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FINAL REPORT

Distributed Energy Alternatives to Electrical Distribution Grid Expansion in Consolidated Edison Service Territory

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EXECUTIVE SUMMARY

The nation's power grid, specifically the New York region, faces burgeoning energy demand and suffers from congested corridors and aging equipment that cost New York consumers millions of dollars. Compounding the problem is high-density buildup in urban areas that limits available space to expand grid capacity. Coincidently, these urban areas are precisely where additional power is required.

DER in this study refers to combined heat and power (CHP) technology, which simultaneously generates heat and electricity at or near the point where the energy will be consumed. There are multiple CHP options available that, combined with a portfolio of other building energy efficiency (EE) strategies, can help achieve a more efficient supply-demand balance than what the grid can currently provide. As an alternative to expanding grid capacity, CHP and EE strategies can be deployed in a flexible manner at virtually any point on the grid to relieve load. What's more, utilities and customers can install them in a variety of potentially profitable applications that are more environmentally friendly.

Under the auspices of the New York State Energy Research and Development Authority (NYSERDA) and the Oak Ridge National Laboratory representing the Office of Electricity of the U.S. Department of Energy, Gas Technology Institute (GTI) conducted this study in cooperation with Consolidated Edison to help broaden the market penetration of EE and DER. This study provides realistic load models and identifies the impacts that EE and DER can have on the electrical distribution grid; specifically within the current economic and regulatory environment of a high load growth area of New York City called Hudson Yards in Midtown Manhattan. These models can be used to guide new policies that improve market penetration of appropriate CHP and EE technologies in new buildings. The following load modeling scenarios were investigated:

1. Baseline: All buildings are built per the Energy Conservation Construction Code of New York State (No CHP applied and no EE above the code)
2. Current Policy: This is a business-as-usual (BAU) scenario that incorporates some EE and DER based on market potential in the current economic and regulatory environment
3. Modified Rate 14RA: This economic strategy is meant to decrease CHP payback by removing the contract demand from, and adding the delivery charge to the Con Edison Standby Rate PSC2, SC14-RA
4. Carbon Trade at $20/metric tonne (mt): This policy establishes a robust carbon trading system in NY that would allow building owners to sell the carbon reduction resulting from CHP and EE

As can be seen in Figure 1 and Figure 2, under a business-as-usual scenario EE and CHP have the potential to reduce the Hudson Yards peak demand by only about 6% and the carbon footprint by only about 3%. Peak demand for the Hudson Yards redevelopment area can be reduced by up to 20% (almost 50MW) and the carbon footprint reduced by about 10% (equivalent to removing approximately 10,000 cars) with some individual policy changes.

Figure 1 - Hudson Yards Predicted Peak Demands for Business-as-Usual and High Market Penetrations

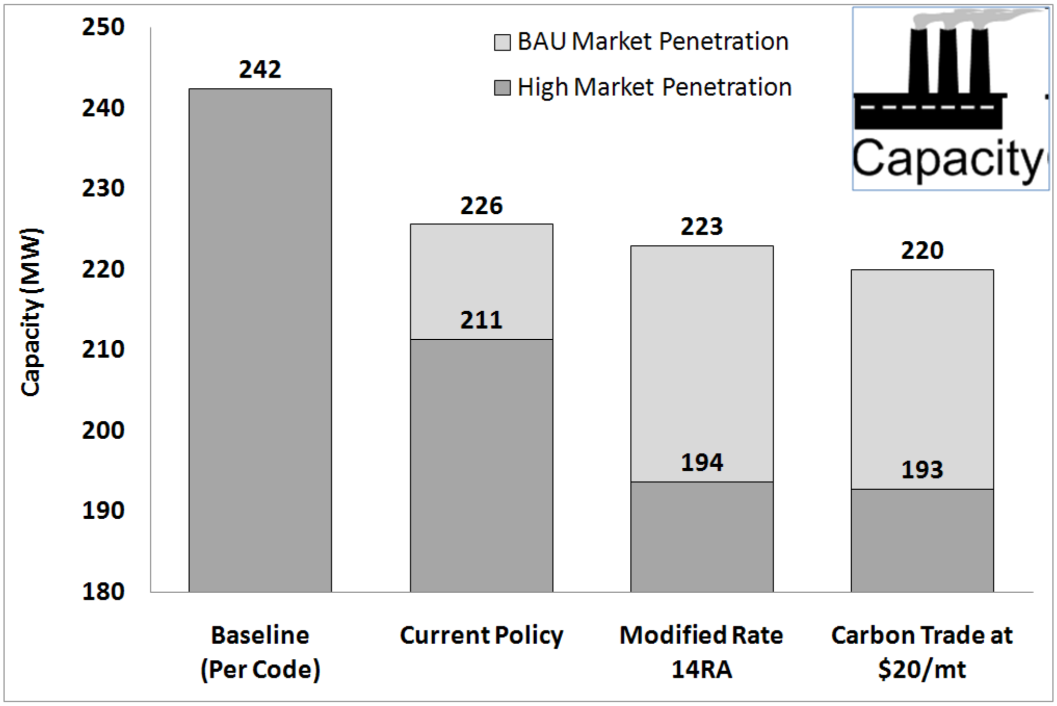
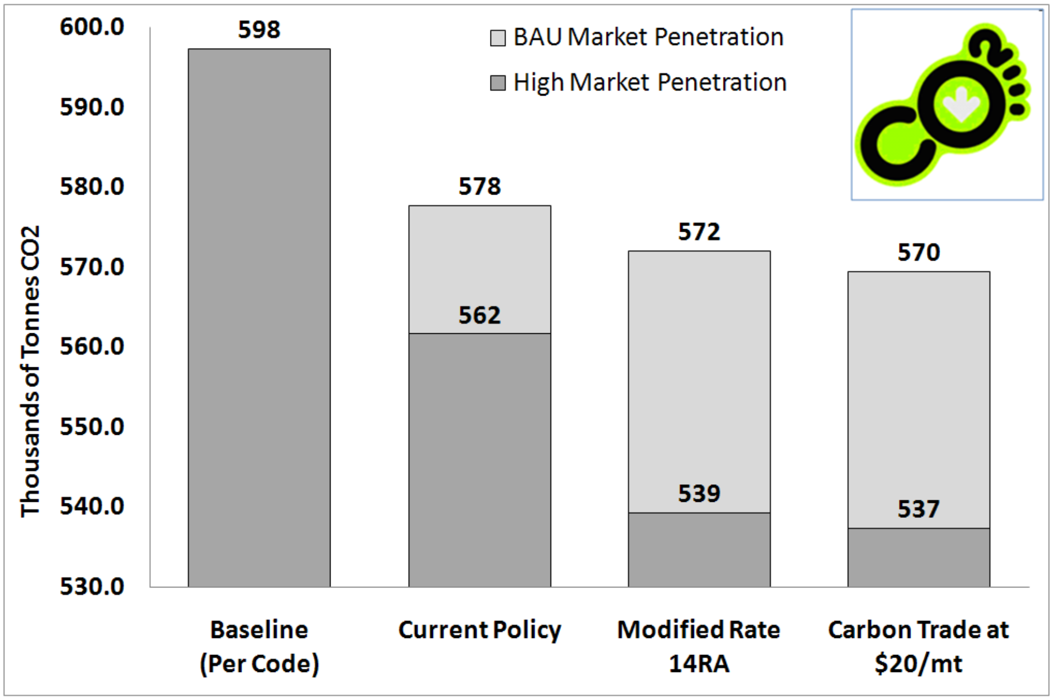


Figure 2 - Carbon Footprint for Business-as-Usual and High Market Penetrations



***Conclusion #1**: Customer adoption rates of EE and CHP decrease exponentially with increasing simple payback. As such, CHP market penetration rates are limited in Hudson Yards due to simple paybacks in the range of 7 to 10 years even with current subsidies at $600/kW (capped at $2 million).*

***Conclusion #2**: Under a business-as-usual scenario EE and CHP have the potential to reduce the Hudson Yards peak demand by only about 6% and the carbon footprint by only about 3%.*

***Conclusion #3**: Peak demand for the Hudson Yards redevelopment area can be reduced by up to 20% (almost 50MW) and the carbon footprint reduced by about 10% (equivalent to removing approximately 10,000 cars) with some individual policy changes.*

***Conclusion #4**: Carbon credits, fixed capacity payments in addition to current variable payments, and a pro-CHP tariff structure are all effective policy tools to reduce peak demand and emissions (including carbon footprint). Combining these policy tools would generate significantly higher peak demand and emissions reductions than individual policy changes.*

***Conclusion #5**: CHP alone can be more effective at reducing peak demand, source energy and emissions (including carbon footprint) than high-efficiency building envelope material and high-efficiency mechanical equipment combined.*

***Recommendation #1**: Adopt the following policies and actions that appropriately value or reduce the cost of EE and CHP:*

- *Provide a fixed 25 year capacity payment in the range of $150/kW/yr*
- *Establish a robust carbon trading system in NY that would allow building owners to sell the carbon reduction resulting from CHP and EE*
- *Accelerate the completion of the ConEd system upgrades for Hudson Yards to provide for synchronous interconnection of CHP, thereby reducing CHP system first costs by up to $600/KW. (about the same as the current NYSERDA incentive for CHP)*

***Recommendation #2**: Consider changing the focus of incentive requirements from high efficiency to carbon reduction.*

- *Option A: Instead of requiring that CHP systems meet a minimum efficiency, establish a minimum carbon reduction percentage, and/or;*
- *Option B: Reduce the minimum CHP system efficiency from 60% to 50% to allow for larger CHP systems in commercial buildings. This may only apply to certain building types.*

***Observation #1**: Electric chillers 20% more efficient than required by the Energy Conservation Construction Code of New York City could be economically attractive energy efficiency measures for all buildings modeled in this study.*

***Observation #2**: Ice-on-Coil thermal storage systems sized conservatively to accommodate 15% to 25% of the total cooling capacity may be economically attractive peak demand reduction measures for office buildings modeled in this study.*

***Observation #3**: Pending reductions to output-based emissions requirements could increase the first and operating costs of CHP, thereby reducing market penetration rates and potential for peak demand and emissions reductions.*

***Observation #4**: Growing pressure for building owners to obtain Energy Star building certification could increase CHP and EE penetration rates. Improving the overall building energy efficiency increases the Energy Star rating.*

***Observation #5**: Current NOx and SO2 cap and trade policies in New York do not allow building owners to obtain credit for their NOx and SO2 reductions associated with reducing building electricity consumption via EE and CHP. Reductions in electricity at the point of use are not factored into the overall state/region NOx and SO2 cap. This issue will need to be addressed if a carbon trading program is to be established. The carbon trading program should assign carbon credits to building owners that reduce electricity consumption so that building owners can be rewarded for their efficiency efforts.*

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BACKGROUND

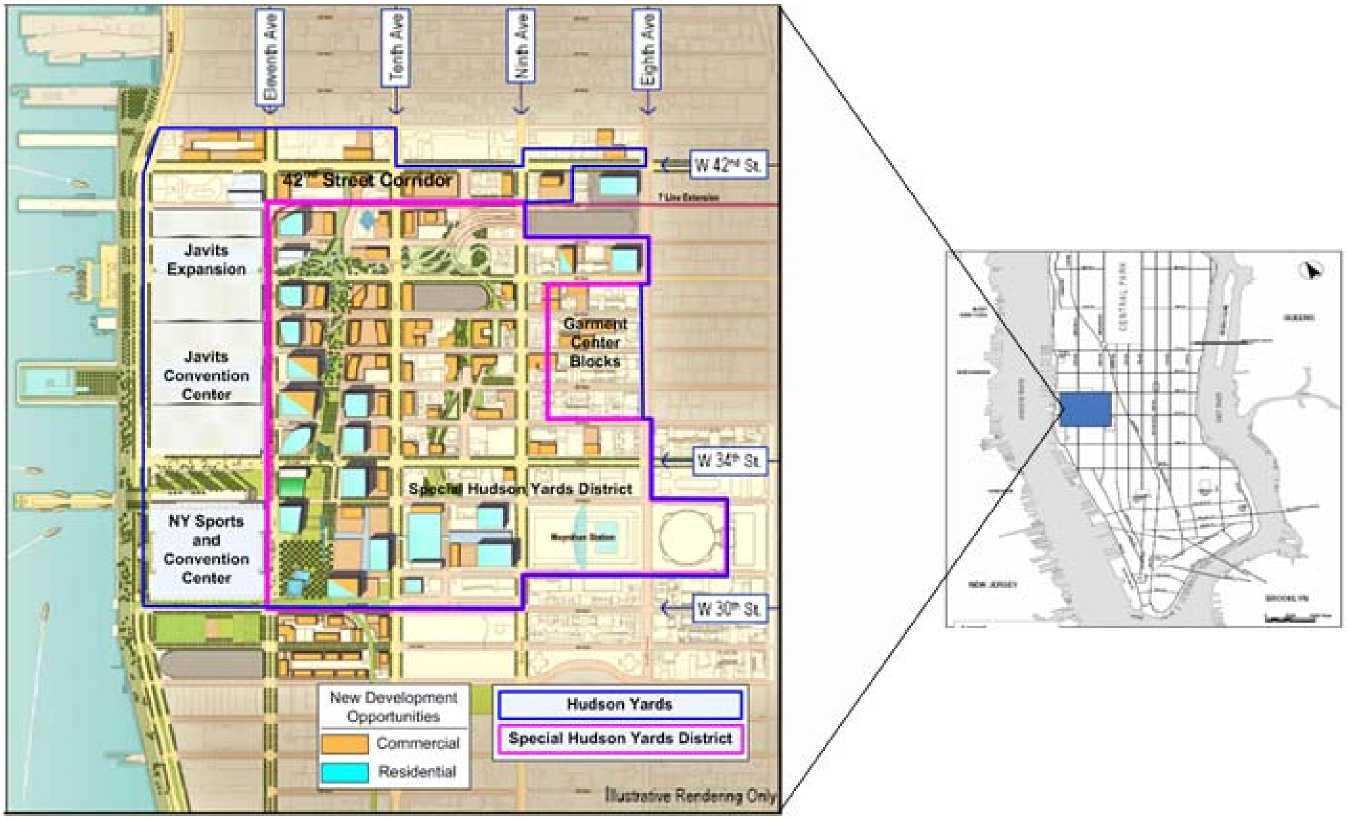
Under the auspices of the New York State Energy Research and Development Authority (NYSERDA) and the Oak Ridge National Laboratory representing the Office of Electricity of the U.S. Department of Energy, Gas Technology Institute (GTI) conducted this technology transfer study to help broaden the market penetration of building energy efficiency (EE) and distributed energy resources (DER). This study provides realistic models of the impacts that building EE and DER can have on the electrical distribution grid within the current economic and regulatory environment in New York. These models can be used to guide policies that improve market penetration of appropriate energy efficiency strategies.

Case Study

A high-growth area called Hudson Yards in Midtown Manhattan was selected to conduct a case study that shows which EE and DER technologies can be deployed to successfully reduce grid capacity demand. Hudson Yards is a 360 acre underutilized area proposed in 2003 by the New York Department of City Planning and Economic Development to be redeveloped within the next 20 years.[i] Hudson Yards is bounded roughly by West 42nd Street and West 30th Street, Eighth Avenue to the Hudson River. In 2005, the New York City Council adopted an amendment to the New York City Zoning Resolution that rezoned much of the manufacturing zone in the area to commercial and residential uses and allows for mixed-use developments and increased densities in sections of the area.[ii]

The study area for this project was limited to an area defined as the "Special Hudson Yards District" as shown in Figure 3. The Special Hudson Yards District excludes atypical areas like the Javits Convention Center and the convention and sport center expansions, the Garment Center Blocks, which have specific preservation requirements, and the 42nd Street Corridor, which is essentially planned as a theatre district.

Figure 3 - Hudson Yards and Special Hudson Yards District Map



The amended zoning map for the Special Hudson Yards District can accommodate roughly 57 new buildings with various floor area ratios and land-use designations. Along with the zoning map, GTI researched ongoing development efforts and worked with several real estate developers in the area to devise a dozen representative building prototypes. The prototype buildings were used to develop various energy models that were then used to develop aggregate electric distribution load models. The various load models can be used by the city and policy makers to help identify and target energy efficiency strategies.

Utility Infrastructure

To ensure reliable power for customers in the Manhattan area, Con Edison built network systems that distribute power through a complex web of power lines that connect to individual customers through multiple paths. Substations provide multiple feeders to multiple interconnected networks that are quilted throughout the city blocks. As such, load analysis restricted to individual feeders, networks or substations is insufficient because power load can be transferred across the systems. This study concentrates on the Special Hudson Yards District because it has significant potential for peak load reduction.

The Hudson Yards redevelopment area is currently served by the Pennsylvania electric network, which serves a total load of approximately 240 MW in midtown Manhattan. This network is supplied by the West 42nd Street No. 1 substation. In 2005, Con Edison prepared an Energy Infrastructure Master Plan (EIMP) for the Hudson Yards redevelopment area.[iii] As part of the plan, Con Edison conducted analyses to determine the need for load relief actions, including transfer of loads to nearby substations, expansion of existing substation capacities, and establishment of new substations. The net demand growth associated with the Hudson Yards redevelopment was predicted by Con Edison to be about 81 MW by 2010 and 310 MW by 2025. To accommodate the load growth Con Edison projected the following staged electric infrastructure upgrades:

To accommodate the 81 MW of load growth by 2010, Con Edison's plan would be to transfer load between substations and upgrade a substation. The cost associated with that load growth is approximated at $280/kW. To accommodate the 310 MW of load growth by 2025, Con Edison's plan is expanded to add two new substations, a new switching station, and associated feeders and distribution infrastructure. The total cost associated with the entire 20-year load growth is approximated at $2375/kW.

The Hudson Yards District is in an area of Con Edison's electric grid that still requires fault mitigation for synchronous distributed generation. Fault current limiters have been installed across a majority of Manhattan Island and are planned for the Hudson Yards District.

Con Edison's EIMP indicates that the gas system appears to have adequate capacity to support a large amount of distributed generation with only minimal reinforcements. Reinforcements could include extension of gas mains and installation/upgrade of gas regulating stations.

Con Edison's EIMP also indicates that extension of the steam system to serve Hudson Yards would be very costly and would also require construction of new steam generating capacity. These costs would exceed the savings that would be realized in electric and gas infrastructure if steam were utilized. This study is based on electric and gas infrastructure.

PROGRAM OBJECTIVES

Load Models

The primary objective of this study was to build energy load models to predict load growth in the selected area and determine the impacts of building EE and DER strategies on the load growth. The energy load models include:

1. A Baseline load growth model that is an aggregate of all foreseen new buildings in the Special Hudson Yards District built to the Energy Conservation Construction Code of New York State
2. A Business as Usual (BAU) load growth model that incorporates some EE and DER based on the current economic and regulatory environment
3. Alternative load growth models that incorporate more EE and DER than the BAU case due to improved economic and regulatory environments

EE and DER Strategies

Various EE and DER strategies were analyzed for the BAU and alternative cases. Each of the strategies improves upon the ECCC and is based on currently available technology and cost. The following categories were evaluated:

1. Energy Star –rated appliances for residential spaces
2. Reflective roofs (Cool Roofs)
3. High efficiency domestic hot water heating
4. High efficiency glazing (windows)
5. High efficiency space heating
6. High efficiency cooling
7. High efficiency lighting
8. Improved roof insulation
9. Improved wall insulation
10. Thermal storage in the form of ice-on-coil air conditioning
11. Building cooling heating and power DER systems that use waste heat for heating domestic hot water, space heating and absorption chillers for cooling

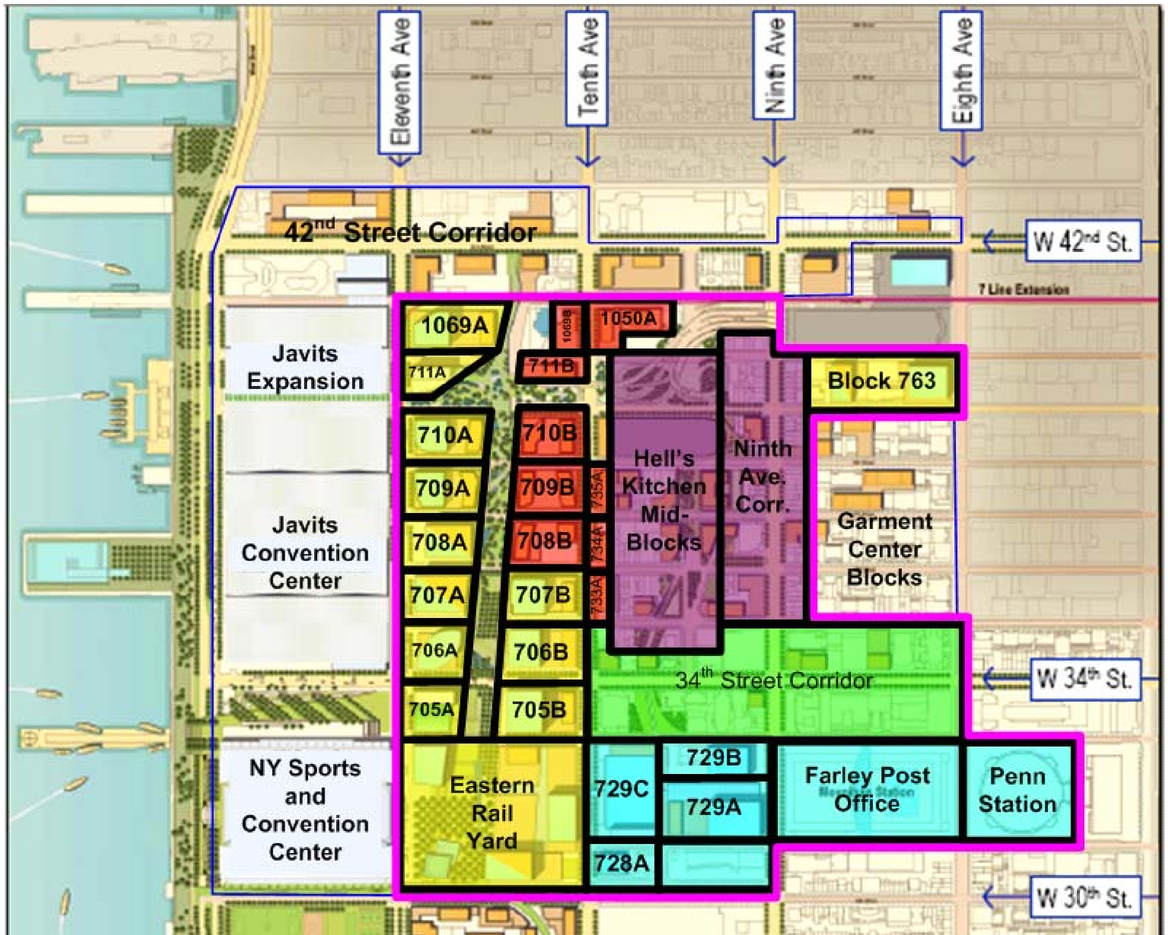
There are many assumptions associated with the building prototypes, the energy models, and the EE and DER strategies. Appendix A is a summary of the assumptions used to meet the objectives of this study.

MODELING AND METHODOLOGY

Building Prototypes

The Special Hudson Yards District is divided into zoning districts and potential development lots as shown in Figure 4. Each of the potential development lots is classified by a zoning district that identifies the primary land use and the target floor area ratios (FARs). The zoning district also requires ground floor retail development for the entire area. Through research and discussions with real estate developers, GTI identified key building characteristics such as planned use, square footage, and number of stories for some of the buildings already being built or planned to be built. Known building characteristics are highlighted grey in the proposed new buildings list in Figure 5. Otherwise, multiplying the lot sizes (square feet) by the zoning FARs, determines the allowable building floor areas and approximate stories.

Figure 4 - Special Hudson Yards District Development Lots



Zoning District	Primary Land Use	Target Floor Area Ratios		
		Commercial	Residential	Community
Large Scale Plan	High-Density Commercial	10	6	2
Eastern Rail Yard	High-Density Commercial	9	3	2
34th Street Corridor	Medium- to High-Density Commercial	10	6	10
10th Avenue Corridor	High-Density Residential	2	6.5	6.5
Hell's Kitchen Mid-blocks	Medium-Density Residential	2	6	6.5
Farley Corridor	High Density Commercial	10	5	2

Figure 5 - Special Hudson Yards District Development Proposed New Buildings

Proposed New Building List				
Site	Type	Total Sq-ft	GF Sq-ft	Stories
Eastern Rail Yard	Office	3,420,000	93,000	46
	Residential	1,710,000	79,000	27
	Residential	1,140,000	57,000	25
705A	Office	1,500,000	45,000	42
705B	Office	1,914,000	43,000	56
	Residential	436,000	11,000	51
706A	Mixed	2,000,000	45,000	55
706B	Office	2,500,000	89,000	35
	Residential	416,000	14,000	36
707A	Hotel	1,250,000	47,000	33
707B	Office	1,146,000	36,000	40
	Residential	395,000	12,000	41
708A	Office	1,846,000	58,000	40
708B	Residential	264,000	8,000	44
	Residential	398,000	14,000	36
709A	Office	1,008,000	32,000	40
	Residential	396,000	16,000	31
709B	Residential	534,000	19,000	36
	Residential	354,000	10,000	44
710A	Office	960,000	34,000	35
	Residential	431,000	17,000	31
710B	Residential	500,000	17,000	36
	Residential	332,000	9,000	44
711A	Office	736,000	28,000	33
711B	Residential	347,000	11,000	39
1069A	Office	1,314,000	41,000	40
	Residential	516,000	21,000	31
1050A	Office	172,000	17,000	13
	Residential	199,000	17,000	15
733A	Residential	651,000	23,000	35
734A	Residential	446,000	23,000	24
735A	Residential	873,000	45,000	24
Block 763	Hotel	257,000	18,000	18
	Hotel	257,000	18,000	18
	Hotel	257,000	18,000	18
	Hotel	192,000	13,000	18
	Hotel	192,000	13,000	18
Hell's Kitchen	Residential	650,000	45,000	18
	Residential			18
Hell's Kitchen and Ninth Avenue Corridor	Residential	67,000	10,000	8
	Residential	226,000	35,000	8
	Residential	138,000	22,000	8
	Residential	314,000	22,000	18
	Residential	338,000	26,000	16
	Residential	81,000	13,000	8
	Residential	38,000	6,000	8
	Residential	80,000	13,000	8
34th Street Cooridor	Residential	186,000	19,000	12
	Residential	73,000	8,000	12
	Residential	218,000	23,000	12
728A	Office	362,000	21,000	22
729A	Office	1,686,000	64,000	33
	Residential	1175000	64,000	23
729B	Office	1839000	64,000	36
729C	Office	2,115,000	102,000	26
	Residential	851,000	34,000	31
Development rights transferred from Farley Post Office (Western Annex)	Residential or Residential plus Hotel	1,100,000	120,000	58

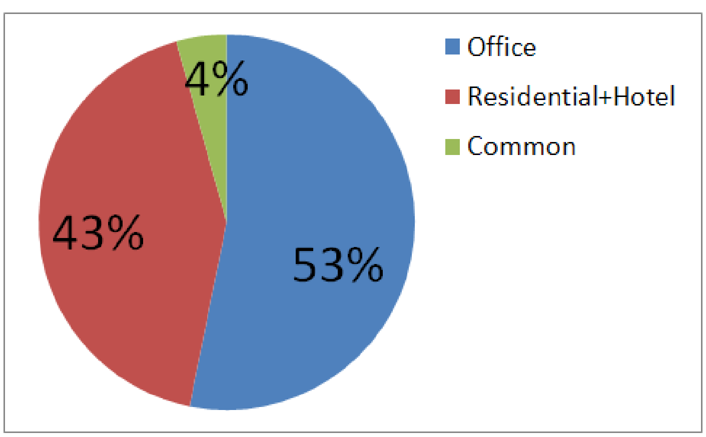
For the purpose of this study, 12 building prototype models were developed along with ground-floor models for corner retail shops, internal retail shops with only one external wall, and corner restaurant space. Furthermore, buildings greater than 20 stories were modeled as frame-wall type with structural steel interior frame and exterior unitized curtain wall systems. Buildings 20 stories or less were modeled as mass-wall type structural steel frame with pre-cast concrete exterior wall systems. All of the building prototype details are defined in Appendix A. The building models are summarized in Table 1:

Table 1- Special Hudson Yards District Prototype Model Summary

Prototype	Type	Construction	Stories	Area (ft^2)	Ground-floor Area (ft^2)	Quantity
1	High Rise Office	Frame-wall	56	1,914,000	43,000	1
2	High Rise Office	Frame-wall	41	1,706,000	51,000	6
3	High Rise Office	Frame-wall	34	1,544,000	56,000	5
4	Mid Rise Office	Mass-wall	20	883,000	47,000	3
5	High Rise Hotel	Frame-wall	33	1,250,000	47,000	1
6	Mid Rise Hotel	Mass-wall	18	231,000	16,000	5
7	High Rise Residential	Frame-wall	55	768,000	65,000	2
8	High Rise Residential	Frame-wall	43	336,000	10,000	4
9	High Rise Residential	Frame-wall	34	504,000	19,000	10
10	High Rise Residential	Frame-wall	25	1,069,000	54,000	5
11	Mid Rise Residential	Mass-wall	12	186,000	19,000	14
12	Mixed Use	Frame-wall	55	2,000,000	45,000	1
Common	Corner Retail	Frame-wall	-	-	2,000	-
Common	Internal Retail	Frame-wall	-	-	2,000	-
Common	Restaurant	Frame-wall	-	-	7,400	-
Common	Corner Retail	Mass-wall	-	-	2,000	-
Common	Internal Retail	Mass-wall	-	-	2,000	-
Common	Restaurant	Mass-wall	-	-	7,400	-

The distribution of prototypes across the Special Hudson Yards District can be found in Appendix A. The resulting land use percentages are shown in Figure 6.

Figure 6 - Special Hudson Yards District Prototype Use by Square Footage



Building energy models for the Special Hudson Yards District were calibrated by comparing their energy use to that of several Manhattan buildings that were built in the late 60's and early 70's. Annual hourly energy data (8,760) were acquired from the owners for each of these buildings and used for calibrating each of the prototype models. The prototype calibrations can be found in Appendix B. Building use, square footage, and number of stories were known for each of the existing Manhattan buildings used for calibration. However, details of the mechanical equipment were very limited.

It was apparent that most of the energy consumption data came from buildings that had some degree of steam-driven cooling, and all of them were heated with central steam. New buildings in the Hudson Yards District will be heated with dedicated gas-fired boilers and cooled with electric chillers. Therefore, the building prototypes were first calibrated assuming central steam heating and 50% steam-driven cooling. The central steam heating and steam-driven cooling were then replaced with dedicated gas-fired boilers and electric chillers for the analyses.

The 13 buildings that data were acquired for are primarily office buildings. Data were acquired for one residential building, but no hotels. As such, typical hotel data within the computer energy modeling software were used to develop the hotel prototypes. They were then compared to the residential data. Typical data were also used to develop the retail and restaurant models.

Building Energy Modeling

Building Energy Analyzer (BEA) computer energy modeling software was used to generate hourly loads for each of the buildings.[iv] The coincident hourly loads for the individual buildings are then summed to produce aggregate load duration curves (load curves) for the entire area. BEA consists of hour-by-hour computer simulation models for various building types, heat and power generation equipment, and HVAC equipment. Within the BEA models, equipment (e.g. lighting, HVAC, etc.) and building parameters (e.g. wall material, window designs, roofing, etc.), energy rates, and geographical weather data can be defined for specific applications.

BEA forecasts and reports annual hour-by-hour heat and power loads along with hour-by-hour fuel requirements. Additionally, the software allows for the aggregation of multiple building loads for energy impact analyses.

BEA uses weather data from the typical meteorological year (TMY2) data sets derived from the 1961-1990 National Solar Radiation Data Base (NSRDB).[v] The load models generated from the 8760 building model data streams are typical for weather during the TMY2 time span for New York City.

Aggregate Energy Load Modeling

In August 2007 the New York State Department of State Division of Code Enforcement and Administration published the Energy Conservation Construction Code of New York State (ECCC).[vi] The code is intended to regulate the design and construction of newly built residential and commercial buildings for the effective use of energy. The baseline load model for this study is an aggregate of building load models that meet, but do not exceed, the ECCC standards. As such, the baseline load model does not include DER in any of the buildings. The load model is intended to show the potential electric load with zero market penetration of EE and DER strategies.

The National Energy Modeling System (NEMS) has formulated a market penetration curve for energy efficiency strategies based on payback years.[vii] The curve is defined by Equation 1, which demonstrates that when a given EE measure generates positive cash flow within one year, roughly 48% of the market will adopt the measure. This is considered the maximum market penetration rate. The rate of adoption decays exponentially as the payback increases, as shown in Figure 7.

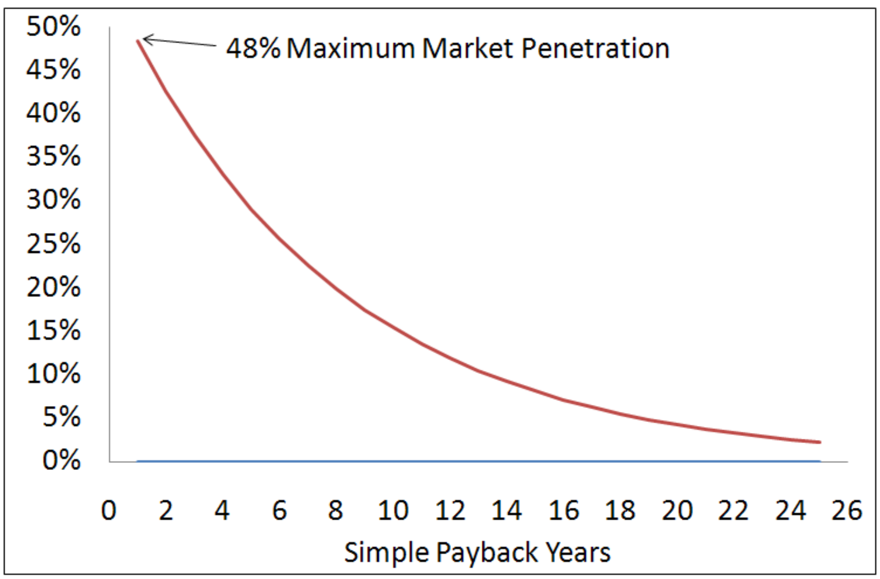
Equation 1: $$\text{Market penetration} = \frac{1.1 \times penparm}{e^{(0.24 \times PCF)}}$$

where:

penparm = penetration parameter, NEMS uses 50%

PCF = number of years to positive cash flow (approximately half the simple payback period)

Figure 7 – NEMS Market Penetration Curve



Based on the NEMS market penetration curve, the Business as Usual (BAU) energy load model was developed. For each building model all of the EE and DER strategies defined in the objectives were applied individually. Using BEA, the energy cost savings were calculated and simple paybacks were determined based on the total cost of the EE or DER measure. Simple paybacks were then changed to *PCF's* and used in Equation 1 to determine BAU market adoption of the EE or DER measures.

A series of alternative energy load models were then developed that incorporate more EE and DER than the BAU case due to an improved economic and regulatory environment.

The increase in adoption of EE and DER strategies occurs as a result of the following parameter changes:

1. Decreasing simple payback, thus *PCF* in Equation 1. This can happen by way of an improved economic environment.
2. Increasing *penparm* in Equation 1. This is fundamentally the same as increasing the maximum market penetration to be greater than 48% and can happen by way of an improved regulatory environment.

To address each of these alternative approaches, multiple energy load models were developed that implement the following economic and regulatory strategies.

1. Decrease simple payback, thus *PCF*, by implementing a carbon cap and trade policy. NYC issued PlanNYC which calls for a 30% reduction in global warming emissions.[viii] The carbon cap and trade policy fundamentally decreases *paybacks* for EE and DER strategies that reduce carbon emissions. Energy load sensitivities were generated for $5 to $20 incrementally at $5 per metric tonne ($/mt) of CO2 emitted. At the time of this report, the Chicago Climate Exchange (CCX) was actively trading CO2 in the North America's at about $6/mt.[ix] The European Climate Exchange (ECX), launched by CCX, is the leading exchange operating in the European Union Emissions Trading Scheme. At the time of this report ECX was actively trading CO2 in Europe at about EUR25/mt; the USD equivalent is $38/mt. The trading values of CO2 for both CCX and ECX, have been steadily increasing in 2008.
2. Con Edison's applicable rate without CHP is PSC9, SC4, Rate II and has a delivery energy charge component of 0.58 cents per kWh in addition to their commodity energy charge. Con Edison's Standby Rate PSC2, SC14-RA does not include the delivery energy charge. Instead, the standby rate applies a contract demand charge of $8.02/kW to offset the nonexistent delivery charge and to account for standby demand. This economic strategy is meant to decrease simple payback, thus *PCF*, by removing the contract demand of $8.02/kW from, and adding the delivery charge of approximately 0.58 cents per kWhr to the commodity energy charge of Con Edison Standby Rate PSC2, SC14-RA.
3. Increase *penparm* from about 50% to 90% in increments of 10 percentage points through regulatory policy. This results in calculated market penetration rates for a one-year simple payback of 48%, 58%, 68%, 77% and 87%.

Results, including tables, charts, and conclusions in this report refer to the incremental increases to the maximum market penetration rates (penparm) as follows:

Low Market Penetration: 48% (this is business-as-usual BAU)
Mid-Low Market Penetration: 58%
Mid Market Penetration: 68%
Mid-High Market Penetration: 77%
High Market Penetration: 87%

These percentages represent the market penetration rate when the simple payback is one year.

Other Acronyms used in the results are:

Baseline	*All buildings built per ECCC (No CHP applied and no EE above the ECCC)*
EE	*All energy efficiency strategies, including cold storage, except CHP*
CHP	*Building Cooling, Heating, and Power*
14RA	*Modified Con Edison Standby rate PSC2, SC14-RA, Rate II*
CCT5	*Carbon Cap & Trade policy at $5/mt of CO2*
CCT10	*Carbon Cap & Trade policy at $10/mt of CO2*
CCT15	*Carbon Cap & Trade policy at $15/mt of CO2*
CCT20	*Carbon Cap & Trade policy at $20/mt of CO2*

ANALYSIS RESULTS

Summary of Results

The results in this section are a series of load curves and bar charts that show the annual energy load profiles, totals, and corresponding annual CO_2, SO_2, and NOx emissions. The load curves are developed by sorting the 8,760 hourly loads in descending order so that the highest demands for the year are at the far left of the graph. Bar charts for energy and emissions are provided with the contributions from gas and electric shown stacked. Bar charts showing the collective energy and emissions contributions from gas and electric are also provided with greater resolution so that the total impacts can be seen well.

Table 2 summarizes the scenarios as assembled in the graphs and charts in Figure 12 through Figure 29. The tables in Appendix C show which and how many EE and DER strategies are adopted based on the various scenarios. Table 3 shows the ranges of predicted reductions in peak electric demand and associated emissions given BAU and High market penetrations. Table 4 shows the ranges of predicted reductions in peak electric demand and associated emissions given Low and High market penetrations and a carbon cap and trade policy at $5 to $20/mt. Finally, Table 5 through Table 10 show the levels of CHP adoption on a kW basis for the various scenarios.

To clarify the nomenclature used in Table 5 through Table 10, in Table 5 there are six Prototype 02 buildings that could each install a total of 5,500 kW of CHP. However, applying the market penetration rates for the BAU scenario, only one out of the six installs a total of 5,500 kW of CHP (i.e. 5,500 x 1).

Table 2 – Summary of Graphs, Charts and Tables Showing Results with Parametric Variations Compared to the Baseline Case

Figures	Tables	Held Constant		Varied Parametrically
		Market penetration	Measures Applied	
8,9	11,24	-	EE and CHP	Market penetration rates: BAU, Mid-low, Mid, Mid-High, and High
10,11	12,24	BAU	-	Measures applied: EE only, CHP only, CHP and EE, CHP only with modified 14RA
12,13	13,25	BAU	EE and CHP	Carbon Cap and Trade Policy: none, CCT5, CCT10, CCT15, and CCT20
14,15	14,26	Mid-Low	-	Measures applied: EE only, CHP only, CHP and EE, CHP only with modified 14RA
16,17	15,26	Mid-Low	EE and CHP	Carbon Cap and Trade Policy: none, CCT5, CCT10, CCT15, and CCT20
18,19	16,27	Mid	-	Measures applied: EE only, CHP only, CHP and EE, CHP only with modified 14RA
20,21	17,27	Mid	EE and CHP	Carbon Cap and Trade Policy: none, CCT5, CCT10, CCT15, and CCT20
22,23	18,28	Mid-High	-	Measures applied: EE only, CHP only, CHP and EE, CHP only with modified 14RA
24,25	19,28	Mid-High	EE and CHP	Carbon Cap and Trade Policy: none, CCT5, CCT10, CCT15, and CCT20
26,27	20,29	High	-	Measures applied: EE only, CHP only, CHP and EE, CHP only with modified 14RA
28,29	21,29	High	EE and CHP	Carbon Cap and Trade Policy: none, CCT5, CCT10, CCT15, and CCT20

Table 3 – Predicted Reductions from Baseline due to the Implementation of EE and CHP for a range of Market Penetrations levels from BAU to High

Measure	Peak Demand	CO2 Emitted	SO2 Emitted	NOx Emitted
EE	3% to 6%	1% to 2%	1% to 2%	1% to 2%
CHP	4% to 7%	2% to 4%	6% to 11%	3% to 5%
EE+CHP	7% to 13%	3% to 6%	7% to 12%	4% to 7%
CHP 14RA	7% to 15%	3% to 8%	10% to 22%	4% to 10%

Table 4 - The Range of Predicted Reductions from Baseline Due to the Implementation of CHP and EE with Market Penetrations Varied from BAU to High and CCT Policy Varied from $5 to $20/mt

Measure	CCT	Peak Demand	CO2 Emitted	SO2 Emitted	NOx Emitted
EE+CHP	$0	7% to 13%	3% to 6%	7% to 12%	4% to 7%
EE+CHP	$5	7% to 18%	3% to 9%	7% to 19%	4% to 11%
EE+CHP	$10	9% to 18%	5% to 9%	10% to 20%	5% to 10%
EE+CHP	$15	9% to 20%	5% to 10%	10% to 23%	5% to 12%
EE+CHP	$20	9% to 21%	5% to 10%	11% to 24%	5% to 12%

Table 5 – Predicted CHP Adoption Levels by Building where Rate 14RA is Unmodified and there is no Carbon Cap and Trade Policy

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 1
03	5	0	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1
04	3	0	0	0	0	0
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 1	400 x 1	400 x 2
07	2	0	0	0	0	0
08	4	0	0	0	750 x 1	750 x 1
09	10	850 x 2	850 x 2	850 x 2	850 x 3	850 x 3
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 1
11	14	250 x 1	250 x 1	250 x 2	250 x 2	250 x 2
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	9,350	13,850	14,100	15,700	16,100

Table 6 - Predicted CHP Adoption Levels by Building where Rate 14RA is Modified and there is no Carbon Cap and Trade Policy

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 2	5,500 x 2	5,500 x 2
03	5	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 2	4,500 x 2
04	3	0	0	3000 x 1	3000 x 1	3000 x 1
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 1	400 x 2	400 x 2
07	2	0	0	0	0	0
08	4	0	750 x 1	750 x 1	750 x 1	750 x 1
09	10	850 x 2	850 x 3	850 x 3	850 x 4	850 x 4
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 2	1,500 x 2
11	14	250 x 2	250 x 3	250 x 3	250 x 4	250 x 5
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	14,100	15,950	24,450	31,950	32,200

Table 7 - Predicted CHP Adoption Levels by Building where Rate 14RA is Unmodified and there is a Carbon Cap and Trade Policy at $5/mt

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 1
03	5	0	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1
04	3	0	0	0	0	3000 x 1
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 1	400 x 1	400 x 2
07	2	0	0	0	0	0
08	4	0	0	750 x 1	750 x 1	750 x 1
09	10	850 x 2	850 x 2	850 x 3	850 x 3	850 x 3
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 2
11	14	250 x 1	250 x 2	250 x 2	250 x 3	250 x 3
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	9,350	14,100	15,700	15,950	20,850

Table 8 - Predicted CHP Adoption Levels by Building where Rate 14RA is Unmodified and there is a Carbon Cap and Trade Policy at $10/mt

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 2	5,500 x 2
03	5	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1
04	3	0	0	0	3000 x 1	3000 x 1
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 1	400 x 2	400 x 2
07	2	0	0	0	0	0
08	4	0	750 x 1	750 x 1	750 x 1	750 x 1
09	10	850 x 2	850 x 2	850 x 3	850 x 3	850 x 4
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 2	1,500 x 2
11	14	250 x 2	250 x 2	250 x 3	250 x 3	250 x 4
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	14,100	14,850	15,950	26,350	27,450

Table 9 - Predicted CHP Adoption Levels by Building where Rate 14RA is Unmodified and there is a Carbon Cap and Trade Policy at $15/mt

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 1	5,500 x 2	5,500 x 2
03	5	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 2
04	3	0	0	0	3000 x 1	3000 x 1
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 1	400 x 2	400 x 2
07	2	0	0	0	0	0
08	4	0	750 x 1	750 x 1	750 x 1	750 x 1
09	10	850 x 2	850 x 3	850 x 3	850 x 4	850 x 4
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 2	1,500 x 2
11	14	250 x 2	250 x 3	250 x 3	250 x 4	250 x 4
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	14,100	15,950	15,950	27,450	31,950

Table 10 - Predicted CHP Adoption Levels by Building where Rate 14RA is Unmodified and there is a Carbon Cap and Trade Policy at $20/mt

Prototype	Bldgs Qty	BAU	Mid-Low	Mid	Mid-High	High
01	1	0	0	0	0	0
02	6	5,500 x 1	5,500 x 1	5,500 x 2	5,500 x 2	5,500 x 2
03	5	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 1	4,500 x 2
04	3	0	0	3000 x 1	3000 x 1	3000 x 1
05	1	0	0	0	0	0
06	5	400 x 1	400 x 1	400 x 2	400 x 2	400 x 2
07	2	0	0	0	0	0
08	4	0	750 x 1	750 x 1	750 x 1	750 x 1
09	10	850 x 2	850 x 3	850 x 3	850 x 4	850 x 4
10	5	1,500 x 1	1,500 x 1	1,500 x 1	1,500 x 2	1,500 x 2
11	14	250 x 2	250 x 3	250 x 3	250 x 4	250 x 5
12 Office	1	0	0	0	0	0
12 Res		0	0	0	0	0
Totals	57	14,100	15,950	24,850	27,450	32,200

Business as Usual – Low Market Penetration

Figure 8 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Market Penetration Rates of EE and CHP

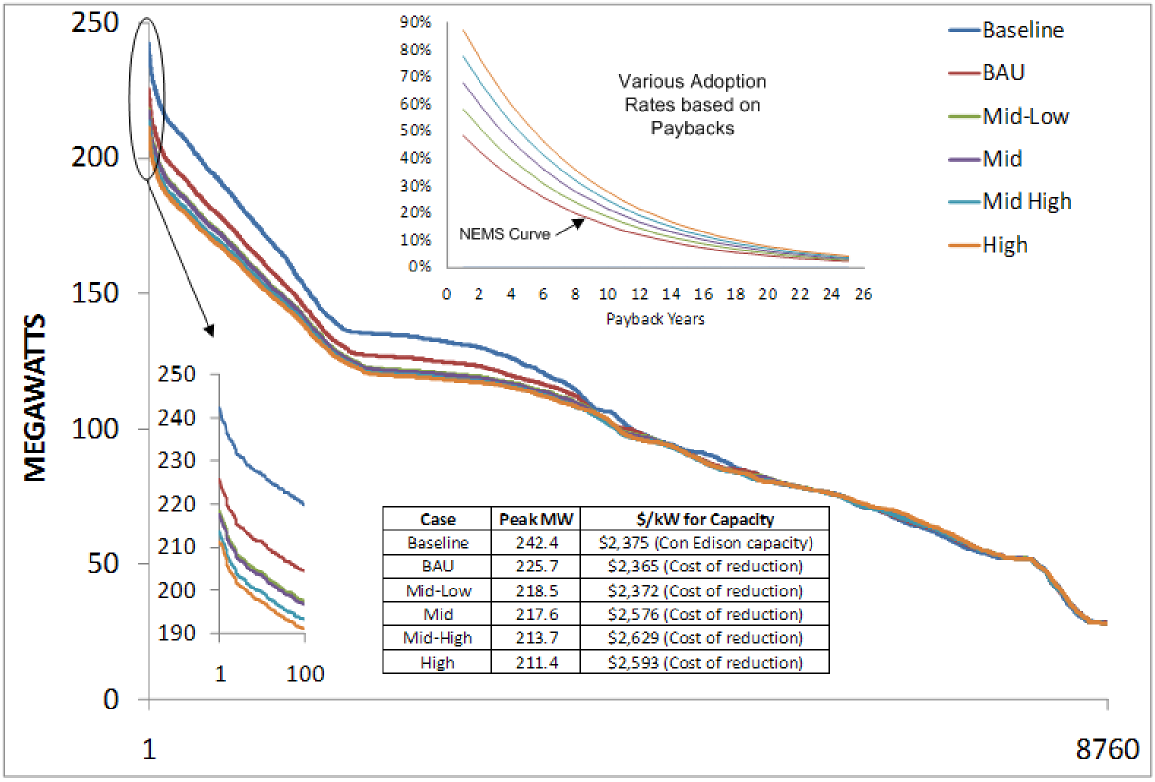


Table 11 – Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Market Penetration Rates of EE and CHP

Measure	Peak Demand
BAU	6.9%
Mid-Low	9.9%
Mid	10.2%
Mid-High	11.8%
High	12.8%

Figure 9 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Market Penetration Rates of EE and CHP

Trillions of Btu

	Baseline	BAU	Mid-Low	Mid	Mid-Hi	High
Gas	2.804	2.986	3.104	3.102	3.124	3.118
Electric	10.783	10.062	9.702	9.661	9.521	9.494
Total	13.587	13.047	12.806	12.763	12.645	12.612

Thousands of Tonnes CO2

	Baseline	BAU	Mid-Low	Mid	Mid-Hi	High
Gas	142.8	155.9	163.8	163.8	165.5	165.3
Electric	454.6	421.9	405.6	403.8	397.5	396.3
Total	597.4	577.7	569.4	567.6	563.0	561.7

Thousands of Tonnes SO2

	Baseline	BAU	Mid-Low	Mid	Mid-Hi	High
Gas	0.001	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.763	1.697	1.690	1.665	1.660
Total	1.895	1.764	1.698	1.691	1.665	1.661

Thousands of Tonnes NOx

	Baseline	BAU	Mid-Low	Mid	Mid-Hi	High
Gas	0.112	0.126	0.135	0.135	0.137	0.137
Electric	0.585	0.545	0.524	0.522	0.514	0.513
Total	0.697	0.671	0.659	0.657	0.651	0.650

Figure 10 - Hudson Yards Aggregate Annual Electric Load Curves – Impact of Varying the Measures Applied to Achieve Load Reductions under a BAU Market Penetration Rate

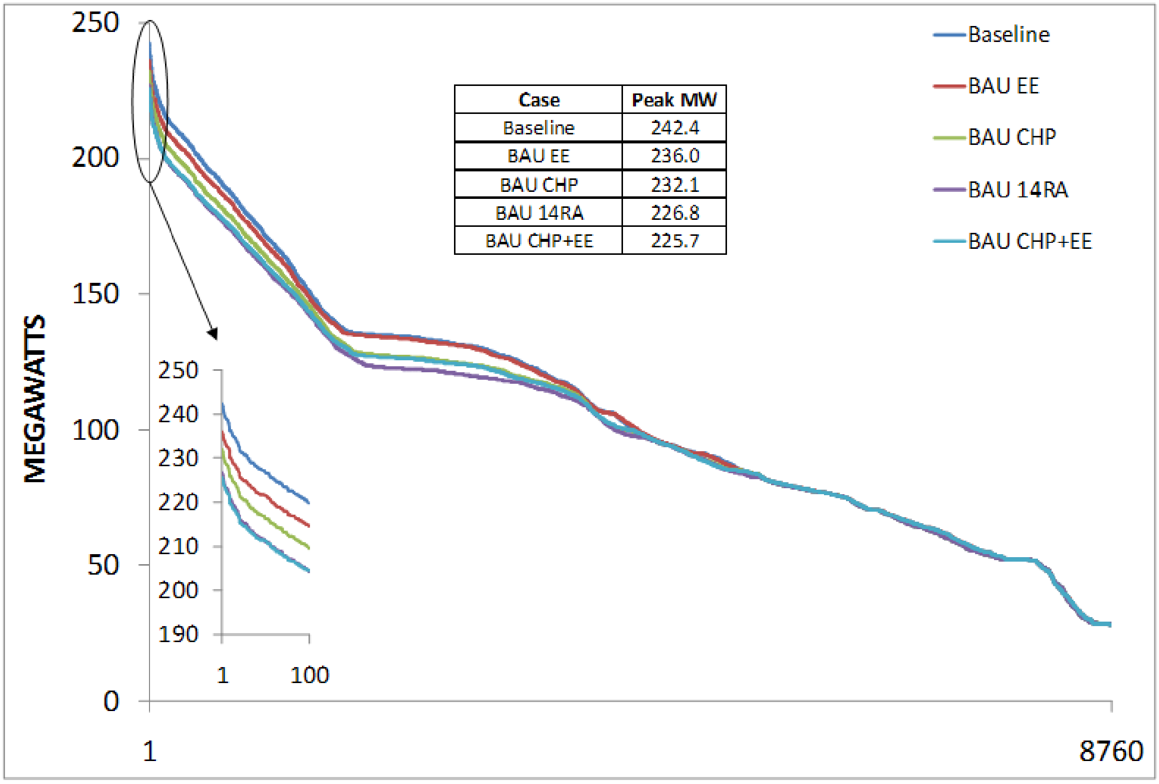


Table 12 - Peak Demand Reduction from Baseline - Impact of Varying the Measures Applied to Achieve Load Reductions under a BAU Market Penetration Rate

Measure	Peak Demand
BAU EE	2.6%
BAU CHP	4.3%
BAU 14RA	6.4%
BAU CHP+EE	6.9%

Figure 11 - Hudson Yards Aggregate Annual Energy Consumption and Emissions – Impact of Varying the Measures Applied to Achieve Load Reductions under a BAU Market Penetration Rate

Figure 12 - Hudson Yards Aggregate Annual Electric Load Curves – Impact of Varying the Carbon Cap and Trade Price under a BAU Market Penetration Rate for CHP & EE

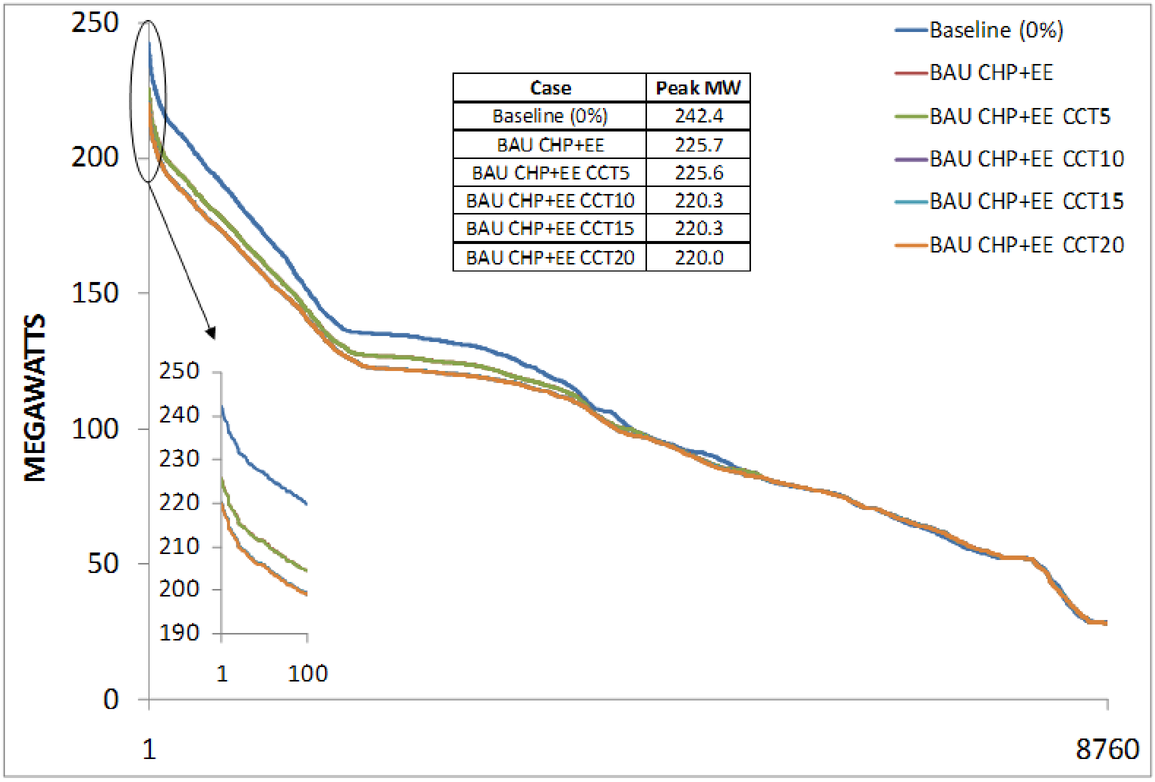


Table 13 - Peak Demand Reduction from Baseline – Impact of Varying the Carbon Cap and Trade Price under a BAU Market Penetration Rate for CHP & EE

Measure	Peak Demand
BAU CHP+EE	6.9%
BAU CHP+EE CCT5	6.9%
BAU CHP+EE CCT10	9.1%
BAU CHP+EE CCT15	9.1%
BAU CHP+EE CCT20	9.2%

Figure 13 - Hudson Yards Aggregate Annual Energy Consumption and Emissions – Impact of Varying the Carbon Cap and Trade Price under a BAU Market Penetration Rate for CHP & EE

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Gas	2.804	2.986	2.981	3.124	3.124	3.112
Electric	10.783	10.062	10.059	9.701	9.701	9.695

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Total	13.59	13.05	13.04	12.83	12.82	12.81

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Gas	142.8	155.9	155.6	164.9	164.9	164.3
Electric	454.6	421.9	421.8	405.5	405.5	405.2

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Total	597.4	577.7	577.4	570.4	570.4	569.5

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Gas	0.001	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.763	1.763	1.697	1.697	1.696

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Total	1.895	1.764	1.763	1.698	1.698	1.697

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Gas	0.112	0.126	0.126	0.136	0.136	0.135
Electric	0.585	0.545	0.544	0.524	0.524	0.524

	Baseline	BAU EE+CHP	BAU EE+CHP CCT5	BAU EE+CHP CCT10	BAU EE+CHP CCT15	BAU EE+CHP CCT20
Total	0.697	0.671	0.671	0.660	0.660	0.659

Improved Market Penetration Rate – Mid-Low Market Penetration

Figure 14 - Hudson Yards Aggregate Annual Electric Load Curves – Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-Low Market Penetration Rate

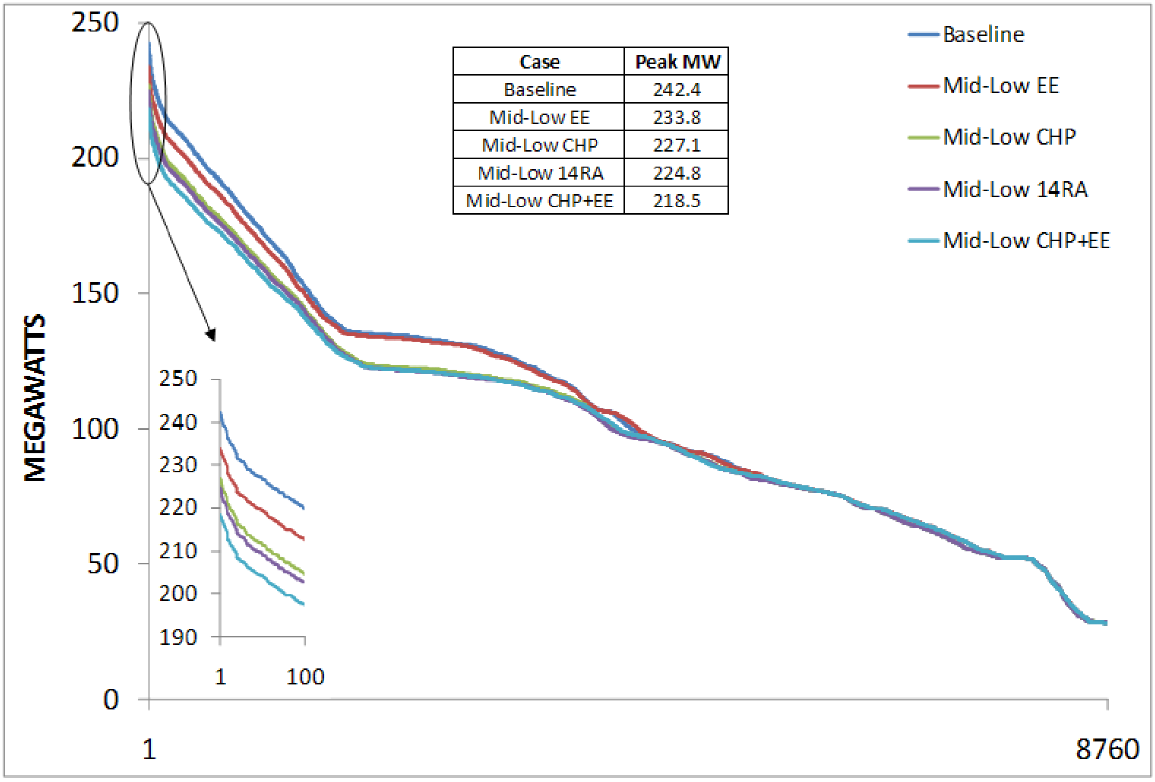
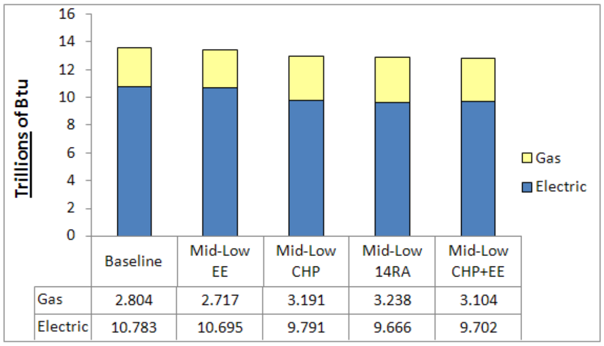


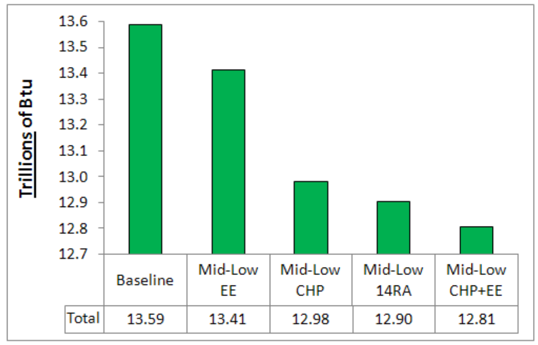
Table 14 - Percentages of Peak Demand Reduction from Baseline – Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-Low Market Penetration Rate

Measure	Peak Demand
Mid-Low EE	3.5%
Mid-Low CHP	6.3%
Mid-Low 14RA	7.3%
Mid-Low CHP+EE	9.9%

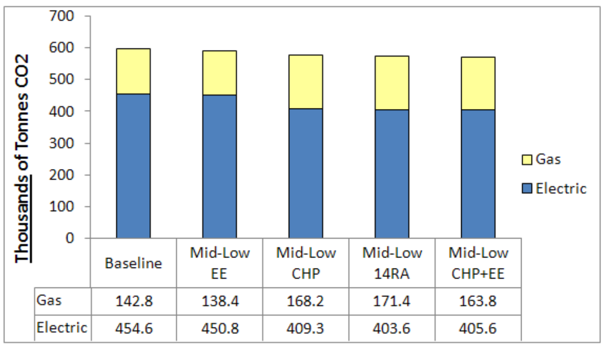
Figure 15 - Hudson Yards Aggregate Annual Energy Consumption and Emissions – Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-Low Market Penetration Rate



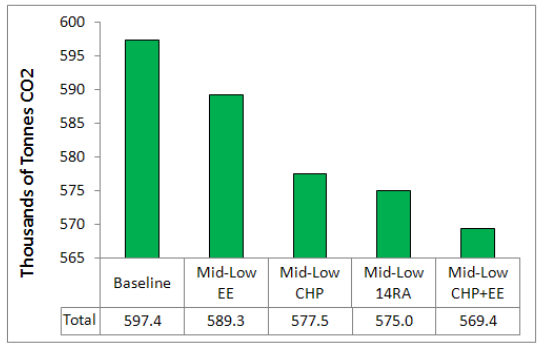
	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Gas	2.804	2.717	3.191	3.238	3.104
Electric	10.783	10.695	9.791	9.666	9.702



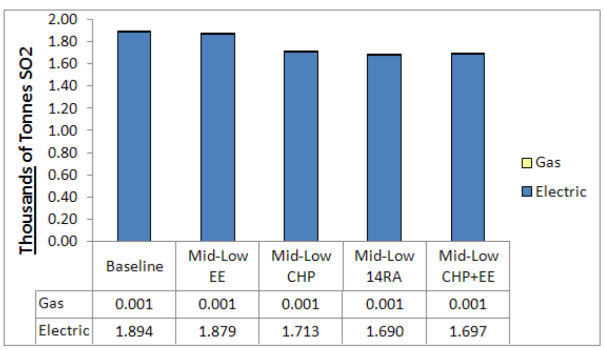
	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Total	13.59	13.41	12.98	12.90	12.81



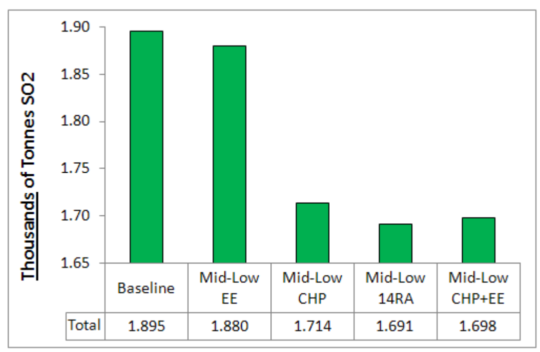
	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Gas	142.8	138.4	168.2	171.4	163.8
Electric	454.6	450.8	409.3	403.6	405.6



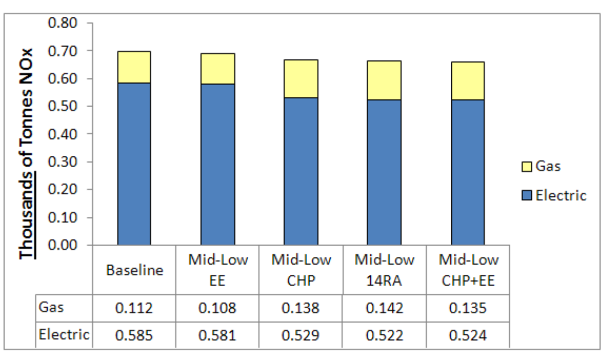
	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Total	597.4	589.3	577.5	575.0	569.4



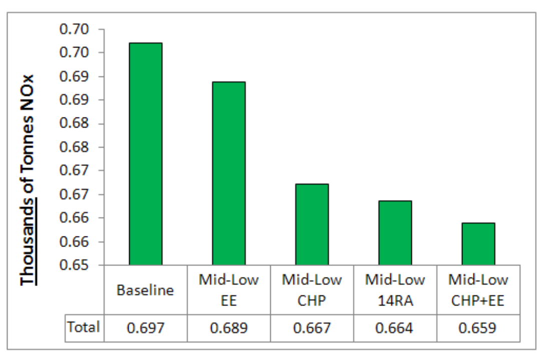
	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Gas	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.879	1.713	1.690	1.697



	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Total	1.895	1.880	1.714	1.691	1.698



	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Gas	0.112	0.108	0.138	0.142	0.135
Electric	0.585	0.581	0.529	0.522	0.524



	Baseline	Mid-Low EE	Mid-Low CHP	Mid-Low 14RA	Mid-Low CHP+EE
Total	0.697	0.689	0.667	0.664	0.659

Figure 16 - Hudson Yards Aggregate Annual Electric Load Curves – Impact of Varying the Carbon Cap and Trade Price under a Mid-Low Market Penetration Rate for CHP & EE

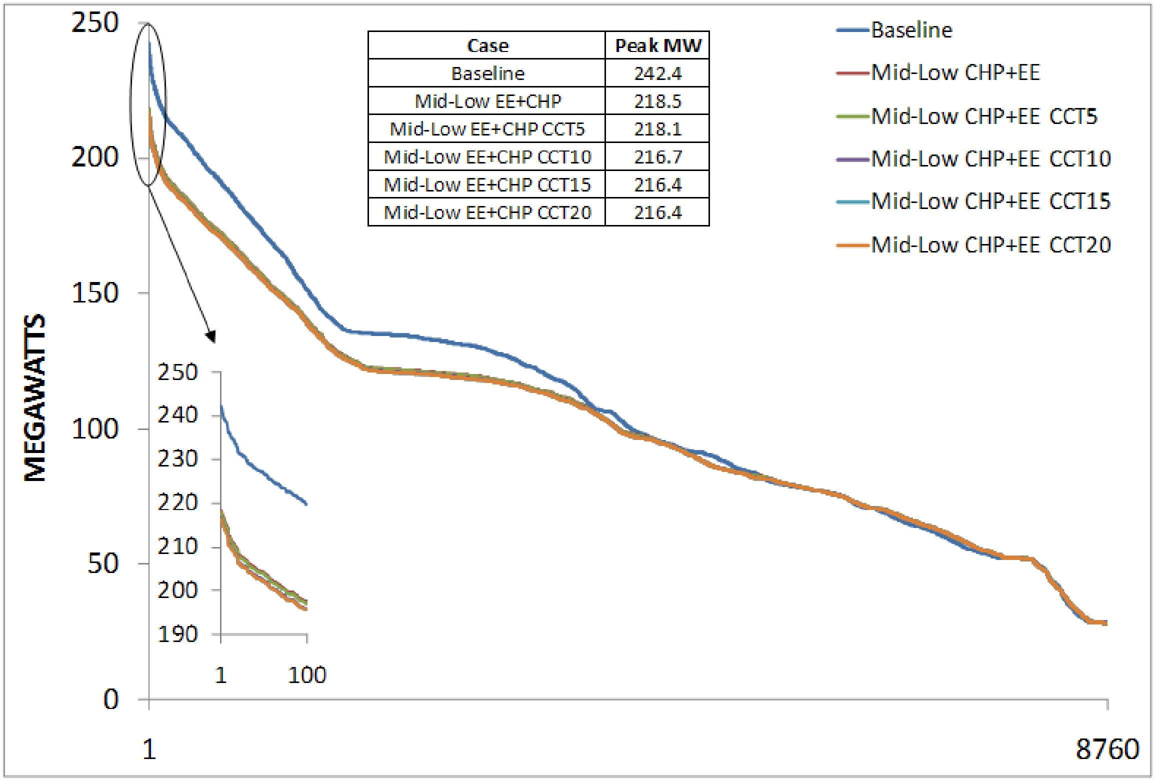


Table 15 - Percentages of Peak Demand Reduction from Baseline – Impact of Varying the Carbon Cap and Trade Price under a Mid-Low Market Penetration Rate for CHP & EE

Measure	Peak Demand
Mid-Low CHP+EE	9.9%
Mid-Low CHP+EE CCT5	10.0%
Mid-Low CHP+EE CCT10	10.6%
Mid-Low CHP+EE CCT15	10.7%
Mid-Low CHP+EE CCT20	10.7%

Figure 17 - Hudson Yards Aggregate Annual Energy Consumption and Emissions – Impact of Varying the Carbon Cap and Trade Price under a Mid-Low Market Penetration Rate for CHP & EE

Improved Market Penetration Rate – Mid Market Penetration

Figure 18 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid Market Penetration Rate

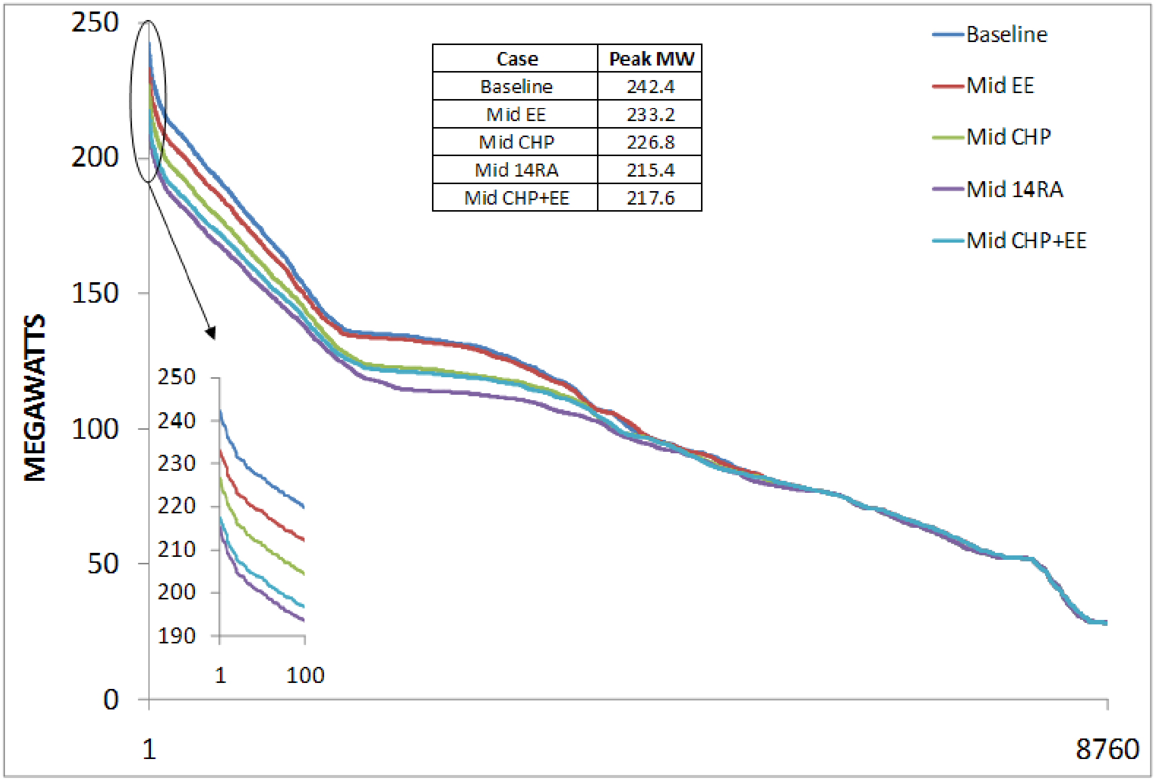
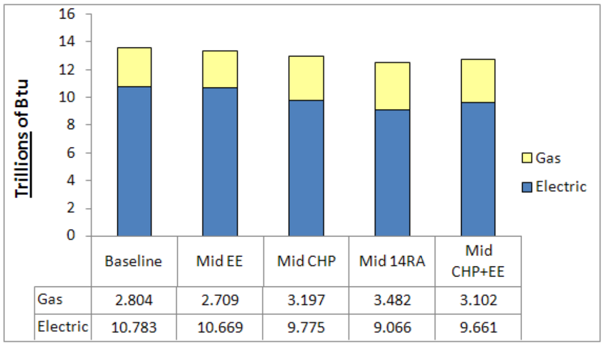


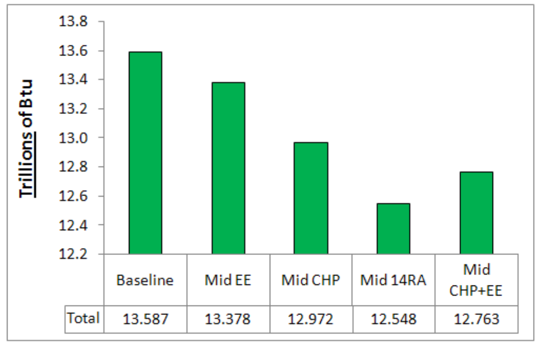
Table 16 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid Market Penetration Rate

Measure	Peak Demand
Mid EE	3.8%
Mid CHP	6.4%
Mid 14RA	11.1%
Mid CHP+EE	10.2%

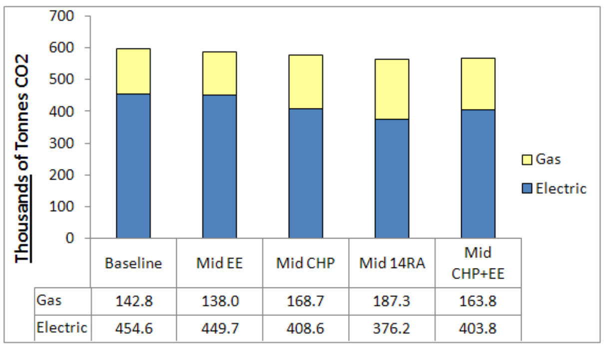
Figure 19 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid Market Penetration Rate



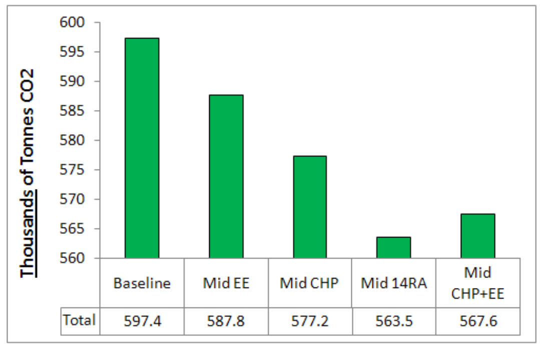
	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Gas	2.804	2.709	3.197	3.482	3.102
Electric	10.783	10.669	9.775	9.066	9.661



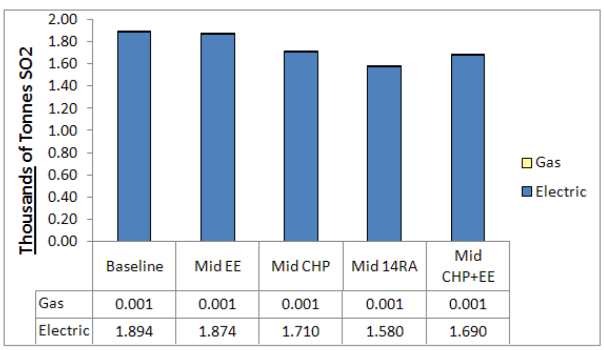
	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Total	13.587	13.378	12.972	12.548	12.763



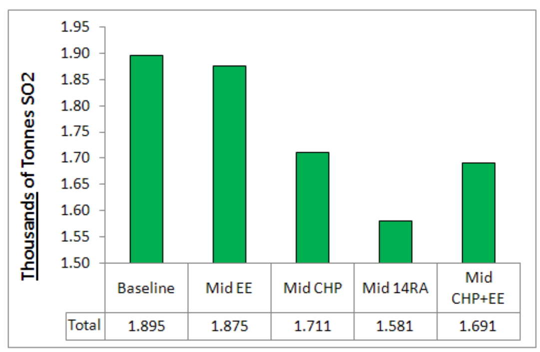
	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Gas	142.8	138.0	168.7	187.3	163.8
Electric	454.6	449.7	408.6	376.2	403.8



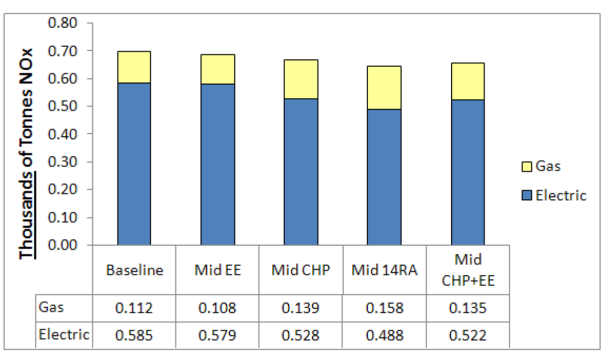
	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Total	597.4	587.8	577.2	563.5	567.6



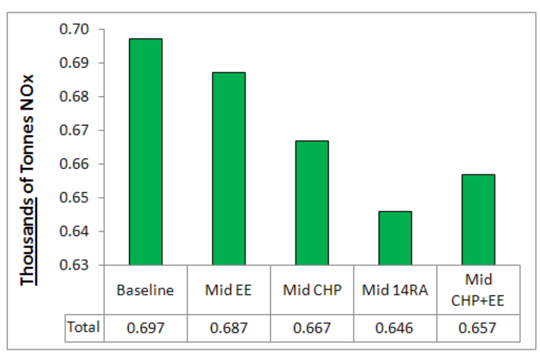
	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Gas	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.874	1.710	1.580	1.690



	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Total	1.895	1.875	1.711	1.581	1.691

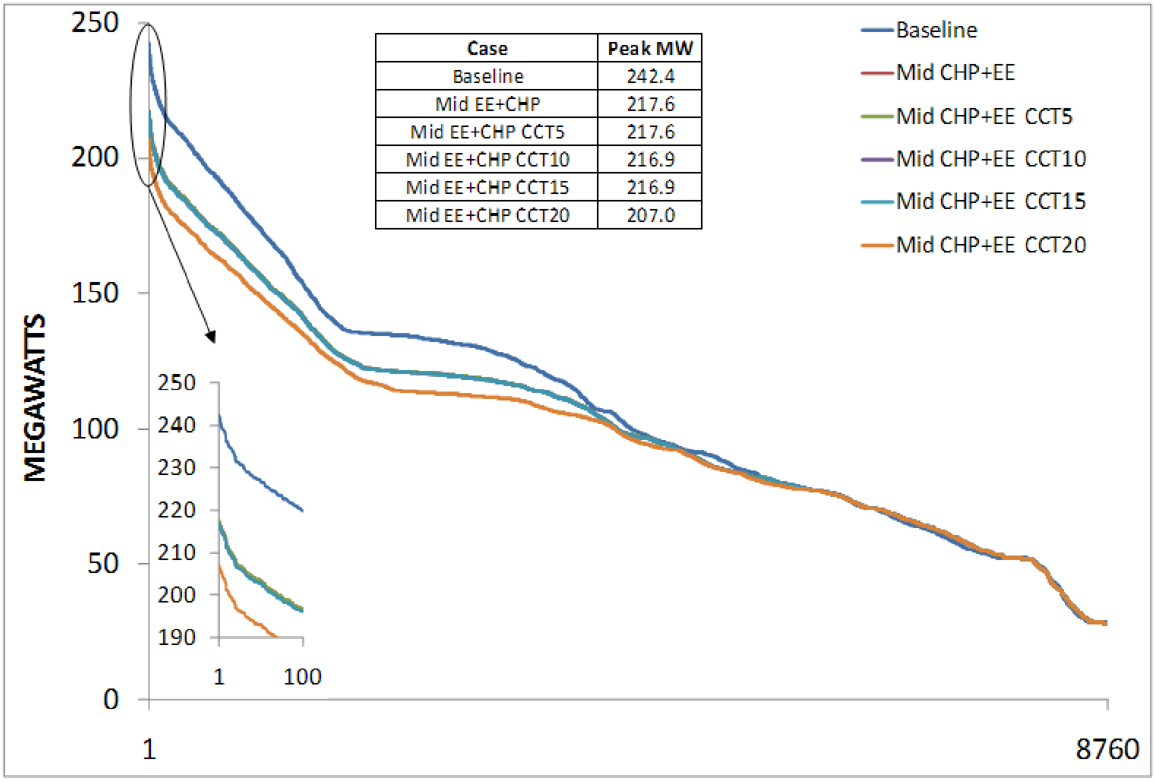


	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Gas	0.112	0.108	0.139	0.158	0.135
Electric	0.585	0.579	0.528	0.488	0.522



	Baseline	Mid EE	Mid CHP	Mid 14RA	Mid CHP+EE
Total	0.697	0.687	0.667	0.646	0.657

Figure 20 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Carbon Cap and Trade Price under a Mid Market Penetration Rate for CHP & EE



Case	Peak MW
Baseline	242.4
Mid EE+CHP	217.6
Mid EE+CHP CCT5	217.6
Mid EE+CHP CCT10	216.9
Mid EE+CHP CCT15	216.9
Mid EE+CHP CCT20	207.0

Table 17 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Carbon Cap and Trade Price under a Mid Market Penetration Rate for CHP & EE

Measure	Peak Demand
Mid CHP+EE	10.2%
Mid CHP+EE CCT5	10.2%
Mid CHP+EE CCT10	10.5%
Mid CHP+EE CCT15	10.5%
Mid CHP+EE CCT20	14.6%

Figure 21 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Carbon Cap and Trade Price under a Mid Market Penetration Rate for CHP & EE

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Gas	2.804	3.102	3.102	3.109	3.109	3.361
Electric	10.783	9.661	9.661	9.639	9.639	9.010

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Total	13.587	12.763	12.763	12.747	12.747	12.371

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Gas	142.8	163.8	164.4	164.8	164.8	181.3
Electric	454.6	403.8	403.8	402.8	402.8	374.1

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Total	597.4	567.6	568.2	567.6	567.6	555.4

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Gas	0.001	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.690	1.690	1.686	1.686	1.571

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Total	1.895	1.691	1.691	1.687	1.687	1.572

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Gas	0.112	0.135	0.136	0.136	0.136	0.153
Electric	0.585	0.522	0.522	0.521	0.521	0.485

	Baseline	Mid EE+CHP	Mid EE+CHP CCT5	Mid EE+CHP CCT10	Mid EE+CHP CCT15	Mid EE+CHP CCT20
Total	0.697	0.657	0.658	0.657	0.657	0.639

Improved Market Penetration Rate – Mid-High Market Penetration

Figure 22 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-High Market Penetration Rate

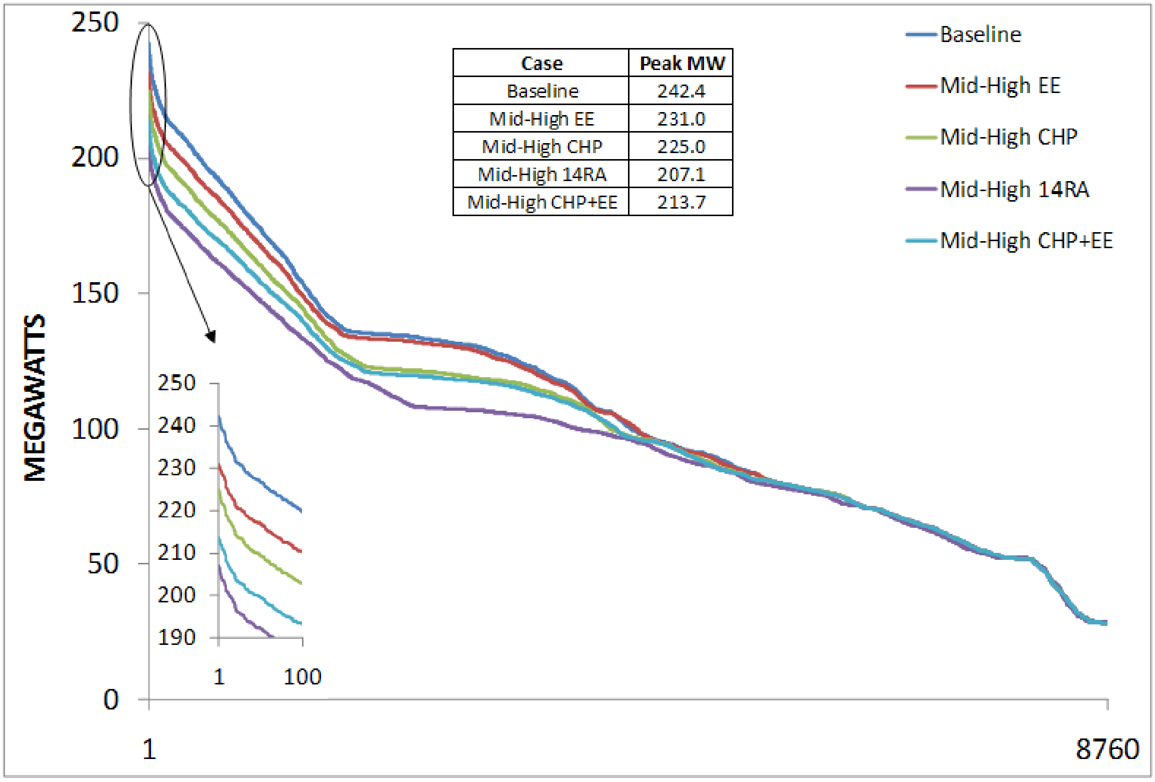


Table 18 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-High Market Penetration Rate

Measure	Peak Demand
Mid-High EE	4.7%
Mid-High CHP	7.2%
Mid-High 14RA	14.6%
Mid-High CHP+EE	11.9%

Figure 23 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Measures Applied to Achieve Load Reductions under a Mid-High Market Penetration Rate

Figure 24 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Carbon Cap and Trade Price under a Mid-High Market Penetration Rate for CHP & EE

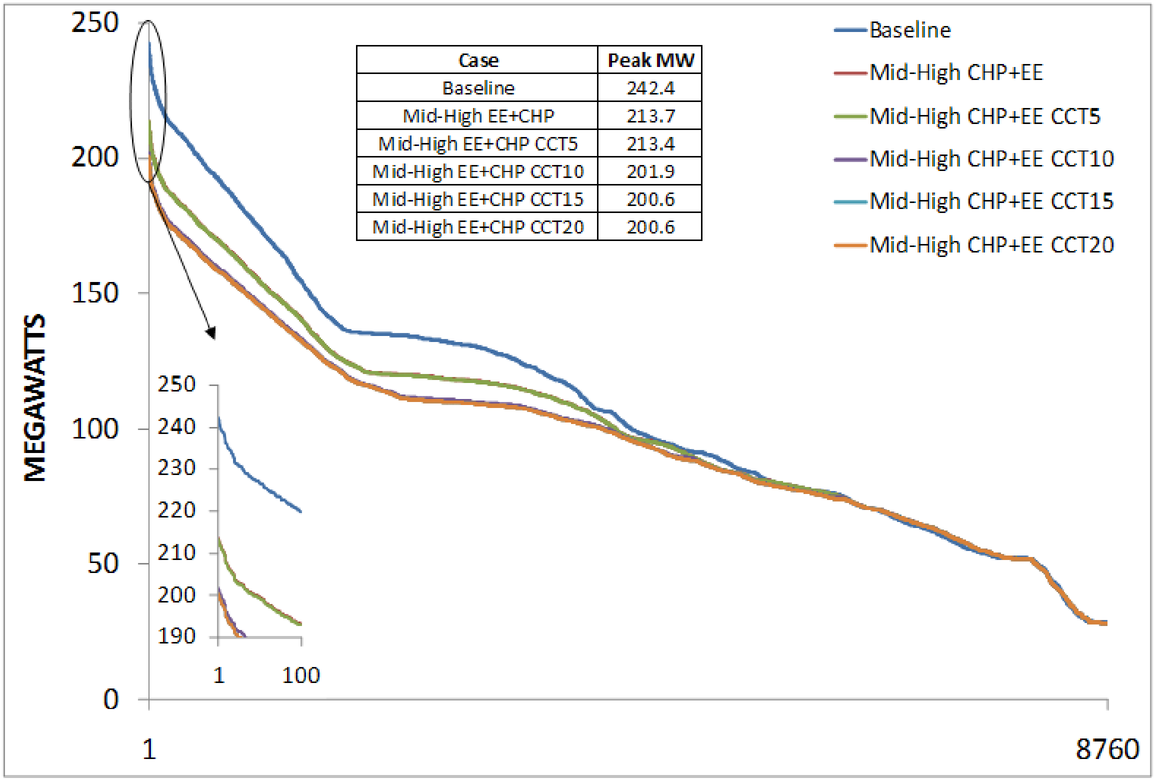


Table 19 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Carbon Cap and Trade Price under a Mid-High Market Penetration Rate for CHP & EE

Measure	Peak Demand
Mid-High CHP+EE	11.9%
Mid-High CHP+EE CCT5	12.0%
Mid-High CHP+EE CCT10	16.7%
Mid-High CHP+EE CCT15	17.3%
Mid-High CHP+EE CCT20	17.3%

Figure 25 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Carbon Cap and Trade Price under a Mid-High Market Penetration Rate for CHP & EE

Trillions of Btu	Baseline	Mid-Hi EE+CHP	Mid-Hi EE+CHP CCT5	Mid-Hi EE+CHP CCT10	Mid-Hi EE+CHP CCT15	Mid-Hi EE+CHP CCT20
Gas	2.804	3.124	3.131	3.412	3.430	3.430
Electric	10.783	9.521	9.505	8.778	8.707	8.707
Total	13.587	12.645	12.636	12.191	12.137	12.137

Thousands of Tonnes CO2	Baseline	Mid-Hi EE+CHP	Mid-Hi EE+CHP CCT5	Mid-Hi EE+CHP CCT10	Mid-Hi EE+CHP CCT15	Mid-Hi EE+CHP CCT20
Gas	142.8	165.5	165.9	184.5	185.8	185.8
Electric	454.6	397.5	396.8	363.7	360.4	360.4
Total	597.4	563.0	562.8	548.1	546.2	546.2

Thousands of Tonnes SO2	Baseline	Mid-Hi EE+CHP	Mid-Hi EE+CHP CCT5	Mid-Hi EE+CHP CCT10	Mid-Hi EE+CHP CCT15	Mid-Hi EE+CHP CCT20
Gas	0.001	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.665	1.662	1.529	1.516	1.516
Total	1.895	1.665	1.663	1.530	1.517	1.517

Thousands of Tonnes NOx	Baseline	Mid-Hi EE+CHP	Mid-Hi EE+CHP CCT5	Mid-Hi EE+CHP CCT10	Mid-Hi EE+CHP CCT15	Mid-Hi EE+CHP CCT20
Gas	0.112	0.137	0.137	0.157	0.158	0.158
Electric	0.585	0.514	0.513	0.472	0.468	0.468
Total	0.697	0.651	0.651	0.629	0.626	0.626

Improved Market Penetration Rate – High Market Penetration

Figure 26 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Measures Applied to Achieve Load Reductions under a High Market Penetration Rate

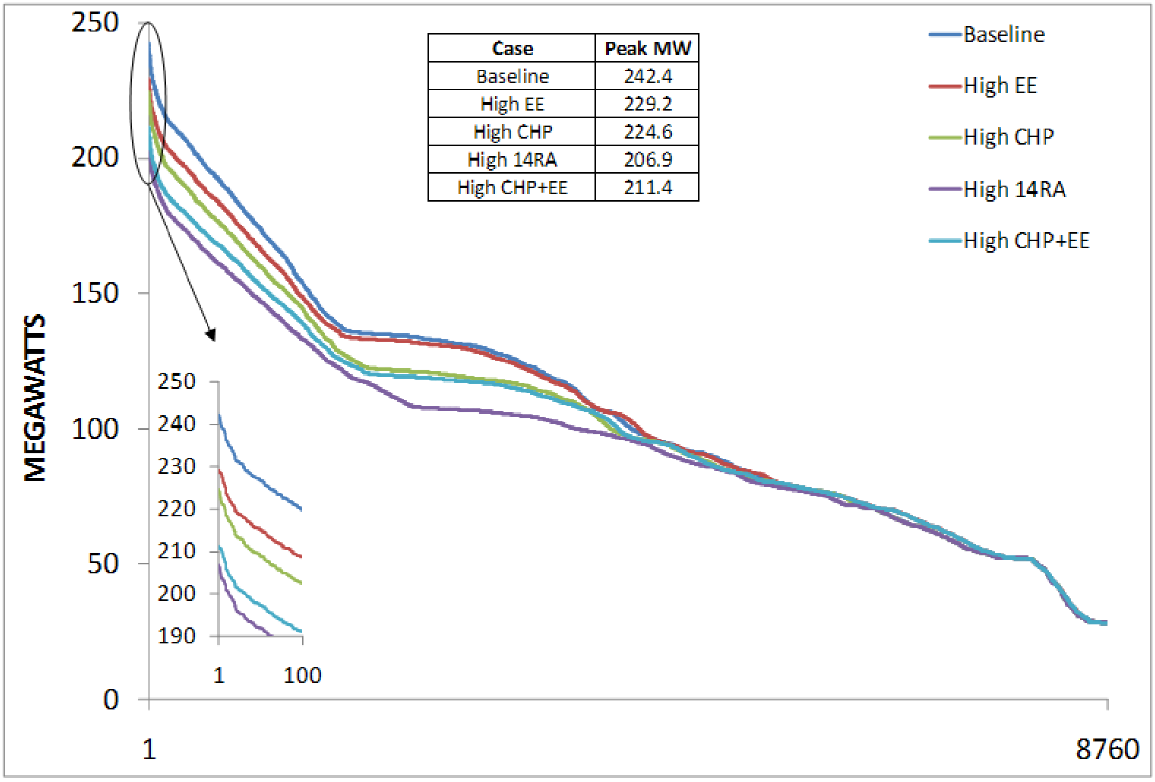
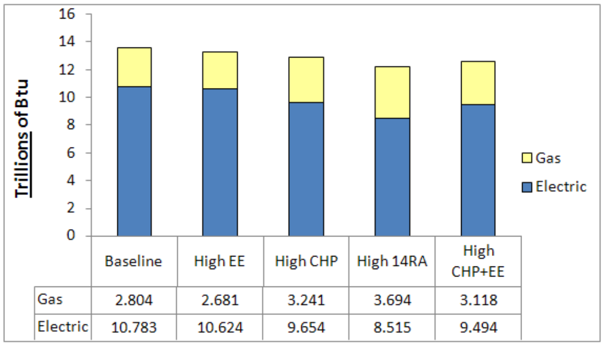


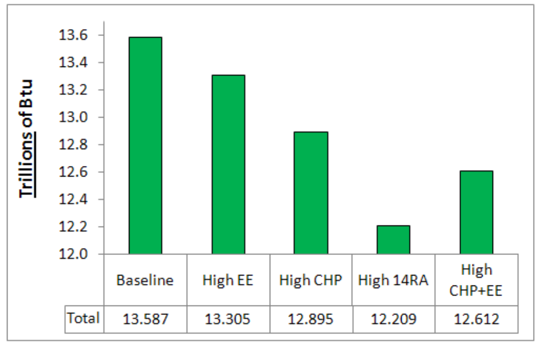
Table 20 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Measures Applied to Achieve Load Reductions under a High Market Penetration Rate

Measure	Peak Demand
High EE	5.5%
High CHP	7.3%
High 14RA	14.7%
High CHP+EE	12.8%

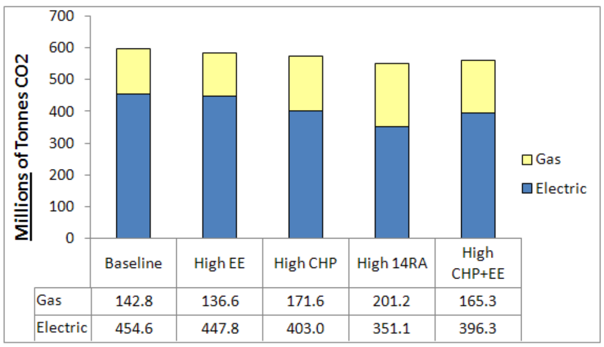
Figure 27 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Measures Applied to Achieve Load Reductions under a High Market Penetration Rate



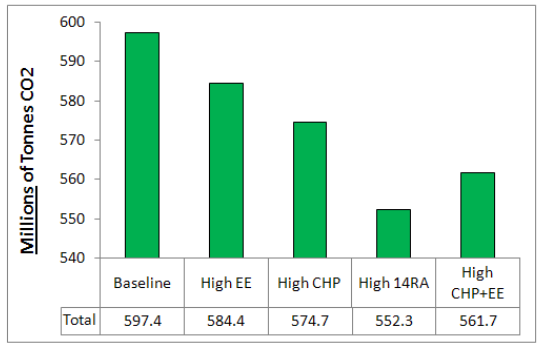
	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Gas	2.804	2.681	3.241	3.694	3.118
Electric	10.783	10.624	9.654	8.515	9.494



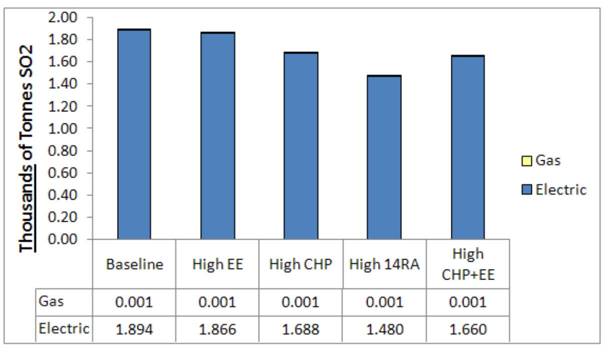
	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Total	13.587	13.305	12.895	12.209	12.612



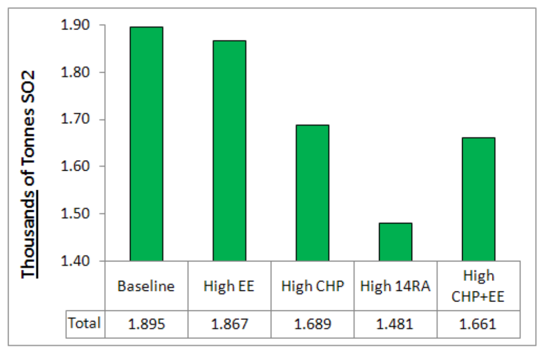
	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Gas	142.8	136.6	171.6	201.2	165.3
Electric	454.6	447.8	403.0	351.1	396.3



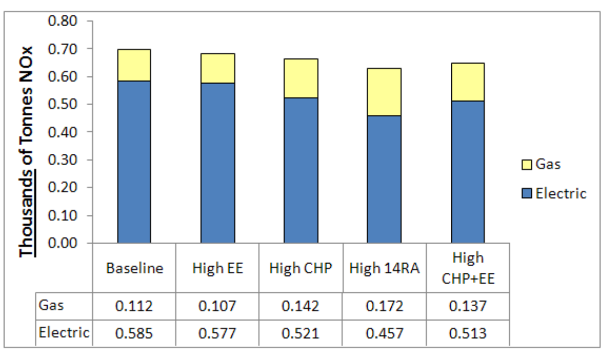
	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Total	597.4	584.4	574.7	552.3	561.7



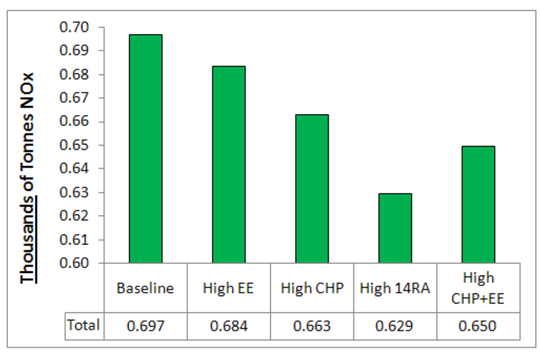
	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Gas	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.866	1.688	1.480	1.660



	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Total	1.895	1.867	1.689	1.481	1.661



	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Gas	0.112	0.107	0.142	0.172	0.137
Electric	0.585	0.577	0.521	0.457	0.513



	Baseline	High EE	High CHP	High 14RA	High CHP+EE
Total	0.697	0.684	0.663	0.629	0.650

Figure 28 - Hudson Yards Aggregate Annual Electric Load Curves - Impact of Varying the Carbon Cap and Trade Price under a High Market Penetration Rate for CHP & EE

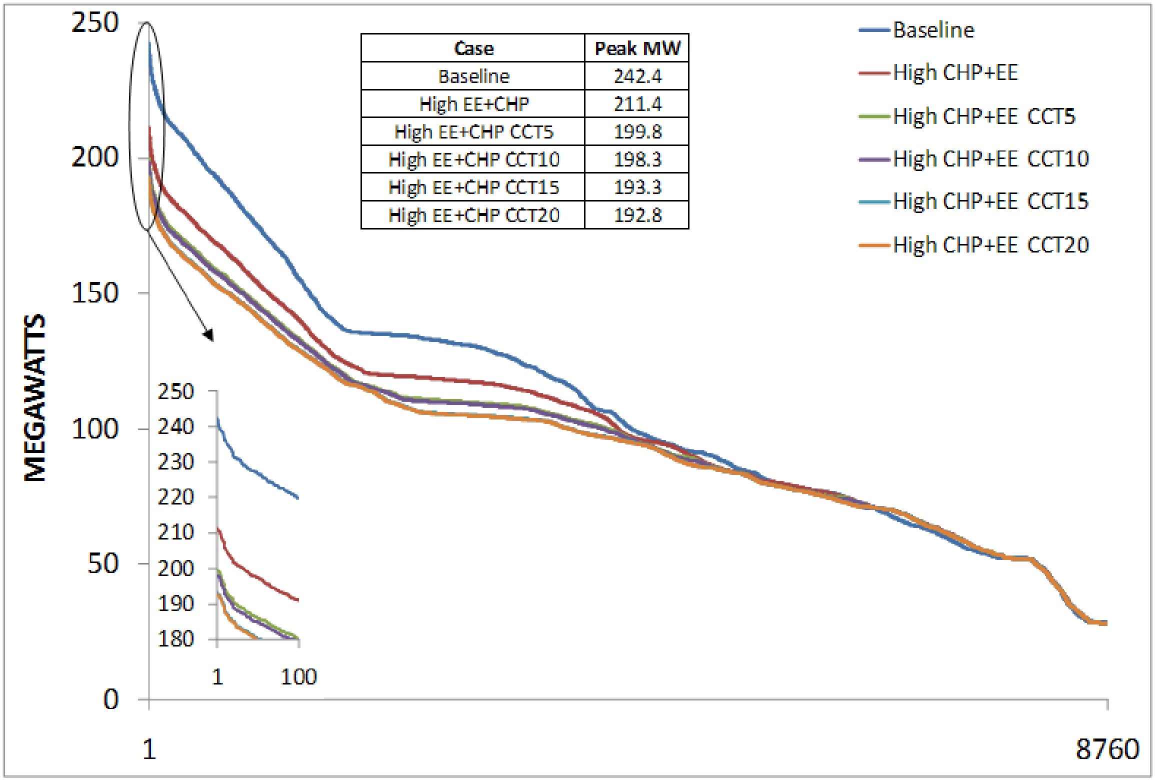


Table 21 - Percentages of Peak Demand Reduction from Baseline - Impact of Varying the Carbon Cap and Trade Price under a High Market Penetration Rate for CHP & EE

Measure	Peak Demand
High CHP+EE	12.8%
High CHP+EE CCT5	17.6%
High CHP+EE CCT10	18.2%
High CHP+EE CCT15	20.3%
High CHP+EE CCT20	20.5%

Figure 29 - Hudson Yards Aggregate Annual Energy Consumption and Emissions - Impact of Varying the Carbon Cap and Trade Price under a High Market Penetration Rate for CHP & EE

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Gas	2.804	3.118	3.396	3.409	3.545	3.546
Electric	10.783	9.494	8.776	8.700	8.358	8.339

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Total	13.587	12.612	12.172	12.109	11.903	11.885

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Gas	142.8	165.3	181.3	184.7	193.6	193.7
Electric	454.6	396.3	363.6	360.1	344.5	343.7

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Total	597.4	561.7	544.9	544.8	538.1	537.4

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Gas	0.001	0.001	0.001	0.001	0.001	0.001
Electric	1.894	1.660	1.528	1.515	1.452	1.449

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Total	1.895	1.661	1.529	1.516	1.453	1.450

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Gas	0.112	0.137	0.151	0.157	0.166	0.167
Electric	0.585	0.513	0.472	0.468	0.448	0.447

	Baseline	High EE+CHP	High EE+CHP CCT5	High EE+CHP CCT10	High EE+CHP CCT15	High EE+CHP CCT20
Total	0.697	0.650	0.623	0.625	0.615	0.614

ANALYSIS DISCUSSION

Overall Capacity, Source Energy, and Emissions Impacts

The Hudson Yards redevelopment presents challenging electric demand growth with potentially difficult in-city power, transmission, and distribution siting and financing issues. As such, reducing demand capacity is critical. Furthermore, developers are increasingly being pressured to reduce their carbon footprints. In fact, over 52 cities in New York, including New York City, have joined the Cool Cities initiative, committing to reduce carbon emissions to 1990 levels.[x] The results of this report provide key insights toward the impact that energy efficiency strategies and CHP can have on the rising electricity demand and associated emissions in New York City. Figure 30 provides a range of results based on market penetration rates from BAU to High market penetrations for the following scenarios:

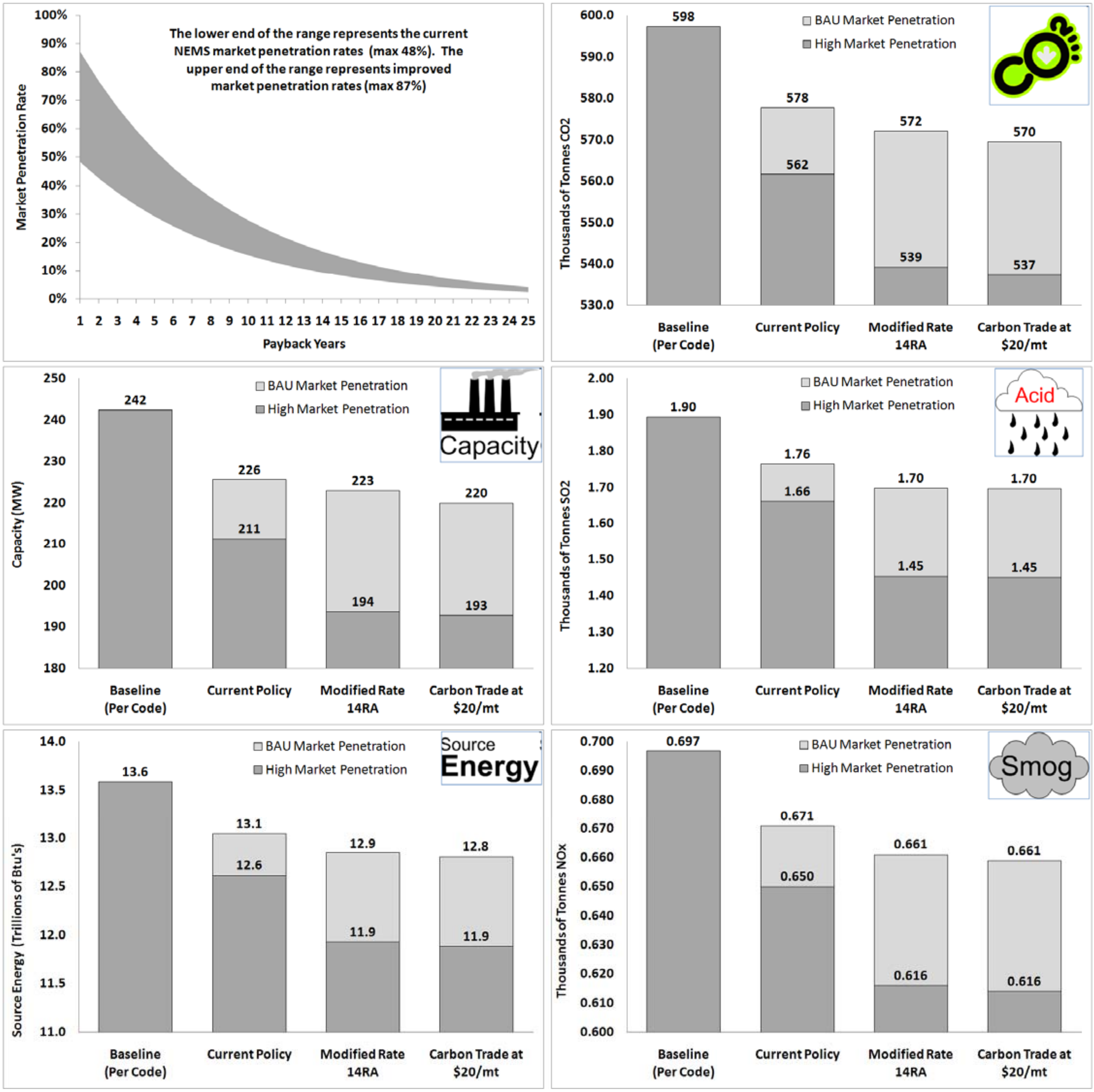
1. Baseline – All buildings built per code with no market penetration of CHP or energy efficiency strategies above code
2. Current Policy – Potential market as it exists today without modifications to energy rates or implementation of carbon trading policies
3. Modified Rate 14RA - Replace the contract demand of $8.02/kW with a delivery charge of approximately 0.58 cents per kWhr in Con Edison Cogeneration Standby Rate PSC2, SC14-RA
4. Carbon Trade at $20/mt – Implement a carbon trading policy that puts a value on carbon at $20/mt

The charts shown in Figure 30 show that there is significant potential to reduce demand capacity, source energy, and associated emissions in Hudson Yards if improved market penetration rates are achieved. Up to 30MW of capacity can be eliminated while saving a trillion BTU's of source energy, thereby reducing the annual carbon footprint by 36,000 tonnes. That reduction in carbon footprint is equivalent to removing about 6,000 cars from the road at 12,000 mi/yr and 21 mpg.

The charts in Figure 30 also show that modifying Con Edison's Standby rate has about the same effect as implementing a carbon trade policy at $20/mt. Almost 50MW of capacity can be eliminated while saving 1.7 trillion BTU's of source energy, thereby reducing the annual carbon footprint by over 60,000 tonnes. That reduction in carbon footprint is equivalent to removing over 10,000 cars from the road at 12,000 mi/yr and 21 mpg. Proportional reductions in SO2 and NOx are also possible as reflected in the charts.

Reducing electric energy consumption from load growth reduces new utility revenue. However, reducing electric capacity from load growth reduces utility capital expense. Lost revenue from load growth could be as high as $23 million per year, which represents considerably less than one half percent of Con Edison's annual revenue from electric sales. With Con Edison's predicted long-term cost for capacity at $2,375/kW, a 50 MW drop in capacity represents almost $120 million in reduced capital investment.

Figure 30 – Capacity, Source Energy, and Emissions Charts - Impacts due to the Implementation of EE and CHP for a range of Market Penetrations levels from BAU to High

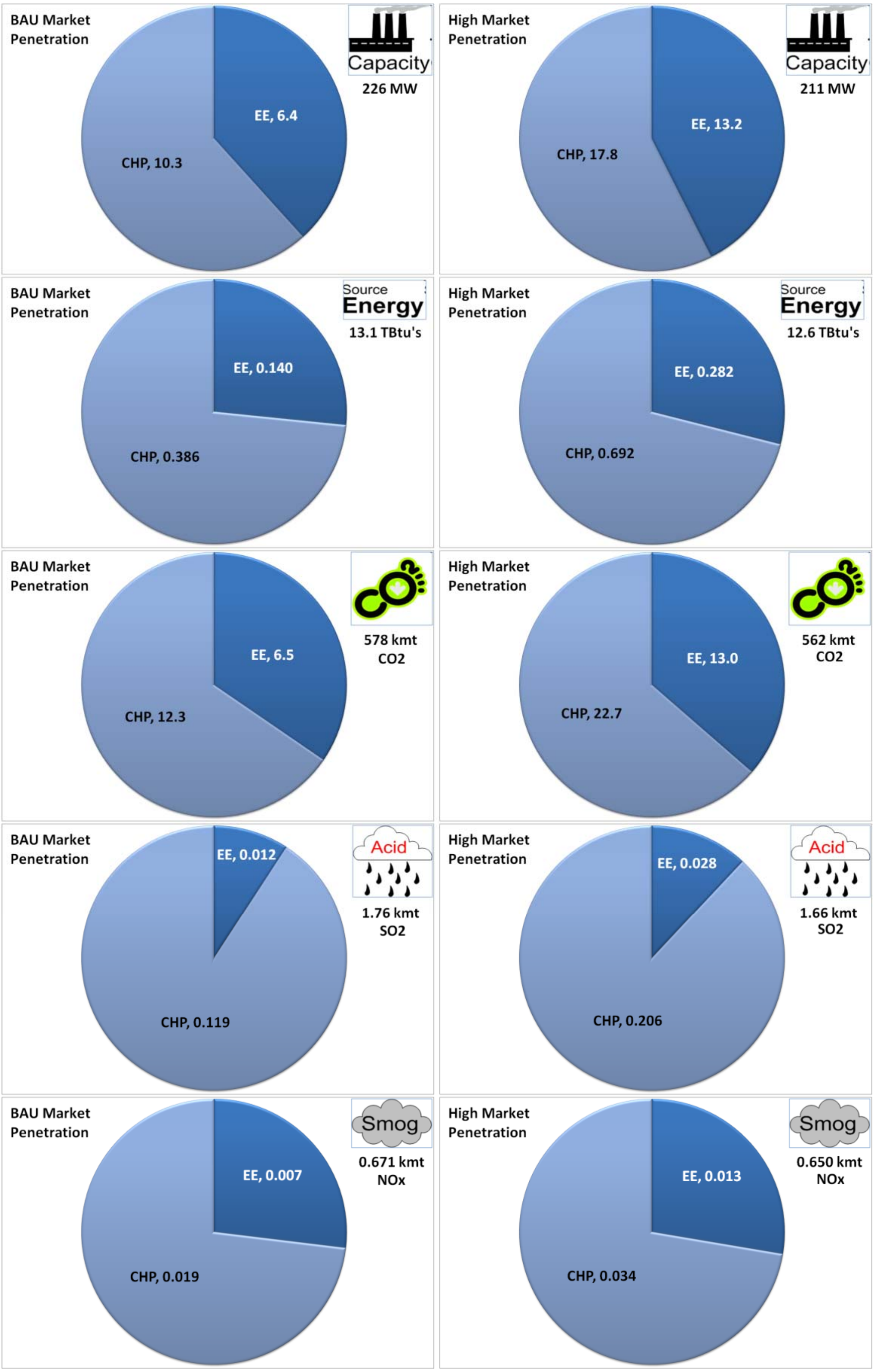


Energy Efficiency vs. CHP Impacts

The charts in Figure 31 show the contribution in reductions to capacity, source energy, and emissions from CHP and EE. The charts down the left side show the results based on current NEMS maximum market penetration rate of about 50%. The charts down the right side show the results based on an improved maximum market penetration rate of about 90%. It is clear from these charts that adopted CHP plays a larger role in reductions than all of the adopted EE measures combined. This is more evident in source energy and emissions reductions than in capacity reductions. However, CHP is still the dominant factor in capacity reduction as well.

As an example, the upper left pie chart shows the capacity (MW) savings for the BAU market penetration. CHP reduces the capacity by 10.3 MW, from 226 MW to about 216 MW. EE reduces the capacity by 6.4 MW, from 226 MW to about 220 MW.

Figure 31 – Energy Efficiency and CHP Charts - Impacts due to the Implementation of EE and CHP for a range of Market Penetrations levels from BAU to High



Energy Efficiency Measures

Impacts on the aggregate Hudson Yards load from individual EE measure were not analyzed. However, the building-by-building analyses reveal some useful results (Reference Table 24 through Table 29 in Appendix C). For example, some of the more attractive EE measures with respect to adoption include:

1. Space cooling chiller efficiency that is 20% better than ECCC requirements for office, residential, and hotel buildings
2. Space cooling unitary air conditioning that is 20% better than ECCC requirements for retail and restaurant space
3. Ice-on-Coil thermal storage systems sized conservatively to accommodate 15% to 25% of the total cooling capacity for office buildings
4. Boilers with efficiency levels at 85% as opposed to 80% for hotel and residential buildings
5. Individual gas-fired, warm air furnaces with AFUE levels at 94% as opposed to 78% for retail and restaurant spaces
6. Gas-fired instantaneous water heaters as opposed to gas-fired storage water heaters for retail spaces

Some of the EE measures that performed exceptionally poor with respect to adoption include:

1. Boilers with efficiency levels at 85% as opposed to 80% for office buildings
2. Energy Star rated appliances for individual dwellings in residential buildings
3. Lighting efficiencies better than ECCC requirements for both hotel and residential buildings (ECCC requirements are already relatively stringent)
4. Ice-on-Coil thermal storage systems for large residential buildings

CHP Measures

Current deployment of CHP in New York City lags far below the significant potential as defined by the current market penetration for this study; and there are many well-documented factors that influence the current deployment situation. A recent study by Columbia University's Urban Energy Program identifies three of the key obstacles to CHP deployment as:[xi]

1. The mechanics of connecting to the Consolidated Edison grid (adds cost)
2. A complex policy environment and approval process (adds cost)
3. Project economics (Items 1 and 2 contribute to this)

The study also suggests that while there is a clear role for CHP to play in filling the supply gap, CHP's potential will only be realized to the extent that a pro-CHP policy environment can be implemented within New York City.[xi] The authors recommend that research be conducted into new market structures and regulatory systems that more systematically incentivize CHP interconnections with the local grid. To achieve desirable market penetration rates, it is clear that the three key obstacles mentioned above must be addressed. In fact, the cost for CHP in this study was set unusually high at $3,000/kW to account for the additional costs.

This study addresses CHP with respect to project economics and policy environment by analyzing the impacts of a more CHP-friendly tariff structure (modified 14RA) and carbon crediting that can incentivize CHP interconnections. Table 22 shows a breakdown of the economic scenarios for 6.5MW of CHP in building prototype 1 (56-story highrise office), including the annual costs and simple payback calculations. The business-as-usual CHP scenario for prototype 1 results in a 9.1-yr simple payback and a predicted market penetration rate of 17% across the 20-yr study period. Providing carbon credit (for CHP alone) reduces the simple payback to 8.2 years but that only increases the penetration rate to 19%. It is important to note that Table 22 reflects the results of CHP only. Other EE measures that may have been adopted for building prototype 1 are not included so that the results for CHP alone can be seen.

Upon further observation of the cost breakdowns for the building with CHP and without CHP, it can be seen that the energy cost components (i.e. electric energy plus metered gas) are within about 10% of one another. In contrast, the demand savings from CHP are over 500%. In effect, all of the electric savings from CHP can be attributed to lowering the buildings on-peak demand charges because the CHP system operates during the entire on-peak period. However, Con Edison applies a standby contract demand charge in return for backup power service during peak periods. The contract demand accounts for almost 15% of the total annual energy bill and cuts the demand savings by well over half (i.e. 500% to 210%). The Columbia University study suggests that policymakers and Con Edison would both benefit from an independent assessment of Con Edison's fundamental approach toward distributed generation. The assessment would examine whether their approach is excessively cautious, or whether it is entirely appropriate give the need to maintain high levels of system reliability. Clearly from the aggregate results, reducing the paybacks for CHP under a modified rate 14RA has a positive impact on capacity, source energy, and emissions reductions. Reducing the payback for CHP in building Prototype 1 from 9.1 yrs to 6.4 yrs, as shown in Table 22 increases the penetration rate for that building type to almost 25%. Furthermore, combining carbon credits with standby relief would increase the penetration rates for building Prototype 1 to over 25%.

Table 22 – BAU CHP Cost Breakdowns for Prototype 1 with Modified 14RA and CCT

Annual Cost Component	No CHP		CHP		CHP 14RA		CHP CCT20		CHP 14RA+CCT20	
Electric Energy	$4,455,205	54%	$1,541,960	24%	$1,645,832	30%	$1,541,960	25%	$1,645,832	31%
Electrc Demand	$3,399,367	41%	$668,294	11%	$668,294	12%	$668,294	11%	$668,294	12%
14RA Contract Demand	$0	0%	$905,042	14%	$0	0%	$905,042	15%	$0	0%
Fixed Electricity Charge	$672	0%	$13,632	0%	$13,632	0%	$13,632	0%	$13,632	0%
Metered Gas	$422,954	5%	$2,819,378	44%	$2,819,378	51%	$2,819,378	46%	$2,819,378	53%
CHP Carbon Credit*	$0	0%	$0	0%	$0	0%	-$202,000	-3%	-$202,000	-4%
CHP System O&M	$0	0%	$403,272	6%	$403,272	7%	$403,272	7%	$403,272	8%
Total Annual Energy $	$8,278,198	100%	$6,351,578	100%	$5,550,408	100%	$6,149,578	100%	$5,348,408	100%
Total CHP System Cost	NA		$19,520,836	-	$19,520,836	-	$19,520,836	-	$19,520,836	-
Incentive Capped at $2M			$2,000,000	10%	$2,000,000	10%	$2,000,000	10%	$2,000,000	10%
Total Capital Cost			$17,520,836	90%	$17,520,836	90%	$17,520,836	90%	$17,520,836	90%
Annual Savings			$1,926,620	10%	$2,727,790	14%	$2,128,620	11%	$2,929,790	15%
Simple Payback			9.1		6.4		8.2		6.0	

* Carbon Credit from CHP only, no EE measures

Suppose Con Edison's fundamental approach toward distributed generation is appropriate given the need to maintain system reliability, and that eliminating the standby charges is inappropriate; an alternative could be for New York electricity markets to provide ancillary payments for CHP services in the form of variable or fixed capacity payments. Current variable capacity payments are down from $12/kW/mo a year ago to $6/kW/mo according to NY ISO.[xii] For Prototype 1 above, the total annual payments would be about $468,000 at $6/kW/mo. These payments would compensate building owners for providing much needed capacity in New York City.

New York's surging peak demand will necessitate the building of new central generation, transmission, and distribution, unless EE and CHP penetration rates are improved. New central generation plant costs have risen dramatically over the past three years with coal plant costs exceeding $2,500/KW, not including the T&D needed to carry this generation to a building.[xiii] While the NY ISO is providing a small variable capacity payment, policy makers should consider also providing a fixed capacity payment that would provide a performance based incentive for new on-site capacity. An annual capacity payment equal to the cost of spending $2,500/KW up front for new generation is about $150/KW/yr across 25 years at a discount rate of 3%. A fixed capacity payment at about $150/KW/yr would increase annual payments from about $468,000 to $975,000.

Another way for New York to increase CHP deployment is to accelerate the completion of the Con Edison network system upgrades that will allow parallel interconnection of synchronous generators in Hudson Yards and other locations. Older network protectors installed in Con Edison's territory require a disconnect from the grid in approximately one quarter cycle or less in the presence of a fault current. Otherwise, the network protector can be damaged and cause outages. Newer network protectors do not have such stringent disconnect requirements. Though some smart fuses can disconnect within one quarter cycle, they require a fault current much higher than what Con Edison currently allows. Inverters downstream of synchronous generators can be used to meet the disconnect requirement, but add up to $600 per kW installed to the project.[xiv] The installed costs include the cost of the inverters, additional electrical wiring and special chilled water circuits for cooling the inverters. These costs were factored in to the costs for the CHP analyses in this study.

Con Edison is in the process of upgrading the network protectors. The Hudson Yards District is scheduled to be upgraded in 2012. If this schedule can be accelerated so that the fault current protection is not required, the installed CHP costs can be reduced by approximately 15%.

The installed cost for CHP as defined in the assumptions was $3,000/kW with a $600/kW subsidy capped at $2M. Considering the subsidy and the cost of inverters, the total installed cost for 6.5MW of CHP in building prototype 1 can be $19.5M (without subsidy), $17.5M (with subsidy) and $16.7M (with subsidy and no inverters).

Table 1 shows the effects of various policies on paybacks for CHP in building prototype 1 at the various costs.

Table 23 - CHP Cost Breakdowns for Prototype 1 with Capacity Payments and CCT

	CHP without Subsidy First Cost = $19,500,000		CHP with $2M Subsidy First Cost = $17,500,000		CHP w/ $2M Subsidy & no Inverters First Cost = $16,700,000	
Policy Scenarios	**Annual Savings**	**Payback**	**Annual Savings**	**Payback**	**Annual Savings**	**Payback**
BAU	$1,900,000	10.3	$1,900,000	9.1	$1,900,000	8.8
Modified 14RA	$2,700,000	7.2	$2,700,000	6.4	$2,700,000	6.2
Variable Capacity	$2,368,000	8.2	$2,368,000	7.4	$2,368,000	7.1
+Fixed Capacity	$3,343,000	5.8	$3,343,000	5.2	$3,343,000	5.0
+Carbon CCT 20	$4,143,000	4.7	$4,143,000	4.2	$4,143,000	4.0

The BAU CHP scenario for prototype 1 results in a 9.1-yr simple payback and a predicted market penetration of 17%. The market penetration drops to 15% without the subsidy and jumps to 33% with a 4-yr payback if variable capacity, fixed capacity, and CCT20 policies are collectively implemented. At High market penetration rates, the market penetration for a 4-yr CHP payback is 60%.

Other market factors that could increase market penetration include:

1. Building certification requirements such as LEED and Energy Star are now being considered by many building owners. In addition, some large cities including New York City are considering requiring building certification. CHP can have a major impact on a building's Energy Star rating. This is because Energy Star converts energy consumptions from site energy to source energy. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, thereby enabling a complete and equitable assessment of energy efficiency in a building. Source-site energy ratios are applied to convert each Btu of energy used on site into the total Btu of equivalent source energy consumed. The source to site ratio for electricity is 3.34. As a result, CHP reduces the total Btu's, thereby increasing a building Energy Star rating. Preliminary modeling of a large office building with and without CHP using the Energy Star on line program revealed that CHP could increase Energy Star rating by as much as 8 points.[xv]

Other factors that could decrease penetration rates include:

1. The New York environmental board is proposing new emissions rules that would lower the current output based emission limits to 0.9 lb/MWh. Pending changes

to output-based emissions requirements could increase the first and operating costs of CHP, thereby reducing penetration rates.

CHP Performance Requirements

NYSERDA's Commercial/Industrial Performance Program is designed to financially incentivize CHP systems that provide at least 500 kW of summer on-peak demand reduction. Additionally, the program requires that the system demonstrates a minimum annual fuel conversion efficiency of 60% at design. Building Prototype 1 has a predicted summer peak demand of about 10 MW. Given the thermal loads and mechanical arrangement of the building, the appropriate system size to only just meet the 60% efficiency requirement is about 6.5 MW. Coincidently, 6.5 MW is also the optimal size for best economics. However, in some cases the system size has to be reduced because lower heating and cooling requirements in the shoulder months prevent the systems thermal output from being fully utilized, even with an absorption chiller. As a result, the NYSERDA minimum efficiency requirement incentivizes building owners to put in smaller systems than would otherwise be optimal for meeting the electrical demand requirements of the building and maximizing the economics. The reduction in size would make an even bigger impact on the economics if capacity payments were considered. As such, the minimum efficiency policy can reduce CHP market penetration, peak load reduction, and CO2 reduction in some cases.

During periods of high peak loads on the grid, less efficient and higher CO2-producing generators are brought on line as electricity prices increase during the peak periods. Modern engines used in CHP plants typically produce less CO2 than smaller, less efficient peaker plants. Since the NYSERDA requirements, in some cases, ultimately incentivize smaller plants, more power from the less efficient plants will be produced. It is understood that NYSERDA's goal is to promote energy efficient plants. In light of the needs in New York City to reduce peak demand and reduce CO2, NYSERDA should consider modifying the requirements to also give credit for demand reduction and CO2 reduction as well as efficiency. NYSERDA does have an incentive program for demand reduction but this does not currently include CHP plants as they are not considered permanent load reduction.

CONCLUSIONS, RECOMMENDATIONS, OBSERVATIONS

The following conclusions, recommendations and observations can be drawn from the results of this study:

Conclusion #1: Customer adoption rates of EE and CHP decrease exponentially with increasing simple payback. As such, CHP market penetration rates are limited in Hudson Yards due to simple paybacks in the range of 7 to 10 years even with current subsidies at $600/kW (capped at $2 million).

Conclusion #2: Under a business-as-usual scenario EE and CHP have the potential to reduce the Hudson Yards peak demand by only about 6% and the carbon footprint by only about 3%.

Conclusion #3: Peak demand for the Hudson Yards redevelopment area can be reduced by up to 20% (almost 50MW) and the carbon footprint reduced by about 10% (equivalent to removing approximately 10,000 cars) with some individual policy changes.

Conclusion #4: Carbon credits, fixed capacity payments in addition to current variable payments, and a pro-CHP tariff structure are all effective policy tools to reduce peak demand and emissions (including carbon footprint). Combining these policy tools would generate significantly higher peak demand and emissions reductions than individual policy changes.

Conclusion #5: CHP alone can be more effective at reducing peak demand, source energy and emissions (including carbon footprint) than high-efficiency building envelope material and high-efficiency mechanical equipment combined.

Recommendation #1: Adopt the following policies and actions that appropriately value or reduce the cost of EE and CHP:

- Provide a fixed 25 year capacity payment in the range of $150/kW/yr
- Establish a robust carbon trading system in NY that would allow building owners to sell the carbon reduction resulting from CHP and EE
- Accelerate the completion of the ConEd system upgrades for Hudson Yards to provide for synchronous interconnection of CHP, thereby reducing CHP system first costs by up to $600/KW. (about the same as the current NYSERDA incentive for CHP)

Recommendation #2: Consider changing the focus of incentive requirements from high efficiency to carbon reduction.

- Option A: Instead of requiring that CHP systems meet a minimum efficiency, establish a minimum carbon reduction percentage, and/or;
- Option B: Reduce the minimum CHP system efficiency from 60% to 50% to allow for larger CHP systems in commercial buildings. This may only apply to certain building types.

Observation #1: Electric chillers 20% more efficient than required by the Energy Conservation Construction Code of New York City could be economically attractive energy efficiency measures for all buildings modeled in this study.

Observation #2: Ice-on-Coil thermal storage systems sized conservatively to accommodate 15% to 25% of the total cooling capacity may be economically attractive peak demand reduction measures for office buildings modeled in this study.

Observation #3: Pending reductions to output-based emissions requirements could increase the first and operating costs of CHP, thereby reducing market penetration rates and potential for peak demand and emissions reductions.

Observation #4: Growing pressure for building owners to obtain Energy Star building certification could increase CHP and EE penetration rates. Improving the overall building energy efficiency increases the Energy Star rating.

Observation #5: Current NOx and SO2 cap and trade policies in New York do not allow building owners to obtain credit for their NOx and SO2 reductions associated with reducing building electricity consumption via EE and CHP. Reductions in electricity at the point of use are not factored into the overall state/region NOx and SO2 cap. This issue will need to be addressed if a carbon trading program is to be established. The carbon trading program should assign carbon credits to building owners that reduce electricity consumption so that building owners can be rewarded for their efficiency efforts.

APPENDIX A - ASSUMPTIONS

Construction Types

For the purposes of this study, the following two construction types apply unless otherwise noted.

Type I: Frame wall - Structural steel interior frame with exterior unitized curtain wall system (prefabricated panels). The curtain wall system is comprised of aluminum framing; double glazed insulating glass units; single-pane opacified spandrel glass or equivalent panel coverings (e.g. granite panels); insulation is placed within metal back-pans behind the spandrel glass; gypsum board is used for the interior. Roofs are low-slope structural concrete decks with parapets. Continuous tapered insulation is placed over the concrete and modified bitumen membrane is placed over the insulation.

Type II: Mass Wall - Structural steel interior frame with pre-cast concrete exterior wall system; double glazed insulating glass; cavity insulation is placed within a metal-stud back-up wall assembly behind the concrete; gypsum board is used for the interior. Roofs are low-slope structural concrete decks with parapets. Continuous tapered insulation is placed over the concrete and modified bitumen membrane is placed over the insulation.

Building Prototypes

For classification purposes, although in many cases more than one type of construction may be used, a single construction type for each prototype was selected. The construction types are intended to meet the 2007 Energy Conservation Construction Code of New York State (NYS ECCC) but be specific to this study.

Corner Retail Shops and Restaurants are modeled with two adiabatic walls each and adiabatic roofs. Internal Retail Shops are modeled with three adiabatic walls each and adiabatic roofs. The Mixed Use Residential is modeled with an adiabatic floor and the Mixed Use Office is modeled with an adiabatic roof.

High Rise Office Buildings – Prototypes 1-3

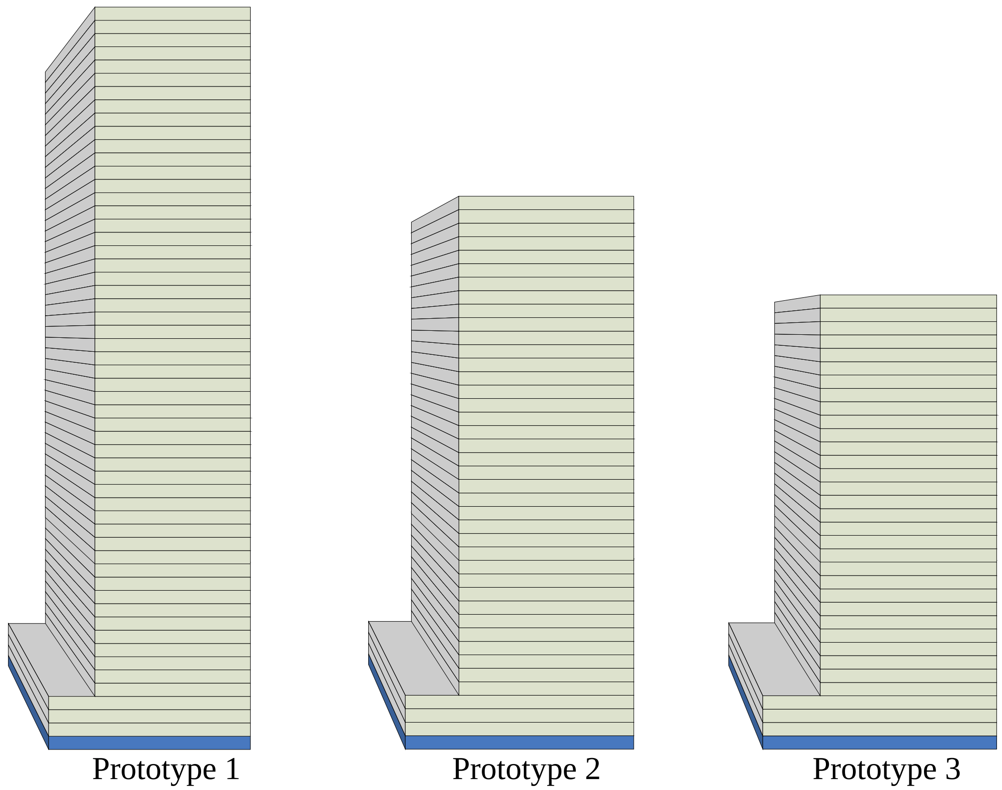
Prototypes 1-3 are Type I construction with an unconditioned basement below grade. The ground floor includes a 7,400 sqft corner restaurant and individual retail shops at approximately 2,000 sqft each. All but one floor above the ground floor are occupied by offices. The remaining floor is used for mechanical equipment and is unconditioned. The floor-to-floor height for all levels is 13'-6".

<u>Prototype 1, High Rise Office Building</u>; Approximately 1,914,000 sqft 56-story building with approximately 43,000 sqft of commercial space at ground level demised to accommodate 18 individual retail shops and a corner restaurant. Approximately 1,837,000 sqft of conditioned office space including corridors is above the ground floor.

<u>Prototype 2, High Rise Office Building</u>; Approximately 1,706,000 sqft 41-story building with approximately 51,000 sqft of commercial space at ground level demised to

accommodate 22 individual retail shops and a corner restaurant. Approximately 1,613,000 sqft of conditioned office space including corridors is above the ground floor.

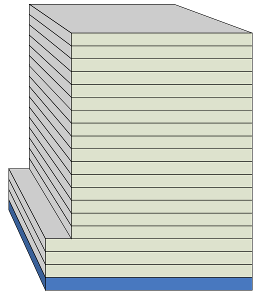
Prototype 3, High Rise Office Building; Approximately 1,544,000 sqft 34-story building with 56,000 sqft of commercial space at ground level demised to accommodate 24 individual retail shops and a corner restaurant. Approximately 1,443,000 sqft of conditioned office space including corridors is above the ground floor.



Mid Rise Office Building – Prototype 4

Prototype 4 is Type II construction with an unconditioned basement below grade. The ground floor includes a 7,400 sqft corner restaurant and individual retail shops at approximately 2,000 sqft each. All but one floor above the ground floor are occupied by offices. The remaining floor is used for mechanical equipment and is unconditioned. The floor-to-floor height for all levels is 13'-6".

Prototype 4 is an approximately 883,000 sqft 20-story building with approximately 47,000 sqft of commercial space at ground level demised to accommodate 20 individual retail shops and a corner restaurant. Approximately 792,000 sqft of conditioned office space including corridors is above the ground floor.

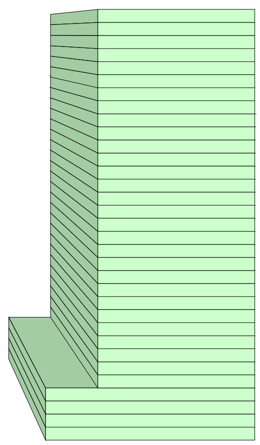


Prototype 4

High Rise Hotel – Prototype 5

Prototype 5 is Type I construction. The hotel lobby, ballrooms, and meeting rooms consume 25% of the total occupied space. The integrated hotel restaurant and laundry areas consume an additional 5% of the total occupied space. The floor-to-floor height for all levels is 13'-6".

Prototype 5 is an approximately 1,250,000 sqft 33-story hotel with 1400 rooms. Approximately 875,000 sqft of space is available for hotel guest rooms at an average 750 sqft per room.

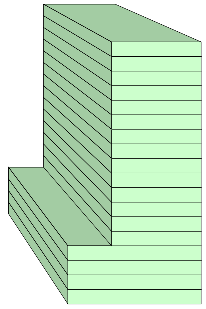


Prototype 5

Mid Rise Hotel – Prototype 6

Prototype 6 is Type II construction. The hotel lobby consumes 5% of the total occupied space. The hotel laundry area consumes an additional 5% of the total occupied space. The floor-to-floor height for all levels is 13'-6".

Prototype 6 is an approximately 231,000 sqft 18-story hotel with 233 rooms. Approximately 208,000 sqft of space is available for hotel guest rooms at an average 750 sqft per room.



Prototype 6

High Rise Residential Buildings – Prototypes 7-10

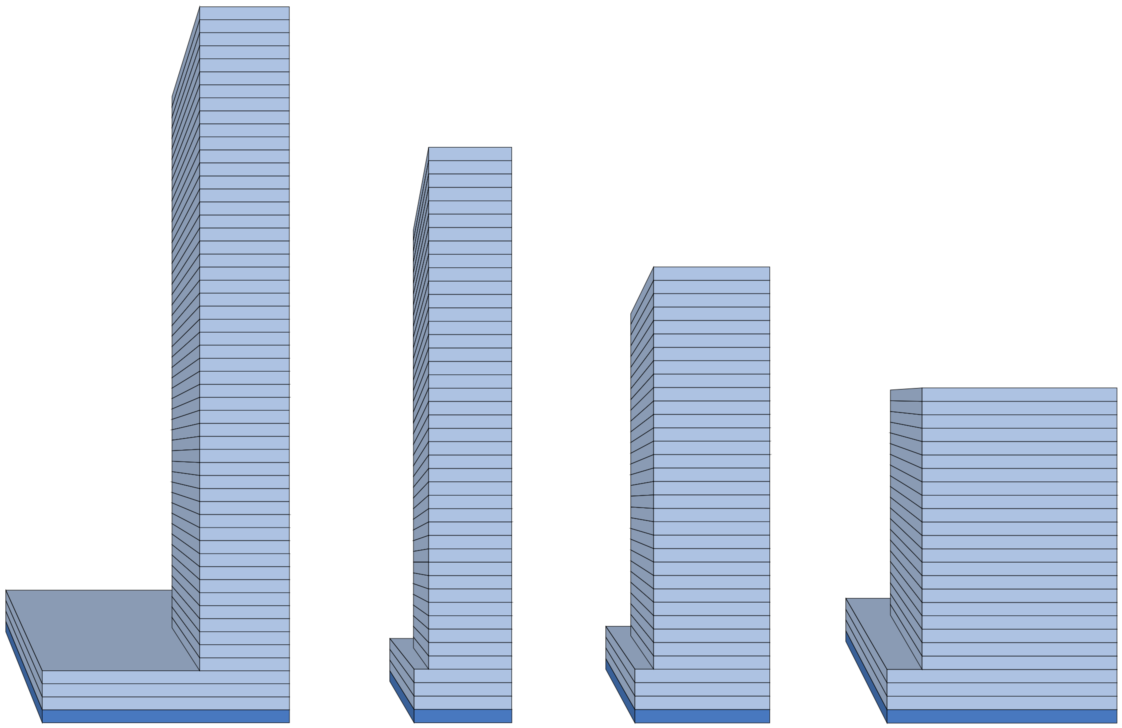
Prototypes 7-10 are Type I construction with an unconditioned basement below grade. The ground floor includes a 7,400 sqft corner restaurant and individual retail shops at approximately 2,000 sqft each. All but one floor above the ground floor are occupied by residential units at an average 1,000 sqft per unit. The remaining floor is used for mechanical equipment and is unconditioned. The floor-to-floor height for all levels is 13’-6”.

Prototype 7, High Rise Residential Building; Approximately 768,000 sqft 55-story building with approximately 65,000 sqft of commercial space at ground level demised to accommodate 29 individual retail shops and a corner restaurant. Approximately 689,000 sqft of conditioned residential space including corridors is above the ground floor. The residential space is demised to accommodate 588 units at an average 2.7 people per unit.

Prototype 8, High Rise Residential Building; Approximately 336,000 sqft 43-story building with approximately 10,000 sqft of commercial space at ground level demised to accommodate 5 individual retail shops. Approximately 319,000 sqft of conditioned residential space including corridors is above the ground floor. The residential space is demised to accommodate 269 units at an average 2.7 people per unit.

Prototype 9, High Rise Residential Building; Approximately 504,000 sqft 34-story building with approximately 19,000 sqft of commercial space at ground level demised to accommodate 6 individual retail shops and a corner restaurant. Approximately 471,000 sqft of conditioned residential space including corridors is above the ground floor. The residential space is demised to accommodate 397 units at an average 2.7 people per unit.

Prototype 10, High Rise Residential Building; Approximately 1,069,000 sqft 25-story building with approximately 54,000 sqft of commercial space at ground level demised to accommodate 23 individual retail shops and a corner restaurant. Approximately 973,000 sqft of conditioned residential space including corridors is above the ground floor. The residential space is demised to accommodate 820 units at an average 2.7 people per unit.

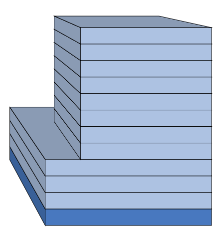


Prototype 7 Prototype 8 Prototype 9 Prototype 10

Mid Rise Residential Building – Prototype 11

Prototype 11 is Type II construction with an unconditioned basement below grade. The ground floor includes individual retail shops at approximately 2,000 sqft each. All but one floor above the ground floor are occupied by residential units. The remaining floor is used for mechanical equipment and is unconditioned. The floor-to-floor height for all levels is 13'-6".

Prototype 11 is approximately 186,000 sqft 12-story building with approximately 19,000 sqft of commercial space at ground level demised to accommodate 9 individual retail shops. Approximately 153,000 sqft of conditioned residential space including corridors is above the ground floor. The residential space is demised to accommodate 129 units at an average 2.7 people per unit.

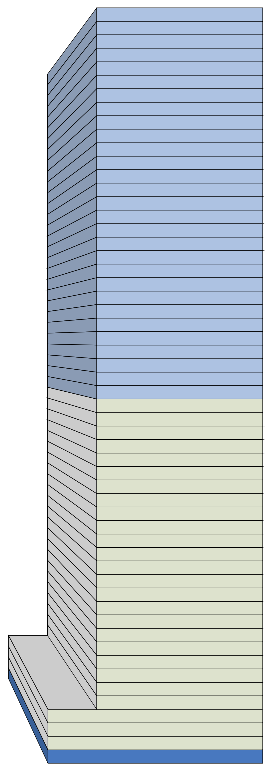


Prototype 11

High Rise Mixed Use Building – Prototype 12

Prototype 12 is Type I construction with an unconditioned basement below grade. The ground floor includes a 7,400 sqft corner restaurant and individual retail shops at approximately 2,000 sqft each. All but one floor above the ground floor are occupied by residential units and office space. The remaining floor is used for mechanical equipment and is unconditioned. The floor-to-floor height for all levels is 13'-6".

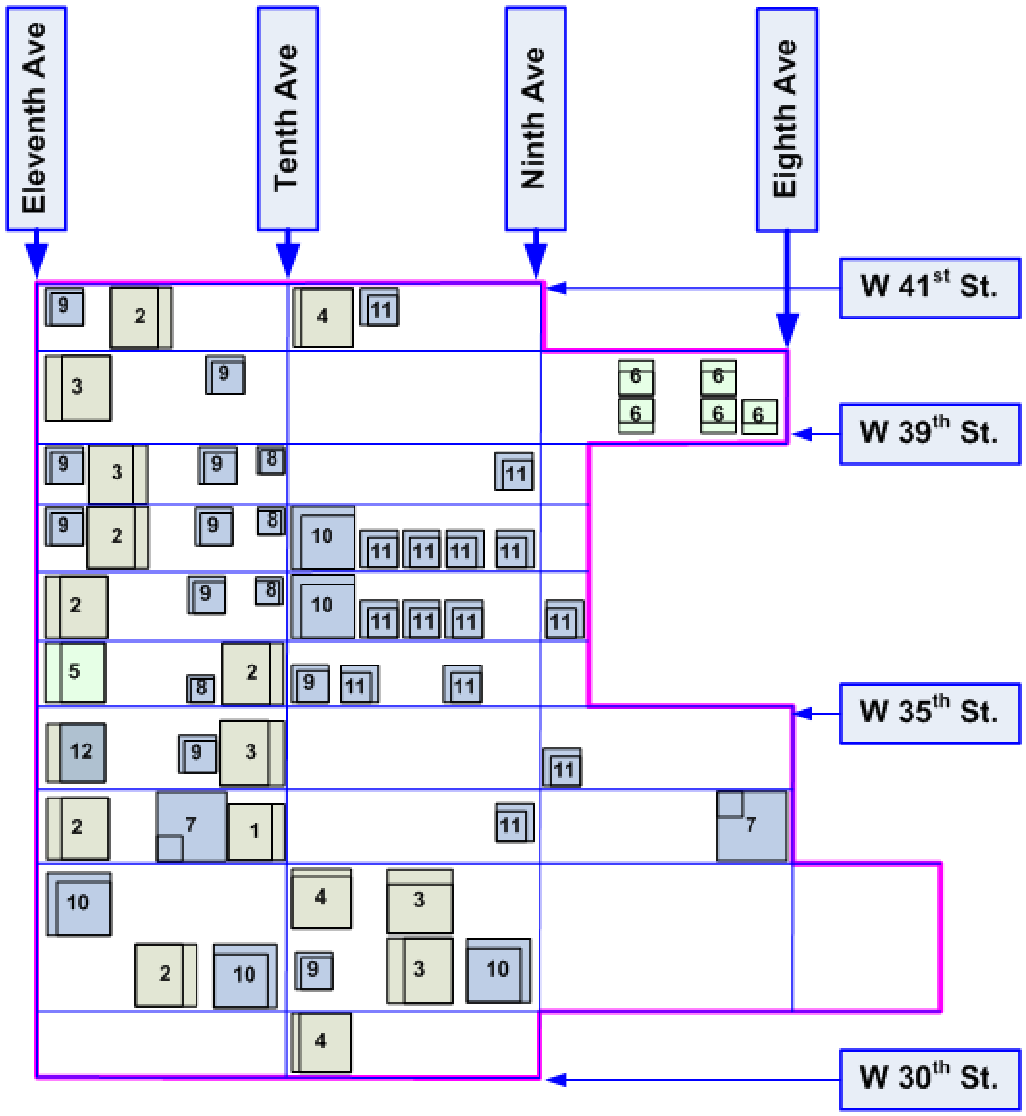
Prototype 12 is approximately 2,000,000 sqft 55-story building with approximately 45,000 sqft of commercial space at ground level demised to accommodate 19 individual retail shops and a corner restaurant. Approximately 869,000 sqft of conditioned residential space and 1,045,000 sqft of conditioned office space including corridors are above the ground floor. The residential space is demised to accommodate 824 units at an average 2.7 people per unit and is above the office space.



Prototype 12

The assumed distribution of these prototypical buildings within the Hudson Yards district is shown on the following site plan.

Integrated Building Model Plan



Prototype	Qty
1	1
2	6
3	5
4	3
5	1
6	5
7	2
8	4
9	10
10	5
11	14
12	1

Material Costing

Incremental costs for Baseline vs. Alternative material and equipment were obtained from the California Energy Commission Database for Energy Efficient Resources unless otherwise cited.[xvi] The database provides well-documented estimates of measure costs and effective useful lives for the measures.

Mechanical Systems and Appliances

Some parameters not defined by the ECCC, such as HVAC ventilation requirements and occupancy loads, were taken from the Mechanical Code of New York State.[xvii]

Appliance standards not defined by the ECCC, as indicated, were taken from federal appliance and commercial equipment standards.[xviii]

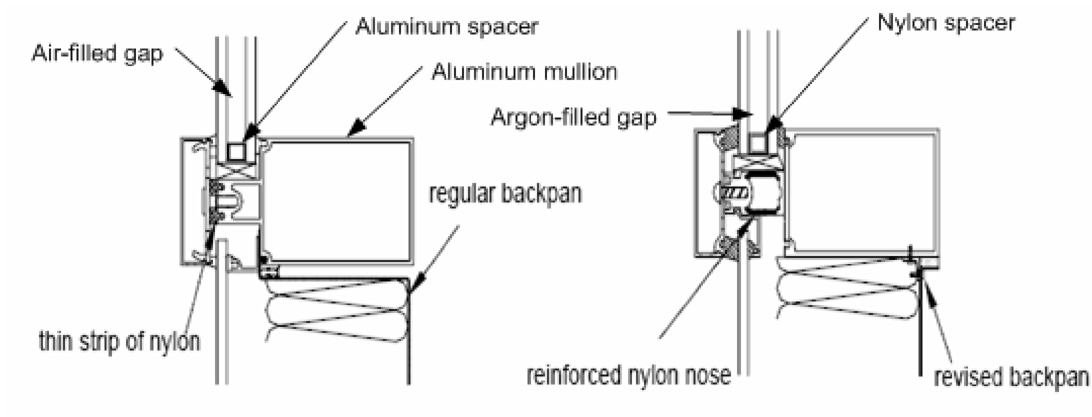
External Walls

External Window/Wall Assemblies – Type I Construction

Applicable to the following Type I prototypes:	Prototype #
High Rise Office, 56-story and associated Retail and Restaurant Space	1
High Rise Office, 41-story and associated Retail and Restaurant Space	2
High Rise Office, 34-story and associated Retail and Restaurant Space	3
High Rise Hotel, 33-story and associated Retail and Restaurant Space	5
High Rise Residential, 55-story and associated Retail and Restaurant Space	7
High Rise Residential, 43-story and associated Retail and Restaurant Space	8
High Rise Residential, 34-story and associated Retail and Restaurant Space	9
High Rise Residential, 25-story and associated Retail and Restaurant Space	10
High Rise Mixed-use, 55-story and associated Retail and Restaurant Space	12

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative (See diagram)[xix]**
Min cavity insulation: R11 Min continuous insulation: R0 Window Wall Ratio (WWR)	Curtain wall system. All aluminum framing w/ nylon strip at mullion nose for thermal break. Standard double IGU ¼" thick clear glass w/ ½" air gap and aluminum spacer. Spandrel panels are ¼" opacified glass with R11 cavity insulation in metal backpan behind a ¾" air gap. 5/8" gypsum wall board interior.	Same as Baseline Model except reinforced all nylon mullion nose for improved thermal break, and High-performance double IGU ¼" thick Low-E glass w/ ½" Argon gap and nylon spacer, and revised backpan that butts up against the mullion.
Window U = 0.50	Window U = 0.50	Window U = 0.26
U-values Not Available	Window/Wall Assembly U = 0.517	Window/Wall Assembly U = 0.412
Above ground floor WWR: max 50%	Above ground floor: WWR 50%	Above ground floor: WWR 50%
Retail Corner WWR: max 50%	Retail Corner WWR: 24%	Retail Corner WWR: 24%
Retail Internal WWR: max 50%	Retail Internal WWR: 12%	Retail Internal WWR: 12%
Corner Restaurant WWR: max 50%	Corner Restaurant WWR: 24%	Corner Restaurant WWR: 24%

Alternative Incremental Costs (Alternative – Baseline)	$6.50/sqft



Baseline **Alternative**

External Walls – Type II Construction

Applicable to the following Type II prototypes:	Prototype #
Midrise Office, 20-story	4
Midrise Hotel, 18-story	6
Midrise Residential, 12-story	11

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative 1**
Min cavity insul: R11 Min continuous insul: R0	4" Pre-cast concrete wall system, R11 cavity insulation within 2x4.16 metal-stud back-up wall assembly behind concrete, 5/8" gypsum board interior.	Same as Baseline Model, except R19 cavity insulation within 2x6.16 metal-stud back-up wall assembly
Overall U Not Available	Overall U = 0.132	Overall U = 0.114

Alternative Incremental Costs (Alternative – Baseline)	$0.43/sqft

Roofing Material

Roofing Construction & Insulation – Types I & II Construction

Applicable to the following Type I & II prototypes:	**Prototype #**
High Rise Office, 56-story	1
High Rise Office, 41-story	2
High Rise Office, 34-story	3
Midrise Office, 20-story	4
High Rise Hotel, 33-story	5
Midrise Hotel, 18-story	6
High Rise Residential, 55-story	7
High Rise Residential, 43-story	8
High Rise Residential, 34-story	9
High Rise Residential, 25-story	10
Midrise Residential, 12-story	11
High Rise Mixed-use, 55-story	12

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Min continuous insulation: R19	6" low-slope structural concrete deck with continuous 5" R19 tapered expanded polystyrene over the concrete and modified bitumen membrane over the insulation	Same as Baseline except 6" R23 tapered expanded polystyrene over the concrete
U-values Not Available	Overall U = 0.044	Overall U = 0.036

Alternative Incremental Costs (Alternative – Baseline)	$0.18/sqft

Cool Roof – Types I & II Construction

Applicable to the following Type I & II prototypes:	Prototype #
High Rise Office, 56-story	1
High Rise Office, 41-story	2
High Rise Office, 34-story	3
Midrise Office, 20-story	4
High Rise Hotel, 33-story	5
Midrise Hotel, 18-story	6
High Rise Residential, 55-story	7
High Rise Residential, 43-story	8
High Rise Residential, 34-story	9
High Rise Residential, 25-story	10
Midrise Residential, 12-story	11
High Rise Mixed-use, 55-story (Residential Space Only)	12

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
No Cool Roof Requirements	No Cool Roof. Standard black exposed modified bitumen membrane	Same as Baseline except with White elastomeric reflective coating for modified bitumen membrane
Not Available	Reflectance = 0.08	Reflectance = 0.83
Not Available	Thermal Emittance = 0.83	Thermal Emittance = 0.83
Not Available	Absorptance = 0.90	Absorptance = 0.30

Alternative Incremental Costs (Alternative – Baseline)	$0.33/sqft

Windows

Windows – Type II Construction

Applicable to the following Type II prototypes:	Prototype #
High Rise Office, 56-story and associated Retail and Restaurant Space	1
High Rise Office, 41-story and associated Retail and Restaurant Space	2
High Rise Office, 34-story and associated Retail and Restaurant Space	3
Midrise Office, 20-story and associated Retail and Restaurant Space	4
High Rise Hotel, 33-story and associated Retail and Restaurant Space	5
Midrise Hotel, 18-story and associated Retail and Restaurant Space	6
High Rise Residential, 55-story and associated Retail and Restaurant Space	7
High Rise Residential, 43-story and associated Retail and Restaurant Space	8
High Rise Residential, 34-story and associated Retail and Restaurant Space	9
High Rise Residential, 25-story and associated Retail and Restaurant Space	10
Midrise Residential, 12-story and associated Retail and Restaurant Space	11
High Rise Mixed-use, 55-story and associated Retail and Restaurant Space	12

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
No Description	Standard double IGU ¼" thick clear glass w/ ½" air gap and aluminum spacer.	High-performance double IGU ¼" thick Low-E glass w/ ½" Argon gap and nylon spacer.
Window U = 0.50	Window U = 0.50	Window U = 0.26
Window SHGC = 0.30 (PF< 0.25)	Window SHGC = 0.35	Window SHGC = 0.29
Above ground floor WWR: max 50%	Above ground floor WWR: 50%	Above ground floor WWR: 50%
Retail Corner WWR: max 50%	Retail Corner WWR: 24%	Retail Corner WWR: 24%
Retail Internal WWR: max 50%	Retail Internal WWR: 12%	Retail Internal WWR: 12%
Corner Restaurant WWR: max 50%	Corner Restaurant WWR: 24%	Corner Restaurant WWR: 24%

Alternative Incremental Costs (Alternative – Baseline)	$6.50/sqft

HVAC

HVAC Summary

Space	Cooling	Heating
Office	Central water-cooled, electrically operated, centrifugal chiller w/ economizer and VAV fan control, dehumidification w/ reheat	Central gas-fired hot water boiler (No condenser heat recovery for service water heating because facility does not operate 24 hours per day)
Residential	Central water-cooled, electrically operated, centrifugal chiller w/ economizer and VAV fan control	Central gas-fired hot water boiler (No condenser heat recovery for service water heating because residential units have individual hot water heaters)
Hotel	Central water-cooled, electrically operated, centrifugal chiller w/ economizer and VAV fan control	Central gas-fired hot water boiler w/ condenser heat recovery for service water heating as required by NYS ECCC ‘07
Retail	Individual electrically operated, air-cooled, unitary air conditioner w/ economizer and CAV fan control	Individual gas-fired, warm air furnace
Restaurant	Individual electrically operated, air-cooled, unitary air conditioner w/ economizer and CAV fan control	Individual gas-fired, warm air furnace

HVAC – Office, Residential, and Hotel Central Cooling Plant

Applicable to the following spaces:	Prototype #
High- and Mid-Rise Office	All
High- and Mid-Rise Residential	All
High- and Mid-Rise Hotel	All

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Water cooled, electrically operated, centrifugal chiller	Central water-cooled, electrically operated, centrifugal chillers	Central water-cooled, electrically operated, centrifugal chillers
150-300 tons: 0.634 kW/ton	150-300 tons: 0.634 kW/ton	150-300 tons: 0.507 kW/ton
> 300 tons: 0.576 kW/ton	> 300 tons: 0.576 kW/ton	> 300 tons: 0.461 kW/ton
Variable-air-volume	Variable-air-volume	Variable-air-volume
Economizer	Economizer	Economizer
Infiltration: 0.3 cfm/sqft of fenestration	Infiltration: 0.3 cfm/sqft of fenestration	Infiltration: 0.3 cfm/sqft of fenestration
Office Ventilation: 19.75 cfm/person	Office Ventilation: 19.75 cfm/person	Office Ventilation: 19.75 cfm/person
Residential Vent: 17.00 cfm/person	Residential Vent: 17.00 cfm/person	Residential Vent: 17.00 cfm/person
Hotel Ventilation: 31 cfm/room	Hotel Ventilation: 31 cfm/room	Hotel Ventilation: 31 cfm/room
Office max occupant load: 10 people per 1000 sqft	Office max occupant load: 10 people per 1000 sqft	Office max occupant load: 10 people per 1000 sqft
Residential max occupant load: 2.7 people per 1000 sqft	Residential max occupant load: 2.7 people per 1000 sqft	Residential max occupant load: 2.7 people per 1000 sqft
Hotel max occupant load: 20 people per 1000 sqft	Hotel max occupant load: 20 people per 1000 sqft	Hotel max occupant load: 20 people per 1000 sqft

Alternative Incremental Costs (Alternative – Baseline)	
150-300 tons	$77.07/ton
> 300 tons	$83.08/ton

HVAC – Retail and Restaurant Unitary AC

Applicable to the following spaces:	Prototype #
Corner retail shops	All
Internal retail shops	All but 5 & 6
Corner Restaurants	All but 6 & 11

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Electrically operated, air-cooled, unitary air conditioner	Individual electrically operated, air-cooled, unitary air conditioners	Individual electrically operated, air-cooled, unitary air conditioners
< 65k Btu/hr: 10 SEER	< 65k Btu/hr: 10 SEER, 9.5 EER	< 65k Btu/hr: 14 SEER, 12.5 EER
Infiltration: 0.3 cfm/sqft of fenestration	Infiltration: 0.3 cfm/sqft of fenestration	Infiltration: 0.3 cfm/sqft of fenestration
Retail Ventilation: 0.30 cfm/sqft	Retail Ventilation: 0.30 cfm/sqft	Retail Ventilation: 0.30 cfm/sqft
Restaurant Vent: 17.25 cfm/person	Restaurant Vent: 17.25 cfm/person + 18 cfm/sqft of hood space	Restaurant Vent: 17.25 cfm/person + 18 cfm/sqft of hood space
Retail max occupant load: Undefined	Retail max occupant load: 29 people per 1000 sqft	Retail max occupant load: 29 people per 1000 sqft
Restaurant max occupant load: (70 dining, 20 kitchen) people per 1000 sqft	Restaurant max occupant load: (70 dining, 20 kitchen) people per 1000 sqft	Restaurant max occupant load: (70 dining, 20 kitchen) people per 1000 sqft

Alternative Incremental Costs (Alternative – Baseline)	
< 65k Btu/hr or 5.4 tons	$295.82/ton

HVAC – Office, Residential, and Hotel Central Boiler

Applicable to the following spaces:	**Prototype #**
High- and Mid-Rise Office	All
High- and Mid-Rise Residential	All
High- and Mid-Rise Hotel	All

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Gas-fired hot water boiler	Gas-fired hot water boiler	Gas-fired hot water boiler
> 2,500,000 Btu/hr Combustion Efficiency: 80%	> 2,500,000 Btu/hr Combustion Efficiency: 80%	> 2,500,000 Btu/hr Combustion Efficiency: 85%
Hotel: condenser heat recovery for service water heating	Hotel: condenser heat recovery for service water heating	Hotel: condenser heat recovery for service water heating

Alternative Incremental Costs (Alternative – Baseline)	
> 2,500,000 Btu/hr	$12.31/kBtu/hr

HVAC – Retail and Restaurant Furnace

Applicable to the following spaces:	Prototype #
Corner retail shops	All but 5 & 6
Internal retail shops	All but 5 & 6
Corner Restaurants	All but 6 & 11

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Gas-fired, warm air furnace	Individual gas-fired, warm air furnace	Individual gas-fired, warm air furnace
< 225,000 Btu/hr: 78% AFUE	< 225,000 Btu/hr: 78% AFUE	< 225,000 Btu/hr: 94% AFUE

Alternative Incremental Costs (Alternative – Baseline)	
110,000 Btu/hr	$8.25/kBtu/hr
115,000 Btu/hr	$8.15/kBtu/hr
120,000 Btu/hr	$8.09/kBtu/hr
125,000 Btu/hr	$8.07/kBtu/hr
140,000 Btu/hr	$8.19/kBtu/hr

Appliances

Domestic (Service) Hot Water Summary

Space	Service Water System
Office	Central gas-fired hot water boiler (Reference HVAC – Central Boiler)
Residential	Central gas-fired hot water boiler (Reference HVAC – Central Boiler)
Hotel	Central gas-fired hot water boiler (Reference HVAC – Central Boiler)
Retail	Individual gas-fired, storage water heaters less than 75,000 btuh each
Restaurant	Individual gas-fired, storage water heaters less than 75,000 btuh each

Domestic (Service) Hot Water – Retail and Restaurant

Applicable to the following spaces:	**Prototype #**
Corner retail shops	All but 5 & 6
Internal retail shops	All but 5 & 6
Corner Restaurants	All but 6 & 11

<table>
<tr><th colspan="3">Scenarios</th></tr>
<tr><th>NYS ECCC ‘07</th><th>Baseline Model</th><th>Alternative</th></tr>
<tr><td>Gas-fired storage and instantaneous water heaters</td><td>Individual 50 gallon gas-fired storage water heaters</td><td>Individual 50 gallon equivalent gas-fired Instantaneous water heaters</td></tr>
<tr><td>Storage < 75,000 Btu/hr:
EF = 0.62-0.0019V</td><td>Storage < 75,000 Btu/hr:
EF = 0.62-0.0019V = 52.5%</td><td rowspan="3">Instantaneous 150,000 Btu/hr
Thermal Efficiency = 82.3%
(based on Takagi T-M199)</td></tr>
<tr><td>Storage 75,000-155,000 Btu/hr:
Thermal Efficiency = 80%</td><td>Storage 75,000-155,000 Btu/hr: Thermal Efficiency = 80%</td></tr>
<tr><td>Storage > 155,000 Btu/hr
Thermal Efficiency = 80%</td><td>Storage > 155,000 Btu/hr
Thermal Efficiency = 80%</td></tr>
</table>

Alternative Incremental Costs (Alternative – Baseline)	
150,000 Btu/hr	$370.64/appliance

Energy Star[xx] – Residential Dishwasher, Clothes Washer, Refrigerator

Applicable to the following spaces:	**Prototype #**
High- and Mid-Rise Residential	All

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Dishwasher: No requirement	Typical dishwasher (160 cycles/yr) based on federal regulations EF = 0.46 154 kWh/yr	Energy Star rated dishwasher EF = 0.64 (160 cycles/yr) 111 kWh/yr
Clothes Washer: No Requirement	Typical clothes washer (2.65 cf) based on federal regulations MMEF = 1.26 78.5 kWh/yr	Energy Star rated clothes washer (2.65 cf) MMEF = 2.00 49 kWh/yr
Clothes Drier: No Requirement	Typical clothes drier (416 dry cycles) based on federal regulations EF = 2.67 5.4 MBtu/yr 57 kWh/yr	Energy Star rated clothes drier (416 dry cycles) EF = 2.67 5.4 MBtu/yr 51.3 kWh/yr
Refrigerator: No Requirement	Typical refrigerator based on federal regulations 569 kWh/yr	NA
Gas Range: No Requirement	Typical gas range based on federal regulations 2.4 MBtu/yr	NA

Alternative Incremental Costs (Alternative – Baseline)	
Energy Star Dishwasher	$133.64/appliance
Energy Star Clothes Washer	$131.00/Appliance
Energy Star Clothes Drier	$242.26/Appliance
Total Energy Star Cost	$506.90/household

Lighting

Lighting – Residential and Commercial

Applicable to the following spaces:	Prototype #
High- and Mid-Rise Office	All
High- and Mid-Rise Residential	All
High- and Mid-Rise Hotel	All
Corner retail shops	All but 5 & 6
Internal retail shops	All but 5 & 6
Corner Restaurants	All but 6 & 11

Scenarios		
NYS ECCC '07	**Baseline Model**	**Alternative**
Office: 1.1 W/sqft	Primarily area lighting 1.1 W/Sqft	Reduced area lighting plus task lighting 0.9 W/sqft
Hotel Tenant Area: 1.3 W/sqft Hotel Lobby: 1.1 W/sqft Hotel Meeting Rooms: 1.3 W/sqft	Mix of 60 LPW screw-in CFL and dimmable incandescent 1.3 W/sqft	Replace CFLs w/ 69 LPW recessed fixtures with 4-pin triple tubes 1.19 W/sqft
Multifamily Residential: 0.7 W/sqft	Mix of 60 LPW screw-in CFL and dimmable incandescent 0.700 W/sqft	Replace CFLs w/ 69 LPW recessed fixtures with 4-pin triple tubes 0.675 W/sqft
Retail Sales: 1.5 W/sqft	Typical fluorescent 1.5 W/sqft	NA
Restaurant: 1.6 W/sqft	Typical fluorescent 1.6 W/sqft	NA

Alternative Incremental Costs (Alternative – Baseline)	
All Spaces	$2.5/sqft

In most cases, the ECCC requirements are already relatively stringent. Lighting alternatives were derived from the New Buildings Institute Advanced Lighting Guidelines.[xxi]

On-site Power and Thermal Generation

Each on-site power and thermal generation system is optimized per application

Installed cost for CHP system is defined by:

Engines:
$3,000/kW[xxii]
$600/kW (capped at $2,000,000) NYSERDA incentive[xxiii]
$2,400/kW with incentive
O&M cost for CHP system is $0.020/kWh[xxii]
CHP system maximum efficiencies are:
< 900 kW: Electric = 34%, Total = 76%
> 900 kW: Electric = 35%, Total = 77%
< 900 kW: Jacket water temp = 215 F, Exhaust temp = 900 F
> 900 kW: Jacket water temp = 235 F, Exhaust temp = 850 F

CHP systems recover heat to domestic hot water, space heating, and absorption cooling at the following maximum efficiencies.

Electric Power Gen Efficiency	Jacket Water Heat Efficiency	Exhaust Heat Efficiency	Total Efficiency
34/35%	26%	16%	76/77%

CHP system sizes and run-time are optimized and are configured to track electric load with the following part-load correction factors.

Load	Electric Power Gen Efficiency	Jacket Water Heat Efficiency	Exhaust Heat Efficiency
100%	1.000	1.000	1.000
75%	0.769	0.860	0.760
50%	0.558	0.740	0.520
25%	0.344	0.600	0.250

Absorption Chillers:
Absorption efficiency: 0.70 COP
Installed cost for hot water single effect absorption chillers is defined by:
< 300 tons: $520/ton
300 to 500 tons: $430/ton
500 to 1000 tons: $365/ton

Installed cost for electric chillers is defined by:
< 500 tons: $340/ton
500 to 1000 tons: $350/ton

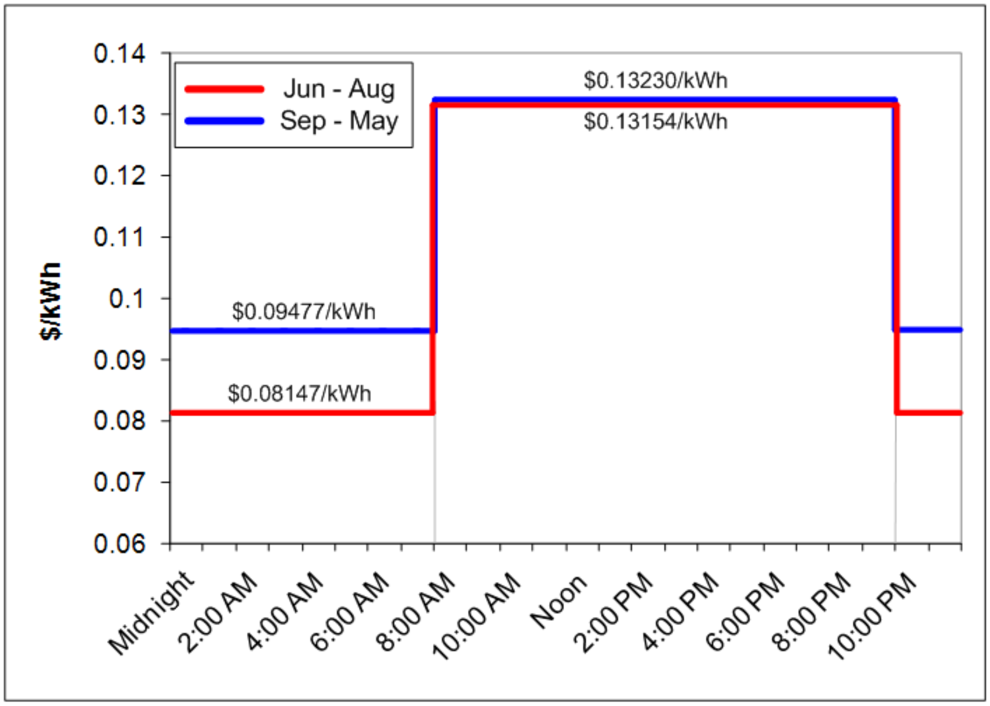
O&M cost for absorption chillers is defined by:
$Y = 644.61X^{-0.8454}$, where X = refrigeration tons

Thermal Storage[xxiv]

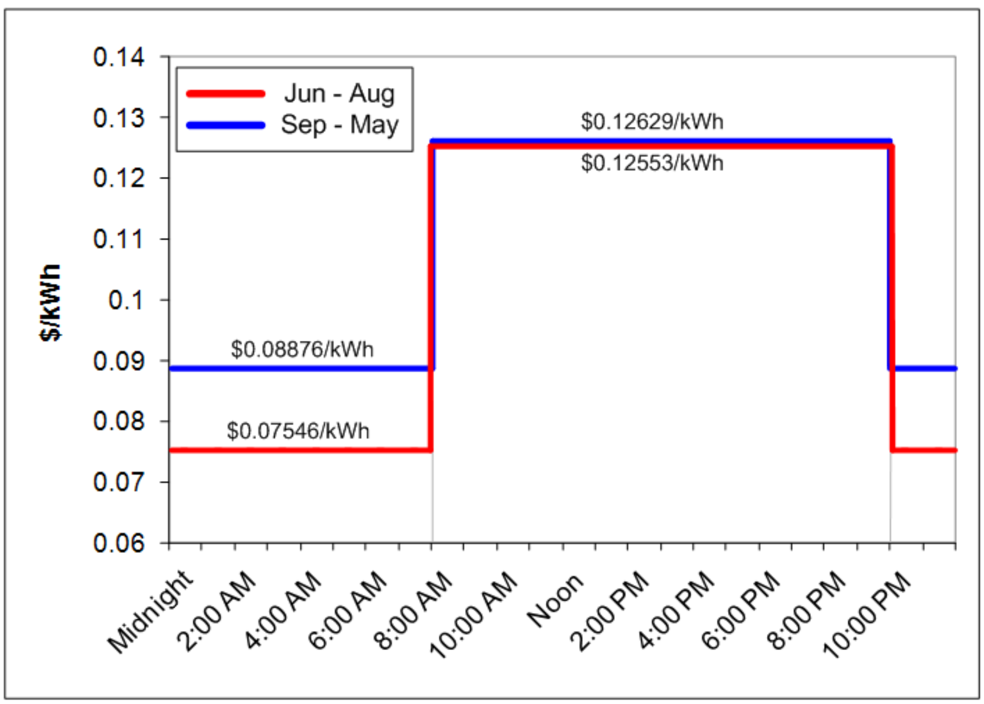
Ice-on-coil system @ $70/ton-hr applied to spaces with chillers only
Charge during mid- and off-peak periods
Serves 15% to 25% of the cooling capacity (optimized on a case-by-case basis)
Starting efficiency equals baseline chiller efficiency. Ending efficiency equals approx. 40% lower.

Utility Rates[xxv]

2007 PSC9, SC4, Rate II Total
Daily Summer and Winter Electric Energy Rates

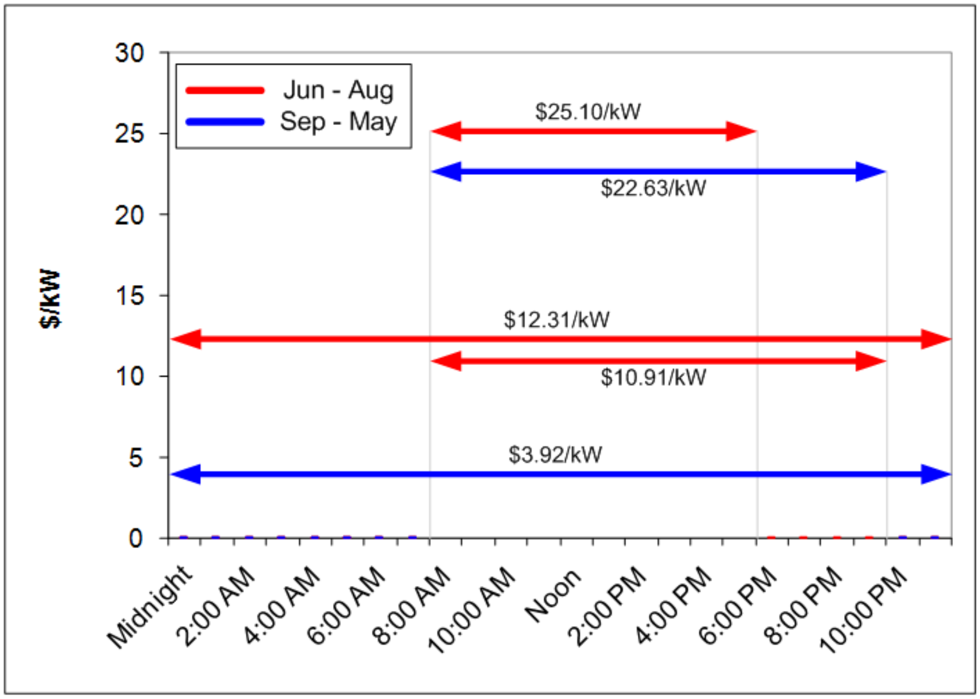


2007 PSC2, SC14-RA, Rate II Total
Daily Summer and Winter Electric Energy Rates

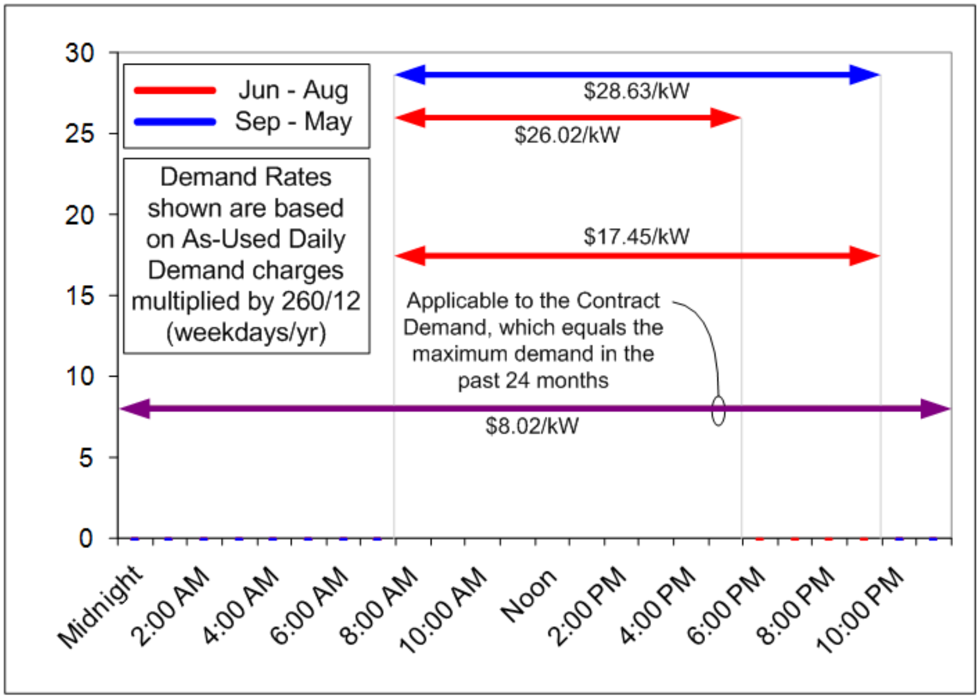


Note, this rate is essentially the same as PSC9, SC4, Rate II minus the delivery component of the charge (i.e. commodity charge only).

2007 PSC9, SC4, Rate II Total
Daily Summer and Winter Electric Demand Rates



2007 PSC2, SC14-RA, Rate II Total
Daily Summer and Winter Electric Demand Rates



A rate sensitivity analysis was performed on PSC2, SC14-RA, Rate II as follows:

1. The contract demand of $8.02/kW was removed
2. The energy delivery charge was added making the energy rates equivalent to PSC9, SC4, Rate II energy rates

2007 Summer and Winter Gas Rates

SC2, Rate II	Summer	Winter	Units
Up to 90 Therms	1.7529	1.7518	$/therm
Up to 3000 Therms	1.5612	1.5601	$/therm
Over 3000 Therms	1.4445	1.4434	$/therm

Rider H, Rate I	Summer	Winter	Units
Less than 5 MW	1.3294	1.3612	$/therm

Rider H, Rate II	Summer	Winter	Demand*	Units
Greater than 5 MW	1.2242	1.2299	22.12	$/therm

*Demand equals maximum generator demand in past 12 months

1 therm = 100,000 Btu

Electric Power Generation and Residential Heating Emission Factors[xxvi]

		Baseload Central Power Plant (lb/MWh of Electricity)	Non-Baseload Central Power Plant (lb/MWh of Electricity)	Gas Heating (lb/MMBtu of Fuel Use)	CHP (tuned for low Nox) (lb/MMBtu of Fuel Use)
Global Warming	CO2	610	1688.236	117.6	147.6
Acid Rain	SO2	3.476	5.729	0.00059	0.00059
Ozone/Smog	NOX	1.059	1.791	0.092	0.15

Non-Baseload Central Power Plant operation is defined as 8 am to 10 pm weekdays only.

Building energy consumptions are converted from site energy to source energy. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, thereby enabling a complete and equitable assessment of energy efficiency in a building. Source-site energy ratios are applied to convert each Btu of energy used on site into the total Btu of equivalent source energy consumed.[xxvii] The following ratios were used.

Fuel Type	Source-Site Ratio
Electricity	3.340
Natural Gas	1.047

Energy Efficiency Measure Useful Lives

Database for Energy Efficient Resources DEER[xvi]

Measure	Useful Life (yrs)
Wall Insulation	50
Roof Insulation	50
Cool Roof	15
Windows	20
Appliances	14
DHW Heater	14
Lighting	12
HVAC	18
CHP	20
Thermal Storage	18

Market Penetration Curves

The following curves apply to all alternative measures, including CHP and Energy Efficiency strategies. The bottom curve is based on the National Energy Modeling System (NEMS) maximum market penetration defined by

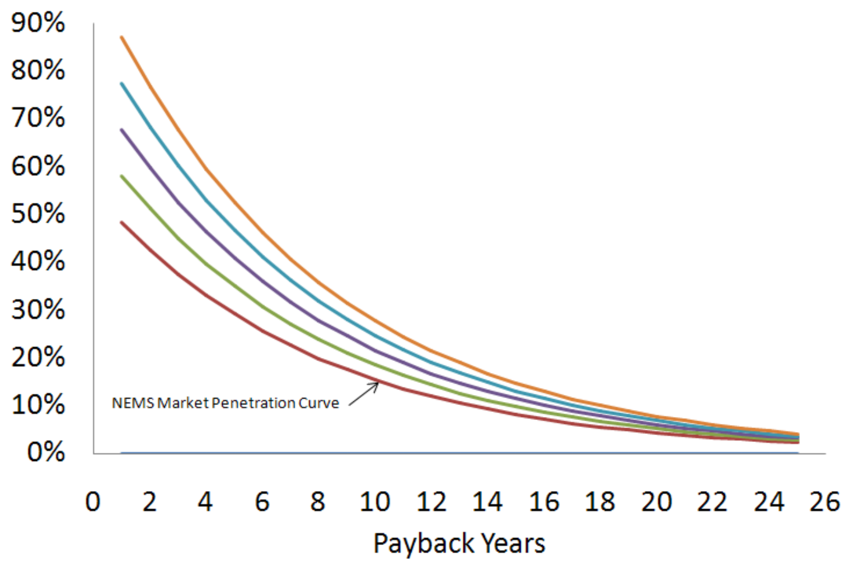
Equation 2: $\text{Market penetration} = \dfrac{1.1\times \textit{penparm}}{e^{(0.24\times \textit{payback})}}$

where:

penparm = penetration parameter, NEMS uses 50%

payback = number of years to positive cash flow (approximately half the simple payback period) [vii]

This equation results in a 48% market penetration rate at a 1-yr payback. For sensitivity analysis, the equation was modified by increasing *penparm* to 60%, 70%, 80%, and 90%, thereby increasing the resulting maximum market penetration rate at a 1-yr payback to 58%, 68%, 77%, and 87% respectively.



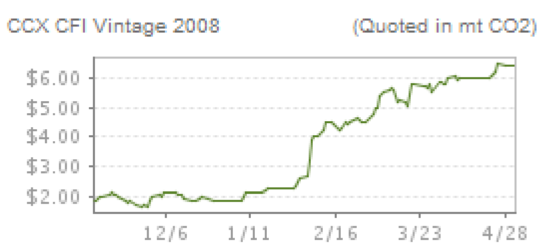
Payback	Baseline	BAU (Max 50%)	IMPR (Max 60%)	IMPR (Max 70%)	IMPR (Max 80%)	IMPR (Max 90%)
1	0%	48%	58%	68%	77%	87%
2	0%	43%	51%	60%	68%	77%
3	0%	38%	45%	53%	60%	68%
4	0%	33%	40%	46%	53%	60%
5	0%	29%	35%	41%	47%	52%
6	0%	26%	31%	36%	41%	46%
7	0%	23%	27%	32%	36%	41%
8	0%	20%	24%	28%	32%	36%
9	0%	18%	21%	25%	28%	32%
10	0%	15%	18%	22%	25%	28%
11	0%	14%	16%	19%	22%	24%
12	0%	12%	14%	17%	19%	22%
13	0%	11%	13%	15%	17%	19%
14	0%	9%	11%	13%	15%	17%
15	0%	8%	10%	11%	13%	15%
16	0%	7%	9%	10%	11%	13%
17	0%	6%	8%	9%	10%	11%
18	0%	6%	7%	8%	9%	10%
19	0%	5%	6%	7%	8%	9%
20	0%	4%	5%	6%	7%	8%
21	0%	4%	5%	5%	6%	7%
22	0%	3%	4%	5%	5%	6%
23	0%	3%	4%	4%	5%	5%
24	0%	3%	3%	4%	4%	5%
25	0%	2%	3%	3%	4%	4%

Carbon Cap and Trade Analysis

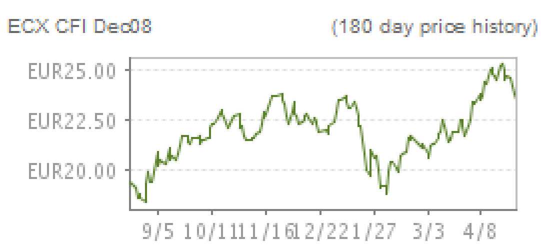
Sensitivity analyses were performed to determine the impact of a carbon cap and trade policy. For the sensitivities, carbon emissions in the form of CO_2 can be traded at the following values:

1. \$5/ton of CO_2 saved
2. \$10/ton of CO_2 saved
3. \$15/ton of CO_2 saved
4. \$20/ton of CO_2 saved

Current voluntary trading in North America through the Chicago Climate Exchange is approximately \$6/ton.[ix]

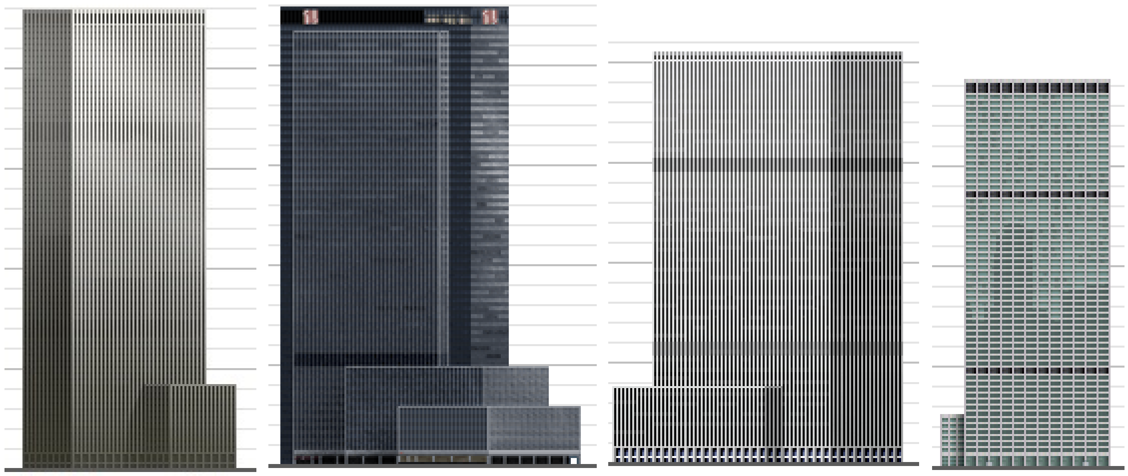


Current trading in Europe through the Chicago Climate Exchange is approximately \$38/ton.[ix]

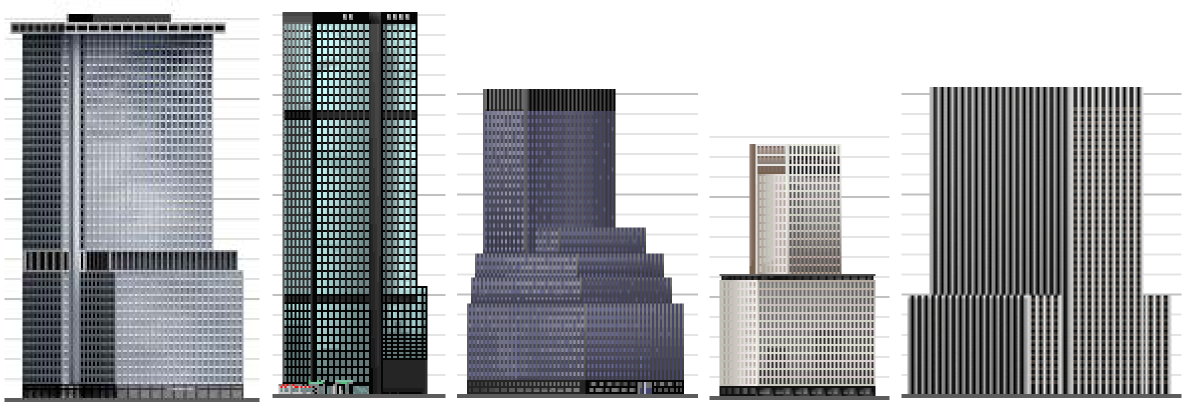


APPENDIX B – BUILDING CALIBRATIONS

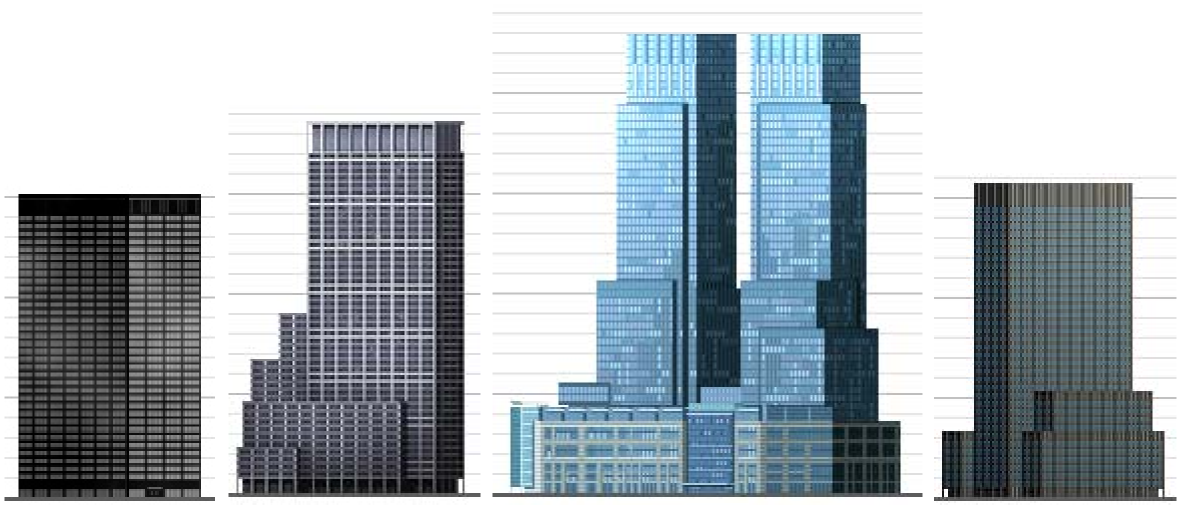
Illustrated below are Manhattan buildings that were built in the late 60's and early 70's. Annual hourly energy data (8,760) were acquired from the owners for each of these buildings and used for calibrating Hudson Yards prototype models. The hourly energy data for each individual building is shown in light gray in the following figures in this appendix. The buildings are used for office, residential, or a mix of both.



2,300,000 sqft, 54-stories   2,585,000 sqft, 57-stories   2,500,000 sqft, 52-stories   1,810,000 sqft, 44-stories

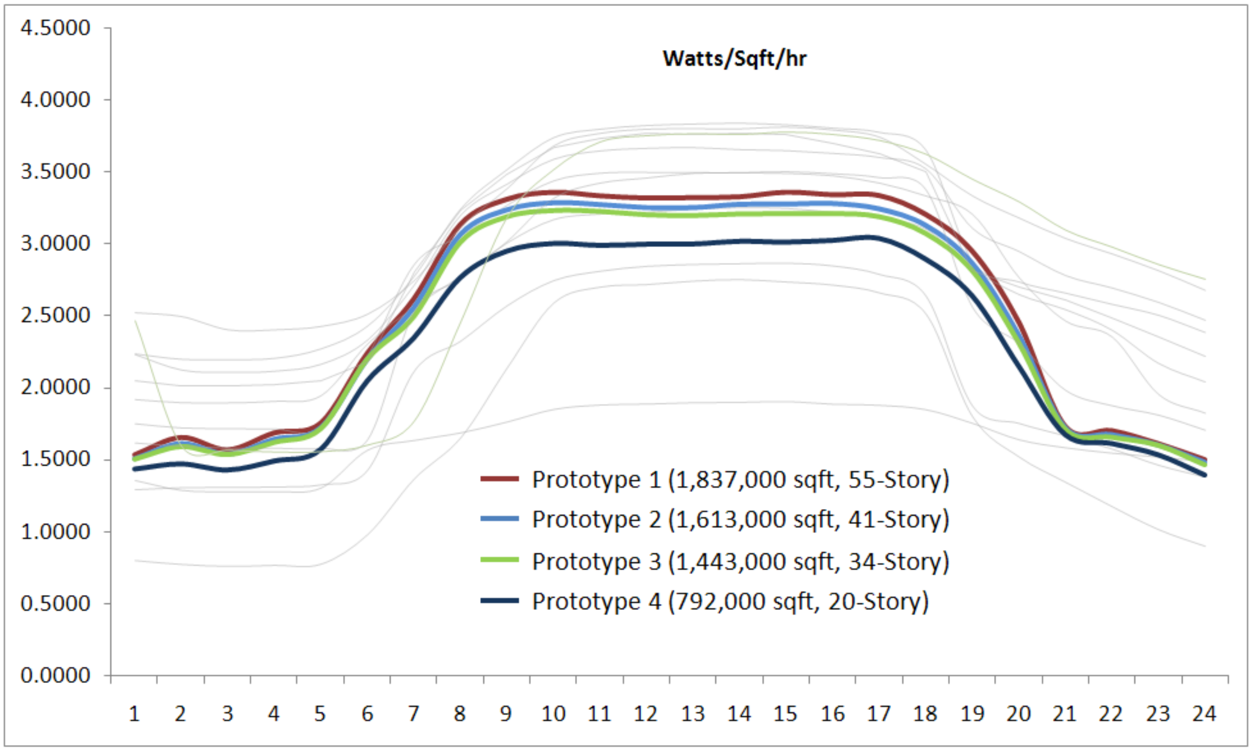


2,500,000 sqft, 50-stories   896,000 sqft, 46-stories   900,000 sqft, 40-stories   1,200,000 sqft, 30-stories   1,145,000 sqft, 40-stories

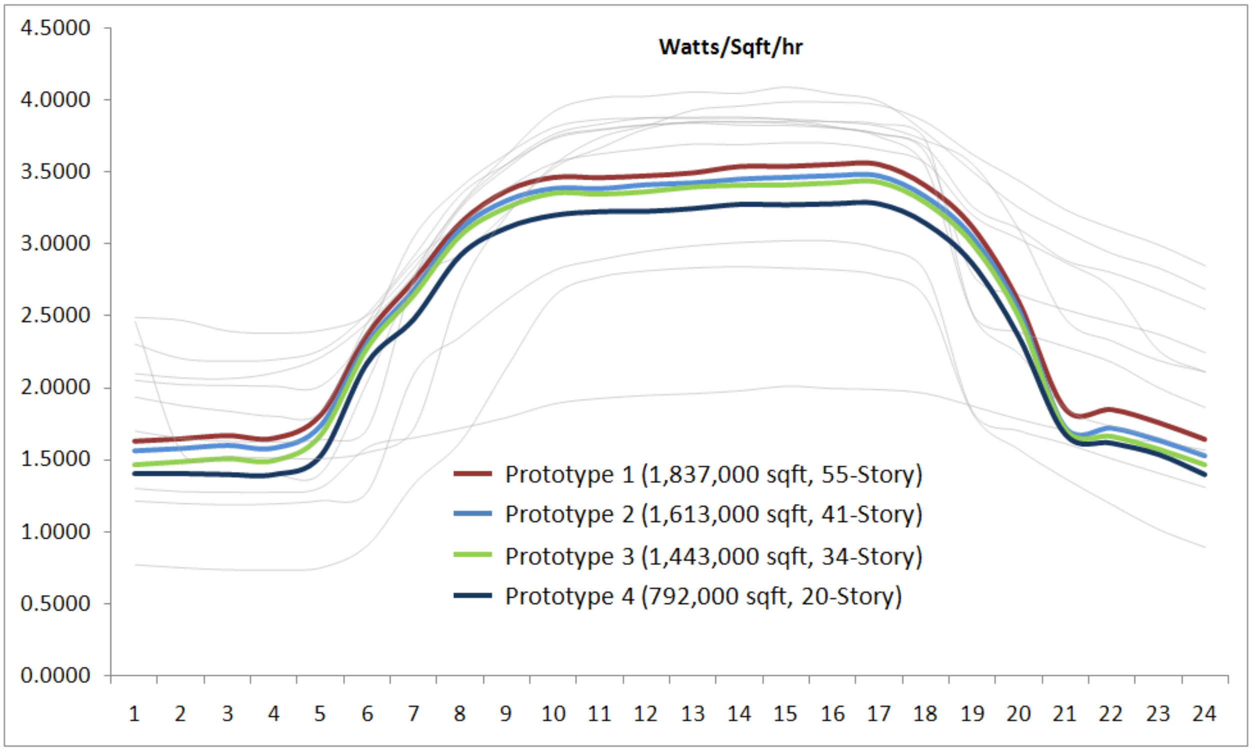


750,000 sqft, 35-stories   1,770,000 sqft, 46-stories   2,989,000 sqft, 54-stories   1,680,000 sqft, 41-stories

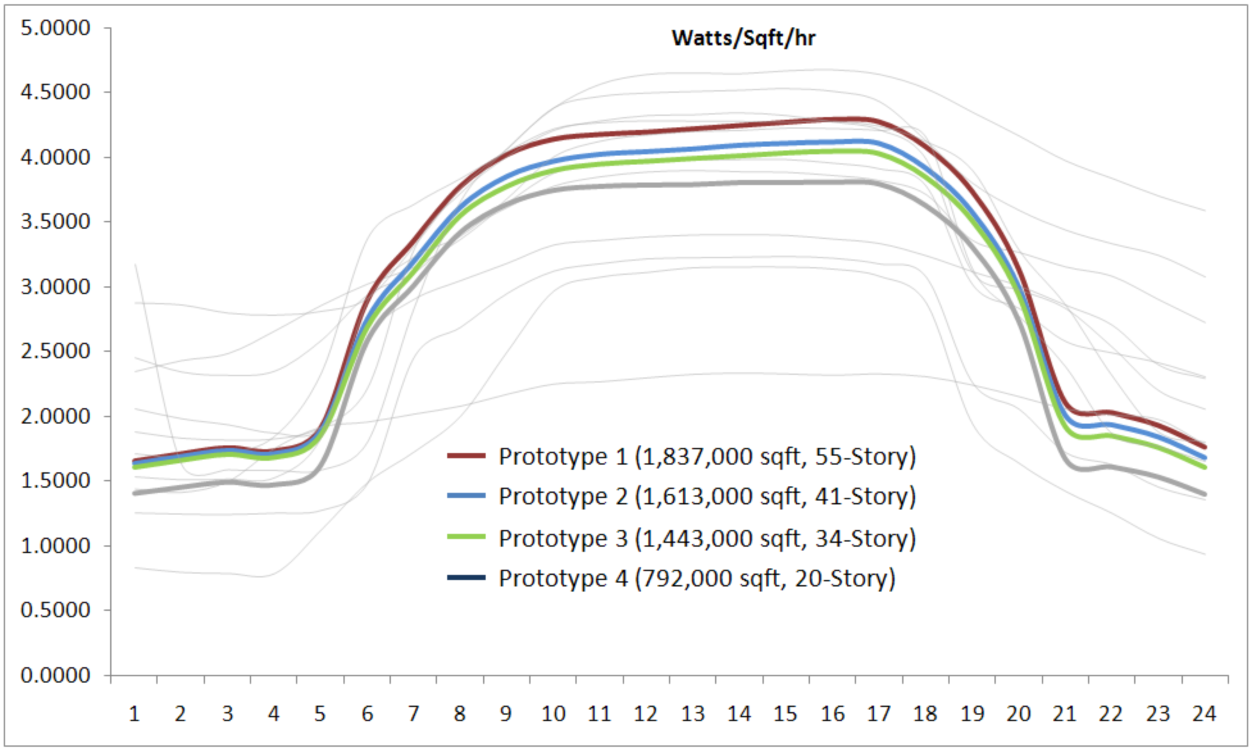
High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Electricity for December – March



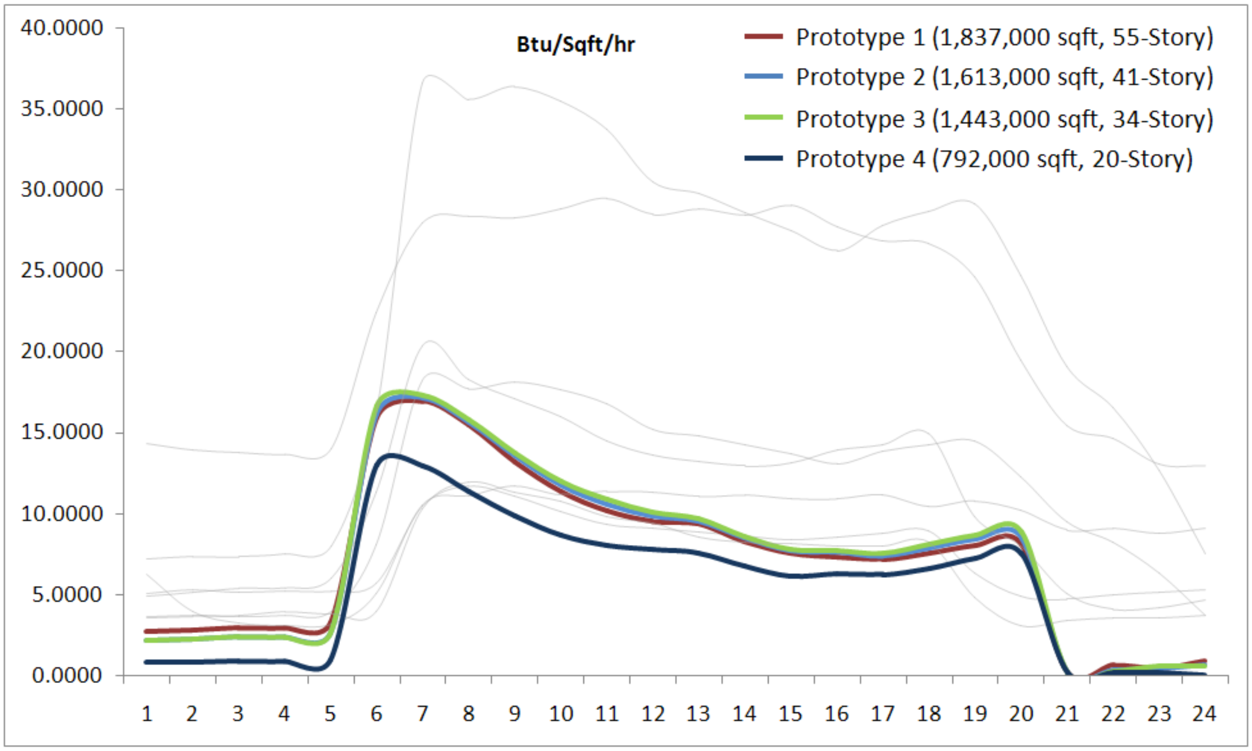
High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Electricity for April – May and October - November



High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Electricity for June - September

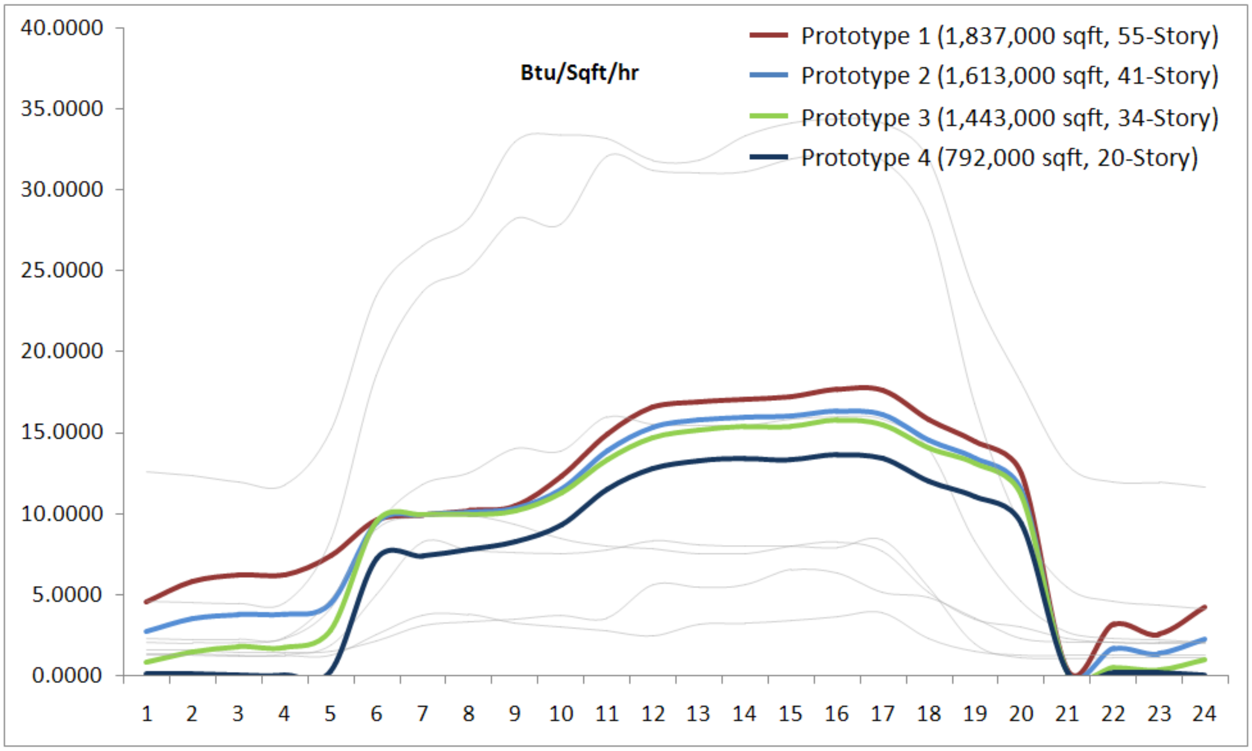


High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Heat for December – March



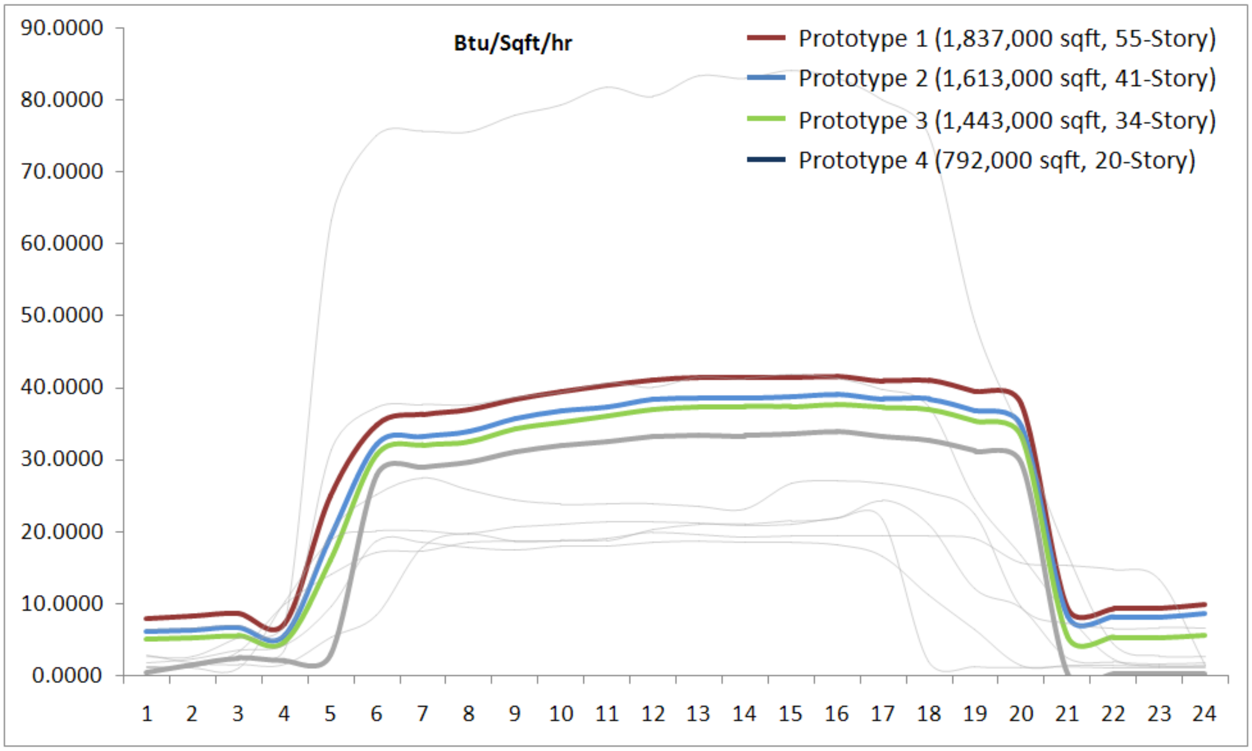
Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Heat for April – May and October – November



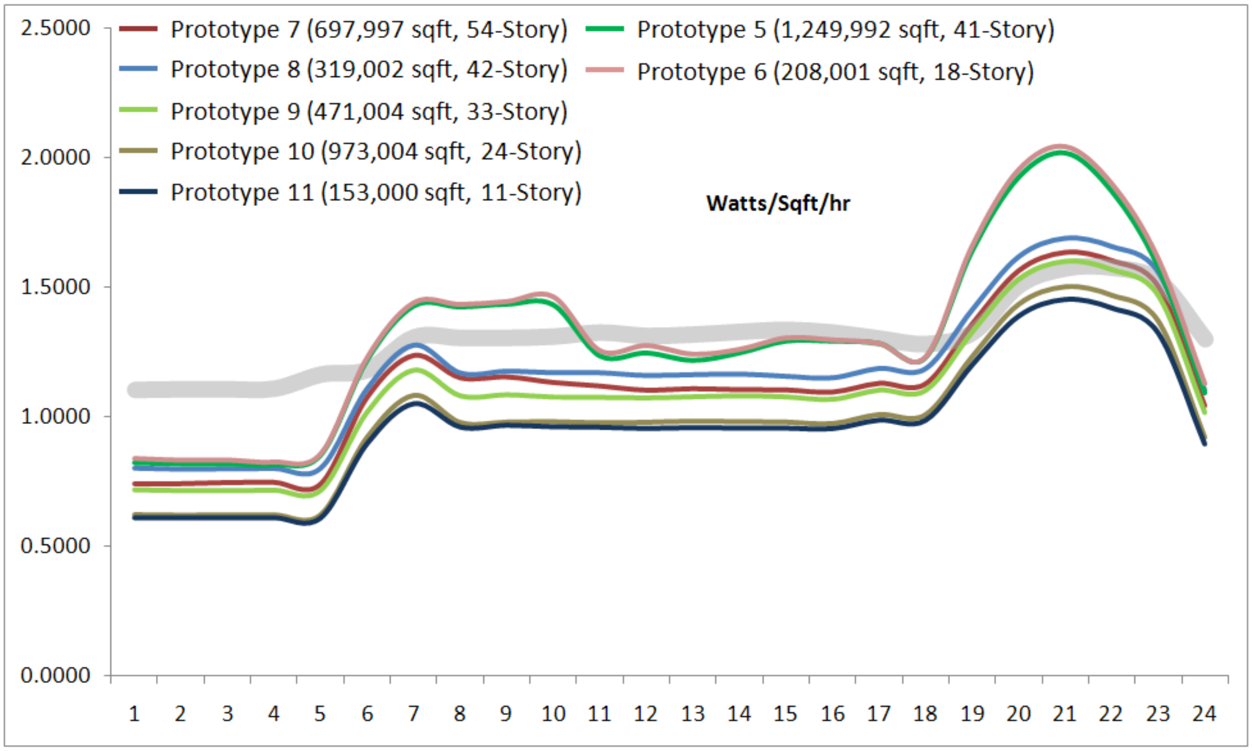
Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

High Rise Office Buildings – Prototypes 1, 2, 3 and 4 Average Heat for June – September

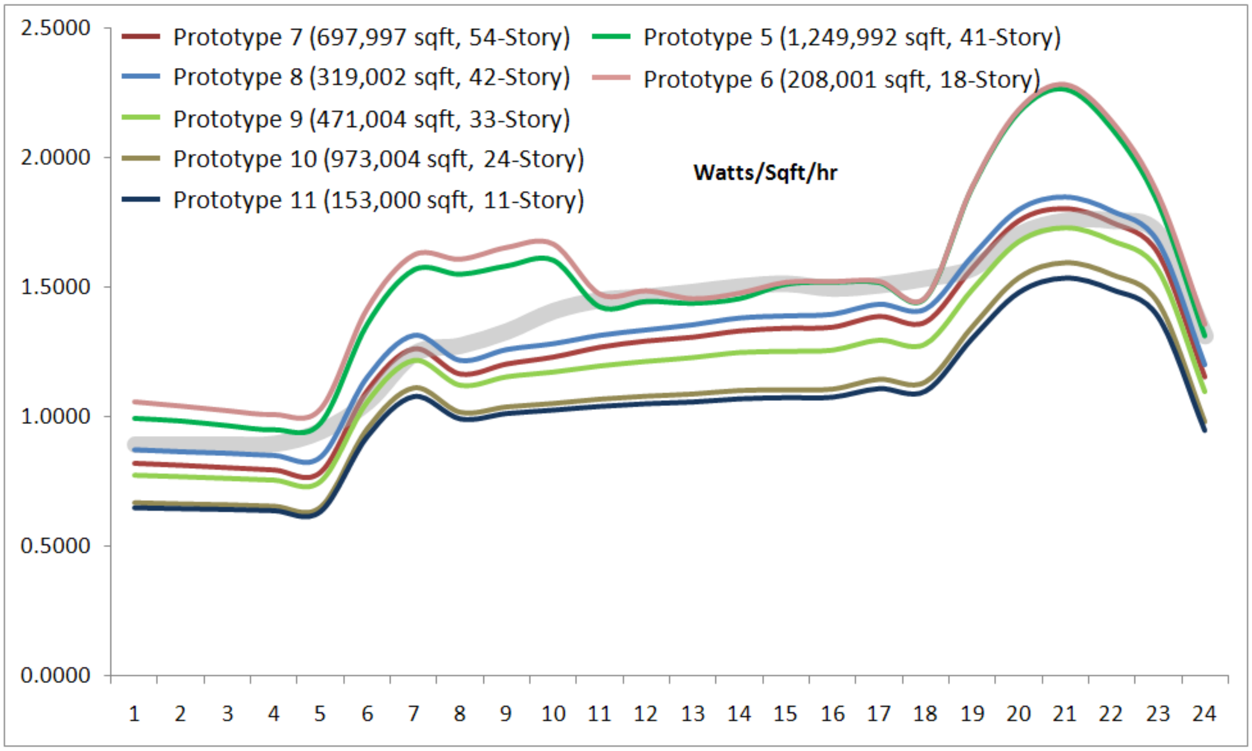


Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

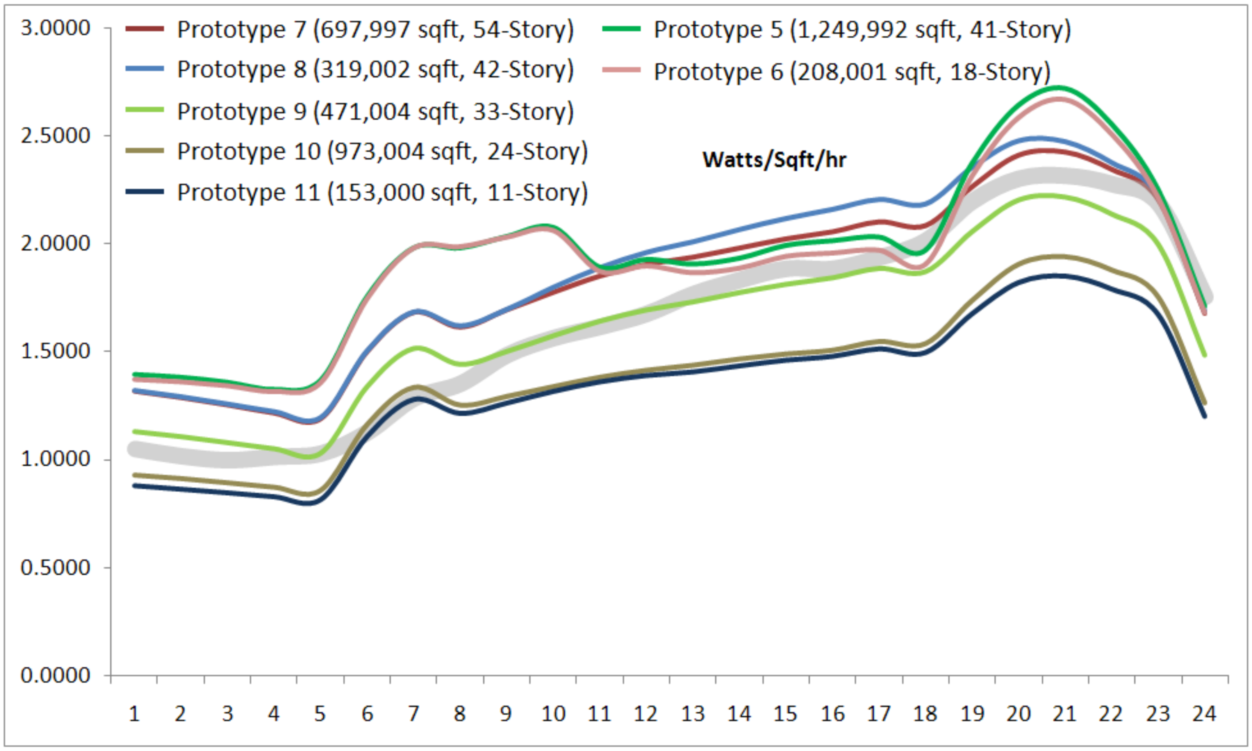
High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Electricity for December – March



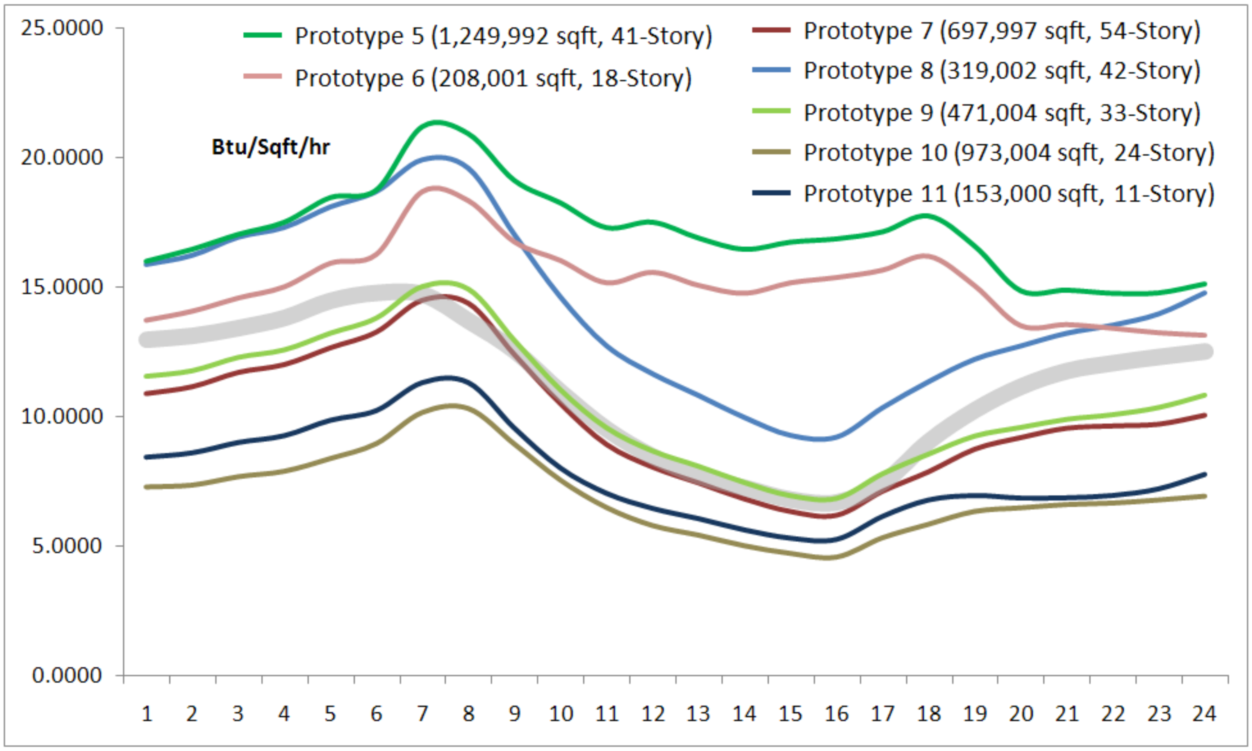
High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Electricity for April – May and October – November



High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Electricity for June – September

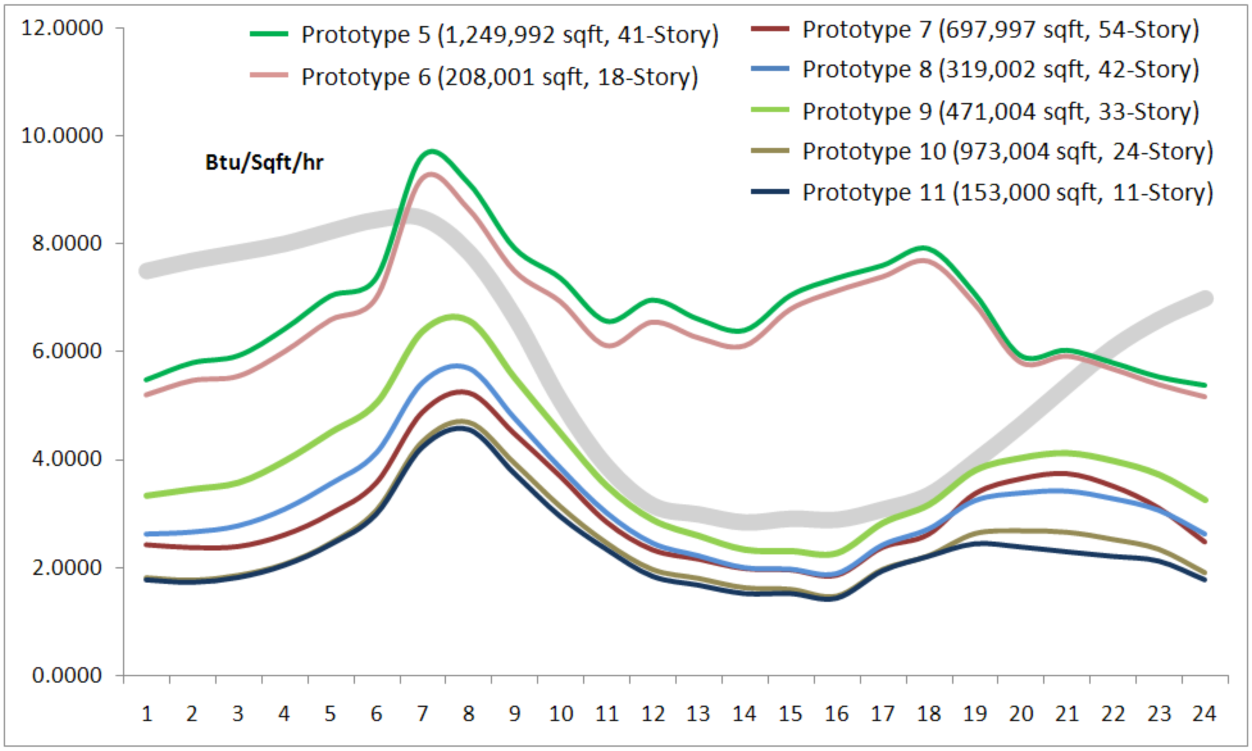


High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Heat for December – March



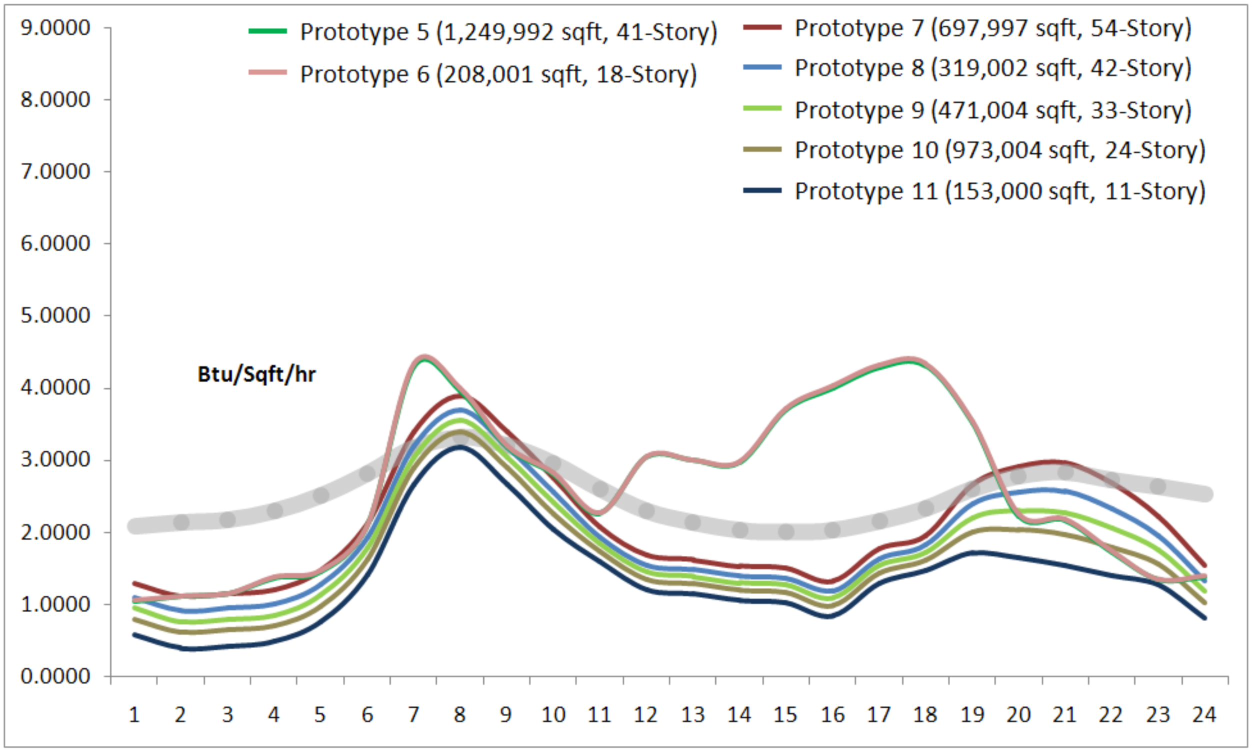
Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Heat for April – May and October – November



Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

High Rise Residential & Hotel Buildings – Prototypes 5, 6, 7, 8, 9, 10 and 11 Average Heat for June – September



Building prototypes were calibrated assuming central steam heating and 50% steam-driven cooling.

APPENDIX C – DATA

Table 24 - Quantity of Spaces that Adopt Efficiency Measures at Various Market Penetrations without a Carbon Cap and Trade Policy

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		BAU	Mid-Low	Mid	Mid-High	High
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	1	2	2	2	2
	14RA (CHP only)	2	2	4	5	5
	Cool Roof	1	1	1	3	3
	Water Heating	0	0	0	0	0
	Glazing	2	2	2	3	3
	Space Heating	0	0	0	0	0
	Space Cooling	5	6	6	9	9
	Lighting	0	0	1	2	2
	Roof Insulation	1	3	3	4	5
	Thermal Storage	2	4	4	4	6
	Wall Insulation	1	2	2	2	2
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	1	1	1	1	2
	14RA (CHP only)	1	1	1	2	2
	Cool Roof	0	0	0	0	0
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	1	2	2	2	3
	Space Cooling	2	2	3	3	3
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	1	1	1	1
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	4	4	5	7	7
	14RA (CHP only)	5	8	8	11	12
	Cool Roof	7	8	9	11	13
	Water Heating	0	0	0	0	0
	Glazing	5	7	8	9	11
	Space Heating	9	10	13	14	17
	Space Cooling	12	15	18	21	23
	Lighting	0	0	0	0	0
	Roof Insulation	1	3	4	4	5
	Thermal Storage	1	1	1	3	3
	Wall Insulation	5	7	7	9	9
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	14RA (CHP only)	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	44	56	66	74	84
	Glazing	75	112	112	127	127
	Space Heating	33	40	47	53	61
	Space Cooling	32	39	48	54	60
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	75	112	112	127	127
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	14RA (CHP only)	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	7	10	12	13	15
	Glazing	6	8	8	10	10
	Space Heating	21	25	28	33	37
	Space Cooling	16	19	23	27	30
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	6	8	8	10	10

Table 25 - Quantity of Spaces that Adopt Efficiency Measures at BAU Market Penetration with a CCT Policy of $5 to $20/MT

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		No CCT	CCT5	CCT10	CCT15	CCT20
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	1	1	2	2	2
	Cool Roof	1	1	1	1	1
	Water Heating	0	0	0	0	0
	Glazing	2	2	2	2	2
	Space Heating	0	0	0	0	0
	Space Cooling	5	5	5	5	5
	Lighting	0	0	0	0	0
	Roof Insulation	1	1	2	2	3
	Thermal Storage	2	2	2	2	2
	Wall Insulation	1	1	1	1	2
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	1	1	1	1	1
	Cool Roof	0	0	0	0	0
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	1	1	1	1	1
	Space Cooling	2	2	2	2	2
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	4	4	5	5	5
	Cool Roof	7	7	7	7	7
	Water Heating	0	0	0	0	0
	Glazing	5	6	6	6	6
	Space Heating	9	9	9	9	9
	Space Cooling	12	12	13	13	13
	Lighting	0	0	0	0	0
	Roof Insulation	1	1	2	2	3
	Thermal Storage	1	1	1	1	1
	Wall Insulation	5	5	5	5	5
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	44	45	45	48	48
	Glazing	75	75	75	75	99
	Space Heating	33	33	33	34	34
	Space Cooling	32	33	34	36	36
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	75	75	75	75	99
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	7	9	9	9	9
	Glazing	6	6	6	6	7
	Space Heating	21	21	21	21	21
	Space Cooling	16	16	16	17	18
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	6	6	6	6	7

Table 26 - Quantity of Spaces that Adopt Efficiency Measures at Mid-Low Market Penetrations with a CCT Policy of $5 to $20/MT

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		No CCT	CCT5	CCT10	CCT15	CCT20
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	2	2	2	2	2
	Cool Roof	1	1	1	1	1
	Water Heating	0	0	0	0	0
	Glazing	2	2	2	2	2
	Space Heating	0	0	0	0	0
	Space Cooling	6	6	6	6	6
	Lighting	0	0	1	1	1
	Roof Insulation	3	3	3	3	3
	Thermal Storage	4	4	4	4	4
	Wall Insulation	2	2	2	2	2
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	1	1	1	1	1
	Cool Roof	0	0	0	0	0
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	2	2	2	2	2
	Space Cooling	2	2	2	2	2
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	1	1	1	1	1
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	4	5	6	8	8
	Cool Roof	8	8	8	8	9
	Water Heating	0	0	0	0	0
	Glazing	7	7	8	8	8
	Space Heating	10	10	10	10	10
	Space Cooling	15	17	17	17	17
	Lighting	0	0	0	0	0
	Roof Insulation	3	4	4	4	4
	Thermal Storage	1	1	1	1	1
	Wall Insulation	7	7	7	7	7
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	56	56	56	56	56
	Glazing	112	112	112	112	112
	Space Heating	40	40	40	41	41
	Space Cooling	39	42	42	42	42
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	112	112	112	112	112
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	10	10	10	10	10
	Glazing	8	8	8	8	8
	Space Heating	25	25	25	25	25
	Space Cooling	19	20	21	21	21
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	8	8	8	8	8

Table 27 - Quantity of Spaces that Adopt Efficiency Measures at Mid Market Penetrations with a CCT Policy of $5 to $20/MT

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		No CCT	CCT5	CCT10	CCT15	CCT20
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	2	2	2	2	4
	Cool Roof	1	1	1	1	1
	Water Heating	0	0	0	0	0
	Glazing	2	2	2	2	2
	Space Heating	0	0	0	0	0
	Space Cooling	6	6	7	7	7
	Lighting	1	1	1	2	2
	Roof Insulation	3	3	4	4	4
	Thermal Storage	4	4	4	4	4
	Wall Insulation	2	2	2	2	2
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	1	1	1	1	2
	Cool Roof	0	0	0	0	0
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	2	2	2	2	2
	Space Cooling	3	3	3	3	3
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	1	1	1	1	1
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	5	7	8	8	8
	Cool Roof	9	10	10	11	11
	Water Heating	0	0	0	0	0
	Glazing	8	8	8	9	9
	Space Heating	13	13	13	13	13
	Space Cooling	18	18	18	19	20
	Lighting	0	0	0	0	0
	Roof Insulation	4	4	4	4	5
	Thermal Storage	1	1	1	1	1
	Wall Insulation	7	8	8	9	9
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	66	66	66	66	66
	Glazing	112	118	118	127	127
	Space Heating	47	47	47	47	47
	Space Cooling	48	48	48	48	50
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	112	118	118	127	127
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	12	12	12	12	12
	Glazing	8	9	9	10	10
	Space Heating	28	28	30	30	30
	Space Cooling	23	24	24	24	24
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	8	9	9	10	10

Table 28 - Quantity of Spaces that Adopt Efficiency Measures at Mid-High Market Penetratios with a CCT Policy of $5 to $20/MT

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		No CCT	CCT5	CCT10	CCT15	CCT20
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	2	2	4	4	4
	Cool Roof	3	3	3	3	3
	Water Heating	0	0	0	0	0
	Glazing	3	3	3	3	3
	Space Heating	0	0	0	0	0
	Space Cooling	9	9	9	9	9
	Lighting	2	2	2	2	2
	Roof Insulation	4	4	5	5	5
	Thermal Storage	4	4	4	4	4
	Wall Insulation	2	2	2	2	2
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	1	1	2	2	2
	Cool Roof	0	0	0	0	0
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	2	2	2	2	2
	Space Cooling	3	3	3	3	3
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	1	1	1	1	1
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	7	8	9	11	11
	Cool Roof	11	12	12	12	14
	Water Heating	0	0	0	0	0
	Glazing	9	9	10	11	11
	Space Heating	14	14	14	16	16
	Space Cooling	21	21	21	21	21
	Lighting	0	0	0	0	0
	Roof Insulation	4	5	5	5	5
	Thermal Storage	3	3	3	3	3
	Wall Insulation	9	9	9	9	9
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	74	74	74	74	74
	Glazing	127	127	127	127	127
	Space Heating	53	53	54	55	55
	Space Cooling	54	54	56	56	56
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	127	127	127	127	127
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	13	13	13	13	15
	Glazing	10	10	10	10	10
	Space Heating	33	33	33	34	34
	Space Cooling	27	27	27	28	28
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	10	10	10	10	10

Table 29 - Quantity of Spaces that Adopt Efficiency Measures at High Market Penetrations with a CCT Policy of $5 to $20/MT

	Efficiency Measure	Quantity of Spaces that Adopt Efficiency Measure				
		No CCT	CCT5	CCT10	CCT15	CCT20
Office (Total 16)	Appliances	0	0	0	0	0
	CHP	2	4	4	5	5
	Cool Roof	3	4	4	4	4
	Water Heating	0	0	0	0	0
	Glazing	3	4	4	4	4
	Space Heating	0	0	0	0	0
	Space Cooling	9	9	9	9	9
	Lighting	2	2	2	2	2
	Roof Insulation	5	5	5	5	6
	Thermal Storage	6	6	6	6	6
	Wall Insulation	2	2	3	3	3
Hotel (Total 6)	Appliances	0	0	0	0	0
	CHP	2	2	2	2	2
	Cool Roof	0	0	0	0	1
	Water Heating	0	0	0	0	0
	Glazing	0	0	0	0	0
	Space Heating	3	3	3	3	3
	Space Cooling	3	3	3	3	4
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	1	1	1	1	1
	Wall Insulation	0	0	0	0	0
Residential (Total 36)	Appliances	0	0	0	0	0
	CHP	7	9	11	11	12
	Cool Roof	13	15	15	15	15
	Water Heating	0	0	0	0	0
	Glazing	11	11	12	12	12
	Space Heating	17	18	18	18	18
	Space Cooling	23	24	24	24	25
	Lighting	0	0	0	0	0
	Roof Insulation	5	5	5	5	5
	Thermal Storage	3	3	3	3	3
	Wall Insulation	9	9	11	11	12
Retail (Total 724)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	84	84	84	84	84
	Glazing	127	127	164	164	187
	Space Heating	61	61	61	62	62
	Space Cooling	60	62	62	63	64
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	127	127	164	164	187
Restaurant (Total 47)	Appliances	0	0	0	0	0
	CHP	0	0	0	0	0
	Cool Roof	0	0	0	0	0
	Water Heating	15	15	16	16	16
	Glazing	10	10	13	13	14
	Space Heating	37	37	37	37	37
	Space Cooling	30	30	31	31	31
	Lighting	0	0	0	0	0
	Roof Insulation	0	0	0	0	0
	Thermal Storage	0	0	0	0	0
	Wall Insulation	10	10	13	13	14

Prototype 01 – 56-story Highrise Office Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$7,855,243	$422,954	$8,278,197	$0	NA
Baseline + Combined Heat and Power, 6500 kW, 1390 ton absorber	$3,128,928	$2,819,377	$5,948,305	$17,520,836	9.1
Baseline + Cool Roof, 100% of roof at Abs=0.3	$7,854,360	$423,291	$8,277,651	$11,022	20.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$7,735,254	$305,473	$8,040,727	$1,764,062	7.4
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$7,855,243	$398,671	$8,253,914	$459,360	18.9
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$7,580,850	$422,954	$8,003,804	$508,367	1.9
Baseline + High Efficiency Lighting, 0.9 watts/sqft	$7,430,794	$434,947	$7,865,741	$4,592,517	11.1
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$7,853,260	$422,732	$8,275,992	$6,012	2.7
Baseline + Thermal Storage, 25% of max load, 23376 ton-hrs	$7,661,938	$422,954	$8,084,892	$1,636,332	8.5
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$7,769,615	$313,469	$8,083,085	$1,764,062	9.0
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	38,767,980	441,802	30,348	472,150	0
Baseline + Combined Heat and Power, 6500 kW, 1390 ton absorber	17,283,500	196,963	223,037	420,000	52,150
Baseline + Cool Roof, 100% of roof at Abs=0.3	38,774,800	441,882	30,372	472,254	-104
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	38,248,720	435,887	21,827	457,714	14,437
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	38,767,980	441,802	28,586	470,388	1,762
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	37,746,150	430,159	30,348	460,507	11,643
Baseline + High Efficiency Lighting, 0.9 watts/sqft	36,913,150	420,666	31,218	451,885	20,265
Baseline + Envelope Insulation - Roof, 6" R23 XPS	38,752,680	441,628	30,332	471,960	190
Baseline + Thermal Storage, 25% of max load, 23376 ton-hrs	39,421,300	449,250	30,348	479,598	-7,448
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	38,376,280	437,340	22,407	459,746	12,404

Prototype 02 – 41-story Highrise Office Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$6,608,378	$396,177	$7,004,555	$0	NA
Baseline + Combined Heat and Power, 5500 kW, 1150 ton absorber	$2,602,070	$2,411,465	$5,013,535	$14,517,192	8.8
Baseline + Cool Roof, 100% of roof at Abs=0.3	$6,606,996	$396,464	$7,003,460	$13,307	12.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$6,515,729	$298,760	$6,814,490	$1,409,693	7.4
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$6,608,378	$373,344	$6,981,723	$432,758	19.0
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$6,393,825	$396,177	$6,790,002	$419,471	2.0
Baseline + High Efficiency Lighting, 0.9 watts/sqft	$6,243,810	$408,176	$6,651,986	$4,032,506	11.4
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$6,607,094	$395,975	$7,003,069	$7,259	4.9
Baseline + Thermal Storage, 25% of max load, 15073 ton-hrs	$6,408,409	$396,177	$6,804,586	$1,055,081	5.3
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$6,543,264	$305,194	$6,848,458	$1,409,693	9.0
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	32,359,210	368,769	28,406	397,176	0
Baseline + Combined Heat and Power, 5500 kW, 1150 ton absorber	14,105,440	160,748	190,703	351,450	45,725
Baseline + Cool Roof, 100% of roof at Abs=0.3	32,363,580	368,820	28,427	397,247	-71
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	31,921,900	363,786	21,340	385,126	12,049
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	32,359,210	368,769	26,750	395,519	1,656
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	31,611,400	360,246	28,406	388,652	8,524
Baseline + High Efficiency Lighting, 0.9 watts/sqft	30,726,770	350,166	29,276	379,442	17,734
Baseline + Envelope Insulation - Roof, 6" R23 XPS	32,349,180	368,653	28,391	397,044	132
Baseline + Thermal Storage, 25% of max load, 15073 ton-hrs	32,826,030	374,087	28,406	402,493	-5,317
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	32,029,310	365,009	21,806	386,814	10,361

Prototype 03 – 34-story Highrise Office Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$5,777,791	$369,041	$6,146,832	$0	NA
Baseline + Combined Heat and Power, 4500 kW, 1020 ton absorber	$2,445,646	$2,115,914	$4,561,560	$11,515,326	8.9
Baseline + Cool Roof, 100% of roof at Abs=0.3	$5,775,495	$369,331	$6,144,825	$14,430	7.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$5,694,205	$285,642	$5,979,848	$1,211,066	7.3
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$5,777,791	$347,756	$6,125,547	$391,261	18.4
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$5,594,845	$369,041	$5,963,885	$373,943	2.0
Baseline + High Efficiency Lighting, 0.9 watts/sqft	$5,452,965	$381,340	$5,834,305	$3,607,511	11.5
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$5,777,079	$368,854	$6,145,933	$7,871	8.8
Baseline + Thermal Storage, 25% of max load, 16172 ton-hrs	$5,600,953	$369,041	$5,969,993	$1,132,005	6.4
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$5,717,690	$291,002	$6,008,692	$1,211,066	8.8
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	28,152,040	320,824	26,438	347,261	0
Baseline + Combined Heat and Power, 4500 kW, 1020 ton absorber	12,667,300	144,358	162,517	306,876	40,386
Baseline + Cool Roof, 100% of roof at Abs=0.3	28,147,870	320,777	26,458	347,235	27
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	27,771,460	316,485	20,388	336,873	10,388
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	28,152,040	320,824	24,893	345,717	1,544
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	27,530,860	313,743	26,438	340,181	7,081
Baseline + High Efficiency Lighting, 0.9 watts/sqft	26,688,450	304,144	27,330	331,474	15,788
Baseline + Envelope Insulation - Roof, 6" R23 XPS	28,146,790	320,764	26,424	347,188	74
Baseline + Thermal Storage, 25% of max load, 16172 ton-hrs	28,518,920	325,005	26,438	351,443	-4,182
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	27,860,100	317,497	20,777	338,274	8,988

Prototype 04 – 20-story Midrise Office Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$2,979,295	$156,522	$3,135,817	$0	NA
Baseline + Combined Heat and Power, 3000 kW, 490 ton absorber	$959,703	$1,205,189	$2,164,892	$7,207,338	9.0
Baseline + Cool Roof, 100% of roof at Abs=0.3	$2,977,004	$156,948	$3,133,952	$13,756	7.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$2,944,167	$128,404	$3,072,570	$680,795	10.8
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$2,979,295	$147,510	$3,126,805	$204,826	22.7
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$2,889,343	$156,522	$3,045,865	$179,037	2.0
Baseline + High Efficiency Lighting, 0.9 watts/sqft	$2,800,867	$165,732	$2,966,599	$1,979,998	11.7
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$2,978,638	$156,099	$3,134,737	$7,503	6.9
Baseline + Thermal Storage, 25% of max load, 7818 ton-hrs	$2,870,071	$156,522	$3,026,593	$547,243	5.0
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$2,978,441	$153,788	$3,132,229	$45,037	12.6

Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	14,371,930	163,784	11,065	174,848	0
Baseline + Combined Heat and Power, 3000 kW, 490 ton absorber	5,542,578	63,163	92,572	155,734	19,114
Baseline + Cool Roof, 100% of roof at Abs=0.3	14,366,120	163,717	11,096	174,813	35
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	14,226,000	162,120	9,032	171,153	3,696
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	14,371,930	163,784	10,418	174,201	647
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	14,084,210	160,504	11,065	171,568	3,280
Baseline + High Efficiency Lighting, 0.9 watts/sqft	13,579,380	154,752	11,733	166,485	8,363
Baseline + Envelope Insulation - Roof, 6" R23 XPS	14,368,340	163,744	11,034	174,778	70
Baseline + Thermal Storage, 25% of max load, 7818 ton-hrs	14,485,280	165,076	11,065	176,141	-1,293
Baseline + Envelope Insulation - Walls, R19, 2x4.16	14,365,820	163,713	10,867	174,580	268

Prototype 05 – 33-story Highrise Hotel Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$3,125,714	$1,341,522	$4,467,237	$0	NA
Baseline + Combined Heat and Power, 2500 kW, 500 ton absorber	$1,377,275	$2,019,232	$3,396,507	$6,007,570	6.5
Baseline + Cool Roof, 100% of roof at Abs=0.3	$3,124,742	$1,341,947	$4,466,689	$12,500	22.8
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$3,123,103	$1,241,680	$4,364,782	$1,127,165	11.0
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$3,125,714	$1,271,467	$4,397,182	$230,271	3.3
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$3,021,314	$1,341,522	$4,362,836	$230,381	2.2
Baseline + High Efficiency Lighting, 1.19 watts/sqft	$3,045,015	$1,348,890	$4,393,904	$3,124,976	42.6
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$3,125,656	$1,341,075	$4,466,731	$6,818	13.5
Baseline + Thermal Storage, 15% of max load, 7799 ton-hrs	$3,065,626	$1,341,522	$4,407,149	$545,930	9.1
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$3,130,476	$1,243,736	$4,374,213	$1,127,165	12.1

Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	17,289,660	197,033	96,974	294,007	0
Baseline + Combined Heat and Power, 2500 kW, 500 ton absorber	9,707,363	110,627	150,694	261,321	32,686
Baseline + Cool Roof, 100% of roof at Abs=0.3	17,284,260	196,973	97,005	293,978	30
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	17,329,680	197,491	89,732	287,223	6,785
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	17,289,660	197,033	91,892	288,925	5,082
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	16,822,640	191,713	96,974	288,687	5,321
Baseline + High Efficiency Lighting, 1.19 watts/sqft	16,881,320	192,381	97,508	289,889	4,119
Baseline + Envelope Insulation - Roof, 6" R23 XPS	17,289,770	197,037	96,942	293,978	29
Baseline + Thermal Storage, 15% of max load, 7799 ton-hrs	17,393,510	198,219	96,974	295,193	-1,186
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	17,378,830	198,052	89,881	287,933	6,075

Prototype 06 – 18-story Midrise Hotel Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$520,602	$208,942	$729,545	$0	NA
Baseline + Combined Heat and Power, 400 kW, 80 ton absorber	$246,143	$324,547	$570,690	$961,198	7.1
Baseline + Cool Roof, 100% of roof at Abs=0.3	$520,267	$209,039	$729,306	$3,813	16.0
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$520,781	$199,033	$719,814	$339,583	34.9
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$520,602	$198,344	$718,947	$34,271	3.2
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$502,864	$208,942	$711,806	$33,834	1.9
Baseline + High Efficiency Lighting, 1.19 watts/sqft	$506,896	$209,845	$716,740	$520,002	40.6
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$520,580	$208,818	$729,399	$2,080	14.2
Baseline + Thermal Storage, 15% of max load, 1265 ton-hrs	$509,934	$208,942	$718,876	$88,538	8.3
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$520,842	$207,689	$728,532	$22,465	22.2
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	2,895,951	33,003	14,824	47,827	0
Baseline + Combined Heat and Power, 400 kW, 80 ton absorber	1,642,262	18,714	23,980	42,695	5,133
Baseline + Cool Roof, 100% of roof at Abs=0.3	2,894,049	32,979	14,832	47,811	16
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	2,914,989	33,220	14,106	47,326	501
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	2,895,951	33,003	14,056	47,059	768
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	2,814,202	32,071	14,824	46,895	932
Baseline + High Efficiency Lighting, 1.19 watts/sqft	2,826,321	32,208	14,890	47,098	729
Baseline + Envelope Insulation - Roof, 6" R23 XPS	2,895,858	33,003	14,815	47,818	9
Baseline + Thermal Storage, 15% of max load, 1265 ton-hrs	2,913,303	33,200	14,824	48,024	-197
Baseline + Envelope Insulation - Walls, R19, 2x4.16	2,898,873	33,036	14,733	47,769	58

Prototype 07 – 55-story Highrise Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$1,551,558	$505,528	$2,057,086	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$1,550,950	$505,571	$2,056,424	$155,608	235.1
Baseline + Combined Heat and Power, 1500 kW, 300 ton absorber	$637,897	$910,283	$1,548,180	$3,604,478	8.3
Baseline + Cool Roof, 100% of roof at Abs=0.3	$1,550,915	$505,705	$2,056,620	$4,266	9.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$1,488,622	$402,701	$1,891,324	$1,077,459	6.5
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$1,551,558	$480,836	$2,032,394	$122,608	5.0
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$1,497,032	$505,528	$2,002,559	$109,250	2.0
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$1,536,395	$506,413	$2,042,808	$1,744,993	122.2
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$1,551,397	$505,391	$2,056,788	$2,327	7.8
Baseline + Thermal Storage, 15% of max load, 3751 ton-hrs	$1,543,104	$505,528	$2,048,632	$262,547	31.1
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$1,504,398	$410,653	$1,915,051	$1,077,459	7.6
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	8,664,978	98,747	36,336	135,083	0
Baseline + High Efficiency Appliances, Energy Star Rated	8,660,950	98,700	36,339	135,040	44
Baseline + Combined Heat and Power, 1500 kW, 300 ton absorber	4,762,240	54,272	68,112	122,383	12,700
Baseline + Cool Roof, 100% of roof at Abs=0.3	8,661,909	98,710	36,349	135,059	24
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	8,334,327	94,980	28,877	123,857	11,226
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	8,664,978	98,747	34,546	133,293	1,790
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	8,407,912	95,818	36,336	132,154	2,929
Baseline + High Efficiency Lighting, 0.675 watts/sqft	8,585,753	97,845	36,400	134,245	838
Baseline + Envelope Insulation - Roof, 6" R23 XPS	8,664,109	98,737	36,327	135,064	19
Baseline + Thermal Storage, 15% of max load, 3751 ton-hrs	8,754,765	99,769	36,336	136,105	-1,022
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	8,435,743	96,135	29,454	125,589	9,494

Prototype 08 – 43-story Highrise Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$737,107	$310,309	$1,047,416	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$736,794	$310,331	$1,047,125	$71,188	244.6
Baseline + Combined Heat and Power, 750 kW, 160 ton absorber	$307,967	$503,866	$811,833	$1,802,353	9.0
Baseline + Cool Roof, 100% of roof at Abs=0.3	$736,737	$310,439	$1,047,175	$2,506	10.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$699,553	$245,720	$945,273	$642,390	6.3
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$737,107	$294,024	$1,031,131	$76,334	4.7
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$711,398	$310,309	$1,021,707	$57,408	2.2
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$730,474	$310,762	$1,041,237	$797,506	129.1
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$737,011	$310,208	$1,047,219	$1,367	6.9
Baseline + Thermal Storage, 15% of max load, 1820 ton-hrs	$729,310	$310,309	$1,039,619	$127,423	16.3
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$708,760	$250,838	$959,597	$642,390	7.3
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	4,094,859	46,666	22,178	68,844	0
Baseline + High Efficiency Appliances, Energy Star Rated	4,093,069	46,646	22,179	68,825	19
Baseline + Combined Heat and Power, 750 kW, 160 ton absorber	2,239,767	25,524	37,403	62,927	5,917
Baseline + Cool Roof, 100% of roof at Abs=0.3	4,093,093	46,646	22,187	68,833	11
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	3,889,771	44,328	17,492	61,821	7,023
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	4,094,859	46,666	20,995	67,662	1,182
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	3,980,826	45,367	22,178	67,545	1,299
Baseline + High Efficiency Lighting, 0.675 watts/sqft	4,059,815	46,266	22,210	68,476	368
Baseline + Envelope Insulation - Roof, 6" R23 XPS	4,094,356	46,660	22,170	68,830	14
Baseline + Thermal Storage, 15% of max load, 1820 ton-hrs	4,132,463	47,094	22,178	69,272	-428
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	3,952,591	45,043	17,863	62,906	5,938

Prototype 09 – 34-story Highrise Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$970,010	$353,124	$1,323,134	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$969,546	$353,161	$1,322,708	$105,062	246.6
Baseline + Combined Heat and Power, 850 kW, 180 ton absorber	$421,136	$598,073	$1,019,209	$2,042,676	7.9
Baseline + Cool Roof, 100% of roof at Abs=0.3	$969,201	$353,299	$1,322,500	$4,710	7.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$930,344	$284,617	$1,214,961	$691,905	6.4
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$970,010	$334,590	$1,304,600	$85,456	4.6
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$940,844	$353,124	$1,293,968	$65,301	2.2
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$959,957	$353,814	$1,313,771	$1,177,509	125.8
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$969,844	$352,987	$1,322,831	$2,569	8.5
Baseline + Thermal Storage, 15% of max load, 2143 ton-hrs	$961,013	$353,124	$1,314,136	$150,022	16.7
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$940,177	$290,772	$1,230,949	$691,905	7.5
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	5,419,618	61,763	25,283	87,046	0
Baseline + High Efficiency Appliances, Energy Star Rated	5,416,972	61,733	25,285	87,018	28
Baseline + Combined Heat and Power, 850 kW, 180 ton absorber	2,996,552	34,148	44,579	78,727	8,319
Baseline + Cool Roof, 100% of roof at Abs=0.3	5,415,965	61,720	25,296	87,015	31
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	5,200,928	59,272	20,313	79,584	7,462
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	5,419,618	61,763	23,939	85,702	1,344
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	5,287,690	60,260	25,283	85,543	1,503
Baseline + High Efficiency Lighting, 0.675 watts/sqft	5,367,563	61,169	25,332	86,501	545
Baseline + Envelope Insulation - Roof, 6" R23 XPS	5,418,693	61,753	25,272	87,026	20
Baseline + Thermal Storage, 15% of max load, 2143 ton-hrs	5,463,198	62,258	25,283	87,541	-494
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	5,268,925	60,047	20,760	80,806	6,240

Prototype 10 – 25-story Highrise Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$1,746,538	$504,831	$2,251,369	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$1,745,561	$504,890	$2,250,451	$217,005	236.4
Baseline + Combined Heat and Power, 1500 kW, 250 ton absorber	$738,484	$930,551	$1,669,035	$3,603,807	7.2
Baseline + Cool Roof, 100% of roof at Abs=0.3	$1,744,334	$505,242	$2,249,576	$13,379	7.5
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$1,699,760	$425,326	$2,125,086	$848,086	6.7
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$1,746,538	$478,363	$2,224,901	$118,139	4.5
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$1,704,085	$504,831	$2,208,916	$92,883	2.2
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$1,725,749	$506,153	$2,231,902	$2,432,509	125.0
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$1,746,073	$504,541	$2,250,614	$7,298	9.7
Baseline + Thermal Storage, 15% of max load, 3299 ton-hrs	$1,734,740	$504,831	$2,239,571	$230,930	19.6
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$1,711,046	$432,297	$2,143,343	$848,086	7.9
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	9,816,055	111,863	36,286	148,149	0
Baseline + High Efficiency Appliances, Energy Star Rated	9,810,413	111,800	36,290	148,090	59
Baseline + Combined Heat and Power, 1500 kW, 250 ton absorber	5,429,196	61,870	69,878	131,748	16,401
Baseline + Cool Roof, 100% of roof at Abs=0.3	9,803,718	111,723	36,315	148,038	111
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	9,560,870	108,957	30,518	139,475	8,674
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	9,816,055	111,863	34,366	146,229	1,920
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	9,621,466	109,646	36,286	145,931	2,218
Baseline + High Efficiency Lighting, 0.675 watts/sqft	9,707,522	110,627	36,381	147,009	1,141
Baseline + Envelope Insulation - Roof, 6" R23 XPS	9,813,230	111,833	36,265	148,098	51
Baseline + Thermal Storage, 15% of max load, 3299 ton-hrs	9,888,220	112,688	36,286	148,974	-825
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	9,640,668	109,866	31,024	140,890	7,260

Prototype 11 – 12-story Midrise Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$270,294	$86,909	$357,203	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$270,147	$86,922	$357,069	$34,139	254.8
Baseline + Combined Heat and Power, 250 kW, 40 ton absorber	$120,781	$173,803	$294,584	$600,620	12.1
Baseline + Cool Roof, 100% of roof at Abs=0.3	$269,085	$87,036	$356,120	$4,590	4.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$258,983	$71,449	$330,432	$227,677	8.5
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$270,294	$82,143	$352,437	$20,853	4.4
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$263,659	$86,909	$350,568	$14,027	2.1
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$266,874	$87,212	$354,086	$382,501	122.7
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$270,215	$86,889	$357,103	$2,504	25.0
Baseline + Thermal Storage, 15% of max load, 506 ton-hrs	$267,670	$86,909	$354,579	$35,438	13.5
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$269,902	$85,469	$355,371	$15,062	8.2
Category and Measure	**Elec kWh**	**Elec MMBtu**	**Gas MMBtu**	**Total MMBtu**	**MMBtu Diff**
Baseline	1,522,627	17,351	6,047	23,399	0
Baseline + High Efficiency Appliances, Energy Star Rated	1,521,775	17,341	6,049	23,390	9
Baseline + Combined Heat and Power, 250 kW, 40 ton absorber	830,077	9,459	12,717	22,176	1,223
Baseline + Cool Roof, 100% of roof at Abs=0.3	1,517,903	17,298	6,057	23,355	44
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	1,459,927	16,637	4,933	21,570	1,829
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	1,522,627	17,351	5,707	23,058	340
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	1,491,627	16,997	6,047	23,045	354
Baseline + High Efficiency Lighting, 0.675 watts/sqft	1,506,623	17,171	6,069	23,240	158
Baseline + Envelope Insulation - Roof, 6" R23 XPS	1,522,280	17,348	6,046	23,394	4
Baseline + Thermal Storage, 15% of max load, 506 ton-hrs	1,525,671	17,388	6,047	23,436	-37
Baseline + Envelope Insulation - Walls, R19, 2x4.16	1,520,553	17,328	5,944	23,272	127

Prototype 12 – 55-story Highrise Mixed Use, Office Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$3,888,611	$291,930	$4,180,541	$0	NA
Baseline + Combined Heat and Power, 3500 kW, 680 ton absorber	$1,417,114	$1,542,199	$2,959,313	$8,510,130	8.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$3,827,554	$228,393	$4,055,947	$901,609	7.2
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$3,888,611	$275,032	$4,163,643	$300,647	17.8
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$3,768,660	$291,930	$4,060,591	$247,163	2.1
Baseline + High Efficiency Lighting, 0.9 watts/sqft	$3,672,496	$301,957	$3,974,453	$2,443,757	11.9
Baseline + Thermal Storage, 25% of max load, 10798 ton-hrs	$3,745,058	$291,930	$4,036,989	$755,848	5.3
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$3,843,543	$232,033	$4,075,576	$901,609	8.6
Category and Measure	**Elec kWh**	**Elec MMBtu**	**Gas MMBtu**	**Total MMBtu**	**MMBtu Diff**
Baseline	18,848,550	214,799	20,858	235,657	0
Baseline + Combined Heat and Power, 3500 kW, 680 ton absorber	7,758,062	88,413	118,310	206,723	28,934
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	18,567,840	211,599	16,250	227,850	7,808
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	18,848,550	214,799	19,638	234,436	1,221
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	18,456,650	210,333	20,858	231,191	4,466
Baseline + High Efficiency Lighting, 0.9 watts/sqft	17,873,240	203,683	21,586	225,269	10,388
Baseline + Thermal Storage, 25% of max load, 10798 ton-hrs	19,028,540	216,850	20,858	237,708	-2,051
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	18,625,810	212,260	16,514	228,775	6,882

Prototype 12 – 55-story Highrise Mixed Use, Residential Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$1,791,409	$522,467	$2,313,876	$0	NA
Baseline + High Efficiency Appliances, Energy Star Rated	$1,790,462	$522,494	$2,312,956	$218,063	237.0
Baseline + Combined Heat and Power, 1500 kW, 270 ton absorber	$773,138	$957,670	$1,730,808	$3,604,028	7.2
Baseline + Cool Roof, 100% of roof at Abs=0.3	$1,789,493	$522,846	$2,312,339	$11,947	7.8
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$1,741,437	$435,148	$2,176,585	$901,609	6.6
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	$1,791,409	$495,343	$2,286,753	$122,201	4.5
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	$1,745,939	$522,467	$2,268,405	$98,284	2.2
Baseline + High Efficiency Lighting, 0.675 watts/sqft	$1,770,355	$523,030	$2,293,384	$2,443,757	119.3
Baseline + Envelope Insulation - Roof, 6" R23 XPS	$1,791,028	$522,396	$2,313,424	$6,517	14.4
Baseline + Thermal Storage, 15% of max load, 3472 ton-hrs	$1,780,065	$522,467	$2,302,532	$243,034	21.4
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$1,753,358	$442,714	$2,196,072	$901,609	7.7
Category and Measure	**Elec kWh**	**Elec MMBtu**	**Gas MMBtu**	**Total MMBtu**	**MMBtu Diff**
Baseline	10,064,280	114,692	37,564	152,257	0
Baseline + High Efficiency Appliances, Energy Star Rated	10,058,920	114,632	37,566	152,199	58
Baseline + Combined Heat and Power, 1500 kW, 270 ton absorber	5,588,816	63,690	71,888	135,579	16,678
Baseline + Cool Roof, 100% of roof at Abs=0.3	10,053,900	114,575	37,593	152,168	89
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	9,791,154	111,579	31,231	142,810	9,446
Baseline + High Efficiency Heating, Boiler Comb Eff = 85%	10,064,280	114,692	35,598	150,290	1,966
Baseline + High Efficiency Cooling, 0.461 kW/ton Centrifugal Chillers	9,854,940	112,308	37,564	149,872	2,385
Baseline + High Efficiency Lighting, 0.675 watts/sqft	9,954,384	113,440	37,605	151,045	1,212
Baseline + Envelope Insulation - Roof, 6" R23 XPS	10,062,010	114,669	37,560	152,229	28
Baseline + Thermal Storage, 15% of max load, 3472 ton-hrs	10,140,410	115,561	37,564	153,125	-868
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	9,876,738	112,555	31,780	144,334	7,922

Corner Retail Shop – Type I Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$9,681	$3,108	$12,789	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$9,681	$2,818	$12,499	$371	1.3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$9,313	$2,933	$12,246	$3,767	6.9
Baseline + High Efficiency Heating, Furnace 94% AFUE	$9,681	$2,756	$12,437	$1,163	3.3
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$8,988	$3,108	$12,097	$2,588	3.7
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$9,492	$2,895	$12,387	$11,930	29.7
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	44,572	508	188	696	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	44,572	508	170	677	19
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	42,964	491	177	668	28
Baseline + High Efficiency Heating, Furnace 94% AFUE	44,572	508	165	673	23
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	42,399	484	188	673	23
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	43,709	498	174	671	25

Internal Retail Shop – Type I Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$8,561	$2,485	$11,046	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$8,561	$2,193	$10,753	$371	1.3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$8,410	$2,392	$10,802	$1,884	7.7
Baseline + High Efficiency Heating, Furnace 94% AFUE	$8,561	$2,242	$10,802	$891	3.7
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$8,015	$2,485	$10,500	$2,050	3.8
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$8,451	$2,365	$10,816	$13,813	60.1
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	39,669	451	147	597	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	39,669	451	129	580	18
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	39,065	444	140	585	13
Baseline + High Efficiency Heating, Furnace 94% AFUE	39,669	451	131	582	16
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	37,918	431	147	577	20
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	39,219	448	139	587	11

Corner Restaurant – Type I Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$71,291	$43,804	$115,095	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$71,291	$43,640	$114,931	$1,483	9.0
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$70,880	$43,337	$114,218	$7,247	8.3
Baseline + High Efficiency Heating, Furnace 94% AFUE	$71,291	$40,582	$111,872	$7,019	2.2
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$69,330	$43,804	$113,135	$7,674	3.9
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	$70,896	$43,400	$114,296	$22,947	28.7
Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	376,430	4,289	2,933	7,221	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	376,430	4,289	2,922	7,211	10
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	374,525	4,269	2,900	7,169	52
Baseline + High Efficiency Heating, Furnace 94% AFUE	376,430	4,289	2,706	6,995	226
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	369,577	4,212	2,933	7,144	77
Baseline + Envelope Insulation - Walls, Reduced thermal bridging	374,653	4,269	2,904	7,173	48

Corner Retail Shop – Type II Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$9,039	$2,279	$11,318	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$9,039	$1,987	$11,025	$371	1.3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$8,753	$2,150	$10,903	$3,767	9.1
Baseline + High Efficiency Heating, Furnace 94% AFUE	$9,039	$2,067	$11,106	$908	4.3
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$8,414	$2,279	$10,693	$2,242	3.6
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$9,013	$2,225	$11,239	$789	10.0

Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	41,614	474	133	607	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	41,614	474	115	589	18
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	40,421	461	125	586	22
Baseline + High Efficiency Heating, Furnace 94% AFUE	41,614	474	119	594	14
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	39,613	451	133	584	23
Baseline + Envelope Insulation - Walls, R19, 2x4.16	41,495	474	130	604	3

Internal Retail Shop – Type II Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$8,244	$2,018	$10,262	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$8,244	$1,720	$9,963	$371	1.2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$8,094	$1,949	$10,042	$1,884	8.6
Baseline + High Efficiency Heating, Furnace 94% AFUE	$8,244	$1,853	$10,096	$751	4.5
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$7,734	$2,018	$9,753	$1,890	3.7
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$8,229	$1,985	$10,215	$914	19.4

Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	38,274	438	116	554	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	38,274	438	97	535	19
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	37,636	428	111	539	15
Baseline + High Efficiency Heating, Furnace 94% AFUE	38,274	438	105	542	12
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	36,617	418	116	534	20
Baseline + Envelope Insulation - Walls, R19, 2x4.16	38,197	434	113	547	6

Corner Restaurant – Type II Construction Data

Category and Measure	Elec Cost	Gas Cost	Total Cost	Alt Cost	Payback
Baseline	$69,911	$42,231	$112,141	$0	NA
Baseline + High Efficiency Domestic Hot Water, EF=0.823	$69,911	$42,067	$111,978	$1,483	9.1
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	$69,585	$41,888	$111,473	$7,247	10.8
Baseline + High Efficiency Heating, Furnace 94% AFUE	$69,911	$39,244	$109,155	$6,495	2.2
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	$68,084	$42,231	$110,315	$6,940	3.8
Baseline + Envelope Insulation - Walls, R19, 2x4.16	$69,818	$42,134	$111,953	$1,518	8.1

Category and Measure	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Diff
Baseline	370,202	4,218	2,822	7,040	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	370,202	4,218	2,810	7,029	12
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.29	368,631	4,202	2,798	6,999	41
Baseline + High Efficiency Heating, Furnace 94% AFUE	370,202	4,218	2,613	6,832	208
Baseline + High Efficiency Cooling, 14 SEER, 12.5 EER Unitary AC	363,708	4,145	2,822	6,967	73
Baseline + Envelope Insulation - Walls, R19, 2x4.16	369,779	4,215	2,814	7,029	11

Prototype 01 - 56-story Highrise Office (Qty 1)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.4	21%	0	26%	0	30%	0	34%	0	38%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.9	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	61%	0	70%	0	78%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.1	13%	0	16%	0	19%	0	21%	0	24%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.7	39%	0	47%	0	54%	0	62%	0	70%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	9.0	17%	0	21%	0	24%	0	28%	0	31%	0

Prototype 02 - 41-story Highrise Office (Qty 6)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	8.8	18%	1	22%	1	25%	1	29%	1	32%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.4	21%	1	26%	1	30%	1	34%	2	39%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	19.0	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	2	51%	3	60%	3	69%	4	77%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.4	13%	0	15%	0	18%	1	21%	1	23%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	4.9	30%	1	35%	2	41%	2	47%	2	53%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	9.0	17%	1	21%	1	24%	1	28%	1	31%	1

Prototype 03 - 34-story Highrise Office (Qty 5)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	8.9	18%	0	21%	1	25%	1	28%	1	32%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.2	22%	1	26%	1	31%	1	35%	1	40%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.3	22%	1	26%	1	31%	1	35%	1	39%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.4	5%	0	6%	0	7%	0	8%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	42%	2	51%	2	59%	2	68%	3	76%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.5	13%	0	15%	0	18%	0	20%	1	23%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	8.8	18%	0	22%	1	25%	1	29%	1	33%	1
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.8	18%	0	22%	1	25%	1	29%	1	32%	1

Prototype 04 - 20-story Midrise Office (Qty 3)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	9.0	18%	0	21%	0	25%	0	28%	0	32%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.4	22%	0	26%	0	30%	0	34%	1	39%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.8	14%	0	17%	0	20%	0	22%	0	25%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	22.7	3%	0	4%	0	4%	0	5%	0	5%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	1	51%	1	60%	1	68%	2	77%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.7	12%	0	15%	0	17%	0	20%	0	22%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.9	23%	0	27%	0	32%	0	36%	1	41%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	12.6	11%	0	13%	0	16%	0	18%	0	20%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	6.5	24%	0	29%	0	34%	0	39%	0	44%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	22.8	3%	0	4%	0	4%	0	5%	0	5%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	11.0	14%	0	16%	0	19%	0	22%	0	24%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.3	36%	0	43%	0	51%	0	58%	0	65%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	0	50%	0	58%	0	66%	0	75%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	42.6	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.5	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	7.1	22%	1	27%	1	31%	1	36%	1	40%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	16.0	7%	0	9%	0	10%	0	12%	0	13%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.2	36%	1	44%	2	51%	2	58%	2	66%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	60%	3	69%	3	78%	3
Lighting	1.3 watts/sqft	1.19 watts/sqft	40.6	0%	0	0%	0	0%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	14.2	9%	0	11%	0	13%	0	14%	0	16%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)				BAU		Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	235.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	8.3	19%	0	23%	0	27%	0	31%	0	35%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	9.2	17%	0	21%	0	24%	0	27%	0	31%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.5	24%	0	29%	0	34%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	5.0	29%	0	35%	0	41%	0	47%	0	53%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	0	51%	1	60%	1	68%	1	77%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	122.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.8	20%	0	24%	0	29%	0	33%	0	37%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.6	21%	0	25%	0	29%	0	34%	0	38%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	244.6	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	9.0	18%	0	21%	0	25%	0	28%	1	32%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	10.4	15%	0	18%	0	21%	0	23%	0	26%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.3	25%	0	30%	1	35%	1	40%	1	44%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.7	30%	1	36%	1	42%	1	48%	1	55%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	41%	1	50%	1	58%	2	66%	2	75%	2
Lighting	0.70 watts/sqft	0.675 watts/sqft	129.1	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.9	23%	0	27%	1	32%	1	36%	1	41%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.3	22%	0	26%	1	30%	1	35%	1	39%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	246.6	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	7.9	20%	2	24%	2	28%	2	32%	3	36%	3
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.4	21%	2	26%	2	30%	2	34%	3	38%	3
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.4	24%	2	29%	2	34%	3	39%	3	44%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.6	31%	3	37%	3	43%	4	49%	4	55%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	41%	4	50%	4	58%	5	66%	6	74%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	125.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.5	19%	1	22%	2	26%	2	30%	2	34%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.5	21%	2	25%	2	30%	2	34%	3	38%	3

Prototype 10 - 25-story Highrise Residential (Qty 5)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	236.4	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	7.2	22%	1	26%	1	31%	1	35%	1	40%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.5	21%	1	26%	1	30%	1	34%	1	38%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.7	23%	1	28%	1	33%	1	37%	1	42%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	1	37%	1	44%	2	50%	2	56%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	2	50%	2	58%	2	67%	3	75%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	125.0	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	9.7	16%	0	19%	0	23%	1	26%	1	29%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.9	20%	1	24%	1	28%	1	32%	1	36%	1

Prototype 11 - 12-story Midrise Residential (Qty 14)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	254.8	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	12.1	12%	1	14%	1	17%	2	19%	2	21%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	4.2	32%	4	38%	5	45%	6	51%	7	58%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.5	19%	2	22%	3	26%	3	30%	4	34%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	32%	4	38%	5	44%	6	50%	7	57%	7
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	5	50%	7	59%	8	67%	9	76%	10
Lighting	0.70 watts/sqft	0.675 watts/sqft	122.7	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	25.0	2%	0	3%	0	3%	0	4%	0	4%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	8.2	19%	2	23%	3	27%	3	31%	4	35%	4

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	8.4	19%	0	23%	0	26%	0	30%	0	34%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA		NA		NA		NA	
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.2	22%	0	26%	0	31%	0	35%	0	39%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.8	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	0	51%	0	59%	0	68%	0	76%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.9	12%	0	15%	0	17%	0	19%	0	22%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA		NA		NA		NA	
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.6	18%	0	22%	0	26%	0	30%	0	33%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	237.0	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	7.2	22%	0	26%	0	31%	0	35%	0	39%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.8	20%	0	25%	0	29%	0	33%	0	37%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	0	29%	0	33%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	0	37%	0	43%	0	50%	0	56%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	0	50%	0	58%	0	67%	0	75%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	119.3	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	14.4	9%	0	11%	0	12%	0	14%	0	16%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.7	21%	0	25%	0	29%	0	33%	0	37%	0

Corner Retail Shop - Type I Construction (Qty 34 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.3	47%	15	56%	19	65%	22	75%	25	84%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.9	23%	12	27%	18	32%	18	36%	21	41%	21
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.3	36%	12	43%	14	51%	17	58%	19	65%	22
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.7	34%	11	41%	13	48%	16	55%	18	62%	20
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	29.7	1%	12	2%	18	2%	18	2%	21	2%	21

Internal Retail Shop - Type I Construction (Qty 34 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.3	47%	15	56%	19	66%	22	75%	25	84%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.7	21%	45	25%	67	29%	67	33%	70	37%	70
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.7	35%	11	41%	14	48%	16	55%	18	62%	21
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.8	34%	11	41%	13	48%	16	55%	18	61%	20
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	60.1	0%	45	0%	67	0%	67	0%	70	0%	70

Corner Restaurant - Type I Construction (Qty 30 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	9.0	17%	5	21%	7	24%	8	28%	9	31%	10
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.3	19%	4	23%	5	27%	5	31%	6	35%	6
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.2	42%	14	50%	17	58%	19	67%	22	75%	25
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.9	33%	11	40%	13	47%	15	53%	18	60%	20
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	28.7	1%	4	2%	5	2%	5	2%	6	3%	6

Corner Retail Shop - Type II Construction (Qty 17 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.3	47%	7	56%	9	66%	11	75%	12	84%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	9.1	17%	6	21%	9	24%	9	28%	12	31%	12
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.3	32%	5	38%	6	45%	7	51%	8	57%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	5	42%	7	49%	8	56%	9	63%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	10.0	15%	6	19%	9	22%	9	25%	12	28%	12

Internal Retail Shop - Type II Construction (Qty 17 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	7	56%	9	66%	11	75%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.6	19%	12	22%	18	26%	18	30%	24	33%	24
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.5	31%	5	37%	6	43%	7	50%	8	56%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.7	34%	5	41%	6	48%	8	55%	9	62%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	19.4	5%	12	6%	18	6%	18	7%	24	8%	24

Corner Restaurant - Type II Construction (Qty 17 Bldgs)			BAU			Mid-Low		Mid		Mid-High		High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	9.1	17%	2	21%	3	24%	4	28%	4	31%	5
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.8	14%	2	17%	3	19%	3	22%	4	25%	4
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.2	42%	7	50%	8	58%	9	67%	11	75%	12
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.8	34%	5	41%	6	47%	8	54%	9	61%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	8.1	20%	2	24%	3	28%	3	32%	4	35%	4

Prototype 01 - 56-story Highrise Office (Qty 1)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	6.4	24%	0	29%	0	34%	0	39%	0	44%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.4	21%	0	26%	0	30%	0	34%	0	38%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.9	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	61%	0	70%	0	78%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.1	13%	0	16%	0	19%	0	21%	0	24%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.7	39%	0	47%	0	54%	0	62%	0	70%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	9.0	17%	0	21%	0	24%	0	28%	0	31%	0

Prototype 02 - 41-story Highrise Office (Qty 6)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	6.2	25%	1	30%	1	35%	2	40%	2	45%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.4	21%	1	26%	1	30%	1	34%	2	39%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	19.0	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	2	51%	3	60%	3	69%	4	77%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.4	13%	0	15%	0	18%	1	21%	1	23%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	4.9	30%	1	35%	2	41%	2	47%	2	53%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	9.0	17%	1	21%	1	24%	1	28%	1	31%	1

Prototype 03 - 34-story Highrise Office (Qty 5)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	6.1	25%	1	30%	1	35%	1	41%	2	46%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.2	22%	1	26%	1	31%	1	35%	1	40%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.3	22%	1	26%	1	31%	1	35%	1	39%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.4	5%	0	6%	0	7%	0	8%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	42%	2	51%	2	59%	2	68%	3	76%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.5	13%	0	15%	0	18%	0	20%	1	23%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	8.8	18%	0	22%	1	25%	1	29%	1	33%	1
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.8	18%	0	22%	1	25%	1	29%	1	32%	1

Prototype 04 - 20-story Midrise Office (Qty 3)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	6.5	24%	0	29%	0	34%	1	38%	1	43%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.4	22%	0	26%	0	30%	0	34%	1	39%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.8	14%	0	17%	0	20%	0	22%	0	25%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	22.7	3%	0	4%	0	4%	0	5%	0	5%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	1	51%	1	60%	1	68%	2	77%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.7	12%	0	15%	0	17%	0	20%	0	22%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.9	23%	0	27%	0	32%	0	36%	1	41%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	12.6	11%	0	13%	0	16%	0	18%	0	20%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	5.0	29%	0	35%	0	41%	0	47%	0	52%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	22.8	3%	0	4%	0	4%	0	5%	0	5%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	11.0	14%	0	16%	0	19%	0	22%	0	24%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.3	36%	0	43%	0	51%	0	58%	0	65%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	0	50%	0	58%	0	66%	0	75%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	42.6	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.5	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	5.3	28%	1	34%	1	39%	1	45%	2	50%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	16.0	7%	0	9%	0	10%	0	12%	0	13%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.2	36%	1	44%	2	51%	2	58%	2	66%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	60%	3	69%	3	78%	3
Lighting	1.3 watts/sqft	1.19 watts/sqft	40.6	0%	0	0%	0	0%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	14.2	9%	0	11%	0	13%	0	14%	0	16%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	**Baseline**	**Alternative**	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	235.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	6.1	25%	0	30%	0	35%	0	41%	0	46%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	9.2	17%	0	21%	0	24%	0	27%	0	31%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.5	24%	0	29%	0	34%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	5.0	29%	0	35%	0	41%	0	47%	0	53%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	0	51%	1	60%	1	68%	1	77%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	122.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.8	20%	0	24%	0	29%	0	33%	0	37%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.6	21%	0	25%	0	29%	0	34%	0	38%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	244.6	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	6.4	24%	0	29%	1	34%	1	39%	1	44%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	10.4	15%	0	18%	0	21%	0	23%	0	26%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.3	25%	0	30%	1	35%	1	40%	1	44%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.7	30%	1	36%	1	42%	1	48%	1	55%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	41%	1	50%	1	58%	2	66%	2	75%	2
Lighting	0.70 watts/sqft	0.675 watts/sqft	129.1	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.9	23%	0	27%	1	32%	1	36%	1	41%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.3	22%	0	26%	1	30%	1	35%	1	39%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	246.6	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	5.7	27%	2	32%	3	37%	3	43%	4	48%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.4	21%	2	26%	2	30%	2	34%	3	38%	3
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.4	24%	2	29%	2	34%	3	39%	3	44%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.6	31%	3	37%	3	43%	4	49%	4	55%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	41%	4	50%	4	58%	5	66%	6	74%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	125.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.5	19%	1	22%	2	26%	2	30%	2	34%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.5	21%	2	25%	2	30%	2	34%	3	38%	3

Prototype 10 - 25-story Highrise Residential (Qty 5)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	236.4	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	5.4	28%	1	33%	1	39%	1	44%	2	50%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.5	21%	1	26%	1	30%	1	34%	1	38%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.7	23%	1	28%	1	33%	1	37%	1	42%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	1	37%	1	44%	2	50%	2	56%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	2	50%	2	58%	2	67%	3	75%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	125.0	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	9.7	16%	0	19%	0	23%	1	26%	1	29%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.9	20%	1	24%	1	28%	1	32%	1	36%	1

Prototype 11 - 12-story Midrise Residential (Qty 14)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	254.8	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	8.0	20%	2	24%	3	28%	3	32%	4	36%	5
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	4.2	32%	4	38%	5	45%	6	51%	7	58%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.5	19%	2	22%	3	26%	3	30%	4	34%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	32%	4	38%	5	44%	6	50%	7	57%	7
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	5	50%	7	59%	8	67%	9	76%	10
Lighting	0.70 watts/sqft	0.675 watts/sqft	122.7	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	25.0	2%	0	3%	0	3%	0	4%	0	4%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	8.2	19%	2	23%	3	27%	3	31%	4	35%	4

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	6.1	25%	0	30%	0	35%	0	41%	0	46%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA	0	NA	0	NA	0	NA	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.2	22%	0	26%	0	31%	0	35%	0	39%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.8	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	0	51%	0	59%	0	68%	0	76%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.9	12%	0	15%	0	17%	0	19%	0	22%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA	0	NA	0	NA	0	NA	0
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.6	18%	0	22%	0	26%	0	30%	0	33%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			Mod 14-RA, BAU			Mod 14RA Mid-Low		Mod 14RA Mid		Mod 14RA Mid-High		Mod 14RA High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	237.0	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	5.4	28%	0	33%	0	39%	0	44%	0	50%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.8	20%	0	25%	0	29%	0	33%	0	37%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	0	29%	0	33%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	0	37%	0	43%	0	50%	0	56%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.2	42%	0	50%	0	58%	0	67%	0	75%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	119.3	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	14.4	9%	0	11%	0	12%	0	14%	0	16%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.7	21%	0	25%	0	29%	0	33%	0	37%	0

Prototype 01 - 56-story Highrise Office (Qty 1)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	8.3	19%	0	23%	0	27%	0	31%	0	35%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.2	22%	0	26%	0	31%	0	35%	0	40%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.6	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	0	53%	0	61%	0	70%	0	79%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.7	14%	0	17%	0	20%	0	23%	0	25%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.6	40%	0	48%	0	56%	0	64%	0	72%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.8	18%	0	22%	0	25%	0	29%	0	32%	0

Prototype 02 - 41-story Highrise Office (Qty 6)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	8.0	20%	1	24%	1	28%	1	32%	1	36%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.2	22%	1	26%	1	31%	1	35%	2	40%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.6	5%	0	6%	0	7%	0	8%	0	9%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	3	61%	3	69%	4	78%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.0	14%	0	16%	0	19%	1	22%	1	25%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	4.6	31%	1	37%	2	43%	2	49%	2	55%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.8	18%	1	22%	1	25%	1	29%	1	32%	1

Prototype 03 - 34-story Highrise Office (Qty 5)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	8.0	20%	0	24%	1	28%	1	32%	1	36%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.1	22%	1	27%	1	31%	1	36%	1	40%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.0	22%	1	27%	1	31%	1	36%	1	40%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.0	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	2	51%	2	60%	2	68%	3	77%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.1	13%	0	16%	0	19%	0	22%	1	24%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	8.3	19%	0	23%	1	27%	1	31%	1	35%	1
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.5	19%	0	22%	1	26%	1	30%	1	34%	1

Prototype 04 - 20-story Midrise Office (Qty 3)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	8.2	19%	0	23%	0	27%	0	31%	0	35%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.2	22%	0	26%	0	31%	0	35%	1	40%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.4	15%	0	17%	0	20%	0	23%	0	26%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	22.3	3%	0	4%	0	5%	0	5%	0	6%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	1	52%	1	60%	1	69%	2	77%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.2	13%	0	16%	0	18%	0	21%	0	24%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.7	23%	0	28%	0	33%	0	38%	1	42%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	12.2	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	5.9	26%	0	31%	0	36%	0	41%	0	47%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	21.2	4%	0	4%	0	5%	0	6%	0	7%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.8	14%	0	17%	0	19%	0	22%	0	25%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.2	36%	0	44%	0	51%	0	58%	0	66%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	0	50%	0	59%	0	67%	0	76%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	40.5	0%	0	0%	0	0%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.3	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	14.9	8%	0	10%	0	12%	0	13%	0	15%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.2	37%	1	44%	2	51%	2	59%	2	66%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	2	52%	2	61%	3	70%	3	78%	3
Lighting	1.3 watts/sqft	1.19 watts/sqft	38.7	0%	0	0%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	14.0	9%	0	11%	0	13%	0	15%	0	17%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	222.2	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	7.6	21%	0	25%	0	29%	0	34%	0	38%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	8.6	18%	0	22%	0	26%	0	29%	0	33%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.3	25%	0	30%	0	35%	0	39%	0	44%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.9	30%	0	35%	0	41%	0	47%	0	53%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	1	60%	1	69%	1	78%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	116.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.5	21%	0	25%	0	30%	0	34%	0	38%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.4	22%	0	26%	0	30%	0	34%	0	39%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	231.5	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	8.2	19%	0	23%	0	27%	1	31%	1	35%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	9.8	16%	0	19%	0	22%	0	25%	1	28%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.1	25%	1	30%	1	35%	1	40%	1	46%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.6	31%	1	37%	1	43%	1	49%	1	55%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	1	50%	2	59%	2	67%	2	75%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	122.6	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.7	23%	0	28%	1	33%	1	38%	1	42%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.1	22%	0	27%	1	31%	1	36%	1	40%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	233.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	7.2	22%	2	27%	2	31%	3	35%	3	40%	3
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.1	22%	2	27%	2	31%	3	36%	3	40%	4
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.2	25%	2	30%	2	35%	3	40%	3	45%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	3	37%	3	43%	4	49%	4	56%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	4	50%	5	59%	5	67%	6	75%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	119.6	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.2	19%	1	23%	2	27%	2	31%	3	35%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.3	22%	2	26%	2	30%	3	35%	3	39%	3

Prototype 10 - 25-story Highrise Residential (Qty 5)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	223.7	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	6.6	24%	1	28%	1	33%	1	38%	1	43%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.0	22%	1	27%	1	31%	1	36%	1	40%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.5	24%	1	29%	1	34%	1	38%	1	43%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	31%	1	38%	1	44%	2	50%	2	57%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	2	51%	2	59%	2	67%	3	76%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	118.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	9.3	17%	0	20%	1	24%	1	27%	1	30%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.6	21%	1	25%	1	29%	1	33%	1	37%	1

Prototype 11 - 12-story Midrise Residential (Qty 14)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	240.2	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	10.6	14%	1	17%	2	20%	2	23%	3	26%	3
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	4.1	33%	4	39%	5	46%	6	52%	7	59%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.2	19%	2	23%	3	27%	3	31%	4	35%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.3	32%	4	38%	5	45%	6	51%	7	57%	8
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	5	51%	7	60%	8	68%	9	77%	10
Lighting	0.70 watts/sqft	0.675 watts/sqft	117.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	24.3	3%	0	3%	0	4%	0	4%	0	5%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	8.0	20%	2	24%	3	28%	3	32%	4	36%	4

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	7.7	21%	0	25%	0	29%	0	33%	0	37%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA		NA		NA		NA	
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.0	23%	0	27%	0	32%	0	36%	0	41%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.5	6%	0	7%	0	8%	0	10%	0	11%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	0	51%	0	60%	0	68%	0	77%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	11.4	13%	0	16%	0	18%	0	21%	0	23%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA		NA		NA		NA	
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.3	19%	0	23%	0	27%	0	30%	0	34%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	224.9	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	6.6	24%	0	28%	0	33%	0	38%	0	43%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.3	22%	0	26%	0	30%	0	35%	0	39%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.4	24%	0	29%	0	34%	0	39%	0	44%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	31%	0	38%	0	44%	0	50%	0	56%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	0	51%	0	59%	0	68%	0	76%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	113.5	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.8	10%	0	11%	0	13%	0	15%	0	17%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.4	21%	0	26%	0	30%	0	34%	0	38%	0

Corner Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.3	47%	15	56%	19	66%	22	75%	25	84%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.7	23%	12	28%	18	33%	21	37%	21	42%	21
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.2	36%	12	44%	14	51%	17	58%	19	65%	22
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	11	42%	14	48%	16	55%	18	62%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	28.8	1%	12	2%	18	2%	21	2%	21	3%	21

Internal Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	15	56%	19	66%	22	75%	25	84%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.5	21%	45	25%	67	30%	70	34%	70	38%	70
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.6	35%	11	42%	14	49%	16	56%	18	63%	21
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	11	42%	14	48%	16	55%	18	62%	21
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	58.9	0%	45	0%	67	0%	70	0%	70	0%	70

Corner Restaurant - Type I Construction (Qty 30 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.9	18%	6	21%	7	25%	8	28%	9	32%	10
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.0	20%	4	24%	5	28%	6	32%	6	36%	6
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	14	50%	17	59%	19	67%	22	75%	25
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.8	34%	11	41%	13	48%	16	54%	18	61%	20
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	27.9	2%	4	2%	5	2%	6	3%	6	3%	6

Corner Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	7	56%	9	66%	11	75%	12	84%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.8	18%	6	22%	9	25%	9	29%	12	32%	12
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.2	32%	5	39%	6	45%	7	52%	8	58%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	6	42%	7	49%	8	57%	9	64%	10
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	9.9	16%	6	19%	9	22%	9	25%	12	28%	12

Internal Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	8	57%	9	66%	11	75%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.2	19%	12	23%	18	27%	18	31%	24	35%	24
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.4	31%	5	38%	6	44%	7	50%	8	56%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	5	42%	7	49%	8	56%	9	63%	10
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	18.1	6%	12	7%	18	8%	18	9%	24	10%	24

Corner Restaurant - Type II Construction (Qty 17 Bldgs)			CCT5, BAU			CCT5, Mid-Low		CCT5 Mid		CCT5, Mid-High		CCT5, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.9	18%	3	21%	3	25%	4	28%	4	32%	5
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.5	14%	2	17%	3	20%	3	23%	4	26%	4
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	7	50%	8	59%	9	67%	11	75%	12
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.7	34%	5	41%	7	48%	8	55%	9	62%	10
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.9	20%	2	24%	3	28%	3	32%	4	36%	4

Prototype 01 - 56-story Highrise Office (Qty 1)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	7.6	21%	0	25%	0	29%	0	34%	0	38%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.0	23%	0	27%	0	32%	0	36%	0	41%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.2	5%	0	6%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.7	44%	0	53%	0	62%	0	71%	0	79%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.3	15%	0	18%	0	21%	0	24%	0	27%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.4	41%	0	49%	0	57%	0	65%	0	73%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.5	19%	0	22%	0	26%	0	30%	0	33%	0

Prototype 02 - 41-story Highrise Office (Qty 6)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	7.4	22%	1	26%	1	30%	1	35%	2	39%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.0	23%	1	27%	1	32%	1	36%	2	41%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.3	5%	0	6%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	2	52%	3	61%	3	70%	4	78%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.5	14%	0	17%	1	20%	1	23%	1	26%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	4.3	32%	1	38%	2	45%	2	51%	3	57%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.5	19%	1	22%	1	26%	1	30%	1	34%	2

Prototype 03 - 34-story Highrise Office (Qty 5)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	7.3	22%	1	26%	1	30%	1	35%	1	39%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.0	23%	1	27%	1	32%	1	36%	1	41%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.8	23%	1	28%	1	32%	1	37%	1	42%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.7	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	60%	3	69%	3	78%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.6	14%	0	17%	0	20%	0	23%	1	26%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	7.8	20%	1	24%	1	28%	1	33%	1	37%	1
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.3	19%	0	23%	1	27%	1	31%	1	35%	1

Prototype 04 - 20-story Midrise Office (Qty 3)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	7.6	21%	0	25%	0	29%	0	34%	1	38%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.0	23%	0	27%	0	32%	0	36%	1	41%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.2	15%	0	18%	0	21%	0	24%	0	27%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	21.9	3%	0	4%	0	5%	0	5%	0	6%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	1	52%	1	61%	1	69%	2	78%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.8	14%	0	17%	0	20%	0	22%	0	25%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.5	24%	0	29%	0	34%	1	39%	1	44%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	11.8	12%	0	15%	0	17%	0	20%	0	22%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	5.5	27%	0	33%	0	38%	0	44%	0	49%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	19.7	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.7	14%	0	17%	0	20%	0	23%	0	25%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.2	37%	0	44%	0	51%	0	59%	0	66%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	42%	0	51%	0	59%	0	68%	0	76%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	38.7	0%	0	0%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.2	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	5.9	26%	1	31%	1	36%	1	42%	2	47%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	13.9	9%	0	11%	0	13%	0	15%	0	17%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.1	37%	1	44%	2	52%	2	59%	2	67%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	2	53%	2	62%	3	70%	3	79%	3
Lighting	1.3 watts/sqft	1.19 watts/sqft	36.9	1%	0	1%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.8	10%	0	11%	0	13%	0	15%	0	17%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	210.7	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	7.0	23%	0	27%	0	32%	0	36%	0	41%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	8.2	19%	0	23%	0	27%	0	31%	0	35%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.1	25%	0	30%	0	35%	0	40%	0	45%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.8	30%	0	36%	0	42%	0	48%	0	54%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	0	52%	1	61%	1	70%	1	78%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	110.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.3	22%	0	26%	0	30%	0	35%	0	39%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.2	22%	0	26%	0	31%	0	35%	0	40%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	219.7	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	7.5	21%	0	25%	1	30%	1	34%	1	38%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	9.3	17%	0	20%	0	24%	0	27%	1	30%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.9	26%	1	31%	1	36%	1	41%	1	47%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.5	31%	1	37%	1	43%	1	50%	1	56%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	1	51%	2	59%	2	68%	2	76%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	116.7	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.5	24%	0	29%	1	34%	1	39%	1	44%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.9	23%	0	27%	1	32%	1	36%	1	41%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	221.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	6.6	24%	2	29%	2	33%	3	38%	3	43%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.7	23%	2	28%	2	33%	3	37%	3	42%	4
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.0	26%	2	31%	3	36%	3	41%	4	46%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	31%	3	37%	3	44%	4	50%	4	56%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.1	42%	4	51%	5	59%	5	68%	6	76%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	114.0	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.9	20%	2	24%	2	28%	2	32%	3	36%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.1	22%	2	27%	2	31%	3	36%	3	40%	4

Prototype 10 - 25-story Highrise Residential (Qty 5)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	212.3	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	6.1	25%	1	30%	1	35%	1	41%	2	46%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.6	24%	1	28%	1	33%	1	38%	1	43%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.3	25%	1	30%	1	34%	1	39%	1	44%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.3	32%	1	38%	1	45%	2	51%	2	57%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	2	51%	2	60%	2	68%	3	77%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	113.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.9	18%	0	21%	1	25%	1	28%	1	32%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.4	21%	1	26%	1	30%	1	34%	1	38%	1

Prototype 11 - 12-story Midrise Residential (Qty 14)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	227.2	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	9.5	16%	2	20%	2	23%	3	26%	3	30%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	3.9	33%	4	40%	5	47%	6	53%	7	60%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.0	20%	2	24%	3	28%	3	32%	4	36%	5
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.2	32%	4	39%	5	45%	6	51%	7	58%	8
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	6	52%	7	60%	8	69%	9	77%	10
Lighting	0.70 watts/sqft	0.675 watts/sqft	112.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	23.6	3%	0	3%	0	4%	0	4%	0	5%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.8	20%	2	24%	3	28%	3	33%	4	37%	5

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	7.1	22%	0	27%	0	31%	0	36%	0	40%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA		NA		NA		NA	
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.8	23%	0	28%	0	32%	0	37%	0	42%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.2	6%	0	7%	0	9%	0	10%	0	11%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	60%	0	69%	0	77%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.9	14%	0	17%	0	19%	0	22%	0	25%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA		NA		NA		NA	
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.1	20%	0	24%	0	28%	0	31%	0	35%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	213.9	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	6.1	25%	0	30%	0	36%	0	41%	0	46%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.0	23%	0	27%	0	32%	0	36%	0	41%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.2	25%	0	30%	0	35%	0	40%	0	45%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.3	32%	0	38%	0	44%	0	51%	0	57%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	0	51%	0	60%	0	68%	0	77%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	108.3	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.2	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.3	22%	0	26%	0	31%	0	35%	0	39%	0

Corner Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	None	NA			NA		NA		NA		NA	
Roof Material	None	None	NA			NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	15	56%	19	66%	22	75%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.5	24%	12	29%	18	34%	21	38%	21	43%	27
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.2	37%	12	44%	14	51%	17	59%	19	66%	22
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	11	42%	14	49%	16	56%	19	63%	21
Lighting	1.50 watts/sqft	None	NA			NA		NA		NA		NA	
Roof Insulation	None	None	NA			NA		NA		NA		NA	
Thermal Storage	None	None	NA			NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	28.0	2%	12	2%	18	2%	21	3%	21	3%	27

Internal Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	15	56%	19	66%	22	75%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.3	22%	45	26%	67	30%	70	35%	70	39%	92
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.5	35%	11	42%	14	49%	16	56%	19	63%	21
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	11	42%	14	49%	16	56%	19	63%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	57.7	0%	45	0%	67	0%	70	0%	70	0%	92

Corner Restaurant - Type I Construction (Qty 30 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.8	18%	6	22%	7	25%	8	29%	9	33%	11
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.8	20%	4	24%	5	28%	6	33%	6	37%	8
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	14	51%	17	59%	20	67%	22	76%	25
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.7	34%	11	41%	14	48%	16	55%	18	62%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	27.1	2%	4	2%	5	2%	6	3%	6	3%	8

Corner Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.823	EF=0.823	1.2	47%	7	56%	9	66%	11	75%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.5	19%	6	22%	9	26%	9	30%	12	33%	15
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.1	32%	5	39%	6	45%	7	52%	8	58%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.4	36%	6	43%	7	50%	8	57%	9	64%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	9.8	16%	6	19%	9	22%	9	25%	12	28%	15

Internal Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	8	57%	9	66%	11	76%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.9	20%	12	24%	18	28%	18	32%	24	36%	30
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.4	32%	5	38%	6	44%	7	50%	8	57%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	6	42%	7	49%	8	56%	9	64%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	16.9	6%	12	8%	18	9%	18	10%	24	12%	30

Corner Restaurant - Type II Construction (Qty 17 Bldgs)			CCT10, BAU			CCT10, Mid-Low		CCT10 Mid		CCT10, Mid-High		CCT10, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.8	18%	3	22%	3	25%	4	29%	4	32%	5
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.2	15%	2	18%	3	21%	3	24%	4	27%	5
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	7	51%	8	59%	10	67%	11	76%	12
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	5	42%	7	49%	8	56%	9	63%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.7	21%	2	25%	3	29%	3	33%	4	37%	5

Prototype 01 - 56-story Highrise Office (Qty 1)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	7.0	23%	0	27%	0	32%	0	36%	0	41%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.8	23%	0	28%	0	32%	0	37%	0	42%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.9	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.7	44%	0	53%	0	62%	0	71%	0	80%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	9.9	16%	0	19%	0	22%	0	25%	0	28%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.3	41%	0	49%	0	58%	0	66%	0	74%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.3	19%	0	23%	0	27%	0	31%	0	34%	0

Prototype 02 - 41-story Highrise Office (Qty 6)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	6.8	23%	1	28%	1	32%	1	37%	2	42%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.8	23%	1	28%	1	33%	1	37%	2	42%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	18.0	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	2	53%	3	61%	3	70%	4	79%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.1	15%	0	18%	1	21%	1	24%	1	27%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	4.1	33%	1	39%	2	46%	2	53%	3	59%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.3	19%	1	23%	1	27%	1	31%	1	35%	2

Prototype 03 - 34-story Highrise Office (Qty 5)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	6.7	23%	1	28%	1	33%	1	37%	1	42%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.8	23%	1	28%	1	32%	1	37%	1	41%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	1	28%	1	33%	1	38%	1	43%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.4	6%	0	7%	0	8%	0	10%	0	11%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	61%	3	69%	3	78%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.2	15%	0	18%	0	21%	1	24%	1	27%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	7.4	21%	1	26%	1	30%	1	34%	1	39%	1
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.0	20%	0	24%	1	28%	1	32%	1	36%	1

Prototype 04 - 20-story Midrise Office (Qty 3)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	7.0	23%	0	27%	0	32%	0	36%	1	41%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.8	23%	0	28%	0	32%	0	37%	1	41%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	9.9	16%	0	19%	0	22%	0	25%	0	28%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	21.5	4%	0	4%	0	5%	0	6%	0	6%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	1	52%	1	61%	1	70%	2	79%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.3	15%	0	18%	0	21%	0	24%	0	27%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.2	25%	0	30%	0	35%	1	40%	1	45%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	11.5	13%	0	15%	0	18%	0	20%	0	23%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	5.1	29%	0	34%	0	40%	0	46%	0	52%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	18.5	5%	0	6%	0	7%	0	8%	0	9%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.6	14%	0	17%	0	20%	0	23%	0	26%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.1	37%	0	44%	0	52%	0	59%	0	67%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	0	51%	0	60%	0	69%	0	77%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	36.9	1%	0	1%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.1	10%	0	13%	0	15%	0	17%	0	19%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA			NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	5.5	27%	1	33%	1	38%	1	44%	2	49%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	13.1	10%	0	13%	0	15%	0	17%	0	19%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.1	37%	1	45%	2	52%	2	60%	2	67%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.7	44%	2	53%	2	62%	3	71%	3	80%	3
Lighting	1.3 watts/sqft	1.19 watts/sqft	35.3	1%	0	1%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.6	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	200.3	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	6.5	24%	0	29%	0	34%	0	39%	0	43%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.8	20%	0	25%	0	29%	0	33%	0	37%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.0	26%	0	31%	0	36%	0	41%	0	46%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.7	30%	0	36%	0	42%	0	48%	0	54%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	0	53%	1	62%	1	70%	1	79%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	105.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.0	22%	0	27%	0	31%	0	36%	0	40%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.0	23%	0	27%	0	32%	0	36%	0	41%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	209.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	7.0	23%	0	27%	1	32%	1	36%	1	41%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	8.8	18%	0	21%	0	25%	1	29%	1	32%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.8	26%	1	32%	1	37%	1	42%	1	48%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	31%	1	38%	1	44%	1	50%	2	56%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	1	51%	2	60%	2	68%	2	77%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	111.4	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.2	25%	0	30%	1	35%	1	40%	1	45%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.7	23%	0	28%	1	33%	1	37%	1	42%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	210.2	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	6.1	25%	2	30%	3	35%	3	41%	4	46%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.4	24%	2	29%	2	34%	3	39%	3	44%	4
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.9	26%	2	31%	3	37%	3	42%	4	47%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	32%	3	38%	3	44%	4	50%	5	57%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	2.0	43%	4	51%	5	60%	5	68%	6	77%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	108.8	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.6	21%	2	25%	2	29%	2	33%	3	37%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.9	23%	2	27%	2	32%	3	36%	3	41%	4

Prototype 10 - 25-story Highrise Residential (Qty 5)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	202.0	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	5.7	27%	1	32%	1	37%	1	43%	2	48%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.3	25%	1	30%	1	35%	1	39%	1	44%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.1	25%	1	30%	1	35%	1	40%	2	45%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.2	32%	1	39%	1	45%	2	51%	2	58%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	60%	3	69%	3	77%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	108.1	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.6	18%	0	22%	1	26%	1	29%	1	33%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.2	22%	1	26%	1	31%	1	35%	1	39%	1

Prototype 11 - 12-story Midrise Residential (Qty 14)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	215.6	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	8.6	18%	2	22%	3	26%	3	30%	4	33%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	3.8	34%	4	41%	5	48%	6	54%	7	61%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.7	21%	2	25%	3	29%	4	33%	4	37%	5
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.1	32%	4	39%	5	45%	6	52%	7	58%	8
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	6	52%	7	61%	8	69%	9	78%	10
Lighting	0.70 watts/sqft	0.675 watts/sqft	107.7	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	22.9	3%	0	4%	0	4%	0	5%	0	5%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.6	21%	2	25%	3	29%	4	33%	4	37%	5

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	6.5	24%	0	29%	0	34%	0	38%	0	43%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA		NA		NA		NA	
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	0	28%	0	33%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	16.9	6%	0	8%	0	9%	0	10%	0	12%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	61%	0	69%	0	78%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.5	15%	0	17%	0	20%	0	23%	0	26%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA		NA		NA		NA	
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.9	20%	0	24%	0	28%	0	32%	0	36%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	State Appliance Regulations	Energy Star Rated	203.9	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	5.6	27%	0	32%	0	38%	0	43%	0	48%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.6	24%	0	28%	0	33%	0	38%	0	43%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.0	26%	0	31%	0	36%	0	41%	0	46%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.3	32%	0	38%	0	45%	0	51%	0	58%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	60%	0	69%	0	78%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	103.5	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	12.7	11%	0	13%	0	15%	0	18%	0	20%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.1	22%	0	27%	0	31%	0	36%	0	40%	0

Corner Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	16	57%	19	66%	22	75%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.3	25%	12	29%	18	34%	21	39%	21	44%	27
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.1	37%	12	44%	15	52%	17	59%	20	66%	22
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.4	35%	12	43%	14	50%	16	57%	19	64%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	27.2	2%	12	2%	18	2%	21	3%	21	3%	27

Internal Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	16	57%	19	66%	22	75%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.1	22%	45	27%	67	31%	70	36%	70	40%	92
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.5	35%	12	42%	14	49%	16	57%	19	64%	21
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.4	36%	12	43%	14	50%	16	57%	19	64%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	56.6	0%	45	0%	67	0%	70	0%	70	0%	92

Corner Restaurant - Type I Construction (Qty 30 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.6	18%	6	22%	7	26%	8	29%	9	33%	11
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.6	21%	4	25%	5	29%	6	33%	6	38%	8
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	14	51%	17	59%	20	68%	23	76%	25
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.6	35%	11	42%	14	49%	16	56%	19	63%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	26.3	2%	4	2%	5	3%	6	3%	6	3%	8

Corner Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.823	EF=0.823	1.2	47%	8	57%	9	66%	11	75%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.3	19%	6	23%	9	27%	12	31%	12	35%	15
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.1	33%	5	39%	6	46%	7	52%	8	59%	10
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.3	36%	6	43%	7	51%	8	58%	9	65%	11
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	9.7	16%	6	19%	9	22%	12	26%	12	29%	15

Internal Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	8	57%	9	66%	11	76%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.6	21%	12	25%	18	29%	24	34%	24	38%	30
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.3	32%	5	38%	6	45%	7	51%	8	57%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.4	36%	6	43%	7	50%	8	57%	9	64%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	15.8	7%	12	9%	18	10%	24	12%	24	13%	30

Corner Restaurant - Type II Construction (Qty 17 Bldgs)			CCT15, BAU			CCT15, Mid-Low		CCT15, Mid		CCT15, Mid-High		CCT15, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.6	18%	3	22%	3	26%	4	29%	4	33%	5
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	9.9	16%	2	19%	3	22%	4	25%	4	28%	5
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.1	42%	7	51%	8	59%	10	68%	11	76%	12
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	6	43%	7	50%	8	57%	9	64%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.5	21%	2	25%	3	30%	4	34%	4	38%	5

Prototype 01 - 56-story Highrise Office (Qty 1)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	6500 kW, 1390 ton absorber	6.5	24%	0	29%	0	34%	0	39%	0	43%	0
Cool Roof	100% of roof at Abs=0.90	100% of roof at Abs=0.3	20.2	4%	0	5%	0	6%	0	7%	0	8%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	0	28%	0	33%	0	38%	0	43%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.6	6%	0	7%	0	8%	0	9%	0	11%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.6	45%	0	54%	0	63%	0	72%	0	81%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	9.5	16%	0	20%	0	23%	0	26%	0	29%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	2.1	42%	0	50%	0	59%	0	67%	0	75%	0
Thermal Storage	None	25% of max load, 23376 ton-hrs	8.5	19%	0	22%	0	26%	0	30%	0	34%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.1	20%	0	24%	0	28%	0	31%	0	35%	0

Prototype 02 - 41-story Highrise Office (Qty 6)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	5500 kW, 1150 ton absorber	6.3	25%	1	30%	1	34%	2	39%	2	44%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.2	12%	0	14%	0	16%	0	19%	1	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.6	24%	1	29%	1	33%	1	38%	2	43%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.6	6%	0	7%	0	8%	0	9%	0	10%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.7	44%	2	53%	3	62%	3	71%	4	79%	4
Lighting	1.1 watts/sqft	0.9 watts/sqft	9.7	16%	0	19%	1	22%	1	25%	1	29%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	3.8	34%	2	41%	2	47%	2	54%	3	61%	3
Thermal Storage	None	25% of max load, 15073 ton-hrs	5.3	28%	1	34%	2	39%	2	45%	2	51%	3
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	8.0	20%	1	24%	1	28%	1	32%	1	36%	2

Prototype 03 - 34-story Highrise Office (Qty 5)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	4500 kW, 1020 ton absorber	6.2	25%	1	30%	1	35%	1	40%	1	45%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.7	23%	1	28%	1	33%	1	37%	1	42%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.5	24%	1	29%	1	34%	1	39%	1	44%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	17.1	6%	0	7%	0	9%	0	10%	0	11%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	2	52%	2	61%	3	70%	3	79%	3
Lighting	1.1 watts/sqft	0.9 watts/sqft	9.8	16%	0	19%	0	22%	1	25%	1	28%	1
Roof Insulation	5" R19 XPS	6" R23 XPS	7.1	22%	1	27%	1	31%	1	36%	1	40%	2
Thermal Storage	None	25% of max load, 16172 ton-hrs	6.4	24%	1	29%	1	34%	1	39%	1	44%	2
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.8	20%	1	24%	1	29%	1	33%	1	37%	1

Prototype 04 - 20-story Midrise Office (Qty 3)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3000 kW, 490 ton absorber	6.5	24%	0	29%	0	34%	1	38%	1	43%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.7	23%	0	28%	0	33%	0	38%	1	42%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	NA	See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	9.6	16%	0	19%	0	23%	0	26%	0	29%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	21.2	4%	0	4%	0	5%	0	6%	0	7%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	1	53%	1	61%	1	70%	2	79%	2
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.0	15%	0	19%	0	22%	0	25%	0	28%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.0	26%	0	31%	0	36%	1	41%	1	46%	1
Thermal Storage	None	25% of max load, 7818 ton-hrs	5.0	29%	0	35%	1	41%	1	47%	1	52%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	11.2	13%	0	16%	0	19%	0	21%	0	24%	0

Prototype 05 - 33-story Highrise Hotel (Qty 1)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	2500 kW, 500 ton absorber	4.8	30%	0	36%	0	42%	0	48%	0	54%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	17.4	6%	0	7%	0	8%	0	10%	0	11%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	10.4	15%	0	18%	0	20%	0	23%	0	26%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.1	37%	0	45%	0	52%	0	60%	0	67%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	0	52%	0	61%	0	69%	0	78%	0
Lighting	1.3 watts/sqft	1.19 watts/sqft	35.4	1%	0	1%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	12.9	11%	0	13%	0	15%	0	17%	0	19%	0
Thermal Storage	None	15% of max load, 7799 ton-hrs	9.1	17%	0	21%	0	24%	0	28%	0	31%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	12.1	12%	0	14%	0	16%	0	19%	0	21%	0

Prototype 06 - 18-story Midrise Hotel (Qty 5)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	400 kW, 80 ton absorber	5.1	29%	1	35%	1	40%	2	46%	2	52%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	12.3	11%	0	14%	0	16%	0	18%	0	21%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	34.9	1%	0	1%	0	1%	0	1%	0	1%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	3.0	37%	1	45%	2	52%	2	60%	2	67%	3
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.6	45%	2	54%	2	63%	3	72%	3	81%	4
Lighting	1.3 watts/sqft	1.19 watts/sqft	33.8	1%	0	1%	0	1%	0	1%	0	1%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	13.4	10%	0	12%	0	14%	0	16%	0	18%	0
Thermal Storage	None	15% of max load, 1265 ton-hrs	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Wall Insulation	R11, 2x4.16	R19, 2x4.16	22.2	3%	0	4%	0	5%	0	5%	0	6%	0

Prototype 07 - 55-story Highrise Residential (Qty 2)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	190.9	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 300 ton absorber	6.0	26%	0	31%	0	36%	0	41%	0	46%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	7.4	21%	0	26%	0	30%	0	34%	0	39%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%		See Space Heating		See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.8	26%	0	32%	0	37%	0	42%	0	47%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.6	31%	0	37%	0	43%	0	49%	0	55%	1
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.7	44%	0	53%	1	62%	1	71%	1	80%	1
Lighting	0.70 watts/sqft	0.675 watts/sqft	101.3	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.8	23%	0	28%	0	32%	0	37%	0	42%	0
Thermal Storage	None	15% of max load, 3751 ton-hrs	31.1	1%	0	1%	0	1%	0	2%	0	2%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.8	23%	0	28%	0	32%	0	37%	0	42%	0

Prototype 08 - 43-story Highrise Residential (Qty 4)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	199.4	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	750 kW, 160 ton absorber	6.5	24%	0	29%	1	34%	1	38%	1	43%	1
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	8.4	19%	0	23%	0	26%	1	30%	1	34%	1
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.6	27%	1	32%	1	38%	1	43%	1	49%	1
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.4	32%	1	38%	1	44%	1	51%	2	57%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	1	52%	2	60%	2	69%	2	78%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	106.5	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	6.0	26%	1	31%	1	36%	1	41%	1	46%	1
Thermal Storage	None	15% of max load, 1820 ton-hrs	16.3	7%	0	8%	0	10%	0	11%	0	12%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.6	24%	0	29%	1	33%	1	38%	1	43%	1

Prototype 09 - 34-story Highrise Residential (Qty 10)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	200.3	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	850 kW, 180 ton absorber	5.7	27%	2	32%	3	37%	3	43%	4	48%	4
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.1	25%	2	30%	3	35%	3	40%	4	45%	4
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.7	27%	2	32%	3	37%	3	43%	4	48%	4
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.3	32%	3	38%	3	45%	4	51%	5	57%	5
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	4	52%	5	60%	6	69%	6	78%	7
Lighting	0.70 watts/sqft	0.675 watts/sqft	104.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	7.4	21%	2	26%	2	30%	3	34%	3	39%	3
Thermal Storage	None	15% of max load, 2143 ton-hrs	16.7	7%	0	8%	0	9%	0	11%	1	12%	1
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.7	23%	2	28%	2	33%	3	37%	3	42%	4

Prototype 10 - 25-story Highrise Residential (Qty 5)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	192.7	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 250 ton absorber	5.3	28%	1	34%	1	39%	1	45%	2	51%	2
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.0	26%	1	31%	1	36%	1	41%	2	46%	2
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.0	26%	1	31%	1	36%	1	41%	2	46%	2
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.2	32%	1	39%	1	45%	2	52%	2	58%	2
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.9	43%	2	52%	2	61%	3	69%	3	78%	3
Lighting	0.70 watts/sqft	0.675 watts/sqft	103.5	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	8.3	19%	0	23%	1	27%	1	31%	1	34%	1
Thermal Storage	None	15% of max load, 3299 ton-hrs	19.6	5%	0	5%	0	6%	0	7%	0	8%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.1	22%	1	27%	1	31%	1	36%	1	40%	2

Prototype 11 - 12-story Midrise Residential (Qty 14)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	205.1	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	250 kW, 40 ton absorber	7.8	20%	2	24%	3	28%	3	33%	4	37%	5
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	3.7	35%	4	41%	5	48%	6	55%	7	62%	8
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.5	21%	2	25%	3	30%	4	34%	4	38%	5
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.1	33%	4	39%	5	46%	6	52%	7	59%	8
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	6	53%	7	61%	8	70%	9	79%	11
Lighting	0.70 watts/sqft	0.675 watts/sqft	103.4	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	22.3	3%	0	4%	0	5%	0	5%	0	6%	0
Thermal Storage	None	15% of max load, 506 ton-hrs	13.5	10%	1	12%	1	14%	1	16%	2	18%	2
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.5	21%	2	26%	3	30%	4	34%	4	38%	5

Prototype 12 - 55-story Highrise Mixed Use, Office (Qty 1)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None	NA	NA		NA		NA		NA		NA	
CHP	None	3500 kW, 680 ton absorber	6.1	25%	0	30%	0	36%	0	41%	0	46%	0
Roof Material	100% of roof at Abs=0.90	None	NA	NA		NA		NA		NA		NA	
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.4	24%	0	29%	0	34%	0	39%	0	44%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	16.6	7%	0	8%	0	9%	0	11%	0	12%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	0	52%	0	61%	0	70%	0	78%	0
Lighting	1.1 watts/sqft	0.9 watts/sqft	10.1	15%	0	18%	0	21%	0	24%	0	27%	0
Roof Insulation	5" R19 XPS	None	NA	NA		NA		NA		NA		NA	
Thermal Storage	None	25% of max load, 10798 ton-hrs	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	7.6	21%	0	25%	0	29%	0	33%	0	37%	0

Prototype 12 - 55-story Highrise Mixed Use, Residential (Qty 1)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	State Appliance Regulations	Energy Star Rated	194.9	0%	0	0%	0	0%	0	0%	0	0%	0
CHP	None	1500 kW, 270 ton absorber	5.3	28%	0	34%	0	39%	0	45%	0	51%	0
Roof Material	100% of roof at Abs=0.90	100% of roof at Abs=0.3	6.3	25%	0	30%	0	35%	0	40%	0	44%	0
Water Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	See Space Heating			See Space Heating		See Space Heating		See Space Heating		See Space Heating	
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	5.8	26%	0	31%	0	37%	0	42%	0	47%	0
Space Heating	Boiler Comb Eff = 80%	Boiler Comb Eff = 85%	4.2	32%	0	39%	0	45%	0	52%	0	58%	0
Space Cooling	0.576 kW/ton Centrifugal Chillers	0.461 kW/ton Centrifugal Chillers	1.8	44%	0	52%	0	61%	0	70%	0	78%	0
Lighting	0.70 watts/sqft	0.675 watts/sqft	99.2	0%	0	0%	0	0%	0	0%	0	0%	0
Roof Insulation	5" R19 XPS	6" R23 XPS	12.2	12%	0	14%	0	16%	0	19%	0	21%	0
Thermal Storage	None	15% of max load, 3472 ton-hrs	21.4	4%	0	4%	0	5%	0	6%	0	6%	0
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	6.9	23%	0	27%	0	32%	0	37%	0	41%	0

Corner Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	Baseline	Alternative	Payback	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen	Pen Rate	Total Pen
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	16	57%	19	66%	22	76%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.2	25%	15	30%	18	35%	21	40%	21	45%	30
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.1	37%	12	45%	15	52%	17	59%	20	67%	22
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.4	36%	12	43%	14	50%	17	57%	19	65%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	26.5	2%	15	2%	18	3%	21	3%	21	3%	30

Internal Retail Shop - Type I Construction (Qty 34 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	16	57%	19	66%	22	76%	25	85%	28
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	6.9	23%	66	27%	67	32%	70	37%	70	41%	112
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	3.4	36%	12	43%	14	50%	16	57%	19	64%	21
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.3	36%	12	43%	14	50%	17	58%	19	65%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	55.6	0%	66	0%	67	0%	70	0%	70	0%	112

Corner Restaurant - Type I Construction (Qty 30 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.5	19%	6	22%	7	26%	8	30%	10	34%	11
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.4	21%	5	26%	5	30%	6	34%	6	39%	9
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.0	42%	14	51%	17	59%	20	68%	23	76%	25
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.5	35%	12	42%	14	50%	16	57%	19	64%	21
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	Typical Aluminum Curtain Wall	Reduced thermal bridging	25.6	2%	5	3%	5	3%	6	3%	6	4%	9

Corner Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	8	57%	9	66%	11	76%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	8.0	20%	6	24%	9	28%	12	32%	12	36%	15
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.0	33%	5	40%	6	46%	7	53%	8	59%	10
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.2	37%	6	44%	7	51%	8	59%	9	66%	11
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	9.6	16%	6	19%	9	23%	12	26%	12	29%	15

Internal Retail Shop - Type II Construction (Qty 17 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.525	EF=0.823	1.2	47%	8	57%	9	66%	11	76%	12	85%	14
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	7.3	22%	12	26%	18	31%	24	35%	24	39%	30
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	4.2	32%	5	39%	6	45%	7	51%	8	58%	9
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.3	36%	6	43%	7	51%	8	58%	9	65%	11
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	14.9	8%	12	10%	18	12%	24	13%	24	15%	30

Corner Restaurant - Type II Construction (Qty 17 Bldgs)			CCT20, BAU			CCT20, Mid-Low		CCT20, Mid		CCT20, Mid-High		CCT20, High	
Measure	**Baseline**	**Alternative**	**Payback**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**	**Pen Rate**	**Total Pen**
Appliances	None	None		NA		NA		NA		NA		NA	
CHP	None	None		NA		NA		NA		NA		NA	
Roof Material	None	None		NA		NA		NA		NA		NA	
Water Heating	EF=0.800	EF=0.823	8.5	19%	3	22%	3	26%	4	30%	5	34%	5
Windows	U=0.50, SHGC=0.35	U=0.26, SHGC=0.29	9.7	16%	2	19%	3	22%	4	26%	4	29%	5
Space Heating	Furnace 78% AFUE	Furnace 94% AFUE	2.0	42%	7	51%	8	59%	10	68%	11	76%	12
Space Cooling	10 SEER, 9.5 EER Unitary AC	14 SEER, 12.5 EER Unitary AC	3.3	36%	6	43%	7	50%	8	57%	9	65%	10
Lighting	1.50 watts/sqft	None		NA		NA		NA		NA		NA	
Roof Insulation	None	None		NA		NA		NA		NA		NA	
Thermal Storage	None	None		NA		NA		NA		NA		NA	
Wall Insulation	R11, 2x4.16	R19, 2x4.16	7.3	22%	2	26%	3	30%	4	35%	4	39%	5

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