U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

63 and Me: What Have We Learned From the Field Studies in the Northwest Region?

National Energy Codes Conference Seminar Series

Building Technologies Office

Fall 2020

NECC Seminar Series Lineup

Catch the entire lineup of sessions weekly—Thursdays @ 1p ET:

- 10/01: Kickoff to the Series
- 10/08: Electronic Permitting
- 10/15: HVAC for Low-Load Homes
- 10/22: Performance-Based Compliance
- 10/29: 2021 IECC Commercial
- 11/05: Remote and Virtual Inspections
- 11/12: New for ASHRAE Standard 90.1
- 11/19: 2021 IECC Residential
- 11/24: Energy Codes Around the World
- 12/03: Advanced Technology and Codes
- 12/10: Policies for EE + Resilience
- 12/17: Field Studies in the NW Region

> Learn more: energycodes.gov/2020-building-energy-code-webinar-series

Building Energy Codes
U.S. DEPARTMENT OF ENERGY

63 and Me: What Have We Learned From the Field Studies in the Northwest Region?

David Freelove
Cornerstone Integrated Industries

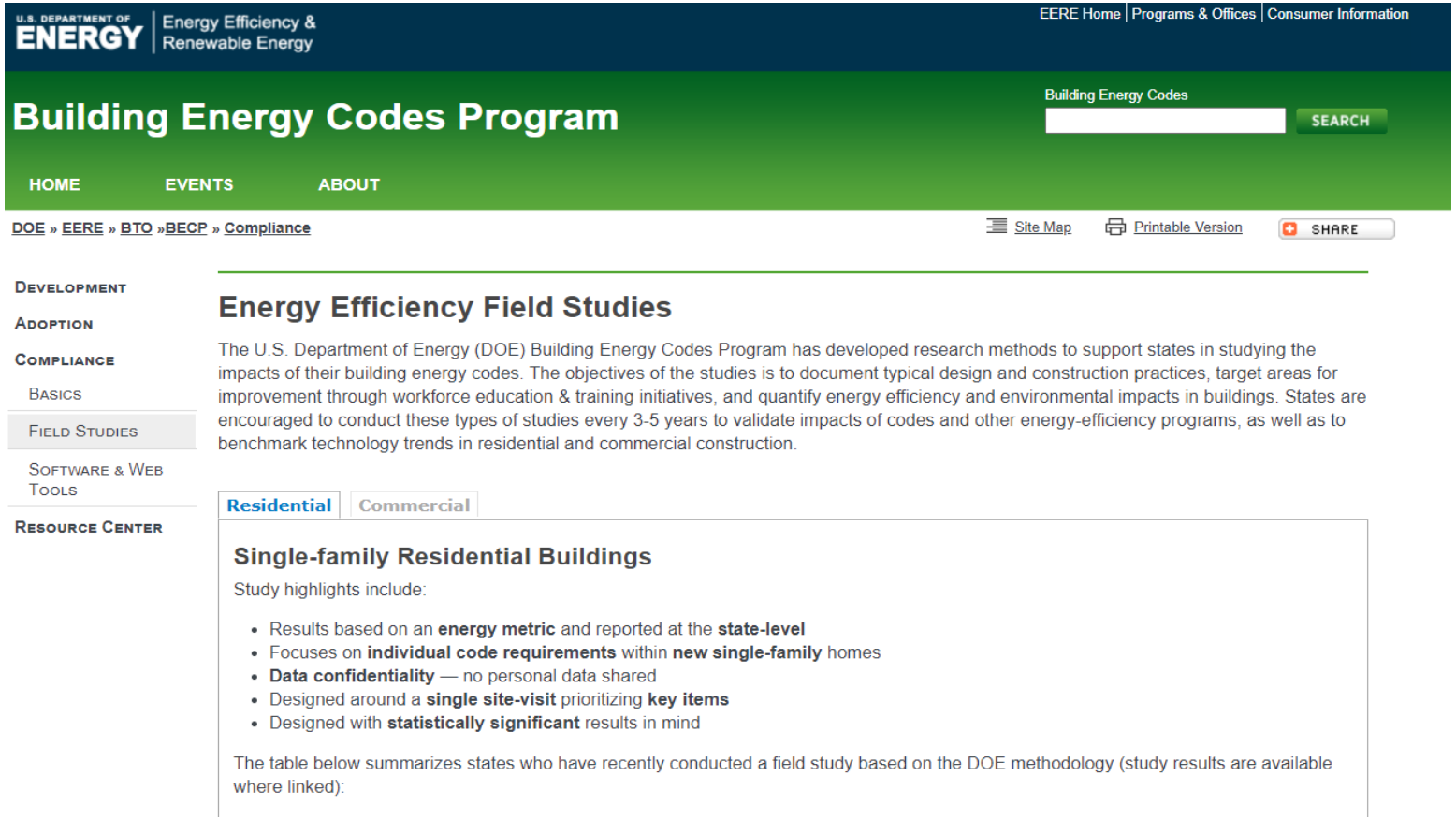
Greg Lasher
TRC

Bruce Manclark
CLEAResult

DOE Field Studies

For more information on DOE Energy Efficiency Field Studies, visit:

https://www.energycodes.gov/compliance/energy-code-field-studies



Team CII & NEEA Partnership

Data Collection Studies

12.15.2020

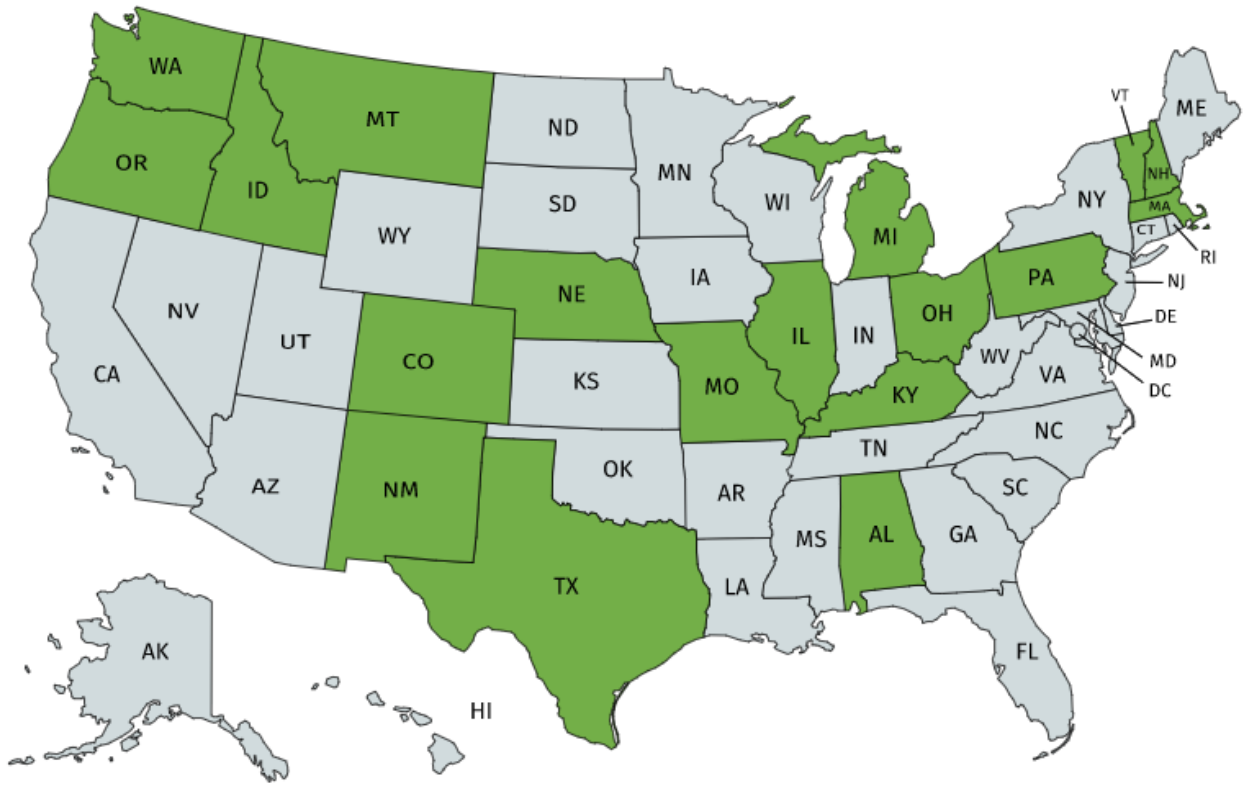
Cornerstone Integrated Industries

Collaborate. Innovate. Integrate.

Field Data Collection
Recruitment Strategies

Involvement

- Kentucky (2)
- Oregon (2)
- Alabama (2)
- Missouri
- Ohio
- Washington
- Texas
- Idaho
- Montana
- Michigan



Sample Plan Examples

IDAHO

	Option 5	
	Location	**Count**
1	Meridian, Ada County	7
2	Boise City, Ada County	3
3	Caldwell, Canyon County	2
4	Eagle, Ada County	5
5	Ada County Unincorporated Area, Ada County	5
6	Nampa, Canyon County	4
7	Kootenai County Unincorporated Area, Kootenai County	4
8	Coeur dAlene, Kootenai County	3
9	Bonneville County Unincorporated Area, Bonneville County	1
10	Post Falls, Kootenai County	4
11	Kuna, Ada County	2
12	Twin Falls, Twin Falls County	1

MONTANA

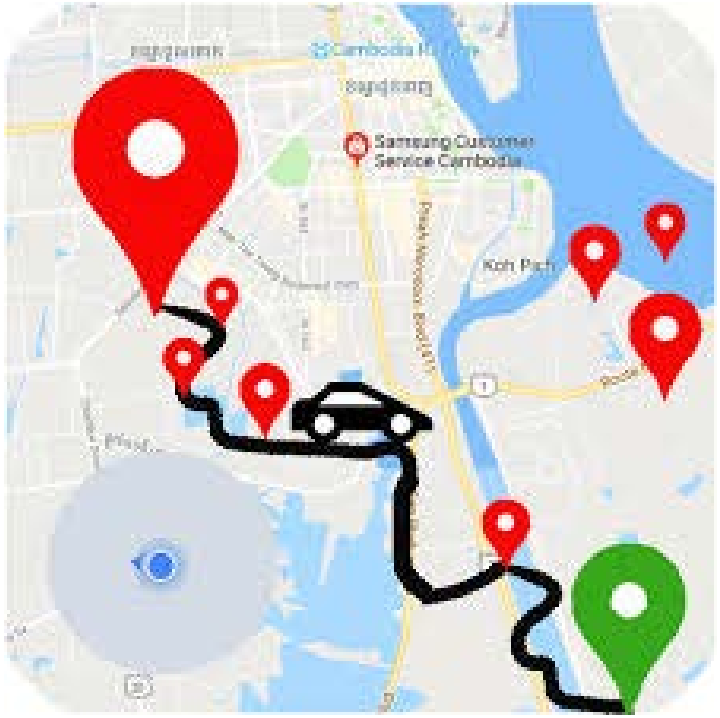
Option 6	
Location	**Count**
Yellowstone County Unincorporated Area, Yellowstone County	14
Billings, Yellowstone County	10
Gallatin County Unincorporated Area, Gallatin County	12
Bozeman, Gallatin County	8
Missoula, Missoula County	5
Missoula County Unincorporated Area, Missoula County	1
Cascade County Unincorporated Area, Cascade County	1
Belgrade, Gallatin County	2
Kalispell, Flathead County	3
Whitefish, Flathead County	3
Helena, Lewis and Clark County	2
Great Falls, Cascade County	2
Total	**63**

Recruitment

- Follow DOE protocols
- Efficient travel plans
- Initial contact
- Image
- Conversations
- Follow up

Travel Plans

- Route efficiently
- Schedule with builders in same area
- Leave openings for random homes/ leads
- Ship/store test equipment
- Travel trailers/motorhomes
- Apartments
- 10-14 day trips



Initial Contact Conversation

- Make small talk
- Find a connection
- Power of persuasion
- Ease into reason for visit
- Do not overwhelm with technical talk
- Minimize testing
- Stress no contact with building dept.
- Insure anonymity

Image!

- DO NOT overdress
- What are you driving?
- License plate?

Personal Protective Equipment (PPE)

- Pants
- Steel toe boots
- Hard hat
- Eye protection
- High visibility vest
- Some contractor require all of it

Follow Up

- Offer feedback to builder
- Test results
- Ask if you can provide any other information
- Provide contact information
- Provide study overview information

My Contact Information

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David Freelove
Idaho Energy Code Circuit Rider

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energy@idabo.org

Oregon: 63 and Me

NEEA 2019 Oregon Residential New Construction Field Study

December 17, 2020

INTEGRATED

[RESILIENT]

SUSTAINABLE

AGENDA

- Oregon's Energy Code
  - Prescriptive vs Additional Measures
- Building Trends & Observations
  - Above Code
  - Water Heating
  - Envelope
  - Ducts
  - Infiltration

Prescriptive plus Additional Measures

Prescriptive Requirements

TABLE N1101.1(1)
PRESCRIPTIVE ENVELOPE REQUIREMENTS[a]

BUILDING COMPONENT	STANDARD BASE CASE		LOG HOMES ONLY	
	Required Performance	Equiv. Value[b]	Required Performance	Equiv. Value[b]
Wall insulation—above grade	U-0.059[c]	R-21 Intermediate[c]	Note d	Note d
Wall insulation—below grade[e]	C-0.063	R-15/R-21	C-0.063	R-15/R-21
Flat ceilings[f]	U-0.021	R-49	U-0.020	R-49 A[h]
Vaulted ceilings[g]	U-0.033	R-30 Rafter or R-30A[g,h] Scissor Truss	U-0.027	R-38A[h]
Underfloors	U-0.033	R-30	U-0.033	R-30
Slab edge perimeter	F-0.520	R-15	F-0.520	R-15
Heated slab interior[i]	n/a	R-10	n/a	R-10
Windows[j]	U-0.30	U-0.30	U-0.30	U-0.30
Window area limitation[j, k]	n/a	n/a	n/a	n/a
Skylights[l]	U-0.50	U-0.50	U-0.50	U-0.50
Exterior doors[m]	U-0.20	U-0.20	U-0.54	U-0.54
Exterior doors with > 2.5 ft^2 glazing[n]	U-0.40	U-0.40	U-0.40	U-0.40
Forced air duct insulation	n/a	R-8	n/a	R-8

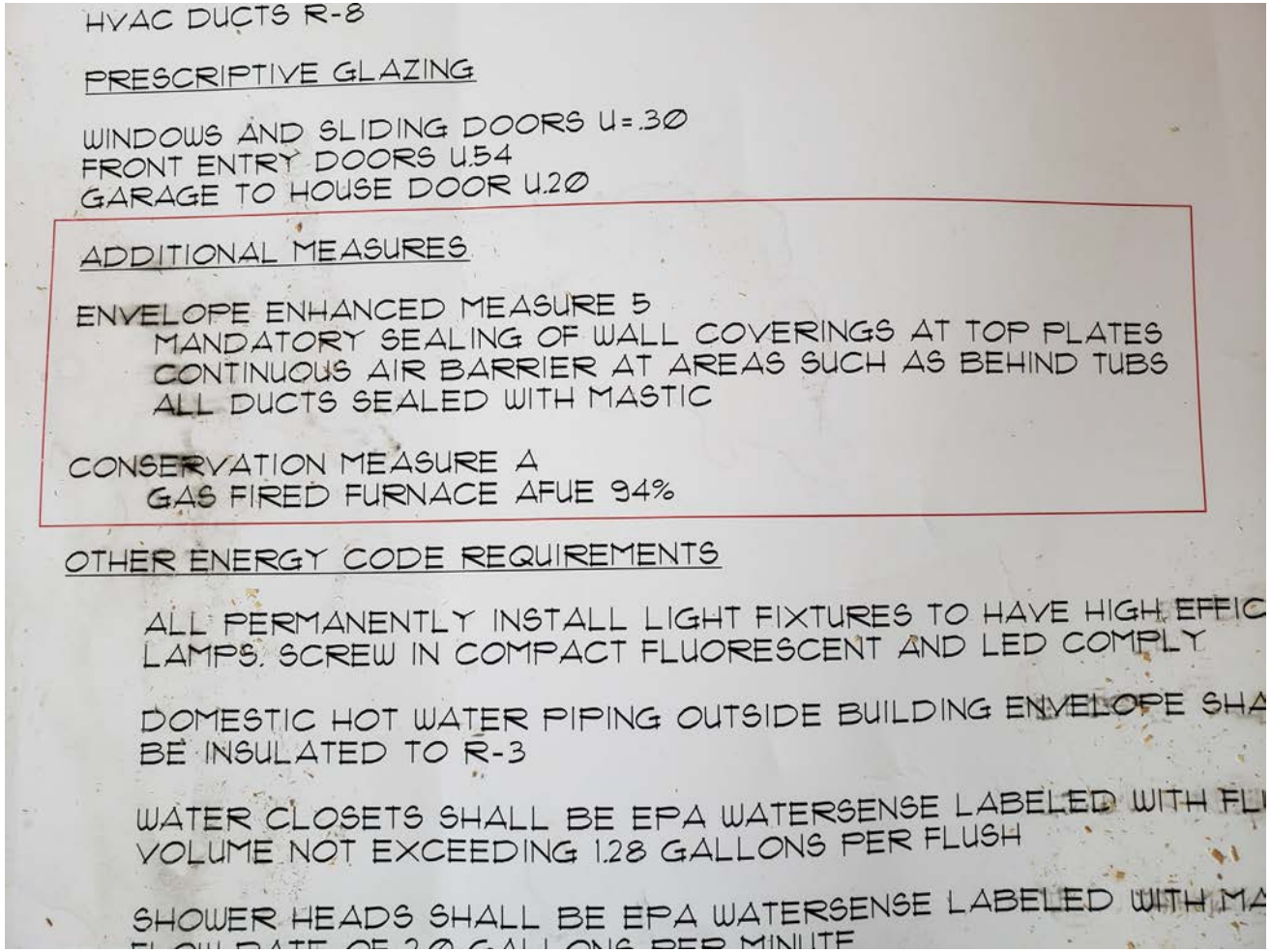
Additional Measures

TABLE N1101.1(2)
ADDITIONAL MEASURES

Envelope Enhancement Measures (Select One)	1	**High efficiency walls**
		Exterior walls—U-0.045/R-21 cavity insulation + R-5 continuous
	2	**Upgraded features**
		Exterior walls—U-0.057/R-23 intermediate or R-21 advanced, Framed floors—U-0.026/R-38, and Windows—U-0.28 (average UA)
	3	**Upgraded features**
		Exterior walls—U-0.055/R-23 intermediate or R-21 advanced, Flat ceiling[e]—U-0.017/R-60, and Framed floors—U-0.026/R-38
	4	**Super Insulated Windows and Attic OR Framed Floors**
		Windows—U-0.22 (Triple Pane Low-e), and Flat ceiling[e]—U-0.017/R-60 or Framed floors—U-0.026/R-38
	5	**Air sealing home and ducts**
		Mandatory air sealing of all wall coverings at top plate and air sealing checklist[f], and Mechanical whole-building ventilation system with rates meeting M1503 or ASHRAE 62.2, and All ducts and air handlers contained within building envelope[d] or All ducts sealed with mastic[b]
	6	**High efficiency thermal envelope UA[g]**
		Proposed UA is 8% lower than the code UA
Conservation Measure (Select One)	A	**High efficiency HVAC system[a]**
		Gas-fired furnace or boiler AFUE 94%, or Air source heat pump HSPF 9.5/15.0 SEER cooling, or Ground source heat pump COP 3.5 or Energy Star rated
	B	**Ducted HVAC systems within conditioned space**
		All ducts and air handlers contained within building envelope[d] *Cannot be combined with Measure 5*
	C	**Ductless heat pump**
		Ductless heat pump HSPF 10.0 in primary zone of dwelling
	D	**High efficiency water heater[c]**
		Natural gas/propane water heater with UEF 0.85 OR Electric heat pump water heater Tier 1 Northern Climate Specification Product

Additional Measures

5A



HVAC DUCTS R-8

PRESCRIPTIVE GLAZING

WINDOWS AND SLIDING DOORS U=.30
FRONT ENTRY DOORS U.54
GARAGE TO HOUSE DOOR U.20

ADDITIONAL MEASURES

ENVELOPE ENHANCED MEASURE 5
MANDATORY SEALING OF WALL COVERINGS AT TOP PLATES
CONTINUOUS AIR BARRIER AT AREAS SUCH AS BEHIND TUBS
ALL DUCTS SEALED WITH MASTIC

CONSERVATION MEASURE A
GAS FIRED FURNACE AFUE 94%

OTHER ENERGY CODE REQUIREMENTS

ALL PERMANENTLY INSTALL LIGHT FIXTURES TO HAVE HIGH EFFIC
LAMPS. SCREW IN COMPACT FLUORESCENT AND LED COMPLY

DOMESTIC HOT WATER PIPING OUTSIDE BUILDING ENVELOPE SHA
BE INSULATED TO R-3

WATER CLOSETS SHALL BE EPA WATERSENSE LABELED WITH FL
VOLUME NOT EXCEEDING 1.28 GALLONS PER FLUSH

SHOWER HEADS SHALL BE EPA WATERSENSE LABELED WITH MA

Additional Measures

6A & 2A

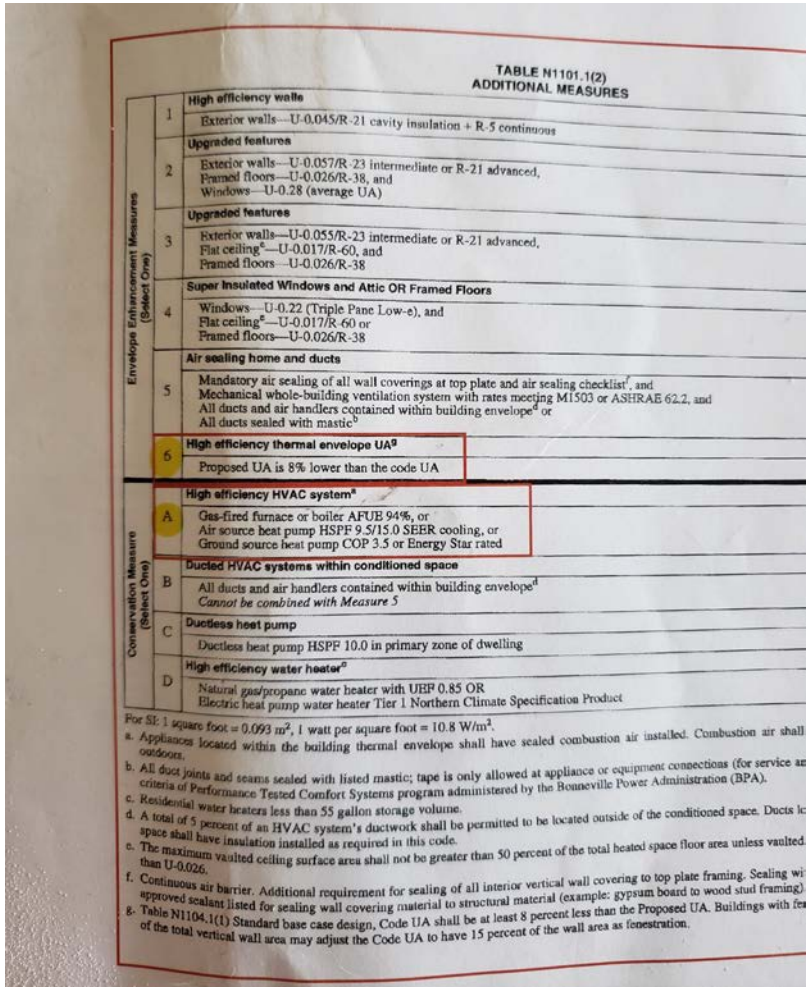


TABLE N1101.1(2)
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	3	**Upgraded features** Exterior walls—U-0.055/R-23 intermediate or R-21 advanced, Flat ceiling[c]—U-0.017/R-60, and Framed floors—U-0.026/R-38
	4	**Super Insulated Windows and Attic OR Framed Floors** Windows—U-0.22 (Triple Pane Low-e), and Flat ceiling[c]—U-0.017/R-60 or Framed floors—U-0.026/R-38
	5	**Air sealing home and ducts** Mandatory air sealing of all wall coverings at top plate and air sealing checklist[f], and Mechanical whole-building ventilation system with rates meeting M1503 or ASHRAE 62.2, and All ducts and air handlers contained within building envelope[d] or All ducts sealed with mastic[b]
	6	**High efficiency thermal envelope UA[g]** Proposed UA is 8% lower than the code UA
Conservation Measure (Select One)	A	**High efficiency HVAC system[a]** Gas-fired furnace or boiler AFUE 94%, or Air source heat pump HSPF 9.5/15.0 SEER cooling, or Ground source heat pump COP 3.5 or Energy Star rated
	B	**Ducted HVAC systems within conditioned space** All ducts and air handlers contained within building envelope[d] *Cannot be combined with Measure 5*
	C	**Ductless heat pump** Ductless heat pump HSPF 10.0 in primary zone of dwelling
	D	**High efficiency water heater[e]** Natural gas/propane water heater with UEF 0.85 OR Electric heat pump water heater Tier 1 Northern Climate Specification Product

For SI: 1 square foot = 0.093 m², 1 watt per square foot = 10.8 W/m².

a. Appliances located within the building thermal envelope shall have sealed combustion air installed. Combustion air shall outdoors.

b. All duct joints and seams sealed with listed mastic; tape is only allowed at appliance or equipment connections (for service a criteria of Performance Tested Comfort Systems program administered by the Bonneville Power Administration (BPA).

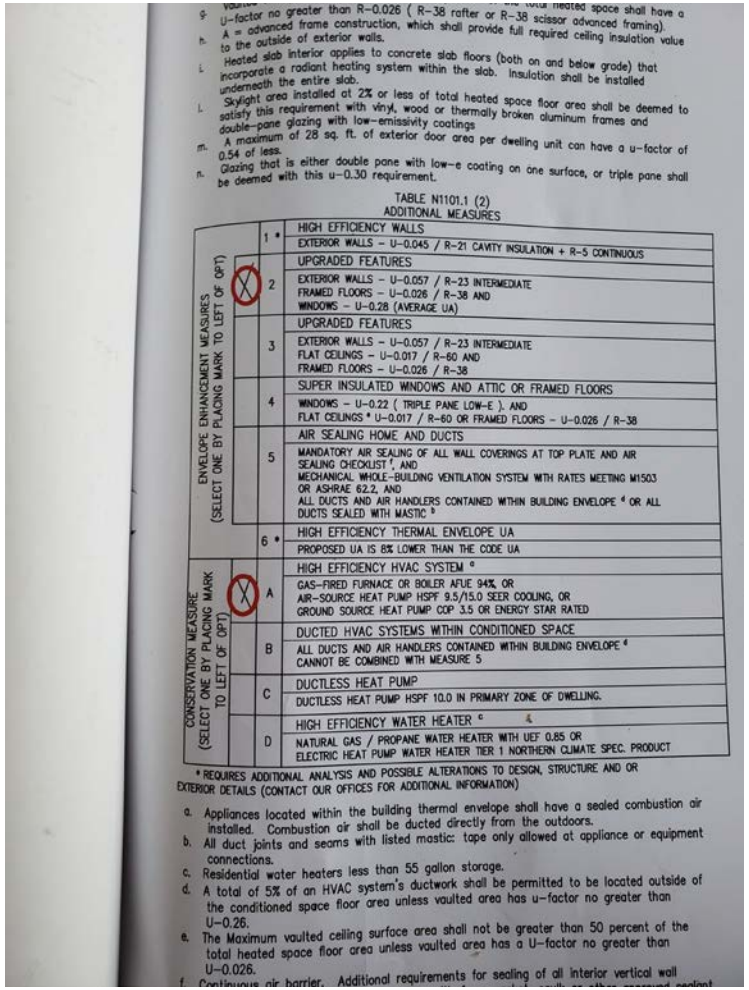
c. Residential water heaters less than 55 gallon storage volume.

d. A total of 5 percent of an HVAC system's ductwork shall be permitted to be located outside of the conditioned space. Ducts l space shall have insulation installed as required in this code.

e. The maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless vaulted than U-0.026.

f. Continuous air barrier. Additional requirement for sealing of all interior vertical wall covering to top plate framing. Sealing wi approved sealant listed for sealing wall covering material to structural material (example: gypsum board to wood stud framing).

g. Table N1104.1(1) Standard base case design, Code UA shall be at least 8 percent less than the Proposed UA. Buildings with fe of the total vertical wall area may adjust the Code UA to have 15 percent of the wall area as fenestration.



U-factor no greater than R-0.026 (R-38 rafter or R-38 scissor advanced framing).

h. A = advanced frame construction, which shall provide full required ceiling insulation value to the outside of exterior walls.

i. Heated slab interior applies to concrete slab floors (both on and below grade) that incorporate a radiant heating system within the slab. Insulation shall be installed underneath the entire slab.

j. Skylight area installed at 2% or less of total heated space floor area shall be deemed to satisfy this requirement with vinyl, wood or thermally broken aluminum frames and double-pane glazing with low-emissivity coatings

k. A maximum of 28 sq. ft. of exterior door area per dwelling unit can have a u-factor of 0.54 of less.

l. Glazing that is either double pane with low-e coating on one surface, or triple pane shall be deemed with this u-0.30 requirement.

TABLE N1101.1 (2)
ADDITIONAL MEASURES

ENVELOPE ENHANCEMENT MEASURES (SELECT ONE BY PLACING MARK TO LEFT OF OPT)	1 *	HIGH EFFICIENCY WALLS EXTERIOR WALLS – U-0.045 / R-21 CAVITY INSULATION + R-5 CONTINUOUS
	X 2	UPGRADED FEATURES EXTERIOR WALLS – U-0.057 / R-23 INTERMEDIATE FRAMED FLOORS – U-0.026 / R-38 AND WINDOWS – U-0.28 (AVERAGE UA)
	3	UPGRADED FEATURES EXTERIOR WALLS – U-0.057 / R-23 INTERMEDIATE FLAT CEILINGS – U-0.017 / R-60 AND FRAMED FLOORS – U-0.026 / R-38
	4	SUPER INSULATED WINDOWS AND ATTIC OR FRAMED FLOORS WINDOWS – U-0.22 (TRIPLE PANE LOW-E), AND FLAT CEILINGS * U-0.017 / R-60 OR FRAMED FLOORS – U-0.026 / R-38
	5	AIR SEALING HOME AND DUCTS MANDATORY AIR SEALING OF ALL WALL COVERINGS AT TOP PLATE AND AIR SEALING CHECKLIST [f], AND MECHANICAL WHOLE-BUILDING VENTILATION SYSTEM WITH RATES MEETING M1503 OR ASHRAE 62.2, AND ALL DUCTS AND AIR HANDLERS CONTAINED WITHIN BUILDING ENVELOPE [d] OR ALL DUCTS SEALED WITH MASTIC [b]
	6 *	HIGH EFFICIENCY THERMAL ENVELOPE UA PROPOSED UA IS 8% LOWER THAN THE CODE UA
CONSERVATION MEASURE (SELECT ONE BY PLACING MARK TO LEFT OF OPT)	X A	HIGH EFFICIENCY HVAC SYSTEM [a] GAS-FIRED FURNACE OR BOILER AFUE 94% OR AIR-SOURCE HEAT PUMP HSPF 9.5/15.0 SEER COOLING, OR GROUND SOURCE HEAT PUMP COP 3.5 OR ENERGY STAR RATED
	B	DUCTED HVAC SYSTEMS WITHIN CONDITIONED SPACE ALL DUCTS AND AIR HANDLERS CONTAINED WITHIN BUILDING ENVELOPE [d] CANNOT BE COMBINED WITH MEASURE 5
	C	DUCTLESS HEAT PUMP DUCTLESS HEAT PUMP HSPF 10.0 IN PRIMARY ZONE OF DWELLING.
	D	HIGH EFFICIENCY WATER HEATER [e] NATURAL GAS / PROPANE WATER HEATER WITH UEF 0.85 OR ELECTRIC HEAT PUMP WATER HEATER TIER 1 NORTHERN CLIMATE SPEC. PRODUCT

* REQUIRES ADDITIONAL ANALYSIS AND POSSIBLE ALTERATIONS TO DESIGN, STRUCTURE AND OR EXTERIOR DETAILS (CONTACT OUR OFFICES FOR ADDITIONAL INFORMATION)

a. Appliances located within the building thermal envelope shall have a sealed combustion air installed. Combustion air shall be ducted directly from the outdoors.

b. All duct joints and seams with listed mastic: tape only allowed at appliance or equipment connections.

c. Residential water heaters less than 55 gallon storage.

d. A total of 5% of an HVAC system's ductwork shall be permitted to be located outside of the conditioned space floor area unless vaulted area has u-factor no greater than U-0.26.

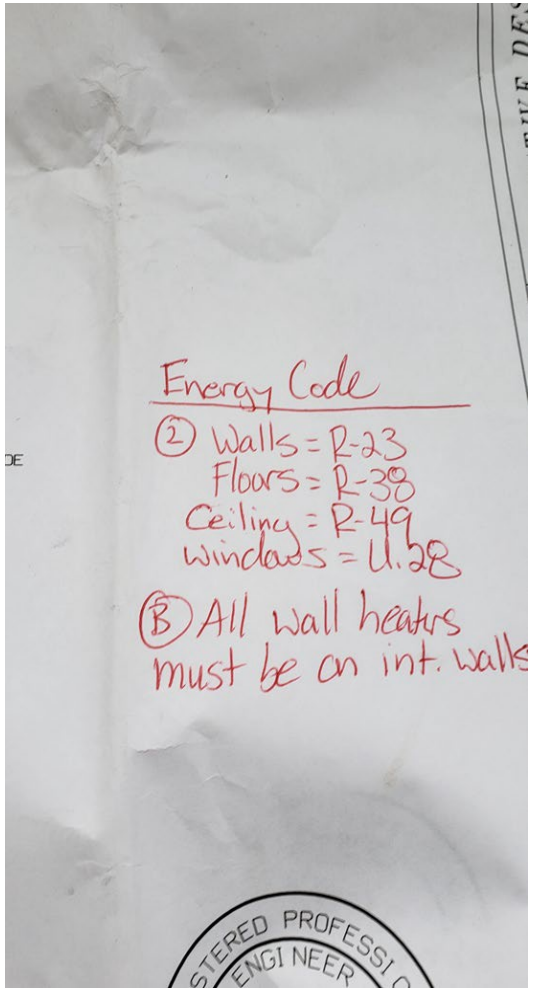
e. The Maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless vaulted area has a U-factor no greater than U-0.026.

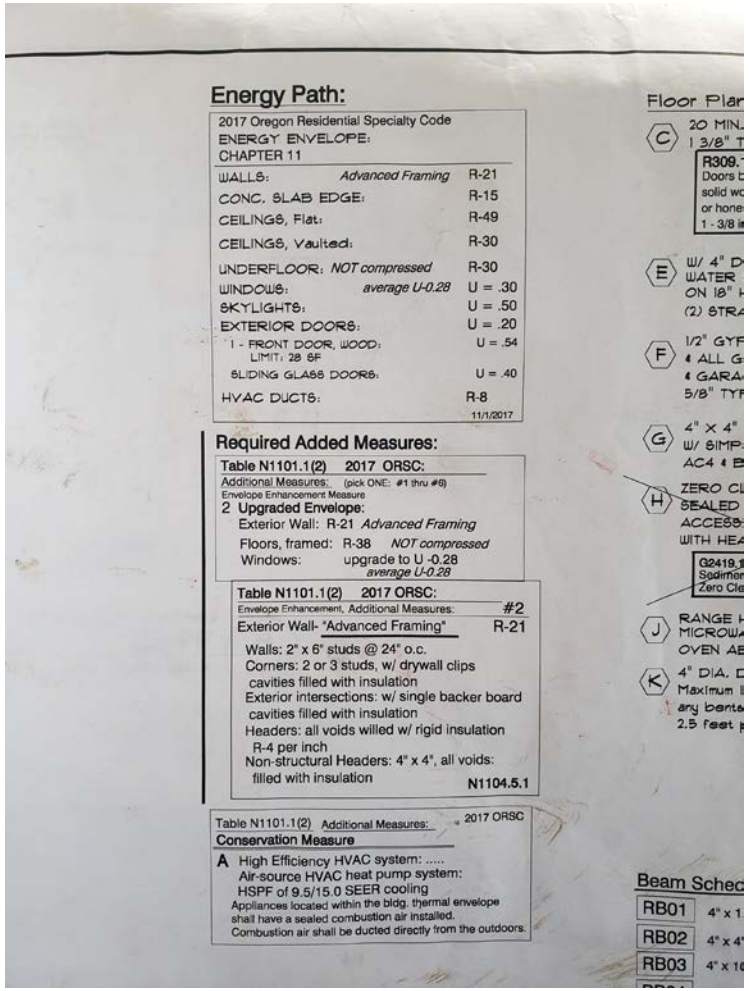
f. Continuous air barrier. Additional requirements for sealing of all interior vertical wall

neea

Additional Measures

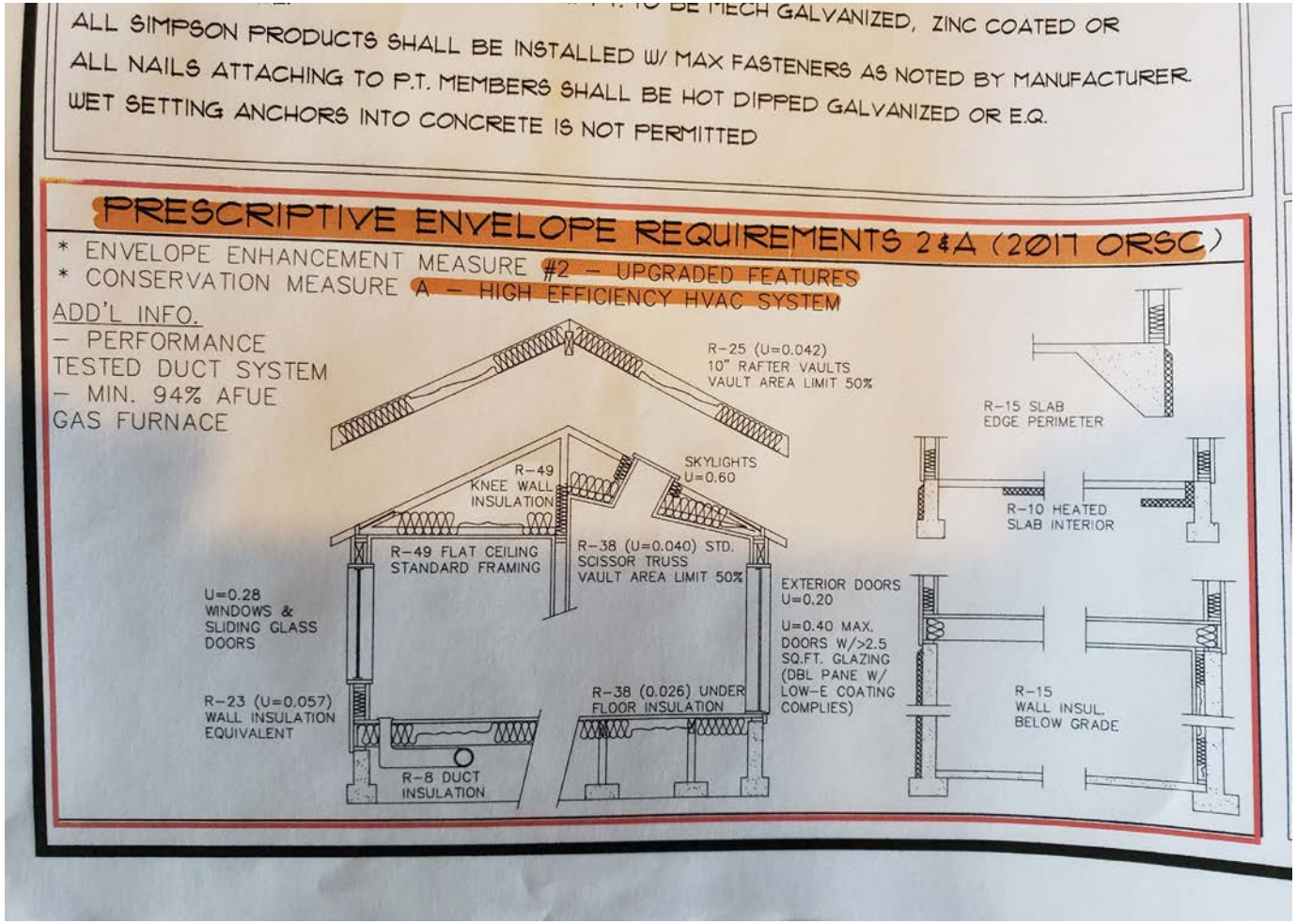
2B & 2A





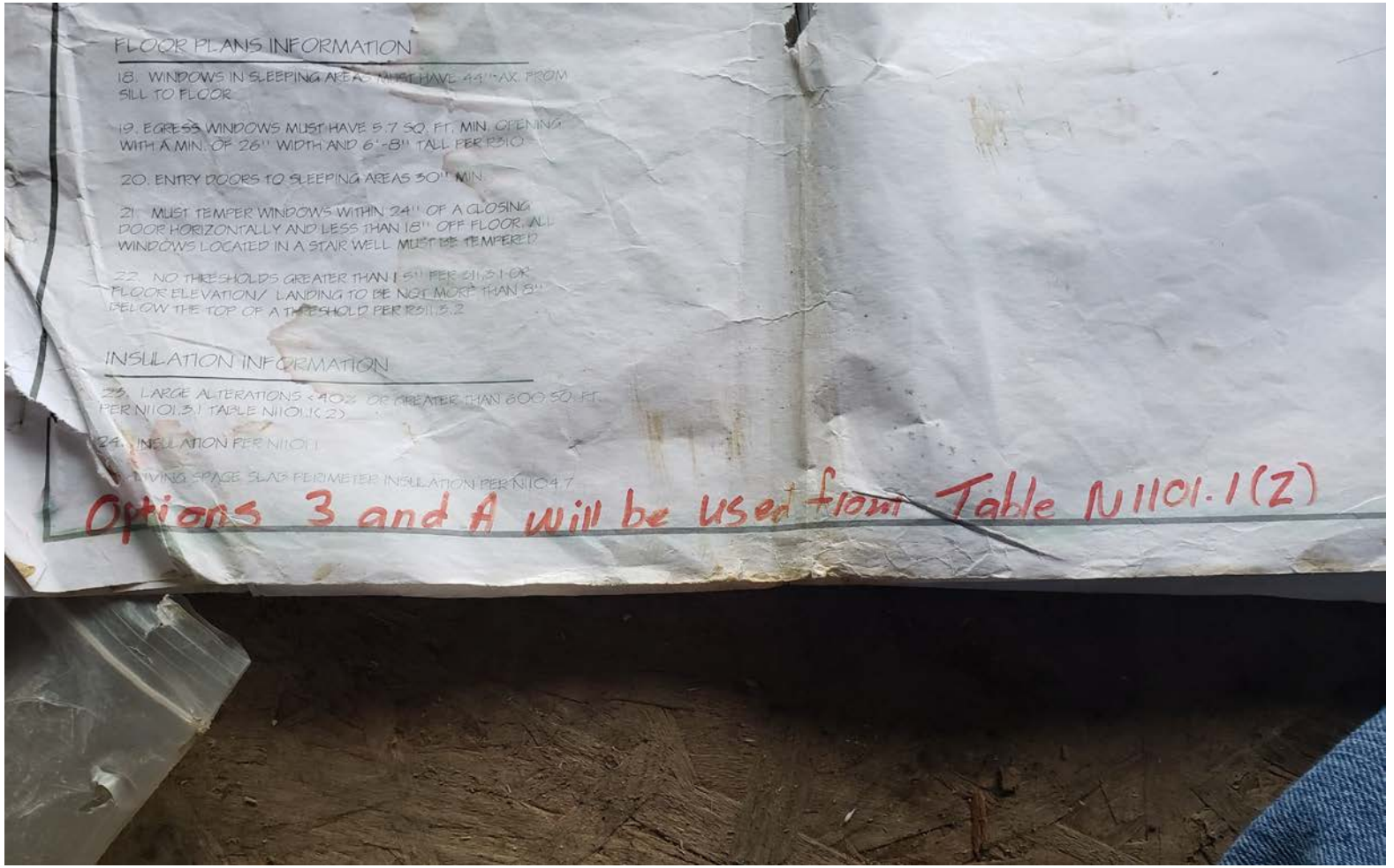
Additional Measures

2A

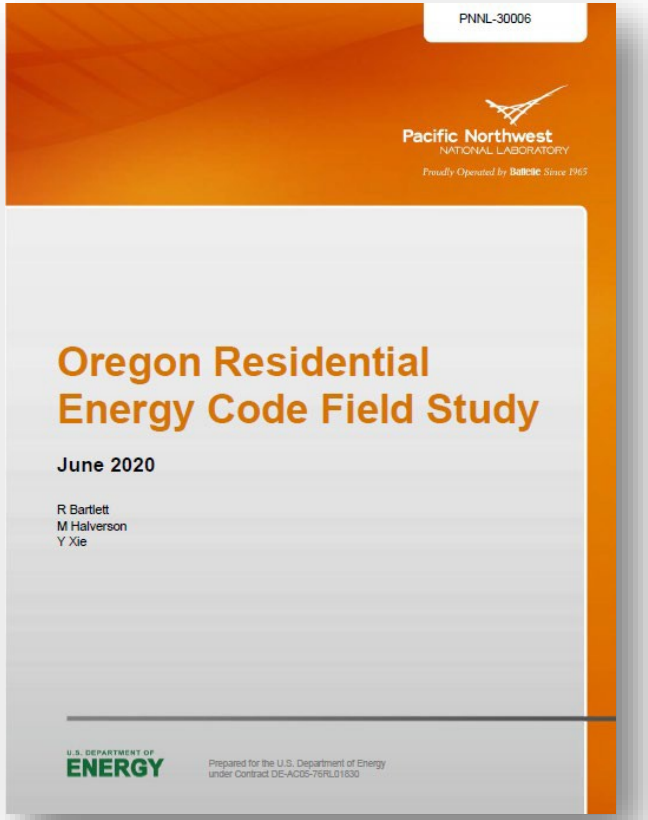


Additional Measures

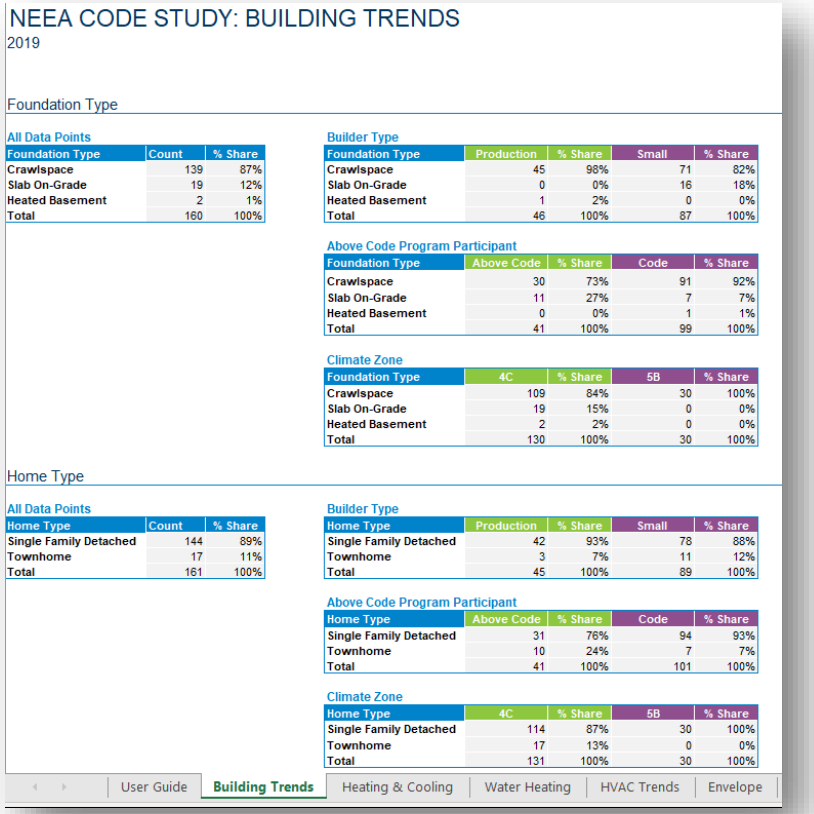
3A



1 2019 Oregon Residential Energy Code Field Study



2 Building Trends & Observations



NEEA CODE STUDY: BUILDING TRENDS
2019

Foundation Type

All Data Points

Foundation Type	Count	% Share
Crawlspace	139	87%
Slab On-Grade	19	12%
Heated Basement	2	1%
Total	160	100%

Builder Type

Foundation Type	Production	% Share	Small	% Share
Crawlspace	45	98%	71	82%
Slab On-Grade	0	0%	16	18%
Heated Basement	1	2%	0	0%
Total	46	100%	87	100%

Above Code Program Participant

Foundation Type	Above Code	% Share	Code	% Share
Crawlspace	30	73%	91	92%
Slab On-Grade	11	27%	7	7%
Heated Basement	0	0%	1	1%
Total	41	100%	99	100%

Climate Zone

Foundation Type	4C	% Share	5B	% Share
Crawlspace	109	84%	30	100%
Slab On-Grade	19	15%	0	0%
Heated Basement	2	2%	0	0%
Total	130	100%	30	100%

Home Type

All Data Points

Home Type	Count	% Share
Single Family Detached	144	89%
Townhome	17	11%
Total	161	100%

Builder Type

Home Type	Production	% Share	Small	% Share
Single Family Detached	42	93%	78	88%
Townhome	3	7%	11	12%
Total	45	100%	89	100%

Above Code Program Participant

Home Type	Above Code	% Share	Code	% Share
Single Family Detached	31	76%	94	93%
Townhome	10	24%	7	7%
Total	41	100%	101	100%

Climate Zone

Home Type	4C	% Share	5B	% Share
Single Family Detached	114	87%	30	100%
Townhome	17	13%	0	0%
Total	131	100%	30	100%

User Guide | Building Trends | Heating & Cooling | Water Heating | HVAC Trends | Envelope

https://www.energycodes.gov/sites/default/files/documents/Oregon_Residential_Field_Study.pdf

Definitions of Line 15

- **Above Code Program Participant:** Home was certified or incentivized as an above code home through EPS for New Construction, Earth Advantage, or LEED

Water Heating

Water Heating

Tankless Gas Water Heater

Water Heating

Gas Storage Water Heater

Water Heating

Electric Storage Water Heater

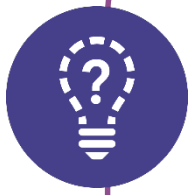
Water Heating

Heat Pump Water Heater

Water Heating
Above Code Participation

Above Code Program Participant

Device	Above Code	% Share	Code	% Share
Electric Storage	0	0%	8	21%
HPWH	9	35%	3	8%
Gas Storage	1	4%	22	56%
Gas Tankless	16	62%	6	15%
Total	26	100%	39	100%



KEY INSIGHT

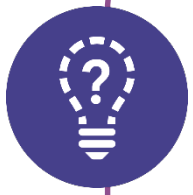
Builders who participated in an above code program chose the two most efficient options, gas tankless and HPWH, in far higher numbers than builders who did not participate in an above code program.

Water Heating

2014 vs. 2019

Code Study Comparison

Equipment	2014	% Share	2019	% Share
Electric Storage	25	28%	11	18%
HPWH	-	-	15	25%
Gas Storage	55	61%	13	21%
Gas Tankless	10	11%	22	36%
Total	90	100%	61	100%



KEY INSIGHT

The 2014 Oregon code field study found no heat pump water heaters, despite their market availability. The 2019 code study found heat pump water heaters comprised 25% of all water heating systems.

Envelope

Hatch Insulation

All Data Points

Compliance	Count	% Share
Complies	20	53%
Does Not Comply	18	47%
Total	38	100%

KEY INSIGHT

Nearly half of homes with hatch insulation did not meet surrounding R-value.

Hatch Insulation

Poorly Insulated

Hatch Insulation

Not Insulated

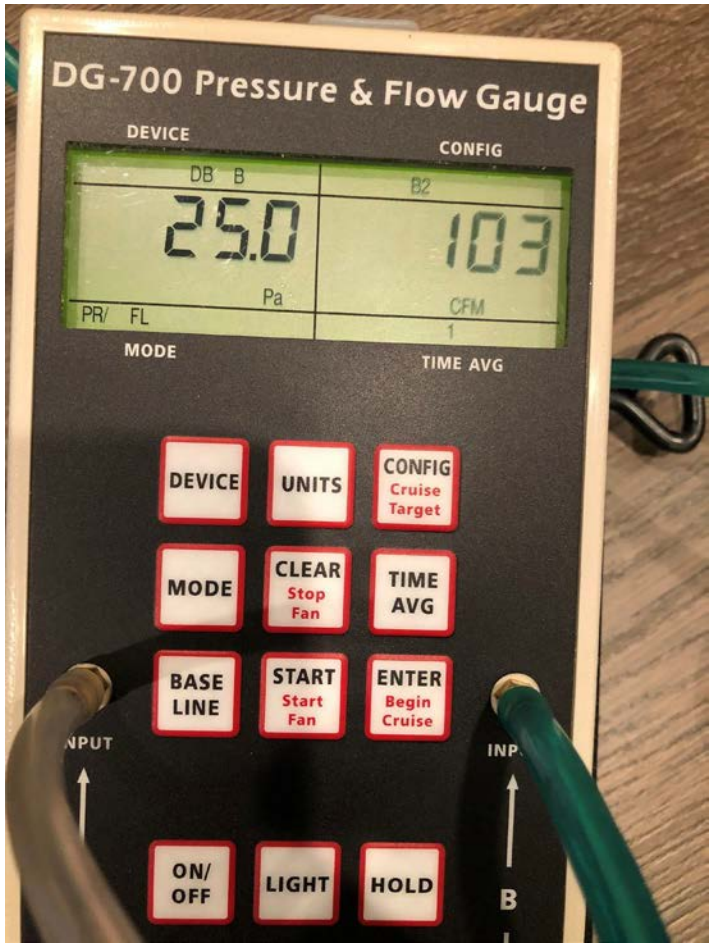
Wall Insulation

Grade 3

Ducts

Ducts

Duct Leakage Test



Ducts

Good Duct Sealing

Ducts

Duct Leakage

All Data Points

CFM	Value
Average	6.1

Above Code Program Participant

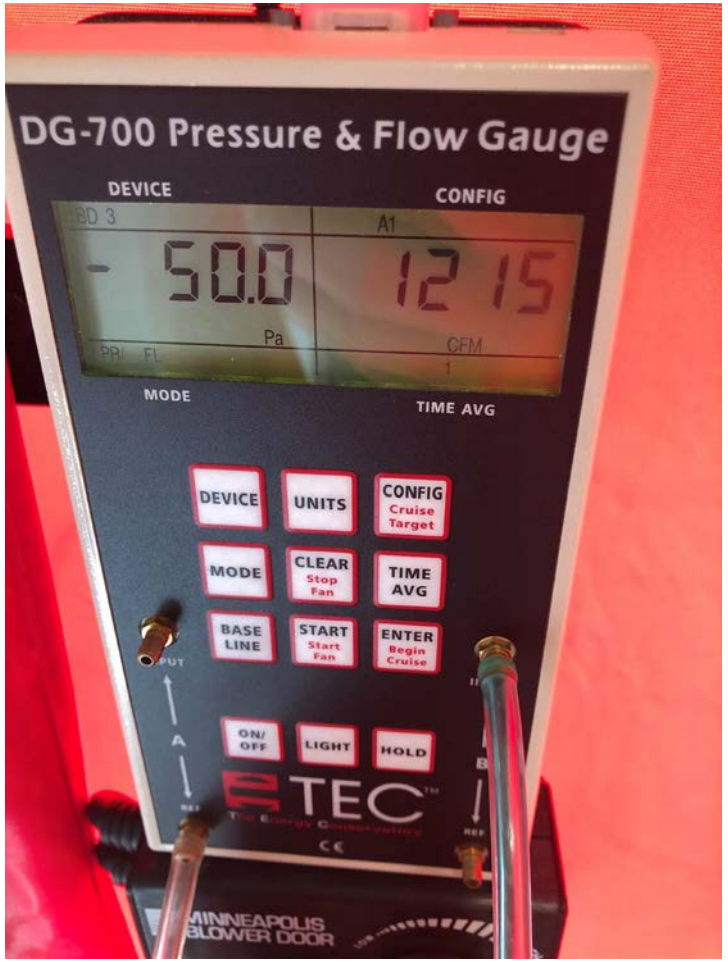
CFM	Above Code	Code
Average	4.9	6.8

KEY INSIGHT

Above code program participants lowered the duct leakage rate to an average of 4.9 CFM/100 square feet. Conversely, homes built to code had a higher than average leakage rate of 6.8 CFM/100 square feet.

Infiltration

Blower Door


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
BD 3
A1
- 50.0
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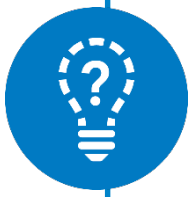
1215
CFM
PR FL
1
MODE
TIME AVG
DEVICE
UNITS
CONFIG
Cruise
Target
MODE
CLEAR
Stop
Fan
TIME
AVG
BASE
LINE
START
Start
Fan
ENTER
Begin
Cruise
ON/
OFF
LIGHT
HOLD
TEC
MINNEAPOLIS
BLOWER DOOR

Envelope Infiltration

Above Code Program Participant

ACH50	Above Code	Code
Min	1.7	2.9
Average	3.4	4.6
Max	5.3	8.1



KEY INSIGHT

Reducing the air leakage from a home's envelope requires a concerted effort on the part of the builder. Homes built by above code program participants had an average ACH50 of 3.4, compared to 4.6 for homes built by non-participants.

Air Sealing Examples

Good Air Sealing Examples

Air Sealing Missed Opportunities

Thank You

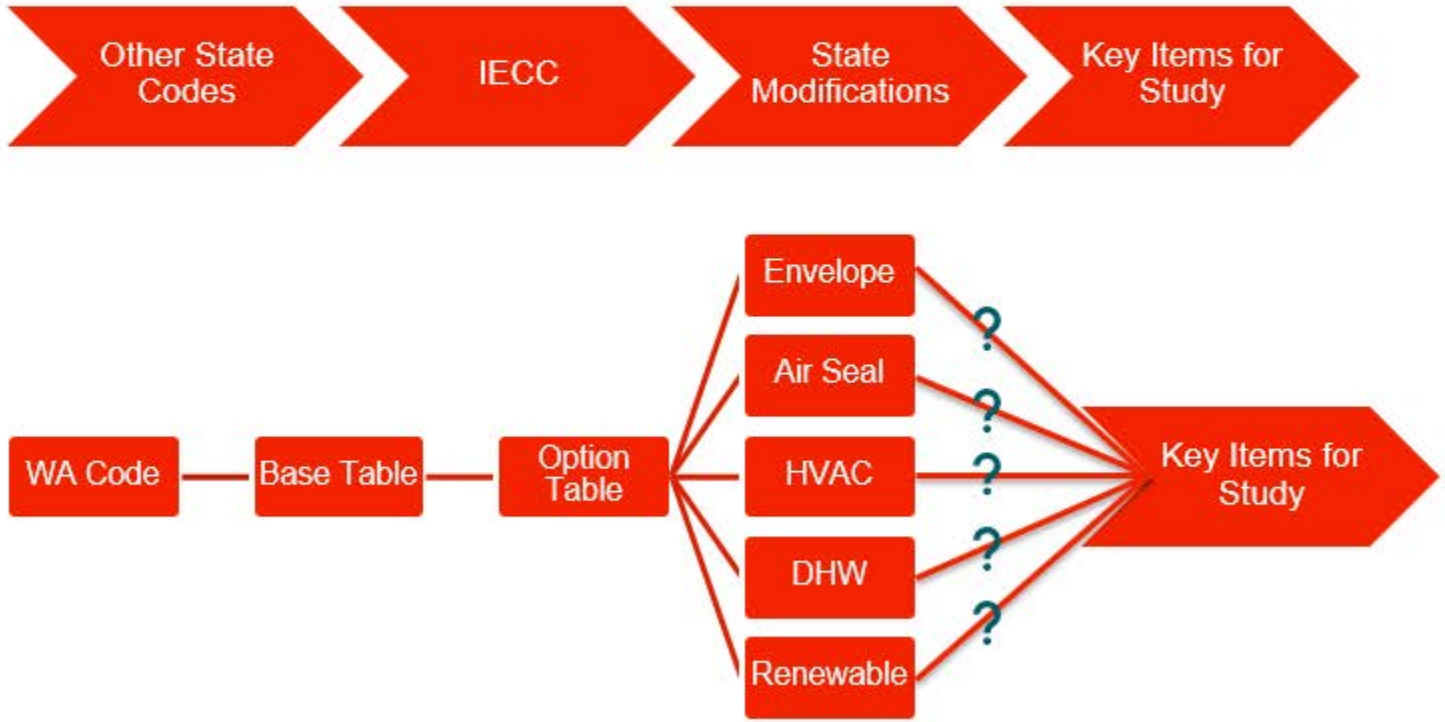
Greg Lasher

TRC

glasher@trccompanies.com

63 And Me, or A Field Person's View of Code Compliance

WA Code vs Other State Codes



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Two-Stage Approach

- **Phase 1:** What combination of options are being used to meet code?
  - Review plans from sample of Jurisdictions
  - Use results to build prototypes and prototype weights in final analysis
- **Phase 2:** Field data collection of components
  - Similar to standard data collection, but with more end points because of the mechanical pathways that can be used to meet code

Findings

- Phase 1
  - 92% homes built with just 6 combinations of options
  - HVAC and DHW options always selected in these 6 common combinations
  - Then either select the first level of envelope or air sealing options
  - Data collected from 342 homes plans from 13 jurisdictions (small, medium, and large size jurisdictions represented)
- Phase 2
  - 184 homes to get 63 observations of 11 key items (7 from DOE protocol + 4 from WA compliance pathways identified in Phase 1)
  - Annual Statewide potential:

Measure	Total Energy Savings (MMBtu/year)	Total Energy Cost Savings ($/year)
Wall Insulation	25,672	328,142
Air Sealing	7,019	91,558
Duct Tightness	6,218	75,733
Low-Flow Fixtures	5,816	73,124
DHW	3,653	63,694
Ceiling Insulation	2,438	31,202
Foundation Insulation	1,116	14,028
Total	51,932	677,480

How We Found The Homes and Convinced Builders to Let us in

Start With The Local Jurisdiction

Responses From Code Officials

Here is a list of open projects

Here is a list of builders with open projects

No response

We don’t have time

It’s an unfunded mandate $$$$$

Follow The Flags

Track The Truck

Scan For The Can

Zero In With Zillow

CHELAN COUNTY

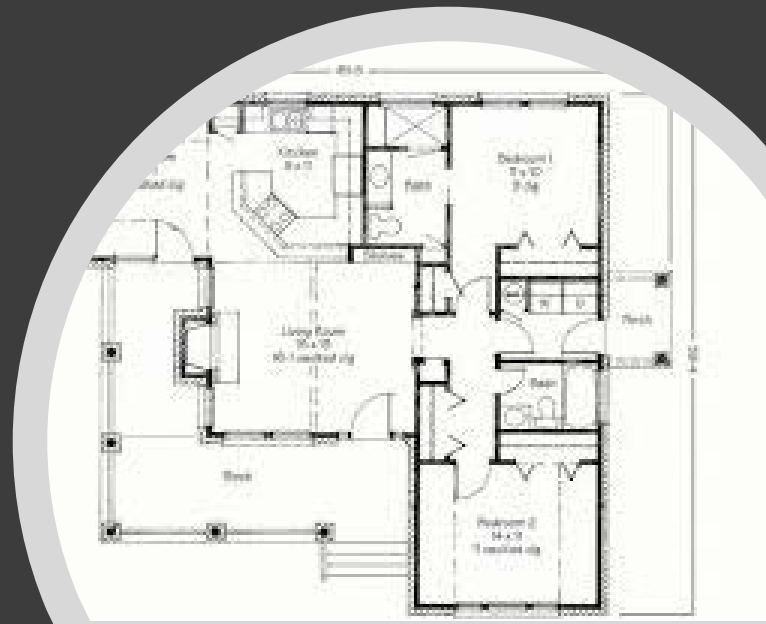
Utilize the Utilities

Reel in the Real Estate Agents (They work Sundays too)

Search For The Shack

Finding The Plans

- At the house (think Easter egg hunt)
- Back to the building department
- The site shack



The Ideal


VA Lot 77
1821 NE 81st
NHC-2019-01406
Fire Permit
FEX-2019-00176

Dumpster Diving

Revisit Local Jurisdiction

Other Findings And Trends

Ducts on the inside make for a better duct system

Ducts have migrated from the crawl to the attic

Web Trusses Used as Garage Ceilings: Hard Not to Have Gaps

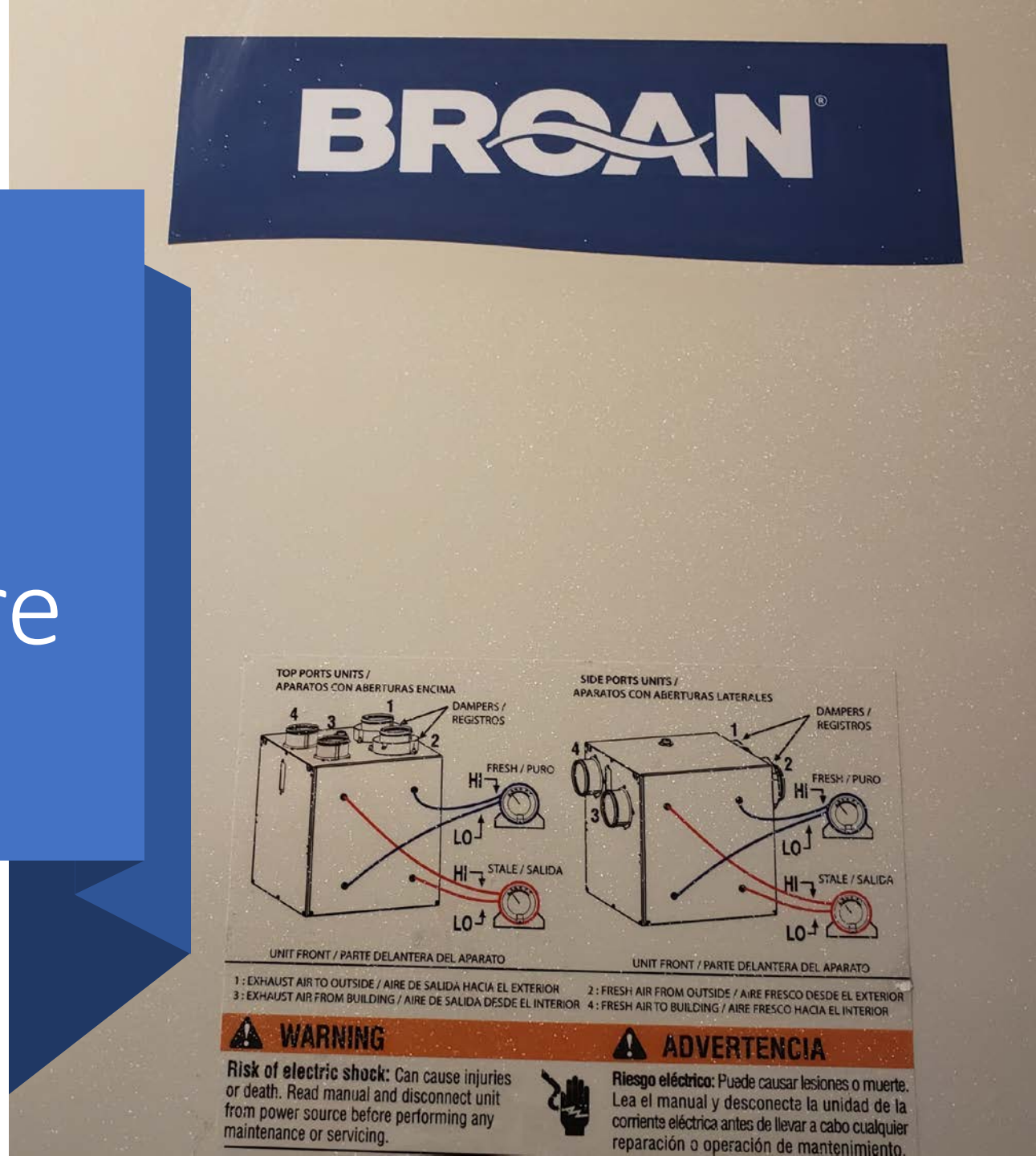
10 foot walls

Controllers Control What?

Ventilation System Controllers not set

Ventilation Timers Usually Not Set

HRVS Not Balanced, Or Results Posted are Wrong

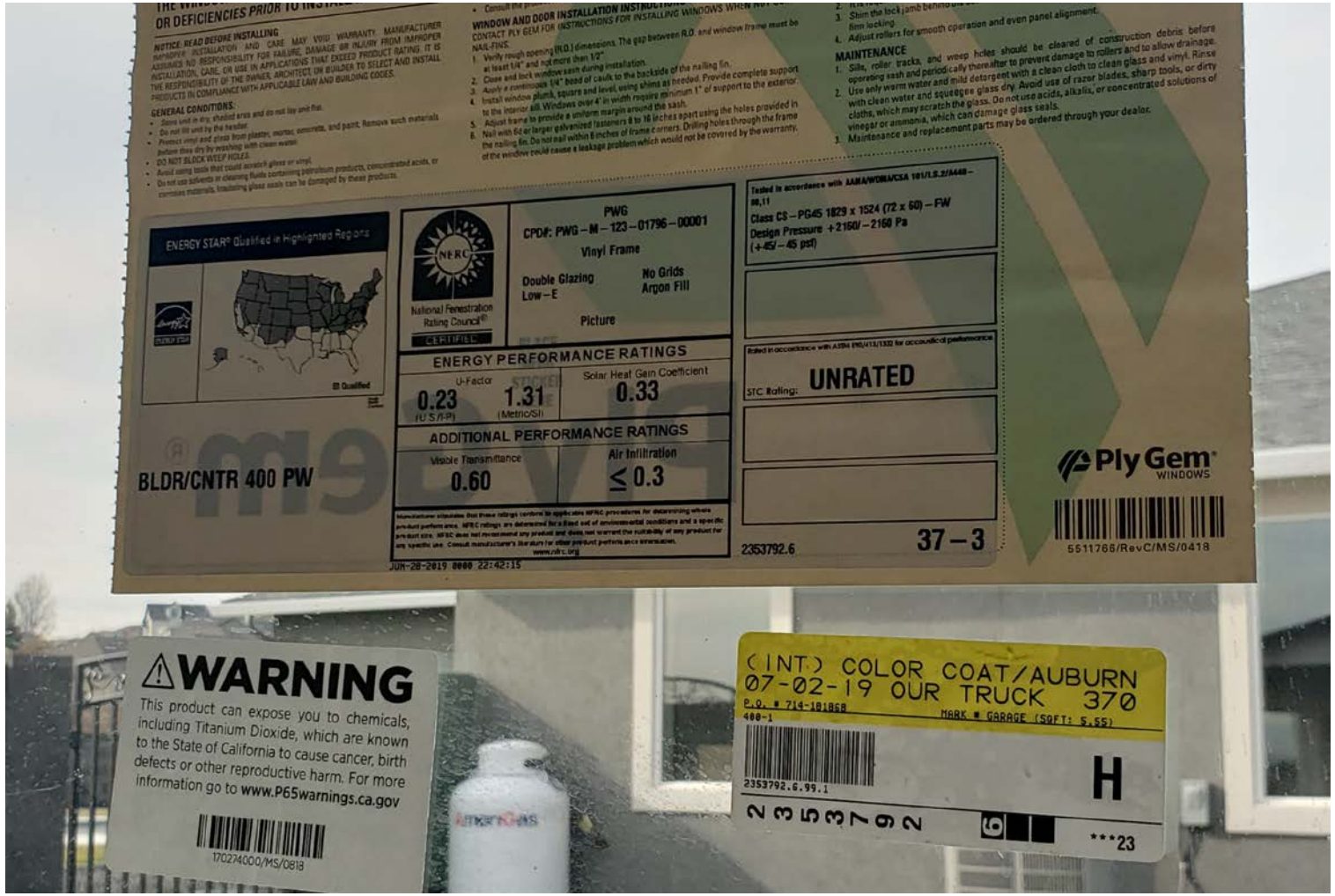


ECMS Not Used on Air handlers Used With Ventilation Systems.

HVAC Sizing Project

- Heat pump balance points were in the mid 20’s
- HVAC sizing calculations were seldom located
- Gas furnaces are oversized

Heat Pump Controllers Not Set up



New Subdivisions may have non utility fuel sources

Local Code Officials Sometimes Require Strange Things

Looking Ahead to the Next Code: Where we Think Additional Training and Assistance is Needed

- Getting Ducts inside
- Ventilation commissioning
- HRV design, installation and commissioning
- Heat Pump commissioning
- Advanced air sealing techniques

Thank you for your time!

QUESTIONS?

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Thank You!

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