BOMA Seattle King County

MacDonald-Miller FACILITY SOLUTIONS®

Building Performance Standards

AN ANALYSIS TO ACHIEVE ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS TARGETS

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Completed by MacDonald-Miller Facility Solutions

Jeremy Del Real, Energy Efficiency Engineering Manager

Brian Hanson, Project Development Engineering Manager

Perry England, Building Performance Vice President

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TABLE OF CONTENTS

GLOSSARY OF TERMS & ACRONYMS

ASHRAE	American Society of Heating Refrigerating and Air-Conditioning Engineers
BEPS	Building Emissions Performance Standard
CBPS	Clean Buildings Performance Standard
COP	Coefficient of Performance
DDC	Direct Digital Controls
DHW	Domestic Hot Water
DX	Direct-Expansion
EEM	Energy Efficiency Measure
ESPM	Energy Star Portfolio Manager
EUI	Energy Use Intensity
HX	Heat Exchanger
GFA	Gross Floor Area
GHGI	Greenhouse Gas Intensity
LED	Light Emitting Diode
PV	Photovoltaic
ROM	Rough Order Magnitude
RTU	Rooftop Unit
SEC	Seattle Energy Code
VAV	Variable Air Volume
VFD	Variable Frequency Drive
VRF	Variable Refrigerant Flow
WSEC	Washington State Energy Code

EXECUTIVE SUMMARY

The intent of this report is to highlight the overlap between Washington state's building energy efficiency standard and Seattle's proposed building emissions standard, as well as the respective 2021 energy codes. Using a representative sample of commercial and industrial offices and hospitality venues, the impacts of these energy and emissions standards were analyzed. The results of this analysis provide important insight into how building owners and managers can achieve compliance through informed capital investment planning.

Capital Planning Considerations

Tables 1 and 2 reflect the project investment cost, per gross floor area, per energy reduction, required to achieve the respective target. Each table represents the total investment cost. They do not account for costs associated with planned capital improvements and replacements, available utility incentives, or grants. Project measures and costs used in the analysis were divided into two categories:

1. **Those needed to achieve a building's energy target.**

INVESTMENT TO ACHIEVE ENERGY TARGET ($ / sqft / EUI reduction)			
Building Type	**Min**	**Avg**	**Max**
Commercial Offices	$0.51	$0.70	$0.94
Hotel / Hospitality	$0.41	$1.20	$3.98
Industrial Offices	$0.65	$1.52	$3.01

Table 1: Total Project Cost Investment to Achieve Energy Targets

2. **Those needed to meet a building's energy and emissions target.**

INVESTMENT TO ACHIEVE ENERGY & EMISSIONS TARGET ($ / sqft / EUI reduction)			
Building Type	**Min**	**Avg**	**Max**
Commercial Office	$0.69	$1.34	$2.36
Hotel / Hospitality	$0.49	$2.32	$3.98
Industrial Office	$0.69	$1.54	$3.01

Table 2: Total Project Cost Investment to Achieve Energy & Emissions Targets

All Electric Buildings and Buildings with Electricity as the Primary Heating Source

Achieving the energy targets for these buildings will *most likely* achieve the emissions target, therefore the energy efficiency targets should be the primary focus.

Buildings Primarily Heated by Natural Gas, Steam, or Other Fossil Fuels

Buildings that have natural gas as the primary heating source also typically have gas domestic hot water. As measures are developed to reduce energy use, the 2021 energy codes dictate the conversion of fossil fuel consuming equipment to electric alternatives. As such, the costs associated with meeting the required energy reductions through electrification results in *higher* project investment costs. Once the energy target is achieved, incremental emission reduction projects can be identified and implemented prior to the reporting interval.

Buildings that utilize district steam should focus on achieving the energy target while electrifying as many steam end-use devices as feasible. Due to the high emissions factor associated with district steam, achieving the emissions target for the *first* reporting interval (2026-2030) *will achieve* the energy efficiency target. Achieving future compliance with the emissions standard and 2021 energy code *will require* significant investments associated with changing HVAC system types, and therefore, may need to seek alternative compliance or exemptions.

For fossil fuel heated buildings, meeting the emissions compliance criteria *will* satisfy the state's published energy efficiency criteria. Any significant energy efficiency focused projects requiring a permit *must* satisfy the 2021 energy codes after July 1, 2023. For this report, emissions compliance achieves the greenhouse gas emissions targets for the *second* reporting interval (2031-2035) of Seattle's proposed emissions standard.

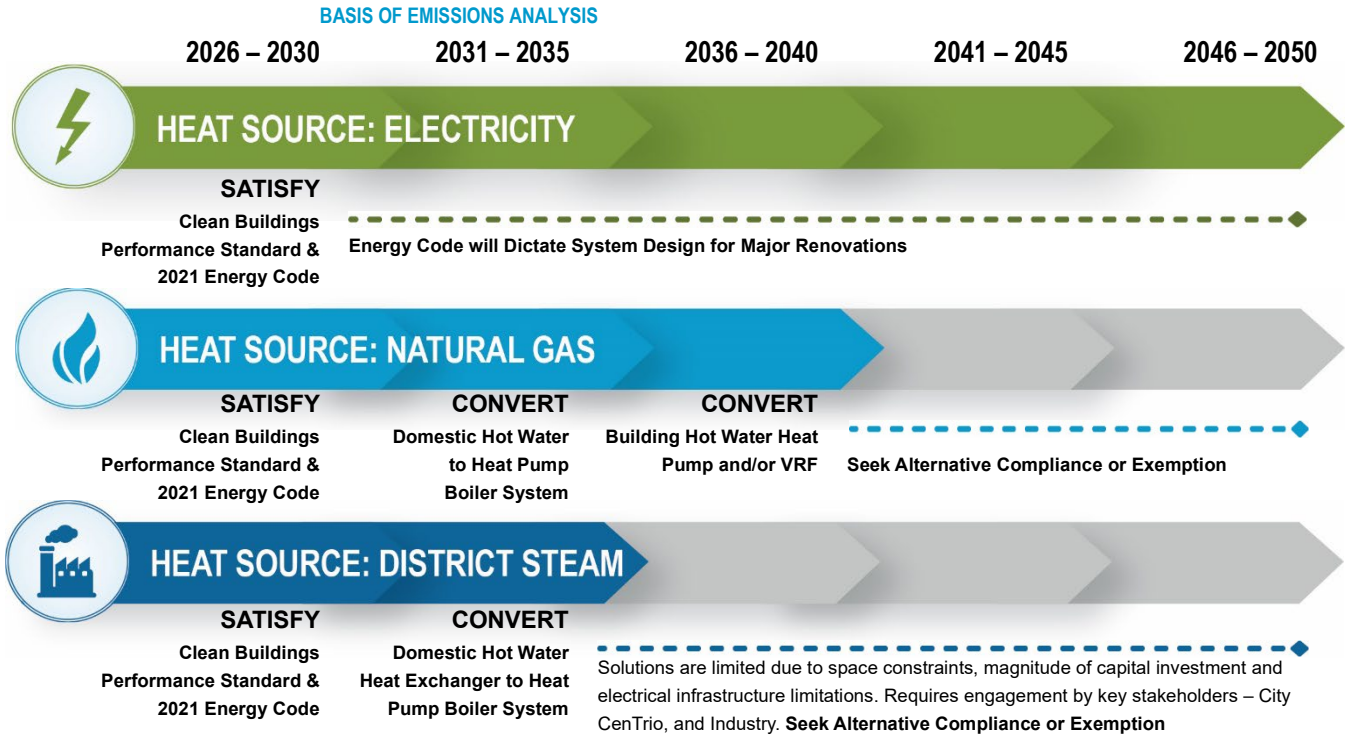


Figure 1: BEPS Compliance Recommendations

Compliance is Multi-Faceted

In some cases, meeting the building emissions criteria can be achieved over a longer period than may be required for all-electric buildings. The emissions standard provides **alternative compliance paths and exemptions** which allow buildings additional time to lower emissions to the established target. This is because for some fossil fuel heated buildings, electrification to meet emissions targets brings significant considerations and project costs to accommodate new electric equipment. This may include structural improvements, finding space to host equipment, upgrading electric service equipment, and potential distribution system redesign. For electricity heated buildings, accommodations for electrification alternatives are relatively straightforward and less financially intensive.

INTRODUCTION

Washington state currently has the Clean Buildings Performance Standard (CBPS) as well as the State Energy Code. While the CBPS sets energy efficiency targets for **existing commercial buildings**, the State Energy Code sets the energy efficiency requirements for all **new construction and alteration projects**. In addition, the city of Seattle has its *own* energy code as well as developing Building Emissions Performance Standards (BEPS), which establish Greenhouse Gas Intensity (GHGI) targets for commercial buildings.

Given the various codes and standards in Washington state, it is becoming increasingly difficult for building owners to know where and how each might overlap. This report provides initial guidance for building owners and managers affected by these codes and standards.

The analysis is based on 16 buildings representing commercial offices, industrial offices, and hospitality venues (hotels, convention centers, and health clubs) where energy efficiency projects have been completed or currently in development with MacDonald-Miller. Each building had monthly utility usage data for at least 12 consecutive months between 2019 to 2021 and Energy Efficiency Measures (EEMs) with associated investment costs. See **Appendix** for the unique profiles of each building.

Energy Star Portfolio Manager (ESPM) was used to calculate each building's weather normalized Energy Use Intensity (EUI). The building's **EUI** was then compared to its **calculated EUI target**, per Section 7 of the CBPS first compliance interval. The building's **GHGI** was then calculated by applying the **emission factors** published in Seattle's BEPS to the building's energy source. The scope of this study evaluated achieving the GHGI targets for only the first and second reporting intervals.

Achieving CBPS EUI targets was the priority for all 16 buildings. For buildings that did not achieve the GHGI targets for the first reporting interval after satisfying the EUI targets, additional EEMs were identified and added to the evaluation. Using the same representative buildings, MacDonald-Miller then examined the required EUI reductions and costs to achieve the GHGI targets for the second reporting Interval (2031-2035) of Seattle's BEPS. Due to the complexities of the technical solution, achieving net zero emissions is not included in this study.

METHODOLOGY

APPROACH

This study used a quantitative approach to determine how the CBPS and Seattle BEPS impact actual buildings. The results were used to develop guidance for building owners and managers to approach compliance across the various standards as well as provide a better understanding of the investment needed.

SELECTED BUILDING POPULATION

MacDonald-Miller used a set of 16 buildings, with 12 located in the Seattle metro area and the remaining in the Puget Sound Region. Both areas are within climate zone 4C as defined in ASHRAE (American Society of Heating Refrigerating and Air-Conditioning Engineers).

Buildings were categorized by building type, vintage (year built), gross floor area (GFA), and primary heating type. Given the primary stakeholders of this study, the building types were primarily office, with an additional subcategory of industrial office. Hotels were also included along with a health club and a convention center.

BUILDING ID	BUILDING TYPE	VINTAGE CATEGORY	GFA CATEGORY	PRIMARY HEATING FUEL
Bldg 1	Office	1966-1970	90k to 220k	Steam
Bldg 2	Office	1986-1990	>220k	Electricity
Bldg 3	Office	1971-1975	>220k	Steam
Bldg 4	Office	1956-1960	>220k	Steam
Bldg 5	Office	1996-2000	50k to 90k	Electricity
Bldg 6	Office	1986-1990	50k to 90k	Electricity
Bldg 7	Office	1976-1980	>220k	Electricity
Bldg 8	Hotel	1981-1985	>220k	Natural Gas
Bldg 9	Health Club	1926-1930	>220k	Steam
Bldg 10	Hotel	1921-1925	>220k	Steam
Bldg 11	Hotel	1971-1975	>220k	Steam
Bldg 12	Convention Center	1991-1995	90k to 220k	Natural Gas
Bldg 13	Industrial Office	1976-1980	90k to 220k	Natural Gas
Bldg 14	Industrial Office	1966-1970	50k to 90k	Electricity
Bldg 15	Industrial Office	1966-1970	50k to 90k	Natural Gas
Bldg 16	Industrial Office	1986-1990	50k to 90k	Natural Gas

Table 3: Overview of Representative Buildings

The following definitions were taken from Energy Star Portfolio Manager definitions for property type and used to categorize the buildings in this report. [1]

- **Office** refers to buildings used to conduct commercial or governmental business activities. This includes administrative and professional offices.
- **Industrial office** refers to buildings which contain at least 50% GFA of office space as well as a warehouse, vehicle repair, manufacturing, and/or other industrial space.1F 2
- **Hotel** refers to buildings renting overnight accommodations on a room/suite and nightly basis, and typically include a bath/shower and other facilities in guest rooms. Hotel properties typically have daily services available to guests including meeting rooms, food service, housekeeping/laundry, and a front desk/concierge.
- **Health Club** refers to buildings used for recreational or professional athletic training and related activities. Health Club properties typically have additional services such as lodging, food service, and meeting spaces requiring extended operating hours.
- **Convention Center** refers to buildings used primarily for large conferences, exhibitions, and similar events. Convention centers may include a diverse variety of spaces, including large exhibition halls, meeting rooms, and concession stands.

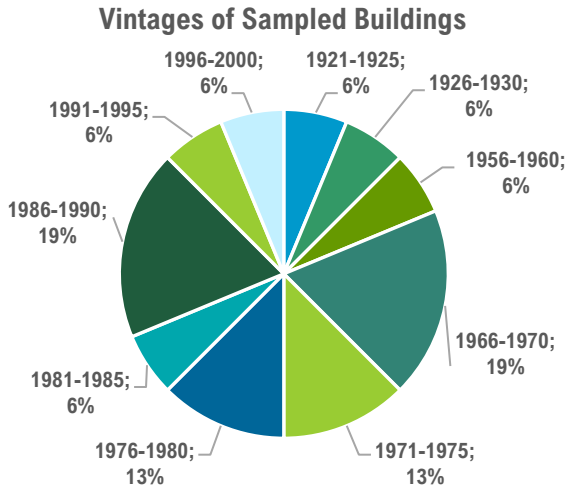


Figure 2:
Vintages of Sampled Buildings

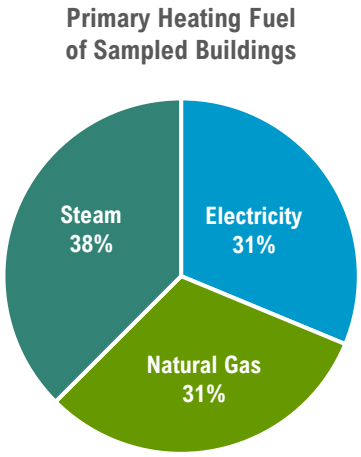


Figure 3:
Primary Heat Source of Sampled Buildings

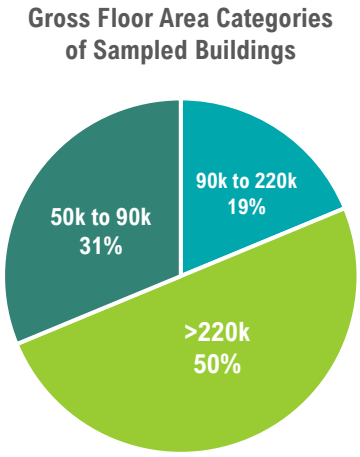


Figure 4:
Floor Area of Sampled Buildings

[1] https://www.energystar.gov/buildings/benchmark/understand_metrics/property_types

[2] Not listed in Energy Star Portfolio Manager property type definitions.

DATA COLLECTION PROCEDURE

ENERGY USE AND COSTS

2019 is used as the basis for the pre-project condition for most buildings in this study. Where 2019 data is unavailable, data from a more recent and appropriate typical operating year is used. Energy data is taken directly from utility bills collected during the project development phase by MacDonald-Miller. Where bills in the project files did not include 2019, utility data from Energy Star Portfolio Manager profiles managed by or shared with MacDonald-Miller was used since data is typically auto-uploaded monthly from the utility.

Project Utility Costs are Normalized to the Following Rates

UTILITY RATES			
MEASUREMENT	ENERGY SOURCE		
	Electricity	Natural Gas	District Steam
Unit	kWh	therms	klbs
Rate per Unit	$0.10	$0.90	$40.00

Table 4: Utility Rates Used in Analysis

GREEHHOUSE GAS EMISSIONS FACTORS

Greenhouse gas emissions factors by energy type are per the proposed BEPS ordinance and identified below in **Table 5**.

GREENHOUSE GAS EMISSIONS FACTORS		
ENERGY SOURCE	EMISSIONS FACTORS (kg CO2e/kBTU)	
	Baseline Years 2019, 2022, 2023, or 2024	Compliance Interval 1 2026 - 2030
Electricity	0.0055	0.0055
Natural Gas	0.053	0.053
District Steam	0.083	0.083

Table 5: Greenhouse Gas Emissions Factors by Energy Type

ENERGY EFFICIENCY MEASURES

The scope of the EEMs for each building were identified during the project development for each building by MacDonald-Miller. The primary motivation for these projects was energy savings and, in most instances, compliance with the CBPS. The scopes varied from building to building and were specific to the operating requirements and existing equipment conditions. **Figure 5** provides a general description of the measures identified across all the buildings based on the primary heating source.

	ELECTRICITY	NATURAL GAS	STEAM
CONTROLS & ANALYTICS	Schedule Optimization, Retro-commissioning, Enhanced Sequences of Operation, Building Analytics & Fault Detection		
VENTILATION & DISTRIBUTION	Variable Frequency Drives (VFD) to Pump & Fan Motors	Variable Frequency Drives (VFD) to Pump & Fan Motors	N/A
COOLING	Replace DX AC-units with high efficiency heat pumps Replace air-cooled or water cooled chillers with high efficiency heat recovery chillers	Replace DX AC-units with high efficiency heat pumps Replace air-cooled or water-cooled chillers with high efficiency heat recovery chillers	N/A
HEATING	N/A	Replace hot water non-condensing boilers with hot water condensing boilers or, when possible, heat pump boilers Convert gas-fired package units to heat pump package units	Replace failed steam traps and control valves Add pipe insulation to uninsulated lengths of pipe on the steam, heating hot water, and/or domestic hot water distribution systems Add heat exchanger to recover condensate waste heat and use as hot water pre-heat
LIGHTING	LED Fixtures Space Level Lighting Controls	N/A	N/A
BUILDING ENVELOPE	Replace Existing Roofs with Better Insulated New Roof and Replace Air Curtains at Main Service Doors		
RENEWABLE ENERGY	Solar Photovoltaics	Solar Photovoltaics	N/A

Figure 5: Energy Efficiency Measures by Energy Type

PROJECT COSTS

The project costs required to achieve the EUI reductions are the basis of the cost analysis. Project costs are adjusted to reflect 2023 dollars and consider the equipment and labor inflation from the time of the original estimate or project completion. These costs are turn-key costs and consist of all labor and material needed to construct the project, along with project management, engineering, permits, and taxes.

Costs for the incremental effort needed to achieve compliance with the BEPS were based on recent MacDonald-Miller projects where low-carbon or electrification equipment was proposed or part of an installed project. Equipment costs were dependent on the type of existing heating systems (e.g., gas-fired package units vs. hot water boilers) and appropriate low-carbon/electrification alternative. In addition to equipment costs, estimates of significant infrastructure upgrades (e.g., switch gear upgrades, structural upgrades, additional space requirements, etc.) were also approximated on a consistent dollar per floor area basis.

DATA ANALYSIS PROCEDURE

The analysis involved developing CBPS and BEPS targets, pre-project and post-project EUI and GHGI metrics. Pre-project conditions are prior to the implementation of EEMs. Post-project conditions are after the implementation of EEMs.

The EEMs were evaluated according to the energy reductions needed to achieve CBPS compliance. When additional measures were needed to achieve BEPS compliance, energy savings and associated emissions reductions are estimated based on the electrification of post-project natural gas or steam heating.

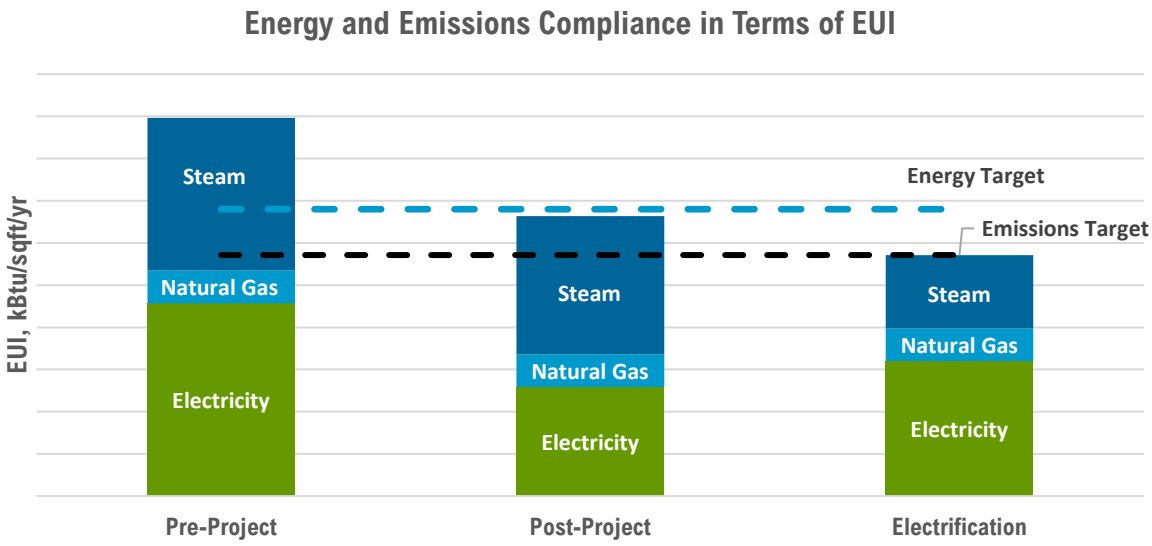


Figure 6: Energy & Emissions EUI Compliance

ENERGY AND EMISSIONS TARGETS

EUI targets were calculated for each building according to the process identified in the energy-use analysis and target requirements, Section 7 of the Clean Buildings Performance Standard. GHGI targets were calculated using the published emissions factors and proposed targets for reporting Intervals 1 and 2 as detailed in Seattle's BEPS.

PRE-PROJECT METRICS

Pre- project EUI were calculated using baseline energy consumption and GFA of each building. GHGI metrics were calculated by applying the appropriate emissions factor for the corresponding fuel.

Building ID	EUI kBtu/sqft/yr	GHGI kg CO2e/sqft/yr	EUI Target kBtu/sqft/yr	2026-2030 GHGI Target kg CO2e/sqft/yr	2031-2035 GHGI Target kg CO2e/sqft/yr
Bldg 1	75.1	3.58	63.0	0.63	0.44
Bldg 2	46.0	0.43	65.8	0.67	0.47
Bldg 3	80.7	1.96	67.4	0.72	0.50
Bldg 4	99.2	4.23	62.6	0.69	0.48
Bldg 5	56.6	0.31	63.0	0.63	0.44
Bldg 6	47.6	0.26	63.0	0.63	0.44
Bldg 7	57.0	0.31	63.0	0.63	0.44
Bldg 8	97.9	2.38	68.0	2.22	1.57
Bldg 9	111.8	5.61	114.5	3.25	2.29
Bldg 10	92.4	4.06	68.0	2.22	1.57
Bldg 11	89.7	3.64	68.0	2.22	1.57
Bldg 12	89.5	2.42	55.0	1.85	0.89
Bldg 13	72.4	2.31	56.0	0.79	0.56
Bldg 14	46.1	0.43	42.8	0.65	0.46
Bldg 15	84.4	2.75	57.6	0.63	0.44
Bldg 16	51.9	1.17	63.0	0.63	0.44

Table 6: Building Metrics Pre-Project

POST-PROJECT METRICS

Post-project EUI were calculated by deducting the project EEMs energy savings by fuel source from the baseline energy consumption for each building. In a couple instances, the resulting EUI did not achieve the desired emissions goal/target. The additional EUI reduction needed to achieve the emissions target required additional electrification of natural gas or steam heating equipment.

Similar to the pre-project metrics, GHGI was calculated by applying the appropriate emissions factor for the corresponding fuel to the resulting EUI for each building. If the post-project GHGI **met the second interval target**, then no further action was required; therefore, the building satisfied CBPS and BEPS compliance. However, this only occurred in buildings with electricity as the primary heating fuel. For the buildings where post-project GHGI was **above the second interval target**, the additional EUI reduction was calculated to achieve GHGI compliance by electrifying district steam or natural gas consuming equipment[3].

Building ID	EUI kBtu/sqft/yr	GHGI kg CO2e/sqft/yr	EUI Target kBtu/sqft/yr	2026-2030 GHGI Target kg CO2e/sqft/yr	2031-2035 GHGI Target kg CO2e/sqft/yr
Bldg 1	41.6	0.44	63.0	0.63	0.44
Bldg 2	39.9	0.40	65.8	0.67	0.47
Bldg 3	48.0	0.50	67.4	0.72	0.50
Bldg 4	44.0	0.48	62.6	0.69	0.48
Bldg 5	38.4	0.21	63.0	0.63	0.44
Bldg 6	28.7	0.16	63.0	0.63	0.44
Bldg 7	39.0	0.21	63.0	0.63	0.44
Bldg 8	68.0	1.57	68.0	2.22	1.57
Bldg 9	78.5	2.29	114.5	3.25	2.29
Bldg 10	60.6	1.57	68.0	2.22	1.57
Bldg 11	57.1	1.57	68.0	2.22	1.57
Bldg 12	50.3	0.82	55.0	1.85	0.89
Bldg 13	43.3	0.44	56.0	0.79	0.56
Bldg 14	43.5	0.40	42.8	0.65	0.46
Bldg 15	58.8	0.19	57.6	0.63	0.44
Bldg 16	45.0	0.28	63.0	0.63	0.44

Table 7: Building Metrics Post-Project

[3] Net EUI impact accounted for additional electricity use from electrification assuming natural gas heating system efficiency was 80% and new heat pump heating had a 2.5 COP.

ENERGY AND EMISSIONS FORMULAS

The costs to achieve the energy and emissions targets are expressed as a function of equivalent EUI reductions are illustrated by the formulas in **Figure 7**, below.

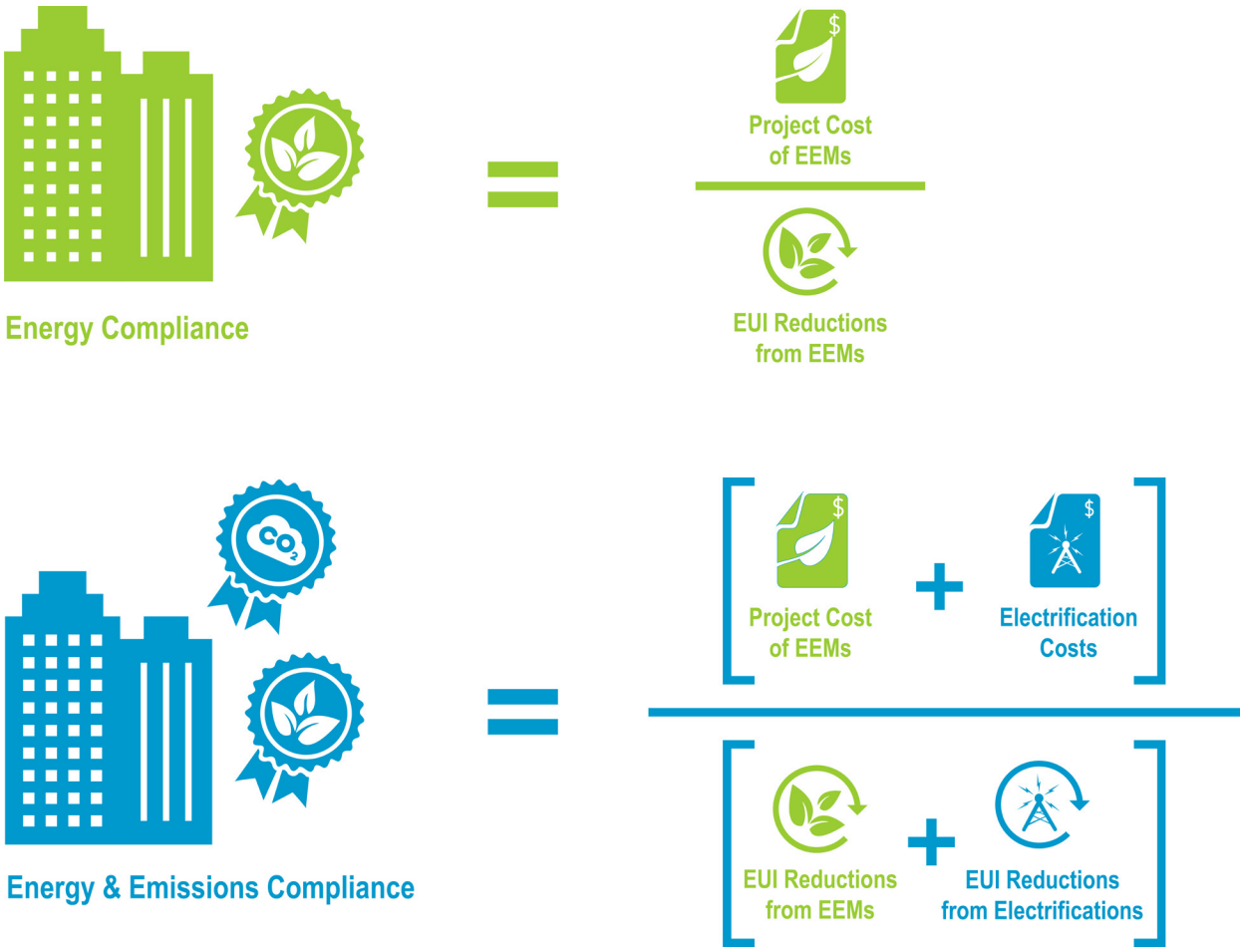


Figure 7: Energy & Emissions Reduction Formulas

RESULTS & DISCUSSION

Table 8 summarizes the average project investment costs, per gross floor area, per EUI reduction, required to achieve the respective target. The costs represent the **total investment** required to achieve the reductions. They do not account for any budgeted capital improvements, utility incentives, or grants.

AVERAGE REDUCTIONS & INVESTMENT Per Gross Floor Area				
BUILDING TYPE	**ENERGY**		**EMISSIONS**	
	EUI Reduction kBTU/SF/YR	**Investment** $/SF/EUI	**GHGI Reduction** kg CO2e/SF/YR	**Investment** $/SF/EUI
Commercial Office (All Heat Sources)	**20.9**	**$0.70**	**0.523**	**$1.34**
All Electric	15.3	$0.81	0.084	$0.81
District Steam Heated	28.3	$0.56	1.190	$2.05
Hotel / Hospitality (All Heat Sources) *Excludes Building 12 that fully electrified*	**22.5**	**$0.50**	**0.557**	**$2.32**
Natural Gas Heated	11.4	$0.53	0.063	$2.34
District Steam Heated	24.3	$0.53	0.998	$2.39
Industrial Office (All Heat Sources)	**17.5**	**$1.52**	**0.905**	**$1.54**
All Electric	4.5	$1.43	0.025	$1.43
Natural Gas Heated	21.8	$1.56	1.199	$1.57

Table 8: Average Reduction and Investment by Building Type

COMMERCIAL OFFICE SECTOR

Result

Four of the seven commercial office buildings achieved the required emissions reductions for the second reporting interval of BEPS by meeting the CBPS energy efficiency targets.

Discussion

The remaining three buildings required additional investment to achieve the second reporting interval for BEPS emissions compliance. This required surgical replacement of select steam to hot water heat exchangers with heat pump boilers due to their primary heating fuel being district steam.

HOTEL / HOSPITALITY SECTOR

Result

The hotel/hospitality sector was furthest from the CBPS energy targets and had the highest cost for BEPS compliance.

Discussion

Due to the dependency on fossil fuel energy sources, the hospitality sector had the highest investment cost to achieve BEPS emissions compliance because of the requirements of electrification. This included the conversion of the domestic hot water system from steam or natural gas to electric heat pump boilers.

For the purposes of CBPS energy compliance, the hospitality sector was furthest from their energy target, but the actual investment needed was the lowest of the three sectors. This is due to the nature of the EEMs being very controls intensive and changes systems to operation to being demand based. Specifically, these improvements avoided having to replace major equipment such as chillers, boilers, and air handlers.

INDUSTRIAL OFFICE SECTOR

Result

The industrial office sector achieved compliance with both CBPS and BEPS by satisfying the 2021 energy code for comparable investment costs. Meaning, by investing in the upgrades that would satisfy the 2021 energy code, the capital expenditure required was no greater in achieving compliance with all 3 targets.

Discussion

Due to 2021 energy code restrictions, many of these buildings had gas-fired equipment at the end of its useful life and could not be replaced in-kind with more efficient gas-fired equipment. Therefore, the natural gas fueled equipment was replaced with heat pump technologies. Therefore, for this sampling of buildings, meeting the energy code achieved compliance with both energy and emissions standards at a similar cost of investment to that of meeting CBPS or BEPS compliance.

INVESTMENT COMPARISONS

Figure 8 represents the investment per square foot *versus* the EUI reduction needed to achieve the energy target. As expected, the further away from the energy target, the greater the cost to achieve the target.

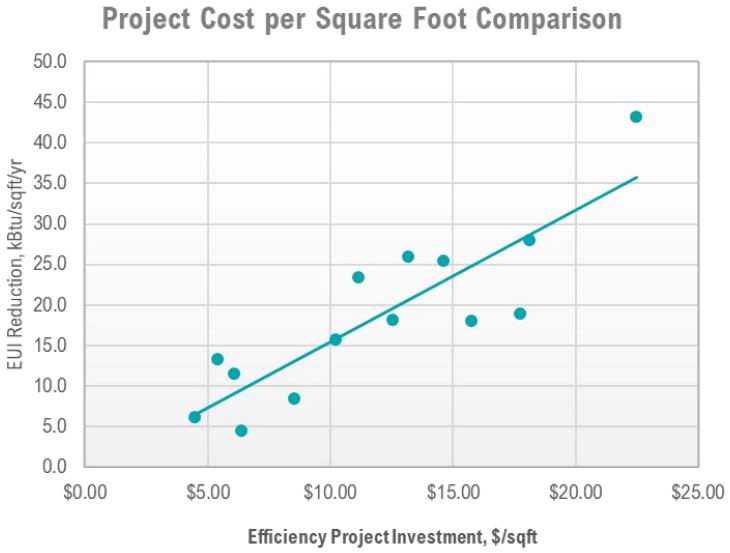


Figure 8: Project Cost Per Square Foot

CONSIDERATIONS

Electric Heated Buildings

For electric heated buildings, achieving the energy target should be the primary focus. Additional considerations to further lower energy consumption and emissions would be to investigate the cost-effectiveness of adding renewable energy technologies such as solar PV and sewer heat recovery.

Natural Gas or Steam Heated Buildings

Buildings with natural gas or district steam heating can achieve EUI targets with a similar approach to all-electric heating buildings. Due to the Washington state and 2021 energy codes, recommended measures *should include* conversions of gas fired RTUs *and* conversion of domestic hot water to heat pump technology as part of the energy reduction measures to address the GHGI.

It should be noted that the GHGI of gas heated buildings tends to be 1.5 - 2.5 times their second interval target, and up to 8 times for district steam, so further action is needed to meet emissions targets for these fossil fuel heated buildings.

Electric Vehicle Charging

With increasing electric vehicle (EV) adoption, more EV charging infrastructure is being installed on commercial properties; in turn, impacting building energy consumption. Both building standards allow for deductions for energy use associated with EV charging but will require proper metering of charging equipment. In some instances, this may be installed by the utility, but if not, submetering equipment should be budgeted and accounted for in any compliance reporting to avoid impacts to building energy and emissions metrics.

New Constructions and Retrofit Projects

As of July 1, 2023, building designs for new construction and retrofit projects must comply with the 2021 Washington State Energy Code (WSEC) or the 2021 Seattle Energy Code (SEC). Both codes limit the use of fossil fuel-based HVAC heating equipment.

Alternative Pathways

Specific to natural gas and district steam buildings, there are alternative pathways to comply with the BEPS; however, these are very case specific and not included in this study. This is due to the various combinations under which they might apply as summarized below.

- **Partial Compliance** - For the first reporting interval only, buildings can achieve compliance by reducing emissions a minimum of 10% in lieu of meeting the GHGI target.
- **Exemptions** - For buildings meeting certain criteria or building types *not covered* by standard targets, a building's baseline may be used to establish a 25% GHGI reduction target for each interval.

- **Hardships** - Hardship compliance plans for significant extenuating circumstances are possible. Examples include substantial alteration, unreinforced masonry, city landmark historic building, electric service capacity constraints, district campus central plant upgrade, or when no practicable low or zero GHG emissions alternatives are available.
- **Alternative Compliance Payment** – Covered buildings may meet up to 100% of their emissions reductions required for compliance in any reporting interval by paying into the Clean Buildings Investment Fund.
- **Exclusions of Certain Equipment**
  - Fossil-fuel equipment permitted under the 2018 Seattle Energy Code (first reporting interval only).
  - Commercial cooking equipment (first and second reporting interval only).
  - High-intensity process equipment in hospitals, laboratories & hotels (first and second reporting interval only).

While deductions and alternative compliance may be options in the near or mid-term, ultimately the BEPS is moving toward “net-zero” emissions, so eventually, these alternative pathways may not be available.

Space Considerations

The compliance path to net zero emissions for fossil fuel heated buildings presents some notable non-financial hardships. For some district steam buildings, considerations for the placement of new equipment are required. Since these buildings often have small mechanical rooms which typically contain piping, circulation pumps, and heat exchangers, replacement equipment requires significant space. Furthermore, steam pipes tend to enter the building from below grade, such as through a basement. If equipment needs to be placed on the roof, this will not only require structural analysis of the roof, but also a distribution system redesign.

Figure 9 illustrates the relative size comparison of one scenario where steam-to-hot water heat exchangers could be replaced with condensing boilers or heat pump boilers.

Electrical Capacity Limitations

Additional electric capacity is needed for natural gas or district steam heated buildings requiring electrification. This can require upgrades to switch gear, transformers, and electrical panels, and, in extreme cases, may require service upgrades or new service delivery points from the electric utility. These upgrades may already be necessary depending upon the age of existing electrical infrastructure equipment, regardless of whether electrification equipment is being installed.

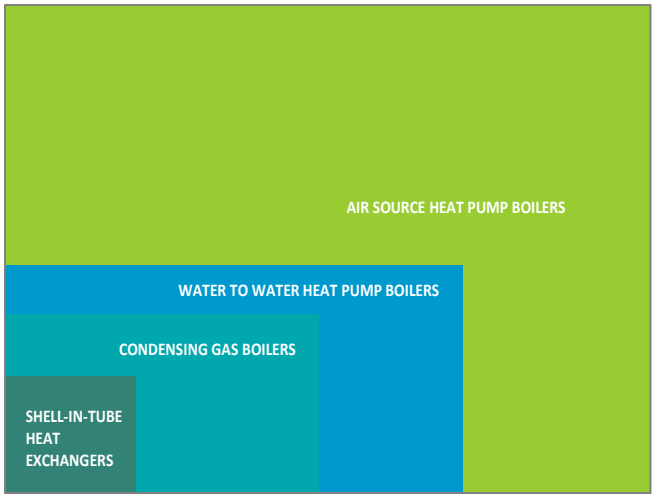


Figure 9: Space Requirements for Equivalent Heating System

RECOMMENDATION

Based on the convergence of the Clean Buildings Performance Standard, 2021 Energy Code, and potential Building Emissions Performance Standard, the outcomes of this study encourage building owners/managers to incorporate the combined effects of each into one compliance and capital planning exercise. **Figure 10** illustrates the recommended steps along the path for compliance with these performance standards. By taking action, these important steps provide adequate insights for capital planning as the existing building performance standards continue to evolve.

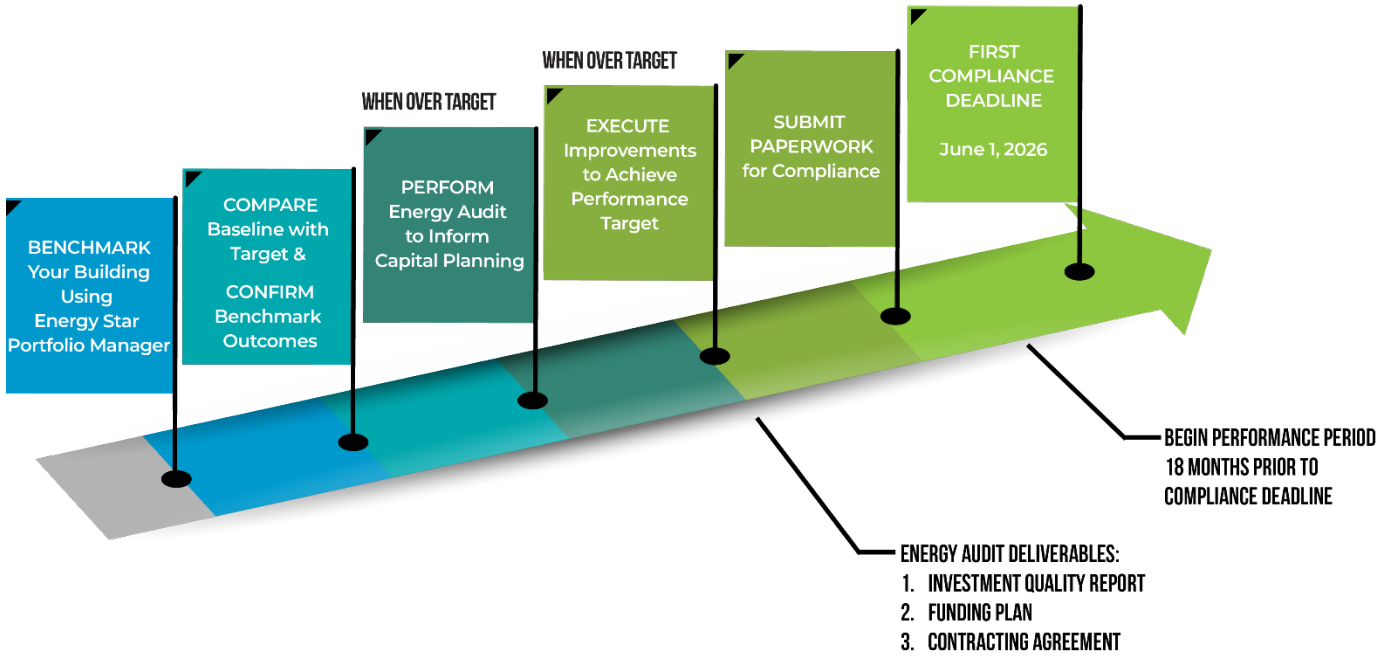


Figure 10: Building Performance Standards Compliance Pathway

REFERENCES

Clean Buildings Act (HB 1257, 2019 and RCW 19.27A.200)
http://www.commerce.wa.gov/wp-content/uploads/2019/06/HB1257.pdf

https://apps.leg.wa.gov/wac/default.aspx?cite=194-50

Clean Buildings Performance Standard (Chapter 194-50 WAC)
https://apps.leg.wa.gov/wac/default.aspx?cite=194-50

Seattle Building Emissions Performance Standard, Guide to the Proposed Policy (01/17/23 DRAFT)
https://www.seattle.gov/documents/Departments/OSE/Building%20Energy/BEPS-Proposed-Policy-Guide-01.17.23.pdf

2021 Washington State Energy Code
https://app.leg.wa.gov/WAC/default.aspx?cite=51-11C

2021 Seattle Energy Code
https://www.seattle.gov/sdci/codes/changes-to-code/2021-seattle-code-adoption

INDEX OF TABLES

INDEX OF FIGURES

APPENDIX

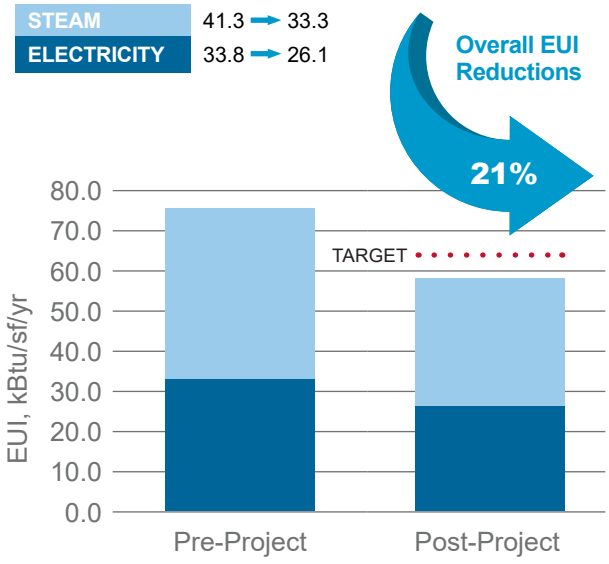
BUILDING PROFILES

BUILDING 1

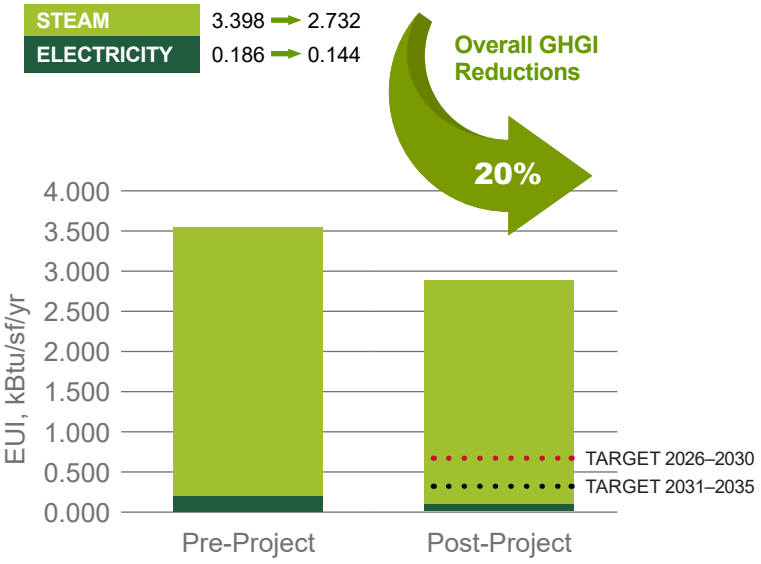
Property Type	**Office**
Vintage	**1966–1970**
GFA Category	**90k–220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$557,000**
Utility Costs per SF	**$2.37**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Heating is provided by perimeter induction units with steam coils.
- Cooling provided by water-cooled chillers.
- Controls combination of old pneumatic and newer DDC.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Add optimal start, energy coasting, enhanced economizer, and air-side and water-side reset control sequencing.
- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Replace/Repair failed steam traps on building induction units' steam distribution system.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.65**
Energy and Emissions Compliance	**$2.22**

Additional GHG Reduction Recommendations

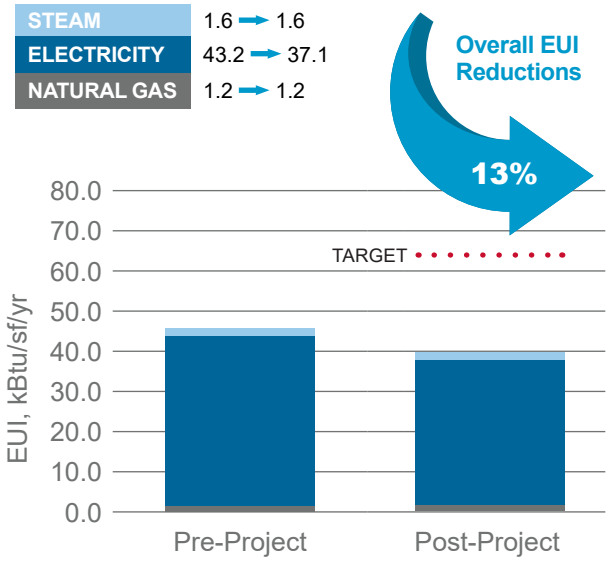
Add heat pump boilers and replace induction steam coils with hot water coils. Could implement changes on floor-by-floor basis.

BUILDING 2

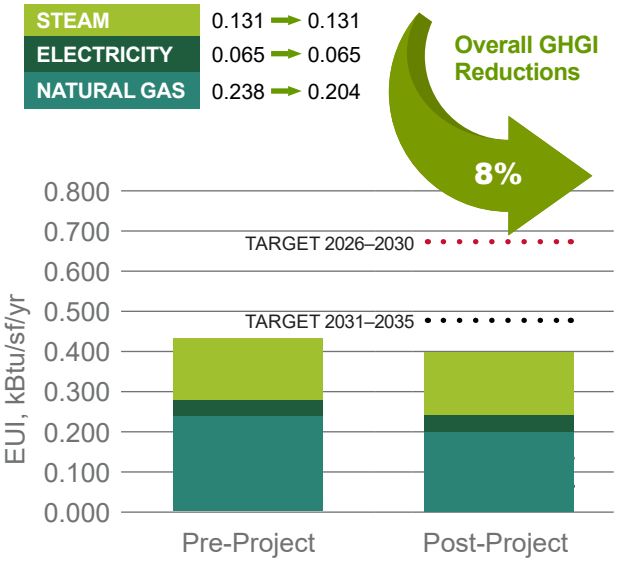
Property Type	**Office**
Vintage	**1986–1990**
GFA Category	**>220k**

Primary Heating Fuel	**Electricity**
Annual Utility Cost	**$1,501,000**
Utility Costs per SF	**$1.33**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Heating is provided by terminal units with electric reheat.
- Central water-cooled chiller system provides cooling.
- DDC controls are original to the building.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Add optimal start, energy coasting, enhanced economizer, and air-side and water-side reset control sequencing.
- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.73**
Energy and Emissions Compliance	**$0.73**

Additional GHG Reduction Recommendations

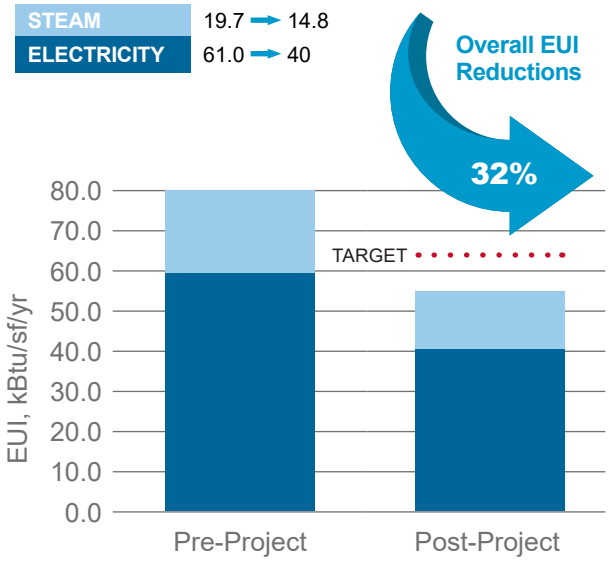
No additional electrification required.

BUILDING 3

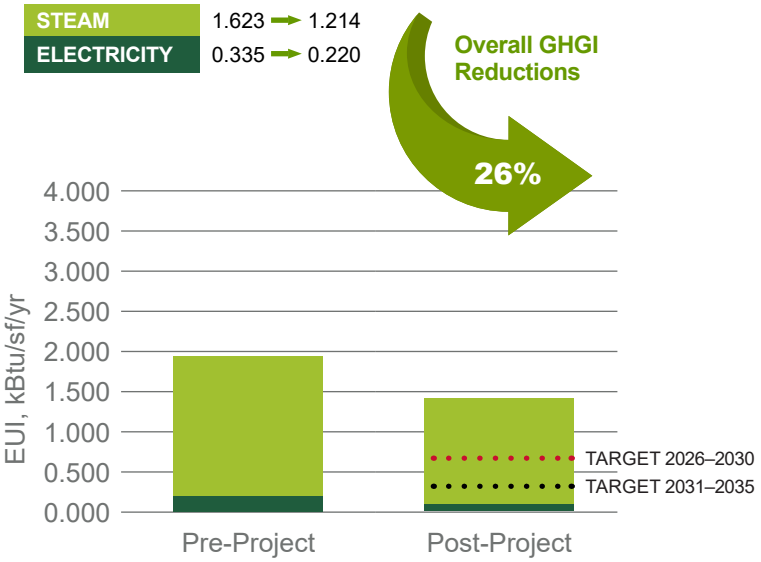
Property Type	**Office**
Vintage	**1971–1975**
GFA Category	**>220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$1,005,000**
Utility Costs per SF	**$2.45**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Heating is provided by perimeter induction units with steam coils.
- Cooling provided by water-cooled chillers.
- Controls combination of pneumatic and newer DDC.

Measures in Project

- Convert pneumatic controllers on induction units to DDC.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Add smart building fault analytics and monitoring to major equipment.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.51**
Energy and Emissions Compliance	**$2.36**

Additional GHG Reduction Recommendations

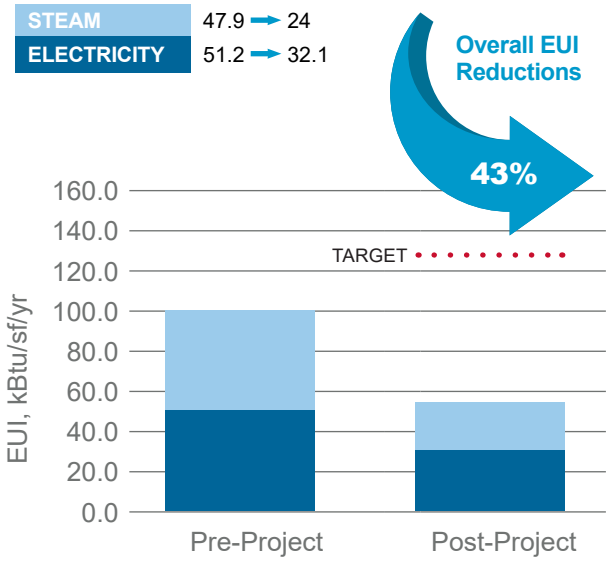
Add heat pump boilers and replace induction steam coils with hot water coils. Could implement changes on floor-by-floor basis.

BUILDING 4

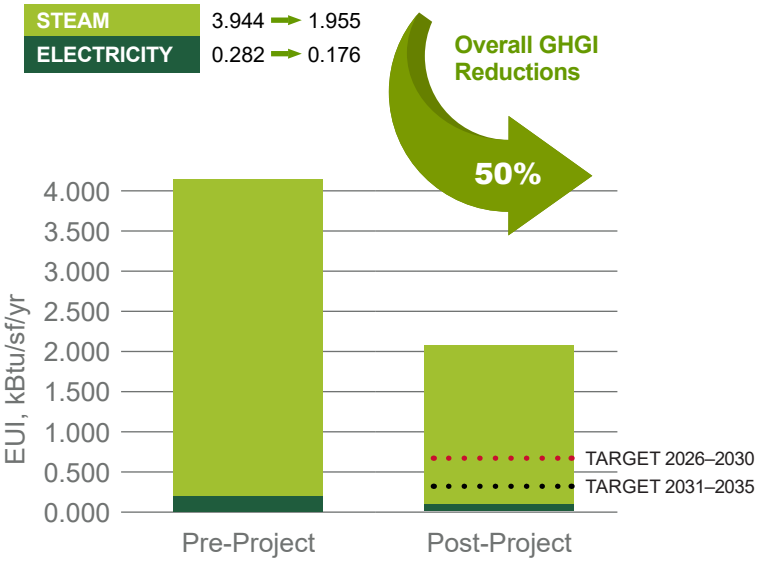
Property Type	**Office**
Vintage	**1956–1960**
GFA Category	**>220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$945,000**
Utility Costs per SF	**$3.11**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Heating is provided by steam induction units.
- Cooling is provided by water-cooled chillers.
- Controls are a combination of pneumatic and DDC.

Measures in Project

- Convert pneumatic controllers on induction units to DDC.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Install smart building analytics to optimize control sequences to achieve peak energy performance.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.52**
Energy and Emissions Compliance	**$1.57**

Additional GHG Reduction Recommendations

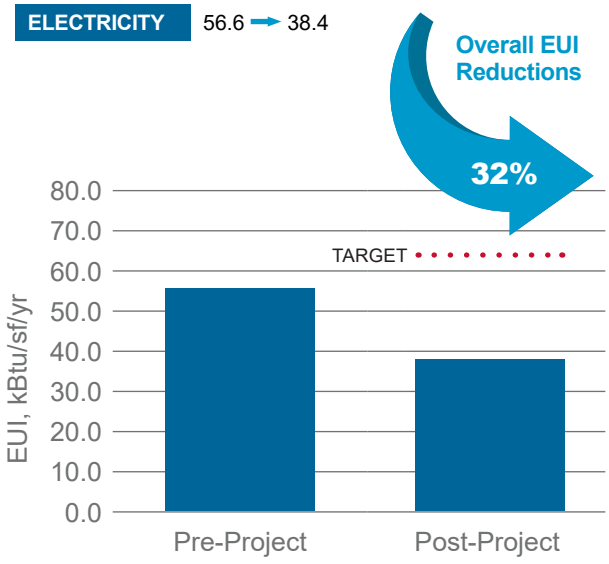
Add heat pump boilers and replace induction steam coils with hot water coils. Could implement changes on floor-by-floor basis.

BUILDING 5

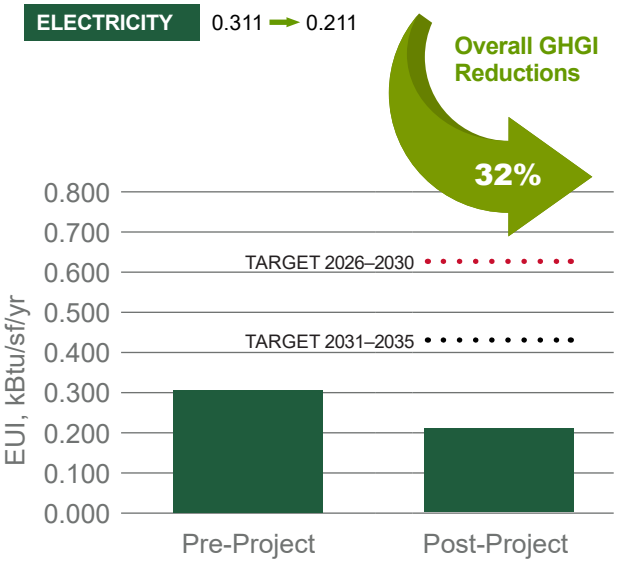
Property Type	Office
Vintage	1966–2000
GFA Category	50k–90k

Primary Heating Fuel	Electricity
Annual Utility Cost	$125,000
Utility Costs per SF	$1.66

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Heating is provided by VAV boxes with electric resistance heat.
- Cooling is provided by roof-top package units with DX coils.
- Controls are DDC.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Install smart buildings analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Replace failed DX RTUs with higher efficiency units.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Add solar PV arrays to roof.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	$0.69
Energy and Emissions Compliance	$0.69

Additional GHG Reduction Recommendations

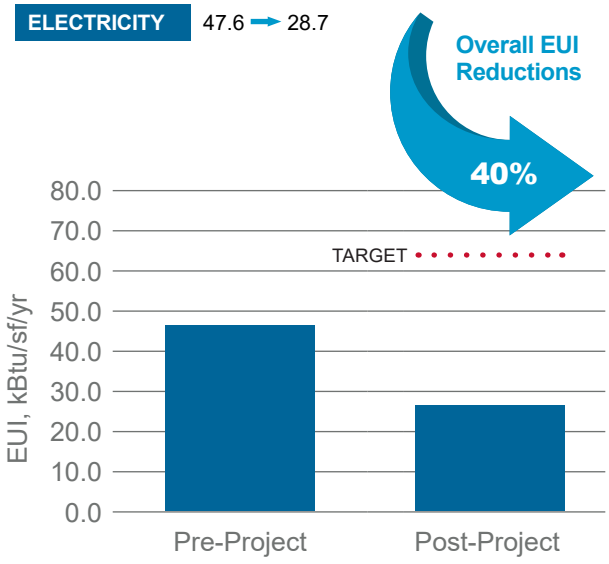
No additional electrification required.

BUILDING 6

Property Type	**Office**
Vintage	**1986–1990**
GFA Category	**50k–90k**

Primary Heating Fuel	**Electricity**
Annual Utility Cost	**$73,000**
Utility Costs per SF	**$1.39**

BUILDING EUI



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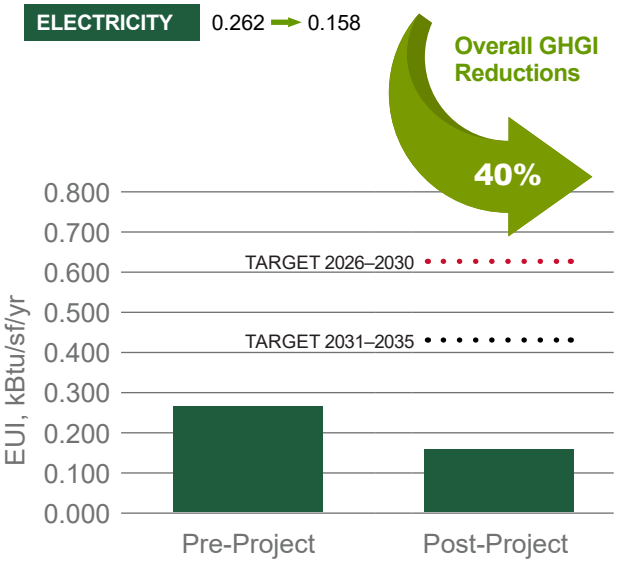


Pre-Project Condition

- Heating is provided by VAV boxes with electric resistance heat.
- Cooling is provided by roof-top package units with DX coils.
- Controls are DDC.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Add optimal start, energy coasting, enhanced economizer, and air-side and water-side reset control sequencing.
- Install smart buildings analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Replace failed DX RTUs with higher efficiency units.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.94**
Energy and Emissions Compliance	**$0.94**

Additional GHG Reduction Recommendations

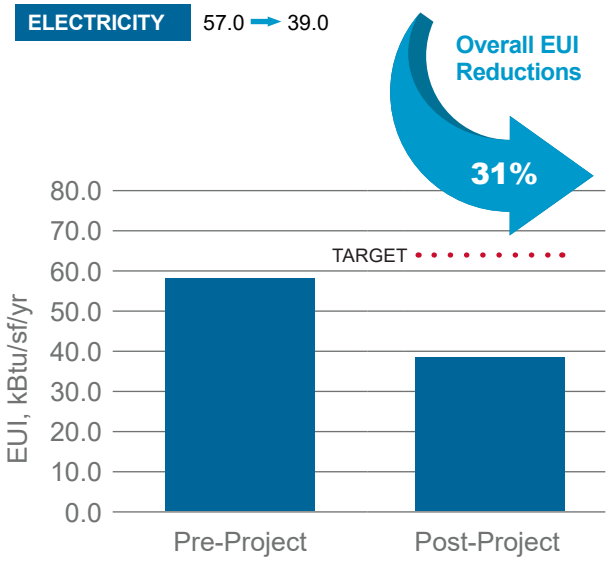
No additional electrification required.

BUILDING 7

Property Type	**Office**
Vintage	**1976–1980**
GFA Category	**>220k**

Primary Heating Fuel	**Electricity**
Annual Utility Cost	**$1,083,000**
Utility Costs per SF	**$1.67**

BUILDING EUI



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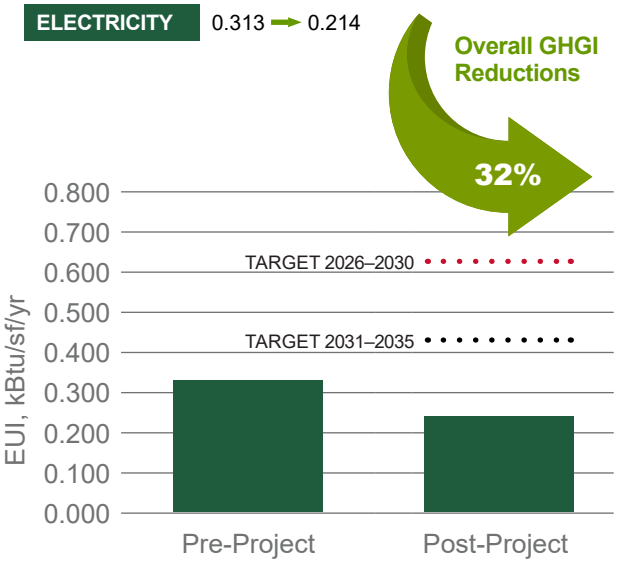


Pre-Project Condition

- Heating is provided by heat recovery chillers and electric resistance induction units.
- Cooling is provided by water-cooled chillers.
- Controls are DDC.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Install smart building analytics to optimize control sequences to achieve peak energy performance
- Replace failed devices and equipment level controllers
- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Convert pneumatic controllers on induction units to DDC.
- Mitigate stack effect and floor pressurization control.
- Add heat recover to auxiliary cooling loop.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.88**
Energy and Emissions Compliance	**$0.88**

Additional GHG Reduction Recommendations

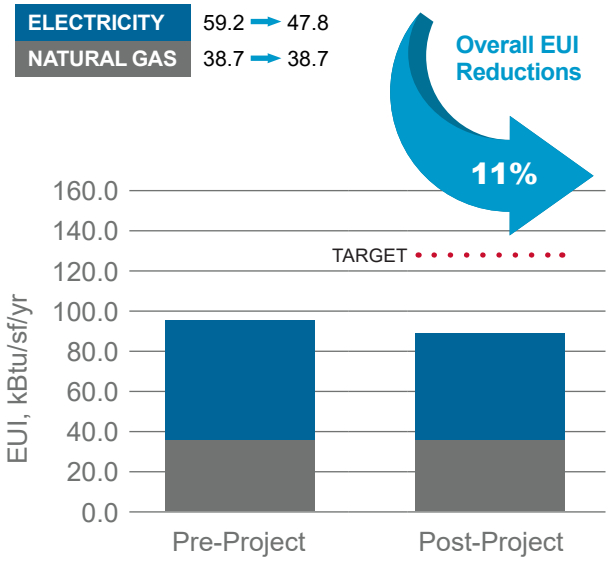
No additional electrification required.

BUILDING 8

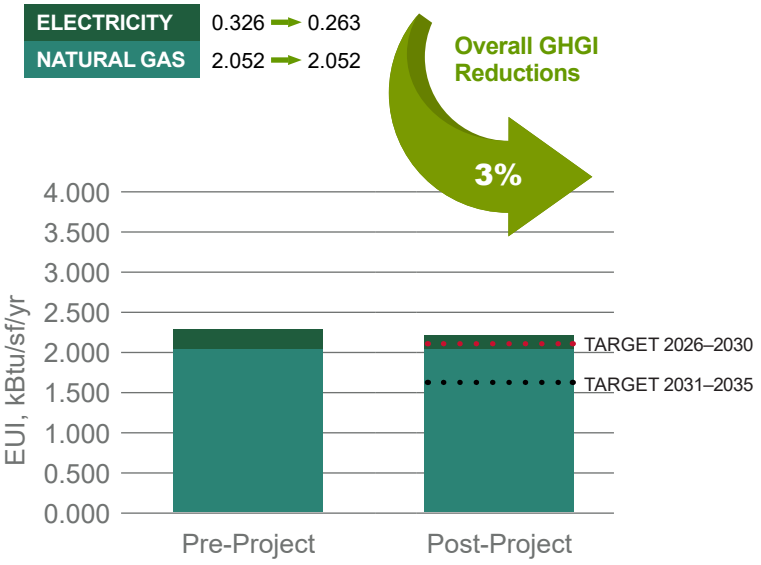
Property Type	**Hotel**
Vintage	**1981–1985**
GFA Category	**>220k**

Primary Heating Fuel	**Natural Gas**
Annual Utility Cost	**$726,000**
Utility Costs per SF	**$2.08**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Guest rooms served by package terminal heat pumps, common areas, and conference space served by water-source heat pumps.
- Controls are DDC.

Measures in Project

- Connect HPs to control system.
- Convert garage fluorescent lighting fixtures to LED fixtures.
- Modify kitchen exhaust system, add VFDs to motors for demand-based control.
- Add heat recover to laundry DHW system (previous laundry load water pre-heats next load water).

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.53**
Energy and Emissions Compliance	**$2.34**

Additional GHG Reduction Recommendations

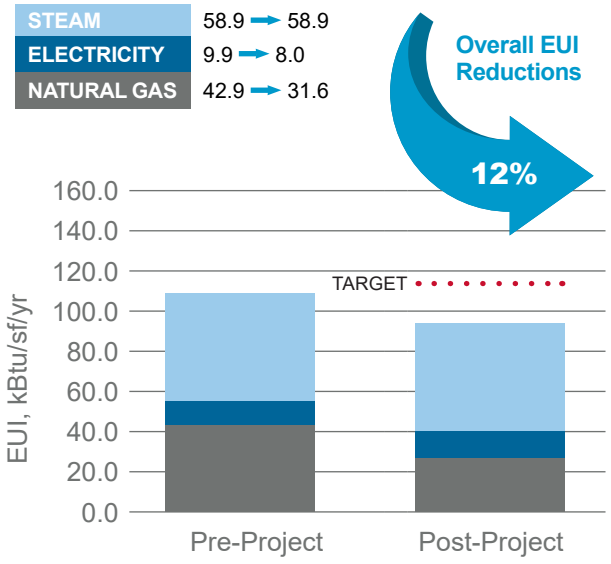
Convert gas domestic hot water boilers to heat pump boilers.

BUILDING 9

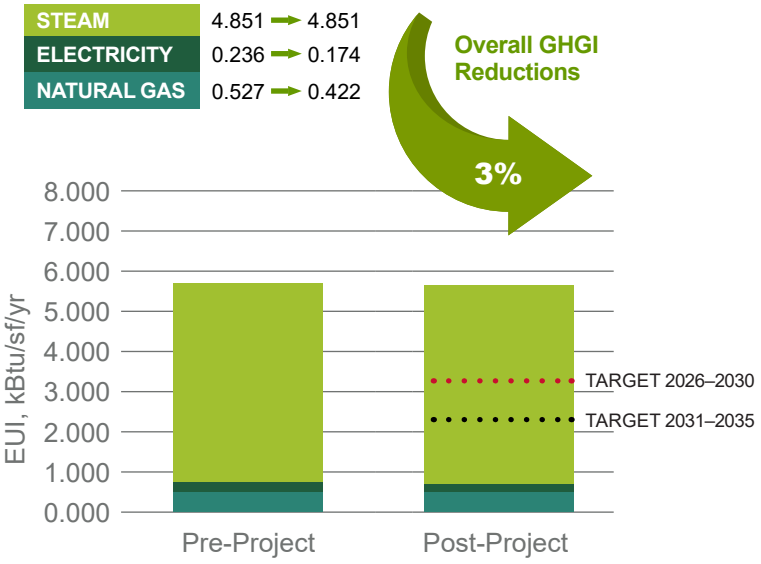
Property Type	**Health Club**
Vintage	**1926–1930**
GFA Category	**>220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$977,000**
Utility Costs per SF	**$3.32**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Guest rooms served by unit ventilators (steam heating, chilled water cooling).
- Common spaces served by terminal units with steam coils.
- Controls are DDC.

Measures in Project

- Optimize equipment schedules to align better with occupancy.
- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Add VFDs to secondary chilled water pumps.
- Implement demand-based kitchen ventilation control.
- Repair worn/damaged pipe insulation on district steam system. Add insulation to uninsulated pipe lengths.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.41**
Energy and Emissions Compliance	**$0.49**

Additional GHG Reduction Recommendations

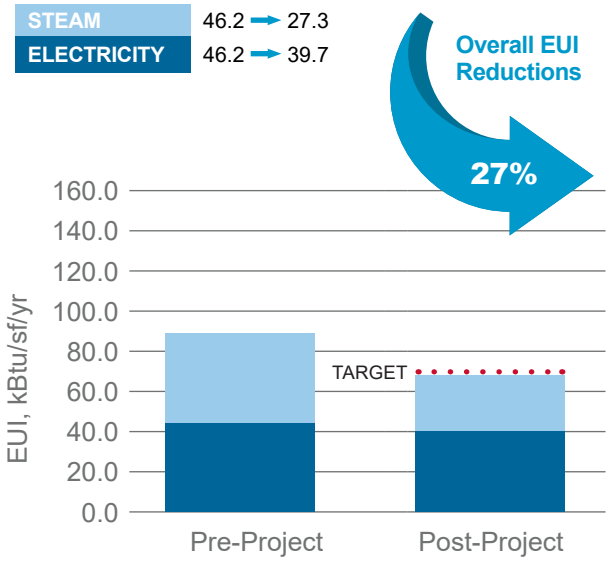
Replace steam HX with heat pump boilers to provide domestic hot water. Replace chillers with heat pump machines to supply building heating and cooling.

BUILDING 10

Property Type	**Hotel**
Vintage	**1921–1925**
GFA Category	**>220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$1,574,000**
Utility Costs per SF	**$2.90**

BUILDING EUI



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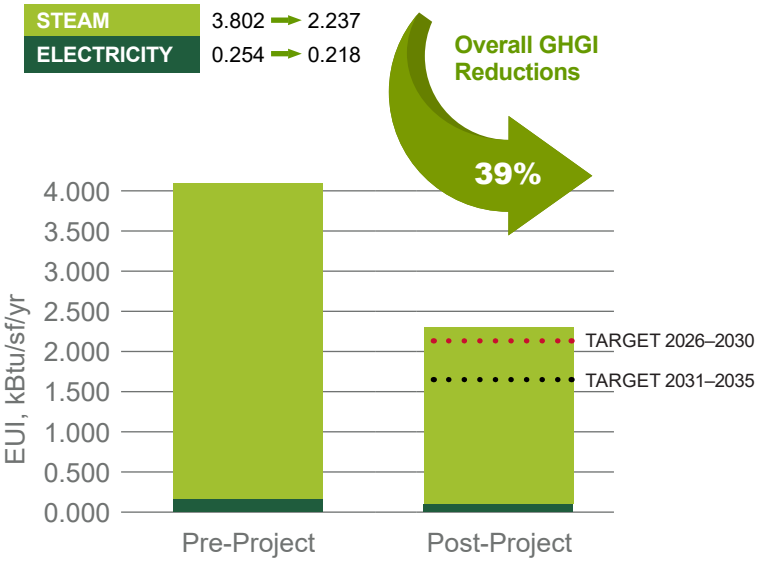


Pre-Project Condition

- Guest rooms served by four-pipe fan coil units.
- Heating provided by steam-to-hot water heat exchangers.
- Cooling provided by water-cooled chiller.
- Controls are DDC.

Measures in Project

- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Upgrade steam-to-hot water heat exchangers.
- Implement demand-based kitchen ventilation control sequence.
- Repair worn/damaged pipe insulation on district steam system.
- Upgrade to high performance windows.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.58**
Energy and Emissions Compliance	**$2.47**

Additional GHG Reduction Recommendations

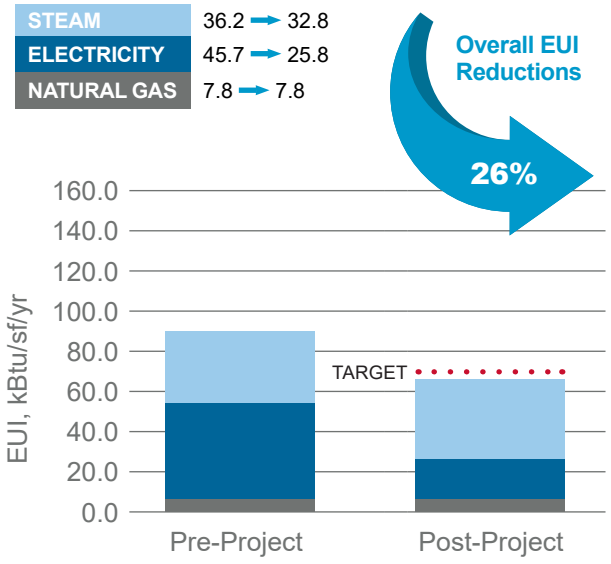
Replace steam HX with heat pump boilers to provide domestic hot water. Replace chillers with heat pump machines to supply building heating and cooling.

BUILDING 11

Property Type	**Hotel**
Vintage	**1971–1975**
GFA Category	**>220k**

Primary Heating Fuel	**Steam**
Annual Utility Cost	**$872,000**
Utility Costs per SF	**$2.63**

BUILDING EUI



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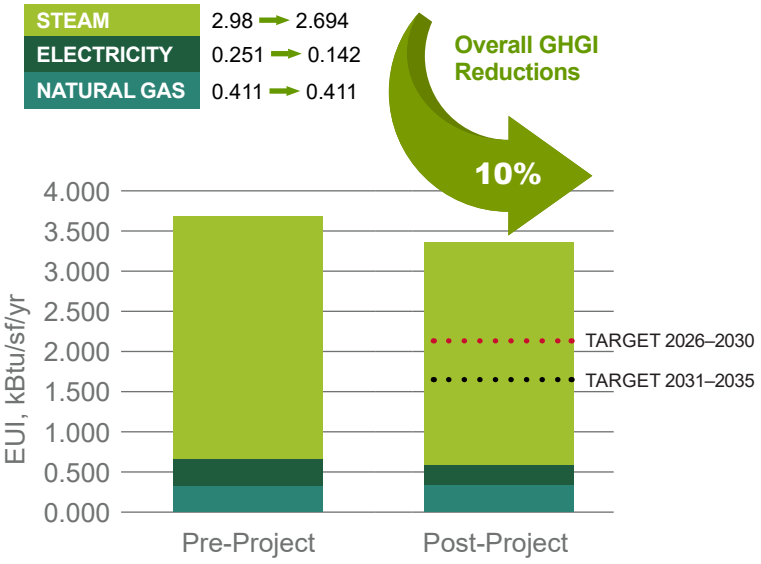


Pre-Project Condition

- Guest rooms served by four-pipe fan coil units.
- Heating provided by steam-to-hot water heat exchangers.
- Cooling provided by water-cooled chiller.
- Controls are DDC.

Measures in Project

- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Repair worn/damaged pipe insulation on district steam system and add insulation to uninsulated pipe lengths.
- Add heat recovery to steam condensate system for domestic hot water preheat.
- Convert guest room AC/ventilation units to VAV.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.48**
Energy and Emissions Compliance	**$2.31**

Additional GHG Reduction Recommendations

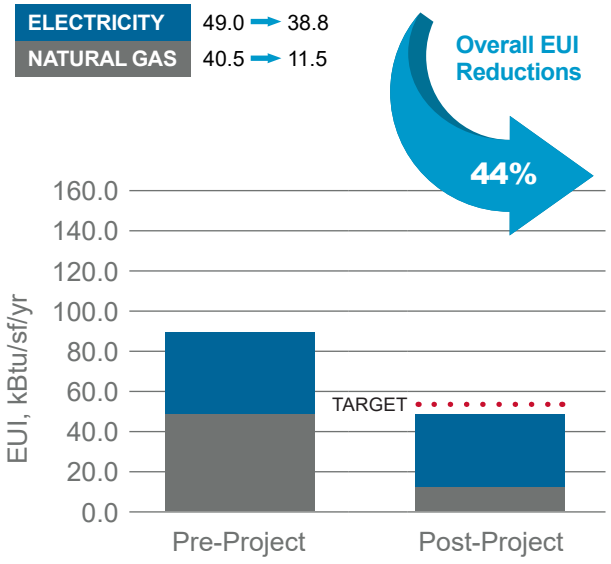
Remove steam-to-hot water heat exchangers (HX) and add heat pump boilers to provide hot water. Could implement on HX-by-HX basis. Replace chillers with heat pump machines to supply building heating and cooling.

BUILDING 12

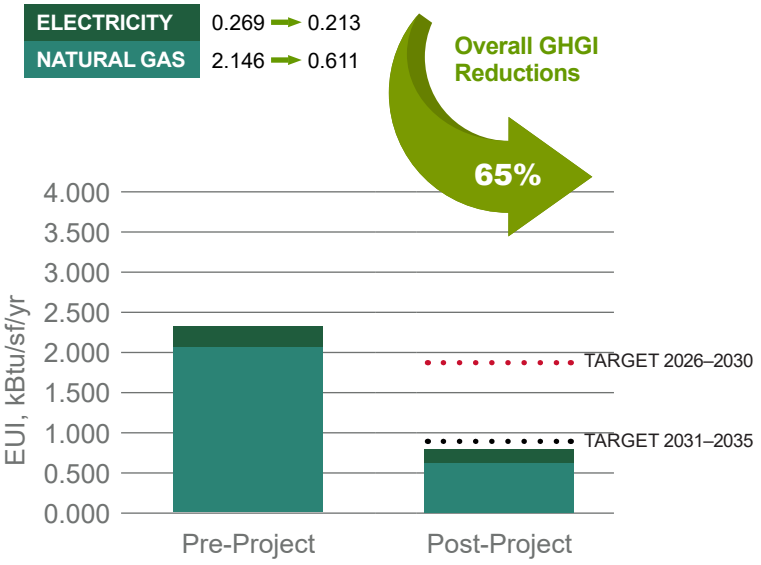
Property Type	**Convention Center**
Vintage	**1991–1995**
GFA Category	**90k–220k**

Primary Heating Fuel	**Natural Gas**
Annual Utility Cost	**$273,000**
Utility Costs per SF	**$1.80**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Gas-fired package RTUs provide air to water-source heat pumps which provide heating and cooling to respective zones.
- Gas boilers provide heat to condenser water loop.
- Controls are DDC.

Measures in Project

- Install smart building analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Replace aging water-source heat pumps with higher efficiency units.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Replace gas package RTUs with package air-source heat pumps. Upgrade non-condensing hot water boilers to condensing boilers.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$3.98**
Energy and Emissions Compliance	**$3.98**

Additional GHG Reduction Recommendations

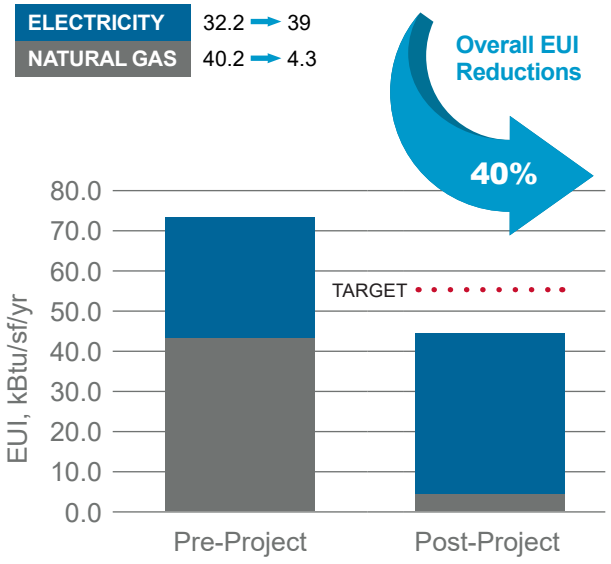
Converting gas fired RTUs to heat pumps was part of original project scope. No additional electrification needed to achieve GHGI target.

BUILDING 13

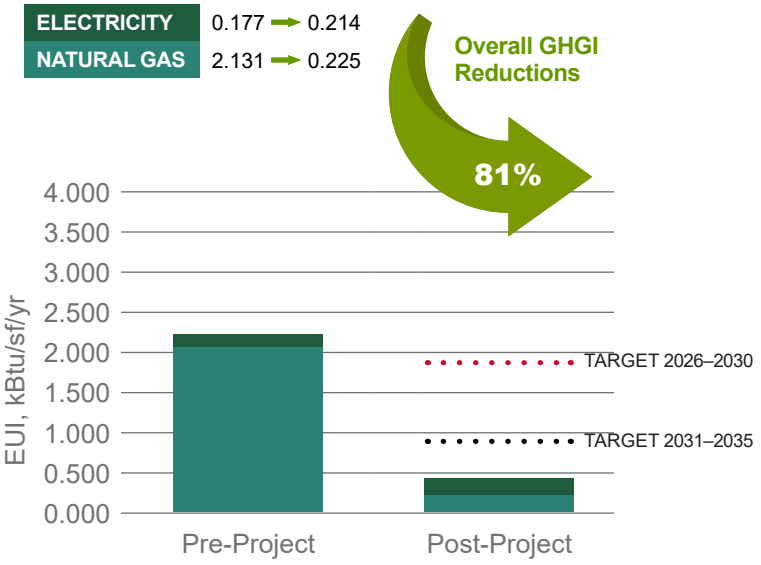
Property Type	**Industrial Office**
Vintage	**1976–1980**
GFA Category	**90k–220k**

Primary Heating Fuel	**Natural Gas**
Annual Utility Cost	**$149,000**
Utility Costs per SF	**$1.30**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Gas-fired package RTUs provide heating and cooling respective zones or to VAV boxes with electric reheat.
- Controls are DDC.

Measures in Project

- Add optimal start, energy coasting, enhanced economizer, and air-side and water-side reset control sequencing. Install smart buildings analytics to optimize control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.
- Replace all gas-fired RTUs with 4-pipe fan coils/air-handlers.
- Add new heat pump boilers. Add new air-cooled chiller with heat recovery.
- Replace make-up air units over vehicle bay with heat recovery units.
- Convert fluorescent fixtures and lamps to LED lighting fixtures.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$3.01**
Energy and Emissions Compliance	**$3.01**

Additional GHG Reduction Recommendations

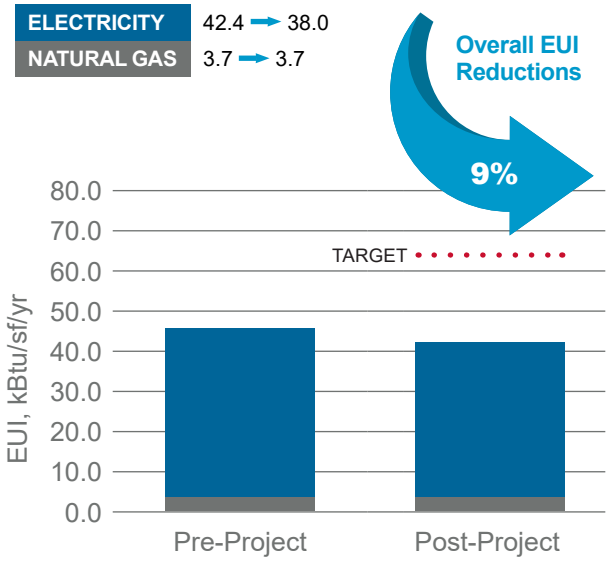
Converting gas fired RTUs to water-source heat pumps was part of original project scope. No additional electrification needed to achieve GHGI target.

BUILDING 14

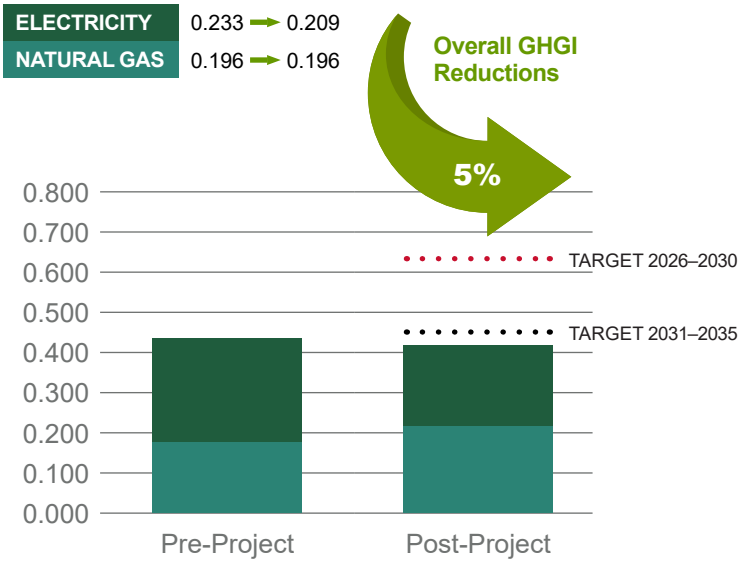
Property Type	**Industrial Office**
Vintage	**1966–1970**
GFA Category	**50k–90k**

Primary Heating Fuel	**Electricity**
Annual Utility Cost	**$41,000**
Utility Costs per SF	**$1.28**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Packaged rooftop heat pumps provides heating and cooling to individual tenants.
- Standalone controls.
- T-8 lighting.

Measures in Project

- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Reprogram thermostats for optimized occupied and unoccupied setpoints and schedules.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$1.43**
Energy and Emissions Compliance	**$1.43**

Additional GHG Reduction Recommendations

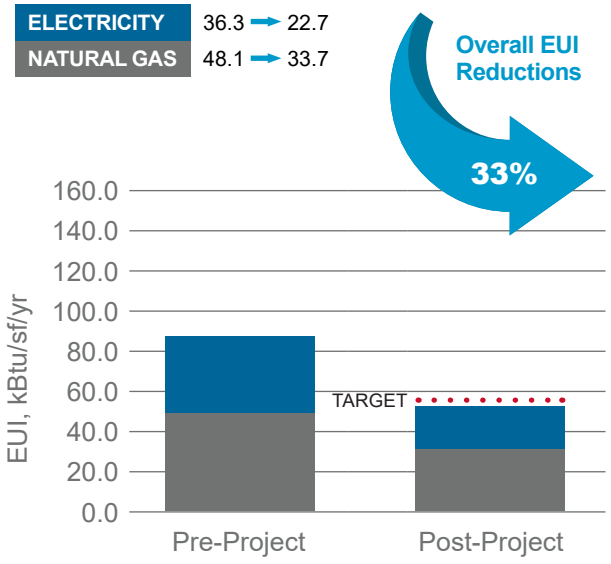
No additional electrification required.

BUILDING 15

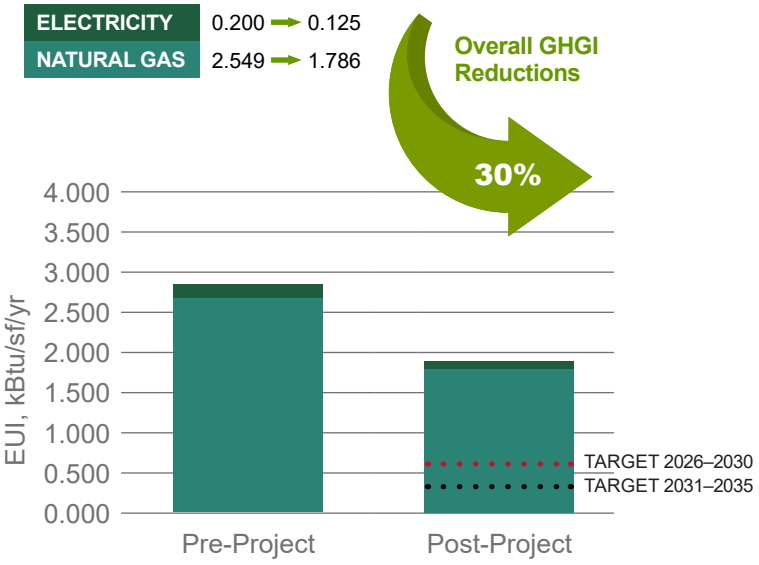
Property Type	**Industrial Office**
Vintage	**1966–1970**
GFA Category	**50k–90k**

Primary Heating Fuel	**Natural Gas**
Annual Utility Cost	**$83,000**
Utility Costs per SF	**$1.50**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Gas-fired package RTUs provide heating and cooling to individual tenants.
- Standalone controls.
- T-8 lighting.

Measures in Project

- Convert fluorescent fixtures and lamps to LED lighting fixtures.
- Optimize equipment schedules to align better with occupancy.
- Add optimal start, energy coasting, enhanced economizer, and air-side and water-side reset control sequencing.
- Install smart building analytics to control sequences to achieve peak energy performance.
- Replace failed devices and equipment level controllers.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$0.65**
Energy and Emissions Compliance	**$0.69**

Additional GHG Reduction Recommendations

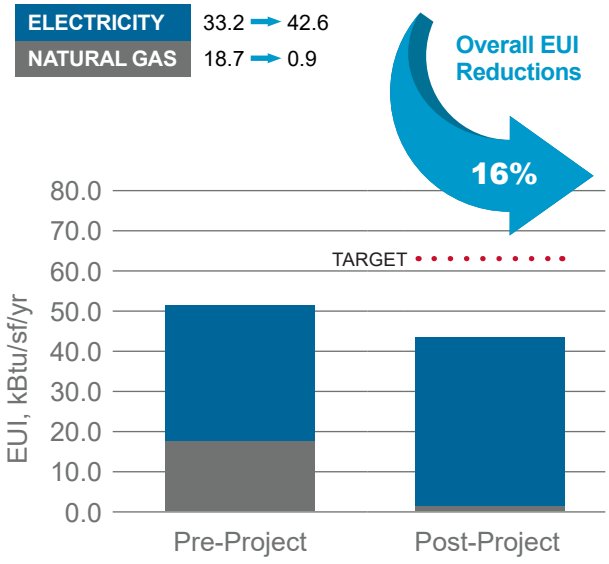
Replace gas-fired RTUs with heat pumps.

BUILDING 16

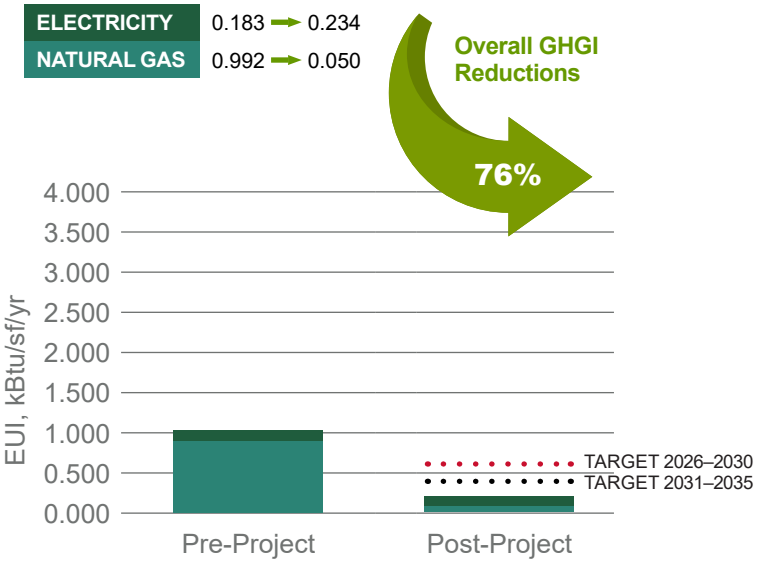
Property Type	**Industrial Office**
Vintage	**1986–1990**
GFA Category	**50k–90k**

Primary Heating Fuel	**Natural Gas**
Annual Utility Cost	**$35,000**
Utility Costs per SF	**$1.14**

BUILDING EUI



BUILDING GHGI



Pre-Project Condition

- Gas-fired package RTUs provide heating and cooling to individual zones.
- Standalone controls.
- LED lighting.

Measures in Project

- Replace Gas-Fired RTUs with package heat pumps.
- Reprogram thermostats for optimized occupied and unoccupied setpoints and schedules.

PROJECT COSTS PER SQUARE FOOT PER REDUCTION ($/SF/EUI)

Energy Compliance	**$1.01**
Energy and Emissions Compliance	**$1.01**

Additional GHG Reduction Recommendations

Converting gas-fired RTUs to heat pumps was part of the original project scope. No additional electrification needed to achieve GHGI target.