The Impact on Energy Use and Peak Demand of Awnings and Roller Shades in Residential Buildings

Version 3.0

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Acknowledgments

This report was developed with support from the Professional Awning Manufacturers Association (PAMA) and Phifer Incorporated. In particular, I wish to express my appreciation to John Gant of Glen-Raven, Michelle Sahlin, Managing Director of PAMA, and Andrew Caldwell of Phifer Incorporated for initiating and providing input throughout the course of this project.

I wish to thank my former co-authors John Carmody and Kerry Haglund for providing the format and some of the graphics from Version 2, which I have liberally used in this Version 3. I would also like to thank Jacob Jonsson of the Windows and Glazings Program at Lawrence Berkeley National Laboratory for providing measured angular solar properties of Phifer fabrics, and Dr. John Wright of the University of Waterloo, Canada, for his insights on modeling the solar properties of glazing combined with exterior shading devices

Introduction

The benefits of awnings and roller shades

Awnings and external roller shades have advantages that contribute to more sustainable buildings. First, they result in cooling energy savings by reducing direct solar gain through windows. They also lower the peak electricity demand, which in a new house can potentially result in reduced mechanical equipment costs. While in an existing house, awnings and roller shades will not lower the peak electricity demand of the individual house (because the air-conditioner does not change), they will contribute to the peak demand reduction for the utility company, which ultimately decreases the need to build new generating capacity.

Scope of analysis

In the previous Version 2 study in 2007, only one kind of awning (90 degrees extension covering half of the window) was analyzed for 12 representative locations. In this Version 3 study, we have expanded the analysis to many more types of awnings and exterior roller shades, two types of operations (cooling season only or all year), and two climate conditions (typical year and an unusually hot year). This has resulted in 500 pages of tables, which has necessitated a different method for information dissemination. Although the entire report has been produced as an electronic document, the data tables for each city and the two shade types (awning or exterior roller shade) have been kept as separate PDF files, so that readers can obtain just those files for their locations.

Types of awnings

Four types of awnings have been studied:

1. 90° Black awning with a solar transmission of 8%
2. 90° Linen awning with a solar transmission of 16%
3. 165° Black awning with a solar transmission of 8%
4. 165° Linen awning with a solar transmission of 16%

Figure 1. 90° awning

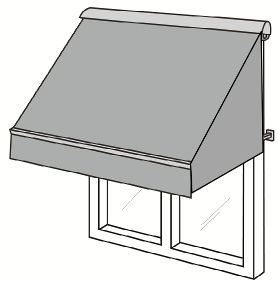
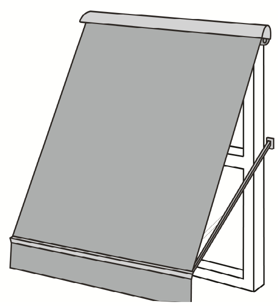


Figure 2. 165° linen awning



These awnings have been modeled as BUILDING-SHADEs using the DOE-2.1E building energy simulation program. Technical details on the modeling are given in Appendix A.

Types of external roller shades

Five types of external roller shades have been studied:

1. Black / Brown 25% Openness Factor
2. Black / Brown 10% Openness Factor
3. Black / Brown 10% Openness Factor full basketweave
4. Black 5% Openness Factor, full basketweave
5. White 5% Openness Factor, full basketweave

These external roller blinds have been modeled as SHADING-SCHEDULEs in DOE-2.1E. Technical details on the modeling are given in Appendix B.

Building conditions used in the computer modeling

The energy savings and peak demand reductions provided by awnings and roller blinds obviously depend on the building on which they're used, and how that building is operated. In this analysis, we have modeled the building as an existing one-story house with a floor area of 1700 ft^2, and 255 ft^2 of windows, for a floor area to window ratio of 15%.

The basic modeling methodology of the house has been taken virtually unchanged from the previous work by the author in modeling window energy performance for the US Department of Energy (DOE) while he was a staff scientist at Lawrence Berkeley National Laboratory (LBNL), in particular the development of the RESFEN program and the analysis of the EnergyStar® program in 2003 and 2008 (see references at end of report). For the modeling assumptions of the house, please see Appendix C.

Window conditions

Since the performance of the awnings and exterior roller shades are strongly related to the window conditions and orientation, this analysis considered three types of windows and four window orientations.

The window types modeled include

1. single-pane window with clear glass and an aluminum frame (U= 1.16, SHGC = 0.77)
2. double-pane clear with a wood / vinyl frame (U= 0.49, SHGC = 0.56)
3. double-pane clear with high-solar Low-E glazing with a wood / vinyl frame (U= 0.37, SHGC = 0.53)

Four window distributions have been considered : equal distribution, i.e., 63.75 ft^2 per side, or predominantly oriented to either the south, east, or west. In these cases, the window area in that orientation is 204 ft^2 (12%) and the remaining 51 ft^2 distributed equally on the other three sides.

Window shade operations

Awnings and roller shades save cooling energy use during the summer by reducing unwanted solar heat gain through windows. However, if they are deployed at other times of the year, they can lead to increased heating energy use by blocking the "free heat" of the sun. To quantify the magnitude of this heating penalty, two modes of operations have been modeled: (1) deployed only when cooling is needed during the month (for awnings) or over the past four days (for roller shades)[1], and (2) deployed throughout the year.

Locations and climates

A primary objective for this study was to extend the analysis beyond the 12 locations in the Version 2 study. After much review of climate variations and market significance, a final list of 50 locations were chosen. These are listed in Appendix D.

An innovative aspect of this study are the clients' request to simulate the performance of awnings and roller blinds not just in a typical year, but also in a particularly hot year, such as the year 2011 for much of the South when this project was being defined!

For the typical year conditions, the simulations are done using the TMY3 (Typical Meteorological Year, Version 3) weather files developed by the National Renewable Energy Laboratory (NREL). For the hot year condition, the author created weather files for the last twelve years for all 50 locations, and then picked the hottest year from the twelve for the simulations. The year picked as the "Hot Year", and the heating and cooling degree days for that year, as well as for the TMY3 weather file for each location are also listed in Appendix D. Depending on the severity of the cooling season, the number of cooling degree days found increase from 10% in Miami, to over 40% in the milder locations.

Utility prices

In order to properly weight the heating penalties against the cooling savings, as well as give a sense of the dollar amount of benefits, the prices for electricity and natural gas are needed. Although we considered obtaining the prices directly from the utility companies for each city, this was not practical because of the number of cities, and the fact that some locations have a number of utility companies and price structures.

Therefore, we based our utility prices on the latest information from the Energy Information Agency (EIA), which lists the average utility prices by state in 2010. This table appears in Appendix E.

Cooling energy and net energy cost savings, and peak demand reductions

A total of 480 simulations have been done for each of the 50 cities. The detailed results are presented in city-by-city reports containing 16 tables (8 for awnings, and 8 for roller shades) per city that give the heating energy penalties, cooling energy savings, net energy cost savings, and peak cooling demand reductions for every combination of awning or roller shade, window type and orientation, shade operations, and weather condition. These tables begin on page 22 and take up 500 pages of the report. To avoid unnecessary clutter, the city tables are being released as individual PDF files for those interested, with only the first two pages of one sample city report for Washington DC included as Figure 3 on page 21 of this introduction to explain their contents.

Tables 1 - 10 are meant to give a general view of the results for all the simulated conditions across all 50 cities. Tables 1 - 5 are for awnings, and Tables 6 - 10 are the equivalent for roller shades. With the exception of Tables 5 and 10, which are for peak demand reductions, the other eight tables (1 - 4 and 6 - 10) share the same format, with the columns showing (from left to right): (A) cooling kWh use for the unshaded house, (B) cooling energy use for the shaded house, (C) cooling kWh savings (i.e., A - B), (D) percent cooling savings, (E) heating and cooling energy, (F) heating penalty, (G) cooling savings, and (H) net energy savings, all in dollars, and (I) in percent. The numbers in all ten tables are averaged across the shading types (4 awnings or 5 roller shades) and the three window types (single, double, and double with high-solar Low-E, all clear).

Table 1 shows the impact of awnings on cooling energy use and energy cost savings for the most generalized case of equally-distributed windows deployed during the cooling season under "typical year" weather conditions. As to be expected, the highest cooling savings are found in the cities where the cooling season are the longest (2168 kWh in Honolulu and 1916 kWh in Miami) or the most sunny (1666 kWh in Phoenix or 1227 kWh in Las Vegas), gradually decreasing as the cooling season shortens going north, e.g., 1059 kWh in Atlanta, 752 kWh in Washington, 613 kWh in Chicago, 585 kWh in New York, and 274 kWh in Portland ME. Although the cooling kWh savings decrease, the percent cooling savings increase in the cooler climates. For example, the percent cooling savings are 24-26% in Miami and Honolulu, 17-19% in Phoenix and Las Vegas, but 30% in Atlanta, 39% in Washington, 48% in Chicago, 37% in New York, and 61% in Portland ME. In the extreme cases of San Francisco and Anchorage, which have very little cooling energy, awnings can potential reduce all need for mechanical cooling.

Table 1 also shows that , despite the awnings being used only in months when air-conditioning is needed, there are still small heating penalties ranging from \$0 (in Honolulu) to \$60 (in Boston and Medford OR). These heating penalties

[1] The differing criteria for cooling season operations is dictated by the capabilities of the DOE-2.1E program in modeling awnings as building shades, which is done only on the first day of the month, versus roller shades as window shading fractions which can be changed on a day-to-day basis.

lower the net energy cost savings by a small amount in the hot locations, to a substantial amount in the cooler locations, and can result in net energy increases in the coldest locations.

Table 2 shows how the impact of awnings change when they are used on a house where the windows are predominantly facing west, typically the orientation with the highest cooling energy use. Although it's difficult to generalize the results for all 50 locations, in most cases the cooling energy and net energy cost savings are increased.

Table 3 shows how the impact of awnings change if they are kept in place all year around, instead of used only during the cooling season. Compared to Table 1, there is very little change in the cooling energy savings, but a great deal of change in the heating penalties. Going north from Las Vegas in the western, Fort Worth and Little Rock in the central, and Jacksonville in the eastern part of the country, there will be a net energy penalty from the use of awnings.

Table 4 shows how the impact of awnings change when the weather conditions are for the hottest year over the past twelve, rather than the typical year. The cooling and net energy savings compared to Table 1 are increased on an absolute basis, although not always on a percent basis. Furthermore, while the increase in cooling energy savings compared the typical year (Table 1) may vary, the percent increase is smaller in the hottest locations (19% in Miami) and larger in the more inland locations prone to heat spells (35% in Fort Worth).

Table 5 compares the impact of awnings on reducing the peak cooling demand for houses with equally-distributed and west-facing windows. In the first case (equally-distributed windows), the reductions are in the range of 0.45 - 0.77 kW, while for the second case (west-facing windows) they are more than doubled, being in the range of 1.10 - 1.92 kW. It should be pointed out that these calculated peaks do not represent the instantaneous peak of an air-conditioner, which is basically fixed and a characteristic of the equipment, but are the highest electricity use over the peak hour. Thus, these reductions are of more interest to a utility company attempting to manage its load shape on the hottest days, rather than to an individual house owner.

Tables 6 - 10 repeat the information from Table 1 -5, except that they apply to the use of an average roller shade, rather than an awning, averaged over all three window types. Compared to the previous five tables, the trends are similar, but the savings tend to be smaller by 20-30%. There are several reasons for this difference: (1) the inherent shading effectiveness of the roller shades as compared to awnings, and (2) the relatively high SHADING-FRACTIONs at lower solar incidence angles, especially when compared to that of awnings.

Explanation of detailed city-by-city reports

Detailed tables giving the heating energy penalties, cooling energy savings, net energy cost savings, and peak cooling demand reductions for every combination of awning or roller shade, window type and orientation, shade operations, and weather condition are contained in Tables 11 through 410. These tables have been kept as individual PDF files by city and shade type (awning or roller shade) are available online, so that users can download and refer to only those reports for their cities of interest.

The first two pages of an example PDF file for Washington DC has been reproduced in Figures 3 and 4 to illustrate and explain the contents of these city reports.

The first page of the city report (see Figure 3) gives the heating and cooling degrees in a typical year and the hottest year of the past twelve for that city, followed by a brief narrative summary of the results from the simulations.

This is then followed by eight tables of the same format showing the impact of shading (either awnings or roller shades) on a house in that location under these eight conditions:

1. equally-distributed windows on a typical year
2. east-facing windows on a typical year
3. south-facing windows on a typical year
4. west-facing windows on a typical year
5. equally-distributed windows on a hot year
6. east-facing windows on a hot year
7. south-facing windows on a hot year
8. west-facing windows on a hot year

In each table, every row presents the results of a single DOE-2.1E simulation. The first three columns identify the window type, awning type, and window operation, followed by the heating energy in MBtu, and the heating energy savings in MBtu or dollars ($). The heating savings are always negative because shading can only increase heating energy use. The following columns give the equivalent numbers for cooling, i.e., cooling energy in kWh, cooling energy savings in kWh and dollars ($), and the percent cooling energy savings. The next three columns give the total space conditioning energy costs (heating plus cooling) in dollars, followed by the net savings in dollars and the percent net savings. The last three columns give the peak cooling demand in kW, followed by the demand reduction in kW and the percent demand reduction.

The last part of the first page gives the technical specifications for the three glass types and the utility prices used for natural gas (assumed for heating) and electricity (assumed for cooling).

Two spreadsheets combining all the city tables for the awnings or roller shades have also been made available.

Table 1. Summary of the impacts of equally-distributed awnings used during the cooling season on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Awnings (kWh)	Cool. Energy Awnings (kWh)	Cool. Energy Savings Awnings (kWh)	Cool. Energy Savings Awnings (%)	Heat+Cool No Awnings ($)	Heat Penalties Awnings ($)	Cool Savings Awnings ($)	Net Savings Awnings ($)	Net Savings Awnings (%)
AK	Anchorage	6	0	6	100	851	-12	1	-11	-1
AL	Birmingham	3589	2526	1063	30	799	-35	94	59	7
AL	Mobile	4594	3389	1206	26	654	-17	107	90	14
AR	Little Rock	4001	2934	1067	27	803	-39	78	39	5
AZ	Phoenix	9653	7988	1666	17	1048	-33	161	128	12
AZ	Tucson	6208	4909	1299	21	810	-43	126	83	10
CA	Burbank	2804	1912	892	32	492	-32	116	84	17
CA	Fresno	4510	3423	1087	24	869	-20	141	121	14
CA	Palm Springs	9450	7760	1690	18	1272	-22	220	198	16
CA	Sacramento	2408	1544	864	36	662	-19	112	94	14
CA	San Diego	1048	565	483	46	191	-12	63	51	27
CA	San Francisco	119	34	86	72	299	-38	11	-27	-9
CO	Denver	1537	882	655	43	901	-20	60	40	4
DC	Washington	1933	1181	752	39	1353	-42	100	59	4
FL	Jacksonville	4844	3537	1307	27	778	-57	138	82	11
FL	Miami	8105	6190	1916	24	871	-8	203	195	22
FL	Tampa	6559	4923	1636	25	794	-47	173	126	16
GA	Atlanta	3574	2514	1059	30	950	-39	94	55	6
HI	Honolulu	8257	6089	2168	26	2074	0	545	545	26
ID	Boise	1460	847	613	42	897	-49	40	-9	-1
IL	Chicago	1281	668	613	48	1125	-28	56	27	2
IN	Indianapolis	1725	997	728	42	1196	-46	56	9	1
LA	New Orleans	5123	3801	1322	26	573	-23	103	80	14
MA	Boston	899	445	454	51	1542	-61	65	4	0
ME	Portland	447	173	274	61	2755	-45	35	-10	0
MI	Detroit	1007	486	521	52	1224	-17	51	35	3
MN	Minneapolis	1035	512	523	51	1354	-38	44	6	0
MO	Kansas City	2133	1373	761	36	1162	-38	59	21	2
MO	St. Louis	2421	1597	824	34	1036	-55	64	10	1
NC	Charlotte	3592	2638	953	27	1342	-26	83	57	4
NE	Omaha	2121	1337	785	37	1097	-33	59	26	2
NM	Albuquerque	2473	1693	781	32	764	-29	66	36	5
NV	Las Vegas	6595	5369	1227	19	937	0	119	119	13
NY	Buffalo	653	279	374	57	1724	-14	61	47	3
NY	New York	1566	982	585	37	1372	-29	96	67	5
OH	Cincinnati	1598	964	635	40	1030	-35	58	23	2
OK	Oklahoma City	3935	2900	1035	26	913	-17	79	61	7
OR	Medford	1746	1062	684	39	1313	-60	52	-8	-1
OR	Portland	946	484	462	49	1311	-54	35	-19	-1
PA	Philadelphia	1867	1183	684	37	1312	-46	70	24	2
PA	Pittsburgh	775	349	426	55	1307	-58	44	-14	-1
SC	Charleston	4872	3667	1204	25	1112	-41	102	61	5
TN	Memphis	4836	3791	1046	22	1364	-34	90	56	4
TX	El Paso	4161	3086	1074	26	623	-21	100	79	13
TX	Fort Worth	5349	4271	1077	20	886	-13	101	88	10
TX	Houston	5436	4063	1373	25	677	-37	128	91	14
TX	San Antonio	5787	4379	1408	24	715	-26	131	106	15
UT	Salt Lake City	1859	1226	634	34	887	-30	44	14	2
VA	Norfolk	2622	1800	822	31	954	-52	71	20	2
WA	Seattle	270	78	193	71	797	-58	13	-45	-6

Table 2. Summary of the impacts of west-oriented awnings used during the cooling season on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Awnings (kWh)	Cool. Energy Awnings (kWh)	Cool. Energy Savings Awnings (kWh)	Cool. Energy Savings Awnings (%)	Heat+Cool No Awnings ($)	Heat Penalties Awnings ($)	Cool Savings Awnings ($)	Net Savings Awnings ($)	Net Savings Awnings (%)
AK	Anchorage	20	0	20	100	859	-11	3	-8	-1
AL	Birmingham	3859	2543	1316	34	847	-35	117	82	10
AL	Mobile	4948	3429	1519	31	702	-13	135	122	17
AR	Little Rock	4343	2969	1374	32	846	-38	100	62	7
AZ	Phoenix	10372	8088	2284	22	1133	-28	221	193	17
AZ	Tucson	6762	4979	1783	26	890	-36	173	137	15
CA	Burbank	3220	1957	1263	39	561	-27	164	137	24
CA	Fresno	5041	3468	1573	31	955	-19	205	185	19
CA	Palm Springs	10217	7927	2290	22	1380	-18	298	280	20
CA	Sacramento	2824	1588	1236	44	737	-18	161	142	19
CA	San Diego	1388	608	780	56	246	-12	101	90	37
CA	San Francisco	154	40	114	74	321	-41	15	-26	-8
CO	Denver	1741	912	829	48	950	-18	76	58	6
DC	Washington	2120	1183	938	44	1414	-38	125	87	6
FL	Jacksonville	5065	3520	1544	30	818	-51	163	113	14
FL	Miami	8355	6182	2173	26	901	-6	230	224	25
FL	Tampa	6832	4927	1905	28	833	-40	202	161	19
GA	Atlanta	3882	2542	1339	35	1004	-37	119	81	8
HI	Honolulu	8565	6187	2378	28	2152	0	597	597	28
ID	Boise	1770	882	888	50	951	-45	58	13	1
IL	Chicago	1386	664	722	52	1154	-29	66	36	3
IN	Indianapolis	1978	1023	955	48	1241	-47	73	27	2
LA	New Orleans	5416	3832	1584	29	606	-22	124	102	17
MA	Boston	1022	462	560	55	1593	-64	80	16	1
ME	Portland	545	179	366	67	2833	-47	47	0	0
MI	Detroit	1169	495	674	58	1262	-17	67	50	4
MN	Minneapolis	1254	535	719	57	1398	-40	60	20	1
MO	Kansas City	2467	1421	1046	42	1220	-39	81	43	4
MO	St. Louis	2707	1638	1069	39	1086	-53	83	30	3
NC	Charlotte	3915	2674	1242	32	1407	-23	108	85	6
NE	Omaha	2393	1372	1022	43	1137	-33	77	44	4
NM	Albuquerque	2821	1728	1093	39	830	-28	92	64	8
NV	Las Vegas	7139	5401	1738	24	1023	0	169	169	17
NY	Buffalo	764	282	482	63	1768	-12	79	67	4
NY	New York	1760	1009	751	43	1429	-27	123	96	7
OH	Cincinnati	1776	982	795	45	1067	-33	73	39	4
OK	Oklahoma City	4373	2971	1402	32	968	-16	106	90	9
OR	Medford	2127	1106	1021	48	1377	-55	77	22	2
OR	Portland	1184	494	690	58	1358	-57	52	-5	0
PA	Philadelphia	2050	1199	851	42	1360	-44	88	44	3
PA	Pittsburgh	926	363	563	61	1346	-57	58	1	0
SC	Charleston	5091	3627	1465	29	1156	-38	124	87	8
TN	Memphis	5221	3841	1379	26	1422	-33	119	86	6
TX	El Paso	4709	3158	1551	33	698	-20	145	125	18
TX	Fort Worth	5729	4296	1434	25	939	-13	134	121	13
TX	Houston	5743	4080	1663	29	715	-34	155	121	17
TX	San Antonio	6257	4409	1848	30	770	-24	173	148	19
UT	Salt Lake City	2156	1265	891	41	930	-30	62	31	3
VA	Norfolk	2762	1777	984	36	993	-53	86	33	3
WA	Seattle	420	89	331	79	835	-59	22	-37	-4

Table 3. Summary of the impacts of equally-distributed awnings used throughout the year on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Awnings (kWh)	Cool. Energy Awnings (kWh)	Cool. Energy Savings Awnings (kWh)	Cool. Energy Savings Awnings (%)	Heat+Cool No Awnings ($)	Heat Penalties Awnings ($)	Cool Savings Awnings ($)	Net Savings Awnings ($)	Net Savings Awnings (%)
AK	Anchorage	6	0	6	100	851	-70	1	-69	-8
AL	Birmingham	3589	2520	1069	30	799	-141	95	-40	-5
AL	Mobile	4594	3379	1216	26	654	-108	108	12	2
AR	Little Rock	4001	2932	1069	27	803	-107	78	-20	-2
AZ	Phoenix	9653	7985	1668	17	1048	-60	162	111	11
AZ	Tucson	6208	4890	1318	21	810	-91	128	42	5
CA	Burbank	2804	1904	900	32	492	-62	117	62	13
CA	Fresno	4510	3423	1087	24	869	-80	141	67	8
CA	Palm Springs	9450	7760	1690	18	1272	-29	220	198	16
CA	Sacramento	2408	1539	869	36	662	-94	113	21	3
CA	San Diego	1048	556	491	47	191	-54	64	17	9
CA	San Francisco	119	30	90	75	299	-149	12	-132	-44
CO	Denver	1537	882	655	43	901	-133	60	-61	-7
DC	Washington	1933	1179	754	39	1353	-168	101	-56	-4
FL	Jacksonville	4844	3537	1307	27	778	-100	138	52	7
FL	Miami	8105	6190	1916	24	871	-16	203	195	22
FL	Tampa	6559	4923	1636	25	794	-48	173	126	16
GA	Atlanta	3574	2513	1061	30	950	-150	94	-52	-5
HI	Honolulu	8257	6089	2168	26	2074	-12	545	545	26
ID	Boise	1460	847	613	42	897	-124	40	-83	-9
IL	Chicago	1281	668	613	48	1125	-121	56	-55	-5
IN	Indianapolis	1725	992	734	43	1196	-132	56	-66	-6
LA	New Orleans	5123	3798	1325	26	573	-68	103	46	8
MA	Boston	899	442	457	51	1542	-205	65	-134	-9
ME	Portland	447	171	276	62	2755	-394	35	-342	-12
MI	Detroit	1007	483	524	52	1224	-151	52	-66	-5
MN	Minneapolis	1035	512	523	51	1354	-142	44	-86	-6
MO	Kansas City	2133	1373	761	36	1162	-158	59	-87	-7
MO	St. Louis	2421	1597	824	34	1036	-141	64	-63	-6
NC	Charlotte	3592	2636	956	27	1342	-163	83	-68	-5
NE	Omaha	2121	1337	785	37	1097	-118	59	-45	-4
NM	Albuquerque	2473	1693	781	32	764	-168	66	-93	-12
NV	Las Vegas	6595	5363	1233	19	937	-127	120	7	1
NY	Buffalo	653	279	375	57	1724	-171	62	-99	-6
NY	New York	1566	979	587	37	1372	-160	96	-49	-4
OH	Cincinnati	1598	964	635	40	1030	-132	58	-60	-6
OK	Oklahoma City	3935	2898	1038	26	913	-138	79	-48	-5
OR	Medford	1746	1062	684	39	1313	-157	52	-94	-7
OR	Portland	946	484	462	49	1311	-153	35	-105	-8
PA	Philadelphia	1867	1183	684	37	1312	-171	70	-88	-7
PA	Pittsburgh	775	347	429	55	1307	-160	44	-102	-8
SC	Charleston	4872	3667	1204	25	1112	-132	102	-17	-2
TN	Memphis	4836	3790	1046	22	1364	-124	90	-23	-2
TX	El Paso	4161	3085	1076	26	623	-114	100	-4	-1
TX	Fort Worth	5349	4267	1082	20	886	-107	101	4	0
TX	Houston	5436	4063	1373	25	677	-63	128	74	11
TX	San Antonio	5787	4369	1418	25	715	-62	132	76	11
UT	Salt Lake City	1859	1225	634	34	887	-119	44	-70	-8
VA	Norfolk	2622	1799	822	31	954	-144	71	-63	-7
WA	Seattle	270	78	193	71	797	-137	13	-112	-14

Table 4. Summary of the impacts of equally-distributed awnings during the cooling season on building energy use in 50 US cities under hot year weather conditions

St	City	Cool. Energy No Awnings (kWh)	Cool. Energy Awnings (kWh)	Cool. Energy Savings Awnings (kWh)	Cool. Energy Savings Awnings (%)	Heat+Cool No Awnings ($)	Heat Penalties Awnings ($)	Cool Savings Awnings ($)	Net Savings Awnings ($)	Net Savings Awnings (%)
AK	Anchorage	35	7	29	81	880	-14	4	-9	-1
AL	Birmingham	4916	3696	1220	25	1086	-6	108	102	9
AL	Mobile	5163	3848	1316	25	718	-24	117	93	13
AR	Little Rock	5637	4317	1319	23	883	-3	96	93	11
AZ	Phoenix	11398	9555	1843	16	1201	-11	179	167	14
AZ	Tucson	7600	6003	1597	21	938	-25	155	129	14
CA	Burbank	3710	2566	1144	31	608	-18	149	131	22
CA	Fresno	5438	4167	1271	23	977	-22	165	143	15
CA	Palm Springs	10855	9046	1809	17	1471	-15	235	220	15
CA	Sacramento	3277	2268	1009	31	693	-6	131	125	18
CA	San Diego	1656	1005	651	39	263	0	85	85	32
CA	San Francisco	318	166	152	48	318	-9	20	10	3
CO	Denver	1707	1008	699	41	913	-34	64	30	3
DC	Washington	2898	1956	942	33	1401	-28	126	98	7
FL	Jacksonville	5758	4194	1564	27	739	-41	165	125	17
FL	Miami	9789	7508	2281	23	1040	-2	241	239	23
FL	Tampa	7895	5979	1916	24	878	-11	203	192	22
GA	Atlanta	4806	3579	1227	26	1189	-8	109	101	9
HI	Honolulu	10231	7817	2415	24	2570	0	607	607	24
ID	Boise	2464	1630	835	34	864	-23	55	31	4
IL	Chicago	1854	1148	706	38	1111	-37	64	27	2
IN	Indianapolis	2664	1756	908	34	1137	-23	70	47	4
LA	New Orleans	6733	5120	1613	24	661	-23	126	103	16
MA	Boston	1421	824	598	42	1392	-20	85	65	5
ME	Portland	885	427	458	52	2211	-35	59	24	1
MI	Detroit	1807	1112	695	38	1149	-20	69	49	4
MN	Minneapolis	1583	905	678	43	1286	-19	57	38	3
MO	Kansas City	3426	2465	961	28	1054	-28	75	46	4
MO	St. Louis	3560	2509	1051	30	1059	-17	82	65	6
NC	Charlotte	5236	4009	1227	23	1595	-21	106	86	5
NE	Omaha	2718	1776	942	35	1065	-36	71	34	3
NM	Albuquerque	3653	2697	956	26	789	-21	80	59	8
NV	Las Vegas	8526	7054	1472	17	1046	-10	143	133	13
NY	Buffalo	1398	794	603	43	1779	-13	99	86	5
NY	New York	2065	1374	691	33	1384	-11	113	103	7
OH	Cincinnati	2766	1808	958	35	1092	-29	88	59	5
OK	Oklahoma City	5926	4672	1254	21	1014	-23	95	72	7
OR	Medford	3157	2244	913	29	1203	-28	69	41	3
OR	Portland	1531	962	569	37	1409	-44	43	-1	0
PA	Philadelphia	2984	2094	890	30	1321	-43	92	49	4
PA	Pittsburgh	1772	1050	723	41	1506	-42	74	33	2
SC	Charleston	5955	4640	1315	22	1106	-45	112	67	6
TN	Memphis	6549	5242	1307	20	1370	-28	112	84	6
TX	El Paso	6522	5114	1407	22	846	-6	131	126	15
TX	Fort Worth	7817	6361	1455	19	979	-9	136	127	13
TX	Houston	7803	6161	1642	21	880	-17	153	136	15
TX	San Antonio	7893	6259	1634	21	899	-19	153	134	15
UT	Salt Lake City	2941	2087	854	29	976	-26	59	33	3
VA	Norfolk	3697	2635	1062	29	1023	-15	92	77	8
WA	Seattle	618	311	307	50	846	-30	20	-10	-1

Table 5. Summary of the impacts of equally-distributed awnings used during the cooling season on peak cooling demand in 50 US cities under typical year weather conditions

		Equal Window Orientation				Mostly West Window Orientation			
St	City	Peak Demand No Awnings (kW)	Peak Demand Awnings (kW)	Peak Demand Savings Awnings (kW)	Peak Demand Savings Awnings (%)	Peak Demand No Awnings (kW)	Peak Demand Awnings (kW)	Peak Demand Savings Awnings (kW)	Peak Demand Savings Awnings (%)
AK	Anchorage	1.12	0.12	1.00	89	2.11	0.22	1.89	90
AL	Birmingham	3.53	2.89	0.65	18	4.34	2.96	1.37	32
AL	Mobile	3.68	3.02	0.66	18	4.47	3.07	1.40	31
AR	Little Rock	4.29	3.70	0.59	14	5.23	3.81	1.42	27
AZ	Phoenix	6.02	5.27	0.75	12	7.37	5.45	1.92	26
AZ	Tucson	4.87	4.28	0.59	12	6.27	4.49	1.78	28
CA	Burbank	4.37	3.68	0.70	16	5.22	3.70	1.52	29
CA	Fresno	4.68	4.03	0.65	14	5.82	4.17	1.66	28
CA	Palm Springs	6.97	6.41	0.56	8	8.58	6.74	1.84	21
CA	Sacramento	4.61	4.01	0.59	13	5.81	4.19	1.62	28
CA	San Diego	2.30	1.70	0.60	26	3.24	1.87	1.37	42
CA	San Francisco	1.95	1.36	0.58	30	2.69	1.64	1.04	39
CO	Denver	3.91	3.16	0.75	19	5.34	3.37	1.97	37
DC	Washington	4.00	3.17	0.82	21	4.80	3.23	1.57	33
FL	Jacksonville	4.45	3.77	0.68	15	4.89	3.74	1.16	24
FL	Miami	4.00	3.32	0.68	17	4.53	3.34	1.19	26
FL	Tampa	3.99	3.31	0.68	17	4.48	3.35	1.14	25
GA	Atlanta	4.08	3.39	0.68	17	4.81	3.47	1.34	28
HI	Honolulu	3.33	2.77	0.56	17	4.10	2.87	1.23	30
ID	Boise	3.65	2.90	0.76	21	5.15	3.10	2.05	40
IL	Chicago	3.45	2.68	0.77	22	3.90	2.64	1.26	32
IN	Indianapolis	3.77	3.05	0.72	19	4.83	3.16	1.66	34
LA	New Orleans	3.62	3.03	0.58	16	4.61	3.17	1.44	31
MA	Boston	3.33	2.63	0.70	21	4.19	2.77	1.43	34
ME	Portland	2.69	2.01	0.68	25	3.69	2.07	1.63	44
MI	Detroit	3.35	2.58	0.77	23	3.62	2.57	1.05	29
MN	Minneapolis	3.66	2.93	0.73	20	4.80	3.07	1.73	36
MO	Kansas City	3.48	2.84	0.64	18	4.84	3.06	1.78	37
MO	St. Louis	3.78	3.09	0.69	18	4.63	3.18	1.46	31
NC	Charlotte	4.52	3.88	0.64	14	5.79	4.01	1.78	31
NE	Omaha	4.06	3.38	0.69	17	5.16	3.50	1.66	32
NM	Albuquerque	3.75	3.27	0.48	13	5.10	3.44	1.66	33
NV	Las Vegas	5.46	4.90	0.55	10	7.02	5.05	1.97	28
NY	Buffalo	2.30	1.61	0.69	30	2.90	1.58	1.32	45
NY	New York	3.03	2.45	0.58	19	3.61	2.51	1.10	30
OH	Cincinnati	3.83	3.10	0.73	19	4.65	3.20	1.45	31
OK	Oklahoma City	4.43	3.82	0.61	14	5.77	4.04	1.72	30
OR	Medford	4.89	4.03	0.86	18	6.13	4.17	1.96	32
OR	Portland	4.86	4.11	0.76	16	5.81	4.13	1.68	29
PA	Philadelphia	3.68	3.01	0.66	18	4.46	3.05	1.41	32
PA	Pittsburgh	2.59	1.80	0.79	31	3.28	1.85	1.42	43
SC	Charleston	5.18	4.66	0.53	10	5.85	4.62	1.24	21
TN	Memphis	4.96	4.51	0.45	9	5.98	4.54	1.44	24
TX	El Paso	3.79	3.22	0.57	15	4.92	3.37	1.55	32
TX	Fort Worth	4.65	4.05	0.61	13	5.42	4.09	1.32	24
TX	Houston	4.59	3.93	0.67	15	5.35	3.97	1.38	26
TX	San Antonio	4.22	3.50	0.71	17	5.14	3.59	1.55	30
UT	Salt Lake City	3.53	2.89	0.65	18	4.77	3.00	1.77	37
VA	Norfolk	4.01	3.29	0.72	18	4.70	3.28	1.42	30
WA	Seattle	2.29	1.58	0.71	31	3.43	1.78	1.64	48

Table 6. Summary of the impacts of equally-distributed roller shades used during the cooling season on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Roller Shades (kWh)	Cool. Energy Roller Shades (kWh)	Cool. Energy Savings Roller Shades (kWh)	Cool. Energy Savings Roller Shades (%)	Heat+Cool No Roller Shades ($)	Heat Penalties ($)	Cool Savings ($)	Net Savings ($)	Net Savings (%)
AK	Anchorage	6	6	0	0	851	0	0	0	0
AL	Birmingham	3589	2874	715	20	799	-7	64	56	7
AL	Mobile	4594	3678	917	20	654	-5	81	76	12
AR	Little Rock	4001	3207	794	20	803	-3	58	54	7
AZ	Phoenix	9653	8158	1495	15	1048	-5	145	140	13
AZ	Tucson	6208	5080	1129	18	810	-4	109	105	13
CA	Burbank	2804	2198	605	22	492	-1	79	78	16
CA	Fresno	4510	3535	976	22	869	-3	127	124	14
CA	Palm Springs	9450	7863	1587	17	1272	-4	207	202	16
CA	Sacramento	2408	1746	662	27	662	-5	86	81	12
CA	San Diego	1048	758	289	28	191	0	38	38	20
CA	San Francisco	119	100	19	16	299	-2	2	0	0
CO	Denver	1537	1048	489	32	901	-3	45	42	5
DC	Washington	1933	1451	481	25	1353	-5	64	59	4
FL	Jacksonville	4844	3882	962	20	778	-9	102	93	12
FL	Miami	8105	6621	1484	18	871	-6	157	151	17
FL	Tampa	6559	5298	1261	19	794	-10	133	123	15
GA	Atlanta	3574	2843	731	20	950	-5	65	60	6
HI	Honolulu	8257	6415	1842	22	2074	0	463	463	22
ID	Boise	1460	1062	398	27	897	-5	26	21	2
IL	Chicago	1281	860	421	33	1125	-4	38	35	3
IN	Indianapolis	1725	1219	506	29	1196	-3	39	36	3
LA	New Orleans	5123	4154	969	19	573	-3	76	73	13
MA	Boston	899	650	249	28	1542	-1	35	35	2
ME	Portland	447	353	94	21	2755	-3	12	9	0
MI	Detroit	1007	681	325	32	1224	-3	32	29	2
MN	Minneapolis	1035	756	279	27	1354	-1	23	22	2
MO	Kansas City	2133	1545	588	28	1162	-3	46	43	4
MO	St. Louis	2421	1849	572	24	1036	-5	45	40	4
NC	Charlotte	3592	2911	681	19	1342	-6	59	53	4
NE	Omaha	2121	1597	524	25	1097	-4	39	35	3
NM	Albuquerque	2473	1856	618	25	764	-4	52	48	6
NV	Las Vegas	6595	5456	1139	17	937	-3	111	107	11
NY	Buffalo	653	427	226	35	1724	-4	37	33	2
NY	New York	1566	1126	440	28	1372	-1	72	71	5
OH	Cincinnati	1598	1178	420	26	1030	-3	38	36	3
OK	Oklahoma City	3935	3148	787	20	913	-3	60	57	6
OR	Medford	1746	1308	438	25	1313	-6	33	28	2
OR	Portland	946	749	196	21	1311	-3	15	12	1
PA	Philadelphia	1867	1410	457	25	1312	-2	47	45	3
PA	Pittsburgh	775	607	169	22	1307	-3	17	14	1
SC	Charleston	4872	3994	878	18	1112	-13	75	61	6
TN	Memphis	4836	4025	812	17	1364	-5	70	65	5
TX	El Paso	4161	3247	913	22	623	-5	85	81	13
TX	Fort Worth	5349	4458	891	17	886	-4	83	79	9
TX	Houston	5436	4437	999	18	677	-8	93	85	13
TX	San Antonio	5787	4693	1094	19	715	-4	102	98	14
UT	Salt Lake City	1859	1348	512	28	887	-3	36	33	4
VA	Norfolk	2622	2022	599	23	954	-4	52	48	5
WA	Seattle	270	191	80	29	797	-2	5	4	0

Table 7. Summary of the impacts of west-oriented roller shades used during the cooling season on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Roller Shades (kWh)	Cool. Energy Roller Shades (kWh)	Cool. Energy Savings Roller Shades (kWh)	Cool. Energy Savings Roller Shades (%)	Heat+Cool No Roller Shades ($)	Heat Penalties ($)	Cool Savings ($)	Net Savings ($)	Net Savings (%)
AK	Anchorage	20	20	0	0	859	0	0	0	0
AL	Birmingham	3859	3160	699	18	847	-4	62	58	7
AL	Mobile	4948	4021	927	19	702	-3	82	80	11
AR	Little Rock	4343	3467	876	20	846	-2	64	62	7
AZ	Phoenix	10372	8679	1693	16	1133	-3	164	161	14
AZ	Tucson	6762	5483	1279	19	890	-2	124	122	14
CA	Burbank	3220	2486	734	23	561	0	95	95	17
CA	Fresno	5041	3895	1146	23	955	-1	149	148	15
CA	Palm Springs	10217	8461	1756	17	1380	-2	229	227	16
CA	Sacramento	2824	2054	770	27	737	-3	100	98	13
CA	San Diego	1388	1005	383	28	246	0	50	50	20
CA	San Francisco	154	136	18	12	321	-1	2	1	0
CO	Denver	1741	1252	489	28	950	-1	45	43	5
DC	Washington	2120	1622	498	24	1414	-2	67	64	5
FL	Jacksonville	5065	4125	940	19	818	-5	99	95	12
FL	Miami	8355	6959	1396	17	901	-2	148	146	16
FL	Tampa	6832	5635	1197	18	833	-5	127	122	15
GA	Atlanta	3882	3149	733	19	1004	-3	65	62	6
HI	Honolulu	8565	7250	1315	15	2152	0	330	330	15
ID	Boise	1770	1289	481	27	951	-2	31	29	3
IL	Chicago	1386	978	409	29	1154	-3	37	35	3
IN	Indianapolis	1978	1428	550	28	1241	-1	42	41	3
LA	New Orleans	5416	4465	952	18	606	-1	74	73	12
MA	Boston	1022	775	247	24	1593	0	35	35	2
ME	Portland	545	448	97	18	2833	-1	12	12	0
MI	Detroit	1169	823	346	30	1262	-3	34	32	3
MN	Minneapolis	1254	925	329	26	1398	-1	28	27	2
MO	Kansas City	2467	1786	681	28	1220	-2	53	51	4
MO	St. Louis	2707	2079	629	23	1086	-3	49	46	4
NC	Charlotte	3915	3157	758	19	1407	-2	66	63	4
NE	Omaha	2393	1805	589	25	1137	-3	44	41	4
NM	Albuquerque	2821	2144	677	24	830	-2	57	54	7
NV	Las Vegas	7139	5868	1271	18	1023	-1	124	122	12
NY	Buffalo	764	505	259	34	1768	-2	43	40	2
NY	New York	1760	1288	471	27	1429	-1	77	77	5
OH	Cincinnati	1776	1365	411	23	1067	-1	38	37	3
OK	Oklahoma City	4373	3506	867	20	968	-2	66	64	7
OR	Medford	2127	1571	555	26	1377	-2	42	40	3
OR	Portland	1184	930	254	21	1358	-1	19	18	1
PA	Philadelphia	2050	1585	465	23	1360	-1	48	47	3
PA	Pittsburgh	926	716	210	23	1346	-2	22	20	1
SC	Charleston	5091	4165	926	18	1156	-7	79	71	6
TN	Memphis	5221	4329	891	17	1422	-2	77	75	5
TX	El Paso	4709	3617	1092	23	698	-3	102	99	14
TX	Fort Worth	5729	4754	975	17	939	-3	91	88	9
TX	Houston	5743	4724	1019	18	715	-5	95	91	13
TX	San Antonio	6257	5065	1192	19	770	-2	111	109	14
UT	Salt Lake City	2156	1570	585	27	930	-1	41	40	4
VA	Norfolk	2762	2158	603	22	993	-1	52	51	5
WA	Seattle	420	324	96	23	835	-1	6	5	1

Table 8. Summary of the impacts of equally-distributed roller shades used throughout the year on building energy use in 50 US cities under typical year weather conditions

St	City	Cool. Energy No Roller Shades (kWh)	Cool. Energy Roller Shades (kWh)	Cool. Energy Savings Roller Shades (kWh)	Cool. Energy Savings Roller Shades (%)	Heat+Cool No Roller Shades ($)	Heat Penalties ($)	Cool Savings ($)	Net Savings ($)	Net Savings (%)
AK	Anchorage	6	0	6	99	851	-62	1	-61	-7
AL	Birmingham	3589	2708	881	25	799	-129	78	-51	-6
AL	Mobile	4594	3554	1040	23	654	-92	92	0	0
AR	Little Rock	4001	3072	930	23	803	-92	68	-25	-3
AZ	Phoenix	9653	7973	1680	17	1048	-56	163	107	10
AZ	Tucson	6208	4883	1325	21	810	-92	128	37	5
CA	Burbank	2804	1928	876	31	492	-55	114	59	12
CA	Fresno	4510	3424	1087	24	869	-70	141	71	8
CA	Palm Springs	9450	7715	1735	18	1272	-26	226	200	16
CA	Sacramento	2408	1558	850	35	662	-88	111	23	3
CA	San Diego	1048	579	469	45	191	-45	61	16	8
CA	San Francisco	119	35	85	71	299	-130	11	-119	-40
CO	Denver	1537	923	614	40	901	-120	56	-64	-7
DC	Washington	1933	1320	613	32	1353	-146	82	-65	-5
FL	Jacksonville	4844	3746	1098	23	778	-84	116	33	4
FL	Miami	8105	6541	1564	19	871	-8	165	157	18
FL	Tampa	6559	5125	1434	22	794	-47	152	104	13
GA	Atlanta	3574	2701	873	24	950	-137	77	-60	-6
HI	Honolulu	8257	6376	1881	23	2074	0	473	473	23
ID	Boise	1460	851	609	42	897	-119	40	-79	-9
IL	Chicago	1281	771	510	40	1125	-98	47	-52	-5
IN	Indianapolis	1725	1120	605	35	1196	-107	46	-60	-5
LA	New Orleans	5123	4032	1091	21	573	-53	85	32	6
MA	Boston	899	523	376	42	1542	-177	54	-124	-8
ME	Portland	447	208	239	53	2755	-345	31	-315	-11
MI	Detroit	1007	570	436	43	1224	-103	43	-60	-5
MN	Minneapolis	1035	584	450	44	1354	-122	38	-84	-6
MO	Kansas City	2133	1455	678	32	1162	-138	53	-85	-7
MO	St. Louis	2421	1715	706	29	1036	-117	55	-62	-6
NC	Charlotte	3592	2789	803	22	1342	-147	70	-77	-6
NE	Omaha	2121	1441	680	32	1097	-97	51	-46	-4
NM	Albuquerque	2473	1710	763	31	764	-162	64	-98	-13
NV	Las Vegas	6595	5330	1265	19	937	-117	123	6	1
NY	Buffalo	653	341	312	48	1724	-137	51	-85	-5
NY	New York	1566	1083	483	31	1372	-131	79	-52	-4
OH	Cincinnati	1598	1089	509	32	1030	-110	47	-63	-6
OK	Oklahoma City	3935	2997	938	24	913	-119	71	-48	-5
OR	Medford	1746	1068	678	39	1313	-137	51	-86	-7
OR	Portland	946	520	426	45	1311	-119	32	-86	-7
PA	Philadelphia	1867	1310	557	30	1312	-147	57	-89	-7
PA	Pittsburgh	775	443	332	43	1307	-129	34	-94	-7
SC	Charleston	4872	3873	999	21	1112	-115	85	-30	-3
TN	Memphis	4836	3940	896	19	1364	-108	77	-31	-2
TX	El Paso	4161	3110	1051	25	623	-107	98	-9	-1
TX	Fort Worth	5349	4389	959	18	886	-91	90	-2	0
TX	Houston	5436	4303	1133	21	677	-50	106	56	8
TX	San Antonio	5787	4593	1194	21	715	-52	111	60	8
UT	Salt Lake City	1859	1262	598	32	887	-105	41	-63	-7
VA	Norfolk	2622	1945	676	26	954	-125	59	-66	-7
WA	Seattle	270	84	187	69	797	-106	12	-93	-12

Table 9. Summary of the impacts of equally-distributed roller shades during the cooling season on building energy use in 50 US cities under hot year weather conditions

St	City	Cool. Energy No Roller Shades (kWh)	Cool. Energy Roller Shades (kWh)	Cool. Energy Savings Roller Shades (kWh)	Cool. Energy Savings Roller Shades (%)	Heat+Cool No Roller Shades ($)	Heat Penalties ($)	Cool Savings ($)	Net Savings ($)	Net Savings (%)
AK	Anchorage	35	30	5	15	880	0	1	1	0
AL	Birmingham	4916	3940	976	20	1086	-8	87	78	7
AL	Mobile	5163	4205	958	19	718	-7	85	79	11
AR	Little Rock	5637	4608	1029	18	883	-5	75	70	8
AZ	Phoenix	11398	9605	1793	16	1201	-3	174	171	14
AZ	Tucson	7600	6063	1537	20	938	-10	149	139	15
CA	Burbank	3710	2822	888	24	608	-8	116	108	18
CA	Fresno	5438	4236	1202	22	977	-3	156	153	16
CA	Palm Springs	10855	9098	1757	16	1471	-2	229	227	15
CA	Sacramento	3277	2337	941	29	693	-5	122	117	17
CA	San Diego	1656	1257	399	24	263	0	52	52	20
CA	San Francisco	318	230	88	28	318	-1	11	10	3
CO	Denver	1707	1173	534	31	913	-7	49	42	5
DC	Washington	2898	2253	646	22	1401	-12	86	74	5
FL	Jacksonville	5758	4641	1116	19	739	-7	118	111	15
FL	Miami	9789	8032	1757	18	1040	-2	186	184	18
FL	Tampa	7895	6347	1548	20	878	-4	164	160	18
GA	Atlanta	4806	3909	897	19	1189	-6	80	74	6
HI	Honolulu	10231	8226	2005	20	2570	0	504	504	20
ID	Boise	2464	1739	725	29	864	-7	47	40	5
IL	Chicago	1854	1355	499	27	1111	-2	46	43	4
IN	Indianapolis	2664	2030	634	24	1137	-1	49	47	4
LA	New Orleans	6733	5493	1240	18	661	-2	97	94	14
MA	Boston	1421	1101	321	23	1392	0	46	46	3
ME	Portland	885	595	290	33	2211	-2	37	35	2
MI	Detroit	1807	1313	494	27	1149	-2	49	47	4
MN	Minneapolis	1583	1190	393	25	1286	-1	33	32	3
MO	Kansas City	3426	2796	629	18	1054	-3	49	46	4
MO	St. Louis	3560	2858	702	20	1059	-4	55	51	5
NC	Charlotte	5236	4308	929	18	1595	-7	81	74	5
NE	Omaha	2718	1973	745	27	1065	-4	56	52	5
NM	Albuquerque	3653	2856	797	22	789	-7	67	60	8
NV	Las Vegas	8526	7016	1509	18	1046	-5	147	142	14
NY	Buffalo	1398	1006	392	28	1779	-3	64	61	3
NY	New York	2065	1597	468	23	1384	-1	77	76	5
OH	Cincinnati	2766	2043	723	26	1092	-3	66	63	6
OK	Oklahoma City	5926	4927	999	17	1014	-8	76	68	7
OR	Medford	3157	2406	751	24	1203	-6	57	51	4
OR	Portland	1531	1315	216	14	1409	-2	16	15	1
PA	Philadelphia	2984	2360	624	21	1321	-3	64	61	5
PA	Pittsburgh	1772	1278	494	28	1506	-2	51	49	3
SC	Charleston	5955	5026	929	16	1106	-5	79	74	7
TN	Memphis	6549	5553	996	15	1370	-5	86	80	6
TX	El Paso	6522	5059	1462	22	846	-4	137	132	16
TX	Fort Worth	7817	6509	1308	17	979	-1	122	121	12
TX	Houston	7803	6372	1431	18	880	-8	134	126	14
TX	San Antonio	7893	6545	1348	17	899	-7	126	119	13
UT	Salt Lake City	2941	2249	692	24	976	-5	48	43	4
VA	Norfolk	3697	2998	699	19	1023	-3	61	57	6
WA	Seattle	618	440	177	29	846	-1	12	11	1

Table 10. Summary of the impacts of equally-distributed roller shades used during the cooling season on peak cooling demand in 50 US cities under typical year weather conditions

		Equal Window Orientation				Mostly West Window Orientation			
St	City	Peak Demand No Roller Shades (kW)	Peak Demand Roller Shades (kW)	Peak Demand Savings Roller Shades (kW)	Peak Demand Savings Roller Shades (%)	Peak Demand No Roller Shades (kW)	Peak Demand Roller Shades (kW)	Peak Demand Savings Roller Shades (kW)	Peak Demand Savings Roller Shades (%)
AK	Anchorage	1.12	1.12	0.00	0	2.11	2.11	0.00	0
AL	Birmingham	3.53	3.00	0.53	15	4.34	3.33	1.00	23
AL	Mobile	3.68	3.19	0.49	13	4.47	3.30	1.17	26
AR	Little Rock	4.29	3.77	0.53	12	5.23	3.95	1.27	24
AZ	Phoenix	6.02	5.30	0.72	12	7.37	5.61	1.77	24
AZ	Tucson	4.87	4.37	0.51	10	6.27	4.54	1.73	28
CA	Burbank	4.37	4.07	0.30	7	5.22	5.22	0.00	0
CA	Fresno	4.68	4.60	0.09	2	5.82	5.51	0.31	5
CA	Palm Springs	6.97	6.46	0.51	7	8.58	6.95	1.63	19
CA	Sacramento	4.61	4.02	0.59	13	5.81	4.77	1.04	18
CA	San Diego	2.30	2.12	0.18	8	3.24	3.10	0.14	4
CA	San Francisco	1.95	1.95	0.00	0	2.69	2.69	0.00	0
CO	Denver	3.91	3.13	0.78	20	5.34	3.83	1.51	28
DC	Washington	4.00	3.42	0.57	14	4.80	4.13	0.67	14
FL	Jacksonville	4.45	3.99	0.46	10	4.89	3.93	0.97	20
FL	Miami	4.00	3.48	0.52	13	4.53	3.51	1.02	22
FL	Tampa	3.99	3.48	0.51	13	4.48	3.56	0.93	21
GA	Atlanta	4.08	3.52	0.56	14	4.81	3.63	1.18	25
HI	Honolulu	3.33	2.85	0.48	14	4.10	3.20	0.90	22
ID	Boise	3.65	3.17	0.48	13	5.15	4.77	0.38	7
IL	Chicago	3.45	2.91	0.54	16	3.90	3.02	0.88	23
IN	Indianapolis	3.77	3.14	0.63	17	4.83	3.34	1.49	31
LA	New Orleans	3.62	3.13	0.49	13	4.61	3.27	1.34	29
MA	Boston	3.33	2.75	0.59	18	4.19	3.07	1.13	27
ME	Portland	2.69	2.69	0.00	0	3.69	3.69	0.00	0
MI	Detroit	3.35	2.81	0.54	16	3.62	3.10	0.52	14
MN	Minneapolis	3.66	3.03	0.63	17	4.80	3.57	1.23	26
MO	Kansas City	3.48	2.85	0.63	18	4.84	3.13	1.71	35
MO	St. Louis	3.78	3.21	0.58	15	4.63	3.35	1.28	28
NC	Charlotte	4.52	3.96	0.56	12	5.79	4.77	1.02	18
NE	Omaha	4.06	3.45	0.62	15	5.16	3.68	1.47	29
NM	Albuquerque	3.75	3.22	0.53	14	5.10	4.39	0.71	14
NV	Las Vegas	5.46	4.92	0.54	10	7.02	5.11	1.91	27
NY	Buffalo	2.30	2.04	0.25	11	2.90	2.83	0.07	2
NY	New York	3.03	2.52	0.51	17	3.61	2.78	0.82	23
OH	Cincinnati	3.83	3.22	0.61	16	4.65	3.36	1.28	28
OK	Oklahoma City	4.43	3.85	0.59	13	5.77	4.19	1.57	27
OR	Medford	4.89	4.89	0.00	0	6.13	6.13	0.00	0
OR	Portland	4.86	4.15	0.71	15	5.81	4.89	0.92	16
PA	Philadelphia	3.68	3.17	0.50	14	4.46	3.45	1.01	23
PA	Pittsburgh	2.59	2.59	0.00	0	3.28	3.27	0.00	0
SC	Charleston	5.18	4.75	0.43	8	5.85	4.74	1.11	19
TN	Memphis	4.96	4.60	0.36	7	5.98	4.62	1.37	23
TX	El Paso	3.79	3.30	0.49	13	4.92	3.54	1.38	28
TX	Fort Worth	4.65	4.11	0.55	12	5.42	4.25	1.16	21
TX	Houston	4.59	4.00	0.60	13	5.35	4.15	1.20	22
TX	San Antonio	4.22	3.66	0.56	13	5.14	3.73	1.41	27
UT	Salt Lake City	3.53	2.92	0.62	17	4.77	3.39	1.37	29
VA	Norfolk	4.01	3.40	0.61	15	4.70	3.82	0.87	19
WA	Seattle	2.29	1.65	0.64	28	3.43	2.93	0.50	15

Figure 3. Page 1 of detailed city report for awnings in Washington DC

Washington, DC — Awnings

Typical Year (TMY3) HDD65 4920 / CDD65 1112, Hot Year (2010) HDD65 4511 / CDD65 1590

Tables 115-118 show the impact of awnings on a typical house in Washington with different window orientations over a typical year. Tables 119-122 repeat this analysis for a hot year in Washington. The impact varies depending on the type of window glazing and whether the awnings are in place all twelve months or only during the cooling season. For a house with windows equally distributed in the four orientations, Table 115 shows the annual heating and cooling energy use as well as the peak electricity demand for each combination of glazing and shading condition. The table also shows the impact on the total cost for heating and cooling. In all cases, the net and percent savings are in reference to a house with no shading.

Table 115 shows that awnings reduce cooling energy use by 32-48 percent as compared to the unshaded house. The higher savings are for awnings at 165 degrees over windows with clear glazings, while the lower savings are for awnings at 90 degrees over windows with Low-E glazings. Because awnings block useful solar gain in winter, heating energy use increases when the awnings remain in place 12 months a year. Using the awnings only during the cooling season produces the largest net energy savings. The net energy savings are from 4 to 5 percent in Washington when awnings are used only during the cooling season from April through October, while the penalties are from -6 to -3 percent when they are deployed throughout the year.

Table 115 also shows that awnings reduce peak electricity demand by 16-25 percent in Washington, with larger reductions for the clear glazings and smaller reductions for the Low-E glazing. Tables 116, 117, and 118 show results for houses in Washington where the windows predominantly face to the east, south, and west, respectively. Both the cooling energy savings and the peak demand reductions are largest on west-facing awnings. Tables 119-122 show the impact of awnings on a particularly hot year (2010) in Washington. The main effect is to increase the cooling savings by 68 percent due to the hotter or longer summer.

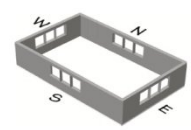


Table 115. Impact of awnings on a house in Washington, DC with equally distributed windows on a typical year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		77.0			2149				1554			4.47		
	Black Awning 90°	summer	79.8	-2.8	-46	1281	868	116	40	1484	70	4	3.51	0.96	21
		12 month	87.3	-10.2	-168	1277	872	116	41	1606	-52	-3	3.51	0.96	21
	Linen Awning 90°	summer	79.3	-2.3	-38	1397	752	100	35	1491	62	4	3.65	0.83	18
		12 month	85.8	-8.8	-144	1394	755	101	35	1598	-44	-3	3.65	0.83	18
	Black Awning 165°	summer	80.6	-3.6	-59	1125	1024	137	48	1476	78	5	3.34	1.14	25
		12 month	90.3	-13.2	-218	1122	1027	137	48	1635	-81	-5	3.34	1.14	25
	Linen Awning 165°	summer	79.9	-2.8	-47	1271	878	117	41	1483	70	5	3.51	0.97	22
		12 month	87.9	-10.9	-179	1267	882	118	41	1616	-62	-4	3.51	0.97	22
Double Clear	None		64.1			1840				1301			3.84		
	Black Awning 90°	summer	66.5	-2.4	-39	1157	683	91	37	1248	52	4	3.08	0.75	20
		12 month	72.7	-8.6	-141	1155	685	91	37	1350	-50	-4	3.08	0.75	20
	Linen Awning 90°	summer	66.1	-2.0	-33	1249	591	79	32	1254	46	4	3.19	0.64	17
		12 month	71.5	-7.4	-122	1247	593	79	32	1343	-43	-3	3.19	0.65	17
	Black Awning 165°	summer	67.1	-3.0	-49	1032	808	108	44	1242	59	5	2.94	0.89	23
		12 month	75.2	-11.0	-181	1031	809	108	44	1374	-73	-6	2.94	0.89	23
	Linen Awning 165°	summer	66.5	-2.4	-39	1148	692	92	38	1248	53	4	3.08	0.76	20
		12 month	73.3	-9.1	-150	1146	694	93	38	1358	-57	-4	3.08	0.76	20
Double HiSol LowE	None		58.5			1809				1203			3.68		
	Black Awning 90°	summer	60.7	-2.3	-37	1138	671	90	37	1151	52	4	2.96	0.72	20
		12 month	66.8	-8.4	-138	1137	672	90	37	1251	-48	-4	2.96	0.72	20
	Linen Awning 90°	summer	60.3	-1.9	-31	1228	581	78	32	1157	47	4	3.05	0.62	17
		12 month	65.7	-7.2	-119	1226	583	78	32	1244	-41	-3	3.05	0.62	17
	Black Awning 165°	summer	61.3	-2.9	-47	1015	794	106	44	1144	59	5	2.83	0.85	23
		12 month	69.2	-10.7	-177	1014	795	106	44	1274	-71	-6	2.83	0.85	23
	Linen Awning 165°	summer	60.8	-2.3	-38	1128	681	91	38	1150	53	4	2.95	0.73	20
		12 month	67.4	-8.9	-146	1126	683	91	38	1258	-55	-5	2.95	0.73	20

Window Type	Frame	U-factor	SHGC
Single Clear	Aluminum	1.16	0.77
Double Clear	Wood/vinyl	0.49	0.56
Double HiSol LowE	Wood/vinyl	0.37	0.53

The costs shown here are annual costs for heating and cooling only and thus will be less than the total utility bill. Heating is assumed to be provided by a gas furnace and cooling by a central air-conditioner. Electricity costs used in the analysis are 13.4 cents per kWh and natural gas costs are $16.96 per MBTU, which are the average costs in 2009 for the state of DC according to the Energy Information Administration (see Appendix E for details).

Figure 4. Page 2 of detailed city report for awnings in Washington DC

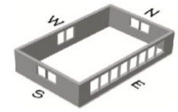


Table 116. Impact of awnings on a house in Washington, DC with east-facing windows on a typical year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		77.1			2268				1571			4.43		
	Black Awning	summer	80.1	-3.0	-50	1260	1008	135	44	1486	85	5	3.43	0.99	22
	90°	12 month	86.8	-9.7	-159	1258	1010	135	45	1595	-25	-2	3.43	0.99	22
	Linen Awning	summer	79.6	-2.5	-41	1399	869	116	38	1496	75	5	3.57	0.86	19
	90°	12 month	85.4	-8.3	-136	1397	871	116	38	1591	-20	-1	3.57	0.86	19
	Black Awning	summer	81.4	-4.4	-72	1072	1196	160	53	1482	88	6	3.24	1.19	27
	165°	12 month	90.1	-13.0	-215	1071	1197	160	53	1625	-55	-3	3.24	1.19	27
	Linen Awning	summer	80.5	-3.4	-56	1246	1022	136	45	1490	81	5	3.42	1.01	23
	165°	12 month	87.7	-10.7	-176	1244	1024	137	45	1609	-39	-2	3.42	1.01	23
Double Clear	None		64.5			1966				1324			3.82		
	Black Awning	summer	67.2	-2.7	-44	1147	819	109	42	1258	66	5	3.04	0.78	21
	90°	12 month	72.9	-8.4	-138	1146	820	109	42	1353	-29	-2	3.04	0.78	21
	Linen Awning	summer	66.8	-2.2	-37	1255	711	95	36	1266	58	4	3.15	0.67	18
	90°	12 month	71.8	-7.2	-119	1254	712	95	36	1348	-24	-2	3.15	0.67	18
	Black Awning	summer	68.2	-3.7	-61	990	976	130	50	1254	69	5	2.88	0.94	25
	165°	12 month	75.7	-11.2	-184	989	977	130	50	1378	-54	-4	2.88	0.94	25
	Linen Awning	summer	67.5	-2.9	-48	1135	831	111	42	1261	63	5	3.02	0.80	21
	165°	12 month	73.7	-9.2	-152	1134	832	111	42	1364	-40	-3	3.02	0.80	21
Double HiSol LowE	None		58.6			1917				1220			3.65		
	Black Awning	summer	61.1	-2.6	-42	1126	791	106	41	1156	63	5	2.90	0.75	21
	90°	12 month	66.8	-8.2	-135	1126	791	106	41	1250	-30	-2	2.90	0.75	21
	Linen Awning	summer	60.7	-2.1	-35	1234	683	91	36	1163	56	5	3.00	0.65	18
	90°	12 month	65.7	-7.1	-116	1233	684	91	36	1245	-25	-2	3.00	0.65	18
	Black Awning	summer	62.1	-3.5	-58	972	945	126	49	1152	68	6	2.76	0.89	24
	165°	12 month	69.5	-10.9	-180	972	945	126	49	1273	-54	-4	2.76	0.89	24
	Linen Awning	summer	61.4	-2.8	-46	1113	804	107	42	1158	61	5	2.88	0.77	21
	165°	12 month	67.6	-9.0	-148	1113	804	107	42	1260	-41	-3	2.88	0.77	21

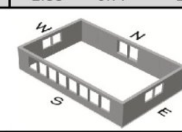


Table 117. Impact of awnings on a house in Washington, DC with south-facing windows on a typical year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		69.9			2113				1432			4.33		
	Black Awning	summer	73.2	-3.3	-54	1224	889	119	42	1367	65	5	3.45	0.88	20
	90°	12 month	85.5	-15.6	-257	1224	889	119	42	1570	-138	-10	3.45	0.88	20
	Linen Awning	summer	72.5	-2.6	-43	1336	777	104	37	1371	61	4	3.57	0.76	18
	90°	12 month	83.1	-13.2	-216	1336	777	104	37	1545	-113	-8	3.57	0.76	18
	Black Awning	summer	73.8	-3.8	-63	1110	1003	134	47	1362	71	5	3.28	1.05	24
	165°	12 month	90.2	-20.3	-334	1110	1003	134	47	1632	-200	-14	3.28	1.05	24
	Linen Awning	summer	72.9	-2.9	-48	1245	868	116	41	1365	68	5	3.43	0.89	21
	165°	12 month	86.3	-16.4	-270	1245	868	116	41	1586	-154	-11	3.43	0.89	21
Double Clear	None		58.5			1815				1205			3.75		
	Black Awning	summer	61.4	-2.8	-47	1119	696	93	38	1159	46	4	3.05	0.70	19
	90°	12 month	72.0	-13.4	-221	1119	696	93	38	1333	-128	-11	3.05	0.70	19
	Linen Awning	summer	60.8	-2.3	-38	1207	608	81	33	1162	43	4	3.15	0.60	16
	90°	12 month	69.9	-11.4	-187	1207	608	81	33	1311	-106	-9	3.15	0.60	16
	Black Awning	summer	61.8	-3.3	-54	1022	793	106	44	1154	51	4	2.92	0.84	22
	165°	12 month	75.7	-17.2	-283	1022	793	106	44	1382	-177	-15	2.92	0.84	22
	Linen Awning	summer	61.1	-2.6	-43	1130	685	91	38	1156	49	4	3.04	0.72	19
	165°	12 month	72.6	-14.0	-231	1130	685	91	38	1344	-139	-12	3.04	0.72	19
Double HiSol LowE	None		53.0			1760				1106			3.57		
	Black Awning	summer	55.7	-2.7	-45	1096	664	89	38	1062	44	4	2.90	0.68	19
	90°	12 month	65.9	-13.0	-213	1096	664	89	38	1231	-125	-11	2.90	0.68	19
	Linen Awning	summer	55.1	-2.2	-36	1180	580	77	33	1065	41	4	2.99	0.58	16
	90°	12 month	64.0	-11.0	-181	1180	580	77	33	1210	-104	-9	2.99	0.58	16
	Black Awning	summer	56.2	-3.2	-53	1000	760	101	43	1057	49	4	2.78	0.79	22
	165°	12 month	69.6	-16.6	-274	1000	760	101	43	1279	-172	-16	2.78	0.79	22
	Linen Awning	summer	55.5	-2.5	-41	1105	655	87	37	1060	46	4	2.89	0.69	19
	165°	12 month	66.5	-13.6	-223	1105	655	87	37	1242	-136	-12	2.89	0.69	19

Figure 5. Page 3 of detailed city report for awnings in Washington DC

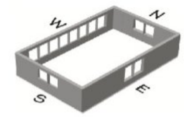


Table 118. Impact of awnings on a house in Washington, DC with west-facing windows on a typical year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		79.9			2370				1630			5.36		
	Black Awning	summer	82.3	-2.4	-40	1300	1070	143	45	1528	103	6	3.57	1.79	33
	90°	12 month	88.8	-8.9	-146	1296	1074	143	45	1633	-3	0	3.57	1.79	33
	Linen Awning	summer	81.9	-2.0	-33	1442	928	124	39	1540	91	6	3.83	1.54	29
	90°	12 month	87.5	-7.6	-125	1438	932	124	39	1631	-1	0	3.83	1.54	29
	Black Awning	summer	83.2	-3.3	-55	1089	1281	171	54	1514	116	7	3.29	2.08	39
	165°	12 month	91.6	-11.8	-193	1084	1286	172	54	1652	-22	-1	3.29	2.08	39
	Linen Awning	summer	82.5	-2.6	-43	1273	1097	146	46	1527	104	6	3.56	1.80	34
	165°	12 month	89.5	-9.7	-159	1268	1102	147	46	1642	-12	-1	3.56	1.80	34
Double Clear	None		66.3			2032				1362			4.62		
	Black Awning	summer	68.4	-2.1	-35	1173	859	115	42	1282	80	6	3.15	1.47	32
	90°	12 month	74.0	-7.7	-127	1170	862	115	42	1374	-12	-1	3.15	1.47	32
	Linen Awning	summer	68.1	-1.8	-29	1287	745	99	37	1292	71	5	3.37	1.26	27
	90°	12 month	72.9	-6.6	-109	1285	747	100	37	1371	-9	-1	3.37	1.26	27
	Black Awning	summer	69.2	-2.8	-47	1001	1031	138	51	1271	91	7	2.90	1.72	37
	165°	12 month	76.4	-10.1	-166	998	1034	138	51	1391	-28	-2	2.90	1.72	37
	Linen Awning	summer	68.6	-2.3	-37	1150	882	118	43	1282	81	6	3.16	1.46	32
	165°	12 month	74.7	-8.3	-137	1147	885	118	44	1381	-19	-1	3.16	1.46	32
Double HiSol LowE	None		60.1			1959				1251			4.41		
	Black Awning	summer	62.2	-2.0	-34	1139	820	109	42	1175	76	6	3.00	1.41	32
	90°	12 month	67.7	-7.6	-124	1136	823	110	42	1265	-14	-1	3.00	1.41	32
	Linen Awning	summer	61.8	-1.7	-28	1247	712	95	36	1184	67	5	3.21	1.21	27
	90°	12 month	66.6	-6.5	-107	1244	715	95	36	1262	-11	-1	3.21	1.21	27
	Black Awning	summer	62.9	-2.7	-45	974	985	131	50	1164	87	7	2.74	1.67	38
	165°	12 month	70.0	-9.9	-163	972	987	132	50	1282	-31	-2	2.74	1.67	38
	Linen Awning	summer	62.3	-2.2	-36	1117	842	112	43	1174	77	6	3.00	1.41	32
	165°	12 month	68.3	-8.2	-134	1114	845	113	43	1272	-22	-2	3.00	1.41	32

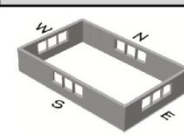


Table 119. Impact of awnings on a house in Washington, DC with equally distributed windows on a hot year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		71.4			3214				1604			4.29		
	Black Awning	summer	73.2	-1.8	-30	2128	1086	145	34	1489	115	7	3.50	0.79	18
	90°	12 month	80.8	-9.4	-155	2128	1086	145	34	1614	-10	-1	3.50	0.79	18
	Linen Awning	summer	72.9	-1.5	-25	2271	943	126	29	1502	101	6	3.61	0.68	16
	90°	12 month	79.5	-8.1	-133	2271	943	126	29	1611	-7	0	3.61	0.68	16
	Black Awning	summer	73.9	-2.5	-42	1911	1303	174	41	1471	132	8	3.37	0.92	21
	165°	12 month	84.0	-12.6	-208	1911	1303	174	41	1638	-34	-2	3.37	0.92	21
	Linen Awning	summer	73.4	-2.0	-32	2100	1114	149	35	1487	116	7	3.51	0.78	18
	165°	12 month	81.8	-10.4	-171	2100	1114	149	35	1625	-22	-1	3.51	0.78	18
Double Clear	None		59.3			2782				1348			3.77		
	Black Awning	summer	60.8	-1.5	-25	1925	857	114	31	1258	90	7	3.14	0.63	17
	90°	12 month	67.2	-7.9	-129	1925	857	114	31	1363	-15	-1	3.14	0.63	17
	Linen Awning	summer	60.6	-1.2	-20	2040	742	99	27	1269	79	6	3.23	0.54	14
	90°	12 month	66.1	-6.8	-111	2040	742	99	27	1360	-12	-1	3.23	0.54	14
	Black Awning	summer	61.4	-2.0	-34	1754	1028	137	37	1244	104	8	3.02	0.75	20
	165°	12 month	69.8	-10.5	-172	1754	1028	137	37	1382	-35	-3	3.02	0.75	20
	Linen Awning	summer	60.9	-1.6	-26	1903	879	117	32	1257	91	7	3.14	0.63	17
	165°	12 month	68.0	-8.6	-142	1903	879	117	32	1372	-24	-2	3.14	0.63	17
Double HiSol LowE	None		54.1			2699				1251			3.63		
	Black Awning	summer	55.5	-1.4	-23	1880	819	109	30	1164	86	7	3.02	0.61	17
	90°	12 month	61.8	-7.6	-126	1880	819	109	30	1267	-16	-1	3.02	0.61	17
	Linen Awning	summer	55.3	-1.2	-19	1990	709	95	26	1175	75	6	3.11	0.52	14
	90°	12 month	60.7	-6.6	-108	1990	709	95	26	1264	-14	-1	3.11	0.52	14
	Black Awning	summer	56.0	-1.9	-32	1711	988	132	37	1150	100	8	2.90	0.73	20
	165°	12 month	64.3	-10.1	-167	1711	988	132	37	1285	-35	-3	2.90	0.73	20
	Linen Awning	summer	55.6	-1.5	-25	1859	840	112	31	1163	87	7	3.02	0.61	17
	165°	12 month	62.5	-8.4	-137	1859	840	112	31	1276	-25	-2	3.02	0.61	17

Figure 6. Page 4 of detailed city report for awnings in Washington DC

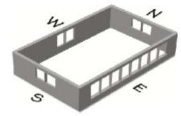


Table 120. Impact of awnings on a house in Washington, DC with east-facing windows on a hot year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		71.3			3433				1630			4.70		
	Black Awning	summer	73.2	-2.0	-32	2159	1274	170	37	1493	138	8	3.44	1.26	27
	90°	12 month	80.3	-9.0	-149	2158	1275	170	37	1609	22	1	3.44	1.26	27
	Linen Awning	summer	72.8	-1.6	-26	2330	1103	147	32	1509	121	7	3.51	1.19	25
	90°	12 month	79.0	-7.7	-127	2328	1105	148	32	1610	20	1	3.51	1.19	25
	Black Awning	summer	74.4	-3.2	-52	1872	1561	208	45	1474	156	10	3.35	1.35	29
	165°	12 month	84.1	-12.9	-212	1870	1563	209	46	1633	-3	0	3.35	1.35	29
	Linen Awning	summer	73.7	-2.4	-40	2102	1331	178	39	1492	138	8	3.45	1.26	27
	165°	12 month	81.7	-10.5	-172	2100	1333	178	39	1624	6	0	3.45	1.26	27
Double Clear	None		59.5			2993				1379			3.99		
	Black Awning	summer	61.2	-1.7	-28	1965	1028	137	34	1269	110	8	3.12	0.87	22
	90°	12 month	67.3	-7.8	-128	1965	1028	137	34	1370	9	1	3.12	0.87	22
	Linen Awning	summer	60.9	-1.4	-23	2104	889	119	30	1283	96	7	3.18	0.81	20
	90°	12 month	66.2	-6.7	-110	2104	889	119	30	1370	9	1	3.18	0.81	20
	Black Awning	summer	62.2	-2.6	-43	1729	1264	169	42	1254	125	9	3.04	0.95	24
	165°	12 month	70.5	-11.0	-180	1728	1265	169	42	1390	-11	-1	3.04	0.95	24
	Linen Awning	summer	61.6	-2.0	-33	1918	1075	144	36	1269	110	8	3.12	0.87	22
	165°	12 month	68.5	-8.9	-147	1918	1075	144	36	1383	-4	0	3.12	0.87	22
Double HiSol LowE	None		54.0			2905				1277			3.82		
	Black Awning	summer	55.6	-1.6	-26	1916	989	132	34	1171	106	8	3.00	0.83	22
	90°	12 month	61.6	-7.6	-125	1916	989	132	34	1270	7	1	3.00	0.83	22
	Linen Awning	summer	55.4	-1.3	-21	2050	855	114	29	1184	93	7	3.05	0.77	20
	90°	12 month	60.6	-6.5	-107	2049	856	114	29	1270	7	1	3.05	0.77	20
	Black Awning	summer	56.5	-2.5	-41	1685	1220	163	42	1155	122	10	2.92	0.91	24
	165°	12 month	64.7	-10.6	-175	1684	1221	163	42	1289	-12	-1	2.92	0.91	24
	Linen Awning	summer	56.0	-1.9	-31	1872	1033	138	36	1170	107	8	2.99	0.83	22
	165°	12 month	62.8	-8.7	-143	1871	1034	138	36	1282	-5	0	2.99	0.83	22

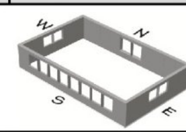


Table 121. Impact of awnings on a house in Washington, DC with south-facing windows on a hot year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		65.7			3158				1502			4.48		
	Black Awning	summer	67.7	-2.1	-34	2023	1135	152	36	1384	118	8	3.38	1.11	25
	90°	12 month	79.7	-14.0	-231	2023	1135	152	36	1581	-79	-5	3.38	1.11	25
	Linen Awning	summer	67.3	-1.6	-27	2165	993	133	31	1396	106	7	3.44	1.05	23
	90°	12 month	77.4	-11.8	-194	2165	993	133	31	1563	-61	-4	3.44	1.05	23
	Black Awning	summer	68.2	-2.5	-41	1882	1276	170	40	1372	129	9	3.32	1.16	26
	165°	12 month	84.4	-18.7	-308	1882	1276	170	40	1639	-138	-9	3.32	1.16	26
	Linen Awning	summer	67.5	-1.9	-31	2058	1100	147	35	1386	116	8	3.38	1.10	25
	165°	12 month	80.7	-15.1	-248	2058	1100	147	35	1603	-101	-7	3.38	1.10	25
Double Clear	None		55.0			2746				1271			3.77		
	Black Awning	summer	56.7	-1.8	-29	1850	896	120	33	1180	91	7	3.06	0.71	19
	90°	12 month	67.0	-12.0	-197	1850	896	120	33	1349	-78	-6	3.06	0.71	19
	Linen Awning	summer	56.4	-1.4	-23	1963	783	105	29	1190	82	6	3.11	0.66	17
	90°	12 month	65.1	-10.1	-167	1963	783	105	29	1333	-62	-5	3.11	0.66	17
	Black Awning	summer	57.1	-2.1	-35	1730	1016	136	37	1171	100	8	2.99	0.78	21
	165°	12 month	70.8	-15.8	-260	1730	1016	136	37	1395	-124	-10	2.99	0.78	21
	Linen Awning	summer	56.6	-1.6	-27	1871	875	117	32	1181	90	7	3.05	0.72	19
	165°	12 month	67.8	-12.8	-211	1871	875	117	32	1365	-94	-7	3.05	0.72	19
Double HiSol LowE	None		49.8			2664				1176			3.59		
	Black Awning	summer	51.5	-1.6	-27	1805	859	115	32	1088	88	7	2.94	0.66	18
	90°	12 month	61.3	-11.5	-189	1805	859	115	32	1250	-74	-6	2.94	0.66	18
	Linen Awning	summer	51.1	-1.3	-22	1913	751	100	28	1097	79	7	2.99	0.61	17
	90°	12 month	59.6	-9.7	-160	1913	751	100	28	1235	-60	-5	2.99	0.61	17
	Black Awning	summer	51.9	-2.0	-33	1685	979	131	37	1078	98	8	2.86	0.73	20
	165°	12 month	65.0	-15.2	-250	1685	979	131	37	1295	-119	-10	2.86	0.73	20
	Linen Awning	summer	51.4	-1.5	-25	1824	840	112	32	1089	87	7	2.93	0.66	18
	165°	12 month	62.1	-12.3	-202	1824	840	112	32	1266	-90	-8	2.93	0.66	18

Figure 7. Page 5 of detailed city report for awnings in Washington DC

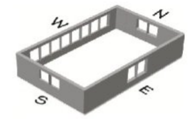


Table 122. Impact of awnings on a house in Washington, DC with west-facing windows on a hot year

Window Type	Awning	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		74.6			3580				1705			6.06		
	Black Awning	summer	76.3	-1.7	-28	2216	1364	182	38	1550	154	9	3.82	2.24	37
	90°	12 month	82.8	-8.2	-135	2208	1372	183	38	1656	48	3	3.82	2.24	37
	Linen Awning	summer	76.0	-1.4	-23	2392	1188	159	33	1569	135	8	4.14	1.92	32
	90°	12 month	81.6	-7.1	-116	2384	1196	160	33	1661	44	3	4.14	1.92	32
	Black Awning	summer	77.2	-2.6	-43	1898	1682	225	47	1523	182	11	3.37	2.69	44
	165°	12 month	86.0	-11.4	-188	1890	1690	226	47	1667	38	2	3.37	2.69	44
	Linen Awning	summer	76.5	-2.0	-32	2141	1439	192	40	1545	160	9	3.73	2.33	38
	165°	12 month	83.9	-9.3	-153	2133	1447	193	40	1664	41	2	3.73	2.33	38
Double Clear	None		61.6			3101				1428			5.17		
	Black Awning	summer	63.0	-1.4	-23	1997	1104	147	36	1303	125	9	3.36	1.81	35
	90°	12 month	68.7	-7.0	-116	1995	1106	148	36	1396	32	2	3.36	1.81	35
	Linen Awning	summer	62.8	-1.2	-19	2142	959	128	31	1319	109	8	3.61	1.56	30
	90°	12 month	67.7	-6.1	-100	2140	961	128	31	1399	29	2	3.61	1.56	30
	Black Awning	summer	63.7	-2.1	-35	1742	1359	181	44	1281	147	10	3.00	2.17	42
	165°	12 month	71.4	-9.7	-160	1740	1361	182	44	1406	21	2	3.00	2.17	42
	Linen Awning	summer	63.2	-1.6	-26	1940	1161	155	37	1299	129	9	3.30	1.88	36
	165°	12 month	69.6	-7.9	-131	1939	1162	155	37	1403	25	2	3.30	1.88	36
Double HiSol LowE	None		55.9			3011				1321			4.96		
	Black Awning	summer	57.2	-1.3	-21	1948	1063	142	35	1201	121	9	3.22	1.73	35
	90°	12 month	62.7	-6.9	-113	1947	1064	142	35	1292	29	2	3.22	1.73	35
	Linen Awning	summer	56.9	-1.1	-18	2088	923	123	31	1215	106	8	3.47	1.49	30
	90°	12 month	61.8	-5.9	-97	2087	924	123	31	1295	26	2	3.47	1.49	30
	Black Awning	summer	57.8	-2.0	-32	1699	1312	175	44	1178	143	11	2.88	2.08	42
	165°	12 month	65.3	-9.4	-155	1698	1313	175	44	1301	20	2	2.88	2.08	42
	Linen Awning	summer	57.4	-1.5	-24	1895	1116	149	37	1196	125	9	3.16	1.79	36
	165°	12 month	63.6	-7.7	-127	1894	1117	149	37	1299	22	2	3.16	1.79	36

Figure 8. Page 1 of detailed city report for roller shades in Washington DC

Washington, DC — Roller Shades

Typical Year (TMY3) HDD65 4920 / CDD65 1112, Hot Year (2010) HDD65 4511 / CDD65 1590

Tables 515-518 show the impact of shade screens on a typical house in Washington with different window orientations over a typical year. Tables 519-522 repeat this analysis for a hot year in Washington. The impact varies depending on the type of window glazing and whether the shade screens are in place all twelve months or only during the cooling season. For a house with windows equally distributed in the four orientations, Table 515 shows the annual heating and cooling energy use as well as the peak electricity demand for each combination of glazing and shading condition. The table also shows the impact on the total cost for heating and cooling. In all cases, the net and percent savings are in reference to a house with no shading.

Table 515 shows that shade screens reduce cooling energy use by 21-29 percent as compared to the unshaded house. The higher savings are for the more dense shade screens over windows with clear glazings, while the lower savings are for less dense shade screens over windows with Low-E glazings. Because shade screens block useful solar gain in winter, heating energy use increases when the shade screens remain in place 12 months a year. Using the shade screens only during the cooling season produces the largest net energy savings. The net energy savings are 4-5 percent in Washington when shade screens are used only during the cooling season from April through October, while the penalties are from -5 to -4 percent when they are deployed throughout the year.

Table 515 also shows that shade screens reduce peak electricity demand by 12-16 percent in Washington, with larger reductions for the clear glazings and smaller reductions for the Low-E glazing. Tables 516, 517, and 518 show results for houses in Washington where the windows predominantly face to the east, south, and west, respectively. The cooling energy savings are largest on west-facing shade screens, and the peak demand reductions largest on south facing shade screens. Tables 519-522 show the impact of shade screens on a particularly hot year (2010) in Washington. The main effect is to increase the cooling savings by 56 percent due to the hotter or longer summer.

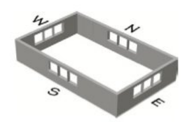


Table 515. Impact of shade screens on a house in Washington, DC with equally distributed windows on a typical year

Window Type	Shade Screen	Operation	Heating			Cooling				Heat+Cool			Peak Cooling		
			Energy (MBtu)	Savings (MBtu)	Savings ($)	Cool (kWh)	Savings (kWh)	Savings ($)	Savings (%)	Cost ($)	Savings ($)	Savings (%)	Peak (kW)	Savings (kW)	Savings (%)
Single Clear	None		77.0			2149				1554			4.47		
	Black/Brown 25% Openness Factor	summer	77.3	-0.3	-5	1666	483	64	22	1494	60	4	3.86	0.61	14
		12 month	85.5	-8.5	-139	1522	627	84	29	1609	-55	-4	3.86	0.61	14
	Black/Brown 10% Openness Factor	summer	77.4	-0.4	-6	1591	558	74	26	1485	69	4	3.79	0.68	15
		12 month	87.3	-10.3	-169	1429	720	96	34	1627	-73	-5	3.79	0.68	15
	Black/Brown 10% Openness Factor, full basketweave	summer	77.4	-0.4	-6	1588	561	75	26	1485	69	4	3.80	0.67	15
		12 month	87.5	-10.5	-173	1425	724	97	34	1630	-76	-5	3.80	0.67	15
	Black 5% Openness Factor, full basketweave	summer	77.4	-0.4	-6	1578	571	76	27	1484	70	4	3.80	0.68	15
		12 month	87.9	-10.9	-179	1413	736	98	34	1634	-81	-5	3.80	0.68	15
	White 5% Openness Factor, full basketweave	summer	77.4	-0.4	-7	1534	615	82	29	1479	75	5	3.72	0.75	17
		12 month	88.4	-11.4	-187	1358	791	106	37	1635	-82	-5	3.72	0.75	17
Double Clear	None		64.1			1840				1301			3.84		
	Black/Brown 25% Openness Factor	summer	64.3	-0.2	-4	1451	389	52	21	1252	48	4	3.36	0.48	12
		12 month	71.0	-6.9	-114	1345	495	66	27	1348	-47	-4	3.36	0.48	12
	Black/Brown 10% Openness Factor	summer	64.4	-0.3	-5	1393	447	60	24	1246	55	4	3.30	0.53	14
		12 month	72.5	-8.4	-139	1275	565	75	31	1364	-63	-5	3.30	0.53	14
	Black/Brown 10% Openness Factor, full basketweave	summer	64.4	-0.3	-5	1382	458	61	25	1244	56	4	3.30	0.54	14
		12 month	72.9	-8.8	-144	1262	578	77	31	1367	-67	-5	3.30	0.54	14
	Black 5% Openness Factor, full basketweave	summer	64.4	-0.3	-5	1376	464	62	25	1244	57	4	3.30	0.54	14
		12 month	73.1	-9.0	-147	1255	585	78	32	1370	-69	-5	3.30	0.54	14
	White 5% Openness Factor, full basketweave	summer	64.5	-0.3	-5	1342	498	66	27	1239	61	5	3.23	0.61	16
		12 month	73.3	-9.2	-151	1213	627	84	34	1368	-67	-5	3.23	0.61	16
Double HiSol LowE	None		58.5			1809				1203			3.68		
	Black/Brown 25% Openness Factor	summer	58.6	-0.2	-3	1433	376	50	21	1156	47	4	3.23	0.45	12
		12 month	65.1	-6.6	-109	1332	477	64	26	1248	-45	-4	3.23	0.45	12
	Black/Brown 10% Openness Factor	summer	58.7	-0.2	-4	1379	430	57	24	1149	54	4	3.18	0.50	14
		12 month	66.3	-7.9	-129	1267	542	72	30	1260	-57	-5	3.18	0.50	14
	Black/Brown 10% Openness Factor, full basketweave	summer	58.7	-0.2	-4	1370	439	59	24	1148	55	5	3.18	0.50	14
		12 month	66.6	-8.1	-134	1256	553	74	31	1263	-60	-5	3.18	0.50	14
	Black 5% Openness Factor, full basketweave	summer	58.7	-0.2	-4	1364	445	59	25	1148	55	5	3.17	0.51	14
		12 month	66.8	-8.3	-137	1249	560	75	31	1266	-62	-5	3.17	0.51	14
	White 5% Openness Factor, full basketweave	summer	58.7	-0.3	-4	1324	485	65	27	1143	60	5	3.10	0.58	16
		12 month	67.2	-8.7	-144	1201	608	81	34	1266	-63	-5	3.10	0.58	16

Window Type	Frame	U-factor	SHGC
Single Clear	Aluminum	1.16	0.77
Double Clear	Wood/vinyl	0.49	0.56
Double HiSol LowE	Wood/vinyl	0.37	0.53

The costs shown here are annual costs for heating and cooling only and thus will be less than the total utility bill. Heating is assumed to be provided by a gas furnace and cooling by a central air-conditioner. Electricity costs used in the analysis are 13.4 cents per kWh and natural gas costs are $16.96 per MBTU, which are the average costs in 2009 for the state of DC according to the Energy Information Administration (see Appendix E for details).

Figure 9. Page 2 of detailed city report for roller shades in Washington DC

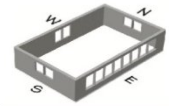


Table 516. Impact of shade screens on a house in Washington, DC with east-facing windows on a typical year

Window Type	Shade Screen	Operation	Heating			Cooling				Heat+Cool			Peak Cooling		
			Energy (MBtu)	Savings (MBtu)	Savings ($)	Cool (kWh)	Savings (kWh)	Savings ($)	Savings (%)	Cost ($)	Savings ($)	Savings (%)	Peak (kW)	Savings (kW)	Savings (%)
Single Clear	None		77.1			2268				1571			4.43		
	Black/Brown 25% Openness Factor	summer	77.3	-0.3	-4	1827	441	59	19	1516	55	3	4.17	0.26	6
		12 month	83.2	-6.1	-100	1709	559	75	25	1596	-26	-2	4.17	0.26	6
	Black/Brown 10% Openness Factor	summer	77.4	-0.4	-6	1746	522	70	23	1507	64	4	4.13	0.29	7
		12 month	84.5	-7.5	-123	1606	662	88	29	1605	-34	-2	4.13	0.29	7
	Black/Brown 10% Openness Factor, full basketweave	summer	77.5	-0.4	-7	1734	534	71	24	1506	65	4	4.13	0.30	7
		12 month	84.7	-7.6	-126	1593	675	90	30	1606	-35	-2	4.13	0.30	7
	Black 5% Openness Factor, full basketweave	summer	77.5	-0.4	-7	1719	549	73	24	1504	66	4	4.12	0.30	7
		12 month	85.0	-7.9	-130	1574	694	93	31	1608	-37	-2	4.12	0.30	7
	White 5% Openness Factor, full basketweave	summer	77.5	-0.4	-7	1694	574	77	25	1501	70	4	4.10	0.32	7
		12 month	85.4	-8.3	-137	1542	726	97	32	1610	-40	-3	4.10	0.32	7
Double Clear	None		64.5			1966				1324			3.82		
	Black/Brown 25% Openness Factor	summer	64.7	-0.2	-3	1606	360	48	18	1279	45	3	3.64	0.18	5
		12 month	69.5	-5.0	-82	1513	453	60	23	1345	-22	-2	3.64	0.18	5
	Black/Brown 10% Openness Factor	summer	64.8	-0.3	-5	1540	426	57	22	1272	52	4	3.61	0.21	6
		12 month	70.6	-6.1	-101	1431	535	71	27	1353	-29	-2	3.61	0.21	6
	Black/Brown 10% Openness Factor, full basketweave	summer	64.8	-0.3	-5	1526	440	59	22	1270	54	4	3.60	0.22	6
		12 month	70.9	-6.4	-105	1413	553	74	28	1355	-31	-2	3.60	0.22	6
	Black 5% Openness Factor, full basketweave	summer	64.8	-0.3	-5	1513	453	60	23	1269	55	4	3.60	0.22	6
		12 month	71.0	-6.5	-107	1398	568	76	29	1355	-31	-2	3.60	0.22	6
	White 5% Openness Factor, full basketweave	summer	64.8	-0.3	-5	1504	462	62	23	1268	56	4	3.58	0.24	6
		12 month	71.2	-6.7	-110	1387	579	77	29	1357	-33	-2	3.58	0.24	6
Double HiSol LowE	None		58.6			1917				1220			3.65		
	Black/Brown 25% Openness Factor	summer	58.8	-0.2	-3	1569	348	46	18	1176	43	4	3.48	0.17	5
		12 month	63.4	-4.8	-79	1478	439	59	23	1240	-20	-2	3.48	0.17	5
	Black/Brown 10% Openness Factor	summer	58.8	-0.2	-4	1509	408	54	21	1169	51	4	3.45	0.20	5
		12 month	64.3	-5.7	-94	1405	512	68	27	1245	-25	-2	3.45	0.20	5
	Black/Brown 10% Openness Factor, full basketweave	summer	58.9	-0.3	-4	1495	422	56	22	1168	52	4	3.45	0.20	6
		12 month	64.5	-5.9	-97	1389	528	70	28	1246	-27	-2	3.45	0.20	6
	Black 5% Openness Factor, full basketweave	summer	58.9	-0.3	-4	1487	430	57	22	1167	53	4	3.44	0.21	6
		12 month	64.6	-6.0	-100	1378	539	72	28	1247	-28	-2	3.44	0.21	6
	White 5% Openness Factor, full basketweave	summer	58.9	-0.3	-5	1466	451	60	24	1164	56	5	3.43	0.22	6
		12 month	65.0	-6.4	-105	1352	565	75	29	1249	-30	-2	3.43	0.22	6

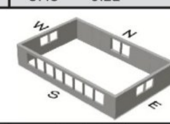


Table 517. Impact of shade screens on a house in Washington, DC with south-facing windows on a typical year

Window Type	Shade Screen	Operation	Heating			Cooling				Heat+Cool			Peak Cooling		
			Energy (MBtu)	Savings (MBtu)	Savings ($)	Cool (kWh)	Savings (kWh)	Savings ($)	Savings (%)	Cost ($)	Savings ($)	Savings (%)	Peak (kW)	Savings (kW)	Savings (%)
Single Clear	None		69.9			2113				1432			4.33		
	Black/Brown 25% Openness Factor	summer	70.1	-0.2	-3	1586	527	70	25	1365	67	5	3.58	0.75	17
		12 month	82.5	-12.6	-207	1393	720	96	34	1543	-111	-8	3.58	0.75	17
	Black/Brown 10% Openness Factor	summer	70.2	-0.3	-5	1533	580	77	27	1359	73	5	3.56	0.77	18
		12 month	85.7	-15.7	-259	1323	790	105	37	1586	-153	-11	3.56	0.77	18
	Black/Brown 10% Openness Factor, full basketweave	summer	70.2	-0.3	-5	1544	569	76	27	1361	71	5	3.57	0.75	17
		12 month	86.1	-16.2	-266	1335	778	104	37	1595	-162	-11	3.57	0.75	17
	Black 5% Openness Factor, full basketweave	summer	70.2	-0.3	-5	1541	572	76	27	1361	72	5	3.58	0.75	17
		12 month	86.8	-16.9	-278	1331	782	104	37	1605	-173	-12	3.58	0.75	17
	White 5% Openness Factor, full basketweave	summer	70.3	-0.3	-5	1470	643	86	30	1352	80	6	3.52	0.81	19
		12 month	87.5	-17.5	-288	1244	869	116	41	1605	-172	-12	3.52	0.81	19
Double Clear	None		58.5			1815				1205			3.75		
	Black/Brown 25% Openness Factor	summer	58.7	-0.2	-3	1405	410	55	23	1153	52	4	3.22	0.53	14
		12 month	69.1	-10.6	-174	1273	542	72	30	1307	-102	-8	3.22	0.53	14
	Black/Brown 10% Openness Factor	summer	58.7	-0.2	-3	1365	450	60	25	1149	57	5	3.20	0.55	15
		12 month	71.8	-13.3	-218	1221	594	79	33	1344	-139	-12	3.20	0.55	15
	Black/Brown 10% Openness Factor, full basketweave	summer	58.8	-0.2	-4	1362	453	60	25	1148	57	5	3.20	0.55	15
		12 month	72.4	-13.8	-228	1218	597	80	33	1353	-148	-12	3.20	0.55	15
	Black 5% Openness Factor, full basketweave	summer	58.8	-0.2	-4	1360	455	61	25	1148	57	5	3.21	0.54	15
		12 month	72.8	-14.2	-234	1216	599	80	33	1359	-154	-13	3.21	0.54	15
	White 5% Openness Factor, full basketweave	summer	58.8	-0.3	-4	1300	515	69	28	1140	65	5	3.15	0.60	16
		12 month	72.9	-14.3	-236	1143	672	90	37	1351	-146	-12	3.15	0.60	16
Double HiSol LowE	None		53.0			1760				1106			3.57		
	Black/Brown 25% Openness Factor	summer	53.1	-0.1	-2	1384	376	50	21	1058	48	4	3.09	0.48	13
		12 month	63.3	-10.3	-170	1263	497	66	28	1210	-104	-9	3.09	0.48	13
	Black/Brown 10% Openness Factor	summer	53.1	-0.2	-3	1345	415	55	24	1054	53	5	3.08	0.50	14
		12 month	65.5	-12.5	-205	1215	545	73	31	1239	-133	-12	3.08	0.50	14
	Black/Brown 10% Openness Factor, full basketweave	summer	53.1	-0.2	-3	1343	417	56	24	1053	53	5	3.08	0.50	14
		12 month	66.0	-13.0	-214	1212	548	73	31	1247	-141	-13	3.08	0.50	14
	Black 5% Openness Factor, full basketweave	summer	53.1	-0.2	-3	1341	419	56	24	1053	53	5	3.08	0.49	14
		12 month	66.3	-13.4	-220	1210	550	73	31	1253	-147	-13	3.08	0.49	14
	White 5% Openness Factor, full basketweave	summer	53.2	-0.2	-4	1278	482	64	27	1045	61	5	3.03	0.54	15
		12 month	66.8	-13.9	-228	1134	626	84	36	1251	-144	-13	3.03	0.54	15

Figure 10. Page 3 of detailed city report for roller shades in Washington DC

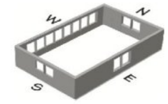


Table 518. Impact of shade screens on a house in Washington, DC with west-facing windows on a typical year

Window Type	Shade Screen	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		79.9			2370				1630			5.36		
	Black/Brown 25% Openness Factor	summer	80.0	-0.1	-2	1885	485	65	20	1568	62	4	4.66	0.71	13
		12 month	85.4	-5.5	-90	1710	660	88	28	1632	-2	0	4.06	1.31	24
	Black/Brown 10% Openness Factor	summer	80.0	-0.2	-3	1792	578	77	24	1556	74	5	4.66	0.71	13
		12 month	86.4	-6.6	-108	1589	781	104	33	1634	-4	0	3.75	1.61	30
	Black/Brown 10% Openness Factor, full basketweave	summer	80.1	-0.2	-3	1781	589	79	25	1555	76	5	4.66	0.71	13
		12 month	86.5	-6.7	-109	1574	796	106	34	1634	-3	0	3.71	1.66	31
	Black 5% Openness Factor, full basketweave	summer	80.1	-0.2	-3	1766	604	81	25	1553	78	5	4.66	0.71	13
		12 month	86.7	-6.8	-113	1554	816	109	34	1634	-4	0	3.69	1.68	31
	White 5% Openness Factor, full basketweave	summer	80.1	-0.2	-3	1731	639	85	27	1548	82	5	4.66	0.71	13
		12 month	87.2	-7.3	-120	1512	858	115	36	1636	-6	0	3.62	1.75	33
Double Clear	None		66.3			2032				1362			4.62		
	Black/Brown 25% Openness Factor	summer	66.4	-0.1	-1	1639	393	52	19	1311	51	4	3.96	0.66	14
		12 month	70.7	-4.4	-72	1512	520	69	26	1365	-3	0	3.54	1.08	23
	Black/Brown 10% Openness Factor	summer	66.4	-0.1	-2	1562	470	63	23	1301	61	4	3.96	0.66	14
		12 month	71.6	-5.3	-87	1411	621	83	31	1366	-4	0	3.27	1.35	29
	Black/Brown 10% Openness Factor, full basketweave	summer	66.4	-0.1	-2	1544	488	65	24	1299	63	5	3.96	0.66	14
		12 month	71.8	-5.5	-90	1389	643	86	32	1366	-4	0	3.23	1.39	30
	Black 5% Openness Factor, full basketweave	summer	66.4	-0.1	-2	1536	496	66	24	1298	64	5	3.96	0.66	14
		12 month	71.9	-5.6	-91	1378	654	87	32	1366	-4	0	3.22	1.40	30
	White 5% Openness Factor, full basketweave	summer	66.5	-0.1	-2	1516	516	69	25	1295	67	5	3.96	0.66	14
		12 month	72.2	-5.9	-96	1355	677	90	33	1368	-6	0	3.18	1.44	31
Double HiSol LowE	None		60.1			1959				1251			4.41		
	Black/Brown 25% Openness Factor	summer	60.2	-0.1	-1	1587	372	50	19	1202	49	4	3.78	0.63	14
		12 month	64.3	-4.2	-69	1463	496	66	25	1253	-2	0	3.33	1.09	25
	Black/Brown 10% Openness Factor	summer	60.2	-0.1	-1	1520	439	59	22	1194	57	5	3.78	0.63	14
		12 month	65.0	-4.9	-81	1376	583	78	30	1254	-3	0	3.11	1.30	29
	Black/Brown 10% Openness Factor, full basketweave	summer	60.2	-0.1	-2	1505	454	61	23	1192	59	5	3.78	0.63	14
		12 month	65.2	-5.1	-83	1358	601	80	31	1254	-3	0	3.06	1.35	31
	Black 5% Openness Factor, full basketweave	summer	60.2	-0.1	-2	1497	462	62	24	1191	60	5	3.78	0.63	14
		12 month	65.3	-5.2	-85	1347	612	82	31	1254	-3	0	3.05	1.36	31
	White 5% Openness Factor, full basketweave	summer	60.3	-0.1	-2	1469	490	65	25	1187	64	5	3.78	0.63	14
		12 month	65.7	-5.6	-91	1314	645	86	33	1256	-5	0	2.99	1.42	32

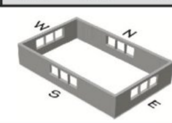


Table 519. Impact of shade screens on a house in Washington, DC with equally distributed windows on a hot year

Window Type	Shade Screen	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		71.4			3214				1604			4.29		
	Black/Brown 25% Openness Factor	summer	72.1	-0.7	-12	2564	650	87	20	1528	75	5	3.72	0.57	13
		12 month	79.3	-7.9	-130	2420	794	106	25	1628	-24	-2	3.72	0.57	13
	Black/Brown 10% Openness Factor	summer	72.3	-0.9	-14	2457	757	101	24	1517	87	5	3.65	0.65	15
		12 month	81.1	-9.7	-160	2293	921	123	29	1641	-37	-2	3.65	0.65	15
	Black/Brown 10% Openness Factor, full basketweave	summer	72.3	-0.9	-15	2450	764	102	24	1516	87	5	3.64	0.65	15
		12 month	81.4	-10.0	-164	2285	929	124	29	1643	-40	-2	3.64	0.65	15
	Black 5% Openness Factor, full basketweave	summer	72.3	-0.9	-15	2436	778	104	24	1515	89	6	3.63	0.66	15
		12 month	81.7	-10.3	-170	2267	947	126	29	1647	-43	-3	3.63	0.66	15
	White 5% Openness Factor, full basketweave	summer	72.4	-1.0	-16	2379	835	111	26	1509	95	6	3.58	0.71	16
		12 month	82.2	-10.8	-178	2200	1014	135	32	1646	-42	-3	3.58	0.71	16
Double Clear	None		59.3			2782				1348			3.77		
	Black/Brown 25% Openness Factor	summer	59.9	-0.6	-9	2264	518	69	19	1288	60	4	3.31	0.46	12
		12 month	65.8	-6.5	-107	2154	628	84	23	1371	-23	-2	3.31	0.46	12
	Black/Brown 10% Openness Factor	summer	60.0	-0.7	-11	2175	607	81	22	1278	70	5	3.25	0.52	14
		12 month	67.3	-8.0	-131	2049	733	98	26	1381	-33	-2	3.25	0.52	14
	Black/Brown 10% Openness Factor, full basketweave	summer	60.1	-0.7	-12	2159	623	83	22	1276	71	5	3.23	0.54	14
		12 month	67.6	-8.3	-137	2031	751	100	27	1384	-36	-3	3.23	0.54	14
	Black 5% Openness Factor, full basketweave	summer	60.1	-0.7	-12	2151	631	84	23	1275	72	5	3.23	0.54	14
		12 month	67.8	-8.5	-140	2021	761	102	27	1386	-38	-3	3.23	0.54	14
	White 5% Openness Factor, full basketweave	summer	60.1	-0.8	-13	2110	672	90	24	1270	77	6	3.19	0.58	15
		12 month	68.0	-8.7	-143	1974	808	108	29	1382	-35	-3	3.19	0.58	15
Double HiSol LowE	None		54.1			2699				1251			3.63		
	Black/Brown 25% Openness Factor	summer	54.6	-0.5	-8	2211	488	65	18	1194	57	5	3.18	0.45	12
		12 month	60.4	-6.3	-103	2108	591	79	22	1275	-24	-2	3.18	0.45	12
	Black/Brown 10% Openness Factor	summer	54.7	-0.6	-10	2136	563	75	21	1185	65	5	3.13	0.50	14
		12 month	61.6	-7.5	-123	2019	680	91	25	1282	-32	-3	3.13	0.50	14
	Black/Brown 10% Openness Factor, full basketweave	summer	54.8	-0.6	-11	2122	577	77	21	1184	67	5	3.12	0.51	14
		12 month	61.9	-7.7	-127	2002	697	93	26	1285	-34	-3	3.12	0.51	14
	Black 5% Openness Factor, full basketweave	summer	54.8	-0.7	-11	2112	587	78	22	1183	68	5	3.11	0.52	14
		12 month	62.0	-7.9	-130	1991	708	95	26	1287	-36	-3	3.11	0.52	14
	White 5% Openness Factor, full basketweave	summer	54.8	-0.7	-12	2063	636	85	24	1177	73	6	3.07	0.56	15
		12 month	62.4	-8.3	-136	1934	765	102	28	1285	-34	-3	3.07	0.56	15

Figure 11. Page 4 of detailed city report for roller shades in Washington DC

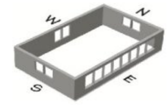


Table 520. Impact of shade screens on a house in Washington, DC with east-facing windows on a hot year

Window Type	Shade Screen	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		71.3			3433				1630			4.70		
	Black/Brown 25% Openness Factor	summer	71.9	-0.6	-10	2830	603	81	18	1560	70	4	3.96	0.74	16
		12 month	77.1	-5.9	-97	2721	712	95	21	1632	-2	0	3.96	0.74	16
	Black/Brown 10% Openness Factor	summer	72.1	-0.8	-14	2706	727	97	21	1547	83	5	3.94	0.76	16
		12 month	78.5	-7.3	-120	2577	856	114	25	1636	-5	0	3.94	0.76	16
	Black/Brown 10% Openness Factor, full basketweave	summer	72.1	-0.9	-15	2688	745	99	22	1546	85	5	3.94	0.76	16
		12 month	78.7	-7.5	-123	2556	877	117	26	1636	-6	0	3.94	0.76	16
	Black 5% Openness Factor, full basketweave	summer	72.2	-0.9	-15	2666	767	102	22	1543	87	5	3.94	0.76	16
		12 month	79.0	-7.7	-127	2531	902	120	26	1637	-7	0	3.94	0.76	16
	White 5% Openness Factor, full basketweave	summer	72.3	-1.0	-16	2633	800	107	23	1540	90	6	3.93	0.77	16
		12 month	79.4	-8.1	-134	2492	941	126	27	1639	-8	-1	3.93	0.77	16
Double Clear	None		59.5			2993				1379			3.99		
	Black/Brown 25% Openness Factor	summer	60.1	-0.5	-9	2511	482	64	16	1323	56	4	3.54	0.45	11
		12 month	64.4	-4.8	-79	2423	570	76	19	1382	-3	0	3.54	0.45	11
	Black/Brown 10% Openness Factor	summer	60.3	-0.7	-12	2404	589	79	20	1312	67	5	3.53	0.46	12
		12 month	65.5	-6.0	-99	2300	693	93	23	1385	-6	0	3.53	0.46	12
	Black/Brown 10% Openness Factor, full basketweave	summer	60.3	-0.8	-13	2379	614	82	21	1310	69	5	3.53	0.47	12
		12 month	65.8	-6.3	-103	2272	721	96	24	1386	-7	-1	3.53	0.47	12
	Black 5% Openness Factor, full basketweave	summer	60.3	-0.8	-13	2366	627	84	21	1308	71	5	3.52	0.47	12
		12 month	66.0	-6.4	-105	2258	735	98	25	1386	-7	-1	3.52	0.47	12
	White 5% Openness Factor, full basketweave	summer	60.3	-0.8	-13	2354	639	85	21	1307	72	5	3.52	0.47	12
		12 month	66.1	-6.6	-108	2242	751	100	25	1387	-8	-1	3.52	0.47	12
Double HiSol LowE	None		54.0			2905				1277			3.82		
	Black/Brown 25% Openness Factor	summer	54.5	-0.5	-8	2436	469	63	16	1222	55	4	3.40	0.42	11
		12 month	58.7	-4.7	-76	2350	555	74	19	1279	-2	0	3.40	0.42	11
	Black/Brown 10% Openness Factor	summer	54.7	-0.6	-11	2348	557	74	19	1213	64	5	3.39	0.43	11
		12 month	59.7	-5.6	-92	2250	655	87	23	1282	-5	0	3.39	0.43	11
	Black/Brown 10% Openness Factor, full basketweave	summer	54.7	-0.7	-11	2328	577	77	20	1211	66	5	3.39	0.43	11
		12 month	59.9	-5.9	-96	2227	678	91	23	1283	-6	0	3.39	0.43	11
	Black 5% Openness Factor, full basketweave	summer	54.8	-0.7	-12	2316	589	79	20	1210	67	5	3.39	0.44	11
		12 month	60.0	-6.0	-99	2213	692	92	24	1283	-6	0	3.39	0.44	11
	White 5% Openness Factor, full basketweave	summer	54.8	-0.7	-12	2289	616	82	21	1207	70	5	3.38	0.44	12
		12 month	60.3	-6.3	-103	2181	724	97	25	1284	-7	-1	3.38	0.44	12

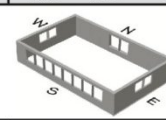


Table 521. Impact of shade screens on a house in Washington, DC with south-facing windows on a hot year

Window Type	Shade Screen	Operation	Heating Energy (MBtu)	Heating Savings (MBtu)	Heating Savings ($)	Cooling Cool (kWh)	Cooling Savings (kWh)	Cooling Savings ($)	Cooling Savings (%)	Heat+Cool Cost ($)	Heat+Cool Savings ($)	Heat+Cool Savings (%)	Peak Cooling Peak (kW)	Peak Cooling Savings (kW)	Peak Cooling Savings (%)
Single Clear	None		65.7			3158				1502			4.48		
	Black/Brown 25% Openness Factor	summer	66.3	-0.7	-11	2493	665	89	21	1424	78	5	3.64	0.85	19
		12 month	77.1	-11.4	-188	2260	898	120	28	1570	-68	-5	3.64	0.85	19
	Black/Brown 10% Openness Factor	summer	66.5	-0.8	-13	2425	733	98	23	1417	85	6	3.62	0.87	19
		12 month	80.0	-14.4	-236	2167	991	132	31	1605	-104	-7	3.62	0.87	19
	Black/Brown 10% Openness Factor, full basketweave	summer	66.4	-0.8	-13	2439	719	96	23	1419	83	6	3.63	0.86	19
		12 month	80.4	-14.8	-243	2182	976	130	31	1615	-113	-8	3.63	0.86	19
	Black 5% Openness Factor, full basketweave	summer	66.5	-0.8	-13	2436	722	96	23	1418	83	6	3.63	0.86	19
		12 month	81.1	-15.4	-254	2175	983	131	31	1624	-123	-8	3.63	0.86	19
	White 5% Openness Factor, full basketweave	summer	66.6	-0.9	-15	2350	808	108	26	1409	93	6	3.58	0.91	20
		12 month	81.7	-16.0	-264	2076	1082	144	34	1621	-119	-8	3.58	0.91	20
Double Clear	None		55.0			2746				1271			3.77		
	Black/Brown 25% Openness Factor	summer	55.5	-0.5	-9	2235	511	68	19	1212	59	5	3.26	0.51	14
		12 month	64.6	-9.6	-158	2060	686	92	25	1337	-66	-5	3.26	0.51	14
	Black/Brown 10% Openness Factor	summer	55.6	-0.6	-10	2183	563	75	21	1206	65	5	3.25	0.52	14
		12 month	67.0	-12.0	-198	1994	752	100	27	1369	-98	-8	3.25	0.52	14
	Black/Brown 10% Openness Factor, full basketweave	summer	55.6	-0.6	-10	2179	567	76	21	1206	65	5	3.25	0.52	14
		12 month	67.6	-12.6	-207	1988	758	101	28	1377	-106	-8	3.25	0.52	14
	Black 5% Openness Factor, full basketweave	summer	55.6	-0.6	-11	2177	569	76	21	1206	65	5	3.25	0.52	14
		12 month	67.9	-12.9	-213	1984	762	102	28	1382	-111	-9	3.25	0.52	14
	White 5% Openness Factor, full basketweave	summer	55.7	-0.7	-12	2103	643	86	23	1197	74	6	3.20	0.57	15
		12 month	68.0	-13.0	-215	1899	847	113	31	1372	-101	-8	3.20	0.57	15
Double HiSol LowE	None		49.8			2664				1176			3.59		
	Black/Brown 25% Openness Factor	summer	50.3	-0.5	-8	2190	474	63	18	1120	55	5	3.14	0.45	13
		12 month	59.1	-9.3	-153	2032	632	84	24	1244	-69	-6	3.14	0.45	13
	Black/Brown 10% Openness Factor	summer	50.4	-0.5	-9	2141	523	70	20	1115	61	5	3.13	0.47	13
		12 month	61.1	-11.3	-186	1968	696	93	26	1268	-93	-8	3.13	0.47	13
	Black/Brown 10% Openness Factor, full basketweave	summer	50.4	-0.5	-9	2138	526	70	20	1114	61	5	3.13	0.47	13
		12 month	61.6	-11.8	-193	1964	700	93	26	1276	-100	-9	3.13	0.47	13
	Black 5% Openness Factor, full basketweave	summer	50.4	-0.6	-9	2137	527	70	20	1114	61	5	3.13	0.47	13
		12 month	62.0	-12.1	-199	1961	703	94	26	1281	-105	-9	3.13	0.47	13
	White 5% Openness Factor, full basketweave	summer	50.5	-0.7	-11	2059	605	81	23	1106	70	6	3.09	0.51	14
		12 month	62.4	-12.5	-206	1870	794	106	30	1276	-100	-9	3.09	0.51	14

Figure 12. Page 5 of detailed city report for roller shades in Washington DC

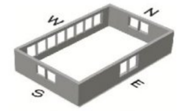


Table 522. Impact of shade screens on a house in Washington, DC with west-facing windows on a hot year

Window Type	Shade Screen	Operation	Heating			Cooling				Heat+Cool			Peak Cooling		
			Energy (MBtu)	Savings (MBtu)	Savings ($)	Cool (kWh)	Savings (kWh)	Savings ($)	Savings (%)	Cost ($)	Savings ($)	Savings (%)	Peak (kW)	Savings (kW)	Savings (%)
Single Clear	None		74.6			3580				1705			6.06		
	Black/Brown 25% Openness Factor	summer	75.0	-0.4	-7	2867	713	95	20	1616	88	5	4.26	1.79	30
		12 month	79.8	-5.2	-85	2706	874	117	24	1673	31	2	4.26	1.79	30
	Black/Brown 10% Openness Factor	summer	75.1	-0.5	-9	2725	855	114	24	1599	106	6	4.18	1.87	31
		12 month	80.8	-6.2	-103	2542	1038	139	29	1669	36	2	3.86	2.20	36
	Black/Brown 10% Openness Factor, full basketweave	summer	75.1	-0.5	-9	2706	874	117	24	1597	108	6	4.18	1.87	31
		12 month	80.9	-6.4	-105	2519	1061	142	30	1668	37	2	3.80	2.25	37
	Black 5% Openness Factor, full basketweave	summer	75.2	-0.6	-9	2680	900	120	25	1594	111	6	4.18	1.87	31
		12 month	81.1	-6.6	-108	2490	1090	146	30	1667	38	2	3.73	2.32	38
	White 5% Openness Factor, full basketweave	summer	75.2	-0.6	-10	2637	943	126	26	1589	116	7	4.18	1.87	31
		12 month	81.6	-7.0	-115	2437	1143	153	32	1667	37	2	3.69	2.37	39
Double Clear	None		61.6			3101				1428			5.17		
	Black/Brown 25% Openness Factor	summer	61.9	-0.3	-5	2525	576	77	19	1356	72	5	3.68	1.49	29
		12 month	65.8	-4.1	-68	2406	695	93	22	1403	25	2	3.68	1.49	29
	Black/Brown 10% Openness Factor	summer	62.0	-0.4	-7	2403	698	93	23	1341	87	6	3.58	1.60	31
		12 month	66.7	-5.1	-83	2265	836	112	27	1399	28	2	3.39	1.79	35
	Black/Brown 10% Openness Factor, full basketweave	summer	62.0	-0.4	-7	2377	724	97	23	1338	90	6	3.58	1.60	31
		12 month	66.9	-5.3	-87	2235	866	116	28	1399	29	2	3.32	1.85	36
	Black 5% Openness Factor, full basketweave	summer	62.1	-0.5	-7	2362	739	99	24	1336	91	6	3.58	1.60	31
		12 month	67.0	-5.4	-88	2219	882	118	28	1398	29	2	3.28	1.89	37
	White 5% Openness Factor, full basketweave	summer	62.1	-0.5	-8	2341	760	101	25	1334	94	7	3.58	1.60	31
		12 month	67.3	-5.6	-93	2194	907	121	29	1399	28	2	3.29	1.88	36
Double HiSol LowE	None		55.9			3011				1321			4.96		
	Black/Brown 25% Openness Factor	summer	56.1	-0.3	-4	2448	563	75	19	1250	71	5	3.48	1.48	30
		12 month	59.8	-3.9	-65	2337	674	90	22	1296	25	2	3.48	1.48	30
	Black/Brown 10% Openness Factor	summer	56.2	-0.3	-5	2349	662	88	22	1238	83	6	3.45	1.50	30
		12 month	60.5	-4.7	-77	2221	790	105	26	1292	29	2	3.25	1.70	34
	Black/Brown 10% Openness Factor, full basketweave	summer	56.2	-0.4	-6	2325	686	92	23	1235	86	6	3.45	1.51	30
		12 month	60.7	-4.8	-79	2194	817	109	27	1291	30	2	3.20	1.76	35
	Black 5% Openness Factor, full basketweave	summer	56.2	-0.4	-6	2311	700	93	23	1234	87	7	3.45	1.51	30
		12 month	60.8	-4.9	-81	2179	832	111	28	1291	30	2	3.16	1.80	36
	White 5% Openness Factor, full basketweave	summer	56.3	-0.4	-7	2277	734	98	24	1230	91	7	3.45	1.51	30
		12 month	61.2	-5.3	-88	2137	874	117	29	1292	29	2	3.13	1.83	37

The 50 city reports for awnings and 50 city reports for roller shades are available through the PAMA website:

Awning: http://awninginfo.com/pama_es2_awning_reports.html

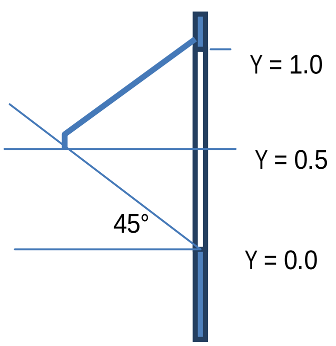
Exterior Roller Shades: http://awninginfo.com/pama_es2_shades_reports.html

Appendix A. Modeling of awnings

Awnings can only be modeled as a fixed BUILDING-SHADE in the DOE-2 program. However, the effect of a seasonally operated awning system, i.e., one that is deployed only during the cooling season but retracted during the heating system to avoid reducing useful solar heat gain can be approximated by adding a schedule that sets the TRANSMITTANCE of the BUILDING-SHADE to 100.0, i.e. making the awning transparent. When the awnings are deployed, the TRANSMITTANCE is set to 0.0 and 0.16 for the black and linen awnings, respectively.

There are, however, several limitations with the BUILDING-SHADE feature in DOE-2:

1. It blocks only the direct beam radiation, not the diffuse radiation from the sky; to take the effect of the awnings on reducing diffuse radiation, adjustments are made to the SKY-FORM-FACTOR (SFF) and GROUND-FORM-FACTOR (GFF), which represent the amount of the sky or ground visible from the window; for an unshaded window, the default SFF and GFF would be 0.50 each. For the 90 º awning, a quick calculation produced SFFs of 0.083 and 0.143 for the black and linen awnings (see sketch below); for the 165 º, the SFF is set to 0.



What to set for the GFF, however, is open to interpretation, especially for the 165" awning. The GFF is used to calculate the amount of reradiated solar gain from the ground, which test runs have shown to be not insignificant, so that setting GFF to (1.0 - SFF) produced savings that were substantially different than from the roller shades, whereas by simple logic the two systems, i.e. the 165º awning and a roller shade, should have similar performance;
in actuality, the window is seeing the back side of the awning, and not the ground. In the end, it was decided to increase the GFF by half of the area subtended by the awning; another problem with the use of the SFF and GFF is that these are constant inputs to DOE-2, so that they cannot be modified during the simulation, such as resetting them to 0.50 and 0.50 for when the awnings are withdrawn; this was taken into account by splicing in the simulation results for the unshaded case for when the awnings are not deployed.

2. Since DOE-2 calculates the hourly solar position only on the first day for each month, the schedule for any changes in the awning position can only be on the first day of each month.

Given the limitations just described, this is as bout as good as possible in modeling awnings using the DOE-2 program.

Appendix B. Modeling of roller shades

The modeling of the roller shades has been done in a very different way from the awnings. Since the roller shades are planar parallel and cover the entire surface of the window, there is no need to calculate the solar geometry. Instead, the roller shades plus the window glazing are considered as a single assembly with a combined Solar Heat Gain Coefficient (SHGC) or Shading Coefficient (SC), as used in DOE-2.

Furthermore, Phifer Incorporated has asked laboratories to measure the combined optical and solar properties of their products placed in front of various types of windows, such as the three window types selected for this analysis, and at various sun angles.

For this study, the measured SHGCs for the roller shade and window assembly at different sun angles (typically 0, 30º, 45º and 75º) are compared to the SHGCs for the glazing alone, and effective SHADING-FRACTIONs derived.

In order to extend these SHADING-FRACTIONs to all sun angles, regressions are done against the sun angle to produce quadratic equations that are then used in the DOE-2 simulation as fractional multipliers to a SHADING-SCHEDULE that reduce the amount of solar gain entering the building.

There are in total 15 equations for the five roller blind fabrics combined with three types of windows. To illustrate this procedure, Figure B.1 shows the measured data for a Black / Brown fabric with an Openness Factor (OF) of 25% at three angles converted to Shading Fractions by dividing by the measured SHGC by the glazing SHGC. Figure B.2 shows the quadratic equations that are developed by regression analysis.

Figure B.1 Measured Solar Fractions for roller shade fabric

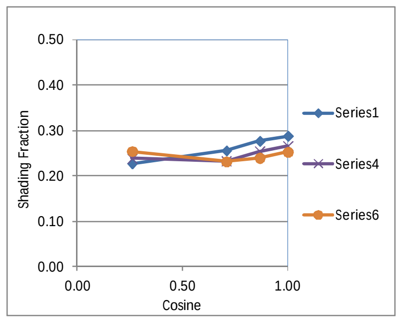
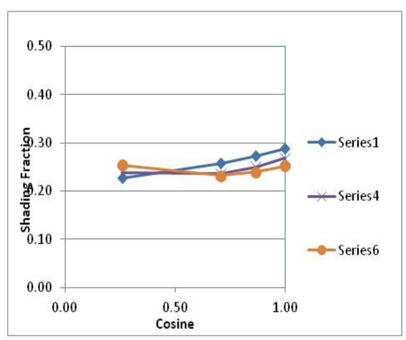


Figure B.2 Regression equations of Solar Fractions for roller shade



Appendix C. Modeling of existing house

The modeling methodology for the house is taken without change from previous work by the author in developing the RESFEN program and updated in analyzing the energy saving potentials for DOE's EnergyStar® Windows program in 2008. The following table is quoted verbatim as it describes the evolution of the modeling assumptions from RESFEN 5 (c2004) to RESFEN 6 (c2008) that was used for the EnergyStar® analysis. *(excerpted from Arasteh, Huang, Selkowitz, and Mitchell 2008)*

Table 0-1. RESFEN 6 Assumptions – Reference House for Energy Star Analysis

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
Floor Area (ft^2 & dimensions)	Reference House: 2000 sf Specific House: Variable, from 1,000 to 4,000 square feet, input by user.	Reference House: New – 1 Story: 1700sf New – 2 Story: 2800sf Existing 1 Story: 1700sf Existing 2 Story: 2600sf	NFRC noted the following: New Construction: 2005 U.S. Census Bureau Characteristics Median New house size is 2200sf; Average is 2400. Existing Construction: Keep same default as RESFEN 5 unless new data to the contrary is presented. LBNL decided to keep with these basic numbers, but differentiate between smaller single story homes and larger two story homes. [For the EnergyStar® analysis, results for both 1 and 2 story homes will be generated. End results will be based on appropriate regional weightings of 1 and 2 story homes.] Using RECS 2001, an analysis of public use microdata, we came up with the following, at a national level: - For existing homes (defined as pre-1990), RECS supports an average house size of 2000 sf, as NFRC had agreed upon. Single story homes (65% of existing homes nationally) are 1700sf and Two+ story homes (35%) are 2600sf. When weighted by fractions of the population, the average comes out to 2000. - For New (after 1990) homes, NFRC had chosen to go with the census data Median of 2200, not the average of 2400. We agree that it makes sense to use a Median so that the size is not skewed by the small number of very large houses. RECS comes up with

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
			a slightly different average of 2600 (2000sf for single and 3400 Sf for 2+ story). We decided we should keep the NFRC value of 2200 as the normalized area but use RECS data on 1 and 2 story to modify this average number. This leads to using 1700 sf for New - 1 story (58%) and 2800 sf for New 2-story (42%).
House Type	New Construction Existing Construction	Reference House: New Construction is frame. Existing Construction is frame. Both 1 and 2 story houses are modeled in all climates. National or regional energy impact studies will be based on the fractions of 1 and 2 story homes in each climate, for New and Existing.	For reference, see census map: http://www.eia.doe.gov/emeu/recs/census_map.html IECC Climate map at: www.energycodes.gov/implement/pdfs/color_map_climate_zones_Mar03.pdf Data on New Construction; From http://www.census.gov/const/www/charindex.html#singlecomplete Look at Number of Stories Data on Existing Construction Source: RECS 2001 Microdata, http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html
Foundation	Foundation is based on location based on NAHB data. There are a maximum of three options per climate zone, chosen from: Basement Slab-on-Grade Crawlspace	Default foundation based on location as with RESFEN 5.	What is in RESFEN is very similar to NFRC. NFRC proposed: New and Existing Construction: Basement in climate zone 5-8; Crawlspace in climate zone 4; Slab-on-grade in climate zones 1-3. What is in RESFEN is essentially this, except that some southern Zone 4 cities have slabs and some northern Zone 4 cities have basements to better represent current practice. Foundation modeling process updated based on 1998 research: Winkelmann, FC. 1998. "Underground Surfaces: How to Get a Better Underground Surface Heat Transfer Calculation in DOE-2.1E", Building Energy Simulation Users' News, Vol. 19, No. 1 (Spring

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
			1998), pp. 6-12, Lawrence Berkeley National Laboratory, Berkeley CA, Electronic versions of the Users' News are available at http://gundog.lbl.gov.
Insulation [a]	Envelope insulation levels are based on location. See RESFEN 5 documentation, Table 6-1 for a list of Packages that correspond to each location. See Tables 6-3 and 6-4 for a list of R-values for each building component for each location. See Table 6-_ for a list of U-factors that correspond to the R-value constructions. New construction: See Table 6-4. (Council of American Building Officials, 1993) Existing construction: See Table 6-5. (Ritschard, et al. 1992)	New Construction: Envelope insulation levels based on location using 2006 IECC requirements in Table 402.1.1 (except for fenestration). Existing: Same as RESFEN 5.0.	
Infiltration	New Construction: ELA=0.77 ft^2 (0.58 ACH) Existing Construction: ELA=1.00 ft^2 (0.70 ACH)	New Construction: SLA = 0.00036 Existing Construction: SLA = 0.00054	As proposed by NFRC. Consistent with 2006 IECC reference home Table 404.5.2(1). SLA is EA/total sf. [Note: inconsistency between RESFEN 3.1/5.0 documentation and code; infiltration in code was set to SLA=.00057.]
Structural Mass (lb/ft^2)	This is a parameter used in programs that don't explicitly model internal walls. In RESFEN, we use a simple equation to estimate the amount of internal walls per floor area: interior wall area = 0.527 * floor area RESFEN then models the amount of internal walls. Since interior walls are typically 2x4 16" oc with 0.5" of gypboard on each side, the amount of material per	Internal walls are modeled explicitly as with RESFEN 5. Where masonry floors are used: 80% of floor area covered by R-2 carpet and pad, and 20% of floor directly exposed to room air. This is in addition to the 3.5 lb/ft2/	Consistent with 2006 IECC reference home Table 404.5.2(1) average value.

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
	square foot of wall is 1" x 12" x 12" or 0.08333 ft3 of gypboard 3.5" x 1.625" x 12" /16 or 0.002469 ft3 of wood The total weight per floor area of *floor* adds up to 2.24 lbs/ft2, which is somewhat lower than the 3.5 lb/ft2 cited. But in a 2-story, there's also the floor that would add another 2.20 lbs/ft2, for a total of 4.44 lbs/ft2. This is consistent with the average value of 3.5 lb/ft2 in the IECC. Basement walls and slabs are modeled separately.	Basement walls: masonry, and include insulation located on the exterior of the walls (new construction) and the interior side of the walls (existing construction). This is in addition to above.	
Internal Mass Furniture (lb/ft^2)	8.0 lb/ft^2 of floor area, in accordance with the Model Energy Code and NFRC Annual Energy Performance Subcommittee recommendation (September 1998).	8.0 lb/ft^2 of floor area	Consistent with 2006 IECC reference home Table 404.5.2(1).
Solar Gain Reduction	Of 7 options, Typical is used: Typical(b): to represent a statistically average solar gain reduction for a generic house. this option includes: interior shades (Seasonal SHGC multiplier, summer value = 0.80, winter value = 0.90); 1' overhang; a 67% transmitting same-height obstruction 20' away intended to represent adjacent buildings. To account for other sources of solar heat gain reduction (insect	Same as RESFEN 5. Reference House uses Typical.	RESFEN assumptions of typical should be maintained unless there is valid data to the contrary; otherwise impacts of windows are overstated

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
	screens, trees, dirt, building & window self-shading), the SHGC multiplier was further reduced by 0.1. This results in a final winter SHGC multiplier of 0.8 and a final summer SHGC multiplier of 0.7. (Note these factors are multipliers; i.e. a window with a SHGC of 0.5 is reduced to 0.4 in the winter and 0.35 in the summer.)		
Window Area (% Floor Area)	Variable	Specific House: Variable Reference House: 15%	18% is too high. A recent DOE/PNNL study from a few years ago found 13.5% to be average. IECC implies that below 12% is low and above 18% is high….which implies 15% (as used in RESFEN) is appropriate.
Window Type	Variable	Variable	
Window Distribution	Variable	Specific House: Variable Reference House: Evenly Distributed on All four orientations.	
HVAC System	Furnace & A/C, Heat Pump	Gas furnace & A/C. Heat Pump with A/C in South and SW	There are a significant number of Heat Pumps in the South (half of new construction in the south) and some in the West (presumably the SW). from: http://www.census.gov/const/www/charindex.html#singlecomplete Look at Type of Heating Fuel; *Data on Existing Construction* There is also Oil Heating in the Northeast (49% in New England and 24% in Mid-Atlantic) in Existing Homes. Rather than model Oil homes in the NE region in Existing houses; or we can account for this later in the spreadsheet part of this project. (Not much in New Construction.)
HVAC System Sizing	For each climate, system sizes are fixed for all window options. Fixed sizes are based on the use	Same as RESFEN 5 for Existing homes.	Consistent with 2006 IECC reference home Table 404.5.2(1). Section M1401.3 of the International Residential

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
	of DOE-2 auto-sizing for the same house as defined in the analysis, with the most representative window for that specific climate. An auto-sizing multiplier of 1.3 used to account for a typical safety factor. [e]	Autosizing is used for New homes – they are sized with the specific windows chosen.	Code says " Heating and cooling equipment shall be sized based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies."
HVAC Efficiency	New Construction: AFUE = 0.78, A/C SEER=10.0 Existing Construction: AFUE = 0.70, A/C SEER= 8.0	New: Gas furnace: AFUE = 0.80 in climate zones 1-3, 0.90 in climate zones 4-8. A/C SEER = 13. Heat pump HSPF = 7.7; Oil furnace AFUE = 0.80 Existing: Gas furnace AFUE = 0.78; A/C (& Heat Pump) SEER = 10; Heat pump HSPF = 6.8	For New, as per NFRC: Gas furnace: 2005 Gas Appliance Manufacturers Association data showed 34% of all U.S. furnaces sold are condensing (AFUE 90+%). We assume most of these are used in the north, so use new federal minimum (0.80) in zones 1-3, and condensing furnace (0.90) in zones 4-8. A/C: New federal minimum. Heat pump: New federal minimum. Conversion from SEER or HPSF to COP (1/CEIR) for use in DOE2 using updated research: http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-413-04/
Duct Losses	Heating: 10% (fixed) Cooling: 10% (fixed)	12% for basement foundation 20% for crawlspace and slab-on-grade foundations	Consistent with 2006 IECC proposed design default distribution efficiencies (Table 404.5.2(2). As proposed by NFRC. Duct losses entered into DOE2 by modifying efficiencies.
Part-Load Performance	New part-load curves for DOE2 (Henderson 1998) for both new and existing house types	Same as RESFEN 5.	
Thermostat Settings	Heating: 70°F, Cooling: 78°F Basement (partially conditioned): Heating 62°F, Cooling 85°F	Heating: 70°F, Cooling: 78°F Basement (partially conditioned): Heating 62°F, Cooling 85°F	
Night Heating Setback	65°F (11 PM – 6 AM[d])	65°F (11 PM – 6 AM)	
Cooling Setup	N/A	N/A	

PARAMETER	RESFEN 5	RESFEN 6 - DRAFT	Notes on changes
Internal Loads	Sensible: 43,033 Btu/day + (floor area * 8.42 Btu/ft^2-day for lighting) Latent: 12.2 kBtu/day	Use IECC [Table 404.5.2(1)] proposal of: Internal gain (Btu/day) = 17,900 + 23.8×floor area + 4104×number of bedrooms. 3 bedrooms shall be used.	This includes latent as well as sensible, as well as lighting loads (per conversation with Phil Fairey, 1/11/08). The way FSEC uses the equation is for the total internal loads of the house. They then subtract out the people heat gain, which they model as per standard DOE-2/ASHRAE assumption (255 sensible/200 latent per person per hour, etc.). The remainder is then assumed to be 0.80 sensible and 0.20 latent. The hourly profile is based on modeling assumptions developed by the California Energy Commission in 1980 (Mickey Horn and Cynthia Helmich 1980. "Assumptions Used with Energy Performance Computer Programs", Project Report No. 7 for "1980 Residential Building Standard Development Project", June 1980, P400-80-026, pp. 33-48).
Natural Ventilation	Enthalpic – Sherman-Grimsrud (78°F / 72°F based on 4 days' history[(e)]) Windows closed from 11pm to 6am. Only 25% of window area can be open for ventilation. Windows will only open if outdoor temperature has been below the setpoint for prior 4 days.	Maximum operable window area reduced from 25% to 12.5%. Max ACH capped at 10. Based on California research on use of windows for ventilation.	RESFEN 6 algorithm updated based on the reported operation of windows in the recent Sherman and Price report, "Study of Ventilation Practices and Household Characteristics in New California Homes:" http://www.arb.ca.gov/research/apr/past/03-326.pdf
Weather Data	All TMY2[(f)]		N/A for awning study
Number of Locations	239 US cities[(f)] 4 Canadian cities	For E* analysis: 97 EWC climates plus Charlotte NC, Amarillo TX, and Prescott AZ	50 locations
Calculation Tool	DOE-2.1E	DOE 2.1E version 1.14	

Footnotes

(a) Insulation values do not include exterior siding, structural sheathing, and interior drywall. For examples, an R-19 requirement could be met EITHER by R-19 cavity insulation OR R-13 cavity insulation plus R-6 insulating sheathing. Wall requirements apply to wood-frame or mass (concrete, masonry, and log) wall constructions, but do not apply to metal-frame construction."

(b) These assumptions are intended to represent the average solar heat gain reduction for a large sample of houses. A one-foot overhang is assumed on all four orientations in order to represent the average of a two-foot overhang and no overhang. A 67% transmitting obstruction 20 feet away on all four orientations represents the average of obstructions (such as neighboring buildings and trees) 20 feet away on one-third of the total windows and no obstructions in front of the remaining two-thirds of windows. An interior shade is assumed to have a Solar Heat Gain Coefficient multiplier of 0.9 during the winter and 0.8 during the summer. To account for solar heat gain reducing effects from other sources such as screens, trees, dirt, and self-shading of the building, the SHGC multiplier was further reduced by 0.1 throughout the year. This amounts to a 12.5% decrease in the summer and an 11.1% decrease in the winter. The final SHGC multipliers (0.8 in the winter and 0.7 in the summer) thus reflect the combined effects of shading devices and other sources.

(c) RESFEN 5: For each climate, DOE-2's auto-sizing feature was used with the window most likely to be installed in new construction (assumed to be the MEC default). Tables 6.4 and 6.5 show the required prescriptive U-factors for windows for the 52 climates. For climates where the U-factor requirement is greater than or equal to 1.0, an aluminum frame window with single glazing (U-factor = 1.30; SHGC = 0.74) is used. For climates where the U-factor requirement is between 0.65 and 1.0, an aluminum frame window with double glazing (U-factor = 0.87; SHGC = 0.66) is used. For climates where the U-factor requirements are below 0.65, as well as in the four Canadian climates, a vinyl frame window with double glazing (U-factor = 0.49; SHGC = 0.57) is used for the sizing calculation.

(d) RESFEN models a moderate setback of 65^{o} F in recognition that some but not all houses may use night setbacks. Recent studies of residential indoor conditions have shown that, during the heating season, nighttime temperatures are significantly lower than daytime temperatures (Ref: “Occupancy Patterns and Energy Consumption in New California Houses,” Berkeley Solar Group for the California Energy Commission, 1990).

(e) RESFEN uses a feature in DOE-2 that allows the ventilation temperature to switch between a higher heating (or winter) and a lower cooling (or summer) temperature based on the cooling load over the previous four days.

(f) RESFEN uses Typical Meteorological Year (TMY2) weather tapes from the National Renewable Energy Laboratory. There are 239 TMY2 locations with average weather data compiled from 30+ years of historical weather data. (National Renewable Energy Laboratory, 1995)

Appendix D. Heating and Cooling Degree Days for 50 representative locations

		TMY3		Hot Year		
St	City	HDD65	CDD65	Year	HDD65	CDD65
AK	Anchorage	10156	0	2003	9378	22
AL	Birmingham	2697	1913	2010	3054	2567
AL	Mobile	1723	2524	2011	1541	2813
AR	Little Rock	3076	2075	2010	2976	2801
AZ	Phoenix	996	4591	2007	985	5121
AZ	Tucson	1596	3019	2007	1470	3567
CA	Burbank	1435	1442	2008	1199	1812
CA	Fresno	2326	2102	2001	2313	2389
CA	Palm Springs	666	4331	2001	803	4793
CA	Sacramento	2585	1169	2003	2347	1442
CA	San Diego	1019	741	2006	1162	984
CA	San Francisco	2737	96	2010	2673	240
CO	Denver	5655	923	2001	5841	964
DC	Washington	4920	1112	2010	4511	1590
FL	Jacksonville	1280	2566	2007	860	2920
FL	Miami	148	4293	2011	66	4853
FL	Tampa	645	3441	2011	390	3850
GA	Atlanta	2772	1809	2010	3257	2338
HI	Honolulu	0	4560	2004	0	4977
ID	Boise	5395	755	2003	4959	1294
IL	Chicago	6397	830	2005	6120	1148
IN	Indianapolis	5844	1043	2010	5316	1566
LA	New Orleans	1357	2784	2011	1205	3416
MA	Boston	5792	734	2010	5148	1033
ME	Portland	7679	335	2010	6208	539
MI	Detroit	6257	893	2005	5965	1202
MN	Minneapolis	7781	731	2007	7165	1032
MO	Kansas City	4284	1898	2011	4570	1951
MO	St Louis	4846	1555	2010	4520	2020
NC	Charlotte	3152	1674	2010	3578	2123
NE	Omaha	5955	1274	2005	5733	1444
NM	Albuquerque	4157	1269	2001	3940	1535
NV	Las Vegas	2300	3186	2007	1854	3987
NY	Buffalo	6611	468	2005	6667	859
NY	New York	4884	1133	2010	4607	1350
OH	Cincinnati	4915	1034	2007	4507	1564
OK	Oklahoma City	4009	2088	2006	2884	2287
OR	Medford	4529	601	2003	4086	1048
OR	Portland	4186	367	2009	4406	603
PA	Philadelphia	4824	1184	2010	4440	1774
PA	Pittsburgh	5240	624	2010	5418	1128
SC	Charleston	2050	2302	2011	1677	2638
TN	Memphis	2998	2133	2007	2591	2834
TX	El Paso	2498	2170	2011	2397	3125
TX	Fort Worth	2779	2743	2010	1539	3963
TX	Houston	1438	2974	2011	1329	3846
TX	San Antonio	1548	2992	2011	1405	3889
UT	Salt Lake	5348	1118	2007	5643	1625
VA	Norfolk	3410	1629	2010	3631	2105
WA	Seattle	4640	128	2009	4956	307

Appendix E. U.S. utility prices for 2010 by state

Name	Average Retail Electricity Price 2010 (cents/kWh)	Average Natural Gas Prices 2010 ($/MBTU)
Alabama	8.89	11.39
Alaska	14.76	15.81
Arizona	9.69	8.89
Arkansas	7.28	15.87
California	13.01	11.53
Colorado	9.15	9.92
Connecticut	17.39	8.13
Delaware	11.97	14.93
District of Columbia	13.35	15.12
Florida	10.58	13.53
Georgia	8.87	17.89
Hawaii	25.12	15.17
Idaho	6.54	44.5
Illinois	9.13	8.95
Indiana	7.67	9.39
Iowa	7.66	8.62
Kansas	8.35	9.57
Kentucky	6.73	10.54
Louisiana	7.8	10.02
Maine	12.84	11.73
Maryland	12.7	14.14
Massachusetts	14.26	12.44
Michigan	9.88	14.53
Minnesota	8.41	11.32
Mississippi	8.59	8.76
Missouri	7.78	10.19
Montana	7.88	11.66
Nebraska	7.52	8.64
Nevada	9.73	8.95
New Hampshire	14.84	12.25
New Jersey	14.68	14.46
New Mexico	8.4	12.84
New York	16.41	9.63
North Carolina	8.67	14.04
North Dakota	7.11	12.5
Ohio	9.14	8.08
Oklahoma	7.59	11.13
Oregon	7.56	11.13
Pennsylvania	10.31	12.49
Rhode Island	14.08	12.9
South Carolina	8.49	16.48
South Dakota	7.82	13.03
Tennessee	8.61	8.77
Texas	9.34	10.46
Utah	6.94	10.81
Vermont	13.24	8.22
Virginia	8.69	16.14
Washington	6.66	12.73
West Virginia	7.45	12.24
Wisconsin	9.78	11.39
Wyoming	6.2	10.34
U.S. Total	9.83	8.58

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