LL97 Deep Energy Retrofit Studies

One Grand Central Place
1400 Broadway
501 7th Avenue
111 W 33rd Street

March 13th, 2024
REV 04 - Updated LL97 Limits

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111 W 33rd Street

501 7th Avenue

One Grand Central Place

1400 Broadway

ESRT 2.0 Building Retrofit Goals

Building Case Studies (111, OGCP, 501,1400)

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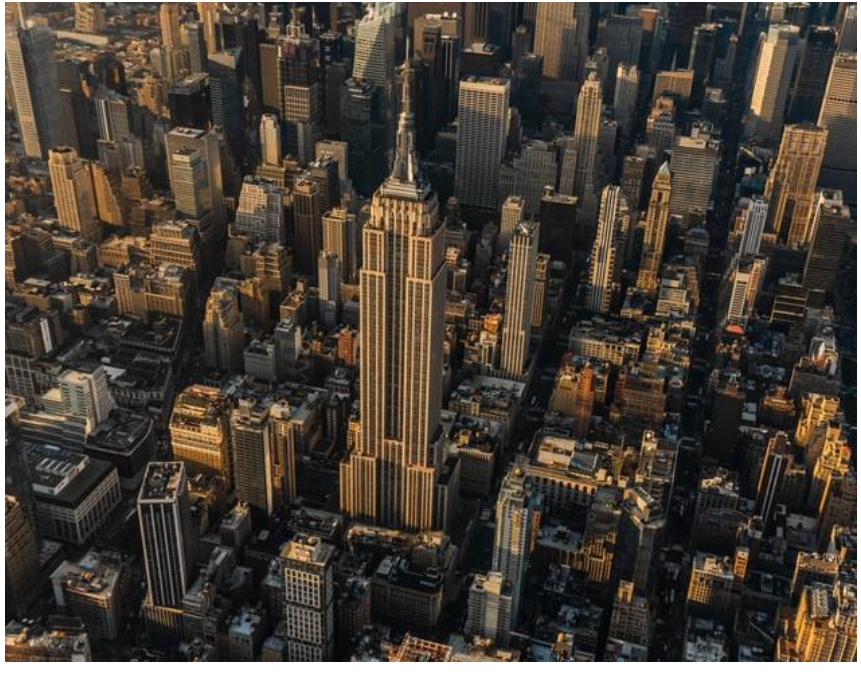
Lessons Learned

Appendix

ESRT 2.0 - 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



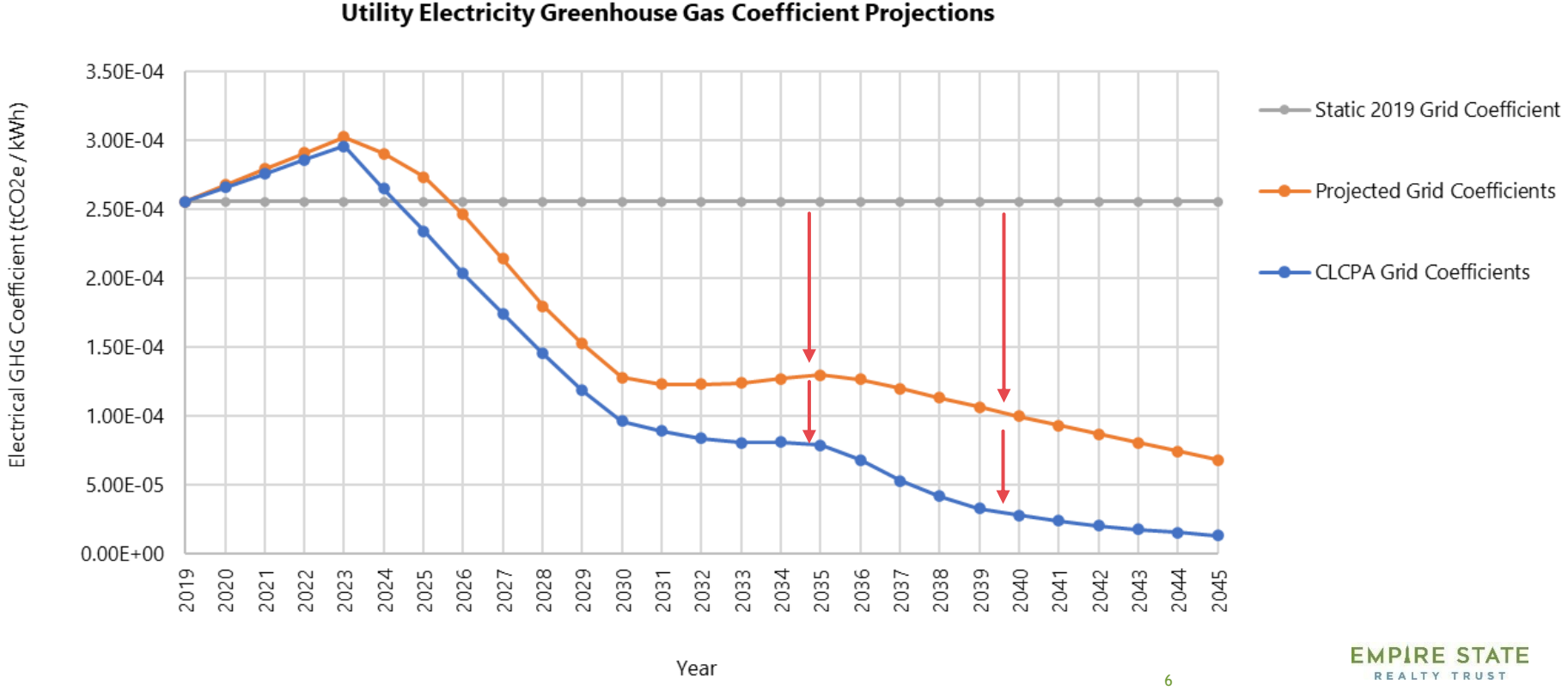
Defining Net-Zero Carbon

ESRT's working definition of net-zero 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 net-zero carbon through an 80% operational carbon reduction - achieved through a combination of energy efficiency measures and a more renewably sourced grid - and a 20% offset with off-site clean energy generation and RECs.

Grid Projections: CLCPA Grid Scenario vs. Projected Grid Scenario

Static Grid – 2019 electricity GHG coefficient
Projected Grid – projected electricity GHG coefficients
CLCPA Grid – electricity GHG coefficients in alignment with the NYS Climate Act (CLCPA)



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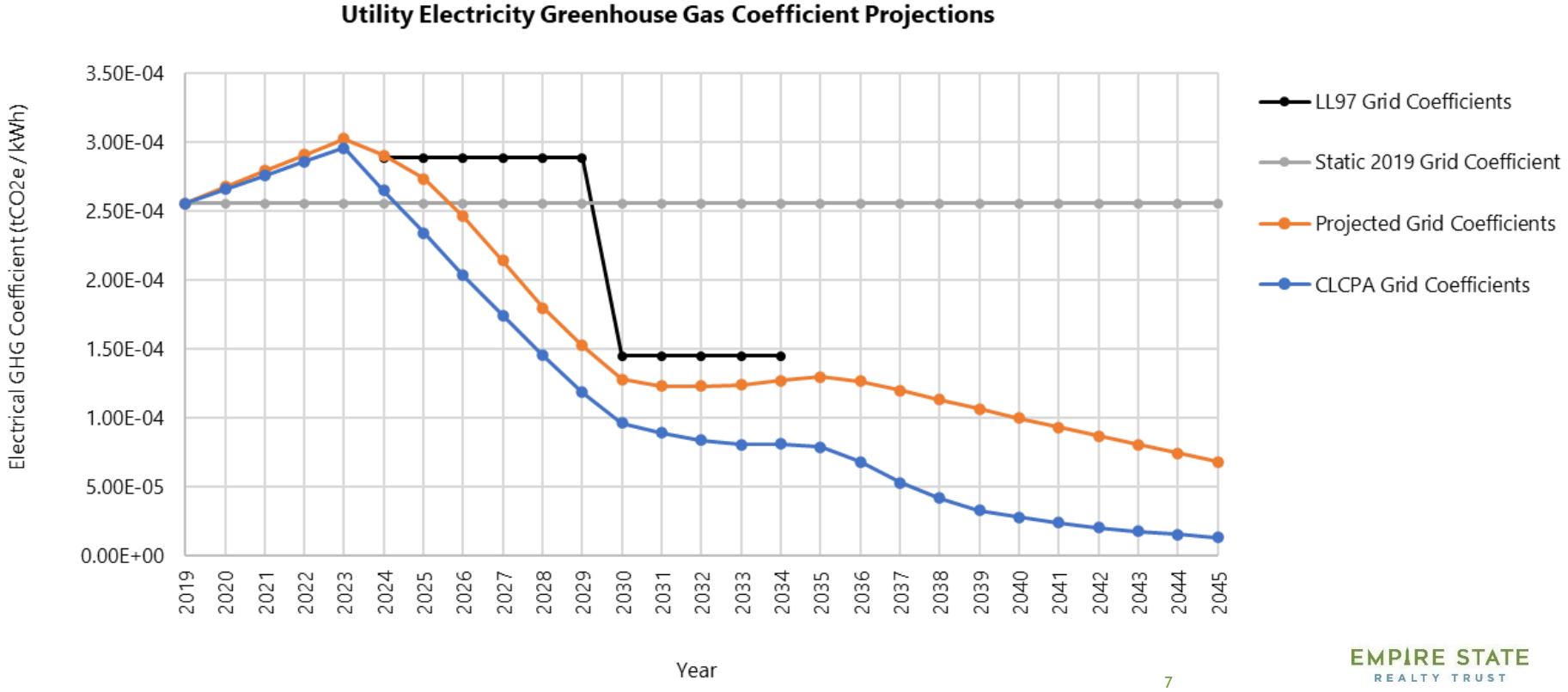
Grid Projections: LL97 Grid Emissions (2024-2034)

LL97 Grid - electricity GHG coefficients for 2024-2029 and 2030-2034 provided in LL97 of 2019 and 2022 proposed rules



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One Grand Central Case Study

Baseline Energy Modeling
ECM Phasing and Packaging
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One Grand Central Place - Current Building Systems

A mix of mostly air-cooled as well as limited water-cooled and chilled water systems. Heating is provided by district steam connected to radiators. 2021 Energy Grade: B/74

- Cooling
  - Self contained air cooled vertical AC units. Some newer units are VAV, most units are older and constant volume
  - Water cooled units serving retail and floors 3, 4, 46 and 47 with numerous cooling towers and circulating systems. 50 year-old indoor cooling towers serve equally old units on 46 and 47.
  - Chilled water plants serving the lobby, multi-tenant corridors, and floors 48-55
- Central chiller plant & cooling towers
  - (1) 90-ton water cooled screw chiller serving the lobby (recently retrofit)
  - (1) 90-ton water cooled modular chiller as backup for the lobby
  - (1) 210-ton water cooled modular chiller serving floors 48-55 (recent installation)
  - (1) 400-ton cooling tower serving 48-55 chiller (recent installation)
  - (1) 200-ton air cooled modular chiller serving multi-tenant corridors (due for replacement)
  - Numerous smaller condenser water systems at 3rd floor serving retail tenants, lobby chiller and 3rd and 4th floor tenant with varying ages and conditions.
- Utility steam
  - Space heat: cast iron radiators throughout, a small hot water loop serving parts of floors 48-55 and an air handler coil serving the Madison Ave concourse
  - Base building domestic hot water
  - Steam kettles in Pera's kitchen

2019 Energy Breakdown by Utility

Carbon Intensity vs. Energy Intensity

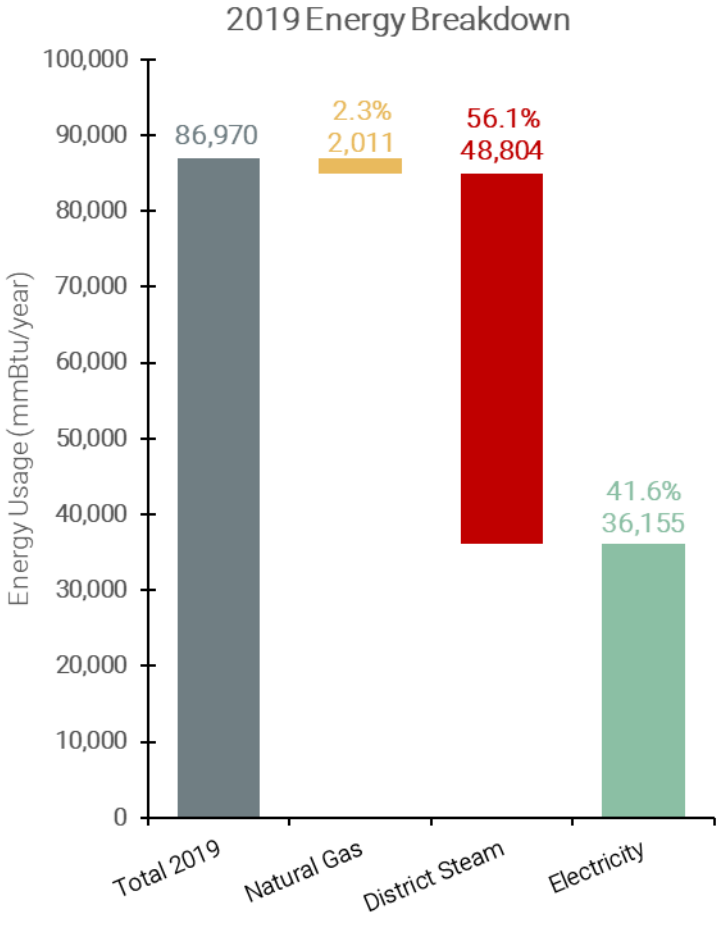
District Steam

- 56.1% of energy usage
- 43.7% of CO_2e emissions

Electricity

- 41.6% of energy usage
- 54.1% of CO_2e emissions

2019 OGCP Energy Use Index (EUI)		
Energy Source	EUI	Units
Electricity	9.3	kWh/SF/year
Natural Gas	1.8	kBtu/SF/year
District Steam	42.7	kBtu/SF/year
Total	**76.0**	**kBtu/SF/year**



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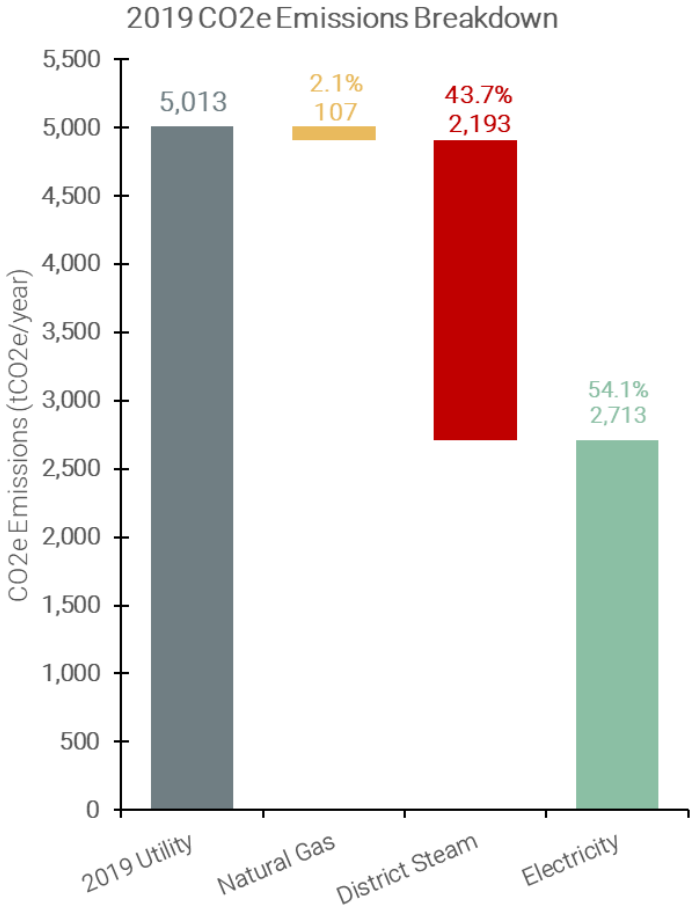
2019 CO_2e Emissions Breakdown by Utility

Electricity – 256.0 tCO_2e/GWh (Luthin)

Steam – 153.3 tCO_2e/GWh (LL97)

Natural Gas - 181.21 tCO_2e/GWh (LL97)



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2019 Operational Cost Breakdown by Utility

Steam vs Electricity Operational Costs

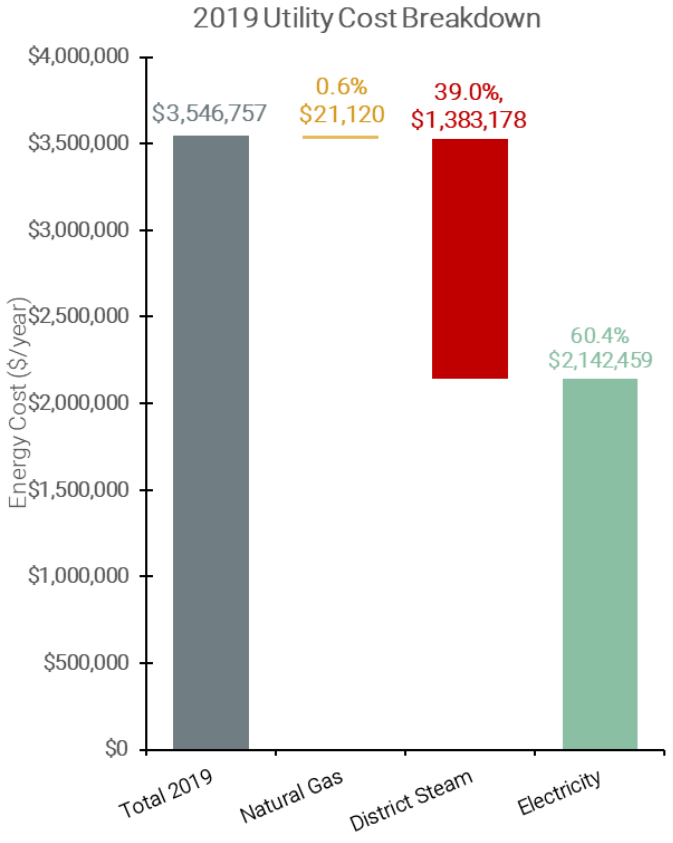
District Steam

- 39.0% of operational costs
- 56.1% of energy usage

Electricity

- 60.4% of operational costs
- 41.6% of energy usage

Natural Gas only used in specific retail spaces



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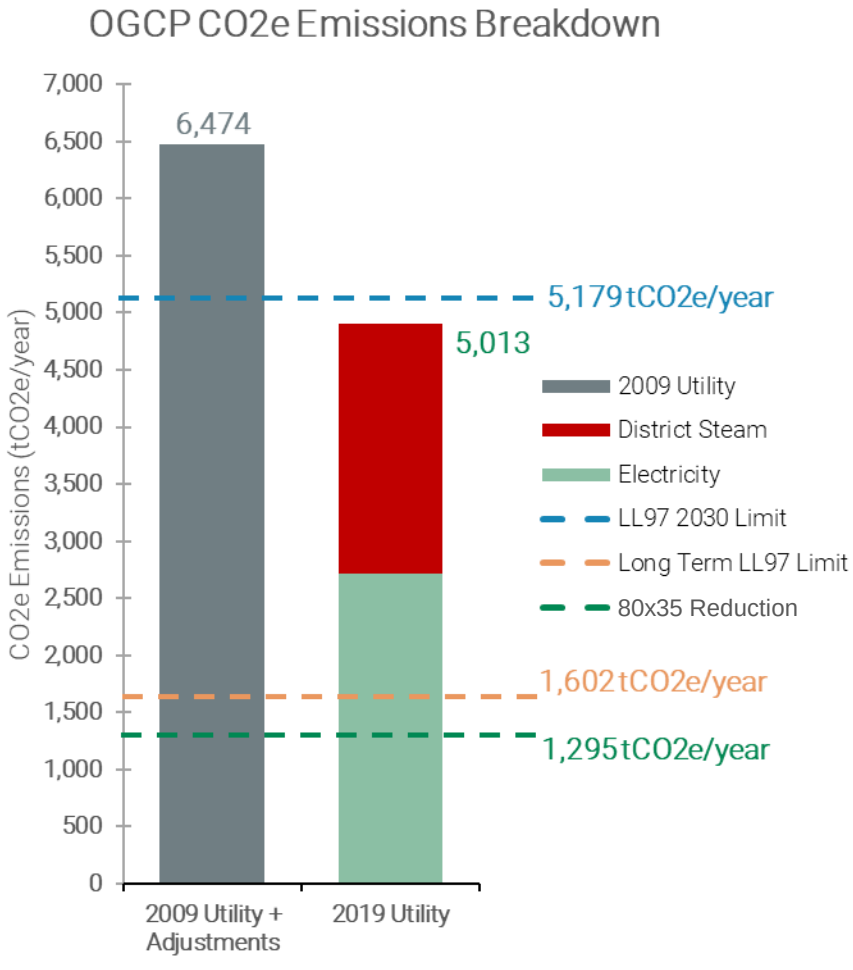
OGCP Current Status for LL97 and 80x35 Challenge



Key Takeaways:

- Building meets 2024 Limit of 9,698 tCO_2e/year
- Building meets 2030 Limit of 5,179 tCO_2e/year
- 68% reduction is required to meet LL97 2035 target

24% CO_2e Reduction from 2009 to 2019

- 43% due to electrical grid improvements
- 57% due to building improvements

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OGCP Energy Breakdown by Major End Users

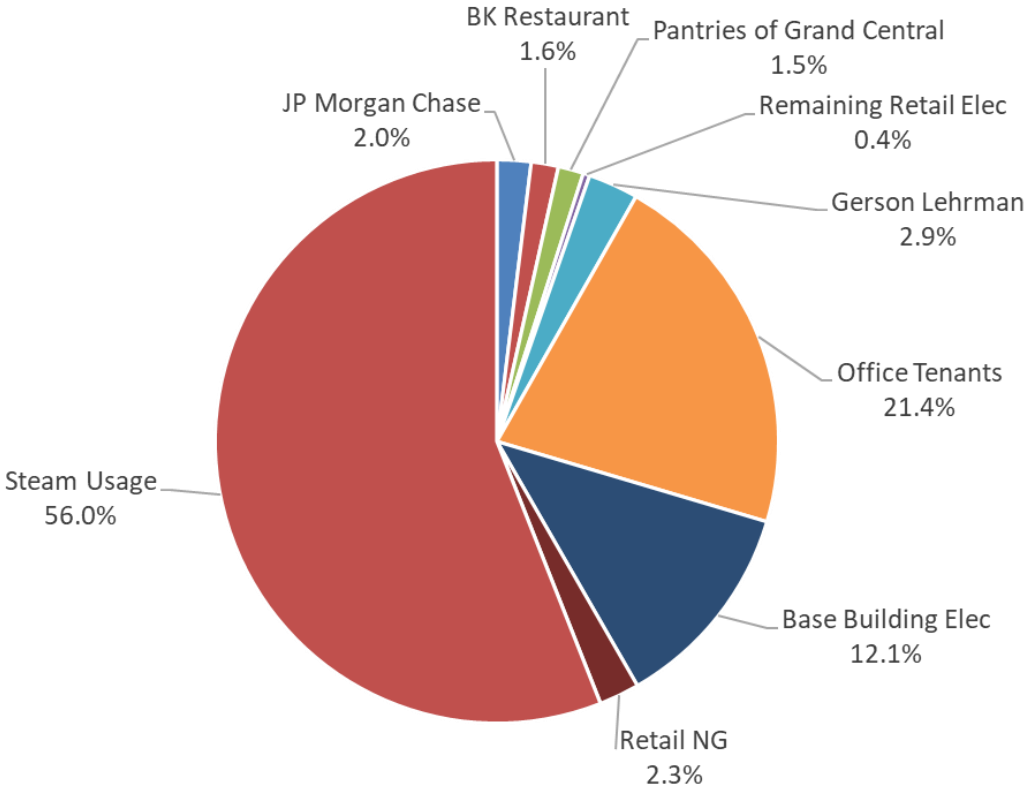
Steam Usage – 56%

Retail Tenants– 7.8%

Office Tenants – 24.3%

Base Building – 12.1%

- Tenant usage is based on Utilivisor Spreadsheet.
- Gerson Lehrman occupy 3rd and 4th floor.
- BK Restaurant has highest EUI – 34 kBtu/SF



OGCP Electricity Breakdown by Major End Users

Office Tenants – 58.2%

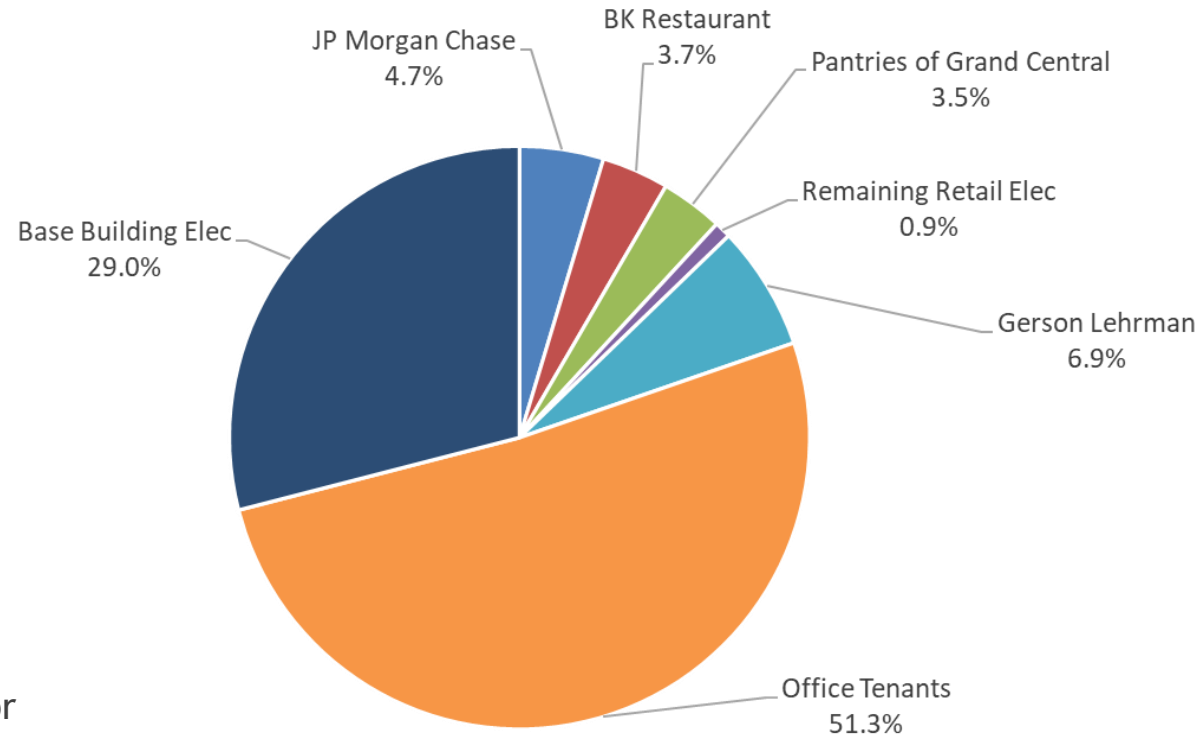
- Ltg, Office Equip, IT Loads
- Tenant CW,CHW Systems?
- AHU Fans and DX cooling?

Base Building– 29.0%

- Lobby and BB CHW Systems
- CW, CHW, DHW pumps
- Elevators
- BB AHU, Ltg and Equipment

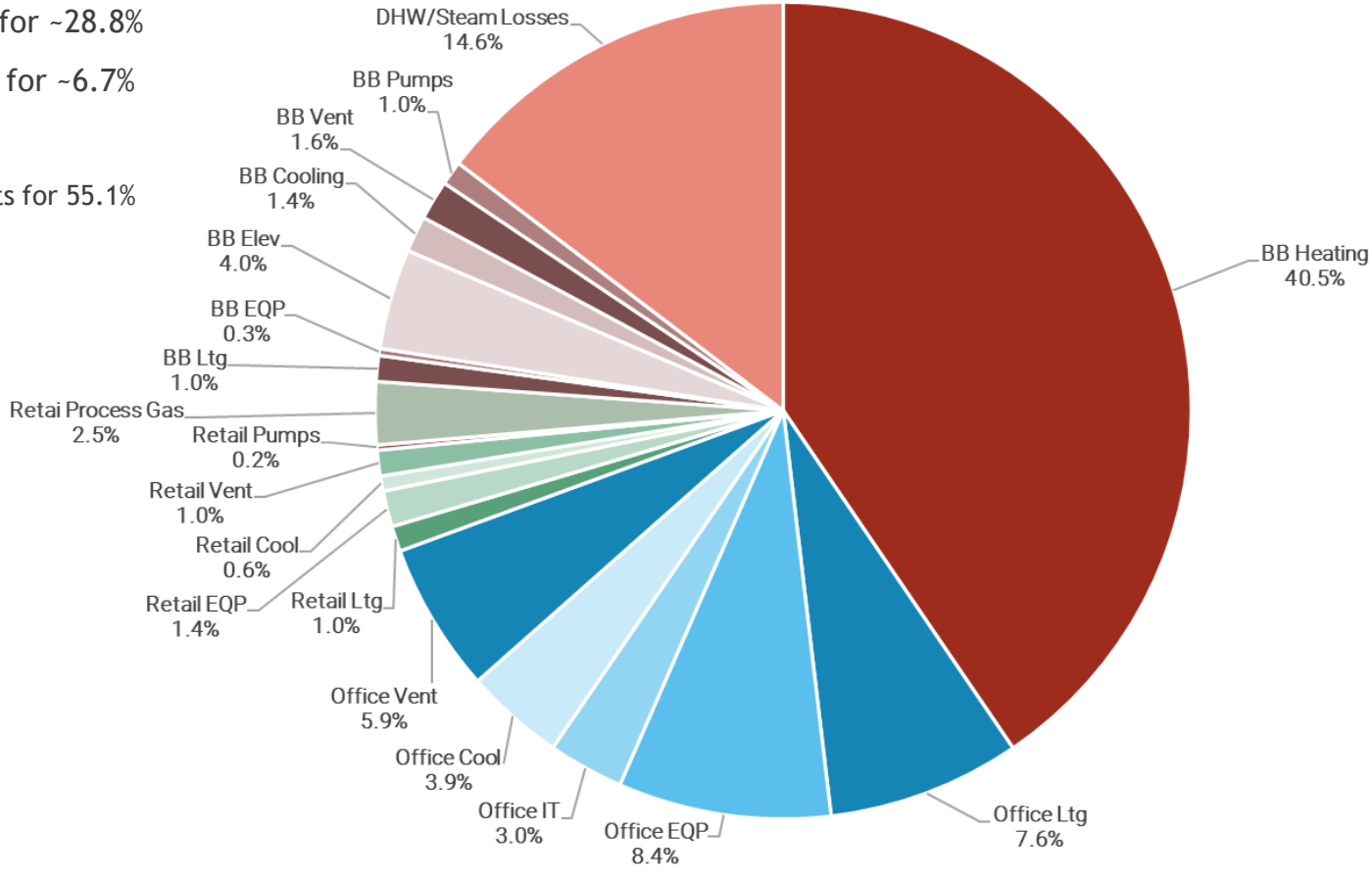
Retail Tenants– 12.8%

Tenant usage is based on Utilivisor Spreadsheet.



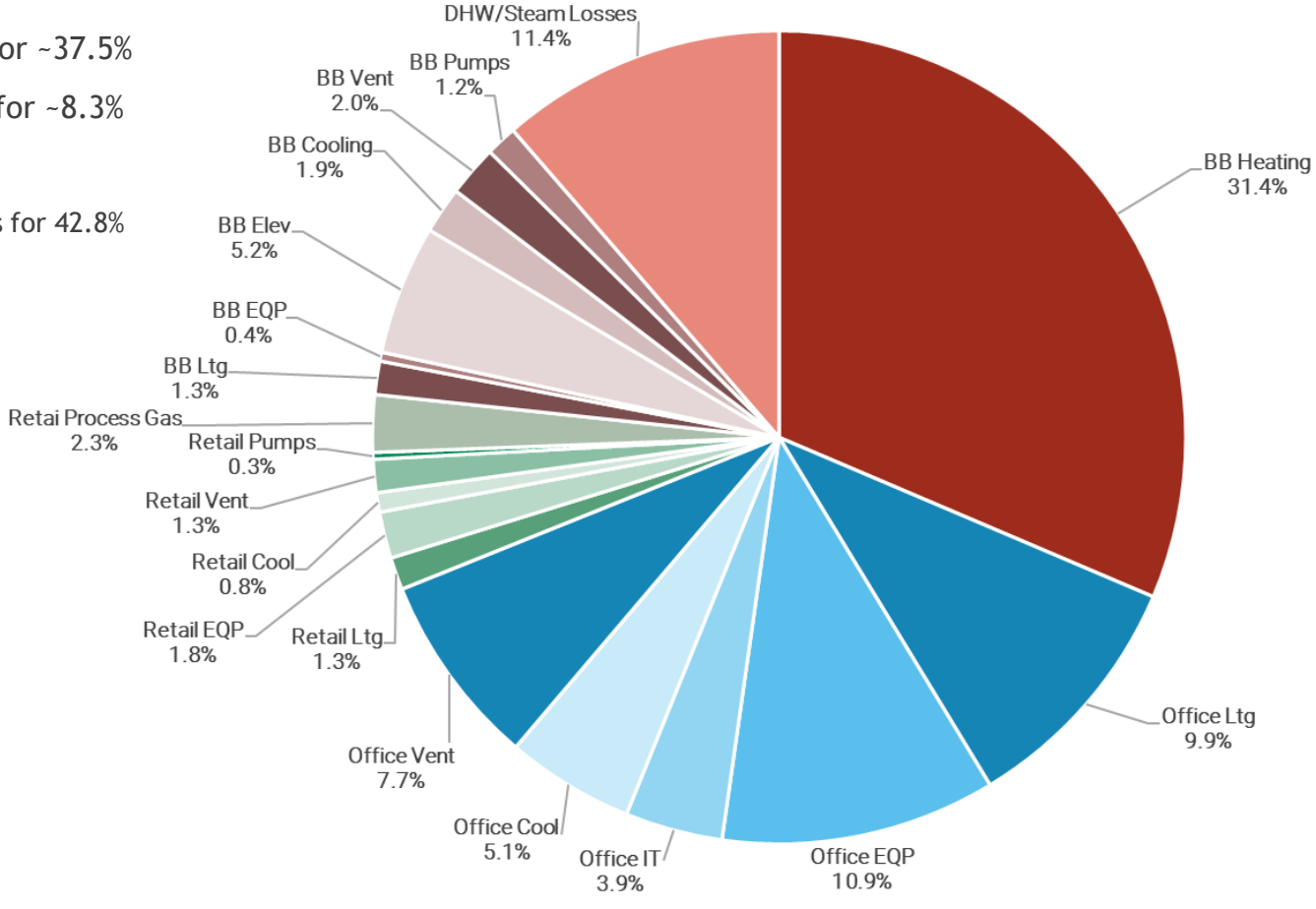
OGCP Energy Model: 2019 Energy Breakdown

- Office Tenants account for ~28.8%
- Retail Tenants accounts for ~6.7%
- Base Building 63.4%
  - Steam system accounts for 55.1%



OGCP Energy Model: 2019 CO_2e Emissions Breakdown

- Office Tenants account for ~37.5%
- Retail Tenants accounts for ~8.3%
- Base Building 54.2%
  - Steam system accounts for 42.8%



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ECM Packages – Recommended Package is CO_2 High

Four packages of ECMs were developed to optimize NPV and CO_2 reductions

1	2	3	4
CO_2 Light **No Electrification**	**CO_2 Mid** **Full Electrification: VRF + AWHPs**	**CO_2 High** **Full Electrification: VRF + AWHPs**	**CO_2 Max** **Full Electrification: VRF**
BMS integration & controls optimizations, steam upgrades, infiltration mitigation, VFDs for lobby AHUs, regen drives for elevators, replace DC motors, tenant load improvements (lighting upgrades, plug load controls), conversion of CV systems to VAV	CO_2 Light + freight vestibules, VRF on L3-47 and roof-top AWHPs serving VAV reheats on L48-55.	CO_2 Mid + vestibules at entrances, DHW electric heaters	CO_2 High + window retrofits, repair louver connections & VRF on L48-55 in lieu of AWHPs

Carbon Reduction

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ECM Phases & Implementation Timeline: CO_2 High

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE											
Phase	**Tag**	**ECM Description**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Phase 1	CO001	**BMS Integration of VAV Boxes & Radiator Valves & ASHRAE Guideline 36**	33%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	SS001	**Steam Cycle and Pressure Optimization**	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	EN005	**Hoistway Vent Closure**	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	CO005	**Control Valves & VFDs for Lobby AHUs**	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN008	**Fix Seals on the Revolving Doors**	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN004	**Freight Vestibule**	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN002	**Vestibule at Street**	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	DW002	**Conversion of Steam Domestic Hot Water Heating to Electric**	0%	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	UL001	**Replace DC Motors (Fans, Pumps) with AC**	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	VT001	**Regenerative Drives & Destination Dispatch for Elevators**	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%
Phase 3	EN001	**Radiant Barrier**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 3	SS003	**Radiator Pipe Insulation**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 3	TL002	**Lighting Upgrades & Controls**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 3	TL001	**Plug Load Control**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 3	EL001	**VRF Systems (ERV + DCV) for Office Tenants on Levels 3-47**	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 4	EL004	**Replace Corridor Air-Cooled Chiller with AWHP Serving Levels 48-55**	0%	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%

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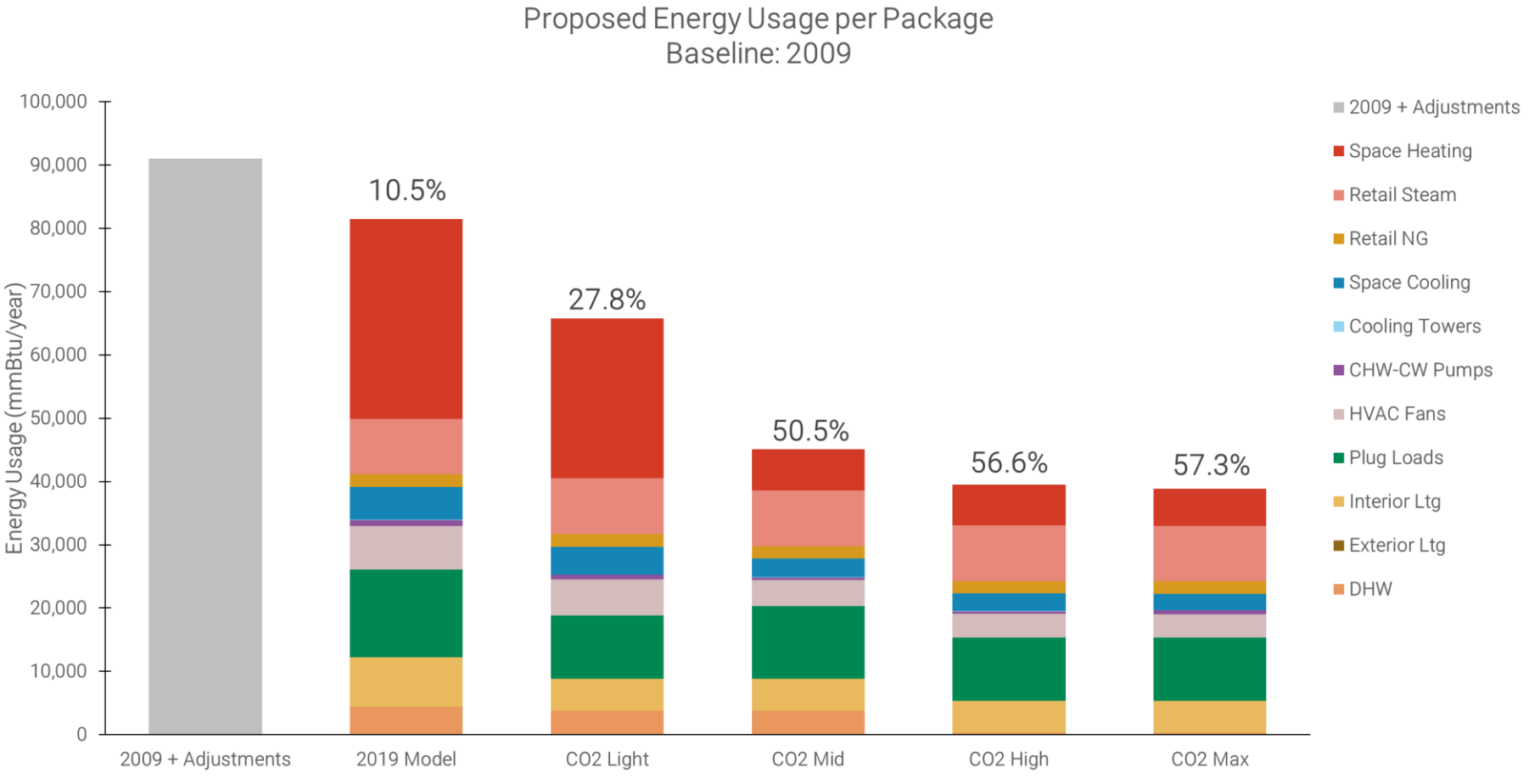
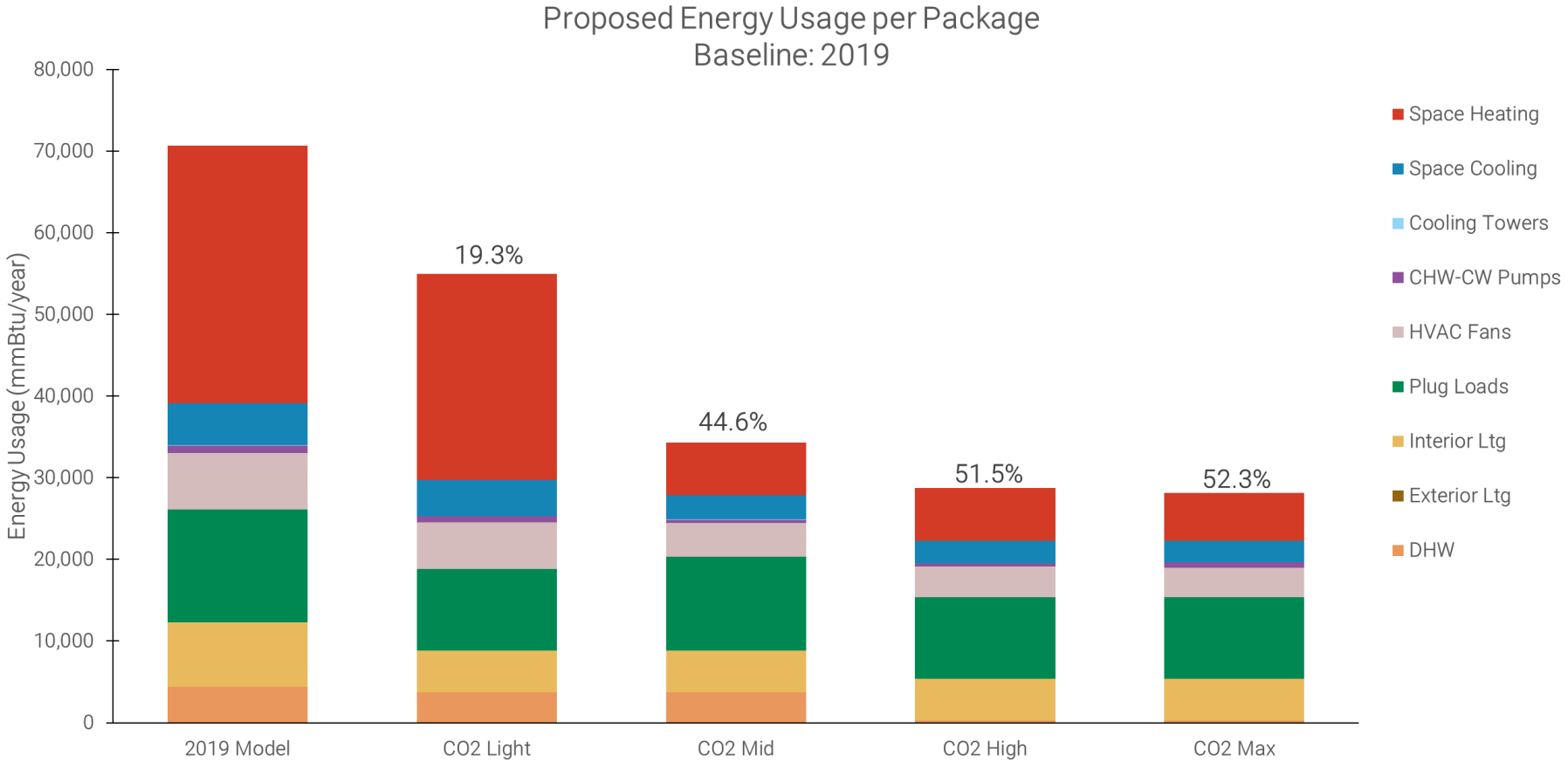
OGCP ECM Package Comparison: Energy

Baseline: 2009

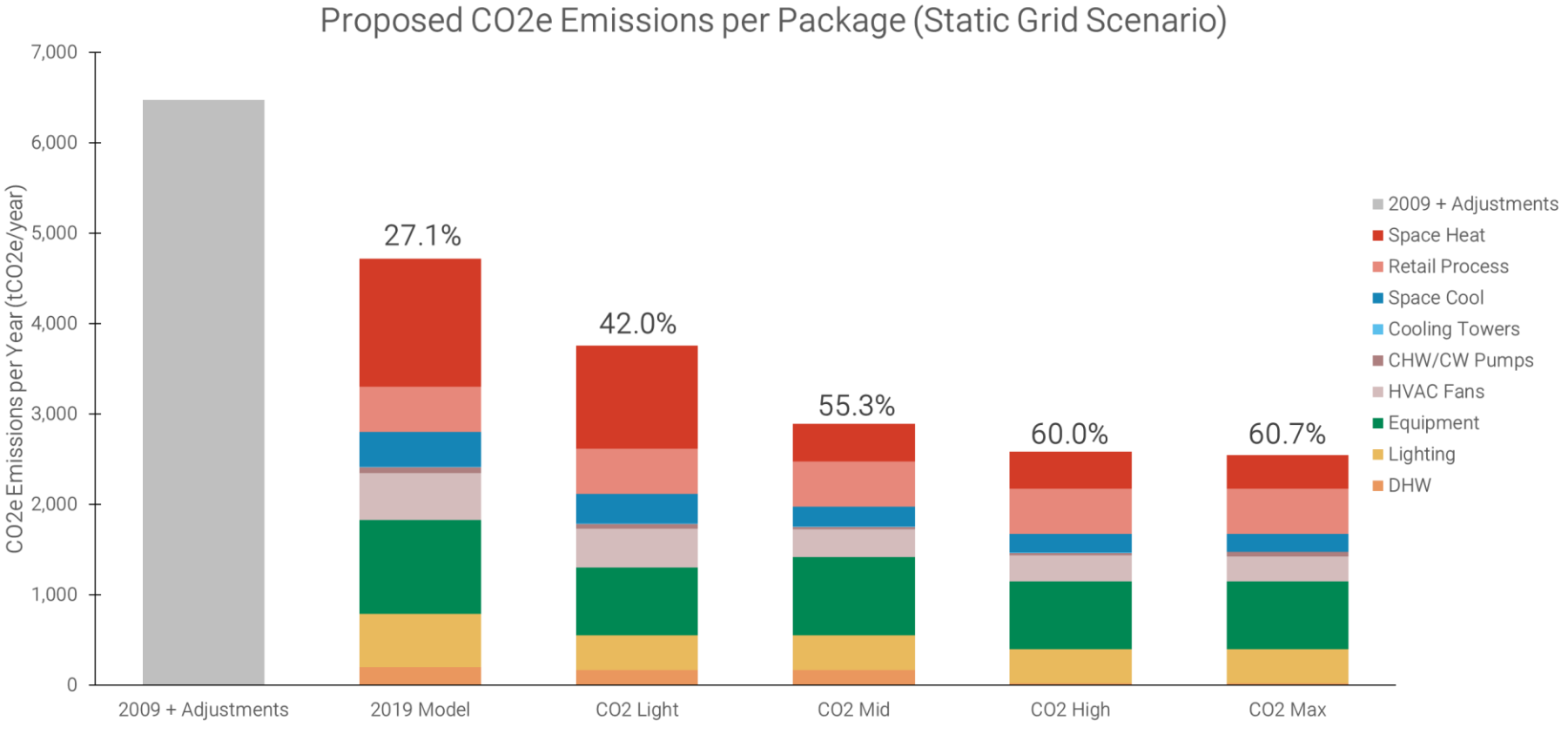


OGCP ECM Package Comparison: Energy

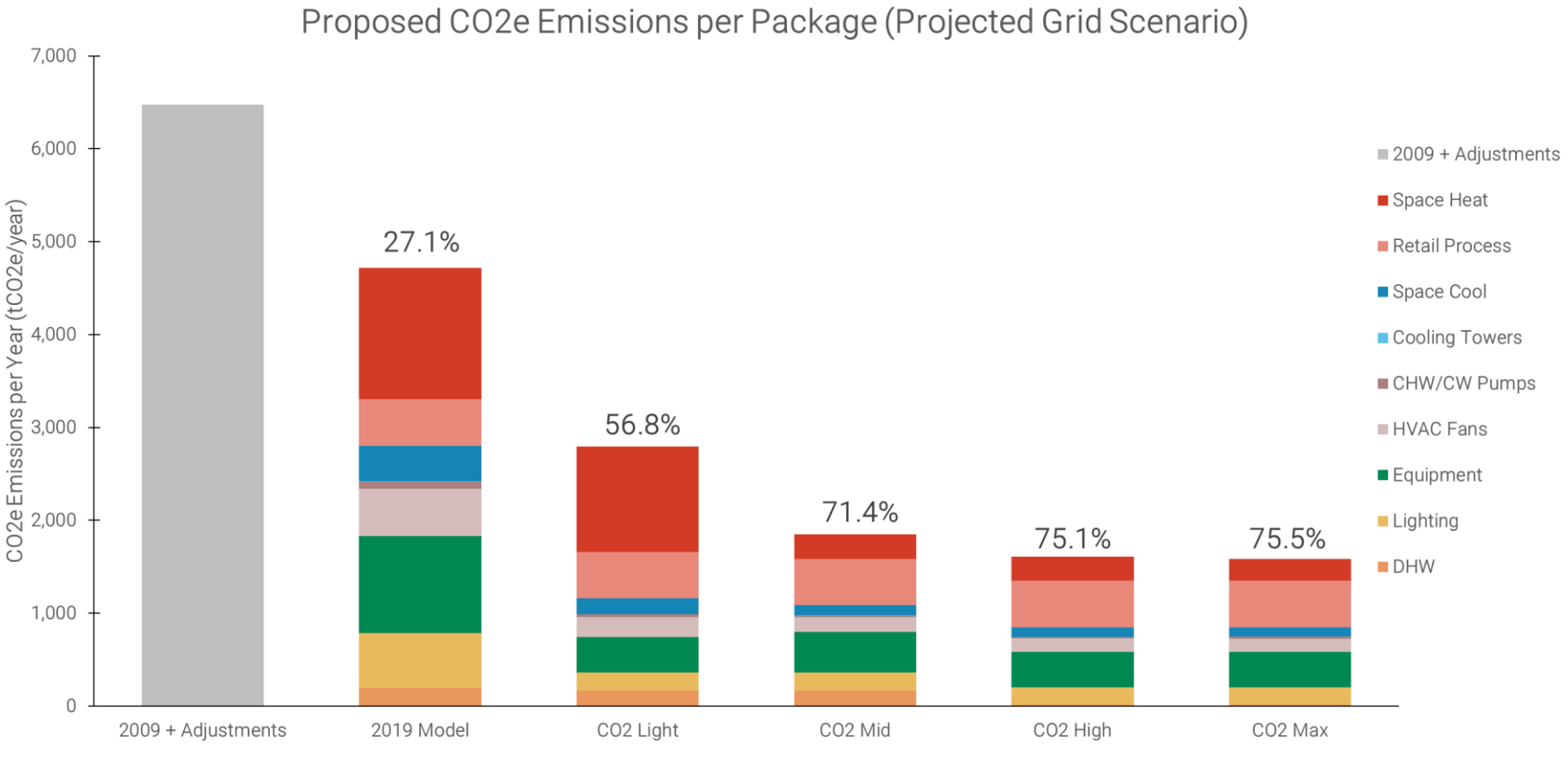
Baseline: 2019



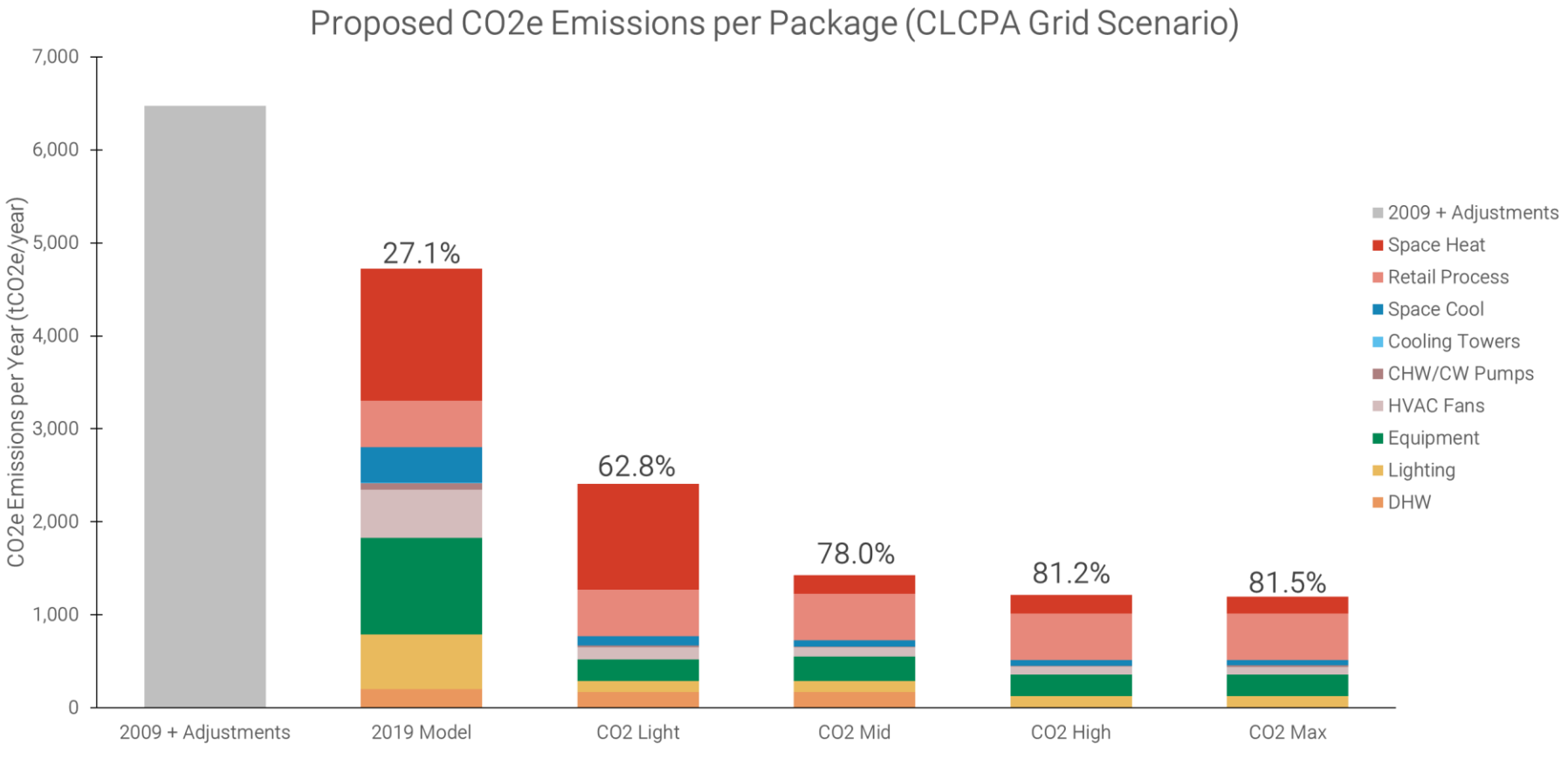
Projected CO_2 Emissions: Static 2019 Grid Scenario



Projected CO_2 Emissions: Projected Grid Scenario

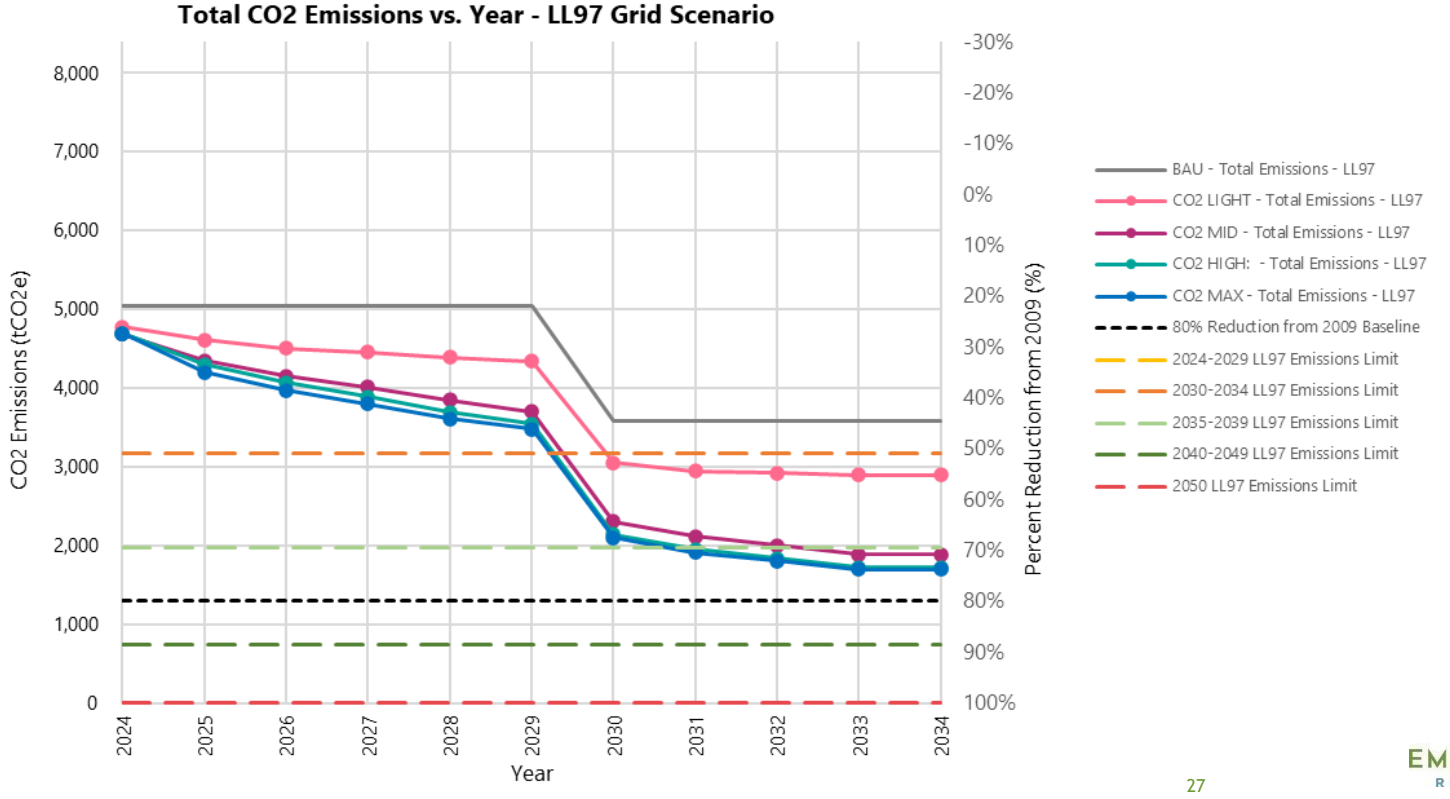


Projected CO_2 Emissions: CLCPA Grid Scenario



Projected Annual Carbon Emissions – LL97 Compliance

BAU does not achieve 2030 LL97 compliance;
All packages are below 2024 and 2030 LL97 emissions limits



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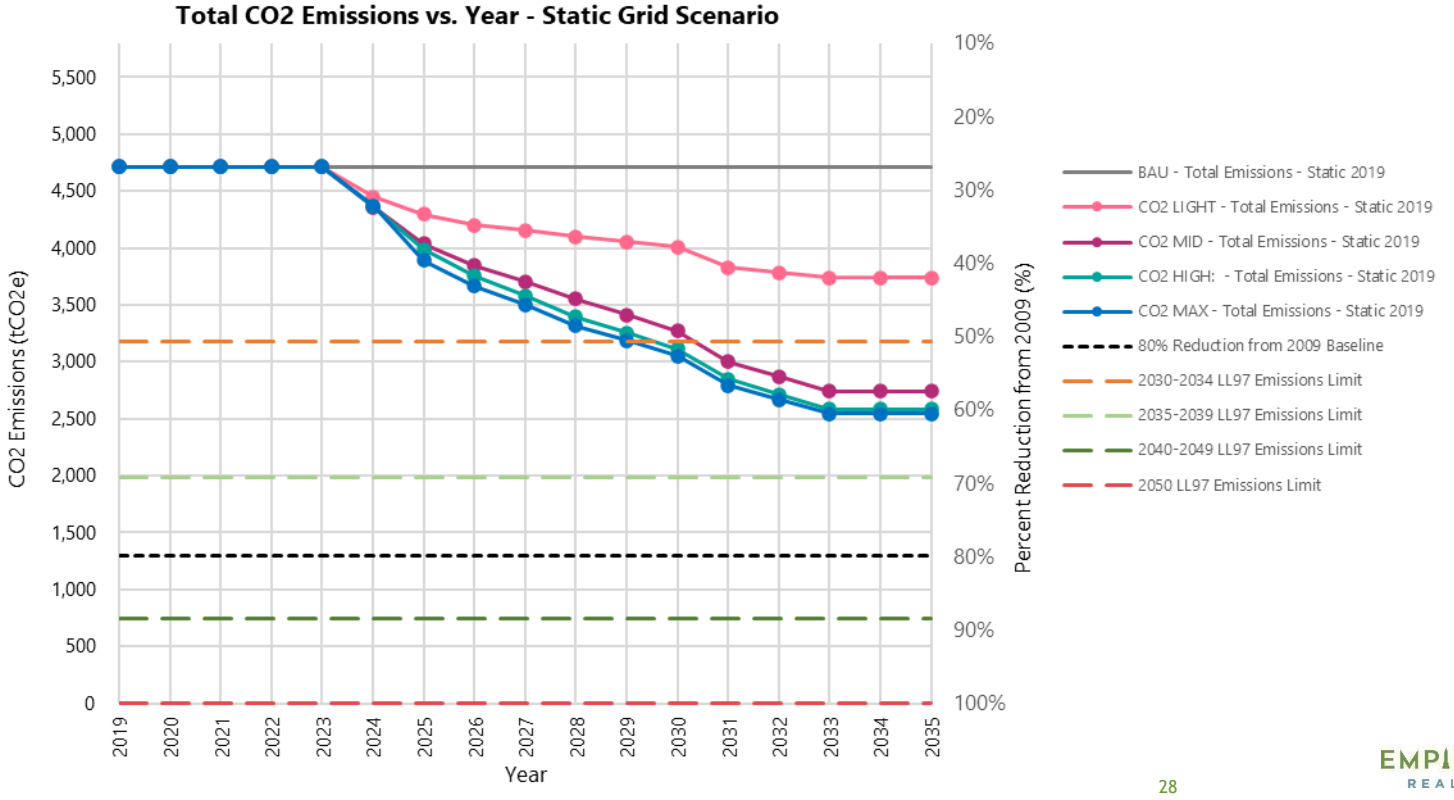
Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035** without grid decarbonization; Only CO_2 High and above packages would meet **2030 LL97** limit; CO_2 Mid achieves limit by 2031



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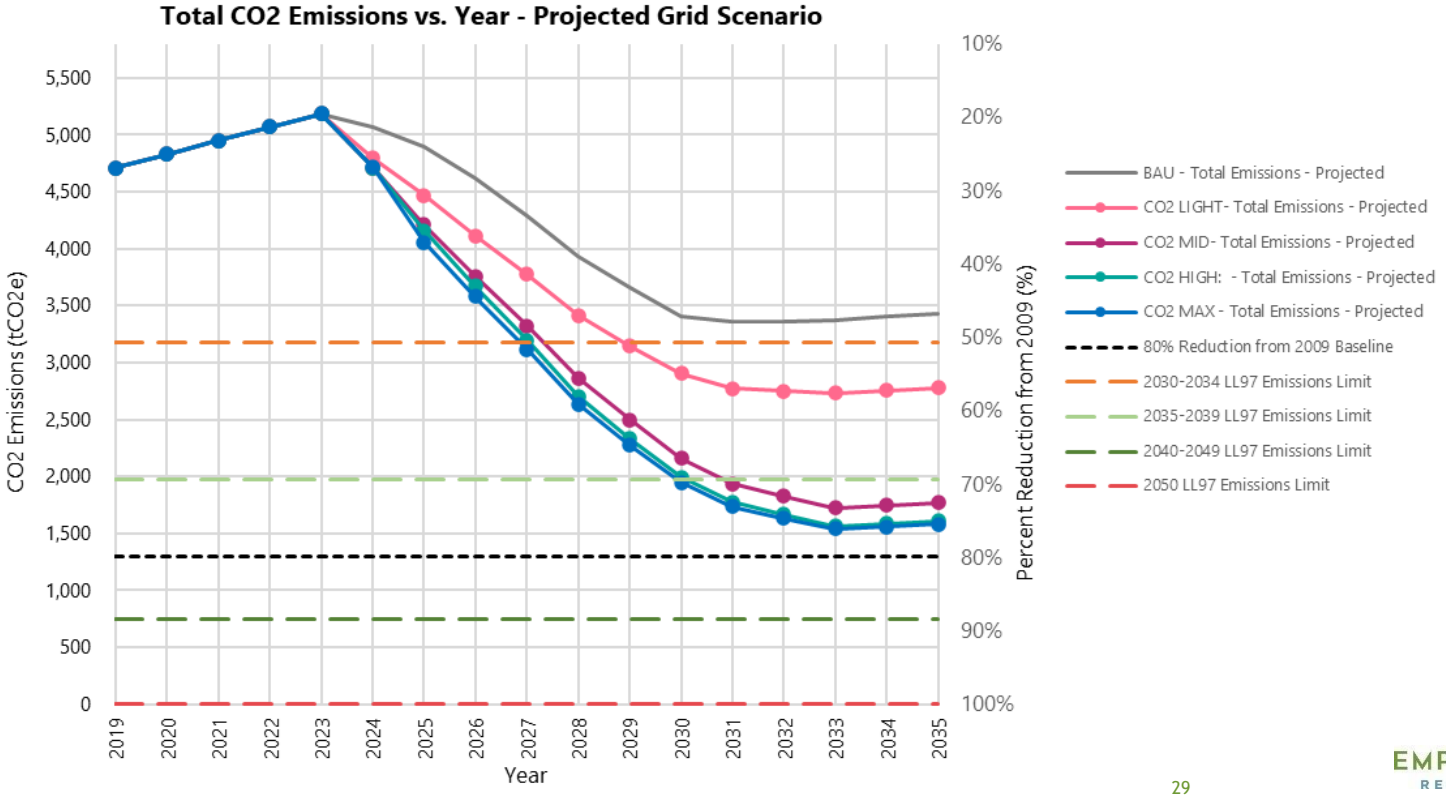
Projected Annual Carbon Emissions – Projected Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2035**;
CO_2 Mid and above packages meet **2035 LL97 limit**



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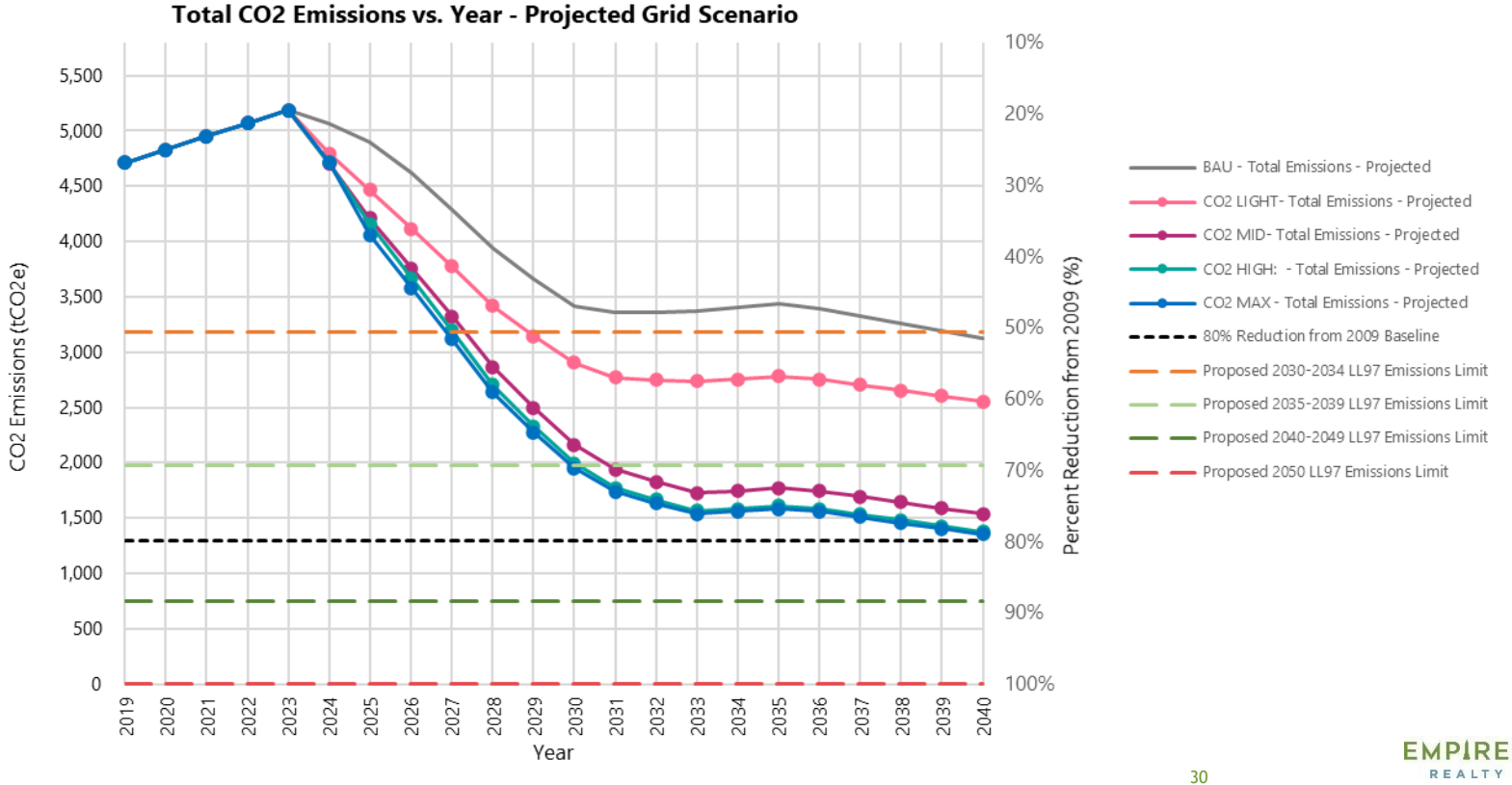
Carbon Emissions Extended to 2040 – Projected Grid Scenario

No packages would meet **80% reduction** from 2009 baseline by **2040**;
Projected fines for CO_2 Light, Mid, High & Max from 2035-2040[1]: **$1,448,333 (Light), $212,384 (Mid), $168,780 (High), $162,936 (Max)**



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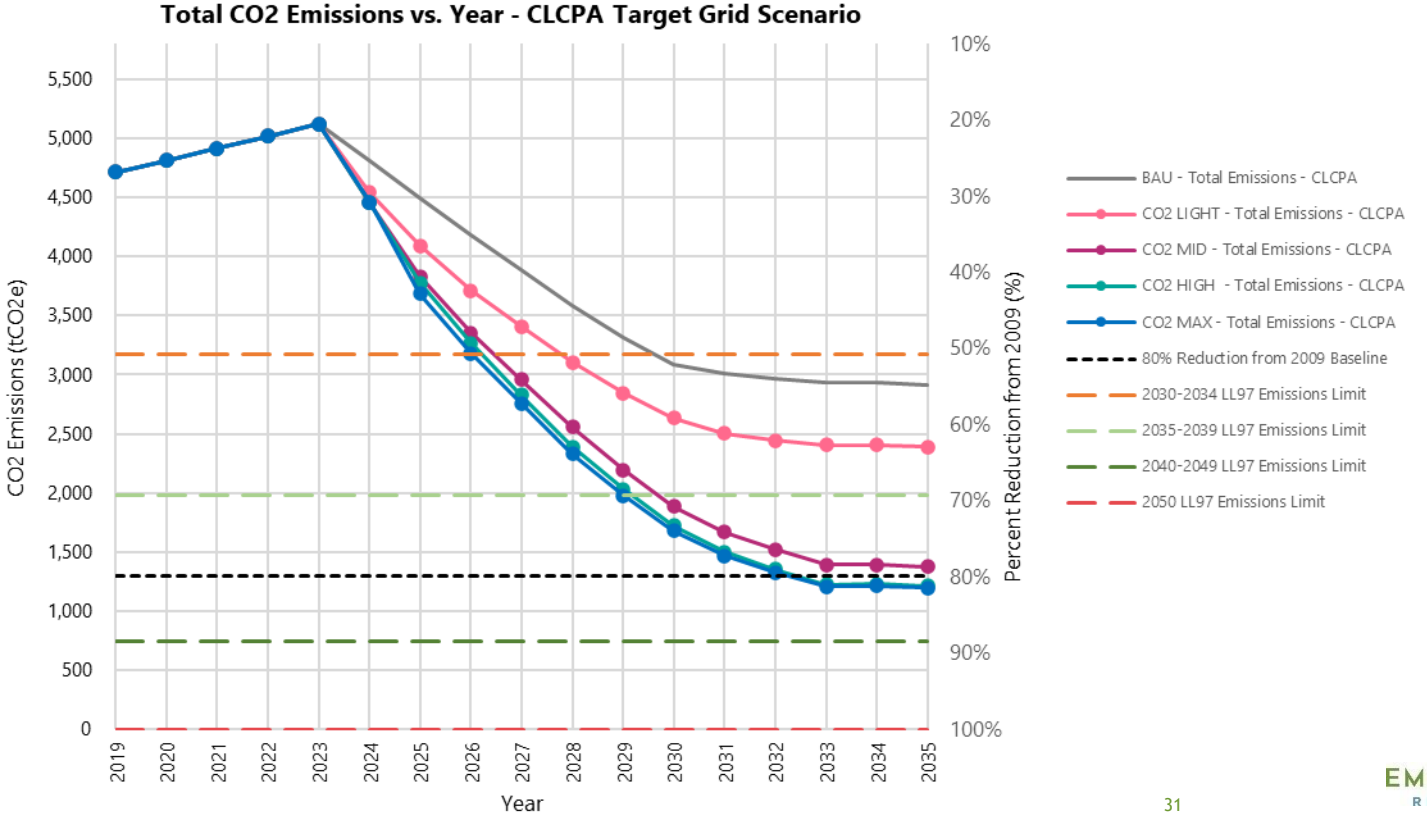
1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the Projected grid scenario

Projected Annual Carbon Emissions – CLCPA Grid Scenario

Only CO_2 Max and CO_2 High would meet **80% reduction** from 2009 baseline by **2035;**
All packages except CO_2 Light would meet **2035 LL97 limit**



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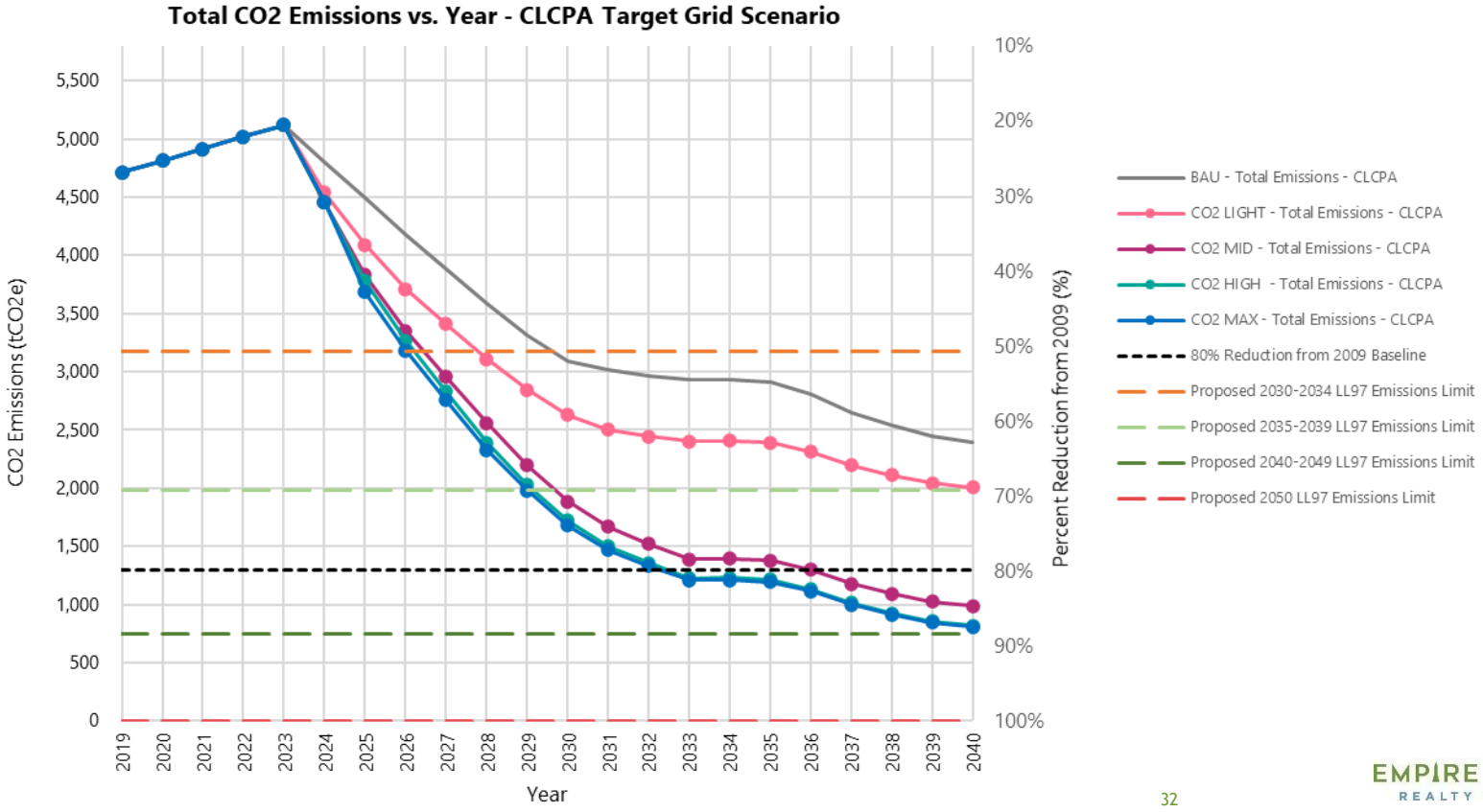
Carbon Emissions Extended to 2040 – CLCPA Grid Scenario

CO_2 Mid package meets **80% reduction** from 2009 baseline by **2036;** CO_2 Light does not meet **80% reduction** from 2009 baseline by **2040;** Projected fines for CO_2 Light, Mid, High & Max from 2035-2040[1]: **$645,489 (Light), $64,168 (Mid), $19,436 (High), $15,945 (Max)**



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1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the CLCPA grid scenario

Percent Carbon Emissions Reductions – All Grid Scenarios

80x35 target based on reductions from 2009 baseline

Reductions from 2019 baseline show impact of packages compared to current usage

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-35.2%	-46.0%	**-52.8%**	**-60.7%**
CO2 HIGH	-33.9%	-45.1%	**-51.9%**	**-60.1%**
CO2 MID	-30.6%	-41.9%	**-49.5%**	**-57.7%**
CO2 LIGHT	-14.9%	-20.7%	**-38.1%**	**-42.3%**

No packages would meet **80% reduction** from 2009 baseline by **2035** without grid decarbonization;
Only CO_2 High and above packages would meet **2030 LL97** limit; CO_2 Mid achieves limit by 2031

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-58.6%	-66.4%	**-69.9%**	**-75.5%**
CO2 HIGH	-57.7%	-65.8%	**-69.2%**	**-75.1%**
CO2 MID	-54.2%	-62.4%	**-66.6%**	**-72.7%**
CO2 LIGHT	-38.4%	-41.0%	**-55.2%**	**-57.1%**

No packages would meet **80% reduction** from 2009 baseline by **2035**;
CO_2 Mid and above packages meet **2035 LL97 limit**

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-64.4%	-74.7%	**-74.1%**	**-81.6%**
CO2 HIGH	-63.5%	-74.3%	**-73.4%**	**-81.3%**
CO2 MID	-60.0%	-70.8%	**-70.9%**	**-78.7%**
CO2 LIGHT	-44.2%	-49.3%	**-59.4%**	**-63.1%**

Only CO_2 Max and CO_2 High would meet **80% reduction** from 2009 baseline by **2035;**
All packages except CO_2 Light would meet **2035 LL97 limit**

One Grand Central Case Study

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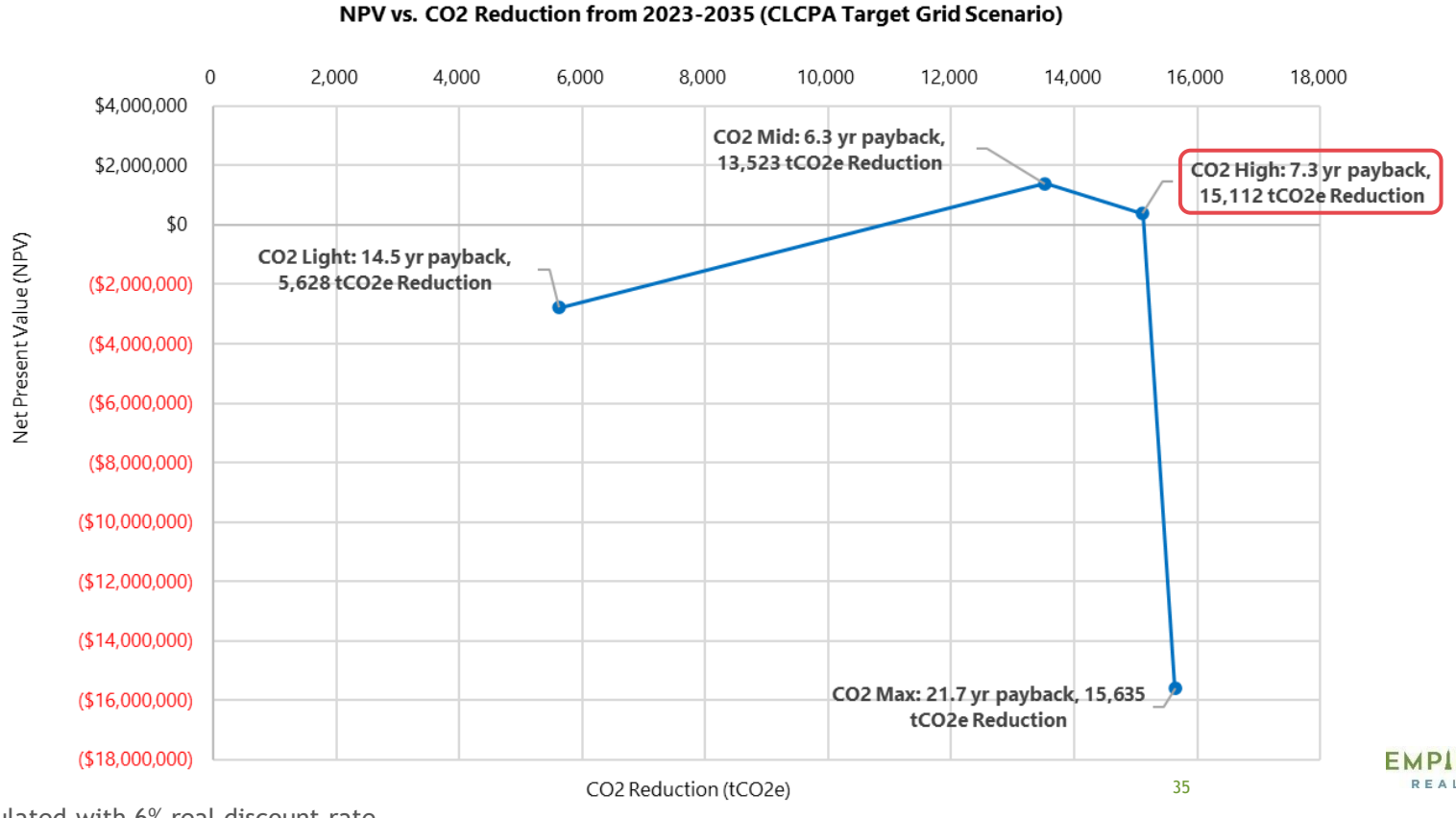
NPV, CO_2 Reductions and Simple Payback for all Packages

Net Present Value for 2023-2035; CO_2 reduction based on CLCPA scenario



NPV calculated with 6% real discount rate

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Projected LL97 Fines From 2024-2034

No LL97 fines projected for the baseline for 2024-2029;
Fines possible from 2030-2034 for baseline if 2022 emissions limits are approved, though all packages offset the potential fines.

Packages	LL97 Fines From 2024-2034					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034
BAU (2019 Baseline)	$0	$0	-	$0	$545,700	-
CO_2 Light	$0	$0	$0	$0	$0	$545,700
CO_2 Mid	$0	$0	$0	$0	$0	$545,700
CO_2 High	$0	$0	$0	$0	$0	$545,700
CO_2 Max	$0	$0	$0	$0	$0	$545,700

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2024-2029 are based on GHG coefficients provided in LL97 of 2019.
4. Fine calculations for 2030-2034 are based on additional GHG coefficients provided in the proposed rules for LL97 released Oct. 2022.

Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario

Fines projected for the baseline and all packages except for CO_2 Max under currently published LL97 limits, though CO_2 Mid & High packages offset most of the fines;
Fines possible from 2035-2049 for baseline and all packages if 2022 emissions limits are approved, though CO_2 Mid, High & Max offset most of the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$5,787,505	-	$322,502	$7,571,737	-	$751,722
CO_2 Light	$3,560,363	$2,227,142	$189,938	$5,344,596	$2,227,142	$619,158
CO_2 Mid	$119,319	$5,668,186	$0	$1,663,021	$5,908,717	$347,271
CO_2 High	$2,078	$5,785,427	$0	$1,223,469	$6,348,269	$303,169
CO_2 Max	$0	$5,787,505	$0	$1,172,347	$6,399,391	$298,363

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario

Fines projected for the baseline and CO_2 Light under currently published LL97 limits; packages CO_2 Mid, High, and Max offset all the fines.

Fines possible from 2035-2049 for baseline and all packages if 2022 emissions limits are approved, though CO_2 Mid, High, and Max packages offset most of the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$3,265,743	-	$172,808	$5,049,976	-	$602,028
CO_2 Light	$1,672,187	$1,593,556	$77,854	$3,456,420	$1,593,556	$507,074
CO_2 Mid	$0	$3,265,743	$0	$417,784	$4,632,192	$233,980
CO_2 High	$0	$3,265,743	$0	$33,906	$5,016,070	$189,016
CO_2 Max	$0	$3,265,743	$0	$23,817	$5,026,159	$186,008

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Financial & Carbon Summary - Recommended Package is CO_2 High

Meets 80x35 Target (CLCPA Grid, Y/N)	CO_2 Light (N)	CO_2 Mid (N)	CO_2 High (Y)	CO_2 Max (Y)
Carbon Emissions in 2035 (CLCPA Grid)	2,391	1,377	1,213	1,194
NPV (2023-2035)[1]	($2,790,703)	$1,387,275	$371,618	($15,598,803)
NPV (Asset Life)[1]	$570,550	$7,058,693	$6,114,559	($12,270,285)
Base Capital Cost[2]	($127,064,053)	($131,484,932)	($131,484,932)	($127,337,862)
Incremental Capital Cost[2]	($11,238,013)	($11,729,993)	($13,519,187)	($34,713,480)
Annual Energy Cost Savings[2]	$691,438	$1,296,856	$1,379,914	$1,444,507
Annual Repairs & Maintenance Savings	$6,650	$1,950	($16,250)	($9,950)
Incentives	$1,095,382	$3,576,505	$3,580,040	$3,653,195
Simple Payback	14.5	6.3	7.3	21.7

12% decrease

6.4% increase

CO_2 Light Reduction – BMS integration & controls optimizations, steam upgrades, infiltration mitigation, VFDs for lobby AHUs, regen drives for elevators, replace DC motors, tenant load improvements (lighting upgrades, plug load controls), conversion of CV systems to VAV
CO_2 Mid Reduction – CO_2 Light + freight vestibules, **full electrification** via VRF on L3-47 and roof-top AWHPs serving VAV reheats on L48-55.
CO_2 High Reduction – CO_2 Mid + vestibules at entrances, electrification of DHW
CO_2 Max Reduction – CO_2 High + window retrofits, repair louver connections & **full electrification** of L48-55 via VRF

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.

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Financial Breakdown - Recommended Package is CO_2 High

	CO_2 Light	CO_2 Mid	CO_2 High	CO_2 Max
NPV (2023-2035)[1]	($2,790,703)	$1,387,275	$371,618	($15,598,803)
NPV (Asset Life)[1]	$570,550	$7,058,693	$6,114,559	($12,270,285)
Base Capital Cost[2]	($127,064,053)	($131,484,932)	($131,484,932)	($127,337,862)
➢ Base Building Infrastructure	($13,750,000)	($18,170,879)	($18,170,879)	($14,023,809)
➢ Tenant Fitout HVAC[3]	($113,314,053)	($113,314,053)	($113,314,053)	($113,314,053)
Incremental Capital Cost[2]	($11,238,013)	($11,729,993)	($13,519,187)	($34,713,480)
Annual Energy Cost Savings[2]	$691,438	$1,296,856	$1,379,914	$1,444,507
Annual Repairs & Maintenance Savings	$6,650	$1,950	($16,250)	($9,950)
Incentives	$1,095,382	$3,576,505	$3,580,040	$3,653,195
Simple Payback	14.5	6.3	7.3	21.7

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.
3. Tenant fitout HVAC base capital costs include cost of new tenant VAV systems with electronic radiator valves, including new AHUs, and code minimum plug load controls

Recommended Package – CO_2 High

- Replace aged air-cooled chiller serving interior corridors with new air to water heat pump (AWHP)
  - AWHP installation provides heating for floors 48-55 during the winter when the corridor CHW system is not used
- Replace tenant cooling systems with VRF at every tenant fit out on floors 3-47
  - High heating load means it is critical to change heating from steam to heat pumps to meet targets by 2035
  - VRF systems are estimated to be the same cost as installation of the self-contained air-cooled vertical systems that have previously been installed in the building
- Install point of use domestic water heating in core restrooms at the time of cosmetic upgrades
  - Provides significant reduction in standby losses
- Improve upon efficiencies of existing steam system
  - Optimize steam cycle control and reduce pressure of steam distribution to reduce overheating from piping and oversized radiators
  - Replace thermostatic radiator valves with electronic control valves tied to the BMS to prevent simultaneous heating and cooling
- Convert existing constant volume lobby AHUs to operate with variable flow tied to the BMS
- Reduce lobby infiltration with the correction of leaky revolving doors and re-introduction of vestibules

One Grand Central Case Study

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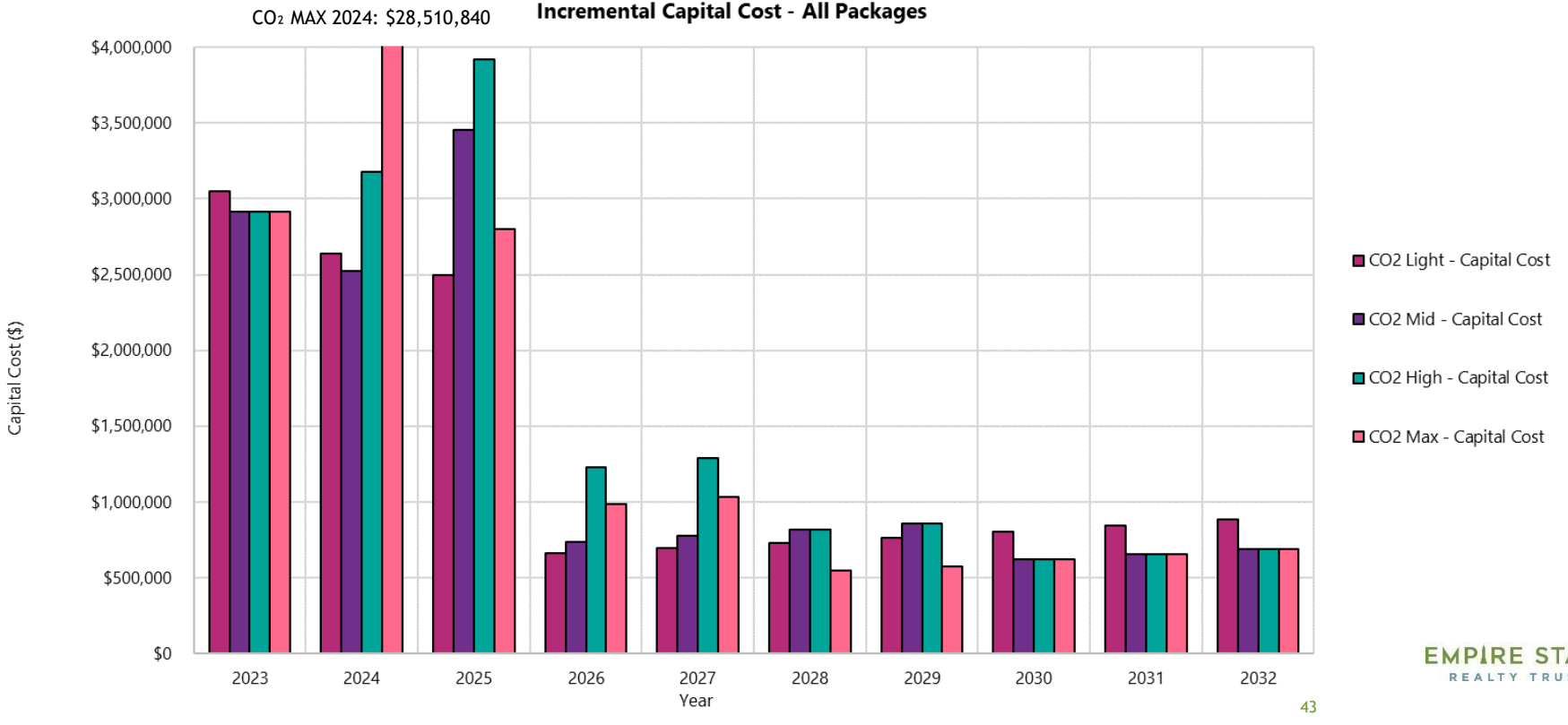
Annual Incremental Capital Cost per Package

Most of the capital expenditure occurs in the first 3 years to cover base building projects like controls & steam system optimizations, infiltration mitigation, electrification of DHW, & installation of AWHPs on the roof



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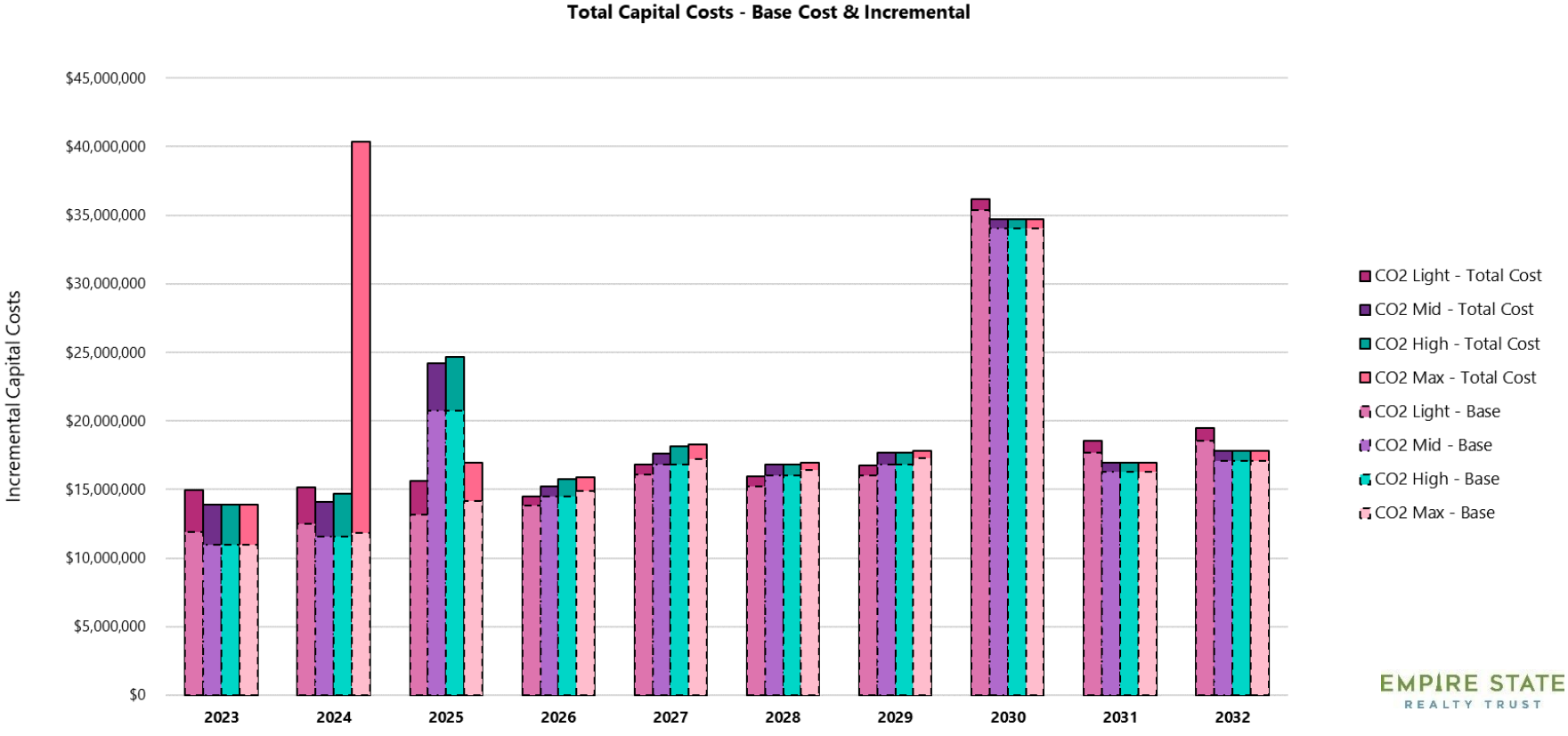
Annual Incremental Capital Cost vs. Base Cost per Package

Base costs include planned elevator modernization & DC conversion, code minimum plug load controls, replacement of aged roof-top AC chillers, required radiator valve replacements, & conversion to VAV systems



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OGCP Next Steps – 2023 Projects

The recommended 2023 measures are focused on controls & envelope measures to upgrade central infrastructure and have a combined payback of ~12.5 yrs

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
BMS Integration of VAV Boxes & Radiator Valves & ASHRAE Guideline 36[1]	$1,689,690	$400,000	$1,289,690	$37,268
Steam Cycle and Pressure Optimization	$756,865	$138,240	$618,625	$62,845
Hoistway Vent Closure	$29,869	$18,818	$11,052	$50,021
Total LL97 Budget	$2,476,425	$557,057	$1,919,367	$150,134

Note:
1. Capex and savings for BMS integration of VAV boxes and electronic radiator valves has been distributed over a 3-year period.

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1400 Broadway Case Study

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1400 Broadway - Current Building Systems

Two condenser water systems serve water-cooled air conditioners throughout the building. A few spaces still use air cooled units. Boilers make steam for heating in radiators.
2021 Energy Grade: B/83

- Condenser Water Systems
  - (1) 800-ton cooling tower with (3) 125-hp pumps
  - (3) 500-ton cooling towers with (3) 150-hp pumps
  - Many water-cooled AC units in good condition
- Air Cooled Systems
  - Some tenants have air cooled AC systems
- Steam System
  - (3) dual-fuel (natural gas & fuel oil #2) low pressure steam boilers serve cast iron radiators

2019 Energy Breakdown by Utility

Building Energy Utilization Index = 73.3 kBtu/SF/year

Electricity

- 60.0% of energy usage
- 61.8% of CO_2e emissions

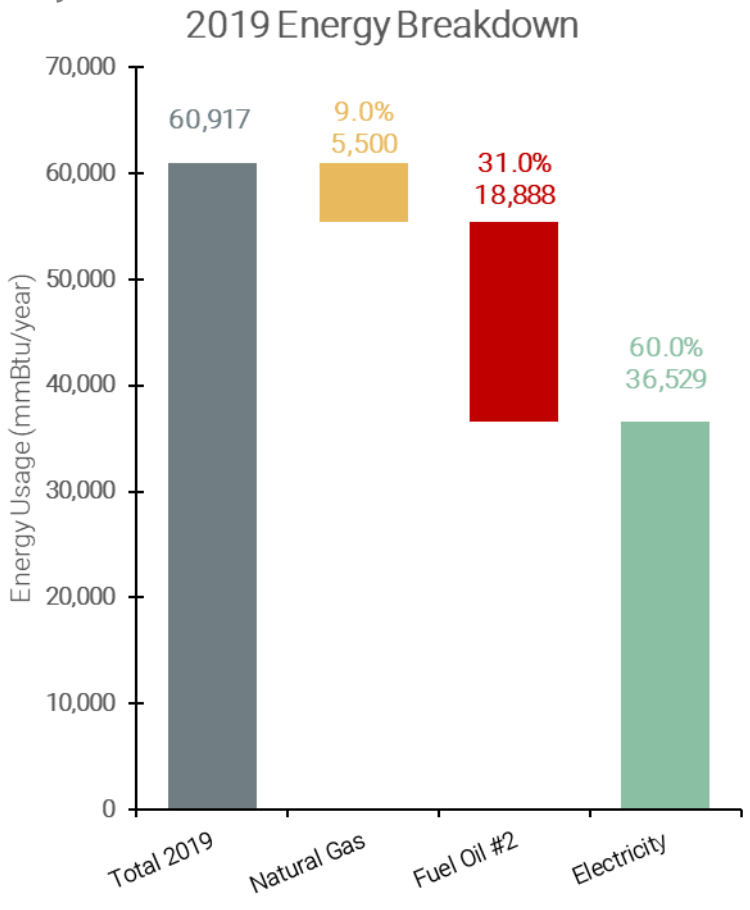
Fuel Oil #2

- 31.0% of energy usage
- 31.6% of CO_2e emissions

Natural Gas

- 9.0% of energy usage
- 6.6% of CO_2e emissions

Energy Source	EUI	Units
Electricity	12.9	kWh/SF/year
Natural Gas	6.6	kBtu/SF/year
Fuel Oil	22.7	kBtu/SF/year
Total	**73.3**	**kBtu/SF/year**



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2019 Operational Cost Breakdown by Utility

Fuel Oil #2/Natural Gas vs Electricity Operational Costs

2019 utility operational cost = $2,262,689

Electricity

- 79.9% of operational costs
- 60.0% of energy usage

Fuel Oil #2

- 15.3% of operational costs
- 31.0% of energy usage

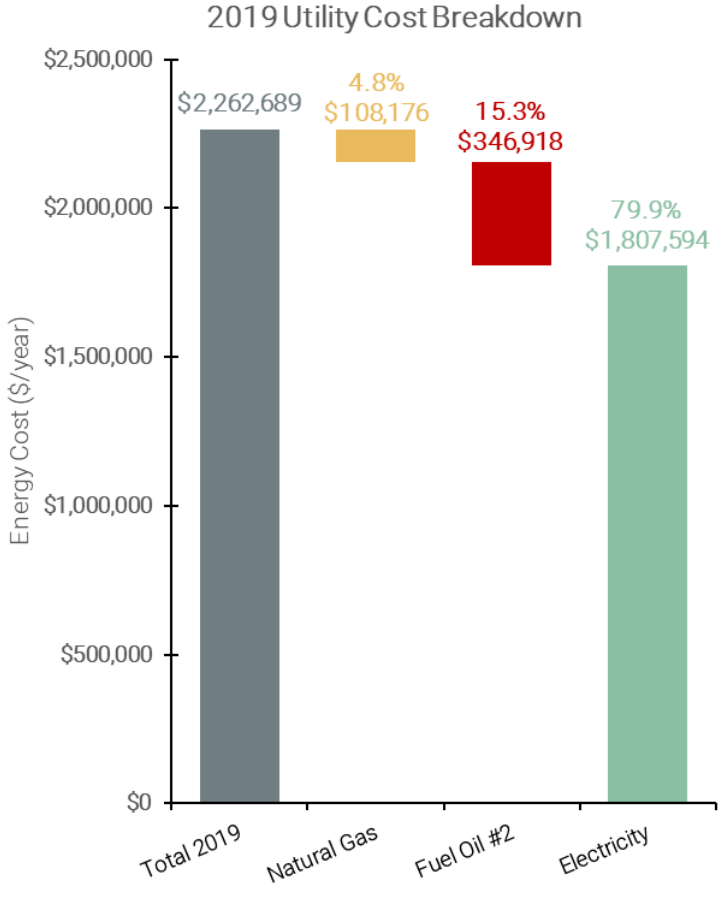
Natural Gas

- 4.8% of operational costs
- 9.0% of energy usage

Electricity - $49.48 per MMBtu

Natural Gas- $19.67 per MMBtu

Fuel Oil #2- $18.37 per MMBtu



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2019 CO_2e Emissions Breakdown by Utility

Electricity

- 61.8% of CO_2e emissions
- 60.0% of energy usage

Fuel Oil #2

- 31.6% of CO_2e emissions
- 31.0% of energy usage

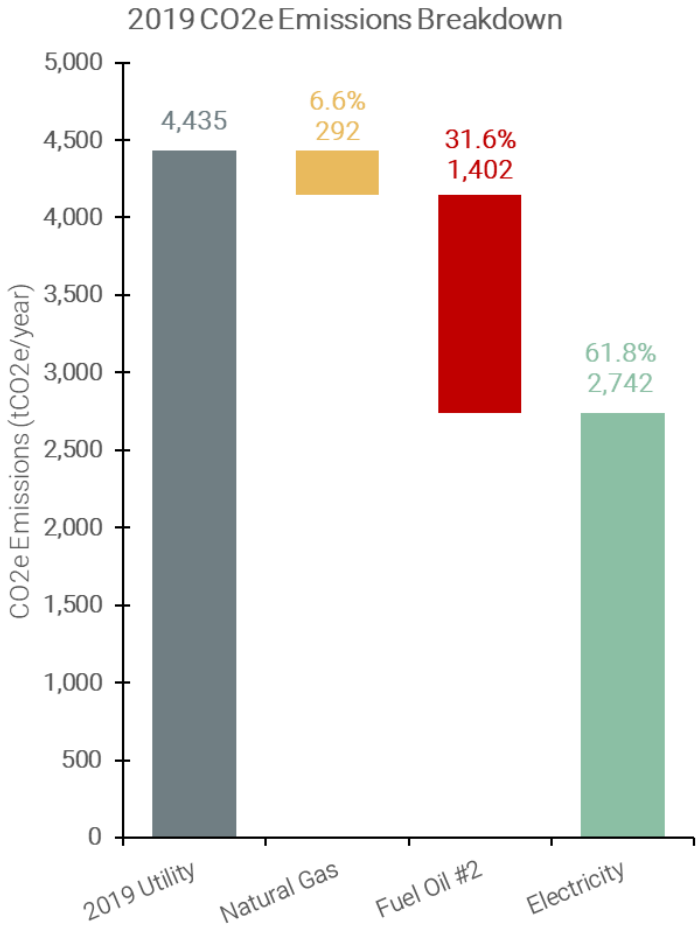
Natural Gas

- 6.6% of CO_2e emissions
- 9.0% of energy usage

Electricity – 256.0 tCO_2e/GWh (Luthin)

Fuel Oil #2 – 253.21 tCO_2e/GWh (LL97)

Natural Gas – 181.22 tCO_2e/GWh (LL97)



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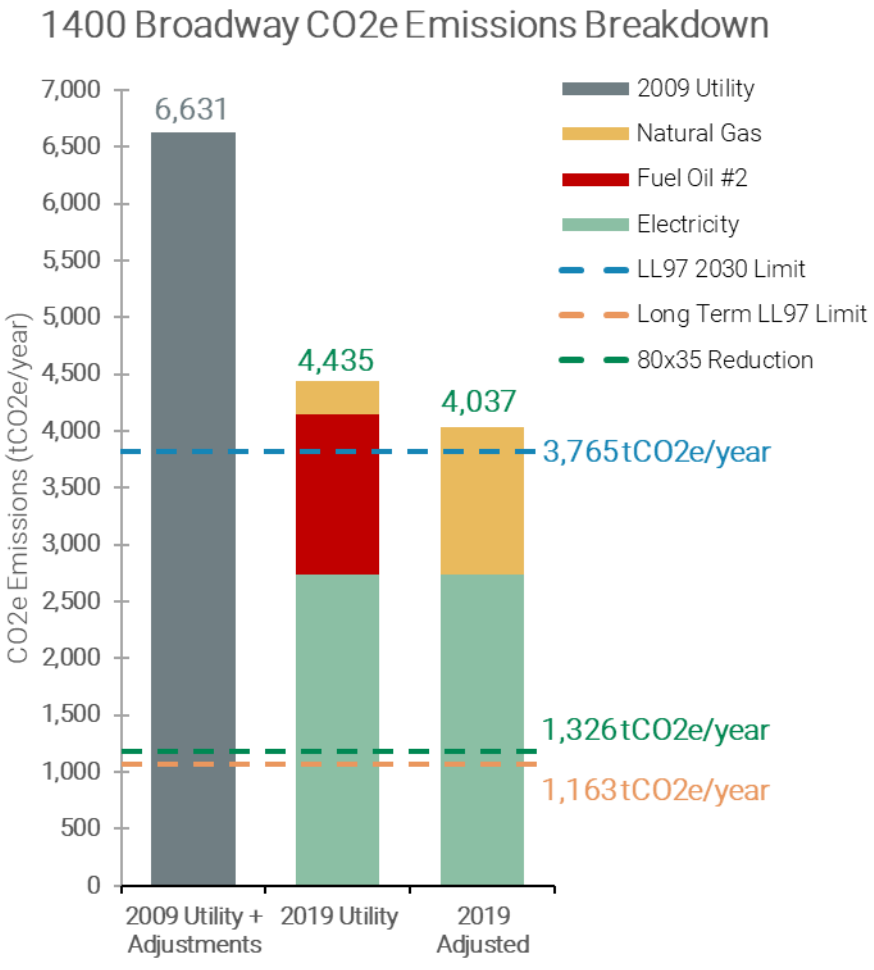
1400 Broadway Current Status for LL97 and 80x35 Challenge



Key Takeaways:

- Building meets 2024 Limit of 7,080 tCO_2e/year
- Transition from Fuel Oil to Natural Gas provides immediate CO_2e emission reduction
- 6.8% reduction is required to meet LL97 2030 target of 3,765 tCO_2e/year
- 71.2% reduction is required to meet LL97 2035 target of 1,163 tCO_2e/year
  - Building + grid improvements

31.0% CO_2e Reduction from 2009 to 2019

- 31.4% due to electrical grid improvements
- Remaining due occupancy changes and/or building improvements

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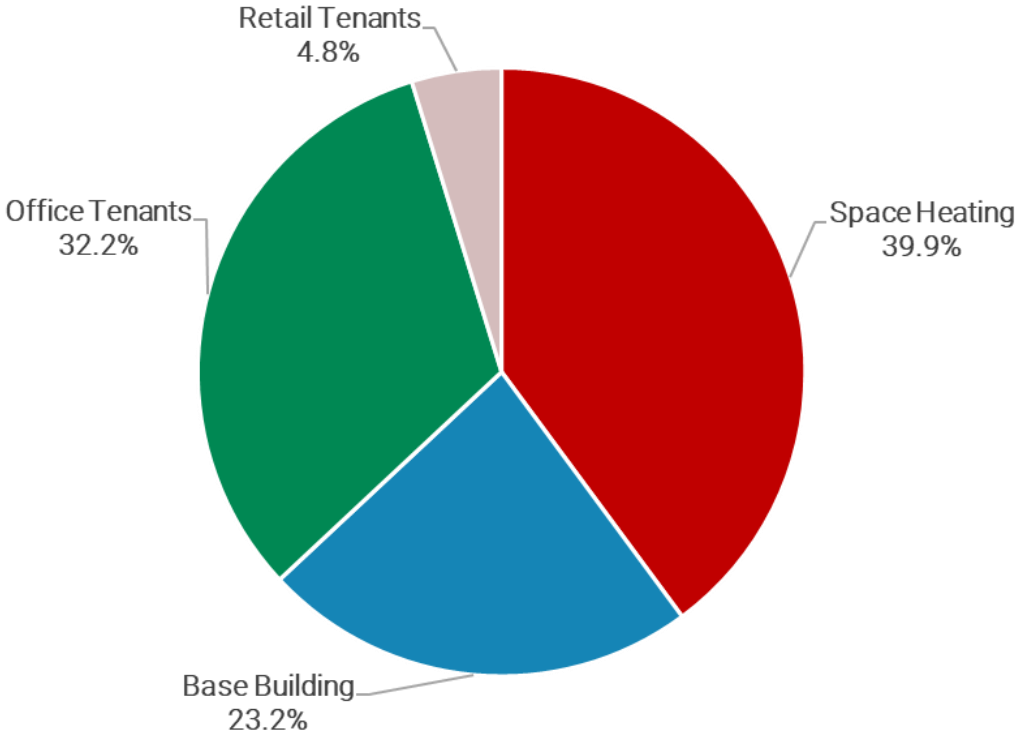
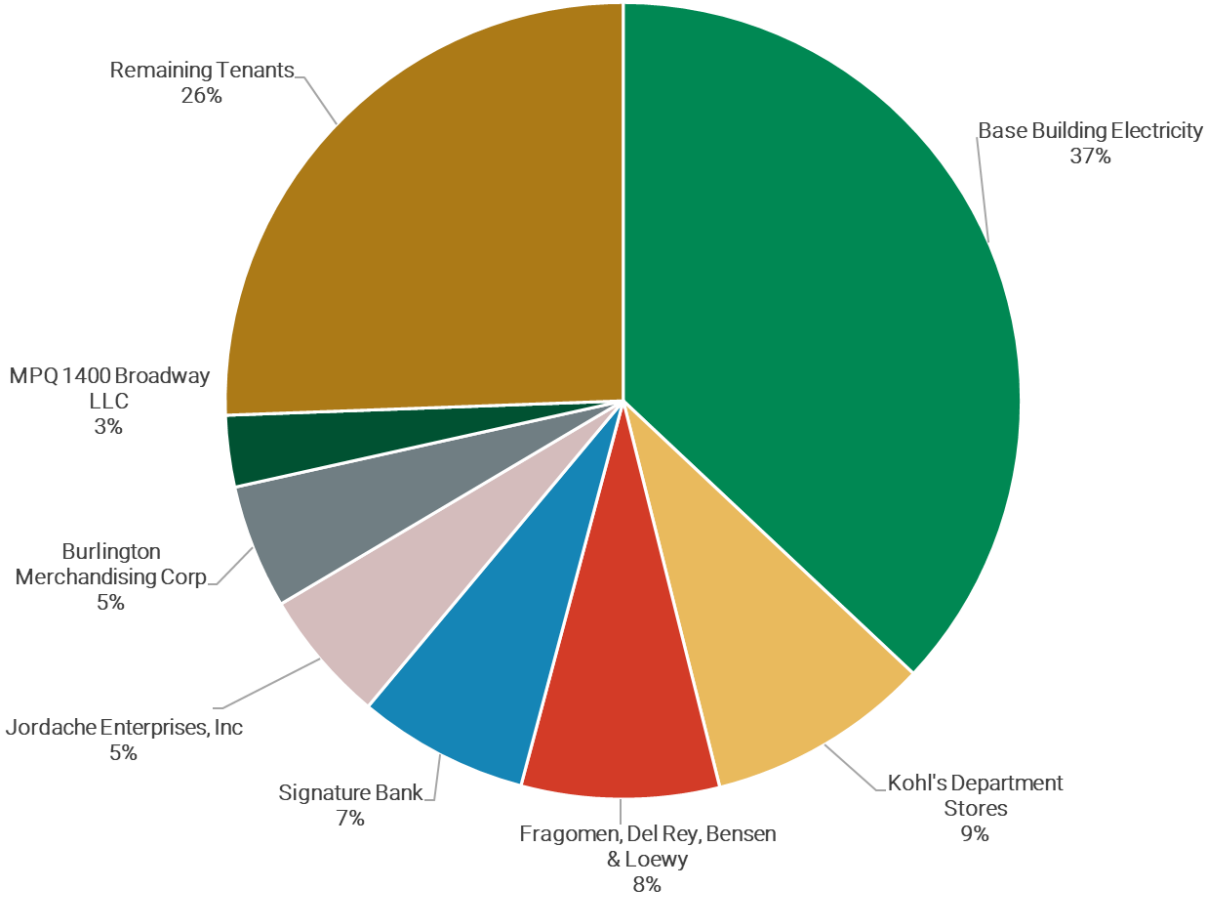
1400 Broadway Energy Breakdown by Major End Users

Data based on utility meters and Utilivisor Data

- **Base Building - 63.1%**
  - Electricity – 23.2%
  - Fossil Fuel – 39.9%
- **Office Tenants - 32.2%**
- **Retail Tenants- 4.8%**



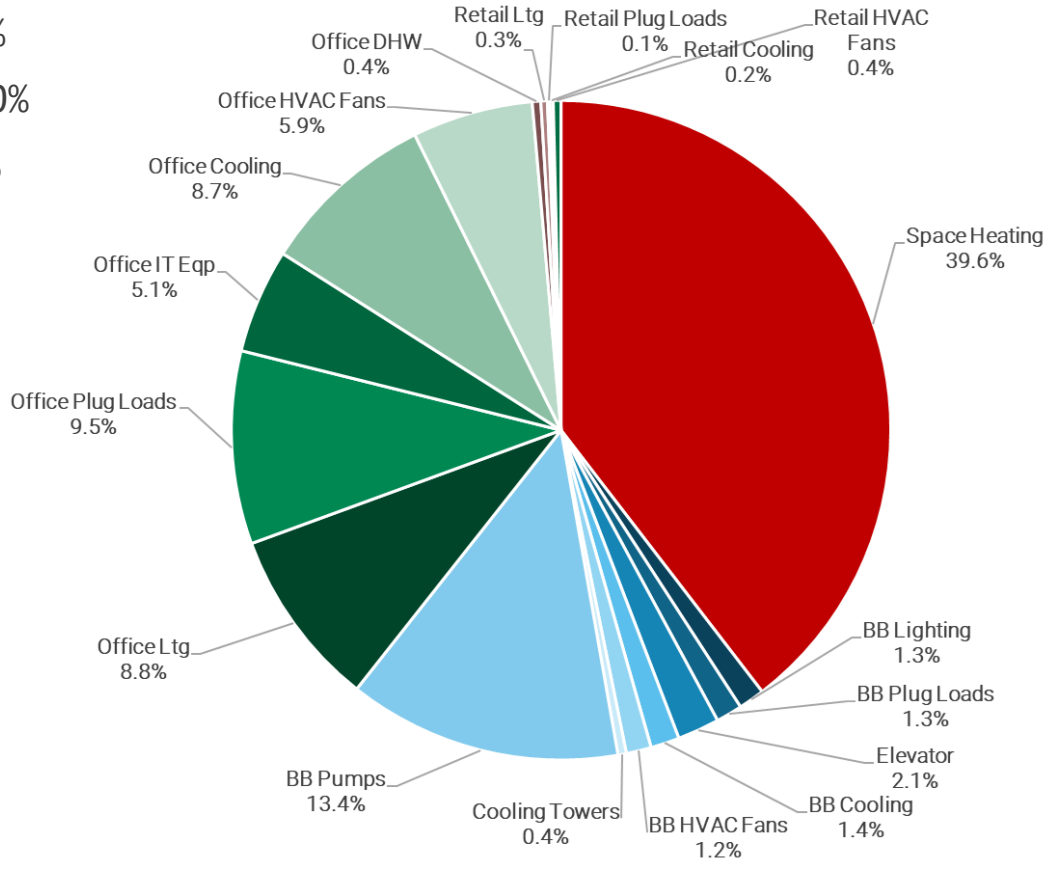
1400 Broadway Electricity Breakdown by End Users



1400 Broadway Energy Model: 2019 Energy Breakdown

Analyzes major end-uses and highlight opportunities for improvement

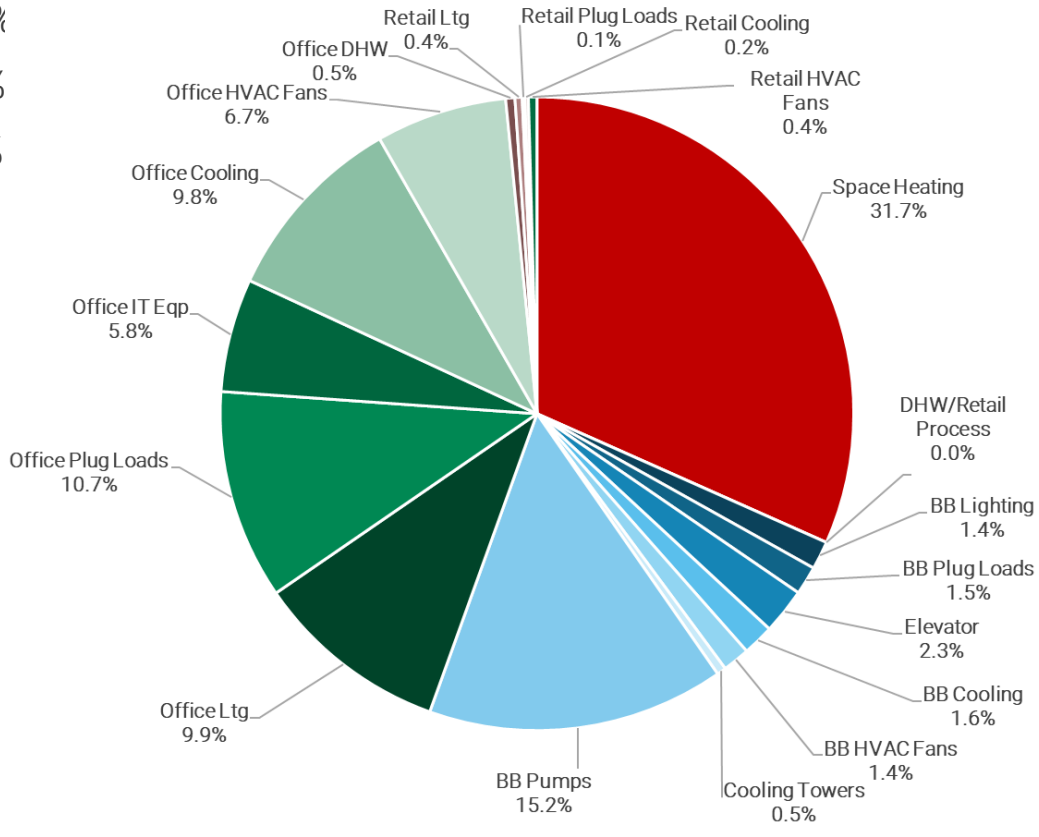
- Office Tenants account for ~38%
- Retail Tenants accounts for ~1.0%
- Base building accounts for ~61%
  - Space Heating accounts for 39.6%



1400 Broadway Energy Model: 2019 CO_2e Emissions Breakdown

Analyzes major end-uses and highlight opportunities for improvement

- Office Tenants account for ~43.4%
- Space Heating accounts for 31.7%
- Retail Tenants accounts for ~1.1%
- Base Building 23.8%



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ECM Packages - Recommended Package is CO_2 High

Four packages of ECMs were developed to optimize NPV and CO_2 reductions

1	2	3	4
CO_2 Light **No Electrification**	**CO_2 Mid** **Partial Electrification: WWHPs**	**CO_2 High** **Full Electrification: VRF**	**CO_2 Max** **Full Electrification: VRF**
BMS integration & controls optimizations, CW optimization, mitigate lobby infiltration, EMR cooling improvements, BOH lighting upgrades, DHW electric heaters, tenant load improvements (IT cooling, lighting upgrades, plug controls), conversion of CV systems to VAV, ERVs	CO_2 Light + WWHPs on C-L20; excludes DHW electric heaters	CO_2 Mid + VRF on C-L37, retail lighting improvements; excludes WWHPs	CO_2 High + window improvements, retail BMS integration & controls, regen drives for elevators, DHW electric heaters

Carbon Reduction

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ECM Phases & Implementation Timeline: CO_2 High

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE												
Phase	Tag	ECM Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Phase 1	SS001	Reduce Steam Pressure & Steam Cycling	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO001	BMS Integration of VAV Boxes & Radiator Valves & ASHRAE Guideline 36	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CW001	Optimize Condenser Water System	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%
Phase 2	LT001	Common Area Lighting Upgrades	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	LT003	Retail Lighting Improvements	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	AS006	Improve EMR cooling	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4	EL003	Full Electrification: Full-Load Heating VRF Condenser Farm on Roof Serving Upper Floors Full-Load Heating VRF Systems Serving Lower Office Tenant Floors	0%	15%	16%	19%	19%	19%	29%	33%	36%	36%	38%	41%	53%
Phase 4	LT002	Lighting Upgrades & Controls	0%	15%	16%	19%	19%	19%	29%	33%	36%	36%	38%	41%	53%
Phase 4	TL001	Plug Load Control	0%	15%	16%	19%	19%	19%	29%	33%	36%	36%	38%	41%	53%
Phase 4	TL002	Tenant IT Cooling	0%	15%	16%	19%	19%	19%	29%	33%	36%	36%	38%	41%	53%

Note: Only 53% of Tenant Area Rolls by 2035

1400 Broadway Case Study

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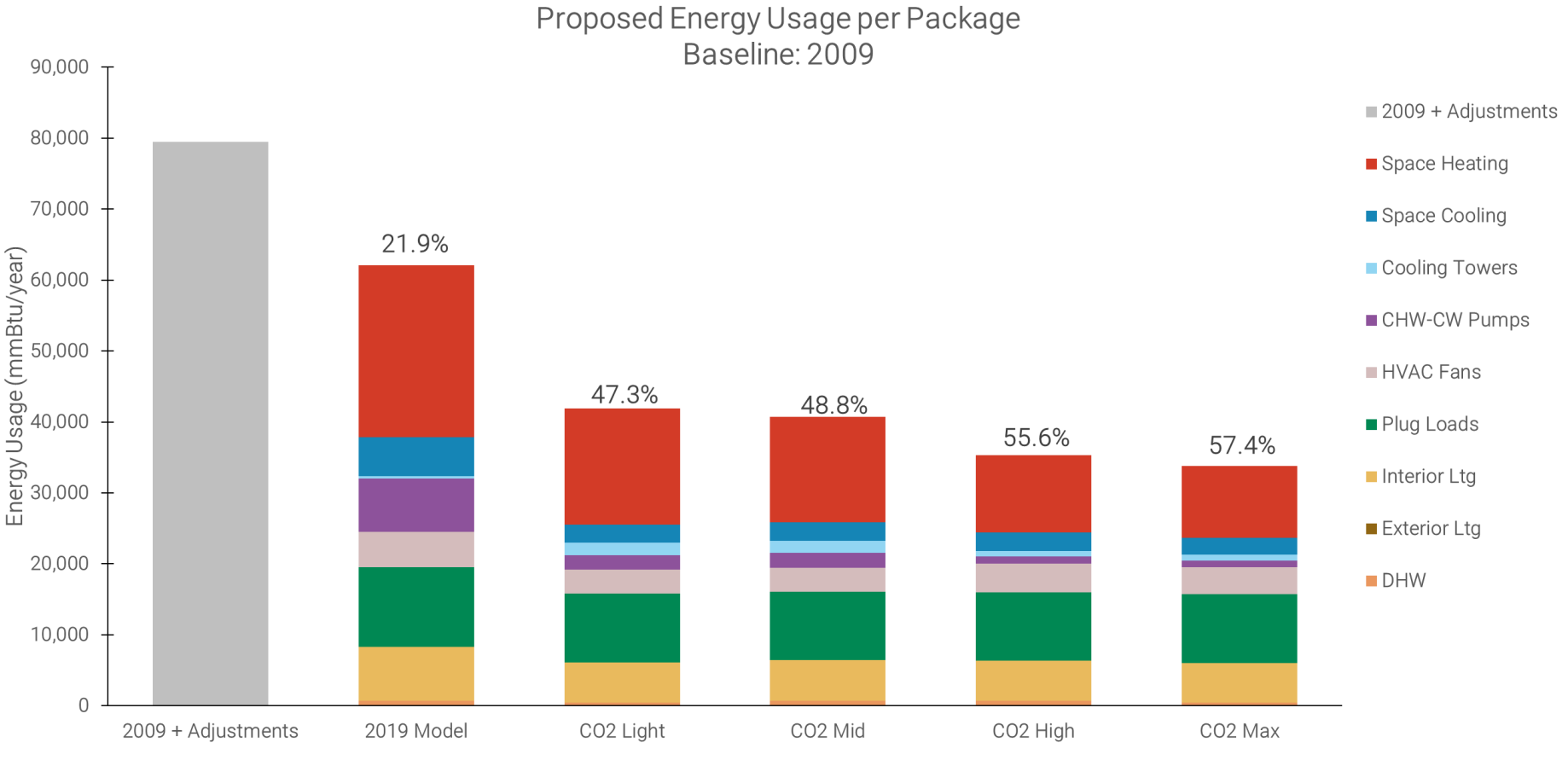
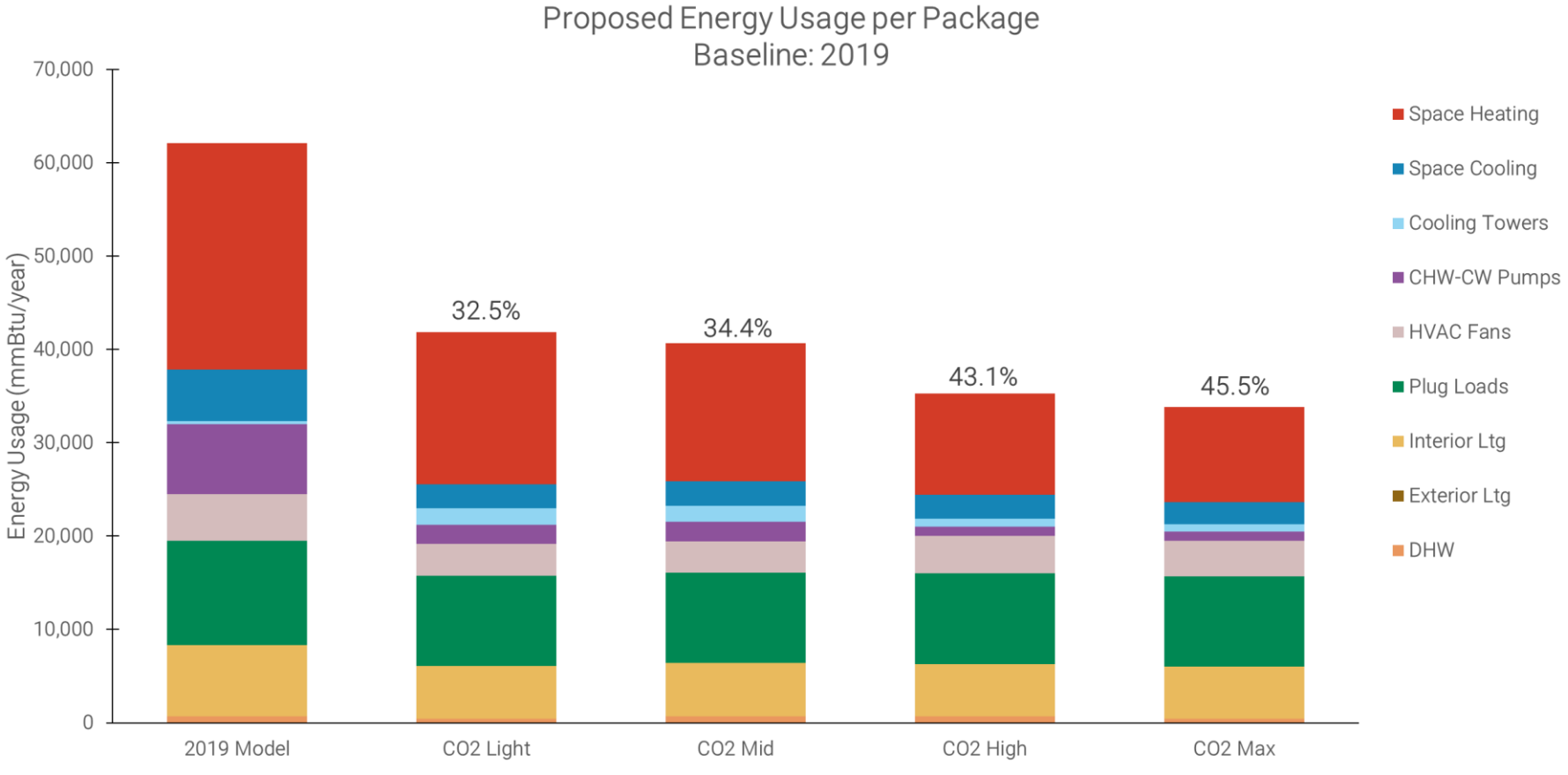
1400 Broadway ECM Package Comparison: Energy

Baseline: 2009

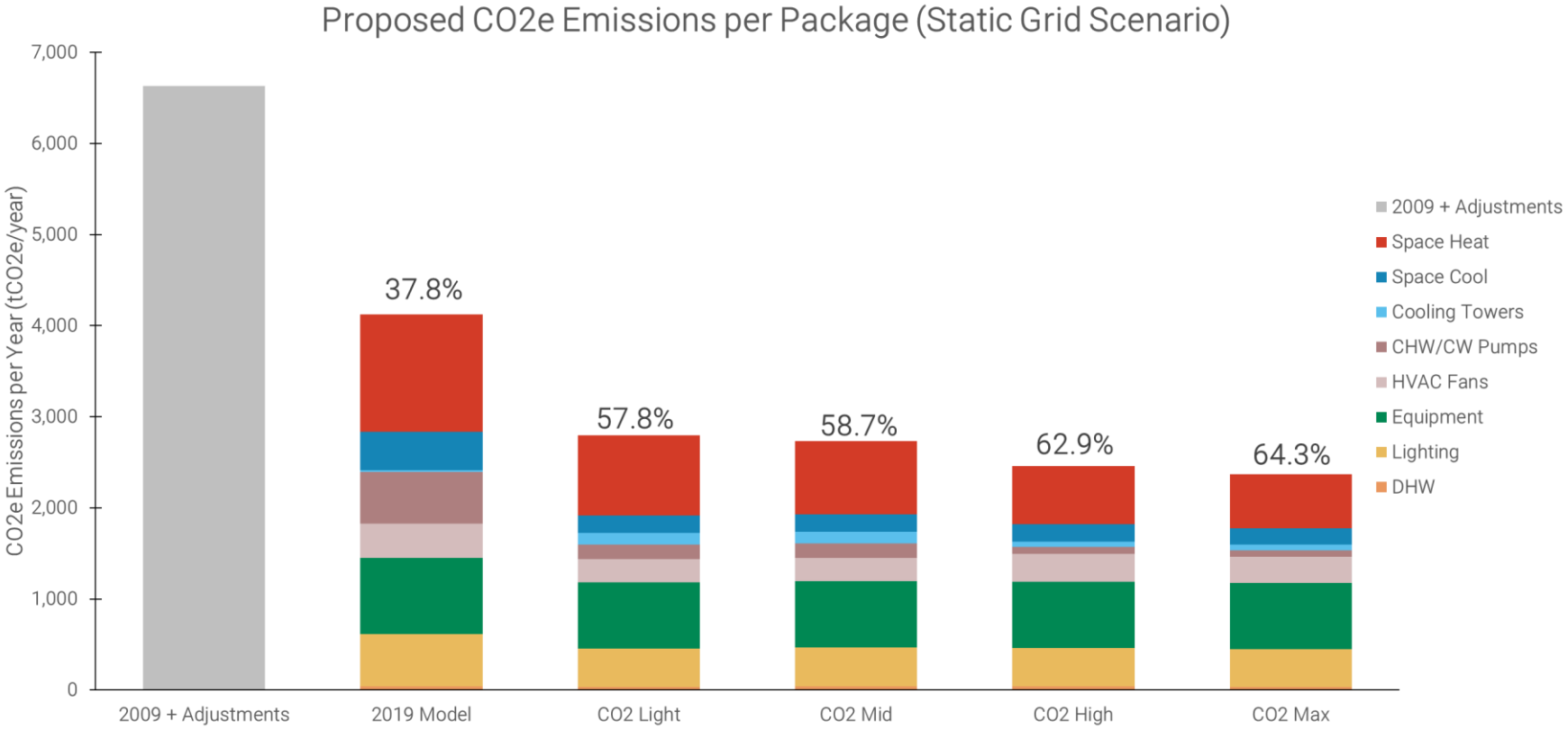


1400 Broadway ECM Package Comparison: Energy

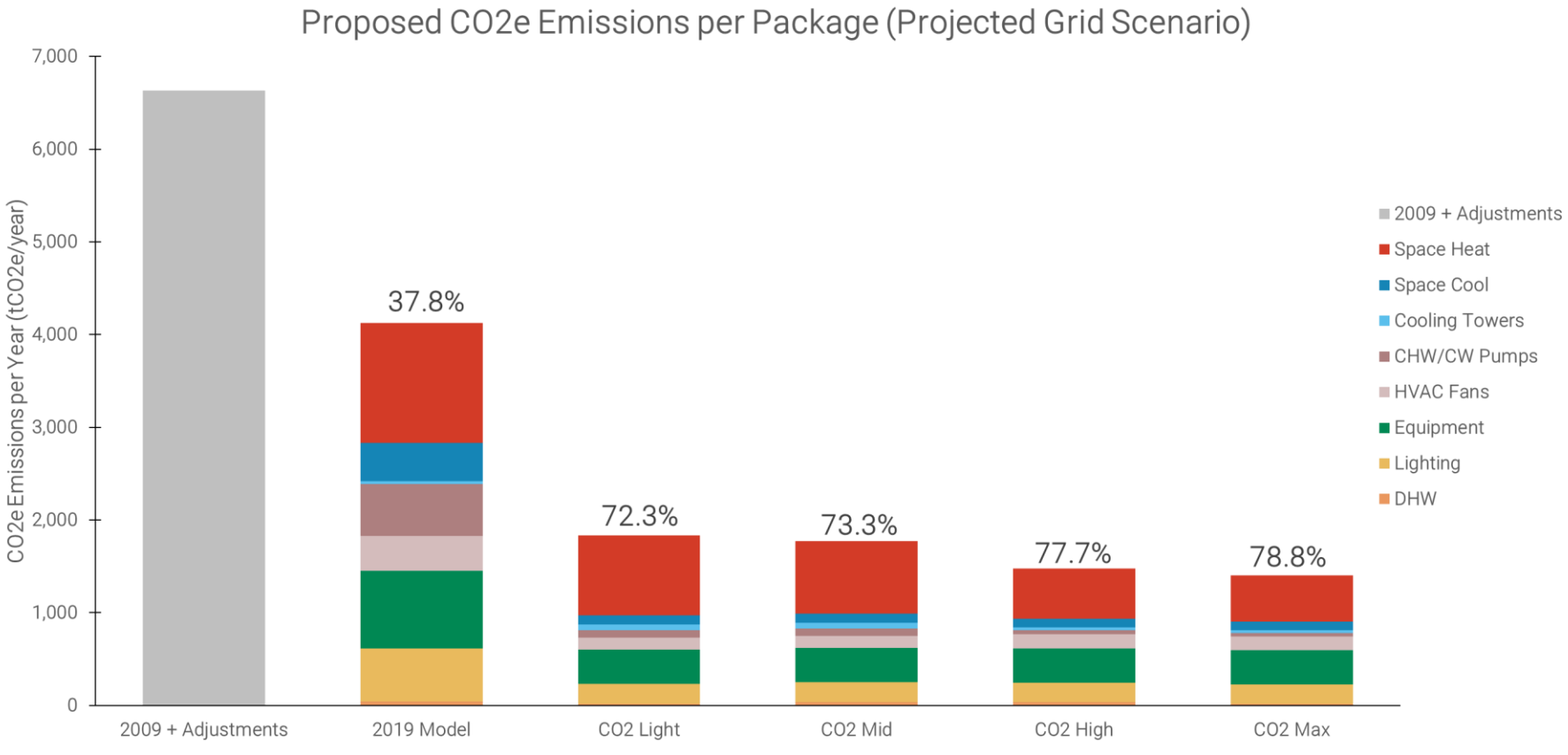
Baseline: 2019



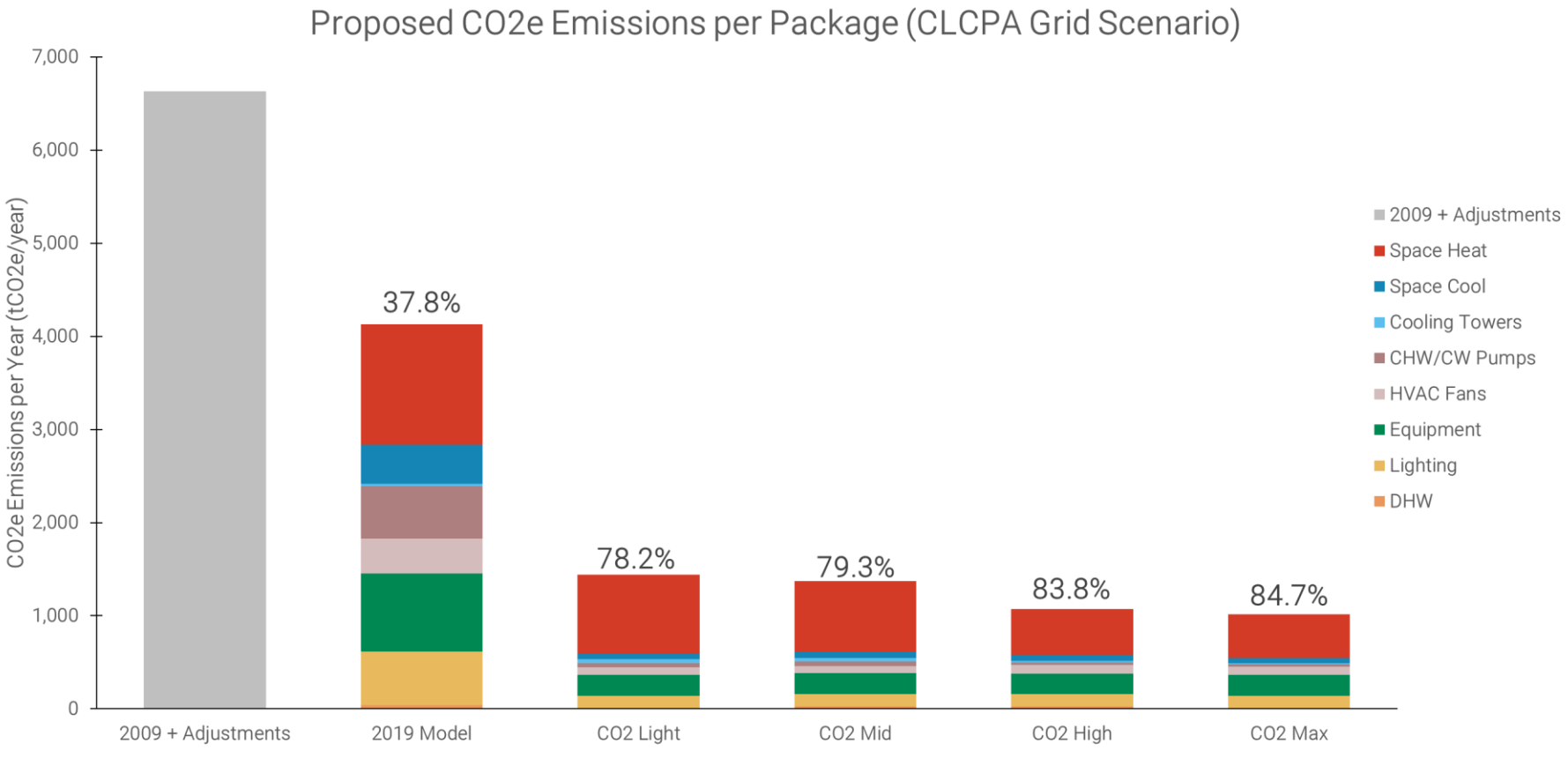
Projected CO_2 Emissions: Static 2019 Grid Scenario



Projected CO_2 Emissions: Projected Grid Scenario

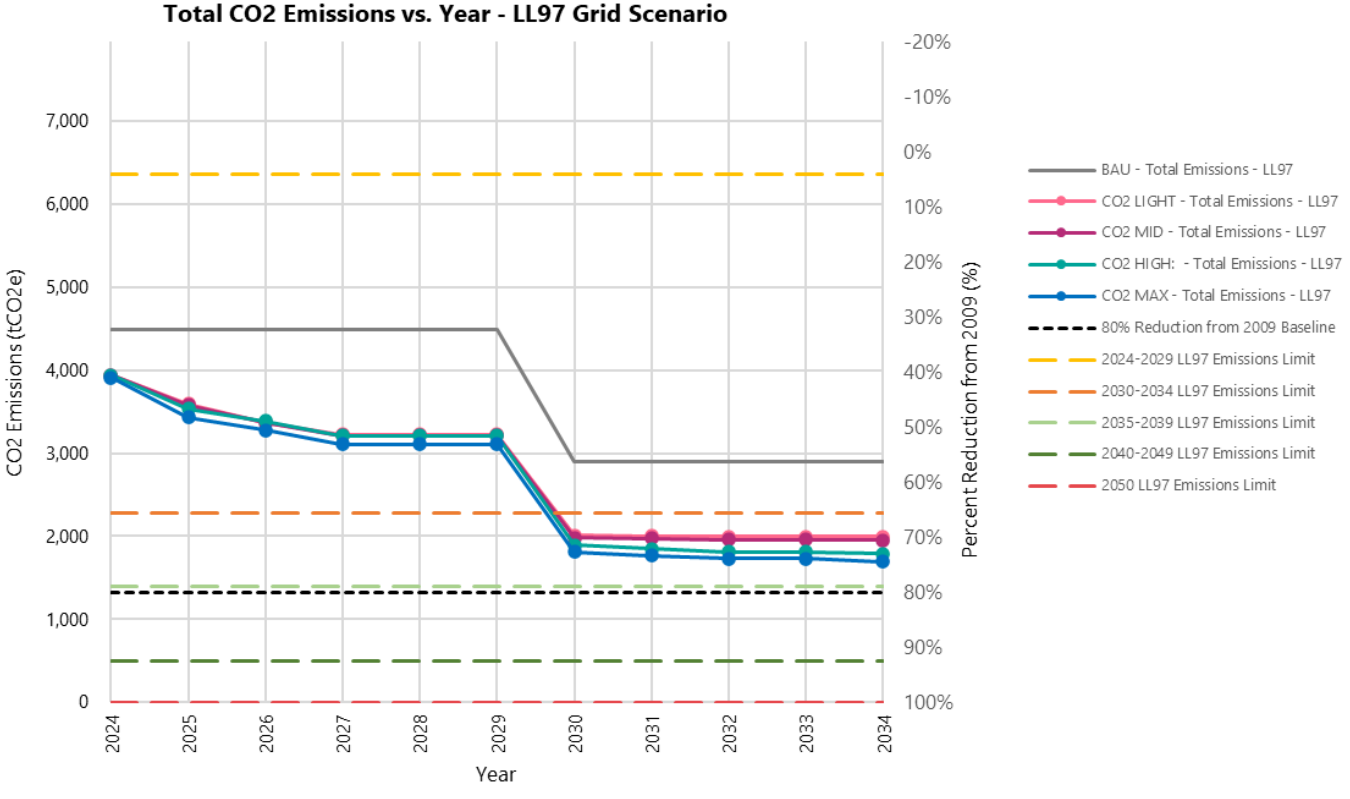


Projected CO_2 Emissions: CLCPA Grid Scenario



Projected Annual Carbon Emissions – LL97 Compliance

BAU does not achieve 2030 LL97 compliance



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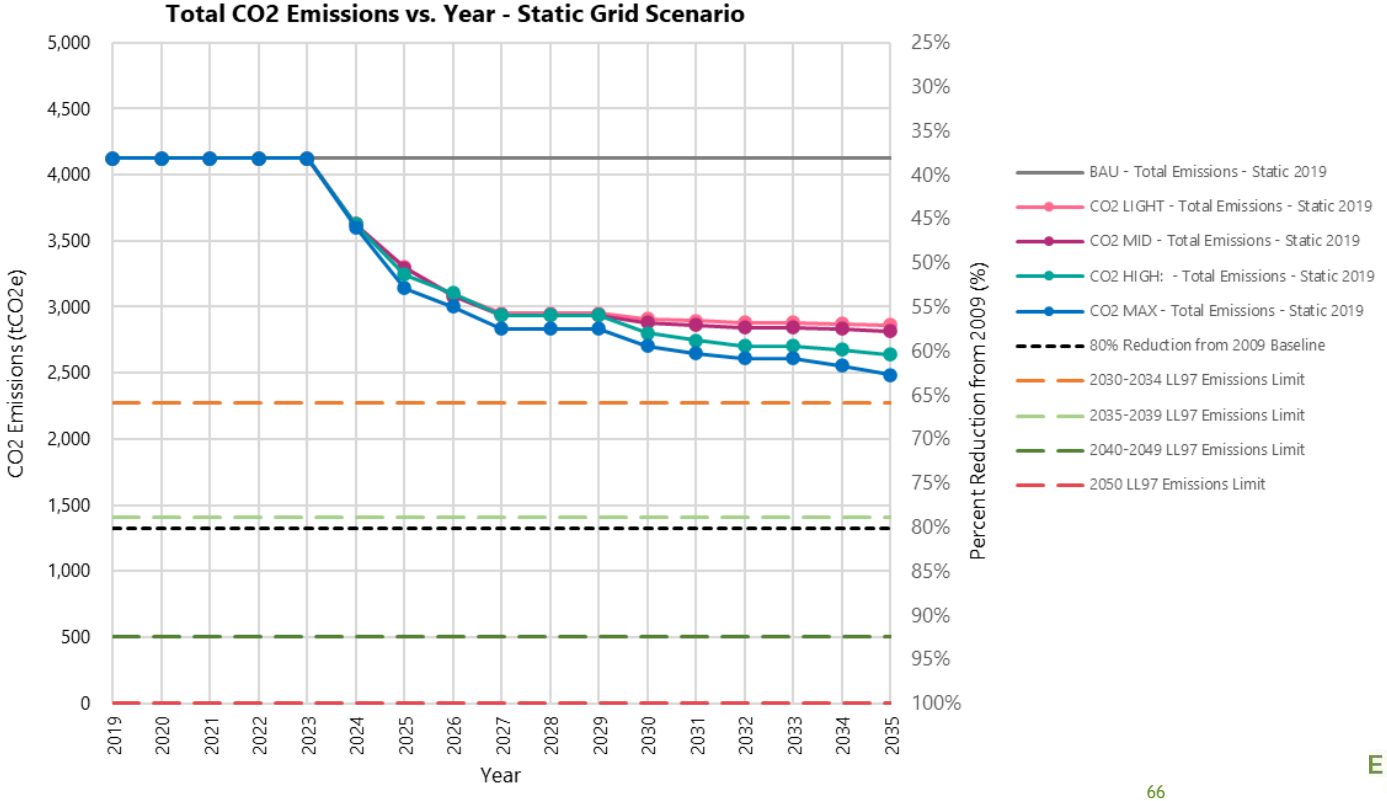
Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization;
No packages achieve 2030 LL97 compliance without grid decarbonization



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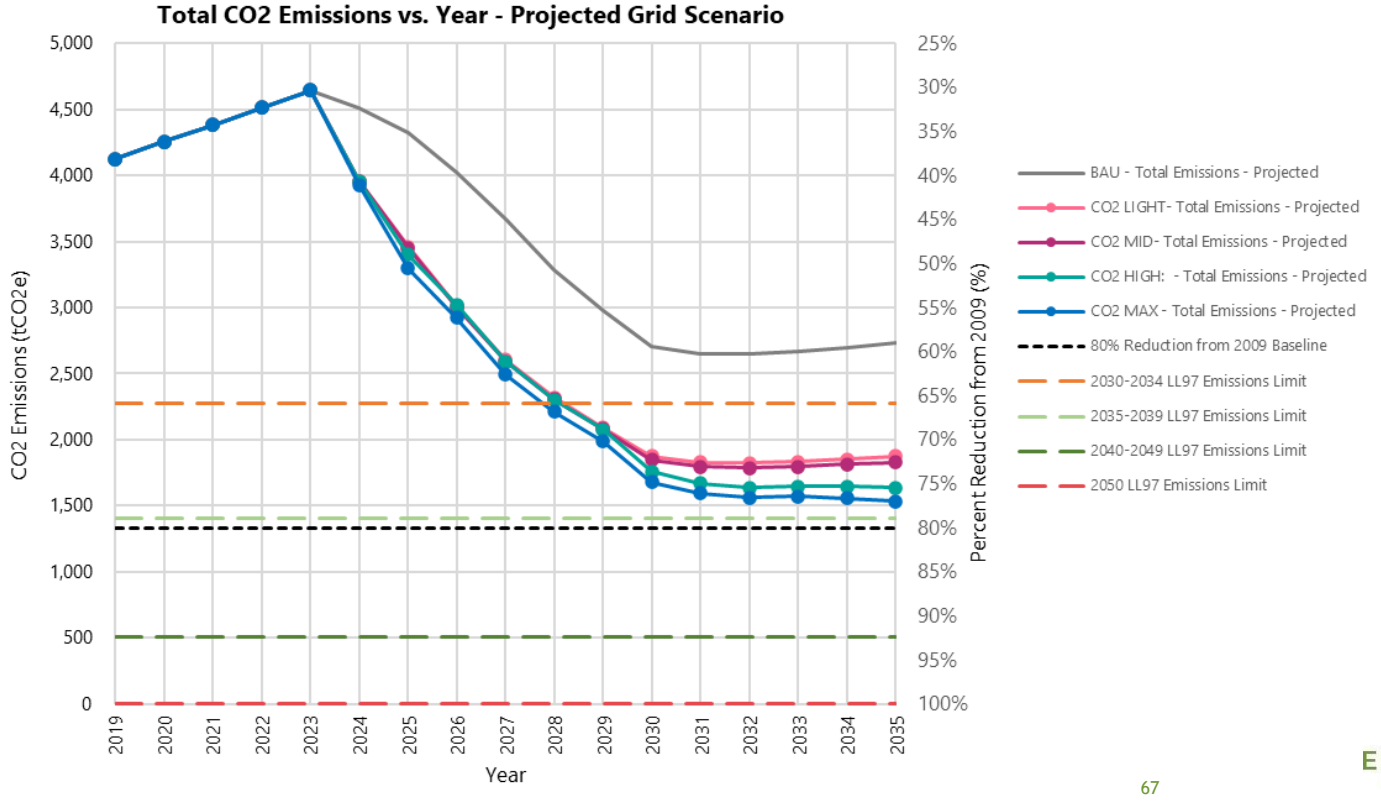
Projected Annual Carbon Emissions – Projected Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035;
No packages achieve 2035 LL97 compliance



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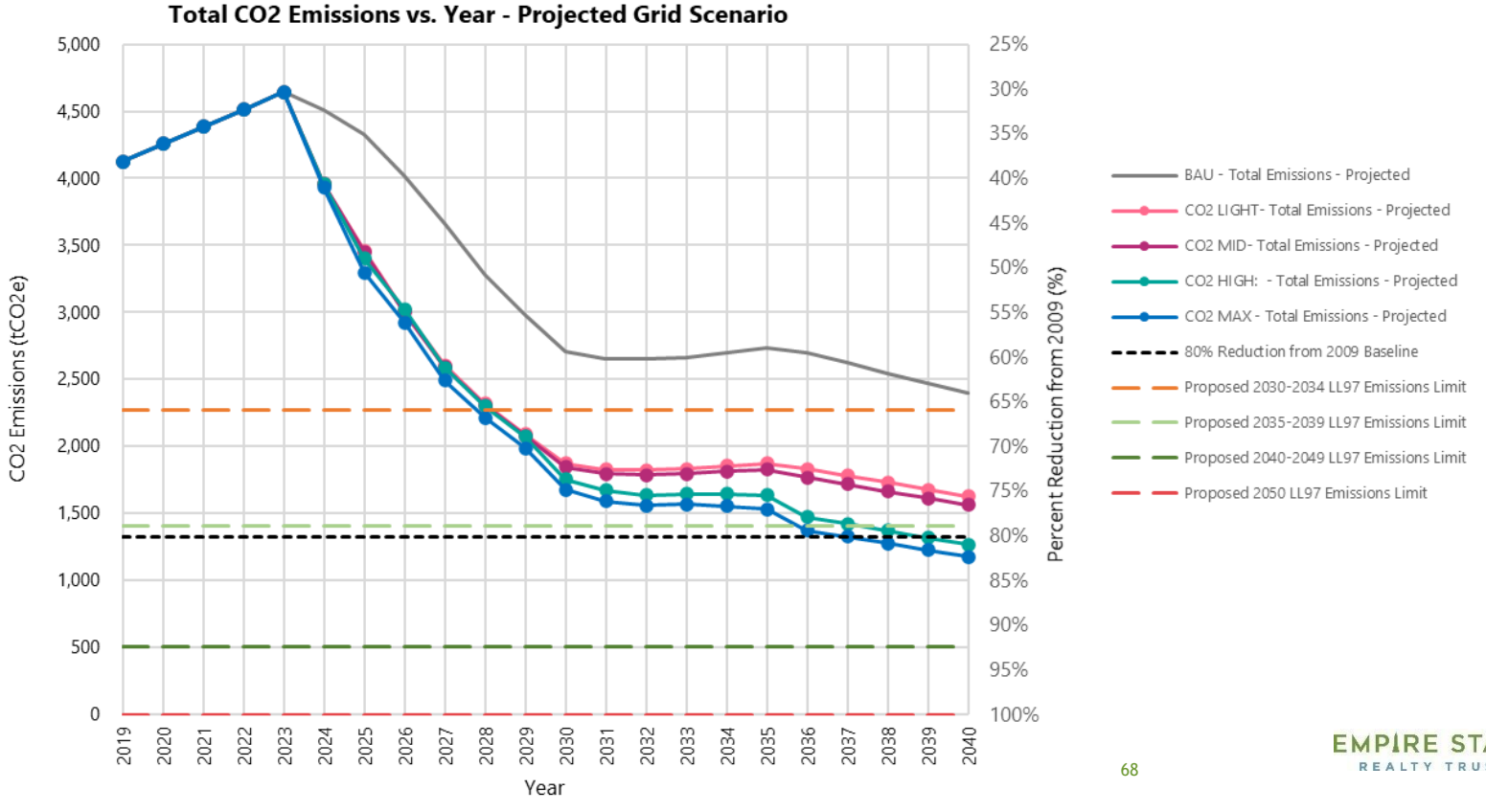
Carbon Emissions Extended to 2040 – Projected Grid Scenario

CO_2 Light & Mid packages do not meet **80% reduction** from 2009 baseline by **2040;**
CO_2 High package meets **80% reduction** from 2009 baseline by **2039;** CO_2 Max package meets **80% reduction** from 2009 baseline by **2037;**
Projected fines for CO_2 Light, Mid, High & Max from 2035-2040[1]: **$803,913 (Light), $705,415 (Mid), $289,881 (High), $214,617 (Max)**



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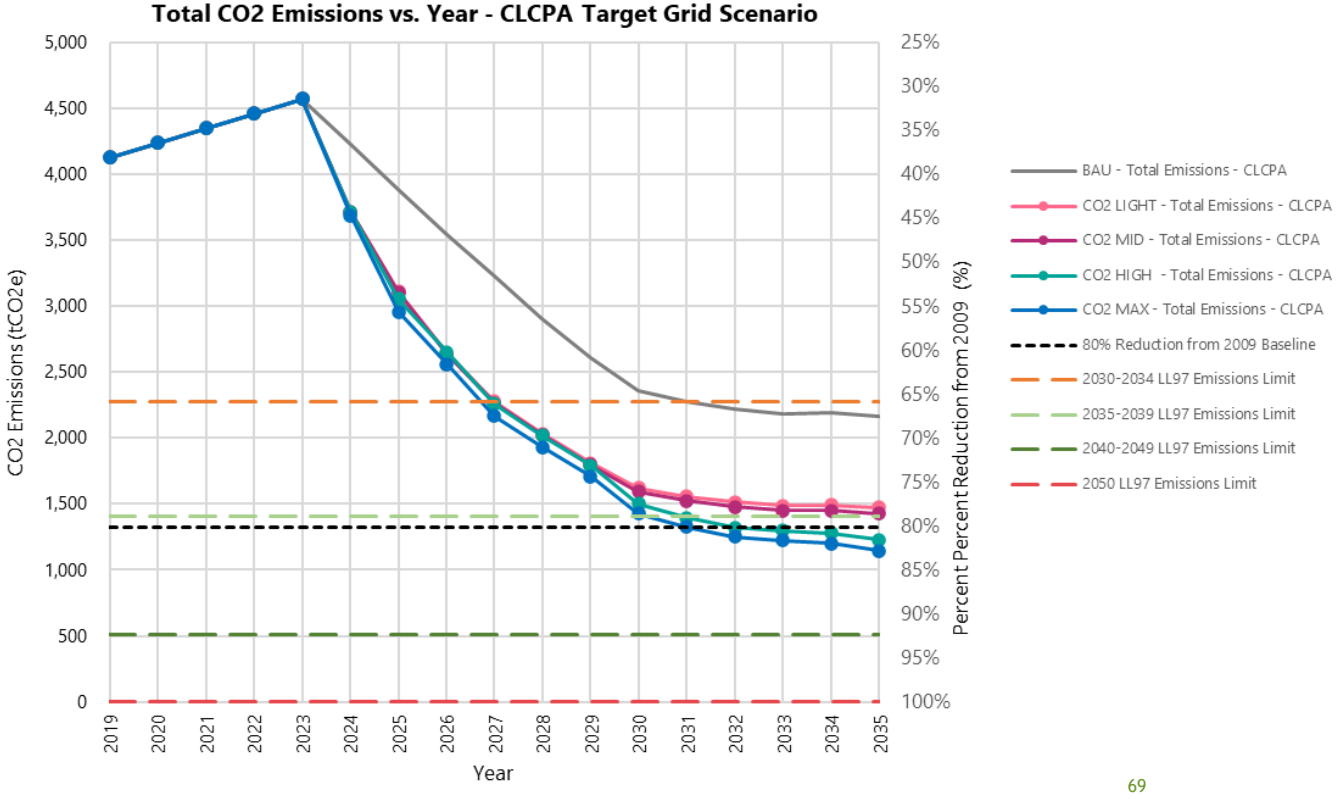
1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the Projected grid scenario

Projected Annual Carbon Emissions – CLCPA Grid Scenario

Only CO_2 Max and CO_2 High packages would meet 80% reduction from 2009 baseline by 2035;
Only CO_2 High and Max packages achieve 2035 LL97 compliance on time; CO_2 Mid complies by 2036



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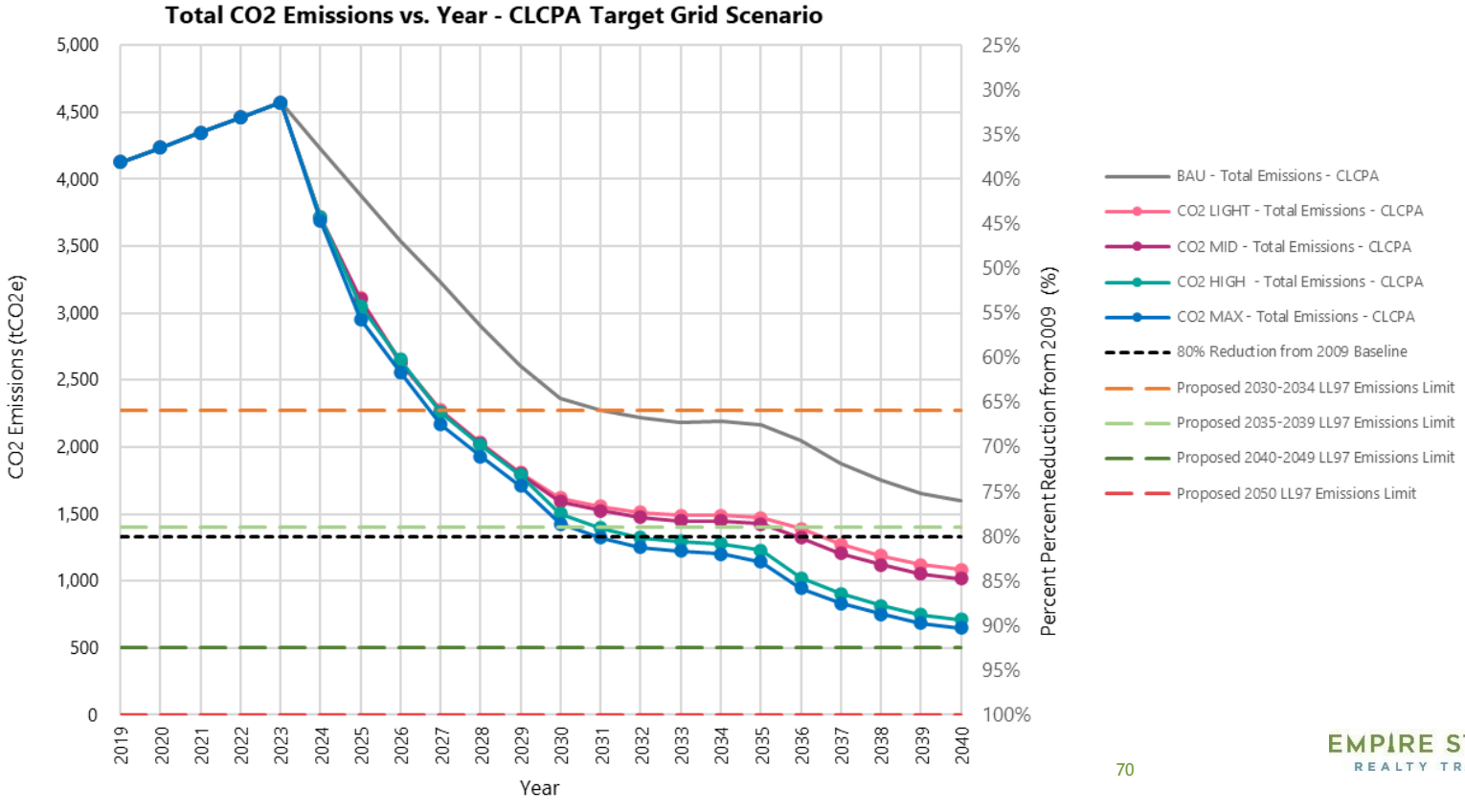
Carbon Emissions Extended to 2040 – CLCPA Grid Scenario

CO_2 Light package meets **80% reduction** from 2009 baseline by **2037;**
CO_2 Mid package meets **80% reduction** from 2009 baseline by **2036;**
Projected fines for CO_2 Light, Mid, High, & Max from 2035-2040[1]: **$173,171 (Light), $143,050 (Mid), $54,659 (High), $38,491 (Max)**



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1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the CLCPA grid scenario

Percent Carbon Emissions Reductions – All Grid Scenarios

80x35 target based on reductions from 2009 baseline
Reductions from 2019 baseline show impact of packages compared to current usage

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-34.5%	-39.8%	**-59.2%**	**-62.5%**
CO2 HIGH	-32.1%	-36.1%	**-57.8%**	**-60.2%**
CO2 MID	-30.1%	-31.7%	**-56.5%**	**-57.5%**
CO2 LIGHT	-29.5%	-30.6%	**-56.1%**	**-56.8%**

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization;
No packages achieve 2030 LL97 compliance without grid decarbonization

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-59.4%	-62.9%	**-74.7%**	**-76.9%**
CO2 HIGH	-57.4%	-60.3%	**-73.5%**	**-75.3%**
CO2 MID	-55.2%	-55.7%	**-72.1%**	**-72.4%**
CO2 LIGHT	-54.6%	-54.6%	**-71.7%**	**-71.7%**

No packages would meet 80% reduction from 2009 baseline by 2035;
No packages achieve 2035 LL97 compliance

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-65.5%	-72.3%	**-78.5%**	**-82.7%**
CO2 HIGH	-63.6%	-70.2%	**-77.4%**	**-81.4%**
CO2 MID	-61.4%	-65.4%	**-76.0%**	**-78.5%**
CO2 LIGHT	-60.8%	-64.3%	**-75.6%**	**-77.8%**

Only CO_2 Max and CO_2 High packages would meet 80% reduction from 2009 baseline by 2035;
Only CO_2 High and Max packages achieve 2035 LL97 compliance on time; CO_2 Mid complies by 2036

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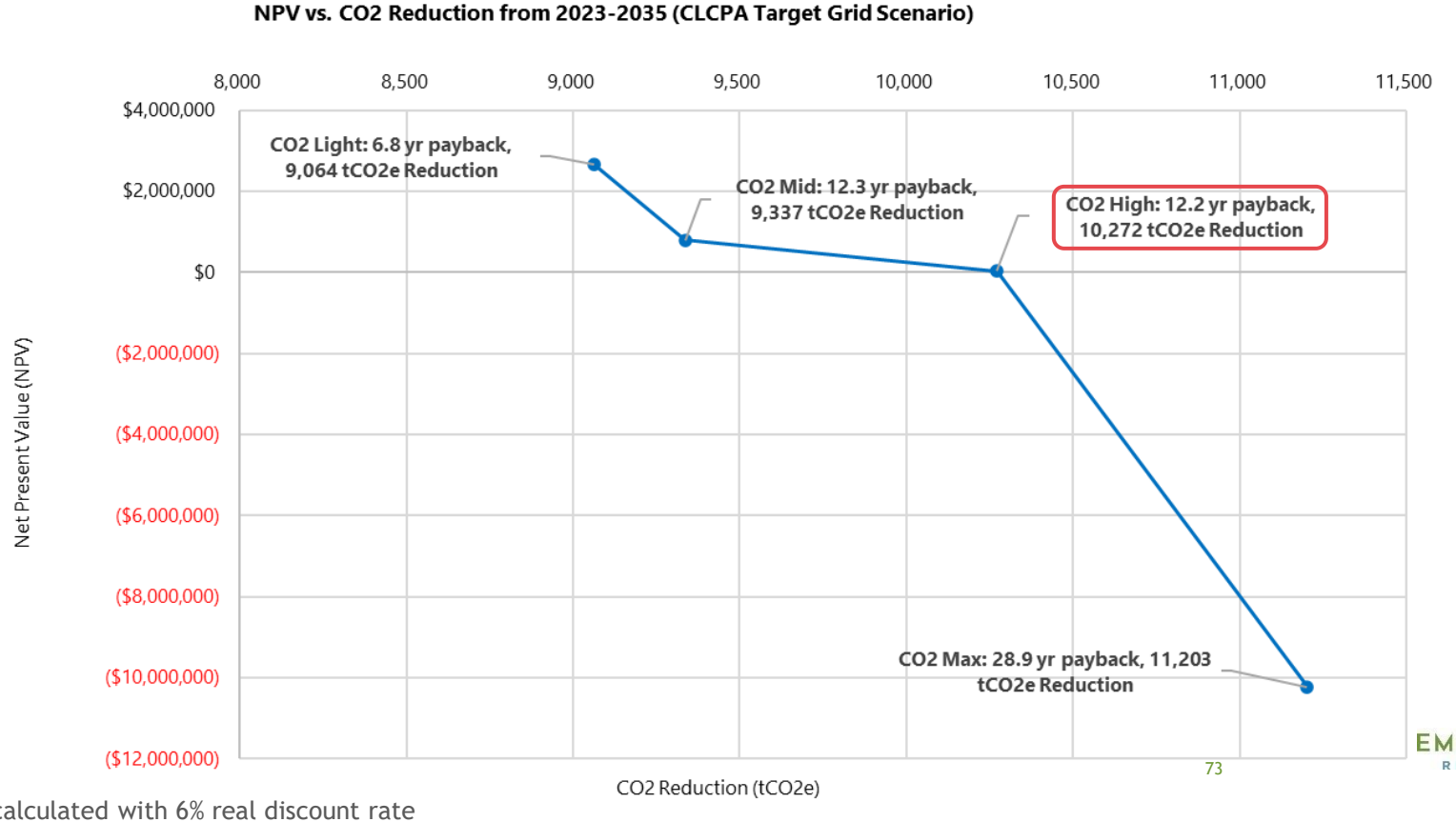
NPV, CO_2 Reductions and Simple Payback for all Packages

Net Present Value for 2023-2035; CO_2 reduction based on CLCPA scenario



NPV calculated with 6% real discount rate

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Projected LL97 Fines From 2024-2034

No LL97 fines projected for the baseline or packages for 2024-2029
Fines possible from 2030-2034 for baseline if 2022 emissions limits are approved, though all packages offset the potential fines.

Packages	LL97 Fines From 2024-2034					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034
BAU (2019 Baseline)	$0	$0	-	$0	$831,515	-
CO_2 Light	$0	$0	$0	$0	$0	$831,515
CO_2 Mid	$0	$0	$0	$0	$0	$831,515
CO_2 High	$0	$0	$0	$0	$0	$831,515
CO_2 Max	$0	$0	$0	$0	$0	$831,515

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2024-2029 are based on GHG coefficients provided in LL97 of 2019.
4. Fine calculations for 2030-2034 are based on additional GHG coefficients provided in the proposed rules for LL97 released Oct. 2022.

Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario

Fines projected for baseline and all packages under currently published LL97 limits, though all packages offset most of the fines;

Fines possible from 2035-2049 for baseline and all packages if 2022 emissions limits are approved, though CO_2 Mid, High & Max packages offset most of the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$4,591,821	-	$237,130	$6,034,034	-	$548,948
CO_2 Light	$1,615,449	$2,976,371	$60,080	$3,057,663	$2,976,371	$371,898
CO_2 Mid	$1,359,296	$3,232,525	$42,518	$2,801,510	$3,232,525	$354,336
CO_2 High	$417,365	$4,174,456	$0	$1,661,275	$4,372,760	$273,572
CO_2 Max	$250,005	$4,341,816	$0	$1,396,417	$4,637,617	$253,220

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario

Fines projected for baseline and all packages except CO_2 Max under currently published LL97 limits, though all packages offset most of2035-2049 for baseline and all packages if 2022 emissions limits are approved, though all packages offset most of the potential fines. the fines;
Fines possible from

Packages	Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$1,844,704	-	$74,059	$3,286,918	-	$385,877
CO_2 Light	$178,450	$1,666,255	$0	$1,344,172	$1,942,746	$260,081
CO_2 Mid	$124,602	$1,720,103	$0	$1,152,888	$2,134,030	$242,156
CO_2 High	$17,867	$1,826,838	$0	$321,069	$2,965,849	$159,458
CO_2 Max	$0	$1,844,704	$0	$170,686	$3,116,232	$144,826

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Financial & Carbon Summary - Recommended Package is CO_2 High

Meets 80x35 Target (CLCPA Grid, Y/N)	CO_2 Light (N)	CO_2 Mid (N)	CO_2 High (Y)	CO_2 Max (Y)
Carbon Emissions in 2035 (CLCPA Grid)	1472	1427	1230	1145
NPV (2023-2035)[1]	$2,654,279	$794,510	$24,288	($10,232,517)
NPV (Asset Life)[1]	$4,970,675	$2,012,857	$820,945	($11,123,660)
Base Capital Cost[2]	($47,423,169)	($47,423,169)	($47,423,169)	($47,423,169)
Incremental Capital Cost[2]	($6,457,191)	($10,691,121)	($12,409,225)	($27,399,953)
Annual Energy Cost Savings[2]	$692,886	$708,926	$743,228	$827,344
Annual Repairs & Maintenance Savings	$0	($3,150)	($6,150)	($6,150)
Incentives	$1,763,851	$1,982,965	$3,382,760	$3,681,298
Simple Payback	6.8	12.3	12.2	28.9

14% decrease

5% increase

CO_2 Light Reduction -BMS integration & controls optimizations, CW optimization, mitigate lobby infiltration, EMR cooling improvements, BOH lighting upgrades, DHW electric heaters, tenant load improvements (IT cooling, lighting upgrades, plug controls), conversion of CV systems to VAV, ERVs
CO_2 Mid Reduction – CO_2 Light + WWHPs on C-L20; excludes DHW electric heaters
CO_2 High Reduction – CO_2 Mid + VRF on C-L37, retail lighting improvements; excludes WWHPs
CO_2 Max Reduction – CO_2 High + window improvements, retail BMS integration & controls, regen drives for elevators, DHW electric heaters

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.

Financial Breakdown - Recommended Package is CO_2 High

	CO_2 Light	CO_2 Mid	CO_2 High	CO_2 Max
NPV (2023-2035)[1]	$2,654,279	$794,510	$24,288	($10,232,517)
NPV (Asset Life)[1]	$4,970,675	$2,012,857	$820,945	($11,123,660)
Base Capital Cost[2]	($47,423,169)	($47,423,169)	($47,423,169)	($47,423,169)
➢ Base Building Infrastructure	($472,000)	($472,000)	($472,000)	($472,000)
➢ Tenant Fitout HVAC[3]	($46,951,169)	($46,951,169)	($46,951,169)	($46,951,169)
Incremental Capital Cost[2]	($6,457,191)	($10,691,121)	($12,409,225)	($27,399,953)
Annual Energy Cost Savings[2]	$692,886	$708,926	$743,228	$827,344
Annual Repairs & Maintenance Savings	$0	($3,150)	($6,150)	($6,150)
Incentives	$1,763,851	$1,982,965	$3,382,760	$3,681,298
Simple Payback	6.8	12.3	12.2	28.9

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.
3. Tenant fitout HVAC base capital costs include cost of new tenant VAV systems with electronic radiator valves, excluding new AHUs, code minimum plug load controls, and planned CapEx for LL88 compliance

Recommended Package – CO_2 High

- Replace water-cooled systems with air-cooled VRF at tenant fit out
  - Similar issues and drivers with floors 7-12 of 1333 Broadway:
    - Existing water-cooled systems are proving to be inefficient due to pumping energy
  - Roof area is inadequate to install a central hot water system covering the entire building, but is adequate to house VRF condensers for upper floors retaining windows with better views
  - Mechanical rooms are typically on the perimeter, VRF condensers should not significantly impact MER area compared to existing systems, but may impact number of windows. Louvers can be strategically placed where existing windows have limited light and views
- Controls
  - Immediately make improvements to optimize condenser water flow
  - Address uncontrolled heat (replace manual valves and TRVs with electronic)
  - Integrate tenant BMS with base building to ensure systems are operating efficiently

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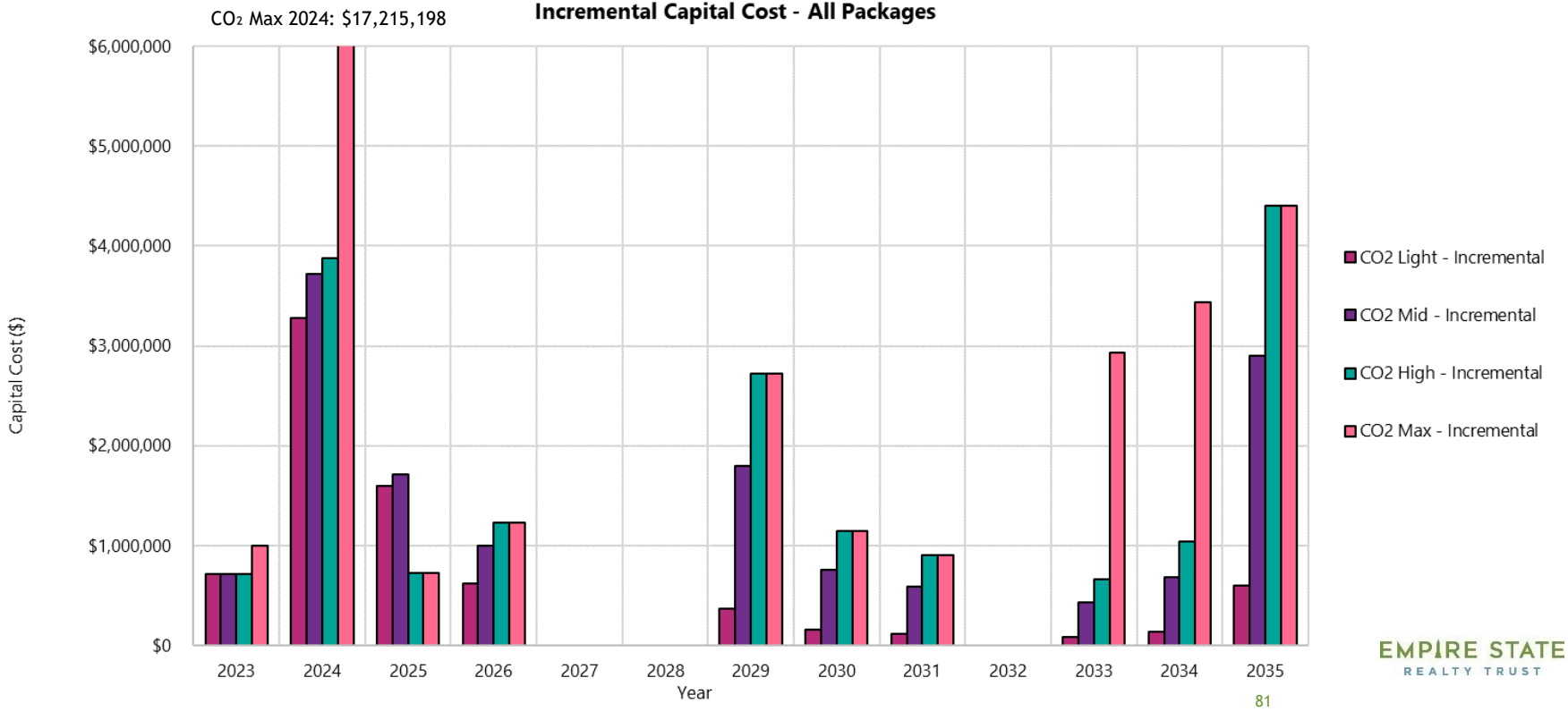
Annual Incremental Capital Cost per Package

Short term capital expenditure covers base building projects like controls, steam & CW optimizations, infiltration mitigation, BOH lighting upgrades, & DHW electric heaters. Longer term incremental costs align with tenant lease rolls



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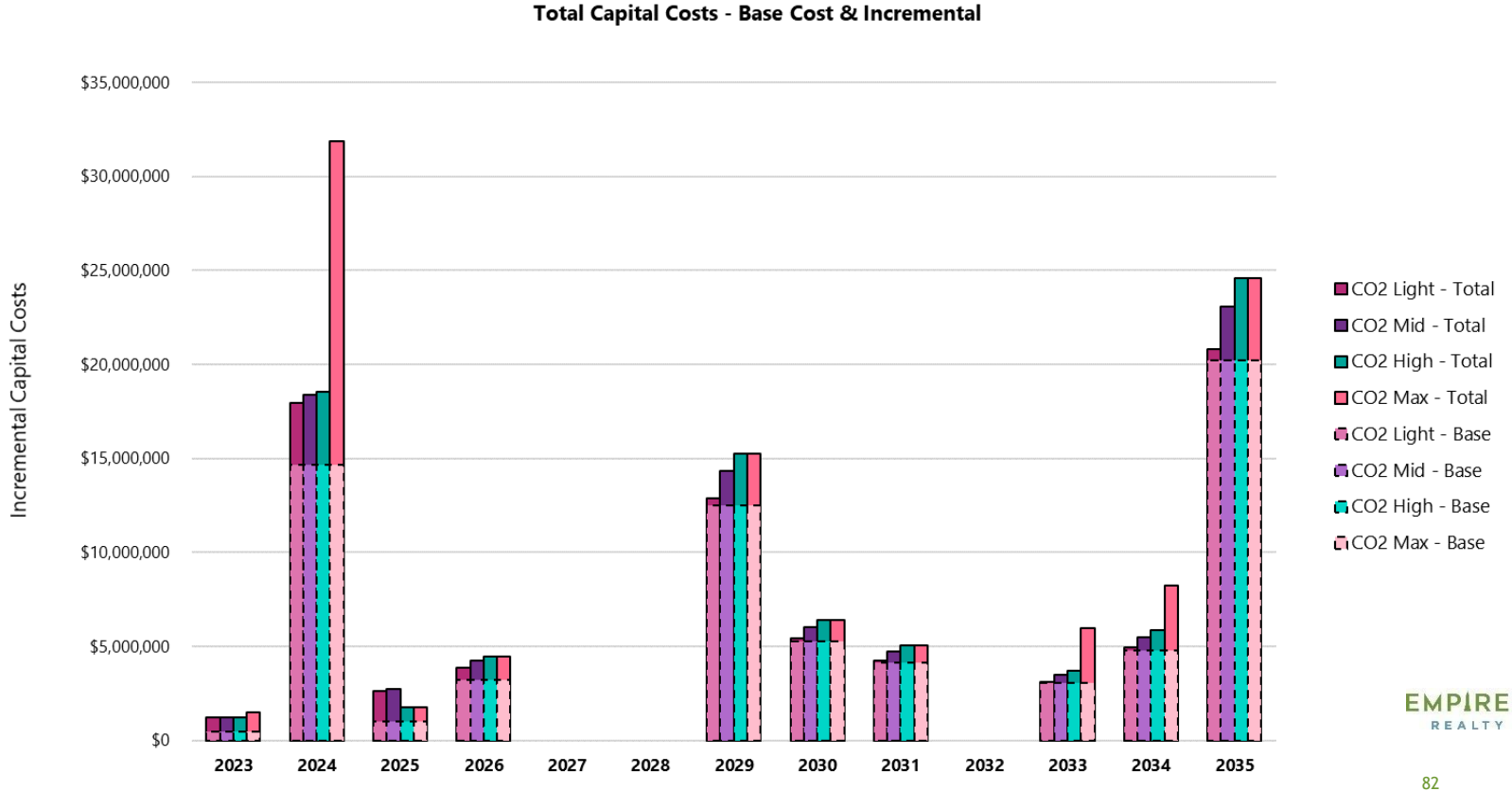
Annual Incremental Capital Cost vs. Base Cost per Package

Base costs include steam system maintenance & upgrades, LL88 lighting upgrades, code minimum plug load controls, required radiator control valve replacements, & installation of VAV systems at tenant fit out.



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1400 Broadway Next Steps – 2023 Projects

The recommended 2023 measures are focused on BMS integration & controls optimizations that have a combined payback of ~1.0 yrs

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
Reduce Steam Pressure & Steam Cycling (Includes Radiator Trap Audit & Replacements)	$495,883 To Be Included in LL87 Compliance Budget	-	-	$3,398
BMS Integration of VAV Boxes & Radiator Valves & ASHRAE Guideline 361	$457,937	$192,283	$265,654	$76,349
Optimize Condenser Water System	$264,136	$166,406	$97,731	$296,380
Total LL97 Budget	$722,074	$358,689	$363,385	$376,127

Note:
1. Capex and savings for BMS integration of VAV boxes and electronic radiator valves has been distributed over a 4-year period.

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501 7th Avenue - Current Building Systems

Water cooled AC units provide cooling and steam boilers provide heating to radiators
2021 Energy Grade: B/81

- Condenser water system
  - (2) 750-ton cooling towers
  - (3) 100-hp main circulating pumps
  - Smaller circulating pumps distributed throughout building for after-hours use
  - Many water-cooled AC units in good condition
- Boiler steam (fuel-oil to natural gas conversion underway)
  - Serves perimeter radiators
  - Boilers currently utilize fuel-oil, waiting on LL11 completion to finish natural gas conversion
- Other systems
  - Limited air-cooled units serving some retail and portions of floors 3 and 4

2019 Energy Breakdown by Utility

Building Energy Utilization Index = 69.7 kBtu/SF/year

Electricity

- 64.4% of energy usage
- 65.3% of CO_2e emissions

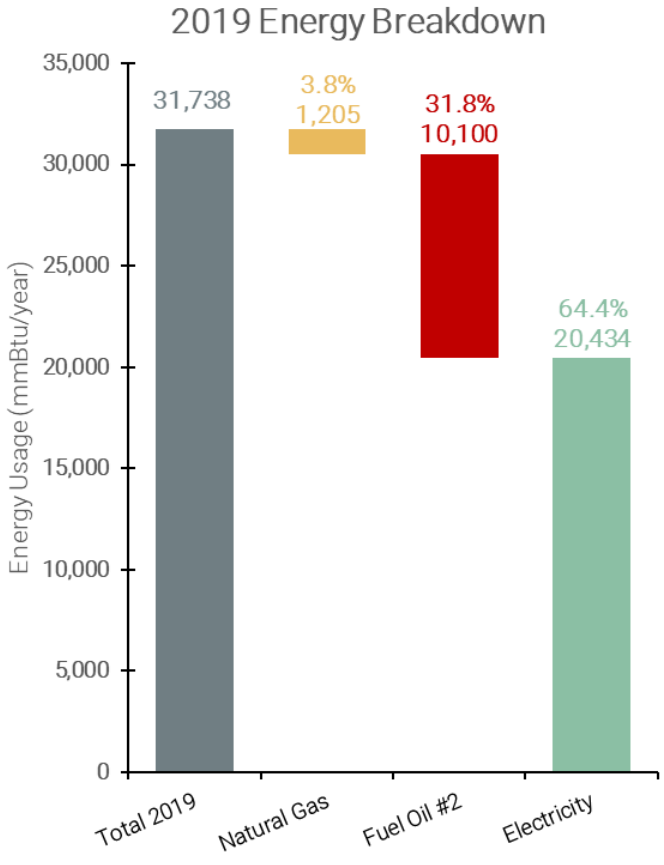
Fuel Oil #2

- 31.8% of energy usage
- 31.9% of CO_2e emissions

Natural Gas

- 3.8% of energy usage
- 2.7% of CO_2e emissions

Energy Source	EUI	Units
Electricity	13.2	kWh/SF/year
Natural Gas	2.6	kBtu/SF/year
Fuel Oil	22.2	kBtu/SF/year
Total	**69.7**	**kBtu/SF/year**



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2019 Operational Cost Breakdown by Utility

Fuel Oil #2/Natural Gas vs Electricity Operational Costs

2019 utility operational cost = $1,302,328

Electricity

- 84.5% of operational costs
- 64.4% of energy usage

Fuel Oil #2

- 14.5% of operational costs
- 31.8% of energy usage

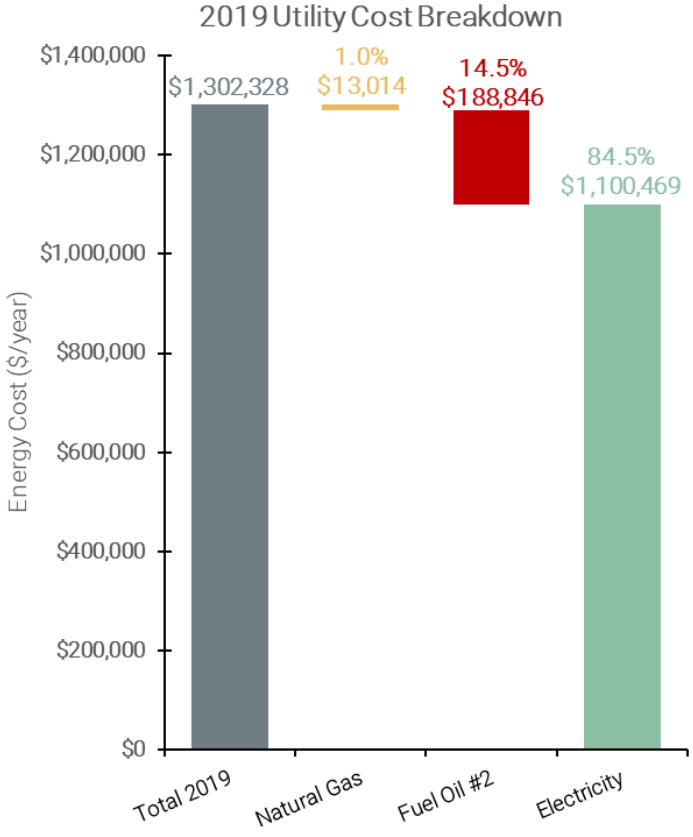
Natural Gas

- 1.0% of operational costs
- 3.8% of energy usage

Electricity - $53.86 per MMBtu

Fuel Oil #2 - $18.70 per MMBtu

Natural Gas - $10.80 per MMBtu



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2019 CO_2e Emissions Breakdown by Utility

Electricity

- 65.3% of CO_2e emissions
- 64.4% of energy usage

Fuel Oil #2

- 31.9% of CO_2e emissions
- 31.8% of energy usage

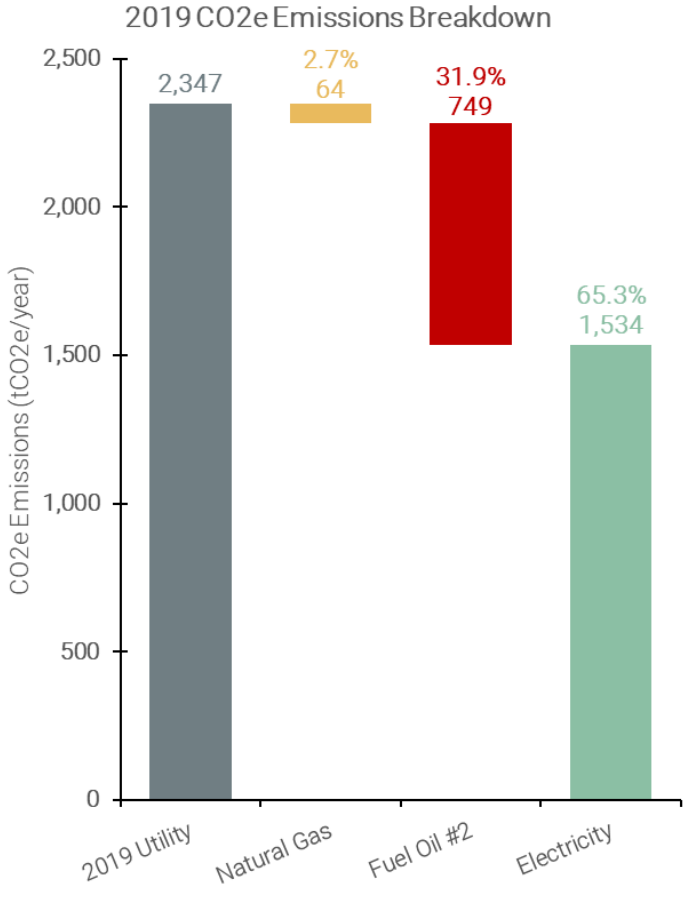
Natural Gas

- 2.7% of CO_2e emissions
- 3.8% of energy usage

Electricity – 256.0 tCO_2e/GWh (Luthin)

Fuel Oil #2 – 253.21 tCO_2e/GWh (LL97)

Natural Gas – 181.22 tCO_2e/GWh (LL97)



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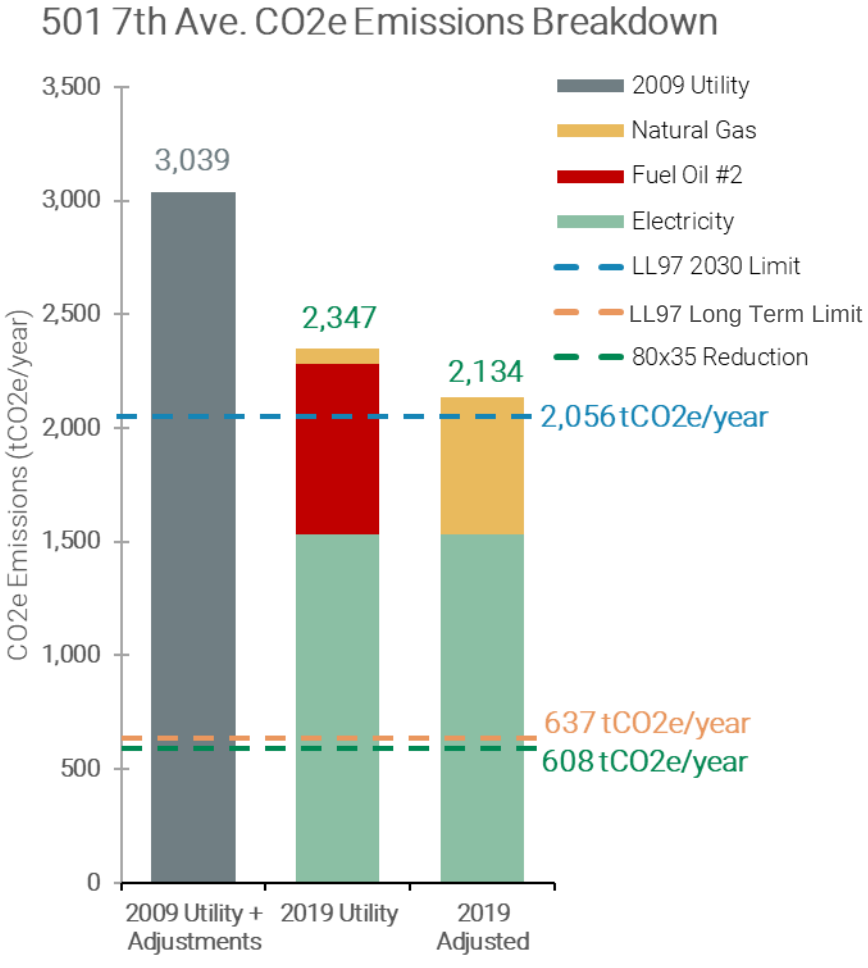
501 7th Ave. Current Status for LL97 and 80x35 Challenge



Key Takeaways for 2019 Adjusted Baseline:

- Building meets 2024 Limit of 3,885 tCO_2e/year
- 4.0% reduction is required to meet LL97 2030 target of 2,056 tCO_2e/year
- 70.0% reduction is required to meet LL97 2035 target of 637 tCO_2e/year
  - Building + grid improvements

22.8% CO_2e Reduction from 2009 to 2019

- 55.6% due to electrical grid improvements
- Remaining due occupancy changes and/or building improvements

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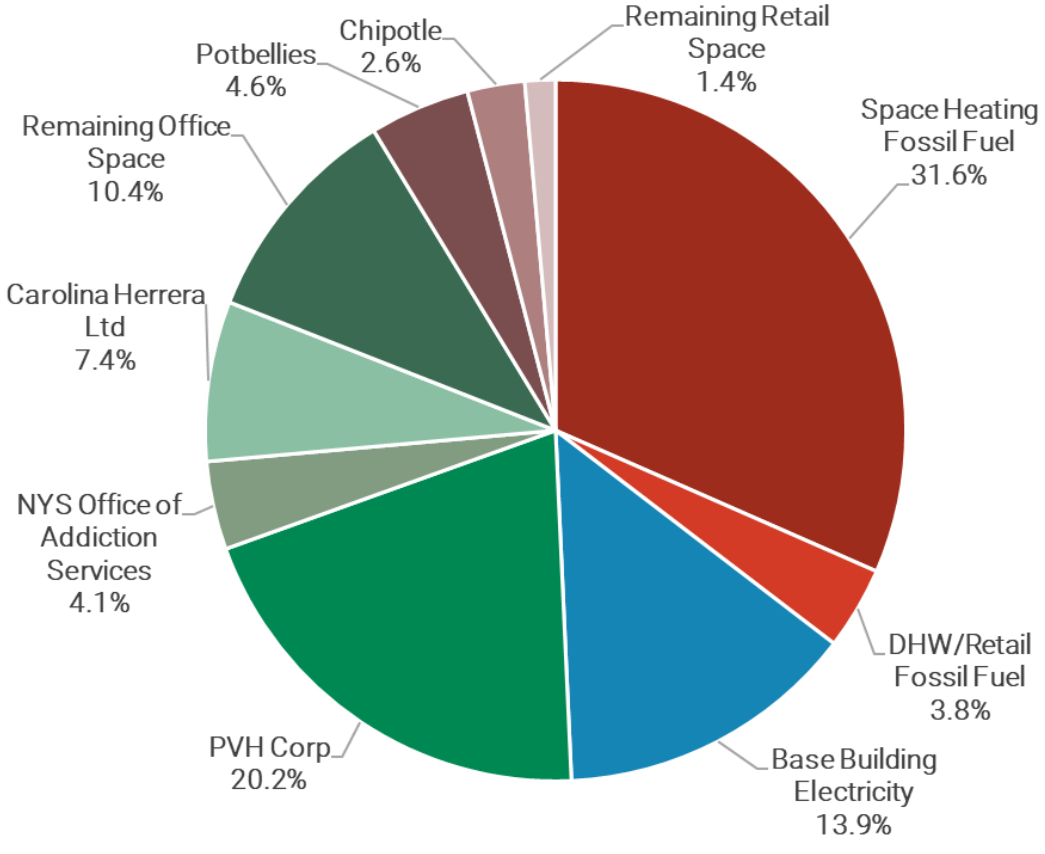
501 7th Ave. Energy Breakdown by Major End Users

Data based on utility meters and Utilivisor Data

- **Base Building - 49.3%**
  - Electricity – 13.9%
  - Fossil Fuel - 35.4%
- **Office Tenants - 42.1%**
  - Carolina Herrera – 22.6 kWh/SF
  - NYS Office of Addiction Services – 12.5 kWh/SF
  - PVH Corp - 8.00 kWh/SF
- **Retail Tenants- 8.6%**
  - Potbellies EUI = 33.6 kWh/SF (179 kBtu/SF)
  - Chipotle EUI = 37.3 kWh/SF (198 kBtu/SF)



501 7th Ave Electricity Breakdown by Major End Users

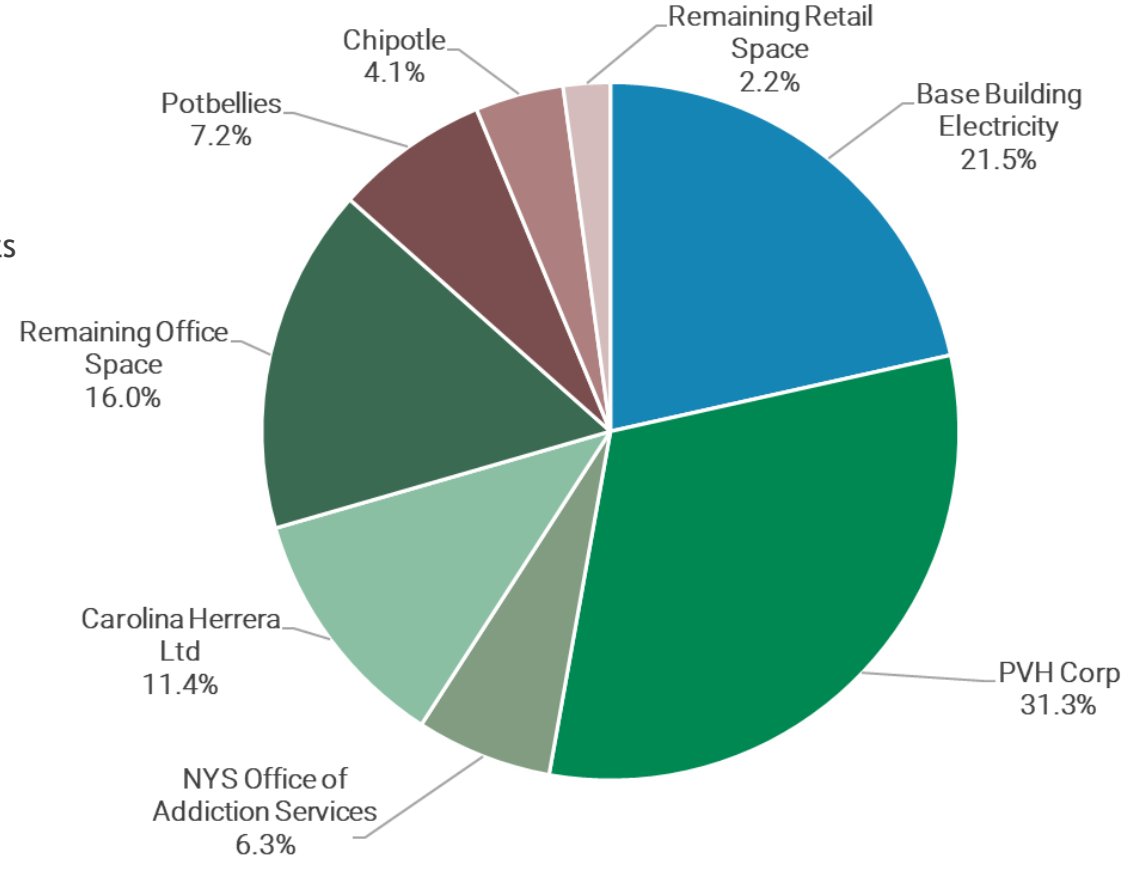
Base Building- 21.5%

- Condenser water system
- Lobby AHUs and Ltg
- Base Bldg Ltg, Equip, HVAC units
- Elevators
- Condensate Vacuum Pumps

Office Tenants - 65%

- Flr-by-flr AHUs
- Tenant Ltg + Equipment
- Data Center/Electrical Rms

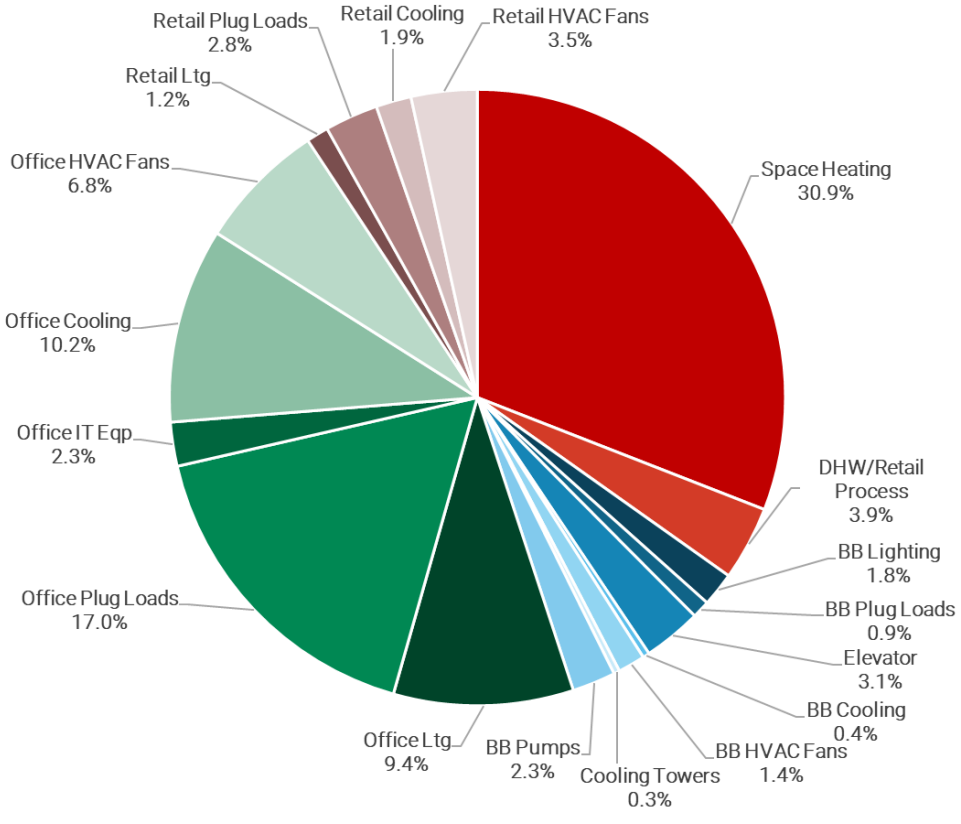
Retail Tenants - 13.5%



501 7th Ave. Energy Model: 2019 Energy Breakdown

Analyzes major end-uses and highlight opportunities for improvement

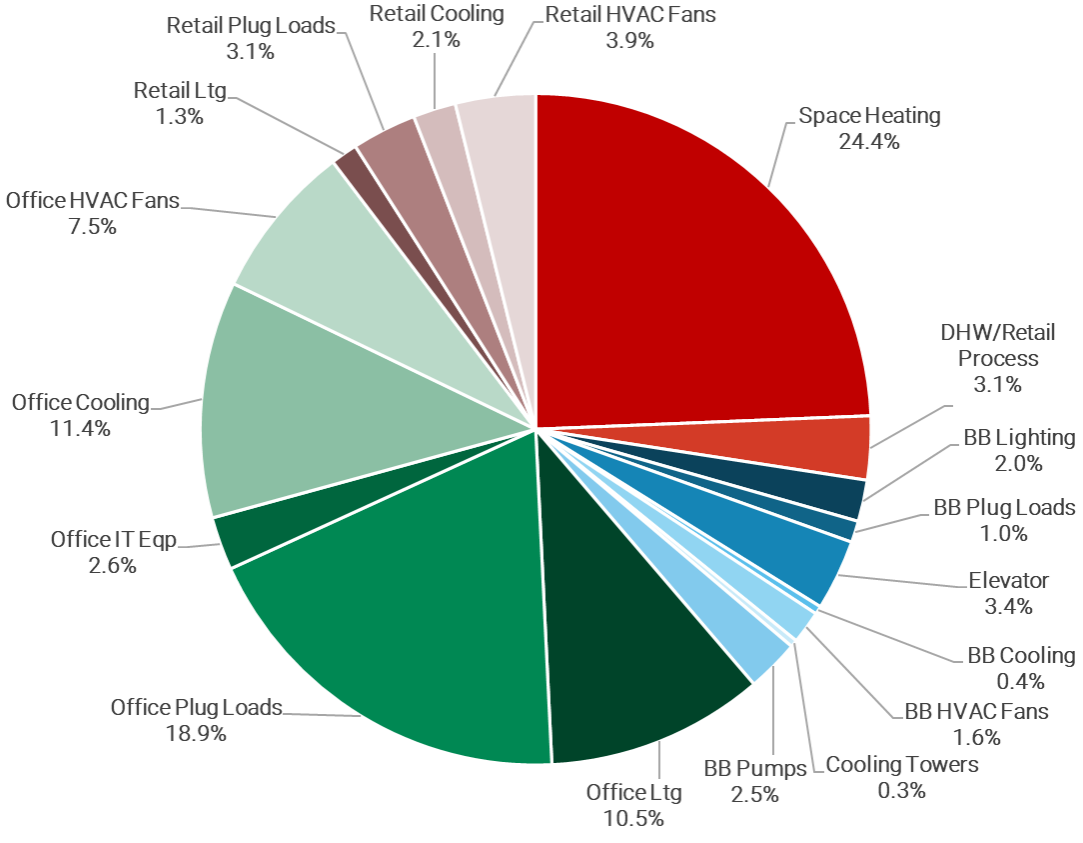
- Office Tenants account for ~45%
- Space Heating accounts for 30.9%
- Retail Tenants accounts for ~9% of total energy usage (only 5% of square footage)
- Base building accounts for ~15% of total energy usage
  - Optimized condenser water controls



501 7th Ave. Energy Model: 2019 CO_2e Emissions Breakdown

Analyzes major end-uses and highlight opportunities for improvement

- Office Tenants account for ~50%
- Space Heating accounts for 24.4%
- Retail Tenants accounts for ~9% of total energy usage (only 5% of square footage)
- Base Building 16%



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ECM Packages - Recommended Package is CO_2 Mid

Four packages of ECMs were developed to optimize NPV and CO_2 reductions

1	2	3	4
			
CO_2 Light **No Electrification**	**CO_2 Mid** **Partial Electrification: WWHPs**	**CO_2 High** **Partial Electrification: WWHPs + Roof-Top AWHPs**	**CO_2 Max:** **Full Electrification: WWHPs + AWHPs Serving Office & Retail**
BMS integration & controls improvements, CW optimization, infiltration mitigation, tenant load improvements (lighting, plug loads, IT cooling), conversion of CV systems to VAV, ERVs	CO_2 Light + distributed WWHPs on L2-4, EMR cooling improvements	CO_2 Mid + beneficial electrification via centralized AWHPs on roof, DHW electric heaters, electrical switchgear room temp control, retail lighting improvements, AFMS & DCV, radiant barriers, steam piping insulation	CO_2 High + increased capacity AWHPs for full load heating of office and retail, TX ERV, integration of retail systems on BMS & lighting upgrades, window retrofits, regen drives for elevators

Carbon Reduction

ECM Phases & Implementation Timeline: CO_2 Mid

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE												
Phase	Tag	ECM Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Phase 1	SS001	Reduce Steam Pressure and Steam Cycling with Trap audit and replacement as necessary	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO001	DDC VAV Boxes and Electronic Radiator Valves & ASHRAE 36	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO002	Tie-In VAV Diffuser Systems to BMS + Electronic Radiator Valves	25%	50%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CW001	Optimize Condenser Water System	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	AS005	Improve EMR Cooling	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN003	Hoistway Smoke Vent Closure	0%	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%
Phase 2	LT001	Common Area Lighting Upgrades	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	AS003	Energy Recovery Ventilators for Office Tenant Floors	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3	EL001	Distributed Water-Water Heat Pumps Connected to Existing Condenser Water System + VAV Reheat on Lower Office Floors (2-4)	33%	67%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4	AS002	Convert CV & VAV Diffuser Systems to VAV Systems at Tenant Lease Roll	17%	19%	21%	38%	39%	92%	99%	99%	99%	100%	100%	100%	100%
Phase 4	LT002	Lighting Upgrades & Controls	17%	19%	21%	38%	39%	92%	99%	99%	99%	100%	100%	100%	100%
Phase 4	TL001	Plug Load Controls	17%	19%	21%	38%	39%	92%	99%	99%	99%	100%	100%	100%	100%
Phase 4	TL002	Tenant IT Cooling	17%	19%	21%	38%	39%	92%	99%	99%	99%	100%	100%	100%	100%

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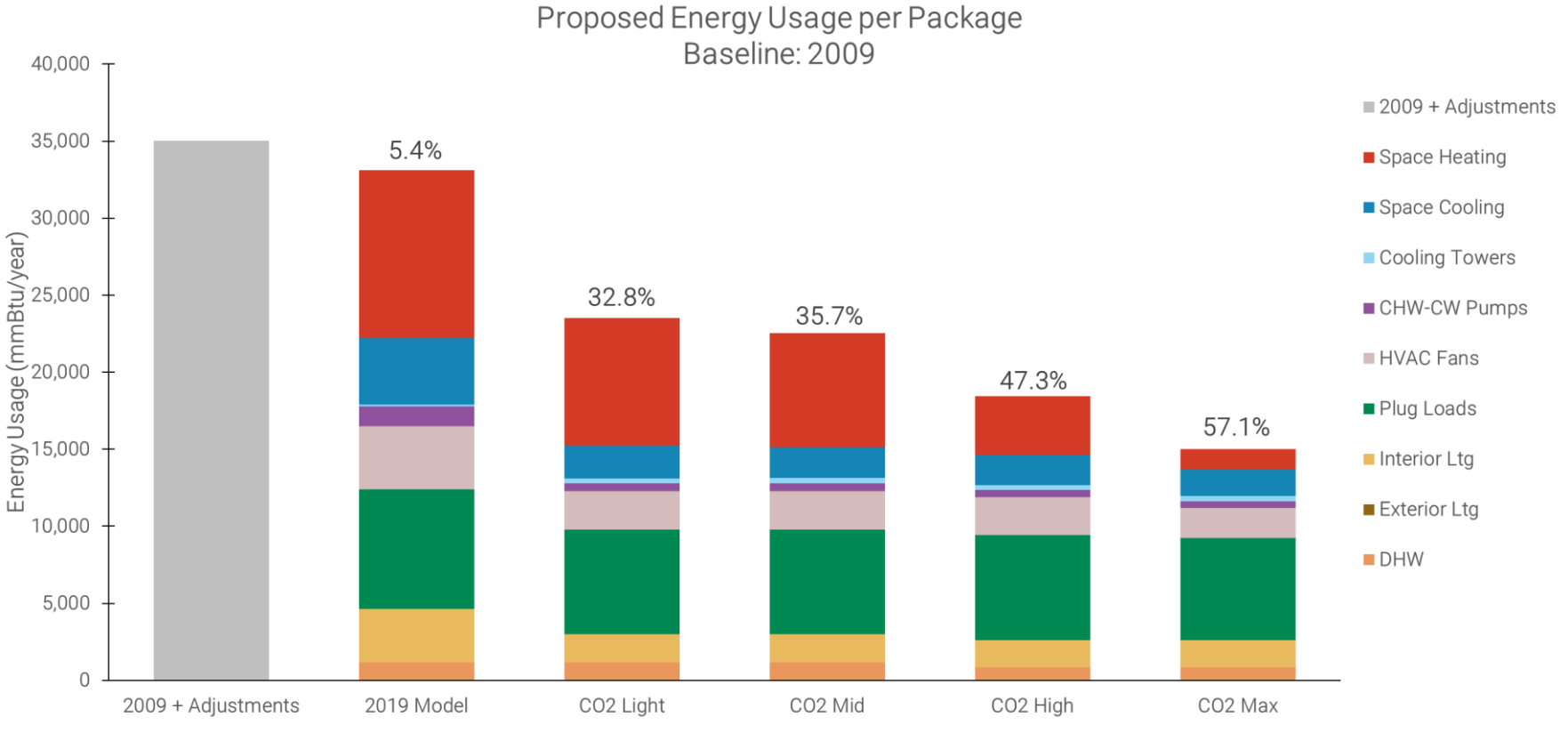
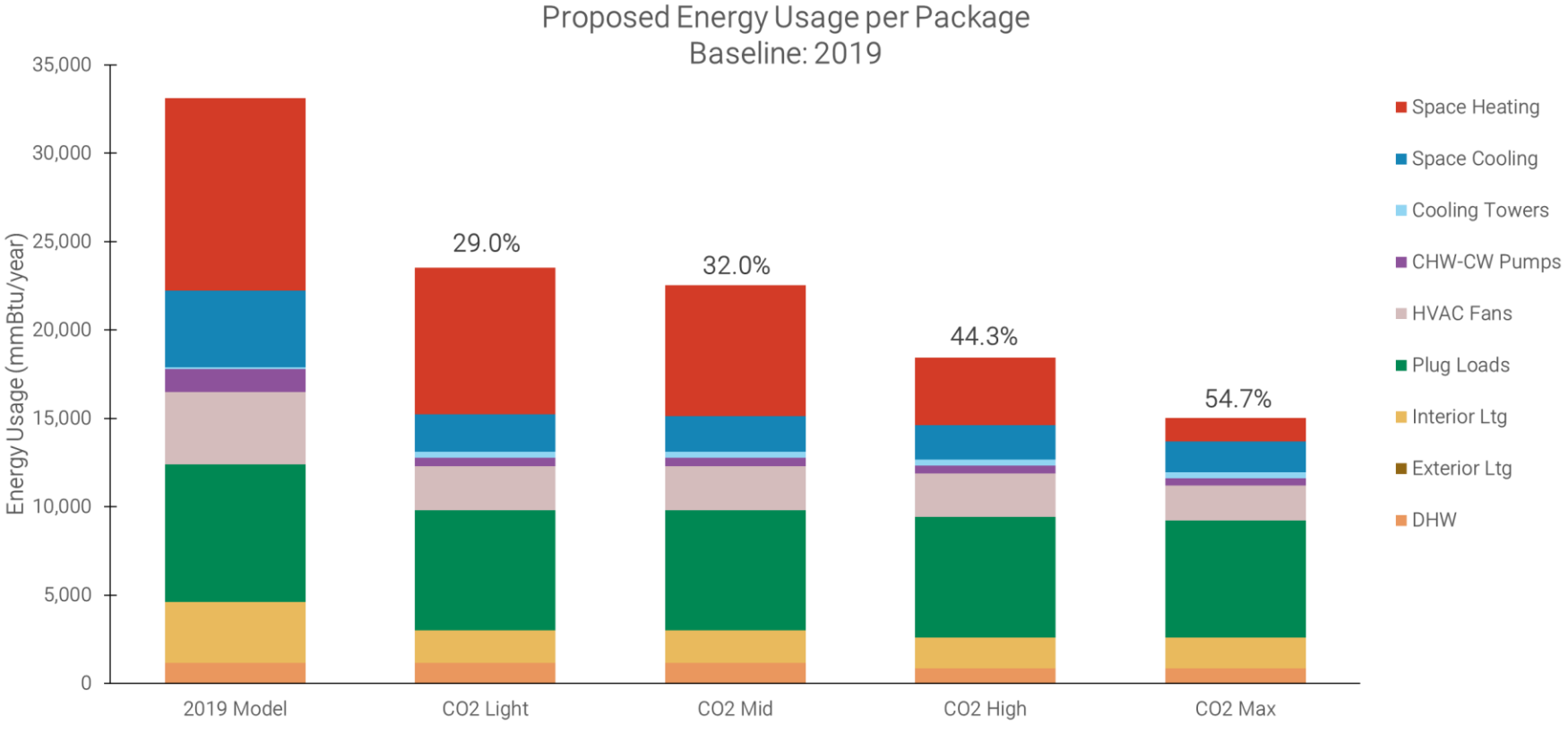
501 7th Ave. ECM Package Comparison: Energy

Baseline: 2009

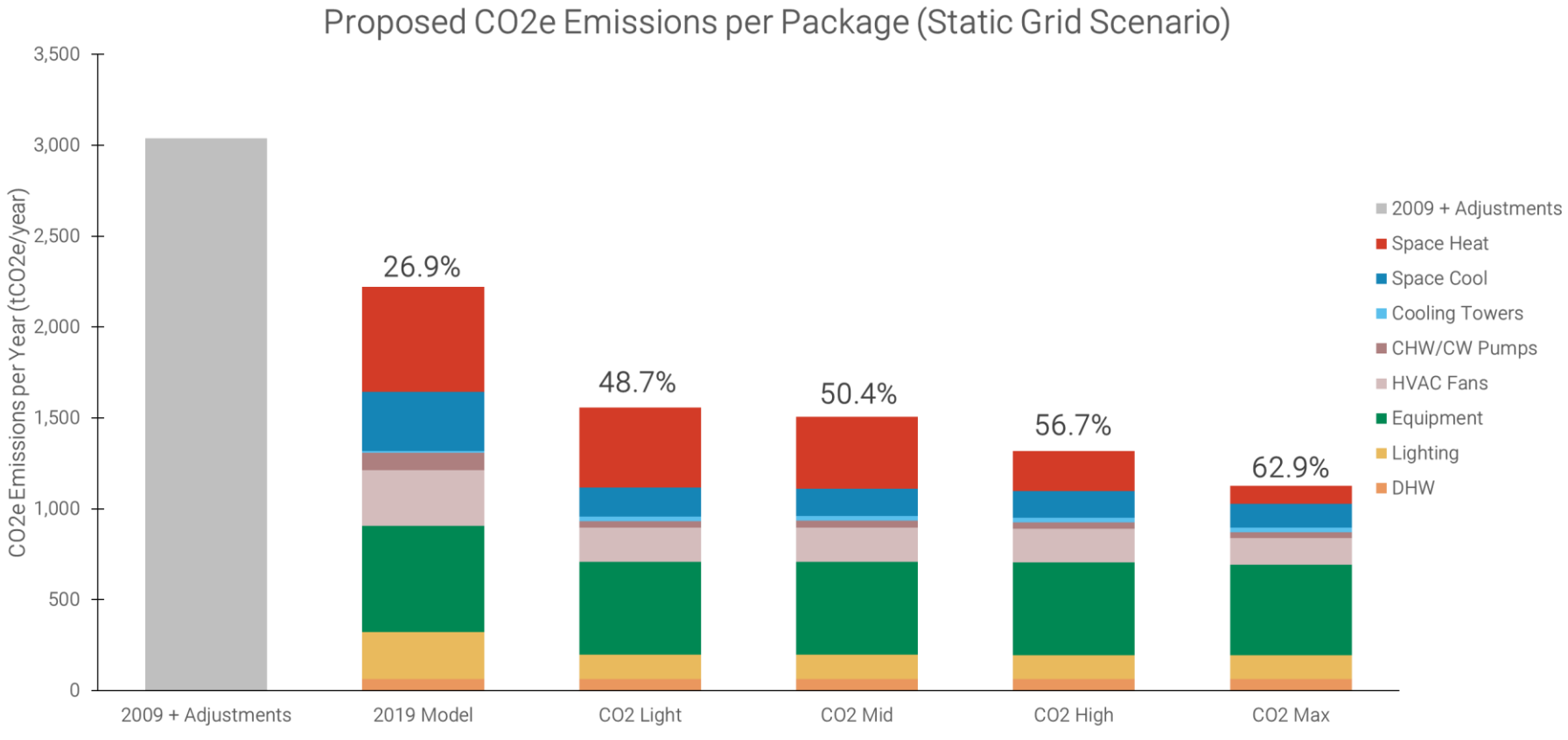


501 7th Ave. ECM Package Comparison: Energy

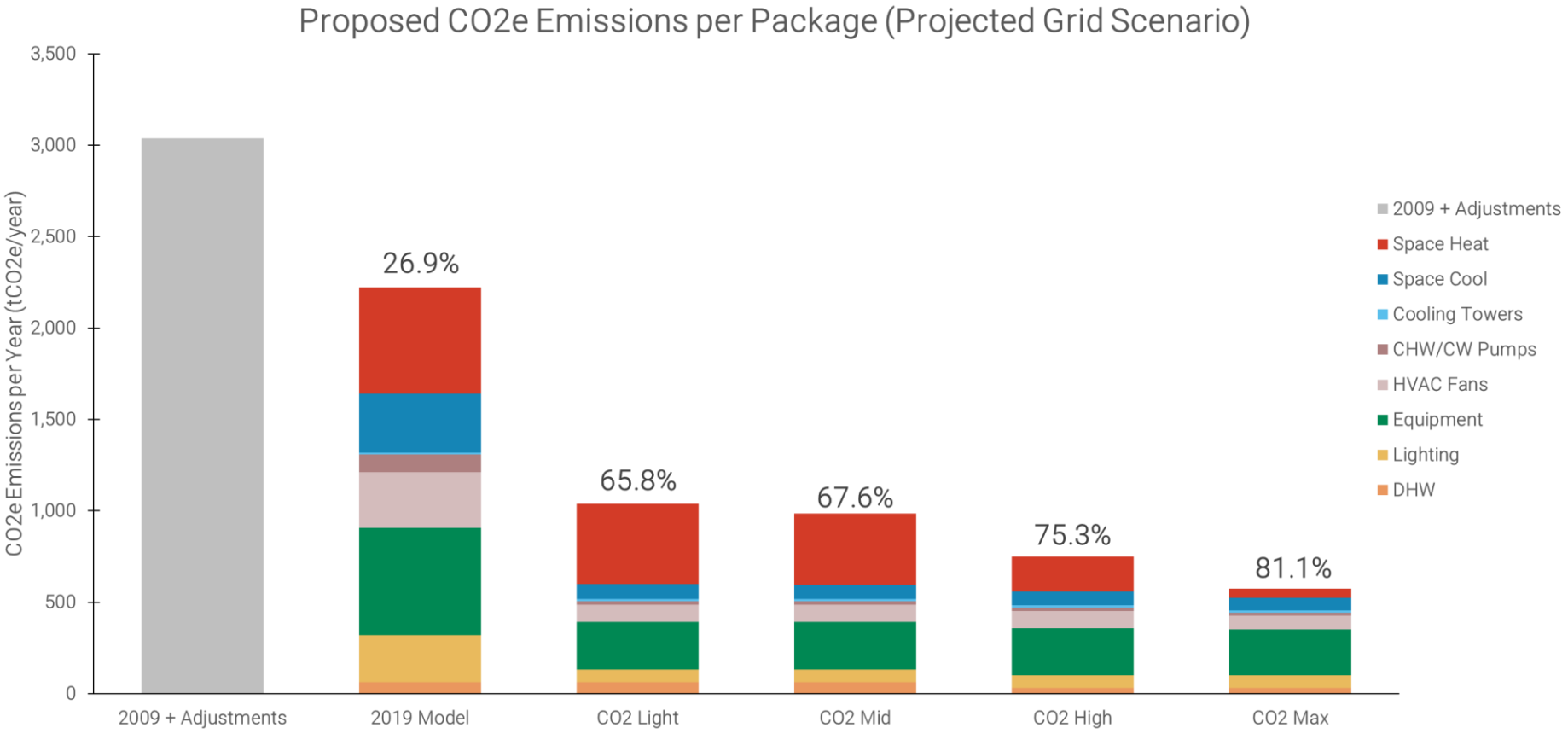
Baseline: 2019



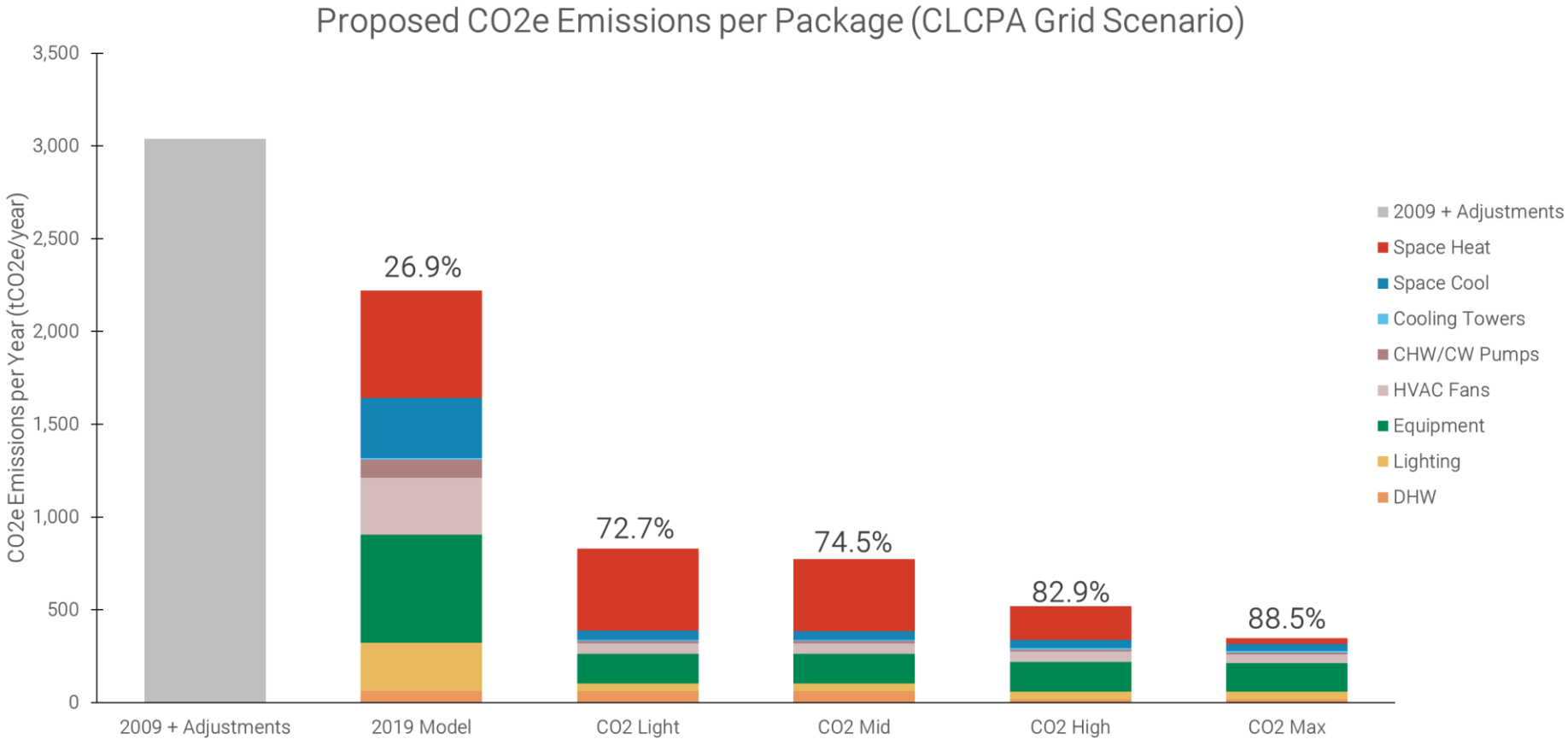
Projected CO_2 Emissions: Static 2019 Grid Scenario



Projected CO_2 Emissions: Projected Grid Scenario

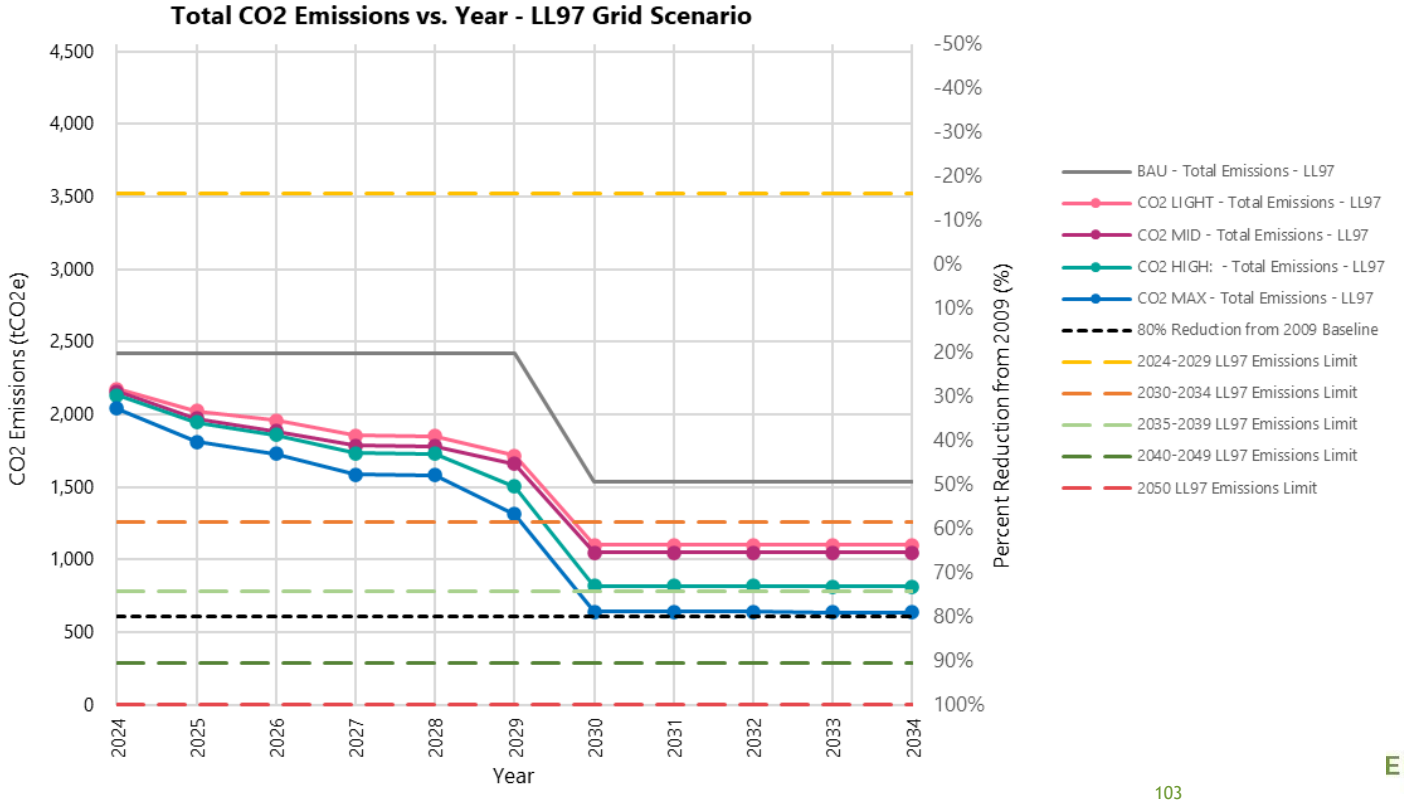


Projected CO_2 Emissions: CLCPA Grid Scenario



Projected Annual Carbon Emissions – LL97 Compliance

BAU does not achieve 2030 LL97 compliance



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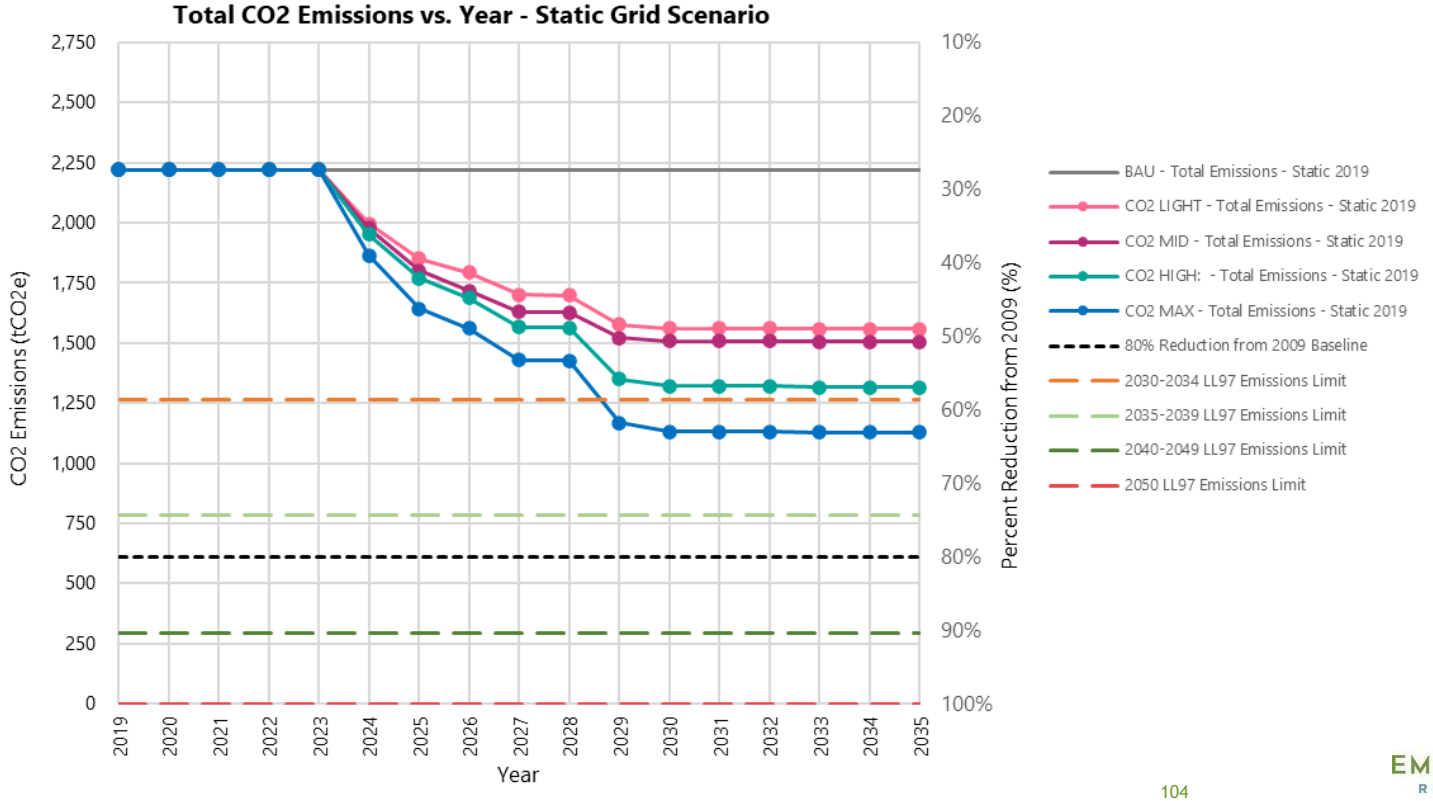
Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization;
No packages would meet 2035 LL97 limit without grid decarbonization



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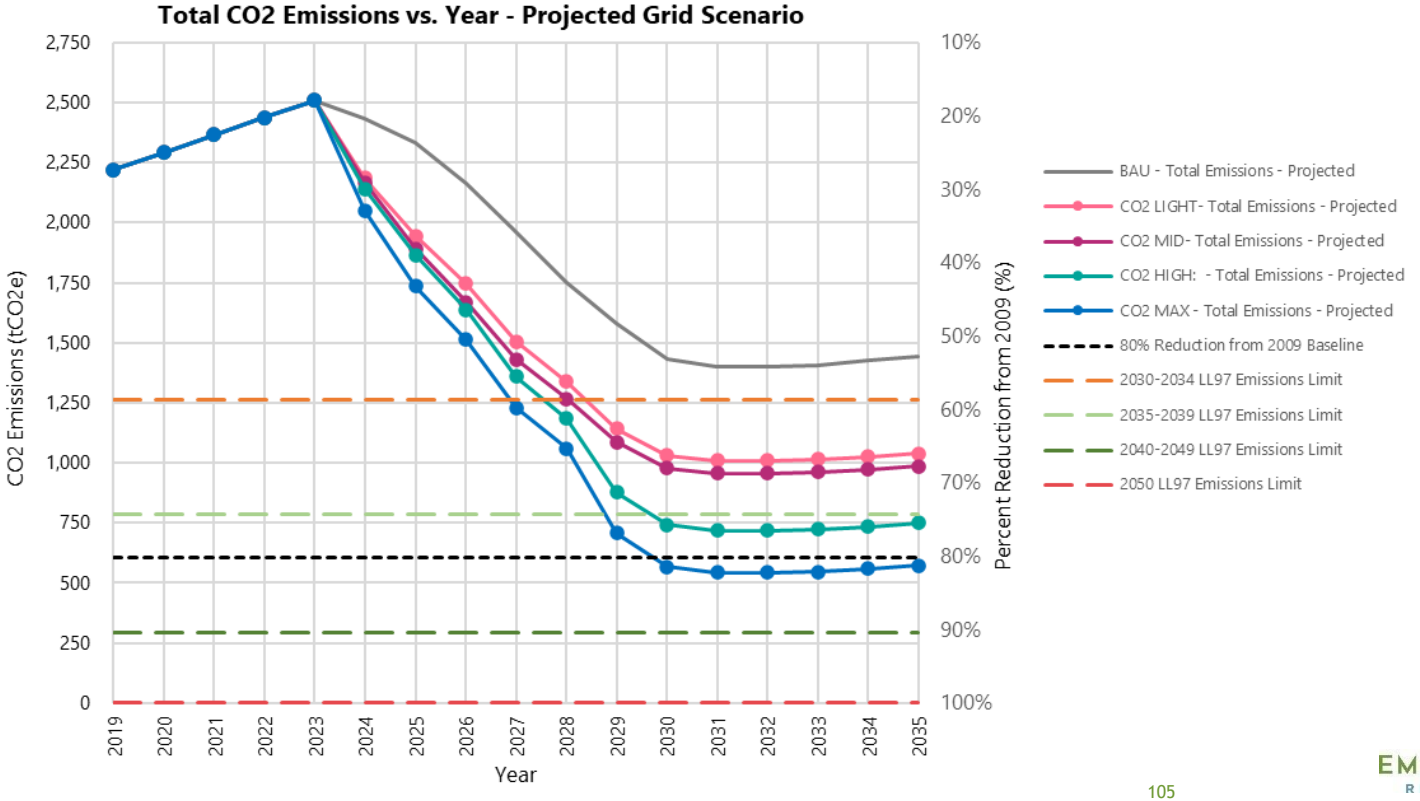
Projected Annual Carbon Emissions – Projected Grid Scenario

Only CO_2 Max package would meet 80% reduction from 2009 baseline by 2035;
CO_2 High and Max packages achieve 2035 LL97 compliance



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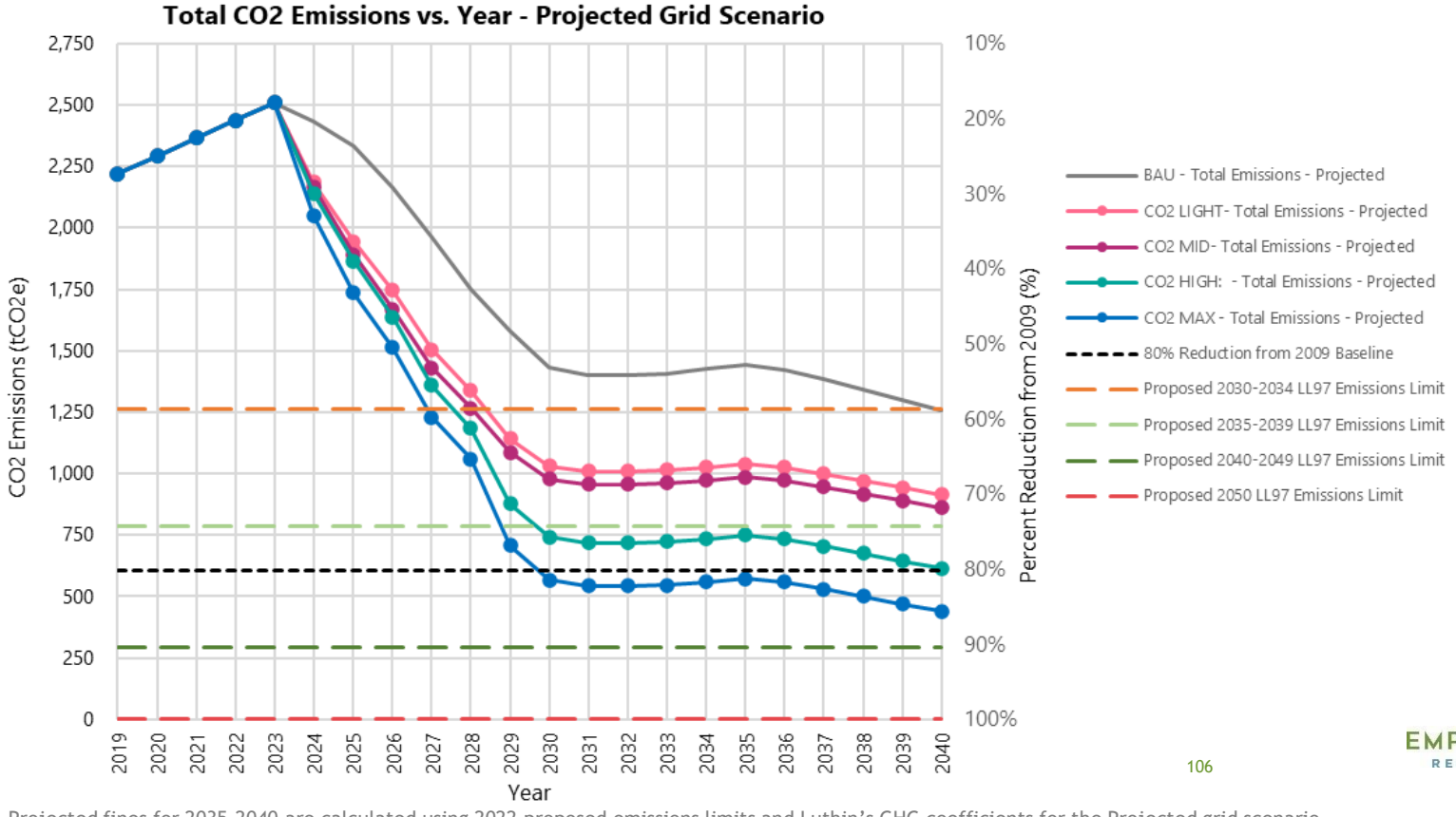
Carbon Emissions Extended to 2040 – Projected Grid Scenario

CO_2 Light, Mid, & High packages do not meet **80% reduction** from 2009 baseline by **2040;**
Projected fines for CO_2 Light, Mid, High & Max from 2035-2040: **$397,072 (Light), $311,148 (Mid), $86,735 (High), $40,290 (Max)**



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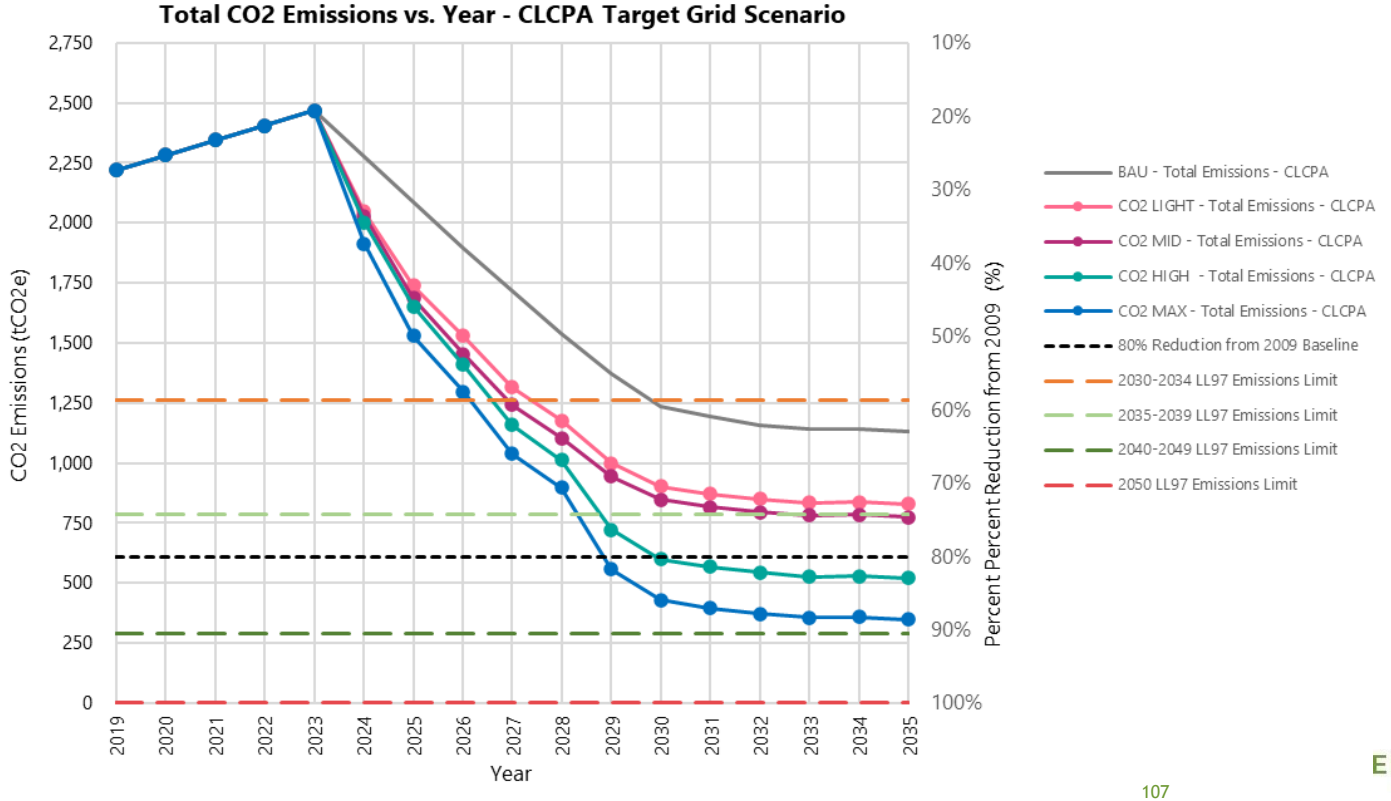
1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the Projected grid scenario

Projected Annual Carbon Emissions – CLCPA Grid Scenario

Only CO_2 High & Max packages would meet 80% reduction from 2009 baseline by 2035; CO_2 Mid and above packages achieve 2035 LL97 compliance



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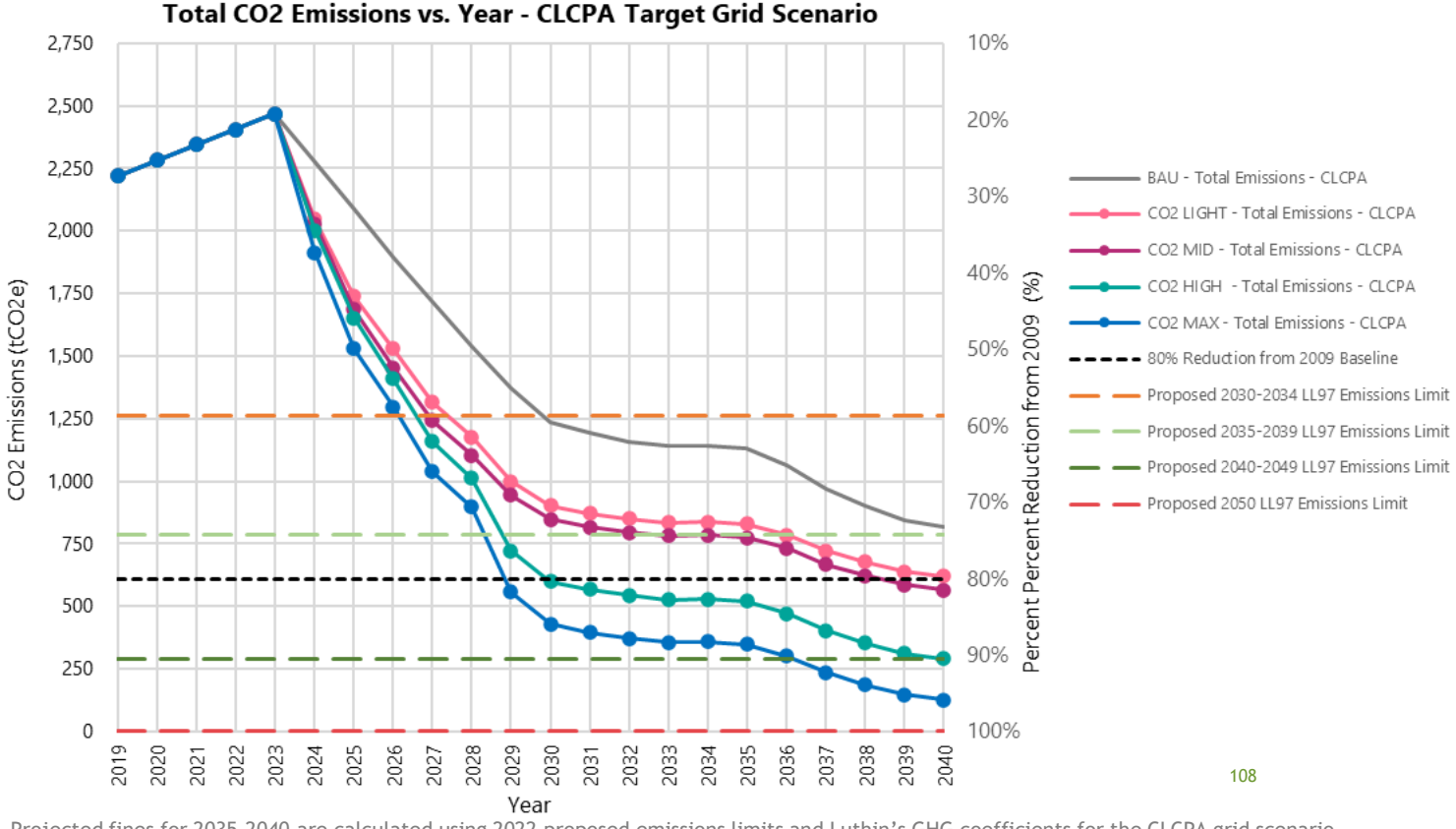
Carbon Emissions Extended to 2040 – CLCPA Grid Scenario

CO_2 Mid package meets **80% reduction** from 2009 baseline by **2039;**
Projected fines for CO_2 Light & Mid respectively from 2035-2040[1]: **$73,863 (Light), $58,735 (Mid)**



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1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the CLCPA grid scenario

Percent Carbon Emissions Reductions – All Grid Scenarios

80x35 target based on reductions from 2009 baseline
Reductions from 2019 baseline show impact of packages compared to current usage

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-49.1%	-49.2%	**-62.8%**	**-62.9%**
CO2 HIGH	-40.6%	-40.7%	**-56.6%**	**-56.7%**
CO2 MID	-32.1%	-32.2%	**-50.4%**	**-50.4%**
CO2 LIGHT	-29.8%	-29.8%	**-48.7%**	**-48.7%**

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization;
No packages would meet 2035 LL97 limit without grid decarbonization

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-74.5%	-74.2%	**-81.4%**	**-81.1%**
CO2 HIGH	-66.6%	-66.2%	**-75.6%**	**-75.3%**
CO2 MID	-56.0%	-55.6%	**-67.8%**	**-67.6%**
CO2 LIGHT	-53.5%	-53.2%	**-66.1%**	**-65.8%**

Only CO_2 Max package would meet 80% reduction from 2009 baseline by 2035;
CO_2 High and Max packages achieve 2035 LL97 compliance

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-80.7%	-84.3%	**-85.9%**	**-88.5%**
CO2 HIGH	-73.0%	-76.6%	**-80.3%**	**-82.9%**
CO2 MID	-61.8%	-65.1%	**-72.1%**	**-74.5%**
CO2 LIGHT	-59.4%	-62.7%	**-70.3%**	**-72.7%**

Only CO_2 High & Max packages would meet 80% reduction from 2009 baseline by 2035;
CO_2 Mid and above packages achieve 2035 LL97 compliance

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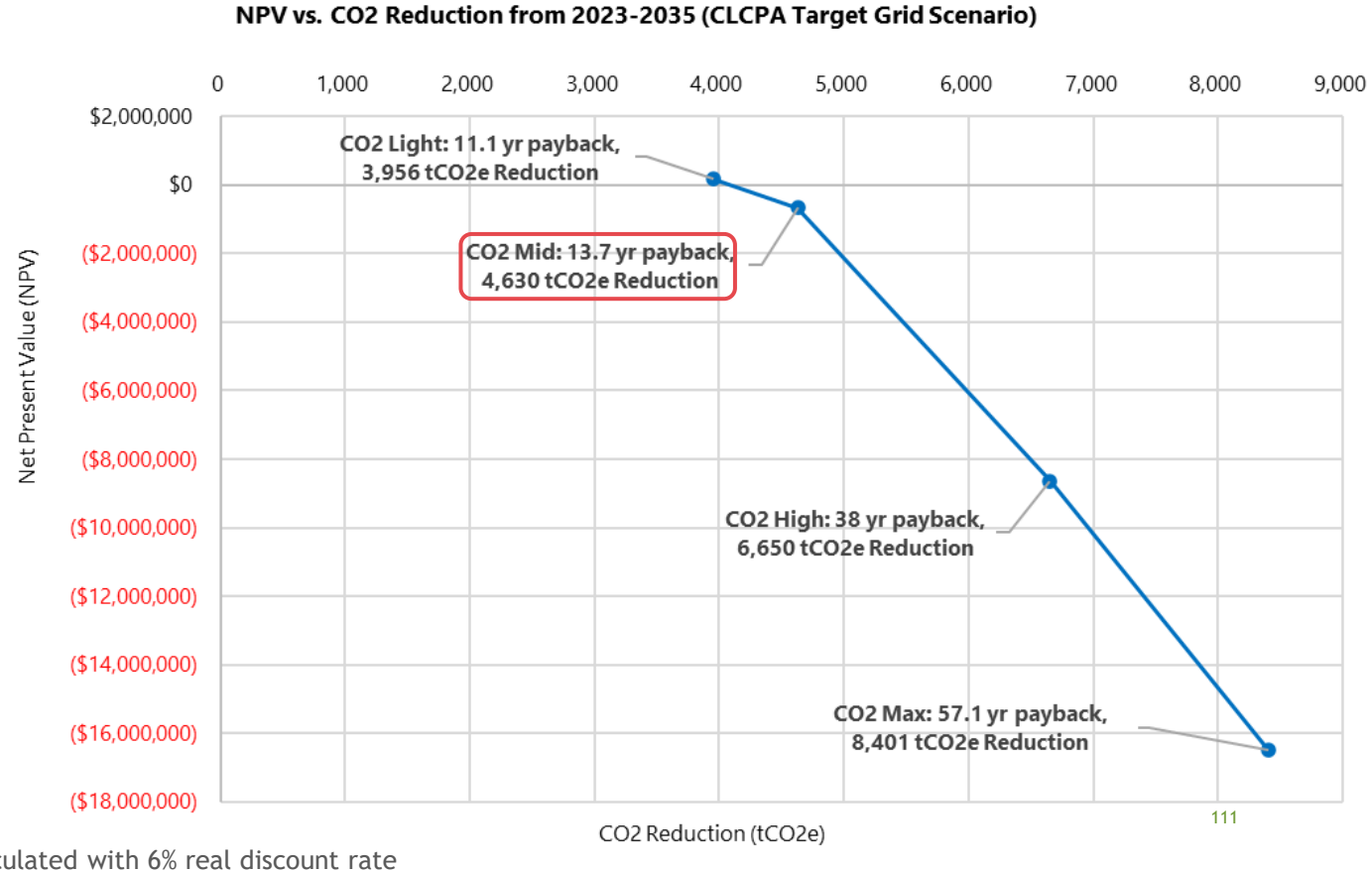
NPV, CO_2 Reductions and Simple Payback for all Packages

Net Present Value for 2023-2035; CO_2 reduction based on CLCPA scenario



NPV calculated with 6% real discount rate

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Projected LL97 Fines From 2024-2034

No LL97 fines projected for the baseline for 2024-2029

Fines possible from 2030-2034 for baseline if 2022 emissions limits are approved, though all packages offset the potential fines.

Packages	LL97 Fines From 2024-2034					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034
BAU (2019 Baseline)	$0	$0	-	$0	$366,935	-
CO_2 Light	$0	$0	$0	$0	$0	$366,935
CO_2 Mid	$0	$0	$0	$0	$0	$366,935
CO_2 High	$0	$0	$0	$0	$0	$366,935
CO_2 Max	$0	$0	$0	$0	$0	$366,935

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2024-2029 are based on GHG coefficients provided in LL97 of 2019.
4. Fine calculations for 2030-2034 are based on additional GHG coefficients provided in the proposed rules for LL97 released Oct. 2022.

Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario

Fines projected for baseline and all packages except for CO_2 Max under currently published LL97 limits, though all packages offset most of the fines;
Fines possible from 2035-2049 for baseline and all packages if 2022 emissions limits are approved, though CO_2 Mid, High & Max offset most of the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$2,291,419	-	$114,341	$3,022,980	-	$285,079
CO_2 Light	$980,167	$1,311,252	$39,673	$1,711,728	$1,311,252	$210,411
CO_2 Mid	$764,377	$1,527,042	$25,227	$1,495,938	$1,527,042	$195,965
CO_2 High	$86,451	$2,204,968	$0	$597,464	$2,425,516	$126,386
CO_2 Max	$0	$2,291,419	$0	$139,375	$2,883,605	$80,843

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario

Fines projected for the baseline, CO_2 Light and Mid under currently published LL97 limits, though packages offset most of the fines;

Fines possible from 2035-2049 for the baseline, CO_2 Light and Mid if 2022 emissions limits are approved, though all packages offset most of the potential fines

Packages	Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$761,581	-	$23,528	$1,493,142	-	$194,266
CO_2 Light	$124,981	$636,600	$0	$773,620	$719,522	$149,733
CO_2 Mid	$70,619	$690,963	$0	$615,334	$877,808	$135,144
CO_2 High	$0	$761,581	$0	$0	$1,493,142	$60,036
CO_2 Max	$0	$761,581	$0	$0	$1,493,142	$16,055

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Financial & Carbon Summary - Recommended Package is CO_2 Mid

Meets 80x35 Target (CLCPA Grid, Y/N)	CO_2 Light (N)	CO_2 Mid (N)	CO_2 High (Y)	CO_2 Max (Y)
Carbon Emissions in 2035 (CLCPA Grid)	829	6.5% decrease → 775	519	348
NPV (2023-2035)[1]	$171,748	($676,270)	($8,643,125)	($16,470,143)
NPV (Asset Life)[1]	$1,491,953	$618,221	($8,279,746)	($17,313,245)
Base Capital Cost[2]	($45,645,813)	($45,645,813)	($46,128,933)	($46,128,933)
Incremental Capital Cost[2]	($5,484,359)	($6,748,860)	($16,634,033)	($27,217,779)
Annual Energy Cost Savings[2]	$386,055	3.0% increase → $397,736	$396,886	$442,158
Annual Repairs & Maintenance Savings	$0	$0	$0	$0
Incentives	$1,216,360	$1,281,481	$1,555,535	$1,980,363
Simple Payback	11.1	13.7	38.0	57.1

CO_2 Light Reduction BMS integration & controls improvements, CW optimization, infiltration mitigation, tenant load improvements (lighting, plug loads, IT cooling), conversion of CV systems to VAV, ERVs
CO_2 Mid Reduction CO_2 Light + distributed WWHPs on L2-4, EMR cooling improvements
CO_2 High Reduction CO_2 Mid + beneficial electrification via centralized AWHPs on roof, electrical switchgear room temp control, DHW electric heaters, retail lighting improvements, AFMS & DCV, radiant barriers, steam piping insulation
CO_2 Max Reduction – CO_2 High + increased capacity AWHPs for full load heating of office and retail, TX ERV, integration of retail systems on BMS & lighting upgrades, window retrofits, regen drives for elevators

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Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.

Financial Breakdown - Recommended Package is CO_2 Mid

	CO_2 Light	CO_2 Mid	CO_2 High	CO_2 Max
NPV (2023-2035)[1]	$171,748	($676,270)	($8,643,125)	($16,470,143)
NPV (Asset Life)[1]	$1,491,953	$618,221	($8,279,746)	($17,313,245)
Base Capital Cost[2]	($45,645,813)	($45,645,813)	($46,128,933)	($46,128,933)
➢ Base Building Infrastructure	($182,000)	($182,000)	($182,000)	($182,000)
➢ Tenant Fitout HVAC[3]	($45,463,813)	($45,463,813)	($45,946,933)	($45,946,933)
Incremental Capital Cost[2]	($5,484,359)	($6,748,860)	($16,634,033)	($27,217,779)
Annual Energy Cost Savings[2]	$386,055	$397,736	$396,886	$442,158
Annual Repairs & Maintenance Savings	$0	$0	$0	$0
Incentives	$1,216,360	$1,281,481	$1,555,535	$1,980,363
Simple Payback	11.1	13.7	38.0	57.1

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.
3. Tenant fitout HVAC base capital costs include cost of new tenant VAV systems with electronic radiator valves, excluding new AHUs, code minimum plug load controls, and CO_2 sensors for CO_2 High and Max packages

Recommended Package – CO_2 Mid

- Near term installation of water to water heat pumps on 3 lower floors to provide heating for anticipated full floor fit outs in the next 2-3 years
  - Waste heat from cooling loads elsewhere in the building allows for heating electrification
  - Taking advantage of high server room and switchgear loads which are otherwise rejected to atmosphere in winter
- Immediate installation of ERVs
  - Existing mechanical rooms have plenty of space for ERVs which provide immediate heating and cooling savings, pipe freeze protection, continuous demand reduction, and improved humidity control
- Controls
  - Immediately link base building and extensive tenant BMS to allow energy efficient coordination of control of AHUs and VAV boxes & radiators to prevent simultaneous heating and cooling
- While there is currently no business case to install air to water heat pumps for additional heating electrification, we recommend re-evaluating the business case in the future as the market changes
  - Sufficient roof space available for future installation of AWHPs

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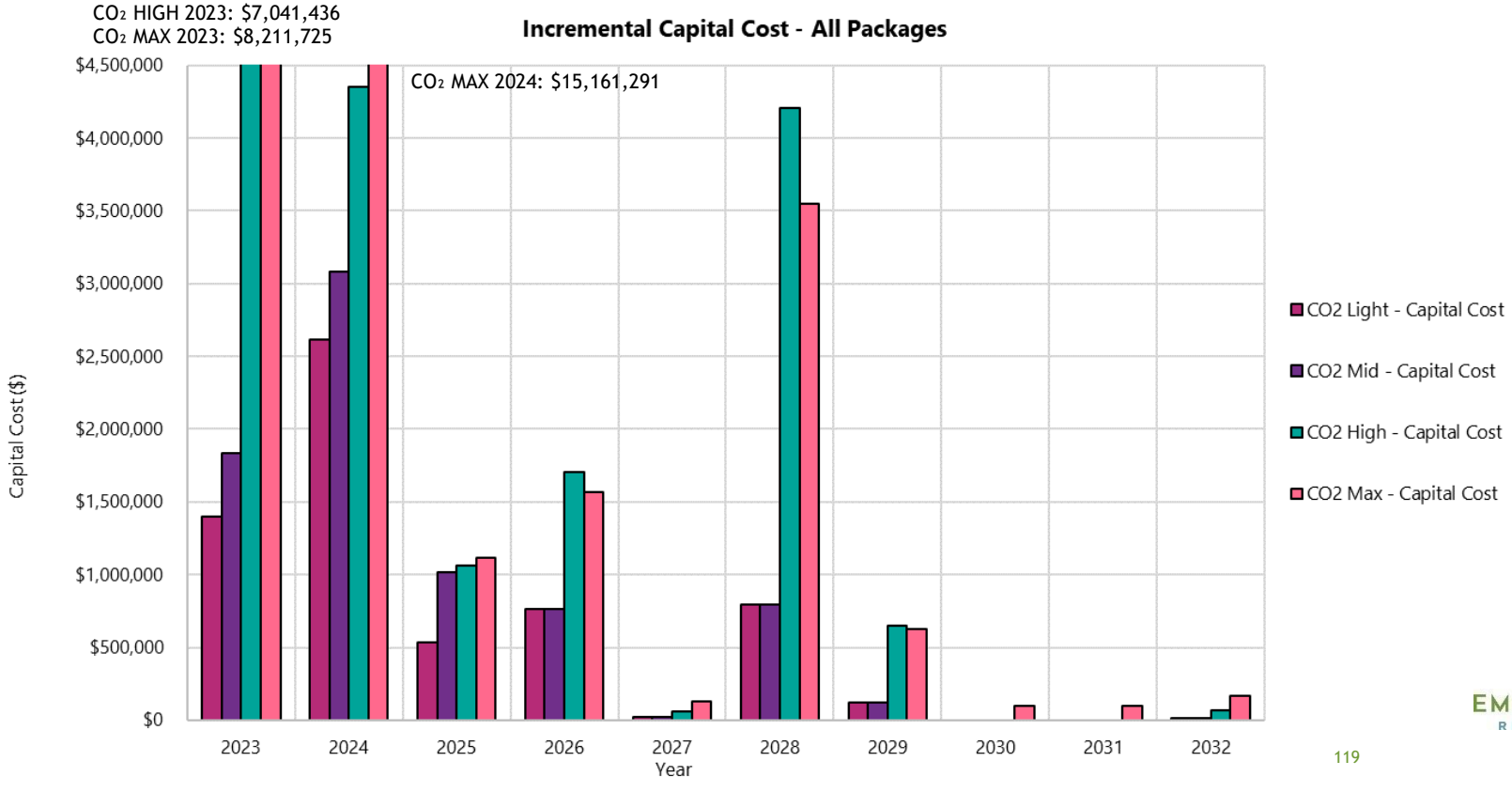
Annual Incremental Capital Cost per Package

Most of the capital expenditure for all packages occurs in the first 2 years to cover base building projects, including AWHP installation for CO_2 High & Max. Incremental costs align with tenant lease roll schedules.



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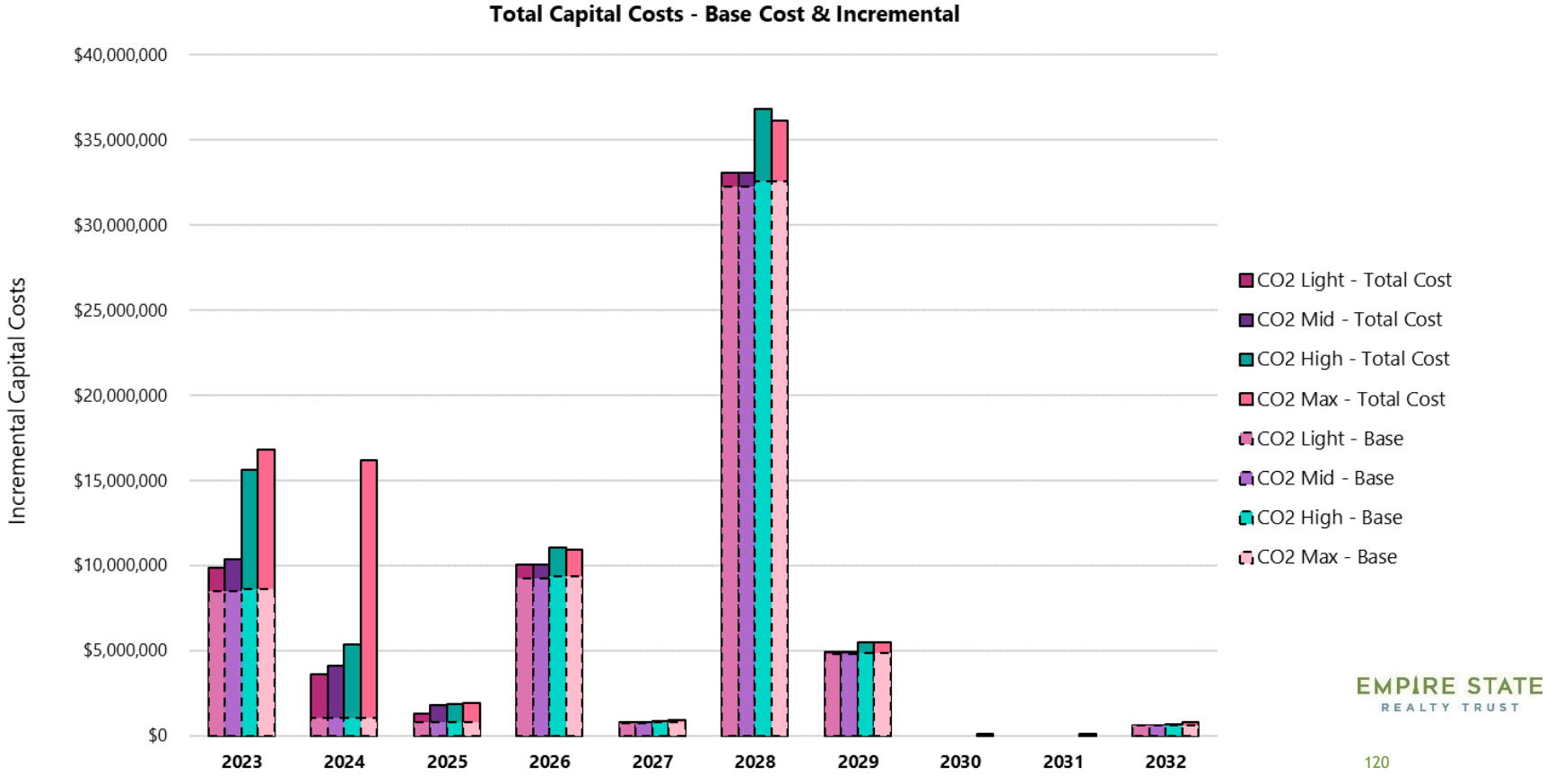
Annual Incremental Capital Cost vs. Base Cost per Package

Base costs include steam system maintenance & upgrades, conversion code minimum plug load controls, required radiator control valve replacements, & installation of VAV systems & CO_2 sensors at tenant fit out.



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501 7th Street Next Steps – 2023 Projects

The recommended 2023 measures are focused on BMS integration & controls optimizations that have a combined payback of ~7.0 yrs

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
Reduce Steam Pressure and Steam Cycling with Trap audit and replacement as necessary	$191,209 To Be Included in LL87 Compliance Budget	-	-	$2,405
DDC VAV Boxes & VAV Diffusers and Electronic Radiator Valves & ASHRAE 361	$464,670	$139,401	$325,269	$38,428
Optimize Condenser Water System	$728,161	$209,497	$518,664	$82,108
Total LL97 Budget	$1,192,831	$348,898	$843,933	$122,940

Note:
1. Capex and savings for BMS integration of VAV boxes and electronic radiator valves has been distributed over a 4-year period.

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111 W 33rd Street Case Study

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111 W 33rd Street - Current Building Systems

Chiller plant provides cooling, district steam used to generate hot water for perimeter induction units
2021 Energy Grade: B/82

- Central chiller plant & cooling towers
  - (1) 1200-ton magnetic-bearing centrifugal SMARDT water-cooled chiller installed in 2017. Chiller has (4) compressors, largest compressors are ~357 tons
  - (1) 1300-ton steam turbine centrifugal YORK chiller installed in 1991; intended for redundancy but not operational
  - (3) cell 1800-ton total base building cooling tower installed in 1995
  - (3) cell 750-ton total tenant cooling tower installed in 2014. Tenant condenser water system serves IT units, 2 office AHUs, and retail
- Utility steam
  - Serves heating coils in the AHUs
  - Used to generate heating hot water for secondary dual temperature system
- Secondary dual temperature system
  - (5) zoned heat exchangers (1 standby) installed in 1995 generate chilled or hot water to perimeter induction units

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2019 Energy Breakdown by Utility

Building Energy Utilization Index = 48.3 kBtu/SF/year

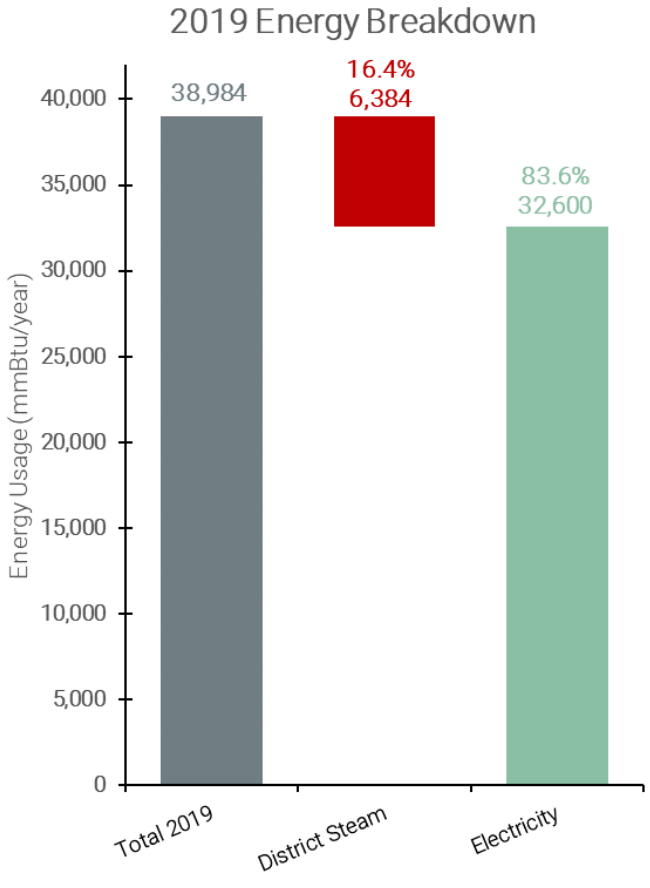
Electricity

- 83.6% of energy usage
- 89.5% of CO_2e emissions

District Steam

- 16.4% of energy usage
- 10.5% of CO_2e emissions

Energy Source	EUI	Units
Electricity	11.8	kWh/SF/year
Steam	7.9	kBtu/SF/year
Total	**48.3**	**kBtu/SF/year**



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2019 Operational Cost Breakdown by Utility

District Steam vs Electricity Operational Costs

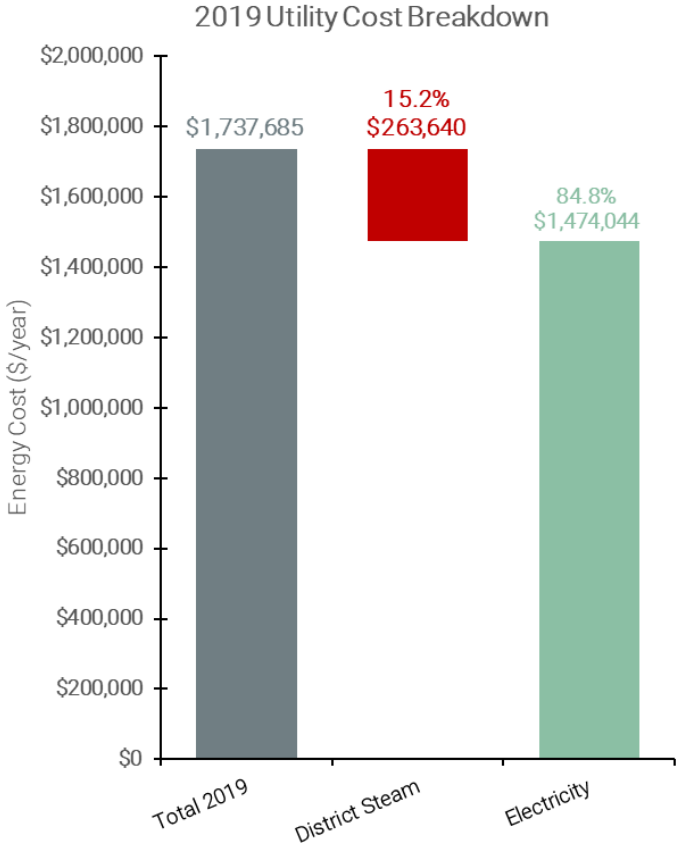
2019 utility operational cost = $1,737,685

Electricity

- 84.8% of operational costs
- 83.6% of energy usage

District Steam

- 15.2% of operational costs
- 16.4% of energy usage



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2019 CO_2e Emissions Breakdown by Utility

District steam has slightly lower associated emissions than electricity

Electricity

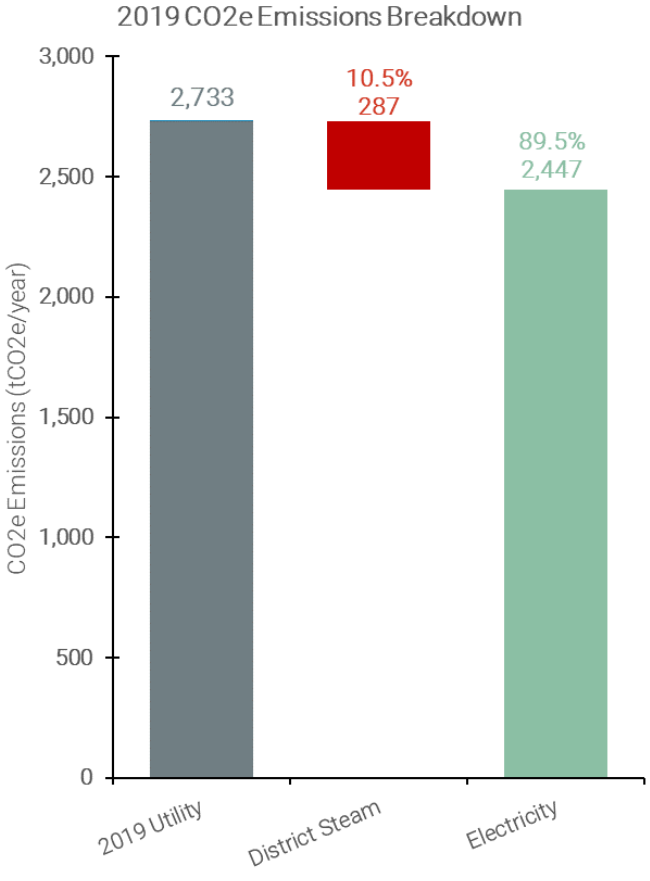
- 89.5% of CO_2e emissions
- 83.6% of energy usage

District Steam

- 10.5% of CO_2e emissions
- 16.4% of energy usage

Electricity – 256.0 tCO_2e/GWh (Luthin)

Steam – 153.3 tCO_2e/GWh (LL97)



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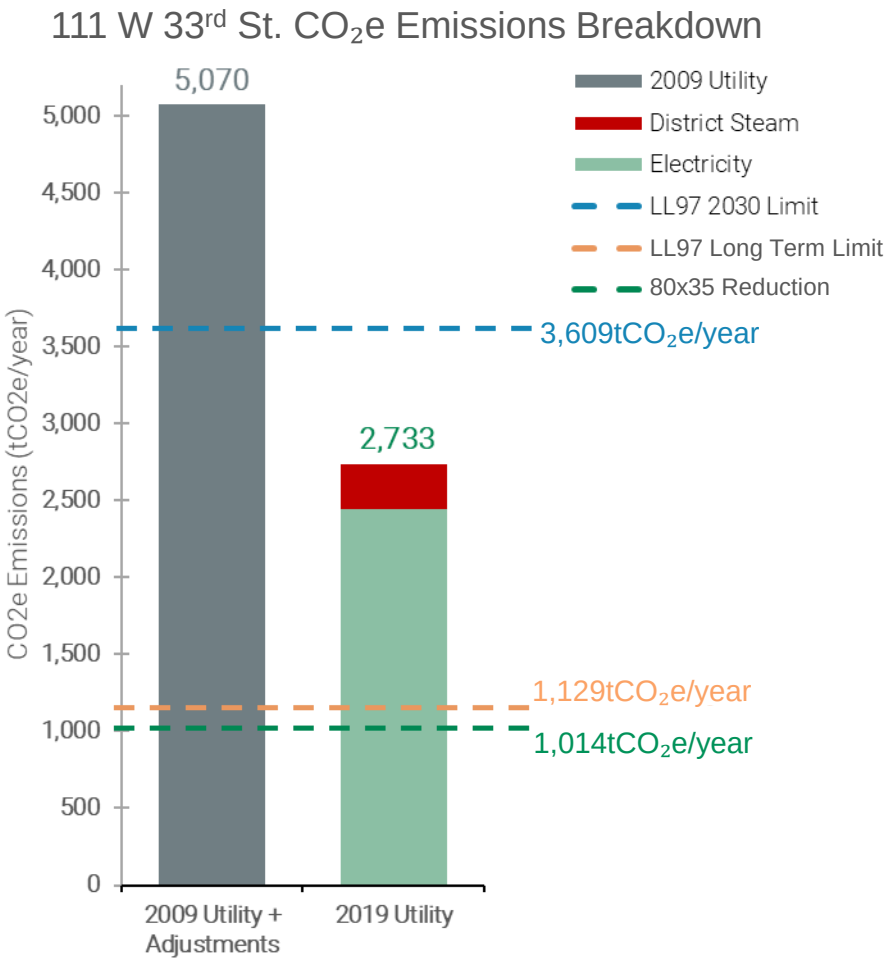
111 W 33rd St. Current Status for LL97 and 80x35 Challenge



Key Takeaways:

- Building meets 2024 Limit of 7,023 tCO_2e/year
- Building meets 2030 Limit of 3,624 tCO_2e/year
- 58.7% reduction is required to meet LL97 2035 target
  - Building + grid improvements

46.1% CO_2e Reduction from 2009 to 2019

- 23% due to switch from steam to electric chillers
- 26% due to electrical grid improvements
- Remaining due occupancy changes and/or building improvements

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111 W 33rd St. Energy Breakdown by Major End Users

Data based on utility meters and Utilivisor

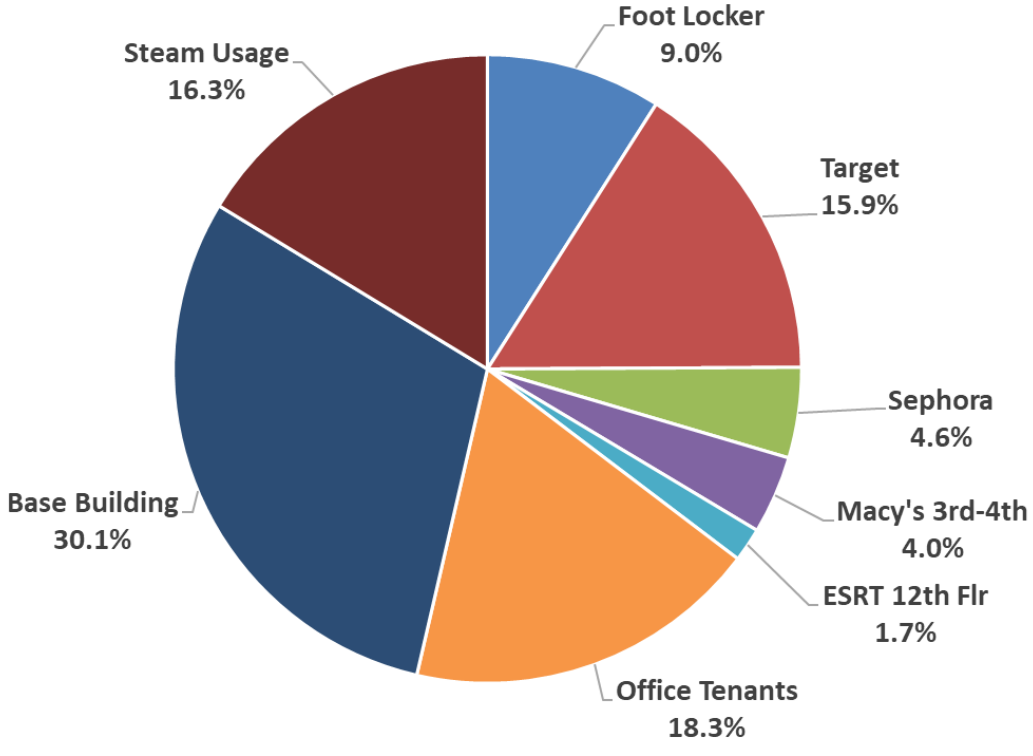
Base Building – 46.4%

Electricity – 30.1%

Steam - 16.3%

Retail Tenants– 29.5%

Office Tenants – 24.1%



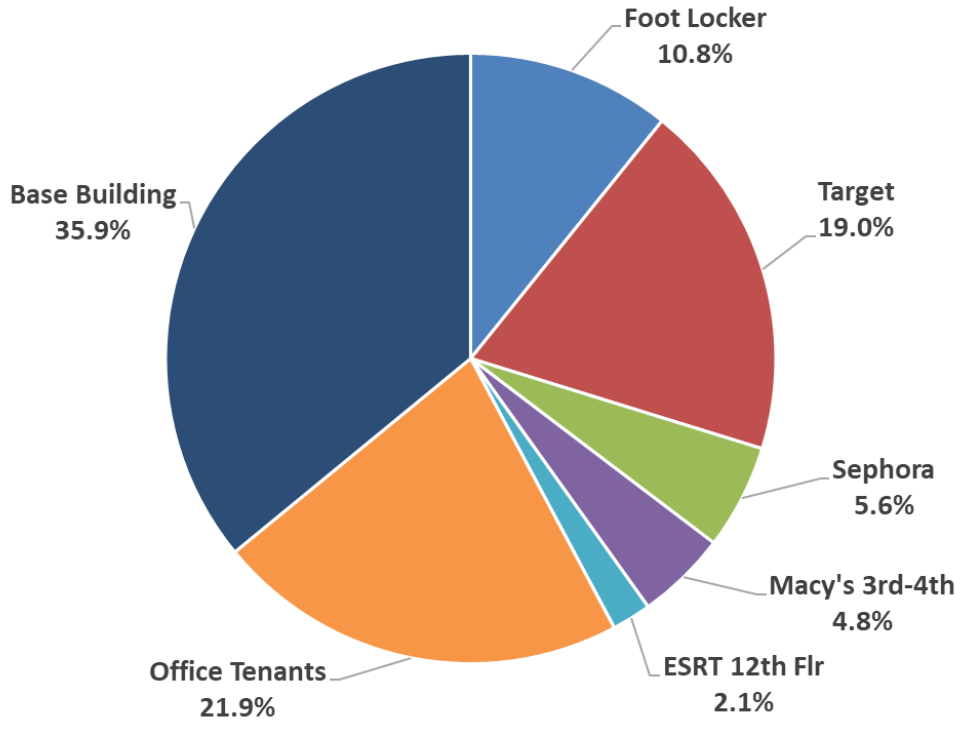
111 W 33rd St. Electricity Breakdown by Major End Users

Base Building- 35.9%

Retail Tenants – 35.4%

Office Tenants – 28.8%

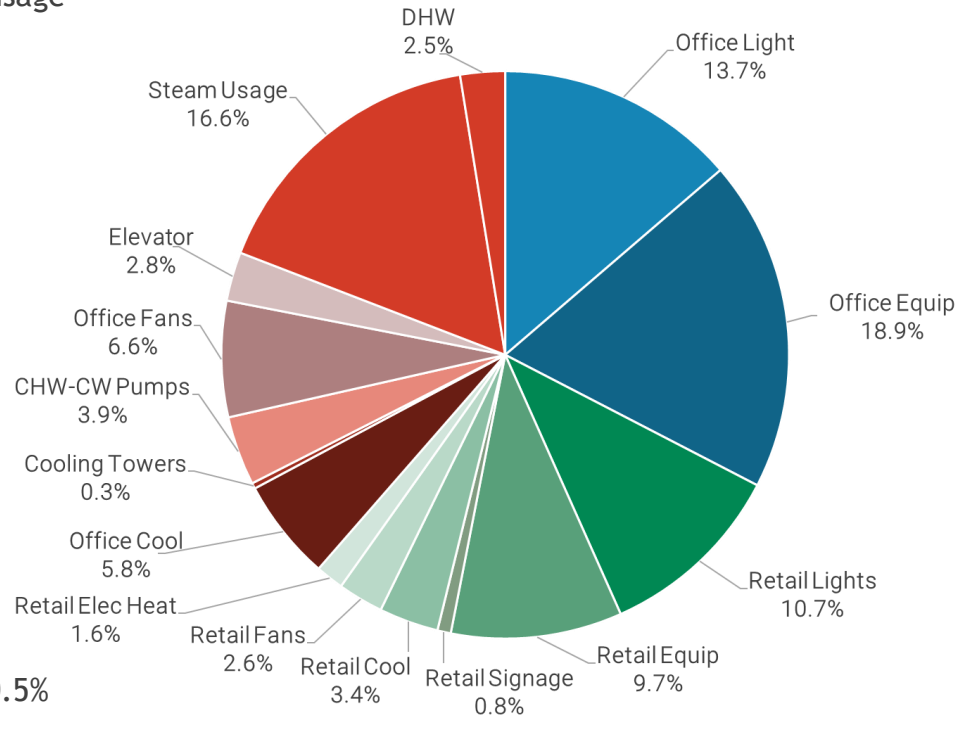
- Retail and Office tenant usage is based on Utilivisor Spreadsheet.



111 W 33rd St. Energy Model: 2019 Energy Breakdown

Analyzes major end-uses and highlight opportunities for improvement

- Retail Tenants accounts for ~29% of total energy usage (only 10% of square footage)
  - High lighting power density
  - 24/7 lighting, HVAC
  - Refrigeration equipment (Target)
- Office Tenants account for ~32.5%
  - Potential for plug load controls
  - Potential LPD reduction to 0.6 W/SF
  - IT Loads improvements
- Steam Heating accounts for 16.5%
  - Improved HVAC Controls
  - Heating electrification
- Distribution energy (Fans + Pumps) account for 10.5%
  - Improved CHW/CW pump controls
  - Optimized BMS and ASHRAE Guideline 36 Sequence



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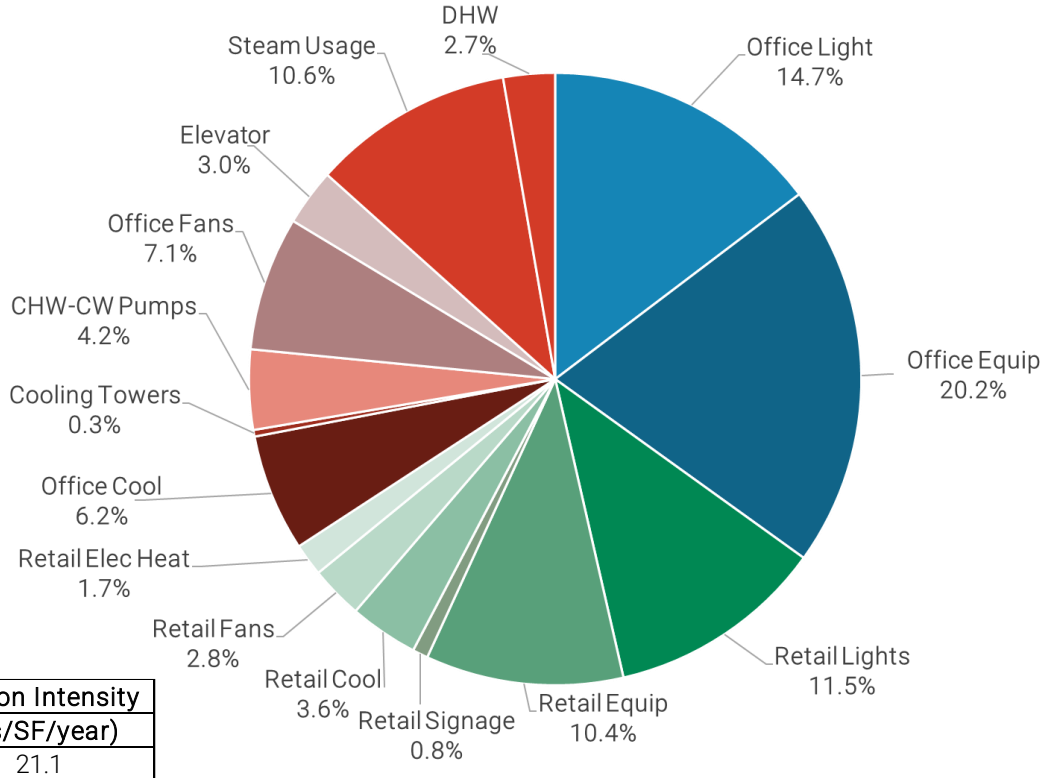
111 W 33rd St. Energy Model: 2019 CO_2e Emissions Breakdown

Analyzes major end-uses and highlight opportunities for improvement

- Retail Tenants accounts for ~31% of total CO_2e emissions (only 10% of square footage)
- Office Tenants account for ~35%
- Base Building accounts for ~34%
  - Steam Heating accounts for 10.6%
  - Distribution energy (pumps + fans) 11.3%



Space Type	Square Footage		Energy Intensity	Carbon Intensity
	SF	%	(kBtu/SF/year)	(lbs/SF/year)
Retail Tenants	88,151	11%	128.7	21.1
Office Tenants	718,266	89%	17.4	2.9
Space Heating	806,417		8.82	1.04

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111 W 33rd Street Case Study

Baseline Energy Modeling
ECM Phasing and Packaging
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ECM Packages - Recommended Package is CO_2 Mid

Four packages of ECMs were developed to optimize NPV and CO_2 reductions

1	2	3	4
			
CO_2 Light **No Electrification**	**CO_2 Mid** **Partial Electrification: AWHP on L18**	**CO_2 High** **Partial Electrification: AWHP on L18 + Retail**	**CO_2 Max** **Full Electrification: AWHP on L18 + Roof**
BMS integration & controls, CW & pumping optimizations, retail lighting improvements, tenant load improvements (lighting upgrades, plug load controls), electronic IU control valves	CO_2 Light + central plant optimization, infiltration mitigation, IT cooling improvements, ERVs, beneficial electrification via AWHPs on L18 & condensate recovery	CO_2 Mid + TX ERV, entry vestibules, partial electrification of retail, & PVs on L18 & roof	CO_2 High + increased capacity AWHPs for full load heating of office, replacement of induction units with FCUs, AHU improvements, regenerative drives for elevators, PVs on setbacks only

Carbon Reduction

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ECM Phases & Implementation Timeline: CO_2 Mid

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE											
Phase	**Tag**	**Short Name**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Phase 1	CO001	BMS Integration & ASHRAE Guideline 36	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CW002	Retrocommission Tenant Condenser Water Economizer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CW005	Pumping Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	CO003	Chiller Plant Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	EN001	Hoistway Smoke Vent Closure	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	LT003	Reduce Retail LPD	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 1	LT002	Reduce Retail Lighting Levels Overnight	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	EN002	Mitigate Lobby Infiltration	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 2	AS002	ERVs at AHUs	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 3	EL001	Partial Heating Electrification: Air-to-Water Heat Pumps on 18th Floor + Steam Improvements & Condensate Recovery	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Phase 4	CO002	Induction Unit Control Valves	14%	29%	43%	57%	71%	86%	100%	100%	100%	100%	100%	100%	100%
Phase 4	LT001	Lighting Upgrades & Controls	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 4	TL001	Plug Load Controls	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 4	TL002	IT Cooling Improvements	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%	100%	100%
Phase 5	EL005	Photovoltaics on L18 & Roof	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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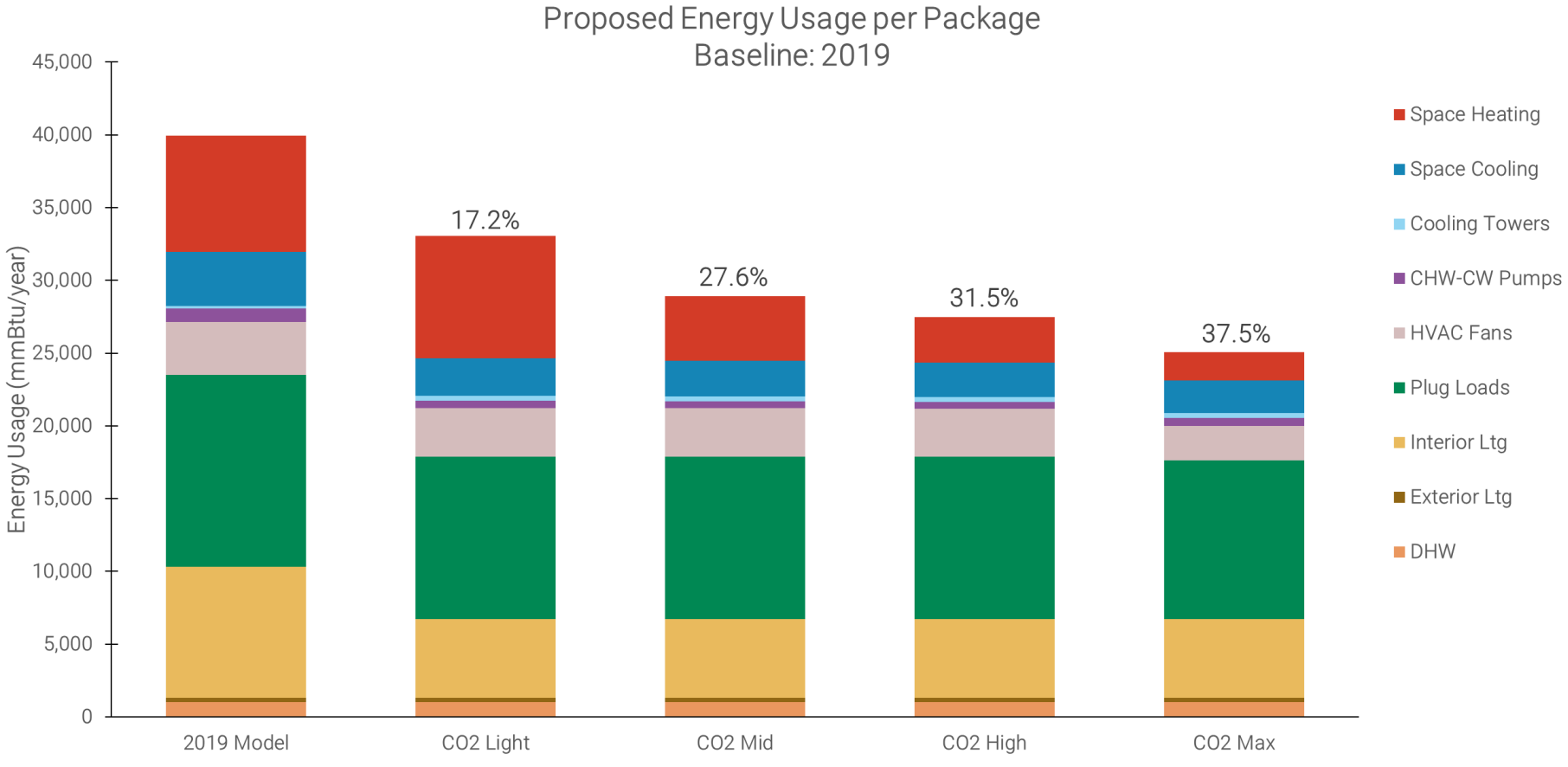
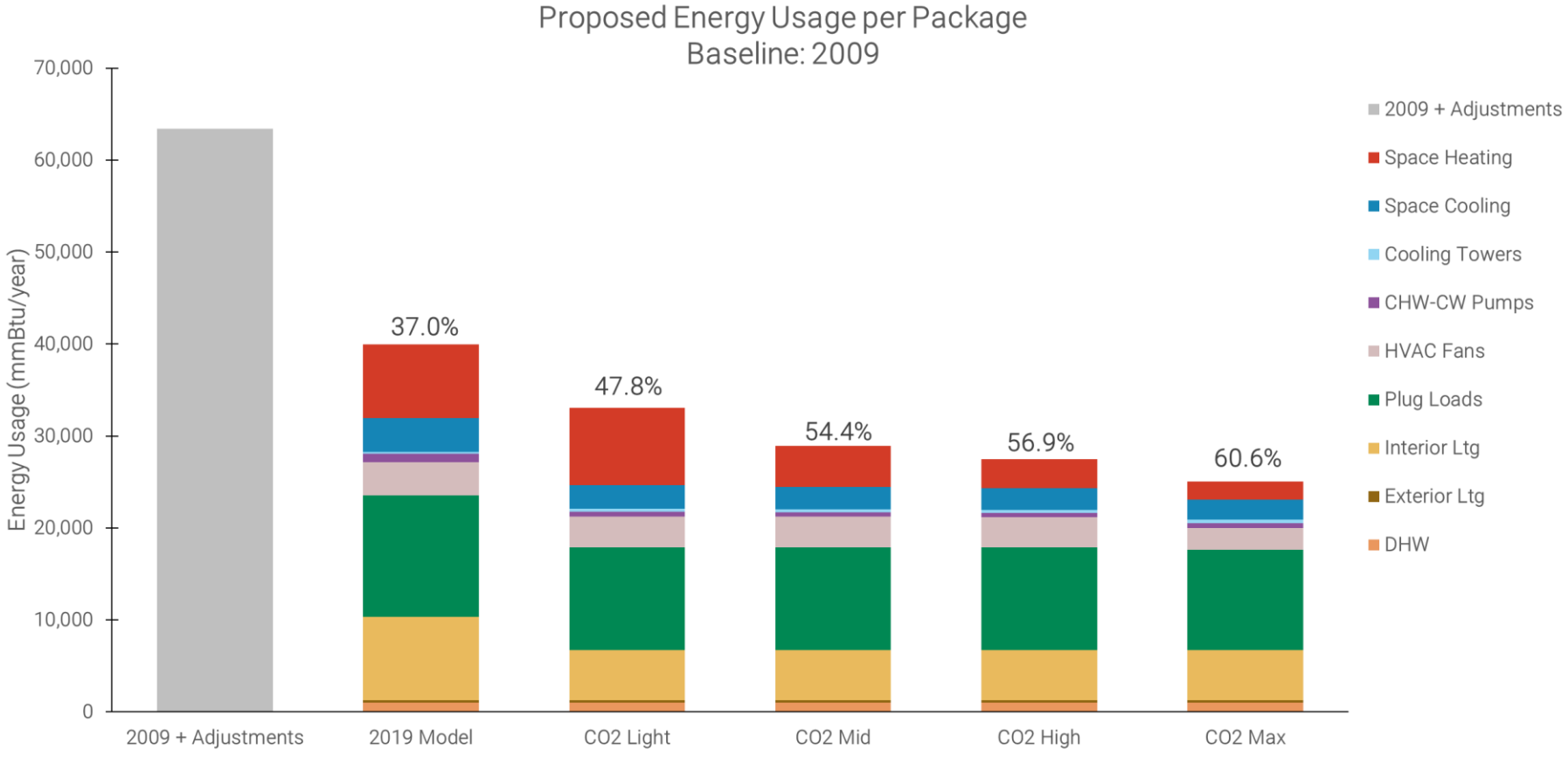
111 W 33rd St. ECM Package Comparison: Energy

Baseline: 2019

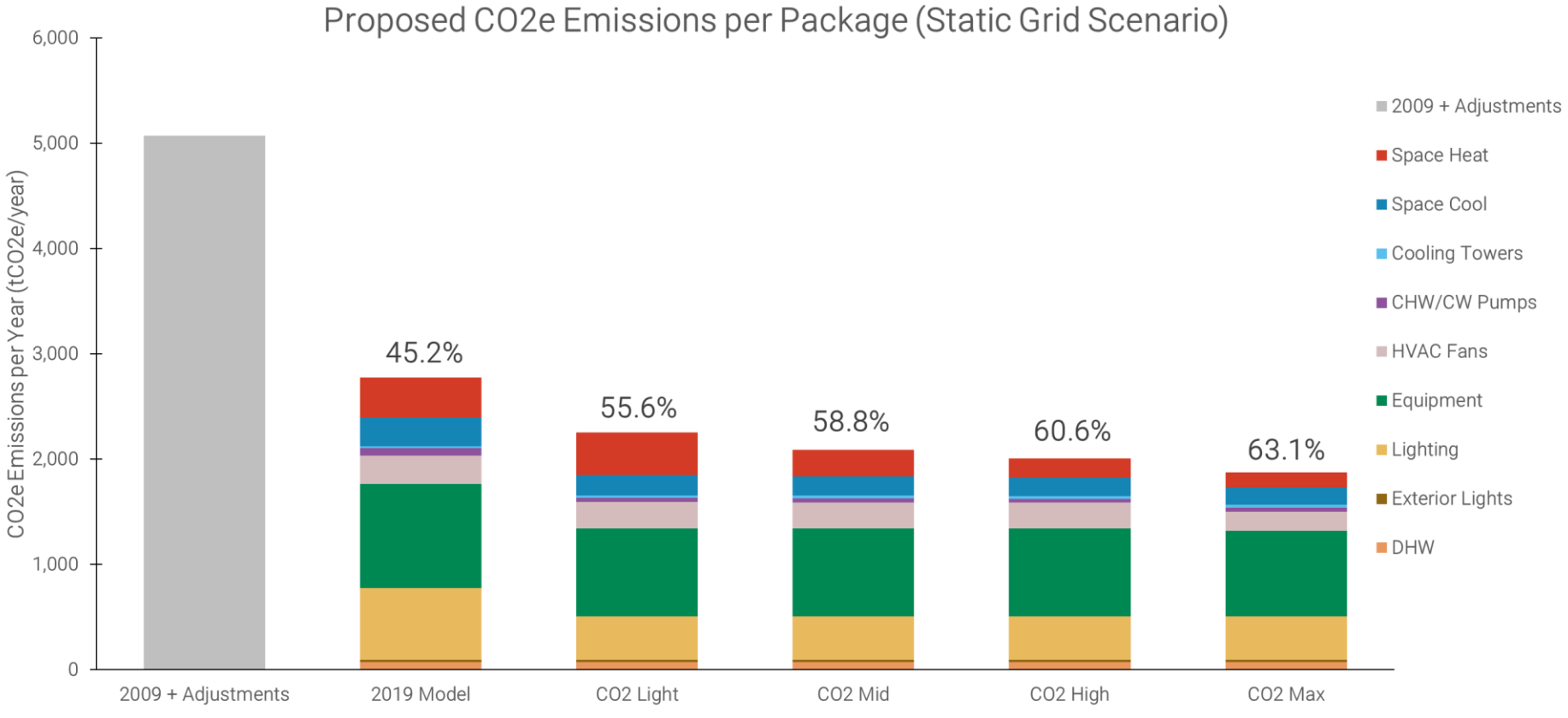


111 W 33rd St. ECM Package Comparison: Energy

Baseline: 2009

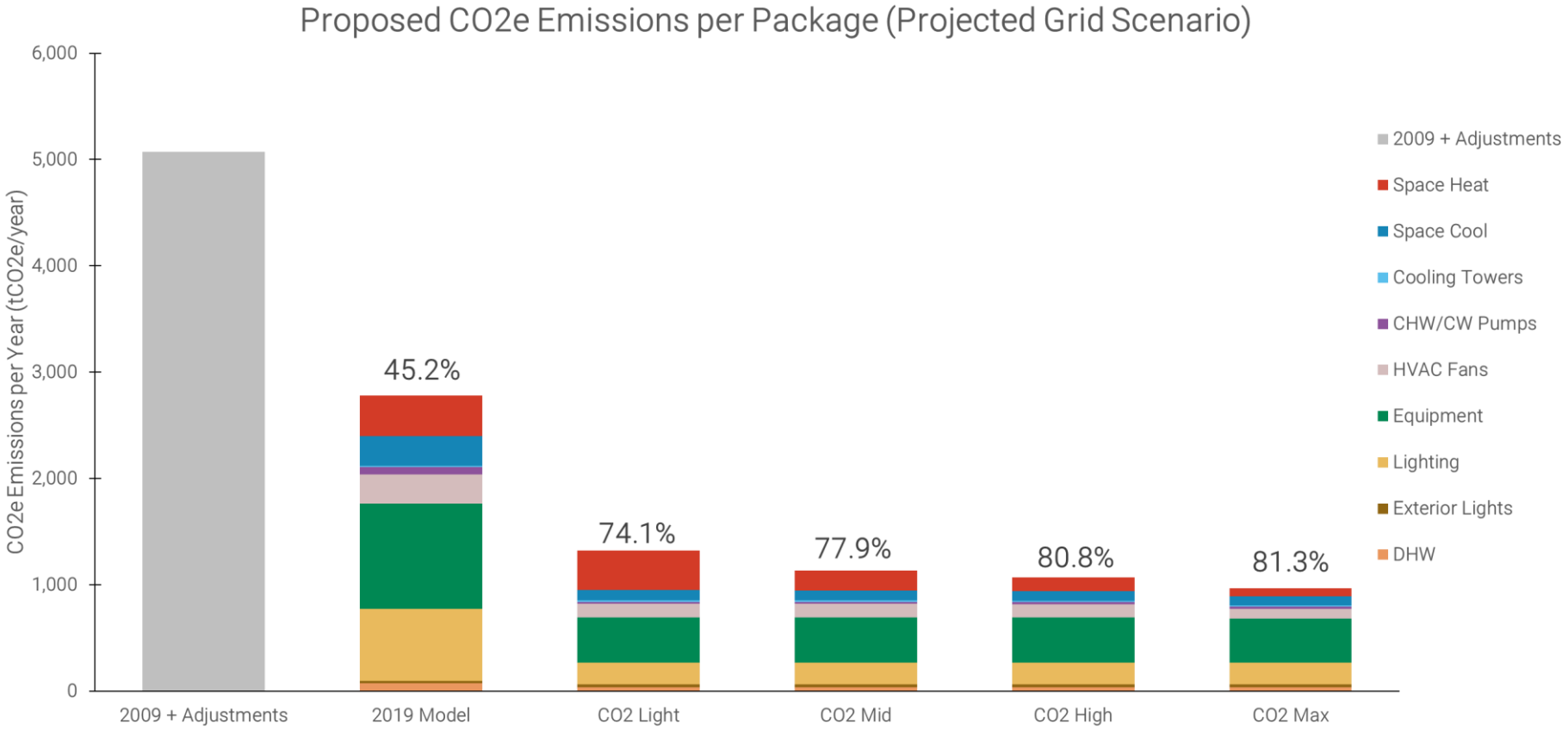


Projected CO_2 Emissions: Static 2019 Grid Scenario



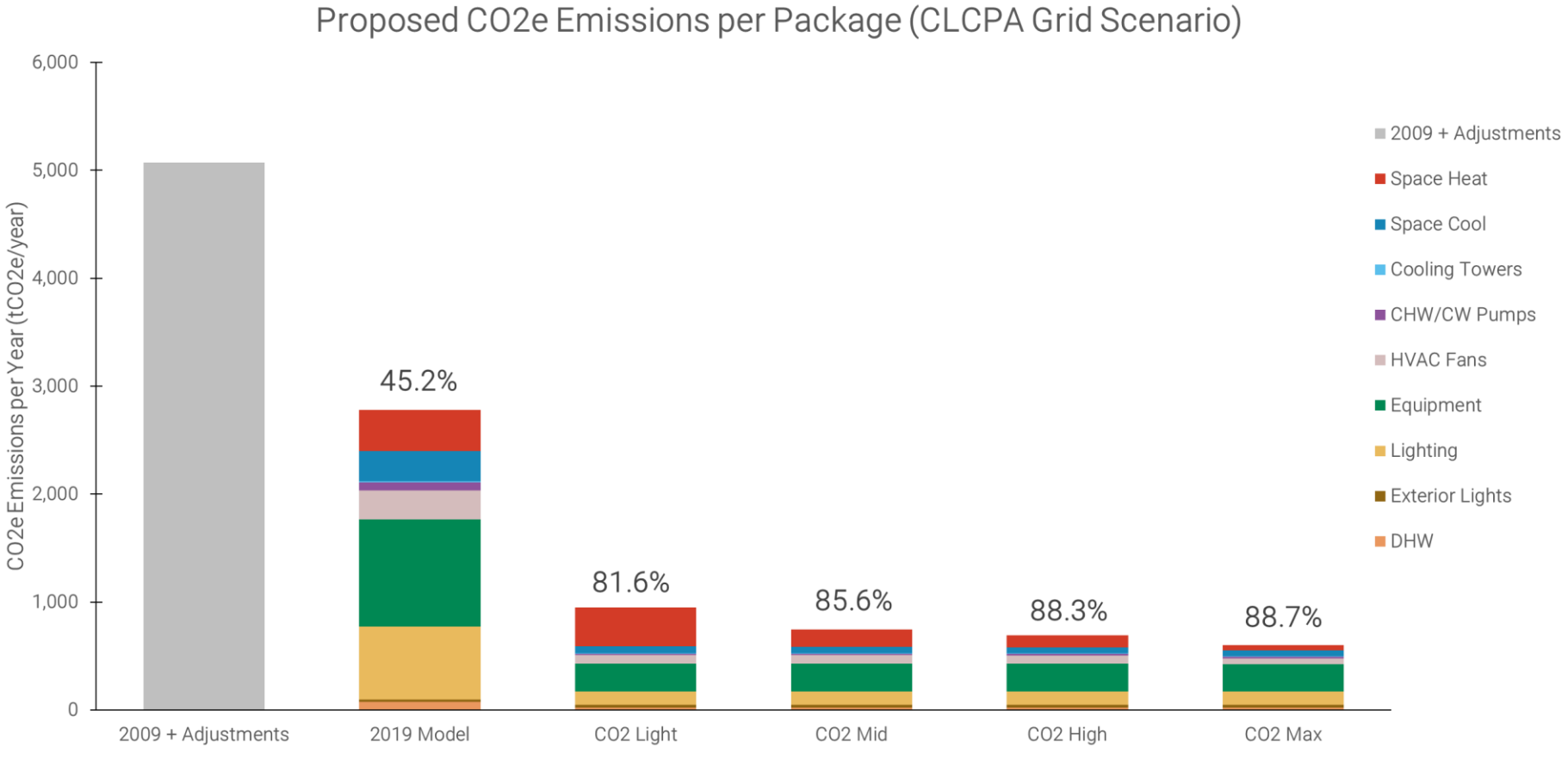
Projected CO_2 Emissions: Projected Grid Scenario

LL97 long term limit is 1,129 tCO_2e/year. All packages but CO_2 Light would meet this threshold



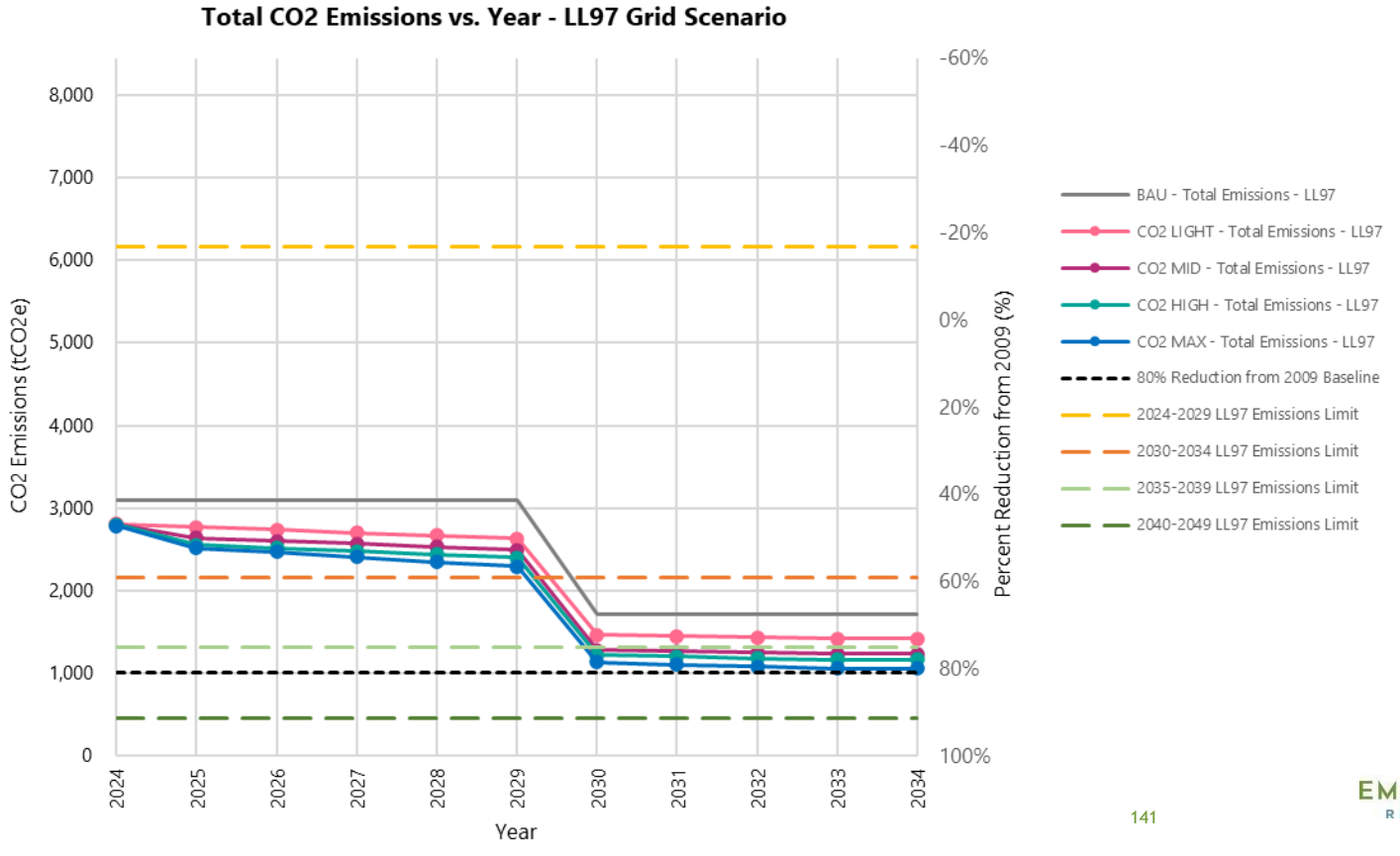
Projected CO_2 Emissions: CLCPA Grid Scenario

2035 LL97 Limit is 1,129 tCO_2e/year. All packages would meet this threshold.



Projected Annual Carbon Emissions – LL97 Compliance

Current 2019 baseline & all packages are below 2024 and 2030 LL97 emissions limits



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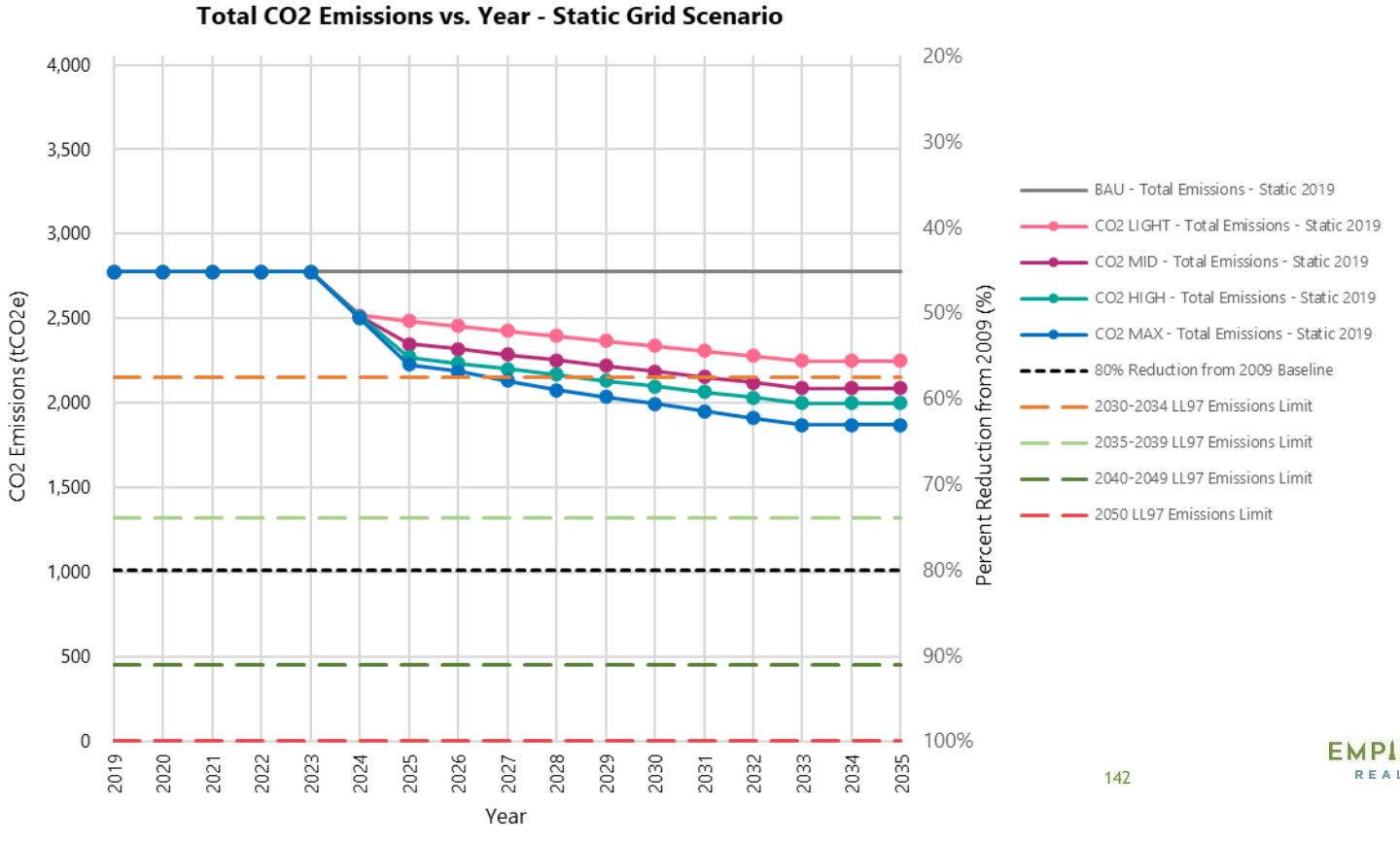
Projected Annual Carbon Emissions – Static 2019 Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization; CO_2 High and Max packages achieve 2030 LL97 compliance on time; CO_2 Mid complies by 2031



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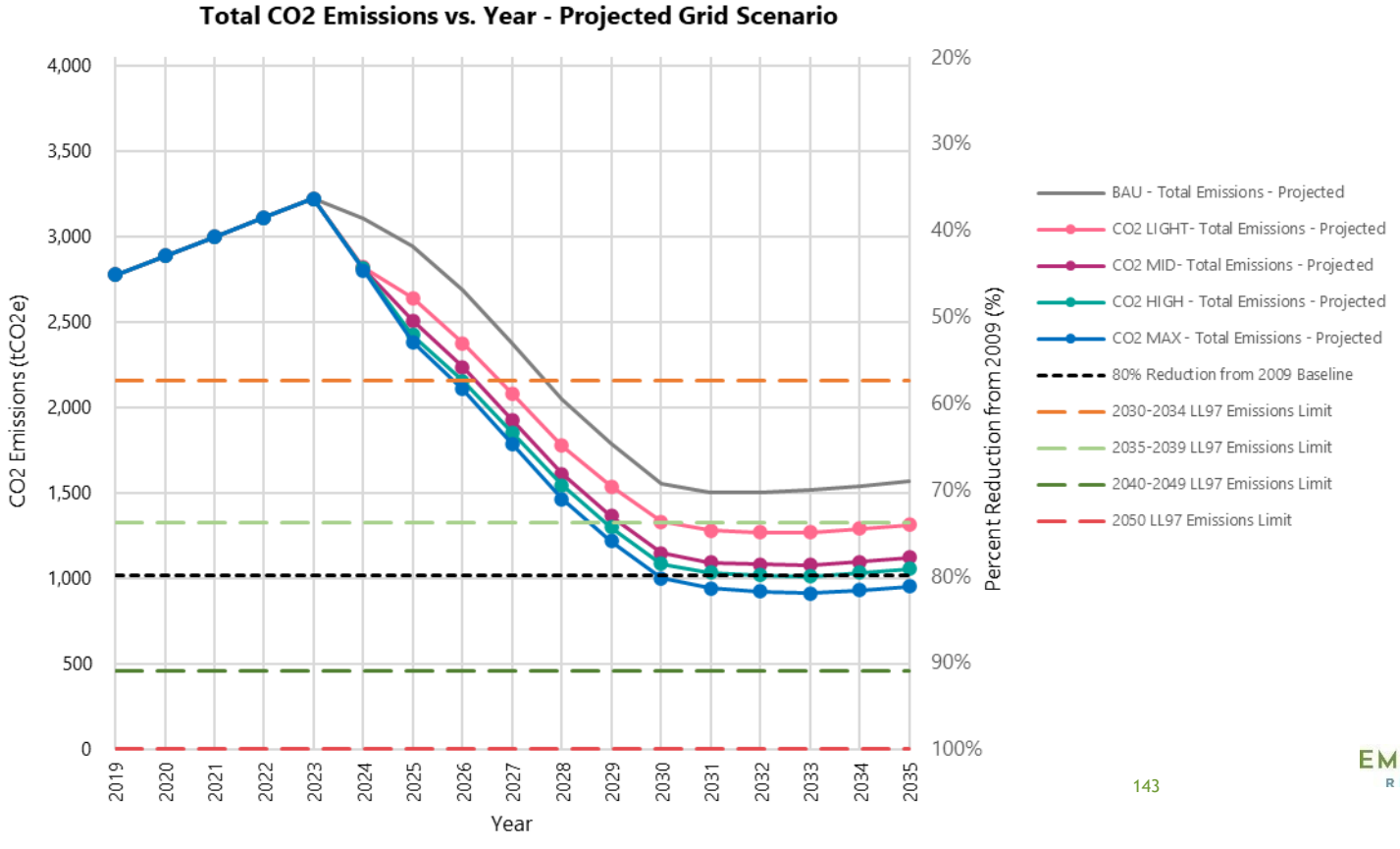
Projected Annual Carbon Emissions – Projected Grid Scenario

Only CO_2 Max package would meet 80% reduction from 2009 baseline by 2035;
All packages achieve 2035 LL97 compliance



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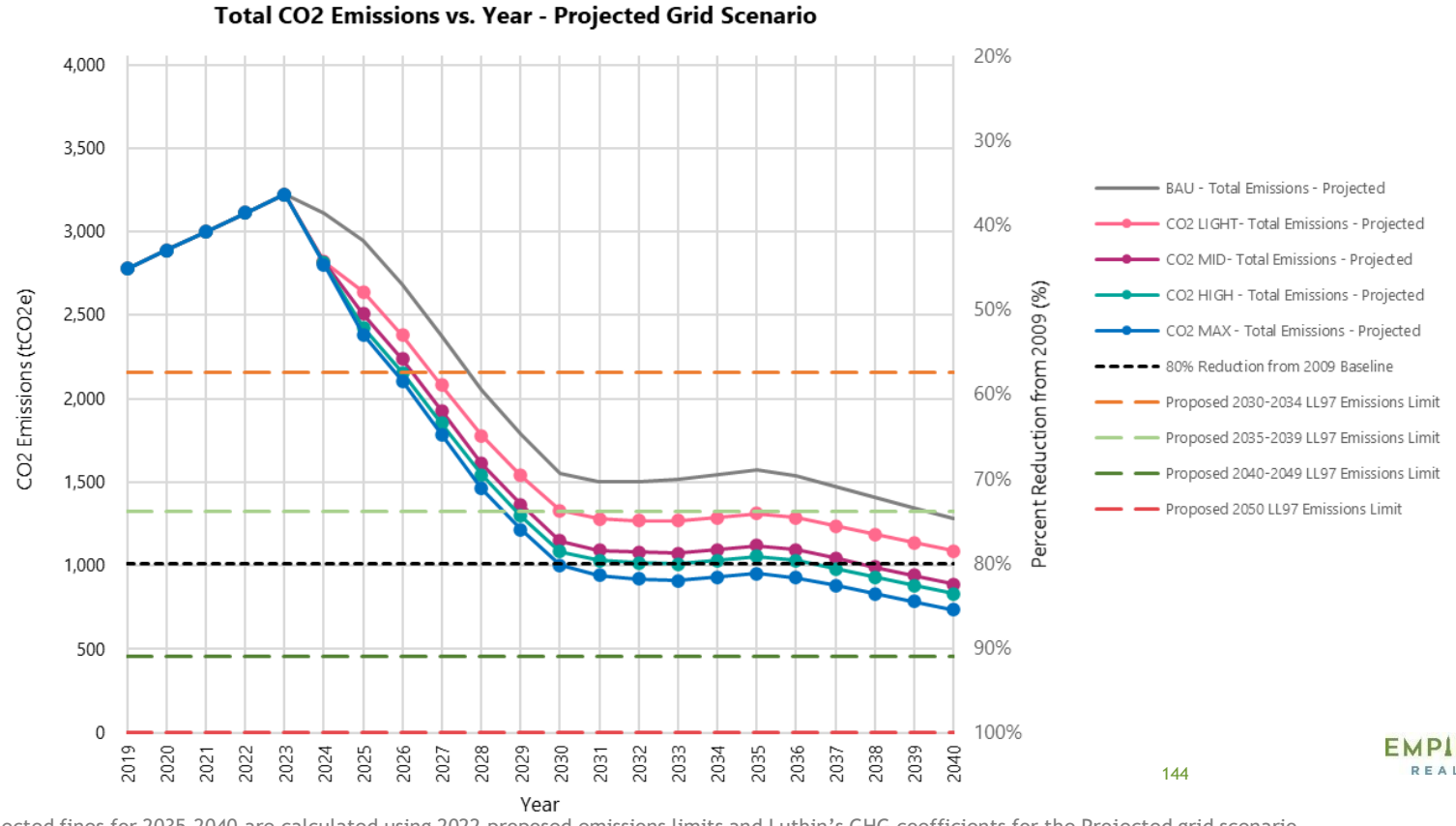
Carbon Emissions Extended to 2040 – Projected Grid Scenario

CO_2 Light package does not meet **80% reduction** from 2009 baseline by **2040;**
CO_2 Mid package meets **80% reduction** from 2009 baseline by **2038;** CO_2 High package meets **80% reduction** from 2009 baseline by **2037;**
Projected fines for CO_2 Light, Mid, High & Max from 2035-2040[1]: **$170,036 (Light), $116,814 (Mid), $100,906 (High), $75,490 (Max)**



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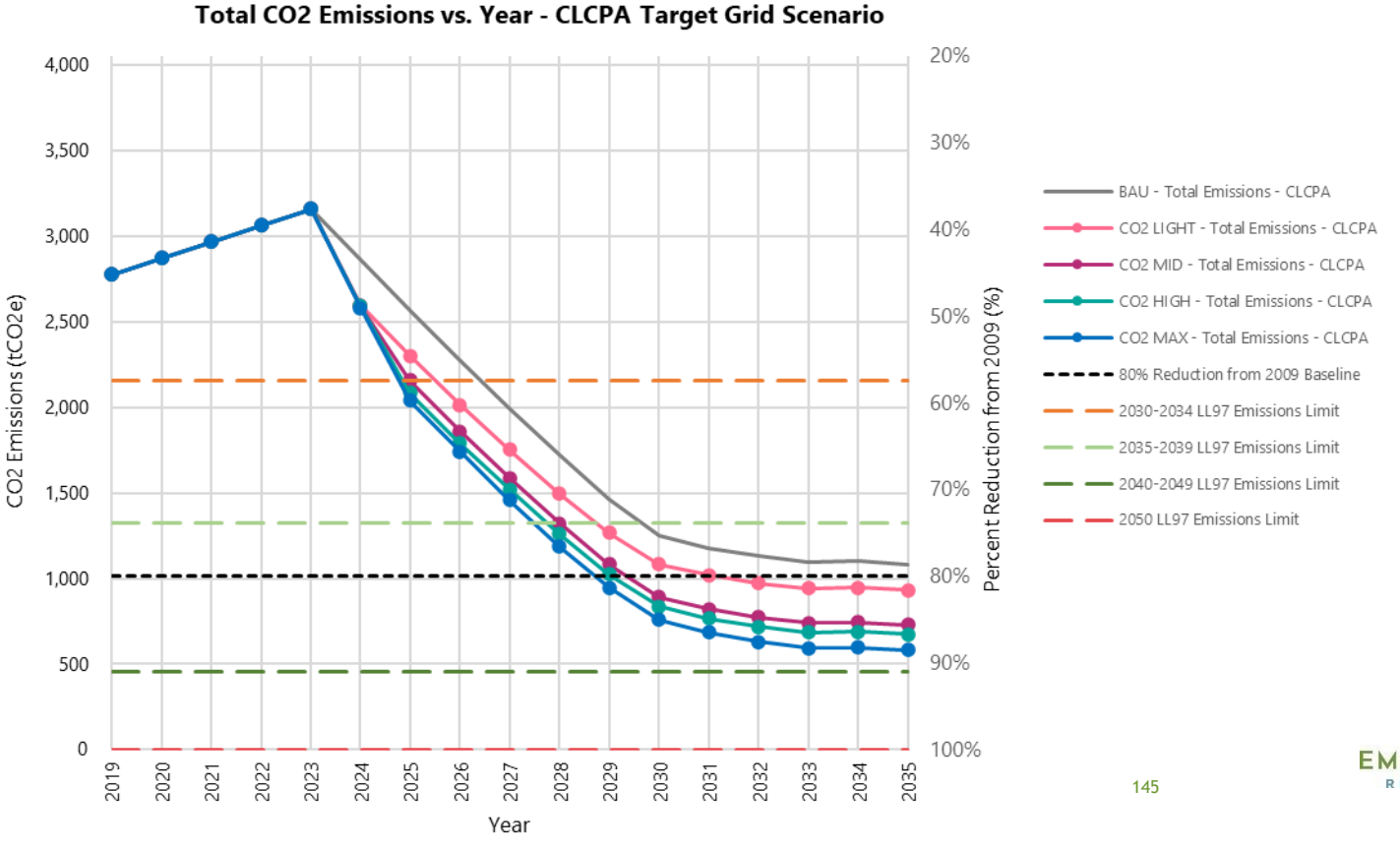
1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the Projected grid scenario

Projected Annual Carbon Emissions – CLCPA Grid Scenario

All packages would meet 80% reduction from 2009 baseline by 2035, but BAU does not;
All packages & BAU would meet 2035 LL97 compliance



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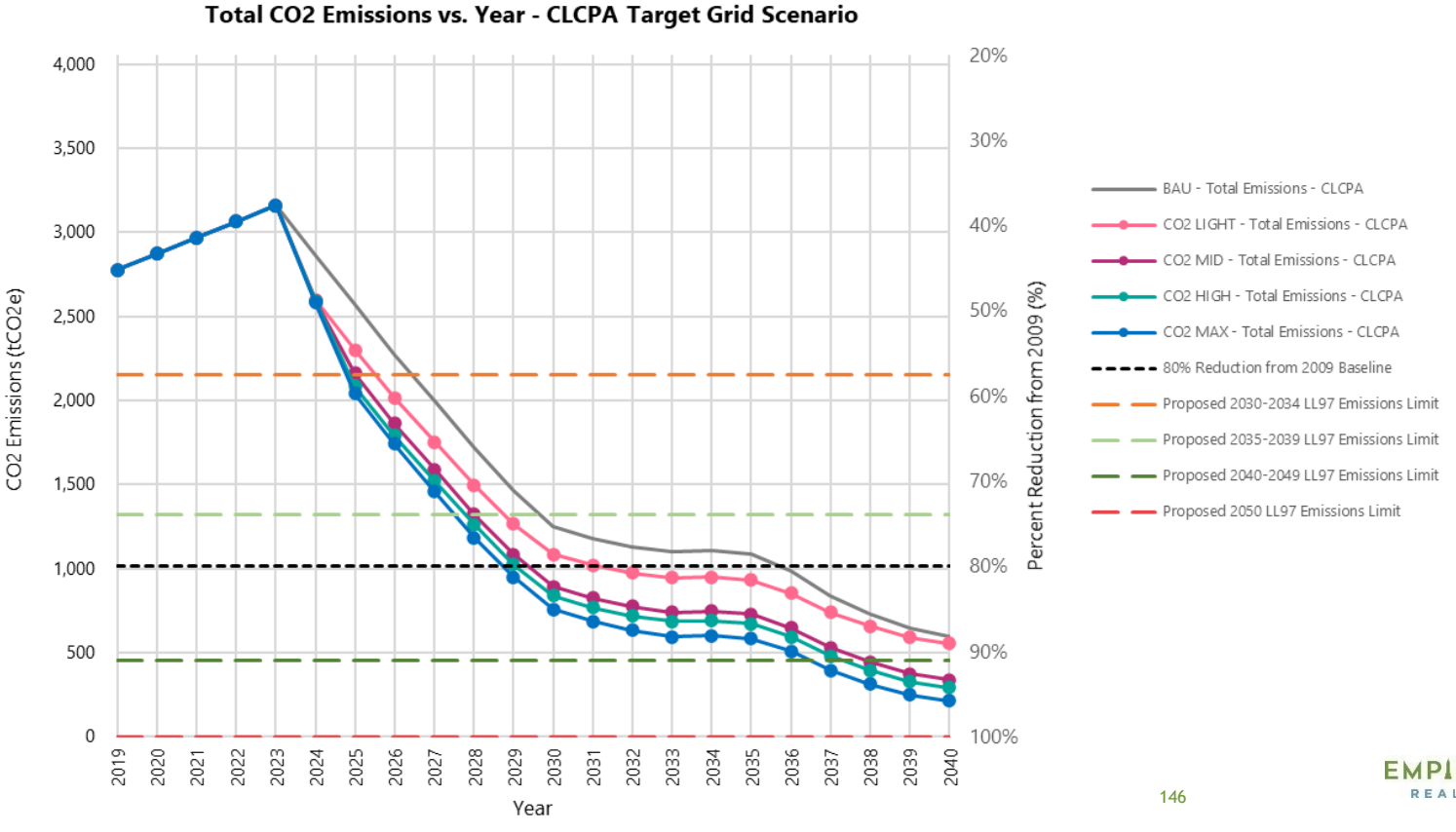
Carbon Emissions Extended to 2040 – CLCPA Grid Scenario

Projected fines for CO_2 Light, Mid, High, & Max from 2035-2040[1]: **$26,556 (Light)**



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1. Projected fines for 2035-2040 are calculated using 2022 proposed emissions limits and Luthin's GHG coefficients for the CLCPA grid scenario

Percent Carbon Emissions Reductions – All Grid Scenarios

80x35 target based on reductions from 2009 baseline
Reductions from 2019 baseline show impact of packages compared to current usage

STATIC GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-28.2%	-32.7%	**-60.7%**	**-63.1%**
CO2 HIGH	-24.4%	-28.0%	**-58.6%**	**-60.6%**
CO2 MID	-21.3%	-24.8%	**-56.9%**	**-58.8%**
CO2 LIGHT	-15.8%	-19.0%	**-53.9%**	**-55.6%**

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization; CO_2 High and Max packages achieve 2030 LL97 compliance on time; CO_2 Mid complies by 2031

PROJECTED GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-63.9%	-65.6%	**-80.2%**	**-81.2%**
CO2 HIGH	-60.9%	-62.0%	**-78.6%**	**-79.2%**
CO2 MID	-58.7%	-59.6%	**-77.4%**	**-77.9%**
CO2 LIGHT	-52.0%	-52.7%	**-73.7%**	**-74.1%**

Only CO_2 Max package would meet 80% reduction from 2009 baseline by 2035;
All packages achieve 2035 LL97 compliance

CLCPA TARGET GRID SCENARIO

	2019 - 2030	2019 - 2035	**2009 - 2030**	**2009 - 2035**
CO2 MAX	-72.7%	-79.0%	**-85.1%**	**-88.5%**
CO2 HIGH	-69.9%	-75.8%	**-83.5%**	**-86.7%**
CO2 MID	-67.9%	-73.8%	**-82.4%**	**-85.6%**
CO2 LIGHT	-61.0%	-66.4%	**-78.6%**	**-81.6%**

All packages would meet 80% reduction from 2009 baseline by 2035, but BAU does not;
All packages & BAU would meet 2035 LL97 compliance

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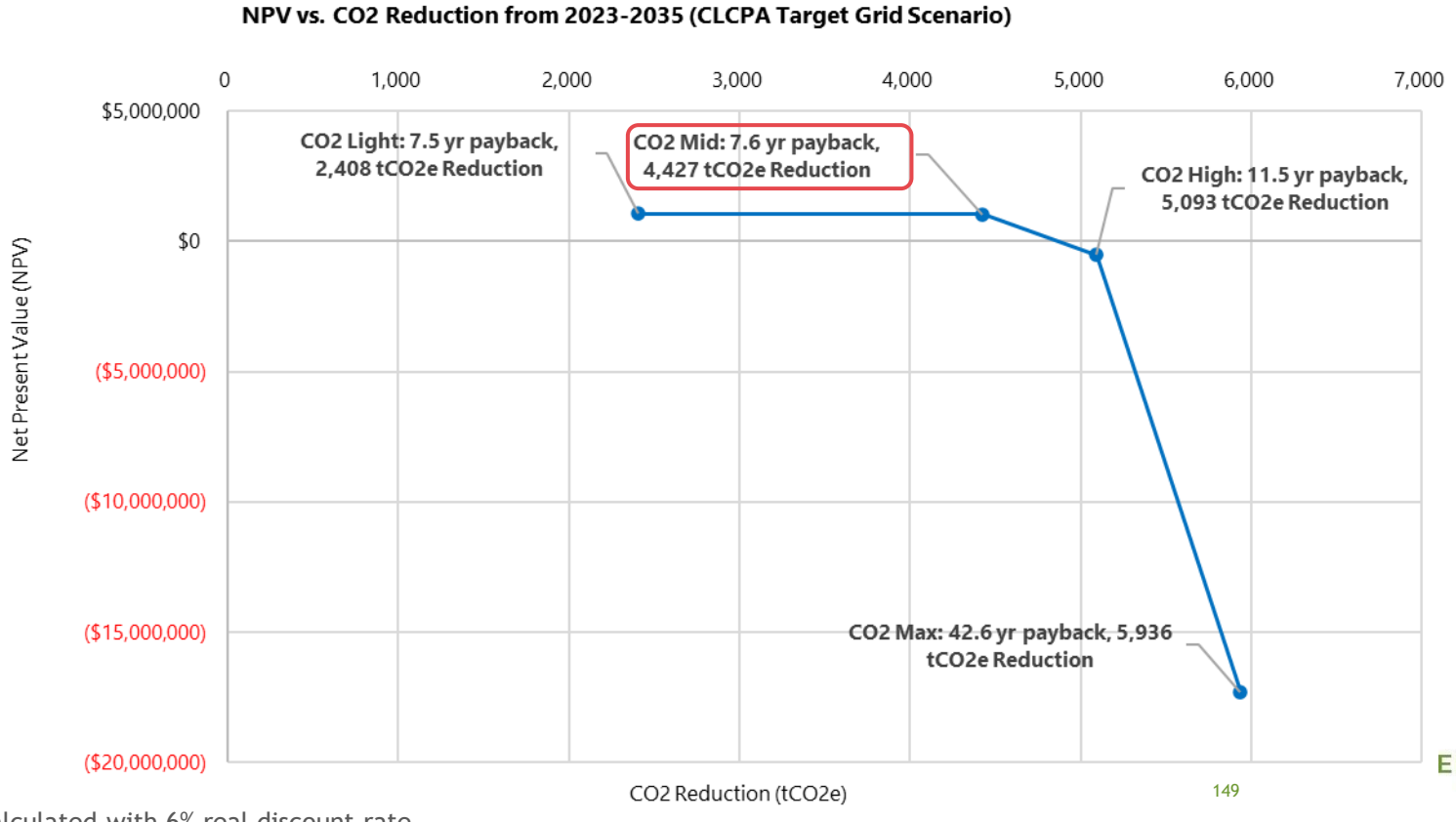
NPV, CO_2 Reductions and Simple Payback for all Packages

Net Present Value for 2023-2035; CO_2 reduction based on CLCPA scenario



NPV calculated with 6% real discount rate

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Projected LL97 Fines From 2024-2034

No LL97 fines projected for the baseline for 2024-2029 or 2030-2034

Packages	LL97 Fines From 2024-2034					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034	Total Fine From 2024-2029[3]	Total Fine From 2030-2034[4]	Fine Avoidance From 2024-2034
BAU (2019 Baseline)	$0	$0	-	$0	$0	-
CO_2 Light	$0	$0	$0	$0	$0	$0
CO_2 Mid	$0	$0	$0	$0	$0	$0
CO_2 High	$0	$0	$0	$0	$0	$0
CO_2 Max	$0	$0	$0	$0	$0	$0

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2024-2029 are based on GHG coefficients provided in LL97 of 2019.
4. Fine calculations for 2030-2034 are based on additional GHG coefficients provided in the proposed rules for LL97 released Oct. 2022.

Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario

Fines projected for baseline and CO_2 Light under currently published LL97 limits, though all packages offset most if not all the fines;
Fines possible from 2035-2049 for baseline and all packages if 2022 emissions limits are approved, though CO_2 Mid, High & Max offset most of the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on Projected Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$532,738	-	$0	$1,852,494	-	$263,260
CO_2 Light	$139,214	$393,524	$0	$1,254,261	$598,234	$228,522
CO_2 Mid	$0	$532,738	$0	$707,764	$1,144,731	$173,275
CO_2 High	$0	$532,738	$0	$560,761	$1,291,733	$159,079
CO_2 Max	$0	$532,738	$0	$319,676	$1,532,819	$135,517

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario

No fines projected for the baseline or packages under currently published LL97 limits.
Fines possible from 2035-2049 for baseline and CO_2 Light if 2022 emissions limits are approved; CO_2 Mid, High, & Max offset all the potential fines.

Packages	Projected LL97 Fines From 2035-2050 Based on CLCPA Grid Scenario					
	LL97 of 2019 Emissions Limits[1]			2022 Proposed Emissions Limits[2]		
	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]	Total Fine From 2035-2049[3]	Fine Avoidance From 2035-2049	Annual Fine From 2050 Onward[3]
BAU (2019 Baseline)	$0	-	$0	$106,721	-	$122,431
CO_2 Light	$0	$0	$0	$63,308	$43,413	$118,851
CO_2 Mid	$0	$0	$0	$0	$106,721	$60,092
CO_2 High	$0	$0	$0	$0	$106,721	$48,866
CO_2 Max	$0	$0	$0	$0	$106,721	$28,518

1. LL97 of 2019 emissions limits are calculated using the building emissions intensity limits provided in LL97 of 2019, which are based on occupancy group classifications, and the average building emissions limit expected to be enacted by 2050 (0.0014 $tCO_2e/SF/yr$).
2. 2022 proposed emissions limits are calculated using the building emissions factors provided in the proposed rules for LL97 released Oct. 2022, which are based on Energy Star property types.
3. Fine calculations for 2035-2049 and from 2050 onward are based on Luthin's GHG coefficients for the CLCPA grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

Financial & Carbon Summary - Recommended Package is CO_2 Mid

Meets 80x35 Target (CLCPA Grid, Y/N)	CO_2 Light (Y)	CO_2 Mid (Y)	CO_2 High (Y)	CO_2 Max (Y)
Carbon Emissions in 2035 (CLCPA Grid)	932	22% decrease → 728	673	583
NPV (2023-2035)[1]	$1,071,139	$1,043,020	($521,199)	($17,271,850)
NPV (Asset Life)[1]	$2,244,308	$2,765,979	$1,261,539	($17,995,341)
Base Capital Cost[2]	($3,015,512)	($4,515,512)	($4,515,512)	($5,798,355)
Incremental Capital Cost[2]	($3,088,293)	($4,563,915)	($7,252,984)	($30,691,072)
Annual Energy Cost Savings[2]	$316,435	50% increase → $474,641	$534,765	$648,425
Annual Repairs & Maintenance Savings	$650	($1,750)	($4,750)	$36,019
Incentives	$703,954	$987,484	$1,164,943	$1,500,503
Simple Payback	7.5	7.6	11.5	42.6

CO_2 Light Reduction – BMS integration & controls, CW & pumping optimizations, retail lighting improvements, tenant load improvements (lighting upgrades, plug load controls), electronic IU control valves
CO_2 Mid Reduction CO_2 Light + central plant optimization, infiltration mitigation, IT cooling improvements, ERVs, beneficial electrification via AWHPs on L18 & condensate recovery
CO_2 High Reduction – CO_2 Mid + TX ERV, entry vestibules, partial electrification of retail, & PVs on L18 & roof
CO_2 Max Reduction – CO_2 High + increased capacity AWHPs for full load heating of office, replacement of induction units with FCUs, AHU improvements, regenerative drives for elevators, PVs on setbacks only

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.

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Financial Breakdown - Recommended Package is CO_2 Mid

	CO_2 Light	CO_2 Mid	CO_2 High	CO_2 Max
NPV (2023-2035)[1]	$1,071,139	$1,043,020	($521,199)	($17,271,850)
NPV (Asset Life)[1]	$2,244,308	$2,765,979	$1,261,539	($17,995,341)
Base Capital Cost[2]	($3,015,512)	($4,515,512)	($4,515,512)	($5,798,355)
➢ Base Building Infrastructure	$0	($1,500,000)	($1,500,000)	($2,782,843)
➢ Tenant Fitout HVAC[3]	($3,015,512)	($3,015,512)	($3,015,512)	($3,015,512)
Incremental Capital Cost[2]	($3,088,293)	($4,563,915)	($7,252,984)	($30,691,072)
Annual Energy Cost Savings[2]	$316,435	$474,641	$534,765	$648,425
Annual Repairs & Maintenance Savings	$650	($1,750)	($4,750)	$36,019
Incentives	$703,954	$987,484	$1,164,943	$1,500,503
Simple Payback	7.5	7.6	11.5	42.6

Notes:
1. NPV calculated with 6% real discount rate
2. Base and incremental capital costs listed are based on current cost estimates and excludes future construction escalation costs. Annual energy cost savings listed are based on current 2022 estimates and exclude benefit from future utility cost escalations.
3. Tenant fitout HVAC base capital costs include cost of electronic induction unit control valves, code minimum plug load controls, and planned CapEx for LL88 lighting upgrades

Recommended Package – CO_2 Mid

- Installation of 275-ton air-to-water heat pump (AWHP) capacity on level 18 setback partially electrifies space heating for office tenants in a cost-effective manner and provides redundancy for the central cooling plant
  - Provides low risk, cost-effective opportunity to test a heat pump installation with immediate benefit. Near term installation would benefit from opportunity to claim Clean Heat incentive from Con Ed (~10% of CapEx)
  - Existing chilled water piping system is converted operationally to a dual temperature changeover system to minimize new piping costs; in the winter AWHPs generate heating hot water to be used at existing AHU heating coils/perimeter induction loop
  - Installation of ~25% of the peak heating capacity provides over 75% of the available energy and carbon savings associated with electrification of the office tenant spaces
  - AWHP installation provides redundancy roughly equivalent to one of the SMARDT chiller compressors
- Although excluded from the recommended package to save on first costs, it is recommended that the retail tenants be engaged to consider the heating electrification retrofits in CO_2 High. These minimally disruptive alterations to existing retail systems in Target and Footlocker would partially electrify space heating by recovering heat from tenant condenser water loop saving cooling tower fan energy
  - Target has heat pumps installed already for cooling that can be utilized for heating as well in lieu of steam by reprogramming controls
  - Footlocker has chilled water FCUs with electric heating coils that can be strategically converted to heat pumps with economizer coils in exterior zones
- Photovoltaic installations on level 18 setback and roof should be explored further with a PV installer to further evaluate cost, financing options, incentives, and tax rebates available; PV installation may qualify for federal solar tax credits provided by the IRA

111 W 33rd Street Case Study

Baseline Energy Modeling
ECM Phasing and Packaging
Energy and Carbon Emissions Results
Financial Analysis, LL97 Fines, and Recommendations
Capital Expenditure and 2023 Budget

Annual Incremental Capital Cost per Package

Most of the capital expenditure occurs in the first 2 years to cover base building projects like controls optimizations, ERVs, and heating electrification (CO_2 Light – Max)

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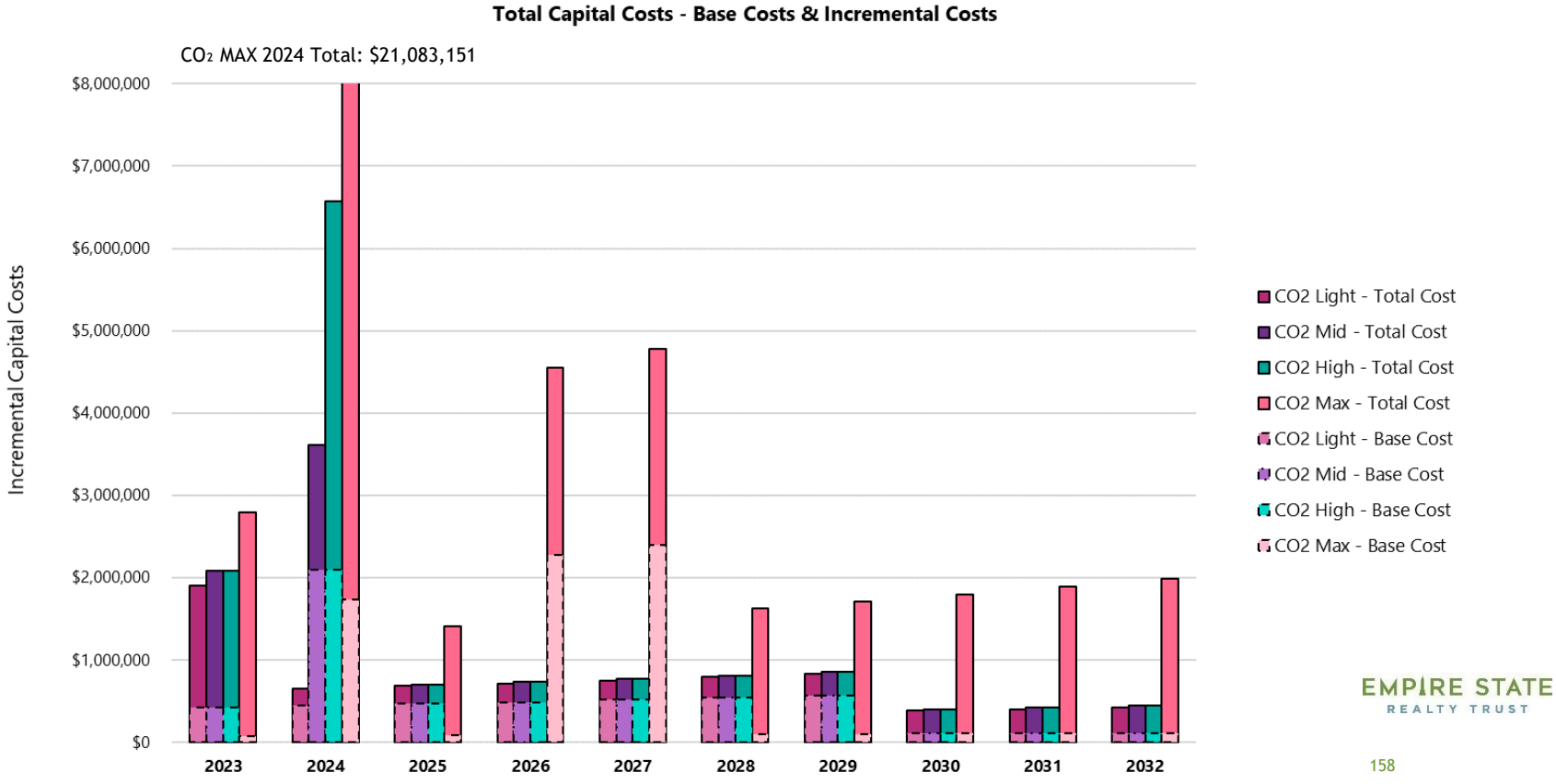
Annual Incremental Capital Cost vs. Base Cost per Package

Base costs include planned replacement of steam chiller, induction unit control valve upgrades, planned LL88 lighting upgrades, code minimum plug load controls, & planned elevator modernization



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111 W 33rd Street Next Steps – 2023 Projects

The recommended 2023 measures are focused on controls & lighting measures that have a combined payback of ~5.7 yrs & design of major 2024 projects

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
BMS Integration & ASHRAE Guideline 36	$1,011,255	$303,377	$707,879	$58,217
Retrocommission Tenant Condenser Water Economizer	$97,940	$28,697	$69,244	$9,946
Pumping Optimization	$87,283	$54,988	$32,295	$33,314
Chiller Plant Optimization	$167,818	$50,345	$117,472	$1,166
Hoistway Smoke Vent Closure	$12,922	$8,141	$4,781	$7,483
Reduce Retail LPD	$62,190	$0	$62,190	$25,435
Reduce Retail Lighting Levels Overnight	$9,061	$0	$9,061	$39,669
Design of Heat Pumps, Condensate Recovery & ERVs	$225,731	NA	$225,731	NA
Total LL97 Budget	$1,674,201	$445,547	$1,228,653	$175,230

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Lessons Learned

Summary of Building Carbon Reduction Recommendations

- **OGCP**
  - Change out AC systems with VRF at every TI renovation up to floor 47 to stay on track with 2035 emissions targets without capex impact compared to replacements in kind
  - Methodically address sources of air leakage in the building to reduce heating load, including building entrances.
  - Change core bathroom water heating to electric as bathrooms are updated to eliminate summer steam usage.
  - Leverage replacement of aging corridor chiller to provide efficient heating to floors 48-55
  - Ensure that necessary elevator modernization isn't delayed; install regenerative drives
- **1400**
  - Transition away from water cooled systems to VRF. Upper floor condensing units can be roof mounted to preserve views. Lower floor condensing units can be located at windows with less desirable views.
  - Heating electrification is key to meeting 2035 targets. Existing leases extending past 2035 will impede retrofit of significant portions of the building prior to 2035 meaning every available opportunity must be taken
  - Immediately address uncontrolled heating at radiators and simultaneous heating and cooling through controls improvements.

Summary of Building Carbon Reduction Recommendations (Continued)

- **501**
  - Take advantage of available MER space to bring immediate reduction in cooling and heating consumption through ERV installations
  - Install heat pumps to use waste heat in the condenser water system to heat floors 3 and 4 as spaces turn or at the time of consolidation into full floor or half floor leases.
  - Coordinate disconnected tenant and landlord BMS to provide more energy efficient control
- **111 W 33rd Street**
  - Make targeted central plant and controls updates which take advantage of inherent efficiency of existing distribution design and MER space
  - Installation of 275-ton air-to-water heat pump (AWHP) capacity on level 18 setback partially electrifies space heating for office tenants in a cost-effective manner and provides redundancy for the central cooling plant
  - Consider engaging retail tenants to make targeted changes to the control of Target's heating systems and make a quick swap of a few of Foot Locker's AC units to achieve partial electrification and enable significant carbon emissions reductions.

Carbon Emissions Reductions Across the Portfolio

Overall carbon emissions reduction for the portfolio is 85.2% with the CLCPA grid and 79.1% with the projected grid

Building	Recommended Package	Baseline Emissions (tCO_2e)[1]	2035 Emissions - CLCPA Grid[2] (tCO_2e)	2035 Emissions - Projected Grid[2] (tCO_2e)	Emissions Reduction - CLCPA Grid (%)	Emissions Reduction - Projected Grid (%)
Empire State Building	CO_2 Mid	34,171	3,986	5,766	88.3%	83.1%
250 W 57th Street	CO_2 Mid	3,846	586	872	84.8%	77.3%
1350 Broadway	CO_2 Mid	2,173	484	682	77.7%	68.6%
1359 Broadway	CO_2 Mid	3,367	508	763	84.9%	77.3%
1333 Broadway	CO_2 High-VRF	2,282	413	594	81.9%	74.0%
111 W 33rd Street	CO_2 Mid	5,070	728	1,121	85.6%	77.9%
One Grand Central Place	CO_2 High	6,474	1,232	1,627	81.0%	74.9%
501 7th Avenue	CO_2 Mid	3,039	732	956	75.9%	68.6%
1400 Broadway	CO_2 High	6,631	1,230	1,636	81.4%	75.3%
		67,053	**9,898**	**14,017**	**85.2%**	**79.1%**

Notes:

1. Baseline emissions are based on 2007 utility bills and grid coefficients for the Empire State Building and 2009 utility bills and grid coefficients for all other buildings in the portfolio.
2. Projected emissions for 2035 are based on GHG coefficients published in LL97 for natural gas and steam, and Luthin's GHG coefficients for the CLCPA grid scenario and the Projected grid scenario, since GHG coefficients for the electrical grid have not yet been published by the City for these years.

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Lessons Learned

- Planned CapEx provides an opportunity for improvements, 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.
    - OGCP VRF installation
    - OGCP AWHP installation/corridor chiller needs
    - 111 AWHP installation/chiller resiliency needs
  - Carbon and energy efficiency improvements will be strategically timed to optimize unit service life and meet carbon targets by 2035
    - Water-cooled AHUs at 501 7th Ave which are in good condition will be retained through their useful life
- Steam heating distribution is linked with higher carbon emissions across the portfolio
  - Steam heat: 250 W 57, OGCP, 1400 Broadway, 501 7th Ave, ESB
  - Hot water heat: 111 W 33, Westchester and Connecticut properties
- Tenant-installed water-cooled systems without modulating control prevent central systems from reducing flow at part load, wasting energy. Improved water flow control for these systems is an immediate opportunity for savings.
  - Examples include tenant systems in 1400 Broadway and the ESB retail loop
- 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 will delay achievement of carbon targets
  - Consider long-term ROI and operational consequences of first-cost decisions on all projects. Small decisions add up to big impact.

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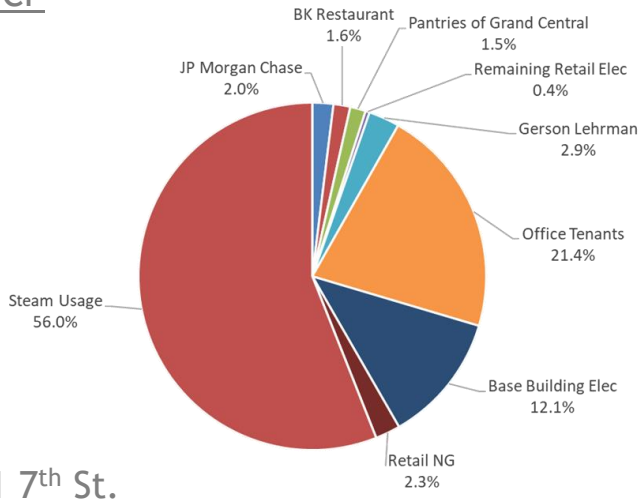
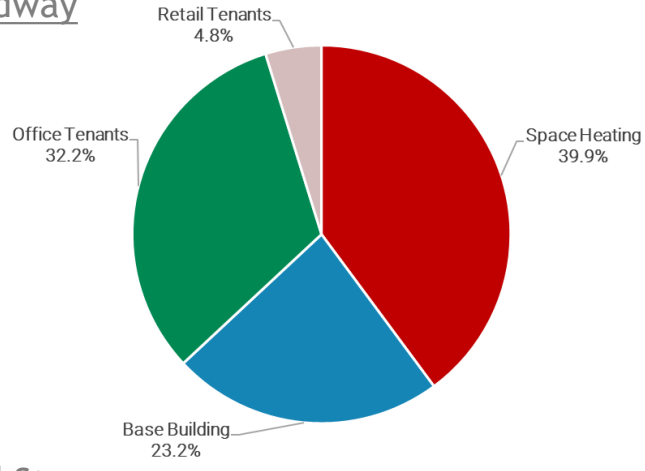
Energy Breakdown by Major End Users - All Buildings

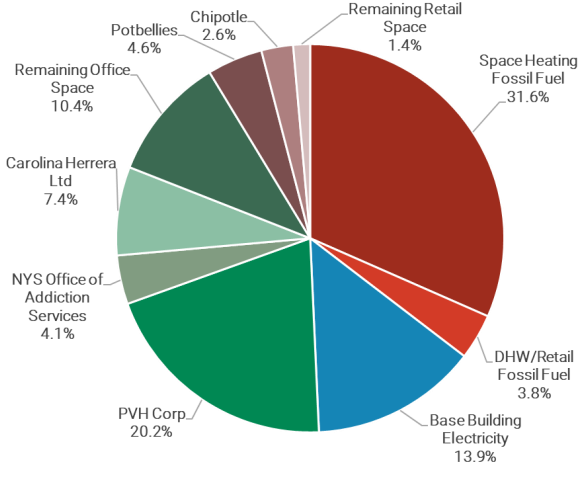
OGCP



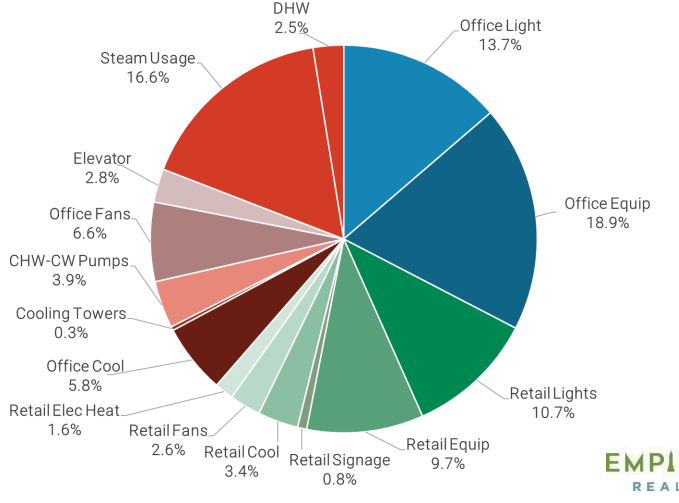
1400 Broadway



501 7th St.



111 W 33rd St.



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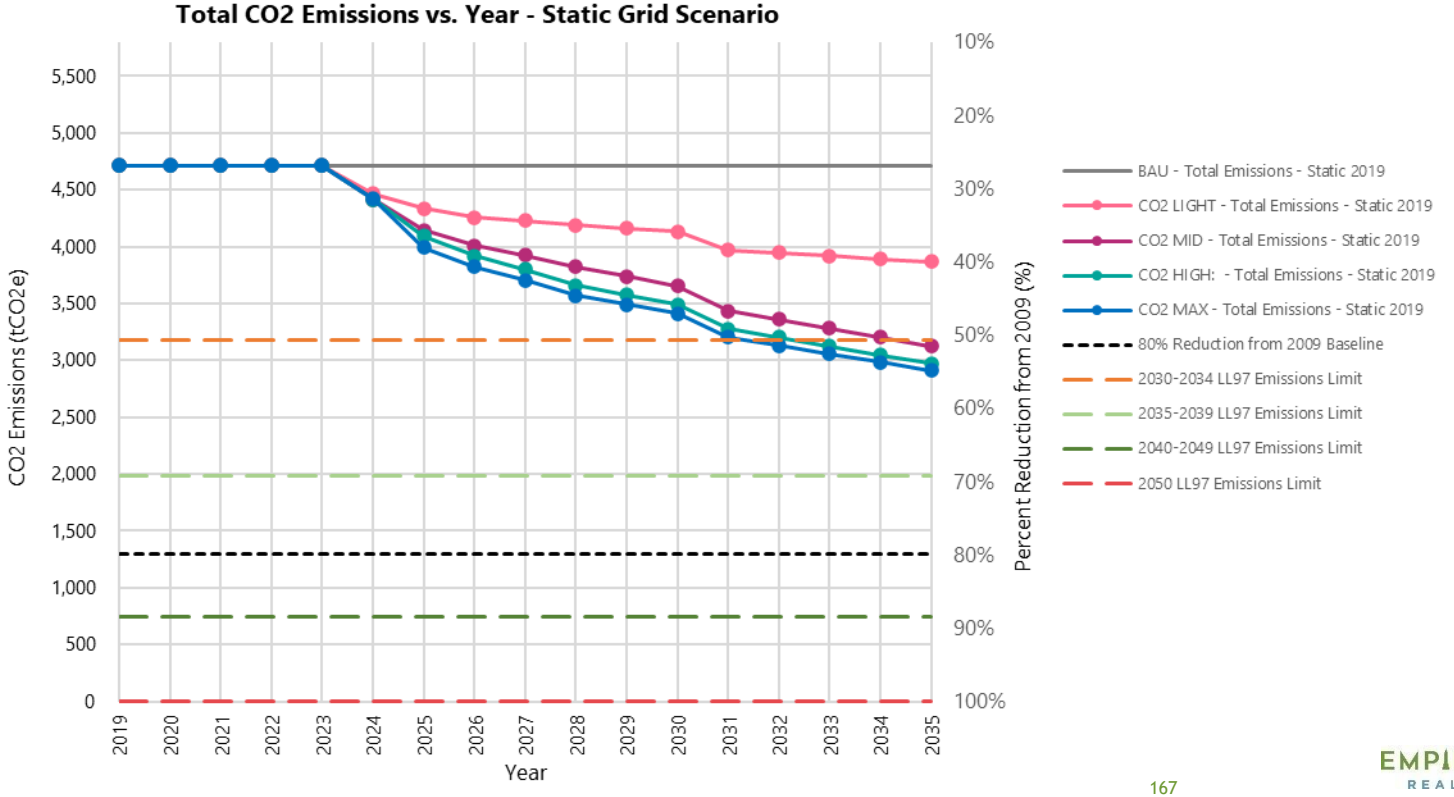
Impact of Delays – OGCP as Example

ENERGY CONSERVATION MEASURES (ECMS)			IMPLEMENTATION TIMELINE																	
Phase	Tag	ECM Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Phase 1	CO001	BMS Integration of VAV Boxes & Radiator Valves & ASHRAE Guideline 36	33%	67%	100%															
Phase 1	SS001	Steam Cycle and Pressure Optimization	100%																	
Phase 1	EN005	Hoistway Vent Closure	100%																	
Phase 2	CO005	Control Valves & VFDs for Lobby AHUs		100%																
Phase 2	EN008	Fix Seals on the Revolving Doors		100%																
Phase 2	EN004	Freight Vestibule		100%																
Phase 2	EN002	Vestibule at Street		100%																
Phase 2	DW002	Conversion of Steam Domestic Hot Water Heating to Electric		25%	50%	75%	100%													
Phase 2	UL001	Replace DC Motors (Fans, Pumps) with AC					100%													
Phase 2	VT001	Regenerative Drives & Destination Dispatch for Elevators								100%										
Phase 3	EN001	Radiant Barrier	6%	11%	17%	22%	28%	33%	39%	44%	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
Phase 3	SS003	Radiator Pipe Insulation	6%	11%	17%	22%	28%	33%	39%	44%	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
Phase 3	TL002	Lighting Upgrades & Controls	6%	11%	17%	22%	28%	33%	39%	44%	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
Phase 3	TL001	Plug Load Control	6%	11%	17%	22%	28%	33%	39%	44%	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
Phase 3	EL001	VRF Systems (ERV + DCV) for Office Tenants on Levels 3-47	6%	11%	17%	22%	28%	33%	39%	44%	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
Phase 4	EL004	Replace Corridor Air-Cooled Chiller with AWHP Serving Levels 48-55			20%	40%	60%	80%	100%											

Slower roll-out of ECMs in tenant spaces

Impact of Delays – OGCP Static 2019 Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035 without grid decarbonization;
No packages achieve 2030 LL97 compliance on time; CO_2 High and Max achieve limit by 2033 and 2032 respectively



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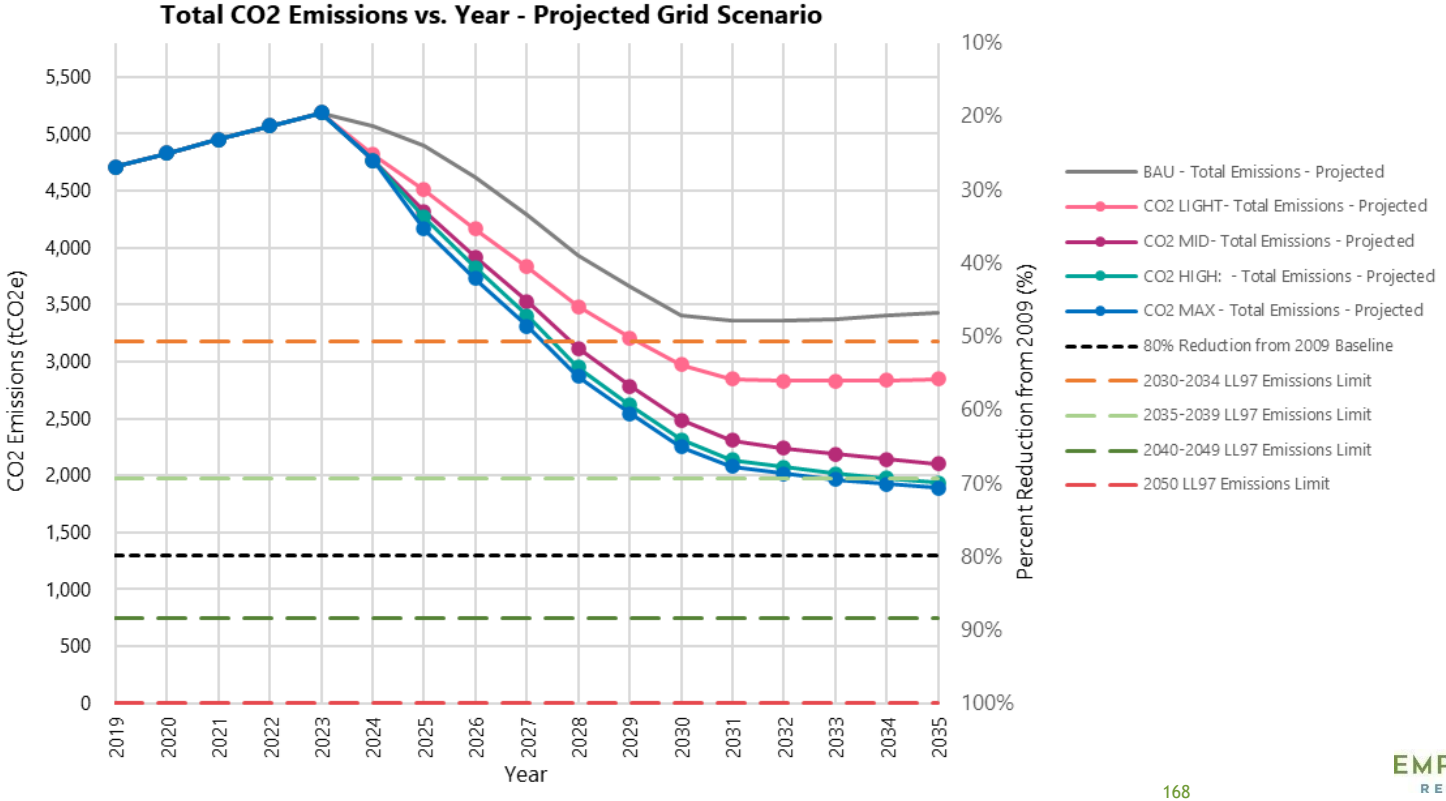
Impact of Delays – OGCP Projected Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035;
Only CO_2 High and above packages meet 2035 LL97 limit



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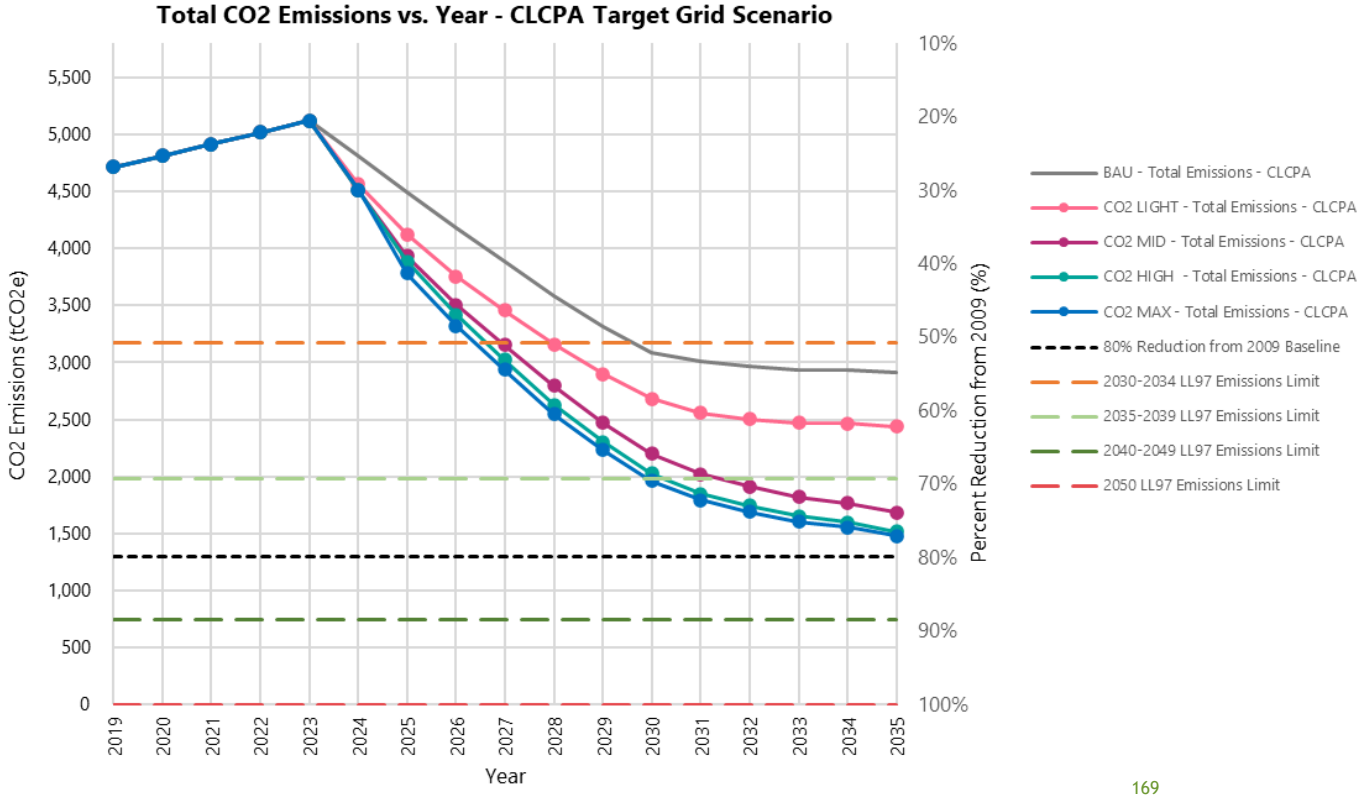
Impact of Delays – OGCP CLCPA Grid Scenario

No packages would meet 80% reduction from 2009 baseline by 2035;
Only CO_2 Mid and above packages would meet 2035 LL97 limit



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Appendix

Financial Model Assumptions Used for Discounted Cashflow Analysis

- Real discount rate: 6%
- Construction escalation rate: 3%
- Utility escalation rates used for analysis of buildings in 2022:

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity	0.0%	0.0%	3.8%	0.1%	10.2%	27.9%	7.4%	7.0%	4.8%	4.8%	4.8%	4.8%	4.9%	4.9%	5.0%	5.0%	5.0%
Steam	0.0%	0.0%	1.4%	12.5%	2.2%	-3.6%	5.4%	6.0%	4.9%	5.0%	5.1%	5.1%	5.0%	5.2%	4.0%	4.0%	4.0%
Natural Gas	0.0%	0.0%	1.4%	2.8%	42.5%	-9.7%	0.4%	2.9%	3.4%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%

- Previous utility escalation rates used for analysis of buildings in 2021:

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity	0.0%	0.0%	3.8%	5.2%	3.7%	9.4%	5.1%	5.1%	5.0%	5.0%	5.0%	5.0%	4.6%	4.6%	4.8%	4.8%	4.9%
Steam	0.0%	0.0%	1.4%	2.8%	2.2%	2.4%	2.8%	3.4%	2.2%	2.3%	2.5%	2.5%	2.3%	2.5%	1.4%	1.4%	1.4%
Natural Gas	0.0%	0.0%	0.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%

Utility Rates Based on Discounted Cashflow Analysis

Utility rates used for analysis of buildings in 2022

OGCP

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity ($/kWh)	$0.20	$0.21	$0.22	$0.22	$0.24	$0.31	$0.33	$0.36	$0.37	$0.39	$0.41	$0.43	$0.45	$0.47	$0.50	$0.52	$0.55
Steam ($/MLb)	$33.94	$32.47	$34.12	$38.39	$39.25	$37.84	$39.90	$42.29	$44.35	$46.54	$48.90	$51.39	$53.95	$56.73	$59.00	$61.36	$63.81
Natural Gas ($/therm)	$1.20	$1.20	$1.22	$1.25	$1.78	$1.61	$1.62	$1.66	$1.72	$1.81	$1.91	$2.01	$2.11	$2.23	$2.34	$2.47	$2.60

111 W 33rd St

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity ($/kWh)	$0.18	$0.19	$0.19	$0.19	$0.21	$0.27	$0.29	$0.31	$0.33	$0.34	$0.36	$0.38	$0.40	$0.41	$0.44	$0.46	$0.48
Steam ($/MLb)	$49.56	$49.56	$50.25	$56.55	$57.81	$55.74	$58.77	$62.28	$65.31	$68.55	$72.02	$75.69	$79.45	$83.54	$86.89	$90.36	$93.98

Utility Rates Based on Discounted Cashflow Analysis

Utility rates used for analysis of buildings in 2022

501 7th Ave

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity ($/kWh)	$0.19	$0.19	$0.19	$0.19	$0.21	$0.27	$0.29	$0.31	$0.32	$0.34	$0.35	$0.37	$0.39	$0.41	$0.43	$0.45	$0.47
Natural Gas ($/therm)	$1.20	$1.20	$1.22	$1.25	$1.78	$1.61	$1.62	$1.66	$1.72	$1.81	$1.91	$2.01	$2.11	$2.23	$2.34	$2.47	$2.60

1400 Broadway

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Electricity ($/kWh)	$0.17	$0.17	$0.17	$0.17	$0.19	$0.24	$0.26	$0.27	$0.29	$0.30	$0.32	$0.33	$0.35	$0.36	$0.38	$0.40	$0.42
Natural Gas ($/therm)	$1.20	$1.20	$1.22	$1.25	$1.78	$1.61	$1.62	$1.66	$1.72	$1.81	$1.91	$2.01	$2.11	$2.23	$2.34	$2.47	$2.60

Simple Payback Calculation Description

- Simple payback is calculated using:
  - Incremental capital cost associated with complete implementation of the ECM or package, based on 2022 cost estimates
  - Incentives available for complete implementation of the ECM or package, calculated using latest rates for programs from Con Edison and NYSERDA
  - Energy cost savings associated with complete implementation of the ECM or package, calculated using 2022 utility rates
  - Estimated annual impact to maintenance and repairs of systems

$$\text{Simple Payback} = \frac{\text{Incremental Capital Cost} - \text{Incentives}}{\text{Annual Energy Cost Savings} + \text{Annual Maintenance Impacts}}$$

Empire State Building Next Steps – 2023 Projects

The recommended 2023 measures are focused on completing controls optimizations, EBC pilots and studies, chiller plant upgrades.

Project	2023 Total Project Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
HX for Cooling Plant Redundancy	$445,967	$0	$445,967	$0
Integration of Lighting with BMS - HVAC Scope	$58,097	$0	$58,097	$0
ERV Addition (Construction)	$143,951	$218,976	$0	$218,976
Electrification Phase 1 (Construction):Heating to AHUs (Combined w/ Steam Phase-Out Perimeter Systems)	$7,101,080	$4,358,201	$2,742,879	$4,358,201
Chiller Sequence of Operations (Design & Implementation)	$450,000	$849,778	$0	$849,778
Airside Sequence of Operations (Design & Implementation)	$325,000	$353,851	$0	$353,851
Domestic Water Pumps VFDs	$465,791	$54,093	$411,698	$54,093
Airside Retro-Commissioning (Continued)	$175,000	$0	$175,000	$0
Retail Condenser Water Pump Design Study	$90,000	$289,578	$0	$289,578
Domestic Hot Water Heat Pump (EBC Pilot)	$132,417	$74,494	$57,923	$74,494
Support ERV Pilots	$25,000	$0	$25,000	$0
Chiller Plant Upgrades - Low & Mid Zone	$1,515,000	$0	$1,515,000	$0
Chiller Plant Upgrades - High Zone	$1,215,000	$0	$1,215,000	$0
VAV Reheat Pilot	$376,200	$0	$376,200	$0
Electrification Phase 2: High Zone Heating Design	$160,000	$0	$160,000	$0
Total	$12,678,503	$6,198,971	$7,182,764	$3,426,579

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1350 Broadway Next Steps – 2023 Projects

The recommended 2023 measures are focused on infiltration mitigation, energy recovery ventilation, and low flow fixtures.

Project	2023 Total Project Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
Toilet Exhaust Energy Recovery Ventilator	$544,706	$0	$544,706	$26,659
Low flow fixtures	$15,936	$0	$15,936	$4,641
Mitigate Lobby Infiltration	$11,589	$3,909	$7,680	$2,268
Total	$572,231	$3,909	$568,322	$33,569

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1359 Broadway Next Steps – 2023 Projects

The recommended 2023 measures are focused on infiltration mitigation, demand control ventilation for retail, and electrification of domestic hot water for retail.

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
Demand Control Ventilation for Kitchen	$117,054	$35,116	$81,938	$6,808
Wolfgang's Domestic Water Heat Pump	$257,287	$47,097	$210,189	-$1,307
Mitigate Lobby Infiltration	$28,394	$5,565	$22,829	$1,012
Total	$402,735	$87,778	$314,956	$6,513

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250 W 57th Street Next Steps – 2023 Projects

The recommended 2023 measures are focused on lighting upgrades, infiltration mitigation, energy recovery ventilation, and installation of additional cooling capacity via heat pumps.

Project	2023 Total Incremental Cost ($)	Anticipated Incentives ($)	Total 2023 Cost w/ Incentives ($)	Energy Cost Savings ($)
Electrification Phase 1: 300 Ton Heat Pump and Riser Construction	$4,427,328	$647,474	$3,779,854	$44,132
Toilet Exhaust Energy Recovery Ventilator	$544,705	$127,808	$416,897	$16,486
Mitigate Lobby Infiltration	$11,590	$5,902	$5,688	$3,191
Common Area Lighting Upgrades	$6,780	$5,850	$930	$14,907
Total	$4,990,403	$731,647	$4,258,757	$78,716

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