250 W 57th Street
1350 Broadway
1359 Broadway
1333 Broadway
Empire State Building

LL97 Deep Energy Retrofit

Results and Recommendations

November 16th, 2021

EMPIRE STATE
REALTY TRUST

Table of Contents

- Executive Summary
- Building Case Studies
  - Energy Modeling
  - ECM Phasing and Packaging
  - Energy and Carbon Emissions Results
  - Financial Analysis and Recommendations
  - Capital Expenditure and 2022 Budget
- Lessons Learned

250 W 57th Street | 1350 Broadway | 1359 Broadway

1333 Broadway | Empire State Building

Overview of Case Study

Executive Summary

Building Case Study

- Energy Modeling
- ECM Phasing and Packaging
- Energy and Carbon Emissions Results
- Financial Analysis and Recommendations
- Capital Expenditure and 2022 Budget

Lessons Learned

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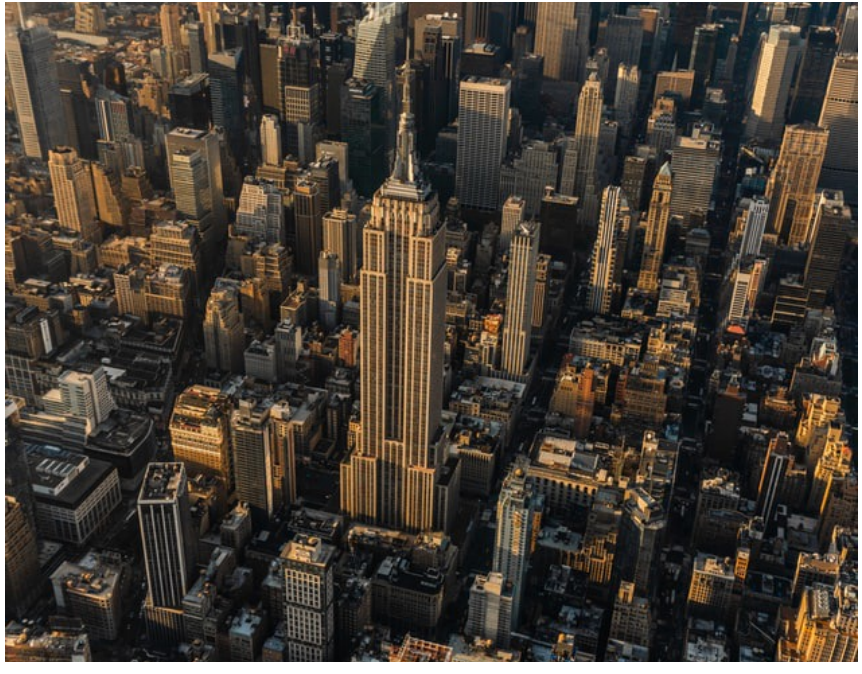
ESRT LL97 Deep Energy Retrofit Goals

- Evaluate the technical and economic potential to achieve carbon neutrality
- Define technical and economic needs to meet and exceed State and City targets and plans for 2024, 2030, 2035, 2050
- Evaluate the effects of different grid commitments
- Conduct a thorough technology review via pilots, building tests, energy modeling, site visits and vendor evaluations
- Analyze whole system approach based on energy models, economic assessment and supply side opportunities
- Utilize private know-how, leadership and public funding
- Utilize multi-stakeholder engagement which thoroughly explores the role of tenants to meet targets

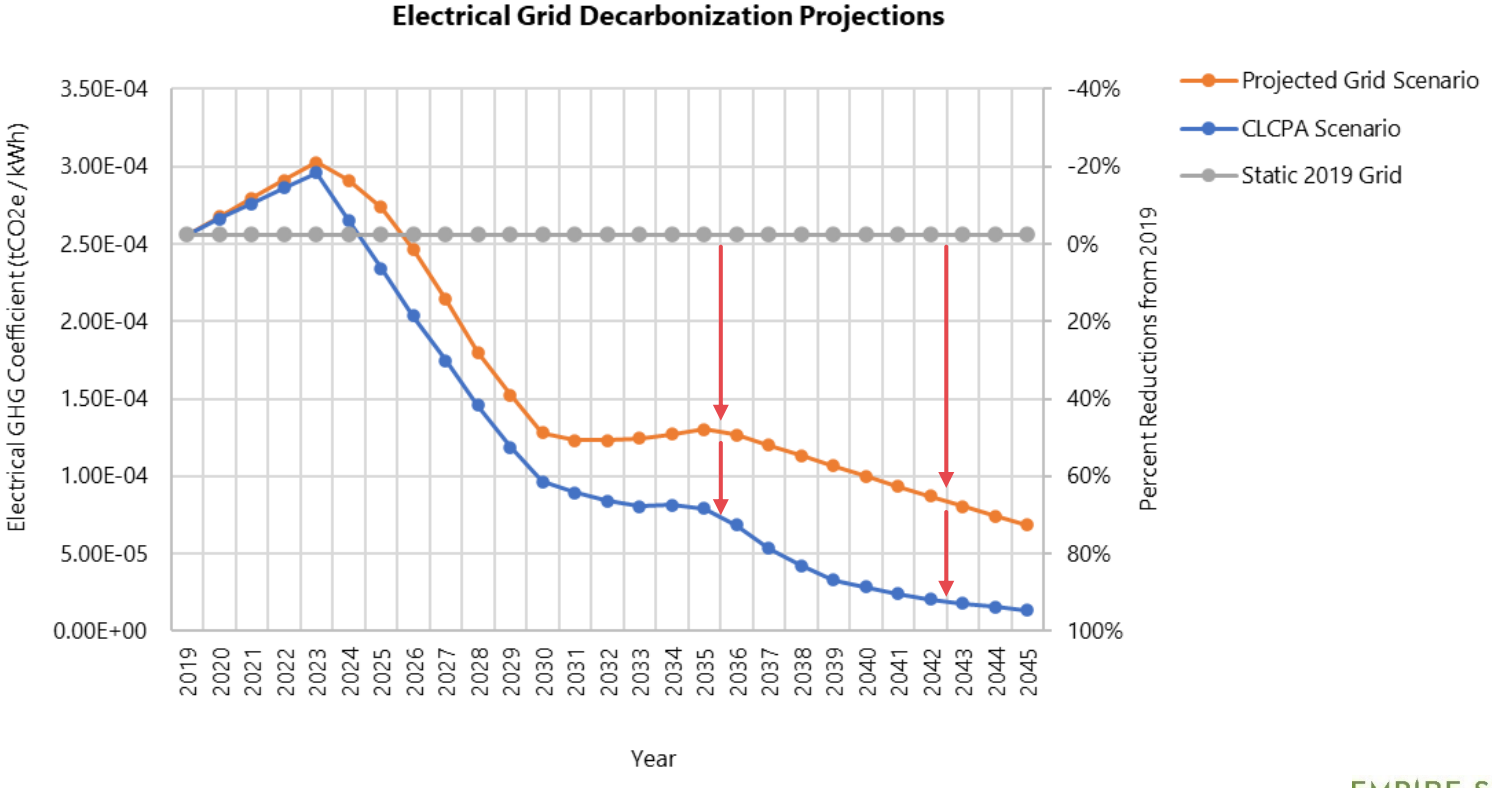


Defining Net-Zero Carbon

ESRT's working definition for carbon neutral existing buildings is that by drastically reducing building operational emissions, partnering with a renewably sourced grid aligned with CLCPA, and offsetting residual emissions through clean energy generation and/or RECs through a transparent accounting and reporting process, net annual building operational carbon emissions are equal to zero.

By 2035, the ESRT portfolio will target carbon neutrality through an 80% operational carbon reduction, achieved through a combination of energy efficiency measures, a more renewably sourced grid, and a 20% offset with off-site clean energy generation and RECs.

Grid Projections: CLCPA Target Grid Scenario vs. Projected Grid Scenario



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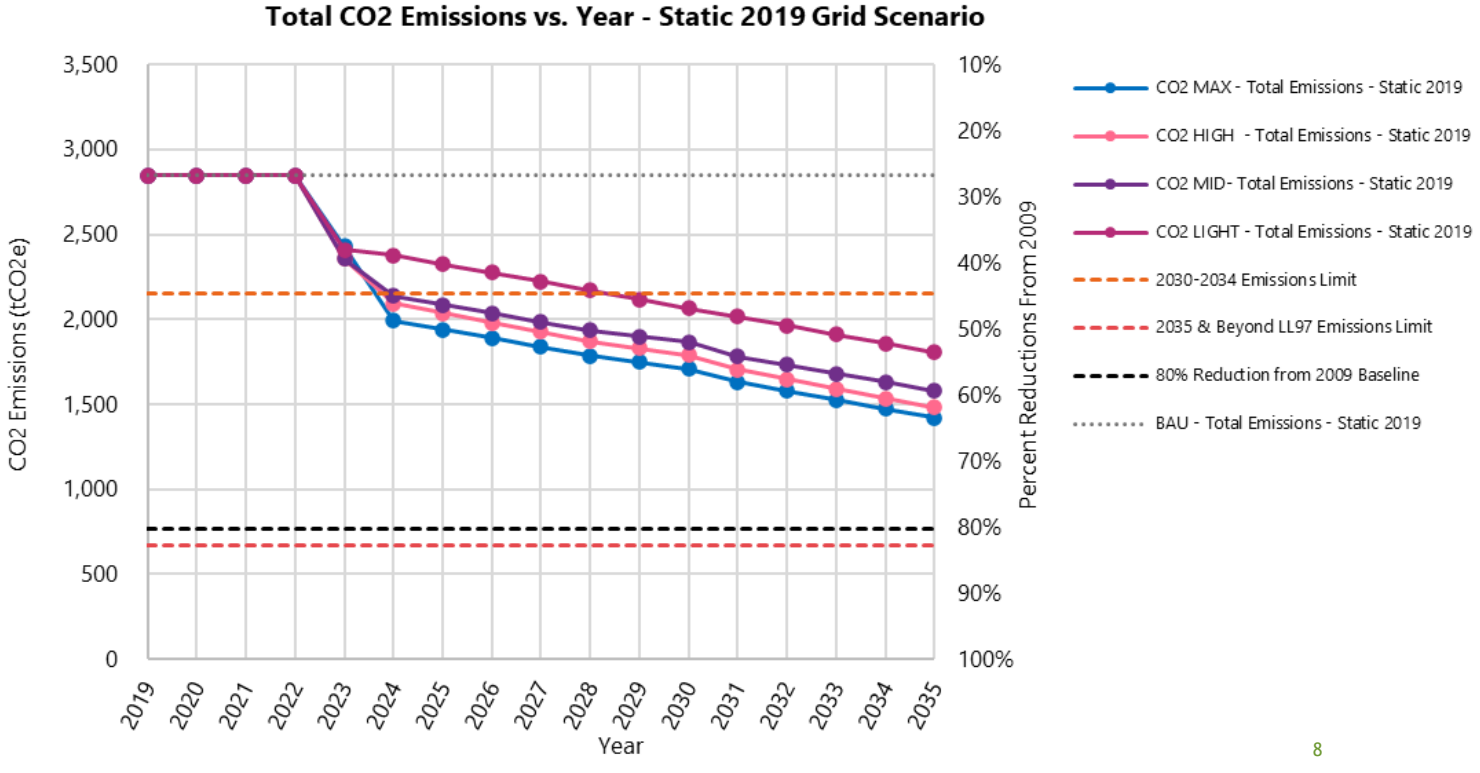
250 W 57th Street

Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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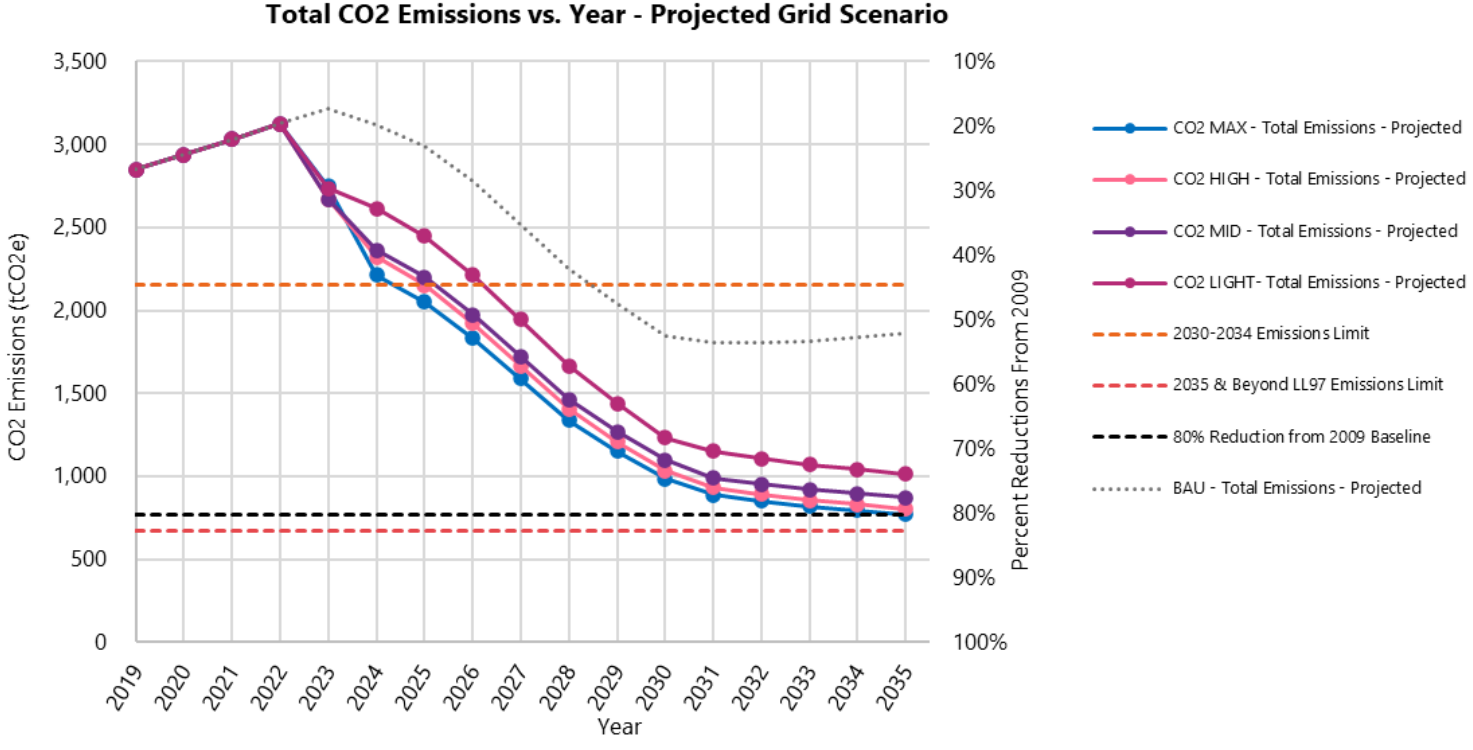
Projected Annual Carbon Emissions – Projected Grid Scenario

CO2 Max package would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit** by 2035



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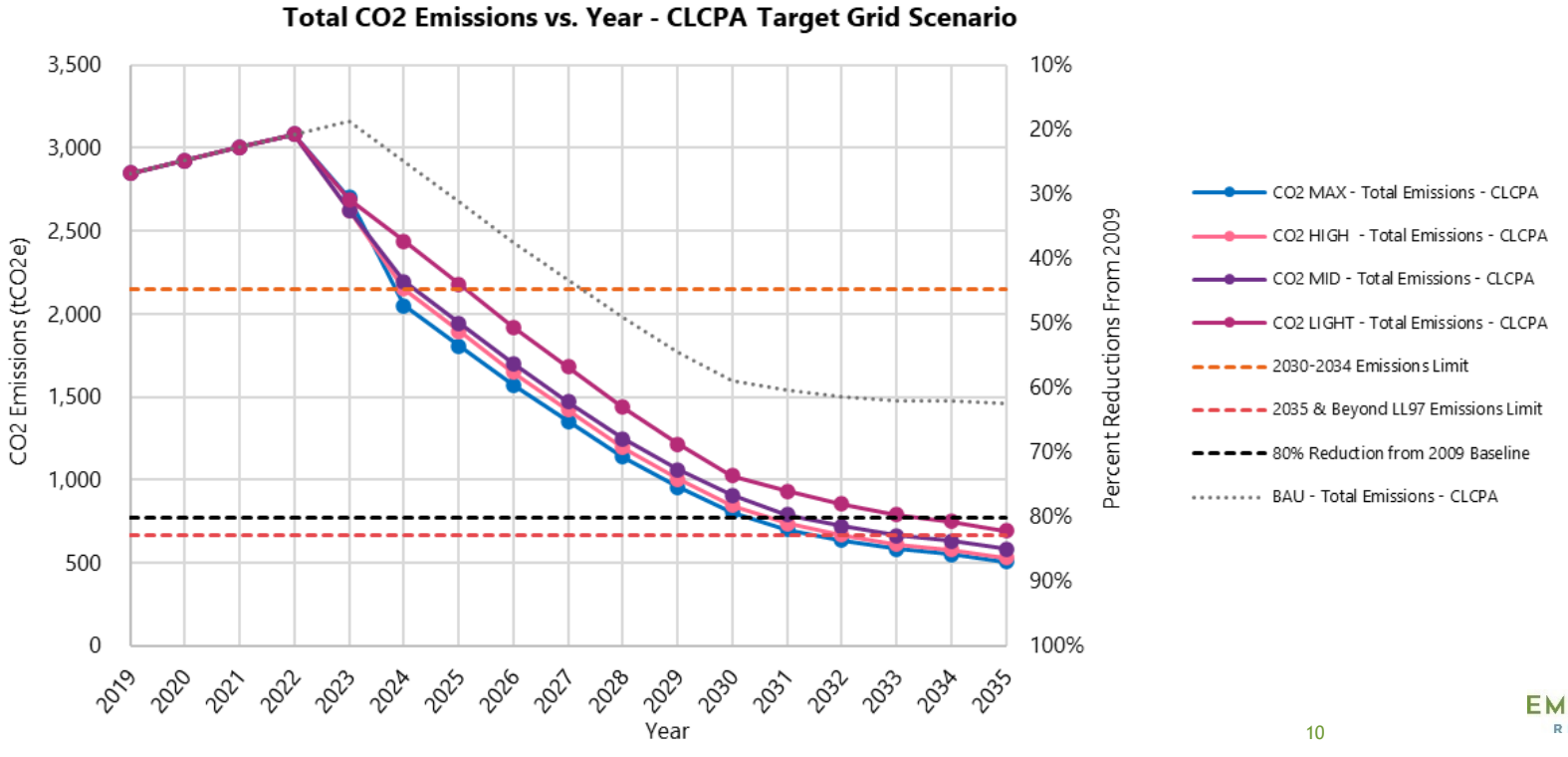
Projected Annual Carbon Emissions – CLCPA Grid Scenario

All packages would meet **80% reduction** from 2009 baseline by **2035**;
All packages except CO2 Light would meet **average long-term LL97 limit by 2035**



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Percent Carbon Emissions Reductions – All Grid Scenarios

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-40.0%	-50.1%	-55.6%	-63.0%
CO2 HIGH	-37.2%	-48.0%	-53.5%	-61.5%
CO2 MID	-34.5%	-44.5%	-51.5%	-58.9%
CO2 LIGHT	-27.4%	-36.5%	-46.3%	-53.0%

No packages would meet **80% reduction** from 2009 baseline by **2035** or the **average long-term LL97 limit**

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-65.4%	-72.9%	-74.4%	-80.0%
CO2 HIGH	-63.7%	-71.8%	-73.1%	-79.1%
CO2 MID	-61.5%	-69.4%	-71.5%	-77.3%
CO2 LIGHT	-56.7%	-64.4%	-68.0%	-73.6%

CO2 Max package would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit** by 2035

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-71.7%	-82.2%	-79.0%	-86.8%
CO2 HIGH	-70.2%	-81.4%	-77.9%	-86.2%
CO2 MID	-68.1%	-79.4%	-76.4%	-84.8%
CO2 LIGHT	-64.0%	-75.7%	-73.3%	-82.0%

All packages would meet **80% reduction** from 2009 baseline by **2035**;
All packages except CO2 Light would meet **average long-term LL97 limit by 2035**

250 W 57th Street Case Study

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ECM Phasing and Packaging
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250 W 57th Street - Current Building Systems

Major equipment is due for replacement in the next <10 years

- Central chiller plant & cooling towers
  - (2) 325-ton water-cooled chillers (650 tons total) installed in 1999
  - (1) cooling tower, (2) cells (1,100 tons total) installed in 2015
- Gas-to-steam boiler plant
  - (2) low pressure steam boilers installed in 1996 & 2003
  - Perimeter steam radiators
  - Electric unit heaters (inefficient design) at tenant MERs for ventilation heating loads

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2019 Energy Breakdown by Utility

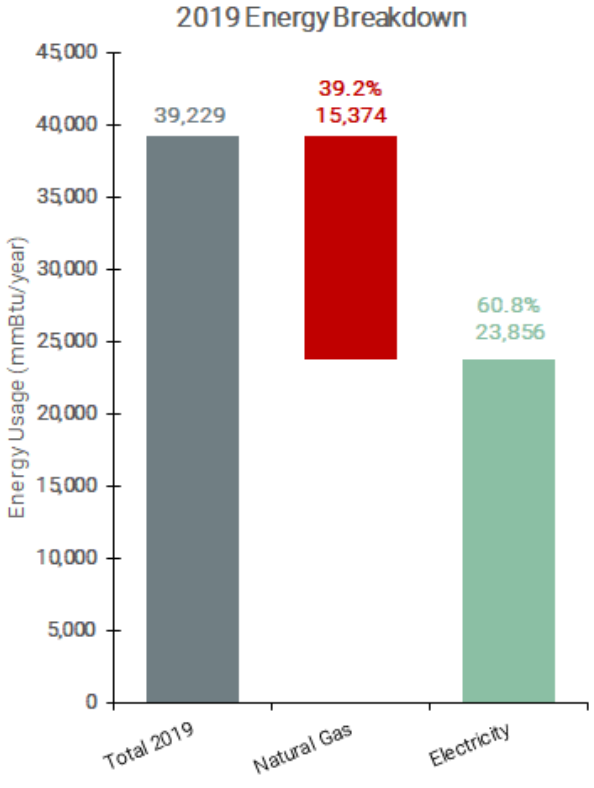
Natural gas consumption used for heating makes up a significant portion (39.2%) of energy usage

Electricity

- 60.8% of energy usage
- 68.7% of CO_2e emissions

Natural Gas

- 39.2% of energy usage
- 31.3% of CO_2e emissions



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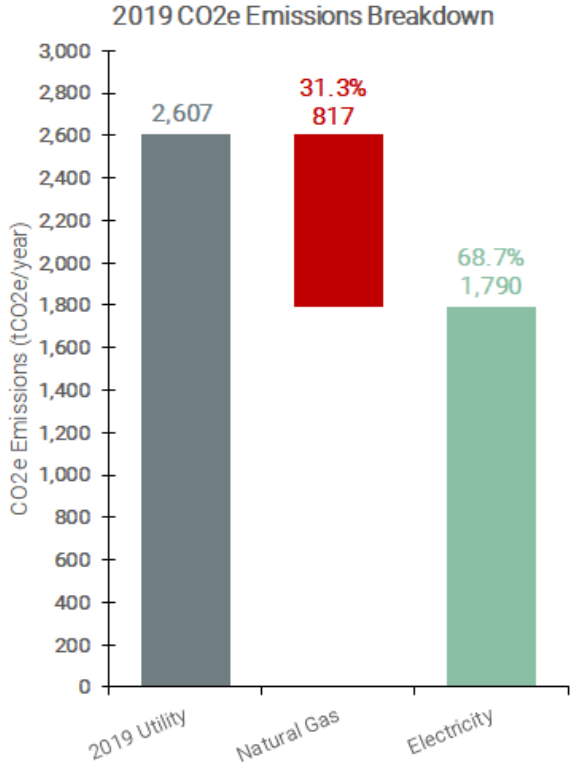
2019 CO2e Emissions Breakdown by Utility

Natural gas has slightly lower associated emissions than electricity

Electricity - 256.0 tCO2e/GWh

Natural Gas - 181.2 tCO2e/GWh (LL97)



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2019 Operational Cost Breakdown by Utility

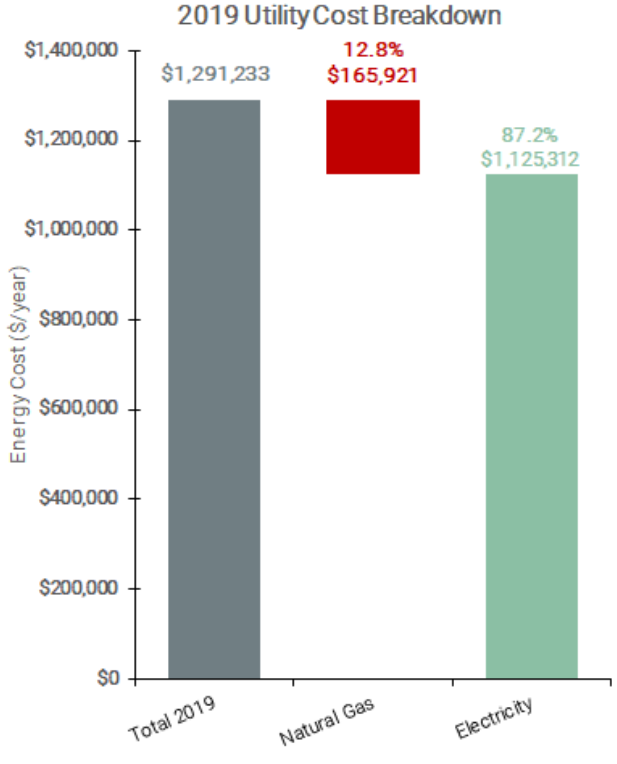
Natural gas is cheaper than electricity & therefore makes up a smaller portion (12.8%) of utility costs

Electricity

- 87.2% of operational costs
- 60.8% of energy usage

Natural Gas

- 12.8% of operational costs
- 39.2% of energy usage



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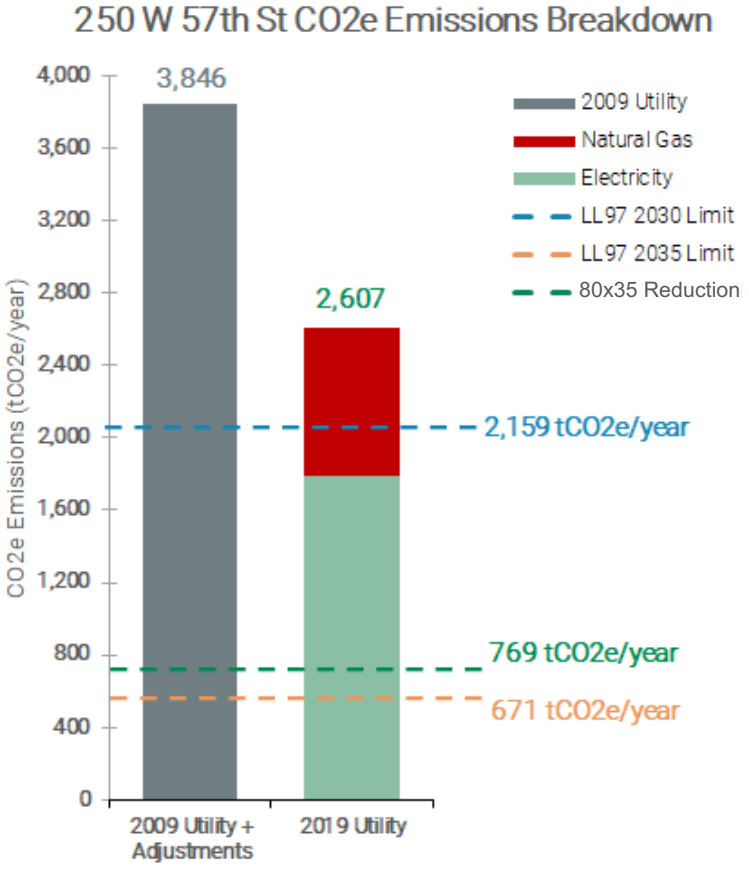
250 W 57th Street Current Status for LL97 and 80x35 Metrics



Key Takeaways:

- Building meets LL97 2024 limit of 4,144 tCO2e/year
- 17.2% emissions reduction is required to meet LL97 2030 target
- 70.5% emissions reduction is required to meet LL97 2035 target
  - Building + grid improvements

32% CO2e reduction from 2009 to 2019

- 36% due to electrical grid improvement
- 59% due to switch from fuel oil #2 to natural gas

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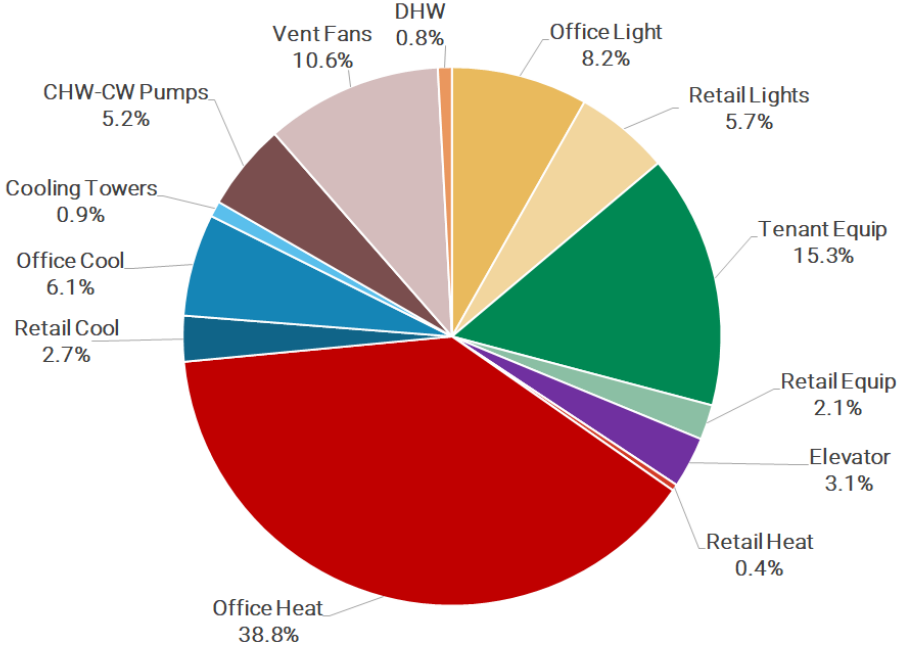
250 W 57th Street Energy Model: 2019 Energy Breakdown by End-Use

Office and retail heating accounts for 39.2% of the total 2019 energy usage

Major End Uses:

- Office + Retail Heating – 39.2%
- Office + Retail Lighting & Equip. – 31.3%
- All Fans – 10.6%
- Office + Retail Cooling – 9.7%
  - Central plant + DX units
- CHW-CW Pumps – 5.2%



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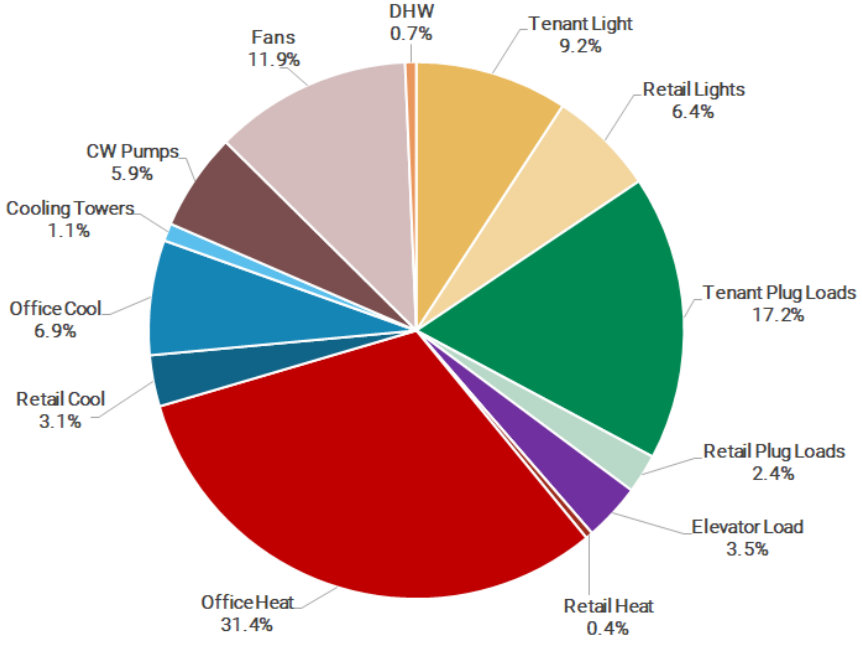
250 W 57th Street Energy Model: 2019 CO2e Emissions Breakdown by End-Use

Office and retail lighting/equipment accounts for 35.2% of the total 2019 CO2e emissions

Major End Uses:

- Office + Retail Lighting & Equip. – 35.2%
- Office + Retail Heating – 31.8%
- All Fans – 11.9%
- Office + Retail Cooling – 11.1%
  - Central plant + DX units
- CHW-CW Pumps – 5.9%



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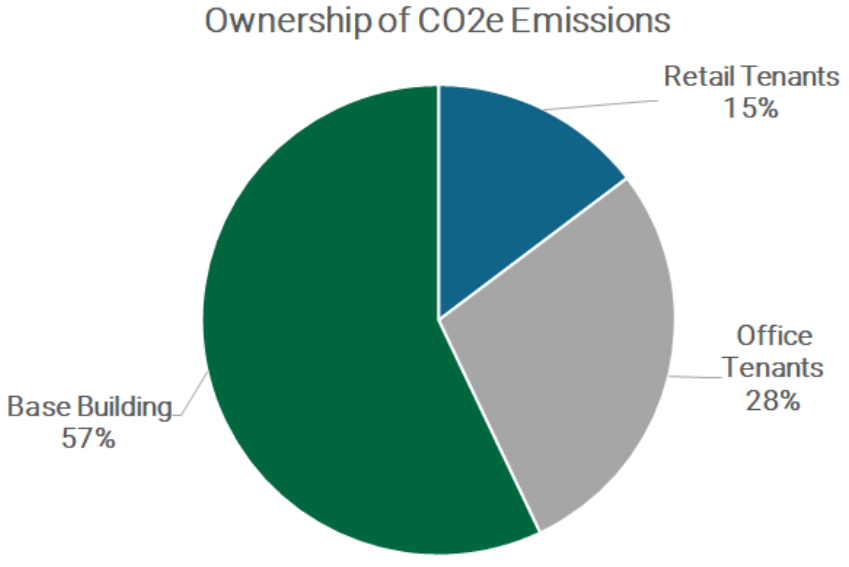
250 Energy Model: 2019 CO2e Emissions Breakdown by User

Office and retail tenants account for only ~43% of total 2019 CO2e emissions

Base Building includes:

- All gas-to-steam heating
- Central cooling plant equipment
- All office tenant AHUs
- Elevators
- Lobby HVAC units
- BOH lighting and equipment



Majority of retail space is TJ Maxx which utilizes VRF systems

Space Type	Square Footage		Energy Intensity	Carbon Intensity
	SF	%	(kBtu/SF/year)	(lbs/SF/year)
Retail Tenants	70,650	17%	71.6	11.8
Office Tenants	353,757	83%	27.6	4.5

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250 W 57th Street Case Study

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ECM Packages

Four packages of ECMs were developed to optimize NPV and CO2 reductions

1	2	3	4
CO2 Light	**CO2 Mid**	**CO2 High**	**CO2 Max**
Controls optimization & BMS tie-in, conversion of CV to VAV, DCV, plug loads, lighting & controls	CO2 Light + retail BMS & lighting, radiant barriers, ERVs	CO2 Mid + retail VRF, DHW heat pump, window improvements	CO2 High + envelope improvements

All packages: 300-ton heat pump & HHW riser in 2023; 500-ton (additional) heat pump in 2030

Carbon Reduction

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ECM Phases & Implementation Timeline: CO2 Mid

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE															
Phase	Tag	Short Name	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Phase 1	CO001	DDC VAV Boxes and Electronic Radiator Valves	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO007	Tie-In VAV Diffuser Systems to BMS + Electronic Radiator Valves	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO003	Single-Zone Variable Flow, Variable Temperature AHUs + Electronic Radiator Valves	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO004	Chiller Plant Metering & Sequence Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO005	Retail BMS Upgrades	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS001	Reduce Steam Pressure and Steam Cycling	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS002	Radiator Trap Audit & Replacement	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	AS001	Toilet Exhaust Energy Recovery Ventilator	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN001	Mitigate Lobby Infiltration	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	LT002	Common Area Lighting Upgrades	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	SS003	Install Radiant Barriers	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3	AS006	Convert VAV Diffuser Systems to VAV Systems at Tenant Lease Roll	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	AS004	Convert Constant Volume AHUs to VAV Systems at Tenant Lease Roll	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	CO006	Outside Air Flow Control & Demand Controlled Ventilation	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	AS005	Energy Recovery Ventilators for Office Tenant Floors	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	TL001	Plug Load Control	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	TL002	Tenant IT Cooling	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	LT003	Day Lighting & Vacancy Control	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	LT004	Efficient Light Fixtures & Lighting Layout	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 3	LT005	Retail Lighting Improvements	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%
Phase 4	EL001	Immediately Install 300-ton Air-Water Heat Pumps and Add Complete Plant Capacity at Chiller End-Of-Life	0%	38%	38%	38%	38%	38%	38%	38%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4	EL002	Immediately Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Boiler System	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4	EL003	Immediately Begin Install of VAV Reheat Coils on Tenant Office Floors	0%	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%

250 W 57th Street Case Study

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ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
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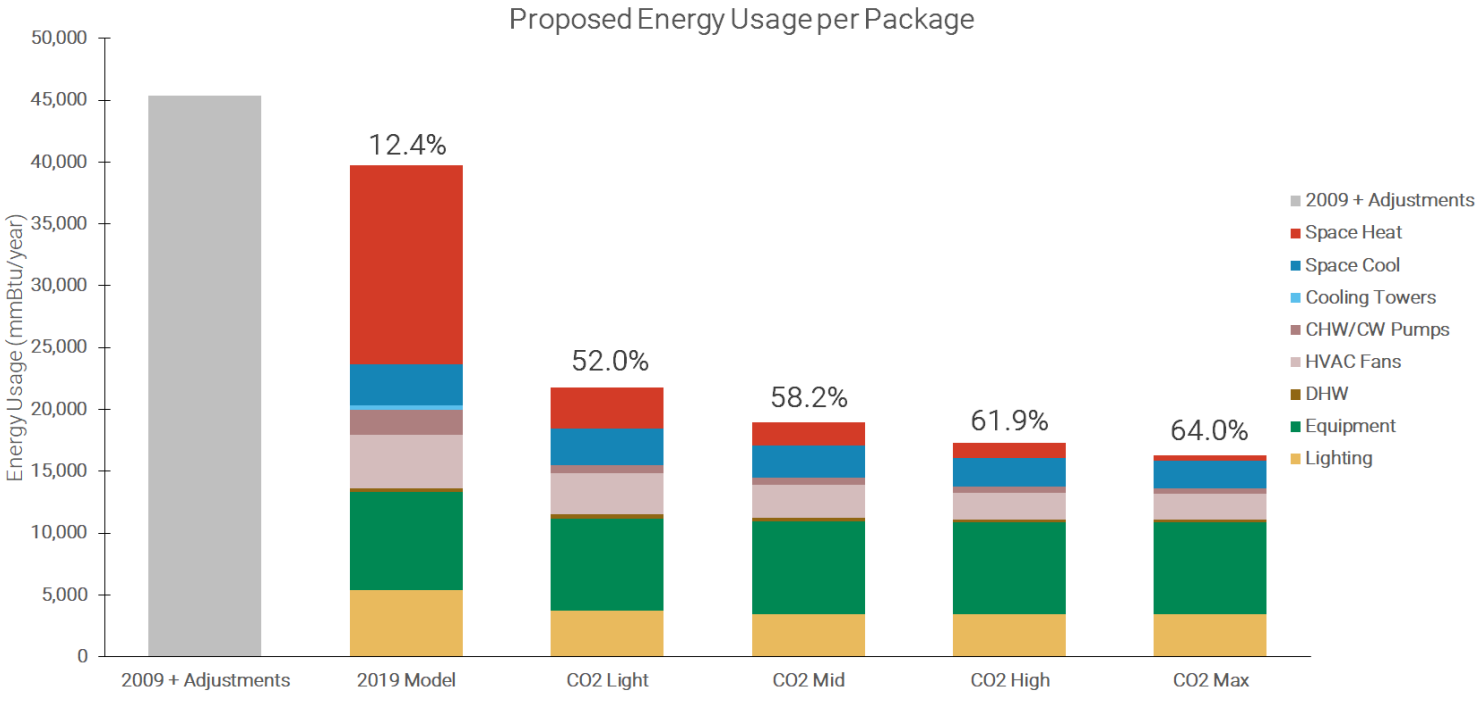
ECM Package Comparison - Energy

Packages range from 52.0% to 64.0% reduction in total energy from 2009 + Adjustments benchmark year



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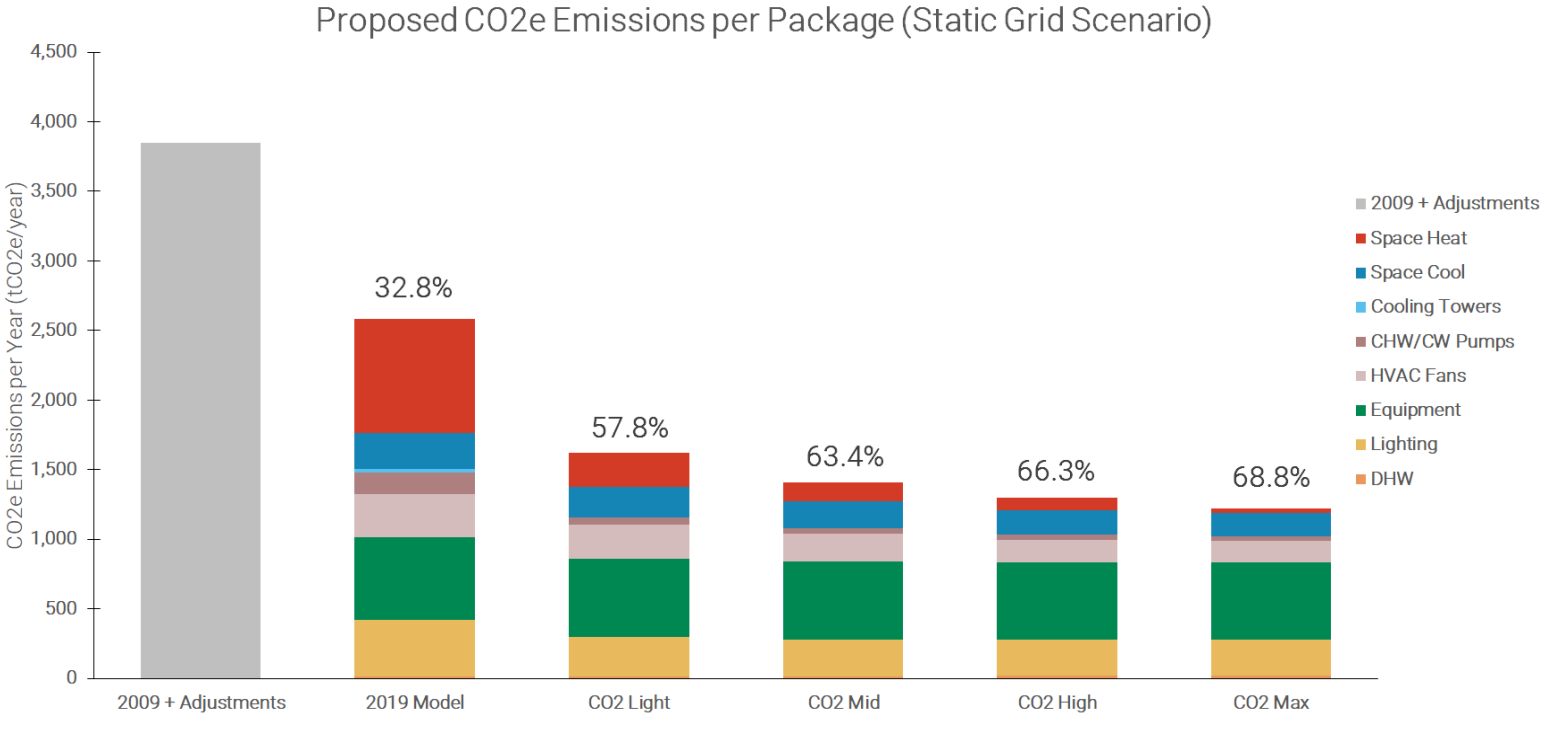
Projected CO2 Emissions – Static 2019 Grid Scenario

Packages range from 57.8% to 68.8% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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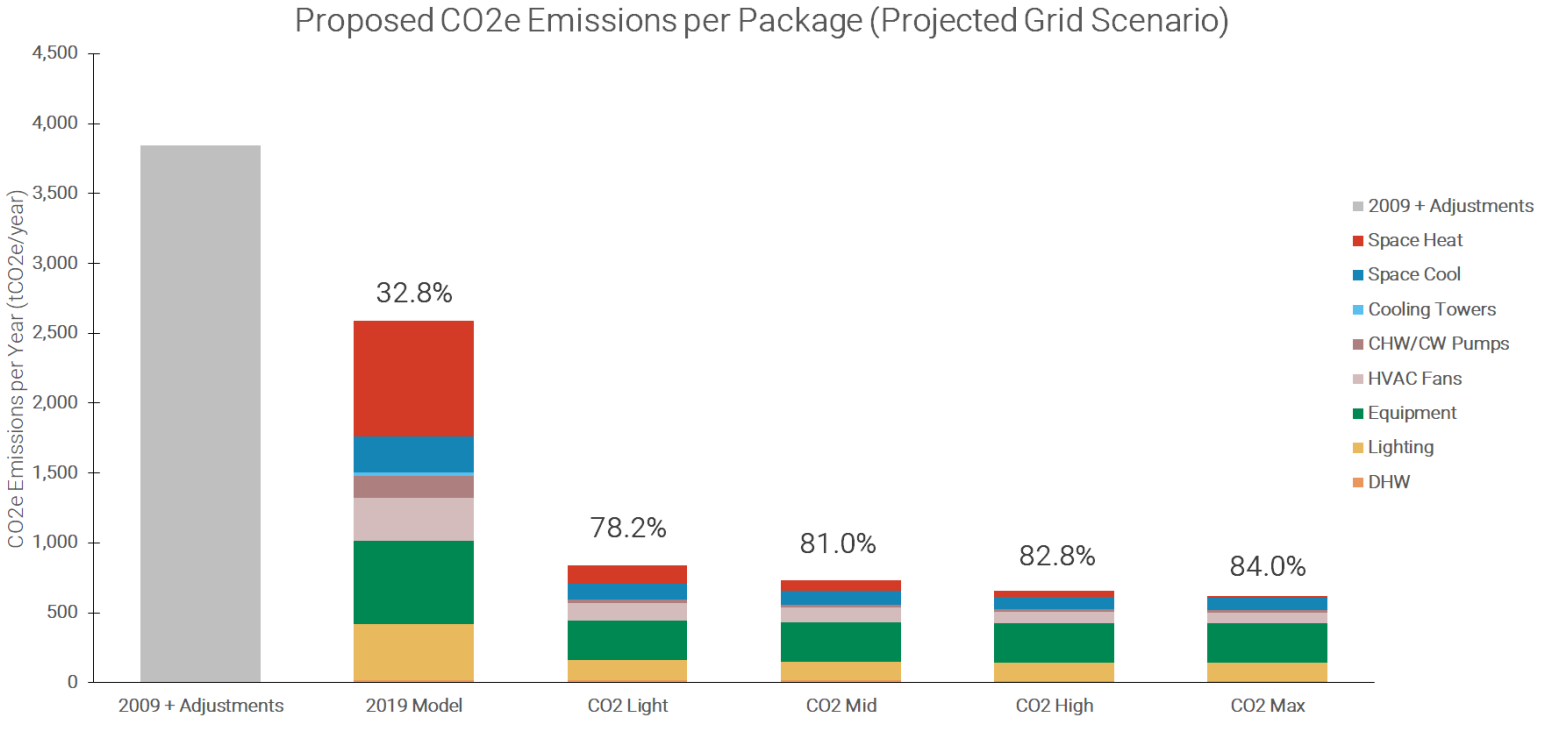
Projected CO2 Emissions – Projected Grid Scenario

Packages range from 78.2% to 84.0% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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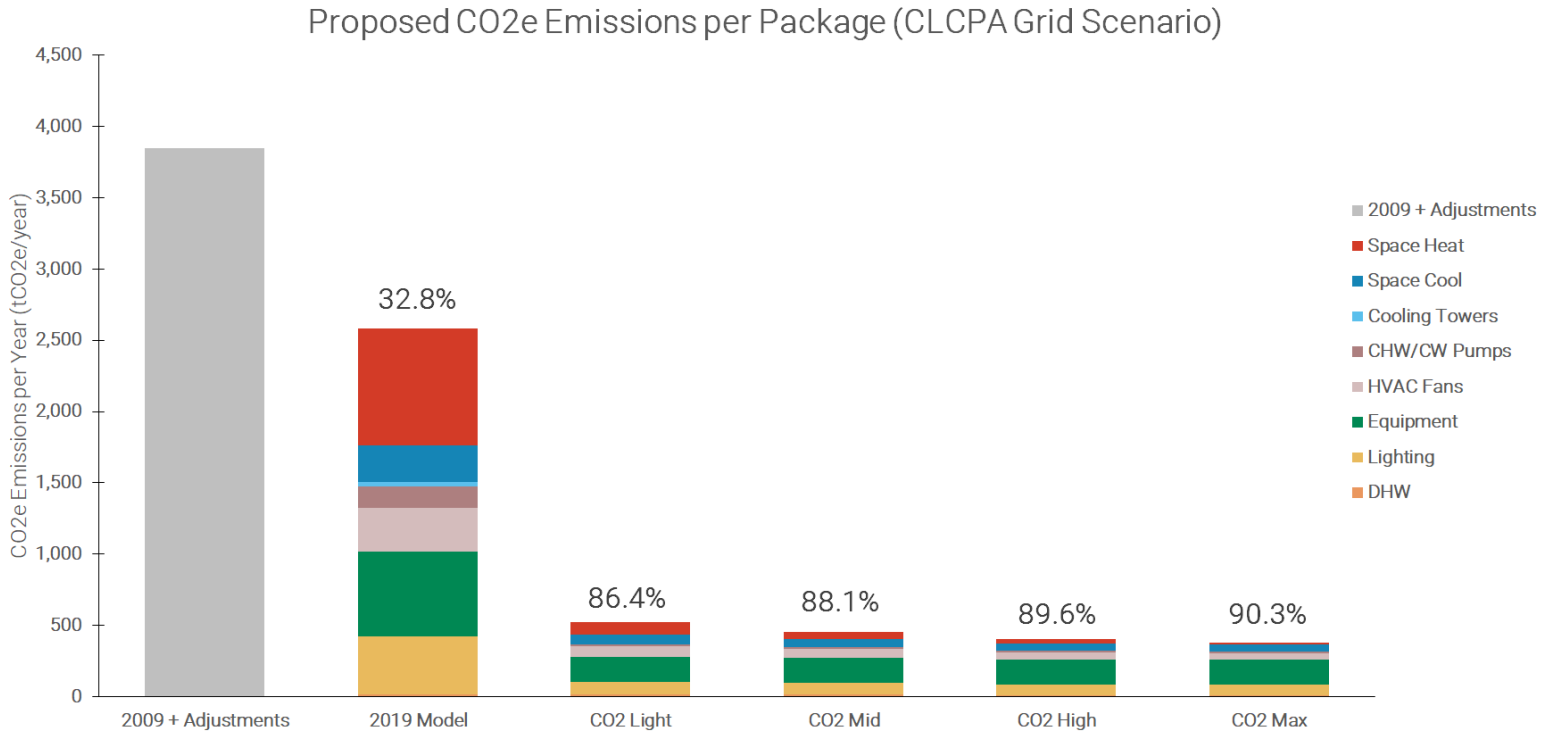
Projected CO2 Emissions - CLCPA Grid Scenario

Packages range from 86.4% to 90.3% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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250 W 57th Street Case Study

Energy Modeling
ECM Phasing and Packaging
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Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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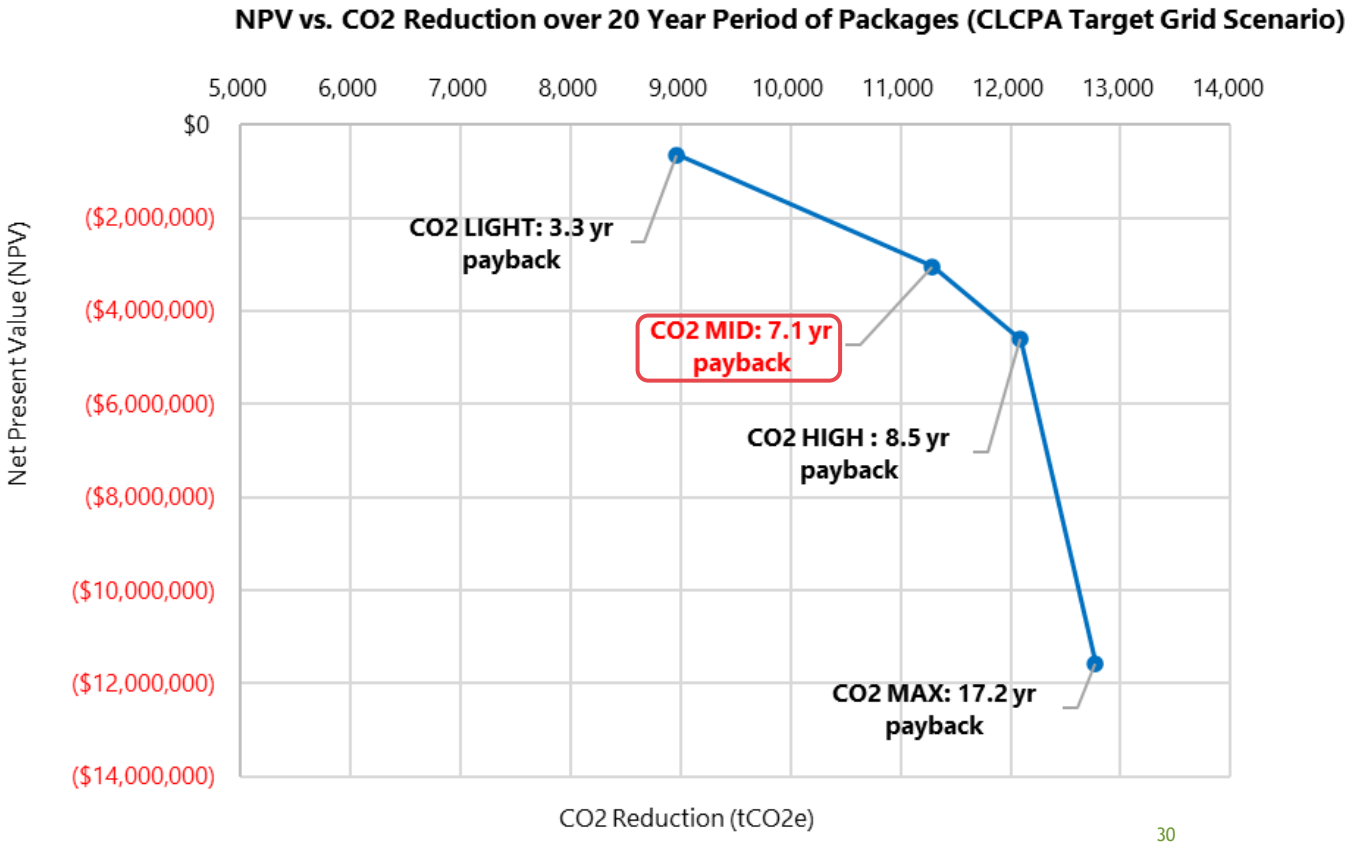
NPV, CO2 Reductions and Simple Payback for all Packages



NPV calculated with 6% discount rate

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LL97 Annual Fines for All Packages

With BAU scenario, 250 would begin seeing fines in 2030 with the static grid scenario
Implementation of CO2 Mid, High or Max packages would avoid all fines in the CLCPA grid scenario

Packages	CLCPA Grid Scenario				Projected Grid Scenario				Static Grid Scenario			
	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages
2019 Baseline	$0	$0	$211,654	-	$0	$0	$318,938	-	$0	$186,480	$583,375	-
CO2 Light	$0	$0	$5,631	$206,023	$0	$0	$91,881	$227,057	$0	$0	$304,473	$278,902
CO2 Mid	$0	$0	$0	$211,654	$0	$0	$53,971	$264,967	$0	$0	$243,451	$339,924
CO2 High	$0	$0	$0	$211,654	$0	$0	$35,677	$283,261	$0	$0	$216,938	$366,437
CO2 Max	$0	$0	$0	$211,654	$0	$0	$26,755	$292,182	$0	$0	$201,362	$382,013

*The 2035 GHG emissions limit has not yet been defined and calculations are based on average long-term LL97 80% reduction limits.

Recommended Package – CO2 Mid

	CO2 Light	CO2 Mid	CO2 High	CO2 Max
NPV TOTALS	($656,692)	($3,040,143)	($4,615,146)	($11,570,434)
Total Capital Cost*	($6,490,898)	($10,969,752)	($13,602,942)	($25,958,174)
Annual Energy Cost Savings	$698,021	$920,288	$1,038,002	$1,143,297
Annual Repairs & Maintenance Savings	$174,980	$174,980	$174,980	$172,380
Incentives	$3,647,210	$3,165,199	$3,314,134	$3,278,968
Simple Payback	**3.26**	**7.13**	**8.48**	**17.24**

CO2 Light Reduction – Controls optimization & BMS tie-in, conversion of CV to VAV, DCV, plug loads, lighting & controls
CO2 Mid Reduction – CO2 Light + retail BMS & lighting, radiant barriers, ERVs
CO2 High Reduction – CO2 Mid + retail VRF, DHW heat pump, window improvements
CO2 Max Reduction – CO2 High + envelope improvements

*Excluding construction escalation costs

Recommended Package – CO2 Mid

- Near term installation of a 300-ton heat pump increases the cooling plant capacity to address issues with existing capacity and resiliency that will persist even after the central chiller plant is optimized.
  - There are several 3-way valves in the building, poor/old AHU controls, and over-pumping of the CHW system that are contributing to low delta T on the chilled water system, which can masquerade as insufficient plant capacity. This will be remedied through the chiller plant optimization measure
  - There are several floors that are currently vacant which will increase the cooling load once occupied
  - There are several existing air-cooled units which will increase the cooling load once replaced and tied into the chilled water system
- Improves the resiliency of the cooling plant and puts it on par with existing resiliency at 1350 and other properties
  - Currently there are (2) chillers sized at < 50% of the existing building load. If one fails, there is no way to provide cooling to a majority of the building
  - Adding 300 tons of heat pump capacity increases the cooling plant capacity by 46%. If one of the existing 325 ton chillers fails, the plant will be able to meet ~ 68% of the peak cooling load.
- Eliminates need for refrigeration engineer for chilled-water operation overnight if tenants request cooling during after hours
- Eliminates the need for expensive hybrid DX units and duplicative electrical distribution to service tenants requiring after hours cooling
- New heating hot water system may be tied into existing boilers via a steam-to-hot water heat exchanger to provide supplemental heating and added resiliency during extreme weather events
- Acoustical mitigation is included for heat pumps installed on the roof

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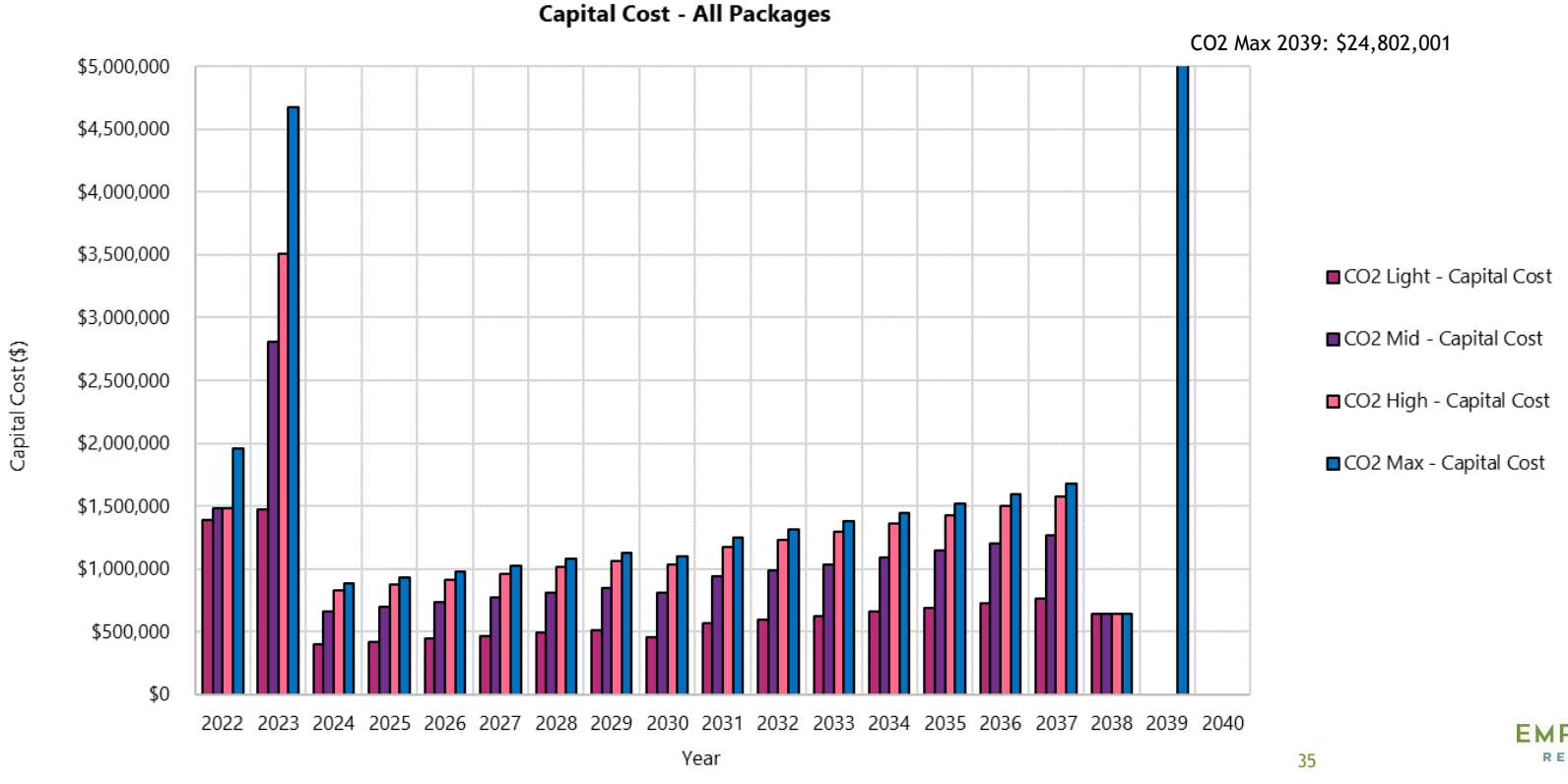
Annual Capital Cost per Package

CO2 Mid requires large capital expenditure in 2023, but heat pump project has an effective negative cost in 2030 (at time of chiller replacement) compared to planned cost of $4M for chiller replacement in kind



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250 W 57th Street Next Steps – 2022 Projects

The recommended 2022 measures are focused on control measures that have a short payback (~3.2 yrs) & will enable further energy reduction

Project	2022 Total Cost	Anticipated Incentives ($)	Total 2022 Cost w/ Incentives ($)	Energy Cost Savings
DDC VAV Boxes and Electronic Radiator Valves	$300,542	$132,167	$168,375	$63,312
Tie-In VAV Diffuser Systems to BMS + Electronic Radiator Valves	$101,288	$30,693	$70,595	$5,390
Single-Zone Variable Flow, Variable Temperature AHUs + Electronic Radiator Valves	$729,498	$221,060	$508,438	$50,967
Chiller Plant Metering & Sequence Optimization	$220,000	$181,807	$38,193	$71,065
Retail BMS Upgrades	$99,000	$90,000	$9,000	$39,303
Reduce Steam Pressure and Steam Cycling	$16,500	$15,000	$1,500	$4,860
Radiator Trap Audit & Replacement	Included in Maintenance Budget	-	-	$7,841
Total	**$1,466,828**	**$670,727**	**$796,101**	**$242,738**

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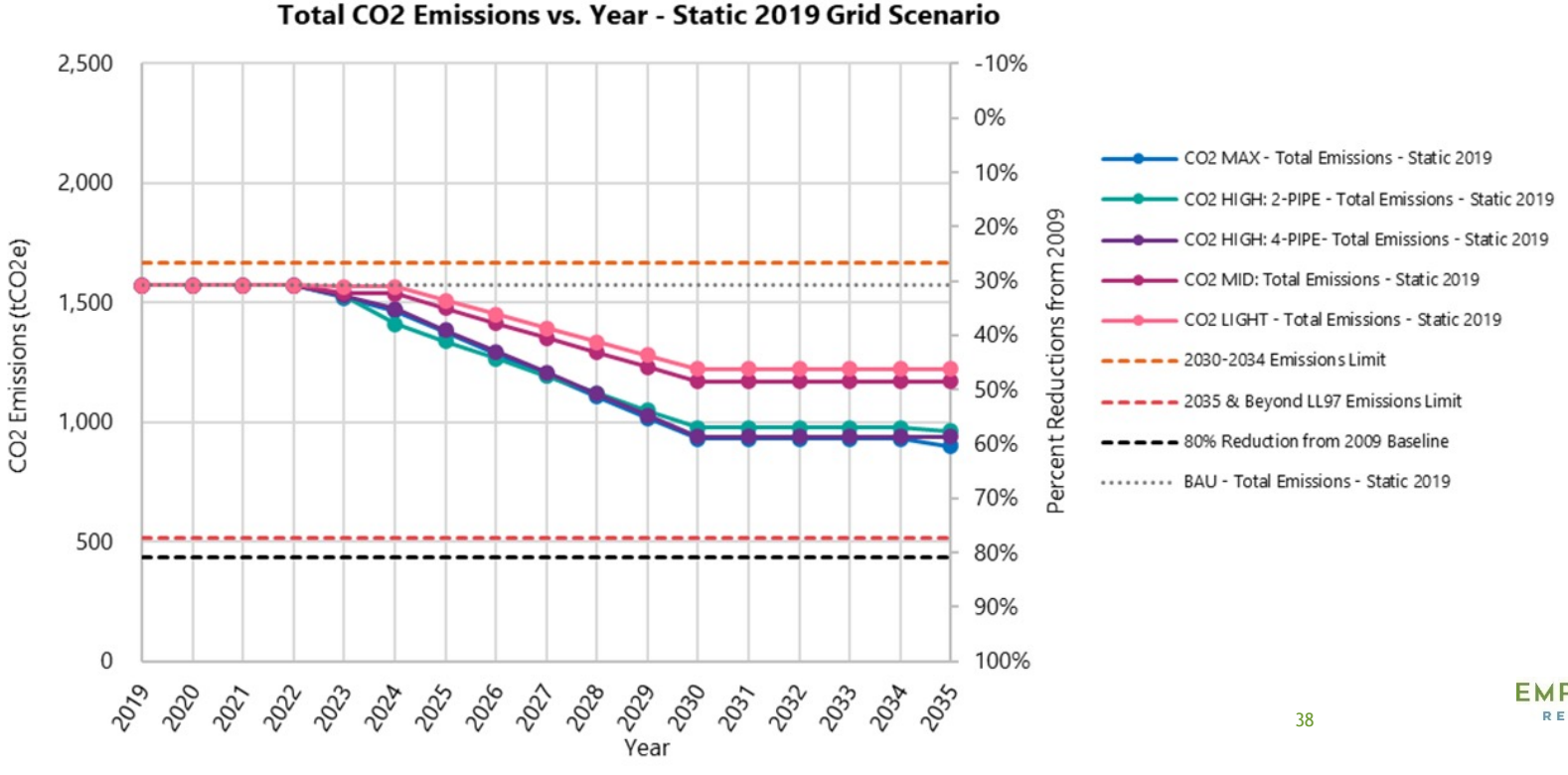
1350 Broadway

Projected Annual Carbon Emissions – Static 2019 Grid Scenario

None of the packages would reach **80% reduction** from 2009 baseline by **2035**;
None of the packages would meet **average long-term LL97 limit**



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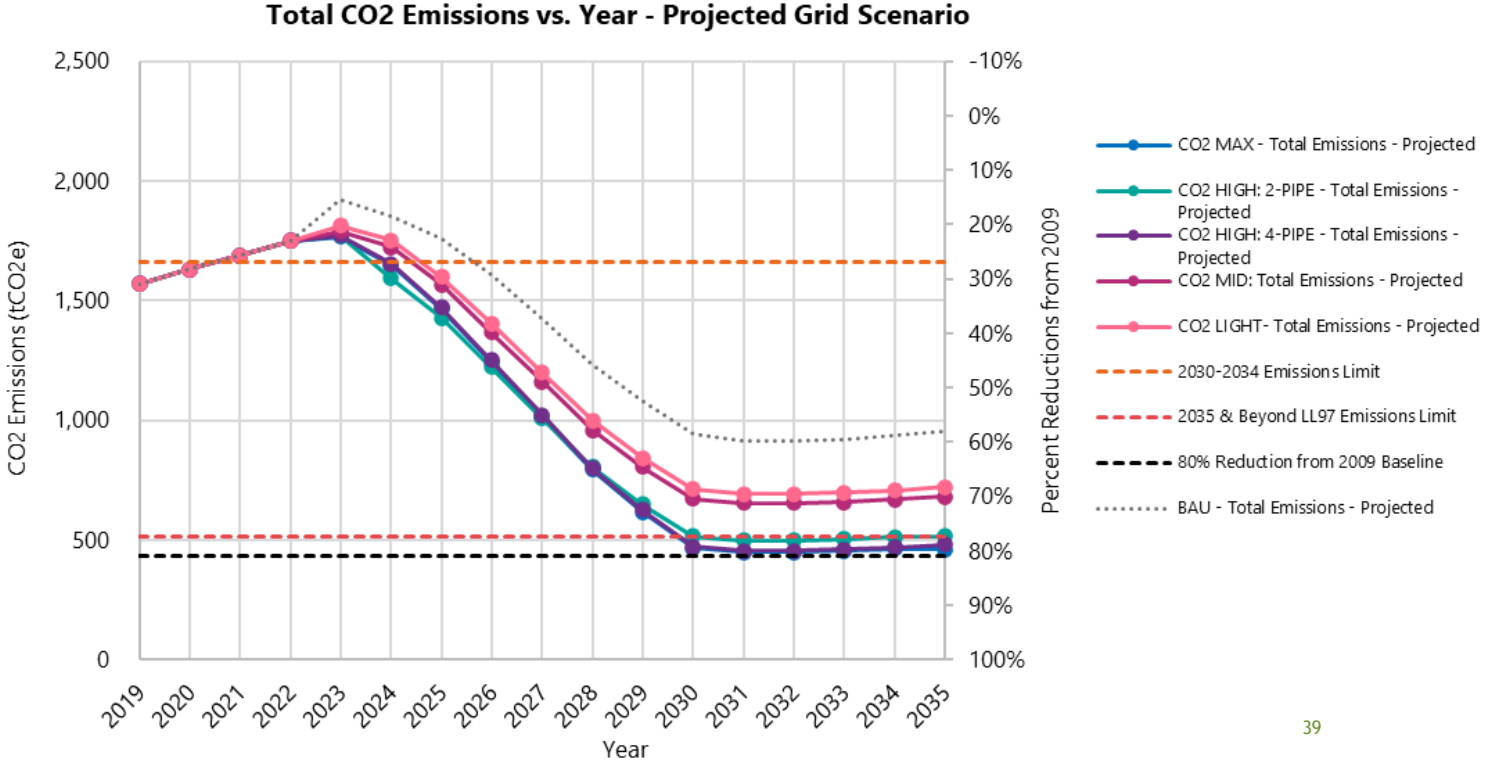
Projected Annual Carbon Emissions – Projected Grid Scenario

None of the packages would meet **80% reduction** from 2009 baseline by **2035**;
CO2 High 4-Pipe and CO2 Max packages would meet **average long-term LL97 limit**



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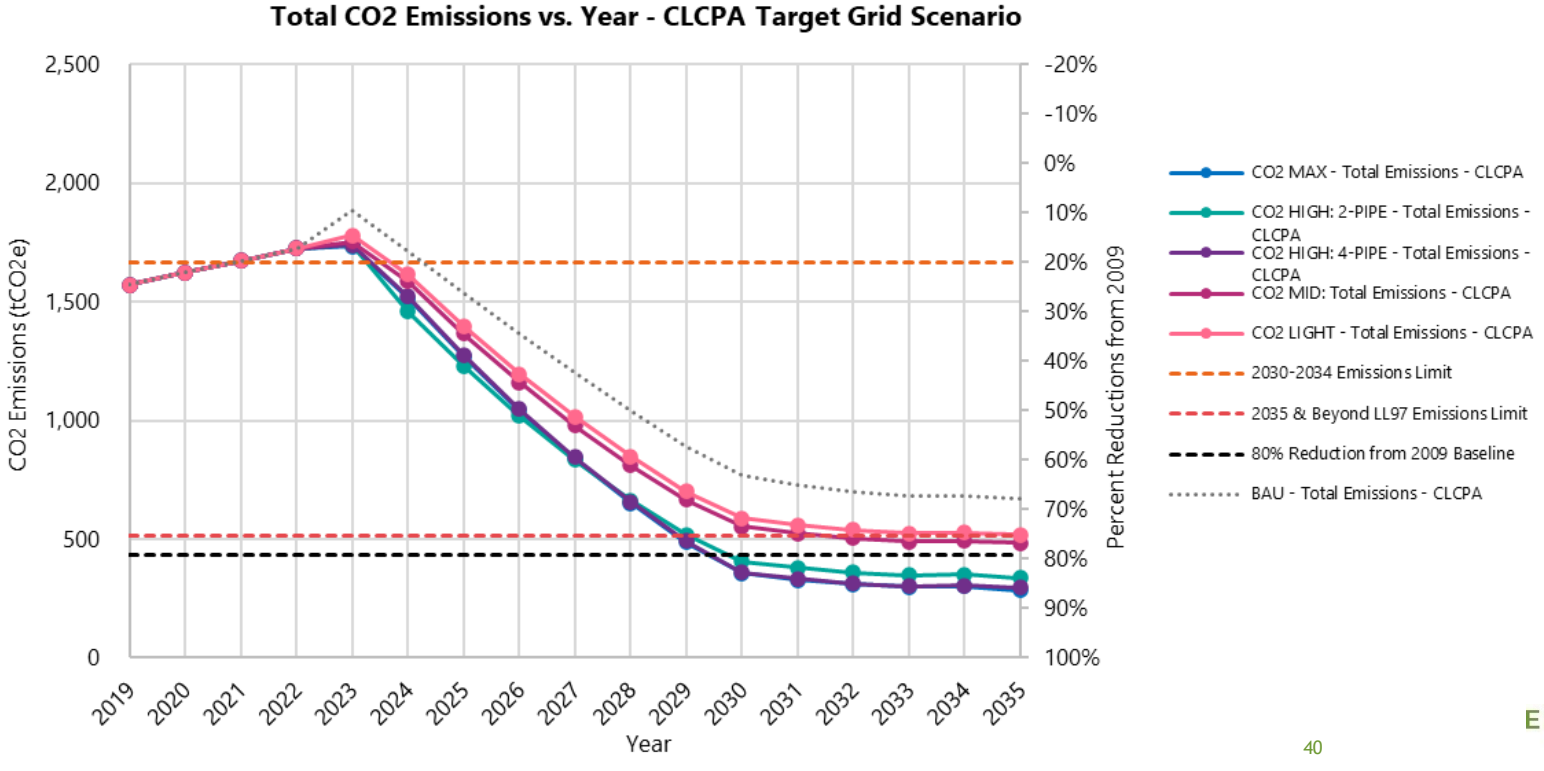
Projected Annual Carbon Emissions – CLCPA Grid Scenario

CO2 High - Max packages would meet **80% reduction** from 2009 baseline by **2035**;
All but CO2 Light package would meet **average long-term LL97 limit**



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Percent Carbon Emissions Reductions – All Grid Scenarios

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-40.9%	-42.8%	**-57.3%**	**-58.7%**
CO2 HIGH 2 PIPE	-37.9%	-38.9%	**-55.1%**	**-55.8%**
CO2 HIGH 4 PIPE	-40.2%	-40.2%	**-56.7%**	**-56.7%**
CO2 MID	-25.6%	-25.6%	**-46.2%**	**-46.2%**
CO2 LIGHT	-22.3%	-22.3%	**-43.8%**	**-43.8%**

None of the packages would reach **80% reduction** from 2009 baseline by **2035**;
None of the packages would meet **average long-term LL97 limit**

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-70.2%	-70.7%	**-78.4%**	**-78.8%**
CO2 HIGH 2 PIPE	-67.1%	-67.1%	**-76.2%**	**-76.2%**
CO2 HIGH 4 PIPE	-69.8%	-69.3%	**-78.2%**	**-77.8%**
CO2 MID	-57.1%	-56.6%	**-69.0%**	**-68.6%**
CO2 LIGHT	-54.6%	-54.1%	**-67.2%**	**-66.8%**

None of the packages would meet **80% reduction** from 2009 baseline by **2035**;
CO2 High 4-Pipe and CO2 Max packages would meet **average long-term LL97 limit**

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-77.4%	-82.0%	**-83.6%**	**-87.0%**
CO2 HIGH 2 PIPE	-74.2%	-78.5%	**-81.4%**	**-84.5%**
CO2 HIGH 4 PIPE	-77.1%	-81.2%	**-83.4%**	**-86.4%**
CO2 MID	-64.9%	-69.2%	**-74.6%**	**-77.7%**
CO2 LIGHT	-62.6%	-67.0%	**-72.9%**	**-76.1%**

CO2 High 4-Pipe, 2-Pipe and CO2 Max packages would meet **80% reduction** from 2009 baseline by **2035**;
All packages except CO2 Light would meet **average long-term LL97 limit**

1350 Broadway Case Study

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1350 Broadway – Current Building Systems

- Cooling
  - Two (2) 500 ton electric centrifugal chillers (converted from steam in 2013)
- Tenant level AHUs
  - Approximately 90 tenant spaces
  - Approximately 120 tenant AHUs
- Air Distribution
  - 50% VAV diffuser/VAV box
  - 50% constant volume (CV)
- Heating
  - District steam
  - Perimeter radiators
  - Electric duct heaters at tenant AHUs for ventilation heating loads (electric resistance-inefficient design)
- BMS
  - Not unified across building, many standalone systems
- Efficiency Rating: A | 85
  - High number of small thermal zones due to segmentation of floor plates results in more tailored airflow
  - Relatively new chillers operate more efficiently at part load

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2019 Energy Breakdown by Utility

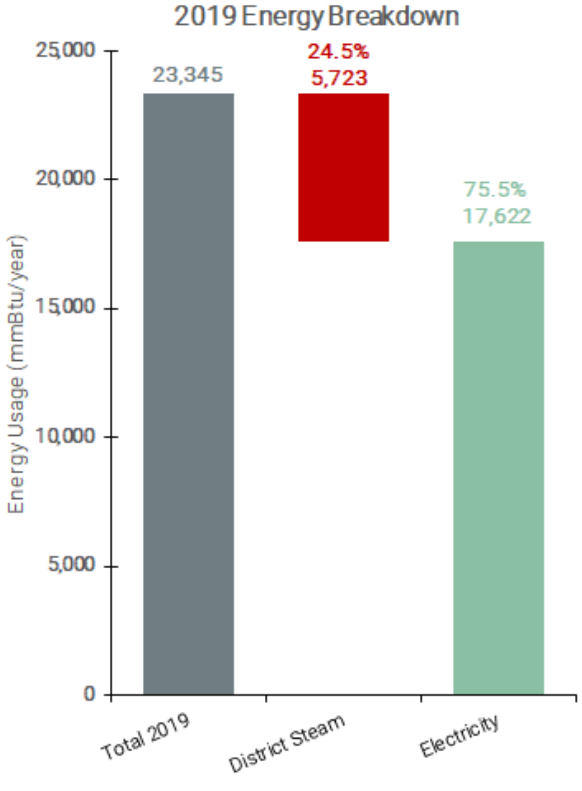
District steam used for heating makes up about a quarter of energy usage

Electricity

- 75.5% of energy usage
- 83.7% of CO2e emissions

District Steam

- 24.5% of energy usage
- 16.3% of CO2e emissions



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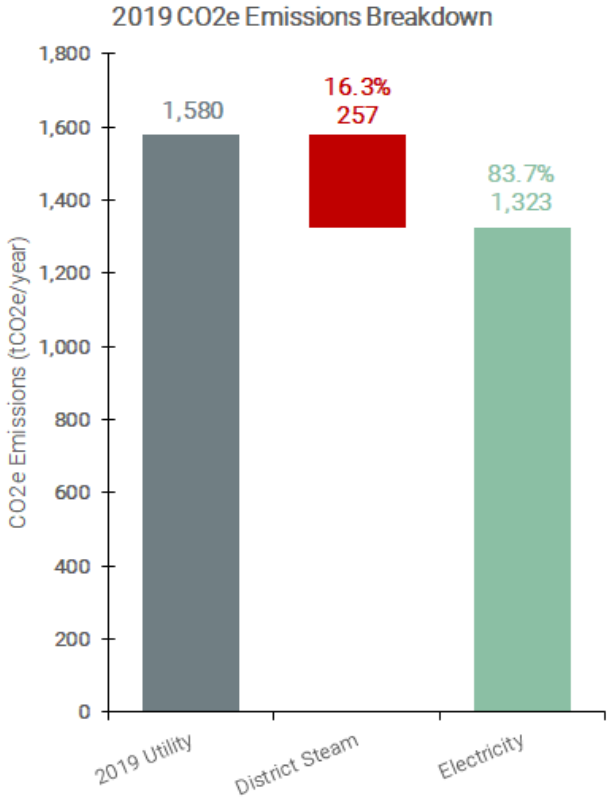
2019 CO2e Emissions Breakdown by Utility

District steam has lower associated emissions than natural gas & electricity

Electricity - 256.0 tCO2e/GWh

District Steam - 153.3 tCO2e/GWh (LL97)



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2019 Operational Cost Breakdown by Utility

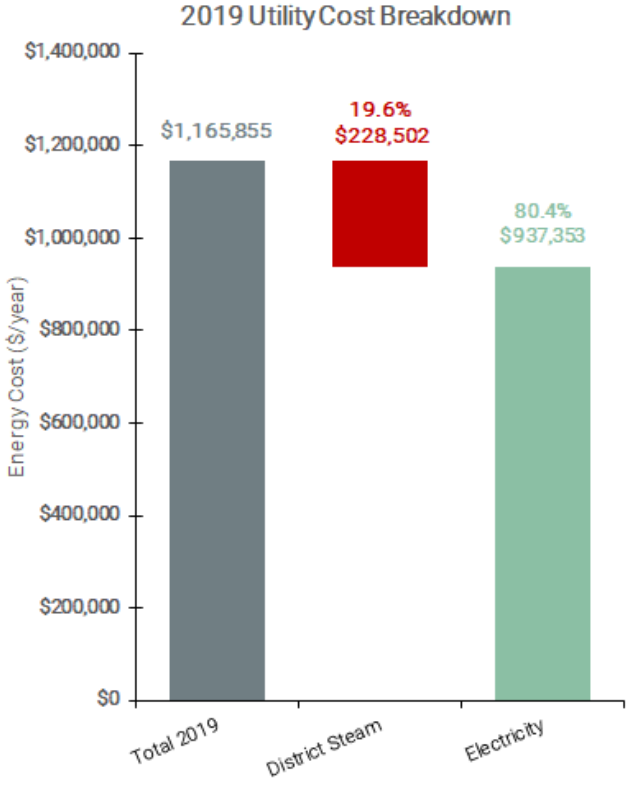
District steam is more expensive than natural gas, but cheaper than electricity

Electricity

- 80.4% of operational costs
- 75.5% of energy usage

District Steam

- 19.6% of operational costs
- 24.5% of energy usage



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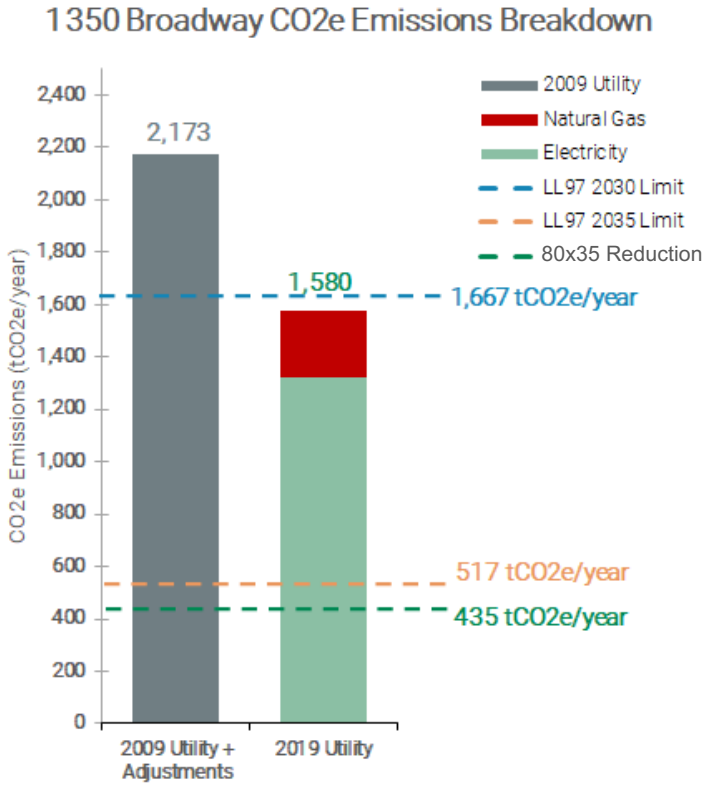
1350 Broadway Current Status for LL97 and 80x35 Metrics



Key Takeaways:

- Building meets 2024 limit of 3,153 tCO2e/year
- Building meets 2030 limit of 1,667 tCO2e/year
- 67.2% emissions reduction is required to meet LL97 2035 target
  - Building + grid improvements

27% CO2e reduction from 2009 to 2019

- 44% due to electrical grid improvements
- 56% due to switch from steam to electric chillers

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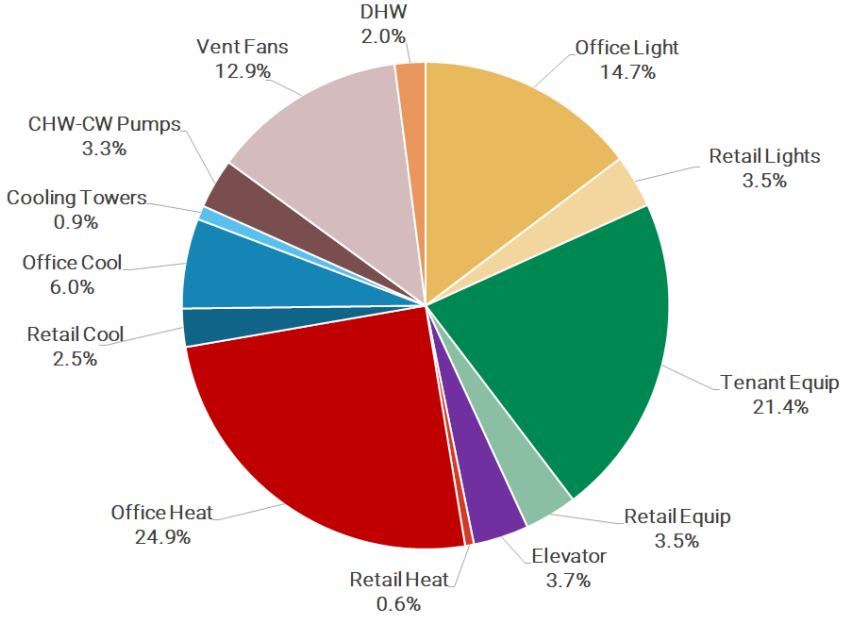
1350 Broadway Energy Model: 2019 Energy Breakdown by End-Use

Office and retail lighting/equipment accounts for 43.1% of the total 2019 energy usage

Major End Uses:

- Office + Retail Lighting & Equip. – 43.1%
- Office + Retail Heating – 25.5%
- All Fans – 12.9%
- Office + Retail Cooling – 9.4%
  - CHW Plant and DX units
- CHW-CW Pumps – 3.3%



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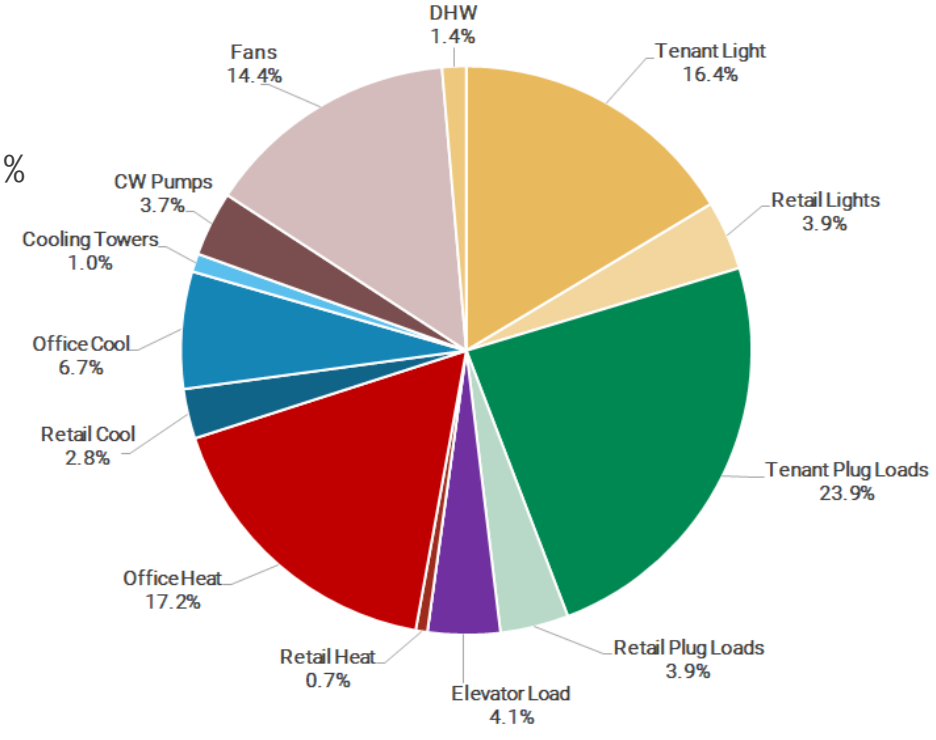
1350 Broadway Energy Model: 2019 CO2e Emissions Breakdown by End-Use

Office and retail lighting/equipment accounts for 48.1% of the total 2019 CO2e emissions

Major End Uses:

- Office + Retail Lighting & Equip. – 48.1%
- Office + Retail Heating – 17.9%
- All Fans – 14.4%
- Office + Retail Cooling – 10.5%
  - CHW Plant and DX units
- CHW-CW Pumps – 3.7%



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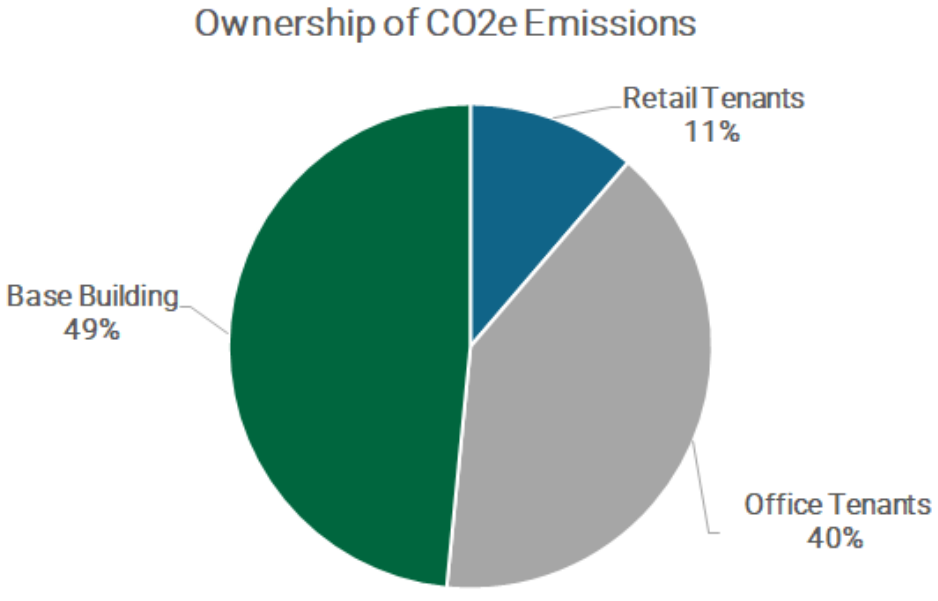
1350 Energy Model: 2019 CO2e Emissions Breakdown by User

Office and retail tenants account for ~51% of total 2019 CO2e emissions

Base Building includes:

- All district steam heating
- Central cooling plant equipment
- All office tenant AHUs
- Elevators
- Lobby HVAC units
- BOH lighting and equipment



Duane Reade operates 24/7

Santander Bank high energy user

Space Type	Square Footage		Energy Intensity	Carbon Intensity
	SF	%	(kBtu/SF/year)	(lbs/SF/year)
Retail Tenants	23,673	7%	100.0	16.5
Office Tenants	293,685	93%	28.7	4.7

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1350 Broadway Case Study

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ECM Phasing and Packaging
Energy and Carbon Emissions Results
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ECM Packages

Five packages of ECMs developed to optimize NPV and CO2 reductions & test various HVAC systems

1	2	3	4	5
CO2 Light	**CO2 Mid**	**CO2 High**	**CO2 High**	**CO2 Max**
Chiller plant optimization, conversion of CV to VAV at lease roll	CO2 Light + toilet exhaust ERV	Centralized 2-pipe heat pump change over system	Centralized 4-pipe heat pump	CO2 High 4-pipe + envelope measures
No electrification	No electrification	Partial near-term electrification	Partial long-term electrification	Full electrification

Carbon Reduction

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4-Pipe vs 2-Pipe Electrification

- 2-pipe change-over system
  - Heat pump to be connected directly to CHWS/R loop. During heating season, heat pump injects heat into the CHWS/R loop, using the AHU coil to temper ventilation air and supplement perimeter steam heating load.
- 4-pipe separate heating and cooling loops
  - Installation of HHWS/R riser and additional distribution piping. During heating season, heat pump provides full heating load for perimeter losses and ventilation air. As tenant lease roll dictates, tenant spaces will be converted to full electric heating via the heat pump.

ECM Phases & Implementation Timeline: CO2 Mid

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE								
Phase	Tag	Short Name	2022	2023	2024	2025	2026	2027	2028	2029	2030
Phase 1	CO001	BMS Backbone	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO002	DDC VAV Boxes and Electronic Radiator Valves	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO003	Optimization of VAV Diffuser Systems + Electronic Radiator Valves	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO005	Chiller Plant Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO006	Control of Pump DP	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS001	Reduce Steam Pressure and Steam Cycling	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS002	Radiator Trap Audit & Replacements	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	AS001	Toilet Exhaust Energy Recovery Ventilator	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	DW001	Low Flow Fixtures	0%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3	SS003	Radiant Barrier	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	EN001	Mitigate Lobby Infiltration	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	AS003	Retrofit VAV Diffuser Systems to VAV Systems at Tenant Lease Roll	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	AS004	Retrofit Constant Volume AHUs to VAV Systems at Tenant Lease Roll	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	CO008	Outside Air Flow Control & Demand Controlled Ventilation	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	TL001	Plug Load Control	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	LT001	Efficient Light Fixtures & Layout	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	LT002	Day Lighting & Vacancy Control	0%	0%	17%	33%	50%	67%	83%	100%	100%
Phase 3	LT003	Retail Tenant Lighting	0%	0%	17%	33%	50%	67%	83%	100%	100%

1350 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
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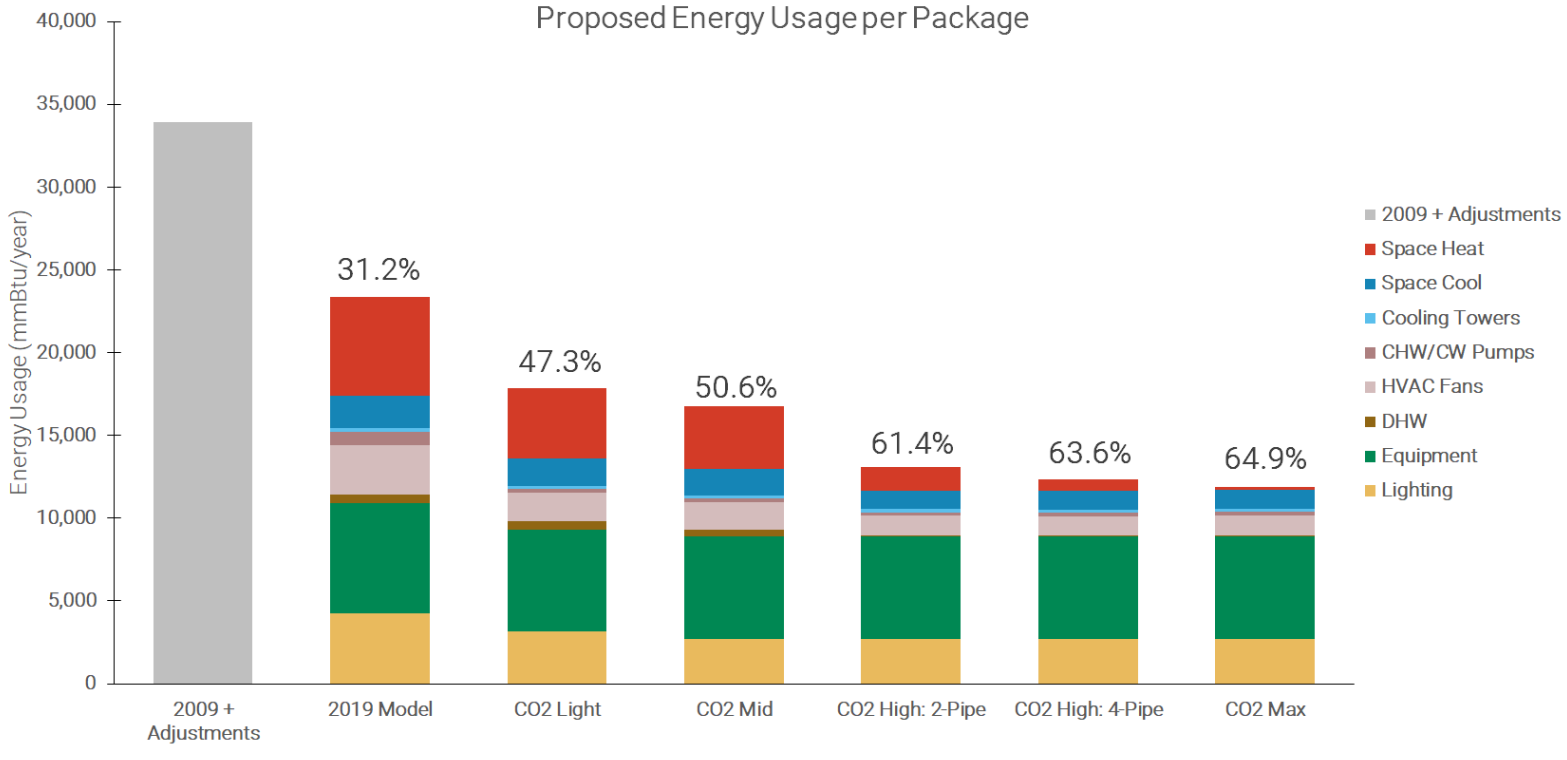
ECM Package Comparison - Energy

Packages range from 47.3% to 64.9% reduction in total energy from 2009 + Adjustments benchmark year



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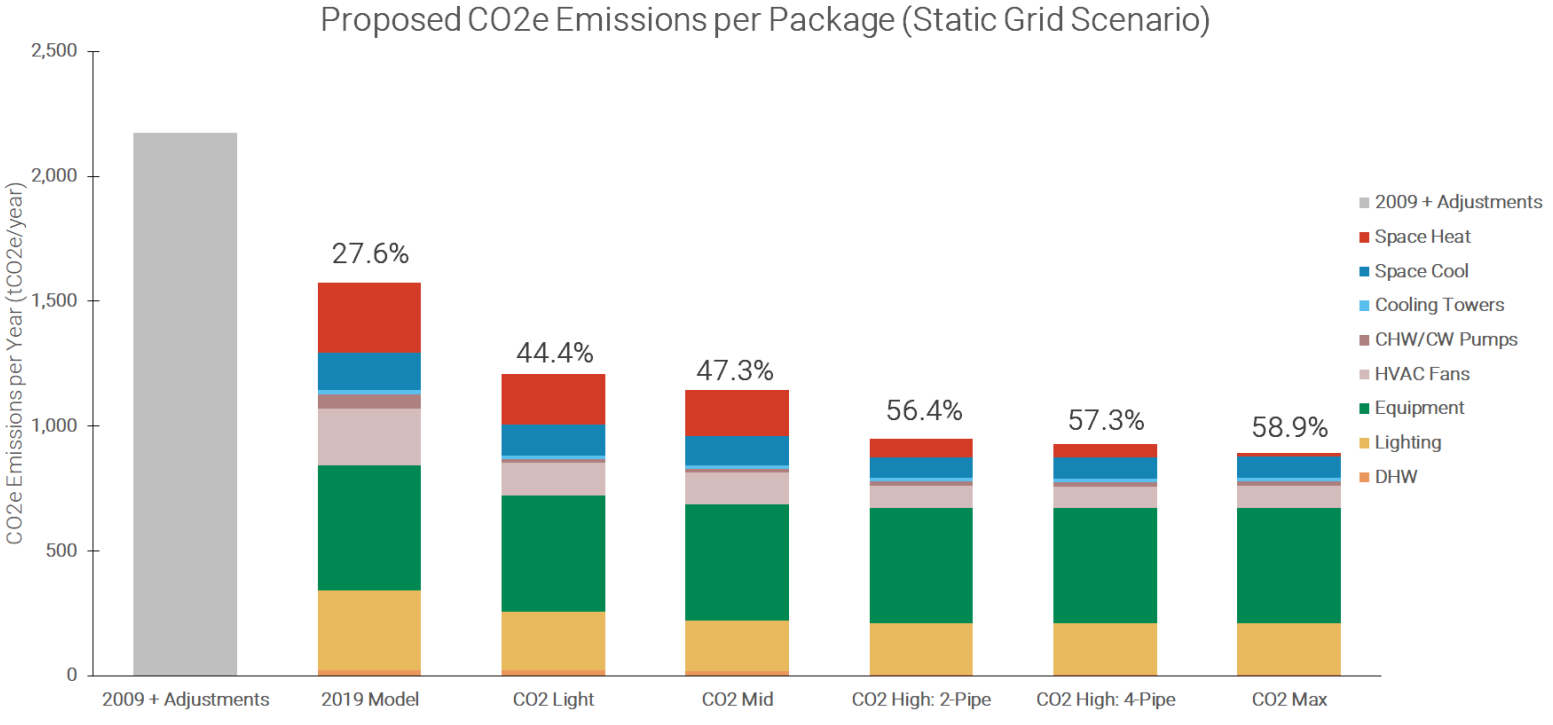
Projected CO2 Emissions – Static 2019 Grid Scenario

Packages range from 44.4% to 58.9% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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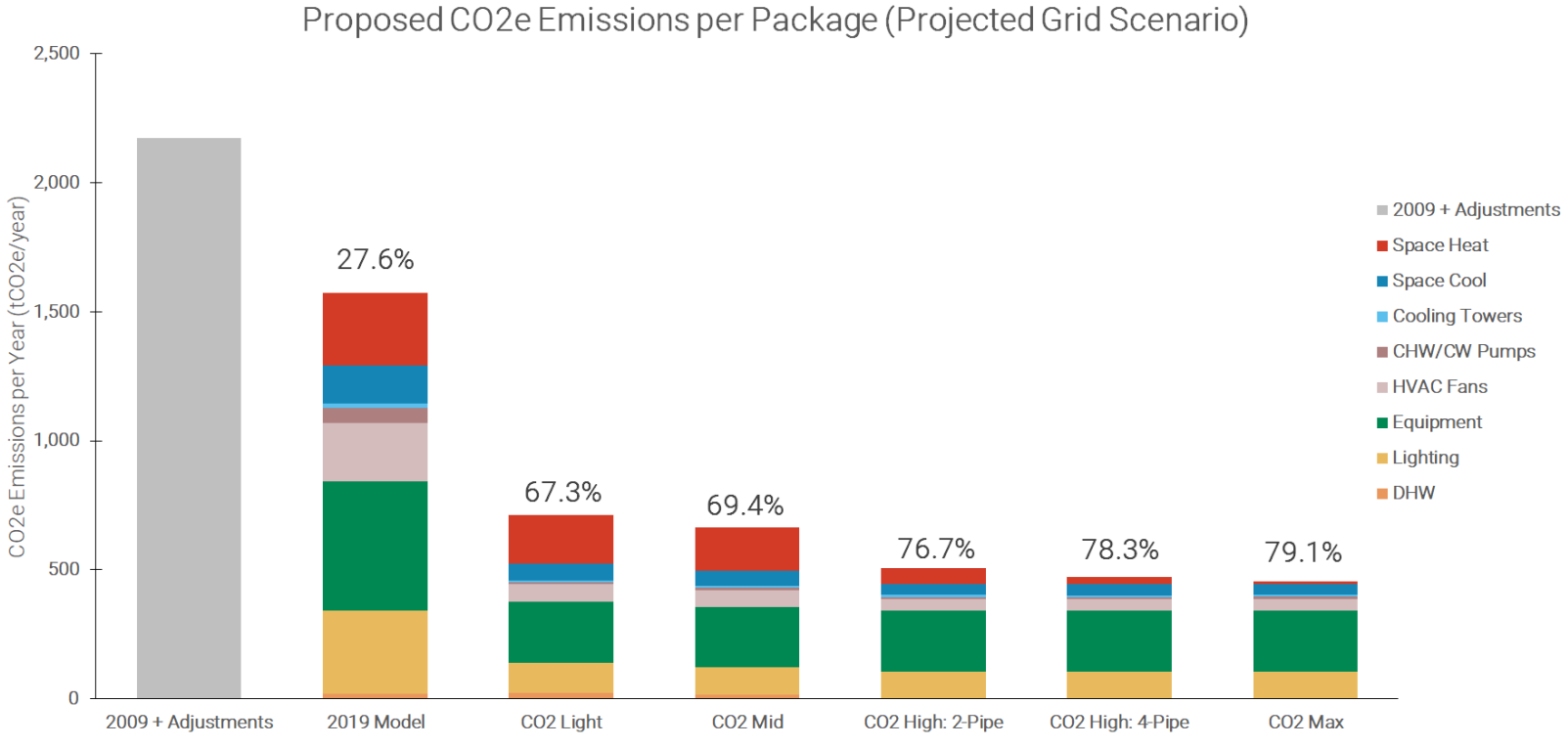
Projected CO2 Emissions – Projected Grid Scenario

Packages range from 67.3% to 79.1% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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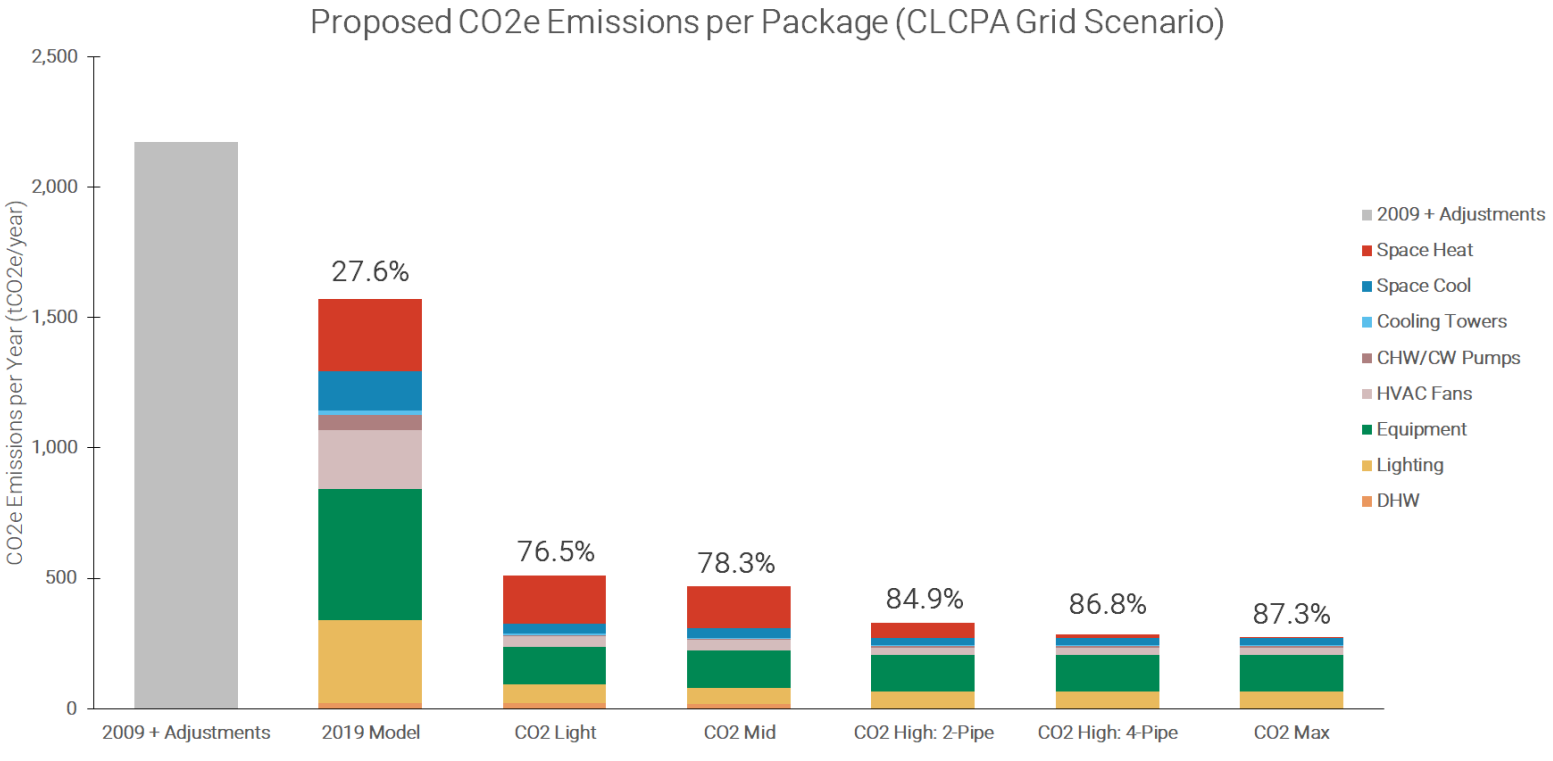
Projected CO2 Emissions - CLCPA Grid Scenario

Packages range from 76.5% to 87.3% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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1350 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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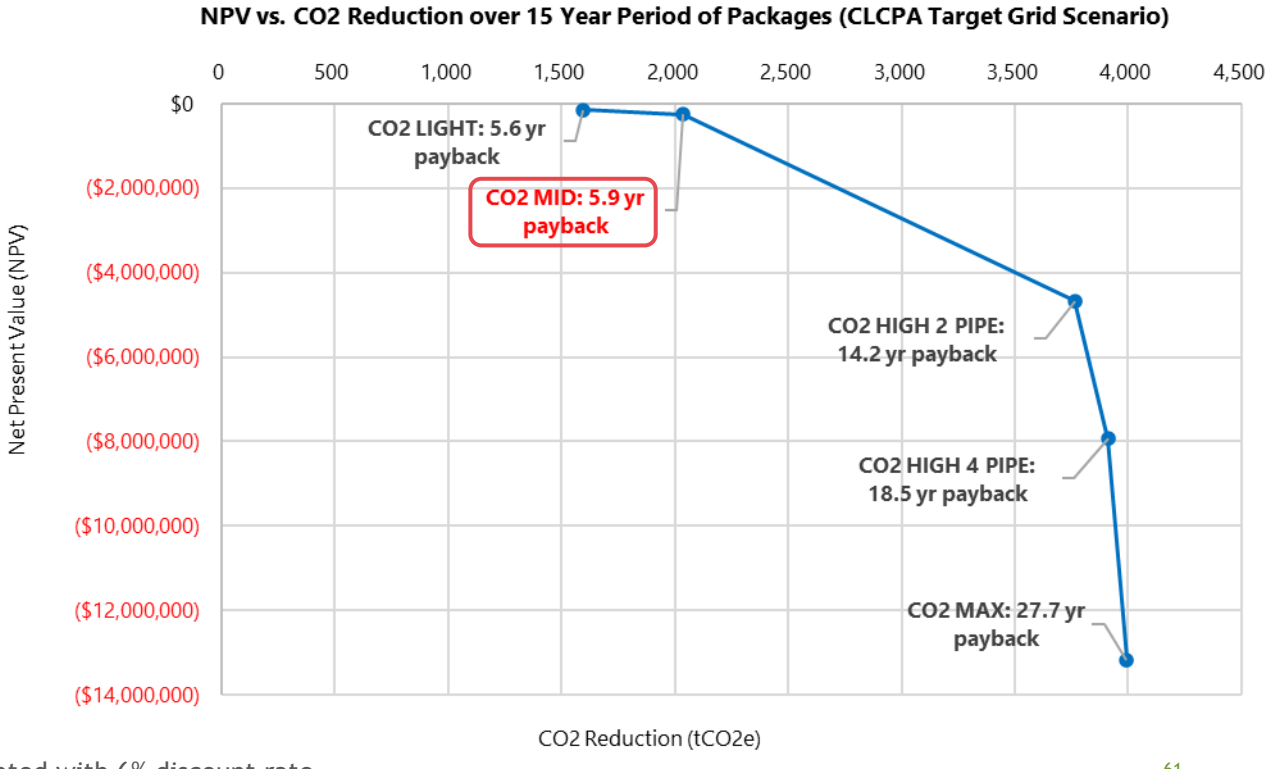
NPV, CO2 Reductions and Simple Payback for all Packages

CO2 Mid package would meet long term LL97 limits and pays back in 5.9 years
CO2 High packages offer nearly twice the carbon savings but at higher cost



NPV calculated with 6% discount rate

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LL97 Annual Fines for all Packages

With BAU consumption, 1350 would begin seeing fines in 2035 with a static grid
Implementation of CO2 Mid - Max packages would avoid all fines for CLCPA grid scenario

Packages	CLCPA Grid Scenario				Projected Grid Scenario				Static Grid Scenario			
	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages
2019 Baseline	$0	$0	$41,290	-	$0	$0	$117,769	-	$0	$0	$306,280	-
C02 Light	$0	$0	$521	$40,768	$0	$0	$54,892	$62,878	$0	$0	$188,907	$117,373
CO2 Mid - No Electrification	$0	$0	$0	$41,290	$0	$0	$44,335	$73,434	$0	$0	$174,953	$131,327
CO2 High - 2 Pipe	$0	$0	$0	$41,290	$0	$0	$242	$117,528	$0	$0	$118,987	$187,293
CO2 High - 4 Pipe	$0	$0	$0	$41,290	$0	$0	$0	$117,769	$0	$0	$113,513	$192,767
CO2 Max - Full Electrification	$0	$0	$0	$41,290	$0	$0	$0	$117,769	$0	$0	$102,315	$203,965

*The 2035 GHG emissions limit has not yet been defined and calculations are based on long-term LL97 80% reduction limits.

Recommended Package – CO2 Mid

Beyond 77% reduction in emissions, reductions become more costly

	CO2 Light	CO2 Mid	CO2 High: 2-Pipe	CO2 High: 4-Pipe	CO2 Max
NPV TOTALS	($144,568)	($242,621)	($4,667,765)	($7,932,494)	($13,179,607)
Total Capital Cost*	($3,395,589)	($4,018,367)	($11,685,992)	($16,231,020)	($25,080,844)
Annual Energy Cost Savings	$415,976	$471,292	$695,302	$724,063	$780,256
Annual Repairs & Maintenance Savings	$39,500	$45,700	$43,200	$72,400	$72,400
Incentives	$829,948	$947,437	$1,232,504	$1,495,279	$1,469,943
Simple Payback	**5.63**	**5.94**	**14.15**	**18.50**	**27.69**

CO2 Light Reduction: Optimize chilled water plant and convert airside systems to VAV at tenant lease roll - no electrification
CO2 Mid Reduction: CO2 Light + TX fan ERV - no electrification
CO2 High 2-Pipe Reduction: Centralized 2-Pipe heat pump change over system - partial near-term electrification
CO2 High 4-Pipe Reduction: Centralized 4-Pipe heat pump - partial long-term electrification
CO2 Max Reduction: CO2 High 4-pipe + envelope measures - Full electrification

*Excluding construction escalation costs

Recommended Package – CO2 Mid

- Fines and energy savings:
  - The building should not incur any LL97 related fines under the CLCPA grid scenario if the CO2 Mid package is implemented.
  - The CO2 Mid package reduces total carbon emissions by 77.7% from the 2009 baseline. The package nearly meets the goal of 80% reduction. CO2 Light does not meet this target, and the additional carbon emissions reductions of CO2 Mid are available at a similar cost per tCO2 and only a few months impact to payback.
- Key ECMs:
  - Chiller plant optimization
  - Conversion of constant volume and VAV diffuser systems to optimized VAV box systems
    - Chiller plant is 8 years old. Full VAV conversion is a better option than converting to VRF, so a VRF option was not analyzed
  - Base building toilet exhaust energy recovery ventilator
- Timeline for heating electrification:
  - Electrification is not required to meet the LL97 2035 and beyond limits.
  - Heating electrification offers significant energy and carbon savings opportunities, but is not financially viable until the chillers reach end-of-life and need replacement (25 years or 2038)
  - When the chillers are nearing end-of-life they should be replaced by heat pumps. Hot water infrastructure installation should begin at least 5 years before heat pump installation to maximize use of the heat pump when installed to accelerate emissions reductions and bring forward the date at which the steam system could be decommissioned, if desired.

1350 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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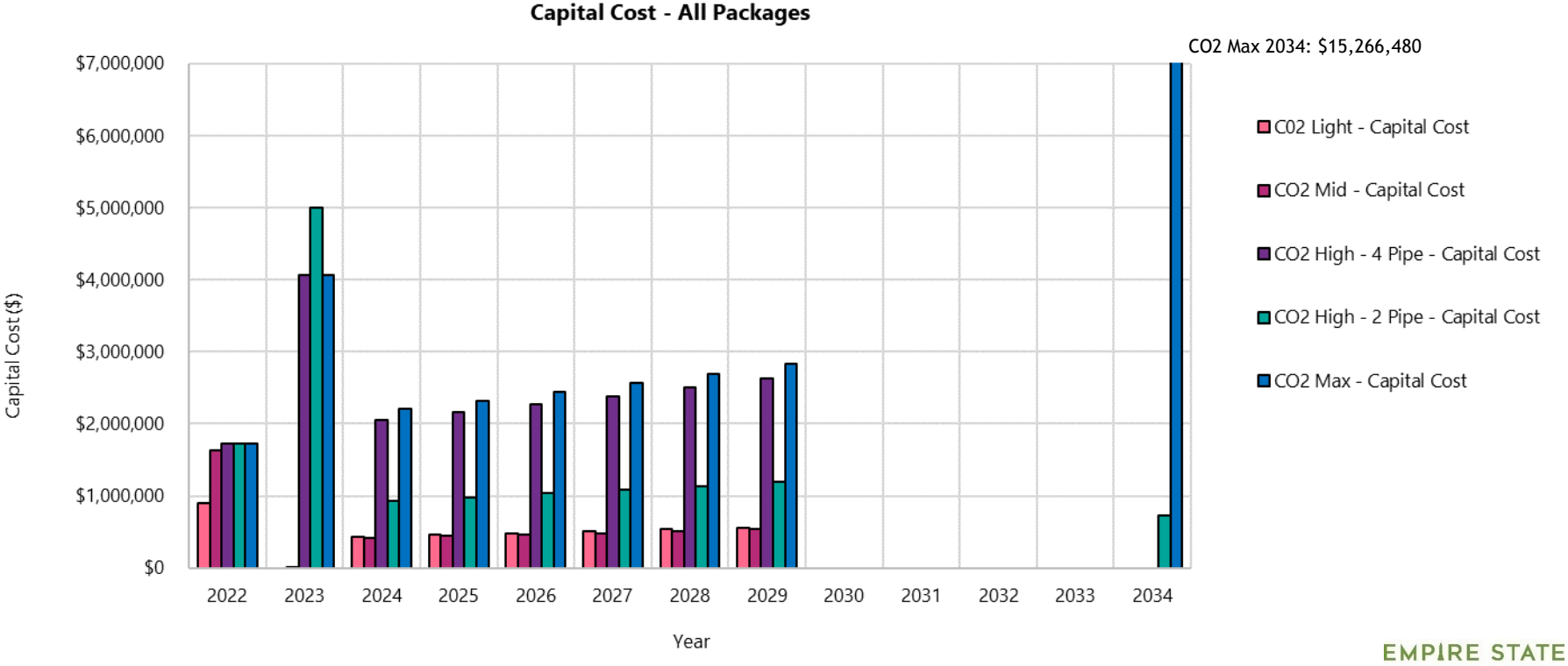
Annual Capital Cost per Package

Capital costs of ECMs that occur at tenant lease roll have been applied to years 2022-2029, since 92% of leases expire within that period.



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1350 Broadway Next Steps – 2022 Projects

The recommended 2022 measures are focused on control measures that have a short payback and will enable energy reduction opportunities in the future

Project	2022 Total Cost	Anticipated Incentives ($)	Total 2022 Cost w/ Incentives ($)	Energy Cost Savings
DDC VAV Boxes and Electronic Radiator Valves	$359,304	$108,880	$250,424	$20,787
Optimization of VAV Diffuser Systems + Electronic Radiator Valves	$216,700	$65,667	$151,033	$10,560
Control of Pump DP	$16,500	$15,000	$1,500	$27,766
Retail BMS Upgrades	$88,000	$26,999	$61,001	$12,933
Chiller Plant Optimization	$66,000	$19,064	$46,936	$8,557
Radiator Trap Audit & Replacements	Included in Maintenance Budget	-	-	$16,357
Reduce Steam Pressure and Steam Cycling	$16,500	$698	$15,802	$5,270
Toilet Exhaust Energy Recovery Ventilator	$517,000	$3,446	$513,554	$25,380
Total	**$1,280,004**	**$239,753**	**$1,040,251**	**$127,610**
BMS Backbone	$440,000	$0	$440,000	$0
Total with BMS	**$1,720,004**	**$239,753**	**$1,480,251**	**$127,610**

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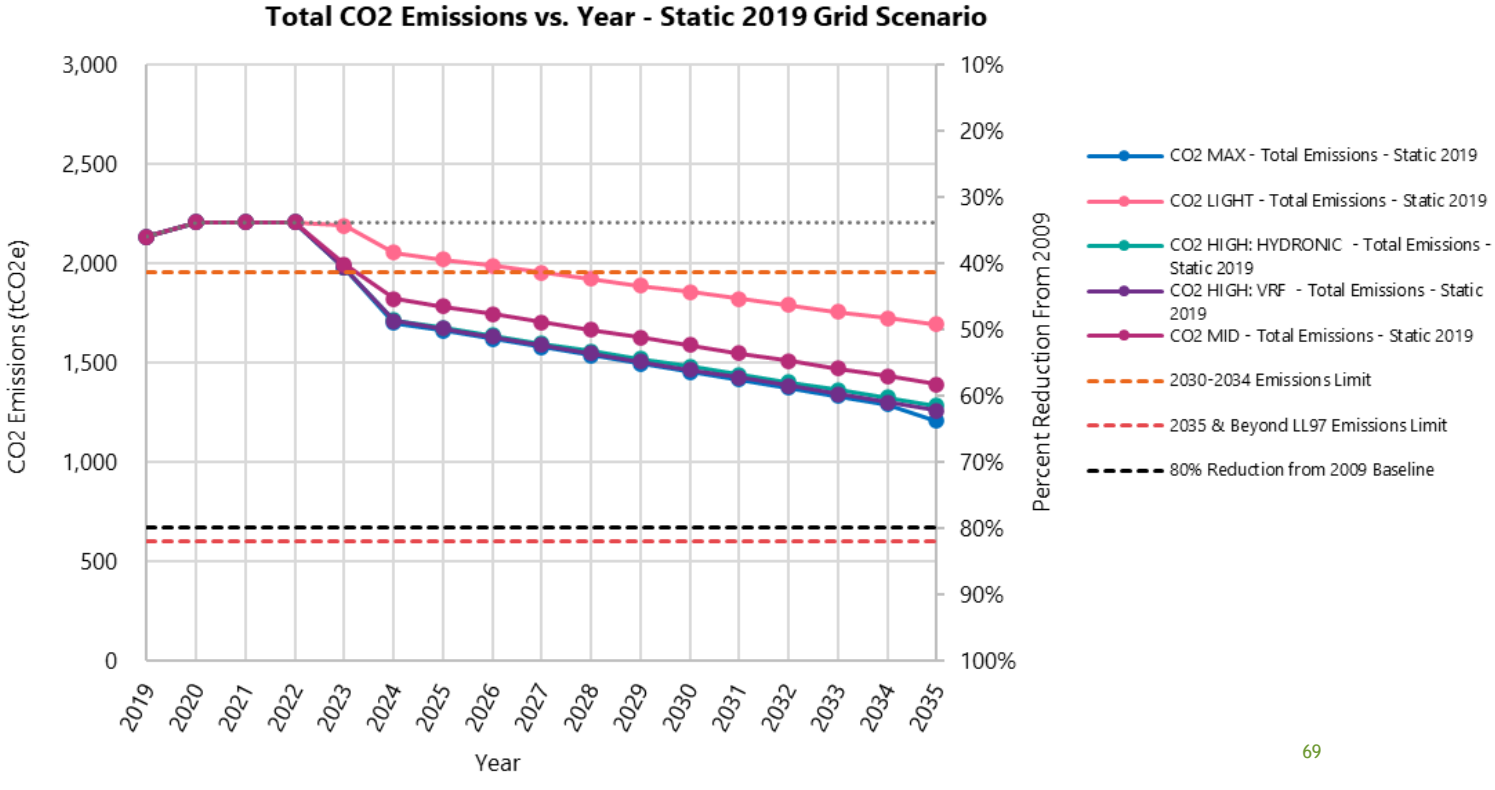
1359 Broadway

Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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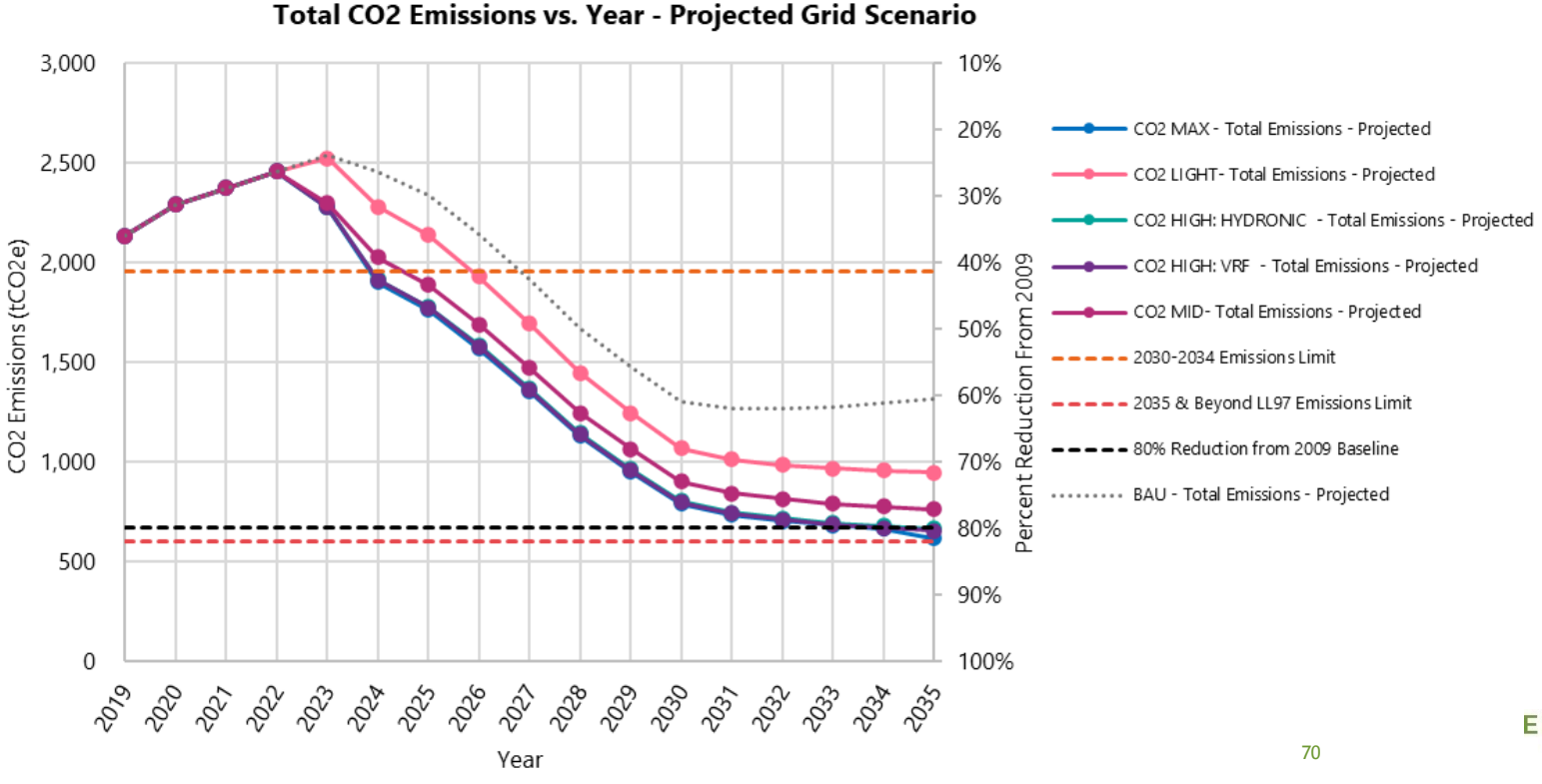
Projected Annual Carbon Emissions – Projected Grid Scenario

CO2 High – Max packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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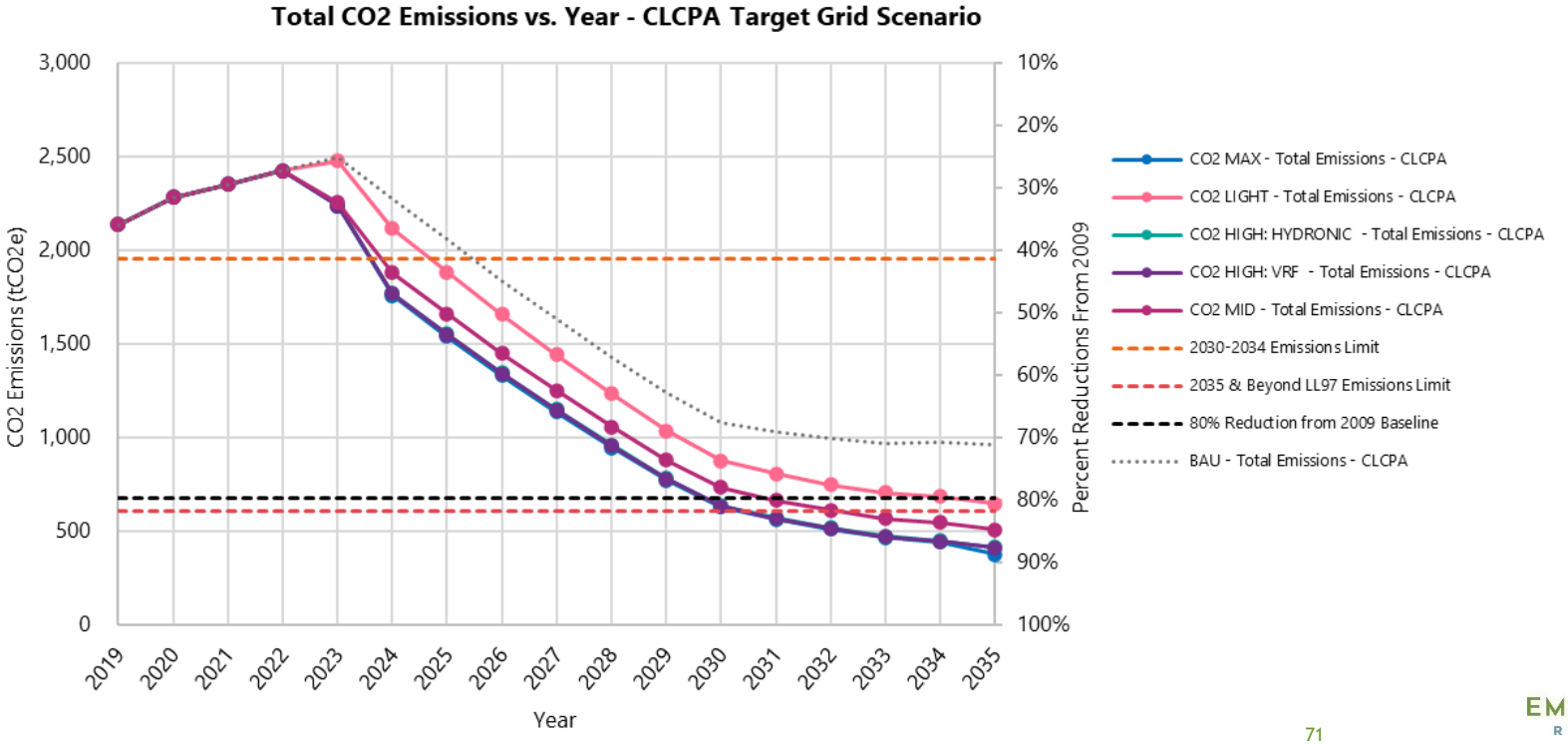
Projected Annual Carbon Emissions – CLCPA Grid Scenario

All packages would meet **80% reduction** from 2009 baseline by **2035**;
All packages **except CO2 Light** would meet **average long-term LL97 limit**



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Percent Carbon Emissions Reductions – All Grid Scenarios

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-31.8%	-43.4%	-56.7%	-64.1%
CO2 HIGH: HYDRONIC	-30.6%	-39.7%	-56.0%	-61.8%
CO2 HIGH: VRF	-31.3%	-40.9%	-56.4%	-62.5%
CO2 MID	-25.6%	-34.7%	-52.8%	-58.6%
CO2 LIGHT	-13.0%	-20.7%	-44.8%	-49.7%

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-62.9%	-71.1%	-76.5%	-81.7%
CO2 HIGH: HYDRONIC	-62.3%	-68.9%	-76.1%	-80.3%
CO2 HIGH: VRF	-62.6%	-69.3%	-76.3%	-80.5%
CO2 MID	-57.8%	-64.2%	-73.2%	-77.3%
CO2 LIGHT	-49.9%	-55.6%	-68.2%	-71.8%

CO2 Max, CO2 High: VRF and CO2 High: Hydronic packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-70.6%	-82.3%	-81.3%	-88.8%
CO2 HIGH: HYDRONIC	-70.2%	-80.7%	-81.1%	-87.7%
CO2 HIGH: VRF	-70.3%	-80.8%	-81.2%	-87.8%
CO2 MID	-65.7%	-76.2%	-78.3%	-84.9%
CO2 LIGHT	-59.0%	-69.7%	-74.0%	-80.8%

All packages would meet **80% reduction** from 2009 baseline by **2035**;
All packages **except CO2 Light** would meet **average long-term LL97 limit**

1359 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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1359 Broadway – Current Building Systems

- Cooling
  - Tenant Systems
    - Self-contained air-cooled AHUs – approximately 51 (3-16 years, average 9)
    - Wolfgangs – condenser water heat pump system (3 years)
    - NYSERDA – VRF (9 years)
    - Ariela Alpha International – 2 RTUs (15 years)
    - I-Deal LLC – 2 air-cooled chillers (16 years)
  - Base Building Systems
    - AHUs – Approximately 7 (10 years)
- Heating
  - Tenant Systems
    - NYSERDA – VRF (9 years - base building radiators disconnected)
    - Electric unit heaters for ventilation (inefficient resistance heat design)
  - Base Building Systems
    - Two Steam Boilers (13 years)
    - Perimeter cast iron radiators (most original)
    - Gas-fired domestic water heater (15 years)
- BMS
  - Present but not unified across building, most systems are standalone

2019 Energy Breakdown by Utility

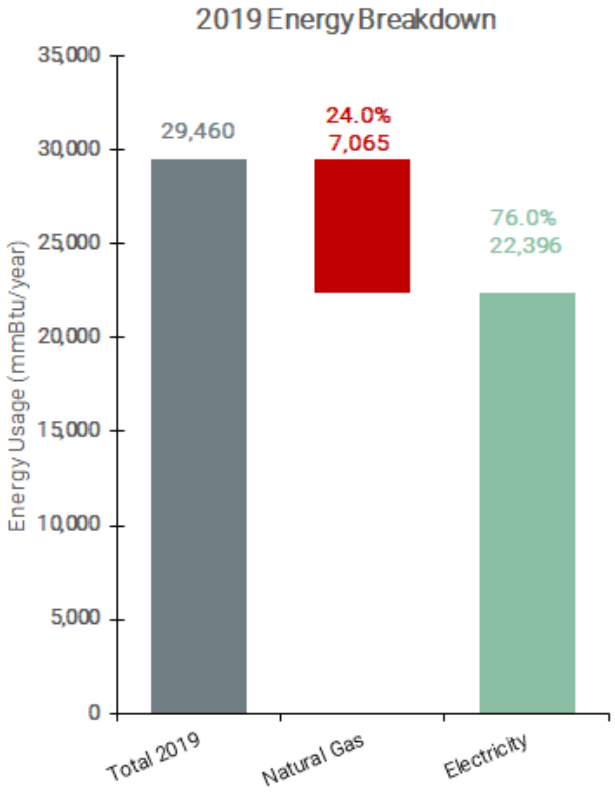
Natural gas consumption used for heating makes up 24.0% of energy usage

Electricity

- 76.0% of energy usage
- 81.8% of CO2e emissions

Natural Gas

- 24.0% of energy usage
- 18.2% of CO2e emissions



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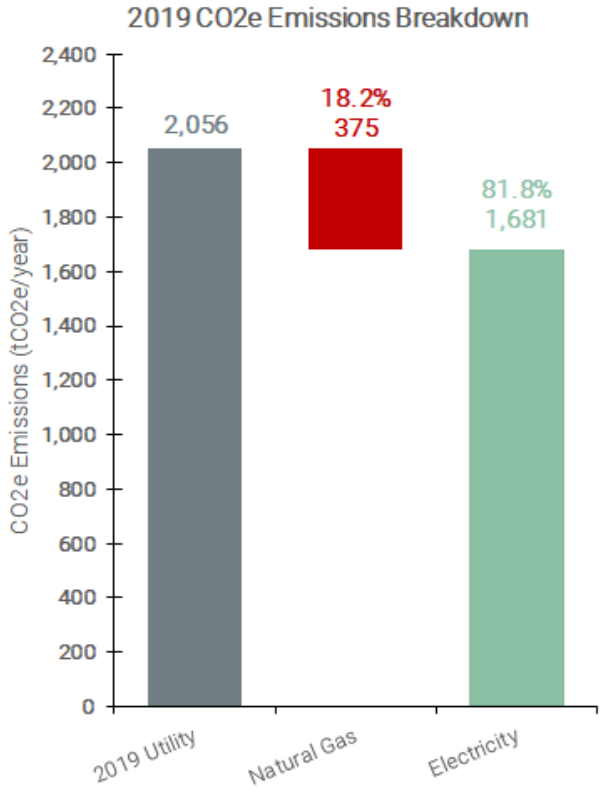
2019 CO2e Emissions Breakdown by Utility

Natural gas has slightly lower associated emissions than electricity

Electricity - 256.0 tCO2e/GWh

Natural Gas - 181.2 tCO2e/GWh (LL97)



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2019 Operational Cost Breakdown by Utility

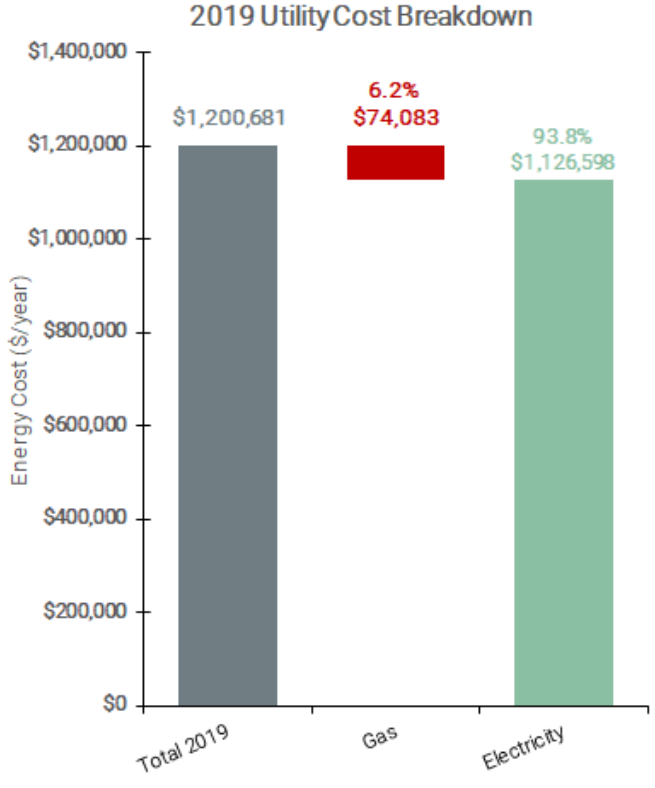
Natural gas is cheaper than electricity & therefore makes up a smaller portion (6.2%) of utility costs

Electricity

- 93.8% of operational costs
- 76.0% of energy usage

Natural Gas

- 6.2% of operational costs
- 24.0% of energy usage



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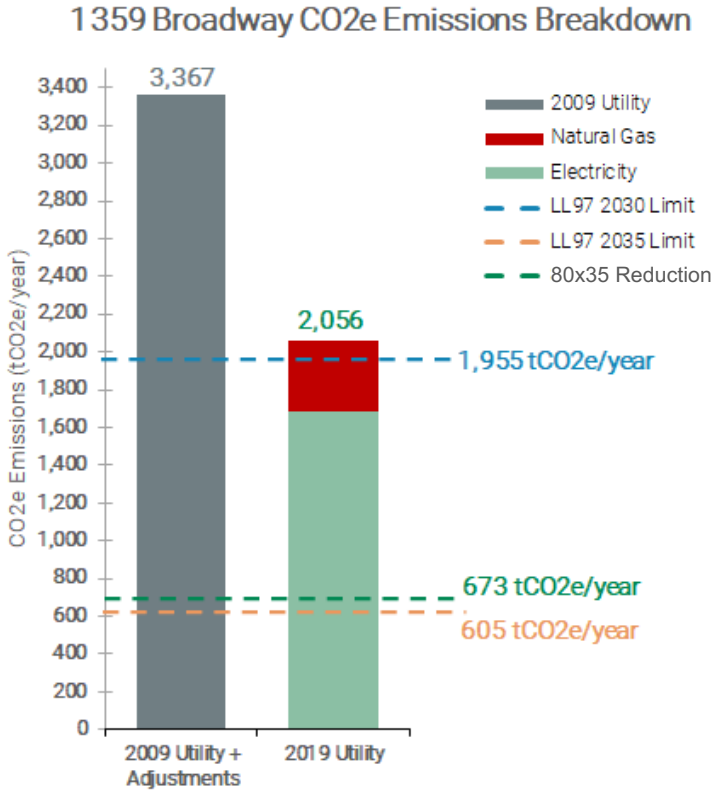
1359 Broadway Current Status for LL97 and 80x35 Metrics



Key Takeaways:

- Building meets 2024 limit of 3,684 tCO2e/year
- 4.9% emissions reduction is required to meet LL97 2030 target
- 70.5% emissions reduction is required to meet LL97 2035 target
  - Building + Grid Improvements

38.9% CO2e reduction between 2009 and 2019

- 32% due to electrical grid improvements
- 27% due to switch of boiler fuel source from fuel oil to natural gas
- 40% due to partial decommissioning of inefficient 2nd floor chiller plant

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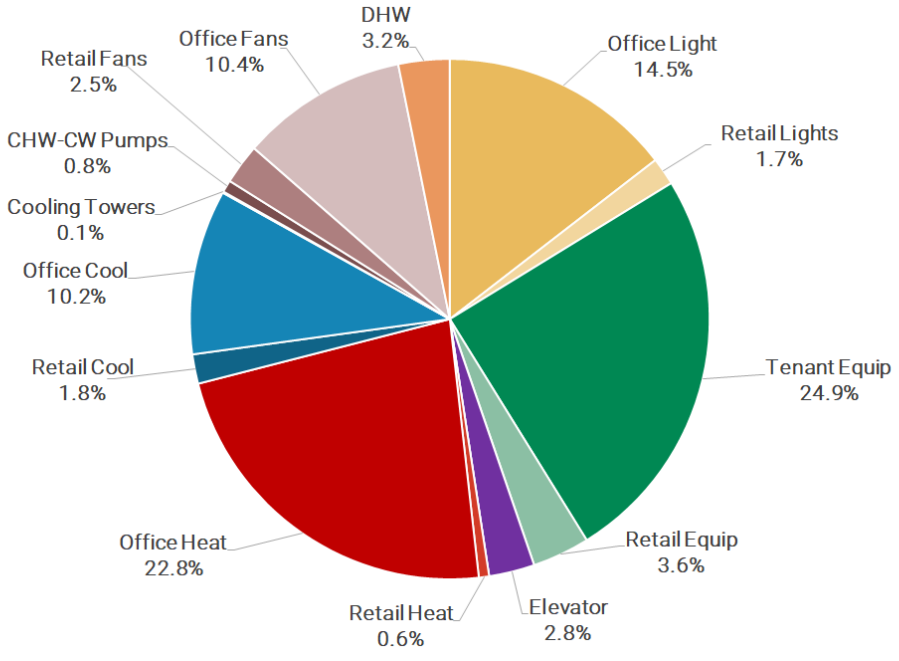
1359 Broadway Energy Model: 2019 Energy Breakdown by End-Use

Office and retail lighting/equipment accounts for 44.7% of the total 2019 energy usage

Major End Uses:

- Office + Retail Lighting & Equip. – 44.7%
- Office + Retail Heating – 23.4%
- Office + Retail Fans – 12.9%
- Office + Retail Cooling – 12.1%
  - DX units and cooling towers



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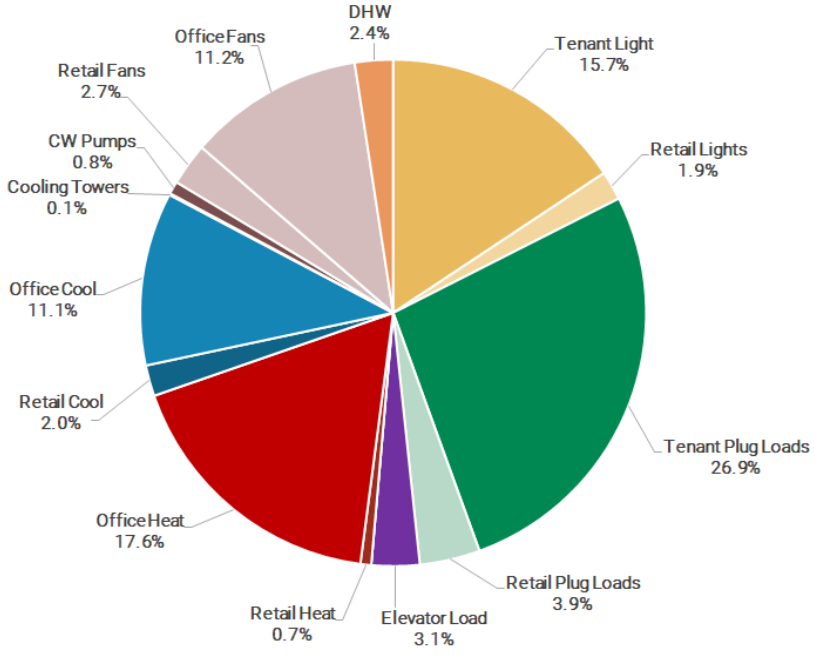
1359 Broadway Energy Model: 2019 CO2e Emissions Breakdown by End-Use

Office and retail lighting/equipment accounts for 48.4% of the total 2019 CO2e emissions

Major End Uses:

- Office + Retail Lighting & Equip. – 48.4%
- Office + Retail Heating – 18.3%
- Office + Retail Fans – 13.9%
- Office + Retail Cooling – 13.2%
  - DX units and cooling towers



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1359 Energy Model: 2019 CO2e Emissions Breakdown by User

Office and retail tenants account for ~76% of total 2019 CO2e emissions

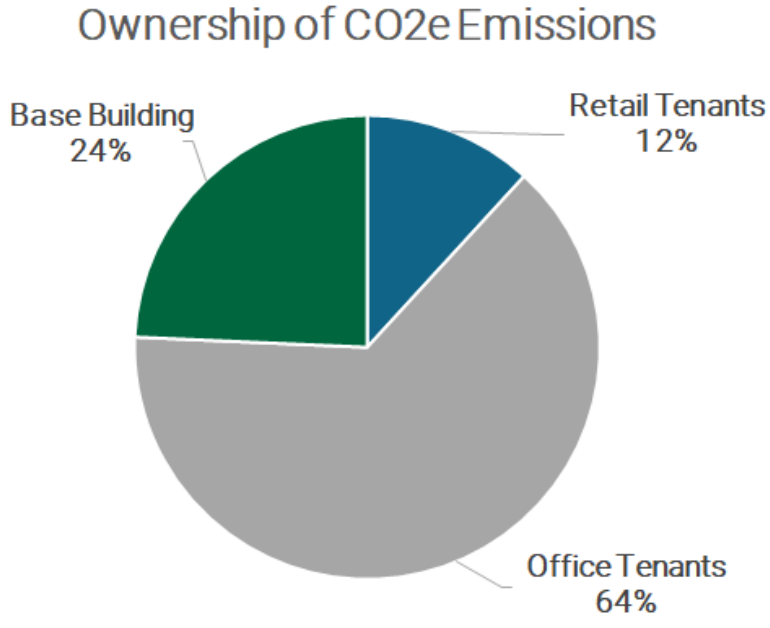
Base Building includes:

- Central gas-to-steam system
- Elevators
- Lobby HVAC units
- BOH lighting and equipment

Office and Retail tenants are responsible for their respective HVAC systems

Wolfgang's and fresh&co (restaurants) are high energy users

Space Type	Square Footage		Energy Intensity	Carbon Intensity
	SF	%	(kBtu/SF/year)	(lbs/SF/year)
Retail Tenants	15,849	4.2%	210.7	34.8
Office Tenants	362,633	95.8%	49.9	8.2



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1359 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

ECM Packages

Five packages of ECMs developed to optimize NPV and CO2 reductions & test various HVAC systems

1	2	3	4	5
CO2 Light	**CO2 Mid**	**CO2 High - VRF**	**CO2 High - Hydro**	**CO2 Max**
Steam trap replacements & upgrade tenant systems (lighting, plug loads, IT cooling, VRF)	CO2 Light + BMS upgrades & VAV optimization, TX ERV, Wolfgang upgrades, 2nd floor chiller optimization	CO2 Mid + radiant barriers, natural ventilation advisor, window upgrades	CO2 High, but exchange VRF with centralized air source heat pump & WWHPs for DHW preheat	CO2 High VRF + envelope measures, central domestic heat pump
Partial electrification	Majority electrification	Majority electrification	Majority electrification	Full electrification

Carbon Reduction

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ECM Phases & Implementation Timeline: CO2 Mid

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE														
Phase	Tag	Short Name	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Phase 1	CO001	BMS Backbone	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO002	DDC VAV boxes & BMS Radiator Valves, Setpoints, Steam Pressure	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO005	Retail BMS Upgrades	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS002	Radiator Trap Audit & Replacements	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	AS004	Decouple IT loads from 2nd Flr Chiller	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	CO006	Demand Control Ventilation for Kitchen	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	DW002	Wolfgang's Domestic Water Heat Pump	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN006	Mitigate Lobby Infiltration	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	LT001	Efficient Light Fixtures & Layout	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3	TL001	Tenant Plug Load Controls	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%
Phase 3	TL002	Tenant IT Cooling	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%
Phase 3	LT002	Day Lighting & Vacancy Control	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%
Phase 3	AS001	VRF + ERV	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%
Phase 3	AS002	TX Duct to ERV	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%
Phase 3	CO003	Outside Air Flow Control & Demand Controlled Ventilation	0%	0%	0%	8%	17%	25%	33%	42%	50%	58%	67%	75%	83%	92%	100%	100%

1359 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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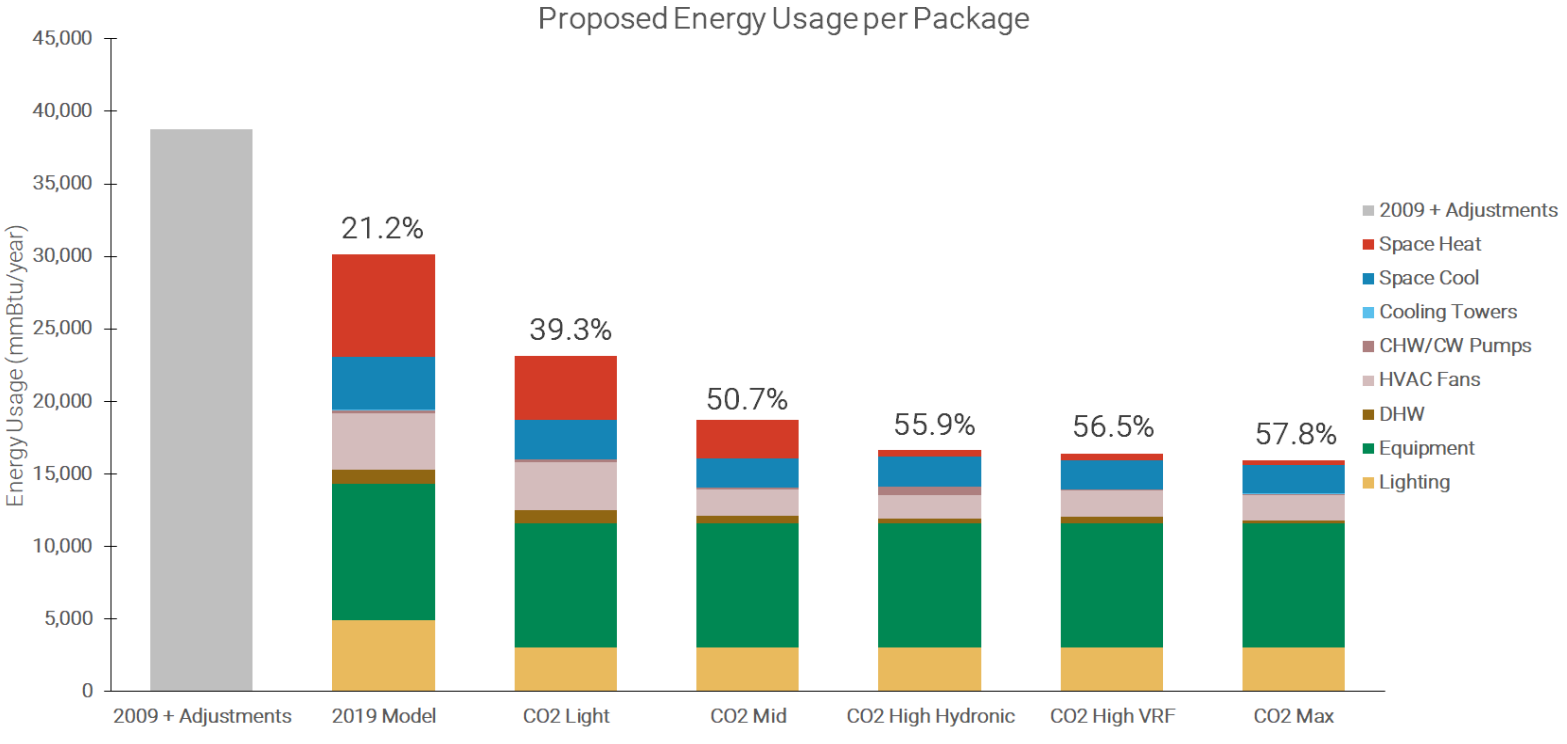
ECM Package Comparison - Energy

Packages range from 39.3% to 57.8% reduction in total energy from 2009 + Adjustments benchmark year



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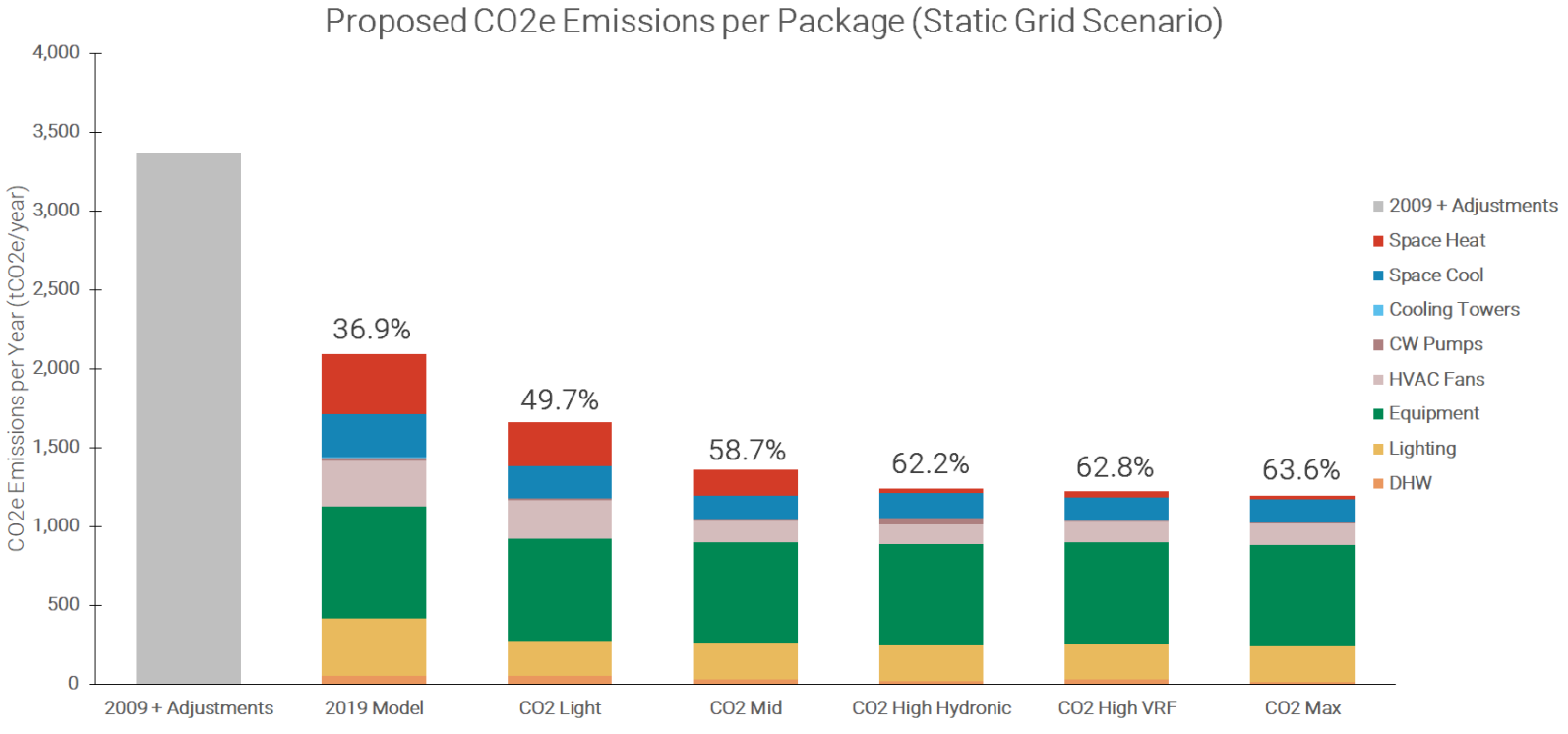
Projected CO2 Emissions – Static 2019 Grid Scenario

Packages range from 49.7% to 63.6% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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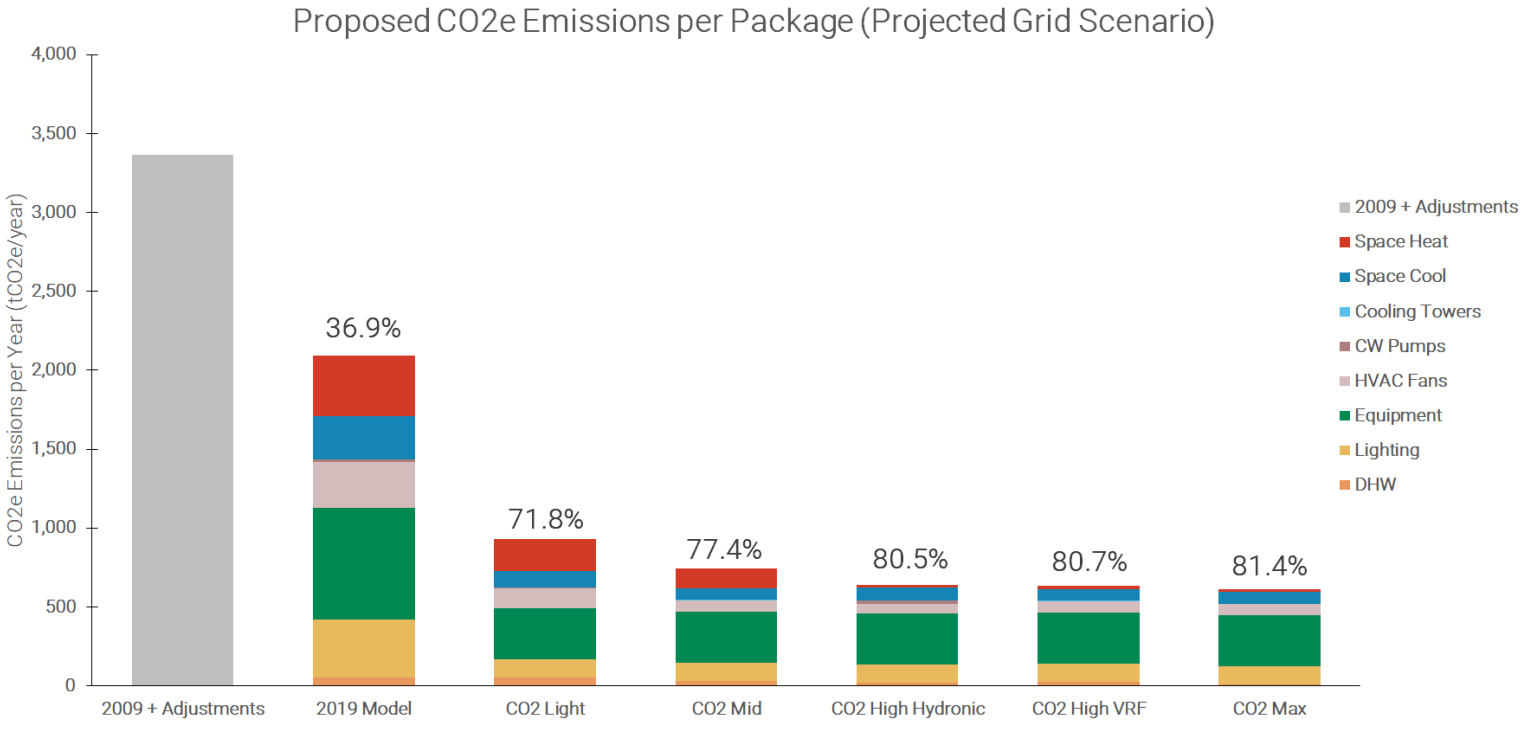
Projected CO2 Emissions – Projected Grid Scenario

Packages range from 71.8% to 81.4% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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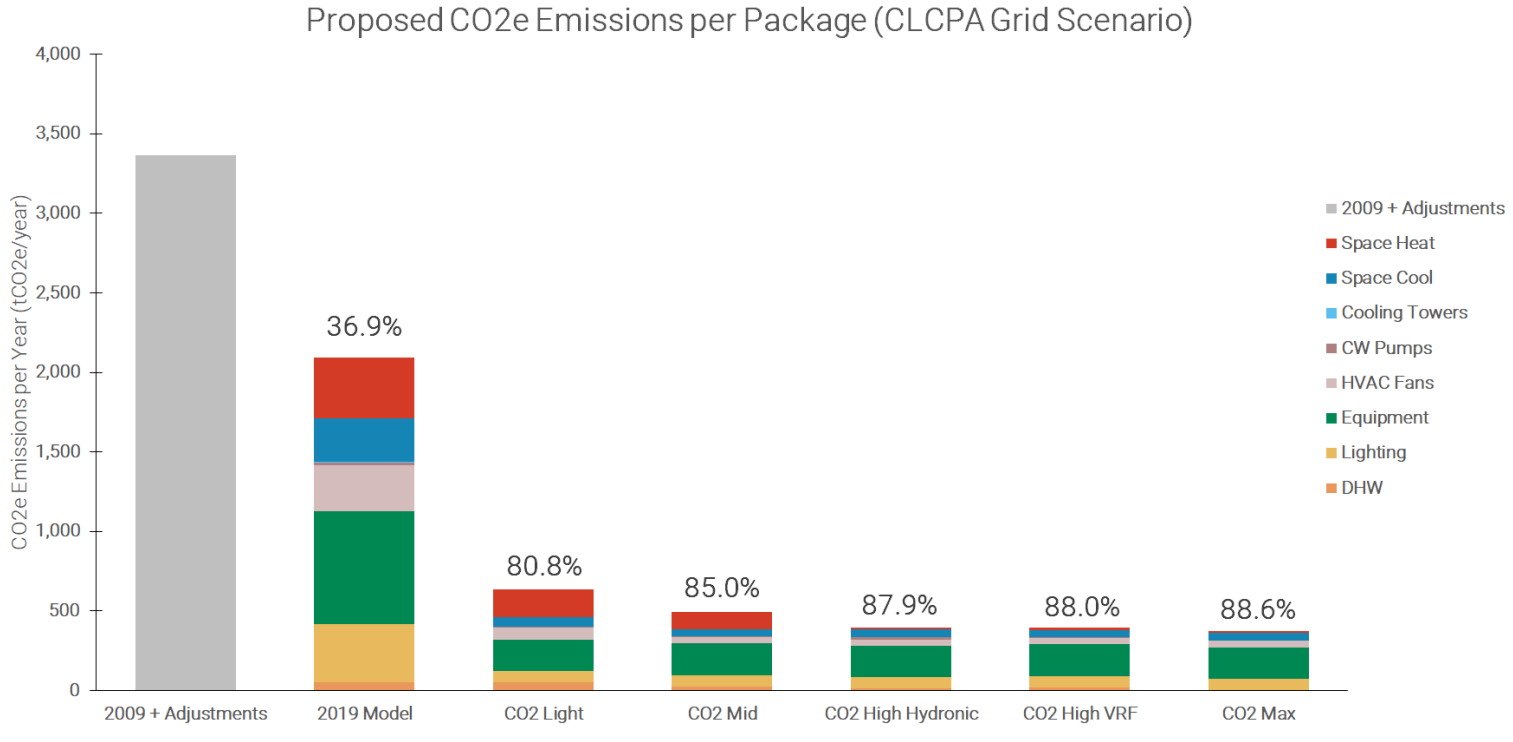
Projected CO2 Emissions - CLCPA Grid Scenario

Packages range from 80.8% to 88.6% reduction in total CO2e emissions from 2009 + Adjustments benchmark year



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1359 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

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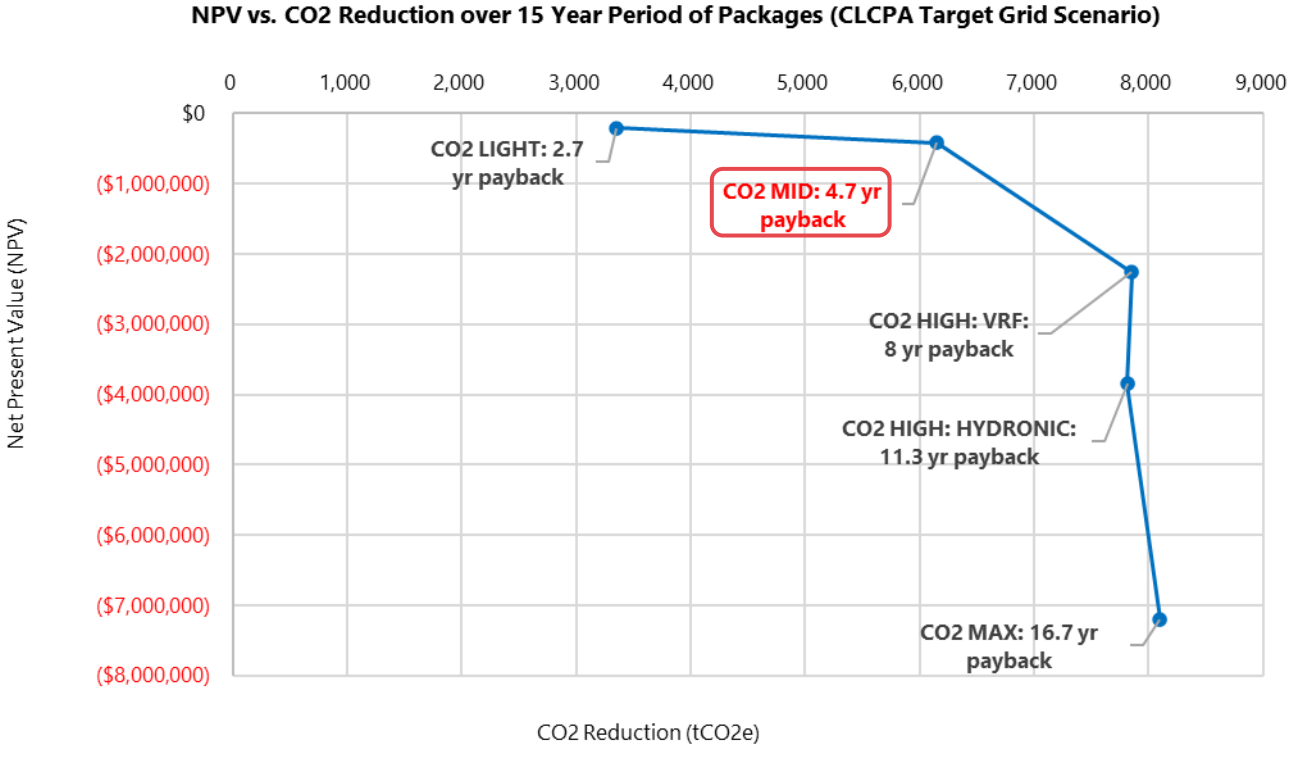
NPV, CO2 Reductions and Simple Payback for all Packages

Although CO2 High VRF has a payback of only 8 yrs, CO2 Mid meets both 80% reduction target and LL97 limits



NPV calculated with 6% discount rate

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LL97 Annual Fines for all Packages

With BAU scenario, 1359 would begin seeing fines in 2030 with a static grid
Implementation of any package between CO2 Mid - Max would eliminate fines for CLCPA grid scenario

Packages	CLCPA Grid Scenario				Projected Grid Scenario				Static Grid Scenario			
	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages
2019 Baseline	$0	$0	$94,416	-	$0	$0	$191,267	-	$0	$68,376	$429,992	-
CO2 Light	$0	$0	$11,184	$83,231	$0	$0	$92,109	$99,158	$0	$0	$291,576	$138,416
CO2 Mid	$0	$0	$0	$94,416	$0	$0	$42,391	$148,876	$0	$0	$211,346	$218,646
CO2 High - VRF	$0	$0	$0	$94,416	$0	$0	$13,407	$177,861	$0	$0	$175,912	$254,081
CO2 High - Hydronic	$0	$0	$0	$94,416	$0	$0	$15,940	$175,327	$0	$0	$182,571	$247,421
CO2 Max	$0	$0	$0	$94,416	$0	$0	$3,244	$188,024	$0	$0	$161,816	$268,176

*The 2035 GHG emissions limit has not yet been defined and calculations are based on long-term LL97 80% reduction limits.

Recommended Package – CO2 Mid

	CO2 Light	CO2 Mid	CO2 High - VRF	CO2 High - Hydronic	CO2 Max
NPV TOTALS	($211,272)	($416,493)	($2,264,058)	($3,843,504)	($7,203,216)
Total Capital Cost*	($3,008,281)	($5,586,968)	($8,588,498)	($10,525,345)	($16,175,533)
Annual Energy Cost Savings	$382,733	$633,622	$709,062	$664,959	$758,815
Annual Repairs & Maintenance Savings	$31,200	$35,200	$53,575	$50,975	$53,575
Incentives	$1,904,620	$2,455,932	$2,505,123	$2,468,499	$2,617,711
Simple Payback	**2.67**	**4.68**	**7.98**	**11.25**	**16.69**

CO2 Light Reduction – Upgrade tenant systems (lighting, plug loads, HVAC), partial electrification
CO2 Mid Reduction – Upgrade tenant systems and resolve current building inefficiencies, partial electrification
CO2 High Reduction: VRF – CO2 Mid and accessory energy saving measures, partial electrification
CO2 High Reduction: Hydronic – CO2 High VRF but with hydronic systems, partial electrification
CO2 Max Reduction – CO2 High VRF + envelope measures + central domestic heat pump, full electrification

*Excluding construction escalation costs

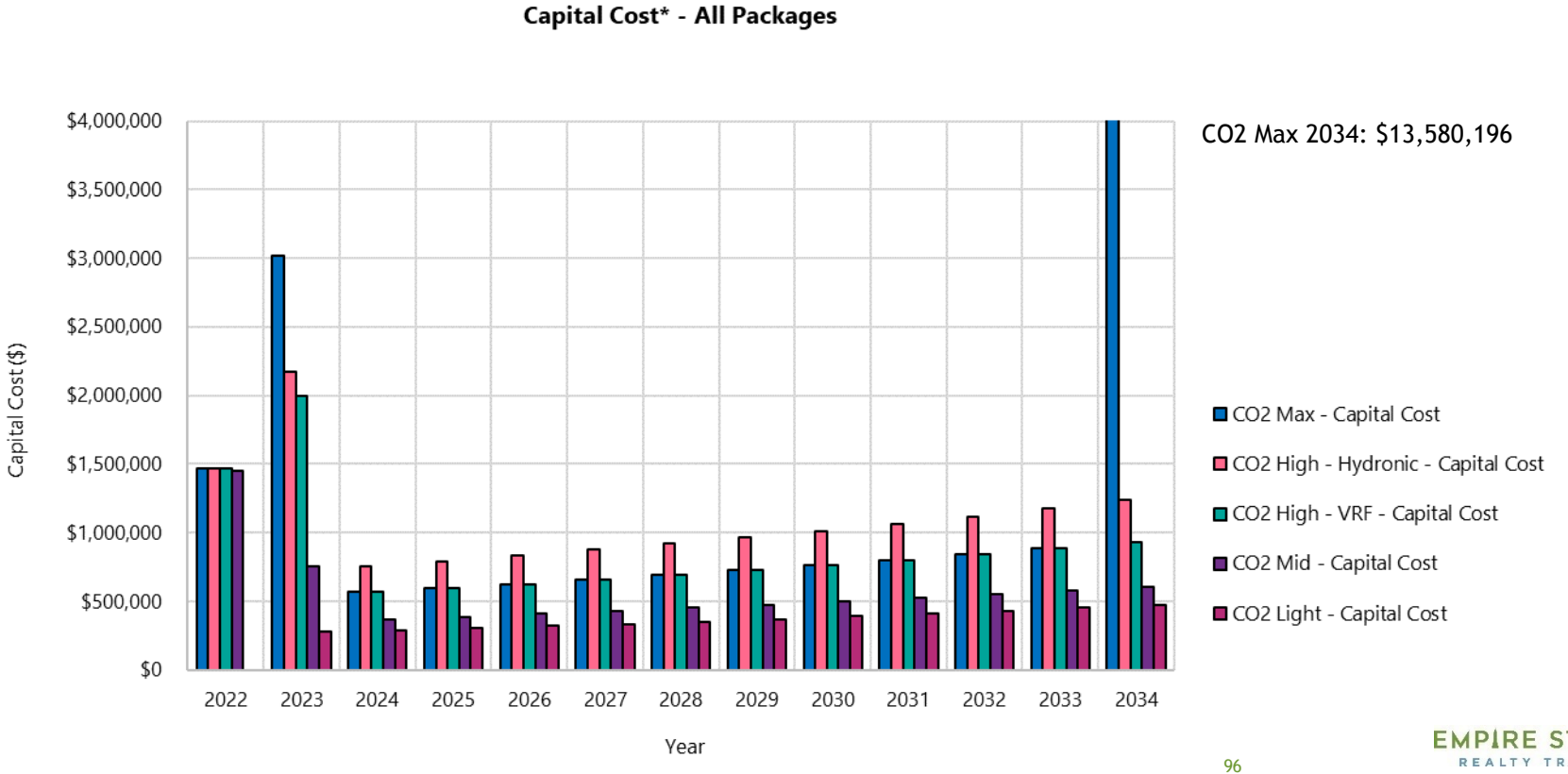
Recommended Package – CO2 Mid

- Upgrade controls for existing systems—not included in CO2 Light— since it provides good, immediate carbon savings and reduces risks of not meeting targets on time if existing systems are kept in place longer than our model anticipates
  - Will reduce system conflict between tenant cooling systems and base building steam heating system
  - These upgrades pay back well within the remaining useful life of these systems and improve comfort and acoustics
- Resolve current building inefficiencies through minor system upgrades
  - Removing IT Loads from the 2nd floor tenant chiller should reduce run time and capacity issues
  - Providing adequate sealing at lobby façade will reduce infiltration and stack effect
  - Providing DCV for kitchen exhaust systems and water source heat pumps for retail DHW usage will improve retail system efficiencies
- Plan for replacement of existing self-contained air-cooled systems with hybrid VRF heat pumps at minimal incremental cost at the time of tenant fit outs
  - Uncompetitive market for through-wall air-cooled units which struggle to conform with forthcoming energy codes; in contrast VRF systems are offered by multiple manufacturers with robust warranties
  - VRF systems are very efficient and allow for on-floor heat recovery:
    - Lower distribution energy required – water/refrigerant is the medium used, not air, up to the space served
    - Each zone produces the volume and temperature of air required to satisfy the load in that specific zone
    - Allows heat recovery to heat perimeter zones using heat produced from cooling interior zones
    - More energy efficient due to multiple inverter driven compressors
    - Allows decoupling of outdoor air and conditioning air – resulting in proper zone ventilation and improved air quality

1359 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

Annual Capital Cost per Package



CO2 Max 2034: $13,580,196

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1359 Broadway Next Steps – 2022 Projects

The recommended 2022 measures are focused on control measures that have a short payback and will enable energy reduction opportunities in the future.

Project	2022 Total Cost	Anticipated Incentives ($)	Total 2022 Cost w/ Incentives ($)	Energy Cost Savings
DDC VAV boxes & BMS Radiator Valves, Setpoints, Steam Pressure	$808,962	$245,140	$563,822	$111,542
Decouple IT loads from 2nd Flr Chiller	$113,300	$12,064	$101,236	$5,488
Retail BMS Upgrades	$44,000	$40,000	$4,000	$18,897
Radiator Trap Audit & Replacements	Included in LL87 Compliance Budget	-	-	$3,787
Natural Ventilation Advisor Pilot	$995	$905	$90	$661
Total	**$967,257**	**$298,109**	**$669,148**	**$140,375**
BMS Backbone	$440,000	$0	$440,000	$0
Total with BMS	**$1,407,257**	**$298,109**	**$1,109,148**	**$140,375**

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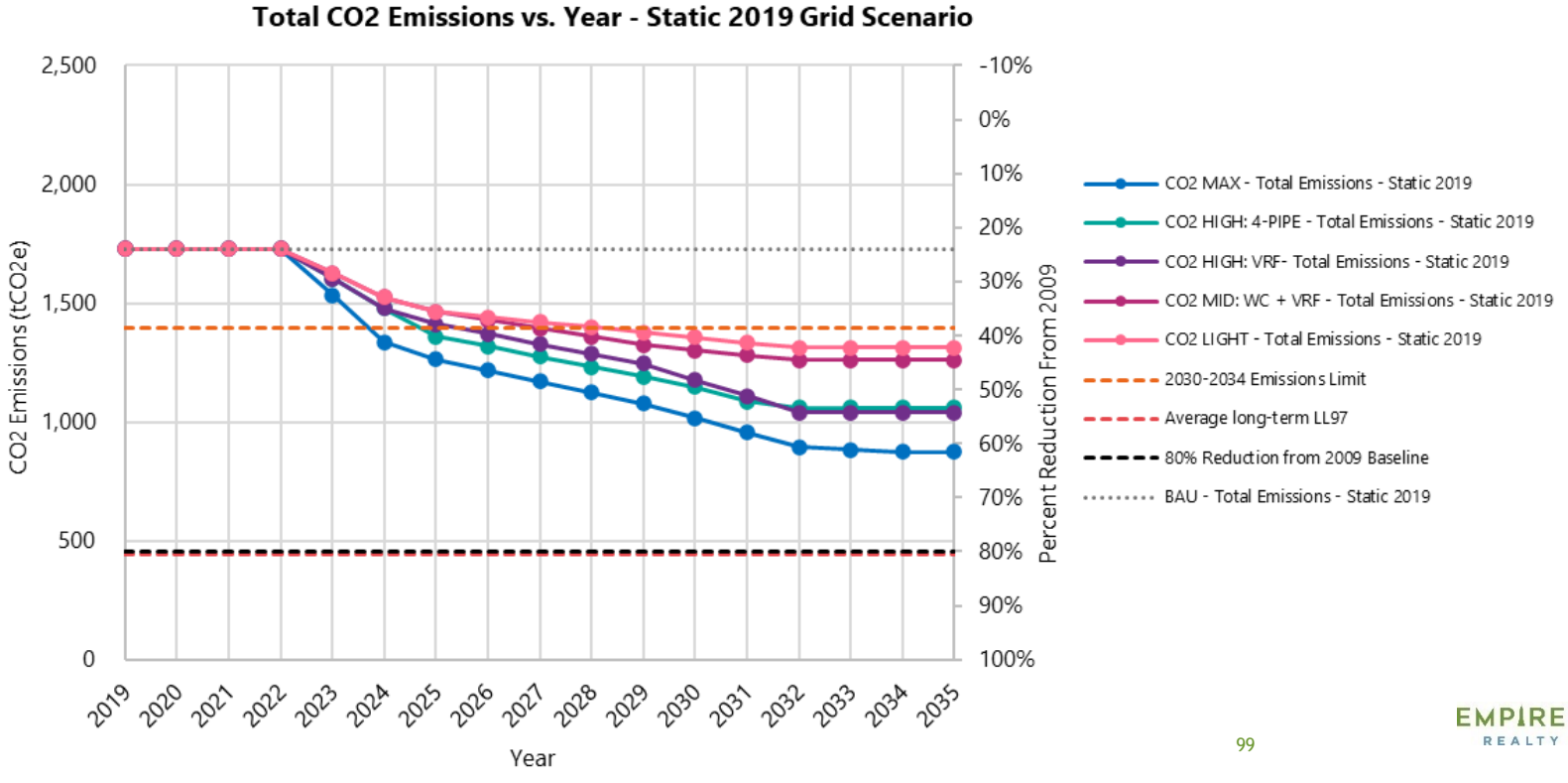
1333 Broadway

Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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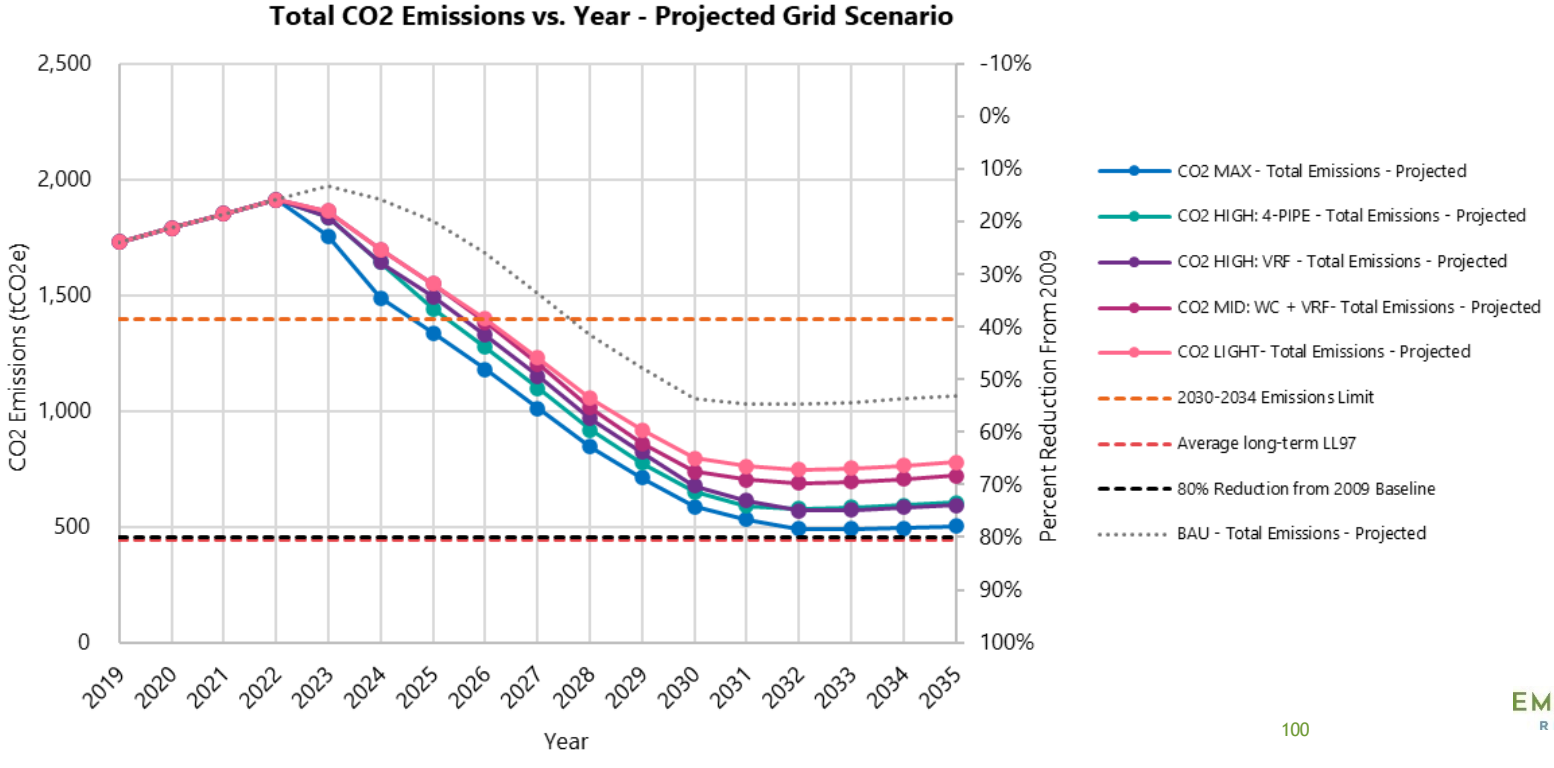
Projected Annual Carbon Emissions – Projected Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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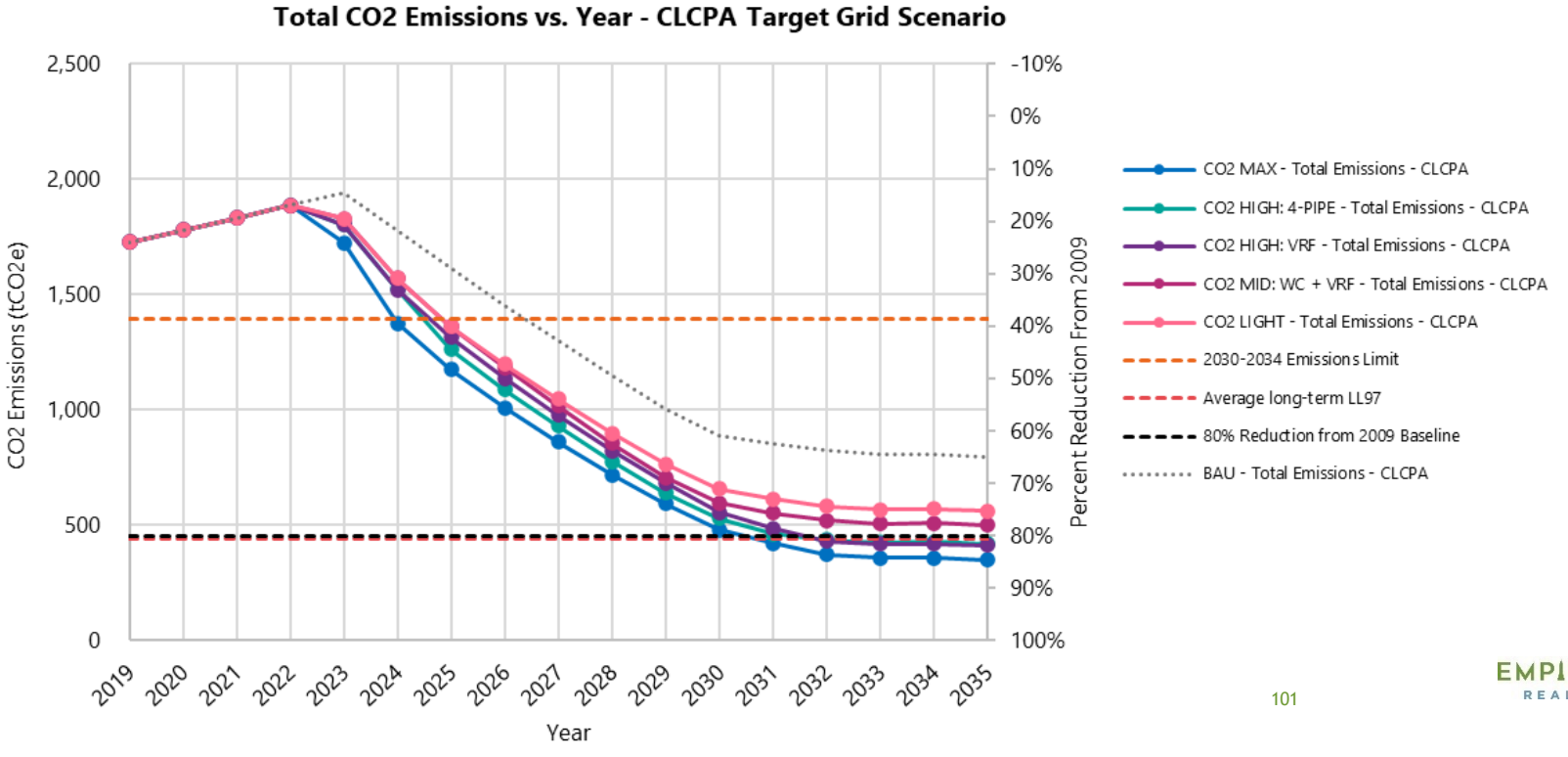
Projected Annual Carbon Emissions – CLCPA Grid Scenario

CO2 High – Max would meet **80% reduction** from 2009 baseline by **2035**;
CO2 High - Max would meet **average long-term LL97 limit**



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Percent Carbon Emissions Reductions – All Grid Scenarios

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-41.2%	-49.3%	-55.4%	-61.6%
CO2 HIGH: 4-PIPE	-33.6%	-38.6%	-49.7%	-53.5%
CO2 HIGH: VRF	-31.9%	-39.8%	-48.4%	-54.4%
CO2 MID: WC + VRF	-24.6%	-27.1%	-42.9%	-44.7%
CO2 LIGHT	-21.5%	-24.0%	-40.5%	-42.4%

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-66.1%	-70.9%	-74.3%	-78.0%
CO2 HIGH: 4-PIPE	-62.3%	-65.0%	-71.4%	-73.5%
CO2 HIGH: VRF	-60.8%	-65.6%	-70.3%	-74.0%
CO2 MID: WC + VRF	-57.4%	-58.3%	-67.7%	-68.4%
CO2 LIGHT	-54.0%	-55.0%	-65.1%	-65.9%

No packages would meet **80% reduction** from 2009 baseline by **2035**;
No packages would meet **average long-term LL97 limit**

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	2009 - 2030	2009 - 2035
CO2 MAX	-72.2%	-79.7%	-78.9%	-84.6%
CO2 HIGH: 4-PIPE	-69.4%	-75.8%	-76.8%	-81.6%
CO2 HIGH: VRF	-67.9%	-76.1%	-75.7%	-81.9%
CO2 MID: WC + VRF	-65.4%	-71.0%	-73.8%	-78.0%
CO2 LIGHT	-62.0%	-67.5%	-71.2%	-75.4%

CO2 Max, CO2 High: 4-Pipe, and CO2 High: VRF packages would meet **80% reduction** from 2009 baseline by **2035**;
CO2 Max, CO2 High: 4-Pipe, and CO2 High: VRF packages would meet **average long-term LL97 limit**

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1333 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

1333 Broadway – Current Building Systems

- Floors 8-12 and part of 7
  - Steam radiators (gas boiler), thermostatic valves and water-cooled DX VAV air handlers
- Floors 3-6 and balance of 7
  - Steam radiators (gas boiler), manual valves and self-contained air-cooled DX VAV
- Urban Outfitters
  - Split DX and gas fired RTUs
- Shake shack
  - Air-cooled VRF
- Other retail
  - Self-contained air-cooled DX

2019 Energy Breakdown by Utility

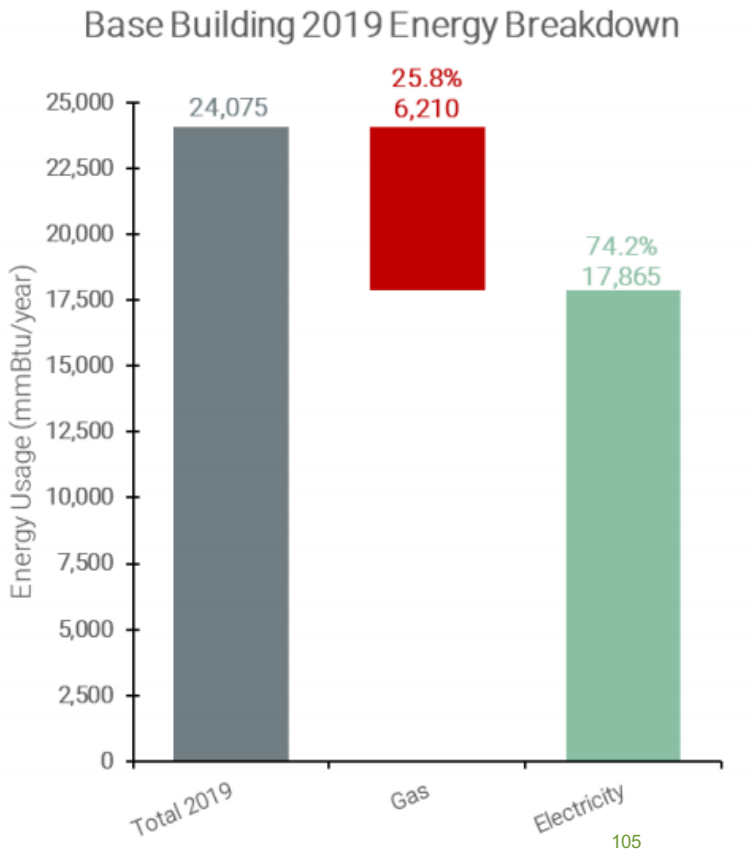
Natural gas consumption used for heating makes up 25.8% of energy usage

Electricity

- 74.2% of energy usage
- 80.3% of CO2e emissions

Natural Gas

- 25.8% of energy usage
- 19.7% of CO2e emissions



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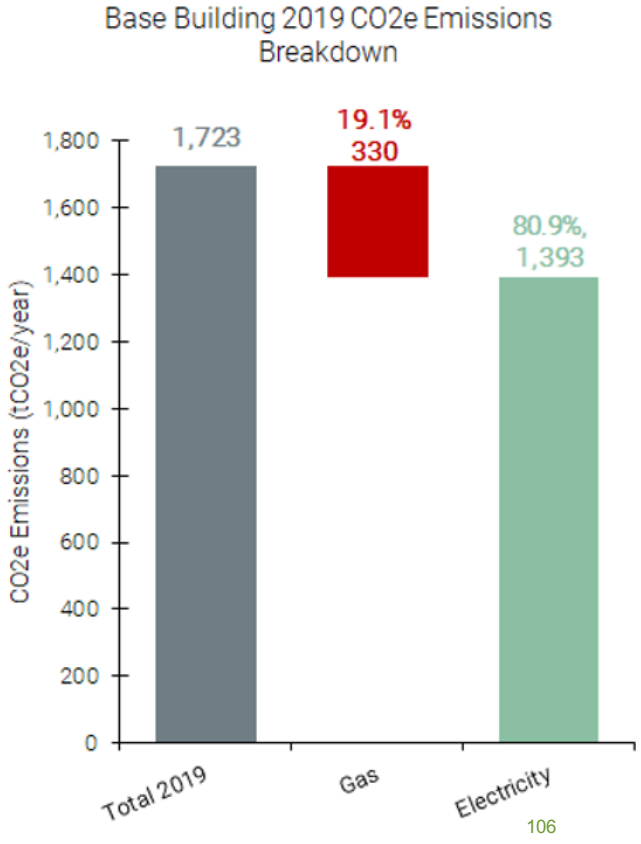
2019 CO2e Emissions Breakdown by Utility

Natural gas has slightly lower associated emissions than electricity

Electricity - 256.0 tCO2e/GWh

Natural Gas - 181.2 tCO2e/GWh (LL97)



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2019 Operational Cost Breakdown by Utility

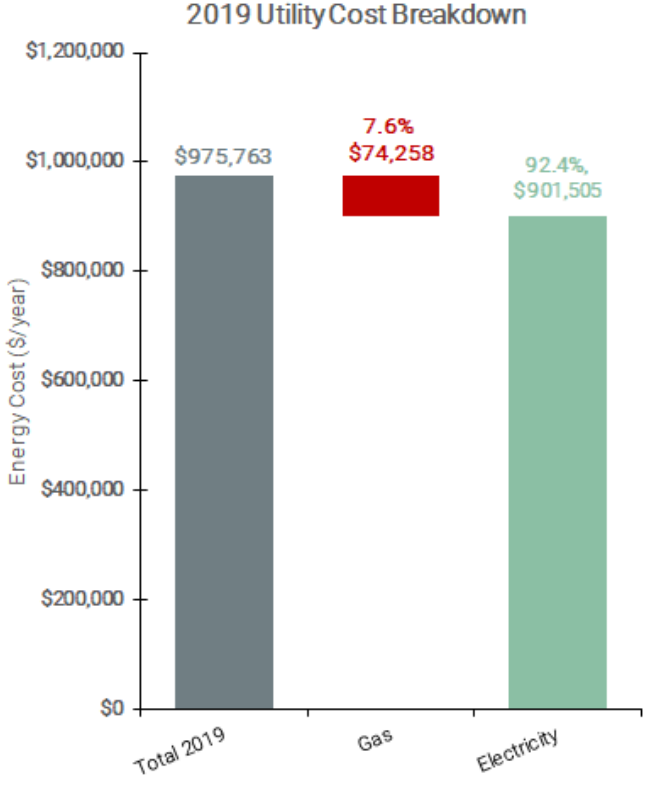
Natural gas is cheaper than electricity & therefore makes up a smaller portion (7.6%) of utility costs

Electricity

- 92.4% of operational costs
- 74.2% of energy usage

Natural Gas

- 7.6% of operational costs
- 25.8% of energy usage



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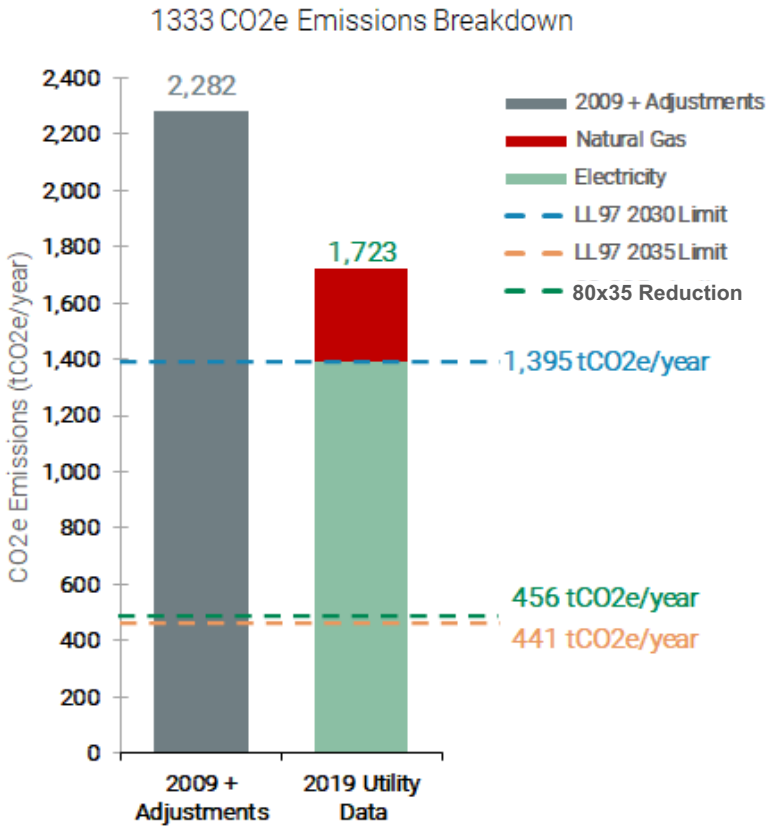
1333 Broadway Current Status for LL97 and 80x35 Metrics



Key Takeaways:

- Building meets 2024 limit of 2,871 tCO2e/year
- 19.0% emissions reduction is required to meet LL97 2030 target
- 74.4% emissions reduction is required to meet LL97 2035 target
  - Building + grid improvements

24.5% CO2e reduction between 2009 and 2019

- 57% due to a switch of boiler fuel source from fuel oil to natural gas
- 43% due to electrical grid improvements

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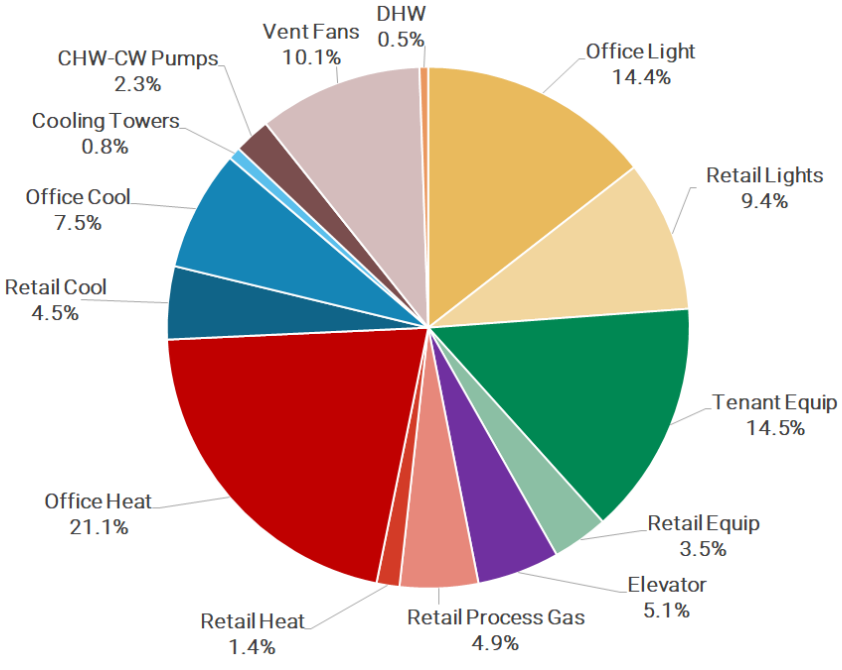
1333 Broadway Energy Model: 2019 Energy Breakdown by End-Use

Office and retail lighting/equipment accounts for 46.7% of the total 2019 energy usage

Major End Uses:

- Office + Retail Lighting & Equip. – 46.7%
- Office + Retail Heating – 22.5%
- Office + Retail Cooling – 12.8%
  - DX units and cooling towers
- All Fans – 10.1%



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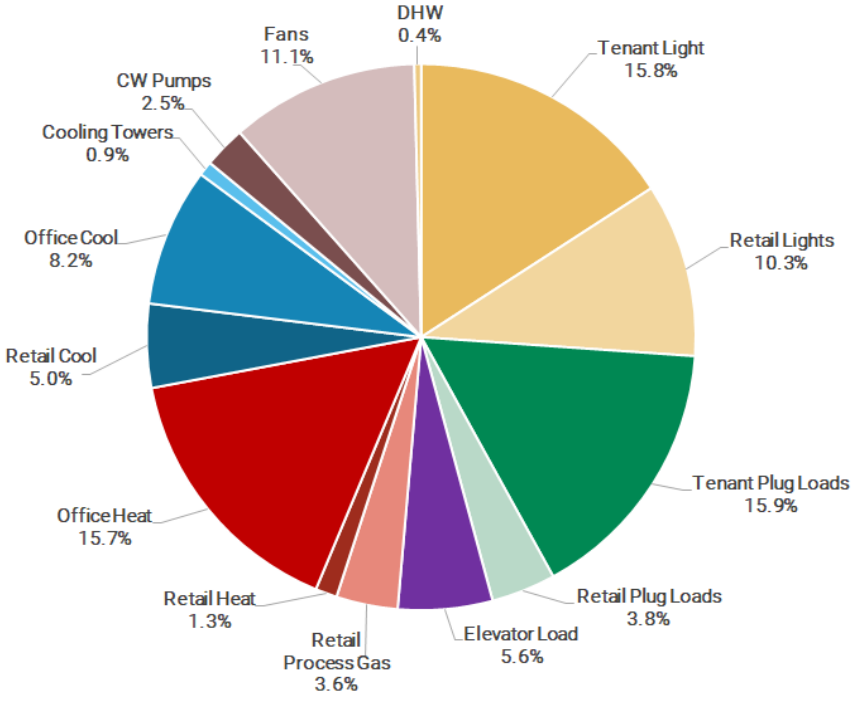
1333 Broadway Energy Model: 2019 CO2e Emissions Breakdown by End-Use

Office and retail lighting/equipment accounts for 49.8% of the total 2019 CO2e emissions

Major End Uses:

- Office + Retail Lighting & Equip. – 49.8%
- Office + Retail Heating – 17.0%
- Office + Retail Cooling – 14.1%
  - DX units and cooling towers
- All Fans – 11.1%



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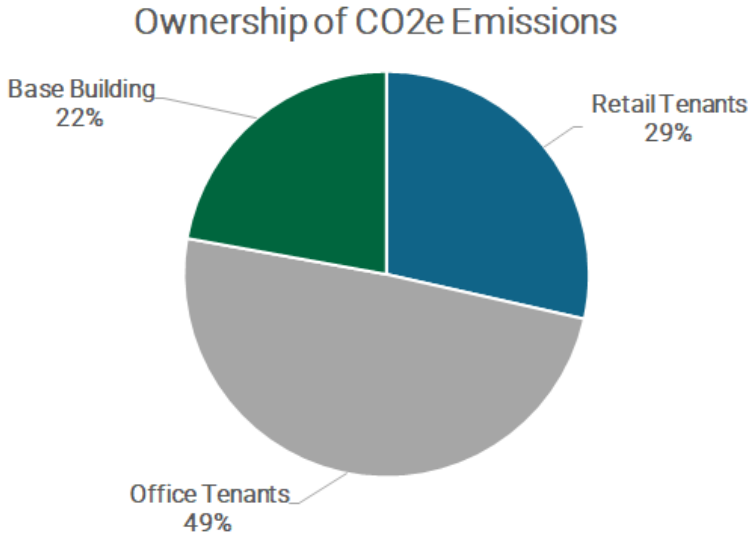
1333 Energy Model: 2019 CO2e Emissions Breakdown by User

Office and retail tenants account for ~68% of total 2019 CO2e emissions

Base Building usage includes:

- Central gas-to-steam system
- Elevators
- Lobby HVAC units
- BOH lighting and equipment



Office and Retail tenants responsible for their respective HVAC and CW system

Urban Outfitters is a high energy user due to lighting use and design

Shake Shack has significant natural gas load

Space Type	Square Footage		Energy Intensity	Carbon Intensity
	SF	%	(kbtu/SF/year)	lbs/SF/year
Retail Tenants	69,563	25%	81.1	14.6
Office Tenants	205,192	75%	56.4	8.6

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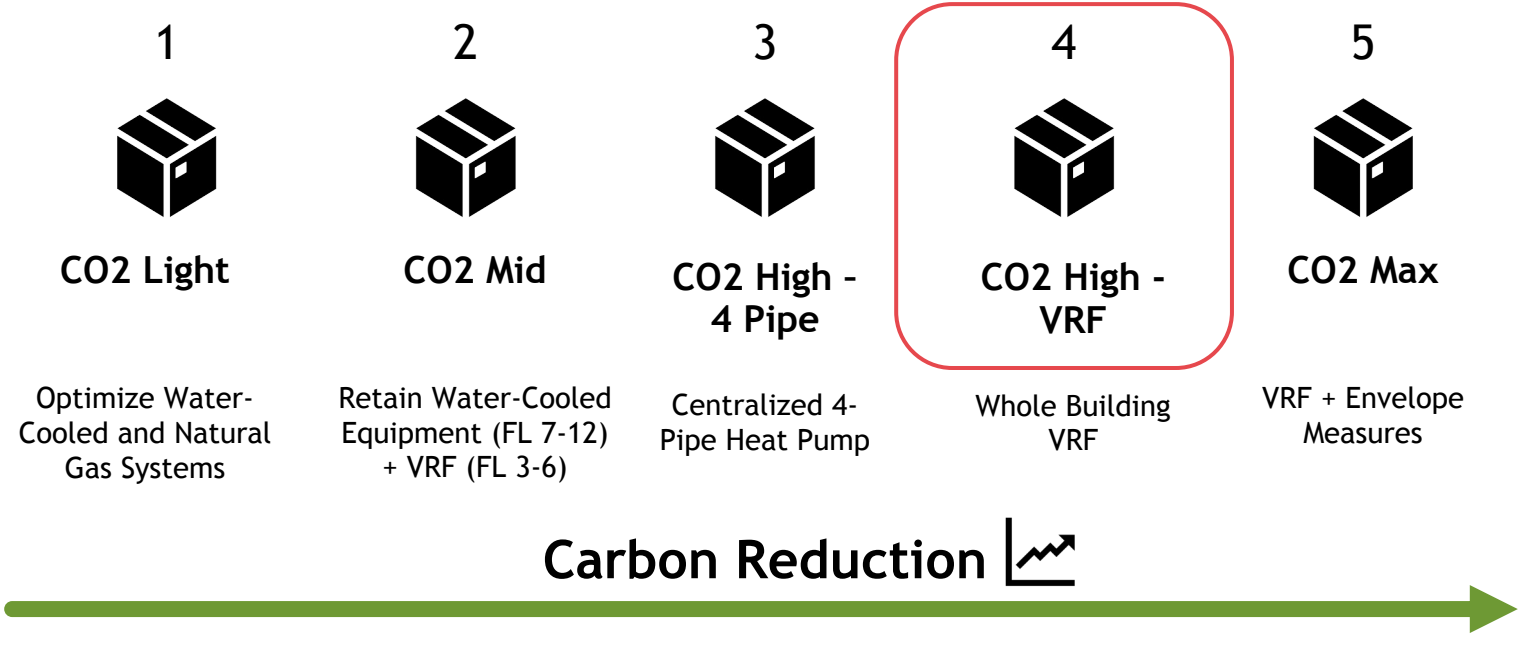
1333 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

ECM Packages

Five packages of ECMs developed to optimize NPV and CO2 reductions & test various HVAC systems



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ECM Phases & Implementation Timeline: CO2 High VRF

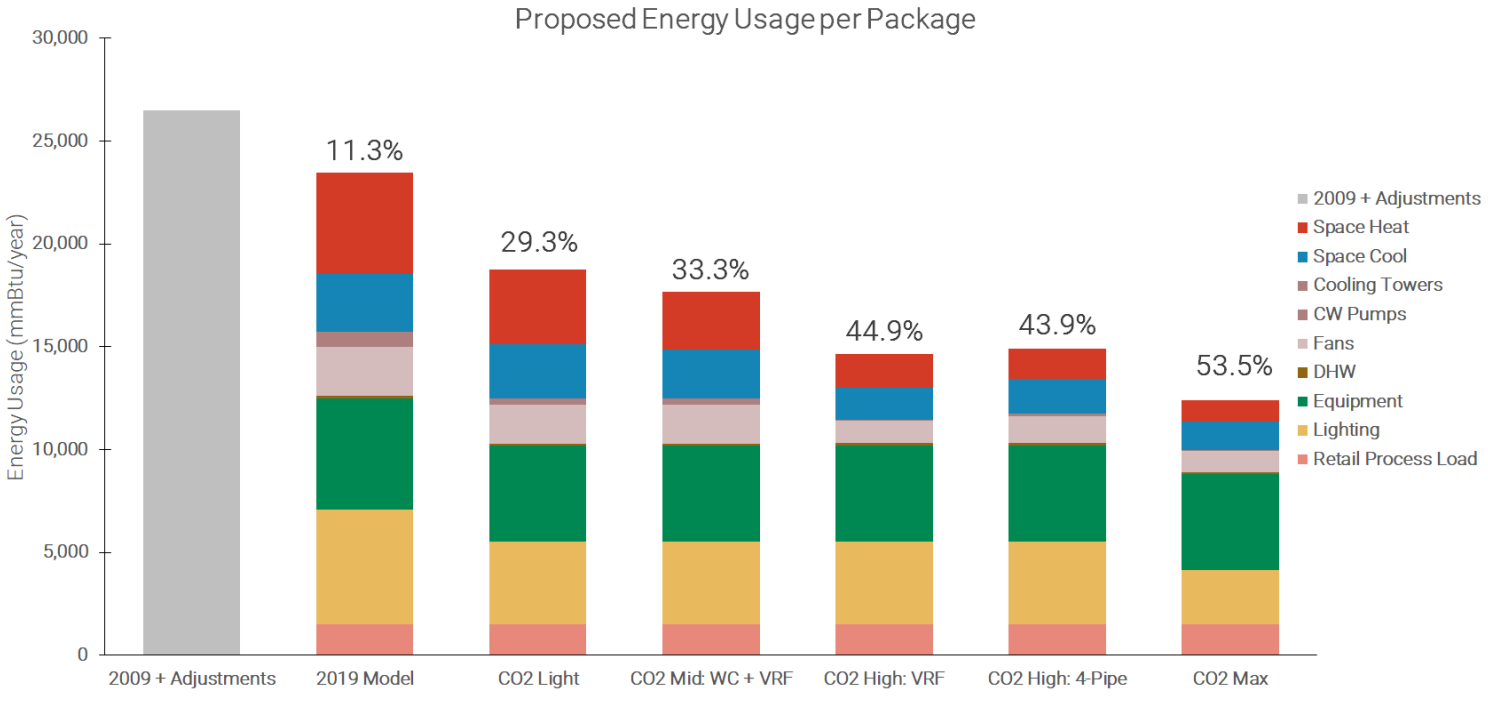
ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE									
Phase	**Tag**	**Short Name**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Phase 1	CO001	**DDC VAV boxes & BMS Radiator Valves, Setpoints, Steam pressure**	33%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO002	**Outside Air Flow Control & Demand Controlled Ventilation**	33%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO005	**Retail Equipment BMS**	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO006	**Condenser Water Pumping & Temperature**	50%	100%									
Phase 1	EN011	**Window U-Value & SHGC Improvements**	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS004	**Radiator Trap Audit & Replacements**	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	LT001	**Plug Load Control**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%
Phase 2	LT002	**Efficient Light Fixtures & Layout**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%
Phase 2	LT005	**Day Lighting & Vacancy Control**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%
Phase 2	LT009	**Tenant IT Cooling**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%
Phase 3	AC003	**Replace Water-Cooled AC w/ Air-Cooled VRF + ERV (Floors 7-12)**	0%	0%	0%	0%	0%	0%	0%	33%	67%	100%	100%
Phase 3	AC004	**Through-Wall or Roof VRF + ERV (Floors 3-6)**	0%	0%	0%	25%	50%	75%	100%	100%	100%	100%	100%
Phase 3	AC005	**Urban Outfitters Space VRF**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%
Phase 3	DW004	**AC Waste Heat Recovery for Domestic Hot Water**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%

1333 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

ECM Package Comparison - Energy

Packages range from 29.3% to 53.5% reduction in total energy from 2009 + Adjustments benchmark year



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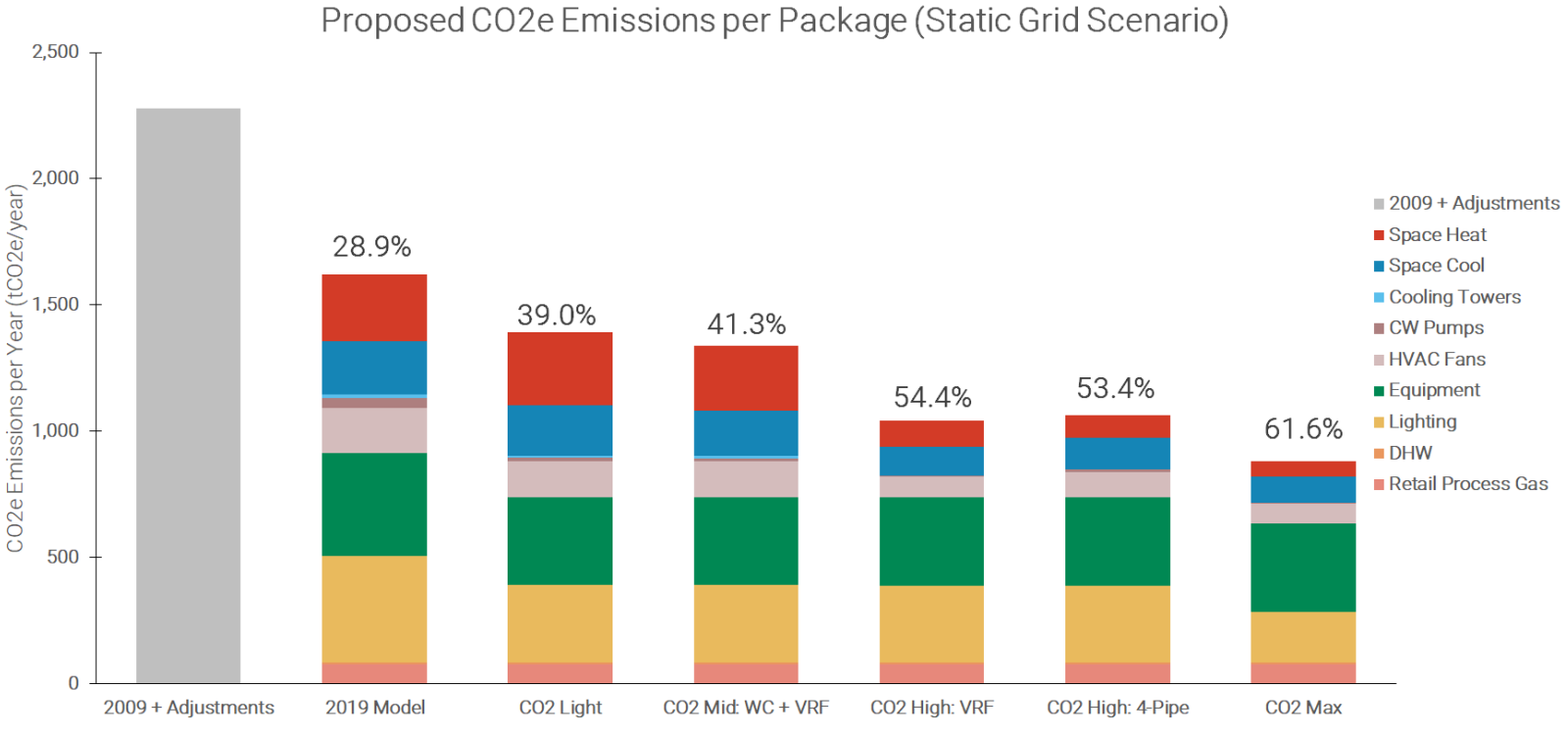
Projected CO2 Emissions – Static 2019 Grid Scenario

Packages range from 39.0% to 61.6% reduction in total emissions from 2009 + Adjustments benchmark year



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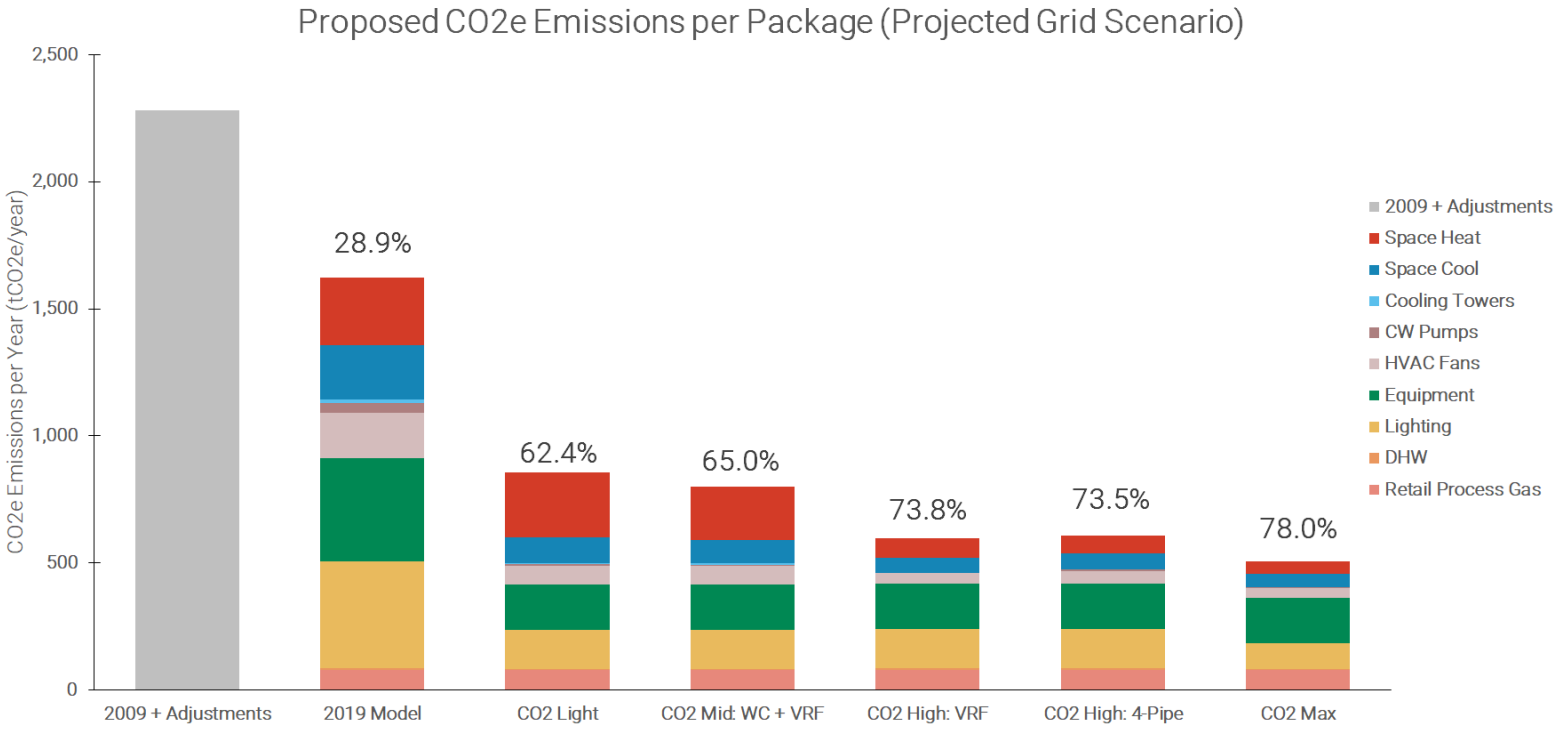
Projected CO2 Emissions – Projected Grid Scenario

Packages range from 62.4% to 78.0% reduction in total emissions from 2009 + Adjustments benchmark year



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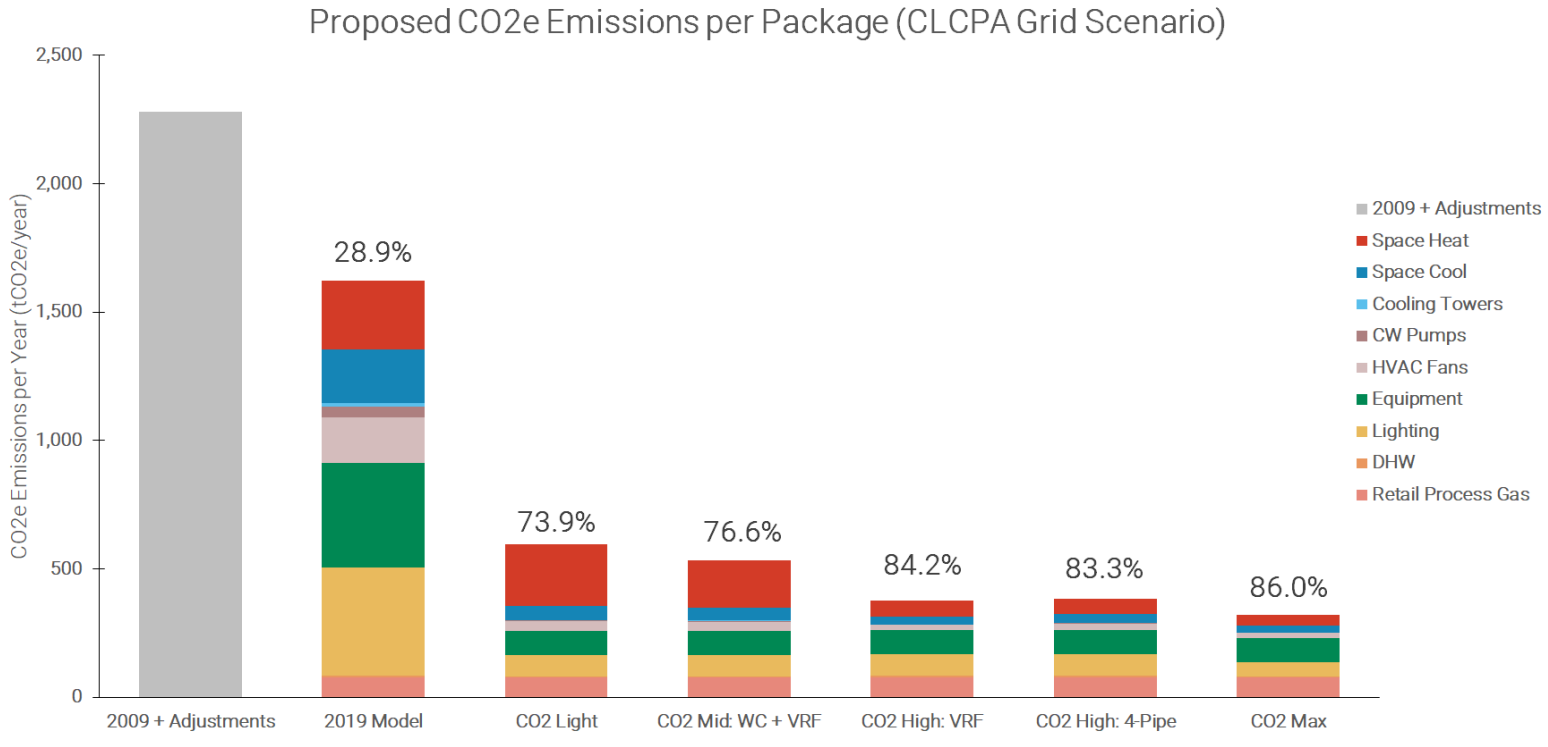
Projected CO2 Emissions - CLCPA Grid Scenario

Packages range from 76.6% to 86.0% reduction in total emissions from 2009 + Adjustments benchmark year



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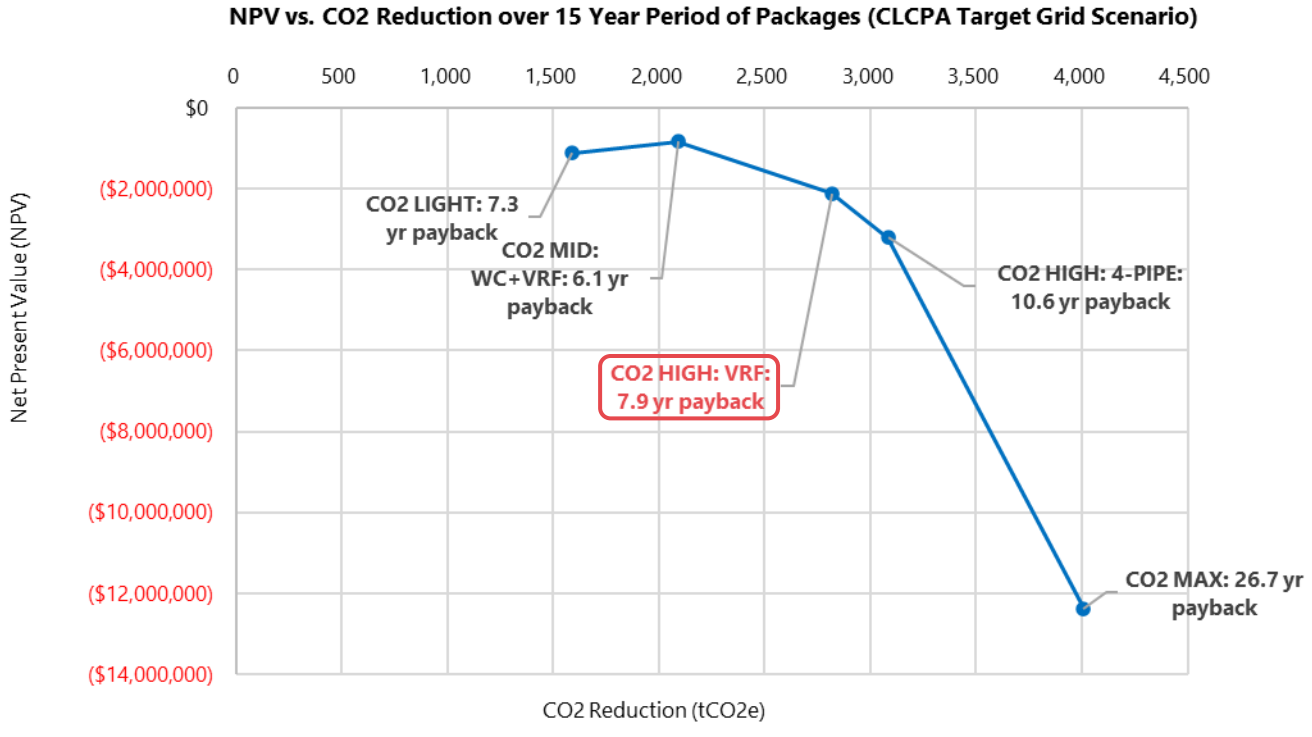
1333 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

NPV, CO2 Reductions and Simple Payback for all Packages



NPV calculated with 6% discount rate

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LL97 Annual Fines for all Packages

The recommended package is the lowest package that would avoid fines.
With BAU scenario, 1333 would begin seeing fines in 2030 with a static grid.
Implementation of 4-Pipe, VRF or CO2 Max packages would avoid all fines in the CLCPA grid scenario.

LL97 ANNUAL FINES												
Packages	**CLCPA Grid Scenario**				**Projected Grid Scenario**				**Static Grid Scenario**			
	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine Starting As Soon As 2035*	Fine Avoidance due to ECM Packages
2019 Baseline Consumption	$0	$0	$95,915	-	$0	$0	$167,797	-	$0	$446,116	$344,974	-
CO2 Light	$0	$0	$32,221	$63,694	$0	$0	$90,387	$77,410	$0	$0	$233,757	$111,217
CO2 Mid: WC + VRF	$0	$0	$16,055	$79,860	$0	$0	$74,774	$93,023	$0	$0	$219,506	$125,467
CO2 High: VRF	$0	$0	$0	$95,915	$0	$0	$40,986	$126,811	$0	$0	$160,560	$184,414
CO2 High: 4-Pipe	$0	$0	$0	$95,915	$0	$0	$43,859	$123,937	$0	$0	$166,330	$178,644
CO2 Max	$0	$0	$0	$95,915	$0	$0	$16,590	$151,207	$0	$0	$116,482	$228,492

*The 2035 GHG emissions limit has not yet been defined and calculations are based on long-term LL97 80% reduction limits.

Recommended Package – CO2 High: VRF

	CO2 Light	CO2 Mid: WC + VRF	CO2 High: VRF	CO2 High: 4-Pipe	CO2 Max
NPV TOTALS	($1,121,458)	($830,644)	($2,157,822)	($3,208,006)	($12,366,843)
Total Capital Cost*	($3,272,554)	($3,567,311)	($7,157,263)	($8,868,060)	($24,221,181)
Annual Energy Cost Savings	$305,945	$316,492	$530,066	$509,032	$668,097
Annual Repairs & Maintenance Savings	$600	$65,800	$160,075	$160,075	$160,075
Incentives	$1,033,931	$1,251,156	$1,674,749	$1,764,403	$2,069,445
Simple Payback	**7.30**	**6.06**	**7.94**	**10.62**	**26.75**

CO2 Light Reduction – Optimize the existing water-cooled and natural gas systems
CO2 Mid Reduction: WC + VRF – Retain water-cooled equipment (FL 7-12) + VRF (FL 3-6)
CO2 High Reduction: VRF – Whole building VRF
CO2 High Reduction: 4-Pipe – Centralized 4-pipe heat pump
CO2 Max Reduction – VRF + Envelope Measures

*Excluding construction escalation costs

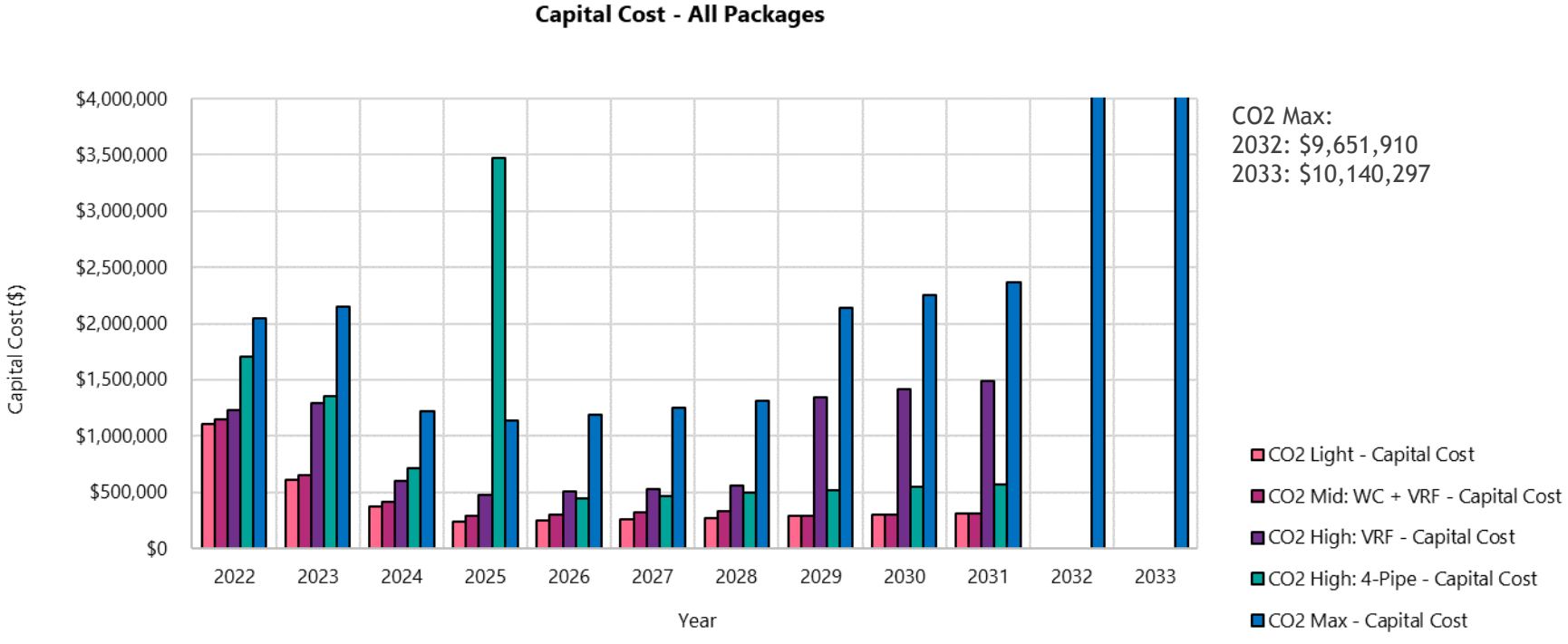
Recommended Package – CO2 High VRF

- Upgrading controls for existing systems provides significant immediate carbon savings and reduces risks of not meeting targets on time since many existing systems are fairly new and while their replacements drive a critical component of carbon emissions reductions, more efficient operation of existing systems will have payback within the remaining useful life of those systems
  - Optimization of cooling tower pumping and fan controls for condenser water system serving floors 7-12
  - Electronic radiator valves and BMS tie into VAV boxes
- This package plans for replacement of existing self-contained air and water-cooled systems with hybrid VRF heat pumps at minimal incremental cost at the time of tenant fit outs
  - Retaining water-cooled systems long term is not recommended because it serves only half of the building and requires a large central heat pump to provide heating to existing water-cooled systems
  - Limited market for through-wall air-cooled units which struggle to conform with forthcoming energy codes; in contrast VRF systems are offered by multiple manufacturers with robust warranties
  - VRF systems are very efficient and allow for on-floor heat recovery:
    - Lower distribution energy required – water/refrigerant is the medium used, not air, up to the space served
    - Each zone produces the volume and temperature of air required to satisfy the load in that specific zone
    - Allows heat recovery to heat perimeter zones using heat produced from cooling interior zones
    - Generally more energy efficient due to multiple inverter driven compressors
    - Allows decoupling of outdoor air and conditioning air – resulting in proper zone ventilation and improved air quality

1333 Broadway Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

Annual Capital Cost per Package



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1333 Broadway Next Steps – 2022 Projects

The recommended 2022 measures are focused on control measures that have a short payback and will enable energy reduction opportunities in the future.

Project	2022 Total Cost	Anticipated Incentives ($)	Total 2022 Cost w/ Incentives ($)	Energy Cost Savings
DDC VAV boxes & BMS Radiator Valves, Setpoints, Steam pressure	$364,131	$142,875	$221,256	$53,194
Outside Air Flow Control & Demand Controlled Ventilation	$155,100	$47,693	$107,407	$12,234
Retail Equipment BMS	$165,000	$98,390	$66,610	$40,056
Radiator Trap Audit & Replacements	Included in LL87 Compliance Budget	-	-	$6,000
Cooling Tower Optimization	$275,000	$82,500	$192,500	$20,876
Total	**$959,231**	**$371,457**	**$587,773**	**$132,360**

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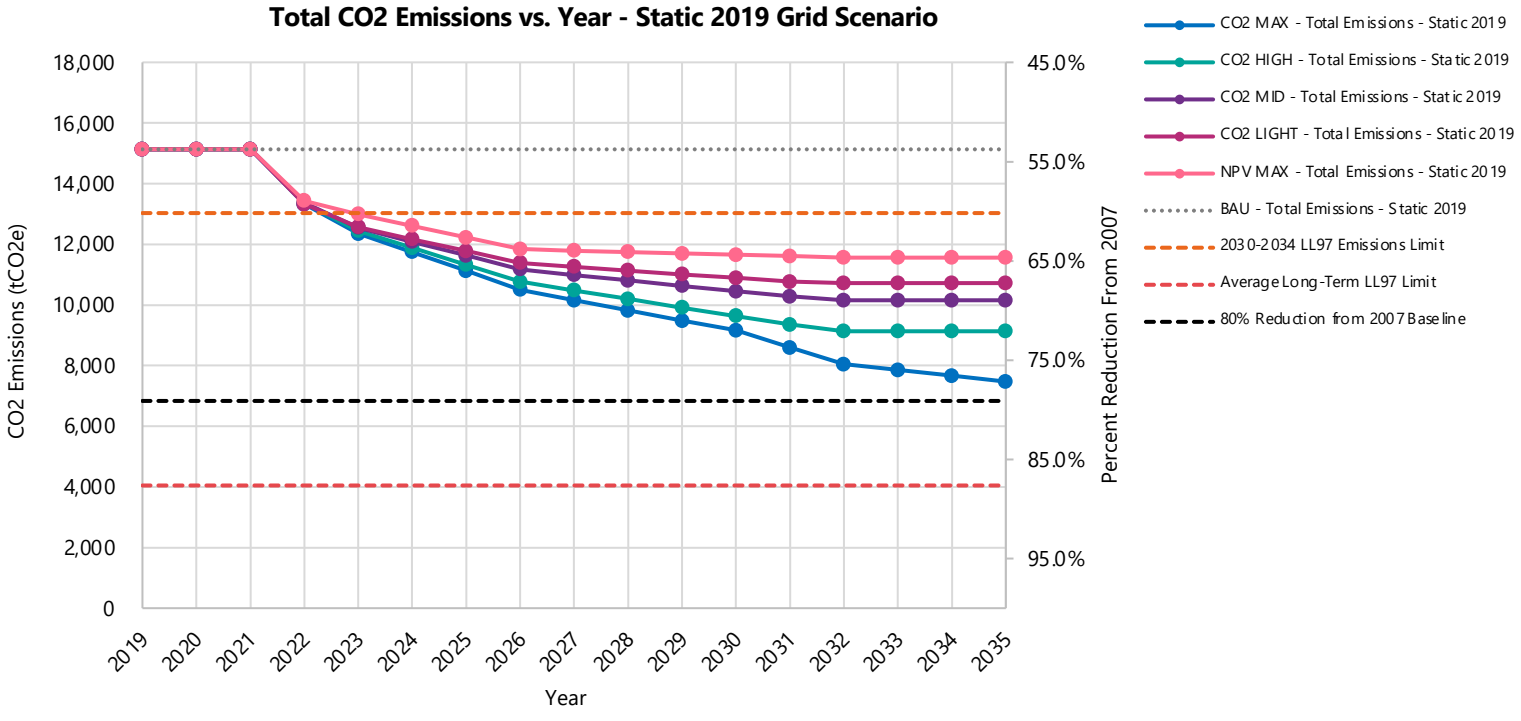
Empire State Building

Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet **80% reduction** from 2007 baseline by **2035**;
No packages would meet **average long-term LL97 limit**



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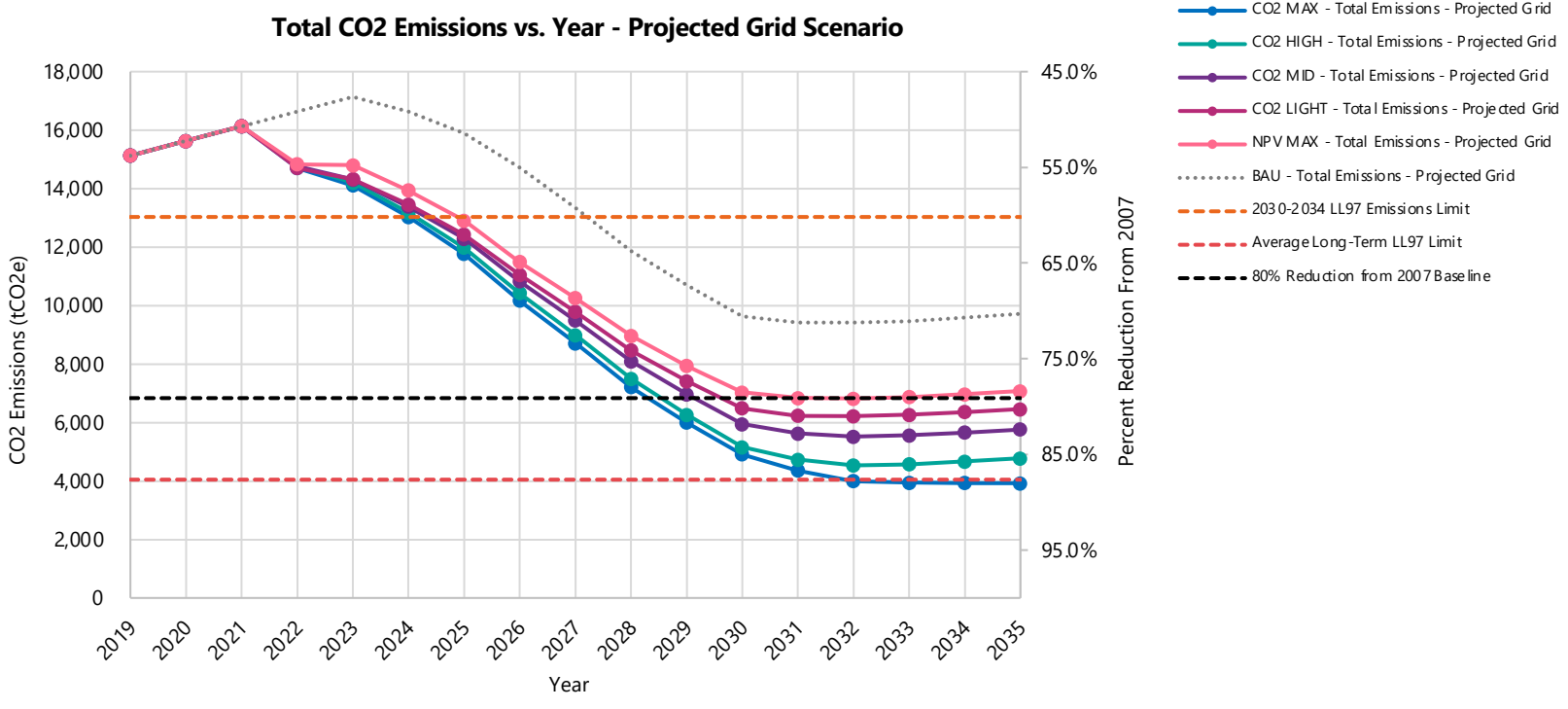
Projected Annual Carbon Emissions – Projected Grid Scenario

All packages except NPV Max would meet **80% reduction** from 2007 baseline by **2035**;
Only CO2 Max would meet **average long-term LL97 limit**



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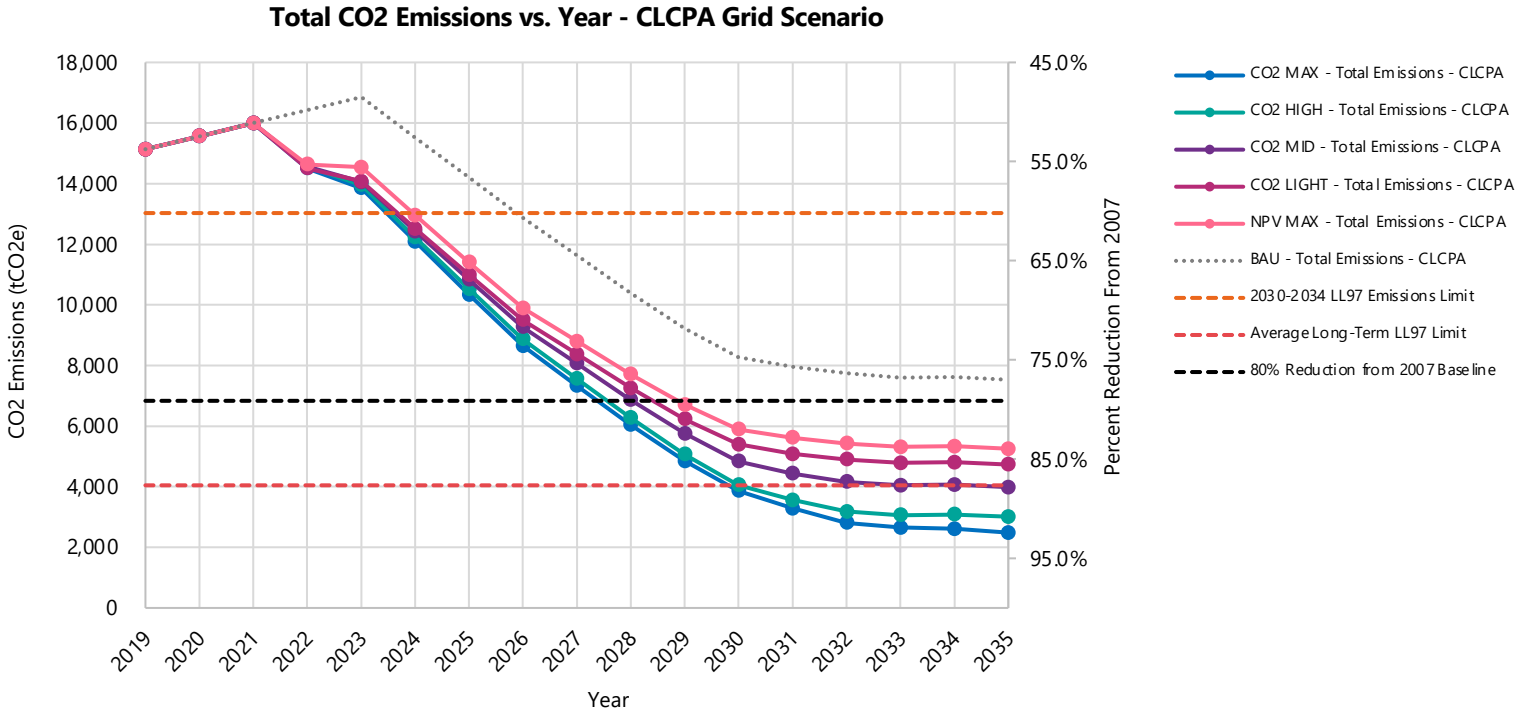
Projected Annual Carbon Emissions – CLCPA Grid Scenario

All packages would meet **80% reduction** from 2007 baseline by **2030**;
Only CO2 Mid package and above would meet **average long-term LL97 limit**



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Percent Carbon Emissions Reductions – All Grid Scenarios

STATIC GRID SCENARIO

	2007 - 2030	2007 - 2035	2019 - 2030	2019 - 2035
CO2 Max	**-73.2%**	**-78.1%**	-39.5%	-50.6%
CO2 High	**-71.8%**	**-73.3%**	-36.3%	-39.7%
CO2 Mid	**-69.4%**	**-70.3%**	-30.9%	-32.9%
CO2 Light	**-68.1%**	**-68.6%**	-28.0%	-29.2%
NPV Max	**-65.9%**	**-66.2%**	-23.0%	-23.6%

No packages would meet **80% reduction** from 2007 baseline by **2035**;
No packages would meet **average long-term LL97 limit**

PROJECTED GRID SCENARIO

	2007 - 2030	2007 - 2035	2019 - 2030	2019 - 2035
CO2 Max	**-85.6%**	**-88.5%**	-67.6%	-74.1%
CO2 High	**-84.9%**	**-86.0%**	-65.9%	-68.4%
CO2 Mid	**-82.6%**	**-83.1%**	-60.7%	-61.9%
CO2 Light	**-81.0%**	**-81.1%**	-57.1%	-57.3%
NPV Max	**-79.4%**	**-79.3%**	-53.5%	-53.3%

All packages besides NPV Max would meet **80% reduction** from 2007 baseline by **2035**;
Only CO2 Max would meet **average long-term LL97 limit**

CLCPA GRID SCENARIO

	2007 - 2030	2007 - 2035	2019 - 2030	2019 - 2035
CO2 Max	**-88.7%**	**-92.7%**	-74.5%	-83.6%
CO2 High	**-88.1%**	**-91.2%**	-73.2%	-80.1%
CO2 Mid	**-85.9%**	**-88.3%**	-68.1%	-73.7%
CO2 Light	**-84.2%**	**-86.2%**	-64.3%	-68.7%
NPV Max	**-82.7%**	**-84.6%**	-61.0%	-65.3%

All packages would meet **80% reduction** from 2007 baseline by **2030**;
Only CO2 Mid package and above would meet **average long-term LL97 limit**

Empire State Building Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

Empire State Building – Current Building Systems

- Offices and base building up to floor 79
  - Steam radiators – district steam
  - VAV chilled water AHUs
  - Electric drive centrifugal chillers located in the cellar separately serving three pressure zones with a common condenser water system
  - Steam chillers as backup only
- Retail
  - Water-cooled DX
- 80th floor and above
  - Multiple air-cooled chillers serving multiple systems including observatory
  - Some self-contained air cooled DX in some broadcast areas

2019 Energy Breakdown by Utility

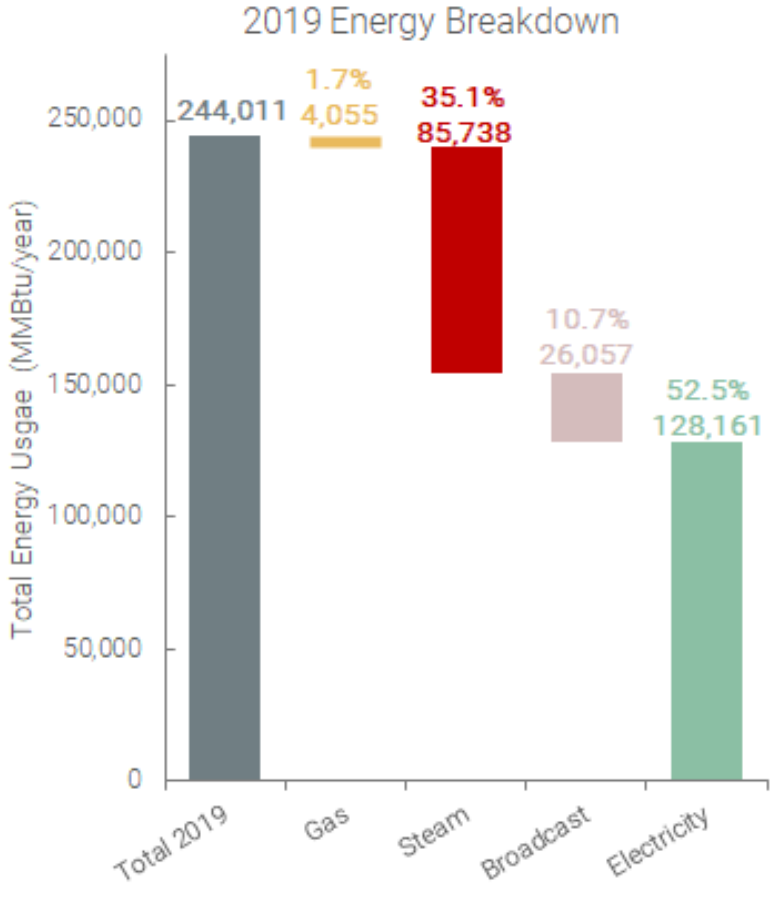
District steam used for heating makes up 35.1% of energy usage

Electricity + Broadcast

- 63.2% of energy usage
- 74.0% of CO2e emissions

District Steam

- 35.1% of energy usage
- 24.6% of CO2e emissions
- Steam Factor: 1,195 kBtu/Mlb



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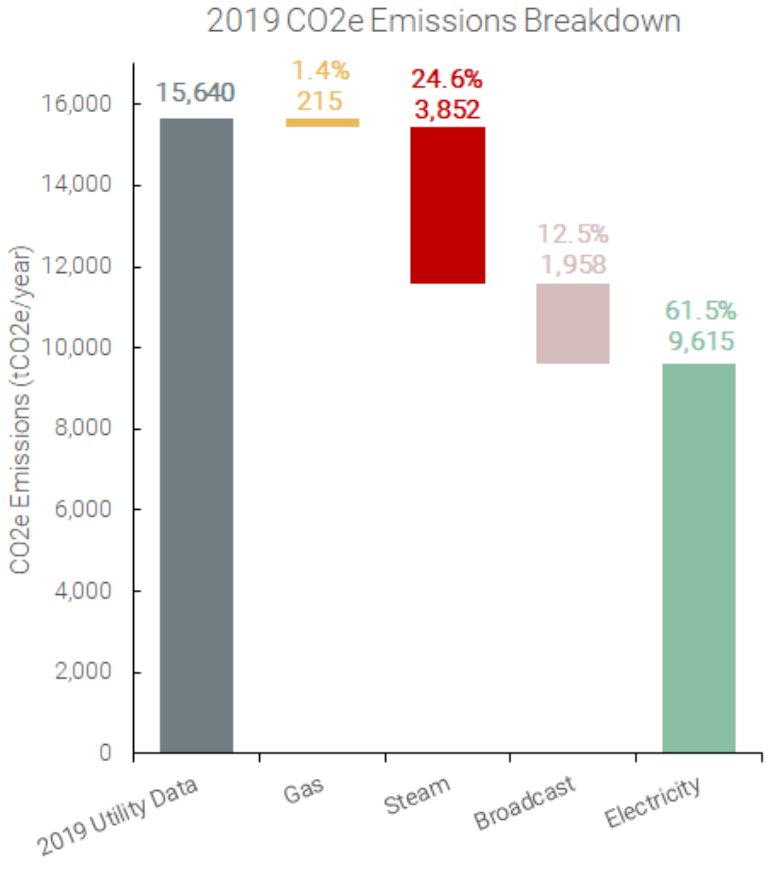
2019 CO2e Emissions Breakdown by Utility

District Steam has lower associated emissions than electricity

Electricity - 256.0 tCO2e/GWh

District Steam - 153.3 tCO2e/GWh (LL97)

- Based on 0.00004493 tCO2e/kBtu (LL97)



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2019 Operational Cost Breakdown by Utility

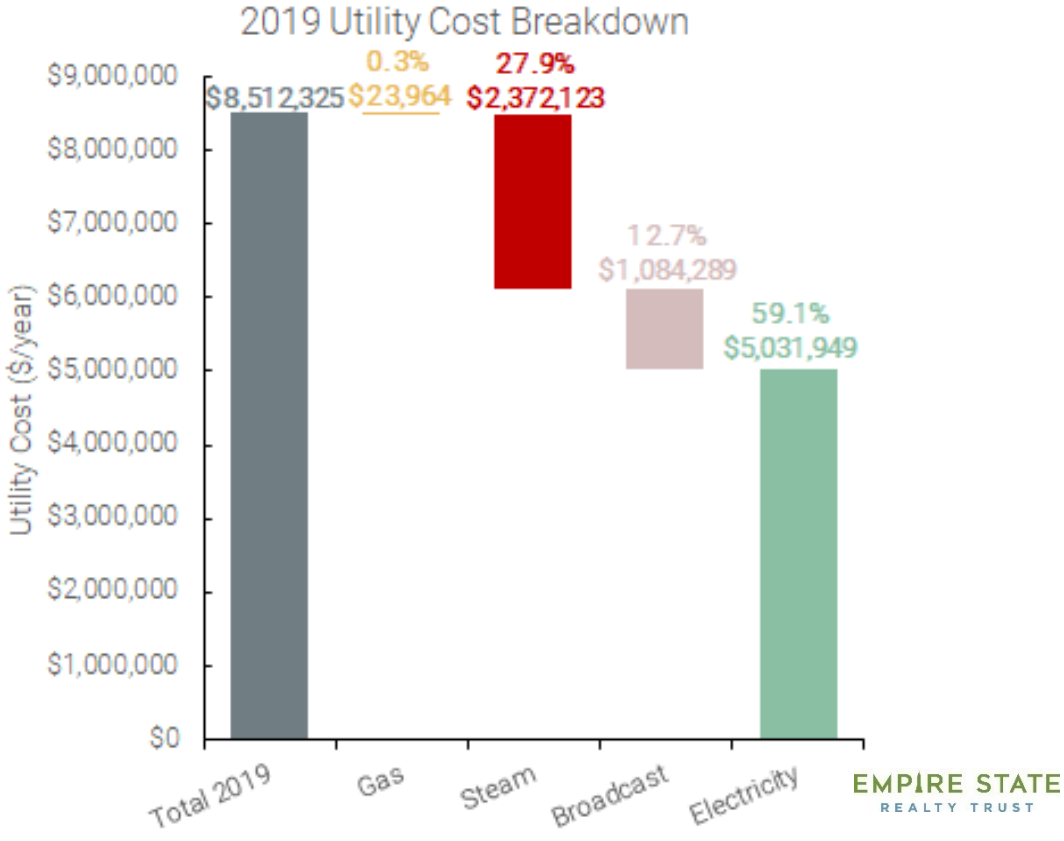
District Steam is cheaper than electricity & therefore makes up a smaller portion (27.9%) of utility costs

Electricity + Broadcast

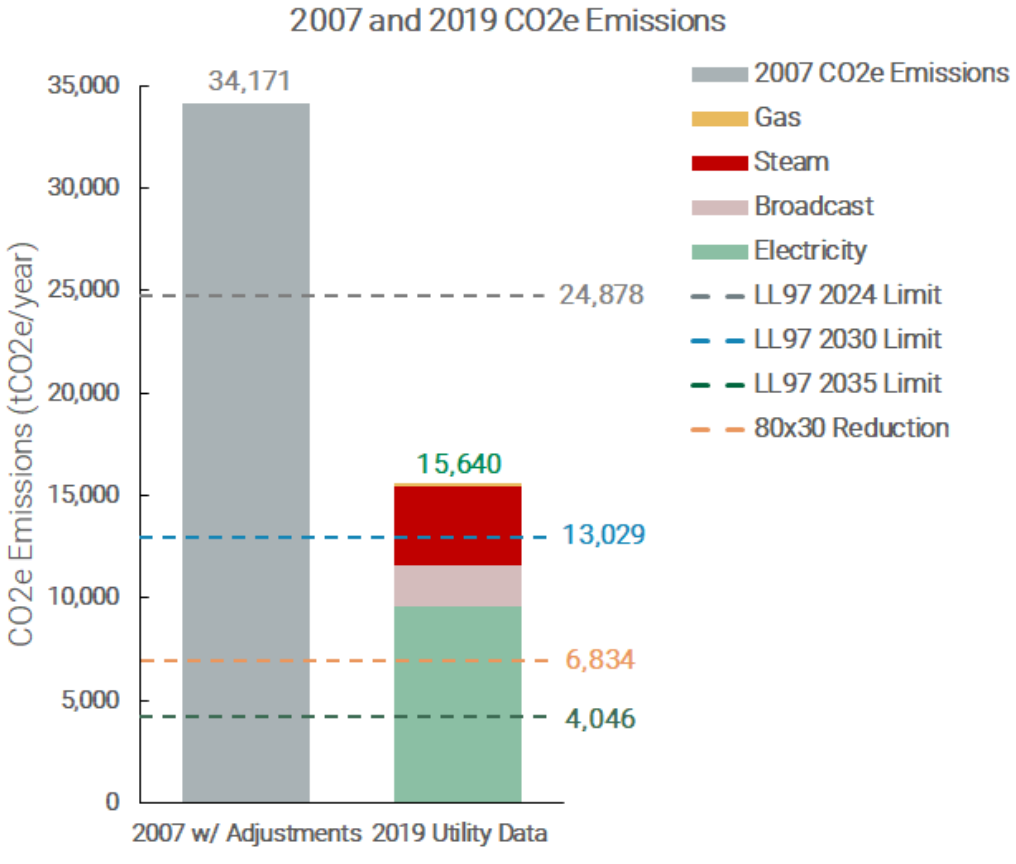
- 71.8% of operational costs
- 63.2% of energy usage

District Steam

- 27.9% of operational costs
- 35.1% of energy usage



ESB Current Status for LL97 and 80x30 Metrics



Key Takeaways:

- Building meets 2024 limit of 24,878 tCO2e/year
- 17% reduction is required to meet LL97 2030 targets
- 74.1% reduction is required to meet LL97 2035
  - Building + grid improvements

54.0% CO2e reduction from 2007 to 2019

- 61% building efficiency measures
  - ESB1.0 SOW
  - Broadcast reduction
- 39% 2007 to 2019 grid improvements

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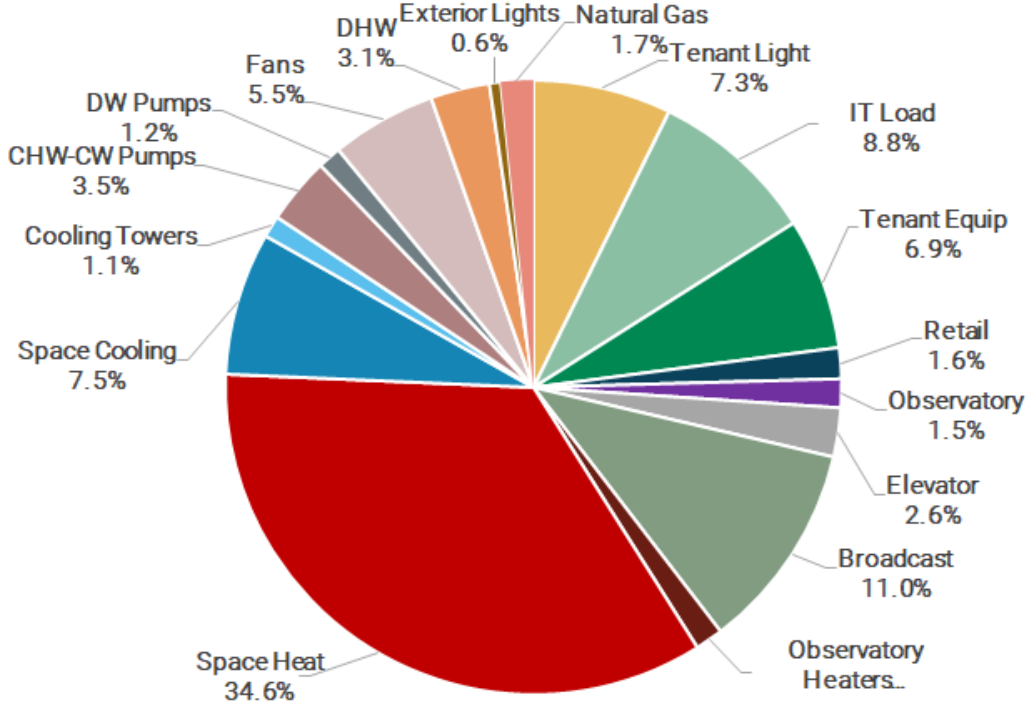
ESB Energy Model: 2019 Energy Breakdown by End-Use

Spacing heating accounts for 34.6% of the total 2019 energy usage

Major End Uses:

- Space Heating – 34.6%
- Tenant Loads – 23.0%
- Broadcast – 11.0%
- Space Cooling – 8.6%
  - Chillers, DX, and Cooling Towers
- Fans – 5.5%
  - AHUs, exhaust, ventilation
- Pumps – 4.7%



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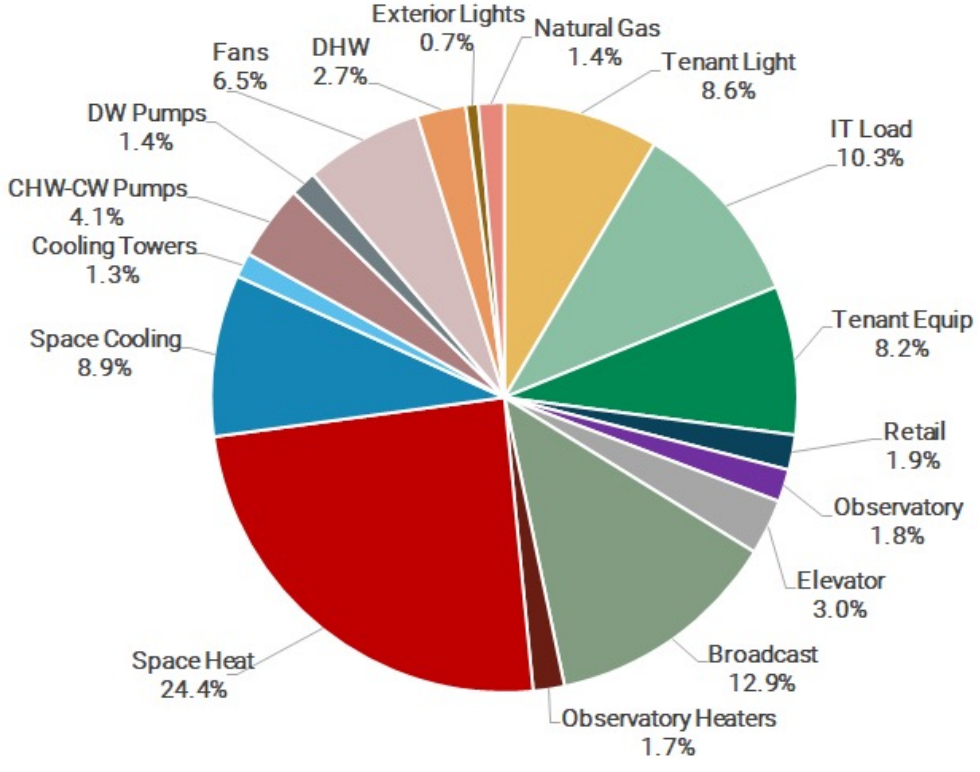
ESB Energy Model: 2019 CO2e Emissions Breakdown by End-Use

Spacing heating accounts for 25% of the total 2019 CO2e emissions

Major End Uses:

- Space Heating – 24.4%
- Tenant Loads – 27.1%
- Broadcast – 12.9%
- Space Cooling – 10.2%
  - Chillers, DX, and Cooling Towers
- Fans – 6.5%
  - AHUs, exhaust, ventilation
- Pumps – 5.5%



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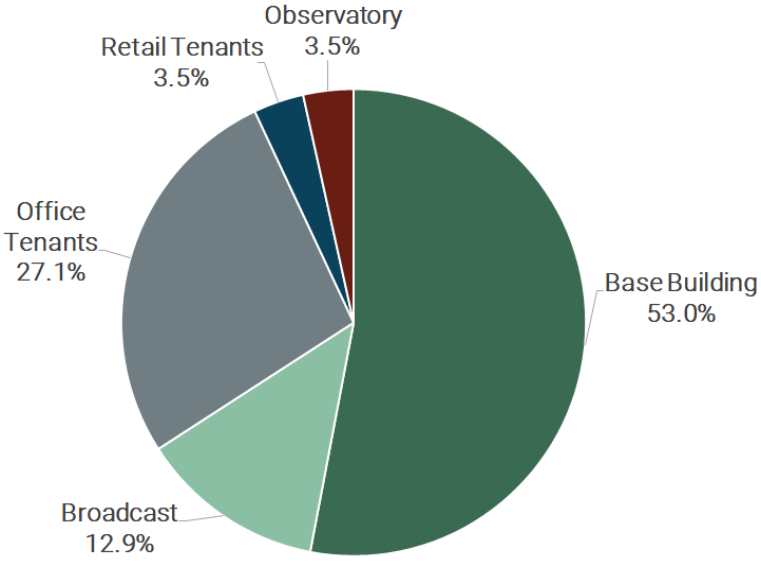
ESB Energy Model: 2019 CO2e Emissions Breakdown by User

Office and retail tenants account for ~31% of total 2019 CO2e emissions

Base Building includes:

- All district steam heating
- Central cooling plant equipment
- All Office Tenant AHUs
- Elevators
- Lobby HVAC unit
- BOH lighting and equipment



Restaurants are high energy users

Space Type	Square Footage		Energy	CO2e	Energy Intensity	Carbon Intensity
	SF	%	mmBtu	tCO2	(kBtu/SF/year)	lbs/SF/year)
Office Tenants	2,617,184	95%	56,355	4,025	21.5	3.4
Retail Tenants	66,063	2%	9,511	757	144.0	25.2
Observatory	71,800	3%	5,945	454	82.8	13.9

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Empire State Building Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
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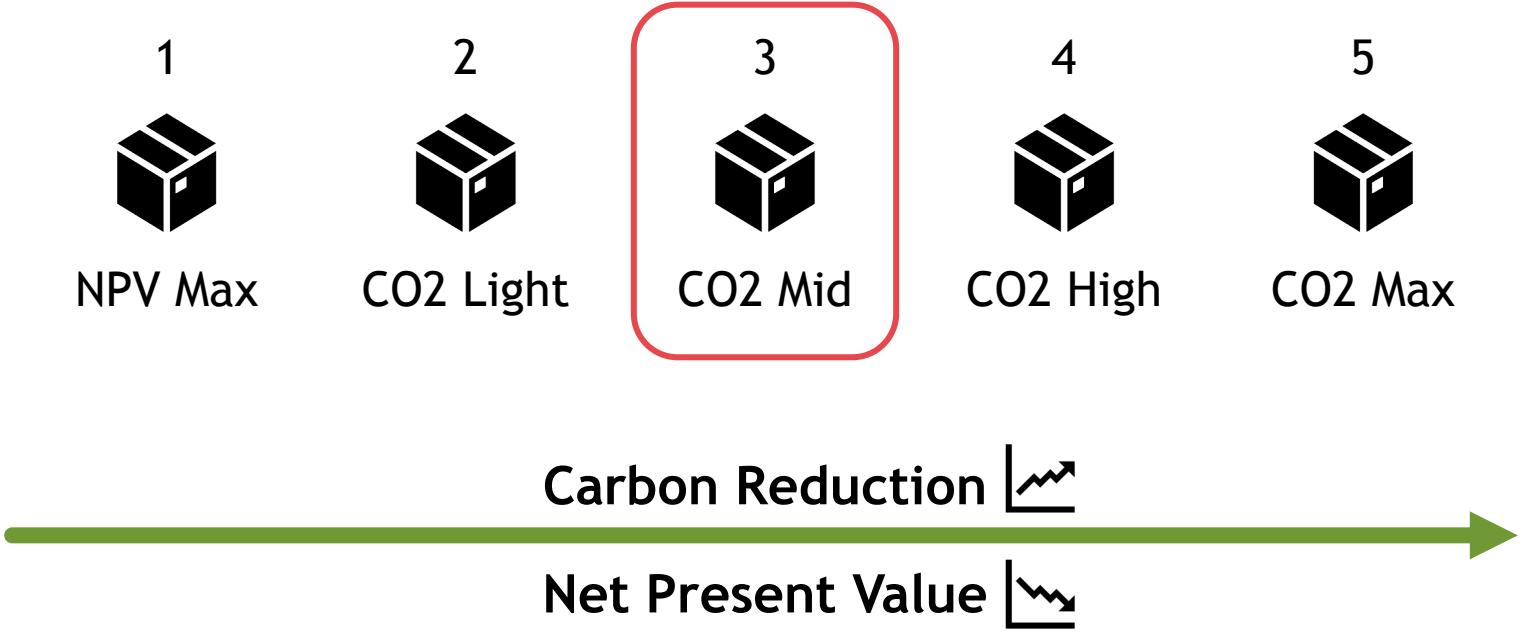
ECM Packages

Five packages of ECMs developed to optimize NPV and CO2 reductions



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ECM Phases & Implementation Timeline

ENERGY EFFICIENCY MEASURES		IMPLEMENTATION TIMELINE															
Phase	**Potential Measures**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Baseline	2019 Baseline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phase 1A	TX Optimization	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1B	1st Floor Lobby Air Distribution Optimization	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1C	All Phase 1C Measures: Setpoints	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1D	All Phase 1D Measures: Central Plant Optimization	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1E	All Phase 1E Measures: Steam Optimization	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1F	All Phase 1F Measures: Retail Optimization	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1G	Eliminate Observatory Electric Heaters	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2A	All Phase 2A Measures: Airside Controls Optimization	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3A	Common Area/BOH Lighting Upgrades	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3B	Domestic Water Pumps VFDs	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3C	Air Distribution Optimization for Elv. Rooms	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4A	Kitchen Hood Exhaust Fan Control	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 5A	Tenant Design Standards & Engagement	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5B	Plug Load Controls	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5C	Tenant Lighting Upgrades	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5D	Daylighting Film	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5E	Optimize IT Equipment	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5F	IT Cooling Optimization	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5G	BIPV	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5H	Wall Insulation	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5I	Window U-value	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5J	Envelope PCM	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 5K	All Phase 5K Measures: Steam Phase-Out	0%	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%	100%
Phase 6A	Optimize Economizer PFHX Connections	0%	0%	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 6B	High Capacity Geothermal	0%	0%	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 6C	Retail WC Heat Pumps	0%	0%	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 7A	Airsource Hot Water Heaters	0%	0%	0%	0%	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%
Phase 8A	Broadcast Heat Recovery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%
Phase 9A	All Phase 9A Measures: Co-Located Data Center	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	40%	60%	80%	100%	100%
Phase 10A	R-22 Chiller Replacement	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%

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Empire State Building Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
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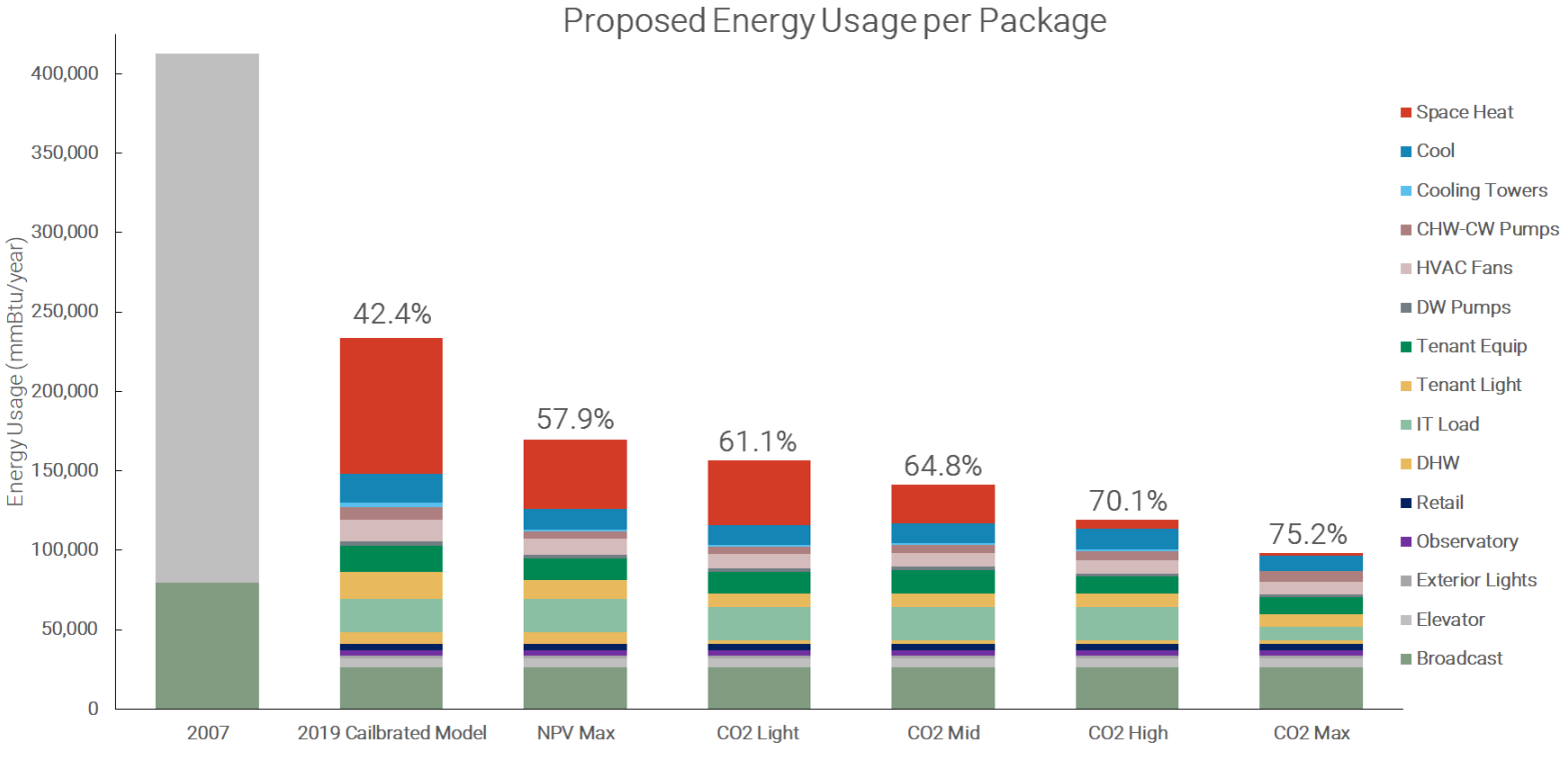
ECM Package Comparison - Energy

Packages range from 57.9% to 75.2% reduction in total energy from 2007 benchmark



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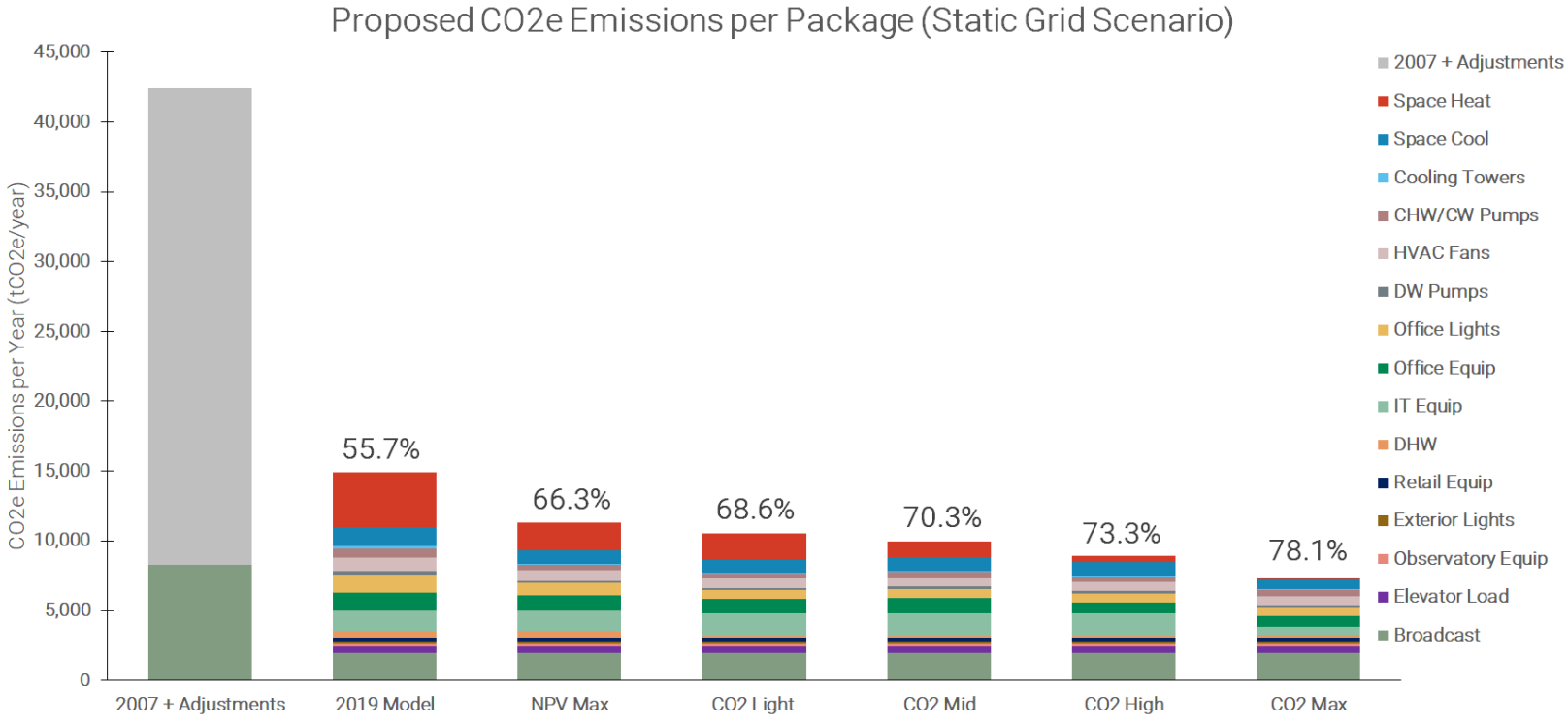
Projected CO2 Emissions – Static 2019 Grid Scenario

Packages range from 66.3% to 78.1% reduction in total emissions from 2007 benchmark year



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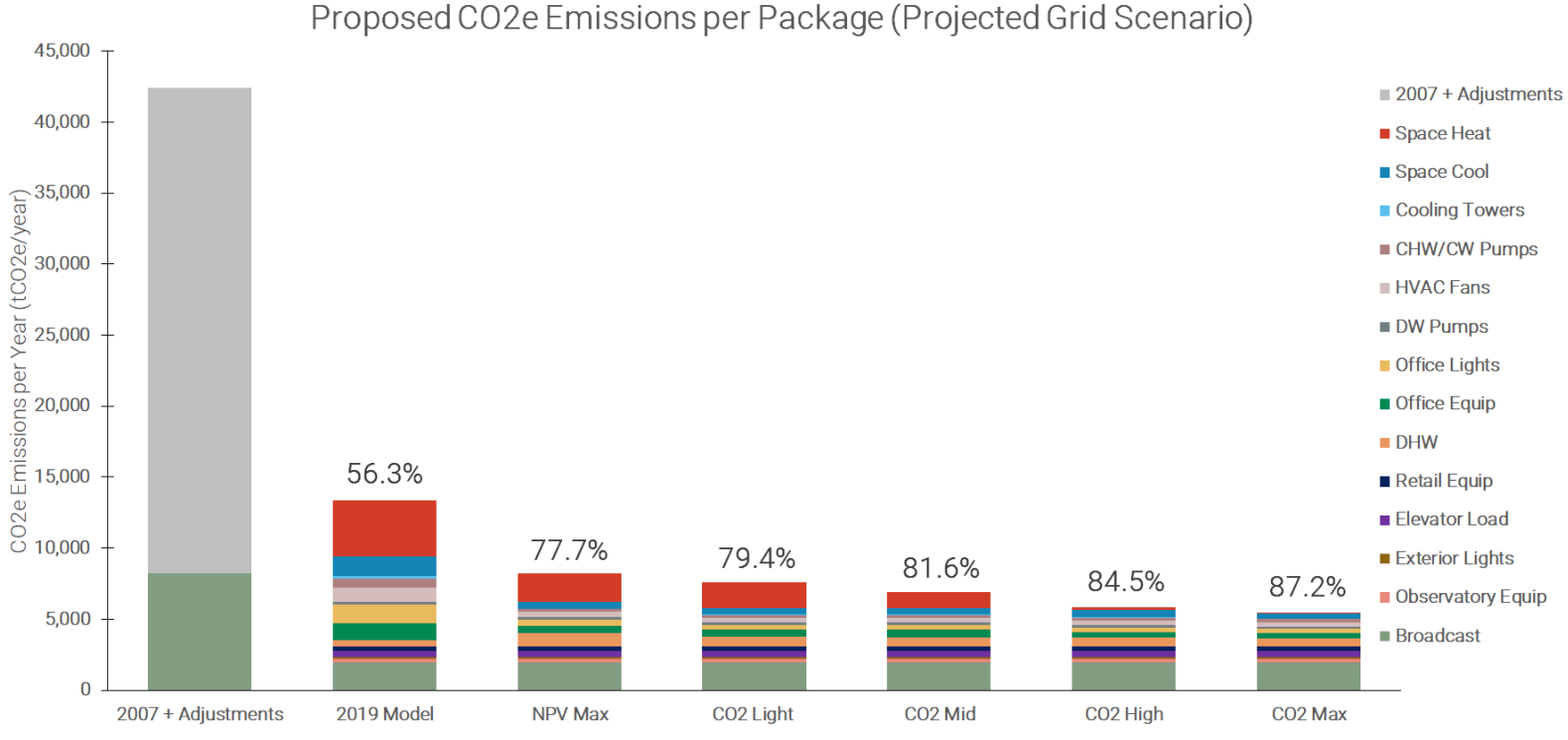
Projected CO2 Emissions – Projected Grid Scenario

Packages range from 77.7% to 87.2% reduction in total emissions from 2007 benchmark year



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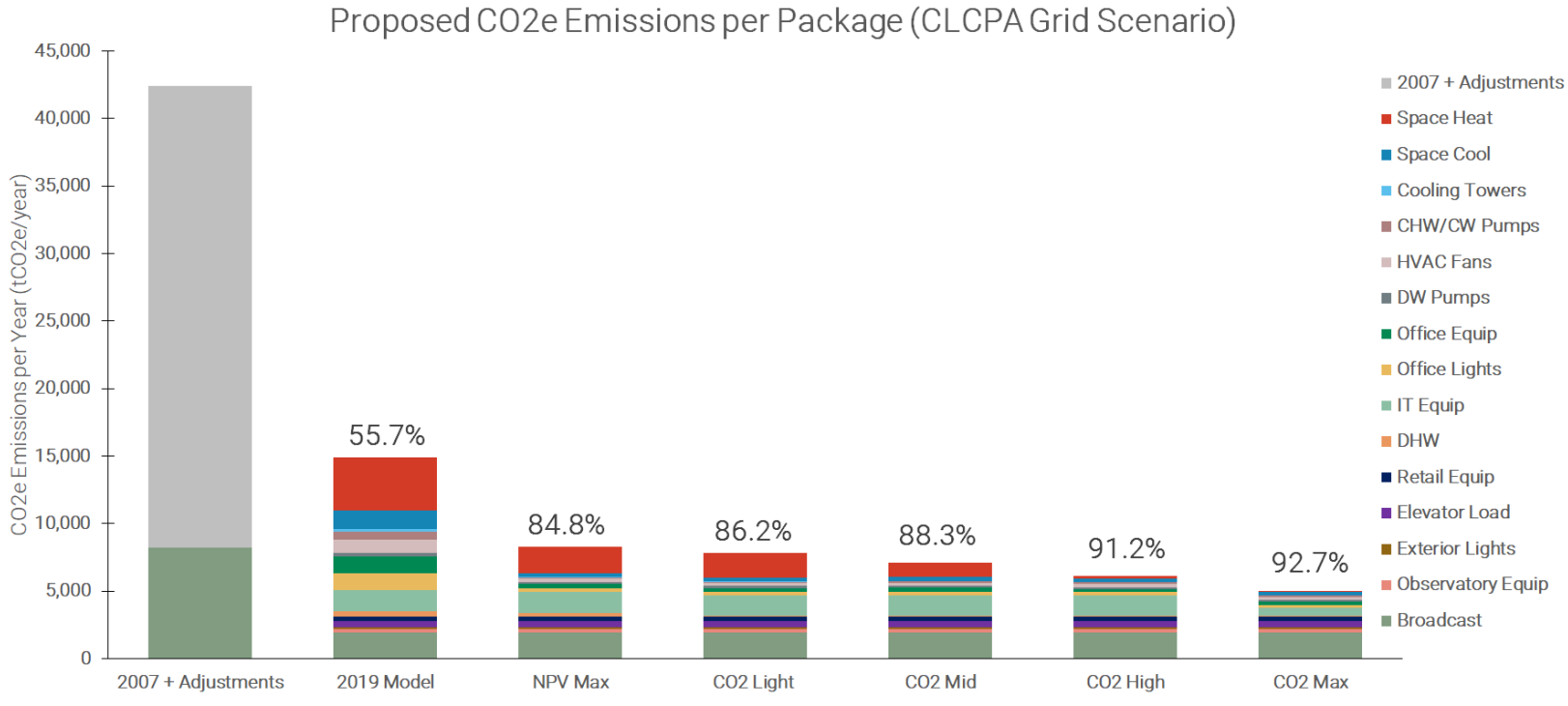
Projected CO2 Emissions –CLCPA Grid Scenario

Packages range from 84.8% to 92.7% reduction in total emissions from 2007 benchmark year



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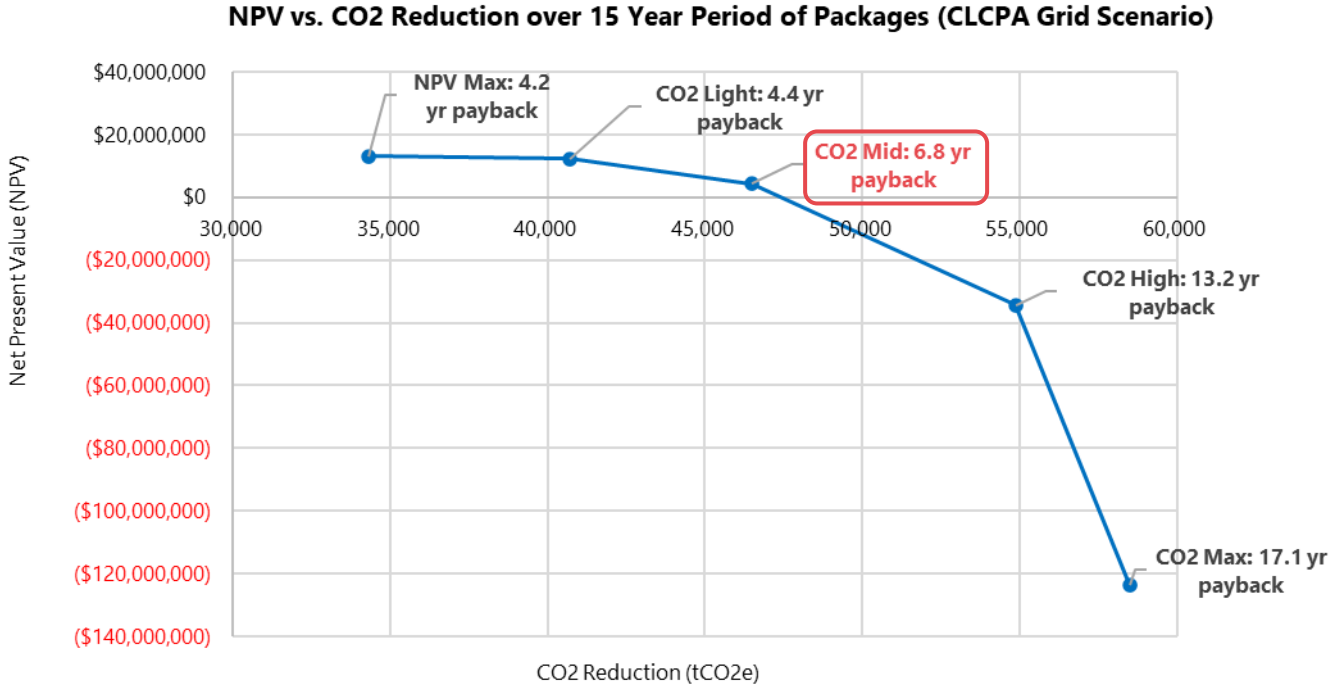
Empire State Building Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

Net Present Value & Carbon Reduction – CLCPA Grid Scenario

CO2 Mid package is **NPV positive** with a **6.8 year** simple payback



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LL97 Annual Fines for all Packages

With BAU scenario, ESB will begin seeing fines in 2030 with a static grid.
Implementation of CO2 Mid, CO2 High or CO2 Max packages will eliminate all fines for CLCPA grid scenario.

LL97 ANNUAL FINES												
Packages	**CLCPA Grid Scenario**				**Projected Grid Scenario**				**Static Grid Scenario**			
	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine w/ Long Term Limit	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine w/ Long Term Limit	Fine Avoidance due to ECM Packages	Total Fine from 2024-2029	Total Fine from 2030-2034	Annual Fine w/ Long Term Limit	Fine Avoidance due to ECM Packages
2019 Baseline	$0	$0	$933,383	-	$0	$0	$1,521,432	-	$0	$563,332	$2,970,882	-
NPV Max	$0	$0	$323,653	$609,730	$0	$0	$811,422	$710,010	$0	$0	$2,013,696	$957,186
CO2 Light	$0	$0	$183,593	$749,790	$0	$0	$646,850	$874,582	$0	$0	$1,788,708	$1,182,174
CO2 Mid	$0	$0	$0	$933,383	$0	$0	$460,908	$1,060,524	$0	$0	$1,636,921	$1,333,960
CO2 High	$0	$0	$0	$933,383	$0	$0	$196,163	$1,325,269	$0	$0	$1,362,970	$1,607,912
CO2 Max	$0	$0	$0	$933,383	$0	$0	$0	$1,521,432	$0	$0	$918,005	$2,052,877

*The 2035 GHG emissions limit has not yet been defined and calculations are based on long-term LL97 80% reduction limits.

Recommended Packages – CO2 Mid

	NPV Max	CO2 Light Reduction	CO2 Mid Reduction	CO2 High Reduction	CO2 Max Reduction
NPV TOTALS	$13,176,520	$12,256,879	$4,257,513	($34,389,091)	($123,592,207)
Total Capital Cost*	($21,734,293)	($26,237,454)	($40,672,466)	($106,351,022)	($244,192,654)
Annual Energy Cost Savings	$2,564,701	$3,197,550	$3,701,538	$6,012,886	$7,857,253
Annual Repairs & Maintenance Savings	$522,001	$546,001	$546,001	$1,003,011	$5,486,271
Incentives	$8,615,851	$9,730,286	$11,687,261	$13,410,330	$16,325,328
Simple Payback	**4.25**	**4.41**	**6.82**	**13.25**	**17.08**

NPV Max – Includes all ECMs that are NPV positive
CO2 Light Reduction – Includes all ECMs that are NPV positive and a few essential ECMs that are NPV negative - electrification of DHW only
CO2 Mid Reduction – Includes a mixture of ECMs that are NPV positive/negative – DHW electrification and partial HVAC electrification
CO2 High Reduction – Includes most ECMs besides the measures that are extremely NPV negative - complete electrification
CO2 Max Reduction – Includes all ECMs studied

*Excluding construction escalation costs

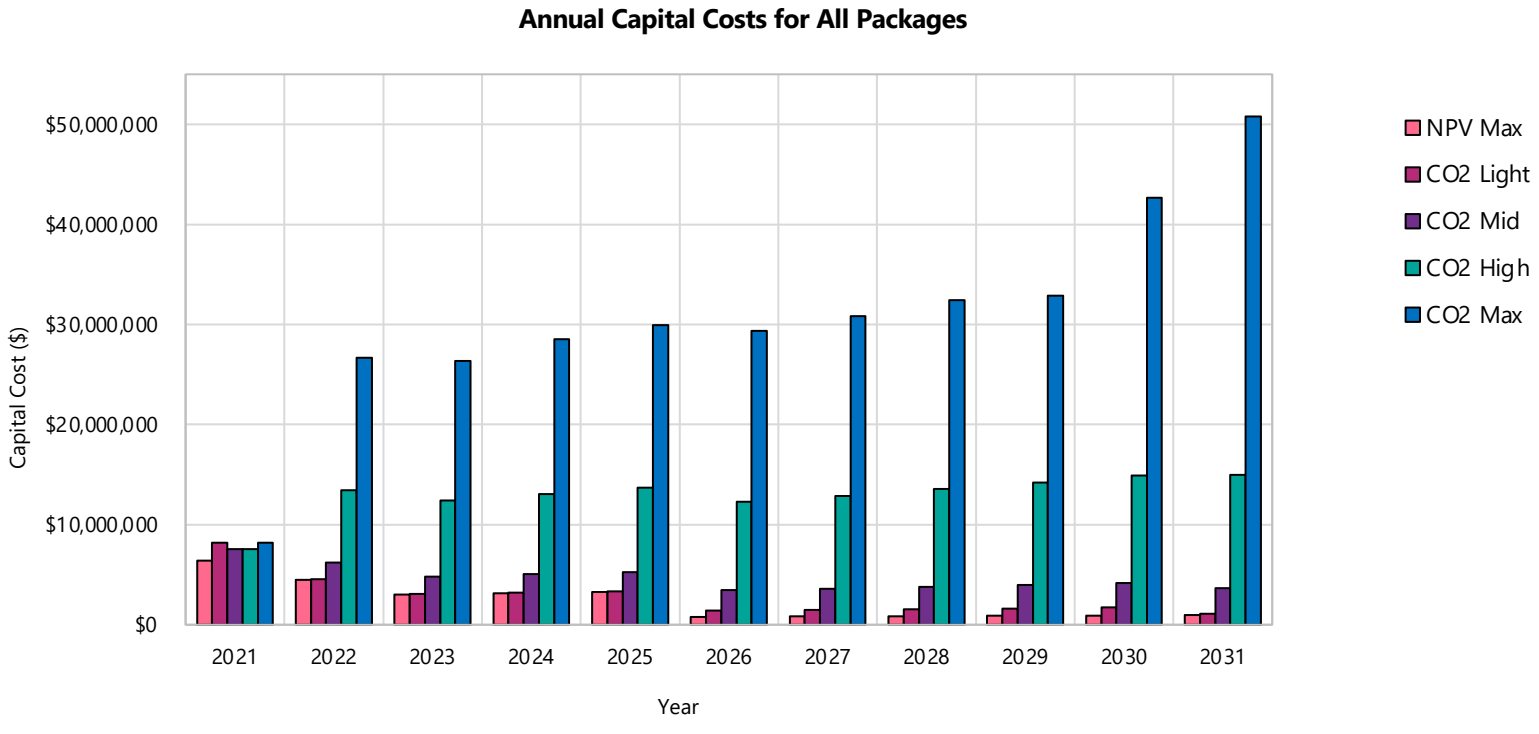
Recommended Package – CO2 Mid

- This package includes many straightforward measures to be implemented at the time of tenant lease turnover or renewal.
- This package includes partial heating electrification which will provide infrastructure to support possible full electrification in the future.
- While less aggressive packages meets the 80% reduction goal, choosing a more aggressive set of measures with decent payback and still positive NPV provides insurance against delayed implementation, for example due to renewing tenants choosing not to refresh their spaces in ways that facilitate key ECMs, while achieving compliance with the average long term LL97 limit

Empire State Building Case Study

Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis and Recommendations
Capital Expenditure and 2022 Budget

Annual Capital Cost per Package



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ESB Next Steps – 2022 Projects

The recommended 2022 measures are focused on control measures that have a short payback and will enable energy reduction opportunities in the future.

Project	2022 Total Cost	Anticipated Incentives ($)	Total 2022 Cost w/ Incentives ($)	Energy Cost Savings
Chiller Sequence of Operations	$450,000	$156,926	$293,074	$55,903
Steam Improvements	$1,145,000	$0	$1,145,000	$62,434
Perimeter Heating Control by BMS	$313,500	$109,171	$204,329	$11,708
AHU Fan Alerton Control Conversion	$502,700	$96,450	$406,250	$40,092
TX Optimization	$41,800	$38,000	$3,800	$120,182
ERV Addition	$1,155,000	$346,500	$808,500	$68,078
Airside Sequence of Operations	$325,000	$300,000	$25,000	$788,530
Airside Retrocomissioning	$405,704	$27,662	$378,042	$67,188
Integration of Lighting with BMS	$60,000	$19,800	$40,200	$0
Heating to AHUs	$1,045,000	$282,734	$762,266	$49,460
Steam Phase-Out Tenant Perimeter Systems	$2,392,500	$1,840,558	$551,942	$538,377
Kitchen Hood Exhaust Fan Control	$38,500	$11,550	$26,950	$3,497
Total	**$7,874,704**	**$3,229,351**	**$4,645,353**	**$1,805,448**

EMPIRE STATE REALTY TRUST

Overview of Case Study

- Executive Summary
- Building Case Study
  - Energy Modeling
  - ECM Phasing and Packaging
  - Energy and Carbon Emissions Results
  - Financial Analysis and Recommendations
  - Next Steps
- **Summary & Lessons Learned**

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Summary of Building Carbon Reduction Recommendations

- **250 W 57th Street: CO2 Mid Reduction Package**
  - Includes near-term (2023) installation of a 300-ton heat pump to increase cooling plant capacity and resiliency, followed by installation of an additional 500-ton heat pump at the time of chiller end-of-life (2030). Electrification of heating provides significant savings and is financially viable due to planned capital expenditure for chiller & boiler replacements
  - At tenant fit out VAV reheat systems are tied into new heating hot water riser
    - Convert existing CV to VAV
    - Add reheat coils to each VAV for heating electrification
- **1350 Broadway: CO2 Mid Reduction Package**
  - Includes optimization of existing chiller plant, conversion of constant volume systems to optimized VAV systems, and core toilet exhaust energy recovery
  - Heating electrification is not required to meet the average long term LL97 limits and is not financially viable within study period due to age of chiller (steam to electric conversion in 2013)
- **1359 Broadway: CO2 Mid Reduction Package**
  - Includes replacement of existing self-contained DX air-cooled systems with VRF heat pumps at the time of tenant fit outs. This is financially viable with nominal incremental cost to replace existing equipment. Through-wall air-cooled DX units currently specified (United Cool Air) will be discontinued by the manufacturer at the end of 2021.

Summary of Building Carbon Reduction Recommendations (Continued)

- **1333 Broadway: CO2 High VRF Reduction Package**
  - Optimization of existing water-cooled systems is recommended in the near term, but these systems should not be retained long term.
  - Includes replacement of existing self-contained air-cooled and water-cooled systems with VRF heat pumps at minimal incremental cost versus end-of-life replacement of existing systems in kind at the time of tenant fit outs
- **Empire State Building: CO2 Mid Reduction Package**
  - Includes many straightforward measures to be implemented at the time of tenant lease turnover *or renewal,* as well as base-building optimization and heat recovery measures
  - Includes partial heating electrification which will provide infrastructure to support possible full electrification should this become economically viable in the future
    - Electrification of heating at AHUs using HW coils and a central heat pump is included

Lessons Learned

- Don't let planned CapEx be a missed opportunity, do not replace in kind
  - When opportunities or needs arise to replace equipment, utilize the opportunity to promote carbon and energy efficiency with good ROI due to low incremental costs compared to replacement in kind.
    - 250 W 57th Street heating electrification
    - 1333 and 1359 Broadway VRF
  - The inverse is also true. If major equipment is not due for replacement for 20 years, carbon and energy efficiency improvements may not financially justify early replacement.
    - 1350 Broadway heating electrification
- Central systems may present more opportunities for optimization based on automation and controls sequences
  - 1333 Broadway condenser water system
  - Empire State Building CHW pumping
- Consistent rollout of high-performance standards is crucial
  - Key internal and external service providers (fit out designers, controls vendors, maintenance contractors, lease negotiators) require technical oversight to ensure all their work supports energy and carbon efficiency goals.
  - Small deviations of tenant designs from energy code and tenant design guidelines can build up to significant impediments to achieving carbon savings.
  - Consider long-term ROI and operational consequences of first-cost decisions on all projects. Small decisions add up to big impact.

Appendix

CLCPA Performance

CLCPA Goals Met Scenario

All values in GWh

Cal. Year	Load	Net Imports	NYISO Gen	Renewable Percentage	CO_2 Free Percentage	MT/GWh or g/kWh	% of 2019
2019	155,832	23,128	134,313	26.1%	59.4%	256.0	100%
2023	150,544	23,128	129,266	28.9%	50.6%	296.2	116%
2025	144,962	15,359	131,470	38.7%	60.1%	227.8	89%
2030	154,097	10,673	145,632	61.6%	81.3%	78.5	31%
2035	181,560	10,673	173,211	79.5%	83.2%	93.4	36%
2040	212,596	10,673	201,931	84.5%	98.7%	9.3	4%

Projected Grid Performance

Cal. Year	All values in GWh: Load	Net Imports	NYISO Gen	Renewable Percentage	CO_2 Free Percentage	MT/GWh or g/kWh	% of 2019
2019	155,832	23,128	134,313	26.1%	59.4%	256.0	100%
2023 [1]	149,268	20,018	131,136	33.1%	51.1%	302.7	118%
2025 [2]	144,962	20,018	127,762	35.3%	53.8%	272.3	106%
2030 [3]	154,097	13,359	143,750	56.7%	73.0%	119.3	47%
2035 [4]	181,560	11,257	173,720	59.6%	72.4%	129.5	51%
2040 [5]	212,596	11,257	208,076	66.6%	77.5%	101.1	40%

1 - 2023: Indian Point Retires, growth in upstate wind and solar

2 - 40% of 2025 solar goal, CHPE, Empire & Sunrise Wind are not complete, onshore wind increased 25% from 2019 actuals

Also retired all FO6, FO2 & Kerosene generation, replacing with continued operations of NG fueled generation.

3 - Wind Goals: Empire & Sunrise online, 4,500 of 9,000 MW of 2035 Offshore Goals, upstate wind increased to 9,907 GWh

Solar: 100% of 2025 Upstate goal of 6,000 MW, 100% of 2025 City Bldg. 100 MW goal

CHPE included at 95% capacity factor of 1,250 MW

4 - 7,500 of 9,000 Mw of 2035 Offshore Goal, upstate wind increased to 12,384 GWh

Solar: total solar output up to 16,788 GWh

Imports: PJM at 25% and ISO-NE at 50% of 2019 actuals, PJM & ISO-NE grid coef. drop to 75% of 2019 actuals

5 - Offshore wind at 10,000 MW and 37,230 GWh, upstate wind increased to 19,815 GW

Solar: total solar output up to 33,436 GWh

Imports: PJM at 25% and ISO-NE at 50% of 2019 actuals, PJM & ISO-NE grid coef. drop to 70% of 2019 actuals

ECM Packages

Several HVAC system implementation timelines were initially considered

There are several timing options available for the installation of new heat pumps and the associated infrastructure (i.e., new HHW riser and connections to VAV reheat distribution on tenant floors)

A. A fraction of the final heat pump capacity (300 TR) may be installed in the short term to assuage concerns about limited cooling capacity and improve the plant resiliency, followed by installation of the remainder of the capacity at the chiller end-of-life.

B. The installation of the new heat pump plant may be delayed until the end-of-useful-life of the existing chillers - *if additional capacity is not needed immediately* - once the associated cooling tower equipment has aged as well (circa 2030). There are two further options for timing of the installation of the HHW riser and connection to VAV reheats:

   1. HHWS riser may be installed at same time that the heat pump plant is installed. This results in a delayed electrification timeline and associated carbon emissions reductions, but it also delays the need for significant capital expenditure

   2. HHW riser may be installed immediately, prior to heat pump installation, and connected to the existing boiler through a steam-to-water HX which will produce hot water. Tenant distribution systems may begin to be converted to VAV reheat and connected to this riser at tenant lease roll. This has the benefit of immediate partial electrification once the heat pump comes online, although it requires immediate capital expenditure with a delay in significant annual cost savings

ECM Packages

Option B-2 requires high capital expenditure with limited energy cost savings until heat pump is installed

ENERGY CONSERVATION MEASURES (ECMS)		IMPLEMENTATION TIMELINE																		
Phasing	**Short Name**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Option A	**Immediately Install 300-ton** Air-Water Heat Pumps and Add Complete Plant Capacity at Chiller End-Of-Life	0%	38%	38%	38%	38%	38%	38%	38%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Boiler System	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Begin Install of VAV Reheat Coils on Tenant Office Floors	0%	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%	100%
Option B-1	**Replace Chillers/Cooling Towers** with Central Air-Water Heat Pump **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Install Heating Hot Water Riser & Branch Taps on Tenant Floors **in 2030** & Connect to Remaining Boiler	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Begin Install of VAV Reheat Coils on Tenant Office Floors Starting **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%
Option B-2	**Replace Chillers/Cooling Towers** with Central Air-Water Heat Pump **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Boiler System	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Begin Install of VAV Reheat Coils on Tenant Office Floors	0%	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%	100%

ECM Packages

Option B-2 requires high capital expenditure with limited energy cost savings until heat pump is installed

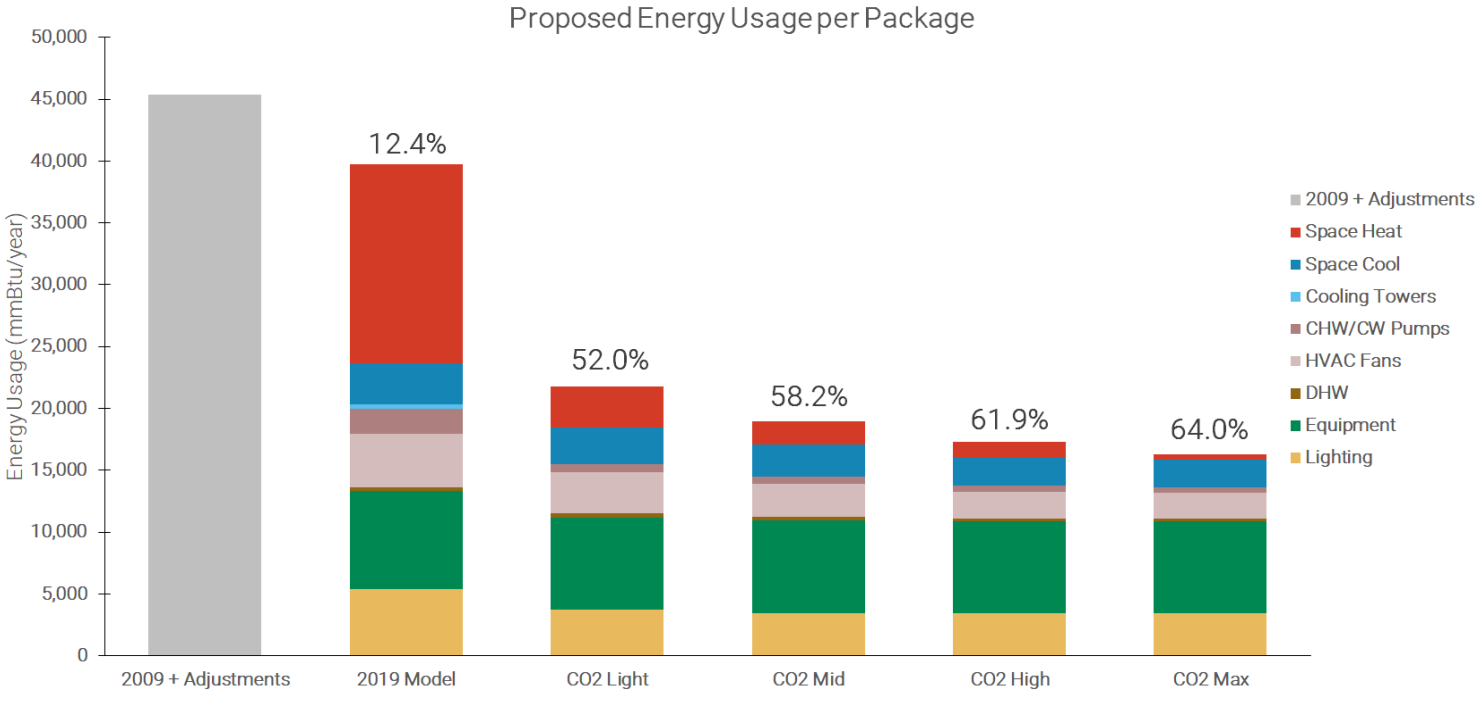
ENERGY CONSERVATION MEASURES (ECMS)		IMPLEMENTATION TIMELINE																	
Phasing	**Short Name**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Option A	**Immediately Install 300-ton** Air-Water Heat Pumps and Add Complete Plant Capacity at Chiller End-Of-Life	0%	38%	38%	38%	38%	38%	38%	38%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Boiler System	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Begin Install of VAV Reheat Coils on Tenant Office Floors	0%	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%	100%
Option B-1	**Replace Chillers/Cooling Towers** with Central Air-Water Heat Pump **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Remaining Boiler	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Begin Install of VAV Reheat Coils on Tenant Office Floors Starting **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%
Option B-2	**Replace Chillers/Cooling Towers** with Central Air-Water Heat Pump **in 2030**	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Install Heating Hot Water Riser & Branch Taps on Tenant Floors & Connect to Boiler System	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Immediately Begin Install of VAV Reheat Coils on Tenant Office Floors	0%	0%	7%	13%	20%	27%	33%	40%	47%	53%	60%	67%	73%	80%	87%	93%	100%	100%	100%

CO2 High Phased + CO2 Max

CO2 Light CO2 Mid CO2 High

250 ECM Package Comparison - Energy

Packages range from 52.0% to 64.0% reduction in total energy from 2009 + Adjustments benchmark year



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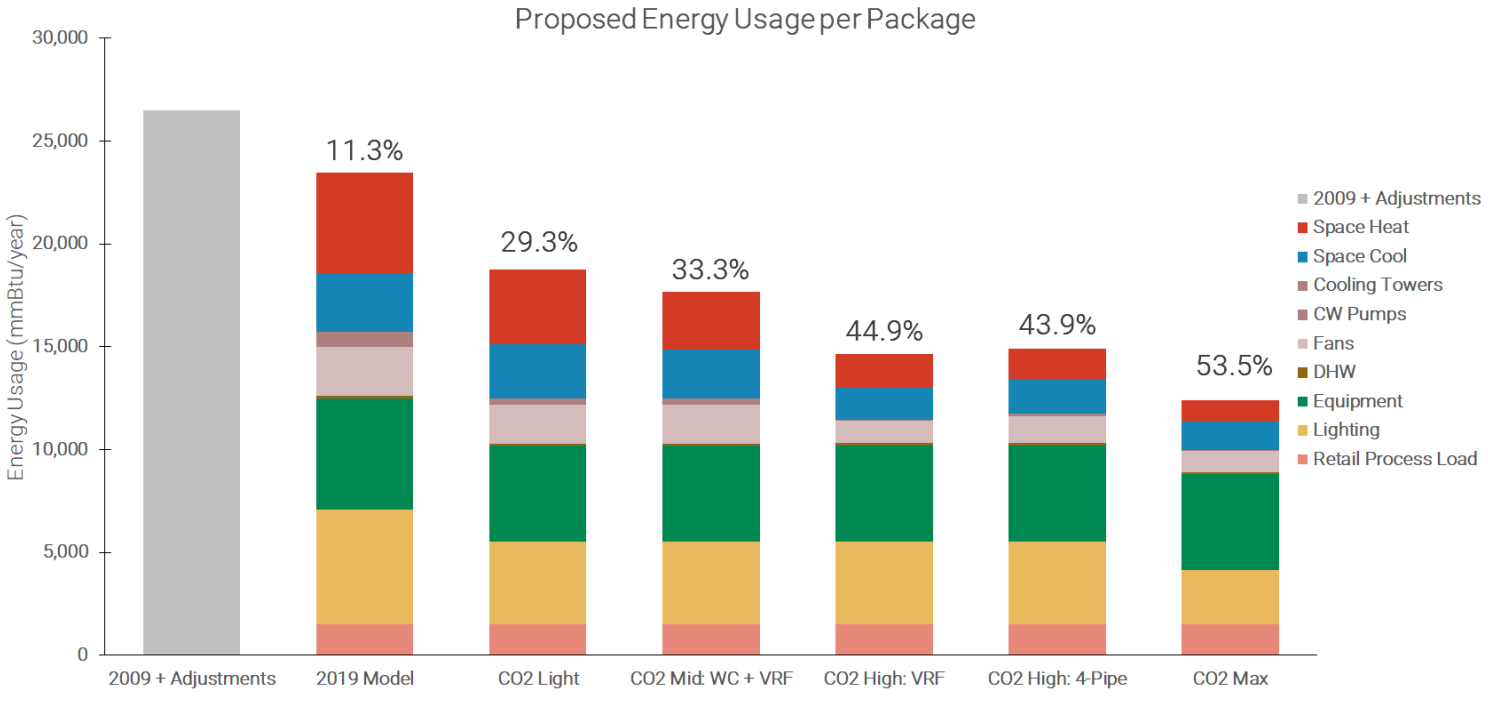
1333 ECM Package Comparison - Energy

Packages range from 29.3% to 53.5% reduction in total energy from 2009 + Adjustments benchmark year



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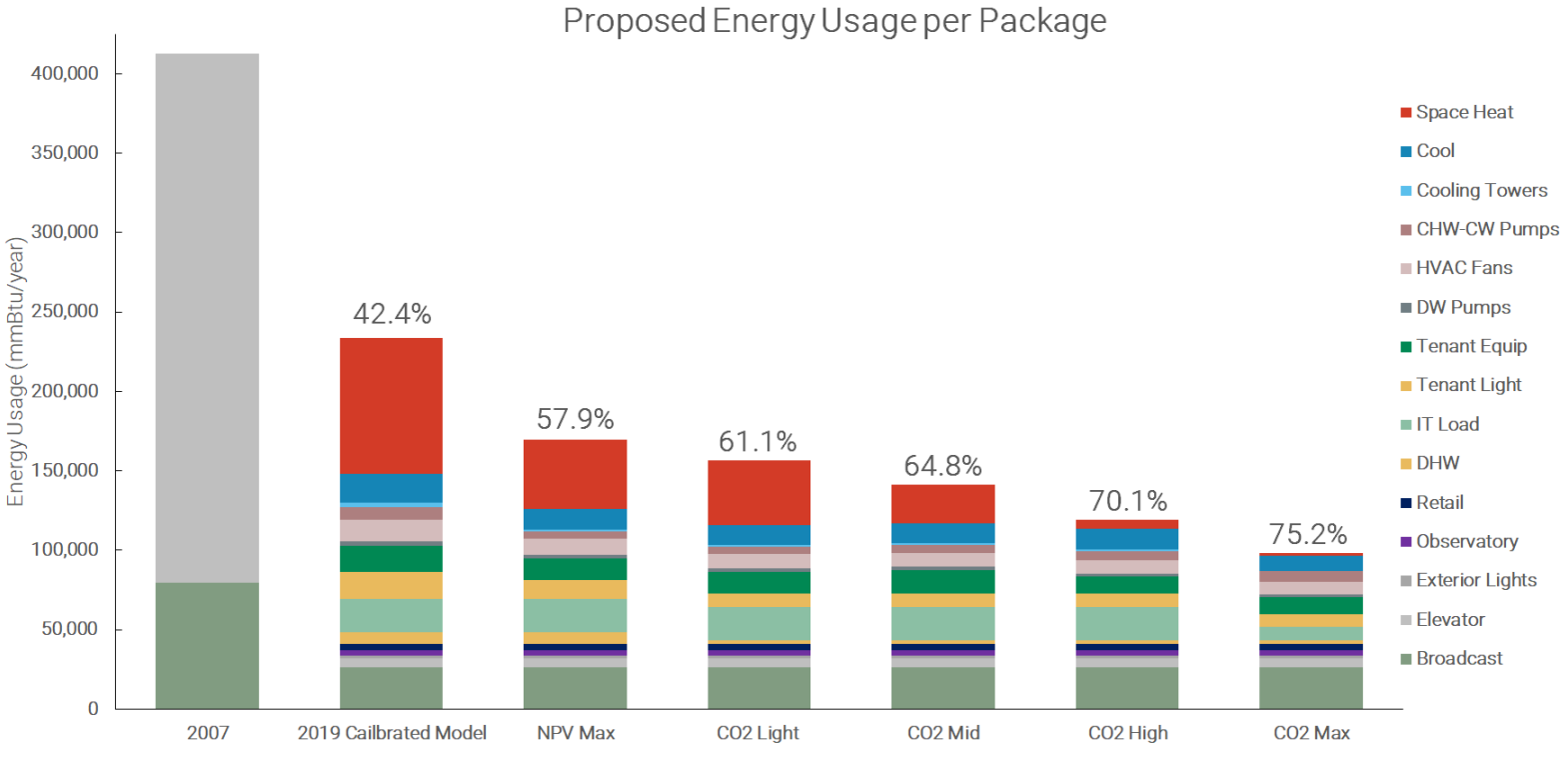
ESB ECM Package Comparison - Energy

Packages range from 57.9% to 75.2% reduction in total energy from 2007 benchmark



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