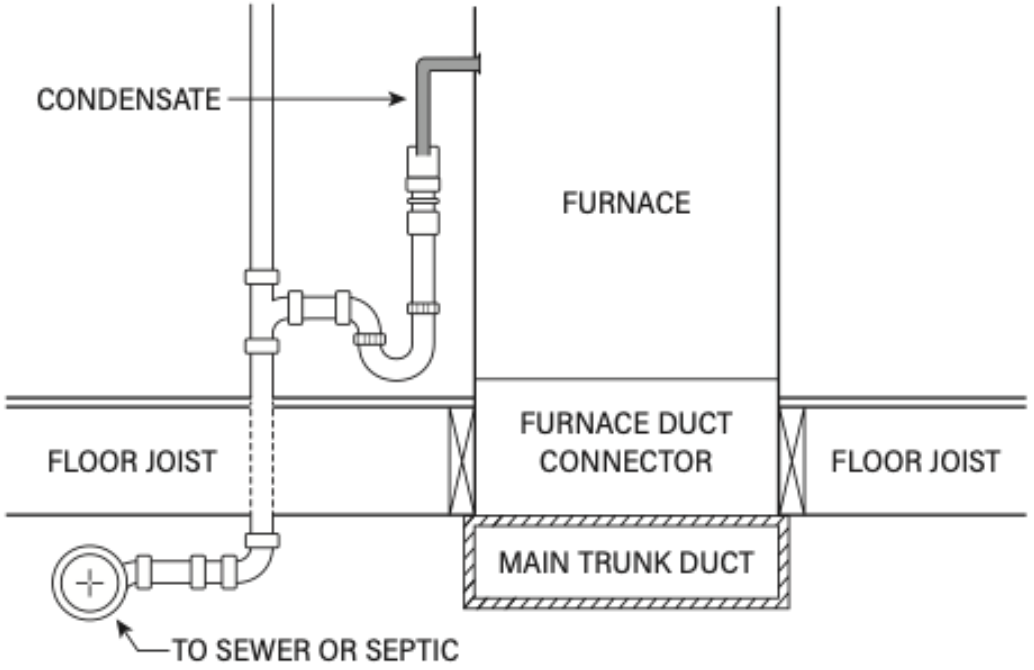


Chase way furnace parallel to trunk duct



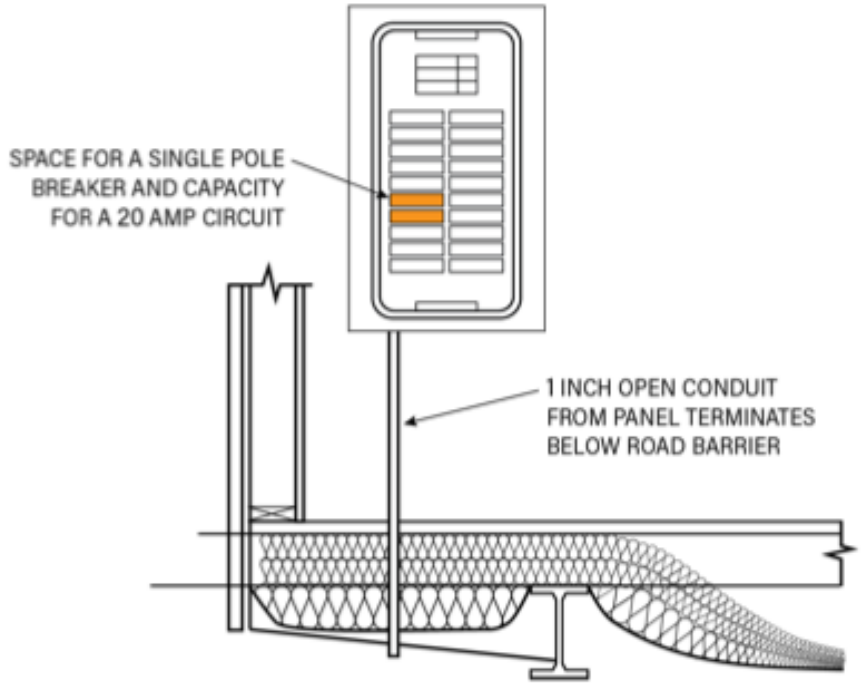
Condensate Drain



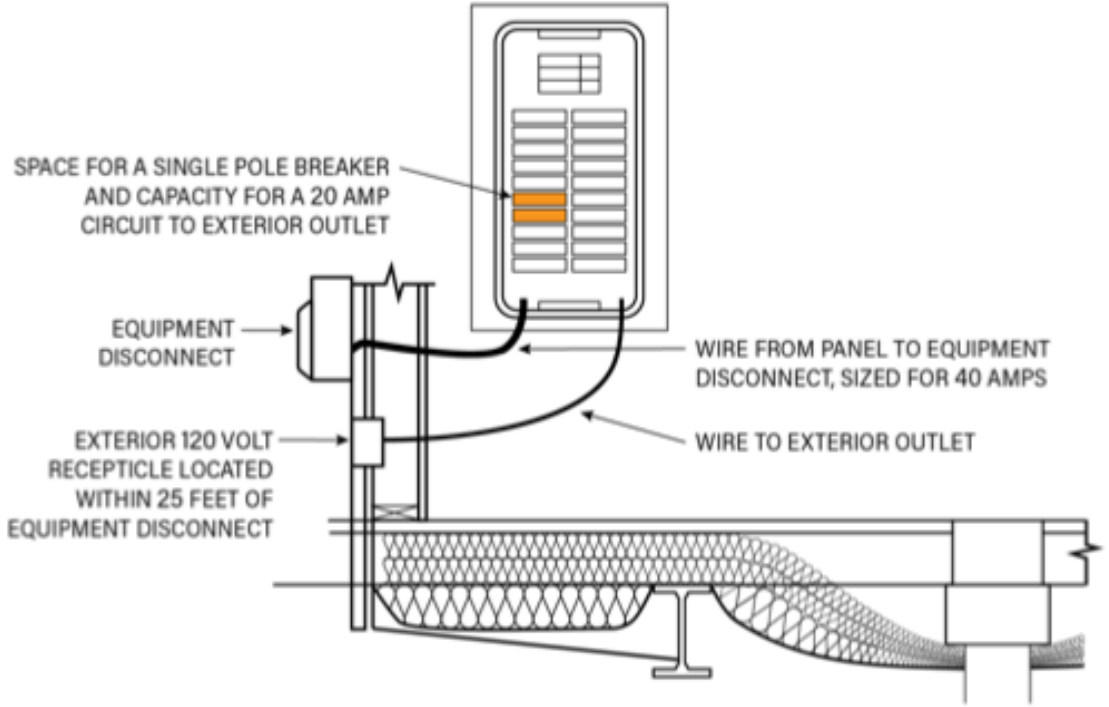


Electrical Chase or Equipment Disconnect

Electrical panel Tier 1



Electrical panel Tier 2



8-Wire T-stat

- Running 8-wires ensures any heat pump can be used
- Features
  - Easy lockout of supplemental heat
  - Crew familiarity
  - Accessory control
  - Easy to explain
- No Fancy GUI that requires contractor to setup wifi

While not directly asked the question, many of the contractors expressed a genuine hatred of "Smart Thermostats"

QR Driven Verification of Installations

- Majority of contractors said that their crews would use a QR code to confirm install
- Many are already taking multiple pictures for code officials
- Suggestions
  - “don’t make the incentive too big or crews will fight over jobs with incentives”
  - “Have points redeemed for tools at Johnstons”

Heat Pump Ready Resources

- NEEM Specification*
- Factory Guide*
- DOE Case Study

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Heat Pump Ready New Manufactured Home

Illustration of new manufactured home with heat pump. *Illustration credit Slipstream*

Manufactured home heat pump installations commonly have mix-and-match systems with indoor and outdoor components from different HVAC manufacturers. Changes to Department of Energy heat pump efficiency requirements that went into effect in 2023 require heat pump installations to use "rated combinations" of equipment components that have been tested together. The new federal test standards require HVAC manufacturers to assume less efficient default air handler performance when a compressor and indoor coil are installed with an existing furnace.

As a result, HVAC contractors installing heat pumps in new manufactured homes must do one of the following:

1. Obtain the compressor and indoor coil from the original equipment manufacturer (OEM) furnace company (which may require purchasing outside preferred supply channels).
2. Install a compressor and coil combination that have an efficiency rating with a "default" air handler.
3. Remove the OEM furnace and install equipment that is available through the contractor's normal distribution channels.

These options result in either a minimum efficiency heat pump from the OEM furnace's equipment line or a challenging job that wrestles with space constraints and limited equipment options—likely resulting in an expensive installation. A different approach where part of the heat pump is installed at the factory and matching parts installed onsite could address this challenge.

Project data

Project Name: Heat Pump Ready New Manufactured Home

Location: Elmira, OR

Home installed: 2022

Conditioned Space: 1,782 square feet
Climate Zone: 4 Marine

Equipment: Carrier 38MARBQ compressor with 40MBAA air handler, ecobee 3 lite

Partners: Northwest Energy Works, Slipstream, FSEC, Pacific Air Comfort (HVAC contractor)

Performance data

Cost of Heat Pump (including labor): $10,487 site installed. Partial factory installed and deployed at scale estimated cost: $8,000

Energy Savings: Heat pump used 63.2% less energy than electric resistance

Heat pumps

A U.S. Department of Energy Advanced Building Construction research team (Slipstream, Northwest Energy Works, and FSEC) identified a relatively new class of heat pump equipment that could prove to be a good fit for manufactured homes and can save residents more than 50 percent of their space conditioning energy usage when replacing electric resistance heating in cold climates. The equipment utilizes a variable speed compressor matched to a ducted central air handler with electronically commutated motor (ECM) fan. The inverter-driven compressor is energy efficient and able to meet the heating load in cold weather. The air handler has a smaller footprint, which can be a good fit in the limited space available in a manufactured home furnace closet. Also, this class of equipment tends to come at a lower price point than comparable conventional unitary equipment.

The Carrier heat pump selected for this project has an air handler that can be configured with electric strip heat and set to operate as an electric furnace independent from the compressor. This flexibility allows for partial heat pump installation in the manufactured home factory and for the home to ship with a functioning heating system, even before the heat pump's installation on site. A home that ships without a complete heating system is required to have an onsite "site completion" inspection to confirm the home's completion, which adds cost to the home.

Case study

The heat pump was installed in a new Clayton manufactured home located in the heating-dominated region of Oregon, and it handled most of the heating load with very little need for back-up electric resistance heat (Figure 2). The system maintained supply air temperatures above 85 degrees (Figure 1), with higher temperatures observed during colder weather when the compressor would speed up to deliver more heat. The residents reported their home is comfortable in the heating season.

*Available from NEEMHomes.com

Concept

Federal Tax Credits – Until 12/31/2032

- EPA ENERGY STAR Certified
  - $2,500 tax credit for manufacturer
- DOE Zero Energy Ready Certified
  - $5,000 tax credit for manufacturer
- Credit goes to corporate parent – not everyone can use it
- New criteria scheduled to be in effect after 7/1/25

EPA ENERGY STAR

- Today
  - Current Version 2.0 ENERGY STAR
  - Home leaves factory certified, not heat pump required
- Future (IRS defined this as post 7/1/25)
  - Version 3.0 ENERGY STAR
  - Home needs heat pump
    - (unless DOE offers path that recognizes NEEM in plant QA)

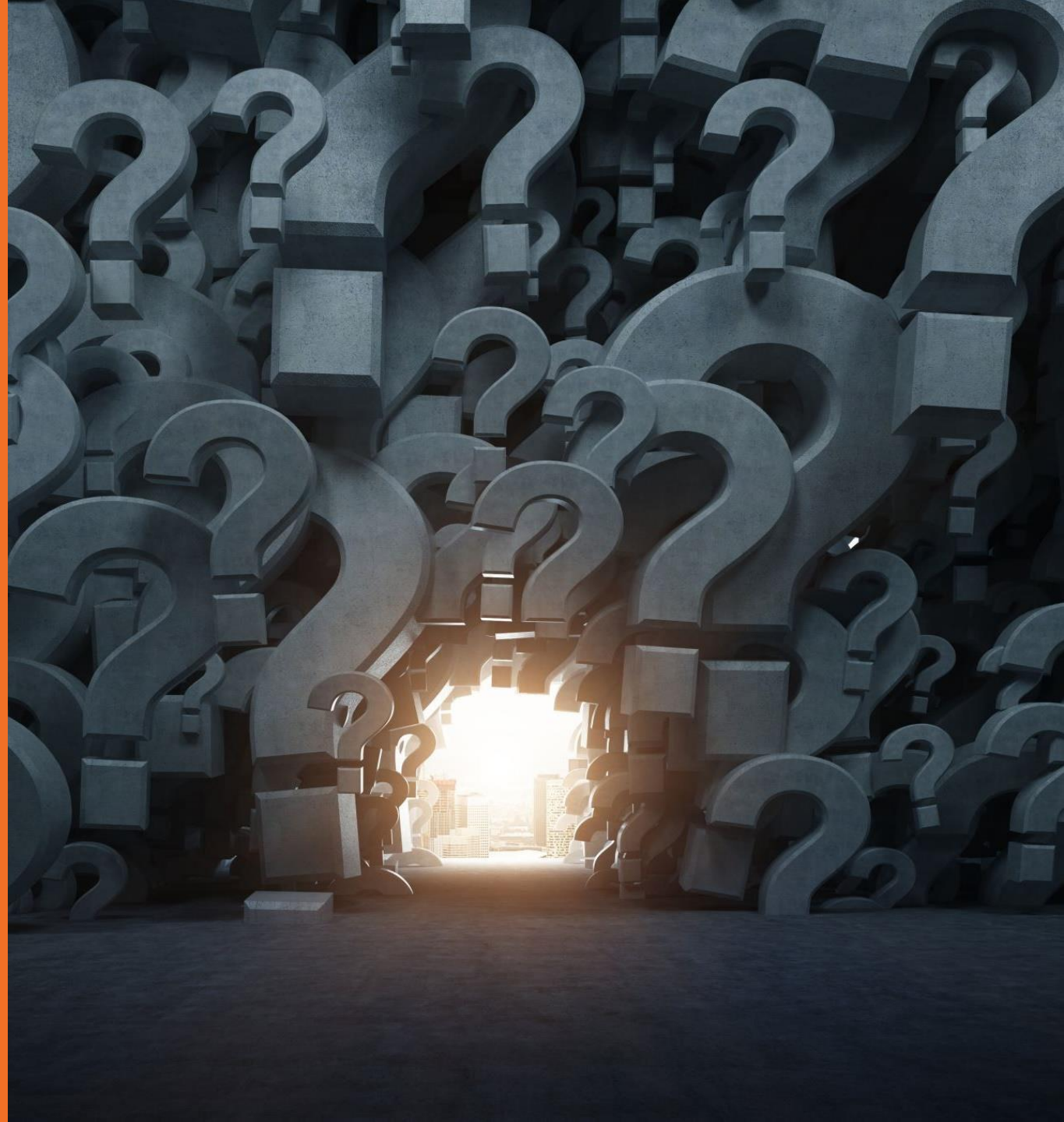
DOE Zero Energy Ready MH

- Today
  - Current Version 1.0 DOE ZERMH Pilot
  - ENERGY STAR v3.0 certified
  - Indoor air quality measures
  - Hot water distribution efficiency
  - Durability measures
  - Space conditioning heat pump required
- Future
  - Possible Version 1.1
    - (NEEA asking DOE offers path that recognizes NEEM in plant QA)

There is a Path

• In Factory Verification	NEEM
• Heat Pump Verification	Installer + NEEM + Utility?
• Certification & Reporting	NEEM Database
• Customer Awareness	Utilities, Retailers
• Factory Support - Technical, Admin, Sales	NEEM
• Retailer Engagement	Utilities, NEEM

Questions and Discussion



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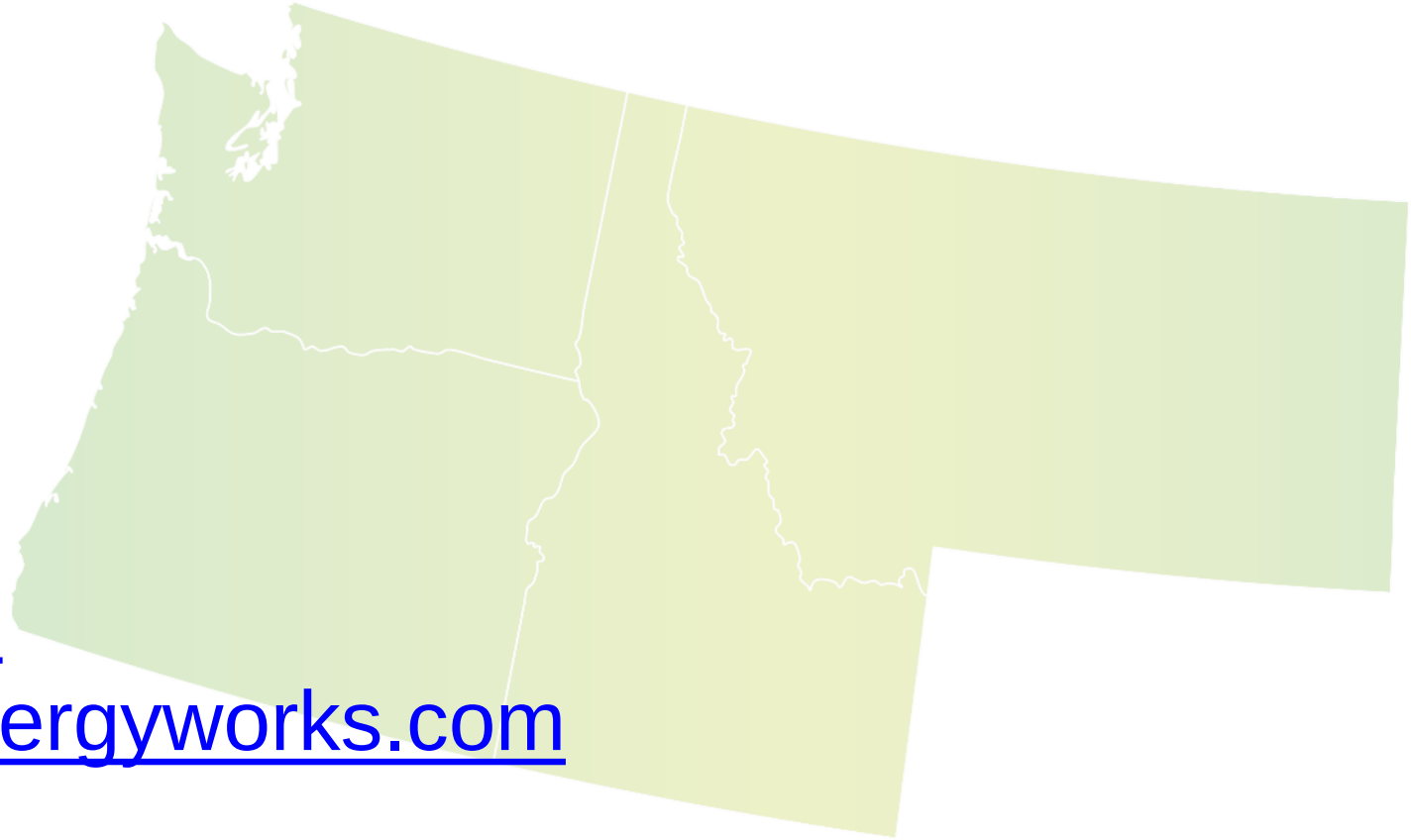
Thank You



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