New Jersey Board of Public Utilities

New Jersey's Clean Energy Program

Protocols to Measure Resource Savings

FY2022 Addendum

Release Date: June 8, 2022

Summary of Changes

The table below details interim modifications to the FY2021 Protocols that have been developed by the TRM Working Group (a subcommittee of the EM&V Working Group).

Addition/Revision	Section/ Measure	Scope/Description of Change
Addition	Residential ENERGY STAR Lighting	Baseline efficiency updated based on A5160 and Federal legislation "Other" lighting category added
Revision	Air Purifiers	Energy Star calculations replace deemed savings tables. Baseline efficiency updated based on A5160.
Revision	Residential Instantaneous Water Heaters	Hot water consumption, water heater setpoint temperature, and incoming water main temperature assumptions updated
Revision	Residential Combination Boilers	Hot water consumption, water heater setpoint temperature, and incoming water main temperature assumptions updated
Revision	Residential Stand-Alone Storage Water Heaters	Hot water consumption, water heater setpoint temperature, and incoming water main temperature assumptions updated
Addition	Hot Water Conservation Measures: Low Flow Showerheads & Faucet Aerators	Added due to inclusion in A5160
Revision	Commercial Electric HVAC	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B; Updated Equations; Added IEER; HVAC Baseline tables updated
Revision	Smart Thermostat	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B
Revision	Commercial Occupancy Controlled Thermostat	Effective Full Load Hours by Building Type and NJ Region

		can now be found in Appendix B
Revision	Commercial Electric Chillers	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B
Revision	Commercial Gas Chillers	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B; Winter gas savings equation updated
Revision	Commercial Prescriptive Boilers	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B
Revision	Commercial Prescriptive Furnaces	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B
Revision	Commercial Boiler Reset Controls	Effective Full Load Hours by Building Type and NJ Region can now be found in Appendix B
Revision	Electric/Gas Commercial Combination Oven/Steamer	Idle Energy Rate and Cooking Efficiency Updated based on A5160 legislation; Idle Energy Rate equation updated
Revision	Electric/Gas Commercial Convection Oven	Idle Energy Rate and Cooking Efficiency Updated based on A5160 legislation; Idle Energy Rate equation updated
Revision	Commercial Gas Rack Oven	Idle Energy Rate and Cooking Efficiency Updated based on A5160 legislation; Idle Energy Rate equation updated
Revision	Electric/Gas Commercial Steamers	Idle Energy Rate and Cooking Efficiency Updated based on A5160 legislation; Idle Energy Rate equation updated
Revision	Electric/Gas Commercial Fryers	Idle Energy Rate and Cooking Efficiency Updated based on A5160 legislation; Idle Energy Rate equation updated

Revision	Commercial Food Holding Cabinets	Idle Energy Rate Updated based on A5160 legislation; Idle Energy Rate equation updated
Revision	Commercial Dishwasher	Incoming water main temperature assumptions updated
Revision	Appendix A. Measure Lives	LED, Performance Lighting and Prescriptive Lighting lifetimes all updated to adjusted measure life (AML)
Revision	Appendix B. HVAC Cooling and Heating Equivalent Full Load Hours	Revised simulation results for cooling and heating EFLH based on NJ climate data; added definition of small and large buildings; added "other" category for large buildings
Addition	Appendix C. Commercial Building Prototypes	Description of Prototypical Commercial Buildings Adopted from the NY TRM

1. Residential ENERGY STAR Lighting

Description

Savings from the installation of screw-in ENERGY STAR LED general service lamps, ENERGY STAR LED fixtures and ENERGY STAR specialty LED lamps. Savings from ENERGY STAR lamps and fixtures are based on a straightforward algorithm that calculates the difference between the baseline lamp/fixture wattage and new lamp/fixture wattage, and the average daily hours of usage for the lighting unit being replaced. Baseline lamp/fixture wattage is based on the lumen output of the ENERGY STAR lamp/fixture and a minimum lamp/fixture lumen per watt efficacy.

Using the relationship in this section, the baseline lamp wattage for General Service Lamps is compliant with Federal regulations issued on May 8, 2022. Full compliance with this standard by retailers shall commence on August 1, 2023 .[1] The baseline lamp wattage for State Regulated General Service lamps is compliant with the New Jersey P.L. 2021, c. 464 minimum standards[2]. Compliance with this standard shall commence on January 1, 2023.

The coincidence factor (CF) discounts the peak demand savings to reflect the demand reduction realized during the summer on-peak demand period. This is based on typical operating schedules for the geographical area covered by the program.

HVAC interactive factors are applied to capture the additional savings or penalty associated with the impact of lighting measures on the building's HVAC system. A reduction in lighting load will result in additional cooling savings during the summer period, and a gas heating penalty during the winter period.

<u>Algorithms</u>

$$\text{Energy Savings}\left(\frac{\text{kWh}}{\text{yr}}\right) = \text{Qty}_q * \frac{(\text{Watts}_\text{b}) - (\text{Watts}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * \text{Hrs} * (1 + \text{HVAC}_\text{e})$$

$$\text{Peak Demand Savings (kW)} = \text{Qty}_q * \frac{(\text{Watts}_\text{b}) - (\text{Watts}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * CF * (1 + \text{HVAC}_\text{d})$$

$$\text{Fuel Penalty}\left(\frac{\text{therms}}{\text{yr}}\right) = -\text{Qty}_q * \frac{(\text{Watts}_\text{b}) - (\text{Watts}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * Hrs * \text{HF} * \left(\frac{0.03412}{\text{nHeat}}\right) * \%\text{FH}$$

[1] https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022
[2] https://legiscan.com/NJ/bill/A5160/2020

Definition of Variables

$Watts_b$ = Wattage of baseline fixture or lamp

$Watts_q$ = Wattage of qualifying fixture or lamp

Qty_q = Quantity of qualifying fixtures or lamps

Hrs = Annual lighting operating hours

CF = Coincidence factor

$HVAC_e$ = HVAC interaction factor for electric energy savings

$HVAC_d$ = HVAC interaction factor for peak demand reduction

HF = Heating factor, or percentage of lighting savings that must be heated

nHeat = Efficiency of heating system

%FH = Percentage of homes using fossil fuel heat

Summary of Inputs

Residential ENERGY STAR Lighting

Component	Type	Value	Source
$Watts_b$[3]	Variable	: $Watts_b = Lumen_q / 45$ lumen/watt	1,3,4
$Watts_q$	Variable	Qualifying Lamp/Fixture Wattage Energy Star v2.1	Application
$Lumen_q$	Variable	Qualifying Lamp/Fixture Lumen Output	Application
Qty_q	Variable	Qualifying Lamp/Fixture Quantity	Application
Hrs	Variable	Interior: 679 hrs Exterior: 1,643 hrs Unknown: 808 hrs[4]	2,5
CF	Fixed	0.06	2
$HVAC_e$[5]	Fixed	Interior: 0.023 Exterior: 0 Unknown: 0.020	2

[3] Baseline wattage calculated from qualifying lamp lumen output and minimum lamp efficacy from NJ P.L. 2021, c. 464 and U.S. DOE.

[4] Based on an average of 9 exterior and 59 interior lamps per home from Residential Lighting End-Use Consumption Study. US DOE December 2012 Table 4.4.

[5] For electric cooling interactivity, value based on NEEP Mid-Atlantic TRM V9, p. 22: Calculated using defaults assuming 89% of homes have electric cooling (per RECS 2015 data) with an average 3.8 COP and a cooling load reduction of 33% of lighting savings; 0.89*(0.33 / 3.8) = 0.077.

For electric heating interactivity, value based on NEEP Mid-Atlantic TRM V9, p. 22: Calculated using defaults assuming 20% of homes are electrically heated (per RECS 2015 data) with an average 1.74 COP and a heating load increase of 47% of lighting savings; -0.20*(0.47 / 1.74) = -0.054. Value of $HVAC_e$ established as the summation of these values; 0.077 – 0.054 = 0.023.

Component	Type	Value	Source
$HVAC_d$[6]	Fixed	Interior: 0.155 Exterior: 0 Unknown: 0.134	2
HF	Fixed	Interior: 0.47 Exterior: 0.00 Unknown: 0.41	2
nHeat[7]	Fixed	0.8	2
%FH[8]	Fixed	0.8	

Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V10. May 2020.
2. NEEP, *Mid-Atlantic Technical Reference Manual*, V9. May 2019.
3. New Jersey P.L. 2021, c. 464 Enacted January 2022.
4. U.S. DOE 2022-05-09 Energy Conservation Program: Definitions for General Service Lamps; Final rule. Published May 8, 2022.
5. U.S. DOE, Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates, December 2012.

[6] From NEEP Mid-Atlantic TRM V9, p. 24: Calculated using defaults assuming 89% of homes have electric cooling (per RECS 2015 data) with an average 3.8 COP and peak cooling load reduction of 66% of lighting savings; 0.89*(0.66 / 3.8) = 0.155.

[7] 10 CFR 430.32 (e)(ii); minimum AFUE for residential non-weatherized gas furnaces.

[8] Based on RECS 2015 data for Middle Atlantic Region (Table HC6.7).

2. Instantaneous Water Heaters

This section provides energy savings algorithms for qualifying instantaneous water heaters installed in residential settings. This measure assumes that the baseline water heater is either a code natural gas standalone storage water heater, or a code instantaneous water heater. The input values are based on federal equipment efficiency standards.

The uniform efficiency factor (UEF) is the measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[9]

Algorithms

Fuel Savings (therm/yr) = GPD * 365 * 8.33 * (Tset – Tmain) * ($1/UEF_b$ – $1/UEF_q$) / 100,000

Definition of Variables

UEF_q	= Uniform energy factor of the qualifying energy efficient water heater.
UEF_b	= Uniform energy factor of the baseline water heater. In New Jersey the 2018 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.
GPD	= gallons per day of hot water use
365	= days per year
8.33	= Btu/gal-F
Tset	= water heater setpoint temperature, F
Tmain	= incoming water main temperature, F
100,000	= Btu/therm

Summary of Inputs

Instantaneous Water Heaters

Component	Type	Value	Source
UEF_q	Variable	Minimum value 0.87	Application
UEF_b	Variable	Storage water heater – 0.657 Instantaneous water heater – 0.81	1
GPD	Variable	Hot water use (gallons per day) = 17.2 gal/person-day * number of people in the home. Use 46 GPD if unknown	2
T_{set}	Fixed	125 deg F	3

[9] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria

Component	Type	Value	Source
T_{main}	Fixed	60 deg F. Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F	4

The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[10] assuming tank sizes of 30 gallons for small units, 40 gallons for medium units, and 55 gallons for large units.

Sources

1. US Government Publishing Office, June 2017, *Electronic Code of Federal Regulations – Title 10, Part 430, Subpart C*; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 https://www.waterrf.org/research/projects/residential-end-uses-water-version-2. GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
3. 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature; available at https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.
4. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory; available at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf.

3. Combination Boilers

This section provides energy savings algorithms for qualifying gas combination boilers installed in residential settings. A combination boiler is defined as a boiler that provides domestic hot water and space heating. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, and DOE2.2 simulations completed by the New York State Joint Utilities.

This measure assumes the existing boiler system has failed or is at the end of its useful life and is replaced with a combination boiler. For the water heating component, this measure assumes that the baseline water heater is a storage water heater, and customers replacing existing instantaneous (tankless) water heaters are not eligible.

The uniform energy factor (UEF) is the current measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[11]

Algorithms

Fuel Savings (therm/yr) = therm/yr Boiler Fuel Savings + therm/yr DHW Fuel Savings

Therm/yr Boiler Fuel Savings/yr = Cap_{in} * $EFLH_h$ * (($AFUE_q$/$AFUE_b$)-1) / 100 kBtu/Cap_{in}

Therm/yr DHW Fuel Savings = GPD * 365 * 8.33 * (Tset – Tmain) * (1/UEF_b – 1/UEF_q) / 100,000

Cap_{in}	= Input capacity of qualifying boiler in kBtu/hr
$EFLH_h$	= The boiler Equivalent Full Load Hours of operation during the heating season
$AFUE_q$	= Annual fuel utilization efficiency of the qualifying boiler
$AFUE_b$	= Annual fuel utilization efficiency of the baseline boiler
UEF_q	= Uniform energy factor of the qualifying energy efficient water heater.
UEF_b	= Uniform energy factor of the baseline water heater. In New Jersey the 2018 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.
GPD	= gallons per day of hot water use
365	= days per year
8.33	= Btu/gal-F
Tset	= water heater setpoint temperature, F
Tmain	= incoming water main temperature, F
100,000	= Btu/therm

Summary of Inputs

[11] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria

Combination Boiler Assumptions

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	965 hours	1
$AFUE_q$	Variable	Minimum value 0.90	Application
$AFUE_b$	Fixed	Gas fired boiler – 82% Oil fired boiler – 84%	2
UEF_b	Fixed	Storage Water Heater – 0.657	2
UEF_q	Fixed	0.87	3
GPD	Variable	Hot water use (gallons per day) = 17.2 gal/person-day x number of people in the home. Use 46 GPD if unknown	4
Tset	Fixed	125 deg F	5
Tmain	Fixed	60 deg F. Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F	6

The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[12] assuming tank sizes of 30 gallons for small water heaters, 40 gallons for medium water heaters, and 55 gallons for large water heaters.

Sources

1. NJ utility analysis of heating customers, annual gas usage.
2. US Government Publishing Office, June 2017, Electronic Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C, §430.32; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
3. Minimum UEF for instantaneous (tankless) water heaters from Energy Star https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria.
4. Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 https://www.waterrf.org/research/projects/residential-end-uses-water-version-2. GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
5. 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature; available at https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.

[12] Available at: https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls

6. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory; available at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf.

4. Stand Alone Storage Water Heaters

This section provides energy savings algorithms for qualifying natural gas standalone storage water heaters installed in residential settings. This measure assumes that the baseline water heater is a code natural gas storage water heater. The input values are based on federal equipment efficiency standards.

The uniform energy fact (UEF) is the measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[13]

Algorithms

Fuel Savings (therm/yr) = GPD * 365 * 8.33 * (Tset – Tmain) * ($1/UEF_b$ – $1/UEF_q$) / 100,000

Definition of Variables

UEF_q = Uniform energy factor of the qualifying energy efficient water heater.

UEF_b = Uniform energy factor of the baseline water heater. In New Jersey the 2018International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

GPD = gallons per day of hot water use
365 = days per year
8.33 = Btu/gal-F
Tset = water heater setpoint temperature
Tmain = incoming water main temperature
100,000 = Btu/therm

Summary of Inputs

Storage Water Heater

Component	Type	Value	Sources
UEF_q	Variable	Minimum value If less than or equal to 55 gal: 0.64 If greater than 55 gal: 0.78	Application
UEF_b	Variable	If gas & less than 55 gal: $UEF_b = 0.6483 – (0.0017 \times V^a)$ If gas & more than 55 gal: $UEF_b = 0.7897 – (0.0004 \times V^a)$	1
GPD	Variable	Hot water use (gallons per day) = 17.2 gal/person-day * number of people in the home. Use 46 GPD if unknown	2
T_{set}	Fixed	125 deg F	3

[13] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria

Component	Type	Value	Sources
T_{main}	Fixed	60 deg F. Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F	4

[a] V is the volume of the installed storage water heater tank in gallons

The referenced federal standards for the baseline and qualified UEF are dependent on both draw pattern and tank size. The baseline and qualified UEF values and formulas shown in the table above are associated with medium draw patterns.

Sources

1. US Government Publishing Office, June 2017, *Electronic Code of Federal Regulations – Title 10, Part 430, Subpart C*; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 https://www.waterrf.org/research/projects/residential-end-uses-water-version-2. GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
3. 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature; available at https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.
4. Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory; available at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf.

5. Hot Water Conservation Measures in Low Income Programs

The protocols savings estimates are based on an average package of domestic hot water measures typically installed by low-income programs. These measures include low-flow showerheads, faucet aerators installed in kitchens and faucet aerators installed in restrooms.

Low Flow Showerheads

Savings for low-flow showerhead measures are determined using the total change in flow rate (gallons per minute) from the baseline (existing) showerhead to the efficient showerhead.

Algorithms

Energy Savings (kWh/yr) = %Electric DHW * (GPM_base – GPM_ee) * kWh/ΔGPM

Peak Demand Savings (kW) = Electricity Impact (kWh) * Demand Factor

Natural Gas Impact (therm) = %Gas DHW * (GPM_base – GPM_ee) * therm/ΔGPM

Definition of Variables

%Electric DHW = proportion of water heating supplied by electricity

GPM_base = Flow rate of the baseline showerhead (gallons per minute)

GPM_ee = Flow rate of the efficient showerhead (gallons per minute)

kWh/ΔGPM = Electric energy savings of efficient showerhead per gallon per minute (GPM)

Demand Factor = energy to demand factor

%Gas DHW = proportion of water heating supplied by natural gas

therm/ΔGPM = natural gas energy savings of efficient showerhead per gallon per minute (GPM)

Low Flow Showerheads

Component	Type	Value	Sources
% Electric DHW	Variable	Electric DHW = 100% Unknown = 13%	1
%Gas DHW	Variable	Natural Gas DHW = 100% Unknown = 81%	1
GPM_base	Variable	Existing: 2.5[14] New: 2.0[15]	2
GPM_ee	Variable	Installed showerhead flowrate. Must be < 2.0 gpm	2
kWh/ΔGPM	Fixed	SF = 360.1 MF = 336.9 Unknown = 390.1	3

[14] Existing refers to the replacement of an existing showerhead.

[15] New refers to the installation of a showerhead where there is no existing showerhead.

Component	Type	Value	Sources
therm/ΔGPM	Fixed	SF = 15.5 MF = 16.9 Unknown = 16.8	3, 4
Demand Factor	Fixed	0.00008013	3

Sources

1. Unknown hot water heating fuel assumption taken from 2009 RECS data for New Jersey; see Table HC8.8 Water Heating in U.S. Homes in Northeast Region, Divisions, and States.
2. Flow rate specification taken from rebate application; default assumption for unknown flow rate taken from Pennsylvania Technical Reference Manual, effective June 2016, p. 120 available at http://www.puc.pa.gov/pcdocs/1370278.docx.
3. Default assumptions from Pennsylvania Technical Reference Manual (ibid).
4. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 4.0, effective June 1, 2015, pp. 657; default assumptions for housing demographic characteristics taken from PA TRM.
5. Baseline flow rates for new showerheads from New Jersey P.L. 2021, c. 464 minimum standards

Low Flow Faucet Aerators

Savings for low-flow faucet aerator measures are determined using the total change in flow rate (gallons per minute) from the baseline (existing) faucet to the efficient faucet.

Algorithms

Energy Savings (kWh/yr) = %Electric DHW * (GPM_base – GPM_ee) * kWh/ΔGPM

Peak Demand Savings (kW) = Electricity Impact (kWh) * Demand Factor

Natural Gas Impact (therm) = %Gas DHW * (GPM_base – GPM_ee) * therm/ΔGPM

Definition of Variables

%Electric DHW = proportion of water heating supplied by electricity

GPM_base = Flow rate of the baseline faucet (gallons per minute)

GPM_ee = Flow rate of the efficient faucet (gallons per minute)

kWh/ΔGPM = Electric energy savings of efficient faucet per gallon per minute (GPM)

Demand Factor = energy to demand factor

%Gas DHW = proportion of water heating supplied by natural gas

therm/ΔGPM = natural gas energy savings of efficient faucet per gallon per minute (GPM)

Low Flow Faucet Aerators

Component	Type	Value	Source
% Electric DHW	Variable	Electric DHW = 100% Unknown = 13%	1

Component	Type	Value	Source
% Gas DHW	Variable	Natural Gas DHW = 100% Unknown = 81%	1
GPM_base	Variable	Existing: All = 2.2 New: Private restroom = 1.5 Kitchen = 1.8 Public restrooom = 0.5	2, 5
GPM_ee	Variable	Installed aerator flowrate. Must be < 1.5 in private restrooms, < 0.5 in public restrooms and < 1.8 in kitchens	5
kWh/ΔGPM	Fixed	SF = 60.5 MF = 71.0 Unknown = 63.7	3
therm/ΔGPM	Fixed	SF = 4.8 MF = 6.5 Unknown = 5.0	3, 4
Demand Factor	Fixed	0.000134	3

Sources

1. Unknown hot water heating fuel assumption taken from 2009 RECS data for New Jersey; see Table HC8.8 Water Heating in U.S. Homes in Northeast Region, Divisions, and States.
2. Flow rate specification taken from rebate application; default assumption for unknown flow rate taken from Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff; available at http://www.puc.pa.gov/pcdocs/1370278.docx.
3. Default assumptions from Pennsylvania Technical Reference Manual (ibid).
4. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 4.0, effective June 1, 2015, pp. 648ff; default assumptions for housing demographic characteristics taken from PA TRM.
5. Baseline flow rates for new aerators established by New Jersey P.L. 2021, c. 464 minimum standards.

6. *Air Purifiers*

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the New Jersey P.L. 2021, c. 464 minimum standards[16]. Compliance with this standard shall commence on January 1, 2023. The following section details savings calculations for ENERGY STAR Air Purifiers in the residential and multi-family sectors.[17]

Algorithms[18]

kWh savings = kWh_base – kWh_eff

Where:

kWh_base = hours * (SmokeCADR_base / (SmokeCADR_per_watt_base * 1000)) + (8760 - hours) * PartialOnModePower_base / 1000)

kWh_eff = hours * (SmokeCADR_eff / (SmokeCADR_per_watt_eff * 1000)) + (8760 - hours) * PartialOnModePower_eff / 1000)

Definition of Variables

kWh_base = Annual Electrical Usage for baseline air purifier (kWh)
kWh_eff = Annual Electrical Usage for efficient air purifier (kWh)
hours = Annual active operating hours = 5840[19]
SmokeCADR_base = Smoke Clean Air Delivery Rate (CADR) for baseline air purifier
SmokeCADR_per_watt_base = Smoke Clean Air Delivery Rate (CADR) per watt for baseline air purifier
PartialOnModePower_base = Partial On Model Power for baseline air purifier by category (watts)
1000 = Conversion factor from watts to kilowatts
SmokeCADR_eff = Smoke Clean Air Delivery Rate (CADR) for efficient air purifier
SmokeCADR_per_watt_eff = Smoke Clean Air Delivery Rate (CADR) per watt for efficient air purifier
PartialOnModePower_eff = Partial On Model Power for efficient air purifier by category (watts)

Baseline air purifier specifications (Source: New Jersey P.L. 2021, c. 464 minimum standards)

Clean Air Delivery Rate (CADR) Range	CADR used in calculation	Smoke CADR per Watt	Partial On Mode Power with WiFi connection (watts)	Partial On Mode Power without WiFi connection (watts)
51 ≤ Smoke CADR < 100	75	1.7	2	1
101 ≤ Smoke CADR < 150	125	1.9	2	1
151≤ Smoke CADR < 200	175	2	2	1
201 ≤ Smoke CADR < 250	225	2	2	1
Smoke CADR >= 250	275	2	2	1

[16] https://legiscan.com/NJ/bill/A5160/2020
[17] ENERGY STAR V2 Room Air Cleaners Data Package (October 11, 2019).
[18] Illinois TRM Ver 10.0, 9/24/2021.
[19] Consistent with ENERGY STAR v.2.0 Room Air Cleaners Data Package and analysis.

Qualifying air purifier specifications (Source: Energy Star 2.0 Air Purifier Specification)

Clean Air Delivery Rate (CADR) Range	CADR used in calculation	Smoke CADR per Watt	Partial On Mode Power with WiFi connection (watts)	Partial On Mode Power without WiFi connection (watts)
51 ≤ Smoke CADR < 100	75	1.9	2	1
101 ≤ Smoke CADR < 150	125	2.4	2	1
151≤ Smoke CADR < 200	175	2.9	2	1
201 ≤ Smoke CADR < 250	225	2.9	2	1
Smoke CADR >= 250	275	2.9	2	1

Deemed kWh Savings based on New Jersey P.L. 2021, c. 464 minimum standards baseline and Energy Star 2.0 Air Purifier Specification as the basis for the qualifying measure

Clean Air Delivery Rate (CADR) Range	CADR used in calculation	kWh Savings	
		Partial On Mode Power with WiFi connection	Partial On Mode Power without WiFi connection
51 ≤ Smoke CADR < 100	75	27	27
101 ≤ Smoke CADR < 150	125	80	80
151≤ Smoke CADR < 200	175	159	159
201 ≤ Smoke CADR < 250	225	204	204
Smoke CADR >= 250	275	249	249

SUMMER COINCIDENT PEAK DEMAND SAVINGS

kWsavings = kWhsavings/Hours *CF / 100

Where:

kWhsavings = Gross customer annual kWh savings for the measure
Hours = Average hours of use per year = 5840 hours
CF = Summer Peak Coincidence Factor for measure = 66.7%[20]

Deemed kW Savings

Clean Air Delivery Rate (CADR) Range	CADR used in calculation	kW Savings	
		Partial On Mode Power with WiFi connection	Partial On Mode Power without WiFi connection
51 ≤ Smoke CADR < 100	75	0.0031	0.0031
101 ≤ Smoke CADR < 150	125	0.0091	0.0091
151≤ Smoke CADR < 200	175	0.0181	0.0181
201 ≤ Smoke CADR < 250	225	0.0233	0.0233

[20] Assumes that the purifier usage is evenly spread throughout the year, therefore coincident peak is calculated as 5840/8760 = 66.7%.

Smoke CADR >= 250	275	0.0285	0.0285

<u>Sources</u>

1. New Jersey P.L. 2021, c. 464.
2. ENERGY STAR v.2.0 Air Purifier Specification.

7. Electric HVAC Systems

This measure provides energy and demand savings algorithms for C&I Electric HVAC systems. The type of systems included in this measure are: split systems, single package systems, air to air cooled heat pumps, packaged terminal systems (PTAC and PTHP), single package vertical systems (SPVAC and SPVHP), central DX AC systems, water source heat pumps, ground water source heat pumps, and/or ground source heat pumps.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline equipment is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the state of New Jersey.

Algorithms

Air Conditioning Algorithms:

Energy Savings (kWh/yr) = N * Tons * ($12/IEER_b$-$12/IEER_q$) * $EFLH_c$
Peak Demand Savings (kW) = N * Tons * ($12/EER_b$-$12/EER_q$) * CF

Heat Pump Algorithms:

Cooling Energy Savings (kWh/yr) = N * Tons * ($12/IEER_b$-$12/IEER_q$) * $EFLH_c$
Peak Demand Savings (kW) = N * Tons * ($12/EER_b$-$12/EER_q$) * CF
Heating Energy Savings (kWh/yr) = N * Heating Capacity * ((1/ (COP_b))-(1/ (COP_q)) * $EFLH_h$ / 3412

Where $_c$ is for cooling and $_h$ is for heating.

Definition of Variables

N = Number of identical pieces of equipment

Tons = Rated cooling capacity of equipment. This value comes from ARI/AHRI or AHAM rating or manufacturer data.

Heating Capacity = Rated heating capacity of equipment in Btu/hr

$IEER_b$ = Integrated Energy Efficiency Ratio of the baseline equipment. For equipment < 65,000 BtuH (5.4 tons), SEER should be used in place of IEER.

EER_b = Energy Efficiency Ratio of the baseline equipment. This data is found in the HVAC and Heat Pumps table below. For equipment < 65,000 BtuH (5.4 tons), SEER should be used in place of EER.

COP_b = Coefficient of Performance of the baseline equipment. This data is found in the HVAC and Heat Pumps table below. For equipment < 65,000 BtuH (5.4 tons), HSPF/3.412 should be used in place of COP

$IEER_q$ = Integrated Energy Efficiency ratio of the high efficiency equipment. For equipment < 65,000 BtuH (5.4 tons), SEER should be used in place of IEER.

EER_q = Energy Efficiency Ratio of the high efficiency equipment. This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For equipment < 65,000 (5.4 tons) Btu/H, SEER should be used in place of EER.

COP_q	= Coefficient of Performance of the high efficiency equipment. This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For equipment < 65,000 Btu/H (5.4 tons), HSPF/3.412 should be used in place of COP.
CF	= Coincidence Factor – This value represents the percentage of the total load which is on during electric system's Peak Window. This value is based on existing measured usage and determined as the average number of operating hours during the peak window period.
$EFLH_{c\ or\ h}$	= Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off-peak periods.
3412	= Conversion factor (Btu/kWh)

Summary of Inputs

HVAC and Heat Pumps

Component	**Type**	**Value**	**Source**
Tons	Variable	Rated Cooling apacity, Tons	Application
Heating Capacity	Variable	Rated heating capacity, Btu/hr	Application
EER_b	Variable	See Table below	1
EER_q	Variable	ARI/AHRI or AHAM Values	Application
$IEER_b$	Variable	See Table below. Use EER if IEER not listed	1
$IEER_q$		ARI/AHRI or AHAM Values	Application
CF	Fixed	50%	2
$EFLH_{(c\ or\ h)}$	Variable	See Appendix B	3

HVAC Baseline Efficiencies Table – New Construction/EUL/RoF

Equipment Type	**Equipment Size**	**Baseline = ASHRAE Std. 90.1 – 2016**
Unitary HVAC/Split Systems and Single Package, Air Cooled	<=5.4 tons, split	13 SEER
	<=5.4 tons, single	14 SEER
	>5.4 to 11.25 tons	11.0 EER, 12.7 IEER
	>11.25 to 20 tons	10.8 EER, 12.2 IEER
	> 21 to 63 tons	9.8 EER, 11.4 IEER
	>63 tons	9.5 EER, 11.0 IEER
Air Cooled Heat Pump Systems, Split System and Single Package: Cooling Mode	<=5.4 tons, split	14 SEER
	<=5.4 tons, single	14 SEER
	>5.4 to 11.25 tons	11.0 EER, 12.2 IEER
	>11.25 to 20 tons	10.6 EER, 11.6 IEER
	>= 20 tons	9.5 EER, 10.6 IEER

Equipment Type	Equipment Size	Baseline = ASHRAE Std. 90.1 – 2016
Air Cooled Heat Pump Systems, Split System and Single Package: Heating Mode	<=5.4 tons, split <=5.4 tons, single >5.4 to 11.25 tons >=11.25 tons	8.2 HSPF 8.0 HSPF 3.3 heating COP 3.2 heating COP
Water Source Heat Pumps (water to air, water loop)	<=1.4 tons >1.4 to 5.4 tons >5.4 to 11.25 tons	12.2 EER, 4.3 heating COP 13.0 EER, 4.3 heating COP 13.0 EER, 4.3 heating COP
Ground Water Source Heat Pumps	<=11.25 tons	18.0 EER, 3.7 heating COP
Ground Source Heat Pumps (brine to air, ground loop)	<=11.25 tons	14.1 EER, 3.2 heating COP
Package Terminal Air Conditioners[21]		14.0 – (0.300 * Cap/1,000), EER
Package Terminal Heat Pumps		14.0 – (0.300 * Cap/1,000), EER 3.7 – (0.052* Cap/1,000), heating COP
Single Package Vertical Air Conditioners	<=5.4 tons >5.4 to 11.25 tons >11.25 to 20 tons	10.0 EER 10.0 EER 10.0 EER
Single Package Vertical Heat Pumps	<=5.4 tons >5.4 to 11.25 tons >11.25 to 20 tons	10.0 EER, 3.0 heating COP 10.0 EER, 3.0 heating COP 10.0 EER, 3.0 heating COP

Sources

1. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
2. C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods. Available at: http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf
3. Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

[21] Cap means the rated cooling capacity of the product in Btu/h.

8. Smart Thermostats

The Smart Thermostat measure involves the replacement of a manually operated or conventional programmable thermostat with an Energy Star certified "smart" thermostat.[22]

This measure only applies to thermostats that control central A/C, heat pump, furnace, or rooftop units (RTUs) with capacity up to 300,000 BTU/h) that serve normal conditioned spaces, not semi-conditioned spaces or spaces with large frequently open doors (e.g. loading docks and car repair shops). Thermostats for larger systems should be treated as custom measures. The baseline equipment is the in-situ manually operated or properly programmed thermostat that was replaced. The total savings should be calculated based on the presence of a cooling system and the heating system fuel.

Algorithms

Cooling Energy Savings (kWh/yr) = CCAP * $EFLH_c$ * 12/SEER * ElecCool_Saving_% / 100
Heating Energy Savings (kWh/yr) = HCAP * $EFLH_h$ * 1/HSPF * ElecHeat_Saving_% / 100 / 1,000
Heating Energy Savings (Therms/yr) = HCAP * $EFLH_h$ * 1/AFUE * FuelHeat_Saving_% / 100 / 100,000
Demand Savings (kW/yr) = 0

Definition of Variables

CCAP	= Cooling capacity of heat pump/AC (Tons) – Provided on Application.
HCAP	= Heating capacity of electric heat, heat pump or furnace (Btu/hr) – Provided on Application.
$EFLH_c$	= Equivalent full load cooling hours
$EFLH_h$	= Equivalent full load heating hours
ElecCool_Saving_%	= Cooling season percent savings
ElecHeat_Saving_%	= Heating season percent savings for electric heating system
FuelHeat_Saving_%	= Heating season percent savings for fuel heating system
$AFUE_h$	= Heating equipment efficiency – Provided on Application. For larger equipment use thermal or combustion efficiency
SEER	= Heat pump/AC cooling efficiency – Provided on Application. For larger equipment use IEER
12	= Conversion factor from Tons to kBtu/hr to acquire consumption in kWh.
100	= Conversion factor percent savings to decimal
1000	= Conversion factor Watts to kW
100,000	= Conversion factor Btu/hr to therm

Summary of Inputs

Occupancy Controlled Thermostats

Component	Type	Value	Source
CCAP	Variable		Application

[22] Energy Star Program Requirements Product Specification for Connected Thermostat Products Ver. 1.0 Rev January 2017.

Component	Type	Value	Source
HCAP	Variable		Application
$EFLH_{c,h}$	Variable	See Appendix B	1
ElecCool_Saving_%	Fixed	See Table below. If baseline tstat type unknown, use 3%	2
ElecHeat_Saving_%	Fixed	See Table below. If baseline tstat type unknown, use 2%	2
FuelHeat_Saving_%		See Table below. If baseline tstat type unknown, use 2%	2
$AFUE_h$	Variable		Application
SEER	Variable		Application

Savings Factors for Smart Thermostats by Baseline Technology

	Baseline Technology	
Fuel and Function	Manual Thermostat	Programmable Thermostat
Savings factor for electric cooling, *ElecCool_Saving_%*	5%	3%
Savings factor for electric heating, *ElecHeat_Saving_%*	4%	2%
Savings factor for fuel heating, *FuelHeat_Saving_%*	5%	2%

Sources

1. Simulations of prototypical buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.
2. Mid-Atlantic TRM v10. Pg. 310.

9. Electric Chillers

The measurement of energy and demand savings for C&I chillers is based on algorithms with key variables.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline chiller is a minimally code compliant chiller with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the state of New Jersey.

Algorithms

Energy Savings (kWh/yr) = N * Tons * EFLH * ($IPLV_b$ – $IPLV_q$)
Peak Demand Savings (kW) = N * Tons * PDC * (FLV_b – FLV_q)

Definition of Variables

N = Number of identical chillers.

Tons = Rated capacity of cooling equipment.

EFLH = Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off peak periods.

PDC = Peak Duty Cycle - Fraction of time the compressor runs during peak hours

$IPLV_b$ = Integrated Part Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

$IPLV_q$ = Integrated Part Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

FLV_b = Full Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

FLV_q = Full Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

Summary of Inputs

Electric Chiller Assumptions

Electric Chillers Component	Type	Situation	Value	Source
Tons	Rated Capacity, Tons	All	Varies	From Application
$IPLV_b$ (kW/ton)	Variable	See table below	Varies	1
$IPLV_q$ (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
FLV_b (kW/ton)	Variable	See table below	Varies	1
FLV_q (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)

Electric Chillers Component	Type	Situation	Value	Source
PDC	Fixed	All	67%	Engineering Estimate
EFLH	Variable	All	See Appendix B	2

Electric Chillers – New Construction

Type	Capacity	ASHRAE 90.1 2016 (Table 6.8.1-3)			
		Path A (see note 1 below)		Path B (see note 2 below)	
		FLV kW/ton	IPLV kW/ton	FLV kW/ton	IPLV kW/ton
Air Cooled	tons < 150	1.188	0.876	1.237	0.759
	tons ≥ 150	1.188	0.857	1.237	0.745
Water Cooled Positive Displacement (rotary screw and scroll)	tons < 75	0.750	0.600	0.780	0.500
	75 ≤ tons < 150	0.720	0.560	0.750	0.490
	150 ≤ tons < 300	0.660	0.540	0.680	0.440
	300 ≤ tons < 600	0.610	0.520	0.625	0.410
	tons ≥ 600	0.560	0.500	0.585	0.380
Water Cooled Centrifugal	tons < 150	0.610	0.550	0.695	0.440
	150 ≤ tons < 300	0.610	0.550	0.635	0.400
	300 ≤ tons < 400	0.560	0.520	0.595	0.390
	400 ≤ tons < 600	0.560	0.500	0.585	0.380
	tons ≥ 600	0.560	0.500	0.585	0.380

Notes:

1. Path A refers to one of two code compliance paths provided in ASHRAE Standard 90.1-2016. Path A is generally used with equipment designed to maximize full load efficiency. Either Path A or Path B may be used to demonstrate compliance.
2. Path B refers to one of two code compliance paths provided in ASHRAE Standard 90.1-2016. Path B is generally used with equipment designed to maximize part-load efficiency. Either Path A or Path B may be used to demonstrate compliance.

Sources

1. ASHRAE Standards 90.1-2016. *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1-3.
2. Simulations of prototypical buildings from NY TRM updated to NJ weather done by NJ Statewide Evaluator, May 2022.

10. ***Gas Chillers***

The measurement of energy savings for C&I gas fired chillers and chiller heaters is based on algorithms with key variables captured on the application form or from manufacturer's data sheets and collaborative/utility studies.For certain fixed components, studies, and surveys developed by the utilities in the state or based on a review of manufacturer's data, other utilities, regulatory commissions or consultants' reports will be used to update the values for future filings.

Algorithms

Winter Gas Savings (therm/yr) = $(VBE_q - BE_b)/VBE_q$ * IR * $EFLH_c$ * 10
Energy Savings (kWh/yr) = Tons * ($kW/Ton_b - kW/Ton_{gc}$) * $EFLH_c$
Summer Gas Usage (therm/yr) = MMBtu Output Capacity / COP * $EFLH_c$ * 10
Net Energy Savings (kWh/yr) = Energy Savings + Winter Gas Savings – Summer Gas Usage
Peak Demand Savings (kW) = Tons * ($kW/Ton_b - kW/Ton_{gc}$) * CF

Definition of Terms

VBE_q = Vacuum Boiler Efficiency
BE_b = Efficiency of the baseline gas boiler
IR = Input Rating, MMBtu/hour
Tons = The rated capacity of the chiller at site design conditions accepted by the program, tons
kW/Ton_b = The baseline efficiency for electric chillers, as shown in the Gas Chiller Verification Summary table below.
kW/Ton_{gc} = Parasitic electrical requirement for gas chiller.
COP = Coefficient of Performance, Efficiency of the gas chiller
MMBtu Output Capacity = Cooling Capacity of gas chiller, MMBtu.
CF = Coincidence Factor. This value represents the percentage of the total load that is on during electric system peak.
$EFLH_c$ = Equivalent Full Load Hours. This represents a measure of chiller use by cooling season.

Summary of Inputs

Gas Chillers

Component	Type	Value	Source
VBE_q	Variable		Application or Manufacturer Data
BE_b	Fixed	80% Et	1, Assumes a baseline hot water boiler with rated input >300 MBh and ≤ 2,500 MBh.

Component	Type	Value	Source
IR	Variable		Application or Manufacturer Data
Tons	Rated Capacity, Tons		Application
MMBtu	Variable		Application
kW/Ton_b	Fixed	<100 tons 1.25 kW/ton 100 to < 150 tons 0.703 kW/ton 150 to <300 tons: 0.634 kW/Ton 300 tons or more: 0.577 kW/ton	Collaborative agreement and C/I baseline study Assumes new electric chiller baseline using air cooled for chillers less than 100 tons; water cooled for chillers greater than 100 tons
kW/Ton_{gc}	Variable		Manufacturer Data
COP	Variable		Manufacturer Data
CF	Fixed	67%	Engineering estimate
$EFLH_c$	Variable	See Appendix B	2

Sources

1. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1 – 6
2. Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

11. Prescriptive Boilers

This prescriptive measure targets the use of smaller-scale boilers (less than or equal to 4000 MBH) and furnaces (no size limitation) in all commercial facilities. Larger sized boilers are treated under the custom measure path.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline boiler is a minimally code compliant boiler with an efficiency as required by ASHRAE Std. 90.1 – 2016 which is the current code adopted by the State of New Jersey.

Algorithms

Fuel Savings (therm/yr) = Cap_{in} * $EFLH_h$ * ((Eff_q/Eff_b)-1) / 100,000 Btu/therm

Definition of Variables

Cap_{in}	= Input capacity of qualifying boiller, Btu/hr
$EFLH_h$	= The Equivalent Full Load Hours of operation during the heating season in hours
Eff_b	= Boiler Baseline Efficiency
Eff_q	= Boiler Proposed Efficiency
100,000	= Conversion from Btu to therm

Summary of Inputs

Prescriptive Boilers

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	See Appendix B	1
Eff_b	Variable	See Table Below	2
Eff_q	Variable		Application

Baseline Boiler Efficiencies (Eff_b)

Boiler Type	Size Category (kBtu input)	Standard 90.1-2016
Hot Water – Gas fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	82% AFUE 80% Et 82% Ec
Hot Water – Oil fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	84% AFUE 82% Et 84% Ec
Steam – Gas fired	< 300	80% AFUE
Steam – Gas fired, all except natural draft	≥ 300 and ≤ 2,500	79% Et

Boiler Type	Size Category (kBtu input)	Standard 90.1-2016
Steam – Gas fired, all except natural draft	> 2,500	79% Ec
Steam – Gas fired, natural	≥ 300 and ≤ 2,500	77% Et
Steam – Gas fired, natural	> 2,500	77% Ec
Steam – Oil fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	82% AFUE 81% Et 81% Ec

Notes:

1. Boiler efficiency is defined as annual fuel utilization efficiency (AFUE), thermal efficiency (Et) or combustion efficiency (Ec) depending on boiler type and size

Sources

1. Simulations of prototypical buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.
2. ASHRAE Standards 90.1-2016. *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1-6.

12. Prescriptive Furnaces

The methodology outlined below shall be adopted for estimating savings for installation of qualifying furnaces.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline furnace is a minimally code compliant furnace with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the State of New Jersey.

Algorithms

$$\text{Fuel Savings (therm/yr)} = Cap_{in} * EFLH_h * ((Eff_q/Eff_b)-1) / 100 \text{ kBtu/therm}$$

Definition of Variables

Cap_{in} = Input capacity of qualifying furnace in kBtu/hr

$EFLH_h$ = The Equivalent Full Load Hours of operation during the heating season in hours

Eff_b = Furnace Baseline Efficiency

Eff_q = Furnace Proposed Efficiency

100 = Conversion from kBtu to therm

Summary of Inputs

Prescriptive Furnaces

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	See Appendix B	1
Eff_q	Variable		Application
Eff_b	Fixed	See Table Below	2

Baseline Furnace Efficiencies (Eff_b)

Furnace Type	Size Category (kBtu input)	Standard 90.1-2016
Gas Fired	< 225 ≥ 225	80% AFUE 80% Ec
Oil Fired	< 225 ≥ 225	78% AFUE (weatherized) 83% AFUE (non-weatherized) 81% Et

Sources

1. Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

2. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. (Table 6.8.1-5).

13. Boiler Reset Controls

The following algorithm detail savings for installation of boiler reset control on commercial boilers. Energy savings are realized through a better control on boiler water temperature. Through the use of software settings, boiler reset controls use outside or return water temperature to control boiler firing and in turn the boiler water temperature.

The input values are based on data supplied by the utilities and customer information on the application form, confirmed with manufacturer data. Boiker reset controller savings are deemed based on study results.

Algorithms

Fuel Savings (therm/yr) = (% Savings) * ($EFLH_h$ * Cap_{in}/hr) / 100 kBtu/therm

Definition of Variables

% Savings	= Estimated percentage reduction in heating load due to boiler reset controls (5%)
$EFLH_h$	= The Equivalent Full Load Hours of operation during the heating season
Cap_{in}	= Input capacity of boiler, kBtu/hr
100	= Conversion from kBtu to therm

Summary of Inputs

Boiler Reset Control Assumptions

Component	Type	Value	Source
% Savings	Fixed	5%	1
$EFLH_h$	Variable	See Appendix B	2
Cap_{in}	Variable		Application

Sources

1. GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4.
2. Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

14. Electric and Gas Combination Oven/Steamer

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein. The baseline idle energy and cooking efficiency is compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial Ovens Version 2.2 as the baseline.[23] Compliance with this standard shall commence on January 1, 2023.

<u>Algorithms</u>

Energy Savings (kWh/yr or Therms/yr) = $D*(E_p + E_{ic} + E_{is} + E_{cc} + E_{cs})$
Peak Demand Savings (kW) = kWh Savings/(D*H)
Preheat Savings†: $E_p = P*(PE_b – PE_q)$
Convection Mode Idle Savings†: $E_{ic} = ((I_{cb} – I_{cq})*(H – P*P_t) – (I_{cb}/PC_{cb} – I_{cq}/PC_{cq})*Lbs)*(1 – S_t)$
Steam Mode Idle Savings†: $E_{is} = ((I_{sb} – I_{sq})*(H – P*P_t) – (I_{sb}/PC_{sb} – I_{sq}/PC_{sq})*Lbs)*S_t$
Convection Mode Cooking Savings: $E_{cc} = Lbs*(1-S_t)*Heat_c*(1/Eff_{cb} – 1/Eff_{cq})/C$
Steam Mode Cooking Savings: $E_{cs} = Lbs*S_t*Heat_s*(1/Eff_{sb} – 1/Eff_{sq})/C$

† – For gas equipment, convert these intermediate values to therms by dividing the result by 100,000 Btu/therm

<u>Definition of Variables (See tables of values below for more information)[24]</u>

C	= Conversion Factor from Btu to kWh or Therms
D	= Operating Days per Year
Effcb	= Baseline Equipment Convection Mode Cooking Efficiency (fraction)
Effcq	= Qualifying Equipment Convection Mode Cooking Efficiency (fraction)
Effsb	= Baseline Equipment Steam Mode Cooking Efficiency (fraction)
Effsq	= Qualifying Equipment Steam Mode Cooking Efficiency (fraction)
H	= Daily Operating Hours
Heatc	= Convection Mode Heat to Food (Btu/lb)
Heats	= Steam Mode Heat to Food (Btu/lb)
Icb	= Baseline Equipment Convection Mode Idle Energy Rate (Btu/hr)
Icq	= Qualifying Equipment Convection Mode Idle Energy Rate (Btu/hr)
Isb	= Baseline Equipment Steam Mode Idle Energy Rate (Btu/hr)
Isq	= Qualifying Equipment Steam Mode Idle Energy Rate (Btu/hr)
Lbs	= Total Daily Food Production (lb/day)

[23] https://legiscan.com/NJ/bill/A5160/2020
[24] Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. Values for Tables 1 and 2 from Work Paper SWFS003-01, "Commercial Steam/Convection Combination Oven," Revision 1, 2018.

P	= Number of Preheats per Day
Pans	= Number of pans
PCcb	= Baseline Equipment Convection Mode Production Capacity (lb/hr)
PCcq	= Qualifying Equipment Convection Mode Production Capacity (lb/hr)
PCsb	= Baseline Equipment Steam Mode Production Capacity (lb/hr)
PCsq	= Qualifying Equipment Steam Mode Production Capacity (lb/hr)
PEb	= Baseline Equipment Preheat Energy (Btu)
PEq	= Qualifying Equipment Preheat Energy (Btu)
Pt	= Preheat Duration (hr)
St	= Percentage of Time in Steam Mode

Summary of Inputs

Table 1: Electric Combination Oven/Steamers

Variable	*Baseline*			*Qualifying*		
	<15 pans	*15-28 pans*	*>28 pans*	*<15 pans*	*15-28 pans*	*>28 pans*
D – Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P – Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q – Preheat Energy (kWh)	3.0	3.75	5.63	1.50	2.00	3.00
I_b & I_q – Idle Energy Rate (kW)	0.080 x Pans + 0.4989	0.080 x Pans + 0.4989	0.080 x Pans + 0.4989	Application	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t – Preheat Duration (hrs)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} – Convection mode Production Capacity (lbs/hr)	80	100	275	100	125	325
Lbs – Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t – Percentage of time in steam mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} – Steam mode Idle Energy Rate (kW)	0.133 x Pans + 0.64	0.133 x Pans + 0.64	0.133 x Pans + 0.64	Application	Application	Application
PC_{sb} & PC_{sq} – Steam mode Production Capacity (lbs/hr)	100	150	350	120	200	400
$Heat_c$ – Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} – Convection Mode Cooking Efficiency	76%	76%	76%	Application	Application	Application
C – Btu/kWh	3,412	3,412	3,412	3,412	3,412	3,412

$Heat_s$ – Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} – Steam Mode Cooking Efficiency	55%	55%	55%	Application	Application	Application

Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Oven Specifications Version 2.2.

Table 2: Gas Combination Oven/Steamers

Variable	*Baseline*			*Qualifying*		
	<15 pans	*15-28 pans*	*>28 pans*	*<15 pans*	*15-28 pans*	*>28 pans*
D – Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P – Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q – Preheat Energy (Btu)	3.0	3.75	5.63	1.50	2.00	3.00
I_b & I_q – Idle Energy Rate (Btu/hr)	150 x Pans + 5,425	150 x Pans + 5,425	150 x Pans + 5,425	Application	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} – Convection mode Production Capacity (lbs/hr)	80	100	275	100	125	325
Lbs – Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t – Percentage of time in steam mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} – Steam mode Idle Energy Rate (Btu/hr)	200 x Pans + 6,511	200 x Pans + 6,511	200 x Pans + 6,511	Application	Application	Application
PC_{sb} & PC_{sq} – Steam mode Production Capacity (lbs/hr)	100	150	350	120	200	400
$Heat_c$ – Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} – Convection Mode Cooking Efficiency	56%	56%	56%	Application	Application	Application
C – Btu/Therm	3,412	3,412	3,412	3,412	3,412	3,412
$Heat_s$ – Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} – Steam Mode Cooking Efficiency	41%	41%	41%	Application	Application	Application

Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Oven Specifications Version 2.2.

Table 3: Operating Days/Hours by Building Type		
Building Type	**Days/Year**	**Hours/Day**
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

15. Electric and Gas Convection Ovens, Gas Conveyor and Rack Ovens, Steamers, Fryers, and Griddles

The measurement of energy savings for these measures are based on algorithms with key variables provided by manufacturer data or prescribed herein. The baseline idle energy and cooking efficiency is compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial Oven Version 2.2 as the baseline for electric and gas convection ovens and gas rack ovens, Energy Star Program Requirements for Commercial Fryers Version 2.0 as the baseline for electric and gas fryers and Energy Star Program Requirements for Commercial Steam Cookers, Version 1.2 as the baseline for electric and gas steamers.[25] Compliance with this standard shall commence on January 1, 2023.

Algorithms

Energy Savings (kWh/yr or Therms/yr) = $D * (E_p + E_i + E_c)$
Peak Demand Savings (kW) = kWh Savings / $(D * H)$
Preheat Savings†: $E_p = P * (PE_b - PE_q)$
Idle Savings†: $E_i = (I_b - I_q) * (H - P*P_t) - (I_b/PC_b - I_q/PC_q) * Lbs$
Cooking Savings: $E_c = Lbs * Heat * (1/Eff_b - 1/Eff_q) / C$

† – For gas equipment, convert these intermediate values to therms by dividing the result by 100,000 Btu/therm

Definition of Variables (See tables of values below for more information)[26]

D	= Operating Days per Year
P	= Number of Preheats per Day
PE_b	= Baseline Equipment Preheat Energy (kWh or Btu – see Tables below)
PE_q	= Qualifying Equipment Preheat Energy (kWh or Btu – see Tables below)
I_b	= Baseline Equipment Idle Energy Rate (kW or Btu/hr – see Tables below)
I_q	= Qualifying Equipment Idle Energy Rate (kW or Btu/hr – see Tables below)
H	= Daily Operating Hours (hr)
P_t	= Preheat Duration (hr)
PC_b	= Baseline Equipment Production Capacity (lb/hr)
PC_q	= Qualifying Equipment Production Capacity (lb/hr)
Lbs	= Total Daily Food Production (lb)
Heat	= Heat to Food (Btu/lb)
Eff_b	= Baseline Equipment Convection Mode Cooking Efficiency (fraction)
Eff_q	= Qualifying Equipment Convection Mode Cooking Efficiency (fraction)
C	= Conversion Factor from Btu to kWh or Therms

[25] https://legiscan.com/NJ/bill/A5160/2020.
[26] Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. Work Paper citations under respective equipment tables.

Summary of Inputs

Table 1: Electric Convection Oven

Variable	*Baseline*		*Qualifying*	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D – Operating Days per Year	Table 3	Table 3	Table 3	Table 3
P – Number of Preheats per Day	1	1	1	1
PE_b & PE_q – Preheat Energy (kWh)	1.5	1.0	1.0	0.90
I_b & I_q – Idle Energy Rate (kW)	1.6	1.0	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	70	45	82	53
Lbs – Total Daily Food Production (lbs)	100	100	100	100
Heat – Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Effq – Heavy Load Cooking Efficiency	71%	71%	Application	Application
C – Btu/kWh	3,412	3,412	3,412	3,412

Source: PGECOFST101 R6, “Commercial Convection Oven – Electric and Gas,” 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Oven Specifications Version 2.2

Table 2: Gas Convection Oven[27]

Variable	*Baseline*		*Qualifying*	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D – Operating Days per Year	Table 3	Table 3	Table 3	Table 3
P – Number of Preheats per Day	1	1	1	1
PE_b & PE_q – Preheat Energy (Btu)	19,000	13,000	11,000	7,500
I_b & I_q – Idle Energy Rate (Btu/hr)	12,000	12,000	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	70	45	82	53
Lbs – Total Daily Food Production (lbs)	100	100	100	100
Heat – Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Effq – Heavy Load Cooking Efficiency	46%	30%	Application	Application
C – Btu/Therm	100,000	100,000	100,000	100,000

Source: PGECOFST101 R6, “Commercial Convection Oven – Electric and Gas,” 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Oven Specifications Version 2.2

27 Energy Star Oven Specifications Version 2.2 excludes half size gas convection ovens.

Table 3: Gas Conveyor Ovens		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (Btu)	21,270	15,000
Ib & Iq - Idle Energy Rate (Btu/hr)	55,000	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	114	158
Lbs - Total Daily Food Production (lbs)	190	190
Heat - Heat to Food (Btu/lb)	250	250
Effb & Effq - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Source: SWFS008-01 R1, "Conveyor Oven, Gas, Commercial," 2019.
Note that Operating Days per Year and Operating Hours per Day can be found in Table 3.
Note: EnergyStar 2.2 excludes conveyor ovens. Baseline established in 2020 Protocols used.

Table 4: Gas Rack Oven

Variable	*Baseline*		*Qualifying*	
	Double Rack	*Single Rack*	*Double Rack*	*Single Rack*
D – Operating Days per Year	Table 3	Table 3	Table 3	Table 3
P – Number of Preheats per Day	1	1	1	1
PE_b & PE_q – Preheat Energy (Btu)	100,000	50,000	85,000	44,000
I_b & I_q – Idle Energy Rate (Btu/hr)	30,000	25,000	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.33	0.33	0.33	0.33
PC_b & PC_q – Production Capacity (lbs/hr)	250	130	280	140
Lbs – Total Daily Food Production (lbs)	1200	600	1200	600
Heat – Heat to Food (Btu/lb)	235	235	235	235
Eff_b & Effq – Heavy Load Cooking Efficiency	52%	48%	Application	Application
C – Btu/Therm	100,000	100,000	100,000	100,000

Source: PGECOFST109, "Commercial Rack Oven– Gas," 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Oven Specifications Version 2.2

Table 5: Electric Steamers

Variable	*Baseline*	*Qualifying*
D – Operating Days per Year	Table 3	Table 3
P – Number of Preheats per Day	1	1
PE_b & PE_q – Preheat Energy (kWh)	1.5	1.5
I_b & I_q – Idle Energy Rate (kW)	3-pan: 0.4 4-pan: 0.53 5-pan: 0.67 6-pan and larger: 0.8	Application
H – Operating Hours per Day	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	11.7*No. of Pans	14.7*No. of Pans
Lbs – Total Daily Food Production (lbs)	100	100
Heat – Heat to Food (Btu/lb)	105	105
Eff_b & Effq – Heavy Load Cooking Efficiency	50%	Application
C – Btu/kWh	3,412	3,412

Source: PGECOFST104 R6, “Commercial Steam Cooker – Electric and Gas,” 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Steam Cooker Specifications Version 1.2

Table 6: Gas Steamers

Variable	*Baseline*	*Qualifying*
D – Operating Days per Year	Table 3	Table 3
P – Number of Preheats per Day	1	1
PE_b & PE_q – Preheat Energy (Btu)	20,000	9,000
I_b & I_q – Idle Energy Rate (Btu/hr)	3-pan: 6,250 4-pan: 8,350 5-pan: 10,400 6-pan and larger: 12,500	Application
H – Operating Hours per Day	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	23.3*No. of Pans	20.8*No. of Pans
Lbs – Total Daily Food Production (lbs)	100	100
Heat – Heat to Food (Btu/lb)	105	105
Eff_b & Effq – Heavy Load Cooking Efficiency	38%	Application
C – Btu/Therm	100,000	100,000

Source: PGECOFST104 R6, “Commercial Steam Cooker – Electric and Gas,” 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Steam Cooker Specifications Version 1.2.

Table 7: Electric Fryers

Variable	*Baseline*	*Qualifying*
D – Operating Days per Year	Table 3	Table 3
P – Number of Preheats per Day	1	1
PE_b & PE_q – Preheat Energy (kWh)	2.4	1.9
I_b & I_q – Idle Energy Rate (kW)	1.0	Application
H – Operating Hours per Day	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	65	71
Lbs – Total Daily Food Production (lbs)	150	150
Heat – Heat to Food (Btu/lb)	570	570
Eff_b & Effq – Heavy Load Cooking Efficiency	80%	Application
C – Btu/kWh	3,412	3,412

Source: PGECOFST102 R6, “Commercial Fryer – Electric and Gas,” 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Fryer Specifications Version 2.0.

Table 8: Gas Fryers

Variable	*Baseline*	*Qualifying*
D – Operating Days per Year	Table 3	Table 3
P – Number of Preheats per Day	1	1
PE_b & PE_q – Preheat Energy (Btu)	18,500	16,000
I_b & I_q – Idle Energy Rate (Btu/hr)	9000	Application
H – Operating Hours per Day	Table 3	Table 3
P_t – Preheat Duaration (hrs)	0.25	0.25
PC_b & PC_q – Production Capacity (lbs/hr)	60	67

Variable	Baseline	Qualifying
Lbs – Total Daily Food Production (lbs)	150	150
Heat – Heat to Food (Btu/lb)	570	570
Eff_b & Effq – Heavy Load Cooking Efficiency	50%	Application
C – Btu/Therm	100,000	100,000

Source: PGECOFST102 R6, "Commercial Fryer – Electric and Gas," 2016.
Note: Baseline Idle Energy Rate and Cooking Efficiency are from Energy Star Fryer Specifications Version 2.0.

Table 9: Electric Griddles

Variable	Baseline	Qualifying
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (kWh)	1.3 x Griddle Width (ft)	0.7 x Griddle Width (ft)
Ib & Iq - Idle Energy Rate (kW)	0.8 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	11.7 x Griddle Width (ft)	16.3 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Effb & Effq - Heavy Load Cooking Efficiency	60%	Application
C - Btu/kWh	3,412	3,412

Source: SWFS004-01 R1, "Commercial Griddle – Electric & Gas," 2018.
Note that Operating Days per Year and Operating Hours per Day can be found in Table 3.
Griddles not addressed in New Jersey P.L. 2021, c. 464. Baseline from 2020 Protocols used.

Table 10: Gas Griddle s

Variable	Baseline	Qualifying
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (Btu)	7,000 x Griddle Width (ft)	5,000 x Griddle Width (ft)
Ib & Iq - Idle Energy Rate (Btu/h)	7,000 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	8.4 x Griddle Width (ft)	16.4 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Effb & Effq - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Source: SWFS004-01 R1, "Commercial Griddle – Electric & Gas," 2018.
Note that Operating Days per Year and Operating Hours per Day can be found in Table 3.
Note: Griddles not addressed in New Jersey P.L. 2021, c. 464. Baseline from 2020 Protocols used.

16. Insulated Food Holding Cabinets

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein. The baseline idle energy is compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial Hot Food Holding Cabinets Version 2.0 as the baseline for electric insulated food holding cabinets. Compliance with this standard shall commence on January 1, 2023.

<u>Algorithms</u>

Energy Savings (kWh/yr) = $D * H * (I_b – I_q)$

Peak Demand Savings (kW) = $I_b – I_q$

<u>Definition of Variables</u>
<u>(See tables of values below for more information)</u>[28]

D = Operating Days per Year

H = Daily Operating Hours

I_b = Baseline Equipment Idle Energy Rate (Watt)

I_q = Qualifying Equipment Idle Energy Rate (Watt)

V = Interior Volume (cubic feet)

<u>Summary of Inputs</u>

Table 11: Insulated Food Holding Cabinets

Variable	*Baseline*			*Qualifying*		
	Full Size (28 <=V)	*¾ Size (13 <= V < 28*	*Half Size (<=21.5V)*	*Full Size*	*¾ Size*	*Half Size*
D – Operating Days per Year	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2
I_b & I_q – Idle Energy Rate (W)	<=3.8V + 203.5	<=2.0V + 254	<=3.8V + 203.5	Application	Application	Application
H – Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3

Note: Baseline Idle Energy from Energy Star Program Requirements for Commercial Hot Food Holding Cabinets Version 2.0.

[28] Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

17. Commercial Dishwashers

This measure is applicable to replacement of existing dishwashers with energy efficient under counter, door type, single-rack and multi-rack conveyor machines testing in accordance with NSF/ANSI 3-2007, ASTM F1696, and ASTM F1920 standards. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein. The baseline idle energy and water consumption specifications are compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial dishwashers Version 2.0 as the baseline for High Temp and Low Temp commercial dishwashers. Compliance with this standard shall commence on January 1, 2023.

Electric energy savings are composed of three parts: electric energy savings from the building water heater, electric energy savings from the booster water heater, and idle electric energy savings. Note that if a building only has a natural gas water heater, then there will still be savings from reduction in idle energy. Note: Depending on water heating system configuration (e.g. gas building water heater with electric booster water heater), annual energy savings may be reported in both therms and kWh.

Algorithms

$$\Delta kWh = \Delta kWh_{WaterHeater} + \Delta kWh_{BoosterHeater} + \Delta kWh_{Idle}$$

$$\Delta kWh_{WaterHeater} = \left((WU_{base} - WU_{ee}) \times RW \times Days\right) \times \frac{\Delta T_{in} \times 1.0 \frac{Btu}{lb \cdot °F} \times 8.2 \frac{lb}{gal}}{RE \times 3{,}412 \frac{Btu}{kWh}}$$

$$\Delta kWh_{BoosterHeater} = \left((WU_{base} - WU_{ee}) \times RW \times Days\right) \times \frac{\Delta T_{in} \times 1.0 \frac{Btu}{lb \cdot °F} \times 8.2 \frac{lb}{gal}}{RE \times 3{,}412 \frac{Btu}{kW}}$$

$$kWh_{Idle} = \left(kW_{base} \times Days \times (HD - RW \times WT/60 \tfrac{Min}{Hr}\right) - \left(kW_{ee} \times Days \times (HD - \frac{(RW \times WT)}{60 \frac{Min}{Hr}}\right)$$

$$\Delta kW_{peak} = \frac{\Delta kW}{HD \times Days} \times CF$$

$$\Delta therm_{WaterHeater} = \left((WU_{base} - WU_{ee}) \times RW \times Days\right) \times \frac{\Delta T_{in} \times 1.0 \frac{Btu}{lb \cdot °F} \times 8.2 \frac{lb}{gal}}{RE \times 100{,}000 \frac{Btu}{therm}}$$

Terms, Values, and References for ENERGY STAR Commercial Dishwashers

Term	Unit	Values	Source
WU_{base}, Water use per rack of baseline dishwasher, varies by machine type and sanitation method	*Gallons*	Table 12	1
WU_{ee}, Water use per rack of ENERGY STAR dishwasher, varies by machine type and sanitation method	*Gallons*	Application	
RW, Number of racks washed per day, varies by machine type and sanitation method	$\frac{Racks\ Washed}{Day}$	Table 12	2

Term	Unit	Values	Source
$Days$, Annual days of dishwasher consumption per year	$\frac{Days}{Year}$	Application. Use default value of 365 if unknown	2
ΔT_{in}, Temperature rise in water delivered by building water heater or booster water heater, value varies by type of water heater source	°F	Building WH = 70 Booster WH = 40	2
RE, Recovery efficiency of water heater	Decimal	0.98 (electric) 0.75(gas)	2
kW_{base}, Idle power draw of baseline dishwasher, varies by machine type and sanitation method	*kW*	Table 12	1
HD, Hours per day of dishwasher operation	$\frac{Hours}{Day}$	Table 12	2
WT, Wash time per dishwasher, varies by machine type and sanitation method	*Minutes*	Table 12	2
kW_{ee}, Idle power draw of ENERGY STAR dishwasher, varies by machine type and sanitation method	*kW*	Application	
Density of Water	*lb/gallon*	8.207	3
CF, Coincidence factor	*None*	0.9	4

Table 12 shows the default values for water user per rack, racks washed per day, wash time per dishwasher, and idle power draws by machine type and sanitation method.

Table 12 : Default Inputs for ENERGY STAR Commercial Dishwasher

Machine Type	Temperature	WU_{base}	RW	WT	kW_{base}
Under Counter	Low	1.19	75	2.0	0.50
Stationary Single Tank Door		1.18	280	1.5	0.60
Single Tank Conveyor		0.79	400	0.3	1.50
Multi Tank Conveyor		0.54	600	0.3	2.00
Pot, Pan, and Utensil		0.58	280	3.0	1.00
Under Counter	High	0.86	75	2.0	0.5
Stationary Single Tank Door		0.89	280	1.0	0.7
Single Tank Conveyor		0.70	400	0.3	1.5
Multi Tank Conveyor		0.54	600	0.2	2.25
Pot, Pan, and Utensil		0.58	280	3.0	1.20

Sources

1) ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers Eligibility Criteria Version 2.0, effective February 1, 2013 https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers/key_product_criteria.

2) ENERGY STAR, Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment. http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx.

3) Dishwasher inlet temperature assumed at 140 degrees F. https://water.usgs.gov/edu/density.html.

4) New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs v6, effective date January 1, 2019.

Appendix A – Measure Lives

Measure	Measure Life (Years)
Residential Sector	
Lighting End Use	
LED	4[29]
Commercial Sector	
Lighting End Use	
Performance Lighting	8[30]
Prescriptive Lighting	8[31]

[29] Adjusted Measure Life (AML) for LED lamps and fixtures. Consensus value based on analysis conducted in Maryland. Reference: Recommended Estimated Useful Life Assumptions for the EmPOWER Upstream Lighting Programs, Joint Recommendation, PSC Staff, PSC Independent Evaluator, Office of Peoples Counsel, Maryland Energy Administration and EmPOWER Electric Utilities, Case No. 9648.

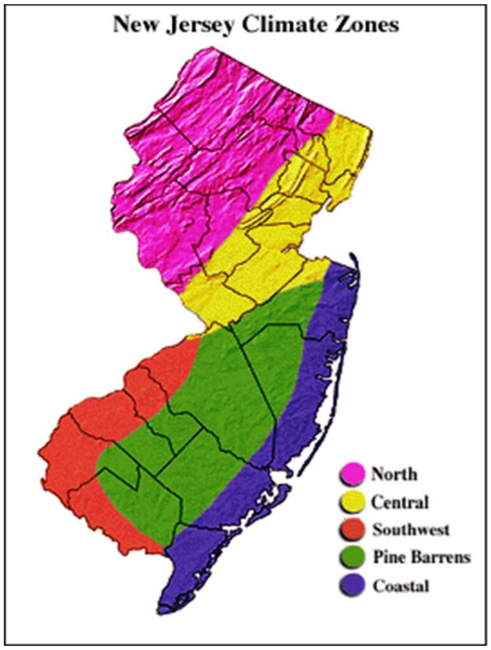
[30] AML for commercial lighting. Consensus value based on research conducted in Connecticut and Massachusetts. Reference: Massachusetts C&I Adjusted Measure Lives for PY2021 and PY2022, Prepared by Geoffrey Cooper, 7/6/2021 and Connecticut C2014 C&I Lighting Saturation and Remaining Potential – Phase One Results and Recommendations, Prepared by Geoff Cooper, Christopher Dyson, and Sue Haselhorst,, 6/15/2021.

[31] Ibid.

Appendix B. Commercial and Multifamily Building Cooling and Heating Equivalent Full Load Hours

Cooling and heating equivalent full load hours derived from building energy simulations of prototypical building models are presented in this Appendix. The prototypical building models were taken from the New York TRM and run with New Jersey specific climate files. See Appendix C for more information about the prototypical models.

The Office of the State Climatologist divides the state into five climate regions as shown below[32]:



A representative city from the TMY3 long term average weather data set was assigned to each of the climate zones[33]. A population weight derived from 2020 Census data was assigned to each of the climate zones to compute a Statewide weighted average value as shown below[34]:

NJ Climate Division	Representative City	Population Weight
Northern Zone	Allentown PA	0.17
Central Zone	Trenton	0.45
Pine Barrens Zone	McGuire AFB	0.11
Southwest Zone	Philadelphia PA	0.11
Coastal Zone	Atlantic City	0.16

[32] https://climate.rutgers.edu/stateclim/
[33] https://www.nrel.gov/docs/fy08osti/43156.pdf
[34] https://www.census.gov/library/stories/state-by-state/new-jersey-population-change-between-census-decade.html

Please note all utilities should use weighted average value for EFLH.

The cooling and heating full load hours are provided by building type. A description of each building type is shown in the table below. The primary distinction between small and large buildings is the number of floors and HVAC system type rather than a specific conditioned floor area criterion. Small buildings in this study utilize packaged or split unitary system HVAC systems or packaged terminal air conditioners (PTAC). Large buildings use built-up HVAC systems with chillers and boilers.

Building Type	*Description*
Assembly	Public buildings that include community centers, libraries, performance and movie theaters, auditoria, police and fire stations, gymnasia, sports arenas, and transportation terminals
Auto	Repair shops and auto dealerships, including parking lots and parking structures.
Big Box	Single story, high-bay retail stores with ceiling heights of 25 feet or more. Majority of floor space is dedicated to non-food items, but could include refrigerated andnon-refrigerated food sales areas.
Community College	Community college campus and post-secondary technical and vocational education buildings, including classroom, computer labs, dining and office. Conditioned by packaged HVAC systems
Dormitory	College or University dormitories
Fast Food	Self-service restaurants with primarily disposable plates, utensils etc.
Full Service Restaurant	Full service restaurants with full dishwashing facilities
Grocery	Refrigerated and non-refrigerated food sales, including convenience stores and specialty food sales
Heavy Industrial	Single or multistory buildings containing industrial processes including pumpstations, water and wastewater treatment plants; may be conditioned or unconditioned.
Hospital	Inpatient and outpatient care facility conditioned by built-up HVAC systems.Excludes medical offices
Hotel	Multifunction lodging facility with guest rooms, meeting space, foodservice conditioned by built-up HVAC system
Large Office	Office space in buildings greater than 3 stories conditioned by built-up HVACsystem.
Light Industrial	Single story work space with heating and air-conditioning; conditioned by packagedHVAC systems.
Multi-family high-rise	Multi-family building with more than 3 stories conditioned by built up HVACsystem
Multi-family low-rise	Multi-family building with 3 stories or less conditioned by packaged HVAC system
Motel	Lodging facilities with primarily guest room space served by packaged HVACsystems
Multi Story Retail	Retail building with 2 or more stories served by built-up HVAC system
Primary School	K-8 school

Building Type	*Description*
Religious	Religious worship
Secondary School	9-12 school
Single-family residential	Single-family detached residences
Small Office	Office occupancy in buildings 3 stories or less served by packaged HVAC systems;includes Medical offices
Small Retail	Single story retail with ceiling height of less than 25 feet; primarily non-food retail and storage areas served by packaged HVAC systems. Includes service businesses,post offices, Laundromats, and exercise facilities.
University	University campus buildings, including classroom, computer labs, biological and/orchemical labs, workshop space, dining and office. Conditioned by built-up HVAC systems
Warehouse	Primarily non-refrigerated storage space could include attached offices served bypackaged HVAC system.

Other building types not included above can be matched to the standard building types as shown below:

Building Type	**Best Match**
Agricultural	Light industrial
Funeral home	Small retail
Police and fire stations	Public assembly
Courthouse	Large office
Detention facility	Multifamily highrise
Municipal airport	Assembly
Nursing home	Hospital
Kennel	Small retail

Note: for commercial buildings that cannot be reasonably associated with one the building types above,savings values for the “other” category should be used.

Small Commercial Building (3 stories or less) Cooling Equivalent Full Load Hours

Facility Type	HVAC Type	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Assembly	Packaged or split unitary system	608	742	690	680	654	693
Auto repair	Packaged or split unitary system	375	486	468	479	408	452
Light industrial	Packaged or split unitary system	481	548	496	574	485	523
Lodging – Motel	Packaged Terminal AC	947	1,023	1,065	1,063	1,039	1,022
Office – small	Packaged or split unitary system	842	931	883	941	880	904
Other	Packaged or split unitary system	707	793	766	786	741	766
Religious worship	Packaged or split unitary system	304	326	353	322	309	322
Restaurant – fast food	Packaged or split unitary system	553	695	631	670	608	647
Restaurant – full service	Packaged or split unitary system	533	660	602	625	573	614
Retail – big box	Packaged or split unitary system	923	1,031	996	1,006	967	996
Retail – Grocery	Packaged or split unitary system	2,100	2,058	1,994	2,036	1,994	2,045
Retail – small	Packaged or split unitary system	846	929	899	931	873	903
School – primary	Packaged or split unitary system	332	398	410	443	369	388
Warehouse	Packaged or split unitary system	324	393	357	392	327	367

Small Commercial Building (3 stories or less) Heating Equivalent Full Load Hours

Facility Type	HVAC Type	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Assembly	Packaged or split unitary system	775	666	653	703	796	708
Auto repair	Packaged or split unitary system	2,387	2,056	2,081	2,090	2,140	2,132
Light industrial	Packaged or split unitary system	1,044	776	768	865	927	854
Lodging – Motel	Packaged Terminal AC	521	404	415	407	478	437
Office – small	Packaged or split unitary system	586	407	427	405	472	449
Other	Packaged or split unitary system	914	749	741	785	852	796
Religious worship	Packaged or split unitary system	837	727	710	739	775	753
Restaurant – fast food	Packaged or split unitary system	1,098	894	863	958	1,056	958
Restaurant – full service	Packaged or split unitary system	1,095	904	885	953	1,061	964
Retail – big box	Packaged or split unitary system	430	345	332	358	398	368
Retail – Grocery	Packaged or split unitary system	1,022	913	861	997	1,140	971
Retail – small	Packaged or split unitary system	765	581	580	604	655	626
School – primary	Packaged or split unitary system	1,060	873	850	945	1,019	933
Warehouse	Packaged or split unitary system	602	486	483	501	505	510

Large Commercial Building (More than 3 Stories) Cooling Equivalent Full Load Hours

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Dormitory	Fan coil	736	880	874	842	886	852
School – Community college	CV econ	708	826	877	859	804	812
	CV noecon	988	1,108	1,132	1,124	1,088	1,089
	VAV	560	569	674	699	586	596
	Unknown	649	692	776	790	697	706
School – secondary	CV econ	424	499	502	487	475	482
	CV noecon	824	899	870	873	879	877
	VAV	300	369	396	369	353	358
	Unknown	400	471	486	465	453	457
Hospital	CV econ	1,229	1,433	1,380	1,405	1,374	1,380
	CV noecon	2,167	2,306	2,230	2,209	2,222	2,250
	VAV	1,035	1,214	1,170	1,195	1,167	1,169
	Unknown	1,141	1,319	1,271	1,293	1,268	1,273
Hotel	CV econ	2,836	2,881	2,909	2,930	2,908	2,886
	CV noecon	3,028	3,065	3,092	3,113	3,100	3,072
	VAV	2,871	2,897	2,883	2,915	2,894	2,892
	Unknown	2,932	2,973	3,000	3,021	3,004	2,979
Large Office	CV econ	648	727	725	725	698	708
	CV noecon	2,223	2,265	2,230	2,235	2,246	2,248
	VAV	634	725	689	708	675	696
	Unknown	746	833	799	816	786	805
Large Retail	CV econ	1,006	1,167	1,157	1,130	1,107	1,125
	CV noecon	1,754	1,876	1,836	1,807	1,846	1,839
	VAV	832	993	972	946	940	950
	Unknown	920	1,077	1,056	1,029	1,026	1,035
School – postsecondary	CV econ	855	872	844	921	934	881
	CV noecon	1,118	1,159	1,153	1,136	1,225	1,160
	VAV	567	667	649	620	607	634
	Unknown	697	775	757	747	753	753
Other	CV econ	1,101	1,201	1,199	1,208	1,186	1,182
	CV noecon	1,729	1,811	1,792	1,785	1,801	1,791
	VAV	971	1,062	1,062	1,065	1,032	1,042
	Unknown	1,069	1,163	1,164	1,166	1,141	1,144

Large Commercial Building (More than 3 stories) Heating Equivalent Full Load Hours

Building Type	HVAC System	Northern	Central	Pine Barrens	Southwest	Coastal	Wt Average
Dormitory	Fan coil	577	452	471	463	504	485
School – Community college	CV econ	1,501	1,371	1,383	1,485	1,358	1,404
	CV noecon	1,340	1,214	1,244	1,343	1,218	1,253
	VAV	481	390	335	509	378	410
	Unknown	772	670	638	789	660	694
School – secondary	CV econ	968	949	918	887	1,000	950
	CV noecon	907	868	844	832	914	875
	VAV	363	254	271	309	327	292
	Unknown	541	457	460	480	522	484
Hospital	CV econ	4,530	3,702	4,009	3,951	4,180	3,980
	CV noecon	4,725	4,103	4,305	3,711	3,904	4,157
	VAV	531	374	373	412	449	416
	Unknown	1,186	938	979	959	1,024	1,001
Hotel	CV econ	1,087	963	974	1,052	1,362	1,059
	CV noecon	832	713	730	772	992	786
	VAV	342	272	294	263	342	297
	Unknown	959	838	852	912	1,177	923
Large Office	CV econ	2,270	2,087	2,128	1,989	2,233	2,136
	CV noecon	2,301	2,101	2,141	1,999	2,278	2,157
	VAV	416	366	376	277	418	375
	Unknown	677	608	623	517	675	623
Large Retail	CV econ	2,083	2,031	2,030	2,047	2,134	2,058
	CV noecon	1,997	1,955	1,971	1,991	2,090	1,989
	VAV	726	645	632	648	787	681
	Unknown	936	861	851	867	999	895
School – postsecondary	CV econ	1,368	1,247	1,170	1,174	1,210	1,245
	CV noecon	1,314	1,108	1,070	1,081	1,086	1,132
	VAV	523	705	356	782	390	592
	Unknown	776	851	593	889	625	777
Other	CV econ	1,972	1,764	1,802	1,798	1,925	1,833
	CV noecon	1,917	1,723	1,758	1,676	1,783	1,764
	VAV	483	429	377	457	442	438
	Unknown	835	746	714	773	812	771

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Cooling	507	550	562
Low-rise, Heating	757	723	503
High-rise, Cooling	793	843	954
High-rise, Heating	526	395	219

Appendix C. COMMERCIAL BUILDING PROTOTYPES

BUILDING TYPES

Analysis used to develop heating and cooling equivalent full load hours is based on DOE-2.2 simulations of a set of prototypical small and large buildings. The prototypical simulation models were derived from the commercial building prototypes used in the CaliforniaDatabase for Energy Efficiency Resources (DEER) study, with adjustments made for local building practices and climate.[35] The simulations were driven using Typical Meteorological Year (TMY3) long-term average weather data.[36]

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[35] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December 2005. Available at www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf.

[36] See: Wilcox and Marion, "Users Manual for TMY3 Data Sets," NREL/TP-581-43156, National Renewable Energy Lab, May 2008. https://www.nrel.gov/docs/fy08osti/43156.pdf

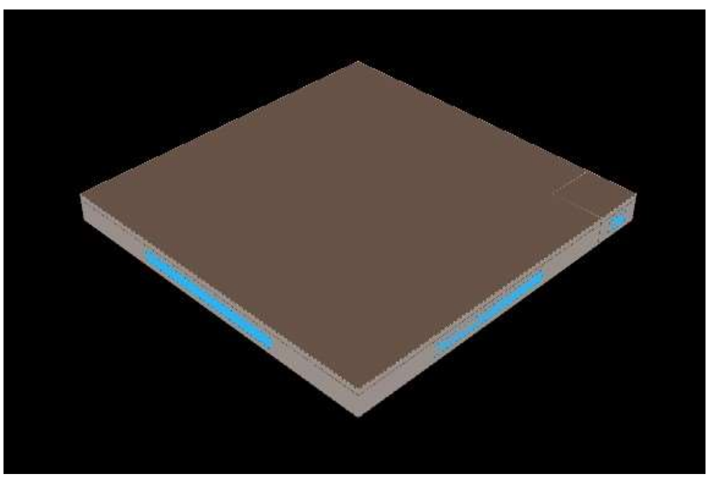
Assembly

A prototypical building energy simulation model for an assembly building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 °F cooling, 72 °F heating Unoccupied hours: 79 °F cooling, 69 °F heating

A computer-generated sketch of the Assembly Building prototype is shown below.



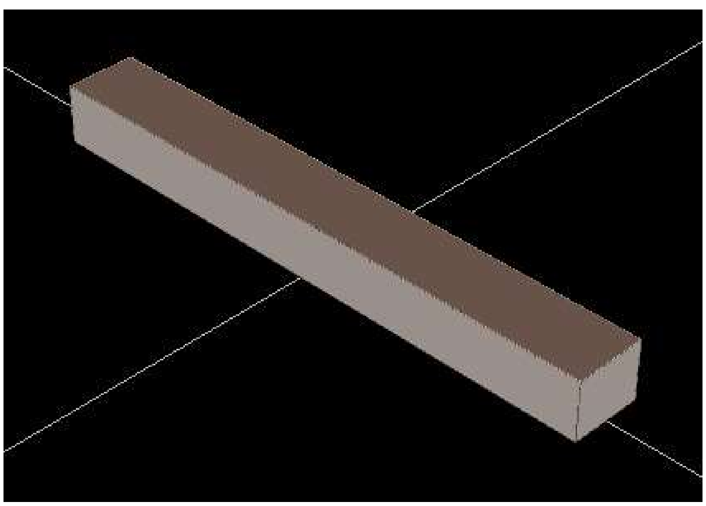
Auto Repair

A prototypical building energy simulation model for an auto repair building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 = ,74U-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 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Auto Repair Building prototype is shown below.



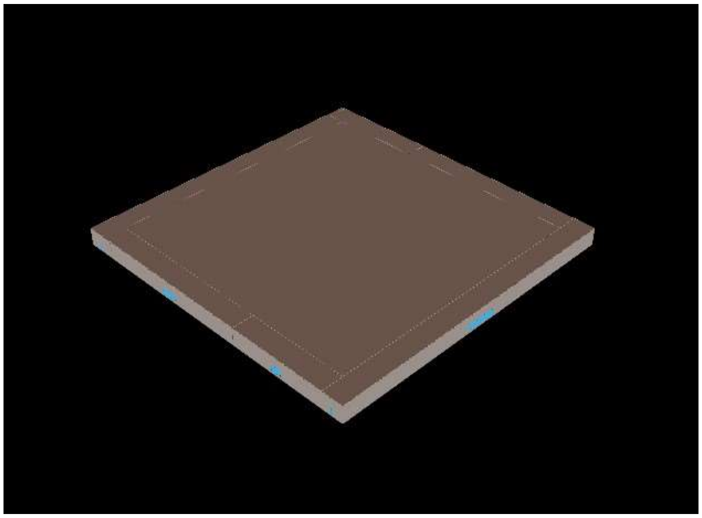
Big Box Retail

A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarizedbelow.

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 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Big Box Building prototype is shown below.



Community College

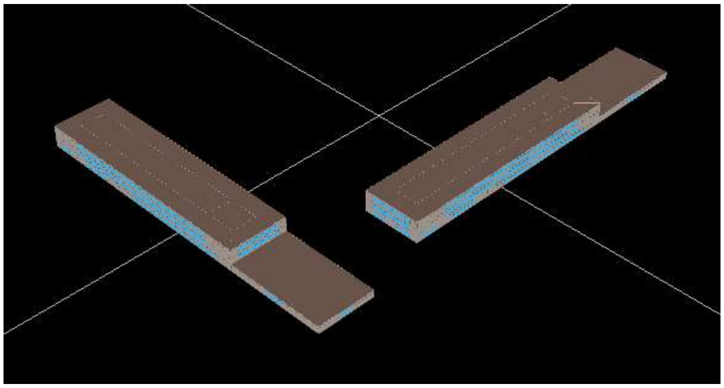
A prototypical building energy simulation model for a community college was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really two identical buildings oriented 90 degreesapart. The characteristics of the prototype are summarized below.

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

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each mea

A computer-generated sketch of the Community College Building prototype is shown below.



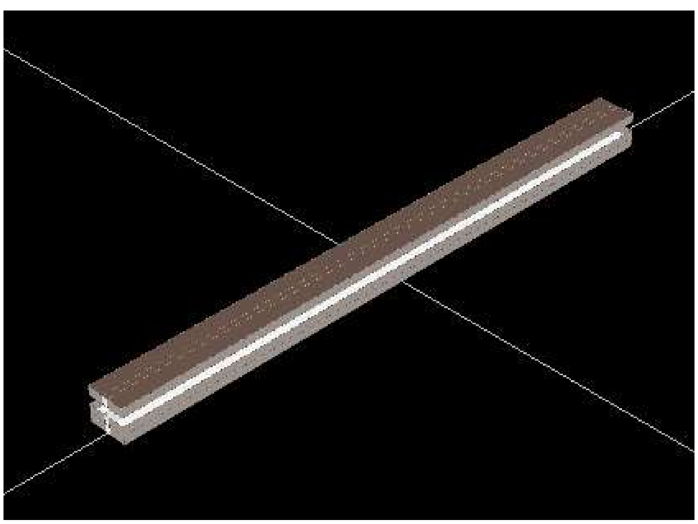
Dormitory

A prototypical building energy simulation model for a university dormitory was developed usingthe DOE-2.2 building energy simulation program. The dormitory building was extracted from the DEER university prototype and modeled separately. The model consists of two identical buildings oriented 90 degrees apart. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 W/SF
Plug load density	Rooms: 0.6 W/SF Corridors and common space: 0.2 W/SF
Operating hours	24/7 – 365 days
HVAC system type	Fan coils with centrifugal chiller and hot water boiler
HVAC system size	800 SF/ton
Thermostat set points	Daytime hours: 76 ºF cooling, 72 ºF heating Night setback hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Dormitory Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and theresults are multiplied by 2 to represent the energy consumption of the 2 middle floors.

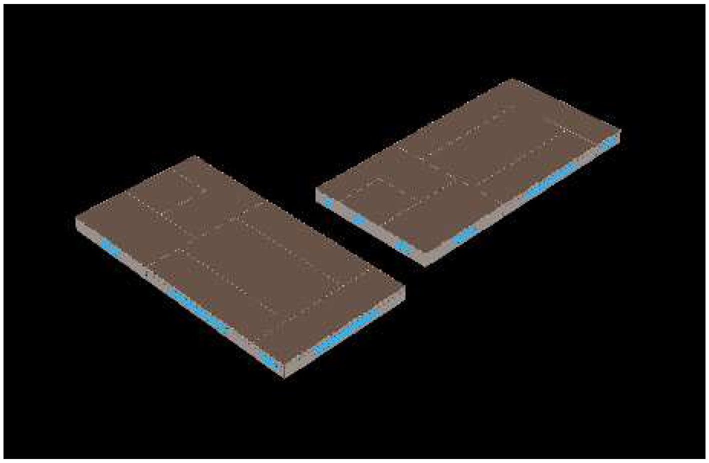
Elementary School

A prototypical building energy simulation model for an elementary school was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized below.

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 °F cooling, 72 °F heating Unoccupied hours: 79 °F cooling, 69 °F heating

A computer-generated sketch of the Elementary School Building prototype is shown below.



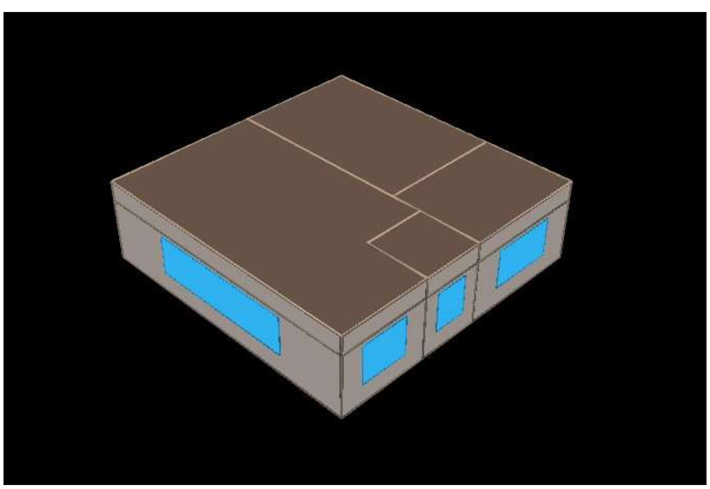
Fast Food Restaurant

A prototypical building energy simulation model for a fast food restaurant was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 °F cooling, 72 °F heating Unoccupied hours: 80 °F cooling, 69 °F heating

A computer-generated sketch of the Fast Food Building prototype is shown below.



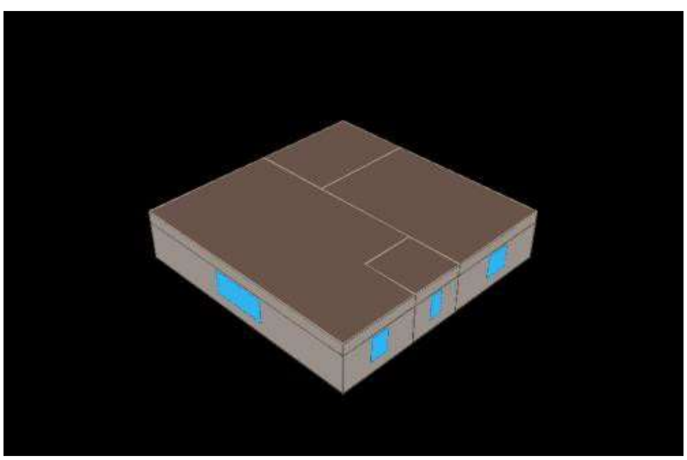
Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developedusing the DOE-2.2 building energy simulation program. The simulations were driven usingTMY3 long-term average weather data. The characteristics of the full service restaurant prototype are summarized below.

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 ºF cooling, 72 ºF heating Unoccupied hours: 80 ºF cooling, 69 ºF heating

A computer-generated sketch of the Full-Service Restaurant Building prototype is shown below.



Grocery

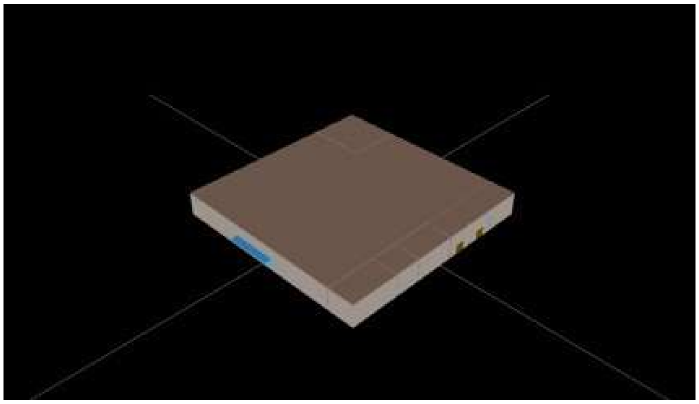
A prototypical building energy simulation model for a grocery building was developed using theDOE-2.2R[37] building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 50ºF prep area: 1,268 SF 35ºF walk-in cooler: 1,560 SF - 5ºF 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 50ºF prep area: 4.3 W/SF 35ºF walk-in cooler: 0.9 W/SF - 5ºF 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 50ºF prep area: 0.23 W/SF + 36 kBTU/h process load 35ºF walk-in cooler: 0.23 W/SF + 17 kBTU/h process load - 5ºF 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 (-20ºF suction temp): 23 compressor ton Medium temperature (18ºF 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: 74ºF cooling, 70ºF heating Unoccupied hours: 79ºF cooling, 65ºF heating

[37] DOE-2.2R is a specialized version of the DOE-2.2 program, designed specifically to model refrigeration systems.

A computer-generated sketch of the Grocery Building prototype is shown below.



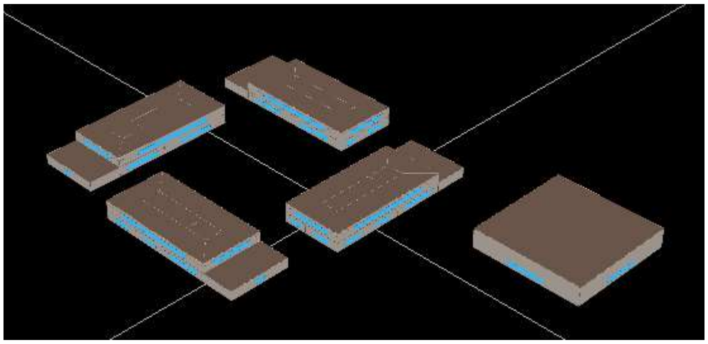
High School

A prototypical building energy simulation model for a high school was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really of four identical buildings oriented in four different directions, with a common gymnasium. The characteristics of the prototype are summarized below.

HIGH SCHOOL PROTOTYPE BUILDING DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	4 buildings, 25,000 square feet each; oriented 90º from each other Classroom: 88,200 SF Computer room: 3,082 SF Dining area: 22,500 SF Gymnasium: 22,500 SF Kitchen: 10,500 SF Office: 3,218 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 waterboiler.
HVAC system size	250 SF/ton
Thermostat set points	Occupied hours: 76ºF cooling, 72 ºF heating Unoccupied hours: 81ºF cooling, 67 ºF heating

A computer-generated sketch of the High School Building prototype is shown below.



Hospital

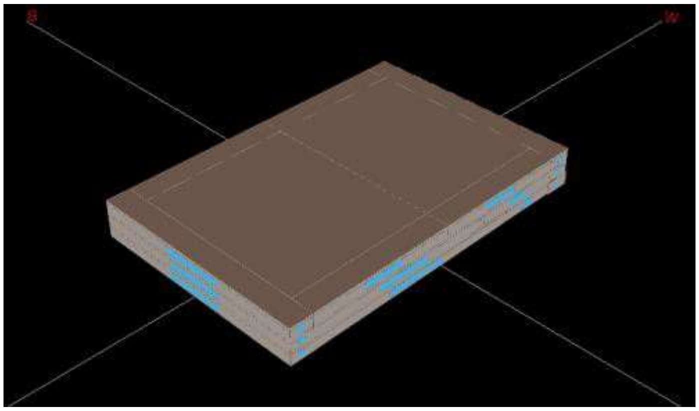
A prototypical building energy simulation model for a large hospital building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarizedbelow.

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 W/SF Dining: 1.7 W/SF Kitchen and food prep: 4.3 W/SF
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 W/SF Dining: 0.6 W/SF Kitchen and food prep: 4.6 W/SF
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-sizingassumed.
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 ºF 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, 180ºF set point
Thermostat set points	Occupied hours: 76ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Hospital Building prototype is shown below.



Hotel

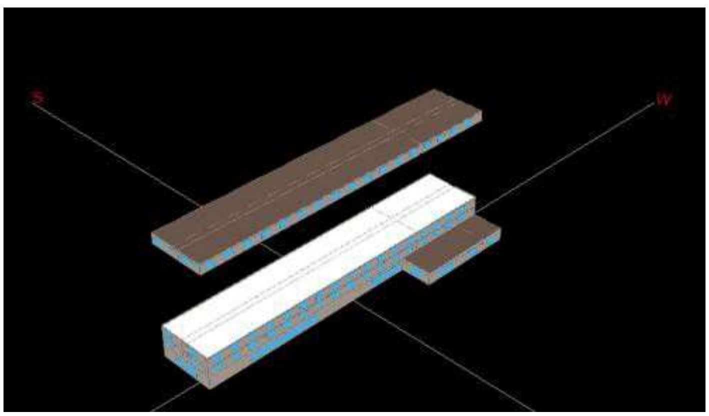
A prototypical building energy simulation model for a hotel building was developed using theDOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

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 SF 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

Characteristic	Value
HVAC system sizeM	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 °F cooling, 72 °F heating Unoccupied hours: 81 °F cooling, 67 °F heating

A computer-generated sketch of the Hotel Building prototype is shown below.



Large Office

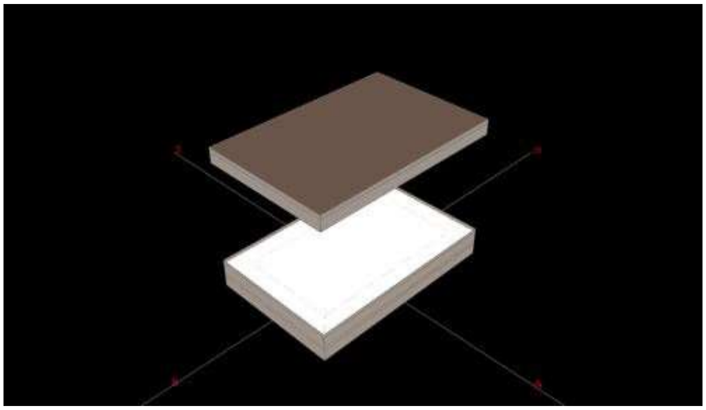
A prototypical building energy simulation model for a large office building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 °F cooling, 70 °F heating Unoccupied hours: 78 °F cooling, 67 °F heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Office Building prototype is shown below.



Note: The middle floors, since they thermally equivalent, are simulated as a single floor, and theresults are multiplied by 8 to represent the energy consumption of the eight middle floors.

Large Retail

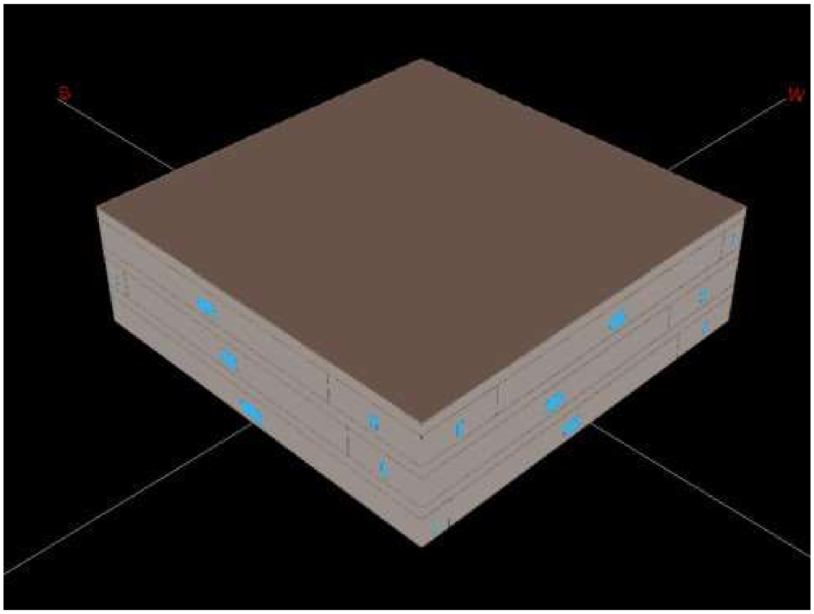
A prototypical building energy simulation model for a large retail building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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 ºF 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 ºF set point
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 81 ºF cooling, 67 ºF heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the Large Retail Building prototype is shown below.



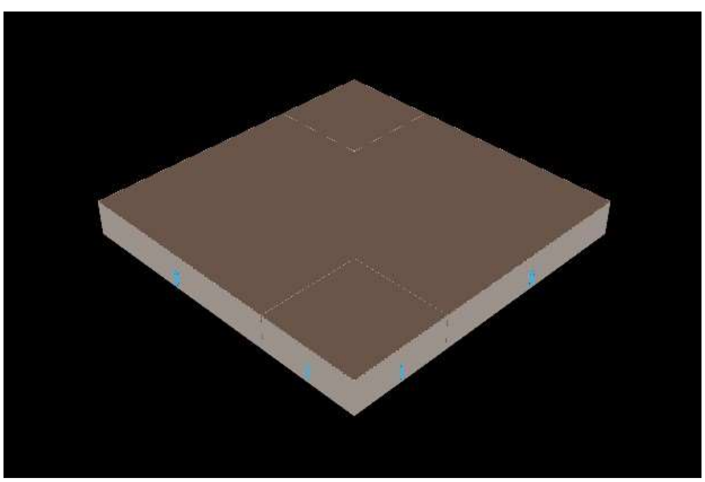
Light Industrial

A prototypical building energy simulation model for a light industrial building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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

A computer-generated sketch of the Light Industrial Building prototype is shown below.



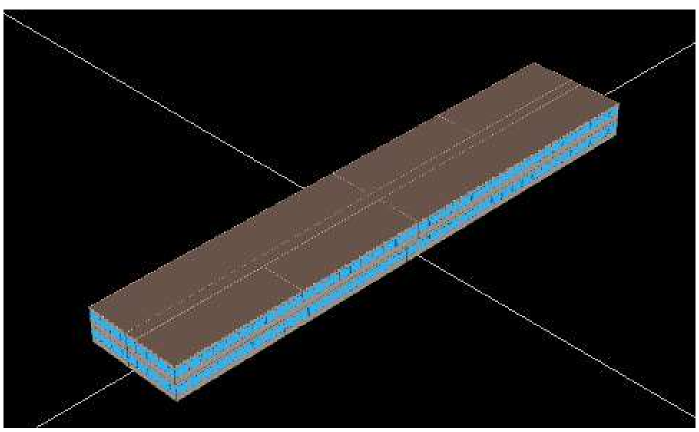
Motel

A prototypical building energy simulation model for a motel was developed using the DOE-2.2building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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: 76ºF cooling, 72 ºF heating Night setback hours: 81 ºF cooling, 67 ºF heating

A computer-generated sketch of the Motel Building prototype is shown below.



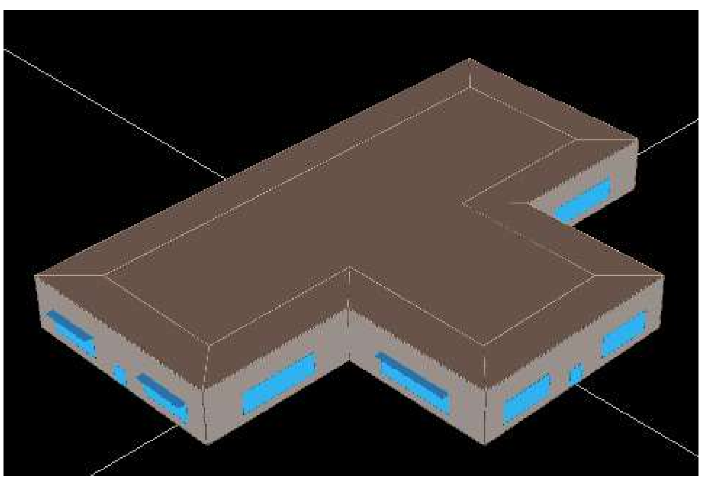
Religious

A prototypical building energy simulation model for a religious worship building was developedusing the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

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: 76ºF cooling, 70 ºF heating Unoccupied hours: 82 ºF cooling, 64 ºF heating

A computer-generated sketch of the Religious Building prototype is shown below.



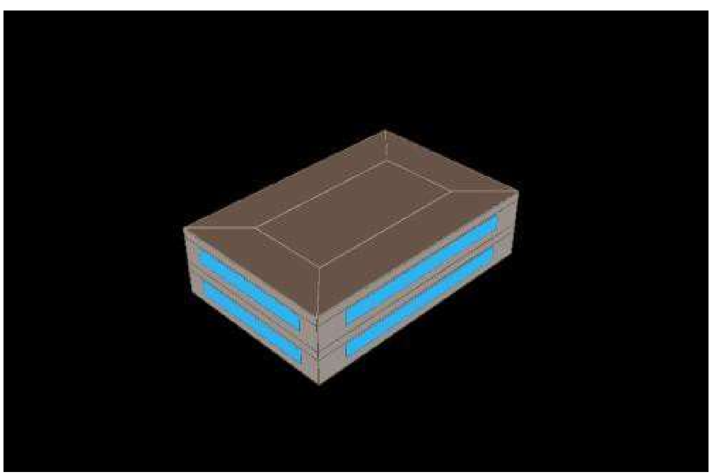
Small Office

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small office prototype are summarized below.

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 °F cooling, 72 °F heating Unoccupied hours: 79 °F cooling, 69 °F heating

A computer-generated sketch of the Small Office Building prototype is shown below.



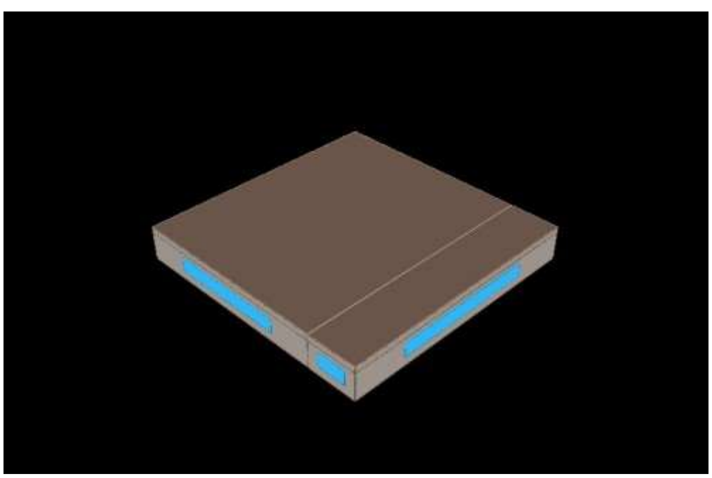
Small Retail

A prototypical building energy simulation model for a small retail building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the small retail building prototype are summarized below.

SMALL RETAIL PROTOTYPE DESCRIPTION

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	Sales Area: 6400 SF Storage Area:1600 SF Total: 8000 SF
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	Mon-Sat: 10 – 10 Sun: 10 – 8
HVAC system type	Packaged single zone, no economizer
HVAC system size	230 – 250 SF/ton depending on climate
Thermostat set points	Occupied hours: 76 ºF cooling, 72 ºF heating Unoccupied hours: 79 ºF cooling, 69 ºF heating

A computer-generated sketch of the Small Retail Building prototype is shown below.



University

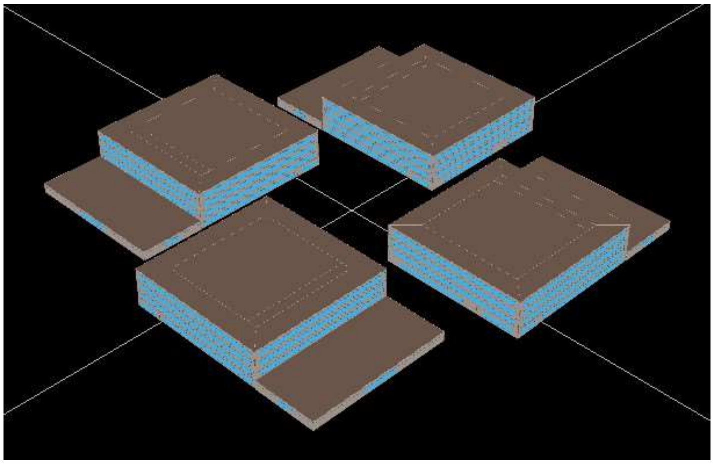
A prototypical building energy simulation model for a university building was developed usingthe DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The model is really four identical buildings oriented 90 degrees apart. The characteristics of the prototype are summarized below.

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 °F cooling, 72 °F heating Unoccupied hours: 81 °F cooling, 67 °F 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

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. Thispresents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the University Building prototype is shown below.



Warehouse

A prototypical building energy simulation model for a warehouse building was developed usingthe DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

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 = 0.84U-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 °F cooling, 68 °F heating Unoccupied hours: 85 °F cooling, 63 °F heating

A computer-generated sketch of the Warehouse Building prototype is shown below.