



FINAL REPORT

X1931-6 PSD HOU/FLH Documentation and Update Study

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ABSTRACT

As part of the ongoing project “X1931 CT Program Savings Document (PSD) Review and Update,” the Connecticut Energy Efficiency Board (EEB) Evaluation Administrators commissioned DNV to update the PSD’s default hours of use/full load hours (HOU/FLH) values. The HOU/FLH values are reported in Table A5-1, Appendix Five of the CT PSD, and are used in savings algorithms of C&I measures whenever site-specific HOU/FLH values are not available. This report presents the methods and results of the research to update and document the source of PSD’s default C&I HOU/FLH values for the following end uses: lighting, HVAC fan, heating, cooling, heating pump, and chilled water pump (CHWP) and cooling towers. We recommend that the next versions of the PSD replace the preexisting Table A5-1, Appendix Five HOU/FLH values with this study’s HOU/FLH values. In parallel with the PSD update, Eversource and United Illuminating should revise all affected savings calculators and tracking systems to incorporate the updated HOU/FLH values.



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1 EXECUTIVE SUMMARY

This report presents the results of the primary research to update and document the source of the hours of use (HOU)/full load hours (FLH) values presented in Appendix Five of the Connecticut Program Savings Document (PSD). This research study was commissioned by the Connecticut Energy Efficiency Board (EEB) Evaluation Administrators (EA) as part of the ongoing project X1931 PSD Review and Update project. The CT PSD reports default HOU/FLH values for 60 commercial and industrial (C&I) facilities; however, the source and recency of those HOU/FLH values are unknown. The objective of this research study was to identify and document the source of PSD’s default C&I HOU/FLH values and to update the HOU/FLH values as available.

1.1 Key Findings

This study involved documenting the source and updating, as applicable, the CT PSD’s C&I default HOU/FLH values for the following end uses: lighting, HVAC fan, heating, cooling, heating pump, and chilled water pump (CHWP) and cooling towers. The PSD primarily uses the default HOU/FLH values in savings calculation algorithms of C&I measures when site-specific HOU/FLH values are not available.

For the lighting end-use category, DNV updated HOU values based on the most recent CT¹ and MA HOU² update studies. We developed HOU/FLH values for the remaining end-uses based on eQuest simulation of commercial building prototypes. Overall, the updated HOU/FLH values presented in this study are 7% higher compared to the C&I default HOU/FLH values reported in the most recent (2021) version of the PSD. Notably, we found significant differences in HVAC fan motor and heating pump HOU values.

Table 1-1 presents the updated HOU/FLH values for all 60 PSD C&I facilities.

Table 1-1. Updated HOU/FLH values

Facility Type	Lighting Hours	Cooling FLHrs (Note [1])	Heating FLHrs (Note [1])	HVAC Fan Motor Hours (Note [1])	CHWP & Cooling Towers (Note [1])	Heating Pumps (Note [1])
Auto Related	2,807 [1]	427	3,122	6,421	1,442	2,484
Bakery	5,468 [2]	565	1,065	4,618	1,037	1,787
Banks, Financial Center (Note [2])	3,748 [3]	853	372	5,519	2,732	5,629
Church	913 [1]	266	938	3,493	785	1,351
College: Cafeteria	5,018 [2]	591	1,178	5,835	1,311	2,258
College: Classes/Administrative (Note [2])	4,839 [2]	680	949	5,995	2,357	6,471
College: Dormitory	4,026 [2]	729	536	3,833	3,833	3,833
Commercial Condo	4,026 [2]	3,186	836	8,760	4,470	8,760
Convenience Store	5,468 [2]	771	831	5,207	1,170	2,015
Convention Center	913 [1]	3,186	836	8,760	4,470	8,760
Court House (Note [2])	4,181 [2]	853	372	5,519	2,732	5,629
Dining: Bar Lounge/Leisure	5,018 [2]	558	1,118	5,264	1,183	2,037
Dining: Cafeteria/Fast Food	5,018 [2]	591	1,178	5,835	1,311	2,258
Dining: Family	5,018 [2]	558	1,118	5,264	1,183	2,037
Entertainment	1,952 [3]	726	1,042	5,737	1,289	2,220
Exercise Center	5,836 [3]	726	1,042	5,737	1,289	2,220
Fast Food Restaurant	5,018 [2]	591	1,178	5,835	1,311	2,258
Fire Station (Unmanned)	4,336 [2]	729	536	3,833	3,833	3,833
Food Store	5,468 [1]	386	840	4,545	1,021	1,758

¹ DNV, 2020 C1635 Impact Evaluation of PY 2016 & 2017 Energy Opportunities (EO) Program

² DNV, 2019 MA C&I Lighting Hours of Use Study

Facility Type	Lighting Hours	Cooling FLHrs (Note [1])	Heating FLHrs (Note [1])	HVAC Fan Motor Hours (Note [1])	CHWP & Cooling Towers (Note [1])	Heating Pumps (Note [1])
Gymnasium	2,586 [3]	726	1,042	5,737	1,289	2,220
Hospital (Note [2])	5,413 [2]	1,204	513	8,683	7,682	8,760
Hospitals/Health Care (Note [2])	5,564 [1]	1,204	513	8,683	7,682	8,760
Industrial: 1 Shift	2,897 [1]	565	1,065	4,618	1,037	1,787
Industrial: 2 Shift	5,793 [1]	767	727	6,771	1,037	2,620
Industrial: 3 Shift	8,690 [1]	972	384	8,760	1,037	3,466
Laundromat	4,056 [3]	771	831	5,207	1,170	2,015
Library	3,748 [3]	726	1,042	5,737	1,289	2,220
Light Manufacturer	5,793 [1]	565	1,065	4,618	1,037	1,787
Lodging (Hotel/Motel)	3,112 [1]	897	628	3,421	769	1,324
Mall Concourse (Note [2])	4,939 [1]	803	672	4,690	3,013	4,932
Manufacturing Facility	5,793 [1]	565	1,065	4,618	1,037	1,787
Medical Office	3,673 [2]	827	598	4,795	1,077	1,855
Motion Picture Theatre	1,954 [3]	726	1,042	5,737	1,289	2,220
Multi-Family (Common Areas)	6,388 [4]	729	536	3,833	3,833	3,833
Museum	3,748 [3]	726	1,042	5,737	1,289	2,220
Nursing Home	5,840 [3]	3,186	836	8,760	4,470	8,760
Office (General Office Types)	4,098 [1]	827	598	4,795	1,077	1,855
Office/Retail	4,181 [1]	827	598	4,795	1,077	1,855
Parking Garage and Lot	6,887 [1]	427	3,122	6,421	1,442	2,484
Penitentiary	5,477 [3]	3,186	836	8,760	4,470	8,760
Performing Arts Theatre	913 [1]	726	1,042	5,737	1,289	2,220
Police/Fire Station (24 Hr)	8,760 [1]	2,007	717	6,778	2,774	5,308
Post Office	3,748 [1]	827	598	4,795	1,077	1,855
Pump Station	1,949 [3]	972	384	2,241	2,097	4,828
Refrigerated Warehouse	6,512 [2]	297	734	3,604	810	1,394
Religious Building	913 [1]	266	938	3,493	785	1,351
Residential (Except Nursing Homes)	3,066 [3]	729	536	3,833	3,833	3,833
Restaurant	5,018 [2]	558	1,118	5,264	1,183	2,037
Retail	4,939 [2]	771	831	5,207	1,170	2,015
School/University (Note [2])	2,967 [1]	680	949	5,995	2,357	6,471
Schools (Jr./Sr. High) (Note [2])	2,967 [1]	485	1,075	2,241	2,097	4,828
Schools (Preschool/Elementary)	2,967 [1]	307	1,086	3,851	865	1,490
Schools (Technical/Vocational) (Note [2])	2,967 [1]	581	783	5,098	2,170	5,620
Small Services	3,748 [1]	827	598	4,795	1,077	1,855
Sports Arena	913 [1]	726	1,042	5,737	1,289	2,220
Town Hall	4,181 [1]	726	1,042	5,737	1,289	2,220



Facility Type	Lighting Hours	Cooling FLHrs (Note [1])	Heating FLHrs (Note [1])	HVAC Fan Motor Hours (Note [1])	CHWP & Cooling Towers (Note [1])	Heating Pumps (Note [1])
Transportation	6,456 [3]	427	3,122	6,421	1,442	2,484
Warehouse (Not Refrigerated)	5,667 [1]	297	734	3,604	810	1,394
Wastewater Treatment Plant	6,631 [3]	972	384	2,241	2,097	4,828
Workshop	3,750 [3]	565	1,065	4,618	1,037	1,787

Note [1]: Developed based on simulation of DOE-2 commercial building prototypes in eQUEST using Hartford weather data.

Note [2]: Results are based on VAV systems with economizers.

1.2 Recommendations

We recommend replacing the PSD’s Appendix Five C&I default HOU/FLH values Table A5-1 with Table 1-1 (along with the references and notes) presented in this report.



2 INTRODUCTION

In Connecticut, as with most jurisdictions, gross energy impacts of C&I energy efficiency measures are estimated using default HOU/FLH values when site-specific HOU/FLH values are not available. The C&I default HOU/FLH values are provided in Appendix Five's Table A5-1 of the CT PSD. The PSD reports HOU/FLH values of 60 C&I facilities for the following six end uses: lighting, HVAC fan, heating, cooling, heating pump, and chilled water pump (CHWP) and cooling towers. The PSD HOU/FLH values have been developed over the years and are revisited during program evaluations. However, the PSD provides no clear documentation on the source or recency of the default HOU/FLH values.

2.1 Study Objectives

The primary objectives of this study were to:

1. Document the source of C&I HOU/FLH values in the PSD's Appendix Five.
2. Develop and update, as applicable, the Appendix Five HOU/FLH values based on CT evaluation reports and other relevant studies.

2.2 Methodology

This section describes the methodologies that DNV used for this study. This study primarily involved conducting a review of available PSD literature and simulating commercial building prototypes in eQuest to develop HOU/FLH values. Each task completed in this study is presented in the following subsections.

2.2.1 Literature Review

DNV compared the most recent (PSD version 2021) version and archived versions (up to PSD version 2005) of the CT PSD to trace the year-to-year evolution and sources of default C&I HOU/FLH values. We investigated ASHRAE handbooks (version 1980, version 1985, and recent versions) and nearby TRMs (NY and MA) to trace the source of PSD HOU/FLH values. We also reviewed existing Connecticut and Massachusetts evaluation reports to determine the availability of possible HOU/FLH value updates. The findings of literature review for each impacted end use are detailed in the subsections below.

2.2.1.1 Lighting HOU

DNV found that the PSD's default C&I lighting HOU values have not been updated since 2005, except for 12 C&I facilities. The 2021 PSD lighting HOU values for 48 out of 60 PSD C&I facilities are based on a 2004-2005 lighting HOU study³. For the remaining 12 C&I facilities, the 2021 PSD's lighting HOU values are based on the C1635 evaluation study⁴ and TRC X1941 multifamily impact evaluation study⁵.

DNV considered findings of Connecticut-specific evaluation studies as well as other nearby evaluation studies to identify updated lighting HOU values. In addition to the C1635 evaluation study and the X1941 study, we identified the 2019 MA C&I lighting HOU study⁶ as a reasonable source with which to update the PSD's C&I default lighting HOU values. We identified updated lighting HOU values for 42 C&I facilities.

³ RLW Analytics, 2006 CT and MA Utilities 2004-2005 Lighting Hours of Use for School Buildings Baseline Study

⁴ DNV, 2020 C1635 Impact Evaluation of PY 2016 & 2017 Energy Opportunities (EO) Program

⁵ TRC, X1941: Multifamily Impact Evaluation, PSD Savings Review, July 2020

⁶ DNV, 2019 MA C&I Lighting Hours of Use Study



2.2.1.2 HVAC Fan HOU

DNV found that the HVAC fan motor HOU values in the PSD are assumed to be the same as the lighting HOU values and have not been updated since 2005. However, we could not identify the source of the PSD's default C&I HVAC fan motor HOU values. As such, we developed a new set of HVAC fan motor HOU values based on eQuest simulation of DOE-2 commercial building prototypes.

2.2.1.3 Heating Pump HOU

We found that the heating pump HOU are assumed to be 5,376 hours per year for all 60 C&I facilities in the CT PSD and have not been updated since 2005. Similar to HVAC fan HOU values, we could not identify the source of the PSD's default C&I heating pump HOU values. We developed new sets of heating pump HOU values based on eQuest simulation of DOE-2 commercial building prototypes.

2.2.1.4 Heating FLH

The heating FLH values in the PSD are unsourced and have not been updated since 2005. We reviewed the available PSD literature but could not identify the source of the PSD's default C&I heating FLH values. As such, we developed new sets of heating FLH values based on eQuest simulation of DOE-2 commercial building prototypes.

2.2.1.5 Cooling FLH

Similar to heating FLH, the cooling FLH values in the PSD have not been updated since 2005. We could not identify the source of the PSD's default C&I cooling FLH values; we developed new sets of cooling FLH values based on eQuest simulation of DOE-2 commercial building prototypes.

2.2.1.6 CHWP and Cooling Towers HOU

We found that the CHWP and cooling towers HOU values have not been updated since 2005. We could not identify the source of the CHWP and cooling towers HOU values reported in the 2021 PSD; we developed new sets of CHWP and cooling towers HOU values based on eQuest simulation of DOE-2 commercial building prototypes.

2.2.2 Simulation of Commercial Building Prototypes

The Connecticut evaluation administration (EA) team provided us with New York commercial building prototypes (prototypical building descriptions shown in Appendix A) for 22 C&I facilities. We used the building prototypes with weather and local building practices adjustments made for Poughkeepsie, NY, because of the similarities in weather conditions between Poughkeepsie and Connecticut. We simulated the building prototypes in eQuest using Hartford weather data – the heating, cooling, HVAC fan motor, chilled water pump, and heating pump HOU/FLH values were obtained from eQuest simulation results.

In large commercial buildings, variable air volume (VAV) systems with economizers are typically installed. As such, we modified the HVAC system type in large commercial building prototypes to represent VAV systems with economizers.



3 RESULTS

DNV simulated 22 commercial building prototypes in eQuest using Hartford climate data. We assigned the results of the 22 prototype models to the 60 C&I PSD facilities based on operational similarities (shown in Appendix 1). The updated HOU/FLH values are presented in the subsections below.

3.1 Lighting HOU

Using the methods described in Section 2.2, we determined the lighting HOU values to be 7% higher on average compared to the 2021 PSD lighting HOU values. The updated lighting HOU values are higher for 17 PSD C&I facilities and lower for 11 PSD C&I facilities compared to the 2021 PSD lighting HOU values. Table 3-1 compares the current PSD and the updated lighting HOU values.

Table 3-1. Lighting HOU values: current PSD vs. updates

Facility Type	2021 CT PSD Values	Updated Values	Difference %
Auto Related	4,056	2,807 [1]	-31%
Bakery	2,854	5,468 [2]	92%
Banks, Financial Center	3,748	3,748 [3]	0%
Church	1,955	913 [1]	-53%
College: Cafeteria	6,376	5,018 [2]	-21%
College: Classes/Administrative	2,586	4,839 [2]	87%
College: Dormitory	3,066	4,026 [2]	31%
Commercial Condo	4,055	4,026 [2]	-1%
Convenience Store	6,376	5,468 [2]	-14%
Convention Center	1,954	913 [1]	-53%
Court House	3,748	4,181 [2]	12%
Dining: Bar Lounge/Leisure	4,182	5,018 [2]	20%
Dining: Cafeteria/Fast Food	6,456	5,018 [2]	-22%
Dining: Family	4,182	5,018 [2]	20%
Entertainment	1,952	1,952 [3]	0%
Exercise Center	5,836	5,836 [3]	0%
Fast Food Restaurant	6,376	5,018 [2]	-21%
Fire Station (Unmanned)	1,953	4,336 [2]	122%
Food Store	5,468	5,468 [1]	0%
Gymnasium	2,586	2,586 [3]	0%
Hospital	7,674	5,413 [2]	-29%
Hospitals/Health Care	5,564	5,564 [1]	0%
Industrial: 1 Shift	2,857	2,897 [1]	1%
Industrial: 2 Shift	5,793	5,793 [1]	0%
Industrial: 3 Shift	6,631	8,690 [1]	31%
Laundromat	4,056	4,056 [3]	0%
Library	3,748	3,748 [3]	0%
Light Manufacturer	2,857	5,793 [1]	103%
Lodging (Hotel/Motel)	3,064	3,112 [1]	2%

Facility Type	2021 CT PSD Values	Updated Values	Difference %
Mall Concourse	4,833	4,939 [1]	2%
Manufacturing Facility	2,857	5,793 [1]	103%
Medical Office	3,748	3,673 [2]	-2%
Motion Picture Theatre	1,954	1,954 [3]	0%
Multi-Family (Common Areas)	6,388	6,388 [4]	0%
Museum	3,748	3,748 [3]	0%
Nursing Home	5,840	5,840 [3]	0%
Office (General Office Types)	4,098	4,098 [1]	0%
Office/Retail	3,748	4,181 [1]	12%
Parking Garage and Lot	6,887	6,887 [1]	0%
Penitentiary	5,477	5,477 [3]	0%
Performing Arts Theatre	2,586	913 [1]	-65%
Police/Fire Station (24 Hr)	7,665	8,760 [1]	14%
Post Office	3,748	3,748 [1]	0%
Pump Station	1,949	1,949 [3]	0%
Refrigerated Warehouse	2,602	6,512 [2]	150%
Religious Building	913	913 [1]	0%
Residential (Except Nursing Homes)	3,066	3,066 [3]	0%
Restaurant	5,018	5,018 [2]	0%
Retail	4,939	4,939 [2]	0%
School/University	2,967	2,967 [1]	0%
Schools (Jr./Sr. High)	2,967	2,967 [1]	0%
Schools (Preschool/Elementary)	2,967	2,967 [1]	0%
Schools (Technical/Vocational)	2,967	2,967 [1]	0%
Small Services	3,748	3,748 [1]	0%
Sports Arena	1,954	913 [1]	-53%
Town Hall	3,748	4,181 [1]	12%
Transportation	6,456	6,456 [3]	0%
Warehouse (Not Refrigerated)	5,667	5,667 [1]	0%
Wastewater Treatment Plant	6,631	6,631 [3]	0%
Workshop	3,750	3,750 [3]	0%

3.2 HVAC Fan HOU

Compared to the current PSD HVAC fan FLH values, we determined updated HVAC fan FLH values to be 53% higher on average. Table 3-2 presents the 2021 PSD and the updated HVAC fan HOU values for all 60 PSD C&I facilities.

Table 3-2. HVAC fan HOU values: current PSD vs. updates

Facility Type	2021 PSD Values	Updated Values	Difference %
Auto Related	4,056	6,421	58%
Bakery	2,854	4,618	62%
Banks, Financial Center ¹	3,748	5,519	47%

Facility Type	2021 PSD Values	Updated Values	Difference %
Church	1,955	3,493	79%
College: Cafeteria	6,376	5,835	-8%
College: Classes/Administrative ¹	2,586	5,995	132%
College: Dormitory	3,066	3,833	25%
Commercial Condo	4,055	8,760	116%
Convenience Store	6,376	5,207	-18%
Convention Center	1,954	8,760	348%
Court House ¹	3,748	5,519	47%
Dining: Bar Lounge/Leisure	4,182	5,264	26%
Dining: Cafeteria/Fast Food	6,456	5,835	-10%
Dining: Family	4,182	5,264	26%
Entertainment	1,952	5,737	194%
Exercise Center	5,836	5,737	-2%
Fast Food Restaurant	6,376	5,835	-8%
Fire Station (Unmanned)	1,953	3,833	96%
Food Store	4,055	4,545	12%
Gymnasium	2,586	5,737	122%
Hospital ¹	7,674	8,683	13%
Hospitals/Health Care ¹	7,666	8,683	13%
Industrial: 1 Shift	2,857	4,618	62%
Industrial: 2 Shift	4,730	6,771	43%
Industrial: 3 Shift	6,631	8,760	32%
Laundromat	4,056	5,207	28%
Library	3,748	5,737	53%
Light Manufacturer	2,857	4,618	62%
Lodging (Hotel/Motel)	3,064	3,421	12%
Mall Concourse ¹	4,833	4,690	-3%
Manufacturing Facility	2,857	4,618	62%
Medical Office	3,748	4,795	28%
Motion Picture Theatre	1,954	5,737	194%
Multi-Family (Common Areas)	7,665	3,833	-50%
Museum	3,748	5,737	53%
Nursing Home	5,840	8,760	50%
Office (General Office Types)	3,748	4,795	28%
Office/Retail	3,748	4,795	28%
Parking Garage and Lot	4,368	6,421	47%
Penitentiary	5,477	8,760	60%
Performing Arts Theatre	2,586	5,737	122%
Police/Fire Station (24 Hr)	7,665	6,778	-12%
Post Office	3,748	4,795	28%



Facility Type	2021 PSD Values	Updated Values	Difference %
Pump Station	1,949	2,241	15%
Refrigerated Warehouse	2,602	3,604	39%
Religious Building	1,955	3,493	79%
Residential (Except Nursing Homes)	3,066	3,833	25%
Restaurant	4,182	5,264	26%
Retail	4,057	5,207	28%
School/University (Ref [1]) ¹	2,187	5,995	174%
Schools (Jr./Sr. High) (Ref [1]) ¹	2,187	2,241	2%
Schools (Preschool/Elementary)	2,187	3,851	76%
Schools (Technical/Vocational) ¹	2,187	5,098	133%
Small Services	3,750	4,795	28%
Sports Arena	1,954	5,737	194%
Town Hall	3,748	5,737	53%
Transportation	6,456	6,421	-1%
Warehouse (Not Refrigerated)	2,602	3,604	39%
Wastewater Treatment Plant	6,631	2,241	-66%
Workshop	3,750	4,618	23%

¹ Results are based on VAV systems with economizers.

3.3 Heating and Cooling FLH values

We determined the updated heating FLH values to be 2% lower, on average, compared to the default C&I heating FLH values reported in the 2021 PSD. The updated heating FLH values are higher for 14 PSD C&I facilities and lower for the remaining 46 PSD C&I facilities compared to the 2021 PSD values.

Compared to the 2021 PSD's C&I default cooling FLH values, we determined the updated cooling FLH values 7% higher on average. The updated cooling FLH values are higher for 24 PSD C&I facilities and lower for the remaining 36 PSD C&I facilities compared to the 2021 PSD values.

The 2021 PSD and the updated heating and cooling FLH values are presented in Table 3-3 below.

Table 3-3. Heating and Cooling FLH Values: current PSD vs. updates

Facility Type	Heating FLH			Cooling FLH		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	Updated Values	Difference %
Auto Related	1,171	3,122	167%	837	427	-49%
Bakery	1,471	1,065	-28%	681	565	-17%
Banks, Financial Center ¹	1,248	372	-70%	797	853	7%
Church	1,694	938	-45%	564	266	-53%
College: Cafeteria	594	1,178	98%	1,139	591	-48%
College: Classes/Administrative ¹	1,537	949	-38%	646	680	5%
College: Dormitory	1,418	536	-62%	709	729	3%
Commercial Condo	1,172	836	-29%	837	3,186	281%
Convenience Store	594	831	40%	1,139	771	-32%

Facility Type	Heating FLH			Cooling FLH		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	Updated Values	Difference %
Convention Center	1,695	836	-51%	564	3,186	465%
Court House ¹	1,248	372	-70%	797	853	7%
Dining: Bar Lounge/Leisure	1,140	1,118	-2%	854	558	-35%
Dining: Cafeteria/Fast Food	574	1,178	105%	1,149	591	-49%
Dining: Family	1,140	1,118	-2%	854	558	-35%
Entertainment	1,695	1,042	-39%	564	726	29%
Exercise Center	728	1,042	43%	1,069	726	-32%
Fast Food Restaurant	594	1,178	98%	1,139	591	-48%
Fire Station (Unmanned)	1,695	536	-68%	564	729	29%
Food Store	1,172	840	-28%	837	386	-54%
Gymnasium	1,537	1,042	-32%	646	726	12%
Hospital ¹	270	513	90%	1,308	1,204	-8%
Hospitals/Health Care ¹	272	513	89%	1,307	1,204	-8%
Industrial: 1 Shift	1,470	1,065	-28%	681	565	-17%
Industrial: 2 Shift	1,003	727	-28%	925	767	-17%
Industrial: 3 Shift	530	384	-28%	1,172	972	-17%
Laundromat	1,171	831	-29%	837	771	-8%
Library	1,248	1,042	-17%	797	726	-9%
Light Manufacturer	1,470	1,065	-28%	681	565	-17%
Lodging (Hotel/Motel)	1,418	628	-56%	708	897	27%
Mall Concourse ¹	978	672	-31%	938	803	-14%
Manufacturing Facility	1,470	1,065	-28%	681	565	-17%
Medical Office	1,248	598	-52%	797	827	4%
Motion Picture Theatre	1,695	1,042	-39%	564	726	29%
Multi-Family (Common Areas)	273	536	96%	1,306	729	-44%
Museum	1,248	1,042	-17%	797	726	-9%
Nursing Home	727	836	15%	1,069	3,186	198%
Office (General Office Types)	1,248	598	-52%	797	827	4%
Office/Retail	1,248	598	-52%	797	827	4%
Parking Garage and Lot	1,094	3,122	185%	878	427	-51%
Penitentiary	817	836	2%	1,022	3,186	212%
Performing Arts Theatre	1,537	1,042	-32%	646	726	12%
Police/Fire Station (24 Hr)	273	717	163%	1,306	2,007	54%
Post Office	1,248	598	-52%	797	827	4%
Pump Station	1,696	384	-77%	563	972	73%
Refrigerated Warehouse	1,533	734	-52%	648	297	-54%
Religious Building	1,694	938	-45%	564	266	-53%
Residential (Except Nursing Homes)	1,418	536	-62%	709	729	3%



Facility Type	Heating FLH			Cooling FLH		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	Updated Values	Difference %
Restaurant	1,140	1,118	-2%	854	558	-35%
Retail	1,171	831	-29%	837	771	-8%
School/University (Ref [1]) ¹	1,637	949	-42%	594	680	14%
Schools (Jr./Sr. High) (Ref [1]) ¹	1,637	1,075	-34%	594	485	-18%
Schools (Preschool/Elementary)	1,637	1,086	-34%	594	307	-48%
Schools (Technical/Vocational) ¹	1,637	783	-52%	594	581	-2%
Small Services	1,247	598	-52%	798	827	4%
Sports Arena	1,695	1,042	-39%	564	726	29%
Town Hall	1,248	1,042	-17%	797	726	-9%
Transportation	574	3,122	444%	1,149	427	-63%
Warehouse (Not Refrigerated)	1,533	734	-52%	648	297	-54%
Wastewater Treatment Plant	530	384	-28%	1,172	972	-17%
Workshop	1,247	1,065	-15%	798	565	-29%

¹ Results are based on VAV systems with economizers.

3.4 Heating Pump and CHWP and Cooling Towers HOU

As mentioned in Section 2.2, the 2021 PSD uses heating pump HOU value of 5,376 hours for all 60 C&I facilities. Compared to the 2021 PSD values, we determined the updated heating HOU values to be 37% lower on average. The updated heating pump HOU values are higher for 11 PSD C&I facilities and lower for the remaining 48 PSD C&I facilities compared to the 2021 PSD values.

We determined the updated CHWP/cooling towers HOU values to be 11% higher on average compared to the 2021 PSD values. Table 3-4 presents the 2021 PSD and the updated HOU values for heating pump and CHWP and cooling towers.

Table 3-4. Heating pump and CHWP and cooling towers HOU values: current PSD vs. updates

Facility Type	Heating Pump HOU			CHWP/Cooling Tower HOU		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	CHWP/Cooling Tower	Difference %
Auto Related	5,376	2,484	-54%	1,878	1,442	-23%
Bakery	5,376	1,787	-67%	1,445	1,037	-28%
Banks, Financial Center ¹	5,376	5,629	5%	1,767	2,732	55%
Church	5,376	1,351	-75%	1,121	785	-30%
College: Cafeteria	5,376	2,258	-58%	2,713	1,311	-52%
College: Classes/Administrative ¹	5,376	6,471	20%	1,348	2,357	75%
College: Dormitory	5,376	3,833	-29%	1,521	3,833	152%
Commercial Condo	5,376	8,760	63%	1,877	4,470	138%
Convenience Store	5,376	2,015	-63%	2,713	1,170	-57%
Convention Center	5,376	8,760	63%	1,121	4,470	299%

Facility Type	Heating Pump HOU			CHWP/Cooling Tower HOU		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	CHWP/Cooling Tower	Difference %
Court House ¹	5,376	5,629	5%	1,767	2,732	55%
Dining: Bar Lounge/Leisure	5,376	2,037	-62%	1,923	1,183	-39%
Dining: Cafeteria/Fast Food	5,376	2,258	-58%	2,742	1,311	-52%
Dining: Family	5,376	2,037	-62%	1,923	1,183	-39%
Entertainment	5,376	2,220	-59%	1,120	1,289	15%
Exercise Center	5,376	2,220	-59%	2,518	1,289	-49%
Fast Food Restaurant	5,376	2,258	-58%	2,713	1,311	-52%
Fire Station (Unmanned)	5,376	3,833	-29%	1,121	3,833	242%
Food Store	5,376	1,758	-67%	1,877	1,021	-46%
Gymnasium	5,376	2,220	-59%	1,348	1,289	-4%
Hospital ¹	5,376	8,760	63%	3,180	7,682	142%
Hospitals/Health Care ¹	5,376	8,760	63%	3,177	7,682	142%
Industrial: 1 Shift	5,376	1,787	-67%	1,446	1,037	-28%
Industrial: 2 Shift	5,376	2,620	-51%	2,120	1,037	-51%
Industrial: 3 Shift	5,376	3,466	-36%	2,805	1,037	-63%
Laundromat	5,376	2,015	-63%	1,878	1,170	-38%
Library	5,376	2,220	-59%	1,767	1,289	-27%
Light Manufacturer	5,376	1,787	-67%	1,446	1,037	-28%
Lodging (Hotel/Motel)	5,376	1,324	-75%	1,521	769	-49%
Mall Concourse ¹	5,376	4,932	-8%	2,157	3,013	40%
Manufacturing Facility	5,376	1,787	-67%	1,446	1,037	-28%
Medical Office	5,376	1,855	-65%	1,767	1,077	-39%
Motion Picture Theatre	5,376	2,220	-59%	1,121	1,289	15%
Multi-Family (Common Areas)	5,376	3,833	-29%	3,177	3,833	21%
Museum	5,376	2,220	-59%	1,767	1,289	-27%
Nursing Home	5,376	8,760	63%	2,520	4,470	77%
Office (General Office Types)	5,376	1,855	-65%	1,767	1,077	-39%
Office/Retail	5,376	1,855	-65%	1,767	1,077	-39%
Parking Garage and Lot	5,376	2,484	-54%	1,990	1,442	-28%
Penitentiary	5,376	8,760	63%	2,389	4,470	87%
Performing Arts Theatre	5,376	2,220	-59%	1,348	1,289	-4%
Police/Fire Station (24 Hr)	5,376	5,308	-1%	3,177	2,774	-13%
Post Office	5,376	1,855	-65%	1,767	1,077	-39%
Pump Station	5,376	4,828	-10%	1,119	2,097	87%
Refrigerated Warehouse	5,376	1,394	-74%	1,354	810	-40%
Religious Building	5,376	1,351	-75%	1,121	785	-30%
Residential (Except Nursing Homes)	5,376	3,833	-29%	1,521	3,833	152%



Facility Type	Heating Pump HOU			CHWP/Cooling Tower HOU		
	2021 PSD Values	Updated Values	Difference %	2021 PSD Values	CHWP/Cooling Tower	Difference %
Restaurant	5,376	2,037	-62%	1,923	1,183	-39%
Retail	5,376	2,015	-63%	1,878	1,170	-38%
School/University (Ref [1]) ¹	5,376	6,471	20%	1,205	2,357	96%
Schools (Jr./Sr. High) (Ref [1]) ¹	5,376	4,828	-10%	1,205	2,097	74%
Schools (Preschool/Elementary)	5,376	1,490	-72%	1,205	865	-28%
Schools (Technical/Vocational) ¹	5,376	5,620	5%	1,205	2,170	80%
Small Services	5,376	1,855	-65%	1,768	1,077	-39%
Sports Arena	5,376	2,220	-59%	1,121	1,289	15%
Town Hall	5,376	2,220	-59%	1,767	1,289	-27%
Transportation	5,376	2,484	-54%	2,742	1,442	-47%
Warehouse (Not Refrigerated)	5,376	1,394	-74%	1,354	810	-40%
Wastewater Treatment Plant	5,376	4,828	-10%	2,805	2,097	-25%
Workshop	5,376	1,787	-67%	1,768	1,037	-41%

¹ Results are based on VAV systems with economizers.



4 CONCLUSION AND RECOMMENDATIONS

This section summarizes the conclusions and recommendations of this study based on the results presented above.

Conclusion 1: The current PSD's default C&I HOU/FLH values are said to have been developed over the years and are considered during program evaluations. However, this study found that the PSD's default HOU/FLH have not been updated since 2005, except for the lighting HOU values for 12 C&I facilities.

Conclusion 2: The current PSD's default C&I lighting HOU values are based on a 2004-2005 study. This study presents updated lighting HOU values for 38 PSD C&I facilities, based on recent studies. The updated lighting HOU values are, on average, 6% higher than the current PSD lighting HOU values. Similarly, the source and recency of the current PSD's default C&I FLH/HOU values for heating, cooling, HVAC fan motor, heating pump, and CHWP and cooling tower end uses are unknown. This study presents updated HOU/FLH for all 60 PSD C&I facilities.

Recommendation 1: Update the PSD's C&I default HOU/FLH values table in Table A5-1, Appendix Five with the updated HOU/FLH values table presented in Table 1-1 of this report.

Conclusion 3: The modeling-based updated HOU/FLH values presented in this study are developed based on the simulation of commercial building prototypes using Hartford (inland) weather data.

Recommendation 2: We recommend running the prototypes using Bridgeport (coastal) weather data as well and reporting separate inland and coastal C&I HOU/FLH values. If one set of statewide HOU/FLH values is desired, the values should reflect a weighted average of inland and coastal values.

Conclusion 4: The 22 commercial building prototypes that we used in the study are based on weather and local building practices adjustments made for Poughkeepsie, NY. The results of those 22 NY commercial building prototypes were assigned to one of the 60 PSD facilities based on operational similarities.

Recommendation 3: We recommend reviewing the key building description assumptions of the NY commercial building prototypes (presented in Appendix A) in future.

Recommendation 4: We recommend reviewing and updating as needed the mapping of NY building prototypes to the PSD facilities presented in Appendix B. For future studies, we also recommend developing CT-specific building prototypes for all 60 PSD facilities.

Conclusion 5: The PSD's Appendix Three C&I realization rates (RRs) are trued up to account for any changes in HOU/FLH values and therefore, revision to the PSD's HOU/FLH values may cause a "domino effect" to the RR values. DNV investigated the potential domino effect of updating the HOU/FLH values to the PSD's RRs. We found that for C&I facilities, the PSD reports heating, and cooling RRs for Energy Conscious Blueprint (ECB), Energy Opportunities (EO), and Small Business Energy Advantage (SBEA) programs, based on the respective program evaluation studies. DNV reviewed the heating and cooling measures and the corresponding impacted facility types evaluated under C1634⁷ ECB evaluation study. We found that updating the HOU/FLH values based on the findings of this study would result in less than a 10% change in the RR values. Per the X1931 prospective RR update guidance⁸, any changes that result in less than 10% impact to the PSD's RRs are considered "insignificant" and do not warrant adjustment of the RRs. As such, adjustment of the Appendix Three RRs to mitigate the domino effect of the HOU/FLH update is not needed at this time.

⁷ Cadmus, C1634 Impact Evaluation of PY 2016 & 2017 Energy Conscious Blueprint Program, Oct. 18, 2020

⁸ X1931 Prospective Realization Rate Update Guidance study, July 14, 2020. Prepared for the CT EA team by ERS.



5 REFERENCES

DNV GL, C1635 Impact Evaluation of PY 2016 & 2017 Energy Opportunities (EO) Program, August 27, 2020.

DNV GL, MA C&I PROJECT 86 Lighting Hours of Use Study, April 12, 2019.

RLW Analytics, CT & MA Utilities 2004-2005 Lighting Hours of Use for School Buildings Baseline Study Final Report, September 7, 2006.

TRC, X1941: Multifamily Impact Evaluation, PSD Savings Review, July 2020.

Cadmus, C1634 Impact Evaluation of PY 2016 & 2017 Energy Conscious Blueprint Program, Oct. 18, 2020.

APPENDIX A. PROTOTYPICAL BUILDING DESCRIPTION

ASSEMBLY PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Auditorium: 3.4 W/SF Office: 2.2 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 - 110 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

AUTO REPAIR PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	5150 square feet
Number of floors	1
Wall construction and R-value	Concrete block, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13,5
Glazing type	Double pane clear; SHGC = ,74 U-value = 0,72
Lighting power density	2.2 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sun: 9am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	280 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

BIG BOX RETAIL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear

Lighting power density	Sales: 3.36 W/SF Storage: 0.88 W/SF Office: 2.2 W/SF Auto repair: 2.15 W/SF Kitchen: 4.3 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 260 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

▪ **Community College Prototype Building Description**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 150,000 square feet each; oriented 90° from each other Classroom: 150,825 SF Computer room: 9,625 SF Dining area: 26,250 SF Kitchen: 5,625 SF Office: 70,175 SF Total: 300,000 SF
Number of floors	3
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency



Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

▪ **DORMITORY PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	170,000 square feet
Number of floors	4
Wall construction and R-value	CMU with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear; SHGC = 0.73 U-value = 0.72
Lighting power density	Rooms: 0.5 W/SF Corridors and common space: 0.8
Plug load density	Rooms: 0.6 W/SF Corridors and common space: 0.2
Operating hours	24/7 - 365
HVAC system type	Fan coils with centrifugal chiller and hot water boiler
HVAC system size	800 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating

▪ **ELEMENTARY SCHOOL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Classroom: 4.4 W/SF Cafeteria: 1.7 W/SF Gymnasium: 2.1 W/SF Kitchen: 4.3 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	160 - 180 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating



▪ **FAST FOOD RESTAURANT PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1,000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	1.7 W/SF dining 2.5 W/SF entry/lobby 4.3 W/SF kitchen 1.0 W/SF restroom
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	100 – 120 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

▪ **FULL-SERVICE RESTAURANT PROTOTYPE DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Dining area: 1.7 W/SF Entry area: 2.5 W/SF Kitchen: 4.3 W/SF Restrooms: 1.0 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	140 – 160 SF/ton depending on climate
Thermostat set points	Occupied hours: 77 cooling, 72 heating Unoccupied hours: 80 cooling, 69 heating

▪ **GROCERY PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage

Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50 °F prep area: 1,268 SF 35 °F walk-in cooler: 1,560 SF - 5 °F walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF 50°F prep area: 4.3 W/SF 35°F walk-in cooler: 0.9 W/SF - 5°F walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50°F prep area: 0.23 W/SF + 36 kBTU/h process load 35°F walk-in cooler: 0.23 W/SF + 17 kBTU/h process load - 5°F walk-in freezer: 0.23 W/SF+ 29 kBTU/h process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20°F suction temp): 23 compressor ton Medium temperature (18°F suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBTU/h THR Medium temperature: 756 kBTU/h THR
Thermostat set points	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

▪ **HIGH SCHOOL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 25,000 square feet each; oriented 90° from each other Classroom: 88,200 SF Computer room: 3082 SF Dining area: 22,500 SF Gymnasium: 22,500 SF Kitchen: 10,500 SF Office: 3218 SF Total: 150,000 SF
Number of floors	2
Wall construction and R-value	CMU with brick veneer, plus R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Gymnasium: 1.8 W/SF Kitchen: 3.6 W/SF

Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 7pm Sat: 8am – 4pm Sun: closed
HVAC system type	Combination PSZ and built-up with screw chiller and hot water boiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

▪ **LARGE HOSPITAL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Patient rooms: 2.3 W/SF Office: 2.2 W/SF Lab: 4.4 Dining: 1.7 Kitchen and food prep: 4.3
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 Dining: 0.6 Kitchen and food prep: 4.6
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space; 1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating



▪ HOTEL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar, cocktail lounge – 800 SF Corridor – 20,100 SF Dining Area – 1,250 SF Guest rooms – 160,680 SF Kitchen – 750 SF Laundry – 4,100 SF Lobby – 8,220 Office – 4,100 SF
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Bar, cocktail lounge – 1.7 W/SF Corridor – 1.0 W/SF Dining Area – 1.7 W/SF Guest rooms – 0.6 W/SF Kitchen – 4.3 W/SF Laundry – 1.8 W/SF Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms 1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC (Packaged Terminal Air Conditioner): Guest rooms PSZ: Corridors
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Minimum outdoor air fraction	Built up system 0.3; PSZ: 0.14; PTAC: 0.11 is typical.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
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▪ **LARGE OFFICE PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point
Thermostat set points	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 78 cooling, 67 heating

▪ **LARGE RETAIL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,000 square feet Sales area: 96,000 SF Storage: 18,000 SF Office: 6,000 SF
Number of floors	3
Wall construction and R-value	Brick and CMU with R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multi-pane; SHGC= 0.73 U-value = 0.72
Lighting power density	Sales area: 2.8 W/SF Storage: 0.8 W/SF Office: 1.8 W/SF
Plug load density	Sales area: 1.1 W/SF Storage: 0.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sat: 9am – 10pm Sun: 9am – 7pm

HVAC system types	1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	340 SF/ton
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

▪ **LIGHT INDUSTRIAL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Factory – 2.1 W/SF Warehouse – 0.9 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	500 - 560 SF/ton depending on climate
Thermostat set points	Occupied hours: 78 cooling, 70 heating Unoccupied hours: 81 cooling, 67 heating

▪ **MOTEL PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	30,000 square feet
Number of floors	2
Wall construction and R-value	Frame with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	0.6 W/SF
Plug load density	0.6 W/SF
Operating hours	24/7 - 365
HVAC system type	PTAC with electric heat
HVAC system size	540 SF/ton
Thermostat set points	Daytime hours: 76 cooling, 72 heating Night setback hours: 81 cooling, 67 heating



▪ **PROTOTYPICAL REFRIGERATED WAREHOUSE MODEL DESCRIPTION**

Characteristic	Value
Vintage	New construction
Shape	Rectangular (400 ft by 230 ft)
Floor area	Freezer: 40,000 SF Cooler: 40,000 SF Shipping Dock: 12,000 SF Total: 92,000 SF
Number of floors	1
Floor to ceiling height	30 ft
Exterior wall construction	Insulated metal panel
Ext wall R-Value	Cooler and loading dock – R-20; Freezer – R-26

▪ **RELIGIOUS WORSHIP PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	11,000 square feet
Number of floors	1
Wall construction and R-value	Brick with R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear; SHGC = .87 U-value = 1.2
Lighting power density	1.7 W/SF
Plug load density	1.2 W/SF
Operating hours	Mon-Sat: 12pm-6pm Sun: 9am – 7pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 70 heating Unoccupied hours: 82 cooling, 64 heating

▪ **SMALL OFFICE PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Perimeter offices: 2.2 W/SF Core offices: 1.5 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 - 245 SF/ton depending on climate

Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating
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SMALL RETAIL PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

▪ **UNIVERSITY PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 200,000 square feet each; oriented 90° from each other Classroom: 431,160 SF Computer room: 27,540 SF Dining area: 24,000 SF Kitchen: 10,500 SF Office: 226,800 SF Total: 800,000 SF
Number of floors	4
Wall construction and R-value	Insulated frame wall with R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Double pane clear, SHGC = 0.73; U-value = 0,72
Lighting power density	Classroom: 3.6 W/SF Computer room: 3.6 W/SF Dining area: 1.5 W/SF Office: 2.0 W/SF Kitchen: 3.6 W/SF
Plug load density	Classroom: 1.1 W/SF Computer room: 5.5 W/SF Dining area: 0.6 W/SF Office: 1.6 W/SF Kitchen: 3.3 W/SF
Operating hours	Mon-Fri: 8am – 10pm Sat: 8am – 7pm Sun: closed
HVAC system type	Combination PSZ and built-up with centrifugal chiller and hot water boiler.



HVAC system size	400 SF/ton
Thermostat set points	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating
Chiller type	Water cooled and air cooled
Chilled water system type	Variable volume with 2 way control valves,
Chilled water system control	Constant CHW Temp, 45 °F set point
Boiler type	Hot water, 80% efficiency
Hot water system type	Variable volume with 2 way control valves,
Hot water system control	Constant HW Temp, 180 °F set point

▪ **WAREHOUSE PROTOTYPE BUILDING DESCRIPTION**

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	500,000
Number of floors	1
Wall construction and insulation R-value	Concrete block, R-5
Roof construction and insulation R-value	Wood deck with built-up roof, R-12
Glazing type	Multi-pane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	0.9 W/SF
Plug load density	0.2 W/SF
Operating hours	Mon-Fri: 7am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Thermostat set points	Occupied hours: 80 cooling, 68 heating Unoccupied hours: 85 cooling, 63 heating

APPENDIX B. ASSIGNMENT OF NY BUILDING PROTOTYPES TO CT PSD FACILITY TYPES

PSD Facility Type	Assigned NY Building Prototype
Auto Related	Auto Repair
Bakery	Light Industrial
Banks, Financial Center	Large Office VAV
Church	Religious
College: Cafeteria	Fast Food
College: Classes/Administrative	University (No Dorm) VAV
College: Dormitory	Dormitory
Commercial Condo	Hotel Common Areas
Convenience Store	Small Retail
Convention Center	Hotel Common Areas
Court House	Large Office VAV
Dining: Bar Lounge/Leisure	Full-Service Restaurant
Dining: Cafeteria/Fast Food	Fast Food
Dining: Family	Full-Service Restaurant
Entertainment	Assembly
Exercise Center	Assembly
Fast Food Restaurant	Fast Food
Fire Station (Unmanned)	Dormitory
Food Store	Grocery
Gymnasium	Assembly
Hospital	Hospital VAV
Hospitals/Health Care	Hospital VAV
Industrial: 1 Shift	Light Industrial
Industrial: 2 Shift	Industrial: 2 Shift
Industrial: 3 Shift	Industrial: 3 Shift
Laundromat	Small Retail
Library	Assembly
Light Manufacturer	Light Industrial
Lodging (Hotel/Motel)	Motel
Mall Concourse	Large Retail VAV
Manufacturing Facility	Light Industrial
Medical Office	Small Office
Motion Picture Theatre	Assembly
Multi-Family (Common Areas)	Dormitory
Museum	Assembly
Nursing Home	Hotel Common Areas
Office (General Office Types)	Small Office
Office/Retail	Small Office



Parking Garage and Lot	Auto Repair
Penitentiary	Hotel Common Areas
Performing Arts Theatre	Assembly
Police/Fire Station (24 Hr)	Average of Office and Hotel
Post Office	Small Office
Pump Station	Industrial: 3 Shift
Refrigerated Warehouse	Warehouse
Religious Building	Religious
Residential (Except Nursing Homes)	Dormitory
Restaurant	Full-Service Restaurant
Retail	Small Retail
School/University	University (No Dorm) VAV
Schools (Jr./Sr. High)	High School VAV
Schools (Preschool/Elementary)	Primary School
Schools (Technical/Vocational)	Community College VAV
Small Services	Small Office
Sports Arena	Assembly
Town Hall	Assembly
Transportation	Auto Repair
Warehouse (Not Refrigerated)	Warehouse
Wastewater Treatment Plant	Industrial: 3 Shift
Workshop	Light Industrial



About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.