Members of the MV&E,

Thank you for the opportunity to present one of our code proposals for reconsideration. As a member of the Energy TAG (Technical Advisor Group), I have seen the proposals and tough decisions ahead of you with this code cycle. The purpose of this letter is to ask the (Mechanical, Ventilation, and Energy Committee (MV&E Committee) to reconsider the ERI index as a viable third option to energy code compliance for WSEC-R. (Washington State Energy Code-Residential).

At the Washington State Energy Code TAG meetings, there was a heated debate about the merits of adopting the ERI index. The vote was close, 9-8-1 against its adoption. I believe more voters would have favored adoption had I been able to present the research data that was provided in the working groups.

I am new to this code development process, and I was unable to submit our supporting data in a timely manner to the entire TAG. While some of the data were presented in the short (blitz style) working groups, I felt it was inappropriate to ask the entire TAG to consider data that was not available 24 hours in advance to the TAG voting members. Therefore, we did not present all the information that we had available.

Included with this letter I have provided all the data that was available in the working group that established similar CO2 calculations in the 301 Standard and SEEM software used by Ecotope. This data was provided by Phillip Fairey with the Florida Solar Energy Center and Ecotope. I have amended the original ERI proposal document based on TAG recommendations so that it includes a gas and electric path in the ERI selection. I have incorporated other recommendations, as well.

There are several major benefits that can come from the incorporation of an ERI index path to code compliance. Among those are:

- Increased flexibility in code compliance without compromising on energy efficiency.
- AHJ Code inspection relief:
    - This code is complicated, and more is required of plans examiners and inspectors to oversee compliance. We are already working with WABO outside of the code development process to develop processes for certifying third party plans examiners and inspectors to help address this issue. The ERI index approach brings with-it third-party review of plans and inspection.
- Verified commissioning of key energy system elements by energy professionals
    - Ventilation commissioning, blower door testing, and duct testing as well as the possible use of 310 Standard (Heat pump commissioning similar to PTCS for new construction) all would be addressed by the third parties.
    - ERI includes 24 minimum inspection areas that encompass the entirety of the building/dwell. The major verification “items”/data points will require photo documentation.
- Data on code compliance approaches can be collected that would be used to help establish future codes

We understand that there are concerns with the ERI approach, as well. The largest area of concern is the quality of modeling that may be performed. This concern has been raised in previous years, and it has been a legitimate concern. We believe that this concern has been largely addressed through

procedural elements of the proposal. Certified ERI's will be a minimum requirement, which means all ERI's will be subject to RESNET's quality assurance, and those must be submitted by energy verifiers who are trained and in compliance with quality assurance policies.

We believe that the main argument against utilizing verifiers in code compliance work is that historically energy modelling was not well standardized, and that those who wanted to "game the system" would be able to do so. We have seen the system improve since the first discussions of adopting an ERI approach for Washington several years ago. The skills and knowledge of the energy verifier community have improved, as has the quality assurance structure under which they operate. This structure of performance and oversight will continue to improve as the ERI approach becomes more integrated into code compliance documentation and enforcement.

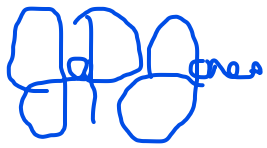
Finally, it is important to understand that quite a bit of modeling and model comparison work led to our comfort with this proposal, and with the specific recommended levels of the ERI for natural gas and electric heat pump heated homes. While we have tried to respond to and address all legitimate questions about the modeling software that would be used under the ERI path and used the software available to help set the ERI levels, we understand that there are still TAG members that are concerned about those tools and the specific ERI levels proposed. We have proposed conservative ERI levels to help address these issues – ones that will ensure that homes complying using the ERI path will be at least as efficient as those following other code compliance paths. As I noted above, I am including our supporting data for those seeking to explore the analysis more fully.

Was a result of this analytical work and extensive discussions with advocates for and opponents of the ERI path, we are proposing adjusting the ERI number(s) to include a gas path and a heat pump path with different ERI ceilings, an ASHRAE 90.2 ERI index 55 for heat pump heated dwellings and ASHRAE 90.2 ERI index 47 natural gas heated dwellings.

I hope that this helps explain why we believe that it is time for the WSEC-R to include an ERI-based compliance path, and therefore why we are requesting that the MVE Committee move forward our proposal for adding that path to the code this code cycle.

Thank you for your consideration of this proposal.

Respectfully,



Jonathan P Jones
Programs Coordinator
Washington State University
WSU Energy Codes Website
1-360-956-2042

21-GP2-097
Proponent Revision
Received 6/14/22

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

Code being amended: ☐ Commercial Provisions X☐ Residential Provisions

Code Section # Adding back in the original R406 (AKA R408) See below

Brief Description: EPA CT

We propose adding back the ERI index into the WSEC-R

Proposed code change text: (Copy the existing text from the Integrated Draft, linked above, and then use underline for new text and ~~strikeout~~ for text to be deleted.)

See attached

Purpose of code change:

Please see attached letter for reconsideration. The purpose is to establish an industry usable metric for code compliance modeling in WSER-R. This would allow overtaxed jurisdictions to use building science technicians in energy code compliance work, again in WSEC-R designated properties. As IBC already has a functional modeling path.

Your amendment must meet one of the following criteria. Select at least one:

☐ Addresses a critical life/safety need.

☐ The amendment clarifies the intent or application of the code.

X☐ Addresses a specific state policy or statute.
(Note that energy conservation is a state policy)

X☐ Consistency with state or federal regulations.

X☐ Addresses a unique character of the state.

X☐ Corrects errors and omissions.

Check the building types that would be impacted by your code change:

X☐ Single family/duplex/townhome ☐ Multi-family 4 + stories ☐ Institutional

X☐ Multi-family 1 – 3 stories ☐ Commercial / Retail ☐ Industrial

Your name	Jonathan P Jones	Email address	JonesJ@energy.wsu.edu
Your organization	Washington State University	Phone number	509-438-7839
Other contact name	Dan Wildenhaus		

Instructions: Send this form as an email attachment, along with any other documentation available, to: sbcc@des.wa.gov. For further information, call the State Building Code Council at 360-407-9278.

Economic Impact Data Sheet

Briefly summarize your proposal's primary economic impacts and benefits to building owners, tenants, and businesses.

The cost of an average energy model which ranges from location to location in the state with an estimated cost ranging from $100- $200/unit typically offering repeat floor plans at discounted rates. Again, this is just an estimated and higher cost of living locations typically charge a little more.

Provide your best estimate of the construction cost (or cost savings) of your code change proposal? (See OFM Life Cycle Cost **Analysis tool** and **Instructions;** use these **Inputs**. **Webinars on the tool can be found Here and Here**)

$Click here to enter text./square foot (For residential projects, also provide $Click here to enter text./ dwelling unit)

Show calculations here, and list sources for costs/savings, or attach backup data pages

There are many cost benefits of using trained consultants that often pay for themselves and then some. However, for the intent of this document the savings would mean actual realized savings and more consistent enforcement of the energy code. Relief to overworked and understaffed jurisdictions were the availability of time to take the necessary training to enforce energy code just doesn't exist.

Provide your best estimate of the annual energy savings (or additional energy use) for your code change proposal?

Click here to enter text.KWH/ square foot (or) Click here to enter text.KBTU/ square foot

(For residential projects, also provide Click here to enter text.KWH/KBTU / dwelling unit)

Show calculations here, and list sources for energy savings estimates, or attach backup data pages

Energy Calculations are attached with this proposal. As you can see the documents clearly support that we can use an established ERI. The final number will have to be adjusted to match the final voted on code. See note below.

Please note, the numbering of this code is based on current code and national code. This proposal may need adjustment in the appropriate place(s) as things change with other proposals and due to currently adopted WSEC amendments. Also please note, the final ERI index number used is a place holder until the final research can be completed to ensure the ERI is deemed as equivalent as the prescriptive path option in WSEC-R.

Attached is the IECC national code for the entire chapter that was removed. To align with national, I believe our (WA) 406 should move to the same options location as nation in the R408 and the national R406 take its place. See attached R 406 Language below. It was vetted as best as possible for WA code equals, not counting new proposals.

Section R406 Energy Rating Index Compliance Alternative.

R406.1 Scope

This section establishes criteria for compliance using an Energy Rating Index (ERI) analysis.

R406.2 ERI Compliance

Compliance based on the ERI requires that the rated design meets all of the following:

1. The requirements of the sections indicated within Table R406.2.

2. Maximum ERI of Table R406.5.

TABLE R406.2

REQUIREMENTS For ENERGY RATING INDEX

SECTION[a]	TITLE
General	
R401.2.5	Additional efficiency packages
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installation
R402.4.1.1	Installation
R402.4.1.2	Testing
Mechanical	
R403.1	Controls
R403.3 except Sections R403.3.2, R403.3.3 and R403.3.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated water calculation and temperature maintenance systems
R403.5.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating

R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
R404.2	Interior lighting controls
R406.3	Building thermal envelope

a. Reference to a code section includes all of the relative subsections except as indicated in the table.

R406.3 Building Thermal Envelope

Building and portions thereof shall comply with Section R406.3.1 or R406.3.2.

R406.3.1 On-Site Renewables Are Not Included

Where on-site renewable energy is not included for compliance using the ERI analysis of Section R406.4, the proposed total building thermal envelope UA, which is sum of *U*-factor times assembly area, shall be less than or equal to the building thermal envelope UA using the prescriptive *U*-factors from Table R402.1.2 multiplied by 1.15 in accordance with Equation 4-1.

$$UA_{\text{Proposed design}} = 1.15 \times UA_{\text{Prescriptive reference design}} \quad \textbf{(Equation 4-1)}$$

R406.3.2 On-Site Renewables Are Included

Where on-site renewable energy is included for compliance using the ERI analysis of Section R406.4, the *building thermal envelope* shall be greater than or equal to the levels of efficiency and SHGC in Table R402.1.2 or Table R402.1.4 of the 2018 *International Energy Conservation Code*.

R406.4 Energy Rating Index

The Energy Rating Index (ERI) shall be determined in accordance with RESNET/ICC 301 except for buildings covered by the *International Residential Code*, the ERI reference design ventilation rate shall be in accordance with Equation 4-2.

$$\text{Ventilation rate, CFM} = (0.01 \times \text{total square foot area of house}) + [7.5 \times (\text{number of bedrooms} + 1)] \quad \textbf{(Equation 4-2)}$$

Energy used to recharge or refuel a vehicle used for transportation on roads that are not on the building site shall not be included in the *ERI reference design* or the *rated design*. For compliance purposes, any reduction in energy use of the rated design associated with on-site renewable energy shall not exceed 5 percent of the total energy use.

R406.5 ERI-Based Compliance

Compliance based on an ERI analysis requires that the *rated proposed design* and confirmed built dwelling be shown to have an ERI less than or equal to the appropriate value indicated in Table R406.5 when compared to the *ERI reference design*.

TABLE R406.5

MAXIMUM ENERGY RATING INDEX

Fuel Type	ERI
Natural Gas	47
Heat Pumps	55

R406.6 Verification by Approved Agency

Verification of compliance with Section R406 as outlined in Sections R406.4 and R406.6 shall be completed by an *approved* third party. Verification of compliance with Section R406.2 shall be completed by the authority having jurisdiction or an *approved* third-party inspection agency in accordance with Section R105.4.

R406.7 Documentation

Documentation of the software used to determine the ERI and the parameters for the *residential building* shall be in accordance with Sections R406.7.1 through R406.7.4.

R406.7.1 Compliance Software Tools

Software tools used for determining ERI shall be *Approved* Software Rating Tools in accordance with RESNET/ICC 301.

All pertinent data that led to the creation/conclusion of the ERI index shall be entered and maintained into a central database approved by and having access to Washington State Universities Energy Program and equivalent state approved agency(s). (See R406.7.7) for technical code support and code development efforts.

R406.7.2 Compliance Report

Compliance software tools shall generate a report that documents that the home and the ERI score of the *rated design* complies with

Sections R406.2, R406.3 and R406.4. Compliance documentation shall be created for the proposed design and shall be submitted with the application for the building permit. Confirmed compliance documents of the built *dwelling unit* shall be created and submitted to the code official for review before a certificate of occupancy is issued. Compliance reports shall include information in accordance with Sections R406.7.2.1 and R406.7.2.2.

R406.7.2.1 Proposed Compliance Report for Permit Application (produced uniformly by WSU approved database(s))

Compliance reports submitted with the application for a building permit shall include the following:

1. Building street address, or other *building site* identification.
2. Declare ERI on title page and building plans.
3. The name of the individual performing the analysis and generating the compliance report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the reference design and/or the rated home.
6. A certificate indicating that the proposed design has an ERI less than or equal to the appropriate score indicated in Table R406.5 when compared to the ERI reference design. The certificate shall document the building component energy specifications that are included in the calculation, including: component level insulation *R*-values or *U*-factors; assumed duct system and building envelope air leakage testing results; and the type and rated efficiencies of proposed heating, cooling, mechanical ventilation, and service water-heating equipment to be installed. If on-site renewable energy systems will be installed, the certificate shall report the type and production size of the proposed system.
7. When a site-specific report is not generated, the proposed design shall be based on the worst-case orientation and configuration of the rated home.

R406.7.2.2 Confirmed Compliance Report for a Certificate of Occupancy (produced uniformly by WSU approved database(s))

A confirmed compliance report submitted for obtaining the certificate of occupancy shall be made site and address specific and include the following:

1. Building street address or other *building site* identification.
2. Declaration of ERI on title page and on building plans.
3. The name of the individual performing the analysis and generating the report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the reference design and/or the rated home.
6. A final confirmed certificate indicating that the confirmed rated design of the built home complies with Sections R406.2 and R406.4. The certificate shall report the energy features

that were confirmed to be in the home, including: component level insulation *R*-values or *U*-factors; results from any required duct system and building envelope air leakage testing; and the type and rated efficiencies of the heating, cooling, mechanical ventilation, and service water-heating equipment installed. Where on-site renewable energy systems have been installed on or in the home, the certificate shall report the type and production size of the installed system.

R406.7.3 Renewable Energy Certificate (REC) Documentation

Where on-site renewable energy is included in the calculation of an ERI, one of the following forms of documentation shall be provided to the code official:

1. Substantiation that the RECs associated with the on-site renewable energy are owned by, or retired on behalf of, the homeowner.
2. A contract that conveys to the homeowner the RECs associated with the on-site renewable energy or conveys to the homeowner an equivalent quantity of RECs associated with other renewable energy.
3. Shall be restricted to WA State Energy Credit selection limitation on the WSEC-R R406.3 table and proven with a manufacture's proprietary software or PVWatts.

R406.7.4 Additional Documentation

The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *ERI reference design*.
2. A certification signed by the builder providing the building component characteristics of the *rated design.*
3. Documentation of the actual values used in the software calculations for the *rated design*.

R406.7.5 Specific Approval

Performance analysis tools meeting the applicable subsections of Section R406 shall be *approved*. Documentation demonstrating the approval of performance analysis tools in accordance with Section R406.7.1 shall be provided.

R406.7.6 Input Values

Where calculations require input values not specified by Sections R402, R403, R404 and R405, those input values shall be taken from RESNET/ICC 301.

R406.7.7 Database Collection

All code data must be maintained and made available to the local jurisdiction Therefore all data will be stored in a database approved by and having access to Washington State Universities Energy Program and equivalent state approved agency(s). (See R406.7.7) for technical code support and code development efforts.

Access to this database will require that the user provide proof of certification to perform all the standards requirements and maintain a good standing within those organization.

All homes entered in the database will be certified or has registered the energy models with the appropriate organizations with the appropriate oversight as necessary.

Jonathan Jones

From: Philip Fairey [redacted]
Sent: Thursday, May 26, 2022 6:17 AM
To: Jonathan Jones
Cc: Michael Lubliner
Subject: Re: Fwd: ERI comparisons

Hi Jonathan,

I'm not exactly sure why Luby chose to not disclose the HERS/ERI value in the screen shot he snipped below but each of these home simulations has an ERI associated with it. I repeat them here for your information.

Title	HERSIndex
WSU_1344-4C_21-001	64.00
WSU_1344-4C_21-002	59.86
WSU_1344-4C_21-003	59.31
WSU_1344-4C_21-004a	58.75
WSU_1344-4C_21-004b	84.80
WSU_1344-5B_21-005	68.09
WSU_1344-5B_21-006	59.05
WSU_1344-5B_21-007	58.45
WSU_1344-5B_21-008a	64.70
WSU_1344-5B_21-008b	86.99
WSU_2200-4C_21-011	54.79
WSU_2200-4C_21-012	47.43
WSU_2200-4C_21-013	47.08
WSU_2200-4C_21-014a	61.42
WSU_2200-4C_21-014b	94.12
WSU_2200-5B_21-015	53.86
WSU_2200-5B_21-016	44.84
WSU_2200-5B_21-017	44.75
WSU_2200-4C_21-018a	62.60
WSU_2200-4C_21-018b	88.63

As you see they vary a lot due to the nature of the configurations I was asked to consider. The full spreadsheet with all of the information on the analysis was attached to my May 24th e-mail messages. The homes analyzed here contained standard appliances but very high efficiency lighting (90% at 90 lumens/watt). If ENERGYSTAR appliances are assumed, the ERIs will be reduced. However, your an Luby's suggestion of ERI=40 is very ambitious unless you are planning to allow PV to contribute this ERI. One of the other implications you need to understand is that climate zone 4C used IECC Climate zone 5 envelope features in the 2006 IECC instead of the climate zone 4A & 4B features that were used everywhere else so these same Climate zone 5 envelope features are used in the RESNET Reference case. As a result, the ERI for homes in climate zone 4C are compared against a more efficient Reference case than homes in other climate zone 4 climates. In fact, the homes in Climate zone 4C have the same Reference case energy features as the homes in Climate zone 5B for this analysis. You actually see this impact in the ERIs shown above and in the spreadsheet results. If you do the math (not counting the 'a' and 'b' results, for which the ERIs are very misleading due to the way the

modeling is done) the Climate Zone 5B results are some 10-14 point lower than the climate zone 4C results. This is due entirely to the fact that 4C is not using the "standard" climate zone 4 Reference case envelope features. The RESNET ERI Reference Home values in question are shown below with the principal difference highlighted.

Table 4.2.2(2) Component Heat Transfer Characteristics for Energy Rating Reference Home[a]

Climate Zone[b]	Fenestration and Opaque Door U-Factor	Glazed Fenestration Assembly SHGC	Ceiling U-Factor	Frame Wall U-Factor	Floor Over Unconditioned Space U-Factor	Basement Wall U-Factor[c]	Slab-on-Grade R-Value & Depth[d,e]
1	1.20	0.40	0.035	0.082	0.064	0.360	0
2	0.75	0.40	0.035	0.082	0.064	0.360	0
3	0.65	0.40	0.035	0.082	0.047	0.360	0
4 except Marine	0.40	0.40	0.030	0.082	0.047	0.059	10, 2 ft.
5 and Marine 4	0.35	0.40	0.030	0.060	0.033	0.059	10, 2 ft.
6	0.35	0.40	0.026	0.060	0.033	0.059	10, 4 ft.
7 and 8	0.35	0.40	0.026	0.057	0.033	0.059	10, 4 ft.

Both of these homes are frame wall homes on crawl space foundations (or over unconditioned garage) and the fenestration U-factor differences also matter quite a bit, more so for the 2200 ft2 home because it has a much greater window/floor area ratio. As a result, we see larger ERI climate zone differences for the 2200 ft home than for the 1344 ft2 home.

If I had to make a recommendation I think it would be to use the ASHRAE 90.2 compliance ERI of 47 in both climates.

I hope all this is helpful (and understandable)

Philip

On 5/25/2022 8:27 PM, Jonathan Jones wrote:

> Good afternoon good sir!
>
> Philip, we (Luby and I) currently have a one sized fit all ERI proposal of 40 with language about adjusting it to match voted and approved amendments. Based on your information/research, what do you think HERS/ERI should be for a WA 2021 code? I don't think the group will get to this in time and I fear it is a stall tactic. I appreciate all the time you have taken thus far and Luby says you have done it all for free. I appreciate that a lot. I personally have spent hours of personal time on this project as well. If an ERI/HERS number was suggested by you it would help with my position to defend it at the TAG against … opposition. I won't make you come talk about it or anything 😊. Just that someone not only smarter than me, but also wasn't me, produced it feels important as the "new guy" in this case.
>
> "Nothing ever exists entirely alone. Everything is in relation to everything else" - Buddha
>
> Jonathan P Jones
> Programs Coordinator
> Washington State University

Title	HERSIndex	RatedE.He	RatedE.Co	RatedE.W	RatedE.M	RatedE.AP	RatedE.To	RefE.Heat	RefE.Cool	RefE.Wate	RefE.Mech	RefE.APPL	RefE.Total	RatedL.He	RatedL.Co	RatedL.W	RatedL.M	RatedL.AP	**RatedL.To**	RefL.Heat	RefL.Cool	RefL.Wate	RefL.Mech	RefL.APPL	**RefL.Total**	IADSave	IAFrh	PVkWh	PEFrac	OnSiteNetProd
WSU_1344-4C_21-001	64.00	4.59	0.23	10.99	1.03	13.77	30.61	9.61	0.63	11.42	1.39	19.27	42.31	7.18	0.51	9.94	1.03	13.77	**32.44**	15.05	1.39	10.33	1.39	19.27	**47.43**	25.60%	1.07		1	
WSU_1344-4C_21-002	59.86	20.71	0.12	4.91	0.96	13.77	40.47	26.67	0.62	11.42	0.89	19.27	58.86	10.75	0.27	4.44	0.96	13.77	**30.19**	15.17	1.38	10.33	0.89	19.27	**47.04**	27.00%	1.07		1	
WSU_1344-4C_21-003	59.31	20.14	0.13	4.91	0.96	13.77	39.91	26.67	0.62	11.42	0.89	19.27	58.86	10.45	0.29	4.44	0.96	13.77	**29.92**	15.17	1.38	10.33	0.89	19.27	**47.04**	27.00%	1.07		1	
WSU_1344-4C_21-004a	58.75	6.39	0.12	4.9	1.17	13.77	26.35	9.61	0.63	11.42	1.39	19.27	42.31	10	0.27	4.43	1.17	13.77	**29.64**	15.05	1.39	10.33	1.39	19.27	**47.43**	23.90%	1.06		1	
WSU_1344-4C_21-004b	84.80	14.78	0.12	4.9	1.17	13.77	34.74	9.61	0.63	11.42	1.39	19.27	42.31	23.14	0.27	4.43	1.17	13.77	**42.78**	15.05	1.39	10.33	1.39	19.27	**47.43**	23.90%	1.06		1	
WSU_1344-5B_21-005	68.09	14.45	0.88	12.21	1.39	13.77	42.69	21.12	1.91	12.68	1.48	19.27	56.44	19.57	2.17	11.16	1.39	13.77	**48.06**	28.6	4.7	11.59	1.48	19.27	**65.64**	28.00%	1.08		1	
WSU_1344-5B_21-006	59.05	38.01	0.67	5.71	0.98	13.77	59.14	50.29	1.88	12.68	0.93	19.27	85.04	19.81	1.67	5.22	0.98	13.77	**41.46**	28.74	4.68	11.59	0.93	19.27	**65.21**	28.50%	1.08		1	
WSU_1344-5B_21-007	58.45	36.74	0.77	5.71	0.98	13.77	57.97	50.29	1.88	12.68	0.93	19.27	85.04	19.15	1.91	5.22	0.98	13.77	**41.04**	28.74	4.68	11.59	0.93	19.27	**65.21**	28.50%	1.08		1	
WSU_1344-5B_21-008a	64.70	17.63	0.54	5.71	1.26	13.77	38.91	21.11	1.91	12.68	1.51	19.27	56.48	23.88	1.34	5.22	1.26	13.77	**45.47**	28.6	4.7	11.59	1.51	19.27	**65.67**	26.10%	1.07		1	
WSU_1344-5B_21-008b	86.99	29.18	0.54	5.71	1.26	13.77	50.47	21.11	1.91	12.68	1.51	19.27	56.48	39.53	1.34	5.22	1.26	13.77	**61.13**	28.6	4.7	11.59	1.51	19.27	**65.67**	26.10%	1.07		1	
WSU_2200-4C_21-011	54.79	7.41	0.4	3.88	1.59	17.36	30.64	15.32	1.01	11.72	1.68	24.75	54.49	12.1	0.9	3.42	1.59	17.36	**35.36**	25.03	2.26	10.33	1.68	24.75	**64.05**	28.90%	1.01		1	
WSU_2200-4C_21-012	47.43	14.44	0.38	3.88	1.53	17.36	37.58	43.84	1.03	11.72	1.69	24.75	83.03	7.52	0.84	3.42	1.53	17.36	**30.66**	25.03	2.26	10.33	1.69	24.75	**64.06**	34.80%	1.01		1	
WSU_2200-4C_21-013	47.08	13.68	0.46	3.88	1.53	17.36	36.9	43.84	1.03	11.72	1.69	24.75	83.03	7.12	1.01	3.42	1.53	17.36	**30.44**	25.03	2.26	10.33	1.69	24.75	**64.06**	34.80%	1.01		1	
WSU_2200-4C_21-014a	61.42	9.61	0.34	4.74	1.61	17.36	33.66	15.32	1.01	11.72	1.68	24.75	54.49	15.69	0.77	4.18	1.61	17.36	**39.6**	25.03	2.26	10.33	1.68	24.75	**64.05**	25.30%	1.01		1	
WSU_2200-4C_21-014b	94.12	22.52	0.34	4.74	1.61	17.36	46.57	15.32	1.01	11.72	1.68	24.75	54.49	36.78	0.77	4.18	1.61	17.36	**60.69**	25.03	2.26	10.33	1.68	24.75	**64.05**	25.30%	1.01		1	
WSU_2200-5B_21-015	53.86	16.81	1.29	4.43	1.66	17.36	41.54	32.96	2.97	12.98	1.73	24.75	75.39	23.11	3.2	3.95	1.66	17.36	**49.27**	45.31	7.38	11.59	1.73	24.75	**90.76**	29.70%	1.01		1	
WSU_2200-5B_21-016	44.84	28.9	1.23	4.42	1.61	17.36	53.52	79.05	2.96	12.98	1.72	24.75	121.46	15.11	3.07	3.95	1.61	17.36	**41.09**	45.31	7.38	11.59	1.72	24.75	**90.76**	36.40%	1.01		1	
WSU_2200-5B_21-017	44.75	27.46	1.49	4.42	1.61	17.36	52.34	79.05	2.96	12.98	1.72	24.75	121.46	14.36	3.73	3.95	1.61	17.36	**41**	45.31	7.38	11.59	1.72	24.75	**90.76**	36.40%	1.01		1	
WSU_2200-4C_21-018a	62.60	22.85	1.15	4.43	1.73	17.36	47.52	32.96	2.97	12.98	1.8	24.75	75.46	31.4	2.86	3.95	1.73	17.36	**57.3**	45.29	7.38	11.59	1.8	24.75	**90.82**	29.70%	1.01		1	
WSU_2200-4C_21-018b	88.63	40.19	1.15	4.43	1.73	17.36	64.86	32.96	2.97	12.98	1.8	24.75	75.46	55.23	2.86	3.95	1.73	17.36	**81.13**	45.29	7.38	11.59	1.8	24.75	**90.82**	29.70%	1.01		1	

Simulations with EnergyGauge v.7.0.05

Prototype		Climate	Components							HVAC					DHW				HERS	Energy Use (MBtu)				Carbon Estimate (short tons)		
		TMY3 City	window	wall	ceiling	floor (crawl)	door	infilt	HRV	heat	fuel	eff.	cooling	ducts	Type	Fuel	UEF	Comments	Index	Total	Heating	Cooling	HotWater	CO2e	refCO2e	Index
WSEC 2021p	Case No																									
1344	21-001	Seattle	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		64	30.61	4.59	0.23	10.99	1.03	1.42	72
1344	21-002	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		60	40.47	20.71	0.12	4.91	2.18	1.42	154
1344	21-003	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		60	39.91	20.14	0.13	4.91	2.14	1.42	151
1344	21-004	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space h	69	29.71	9.75	0.12	4.90	1.00	1.42	70
1344	21-004a	Seattle										DHP							59	26.35	6.39	0.12	4.90	0.88	1.42	62
1344	21-004b	Seattle										elecRes							85	34.74	14.78	0.12	4.90	1.16	1.42	82
1344	21-005	Fairchild	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		68	42.69	14.45	0.88	12.21	1.43	1.89	76
1344	21-006	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		59	59.14	38.01	0.67	5.71	3.50	1.89	185
1344	21-007	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		59	57.97	36.74	0.77	5.71	3.41	1.89	180
1344	21-008	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space h	74	43.54	22.25	0.54	5.71	1.46	1.89	77
1344	21-008a	Fairchild										DHP							65	38.91	17.63	0.54	5.71	1.30	1.89	69
1344	21-008b	Fairchild										elecRes							87	50.47	29.18	0.54	5.71	1.69	1.89	89
2200	21-011	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	55	30.64	7.41	0.40	3.88	1.03	1.83	56
2200	21-012	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	37.58	14.44	0.38	3.88	1.84	1.83	101
2200	21-013	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	36.90	13.68	0.46	3.88	1.78	1.83	98
2200	21-014	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space h	74	38.82	14.77	0.34	4.74	1.30	1.83	71
2200	21-014a	Seattle										DHP							61	33.66	9.61	0.34	4.74	1.13	1.83	62
2200	21-014b	Seattle										elecRes							94	46.57	22.52	0.34	4.74	1.56	1.83	85
2200	21-015	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	54	41.54	16.81	1.29	4.43	1.39	2.53	55
2200	21-016	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	53.52	28.90	1.23	4.42	2.95	2.53	117
2200	21-017	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	52.34	27.46	1.49	4.42	2.85	2.53	113
2200	21-018	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space h	73	54.46	29.79	1.15	4.43	1.82	2.53	72
2200	21-018a	Fairchild										DHP							63	47.52	22.85	1.15	4.43	1.59	2.53	63
2200	21-018b	Fairchild										elecRes							89	64.86	40.19	1.15	4.43	2.17	2.53	86

67 = lb/MBtu - NWPPc weighted average LRMER

147 = lb/MBtu - natural gas emissions

Simulations with EnergyGauge v.7.0.05

Prototype		Climate	Components							HVAC					DHW				HERS	Energy Use (MBtu)				Carbon Estimate (short tons)		
		TMY3 City	window	wall	ceiling	floor (crawl)	door	infilt	HRV	heat	fuel	eff.	cooling	ducts	Type	Fuel	UEF	Comments	Index	Total	Heating	Cooling	HotWater	CO2e	refCO2e	Index
WSEC 2021p	Case No																									
1344	21-001	Seattle	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		64	30.61	4.59	0.23	10.99	1.03	1.42	72
1344	21-002	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		60	40.47	20.71	0.12	4.91	2.18	1.42	154.0968
1344	21-003	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		60	39.91	20.14	0.13	4.91	2.14	1.42	151.1646
1344	21-004	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	69	29.71	9.75	0.12	4.90	1.00	1.42	70.21035
1344	21-004a	Seattle										DHP							59	26.35	6.39	0.12	4.90	0.88	1.42	62.27842
1344	21-004b	Seattle										elecRes							85	34.74	14.78	0.12	4.90	1.16	1.42	82.10825
1344	21-005	Fairchild	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		68	42.69	14.45	0.88	12.21	1.43	1.89	75.63785
1344	21-006	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		59	59.14	38.01	0.67	5.71	3.50	1.89	185.1968
1344	21-007	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		59	57.97	36.74	0.77	5.71	3.41	1.89	180.437
1344	21-008	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	74	43.54	22.25	0.54	5.71	1.46	1.89	77.13501
1344	21-008a	Fairchild										DHP							65	38.91	17.63	0.54	5.71	1.30	1.89	68.94047
1344	21-008b	Fairchild										elecRes							87	50.47	29.18	0.54	5.71	1.69	1.89	89.4224
2200	21-011	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	55	30.64	7.41	0.40	3.88	1.03	1.83	56.2305
2200	21-012	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	37.58	14.44	0.38	3.88	1.84	1.83	100.6089
2200	21-013	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	36.90	13.68	0.46	3.88	1.78	1.83	97.69559
2200	21-014	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	74	38.82	14.77	0.34	4.74	1.30	1.83	71.24977
2200	21-014a	Seattle										DHP							61	33.66	9.61	0.34	4.74	1.13	1.83	61.7728
2200	21-014b	Seattle										elecRes							94	46.57	22.52	0.34	4.74	1.56	1.83	85.46522
2200	21-015	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	54	41.54	16.81	1.29	4.43	1.39	2.53	55.10015
2200	21-016	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	53.52	28.90	1.23	4.42	2.95	2.53	116.7628
2200	21-017	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	52.34	27.46	1.49	4.42	2.85	2.53	112.9169
2200	21-018	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat; D	73	54.46	29.79	1.15	4.43	1.82	2.53	72.23239
2200	21-018a	Fairchild										DHP							63	47.52	22.85	1.15	4.43	1.59	2.53	63
2200	21-018b	Fairchild										elecRes							89	64.86	40.19	1.15	4.43	2.17	2.53	86
																								301	Ekotrope	HERS

67 = lb/MBtu - NWPPc weighted average LRMER

147 = lb/MBtu - natural gas emissions

Note: This was a baseline home specs established by WA state to create the energy models for each code cycle. So this all Energy Gage except the refCO2e

Simulations with EnergyGauge v.7.0.05

Prototype		Climate	Components							HVAC					DHW				HERS	Energy Use (MBtu)				
		TMY3 City	window	wall	ceiling	floor (crawl)	door	infilt	HRV	heat	fuel	eff.	cooling	ducts	Type	Fuel	UEF	Comments	Index	Total	Heating	Cooling	HotWater	balance
WSEC 2021p	Case No																							
1344	21-001	Seattle	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		64	30.61	4.59	0.23	10.99	14.80
1344	21-002	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		60	40.47	20.71	0.12	4.91	14.73
1344	21-003	Seattle	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		60	39.91	20.14	0.13	4.91	14.73
1344	21-004	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	69	29.71	9.75	0.12	4.90	14.94
1344	21-004a	Seattle										DHP							59	26.35	6.39	0.12	4.90	14.94
1344	21-004b	Seattle										elecRes							85	34.74	14.78	0.12	4.90	14.94
1344	21-005	Fairchild	u=0.20	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Base	STD	elect	0.91		68	42.69	14.45	0.88	12.21	15.15
1344	21-006	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	14 SEER	Base	HPWH	elect	2.5		59	59.14	38.01	0.67	5.71	14.75
1344	21-007	Fairchild	u=0.30	R-21+12ci	49	38	R-5	3ACH50	no	FUR	gas	0.95	none	Base	HPWH	elect	2.5		59	57.97	36.74	0.77	5.71	14.75
1344	21-008	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	74	43.54	22.25	0.54	5.71	15.04
1344	21-008a	Fairchild										DHP							65	38.91	17.63	0.54	5.71	15.03
1344	21-008b	Fairchild										elecRes							87	50.47	29.18	0.54	5.71	15.04
2200	21-011	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	55	30.64	7.41	0.40	3.88	18.95
2200	21-012	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	37.58	14.44	0.38	3.88	18.88
2200	21-013	Seattle	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	47	36.90	13.68	0.46	3.88	18.88
2200	21-014	Seattle	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat	74	38.82	14.77	0.34	4.74	18.97
2200	21-014a	Seattle										DHP							61	33.66	9.61	0.34	4.74	18.97
2200	21-014b	Seattle										elecRes							94	46.57	22.52	0.34	4.74	18.97
2200	21-015	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	ASHP	elect	9.5 HSPF	14.5 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	54	41.54	16.81	1.29	4.43	19.01
2200	21-016	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	14 SEER	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	53.52	28.90	1.23	4.42	18.97
2200	21-017	Fairchild	u=0.22	R-21+12ci	49	38	R-5	2ACH50	SHR .65	FUR	gas	0.95	none	Inside	HPWH	elect	2.5	DW HR (plumbing)	45	52.34	27.46	1.49	4.42	18.97
2200	21-018	Fairchild	u=0.24	R-21int	49	30	R-5	2ACH50	SHR .65	Zonal/DHP	elect	10 HSPF	18 SEER	Base	HPWH	elect	2.5	DHP provides 60% of space heat;	73	54.46	29.79	1.15	4.43	19.09
2200	21-018a	Fairchild										DHP							63	47.52	22.85	1.15	4.43	19.09
2200	21-018b	Fairchild										elecRes							89	64.86	40.19	1.15	4.43	19.09

Seattle WA Results									
Cases:	Indices		Rated Home					Ref Home	
	HERS Index	CO_2e Index	TnML (MBtu)	PEfrac	IAF	$totCO_2e$ (Tons)	$saveCO_2e$ (Tons)	TRL (MBtu)	$totCO_2$ (Tons)
gasBase	87	194	55.66	100.0%	1.000	3.683	-1.788	64.03	1.895
elecBase	86	90	55.47	100.0%	1.000	1.698	0.197	64.34	1.895
gasHE	62	160	39.94	100.0%	1.000	3.029	-1.134	64.03	1.895
elecHE	64	63	41.03	100.0%	1.000	1.198	0.697	64.34	1.895
gas4kWPV	34	141	39.94	54.8%	1.000	2.674	-0.779	64.03	1.895
elec4kWPV	35	45	41.03	55.1%	1.000	0.843	1.052	64.34	1.895

Key:

gasBase = 2018 IECC envelope w/ HERS Ref HVAC, DHW, Lighting & Appliances
elecBase = 2018 IECC envelope w/ HERS Ref HVAC, DHW, Lighting & Appliances
gasHE = 2018 IECC envelope w/ high efficiency HVAC, DHW, Lighting & Appliances
elecHE = 2018 IECC envelope w/ high efficiency HVAC, DHW, Lighting & Appliances
gas4kWPV = gasHE with 4 kWdc PV system
elec4kWPV = elecHE with 4 kWdc PV system

Data Files

GasBase
ElecBase
GasHE
ElecHE
GasPV
ElecPV
Ref

Seattle Emissions Charts