International Energy Conservation Code
Consensus Committee-Residential

Draft Meeting Agenda (6/3 posting)

Webex Meeting Link

June 9, 2022
2:00 PM EST to 5 PM EST (3 hours)

Committee Chair: JC Hudgison, CBO, Assoc. AIA
Committee Vice Chair: Bridget Herring & Robin Yochum, LEED Green Associate

1. Call to order.

2. Meeting Conduct.
    a. Identification of Representation/Conflict of Interest
    b. ICC Council Policy 7 Committees: Section 5.1.10 Representation of Interests
    c. ICC Code of Ethics: ICC advocates commitment to a standard of professional behavior that exemplifies the highest ideals and principles of ethical conduct which include integrity, honesty, and fairness. As part of this commitment it is expected that participants shall act with courtesy, competence and respect for others.
    d. ICC Antitrust Compliance Guideline

3. Roll Call.

4. Approve Agenda

5. Approval of Minutes

6. Administrative issues-staff

7. Subcommittee Reports

8. Action Items
    a. Code Change Proposals

REPI-161-21 (Zero Energy Appendix)	(Econ Modeling approve 13-0-4)
CEPI-146-21 Part II (EV Infrastructure)	(Elec disapprove 10-0)
REPI-15-21 (EV Ready Required)	(Elec disapprove 11-0)
REPI-114-21 (PV Required)	(Elec as modified 9-4)
REPI-117-21 (Performance 100% renew)	(Elec as modified 11-0)
REPI-130-21 (ERI Design Options)	(Elec disapprove 12-0)
REPI-143-21 (Existing Buildings)	(Ex Bldgs as modified 6-0)

RECPI-5-21 (Part B of REPI-143) (Ex Bldgs disapprove 6-0-1)
REPI-144-21 (Ext. Bldgs Add. Efficiency Credit) (Ex Bldgs as modified 7-0)
REPI-62-21 (Air Leakage and Ventilation) (HVACR disapprove 7-0-1)
REPI-75-21 (Duct and Air Handler Location)(HVACR disapprove 8-0-2)
REPI-76-21 (Duct and Air Handler location) (HVACR disapprove 7-3-0)
REPI-80-21 (Ducts in Conditioned Space) (HVACR as modified 9-1-2)
REPI-86-21 (Duct Leakage) (HVACR as modified 9-0)
~~REPI-89-21 (Pipe Insulation) (HVACR as modified 10-0)~~move to 6/16
REPI-90-21 (Grid Integrated Water heating) (HVACR as modified 9-0)
~~REPI-91-21 (Hot water compact design)(HVACR as modified 10-0-1)~~move to 6/16
REPI-93-21 (HRV and ERV) (HVACR disapprove 5-4)

9. Other business.

10. Upcoming meetings. June 16 at 2 PM EST

11. Adjourn.

FOR FURTHER IECC Residential INFORMATION BE SURE TO VISIT THE ICC WEBSITE:
IECC Residential Website

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Kristopher Stenger, AIA, CBO
Director of Energy Programs
International Code Council
kstenger@iccsafe.org

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-161-21 Appendix RC
CDP ID #	273
Code	IECC RE
Code Section(s)	202 (new) & RC102.2
Location	Base
Proponent	Diana Burk, NBI
Proposal Status	SC rev
Subcommittee	RE Econ, Model, Metric
Subcommittee Notes	Diana Burk presented REPI-161-21 which adds Section 202 with new definitions and revises definitions and calculation formulas in RC102.2
Recommendation	**Approve As Submitted** Motion: Diana Burk, 2nd Pam Fasse Reason Statement: There was discussion regarding definitions as well as interaction with other proposals in front of the EPLS SC and how their action would affect this proposal. It was agreed by the Econ SC that this proposal should be moved out of SC as submitted for action by the full committee.
Vote	Approve 13-0 (4 Abstain, 3 Not Present)
Recommendation Date	5-11-22
Next Step	To Subcommittee___________________________________ To Advisory Group__________________________________ To Consensus Committee_____X____________
Consensus Committee	
Committee Response	
Vote	Affirmative__________ Negative___________ Table____________ To Subcommittee_________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	CEPI-146-21 Part II EV Infastructure
CDP ID #	452
Code	IECC RE
Code Section(s)	R404.5 New Section y
Location	base
Proponent	Sharon Bonesteel sharon.bonesteel@srpnet.com
Proposal Status	SC rev
Subcommittee	RE Elec, Light
Subcommittee Notes	Representative for Jeremy Williams for CEPI-258 and we had discussed withdrawing it in light of the consensus proposal being approved
Recommendation	Disapproval
Vote	10 in favor, none opposed, none abstaining
Recommendation Date	5/23/22
Next Step	To Subcommittee__________________________________ To Advisory Group__________________________________ To Consensus Committee__________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-015-21 EV Ready required
CDP ID #	557
Code	IECC RE
Code Section(s)	R401, 101 New Section y
Location	base
Proponent	Emily Kelly emily.kelly@chargepoint.com
Proposal Status	SC rev
Subcommittee	RE Elec, Light
Subcommittee Notes	Given approval of RECPI-6 and RECPI-7 move disapproval.
Recommendation	disapproval
Vote	11 in favor, none opposed, none abstaining
Recommendation Date	
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee___________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee____________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-114-21 PV Required
CDP ID #	126
Code	IECC RE
Code Section(s)	R404.4, R404.4.1, 404.4.2, R404.4.4, TABLE R405.2, TABLE R406.2, R406.3.2, TABLE R406.5 New Section y
Location	base
Proponent	Jeremy Williams jeremy.williams@ee.doe.gov
Proposal Status	SC rev
Subcommittee	RE Elec, Light
Subcommittee Notes	Very similar to what was discussed during the last informational call.
Recommendation	Approve as modified
Vote	9 in favor, 4 against motion passes.
Recommendation Date	5/23/2022
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee__________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________

REPI-114-21 AS MODIFIED

IECC®: SECTION 202 (New), R404.4 (N1104.4) (New), R404.4.1 (N1104.4.1) (New), 404.4.2 (N1104.4.2) (New), R404.4.3

(N1104.4.3) (New), TABLE R405.2, TABLE R406.2, R406.3.2, TABLE R406.5

Proposed changes based on stakeholder feedback.

1. Split definition into separate definitions for Potential Solar Zone Area and Annual Solar Access for greater clarity. Moved position of low-sloped roof to clarify that "orientation requirement" only applied to steep slope roofs. Added additional sentence further clarifying the types of obstructions that that can be considered when calculating annual solar access.
2. Editorial change to Exception 1 under both R404.4.1 and R404.4.2.
3. Changed R404.4.1 so that it also applies to other R3 occupancies and that R404.4.2 only applies to R2 and R4 occupancies.
4. Modified R404.4.2 exception 2 to remove CZ 4C and 5C, the PV requirements were found to be cost effective for low-rise multifamily in these CZ per the original Cost Impact statement included in the monograph.
5. Modified R404.4.3 to align with language used in REPI-158 for documentation of RECs.
6. Clarify that requirement in Table R405.2 should be at bottom under Electrical and Lighting Power Systems and not under General
7. Based on approved REPI-126-21 that modified R406, remove proposed changes to R406.3.2 and Table R406.5

Proponents:

2021 International Energy Conservation Code

Add new definition as follows:

R202

POTENTIAL SOLAR ZONE AREA. The combined area of any steep-sloped roofs oriented between 90 degrees and 300 degrees of true north and any low-sloped roofs where the *annual solar access* is 70 percent or greater.

ANNUAL SOLAR ACCESS. The ratio of annual solar insolation with shade to the annual solar insolation without shade. Shading from obstructions located on the roof or any other part of the building shall not be included in the determination of annual solar access. Shading from existing permanent natural or person-made obstructions that are external to the building, including but not limited to trees, hills, and adjacent structures, shall be considered for annual solar access calculations.

Add new text as follows:

R404.4 (N1104.4) On-site renewable energy.

The building shall comply with the requirements of R404.4.1 or R404.4.2.

R404.4.1 (N1104.4.1) One- and two- family dwellings and townhouses and other R-3 Occupancies.

Install an on-site renewable energy system with a nameplate DC power rating measured under standard test conditions, of no less than 2kW

Exceptions:

1. A building with a permanently installed domestic solar water heating system with a solar savings fraction of not less than 0.5.
2. A building in climate zone 4C, 5C or 8.
3. A building where the *potential* solar zone *area* is less than 300 square feet.

404.4.2 (N1104.4.2) Group R2 and R4 Occupancies.
Install an on-site renewable energy system with a rated capacity of not less than 0.75 W/ft2 multiplied by the gross conditioned floor area

Exceptions:

1. A building with a permanently installed domestic solar water heating system with a solar savings fraction of not less than 0.5.
2. A building in climate zone 8.
3. A building where the *potential solar zone area* is less than 300 square feet.

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R404.4.3 Renewable energy certificate (REC) documentation. Where *RECs* are associated with *renewable energy* power production required by Section R404.4.1 or R404.4.2, documentation shall comply with Section R404.5.

Revise as follows:TABLE R405.2 REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE
Portions of table not shown remain unchanged.

SECTION[a]	TITLE
Electrical and Lighting Power Systems	
R404.4	On-site renewable energy

TABLE R406.2 REQUIREMENTS FOR ENERGY RATING INDEX
Portions of table not shown remain unchanged.

SECTION[a]	TITLE
R404.2	Interior lighting controls
R404.4	On-site renewable energy
R406.3	Building thermal envelope

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

Reason: On-site electricity generation using photovoltaics is a key technology for reducing greenhouse gas emissions associated with Commercial and Residential buildings. According to the most recent assessment by the National Renewable Energy Lab (NREL) the cost of installed photovoltaics in 2020 was 3% lower than in 2019 and 65-70% lower than the cost of similar sized systems in 2010. With the continued drop in cost of installing on-site PV the cost per kilowatt hour of PV generated electricity is at parity with grid purchased electricity in many States throughout the country. This proposal describes requirements for prescriptive solar PV that must be installed at the time of construction. Analysis by PNNL shows that on-site renewable electricity generation is cost effective across all low-rise multifamily buildings and most single family and one or two unit townhouses. The analysis was done using each of the Residential prototypes in each ASHRAE climate zone. The capacity requirements were established by calculating the highest on-site solar PV capacity that limited electricity export back to the grid. The threshold used for determining these capacities was a grid export limit of less than 0.5% of total annual building electricity consumption. A review of the hourly results showed it was unrealistic to set a hard limit of zero overproduction. When calculating cost effectiveness no credit was taken for electricity that was exported back to the grid. The calculation of grid exports was done on an hourly basis. The proposed requirements reduce purchased energy from the electrical grid which will help reduce green house gas emissions and energy costs for building owners.
PVs provide substantial benefits to the consumer and society by helping to reduce GHG emissions associated with electricity generation. PV market growth combined with a cleaner grid will support goals of reduced GHG emissions established across the U.S. and others by federal agencies, as well as many states and local governments.

Cost Impact: The code change proposal will increase the cost of construction.
For this analysis of residential building solar PV cost effectiveness was calculated using the Life Cycle Cost methodology established by Pacific Northwest National Lab for determining National and State cost effectiveness of the 2021 International Energy Conservation Code. The DOE methodology accounts for the benefits of energy-efficient home construction over the life of a typical mortgage, balancing initial costs against longer term energy savings. The Life-Cycle Cost methodology provides a full accounting over a 30-year period of the cost savings, considering energy savings, the initial investment financed through increased mortgage costs, tax impacts, and residual values of energy efficiency measures. The installed cost of solar PV was based on costs reported in the U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020 published by NREL in 2021. Installed costs were scaled based on solar PV capacity from 2kW up to 200kW and applied based on the calculated capacity required for each prototype in each climate zone.

The proposed solar PV capacities were shown to be cost effective for R occupancies in each ASHRAE climate zone except for climate zone 8 and for single family residences in all climate zones except 4C, 5C and 8.

Results

	Discount Rate				
	3.84% nominal	3% real	7% real		
	DOE	OMB	OMB		
With SCC value					
Measure incremental LCC	$37,902.21	$31,623.17	$21,228.24		2020$ (+ for
Simple payback				11.43	Years
With SCC = $0					
Measure incremental LCC	$27,755.01	$21,475.98	$11,081.05		2020$ (+ for
Simple payback				13.10	Years

Single Family Dwellings

	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
PV Capacity (kW)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PV Generation (kWh)	3,189	3,082	3,480	3,000	3,651	3,458	2,669	3,593	2,304	2,510	3,154	2,355	2,611	2,775	2,444	1,885
PV Cost @ 3.55	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100	$ 7,100
IECC Cost effectiveness @ $3.55 per Watt																
3.84% Real w/o SCC	$2,956	$2,617	$3,881	$2,356	$4,424	$3,811	$1,305	$4,239	$146	$800	$2,845	$308	$1,121	$1,642	$591	($1,185)
3% Real w/o SCC	$2,164	$1,884	$2,927	$1,669	$3,374	$2,869	$802	$3,223	($154)	$386	$2,073	($20)	$650	$1,080	$213	($1,251)
7% Real w/o SCC	$871	$692	$1,358	$555	$1,645	$1,321	$0.30	$1,547	($611)	($266)	$812	($525)	($97)	$178	($376)	($1,312)
3.84% Real w/ SCC	$4,542	$4,149	$5,611	$3,848	$6,239	$5,531	$2,632	$6,026	$1,292	$2,048	$4,414	$1,479	$2,419	$3,022	$1,806	($247)
3% Real w/ SCC	$3,750	$3,417	$4,657	$3,161	$5,190	$4,589	$2,130	$5,009	$992	$1,634	$3,641	$1,151	$1,949	$2,460	$1,428	($314)
7% Real w/ SCC	$2,457	$2,225	$3,089	$2,047	$3,460	$3,041	$1,328	$3,334	$535	$982	$2,381	$646	$1,202	$1,558	$839	($375)

Low-Rise Multifamily

	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
PV Capacity (kW)	16.22	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
PV Generation (kWh)	25,921	25,050	28,286	24,388	29,675	28,108	21,699	29,208	18,728	20,403	25,634	19,145	21,221	22,554	19,863	15,322
PV Cost @ 2.26/W	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673	$ 36,673
IECC Cost effectiveness @ $2.26 per Watt																
3.84% Real w/o SCC	$45,279	$42,513	$52,789	$40,410	$57,201	$52,224	$31,871	$55,717	$22,436	$27,755	$44,367	$23,760	$30,353	$34,586	$26,040	$11,619
3% Real w/o SCC	$35,929	$33,648	$42,124	$31,914	$45,762	$41,658	$24,871	$44,539	$17,089	$21,476	$35,177	$18,181	$23,619	$27,110	$20,062	$8,167
7% Real w/o SCC	$20,320	$18,862	$24,280	$17,753	$26,606	$23,982	$13,251	$25,824	$8,276	$11,081	$19,840	$8,975	$12,451	$14,683	$10,177	$2,574
3.84% Real w/ SCC	$58,170	$54,971	$66,857	$52,539	$71,959	$66,203	$42,663	$70,244	$31,750	$37,902	$57,116	$33,281	$40,907	$45,803	$35,919	$19,239
3% Real w/ SCC	$48,821	$46,106	$56,192	$44,043	$60,521	$55,637	$35,662	$59,065	$26,403	$31,623	$47,926	$27,702	$34,173	$38,327	$29,940	$15,788
7% Real w/ SCC	$33,212	$31,320	$38,348	$29,883	$41,364	$37,961	$24,043	$40,350	$17,591	$21,228	$32,589	$18,496	$23,005	$25,900	$20,056	$10,194

The installed cost of photovoltaic systems was based on published NREL cost data that was furhter adjusted to account for streamlined permitting under the NREL SolarApp+ program and to account for differences between retrofit and new construction costs. A cost of $3.55 per installed watt was used for 2kW array capacity and $2.26 per installed watt was used for a 16kW array capacity.

, Inc.

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-117-21 Performance 100 % renewable
CDP ID #	99
Code	IECC RE
Code Section(s)	R405.2 New Section n
Location	base
Proponent	Steven Rosenstock srosenstock@eei.org
Proposal Status	SC rev
Subcommittee	RE Elec, Light
Subcommittee Notes	Added exceptions to allow annualized consideration for renewables
Recommendation	Motion to approve as modified
Vote	11 in favor, 0 opposed, 0 abstentions
Recommendation Date	
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee___________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

REPI-117-21

IECC®: R405.2

Proponents:
Steven Rosenstock, representing Edison Electric Institute (srosenstock@eei.org)

2021 International Energy Conservation Code

Revise as follows:

R405.2 (N1105.2) Performance-based compliance.

Compliance based on total building performance requires that a *proposed design* meets all of the following:

- 1.

  The requirements of the sections indicated within Table R405.2.

- 2.

  The building thermal envelope shall be greater than or equal to levels of efficiency and solar heat gain coefficients in Table R402.1.1 or R402.1.3 of the 2009 *International Energy Conservation Code*.

- 3.

  An annual energy cost that is less than or equal to the annual energy cost of the *standard reference design*. Energy prices shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information Administration's State Energy Data System Prices and Expenditures reports. Code officials shall be permitted to require time-of-use pricing in energy cost calculations.

  ~~Exception~~ <u>Exceptions</u>:

  <u>1.</u> *conditioned floor area* shall be permitted to be substituted for the energy cost. The source energy multiplier for electricity shall be 3.16. The source energy multiplier for fuels other than electricity shall be 1.1.The energy use based on source energy expressed in Btu or Btu per square foot of

  <u>2. The energy use based on site energy expressed in Btu or Btu per square foot of conditioned floor area shall be permitted to be substituted for the energy cost for an all-electric building</u> ~~using 100% renewable energy~~ <u>with on-site renewable energy installed.</u>

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-130-21 ERI Design Options
CDP ID #	251
Code	IECC RE
Code Section(s)	R406.3, R406.3.1, R406.3.2, R406.4 New Section n
Location	base
Proponent	Vladimir Kochkin vkochkin@nahb.org
Proposal Status	SC rev
Subcommittee	RE Elec, Light
Subcommittee Notes	Proponent wanted it disapproved based on prior committee action
Recommendation	Motion to disapprove.
Vote	12 in favor, 0 opposed, 0 abstentions
Recommendation Date	
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee___________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee____________________________
Date	

International Energy Conservation Code

Code Change Proposal Tracking Sheet

Proposal #	REPI-143-21 Existing
CDP ID #	441
Code	IECC RE
Code Section(s)	R501.7 (New), ~~SECTION R502, R502.1, R502.2, R502.3, R502.2.2 (New), R502.2.3 (New), R502.3.1, R502.3.2, R502.3.3, R502.3.4 New Section y~~
Location	base
Proponent	Robby Schwarz robby@btankinc.com
Proposal Status	SC rev
Subcommittee	RE Existing Bldg
Subcommittee Notes	The sub-committee discussed this proposal over several meetings. The proposal itself had several changes and was too much for one proposal. The committee recommended that the proposal be split up to help clarify. The proponent agreed and now this proposal contains only moving and modifying section R502.2 to a new section R507.1. Reason: Changes in space conditioning was confusing in the additions section. As additions are new construction would be required to comply with the code. The original language remains with exceptions 2 and 3 removed. Exception #2 was originally intended to address additions, not general changes in space conditioning. So, now, the revised section applies to a change in condition spaces in the general section. This exception says to comply with Section R402.1.5 (UA Alternative). But, since R402.1.5 is an option in the code for "full compliance" as stated in the charging language there is no need to retain exception #2. Exception #3 allowed the use of the "Where complying in accordance with Section R405 and the annual energy cost or energy use of the addition and the existing building, and any alterations that are part of the project, is less than or equal to the annual energy cost of the existing building" Would not the energy use of the existing unconditioned building be very low? Note: The remaining portion of this proposal is now RECPI-5-21 and will be heard by the sub-committee on April 26, 2022

Recommendation	Motion to approve as modified.
Vote	6-0 in favor. Motion passes
Recommendation Date	
Next Step	To Subcommittee___________________________________ To Advisory Group__________________________________ To Consensus Committee_______X____________
Consensus Committee	
Committee Response	
Vote	Affirmative____________Negative_____________Table______________ To Subcommittee___________________________
Date	

REPI-143 a Modification #1

Add new section as follows:

SECTION R501 GENERAL

R501.1 Scope. The provisions of this chapter shall control the *alteration*, *repair*, *addition* and change of occupancy of existing *buildings* and structures.

R501.1.1 General. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing *building* or *building* system lawfully in existence at the time of adoption of this code. Unaltered portions of the existing *building* or *building* supply system shall not be required to comply with this code.

R501.2 Compliance. *Additions*, *alterations*, *repairs* or changes of occupancy to, or relocation of, an existing *building*, *building* system or portion thereof shall comply with Section R502, R503, R504 or R505, respectively, in this code. Changes where unconditioned space is changed to *conditioned space* shall comply with Section R502.

R501.3 Maintenance. *Buildings* and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems that are required by this code shall be maintained in conformance to the code edition under which installed. The owner or the owner's authorized agent shall be responsible for the maintenance of *buildings* and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protection and safety systems and devices in existing structures.

R501.4 Compliance. *Alterations*, *repairs*, *additions* and changes of occupancy to, or relocation of, existing buildings and structures shall comply with the provisions for *alterations*, *repairs*, *additions* and changes of occupancy or relocation, respectively, in this code and the *International Residential Code*, *International Building Code*, *International Existing Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code*, *International Property Maintenance Code*, *International Private Sewage Disposal Code* and NFPA 70.

R501.5 New and replacement materials. Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided that hazards to life, health or property are not created. Hazardous materials shall not be used where the code for new construction would not allow their use in *buildings* of similar occupancy, purpose and location.

R501.6 Historic buildings. Provisions of this code relating to the construction, *repair, alteration*, restoration and movement of structures, and *change of occupancy* shall not be mandatory for *historic buildings* provided that a report has been submitted to the code official and signed by the owner, a *registered design professional*, or a representative of the State Historic Preservation Office or the historic preservation authority having jurisdiction, demonstrating that compliance with that provision would threaten, degrade or destroy the historic form, fabric or function of the *building*.

R501.7 Change in space conditioning. Any unconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

Exceptions:

1. Where the simulated performance option in Section R405 is used to comply with this section, the annual energy cost of the *proposed design* is permitted to be 110 percent of the annual energy cost otherwise allowed by Section R405.2.

~~2. Where, for building envelope compliance purposes only, the Total UA of the existing building or portion thereof undergoing a change in space conditioning, and the *addition*, and any *alterations* that are part of the project complies with Section R402.1.5.~~

~~3. Where complying in accordance with Section R405 and the annual energy cost or energy use of the *addition* and the existing *building* with the change in space conditioning, and any *alterations* that are part of the project, is less than or equal to the annual energy cost of the existing *building* prior to the change in space conditioning. The *addition* and any *alterations* that are part of the project shall comply with Section R405 in its entirety.~~

Revise as Follows:

Move entire Section R502.2 to R501.7 with no change in language

SECTION R502 ADDITIONS

~~**R502.2 Change in Space Conditioning** Any unconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.~~

~~**Exceptions:**~~

~~1. Where the simulated performance option in Section R405 is used to comply with this section,~~

~~the annual energy cost of the *proposed design* is permitted to be 110 percent of the annual energy cost otherwise allowed by Section R405.2.~~
~~2. Where the Total UA, as determined in Section R402.1.5, of the existing *building* and the *addition*, and any *alterations* that are part of the project, is less than or equal to the Total UA generated for the existing *building*.~~
~~3. Where complying in accordance with Section R405 and the annual energy cost or energy use of the *addition* and the existing *building*, and any *alterations* that are part of the project, is less than or equal to the annual energy cost of the existing *building*. The *addition* and any *alterations* that are part of the project shall comply with Section R405 in its entirety.~~

Reason Statement:

The existing Section **R502.2 Change in space conditioning** in the additions chapter 5 Existing homes has no reference to additions. Is speaks to a general condition of changing a low energy space during an alteration to become a conditioned space. This is not an addition, so it was moved to a new section in R501 General as an overarching general requirement rather than one specific to additions.

Modification have been made per the direction of the Existing Homes Subcommittee to ensure that the entirety of the code is applied to change of space conditioning project and that the allowed exception only applies to the building thermal envelope. Two Exceptions have been eliminated for the following reasons:

Exception #2
Exception #2 was originally intended to address additions, not general changes in space conditioning. So, now, the revise section it to apply to change in condition spaces general, this section says to comply with Section R402.1.5 (UA Alternative). But, since R402.1.5 is an option in the code for "full compliance" as stated in the charging language there is no need to retain exception #2.
Exception #3
How is exception #3 any different than exception #1 except that exception #1 give 10% leeway? Given that I would suggest deleting Exception #3. In addition, if the entire building was unconditioned then the energy use or annual energy cost would be very low and this exception creates that as a baseline. Thus, this exception does the opposite (increases stringency and reduces flexibility) of exception #1. Finally, since exception #1 is whole building compliance, there is no need to qualify it as applicable to building thermal envelope only.

Cost of construction will not be impacted

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	RECPI-5-21 Part B of REPI-143-21
CDP ID #	
Code	IECC RE
Code Section(s)	R501.7 (New New Section y
Location	base
Proponent	Robby Schwarz robby@btankinc.com
Proposal Status	SC rev
Subcommittee	RE Existing Bldg
Subcommittee Notes	
Recommendation	**MEETING 5/24/22** Jim Zengel motioned to disapprove – Clifford Swoape second Reason statement - there are too many things that are unfinished and language that is conflicting with charging (existing code) language and the fact that we thought the ERI path needs additional work.
Vote	Disapprove Vote: 6 Yes, 0 No, 1 Abstained
Recommendation Date	5/24/22
Next Step	To Subcommittee___________________________ To Advisory Group__________________________________ To Consensus Committee__________________
Consensus Committee	
Committee Response	
Vote	Affirmative__________ Negative___________ Table_____________ To Subcommittee___________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-144-21 Existing Buildings Additional Efficiency Credits
CDP ID #	413
Code	IECC RE
Code Section(s)	R502.3, R502.3.5, R503.1, R503.1.5, SECTION R506, R506.1 New Section y
Location	base
Proponent	Sean Denniston sean@newbuildings.org
Proposal Status	SC rev
Subcommittee	RE Existing Bldg
Subcommittee Notes	**MEETING 3/22/2022** Modifications were not posted to the public comment document; therefore a motion can't be made. Modifications will be posted; discussion will resume in committee at a later date.
Recommendation	**MEETING 1/25/2022** Mike Brown – motion to disapprove as written. Jim Zengel – second. Seth Wiley – can you remind me what are our options here (what can we vote). Gil reminded the committee what our options are. Mike Brown – I didn't know we could ask them to table it. Mike would like to withdraw his motion. Jim agreed. New motion – Mike Brown motion to table and ask for rewrite Seth Wiley second – discussion, we need to give them a time and some direction – tying it to the IEBC and some justification for this proposal – Amy level 1-3 alterations, what is required for compliance... Next available meeting time is March 22nd to hear the proposal again. **MEETING 3/22/2022** Table until posted to public comment **Meeting 5/24/2022** Robby motion to approve as submitted - Seth second Reason Statement: We believe this is a good step forward ultimately it gives us a foundation to go forward and grow from in the existing building space.
Vote	Approved as modified- Passed Unanimously
Recommendation Date	3/22/2022

REPI-144-21

Add new Definition as follows:

EXTERIOR WALL ENVELOPE. A system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members, including framing and sheathing materials, and conditioned interior space, from the detrimental effects of the exterior environment.

WORK AREA. That portion or portions of a building consisting of all reconfigured spaces as indicated on the construction documents. Work area excludes other portions of the building where incidental work entailed by the intended work must be performed and portions of the building where work not initially intended by the owner is specifically required by this code.

Modify the Section as follows:

R502.3 Prescriptive compliance. Additions shall comply with Sections R502.3.1 through ~~R502.3.4~~ R502.3.5.

Add new Section as follows:

R502.3.5 Additional Efficiency Packages. *Additions* shall comply with Section R506. *Alterations* to the existing building that are not part of the *addition*, but permitted with the *addition*, shall be permitted to be used to achieve this requirement.

Exceptions:

1. *Additions* that increase the *building*'s total *conditioned floor area* by less than 25 percent.
2. *Additions* that do not include the addition or replacement of equipment covered in Sections R403.5 or R403.7.
3. *Additions* that do not contain *conditioned space*.
4. Where the *addition* alone or the existing building and *addition* together comply with Section R405 or R406.

Modify the Section as follows:

SECTION R503

ALTERATIONS

R503.1 General. Alterations to any building or structure shall comply with the requirements of the code for new construction, without requiring the unaltered portions of the existing building or building system to comply with this code. Alterations shall be such that the existing building or structure is not less conforming to the provisions of this code than the existing building or structure was prior to the alteration.

Alterations shall not create an unsafe or hazardous condition or overload existing building systems. Alterations shall be such that the existing building or structure does not use more energy than the existing building or structure prior to the alteration. Alterations to existing buildings shall comply with Sections R503.1.1 through ~~R503.1.4~~ R503.1.5.

Add new Sections as follows:

R503.1.5 Additional Efficiency Packages. *Alterations* shall comply with Section R506 where the *alteration* contains replacement of two or more of the following:

1. HVAC unitary systems or HVAC central heating or cooling equipment serving the *work area* of the *alteration*.
2. Water heating equipment serving the *work area* of the *alteration.*
3. 50% or more of the lighting fixtures in the *work area* of the *alteration*.
4. 50% or more of the area of interior surfaces of the *thermal envelope* in the *work area* of the *alteration.*
5. 50% or more of the area of the *building's exterior wall envelope*

Exceptions:

1. *Alterations* that are permitted with an addition complying with section R502.3.5.
2. *Alterations* that comply with Section R405 or R406.

SECTION R506

ADDITIONAL EFFICIENCY PACKAGE OPTIONS

R506.1 General. Where required in Section R502 or R503, the *building* shall comply with one or more additional efficiency package options in accordance with the following:

1. Enhanced envelope performance in accordance with Section R408.2.1.
2. More efficient HVAC equipment performance in accordance with R408.2.2
3. Reduced energy use in service water-heating in accordance with R408.2.3
4. More efficient duct thermal distribution system in accordance with R408.2.4
5. Improved air sealing and efficient ventilation system in accordance with R408.2.5

Revisions and Reasons

Additions

The additions section has received a minor editorial change for clarity. This proposal works with existing requirements for additions. The code currently includes three paths for demonstrating compliance for additions:

1. The addition complies on its own
2. The addition and the existing building comply together
3. The addition does not increase the total energy usage of the existing building with the addition

The existing prescriptive path for additions was the least stringent compliance path since all other paths require the either the existing building be effectively code compliant or be improved enough to offset the energy use of the addition. By increasing the stringency of the prescriptive path for large additions, this proposal closes the gap between the prescriptive and other compliance options. As long as other proposals for R406 do not weaken these three compliance paths, this proposal should be just as compatible with them as the current code requirements.

Alterations

The revised proposal provides a clearer threshold to ensure that the requirements only apply to substantial alterations. Only alterations that include two of more items from the list would be subject to the requirements. Each of these items are themselves substantial alterations of the major energy systems in a home. 50% was chosen as the threshold for the replacement of luminaires, replacement of the interior surfaces of the thermal envelope and replacement of the exterior wall area because it is a generally used threshold in the I-Codes. For example, a work area that exceeds 50% of the building area is used as the area threshold for Level 3 alterations in the IEBC.

The proposal also introduces two terms. “Work area” from the IEBC is used to clearly define that these thresholds are 50% of just the area of the alteration and not the whole building. “Exterior wall envelope” from the IBC to define re-siding alteration projects.

This approach was chosen over the Level 1-3 approach in the IEBC because those thresholds are not well-tuned to the energy systems. Those thresholds are focused on the impact of the work on the whole building and not just the energy systems. The thresholds for the different levels also reveal an understandable focus on alterations with egress and accessibility implications. A building could be completely gutted and completely reskinned, with all lighting, space conditioning and water heating equipment replaced and still only be considered a Level 1 alteration as long as no door or windows were moved/added and the equipment replacements did not include additional equipment. Conversely, an alteration might be considered Level 3 because it includes substantial space reconfigurations but include only minimal impacts to energy systems.

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-062-21 Air Leakage and Ventilation
CDP ID #	331
Code	IECC RE
Code Section(s)	R402.4.1.2, R402.4.1.3, R403.6, R403.6.1, R502.3.1 New Section
Location	base
Proponent	Seth Wiley seth@siteisreal.com
Proposal Status	SC rev
Subcommittee	HVACR
Subcommittee Notes	Items sticky for the subcommittee. Infiltration rate, Merv13 filter required, mechanical ventilation
Recommendation	The Proponents presented the Proposal and almost immediately the subcommittee made a motion and a second to Disapprove/ reject this Proposal. The subcommittee felt the requirements for infiltration, air quality and mechanical ventilation were too broad. No cost analysis was provided by the Proponent.
Vote	7 to Disapproved / zero no / 1 abstention
Recommendation Date	5/16/2022
Next Step	To Subcommittee ____________________________ To Advisory Group___________________________________ To Consensus Committee___x_______________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-075-21 Duct and air handler locations
CDP ID #	426
Code	IECC RE
Code Section(s)	R403.3, R403.3.1, R403.3.2, R403.3.3, R403.3.3.1 New Section n
Location	base
Proponent	Robby Schwarz robby@btankinc.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	**The concept of this proposal requires further study and collaboration with other affected stakeholders. Some areas of the country wouldn't have a problem with these proposed changes in terms of relocating the air handler to be inside conditioned space. In other areas this is not the case. Therefore, this practice must undergo increased use in the field and acceptance in those areas of the country before it can be considered part of a national code.** HVACR working Group
Recommendation	HVACR working Group having spent hours discussing this Proposal with members, interested parties and the Proponent determined the Proposal needs more work. Recommendation of the subcommittee to disapprove
Vote	Disapprove Vote 8/0/2
Recommendation Date	May 31,2022
Next Step	To Subcommittee___________________________________ To Advisory Group__________________________________ To Consensus Committee_x_________________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-076-21 Duct and air handler locations
CDP ID #	523
Code	IECC RE
Code Section(s)	R403.3, R403.3.2, R403.7, R403.7.1 (New) New Section n
Location	Base
Proponent	Nicholas O'Neil noneil@energy350.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	**The concept of this proposal requires further study and collaboration with other affected stakeholders. Some areas of the country wouldn't have a problem with these proposed changes in terms of relocating the air handler to be inside conditioned space. In other areas this is not the case. Therefore, this practice must undergo increased use in the field and acceptance in those areas of the country before it can be considered part of a national code.**
Recommendation	HVACR working group tirelessly worked on this Proposal along with other and determined this proposal needs more work. **This recommendation should be considered in conjunction with REPI-75 which is similar in nature.**
Vote	Disapprove vote 7/3/0
Recommendation Date	5/31/2022
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee__x________________
Consensus Committee	
Committee Response	

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-080-21 Ducts in Conditioned Space
CDP ID #	238
Code	IECC RE
Code Section(s)	R403.3.2, N1103.3.2 New Section n
Location	base
Proponent	Vladimir Kochkin vkochkin@nahb.org
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	**The original proposal to revise the minimum insulation value for 3.3 was accepted, and further modified to combine Items 3 and 4 as a single Item 3. The proponent participated in the working group's development of these modifications. Greg Johnson with SEHPCAC recommended a rewrite to section 3.3 line item. Final modification received by the HVACR Chair after the subcommittee voted.**
Recommendation	Subcommittee along with SEHPCAC, reviewed the final version of the modification and agreed with the HVACR working group recommendation to approve as Modified REPI-080-21
Vote	Approve "as modified" 9/1/2
Recommendation Date	May 31, 2022
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee__x________________
Consensus Committee	
Committee Response	

Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

REPI-80-21

IECC®: R403.3.2

Proponents:
Vladimir Kochkin, NAHB, representing NAHB (vkochkin@nahb.org)

Revise as follows:
R403.3.2 Ducts located in conditioned space.
For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   2.1 The air handler is located completely within the continuous air barrier and within the building thermal envelope.
   2.2 The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   2.3 The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.
3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:
   3.1 A continuous air barrier installed between unconditioned space and the duct.
   3.2 Insulation installed in accordance with Section R402.2.7.
   3.3 A minimum ~~R-19~~ R-10 insulation installed in the cavity width separating the duct from unconditioned space.
4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:
   4.1 A continuous air barrier installed between unconditioned space and the duct.
   4.2 Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
   4.3 The remainder of the cavity insulation shall be fully insulated to the drywall side.

Reason Statement:
The provision for R19 insulation was added in the 2021 IECC without justification. Apparently, the requirement was copied from a drawing intended for CZ 3 applications where R-19 floor insulation is a requirement. There is no basis for having a separate requirement for insulation at duct locations in floor cavities that is more restrictive than the floor insulation R-value requirement (CZ 0, 1, 2 require R13 floor insulation). Furthermore, duct insulation requirement for ducts in unconditioned space is R6 or R8 depending on the duct diameter. The proposed modification aligns the requirement for ducts in floors with a similar requirement for ducts in exterior walls where ducts must be separated by R-10 (see R403.3.2(4) of 2021 IECC). It is noted that floor insulation installation is always required to be in compliance with Section R402.2.7 and the floor is required to include an air barrier between unconditioned space and the duct. There are no energy use implications associated with this change. The R19 requirement can add cost for constructing a bulkhead to accommodate the added insulation in the floor. **Cost Impact:** The code change proposal will decrease the cost of construction. In certain floor assembly configurations in Climate Zones 0, 1, and 2, this change will reduce costs by avoiding the need for bulkhead construction.

Working Group Recommendation: Accept proposal and further modify as follows:

R403.3.2 Ducts located in conditioned space.
For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   - 2.1 The air handler is located completely within the continuous air barrier and within the building thermal envelope.
   - 2.2 The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   - 2.3 The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.
3. ~~Ductwork in floor cavities located over unconditioned space shall comply with all of the following:~~
   - ~~3.1 A continuous air barrier installed between unconditioned space and the duct.~~
   - ~~3.2 Insulation installed in accordance with Section R402.2.7.~~
   - ~~3.3 A minimum R-19 R-10 insulation installed in the cavity width separating the duct from unconditioned space.~~
4. ~~Ductwork located within exterior walls of the building thermal envelope shall comply with the following:~~
   - ~~4.1 A continuous air barrier installed between unconditioned space and the duct.~~
   - ~~4.2 Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.~~
   - ~~4.3 The remainder of the cavity insulation shall be fully insulated to the drywall side.~~

3. Ductwork located in wall or floor building assemblies separating unconditioned from conditioned space shall comply with the following:

   3.1 A *continuous air barrier* shall be installed as part of the building assembly between the *duct* and the *unconditioned space*.

   3.2 *Ducts* shall be installed in accordance with Section R403.3.1.

   Exception: Where the building assembly cavities containing *ducts* have been air sealed in accordance with Section R402.4.1, *duct* insulation is not required.

   3.3 Not less than R-10 insulation, and not less than 50 percent of the required R-value specified in Table R402.1.3, shall be located between the *duct* and the *unconditioned space*.

   3.4 For *ducts* in these building assemblies to be considered within *conditioned space*, the air handling equipment shall be installed within *conditioned space*.

Working Group Remarks: The original proposal to revise the minimum insulation value for 3.3 was accepted, and further modified to combine Items 3 and 4 as a single Item 3. The proponent participated in the working group's development of these modifications.

Subcommittee Action: Further modify proposed 3.3 for clarity.

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-086-21 Duct Leakage
CDP ID #	462
Code	IECC RE
Code Section(s)	R403.3.6, TABLE R405.2 New Section n
Location	base
Proponent	David Springer iecc-ducts2@2050partners.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	**Subcommittee voted to approve.** Originally this Proposal presented by David Springer. Early on this Proposal was going to be withdrawn but Mark Lyles confirmed the Proposal was not going to be withdrawn and this Proposal moved to discussion with the HVACR subcommittee working group. **As Modified Proposal V5**
Recommendation	This Proposal was presented during the 5/2/2022 HVACR subcommittee for consideration. Gayathri Vijayakumar spoke in favor of the Proposal and the subcommittee agreed voting to approve. Gayathri and the Proponents have been notified the IECC Consensus committee will hear this Proposal on 5/19/2022. Gayathri Vijaykumar has agreed to Present during the call. The last revision to this Proposal is Modification V5 forwarded with this update. On 5/6/2022 our subcommittee received notice of SEHPCAC recommendations received. Because the recommendations came after the subcommittee had voted and before the IECC Committee presentation the Chair HVACR sent the Proposal back to the subcommittee for a vote giving the Proponent and SEHPCAC time to discuss and come to a consensus regarding the recommendations. This proposal with recommendations SEHPCAC was heard by the subcommittee on 5/31/2022 Vote to approve
Vote	Vote to approve "**As modified**" 9 voting members unanimously approved 5/31/2022 vote to approve SEHPCAC recommendations 11/0/0
Recommendation Date	5/2/2022 Proposal and 5/31/2022 with SEHPCAC recommendations
Next Step	To Subcommittee__________________________________ To Advisory Group__________________________________ To Consensus Committee____x______________
Consensus Committee	

Committee Response	
Vote	Affirmative__________ Negative___________ Table____________ To Subcommittee_________________________
Date	

REPI-86-21 (modification replaces the monograph)

IECC®: R403.3.6, TABLE R405.2

Proponents:

David Springer, representing on behalf of the California Statewide Utility Codes and Standards Team (iecc-ducts2@2050partners.com); Mark Lyles, representing New Buildings Institute (markl@newbuildings.org); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

2021 International Energy Conservation Code

CHAPTER 2 [RE] DEFINITIONS

No change (shown for context only):

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

Revise as follows:

R403.3 Duct~~s~~ Systems.

R403.3.5 Duct system testing. Each ~~D~~*duct~~s~~ system* shall be ~~pressure~~ tested for air leakage in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 ~~to determine air leakage~~. Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system. Registers shall be ~~taped or otherwise~~ sealed during the test. A written report of the test results ~~of the test~~ shall be signed by the party conducting the test and provided to the *code official. Duct system* leakage testing at either rough-in or post-construction shall be permitted.. ~~by one of the following methods:~~

~~1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.~~

~~2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.~~

Exception: ~~A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems.~~

~~*Duct system* t~~Testing shall not be required for ~~*ducts* or~~ *duct systems* serving ~~heat or energy recovery ventilators or~~ ventilation systems that are not integrated with ~~*ducts* or~~ *duct systems* serving heating or cooling systems.

R403.3.6 Duct system leakage. ~~The total leakage of the ducts, where measured in accordance with Section R403.3.5, shall be as follows:~~

~~1. Rough-in test: The total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of *conditioned floor area* where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of *conditioned floor area*.~~

~~2. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of *conditioned floor area*.~~

~~3. Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the *building thermal envelope*, total leakage shall be less than or equal to~~

~~8.0 cubic feet per minute (226.6 L/min) per 100 square feet (9.29 m2) of *conditioned floor area*.~~

The total measured *duct system* leakage shall not ~~exceed~~ be greater than the values in Table R403.3.6. For buildings complying with Section R405 or R406, where *duct system* leakage to outside is tested in accordance with ANSI/ RESNET/ICC 380 or ASTM E1554, the ~~duct~~ leakage to outside value shall not be used for compliance with this s~~S~~ection, but shall be permitted to be used in the calculation procedures of Section R405 and R406.

TABLE R403.3.6

MAXIMUM TOTAL DUCT SYSTEM LEAKAGE

	Rough In	**Post Construction**
Duct Systems Serving more than 1,000 ft^2 of Conditioned Floor Area	**cfm/100 ft^2 (LPM/9.29 m^2)**	**cfm/100 ft^2 (LPM/9.29 m^2)**
Air handler is not installed	3 (85)	NA
Air handler is installed	4 (113.3)	4 (113.3)
Duct Systems Located in Conditioned Space, with air handler installed	8 (226.6)	8 (226.6)
Duct Systems Serving less than or equal to 1,000 ft^2 of Conditioned Floor Area	**cfm (LPM)**	**cfm (LPM)**
Air handler is not installed	30 (849.5)	NA
Air handler is installed	40 (1132.7)	40 (1132.7)
Duct Systems Located in Conditioned Space, with air handler installed	80 (2265.4)	80 (2265.4)

Revise as follows:

SECTION R405

TOTAL BUILDING PERFORMANCE

Table R405.2

REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

Portions of table not shown remain unchanged.

R403.3~~, including R403.3.1, except Sections R403.3.2, R403.3.3 and R403.3.6~~	Duct~~s~~ Systems

Revise as follows:

Portions of table not shown remain unchanged.

TABLE R405.4.2(1)

SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Thermal distribution systems	Duct insulation: in accordance with Section R403.3.1.	Duct insulation: as proposed.
	Duct location: same as proposed design.	Duct location: as proposed.
	Duct System Leakage to Outside: For duct systems serving ≤ 1,000ft^2 of *conditioned floor area*, the duct leakage to outside rate shall be 40 cfm (1132.7 L/min). For duct systems serving > 1,000ft^2 of *conditioned floor area*, the duct leakage to outside rate shall be 4 cfm (113.3 L/min) per 100 ft^2 (9.29 m^2) of *conditioned floor area.*	Duct System Leakage to Outside: The measured total duct system leakage rate shall be entered into the software as the duct system leakage to outside rate. **Exceptions:** 1. ~~When~~ Where duct system leakage to outside is tested in accordance ANSI/ RESNET/ICC 380 or ASTM E1554, the measured value shall be permitted to be entered. 2. ~~When~~ Where total duct system leakage is measured without the air handler installed, the simulation value shall be 4 cfm (113.3 L/min) per 100 ft^2 (9.29 m^2) of *conditioned floor area.*

	Distribution System Efficiency (DSE): ~~For all systems other than tested duct systems, a~~ For hydronic systems and ductless systems, a~~A~~ thermal distribution system efficiency (DSE) of 0.88 shall be applied to both the heating and cooling system efficiencies. ~~for all systems other than tested duct systems~~. ~~Duct location:~~ ~~same as proposed design.~~ **Exception:** ~~For nonducted heating and cooling systems that do not have a fan, the standard reference design thermal distribution system efficiency (DSE) shall be 1~~. ~~For tested duct systems, the leakage rate shall be 4 cfm (113.3 L/min) per 100 ft^2 (9.29 m^2) of *conditioned floor area* at a pressure of differential of 0.1 inch w.g. (25 Pa).~~	Distribution System Efficiency (DSE): ~~As tested or, where not tested,~~ For hydronic systems and ductless systems as specified in Table R405.4.2(2).

TABLE R405.4.2(2)

DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR

PROPOSED DESIGNS[a]

Revise as follows:

DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION	FORCED AIR SYSTEMS	HYDRONIC SYSTEMS[b]
Distribution system components located in unconditioned space	NA	0.95

Untested dDistribution system components entirely located in conditioned space [c]	0.88 NA	1
"Ductless" systems[d]	1	NA

a. Default values in this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.

b. Hydronic systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed-loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.

c. Entire system in conditioned space shall mean that no component of the distribution system, including the air-handler unit, is located outside of the conditioned space.

d. Ductless systems shall be allowed to have forced airflow across a coil but shall not have any ducted airflow external to the manufacturer's air-handler enclosure.

Revise as follows:

SECTION R406

ENERGY RATING INDEX COMPLIANCE

ALTERNATIVE

Table R406.2

REQUIREMENTS FOR ENERGY RATING INDEX

Portions of table not shown remain unchanged.

Mechanical	
R403.3, except Sections R403.3.2, R403.3.3 and R403.3.6	Ducts Systems

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-089-21 Pipe Insulation
CDP ID #	404
Code	IECC RE
Code Section(s)	R403.5.2, TABLE R405.2, TABLE R406.2 New Section n
Location	base
Proponent	Gary Klein iecc-pipe-insulation@2050partners.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	Proposal presented to the HVACR subcommittee for the first time on 5/2/2022. Gary Klein presenting as the Proponent. **“as modified v2”**
Recommendation	Proposal presented to the HVACR subcommittee **“as modified V2”** by Gary Klein Proponent. The discussion was light and the subcommittee voted to approve as modified. On 5/6/2022 our subcommittee received notice of SEHPCAC recommendations received. Because the recommendations came after the subcommittee had voted and before the IECC Committee presentation the Chair HVACR sent the Proposal back to the subcommittee for a vote giving the Proponent and SEHPCAC time to discuss and come to a consensus regarding the recommendations. This proposal with recommendations SEHPCAC was heard by the subcommittee on 5/31/2022 Vote to approve as modified V2 SEHPCAC
Vote	10 members voting to approve unanimously “as modified v2” 5/2/2022 with SEHPCAC recommendations approved on 5/31/2022
Recommendation Date	5/2/2022 approval of the Proposal 10/0/0 with SEHPCAC recommendations vote to approve on 5/31/2022 11/0/0
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee__x________________
Consensus Committee	

REPI-89-21

IECC®: R403.5.2, TABLE C403.12.3, TABLE R405.2, TABLE R406.2

Proponents: Gary Klein, representing on behalf of the California Statewide Utility Codes and Standards Team (iecc-pipe-insulation@2050partners.com); Mark Lyles, representing New

Buildings Institute (markl@newbuildings.org); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

From the Monograph:

Revise as follows:

R403.5.2 Hot water pipe insulation.

~~Insulation for e~~Service hot water piping ~~with a thermal resistance, R-value, of not less than R-3~~ shall be thermally insulated in accordance with Table R403.5.2 and be applied to the following:

1. Piping ¾ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space*.

~~2. Piping serving more than one dwelling units.~~

2~~3~~. Piping located outside the *conditioned space*.

3~~4~~. Piping from the water heater to a distribution manifold.

4~~5~~. Piping located under a floor slab.

5~~6~~. Buried piping.

6~~7~~. Supply and return piping in ~~circulation and recirculation systems~~ *circulating hot water systems* ~~other than cold water pipe return demand recirculation systems.~~

Exception: Cold water pipe returns in *demand recirculation water systems*.

TABLE R403.5.2 MINIMUM PIPE INSULATION THICKNESS (in inches)

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		MINIMUM PIPE INSULATION THICKNESS
	Conductivity Btu x in./(h x ft2 x °F)[a]	Mean Rating Temperature, °F	
141-200	0.25 - 0.29	125	1
105-140	0.21 - 0.28	100	1

a. For insulation outside the stated conductivity range listed in Table R403.5.2, the minimum thickness (T) shall be determined as follows:

$T = r[(1 + t/r)^{K/k} - 1]$

where

T = Minimum insulation thickness.

r = Actual outside radius of pipe.

t = Insulation thickness requirement; 1 inch.

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature; [Btu x in/(h x ft^2 x °F)].

k = The upper value of the conductivity range listed in Table R403.5.2 for the applicable fluid temperature; [Btu x in/(h x ft^2 x °F)].

TABLE R405.2 REQUIREMENTES FOR TOTAL BUILDING PERFORMANCE

SECTION	TITLE
Mechanical	
R403.5.1	Heated water circulation and temperature maintenance systems
R403.5.2	Hot water pipe insulation
R403.5.3	Drain water heat recovery units

TABLE R406.2 REQUIREMENTES FOR ENERGY RATING INDEX

SECTION	TITLE
Mechanical	
R403.5.1	Heated water circulation and temperature maintenance systems
R403.5.2	Hot water pipe insulation
R403.5.3	Drain water heat recovery units

As modified by the proponents:

R403.5.2 Hot water pipe insulation.

Insulation for service hot water piping with a thermal resistance, R-value, of not less than R-3 shall be be applied to the following:

1. Piping ¾ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space*.

~~2. Piping serving more than one dwelling units.~~

2~~3~~. Piping located outside the *conditioned space*.

3~~4~~. Piping from the water heater to a distribution manifold.

4~~5~~. Piping located under a floor slab.

5~~6~~. Buried piping.

6~~7~~. Supply and return piping in ~~circulation and recirculation systems~~ *circulating hot water systems* ~~other than cold water pipe return demand recirculation systems.~~

Exception: Cold water ~~pipe~~ returns in *demand recirculation water systems*.

TABLE R405.2 REQUIREMENTES FOR TOTAL BUILDING PERFORMANCE

SECTION	TITLE
Mechanical	
R403.5	Service hot water systems
~~R403.5.1~~	~~Heated water circulation and temperature maintenance systems~~
~~R403.5.3~~	~~Drain water heat recovery units~~

TABLE R406.2 REQUIREMENTES FOR ENERGY RATING INDEX

SECTION	TITLE
Mechanical	
R403.5	Service hot water systems
~~R403.5.1~~	~~Heated water circulation and temperature maintenance systems~~
~~R403.5.3~~	~~Drain water heat recovery units~~

Reasons:

1. **First paragraph**. We are proposing to remove the change to wall thickness and k-value and retain the R-value designation in the existing section. We are also proposing to retain the R-value not less than R-3. While the supporting analysis done for the original proposal shows that a 1-inch wall thickness is economically justified, it is only true if the pipe insulation material is changed from foam to fiberglass or mineral wool. This results in an increase of R-1 over the current requirements, a very small change for a big change in common practice. Getting R-3 pipe insulation (1/2-inch foam) done well is more important than having 1-inch wall thickness installed poorly. **We recommend moving the proposal to increase pipe insulation R-value to Section R408 as part of an efficient SHW distribution system measure.**
2. **Piping serving multiple dwelling units.** Currently text in both IEEC sections R403.5.2 and R403.8 imply applicability for piping serving "more than one dwelling unit" (or "multiple dwelling units"). This apparent conflict raises concerns that two-dwelling unit buildings covered by the IRC will now be directed to the commercial sections. **We recommend deleting the confusing language from this section.**
3. **Supply and Return piping**. The language in the existing code is confusing. This modification uses the same changes as in the original proposal. This new language improves the clarity of the code by using defined terms and by creating an exception to this one clause which was previously part of a convoluted sentence. **We recommend accepting these proposed revisions.**
4. **Tables 405.2 and Table 406.2**. The original proposal added a line for hot water pipe insulation. This makes sense because pipe insulation should be required for the Total Building Performance and Energy Rating Index compliance paths. During discussions, it was pointed out that adding the line for pipe insulation meant that the entire section was now required. With that in mind, we are proposing to have only one line in each of the tables, instead of three. **We recommend accepting this modification to streamline the code, albeit by only one line in each table.**

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-090-21 Grid Integrated Water Heating
CDP ID #	183
Code	IECC RE
Code Section(s)	R403.5.4 (New) New Section y
Location	base
Proponent	Kim Cheslak kim@newbuildings.org
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	Sean Dennison read the proposal and answered questions in Kim Cheslak absence
Recommendation	This proposal adds Demand Response controls for tanked water heaters only. The proposal is for specific tanked water heaters with 3 exceptions listed in the proposal. The reason for the revision replaces a definition for “grid integrated controls”. There was discussion in detail regarding effective date listed as 7/1/2025. After good discussion the subcommittee voted to approve this proposal with a strong vote. On 5/6/2022 our subcommittee received notice of SEHPCAC recommendations received. Because the recommendations came after the subcommittee had voted and before the IECC Committee presentation the Chair HVACR sent the Proposal back to the subcommittee for a vote giving the Proponent and SEHPCAC time to discuss and come to a consensus regarding the recommendations. This proposal with recommendations SEHPCAC was heard by the subcommittee on 5/31/2022 Vote to approve
Vote	Proposal approved 5/2/2022 8/0/0 and with SEHPCAC recommendations vote to approve on 5/31/2022 vote 10/0/0
Recommendation Date	5/2/2022 subcommittee meeting date Vote to approve with SEHPCAC recommendations 5/31/2022 10/0/0
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee__x________________
Consensus Committee	

REPI-90-21

IECC®: SECTION 202 (New), R403.5.4 (New), ANSI Chapter 06 (New)

Proponents:

Kim Cheslak, NBI, representing NBI (kim@newbuildings.org); Josh Keeling, representing Cadeo Group (jkeeling@cadeogroup.com); Ben Rabe, representing Fresh Energy (rabe@fresh-energy.org); Bryan Bomer, representing Department of Permitting Services (bryan.bomer@montgomerycountymd.gov); Lauren Urbanek, representing Natural Resources Defense Council (lurbanek@nrdc.org); Howard Wiig, representing Hawaii State Energy Office (howard.c.wiig@hawaii.gov); Kim Burke, representing Colorado Energy Office (kim.burke@state.co.us); Matt Tidwell, representing Portland General Electric (matthew.tidwell@pgn.com); Chris Castro, representing City of Orlando (chris.castro@orlando.gov); Amber Wood, representing ACEEE (awood@aceee.org); Brad Smith, representing City of Fort Collins (brsmith@fcgov.com)

2021 International Energy Conservation Code

Add new definitions as follows:

~~C202 GRID-INTEGRATED CONTROL.~~

~~An automatic control that can receive, automatically respond to demand response requests from and send information back to a utility, electrical system operator, or third-party demand response program provider.~~

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a demand response signal.

Add new text as follows:

R403.5.4 ~~Grid-integrated~~ Demand responsive water heating. Electric storage water heaters with a ~~storage tank capacity between 37 (140 L) and 120 gallons (454 L)~~ a rated water storage volume of 40 gallons (150L) to 120 gallons (450L) and a nameplate input rating equal to or less than 12kW shall be provided with *~~grid-integrated~~ demand responsive controls* ~~that comply with ANSI/CTA-2045-B Level 2~~ in accordance with Table R403.5.4 or another equivalent *approved* standard.

Exceptions:

1. Water heaters that are capable of delivering water at a temperature of 180°F (82°C) or greater
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code
3. Water heaters that use 3-phase electric power

TABLE R403.5.4

DEMAND RESPONSIVE CONTROLS FOR WATER HEATING

Equipment Type	**Controls**	
	Manufactured Before 7/1/2025	Manufactured On or after 7/1/2025
Electric storage water heaters	ANSI/CTA-2045-B Level 1 and also capable of initiating water heating to meet the temperature set point in response to a *demand response signal.*	ANSI/CTA-2045-B Level 2, except "Price Stream Communication" functionality as defined in the standard.

Revise table as follows:

TABLE R405.2

REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION	TITLE
Mechanical	
R403.5 except Section R403.5.2	Service hot water systems
~~R403.5.1~~	~~Heated water circulation and temperature maintenance systems~~
~~R403.5.3~~	~~Drain water heat recovery units~~

Revise table as follows:

TABLE R406.2

REQUIREMENTS FOR ENERGY RATING INDEX

SECTION	TITLE
Mechanical	
R403.5 except Section R403.5.2	Service hot water systems
~~R403.5.1~~	~~Heated water circulation and temperature maintenance systems~~
~~R403.5.3~~	~~Drain water heat recovery units~~

Add new standard(s) as follows:

ASME

ASME
Two Park Avenue
New York, NY 10016-5990
(800) 843-2763; https://www.asme.org

CTA

Consumer Technology Association
1919 S. Eads Street
Arlington, VA 22202

Standard reference number	*Title*	*Referenced in code section number*
ANSI/CTA-2045-B	*Modular Communications Interface for Energy Management . . . .*	*. R403.5.4*
ASME BPVC	*Boiler and Pressure Vessel Code*	*. R403.5.4*

Reason for AHRI Proposed Change

Exemption#1

Manufacturers want to describe what they can control, which is the actual capability of the product and not the installation.

There is a need for emergency installations that can be used under an emergency type situation (what is available on the truck). Therefore, the manufacturer never knows what can be done in the field, nor can they control it.

Date placement to be aligned with CEPI-125 (Which was accepted in the commercial Committee.)

Reason for revision

- **Minor edit from SEHPCAC review.**

Reason for revision

This revision is the result of a collaboration/negotiation between AHRI and NBI. It makes these key revisions:

- It replaces definitions for "grid integrated control" with "demand responsive control." The market is moving to a more robust implementation of demand response, but has not yet settled on a terminology. This change utilizes a known term, "demand response," until such time as the market settles on a new term that can be defined in code. These definitions are used in Title 24, which is leading the market for demand responsive control requirements.
- The range of storage tank sizes subject to the requirement been aligned with water heaters on which manufacturers are installing controls that comply with these requirements.
- An effective date of 7/1/2025 has been added based on the availability of these controls on the market. Before that date, water heaters will be required to meet requirements that can be met by equipment on the market today. After that date, water heaters will be required to meet requirements that can be met by equipment that manufacturers have committed to having available on the market by that date.
- The proposal uses a table format as that is the precedent for having "on or after" requirements in the IECC.

Reason Statement:

With increasing penetrations of intermittent renewable energy, volatile wholesale power prices, and subsequent growth in dynamic rates/demand response programs, grid-interactive end uses present an opportunity to help homes manage their bills, participate in programs, and support efficient grid operations. Water heaters can provide many services to the grid, including generation, transmission, and distribution capacity, energy arbitrage, and ancillary services. In their assessment of the National Potential for Load Flexibility, Brattle estimated that across all measures these services could provide as much as $15 billion per year in value to the electric system.

As electricity systems transform to include more variable wind and solar energy, demand flexibility becomes increasingly critical to both grid operation and further transformation. Building systems that can use energy when it is abundant, clean, and low-cost not only help decarbonize the entire energy system, they also insulate their owners from future increases in demand charges and peak hour energy rates – a current and accelerating trend. Water heaters offer an unparalleled opportunity for load shifting: tanks full of hot water are inherently energy storage devices. Including the controls necessary to take advantage of this opportunity is relatively simple and affordable in new construction. Compared to other energy storage technologies such as batteries, smart, grid-integrated water heater controls can deliver substantial dispatchable (that is, reliable to the grid operator) energy flexibility. The controls specified by ANSI/CTA-2045-B ensure negligible risk of occupant disruption (that is, the hot water will not run out). Water heaters provide a particularly attractive option as they have inherent thermal storage that allows energy consumption to be shifted with little to no impact to the end user. This capability has been demonstrated in several contexts, most recently through regional demonstrations conducted by EPRI and BPA.

In their Grid-interactive and Efficient Buildings (GEBs) Roadmap, the US Department of Energy estimates that approximately 15 GW of additional load flexibility is expected to be added to the system under reference case assumptions. Combined with energy efficiency, this is expected to provide $13 billion/year of peak demand savings to the power system and its customers. Through a comprehensive literature review and interviewing dozens of national experts, the USDOE team found that one of the biggest barriers was the lack of interoperability. A key tool to solve this problem is building codes, which can help to ensure that interoperable devices and controls are installed at the time of construction. USDOE cited explicitly the use of codes and standards as one of its recommended pathways to enable greater adoption of GEBs technologies.

It is important to include the requirement for two-way communication (specifically, communication from the behind-the-meter control module back to the utility, grid operator, or other third party entity) because this communication ensures that the controls capability can be fully deployed when needed. With legacy demand response systems, a signal is sent out but the ability to track and quantify the impacts of that signal is effectively nonexistent. This one-way communication paradigm is a key reason that the "firmness" or reliability of many flexibility-related demand side management strategies, particularly demand response, is often considered to be very low.
However, a two-way communication paradigm enables much more reliable impact tracking. Buildings whose controls include two-way communication capability, that is, those with grid-interactive controls as defined here, will be better able to participate in the demand response programs of the future, and their owners will have improved financial prospects through enhanced ability to participate in potentially lucrative utility demand response programs.

ANSI/CTA-2045-B standardizes the socket, and communications protocol, for electric water heaters so they can communicate with the grid, and with demand response signal providers. In addition, 2045-B adds control and communications requirements for mixing valves in water heaters, which enable them to provide greater storage capacity to support increased load shifting while eliminating scalding risk.

Versions of this standard are included in codes or other requirements in California, Oregon, and Washington and are referenced explicitly by ENERGY STAR.

Bibliography:

Brattle, The National Potential for Load Flexibility (2019) https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf

BPA, CTA-2045 Water Heater Demonstration Report (2018) https://www.bpa.gov/EE/Technology/demand-response/Documents/Demand%20Response%20-%20FINAL%20REPORT%20110918.pdf

EPRI, CEA-2045 Field Demonstrations Project Description (2014) https://www.epri.com/research/products/000000003002004009

USDOE, A National Roadmap for Grid-Interactive Efficient Buildings (2021) https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf

Washington State Revised Code of Washington, Title 19, Chapter 19.260, Section 19.260.080, available at https://app.leg.wa.gov/RCW/default.aspx?cite=19.260.080

Oregon Department of Energy, Energy Efficiency Standards Rulemaking https://www.oregon.gov/energy/Get-Involved/Pages/EE-Standards-Rulemaking.aspx

U.S. EPA Energy Star Program, Connected Criteria for ENERGY STAR Products, https://www.energystar.gov/products/spec/connected_criteria_energy_star_products_pd

Cost Impact:

The code change proposal will increase the cost of construction.

To enable grid-interactive controls, there are two sources of costs: the incremental cost to ensure that equipment is interoperable with CTA-2045-B and the cost of the control module installed in that device. The incremental manufacturing cost is in the range of a few dollars, and negligible at higher volumes. The current incremental cost to include a CTA-2045-B compliant control module ranges from about $60 (direct current, hard-wired connection) to $160 (alternating current, wireless cellular connection); this is expected to decline as manufacturing lines are brought up to larger scale (source: Advanced Water Heating Initiative). The major determinant of cost if the chosen radio pathway as chipset costs vary considerably between different frequencies/standards.

In the BPA report, manufacturers stated a range of $2-$30 for regional deployment, but noted that there would be economies of scale for a national rollout. The main cost was development of firmware/hardware to accommodate the standard, but these costs have already been incurred to meet codes/standards in OR, WA, and CA.

REPI-90-21

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-091-21 Hot water compact design
CDP ID #	445
Code	IECC RE
Code Section(s)	R403.5.4, R403.5.4.1 New Section y
Location	base
Proponent	Dan Wildenhaus dwildenhaus@trccompanies.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	This Proposal was presented by Dan Wildenhaus on 5/2/2022 to the subcommittee co- proponent Kevin Rose.
Recommendation	Proposal presented by Dan and kevin. A motion to approve on the floor and a second the subcommittee agreed to approve "As modified" - very little discussion regarding this proposal. On 5/6/2022 our subcommittee received notice of SEHPCAC recommendations received. Because the recommendations came after the subcommittee had voted and before the IECC Committee presentation the Chair HVACR sent the Proposal back to the subcommittee for a vote giving the Proponent and SEHPCAC time to discuss and come to a consensus regarding the recommendations. This proposal with recommendations SEHPCAC was heard by the subcommittee on 5/31/2022 Vote to approve
Vote	Vote to approve as modified- 10 yes with 1 abstention / vote to approve with SEHPCAC recommendations 5/31/2022 6/2/1
Recommendation Date	5/2/2022 Proposal to approve/ 5/31/2022 with SEHPCAC recommendations
Next Step	To Subcommittee_________________________________ To Advisory Group_________________________________ To Consensus Committee____x_____________
Consensus Committee	
Committee Response	

REPI-91-21

IECC®: R403.5.4 (New), R403.5.4.1 (New)

Proponents:

Dan Wildenhaus, representing Northwest Energy Efficiency Alliance (dwildenhaus@trccompanies.com); Kevin Rose, representingNorthwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

2021 International Energy Conservation Code

Add new text as follows:

~~R403.5.4 Compact Hot Water Distribution systems (CHWD).~~

~~Where installed, CHWD systems shall comply with the provisions of section R403.5.4.1.~~

~~R403.5.4.1 Water Volume in Pipe Method.~~

~~The hot water distribution system shall store not more than 0.5 gallons (1.9 liters) of water in any piping/manifold between the hot water source and any hot water fixture when calculated using approved engineering calculations. These calculations will use the nominal diameter and length of the piping or tubing, and the longest pipe run from water heater, including both horizontal and vertical run of pipe, shall not be more than 20 feet.~~

R403.5.4.1 Water Volume Determination

The water volume in the piping shall be calculated in accordance with this section. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from Table R403.5.4. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

Table R403.5.4.~~1~~
INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING
OUNCES OF WATER PER FOOT OF TUBE

Nominal Size (inches)	Copper Type M	Copper Type L	Copper Type K	CPVC CTS SDR 11	CPVC SCH 40	CPVC SCH 80	PE-RT SDR 9	Composite ASTM F1281
$^3/_8$	1.06	0.97	0.84	N/A	1.17	—	0.64	0.63
$^1/_2$	1.69	1.55	1.45	1.25	1.89	1.46	1.18	1.31
$^3/_4$	3.43	3.22	2.90	2.67	3.38	2.74	2.35	3.39
1	5.81	5.49	5.17	4.43	5.53	4.57	3.91	5.56
$1^1/_4$	8.70	8.36	8.09	6.61	9.66	8.24	5.81	8.49
$1^1/_2$	12.18	11.83	11.45	9.22	13.20	11.38	8.09	13.88
2	21.08	20.58	20.04	15.79	21.88	19.11	13.86	21.48

For SI: 1 foot = 304.8 mm, 1 inch = 25.4 mm, 1 liquid ounce = 0.030 L, 1 oz/ft^2= 305.15 g/m^2.
N/A = Not Available.

Reason Statement:

This new section uses the same Water Volume Determination that already exists in the IECC Commercial Code in section C404.5.2.1. This update has been provided to most easily align residential and commercial hot water service volume calculations in piping. *Language needs to be introduced into the prescriptive portion of the code's Systems section to be referenced in new R408Additional Efficiency Package Options* *(REPI-142-21).*

Inefficient hot water distribution systems have been recognized as a problem for many years as they result in energy and water waste, and result in long hot water delay times that are the cause of a significant number of complaints by new home buyers. Recirculation systems are a solution to two of the three problems (water and wait time), but the thermal energy impact of different recirculation systemoptions has already been addressed in section R403.5.1.1 Circulation system.[1]

In all non-recirculation distribution options, water heater energy consumption and hot water waste are correlated. A decrease in water heater energy consumption follows a reduction in wasted water; therefore, improving insulation and reducing the piping length and/or pipe diameter have equal benefits for energy and water waste. In recirculation systems, water heater energy consumption and wasted hot water are independent, and often have an inverse effect (when recirculation is not demand based).[2] This distribution system problem exists for a variety of factors including:

- An outdated pipe sizing methodology in the plumbing code that results in oversized hot water distribution systems since theassumed fixture flow rates are much higher than current requirements.
- Municipalities with design recommendations that force plumbers and designers to assume low supply water pressure, resulting in larger distribution piping, which waste more water and energy.
- Increasing efforts to conserve water has resulted in the realization of water savings due to improvements in showerhead and lavatory maximum flow rates; however, reduced flow rates often result in increased wait times if the hot water distribution system is not designed to accommodate lower flows.
- Increasing popularity of gas instantaneous water heaters, which offer improved operating efficiency, but can result in increased water waste when starting from a "cold start up" situation.
- Inefficient plumbing installations that are not focused on minimizing pipe length or pipe diameters.

The IECC has already addressed pipe insulation and Circulation systems in the 2021 IECC Residential provisions.

Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility

Farhad Farahmand, TRC Companies Yanda Zhang, ZYD Energy

[2] *Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* E. Weitzel and M. Hoeschele Alliance for Residential Building Innovation

**https
://energy.cdpaccess.com/proposal/445/976/files/
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Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility Farhad Farahmand, TRC Companie;Yanda Zhang, ZYD Energy

Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models E. Weitzel and M. Hoeschele Alliance for Residential Building Innovation

California Energy Codes & Standards Case Report for *Compact Hot Water Distribution;* Measure Number: 2019-RES-DHW1 -F, Residential Plumbing

Home Innovation Research Labs Annual Builder Practices Survey, 2021

Department of Energy Zero Energy Ready Home National Program Requirements (Rev. 07)

[footnote 15] Efficient hot water distribution system - USBGC LEED BD+C: Homes v4 - LEED

v4

Residential Hot Water Distribution Systems: Roundtable Session; JD Lutz, Lawrence Berkely National Laboratory; G Klein, California Energy Commission; D Springer, Davis Energy Group; BO Howard, Building Environmental Science & Technology

Cost Impact:

The code change proposal will neither increase nor decrease the cost of construction.

Incremental first costs to builders, designers, and plumbers are design based and each builder will need to determine potential cost impacts based on existing designs and measures in use. Depending on current practices and paths taken for IECC compliance this measure may result in small incremental cost increases or decreases. These potential cost differences relative to standard practices are likely to be:

Reduced cost of PEX or copper tubing due to less

material installed. Reduced cost to pipe

insulation due to smaller plumbing layout.

Reduced or neutral cost in labor hours for plumber.

Increased water heating venting costs, if a gas water heater or electric heat pump water heater is centrally located.

Increased venting labor costs, if a gas water heater or electric heat pump water heater is located is centrally located and not on a garage wall.

This measure should not have maintenance costs associated with it compared to

standard practices.REPI-91-21

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-093-21 HRV and ERV
CDP ID #	443
Code	IECC RE
Code Section(s)	R403.6.1 New Section n
Location	base
Proponent	Marian Goebes iecc-sf-hrv-erv@2050partners.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	This Proposal presented by Marian Goebes first on 3/7/2022. When Presented Marian said she had additional information to add and requested to have the vote held at a later date. The Proposal heard on 5/2/2022 (second reading) In the end the subcommittee motion on the floor to disapprove vote 5 disapprove 4 approve motion carried to disapprove REPI-093 **"as modified"**
Recommendation	Marian Goebes and Mark Lyles presented this proposal. This is the second reading of this proposal **"as modified**: The Proponent presented detailed reason statement with supporting cost analysis. The subcommittee did not agree and a motion was presented to disapprove the Proposal. With a second a vote was taken Vote 5 disapprove with 4 no votes motion carried to vote **Disapprove**.
Vote	Vote to Disapprove REPI-093 **"as modified"** 5/4/0
Recommendation Date	5/2/2022
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee___x _______________
Consensus Committee	
Committee Response	

REVIEWED BY SUBCOMMITTEE VERSION 2

Single Family HRV: REPI-093-21 Supporting Documentation

Executive Summary

The proposed HRV measure expands the requirement for heat or energy recovery ventilation systems (HRVs or ERVs) for single-family homes to climate zones 5 and 6. The measure is already required in climate zones 7 and 8.

Original Proposal:

R403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single- and two-family dwellings and townhouses in Climate Zones 0-4.

2. Dwelling units in Climate Zone 3C.

Revised Proposal to Align with REPI-69:

REPI-69 requires heat recovery ventilation for multifamily units in all climate zones except 3C, with additional exceptions for dwelling units < 500 sf. REPI-69 was approved by the Residential Consistency and Administration subcommittee (2/15/22), and the Residential Consensus Committee (3/2/22).

403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single and two-family buildings in Climate Zones 0-~~6~~4.

2. Dwelling units in Group-R occupancies that comply with Section C403.7.4.1.

Methodology supporting this proposal (REPI-093)

- Energy savings:
    - Modeled with EnergyPlus v9.5 and PNNL detached single-family house prototype.
    - Assumed 2-story above grade (with conditioned basement for select climate zones), 3-bedroom, with 60 cfm continuous ventilation
- Cost Assumptions:
    - Estimated cost of HRV (proposed) compared to exhaust-only ventilation (base case)
    - Total incremental first cost for HRV $1,084, including:
        - Cost of HRV $738, based on average HRV/ERV product cost from online research
        - HRV ducted into supply side of furnace air handling unit (no additional cost), but with separate HRV return duct and HRV return register (estimated using floor plan that aligns with PNNL prototype): $169
        - Installation labor: $177
    - Assumed weighted mix of heating systems: 83% gas furnace, 11% heat pumps, 6% propane furnace in CZ5A and 6A; 76% gas furnace, 18% heat pumps, 6% propane furnace in CZs 5B, 5C, and 6B

Table 1. LCC Assumption Summary

Parameter	Value	Source
Real discount rate	3% or 7%	IECC subcommittee
Inflation Rate	2.3%	Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2021
Nominal discount Rate	3%, 5.3%, or 9.3%	DOE/PNNL, or real rate from IECC subcommittee plus inflation
First cost for measure	$1,084	Online research of HRVs and ERVs, including ductwork
Replacement cost	$806	Assumes HRV replaced at year 15
Baseline fuel prices	$0.137 / kWh $1.1803 / therm natural gas $2.48 / gallon propane	2021 US residential price from EIA
Fuel price escalators	-0.10% for electricity 0.50% for natural gas 1.4% for propane	EIA AEO 2021 reference case, residential by fuel, national
Social cost of carbon	$51/metric ton in 2020	Interagency Working Group on Social Cost of Greenhouse Gases
Period of Analysis	30 years	Mortgage loan

Cost Effectiveness Results

All climate zones analyzed (5 and 6) are cost effective under a nominal discount rate of 3%, 5.3%, and 9.3%, ignoring the social cost of carbon (SCC: assumes SCC = $0). (The 5.3% and 9.3% nominal discount rates assume a real discount rate of 3% and 7% respectively, plus 2.3% for inflation.) Results are more cost-effective when the SCC of $51 per metric ton is included.

Table 2. Cost Effectiveness Results

LCC Assumptions	**3% nominal discount rate** (DOE/PNNL) **SCC = $0**	**3% nominal discount rate** (DOE/PNNL) **SCC = $51**	**5.3% nominal** 3% real discount rate (IECC) + inflation **SCC = $0**	**5.3% nominal** 3% real discount rate (IECC) + inflation **SCC = $51**	**9.3% nominal** 7% real discount rate (IECC) + inflation **SCC = $0**	**9.3% nominal** 7% real discount rate (IECC) + inflation **SCC = $51**
LCC ($) CZ 5A	$1,529	$2,435	$1,037	$1,681	$591	$983
LCC ($) CZ 5B	$517	$1,146	$304	$752	$132	$404
LCC ($) CZ 5C	$1,236	$2,051	$825	$1,405	$458	$812
LCC ($) CZ 6A	$2,139	$3,200	$1,479	$2,233	$869	$1,329
LCC ($) CZ 6B	$1,692	$2,606	$1,158	$1,807	$670	$1,066
Cost effective CZs	**All analyzed**	**All analyzed**	**All analyzed**	**All analyzed**	**All analyzed**	**All analyzed**

Response to HVACR Subcommittee Questions

In response to HVACR subcommittee questions from the March 7, 2022 HVACR subcommittee meeting on simple payback:

- Assuming a Social Cost of Carbon (SCC) of $51: simple payback is 9 years in CZ 5A and 5C, 12 years in CZ 5B, and 7-8 yrs in CZ 6
- Assuming SCC = $0 (so ignoring SCC): simple payback is 11 years in CZ 5A and 5C, 15 years in CZ 5B, and 9-10 years in CZ 6
- Side note: Past IECC cycles have used LCC (Taylor, 2018), and current guidance from the ICC is to continue to use LCC. For example, ICC, Leading the Way to Energy Efficiency – R101.3 (Intent) specifically cites LCC, and not simple payback.[1] So we still think LCC is the better metric.

We estimated current HRV/ ERV prevalence in CZs 5 and 6 using RESNET data in response to subcommittee questions. This data is based on ratings from March 2020 through February 2022. The values for 6A are surprisingly high. RESNET staff reported that most rated homes in 6A are in MN, and that many production home builders in St. Paul / Minneapolis use ERVs/HRVs.

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[1] From ICC, Leading the Way to Energy Efficiency – R101.3: "The International Energy Conservation Code-Residential provides market-driven, enforceable requirements for the design and construction of residential buildings, providing minimum efficiency requirements for buildings that result in the maximum level of energy efficiency that is safe, technologically feasible, and **life cycle cost** effective, considering economic feasibility, including potential costs and savings for consumers and building owners, and return on investment."

Table 3. Estimate of ERV/HRV Prevalence by Climate Zone

RESNET single-family* home data by Climate Zone (CZ)	5A	5B	6A	6B
Single family homes with ERV or HRV	4,351	1,176	15,955	120
All single family homes rated in CZ	71,127	38,792	21,194	843
Percent of Single-family homes with ERV or HRV	6%	3%	75%	14%

*Single-family includes duplexes, but not low-rise multifamily

NOT REVIEWED BY SUBCOMMITTEE VERSION 3

Single Family HRV: REPI-093-21: Executive Summary

Expands the requirement for heat or energy recovery ventilation systems (HRVs or ERVs) for single-family homes to climate zones 5 and 6. The measure is already required in climate zones 7 and 8.

Original REPI 093 from Monograph

R403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single- and two-family dwellings and townhouses in Climate Zones 0-4.

2. Dwelling units in Group-R occupancies in Climate Zone 3C.

Revised Proposal to Align with REPI-69:

REPI-69 requires heat recovery ventilation for multifamily units in all climate zones except 3C, with additional exceptions for dwelling units < 500 sf. REPI-69 was approved by the Residential Consistency and Administration subcommittee (2/15/22), and the Residential Consensus Committee (3/2/22).

Green = Our revisions to original REPI -093 to align with REPI-069 (approved)

Red = substantive change to IECC-2021 proposed here, through REPI-093

403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single and two-family buildings in Climate Zones 0-~~6~~4.

2. Dwelling units in Group-R occupancies that comply with Section C403.7.4.1.

Reason Statement

Goal: Expand current requirement in 2021 IECC for heat or energy recovery ventilation from CZ 7 and 8 to CZ 5 through 8, because it is cost effective in CZ's 5 and 6.

Cost Impact

Methodology supporting this proposal (REPI-093)

- Energy savings: Modeled with EnergyPlus v9.5 and PNNL detached single-family home prototype
- Cost Assumptions:
  - Used assumptions from IECC cost effectiveness advisory group
  - Estimated cost of HRV (proposed) compared to exhaust-only ventilation (base case)
  - The proposal is independent of heating and cooling system. But for the cost analysis, we assumed a weighted mix of heating systems: 83% gas furnace, 11% heat pumps, 6% propane furnace in CZ5A and 6A; 76% gas furnace, 18% heat pumps, 6% propane furnace in CZs 5B, 5C, and 6B
  - Total incremental first cost for HRV $1,084, including:
    - Cost of HRV $738, based on average HRV/ERV product cost from online research
    - The proposal does not specify a distribution system. But for the cost analysis, we assumed HRV is ducted into supply side of furnace air handling unit, with a separate HRV return duct and HRV return register: $169
    - Installation labor: $177

Table 4. LCC Assumption Summary

Parameter	Value	Source
Discount Rate	3.8%	IECC cost effectiveness advisory group calculator ("IECC calculator"), based on DOE/PNNL
First cost for measure	$1,084	Online research of HRVs and ERVs, including ductwork
Replacement cost	$806	Assumes HRV replaced at year 15
Baseline fuel prices	$0.137 / kWh $1.18 / therm natural gas $2.48 / gallon propane	IECC calculator, based on 2021 US residential price from EIA
Savings per Year, ignoring Social cost of carbon	CZ 5A: $114/year CZ 5B: $79/year CZ 6: $121-$136/ year	Calculations done here, based on IECC calculator
Social cost of carbon (SCC)	$51/metric ton in 2020	IECC calculator, based on Interagency Working Group on Social Cost of Greenhouse Gases
Period of Analysis	30 years	IECC calculator, based on typical Mortgage loan

Cost Effectiveness Results

All climate zones analyzed (5 and 6) are cost effective. Results are more cost-effective when the SCC of $51 per metric ton is included.

Table 5. Cost Effectiveness Results

Climate Zone	**Ignores SCC SCC = $0**	**Accounts for SCC SCC = $51**
LCC ($) CZ 5A	$1,237	$2,037
LCC ($) CZ 5B	$337	$892
LCC ($) CZ 5C	$976	$1,697
LCC ($) CZ 6A	$1,779	$2,717
LCC ($) CZ 6B	$1,383	$2,190
Cost effective CZs	**All analyzed**	**All analyzed**

Reasons Disapproved in HVACR Subcommittee Meeting

- One negative commenter disagreed with electricity rate
    - Proposal assumes $0.137 / kWh, per IECC cost effectiveness advisory group (based on 2021 US residential price from EIA)
    - Negative commenter assumed $0.07/kWh
- Confusion over whether proposal would affect heating and cooling system, or ducting
    - Negative commenters thought proposal would require specific types of heating and cooling systems, and specifies ducting. Neither is correct; this was a misunderstanding.
    - Proposal simply expands current requirement to additional climate zones and only affects ventilation system. An HRV/ERV could integrate with any heating and cooling system or be a stand-alone system. Similarly, the HRV/ERV could duct into the AHU return side, have its own ductwork, or supply air in one central location.
- Concern the prevalence of HRVs/ERVs is too low in these climate zones.
    - RESNET data (ratings from March 2020 through February 2022) shows significant presence of this equipment in CZ's 5 and 6.

Table 6. Estimate of ERV/HRV Prevalence by Climate Zone

RESNET single-family* home data by Climate Zone (CZ)	**5A**	**5B**	**6A**[2]	**6B**
Single family homes with ERV or HRV	4,351	1,176	15,955	120
All single family homes rated in CZ	71,127	38,792	21,194	843
Percent of Single-family homes with ERV or HRV	6%	3%	75%	14%

[2] The values for 6A are surprisingly high. RESNET staff reported that most rated homes in 6A are in MN, and that many production home builders in St. Paul / Minneapolis use ERVs/HRVs.

*Single-family includes duplexes, but not low-rise multifamily

Detailed Analysis

Table of Contents

Overview

The proposed HRV measure expands the requirement for heat or energy recovery ventilation systems (HRVs or ERVs) for single-family homes to climate zones 5 and 6. The measure is already required in climate zones 7 and 8. There was a separate proposal submitted by NBI to expand the requirement in multifamily dwelling units (REPI-069) to all climate zones except 3C, with further exceptions for dwelling units < 500 square feet, which the Residential Consistency and Administration subcommittee passed.

Code Language

Original Proposal:

R403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single- and two-family dwellings and townhouses in Climate Zones 0-4.

2. Dwelling units in Climate Zone 3C.

Revised Proposal to Align with REPI-69.

403.6.1 Heat or energy recovery ventilation

Dwelling units shall be provided with a heat recovery or energy recovery ventilation system ~~in Climate Zones 7 and 8~~. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

Exceptions:

1. Dwelling units in single and two-family buildings in Climate Zones 0-~~6~~4.

2. Dwelling units in Group-R occupancies that comply with Section C403.7.4.1.

Methodology

Simulation tool

This analysis used EnergyPlus v9.5 for modeling energy savings.

Description of Prototype

The proposal team selected one single-family prototype house to evaluate the cost-effectiveness of the proposed measure. The building geometry was consistent with PNNL's 2021 IECC determination (Salcido R. , Chen, Xie, & Taylor, 2021a), also reflected in DOE's prototype building files (US Department of Energy, 2021). The detailed specifications are documented in an earlier PNNL report evaluating the 2012 IECC revisions (Lucas, Mendon, & Goel, 2013). Where the PNNL reports are silent, the proposal team used building attributes consistent with the Standard Reference Design established for the Total Building Performance Option in the 2021 IECC, or common building construction practice if no requirements are specified in any of the reference documents.

The proposal team assumed the foundation types shown in Table 4, considering both typical construction for the PNNL representative city and for the region included in that climate zone. The proposal team assumed a basement for Climate zone 6, since basements are common in the representative cities for 6A and 6B, and because climate zone 6 is mostly in the Midwest and Northeast where basements are common. (Although Climate zone 6 also includes small parts of the West, where many homes use slab-on-grade construction.) The analysis assumed a basement for Climate Zone 5A, since the representative city is Buffalo, NY and this region includes the Midwest and Northeast where basements are common. For 5B and 5C, the analysis assumed slab-on-grade, since this is common in the representative cities and in the western regions of the U.S. (of which large portions are in these climate zones). The basement was assumed to be conditioned.

Table 7. Foundations Assumed

Climate Zone	Representative City	Typical Construction for Single-Family New Construction for Representative City (NAHB, 2019)	Foundation Assumed
5A	Buffalo, NY	Basement	Basement
5B	Denver, CO	Mix of slab-on-grade and basement	Slab-on-grade
5C	Port Angeles, WA	Slab-on-grade	Slab-on-grade
6A	Rochester, Minnesota	Basement	Basement
6B	Great Falls, Montana	Mix of slab-on-grade and basement	Basement

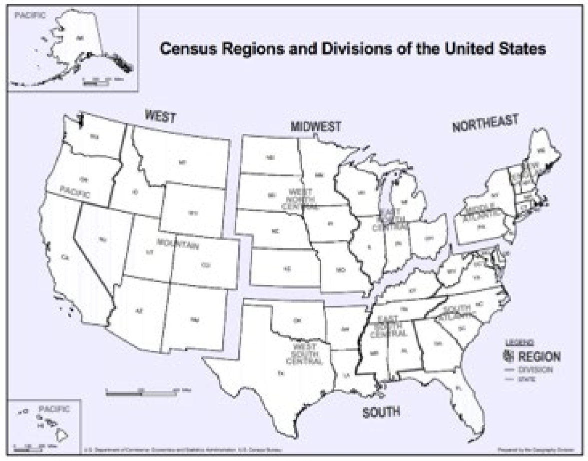
Basic characteristics that apply to the model include the following:

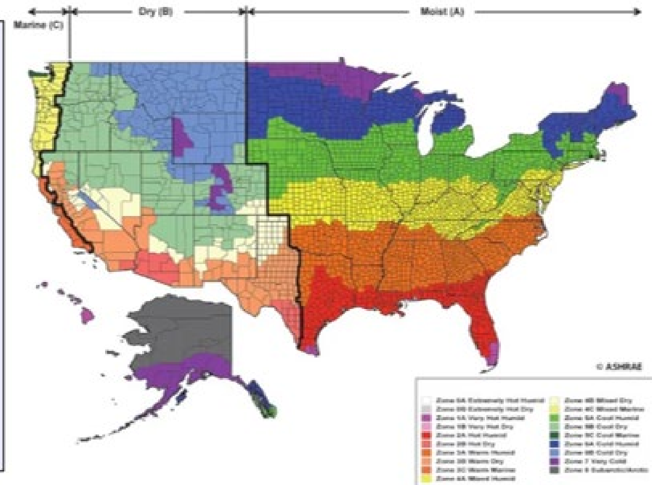
- 2-story above grade (with conditioned basement for select climate zones – described in Table 4, 3-bedroom, detached single-family house
- 2,400 ft^2 of conditioned space for slab-on-grade homes, and 3,600 ft^2 for homes with basement
- 40 ft. x 30 ft. exterior dimensions, 8.5 ft ceilings
- 2x6 wood framing, 16” OC for walls, 24” OC for ceiling
- Fiberglass batt insulation, with R-5 insulating sheathing added for walls where required
- No exterior shading
- Ducts in vented attic
- 60 cfm continuous ventilation

For the heating system, this analysis used a weighted average of the following, based on U.S. census 2020 data[3]. The division between the West and Midwest in the census (Figure 1 - left image) align with the break between the IECC division between moist (A) and dry (B) climates (Figure 1 - right image).

Figure 1. Comparison of U.S. Census Regions with IECC Moist (A) vs. Dry (B) Climate Zones

[3] https://www.census.gov/construction/chars/





Based on the 2020 census data, after removing for other types of heating systems, furnaces comprise 89% and heat pumps comprise 11% of heating systems in new homes in the Northeast and Midwest. In the West, furnaces comprise 82% and heat pumps 18% of heating systems.

Table 8. Heating Systems Found in Census

	Raw Percentages from Census			Normalized to 100% for just furnaces and heat pumps (Removing Other)	
Region	Heat pump	Forced air furnace	Other	Heat pump	Forced Air Furnace
Northeast	10%	79%	11%	11%	89%
Midwest	10%	85%	5%	11%	89%
West	17%	80%	3%	18%	82%

Because the EIA found that 6% of U.S. homes use propane as a heating source (U.S. Energy Information Administration, 2017), this analysis assumed 6% of the forced air furnaces were propane, and assumed the remainder were natural gas. This led to the assumed weights for heating systems shown in Table 6.

Table 9. Heating Scenarios Assumed for Analysis

Scenario for LCC	Prevalence for Northeast and Midwest: CZ 5A and 6A (% of single family homes)	Prevalence for West: CZ 5B, 5C, 6B (% of single family homes)	**Source for Assumption**
Natural gas furnace	83%	76%	U.S. 2020 census for split between gas furnaces and electric heat, with “gas furnaces” appropriated between natural gas and propane based on EIA (2017)

Electric heat pump	11%	18%	U.S. 2020 census for split between gas furnaces and electric heat, with "gas furnaces" appropriated between natural gas and propane based on EIA (2017)
Propane furnace	6%	6%	EIA (U.S. Energy Information Administration, 2017)

Weather Locations

Representative cities and corresponding TMY3 weather stations for each Climate Zone were consistent with the DOE Energy Codes website (US Department of Energy, 2021), as summarized in Table 7 below.

Table 10. Representative cities and weather stations for modeling energy savings in each Climate Zone.

Climate Zone	Representative City	TMY3 Weather Station
5A	Buffalo, NY	Buffalo Niagara Intl. Airport
5B	Denver, CO	Denver-Aurora-Buckley Air Force Base
5C	Port Angeles, WA	Port Angeles – Williams Fairchild Intl. Airport
6A	Rochester, Minnesota	Rochester Intl. Airport
6B	Great Falls, Montana	Great Falls Intl. Airport

Site, Source, Carbon Emissions and Energy Cost Calculations

This analysis calculated site energy, source energy, carbon emissions, and energy costs using generally accepted engineering methods and authoritative references. The following sections provide details.

Energy Analysis

This analysis focused on climate zones 5 and 6. The measure is already required in climate zones 7 and 8; the measure is more cost effective in climate zones 7 and 8 than climate zone 6 because of the higher heating degree days in climate zones 7 and 8 (Taylor, 2018).

Description of base case

The energy analysis used EnergyPlus to model a 2021 IECC minimally-compliant prototype single-family home. The above-grade interior space was modeled as a single thermal zone. The PNNL energy model for the prototype single-family home uses balanced ventilation, so the proposal team used this as the base case for the model. However, as described in the Incremental Cost section, the proposal team assumed an exhaust-only ventilation system in the base case for costs, since that is the most common ventilation strategy for single-family homes in climate zones 5 and 6. The ventilation fans (both supply and exhaust fans) in the base case used the values in the PNNL single family prototype model: 10.7 W and deliver 60 cfm and therefore have an efficacy of 5.6 cfm/W, which (as described below for the Proposed Case) have a much higher efficacy than what the proposal team assumed for the HRV.

Proposed Case

For the HRV specifications, the analysis assumes:

- An HRV energy consumption of 37.5 W to deliver 60 cfm of pre-conditioned supply air to the home (and remove 60 cfm of exhaust air from the home). This translates to an HRV efficacy of 1.6 cfm/W. This includes fan energy and energy used for any ancillary loads, such as controllers. This efficacy is slightly higher than the federal minimum requirements (1.2 cfm/W) but slightly lower (i.e., more conservative) than the average of the products reviewed (1.9 cfm/W), shown in Table 8.
- A Sensible Recover Efficiency (SRE) of 65. This is lower (more conservative) than the average of the products reviewed (SRE = 70), shown in Table 8.
- A cost of $738

These values were based on a review of ERVs/ HRVs identified through online research, shown in Table 8. The proposal team used SRE, airflow, and power consumption (wattage) from the Home Ventilating Institute (HVI) where possible. Two of the products were not listed in the HVI directory, so product data were obtained from other online sources.

The average retail cost of the products is $738, which the proposal team assumed for the cost effectiveness calculations. The proposal team did find cheaper products that did not meet the specifications here, so did not include them.[4]

Table 11. Summary Characteristics of HRVs and ERVs from Online Research

Product Category	Manufacturer	Model	Airflow (CFM)	Wattage	CFM/W	Cost	SRE
HRV	Broan[5]	B110H65RS	64	33	1.9	$808	68
ERV	Panasonic[6]	FV-10VES	66	39	1.7	$942	77
ERV	Fantech[7]	SE704N	78	40	2.0	$545	66

[4] For example, the Lifebreath RNC6 has a price of $650 and SRE of 65, but a fan efficacy of 1.3 cfm/W so was not included. With this model the average HRV price would be lower.
[5] Pricing: Camperid.com, HRV SRE, cfm, W: HVI directory
[6] Pricing: Supplyhouse.com , HRV SRE, cfm, W: HVI directory database shows 81 SRE and 54 cfm at the max SRE; the proposal team used product cutsheet to select a lower SRE (77) with a higher corresponding airflow (66 cfm)
[7] Pricing, W, cfm: Supplyhouse.com , HRV SRE: SupplyHouse.com

ERV	Aldes[8]	E110-TF	65	32	2.0	$656	68
Average			*68*	*36*	*1.9*	*$738*	*70*

This analysis only included sensible energy recovery (from both heating and cooling), which would be captured by an HRV or ERV. It does not include latent energy recovery which would be captured by an ERV. Consequently, ERV energy savings would be higher than what is shown in this analysis.

In addition to the 37.5 W assumed for the HRV, the proposed case also assumes the same supply and ventilation fans as the base case: 10.7 W each. Consequently, the HRV energy savings are underestimated in this analysis, since it assumes fan energy of the balanced ventilation system without heat recovery (the supply fan and exhaust fan) and the fan energy of the HRV.

Incremental Cost

This section describes the incremental cost associated with an HRV. The analysis assumes a replacement of equipment at year 15 (a typical assumption for residential HVAC equipment[9]), when the HRV is assumed to be replaced (at the end of its estimated Effective Useful Life). The analysis assumes no maintenance costs, because many HRVs have washable filters. To estimate the incremental cost for the proposed case (HRV), this analysis considered the following differences between the base case: exhaust-only ventilation without heat recovery, and proposed case: balanced ventilation with an HRV, including:

- Materials and labor for the HRV (proposed) case
- Additional ductwork needed for the HRV
- Additional return register needed for the HRV
- Insulation for the HRV for the ductwork connecting it to the outdoors – i.e., for the outdoor air supply duct to the HRV to prevent condensation.[10]

To determine duct lengths, the proposal team developed a floor plan for the prototype home, and identified differences for the base case (exhaust-only ventilation) and proposed case (HRV).

The proposed case assumes one HRV serving the home. The proposed requirement affects ventilation equipment only, so does not affect ductwork. But for cost assumptions, the proposal team assumed that HRV return grille is located in the middle of the home, close to the heating system return grille. The team assumed the HRV's supply duct (providing pre-heated or pre-cooled fresh air) connects to the heating and cooling system ductwork, which would distribute the ventilation air. For heating and cooling

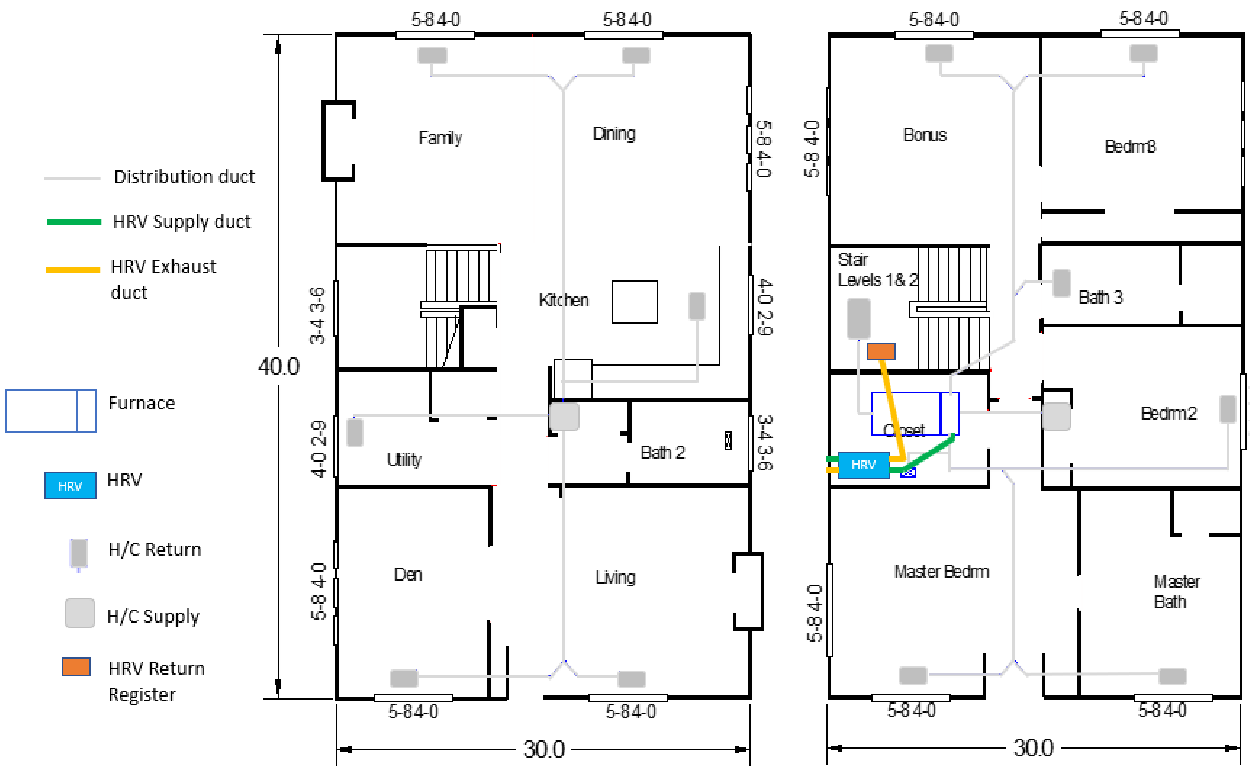
[8] Pricing: HVACQuick.com , HRV SRE, cfm, W: HVACQuick.com

[9] The PNNL study of HRVs, PNNL (2018), assumed 20 years. The proposal team assumed 15 years, to be conservative, and since many resources (such as the California Database of Energy Efficiency Resources) assume 15 years for residential HVAC equipment.

[10] The exhaust duct running from the return register to the HRV was not assumed to be insulated, since it is in conditioned space. The exhaust duct running from the HRV to the outside was not assumed to be insulated, since it is also in conditioned space and heat losses from this duct do not matter.

systems with no ductwork, such as ductless heat pumps, the HRV's supply air would simply be discharged at one location in the home. Thus, there is no significant difference in HRV costs for a home with a ductless heating system (e.g., ductless heat pump) than one with a ducted system (e.g., ducted furnace). HRV/ERV savings associated with single package unit heat pumps will be higher than split-system heat pumps, since split-system heat pumps have higher minimum federal efficiency requirements than split systems

Figure 2. Floor plan of HRV, exhaust fans, and duct layout for proposed case.



The following table shows the incremental cost for the proposed (HRV) case compared to the base (exhaust-only ventilation without heat recovery) case. Labor assumptions and assumptions for the cost of ductwork and duct insulation are from RSMeans. This table only shows incremental costs, not costs included in both the proposed and base case.

Table 12 . Incremental Costs for HRV installed in Single-family Home

Category	Unit	Material Costs ($/Unit)	Total Material Costs ($)	Crew (RSMeans)	Crew Labor Rate with O&P and 10% GC markup	Labor Hours (Hrs/Unit)	Total Labor Costs ($)	Total Installed Cost ($)
Duct	18 linear feet	$7.80	$140	Q9	$66	0.057	$68	$208

Duct Insulation	1.5 sf	$3.81	$6	Q9	$66	0.163	$16	$22
Return register	1 register	$23.00	$23	1 Sheet metal worker	$73	0.333	$24	$47
HRV	1 HRV	$738.00	$738	Q20	$68	1	$68	$806
Total cost								**$1,084**

As shown in Table 9, this analysis found an incremental cost of $1,084. This is lower than what a PNNL study (Taylor, 2018) assumed, which is the primary reason why this analysis finds this measure cost effective in Climate zone 6 while Taylor (2018) did not. While Taylor (2018) assumed a total measure cost of $1,500 in its analysis, that study found a “best-case” cost assumption of $500 for the HRV. As stated in Taylor (2018), “The cost of HRV equipment ranges from about $500 to a few thousand dollars, depending on the manufacturer, capacity, configuration, and the base design of the home.” These costs include equipment and labor costs for both the HRV appliance itself as well as related ductwork.

LCC Approach

The Life Cycle Cost (LCC) approach used is similar to the DOE/PNNL cost analysis methodology[11], but it uses updated sources for some parameters and is simplified to ease the burden for proponents to analyze their proposed amendments.

The methodology uses an LCC approach, where the cashflows over a 30-year analysis period for cash outflows (expenses, negative values) and inflows (savings, positive values) are used to calculate a net present value based on the time value of money. A positive LCC value indicates that the savings of a measure exceed its costs over the analysis period, while a negative value indicates the opposite.

For costs, the methodology assumes that any up-front incremental costs are financed through the mortgage on the home. Most proposed code amendments will predominantly impact new construction, and most new homes are financed through a 30-year mortgage. Given the high standard deductible for federal income taxes ($25,900 for joint filers), it is assumed that the increase in mortgage payments does not result in a change in income taxes. It is also assumed that proposed measures have a minimal impact on property assessments for local taxes, so changes in property taxes are assumed to be zero. Property tax assessments tend to be based on high-level data points, such as floor area, general condition, location, number of bedrooms and bathrooms, presence of air conditioning, and types of wall and floor finishes. It is not clear that the cost of efficiency-related features will result in an identical increase in property-tax valuation, and the DOE/PNNL methodology document provides no supporting evidence for the assumption that it will.

[11] Methodology for Evaluating Cost- Effectiveness of Residential Energy Code Changes, Pacific Northwest National Laboratory, 2015, https://www.energycodes.gov/sites/default/files/2021-07/residential_methodology_2015.pdf

Energy prices used to calculate savings are based on national averages of projected prices. The LCC is calculated both with the social benefit of avoided carbon, and assuming a zero societal cost of carbon (SCC). When included, the SCC is calculated using the energy savings, U.S. EIA emissions factors, and social cost data from the technical support document of the Interagency Working Group on Social Cost of Greenhouse Gases (2021). Specifically, this proposal used the 2020-2050 5-year time series of social cost of carbon dioxide at a 3% discount rate in Interagency Working Group on Social Cost of Greenhouse Gases (2021), interpolating for interim years.

The following table summarizes the parameters in the LCC modeling and their sources.

Table 13. LCC Assumptions

Parameter	Value	Source
Discount rate	3.8%	IECC cost effectiveness advisory group calculator ("IECC calculator"), based on DOE/PNNL
First cost for measure	$1,084	Online research of HRVs and ERVs See Incremental Cost section
Replacement cost for measure	$806	Assumes HRV replaced but not ductwork
Baseline fuel prices	$0.137 / kWh $1.1803 / therm natural gas $2.48 / gallon propane	IECC calculator, based on 2021 US residential price from EIA
Fuel price escalators	-0.10% for electricity 0.50% for natural gas 1.4% for propane	IECC calculator, based on EIA AEO 2021 reference case, residential by fuel, national
Social cost of carbon	$51 in 2020. See source document for time series.	IECC calculator, based on Interagency Working Group on Social Cost of Greenhouse Gases
Period of Analysis	30 years	Mortgage loan
Mortgage Interest Rate	3.8% nominal	IECC calculator: DOE / PNNL 2021 Analysis
Down Payment Rate	12%	IECC calculator: DOE / PNNL 2021 Analysis
Points and Loan Fees	1.00% nominal	IECC calculator: DOE / PNNL 2021 Analysis

Cost Effectiveness Results

The estimated energy savings are summarized below in Table 11. The proposal team used the gas results (in therms) for both natural gas and propane savings results. As shown, the energy use (in kBTU) is higher for the base case than the HRV case in all climate zones.

Table 14. Energy Savings from HRV

CZ	Heating system	Case	Total Energy (kBtu)	Electricity (kBtu)	Natural Gas (kBtu)	Fans (Elec kBtu)	Heat Recovery (Elec kBtu)	Heating (Gas kBtu)	Cooling (Elec kBtu)	Total kBtu savings	kWh savings	Therms savings
5A-Buffalo, NY	Gas furnace	Base	141,266	42,502	98,763	3,914	0	76,084	3,492			
		Proposed (HRV)	131,068	43,552	87,516	3,629	1,122	64,836	3,706	10,198	-308	112
	Heat Pump	Base	94,637	94,637	0	3,990		47,984	2,563			
		Proposed (HRV)	88,872	88,872	0	3,868	1,122	41,085	2,702	5,765	1690	0
5B-Denver, CO	Gas furnace	Base	106,370	39,132	67,238	4,675	0	44,935	6,238			
		Proposed (HRV)	98,812	40,090	58,722	4,328	1,122	36,419	6,422	7,558	-281	85
	Heat Pump	Base	70,858	70,858	0	4,629	0	26,340	4,899			
		Proposed (HRV)	67,727	67,727	0	4391	1,122	22,212	5,015	3,131	918	0
5C-Port Angeles, WA	Gas furnace	Base	100,215	33,797	66,418	3,608	0	43,841	1,971			
		Proposed (HRV)	90,415	34,775	55,641	3,140	1,122	33,064	2,294	9,800	-286	108
	Heat Pump	Base	62,631	62,631	0	3,530	0	22,958	1,401			
		Proposed (HRV)	59,343	59,343	0	3251	1,122	18,589	1,642	3,289	964	0
6A-Rochester, MN	Gas furnace	Base	168,813	42,950	125,863	4,061	0	102,190	3,793			
		Proposed (HRV)	157,060	43,992	113,068	3,801	1,122	89,394	3,973	11,754	-305	128
	Heat Pump	Base	117,455	117,455	0	4,424	0	69,670	2,857			
		Proposed (HRV)	111,009	111,009	0	4,309	1,122	62,128	2,962	6,446	1889	0

6B-Great Falls, MT	Gas furnace	Base	146,607	42,545	104,062	4,141	0	80,641	3,308			
		Proposed (HRV)	136,415	43,547	92,869	3,851	1,122	69,448	3,478	10,192	-293	112
	Heat Pump	Base	98,829	98,829	0	4,821	0	51,036	2,380			
		Proposed (HRV)	93,695	93,695	0	4,617	1,122	44,906	2,469	5,134	1505	0

The proposal team calculated the LCC for each climate zone, for each heating system, using the approach described above. As an example, Table 12 shows the LCC inputs and results for Climate Zone 6A, for the natural gas furnace.

Table 15. Example LCC Calculation for Climate Zone 6A and Natural Gas Furnace

Net measure cost	$1,084	2021$
Measure electric savings	-305	kWh/year
Measure natural gas savings	128	therms/year
Measure propane savings	0	gallons/year
Change in maintenance or other non-energy operating costs	0	2021$/year
Year of replacement	15	For measures with life <30 years, # of years from date of construction
Net measure cost for replacement	$806	2021$. Includes cost for HRV, but assumes ductwork, duct insulation, and return grille (all specifically serving HRV) can be retained (not replaced)
Without Social Cost of Carbon (SCC)		
Measure incremental LCC	$1,388	2020$ (+ for savings, - for increased cost)
Annual savings	$90/year	Calculations based on IECC calculator
Simple payback	9.9	Years
With Social Cost of Carbon		
Measure incremental LCC	$2,409	2020$ (+ for savings, - for increased cost)
Annual savings	$141/year	Calculations based on IECC calculator
Simple payback	7.8	Years

Simple payback was estimated by dividing measure incremental cost by annual energy savings (in $).

For each climate zone, the proposal team generated a table similar to the one above for the three heating systems: natural gas furnace, electric heat pump, and propane furnace, and weighted results based on the prevalence of that heating system type. The proposal team repeated the process for all climate zones studied.

The cost effectiveness results excluding the SCC (assuming a zero cost for carbon) are shown in Table 13 below for each heating system type, and for the weighted average for each climate zone. As shown, the proposed measure is cost-effective in all climate zones analyzed using the approach of weighting results by heating-fuel prevalence.

*Table 16. LCC Results for All Climate Zones, **excluding** SCC*

Scenario	Heating System Prevalence for CZ5 (% of single family homes)	Heating System Prevalence for CZ6 (% of single family homes)	LCC ($) 5A	LCC ($) 5B	LCC ($) 5C	LCC ($) 6A	LCC ($) 6B
Natural gas furnace	83%	76%	$625	($93)	$569	$1,111	$673
Electric heat pump	11%	18%	$3,668	$1,203	$1,350	$4,304	$3,078
Propane furnace	6%	6%	$5,240	$3,180	$5,010	$6,386	$5,288
Weighted LCC Results	**100%**	**100%**	$1,237	$337	$976	$1,779	$1,383

Assuming social cost of carbon (SCC) = $51 per metric ton:

*Table 17. LCC Results for All Climate Zones, **including** SCC*

Scenario	Heating System Prevalence for CZ5 (% of single family homes)	Heating System Prevalence for CZ6 (% of single family homes)	LCC ($) 5A	LCC ($) 5B	LCC ($) 5C	LCC ($) 6A	LCC ($) 6B
Natural gas furnace	83%	76%	$1,389	$457	$1,310	$2,013	$1,446
Electric heat pump	11%	18%	$4,723	$1,776	$1,951	$5,482	$4,017
Propane furnace	6%	6%	$6,081	$3,758	$5,826	$7,376	$6,138
Weighted LCC Results	**100%**	**100%**	$2,037	$892	$1,697	$2,717	$2,190

The analysis did not consider climate zones 7 and 8, since PNNL (2018) already found the measure cost effective in those climate zones. Furthermore, since those have higher heating loads (greater number of heating degree days – HDDs), if the measure is cost effective in CZ6, it will be cost effective in CZs 7 and 8.

HRV/ ERV Prevalence

The proposal team estimated the prevalence of HRV and ERVs in climate zones 5 and 6 using data provided upon request by RESNET. RESNET provided the following information, by climate zone:

- All rated homes with an HRV, by home type (single-family, duplex, and low-rise multifamily), for March 2020 – February 2022
- All rated homes with an ERV, by home type (single-family, duplex, and low-rise multifamily), for March 2020 – February 2022
- All rated homes (*not* broken out by home type) for March 2020 – February 2022
- All rated homes, by home type (single-family combined with duplex, and low-rise multifamily graphed separately) for 2020

The proposal team used the following calculation methodology to estimate prevalence of single-family homes (including duplexes) with HRVs and ERVs:

Table 18. Calculation of Prevalence of Single-Family Homes with ERVs or HRVs

Step	Calculation	5A	5B	6A	6B	Total
1	Number of homes with ERV – single family + duplex: March 2020 – Feb 2022 *From the RESNET ERV workbook. Filtered out (removed) multifamily*	3409	740	7557	92	11,798
2	Number of homes with HRV – single family + duplex: March 2020 – Feb 2022 *Same thing as above, but for the RESNET HRV workbook.*	942	436	8398	28	9,804
3	Number of single family homes (includes duplex) with ERV or HRV: March 2020 – Feb 2022 *Add 2 rows above.*	4351	1176	15,955	120	21,602
4	Number of rated homes in climate zone – all homes types, March 2020 – Feb 2022 *From RESNET "Climate Zone data" excel workbook*	104,598	48,490	25,535	1,095	
5	Percent of single family homes / total. *Based on bar graph of Multifamily vs. single-family ratings by CZ for 2020.*	68%	80%	83%	*Almost no data from 2020. Use the average for other climate zones: 77%*	
6	Percent of Single-family homes (including duplex) with ERV or HRV: Step 3 / (Step 4 x Step 5)	6%	3%	75%	*14%*	

Prevalence for most climate zones analyzed ranged from 3% to 14%. The value for 6A is surprisingly high. RESNET staff reported that most rated homes in 6A are in MN, and that many production home builders in St. Paul / Minneapolis use ERVs/HRVs.

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