Group 2 Energy Code-Residential Proposals - 2019

Date Received	Proponent	Code	Section	Subject	Init. Log Number
2/12/2018	Bellingham/Jim Tinner	WSEC-R	R202	Def: Res Bldg	19-WSEC-R01
2/19/2019	City of Cheney/Shane Nilles	WSEC-R	R202	Def: Res Bldg	19-WSEC-R03
4/15/2019	Commerce/Bill Kraus	WSEC-R	R202	Ductless mini split	19-WSEC-R17
4/15/2019	Commerce/Bill Kraus	WSEC-R	R202	High efficacy lamps	19-WSEC-R19
4/10/2019	Mike Moore/Broan	WSEC-R	R401.3	Certificate	19-WSEC-R08
4/15/2019	WSU/Mike Lubliner	WSEC-R	R401.3	Certificate	19-WSEC-R13
4/15/2019	Commerce/Bill Kraus	WSEC-R	R402	Reorganization	19-WSEC-R21
3/21/2019	David Mann, ACC	WSEC-R	Table R402.1.1	Wall R-value	19-WSEC-R05
4/15/2019	WSU/Mike Lubliner	WSEC-R	Table R402.1.1	Existing slab insulation	19-WSEC-R12
4/15/2019	Commerce/Bill Kraus	WSEC-R	Table R402.1.1	Log walls	19-WSEC-R22
4/15/2019	WSU/Mike Lubliner	WSEC-R	R402.1.2	R-value computation	19-WSEC-R14
4/15/2019	Patrick Hayes	WSEC-R	R402.1.4	REScheck	19-WSEC-R25
4/15/2019	Energeo/Tyler Kafentzis	WSEC-R	R402.4.1.1/ R403.3.1/ R406.2	Unvented crawlspace	19-WSEC-R34
3/21/2019	David Mann, ACC	WSEC-R	R402.4.1.2	Air leakage rate	19-WSEC-R06
4/15/2019	Commerce/Chuck Murray	WSEC-R	R402.4.1.2	Air leakage test	19-WSEC-R20
4/15/2019	Nick O'Neil	WSEC-R	R402.4.2.1	Gas fireplace efficiency	19-WSEC-R27
4/15/2019	Seattle/Duane Jonlin	WSEC-R	R402.4/ R403.3.7 / R406	Air leakage/ducts/add'l credits	19-WSEC-R31
4/15/2019	Commerce/Bill Kraus	WSEC-R	R403	Performance requirements	19-WSEC-R18
4/5/2019	Gary Heikkinen	WSEC-R	R403.1.1	Programmable Therm	19-WSEC-R07
4/15/2019	Seattle/Jennifer Gilliland	WSEC-R	R403.1.1	Programmable Therm	19-WSEC-R11
4/15/2019	Nick O'Neil	WSEC-R	R403.1.3	Pilot lights	19-WSEC-R28
4/15/2019	Env. WA/Chris Connolly	WSEC-R	R403.13	Required PV	19-WSEC-R30
12/19/2018	Robert Hitchner	WSEC-R	R403.5.4/R406	Drain water heat recovery	19-WSEC-R02

2/19/2019	City of Cheney/Shane Nilles	WSEC-R	R403.5.5	Water heater Insulation	19-WSEC-R04
4/12/2019	Gary Heikkinen	WSEC-R	R403.7.1	Elec resistance therm	19-WSEC-R09
4/15/2019	Shift Zero/Poppy Storm	WSEC-R	R404.2	Electric ready	19-WSEC-R33
4/15/2019	Commerce/Chuck Murray	WSEC-R	R406	Credit updates	19-WSEC-R23
4/9/2019	Alan Nolan/SHBA	WSEC-R	Table R406.2	Advanced framing	19-WSEC-R10
4/15/2019	Alan Nolan/SHBA	WSEC-R	Table R406.2	Buried attic ducts	19-WSEC-R15
4/15/2019	Alan Nolan/SHBA	WSEC-R	Table R406.2	High efficacy lighting	19-WSEC-R16
4/15/2019	Alan Nolan/SHBA	WSEC-R	Table R406.2	Air Leakage/Ventilation	19-WSEC-R24
4/15/2019	Patrick Hayes	WSEC-R	Table R406.2	Efficient building envelope	19-WSEC-R26
4/15/2019	Alan Nolan/SHBA	WSEC-R	Table R406.2	Building envelope	19-WSEC-R29
4/15/2019	Shift Zero/Graham Wright	WSEC-R	R408	Passive House compliance	19-WSEC-R32

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

2018 Washington State Energy Code Development

Standard Energy Code Proposal Form

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions
(A MS Word version of the code is linked to the name)

Code Section # R202 General Definitions

Brief Description: Adding IRC accessory buildings and IBC R-3 accessory buildings to the definition of "residential building".

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.)

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) and their accessory buildings as well as Group R-2, R-3, R-3 accessory buildings, and R-4 buildings three stories or less in height above grade plane.

Purpose of code change:

Currently, the code is ambiguous at best as to whether it is applicable to accessory buildings. The proposed change is intended to clarify that the residential energy code is intended to apply IRC accessory buildings as well as IBC R-3 accessory buildings.

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

☐ Addresses a critical life/safety need.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☒ Corrects errors and omissions.

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

☒ Single family/duplex/townhome

☐ Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name James E. Tinner, CBO Your organization City of Bellingham

April 2, 2019

Other contact name Click here to enter text. Phone number 360 778-8307

Email address jetinner@comcast.net

Instructions: Send this form as an email attachment, along with any other documentation available, to: sbcc@ga.wa.gov. For further information, call the State Building Code Council at 360-407-9280. **Deadline for all 2015 code change proposals is March 1, 2015 at 11:59 PM.**

Economic Impact Data Sheet

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

Most, if not all, jurisdictions in the state are interpreting the scoping language of the IECC which includes the term "site" to mean residential accessory structures. The intent of the code change proposal is to clarify that such structures are included in the scope of the code rather than impose additional regulations. Accordingly, there should be little to no economic impact.

Provide your best estimate of the construction cost (or cost savings) of your code change proposal?

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

No new requirements in this proposal.

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

0KWH/ square foot (or) 0KBTU/ square foot

(For residential projects, also provide 0KWH/KBTU / dwelling unit)

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

There should be no impact on review or inspection staff.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. _____

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # __R403.5.4 and Table 406.2 section 5(d)_____

Brief Description:

This is a proposal to amend the language in the Code to recognize drain water heat recovery devices that are certified and rated to an IAPMO standard for drain water heat recovery. Without this amendment, the current draft language only recognizes those devices certified to the CSA standard.

This amendment will make it possible to earn Washington State Energy credits in new buildings where it is necessary to install sloped (e.g. horizontal) drain water heat recovery devices, which can be certified to the IAPMO standard (but not to the current CSA standard).

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.)

R403.5.4 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA 55.2 or IAPMO PS 92. Drain water heat recovery units shall be in accordance with CSA 55.1 or IAPMO IGC 346-2017. ~~Potable water-side pressure loss of drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers.~~

Table 406.2

Energy Credits, section 5 (d)

EFFICIENT WATER HEATING 5d:
A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 52% if installed for unequal flow. Such units shall be rated in accordance CSA B55.1 or IAPMO IGC 346-2017 and be so labeled.

To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specified the drain water heat recovery units and the plumbing layout needed to install it and labels or other documentation shall be provided that demonstrates that the unit complies with the standard.

Purpose of code change:

This existing draft code recognizes only those drain water heat recovery units that are compliant with CSA. Another reputable and recognized standards organization, IAPMO, also has established standards for drain water heat recovery. The change proposed here would give equal recognition to drain water heat recovery units as certified to the standards of either CSA or IAPMO.

The technical standards applied by CSA and IAPMO are almost exactly the same with respect to drain water heat recovery devices that are designed for vertical installation. The protocol for rating the effectiveness of the device is also the same.

The key difference between the CSA and IAPMO standards is that CSA only certifies units that are designed for vertical installation, while IAPMO will also certify units that are designed for sloped (e.g. horizontal) installation.

By recognizing those devices compliant to the IAPMO standard, it will become possible to install devices in locations where the vertical drop is not sufficient to install a vertical device (e.g. showers in basements and many ground floors).

Incidentally, California has recently adopted similar language in its 2019 Title 24 provisions for drain water heat recovery. You can review the California Title 24 language, including references to the IAPMO PS 92 and IAPMO IGC 346-2017 standards, in the 2019 Residential Appendix, sections RA3.6.9 and RA4.4.21, which can be accessed from the California Energy Commission website here (as of December 18, 2018):

https://www.energy.ca.gov/2018publications/CEC-400-2018-021/CEC-400-2018-021-CMF.pdf

We also propose that the requirements related to rated pressure loss be removed from R403.5.4. Given that these devices are installed by licensed plumbing professionals who are knowledgeable about pressure loss in plumbing systems, and the impact of pressure loss is highly dependent on the water pressure of the supply system, it seems reasonable to leave this determination to the architect, plumbing designer and the installing contractor.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☒ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories

☐ Commercial / Retail ☐ Institutional ☐ Industrial

Your name	Robert Hitchner	Email address	bhitchner@ecodrain.com
Your organization	Ecodrain Ltd.	Phone number	805-444-3275
Other contact name	David Velan		

Economic Impact Data Sheet

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

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. _____

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # R202; Definition for "Residential Building"

Brief Description:

Revise the definition of "residential building" in the residential energy code to include accessory structures to ensure the scope aligns with the intent of the code and limits confusion and misinterpretation.

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.)

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings, ~~and~~ multiple single-family dwellings (townhouses), ~~as well as~~and ~~-~~Group R-2 R-3 and R-4 buildings three stories or less in height above grade plane, as well as any accessory structures thereto.

Purpose of code change:

The definition of residential buildings does not include their accessory structures. As the commercial energy code's scope includes *commercial buildings*, which is defined as "all buildings not included in the definition of *residential buildings*", it would require residential buildings' accessory structures to meet the commercial energy code. This is not the intent of the code or how building officials regularly apply the codes. The code change appropriately corrects this issue and ensures that building officials will be able to consistently apply the code throughout the state.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

- [x] Single family/duplex/townhome — Accessory Structures
- [x] Multi-family 1 – 3 stories — Accessory Structures
- [ ] Multi-family 4 + stories
- [ ] Commercial / Retail
- [ ] Institutional
- [ ] Industrial

Your name	Shane Nilles	Email address	snilles@cityofcheney.org
Your organization	City of Cheney	Phone number	509-498-9229
Other contact name	Click here to enter text.		

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.

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. _____

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # R403.5.5

Brief Description:

Correct the language to not require insulation under electric water heaters in heated spaces.

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.)

R403.5.5 Electric water heater insulation. All electric water heaters ~~in unheated spaces or~~ on concrete floors, and located in an unheated space, shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

Purpose of code change:

The provision for requiring insulation underneath an electric water heater was intended to apply to those located in unheated spaces only. As it is currently written, it would require insulation be placed under a water heater installed on any concrete floor, regardless of the location. For instance, this would require an electric water heater that is installed in a 2nd story apartment unit's closet to be placed on R-10 insulation where the rated floor assembly incorporates a concrete layer for the upper membrane. This requires then that insulation be added where there is no benefit. By making the change, the code will apply the provision more appropriately and help building official apply the code more consistently.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome

☒ Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Shane Nilles Your organization City of Cheney

February 8, 2019

Other contact name Click here to enter text. Phone number 509-498-9229

Email address snilles@cityofcheney.org

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.

Primary economic impact would be a savings to the owner of approximately $15/dwelling unit where previously required to comply with the unnecessary provision. Savings may be much greater in cases where the insulation had to be installed upon issuance of a correction notice by an inspector whereas the cost for the installation of the foam would be hundreds of dollars greater due to the amount of time needed to obtain the insulation, mobilization to the site, and the time to drain a water heater or other incidental costs needed to make the necessary room / piping adjustments due to the raising of the water heater. No annual energy savings/costs apply.

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**)

$(0.01)/square foot (For residential projects, also provide $(15)/ dwelling unit)

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

Typical unit contains (1) water heater. If the unit contains an electric water heater, and has concrete floors, there would be the savings for the cost of the insulation IF located in a jurisdiction that previously interpreted the code to require the insulation in conditioned spaces. The cost for 2' X 2' of R-10 foam board, with installation, is approximately $15.

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

N/A

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

N/A

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

N/A

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. _____

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # __**TABLE R402.1.1**_____

Brief Description:

This proposal provides updates to the wood frame wall insulation requirements in the R-value table of the prescriptive compliance path with an R15+5 and R-13+6 option to allow use of continuous insulation. These are thermally equivalent to an R21 wall, according to Appendix A. Adding the continuous insulation options do not preclude other equivalent solutions, rather they enhance the ease-of-use and achievability of the code and keep it in line with the IECC's practice of providing multiple wall insulation options in its prescriptive R-value table.

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.)

Revise Table R402.1.1 as follows:

	5 and Marine 4
…	
Wood Frame Wall R-Value	**R-21 int or R15+5 std or R13+6**

Purpose of code change:

This proposal adds an option of "R15+5 std" and "R13+6" to the current "R-21 int" requirement.

The current "R-21 int" requires framing practices in Appendix A that are non-standard. It also limits framing to 2x6 construction unless a U-factor substitution is made. More importantly, the intermediate framing practice requires 2-stud corners and 2-studs at openings. This does not factor in that various wall openings may require more than 2-studs depending on opening span, floor/roof spans, number of stories supported, etc. In addition, wall bracing as required to satisfy the higher seismic hazard conditions in WA often requires additional boundary studs (at corners or ends of shear wall segments) to provide for adequate attachment of hold-down brackets and/or to provide surface for additional edge nailing of shear panels to framing (to provide adequate shear capacity and avoid splitting of framing under seismic loading). Consequently, it is important to include an equivalent insulation solution for the many cases where "standard" framing must be used to properly construct and structurally detail a low-rise wood frame residential or other building.

The current R-21 cavity insulation option also limits the types of cavity insulation materials that can be used to comply via the R-value table. For example, insulation materials such as open cell spray polyurethane foam (ocSPF) can achieve an R-20 within the limits of a 2x6 cavity depth but not R-21.

To satisfy the above concerns and extend the utility of the prescriptive R-value table, an R-15 + 5 ci and an R-13 + 6 standard framing ("std") insulation option is included. Both are equivalent to R-21 intermediate framing ("int") currently in the code.

These alternatives are thermally equivalent to R21 int so the code does not get any weaker or more stringent. Adding options for continuous insulation does not preclude other equivalent solutions, but rather enhances the ease-of-use and achievability of the code.

Two options are recommended because the current code is already beyond the 2018 IECC requirements. Our goal is to have a continuous insulation alternative that does not require 2x6 framing and advanced/int (24"oc framing). Both R15+5 and R13+6 would achieve that goal. R15+5 is constructible with a single inch thickness of most rigid foams, an important consideration for wide-spread market acceptance. However, other materials and spray foams are better suited for R13+6. The proposed options would allow for both 2x4 and 2x6 wall construction and a variety of insulation materials for cavity and continuous insulation.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome

☒ Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name	David Mann	Email address	david_mann@americanchemistry.com
Your organization	American Chemistry Council		
Other contact name	Click here to enter text.	Phone number	202-680-0459

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 benefit to builders, homeowners, and tenants is increased flexibility and thus potentially reduced construction costs.

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

No cost savings or cost increases are anticipated – the proposal provides an alternative for compliance and does not weaken or increase the stringency of the code or create any new requirements. As an alternative option, we presume builders will only use it where it either saves cost or adds value. Because it is thermally equivalent there are no energy impacts. Further, the 2018 IECC provides both a cavity-only and continuous insulation option.

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

The proposal provides an alternative for compliance that is thermally equivalent to the current requirement and thus no impact on energy use is anticipated.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

The proposal provides an alternative for compliance that should not impact enforcement times.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. _____

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # ____**R402.4.1.2**_____

Brief Description:

This proposal updates the air leakage requirement from 5ACH to 3ACH to align with the requirements of the 2018 IECC and to save Washington State homeowners and tenants money and to reduce energy use.

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.)

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 3.0 ~~5~~ air changes per hour

Purpose of code change:

This proposal updates the air leakage requirement from 5ACH to 3ACH to align with the requirements of the 2018 IECC to save Washington State homeowners and tenants money and to reduce energy loss. The relevant text of the 2018 IECC is as follows:

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

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

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

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Your name	David Mann	Email address	david_mann@americanchemistry.com
Your organization	American Chemistry Council		
Other contact name	Click here to enter text.	Phone number	202-680-0459

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.

Insulation products can provide thermal resistance by reducing both conductive and convective heat flows. Eliminating convective heat transfer (air flow) through walls and roof assemblies can provide significant energy savings. The U.S. Department of Energy estimates that up to 40% of a building's heating and cooling energy is lost due to air leaks, a major source of convective heat transfer in the building envelope. Reducing air leaks will save Washington State homeowners and tenants money and reduce energy use.

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

This proposal changes the air leakage requirement to be consistent with the 2018 IECC. We understand the 2018 IECC to be the model code under review at this time and do not have a separate cost/benefit analysis of this component.

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

This proposal changes the air leakage requirement to be consistent with the 2018 IECC. We understand the 2018 IECC to be the model code under review at this time and do not have a separate cost/benefit analysis of this component.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This proposal will not impact enforcement time. The air leakage testing requirement is already mandatory.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

Log No. 19-WSEC-R07

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # 403.1.1 Programmable Thermostat _____

Brief Description: This change adds smart thermostats and then changes language to be consistent with the 2018 IECC.

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.)

R403.1.1 Programmable or smart thermostat. The thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature setpoints at different times of the day. ~~Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day~~. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback/setup periods per day. This thermostat shall include the capability to set back, set up or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C). The thermostat shall initially be programmed by the manufacturer or installer with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C). The thermostat and/or control system shall have an adjustable deadband of not less than 10°F.

Exceptions:

1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.

Purpose of code change:

Adds specific reference to smart thermostats because of their unique capabilities. Changes requirement to include all heating and cooling systems and not just forced air furnaces to make it consistent with language in 2018 IECC. Programmable heat pump thermostats are available for use specifically with heat pumps. In addition to modest savings possible in the heating mode, savings can also be achieved in the cooling mode with the programmable or smart thermostat.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state. ☐ Corrects errors and omissions.

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

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

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

Your name	Gary Heikkinen, PE	Email address	gary.heikkinen@nwnatural.com
Your organization	NW Natural	Phone number	503-721-2471
Other contact name	Click here to enter text.		

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.

Zero to modest first cost increase to install programmable thermostat on systems other than forced air furnaces. Potential for modest heating energy savings and measureable cooling energy savings.

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 $100-$200/ dwelling unit)

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

$50-$150 for programmable thermostat and $150-$250 for smart thermostat.

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

Estimate 5-10% of total heating and cooling energy saved on average.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R08 Rev

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # ___R401.3_____

Brief Description: Include whole-house mechanical ventilation test results on permanent certificate.

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.)

R401.3 Certificate (Mandatory). A permanent certificate shall be completed by the builder or other approved party and posted on a wall in the space where the furnace is located, a utility room, or an approved location inside the building. When located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, below-grade wall, and/or floor) and ducts outside conditioned spaces; U-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration~~,~~; ~~and~~ the results from any required duct system and building envelope air leakage testing done on the building; and the results from the whole-house mechanical ventilation system flow rate test. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling, whole-house mechanical ventilation, and service water heating appliances ~~equipment~~. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall list "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be listed for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters.

Informational note: The following text is being submitted to simultaneously amend the WA State residential code:

M1507.3.3 Mechanical ventilation rate. The whole-house mechanical ventilation system shall provide outdoor air to each dwelling unit at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).
Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

M1507.3.3.1 Testing. Whole-house mechanical ventilation systems shall be tested and verified to provide a flow rate not less than the minimum required by Section M1507.3.3. Testing shall be performed according to the ventilation equipment manufacturer's instructions, or by using a flow hood, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles or in the connected ventilation ducts. Where required by the building official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the building official.

Purpose of code change:

If installed incorrectly, whole-house mechanical ventilation systems can fail to deliver the minimum

outdoor air needed to provide acceptable indoor air quality. A recent study in Florida* found that only three of 21 whole house mechanical ventilation systems had a flow rate near the design level. Because these systems perform a vital function in supporting building durability and occupant health, these systems should be verified for flow when installed. This requirement and text are aligned with ASHRAE 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings. Finally, because the whole-house mechanical ventilation system is a critical component of the build-tight/ventilate-right approach to energy efficient, durable, and healthy construction, the verified ventilation rate should be listed on the home's permanent certificate, along side other performance metrics and values for critical appliances and assemblies.

* Sonne et al. (2015). Investigation of the Effectiveness and Failure Rates of Whole-House Mechanical Ventilation Systems in Florida. FSEC-CR-2002-15. http://w w w .fsec.ucf.edu/en/publications/pdf/FSECCR-2002-15.pdf.

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

- [X] Addresses a critical life/safety need.
- [ ] The amendment clarifies the intent or application of the code.
- [ ] Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- [ ] Consistency with state or federal regulations.
- [ ] Addresses a unique character of the state.
- [ ] Corrects errors and omissions.

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

- [X] Single family/duplex/townhome
- [X] Multi-family 1 – 3 stories
- [ ] Multi-family 4 + stories
- [ ] Commercial / Retail
- [ ] Institutional
- [ ] Industrial

Your name	Mike Moore	Email address	mmoore@newportventures.net
Your organization	Newport	Phone number	303.408.7015

Other contact name Click here to enter text.

Economic Impact Data Sheet

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

Presumably, a component of this inspection is flow rate verification. If this is not the case, and IECC R104.2.4 does not trigger a requirement for whole-house flow rate verification, then the cost associated with flow rate verification can be estimated as $9-$12, assuming a time requirement of 15-20 minutes for a skilled laborer with a labor rate of $35/hour to test the airflow of a whole house mechanical ventilation system. The test can be completed by the same technician performing the blower door test. Also, there is no requirement for a third party to conduct the test, which can help moderate costs. Further, any increase in cost is expected to be offset by the health benefits expected from properly commissioned whole-house mechanical ventilation systems. Research suggests that the costs associated with poor indoor air quality in the U.S. is around $500 annually per person.[1,2,3,4,5]

References:

1. Logue JM, Price PN, Sherman MH, & Singer BC. 2012. A Method to Estimate the Chronic Health I mpact of Air Pollutants in U.S. Residences. Environmental Health Perspectives 120(2): 216-222.
2. Turner WJN, Logue JM, and Wray CP. 2012. Commissioning Residential Ventilation Systems: A C ombined Assessment of Energy and Air Quality Potential Values. LBNL969E.
3. Brown DW. 2008. Economic value of disabilityadjusted life years lost to violence: estimates for WH O Member States. Rev. Panam Salud Publica, 24, 203to209.
4. Lvovsky K, Huges G, Maddison D, Ostro B, and Pearce D. 2000. Environmental costs of fossil fuels : a rapid assessment method with application to six cities. Washington, D.C.: The World Bank Envir onment Department.
5. Highfill T and Bernstein E. 2014. Using Disability Adjusted Life Years to Value the Treatment of T hirty Chronic Conditions in the U.S. from 1987to2010. U.S. Department of Commerce Bureau of Ec onomic Analysis WP 2014-9.

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**)

$0-0.006/square foot ($0-12/ dwelling unit)

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

$35/hour*(1/3 hour) = $11.67/2000 ft2 = $0.006/ft2

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

Energy costs or savings will be dependent on the design and actual, unadjusted whole-house ventilation system flow rate. In the case that the design flow rate was not achieved prior to commissioning, the energy costs will increase to what is expected for minimally code-compliant dwelling units. In the case that the targeted flow rate is exceeded prior to commissioning, there is an opportunity to harvest energy savings by reducing the flow rate to the code-minimum requirement. Fan energy use for minimally code compliant WHMV systems can range from 188 kWh to 438 kWh for a typical home (2000 ft2, 3 bedroom) with a whole-house mechanical ventilation flow rate of 100 cfm. A commissioning procedure that produces a 30% reduction in flow rate would result in up to 219 kWh in annual fan savings alone (not to mention commensurate heating and cooling energy savings).

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

(219 KWH/ dwelling unit)

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

= 100 cfm/(0.0012 – 0.0028 cfm/kW)*8760 hours = 93 – 219 kWh

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application: ~5-10 minutes to verify that the targeted WHMV flow rate has been field verified.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

Log No. 19-WSEC-R09__

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # **R403.7.1 Electric resistance zone heated units**._____

Brief Description: Add requirement for programmable or smart heat pump thermostat to control ductless mini-split heat pump and a programmable or smart thermostat for electric zonal systems 2Kw or larger.

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.)

R403.7.1 Electric resistance zone heated units. All detached one- and two-family dwellings and multiple single-family dwellings (townhouses) up to three stories in height above grade plan using electric zonal heating as the primary heat source shall install an inverter-driven ductless mini-split heat pump, controlled by a programmable or smart heat pump thermostat, in the largest zone in the dwelling. Any rooms with zonal electric heating capacity of 2Kw or larger shall be controlled by a programmable or smart thermostat. Building permit drawings shall specify the heating equipment type and location of the heating system.

Exceptions:

1. Total installed heating capacity of less than 2Kw per dwelling ~~or less~~.
2. Systems or units controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
3. Systems or units controlled solely by a manually operated timer capable of operating the system for no more than two hours.

Purpose of code change:

To provide additional savings for both heating and cooling energy in dwelling units using these systems.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

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

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

Your name	Gary Heikkinen, PE	Email address	gary.heikkinen@nwnatural.com
Your organization	NW Natural	Phone number	503-721-2471

Other contact name Click here to enter text.

Economic Impact Data Sheet

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

Slight upfront cost to provide and/or install a programmable or smart thermostat, but will result in additional heating and cooling energy savings.

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 $50-$150/ dwelling unit)

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

Internet search shows costs in this range for programmable and smart thermostats.

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

Estimate 5%-10% energy cost savings associated with heating and cooling. Internet search shows savings higher than this for programmable and smart thermostats. This should be a conservative estimate.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

Log No. 19-WSEC-R10 REV#3

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # Table 406.2

Brief Description: Provide option to earn a 0.5 energy credits in the prescriptive table for advanced framing and raised heel trusses or rafters.

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.)

Under option column of table: TBD

Under description column of table: ADVANCED FRAMING AND RAISED HEEL TRUSSES OR RAFTERS.

Advanced Framed Walls as defined in Section R202. Under this option, additional framing members in exterior walls are allowable only where required to ensure structural stability as directed by code or code official. Materials added to provide nailing surface for other components that do not create a thermal bridge across the span of the wall are acceptable.

Truss or rafter systems used where attic insulation is placed directly on top of the ceiling shall provide space for insulation along the exterior wall. For loose fill insulation, a minimum of 12" free space shall be provided. For other insulation types, space to install the full planned R-value must be provided. Space needed for attic/roof ventilation may not be counted towards the requirement.

Under option credits of table: 0.5

Purpose of code change: Advanced framing is an effective practice to decrease thermal bridging and maximize insulation in wood frame construction, but is rarely used. Providing energy credit for advanced framing techniques will create an incentive for broader use in residential construction.

Standard roof trusses and rafters reduce space for insulation along exterior walls to near zero. Trusses or rafters built with a raised heel provide free space at exterior walls for insulation, increasing the overall insulating effectiveness of the roof assembly.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Alan Nolan	Email address	alan@509.design
Your organization	Spokane Home Builders Assoc.	Phone number	509-847-4651
Other contact name	Kieran Sprague, 360-791-7462		

Economic Impact Data Sheet

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

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**)

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

Advanced Framing, or Optimum Value Engineering, has been shown to reduce labor and materials costs between 3-5%. Raised heel trusses typically increase costs by 10-15%. Adding similar free space for rafter systems is less than 5% cost difference. Cost estimate in LCCA shown for truss-style construction.

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

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

(For residential projects, also provide 588 KWH/KBTU / dwelling unit)

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

See attached excel document showing calculations for 2200 Sq Ft, gas heated single family residence on u-value improvements for wall and roof assemblies. Calculations adapted from 2015 WSEC Total UA worksheet and values drawn from 2015 WSEC Appendix.

Other sources include US Department of Energy, which estimates Advanced Framing can reduce heating and cooling requirements by up to 5%. A typical 2,200 Sq Ft home built per 2015 WSEC standards is assessed to use 11,762 kWH of energy per year. At 5% savings, Advanced Framing would yield saving in excess of 500 kWH per year or about 0.25 kWH per Sq Ft.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Due to the limited use, there will be some additional time for plans review and inspections when building officials are first encounter advanced framing to gain familiarity with the practice. After initial spin up/review, no additional

enforcement time is required plans review or framing inspections. Changes to truss/rafter would not increase plan review or inspection requirements.

Attachments


Advanced Framing u-value comparison.x


LCCA Executive Report.pdf


LCCA Baseline scenario.pdf


LCCA Alternative 1.pdf


LCCA Expenditure Report.pdf

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R11

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # R403.1.1

Brief Description: Requires a programmable thermostat as defined by R403.1.1 be installed in accessory dwelling units.

Proposed code change text:

R403.1 Controls (Mandatory). At least one thermostat shall be provided for each separate heating and cooling system.

R403.1.1 Programmable thermostat. Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit and accessory dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day. This thermostat shall include the capability to set back or temporarily operate the system to maintain *zone* temperatures down to 55°F (13°C) or up to 85°F (29°C). The thermostat shall initially be programmed by the manufacturer with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C). The thermostat and/or control system shall have an adjustable deadband of not less than 10°F.

Purpose of code change:

Accessory dwelling units (ADU's), sometimes known as mother-in-law apartments, often include a room or set of rooms in a one-family dwelling designed or configured to be used as a separate dwelling unit. In some jurisdictions, they are also allowed to be a separate building that is placed on a lot that already has a single-family dwelling unit on it. While there is no definition in the Washington State Codes for ADU, within the definition of *dwelling unit* it contains language stating that dwelling unit can contain the following uses: …

"3. One accessory dwelling unit which need not be considered a separated dwelling unit…"

It's not clear in the current residential energy code that ADU units would be required to have a separate programmable thermostat that would give them control over the temperature in their unit. This code proposal would make them mandatory for ADU's when a new ADU is created or in existing buildings if the change to the existing system meets the thresholds described in RE-39.

The purpose of the code change is to ensure that an ADU's occupants can control their internal environment and benefit from the energy savings that come with being able to adjust the temperature to correspond with the use of the space.

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.

☒ Addresses a specific state policy or statute.

(Note that energy conservation is a state policy)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome

☐ Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Jenifer Gilliland

Your organization Seattle Department of Construction and Inspections

Other contact name Micah Chappell

Email address Jenifer.gilliland@seattle.gov

Phone number (206)233-2766

Economic Impact Data Sheet

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

This proposal will increase the cost of construction for contractors because an additional programmable thermostat will be required in accessory dwelling units. Tenants will see energy savings because they will be able to optimize the control of their thermostat.

Provide your best estimate of the construction cost (or cost savings) of your code change proposal? Show calculations here, and list sources for costs/savings, or attach backup data pages

According to www.costhelper.com, a more advanced programmable thermostat model that includes (5/2 programming and 7 day programming run between $80-$250 dollars. The installation costs by an HVAC contractor could be $75-$150.

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

From www.energystar.gov, Proper Use Guidelines for Programmable Thermostats:

"Through proper use of a programmable thermostat (using the four pre-programmed settings) you can save about $180* every year in energy costs. The $180 savings assumes a typical, single-family

home with a 10--hour daytime setback of 8° F in winter and setup of 7° F in summer, and an 8-hour nighttime setback of 8° F in winter and a setup of 4° F in summer."

The savings generated from a programmable thermostat in an ADU wouldn't be quite as large as an entire single-family dwelling, but if the typical single-family home was 2,000 sq ft in the Energy Star Model, that would equate to roughly $45 a year in savings for the tenant of a 500 sq. ft ADU within the dwelling.

From the Department of Energy, www.energy.gov

"You can save as much as 10% a year on heating and cooling by simply turning your thermostat back 7°-10°F for 8 hours a day from its normal setting. The percentage of savings from setback is greater for buildings in milder climates than for those in more severe climates."

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This shouldn't increase code enforcement time because the inspector would not need to take extra trips to verify that the programmable thermostat has been installed.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R12

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section # Table R402.1.1 add to footnote d

Brief Description: The proposal seeks to add a footnote below to Table R402.1.1 that would allow the use of Table R402.1.1 *Insulation and Fenestration Requirements by Component.* The proposal objective is to provide more flexibility allowing a prescriptive compliance option when existing garages, metal or masonry shops are permitted as converted from unconditioned space to conditioned space for ADU units or non-dwelling buildings such as heated shops. The proposal seeks compliance flexibility to improve compliance with Chapter 5 *Existing Buildings.*

Proposed code change text would add a new footnote (f) to table R402.1.1 related to *Slab R-value and Depth.* Note: This proposed text may also want to be linked to chapter 502.1:

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

[f] R-10 continuous insulation is required under heated slab on grade floors. See R402.2.9.1. R-7.5 continuous insulation installed over an existing slab is deemed to be equivalent to the required perimeter slab insulation when applied to existing slabs complying with section R503.1.1.

Purpose of code change: The proposal seeks to improve energy savings and economics associated with WSEC *Existing Buildings* - Chapter 5 compliance. It is not practical to insulate the existing slab perimeter as required in the current table 402.1.1. This proposal provides greater design flexibility and eliminates the need to conduct a UA tradeoff analysis for existing slabs. The proposal adds a footnote that accepts an R7.5 rigid foam insulation over the existing slab as equal to the R10 slab perimeter insulation requirements. WSU has been using this informally accepted workaround since 2016. (*) A typical example is an existing garage being converted to a bedroom.

The proposal will reduce the current situation that burdens; DIY consumer, contractors, WSU hotline and others trying to comply with Chapter 5, for ADU and shop conversions. The proposal seeks to reduce code enforcement time and confusion associated with the existing slab detail.

☐ Addresses a critical life/safety need.

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

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

☐ Consistency with state or federal regulations.

☐ 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

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

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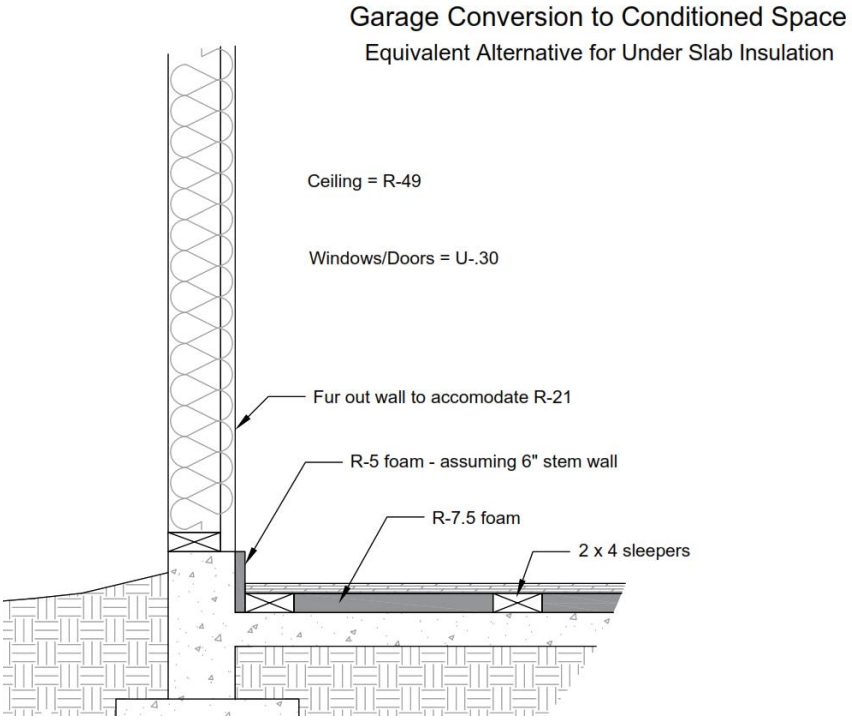
Your organization WSU Energy Program Phone number 360-951-1569 cell

Other contact name Todd Currier

Economic Impact Data Sheet

There is no negative economic impact, if code compliance is assumed in the baseline. The energy saving from this proposal will improve the compliance and enforcement with WSEC chapter 5 ADU and heated shop additions. Currently, some will "go rogue" due to the lack of an available prescriptive or simulated performance path option. The proposal will reduce the current situation that burdens; DIY consumer, contractors, WSU hotline and others trying to comply with Chapter 5, for ADU and shop conversions. It is currently not practical to insulate the slab perimeter as required in table 402.1.1. This proposal reduces code enforcement time for additional plan review. ADU that use existing slabs are problematic and compliance is difficult. WSU believes this footnote will improve the economics of WSEC compliance with chapter 5.

(*) Draft example that could be added to WSU training and Web Page:



STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R13

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section # R401.3 Certificate (mandatory)

Brief Description: This proposal seeks to:

- Improve on "build tight" documentation of important envelope leakage and duct testing on the certificate. The proposal adds a new certificate requirement to also document "ventilate right", based on an assumption that MVE will require measurement of ventilation system at commissioning.
- Extends those requirements by adding to the certificate the important "ventilate right" information.
- Empowers AHJ to request additional time stamp and geo location information to document when and where the test was conducted. (*) The proposal seeks to improve realized energy savings by reducing the frequency of falsified affidavits. WSU has heard from the hotline that testing QA is an area requiring improvement.

Proposed code change test:

R401.3 Certificate (Mandatory). A permanent certificate shall be completed by the builder or registered design professional and posted on a wall in the space where the furnace is located, a utility room, or an approved location inside the building. When located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, below-grade wall, and/or floor) and ducts outside conditioned spaces; U-factors for fenestration the solar heat gain coefficient (SHGC) of fenestration, and the results from any required duct system and building envelope air leakage testing done on the building. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling, <u>whole house ventilation</u> and service water heating equipment.

<u>The certificate(s) shall provide the results from any required duct system, building envelope air leakage testing and whole house ventilation system flow rates. The AHJ may require that documentation of these test results include an electronic record of the time/date and location of test. A date-stamped smart phone photo or air leakage testing software may be used to satisfy this requirement.</u>

Purpose of the code change: The proposal seeks to improve the design, installation, operation and maintenance of whole house mechanical ventilation systems. The proposal is based on 35 years of research findings related to the challenges to improve; design, installation operation and maintenance. Based on this research the proposal will result in improved indoor air quality (IAQ) as compared to current practice. The proposal seeks to clarify and improve the whole house mechanical ventilation system commissioning process that provides greater "building tight and ventilating right" documentation at design and final inspection. This proposal is crucial given the direction in the WSEC for tighter homes mechanically ventilated with more complex ventilation system than typical whole house continuously operating exhaust ventilation. Improve on "build tight" documentation of important envelope leakage and duct testing on the certificate.

An example of the "Build Tight Ventilate Right" Certificate is as follows:

2019 WSEC Residential Energy Compliance Certificate

Property Address: _____

Builder/Registered Design Professional Name: _____

Builder/Reg. Design Pro. Signature: _____

Conditioned Floor Area: _____ ft² (per building permit)

Signature: _____ *Date:* _____

HVAC System "duct" Leakage Testing

All ductwork & Air Handler in conditioned space: Y or N (circle one)

All ductwork & Air Handler outside conditioned space insulated to minimum R8? Y or N (circle one)

Air Handler Present at duct leakage test? Y or N (circle one)

HVAC System Leakage Test Calculated Design Target: _____ cfm @ 25PA

HVAC System Leakage Test Measured Results: _____ cfm @ 25PA

Do HVAC Leakage Tests include GPS & Time Stamp Verification? Y or N (circle)

Building Leakage Testing

Building Leakage Test Calculated Design Target: _____ cfm @ 50PA

Do Building Leakage Tests include GPS & Time Stamp Verification? Y or N (circle)

Whole House Ventilation (WHV) System Measured Flow Rates

The WHV system operation and maintenance (O&M) instructions were provided to the building owner? Y or N (circle one)

Provided to: _____ on _____ (date)

Are the system controls correctly labelled? Y or N (circle one)

WHV System Type: (circle one)

(1) Whole House Exhaust Fan Operating Continuous

(2) Whole House Exhaust Fan Operating Intermittently
Specify run-time: _____ hours/day

(3) Balance Heat Recovery Ventilator Operating Continuous

(4) Balance Heat Recovery Ventilator Operating Intermittently
Specify run-time: _____ hours/day

(5) Supply or HRV WHV integral to the air handler. Describe system control sequence of operations: _____

_____

WHV Calculated Design Minimum Flow Rate: _____ cfm

WHV Measured Minimum Flow Rate: _____ cfm

WHV Measured High Speed Flow Rate: _____ cfm

Do Measured Flow Rate Test Results include GPS & Time Stamp Verification? Y or N (circle one)

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

X 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.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

x Single family/duplex/townhome

x Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Michael Lubliner

Your organization WSU Energy Program

April 17, 2019

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R14

Code being amended: ☐ Commercial Provisions ☐ Residential Provisions

Code Section # R402.1.2 R-values computation.

Brief Description: The proposal seeks to reduce the use of untested rigid and semi rigid insulation products.

Proposed code change text:

R402.1.2 *R*-value computation. Insulation R-value shall be determined as specified in section R303.1.4. Insulation material used in layers, such as framing cavity insulation or continuous insulation, shall be summed to compute the corresponding component *R*-value. The manufacturer's settled *R*-value shall be used for blown insulation. Computed *R*-values shall not include an *R*-value for other building materials or air films. ~~Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.1, the manufacturer must supply an ICC Report that the R-factor has been certified, or use R-5 per inch for extruded polystyrene, and R-6 per inch for polyisocyanurate rigid insulation.~~ Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled R-value for insulated siding shall be reduced by R-0.6.

Purpose of code change: The proposal seeks to reduce the use of untested rigid and semi rigid insulation products. There are questions about some CI products that do not have FTC approved R-value labelling. The proposal will ensure that rigid foam manufactured with tested and labelled products are NOT disadvantaged in the market. The proposal reduces wasted energy, to the extent that these untested unlabeled products do not provide FTC R-values. This proposed deletion also makes the WSEC more consistent with the 2015 IECC, which also does not permit untested insulation products.

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.

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

X Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ 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

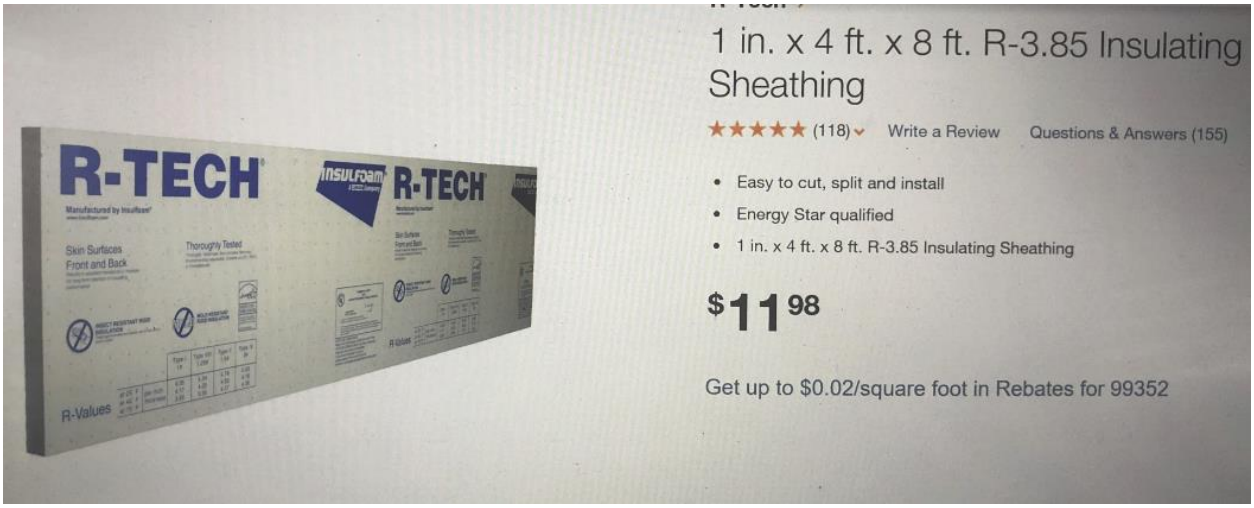
Your name	Michael Lubliner	Other contact name	Todd Currier
Your organization	WSU Energy Program	Email address	lublinerm@energy.wsu.edu

Phone number 360-951-1569

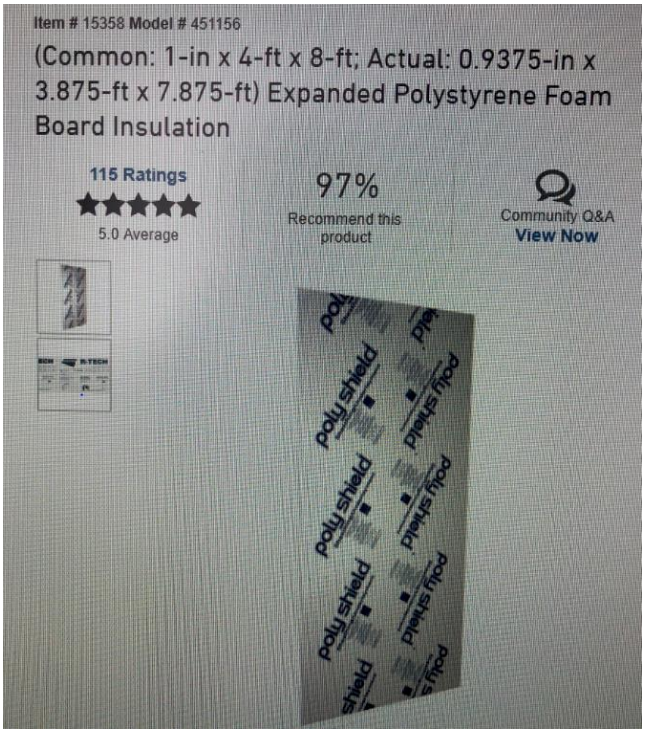
Economic Impact Data Sheet

There is little additional code enforcement time for additional plan review. The proposal seeks to improve and facilitate inspection compliance for CI R-value, since the R-value products are clearly labelled as such.

Below is an example of labeled “Energy Star qualified” EPS foam often sold in “big box” stores along side with unlabeled testing foam products:



Below is an example of unlabeled “Energy Star qualified” EPS foam often sold in “big box” stores along side with labelled testing foam products:



STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R15

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # Table 406.2

Brief Description: Provide option to earn a 0.5 energy credit under section 4 of the prescriptive table for mechanical ductwork that is deeply buried in under attic insulation.

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.)

Under option column of table: 4a

Under description column of table: All supply and return ducts deeply buried in ceiling insulation per requirements in paragraph R403.3.6

For mechanical equipment located outside the conditioned space, a maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts connections to the equipment may be outside the deeply buried insulation. All metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic. If flex ducts are used, they cannot contain splices.

Under option credits of table: 0.5

Under option column of table, row currently labeded 4: 4b

Purpose of code change: Deeply buried supply and return ductwork provide almost the same energy efficiency improvement as placing the entire HVAC distribution system in the conditioned space. Locating ductwork underneath ceiling insulation is optional, so providing energy credits will encourage broader use of what is a cost neutral building practice in residential construction and improve energy efficiency.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Alan Nolan	Email address	alan@509.design
Your organization	Spokane Home Builders Assoc.	Phone number	509-847-4651
Other contact name	Kieran Sprague, 360-791-7462		

Economic Impact Data Sheet

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

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**)

$-0.16/square foot (For residential projects, also provide $-396/ dwelling unit)

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

Installation of flexible ductwork for deeply buried ducts requires ~25% less materials (~100 LF @ $2/LF) and 15-20% less labor (~5.6 hrs @$35/hr). In a typical 2,500 Sq Ft single family residence, this equates to a savings of $396.

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

0.15 KWH/ square foot or ~375KWH / dwelling unit.

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

Per REMRate V15.7.3 modeling a 2,500 Sq Ft single family residence with 9 HSPF, 14.5 SEER heat pump and attic hung ductwork has annual energy consumption of 7,028KWH heating / 632kwh cooling, while the same residence with deeply buried ductwork has 66,53KWH heating / 598 KWH cooling.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Proposal would not create any additional demands for plan review or inspection.

Attachments


LCCA Executive Report.pdf


LCCA Baseline scenario.pdf


LCCA Alternative 1.pdf


LCCA Expenditure Report.pdf

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

Log No. 19-WSEC-R16

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _Table 406.2_____

Brief Description: Provide credit for increased use of high-efficacy lighting and recognize real-world limitations inspectors face on ensuring compliance with WSEC requirements for permanently installed lighting.

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.)

Under option column of table: Numbering to be determined.

Under description column of table: HIGH EFFICACY LIGHTING.

100% of permanently installed lighting fixtures shall be high-efficacy lamps.

Under option credits of table: 0.5

Purpose of code change: Lighting fixture efficiency has increased dramatically over the last and code requirements have consistently increased required percentage of these fixtures as well. Adopting proposed change will increase the percentage of permanently installed high efficacy lamps, but also improve enforcement of required levels.

Code enforcement final electrical inspections appropriately focus on health and safety factors, not the percentage of installed lighting types. If a residence is claiming credits for 100% high-efficacy lighting, it eases inspector responsibility by making it a simple yes or no as to whether the structure complies with the requirement. Time constraints on inspectors work against their ability to effectively enforce current or proposed percentage-level requirements for high-efficacy lighting.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome ☒ Multi-family 1 – 3 stories ☐ Multi-family 4 + stories

☐ Commercial / Retail ☐ Institutional ☐ Industrial

Your name	Alan Nolan	Email address	alan@509.design
Your organization	Genesis Construction	Phone number	509-847-4651
Other contact name	Kieran Sprague, 509-532-4330		

Economic Impact Data Sheet

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

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**)

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

While individual hi-efficacy bulbs are still slightly more expensive per unit than standard incandescent bulbs, there is little to no additional costs for installation of a permanently installed high-efficacy light.

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

0.174 KWH/ square foot or also provide 434 KWH/dwelling unit

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

Per REMRate V15.7.3 modeling a 2,500 Sq Ft single family residence with 9 HSPF, 14.5 SEER heat pump, installation of 100% LED lighting fixtures will use 706.7 KWH/yr, while permanently installed lighting using 90% high-efficacy fixtures will use 1,140.5 KHW/yr. The 2006 baseline, which has no high-efficacy lights, uses 2,996.4 KWH/yr.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

No additional time is required for plan review or inspection.

Attachments


LCCA Executive Report.pdf


LCCA Baseline scenario.pdf


LCCA Alternative 1.pdf


LCCA Alternative 2.pdf


LCCA Expenditure Report.pdf

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R17

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section # R202

Brief Description:

To add a definition for Ductless Mini-split system to the Energy Code.

Proposed code change text

Ductless Mini-split system: A heating and cooling system that is comprised of one or multiple indoor evaporator/air-handling units and an outdoor condensing unit that is connected by refrigerant piping and electrical wiring. A ductless mini-split system is capable of cooling or heating one or more rooms without the use of traditional ductwork system.

Purpose of code change:

This proposal adopts the definition of Ductless Mini-split system from the IMC.

Ductless Mini-Split systems are required in section R403.7.1 and an option in C406. There is currently a lack of a definition for Ductless Mini-Split system in the Energy Code. To assure the energy savings are achieved a good definition is needed. Adding this definition would add clarification to the code.

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.

☐ 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

X Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Bill Kraus Your organization Commerce, State Energy Office

April 17, 2019

Other contact name Chuck Murray

Phone number 360-725-5011
360-725-3113

Email address bill.kraus@commerce.wa.gov
chuck.murray@commerce.wa.gov

Economic Impact Data Sheet

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

There are no economic impacts.

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This clarifies the existing rules, making code enforcement easier.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R18

Code being amended: ☐ Commercial Provisions ☐ X Residential Provisions

Code Section # R403

Brief Description:

Add a HVAC and service water heating equipment reference tables by reference to equipment performance requirements in the commercial code.

Proposed code change text:

R403.0 HVAC equipment performance requirements. Equipment shall meet the minimum federal efficiency standards as referenced in the efficiency requirements of Tables C403.2.3(1),C403.2.3(2), C403.2.3(3), C403.2.3(4), C403.2.3(5), C403.2.3(6), C403.2.3(7), C403.2.3(8) and C403.2.3(9) tested and rated in accordance with the applicable test procedure.

C403.5.0 Service water-heating equipment performance requirements. Service water-heating equipment shall meet the requirements of DOE 10 CFR Part 430 Uniform Energy Factor or the equipment shall meet the requirements C404.2.

R403.5 Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.5.1 through R403.5.~~5~~6.

Purpose of code change:

There are no references to the required minimum equipment or equipment test procedures in the current residential sections of the code. This is published in the commercial code. This provides references from the commercial code.

For small water heating equipment, ASHRAE 90.1 2016 simply refers to the DOE 10 CFR Part 430 Uniform Energy Factor. This energy factor is unique to small systems and is the only reference needed.

These have been numbers "0" to avoid renumbering the entire section.

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.

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

X Consistency with state or federal regulations.

☐ 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 Bill Kraus

Your organization Commerce, State Energy Office

Other contact name Chuck Murray

Email address bill.kraus@commerce.wa.gov
chuck.murray@commerce.wa.gov

Phone number 360-725-5011
360-725-3113

Economic Impact Data Sheet

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

There is no economic impact.

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This code change supports code enforcement by providing good references to existing standards.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R19

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section Chapter 2, **HIGH-EFFICACY LAMPS.**

Brief Description:

Remove CFL from the qualified lamps. Create a uniform standard 65 lumens per watt.

Proposed code change text

HIGH-EFFICACY LAMPS. ~~Compact fluorescent lamps,~~ Llight emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with a minimum efficacy of 65 lumens per watt.

1. ~~60 lumens per watt for lamps over 40 watts;~~
2. ~~50 lumens per watt for lamps over 15 watts to 40 watts; and~~
3. ~~40 lumens per watt for lamps 15 watts or less.~~

Purpose of code change:

Save energy, provide good purchasing guidance.

LED lamps cost no more than CFL, and in many cases less. LED are dimmable, come in many form factors and a variety of color temperatures. In many cases LED are available when CFL are not. Some CFL will still qualify at 65 lumens per watt, but not all.

There are no barriers to raising the standard.

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)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

X Single family/duplex/townhome

X Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Bill Kraus

Your organization Commerce, State Energy Office

Other contact name Chuck Murray

Email address bill.kraus@commerce.wa.gov
chuck.murray@commerce.wa.gov

Phone number 360-725-5011
360-725-3113

Economic Impact Data Sheet

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

The life cycle cost tool demonstrates that 30 LED lamps operating 1000 hours per year will provide net present savings of $959, compared to CFL providing similar output. LCCT study attached below.

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**)

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

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

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

(For residential projects, also provide 210 KWH / dwelling unit)

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

LCCT below. Cost clips below.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

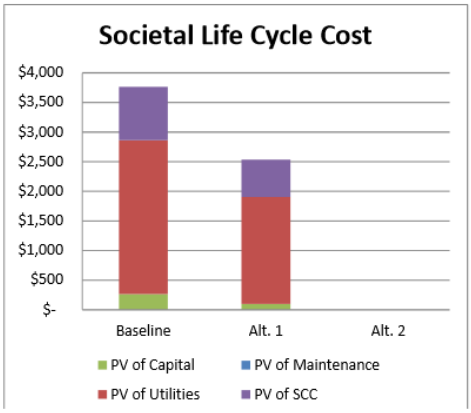
This clarifies the existing rules, making code enforcement easier.

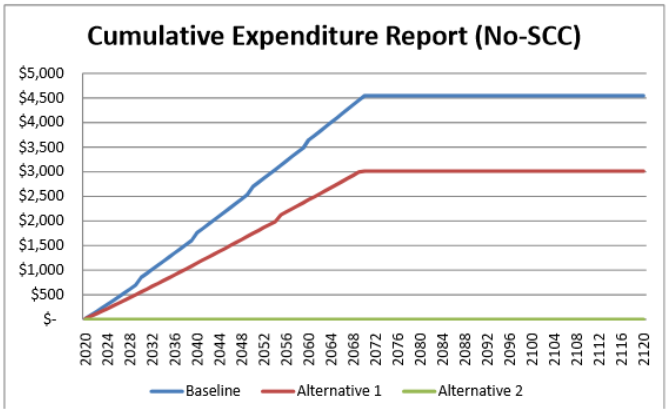
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	1.1	0.7	
1st Construction Costs	$ 75	$ 75	$ -
PV of Capital Costs	$ 264	$ 96	$ -
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 2,598	$ 1,807	$ -
Total Life Cycle Cost (LCC)	**$ 2,863**	**$ 1,903**	**$ -**
Net Present Savings (NPS)	**N/A**	**$ 959**	**$ -**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	14	10	-
% CO2e Reduction vs. Baseline	N/A	30%	144%
Present Social Cost of Carbon (SCC)	$ 902	$ 627	$ -
Total LCC with SCC	**$ 3,764**	**$ 2,531**	**$ -**
NPS with SCC	**N/A**	**$ 1,234**	**$ -**

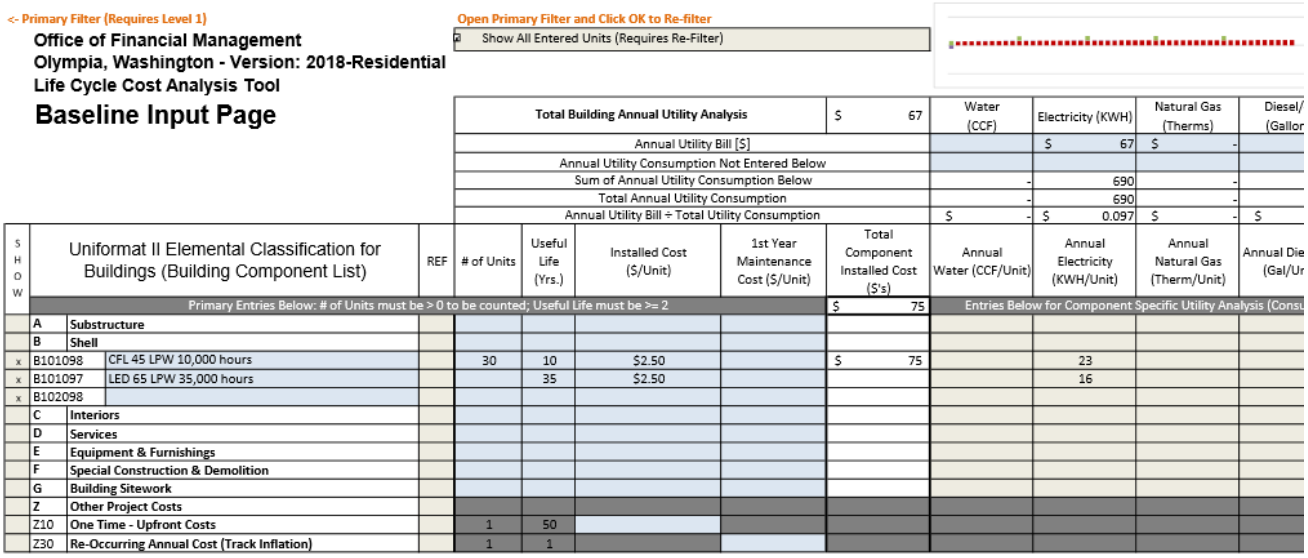
Warning: OFM Assigned Variables Not Used





All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

BASE Case CFL Lighting



<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

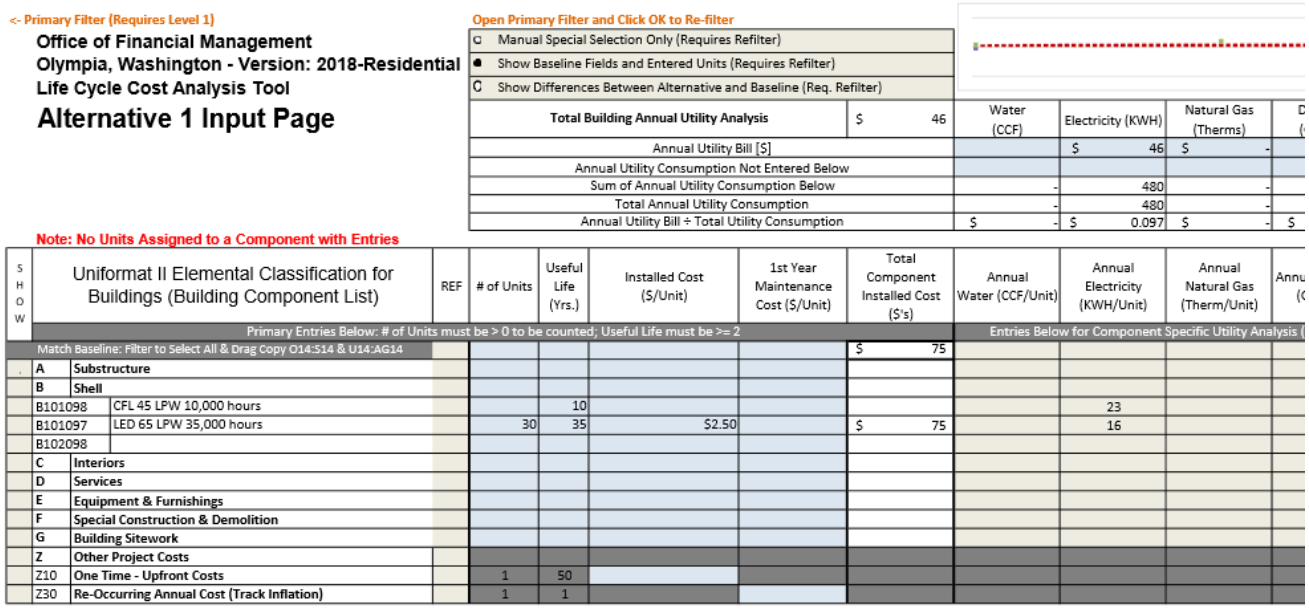
Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☐ Show All Entered Units (Requires Re-Filter)

				Total Building Annual Utility Analysis			$ 67	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/ (Gallor
				Annual Utility Bill [$]					$ 67	$ -	
				Annual Utility Consumption Not Entered Below							
				Sum of Annual Utility Consumption Below				-	690	-	
				Total Annual Utility Consumption				-	690	-	
				Annual Utility Bill ÷ Total Utility Consumption				$ -	$ 0.097	$ -	$
SHOW		Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Die (Gal/Ur
		Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 75	Entries Below for Component Specific Utility Analysis (Consu			
	A	**Substructure**											
	B	**Shell**											
x	B101098	CFL 45 LPW 10,000 hours			30	10	$2.50		$ 75		23		
x	B101097	LED 65 LPW 35,000 hours				35	$2.50				16		
x	B102098												
	C	**Interiors**											
	D	**Services**											
	E	**Equipment & Furnishings**											
	F	**Special Construction & Demolition**											
	G	**Building Sitework**											
	Z	**Other Project Costs**											
	Z10	**One Time - Upfront Costs**			1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**			1	1							

LED Example



<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

☐ Manual Special Selection Only (Requires Refilter)
● Show Baseline Fields and Entered Units (Requires Refilter)
○ Show Differences Between Alternative and Baseline (Req. Refilter)

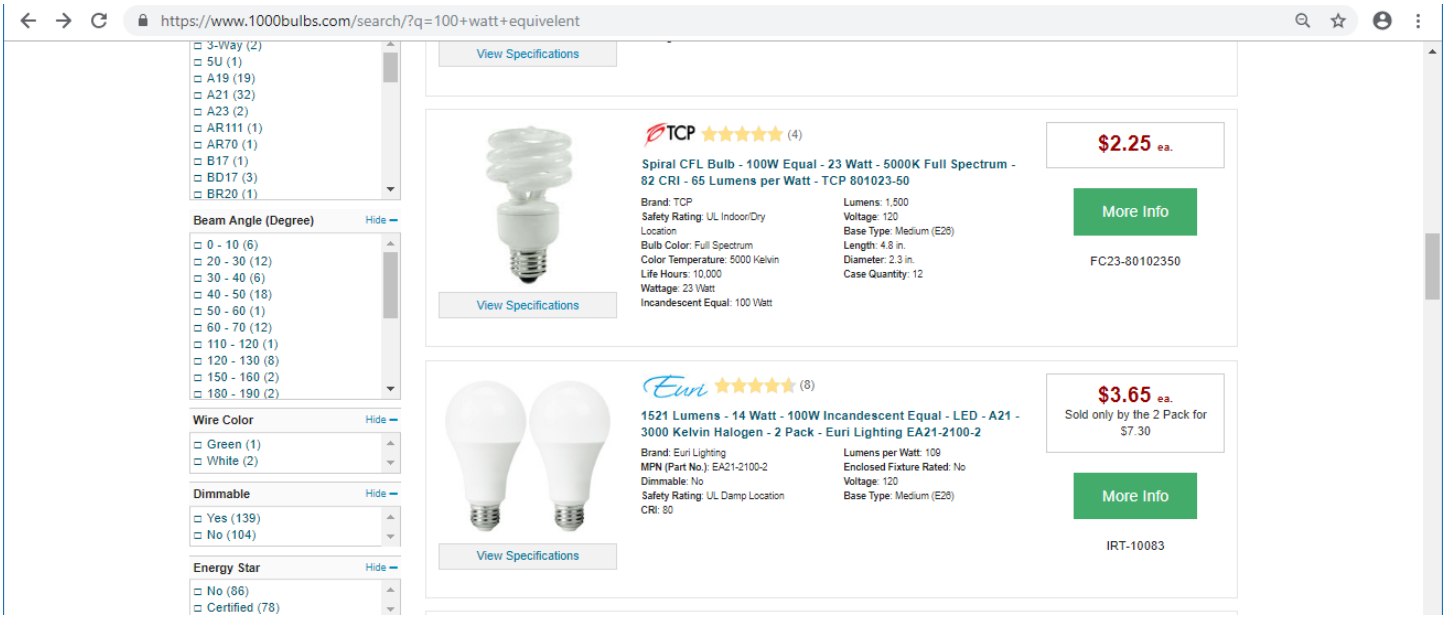
				Total Building Annual Utility Analysis			$ 46	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	D
				Annual Utility Bill [$]					$ 46	$ -	
				Annual Utility Consumption Not Entered Below							
				Sum of Annual Utility Consumption Below				-	480	-	
				Total Annual Utility Consumption				-	480	-	
				Annual Utility Bill ÷ Total Utility Consumption				$ -	$ 0.097	$ -	$

Note: No Units Assigned to a Component with Entries

SHOW		Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annu ((
		Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis (			
		Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 75				
	A	**Substructure**											
	B	**Shell**											
	B101098	CFL 45 LPW 10,000 hours				10					23		
	B101097	LED 65 LPW 35,000 hours			30	35	$2.50		$ 75		16		
	B102098												
	C	**Interiors**											
	D	**Services**											
	E	**Equipment & Furnishings**											
	F	**Special Construction & Demolition**											
	G	**Building Sitework**											
	Z	**Other Project Costs**											
	Z10	**One Time - Upfront Costs**			1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**			1	1							

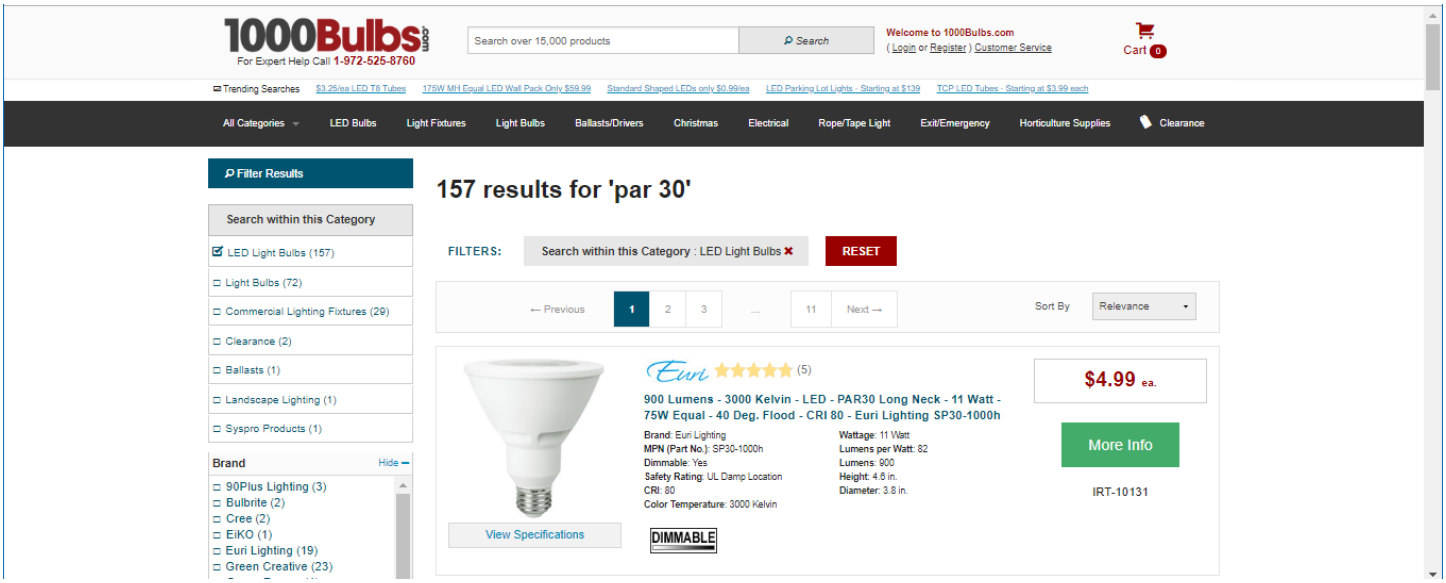
All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

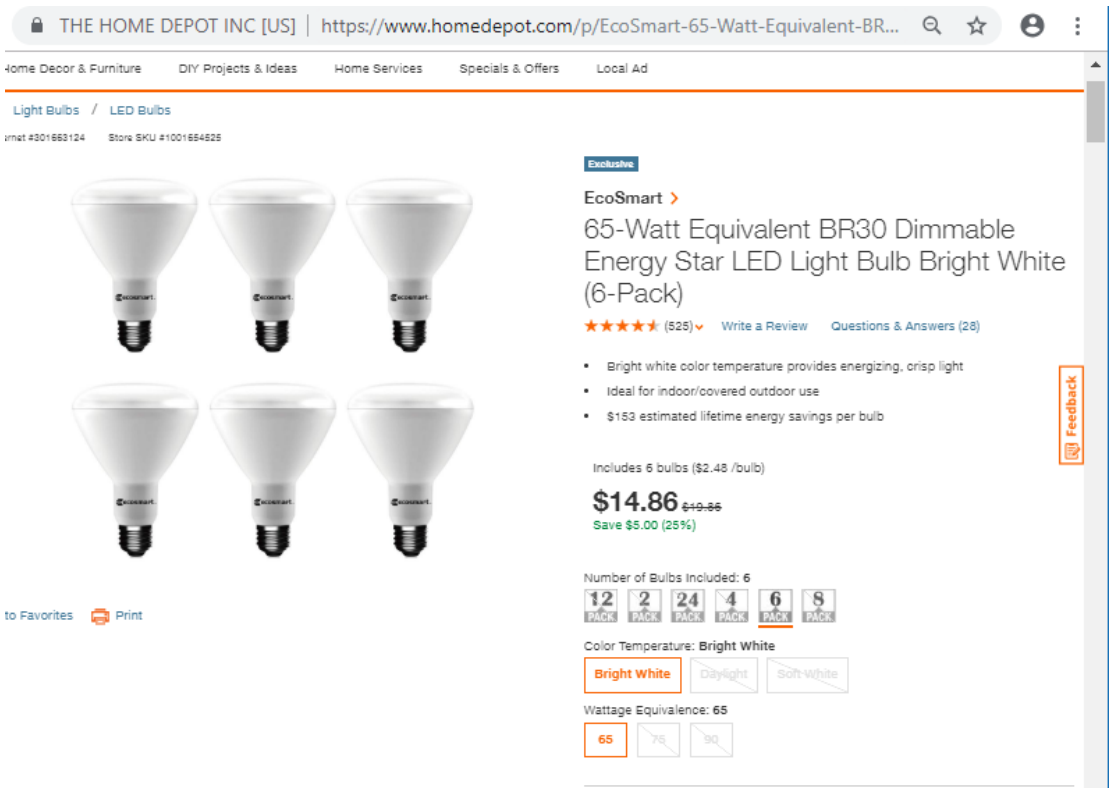
“100 WATT Equivalent Lamps”, LED cost less than CFL



PAR 30 Lamps, LED cost less than CFL

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.





All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R20

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section # **R402.4.1.2 Testing**

Brief Description:

For the purpose of air leakage testing only, the volume of the living space shall be the conditioned floor area (square feet) multiplied by 8.5 (feet).

Proposed code change text:

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). For this test only, the volume of the home shall be the conditioned floor area ft^2 (m^2) multiplied by 8.5 ft. (2.6m). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope*. Once visual inspection has confirmed sealing (see Table R402.4.1.1), operable windows and doors manufactured by *small business* shall be permitted to be sealed off at the frame prior to the test.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures;
2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open, access hatches to conditioned crawl spaces and conditioned attics shall be open;
4. Exterior or interior terminations for continuous ventilation systems and heat recovery ventilators shall be sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

Exceptions:

1. Additions less than 500 square feet of conditioned floor area.
2. Additions tested with the existing home having a combined maximum air leakage rate of 7 air changes per hour. To qualify for this exception, the date of construction of the existing house must be prior to the 2009 Washington State Energy Code.

Purpose of code change:

The method for setting targets for air leakage control are not well aligned with the benefits of air leakage control. Under the current code, a home with a 10 foot average ceiling height is allowed a 20% higher blower door test result than a building with an average ceiling height of 8 feet. But the benefits of air sealing are greater for the taller home. Taller buildings are exposed to greater infiltration impacts related to stack pressure and wind exposure.

The effort required to air seal a home is not meaningfully related to ceiling height. The two illustrations provided below shows the dominant air leakage pathways in homes. You will note that the air leakage details called out in these illustrations are not related wall height. They illustrate air leakage pathways that exist in most homes regardless of height. (Pacific Northwest National Laboratory Buildings Technology Program, Air Leakage Guide, U.S. Department of Energy, 2011)

Any additional cost for air sealing a taller home is not related to meeting the air leakage requirements. Interior drywall required to create an interior air barrier will be installed regardless of this requirement. A taller wall using and exterior air barrier will require more structural board, weather resistive barriers or exterior insulation. But all will be installed to meet other building code requirements.

National studies show that wall heights are increasing. (Home Innovations Research Labs, Trends and opportunities in the U.S. Building Materials Market, 2018 International Builders' Show) This will increase allowable building energy use if the air leakage testing method is not modified as recommended by this proposal.

This proposal will simplify the code and improve code compliance. This method ties the formula for determining the blower door test result to the conditioned floor area printed on the design documents and a fixed multiplier, 8.5 feet. This addresses miscalculations of the ceiling height we have observed in some test results. In some cases we have observed cases where the ceiling height used in developing the target air leakage rate for the building have been overstated to increase the allowance.

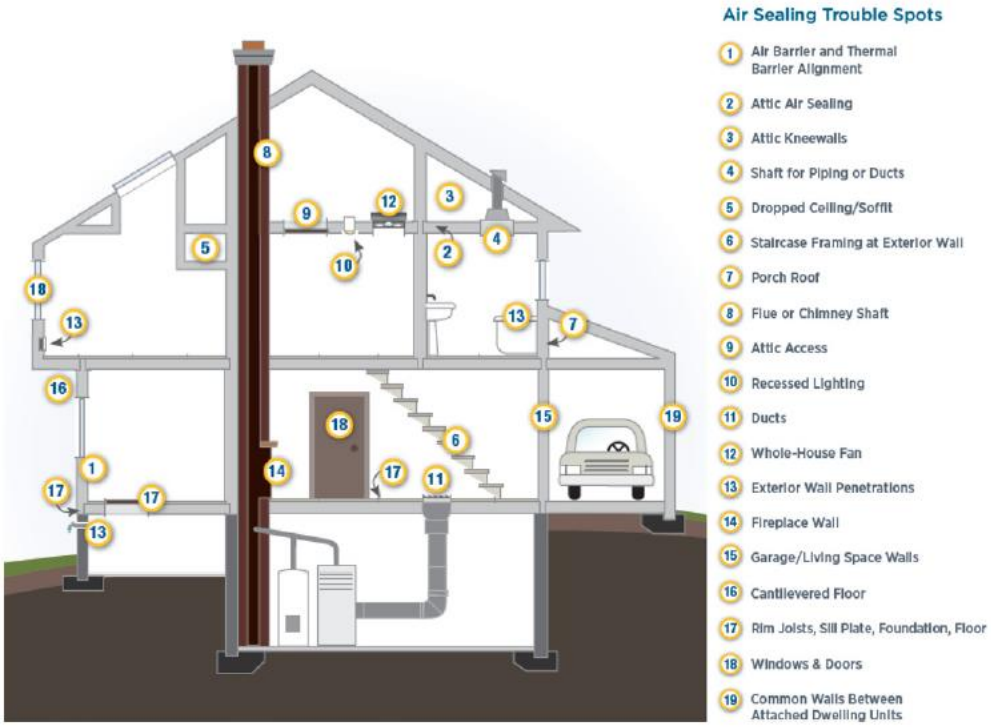
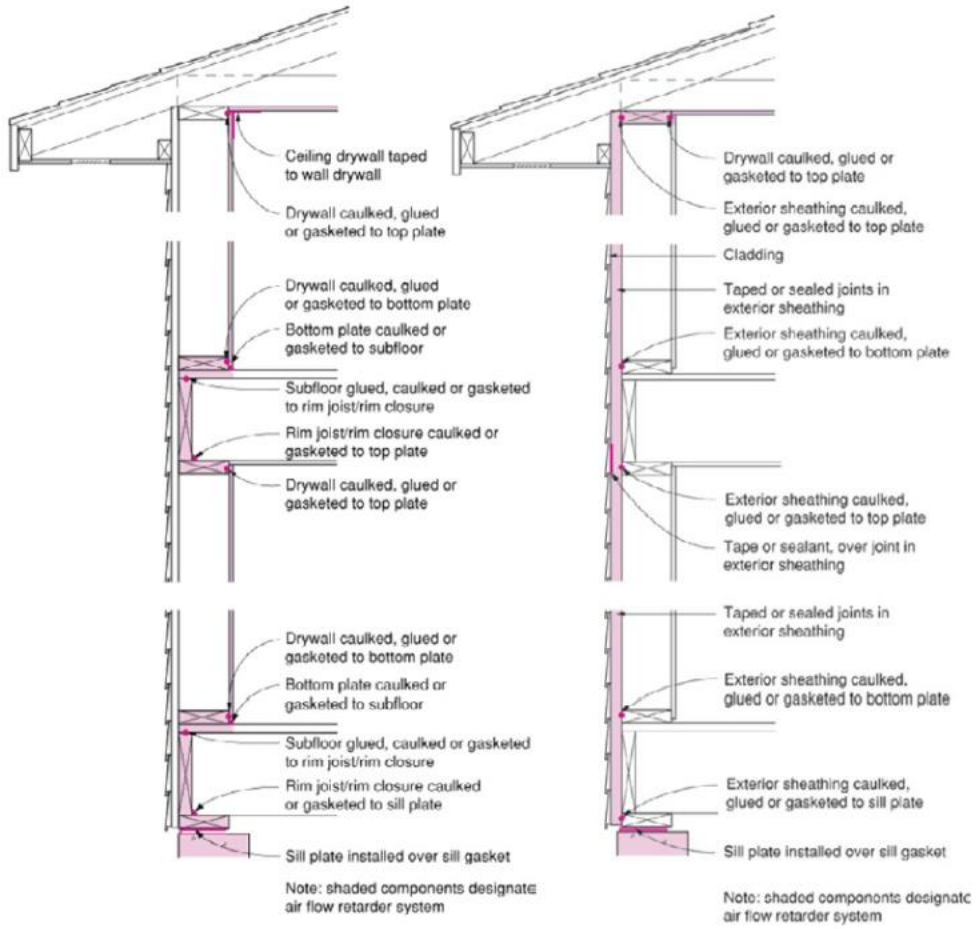


Figure 4: Building America—air sealing trouble spots

Envelope Air Sealing



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

☐ Addresses a critical life/safety need.

X 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)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

X Single family/duplex/townhome

X Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name Chuck Murray

Your organization Commerce, State Energy Office

Other contact name Bill Kraus

Email address chuck.murray@commerce.wa.gov, bill.kraus@commerce.wa.gov

Phone number 360 725-3113, 360-725-5011

Economic Impact Data Sheet

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

LCCA worksheet results are posted below. Three cases are illustrated. As noted in the explanatory statement above, Commerce does not believe there is a real difference in cost of air sealing a home with a taller wall. Most air leakage sites are not related with wall height. But, for the sake of this analysis we have added cost savings and increases to the life cycle assessment.

- Base= 2200 SF home with 8 foot wall height Cost savings $100
- Alt 1 = 2200 SF home with 8.5 foot wall height Cost $0
- Alt 2 = 2200 SF home with 10 foot wall height Cost for taller home $500

Results summary:

The results of the live cycle cost show that the home with the 8' wall will result in some increased energy use and life cycle cost.

The building with taller walls will have more than $1000 of energy savings, twice the value of the additional cost evaluated.

Energy Savings were adopted from SEEM runs developed in support of the C406 code change proposal.

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

As noted in the introduction, and on the LCCT tables.

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) from -.27 to plus 1.18 KBTU/ square foot

(For residential projects, also provide 2600 KBTU / dwelling unit)

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

Energy Savings were adopted from SEEM runs developed in support of the C406 code change proposal. Economic evaluation using the required LCCT model.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This will simplify code implementation. The conditioned floor area is typically on the plans, but not the home volume. The proposed method for setting the air leakage target will be based on the conditioned floor area X 8.5 feet tall. The existing system of calculating the volume of homes is more complex and subject to error.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Executive Report

Project Information	
Project:	Air Leakage - Medium Home - Gas
Address:	
Company:	
Contact:	
Contact Phone:	
Contact Email:	

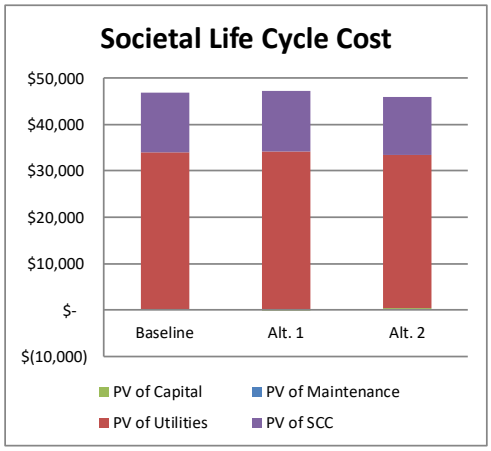
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

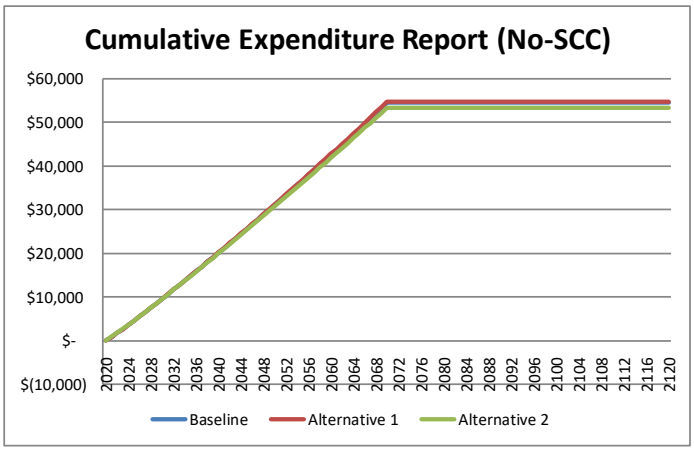
Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	25.8	26.1	24.6
1st Construction Costs	$ -	$ (100)	$ 500
PV of Capital Costs	$ -	$ (99)	$ 494
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 34,002	$ 34,246	$ 32,942
Total Life Cycle Cost (LCC)	**$ 34,002**	**$ 34,148**	**$ 33,436**
Net Present Savings (NPS)	**N/A**	**$ (146)**	**$ 566**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	203	205	197
% CO2e Reduction vs. Baseline	N/A	-1%	3%
Present Social Cost of Carbon (SCC)	$ 12,916	$ 13,017	$ 12,478
Total LCC with SCC	**$ 46,918**	**$ 47,165**	**$ 45,913**
NPS with SCC	**N/A**	**$ (247)**	**$ 1,004**

Warning: OFM Assigned Variables Not Used





Baseline Short Description
8 Foot Ceiling - 5 ach50
Alternative 1 Short Description
8.5 Foot Ceiling 5 ach50
Alternative 2 Short Description
10 Foot Ceiling 5 ach50

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☐ Show All Entered Units (Requires Re-Filter)

	Total Building Annual Utility Analysis	$ 879	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/#2 (Gallons)
	Annual Utility Bill [$]			$ 443	$ 436	
	Annual Utility Consumption Not Entered Below			4,581	411	
	Sum of Annual Utility Consumption Below		-	-	-	
	Total Annual Utility Consumption		-	4,581	411	
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062	$

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Diesel (Gal/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ -	Entries Below for Component Specific Utility Analysis (Consum			
	A	**Substructure**										
	B	**Shell**										
x	B101098	8 Foot Ceiling - 5 ach50			50	$100.00					6	
x	B101097	8.5 Foot Ceiling 5 ach50		1	50	$0.00		$ -			0	
x	B102098	10 Foot Ceiling 5 ach50			50	$500.00					-26	
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

☐ Manual Special Selection Only (Requires Refilter)
● Show Baseline Fields and Entered Units (Requires Refilter)
☐ Show Differences Between Alternative and Baseline (Req. Refilter)

	Total Building Annual Utility Analysis	$ 885	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Di (G
	Annual Utility Bill [$]			$ 443	$ 443	
	Annual Utility Consumption Not Entered Below			4,581	411	
	Sum of Annual Utility Consumption Below		-	-	6	
	Total Annual Utility Consumption		-	4,581	417	
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062	$

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annua (Ga
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis (C			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ (100)				
	A	**Substructure**										
	B	**Shell**										
	B101098	8 Foot Ceiling - 5 ach50		1	50	$100		$ (100)			6	
	B101097	8.5 Foot Ceiling 5 ach50			50							
	B102098	10 Foot Ceiling 5 ach50			50	$500.00					-26	
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 851	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diese (Gallo
Annual Utility Bill [$]			$ 443	$ 409	
Annual Utility Consumption Not Entered Below		-	4,581	411	
Sum of Annual Utility Consumption Below		-	-	(26)	
Total Annual Utility Consumption		-	4,581	385	
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062	$

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual D (Gal/U
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis (Cons			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 500				
	A	**Substructure**										
	B	**Shell**										
	B101098	8 Foot Ceiling - 5 ach50			50	$100.00					6	
	B101097	8.5 Foot Ceiling 5 ach50			50							
	B102098	10 Foot Ceiling 5 ach50		1	50	$500.00		$ 500			-26	
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ -	$ (20)	$ 100	$ -	$ (20)	$ 100
2021	$ 884	$ 865	$ 981	$ 884	$ 885	$ 881
2022	$ 1,772	$ 1,755	$ 1,866	$ 888	$ 890	$ 885
2023	$ 2,670	$ 2,654	$ 2,760	$ 898	$ 899	$ 894
2024	$ 3,615	$ 3,601	$ 3,699	$ 945	$ 947	$ 938
2025	$ 4,590	$ 4,580	$ 4,665	$ 976	$ 978	$ 967
2026	$ 5,575	$ 5,567	$ 5,641	$ 985	$ 988	$ 975
2027	$ 6,573	$ 6,569	$ 6,628	$ 998	$ 1,001	$ 988
2028	$ 7,576	$ 7,575	$ 7,620	$ 1,003	$ 1,006	$ 992
2029	$ 8,592	$ 8,594	$ 8,624	$ 1,016	$ 1,019	$ 1,004
2030	$ 9,617	$ 9,622	$ 9,635	$ 1,025	$ 1,028	$ 1,012
2031	$ 10,646	$ 10,656	$ 10,651	$ 1,029	$ 1,033	$ 1,016
2032	$ 11,680	$ 11,693	$ 11,670	$ 1,034	$ 1,038	$ 1,020
2033	$ 12,718	$ 12,736	$ 12,694	$ 1,038	$ 1,042	$ 1,024
2034	$ 13,766	$ 13,787	$ 13,726	$ 1,047	$ 1,051	$ 1,032
2035	$ 14,818	$ 14,843	$ 14,761	$ 1,052	$ 1,056	$ 1,036
2036	$ 15,874	$ 15,904	$ 15,801	$ 1,056	$ 1,061	$ 1,039
2037	$ 16,930	$ 16,964	$ 16,839	$ 1,056	$ 1,061	$ 1,039
2038	$ 17,995	$ 18,034	$ 17,886	$ 1,065	$ 1,070	$ 1,047
2039	$ 19,064	$ 19,108	$ 18,937	$ 1,070	$ 1,074	$ 1,051
2040	$ 20,138	$ 20,187	$ 19,992	$ 1,074	$ 1,079	$ 1,055
2041	$ 21,216	$ 21,270	$ 21,050	$ 1,078	$ 1,083	$ 1,059
2042	$ 22,299	$ 22,358	$ 22,113	$ 1,083	$ 1,088	$ 1,062
2043	$ 23,386	$ 23,450	$ 23,179	$ 1,087	$ 1,092	$ 1,066
2044	$ 24,478	$ 24,547	$ 24,249	$ 1,091	$ 1,097	$ 1,070
2045	$ 25,574	$ 25,648	$ 25,324	$ 1,096	$ 1,101	$ 1,074
2046	$ 26,674	$ 26,754	$ 26,401	$ 1,100	$ 1,106	$ 1,078
2047	$ 27,783	$ 27,869	$ 27,488	$ 1,109	$ 1,115	$ 1,086
2048	$ 28,892	$ 28,984	$ 28,573	$ 1,109	$ 1,115	$ 1,086
2049	$ 30,006	$ 30,103	$ 29,663	$ 1,114	$ 1,119	$ 1,090
2050	$ 31,124	$ 31,227	$ 30,757	$ 1,118	$ 1,124	$ 1,094
2051	$ 32,246	$ 32,358	$ 31,844	$ 1,122	$ 1,130	$ 1,087
2052	$ 33,373	$ 33,492	$ 32,936	$ 1,127	$ 1,135	$ 1,092
2053	$ 34,504	$ 34,632	$ 34,032	$ 1,131	$ 1,139	$ 1,096
2054	$ 35,640	$ 35,775	$ 35,132	$ 1,136	$ 1,144	$ 1,100
2055	$ 36,780	$ 36,923	$ 36,236	$ 1,140	$ 1,148	$ 1,104
2056	$ 37,924	$ 38,076	$ 37,345	$ 1,144	$ 1,153	$ 1,109
2057	$ 39,073	$ 39,233	$ 38,458	$ 1,149	$ 1,157	$ 1,113
2058	$ 40,226	$ 40,394	$ 39,575	$ 1,153	$ 1,161	$ 1,117
2059	$ 41,383	$ 41,560	$ 40,696	$ 1,157	$ 1,166	$ 1,121
2060	$ 42,545	$ 42,730	$ 41,822	$ 1,162	$ 1,170	$ 1,126
2061	$ 43,711	$ 43,905	$ 42,951	$ 1,166	$ 1,175	$ 1,130
2062	$ 44,882	$ 45,084	$ 44,085	$ 1,171	$ 1,179	$ 1,134
2063	$ 46,057	$ 46,268	$ 45,224	$ 1,175	$ 1,184	$ 1,138
2064	$ 47,236	$ 47,456	$ 46,366	$ 1,179	$ 1,188	$ 1,142
2065	$ 48,420	$ 48,648	$ 47,513	$ 1,184	$ 1,192	$ 1,147
2066	$ 49,609	$ 49,845	$ 48,664	$ 1,188	$ 1,197	$ 1,151
2067	$ 50,801	$ 51,046	$ 49,819	$ 1,193	$ 1,201	$ 1,155
2068	$ 51,998	$ 52,252	$ 50,978	$ 1,197	$ 1,206	$ 1,159
2069	$ 53,200	$ 53,462	$ 52,142	$ 1,201	$ 1,210	$ 1,164
2070	$ 54,405	$ 54,677	$ 53,310	$ 1,206	$ 1,215	$ 1,168

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

2015 Washington State Energy Code Development

Energy Code Proposal Short Form

For editorial **Coordination, Clarifications & Corrections** only, without substantive energy or cost impacts

May 2018

Log No. 19-WSEC-R21

Code being amended: ☐ Commercial Provisions ☐ Residential Provisions
(A MS Word version of the code is linked to the name)

Code Section # R402

Brief Description: Create consistent and enforceable building envelope section. This change provides clarifications, but not change the requirements of the code.

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.)

SECTION R402
BUILDING THERMAL ENVELOPE

R402.1 General (Prescriptive). The *building thermal envelope* shall meet the requirements of Sections R402.1.1 through R402.1.~~5~~6.

Exception: The following buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this code shall be exempt from the building thermal envelope provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h • ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 of floor area for space conditioning purposes.
2. Those that do not contain conditioned space.
3. Greenhouses isolated from any conditioned space and not intended for occupancy.

R402.1.1 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.1 based on the climate zone specified in Chapter 3.

R402.1.2 *R*-value computation. Insulation R-value shall be determined as specified in section R303.1.4. Insulation material used in layers, such as framing cavity insulation or continuous insulation, shall be summed to compute the corresponding component *R*-value. The manufacturer's settled *R*-value shall be used for blown insulation. Computed *R*-values shall not include an *R*-value for other building materials or air films. ~~Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.1, the manufacturer must supply an ICC Report that the R-factor has been certified, or use R-5 per inch for extruded polystyrene, and R-6 per inch for polyisocyanurate rigid insulation.~~ Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled R-value for insulated siding shall be reduced by R-0.6.

R402.1.3 *U*-factor alternative. An assembly with a *U*-factor equal to or less than that specified in Table R402.1.3 shall be permitted as an alternative to the *R*-value in Table R402.1.1. U-factors shall be determined as specified in section R402.1.5.

R402.1.4 Total UA alternative. If the ~~total~~ proposed *building thermal envelope* UA ~~(sum of *U*-factor times assembly area)~~ is less than or equal to the ~~total~~ target UA ~~resulting from using the *U*-factors in Table R402.1.3 (multiplied by the~~

~~same assembly area as in the proposed building),~~ the building shall be considered in compliance with Table R402.1.1. The proposed UA shall be calculated as specified by Equation 2. The target UA shall be calculated as specified by Equation 1. U-factors shall be determined as specified in section R402.1.5.

R402.1.5 U-factor reference and calculations. The *U*-factors for typical construction assemblies are included in Appendix A in chapter 51-11C WAC. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Appendix A, values shall be calculated in accordance with the ASHRAE *Handbook of Fundamentals* using the framing factors listed in Appendix A where applicable and shall include the thermal bridging effects of framing materials. Fenestration U-factors shall comply with section R303.1.3 Fenestration product rating. ~~The SHGC requirements shall be met in addition to UA compliance. When using REScheck, the *U*-factors calculated by the software based on component *R*-value descriptions are acceptable. For the base building UA calculation, the maximum glazing area is 15% of the floor area.~~

R402.1.~~5~~ 6 Vapor retarder. Wall assemblies in the *building thermal envelope* shall comply with the vapor retarder requirements of Section R702.7 of the *International Residential Code* or Section 1405.3 of the *International Building Code,* as applicable.

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	5 AND MARINE 4
FENESTRATION U-FACTOR[b]	0.30
SKYLIGHT[b] U-FACTOR	0.50
~~GLAZED FENESTRATION SHGC[b, e]~~	~~NR~~
CEILING R-VALUE[k~~e~~]	49
WOOD FRAME WALL[g, ~~m,n~~ f,g] R-VALUE	21 int
~~Mass Wall R-Value[i]~~	~~21/21~~
FLOOR R-VALUE	30
BELOW-GRADE[c,m] WALL R-VALUE	10/15/21 int + 5 TB
SLAB[d] R-VALUE & DEPTH	10, 2 ft

For SI: 1 foot = 304.8 mm, ci = continuous insulation, int = intermediate framing.

[a] *R*-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the compressed *R*-value of the insulation from Appendix Table A101.4 shall not be less than the *R*-value specified in the table.

[b] The fenestration *U*-factor column excludes skylights. ~~The SHGC column applies to all glazed fenestration.~~

[c] "10/15/21 + 5 TB" means R-10 continuous insulation on the exterior of the wall, or R-15 continuous insulation on the interior of the wall, or R-21 cavity insulation plus a thermal break between the slab and the basement wall at the interior of the basement wall. "10/15/21 + 5 TB" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the wall. "TB" means R-5 thermal break between floor slab and basement wall.

[d] R-10 continuous insulation is required under heated slab on grade floors. See R402.2.9.1.

[e] ~~Reserved. There are no SHGC requirements in the Marine Zone.~~

[f] ~~Reserved.~~

[g] ~~Reserved.~~

[h] ~~Reserved.~~

[i] ~~Mass walls shall be in accordance with Section R402.2.5. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.~~

[j] Reserved.

[k-e] For single rafter- or joist-vaulted ceilings, the insulation may be reduced to R-38 if the full insulation depth extends over the top plate of the exterior wall .

[l] ~~Reserved.~~

[m] Int. (intermediate framing) denotes framing and insulation as described in section A103.2.2 including standard framing 16 inches on center, 78 percent of the wall cavity insulated and ~~with~~ headers insulated with a minimum of R-10 insulation.

[n-g] Log and solid timber walls with a minimum average thickness of 3.5 inches are exempt from this insulation requirement.

TABLE R402.1.3
EQUIVALENT U-FACTORS[a]

CLIMATE ZONE 5 AND MARINE 4	
FENESTRATION U-FACTOR	0.30
SKYLIGHT U-FACTOR	0.50
CEILING U-FACTOR	0.026
ABOVE-GRADE ~~WOOD FRAME~~ WALL U-FACTOR	0.056
~~Mass Wall U-factor[b]~~	~~0.056~~
FLOOR U-FACTOR	0.029
~~BELOW-GRADE WALL U-factor~~	~~0.042~~
Slab on Grade F-factor	0.54
Below Grade 2' Depth: Wall U-factor Slab F-factor	 0.042 0.59
Below Grade 3.5' Depth: Wall U-factor Slab F-factor	 0.040 0.57
Below Grade 7' Depth: Wall U-factor Slab F-factor	 0.035 0.50

[a] ~~Nonfenestration~~ *U*-factors or F-factors shall be obtained from measurement, calculation or an approved source or as specified in Section R402.1.5 ~~R402.1.3.~~

[b] ~~Reserved.~~

[c] ~~Reserved.~~

R402.2 Specific insulation requirements (Prescriptive). In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.11.

R402.2.1 Ceilings with attic spaces. Where Section R402.1.1 would require R-49 in the ceiling, installing R-38 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-49 wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the *U*-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

R402.2.1.1 Loose insulation in attic spaces. Open-blown or poured loose fill insulation may be used in attic spaces where the slope of the ceiling is not more than 3 feet in 12 inches and there is at least 30 inches of clear distance from the top of the bottom chord of the truss or ceiling joist to the underside of the sheathing at the roof ridge.

R402.2.2 Reserved.

R402.2.3 Eave baffle. For air permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal to or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.

R402.2.4 Access hatches and doors. Access doors from conditioned spaces to unconditioned spaces (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment that prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed *R*-value of the loose fill insulation.

Exception: Vertical doors that provide access from conditioned to unconditioned spaces shall be permitted to meet the fenestration requirements of Table R402.1.1.

R402.2.6 Steel-frame ceilings, walls, and floors. Steel-frame ceilings, walls, and floors shall comply with the *U*-factor requirements of Table R402.1.3.

R402.2.7 Floors. Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of the subfloor decking. Insulation supports shall be installed so spacing is no more than 24-inches on center. Foundation vents shall be placed so that the top of the vent is below the lower surface of the floor insulation.

Exceptions:

1. The floor framing cavity insulation shall be permitted to be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum Wood Frame R-value in Table R402.1.1 and extends from the bottom to the top of all perimeter floor framing members.
2. When foundation vents are not placed so that the top of the vent is below the lower surface of the floor insulation, a permanently attached baffle shall be installed at an angle of 30° from horizontal, to divert air flow below the lower surface of the floor insulation.
3. Substantial contact with the surface being insulated is not required in enclosed floor/ceiling assemblies containing ducts where full R-value insulation is installed between the duct and the exterior surface.

R402.2.8 Below-grade walls. Below-grade exterior wall insulation used on the exterior (cold) side of the wall shall extend from the top of the below-grade wall to the top of the footing and shall be approved for below-grade use. Above-grade insulation shall be protected. Insulation used on the interior (warm) side of the wall shall extend from the top of the below-grade wall to the below-grade floor level and shall include R-5 rigid board providing a thermal break between the concrete wall and the slab.

R402.2.9 Slab-on-grade floors. The minimum thermal resistance (*R*-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table R402.1.1. The insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. A two-inch by two-inch (maximum) pressure treated nailer may be placed at the finished floor elevation for attachment of interior finish materials. Insulation extending away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil.

R402.2.9.1 Heated slab-on-grade floors. The entire area of a heated slab-on-grade floor shall be thermally isolated from the soil with a minimum of R-10 insulation. The insulation shall be an approved product for its intended use. If a soil gas control system is present below the heated slab-on-grade floor, which results in increased convective flow below the heated slab-on-grade floor, the heated slab-on-grade floor shall be thermally isolated from the sub-slab gravel layer. R-10 heated slab-on-grade floor insulation is required for all compliance paths.

R402.2.10 Reserved.

R402.2.11 Masonry veneer. Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

R402.3 Fenestration (Prescriptive). In addition to the requirements of Section R402, fenestration shall comply with Sections R402.3.1 through R402.3.5.

R402.3.1 *U*-factor. An area-weighted average of fenestration products shall be permitted to satisfy the *U*-factor requirements.

R402.3.2 Glazed fenestration SHGC. An area-weighted average of fenestration products more than 50 percent glazed shall be permitted to satisfy the SHGC requirements.

R402.3.3 Glazed fenestration exemption. Up to 15 square feet (1.4 m^2) of glazed fenestration per dwelling unit shall be permitted to be exempt from *U*-factor and SHGC requirements in Section R402.1.1. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

R402.3.4 Opaque door exemption. One side-hinged opaque door assembly up to 24 square feet (2.22 m^2) in area is exempted from the *U*-factor requirement in Section R402.1.1. This exemption shall not apply to the *U*-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

R402.3.5 Reserved.

EQUATION 1 — GROUP R OCCUPANCY
TARGET UA

$$UA_T = U_W A_W + U_{BGW} A_{BGW} + U_{VG} A_{VG} + U_{OG} A_{OG} + U_F A_F + U_{RC} A_{RC} + U_D A_D + F_S P_S + F_{BGS} P_{BGS}$$

Where:

UA_T = the target combined thermal transmittance of the gross exterior wall, floor and roof/ceiling area.

U_W = the thermal transmittance value of the opaque above grade wall found in Table R 402.1.3.

A_W = opaque above grade wall area.

U_{BGW} = the thermal transmittance value of the below grade opaque wall found in Table R 402.1.3.

A_{BGW} = opaque below grade wall area.

U_{VG} = the thermal transmittance value of the fenestration found in Table R 402.1.3.

A_{VG} = (a) The proposed glazing area; where proposed fenestration glazing area is less than 15% of the conditioned floor area, minus A_{OG}.

(b) 15% of the conditioned floor area; where the proposed fenestration glazing area is 15% or more of the conditioned floor area, minus A_{OG}.

U_{OG} = the thermal transmittance value of the skylight glazing found in Table R 402.1.3.

A_{OG} = skylight glazing area (if the proposed A_{OG} exceeds 15 percent, the target A_{OG} shall be 15 percent of the total floor area of the conditioned space).

U_F = the thermal transmittance value of the floor found in Table R 402.1.3.

A_F = floor area over unconditioned space.

U_{RC} = the thermal transmittance value of the ceiling found in Table R 402.1.3.

A_{RC} = roof/ceiling area.

U_D = the thermal transmittance value of the fenestration found in Table R 402.1.3.

A_D = opaque door area.

F_S = concrete slab on grade component F-factor found in Table R 402.1.3.

P_S = lineal ft. of concrete slab on grade perimeter.

F_{BGS} = concrete below grade slab component F-factor found in Table R 402.1.3.

P_{BGS} = lineal ft. of concrete below grade slab perimeter.

EQUATION 2 — GROUP R OCCUPANCY
PROPOSED UA

$$UA = U_W A_W + U_{BGW} A_{BGW} + U_{VG} A_{VG} + U_{OG} A_{OG} + U_F A_F + U_{RC} A_{RC} + U_D A_D + F_S P_S + F_{BGS} P_{BGS}$$

Where:

UA = the combined thermal transmittance of the gross exterior wall, floor and roof/ceiling assembly area.

U_W = the thermal transmittance of the opaque above grade wall area.

A_W = opaque above grade wall area.

U_{BGW} = the thermal transmittance value of the below grade opaque wall.

A_{BGW} = opaque below grade wall area.

U_{VG} = the thermal transmittance value of the fenestration glazing.

A_{VG} = fenestration glazing area, including windows in exterior doors.

U_{OG} = the thermal transmittance value of the skylight glazing.

A_{OG} = skylight glazing area.

U_F = the thermal transmittance of the floor.

A_F = floor area over unconditioned space.

U_{RC} = the thermal transmittance of the ceiling.

A_{RC} = ceiling area.

U_D = the thermal transmittance value of the opaque door area.

A_D = opaque door area.

F_S = concrete slab on grade component F-factor.

P_S = lineal ft. of concrete slab on grade perimeter.

F_{BGS} = concrete below grade slab component F-factor.

P_{BGS} = lineal ft. of concrete below grade slab perimeter.

NOTE: Where more than one type of wall, window, roof/ceiling, door and skylight is used, the U and A terms for those items shall be expanded into sub-elements as:

$$U_{W1} A_{W1} + U_{W2} A_{W2} + U_{W3} A_{W3} + \text{...etc.}$$

~~TABLE A104.1~~
~~DEFAULT WALL U-FACTORS AND SLAB F-FACTORS FOR BASEMENTS~~

	~~Below Grade Wall U-factor~~	~~Below Grade Slab F-factor~~
~~2 Foot Depth Below Grade~~		
~~Uninsulated~~	~~0.350~~	~~0.59~~
~~R-11 Interior~~	~~0.065~~	~~0.59~~
~~R-11 Interior w/TB~~	~~0.070~~	~~0.60~~
~~R-19 Interior~~	~~0.043~~	~~0.69~~
~~R-19 Interior w/TB~~	~~0.045~~	~~0.61~~
~~R-10 Exterior~~	~~0.070~~	~~0.60~~
~~R-12 Exterior~~	~~0.061~~	~~0.60~~
~~3.5 Foot Depth Below Grade~~		
~~Uninsulated~~	~~0.278~~	~~0.53~~
~~R-11 Interior~~	~~0.062~~	~~0.63~~
~~R-11 Interior w/TB~~	~~0.064~~	~~0.57~~
~~R-19 Interior~~	~~0.041~~	~~0.64~~
~~R-19 Interior w/TB~~	~~0.042~~	~~0.57~~
~~R-10 Exterior~~	~~0.064~~	~~0.57~~
~~R-12 Exterior~~	~~0.057~~	~~0.57~~
~~7 Foot Depth Below Grade~~		
~~Uninsulated~~	~~0.193~~	~~0.46~~
~~R-11 Interior~~	~~0.054~~	~~0.56~~
~~R-11 Interior w/TB~~	~~0.056~~	~~0.42~~
~~R-19 Interior~~	~~0.037~~	~~0.57~~
~~R-19 Interior w/TB~~	~~0.038~~	~~0.43~~
~~R-10 Exterior~~	~~0.056~~	~~0.42~~
~~R-12 Exterior~~	~~0.050~~	~~0.42~~

~~TB = Thermal Break~~

TABLE A104.1
DEFAULT WALL U-FACTORS AND SLAB F-FACTORS FOR BASEMENTS

	Below Grade Wall U-factor	Below Grade Slab F-factor
2 Foot Depth Below Grade		
Uninsulated	0.331	0.58
R-11 Interior	0.063	0.67
R-11 Interior w/TB	0.070	0.60
R-19 Interior	0.042	0.68
R-19 Interior w/TB	0.045	0.61
R-21 Interior	0.040	0.68
R-21 Interior w/TB	0.045	0.59
R-21+R-5 ci Interior	0.029	0.68
R-21+R-5 Interior w/TB	.0042	0.59

R-21 plus R-7 ci	0.029	0.68
R-10 Exterior	0.089	0.56
R-12 Exterior	0.061	0.60
3.5 Foot Depth Below Grade		
Uninsulated	0.271	0.51
R-11 Interior	0.058	0.61
R-11 Interior w/TB	0.061	0.55
R-19 Interior	0.041	0.62
R-19 Interior w/TB	0.042	0.53
R-21 Interior	0.038	0.63
R-21 Interior w/TB	0.044	0.56
R-21+R-5 Interior	0.030	.632
R-21+R-5 Interior w/TB	0.031	0.56
R-21 plus R-7 ci	0.027	0.63
R-21 plus R-7 ci w/TB	0.029	0.56
R-10 Exterior	0.075	0.52
R-12 Exterior	0.057	0.57
7 Foot Depth Below Grade		
Uninsulated	0.185	0.43
R-11 Interior	0.051	0.541
R-11 Interior w/TB	0.053	0.49
R-19 Interior	0.036	0.54
R-19 Interior w/TB	0.037	0.50
R-21+R-5 Interior	0.027	0.56
R-21+R-5 Interior w/TB	0.028	0.50
R-21+R-7 Interior	0.025	0.57
R-21+R-7 Interior w/TB	0.026	0.51
R-10 Exterior	0.058	0.47
R-12 Exterior	0.050	0.42

TB = R-5 Thermal Break

Purpose of code change:

Create consistent and enforceable building envelope section. This change provides clarifications, but not change the requirements of the code. The current code language does not provide specific instruction in the application of the R-value and U-factor alternative approaches. Updates to footnotes.

R402.1.2 *R*-value computation. This language was adopted from the 2018 IECC. The reference to section R303 is in addition to the IECC language.

R402.1.3 *U*-factor alternative. Added a pointer to the source of u-factors - appendix A.

R402.1.4 Total UA alternative.

The primary objective of this code change is to clarify the Total UA alternative. It begins with the changes in this paragraph.

This proposal adopts with modifications equation 1 and equation 2 from the 2009 WSEC. The primary modification is the adoption of the 15% glazing area language from the existing standard and as represented in the systems analysis approach. “For the base building UA calculation, the maximum glazing area is 15% of the floor area”.

NEW R402.1.5 U-factor reference and calculations. This section has been separated from R402.1.4 because it *also* applies to section R402.1.3 and many other UA references in the code.

TABLE R402.1.1

Deleted SHGC row. This is not used in the WSEC
Deleted Mass Wall row. This is not any different than other above grade walls. Walls other than wood frame should comply with the prescriptive U-factor requirement R402.1.3 U-factor alternative.
Modified below grade wall R-value to include the required R-5 thermal break requirement.

Modified table footnotes to provide clarifications.
b. modified to be consistent with the deleted SHGC requirements
c. modified to include the required R-5 thermal break requirement
e,f,g,h,i.j and l Deleted footnotes. No longer used
k. added detail to the footnote for clarity. Based on the text from section R402.2.1 Now footnote e in the table and reference.
m. added detail to clarify the requirements for “int” framing based on the description in appendix a. Now footnote f in the table and reference.
n. Now footnote g in the table and reference.

TABLE R402.1.3

Changed Wood Frame Wall U-factor to above grade wall u-factor providing reference u for all above grade walls.

Deleted mass wall u-factor. It is no different than other walls in the WSEC.

Deleted below grade wall u-factor row. Replaced with below grade wall u-factors and F-factors found in appendix A of the code book. This is consistent with the method used in the WSEC 2009.

Footnote changes:

a. Updated the language consistent with changes in section R402.1.5
b. and c. Deleted.

R402.2.1.1 Add “inches” to the roof slope

Added equation 1 and 2. These equations were added to clarify the required calculation method. This proposal adopts with modifications equation 1 and equation 2 from the 2009 WSEC. The primary modification is the adoption of the 15% glazing area language from the existing standard and as represented in the systems analysis approach. “For the base building UA calculation, the maximum glazing area is 15% of the floor area”.

TABLE A104.1. Update the below grade wall u-factor table to support existing rules. Code requires R-21 + R5 TB. This and other values were added based on the Super Good Cents Heat Loss Reference Guide IV, 1991. Target U-factors in Table R402.1.3 were updated to be consistent with these reference values.

Your name Bill Krause

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STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R22

Code being amended: ☐ Commercial Provisions X Residential Provisions

Code Section # **TABLE R402.1.1**

Brief Description: Upgrade log wall standards to the national IRC requirements.

Proposed code change text

Chapter 2 Definitions

Log Structure. A type of construction whose primary structural elements are formed by a system of logs.

Log Wall. An assembly of individual structural logs for use as an exterior or interior load bearing wall, shear wall or non-load bearing wall.

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

~~[a] Log and solid timber walls with a minimum average thickness of 3.5 inches are exempt from this insulation requirement.~~

[n] For log structures developed in compliance with standard ICC 400, log walls shall meet the requirements for climate zone 5 of ICC 400.

Chapter 6 Referenced Standards

2017 – ICC 400 Standard on the Design and Construction of Log Structures

Appendix A

A103.3.4 Log wall. ~~See Table A103.3.4.~~ U-factors for log walls shall be determined using ICC 400 Table 305.3.1.1, U-Factor of Log Wall (U_W) By Log Thickness (W_L) and Specific Gravity.

(Delete existing table A103.3.4)

~~**TABLE A103.3.4**~~
~~**LOG WALLS**~~

Average Log Diameter, Inches	U-factor
6	0.148
8	0.111
10	0.089
12	0.074
14	0.063
16	0.056

~~**NOTE:**~~
~~R-value of wood: R-1.25 per inch thickness~~
~~Average wall thickness 90% average log diameter~~

Purpose of code change: Upgrade log wall standards to the national IRC requirements. This will require a 5” to 7” inch wall depending on the wood species and specific gravity of the source wood.

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)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

X Single family/duplex/townhome

X Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

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360-725-3113

Economic Impact Data Sheet

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

See the assessment below.

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**)

$5.55 /square foot (For residential projects, also provide $ 5272 / dwelling unit)

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

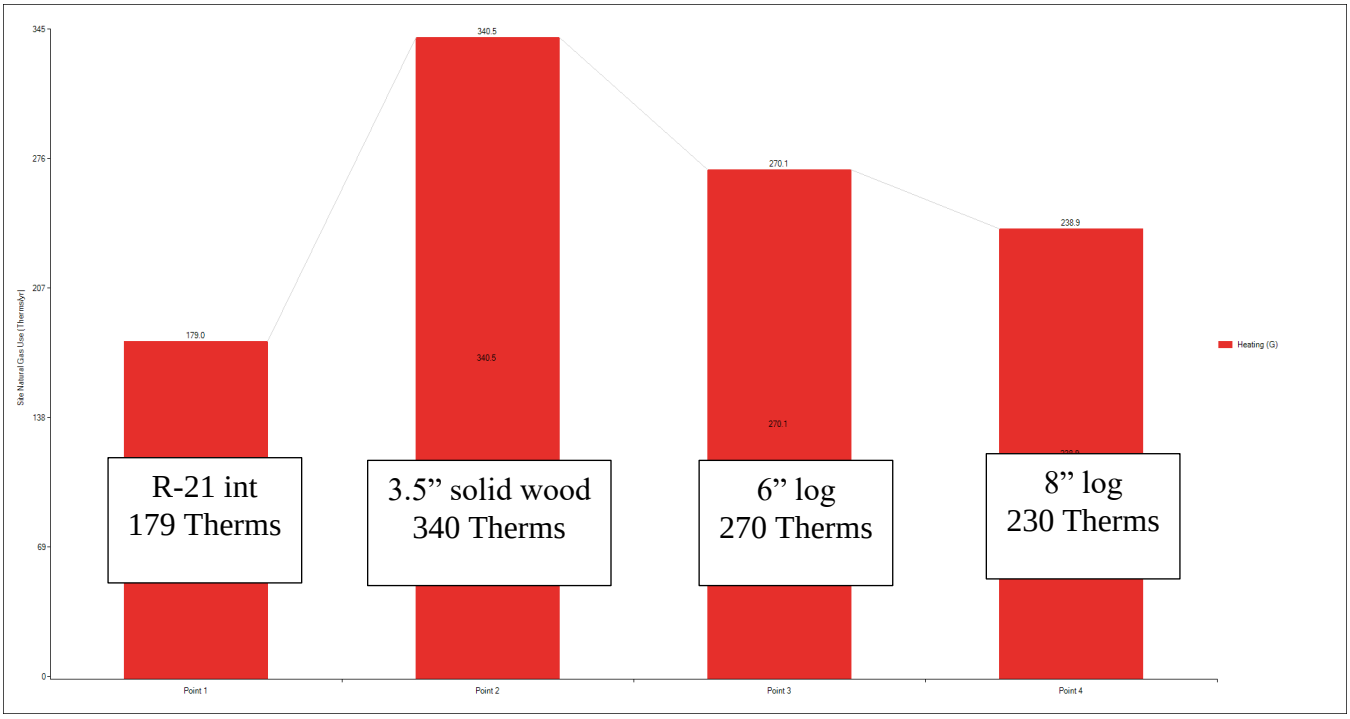
Provide your best estimate of the annual energy savings (or additional energy use) for your code change proposal?

Click here to enter text.KWH/ square foot (or) 7.5 KBTU/ square foot

(For residential projects, also provide 107 therms KWH/KBTU / dwelling unit) per year.

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

Energy Consumption:
The energy use of log walls was compared to the energy use of a R-21 int wall using Beopt energy simulation program. Beopt provides modeling using the energyplus engine and provides full hourly analysis, including the benefits of mass construction. Presented below is the space heating energy use only for a 1344 SF home meeting the 2015 WSEC.



First Cost:
For the life cycle cost model, we assumed the following first cost for construction.

- **Baseline** 3.5 inch solid wood - $14.00 - Based on internet cost of kit home. Labor component added.
- **Alt 1.** 8 Inch log Wall - $19.55 – Source RSmeans derived from whole building cost comparison.
- **Alt 2.** R-21 int. – $11.50 SF – Source RSmeans.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

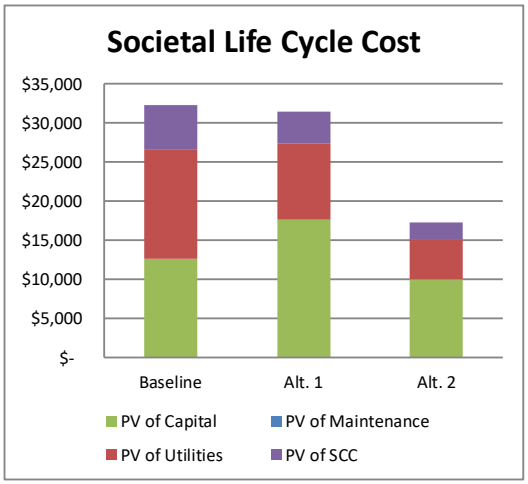
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	1,344
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	1,344
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

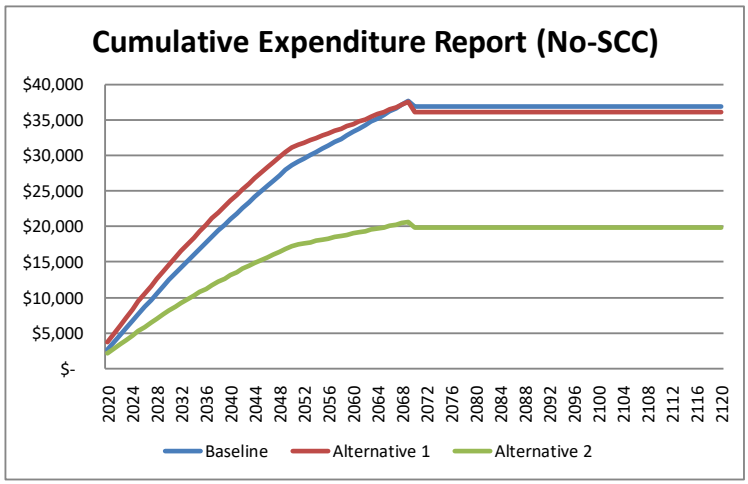
Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	25.3	17.7	9.4
1st Construction Costs	$ 13,300	$ 18,573	$ 10,450
PV of Capital Costs	$ 12,667	$ 17,689	$ 9,953
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 13,858	$ 9,700	$ 5,157
Total Life Cycle Cost (LCC)	**$ 26,525**	**$ 27,389**	**$ 15,110**
Net Present Savings (NPS)	**N/A**	**$ (864)**	**$ 11,415**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	90	63	34
% CO2e Reduction vs. Baseline	N/A	30%	63%
Present Social Cost of Carbon (SCC)	$ 5,731	$ 4,012	$ 2,133
Total LCC with SCC	**$ 32,256**	**$ 31,401**	**$ 17,243**
NPS with SCC	**N/A**	**$ 855**	**$ 15,014**

Warning: OFM Assigned Variables Not Used





All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

Total Building Annual Utility Analysis	$ 361	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ -	$ 361
Annual Utility Consumption Not Entered Below				
Sum of Annual Utility Consumption Below		-	-	340
Total Annual Utility Consumption		-	-	340
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 13,300	Entries Below for Component Specific Utility Analy			
	A	**Substructure**										
x	A101098	Small Gas Home										
x	A101097	Log 3.5		950	55	$14.00		$ 13,300			0.357895	
x	A102097	Log 8			55	$19.55					0.250526	
x	A103098	R-21 int			55	$11.00					0.188421	
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	X904003		0.5									
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

○ Manual Special Selection Only (Requires Refilter)
● Show Baseline Fields and Entered Units (Requires Refilter)
○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 253	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ -	$ 253
Annual Utility Consumption Not Entered Below				
Sum of Annual Utility Consumption Below		-	-	238
Total Annual Utility Consumption		-	-	238
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analy			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 18,573				
	A	**Substructure**										
	A101098	Small Gas Home										
	A101097	Log 3.5			55	$14.00					0.357894737	
	A102097	Log 8		950	55	$19.55		$ 18,573			0.250526316	
	A103098	R-21 int			55	$11.00					0.188421053	
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 134	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ -	$ 134
Annual Utility Consumption Not Entered Below		-		
Sum of Annual Utility Consumption Below		-	-	127
Total Annual Utility Consumption		-	-	127
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Ar
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analys			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 10,450				
	A	**Substructure**										
	A101098	Small Gas Home			55							
	A101097	Log 3.5			55	$14.00					0.25297619	
	A102097	Log 8			55	$19.55					0.177083333	
	A103098	R-21 int		950	55	$11.00		$ 10,450			0.133184524	
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Enforcement will be more consistent with national and state IRC requirements.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R23

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # **R402.4.1.2, R403.3.7, R405.3, R406, Chapter 6**

Brief Description: **This proposal updates Section R406 and requires additional energy efficiency credits. It also amends portions of the prescriptive code, as required, to support proposed revisions to Section R406.**

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.)

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope. Once visual inspection has confirmed sealing (see Table R402.4.1.1), operable windows and doors manufactured by small business shall be permitted to be sealed off at the frame prior to the test.

Exception. For dwelling units that are accessed directly from the outdoors, other than detached one-family dwellings and townhouses, an air leakage rate not exceeding 0.4 cfm per ft2 of the dwelling unit enclosure area shall be an allowable alternative. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals) in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827. Doors and windows of adjacent dwelling units (including top and bottom units) shall be open to the outside during the test. This exception is not permitted for dwelling units that are accessed from corridors or other enclosed common areas.

R403.3.7 Ducts located in conditioned space. For ducts to be considered as being located inside a conditioned space, such ducts shall comply with one of the following:

1) All duct systems shall be located completely within the continuous air barrier and within the building thermal envelope.
2) All heating, cooling and ventilation system components shall be installed inside the conditioned space, including but not limited to forced air ducts, hydronic piping, hydronic floor heating loops, convectors and radiators. Combustion equipment shall be direct vent or sealed combustion.
3) For forced air ducts: A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts is permitted to be located outside the conditioned space, provided they are insulated to a minimum of R-8.
   a) Metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic.
   b) If flex ducts are used, they cannot contain splices. Flex duct connections must be made with nylon straps and installed using a plastic strapping tensioning tool

R405.3 Performance-based compliance. Compliance based on simulated energy performance requires that a proposed residence (*proposed design*) be shown to have an annual energy consumption based on site energy expressed in Btu and Btu per square foot of *conditioned floor area* as follows:

1. For structures less than 1,500 square feet of conditioned floor area, the annual energy consumption shall be less than or equal to ~~80~~ 70 percent of the annual energy consumption of the *standard reference design*.

2. For structures 1,500 to 5,000 square feet of conditioned floor area, the annual energy consumption shall be no more than ~~72~~ 62 percent of the *standard reference design*.
3. For structures over 5,000 square feet of conditioned floor area, the annual energy consumption shall be no more than ~~66~~ 56 percent of the *standard reference design*.
4. ~~**Exception:**~~ For structures serving Group R-2 occupancies, the annual energy consumption shall be less than or equal to ~~85~~ 70 percent of the annual energy consumption of the *standard reference design*.

SECTION R406
ADDITIONAL ENERGY EFFICIENCY REQUIREMENTS

~~**R406.1 Scope.** This section establishes options for additional criteria to be met for one- and two-family dwellings and townhouses, as defined in Section 101.2 of the *International Residential Code*, and dwelling units in *residential buildings*, to demonstrate compliance with this code.~~

R406.1 Scope. This section establishes additional energy efficiency requirements for all new construction covered by this code including additions subject to section R502 and change of occupancy or use subject to section R505 unless specifically exempted in section R406

R406.2 Additional energy efficiency requirements ~~(Mandatory)~~. Each dwelling unit in a residential building shall comply with sufficient options from Table R406.2 so as to achieve the following minimum number of credits:

1. Small Dwelling Unit: .....~~1.5~~ 4.0 credits
   Dwelling units less than 1500 square feet in conditioned floor area with less than 300 square feet of fenestration area.
   Additions to existing building greater than 500 square feet of heated floor area but less than 1500 square feet.
2. Medium Dwelling Unit: ..... ~~3.5~~ 5.0 credits
   All dwelling units that are not included in #1, ~~or~~ #3, or #4.
   ~~**Exception:** Dwelling units serving R-2 occupancies shall require 2.5 credits.~~
3. Large Dwelling Unit: ..... ~~4.5~~ 6.0 credits
   Dwelling units exceeding 5000 square feet of conditioned floor area.
   ~~**Exception:** Dwelling units serving R-2 occupancies shall require 2.5 credits.~~

~~4. Additions less than 500 square feet: 0.5 credits~~

4. Dwelling units serving R-2 occupancies: …… 4.5 credits (from Group R-2 Credit column in Table R406.2)
5. Additions less than or equal to 500 square feet: … 1.5 credits

The drawings included with the building permit application shall identify which options have been selected and the point value of each option, regardless of whether separate mechanical, plumbing, electrical, or other permits are utilized for the project

TABLE 406.2 ENERGY CREDITS

OPTION	DESCRIPTION	CREDIT(S) (Single family and townhouse)	CREDIT(S) (Group R-2 Only)
1a	EFFICIENT BUILDING ENVELOPE 1a: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.28 Floor R-38 Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 5%.	0.5	N/A

1b	EFFICIENT BUILDING ENVELOPE 1b: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.25 Wall R-21 int plus R-4 ci Floor R-38 Basement wall R-21 int plus R-5 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 15%.	1.0	1.0
1c	EFFICIENT BUILDING ENVELOPE 1c: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.22 Ceiling and single-rafter or joist-vaulted R-49 advanced Wood frame wall R-21 int plus R-12 ci Floor R-38 Basement wall R-21 int plus R-12 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 30%.	2.0	1.5
1d~~ab~~	EFFICIENT BUILDING ENVELOPE 1d: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.24	0.5	0.5
1e	EFFICIENT BUILDING ENVELOPE 1e: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.18 Ceiling and single-rafter or joist-vaulted R-60 advanced Wood frame wall R-21 int plus R-16 ci Floor R-48 Basement wall R-21 int plus R-16 ci Slab on grade R-20 perimeter and under entire slab Below grade slab R-20 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 40%.	3.0	2.0
1f[c]	EFFICIENT BUILDING ENVELOPE 1f: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.20	1.0	1.0
2a	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2a: Compliance based on R402.4.1.2: Reduce the tested air leakage to 3.0 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.3 cfm/ft^2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a high efficiency fan (maximum 0.35 watts/cfm), not interlocked with the furnace fan (if present). Ventilation systems using a furnace including an ECM motor are allowed, provided that they are controlled to operate at low speed in ventilation only mode. To qualify to claim this credit, the building permit drawings shall specify the option being selected, ~~and shall specify~~ the maximum tested building air leakage, ~~and shall show~~ the qualifying ventilation system and its control sequence of operation.	0.5	1.0

2b	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2b: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 2.0 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.25 cfm/ft^2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of ~~0.70~~ 0.65. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	1.0	1.5
2c	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2c: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 1.5 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.20 cfm/ft2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of ~~0.85~~ 0.75. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	1.5	2.0
2d	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2d: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.6 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.15 cfm/ft2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.80. Duct installation shall comply with Section R403.3.7. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	2.0	2.5
3a~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3a: Energy Star Rated (U.S. North) Gas or propane ~~or oil-fired~~ furnace with minimum AFUE of ~~94%~~95%, or Energy Star Rated Gas or propane ~~or oiled-fired~~ boiler with minimum AFUE of ~~92%~~90% To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	1.0
3b~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3b: Air-source, centrally ducted heat pump with minimum HSPF of ~~9.0~~9.5 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	~~1.00~~0.5	N/A
3c~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3c: Closed-loop ground source heat pump; with a minimum COP of 3.3 **or** Open loop water source heat pump with a maximum pumping hydraulic head of 150 feet and minimum COP of 3.6 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.5	1.0

3d~~b~~d	HIGH EFFICIENCY HVAC EQUIPMENT 3d: Ductless Split System Heat Pumps, Zonal Control: In homes where the primary space heating system is zonal electric heating, a ductless heat pump system with a minimum HSPF of 10.0 shall be installed and provide heating to the largest zone of the housing unit. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	2.0
3e[d,e]	HIGH EFFICIENCY HVAC EQUIPMENT 3e: Air-source, centrally ducted heat pump with minimum HSPF of 11.0 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	0.5
3f[d,e]	HIGH EFFICIENCY HVAC EQUIPMENT 3f: Ductless Split System Heat Pumps with no electric resistance heating in the primary living areas. A ductless heat pump system with a minimum HSPF of 10 shall be sized and installed to provide heat to entire dwelling unit at the design outdoor air temperature. To qualify to claim this credit, the building permit drawings shall specify the option being selected, the heated floor area calculation, the heating equipment type(s), the minimum equipment efficiency, and total installed heat capacity (by equipment type).	1.5	2.5
4	HIGH EFFICIENCY HVAC DISTRIBUTION SYSTEM: ~~All heating and cooling system components installed inside the conditioned space. This includes all equipment and distribution system components such as forced air ducts, hydronic piping, hydronic floor heating loop, convectors and radiators. All combustion equipment shall be direct vent or sealed combustion.~~ ~~For forced air ducts: A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts may be located outside the conditioned space. All metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic. If flex ducts are used, they cannot contain splices. Flex duct connections must be made with nylon straps and installed using a plastic strapping tensioning tool. Ducts located outside the conditioned space must be insulated to a minimum of R-8.~~ HVAC equipment and associated duct system(s) installation shall comply with requirements of Section R403.3.7 Locating system components in conditioned crawl spaces is not permitted under this option. Electric resistance heat and ductless heat pumps are not permitted under this option. Direct combustion heating equipment with AFUE less than 80% is not permitted under this option. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and shall show the location of the heating and cooling equipment and all the ductwork.	1.0	N/A
5a	~~EFFICIENT WATER HEATING 5a:~~ ~~All showerhead and kitchen sink faucets installed in the house shall be rated at 1.75 GPM or less. All other lavatory faucets shall be rated at 1.0 GPM or less.[c]~~ ~~To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum flow rates for all showerheads, kitchen sink faucets, and other lavatory faucets.~~ EFFICIENT WATER HEATING 5a: A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 52% if installed for unequal flow. Such units shall be rated in accordance with CSA B55.1 and be so labeled. To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specifies the drain water heat recovery units and the plumbing layout needed to install it. Labels or other documentation shall be provided that demonstrates that the unit complies with the standard.	0.5	0.5

5b	EFFICIENT WATER HEATING 5b: Water heating system shall include one of the following: Energy Star Rated Gas or propane ~~or oil~~ water heater with a minimum ~~EF~~ UEF of ~~0.74~~ 0.8 ~~or~~ ~~Water heater heated by ground source heat pump meeting the requirements of Option 3c.~~ ~~or~~ ~~For R-2 occupancy, a central heat pump water heater with an EF greater than 2.0 that would supply DHW to all the units through a central water loop insulated with R-8 minimum pipe insulation.~~ To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	~~1.00~~0.5	0.5
5c	EFFICIENT WATER HEATING 5c: Water heating system shall include one of the following: Energy Star Rated Gas or propane ~~or oil~~ water heater with a minimum ~~EF~~ UEF of 0.91 **or** Solar water heating supplementing a minimum standard water heater. Solar water heating will provide a rated minimum savings of 85 therms or 2000 kWh based on the Solar Rating and Certification Corporation (SRCC) Annual Performance of OG-300 Certified Solar Water Heating Systems. **or** Water heater heated by ground source heat pump meeting the requirements of Option 3c. ~~or~~ ~~Electric heat pump water heater with a minimum EF of 2.0 and meeting the standards of NEEA's Northern Climate Specifications for Heat Pump Water Heaters.~~ To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency and, for solar water heating systems, the calculation of the minimum energy savings.	~~1.5~~1.0	1.0
5d	EFFICIENT WATER HEATING 5d: ~~A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 52% if installed for unequal flow. Such units shall be rated in accordance with CSA B55.1 and be so labeled.~~ ~~To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specifies the drain water heat recovery units and the plumbing layout needed to install it and labels or other documentation shall be provided that demonstrates that the unit complies with the standard.~~ Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier I of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier I of NEEA's Advanced Water Heating Specification, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	~~0.5~~1.5	2.0

5e	EFFICIENT WATER HEATING 5e: Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier III of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's Advanced Water Heating Specification, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	2.0	2.5
5f	EFFICIENT WATER HEATING 5f: Water heating system shall include one of the following: Electric heat pump water heater with a minimum UEF of 2.9 and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors. Equipment shall meet the standards of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's Advanced Water Heating Specification and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	2.5	3.0
6	RENEWABLE ELECTRIC ENERGY: For each 1200 kWh of electrical generation per housing unit provided annually by on-site wind or solar equipment a 0.5 credit shall be allowed, up to 3 credits. Generation shall be calculated as follows: For solar electric systems, the design shall be demonstrated to meet this requirement using the National Renewable Energy Laboratory calculator PVWATTs or approved alternate by the Authority Having Jurisdiction. Documentation noting solar access shall be included on the plans. For wind generation projects designs shall document annual power generation based on the following factors: The wind turbine power curve; average annual wind speed at the site; frequency distribution of the wind speed at the site and height of the tower. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the photovoltaic or wind turbine equipment type, provide documentation of solar and wind access, and include a calculation of the minimum annual energy power production.	0.5	0.5
7	APPLIANCE PACKAGE: All of the following appliances shall be provided with the dwelling unit and shall meet the following standards: Dishwasher – Energy Star Rated Refrigerator – Energy Star Rated Washing Machine – Energy Star Rated Dryer – Energy Star Rated, ventless dryer with a minimum CEF rating of 5.2 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the appliance type and provide documentation of Energy Star Compliance. At the time of inspection, all appliances shall be installed and connected to utilities. Dryer ducts and exterior dryer vent caps are not permitted to be installed in the dwelling unit.	0.5	1.0

a. Compliance with the conductive UA targets is demonstrated using R402.1.4 Total UA alternative where: [1-(Proposed UA/Target UA)] > the required % UA reduction.

b. Projects using this option may not use Option 1a, 1b, ~~or~~ 1c, 1e or 1f.

c. Projects using this option may not use Option 1a, 1b, 1c, 1d or 1e.

d. Projects may only include credit from one space heating option, 3a, 3b, 3c, ~~or~~ 3d, 3e or 3f. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.

~~e. **Plumbing Fixtures Flow Ratings.** Low flow plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements:~~

~~1. Residential bathroom lavatory sink faucets: Maximum flow rate - 3.8 L/min (1.0 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

~~2. Residential kitchen faucets: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

~~3. Residential showerheads: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

e. An alternative heating source sized at a maximum of 0.5 Watts/ft2 (equivalent) of heated floor area or 500 Watts, whichever is bigger, may be installed in the dwelling unit

Chapter 6 REFERENCED STANDARDS

CSA Canadian Standards Association 5060 Spectrum Way Mississauga, Ontario, Canada L4W 5N6

Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440—11	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	R402.4.3
CSA B55.1: 2015	Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units	Table R406.2

NEEA Northwest Energy Efficiency Alliance 421 SW 6th Ave, Suite 600 Portland, OR 97204

Standard reference number	Title	Referenced in code section number
~~NEEA 2011~~	~~Northern Climate Specification for Heat Pump Water Heaters, Vers. 4.0~~	~~Table R406.2~~
NEEA 2016	Advanced Water Heating Specification, Vers. 6.0	Table R406.2

Purpose of code change:

Incremental Improvements in Energy Efficiency consistent with RCW 19.27a.160.

Change in Scope: New to 2018, low-rise multifamily now has dedicated credit values that more appropriately honor the energy savings potential for any given measure. For instance, domestic hot water energy consumption in multifamily represents a bigger portion of the total energy use compared to detached single family housing (20-25% compared to 14-18%, respectively), therefore a more efficient water heating system installed in the low-rise multifamily building will earn more credits under Table 406.2 than single family. Because this code covers low-rise multifamily, additions, as well as single family homes, energy conservation targets are specific to each of these unique construction types and credit values are representative of each building type. We have also added a few prescriptive code changes to strengthen and clarify the requirements set out in Section R406.

Consider clarifications and implementation changes: To provide clear enforceable code language, several editorial changes have been included. We have moved most of the language under option 4 into the base code to clarify requirements and make this section referable in other sections of the code. Low flow fixtures have been mandated through the legislature, therefore cannot be awarded as an energy credit under R406 – this has been eliminated from the table. Low-rise multifamily is now addressed as a unique building type, instead of being rolled up with single-family construction. Appliances are a newly proposed option in the table. As the total energy consumption of the residential sector drops with each code cycle and since appliances have not been addressed in previous code cycles, this end-use represents a larger portion of the total energy consumption and as such, needs to be targeted as we approach 2031 goals.

Add New Efficiency Options: To continue to provide a diverse set of options for implementation, several new options have been added.

- Option 1e provides credit for 40% UA reduction
- Option 1f provides credit for higher performing triple pane glazing
- Option 2d allows credit for tighter envelope construction and highly efficient ERVs
- Option 3e provides credit for inverter-driven, variable speed compressors in central heat pumps
- Option 3f allows credit for homes with minisplit heat pump heating. Eliminating the majority of electric resistance heating leads to increased energy savings
- Options 5d, e, f are meant to more thoroughly cover available heat pump water heating technologies
- Option 7 gives credit for Energy Star rated appliances (primarily to ventless dryers)

Calculate Building Energy Use for the base code and section 406 options: The base code (prescriptive) changes made in 2015 and by the 2018 IECC additions, along with WA state law, are first assessed to determine the base energy use of the seven, modeled prototype buildings (representing the wide range of residential construction within the state). Based on this, the value of each credit is reassessed and if needed, reassigned. For example, WA state law now mandating low-flow fixtures reduces the savings potential from water heating equipment efficiencies – thus lowering their effective value, compared to previous years. The savings attributed to low-flow fixtures are not 'lost' in the analysis however, as the energy savings is now reflected in the 2018 baseline (prescriptive) energy use of the residential sector. Changes in prescriptive lighting requirements also lead to changes in the energy use between code cycles.

Assess the number of credits required to achieve the objectives of RCW 19.27a.160: This proposal is designed to meet the high-level goal of RCW 19.27a.160. This 2018 Section R406 code change proposal, along with other changes (lighting, low-flow fixtures), is expected to lead a 40% energy reduction over a 2006 WSEC compliant home. These savings are primarily attributed to the credits required to comply with code in Section R406.2.

Adjust the targets for systems analysis approach, section 405.3: The last step is to assess the performance-based approach. The targets have been reduced by an additional 10 percent.

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.

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

☒ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome

☒ Multi-family 1 – 3 stories

☐ Multi-family 4 + stories

☐ Commercial / Retail

☐ Institutional

☐ Industrial

Your name	Chuck Murray
Your organization	WA Dept. Of Commerce
Other contact name	Henry Odum, Ecotope Inc.
Email address	chuck.murray@commerce.wa.gov
Phone number	(360) 725-3113

Economic Impact Data Sheet

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

First cost and energy savings

First cost and energy savings estimates have been developed using an estimating procedure used by the Northwest Power and Conservation Council (NPCC). This method uses 6 prototype single family homes and one multi-family building to assess regional energy impacts. This includes: a 1344 sf rambler (crawl space and slab), a 2200 square foot rambler (crawl space and slab), a 2866 sf home with half basement, a 5000 sf home with a full basement, and a 820 sf multifamily dwelling unit (modeled a 3 story, exterior entry, low-rise building). For each building both cost and energy savings are estimated for each prototype and each measure.

First Cost: The first cost included in Tables 1 and 2 were developed using multiple sources of information:

- NPCC, the Regional Technical Forum (RTF), http://rtf.nwcouncil.org/ This is a federally mandated multi-state compact that develops the efficiency resources for the region's electric utilities
- Navigant is a business consulting firm which provides resource planning for both gas and electric utilities, including gas utilities in Washington State. http://www.navigant.com/industries/energy/
- CEE is the Consortium for Energy Efficiency. CEE is the US and Canadian consortium of gas and electric efficiency program administrators. http://www.cee1.org/
- This study also uses cost information provided to the SBCC by Ecotope

The cost of each option is included in Table 1 and 2. Cost are considered for 6 single family and 1 multi-family prototype. For single family prototypes, the crawlspace and slab variations have already been incorporated in the '1344sf' and 2200sf prototypes – which is why only 4 cost numbers are shown.

Table 1: Total Measure Costs by Single Family Prototypes

			Prototypes Weight % by Floor Area			
			1344	2200	2688	5000
Option-Description	Credit Value	**Weighted Measure Cost**	15%	72%	11%	2%
1a - 5% UA reduc	0.5	**$ 1,102**	$ 767	$ 1,097	$ 1,667	$ 676
1b - 15% UA reduc	1	**$ 4,311**	$ 2,649	$ 4,565	$ 4,582	$ 6,127
1c - 30% UA reduc	2	**$ 7,947**	$ 4,869	$ 8,537	$ 7,609	$ 11,659
1d - U-.24 Glaze	0.5	**$ 1,583**	$ 907	$ 1,638	$ 1,818	$ 3,375
1e - 40% UA reduc	3	**$ 11,889**	$ 7,641	$ 12,925	$ 10,191	$ 15,828
1f - U-.20 Glaze	1	**$ 3,166**	$ 1,814	$ 3,276	$ 3,636	$ 6,750
2a - 3ACH , fan eff	0.5	**$ 517**	$ 349	$ 521	$ 618	$ 1,081
2b - 2 ACH, HRV	1	**$ 2,727**	$ 1,680	$ 2,750	$ 3,360	$ 6,250
2c - 1.5 ACH, HRV	1.5	**$ 6,108**	$ 3,763	$ 6,160	$ 7,526	$ 14,000
2d - 0.6 ACH, HRV	2	**$ 8,725**	$ 5,376	$ 8,800	$ 10,752	$ 20,000
3a - Furnace	1	**$ 230**	$ 230	$ 230	$ 230	$ 230
3b - 9.5 HSPF HP	0.5	**$ 1,270**	$ 1,270	$ 1,270	$ 1,270	$ 1,270
3c - GSHP	1.5	**$ 11,034**	$ 10,900	$ 10,900	$ 10,900	$ 17,600
3d - DHP	1	**$ 1,400**	$ 1,400	$ 1,400	$ 1,400	$ 1,400
3e - 11.0 HSPF HP	1	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
3f - DHP (15% elec)	1.5	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
4 - HVAC inside	1	**$ 300**	$ 300	$ 300	---	---
5a - DWR	0.5	**$ 400**	$ 400	$ 400	$ 400	$ 400
5b - 0.80 gas DHW	0.5	**$ 586**	$ 586	$ 586	$ 586	$ 586
5c - 0.91 gas DHW, GSHP	1	**$ 923**	$ 923	$ 923	$ 923	$ 923
5d - Tier I HPWH	1.5	**$ 874**	$ 874	$ 874	$ 874	$ 874
5e - Tier III HPWH	2	**$ 874**	$ 874	$ 874	$ 874	$ 874
5f - Tier III HPWH Split	2.5	**$ 3,500**	$ 3,500	$ 3,500	$ 3,500	$ 3,500
6 - Solar pV	0.5	**$ 5,040**	$ 5,040	$ 5,040	$ 5,040	$ 5,040
7 - ES Appl+ventless Dryer	0.5	**$ 462**	$ 462	$ 462	$ 462	$ 462

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 2: Total Measure Costs for Multifamily prototype

Option-Description	Credit Value	Measure Cost
1a - 5% UA reduc	---	---
1b - 15% UA reduc	1	**$ 1,359**
1c - 30% UA reduc	1.5	**$ 2,615**
1d - U-.24 Glaze	0.5	**$ 554**
1e - 40% UA reduc	2	**$ 3,773**
1f - U-.20 Glaze	1	**$ 1,107**
2a - 3ACH , fan eff	1	**$ 245**
2b - 2 ACH, HRV	1.5	**$ 1,025**
2c - 1.5 ACH, HRV	2	**$ 2,296**
2d - 0.6 ACH, HRV	2.5	**$ 3,280**
3a - Furnace	1	---
3b - 9.5 HSPF HP	---	---
3c - GSHP	1	---
3d - DHP	2	**$ 2,800**
3e - 11.0 HSPF HP	0.5	---
3f - DHP (15% elec)	2.5	**$ 4,800**
4 - HVAC inside	---	---
5a - DWR	0.5	**$ 133**
5b - 0.80 gas DHW	0.5	---
5c - 0.91 gas DHW, GSHP	1	---
5d - Tier I HPWH	2	**$ 291**
5e - Tier III HPWH	2.5	**$ 291**
5f - Tier III HPWH Split	3	**$ 1,167**
6 - Solar pV	0.5	**$ 5,040**
7 - HP dryers, ES Appl	1	**$ 462**

Energy Savings Estimates

The energy savings estimates below have been developed using 6 single family and one multi-family prototype. For each building prototype, each predominant HVAC system (gas furnace, gas furnace with AC, central heat pump and Ductless heat pumps with zonal electric) was modeled and located in various weather climates within the state. The energy savings attributed to each option listed in Table 406.2 were then weighted to consolidate energy savings estimates for the 4 primary categories of homes in Section R406.2 (small, medium, large, and R-2 dwelling units). As shown in Table 1, large homes (greater than 5000sf) only compromise 2% of the total building stock – therefore energy savings estimates used for the Life Cycle Cost Analysis have been omitted from this economic analysis.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 3: Savings All Climates, All Systems

Savings are positive	Small Single Family (less than 1500sf)				Medium Single Family				Multifamily (R-2 occ)
	Gas Home		Central HP	Zonal Elec	Gas Home		Central HP	Zonal Elec	Zonal Elec
Option-Description	kWh	Therm	kWh	kWh	kWh	Therm	kWh	kWh	kWh
1a - 5% UA reduc	-5	25	212	477	-5	41	355	810	135
1b - 15% UA reduc	-6	57	516	1034	-5	100	908	1884	517
1c - 30% UA reduc	-11	99	891	1787	-12	169	1519	3194	898
1d - U-.24 Glaze	-2	17	150	315	-1	36	325	689	228
1e - 40% UA reduc	-27	135	1193	2419	-30	229	2024	4316	1172
1f - U-.20 Glaze	-6	29	253	541	-7	62	546	1185	391
2a - 3ACH , fan eff	52	14	177	313	52	43	440	905	475
2b - 2 ACH, HRV	-313	20	-92	-4	-313	56	231	767	939
2c - 1.5 ACH, HRV	-203	33	137	331	-204	75	520	1239	1284
2d - 0.6 ACH, HRV	-205	46	253	560	-205	100	737	1708	1533
3a - Furnace	0	41	---	---	0	77	---	---	---
3b - 9.5 HSPF HP	---	---	180	---	---	---	343	---	---
3c - GSHP	---	---	729	---	---	---	1301	---	---
3d - DHP	---	---	---	1835	---	---	---	3526	1132
3e - 11.0 HSPF HP	---	---	407	---	---	---	784	---	---
3f - DHP (15% elec)	---	---	---	1928	---	---	---	3700	1193
4 - HVAC inside	11	46	517	---	13	60	638	---	---
5a (5g) - DWR	0	17	322	322	0	19	368	368	265
5b - 0.74 gas DHW	0	22	---	---	0	24	---	---	---
5c - 0.91 gas DHW, GSHP	0	32	---	---	0	36	---	---	---
5d - Tier I HPWH	---	---	1236	1236	---	---	1393	1393	1038
5e - Tier III HPWH	---	---	1623	1623	---	---	1823	1823	1369
5f - Tier III HPWH Split	---	---	1836	1836	---	---	2064	2064	1547
6 - Solar pV	1262	---	1262	1262	1262	---	1262	1262	1262
7 - Appliances	840	---	840	840	840	---	840	840	612

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

See Table 3 for kWh/dwelling unit or therm/dwelling unit savings (savings values are positive)

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This process is consistent with the current code. We do not anticipate additional enforcement cost.

Provide your best estimate of the construction cost (or cost savings) of your code change proposal?

See Table 4 for square foot cost of various measures. Also, see Table 1 and 2 for per dwelling unit cost of each measure, by prototype.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 4: Measure cost estimates ($/component area, SF or housing unit)

Component	Base Level	Measures Beyond Base Level	Cost $/ft2 or $/unit	Source
Envelope				
Ceiling	R-49	R-49 RH Ceiling Insulation	$ 0.20	ResSFEStarBuiltGreenHomesWA2014_v2_5.xlsm
Ceiling	R-49	R-60 RH Ceiling Insulation	$ 0.23	CERF
Wall	R-21 Std	R-21 int Wall + R4 Foam Sheathing	$ 0.96	RTF RESnew.xls 6th plan
Wall	R-21 Std	R-21 int Wall + R12 Foam Sheathing	$ 2.25	RTF RESnew.xls passiveHouse Consultant
Wall	R-21 Std	R-21 int Wall + R16 Foam Sheathing	$ 3.00	passiveHouse Consultant
Floor	R-30	R-38 Floor	$ 0.38	RTF-ResNCMTHouseID_v_3_0 .xlsm April 4, 2018; ShellCosts tab
Floor	R-30	R-48 Floor	$ 1.50	Assuming high density foam (R-6.inch) installed in std 12" joists
Slab	R-10 2' perim	Slab R-10 Full	$ 0.91	6th Plan Appendix G
Slab	R-10 2' perim	Slab R-20 Full	$ 1.22	NextStepHomes data
Window	U-0.30	Window U-0.28	$ 0.80	NPCC Standard workbook
Window	U-0.30	Window U-0.25	$ 4.50	NPCC Standard workbook
Window	U-0.30	Window U-0.24	$ 4.50	NPCC Standard workbook
Window	U-0.30	Window U-0.22	$ 6.60	NPCC Standard workbook
Window	U-0.30	Window U-0.18	$ 9.00	MF bids (tripleglaze-BidPrices.xl)
Air Sealing & Ventilation				
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 3 ACH50	$ 0.20	RTF Workbook. ResWXSF_FY10v2_1.xls passiveHouse consultant
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 2 ACH50	$ 0.50	
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 1.5 ACH50	$ 0.80	
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 0.6 ACH50	$ 1.50	
Exhaust Fan	Pt Source Exhaust Fan =0.75W/cfm	Pt Source Exhaust Fan <0.35W/cfm	$ 80.64	navigant 2013
ERV	No ERV	ERV with SHR>= 0.65	$ 0.75	Whispercomfort and minimal ducting
ERV	No ERV	ERV with SHR>= 0.75	$ 2.00	renewaire or lifebreath
ERV	No ERV	ERV with SHR>= 0.80	$ 2.50	high efficiency HRV with ducting (venmar, zhender)

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Component	Base Level	Measures Beyond Base Level	Cost $/ft2 or $/unit	Source
HVAC System				
Ducts	Code level is sealed	Ducts Inside	$ 300.00	NPCC Sixth Power Plan, Support documentation
Furnace	0.8	Furnace Upgrade to 94AFUE	$ 230.25	Navigant Sept 2011 Report for NEEP
Heat Pump	8.2 HSPF	9.5 HSPF	$ 1,270.00	NPCC Standard workbook, with linear regression
DHP	Zonal Resistance (MF)	1-ton single zone DHP	$ 2,800.00	Ecotope analysis of NEEA DHP pilot program database
11.0 DHP	8.2 DHP (SF)	1-ton single zone DHP	$1,400.00	Ecotope analysis of NEEA DHP pilot program database
Heat Pump	8.2 HSPF	11 HSPF	$ 5,400.00	3 ton unit. ResSFExistingHVAC
multizone 11.0 DHP	8.2 HSPF	10 HSPF efficiency with no electric resistance. Reduction in elec heat but higher tonnage	$5,400	Ecotope analysis of NEEA DHP pilot program database
Domestic Hot Water				
Water Htr	0.59 EF	Gas Water Heater >=0.80 EF	$ 586.00	NREL, 2013
Water Htr	0.59 EF	Gas Water Heater >=0.91 EF	$ 923.00	NREL, 2013
Water Htr	0.95 EF	Heat Pump Water Heater 2 EF	$ 874.00	RTF ResHPWH.xls
DWHR	none	Drain water heat recovery pipe	$ 400.00	RTF RESDHWDrainWaste.xls
Water Htr	0.95 EF	Tier 3 Water Heater 3 EF	$ 874.00	RTF ResHPWH.xls
Water Htr	0.95 EF	CO2 Water Heater 4 EF	$ 3,500.00	RTF ResHPWH.xls
Appliances				
Dryers, refr, dishwasher	Fed pre-empted	ventless dryers, ES appliances	$ 462.000	RTF-ResClothesDryers, ResRef, HD.com $420 for HP dryer, +$40 for Cloth washer, +$90 for refr

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Life Cycle Cost Analysis of 2018 WSEC R406 Code Change Proposal

Henry Odum and Dave Baylon, Ecotope
Chuck Murray, Washington State Department of Commerce April 2019
Northwest Energy Efficiency Alliance (NEEA)

The following documentation provides a life cycle cost assessment of the R406 code change proposal. This proposal modifies sections R402.4.1.2, R403.3.7, R405.3, and R406. It is anticipated that adoption of this code change will reduce energy use in typical new homes and low-rise apartments by 13% over a 2015 code-compliant home and 40% over a 2006 code compliance home.

The life cycle cost approach presented builds on the methodology used in previous code development cycles. However, all energy modeling was completed from the 'ground-up' – meaning all modeled energy use, energy savings, and code-to-code comparisons (i.e 2006 vs 2018 and 2015 vs 2018) were completely redone for this analysis. No assumptions or previous models were carried over from past years. The life cycle cost analysis was completed using the Office of Financial Management Life Cycle Cost Tool, as approved by the State Building Code Council on March 18, 2019.

The analysis was developed by Henry Odum, Dave Baylon, Adria Banks, and Ben Larson (all of Ecotope) and Chuck Murray, Washington State Department of Commerce. Ecotope provided the first cost estimates and the energy savings analysis. Commerce incorporated the results into the life cycle cost tool, including additional cost detailed in ALT2.

Approach to the development of the R406 energy code proposal:

The following outlines the process used to develop the R406 code change proposal. It is a process with multiple steps.

Change in Scope: For the 2018 WSEC, section 406, this proposal developed credits specific to multifamily construction. The value of each credit has been assessed specifically for multifamily. Multifamily now has dedicated credit values that more appropriately honor the energy savings potential for any given measure in this context. For instance, domestic hot water energy consumption in multifamily represents a bigger portion of the total energy use compared to detached single family housing (20-25% compared to 14-18%, respectively), therefore a more efficient water heating system installed in the low-rise multifamily building will earn more credits under Table 406.2 than single family. Because this code covers low-rise multifamily, additions, as well as single family homes, energy conservation targets are specific to each of these unique construction types and credit values are representative of each building type.

We have also added a few prescriptive code changes to strengthen and clarify the requirements set out in Section R406.

Consider clarifications and implementation changes: To provide clear enforceable code language, several editorial changes have been included. We have moved the requirements of option 4 into the base code consistent with the format of the 2018 IECC. Low flow fixtures are expected to be mandated through the adoption of HB 1444, and have been incorporated into the base code assumption for 2018. Low-rise multifamily is now addressed as a unique building type, instead of being rolled up with single-family construction. Since, appliances have not been addressed in previous code cycles and as the total energy consumption of the residential sector drops with each code cycle, this end-use represents a larger portion of the total energy consumption; and as such, needs to be targeted as we approach 2031 goals.

Add New Efficiency Options: To continue to provide a diverse set of options for implementation, several new options have been added.

- Option 1e provides credit for 40% UA reduction
- Option 1f provides credit for higher performing triple pane glazing
- Option 2d allows credit for tighter envelope construction and highly efficient ERVs
- Option 3e provides credit for inverter-driven, variable speed compressors in central heat pumps
- Option 3f allows credit for homes with ductless minisplit heat pump heating. Eliminating the majority of electric resistance heating leads to increased energy savings
- Options 5d, e, f are meant to more thoroughly cover available heat pump water heating technologies
- Option 7 gives credit for Energy Star rated appliances (primarily to ventless clothes dryers)

Calculate Building Energy Use for the base code and section 406 options: The base code (prescriptive) changes made in 2015 and by the 2018 IECC additions, along with WA state law, are first assessed to determine the base energy use of the prototype buildings within both major climate zones in the state. This ultimately impacts the credits awarded by Section R406 options.

After the new base code energy use is established, the value of each credit is reassessed and if needed, reassigned. For example, WA state law mandating low-flow fixtures reduces the savings potential from water heating equipment efficiencies – thus lowering their effective value. The savings attributed to low-flow fixtures are not 'lost' in the analysis however, as the energy savings is now reflected in the 2018 baseline (prescriptive) energy use of the residential sector. Changes in prescriptive lighting requirements to be proposed by Commerce also lead to changes in the base energy use between code cycles. In addition to compensating for base code requirements, there have been some adjustments in the equipment efficiency requirements prescribed for each credit.

Assess the number of credits required to achieve the objectives of RCW 19.27a.160: This proposal is designed to meet the high-level goal of RCW 19.27a.160. This 2018 Section R406 code change proposal, along with other changes (lighting, low-flow fixtures), is expected to lead a 40% energy reduction over a 2006 WSEC compliant home. These savings are primarily attributed to the credits required to comply with code in Section R406.2.

Adjust the targets for systems analysis approach, section 405.3: The last step is to assess the performance-based approach. The targets under this section have been reduced by an additional 10 percent over the 2018 prescriptive code requirements. This accounts for both the required increase in efficiency and the somewhat lower energy use baseline.

Energy Savings Estimates

Energy savings estimates used in the life cycle cost analysis were developed using SEEM. The SEEM energy simulation program was used to develop the energy savings targets and estimates for the 2009, 2012, and 2015 iterations of the residential portion of Washington State Energy Code. SEEM is used by the Northwest Power and Conservation Council RTF to estimate savings for most of the regional utility conservation programs. The modeling protocol is intended to represent the wide variety of new homes constructed in Washington, to summarize the average savings that can be attributed to each option listed in Table R406.2, and estimate the overall consumption of the residential sector for each code cycle.

The SEEM program is designed to model small scale residential building energy use. The program consists of an hourly thermal simulation and an hourly moisture (humidity) simulation that interacts with duct specifications, equipment, and weather parameters to calculate the annual heating and cooling energy requirements of the home. It is based on algorithms consistent with current American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), American Heating and Refrigeration Institute (AHRI), and International Organization for Standards (ISO) calculation standards. In order for the SEEM model to be used in efficiency measure assessments, it

must be calibrated to baseline and efficient-case consumption. Calibration for single family, multi-family, and manufactured homes are separate endeavors that utilize metered data from a sample of homes in the NW to estimate energy consumption. SEEM was recalibrated in response to findings from the 2011 Residential Building Stock Assessment. This provides calibrated results for Pacific NW homes.

For single family construction, the energy model is built using six RTF-approved prototype designs, including: a 1344 sf rambler (both on a slab and over a crawlspace), 2200 sf rambler (both on a slab and over a crawlspace), 2688 with half basement and 5000 sf full basement home. These six prototypes are then modeled with the three primary heating system types ("gas home", "Heat Pump Home" and "Electric Resistance Home") and then simulated in the two major climate zones in the state. Different climate zones require different heating/cooling signatures - for instance, a home in Spokane will see much greater heating energy savings from central heat pump than home in Olympia. With all these variables considered, each energy conservation measure (option in Table R406.2) is then modeled independently in each of these scenarios, with the energy savings weighted down to a representative, single credit value shown in Table R406.2.

For low-rise multifamily construction, the same method was used as for single family but only one prototype was modeled. The presumed, predominant construction-type was a 3-story, garden style (exterior entry) building. To simplify the model, a "sliver" of the overall building was modeled; meaning one stack of 3 apartments was modeled in the SEEM program. The annual energy use, utility savings, and incremental cost were then normalized to a per unit basis. The substantial increase in credit requirement for 2018 is supported by the updated credit values, which award more value to important and reasonable conservation measures related to low-rise construction. For instance, a ductless heat pump for multifamily will now earn 2 credits as opposed to a single credit on 2015.

After individual measures were modeled independently and associated savings determined, each prototype summarized in this LCCA was modeled with a selection (package) of R406 options required to be code compliant (both in 2015 and 2018). This important step not only illustrated the code-to-code savings, but it also accounts for interaction between different credit options within the table. As more measures are utilized in a home, more interaction occurs between measures, and the individual savings attributed to that measure are not realized when paired with a host of other options. For instance, higher envelope insulation will de-rate the savings available from increased equipment efficiencies. It is important to capture this interaction through the modeling exercise or else the anticipated savings estimates will be overinflated. It is the annual energy savings obtained from these packages of measures that are used in determining the life cycle cost of the code change proposal. Therefore, the energy savings estimates shown in our measure summary tables might differ than those savings numbers shown in the LCCA runs.

First Cost method:

First cost and energy savings estimates have been developed using an estimating procedure used by the Northwest Power and Conservation Council (NPCC) and ran through the Office of Financial Management Life Cycle Cost Tool. The first costs were developed using multiple sources of information:

- NPCC, the Regional Technical Forum (RTF), http://rtf.nwcouncil.org/ This is a federally mandated multi-state compact that develops the efficiency resources for the region's electric utilities
- Navigant is a business consulting firm which provides resource planning for both gas and electric utilities, including gas utilities in Washington State. http://www.navigant.com/industries/energy/
- CEE is the Consortium for Energy Efficiency. CEE is the US and Canadian consortium of gas and electric efficiency program administrators. http://www.cee1.org/
- This study also uses cost information provided to the SBCC by Ecotope
- PassiveHouse consultant aided with pricing the higher insulation and envelope detailing

All costs shown are incremental costs for each measure, the base cost is related to the prescriptive requirement of the code and the incremental costs are associated with the option requirement of Table R406.2. Keeping this in mind, the incremental cost for a ductless minisplit, in single family, is the added equipment cost associated with purchasing a higher efficiency heat pump (since DHPs are required in the prescriptive code in electric zonal single-family homes);

while in multifamily, the incremental cost of a heat pump is higher because it is compared to electric baseboards. Water heating systems in multifamily are assumed to serve more than one unit, therefore their incremental costs are lower than for single family.

The cost analyses provided in this report use a weighted average cost method to represent the wide range of new homes constructed in Washington. Each of the predominant dwellings, as defined in Section R406.2, are shown in the LCCA case studies (large dwelling units represent a minor fraction of the overall building stock, therefore were omitted from the analysis). For each single-family dwelling unit size, the predominant heating system types are shown individually ("Gas Home", "Heat Pump Home" and "Electric Resistance Home") in order to show cost effectiveness for all available heating system types. The cost model is built using the six prototype designs, including a 1344 sf rambler (both on a slab and over a crawlspace), 2200 sf rambler (both on a slab and over a crawlspace), 2688 with half basement and 5000 sf full basement home. The costs associated with the crawl space and slab prototypes were normalized into each of the dwelling unit sizes per Section R406.2. Multifamily costs were based on one 820sf prototype with an electric zonal heating system. A first cost estimate is developed for each option and for each prototype. Then, the incremental cost of each prototype is weighted by the expected construction volumes to provide an overall average measure cost. Table 1 and Table 3 provides individual prototype and overall weighted measure cost.

Unlike the energy savings estimates, the first cost numbers are a fixed value for each energy measure and do not change based on the selected package of measures modeled for the LCCA. This assumes that incremental costs of each option do not have the any interdependency – contrary to the associated energy savings, as stated earlier. This will no longer be the case as buildings become more efficient. Higher levels of envelope insulation and tighter construction leads to smaller HVAC systems, and therefore a cost credit should be applied. But as mentioned, this approach was not applied in this analysis.

Energy and Cost Summary Tables:

Table 1: Incremental Cost of Single Family options, by home size

Incremental Cost of Single Family Options						
			Prototypes Weight % by Floor Area			
			1344	2200	2688	5000
Option-Description	Credit Value	**Weighted Measure Cost**	15%	72%	11%	2%
1a - 5% UA reduc	0.5	**$ 1,102**	$ 767	$ 1,097	$ 1,667	$ 676
1b - 15% UA reduc	1	**$ 4,311**	$ 2,649	$ 4,565	$ 4,582	$ 6,127
1c - 30% UA reduc	2	**$ 7,947**	$ 4,869	$ 8,537	$ 7,609	$ 11,659
1d - U-.24 Glaze	0.5	**$ 1,583**	$ 907	$ 1,638	$ 1,818	$ 3,375
1e - 40% UA reduc	3	**$ 11,889**	$ 7,641	$ 12,925	$10,191	$ 15,828
1f - U-.20 Glaze	1	**$ 3,166**	$ 1,814	$ 3,276	$ 3,636	$ 6,750
2a - 3ACH , fan eff	0.5	**$ 517**	$ 349	$ 521	$ 618	$ 1,081
2b - 2 ACH, HRV	1	**$ 2,727**	$ 1,680	$ 2,750	$ 3,360	$ 6,250
2c - 1.5 ACH, HRV	1.5	**$ 6,108**	$ 3,763	$ 6,160	$ 7,526	$ 14,000
2d - 0.6 ACH, HRV	2	**$ 8,725**	$ 5,376	$ 8,800	$10,752	$ 20,000
3a - Furnace	1	**$ 230**	$ 230	$ 230	$ 230	$ 230
3b - 9.5 HSPF HP	0.5	**$ 1,270**	$ 1,270	$ 1,270	$ 1,270	$ 1,270
3c - GSHP	1.5	**$ 11,034**	$ 10,900	$ 10,900	$10,900	$ 17,600
3d - DHP	1	**$ 1,400**	$ 1,400	$ 1,400	$ 1,400	$ 1,400
3e - 11.0 HSPF HP	1	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
3f - DHP (15% elec)	1.5	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
4 - HVAC inside	1	**$ 300**	$ 300	$ 300	---	---
5a - DWR	0.5	**$ 400**	$ 400	$ 400	$ 400	$ 400
5b - 0.80 gas DHW	0.5	**$ 586**	$ 586	$ 586	$ 586	$ 586
5c - 0.91 gas DHW, GSHP	1	**$ 923**	$ 923	$ 923	$ 923	$ 923
5d - Tier I HPWH	1.5	**$ 874**	$ 874	$ 874	$ 874	$ 874
5e - Tier III HPWH	2	**$ 874**	$ 874	$ 874	$ 874	$ 874
5f - Tier III HPWH Split	2.5	**$ 3,500**	$ 3,500	$ 3,500	$ 3,500	$ 3,500
6 - Solar pV	0.5	**$ 5,040**	$ 5,040	$ 5,040	$ 5,040	$ 5,040
7 - ES Appl+ventless Dryer	0.5	**$ 462**	$ 462	$ 462	$ 462	$ 462

Table 2: Modeled Energy Savings - Single Family, by home size and heating system type

Savings are positive	Small Single Fmily (less than 1500sf)				Medium Single Family			
	Gas Home		Central HP	Zonal Elec	Gas Home		Central HP	Zonal Elec
Option-Description	kWh	Therm	kWh	kWh	kWh	Therm	kWh	kWh
1a - 5% UA reduc	-5	25	212	477	-5	41	355	810
1b - 15% UA reduc	-6	57	516	1034	-5	100	908	1884
1c - 30% UA reduc	-11	99	891	1787	-12	169	1519	3194
1d - U-.24 Glaze	-2	17	150	315	-1	36	325	689
1e - 40% UA reduc	-27	135	1193	2419	-30	229	2024	4316
1f - U-.20 Glaze	-6	29	253	541	-7	62	546	1185
2a - 3ACH , fan eff	52	14	177	313	52	43	440	905
2b - 2 ACH, HRV	-313	20	-92	-4	-313	56	231	767
2c - 1.5 ACH, HRV	-203	33	137	331	-204	75	520	1239
2d - 0.6 ACH, HRV	-205	46	253	560	-205	100	737	1708
3a - Furnace	0	41	---	---	0	77	---	---
3b - 9.5 HSPF HP	---	---	180	---	---	---	343	---
3c - GSHP	---	---	729	---	---	---	1301	---
3d - DHP	---	---	---	1835	---	---	---	3526
3e - 11.0 HSPF HP	---	---	407	---	---	---	784	---
3f - DHP (15% elec)	---	---	---	1928	---	---	---	3700
4 - HVAC inside	11	46	517	---	13	60	638	---
5a (5g) - DWR	0	17	322	322	0	19	368	368
5b - 0.74 gas DHW	0	22	---	---	0	24	---	---
5c - 0.91 gas DHW, GSHP	0	32	---	---	0	36	---	---
5d - Tier I HPWH	---	---	1236	1236	---	---	1393	1393
5e - Tier III HPWH	---	---	1623	1623	---	---	1823	1823
5f - Tier III HPWH Split	---	---	1836	1836	---	---	2064	2064
6 - Solar pV	1262	---	1262	1262	1262	---	1262	1262
7 - HP dryers, ES Appl	840	---	840	840	840	---	840	840

Table 3: Incremental Cost of Multifamily options and Modeled Energy Savings (Zonal Electric only)

Incremental Cost of MF Options			
Option-Description	Credit Value	**Measure Cost**	Savings kWh
1a - 5% UA reduc	---	**---**	135
1b - 15% UA reduc	1	**$ 1,359**	517
1c - 30% UA reduc	1.5	**$ 2,615**	898
1d - U-.24 Glaze	0.5	**$ 554**	228
1e - 40% UA reduc	2	**$ 3,773**	1172
1f - U-.20 Glaze	1	**$ 1,107**	391
2a - 3ACH , fan eff	1	**$ 245**	475
2b - 2 ACH, HRV	1.5	**$ 1,025**	939
2c - 1.5 ACH, HRV	2	**$ 2,296**	1284
2d - 0.6 ACH, HRV	2.5	**$ 3,280**	1533
3a - Furnace	1	**---**	---
3b - 9.5 HSPF HP	---	**---**	---
3c - GSHP	1	**---**	---
3d - DHP	2	**$ 2,800**	1132
3e - 11.0 HSPF HP	0.5	**---**	---
3f - DHP (15% elec)	2.5	**$ 4,800**	1193
4 - HVAC inside	---	**---**	---
5a - DWR	0.5	**$ 133**	265
5b - 0.80 gas DHW	0.5	**---**	---
5c - 0.91 gas DHW, GSHP	1	**---**	---
5d - Tier I HPWH	2	**$ 291**	1038
5e - Tier III HPWH	2.5	**$ 291**	1369
5f - Tier III HPWH Split	3	**$ 1,167**	1547
6 - Solar pV	0.5	**$ 5,040**	1262
7 - HP dryers, ES Appl	1	**$ 462**	612

Life Cycle Cost Analysis

Life Cycle Cost Analysis (LCCA) is an analytical technique capable of comparing the present value of upfront capital cost to future operational costs. LCCA helps decision makers determine which project designs are likely to deliver the lowest total Life Cycle Cost (LCC).

The State Building Code Council has adopted the use of Washington State Department of Financial Managements (OFM) life cycle cost tool for this analysis. The OFM life cycle cost tool used to provide these results is based on the methodology of National Institute of Standards, HANDBOOK 135 Life-Cycle Costing Manual. The OFM model is designed for state projects and commercial construction. This model was modified to support residential construction. This primarily required changing the fuel escalation rates from commercial to a residential standard.

Standard inputs for Life cycle cost on all the submitted documents are included in the table below. A user value has been used to reflect the values adopted by the Council in March of 2019. As a result of not using OFM inputs, there will be warnings on each page of the output. These may be disregarded for this analysis.

Key Variables	○ OFM	◉ User	Value
Building Life	50	50	50
Real Discount Rate	0.53%	1.93%	1.93%
Standard Maintenance Escalation	1.00%	1.00%	1.00%
General Inflation	3.12%	3.01%	3.01%
Study Period (years)	50	50	50
Fuel Escalation Assumptions Located on Fuel Escalation Page			

User Inputs are for sensitivity analysis only, final submissions must be made using OFM

Timing Variables	Year(s)
Base Year (Generally Current Year)	2020
Additional Construction Years beyond 2020	0

1st Operation Year = 20

Finance 1st Purchases for ->	☑ Baseline	☑ Alt. 1	☑ Alt. 2
Down Payment (%)	20%	20%	20%
Term (Years)	30	30	30
Nominal Interest Rate	5.00%	5.00%	5.00%
Real Interest Rate	1.82%	1.82%	1.82%

Life Cycle Cost Reports

Below are the results of life cycle cost calculations for 5 of the 6 single family prototype buildings, each with a central heat pump, gas furnace, and zonal electric as well as the single multifamily prototype with zonal electric heat. Each prototype includes 5 pages of report.

Executive report: This page summarizes the total life cycle cost results for three alternatives based on a 50-year life cycle cost assessment.

Baseline: The baseline report describes the life cycle cost impact for a 2015 WSEC compliant structure. Each includes the number of credits that would be required to meet the 2015 WSEC.

Alt 1. This report provides the inputs for the 2018 WSEC proposal. The cost and benefits included reflect the information detailed in this report.

Alt 2. This report is identical to Alt1, except $0.75 per square foot of floor area is added to the cost. This provides a buffer to cover uncertainty about the first cost assessment.

Expenditure Report. We have included the results of the expenditure report for each project. This allows the reader to view the year over year cash flow for each model.

LCCA Results

Small Gas Home – Executive Report

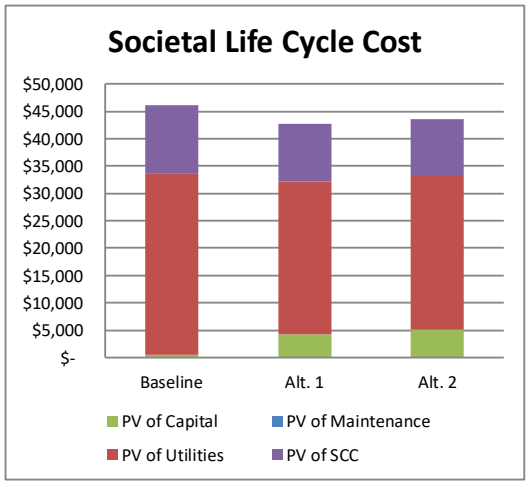
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	1,344
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	1,344
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

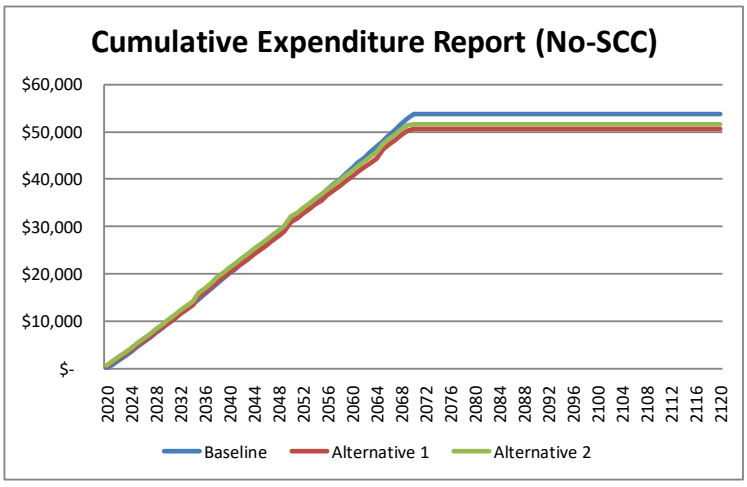
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	39.4	31.0	31.0
1st Construction Costs	$ 255	$ 2,569	$ 3,577
PV of Capital Costs	$ 511	$ 4,163	$ 5,123
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 33,189	$ 28,060	$ 28,060
Total Life Cycle Cost (LCC)	**$ 33,701**	**$ 32,223**	**$ 33,183**
Net Present Savings (NPS)	**N/A**	**$ 1,477**	**$ 517**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	197	164	164
% CO2e Reduction vs. Baseline	N/A	17%	17%
Present Social Cost of Carbon (SCC)	$ 12,501	$ 10,437	$ 10,437
Total LCC with SCC	**$ 46,202**	**$ 42,660**	**$ 43,620**
NPS with SCC	**N/A**	**$ 3,542**	**$ 2,582**

Warning: OFM Assigned Variables Not Used





LCCA Results

Small Gas Home – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

							Total Building Annual Utility Analysis	$ 857	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	
							Annual Utility Bill [$]			$ 473	$ 385	
							Annual Utility Consumption Not Entered Below			4,895	414	
							Sum of Annual Utility Consumption Below		-	-	(52)	
							Total Annual Utility Consumption		-	4,895	362	
							Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062	

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	An
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 255	Entries Below for Component Specific Utility Analysi			
	A	**Substructure**										
x	A101098	Small gas home										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
x	G909097	Added Cost			55	$0.75						
x	**X**	**Other Categories**										
x	X90	**Other Categories**										
x	X9010	Building Envelope										
x	X901001	1a - 5% UA reduc	0.5		50	$766.60				5.09	-25.30	
x	X901002	1b - 15% UA reduc	1		50	$2,649.16				5.61	-57.17	
x	X901003	1c - 30% UA reduc	2		50	$4,868.68				11.35	-98.72	
x	X901004	1d - U-.24 Glaze	0.5		50	$907.20				1.97	-16.89	
x	X901005	1e - 40% UA reduc	3		50	$7,641.34				26.84	-134.84	
x	X901006	1f - U-.20 Glaze	1		50	$1,814.40				5.67	-29.19	
x	X901007	2a - 3ACH , fan eff	0.5		50	$349.44				-52.18	-13.70	
x	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				312.61	-20.42	
x	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				203.35	-33.29	
x	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				204.58	-46.08	
x	X9020	HVAC										
x	X902001	3a - Furnace	1	1	18	$230.25		$ 230		0.00	-40.92	
x	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00						
x	X902003	3c - GSHP	1.5		20	$10,900.00						
x	X902004	3d - DHP	1		18	$1,400.00						
x	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00						
x	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00						
x	X902007	4 - HVAC inside	1		50	$300.00				-10.81	-46.38	
x	X9030	Hot Water										
x	X903001	5a - DWR	0.5		50	$400.00				0.00	-16.86	
x	X903002	5b - 0.80 gas DHW	0.5		15	$586.00				0.00	-22.20	
x	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00				0.00	-32.11	
x	X903004	5d - Tier I HPWH	1.5		15	$874.00						
x	X903005	5e - Tier III HPWH	2		15	$874.00						
x	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00						
x	X9040	Other										
x	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262.00	0.00	
x	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840.00	0.00	
x	X904003	(legacy) 5a - low flow fixtures	0.5	1	50	$25.00		$ 25		0	-11	
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Small Gas Home – ALT 1

<- Primary Filter (Requires Level 1)

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Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 724	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 451	$ 273
Annual Utility Consumption Not Entered Below			4,727	403
Sum of Annual Utility Consumption Below		-	(58)	(146)
Total Annual Utility Consumption		-	4,669	257
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Anal		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 2,569			
	A	**Substructure**									
	A101098	Small gas home									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909097	Added Cost			55	$0.75					
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5	1	50	$766.60		$ 767		5	-21
	X901002	1b - 15% UA reduc	1		50	$2,649.16				6	-57
	X901003	1c - 30% UA reduc	2		50	$4,868.68				11	-99
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				2	-17
	X901005	1e - 40% UA reduc	3		50	$7,641.34				27	-135
	X901006	1f - U-.20 Glaze	1		50	$1,814.40				6	-29
	X901007	2a - 3ACH , fan eff	0.5	1	50	$349.44		$ 349		-52	-12
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				313	-20
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				203	-33
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				205	-46
	X9020	HVAC									
	X902001	3a - Furnace	1	1	18	$230.25		$ 230			-38
	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00					
	X902003	3c - GSHP	1.5		20	$10,900.00					
	X902004	3d - DHP	1		18	$1,400.00					
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00					
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00					
	X902007	4 - HVAC inside	1	1	50	$300.00		$ 300		-11	-43
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400.00					-17
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					-22
	X903003	5c - 0.91 gas DHW, GSHP	1	1	15	$923.00		$ 923			-32
	X903004	5d - Tier I HPWH	1.5		15	$874.00					
	X903005	5e - Tier III HPWH	2		15	$874.00					
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00					
	X9040	Other									
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262	
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00					-11
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1						

LCCA Results

Small Gas Home – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 724	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 451	$ 273
Annual Utility Consumption Not Entered Below		-	4,727	403
Sum of Annual Utility Consumption Below		-	(58)	(146)
Total Annual Utility Consumption		-	4,669	257
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Anal		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 3,577			
	A	**Substructure**									
	A101098	Small gas home									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909097	Added Cost		1344	55	$0.75		$ 1,008			
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5	1	50	$766.60		$ 767		5	-21
	X901002	1b - 15% UA reduc	1		50	$2,649.16				6	-57
	X901003	1c - 30% UA reduc	2		50	$4,868.68				11	-99
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				2	-17
	X901005	1e - 40% UA reduc	3		50	$7,641.34				27	-135
	X901006	1f - U-.20 Glaze	1		50	$1,814.40				6	-29
	X901007	2a - 3ACH , fan eff	0.5	1	50	$349.44		$ 349		-52	-12
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				313	-20
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				203	-33
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				205	-46
	X9020	HVAC									
	X902001	3a - Furnace	1	1	18	$230.25		$ 230			-38
	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00					
	X902003	3c - GSHP	1.5		20	$10,900.00					
	X902004	3d - DHP	1		18	$1,400.00					
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00					
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00					
	X902007	4 - HVAC inside	1	1	50	$300.00		$ 300		-11	-43
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400.00					-17
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					-22
	X903003	5c - 0.91 gas DHW, GSHP	1	1	15	$923.00		$ 923			-32
	X903004	5d - Tier I HPWH	1.5		15	$874.00					
	X903005	5e - Tier III HPWH	2		15	$874.00					
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00					
	X9040	Other									
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262	
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00					-11
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1						

LCCA Results

Small Gas Home – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 51	$ 514	$ 715	$ 51	$ 514	$ 715
2021	$ 926	$ 1,372	$ 1,624	$ 875	$ 858	$ 908
2022	$ 1,807	$ 2,232	$ 2,533	$ 881	$ 860	$ 910
2023	$ 2,697	$ 3,098	$ 3,447	$ 890	$ 866	$ 914
2024	$ 3,630	$ 3,994	$ 4,389	$ 933	$ 896	$ 942
2025	$ 4,592	$ 4,909	$ 5,348	$ 962	$ 915	$ 960
2026	$ 5,563	$ 5,829	$ 6,313	$ 971	$ 921	$ 964
2027	$ 6,547	$ 6,759	$ 7,284	$ 984	$ 929	$ 971
2028	$ 7,536	$ 7,689	$ 8,256	$ 989	$ 931	$ 972
2029	$ 8,536	$ 8,627	$ 9,233	$ 1,001	$ 938	$ 977
2030	$ 9,546	$ 9,569	$ 10,213	$ 1,009	$ 942	$ 980
2031	$ 10,559	$ 10,513	$ 11,194	$ 1,014	$ 944	$ 981
2032	$ 11,578	$ 11,458	$ 12,176	$ 1,018	$ 945	$ 982
2033	$ 12,601	$ 12,405	$ 13,158	$ 1,023	$ 947	$ 982
2034	$ 13,632	$ 13,357	$ 14,144	$ 1,031	$ 952	$ 986
2035	$ 14,668	$ 15,234	$ 16,054	$ 1,036	$ 1,877	$ 1,910
2036	$ 15,707	$ 16,188	$ 17,040	$ 1,039	$ 954	$ 986
2037	$ 16,747	$ 17,140	$ 18,023	$ 1,039	$ 952	$ 983
2038	$ 18,024	$ 18,327	$ 19,240	$ 1,278	$ 1,187	$ 1,217
2039	$ 19,077	$ 19,286	$ 20,228	$ 1,052	$ 959	$ 988
2040	$ 20,133	$ 20,245	$ 21,216	$ 1,056	$ 959	$ 988
2041	$ 21,193	$ 21,207	$ 22,205	$ 1,060	$ 962	$ 989
2042	$ 22,257	$ 22,170	$ 23,194	$ 1,064	$ 962	$ 989
2043	$ 23,326	$ 23,135	$ 24,185	$ 1,069	$ 965	$ 991
2044	$ 24,398	$ 24,100	$ 25,176	$ 1,072	$ 966	$ 991
2045	$ 25,475	$ 25,069	$ 26,169	$ 1,077	$ 968	$ 993
2046	$ 26,556	$ 26,038	$ 27,162	$ 1,081	$ 969	$ 993
2047	$ 27,645	$ 27,013	$ 28,159	$ 1,089	$ 975	$ 998
2048	$ 28,733	$ 27,986	$ 29,154	$ 1,089	$ 973	$ 995
2049	$ 29,826	$ 28,961	$ 30,151	$ 1,093	$ 975	$ 996
2050	$ 30,923	$ 30,860	$ 32,071	$ 1,097	$ 1,900	$ 1,920
2051	$ 32,019	$ 31,787	$ 32,998	$ 1,096	$ 927	$ 927
2052	$ 33,119	$ 32,718	$ 33,929	$ 1,100	$ 930	$ 930
2053	$ 34,223	$ 33,652	$ 34,862	$ 1,104	$ 934	$ 934
2054	$ 35,332	$ 34,589	$ 35,800	$ 1,108	$ 937	$ 937
2055	$ 36,445	$ 35,530	$ 36,741	$ 1,113	$ 941	$ 941
2056	$ 37,792	$ 36,704	$ 37,915	$ 1,347	$ 1,175	$ 1,175
2057	$ 38,913	$ 37,652	$ 38,863	$ 1,121	$ 948	$ 948
2058	$ 40,038	$ 38,603	$ 39,814	$ 1,125	$ 951	$ 951
2059	$ 41,168	$ 39,558	$ 40,769	$ 1,130	$ 955	$ 955
2060	$ 42,302	$ 40,516	$ 41,727	$ 1,134	$ 958	$ 958
2061	$ 43,440	$ 41,477	$ 42,688	$ 1,138	$ 962	$ 962
2062	$ 44,582	$ 42,442	$ 43,653	$ 1,142	$ 965	$ 965
2063	$ 45,728	$ 43,411	$ 44,622	$ 1,146	$ 969	$ 969
2064	$ 46,879	$ 44,383	$ 45,594	$ 1,151	$ 972	$ 972
2065	$ 48,034	$ 46,281	$ 47,492	$ 1,155	$ 1,898	$ 1,898
2066	$ 49,193	$ 47,260	$ 48,471	$ 1,159	$ 979	$ 979
2067	$ 50,356	$ 48,243	$ 49,454	$ 1,163	$ 982	$ 982
2068	$ 51,523	$ 49,229	$ 50,439	$ 1,167	$ 986	$ 986
2069	$ 52,695	$ 50,218	$ 51,429	$ 1,172	$ 989	$ 989
2070	$ 53,820	$ 50,544	$ 51,663	$ 1,125	$ 326	$ 235

LCCA Results

Small Heat Pump Home – Executive Report

Project Information	
Project:	Small Home - HP
Address:	
Company:	
Contact:	
Contact Phone:	
Contact Email:	

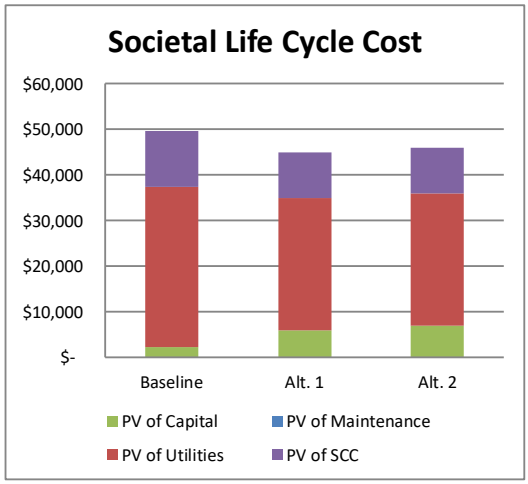
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	1,344
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	1,344
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

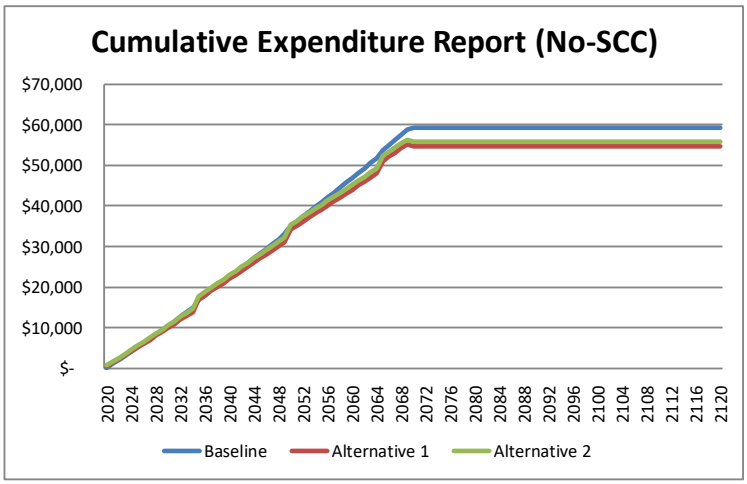
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	23.7	19.6	19.6
1st Construction Costs	$ 874	$ 2,793	$ 3,801
PV of Capital Costs	$ 2,157	$ 5,933	$ 6,893
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 35,172	$ 29,000	$ 29,000
Total Life Cycle Cost (LCC)	**$ 37,330**	**$ 34,934**	**$ 35,894**
Net Present Savings (NPS)	**N/A**	**$ 2,396**	**$ 1,436**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	192	159	159
% CO2e Reduction vs. Baseline	N/A	18%	18%
Present Social Cost of Carbon (SCC)	$ 12,209	$ 10,066	$ 10,066
Total LCC with SCC	**$ 49,538**	**$ 45,000**	**$ 45,960**
NPS with SCC	**N/A**	**$ 4,538**	**$ 3,578**

Warning: OFM Assigned Variables Not Used





LCCA Results

Small Heat Pump Home – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

	Total Building Annual Utility Analysis	$ 902	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
	Annual Utility Bill [$]			$ 902	$ -
	Annual Utility Consumption Not Entered Below			10,577	
	Sum of Annual Utility Consumption Below		-	(1,236)	-
	Total Annual Utility Consumption		-	9,341	-
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)	REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2						$ 874	Entries Below for Component Specific Utility Analy			
	A Substructure										
x	A101098 Small HP										
	B Shell										
	C Interiors										
	D Services										
	E Equipment & Furnishings										
	F Special Construction & Demolition										
	G Building Sitework										
x	G909097 Added Cost			55	$0.75						
x	**X Other Categories**										
x	X90 **Other Categories**										
x	X9010 Building Envelope										
x	X901001 1a - 5% UA reduc	0.5		50	$766.60				-212		
x	X901002 1b - 15% UA reduc	1		50	$2,649.16				-516		
x	X901003 1c - 30% UA reduc	2		50	$4,868.68				-891		
x	X901004 1d - U-.24 Glaze	0.5		50	$907.20				-150		
x	X901005 1e - 40% UA reduc	3		50	$7,641.34				-1193		
x	X901006 1f - U-.20 Glaze	1		50	$1,814.40				-253		
x	X901007 2a - 3ACH , fan eff	0.5		50	$349.44				-177		
x	X901008 2b - 2 ACH, HRV	1		50	$1,680.00				92		
x	X901009 2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-137		
x	X901010 2d - 0.6 ACH, HRV	2		50	$5,376.00				-253		
x	X9020 HVAC										
x	X902001 3a - Furnace	1		18	$230.25						
x	X902002 3b - 9.5 HSPF HP	0.5		15	$1,270.00				-180		
x	X902003 3c - GSHP	1.5		20	$10,900.00				-729		
x	X902004 3d - DHP	1		18	$1,400.00						
x	X902005 3e - 11.0 HSPF HP	1		15	$5,400.00				-407		
x	X902006 3f - DHP (15% elec)	1.5		18	$5,400.00						
x	X902007 4 - HVAC inside	1		50	$300.00				-517		
x	X9030 Hot Water										
x	X903001 5a - DWR	0.5		50	$400.00				-322		
x	X903002 5b - 0.80 gas DHW	0.5		15	$586.00						
x	X903003 5c - 0.91 gas DHW, GSHP	1		15	$923.00						
x	X903004 5d - Tier I HPWH	1.5	1	15	$874.00		$ 874		-1236		
x	X903005 5e - Tier III HPWH	2		15	$874.00				-1623		
x	X903006 5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836		
x	X9040 Other										
x	X904001 6 - Solar pV	0.5		25	$5,040.00						
x	X904002 7 - HP dryers, ES Appl	0.5		15	$462.00						
x	X904003 (legacy) 5a - low flow fixtures	0.5		50	$25.00				-215		
	Z Other Project Costs										
	Z10 **One Time - Upfront Costs**		1	50							
	Z30 **Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Small Heat Pump Home – ALT 1

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 744	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 744	$ -
Annual Utility Consumption Not Entered Below			10,194	
Sum of Annual Utility Consumption Below		-	(2,493)	-
Total Annual Utility Consumption		-	7,701	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	An
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analys			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 2,793				
	A	**Substructure**										
	A101098	Small HP										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Added Cost			55	$0.75						
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc	0.5		50	$766.60				-212		
	X901002	1b - 15% UA reduc	1		50	$2,649.16				-516		
	X901003	1c - 30% UA reduc	2		50	$4,868.68				-891		
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				-150		
	X901005	1e - 40% UA reduc	3		50	$7,641.34				-1193		
	X901006	1f - U-.20 Glaze	1		50	$1,814.40				-253		
	X901007	2a - 3ACH , fan eff	0.5	1	50	$349.44		$ 349		-174		
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				92		
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-137		
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				-253		
	X9020	HVAC										
	X902001	3a - Furnace	1		18	$230.25						
	X902002	3b - 9.5 HSPF HP	0.5	1	15	$1,270.00		$ 1,270		-177		
	X902003	3c - GSHP	1.5		20	$10,900.00				-729		
	X902004	3d - DHP	1		18	$1,400.00						
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00				-407		
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00						
	X902007	4 - HVAC inside	1	1	50	$300.00		$ 300		-517		
	X9030	Hot Water										
	X903001	5a - DWR	0.5		50	$400.00				-322		
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00						
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00						
	X903004	5d - Tier I HPWH	1.5		15	$874.00				-1236		
	X903005	5e - Tier III HPWH	2	1	15	$874.00		$ 874		-1623		
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836		
	X9040	Other										
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262		
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00				-215		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Small Heat Pump Home – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ◉ Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 744	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 744	$ -
Annual Utility Consumption Not Entered Below		-	10,194	
Sum of Annual Utility Consumption Below		-	(2,493)	-
Total Annual Utility Consumption		-	7,701	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analy		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 3,801			
	A	**Substructure**									
	A101098	Small HP									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909097	Added Cost		1344	55	$0.75		$ 1,008			
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5		50	$766.60				-212	
	X901002	1b - 15% UA reduc	1		50	$2,649.16				-516	
	X901003	1c - 30% UA reduc	2		50	$4,868.68				-891	
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				-150	
	X901005	1e - 40% UA reduc	3		50	$7,641.34				-1193	
	X901006	1f - U-.20 Glaze	1		50	$1,814.40				-253	
	X901007	2a - 3ACH , fan eff	0.5	1	50	$349.44		$ 349		-174	
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				92	
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-137	
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				-253	
	X9020	HVAC									
	X902001	3a - Furnace	1		18	$230.25					
	X902002	3b - 9.5 HSPF HP	0.5	1	15	$1,270.00		$ 1,270		-177	
	X902003	3c - GSHP	1.5		20	$10,900.00				-729	
	X902004	3d - DHP	1		18	$1,400.00					
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00				-407	
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00					
	X902007	4 - HVAC inside	1	1	50	$300.00		$ 300		-517	
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400.00				-322	
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00					
	X903004	5d - Tier I HPWH	1.5		15	$874.00				-1236	
	X903005	5e - Tier III HPWH	2	1	15	$874.00		$ 874		-1623	
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836	
	X9040	Other									
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262	
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00				-215	
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1						

LCCA Results

Small Heat Pump Home – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 175	$ 559	$ 760	$ 175	$ 559	$ 760
2021	$ 1,130	$ 1,451	$ 1,703	$ 955	$ 892	$ 942
2022	$ 2,103	$ 2,354	$ 2,655	$ 973	$ 903	$ 952
2023	$ 3,093	$ 3,268	$ 3,617	$ 990	$ 914	$ 962
2024	$ 4,101	$ 4,193	$ 4,589	$ 1,007	$ 926	$ 972
2025	$ 5,125	$ 5,131	$ 5,570	$ 1,025	$ 937	$ 982
2026	$ 6,168	$ 6,079	$ 6,563	$ 1,042	$ 949	$ 992
2027	$ 7,227	$ 7,040	$ 7,565	$ 1,060	$ 960	$ 1,003
2028	$ 8,295	$ 8,004	$ 8,571	$ 1,068	$ 965	$ 1,005
2029	$ 9,372	$ 8,973	$ 9,579	$ 1,076	$ 969	$ 1,008
2030	$ 10,456	$ 9,946	$ 10,591	$ 1,084	$ 973	$ 1,012
2031	$ 11,549	$ 10,924	$ 11,606	$ 1,093	$ 978	$ 1,015
2032	$ 12,650	$ 11,906	$ 12,624	$ 1,101	$ 982	$ 1,018
2033	$ 13,759	$ 12,893	$ 13,646	$ 1,109	$ 987	$ 1,022
2034	$ 14,877	$ 13,885	$ 14,672	$ 1,118	$ 992	$ 1,026
2035	$ 16,877	$ 17,025	$ 17,845	$ 2,000	$ 3,140	$ 3,173
2036	$ 18,003	$ 18,019	$ 18,871	$ 1,125	$ 994	$ 1,026
2037	$ 19,127	$ 19,010	$ 19,893	$ 1,125	$ 991	$ 1,022
2038	$ 20,260	$ 20,006	$ 20,919	$ 1,133	$ 996	$ 1,026
2039	$ 21,402	$ 21,007	$ 21,950	$ 1,142	$ 1,001	$ 1,030
2040	$ 22,543	$ 22,006	$ 22,977	$ 1,141	$ 999	$ 1,027
2041	$ 23,692	$ 23,010	$ 24,008	$ 1,149	$ 1,004	$ 1,032
2042	$ 24,841	$ 24,012	$ 25,037	$ 1,149	$ 1,002	$ 1,028
2043	$ 25,998	$ 25,019	$ 26,070	$ 1,157	$ 1,007	$ 1,033
2044	$ 27,154	$ 26,025	$ 27,100	$ 1,157	$ 1,005	$ 1,030
2045	$ 28,320	$ 27,035	$ 28,135	$ 1,165	$ 1,011	$ 1,035
2046	$ 29,484	$ 28,044	$ 29,167	$ 1,165	$ 1,009	$ 1,032
2047	$ 30,658	$ 29,058	$ 30,205	$ 1,173	$ 1,014	$ 1,037
2048	$ 31,830	$ 30,071	$ 31,239	$ 1,173	$ 1,012	$ 1,035
2049	$ 33,006	$ 31,085	$ 32,275	$ 1,176	$ 1,014	$ 1,035
2050	$ 35,059	$ 34,244	$ 35,454	$ 2,053	$ 3,159	$ 3,180
2051	$ 36,224	$ 35,204	$ 36,415	$ 1,165	$ 960	$ 960
2052	$ 37,392	$ 36,167	$ 37,378	$ 1,168	$ 963	$ 963
2053	$ 38,564	$ 37,134	$ 38,344	$ 1,172	$ 966	$ 966
2054	$ 39,740	$ 38,103	$ 39,314	$ 1,176	$ 969	$ 969
2055	$ 40,919	$ 39,076	$ 40,286	$ 1,179	$ 973	$ 973
2056	$ 42,103	$ 40,051	$ 41,262	$ 1,183	$ 976	$ 976
2057	$ 43,289	$ 41,030	$ 42,241	$ 1,187	$ 979	$ 979
2058	$ 44,480	$ 42,012	$ 43,222	$ 1,191	$ 982	$ 982
2059	$ 45,674	$ 42,996	$ 44,207	$ 1,194	$ 985	$ 985
2060	$ 46,873	$ 43,984	$ 45,195	$ 1,198	$ 988	$ 988
2061	$ 48,074	$ 44,975	$ 46,186	$ 1,202	$ 991	$ 991
2062	$ 49,280	$ 45,969	$ 47,180	$ 1,206	$ 994	$ 994
2063	$ 50,489	$ 46,966	$ 48,177	$ 1,209	$ 997	$ 997
2064	$ 51,702	$ 47,966	$ 49,177	$ 1,213	$ 1,000	$ 1,000
2065	$ 53,793	$ 51,114	$ 52,324	$ 2,091	$ 3,147	$ 3,147
2066	$ 55,013	$ 52,120	$ 53,331	$ 1,220	$ 1,006	$ 1,006
2067	$ 56,237	$ 53,129	$ 54,340	$ 1,224	$ 1,009	$ 1,009
2068	$ 57,465	$ 54,142	$ 55,352	$ 1,228	$ 1,012	$ 1,012
2069	$ 58,697	$ 55,157	$ 56,368	$ 1,232	$ 1,015	$ 1,015
2070	$ 59,350	$ 54,746	$ 55,865	$ 653	$ (411)	$ (502)

LCCA Results

Small Zonal Electric Home – Executive Report

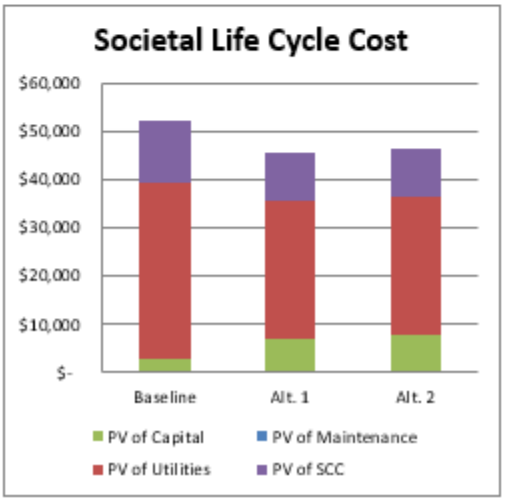
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	1,344
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	1,344
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

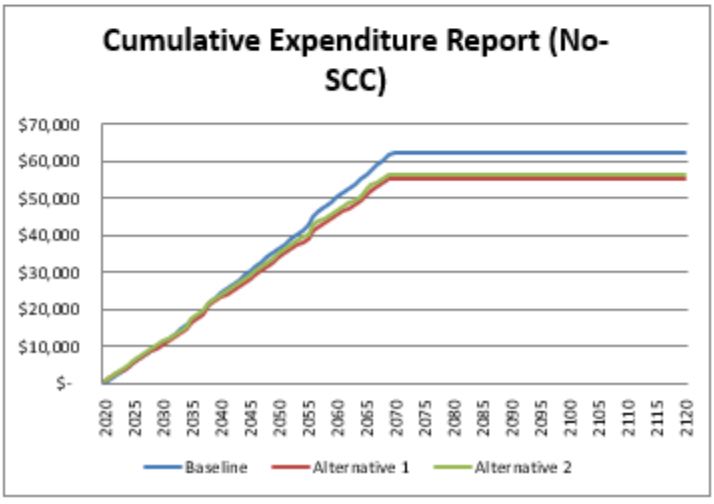
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	24.6	19.4	19.4
1st Construction Costs	$ 1,425	$ 4,088	$ 5,096
PV of Capital Costs	$ 2,983	$ 6,907	$ 7,867
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 36,467	$ 28,709	$ 28,709
Total Life Cycle Cost (LCC)	**$ 39,451**	**$ 35,616**	**$ 36,576**
Net Present Savings (NPS)	**N/A**	**$ 3,834**	**$ 2,874**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	199	157	157
% CO2e Reduction vs. Baseline	N/A	21%	21%
Present Social Cost of Carbon (SCC)	$ 12,658	$ 9,965	$ 9,965
Total LCC with SCC	**$ 52,109**	**$ 45,581**	**$ 46,541**
NPS with SCC	**N/A**	**$ 6,528**	**$ 5,568**

Warning: OFM Assigned Variables Not Used





LCCA Results

Small Zonal Electric Home – Baseline Input

‹- Primary Filter (Requires Level 1)
Office of Financial Management
Olympia, Washington - Version: 2018-Resider
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter
☑ Show All Entered Units (Requires Re-Filter)

					Total Building Annual Utility Analysis		$ 936	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	
					Annual Utility Bill [$]				$ 936	$ -	
					Annual Utility Consumption Not Entered Below				11,734		
					Sum of Annual Utility Consumption Below			-	(2,050)	-	
					Total Annual Utility Consumption			-	9,684	-	
					Annual Utility Bill ÷ Total Utility Consumption			$ -	$ 0.097	$ -	
SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 1,425	Entries Below for Component Specific Utili		
	A	**Substructure**									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
x	G909099	Other Special Construction			55	$0.75					
x	**X**	**Other Categories**									
x	X9	**Other Categories**									
x	X9010	Building Envelope									
x	X901001	1a - 5% UA reduc	0.5		50	$766.60				-477	
x	X901002	1b - 15% UA reduc	1		50	$2,649.16				-1034	
x	X901003	1c - 30% UA reduc	2		50	$4,868.68				-1787	
x	X901004	1d - U-.24 Glaze	0.5		50	$907.20				-315	
x	X901005	1e - 40% UA reduc	3		50	$7,641.34				-2419	
x	X901006	1f - U-.20 Glaze	1		50	$1,814.40				-541	
x	X901007	2a - 3ACH, fan eff	0.5		50	$349.44				-313	
x	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				4	
x	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-331	
x	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				-560	
x	X9020	HVAC									
x	X902001	3a - Furnace	1		18	$230.25					
x	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00					
x	X902003	3c - GSHP	1.5		20	$10,900.00					
x	X902004	3d - DHP	1	1	18	$1,400.00		$ 1,400		-1835	
x	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00					
x	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00				-1928	
x	X902007	4 - HVAC inside	1		50	$300.00					
x	X9030	Hot Water									
x	X903001	5a - DWR	0.5		50	$400.00				-322	
x	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					
x	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00					
x	X903004	5d - Tier I HPWH	1.5		15	$874.00				-1236	
x	X903005	5e - Tier III HPWH	2		15	$874.00				-1623	
x	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836	
x	X9040	Other									
x	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262.00	
x	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840.00	
x	X904003	(legacy) 5a - low flow fixtures	0.5	1	50	$25.00		$ 25		-215	
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track**		1	1						

LCCA Results

Small Zonal Electric Home – ALT 1

<- Primary Filter (Requires Level 1)
Office of Financial Management
Olympia, Washington - Version: 2018-Residen
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ◉ Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refil

Total Building Annual Utility Analysis	$ 736	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 736	$ -
Annual Utility Consumption Not Entered Below			11,360	
Sum of Annual Utility Consumption Below		-	(3,736)	-
Total Annual Utility Consumption		-	7,624	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utilit		
.	**A**	**Substructure**									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909099	Other Special Construction			55	$0.75					
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5		50	$766.60				-477	
	X901002	1b - 15% UA reduc	1		50	$2,649.16				-1034	
	X901003	1c - 30% UA reduc	2		50	$4,868.68				-1787	
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				-315	
	X901005	1e - 40% UA reduc	3		50	$7,641.34				-2419	
	X901006	1f - U-.20 Glaze	1	1	50	$1,814.40		$ 1,814		-454	
	X901007	2a - 3ACH , fan eff	0.5		50	$349.44				-313	
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				4	
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-331	
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				-560	
	X9020	HVAC									
	X902001	3a - Furnace	1		18	$230.25					
	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00					
	X902003	3c - GSHP	1.5		20	$10,900.00					
	X902004	3d - DHP	1	1	18	$1,400.00		$ 1,400		-1659	
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00					
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00				-1928	
	X902007	4 - HVAC inside	1		50	$300.00					
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400.00				-322	
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00					
	X903004	5d - Tier I HPWH	1.5		15	$874.00				-1236	
	X903005	5e - Tier III HPWH	2	1	15	$874.00		$ 874		-1623	
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836	
	X9040	Other									
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262	
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00				-215	
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track**		1	1						

LCCA Results

Small Zonal Electric Home – ALT 2

<- Primary Filter (Requires Level 1)
Office of Financial Management
Olympia, Washington - Version: 2018-Residen
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ◉ Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refil

Total Building Annual Utility Analysis	$ 736	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 736	$ -
Annual Utility Consumption Not Entered Below		-	11,360	
Sum of Annual Utility Consumption Below		-	(3,736)	-
Total Annual Utility Consumption		-	7,624	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 &							$ 5,096			
.	A	**Substructure**									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909099	Other Special Construction		1344	55	$0.75		$ 1,008			
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5		50	$766.60				-477	
	X901002	1b - 15% UA reduc	1		50	$2,649.16				-1034	
	X901003	1c - 30% UA reduc	2		50	$4,868.68				-1787	
	X901004	1d - U-.24 Glaze	0.5		50	$907.20				-315	
	X901005	1e - 40% UA reduc	3		50	$7,641.34				-2419	
	X901006	1f - U-.20 Glaze	1	1	50	$1,814.40		$ 1,814		-454	
	X901007	2a - 3ACH , fan eff	0.5		50	$349.44				-313	
	X901008	2b - 2 ACH, HRV	1		50	$1,680.00				4	
	X901009	2c - 1.5 ACH, HRV	1.5		50	$3,763.20				-331	
	X901010	2d - 0.6 ACH, HRV	2		50	$5,376.00				-560	
	X9020	HVAC									
	X902001	3a - Furnace	1		18	$230.25					
	X902002	3b - 9.5 HSPF HP	0.5		15	$1,270.00					
	X902003	3c - GSHP	1.5		20	$10,900.00					
	X902004	3d - DHP	1	1	18	$1,400.00		$ 1,400		-1659	
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00					
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00				-1928	
	X902007	4 - HVAC inside	1		50	$300.00					
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400.00				-322	
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00					
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00					
	X903004	5d - Tier I HPWH	1.5		15	$874.00				-1236	
	X903005	5e - Tier III HPWH	2	1	15	$874.00		$ 874		-1623	
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-1836	
	X9040	Other									
	X904001	6 - Solar pV	0.5		25	$5,040.00				-1262	
	X904002	7 - HP dryers, ES Appl	0.5		15	$462.00				-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$25.00				-215	
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track**		1	1						

LCCA Results

Small Zonal Electric Home– Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 285	$ 818	$ 1,019	$ 285	$ 818	$ 1,019
2021	$ 1,302	$ 1,767	$ 2,019	$ 1,017	$ 949	$ 1,000
2022	$ 2,336	$ 2,725	$ 3,027	$ 1,034	$ 958	$ 1,007
2023	$ 3,387	$ 3,693	$ 4,042	$ 1,051	$ 968	$ 1,015
2024	$ 4,455	$ 4,670	$ 5,065	$ 1,068	$ 977	$ 1,023
2025	$ 5,541	$ 5,656	$ 6,096	$ 1,086	$ 986	$ 1,031
2026	$ 6,644	$ 6,652	$ 7,136	$ 1,103	$ 996	$ 1,040
2027	$ 7,764	$ 7,659	$ 8,184	$ 1,120	$ 1,006	$ 1,048
2028	$ 8,892	$ 8,667	$ 9,233	$ 1,128	$ 1,009	$ 1,049
2029	$ 10,028	$ 9,678	$ 10,284	$ 1,136	$ 1,011	$ 1,051
2030	$ 11,173	$ 10,692	$ 11,336	$ 1,144	$ 1,014	$ 1,052
2031	$ 12,325	$ 11,709	$ 12,390	$ 1,152	$ 1,017	$ 1,054
2032	$ 13,485	$ 12,729	$ 13,446	$ 1,160	$ 1,020	$ 1,056
2033	$ 14,653	$ 13,752	$ 14,504	$ 1,168	$ 1,023	$ 1,058
2034	$ 15,830	$ 14,778	$ 15,565	$ 1,176	$ 1,026	$ 1,060
2035	$ 17,015	$ 16,682	$ 17,501	$ 1,185	$ 1,904	$ 1,937
2036	$ 18,198	$ 17,707	$ 18,559	$ 1,183	$ 1,026	$ 1,058
2037	$ 19,380	$ 18,729	$ 19,612	$ 1,182	$ 1,022	$ 1,053
2038	$ 21,970	$ 21,155	$ 22,068	$ 2,590	$ 2,426	$ 2,456
2039	$ 23,169	$ 22,184	$ 23,126	$ 1,199	$ 1,030	$ 1,059
2040	$ 24,366	$ 23,210	$ 24,181	$ 1,197	$ 1,026	$ 1,054
2041	$ 25,572	$ 24,240	$ 25,238	$ 1,206	$ 1,030	$ 1,058
2042	$ 26,776	$ 25,267	$ 26,292	$ 1,205	$ 1,027	$ 1,053
2043	$ 27,990	$ 26,298	$ 27,349	$ 1,213	$ 1,031	$ 1,057
2044	$ 29,202	$ 27,326	$ 28,402	$ 1,212	$ 1,028	$ 1,053
2045	$ 30,422	$ 28,358	$ 29,458	$ 1,221	$ 1,032	$ 1,057
2046	$ 31,642	$ 29,388	$ 30,511	$ 1,220	$ 1,029	$ 1,053
2047	$ 32,870	$ 30,422	$ 31,568	$ 1,228	$ 1,034	$ 1,057
2048	$ 34,097	$ 31,454	$ 32,622	$ 1,227	$ 1,031	$ 1,054
2049	$ 35,328	$ 32,485	$ 33,675	$ 1,230	$ 1,032	$ 1,053
2050	$ 36,561	$ 34,391	$ 35,602	$ 1,233	$ 1,906	$ 1,927
2051	$ 37,768	$ 35,342	$ 36,553	$ 1,207	$ 951	$ 951
2052	$ 38,980	$ 36,296	$ 37,507	$ 1,211	$ 954	$ 954
2053	$ 40,195	$ 37,252	$ 38,463	$ 1,215	$ 957	$ 957
2054	$ 41,414	$ 38,212	$ 39,423	$ 1,219	$ 960	$ 960
2055	$ 42,637	$ 39,175	$ 40,386	$ 1,223	$ 963	$ 963
2056	$ 45,263	$ 41,541	$ 42,751	$ 2,627	$ 2,366	$ 2,366
2057	$ 46,494	$ 42,509	$ 43,720	$ 1,231	$ 969	$ 969
2058	$ 47,729	$ 43,481	$ 44,692	$ 1,234	$ 972	$ 972
2059	$ 48,967	$ 44,456	$ 45,667	$ 1,238	$ 975	$ 975
2060	$ 50,209	$ 45,434	$ 46,645	$ 1,242	$ 978	$ 978
2061	$ 51,455	$ 46,415	$ 47,626	$ 1,246	$ 981	$ 981
2062	$ 52,705	$ 47,399	$ 48,610	$ 1,250	$ 984	$ 984
2063	$ 53,959	$ 48,386	$ 49,597	$ 1,254	$ 987	$ 987
2064	$ 55,217	$ 49,376	$ 50,587	$ 1,258	$ 990	$ 990
2065	$ 56,478	$ 51,243	$ 52,454	$ 1,261	$ 1,867	$ 1,867
2066	$ 57,743	$ 52,239	$ 53,450	$ 1,265	$ 996	$ 996
2067	$ 59,013	$ 53,239	$ 54,449	$ 1,269	$ 999	$ 999
2068	$ 60,286	$ 54,241	$ 55,452	$ 1,273	$ 1,002	$ 1,002
2069	$ 61,563	$ 55,246	$ 56,457	$ 1,277	$ 1,005	$ 1,005
2070	$ 62,532	$ 55,361	$ 56,480	$ 970	$ 115	$ 23

LCCA Results

Medium Gas Home – Executive Report

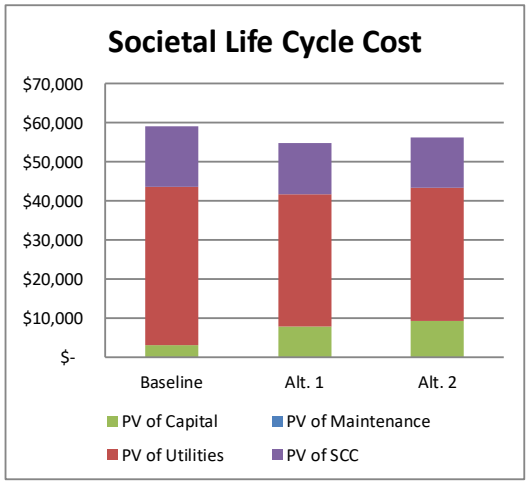
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

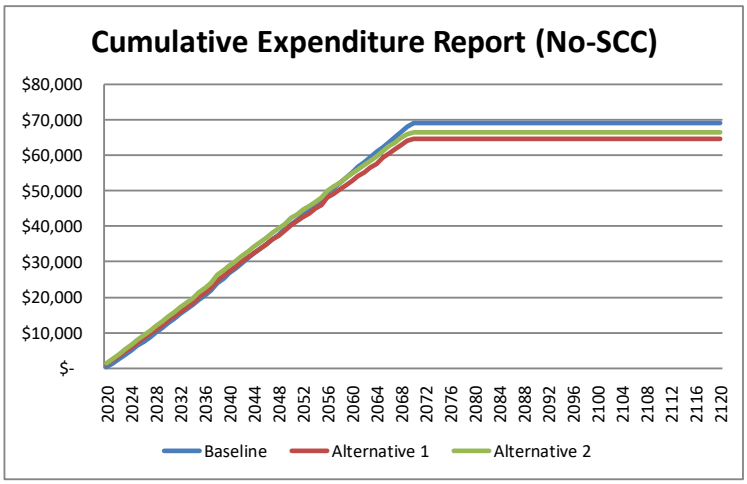
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	31.1	25.8	25.8
1st Construction Costs	$ 1,737	$ 5,916	$ 7,566
PV of Capital Costs	$ 2,974	$ 7,784	$ 9,356
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 40,603	$ 34,019	$ 34,019
Total Life Cycle Cost (LCC)	**$ 43,576**	**$ 41,803**	**$ 43,375**
Net Present Savings (NPS)	**N/A**	**$ 1,773**	**$ 202**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	244	204	204
% CO2e Reduction vs. Baseline	N/A	16%	20%
Present Social Cost of Carbon (SCC)	$ 15,456	$ 12,923	$ 12,923
Total LCC with SCC	**$ 59,033**	**$ 54,726**	**$ 56,298**
NPS with SCC	**N/A**	**$ 4,306**	**$ 2,735**

Warning: OFM Assigned Variables Not Used





LCCA Results

Medium Gas Home – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

	Total Building Annual Utility Analysis	$ 1,050	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
	Annual Utility Bill [$]			$ 516	$ 534
	Annual Utility Consumption Not Entered Below			5,390	670
	Sum of Annual Utility Consumption Below		-	(52)	(167)
	Total Annual Utility Consumption		-	5,338	503
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 1,737	Entries Below for Component Specific Utility Analy			
	A	**Substructure**										
x	A101098	Medium Gas										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
x	G909097	Other			55	$0.75						
x	**X**	**Other Categories**										
x	X90	**Other Categories**										
x	X9010	Building Envelope										
x	X901001	1a - 5% UA reduc	0.5		50	$1,171				5.25	-41.39	
x	X901002	1b - 15% UA reduc	1		50	$4,568				5.15	-99.81	
x	X901003	1c - 30% UA reduc	2		50	$8,417				11.51	-168.78	
x	X901004	1d - U-.24 Glaze	0.5		50	$1,661				1.35	-35.73	
x	X901005	1e - 40% UA reduc	3		50	$12,569				30.42	-228.96	
x	X901006	1f - U-.20 Glaze	1		50	$3,323				6.96	-61.76	
x	X901007	2a - 3ACH , fan eff	0.5	1	50	$533		$ 533		-51.66	-38.63	
x	X901008	2b - 2 ACH, HRV	1		50	$2,829				313.45	-56.09	
x	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				203.87	-75.40	
x	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				204.90	-99.77	
x	X9020	HVAC										
x	X902001	3a - Furnace	1	1	20	$230		$ 230		0.00	-72.77	
x	X902002	3b - 9.5 HSPF HP	0.5		15	$270						
x	X902003	3c - GSHP	1.5		20	$10,900						
x	X902004	3d - DHP	1		18	$1,400						
x	X902005	3e - 11.0 HSPF HP	1		15	$5,400						
x	X902006	3f - DHP (15% elec)	1.5		18	$5,400						
x	X902007	4 - HVAC inside	1		50	$300				-13.26	-60.11	
x	X902008	Other										
x	X902009	Other										
x	X902010	Other										
x	X9030	Hot Water										
x	X903001	5a - DWR	0.5		50	$400				0.00	-19.23	
x	X903002	5b - 0.80 gas DHW	0.5		18	$586				0.00	-24.41	
x	X903003	5c - 0.91 gas DHW, GSHP	1	1	18	$923		$ 923		0.00	-39.62	
x	X903004	5d - Tier I HPWH	1.5		18	$874						
x	X903005	5e - Tier III HPWH	2		18	$874						
x	X903006	5f - Tier III HPWH Split	2.5		18	$3,500						
x	X903007											
x	X903008	Other										
x	X903009	Other										
x	X903010	Other										
x	X9040	Other										
x	X904001	6 - Solar pV	0.5		50	$5,040				-1262.00	0.00	
x	X904002	7 - HP dryers, ES Appl	0.5		15	$462				-840.00	0.00	
x	X904003	(legacy) 5a - low flow fixtures	0.5	1	50	$50		$ 50		0	-16	
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Gas Home – ALT 1

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 879	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 443	$ 437
Annual Utility Consumption Not Entered Below			5,115	654
Sum of Annual Utility Consumption Below		-	(534)	(243)
Total Annual Utility Consumption		-	4,581	411
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analy			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 5,916				
	A	**Substructure**										
	A101098	Medium Gas										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Other			55	$0.75						
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc	0.5	1	50	$1,171		$ 1,171		5	-35	
	X901002	1b - 15% UA reduc	1		50	$4,568				5	-100	
	X901003	1c - 30% UA reduc	2		50	$8,417				12	-169	
	X901004	1d - U-.24 Glaze	0.5		50	$1,661				1	-36	
	X901005	1e - 40% UA reduc	3		50	$12,569				30	-229	
	X901006	1f - U-.20 Glaze	1		50	$3,323				7	-62	
	X901007	2a - 3ACH , fan eff	0.5		50	$533				-52	-43	
	X901008	2b - 2 ACH, HRV	1	1	50	$2,829		$ 2,829		313	-48	
	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				204	-75	
	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				205	-100	
	X9020	HVAC										
	X902001	3a - Furnace	1	1	20	$230		$ 230			-70	
	X902002	3b - 9.5 HSPF HP	0.5		15	$270						
	X902003	3c - GSHP	1.5		20	$10,900						
	X902004	3d - DHP	1		18	$1,400						
	X902005	3e - 11.0 HSPF HP	1		15	$5,400						
	X902006	3f - DHP (15% elec)	1.5		18	$5,400						
	X902007	4 - HVAC inside	1	1	50	$300		$ 300		-12	-54	
	X902008	Other										
	X902009	Other										
	X902010	Other										
	X9030	Hot Water										
	X903001	5a - DWR	0.5		50	$400					-19	
	X903002	5b - 0.80 gas DHW	0.5		18	$586					-24	
	X903003	5c - 0.91 gas DHW, GSHP	1	1	18	$923		$ 923			-36	
	X903004	5d - Tier I HPWH	1.5		18	$874						
	X903005	5e - Tier III HPWH	2		18	$874						
	X903006	5f - Tier III HPWH Split	2.5		18	$3,500						
	X903007											
	X903008	Other										
	X903009	Other										
	X903010	Other										
	X9040	Other										
	X904001	6 - Solar pV	0.5		50	$5,040				-1262		
	X904002	7 - HP dryers, ES Appl	0.5	1	15	$462		$ 462		-840		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$50					-16	
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Gas Home – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 879	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 443	$ 437
Annual Utility Consumption Not Entered Below		-	5,115	654
Sum of Annual Utility Consumption Below		-	(534)	(243)
Total Annual Utility Consumption		-	4,581	411
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 7,566			
	A	**Substructure**									
	A101098	Medium Gas									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909097	Other		2200	55	$0.75		$ 1,650			
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5	1	50	$1,171		$ 1,171		5	-35
	X901002	1b - 15% UA reduc	1		50	$4,568				5	-100
	X901003	1c - 30% UA reduc	2		50	$8,417				12	-169
	X901004	1d - U-.24 Glaze	0.5		50	$1,661				1	-36
	X901005	1e - 40% UA reduc	3		50	$12,569				30	-229
	X901006	1f - U-.20 Glaze	1		50	$3,323				7	-62
	X901007	2a - 3ACH , fan eff	0.5		50	$533				-52	-43
	X901008	2b - 2 ACH, HRV	1	1	50	$2,829		$ 2,829		313	-48
	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				204	-75
	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				205	-100
	X9020	HVAC									
	X902001	3a - Furnace	1	1	20	$230		$ 230			-70
	X902002	3b - 9.5 HSPF HP	0.5		15	$270					
	X902003	3c - GSHP	1.5		20	$10,900					
	X902004	3d - DHP	1		18	$1,400					
	X902005	3e - 11.0 HSPF HP	1		15	$5,400					
	X902006	3f - DHP (15% elec)	1.5		18	$5,400					
	X902007	4 - HVAC inside	1	1	50	$300		$ 300		-12	-54
	X902008	Other									
	X902009	Other									
	X902010	Other									
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400					-19
	X903002	5b - 0.80 gas DHW	0.5		18	$586					-24
	X903003	5c - 0.91 gas DHW, GSHP	1	1	18	$923		$ 923			-36
	X903004	5d - Tier I HPWH	1.5		18	$874					
	X903005	5e - Tier III HPWH	2		18	$874					
	X903006	5f - Tier III HPWH Split	2.5		18	$3,500					
	X903007										
	X903008	Other									
	X903009	Other									
	X903010	Other									
	X9040	Other									
	X904001	6 - Solar pV	0.5		50	$5,040				-1262	
	X904002	7 - HP dryers, ES Appl	0.5	1	15	$462		$ 462		-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$50					-16
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1						

LCCA Results

Medium Gas Home – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 347	$ 1,183	$ 1,513	$ 347	$ 1,183	$ 1,513
2021	$ 1,490	$ 2,364	$ 2,777	$ 1,142	$ 1,181	$ 1,264
2022	$ 2,635	$ 3,541	$ 4,034	$ 1,145	$ 1,177	$ 1,257
2023	$ 3,788	$ 4,718	$ 5,290	$ 1,153	$ 1,177	$ 1,255
2024	$ 4,997	$ 5,935	$ 6,582	$ 1,209	$ 1,217	$ 1,292
2025	$ 6,239	$ 7,174	$ 7,894	$ 1,243	$ 1,239	$ 1,312
2026	$ 7,491	$ 8,414	$ 9,205	$ 1,251	$ 1,240	$ 1,311
2027	$ 8,756	$ 9,660	$ 10,520	$ 1,265	$ 1,246	$ 1,315
2028	$ 10,024	$ 10,903	$ 11,830	$ 1,268	$ 1,243	$ 1,310
2029	$ 11,305	$ 12,152	$ 13,144	$ 1,282	$ 1,249	$ 1,314
2030	$ 12,595	$ 13,403	$ 14,458	$ 1,290	$ 1,251	$ 1,314
2031	$ 13,889	$ 14,652	$ 15,768	$ 1,293	$ 1,249	$ 1,310
2032	$ 15,186	$ 15,899	$ 17,073	$ 1,297	$ 1,247	$ 1,306
2033	$ 16,486	$ 17,143	$ 18,376	$ 1,300	$ 1,245	$ 1,302
2034	$ 17,795	$ 18,391	$ 19,679	$ 1,309	$ 1,247	$ 1,303
2035	$ 19,108	$ 20,099	$ 21,441	$ 1,313	$ 1,708	$ 1,762
2036	$ 20,424	$ 21,343	$ 22,738	$ 1,316	$ 1,244	$ 1,297
2037	$ 21,738	$ 22,582	$ 24,027	$ 1,314	$ 1,239	$ 1,290
2038	$ 23,985	$ 24,747	$ 26,242	$ 2,246	$ 2,165	$ 2,214
2039	$ 25,312	$ 25,988	$ 27,531	$ 1,327	$ 1,241	$ 1,289
2040	$ 26,873	$ 27,459	$ 29,048	$ 1,561	$ 1,471	$ 1,517
2041	$ 28,208	$ 28,699	$ 30,333	$ 1,335	$ 1,240	$ 1,285
2042	$ 29,546	$ 29,939	$ 31,616	$ 1,339	$ 1,240	$ 1,283
2043	$ 30,889	$ 31,178	$ 32,898	$ 1,342	$ 1,239	$ 1,282
2044	$ 32,235	$ 32,417	$ 34,178	$ 1,346	$ 1,239	$ 1,280
2045	$ 33,585	$ 33,657	$ 35,457	$ 1,350	$ 1,239	$ 1,279
2046	$ 34,940	$ 34,896	$ 36,735	$ 1,354	$ 1,239	$ 1,278
2047	$ 36,304	$ 36,140	$ 38,016	$ 1,364	$ 1,244	$ 1,281
2048	$ 37,666	$ 37,380	$ 39,292	$ 1,363	$ 1,240	$ 1,276
2049	$ 39,033	$ 38,620	$ 40,568	$ 1,367	$ 1,240	$ 1,276
2050	$ 40,404	$ 40,323	$ 42,305	$ 1,371	$ 1,703	$ 1,737
2051	$ 41,744	$ 41,446	$ 43,428	$ 1,340	$ 1,123	$ 1,123
2052	$ 43,089	$ 42,573	$ 44,555	$ 1,345	$ 1,127	$ 1,127
2053	$ 44,440	$ 43,705	$ 45,687	$ 1,351	$ 1,132	$ 1,132
2054	$ 45,796	$ 44,841	$ 46,823	$ 1,356	$ 1,136	$ 1,136
2055	$ 47,157	$ 45,981	$ 47,963	$ 1,361	$ 1,140	$ 1,140
2056	$ 49,446	$ 48,049	$ 50,031	$ 2,289	$ 2,068	$ 2,068
2057	$ 50,818	$ 49,198	$ 51,180	$ 1,372	$ 1,149	$ 1,149
2058	$ 52,195	$ 50,352	$ 52,334	$ 1,377	$ 1,154	$ 1,154
2059	$ 53,577	$ 51,510	$ 53,492	$ 1,382	$ 1,158	$ 1,158
2060	$ 55,195	$ 52,903	$ 54,885	$ 1,618	$ 1,393	$ 1,393
2061	$ 56,588	$ 54,070	$ 56,052	$ 1,393	$ 1,167	$ 1,167
2062	$ 57,986	$ 55,241	$ 57,223	$ 1,398	$ 1,171	$ 1,171
2063	$ 59,389	$ 56,417	$ 58,399	$ 1,403	$ 1,176	$ 1,176
2064	$ 60,798	$ 57,597	$ 59,579	$ 1,409	$ 1,180	$ 1,180
2065	$ 62,212	$ 59,243	$ 61,225	$ 1,414	$ 1,646	$ 1,646
2066	$ 63,631	$ 60,432	$ 62,414	$ 1,419	$ 1,189	$ 1,189
2067	$ 65,055	$ 61,625	$ 63,607	$ 1,424	$ 1,193	$ 1,193
2068	$ 66,485	$ 62,823	$ 64,805	$ 1,430	$ 1,198	$ 1,198
2069	$ 67,920	$ 64,025	$ 66,007	$ 1,435	$ 1,202	$ 1,202
2070	$ 69,040	$ 64,603	$ 66,435	$ 1,120	$ 578	$ 428

LCCA Results

Medium Heat Pump Home – Executive Report

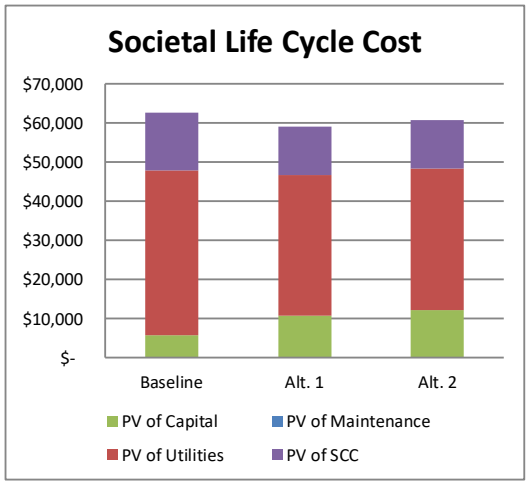
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

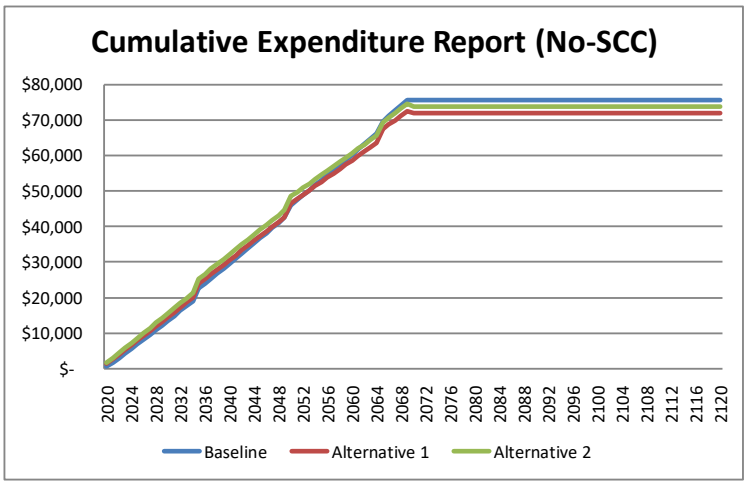
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	17.4	14.8	14.8
1st Construction Costs	$ 2,494	$ 6,906	$ 8,556
PV of Capital Costs	$ 5,638	$ 10,679	$ 12,250
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 42,270	$ 36,024	$ 36,024
Total Life Cycle Cost (LCC)	**$ 47,908**	**$ 46,703**	**$ 48,274**
Net Present Savings (NPS)	**N/A**	**$ 1,206**	**$ (366)**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	231	197	197
% CO2e Reduction vs. Baseline	N/A	15%	15%
Present Social Cost of Carbon (SCC)	$ 14,673	$ 12,504	$ 12,504
Total LCC with SCC	**$ 62,581**	**$ 59,207**	**$ 60,778**
NPS with SCC	**N/A**	**$ 3,374**	**$ 1,802**

Warning: OFM Assigned Variables Not Used





LCCA Results

Medium Heat Pump Home – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

		Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Total Building Annual Utility Analysis	$ 1,084			
Annual Utility Bill [$]			$ 1,084	
Annual Utility Consumption Not Entered Below			13,873	
Sum of Annual Utility Consumption Below		-	(2,647)	-
Total Annual Utility Consumption		-	11,226	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)	REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Ar
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2						$ 2,494	Entries Below for Component Specific Utility Analys			
	A Substructure										
x	A101098 Medium HP										
	B Shell										
	C Interiors										
	D Services										
	E Equipment & Furnishings										
	F Special Construction & Demolition										
	G Building Sitework										
x	G909097 Added Cost			55	$0.75						
x	X Other Categories										
x	X90 Other Categories										
x	X9010 Building Envelope										
x	X901001 1a - 5% UA reduc	0.5		50	$1,171				-355		
x	X901002 1b - 15% UA reduc	1		50	$4,568				-908		
x	X901003 1c - 30% UA reduc	2		50	$8,417				-1519		
x	X901004 1d - U-.24 Glaze	0.5		50	$1,661				-325		
x	X901005 1e - 40% UA reduc	3		50	$12,569				-2024		
x	X901006 1f - U-.20 Glaze	1		50	$3,323				-546		
x	X901007 2a - 3ACH , fan eff	0.5		50	$533				-440		
x	X901008 2b - 2 ACH, HRV	1		50	$2,829				-231		
x	X901009 2c - 1.5 ACH, HRV	1.5		50	$6,338				-520		
x	X901010 2d - 0.6 ACH, HRV	2		50	$9,054				-737		
x	X9020 HVAC										
x	X902001 3a - Furnace	1		20	$230						
x	X902002 3b - 9.5 HSPF HP	0.5	1	15	$1,270		$ 1,270		-327		
x	X902003 3c - GSHP	1.5		20	$10,900				-1301		
x	X902004 3d - DHP	1		18	$1,400						
x	X902005 3e - 11.0 HSPF HP	1		15	$5,400				-784		
x	X902006 3f - DHP (15% elec)	1.5		18	$5,400						
x	X902007 4 - HVAC inside	1	1	50	$300		$ 300		-621		
x	X902008 Other										
x	X902009 Other										
x	X902010 Other										
x	X9030 Hot Water										
x	X903001 5a - DWR	0.5		50	$400				-368		
x	X903002 5b - 0.80 gas DHW	0.5		15	$586						
x	X903003 5c - 0.91 gas DHW, GSHP	1		15	$923						
x	X903004 5d - Tier I HPWH	1.5	1	15	$874		$ 874		-1393		
x	X903005 5e - Tier III HPWH	2		15	$874				-1823		
x	X903006 5f - Tier III HPWH Split	2.5		15	$3,500				-2064		
x	X903007										
x	X903008 Other										
x	X903009 Other										
x	X903010 Other										
x	X9040 Other										
x	X904001 6 - Solar pV	0.5		50	$5,040				-1262		
x	X904002 7 - HP dryers, ES Appl	0.5		15	$462				-840		
x	X904003 (legacy) 5a - low flow fixtures	0.5	1	50	$50		$ 50		-307		
	Z Other Project Costs										
	Z10 One Time - Upfront Costs		1	50							
	Z30 Re-Occurring Annual Cost (Track Inflation)		1	1							

LCCA Results

Medium Heat Pump Home – ALT 1

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 924	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 924	
Annual Utility Consumption Not Entered Below			13,291	
Sum of Annual Utility Consumption Below		-	(3,724)	-
Total Annual Utility Consumption		-	9,567	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Anal		
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 6,906			
	A	**Substructure**									
	A101098	Medium HP									
	B	**Shell**									
	C	**Interiors**									
	D	**Services**									
	E	**Equipment & Furnishings**									
	F	**Special Construction & Demolition**									
	G	**Building Sitework**									
	G909097	Added Cost			55	$0.75					
	X	**Other Categories**									
	X90	**Other Categories**									
	X9010	Building Envelope									
	X901001	1a - 5% UA reduc	0.5		50	$1,171		$ 1,171		-329	
	X901002	1b - 15% UA reduc	1		50	$4,568				-908	
	X901003	1c - 30% UA reduc	2		50	$8,417				-1519	
	X901004	1d - U-.24 Glaze	0.5		50	$1,661				-325	
	X901005	1e - 40% UA reduc	3		50	$12,569				-2024	
	X901006	1f - U-.20 Glaze	1		50	$3,323				-546	
	X901007	2a - 3ACH , fan eff	0.5		50	$533				-440	
	X901008	2b - 2 ACH, HRV	1	1	50	$2,829		$ 2,829		-214	
	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				-520	
	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				-737	
	X9020	HVAC									
	X902001	3a - Furnace	1		20	$230					
	X902002	3b - 9.5 HSPF HP	0.5	1	15	$1,270		$ 1,270		-328	
	X902003	3c - GSHP	1.5		20	$10,900				-1301	
	X902004	3d - DHP	1		18	$1,400					
	X902005	3e - 11.0 HSPF HP	1		15	$5,400				-784	
	X902006	3f - DHP (15% elec)	1.5		18	$5,400					
	X902007	4 - HVAC inside	1	1	50	$300		$ 300		-621	
	X902008	Other									
	X902009	Other									
	X902010	Other									
	X9030	Hot Water									
	X903001	5a - DWR	0.5		50	$400				-368	
	X903002	5b - 0.80 gas DHW	0.5		15	$586					
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923					
	X903004	5d - Tier I HPWH	1.5	1	15	$874		$ 874		-1393	
	X903005	5e - Tier III HPWH	2		15	$874				-1823	
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500				-2064	
	X903007										
	X903008	Other									
	X903009	Other									
	X903010	Other									
	X9040	Other									
	X904001	6 - Solar pV	0.5		50	$5,040				-1262	
	X904002	7 - HP dryers, ES Appl	0.5	1	15	$462		$ 462		-840	
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$50				-307	
	Z	**Other Project Costs**									
	Z10	**One Time - Upfront Costs**		1	50						
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1						

LCCA Results

Medium Heat Pump Home – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 924	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 924	
Annual Utility Consumption Not Entered Below		-	13,291	
Sum of Annual Utility Consumption Below		-	(3,724)	-
Total Annual Utility Consumption		-	9,567	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analy			
	Match Baseline: Filter to Select All & Drag Copy O14:514 & U14:AG14							$ 8,556				
	A	**Substructure**										
	A101098	Medium HP										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Added Cost		2200	55	$0.75		$ 1,650				
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc	0.5	1	50	$1,170.98		$ 1,171		-329		
	X901002	1b - 15% UA reduc	1		50	$4,567.51				-908		
	X901003	1c - 30% UA reduc	2		50	$8,416.67				-1519		
	X901004	1d - U-.24 Glaze	0.5		50	$1,661.40				-325		
	X901005	1e - 40% UA reduc	3		50	$12,569.16				-2024		
	X901006	1f - U-.20 Glaze	1		50	$3,322.80				-546		
	X901007	2a - 3ACH , fan eff	0.5		50	$533.33				-440		
	X901008	2b - 2 ACH, HRV	1	1	50	$2,829.30		$ 2,829		-214		
	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,337.63				-520		
	X901010	2d - 0.6 ACH, HRV	2		50	$9,053.76				-737		
	X9020	HVAC										
	X902001	3a - Furnace	1		20	$230.25						
	X902002	3b - 9.5 HSPF HP	0.5	1	15	$1,270.00		$ 1,270		-328		
	X902003	3c - GSHP	1.5		20	$10,900.00				-1301		
	X902004	3d - DHP	1		18	$1,400.00						
	X902005	3e - 11.0 HSPF HP	1		15	$5,400.00				-784		
	X902006	3f - DHP (15% elec)	1.5		18	$5,400.00						
	X902007	4 - HVAC inside	1	1	50	$300.00		$ 300		-621		
	X902008	Other										
	X902009	Other										
	X902010	Other										
	X9030	Hot Water										
	X903001	5a - DWR	0.5		50	$400.00				-368		
	X903002	5b - 0.80 gas DHW	0.5		15	$586.00						
	X903003	5c - 0.91 gas DHW, GSHP	1		15	$923.00						
	X903004	5d - Tier I HPWH	1.5	1	15	$874.00		$ 874		-1393		
	X903005	5e - Tier III HPWH	2		15	$874.00				-1823		
	X903006	5f - Tier III HPWH Split	2.5		15	$3,500.00				-2064		
	X903007											
	X903008	Other										
	X903009	Other										
	X903010	Other										
	X9040	Other										
	X904001	6 - Solar pV	0.5		50	$5,040.00				-1262		
	X904002	7 - HP dryers, ES Appl	0.5	1	15	$462.00		$ 462		-840		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$50.00				-307		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Heat Pump Home – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 499	$ 1,381	$ 1,711	$ 499	$ 1,381	$ 1,711
2021	$ 1,720	$ 2,662	$ 3,075	$ 1,221	$ 1,280	$ 1,363
2022	$ 2,959	$ 3,951	$ 4,444	$ 1,239	$ 1,289	$ 1,369
2023	$ 4,217	$ 5,249	$ 5,820	$ 1,258	$ 1,298	$ 1,376
2024	$ 5,494	$ 6,556	$ 7,203	$ 1,277	$ 1,307	$ 1,383
2025	$ 6,790	$ 7,873	$ 8,593	$ 1,296	$ 1,317	$ 1,390
2026	$ 8,105	$ 9,199	$ 9,990	$ 1,315	$ 1,327	$ 1,398
2027	$ 9,439	$ 10,536	$ 11,396	$ 1,334	$ 1,337	$ 1,406
2028	$ 10,781	$ 11,873	$ 12,800	$ 1,342	$ 1,337	$ 1,404
2029	$ 12,131	$ 13,212	$ 14,204	$ 1,350	$ 1,339	$ 1,403
2030	$ 13,489	$ 14,552	$ 15,607	$ 1,358	$ 1,340	$ 1,403
2031	$ 14,856	$ 15,893	$ 17,009	$ 1,367	$ 1,342	$ 1,403
2032	$ 16,231	$ 17,237	$ 18,412	$ 1,375	$ 1,343	$ 1,403
2033	$ 17,614	$ 18,582	$ 19,815	$ 1,384	$ 1,345	$ 1,403
2034	$ 19,006	$ 19,930	$ 21,218	$ 1,392	$ 1,348	$ 1,403
2035	$ 22,551	$ 23,886	$ 25,228	$ 3,545	$ 3,956	$ 4,010
2036	$ 23,950	$ 25,230	$ 26,624	$ 1,398	$ 1,343	$ 1,396
2037	$ 25,346	$ 26,566	$ 28,012	$ 1,396	$ 1,337	$ 1,388
2038	$ 26,750	$ 27,906	$ 29,401	$ 1,405	$ 1,340	$ 1,389
2039	$ 28,164	$ 29,250	$ 30,792	$ 1,414	$ 1,343	$ 1,391
2040	$ 29,576	$ 30,587	$ 32,176	$ 1,412	$ 1,337	$ 1,384
2041	$ 30,996	$ 31,928	$ 33,562	$ 1,421	$ 1,341	$ 1,386
2042	$ 32,415	$ 33,263	$ 34,941	$ 1,419	$ 1,335	$ 1,379
2043	$ 33,843	$ 34,603	$ 36,322	$ 1,428	$ 1,339	$ 1,382
2044	$ 35,269	$ 35,937	$ 37,697	$ 1,426	$ 1,334	$ 1,375
2045	$ 36,704	$ 37,275	$ 39,075	$ 1,435	$ 1,338	$ 1,378
2046	$ 38,137	$ 38,608	$ 40,447	$ 1,433	$ 1,333	$ 1,372
2047	$ 39,580	$ 39,946	$ 41,823	$ 1,443	$ 1,338	$ 1,375
2048	$ 41,021	$ 41,280	$ 43,192	$ 1,441	$ 1,333	$ 1,370
2049	$ 42,465	$ 42,612	$ 44,560	$ 1,444	$ 1,333	$ 1,368
2050	$ 46,056	$ 46,550	$ 48,532	$ 3,591	$ 3,938	$ 3,972
2051	$ 47,455	$ 47,743	$ 49,725	$ 1,400	$ 1,193	$ 1,193
2052	$ 48,859	$ 48,940	$ 50,922	$ 1,404	$ 1,197	$ 1,197
2053	$ 50,268	$ 50,140	$ 52,122	$ 1,409	$ 1,200	$ 1,200
2054	$ 51,681	$ 51,344	$ 53,326	$ 1,413	$ 1,204	$ 1,204
2055	$ 53,099	$ 52,552	$ 54,534	$ 1,418	$ 1,208	$ 1,208
2056	$ 54,521	$ 53,764	$ 55,746	$ 1,422	$ 1,212	$ 1,212
2057	$ 55,947	$ 54,980	$ 56,962	$ 1,426	$ 1,216	$ 1,216
2058	$ 57,378	$ 56,199	$ 58,181	$ 1,431	$ 1,219	$ 1,219
2059	$ 58,813	$ 57,423	$ 59,405	$ 1,435	$ 1,223	$ 1,223
2060	$ 60,253	$ 58,650	$ 60,632	$ 1,440	$ 1,227	$ 1,227
2061	$ 61,698	$ 59,881	$ 61,863	$ 1,444	$ 1,231	$ 1,231
2062	$ 63,147	$ 61,115	$ 63,097	$ 1,449	$ 1,235	$ 1,235
2063	$ 64,600	$ 62,354	$ 64,336	$ 1,453	$ 1,239	$ 1,239
2064	$ 66,058	$ 63,596	$ 65,578	$ 1,458	$ 1,242	$ 1,242
2065	$ 69,664	$ 67,449	$ 69,430	$ 3,606	$ 3,852	$ 3,852
2066	$ 71,131	$ 68,698	$ 70,680	$ 1,467	$ 1,250	$ 1,250
2067	$ 72,602	$ 69,952	$ 71,934	$ 1,471	$ 1,254	$ 1,254
2068	$ 74,077	$ 71,210	$ 73,192	$ 1,476	$ 1,258	$ 1,258
2069	$ 75,558	$ 72,471	$ 74,453	$ 1,480	$ 1,261	$ 1,261
2070	$ 75,613	$ 71,999	$ 73,831	$ 55	$ (472)	$ (622)

LCCA Results

Medium Zonal Electric Home – Executive Report

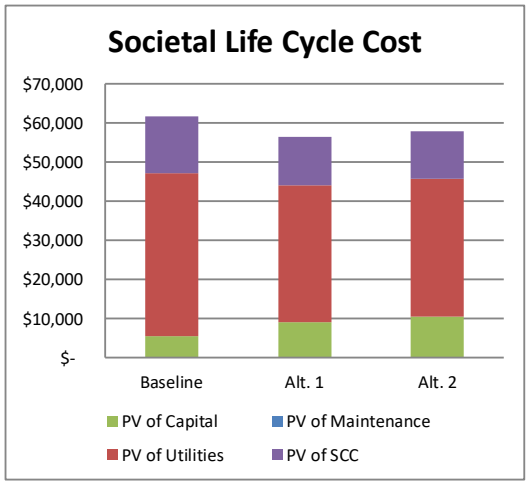
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

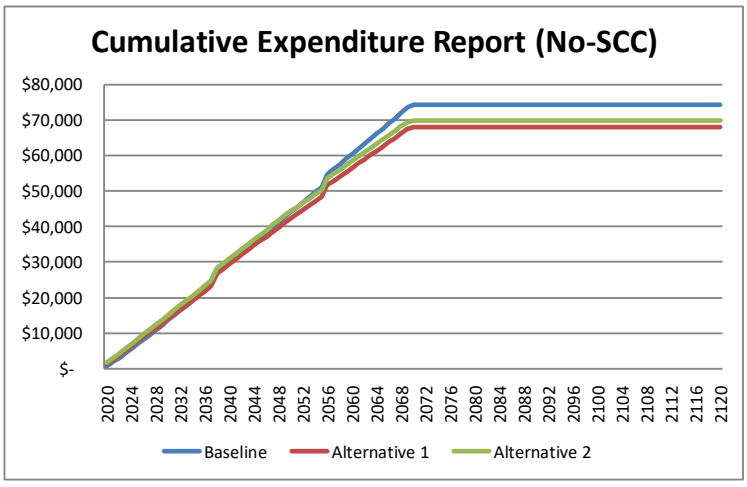
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	17.2	14.5	14.5
1st Construction Costs	$ 2,857	$ 6,530	$ 8,180
PV of Capital Costs	$ 5,382	$ 9,008	$ 10,579
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 41,810	$ 35,153	$ 35,153
Total Life Cycle Cost (LCC)	**$ 47,192**	**$ 44,161**	**$ 45,732**
Net Present Savings (NPS)	**N/A**	**$ 3,031**	**$ 1,460**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	229	192	192
% CO2e Reduction vs. Baseline	N/A	16%	16%
Present Social Cost of Carbon (SCC)	$ 14,513	$ 12,202	$ 12,202
Total LCC with SCC	**$ 61,705**	**$ 56,362**	**$ 57,934**
NPS with SCC	**N/A**	**$ 5,342**	**$ 3,771**

Warning: OFM Assigned Variables Not Used





LCCA Results

Medium Zonal Electric Home – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

	Total Building Annual Utility Analysis	$ 1,073	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
	Annual Utility Bill [$]			$ 1,073	
	Annual Utility Consumption Not Entered Below			16,864	
	Sum of Annual Utility Consumption Below		-	(5,760)	-
	Total Annual Utility Consumption		-	11,103	-
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	An
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 2,857	Entries Below for Component Specific Utility Analys			
	A	**Substructure**										
x	A101098	Medium Zone Electric										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
x	G909097	Added Cost			55	$0.75						
x	X	**Other Categories**										
x	X90	**Other Categories**										
x	X9010	Building Envelope										
x	X901001	1a - 5% UA reduc	0.5		50	$1,171				-810		
x	X901002	1b - 15% UA reduc	1		50	$4,568				-1884		
x	X901003	1c - 30% UA reduc	2		50	$8,417				-3194		
x	X901004	1d - U-.24 Glaze	0.5		50	$1,661				-689		
x	X901005	1e - 40% UA reduc	3		50	$12,569				-4316		
x	X901006	1f - U-.20 Glaze	1		50	$3,323				-1185		
x	X901007	2a - 3ACH , fan eff	0.5	1	50	$533		$ 533		-718		
x	X901008	2b - 2 ACH, HRV	1		50	$2,829				-767		
x	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				-1239		
x	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				-1708		
x	X9020	HVAC										
x	X902001	3a - Furnace	1		20	$230						
x	X902002	3b - 9.5 HSPF HP	0.5		15	$270						
x	X902003	3c - GSHP	1.5		20	$10,900						
x	X902004	3d - DHP	1	1	18	$1,400		$ 1,400		-3342		
x	X902005	3e - 11.0 HSPF HP	1		15	$5,400						
x	X902006	3f - DHP (15% elec)	1.5		18	$5,400				-3700		
x	X902007	4 - HVAC inside	1		50	$300						
x	X902008	Other										
x	X902009	Other										
x	X902010	Other										
x	X9030	Hot Water										
x	X903001	5a - DWR	0.5		50	$400				-368		
x	X903002	5b - 0.80 gas DHW	0.5		18	$586						
x	X903003	5c - 0.91 gas DHW, GSHP	1		18	$923						
x	X903004	5d - Tier I HPWH	1.5	1	18	$874		$ 874		-1393		
x	X903005	5e - Tier III HPWH	2		18	$874				-1823		
x	X903006	5f - Tier III HPWH Split	2.5		18	$3,500				-2064		
x	X903007											
x	X903008	Other										
x	X903009	Other										
x	X903010	Other										
x	X9040	Other										
x	X904001	6 - Solar pV	0.5		50	$5,040				-1262		
x	X904002	7 - HP dryers, ES Appl	0.5		15	$462				-840		
x	X904003	(legacy) 5a - low flow fixtures	0.5	1	50	$50		$ 50		-307		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Zonal Electric Home – ALT 1

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 902	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 902	
Annual Utility Consumption Not Entered Below			16,282	
Sum of Annual Utility Consumption Below		-	(6,947)	-
Total Annual Utility Consumption		-	9,335	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)	REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	An
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							Entries Below for Component Specific Utility Analys			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14						$ 6,530				
	A Substructure										
	A101098 Medium Zone Electric										
	B Shell										
	C Interiors										
	D Services										
	E Equipment & Furnishings										
	F Special Construction & Demolition										
	G Building Sitework										
	G909097 Added Cost			55	$0.75						
	X Other Categories										
	X90 **Other Categories**										
	X9010 Building Envelope										
	X901001 1a - 5% UA reduc	0.5		50	$1,171				-810		
	X901002 1b - 15% UA reduc	1		50	$4,568				-1884		
	X901003 1c - 30% UA reduc	2		50	$8,417				-3194		
	X901004 1d - U-.24 Glaze	0.5		50	$1,661				-689		
	X901005 1e - 40% UA reduc	3		50	$12,569				-4316		
	X901006 1f - U-.20 Glaze	1	1	50	$3,323		$ 3,323		-940		
	X901007 2a - 3ACH , fan eff	0.5	1	50	$533		$ 533		-729		
	X901008 2b - 2 ACH, HRV	1		50	$2,829				-767		
	X901009 2c - 1.5 ACH, HRV	1.5		50	$6,338				-1239		
	X901010 2d - 0.6 ACH, HRV	2		50	$9,054				-1708		
	X9020 HVAC										
	X902001 3a - Furnace	1		20	$230						
	X902002 3b - 9.5 HSPF HP	0.5		15	$270						
	X902003 3c - GSHP	1.5		20	$10,900						
	X902004 3d - DHP	1	1	18	$1,400		$ 1,400		-3086		
	X902005 3e - 11.0 HSPF HP	1		15	$5,400						
	X902006 3f - DHP (15% elec)	1.5		18	$5,400				-3700		
	X902007 4 - HVAC inside	1		50	$300						
	X902008 Other										
	X902009 Other										
	X902010 Other										
	X9030 Hot Water										
	X903001 5a - DWR	0.5	1	50	$400		$ 400		-368		
	X903002 5b - 0.80 gas DHW	0.5		18	$586						
	X903003 5c - 0.91 gas DHW, GSHP	1		18	$923						
	X903004 5d - Tier I HPWH	1.5		18	$874				-1393		
	X903005 5e - Tier III HPWH	2	1	18	$874		$ 874		-1823		
	X903006 5f - Tier III HPWH Split	2.5		18	$3,500				-2064		
	X903007										
	X903008 Other										
	X903009 Other										
	X903010 Other										
	X9040 Other										
	X904001 6 - Solar pV	0.5		50	$5,040				-1262		
	X904002 7 - HP dryers, ES Appl	0.5		15	$462				-840		
	X904003 (legacy) 5a - low flow fixtures	0.5		50	$50				-307		
	Z Other Project Costs										
	Z10 **One Time - Upfront Costs**		1	50							
	Z30 **Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Zonal Electric Home – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 902	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
Annual Utility Bill [$]			$ 902	
Annual Utility Consumption Not Entered Below		-	16,282	
Sum of Annual Utility Consumption Below		-	(6,947)	-
Total Annual Utility Consumption		-	9,335	-
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	An
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysi			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 8,180				
	A	**Substructure**										
	A101098	Medium Zone Electric										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Added Cost		2200	55	$0.75		$ 1,650				
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc	0.5		50	$1,171				-810		
	X901002	1b - 15% UA reduc	1		50	$4,568				-1884		
	X901003	1c - 30% UA reduc	2		50	$8,417				-3194		
	X901004	1d - U-.24 Glaze	0.5		50	$1,661				-689		
	X901005	1e - 40% UA reduc	3		50	$12,569				-4316		
	X901006	1f - U-.20 Glaze	1	1	50	$3,323		$ 3,323		-940		
	X901007	2a - 3ACH , fan eff	0.5	1	50	$533		$ 533		-729		
	X901008	2b - 2 ACH, HRV	1		50	$2,829				-767		
	X901009	2c - 1.5 ACH, HRV	1.5		50	$6,338				-1239		
	X901010	2d - 0.6 ACH, HRV	2		50	$9,054				-1708		
	X9020	HVAC										
	X902001	3a - Furnace	1		20	$230						
	X902002	3b - 9.5 HSPF HP	0.5		15	$270						
	X902003	3c - GSHP	1.5		20	$10,900						
	X902004	3d - DHP	1	1	18	$1,400		$ 1,400		-3086		
	X902005	3e - 11.0 HSPF HP	1		15	$5,400						
	X902006	3f - DHP (15% elec)	1.5		18	$5,400				-3700		
	X902007	4 - HVAC inside	1		50	$300						
	X902008	Other										
	X902009	Other										
	X902010	Other										
	X9030	Hot Water										
	X903001	5a - DWR	0.5	1	50	$400		$ 400		-368		
	X903002	5b - 0.80 gas DHW	0.5		18	$586						
	X903003	5c - 0.91 gas DHW, GSHP	1		18	$923						
	X903004	5d - Tier I HPWH	1.5		18	$874				-1393		
	X903005	5e - Tier III HPWH	2	1	18	$874		$ 874		-1823		
	X903006	5f - Tier III HPWH Split	2.5		18	$3,500				-2064		
	X903007											
	X903008	Other										
	X903009	Other										
	X903010	Other										
	X9040	Other										
	X904001	6 - Solar pV	0.5		50	$5,040				-1262		
	X904002	7 - HP dryers, ES Appl	0.5		15	$462				-840		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$50				-307		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Medium Zonal Electric Home – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 571	$ 1,306	$ 1,636	$ 571	$ 1,306	$ 1,636
2021	$ 1,799	$ 2,545	$ 2,958	$ 1,227	$ 1,239	$ 1,322
2022	$ 3,043	$ 3,793	$ 4,286	$ 1,245	$ 1,248	$ 1,328
2023	$ 4,306	$ 5,049	$ 5,620	$ 1,263	$ 1,257	$ 1,335
2024	$ 5,587	$ 6,315	$ 6,962	$ 1,281	$ 1,266	$ 1,342
2025	$ 6,886	$ 7,591	$ 8,311	$ 1,299	$ 1,276	$ 1,349
2026	$ 8,204	$ 8,876	$ 9,668	$ 1,317	$ 1,285	$ 1,357
2027	$ 9,539	$ 10,172	$ 11,032	$ 1,336	$ 1,296	$ 1,365
2028	$ 10,883	$ 11,469	$ 12,396	$ 1,343	$ 1,297	$ 1,364
2029	$ 12,233	$ 12,767	$ 13,758	$ 1,351	$ 1,298	$ 1,363
2030	$ 13,592	$ 14,066	$ 15,121	$ 1,358	$ 1,300	$ 1,362
2031	$ 14,958	$ 15,368	$ 16,483	$ 1,366	$ 1,301	$ 1,362
2032	$ 16,332	$ 16,671	$ 17,846	$ 1,374	$ 1,303	$ 1,363
2033	$ 17,714	$ 17,977	$ 19,209	$ 1,382	$ 1,306	$ 1,363
2034	$ 19,104	$ 19,285	$ 20,573	$ 1,390	$ 1,308	$ 1,364
2035	$ 20,503	$ 20,595	$ 21,937	$ 1,398	$ 1,311	$ 1,365
2036	$ 21,898	$ 21,900	$ 23,294	$ 1,395	$ 1,304	$ 1,357
2037	$ 23,291	$ 23,198	$ 24,643	$ 1,393	$ 1,298	$ 1,349
2038	$ 26,966	$ 26,773	$ 28,268	$ 3,675	$ 3,575	$ 3,625
2039	$ 28,376	$ 28,078	$ 29,620	$ 1,410	$ 1,305	$ 1,353
2040	$ 29,783	$ 29,377	$ 30,966	$ 1,407	$ 1,299	$ 1,345
2041	$ 31,199	$ 30,680	$ 32,313	$ 1,416	$ 1,303	$ 1,348
2042	$ 32,612	$ 31,977	$ 33,654	$ 1,413	$ 1,297	$ 1,341
2043	$ 34,034	$ 33,279	$ 34,998	$ 1,422	$ 1,302	$ 1,344
2044	$ 35,455	$ 34,575	$ 36,336	$ 1,420	$ 1,297	$ 1,338
2045	$ 36,884	$ 35,876	$ 37,677	$ 1,429	$ 1,301	$ 1,341
2046	$ 38,310	$ 37,173	$ 39,011	$ 1,427	$ 1,296	$ 1,335
2047	$ 39,746	$ 38,473	$ 40,350	$ 1,436	$ 1,301	$ 1,338
2048	$ 41,180	$ 39,770	$ 41,683	$ 1,434	$ 1,296	$ 1,333
2049	$ 42,617	$ 41,066	$ 43,014	$ 1,437	$ 1,296	$ 1,331
2050	$ 44,056	$ 42,361	$ 44,343	$ 1,439	$ 1,295	$ 1,330
2051	$ 45,440	$ 43,525	$ 45,507	$ 1,384	$ 1,164	$ 1,164
2052	$ 46,829	$ 44,693	$ 46,675	$ 1,389	$ 1,168	$ 1,168
2053	$ 48,222	$ 45,864	$ 47,846	$ 1,393	$ 1,171	$ 1,171
2054	$ 49,620	$ 47,039	$ 49,021	$ 1,398	$ 1,175	$ 1,175
2055	$ 51,022	$ 48,218	$ 50,200	$ 1,402	$ 1,179	$ 1,179
2056	$ 54,703	$ 51,675	$ 53,657	$ 3,681	$ 3,457	$ 3,457
2057	$ 56,114	$ 52,861	$ 54,843	$ 1,411	$ 1,186	$ 1,186
2058	$ 57,529	$ 54,051	$ 56,033	$ 1,415	$ 1,190	$ 1,190
2059	$ 58,949	$ 55,245	$ 57,227	$ 1,420	$ 1,194	$ 1,194
2060	$ 60,373	$ 56,442	$ 58,424	$ 1,424	$ 1,197	$ 1,197
2061	$ 61,802	$ 57,643	$ 59,625	$ 1,429	$ 1,201	$ 1,201
2062	$ 63,235	$ 58,848	$ 60,830	$ 1,433	$ 1,205	$ 1,205
2063	$ 64,672	$ 60,057	$ 62,039	$ 1,437	$ 1,209	$ 1,209
2064	$ 66,114	$ 61,269	$ 63,251	$ 1,442	$ 1,212	$ 1,212
2065	$ 67,560	$ 62,485	$ 64,467	$ 1,446	$ 1,216	$ 1,216
2066	$ 69,011	$ 63,705	$ 65,687	$ 1,451	$ 1,220	$ 1,220
2067	$ 70,466	$ 64,928	$ 66,910	$ 1,455	$ 1,223	$ 1,223
2068	$ 71,926	$ 66,155	$ 68,137	$ 1,460	$ 1,227	$ 1,227
2069	$ 73,390	$ 67,386	$ 69,368	$ 1,464	$ 1,231	$ 1,231
2070	$ 74,353	$ 68,116	$ 69,947	$ 963	$ 729	$ 579

LCCA Results

Multifamily – Executive Report

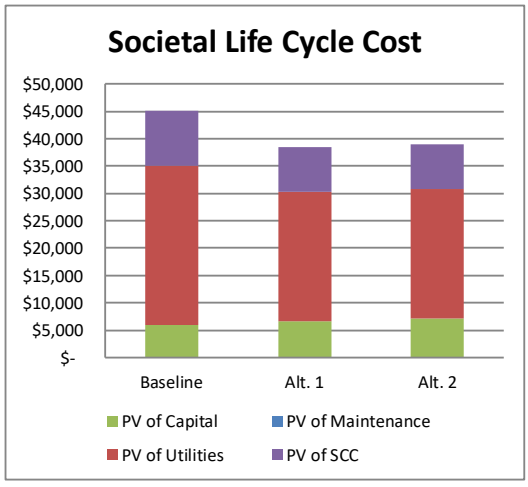
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	820
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	820
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

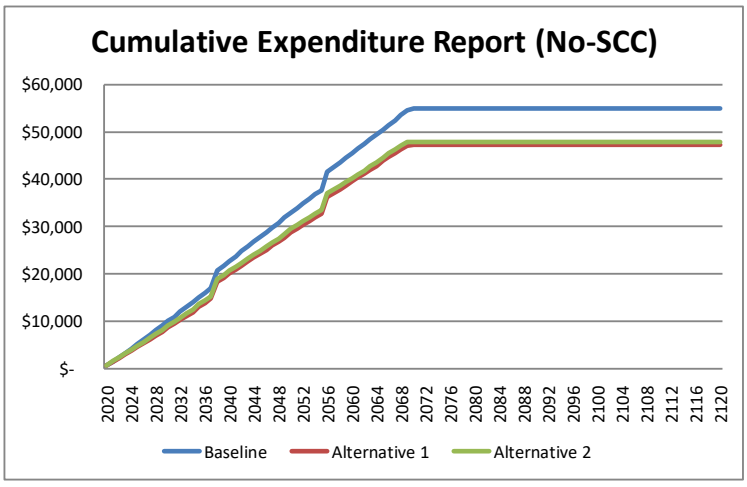
Life Cycle Cost Analysis		**BEST**	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	32.2	26.1	26.1
1st Construction Costs	$ 2,817	$ 3,091	$ 3,691
PV of Capital Costs	$ 5,934	$ 6,636	$ 7,208
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 29,095	$ 23,627	$ 23,627
Total Life Cycle Cost (LCC)	**$ 35,029**	**$ 30,263**	**$ 30,834**
Net Present Savings (NPS)	**N/A**	**$ 4,767**	**$ 4,195**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		**BEST**	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	159	129	129
% CO2e Reduction vs. Baseline	N/A	19%	19%
Present Social Cost of Carbon (SCC)	$ 10,099	$ 8,201	$ 8,201
Total LCC with SCC	**$ 45,129**	**$ 38,464**	**$ 39,035**
NPS with SCC	**N/A**	**$ 6,665**	**$ 6,093**

Warning: OFM Assigned Variables Not Used





LCCA Results

Multifamily – Baseline Input

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

Open Primary Filter and Click OK to Re-filter

☑ Show All Entered Units (Requires Re-Filter)

							Total Building Annual Utility Analysis		$ 746	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)
							Annual Utility Bill [$]				$ 746	
							Annual Utility Consumption Not Entered Below				9,166	
							Sum of Annual Utility Consumption Below			-	(1,439)	-
							Total Annual Utility Consumption			-	7,727	-
							Annual Utility Bill ÷ Total Utility Consumption			$ -	$ 0.097	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	A
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ 2,817	Entries Below for Component Specific Utility Analy			
	A	**Substructure**										
x	A101098	MF										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
x	G909097	Additional Cost			55	$0.75						
x	X	**Other Categories**										
x	X90	**Other Categories**										
x	X9010	Building Envelope										
x	X901001	1a - 5% UA reduc	0.5		50	$192				-337		
x	X901002	1b - 15% UA reduc	1		50	$1,359				-517		
x	X901003	1c - 30% UA reduc	2		50	$2,615				-898		
x	X901004	1d - U-.24 Glaze	0.5		50	$554				-228		
x	X901005	1e - 40% UA reduc	3		50	$3,773				-1172		
x	X901006	1f - U-.20 Glaze	1		50	$1,107				-391		
x	X901007	2a - 3ACH , fan eff	0.5		50	$245				-475		
x	X901008	2b - 2 ACH, HRV	1		50	$1,025				-939		
x	X901009	2c - 1.5 ACH, HRV	1.5		50	$2,296				-1284		
x	X901010	2d - 0.6 ACH, HRV	2		50	$3,280				-1533		
x	X9020	HVAC			0							
x	X902001	3a - Furnace	1		18							
x	X902002	3b - 9.5 HSPF HP	0.5		15							
x	X902003	3c - GSHP	1.5		20							
x	X902004	3d - DHP	1	1	18	$2,800		$ 2,800		-1132		
x	X902005	3e - 11.0 HSPF HP	1		15							
x	X902006	3f - DHP (15% elec)	1.5		18	$4,800				-1193		
x	X902007	4 - HVAC inside	1		50							
x	X902008	Other			0							
x	X902009	Other			0							
x	X902010	Other			0							
x	X9030	Hot Water			0							
x	X903001	5a - DWR	0.5		50	$133				-265		
x	X903002	5b - 0.80 gas DHW	0.5		15							
x	X903003	5c - 0.91 gas DHW, GSHP	1		15							
x	X903004	5d - Tier I HPWH	1.5		15	$291				-1038		
x	X903005	5e - Tier III HPWH	2		15	$291				-1369		
x	X903006	5f - Tier III HPWH Split	2.5		15	$1,167				-1547		
x	X903007				0							
x	X903008	Other			0							
x	X903009	Other			0							
x	X903010	Other			0							
x	X9040	Other			0							
x	X904001	6 - Solar pV	0.5		25	$5,040				-1262		
x	X904002	7 - HP dryers, ES Appl	0.5		15	$462				-612		
x	X904003	(legacy) 5a - low flow fixtures	0.5	1	50	$17		$ 17		-307		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Multifamily – ALT 1

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 606	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	
Annual Utility Bill [$]			$ 606	$ -	
Annual Utility Consumption Not Entered Below			8,776		
Sum of Annual Utility Consumption Below		-	(2,502)	-	
Total Annual Utility Consumption		-	6,274	-	
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -	$

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Ann
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 3,091				
	A	**Substructure**										
	A101098	MF										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Additional Cost			55	$0.75						
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc			50	$192						
	X901002	1b - 15% UA reduc	1		50	$1,359				-517		
	X901003	1c - 30% UA reduc	1.5		50	$2,615				-898		
	X901004	1d - U-.24 Glaze	0.5		50	$554				-228		
	X901005	1e - 40% UA reduc	2		50	$3,773				-1172		
	X901006	1f - U-.20 Glaze	1		50	$1,107				-391		
	X901007	2a - 3ACH , fan eff	1		50	$245				-475		
	X901008	2b - 2 ACH, HRV	1.5		50	$1,025				-939		
	X901009	2c - 1.5 ACH, HRV	2		50	$2,296				-1284		
	X901010	2d - 0.6 ACH, HRV	2.5		50	$3,280				-1533		
	X9020	HVAC										
	X902001	3a - Furnace	1		18							
	X902002	3b - 9.5 HSPF HP			15							
	X902003	3c - GSHP	1		20							
	X902004	3d - DHP	2	1	18	$2,800		$ 2,800		-1132		
	X902005	3e - 11.0 HSPF HP	0.5		15							
	X902006	3f - DHP (15% elec)	2.5		18	$4,800				-1193		
	X902007	4 - HVAC inside			50							
	X902008	Other										
	X902009	Other										
	X902010	Other										
	X9030	Hot Water										
	X903001	5a - DWR	0.5		50	$133				-265		
	X903002	5b - 0.80 gas DHW	0.5		15							
	X903003	5c - 0.91 gas DHW, GSHP	1		15							
	X903004	5d - Tier I HPWH	2		15	$291				-1038		
	X903005	5e - Tier III HPWH	2.5	1	15	$291		$ 291		-1369		
	X903006	5f - Tier III HPWH Split	3		15	$1,167				-1547		
	X903007											
	X903008	Other										
	X903009	Other										
	X903010	Other										
	X9040	Other										
	X904001	6 - Solar pV	0.5		25	$5,040				-1262		
	X904002	7 - HP dryers, ES Appl	1		15	$462				-612		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$17				-307		
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Multifamily – ALT 2

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 2 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ● Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 606	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	
Annual Utility Bill [$]			$ 606		
Annual Utility Consumption Not Entered Below		-	8,776		
Sum of Annual Utility Consumption Below		-	(2,502)	-	
Total Annual Utility Consumption		-	6,274	-	
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ -	$

Note: No Units Assigned to a Component with Entries

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Ann
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis			
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 3,706				
	A	**Substructure**										
	A101098	MF										
	B	**Shell**										
	C	**Interiors**										
	D	**Services**										
	E	**Equipment & Furnishings**										
	F	**Special Construction & Demolition**										
	G	**Building Sitework**										
	G909097	Additional Cost		820	55	$0.75		$ 615				
	X	**Other Categories**										
	X90	**Other Categories**										
	X9010	Building Envelope										
	X901001	1a - 5% UA reduc			50							
	X901002	1b - 15% UA reduc	1		50	$1,359				-517		
	X901003	1c - 30% UA reduc	1.5		50	$2,615				-898		
	X901004	1d - U-.24 Glaze	0.5		50	$554				-228		
	X901005	1e - 40% UA reduc	2		50	$3,773				-1172		
	X901006	1f - U-.20 Glaze	1		50	$1,107				-391		
	X901007	2a - 3ACH , fan eff	1		50	$245				-475		
	X901008	2b - 2 ACH, HRV	1.5		50	$1,025				-939		
	X901009	2c - 1.5 ACH, HRV	2		50	$2,296				-1284		
	X901010	2d - 0.6 ACH, HRV	2.5		50	$3,280				-1533		
	X9020	HVAC										
	X902001	3a - Furnace	1		18							
	X902002	3b - 9.5 HSPF HP			15							
	X902003	3c - GSHP	1		20							
	X902004	3d - DHP	2	1	18	$2,800		$ 2,800		-1132		
	X902005	3e - 11.0 HSPF HP	0.5		15							
	X902006	3f - DHP (15% elec)	2.5		18	$4,800				-1193		
	X902007	4 - HVAC inside			50							
	X902008	Other										
	X902009	Other										
	X902010	Other										
	X9030	Hot Water										
	X903001	5a - DWR	0.5		50	$133				-265		
	X903002	5b - 0.80 gas DHW	0.5		15							
	X903003	5c - 0.91 gas DHW, GSHP	1		15							
	X903004	5d - Tier I HPWH	2		15	$291				-1038		
	X903005	5e - Tier III HPWH	2.5	1	15	$291		$ 291		-1369		
	X903006	5f - Tier III HPWH Split	3		15	$1,167				-1547		
	X903007											
	X903008	Other										
	X903009	Other										
	X903010	Other										
	X9040	Other										
	X904001	6 - Solar pV	0.5		25	$5,040				-1262		
	X904002	7 - HP dryers, ES Appl	1		15	$462				-612		
	X904003	(legacy) 5a - low flow fixtures	0.5		50	$17						
	Z	**Other Project Costs**										
	Z10	**One Time - Upfront Costs**		1	50							
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1							

LCCA Results

Multifamily – Expenditure Report

Expenditure Report Page In Constant 2020 $'s

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ 563	$ 618	$ 741	$ 563	$ 618	$ 741
2021	$ 1,459	$ 1,386	$ 1,540	$ 896	$ 768	$ 798
2022	$ 2,366	$ 2,161	$ 2,345	$ 907	$ 775	$ 805
2023	$ 3,284	$ 2,945	$ 3,157	$ 918	$ 783	$ 812
2024	$ 4,213	$ 3,736	$ 3,977	$ 929	$ 791	$ 820
2025	$ 5,154	$ 4,536	$ 4,804	$ 941	$ 800	$ 827
2026	$ 6,106	$ 5,344	$ 5,639	$ 952	$ 808	$ 835
2027	$ 7,070	$ 6,160	$ 6,481	$ 964	$ 817	$ 842
2028	$ 8,039	$ 6,979	$ 7,325	$ 968	$ 819	$ 844
2029	$ 9,011	$ 7,801	$ 8,170	$ 973	$ 821	$ 846
2030	$ 9,988	$ 8,625	$ 9,018	$ 977	$ 824	$ 847
2031	$ 10,970	$ 9,451	$ 9,867	$ 981	$ 827	$ 849
2032	$ 11,955	$ 10,281	$ 10,719	$ 986	$ 829	$ 852
2033	$ 12,946	$ 11,113	$ 11,572	$ 991	$ 832	$ 854
2034	$ 13,941	$ 11,948	$ 12,429	$ 995	$ 835	$ 856
2035	$ 14,942	$ 13,078	$ 13,579	$ 1,000	$ 1,130	$ 1,150
2036	$ 15,939	$ 13,914	$ 14,433	$ 997	$ 835	$ 855
2037	$ 16,934	$ 14,746	$ 15,285	$ 995	$ 833	$ 851
2038	$ 20,734	$ 18,382	$ 18,939	$ 3,800	$ 3,636	$ 3,654
2039	$ 21,739	$ 19,221	$ 19,796	$ 1,005	$ 839	$ 857
2040	$ 22,741	$ 20,058	$ 20,650	$ 1,003	$ 837	$ 854
2041	$ 23,749	$ 20,898	$ 21,507	$ 1,008	$ 840	$ 857
2042	$ 24,754	$ 21,736	$ 22,361	$ 1,006	$ 838	$ 854
2043	$ 25,765	$ 22,578	$ 23,219	$ 1,011	$ 842	$ 857
2044	$ 26,774	$ 23,417	$ 24,073	$ 1,009	$ 839	$ 854
2045	$ 27,789	$ 24,260	$ 24,931	$ 1,014	$ 843	$ 858
2046	$ 28,801	$ 25,101	$ 25,786	$ 1,012	$ 841	$ 855
2047	$ 29,819	$ 25,946	$ 26,645	$ 1,018	$ 845	$ 859
2048	$ 30,835	$ 26,789	$ 27,502	$ 1,016	$ 843	$ 856
2049	$ 31,852	$ 27,632	$ 28,358	$ 1,017	$ 843	$ 856
2050	$ 32,871	$ 28,767	$ 29,506	$ 1,019	$ 1,135	$ 1,148
2051	$ 33,835	$ 29,549	$ 30,288	$ 963	$ 782	$ 782
2052	$ 34,801	$ 30,334	$ 31,073	$ 966	$ 785	$ 785
2053	$ 35,771	$ 31,121	$ 31,860	$ 970	$ 787	$ 787
2054	$ 36,743	$ 31,911	$ 32,650	$ 973	$ 790	$ 790
2055	$ 37,719	$ 32,704	$ 33,442	$ 976	$ 792	$ 792
2056	$ 41,498	$ 36,298	$ 37,037	$ 3,779	$ 3,595	$ 3,595
2057	$ 42,480	$ 37,096	$ 37,834	$ 982	$ 797	$ 797
2058	$ 43,464	$ 37,896	$ 38,634	$ 985	$ 800	$ 800
2059	$ 44,452	$ 38,698	$ 39,437	$ 988	$ 802	$ 802
2060	$ 45,444	$ 39,503	$ 40,241	$ 991	$ 805	$ 805
2061	$ 46,438	$ 40,310	$ 41,049	$ 994	$ 807	$ 807
2062	$ 47,435	$ 41,120	$ 41,858	$ 997	$ 810	$ 810
2063	$ 48,435	$ 41,932	$ 42,671	$ 1,000	$ 812	$ 812
2064	$ 49,439	$ 42,747	$ 43,486	$ 1,003	$ 815	$ 815
2065	$ 50,445	$ 43,856	$ 44,594	$ 1,006	$ 1,109	$ 1,109
2066	$ 51,455	$ 44,675	$ 45,414	$ 1,010	$ 820	$ 820
2067	$ 52,467	$ 45,498	$ 46,236	$ 1,013	$ 822	$ 822
2068	$ 53,483	$ 46,322	$ 47,061	$ 1,016	$ 825	$ 825
2069	$ 54,502	$ 47,150	$ 47,888	$ 1,019	$ 827	$ 827
2070	$ 54,902	$ 47,163	$ 47,846	$ 400	$ 13	$ (43)

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R24

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _Table 406.2_____

Brief Description: Replace the requirement for whole ventilation through a heat recovery ventilation system in options 2b and 2c with the requirement to install a balanced ventilation system commissioned per ASHRE 26.2 standards. Proposal would create a separate credit for installation of a heat recovery or energy recovery ventilation system

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.)

AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2b:
Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 2.0 air changes per hour maximum

and

All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* shall be met with a balanced ventilation system commissioned in accordance with ASHRE standard 26.2. ~~heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.70.~~

~~To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.~~

AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2c:
Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 1.5 air changes per hour maximum

and

All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* shall be met with a balanced ventilation system commissioned in accordance with ASHRE standard 26.2. ~~heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.85.~~

~~To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.~~

AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2d:
All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* shall be met with a heat recovery or energy recovery ventilation system with minimum sensible heat recovery efficiency of 0.75.

To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.

Under option credits of table: 0.5

Purpose of code change: Controlling air leakage is critical to improving the long-term energy efficiency of new residential construction, but energy credits for better air seal are rarely pursued. Two major reasons why air seal is not emphasized in residential construction is the low incentive for better ACH50 performance along and the cost/complexity of heat recovery ventilation systems.

Heat Recovery Ventilation (HRV) systems are costly in terms of the unit itself and the additional ductwork required, but also because the installation breaks up the work of various trades (framing, drywall), complicating the build and decreasing productivity. Moreover, studies and anecdotal evidence indicate heat recovery ventilation systems are not economically justified and make no difference in utility costs. Finally, HRVs require maintenance for effective operation, maintenance that often is not performed in the residential market. HRVs are currently an obstacle to broad adoption of building practices proven to tighten air envelopes and provide little benefit in the cases where installed.

Tight air seal requires smart ventilation to ensure indoor air quality, but less expensive options exist to provide balanced air exchange. Heat Recovery and Energy Recovery Ventilation (ERVs) systems are capable of maintaining indoor air quality, but should be handled as a separate prescriptive option instead of an associated requirement to Air Leakage Control performance levels.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Alan Nolan	Email address	alan@509.design
Your organization	Spokane Home Builder Association	Phone number	509-847-4651
Other contact name	Kieran Sprague, 360-791-7462		

Economic Impact Data Sheet

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

Adopting the proposal will incentivize builders to place greater emphasis on improved air seal while also ensuring indoor air quality is maintained. The option to earn appropriate credits for installing a HRV or ERV system will provide an incentive for their use in residential construction.

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**)

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

There are no additional costs associated with the proposal. All costs for the options revised were previously considered and accepted as part of the residential portion of the 2015 WSEC.

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

0 KWH/ square foot (or) 0 KWH/ dwelling unit)

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

Energy savings for air leakage control and heat recovery ventilation systems are unchanged from residential portion of the 2015 WSEC, proposal simply separates

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Proposal will not create any additional plan review or inspection requirements.

Attachments


LCCA Executive Report.pdf


LCCA Baseline scenario.pdf


LCCA Alternative 1.pdf


LCCA Expenditure Report.pdf

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R25

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _R402.1.4

Brief Description: Delete the last two sentences, as REScheck does not work for the 2015 or later Energy code. These two sentences are confusing, and not in sync with the language above, the prescriptive path is unlimited glazing, R402.1.4 describes the areas shall be the same, these sentences contradict the language above.

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.)

~~When using REScheck, the U-Factors calculated by the software bosed on component R-Value Descriptions are acceptable. For the base building UA Calculations, the maximum glazing are is 15% of the floor area.~~

Purpose of code change:

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

☐ Addresses a critical life/safety need.

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

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ X Corrects errors and omissions.

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

☐ XSingle family/duplex/townhome ☐ Multi-family 4 + stories ☐ Institutional

☐ XMulti-family 1 – 3 stories ☐ Commercial / Retail ☐ Industrial

Your name	Patrick C Hayes	Email address	patrickchayes1@msn.com
Your organization	Energy Consultant	Phone number	206.819.7684

Economic Impact Data Sheet

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

No economic Impact, just making the code easier to follow and enforce.

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R26

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _R406 1b, 1c

Brief Description: Proposing to change the credits to make them more realistic to the additional measures.

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.)

1b, change from ~~1.0~~ to 1.5, 1c change from ~~2.0~~ to 3.0.

Purpose of code change: Proposing to change the credits to make them more realistic to the additional measures.

The credits as they exist are not in line with the % reduction, 1a = -5%, and .5 credits, 1b should be in sync, -15% = 1.5 credits, same for 1c, 30% should be 3 credits.

15% better than the code, is a steel hill, 30% even steeper, possibly not achievable, for both 15% and 30 % the project should be rewarded for the money and effort spent.

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

☐ Addresses a critical life/safety need.

☐ X 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)

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☐ XSingle family/duplex/townhome ☐ Multi-family 4 + stories ☐ Institutional

☐ XMulti-family 1 – 3 stories ☐ Commercial / Retail ☐ Industrial

Your name	Patrick C Hayes	Email address	patrickchayes1@msn.com
Your organization	Energy Consultant	Phone number	206.819.7684
Other contact name	Click here to enter text.		

Economic Impact Data Sheet

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

No economic Impact, just making the code easier to follow and enforce.

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

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

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R27

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # 402.4.2

Brief Description:

This proposal establishes a minimum efficiency performance threshold for fireplaces based on the Canadian FE Standard. (https://www.nrcan.gc.ca/energy/products/energuide/label/reading/13718). We suggest using the FE metric in lieu of AFUE because it more accurately reflects annual heating consumption of the fireplace (taking into account cycling losses, heating and non-heating season efficiency, pilot light contribution, etc.) The standard assesses all gas fireplaces, whether they are decorative units or are used for space heating. It is an accurate measurement that reflects the overall operation of the fireplace, taking into account its use and performance throughout the entire heating season.

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.)

R402.4.2.1 Gas Fireplace Efficiency. All natural-gas fireplaces designed to heat indoor space and/or provide aesthetic appeal (decorative) shall be listed and labeled with a fireplace efficiency (FE) rating of 65% or greater in accordance with CSA P.4.1-15.

Exception: Gas fireplaces that have a rated output < 9,000 btu/h.

Purpose of code change:

Code does not currently address gas fireplace efficiency, (though section 402.4.2 does reference safety standards for wood-burning fireplaces). Gas-burning fireplaces have a wide range of efficiency levels, from 28% to 90% and greater. Gas-fireplaces are most commonly used as secondary heating sources but may still be used for a significant number of hours per heating season. This proposal would create a minimum efficiency level for all gas-fireplaces installed in new homes to meet in line with regional utility program requirements that have been in place for years.

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.

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

☐ Consistency with state or federal regulations.

☐ Addresses a unique character of the state.

☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Nicholas O'Neil	Email address	noneil@energy350.com
Your organization	Energy 350	Phone number	503-333-8161
Other contact name	Louis Starr		

Economic Impact Data Sheet

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

Since gas fireplaces can operate for a significant number of hours per year, using an efficient fireplace over an industry standard fireplace can save a significant amount. The primary economic benefit to the homeowner is lower gas bills during the heating season by using a fireplace that consumes gas in a more efficient manner compared to a market baseline unit.

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**)

$0.07 /square foot (based on 2,200 square foot house) (For residential projects, also provide $147 / dwelling unit)

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

Costs were based on data from the Energy Trust of Oregon residential gas hearth program and the EERE Technical Support Document on gas hearths. There are no added construction or installation costs as the installation of an efficient and non-efficient gas-fireplace is similar. An incremental cost of $147 was found based on an analysis for pilot light configurations and model costs for 65% FE equipment in regional utility programs.

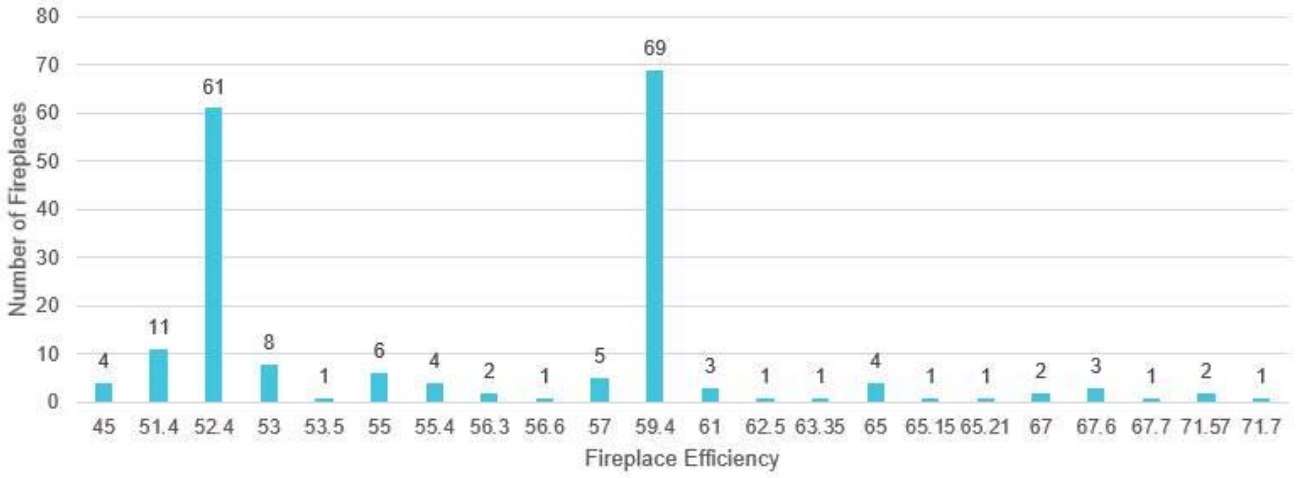
Provide your best estimate of the annual energy savings (or additional energy use) for your code change proposal?

0 KWH/ square foot (or) 0.85 KBTU/ square foot (based on 2,200 square foot house)

(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

Savings are based on the difference between a baseline fireplace and a target efficiency level. We determined the baseline FE score based on recent market characterization studies from the Energy Trust of Oregon in their new homes program. A distribution of fireplace efficiencies from 192 homes in that program is shown in the chart below.



Based on this distribution, a weighted average efficiency level of 56.5% FE was chosen as a representative baseline, which comprises approximately 50% of the market.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

To establish a target efficiency level, we conducted an analysis of available products in the NRCAN database across varying fireplace types, excluding those with standing/continuous pilot ignition and only products that met or exceeded the baseline efficiency level of 56.5% FE. Only unique models were considered in the analysis, eliminating duplicate models that had different product names but were effectively had the same efficiency level, size, and configuration. The mean and median of each fireplace meeting this criteria in the database type is shown in the table below as well as the count of unique manufacturers and models available at those levels.

Configuration	Mean Efficiency FE Score	Median Efficiency FE Score	Unique Manufacturer Count (Mean)	Unique Model Count (Mean)
Frestanding Fireplaces	70.0	69.7	21	73
Insert Fireplaces	69.8	70.7	29	138
Zero Clearance Fireplaces	65.6	65.0	35	395
Any Configuration	67.1	66.5	46	606

As the mean and median values are close, we relied on the mean for this analysis. We discovered slight differences in mean efficiency levels between unit configurations, however a single efficiency level of 65% FE was chosen across all configurations as the target efficiency level to simplify the code requirement and include all model configurations as eligible.

To determine the annual hours of use, we relied on Energy Trust of Oregon's 2017 survey responses to a question about hours of use for fireplace users. "Fireplace users" are considered people who have a fireplace and reported using it at least 0 hrs. (excludes "no use" & "haven't used yet").

Method	Fireplace Users > 0 hr. Use
Mean	11.5 hrs.
Median	5.5 hrs.
Sample Size	n=222

For purposes of savings calculations we used the median value of 5.5 hours per week for the heating season (estimated at 35 days from October – May) which translates to 190 hours per year of use.

Savings can be calculated using the following equation:

$$\Delta therm = hr\, x\, \frac{kBtu}{hr}\, x\, (\frac{1}{baseline} - \frac{1}{FE})$$

The weighted average equipment size for efficient fireplaces (i.e. ≥ 65% FE) is 18 kbtuh and the weighted average equipment size for fireplaces below that threshold is 21.5 kbtuh. Using the equation above and a baseline of 56.5% FE and a target efficiency of 65% FE, a savings of **18.9 therms/yr** is calculated.

Using Washington State data from the 2016 RBSA, mean space heat for a home in Washington was 557.5 therms/yr and used as the baseline gas consumption. Savings of 18.9 therms were subtracted from that baseline usage in the associated lifecycle cost tool.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Additional review time will be minimal as the code official would need to see the rated FE score on the equipment plans. Inspectors would follow a procedure akin to inspecting gas furnaces that meet the efficiency requirements of the code. On-site verification of FE rating is all that is required.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Executive Report

Project Information	
Project:	
Address:	
Company:	Energy 350
Contact:	Nicholas O'Neil
Contact Phone:	503-333-8161
Contact Email:	noneil@energy350.com

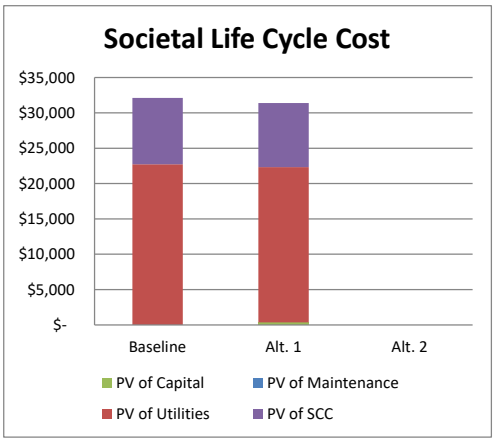
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

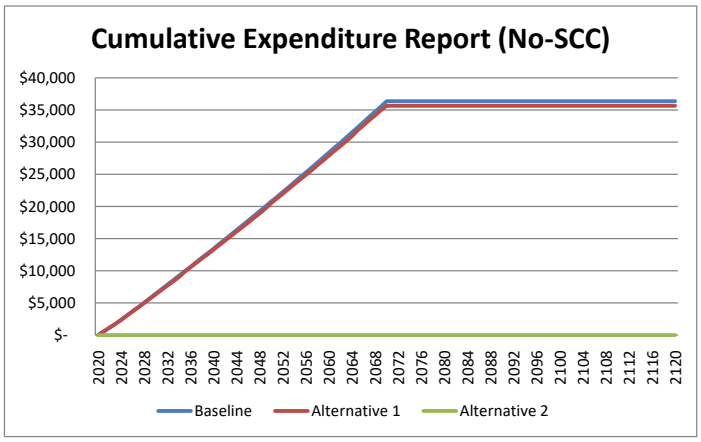
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	25.3	24.5	
1st Construction Costs	$ -	$ 147	$ -
PV of Capital Costs	$ -	$ 363	$ -
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 22,723	$ 21,952	$ -
Total Life Cycle Cost (LCC)	**$ 22,723**	**$ 22,315**	**$ -**
Net Present Savings (NPS)	**N/A**	**$ 407**	**$ -**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	148	143	-
% CO2e Reduction vs. Baseline	N/A	3%	104%
Present Social Cost of Carbon (SCC)	$ 9,398	$ 9,079	$ -
Total LCC with SCC	**$ 32,121**	**$ 31,395**	**$ -**
NPS with SCC	**N/A**	**$ 726**	**$ -**

Warning: OFM Assigned Variables Not Used





Baseline Short Description
Alternative 1 Short Description
Alternative 2 Short Description

<- Primary Filter (Requires Level 1)

Open Primary Filter and Click OK to Re-filter

Show All Entered Units (Requires Re-Filter)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

	Total Building Annual Utility Analysis	$ 592	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/#2 (Gallons)	Gasoline (Gallons)	LPG (Gallons)	District Heat (mmBTU)	Other Annual Building Maint.
	Annual Utility Bill [$]			$ -	$ 592					
	Annual Utility Consumption Not Entered Below				558					Sum of Below
	Sum of Annual Utility Consumption Below		-	-	-	-	-	-	-	$ -
	Total Annual Utility Consumption		-	-	558	-	-	-	-	Total Maint.
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062	$ -	$ -	$ -	$ -	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Diesel/#2 (Gal/Unit)	Annual Gasoline (Gal/Unit	Annual LPG Gal/Unit)	Annual Dist. Heat (KBTU/Unit)	Remaining Life (Years) of Existing Component
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ -	Entries Below for Component Specific Utility Analysis (Consumption per Unit) - Total Building Utility Analysis Above							
	A	**Substructure**														
	B	**Shell**														
	C	**Interiors**														
	D	**Services**														
x	D302099	Other Heat Generating Systems		1	15	$0.00		$ -								
	E	**Equipment & Furnishings**														
	F	**Special Construction & Demolition**														
	G	**Building Sitework**														
	Z	**Other Project Costs**														
	Z10	**One Time - Upfront Costs**		1	50											
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1											

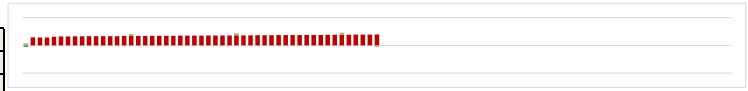
<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ◉ Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)



Total Building Annual Utility Analysis	$ 572	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/#2 (Gallons)	Gasoline (Gallons)	LPG (Gallons)	District Heat (mmBTU)	Other Annual Building Maint.
Annual Utility Bill [$]			$ -	$ 572					$ -
Annual Utility Consumption Not Entered Below				539	-	-	-	-	Sum of Below
Sum of Annual Utility Consumption Below		-	-	-	-	-	-	-	$ -
Total Annual Utility Consumption		-	-	539	-	-	-	-	Total Maint.
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062	$ -	$ -	$ -	$ -	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Diesel/#2 (Gal/Unit)	Annual Gasoline (Gal/Unit	Annual LPG Gal/Unit)	Annual Dist. Heat (KBTU/Unit)	Remaining Life (Years) of Existing Component
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis (Consumption per Unit) - Total Building Utility Analysis Above							
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 147								
.	**A**	**Substructure**														
	B	**Shell**														
	C	**Interiors**														
	D	**Services**														
	D30	**HVAC**														
x	D302099	Other Heat Generating Systems		1	15	$147.00		$ 147								
	E	**Equipment & Furnishings**														
	F	**Special Construction & Demolition**														
	G	**Building Sitework**														
	Z	**Other Project Costs**														
	Z10	**One Time - Upfront Costs**		1	50											
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1											

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ -	$ 29	$ -	$ -	$ 29	$ -
2021	$ 592	$ 609	$ -	$ 592	$ 579	$ -
2022	$ 1,178	$ 1,182	$ -	$ 586	$ 574	$ -
2023	$ 1,765	$ 1,756	$ -	$ 586	$ 573	$ -
2024	$ 2,403	$ 2,379	$ -	$ 639	$ 624	$ -
2025	$ 3,071	$ 3,031	$ -	$ 668	$ 651	$ -
2026	$ 3,738	$ 3,682	$ -	$ 668	$ 651	$ -
2027	$ 4,411	$ 4,339	$ -	$ 673	$ 657	$ -
2028	$ 5,085	$ 4,995	$ -	$ 673	$ 656	$ -
2029	$ 5,770	$ 5,662	$ -	$ 685	$ 667	$ -
2030	$ 6,460	$ 6,335	$ -	$ 691	$ 673	$ -
2031	$ 7,151	$ 7,008	$ -	$ 691	$ 673	$ -
2032	$ 7,842	$ 7,681	$ -	$ 691	$ 673	$ -
2033	$ 8,533	$ 8,353	$ -	$ 691	$ 672	$ -
2034	$ 9,229	$ 9,031	$ -	$ 697	$ 678	$ -
2035	$ 9,926	$ 9,856	$ -	$ 697	$ 825	$ -
2036	$ 10,628	$ 10,539	$ -	$ 702	$ 683	$ -
2037	$ 11,330	$ 11,222	$ -	$ 702	$ 683	$ -
2038	$ 12,039	$ 11,911	$ -	$ 708	$ 689	$ -
2039	$ 12,747	$ 12,599	$ -	$ 708	$ 688	$ -
2040	$ 13,461	$ 13,293	$ -	$ 714	$ 694	$ -
2041	$ 14,175	$ 13,987	$ -	$ 714	$ 694	$ -
2042	$ 14,894	$ 14,686	$ -	$ 720	$ 699	$ -
2043	$ 15,614	$ 15,385	$ -	$ 720	$ 699	$ -
2044	$ 16,340	$ 16,090	$ -	$ 726	$ 705	$ -
2045	$ 17,065	$ 16,794	$ -	$ 726	$ 705	$ -
2046	$ 17,797	$ 17,504	$ -	$ 731	$ 710	$ -
2047	$ 18,534	$ 18,220	$ -	$ 737	$ 716	$ -
2048	$ 19,271	$ 18,935	$ -	$ 737	$ 715	$ -
2049	$ 20,012	$ 19,654	$ -	$ 741	$ 719	$ -
2050	$ 20,756	$ 20,523	$ -	$ 744	$ 869	$ -
2051	$ 21,504	$ 21,245	$ -	$ 748	$ 722	$ -
2052	$ 22,255	$ 21,971	$ -	$ 751	$ 726	$ -
2053	$ 23,009	$ 22,700	$ -	$ 755	$ 729	$ -
2054	$ 23,767	$ 23,432	$ -	$ 758	$ 732	$ -
2055	$ 24,529	$ 24,168	$ -	$ 762	$ 736	$ -
2056	$ 25,294	$ 24,907	$ -	$ 765	$ 739	$ -
2057	$ 26,062	$ 25,649	$ -	$ 769	$ 742	$ -
2058	$ 26,834	$ 26,395	$ -	$ 772	$ 746	$ -
2059	$ 27,610	$ 27,145	$ -	$ 775	$ 749	$ -
2060	$ 28,389	$ 27,897	$ -	$ 779	$ 753	$ -
2061	$ 29,171	$ 28,653	$ -	$ 782	$ 756	$ -
2062	$ 29,957	$ 29,412	$ -	$ 786	$ 759	$ -
2063	$ 30,747	$ 30,175	$ -	$ 789	$ 763	$ -
2064	$ 31,540	$ 30,941	$ -	$ 793	$ 766	$ -
2065	$ 32,336	$ 31,857	$ -	$ 796	$ 916	$ -
2066	$ 33,136	$ 32,630	$ -	$ 800	$ 773	$ -
2067	$ 33,939	$ 33,406	$ -	$ 803	$ 776	$ -
2068	$ 34,746	$ 34,186	$ -	$ 807	$ 779	$ -
2069	$ 35,556	$ 34,969	$ -	$ 810	$ 783	$ -
2070	$ 36,370	$ 35,657	$ -	$ 814	$ 688	$ -
2071	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2072	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2073	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2074	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2075	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2076	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2077	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2078	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2079	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2080	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2081	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2082	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2083	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2084	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2085	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2086	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2087	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2088	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2089	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2090	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2091	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2092	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2093	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2094	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2095	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2096	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2097	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2098	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2099	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2100	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2101	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2102	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2103	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2104	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2105	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2106	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2107	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2108	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2109	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2110	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2111	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2112	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2113	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2114	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2115	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2116	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2117	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2118	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2119	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -
2120	$ 36,370	$ 35,657	$ -	$ -	$ -	$ -

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R28

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # 403.1.3, 403.10.1

Brief Description:

This proposal seeks to prohibit the use of standing (or continuous) pilot lights on select gas-fired appliances. Non-continuous ignition types have long existed in the market to replace antiquated standing pilot lights for many household appliances and space heating systems.

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.)

R403.1.3 Continuously Burning Pilot Lights. The natural gas systems and equipment listed below are not permitted to be equipped with continuously burning pilot lights:

a. Fan-type central furnaces.
b. Household cooking appliances.
   EXCEPTION: Household cooking appliances without electrical supply voltage connections and in which each pilot light consumes less than 150 Btu/hr.
c. Pool heaters.
d. Spa heaters.
e. Fireplaces.

R403.10.1 Heaters. The electric power to heaters shall be controlled by a readily accessible on-off switch that is an integral part of the heater mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. ~~Gas-fired heaters shall not be equipped with continuously burning ignition pilots.~~

Purpose of code change:

Standing pilot lights are no longer necessary with many gas-fired appliances and space heating systems offering market accepted alternative methods. Some models allow standing pilots to operate for a few hours after shutdown and then use electronic ignition to re-start, allowing a variety of models to exist in the market that save energy over continuously burning pilot lights.

A new section is proposed in the WSEC that lists the gas-fired appliances that are prohibited from using standing pilot lights. Code already prohibits standing pilot lights on pool and spa heaters and therefore the existing reference in section R403.10.1 is removed and pool and spa heaters are listed in the newly created section R403.1.3 to maintain clarity and concise placement throughout the code.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name	Nicholas O'Neil	Email address	noneil@energy350.com
Your organization	Energy 350	Phone number	503-333-8161
Other contact name	Louis Starr		

Economic Impact Data Sheet

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

Since gas heating appliances with standing pilot lights consume gas even during non-heating months of the year, using one that has intermittent ignition saves gas for a significant number of hours per year. The primary economic benefit to the homeowner is lower gas bills over the course of the year by using appliances that consumes gas in a more efficient manner compared to those that utilize continuously burning pilot lights.

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**)

$0.047/square foot (For residential projects, also provide $105/ dwelling unit)

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

This prohibition is not expected to add significant cost to any gas-fired appliance or heating system. Past studies have shown between $80 and $105 increase in price to move from a standard continuously lit pilot light to an intermittent ignition system on fireplaces. Costs are based on recently conducted market studies from the Energy Trust of Oregon and support data from DOE on costs for intermittent ignition systems.

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

-0.015 KWH/ square foot (or) 1.27 KBTU/ square foot (based on a 2,200 sqft home)

(For residential projects, also provide -0.012 KWH/KBTU / dwelling unit)

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

To calculate energy savings we relied on work done by the Energy Trust of Oregon on fireplace operating hours as well as DOE during its rulemaking process in 2013 under the *Energy Conservation Program for Consumer Products: Proposed Determination of Hearth Products as a Covered Consumer Product*.

Determining the annual energy consumption of each hearth product ignition system was done by multiplying the heat input of natural gas by the number of hours the pilot ignition system would otherwise be on when the appliance was not in use. The following equation was used to determine the energy use for each ignition system:

$$EnergyUse_{Total} = Q_p \; x \; OH_p + Seconadry \; Effects$$

Where:

- ***Ignition system power*** **(QP):** Standing pilot (SP) or intermittent pilot (IPI) ignition system power
  - ***SP***: Fuel input consumed by the standing pilot, Btu/hr.
  - ***IPI****:* Electrical power consumed by the intermittent pilot ignition system, W.
- ***Ignition System Operating Hours*** **(OHP)**: On-time of the SP or IPI ignition system.
  - ***SP*****:** Determined using field studies and Energy Trust of Oregon survey and metering data.
  - ***IPI:*** Determined based on hearth product main burner operation.
- ***Impact on Space Heating or Cooling Energy Use*** **(Secondary Effects)**: Impact of ignition operation on household space conditioning system energy use.
  - ***Heating Season***: SP heat is counted as beneficial heat and reduces furnace operating hours.
  - ***Non-Heating Season***: SP heat is counted as an additional cooling load and increases air-conditioning operating hours.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

The market share and weight of different ignition types was used in the analysis and is shown in the table below.

Hearth Product Group	Estimated Market Share (%)			Shipments
	Match Lit	Standing Pilot	Electronic Ignition	Representative Shipment Volume
Vented Fireplace, Insert, Stove	5	40	55	10,000
Unvented Fireplace, Insert, Stove	0	88	12	2,000
Vented Gas Log Sets	50	44	6	2,000
Unvented Gas Log Sets	0	94	6	5,000
Outdoor	50	26	24	3,000

The ignition system representative power is shown in the table below based on manufacturer data. Using shipment and market share information above combined with the ignition system energy consumption, a weighted average pilot light btu/h and IPI Wattage was determined and shown in the table below.

Hearth Product Type	Standing Pilot (Btu/h)	Intermittent Pilot Ignition (W)	Main Burner (Btu/h)
Vented Fireplace, Insert, Stove	1,000	50	35,000
Unvented Fireplace, Insert, Stove	1,200	50	30,000
Vented Gas Log Sets	700	50	35,000
Unvented Gas Log Sets	800	50	25,000
Outdoor*	1,000	50	50,000
Average	951	50	
Average (excluding Outdoor)	946	50	

** Though outdoor fireplaces are shown in the table for consistency with the DOE determination, they are excluded from the proposal analysis related to indoor gas appliances.*

The weighted average heat input of the pilot light is therefore 946 Btu/h and the IPI is 50 W.

To determine the hours of use the standing pilot ignition was on during a year, the DOE technical support document relied on RECS surveys and CANMET surveys and the distribution of operating hours based on the mode and reporting of how many users leave their pilot light on all year. Results from the studies indicated that 40% of users left the ignition for the whole year, 20% turn it off daily, and the remaining 40% had many users turning the SP off at the end of the heating season. From this data the average operating hours for SP fireplaces was found to be 3,708 hours/year.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

To determine IPI operating hours several assumptions were made based on the DOE test procedure for vented home heating equipment.

Assumptions:

- *Average Main Burner cycle time = 20 minutes*
- *Main Burner Cycles per hour = 3*
- *IPI Operation per Cycle = 30 seconds*

Using these assumptions the resulting average IPI operating hours was found to be 3.9 hours/year

To determine secondary effects, the following equation was used along with the stated assumptions.

$$(Secondary\ Effects)_s = \frac{E_{USE\_pilot} * \eta_p}{\eta_s}$$

Where:

- *s (index)= season (heating or cooling season)*
- Q_P *= power consumption of the pilot*
- $OH_{P,S}$ *= pilot operating hours in that season*
- $E_{USE,pilot}$ *= energy consumed by the pilot*
- η_p *= fraction of useful heat from the pilot*
    - *Distribution based on field study*
    - *Assumed half for decorative units*
    - *Assumed double for unvented units*
- η_s *= efficiency of the main heating or cooling appliance*

Combining the values found above into the primary Energy use equation for each type yields the following results.

Summary of Standing Pilot Results

Hearth Product Type	Total Fuel Use* (MMBtu/yr)
Vented Fireplace, Insert, Stove	3.99
Unvented Fireplace, Insert, Stove	3.52
Vented Gas Log Sets	3.13
Unvented Gas Log Sets	2.29
Outdoor	3.91
All SP Hearth Products	3.58
All SP Hearth Products (Excluding Outdoor)	3.40

* No electricity used by SP

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Summary of IPI Results

Hearth Product Type	Electricity Use** (kWh/yr)	Space Heating Fuel Impact† (MMBtu/yr)	Space Heating Electricity Impact† (kWh/yr)	Space Cooling Electricity Impact† (kWh/yr)
Vented Fireplace, Insert, Stove	0.19	0.50	25.2	-12.8
Unvented Fireplace, Insert, Stove	0.18	1.30	155	-49.5
Vented Gas Log Sets	0.30	0.29	15.5	-7.0
Unvented Gas Log Sets	0.22	0.92	102	-49.5
Outdoor	0.18	0.00	0.00	0.0
All IPI Hearth Products***	0.20	0.58	45.5	-21.1
All IPI Hearth Products (excluding Outdoor)***	0.21	0.67	58.05	25.71

** No fuel use by IPI.

*** Total impact of IPI calculated using the market-share-weighted average of each product type.

†Reflects impacts of lack of standing pilot heat

The final analysis indicates that IPI consumption over SP consumption (excluding outdoor units) results in a total of **28 therms/yr of gas savings with an increased electricity consumption of 33 kWh/yr.** Details of the LCC analysis can be found in the associated LCC calculator.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

No significant enforcement is expected by the plans examiner or inspector. Standing pilot lights can be visually seen and noted if present, and plans examiners can check model numbers for furnaces and cooking appliances prior to installation to ensure the model selected has a non-continuous ignition type. Section 110.5 of the 2016 Title 24 in California prohibits pilot lights for natural gas furnaces, cooking equipment, and pool and spa heaters so precedent exists already at the state code level.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Executive Report

Project Information	
Project:	
Address:	
Company:	Energy 350
Contact:	Nicholas O'Neil
Contact Phone:	503-333-8161
Contact Email:	noneil@energy350.com

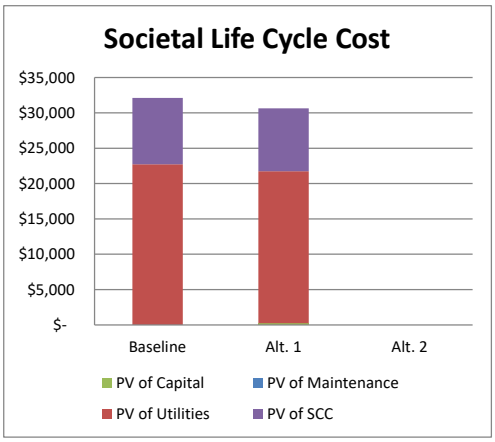
Key Analysis Variables		Building Characteristics	
Study Period (years)	50	Gross (Sq.Ft)	2,200
Nominal Discount Rate	5.00%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2020	Project Phase	0
Construction Years	0	Building Type	0

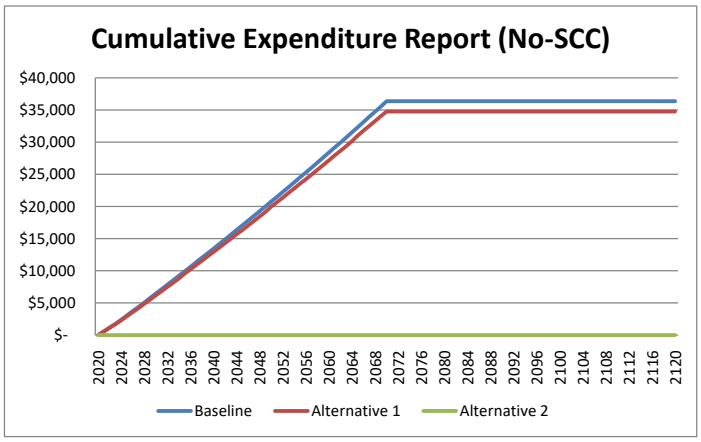
Life Cycle Cost Analysis		BEST	
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	25.3	24.0	
1st Construction Costs	$ -	$ 105	$ -
PV of Capital Costs	$ -	$ 259	$ -
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 22,723	$ 21,488	$ -
Total Life Cycle Cost (LCC)	**$ 22,723**	**$ 21,747**	**$ -**
Net Present Savings (NPS)	**N/A**	**$ 976**	**$ -**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost		BEST	
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	148	140	-
% CO2e Reduction vs. Baseline	N/A	5%	106%
Present Social Cost of Carbon (SCC)	$ 9,398	$ 8,895	$ -
Total LCC with SCC	**$ 32,121**	**$ 30,642**	**$ -**
NPS with SCC	**N/A**	**$ 1,479**	**$ -**

Warning: OFM Assigned Variables Not Used





Baseline Short Description
Alternative 1 Short Description
Alternative 2 Short Description

<- Primary Filter (Requires Level 1)

Open Primary Filter and Click OK to Re-filter

Show All Entered Units (Requires Re-Filter)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Baseline Input Page

	Total Building Annual Utility Analysis	$ 592	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/#2 (Gallons)	Gasoline (Gallons)	LPG (Gallons)	District Heat (mmBTU)	Other Annual Building Maint.
	Annual Utility Bill [$]			$ -	$ 592					
	Annual Utility Consumption Not Entered Below				558					Sum of Below
	Sum of Annual Utility Consumption Below		-	-	-	-	-	-	-	$ -
	Total Annual Utility Consumption		-	-	558	-	-	-	-	Total Maint.
	Annual Utility Bill ÷ Total Utility Consumption		$ -	$ -	$ 1.062	$ -	$ -	$ -	$ -	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Diesel/#2 (Gal/Unit)	Annual Gasoline (Gal/Unit	Annual LPG Gal/Unit)	Annual Dist. Heat (KBTU/Unit)	Remaining Life (Years) of Existing Component
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2							$ -	Entries Below for Component Specific Utility Analysis (Consumption per Unit) - Total Building Utility Analysis Above							
	A	**Substructure**														
	B	**Shell**														
	C	**Interiors**														
	D	**Services**														
x	D302099	Other Heat Generating Systems		1	15	$0.00		$ -								
	E	**Equipment & Furnishings**														
	F	**Special Construction & Demolition**														
	G	**Building Sitework**														
	Z	**Other Project Costs**														
	Z10	**One Time - Upfront Costs**		1	50											
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1											

<- Primary Filter (Requires Level 1)

Office of Financial Management
Olympia, Washington - Version: 2018-Residential
Life Cycle Cost Analysis Tool

Alternative 1 Input Page

Open Primary Filter and Click OK to Re-filter

- ○ Manual Special Selection Only (Requires Refilter)
- ◉ Show Baseline Fields and Entered Units (Requires Refilter)
- ○ Show Differences Between Alternative and Baseline (Req. Refilter)

Total Building Annual Utility Analysis	$ 560	Water (CCF)	Electricity (KWH)	Natural Gas (Therms)	Diesel/#2 (Gallons)	Gasoline (Gallons)	LPG (Gallons)	District Heat (mmBTU)	Other Annual Building Maint.
Annual Utility Bill [$]			$ (3)	$ 563					$ -
Annual Utility Consumption Not Entered Below			(33)	530	-	-	-	-	Sum of Below
Sum of Annual Utility Consumption Below		-	-	-	-	-	-	-	$ -
Total Annual Utility Consumption		-	(33)	530	-	-	-	-	Total Maint.
Annual Utility Bill ÷ Total Utility Consumption		$ -	$ 0.097	$ 1.062	$ -	$ -	$ -	$ -	$ -

SHOW	Uniformat II Elemental Classification for Buildings (Building Component List)		REF	# of Units	Useful Life (Yrs.)	Installed Cost ($/Unit)	1st Year Maintenance Cost ($/Unit)	Total Component Installed Cost ($'s)	Annual Water (CCF/Unit)	Annual Electricity (KWH/Unit)	Annual Natural Gas (Therm/Unit)	Annual Diesel/#2 (Gal/Unit)	Annual Gasoline (Gal/Unit	Annual LPG Gal/Unit)	Annual Dist. Heat (KBTU/Unit)	Remaining Life (Years) of Existing Component
	Primary Entries Below: # of Units must be > 0 to be counted; Useful Life must be >= 2								Entries Below for Component Specific Utility Analysis (Consumption per Unit) - Total Building Utility Analysis Above							
	Match Baseline: Filter to Select All & Drag Copy O14:S14 & U14:AG14							$ 105								
.	**A**	**Substructure**														
	B	**Shell**														
	C	**Interiors**														
	D	**Services**														
	D30	**HVAC**														
x	D302099	Other Heat Generating Systems		1	15	$105.00		$ 105								
	E	**Equipment & Furnishings**														
	F	**Special Construction & Demolition**														
	G	**Building Sitework**														
	Z	**Other Project Costs**														
	Z10	**One Time - Upfront Costs**		1	50											
	Z30	**Re-Occurring Annual Cost (Track Inflation)**		1	1											

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2020	$ -	$ 21	$ -	$ -	$ 21	$ -
2021	$ 592	$ 586	$ -	$ 592	$ 565	$ -
2022	$ 1,178	$ 1,146	$ -	$ 586	$ 559	$ -
2023	$ 1,765	$ 1,705	$ -	$ 586	$ 559	$ -
2024	$ 2,403	$ 2,313	$ -	$ 639	$ 609	$ -
2025	$ 3,071	$ 2,950	$ -	$ 668	$ 636	$ -
2026	$ 3,738	$ 3,585	$ -	$ 668	$ 636	$ -
2027	$ 4,411	$ 4,227	$ -	$ 673	$ 641	$ -
2028	$ 5,085	$ 4,868	$ -	$ 673	$ 641	$ -
2029	$ 5,770	$ 5,519	$ -	$ 685	$ 652	$ -
2030	$ 6,460	$ 6,177	$ -	$ 691	$ 657	$ -
2031	$ 7,151	$ 6,834	$ -	$ 691	$ 657	$ -
2032	$ 7,842	$ 7,491	$ -	$ 691	$ 657	$ -
2033	$ 8,533	$ 8,148	$ -	$ 691	$ 657	$ -
2034	$ 9,229	$ 8,810	$ -	$ 697	$ 662	$ -
2035	$ 9,926	$ 9,577	$ -	$ 697	$ 767	$ -
2036	$ 10,628	$ 10,244	$ -	$ 702	$ 667	$ -
2037	$ 11,330	$ 10,912	$ -	$ 702	$ 667	$ -
2038	$ 12,039	$ 11,584	$ -	$ 708	$ 673	$ -
2039	$ 12,747	$ 12,257	$ -	$ 708	$ 673	$ -
2040	$ 13,461	$ 12,935	$ -	$ 714	$ 678	$ -
2041	$ 14,175	$ 13,613	$ -	$ 714	$ 678	$ -
2042	$ 14,894	$ 14,296	$ -	$ 720	$ 683	$ -
2043	$ 15,614	$ 14,980	$ -	$ 720	$ 683	$ -
2044	$ 16,340	$ 15,668	$ -	$ 726	$ 689	$ -
2045	$ 17,065	$ 16,357	$ -	$ 726	$ 689	$ -
2046	$ 17,797	$ 17,051	$ -	$ 731	$ 694	$ -
2047	$ 18,534	$ 17,750	$ -	$ 737	$ 699	$ -
2048	$ 19,271	$ 18,450	$ -	$ 737	$ 699	$ -
2049	$ 20,012	$ 19,152	$ -	$ 741	$ 703	$ -
2050	$ 20,756	$ 19,963	$ -	$ 744	$ 811	$ -
2051	$ 21,504	$ 20,670	$ -	$ 748	$ 707	$ -
2052	$ 22,255	$ 21,380	$ -	$ 751	$ 710	$ -
2053	$ 23,009	$ 22,094	$ -	$ 755	$ 714	$ -
2054	$ 23,767	$ 22,811	$ -	$ 758	$ 717	$ -
2055	$ 24,529	$ 23,531	$ -	$ 762	$ 720	$ -
2056	$ 25,294	$ 24,254	$ -	$ 765	$ 723	$ -
2057	$ 26,062	$ 24,981	$ -	$ 769	$ 727	$ -
2058	$ 26,834	$ 25,711	$ -	$ 772	$ 730	$ -
2059	$ 27,610	$ 26,445	$ -	$ 775	$ 733	$ -
2060	$ 28,389	$ 27,181	$ -	$ 779	$ 737	$ -
2061	$ 29,171	$ 27,921	$ -	$ 782	$ 740	$ -
2062	$ 29,957	$ 28,665	$ -	$ 786	$ 743	$ -
2063	$ 30,747	$ 29,411	$ -	$ 789	$ 747	$ -
2064	$ 31,540	$ 30,161	$ -	$ 793	$ 750	$ -
2065	$ 32,336	$ 31,019	$ -	$ 796	$ 858	$ -
2066	$ 33,136	$ 31,775	$ -	$ 800	$ 756	$ -
2067	$ 33,939	$ 32,535	$ -	$ 803	$ 760	$ -
2068	$ 34,746	$ 33,298	$ -	$ 807	$ 763	$ -
2069	$ 35,556	$ 34,065	$ -	$ 810	$ 766	$ -
2070	$ 36,370	$ 34,764	$ -	$ 814	$ 700	$ -
2071	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2072	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2073	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2074	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2075	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2076	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2077	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2078	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2079	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2080	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2081	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2082	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2083	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2084	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2085	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2086	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2087	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -

	Cumulative Expenditure Summary			Annual Expenditure Summary		
Year	Baseline	Alt. 1	Alt. 2	Baseline	Alt. 1	Alt. 2
2088	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2089	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2090	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2091	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2092	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2093	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2094	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2095	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2096	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2097	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2098	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2099	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2100	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2101	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2102	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2103	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2104	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2105	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2106	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2107	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2108	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2109	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2110	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2111	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2112	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2113	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2114	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2115	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2116	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2117	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2118	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2119	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -
2120	$ 36,370	$ 34,764	$ -	$ -	$ -	$ -

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R29

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _Table 406.2_____

Brief Description: To correct a probable error on continuous insulation R-value requirements in the prescriptive table.

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.)

Under description column of table:

EFFICIENT BUILDING ENVELOPE 1b:
Prescriptive compliance is based on Table R402.1.1 with the following modifications:
Vertical fenestration U = 0.25
Wall R-21 plus R-4 c.i.[d]
Floor R-38
Basement wall R-21 int plus R-5 ci
Slab on grade R-10 perimeter and under entire slab
Below grade slab R-10 perimeter and under entire slab
or
Compliance based on Section R402.1.4: Reduce the Total UA by 15%.

EFFICIENT BUILDING ENVELOPE 1c:
Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.22
Ceiling and single-rafter or joist-vaulted R-49 advanced
Wood frame wall R-21 int plus R-12 ci
Floor R-38
Basement wall R-21 int plus R-10~~12~~ ci
Slab on grade R-10 perimeter and under entire slab
Below grade slab R-10 perimeter and under entire slab
or
Compliance based on Section R402.1.4: Reduce the Total UA by 30%.

In the notes for Table 406.2

d. Materials used for continuous insulation with a printed R value of 3.5 or greater are considered compliant.

Purpose of code change: Continuous insulation is an exceptionally effective building technique for improving building envelope efficiency at reasonable cost, but it is rarely used because of inconsistency between the prescriptive code requirements and commonly available materials.

The two most commonly available materials for continuous insulation are Expanded Polystyrene (EPS), which has a typical R-value of ~3.85 and Extruded Polystyrene (XPS), which has a typical R-value of 5.0. While both materials are readily available, XPS is typically 2-3 times as expensive as EPS .

The required R-value for option 1b suggests the intent of applying 1" of continuous insulation. Setting the requirement at 4.0 eliminates EPS as an option without the proposed note. Adding the notes encourages use of continuous insulation and makes the R-value requirement consistent with the most economical material available without significantly impact on the efficiency gains to the residence.

Option 1c is not consistent with R-values for commonly available 2" thick foam board made with EPS or XPS. Application of 1" of foam board does not require significant changes to construction techniques. Use of 2" foam board requires additional steps to adequately support exterior cladding, but can be done. Insulation thickness in excess of 2" become problematic for supporting exterior cladding, but is required to meet the R-value established in option 1c.

Option 1c was likely meant as an incentive to insulate with 2" of continuous foam board. Based on the additional steps required to support cladding with 2" of foam board and the number of energy credits offered, it makes sense to require higher R-value available with XPS for the option. To better align WSEC energy credits with commonly available building materials, option 1c should be R-10 to be consistent with insulation provided by 2" of XPS foam.

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.
- ☐ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☒ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name	Alan Nolan	Email address	alan@509.design
Your organization	Spokane Home Builders Assoc.	Phone number	509-847-4651
Other contact name	Kieran Sprague, 360-791-7462		

Economic Impact Data Sheet

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

The proposal will create incentives for increased use of continuous insulation techniques, which are not common in Washington's residential construction industry. Continuous insulation is extremely efficient means to increase insulation and can be done cost effectively if requirements better matched commonly available building materials.

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**)

$0/square foot (For residential projects, also provide $0/ dwelling unit)

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

No additional costs result from proposal, it corrects an error, so OFM cost analysis tool not included with proposal.

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

0 KWH/ square foot or 0 KWH / dwelling unit)

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

Proposal corrects an apparent error, energy savings are consistent with the current prescriptive option and simply align requirements with available building materials.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Proposal will not create any additional requirements for plan review or inspections.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R30

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # __R403_Systems__

Brief Description:

This is a policy addressing rooftop solar photovoltaic systems for new residential buildings.

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.)

SECTION R403.13 Photovoltaic Requirements. All new *residential buildings* shall have a photovoltaic (PV) system meeting the minimum qualification requirements as specified in Joint Appendix JA11, with annual electric output equal to or greater than the dwelling's annual electrical usage, as determined by:

1. The solar panel calculator on solar-estimate.org (https://www.solar-estimate.org/solar-panels-101/how-many-solar-panels-do-i-need#solar-panel-calculator)

   Exceptions:
   1. No PV is required if the effective annual solar access is restricted to less than 80 contiguous square feet by shading from existing permanent natural or manmade barriers external to the dwelling, including but not limited to trees, hills, and adjacent structures. The effective annual solar access shall be 70 percent or greater of the output of an unshaded PV array on an annual basis.
   2. PV sizes may be reduced by 25 percent if installed in conjunction with a battery storage system. The battery storage system shall meet the qualification requirements specified in Joint Appendix JA12 and have a minimum capacity of 7.5 kWh

Appendix JA11 – Qualification Requirements for Photovoltaic System

JA11.1 Purpose and Scope

Joint Appendix JA11 provides the qualification requirements for photovoltaic (PV) system to meet the system standards set forth in R403.13.

JA11.2 System Orientation

No PV systems or strings with module pitches greater than 2:12 or 10 degrees shall be installed outside of the azimuth range between 90 to 300 degrees measured clockwise from true north. If the PV array does not meet this orientation requirement, then the actual orientation of the PV array shall be described in the performance method.

JA11.3Shading

The PV array shall meet either JA11.3.1 or JA11.3.2.

JA11.3.1 Minimal Shading Criterion

The minimal shading criterion is that no obstruction is closer than a distance ("D") of twice the height ("H") it extends above the PV array. (See Figure JA11-1 for an artistic depiction of "H" and "D.") As Figure JA11-1 illustrates, the distance "D" must be at least two times greater than the distance "H." All obstructions that project above the point on the array that is closest to the obstruction shall meet this criterion for the array to be considered minimally shaded. Any obstruction located north of all points on the array need not be considered as shading obstructions. Obstructions that are subject to this criterion include:

(a) Any vent, chimney, architectural feature, mechanical equipment, or other obstruction that is on the roof or any other part of the building.
(b) Any part of the neighboring terrain.
(c) Any tree that is mature at the time of installation of the PV system.
(d) Any tree that is planted on the building lot or neighboring lots or planned to be planted as part of landscaping for the building. (The expected shading shall be based on the mature height of the tree.)
(e) Any existing neighboring building or structure.
(f) Any planned neighboring building or structure that is known to the applicant or building owner.
(g) Any telephone or other utility pole that is closer than 30 feet from the nearest point of the array.

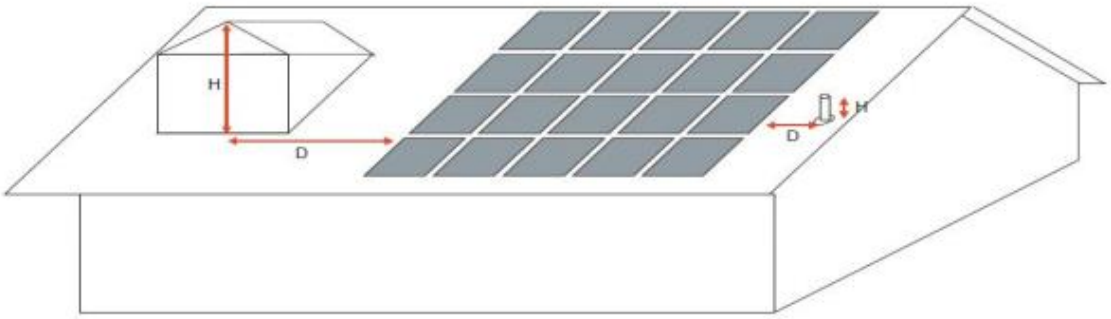


Figure JA11-1: The Minimal Shading Criterion Artistic Depiction of "H" and "D"

JA11.3.2 PV Array Geometries Performance Input
If the PV array does not meet the minimal shading criterion as specified in JA11.3.1, then the detailed geometries of the PV array shall be described in the performance method.

JA11.4 Solar Access Verification
The installer shall provide documentation that demonstrates the shading condition of the actual installation of the PV module is consistent with compliance with either JA11.3.1 or JA11.3.2 by one of the following methods:

a) Solar Assessment Tool. Use a solar assessment tool approved by the Executive Director to ascertain the extent of the shading conditions on the PV system from existing obstructions. At each measurement point, the tool placed on the PV array, leveled, and oriented consistent with the manufacturer's instructions.

Measurements shall be made at all the major corners of the array with no adjacent measurement being more than 40 feet apart. (See example in Figure JA12-2.) The points of measurement shall be distributed evenly between two major corners if they are more than 40 feet apart such that the linear distance between any sequential points is no more than 40 feet. However, if any linear edge of the array has no obstructions that are closer than two times the height they project above the closest point on the array, then the intermediate measurements along that edge do not need to be made.

The measurements shall be made either after the array has been installed or after the roof sheathing has been installed but prior to installation of the array. If the measurements are made

prior to actual installations, the location of the array shall be marked on the roof plans and the measurement points shall be located on the roof and the measurements shall be made. The location of the array shall be marked on the roof so that the actual installation is made consistent with the measurements. If the location of the array is changed during the construction process or new obstructions are introduced that did not exist at the time of the original measurements, the measurements will be re-determined after the actual installation.

b) Alternative Methods. Alternatively, for verification of solar access, the installer shall verify by an aerial satellite image(s), drone image(s), or other digital image(s) along with supporting documents showing the height of shading obstructions as well as the horizontal distance on the actual roof, and surrounding structures and trees, or by using an alternate method approved by the Executive Director to evaluate the solar access availability of the building location.

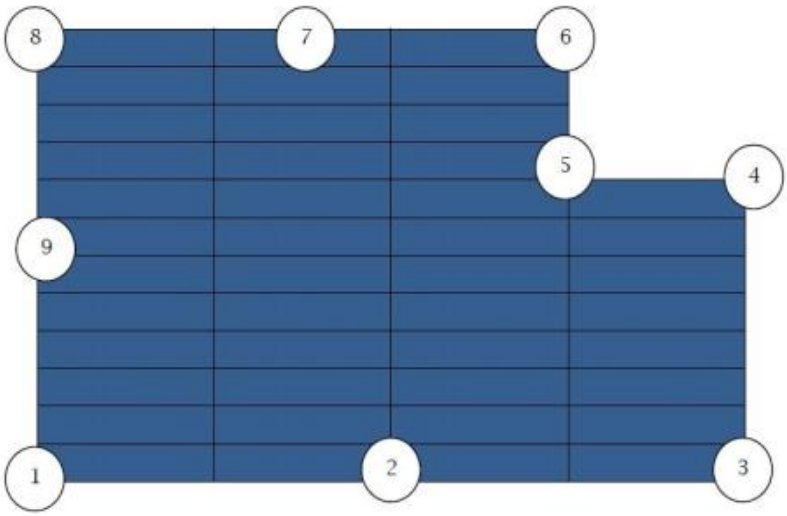


Figure JA12-2: Example of Points Where Measurement Shall Be Made Using a Solar Assessment Tool

JA11.5 System Monitoring Requirements

JA11.5.1 Remote Monitoring Capability

The PV system shall have a web based portal and a mobile device application that at a minimum provide the dwelling occupants access to the following information:

(a) The nominal kW rating of the PV system.
(b) Number of PV modules and the nominal watt rating of each module.
(c) Hourly (or 15 minute interval), daily, monthly, and annual kWh production in numeric and graphic formats.
(d) Running total of daily kWh production.
(e) Daily kW peak power production.
(f) Current kW production of the entire PV system.

Appendix JA12 – Qualification Requirements for Battery Storage System

JA12.1 Purpose and Scope

Joint Appendix JA12 provides the qualification requirements for battery storage system to meet the requirements for battery storage compliance credit(s) available in the performance standards set forth in R403.13 in combination with an on-site photovoltaic system. The primary function of the battery storage system is daily cycling for the purpose of load shifting, maximized solar self-utilization, and grid harmonization.

JA12.2 Qualification Requirements

To qualify as a battery storage system for use for compliance with applicable performance compliance credits, the battery storage system shall be certified to the Energy Commission to meet the following requirements:

JA12.2.1 Safety Requirements

The battery storage system shall be tested in accordance with the applicable requirements given in UL1973 and UL9540. Inverters used with battery storage systems shall be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement A.

JA12.2.2 Minimum Performance Requirements

The installed battery storage system should meet or exceed the following performance specification:

(a) Usable capacity of at least 5 kWh.

(b) Single Charge-discharge cycle AC to AC (round-trip) efficiency of at least 80 percent.

(c) Energy capacity retention of 70 percent of nameplate capacity after 4,000 cycles covered by a warranty, or 70 percent of nameplate capacity under a 10-year warranty.

JA12.2.3 Control Requirements

The requirements below are applicable to all control strategies.

(a) The battery storage system shall have the capability of being remotely programmed to change the charge and discharge periods.

(b) During discharge, the battery storage system shall be programmed to first meet the electrical load of the dwelling unit(s). If during the discharge period the electrical load of the dwelling unit(s) is less than the maximum discharge rate, the battery storage system shall have the capability to discharge electricity into the grid upon receipt of a demand response signal from the local utility or a third-party aggregator.

(c) The battery storage system shall operate in one of the control strategies listed in JA12.2.3.1, JA12.2.3.2, and JA12.2.3.3 except during a power interruption, when it may switch to backup mode. If the battery system switches to backup power mode during a power interruption, upon restoration of power the battery system shall immediately revert to the previously programmed JA12 control strategy.

(d) The battery storage system shall perform a system check on the following dates, to ensure the battery is operating in one of the control strategies listed in JA12.2.3.1, JA12.2.3.2, and JA12.2.3.3:

1) Within 10 calendar days before the onset of summer TOU schedule, and

Within 10 calendar days before the onset of winter TOU schedule. At the time of inspection, the battery storage system shall be installed to meet one of the following control strategies. The battery storage system also shall have the capability to remotely switch to the other control strategies.

JA12.2.3.1 Basic Control

To qualify for the Basic Control, the battery storage system shall be installed in the default operation mode to allow charging only from an on-site photovoltaic system when the photovoltaic system production is greater than the on-site electrical load. The battery storage system shall discharge only when the photovoltaic system production is less than the on-site electrical load.

JA12.2.3.2 Time-of-Use (TOU) Control

To qualify for the TOU Control, the battery storage system shall be installed in the default operation mode to allow charging from an on-site photovoltaic system. The battery storage system shall begin discharging during the highest priced TOU hours of the day. The operation schedule shall be preprogrammed from factory, updated remotely, or programmed during the installation/commissioning of the system. At a minimum, the system shall be capable of programming three separate seasonal TOU schedules, such as spring, summer, and winter.

JA12.2.3.3 Advanced Demand Response Control

To qualify for the Advanced Demand Response Control, the battery storage system shall be programmed by default as Basic Control as described in JA12.2.3.1 or TOU control as described in JA12.2.3.2. Additionally, the battery storage system shall have the capability to change the charging and discharging periods in response to signals from the local utility or a third-party aggregator.

Purpose of code change:

To harness abundant and clean solar energy through increased rooftop solar photovoltaic systems on new residential buildings. Rooftop solar decreases pollution and carbon emissions, saves homeowners money, increases grid resilience, and is cheaper to install at the time of the building's construction.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name *Chris Connolly*

Email address *cconnolly@environmentwashington.org*

Your organization *Environment Washington*

Phone number *(781) 367-1256*

Other contact name *Bruce Speight*

Economic Impact Data Sheet

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

Building owners would have an up-front average cost of $15,150 for a 5 KW system, but the payback period on that system is just 6.56 years, with a 20 year savings of $21,148. These estimates do not include the Federal Investment Tax Credit or any local incentives. The size of the system, and therefore the upfront cost to building owners, would vary by size of building, number of dwelling units, and energy use.

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

Costs/saving info from: https://www.energysage.com/solar-panels/solar-panel-cost/wa/
We're working on a more detailed analysis and will submit it as soon as possible.

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

We're working on a more detailed analysis and will submit it as soon as possible.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R31

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # **R402.4.1.2, R403.3.7, R405.3, R406, Chapter 6**

Brief Description: **This proposal differs from similar proposals being submitted in that it *further* increases the proposed number of additional energy efficiency credits required.**

This proposal updates Section R406 and requires additional energy efficiency credits. It also amends portions of the prescriptive code, as required, to support proposed revisions to Section R406.

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.)

R402.4.1.2 Testing. The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope. Once visual inspection has confirmed sealing (see Table R402.4.1.1), operable windows and doors manufactured by small business shall be permitted to be sealed off at the frame prior to the test.

Exception. For dwelling units that are accessed directly from the outdoors, other than detached one-family dwellings and townhouses, an air leakage rate not exceeding 0.4 cfm per ft2 of the dwelling unit enclosure area shall be an allowable alternative. Testing shall be conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals) in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827. Doors and windows of adjacent dwelling units (including top and bottom units) shall be open to the outside during the test. This exception is not permitted for dwelling units that are accessed from corridors or other enclosed common areas.

R403.3.7 Ducts located in conditioned space. For ducts to be considered as being located inside a conditioned space, such ducts shall comply with one of the following:

1) All duct systems shall be located completely within the continuous air barrier and within the building thermal envelope.
2) All heating, cooling and ventilation system components shall be installed inside the conditioned space, including but not limited to forced air ducts, hydronic piping, hydronic floor heating loops, convectors and radiators. Combustion equipment shall be direct vent or sealed combustion.
3) For forced air ducts: A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts is permitted to be located outside the conditioned space, provided they are insulated to a minimum of R-8.
   a) Metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic.
   b) If flex ducts are used, they cannot contain splices. Flex duct connections must be made with nylon straps and installed using a plastic strapping tensioning tool

R405.3 Performance-based compliance. Compliance based on simulated energy performance requires that a proposed residence (*proposed design*) be shown to have an annual energy consumption based on site energy expressed in Btu and Btu per square foot of *conditioned floor area* as follows:

1. For structures less than 1,500 square feet of conditioned floor area, the annual energy consumption shall be less than or equal to ~~80~~ **67** percent of the annual energy consumption of the *standard reference design*.
2. For structures 1,500 to 5,000 square feet of conditioned floor area, the annual energy consumption shall be no more than ~~72~~ **56** percent of the *standard reference design*.
3. For structures over 5,000 square feet of conditioned floor area, the annual energy consumption shall be no more than ~~66~~ **50** percent of the *standard reference design*.
4. ~~**Exception:**~~ For structures serving Group R-2 occupancies, the annual energy consumption shall be less than or equal to ~~85~~ 70 percent of the annual energy consumption of the *standard reference design*.

SECTION R406
ADDITIONAL ENERGY EFFICIENCY REQUIREMENTS

~~**R406.1 Scope.** This section establishes options for additional criteria to be met for one- and two-family dwellings and townhouses, as defined in Section 101.2 of the *International Residential Code*, and dwelling units in *residential buildings*, to demonstrate compliance with this code.~~

R406.1 Scope. This section establishes additional energy efficiency requirements for all new construction covered by this code including additions subject to section R502 and change of occupancy or use subject to section R505 unless specifically exempted in section R406

R406.2 Additional energy efficiency requirements ~~(Mandatory)~~. Each dwelling unit in a residential building shall comply with sufficient options from Table R406.2 so as to achieve the following minimum number of credits:

1. Small Dwelling Unit: .....~~1.5~~ **4.5** credits
   Dwelling units less than 1500 square feet in conditioned floor area with less than 300 square feet of fenestration area.
   Additions to existing building greater than 500 square feet of heated floor area but less than 1500 square feet.

2. Medium Dwelling Unit: ..... ~~3.5~~ **6.0** credits
   All dwelling units that are not included in #1, ~~or~~ #3, or #4.
   ~~**Exception:** Dwelling units serving R-2 occupancies shall require 2.5 credits.~~

3. Large Dwelling Unit: ..... ~~4.5~~ **7.0** credits
   Dwelling units exceeding 5000 square feet of conditioned floor area.
   ~~**Exception:** Dwelling units serving R-2 occupancies shall require 2.5 credits.~~

~~4. Additions less than 500 square feet: 0.5 credits~~

4. Dwelling units serving R-2 occupancies: …… 4.5 credits (from Group R-2 Credit column in Table R406.2)

5. Additions less than or equal to 500 square feet: … 1.5 credits

The drawings included with the building permit application shall identify which options have been selected and the point value of each option, regardless of whether separate mechanical, plumbing, electrical, or other permits are utilized for the project

TABLE 406.2 ENERGY CREDITS

OPTION	DESCRIPTION	CREDIT(S) (Single family and townhouse)	CREDIT(S) (Group R-2 Only)
1a	EFFICIENT BUILDING ENVELOPE 1a: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.28 Floor R-38 Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 5%.	0.5	N/A

1b	EFFICIENT BUILDING ENVELOPE 1b: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.25 Wall R-21 int plus R-4 ci Floor R-38 Basement wall R-21 int plus R-5 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 15%.	1.0	1.0
1c	EFFICIENT BUILDING ENVELOPE 1c: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.22 Ceiling and single-rafter or joist-vaulted R-49 advanced Wood frame wall R-21 int plus R-12 ci Floor R-38 Basement wall R-21 int plus R-12 ci Slab on grade R-10 perimeter and under entire slab Below grade slab R-10 perimeter and under entire slab **or** Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 30%.	2.0	1.5
1d~~ab~~	EFFICIENT BUILDING ENVELOPE 1d: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.24	0.5	0.5
1e	EFFICIENT BUILDING ENVELOPE 1e: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.18 Ceiling and single-rafter or joist-vaulted R-60 advanced Wood frame wall R-21 int plus R-16 ci Floor R-48 Basement wall R-21 int plus R-16 ci Slab on grade R-20 perimeter and under entire slab Below grade slab R-20 perimeter and under entire slab or Compliance based on Section R402.1.4: Reduce the Total conductive[a] UA by 40%.	3.0	2.0
1f[c]	EFFICIENT BUILDING ENVELOPE 1f: Prescriptive compliance is based on Table R402.1.1 with the following modifications: Vertical fenestration U = 0.20	1.0	1.0
2a	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2a: Compliance based on R402.4.1.2: Reduce the tested air leakage to 3.0 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.3 cfm/ft^2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a high efficiency fan (maximum 0.35 watts/cfm), not interlocked with the furnace fan (if present). Ventilation systems using a furnace including an ECM motor are allowed, provided that they are controlled to operate at low speed in ventilation only mode. To qualify to claim this credit, the building permit drawings shall specify the option being selected, ~~and shall specify~~ the maximum tested building air leakage, ~~and shall show~~ the qualifying ventilation system and its control sequence of operation.	0.5	1.0

2b	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2b: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 2.0 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.25 cfm/ft^2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of ~~0.70~~ 0.65. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	1.0	1.5
2c	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2c: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 1.5 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.20 cfm/ft2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of ~~0.85~~ 0.75. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	1.5	2.0
2d	AIR LEAKAGE CONTROL AND EFFICIENT VENTILATION 2d: Compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.6 air changes per hour maximum at 50 pascals Or For R-2 occupancies, optional compliance based on Section R402.4.1.2: Reduce the tested air leakage to 0.15 cfm/ft2 maximum at 50 pascals **and** All whole house ventilation requirements as determined by Section M1507.3 of the *International Residential Code* or Section 403.8 of the *International Mechanical Code* shall be met with a heat recovery ventilation system with minimum sensible heat recovery efficiency of 0.80. Duct installation shall comply with Section R403.3.7. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum tested building air leakage and shall show the heat recovery ventilation system.	2.0	2.5
3a~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3a: Energy Star Rated (U.S. North) Gas or propane ~~or oil-fired~~ furnace with minimum AFUE of ~~94%~~95%, or Energy Star Rated Gas or propane ~~or oiled-fired~~ boiler with minimum AFUE of ~~92%~~90% To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	1.0
3b~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3b: Air-source, centrally ducted heat pump with minimum HSPF of ~~9.0~~9.5 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	~~1.00~~0.5	N/A
3c~~b~~d,e	HIGH EFFICIENCY HVAC EQUIPMENT 3c: Closed-loop ground source heat pump; with a minimum COP of 3.3 **or** Open loop water source heat pump with a maximum pumping hydraulic head of 150 feet and minimum COP of 3.6 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.5	1.0

3d~~b~~d	HIGH EFFICIENCY HVAC EQUIPMENT 3d: Ductless Split System Heat Pumps, Zonal Control: In homes where the primary space heating system is zonal electric heating, a ductless heat pump system with a minimum HSPF of 10.0 shall be installed and provide heating to the largest zone of the housing unit. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	2.0
3e[d,e]	HIGH EFFICIENCY HVAC EQUIPMENT 3e: Air-source, centrally ducted heat pump with minimum HSPF of 11.0 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and the minimum equipment efficiency.	1.0	0.5
3f[d,e]	HIGH EFFICIENCY HVAC EQUIPMENT 3f: Ductless Split System Heat Pumps with no electric resistance heating in the primary living areas. A ductless heat pump system with a minimum HSPF of 10 shall be sized and installed to provide heat to entire dwelling unit at the design outdoor air temperature. To qualify to claim this credit, the building permit drawings shall specify the option being selected, the heated floor area calculation, the heating equipment type(s), the minimum equipment efficiency, and total installed heat capacity (by equipment type).	1.5	2.5
4	HIGH EFFICIENCY HVAC DISTRIBUTION SYSTEM: ~~All heating and cooling system components installed inside the conditioned space. This includes all equipment and distribution system components such as forced air ducts, hydronic piping, hydronic floor heating loop, convectors and radiators. All combustion equipment shall be direct vent or sealed combustion.~~ ~~For forced air ducts: A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts may be located outside the conditioned space. All metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic. If flex ducts are used, they cannot contain splices. Flex duct connections must be made with nylon straps and installed using a plastic strapping tensioning tool. Ducts located outside the conditioned space must be insulated to a minimum of R-8.~~ HVAC equipment and associated duct system(s) installation shall comply with requirements of Section R403.3.7 Locating system components in conditioned crawl spaces is not permitted under this option. Electric resistance heat and ductless heat pumps are not permitted under this option. Direct combustion heating equipment with AFUE less than 80% is not permitted under this option. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and shall show the location of the heating and cooling equipment and all the ductwork.	1.0	N/A
5a	~~EFFICIENT WATER HEATING 5a:~~ ~~All showerhead and kitchen sink faucets installed in the house shall be rated at 1.75 GPM or less. All other lavatory faucets shall be rated at 1.0 GPM or less.[c]~~ ~~To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the maximum flow rates for all showerheads, kitchen sink faucets, and other lavatory faucets.~~ EFFICIENT WATER HEATING 5a: A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 52% if installed for unequal flow. Such units shall be rated in accordance with CSA B55.1 and be so labeled. To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specifies the drain water heat recovery units and the plumbing layout needed to install it. Labels or other documentation shall be provided that demonstrates that the unit complies with the standard.	0.5	0.5

5b	EFFICIENT WATER HEATING 5b: Water heating system shall include one of the following: Energy Star Rated Gas or propane ~~or oil~~ water heater with a minimum ~~EF~~ UEF of ~~0.74~~ 0.8 ~~or~~ ~~Water heater heated by ground source heat pump meeting the requirements of Option 3c.~~ ~~or~~ ~~For R-2 occupancy, a central heat pump water heater with an EF greater than 2.0 that would supply DHW to all the units through a central water loop insulated with R-8 minimum pipe insulation.~~ To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	~~1.00~~0.5	0.5
5c	EFFICIENT WATER HEATING 5c: Water heating system shall include one of the following: Energy Star Rated Gas or propane ~~or oil~~ water heater with a minimum ~~EF~~ UEF of 0.91 **or** Solar water heating supplementing a minimum standard water heater. Solar water heating will provide a rated minimum savings of 85 therms or 2000 kWh based on the Solar Rating and Certification Corporation (SRCC) Annual Performance of OG-300 Certified Solar Water Heating Systems. **or** Water heater heated by ground source heat pump meeting the requirements of Option 3c. ~~or~~ ~~Electric heat pump water heater with a minimum EF of 2.0 and meeting the standards of NEEA's Northern Climate Specifications for Heat Pump Water Heaters.~~ To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency and, for solar water heating systems, the calculation of the minimum energy savings.	~~1.5~~1.0	1.0
5d	EFFICIENT WATER HEATING 5d: ~~A drain water heat recovery unit(s) shall be installed, which captures waste water heat from all the showers, and has a minimum efficiency of 40% if installed for equal flow or a minimum efficiency of 52% if installed for unequal flow. Such units shall be rated in accordance with CSA B55.1 and be so labeled.~~ ~~To qualify to claim this credit, the building permit drawings shall include a plumbing diagram that specifies the drain water heat recovery units and the plumbing layout needed to install it and labels or other documentation shall be provided that demonstrates that the unit complies with the standard.~~ Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier I of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier I of NEEA's Advanced Water Heating Specification, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	~~0.5~~1.5	2.0

5e	EFFICIENT WATER HEATING 5e: Water heating system shall include one of the following: Electric heat pump water heater meeting the standards for Tier III of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's Advanced Water Heating Specification, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	2.0	2.5
5f	EFFICIENT WATER HEATING 5f: Water heating system shall include one of the following: Electric heat pump water heater with a minimum UEF of 2.9 and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors. Equipment shall meet the standards of NEEA's Advanced Water Heating Specification. or For R-2 occupancy, electric heat pump water heater(s), meeting the standards for Tier III of NEEA's Advanced Water Heating Specification and utilizing a split system configuration with the air-to-refrigerant heat exchanger located outdoors, shall supply Domestic Hot Water to all units. If one water heater is serving more than one dwelling unit, all hot water supply and recirculation piping shall be insulated with R-8 minimum pipe insulation. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the water heater equipment type and the minimum equipment efficiency.	2.5	3.0
6	RENEWABLE ELECTRIC ENERGY: For each 1200 kWh of electrical generation per housing unit provided annually by on-site wind or solar equipment a 0.5 credit shall be allowed, up to 3 credits. Generation shall be calculated as follows: For solar electric systems, the design shall be demonstrated to meet this requirement using the National Renewable Energy Laboratory calculator PVWATTs or approved alternate by the Authority Having Jurisdiction. Documentation noting solar access shall be included on the plans. For wind generation projects designs shall document annual power generation based on the following factors: The wind turbine power curve; average annual wind speed at the site; frequency distribution of the wind speed at the site and height of the tower. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the photovoltaic or wind turbine equipment type, provide documentation of solar and wind access, and include a calculation of the minimum annual energy power production.	0.5	0.5
7	APPLIANCE PACKAGE: All of the following appliances shall be provided with the dwelling unit and shall meet the following standards: Dishwasher – Energy Star Rated Refrigerator – Energy Star Rated Washing Machine – Energy Star Rated Dryer – Energy Star Rated, ventless dryer with a minimum CEF rating of 5.2 To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall show the appliance type and provide documentation of Energy Star Compliance. At the time of inspection, all appliances shall be installed and connected to utilities. Dryer ducts and exterior dryer vent caps are not permitted to be installed in the dwelling unit.	0.5	1.0

a. Compliance with the conductive UA targets is demonstrated using R402.1.4 Total UA alternative where: [1-(Proposed UA/Target UA)] > the required % UA reduction.

b. Projects using this option may not use Option 1a, 1b, ~~or~~ 1c, 1e or 1f.

c. Projects using this option may not use Option 1a, 1b, 1c, 1d or 1e.

d. Projects may only include credit from one space heating option, 3a, 3b, 3c, ~~or~~ 3d, 3e or 3f. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.

~~e. **Plumbing Fixtures Flow Ratings.** Low flow plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements:~~

~~1. Residential bathroom lavatory sink faucets: Maximum flow rate - 3.8 L/min (1.0 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

~~2. Residential kitchen faucets: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

~~3. Residential showerheads: Maximum flow rate - 6.6 L/min (1.75 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.~~

e. An alternative heating source sized at a maximum of 0.5 Watts/ft^2 (equivalent) of heated floor area or 500 Watts, whichever is bigger, may be installed in the dwelling unit

Chapter 6 REFERENCED STANDARDS

CSA Canadian Standards Association 5060 Spectrum Way Mississauga, Ontario, Canada L4W 5N6

Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440—11	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	R402.4.3
CSA B55.1: 2015	Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units	Table R406.2

NEEA Northwest Energy Efficiency Alliance 421 SW 6th Ave, Suite 600 Portland, OR 97204

Standard reference number	Title	Referenced in code section number
~~NEEA 2011~~	~~Northern Climate Specification for Heat Pump Water Heaters, Vers. 4.0~~	~~Table R406.2~~
NEEA 2016	Advanced Water Heating Specification, Vers. 6.0	Table R406.2

Purpose of code change:

Incremental Improvements in Energy Efficiency consistent with RCW 19.27a.160.

SBCC has been directed by the Governor in Executive Order 14-4 to move the energy code forward more rapidly. Since these additional efficiency options have been shown to be cost effective, they should be adopted without further delay.

Change in Scope: New to 2018, low-rise multifamily now has dedicated credit values that more appropriately honor the energy savings potential for any given measure. For instance, domestic hot water energy consumption in multifamily represents a bigger portion of the total energy use compared to detached single family housing (20-25% compared to 14-18%, respectively), therefore a more efficient water heating system installed in the low-rise multifamily building will earn more credits under Table 406.2 than single family. Because this code covers low-rise multifamily, additions, as well as single family homes, energy conservation targets are specific to each of these unique construction types and credit values are representative of each building type. We have also added a few prescriptive code changes to strengthen and clarify the requirements set out in Section R406.

Consider clarifications and implementation changes: To provide clear enforceable code language, several editorial changes have been included. We have moved most of the language under option 4 into the base code to clarify requirements and make this section referable in other sections of the code. Low flow fixtures have been mandated through the legislature, therefore cannot be awarded as an energy credit under R406 – this has been eliminated from the table. Low-rise multifamily is now addressed as a unique building type, instead of being rolled up with single-family construction. Appliances are a newly proposed option in the table. As the total energy consumption of the residential sector drops with

each code cycle and since appliances have not been addressed in previous code cycles, this end-use represents a larger portion of the total energy consumption and as such, needs to be targeted as we approach 2031 goals.

Add New Efficiency Options: To continue to provide a diverse set of options for implementation, several new options have been added.

- Option 1e provides credit for 40% UA reduction
- Option 1f provides credit for higher performing triple pane glazing
- Option 2d allows credit for tighter envelope construction and highly efficient ERVs
- Option 3e provides credit for inverter-driven, variable speed compressors in central heat pumps
- Option 3f allows credit for homes with minisplit heat pump heating. Eliminating the majority of electric resistance heating leads to increased energy savings
- Options 5d, e, f are meant to more thoroughly cover available heat pump water heating technologies
- Option 7 gives credit for Energy Star rated appliances (primarily to ventless dryers)

Calculate Building Energy Use for the base code and section 406 options: The base code (prescriptive) changes made in 2015 and by the 2018 IECC additions, along with WA state law, are first assessed to determine the base energy use of the seven, modeled prototype buildings (representing the wide range of residential construction within the state). Based on this, the value of each credit is reassessed and if needed, reassigned. For example, WA state law now mandating low-flow fixtures reduces the savings potential from water heating equipment efficiencies – thus lowering their effective value, compared to previous years. The savings attributed to low-flow fixtures are not 'lost' in the analysis however, as the energy savings is now reflected in the 2018 baseline (prescriptive) energy use of the residential sector. Changes in prescriptive lighting requirements also lead to changes in the energy use between code cycles.

Assess the number of credits required to achieve the objectives of RCW 19.27a.160: This proposal is designed to meet the high-level goal of RCW 19.27a.160. This 2018 Section R406 code change proposal, along with other changes (lighting, low-flow fixtures), is expected to lead a 40% energy reduction over a 2006 WSEC compliant home. These savings are primarily attributed to the credits required to comply with code in Section R406.2.

Adjust the targets for systems analysis approach, section 405.3: The last step is to assess the performance-based approach. The targets have been reduced by an additional percentage.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☒ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

☒ Single family/duplex/townhome	☐ Multi-family 4 + stories	☐ Institutional
☒ Multi-family 1 – 3 stories	☐ Commercial / Retail	☐ Industrial

Your name	Duane Jonlin
Your organization	City of Seattle
Other contact name	Click here to enter text.
Email address	duane.jonlin@seattle.gov
Phone number	(206) 233-2781

Economic Impact Data Sheet

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

First cost and energy savings

First cost and energy savings estimates have been developed using an estimating procedure used by the Northwest Power and Conservation Council (NPCC). This method uses 6 prototype single family homes and one multi-family building to assess regional energy impacts. This includes: a 1344 sf rambler (crawl space and slab), a 2200 square foot rambler (crawl space and slab), a 2866 sf home with half basement, a 5000 sf home with a full basement, and a 820 sf multifamily dwelling unit (modeled a 3 story, exterior entry, low-rise building). For each building both cost and energy savings are estimated for each prototype and each measure.

First Cost: The first cost included in Tables 1 and 2 were developed using multiple sources of information:

- NPCC, the Regional Technical Forum (RTF), http://rtf.nwcouncil.org/ This is a federally mandated multi-state compact that develops the efficiency resources for the region's electric utilities
- Navigant is a business consulting firm which provides resource planning for both gas and electric utilities, including gas utilities in Washington State. http://www.navigant.com/industries/energy/
- CEE is the Consortium for Energy Efficiency. CEE is the US and Canadian consortium of gas and electric efficiency program administrators. http://www.cee1.org/
- This study also uses cost information provided to the SBCC by Ecotope

The cost of each option is included in Table 1 and 2. Cost are considered for 6 single family and 1 multi-family prototype. For single family prototypes, the crawlspace and slab variations have already been incorporated in the '1344sf' and 2200sf' prototypes – which is why only 4 cost numbers are shown.

Table 1: Total Measure Costs by Single Family Prototypes

			Prototypes Weight % by Floor Area			
			1344	2200	2688	5000
Option-Description	Credit Value	**Weighted Measure Cost**	15%	72%	11%	2%
1a - 5% UA reduc	0.5	**$ 1,102**	$ 767	$ 1,097	$ 1,667	$ 676
1b - 15% UA reduc	1	**$ 4,311**	$ 2,649	$ 4,565	$ 4,582	$ 6,127
1c - 30% UA reduc	2	**$ 7,947**	$ 4,869	$ 8,537	$ 7,609	$ 11,659
1d - U-.24 Glaze	0.5	**$ 1,583**	$ 907	$ 1,638	$ 1,818	$ 3,375
1e - 40% UA reduc	3	**$ 11,889**	$ 7,641	$ 12,925	$ 10,191	$ 15,828
1f - U-.20 Glaze	1	**$ 3,166**	$ 1,814	$ 3,276	$ 3,636	$ 6,750
2a - 3ACH , fan eff	0.5	**$ 517**	$ 349	$ 521	$ 618	$ 1,081
2b - 2 ACH, HRV	1	**$ 2,727**	$ 1,680	$ 2,750	$ 3,360	$ 6,250
2c - 1.5 ACH, HRV	1.5	**$ 6,108**	$ 3,763	$ 6,160	$ 7,526	$ 14,000
2d - 0.6 ACH, HRV	2	**$ 8,725**	$ 5,376	$ 8,800	$ 10,752	$ 20,000
3a - Furnace	1	**$ 230**	$ 230	$ 230	$ 230	$ 230
3b - 9.5 HSPF HP	0.5	**$ 1,270**	$ 1,270	$ 1,270	$ 1,270	$ 1,270
3c - GSHP	1.5	**$ 11,034**	$ 10,900	$ 10,900	$ 10,900	$ 17,600
3d - DHP	1	**$ 1,400**	$ 1,400	$ 1,400	$ 1,400	$ 1,400
3e - 11.0 HSPF HP	1	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
3f - DHP (15% elec)	1.5	**$ 5,400**	$ 5,400	$ 5,400	$ 5,400	$ 5,400
4 - HVAC inside	1	**$ 300**	$ 300	$ 300	---	---
5a - DWR	0.5	**$ 400**	$ 400	$ 400	$ 400	$ 400
5b - 0.80 gas DHW	0.5	**$ 586**	$ 586	$ 586	$ 586	$ 586
5c - 0.91 gas DHW, GSHP	1	**$ 923**	$ 923	$ 923	$ 923	$ 923
5d - Tier I HPWH	1.5	**$ 874**	$ 874	$ 874	$ 874	$ 874
5e - Tier III HPWH	2	**$ 874**	$ 874	$ 874	$ 874	$ 874
5f - Tier III HPWH Split	2.5	**$ 3,500**	$ 3,500	$ 3,500	$ 3,500	$ 3,500
6 - Solar pV	0.5	**$ 5,040**	$ 5,040	$ 5,040	$ 5,040	$ 5,040
7 - ES Appl+ventless Dryer	0.5	**$ 462**	$ 462	$ 462	$ 462	$ 462

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 2: Total Measure Costs for Multifamily prototype

Option-Description	Credit Value	Measure Cost
1a - 5% UA reduc	---	---
1b - 15% UA reduc	1	**$ 1,359**
1c - 30% UA reduc	1.5	**$ 2,615**
1d - U-.24 Glaze	0.5	**$ 554**
1e - 40% UA reduc	2	**$ 3,773**
1f - U-.20 Glaze	1	**$ 1,107**
2a - 3ACH , fan eff	1	**$ 245**
2b - 2 ACH, HRV	1.5	**$ 1,025**
2c - 1.5 ACH, HRV	2	**$ 2,296**
2d - 0.6 ACH, HRV	2.5	**$ 3,280**
3a - Furnace	1	---
3b - 9.5 HSPF HP	---	---
3c - GSHP	1	---
3d - DHP	2	**$ 2,800**
3e - 11.0 HSPF HP	0.5	---
3f - DHP (15% elec)	2.5	**$ 4,800**
4 - HVAC inside	---	---
5a - DWR	0.5	**$ 133**
5b - 0.80 gas DHW	0.5	---
5c - 0.91 gas DHW, GSHP	1	---
5d - Tier I HPWH	2	**$ 291**
5e - Tier III HPWH	2.5	**$ 291**
5f - Tier III HPWH Split	3	**$ 1,167**
6 - Solar pV	0.5	**$ 5,040**
7 - HP dryers, ES Appl	1	**$ 462**

Energy Savings Estimates

The energy savings estimates below have been developed using 6 single family and one multi-family prototype. For each building prototype, each predominant HVAC system (gas furnace, gas furnace with AC, central heat pump and Ductless heat pumps with zonal electric) was modeled and located in various weather climates within the state. The energy savings attributed to each option listed in Table 406.2 were then weighted to consolidate energy savings estimates for the 4 primary categories of homes in Section R406.2 (small, medium, large, and R-2 dwelling units). As shown in Table 1, large homes (greater than 5000sf) only compromise 2% of the total building stock – therefore energy savings estimates used for the Life Cycle Cost Analysis have been omitted from this economic analysis.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 3: Savings All Climates, All Systems

Savings are positive	Small Single Family (less than 1500sf)				Medium Single Family				Multifamily (R-2 occ)
	Gas Home		Central HP	Zonal Elec	Gas Home		Central HP	Zonal Elec	Zonal Elec
Option-Description	kWh	Therm	kWh	kWh	kWh	Therm	kWh	kWh	kWh
1a - 5% UA reduc	-5	25	212	477	-5	41	355	810	135
1b - 15% UA reduc	-6	57	516	1034	-5	100	908	1884	517
1c - 30% UA reduc	-11	99	891	1787	-12	169	1519	3194	898
1d - U-.24 Glaze	-2	17	150	315	-1	36	325	689	228
1e - 40% UA reduc	-27	135	1193	2419	-30	229	2024	4316	1172
1f - U-.20 Glaze	-6	29	253	541	-7	62	546	1185	391
2a - 3ACH , fan eff	52	14	177	313	52	43	440	905	475
2b - 2 ACH, HRV	-313	20	-92	-4	-313	56	231	767	939
2c - 1.5 ACH, HRV	-203	33	137	331	-204	75	520	1239	1284
2d - 0.6 ACH, HRV	-205	46	253	560	-205	100	737	1708	1533
3a - Furnace	0	41	---	---	0	77	---	---	---
3b - 9.5 HSPF HP	---	---	180	---	---	---	343	---	---
3c - GSHP	---	---	729	---	---	---	1301	---	---
3d - DHP	---	---	---	1835	---	---	---	3526	1132
3e - 11.0 HSPF HP	---	---	407	---	---	---	784	---	---
3f - DHP (15% elec)	---	---	---	1928	---	---	---	3700	1193
4 - HVAC inside	11	46	517	---	13	60	638	---	---
5a (5g) - DWR	0	17	322	322	0	19	368	368	265
5b - 0.74 gas DHW	0	22	---	---	0	24	---	---	---
5c - 0.91 gas DHW, GSHP	0	32	---	---	0	36	---	---	---
5d - Tier I HPWH	---	---	1236	1236	---	---	1393	1393	1038
5e - Tier III HPWH	---	---	1623	1623	---	---	1823	1823	1369
5f - Tier III HPWH Split	---	---	1836	1836	---	---	2064	2064	1547
6 - Solar pV	1262	---	1262	1262	1262	---	1262	1262	1262
7 - Appliances	840	---	840	840	840	---	840	840	612

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

See Table 3 for kWh/dwelling unit or therm/dwelling unit savings (savings values are positive)

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

This process is consistent with the current code. We do not anticipate additional enforcement cost.

Provide your best estimate of the construction cost (or cost savings) of your code change proposal?

See Table 4 for square foot cost of various measures. Also, see Table 1 and 2 for per dwelling unit cost of each measure, by prototype.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 4: Measure cost estimates ($/component area, SF or housing unit)

Component	Base Level	Measures Beyond Base Level	Cost $/ft2 or $/unit	Source
Envelope				
Ceiling	R-49	R-49 RH Ceiling Insulation	$ 0.20	ResSFEStarBuiltGreenHomesWA2014_v2_5.xlsm
Ceiling	R-49	R-60 RH Ceiling Insulation	$ 0.23	CERF
Wall	R-21 Std	R-21 int Wall + R4 Foam Sheathing	$ 0.96	RTF RESnew.xls 6th plan
Wall	R-21 Std	R-21 int Wall + R12 Foam Sheathing	$ 2.25	RTF RESnew.xls passiveHouse Consultant
Wall	R-21 Std	R-21 int Wall + R16 Foam Sheathing	$ 3.00	passiveHouse Consultant
Floor	R-30	R-38 Floor	$ 0.38	RTF-ResNCMTHouseID_v_3_0 .xlsm April 4, 2018; ShellCosts tab
Floor	R-30	R-48 Floor	$ 1.50	Assuming high density foam (R-6.inch) installed in std 12" joists
Slab	R-10 2' perim	Slab R-10 Full	$ 0.91	6th Plan Appendix G
Slab	R-10 2' perim	Slab R-20 Full	$ 1.22	NextStepHomes data
Window	U-0.30	Window U-0.28	$ 0.80	NPCC Standard workbook
Window	U-0.30	Window U-0.25	$ 4.50	NPCC Standard workbook
Window	U-0.30	Window U-0.24	$ 4.50	NPCC Standard workbook
Window	U-0.30	Window U-0.22	$ 6.60	NPCC Standard workbook
Window	U-0.30	Window U-0.18	$ 9.00	MF bids (tripleglaze-BidPrices.xl)
Air Sealing & Ventilation				
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 3 ACH50	$ 0.20	RTF Workbook. ResWXSF_FY10v2_1.xls passiveHouse consultant
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 2 ACH50	$ 0.50	
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 1.5 ACH50	$ 0.80	
ACH	Tested Infiltration at 5 ACH 50	Tested Infiltration to 0.6 ACH50	$ 1.50	
Exhaust Fan	Pt Source Exhaust Fan =0.75W/cfm	Pt Source Exhaust Fan <0.35W/cfm	$ 80.64	navigant 2013
ERV	No ERV	ERV with SHR>= 0.65	$ 0.75	Whispercomfort and minimal ducting
ERV	No ERV	ERV with SHR>= 0.75	$ 2.00	renewaire or lifebreath
ERV	No ERV	ERV with SHR>= 0.80	$ 2.50	high efficiency HRV with ducting (venmar, zhender)

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Component	Base Level	Measures Beyond Base Level	Cost $/ft2 or $/unit	Source
HVAC System				
Ducts	Code level is sealed	Ducts Inside	$ 300.00	NPCC Sixth Power Plan, Support documentation
Furnace	0.8	Furnace Upgrade to 94AFUE	$ 230.25	Navigant Sept 2011 Report for NEEP
Heat Pump	8.2 HSPF	9.5 HSPF	$ 1,270.00	NPCC Standard workbook, with linear regression
DHP	Zonal Resistance (MF)	1-ton single zone DHP	$ 2,800.00	Ecotope analysis of NEEA DHP pilot program database
11.0 DHP	8.2 DHP (SF)	1-ton single zone DHP	$1,400.00	Ecotope analysis of NEEA DHP pilot program database
Heat Pump	8.2 HSPF	11 HSPF	$ 5,400.00	3 ton unit. ResSFExistingHVAC
multizone 11.0 DHP	8.2 HSPF	10 HSPF efficiency with no electric resistance. Reduction in elec heat but higher tonnage	$5,400	Ecotope analysis of NEEA DHP pilot program database
Domestic Hot Water				
Water Htr	0.59 EF	Gas Water Heater >=0.80 EF	$ 586.00	NREL, 2013
Water Htr	0.59 EF	Gas Water Heater >=0.91 EF	$ 923.00	NREL, 2013
Water Htr	0.95 EF	Heat Pump Water Heater 2 EF	$ 874.00	RTF ResHPWH.xls
DWHR	none	Drain water heat recovery pipe	$ 400.00	RTF RESDHWDrainWaste.xls
Water Htr	0.95 EF	Tier 3 Water Heater 3 EF	$ 874.00	RTF ResHPWH.xls
Water Htr	0.95 EF	CO2 Water Heater 4 EF	$ 3,500.00	RTF ResHPWH.xls
Appliances				
Dryers, refr, dishwasher	Fed pre-empted	ventless dryers, ES appliances	$ 462.000	RTF-ResClothesDryers, ResRef, HD.com $420 for HP dryer, +$40 for Cloth washer, +$90 for refr

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R32

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # R401, R408 (new section)

Brief Description:

Add passive house certification (PHIUS and PHI) as high-level alternate compliance paths on the same level as the R405 Simulated Performance Alternative, as being sufficient to demonstrate energy code compliance without calculation of a standard reference design. These paths would be bolstered by some additional prescriptive requirements. Verification of the energy design based on plans and specifications would be required for permit, and final certification would be required for certificate of occupancy.

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.)

R401.2 Compliance. Projects shall comply with one of the following:

1. Sections R401 through R404.

2. Section R405. In addition, *dwelling units* and *sleeping units* in a *residential building* shall comply with Section R406.

3. Section R408 (certified passive house).

SECTION R408

CERTIFIED PASSIVE HOUSE

R408.1 General. Projects shall comply with R408.2 or R408.3

R408.2. Passive House Institute US (PHIUS): PHIUS+ 2018 Passive Building Standard, including its USDOE Energy Star and Zero Energy Ready Home co-requisites, and performance calculations by PHIUS-approved software. Projects shall also comply with the provisions of sections R401 through R404 formerly labeled "Mandatory", i.e., R401.3 Certificate, R402.2.9.1 Heated slab-on-grade floors, R402.4 Air leakage, R402.5 Maximum fenestration U-factor, R403.1 Controls, R403.1.2 Heat pump supplementary heat, R403.3.2 Sealing, R403.3.3 Duct testing, R403.3.4 Duct leakage, R403.3.5 Building cavities, R403.4 Mechanical system piping insulation, R403.5.1 Heated water circulation and maintenance system, R403.6 Mechanical ventilation, R403.7 Equipment sizing and efficiency rating, R403.8 Systems serving multiple dwelling units, R403.9 Snow melt system controls, R403.10 Pool and permanent spa energy consumption, R403.11 Portable spas, R404.1 and R404.1.1 Lighting equipment.

R408.2.1 PHIUS Documentation

1. Prior to the issuance of a building permit, the following items must be provided to the Building Official: A list of compliance features, and a PHIUS Pre-certification letter.

2. Prior to the issuance of a certificate of occupancy, the following item must be provided to the building official: A PHIUS+ 2018 (or later) project certificate.

R408.3. Passive House Institute (PHI): Low Energy Building Standard, version 9f or later, including performance calculations by PHI-approved software. Projects shall also comply with the provisions of Section R401 through R404.

R408.3.1 PHI Documentation

1. Prior to the issuance of a building permit, the following items must be provided to the building official: A list of compliance features, and a statement from a Passive House Certifier that the modeled energy performance is congruent with the plans and specifications, and that the modeled performance meets said standard.

2. Prior to the issuance of a certificate of occupancy, the following item must be provided to the building official: A PHI Low Energy Building project certificate.

Purpose of code change:

Supports progress towards the 70% building energy savings and zero-emission goals mandated by RCW 19.27A.160 and RCW 19.27A.020, by recognizing performance-focused passive-building approaches.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name Graham S. Wright

Your organization Shift Zero

Other contact name Poppy Storm

Email address poppy.storm@2050-institute.org, graham@passivehouse.us

Phone number 503 887 7028

Economic Impact Data Sheet

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

Passive house certifications represent a performance-based approach to energy savings, meaning that a number of different combinations of energy-saving measures are possible design choices – there is some design flexibility, as long as the modeled energy use of the proposed design is below the required levels. In contrast, the usual prescriptive approach may become awkward when reaching for deep energy savings, requiring overinvestment in some measures and underinvestment in others.

The main distinguishing feature of passive building standards is that there are separate performance criteria specifically on heating and cooling energy, as well as overall energy use. This makes for a particular focus on using passive measures to reduce heating and cooling loads, which are still the largest energy end-use for most residential buildings in most climates. In normal operation this tends to reduce the seasonal and daily fluctuation in the load on the utility and in outage situations it increases the resilience or passive-survivability of the building from a thermal comfort point of view.

For cold climates the "kit" of passive measures that works well together has been known for some decades now – superinsulation including multi-pane glazing and thermally-broken construction details, air-sealing, balanced ventilation with heat recovery, and any combustion appliances sealed. There are still some pitfalls though, and with a performance-standard approach it becomes important that the energy modeling is done correctly/consistently; this requires some training, and there is energy design work to be done on each project. Certification programs bring 3rd party verification of the energy design and model, and key aspects of the construction quality – such as the air-tightness and the moisture/vapor control.

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**)

$7.10/square foot (For residential projects, also provide $9800/ dwelling unit)

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

The initial cost estimates above are taken from a subset of the life-cycle cost optimization study that was done to set the PHIUS+ 2018 heating and cooling criteria (presentation slide deck attached for background). The cost data is from NREL's National Residential Efficiency Measures Database, as implemented in BEopt 2.8. A total of 300 cases were run in the PHIUS study, covering all North American climate zones, five building sizes from 1000-80000 square feet, and three occupant densities from 875 to 235 square feet per person. Fifteen of those cases happened to occur in Oregon, Washington, or British Columbia, and the numbers quoted above are simple averages of those cases.

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) 11 KBTU/ square foot

(For residential projects, also provide 19500 KBTU / dwelling unit)

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

The numbers entered above assume that what is being asked for here is the difference in site energy use (all end-uses) between WA state 2015 code and the proposal, possibly net of on-site renewables but not of off-site renewables. It also assumes that all projects would use the R408 alternate path; this is an exaggeration.

The assumptions about the 2015 WA code performance are taken from Ecotope's spreadsheet "WSEC2018_proposal_estsavings_weighting" with some additional unit conversions shown in the yellow highlight (see excerpt below in Table 1.) This shows that on a per square foot basis, there is not much difference between single-family and multifamily: 29.6±0.7 kBtu/sf.yr. On a per-unit basis the difference is much larger.

The data for the proposal's energy performance is again taken only from the NW subset of the PHIUS+ 2018 study. On a per square foot basis the site EUI averaged 18.6 kBtu/sf.yr from conservation measures alone (passive and equipment, no renewables). Thus the savings = 29.6 – 18.6 = about 11 kBtu/sf.yr.

The per-unit situation appears more uncertain, with the multifamily showing negative savings, 24872 – 27925 = -3053 kBtu/unit.yr and the single family positive savings 63022 – 20914 = 42108 kBtu/unit. Averaging those two gives the 19500 kBtu/unit entered above, but the uncertainty is something like ±100%.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

Table 1. 2015 WA code EUI benchmarks, by Ecotope.

code	btype	filter_base	Total energy use (kWh equiv)	Savings over 2015	Savings over 2006	heated floor area sf	Total site energy use per unit kBtu/sf	Total site energy use kBtu/sf	PHIUS Net site energy limit kBtu/sf
wa2006	mf	base	10363			820	35358	**43.1**	
wa2006	sf	base	27095			2181	92447	**42.4**	
wa2015	mf	base				820			
wa2015	mf	notbase	7289			820	**24872**	**30.3**	**12.4**
wa2015	sf	base				2181			
wa2015	sf	notbase	18471			2181	**63022**	**28.9**	**12.4**

Table 2. EUI data from NW subset of PHIUS+ 2018 Optimization Study_FINAL – Run list.

Run	Building	Occ nominal	Occ P/sf	Location [1]	Climate Zone	Notional iCFA	WUFI Passive Site Energy (kBTU/ft2.yr)	BEopt site energy kBtu/sf.yr	# units	WUFI Passive Site Energy per unit kBtu/yr	BEopt site energy per unit kBtu/yr	Initial cost premium $/sf	Initial cost premium $/unit
1	SF-duplex small	Lo	0.001003	PORTLAND/HILLSBORO OR	4C	997	16.31	18.75	1	16262	18690	$7.1	$7,095
2	SF-duplex small	Lo	0.001003	HANFORD WA	5B	997	19.56	22.25	1	19502	22180	$13.1	$13,075
60	SF-duplex small	Hi	0.004012	Comox Airp. BC	4	997	33.51	25.56	2	16706	12740	$12.4	$6,191
63	SF-duplex typcl	Lo	0.001109	PORTLAND/HILLSBORO OR	4C	1,803	13.2	9.75	1	23805	17590	$8.2	$14,736
64	SF-duplex typcl	Lo	0.001109	WHITE ROCK, BC	5	1,803	13.37	10.17	1	24111	18340	$10.1	$18,126
97	SF-duplex typcl	Md	0.002773	BURNS MUNICIPAL ARPT [UO] OR	6B	1,803	20.28	14.24	1	36573	25680	$10.7	$19,256
101	SF-duplex typcl	Hi	0.004436	Abbotsford A BC	5	1,803	27.16	17.89	2	24490	16130	$13.2	$11,864
											20914		
153	Townhomes	Md	0.002654	WENATCHEE/PANGBORN WA	5B	15,073	18.67	13.59	8	35177	25614	$4.7	$8,811
211	MF-Midrise	Md	0.002916	EPHRATA AP FCWOS WA	5B	32,920	21.41	21.14	32	22026	21753	$4.1	$4,229
228	MF-Midrise	Hi	0.004374	HANFORD WA	5B	32,920	30.22	29.41	48	20726	20167	$1.2	$827
247	MF-Highrise	Lo	0.000972	Abbotsford A BC	5	82,300	12.89	12.13	40	26521	24964	$4.3	$8,879
251	MF-Highrise	Lo	0.000972	PORTLAND/HILLSBORO OR	4C	82,300	13.45	12.31	40	27673	25327	$3.2	$6,509
256	MF-Highrise	Lo	0.000972	Comox Airp. BC	4	82,300	13.98	13.05	40	28764	26849	$3.5	$7,153
275	MF-Highrise	Md	0.002916	BURNS MUNICIPAL ARPT [UO] OR	6B	82,300	20.07	16.46	40	41294	33863	$6.7	$13,788
283	MF-Highrise	Hi	0.004374	Summerland, BC	6	82,300	27.26	20.91	60	37392	28683	$4.5	$6,201
							18.6			27925		$7.1	$9,783

Also attached are:
An additional draft comparison study of WA code to the earlier PHIUS+ 2015 standard, by TRC solutions.
Three case studies on WA code versus the original PHIUS+ (2012) and PHIUS+ 2015, by PHIUS.

Lastly, note that the PHIUS+ 2018 framework on total impact uses net source energy and credits both on-site and some off-site renewable energy options, including discounted RECs. The equivalent net site energy target (for an all-electric building) would be down around 12.4 depending on occupant density, so the "savings" including renewables would be closer to 17 kBtu/sf.yr, again if everyone used this path.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

Probably not long, 0.25 – 0.5 hours.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

BetterBuiltNW

Energy Performance Comparison: *Passive House Home & WA State Energy Code Home*

August 27, 2018

Introduction

This analysis was completed to compare the modeled performance of a passive house level single family home to a code compliant home in the Northwest. Passive house certification programs, such Passive House Institute US (PHIUS) have their own unique program requirements and performance targets that are not based on a code compliant home comparison. The intent of this analysis was to determine the performance of a passive house level home compared to code. As residential energy codes become more stringent, passive house construction is an optimal high performance path for utilities to achieve beyond code energy savings in the residential sector, especially as a pathway towards net zero energy homes.

This analysis focused on a single family home in Washington, in two different climate locations: Seattle (climate zone 4C) and Spokane (climate zone 5B). The 2015 Washington State Energy Code was referenced as the code baseline case. The passive house level home characteristics were based on the current trends of passive house construction in the Northwest, following the passive house certification requirements of PHIUS+ 2015.

The following sections describe the process and results involved in this analysis.

Process

The analysis involved the following steps:

Define prototype building characteristics

- This analysis used the small RTF prototype house for geometry and building configuration (1,344 sf single story home). Only one single prototype was selected in this analysis to reduce modeling runs. The small prototype home was selected because small homes encounter the largest challenge to achieve savings gains due to a larger percent of the energy use coming from appliances and with a smaller volume relative envelope area. As a result, the analysis of a small prototype home provides the most conservative savings assumption for a passive house level case.

Define model inputs for baseline code and passive house level case

- The baseline model inputs following the 2015 Washington State Energy Code were gathered from the User Defined Reference Home (UDRH) for “Washington, central HVAC configuration, <1,500 sf floor area” (WA Perf Path Central – Small.udr)[1]. This

[1] The 2015 Washington State residential energy code specifies minimum shell and HVAC requirements as well as “energy credit” requirements that can be met through various combinations of optional measures each assigned points (Table 406.2 Energy Credits). Homes under 1,500 sf must attain a total of 1.5 points. The UDRH file (WA Perf Path Central – Small.udr) used in this analysis assumes credit taken for Option 3b – High Efficiency HVAC Equipment (1 pt) and Option 5a – Efficient Water Heating (0.5 pt).

UDRH files was selected because the passive house level case assumes electric space heating with a ducted air source heat pump. Figure 1 summarizes the baseline and passive house level model inputs used in this analysis.

Category	Baseline Case: 2015 WA State Energy Code Compliant	Passive House PHIUS+ 2015 Case
General	Single-family 1 story detached homes, slab-on grade. 3 bedrooms, 4 occupants	Same as base
Building Form	CFA: 1,344 sf Volume: 10,752 cu ft	Same as base
Slab-on Grade Floor	R-10 perimeter insulation (U-0.1)	R-37 perimeter insulation (U-0.027)
Above Grade Wall	U-0.056 (equivalent R-18)	U-0.024 (equivalent R-42)
Roof/Attic	U-0.026 (equivalent R-38)	U-0.021 (equivalent R-45)
Windows	U-0.30, SHGC-0.30 15% glazing area	U-0.15, SHGC-0.50 15% glazing area
Door	R-3 (equivalent U-0.333)	Same as base
Infiltration/Air Tightness	5.0 ACH50	0.3 ACH50
Heating & Cooling	Ducted Heat Pump, HSPF 8.45 (COP-2.47), SEER 14.0	Ducted Heat Pump, HSPF 12.0 (COP-3.51), SEER 20.0
Ventilation	Exhaust Ventilation	Balanced Ventilation
Energy Recovery Ventilator	No ERV	ERV, 83% recovery efficiency
Domestic Hot Water	Conventional Storage Gas Water Heater, EF-0.60	Tankless Gas Water Heater, EF-0.87
Water Fixtures	1.75 GPM	Same as base
Lighting	75% high efficiency	100% high efficiency
Appliances	Refrigerator: 691 kWh Dishwasher: 0.46 EF Clothes Washer: 487 kWh Clothes Dryer (electric): 3.01	Same as base

Figure 1: Model Inputs

Create models in both REM/Rate and WUFI

- The baseline and passive house level home was modeled in two different energy modeling software: REM/Rate v15.3 and WUFI Passive V3.1.1.

    - REM/Rate is the required modeling software by the Northwest Modeling Requirements[2] to generate northwest utility approved savings estimates. These modeling protocols were used in REM/Rate modeling of the passive house level home.[3] The baseline was established using the UDRH file noted above.

    - WUFI Passive is one of the accepted and more widely used modeling software used for PHIUS+ 2015 certification. Modeling in WUFI aligned with energy modeling protocols established by PHIUS in the PHIUS+ 2015 Certification Guide Book[4]. A baseline case and passive house level case was each modeled in WUFI.

- Both the baseline and passive house level building components were modeled as closely to align in both REM/Rate and WUFI Passive, but given both are uniquely different software tool some discrepancies exist, as not all inputs exist in each software tool.

- REM/Rate and WUFI Passive baseline and passive house level models were analyzed in two Washington climate locations: Seattle (climate zone 4C) and Spokane (climate zone 5B). The model inputs for the baseline and proposed did not change. The 2015 Washington State Energy Code has two defined climate zones in state (4C and 5B[5]) and requires the same energy features for each climate zone. Only the location was revised to provide insight on the different savings opportunities with passive house level homes within the states two different climate zones.

[2] Northwest Modeling Requirements (Version 2017 draft 4)
[3] While the Northwest Modeling Requirements were referenced for modeling guidelines, the REM/Rate models were not processed in AXIS, where adjustments to end uses, such as lighting and appliances, are made for utility reported savings.
[4] PHIUS+ 2015 Certification Guidebook (Version 1.1)
[5] The 2015 WSEC defines two climate zones in the state 4C (marine) and 5B (dry). This differs from IECC which defines three climate zones (4C, 5B, and 6B)

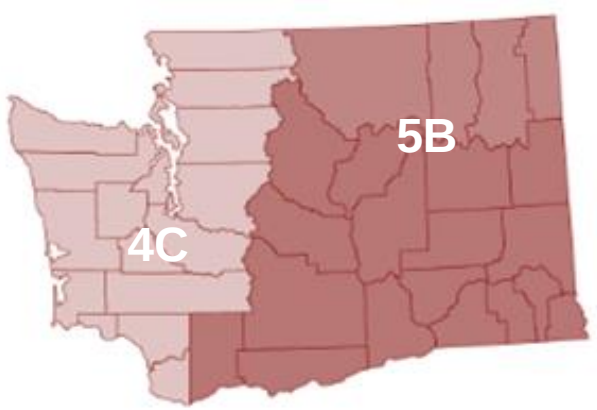


Figure 2: WA Climate Zone Map

- In total, eight (8) different model results were completed in this analysis, as summarized in Figure 3.

Modeling Software	Seattle	Spokane
REM/Rate	1 baseline code model 1 passive house level model	1 baseline code model 1 passive house level model
WUFI Passive	1 baseline code model 1 passive house level model	1 baseline code model 1 passive house level model
Total No. of Models	**4 models**	**4 models**

Figure 3: Summary of Models Developed

Compare results

- When all models were completed, the energy usage was gathered from each software's model output reports. This was compiled to determine the performance of a passive house level home compared to code across multiple software tool and climate zones, as summarized in Figures 4 through 9.

Results

The following results reflect the analysis completed in Seattle, WA (climate zone 4C).

SEATTLE, WA	REM/Rate			WUFI Passive		
	Baseline Code	Passive House	% Savings	Baseline Code	Passive House	% Savings
Heating (kBtu/sf/yr)	11.0	3.3	**70%**	9.6	2.5	**74%**
Cooling (kBtu/sf/yr)	0.8	0.9	**-13%**	0.7	1.6	**-111%**
Water Heating (kBtu/sf/yr)	10.8	6.0	**44%**	10.8	7.7	**28%**
Lighting (kBtu/sf/yr)	2.7	2.0	**26%**	1.8	1.3	**28%**
Appliances (kBtu/sf/yr)	12.1	12.1	**0%**	11.1	10.6[6]	**5%**
TOTAL SITE ENERGY (kBtu/sf/yr)	**37.4**	**24.4**	**35%**	**33.1**	**20.6**	**38%**

Figure 4: Seattle, WA Analysis Results

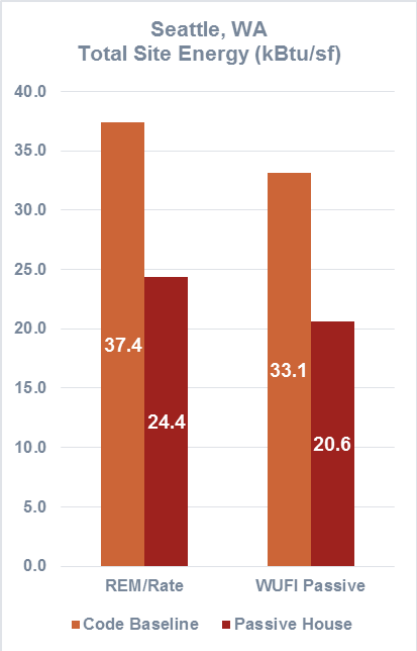


Figure 5: Site EUI (Seattle)

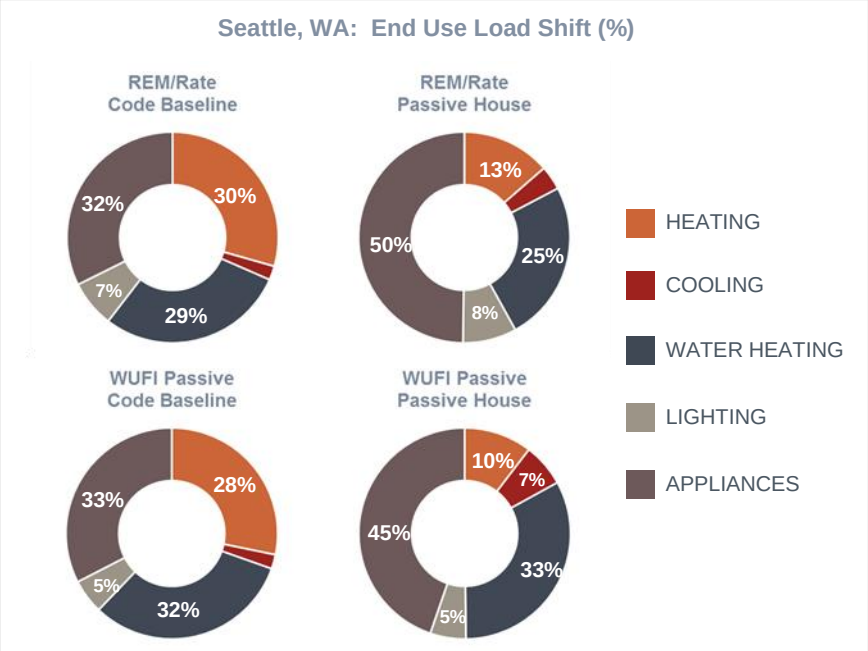


Figure 6: End Use Load Shifts (Seattle)

[6] In the WUFI model, the passive house case shows a slight decrease in appliance usage despite the appliances modeled the same as the baseline case. This slight decrease is attributed to appliances that use hot water including, dishwashers and clothes washers. Based on WUFI output reports, this is likely correlated to the hot water savings associated with the more efficient water heater that has impacts on appliance end uses in WUFI Passive output reports.

The following results reflect the analysis completed in Spokane, WA (climate zone 5B).

SPOKANE, WA	REM/Rate			WUFI Passive		
	Baseline Code	Passive House	% Savings	Baseline Code	Passive House	% Savings
Heating (kBtu/sf/yr)	27.6	6.0	**78%**	14.3	5.1	**64%**
Cooling (kBtu/sf/yr)	1.1	1.3	**-18%**	1.4	2.7	**-89%**
Water Heating (kBtu/sf/yr)	11.9	6.8	**43%**	11.0	7.7	**30%**
Lighting (kBtu/sf/yr)	2.7	2.0	**26%**	1.8	1.3	**28%**
Appliances (kBtu/sf/yr)	12.1	12.1	**0%**	11.1	10.6[7]	**5%**
TOTAL SITE ENERGY (kBtu/sf/yr)	**55.4**	**28.3**	**49%**	**38.0**	**21.8**	**42%**

Figure 4: Spokane, WA Analysis Results

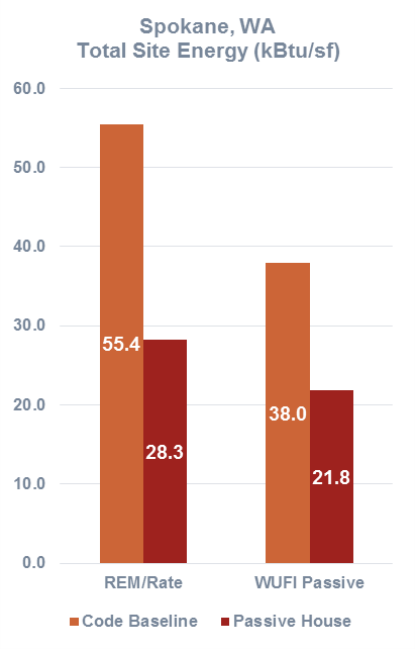


Figure 8: Site EU (Spokane)

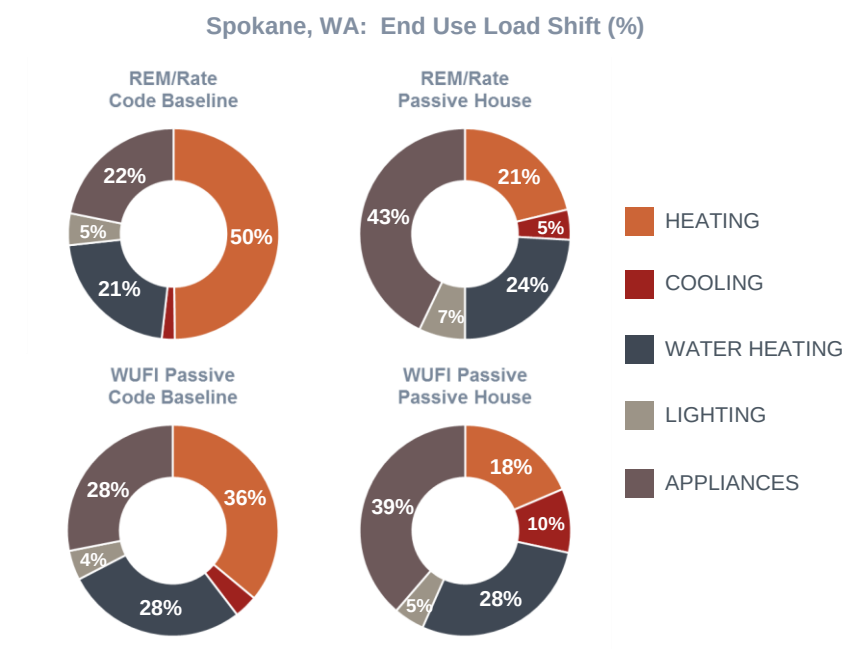


Figure 9: End Use Load Shift (Spokane)

[7] In the WUFI model, the passive house case shows a slight decrease in appliance usage despite the appliances modeled the same as the baseline case. This slight decrease is attributed to appliances that use hot water including, dishwashers and clothes washers. Based on WUFI output reports, this is likely correlated to the hot water savings associated with the more efficient water heater that has impacts on appliance end uses in WUFI output reports.

Results Analysis

- In Seattle, a passive house level home performs 35% above code when modeled in REM/Rate and 38% when modeled in WUFI Passive. *(Figure 4)*

- In Spokane, a passive house level home performs 49% above code when modeled in REM/Rate and 42% when modeled in WUFI Passive. *(Figure 7)*

- *Modeling Software Comparison*: The modeling results demonstrate the variability in the modeling software engines of REM/Rate and WUFI Passive. The heating load is highly variable in Spokane between the two software. The other end uses show similar agreement in Spokane and for all end uses in Seattle. WUFI Passive does reflect lower use generally across all end uses when compared to REM/Rate.

    - Both REM/Rate and WUFI Passive are both static modeling software that utilize annual average loads based on degree days, and are not based on hourly simulation.

    - Climate profiles for Seattle and Spokane may have slight variations between the two software and may impact a modeling results comparison.

    - While modeling inputs were aligned as closely as possible, each software has varying levels of inputs for similar components.
        - WUFI Passive has relatively simplistic inputs for the mechanical systems, appliances, water heating and lighting. The envelope inputs are more detailed, which aligns with the intent of passive house design to prioritize on the envelope.

        - REM/Rate, when compared to WUFI Passive, has more detailed inputs for mechanical systems.

- Passive house design focuses primarily on investing in a good building envelope. This reduces the heating load in the building. When compared to a code-compliant home, a passive house designed home results in significant heating load reductions.

    - In Seattle, the heating load of a code-compliant makes up about 28-30%[8] of the total home energy usage. In contrast, in a passive house home the heating load makes up about 10-13%[9] of the total home energy usage. *(Figure 6)*

[8, 9, 10, 11] Depending on the modeling software.

- In Spokane, the heating load of a code-compliant makes up on about 36-50%[10] of the total home energy usage. In contrast, in a passive house home the heating load makes up 18-21%[11] of the total home energy usage. *(Figure 9)*

- While the passive house's focus on a high performance envelope results in a significant reduction in space heating loads, it's worth noting the increase in cooling load. This is attributed to windows with a higher SHGC and a better insulated envelope that retains heat in the summer months.

    - Shading is a component more closely looked at in passive house level designs, but is often overlooked in most utility energy efficiency programs. The right balance of shading and window SHGC values could be investigated further to reduce the cooling load in the passive house case.

Key Conclusions

Based on this analysis the following conclusions can be made:

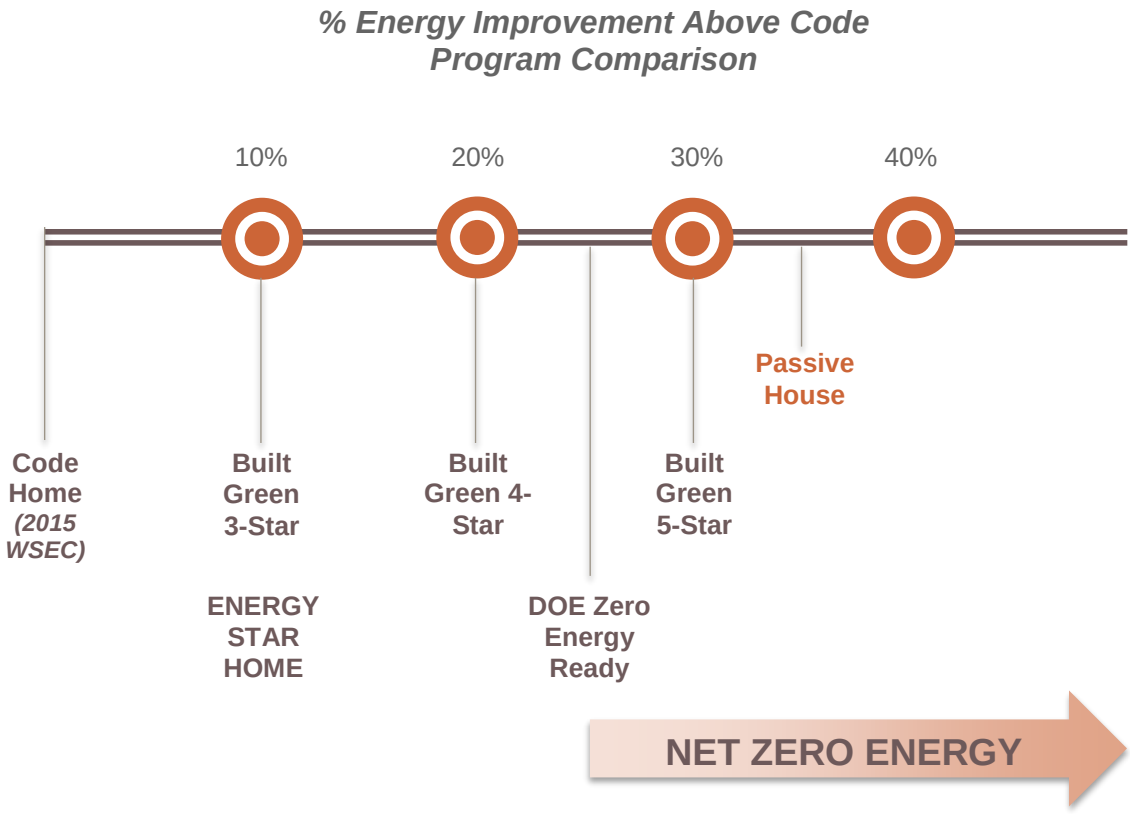


Figure 10: % Energy Improvement Above Code – Program Comparison

- The 2015 Washington State Energy Code is considered one of the country's more stringent residential energy codes. But with a passive house design, energy savings

opportunities still exist ranging from 35-45% savings over code. As residential energy codes become more stringent, passive house construction is an optimal high performance path for utilities to achieve beyond code energy savings in the residential sector.

- Reductions in heating load provide the largest savings opportunity for passive house level homes, however reductions in base loads for water heating and appliances must also be addressed as these loads then become the highest end uses of a home. If these loads are all electric, they can be offset by renewables to achieve a net zero level home. With this design approach, passive house homes serve as an optimal pathway to achieve net zero energy homes.
    - Figure 10 depicts where a Passive House level home lies compared to other certification programs when looking at energy improvement above code. A passive house design provides an ideal framework to reach net zero energy.

Run	Building	Occ nominal	Occ P/sf	Location [1]	Climate Zone	Notional iCFA	WUFI Passive Site Energy (kBTU/ft2.yr)	BEopt site energy kBtu/sf. yr	# units	WUFI Passive Site Energy per unit kBtu/yr	BEopt site energy per unit kBtu/yr	Initial cost premium $/sf	Initial cost premium $/unit	BEopt Baseline site energy consumption kBtu/sf.yr	Net present value $/sf
1	SF-duplex small	Lo	0.001003	PORTLAND/HILLSBORO OR	**4C**	997	16.31	18.75	1	16262	18690	$7.1	$7,095	33.7	$7
2	SF-duplex small	Lo	0.001003	HANFORD WA	**5B**	997	19.56	22.25	1	19502	22180	$13.1	$13,075	46.2	$9
60	SF-duplex small	Hi	0.004012	Comox Airp. BC	**4**	997	33.51	25.56	2	16706	12740	$12.4	$6,191	57.2	$28
63	SF-duplex typcl	Lo	0.001109	PORTLAND/HILLSBORO OR	**4C**	1,803	13.2	9.75	1	23805	17590	$8.2	$14,736	23.8	$30
64	SF-duplex typcl	Lo	0.001109	WHITE ROCK, BC	**5**	1,803	13.37	10.17	1	24111	18340	$10.1	$18,126	27.3	$69
97	SF-duplex typcl	Md	0.002773	BURNS MUNICIPAL ARPT [UO] OR	**6B**	1,803	20.28	14.24	1	36573	25680	$10.7	$19,256	39.9	$57
101	SF-duplex typcl	Hi	0.004436	Abbotsford A BC	**5**	1,803	27.16	17.89	2	24490	16130	$13.2	$11,864	46.4	$114
										20914					
153	Townhomes	Md	0.002654	WENATCHEE/PANGBORN WA	**5B**	15,073	18.67	13.59	8	35177	25614	$4.7	$8,811	33.4	$14
211	MF-Midrise	Md	0.002916	EPHRATA AP FCWOS WA	**5B**	32,920	21.41	21.14	32	22026	21753	$4.1	$4,229	45.8	$30
228	MF-Midrise	Hi	0.004374	HANFORD WA	**5B**	32,920	30.22	29.41	48	20726	20167	$1.2	$827	60.0	$25
247	MF-Highrise	Lo	0.000972	Abbotsford A BC	**5**	82,300	12.89	12.13	40	26521	24964	$4.3	$8,879	34.3	$2
251	MF-Highrise	Lo	0.000972	PORTLAND/HILLSBORO OR	**4C**	82,300	13.45	12.31	40	27673	25327	$3.2	$6,509	28.4	$3
256	MF-Highrise	Lo	0.000972	Comox Airp. BC	**4**	82,300	13.98	13.05	40	28764	26849	$3.5	$7,153	34.6	$3
275	MF-Highrise	Md	0.002916	BURNS MUNICIPAL ARPT [UO] OR	**6B**	82,300	20.07	16.46	40	41294	33863	$6.7	$13,788	45.3	$9
283	MF-Highrise	Hi	0.004374	Summerland, BC	**6**	82,300	27.26	20.91	60	37392	28683	$4.5	$6,201	51.9	$16
							18.6			27925		$7.1	$9,783	40.5	$28

[1] AAF - Army Airfield
AFB - Air Force Base
AMOS - Automatic Meteorological Observing Station
ANGB - Air National Guard Base
AUT - Automatic weather station?
AWOS - Automated Weather Observing Station
MCAS - Marine Corps Air Station
NAAS - Naval Auxiliary Air Station
NAS - Naval Air Station
SURFRAD - Surface Radiation station
USAF - United States Air Force

*Note: This project does not meet PHIUS+ 2015 source energy requirements, as shown below. Was certified under PHIUS+.

CASE 1: OWL HAVEN PASSIVE HOUSE PHIUS+ 2015		
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	2	
Dwelling Units	1	
Airtightness	0.020	cfm50/ft2.envelope
Airtightness	0.46	ACH50
Ventilation	Balanced	Balanced/Exhaust Only
Net Volume	12,652	ft3
iCFA	1543.8	ft2
Spec Heat Capacity	12.7	BTU/ft2.F
Building Envelope		
	IP	
Roof	80	R
Above Grade Walls	45	R
Slab on Grade	59	R
Suspended Floor	N/A	R
Opaque Doors	N/A	R
Operable Window	0.142	U-Whole Window
	0.106	U-glass
	0.167	U-frame
	0.580	SHGC
Operable	0.155	U-w
	0.120	U-glass
	0.200	U-frame
	0.320	SHGC
Fixed Window	0.139	U-Whole Window
	0.106	U-glass
	0.167	U-frame
	0.62	SHGC
Glass Door	0.144	U-Whole Door
	0.088	U-glass
	0.264	U-frame
	0.494	SHGC
Ventilation		
Kitchen	35	cfm continuous
Bathroom	24	cfm continuous
Average ventilation rate	78	cfm
Average ventilation rate	0.3	ACH
Exhaust dryer	N/A	cfm
Exhaust range hood	N/A	cfm
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	2	
Bedrooms	1	
Dishwasher	N/A	kWh/use
Clothes Washer	0.32	kWh/use
Clothes Dryer (electric exhaust)	3.5	kWh/use
Fridge/Freezer Combo	1.42	kWh/day
Cooking	0.25	kWh/use
Plug Loads (80% RESNET)	1509.5	kWh/yr
Interior Lighting (80% RESNET)	562	kWh/yr
Exterior/Garage Lighting (80% RESNET)	55	kWh/yr
Mechanical Systems		
Continuous Ventilation	0.92	% Recovery efficiency
Continuous Ventilation	N/A	% Humidity Recovery Efficiency
Fan Efficiency	0.58	W/cfm
Fan Efficacy	1.72	cfm/W
Electric Resistance Heating	1	Heating COP
Cooling	N/A	Cooling COP
Water Heating	89%	% efficiency
RESULTS		
Specific Site Energy	15.18	kBTU/ft2.yr
Site Energy	23435	kBTU/yr
Site Energy	6868	kWh/yr
% Savings over WA State	**42.3%**	

CASE 2 WA State Energy Code		
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	2	
Dwelling Units	1	
Airtightness	0.129	cfm50/ft2.envelope (= 0.4 cfm75/ft2))
Airtightness	2.99	ACH50
Ventilation	Exhaust Only	Balanced/Exhaust Only
Net Volume	12,652	ft3
iCFA	1543.8	ft2
Spec Heat Capacity	12.7	BTU/ft2.F
Building Envelope		
	IP	
Roof	49	R
Above Grade Walls	21+12CI	R
Slab on Grade	10 throughout	R
Suspended Floor	30	R
Opaque Doors	4.75	R
Fixed/Operable Window/Door	0.220	U-Whole Window
	0.220	U-glass
	0.220	U-frame
	0.220	SHGC (no requirement)
Operable	0.300	U-w
	0.300	U-glass
	0.300	U-frame
	0.500	SHGC (no requirement)
Ventilation		
Kitchen	100	cfm intermittent
Bathroom	50	cfm intermittent
Average ventilation rate	N/A	cfm
Average ventilation rate	N/A	ACH
Exhaust dryer	125	cfm (outside envelope)
Exhaust range hood	100	cfm (noted above)
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	2	
Bedrooms	1	
Dishwasher	1	kWh/use
Clothes Washer	0.32	kWh/use
Clothes Dryer (electric exhaust)	3.5	kWh/use
Fridge/Freezer Combo	1.42	kWh/day
Cooking	0.25	kWh/use
Plug Loads (80% RESNET)	1509.5	kWh/yr
Interior Lighting (80% RESNET)	562	kWh/yr
Exterior/Garage Lighting (80% RESNET)	55	kWh/yr
Mechanical Systems		
Intermittent Ventilation	0	% Recovery efficiency
Intermittent Ventilation	N/A	% Humidity Recovery Efficiency
Fan Efficiency	0.35	W/cfm
Fan Efficacy	2.86	cfm/W
Electric Resistance Heating	4	Heating COP
Cooling	N/A	Cooling COP
Water Heating	89%	% efficiency (incl. stor. & derating)
RESULTS		
Specific Site Energy	26.33	kBTU/ft2.yr
Site Energy	40648	kBTU/yr
Site Energy	11913	kWh/yr

PHIUS+ 2015 COMPARISON: OWL HAVEN PASSIVE HOUSE VS. WA STATE ENERGY CODE

NOTES:

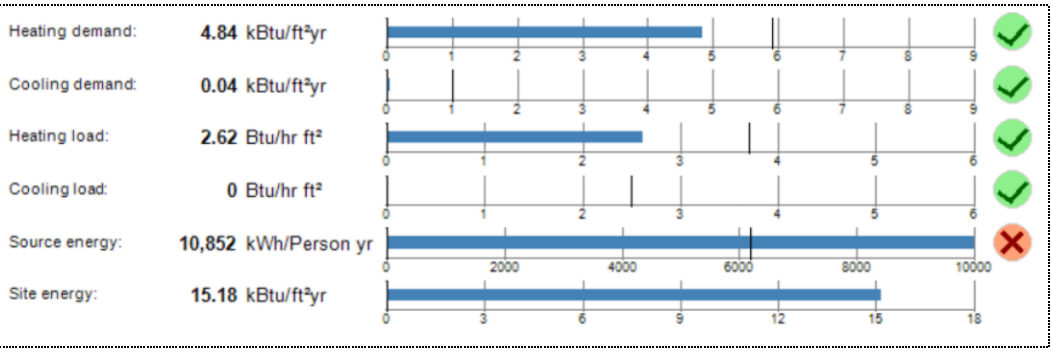
1. This project began construction in 2014, prior to the development of the PHIUS+ 2015 standard, and was certified to the PHIUS+ standard. The base case does not meet our current source energy criterion.

2. This project incorporates relatively typical space heating and hot water mechanical equipment; electric resistance space heating (baseboards, etc.), and a gas water heater were chosen. It seems as though this project team instead invested more heavily into an extremely highly insulated building envelope.

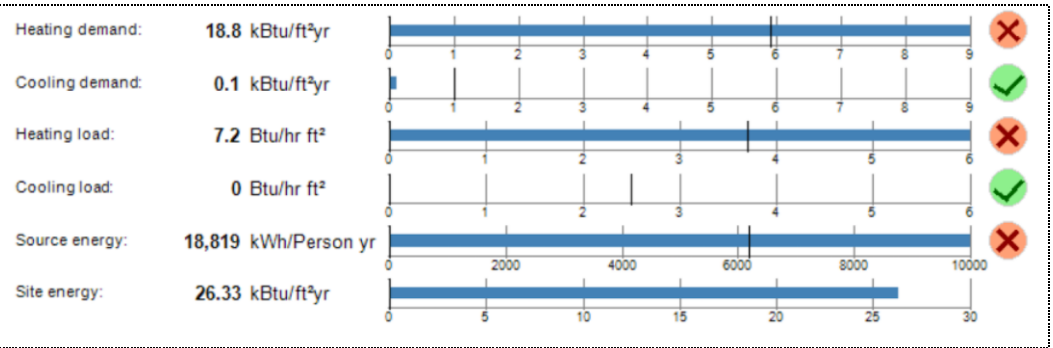
3. The high amount of insulation – under the slab and in the roof specifically – is likely not cost effective for this climate (27" of Cellulose in the roof, and 14" of EPS under the slab).

PROJECT PHOTO:

CASE 1 (PHIUS+ 2015): WUFI PASSIVE RESULTS



CASE 2 (WSEC): WUFI PASSIVE RESULTS



CASE 1: PALATINE PASSIVE HOUSE PHIUS+ 2015		
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	4	
Dwelling Units	1	
Airtightness	0.020	cfm50/ft2.envelope
Airtightness	0.3	ACH50
Ventilation	Balanced	Balanced/Exhaust Only
Net Volume	30,782	ft3
iCFA	2,493	ft2
Spec Heat Capacity	11	BTU/ft2.F

Building Envelope		
	IP	
Roof	62	
Above Grade Walls	45	R
Slab on Grade	N/A	R
Suspended Floor	55	R
Opaque Doors	N/A	R
Tilt Turn Window	0.121	U-Whole Window
	0.106	U-glass
	0.120	U-frame
	0.610	SHGC
Fixed Window	0.118	U-w
	0.106	U-glass
	0.120	U-frame
	0.610	SHGC
Glass Door	0.129	U-w
	0.106	U-glass
	0.13	U-frame
	0.61	SHGC
Awning Window	0.137	U-w
	0.106	U-glass
	0.13	U-frame
	0.61	SHGC

Ventilation		
Kitchen	30	cfm continuous
Bathroom	24	cfm continuous
Average ventilation rate	110	cfm
Average ventilation rate	0.21	ACH
Exhaust dryer	N/A	cfm
Exhaust range hood	N/A	cfm
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	4	
Bedrooms	3	
Dishwasher	1.3	kWh/use
Clothes Washer	0.28	kWh/use
Clothes Dryer (Condensation)	3.5	kWh/use
Fridge/Freezer Combo	1.02	kWh/day
Cooking	0.2	kWh/use
Plug Loads (80% RESNET)	2311	kWh/yr
Interior Lighting (80% RESNET)	816	kWh/yr
Exterior/Garage Lighting (80% RESNET)	65	kWh/yr
Mechanical Systems		
Continuous Ventilation	0.89	% Recovery efficiency
Continuous Ventilation	N/A	% Humidity Recovery Efficiency
Fan Efficiency	0.82	W/cfm
Fan Efficacy	1.22	cfm/W
Minisplit Heat Pump	3.5	Heating COP
Cooling	N/A	Cooling COP
Water Heating	89%	% efficiency
RESULTS		
Specific Site Energy	13.18	kBTU/ft2.yr
Site Energy	32858	kBTU/yr
Site Energy	9630	kWh/yr
% Savings over WA State	**42.5%**	

CASE 2 WA State Energy Code		
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	4	
Dwelling Units	1	
Airtightness	0.202	cfm50/ft2.envelope (= 0.4 cfm75/ft2))
Airtightness	3	ACH50
Ventilation	Exhaust Only	Balanced/Exhaust Only
Net Volume	30,782	ft3
iCFA	2,493	ft2
Spec Heat Capacity	11	BTU/ft2.F

Building Envelope		
	IP	
Roof	49	R
Above Grade Walls	21+12CI	R
Slab on Grade	1 (R10 for 24" perimeter)	R
Suspended Floor	38	R
Opaque Doors	4.75	R
Fixed/Operable Window/Door	0.220	U-Whole Window
	0.220	U-glass
	0.220	U-frame
	0.220	SHGC (no requirement)
Operable	0.300	U-w
	0.300	U-glass
	0.300	U-frame
	0.500	SHGC (no requirement)

Ventilation		
Kitchen	100	cfm intermittent
Bathroom	50	cfm intermittent
Average ventilation rate	N/A	cfm
Average ventilation rate	N/A	ACH
Exhaust dryer	125	cfm (outside envelope)
Exhaust range hood	100	cfm (noted above)
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	4	
Bedrooms	3	
Dishwasher	1.3	kWh/use
Clothes Washer	0.28	kWh/use
Clothes Dryer (electric exhaust)	3.5	kWh/use
Fridge/Freezer Combo	1.02	kWh/day
Cooking	0.2	kWh/use
Plug Loads (80% RESNET)	2311	kWh/yr
Interior Lighting (80% RESNET)	816	kWh/yr
Exterior/Garage Lighting (80% RESNET)	65	kWh/yr
Mechanical Systems		
Intermittent Ventilation	0	% Recovery efficiency
Intermittent Ventilation	N/A	% Humidity Recovery Efficiency
Fan Efficiency	0.35	W/cfm
Fan Efficacy	2.86	cfm/W
Heating	35%@4	Heating COP
Cooling	N/A	Cooling COP
Water Heating	89%	% efficiency (incl. stor. & derating)
RESULTS		
Specific Site Energy	22.91	kBTU/ft2.yr
Site Energy	57115	kBTU/yr
Site Energy	16739	kWh/yr

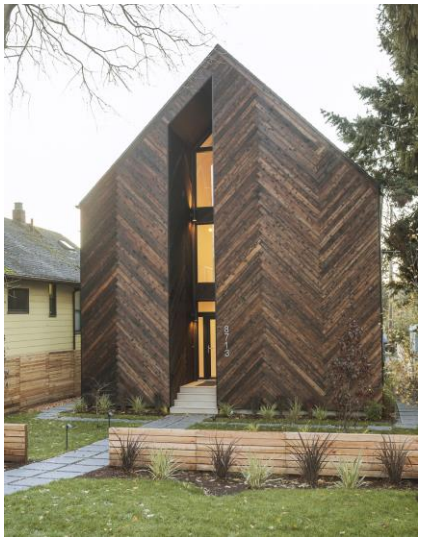
PHIUS+ 2015 COMPARISON: PALATINE PASSIVE HOUSE VS. WA STATE ENERGY CODE

NOTES:

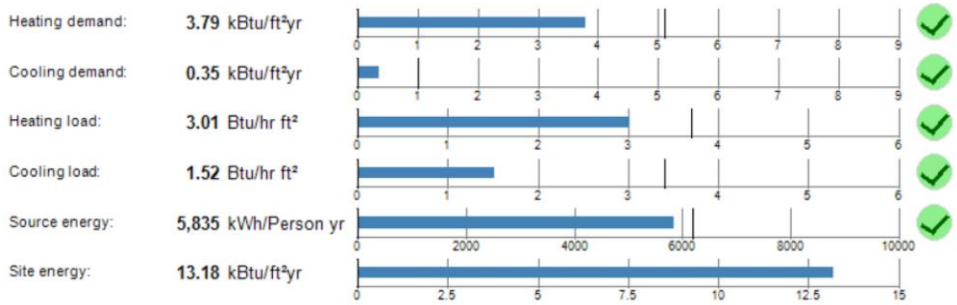
1. This project was certified to the PHIUS+ 2015 standard and all climate specific metrics were met, as is shown in the WUFI Passive results chart.

2. In general, this comparison was straightforward. There were no additional questions or assumptions made for Case 2 apart from altering the opaque assemblies, fenestrations, and mechanical systems as required by WSEC.

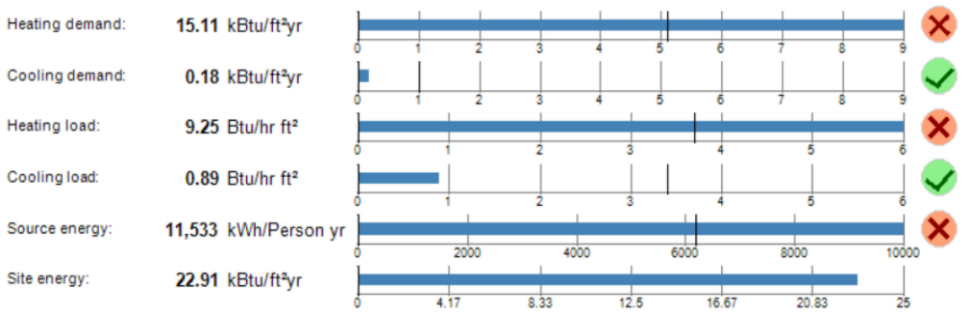
PROJECT PHOTO:



CASE 1 (PHIUS+ 2015): WUFI PASSIVE RESULTS



CASE 2 (WSEC): WUFI PASSIVE RESULTS



PHIUS+ 2018	**Approx WA criteria range**	*across climates, building sizes, and occupant density
	4.0 – 11.8	**Heating Demand (kBtu/ft2.yr)**
	0.0 – 9.8	**Cooling Demand (kBtu/ft2.yr)**
	2.2 – 10.2	**Heating Load (Btu/h.ft2)**
	1.5 – 5.8	**Cooling Load (Btu/h.ft2)**

			Floor Area (ft2)	2000			5000			10000			20000			50000			100000			200000		
			Occupancy	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low
Climate			Occupancy (persons)	9	4	2	21	11	6	43	22	11	85	44	23	213	111	57	426	222	114	851	444	229
			Envelope/iCFA	**3.095**			**2.388**			**1.963**			**1.613**			**1.245**			**1.023**			**0.841**		
	Criteria range		Occupancy (ft2/person)	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875	235	450	875
Olympia (typcl)	4.6 –	10.9	Heating Demand (kBtu/ft2.yr)	10.9	10.9	10.9	7.7	7.7	7.7	6.3	6.3	6.3	5.5	5.5	5.5	4.9	4.9	4.9	4.7	4.7	4.7	4.6	4.6	4.6
	0.0 –	6.7	Cooling Demand (kBtu/ft2.yr)	6.7	5.3	5.6	1.8	0.6	0.8	0.6	0.0	0.0	0.5	0.0	0.0	1.4	0.0	0.3	2.3	1.0	1.3	3.4	2.0	2.3
	2.2 –	6.1	Heating Load (Btu/h.ft2)	6.1	5.4	5.1	4.2	3.6	3.3	3.5	2.9	2.6	3.2	2.6	2.3	3.1	2.5	2.2	3.2	2.6	2.3	3.4	2.8	2.5
	1.5 –	4.5	Cooling Load (Btu/h.ft2)	4.5	4.3	4.2	2.8	2.5	2.4	2.1	1.9	1.8	1.9	1.7	1.5	1.9	1.7	1.6	2.1	1.9	1.7	2.3	2.1	1.9
Fairchild (cold)	5.3 –	11.8	Heating Demand (kBtu/ft2.yr)	11.8	11.8	11.8	8.5	8.5	8.5	7.1	7.1	7.1	6.2	6.2	6.2	5.6	5.6	5.6	5.4	5.4	5.4	5.3	5.3	5.3
	0.0 –	8.0	Cooling Demand (kBtu/ft2.yr)	8.0	6.6	6.9	2.7	1.4	1.6	1.1	0.0	0.1	0.8	0.0	0.0	1.4	0.0	0.3	2.2	0.8	1.1	3.1	1.8	2.1
	4.1 –	9.3	Heating Load (Btu/h.ft2)	9.3	8.6	8.4	6.9	6.3	6.0	5.9	5.3	5.0	5.4	4.8	4.5	5.1	4.5	4.2	5.0	4.4	4.1	5.0	4.4	4.1
	2.0 –	5.3	Cooling Load (Btu/h.ft2)	5.3	5.0	4.9	3.4	3.2	3.0	2.7	2.5	2.3	2.5	2.2	2.1	2.5	2.2	2.0	2.6	2.3	2.2	2.8	2.5	2.4
Hanford (warm)	4.0 –	9.0	Heating Demand (kBtu/ft2.yr)	9.0	9.0	9.0	6.2	6.2	6.2	5.1	5.1	5.1	4.4	4.4	4.4	4.1	4.1	4.1	4.0	4.0	4.0	4.1	4.1	4.1
	0.8 –	9.8	Cooling Demand (kBtu/ft2.yr)	9.8	8.5	8.8	4.3	3.0	3.3	2.6	1.2	1.5	2.1	0.8	1.1	2.6	1.2	1.5	3.3	1.9	2.2	4.2	2.8	3.1
	4.8 –	10.2	Heating Load (Btu/h.ft2)	10.2	9.5	9.3	7.7	7.1	6.9	6.7	6.1	5.8	6.1	5.5	5.2	5.8	5.2	4.8	5.7	5.1	4.8	5.7	5.1	4.8
	2.2 –	5.8	Cooling Load (Btu/h.ft2)	5.8	5.4	5.2	3.8	3.5	3.3	3.1	2.8	2.6	2.8	2.4	2.3	2.7	2.4	2.2	2.8	2.5	2.3	3.0	2.7	2.5

This summary table provides estimated savings between the WSEC 2015 code and current WSEC 2(
heat, whereas Single Family homes included gas furnace, heat pump, as well as zonal system mode

Savings are calculated as the difference between 2015 average energy use and 2018 average energ

code	btype	filter_base	alt_path	kwhequivuse_mean	thermsuse_mean	kwhuse_mean	Total energy use (kWh equiv)	Savings over 2015
wa2006	mf	base	FALSE	10363	28	9553	10363	
wa2006	sf	base	FALSE	27100	647	8135	27095	
wa2015	mf	base	FALSE	9250	25	8531		
wa2015	mf	notbase	FALSE	7289	0	7289	7289	
wa2015	sf	base	FALSE	22907	544	6961		
wa2015	sf	notbase	FALSE	18474	414	6332	18471	
wa2018	mf	base	FALSE	8979	24	8283		
wa2018	mf	notbase	FALSE	6274	0	6274	6274	14%
wa2018	sf	base	FALSE	22356	537	6630		
wa2018	sf	notbase	FALSE	16046	338	6147	16043	13%

)18 code proposal (as of March 2019). Note that WSEC 2018 was modeled using a single Multifamily prototype w
led in 6 different prototypes.

y use for code-compliant homes.

Savings over 2006	heated floor area sf	Total site energy use per unit kBtu/sf	Total site energy use kBtu/sf	PHIUS Net site energy limit kBtu/sf	PHIUS Net source energy limit kBtu/sf
	820	35358	**43.1**		
	2181	92447	**42.4**		
	820				
	820	**24872**	**30.3**	**12.4**	34.8
	2181				
	2181	**63022**	**28.9**	**12.4**	34.8
	820				
39%	820				
	2181				
41%	2181				

Building Type	Therm_savings
Multifamily	0
Single Family	76.56

ıith zonal

kWh_savings
1015.22
184.64

All Climate Zones	
	R-Value[a]
Fenestration U-Factor[b]	n/a
Skylight U-Factor	n/a
Glazed Fenestration SHGC[b,e]	n/a
Ceiling[k]	49[j]
Wood Frame Wall[g,m,n]	21 int
Mass Wall R-Value[i]	21/21[h]
Floor	30[g]
Below Grade Wall[c,m]	10/15/21 int + TB
Slab[d] R-Value & Depth	10, 2 ft

U-Factor[a]
0.30
0.50
n/a
0.026
0.056
0.056
0.029
0.042
n/a

*Note: This project does not meet PHIUS+ 2015 space conditioning requirements, as shown below. Was certified under PHIUS+.

CASE 1: VIEWHAUS 5

PHIUS+ 2015

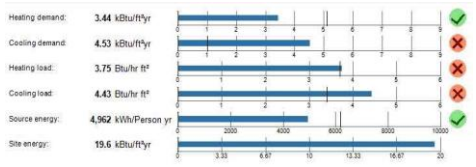
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	3	
Dwelling Units	1	
Airtightness	0.024	cfm50/ft2.envelope
Airtightness	0.5	ACH50
Ventilation	Balanced	Balanced/Exhaust Only
Net Volume	11,236	ft3
iCFA	1161.7	ft2
Spec Heat Capacity	11	BTU/ft2.F

Building Envelope		
	IP	
Roof 1	66	R
Roof 2	56	R
Above Grade Walls	46	R
Slab on Grade	N/A	R
Suspended Floor	40	R
Opaque Doors	N/A	R
Tilt Turn Window	0.132	U-Whole Window
	0.090	U-glass
	0.170	U-frame
	0.500	SHGC
Fixed Window	0.126	U-Whole Window
	0.106	U-glass
	0.12	U-frame
	0.500	SHGC

Ventilation		
Kitchen	36	cfm continuous
Bathroom 1	24	cfm continuous
Bathroom 2	26	cfm continuous
Average ventilation rate	71	cfm
Average ventilation rate	0.4	ACH
Exhaust dryer	N/A	cfm
Exhaust range hood	N/A	cfm
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	3	
Bedrooms	2	
Dishwasher	1.3	kWh/use
Clothes Washer	0.28	kWh/use
Clothes Dryer (clothesline)	N/A	kWh/use
Fridge/Freezer Combo	1.25	kWh/day
Cooking	0.2	kWh/use
Plug Loads (80% RESNET)	1286	kWh/yr
Interior Lighting (80% RESNET)	461	kWh/yr
Exterior Lighting (80% RESNET)	32	kWh/yr
Mechanical Systems		
Continuous Ventilation	0.89	% Recovery efficiency
Fan Efficiency	0.493	W/cfm
Fan Efficacy	2.03	cfm/W
Continuous Ventilation	N/A	% Humidity Recovery Efficiency
Mini Split Heat Pump	3.75	Heating COP
Cooling	3.75	Cooling COP
Water Heating	71%	% efficiency

RESULTS

Specific Site Energy	19.6	kBTU/ft2.yr
Site Energy	22769	kBTU/yr
Site Energy	6673	kWh/yr
% Savings over WA State	47.2%	



CASE 2

WA State Energy Code

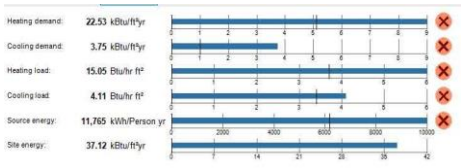
General Building Info		
	IP	
Heating Setpoint	68	F
Cooling Setpoint	77	F
Occupants	3	
Dwelling Units	1	
Airtightness	0.308	cfm50/ft2.envelope (equivalent value to 0.4 cfm75/ft2))
Airtightness	3.59	ACH50
Ventilation	Exhaust Only	Balanced/Exhaust Only
Net Volume	11,236	ft3
iCFA	1161.7	ft2
Spec Heat Capacity	11	BTU/ft2.F

Building Envelope		
	IP	
Roof	49	R
Above Grade Walls	21	R
Slab on Grade	N/A	R
Suspended Floor	30	R
Opaque Doors	4.75	R
Fixed/Operable Hybrid Window	0.300	U-Whole Window
	0.300	U-glass
	0.300	U-frame
	0.500	SHGC (no requirement)

Ventilation		
Kitchen	100	cfm intermittent
Bathroom	20	cfm intermittent
Average ventilation rate	3	cfm intermittent
Average ventilation rate	0.01	ACH
Exhaust dryer	125	cfm (outside envelope)
Exhaust range hood	100	cfm (noted above)
Thermal Bridges		
Internal Loads/Occupancy		
Occupancy	3	
Bedrooms	2	
Dishwasher	1.3	kWh/use
Clothes Washer	0.28	kWh/use
Clothes Dryer (clothesline)	N/A	kWh/use
Fridge/Freezer Combo	1.25	kWh/day
Cooking	0.2	kWh/use
Plug Loads (80% RESNET)	1286	kWh/yr
Interior Lighting (80% RESNET)	461	kWh/yr
Exterior Lighting (80% RESNET)	32	kWh/yr
Mechanical Systems		
Intermittent Ventilation	N/A	% Recovery efficiency
Fan Efficiency	0.714	W/cfm
Fan Efficacy	1.40	cfm/W
Intermittent Ventilation	N/A	% Humidity Recovery Efficiency
Heating	1	Heating COP
Cooling	N/A	Cooling COP
Water Heating	89%	% efficiency (incl. storage & 0.92 derating)

RESULTS

Specific Site Energy	37.12	kBTU/ft2.yr
Site Energy	43122	kBTU/yr
Site Energy	12638	kWh/yr



NOTES:

1. This project began construction in 2014, prior to the development of the PHIUS+ 2015 standard.

2. The annual cooling demand and peak cooling loads are noticeably higher in these cases. This is partially due to the dwelling type itself, which is part of a multifamily housing complex with an adjacent, non-certified unit. These project types typically see higher internal heat gains than those of a single-family nature.

3. There was a discrepancy between the provided energy model and floor plans with regard to the type of clothes dryer. We were unable to resolve this, so assumed 3.5 kWh/Use for each case.

4. Compared to the Owl Haven and Palatine projects, lower energy savings were found. This is expected for this project type in a cold climate for reasons mentioned above.

PHIUS

Passive House Institute US

Webinar: PHIUS+ 2018: The Standard Updated

SELF REPORT AT *phius.org/cphc/self-report*

PH CPHC®

This session qualifies for 1 CPHC CEU, 1 AIA LU|HSW

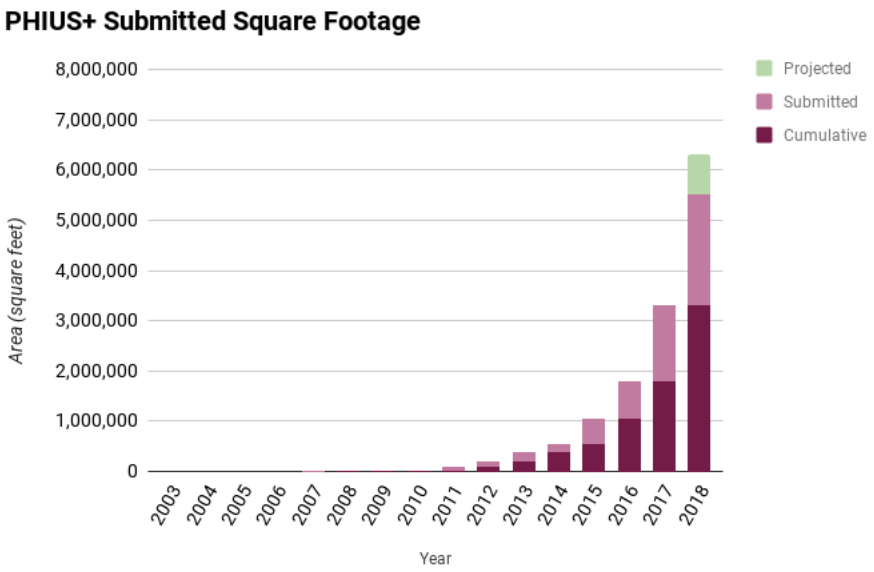
PHIUS+ 2018

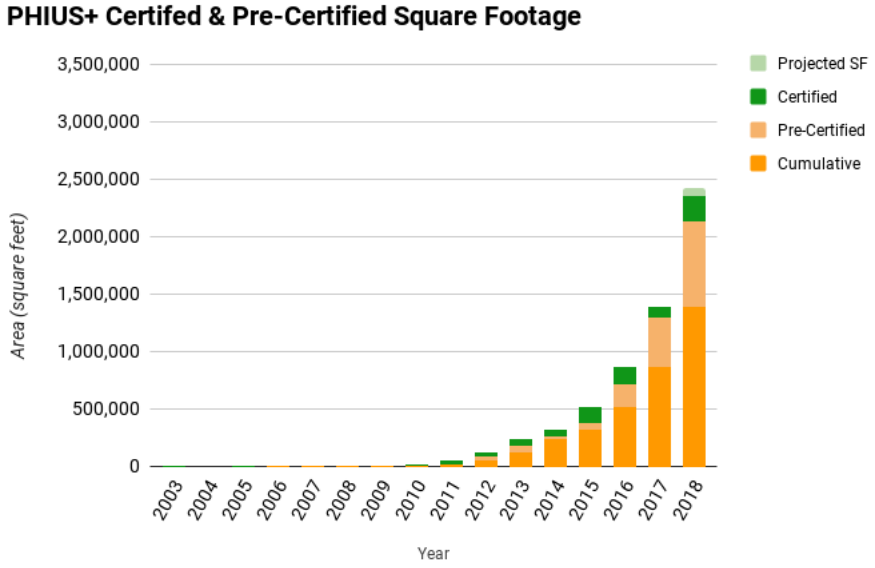
A Rational Exuberance for Passive Building

Graham S. Wright, Ph.D.
Lisa White, M.Sc.

PHIUS+ PROJECT CERTIFICATION

By the numbers





Why certify? It shares the knowledge:

- Of how to do this
- That anything is happening

Overview

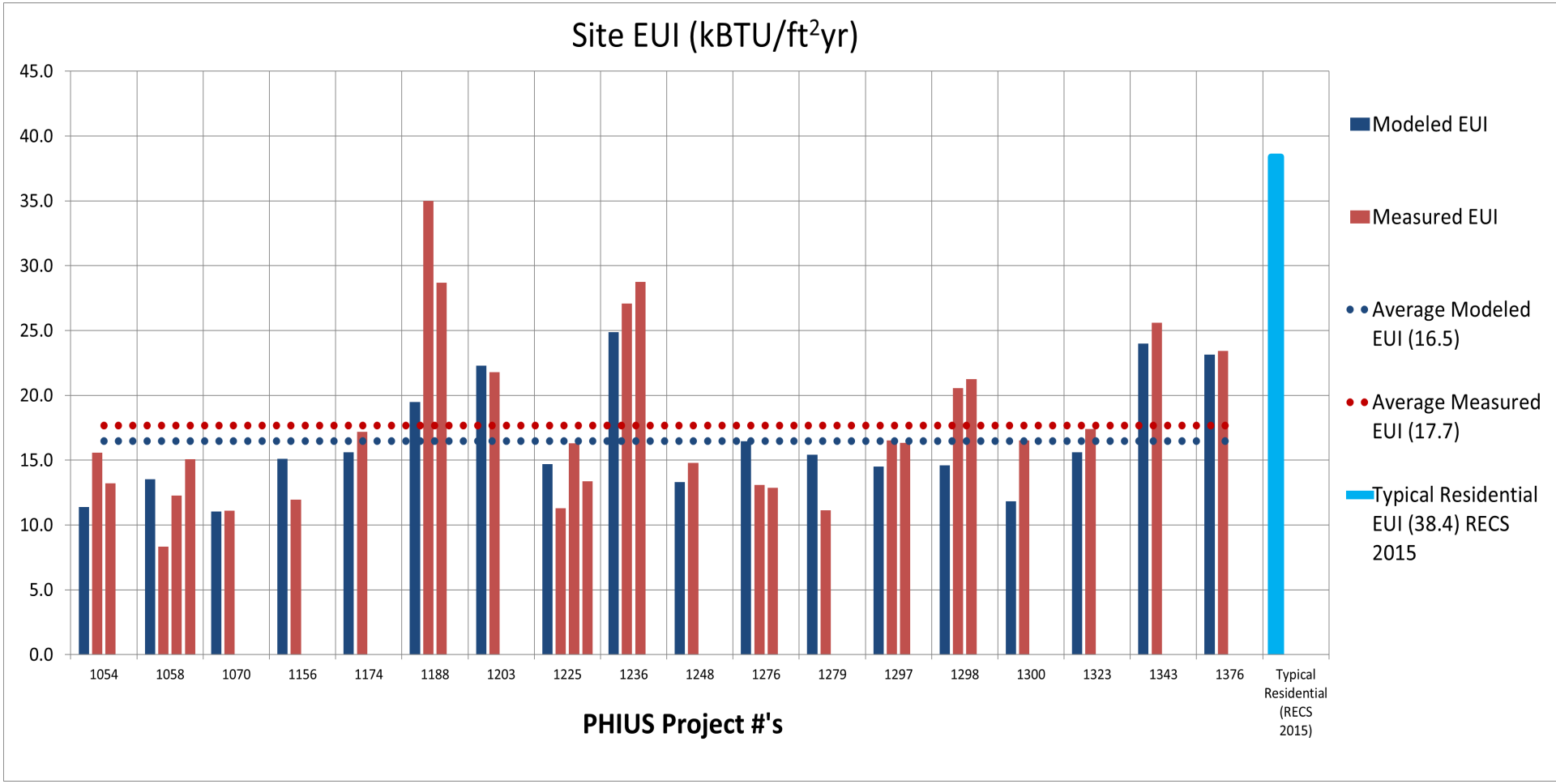
- Remembering the heart of this.

- “Architecture” of, and principles of, the standard.
- How the performance criteria were set.
- What we’ll work on next.

- In conclusion: Game over for the climate?

  The game is never over.

93% Modeled vs Measured



USA TODAY NEWS SPORTS LIFE

ACHIEVING

GLOBAL CLIMATE ACTION SUMMIT

HOME ABOUT PRESSROOM CHALLENGES PAR

19 GLOBAL CITIES COMMIT TO MAKE NEW BUILDINGS "NET-ZERO CARBON" BY 2030

Aug 23, 2018 | Feature, Pressroom, Summit News

Across the country, US
targets under the accord

STILL PASS/FAIL

Three pillars

- Heating and Cooling performance criteria
  - tied to economic feasibility
  - New for 2018 – sensitive to building size & occupancy.
- Overall source energy use criteria
  - tied to global CO2 emission ‘budget’
  - New for 2018 – more stringent, but off-site renewables allowed.
- Quality assurance and commissioning requirements – 3rd party verification.
  - New for 2018 – Nonresidential commissioning requirements.

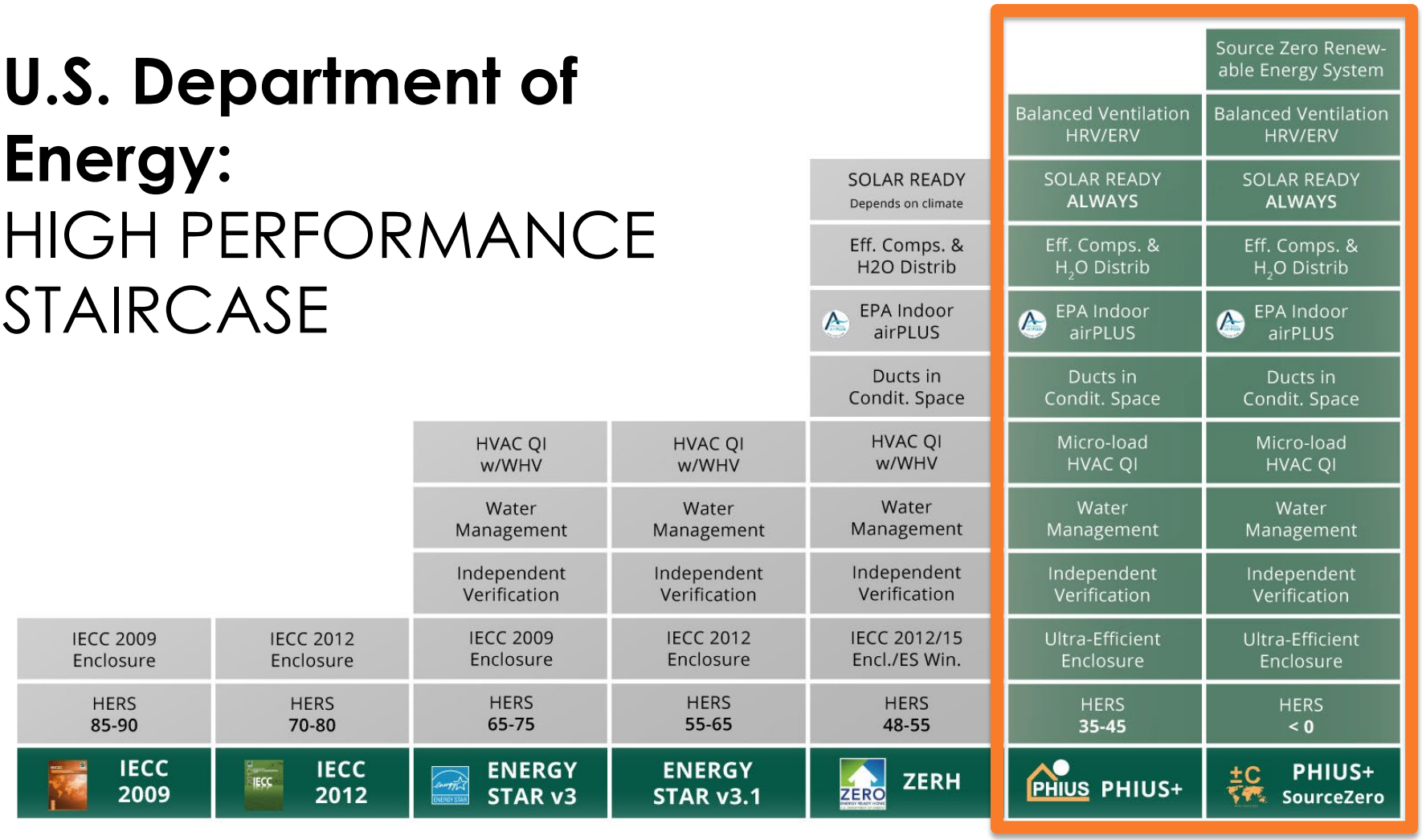
Quality & Commissioning

As in 2015

- Whole-building air-tightness.
- EPA Indoor airPLUS, e.g.:
  - Materials*,
  - no ethanol fireplaces,
  - no building cavities used as ducts…
- DOE ZERH and Energy Star v3, e.g.:
  - ducts inside,
  - water management checklist…
- Moisture-managed assemblies (vapor control).
  - Window condensation resistance.
- Ventilator commissioning.

"The Hands"

U.S. Department of Energy:
HIGH PERFORMANCE STAIRCASE



Nonresidential commissioning

New for 2018

- The process will be comprehensive of USGBC's LEED requirements for basic level commissioning.
  - Supports dual certification
- Provider requirements
  - Two projects experience, or certification from CPMP, BCxP, ACG.
- Procedures follow either:
  - ASHRAE Standard 202 – 2013
  - NEBB Procedural Standards for Whole Building Systems Commissioning for New Construction

Nonresidential commissioning – scope of requirements

- Systems manual for building operators
- Hot water systems
- Heating/Cooling systems
- Ventilation systems
- Envelope systems
- Fenestration systems
- Lighting
- Process loads

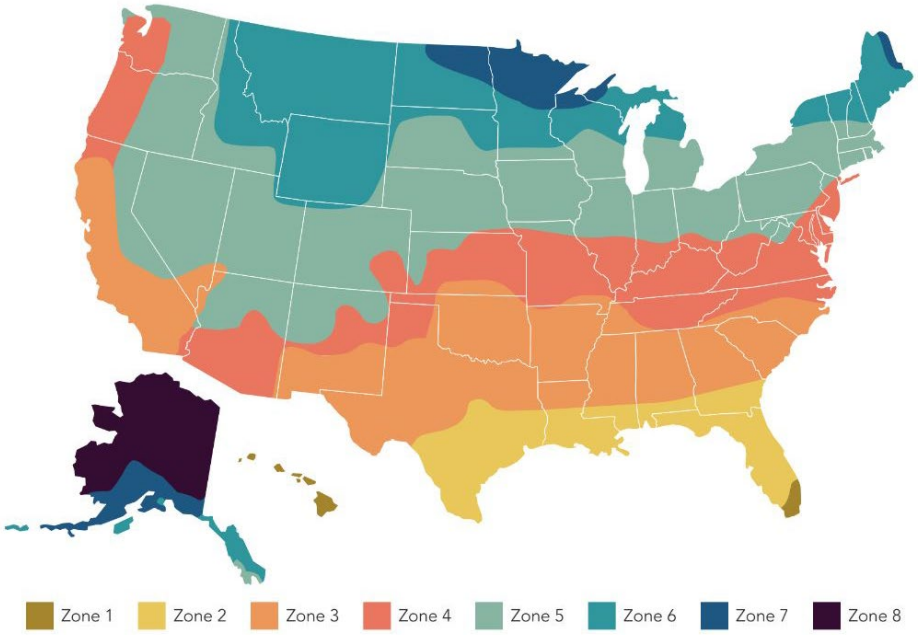
SPACE CONDITIONING

MUST MEET ALL 4 TARGETS!

- Annual Heating Demand ≤ A (kBTU/ft2.yr)
- Annual Cooling Demand ≤ B (kBTU/ft2.yr)
- Peak Heating Load ≤ C (BTU/ft2.hr)
- Peak Cooling Load ≤ D (BTU/ft2.hr)

<u>Different advantages for each:</u>

- Low ***annual demand*** saves energy
- Low ***peak loads*** ensure comfort, resilience, and reduce mechanical system size



Setting the Heating / Cooling criteria

- A “computer experiment”
- 5 building sizes, 3 occupancies -> 15 base buildings.
- Each in 20 climate / energy-price situations.
- Life cycle cost optimization using BEopt
  - Chooses upgrade packages to minimize annualized cost (utility bills + financed upgrade cost)
  - Mandatory minimums enforced.
  - Re-model the chosen optimal packages in WUFI Passive.
- Curve-fit the heating and cooling loads to Env/iCFA, occupant density, climate factors, and energy price. Separate fits for:
  - Annual Heating Demand,
  - Annual Cooling Demand,
  - Peak Heating Load, and
  - Peak Cooling Load.
- Online calculator pre-sets climate factors by city – Choose location and enter building size & occupancy.

R-squared of 0.88 to 0.92

WHEN-TO-STOP INVESTING IN PASSIVE MEASURES

SPACE CONDITIONING TARGETS

VARY BASED ON

BUILDING SIZE AND OCCUPANT DENSITY

PHIUS+ 2018
Space Conditioning Criteria Calculator

METHOD:	CALCULATOR
STATE / PROVINCE	ILLINOIS
CITY	CHICAGO MIDWAY AP
Envelope/iCFA	2.90
iCFA/person	401

**Calculator method is used for official certification targets.*

Space Conditioning Criteria

Annual Heating Demand	9.5	kBTU/ft²yr
Annual Cooling Demand	7.3	kBTU/ft²yr
Peak Heating Load	7.5	BTU/ft²hr
Peak Cooling Load	4.1	BTU/ft²hr

PHIUS+ 2018
Space Conditioning Criteria Calculator

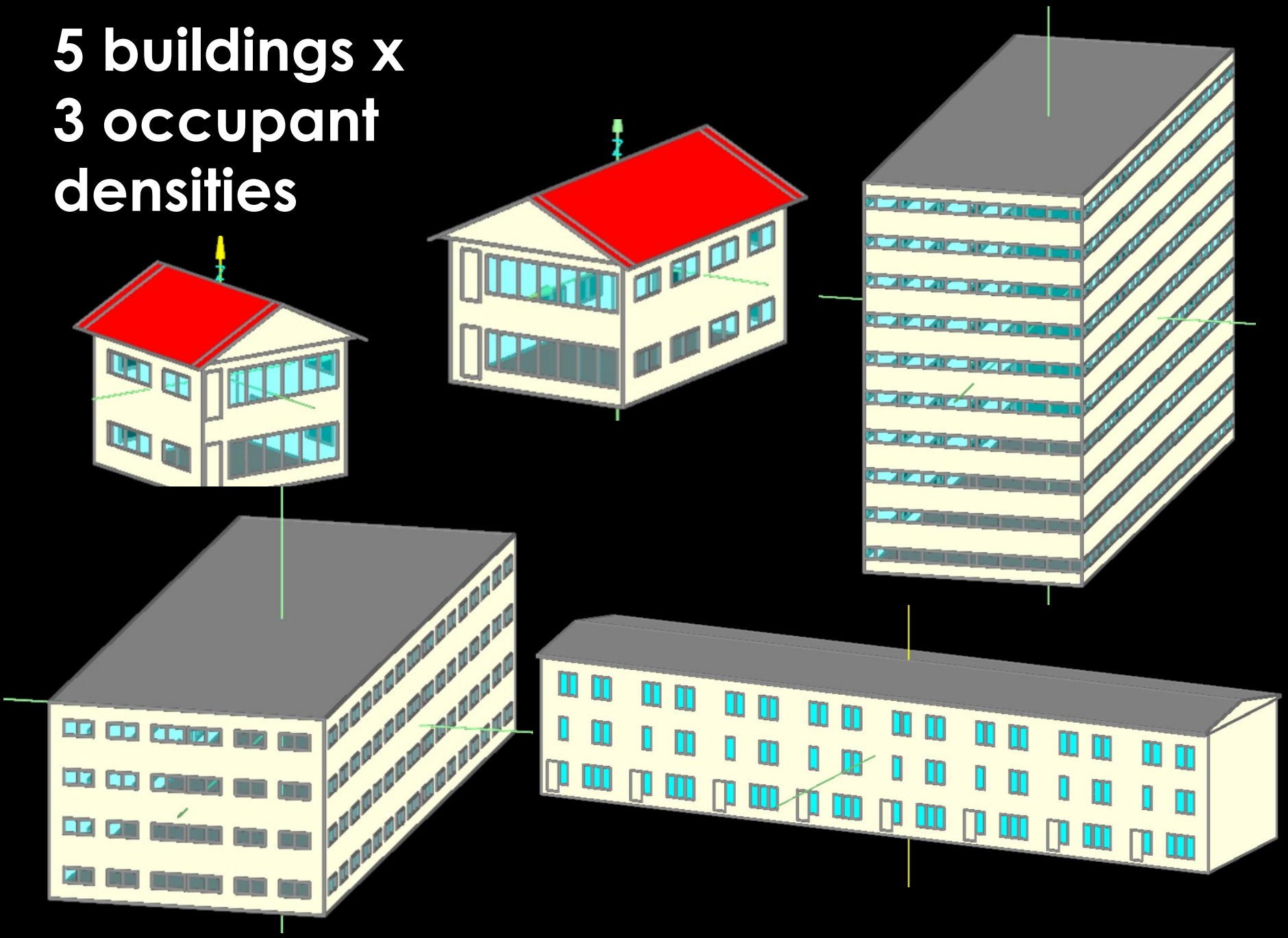
METHOD:	CALCULATOR
STATE / PROVINCE	ILLINOIS
CITY	CHICAGO MIDWAY AP
Envelope/iCFA	1.30
iCFA/person	401

**Calculator method is used for official certification targets.*

Space Conditioning Criteria

Annual Heating Demand	4.8	kBTU/ft²yr
Annual Cooling Demand	2.2	kBTU/ft²yr
Peak Heating Load	4.3	BTU/ft²hr
Peak Cooling Load	2.1	BTU/ft²hr

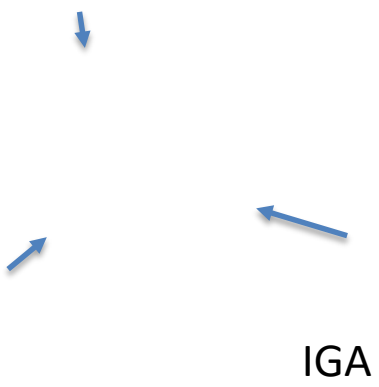
5 buildings x 3 occupant densities



List of runs: Explore the parameter space of climate factors

- 5 to 7 dimensions

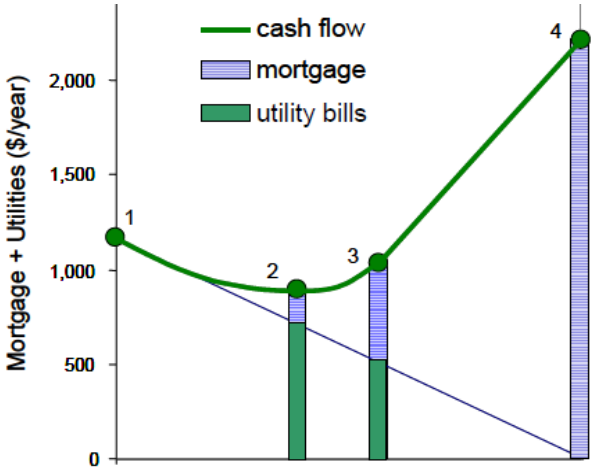
Annual Heat Demand	Peak cooling load
EnvA/iCFA	EnvA/iCFA
Occ/iCFA	Occ/iCFA
HDD65	CDD50
IGA	TCD
$elec	IGCL
	DDHR*
	$elec



- Generate a “space-filling” experiment design.
- Then find best matches among actual climate locations.
  - 1040 available with both EPW and WP data files.
  - 300 runs.
  - 137 unique locations chosen.

METHODOLOGY

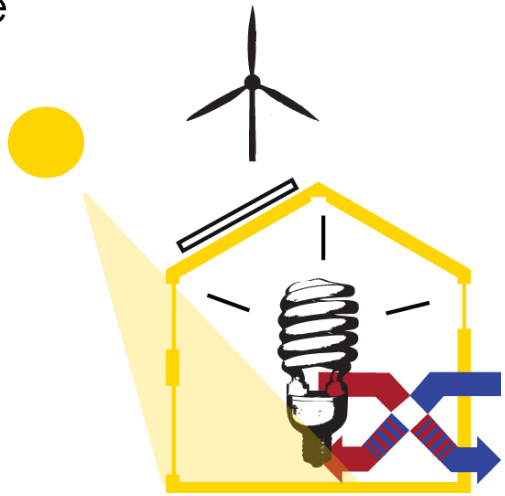
Climate Specific & Cost Competitive Space Conditioning Criteria



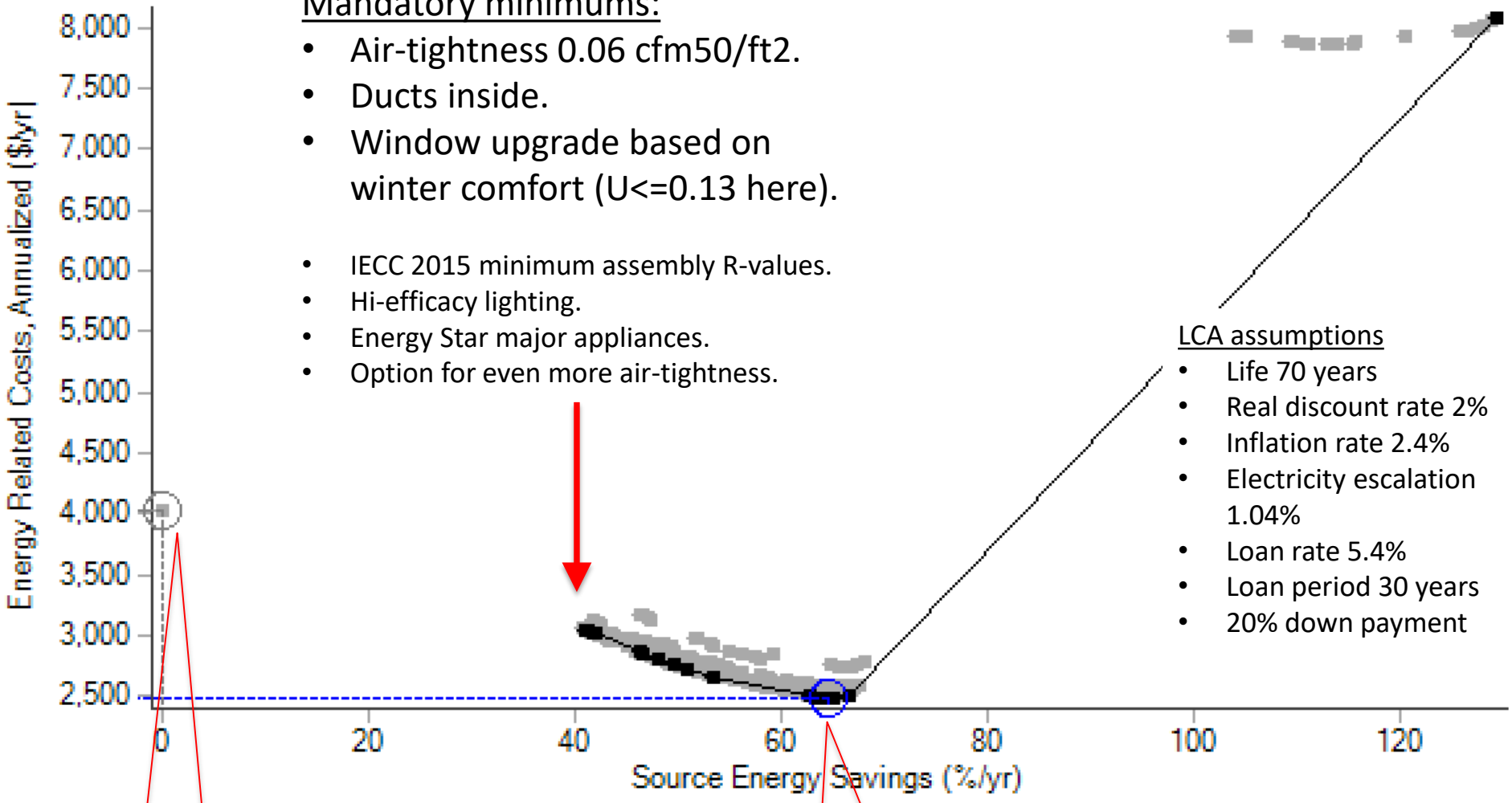
NREL BEopt optimizes upgrade package by climate

Standards defined as cost optimal/competitive sweetspot between conservation and generation

on the path to zero



SF-typcl med-occ Clarinda IA , $0.11/kWh



Mandatory minimums:

- Air-tightness 0.06 cfm50/ft2.
- Ducts inside.
- Window upgrade based on winter comfort (U<=0.13 here).

- IECC 2015 minimum assembly R-values.
- Hi-efficacy lighting.
- Energy Star major appliances.
- Option for even more air-tightness.

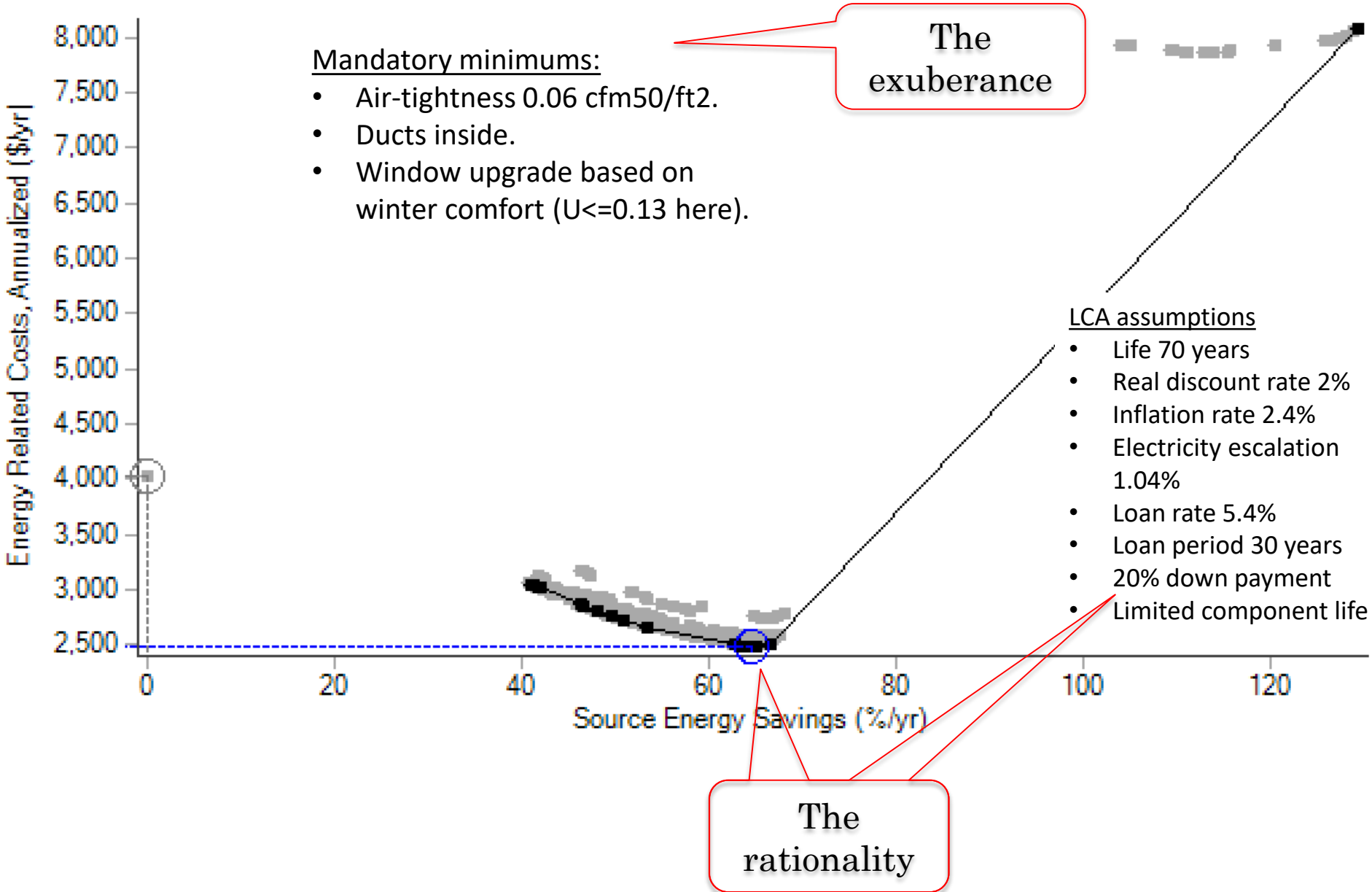
LCA assumptions

- Life 70 years
- Real discount rate 2%
- Inflation rate 2.4%
- Electricity escalation 1.04%
- Loan rate 5.4%
- Loan period 30 years
- 20% down payment

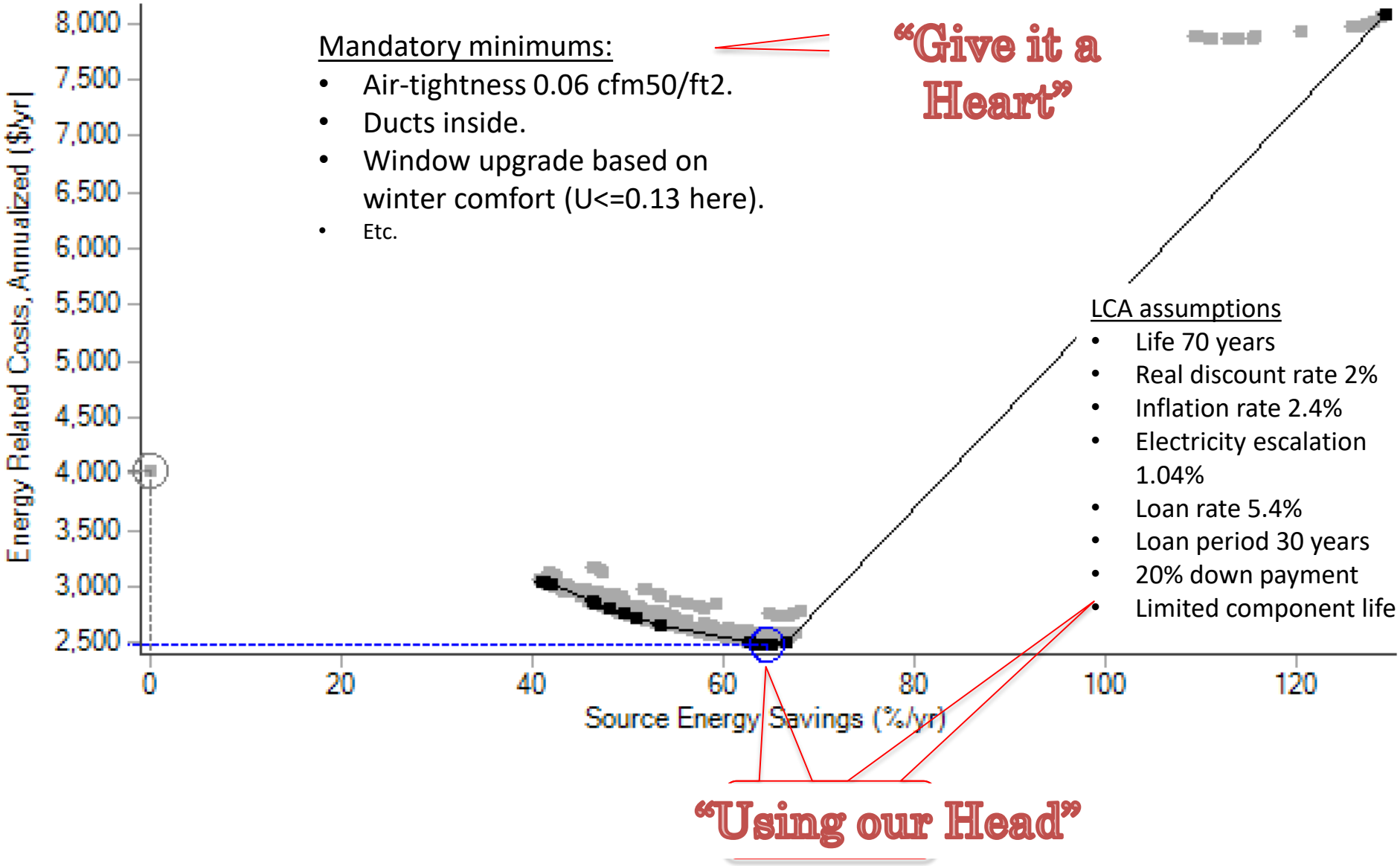
Building America Benchmark (IECC 2009)

Minimum cost point

SF-typcl med-occ Clarinda IA , $0.11/kWh



SF-typcl med-occ Clarinda IA , $0.11/kWh



Mandatory minimums:

- Air-tightness 0.06 cfm50/ft2.
- Ducts inside.
- Window upgrade based on winter comfort (U<=0.13 here).
- Etc.

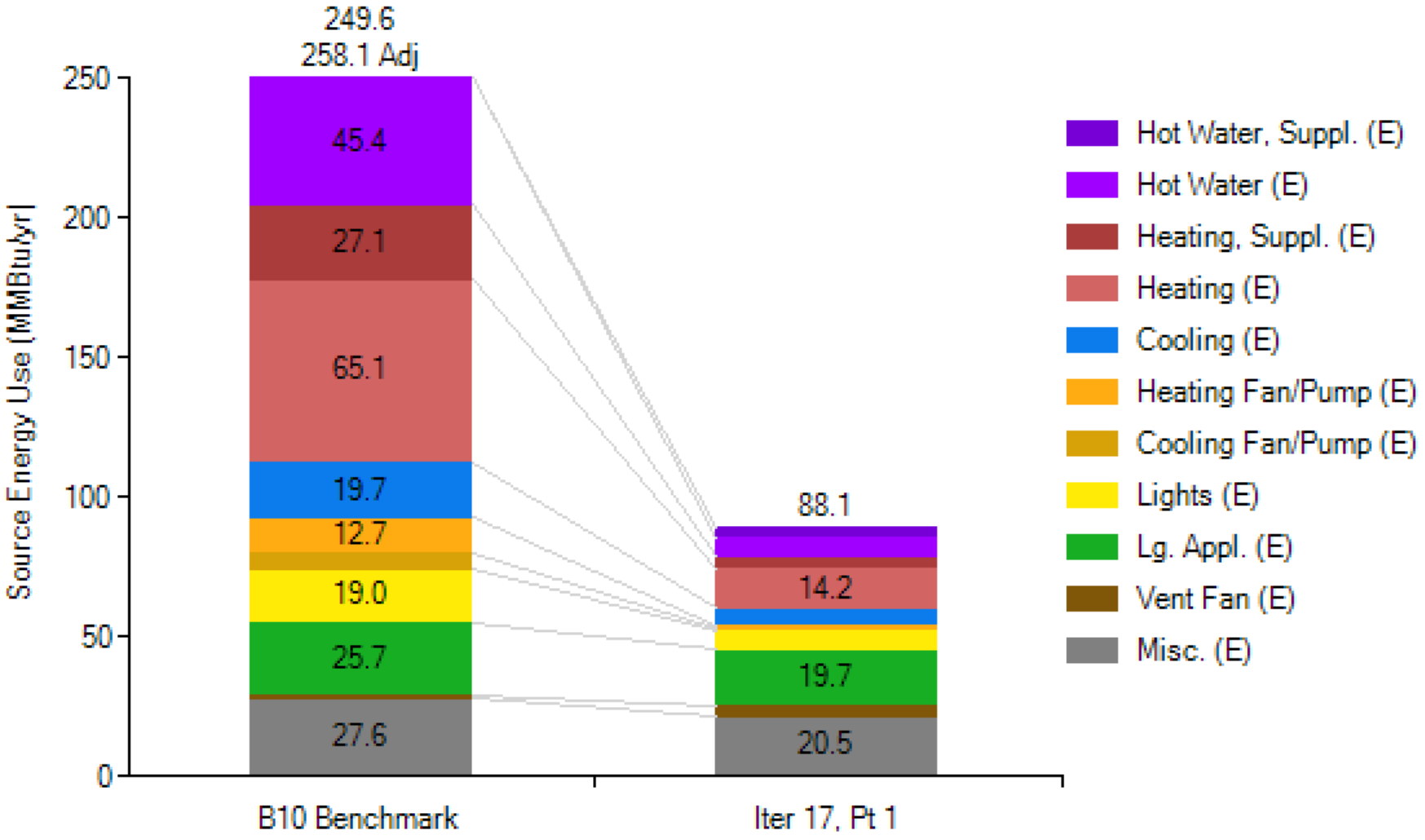
"Give it a Heart"

LCA assumptions

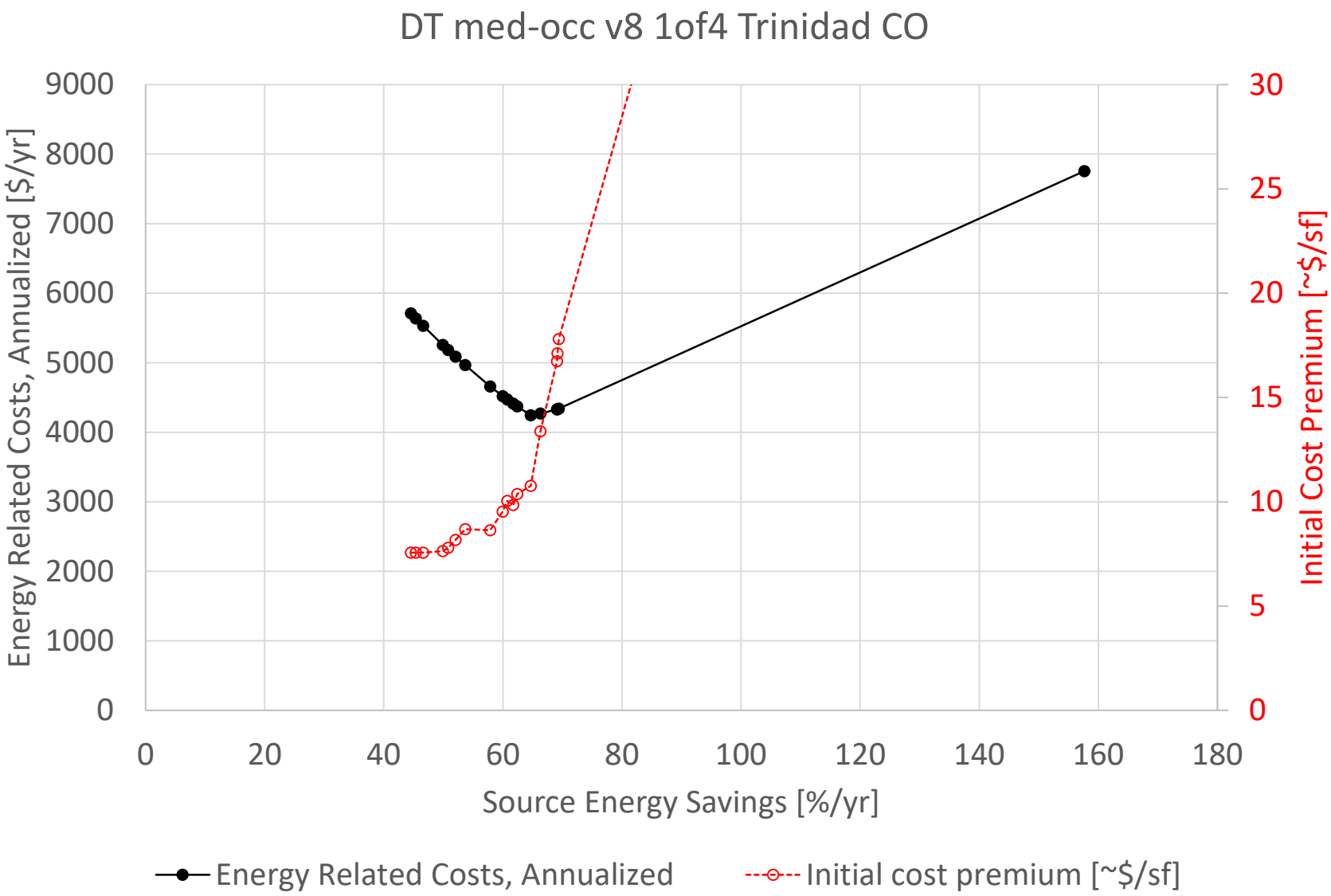
- Life 70 years
- Real discount rate 2%
- Inflation rate 2.4%
- Electricity escalation 1.04%
- Loan rate 5.4%
- Loan period 30 years
- 20% down payment
- Limited component life

"Using our Head"

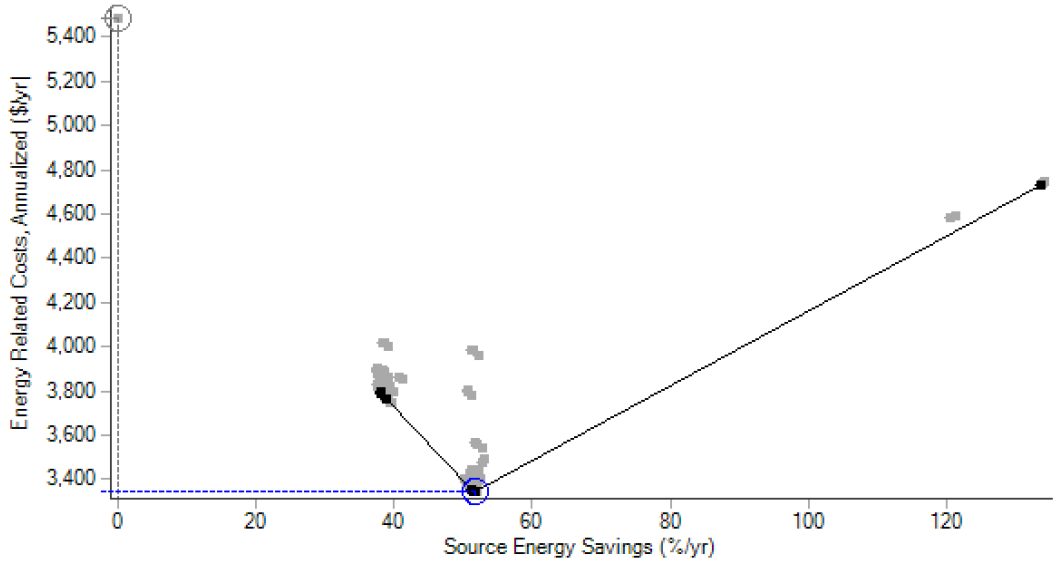
SF-typcl med-occ, Clarinda IA , $0.11/kWh

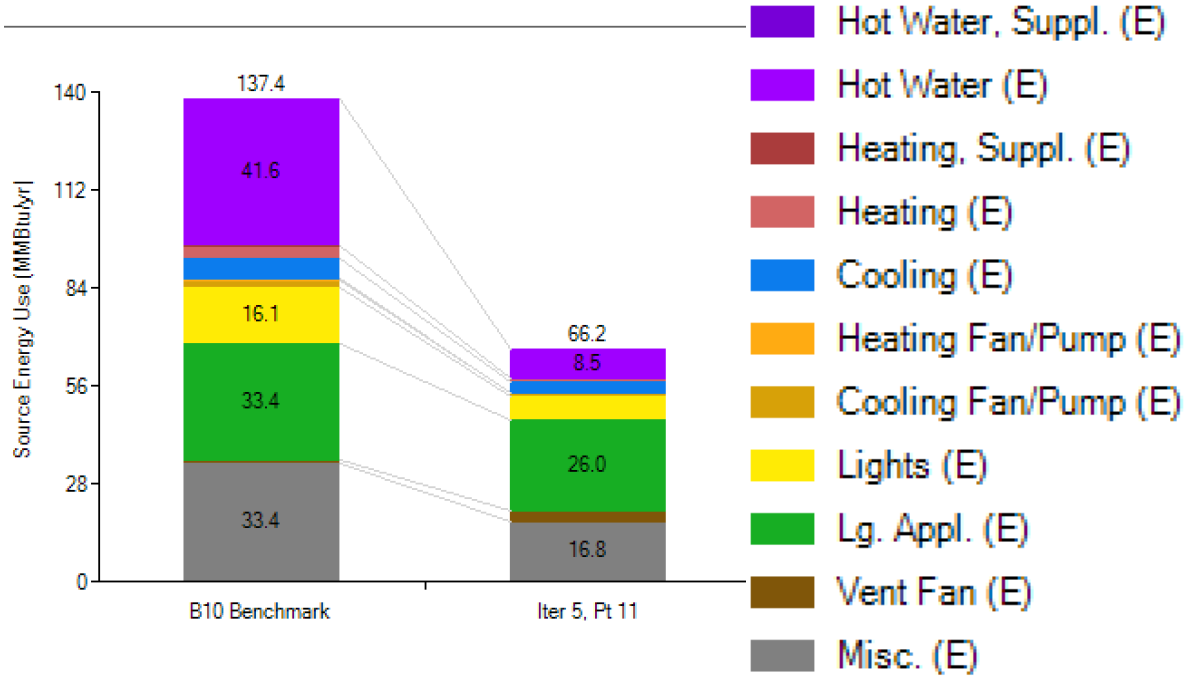


SF-typcl med-occ, Trinidad CO

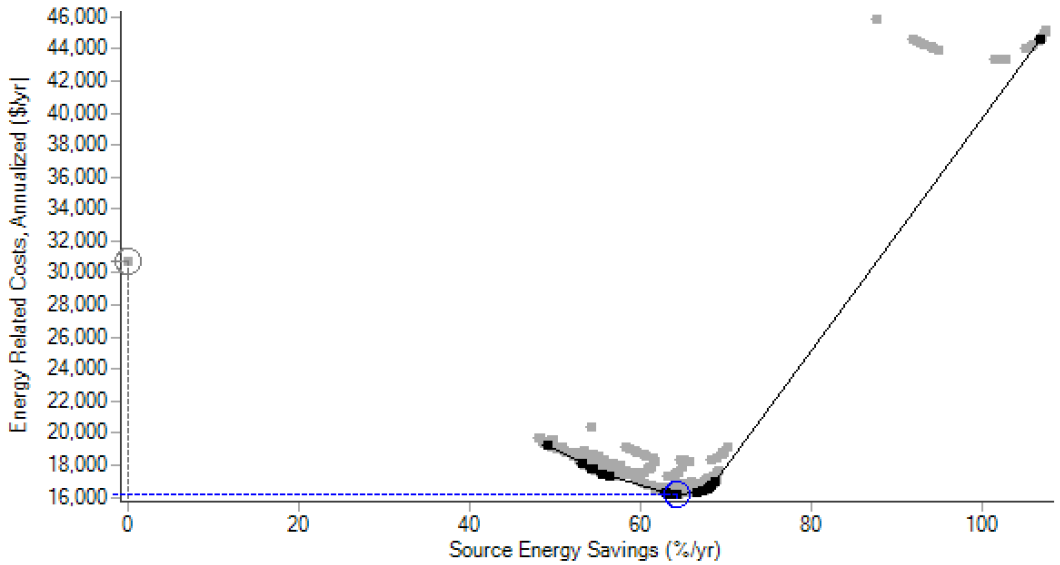


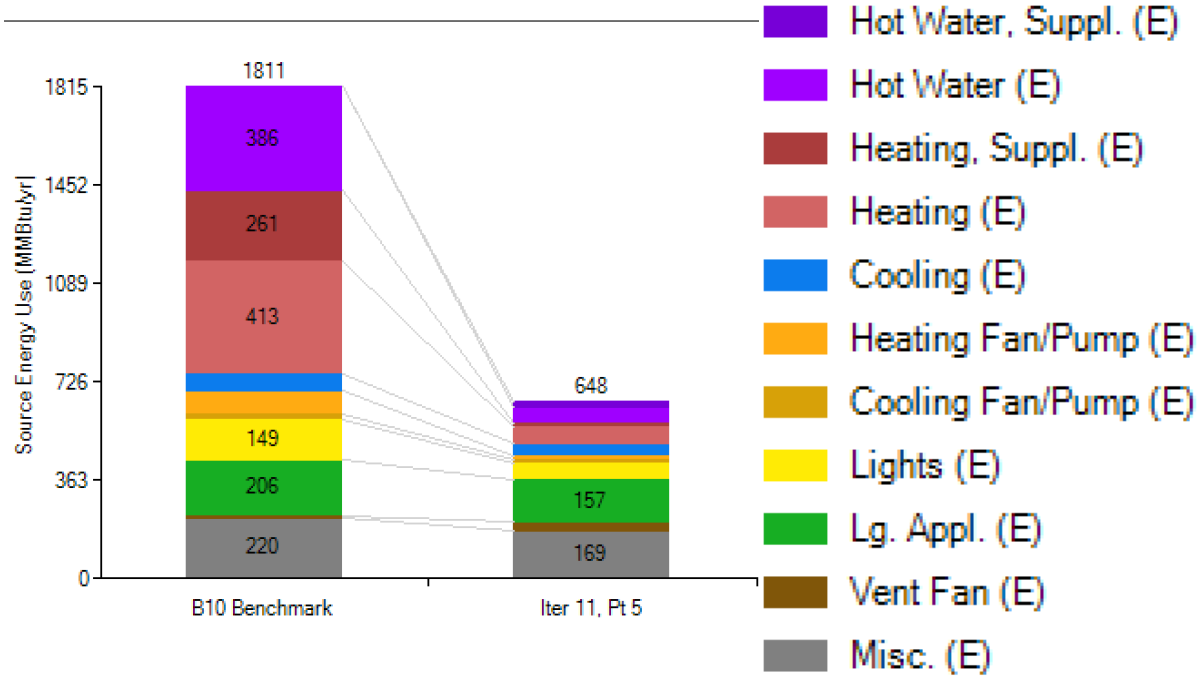
Duplex-small hi-occ Chula Vista CA (Zone 3B)



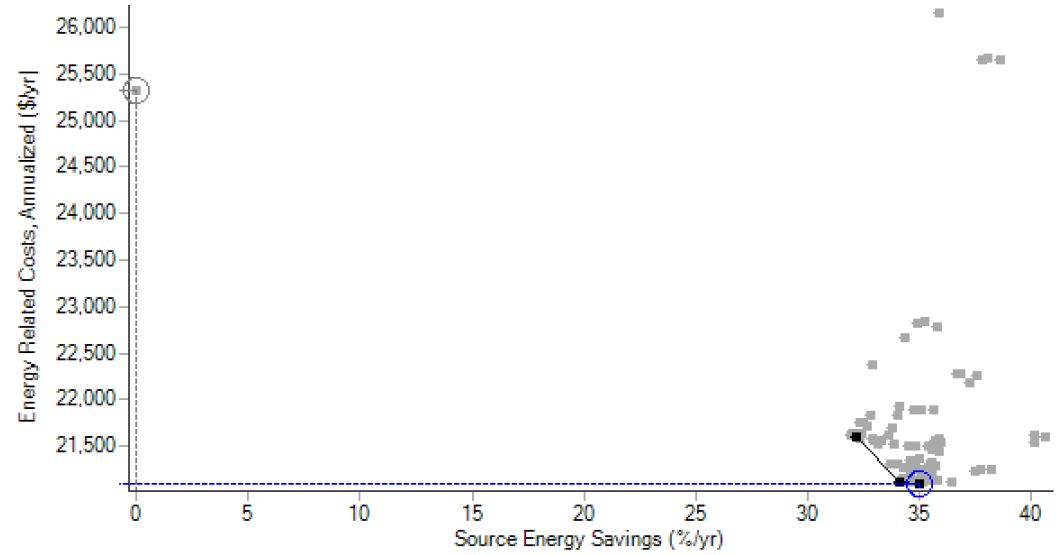


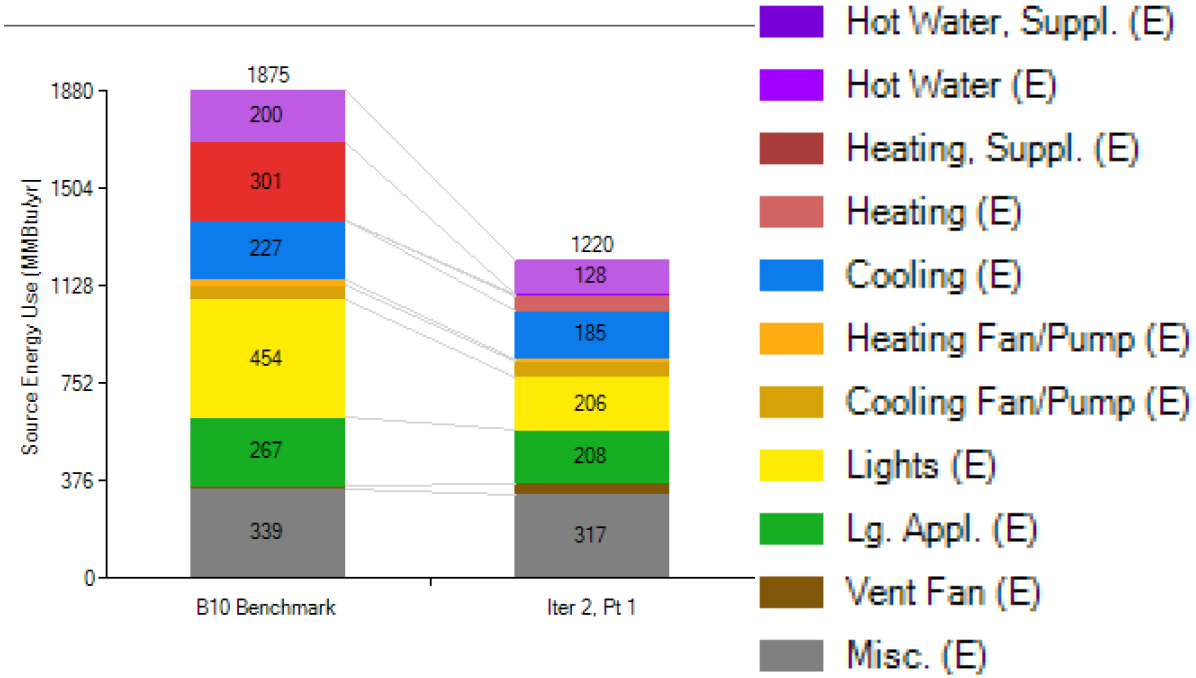
Townhouse med-occ Chicago-Waukegan IL





MF Mid-rise lo-occ McAlester OK (Zone 3A)

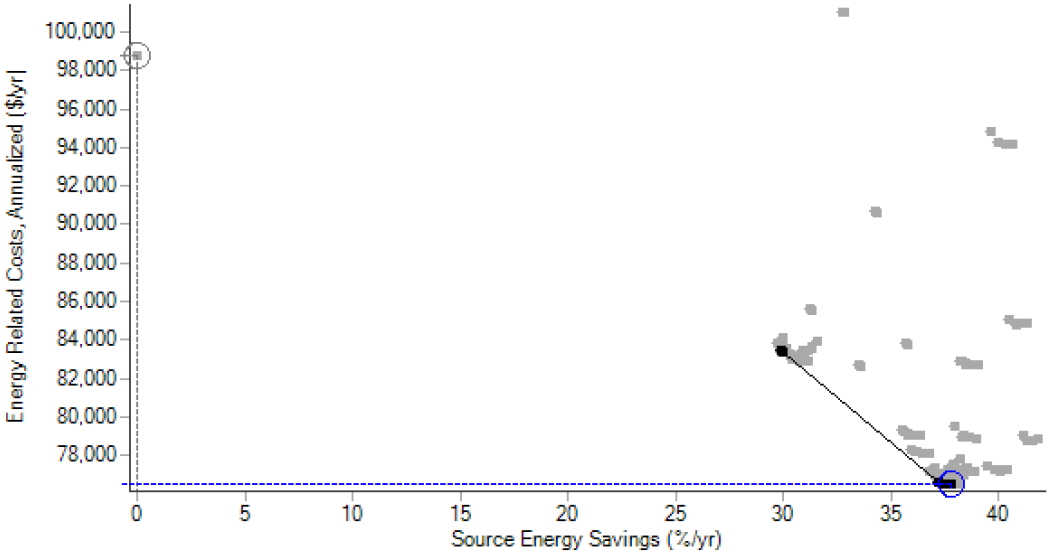


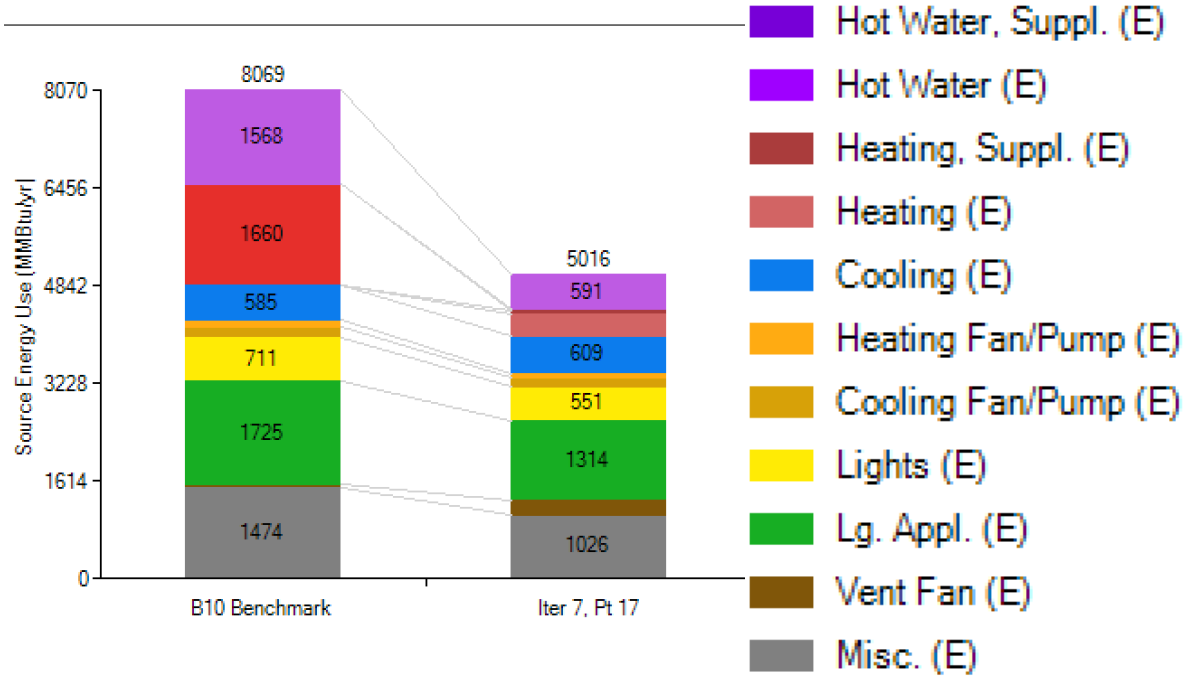


Ignore PV for setting space conditioning targets.

"You can't heat your house with PV."

MF High-rise hi-occ Chariton IA (5A)





Window comfort constraint was relaxed for Mid-rise and High-rise study buildings. (Based on Pilot Program feedback.)

Will add comfort guardrail on window U-value to project certification requirements, depending on climate & window height, to limit cold air pooling under windows.

Window comfort criterion

Maximum temperature difference (ΔT) =

6.0 °F for double-height spaces;

$\mathbf{14.7}$°F $-$ $(\mathbf{0.742}\ \boldsymbol{x}\ \boldsymbol{HHS(ft)})$ for window head-height-from-sill HHS of 10 feet or less,

or 13.3°F, whichever is less;

where the whole-window U is calculated as:

$$\boldsymbol{U = \Delta T/(R_{si})T_{air,inside} - T_d}$$

$$\boldsymbol{R_{si} = 0.74\ \frac{hrft^2°F}{BTU}}$$

$$\boldsymbol{T_{air,inside} = 68°F}$$

$$\boldsymbol{T_d = ASHRAE\ 99\%\ Design\ Temperature}\ °F$$

Exceptions:

- Windows in non 'regularly occupied' areas
  Example: a college dormitory with an entry lobby and no seating, or a hallway in a school with only transient occupants.

- ADA doors.

PHIUS WINDOW COMFORT & CONDENSATION RISK ASSESSMENT

Passive House Institute US

Project Name	
Project #	
State	ILLINOIS
City	CHICAGO MIDWAY AP
ASHRAE 99% Design Temperature [°F]	6.1

http://ashrae-meteo.info/

PHIUS+ Climate Data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ambient Temp (°F)	21.7	28.8	40.8	52.2	57.0	70.5	77.4	75.6	70.2	56.3	47.5	30.6
Dewpoint (°F)	12.6	19.8	29.8	42.6	44.4	57.0	60.8	62.6	58.6	43.9	33.6	21.2

CONDENSATION RISK

ISO 13788 Calculation for Low Thermal Inertia Elements

Is this a Heating Climate?	TRUE
Use simple method for indoor humidity?	TRUE
High occupancy?	TRUE
U-value of window frame/glass [BTU/hr.ft^2.F]	0.25
Safety Factor	15%

Interior Surface Temperature of window frame/glass [°F]	**54.8**
Risk of condensation on interior surface acceptable?	**YES**
Critical fRsi	**0.64**
Critical Month	**JAN**
Critical CRF Rating	**64**

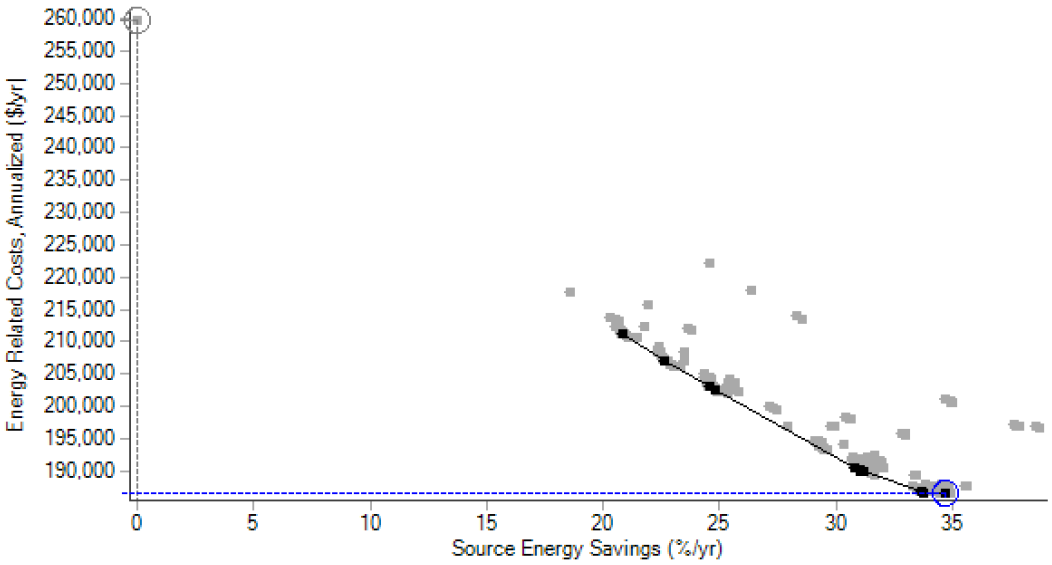
COMFORT REQUIREMENTS

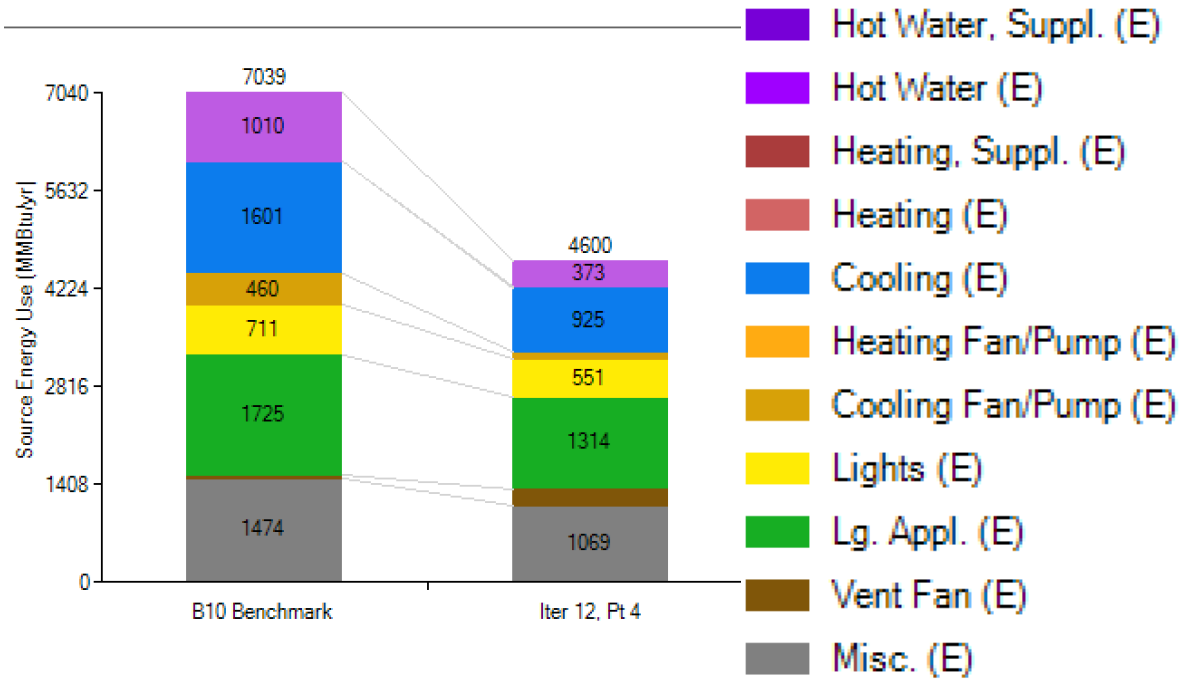
Applies to all projects.

Windows >10' in height and above have the same required U-value.

Window Vertical Height (ft) - Use slider	**5.0**
Required Whole Window U-value [BTU/hr.ft^2.F]	**0.24**

MF High-rise hi-occ Molokai HI





Curve-fitting JMP 13.2

$$
\begin{aligned}
&3.0741786353 \\
&+ 1.7570744179 \bullet EnvFlr \\
&+ 0.0006094673 \bullet HDD65 \\
&+ -0.002236765 \bullet IGA \\
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&+ (EnvFlr - 1.766) \bullet (EnvFlr - 1.766) \bullet 1.1967248787 \\
&+ (EnvFlr - 1.766) \bullet (HDD65 - 5860.0833333) \bullet 0.0002735396 \\
&+ (HDD65 - 5860.0833333) \bullet (HDD65 - 5860.0833333) \bullet -5.520236e\text{-}8 \\
&+ (EnvFlr - 1.766) \bullet (IGA - 1451.0633333) \bullet -0.001480515 \\
&+ (HDD65 - 5860.0833333) \bullet (IGA - 1451.0633333) \bullet -4.578714e\text{-}7 \\
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&+ (HDD65 - 5860.0833333) \bullet (\$elec - 0.2029333333) \bullet -0.001507354
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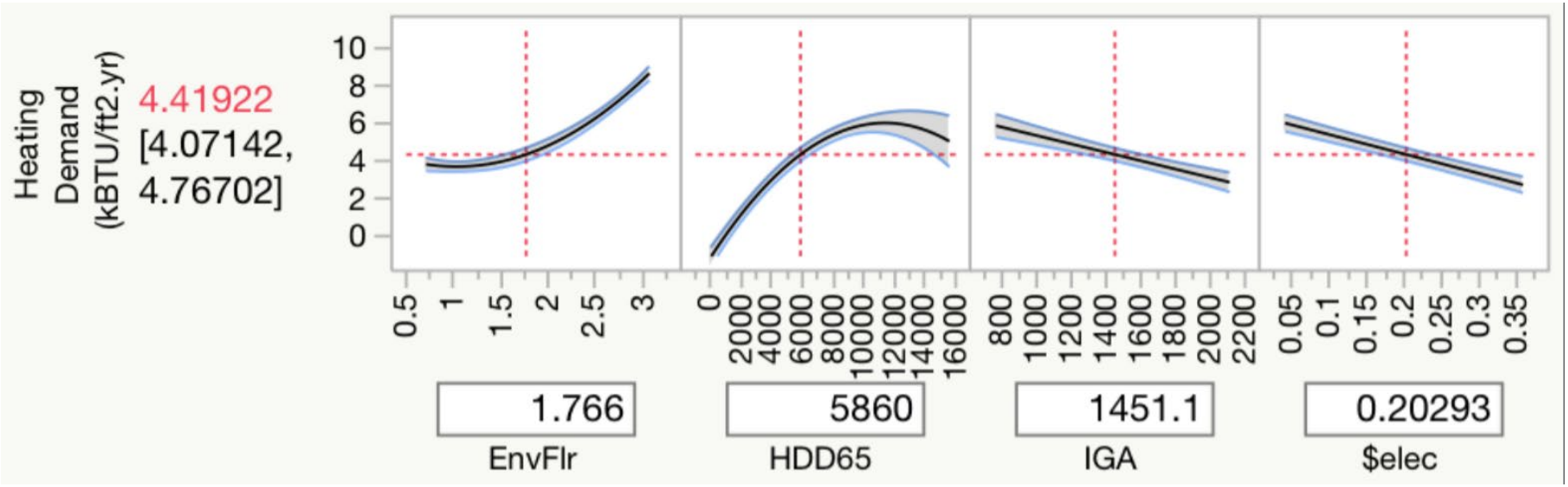
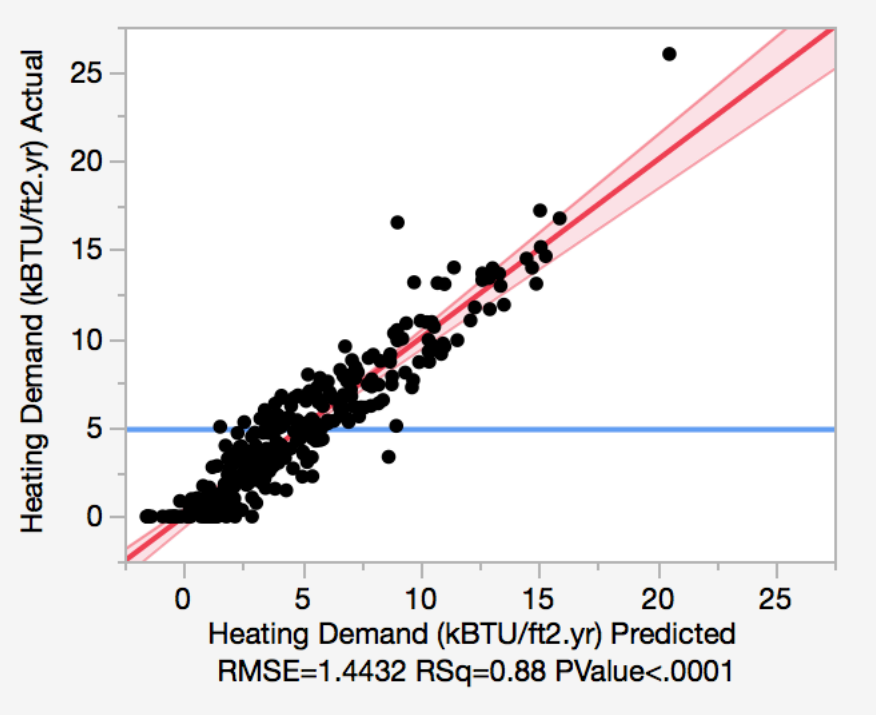
Fitted formula for Annual Heat Demand Criterion

Curve-fitting



Curve-fitting



Annual heating demand, WUFI Passive results vs Fitting formula.

When-to-stop with passive measures

- PHIUS+2018 – at a life-cycle cost optimum, subject to:
  - Some mandatory minimums.
  - Passive measures competing with mechanical, but not with PV.
- Other ideas
  - R-20 floor, R-40 wall, R-60 ceiling everywhere.
  - Benedict-Gifford limit on heating/cooling system size.
  - Limited peak load - supply-air heating sufficient.
  - Conservation only if cheaper than generation.
  - Uniform “% reduction” by conservation.

When to stop with conservation and turn to on-site renewables to offset?

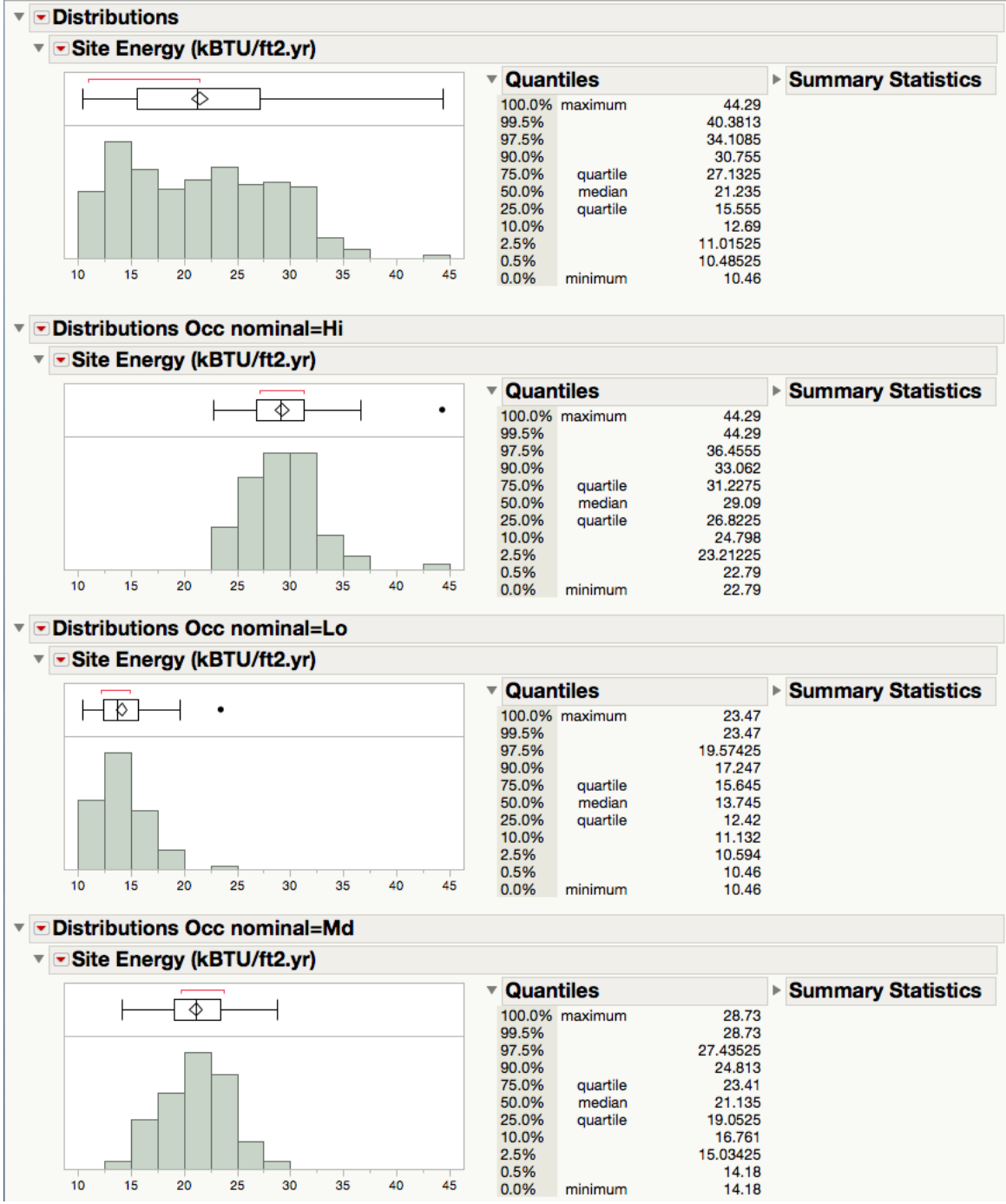
- For 2018 – change of metric, PHIUS+ now regulates annual **net** energy use, and counts both on-site and off-site renewables as offsets.

Net Source Energy Limit

- The question we answer instead:

When has the building done all it can with both conservation and on-site renewables and must look to its energy suppliers for clean/renewable energy?

But FYI, site EUIs should be about 13-31 kBtu/ft2.yr



SOURCE ENERGY

Limit based on:

"Fair share" of CO_2 emissions budget in order to avoid global warming by 2°C.

Tapers to '0' by 2050 at the latest.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

FOR THE SAKE OF EVERYTHING, we-humanity must get to *absolute* zero CO2-equivalent emissions (or less).

Let's review: As of 2015, the remaining emission budget is 270 to 470 GtCO2 according to IPCC ÷ 7 Gpeople -> 39 to 67 tCO2/person. Average emission budget over 35 years is 1.1 to 1.9 tCO2. If the glide path is linear, the beginning year emission budget is twice the average -> 2.2 to 3.8 tCO2/p for all purposes. Allocating 1/3 to the *building sector* gives about 1 tCO2/p for the beginning year. In an all-electric scenario, a building site energy use of 1400 kWh/person scaled to source energy by a factor of 3 gives 4200 kWh/p source; the same site energy scaled to CO2 emissions by a factor of 0.68-0.76 kgCO2/kWh-site-delivered gives 950-1050 kgCO2/p or again about 1 tCO2/p. Thus a *year-2015* source energy limit of 4200 kWh/person corresponds to an equal share of the building sector's emission budget. At a typical occupancy of 35 m2/person, this corresponds to 4200/35 = 120 kWh/m2. The limit should ratchet down every year thereafter.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

Year-2015 source energy budget for the building sector was plausibly 4200 kWh/person for residential, 120 kWh/m2 [38 kBtu/sf] for nonresidential. (If all-electric but supplied by mostly-nonrenewable-generation.)

Temporarily relieved in PHIUS+2015 to 6200 kWh/year due to calculation protocol increase in residential lighting/plug load usage assumptions.

Use of nonrenewable generation should taper off to zero.

Current PHIUS protocol for building certification recognizes only on-site renewables for reducing source energy use.

Tapering the limit to zero with that framework would force all buildings off-grid.

At some point the building has “done all it can” with conservation and on-site renewables, and responsibility shifts to the energy provider to decarbonize / go-renewable.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

For PHIUS+2018, change of framework:

Source energy limit tapers to zero by 2050 *at the latest*. Limit for 2018 is **3840 kWh/p** for residential**,**
110 kWh/m2 [34.8 kBtu/sf] nonresidential.

But: the limit is on Net source energy use and all of the following renewables are recognized as offsets:

- All on-site generation (not just the use-coincident fraction)
- Directly owned off-site renewables.
- Community renewable energy
- Virtual Power Purchase Agreements
- Green-E Certified Renewable Energy Certificates, discounted 80%.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

Additional provisos:

For PPAs, Community RE, and RECs, the building owner must present an actual contract to purchase sufficient RE to meet the (current-year) net source energy target for 20 years.

For onsite renewables or directly-owned off-site, RECs may not be sold off but must be retained/retired.

> Where the building owner does not have ownership of the RECs associated with the on-site RE system, owner must obtain and retire equivalent RECs.

Source energy factor for grid electricity has dropped from 3.14 to 2.80 for U.S., and from 2.06 to 1.96 for Canada. ☺

Timeline

September 21, 2018 – Full launch of PHIUS+ 2018
October 1, 2018 – PHIUS+ 2018 pilot ends

October 2018–March 2019 – Submit under 2015 or 2018

March 31, 2019 – PHIUS+ 2015 ends
April 1, 2019 – All new projects must be under PHIUS+ 2018

***Must have project contract in to secure**
Note: Only WUFI Passive accepted for PHIUS+ 2018

PHIUS Certification for Buildings & Products

Project Certification
- Overview
- PHIUS+ Source Zero
- PHIUS+ 2018: Getting to Zero
- PHIUS+ 2018 Pilot
- PHIUS+ 2015: Passive Building Standard -- North America
- Submitting a Project
- Documents for Download
- Project Certification Review Queue
- Programs Version Dates
- Certification Plaque

PHIUS+ Webinar Series

Certified Projects Database

Certified Projects Map

Case Studies
- RMI Innovation Center
- Orchards at Orenco: Phase I

PHIUS+ 2018: Getting to Zero

PHIUS+ 2018 is the first updated revision to the PHIUS+ 2015 standard, and will fully replace PHIUS+ 2015 by April 2019 (see timeline). This update focuses on adding more nuance for different building types, and supporting an overall transition to renewable energy.

PHIUS+ 2018 Energy Modeling Protocol

PHIUS+ 2018 Standard Setting Documentation

PHIUS Window Comfort & Condensation Risk Assessment

Space Conditioning

What's the same

- Pass/fail, "performance-based" passive building standard with prescriptive quality assurance requirements
- Three pillars: limits on heating/cooling loads, limits on source energy use, required air-tightness & other prescriptive requirements
- Climate-specificity, on a location-by-location basis

New in PHIUS+ 2018

- Occupant density and building size (envelope to floor area ratio) influence heating/cooling load limits
- Calculate Space Conditioning targets using the 'PHIUS+ 2018 Final Calculator' below.

Source Energy

In Conclusion

Opportunities for further improvement

- Better planning tools to get you to the right energy design as fast as possible.
  - Longer-term: Supporting people with both more and less planning resources than it takes to make a WUFI Passive model.
- Revising the peak load calculation so that it is more directly useful for system sizing.
- Grid citizenship – replace net-zero accounting with a metric that values energy differently by hour of day and season of year. (NBI GridOptimal?)
  - Use not just for source energy criteria but also in the standard-setting studies for the heating/cooling criteria.
- Impact of materials – CO2 emission payback is delayed if we build and retrofit with high GWP materials. (MIT – new LCA tool?)

Thank You PHIUS Technical Committee

- Achilles Karagiozis
- Chris McTaggart
- Colin Schless
- Florian Antretter
- Galen Staengl
- Günther Gantioler
- Graham Wright
- John Semmelhack
- Katrin Klingenberg
- Lisa White
- Prudence Ferreira
- Russell Richman
- Ryan Abendroth
- Skylar Swinford
- Stuart Fix

Passive building is both sword and shield against the climate change monster.

And there is an army coming up behind you.

THANK YOU

Please email additional questions to

certification@passivehouse.us

Webinar: PHIUS+ 2018: The Standard Updated

Passive House Institute US

Earn 1 CEU &
1 AIA LU | HSW

SELF REPORT AT *phius.org/cphc/self-report*

CPHC®

VERIFICATION CODE

23012

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R33

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # ___R404_____

Brief Description:

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.)

Add new text as Follows:

R404.2 (IRC N1104.2) Electric readiness (Mandatory) Systems using gas or propane water heaters, dryers, or conventional cooking equipment to serve individual dwelling units shall comply with the requirements of Sections R404.2.1 and R404.2.2. All water heating systems shall comply with Section R404.2.3.

R404.2.1 (IRC N1104.2.1) Receptacle. A dedicated 125-volt, 20-amp electrical receptacle that is connected to the electric panel with a 120/240 volt 3 conductor, 10 AWG copper branch circuit, shall be provided within 3 feet from each gas or propane water heater, dryer, and conventional cooking equipment, accessible with no obstructions.

R404.2.2 (IRC N1104.2.2) Electrification-ready circuits. Both ends of the unused conductors shall be labeled with the word "SPARE" and be electrically isolated. A single pole circuit breaker space shall be reserved in the electrical panel adjacent to each circuit breaker for the branch circuit and labeled with the words "FUTURE 240V USE."

R404.2.3 (IRC N1104.2.3) Water heater space. An indoor space that is at least 3 feet by 3 feet by 7 feet high shall be available within 3 feet of the water heater.

Exception: The water heater space requirement does not need to be met where a heat pump water heater is installed.

Purpose of code change:

This proposal enhances customer choice by making it easy for homeowners to choose either electric or gas appliances and water heating equipment. By ensuring that a home built with gas or propane can easily accommodate future electric appliances and equipment, this proposal protects homeowners from future costs, should natural gas become less affordable or even unavailable over the life of the building.

As the electric grid becomes cleaner, and high-efficiency electric heat pump technology increasingly offers utility bill and pollution reduction benefits over gas, more customers may choose electric space and water heating. Federal, state, and

local environmental and public health policies may also encourage, or even require the transition in some areas over the life of the building. Electric-ready requirements will protect customers from potential high retrofit costs.

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.
- ☒ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☒ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name	Poppy Storm	Email address	poppy.storm@2050-institute.org
Your organization	Shift Zero	Phone number	206-650-7240
Other contact name	Rachel Koller		

Economic Impact Data Sheet

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

The cost of meeting these electric-ready requirements when the house is being built, walls are open, and the trades are already on-site, is marginal. In comparison, the cost of retrofitting a building for these requirements can be orders of magnitude higher and act as a barrier for the homeowner to choose electric appliances. Not making new buildings electric-ready would leave homeowners exposed to potentially high retrofit costs in the future and will greatly inhibit customer choice.

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**)

$.08/square foot (For residential projects, also provide $170/ dwelling unit)

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

The cost estimate for including a dedicated 125-volt, 20-amp electrical receptacle connected to the electrical panel was sourced from similar estimates for dedicated circuits in a California Air Resources Board (CARB) report. The report included a detailed technical and fiscal impact analysis along with suggested code changes for electric vehicle charging infrastructure in multifamily homes. The report estimated (using standard construction cost estimating details from R. S. Means and input from electricians) a total cost of $280. The estimate included a circuit breaker that would not be required by this code. Therefore, we have reduced the cost to $170 for the requirements of this code change proposal.

ELECTRIC VEHICLE (EV) CHARGING INFRASTRUCTURE: MULTIFAMILY BUILDING STANDARDS. Report. April 2018. Accessed April 2019. https://arb.ca.gov/cc/greenbuildings/pdf/tcac2018.pdf.

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

0 KWH/ square foot (or) 0 KBTU/ square foot

(For residential projects, also provide 0 KWH/KBTU / dwelling unit)

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

This proposal is intended to deliver electric ready homes and provide for higher performing homes in the future. Therefore, there are no immediate savings.

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:

No significant additional code enforcement time is estimated.

All questions must be answered to be considered complete. Incomplete proposals will not be accepted.

STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

Washington State Energy Code Development

Standard Energy Code Proposal Form

May 2018

Log No. 19-WSEC-R34

Code being amended: ☐ Commercial Provisions ☒ Residential Provisions

Code Section # _R202, R402.4.1.1, R403.3.1, R406.2__

Brief Description:

The purpose of this amendment to Washington State energy code is to alter and clarify the code in such a way that it can allow for a crawlspace to be sealed and insulated on the perimeter wall (inclusive or rim joist, foundation, and footing), therefore creating an indirectly conditioned space between the earth and the floor system(crawlspace).

The goal of this clarification of the above stated energy code sections is to create consistency for the characterization of sealed crawl spaces. This would create consistency among the energy code definition of a thermal envelope (section R202), the prescriptive crawl space wall insulation (table R402.4.1.1), the prescriptive code for ducting in the thermal envelope(R403.3.1), and how the energy code credits are determined(Table 406.2 option 4). While amending the energy code, we have no intention of changing or amending building code, specifically section 408.3.

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.)

R202: CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaced, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.
Mechanically vented sealed crawl space is an indirectly heated and cooled area room or space within the building thermal envelope if the following conditions are met; stem wall insulation meets or exceeds R21, the floor between house and crawlspace is uninsulated, and the ductwork in the crawl space may or may not be insulated.

TABLE R402.4.1.1: AIR BARRIER AND INSULATION INSTALLATION
Air Barrier Criteria: Crawl space walls Exposed earth in unvented crawl spaces shall be covered with a Class I, black vapor retarder with overlapping joints taped.
Insulation Criteria: Where provided instead of floor insulation, insulation shall be permanently attached to the crawlspace walls meeting or exceeding R21.

R403.3.1 Insulation (Prescriptive). Ducts outside the building thermal envelope shall be insulated to a minimum of R-8. Ducts within a concrete slab or in the ground shall be insulated to R-10 with insulation designed to be used below grade.
Exception: Ducts or portions thereof located completely inside the building thermal envelope; including conditioned mechanically vented sealed crawl spaces. Ducts located in vented crawl spaces do not qualify for this exception.

TABLE 406.2 ENERGY CREDITS: Option 4
HIGH EFFICIENCY HVAC DISTRIBUTION SYSTEM: All heating and cooling system components installed inside the

conditioned space. This includes all equipment and distribution system components such as forced air ducts, hydronic piping, hydronic floor heating loop, convectors and radiators. All combustion equipment shall be direct vent or sealed combustion. For forced air ducts: A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts may be located outside the conditioned space. All metallic ducts located outside the conditioned space must have both transverse and longitudinal joints sealed with mastic. If flex ducts are used, they cannot contain splices. Flex duct connections must be made with nylon straps and installed using a plastic strapping tensioning tool. Ducts located outside the conditioned space must be insulated to a minimum of R-8. Locating system components in conditioned crawl spaces is ~~not~~ permitted under this option. Electric resistance heat and ductless heat pumps are ~~not~~ permitted under this option. Direct combustion heating equipment with AFUE less than 80% is not permitted under this option. To qualify to claim this credit, the building permit drawings shall specify the option being selected and shall specify the heating equipment type and shall show the location of the heating and cooling equipment and all the ductwork.

Purpose of code change:

There have been various building departments that have been confused about energy code regarding sealed mechanically vented conditioned crawlspaces, due to each jurisdiction all having differences in interpretation of the current energy code. The changes that have been proposed would provide clarity in interpreting the code so there is consistency among Washington state energy code

Additional documents to support this proposal:
-IBC 408.3 Unvented Crawl space
-U.S Department of Energy: Residential Provisions of the 2018 International Energy Conservation Code pg. 23-24

-Measured Energy Penalties From Crawl Space Ventilation

-Comparative Study of Vented vs. Unvented Crawlspaces in Identical Side-by-Side Homes in the Mixed Humid Climate

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.
- ☐ Addresses a specific state policy or statute. (Note that energy conservation is a state policy)
- ☐ Consistency with state or federal regulations.
- ☐ Addresses a unique character of the state.
- ☐ Corrects errors and omissions.

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

- ☒ Single family/duplex/townhome
- ☐ Multi-family 1 – 3 stories
- ☐ Multi-family 4 + stories
- ☐ Commercial / Retail
- ☐ Institutional
- ☐ Industrial

Your name	Tyler Kafentzis	Email address	tyler.kafentzis@outlook.com
Your organization	Energeo, LLC	Phone number	509-438-3690
Other contact name	N/A		

Economic Impact Data Sheet

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

This proposal will reduce energy loss through the crawlspace system and allow ductwork to be more easily routed through conditioned spaces, lower air changes per hour due to tighter house seal when used with spray foam application. Lower crawlspace humidity and mold growth potential

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**)

$.75/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

Perimeter insulation @ r21 cost to be at $1.90 per board ft

NA for cost saving as this would change insulation location and not reduce building costs

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

.5 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

See attached studies

$Q = UA \Delta T$
Silt, Sand, Loam @ 15% moisture = .2 K
U = k/s
U = .2/2
Q = .1 x 2500sf x 15°F = 3750 BTUh

This is a saving of approximately 10-20% over current crawlspace design

List any code enforcement time for additional plan review or inspections that your proposal will require, in hours per permit application:
Ductwork should be inspected at time of mechanical rough in. Insulation and vapor barrier inspection should be inspected before CO and take no additional time