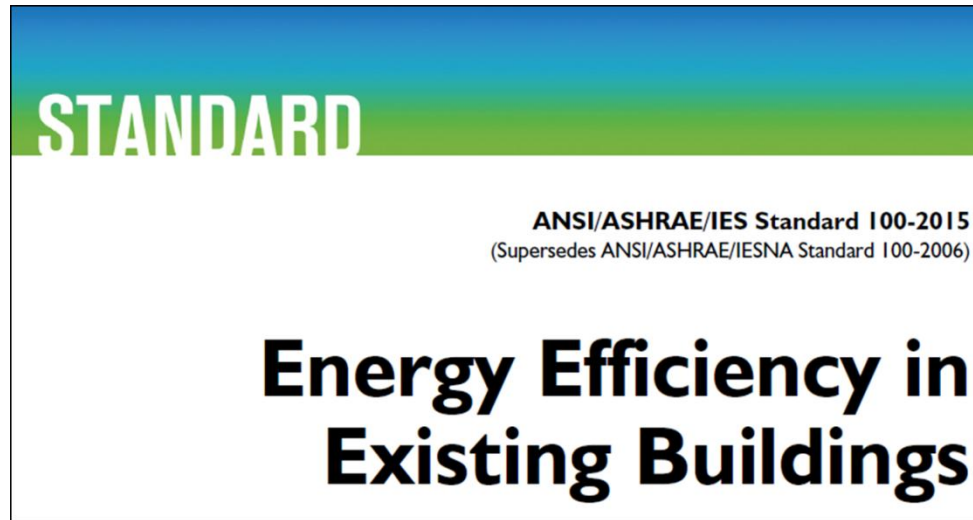


Developing Building Energy Performance Targets For ASHRAE Standard 100



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What's So Cool About Standard 100?

- **Comprehensive** - Covers all building types
- **Simple** measuring stick for compliance -- energy use intensity (EUI)
- **Easy** compliance for high-performers (no energy audit, no building simulation)
- **Flexible** - Two performance levels for authorities
 - Top 25th percentile
 - Top 40th percentile

***GOAL:* Building Total Energy Use Intensity (EUI) Targets To Enable Compliance With An Energy Efficient Building Standard**

Desirable Features:

- EUI targets by building type
- Stringent but reasonable targets that were indicative of energy efficiency
- Local (climate zone or regional) targets
- Strong development foundation

Starting Point: CBECS 2003* (Update coming)

- Real buildings, real energy use data
- Large, U.S. national data set
 - 5,215 observations,
 - 51 building types,
 - 9 regions, 5 climate zones
- Statistically-based sampling
- Updated every 4 years
- Publically available

Desirable Characteristics:

- ✓ EUIs by building type
 - Indicate energy efficiency
- ✓ Local targets
- ✓ Strong foundation

*CBECS 2003 – U.S. EIA Commercial Buildings Energy Consumption Survey; RECS 2005 (residential survey) was added to address residential

Low Observations In Many Building Type/ Climate Zone Bins Limited CBECS Use*

Building Type	CBECS Climate Zone				
	1	2	3	4	5
Admin/professional office	70	141	80	113	68
Bank/other financial	12	21	12	12	
Clinic/other outpatient health	17	29	12	16	14
College/university			11	25	
Convenience store					
Convenience store with gas					
Distribution/shipping center	36	41	31	58	45
Dormitory/fraternity/sorority		12		12	
Elementary/middle school	50	90	38	79	50
Enclosed mall					
Entertainment/culture		16			
Fast food		17		15	
Fire station/police station		13			
Government office	26	30	34	18	16
Grocery store/food market	16	15		16	
High school	22	43	12	20	15
Hospital/inpatient health	24	39	22	39	27
Hotel	11	17	11	21	15
Laboratory		10			

Building Type	CBECS Climate Zone				
	1	2	3	4	5
Medical office (diagnostic)		11			
Mixed-use office	27			35	28
Motel or inn					
Nonrefrigerated warehouse		44			
Nursing home/assisted living					
Other service	16	18	11	22	
Post office/postal center		12			
Preschool/daycare				17	
Recreation	18	21	10	27	10
Refrigerated warehouse					
Religious worship	39	99	35	85	40
Repair shop	10			11	
Restaurant/cafeteria	15	27	18	43	22
Retail store	50	61	52	76	40
Social/meeting	22	14		13	14
Strip shopping mall	38	79	48	90	94
Vehicle dealership/showroom		10		14	
Vehicle service/repair shop	19	34	15	29	13
Vehicle storage/maintenance	34	28		19	

*Blacked out cells are where observations are below 10.

Summary Of Iterative Approach

- Develop national median EUIs by building type
- Determine median EUIs by climate zone
- Determine EUI targets by climate zone
- Develop schedule multipliers for EUIs when two or three shifts exist (via CBECS/RECS analysis)

Step 1: Derive National Energy Use Intensities By Building Type (medians)*

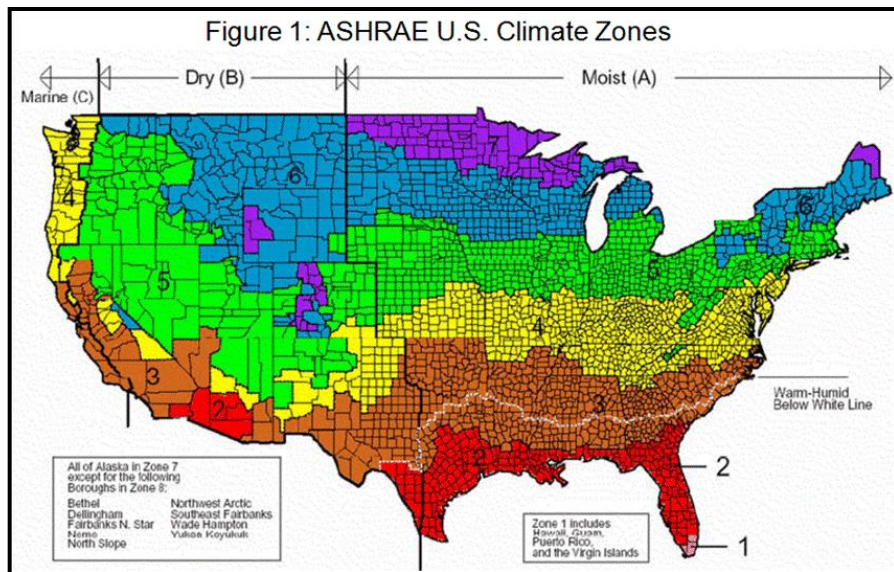
Building Type	EUI*	N
Fast food	419	53
Laboratory	266	31
Convenience store (no gas)	232	19
Restaurant/cafeteria	229	125
Hospital/inpatient	199	171
Grocery store/market	193	59
Nursing home/asst living	126	68
Warehouse (refrigerated)	103	17
Fire/police station	98	38
College/university	97	52
Enclosed mall	90	46
Bank/other financial	87	67
Apartment (2-4 units)	76	309
Hotel	76	75

Building Type	EUI*	N
High school	71	113
Clinic/outpatient	67	88
Admin/prof office	61	481
Elem/middle school	55	307
Medical office	52	27
Retail store	47	279
Single Family (detach)	44	2800
Repair shop	43	36
Social/meeting	41	73
Recreation	40	86
Religious worship	35	298
Entertainment/culture	35	38
Distribution/shipping	34	214
Warehouse	16	158

*Source: 2003 CBECS

Step 2: Use Simulation Results To Proportion National EUIs To Zonal Values*

Zone	Thermal Criteria
1A	$5000 < CDD10^{\circ}C$
2A	$3500 < CDD10^{\circ}C \leq 5000$
3A	$2500 < CDD10^{\circ}C \leq 5000$
6A	$4000 < HDD18^{\circ}C \leq 5000$
7	$5000 < HDD18^{\circ}C \leq 7000$
8	$7000 < HDD18^{\circ}C$



	Miami	Las Vegas	Seattle	Chicago	Helena	Fairbanks
ASHRAE Climate Zone	1A	3B	4C	5A	6B	8
	Ratios of climate zone EUI to average of all zone EUIs					
Large Office	0.9	0.8	1.0	1.1	1.0	1.6
Medium Office	1.0	0.8	0.9	1.1	1.1	1.9
Small Office	0.9	0.7	0.9	1.2	1.2	2.2
Warehouse	0.5	0.5	0.9	1.5	1.7	4.8
Retail	0.9	0.7	0.9	1.2	1.2	2.2
Strip Mall	0.9	0.7	1.0	1.2	1.3	2.3
Primary School	1.0	0.8	0.9	1.1	1.1	1.9
Secondary School	0.9	0.7	1.0	1.2	1.1	2.2
Supermarket	0.8	0.8	1.0	1.1	1.1	1.6
Fast Food	0.9	0.8	1.0	1.1	1.1	1.7
Restaurant	0.9	0.8	1.0	1.1	1.1	1.7
Hospital	1.0	1.0	1.0	1.0	0.9	1.2
Outpatient	1.1	1.0	0.9	1.0	1.0	1.1
Motel	1.1	0.9	0.9	1.0	1.0	1.3
Hotel	0.9	0.9	1.0	1.1	1.1	1.4
Apartment	0.8	0.6	1.0	1.3	1.3	2.3

*<http://energy.gov/eere/buildings/commercial-reference-buildings>

Results: Median EUIs For 16 Climate Zones And 53 Building Types

Energy Use Intensities (EUIs) by Building Type by Climate Zone (kBtu/sf-yr)																
Building Type	ASHRAE Climate Zone															
	1A	2A	2B	3A	3B	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8
Administrative/prof. office	58	60	58	57	47	53	52	63	54	58	68	59	75	67	79	107
Bank/other financial	83	86	83	81	67	75	73	90	77	82	96	83	106	94	112	151
Government office	73	75	73	71	59	66	65	79	68	72	85	73	94	83	98	133
Medical office (non-diagnostic)	50	51	50	49	40	45	44	54	46	49	58	50	64	57	67	91
Mixed-use office	68	70	67	66	54	61	60	73	63	67	79	68	87	77	91	123
Other office	56	58	56	55	45	51	50	61	53	56	66	57	72	64	76	103
Laboratory	252	250	242	248	208	234	226	274	246	253	296	265	328	299	353	468
Distribution/shipping center	46	29	30	29	22	28	24	32	30	28	38	35	45	41	52	81
Non-refrigerated warehouse	22	14	15	14	11	13	12	16	15	14	18	17	22	20	25	39
Convenience store	205	218	207	222	199	206	216	239	219	235	253	234	271	257	290	347
Convenience store with gas	165	176	167	178	160	166	174	193	176	189	204	188	218	207	233	279
Grocery store/food market	171	182	172	185	166	172	180	199	182	196	211	195	226	214	241	289
Other food sales	52	55	52	56	50	52	55	60	55	59	64	59	68	65	73	87
Fire station/police station	93	92	89	91	77	86	83	101	90	93	109	98	121	110	130	172
Other public order and safety	85	84	81	83	70	78	76	92	82	85	99	89	110	100	118	157
Medical office (diagnostic)	45	45	45	44	41	45	39	45	45	40	44	44	46	45	45	53
Clinic/other outpatient health	68	68	68	67	62	68	59	68	67	60	66	66	68	67	68	79
Refrigerated warehouse	98	97	94	96	81	91	87	106	95	98	115	103	127	116	137	181
Religious worship	33	33	32	33	27	31	30	36	32	33	39	35	43	39	46	61
Entertainment/culture	33	33	32	32	27	30	29	36	32	33	39	35	43	39	46	61
Library	87	86	83	85	72	80	78	94	84	87	102	91	113	103	121	161

Step 3: Identify Top 25th and 40th Percentile Performance Levels From EUI Distributions

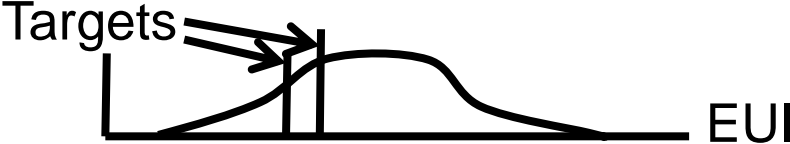


Table 1: Building Total Energy Use Targets (Site Energy)

Energy Use Targets by Building Activity (EUI) (I-P Units)¹

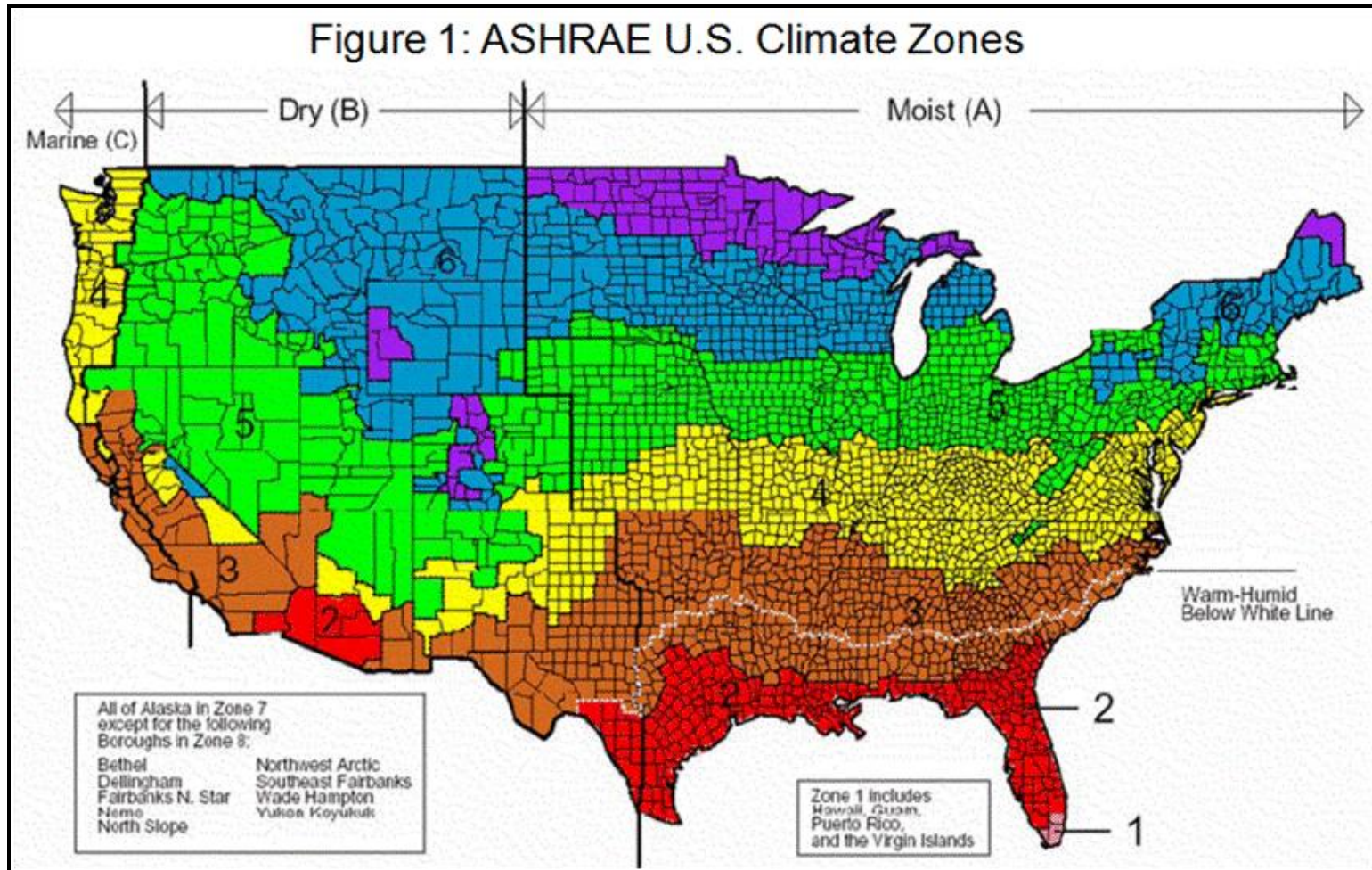
No.	Commercial Building Type	EUIs by Building Type by Climate Zone (kBtu/ft ² -yr)																
		ASHRAE Climate Zone																
		1A	2A	2B	3A	3B Coast	3B Other	3C	4A	4B	4C	5A	5B	5C ²	6A	6B	7	8
1	Admin/professional office	39	40	39	42	33	39	33	46	40	40	48	42	39	54	47	58	81
2	Bank/other financial	55	57	56	59	46	55	47	65	56	57	68	59	56	76	67	82	115
3	Government office	49	50	49	52	41	48	42	57	49	50	60	52	49	67	59	72	101
4	Medical office(non-diagnostic)	33	34	33	35	28	33	28	39	34	34	41	36	33	46	40	49	69
5	Mixed-use office	45	46	45	48	38	45	39	53	46	47	56	48	45	62	55	67	94
6	Other office	38	39	38	40	32	37	32	44	38	39	47	40	38	52	46	56	78
7	Laboratory	178	176	171	175	147	165	159	194	173	179	209	187	181	232	211	249	331
8	Distribution/shipping center	12	16	16	20	11	18	14	27	23	22	36	30	24	49	40	60	113
9	Nonrefrigerated warehouse	6	8	8	10	5	9	7	13	11	11	17	14	12	24	19	29	54
10	Convenience store	135	146	135	152	127	139	141	166	150	157	178	162	167	193	179	208	263
11	Convenience store with gas	108	118	109	122	102	112	114	133	121	126	144	130	135	156	144	168	212
12	Grocery store/food market	112	122	113	127	106	116	118	138	125	131	149	135	139	161	149	174	219
13	Other food sales	34	37	34	38	32	35	36	42	38	40	45	41	42	49	45	53	66
14	Fire station/police station	66	65	63	64	54	61	59	71	64	66	77	69	67	85	78	92	122
15	Other public order and safety	60	59	57	59	49	55	53	65	58	60	70	63	61	78	71	84	111
16	Medical office (diagnostic)	33	32	32	32	30	32	27	32	30	28	30	30	28	31	30	31	35
17	Clinic/other outpatient health	50	48	49	48	45	48	40	48	46	42	46	45	42	47	45	46	52

Step 4: Develop A Means To Normalize For Variances In Operational Hours When Needed To Increase Reliability Of Comparisons

- Impact of operating hours on total building energy use was determined for each building type
- Statistical differences were identified between schedules for each building type
- EUI multipliers developed and available within Standard 100

Building Type	Weekly Hours		
	50 or less	51-167	168
Admin/prof. office	1.0	1.0	1.4
Bank/other financial	1.0	1.0	1.4
Medical office	1.0	1.0	1.4
Elem./middle school	0.8	1.3	1.3
High school	0.8	1.3	1.3
Hospital/inpatient	1.0	1.0	1.0
Nurse home	1.0	1.0	1.0
Hotel	1.0	1.0	1.0
Laboratory	1.0	1.0	1.0
Restaurant/cafeteria	0.4	1.1	2.1
Fast food	0.4	1.1	2.1
Distribution center	0.7	1.4	2.1
Grocery store/market	1.0	1.0	1.4

RESULTS: Targets in Everyone's Backyard -- For 16 Climate Zones (8 ASHRAE Zones Split into Moist, Dry, and Marine Subzones)



Going Forward

- Update targets to 2012 CB ECS survey is coming
- The Standard 100 committee just approved adding optional primary (source) energy based targets
 - Could boost reliability substantially

	Typical Change in Site-Energy Based EUI*	Typical Change in Source-Energy Based EUI*
Miami to Duluth	40%	0%
Miami to Fairbanks	100%	20%

- The Standard 100 committee is seeking to expand the targets for all of North America & beyond

* Source energy is raw fuel from the source; site energy is raw fuel (e.g., oil) delivered to the building added to secondary energy (e.g., electricity).



Questions?

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