International Energy Conservation Code
Consensus Committee-Residential

Draft Meeting Agenda (6/10 posting)

Webex Meeting Link

June 16, 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-93-21 (HRV and ERV) (tabled from 6/9 meeting previous vote for disapproval failed 15-19-2)
        REPI-71-21 (Grid Integrated Thermostat Cntl)(HVACR as modified 10-1)
        REPI-84-21 (Duct testing) (HVACR as modified 6-5)
        REPI-89-21 (Pipe Insulation) (HVACR as modified 11-0)
        REPI-91-21 (Hot water compact design) (HVACR as modified 10-0)
        REPI-142-21 (Hot water distribution Add. Energy Opt) (HVACR as modified 6-5)

REPI-18-21 (Modified R408 points system) (Modeling as modified 9-5)
REPI-19-21 (Additional Energy Efficiency) (Modeling disapprove 17-0)
REPI-33-21 (LBA Additional Energy Efficiency)(Modeling as modified 7-5-4)
REPI-167-21 (Realignment of Energy Measures)(Modeling approve as modified failed 9-6-2)

9. Other business.

10. Upcoming meetings. June 23 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 CODE COUNCIL®

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.

[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

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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

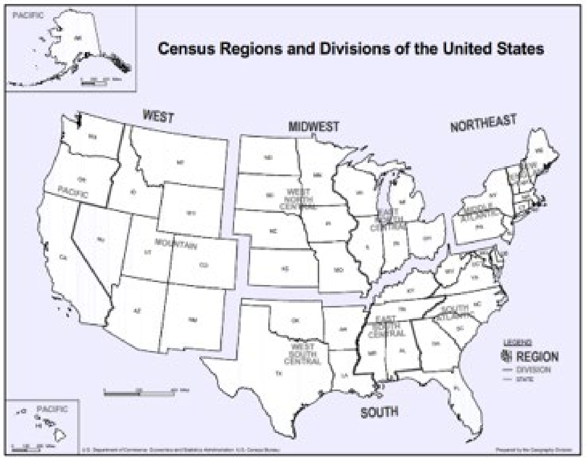
Basic characteristics that apply to the model include the following:

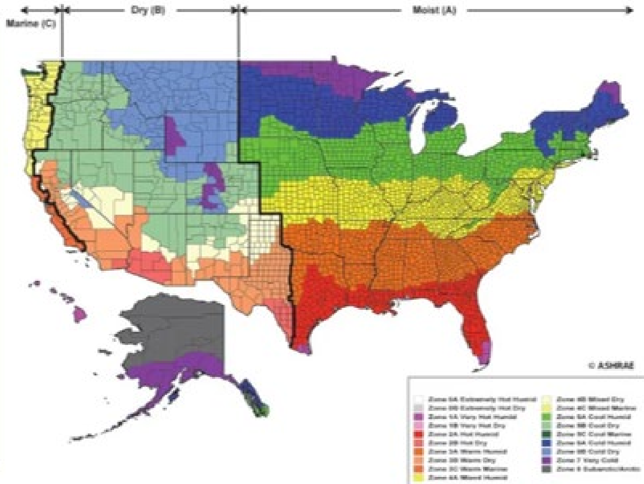
- 2-story above grade (with conditioned basement for select climate zones – described in Table 4, 3-bedroom, detached single-family house
- 2,400 ft^2 of conditioned space for slab-on-grade homes, and 3,600 ft^2 for homes with basement
- 40 ft. x 30 ft. exterior dimensions, 8.5 ft ceilings
- 2x6 wood 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

	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
6B-Great Falls, MT	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.

References:

Interagency Working Group on Social Cost of Greenhouse Gases, United States Government (2021, February), *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990,* Retrieved from whitehouse.gov: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

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U.S. Energy Information Administration. (2017, February). *RESIDENTIAL ENERGY CONSUMPTION SURVEY.* Retrieved from www.eia.gov: https://www.eia.gov/consumption/residential/data/2015/hc/php/hc6.1.php

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International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-071-21 Grid Integrated Thermostat Controls
CDP ID #	181
Code	IECC RE
Code Section(s)	R403.1.1.1 (New), R407.2 New Section y
Location	base
Proponent	Kim Cheslak kim@newbuildings.org
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	Modification received by the subcommittee and a note as this Proposal is similar to REPI-070 on the commercial side of code.
Recommendation	The Proponent has been working with AHRI and DOE for months to align the latest version of the modification aligns with REPI-070 (commercial). Multiple positive comments regarding. Motion to approve with a second vote 10/0/0 motion carried
Vote	Motion to approve as modified 10/0/0
Recommendation Date	6/6/2022
Next Step	To Subcommittee____________________ To Advisory Group____________________ To Consensus Committee__x ____________
Consensus Committee	
Committee Response	
Vote	Affirmative________ Negative________ Table________ To Subcommittee____________________
Date	

REPI-71 As Modified: Revision / Coordination with AHRI, NBI, DOE and REPI-70 + CEPI-99

IECC®: SECTION R202 (New), R403.1.2 (New), R407.2, CTA (New)

Proponents:

Kim Cheslak, representing New Buildings Institute (kim@newbuildings.org)

2021 International Energy Conservation Code

SECTION R202

GENERAL DEFINITIONS

Add new definitions as follows:

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*.

SECTION R403

SYSTEMS

Revise text as follows:

R403.1 Controls. Not less than one thermostat shall be provided for each separate heating and cooling system. The primary heating or cooling system serving the dwelling unit shall comply with Sections R403.1.1 and R403.1.2.

R403.1.1 Programmable thermostat. The thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature setpoints at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain zone temperatures of not less than 55°F (13°C) to not greater than 85°F (29°C). The thermostat shall be programmed initially by the manufacturer with a heating temperature setpoint of not greater than 70°F (21°C) and a cooling temperature setpoint of not less than 78°F (26°C).

R403.1.2 Demand responsive thermostat. The thermostat shall be provided with a *demand responsive control* capable of communicating with the Virtual End Node (VEN) using a wired or wireless bi-directional communication pathway and executing the following actions in response to a *demand response signal*:

1. *Automatically increasing the zone operating cooling set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C), and 4°F (2°C).*
2. *Automatically decreasing the zone operating heating set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C), and 4°F (2°C).*

Thermostats controlling single stage HVAC systems shall comply with Section R403.1.2.1. Thermostats controlling variable capacity HVAC systems shall comply with Section R403.1.2.2. Thermostats controlling ~~two~~ multi-stage HVAC systems shall comply with either Section R403.1.2.1 or R403.1.2.2. Where a *demand responsive signal* is not available the thermostat shall be capable of performing all other functions.

Exception: Assisted living facilities.

R403.1.2.1 Single stage or two-stage HVAC system controls. Thermostats controlling single stage HVAC systems shall be provided with a *demand responsive control* that complies with one of the following:

1. Certified OpenADR 2.0a VEN, as specified under Clause 11, Conformance
2. Certified OpenADR 2.0b VEN, as specified under Clause 11, Conformance
3. Certified by the manufacturer as being capable of responding to a *demand response signal* from a certified OpenADR 2.0b VEN by automatically implementing the control functions requested by the VEN for the equipment it controls
4. IEC 62746-10-1
5. The communication protocol required by a controlling entity, such as a utility or service provider, to participate in an automated demand response program
6. The physical configuration and communication protocol of CTA 2045-A or CTA-2045-B

R403.1.2.2 Variable capacity or two stage HVAC system controls. Thermostats controlling variable capacity and two stage HVAC systems shall be provided with a *demand responsive control* that complies with the communication and performance requirements of AHRI 1380.

SECTION R407

TROPICAL CLIMATE REGION COMPLIANCE PATH

Revise text as follows:

R407.2 Tropical climate region. Compliance with this section requires the following:

1. Not more than one-half of the *occupied* space is air conditioned and is controlled by a thermostat in accordance with Sections R403.1.1 and R403.1.2.

Add new standard(s) as follows:

AHRI Air-Conditioning, Heating, & Refrigeration Institute 2111 Wilson Blvd, Suite 500 Arlington VA 22201

AHRI 1380-2019 Demand Response through Variable Capacity HVAC Systems in Residential and Small Commercial Applications

ANSI American National Standards Institute 25 West 43rd Street, 4th Floor New York NY 10036

CTA Consumer Technology Association Technology & Standards Department 1919 S Eads Street Arlington, VA 22202

ANSI/CTA-2045-A – 2018 Modular Communications Interface for Energy Management

ANSI/CTA-2045-B – 2019 Modular Communications Interface for Energy Management

IEC IEC Regional Centre for North America 446 Main Street 16th Floor Worcester MA 01608 IEC International Electrotechnical Commission.

IEC 62746-10-1 - 2018 Systems interface between customer energy management system and the power management system – Part 10-1: Open automated demand response

OpenADR OpenADR Alliance 111 Deerwood Road Suite 200 San Ramon CA 94583
OpenADR OpenADR Alliance

OpenADR 2.0a and 2.0b – 2019: Profile Specification Distributed Energy Resources

Proposal Originally Submitted

SECTION R202

GENERAL DEFINITIONS

Add new definitions as follows:

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.

SECTION R403

SYSTEMS

Add new text as follows:

R403.1.1.1 Grid-integrated thermostat controls.

The thermostats shall be provided with grid-integrated controls that comply with AHRI 1380 capable of the following:

1. Automatically increasing the zone operating cooling set points by a minimum of 4°F (2.2°C)
2. Automatically decreasing the zone operating heating set points by a minimum of 4°F (2.2°C)
3. Automatically decreasing the zone operating cooling set points by a minimum of 2°F (1.1°C)
4. Automatically increasing the zone operation heating set points by a minimum of 2°F (1.1°C)
5. Both ramp-up and ramp-down logic to prevent the building peak demand from exceeding that expected without the DR implementation.

The thermostat shall be capable of performing all other functions provided by the control when the grid-integrated controls are not available.

Exception: Assisted living facilities.

Revise as follows:

R407.2 Tropical climate region.

Compliance with this section requires the following:
1. Not more than one-half of the occupied space is air conditioned and is controlled by a thermostat in accordance with Section R403.1.1.

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	REPI-084-21 Duct testing
CDP ID #	430
Code	IECC RE
Code Section(s)	R403.3.5, R403.3.6 New Section n
Location	base
Proponent	Robby Schwarz robby@btankinc.com
Proposal Status	SC rev
Subcommittee	RE HVACR & WH
Subcommittee Notes	This Proposal was originally assigned to the subcommittee working group – David Bixby Chair. David presented the Proposal during the 6/6/2022 meeting. The Proponent has made substantial changes in Modification to the Proposal to better align with REPI-086.
Recommendation	This Proposal had a tough time in the working group HVACR subcommittee with the original language. With the modification and alignment with REPI-086- 21 the Proposal was looked at more favorably. Motion to approve Gary Klein with a second by Mary Koban (AHRI) Motion carried with a vote of 6/5/0 approved as modified
Vote	Vote to approved as modified 6/5/0
Recommendation Date	6/6/2022
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee____x______________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________

Date	

REPI-84-21
IECC®: R403.3.5, R403.3.6
Proponents:
Robby Schwarz, BUILDTank, Inc., representing Colorado Chapter of the ICC (robby@btankinc.com)
2021 International Energy Conservation Code

Revise as follows:

Definition
DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to supply and return ducts, includes air handlers, duct fittings boots and elbows, dampers, plenums, filter boxes, ~~fans~~ and accessory air-handling equipment and appliances.

R403.3.5 Duct testing.
Duct~~s~~ systems shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage 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~~ ~~All portions of the duct system, including air handler, filter box, supply and return boots, shall be~~ ~~test~~ed.

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.~~ ~~All portions of the duct system, including air handler, filter box, supply and return boots, shall be tested.~~

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

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

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

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.~~

Exceptions:

1. 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. ~~If~~ Where the HVAC duct system is serving less than or equal to ~~1,200~~ 1,000 square feet of conditioned floor area, the allowable duct leakage shall be ~~50~~ 40 cubic feet per minute or less.

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.

Exception: ~~If~~ Where the HVAC duct system is serving less than or equal to ~~1,200~~ 1,000 square feet of conditioned floor area, the allowable duct leakage shall be ~~50~~ 40 cubic feet per minute or less.

~~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.~~

Reason Statement:

The Modifications made in blue above were made from input from the HVAC duct testing working group chaired by David Bixby and Gary Klein and the HVACR subcommittee during 1st reading of the proposal.

This code change proposal begins by defining a duct leakage test of the entire system, including the duct, the air handler, filter box and supply and return boots. The entire system is what is tested and what needs to pass the requirements of the IECC. This is important to make clear as we are seeing significant leakage at duct boots for example, that many feel are exempt as they are not specifically called out. In addition, although manufacturers are supposed to be delivering tight air handler boxes the reality that they either are not or when they are installed, they continue to leak. Testing the entirety of the HVAC system as installed leads to better efficiency and performance.

An allowance to have ducts that leak as much as 8 CFM per 100 sqft of conditioned floor area has been removed by this proposal as this allowance does not take into consideration the inefficiencies that arise from ductwork that leaks within the building thermal envelope. First, since the code does not require a duct leakage to outside test it is unable to quantify how much of the leakage that is supposed to be leaking inside the envelope is actually leaking outside. Second, duct leakage as high as 8 CFM means that rooms with specific design flows are not being heated or cooled to the design parameters. This causes the occupant to adjust the thermostat to try to compensate for comfort issues associated with duct leakage. This causes more leakage and potential increased stratification of temperature in the home, building durability and potential safety problems in the house. Sticking with efficiency of the system, the thermostat adjustment leads to short cycling as the system that was design to specific set point temperatures tries to achieve arbitrary set points. A consistent duct leakage allowance requirement of 4CFM across the board regardless of duct location simplifies things for contractors and ensure better performance of ducts locating both inside and outside the building.

The duct leakage section of the proposal restructures the requirement with exceptions, one of which is currently awkwardly in the body of the code and one of which is being proposed. For duct work servicing small square footages, it become unreasonable to require the duct to be tighter than 50 CFM. At 1200 sqft the 4 CFM duct leakage target would be 48 CFM, so this appeared to be the perfect starting point for this exception.

Cost Impact:
The code change proposal will increase the cost of construction. This proposal may increase cost in jurisdiction that have not concentrated on total system duct leakage and that have allowed ducts to leak more if they are within the building envelope. The increased cost comes down quickly as installers better understand installation techniques that ensure tighter systems and are also mitigated by better system performance, efficiency, and fewer call backs.

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	
Committee Response	

Vote	Affirmative__________ Negative___________ Table____________ To Subcommittee_________________________
Date	

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-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	

Vote	Affirmative__________ Negative___________ Table____________ To Subcommittee__________________________
Date	

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

Bibliography:

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-142-21 Hot water distribution Additional Energy Option
CDP ID #	446
Code	IECC RE
Code Section(s)	R408.2.6, 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
	Proposal Presented by Dan Wildenhaus "as modified". The subcommittee spent a lot of time deliberating this Proposal but in the end voted to approve **"as modified"**
Recommendation	Proponent presented the proposal with a rocky start. A member of the subcommittee made a motion to disapprove as modified. The motion with a second was voted on and the motion to disapprove failed with a vote of 3 disapprove and 8 against disapproval. With much discussion the proposal was back on track and a motion to approve as modified was made with a second. The subcommittee voted to approve 9/3/0. After the subcommittee voted on this Proposal SEPHCAC met and added requested to make adjustments and add some edits to the code language. Chair Hensley pulled this proposal along with some others from the IECC main committee schedule and sent the Proposal back to the subcommittee for review and a vote. Subcommittee 6/6/2022 this proposal was heard with the recommended language. Initially a motion was made to disapprove SEPHCAC recommendations. The motion did not carry. Another motion was offered and the motion carried with a approval vote of 6/5/0 Revised modification/.
Vote	Vote of the subcommittee is to approve **"as modified"** 9/3/0 - subcommittee vote to approve SEPHCAC recommendations 6/6/2022 approved as modified vote 6/5/0
Recommendation Date	On 5/2/2022 the subcommittee voted to approve as modified the Proposal with a vote of 9/3/0 and on 6/6/2022 the subcommittee voted to approve the Proposal as modified with SEPHCAC recommendations with a vote of 6/5/0
Next Step	To Subcommittee________________________________ To Advisory Group________________________________

	To Consensus Committee____x _____________
Consensus Committee	
Committee Response	
Vote	Affirmative__________ Negative___________ Table____________ To Subcommittee_________________________
Date	

REPI-142-21

IECC®: 408.2.6 (N1108.2.6) (New), 403.5.4 (N1103.5.4) (New), 403.5.4.1 (N1103.5.4.1) (New)

Proponents:

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

2021 International Energy Conservation Code

Add new text as follows:

408.2.6 (N1108.2.6) Improved Domestic Hot Water Distribution.

The hot water distribution system shall meet Section R403 .5.4 and shall be paired with a drain water heat *recover* system per Section R403 .5.3. The storage limit specified by R403 .5.4 shall be measured from the water heating source to the fixture itself. In addition, no more than 0.6 gallons (2.3 liters) of water shall be collected from the hot water fixture before hot water is delivered. The fixture with the greatest stored volume between the fixture and the hot water source (or recirculation loop) will need to be tested. To field verify that the system meets the 0.6 gallon (2.3 liter) limit, verifiers shall first initiate operation of on-demand recirculation systems, if present, and let such systems run for at least 40 seconds. In accordance with Department of Energy's Zero Energy Ready Home National Specification (Rev. 07). Next, a bucket or flow measuring bag (pre-marked for 0.6 gallons) shall be placed under the hot water fixture. The hot water shall be turned on completely and a digital temperature sensor used to record the initial temperature of the water flow. Once the water reaches the pre-marked line at 0.6 gallons (approximately 24 seconds for a lavatory faucet), the water shall be turned off and the ending temperature of the water flow (not the collection bucket) shall be recorded. The temperature of the water flow must increase by not less than 10 °F (5.6ºC).

403.5.4 (N1103.5.4) Compact Hot Water Distribution systems (CHWD).

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

~~403.5.4.1 (N1103.5.4.1) 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 (6.1m).~~

408.2.6 (N1108.2.6) Compact Hot Water Distribution

For Compact Hot Water Distribution system credit, the volume shall store not more than 16 ounces of water between the nearest source of heated water and the termination of the fixture supply pipe where calculated using section R403.5.4 *Construction documents* shall indicate the ounces of water in piping between the hot water source and the termination of the fixture supply.

Reason Statement:

This section is being re-submitted to better align with credit provided for compact hot water distribution outlined in section R405.4 and Table R405.4.2(1), building component "service water heating," utilizing HWDS or the factor for the compactness of the hot water distribution system. 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 the assumed 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.

[1]*Residential Compact Domestic Hot Water Distribution Design:Balancing Energy Savings, Water Savings, and Architectural Flexibility*

Farhad Farahmand, TRC Companies and 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

Savings:

The following savings have been calculated for compact domestic hot water distribution only, as Drain Water Heat Recovery has already been included in the 2021 IECC. The California Energy Codes & Standards Case Report for *Compact Hot Water Distribution.*

Measure Number: 2019-RES-DHW1-F, Residential Plumbing [3] performed savings analysis using 16 California climate zones. This analysis focused on Therm and Water Savings as it's estimated that over 75% of Residential New Construction Water Heaters installed are gas tankless systems. Nationally, ~68% of Residential New Construction Domestic Hot Water systems are gas fueled, according to

the *Home Innovation Research Lab's Annual Builder Practices Survey, 2021[4].* California's climate zones correlate approximately to IECC Climate Zones 2, 3b, 3c, 4c, 5b, and 6. Savings estimated should be conservative for climate zones 4c and higher as ground

temperatures and therefore incoming water temperatures in California homes may be 1 to 3°F higher than in these cooler climates.

Energy Savings Compact Hot Water Distribution Design: In climate zones 3b and lower, first year weighted average residential energy savings (translated from Therms/yr to Mmbtu/yr) are estimated to be per Single Family Home: Climate Zone Savings in Therms Savings in Mmbtu[2] are estimated to be per Single Family Home:

Climate Zone	Savings in Therms	Savings in Mmbtu
2 and 3b	4.48	0.448
3c and higher	5.57	0.557

These estimates come from assumption of a 2,430 sq fthome with 3.5 bedrooms.

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

[4]Home Innovation Research Labs Annual Builder Practices Survey, 2021

Water Savings

Estimated impacts on water use are presented in the table below. Water use savings estimates are challenging given that hot water usage behaviors among individuals and households are highly variable and can depend strongly on the demographics of the household (Parker, D.; Fairey, P.; and Lutz, J.; 2015). In addition, the proposed compliance option approach ensures that compliant hot water distribution systems will be smaller than a conventional non-compact system but cannot precisely specify the design and configuration and hence the impacts on water waste. To provide a best approximation of water savings impacts, the Statewide CASE Team relied on detailed distribution simulation study completed under the U.S. Department of Energy's Building America program (Weitzel, E.; Hoeschele, M. 2014). In these estimates, it was assumed that all water savings occur indoors.

Impacts on Water Use Table

	On-Site Indoor Water Savings (gal/yr)
Per Dwelling Unit Impacts (single family)	962
Per Dwelling Unit Impacts (multifamily)	321

Drain Water Heat Recovery Savings:

Using the most conservative Department of Energy savings estimates of 800kWh per year, with an U.S. Energy Information Agency hybrid electricity rate for the nation of 13.5 cents per kWh show an annual savings estimate for electric water heating at: $108/yr

https://energy.cdpaccess.com/proposal/446/975/files/download/139/ https://energy.cdpaccess.com/proposal/446/975/files/download/138/ https://energy.cdpaccess.com/proposal/446/975/files/download/137/ https://energy.cdpaccess.com/proposal/446/975/files/download/136/ https://energy.cdpaccess.com/proposal/446/975/files/download/135/

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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
- Code Changes and Implications of Residential Low-Flow Hot Water Fixtures – CEC-500-2021-043. Gary Klein, Jim Lutz, Yanda Zhang, John Koeller.
- Time-to-Tap and Volume-until-Hot – Water, Energy, and Time Efficient Hot Water Systems. 2020 Educational Institute, March 2020, Gary Klein presentation.

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.

Energy Savings and Cost Impact for Drain Water Heat Recovery: Using the most conservative Department of Energy savings estimates of 800kWh per year savings, with an U.S. Energy Information Agency hybrid electricity rate for the nation of 13.5 cents perkWh, and an increased cost of $1,000 per unit due to increase copper prices; these systems provide an 11 year simple payback.

REPI-142-21

jr

International Energy Conservation Code
Code Change Proposal Tracking Sheet

June 8th Economics and Modelling subcommittee voted on 4 proposals: REPI-018, REPI-019, REPI-33, REPI-167 in that order

Proposal #	**REPI-018-21 (Mod 3)** Modified R408 proposal using points-based system
CDP ID #	
Code	IECC-RE
Code Section(s)	R408
Location	base
Proponent	Mark Lyles, NBI Shilpa Surana
Proposal Status	SC rev
Subcommittee	RE Econ, Model, Metric
Subcommittee Notes	This proposal was first heard with multiple other R408 proposals that varied in approach. Straw polls of the SC and the main Residential committee showed a preference for the points-based approach used in this proposal, so NBI and others worked to modify the proposal to expand the list of options for builders/developers and incorporate input from other proponents
Recommendation	Motion to Approve as Modified (Mod3) by Gayathri Vijaykumar, 2nd by Thomas Marston
Vote	**9-5 for Approval as Modified (3 abstain, 3 not present)**
Recommendation Date	6-8-22
Next Step	To Subcommittee__ _____ To Advisory Group___________________________________ To Consensus Committee____X________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________

Date	

Revise as follows:

Revision adds Exception to R401.2 and R401.2.4 to capture all sections in R401. Removes reference to R401.2.5. Adds section R401.3 to make a reference to R408. Updates Table R408.2 to include list of measures which were agreed upon by the working group (comprised of R408 proponents and interested stakeholders). Section R408.2 was updated to require two additional efficiency measures be selected from Table 408.2. The points in the Table 408.2 were updated based on the analysis provided by PNNL.

SECTION R401

GENERAL

R401.1 Scope. This chapter applies to residential buildings.

R401.2 Application. Residential buildings shall comply with ~~Section R401.2.5 and~~ either Sections R401.2.1, R401.2.2, R401.2.3 or R401.2.4.

Exception: Additions, *alterations*, repairs and changes of occupancy to existing buildings complying with Chapter 5.

R401.2.1 Prescriptive Compliance Option. The prescriptive compliance option requires compliance with Sections R401 through R404 and R408.

R401.2.2 Total Building Performance Option. The total building performance option requires compliance with Section R405 ~~and one of the following:~~

-

1. ~~Additional efficiency credits as required in Section R408.2 without including such measures in the proposed design under Section R405.~~
2. ~~The proposed design of the building under Section R405.3 shall have an annual energy cost that is less than or equal to 90 X percent of the annual energy cost of the standard reference design.~~

R401.2.3 Energy Rating Index Option. The total building performance option requires compliance with Section R406 ~~and one of the following:~~

-

1. ~~Section R408 without including such measures in the proposed design under Section R405.~~

~~2. The Energy Rating Index value shall be at least 5 X percent less than the Energy Rating Index target specified in Table R406.5.~~

R401.2.4 Tropical Climate Region Option. The Tropical Climate Region Option requires compliance with Section R407.

~~**R401.2.5 Additional energy efficiency.** This section establishes additional requirements applicable to all compliance approaches to achieve additional energy efficiency.~~

1. ~~For buildings complying with Section R401.2.1, one of the additional efficiency package options shall be installed according to or more additional energy efficiency measure(s) shall be installed in accordance with Section R408.2 that cumulatively equal or exceed 10 (ten) credits from Table R408.2.~~
2. ~~For buildings complying with Section R401.2.2, the building shall meet one of the following:~~
   - ~~2.1. One or more of the additional efficiency package options measure(s) in Section R408.2 shall be installed that cumulatively equal meet or exceed ten credits, without including such measures in the proposed design under Section R405; or~~
   - ~~2.2. The proposed design of the building under Section R405.3 shall have an annual energy cost that is less than or equal to 95 90 percent of the annual energy cost of the standard reference design.~~
3. ~~For buildings complying with the Energy Rating Index alternative Section R401.2.3, the Energy Rating Index value shall be at least 5 10 percent less than the Energy Rating Index target specified in Table R406.5.~~

~~The option additional efficiency measures selected for compliance with R408 shall be identified in the certificate required by Section R401.3 and the construction documents as required by Section R103.2.~~

R401.3 Certificate. A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory *label*, service disconnect *label* or other required labels. The certificate shall indicate the following:

1. The predominant R-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls, crawl space walls* and floors and ducts outside *conditioned spaces*.

2. *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration. Where there is more than one value for any component of the building envelope, the certificate shall indicate both the value covering the largest area and the area weighted average value if available.

3. The results from any required duct system and building envelope air leakage testing performed on the building.

4. The types, sizes and efficiencies of heating, cooling and service water-heating equipment. Where a gas-fired unvented room heater, electric furnace or base-board electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces and electric baseboard heaters.

5. Where on-site *photovoltaic panel* systems have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.

6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without any on-site generation, shall be listed on the certificate.

7. The code edition under which the structure was permitted, and the compliance path used, and where applicable, the additional efficiency measures selected for compliance with R408.

SECTION R408

ADDITIONAL EFFICIENCY REQUIREMENTSCREDITSPACKAGE OPTIONS

R408.1 Scope. This section establishes additional efficiency credits package options to achieve additional energy efficiency in accordance with Section R401.2.5.

R408.2 Additional energy efficiency credits requirementspackage options. **Two** Aadditional efficiency package options for compliance with Section R401.2.1 are set forth in Sections R408.2.1 through R408.2.5. measures shall be selected from Table R408.2 that meet or exceed a total of ten credits. Each measure selected shall meet the relevant subsections of Section R408 and receive credit as indicated in the Table for the specific Climate Zone. Interpolation of credits between measures shall not be permitted.

TABLE R408.2
CREDITS FOR ADDITIONAL ENERGY EFFICIENCY

Measure Number	Measure Description		Credit Value							
		CZ 0 & 1	CZ 2	CZ 3	CZ 4	CZ 4C	CZ 5	CZ 6	CZ 7	CZ 8
R408.2.1.1 (1)	≥ 2.5% reduction in total UA	0 1	0 1	0 2	1 2	1 2	1 2	1 3	1 4	1 4
R408.2.1.1 (2)	≥ 5% reduction in total UA	0 3	1 3	1 3	2 3	2 3	3 4	3 5	3 5	3 5

R408.2.1.1 (3)	> 7.5% reduction in total UA	0 ~~5~~	1 ~~5~~	2 ~~5~~	2 ~~5~~	2 ~~5~~	3 ~~6~~	3 ~~7~~	4 ~~8~~	4 ~~8~~
~~R408.2.2 (1)~~	~~20% reduction SHGC~~	~~4~~	~~1~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~
R408.2.1.2 (1)	0.22 U-factor windows	1 ~~NA~~	2 ~~NA~~	2	3 ~~2~~	3 ~~2~~	4 ~~2~~	4 ~~2~~	4 ~~3~~	5 ~~3~~
R408.2.1.2 (2)	U factor and SHGC for windows per Table 408.2.1	1	1	1	0	0	0	0	1	2
R408.2.3 (1)	High performance cooling system option 1	5 ~~9~~	5 ~~7~~	4 ~~3~~	3 ~~2~~	3 ~~NA~~	2 ~~NA~~	1 ~~NA~~	1 ~~NA~~	0 ~~NA~~
R408.2.3 (2)	High performance cooling system option 2	7	6	5	3	3	3	1	1	1
R408.2.3 (3)	High performance gas furnace option 1	0 ~~NA~~	2	3 ~~6~~	5 ~~9~~	5 ~~10~~	7 ~~10~~	8 ~~11~~	8 ~~12~~	10 ~~14~~
R408.2.3 (4)	High performance gas furnace option 2	0	2	2	4	4	5	7	7	8
R408.2.3 (5)	High performance heat pump system option 1	6 ~~NA~~	6 ~~NA~~	5 ~~3~~	5 ~~4~~	5 ~~4~~	5	4	4 ~~3~~	3
R408.2.3 (6)	High performance heat pump system option 2	8	7	6	6	6	6	5	5	4
R408.2.3 (7)	Ground source heat pump	0 ~~NA~~	2	4	6	6	8	7	6	5
R408.2.4 (1)	Fossil fuel service water heating system	7	6 ~~5~~	5 ~~4~~	3	3 ~~2~~	2	2	3 ~~1~~	1
R408.2.4 (2)	High performance heat pump water heating system option 1	12 ~~5~~	11 ~~5~~	11 ~~5~~	8 ~~5~~	8 ~~5~~	6 ~~5~~	5	5	3 ~~5~~
R408.2.4 (3)	High performance heat pump water heating system option 2	12	12	11	8	8	6	5	5	3
R408.2.4 (4)	Solar hot water heating system	4 ~~8~~	5 ~~9~~	6 ~~9~~	6 ~~7~~	6 ~~9~~	6	5	5 ~~4~~	4 ~~3~~
R408.2.4 (5)	Compact hot water distribution	2	2	2	2	2	2	2	2	2
R408.2.5 (1)	More efficient distribution system	4 ~~8~~	6 ~~8~~	7 ~~9~~	10 ~~11~~	10 ~~8~~	12	13 ~~15~~	15 ~~17~~	16 ~~17~~
R408.2.5 (2)	100% of ducts in conditioned space	4 ~~8~~	6 ~~8~~	8 ~~9~~	12 ~~11~~	12 ~~8~~	15 ~~12~~	17 ~~15~~	19 ~~17~~	20 ~~17~~
R408.2.5 (3)	Reduced total duct leakage	1	1	1	1	1	1	2	2	2
R408.2.6 (1)	2 ACH50 air leakage rate with ERV or HRV installed	1 ~~2~~	4 ~~5~~	5 ~~NA~~	10 ~~NA~~	10 ~~NA~~	13 ~~NA~~	15 ~~NA~~	8 ~~NA~~	8 ~~NA~~
R408.2.6 (2)	2 ACH50 air leakage rate with balanced ventilation	2	3	2	4	4	5	6	6	6
R408.2.6 (3)	1.5 ACH50 air leakage rate with ERV or HRV installed	2	4	6	12	12	15	18	11	11
R408.2.6 (4)	1 ACH50 air leakage rate with ERV or HRV installed	2	5	6 ~~7~~	14 ~~9~~	14 ~~9~~	17 ~~9~~	21 ~~10~~	14 ~~11~~	14 ~~11~~
R408.2.7	Energy Efficient Appliances	9	8	8	7	7	5	5	5	4

R408.2.8	Renewable Energy Measure	17	16	17	11	11	9	8	7	4

R408.2.1 Enhanced Envelope Options. The *building thermal envelope* shall meet the requirements of Section R408.2.1.1 or R408.2.1.2.

R408.2.1.1 Enhanced envelope performance UA. The proposed total *building thermal envelope* UA ~~of the *building thermal envelope* as designed shall be one of the following and the sum of U-factor times assembly area, shall be less than or equal to 95 percent of the total UA resulting from multiplying the U-factors in Table R402.1.2 by the same assembly area as in the proposed building.~~ shall be calculated in accordance with Section R402.1.5 and shall meet one of the following: ~~The area-weighted average SHGC of all glazed fenestration shall be less than or equal to 95 percent of the maximum glazed fenestration SHGC in Table R402.1.2.~~

1. Not less than 2.5% below the total UA of the *building thermal envelope*.
2. Not less than 5% below the total UA of the *building thermal envelope*.
3. Not less than 7.5% below the total UA of the *building thermal envelope*.

R408.2.1.2 Improved fenestration. Vertical fenestration shall meet one of the following:

1. ~~20% reduction in glazed area-weighted average SHGC.~~
2. ~~Have a~~ U-factor equal to or less than 0.22 i
3. ~~Vertical fenestration shall have~~ U factor and SHGC equal or less than that specified in T R408.2.1.2

Table 408.2.1.2

Climate Zone	Fenestration U factor	Fenestration SHGC
0	0.32	0.23
1	0.32	0.23
2	0.30	0.23
3	0.25	0.25
4	0.25	~~0.25~~ <0.40
5	0.25	~~0.25~~ ≥0.17

6	0.25	~~0.25~~ ≥0.17
7 and 8	0.25	~~0.25~~ ≥0.17

R408.2.3~~2~~ More efficient HVAC equipment performance options. Heating and cooling equipment shall meet one of the following efficiencies:

1. Greater than or equal to ~~95 AFUE natural gas furnace and 16~~ 18 SEER and 14 EER air conditioner.
2. Greater than or equal to 16 SEER and 12 EER air conditioner.
3. Greater than or equal to 9~~5~~6 AFUE natural gas furnace
4. Greater than or equal to 92 AFUE natural gas furnace
5. Greater than or equal to 10 HSPF/18 SEER air source heat pump.
6. Greater than or equal to 9 HSPF/16 SEER air source heat pump
7. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

R408.2.4~~3~~ Reduced energy use in service water-heating options. The hot water system shall meet one of the following efficiencies:

1. Greater than or equal to 82 EF fossil fuel service water-heating system.
2. Greater than or equal to ~~2.0~~ 2.9 UEF electric service water-heating system.
3. Greater than or equal to 3.2 UEF electric service water-heating system
4. Greater than or equal to 0.4 solar fraction solar water-heating system.
5. Compact hot water distribution. For Compact Hot Water Distribution system credit, the volume shall store not more than 16 ounces of water in the nearest source of heated water and the termination of the fixture supply pipe when calculated using section R403.5.4.

To field or plan review verify that the system meets the prescribed limit, one of the following must be done:

   a. At plan review
      i. Referencing ounces of water per foot of tube on plans as per Table R403.5.4.1
   b. At rough in (plumbing)
      i. Referencing ounces of water per foot of tube installed as per Table R403.5.4.1
   c. At final inspection
      i. In accordance with Department of Energy's Zero Energy Ready Home National Specification (Rev. 07 or higher) footnote on Hot water delivery systems.

~~6. Increase pipe insulation R value to no less than R-4~~

R408.2.5~~4~~ More efficient duct thermal distribution system option. The thermal distribution system shall meet one of the following efficiencies:

~~1. 100 percent of ducts and air handlers located entirely within the *building thermal envelope*.~~

1. 100 percent of ductless thermal distribution system or hydronic thermal distribution system located completely inside the *building thermal envelope*.
2. 100 percent of duct thermal distribution system located in *conditioned space* as defined by Section R403.3.2.
3. When ducts are located outside conditioned space, the total leakage of the ducts, measured in accordance with R403.3.5, shall be in accordance with one of the following:
    a. Where air handler is installed at the time of testing, 2.0 cubic feet per minute per 100 square feet of *conditioned floor area*.
    b. Where air handler is not installed at the time of testing, 1.75 cubic feet per minute per 100 square feet of *conditioned floor area*.

R408.2.6~~5~~ Improved air sealing and efficient ventilation system option. The measured air leakage rate shall be one of the following:

1. ~~l~~Less than or equal to ~~3~~2.0 ACH50, with either an Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV) installed.
2. Less than or equal to 2.0 ACH50, with balanced ventilation as defined in Section 202 of the 2021 International Mechanical Code.
3. Less than or equal to 1.5 ACH50, with either an ERV or HRV installed.
4. Less than equal to 1.0 ACH50, with either an ERV or HRV installed.

Minimum HRV and ERV requirements, measured at the lowest tested net supply airflow, shall be greater than or equal to 75 percent Sensible Recovery Efficiency (SRE), less than or equal to 1.1 cubic feet per minute per watt (0.03 m3/min/watt) and shall not use recirculation as a defrost strategy. In addition, the ERV shall be greater than or equal to 50 percent Latent Recovery/ Moisture Transfer (LRMT).

R408.2.7 Energy efficient appliances. Appliances installed in a dwelling unit shall meet the product energy efficiency specifications listed in Table R408.4.6, or equivalent energy efficiency specifications. Not less than three appliance types from Table R408.4.6 shall be installed for compliance with this section.

Table R408.2.2

APPLIANCE SPECIFICATION REFERENCE DOCUMENT

Refrigerator	Energy Star Program Requirements, Product Specification for Consumer Refrigeration Products, Version 5.1 (08/05/2021)
Dishwasher	Energy Star Program Requirements for Residential Dishwashers, Version 6.0 (01/29/2016)
Clothes Dryer	Energy Star Program Requirements, Product Specification for Clothes Dryers, Version 1.1 (05/05/2017)
Clothes Washer	Energy Star Program Requirements, Product Specification for Clothes Washers, Version 8.1 (02/05/2018)

R408.2.8 Renewable Energy.

Renewable energy resources shall be permanently installed that have the capacity to produce a minimum of 1.0 watt of *on-site renewable energy* per square foot of conditioned floor area. The installed capacity shall be in addition to any onsite renewable energy required by Section R404.4. To qualify for this option, one of the following forms of documentation shall be provided to the code official:

a. Substantiation that the RECs associated with the *on-site renewable energy* are owned by, or retired on behalf of, the homeowner.
b. A contract that conveys to the homeowner the *REC*s associated with the *on-site renewable energy*, or conveys to the homeowner an equivalent quantity of *REC*s associated with other renewable energy

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	**REPI-019-21 R408 additional measures**
CDP ID #	
Code	IECC RE
Code Section(s)	R408
Location	base
Proponent	Amy Boyce amy.boyce@imt.org
Proposal Status	SC rev
Subcommittee	RE Econ, Model, Metric
Subcommittee Notes	This proposal was heard with others in R408 and based on sub-committee and consensus committee straw polls it was agreed to prioritize REPI-018 with a points-based approach instead.
Recommendation	Motion to disapprove based on prior action on REPI-018 by Amy Boyce (proponent), Second by Gayathri Vijaykumar
Vote	**17-0 for disapproval (3 not present)**
Recommendation Date	6-8-22
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 #	**REPI-33-21 (Mod) Modify envelope table and add points to R408**
CDP ID #	
Code	IECC RE
Code Section(s)	R402, R408
Location	base
Proponent	Amanda Hickman, LBA
Proposal Status	SC rev
Subcommittee	RE Econ, Model, Metric
Subcommittee Notes	Initially considered alongside REPI-018-21 – and other R408 measures, this proposal was modified to align with the REPI-018 points-based approach to R408. This proposal weakens the ceiling insulation requirements in R402 and compensates by offering either electrification options or 3 additional points in R408. Note: it also impacts R405
Recommendation	Motion to Approve as Modified from Gayathri Vijayakumar, 2nd by Thomas Marston. This was a close vote in subcommittee with multiple abstentions and non-votes
Vote	**7-5 motion to approve as modified (4 abstain, 4 not present)**
Recommendation Date	6-8-22
Next Step	To Subcommittee___________________________________ To Advisory Group___________________________________ To Consensus Committee___X____________
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

Mod to REPI-33

Replace REPI-33 in its entirety with the following:

TABLE R402.1.2

MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS

CLIMATE ZONE	FENESTRATION *U*-FACTOR[f]	SKYLIGHT *U*-FACTOR	GLAZED FENESTRATION SHGC[d, e]	CEILING *U*-FACTOR	WOOD FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
0	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
1	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.25	0.030 ~~0.026~~	0.084	0.165	0.064	0.360	0.477
3	0.30	0.55	0.25	0.030 ~~0.026~~	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.30	0.55	0.40	0.026 ~~0.024~~	0.045	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.40	0.026 ~~0.024~~	0.045	0.082	0.033	0.050	0.055
6	0.30	0.55	NR	0.026 ~~0.024~~	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	NR	0.026 ~~0.024~~	0.045	0.057	0.028	0.050	0.055

TABLE R402.1.3

INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
0	NR	0.75	0.25	30	13 or 0&10ci	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0&10ci	3/4	13	0	0	0
2	0.40	0.65	0.25	38 ~~49~~	13 or 0&10ci	4/6	13	0	0	0

3	.30	0.55	0.25	38 49	20 or 13&5ci[h] or 0 & 15ci[h]	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	.30	0.55	0.40	49 60	30 or 20& 5ci[h] or 13& 10ci[h] or 0& 20ci[h]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
5 and Marine 4	0.30[i]	0.55	0.40	49 60	30 or 20& 5ci[h] or 13& 10ci[h] or 0& 20ci[h]	13/17	30	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 &5ci
6	0.30[i]	0.55	NR	49 60	30 or 20& 5ci[h] or 13& 10ci[h] or 0& 20ci[h]	15/20	30	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 &5ci
7 and 8	0.30[i]	0.55	NR	49 60	30 or 20& 5ci[h] or 13& 10ci[h] or 0& 20ci[h]	19/21	38	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 &5ci

Modification to the modified REPI-18:

R408.2 Additional efficiency credits ~~package options~~. Two ~~of the~~ ~~A~~additional efficiency ~~package options for compliance with Section R401.2.1 are set forth in Sections R408.2.1 through R408.2.5.~~ measures shall be selected from Table R408.2 that are cumulatively equal to or greater than ~~meet or exceed~~ ten credits. Each measure selected shall meet the relevant subsections of Section R408 and receive credit as ~~indicated~~ specified in ~~the~~ Table 408.2 for the specific Climate Zone. Interpolation of credits between measures shall not be permitted.

R408.2.1 Opaque wall option. For buildings in climate zones 4 and 5, the maximum U-factor of 0.060 shall be permitted to be used for wood frame walls for compliance with Table R402.1.2 where complying with one or more of the following:

1. A heat pump is installed for space heating.
2. All installed water heaters have a UEF equal to or greater than 2.0 or a COP of greater than 1.0.
3. In addition to the number of credits required by Section R408.2, three additional credits are achieved.

International Energy Conservation Code
Code Change Proposal Tracking Sheet

Proposal #	**REPI-167-21 (Mod June 1st) R402 envelope reduction for R408 points**
CDP ID #	
Code	IECC RE
Code Section(s)	R402, R408
Location	base
Proponents	Aaron Vandermeulen, Thomas Marston
Proposal Status	SC rev
Subcommittee	RE Econ, Model, Metric
Subcommittee Notes	Initially considered with other R408 proposals alongside REPI-018-21 – the proponents worked to align with the R408 points based system. This proposal is very similar to REPI-33 however is a more simple envelope reduction trade-off for 3 additional R408 points.
Recommendation	**Motion to Disapprove** The subcommittee voted on a motion to Approve as Modified by Thomas Marston (proponent), seconded by Vladimir Kochkin. That motion failed however, there was not time for a subsequent motion as the meeting ran over time. Based on this vote and prior action on REPI-033 the SC is recommending a Motion to Disapprove
Vote	**Approve as Modified failed 6-9 (2 abstain, 3 not present)**
Recommendation Date	6-8-22
Next Step	To Subcommittee___________________________________ To Advisory Group__________________________________ To Consensus Committee______Motion to disapprove_____
Consensus Committee	
Committee Response	
Vote	Affirmative___________ Negative____________ Table_____________ To Subcommittee___________________________
Date	

REPI 167 Modification

Replace original proposal with the following:

TABLE R402.1.2 MAXIMUM ASSEMBLY U-FACTORS[a] AND FENESTRATION REQUIREMENTS

Portions of table not shown remain unchanged.

CLIMATE ZONE	FENESTRATION *U*-FACTOR[f]	SKYLIGHT *U*-FACTOR	GLAZED FENESTRATION SHGC[d, e]	CEILING *U*-FACTOR	WOOD FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
0	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
1	0.50	0.75	0.25	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.25	0.030 ~~0.026~~	0.084	0.165	0.064	0.360	0.477
3	0.30	0.55	0.25	0.030 ~~0.026~~	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.30	0.55	0.40	0.026 ~~0.024~~	0.060 ~~0.045~~	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.40	0.026 ~~0.024~~	0.060 ~~0.045~~	0.082	0.033	0.050	0.055
6	0.30	0.55	NR	0.026 ~~0.024~~	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	NR	0.026 ~~0.024~~	0.045	0.057	0.028	0.050	0.055

TABLE R402.1.3 INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

Portions of table not shown remain unchanged.

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
0	NR	0.75	0.25	30	13 or 0 & 10ci	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0 & 10ci	3/4	13	0	0	0
2	0.40	0.65	0.25	38 ~~49~~	13 or 0 & 10ci	4/6	13	0	0	0
3	.30	0.55	0.25	38 ~~49~~	20 or 13 & 10ci[h] or 0 & 15ci[h]	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	.30	0.55	0.40	49 ~~60~~	~~30 or~~ 20 ~~& 5ci~~[h] or 13 & 5 ~~10~~ci[h] or 0 & 15 ~~20~~ci[h]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
5 and Marine 4	0.30[j]	0.55	0.40	49 ~~60~~	~~30 or~~ 20 ~~& 5ci~~[h] or 13 & 5 ~~10~~ci[h] or 0 & 15 ~~20~~ci[h]	13/17	30	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 & 5ci
6	0.30[j]	0.55	NR	49 ~~60~~	30 or 20 & 5ci[h] or 13 & 10ci[h] or 0 & 20ci[h]	15/20	30	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 & 5ci
7 and 8	0.30[j]	0.55	NR	49 ~~60~~	30 or 20 & 5ci[h] or 13 & 10ci[h] or 0 & 20ci[h]	19/21	38	15ci or 19 or 13 & 5ci	10ci, 4 ft	15ci or 19 or 13 & 5ci

R408.2 Additional efficiency credits ~~package options~~. Two of the ~~A~~additional efficiency ~~package options for compliance with Section R401.2.1 are set forth in Sections R408.2.1 through R408.2.5.~~ measures shall be selected from Table R408.2 that meet or exceed the total of thirteen credits in climate zones 4 and 5 or the total of ten credits in other climate zones. Each measure selected shall meet the relevant subsections of Section R408 and receive credit as indicated in the Table for the specific Climate Zone. Interpolation of credits between measures shall not be permitted.