Pacific Northwest
NATIONAL LABORATORY

2024 IECC Interim Energy Savings Analysis and Progress Indicator for Commercial Buildings

Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

PNNL-SA-178763

Topics

- Background on the Progress Indicator
- Summary of Proposals
- Interim Results
- Discussion on Specific Proposals

Background

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Purpose of the Interim Progress Indicator

- Track progress of the 2024 IECC commercial provisions based on September-October Public Review Draft
- Identify the set of proposals which can be characterized as having a direct and quantifiable impact on building energy efficiency, and which can be reasonably represented via PNNL's energy savings analysis.
- Track progress toward committee goals, including progress toward net zero, and related energy and environmental impacts

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Progress Indicator Structure

Develop 16 prototype building models using EnergyPlus

Generate minimally code-compliant models for IECC 2021 and 2024 (interim)

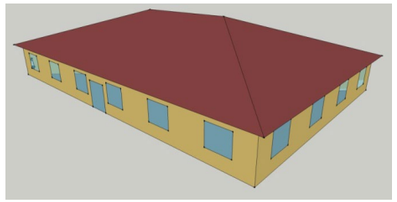
Apply to 8 Thermal Climate Zones (16 Climate Zones)

Assign new building construction weighting factors to each building type in each representative climate location for each Climate Zone

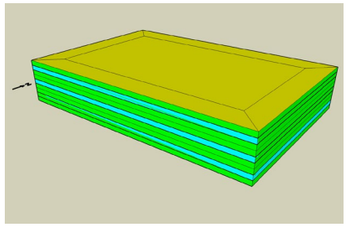
Calculate the national weighted energy use intensity, energy cost index, and savings for each

Commercial Prototype Building Models

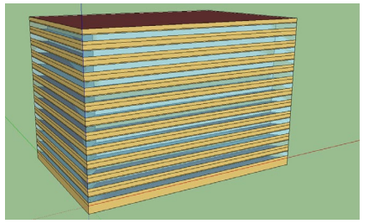
Small Office



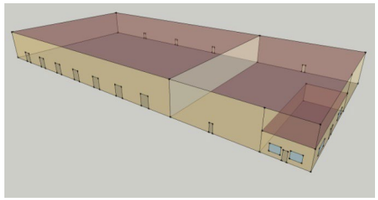
Medium Office



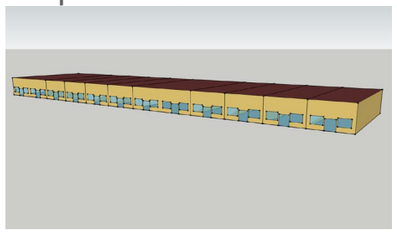
Large Office



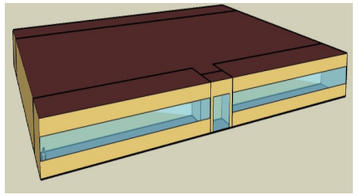
Warehouse



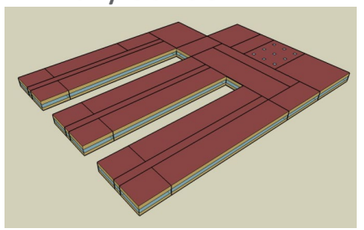
Strip Mall Retail



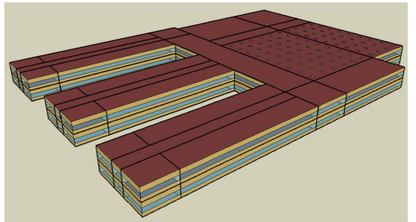
Standalone Retail



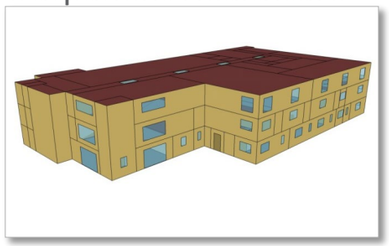
Primary School



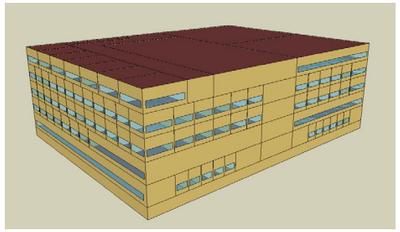
Secondary School



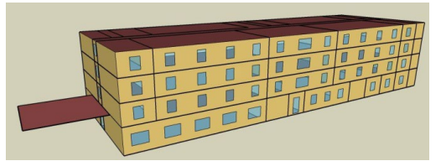
Outpatient Healthcare



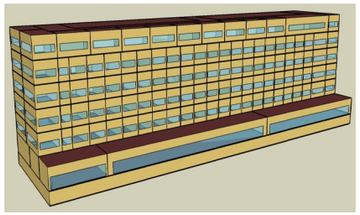
Hospital



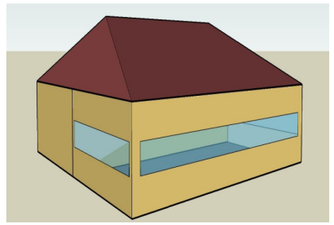
Small Hotel



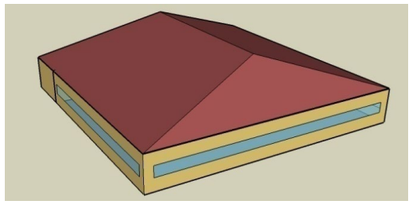
Large Hotel



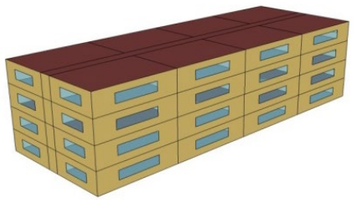
Quick-service Restaurant



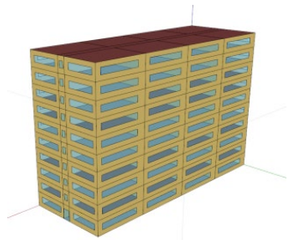
Full-service Restaurant



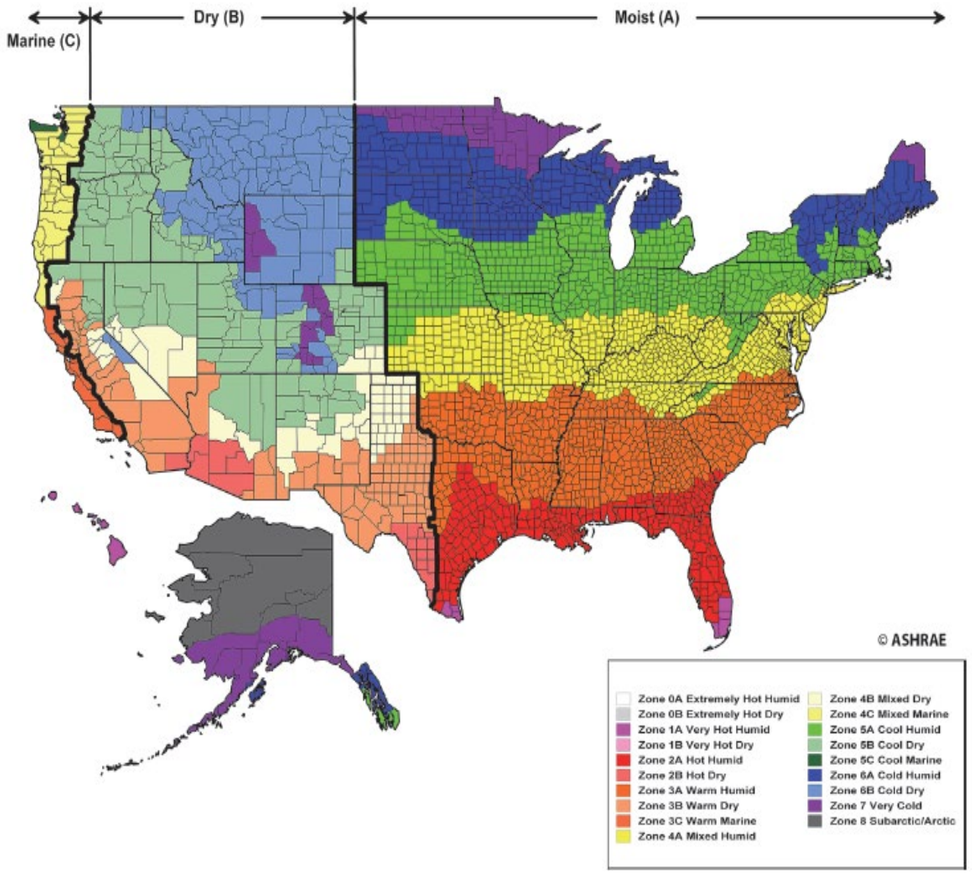
Mid-rise Apartment



High-rise Apartment



Climate Zones and Representative Cities



Climate Zone	Climate Zone Name	Representative City
0A*	Extremely Hot Humid	Ho Chi Minh City, Vietnam
0B*	Extremely Hot Dry	Dubai, United Arab Emirates
1A	Very Hot Humid	Miam, FL
1B*	Very Hot Dry	New Delhi, India
2A	Hot Humid	Tampa, FL
2B	Hot Dry	Tucson, AZ
3A	Warm Humid	Atlanta, GA
3B	Warm Dry	El Paso, TX
3C	Warm Marine	San Diego, CA
4A	Mixed Humid	New York, NY
4B	Mixed Dry	Albuquerque, NM
4C	Mixed Marine	Seattle, WA
5A	Cool Humid	Buffalo, NY
5B	Cool Dry	Denver, CO
5C	Cool Marine	Port Angeles, WA
6A	Cold Humid	Rochester, MN
6B	Cold Dry	Great Falls, MO
7	Very Cold	International Falls, MN
8	Subarctic/Arctic	Fairbanks, AK

ASHRAE Standard 169-2013

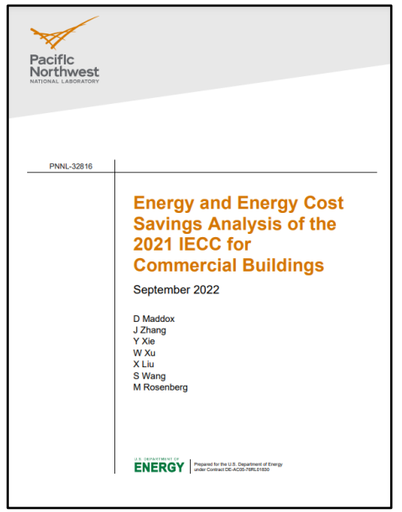
*Prototypes in non-U.S. climate zones were developed but not included in IECC 2024 Interim Progress Indicator.

Prototype Building Models – IECC Commercial

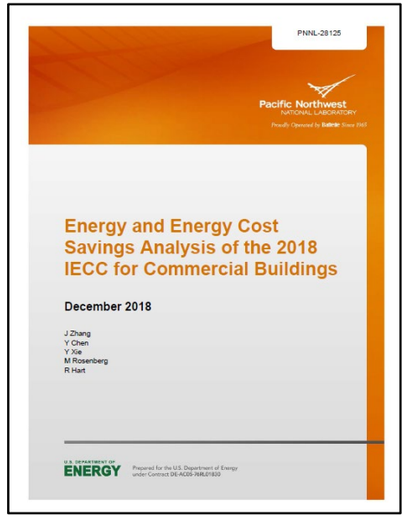
Table 2. Individual IECC Prototype Building Models

Building Type	Complete Set	Scorecard	2012 IECC	2015 IECC	2018 IECC
Small Office	ZIP	XLS	ZIP	ZIP	ZIP
Medium Office	ZIP	XLS	ZIP	ZIP	ZIP
Large Office	ZIP	XLS	ZIP	ZIP	ZIP
Stand-alone Retail	ZIP	XLS	ZIP	ZIP	ZIP
Strip Mall	ZIP	XLS	ZIP	ZIP	ZIP
Primary School	ZIP	XLS	ZIP	ZIP	ZIP
Secondary School	ZIP	XLS	ZIP	ZIP	ZIP
Outpatient Healthcare	ZIP	XLS	ZIP	ZIP	ZIP
Hospital	ZIP	XLS	ZIP	ZIP	ZIP
Small Hotel	ZIP	XLS	ZIP	ZIP	ZIP
Large Hotel	ZIP	XLS	ZIP	ZIP	ZIP
Warehouse (non-refrigerated)	ZIP	XLS	ZIP	ZIP	ZIP
Quick Service Restaurant	ZIP	XLS	ZIP	ZIP	ZIP
Full Service Restaurant	ZIP	XLS	ZIP	ZIP	ZIP
Mid-rise Apartment	ZIP	XLS	ZIP	ZIP	ZIP
High-rise Apartment	ZIP	XLS	ZIP	ZIP	ZIP
All Building Types	ZIP	ZIP	ZIP	ZIP	ZIP

https://www.energycodes.gov/prototype-building-models#IECC
https://www.energycodes.gov/sites/default/files/2022-09/2021_IECC_Commercial_Analysis_Final_2022_09_02.pdf
https://www.energycodes.gov/sites/default/files/2020-07/2018_IECC_Commercial_Analysis_Final.pdf



2021 IECC



2018 IECC

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Construction Weighting Factors (%) – Based on 2003-2018 data (original 2003-2007)

Building Type / Climate Zone:	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8	Weights by Bldg Type
Large Office	0.11	0.54	0.07	0.54	0.26	0.23	1.13	0.00	0.24	0.48	0.15	0.00	0.09	0.00	0.01	0.00	3.85
Medium Office	0.14	0.78	0.19	0.73	0.45	0.16	0.95	0.03	0.17	0.88	0.31	0.00	0.17	0.03	0.02	0.00	5.01
Small Office	0.11	0.77	0.15	0.70	0.27	0.05	0.58	0.03	0.09	0.67	0.21	0.00	0.13	0.02	0.02	0.00	3.80
Stand-Alone Retail	0.29	1.79	0.31	1.78	0.85	0.12	1.92	0.08	0.26	2.37	0.54	0.01	0.49	0.06	0.06	0.01	10.94
Strip Mall	0.16	0.63	0.14	0.70	0.42	0.09	0.66	0.02	0.09	0.61	0.12	0.00	0.06	0.01	0.01	0.00	3.72
Primary School	0.13	0.98	0.12	0.94	0.36	0.04	0.88	0.03	0.12	0.77	0.23	0.00	0.16	0.05	0.02	0.00	4.83
Secondary School	0.26	1.86	0.19	2.16	0.77	0.14	1.98	0.07	0.27	2.18	0.51	0.01	0.37	0.09	0.06	0.01	10.93
Hospital	0.09	0.75	0.11	0.63	0.32	0.10	0.92	0.03	0.13	0.95	0.23	0.01	0.20	0.03	0.03	0.00	4.53
Outpatient Health Care	0.05	0.54	0.09	0.53	0.17	0.04	0.62	0.02	0.10	0.80	0.20	0.00	0.18	0.03	0.03	0.00	3.40
Full Service Restaurant	0.03	0.18	0.03	0.17	0.08	0.01	0.16	0.01	0.02	0.19	0.04	0.00	0.03	0.00	0.00	0.00	0.95
Quick Service Restaurant	0.01	0.07	0.01	0.06	0.02	0.00	0.06	0.00	0.00	0.07	0.02	0.00	0.01	0.00	0.00	0.00	0.33
Large Hotel	0.18	0.71	0.10	0.56	0.55	0.09	0.82	0.02	0.13	0.65	0.19	0.00	0.14	0.04	0.02	0.00	4.20
Small Hotel	0.03	0.30	0.02	0.27	0.11	0.02	0.30	0.01	0.03	0.27	0.10	0.00	0.08	0.03	0.02	0.00	1.59
Non-Refrigerated Warehouse	0.53	3.53	0.63	2.77	2.23	0.18	3.69	0.05	0.54	3.14	0.82	0.00	0.37	0.03	0.04	0.00	18.55
High-rise Apartment	1.44	1.19	0.08	0.57	0.63	0.29	3.26	0.00	0.49	1.36	0.19	0.00	0.11	0.01	0.00	0.00	9.62
Mid-rise Apartment	0.36	2.24	0.27	1.78	1.18	0.49	3.02	0.03	0.71	2.22	0.73	0.01	0.57	0.05	0.04	0.00	13.70
Weights by Climate Zone	3.92	16.86	2.51	14.89	8.67	2.05	20.95	0.43	3.39	17.61	4.59	0.04	3.16	0.48	0.38	0.02	100.00

*McGraw-Hill Construction Project Starts Database (2003-2018)

2024 IECC-C Proposal Summary
Based on Public Review Draft

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124 Proposals Posted in 2024 IECC Public Review CAR

Proposal Numbers				
CECPI-1-21	CEPI-037-21	CEPI-060-21	CEPI-133-21	CEPI-187-21
CECPI-2-21	CEPI-038-21	CEPI-061-21	CEPI-134-21	CEPI-188-21
CECPI-3-21	CEPI-041-21	CEPI-068-21	CEPI-135-21	CEPI-189-21
CECPI-4-21	CEPI-042-21	CEPI-072-21	CEPI-137-21	CEPI-192-21
CECPI-5-21	CEPI-043-21	CEPI-076-21	CEPI-138-21	CEPI-193-21
CECPI-6-21	CEPI-044-21	CEPI-080-21	CEPI-140-21	CEPI-203-21
CECPI-7-21	CEPI-046-21	CEPI-086-21	CEPI-142-21	CEPI-207-21
CEPI-007-21	CEPI-047-21	CEPI-099-21	CEPI-147-21	CEPI-208-21
CEPI-008-21 Part I	CEPI-048-21	CEPI-106-21	CEPI-148-21	CEPI-209-21
CEPI-009-21	CEPI-058-21	CEPI-112-21	CEPI-150-21	CEPI-211-21
CEPI-012-21 Part I	CEPI-060-21	CEPI-125-21	CEPI-152-21	CEPI-212-21
CEPI-014-21	CEPI-061-21	CEPI-138-21	CEPI-154-21	CEPI-215-21
CEPI-016-21 Part I	CEPI-065-21	CEPI-140-21	CEPI-156-21	CEPI-217-21
CEPI-017-21 Part I	CEPI-068-21	CEPI-142-21	CEPI-161-21	CEPI-219-21
CEPI-019-21 Part I	CEPI-069-21	CEPI-148-21	CEPI-164-21	CEPI-220-21
CEPI-023-21	CEPI-071-21	CEPI-150-21	CEPI-166-21	CEPI-221-21
CEPI-024-21 Part I	CEPI-072-21	CEPI-169-21	CEPI-167-21	CEPI-225-21
CEPI-027-21	CEPI-075-21	CEPI-172-21	CEPI-168-21	CEPI-226-21
CEPI-028-21	CEPI-076-21	CEPI-176-21	CEPI-169-21	CEPI-227-21
CEPI-029-21	CEPI-077-21	CEPI-177-21	CEPI-172-21	CEPI-228-21
CEPI-031-21	CEPI-079-21	CEPI-203-21	CEPI-173-21	CEPI-229-21
CEPI-032-21	CEPI-080-21	CEPI-207-21	CEPI-176-21	CEPI-232-21
CEPI-034-21	CEPI-082-21 Part I	CEPI-211-21	CEPI-177-21	CEPI-254-21
CEPI-035-21	CEPI-083-21	CEPI-215-21	CEPI-181-21	CEPI-257-21
CEPI-036-21	CEPI-084-21	CEPI-227-21	CEPI-185-21	

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Not All Proposals Can be Characterized as Having Direct and Quantifiable Energy Savings Impacts.

Common reasons and examples:

- **Alternate Compliance:** Modifying or adding requirements to an optional performance path - changes to R407, HVAC Total System Performance Ratio (TSPR)
- **Definitions:** Changes or adds a new definition (i.e., roof replacement, series heat recovery, DOAS)
- **Editorial/Clarification:** Editorial or clarification to an existing requirement
- **Grid Integration:** Improves integration of building performance with the corresponding electrical grid (e.g., demand responsive thermostats and service water heaters)
- **No Direct Quantifiable Impact**: Outside the scope of the energy savings analysis methodology or adds a new requirement that is accounted for elsewhere (e.g., commissioning, energy monitoring)
- **Alterations or Existing Buildings:** Methodology is focused on new construction
- **Specialized Measures**: Equipment, technology or system not represented in prototypical buildings (e.g., horticulture facilities, parking garages, ceiling fans, ground source heat pumps)
- **Non-U.S. Climates**: Impacts climate zones which are outside the U.S. (i.e., CZs 0A, 0B and 1B)
- **Appendix**: A proposal modifying or adding requirements into an optional Appendix

This approach is consistent with standard approach utilized for similar DOE/PNNL energy savings analysis, including DOE model energy code *determinations*

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41 of the 124 Proposals Have an *Impact on Energy Savings* in Commercial Buildings.

Proposal Numbers				
CECPI-1-21	CEPI-037-21	**CEPI-085-21**	CEPI-133-21	CEPI-187-21
CECPI-2-21	CEPI-038-21	CEPI-086-21	**CEPI-134-21**	CEPI-188-21
CECPI-3-21	CEPI-041-21	**CEPI-097-21**	**CEPI-135-21**	**CEPI-189-21**
CECPI-4-21	CEPI-042-21	CEPI-099-21	CEPI-137-21	CEPI-192-21
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CECPI-6-21	CEPI-044-21	**CEPI-102-21**	CEPI-140-21	CEPI-203-21
CECPI-7-21	CEPI-046-21	CEPI-103-21	CEPI-142-21	CEPI-207-21
CEPI-007-21	CEPI-047-21	CEPI-106-21	CEPI-147-21	CEPI-208-21
CEPI-008-21 Part I	CEPI-048-21	**CEPI-107-21**	CEPI-148-21	CEPI-209-21
CEPI-009-21	**CEPI-058-21**	**CEPI-108-21**	CEPI-150-21	CEPI-211-21
CEPI-012-21 Part I	CEPI-060-21	**CEPI-110-21**	CEPI-152-21	CEPI-212-21
CEPI-014-21	CEPI-061-21	CEPI-112-21	CEPI-154-21	CEPI-215-21
CEPI-016-21 Part I	**CEPI-065-21**	**CEPI-113-21**	CEPI-156-21	**CEPI-217-21**
CEPI-017-21 Part I	CEPI-068-21	CEPI-116-21	CEPI-161-21	**CEPI-219-21**
CEPI-019-21 Part I	CEPI-069-21	CEPI-118-21	**CEPI-164-21**	CEPI-220-21
CEPI-023-21	**CEPI-071-21**	**CEPI-119-21**	CEPI-166-21	CEPI-221-21
CEPI-024-21 Part I	CEPI-072-21	**CEPI-120-21**	CEPI-167-21	CEPI-225-21
CEPI-027-21	**CEPI-075-21**	**CEPI-121-21**	CEPI-168-21	CEPI-226-21
CEPI-028-21	CEPI-076-21	**CEPI-123-21**	CEPI-169-21	CEPI-227-21
CEPI-029-21	**CEPI-077-21**	**CEPI-124-21**	CEPI-172-21	CEPI-228-21
CEPI-031-21	CEPI-079-21	CEPI-125-21	**CEPI-173-21**	CEPI-229-21
CEPI-032-21	CEPI-080-21	**CEPI-127-21**	CEPI-176-21	**CEPI-232-21**
CEPI-034-21	**CEPI-082-21 Part I**	**CEPI-128-21**	CEPI-177-21	CEPI-254-21
CEPI-035-21	**CEPI-083-21**	**CEPI-130-21**	**CEPI-181-21**	CEPI-257-21
CEPI-036-21	**CEPI-084-21**	CEPI-131-21	**CEPI-185-21**	

Green font indicates energy savings, **red** font indicates energy increase

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A Closer Look at the Set of 41 Proposals…

Number	Description	Number	Description
CECPI-2-21	Minimum Renewables	CEPI-113-21	Ventilation Occupied Standby Controls
CECPI-3-21	Air Leakage	CEPI-119-21	Fan Power Limits
CECPI-4-21	Thermal Bridging	CEPI-120-21	Central Fan Integ. Efficacy
CECPI-6-21	Parking Ventilation	CEPI-121-21	Fan Efficacy Table
CECPI-7-21	Lighting Power	CEPI-123-21	Bathroom Intermittent Exhaust Control
CEPI-029-21	Envelope Mechanical Penetrations	CEPI-124-21	Ceiling Fan Energy Index
CEPI-031-21	Wall Solar Reflectance	CEPI-127-21	Water Heating Efficiency Table
CEPI-058-21	Air Barrier Testing	CEPI-128-21	High Capacity SWH Efficiency
CEPI-065-21	Operable opening interlocking	CEPI-130-21	Service water Heating Insulation
CEPI-071-21	Air Leakage reduction	CEPI-134-21	Data Centers - Lighting and Power
CEPI-075-21	Data Centers - HVAC	CEPI-135-21	Sleeping Unit Lighting Power
CEPI-077-21	Boiler High Capacity Space Heating Gas	CEPI-164-21	Daylighting Controls
CEPI-082-21 Part I	Roof Gutter de-icing	CEPI-173-21	Lighting Parking Lot Activity Sensors
CEPI-083-21	Clean Water Pumps	CEPI-181-21	Lighting Unfinished Spaces
CEPI-084-21	Dehumidification Horticulture	CEPI-185-21	Lighting Horticulture
CEPI-085-21	Service Water Pressure-Booster	CEPI-189-21	Lighting exterior updates
CEPI-097-21	Boiler Controls	CEPI-193-21	Additionnal Energy Efficiency Credits
CEPI-102-21	Humidity Controls	CEPI-217-21	Existing Bldgs Add. Efficiency Credits
CEPI-107-21	Direct Digital Control Airflow Rates	CEPI-219-21	Alteration Duct Testing
CEPI-108-21	Ventilation Occupied Standby Controls	CEPI-232-21	Change of Occupancy
CEPI-110-21	HVAC Demand control ventilation		

Green font indicates energy savings, **red** font indicates energy increase

Of the 41 Proposals with Energy Savings, 25 Can Be Captured via the Progress Indicator Analysis.

Number	Description
CECPI-2-21	Minimum Renewables
CECPI-3-21	Air Leakage
CECPI-4-21	Thermal Bridging
CECPI-7-21	Lighting Power
CEPI-058-21	Air Barrier Testing
CEPI-065-21	Operable Opening Interlocking
CEPI-071-21	Air Leakage reduction
CEPI-075-21	Data Centers – HVAC
CEPI-077-21	Boiler High Capacity Space Heating Gas
CEPI-083-21	Clean Water Pumps
CEPI-097-21	Boiler Controls
CEPI-102-21	Humidity Controls
CEPI-107-21	Direct Digital Control Airflow Rates
CEPI-108-21	Ventilation Occupied Standby Controls
CEPI-110-21	HVAC Demand Control Ventilation
CEPI-113-21	Ventilation Occupied Standby Controls
CEPI-119-21	Fan Power Limits
CEPI-120-21	Central Fan Integ. Efficacy
CEPI-127-21	Water Heating Efficiency Table
CEPI-134-21	Data Centers - Lighting and power
CEPI-135-21	Sleeping unit lighting power
CEPI-164-21	Daylighting Controls
CEPI-173-21	Lighting Parking Lot Activity Sensors
CEPI-189-21	Lighting Exterior Updates
CEPI-193-21	Additional Efficiency Credits

This is the final set of proposals which are deemed to have a direct and quantifiable impact on building energy efficiency, and which can be reasonably represented via the energy savings analysis.

These proposals drive the estimated energy savings and results reported on the following slides.

Ultimately, the PNNL analysis is intended to represent average expected impacts across the range of climate zones and building types.

2024 IECC Interim Progress Indicator for Commercial Buildings

Energy and Cost Saving Results

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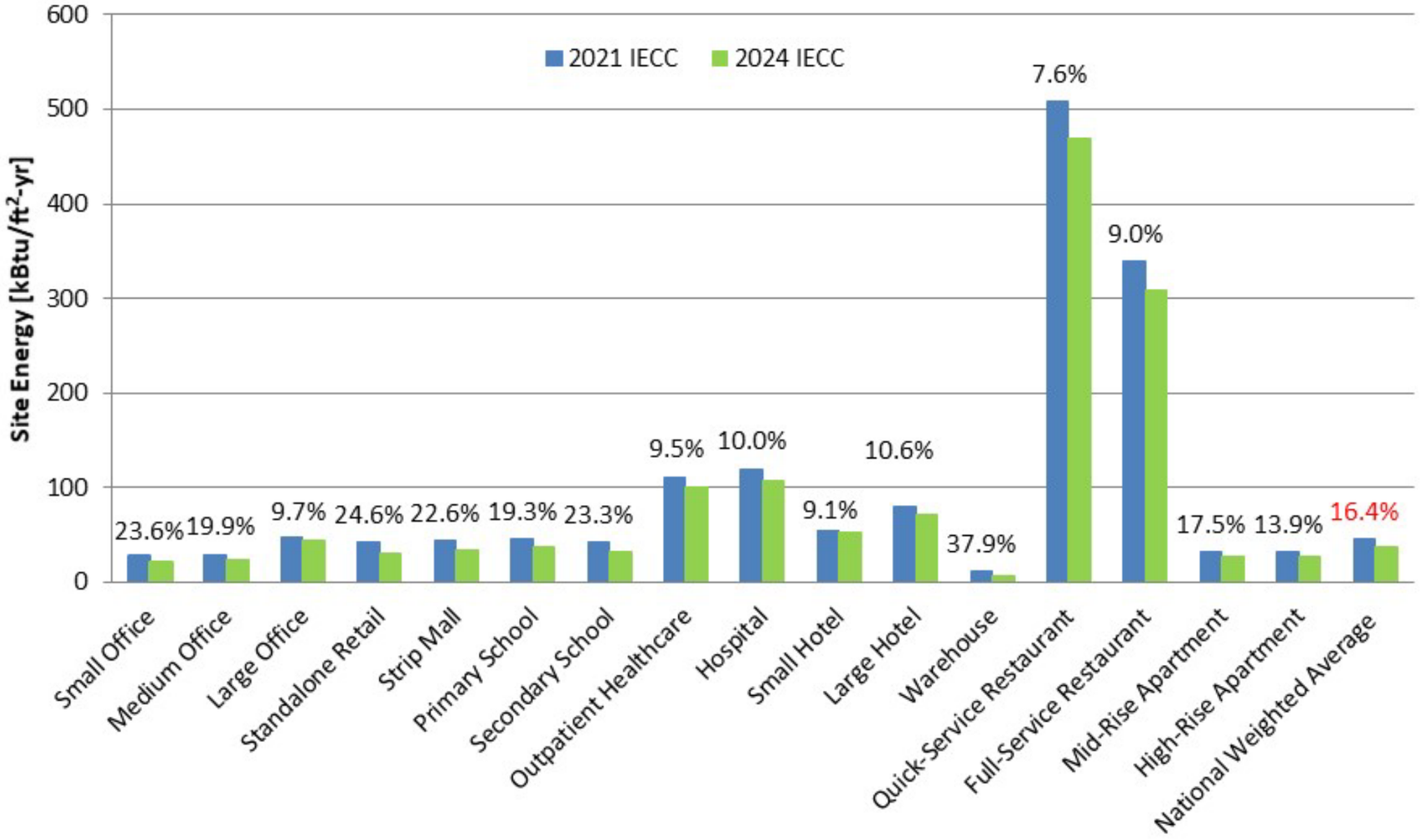
Summary of Results

National Weighted Average		Site Energy [kBtu/ft²-yr] Energy Cost [$/ft²-yr] Emissions [tons/kft²-yr]		% Savings
		IECC 2021	IECC 2024 [Gross] / [Net]	[Gross] / [Net]
Whole Building	Site Energy	45.6	40.8 / 38.1	10.6% / 16.4%
	Energy Cost	$1.22	$1.09 / $1.01	10.2% / 17.2%
	Emissions	7.5	6.7 / 6.2	10.0% / 17.5%

Gross = total before accounting for renewable energy
Net = site energy after accounting for onsite renewable generation

Net Site Energy Savings by Building Type



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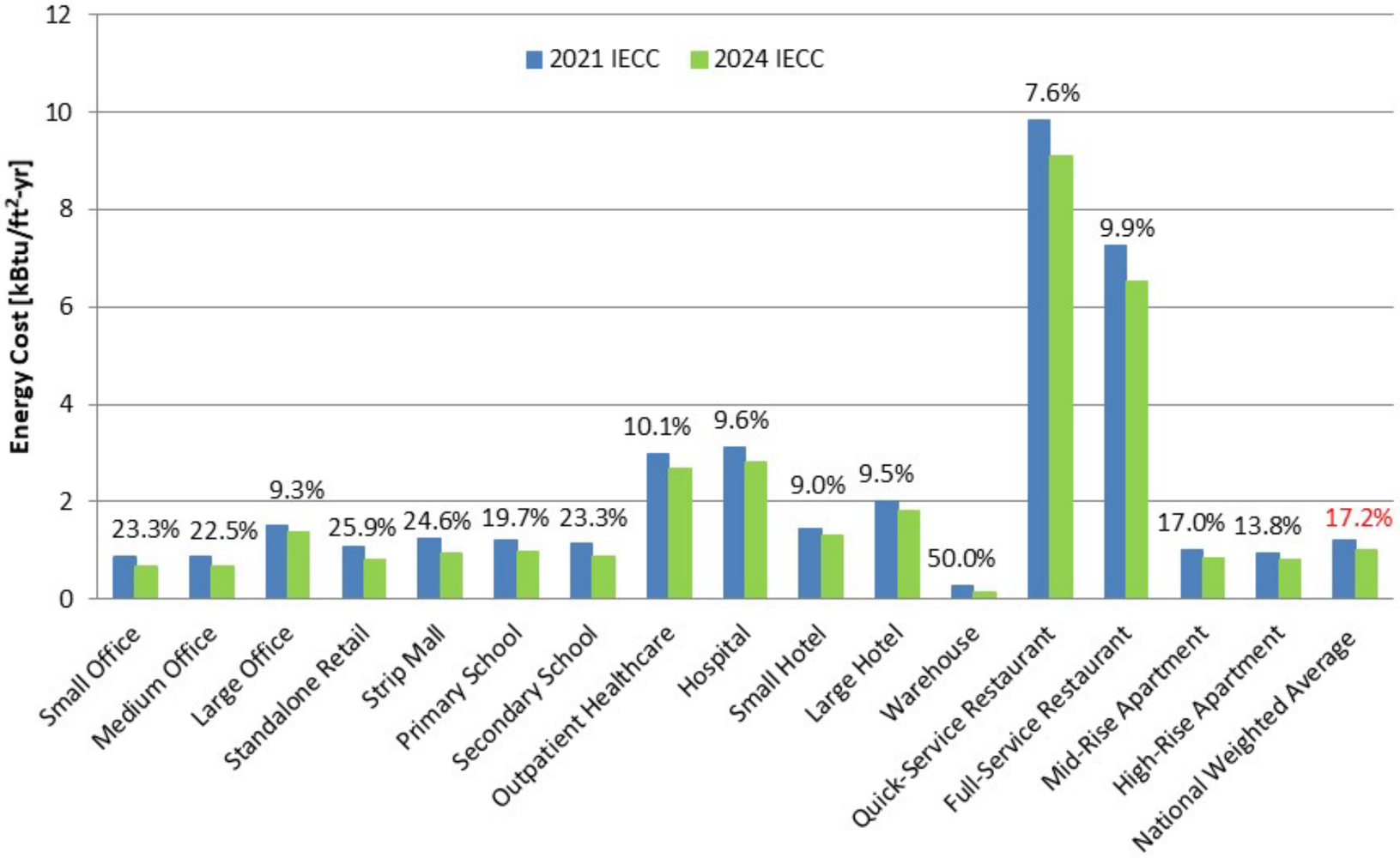
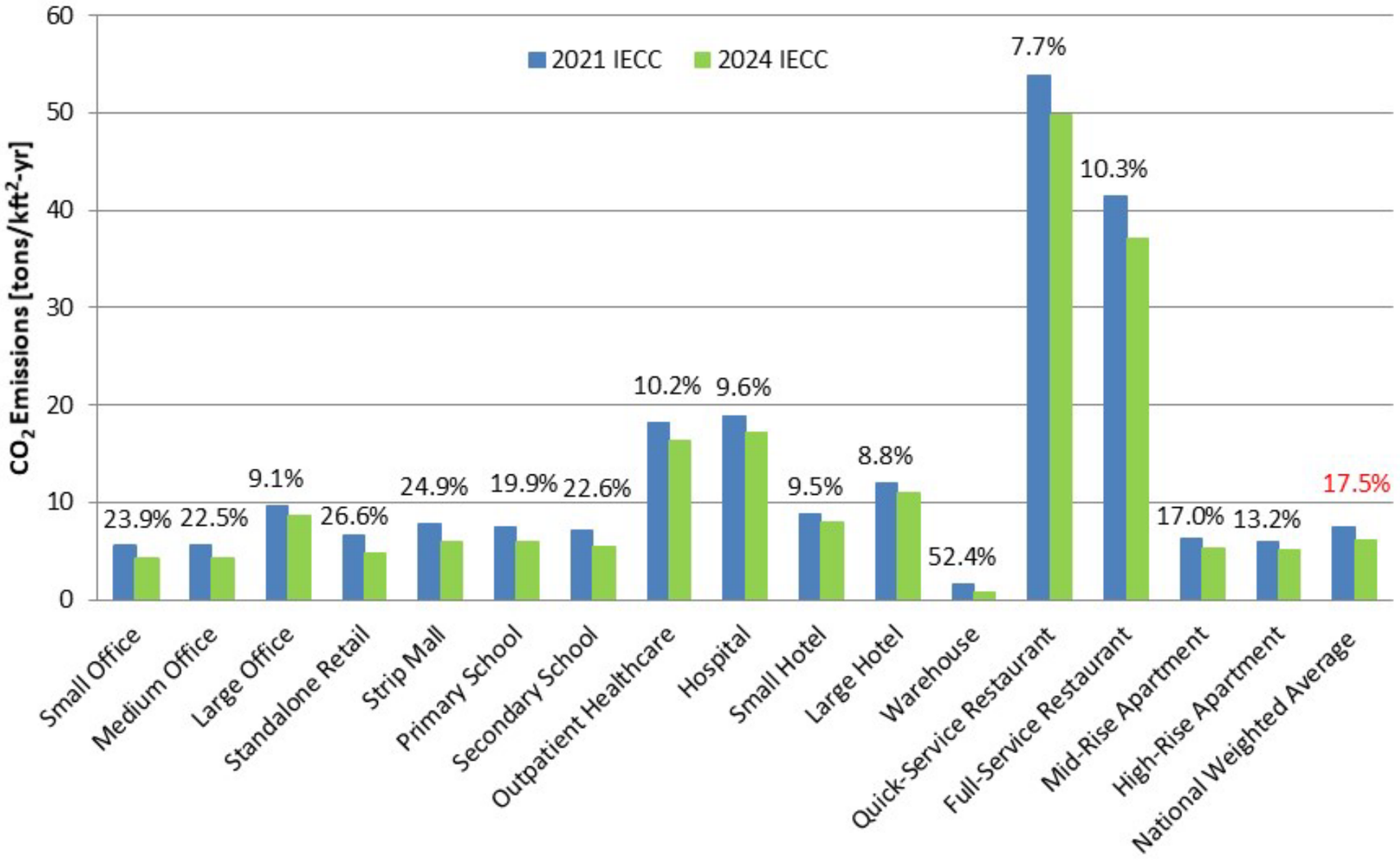
Net Energy Cost Savings by Building Type



Net Emissions Savings by Building Type



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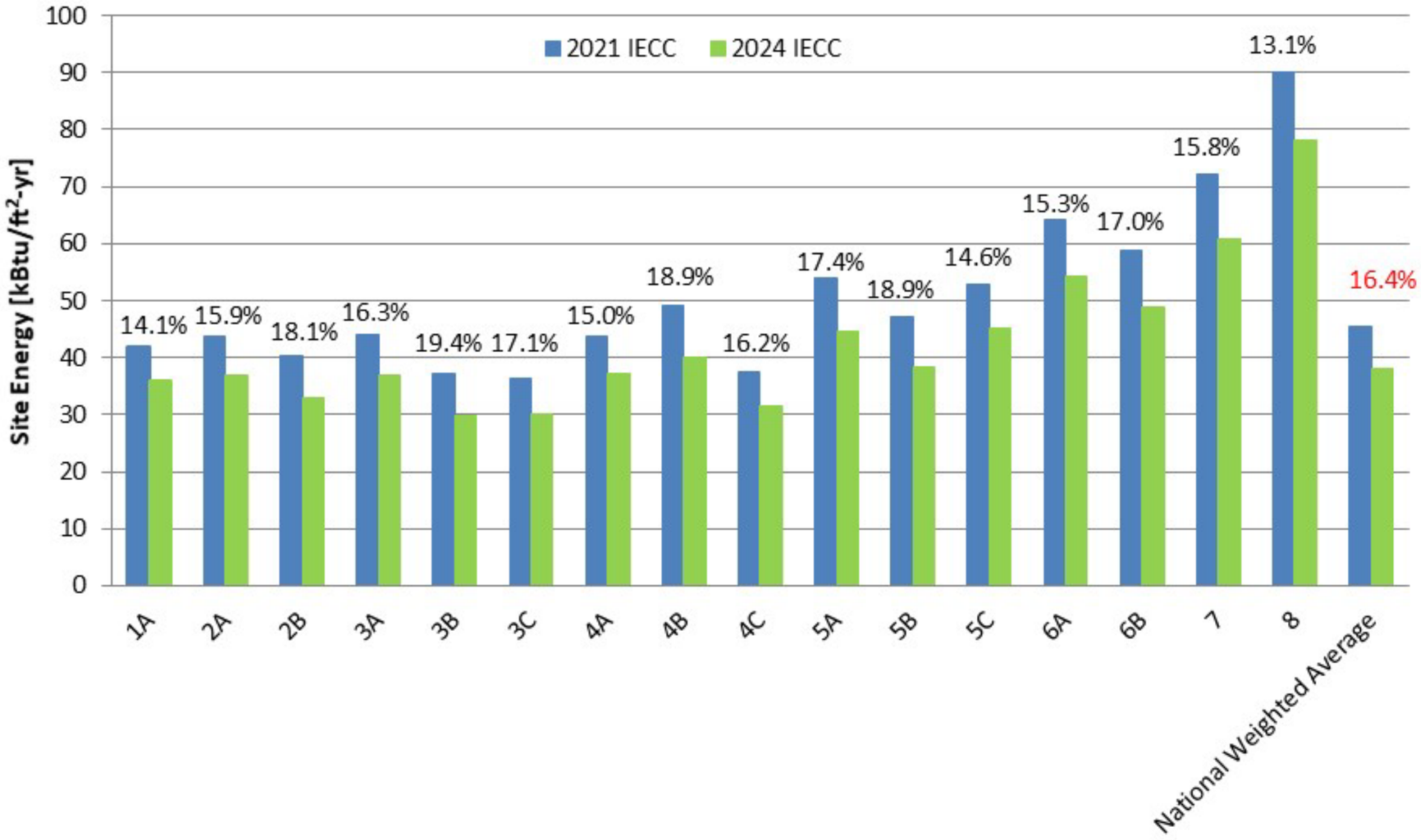
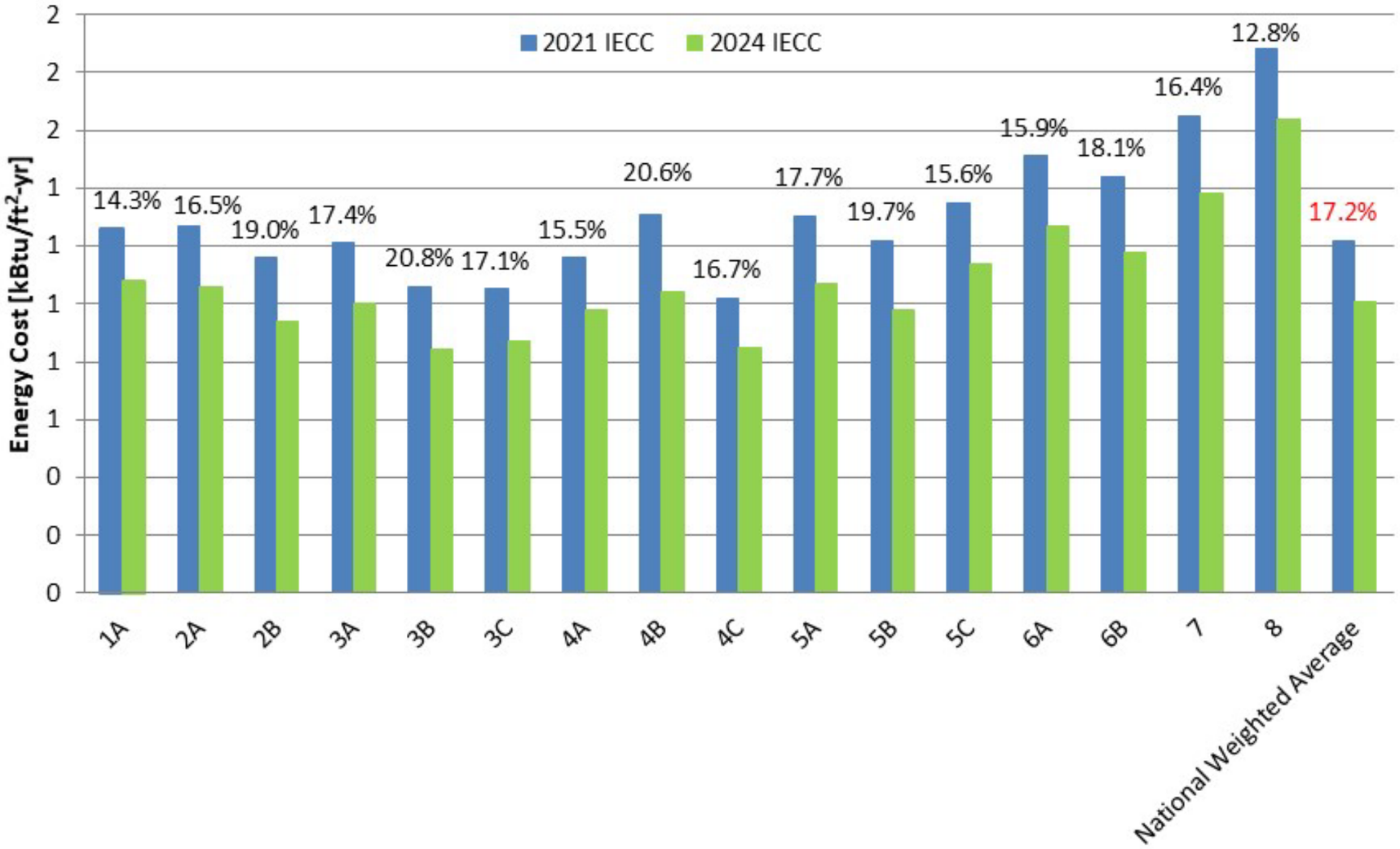
Net Energy Savings by Climate Zone (Commercial)



Net Energy Cost Savings by Climate Zone (Commercial)



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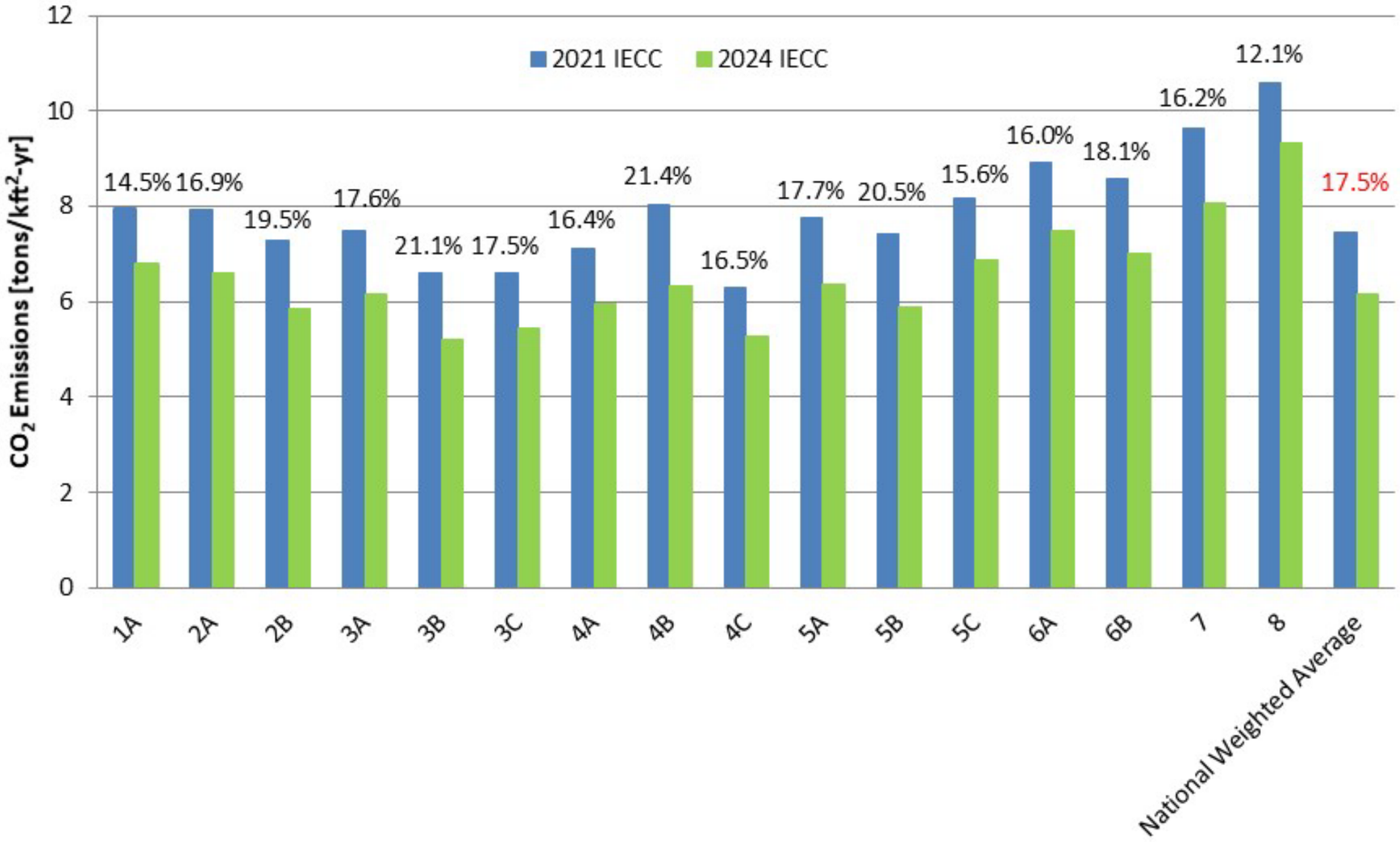
Net Emissions Savings by Climate Zone (Commercial)



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Net Savings Summary by Prototype

Building Activity	Building Prototype	Floor Area Weight (%)	Site EUI (kBtu/ft²-yr)		Site EUI Savings (%)	ECI ($/ft²-yr)		ECI Savings (%)	Emissions (tons/kft²-yr)		Emission Savings (%)
			2021 IECC	2024 IECC		2021 IECC	2024 IECC		2021 IECC	2024 IECC	
Office	Small Office	3.8%	27.5	21.0	23.6%	$0.86	$0.66	23.3%	5.5	4.2	23.9%
	Medium Office	5.0%	29.6	23.7	19.9%	$0.89	$0.69	22.5%	5.6	4.3	22.5%
	Large Office	3.9%	48.4	43.7	9.7%	$1.51	$1.37	9.3%	9.6	8.7	9.1%
Retail	Standalone Retail	10.9%	41.8	31.5	24.6%	$1.08	$0.80	25.9%	6.6	4.8	26.6%
	Strip Mall	3.7%	43.9	34.0	22.6%	$1.26	$0.95	24.6%	7.9	5.9	24.9%
Education	Primary School	4.8%	45.5	36.7	19.3%	$1.22	$0.98	19.7%	7.5	6.0	19.9%
	Secondary School	10.9%	42.0	32.2	23.3%	$1.16	$0.89	23.3%	7.2	5.5	22.6%
Healthcare	Outpatient Healthcare	3.4%	111.5	100.9	9.5%	$2.98	$2.68	10.1%	18.2	16.4	10.2%
	Hospital	4.5%	120.0	108.0	10.0%	$3.11	$2.81	9.6%	18.9	17.1	9.6%
Lodging	Small Hotel	1.6%	58.0	52.7	9.1%	$1.45	$1.32	9.0%	8.8	7.9	9.5%
	Large Hotel	4.2%	80.5	72.0	10.6%	$2.00	$1.81	9.5%	12.0	10.9	8.8%
Warehouse	Warehouse	18.6%	11.6	7.2	37.9%	$0.28	$0.14	50.0%	1.7	0.8	52.4%
Food Service	Quick-Service Restaurant	0.3%	508.9	470.0	7.6%	$9.84	$9.09	7.6%	53.9	49.7	7.7%
	Full-Service Restaurant	1.0%	339.7	309.0	9.0%	$7.26	$6.54	9.9%	41.4	37.2	10.3%
Apartment	Mid-Rise Apartment	13.7%	32.6	26.9	17.5%	$1.00	$0.83	17.0%	6.3	5.3	17.0%
	High-Rise Apartment	9.6%	31.6	27.2	13.9%	$0.94	$0.81	13.8%	5.9	5.1	13.2%
	National Weighted Average	**100%**	**45.6**	**38.1**	**16.4%**	**$1.22**	**$1.01**	**17.2%**	**7.5**	**6.2**	**17.5%**

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Net Savings Summary by Climate Zone

Climate Zones	Site EUI (kBtu/ft²-yr)		Site EUI Savings (%)	ECI ($/ft²-yr)		ECI Savings (%)	Emissions (ton/kft²-yr)		Emission Savings (%)
	2021 IECC	2024 IECC		2021 IECC	2024 IECC		2021 IECC	2024 IECC	
1A	41.8	35.9	14.1%	1.26	1.08	14.3%	7.94	6.79	14.5%
2A	43.9	36.9	15.9%	1.27	1.06	16.5%	7.93	6.59	16.9%
2B	40.3	33.0	18.1%	1.16	0.94	19.0%	7.27	5.85	19.5%
3A	44.1	36.9	16.3%	1.21	1.00	17.4%	7.48	6.16	17.6%
3B	37.1	29.9	19.4%	1.06	0.84	20.8%	6.59	5.20	21.1%
3C	36.3	30.1	17.1%	1.05	0.87	17.1%	6.61	5.45	17.5%
4A	43.9	37.3	15.0%	1.16	0.98	15.5%	7.13	5.96	16.4%
4B	49.3	40.0	18.9%	1.31	1.04	20.6%	8.05	6.33	21.4%
4C	37.6	31.5	16.2%	1.02	0.85	16.7%	6.30	5.26	16.5%
5A	53.9	44.5	17.4%	1.30	1.07	17.7%	7.75	6.38	17.7%
5B	47.2	38.3	18.9%	1.22	0.98	19.7%	7.42	5.90	20.5%
5C	52.9	45.2	14.6%	1.35	1.14	15.6%	8.16	6.89	15.6%
6A	64.1	54.3	15.3%	1.51	1.27	15.9%	8.91	7.48	16.0%
6B	58.9	48.9	17.0%	1.44	1.18	18.1%	8.57	7.02	18.1%
7	72.1	60.7	15.8%	1.65	1.38	16.4%	9.64	8.08	16.2%
8	90.0	78.2	13.1%	1.88	1.64	12.8%	10.60	9.32	12.1%
National Weighted Average	**45.6**	**38.1**	**16.4%**	**1.22**	**1.01**	**17.2%**	**7.47**	**6.16**	**17.5%**

Discussion on Specific Proposals

- Decreases in energy efficiency
- Measures targeting decarbonization

Envelope Air Leakage (CEPI-3-21) - Efficiency Decrease

2021 IECC Air Leakage Rate Limits, cfm/ft^2

Group	Prototypes	Applicability, rated pressure differential	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A to 8
Group R and I	High-Rise Apartment, Mid-Rise Apartment, Hospital, Large Hotel, Small Hotel, Outpatient Health Care	Dwelling Unit (0.2 in.wg)	0.3	0.3	0.3	0.3	0.3	NR	0.3	0.3	1	0.3	0.3	0.3	0.3	0.3	1	0.3
		General (0.3 in.wg)	0.4	0.4	0.4	0.4	0.4	NR	0.4	0.4	1	0.4	0.4	0.4	0.4	0.4	1	0.4
< 5,000 ft^2	Fast Food Restaurant	General (0.3 in.wg)	0.4	0.4	0.4	0.4	0.4	NR	0.4	1	1	0.4	0.4	0.4	0.4	0.4	1	0.4
5,000 to <50,000 ft^2	Office Small, Stand-Alone Retail Strip mall Retail, Sit-Down Restaurant	General (0.3 in.wg)	0.4	1	1	1	1	NR	0.4	1	1	0.4	1	1	0.4	0.4	1	0.4
>= 50,000 ft^2	Medium Office, Large Office, Primary School, Secondary School, Warehouse	General (0.3 in.wg)	1	1	1	1	1	NR	1	1	1	0.4	1	1	0.4	1	1	0.4

2024 IECC Air Leakage Rate Limits, cfm/ft^2

Group	Prototypes	Applicability, rated pressure differential	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A to 8
Group R and I	High-Rise Apartment, Mid-Rise Apartment, Hospital, Large Hotel, Small Hotel, Outpatient Health Care	Dwelling Unit (0.2 in.wg)	0.27	0.27	0.27	0.27	0.27	NR	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
		General (0.3 in.wg)	0.35	0.35	0.35	0.35	0.35	NR	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
<25,000 ft^2	Fast Food Restaurant, Office Small, Stand-Alone Retail Strip mall Retail, Sit-Down Restaurant	General (0.3 in.wg)	0.35	0.35	0.35	0.35	0.35	NR	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
> 25,000 ft^2	Medium Office, Large Office, Primary School, Secondary School, Warehouse	General (0.3 in.wg)	1	1	1	1	1	NR	1	1	1	1	1	1	0.35	0.35	0.35	0.35

- 1.0 cfm/ft^2 @ 0.3 in.wg is the infiltration assumed when air barriers are required but testing is not required by the code
- Since climate zone 4A has much higher weighting than zones 5A through 8, the net effect for large buildings is an increase in energy
- National average of all prototypes/all climates is 0.1% increase in total energy use

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Sleep Unit Lighting (CEPI-135-21) - Efficiency Decrease

2021 IECC

- Guest Room: 0.41 W/ft^2; equivalent to 83 lm/W
- Patient Room: 0.68 W/ft^2; equivalent to 83 lm/W

2024 IECC

- Guest Room: 45 lm/W; equivalent to 0.76 W/ft^2
- Patient Room: 45 lm/W; equivalent to 1.25 W/ft^2

Overall energy increase due to removal of sleeping units from LPD table:

- Hospital: 0.1%
- Small Hotel: 4.3%
- Large Hotel: 3.0%
- **National Average: 0.3%**

Data Center Mechanicals (CEPI-075-21) - Efficiency Decrease

- The 2021 IECC specified Mechanical Load Component (MLC) values for large data centers
- The 2024 IECC removes the MLC values and instead references 90.4-2019 MLC
- For some climates the MLC increases, while for others it decreases

Overall impact is an increase in annual energy of 0.3% for Large Office prototype

Annualized MLC

CZ	2021 IECC	2024 IECC	Change
0A	0.19	0.25	32%
0B	0.2	0.28	40%
1A	0.18	0.26	44%
2A	0.19	0.27	42%
3A	0.18	0.23	28%
4A	0.17	0.21	24%
5A	0.17	0.18	6%
6A	0.17	0.16	-6%
1B	0.16	0.16	0%
2B	0.18	0.17	-6%
3B	0.18	0.17	-6%
4B	0.18	0.14	-22%
5B	0.16	0.14	-13%
6B	0.17	0.14	-18%
3C	0.16	0.14	-13%
4C	0.16	0.14	-13%
5C	0.16	0.14	-13%
7	0.16	0.14	-13%
8	0.16	0.13	-19%

EV Charging Infrastructure (CECPI-001)

Decarbonization – Not Captured in Progress Indicator

Required number of EV capable spaces, EV ready spaces, and EV power supply equipment spaces

- Support of the electric vehicle market aids decarbonization efforts
- Based on average U.S. emissions for electricity generation*, EVs save nearly 70% of the annual CO2e emitted by combustion-engine vehicles.

Savings Examples	Occupancy Group	Number of Total Parking Spaces	EV Supply Equipment (EVSE) Installed Spaces	Carbon Emissions Reduction (lb. CO2e year)
Retail Strip Mall	M	79	8 (10%)	51,604
Midrise Apartment	R-2	69	14 (20%)	90,145

- Savings are based on annual combustion vehicle emissions of 11,435 lb CO2e and electric vehicle emissions of 3,596 lb CO2e, resulting in an annual savings of 7,839 lb CO2e/year.
- The carbon emission calculation assumes 12,000 miles traveled per year, 25.7 miles/gallon, 0.35 kWh/mile, 24.6 lb CO2e/gal, 0.866 lb CO2e/kWh, which is based on eGrid 2020 published data for U.S. average equaling 822.6 CO2e lb/MWH plus 5.3% to account for transmission and distribution losses.

Energy Storage Ready (CECPI-007)

Supports Decarbonization – Not Captured in Progress Indicator

Install electrical storage and reserve ESS-ready areas to accommodate future storage

- Impact assessment of 0.0008 kWh/ft2 energy storage capacity* for the medium office building in all U.S. climate zones.
- Total installed capacity of 43 kWh that shaves peak demand in summer and winter
- Average reduction in summer peak demand period is 12.1%
- Average annual electricity cost savings total 3.5%
- Measure cost savings are higher for buildings with steeper electricity load shapes during summer peak demand period.

Metric		Units	Min	Average	Max
Demand	Max Demand	(W/sq.ft.)	2.13	2.67	3.10
	Peak Period Demand Reduction	(W/sq.ft.)	0.14	0.32	0.44
		(kW)	7.7	17.3	23.8
		(%)	6.7%	12.1%	14.3%
Cost	TOU Elec Cost	($/sq.ft. year)	0.68	0.82	0.96
	TOU Elec Savings	($/sq.ft. year)	0.02	0.03	0.03
		($/year)	1080	1520	1810
		(%)	3.0%	3.5%	3.5%

*Capacity meets 0.00075 kWh/ft2 battery capacity requirement (0.75 W/ft2 PV * 1 kWh/ft2 battery capacity / 1 kW/ft2 PV rated power) and is aligned with the 0.0008 kWh/ft2 energy storage capacity requirement associated with the energy storage ready area.

Grid-Integrated Thermostat (CEPI-099)

Supports Decarbonization – Not Captured in Progress Indicator

- Demand responsive control capable of automatically adjusting thermal set points
  - Impact assessment of set point setup (summer) and setback (winter) during peak cost periods for the medium office building in all U.S. climate zones.
  - Average reduction in summer peak demand period is 17%
  - Average annual electricity cost savings total 2.5%
  - Some additional electricity costs are incurred during the non-peak period due to the winter pick-up heat load
  - Measure cost savings are higher for buildings with steeper electricity load shapes during summer months.

Metric		Units	Min	Average	Max
Demand	Max Demand	(W/sq.ft.)	2.13	2.67	3.10
	Peak Period Demand Reduction	(W/sq.ft.)	0.31	0.45	0.61
		(kW)	16.6	24.4	32.6
		(%)	15%	17%	20%
Cost	TOU Elec Cost	($/sq.ft. year)	0.68	0.82	0.96
	TOU Elec Savings	($/sq.ft. year)	0.01	0.02	0.03
		($/year)	460	1100	1350
		(%)	1.3%	2.5%	2.6%

Lighting Demand Response (CEPI-176)

Supports Decarbonization – Not Captured in Progress Indicator

- Demand responsive lighting control capable of automatically reducing lighting power by not less than 15 percent
  - Impact assessment of the lighting power reduction for the medium office building in all U.S. climate zones.
  - All interior lighting systems impacted
  - Average reduction in summer peak demand period is 3%
  - Average annual electricity cost savings total 1.2%
  - Measure cost savings are higher for CZ locations with higher summer cooling loads

Metric		Units	Min	Average	Max
Demand	Max Demand	(W/sq.ft.)	2.13	2.67	3.10
	Peak Period Demand Reduction	(W/sq.ft.)	0.02	0.08	0.11
		(kW)	0.9	4.3	5.6
		(%)	0.8%	3.0%	3.4%
Cost	TOU Elec Cost	($/sq.ft. year)	0.68	0.82	0.96
	TOU Elec Savings	($/sq.ft. year)	0.01	0.01	0.01
		($/year)	440	530	630
		(%)	1.2%	1.2%	1.2%

Grid-Integrated Water Heating (CEPI-099)
Supports Decarbonization – Not Captured in Progress Indicator

- Demand responsive control capable of automatically adjusting thermal set points
  - Measure preheats SHW above required temperature then shuts of electric SHW equipment during peak energy and demand price periods
  - Average reduction in summer peak demand period is 1.7% for medium office and 10% for small hotel
  - Average annual electricity cost savings total 0.3% for medium office and 2.9% for small hotel
  - Measure cost savings are higher for building types with higher SHW loads

Metric		Units	Medium Office (53,600 sq. ft.)			Small Hotel (43,200 sq. ft.)		
			Min	Average	Max	Min	Average	Max
Demand	Max Demand	(W/sq.ft.)	2.13	2.67	3.10	1.87	2.63	4.17
	Peak Period Demand Reduction	(W/sq.ft.)	0.05	0.05	0.05	0.27	0.27	0.27
		(kW)	2.4	2.4	2.4	11.5	11.5	11.5
		(%)	1.5%	1.7%	2.1%	6%	10%	14%
Cost	TOU Elec Cost	($/sq.ft. year)	0.68	0.82	0.96	0.53	0.60	0.68
	TOU Elec Savings	($/sq.ft. year)	0.003	0.003	0.003	0.017	0.017	0.017
		($/year)	157	157	157	756	756	756
		(%)	0.3%	0.4%	0.4%	2.6%	2.9%	3.3%

Acknowledgements

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IECC Progress Indicator

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IECC Committee Support

Michael Tillou, Project Manager

IECC Commercial Committee Support

Michael Rosenberg and Reid Hart, Modeling Subcommittee
Doug Maddox, Mechanical Subcommittee
Michael Tillou, Envelope Subcommittee
Michael Meyer, Lighting Subcommittee

Questions?

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Thank you

Grid Integration Proposals

Benefits to homeowners and the grid

- Grid integration measures support building load management (LM) and demand response (DR), which play a critical role in grid reliability by aiding in the balance of supply and demand and the avoidance of blackouts during extreme temperatures.
- Proposal benefits were assessed based on carbon emissions or customer costs.
- Customer costs are based on a U.S. representative time-of-use (TOU) rate, which was adopted in February 2019 by the ASHRAE 90.1 Economic Working Group as an optional rate for accessing code-change proposals.

Grid Integration Proposals
U.S. Representative TOU Rate

Rates	Winter On Peak: M-F, 6 AM-10 AM; 5 PM-9PM Off Peak: All other hours				Summer On Peak: M-F, 1 PM-9 PM Off Peak: All other hours			
	kWh Off	kWh Peak	kW Off	kW Peak	kWh Off	kWh Peak	kW Off	kW Peak
Blended Rate	$0.1122	$0.1122	0	0	$0.1122	$0.1122	0	0
2019 ASHRAE TOU Rate	$0.0529	$0.0876	$5.18	$5.18	$0.0543	$0.1023	$5.18	$10.18

- Code proposals can be assessed with a flat blended rate or the TOU rate, which includes a **winter peak energy cost period** and a **summer peak demand cost period**.
- The TOU rate was developed from rate data published in the OpenEI Utility Rate Database and utility survey data
- Based on performance results determined for the medium office prototype, the TOU rate results in close to the same annual energy costs as the blended rate.

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83 of the 124 Proposals Cannot be Characterized as Having Both a Direct and Quantifiable Impact.

Number	Description	Reason for No Savings	Number	Description	Reason for No Savings	Number	Description	Reason for No Savings
CECPI-1	EV Charging	Grid Integration	CEPI-061	Air Leakage Applicability	Editorial/Clarification	CEPI-161	Daylight Control Exceptions	Editorial/Clarification
CECPI-5	NZE Appendix	Appendix	CEPI-068	Envelope Testing Residential	Editorial/Clarification	CEPI-166	Daylight Zones	Editorial/Clarification
CEPI-007	Energy Storage Ready	Grid Integration	CEPI-069	Air Barrier Testing Third Party	Editorial/Clarification	CEPI-167	Daylight Zones and Envelope	Editorial/Clarification
CEPI-008 Pt I	Fee Section Coordination	Administrative	CEPI-072	Air Curtain	Editorial/Clarification	CEPI-168	Display Lighting	Editorial/Clarification
CEPI-009	Kitchen Exhaust	Editorial/Clarification	CEPI-076	HVAC Total System Perf.	Alternate Compliance	CEPI-169	Lighting Guest Room Controls	Editorial/Clarification
CEPI-012 Pt I	Biomass Definition	Definition	CEPI-079	Minimum Pipe Insulation	Editorial/Clarification	CEPI-172	Lighting Business Closing	Editorial/Clarification
CEPI-014	Dedicated Out Air Systems	Definition	CEPI-080	Pipe Insulation Protection	Editorial/Clarification	CEPI-176	Lighting Demand Response	Grid Integration
CEPI-016 Pt I	Fenestration definition	Editorial/Clarification	CEPI-086	Fault Detection	Editorial/Clarification	CEPI-177	Lighting Power Section C405	Alternate Compliance
CEPI-017 Pt I	Roof Replacement	Definition	CEPI-099	Grid Integrated Thermostat	Grid Integration	CEPI-187	Exterior Lighting Power	Editorial/Clarification
CEPI-019 Pt I	Insulation Mark Installation	Editorial/Clarification	CEPI-100	HVACR Start and Sop	Editorial/Clarification	CEPI-188	Exterior Lighting Residential	Editorial/Clarification
CEPI-023	Remove System Type Limit	Editorial/Clarification	CEPI-103	Economizer Exception	Editorial/Clarification	CEPI-192	Transformers	Editorial/Clarification
CEPI-024 Pt I	Performance Path	Editorial/Clarification	CEPI-106	Outdoor Air Relief	Editorial/Clarification	CEPI-203	Energy Use Disclosure	No Direct Quantifiable Impact
CEPI-027	Thermal Envelope	Editorial/Clarification	CEPI-112	Energy Recovery, series	Definition	CEPI-207	Source Energy	Alternate Compliance
CEPI-028	U-factor as Basis for R-values	Editorial/Clarification	CEPI-116	Exhaust Air Recovery	Editorial/Clarification	CEPI-208	Add Insulation	Alternate Compliance
CEPI-032	Air Barrier Terminology	Editorial/Clarification	CEPI-118	Elevator Dampers	Editorial/Clarification	CEPI-209	Mandatory Perf. Envelope items	Alternate Compliance
CEPI-034	Low Energy Buildings	Editorial/Clarification	CEPI-125	Grid Integrated Water Heating	Grid Integration	CEPI-215	Commissioning	No Direct Quantifiable Impact
CEPI-035	R Value Table N	Editorial/Clarification	CEPI-131	Service Water Heating Pump	Editorial/Clarification	CEPI-217	Existing Bldgs Energy Credits	Existing Building/Alteration
CEPI-036	R Value Table Slab note d	Editorial/Clarification	CEPI-133	Lighting General Scope	Editorial/Clarification	CEPI-219	Alteration Duct Testing	Existing Building/Alteration
CEPI-037	R Value Table Slab note g	Editorial/Clarification	CEPI-137	Lighting Section Clean Ups	Editorial/Clarification	CEPI-220	Pool and Spa Reference	Existing Building/Alteration
CEPI-038	R Value Wall Insulation	Editorial/Clarification	CEPI-138	Energy Monitoring	No Direct Quantifiable Impact	CEPI-221	Alterations Building Envelope	Existing Building/Alteration
CEPI-041	Insulation Installation	Editorial/Clarification	CEPI-140	EV Energy Monitoring	Definition	CEPI-225	Definitions and Roof Replacement	Existing Building/Alteration
CEPI-042	Roof Insulation Joints	Editorial/Clarification	CEPI-142	Grid Integrated Inverters	Grid Integration	CEPI-226	Roof Replacement	Existing Building/Alteration
CEPI-043	Steel Assemblies	Editorial/Clarification	CEPI-147	Lighting Control edits	Editorial/Clarification	CEPI-227	Alterations HVAC Controls	Existing Building/Alteration
CEPI-044	Spandrel R-values	Editorial/Clarification	CEPI-148	Lighting emergency 24 hour	Editorial/Clarification	CEPI-228	Alterations Sizing HVAC Equipment	Existing Building/Alteration
CEPI-046	Component Performance	Editorial/Clarification	CEPI-150	Scope of Exterior Lighting	Editorial/Clarification	CEPI-229	Alterations Acceptance Testing	Existing Building/Alteration
CEPI-047	Roof insulation thickness	Editorial/Clarification	CEPI-152	Lighting Safety exception	Editorial/Clarification	CEPI-254	Lighting Units	Editorial/Clarification
CEPI-048	Airspaces	Editorial/Clarification	CEPI-154	Lighting Control exception	Editorial/Clarification	CEPI-257	Glide Path	Appendix
CEPI-060	Elec. Box Air Sealing	Editorial/Clarification	CEPI-156	Dimming Control Min Septoint	Editorial/Clarification			

Of the 41 Proposals with Energy Savings Impacts, 16 Cannot be Reasonably Quantified in the Current Analysis

Number	Description	Reason
CECPI-6-21	Parking Ventilation	Prototypes do not include parking garages
CEPI-029-21	Envelope Mechanical Penet.	Equipment penetrations in prototypes do not meet the 1% threshold
CEPI-031-21	Wall Solar Reflectance	Only applies to CZ 0
CEPI-082-21 Part I	Roof Gutter De-icing	Prototypes do not include roof de-icing equipment
CEPI-084-21	Dehumidification Horticulture	Prototypes do not include horticulture areas
CEPI-085-21	Service Water Pressure-Booster	Service Water Booster pumps are not included in the prototypes
CEPI-121-21	Fan Efficacy Table	Prototypes do not include small fans meeting this requirement.
CEPI-123-21	Bathroom Intermittent Exhaust Control	Prototypes do not include bathrooms with intermittent exhaust
CEPI-124-21	Ceiling Fan Energy Index	Prototypes do not include ceiling fans
CEPI-128-21	High Capacity SWH Efficiency*	Results will be included in final IECC 2024 analysis
CEPI-130-21	Service Water Heating Insulation*	Results will be included in final IECC 2024 analysis
CEPI-181-21	Lighting Unfinished Spaces	Prototypes do not include unfinished areas
CEPI-185-21	Lighting Horticulture	Prototypes do not include horticulture areas
CEPI-217-21	Existing Buildings Additional Efficiency Credits	Analysis is only focused on new construction
CEPI-219-21	Alteration Duct Testing	Analysis is only focused on new construction
CEPI-232-21	Change of Occupancy	Analysis is only focused on new construction

* Capturing the impact of these proposals will require significant enhancements to the prototypes that can be completed if the proposal are included in the final code.