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(Supersedes ANSI/ASHRAE/IESNA Standard 100-2006)

Energy Efficiency in Existing Buildings

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TABLE 7-2 Building Activity Energy Targets (EUI_{t1}) (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 (nondiagnostic)	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/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/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
18	Refrigerated warehouse	69	68	66	68	57	64	62	75	67	69	81	72	70	90	82	96	128
19	Religious worship	23	23	22	23	19	22	21	25	23	23	27	25	24	30	28	33	43
20	Entertainment/culture	23	23	22	23	19	21	21	25	23	23	27	24	24	30	28	32	43
21	Library	61	61	59	60	50	57	55	67	60	61	72	64	62	80	73	86	114
22	Recreation	26	26	25	26	22	24	24	29	26	26	31	28	27	34	31	37	49
23	Social/meeting	28	27	26	27	23	26	25	30	27	28	32	29	28	36	33	39	51
24	Other public assembly	28	28	27	28	23	26	25	31	27	28	33	30	29	37	33	39	52
25	College/university	62	61	60	62	45	58	50	72	60	65	78	65	65	90	78	99	147
26	Elementary/middle school	38	37	36	37	30	35	32	41	36	36	42	37	35	46	41	49	72
27	High school	45	45	44	46	33	42	37	52	44	47	57	48	47	66	57	72	107
28	Preschool/daycare	49	48	46	48	39	45	41	52	46	47	54	47	46	60	53	63	93
29	Other classroom education	25	25	25	25	18	24	21	29	25	26	32	27	27	37	32	40	60
30	Fast food	261	268	263	277	237	266	253	305	280	284	332	301	295	364	333	393	497
31	Restaurant/cafeteria	141	145	141	150	126	143	137	166	151	156	179	163	166	195	181	213	268
32	Other food service	77	79	77	82	69	78	75	91	83	85	98	89	91	107	99	116	146
33	Hospital/inpatient health	142	143	140	141	134	138	130	143	129	135	139	126	135	142	130	144	166
34	Nursing home/assisted living	84	83	81	83	69	78	75	91	82	84	99	88	85	109	100	118	156
35	Dormitory/fraternity/sorority	40	43	42	47	31	43	40	58	48	54	65	55	52	75	66	85	119
36	Hotel	50	51	48	52	47	49	48	55	52	52	57	55	53	61	59	65	75
37	Motel or inn	55	53	52	51	48	50	46	52	50	48	53	50	49	56	52	57	69

Notes:

1. Targets listed in Table 7-2 were derived from Commercial Building Energy Consumption Survey (CBECS) 2003 and Residential Energy Consumption Survey (RECS) 2005 data by Oak Ridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE) and represent the 25th bottom (low energy) percentile of energy use by each building category. The median numbers for each building category from CBECS and RECS data representing all buildings in the building type/activity across all climatic conditions were extrapolated to 17 DOE climate zones using multipliers generated through simulation of a representative building for each group of building categories. Informative Annex J gives a detailed explanation of target table derivation.
2. Zone 5C values based on U.S. building stock (A Canadian building sample was not available at the time of table development.)

TABLE 7-2 Building Activity Energy Targets (EUI_{ft}) (I-P Units)[1] *(Continued)*

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
38	Other lodging	53	50	50	49	46	48	44	49	48	46	50	48	47	53	50	55	66
39	Vehicle dealership/showroom	49	50	49	53	38	48	42	60	52	52	68	58	58	78	69	87	124
40	Retail store	28	29	28	30	21	27	24	34	30	30	39	33	33	45	40	50	71
41	Other retail	49	50	49	52	37	48	42	59	52	52	67	58	57	78	69	86	124
42	Post office/postal center	43	42	41	42	35	39	38	46	41	43	50	45	43	56	51	60	79
43	Repair shop	28	28	27	28	23	26	25	31	28	28	33	30	29	37	34	40	53
44	Vehicle service/repair shop	33	33	32	32	27	31	29	36	32	33	39	35	33	43	39	46	61
45	Vehicle storage/maintenance	14	14	14	14	12	13	13	16	14	14	17	15	15	19	17	20	27
46	Other service	60	60	58	59	50	56	54	65	59	60	71	63	61	78	71	84	112
47	Strip shopping mall	59	59	58	62	46	57	51	71	62	63	82	70	71	94	84	106	151
48	Enclosed mall	56	56	55	59	44	54	49	68	59	60	78	67	68	90	80	101	144
No.	Residential Building Type	ASHRAE Climate Zone																
		1A	2A	2B	3A	3B-Coast	3B-Other	3C	4A	4B	4C	5A	5B	5C[2]	6A	6B	7	8
49	Mobile/manufactured home	38	40	40	45	30	41	38	54	45	51	62	52	49	71	62	80	112
50	Single-family detached	28	30	30	33	22	30	28	40	34	38	46	38	36	52	46	60	83
51	Single-family attached	32	34	34	38	25	35	32	46	39	43	53	44	42	60	53	69	96
52	Apartment (in 2–4 unit building)	47	50	50	56	37	51	47	68	57	64	77	65	61	89	78	101	140
53	Apartment (in 5+ unit building)	32	34	34	38	25	35	32	46	39	43	53	44	42	60	53	68	96

Notes:

1. Targets listed in Table 7-2 were derived from Commercial Building Energy Consumption Survey (CBECS) 2003 and Residential Energy Consumption Survey (RECS) 2005 data by Oak Ridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE) and represent the 25th bottom (low energy) percentile of energy use by each building category. The median numbers for each building category from CBECS and RECS data representing all buildings in the building type/activity across all climatic conditions were extrapolated to 17 DOE climate zones using multipliers generated through simulation of a representative building for each group of building categories. Informative Annex J gives a detailed explanation of target table derivation.
2. Zone 5C values based on U.S. building stock (A Canadian building sample was not available at the time of table development.)

8.2.4 Following the completion of the energy audit, the building owner will select and implement EEMs per the requirements of Section 9.

8.3 Energy Audit Requirements for Buildings with Energy Targets

8.3.1 Buildings that Meet their Energy Targets. Buildings that meet their Energy targets under Section 7 are not required to perform an energy audit.

8.3.2 Buildings that Do not Meet their Energy targets Overall Process. An energy audit shall be conducted and an associated energy audit report shall be provided for all buildings that do not meet their energy target. The energy audit shall be completed by a qualified energy auditor practicing within their field of competency. The energy audit shall be at an audit level specified by the qualified energy auditor to be sufficient to identify and evaluate the EEMs that, if implemented, would result in the building meeting its energy target. The qualified energy auditor may refer to the list of potential EEMs in Informative Annex E.

After the completion of the audit and the selection of EEMs to be implemented, the applicant must calculate an adjusted EUI for the building, based on the estimated energy savings from the selected EEMs and the historical energy use of the building. This adjusted EUI is then compared to the energy target for the building. If the adjusted EUI is less than the energy target, the applicant shall proceed with implementation (see Section 9). If the adjusted EUI is greater than the energy target, a more rigorous energy audit investigation is required to identify additional EEMs. This process is repeated until the building's adjusted EUI is less than its energy target.

Calculation of the adjusted EUI is shown in the following equation:

$$EUI_{adj} = (Energy_{hist} - Energy_{saved})/GFA$$

where

$Energy_{hist}$ = historical annual energy use, kBtu (MJ)

$Energy_{saved}$ = estimated annual energy savings, kBtu (MJ)

GFA = gross floor area, ft^2 (m^2)

TABLE 7-2 Building Activity Energy Targets (EUI_H) (SI Units)[1]

No.	Commercial Building Type	EUIs by Building Type by Climate Zone ($MJ/m^2 \cdot yr$)																
		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	443	456	446	472	372	440	379	518	449	458	547	475	446	608	536	657	921
2	Bank/other financial	628	648	633	670	528	625	537	735	637	651	777	673	633	864	761	932	1307
3	Government office	553	570	556	589	464	550	473	646	560	572	683	592	556	759	669	820	1149
4	Medical office (nondiagnostic)	377	389	380	402	317	375	322	441	382	390	466	404	380	518	457	559	784
5	Mixed-use office	512	528	516	546	430	509	438	599	519	530	633	549	516	704	620	760	1065
6	Other office	428	441	431	456	359	425	366	500	433	443	529	458	431	588	518	634	889
7	Laboratory	2025	2001	1939	1988	1668	1873	1806	2199	1968	2029	2374	2125	2055	2633	2399	2830	3759
8	Distribution/shipping center	140	178	187	227	121	202	163	306	256	248	403	340	271	558	458	682	1280
9	Nonrefrigerated warehouse	68	86	90	110	59	98	79	148	124	120	195	164	131	270	221	330	619
10	Convenience store	1528	1657	1538	1727	1442	1577	1606	1882	1700	1783	2027	1837	1898	2198	2032	2368	2987
11	Convenience store with gas	1231	1335	1239	1391	1161	1270	1294	1516	1370	1436	1633	1480	1529	1770	1637	1907	2407
12	Grocery/food market	1273	1381	1282	1439	1201	1314	1339	1568	1417	1486	1689	1531	1582	1831	1693	1973	2489
13	Other food sales	386	418	388	436	364	398	405	475	429	450	511	463	479	554	513	597	754
14	Fire/police station	746	737	714	732	614	690	665	810	725	747	874	782	757	970	883	1042	1384
15	Other public order and safety	679	672	651	667	560	629	606	738	660	681	797	713	690	884	805	950	1262
16	Medical office (diagnostic)	380	366	369	364	341	365	304	360	346	320	346	337	319	353	342	348	397
17	Clinic/other outpatient health	570	549	554	546	512	548	456	540	519	480	518	506	478	530	514	522	595
18	Refrigerated warehouse	784	775	751	770	646	726	700	852	762	786	920	823	796	1020	929	1096	1456
19	Religious worship	266	263	255	261	219	246	237	289	259	267	312	279	270	346	315	372	494
20	Entertainment/culture	264	261	253	259	217	244	235	286	256	264	309	277	268	343	312	369	490
21	Library	696	688	667	684	574	644	621	756	677	698	816	731	707	905	825	973	1293
22	Recreation	300	297	287	295	247	278	268	326	292	301	352	315	305	390	356	420	557
23	Social/meeting	313	309	300	307	258	290	279	340	304	314	367	329	318	407	371	438	581
24	Other public assembly	321	317	307	315	264	297	286	348	312	321	376	337	326	417	380	448	595
25	College/university	701	697	683	709	509	661	573	817	682	734	888	740	739	1028	882	1125	1668
26	Elementary/middle school	429	422	408	424	345	395	363	463	406	410	479	418	401	525	465	556	818
27	High school	512	508	499	518	372	482	418	596	498	536	648	540	539	750	644	821	1217
28	Preschool/daycare	553	544	526	547	445	510	468	596	523	529	618	538	518	677	599	717	1055
29	Other classroom education	286	284	279	290	208	270	234	333	278	300	362	302	302	419	360	459	681
30	Fast food	2970	3045	2983	3148	2693	3018	2870	3470	3180	3223	3767	3420	3353	4130	3785	4463	5646
31	Restaurant/cafeteria	1605	1651	1599	1709	1429	1620	1557	1882	1720	1769	2038	1846	1882	2220	2051	2420	3044
32	Other food service	877	902	874	934	781	886	851	1029	940	967	1114	1009	1029	1213	1121	1323	1664
33	Hospital/inpatient health	1610	1624	1591	1602	1518	1570	1481	1628	1462	1533	1578	1435	1529	1615	1482	1631	1882
34	Nursing home/assisted living	955	944	915	938	787	884	852	1038	929	958	1120	1002	970	1243	1132	1335	1774
35	Dormitory/fraternity/sorority	457	483	480	538	357	493	456	656	549	613	744	626	586	852	753	968	1352
36	Hotel	563	576	548	585	530	553	548	621	590	594	653	622	599	694	668	735	852
37	Motel or inn	630	598	595	579	542	573	528	586	565	543	600	572	556	634	595	650	779

Notes:

1. Targets listed in Table 7-2 were derived from Commercial Building Energy Consumption Survey (CBECS) 2003 and Residential Energy Consumption Survey (RECS) 2005 data by Oak Ridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE) and represent the 25th bottom (low energy) percentile of energy use by each building category. The median numbers for each building category from CBECS and RECS data representing all buildings in the building type/activity across all climatic conditions were extrapolated to 17 DOE climate zones using multipliers generated through simulation of a representative building for each group of building categories. Informative Annex J gives a detailed explanation of target table derivation.
2. Zone 5C values based on U.S. building stock (A Canadian building sample was not available at the time of table development.)

TABLE 7-2 Building Activity Energy Targets (EUI_{t1}) (SI Units)[1] *(Continued)*

No.	Commercial Building Type	EUIs by Building Type by Climate Zone ($MJ/m^2 \cdot yr$)																
		ASHRAE Climate Zone																
		1A	2A	2B	3A	3B Coast	3B Other	3C	4A	4B	4C	5A	5B	5C[2]	6A	6B	7	8
38	Other lodging	602	571	568	553	518	547	505	560	540	519	573	547	531	606	568	621	745
39	Vehicle dealership/showroom	557	570	555	598	427	542	479	677	588	589	768	663	655	886	784	985	1413
40	Retail store	319	326	318	342	244	310	274	387	336	337	439	379	375	507	449	564	808
41	Other retail	555	568	553	595	425	540	478	674	586	587	765	660	652	883	782	981	1407
42	Post office/postal center	485	479	464	476	400	449	433	527	471	486	569	509	492	631	574	678	900
43	Repair shop	323	319	309	317	266	299	288	351	314	324	379	339	328	420	383	451	600
44	Vehicle service/repair shop	375	370	359	368	309	347	334	407	364	376	439	393	380	487	444	524	696
45	Vehicle storage/maintenance	163	161	156	160	134	150	145	177	158	163	191	171	165	212	193	227	302
46	Other service	685	677	656	672	564	634	611	744	666	686	803	719	695	891	811	957	1271
47	Strip shopping mall	669	668	654	705	520	647	580	812	702	721	929	797	808	1072	952	1200	1716
48	Enclosed mall	637	636	623	671	495	616	552	773	669	686	885	759	770	1021	906	1143	1634
No.	**Residential Building Type**	**ASHRAE Climate Zone**																
		1A	2A	2B	3A	3B-Coast	3B-Other	3C	4A	4B	4C	5A	5B	5C[1]	6A	6B	7	8
49	Mobile/manufactured home	430	454	452	506	336	464	429	617	516	577	699	589	553	801	708	911	1272
50	Single-family detached	319	337	335	376	250	344	318	458	383	428	519	437	410	595	526	676	944
51	Single-family attached	367	388	386	432	287	396	366	527	441	493	598	503	472	685	605	778	1087
52	Apartment (in 2-4 unit building)	539	570	567	635	422	582	538	774	647	723	877	739	693	1006	888	1142	1595
53	Apartment (in 5+ unit building)	367	388	385	432	287	396	366	526	440	492	597	503	472	684	604	777	1085

Notes:

1. Targets listed in Table 7-2 were derived from Commercial Building Energy Consumption Survey (CBECS) 2003 and Residential Energy Consumption Survey (RECS) 2005 data by Oak Ridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE) and represent the 25th bottom (low energy) percentile of energy use by each building category. The median numbers for each building category from CBECS and RECS data representing all buildings in the building type/activity across all climatic conditions were extrapolated to 17 DOE climate zones using multipliers generated through simulation of a representative building for each group of building categories. Informative Annex J gives a detailed explanation of target table derivation.
2. Zone 5C values based on U.S. building stock (A Canadian building sample was not available at the time of table development.)

Following the completion of an energy audit that has identified EEMs sufficient to meet the building's energy target, the applicant shall implement those EEMs per the requirements of Section 9.

Exception: Buildings that have completed an energy audit within the previous three years may use the previous energy audit to identify EEMs for implementation, provided that the scope of the energy audit meets the requirements of this section and there have been minimal changes to the systems within the audit scope. In this case, the same comparison of adjusted EUI to energy target shall be made by the applicant. If the EEMs identified in the audit are still applicable, have not been implemented, and if implemented would result in the building meeting its energy target, these measures shall be implemented by the facility, and the project shall follow the procedures in Section 9. If the identified EEMs do not result in an adjusted EUI less than the energy target, a new energy audit shall be conducted as described Section 8.3.2.

8.4 Energy Audit Levels. This section outlines the requirements for Level 1 and Level 2 energy audits for buildings.

8.4.1 Level 1 Audit. Buildings shall perform a Level 1 audit (walk-through analysis) as defined in ASHRAE's *Procedures for Commercial Building Energy Audits,* 2nd Edition.[5]

8.4.2 Level 2 Audit. Buildings shall perform a Level 2 Audit (energy survey and engineering analysis) as defined in ASHRAE's *Procedures for Commercial Building Energy Audits,* 2nd Edition.[5]

8.5 Energy Audit Report. This section prescribes the overall approaches and methods to be used in the energy audit report for audits completed under Sections 8.4.1 or 8.4.2.

8.5.1 Audit Results. The energy audit report shall define the actions necessary for the building owner to achieve the energy and cost savings that are recommended in the report.

Energy audit results shall be presented in a summary table that includes at a minimum an estimate of each of the following:

- A list of recommended EEMs that, if implemented, will either meet the energy target for the building if it has a

TABLE 7-3 Building Operating Shifts Normalization Factor

No.	Building Activity/Type	Weekly Hours		
		50 or less	51 to 167	168
1	Admin/professional office	1.0	1.0	1.4
2	Bank/other financial	1.0	1.0	1.4
3	Government office	1.0	1.0	1.4
4	Medical office (nondiagnostic)	1.0	1.0	1.4
5	Mixed-use office	1.0	1.0	1.4
6	Other office	1.0	1.0	1.4
7	Laboratory	1.0	1.0	1.0
8	Distribution/ship center	0.7	1.4	2.1
9	Nonrefrigerated warehouse	0.7	1.4	2.1
10	Convenience store	1.0	1.0	1.4
11	Convenience store and gas	1.0	1.0	1.4
12	Grocery/food market	1.0	1.0	1.4
13	Other food sales	1.0	1.0	1.4
14	Fire/police station	0.8	0.8	1.1
15	Other public order/safety	0.8	0.8	1.1
16	Medical office (diagnostic)	1.0	1.0	1.5
17	Clinic/other outpatient health	1.0	1.0	1.5
18	Refrigerated warehouse	1.0	1.0	1.0
19	Religious worship	0.9	1.7	1.7
20	Entertainment/culture	0.8	1.5	1.5
21	Library	0.8	1.5	1.5
22	Recreation	0.8	1.5	1.5
23	Social/meeting	0.8	1.5	1.5
24	Other public assembly	0.8	1.5	1.5
25	College/university	0.8	1.3	1.3
26	Elementary/middle school	0.8	1.3	1.3
27	High school	0.8	1.3	1.3
28	Preschool/daycare	0.8	1.3	1.3
29	Other classroom education	0.8	1.3	1.3
30	Fast food	0.4	1.1	2.1
31	Restaurant/cafeteria	0.4	1.1	2.1
32	Other food service	0.4	1.1	2.1
33	Hospital/inpatient health	1.0	1.0	1.0
34	Nursing home/assisted living	1.0	1.0	1.0
35	Dormitory/fraternity/sorority	1.0	1.0	1.0
36	Hotel	1.0	1.0	1.0
37	Motel or inn	1.0	1.0	1.0
38	Other lodging	1.0	1.0	1.0
39	Vehicle dealership/showroom	0.8	1.2	1.8
40	Retail store	0.8	1.2	1.8
41	Other retail	0.8	1.2	1.8
42	Post office/postal center	0.7	1.5	1.5
43	Repair shop	0.7	1.5	1.5
44	Vehicle service/repair shop	0.7	1.5	1.5
45	Vehicle storage/maintenance	0.7	1.5	1.5
46	Other service	0.7	1.5	1.5
47	Strip shopping mall	1.0	1.0	1.0
48	Enclosed mall	1.0	1.0	1.0

No.	Residential building Activity/Type	Weekly Hours		
		50 or less	51 to 167	168
49	Mobile home	1.0	1.0	1.0
50	Single-family detached	1.0	1.0	1.0
51	Single-family detached	1.0	1.0	1.0
52	Apartment building (2–4 units)	1.0	1.0	1.0
53	Apartment building (5+ units)	1.0	1.0	1.0

target or, if it does not have an energy target, will meet the economic criteria set by the standard in Section 9.

- The estimated energy savings and peak demand savings associated with each recommended EEM, expressed in the cost units used on the building owner's energy bills, and the units used for comparison with the energy target.
- The estimated (modeled) energy cost savings associated with each recommended EEM.
- The estimated cost of implementation for each recommended EEM. The costs of implementation shall include the required monitoring of energy savings per the requirements of Section 9.
- The simple payback or return on investment (ROI) for each recommended EEM or bundle of EEMs.
- The simple payback of the optimized bundle of EEMs that will achieve the energy target for buildings with energy targets or meet the financial criteria set out in the standard for buildings that do not have energy targets.

When considering multiple EEMs with interactive effects, the order of analysis shall start with load reduction

(This annex is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE ANNEX E
ENERGY EFFICIENCY MEASURES

This informative annex provided categorized listings of typical energy efficiency measures (EEMs) that can be applied to enable buildings to meet the set energy targets. It identifies commonly applied elements that can improve building performance but is not intended to suggest specific requirements, nor does it comprehensively covered all of the options available to an owner.

Measures included in these listings are intended to improve energy efficiency and reduce overall energy use. They are not intended to encourage fuel switching unless such actions as installation of cogeneration, trigeneration, or combined heating and cooling plants would result in overall reduction in total energy used.

Some measures, such as demand response/control, may also save energy as an incidental side benefit. Other measures may result in extension of the capacity of given infrastructure systems and/or the ability for energy efficiency to defer or eliminate the need for plant expansions. Such results can be factored into the resulting return on investment or life-cycle cost analysis.

E1. BUILDING ENVELOPE

E1.1 Walls

E1.1.1 Insulate Walls. Retrofit insulation can be external and internal.

E1.1.1.1 External post insulation makes large savings possible, as this type of insulation contributes not only to a reduction of the heat loss through large wall surfaces but also eliminates the traditional thermal bridges where floor and internal wall are anchored in the exterior wall.

E1.1.1.2 Internal insulation is typically used when external insulation is not allowed (e.g., for historical buildings).

E1.1.2 Insulate cavity walls using spray-in insulation.

E1.1.3 Consider converting internal courtyard into an atrium to reduce external wall surface.

E1.2 Roofs

E1.2.1 Use "cool roof" (high-reflectance roofing material) with reroofing projects.

E1.2.2 Determine roof insulation values and recommend roof insulation as appropriate.

E1.2.3 Insulate ceilings and roofs using spray-on insulation.

E1.2.4 Where appropriate, exhaust hot air from attics.

E1.3 Floors

E1.3.1 Insulate floors.

E1.3.2 Insulate floors using spray-on insulation.

E1.3.3 Insulate basement wall with a slab over unheated basement.

E1.4 Windows

E1.4.1 Replace single-pane and leaky windows with thermal/operable windows to minimize cooling and heating loss.

E1.4.2 Install exterior shading, such as blinds or awnings, to cut down on heat loss and to reduce heat gain.

E1.4.3 Install storm windows and multiple glazed windows.

E1.4.4 Use tinted or reflective glazing or energy control/solar window films.

E1.4.5 Replace existing fenestration (toplighting and/or sidelighting) with dual-glazed low-e glass wherever possible to reduce thermal gain.

E1.4.6 Adopt weatherization/fenestration improvements.

E1.4.7 Consider replacing exterior windows with insulated glass block when visibility is not required but light is required.

E1.4.8 Landscape/plant trees to create shade and reduce air-conditioning loads.

E1.5 Doors

E1.5.1 Prevent heat loss through doors by draft sealing and thermal insulation.

E1.5.2 Install automatic doors, air curtains, or strip doors at high-traffic passages between conditioned and unconditioned spaces.

E1.5.3 Use self-closing or revolving doors and vestibules if possible.

E1.5.4 Install high-speed doors between heated/cooled building space and unconditioned space in the areas with high-traffic passages.

E1.6 Install separate smaller doors for people near the area of large vehicle doors air leakage (see Informative Appendix E).

E1.6.1 Seal top and bottom of building.

E1.6.2 Seal vertical shafts, stairways, outside walls, and openings.

E1.6.3 Compartmentalize garage doors and mechanical and vented internal and special-purpose rooms.

E1.7 Moisture Penetration

E1.8 Reduce air leakage.

E1.9 Install vapor barriers in walls, ceilings, and roofs.

E2. HVAC SYSTEMS

E2.1 Ventilation

E2.1.1 Reduce HVAC systems outdoor airflow rates when possible. Minimum outdoor airflow rates should comply with ANSI/ASHRAE Standard 62.1[9] or local code requirements.

E2.1.2 Reduce minimum flow settings in single-duct and dual-duct variable-air-volume (VAV) terminals as low as is practical to meet ventilation requirements.

E2.1.3 Minimize exhaust and makeup (ventilation) rates when possible by complying with the most stringent federal, state, and/or local code requirements.

E2.1.4 When available, use operable windows for ventilation during mild weather (natural ventilation) when outdoor conditions are optimal. Confirm that the facility has been designed for natural ventilation and that control strategies are available to operate the facility in the natural ventilation mode.

E2.1.5 Eliminate outside air ventilation during unoccupied building morning warm up.

E2.1.6 Convert mixing air supply systems into displacement ventilation systems to create a temperature stratification in spaces with high ceilings and predominant cooling needs.

E2.1.7 Consider replacement of all-air HVAC system with a combination of a dedicated outdoor air system coupled with radiant cooling and heating systems.

E2.1.8 Convert constant-volume central exhaust systems into demand-based controlled central exhaust systems when possible.

E2.1.9 Convert HVAC systems to provide ventilation in accordance with ANSI/ASHRAE Standard 62.1.[9]

E2.2 HVAC Distribution Systems

E2.2.1 Convert a constant-air-volume system (CAV) (including dual duct, multizone, and constant-volume reheat systems) into a VAV system with variable speed drives (VFDs) on fan motors. A VAV system is designed to deliver only the volume of air needed for conditioning the actual load.

E2.2.2 Control VAV system VFD speed based on the static pressure needs in the system. Reset the static pressure set point dynamically, as low as is practical to meet the zone setpoints.

E2.2.3 Reset VAV system supply air temperature setpoint when system is at minimum speed to provide adequate ventilation.

E2.2.4 If conversion to VAV from CAV systems is impractical, reset supply air temperatures in response to load. Dynamically control heating duct temperatures as low as possible, and cooling duct temperatures as high as possible, while meeting the load.

E2.2.5 Use high-efficiency fans and pumps; replace or trim impellers of existing fans if they have excessive capacity relative to peak demand.

E2.2.6 Install higher efficiency air filters/cleaners in HVAC system. Size ducts and select filter sizes for low face velocity to reduce pressure drop where available space permits.

E2.2.7 Insulate HVAC ducts and pipes, particularly where they are outside the conditioned space. Ensure that duct insulation and vapor barrier is maintained or enhanced to ensure thermal performance and avoid water vapor intrusion.

E2.2.8 Check for air leaks in HVAC duct systems, and seal ductwork as indicated.

E2.2.9 Rebalance ducting and piping systems.

E2.2.10 Provide cooling effect by creating air movement with fans.

E2.2.11 Select cooling coils with a face velocity range of 300 to 350 fpm (1.5 to 1.75 m/s) to reduce the air pressure drop across the cooling coil and increase the chilled-water system temperature differential across the system.

E2.2.12 Replace standard fan belts with fan belts designed for minimum energy losses, such as cog belts.

E2.2.13 Eliminate or downsize existing HVAC equipment in an existing building or group of buildings when improvements in building envelope, reductions in lighting or plug loads, and other EEMs that reduce cooling or heating loads have been implemented.

E2.2.14 Eliminate HVAC usage in vestibules and unoccupied spaces.

E2.2.15 Minimize direct cooling/heating of unoccupied areas by system zone controls, occupancy sensors or by turning off fan-coil units and unit heaters.

E2.2.16 Replace forced-air heaters with low- or medium-temperature radiant heaters.

E2.2.17 Replace inefficient window air conditioners with high-efficiency (i.e., high SEER rating) modular units or central systems.

E2.2.18 Employ heat recovery from exhaust air and processes for preheating or precooling incoming outdoor air or supply air.

E2.2.19 Install transpired air heating collector (solar wall) for ventilation air preheating.

E2.2.20 Modify controls and/or systems to implement night precooling to reduce cooling energy consumption the following day.

E2.2.21 Use waste heat (e.g., hot gas, return air heat, return hot water) as an energy source for reheating for humidity control. (Often air is cooled to dew-point to remove moisture and then must be reheated to desired temperature and humidity.)

E2.2.22 Avoid temperature stratification with heating, either by proper air supply system design or by using temperature destratifiers (e.g., ceiling fans).

E2.2.23 In humid climates, supply air with a temperature above the dew point to prevent condensation on cold surfaces.

E2.2.24 Insulate fan-coil units and avoid their installation in unconditioned spaces.

E2.2.25 Clean heat exchangers (to maintain heat exchange efficiency) in the evaporators and condensers of refrigeration equipment on a seasonal basis.

E2.2.26 Use high-efficiency dehumidification systems based on either dedicated outdoor air systems (DOAS) or VAV systems.

E2.2.27 Identify if there are any rogue zones (i.e., zones that determine the cooling or heating demand on the entire system) in a multiple-zone air-handling system, and modify them to eliminate their negative impact.

E2.2.28 Modify supply duct systems to eliminate duct configurations that impose high friction losses on the system.

E2.2.29 Convert three-pipe heating/cooling distribution systems to four-pipe or two-pipe systems. Eliminate simultaneous heating and cooling through mixed returns.

E2.2.30 Convert steam or compressed air humidifiers to ultrasonic or high-pressure humidifiers.

E2.2.31 Replace mechanical dehumidification with desiccant systems using heat-recovery regeneration.

E2.2.32 Consider small unitary systems for small zones with long or continuous occupancy. Avoid running large distribution systems to meet needs of small, continuously occupied spaces.

E2.2.33 Install thermostatic control valves on uncontrolled or manually controlled radiators.

E2.2.34 Replace unitary systems with newer units with high-efficiency and high SEER ratings.

E2.2.35 Install evaporative precooling for direct-expansion (DX) systems.

E2.2.36 Install air-side heat recovery for systems using 100% makeup air (e.g., run-around piping or energy exchange wheels).

E2.2.37 In reheat systems, making adjustments as necessary to minimize reheat energy consumption while maintaining indoor environmental quality.

E2.2.38 In multiple-zone systems, identify any rogue zones that consistently cause the reset of system level setpoints in order to satisfy that one zone's heating or cooling demands.

E2.3 Building Automation and Control Systems

E2.3.1 Create building/air-conditioned space zones with separate controls to suit solar exposure and occupancy.

E2.3.2 Use night setback, or turn off HVAC equipment when building is unoccupied.

E2.3.3 Install occupancy sensors with VAV systems; set back temperatures and shut off boxes.

E2.3.4 Install system controls to reduce cooling/heating of unoccupied space.

E2.3.5 Lower heating and raise cooling temperature setpoints to match the comfort range prescribed in ANSI/ASHRAE Standard 55.[8]

E2.3.6 Install an air-side and/or water-side economizer cycle with enthalpy switchover when compatible with the existing equipment, space occupancy, and distribution system

E2.3.7 Schedule off-hour meetings in a location that does not require HVAC in the entire facility.

E2.3.8 Retrofit multiple-zone VAV systems with direct digital controls (DDC) controllers at the zone level, and implement supply air duct pressure reset to reduce supply air duct pressure until at least one zone damper is nearly wide open.

E2.3.9 Eliminate duplicative zone controls (e.g., multiple thermostats serving a single zone with independent controls).

E2.3.10 Adjust hot-water and chilled-water temperature to develop peak-shaving strategies based on an outside air temperature reset schedule.

E2.3.11 Adjust housekeeping schedule to minimize HVAC use.

E2.3.12 Install programmable zone thermostats with appropriate deadbands.

E2.3.13 Use variable-speed drives (VSDs) and DDC on water circulation pump and fan motors and controls.

E2.3.14 Reduce operating hours of complementing heating and cooling systems. Ensure proper location of thermostat to provide balanced space conditioning.

E2.3.15 Implement an energy management system (EMS) designed to optimize and adjust HVAC operations based on environmental conditions, changing uses, and timing.

E3. REFRIGERATION

E3.1 Reduce Loads

E3.1.1 Install strip curtains or automatic fast open and close doors on refrigerated space doorways.

E3.1.2 Replace open refrigerated cases with reach-in refrigerated cases.

E3.1.3 Replace old refrigerated cases with new high-efficiency models (improved glazing, insulation, motor efficiency, and reduced antisweat requirements).

E3.1.4 Replace worn door gaskets.

E3.1.5 Replace broken or missing automatic door closers.

E3.1.6 Check defrost schedules and avoid excessive defrost.

E3.1.7 Repair/install refrigeration piping insulation on suction lines.

E3.1.8 Install humidity-responsive antisweat heating (ASH) controls on refrigerated case doors.

E3.1.9 Install refrigerated case, walk-in, or storage space lighting controls (scheduled and/or occupancy sensors).

E3.1.10 Install night covers to reduce infiltration in open cases.

E3.1.11 Install low/no ASH refrigerated case doors.

E3.1.12 Replace lights with LED strip lights with motion sensors in refrigerated cases and spaces.

E3.1.13 Increase insulation on walk-in boxes and storage spaces that have visible moisture or ice on walls, corners, etc. Ensure that insulation and vapor barrier are maintained or enhanced to ensure thermal performance and avoid water vapor intrusion.

E3.2 Improve System Operating Efficiency

E3.2.1 Clean condenser coils.

E3.2.2 Check the refrigerant charge and add when needed.

E3.2.3 Reclaim heat from hot gas line for domestic water heating or space heating.

E3.2.4 Install floating-head pressure controls, adjustable-head pressure control valve, and balanced port expansion valves for DX systems.

E3.2.5 Install floating suction pressure controls on DX systems.

E3.2.6 Install evaporator fan motor VSDs and controllers in walk-ins and refrigerated storage spaces.

E3.2.7 Replace single-phase, less than 1-hp evaporator fan motors with electrically commutated motors.

E3.2.8 Replace three-phase evaporator and condenser motors with premium efficiency motors.

E3.2.9 Replace single compressor systems with multiplex systems and control system.

E3.2.10 Install mechanical subcooling.

E3.2.11 Install mechanical unloaders on appropriate multiplex reciprocating semihermetic compressors.

E3.2.12 Install VFD on ammonia screw compressors.

E3.2.13 Install high specific-efficiency (Btu/W) condensers.

E3.2.14 Install hybrid air-cooled/evaporative-cooled condensers.

E4. WATER SYSTEMS

E4.1 Domestic Hot-Water Systems

E4.1.1 Lower domestic water setpoint temperatures to 120°F (49°C)

E4.1.2 Install point-of-use gas or electric water heaters.

E4.1.3 Install water-heater blankets on water heaters.

E4.1.4 Where permitted by the manufacturer, and in conjunction with the manufacturer's control system, install automatic flue dampers on fuel-fired water heaters.

E4.1.5 Insulate hot-water pipes.

E4.1.6 Reclaim heat from waste water, refrigeration systems, cogeneration, or chillers.

E4.1.7 Install solar heating where applicable.

E4.1.8 Replace dishwashers by installing low-temperature systems that sanitize primarily through chemical agents rather than high water temperatures.

E4.1.9 Retrofit dishwashers by installing electric-eye or sensor systems in conveyor-type machines so that the presence of dishes moving along the conveyor activates the water flow.

E4.1.10 Reduce operating hours for water-heating systems.

E4.1.11 Install gray water heat recovery from showers, dishwashers, and washing machines.

E4.1.12 Install low-flow dishwashing prewash spray nozzles.

E4.1.13 Replace outdated laundry equipment with newer models.

E4.2 Water Conservation

E4.2.1 Replace faucets with units that have infrared sensors or automatic shutoff.

E4.2.2 Install water flow restrictors on shower heads and faucets.

E4.2.3 Install covers on swimming pools and tanks.

E4.2.4 Install devices to save hot water by pumping water in the distribution lines back to the water heater so that hot water is not wasted. Install industrial waste/sewage metering.

E4.2.5 Install water metering.

E4.2.6 Install landscape irrigation timers to schedule sprinkler use to off-peak, night, or early morning hours when water rates are cheaper and water used is less likely to evaporate.

E4.2.7 Use low-flow sprinkler heads for landscape irrigation instead of turf sprinklers in areas with plants, trees, and shrubs.

E4.2.8 Use sprinkler controls for landscape irrigation that employ soil tensiometers or electric moisture sensors to help determine when soil is dry and to gauge the amount of water needed.

E4.2.9 Use trickle or subsurface drip systems for landscape irrigation that provide water directly to turf roots, preventing water loss by evaporation and runoff.

E4.2.10 Install low-flow toilets and waterless urinals

E4.2.11 Use water reclamation techniques.

E5. ENERGY GENERATION AND DISTRIBUTION

E5.1 Boiler System

E5.1.1 Install air-atomizing and low NOx burners for oil-fired boiler

E5.1.2 Investigate economics of adding insulation on presently insulated or uninsulated lines. If pipe or duct insulation is missing, replace it with new material. Ensure that the pipe insulation and vapor barrier is maintained or enhanced to ensure thermal performance and avoid water vapor intrusion.

E5.1.3 Review mechanical standby turbines presently left in the idling mode.

E5.1.4 Review operation of steam systems used only for occasional services, such as winter-only tracing lines.

E5.1.5 Review pressure-level requirements of steam-driven mechanical equipment to consider using lower exhaust pressure levels.

E5.1.6 Survey condensate presently being discharged to waste drains for feasibility of reclaim or heat recovery.

E5.1.7 Reduce boiler operating pressure to minimize heat losses through leakage.

E5.2 Chiller System

E5.2.1 Chiller retrofits with equipment that has high efficiency at full and part load.

E5.2.2 Cooling tower retrofits including high-efficiency fill, VSD fans, fiberglass fans, hyperbolic stack extensions, fan controls, VSD pump drives, and improved distribution nozzles.

E5.2.3 Install economizer cooling systems (HX between cooling tower loop and chilled-water loop before the chiller).

E5.2.4 Install evaporative cooled, evaporative precooled, or water-cooled condensers in place of air-cooled condensers.

E5.2.5 Isolate offline chillers and cooling towers.

E5.2.6 Reduce overpumping on chilled-water systems.

E5.2.7 Replace single compressor with multiple different-size staged compressors.

E5.2.8 Compressor motors.

E5.2.9 Use of absorption chiller when there is cogeneration system, waste heat, or solar thermal available.

E5.2.10 Install double-bundle chillers for heat recovery.

E5.2.11 Free cooling cycle by piping chilled water to condenser during cold weather.

E5.2.12 Prevent chilled water or condenser water flowing through the offline chiller. Chillers can be isolated by turning off pumps and closing valves.

E5.2.13 For equipment cooling, control makeup water and reduce blowdown by adding temperature control valves to cooling water discharge lines in equipment such as air compressors and refrigeration systems.

E5.2.14 For evaporative cooling systems, install drift eliminators or repair existing equipment.

E5.2.15 For evaporative cooling systems, install softeners for makeup water, side-stream filtration (including nanofiltration, a form of low-pressure reverse osmosis), and side stream injection of ozone.

E5.2.16 For evaporative cooling systems, install submeters for makeup water and bleed-off water for equipment such as cooling towers that use large volumes of water.

E5.2.17 Evaporative cooling systems control cooling tower bleed off based on conductivity by allowing bleed off within a high and narrow conductivity range. This will achieve high cycles of concentration in the cooling system and reduce water use in cooling towers.

E5.2.18 Clean evaporator and condenser surfaces of fouling.

E5.2.19 Optimize plant controls to raise evaporator temperature as high as possible while meeting system loads. Also optimize condenser water temperature control to achieve best combination of chiller and tower efficiency.

E5.2.20 Optimize multiple chiller sequencing.

E5.2.21 Control crankcase heaters off when they're not needed.

E5.2.22 Raise evaporator or lower condenser water temperature.

E5.2.23 Optimize multiple chiller sequencing.

E5.2.24 Use two-speed or variable-speed fans instead of water bypass to modulate the cooling tower capacity.

E5.2.25 Balance water flow in the chilled-water system.

E5.2.26 Use VFDs for the primary chilled-water pumps above 5 hp (3.7 kW). Consult chiller and tower manufacturers' specifications to set appropriate minimum flow limits.

E5.2.27 Apply cooling load-based optimization strategies.

E5.2.28 Install water-source heat pumps (WSHPs) to augment the capacity of the hot-water boiler and to reduce the cooling load on the existing chiller systems when heat is required.

E5.2.29 Trim impellers on all condenser water and chilled-water pumps that are oversized.

E5.2.30 Replace all pump and fan motors with premium efficiency motors.

E5.3 Thermal Storage and Heat Pumps

E5.3.1 Install cool storage to reduce peak demand and lower electric bills.

E5.3.2 Install hot-water storage to shave peaks of hot-water usage or to store reclaimed energy from combined heat and power systems or waste heat from chillers for later use.

E5.3.3 Install add-on heat pumps.

E5.3.4 Install secondary pumping systems.

E5.3.5 Install VFDs on secondary pumps and replace most three-way valves with two-way valves.

E5.3.6 With cool storage and VFDs on fans and pumps, consider use of low-temperature chilled water to reduce fan and pump energy.

E5.3.7 Replace electrically powered air conditioning and heating units with heat pumps. Consider geothermal or ground-source heat pumps.

E5.3.8 Replace electric water heaters with electric heat-pump water heaters.

E5.4 Electric and Heat Cogeneration

E5.4.1 The application of cogeneration should be considered where use of both electrical and thermal energy can be achieved on a cost-effective basis.

E5.4.2 Subject to AHJ approval, where combined heat and power (CHP) plants are installed as energy efficiency improvements, then the energy audit and analysis of overall building energy use performance may follow the FEMP guidelines, *Reporting Guidance for Federal Agency Annual Report on Energy Management* (Per 42 U.S.C. 8258) Attachment 3. Energy efficiency projects may be allowed to receive a credit in the amount of the annual source energy savings from CHP, which would be used to offset the building site energy used in calculating and comparing against the EUI targets.

E6. NONRESIDENTIAL LIGHTING

In implementing any of these EEMs, care should be taken to not compromise the photometric distribution or any required light levels.

E6.1 General. Check the current IES recommended light levels for the tasks in the facility. They may be lower than when the original lighting system was designed. Use these current recommended light levels to help shape all future lighting decisions, including those enumerated here.

E6.2 Daylighting

E6.2.1 In any spaces with fenestration, evaluate opportunities for daylight harvesting by determining the spatial daylight autonomy (sDA) in accordance with IES LM-83. In spaces where $sDA_{300,50\%}$ is greater than 55%, consider installing daylight switching or daylight dimming controls (and appropriate ballasts if the lighting system is fluorescent or HID) to reduce use of electric lighting.

E6.2.2 In any spaces with fenestration, evaluate the need for shading by determining the annual sunlight exposure (ASE) in accordance with IES LM-83. In spaces where $ASE_{1000,250}$ is greater than 10%, interior and/or exterior shading should be installed to reduce solar heat gain and cut down on heat loss and control the amount of light entering the space from the exterior.

E6.2.3 Install a skylight, tubular daylighting device, or sunlight delivery system to reduce the use of electric lighting and provide natural daylight to the internal spaces of the building.

E6.3 Luminaire Upgrades

E6.3.1 Upgrade incandescent lamps in existing luminaires with more effective sources, such as halogen, integrally ballasted compact fluorescent, solid state (LED), or metal halide retrofit lamps. Alternatively, replace incandescent luminaires with luminaires using these sources.

E6.3.2 Upgrade T12 fluorescent luminaires with more effective sources, such as high-performance T8 or T5 systems, by replacing lamps and ballasts, utilizing luminaire upgrade kits, or installing new luminaires.

E6.3.3 If the lighting system is already a high-performance fluorescent system, consider replacing the lamps with reduced wattage lamps (where appropriate).

E6.3.4 For fluorescent lighting, install high-performance electronic ballasts that are multilevel or continuously dimmable with the appropriate controls.

E6.3.5 Replace mercury vapor or probe-start metal halide HID luminaires with pulse-start metal halide or high-performance T8 or T5 fluorescent luminaires.

E6.3.6 Upgrade task and display lighting, including lighting in refrigeration and freezer cases, to more effective sources such as LED.

E6.4 Signage

E6.4.1 Evaluate upgrading standard fluorescent or neon signage with more effective sources, such as high-performance T8 or T5 fluorescent systems or solid-state (LED) systems.

E6.4.2 Upgrade all exit signs to solid state (LED). Supplemental lighting may need to be added if the existing exit sign also provided general lighting.

E6.5 Lighting Controls

E6.5.1 Reduce lighting use through management and controlled systems. In general, consider bringing the lighting control protocols for the building up to ASHRAE/IES Standard 90.1-2010 (Section 9.4.1) standards; this includes the following.

E6.5.2 Reduce operating hours for lighting systems through the use of controls and building management systems. This includes the use of shut-off controls, such as time switches.

E6.5.3 Use reduced lighting levels, including off, when spaces are unoccupied, during nighttime hours, for restocking, cleaning and security. Whenever possible move restocking and cleaning operations to normal operating hours.

E6.5.4 Use occupancy, vacancy, or motion sensors. Wherever applicable, these sensors should either be manual-on or turn lighting on to no more than 50% of lighting power.

E6.5.5 Use controls to provide multiple light levels or dimming where appropriate.

E6.5.6 Recircuit or rezone lighting to allow personnel to only turn on zones based on use rather than operating the entire lighting system.

E6.5.7 Install personal lighting controls so individual occupants can vary the light levels within their spaces.

E6.5.8 Consider installation of lighting systems that facilitate load shed requests from the electric utility or energy aggregator.

E6.5.9 Evaluate turning emergency lighting off or to a lower level when a building or portion of a building is completely unoccupied, without sacrificing safety requirements.

E6.6 Exterior Lighting

E6.6.1 Use automatic controls that can reduce outdoor lighting levels or turn lights off when either sufficient daylight is available or when lighting is not needed. All facade and landscape lighting should be off from an hour after closing until an hour before opening. All other lighting should be reduced by at least 30% during that same time frame or when a motion sensor detects no activity for 15 minutes. These controls are not applicable to lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

E6.6.2 Reduce power levels or turn exterior signage off when appropriate.

E6.6.2.1 Signs that are meant to be on for some part of daylight hours should be reduced in power by at least 65% during nighttime hours. All other sign lighting should automatically turn off during daylight hours and reduced in power by at least 30% from an hour after closing until an hour before opening. These controls are not applicable to sign lighting using metal halide, high-pressure sodium, induction, cold cathode, or neon lamps that are automatically reduced by at least 30% during nighttime hours.

E6.6.3 When selecting new outdoor luminaires, consider the amount of backlight, uplight, and glare delivered by each luminaire type to improve functionality and minimize environmental impacts. See Section 5.3.3 of ANSI/ASHRAE/USGBC/IES Standard 189.1-2011, *Standard for the Design of High-Performance Green Buildings*.

E6.7 Luminaire Layout

E6.7.1 Consider using lower levels of general illumination overall and then supplement with task lighting where needed.

E6.7.2 Consider new layouts that may maximize efficiency and reduce the total connected lighting load. Consider plug-and-play systems to provide flexibility as space use changes.

E6.8 Other

E6.8.1 Implement a plan to recycle lamps, ballasts, and luminaires removed from the building.

E6.8.2 Consider updating lighting systems to provide for demand response capability so that lighting loads are reduced during periods of peak electricity demand. These types of systems can provide day-to-day energy savings in addition to demand response capability.

E7. RESIDENTIAL LIGHTING

E7.1 General

E7.1.1 Replace incandescent lamps with halogen, integrally ballasted compact fluorescent, or solid state (LED) retrofit lamps in existing luminaires.

E7.1.2 Color temperature indicates the color appearance of the light produced by the lamp. Halogen lamps are a more energy-efficient form of incandescent technology and will deliver light similar to incandescent lamps. Linear fluorescent, compact fluorescent, and solid state (LED) lamps are available in a variety of color temperatures. Lamps with color temperatures of 2700 K and 3000 K will deliver the most incandescent-like light. Lamps with a color temperature of 3500 K deliver a neutral, white light. Lamps with color temperatures of 4000 K and higher will deliver cooler, white light; the higher the color temperature number, the cooler the light.

E7.1.3 Select lamps appropriate for use in enclosed luminaires, outdoor applications, and cold temperature applications, and for use with dimming controls. Check the packaging or manufacturer's website for guidance.

E7.1.4 Use energy efficient technologies such as fluorescent, compact fluorescent, or solid state (LED) in applications with the longest operating times.

E7.1.5 Use a whole-home lighting control system that provides energy-saving features, such as dimming, occupancy sensing, and daylight harvesting, and allows occupants to turn all the lights off from a single location or remotely.

E7.2 Interior

E7.2.1 Replace on/off switches with dimming controls, vacancy sensors, or count-down timers. Use dimming controls, vacancy sensors, or count-down timers for lights or fans in bathrooms. Use vacancy sensors in garages, laundry rooms, closets, and utility rooms.

E7.2.2 By replacing lamps and ballasts or installing new luminaires. Ballasts should be FCC rated for residential use.

E7.2.3 Evaluate replacing incandescent and halogen luminaires with dedicated compact fluorescent or solid state (LED) luminaires.

E7.2.4 When replacing fluorescent ballasts or installing new fluorescent luminaires, evaluate using electronic dimming ballasts with the appropriate dimming controls.

E7.2.5 Evaluate adding daylight-sensing controls for general illumination lighting in rooms with windows or skylights. Use in combination with dimming systems so that the electric light level can be adjusted based on the amount of daylight available.

E7.2.6 Install vacancy sensors to automatically turn off lighting in closets, storage, work rooms, garages, and exterior buildings when the space has been vacated for 15 minutes.

E7.2.7 Add task lighting that utilizes energy-efficient technologies, such as fluorescent and solid state (LED), and reduce or eliminate overhead lighting.

E7.3 Exterior

E7.3.1 Install time switches and/or motion sensors to control outdoor lighting.

E8. ELECTRIC SYSTEMS, MOTORS

E8.1 Install energy-efficient transformers. Use infrared cameras to identify high-heat-loss transformers.

E8.2 Install electrical meters for submetering lighting, elevators, plug loads, and HVAC equipment.

E8.3 Reduce demand charges through load shedding, operational changes, and procedural changes.

E8.4 Replace oversized electric motors with right-sized or slightly oversized motors.

E8.5 Replace existing three-phase, 1 hp (746 W) and greater electric motors with premium-efficiency motors (often a better choice than rewinding motors).

E8.6 Replace existing one-phase, 1 hp (746 W) and less motors with electrically commutated motors.

E9. APPLIANCES

E9.1 Install appliances (clothes washers, dehumidifiers, dishwashers, freezers, refrigerators, room air cleaners and purifiers, office equipment, and televisions) that are certified as ENERGY STAR® compliant.

E9.2 Reduce plug loads, using devices to shut off equipment not being used (use occupancy sensors or timers).

E9.3 Install vending-machine controllers.