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Tony Evers, Governor
Dawn Crim, Secretary

VIRTUAL/TELECONFERENCE
COMMERCIAL BUILDING CODE COUNCIL
4822 Madison Yards Way, Virtual, Madison
Contact: Carl Hampton (608) 266-2112
July 12, 2021

The following agenda describes the issues that the Council plans to consider at the meeting. At the time of the meeting, items may be removed from the agenda. Please consult the meeting minutes for a record of the actions of the Council.

AGENDA

10:00 A.M.

OPEN SESSION – CALL TO ORDER – ROLL CALL

A. Adoption of Agenda (1-2)

B. Approval of Minutes from June 14, 2021 (3-4)

C. Reminders: Scheduling Concerns
1) Attendance Conflicts Impacting July 12, 2021 Meeting
2) Attendance Confirmation for August 9, 2021 Meeting

D. Administrative Matters – Discussion and Consideration
1) Department, Staff and Committee Updates

E. Administrative Rules Matters – Discussion and Consideration (5-29)
1) SPS Suggested Code Changes
   a. International Energy Conservation Code (IECC) & SPS 363 – Energy Conservation

F. Public Agenda Requests – Discussion and Consideration
1) Proposed Commercial Energy Code Amendments:
   a. Thermal Bridging **(30-32)**
   b. Horticultural Lighting Efficacy **(33-35)**
   c. Dedicated Outdoor Air Systems **(36-39)**
   d. Electric Vehicle (EV) Readiness **(40-44)**
   e. Renewable Energy **(45-46)**
2) Feedback Regarding IECC C404.5 **(47-48)**

G. Public Comments

ADJOURNMENT

NEXT MEETING: AUGUST 9, 2021

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MEETINGS AND HEARINGS ARE OPEN TO THE PUBLIC, AND MAY BE CANCELLED WITHOUT NOTICE.

Times listed for meeting items are approximate and depend on the length of discussion and voting. All meetings are held at 4822 Madison Yards Way, Madison, Wisconsin, unless otherwise noted. In order to confirm a meeting or to request a complete copy of the board's agenda, please call the listed contact person. The board may also consider materials or items filed after the transmission of this notice. Times listed for the commencement of disciplinary hearings may be changed by the examiner for the convenience of the parties. Requests for interpreters for the deaf or hard of hearing, or other accommodations, are considered upon request by contacting the Affirmative Action Officer, 608-266-2112, or the Meeting Staff at 608-266-5439.

VIRTUAL/TELECONFERENCE
COMMERCIAL BUILDING CODE COUNCIL
MEETING MINUTES
JUNE 14, 2021

PRESENT: Jennifer Emberson Acker, Michael Adamavich, Justin Gavin, Steven Harms, William Hebert, Steven Howard *(excused at 11:27 a.m.)*, Richard Paur, Irina Ragozin, Brian Rinke

EXCUSED: Kevin Bierce, Matthew Marciniak

STAFF: Carl Hampton, DPD Division Administrator; Jameson Whitney, Legal Counsel; Erik Hansen, Consultant, Building Systems-Senior; Thomas Westlund, Consultant, Building Systems-Senior; Garry Krause, Bureau Director, Safety and Buildings; Kimberly Wood, Program Assistant-Adv.; and other Department Staff

CALL TO ORDER

Richard Paur, Chairperson, called the meeting to order at 10:00 a.m. A quorum was confirmed with eight (8) members present.

ADOPTION OF AGENDA

MOTION: Steven Howard moved, seconded by Steven Harms, to adopt the Agenda as published. Motion carried unanimously.

APPROVAL OF MINUTES FROM MAY 10, 2021

MOTION: Irina Ragozin moved, seconded by Steven Howard, to approve the Minutes of May 10, 2021 as published. Motion carried unanimously.

REMARKS REGARDING THE INTERNATIONAL ENERGY CONSERVATION CODE (IECC)

APPEARANCE: DSPS Secretary Dawn Crim & Comments from Special Guest

MOTION: William Hebert moved, seconded by Michael Adamavich, to acknowledge and thank Secretary Dawn Crim and Lieutenant Governor Mandela Barnes for their appearance and comments to the Council. Motion carried unanimously.

ADMINISTRATIVE RULE MATTERS

SPS Suggested Code Changes

SPS 365 – Fuel Gas Appliances

MOTION: Steven Harms moved, seconded by Steven Howard, to recommend approval of SPS 365 Fuel Gas Appliances and related portions of SPS 361

and 362 and the IFGC (Wis. Admin. Codes §§ 362.3002(4), 361.45-361.485(2), 365.0001, 365.0100, 365.0101, 365.0202, 365.0300, 365.0301, 365.0303, 365.0304, 365.0400, 365.0501, 365.0502, 365.0621, 365.0630, 365.0631, 365.0632, 365.0800, 365.0900, and the recommended language in item 121 IFGC 502.1) as outlined in the 6/14/2021 agenda materials with appropriate notes. Motion carried unanimously.

SPS 366 – Existing Buildings

MOTION: Steven Harms moved, seconded by Brian Rinke, to recommend approval of SPS 366 Existing Buildings and related portions of the IEBC (sections 366.0600, 366.0603, 366.0605, 366.0606 (highlighted edits), 366.0609, 366.0701 (highlighted edits), 366.0702 (highlighted edits), 366.0803, 366.1001, 366.1010, 366.1011, 366.1012, 366.1102, IEBC Chapters 1, 5, 6, 7, 10, 11, 12, 15, and Appendix D, and the language in item 100 referencing IECC C503.2) as outlined in the 6/14/2021 agenda materials with appropriate notes. Motion carried unanimously.

SPS 363 – Energy Conservation

MOTION: Irina Ragozin moved, seconded by Steven Howard, to recommend approval of SPS 363 Energy Conservation (sections 363.0202, 363.0303, and IECC Chapters 2 and 3) as outlined in the 6/14/2021 agenda materials with appropriate notes. Motion carried unanimously.

MOTION: Brian Rinke moved, seconded by William Hebert, to table discussion of SPS 363.0302 until a future meeting. Motion carried unanimously.

(Steven Howard was excused at 11:27 a.m.)

ADJOURNMENT

MOTION: Brian Rinke moved, seconded by Irina Ragozin, to adjourn the meeting. Motion carried unanimously.

The meeting adjourned at 12:02 p.m.

State of Wisconsin
Department of Safety & Professional Services

AGENDA REQUEST FORM

1) Name and title of person submitting the request:	2) Date when request submitted:
Erik Hansen, Consultant Building Systems on behalf of Justin Gavin, Section Chief Commercial Buildings	6/28/2021 Items will be considered late if submitted after 12:00 p.m. on the deadline date which is 8 business days before the meeting

3) Name of Board, Committee, Council, Sections:

Commercial Building Code Council

4) Meeting Date:	5) Attachments:	6) How should the item be titled on the agenda page?
7/12/2021	☒ Yes ☐ No	**Recommendations and Proposed Changes to IECC and SPS 363**

7) Place Item in:	8) Is an appearance before the Board being scheduled? *(If yes, please complete Appearance Request for Non-DSPS Staff)*	9) Name of Case Advisor(s), if required:
☒ Open Session ☐ Closed Session	☐ Yes ☐ No	

10) Describe the issue and action that should be addressed:

Proposed changes to the 2021 International Energy Conservation Code and associated Wisconsin Amendments. See attached spread sheet and additional supporting documentation listed as Attachments 1-7.

Submitted for acceptance by the Council.

11) Authorization

Signature of person making this request **Date**

Justin Gavin

Supervisor (if required) **Date**

Executive Director signature (indicates approval to add post agenda deadline item to agenda) **Date**

Directions for including supporting documents:
1. This form should be attached to any documents submitted to the agenda.
2. Post Agenda Deadline items must be authorized by a Supervisor and the Policy Development Executive Director.
3. If necessary, provide original documents needing Board Chairperson signature to the Bureau Assistant prior to the start of a meeting.

DRAFT – SUBJECT TO CHANGE

Recommendations and Proposed Changes to IECC and SPS 363

Final Draft for Code Committee Meeting

July 12, 2021

2021 INTERNATIONAL ENERGY CONSERVATION CODE – IECC (SPS 363)						
COMMERCIAL PROVISIONS						
NO.	**IECC/SPS** (COMMERCIAL)	**ISSUE/REASON FOR CHANGE**	**PROPOSED BY**	**EXISTING LANGUAGE/PROPOSED CHANGE**	**POTENTIAL IMPACT/COST**	**COMMENTS/STATUS**
	GENERAL	CLARIFICATIONS CORRECTIONS	DIS	ICC SUMMARIZES MANY OF THE CHANGES TO THE 2021 EDITION AS "REARRANGING FOR CLARITY AND EASIER READING". THE REQUIREMENTS HAVE NOT CHANGED BUT THE LOCATION WITHIN THE CODE HAS. CORRECT USE OF "EXCEPTION", "CONDITION" AND "ITEM" IN AMENDMENT LANGUAGE AS APPROPRIATE. CORRECT CODE SECTION REFERENCES AS APPLICABLE TO 2021 EDITION VERIFY/CORRECT OTHER TESTING AGENCIES, REFERENCED CODES AND CODE SECTIONS AS APPLICABLE. MINOR CHANGES TO CODE LANGUAGE THAT DOES NOT SIGNIFICANTLY IMPACT STAKEHOLDERS, ADD SIGNIFICANT COST TO PROJECTS PHYSICALLY OR PROCEDURALLY OR IMPACT DEPARTMENT REQUIREMENTS OR PROCESSES ARE DEEMED ACCEPTABLE.	N/A	**ERIK**
	CHAPTER 1	UPDATE	DIS	**SCOPE AND ADMINISTRATION** CONTINUE WITH AMENDED APPROACH UPDATED TO 2021 EDITION.	N/A	**JUSTIN**
	363.0101	UPDATE	DIS	**363.0101 – ADMINISTRATION AND ENFORCEMENT:** RETAIN AMENDMENT AS WRITTEN AND EDIT TO REFLECT 2021 EDITION	N/A	**JUSTIN**
	CHAPTER 2	CLARIFICATIONS	DIS	ADDED DEFINITIONS FOR CLARITY AND CONSISTENCY WITH OTHER ICC CODES - RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING)	N/A	**ERIK**
	363.0202	N/A	DIS	**SPS 363.0202 – GENERAL DEFINITIONS:** TO REMAIN UNCHANGED (ACCEPTED BY COUNCIL AT JUNE 16 MEETING)	N/A	**ERIK**

	CHAPTER 3	REVISED	DIS	**FIGURE C301.1/TABLE C301.1** - **CLIMATE ZONES**: REVISED AND EXPANDED TO INCLUDE MORE ACCURATE TEMPERATURES USED FOR BUILDING ENVELOPE. ZONE MAP SHIFTED LINE OF DEMARCATION SLIGHTLY TO THE SOUTH AND CHANGED ZONES TO SLIGHTLY WARMER– RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	POTENTIAL TO SAVE CONSTRUCTION/ EQUIPMENT COST	**ERIK**
		ADDITIONAL REQUIREMENT		**C303.1.2** – **INSULATION MARK INSTALLATION:** ADDED REQUIREMENT FOR INSULATION CERTIFICATE TO BE PRESENT ON SITE AT TIME OF THE INSTALLATION OF MATERIALS WITHOUT AN OBSERVABLE MANUFACTURERS LABEL FOR USE BY INSPECTIONS – RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	PROCEDURAL CHANGE	**ERIK**
		CLARIFICATION		**C301.3** - **CLIMATE ZONE DEFINITIONS**: SECTION ADDED FOR CLIMATE ZONES NOT LISTED – RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	NONE	**ERIK**
		CLARIFICATION		**TABLE C303.1.3(2)** – **DEFAULT OPAQUE DOOR U-FACTORS:** ADDED CATEGORY FOR INSULATED ROLL UP METAL DOOR (U.90) – RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	ALIGN WITH AVAILABLE PRODUCT	**ERIK**
		CLARIFICATION		**C303.2.2 – MULTIPLE LAYERS OF CONTINUOUS INSULATION BOARD:** ADDED SECTION C303.2.2 WHICH ADDS SPECIFIC REQUIREMENTS FOR THE INSTALLATION OF MULTIPLE LAYERS OF CONTINUOUS INSULATION BOARD – RECOMMEND ACCEPTING (ACCEPTED BY COUINCIL AT JUNE 16 MEETING).	NONE	**ERIK**

	363.0302	UPDATE	DIS	**TABLE SPS 363.0302 – EXTERIOR DESIGN CONDITIONS:** TO REMAIN AS STATED BUT ADD "OR CURRENT ASHRAE VALUES. THIS IS DIFFERENT CRITERIA THAT IS UNAFFECTED BY THE CHANGES TO THE CLIMATE ZONE MAP. PROVIDES OPTION FOR DESIGN IF NOT USING ASHRAE FUNDAMENTALS (TABLED AT JUNE 16 MEETING PENDING FURTHER REVIEW BY DSPS STAFF).	NONE	**ERIK** (REVISIT)
	363.0303	UPDATE	DIS	**SPS 363.0303(1) AND (2) – MATERIAL, SYSTEMS AND EQUIPMENT:** ASHRAE REFERENCE TO BE REVISED TO REFLECT 2021 IECC. TESTING AGENCY REFERENCE NUMBERS TO BE VERIFIED FOR ACCURACY. PROVIDES DETAILED INFORMATION THAT IS REQUIRED IF NOT USING ASHRAE FUNDAMENTALS. (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	POTENTIAL TO SAVE DESIGN COST	**ERIK**

	CHAPTER 4	REVISED	DIS	**C401.2 – APPLICATION:** CONDENSED AND CLARIFIED TO READ BETTER, SPECIFIC LABELING AND BETTER DEFINITION OF REQUIREMENTS FOR THE 3 METHODS OF COMPLIANCE. THERMAL ENVELOPE CERTIFICATE REQUIREMENT ADDED, REPLACEMENT FENESTRATION MOVED TO CHAPTER 5 – EXISTING BUILDINGS.	NONE	**ERIK**
				C406.10 – ENERGY MONITORING: RECOMMEND AMMENDMENT THAT DELETES THIS REQUIREMENT.	NUMEROUS	**ERIK**
	363.0401	RETAIN	DIS	**SPS 363.0401 – GENERAL APPLICATION:** TO REMAIN AS STATED, EDIT TO REFLECT CHANGES TO 2021 EDITION AND SPECIFIC SECTION REFERENCES THAT HAVE CHANGED AS A RESULT. NOTE THAT C406 IS INTENTIONALLY OMITTED.	NUMEROUS	**ERIK**
	363.0402	DELETE	DIS	**SPS 363.0402 – BUILDING ENVELOPE REQUIREMENTS:** REMOVE CURRENT AMENDMENT WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES. **C402.5.1.5 –** AMMEND TO NOT REQUIRE ITEM 3.	POTENTIAL TO SAVE CONSTRUCTION/ EQUIPMENT/ DESIGN COSTS	**ERIK**
	363.0403	REVISE	DIS	**SPS 363.0403 – BUILDING MECHANICAL SYSTEMS:** CORRECT CODE REFERENCES TO 2021 EDITION, ADD "OR CURRENT ASHRAE VALUES" TO **(1)** - CALCULATION OF HEATING AND COOLING LOADS AND **(2)** – EQUIPMENT AND SYSTEM SIZING. THIS WILL ALLOW FOR VARIED PROJECT SIZES AND COMPLEXITIES AS WELL AS DESIGNER AFFILIATION PREFERENCE. REVISE **(3)** CHANGE 54,000 BTUH TO 60,000 BTUH TO ALLOW SMALL PROJECTS WITH RELATIVELY SMALL EQUIPMENT SIZES/COOLING LOADS AND SIMPLE CONTROLS TO EXCLUDE AN ECONOMIZER AND TO ALLOW FOR MULTIPLE SMALL FURNACE SYSTEMS WITH PROPERLY DESIGNED ZONES AND LIMITED INCIDENTAL SHARING OF ATMOSHERES. RETAIN EXCEPTIONS 1-7. DELETE **(4).** RETAIN **(5).** DELETE **(6)** THE CURRENT AMMENDMENT EXEMPTS REQUIREMENTS THAT APPLY TO VERY LARGE ZONES WITH NONSIMULTANEOUS OCCUPANCY. RETAIN **(7)(A), (B) AND (C)** RENUMBER TO (6). DELETE **(8)** WHICH RESULTS FROM CHANGE TO 2021 OPAQUE ASSEMBLIES. DELETE **(9)** DUE TO REQUIREING COMMISSIONING. RETAIN **(10)** AND **(11).** RENUMBER SECTIONS, UPDATE REFERENCES. **C403.2.3/C406.11 – FDD:** AMMEND TO INCLUDE ITEMS 1, 5 AND 6 ONLY.	NONE	**ERIK**

	363.0404	UPDATE	DIS	**SPS 363.0404 – SERVICE WATER HEATING:** AMMENDMENT TO REMAIN AS WRITTEN, UPDATE CODE SECTION REFERENCES. (REQUEST TO TABLE).	NONE	**ERIK**
	363.0405	UPDATE	DIS	**SPS 363.0405 – LIGHTING SYSTEMS:** AMMENDMENT TO REMAIN AS WRITTEN, UPDATE CODE SECTION REFERENCES. CHANGES TO THE WAY WE REVIEW AND ASSESS LIGHTING DESIGN NOT RECOMMENDED UNTIL THE DEPARTMENT CONDUCTS LIGHTING REVIEWS.	NONE	**ERIK**
	363.0406	UPDATE	DIS	**SPS 363.0406 – REQUIREMENTS FOR ADDITIONAL EFFICIENCY PACKAGE OPTIONS:** AMMENDMENT TO REMAIN AS WRITTEN, UPDATE CODE SECTION REFERENCES. ADDITIONAL EFFICIENCIES OR USE OF CREDIT SYSTEM NOT PRACTICAL UNLESS ELECTRICAL AND LIGHTING REVIEW ARE REQUIRED/PERFORMED.	NONE	**ERIK**
	363.0407	UPDATE	DIS	**SPS 363.0407 – TOTAL BUILDING PERFORMANCE:** AMMENDMENT TO REMAIN AS WRITTEN, UPDATE CODE SECTION REFERENCES.	NONE	**ERIK**
	363.0408	UPDATE	DIS	**SPS 363.0408 – SYSTEM COMMISSIONING:** DELETE AMENDMENT. COMMISSIONING AS DESCRIBED IN 2021 IECC TO BE REQUIRED.		**ERIK**
	CHAPTER 5		DIS	**C0500 –** GENERAL EDITING AND REORGANIZATION OF SECTIONS.		**ERIK**
	363.0502	UPDATE	DIS	**SPS 363.0502 – ADDITIONS:** REMOVE CURRENT AMENDMENT WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES.	POTENTIAL TO INCRESE CONSTRUCTION/ EQUIPMENT COST	**ERIK**
	363.0503	UPDATE	DIS	**SPS 363.0503 – ALTERATIONS:** REMOVE CURRENT AMENDMENT ITEMS **(1-6)** WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES.	POTENTIAL TO INCREASE CONSTRUCTION/ EQUIPMENT COST	
	363.0600	UPDATE	DIS	**SPS 363.0600 – REFERENCED STANDARDS:** AMENDMENT TO REMAIN AS WRITTEN. UPDATE CODE SECTION REFERENCES. VERIFY TEST REFERENCES.	NONE	**ERIK**

RESIDENTIAL PROVISIONS						
NO.	**IECC/SPS** (RESIDENTIAL)	**ISSUE/REASON FOR CHANGE**	**PROPOSED BY**	**EXISTING LANGUAGE/PROPOSED CHANGE**	**POTENTIAL IMPACT/COST**	**COMMENTS/STATUS**

	CHAPTER 1	UPDATE	DIS	**SCOPE AND ADMINISTRATION** CONTINUE WITH AMENDED APPROACH UPDATED TO 2021 EDITION.	NONE	**ERIK**
	363.5101	UPDATE	DIS	**363.5101 – SCOPE AND ADMINISTRATION:** RETAIN AMENDMENT AS WRITTEN AND EDIT TO REFLECT 2021 EDITION.	NONE	**ERIK**

	CHAPTER 2	CLARIFICATION		**R202 – DEFINITIONS: "**ACCESSIBLE" TO "READY ACCESS TO".	MINIMAL	**ERIK**
	363.5202	UPDATE	DIS	**363.5202 – SUBSTITUTIONS:** RETAIN AMMENDMENT AS WRITTEN.	NONE	**ERIK**
	CHAPTER 3	UPDATE		**R301 – CLIMATE ZONES:** SEE C301.1 (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	NONE	**ERIK**
	363.5302	CHANGE	DIS	**363.5302 – EXTERIOR DESIGN CONDITIONS:** TO REMAIN AS STATED BUT ADD "OR CURRENT ASHRAE VALUES". THIS IS DIFFERENT CRITERIA THAT IS UNAFFECTED BY THE CHANGES TO THE CLIMATE ZONE MAP. PROVIDES OPTION FOR DESIGN IF NOT USING ASHRAE FUNDAMENTALS. SEE 363.0302. (TABLED AT JUNE 16 MEETING PENDING FURTHER REVIEW BY DSPS STAFF).	NONE	**ERIK** (REVISIT)
	363.5303	UPDATE	DIS	**363.5303 - MATERIAL, SYSTEMS AND EQUIPMENT:** RETAIN AMMENDMENT AS WRITTEN. ASHRAE REFERENCE TO BE REVISED TO REFLECT 2021 IECC. TESTING AGENCY REFERENCE NUMBERS TO BE VERIFIED FOR ACCURACY. PROVIDES DETAILED INFORMATION THAT IS REQUIRED IF NOT USING ASHRAE FUNDAMENTALS. ACCEPTED BY COUNCIL AT JUNE 16 MEETING). **R303.1.2** – **INSULATION MARK INSTALLATION:** ADDED REQUIREMENT FOR INSULATION CERTIFICATE TO BE PRESENT ON SITE AT TIME OF THE INSTALLATION OF MATERIALS WITHOUT AN OBSERVABLE MANUFACTURERS LABEL FOR USE BY INSPECTIONS – RECOMMEND ACCEPTING (ACCEPTED BY COUNCIL AT JUNE 16 MEETING).	NONE	**ERIK**
	CHAPTER 4	REORGANIZE	DIS	**RESIDENTIAL ENERGY EFFICIENCY**	MINIMAL	**ERIK**
	363.5401	UPDATE	DIS	**363.5401 – CERTIFICATE:** AMMENDMENT TO REMAIN AS WRITTEN. UPDATE SECTIONS.	NONE	**ERIK**
	363.5402	UPDATE	DIS	**363.5402 – BUILDING ENVELOPE REQUIREMENTS:** REMOVE CURRENT AMENDMENT WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES.	POTENTIAL TO INCREASE CONSTRUCTION/ EQUIPMENT COST	**ERIK**
	363.5403	UPDATE	DIS	**363.5403 – SYSTEMS:** RETAIN AMMENDMENT AS WRITTEN. UPDATE REFERENCED CODE SECTIONS TO 2021.	NONE	**ERIK**

	363.5404 363.5405	UPDATE UPDATE	DIS DIS	**363.5404 – LIGHTING EQUIPMENT:** RETAIN AMMENDMENT AS WRITTEN. UPDATE REFERENCED CODE SECTIONS TO 2021. **363.5405 – CALCULATION SOFTWARE TOOLS:** RETAIN AMMENDMENT AS WRITTEN. UPDATE REFERENCED CODE SECTIONS TO 2021.	NONE NONE	**ERIK** **ERIK**
	CHAPTER 5 363.5502 363.5503	REORGANIZE UPDATE UPDATE	DIS DIS DIS	**EXISTING BUILDINGS** **363.5502 – ADDITIONS:** REMOVE CURRENT AMENDMENT WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES. **363.5503 – ALTERATIONS:** REMOVE CURRENT AMENDMENT WHICH WILL RUSULT IN REQUIRING COMPLIANCE WITH THE 2021 IECC OPAQUE ASSEMBLY REQUIREMENTS IN TABLES 2021 IECC C402.1.3 AND C402.1.4. SEE ATTACHMENTS 4, 5 AND 6 FOR SPECIFICS OF CHANGES.	POTENTIAL TO INCREASE CONSTRUCTION/ EQUIPMENT COST	**ERIK** **ERIK** **ERIK**
	CHAPTER 6 363.5600	N/A UPDATE	DIS DIS	**REFERENCED STANDARDS** **363.5600 – REFERENCED STANDARDS:** RETAIN AMMENDMENT AS WRITTEN. UPDATE REFERENCED CODE SECTIONS TO 2021.	NONE NONE	**ERIK** **ERIK**

ATTACHMENT 1
1 page

TABLE 301.1—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

4C Kitsap
5B Kittitas
5B Klickitat
4C Lewis
5B Lincoln
4C Mason
6B Okanogan
4C Pacific
6B Pend Oreille
4C Pierce
4C San Juan
4C Skagit
5B Skamania
4C Snohomish
5B Spokane
6B Stevens
4C Thurston
4C Wahkiakum
5B Walla Walla
4C Whatcom
5B Whitman
5B Yakima

WEST VIRGINIA

5A Barbour
4A Berkeley
4A Boone
4A Braxton
5A Brooke
4A Cabell
4A Calhoun
4A Clay
5A Doddridge
5A Fayette
4A Gilmer
5A Grant
5A Greenbrier
5A Hampshire
5A Hancock
5A Hardy
5A Harrison
4A Jackson
4A Jefferson
4A Kanawha
5A Lewis
4A Lincoln
4A Logan
5A Marion
5A Marshall
4A Mason
4A McDowell
4A Mercer
5A Mineral
4A Mingo
5A Monongalia
4A Monroe
4A Morgan
5A Nicholas
5A Ohio
5A Pendleton
4A Pleasants
5A Pocahontas
5A Preston
4A Putnam
5A Raleigh
5A Randolph
4A Ritchie
4A Roane
5A Summers
5A Taylor
5A Tucker
4A Tyler
5A Upshur
4A Wayne
5A Webster
5A Wetzel
4A Wirt
4A Wood
4A Wyoming

WISCONSIN

6A Adams
7 Ashland
6A Barron
7 Bayfield
6A Brown
6A Buffalo
7 Burnett
6A Calumet
6A Chippewa
6A Clark
6A Columbia
6A Crawford
6A Dane
6A Dodge
6A Door
7 Douglas
6A Dunn
6A Eau Claire
7 Florence
6A Fond du Lac
7 Forest
6A Grant
6A Green
6A Green Lake
6A Iowa
7 Iron
6A Jackson
6A Jefferson
6A Juneau
6A Kenosha
6A Kewaunee
6A La Crosse
6A Lafayette
7 Langlade
7 Lincoln
6A Manitowoc
6A Marathon
6A Marinette
6A Marquette
6A Menominee
6A Milwaukee
6A Monroe
6A Oconto
7 Oneida
6A Outagamie
6A Ozaukee
6A Pepin
6A Pierce
6A Polk
6A Portage
7 Price
6A Racine
6A Richland
6A Rock
6A Rusk
6A Sauk
7 Sawyer
6A Shawano
6A Sheboygan
6A St. Croix
7 Taylor
6A Trempealeau
6A Vernon
7 Vilas
6A Walworth
7 Washburn
6A Washington
6A Waukesha
6A Waupaca
6A Waushara
6A Winnebago
6A Wood

WYOMING

6B Albany
6B Big Horn
6B Campbell
6B Carbon
6B Converse
6B Crook
6B Fremont
5B Goshen
6B Hot Springs
6B Johnson
6B Laramie
7 Lincoln
6B Natrona
6B Niobrara
6B Park
5B Platte
6B Sheridan
7 Sublette
6B Sweetwater
7 Teton
6B Uinta
6B Washakie
6B Weston

US TERRITORIES

AMERICAN SAMOA

1A (all)*

GUAM

1A (all)*

NORTHERN MARIANA ISLANDS

1A (all)*

PUERTO RICO

1A (all)*

VIRGIN ISLANDS

1A (all)*

TABLE C301.1—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

3A San Saba*
3B Schleicher
3B Scurry
3B Shackelford
3A Shelby*
4B Sherman
3A Smith*
3A Somervell*
2A Starr*
3A Stephens
3B Sterling
3B Stonewall
3B Sutton
4B Swisher
3A Tarrant*
3B Taylor
3B Terrell
3B Terry
3B Throckmorton
3A Titus*
3B Tom Green
2A Travis*
2A Trinity*
2A Tyler*
3A Upshur*
3B Upton
2B Uvalde
2B Val Verde
3A Van Zandt*
2A Victoria*
2A Walker*
2A Waller*
3B Ward
2A Washington*
2B Webb
2A Wharton*
3B Wheeler
3A Wichita
3B Wilbarger
2A Willacy*
2A Williamson*
2A Wilson*
3B Winkler
3A Wise
3A Wood*
4B Yoakum
3A Young
2B Zapata
2B Zavala

UTAH

5B Beaver
6B Box Elder
6B Cache
6B Carbon
6B Daggett
5B Davis
6B Duchesne
5B Emery
5B Garfield
5B Grand
5B Iron
5B Juab
5B Kane
5B Millard
6B Morgan
5B Piute
6B Rich
5B Salt Lake
5B San Juan
5B Sanpete
5B Sevier
6B Summit
5B Tooele
6B Uintah
5B Utah
6B Wasatch
3B Washington
5B Wayne
5B Weber

VERMONT

6A (all)

VIRGINIA

4A (all)

WASHINGTON

5B Adams
5B Asotin
5B Benton
5B Chelan
4C Clallam
4C Clark
5B Columbia
4C Cowlitz
5B Douglas
6B Ferry
5B Franklin
5B Garfield
5B Grant
4C Grays Harbor
4C Island
4C Jefferson
4C King
4C Kitsap
5B Kittitas
5B Klickitat
4C Lewis
5B Lincoln
4C Mason
6B Okanogan
4C Pacific
6B Pend Oreille
4C Pierce
4C San Juan
4C Skagit
5B Skamania
4C Snohomish
5B Spokane
6B Stevens
4C Thurston
4C Wahkiakum
5B Walla Walla
4C Whatcom
5B Whitman
5B Yakima

WEST VIRGINIA

5A Barbour
4A Berkeley
4A Boone
4A Braxton
5A Brooke
4A Cabell
4A Calhoun
4A Clay
5A Doddridge
5A Fayette
4A Gilmer
5A Grant
5A Greenbrier
5A Hampshire
5A Hancock
5A Hardy
5A Harrison
4A Jackson
4A Jefferson
4A Kanawha
5A Lewis
4A Lincoln
4A Logan
5A Marion
5A Marshall
4A Mason
4A McDowell
4A Mercer
5A Mineral
4A Mingo
5A Monongalia
4A Monroe
4A Morgan
5A Nicholas
5A Ohio
5A Pendleton
4A Pleasants
5A Pocahontas
5A Preston
4A Putnam
5A Raleigh
5A Randolph
4A Ritchie
4A Roane
5A Summers
5A Taylor
5A Tucker
4A Tyler
5A Upshur
4A Wayne
5A Webster
5A Wetzel
4A Wirt
4A Wood
4A Wyoming

WISCONSIN

6A Adams
7 Ashland
6A Barron
7 Bayfield
6A Brown
6A Buffalo
7 Burnett
6A Calumet
6A Chippewa
6A Clark
6A Columbia
6A Crawford
6A Dane
6A Dodge
6A Door
7 Douglas
6A Dunn
6A Eau Claire
7 Florence
6A Fond du Lac
7 Forest
6A Grant
6A Green
6A Green Lake
6A Iowa
7 Iron
6A Jackson
6A Jefferson
6A Juneau
6A Kenosha
6A Kewaunee
6A La Crosse
6A Lafayette
7 Langlade
7 Lincoln
6A Manitowoc
6A Marathon
6A Marinette
6A Marquette
6A Menominee
6A Milwaukee
6A Monroe
6A Oconto
7 Oneida
6A Outagamie

(continued)

TABLE C301.1—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

6A Ozaukee
6A Pepin
6A Pierce
6A Polk
6A Portage
7 Price
6A Racine
6A Richland
6A Rock
6A Rusk
6A Sauk
7 Sawyer
6A Shawano
6A Sheboygan
6A St. Croix
7 Taylor
6A Trempealeau
6A Vernon
7 Vilas
6A Walworth
7 Washburn
6A Washington
6A Waukesha
6A Waupaca
6A Waushara
6A Winnebago
6A Wood

WYOMING

6B Albany
6B Big Horn
6B Campbell
6B Carbon
6B Converse
6B Crook
6B Fremont
5B Goshen
6B Hot Springs
6B Johnson
6B Laramie
7 Lincoln
6B Natrona
6B Niobrara
6B Park
5B Platte
6B Sheridan
7 Sublette
6B Sweetwater
7 Teton
6B Uinta
6B Washakie
6B Weston

US TERRITORIES

AMERICAN SAMOA

1A (all)*

GUAM

1A (all)*

NORTHERN MARIANA ISLANDS

1A (all)*

PUERTO RICO

1A (all)*

VIRGIN ISLANDS

1A (all)*

TABLE C301.3(1)
INTERNATIONAL CLIMATE ZONE DEFINITIONS

MAJOR CLIMATE TYPE DEFINITIONS
Marine (C) Definition—Locations meeting all four criteria: 1. Mean temperature of coldest month between -3°C (27°F) and 18°C (65°F). 2. Warmest month mean < 22°C (72°F). 3. At least four months with mean temperatures over 10°C (50°F). 4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.
Dry (B) Definition—Locations meeting the following criteria: Not marine and $P_{in} < 0.44 \times (TF - 19.5)$ [$P_{cm} < 2.0 \times (TC + 7)$ in SI units] where: P_{in} = Annual precipitation in inches (cm) T = Annual mean temperature in °F (°C)
Moist (A) Definition—Locations that are not marine and not dry.
Warm-humid Definition—Moist (A) locations where either of the following wet-bulb temperature conditions shall occur during the warmest six consecutive months of the year: 1. 67°F (19.4°C) or higher for 3,000 or more hours; or 2. 73°F (22.8°C) or higher for 1,500 or more hours.

For SI: °C = [(°F)-32]/1.8, 1 inch = 2.54 cm.

2- 2/2

Attachment 3
2 pages

TABLE C301.1—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY[a]

US STATES—continued
WEST VIRGINIA *(continued)*
4A Jefferson
4A Kanawha
4A Lewis
4A Lincoln
4A Logan
5A Marion
5A Marshall
4A Mason
4A McDowell
4A Mercer
5A Mineral
4A Mingo
5A Monongalia
4A Monroe
4A Morgan
4A Nicholas
5A Ohio
5A Pendleton
4A Pleasants
5A Pocahontas
5A Preston
4A Putnam
4A Raleigh
5A Randolph
4A Ritchie
4A Roane
4A Summers
5A Taylor
5A Tucker
4A Tyler
4A Upshur
4A Wayne
4A Webster
5A Wetzel
4A Wirt
4A Wood
4A Wyoming
(2009) WISCONSIN
6A 5A Adams
7 6A Ashland
6A Barron
7 6A Bayfield
6A Brown
6A Buffalo
7 6A Burnett
6A 5A Calumet
6A Chippewa
6A Clark
6A 5A Columbia
6A 5A Crawford
6A 5A Dane
6A 5A Dodge
6A Door
7 6A Douglas
6A Dunn
6A Eau Claire
7 6A Florence
6A 5A Fond du Lac
7 6A Forest
6A 5A Grant
6A 5A Green
6A 5A Green Lake
6A 5A Iowa
7 6A Iron
6A Jackson
6A 5A Jefferson
6A 5A Juneau
6A 5A Kenosha
6A Kewaunee
6A 5A La Crosse
6A 5A Lafayette
7 6A Langlade
7 6A Lincoln
6A Manitowoc
6A Marathon
6A Marinette
6A Marquette
6A Menominee
6A 5A Milwaukee
6A 5A Monroe
6A Oconto
7 6A Oneida
5A Outagamie
6A 5A Ozaukee
6A Pepin
6A Pierce
6A Polk
6A Portage

(continued)

TABLE C301.1—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY[a]

US STATES—continued
WISCONSIN *(continued)*
6A Price
5A Racine
5A Richland
5A Rock
6A Rusk
5A Sauk
6A Sawyer
6A Shawano
6A Sheboygan
6A St. Croix
6A Taylor
6A Trempealeau
5A Vernon
6AVilas
5A Walworth
6A Washburn
5A Washington
5A Waukesha
6A Waupaca
5A Waushara
5A Winnebago
6A Wood
WYOMING
6B Albany
6B Big Horn
6B Campbell
6B Carbon
6B Converse
6B Crook
6B Fremont
5B Goshen
6B Hot Springs
6B Johnson
5B Laramie
7 Lincoln
6B Natrona
6B Niobrara
6B Park
5B Platte
6B Sheridan
7 Sublette
6B Sweetwater
7 Teton
6B Uinta
6B Washakie
6B Weston
US TERRITORIES
AMERICAN SAMOA
1A (all)*
GUAM
1A (all)*
NORTHERN MARIANA ISLANDS
1A (all)*
PUERTO RICO
1A (all except as follows:)*
2B Barraquitas
2B Cayey
VIRGIN ISLANDS
1A (all)*

a. Key: A – Moist, B – Dry, C – Marine. Absence of moisture designation indicates moisture regime is irrelevant. Asterisk (*) indicates a Warm Humid location.

TABLE 502.2(1)
BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above deck	R-15ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci
Metal buildings (with R-5 thermal blocks[a, b])	R-19	R-19	R-13 + R-13	R-13 + R-13	R-13 + R-13	R-19	R-13 + R-13	R-19	R-13 + R-13	R-19	R-13 + R-19	R-19	R-13 + R-19	R-19 + R-10	R-11 + R-19	R-19 + R-10
Attic and other	R-30	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R- 38	R-38	R-38	R-38	R-38	R-38	R-49	R-49
Walls, Above Grade																
Mass	NR	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3 ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building[b]	R-16	R-16	R-16	R-16	R-19	R-19	R-19	R-19	R-13 + R-5.6ci	R-13 + R-5.6ci	R-13 + R-5.6ci	R-13 + R-5.6ci	R-19 + R-5.6ci	R-19 + R-5.6ci	R-19 + R-5.6ci	R-19 + R-5.6ci
Metal framed	R-13	R-13	R-13	R-13+ 7.5ci	R-13 + R-3.8ci	R-13 + R-7.5ci	R-13 + R-7.5	R-13 + R-7.5ci	R-13 + R-7.5 ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5 ci	R-13 + R-18.8ci
Wood framed and other	R-13	R-13	R-13	R-13	R-13	R-13	R-13	R-13+ R-3.8ci	R-13 + R-3.8ci	R-13 + R-3.8ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13+ R-7.5ci	R-13 +7.5ci	R-13 + R-15.6ci	R-13 + 15.6ci
Walls, Below Grade																
Below grade wall[d]	NR	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-7.5ci	R-12.5ci
Floors																
Mass	NR	NR	R-6.3ci	R-8.3ci	R-6.3ci	R-8.3ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-14.6ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/Framing (steel/wood)	NR	NR	R-19	R-30	R-19	R-30	R-30	R-30	R-30	R-30	R-30	R-30[e]	R-30	R-30[e]	R-30[e]	R-30[e]
Slab-on-Grade Floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	NR	R-10 for 24 in. below	NR	R-10 for 24 in. below	R-10 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-20 for 24 in. below
Heated slabs	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-10 for 24 in. below	R-10 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-20 for 48 in. below	R-20 for 24 in. below	R-20 for 48 in. below	R-20 for 48 in. below	R-20 for 48 in. below
Opaque doors																
Swinging	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50
Roll-up or sliding	U-1.45	U-1.45	U-1.45	U-1.45	U-1.45	U-1.45	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50

For SI: 1 inch = 25.4 mm.

ci = Continuous insulation. NR = No requirement.

a. When using *R*-value compliance method, a thermal spacer block is required, otherwise use the *U*-factor compliance method. [see Tables 502.1.2 and 502.2(2)].

b. Assembly descriptions can be found in Table 502.2(2).

c. R-5.7 ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in./hr · ft² · °F.

d. When heated slabs are placed below grade, below-grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.

e. Steel floor joist systems shall to be R-38.

TABLE 502.1.2
BUILDING ENVELOPE REQUIREMENTS OPAQUE ELEMENT, MAXIMUM *U*-FACTORS

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6 A		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above deck	U-0.063	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039
Metal buildings	U-0.065	U-0.065	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.049	U-0.035	U-0.035
Attic and other	U-0.034	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027
Walls, Above Grade																
Mass	U-0.58	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.071	U-0.052
Metal building	U-0.093	U-0.093	U-0.093	U-0.093	U-0.084	U-0.084	U-0.084	U-0.084	U-0.069	U-0.069	U-0.069	U-0.069	U-0.057	U-0.057	U-0.057	U-0.057
Metal framed	U-0.124	U-0.124	U-0.124	U-0.064	U-0.084	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.064	U-0.037
Wood framed and other	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, Below Grade																
Below-grade wall[a]	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.119	C-0.075
Floors																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.107	U-0.087	U-0.087	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.064	U-0.051	U-0.057	U-0.051
Joist/Framing	U-0.282	U-0.282	U-0.052	U-0.052	—	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-Grade Floors																
Unheated slabs	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.540	F-0.730	F-0.540	F-0.540	F-0.520	F-0.520	F-0.520	F-0.520	F-0.510
Heated slabs	F-1.020	F-1.020	F-1.020	F-1.020	F-0.900	F-0.900	—	F-0.860	F-0.860	F-0.860	F-0.860	F-0.688	F-0.830	F-0.688	F-0.688	F-0.688

a. When heated slabs are placed below-grade, below grade walls must meet the *F*-factor requirements for perimeter insulation according to the heated slab-on-grade construction.

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[a, b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, above grade																
Mass	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R13 + R-15.6ci or R-20 + R-10ci	R13 + R-15.6ci or R-20 + R-10ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																
Mass[e]	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30[f]	R-30[f]	R-30[f]	R-30[f]	R-30[f]
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-20 for 24″ below
Heated slabs[f]	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 36″ below	R-15 for 36″ below	R-15 for 36″ below	R-20 for 48″ below	R-20 for 24″ below	R-20 for 48″ below	R-20 for 48″ below	R-20 for 48″ below
Opaque doors																
Nonswinging	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No requirement, LS = Liner system.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. "Mass floors" shall include floors weighing not less than:

1. 35 pounds per square foot of floor surface area; or
2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

f. Steel floor joist systems shall be insulated to R-38.

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, below grade																
Below-grade wall[c]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joist/framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs[f]	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.65	F-0.65	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55
Opaque doors																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37

For SI: 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No requirement, LS = Liner system.

a. Use of Opaque assembly *U*-factors, *C*-factors, and *F*-factors from ANSI/ASHRAE/IESNA 90.1 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1 Appendix A.

b. Opaque assembly *U*-factors based on designs tested in accordance with ASTM C1363 shall be permitted. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *F*-factor requirements for heated slabs.

d. "Mass floors" shall include floors weighing not less than:
   1. 35 pounds per square foot of floor surface area; or
   2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

e. These *C*-, *F*- and *U*-factors are based on assemblies that are not required to contain insulation.

f. Evidence of compliance with the *F*-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab *F*-factors and *R-values* derived from ASHRAE 90.1 Appendix A.

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TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-25 + R-11 + R-11 LS	R-25 + R-11 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-60	R-60	R-60	R-60
Walls, above grade																
Mass[f]	R-5.7ci[e]	R-5.7ci[e]	R-5.7ci[e]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-17ci	R-13 + R-19.5ci	R-13 + R-19.5ci	R-13 + R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-18.8ci	R-13 + R-18.8ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R20 + R3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-18.8ci	R-13 + R-18.8ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-10ci	R-15ci	R-15ci	R-15ci	R-15ci	R-15ci
Floors																
Mass[e]	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-14.6ci	R-16.7ci	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-20.9ci	R-20.9ci	R-23ci	R-23ci
Joist/framing	R-13	R-13	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38	R-38	R-38	R-38	R-38
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-20 for 24″ below	R-20 for 24″ below	R-20 for 24″ below	R-20 for 48″ below	R-20 for 48″ below	R-20 for 48″ below	R-25 for 48″ below
Heated slabs[g]	R-7.5 for 12″ below+ R-5 full slab	R-7.5 for 12″ below+ R-5 full slab	R-7.5 for 12″ below+ R-5 full slab	R-7.5 for 12″ below+ R-5 full slab	R-10 for 24″ below+ R-5 full slab	R-10 for 24″ below+ R-5 full slab	R-15 for 24″ below+ R-5 full slab	R-15 for 24″ below+ R-5 full slab	R-15 for 36″ below+ R-5 full slab	R-15 for 36″ below+ R-5 full slab	R-15 for 36″ below+ R-5 full slab	R-20 for 48″ below+ R-5 full slab	R-20 for 48″ below+ R-5 full slab	R-20 for 48″ below+ R-5 full slab	R-20 for 48″ below+ R-5 full slab	R-20 for 48″ below+ R-5 full slab

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.

ci = Continuous Insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 90.1 Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft² °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. "Mass floors" shall be in accordance with Section C402.2.3.

f. "Mass walls" shall be in accordance with Section C402.2.2.

g. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

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TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.029	U-0.029	U-0.029	U-0.026	U-0.026
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.017	U-0.017	U-0.017	U-0.017
Walls, above grade																
Mass[g]	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.050	U-0.050	U-0.050	U-0.050	U-0.050	U-0.044	U-0.039	U-0.039	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.042	U-0.037	U-0.037
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032
Walls, below grade																
Below-grade wall[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-0.119	C-0.092	C-0.119	C-0.092	C-0.092	C-0.063	C-0.063	C-0.063	C-0.063	C-0.063
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.057	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038
Joist/framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	F-0.52	F-0.52	F-0.52	F-0.51	F-0.51	F-0.434	F-0.51	F-0.434	F-0.434	F-0.424
Heated slabs[f]	F-0.69	F-0.69	F-0.69	F-0.69	F-0.66	F-0.66	F-0.62	F-0.62	F-0.62	F-0.62	F-0.62	F-0.602	F-0.602	F-0.602	F-0.602	F-0.602
Opaque doors																
Nonswinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door[h]	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door < 14% glazing[i]	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

For SI: 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.

ci = Continuous Insulation, NR = No Requirement, LS = Liner System.

a. Where assembly *U*-factors, *C*-factors and *F*-factors are established in ANSI/ASHRAE/IESNA 90.1 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1 Appendix A.

b. Where *U*-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *U*-factor requirements for above-grade mass walls.

d. "Mass floors" shall be in accordance with Section C402.2.3.

e. These *C*-, *F*- and *U*-factors are based on assemblies that are not required to contain insulation.

f. The first value is for perimeter insulation and the second value is for full, under-slab insulation.

g. "Mass walls" shall be in accordance with Section C402.2.2.

h. Swinging door *U*-factors shall be determined in accordance with NFRC-100.

i. Garage doors having a single row of fenestration shall have an assembly *U*-factor less than or equal to 0.44 in Climate Zones 0 through 6 and less than or equal to 0.36 in Climate Zones 7 and 8, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

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shall not include an *R*-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled *R*-value for insulated siding shall be reduced by R-0.6.

R402.1.4 *U*-factor alternative. An assembly with a *U*-factor equal to or less than that specified in Table R402.1.4 shall be permitted as an alternative to the *R*-value in Table R402.1.2.

R402.1.5 Total UA alternative. If the total *building thermal envelope* UA (sum of *U*-factor times assembly area) is less than or equal to the total UA resulting from using the *U*-factors in Table R402.1.4 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table R402.1.2. The UA calculation shall be done using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. The SHGC requirements shall be met in addition to UA compliance.

R402.2 Specific insulation requirements (Prescriptive). In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.13.

R402.2.1 Ceilings with attic spaces. Where Section R402.1.2 would require R-38 insulation in the ceiling,

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

For SI: 1 foot = 304.8 mm.

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

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration. Exception: Skylights may be excluded from glazed fenestration SHGC requirements in climate zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.

c. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Or insulation sufficient to fill the framing cavity, R-19 minimum.

h. The first value is cavity insulation, the second value is continuous insulation, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation.

i. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

TABLE R402.1.4
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.35	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.32	0.55	0.026	0.060	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.045	0.057	0.028	0.050	0.055

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure R301.1 and Table R301.1.

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

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b,l]	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 + 10	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0 + 10	3/4	13	0	0	0
2	0.40	0.65	0.25	49	13 or 0 + 10	4/6	13	0	0	0
3	.30	0.55	0.25	49	20 or 13 + 5ci or 0 + 15	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	.30	0.55	0.40	60	20 + 5 or 13 + 10ci or 0 + 15	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
5 and Marine 4	0.30[i]	0.55	0.40	60	20 + 5 or 13 + 10ci or 0 + 15	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	60	20 + 5ci or 13 + 10ci or 0 + 20	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	60	20 + 5ci or 13 + 10ci or 0 + 20	19/21	38	15ci or 19 or 13 + 5ci	10ci, 4 ft	15ci or 19 or 13 + 5ci

For SI: 1 foot = 304.8 mm.
NR = Not Required.
ci = continuous insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. "5ci or 13" means R-5 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "10ci or 13" means R-10 continuous insulation (ci) on the interior or exterior surface of the wall or R-13 cavity insulation on the interior side of the wall. "15ci or 19 or 13 + 5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-19 cavity insulation on the interior side of the wall; or R-13 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or exterior surface of the wall.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs, as indicated in the table. The slab-edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in Warm Humid locations as defined by Figure R301.1 and Table R301.1.

g. The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, "13 + 5" means R-13 cavity insulation plus R-5 continuous insulation.

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

i. A maximum *U*-factor of 0.32 shall apply in Climate Zones 3 through 8 to vertical fenestration products installed in buildings located either:
1. Above 4,000 feet in elevation, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the *International Residential Code*.

R-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.3, the manufacturer's labeled *R*-value for the insulated siding shall be reduced by R-0.6.

R402.1.5 Total UA alternative. Where the total *building thermal envelope* UA, the sum of *U*-factor times assembly area, is less than or equal to the total UA resulting from multiplying the *U*-factors in Table R402.1.2 by the same assembly area as in the proposed *building*, the *building* shall be considered to be in compliance with Table R402.1.2. The UA calculation shall be performed using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. In addition to UA compliance, the SHGC requirements of Table R402.1.2 and the maximum fenestration *U*-factors of Section R402.5 shall be met.

R402.2 Specific insulation requirements. In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.12.

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.

SECTION R402
BUILDING THERMAL ENVELOPE

R402.1 General. The *building thermal envelope* shall comply with the requirements of Sections R402.1.1 through R402.1.5.

Exceptions:

1. The following low-energy *buildings*, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this section shall be exempt from the *building thermal envelope* provisions of Section R402.
   1.1. Those with a peak design rate of energy usage less than 3.4 Btu/h × ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 of floor area for space-conditioning purposes.
   1.2. Those that do not contain *conditioned space*.
2. Log homes designed in accordance with ICC 400.

R402.1.1 Vapor retarder. Wall assemblies in the *building thermal envelope* shall comply with the vapor retarder requirements of Section R702.7 of the *International Residential Code* or Section 1404.3 of the *International Building Code*, as applicable.

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2, based on the *climate zone* specified in Chapter 3. Assemblies shall have a *U*-factor equal to or less than that specified in Table R402.1.2. Fenestration shall have a *U*-factor and glazed fenestration SHGC equal to or less than that specified in Table R402.1.2.

R402.1.3 *R*-value alternative. Assemblies with *R*-value of insulation materials equal to or greater than that specified in Table R402.1.3 shall be an alternative to the *U*-factor in Table R402.1.2

R402.1.4 *R*-value computation. Cavity insulation alone shall be used to determine compliance with the cavity insulation *R*-value requirements in Table R402.1.3. Where cavity insulation is installed in multiple layers, the *R*-values of the cavity insulation layers shall be summed to determine compliance with the cavity insulation *R*-value requirements. The manufacturer's settled *R*-value shall be used for blown-in insulation. Continuous insulation (ci) alone shall be used to determine compliance with the continuous insulation *R*-value requirements in Table R402.1.3. Where continuous insulation is installed in multiple layers, the *R*-values of the continuous insulation layers shall be summed to determine compliance with the continuous insulation *R*-value requirements. Cavity insulation *R*-values shall not be used to determine compliance with the continuous insulation *R*-value requirements in Table R402.1.3. Computed *R*-values shall not include an

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	0.026	0.084	0.165	0.064	0.360	0.477
3	0.30	0.55	0.25	0.026	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.30	0.55	0.40	0.024	0.045	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	NR	0.024	0.045	0.082	0.033	0.050	0.055
6	0.30	0.55	NR	0.024	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	NR	0.024	0.045	0.057	0.028	0.050	0.055

For SI: 1 foot = 304.8 mm.

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. Mass walls shall be in accordance with Section R402.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zones 0 and 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In Warm Humid locations as defined by Figure R301.1 and Table R301.1, the basement wall *U*-factor shall not exceed 0.360.

d. The SHGC column applies to all glazed fenestration.
Exception: In Climate Zones 0 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

e. There are no SHGC requirements in the Marine Zone.

f. A maximum *U*-factor of 0.32 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:
1. Above 4,000 feet in elevation above sea level, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the *International Residential Code*.

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First Name: Diana

Last Name: Burk

Association/Organization: New Buildings Institute

Subject: Proposed Commercial Energy Code Amendment – Thermal Bridging

Issue to Address:

The requirements for overall assembly insulation have been well-addressed in 2021 IECC. However, the existing requirements do little to address the issue of thermal bridges. Thermal bridges are "short cuts" for heat to transfer through the thermal envelope, materials of higher thermal conductance that bypass insulation like studs, joists and structural connections. Thermal bridges can have an over-sized impact on the performance of the thermal envelope. The U-factor and R-value tables in the code assume that heat transfer in through a thermal envelope is parallel. However, heat also transfers laterally, so thermal bridges have a much larger impact on the performance of the envelope than is represented by the area of the envelope that they represent. For example, if 990 square feet of a 1,000 square foot ceiling has insulation with an R-value of R-40 and 10 square feet is uninsulated with an R-value of R-1, the overall R-value of that assembly is R-30 due to thermal bridging effects.

This proposal focuses on reducing thermal bridging through the thermal envelope by:

1. Requiring continuous insulation for balconies and parapets where relatively common and especially problematic thermal bridging issues occur. It is important to note that the proposal does not represent a requirement for additional insulation, but a different application of insulation to meet existing requirements.
2. Identifying and account for thermal bridges in final submittal documents.

Proposed Code Language:

Add new definition in Chapter 2 [CE] Definitions

THERMAL BRIDGE. Thermal bridges are elements that interrupt areas of uniform *thermal resistance* in the b*uilding envelope*.

> ***CLEAR FIELD THERMAL BRIDGE.*** An area-based *thermal transmittance* associated with elements of a *building envelope* assembly which repeat at regular intervals. Examples of *clear field thermal bridges* include metal or wood stud, brick ties and cladding attachments such as z-girts.

LINEAR THERMAL BRIDGE. A length-based *thermal transmittance* associated with horizontal, vertical, or diagonal elements within the *building envelope* and with length measured along the exterior surface of the building envelope. Examples of *linear thermal bridges* include balconies or *floor* assemblies which penetrate *walls* in the building envelope, *fenestration* perimeter interfaces, parapets, and shelf angles. Linear thermal transmittance is heat flow divided by length and by the temperature difference between the interior and exterior sides of the assembly, represented by a Ψ-value (Psi-Value) in units Btu/hr• ft• °F.

POINT THERMAL BRIDGE. An element-based *thermal transmittance* associated with a discrete element that penetrates the *building envelope*. Examples of point *thermal bridges* include a beam penetrating a *wall*, a column penetrating a *roof* or *floor*, and an anchor or connection used to attach an element to the *building* and not otherwise addressed as a *clear field thermal bridge* or *linear thermal bridge*. Point *thermal transmittance* is heat flow divided by the temperature difference between the interior and exterior sides of the assembly, represented by a X-value (Chi-Value) in units Btu/hr • ft• °F.

Add new language in Section 402.2

C402.2 Specific building thermal envelope insulation requirements.
Insulation in building thermal envelope opaque assemblies shall comply with Sections C402.2.1 through C402.2.~~7~~9 and Table C402.1.3

C402.2.8 Continuous insulation
In new *construction*, balconies and parapets that interrupt the *building* thermal envelope shall comply with one of the following:

1. Shall be insulated with *continuous insulation* having a minimum thermal resistance equivalent to the *continuous insulation* component required in the adjacent wall assembly as listed in Table C402.1.3. Where more than one *wall* assembly is interrupted by an adjacent balcony, the higher *thermal resistance* shall be followed.
2. Shall incorporate a minimum R-3 thermal break where the structural element penetrates the *building* thermal envelope.

C402.2.9 Thermal bridges
Applications for construction document approval shall include the following documentation of *thermal bridges*:

C402.2.8.1 Clear field thermal bridges
Where otherwise not included in pre-calculated assembly *U-factors*, *C-factor*s, or F-*factors* outlined in Appendix A of ASHRAE 90.1-2019, *clear field thermal bridges* in a *wall*, roof, or *floor* assembly shall be noted as such in the drawings.

C402.2.8.2 Point thermal bridges
Point thermal bridges greater than or equal in area to 12in^2 and not associated with HVAC or electrical systems shall be noted as *thermal bridges* in the drawings.

C402.2.8.3 Linear thermal bridges
Construction documents shall include the following documentation in tabular format for linear thermal bridges listed in Table C402.2.8.3:

1. *Linear thermal bridge* type.
2. Aggregate length of each type of *linear thermal bridge*.
3. Relevant detail in the construction documents showing a cross-section through the *thermal bridge*.
4. Ψ-value for each *thermal bridge* from Table C402.2.8.3.

Exception to C402.2.8.3
Where *linear thermal bridges* have been tested or modeled using methods approved by the department, alternate values may be used.

TABLE C402.2.8.3 THERMAL BRIDGE Ψ-VALUES

Type of Thermal Bridge	Ψ-value[a] [Btu / hr ft °F]
Balcony	0.50
Floor Slab	0.44
Fenestration Perimeter Transition	0.32
Parapet	0.42
Shelf Angle	0.41

a. Psi-values are derived from the BC Hydro Building Envelope Thermal Bridging Guide Version 1.2 –September 2018 and are based on poor performing details.

b. Fenestration Perimeter Transition is the thermal bridge between any fenestration frame and the typical wall, roof or floor assembly it abuts or is mounted within.

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First Name: Diana

Last Name: Burk

Association/Organization: New Buildings Institute

Subject: Proposed Commercial Energy Code Amendment - Horticultural Lighting Efficacy

Issue to Address:

Indoor agriculture energy usage is projected to grow substantially nationwide over the next several years, driven in large part (but not entirely) by the legalization of medical and recreational marijuana across the country. A total of 46 million square feet of grow area in the U.S. is lit by electric horticultural lighting, 58% of which was in supplemental greenhouses, 41% in non-stacked indoor farms, and 1% in vertical farms.[1] The majority of luminaires in indoor farms and greenhouses are inefficient high-pressure sodium and metal halide high intensity discharge lamps. Because of the large opportunity for energy savings by requiring more efficient luminaires in these applications, the IECC-2021 has adopted requirements for lighting in these applications.

The efficiency metric of µmol/J (micromoles per Joule) in the IECC-2021 was developed in collaboration with the American Society of Agricultural and Biological Engineers and was developed specifically for lighting used for plant growth. It measures the number of photons emitted from the fixture per Joule of energy consumed. Lighting Power Density was developed as a metric to evaluate the light usable for visual tasks relative to the power consumed. Likewise, this metric was developed specifically to measure the light usable for plant growth relative to the power consumed.

[1] *Energy Savings Potential of SSL in Agricultural Applications*, U.S. Department of Energy: Office of Energy Efficiency and Renewable Energy, June 2020, www.energy.gov/sites/prod/files/2020/07/f76/ssl-agriculture-jun2020.pdf.

Table 2-1 Best-in-Class Photosynthetic Photon Efficacy for Horticultural Lighting Products

Lighting Product Type	Best-in-Class PPE (µ-moles/joule)*	Source(s)
Mogul Base HPS	1.02	Table 3 from Nelson & Bugbee, "Economic analysis of greenhouse lighting: light emitting diodes vs. high intensity discharge fixtures", 2014 [8]
Double-Ended HPS (2014)	1.70	
Ceramic Metal Halide	1.46	
Fluorescent Induction	0.95	
T8 Fluorescent	0.84	
LED (2014)	1.70	
Double-ended HPS (2017)	2.1	Philips Lighting, MASTER GreenPower Plus Specification Sheet [9]
LED (2019)	3.2	Philips Lighting, GreenPower LED Toplighting Specification Sheet [10]
Future LED	> 4	DOE SSL Program, "2017 Suggested Research Topics Supplement: Technology and Market Context", 2017 [11]

Figure 1: U.S. DOE. 2020. Energy Savings Potential of SSL in Agricultural Applications.

The most common luminaires used in unregulated horticultural lighting are single-ended High Pressure Sodium and Metal Halide fixtures which have a typical efficacy of 1.02 µmol/J.[2] A double-ended HPS can meet the existing IECC standard of 1.6 µmol/J. The proposed update to the requirement does not require a technology shift within indoor horticulture as all technologies that met the existing standard can also meet the proposed standard

These requirements are consistent with an amendment currently being considered for ASHRAE Standard 90.1.
This efficacy requirement allows the most efficacious double-ended high pressures sodium luminaires and LED luminaires to be installed. 1.9 µmol/J is also the minimum efficacy required to be included in the DesignLights Consortium Qualified Products List (DLC QPL) for this type of lighting. 92% of the products on the DLC QPL had an efficacy of 2.1 µmol/J of higher.[3] These efficacy requirements were recently recommended by Minnesota's Technical Advisory Group to be included in Minnesota's statewide commercial energy code. In 2019, the state of Illinois adopted 2.2 µmol/J as one of the compliance options for their horticultural lighting requirements.

The luminaire efficacy requirement proposed for greenhouses of 1.7 µmol/J is also consistent with standards proposed for Title 24 2022 and can easily be met by almost all LED luminaires on the market for this purpose as well as many double-ended high pressure sodium luminaires. A lower efficacy requirement for greenhouses was established in Title 24 due to lower operating hours in these applications. Buildings that have lighting loads less than 40kW are proposed to be exempt from these requirements to limit additional financial burden on small grow operations.

This requirement was found to be extremely cost effective. Every dollar spent in additional installation costs yielded $7 in operating and maintenance cost savings over a 15-year period for luminaires in indoor grow facilities meeting the 1.9 µmol/J requirement. Every dollar spent in additional fixture costs yielded $2 in operating and maintenance cost savings over 15-years for luminaires in greenhouses meeting the 1.7 µmol/J requirement.

[2] Nelson JA, Bugbee B (2014) *Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures*. PLoS ONE 9(6): e99010. https://doi.org/10.1371/journal.pone.0099010
[3] Ibid.

Proposed Code Language:

Add new definition in Chapter 2 as follows:

> **PHOTOSYNTHETIC PHOTON EFFICACY (PPE).** photosynthetic photon flux divided by input electric power in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.

Modify section as follows:

> **C405.4 Lighting for plant growth and maintenance.** ~~Not less than 95 percent of the~~ All permanently installed luminaires used for plant growth and maintenance shall have a ~~photon efficiency~~ *photosynthetic photon efficacy* of not less than 1.7 µmol/J for *greenhouses* and not less than ~~1.6~~ 1.9 µmol/J for all other indoor growing spaces as defined in accordance with ANSI/ASABE S640.
>
> **Exception:** Buildings with no more than 40kW of aggregate horticultural lighting load.

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First Name: Diana

Last Name: Burk

Association/Organization: New Buildings Institute

Subject: Proposed Commercial Energy Code Amendment – Dedicated Outdoor Air Systems

Issue to Address:

The majority of commercial HVAC systems are based around a central air handling delivery system. This system typically provides heating, cooling and ventilation air from a single source. Since cooling is typically the largest instantaneous load, the fans must be sized large enough to deliver enough air to meet the peak cooling requirements. When the ventilation is integrated, these large fans must operate during all occupied hours to deliver ventilation effectively to the space. This leads to very high fan energy use. With ventilation separated from the heating and cooling delivery, the large heating/cooling fans can be shut off unless there is a call for heating or cooling and the much smaller ventilation-only fans can operate to deliver fresh air to the space. Furthermore, when the ventilation air is delivered using either Energy Recovery Ventilation (ERV) the heating energy requirements associated with tempering the ventilation air are significantly reduced or eliminated. Compliance with this proposed code amendments requires the following in buildings where the cooling or heating system is not 10 percent more efficient than code requirements:

A. 100% ventilation air delivered directly to each zone separate from the heating/cooling system.
B. Ventilation air delivered using an ERV
C. Run heating and cooling equipment (fans and pumps) only when there is a call for conditioning in the zone.

Note that designs based around a DOAS are not new and it has long been established that this design direction leads to more energy efficient buildings. The General Services Administration required DOAS as the baseline design for all new GSA buildings unless otherwise directed by design programming in 1998.[1] The specifications require perimeter and interior systems have 100 percent outside air ventilation systems which are completely independent of any other air distribution system. Enthalpy heat recovery must be included if the outside air required or equipment capacity exceeds a stated amount.[2]

This proposed code change is similar to the requirements currently adopted in the Washington State Energy Code which requires buildings of only certain occupancy types to have a DOAS system. A DOAS would be required in buildings whose occupancy is intended for Mercantile (Group M), and Educational (Group E). A DOAS would also be required in most Business's (Group B) except those exempted, certain Assembly

[1] Mumma, Stanley A. "Designing Dedicated Outdoor Air Systems." *ASHRAE Journal* (May 2001) 28-31.
[2] General Services Administration. GSA 2003 Facilities Standards (P100), 5.5 HVAC Baseline Systems. Accessed March 25, 2021. https://www.gsa.gov/node/81728

occupancies (Group A) for performing arts or motion pictures (except for television and radio studios), casinos, and lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, and places of religious worship.

A DOAS would not be required in buildings where the cooling or heating system is 10 percent more efficient than code requirements. A DOAS would also not be required in the building for occupancies for Residential (Group R), Factory and Industrial (Group F), High Hazard (Group H), Institutional (Group I), Storage (Group S), and Utility and Miscellaneous (Group U).

The proposed code change will increase costs. On average the incremental cost of adding a DOAS for several building prototypes (small, medium and large office, retail, and schools) was found to be $0.88 per square foot.[3] The increased cost of requiring DOAS systems is more than offset by operating cost savings. When compared to a code-minimum multi-zone VAV system, very high efficiency DOAS can reduce HVAC energy by an average of 7% to 16% depending on the type of DOAS system installed in Climate Zone 5A.[4] Iinstalling a DOAS was found to save on average $2.20-$2.80[5] in operating costs for every additional dollar spent to install a DOAS in a building.[3] Buildings with DOAS systems not only save energy but also exhibit improved indoor air quality which is especially important in businesses and schools.

Proposed Code Change:

Add new definition as follows:

DX-DEDICATED OUTDOOR AIR SYSTEM UNITS (DX-DOAS UNITS). A type of air-cooled, water-cooled, or water-source factory assembled product that dehumidifies 100% outdoor air to a low dew point and includes reheat that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned outdoor air is then delivered directly or indirectly via an independent ventilation system to the conditioned spaces. It may precondition *outdoor air* by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.

Add new text as follows:

C403.3.5 Dedicated outdoor air systems (DOAS)

Buildings with occupancies as shown in Table C403.3.5 shall be equipped with an independent ventilation system meeting the requirements of this section and designed to provide not less than the minimum 100-percent outdoor air to each individual occupied space, as specified by the International Mechanical Code. The ventilation system shall meet the requirements for total energy recovery in Section C403.3.5.2.

Exceptions:

1. Occupied spaces that are not ventilated by a mechanical ventilation system and are only ventilated by a natural ventilation system in accordance with Section 402 of the International Mechanical Code.
2. Buildings where the primary heating equipment efficiency exceeds the minimum heating efficiency requirements in Section C403.3 by 10 percent. This exception shall not be used as a substitution for more efficient HVAC performance per Section C406.2.
3. Buildings where the primary cooling or heat rejection equipment exceeds the minimum cooling and heat rejection efficiency requirements in Section C403.3 by 10 percent. Where multiple cooling performance requirements are provided, the equipment shall exceed the annual energy requirement, including IEER, SEER, and IPLV. This exception shall not be used as a substitution for more efficient HVAC performance per Section C406.2.

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[3] *Nonresidential HVAC Controls*, Codes and Standards Enhancement (CASE) Initiative 2022 California Energy Code, Sept. 2020, title24stakeholders.com/wp-content/uploads/2020/10/2022-T24-Final-CASE-Report-HVAC-Controls.pdf.

[4] *Energy Benefits of Different Dedicated Outdoor Air System Configurations in Various Climates*, Shihan Deng, University of Nebraska-Lincoln, May 2014, https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1030&context=archengdiss

[5] Operating costs savings were adjusted to account for the difference in electricity prices between the state where the analysis was conducted with Wisconsin.

TABLE C403.3.5
OCCUPANCY CLASSIFICATIONS REQUIRING DOAS

IBC Occupancy Classification	Inclusions	Exempted
A-1	All occupancies not specifically exempted	Television and radio studios
A-2	Casinos (gaming area)	All other A-2 occupancies
A-3	Lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, places of religious worship	All other A-3 occupancies
A-4, A-5		All occupancies excluded
B	All occupancies not specifically exempted	Food processing establishments including commercial kitchens, restaurants, cafeterias; laboratories for testing and research; data processing facilities and telephone exchanges; air traffic control towers; animal hospitals, kennels, pounds; ambulatory care facilities.
F, H, I, R, S, U		All occupancies excluded
E, M	All occupancies included	

C403.3.5.1 Controls. The HVAC system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads or to outdoor air temperatures. The controls shall reset the supply air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room-air temperature.

C403.3.5.2 Energy recovery ventilation with DOAS. The DOAS shall include energy recovery ventilation. The energy recovery system shall have a 50 percent *enthalpy recovery ratio* in accordance with Section C403.7.4.1. For DOAS having a total fan system motor nameplate hp less than 5 hp, total combined fan power shall not exceed 1 W/cfm of outdoor air. For DOAS having a total fan system motor hp greater than 5 hp, refer to fan power limitations of Section C403.8.1. The airflow rate thresholds for energy recovery requirements in Tables C403.7.4.2-1 and C403.7.4.2-2 do not apply.

Exceptions:

1. Occupied spaces with all of the following characteristics: complying with Section C403.7.4, served by less than 5000 cfm, with an average occupant load greater than 25 people per 1000 square feet (93 m^2) of floor area (as established in Table 403.3.1.1 of the International Mechanical Code) that include demand control ventilation configured to reduce outdoor air by at least 50% below design minimum ventilation rates when the actual occupancy of the space served by the system is less than the design occupancy.
2. Systems installed for the sole purpose of providing makeup air for systems exhausting toxic, flammable, paint, or corrosive fumes or dust, dryer exhaust, or commercial kitchen hoods used for collecting and removing grease vapors and smoke.

C403.3.5.3 Heating/cooling system fan controls. Heating and cooling equipment fans, heating and cooling circulation pumps, and terminal unit fans shall cycle off and terminal unit primary cooling air shall be shut off when there is no call for heating or cooling in the zone.

Exception: Fans used for heating and cooling using less than 0.12 watts per cfm may operate when space temperatures are within the set point dead band (Section C403.4.1.2) to provide destratification and air mixing in the space.

C403.3.5.3 Decoupled DOAS supply air. The DOAS supply air shall be delivered directly to occupied space or downstream of the terminal heating and/or cooling units.

Exceptions:

1. Active chilled beam systems.
2. Sensible only cooling terminal units with pressure independent variable airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.
3. Terminal heating and/or cooling units that comply with the low fan power allowance requirements in the exception of Section C403.3.5.2.

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First Name: Diana

Last Name: Burk

Association/Organization: New Buildings Institute

Subject: Proposed Commercial Energy Code Amendment - EV Readiness

Issue to Address:

According to the most recent Wisconsin Greenhouse Gas Emissions Inventory Report, the transportation sector is the second largest source of Wisconsin's greenhouse gas emissions, representing 24 percent of total Greenhouse Gas emissions in 2017.[1] As Wisconsin moves to 100% carbon free sources of energy by 2050, the impact of the transportation sector on the state's carbon footprint will only increase unless policies are put in place to support the transition from gas-powered vehicles to electric vehicles in the state.

Fortunately, the transition to electric vehicles (EVs) is already underway and auto manufacturers in the Midwest are embracing this change, especially General Motors who recently announced it would only manufacture electric vehicles by 2035.[2] In the United States, EV sales increased by 80 percent from 2017 to 2018. The number of EVs on U.S. roads is projected to grow from 1 million vehicles at the end of 2018, to 18.7 million by 2030. To recharge these new EVs, the U.S. will need 9.6 million charge ports, a substantial portion of which will be installed in single and multi-family residential buildings.[3]

A major barrier to the transition to EVs is the lack of charging infrastructure at homes and businesses and the potential need for extensive electrical upgrades often requiring the installation of conduit through existing concrete to connect the electric vehicle supply equipment (EVSE) to electrical service. It is more cost-effective to ensure a building is "EV ready" when it is being built or undergoing major renovations. A recent study estimated that: "An estimated $8,000 per parking space can be avoided when an individual Level 2 charging station is installed."[4] To reduce expensive retrofit costs, it is therefore critical that Wisconsin's building codes require parking spaces to be EV-ready.

[1] https://dnr.wisconsin.gov/sites/default/files/topic/ClimateChange/WisconsinGreenhouseGasEmissionsInventoryReport.pdf
[2] https://www.nbcnews.com/business/autos/gm-go-all-electric-2035-phase-out-gas-diesel-engines-n1256055
[3] https://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20Celebrates%201%20Million%20Electric%20Vehicles%20on%20U-S-%20Roads.aspx

[4] *EV Charging Infrastructure: Nonresidential Building Standards*, California Air Resources Board, 15 Nov. 2019, ww2.arb.ca.gov/sites/default/files/2020-08/CARB_Technical_Analysis_EV_Charging_Nonresidential_CALGreen_2019_2020_Intervening_Code.pdf.

This proposed code language is currently being considered in Denver, Colorado and captures recent developments in the national conversation about the best way to bring electric vehicle charging infrastructure (EVCI) requirements to code in a way that is consistent, understandable, feasible and ensures the societal benefit of the widest penetration of EV charging possible.

Definitions:
The definitions for Electric Vehicle and Electric Vehicle Supply Equipment are mirrored from NEC-2020 to be useful in defining requirements for electric vehicle infrastructure. The proposal establishes a balance between consistency and flexibility so that the same EVCI framework can be utilized to address parking/charging with different usage patterns and as Wisconsin steadily increases EVCI requirements over time. As a result, unlike the 2019 EVCI code language, terms are defined in a way that allows specific technical requirements to vary while the definitions remain consistent. The prime example of this is the issue of capacity for on-site electrical infrastructure and charging rates.

The proposal also includes definitions for EV, EVSE, EV Capable Space, EV Ready Space, EVSE Space and Automatic Load Management System. EV Ready and EV Capable definitions do not include requirements for minimum capacity for the panels of branch circuit. Different levels of capacity are appropriate for different EV charging scenarios (charging at different building types, parking types, residential types, business types, times of day, etc.) as well as different levels of penetration of EV charging spaces in a parking lot. Therefore, capacity requirements are set in the code text itself to allow for consistent use of the definitions while the capacity requirements change to match the specific EVCI requirements of the parking/charging application and level of penetration of EV spaces over time.

Requirements:
The EV charging infrastructure requirements have been tailored to different charging scenarios. The requirements focus on utilizing EV Ready spaces for residential parking and utilizing EV Capable and EVSE spaces for commercial parking lots.

EV Capable Spaces
The definition of EV Capable is focused on future-proofing parking lots against high retrofit costs in the future. One of the largest costs of retrofitting parking lots for EVCI is retrenching existing parking lots to run wiring for EVSEs. EV Capable spaces are provided with conduit in order to substantially lower the cost of future EVCI retrofits.

EV Ready Spaces
EV Ready spaces are utilized in residential occupancies where EV owners are more likely to choose specific EVSEs with features that meet their personal, long-term needs. The minimum capacity of those EV Ready spaces has been set at Level 1 charging (1.8 kVA) in order to maximize access to EV charging:

- 208/240V NEMA receptacles are not intended for daily plug/unplug cycles, but NEMA 120V receptacles are.
- Nearly all EVs come with at least a Level 1 charger, so Level 1 EV Ready spaces provide immediate access to charging.
- Residential park times are generally much longer which makes Level 1 charging more feasible.
- Lower capacity charging minimizes the cost of EVCI per space, allowing for the maximization of the number of EV spaces, which maximizes access to charging. This is an important equity consideration.
- The requirement for EV Ready spaces to have wiring and panel bus bars that support higher capacity charging will enable a cost-effective upgrade to load managed higher-capacity charging in the future.

EVSE Spaces
EVSE spaces are required for commercial parking lots where shorter parking times are typical and Level 2 or 3 charging is more appropriate. EVSE spaces are required in commercial parking lots to provide

immediate access to charging. The charging rate for an EVSE space is set at 6.2 kW. This is equivalent to a 30A/208V EVSE. 30 and 32A chargers are the most common Level 2 chargers and the highest capacity chargers that can be installed on a 40A branch circuit. kW is used as the metric to indicate total power delivered rather than the specific combination of Volts and Amps.
EV Ready spaces are not required in commercial parking lots for several reasons:

- An EV Ready space does not provide actual charging, particularly when no receptacle is included.
- While the car connection side of Level 2 EVSE are standard, the grid connection side is not. There are up to 8 plugs that could be utilized for portable level 2 chargers, making it less likely that users will have the proper plug. Many chargers come with adapter cables, but few of these are UL listed.
- The NEMA plugs used for 208/240V receptacles are not designed for repeated daily plug/unplug cycles (like 120V receptacles). NEMA has raised concerns about these receptacles being utilized in parking lots.
- Many NEMA 208/240V plugs lack a ground, creating a hazard if they were to be utilized in locations exposed to weather.
- Both 40A and 50A 208/240V circuits utilize the same receptacle plug, creating the chance for circuit overloading and tripped circuit breakers.
-

Monitoring
The 2021 IECC added requirements for sub-metering of building loads. The proposal adds an additional load category to those requirements. Electric Vehicle charging is a transportation load, not a building load, but is often provided through a building electrical service connection. Adding a category for monitoring EV charging separately allows the building load to be measured independently from this non-building load.

Alternate compliance for parking garages
The exception is added to allow capacity to be substituted for conduit in parking garages. EVCI retrofits have different cost considerations in parking garages compared to surface parking lots. Parking garage retrofits do not require retrenching, so the conduit in EV capable spaces does not come with the same future avoided costs.

The percentages in Table C405.14 can be adjusted to tailor the requirements for the specific market needs of Wisconsin. However, the EV Capable space requirements included for all commercial lots recognizes that future needs for EV charging will be much greater than they are now. EV capable spaces avoid the significant cost of parking lot re-trenching, which is one of the largest single costs of EVCI retrofits but only a minor investment in new construction.

Proposed Code Language:

Add new definitions as follows:

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, electric motorcycles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current. Plug-in hybrid electric vehicles are electric vehicles having a second source of motive power. Off-road, self-propelled electric mobile equipment, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats and the like, are not considered electric vehicles.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors and the *electric vehicle* connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *electric vehicle*.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) SPACE. An *automotive parking space* that is provided with a dedicated *EVSE*.

EV CAPABLE SPACE. An *automotive parking space* that is provided with some of the infrastructure necessary for the future installation of an *EVSE* – such as conduit, raceways, electrical capacity, or signage – or reserved physical space for such infrastructure.

EV READY SPACE. An *automotive parking space* that is provided with an electrical circuit capable of supporting an installed *EVSE*.

Revise table as follows:

TABLE
C405.12.2 ENERGY USE CATEGORIES

LOAD CATEGORY	DESCRIPTION OF ENERGY CUSE
Total HVAC system	Heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers, and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use.
Interior lighting	Lighting systems located within the building.
Exterior lighting	Lighting systems located on the building site but not within the building.
Plug loads	Devices, appliances and equipment connected to convenience receptacle outlets.
Process load	Any single load that is not included in HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including but not limited to data centers, manufacturing equipment, and commercial kitchens.
Electric vehicle charging	*Electric vehicle* charging loads.
Building operations and other miscellaneous	The remaining loads not included in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, ornamental fireplaces, swimming pools, in-ground spas and snow-melt systems.

Add new sections as follows:

C405.14 Electric vehicle charging infrastructure. Parking facilities shall be provided with electric vehicle charging infrastructure in accordance with this section and Table C405.14 based on the total number of parking spaces and rounded up to the nearest whole number. *EVSE, EV ready spaces* and *EV capable spaces* may be counted toward meeting minimum parking requirements. *EVSE spaces* may be

used to meet requirements for *EV ready spaces* and *EV capable spaces. EV ready spaces* may be used to meet requirements for *EV capable spaces.* An *ALMS* may be used to reduce the total electrical capacity required by *EVSE spaces* provided that all *EVSE spaces* are capable of simultaneously charging at a minimum rate of 1.4 kW. Where more than one parking facility is provided on a building site, the number of parking spaces required shall be calculated separately for each parking facility.

Exception: In parking garages, the conduit required for *EV capable spaces* may be omitted provided the parking garage electrical service has no less than 1.8 kVA of additional reserved capacity per *EV capable space.*

TABLE C405.14
ELECTRIC VEHICLE CHARGING INFRASTRUCTURE REQUIREMENTS

OCCUPANCY	***EVSE SPACES***	***EV READY SPACES***	***EV CAPABLE SPACES***
Group B Occupancies	15%	NA	40%
Group M Occupancies	25%	NA	40%
R-2 Occupancy	NA	100%[a]	NA
All other Occupancies	10%	NA	40%

a. Or one *EV ready space* per *dwelling unit.*

C405.14.1 EV Capable Spaces. *EV Capable Spaces* shall be provided with electrical infrastructure that meets the following requirements:

1. Conduit that is continuous between a junction box or outlet located within 3 feet (914 mm) of the parking space and an electrical panel serving the area of the parking space
2. The electrical panel to which the conduit connects shall have sufficient dedicated physical space for a dual-pole, 40-amp breaker
3. The conduit shall be sized and rated to accommodate a 40-amp, 208/240-volt branch circuit and have a minimum nominal trade size of 1 inch
4. The electrical junction box and the electrical panel directory entry for the dedicated space in the electrical panel shall have labels stating "For future *electric vehicle* charging"

C405.14.2 EV Ready Spaces. The branch circuit serving *EV Ready Spaces* shall meet the following requirements:

1. Wiring capable of supporting a 40-amp, 208/240-volt circuit,
2. Terminates at an outlet or junction box located within 3 feet (914 mm) of the parking space,
3. A minimum capacity of 1.8 kVA.
4. The electrical panel directory shall designate the branch circuit as "For electric vehicle charging" and the junction box or receptacle shall be labelled "For electric vehicle charging,"

C405.14.2 EVSE Spaces. The *EVSE* serving *EVSE spaces* shall be capable of supplying not less than 6.2 kW to an electric vehicle and shall be located within 3 feet (914 mm) of the parking space.

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First Name: Diana

Last Name: Burk

Association/Organization: New Buildings Institute

Subject: Proposed Commercial Energy Code Amendment - Renewable Energy

Issue to Address:

This code proposal change is based on approved ASHRAE addenda by, ck, and cp to Standard 90.1-2019[1] which will be published in ASHRAE 90.1-2022. The addenda was also recently recommended by the Minnesota Technical Advisory Group for inclusion in the next version of Minnesota's commercial energy code (ASHRAE 90.1-2019). The addenda establishes a prescriptive requirement for onsite renewable energy of 0.25W/s.f. of the three largest floors of all commercial buildings. The size of the required on-site renewable energy is small (on average 4.5% of building energy use) and is a more cost-effective way to require all new commercial buildings to be solar ready. The three exceptions are written to ensure that the requirement is not applied to buildings without adequate space on the roof, to buildings that are in areas of the country where unblocked insolation levels do not provide enough energy to make the equipment cost-effective (according to ASHRAE cost-effective criteria), and to buildings where solar access is wholly or partially blocked. The proposal revises section C406.5 to allow only additional renewable energy to be counted toward compliance with the additional efficiency requirements and requires building owners to retain any renewable energy credits (RECS) associated with the renewable energy so that no other individual or organization can take credit for the production from the system.

Without this code requirement, it may either not be technically possible or it would be economically prohibitive to add solar to commercial buildings constructed today in the future. The proposal will help Governor Evers' Taskforce on Climate Change meet its goal of utilizing "100% carbon-free energy by 2050 while improving the state's economy and environment, diversifying the resources to meet the state's energy needs, and generating family-supporting jobs."

This proposed code change will increase cost of construction modestly. The following table lists the required amount of PV that would be required under this proposed code amendment for a set of typical commercial buildings, the approximate installed costs for solar assuming federal tax credits are received, annual energy cost savings in the first year of production and the simple payback period.

[1] *ANSI/ASHRAE/IES Addendum by, ck, and cp to ANSI/ASHRAE/IES Standards 90.1-2019*, ASHRAE Standards Committee, 31 July 2020, https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_by_ck_cp_20200731.pdf

	PV (kW)	PV Cost	Annual Energy Cost Savings	Simple Payback Period (yrs)
Small Business (3-story, 10,000 s.f.)	2.5	$ 5,070	$ 360	14
Multifamily High Rise (10-story, 80,000 s.f.)	6.0	$ 12,168	$1,155	10
Office (4-story, 50,000 s.f.)	9.4	$ 19,013	$ 1,350	14

Proposed Code Language:

Add new definition as follows:

RENEWABLE ENERGY CERTIFICATE (REC). An instrument that represents the environmental attributes of one megawatt-hour of renewable electricity; also known as an energy attribute certificate (EAC).

Add new text as follows:

C405.13 On site renewable energy. Each building site shall have equipment for on-site renewable energy with a rated capacity of not less than 0.25 W/ft² (2.7 W/m²) multiplied by the sum of the gross conditioned floor area of the three largest floors.

Exceptions:

1. Any building located where an unshaded flat plate collector oriented towards the equator and tilted at an angle from horizontal equal to the latitude receives an annual daily average incident solar radiation less than 3.5 kWh/m²·day (1.1 kBtu/ft²·day).
2. Any building where more than 80 percent of the roof area is covered by any combination of equipment other than for on-site renewable energy systems, planters, vegetated space, skylights, or occupied roof deck.
3. Any building where more than 50 percent of roof area is shaded from direct-beam sunlight by natural objects or by structures that are not part of the building for more than 2,500 annual hours between 8:00 AM and 4:00 PM.

C405.13.1 Renewable energy certificate documentation. Documentation shall be provided to the code official that indicates that renewable energy certificates (RECs) associated with the on-site renewable energy will be retained and retired by or on behalf of the owner or tenant.

Revise text as follows:

C406.5 Onsite renewable energy. The total minimum ratings of on-site renewable energy systems, not including onsite renewable energy system capacity used for compliance with Section C405.13, shall be one of the following:

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First Name: Paul

Last Name: Lippitt

Association/Organization: Private Citizen – Master Plumber

Subject: IECC C404.5

Issue to Address:

My feeling is that the plumbing industry doesn't have to just accept this position from DSPS without questions and appropriate discussion. The decision to apply this code requirement as opposed to that which has been in our code for many years has been very costly, doesn't save energy and could very well cause degradation of the water supply in buildings. I won't touch on the cost issue because I think it's self-evident to anyone that would have an interest in reading this. I will go into the other two in some detail, one at a time. I will focus on the traditional method of temperature maintenance of building hot water with the use of water circulation. The other options of point of use heating and heat tracing temperature maintenance cable are clearly not energy efficient because they use electricity to heat the water and have many other issues associated with their use.

The pumps normally used for hot water circulating systems are very small, fractional horsepower units that use very little energy. Of the small amount of electrical energy that is used, a part is imparted to the passing water in the form of heat. Therefore, there is very little if any energy to be saved with these pumps. The requirement for piping the circulated water to within 24" of every lavatory or hand washing station will actually use considerably more energy for several reasons. Circulation or other means of meeting this requirement add cost and wasted energy in many installations that wouldn't have required it under our existing plumbing code. Adding this additional pipe will create significantly more heat loss from the pipe regardless of how well it is insulated. Adding circuits will create a more complex system will increase the size of the pump and piping to allow the system to be balanced and functional. I've seen a dramatic increase in the size and complexity of these system on state and UW system projects due to the IECC requirement. Often the number of necessary circuits can be 4 or 5 times what they should have been. This means the circulating pumps are that much larger as well and this is clearly not conserving energy. Another issue I commonly see is the oversizing of circulating pumps and placing a balancing valve immediately downstream of the pump to fine tune the flow rate. This means pumping against a dead head and the additional waste of energy.

Much more could be accomplished on energy conservation in building hot water systems by focusing on the larger energy use issues. Actual code requirements for balancing and hot water return sizing guidance would be a good start. Right sizing of the piping systems and water heating equipment would be the biggest improvement.

Another issue with this code section is allowing what I refer to a hot to cold cross over circulating system. IECC 404 allows this as a solution and SPS 363 includes a Wisconsinism that mentions its use as well. The EPA makes it clear on their website that hot water should never be used for human consumption and particularly for mixing with baby formula. This is due to the possibility of excessive lead levels in the hot water system. While hot water is considered to be potable and acceptable for bathing and hygiene purposes, it's not intended for drinking or food preparation. This cross over circulation method is intentionally mixing lower quality water with water that is intended for drinking and it should be prohibited. Another point that isn't made by the EPA, but should be, is that the highest levels of microbial activity occur in the building hot water system. This would include pathogens like Legionella.

This brings me to the second issue of the deterioration of the general water quality of the hot water system. There are several national standards and documents on the web that would indicate that the IECC requirements shouldn't be followed, but I will confine myself to just two scientific papers for reference and backup. The first is the EPA "Technologies for Legionella Control in Premise Plumbing Systems: Scientific Literature Review" (EPA 2016), which is a compilation of information from numerous studies conducted in the last 25 years. The second is from the National Academies of Science, Engineering and Medicine, "Management of Legionella in Water Systems" (NASEM 2019), which is more complete and includes more recent information. Both of these studies can be downloaded off the web if you have lots of time to read them.

There can be many causes or contributing factors that cause the growth of pathogens and non-pathogenic microbes in building potable water systems. I will focus on those that are most applicable to the subject at hand.

1. High water age, or excessive retention time in the system piping. This means a lack of turnover with fresh water and disinfection chemical. Hot water supply and return systems are especially prone to this because the water is continually circulated and mixed with the incoming cold supply. When this happens, the system will tend to produce microbial activity that results in a slimy growth of biofilm on the pipe internal wall. This growth will result in further and faster depletion of the chlorine and begin a cycle of general degradation of the water quality in the system. The biofilm also protects the bacteria that live within it from chemical disinfection and temperature extremes.

2. Excessive surface area. This is the result of adding unnecessary pipe length or oversized pipe. Water treatment equipment such as softeners and oversized hot water storage tanks are another example of excessive surface area. These surface areas are where the biofilm attaches, and the microbes live.

3. Poor system hydraulic properties. Caused for the most part by oversized piping and poorly balanced hot water return systems. This results in excessively low velocity in the actual use conditions. Occasional higher velocity in the system will tend to scrub or clean the biofilm from the pipe wall and provide for improved disinfection residual.

Both of the scientific papers noted above mention these contributing factors many times, and both note that the worst results are most often found in so called "green" buildings. The plumbing industry has done an excellent job in helping to conserve energy and water, but there is an unintended consequence that we must now address. When we reduced the water use, nothing was done to compensate for the sizing of the piping systems and equipment. The premise of "if it's oversized a bit, it won't hurt anything" has proven to be false.

Obviously, the dramatic increase in in the footage of additional piping required by increasing the hot water return system to comply with the IECC code will lead to numbers 1 and 2 above taking place. Number 3 comes into play because we've never really had a specific mandate or guidance on the balancing of hot water return systems and quadrupling the number of circuits is making this problem much worse. The initial setup and balancing of the system are one thing but keeping it that way over the life of a building will prove to be impossible. Another point of concern that many people don't know is that by heating the water, the disinfection chemical is used up, and the higher the temperature the faster this takes place. It's common to find no chlorine residual at distal points in building hot water systems.