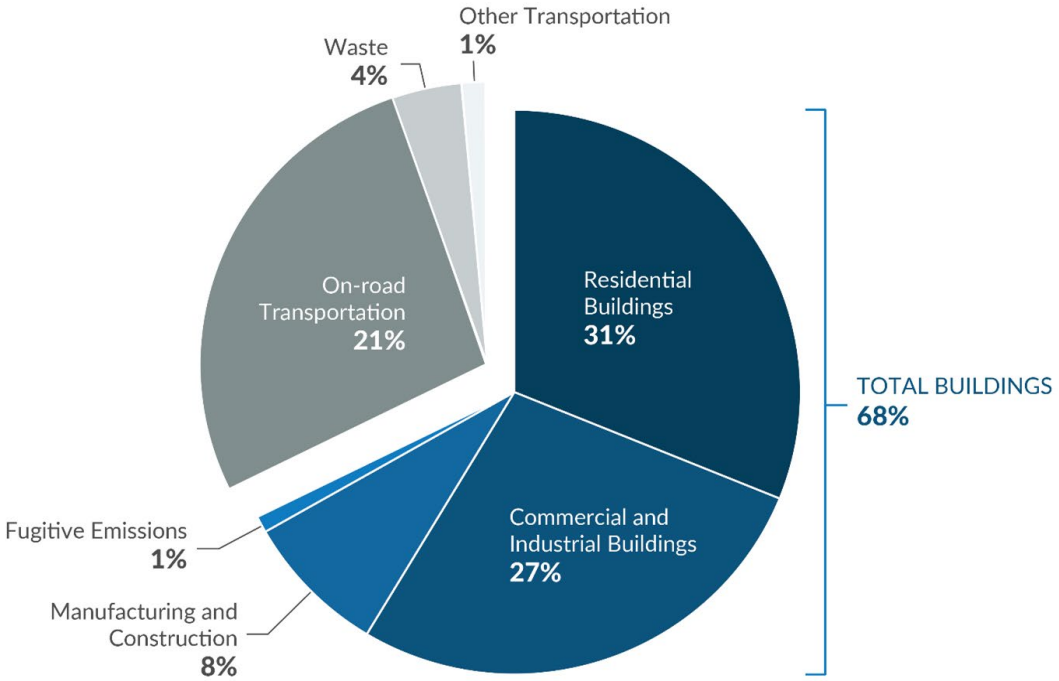
COLUMBIA UNIVERSITY
Photo by Frederick, 2024

STUDIO-II
FINAL REVIEW

THE CARBON INVESTMENT OF HISTORIC BUILDINGS:

EMBODIED & OPERATIONAL CARBON IN THE PRESERVATION OF THE COLUMBIA CAMPUS

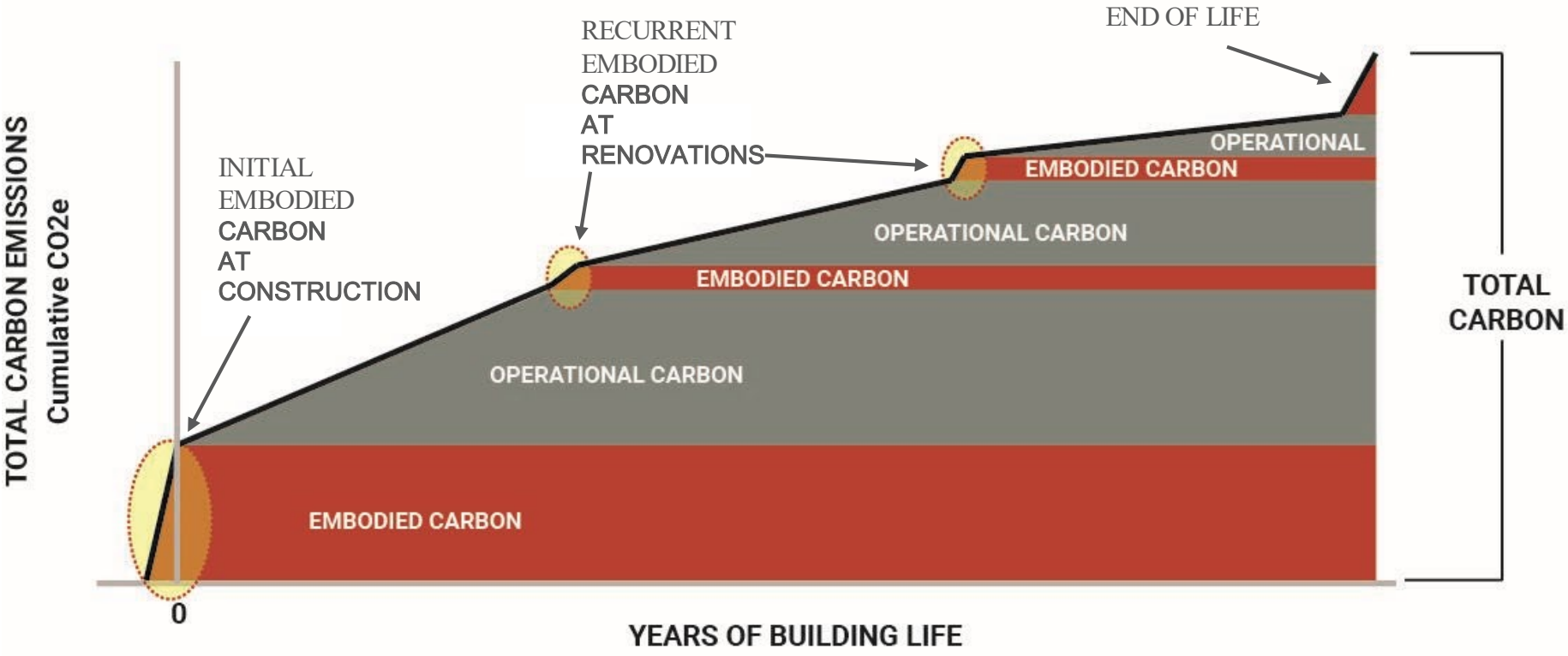
TOTAL CARBON FROM BUILDINGS, NYC: 68%



NYC BUILDINGS ACCOUNT FOR **68%** OF ALL CARBON EMISSIONS

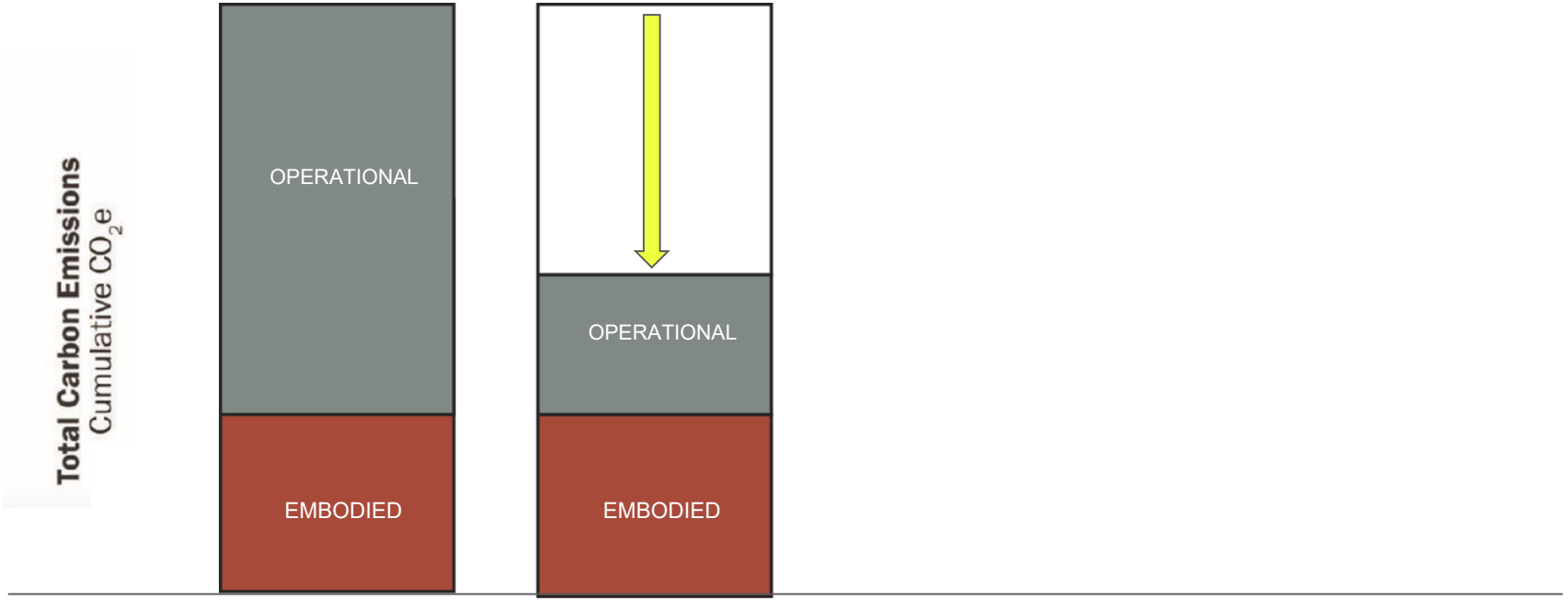
Source: NYC Mayor's Office of Sustainability

CHARTING CARBON OVER A BUILDING'S LIFE

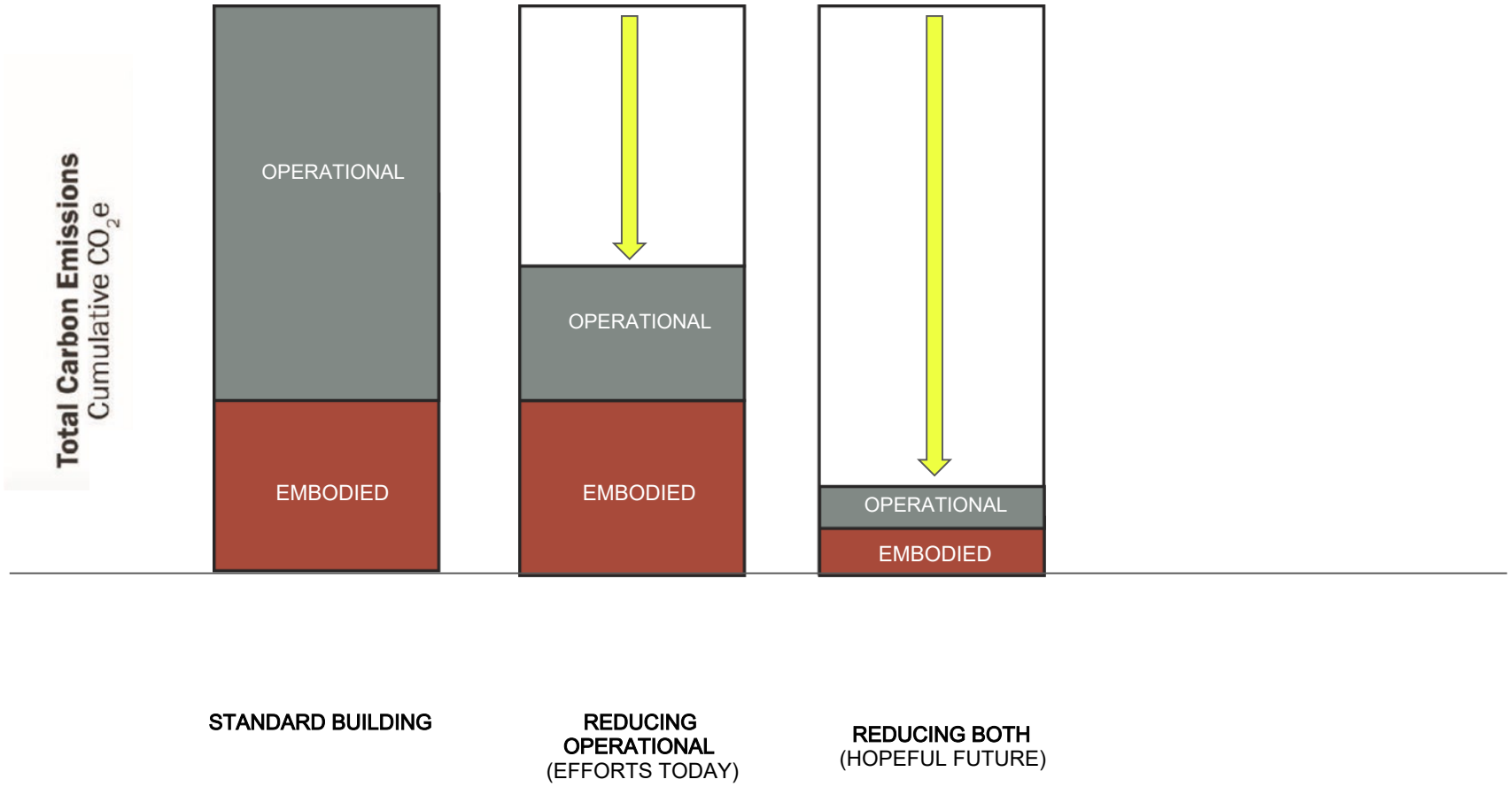


Source: Goody Clancy and Architecture 2030

TODAY, WE ARE FOCUSED ON REDUCING OPERATIONAL CARBON



WE NEED TO REDUCE BOTH OPERATIONAL AND EMBODIED CARBON…



…TO REACH NET ZERO AND AVOID CATASTROPHE

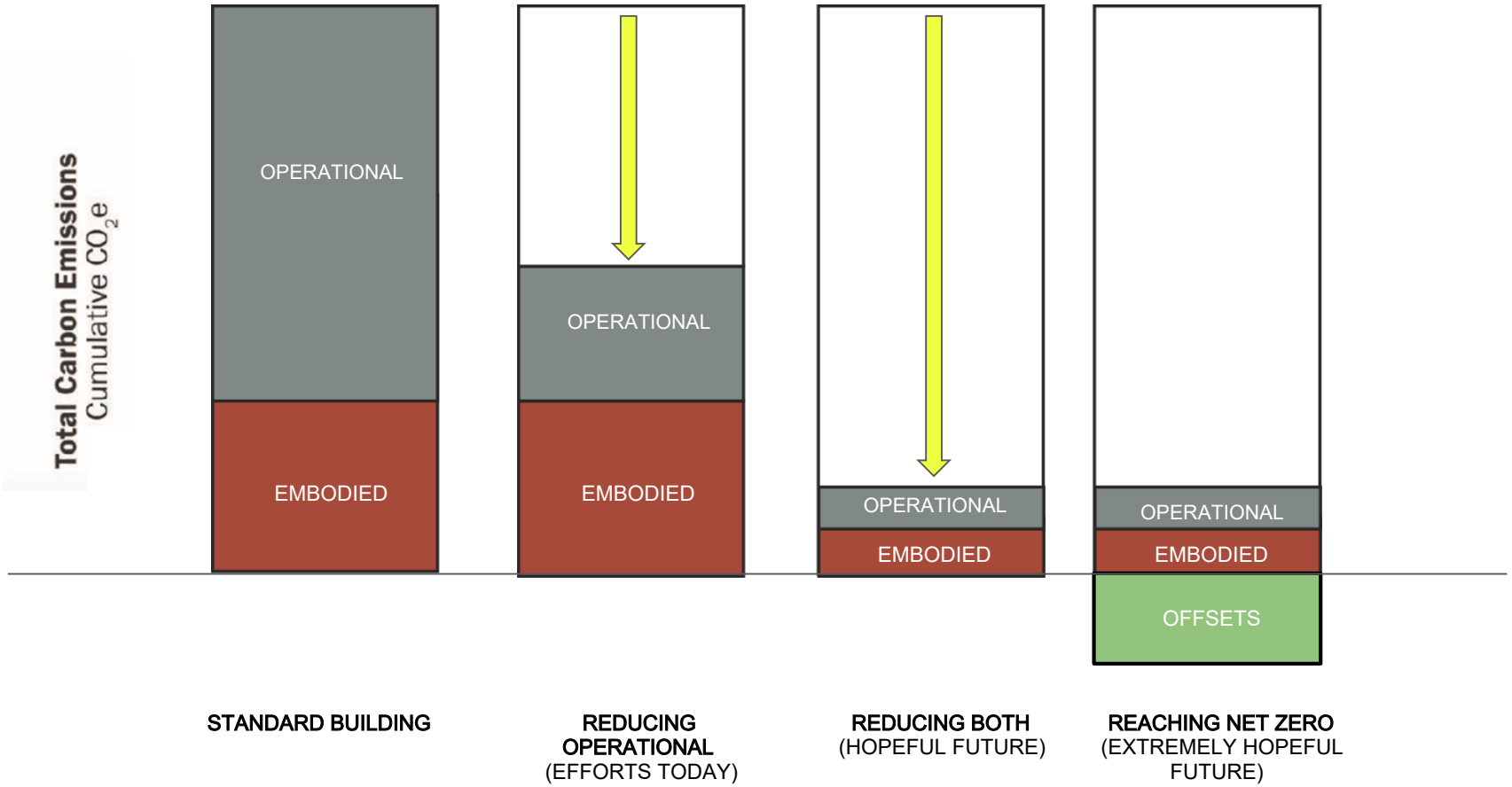
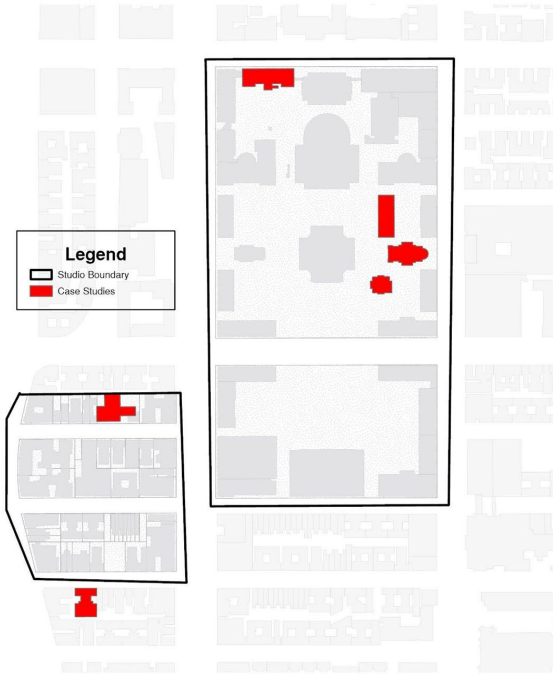


photo: A M Foster, London 2024

CASE STUDY BUILDINGS

INTRODUCTION

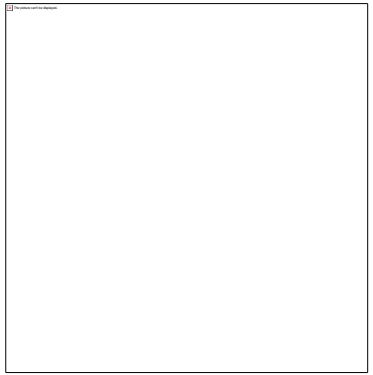


MAP OF OUR STUDIO'S STUDY AREA

Studio-II Mapping Group

AVERY HALL(1912)

PUPIN HALL(1927)



SCHAPIRO(1987)

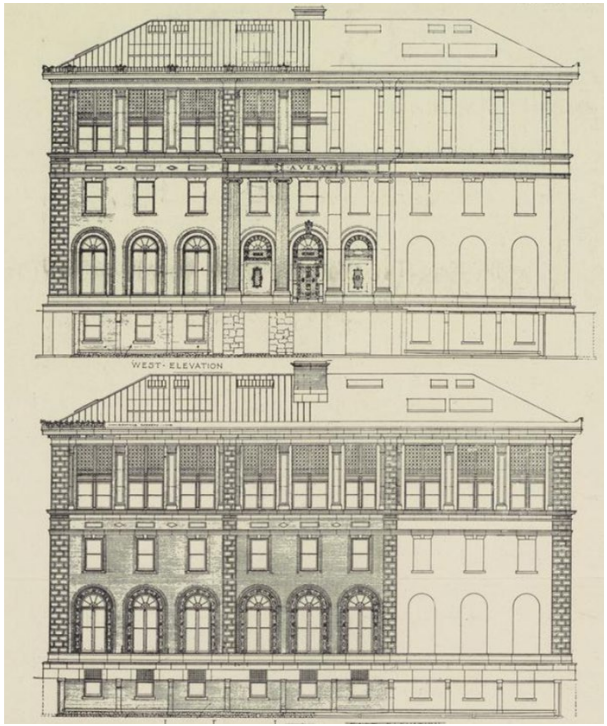
ALUMNI CENTER(1906)

ST. PAUL'S CHAPEL(1907)

BUELL HALL(1885)

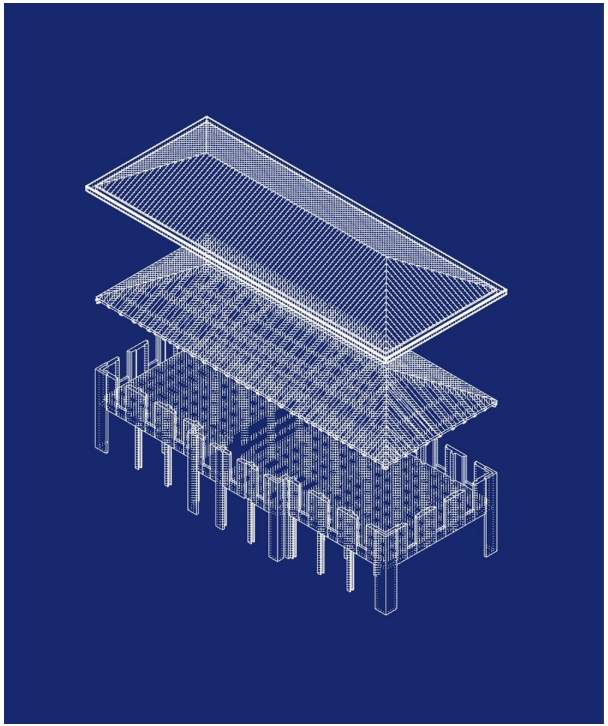
METHODOLOGY FOR DETERMINING EMBODIED CARBON

CASE STUDY BUILDINGS



AVERY HALL ELEVATIONS

The American Architect, 1912



AVERY MODEL WITH RHINO

Lily Garcia, Will Kuang, Aaron Luo

SUMMARY TABLE AND ACCOUNTING						
Member Size/ Name	Volume (m^3)	Member Material	Density (kg/m3)	Mass (kg)	Embodied carbon factor kgCOWe/kg	Total Material EC kgCOW2e
Concrete	0.0223	Concrete	2400	53.462	0.126	32165
Steel	0.0097	Steel Open Section	7850	76.504	1.740	191715
Limestone	0.6371	Limestone	#N/A	#N/A	#N/A	24046
Plaster	434.5503	Plaster	100	43455.033	0.390	16947
Granite	0.0073	Granite	2730	20.019	0.700	14600
Brick	34009.9449	Brick	#N/A	#N/A	#N/A	52146
Copper	267.5608	Copper		0.000	3.600	87454

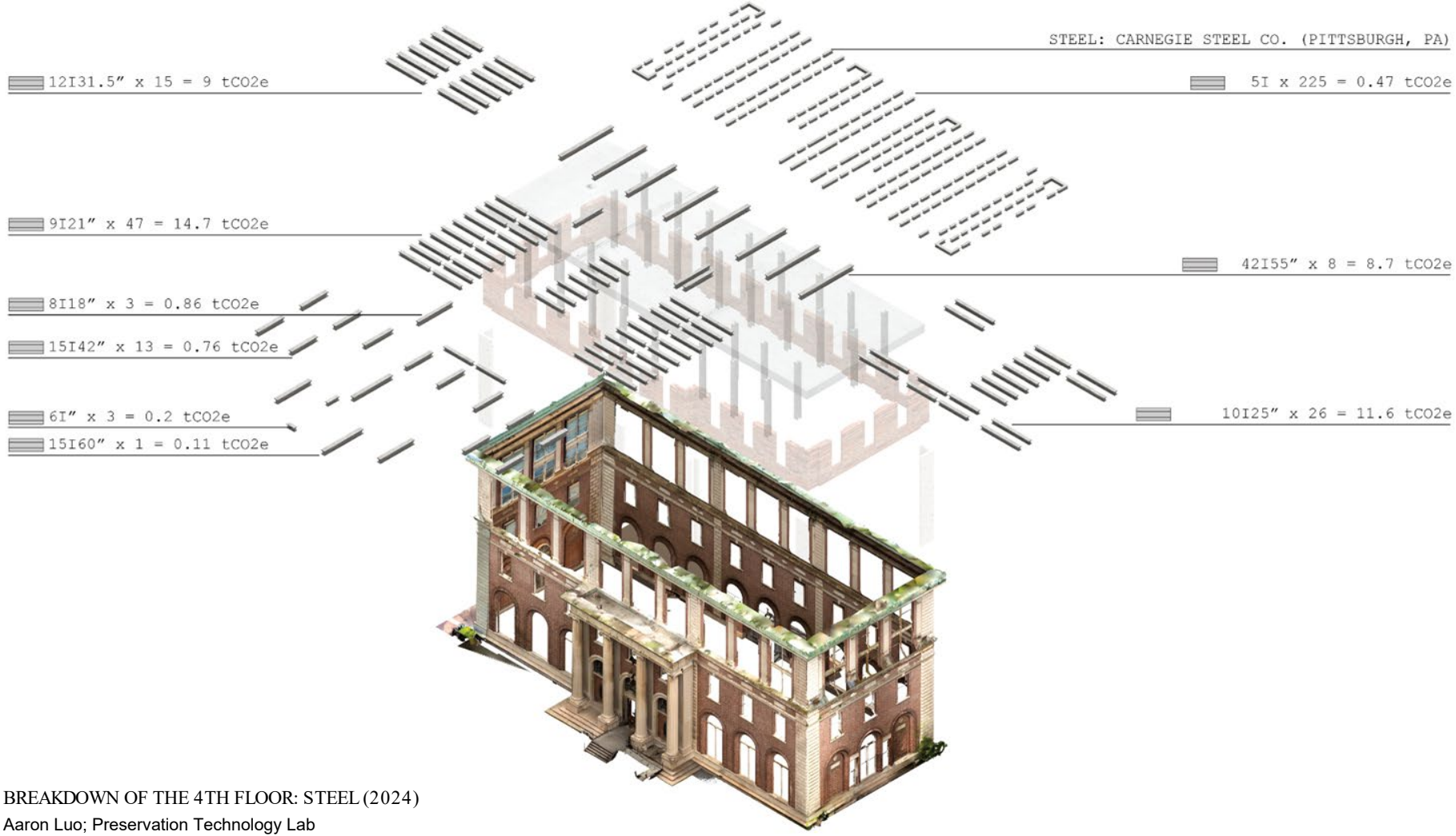
AVERY EMBODIED CARBON ACCOUNTING

Ellie Phetteplace, Lily Garcia, Will Kuang, Aaron Luo

AVERY HALL
Photo by Frederick, 2024

AVERY HALL

STUDIO II CASE STUDIES

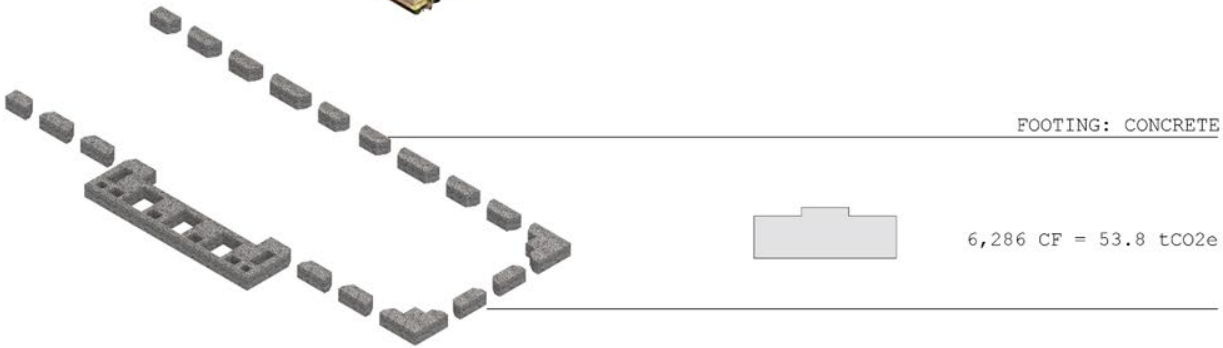


BREAKDOWN OF THE 4TH FLOOR: STEEL (2024)

Aaron Luo; Preservation Technology Lab

FOUNDATION: THE HIDDEN EMBODIED CARBON

MULTI-LAYER INFORMATION



BREAKDOWN OF THE FOUNDATION: FOOTINGS (2024)

Aaron Luo; Preservation Technology Lab

AVERY HALL

COLUMBIA UNIVERSITY

NEW YORK, NY

EMBODIED CARBON ANALYSIS

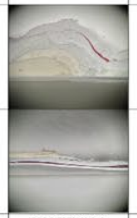
BEDFORD QUARRY
BEDFORD, IN

CARNEGIE STEEL CO.
PITTSBURGH, PA

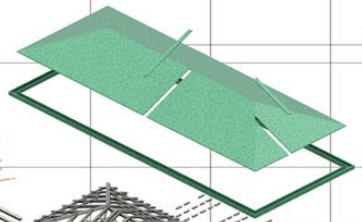
NATIONAL SLATE & TILE ROOFING CO.
GREEN CITY, N.J.

STONEY CREEK GRANITE
BRANTFORD, CT

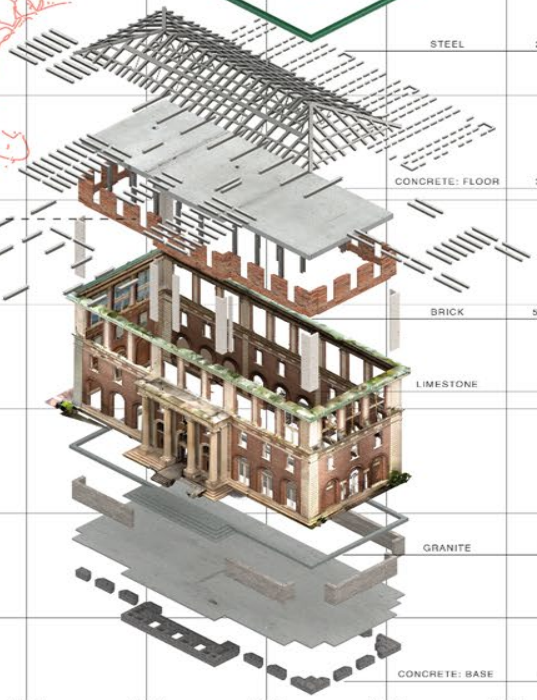
PARTITION WALL
COLOR CODE



PARTITION WALL
CROSS SECTION



COPPER 87.5 tCO2e



STEEL 256.7 tCO2e

CONCRETE: FLOOR 32.16 tCO2e

BRICK 52.146 tCO2e

LIMESTONE 24 tCO2e

GRANITE 24 tCO2e

CONCRETE: BASE 63.8 tCO2e

4000
3500
3000
2500
2000
1500
1000
500
0 MILE

500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000

4.02t CO2e

PARTITION WALL
RECURRENT RENOVATION

5.14t CO2e

2.78t CO2e

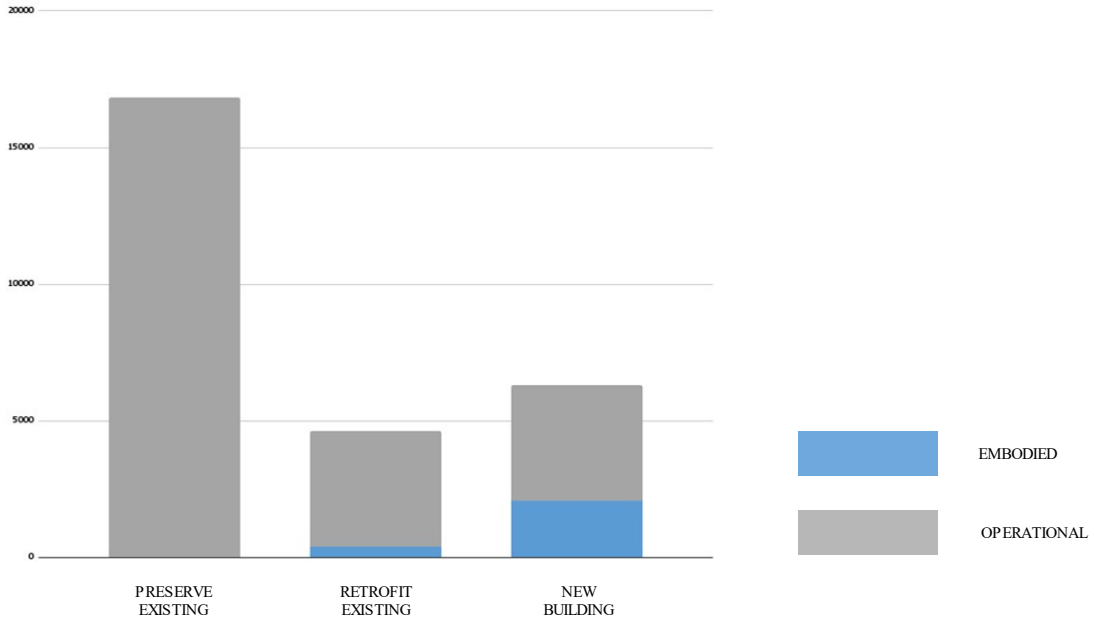
1900 YEAR 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040

THE BEST FUTURE FOR AVERY IS RETROFITTIN

EMBODIED OPERATIONAL

CARE TOOL ANALYSIS

TOTAL EMISSIONS TCO2 / 26 YEARS: 16817 TCO2



	PRESERVE EXISTING	RETROFIT EXISTING	NEW BUILDING
TOTAL CARBON INTENSITY (EMBODIED + OPERATIONAL)	310	85	116

PUPIN HALL
Photo by Frederick, 2024

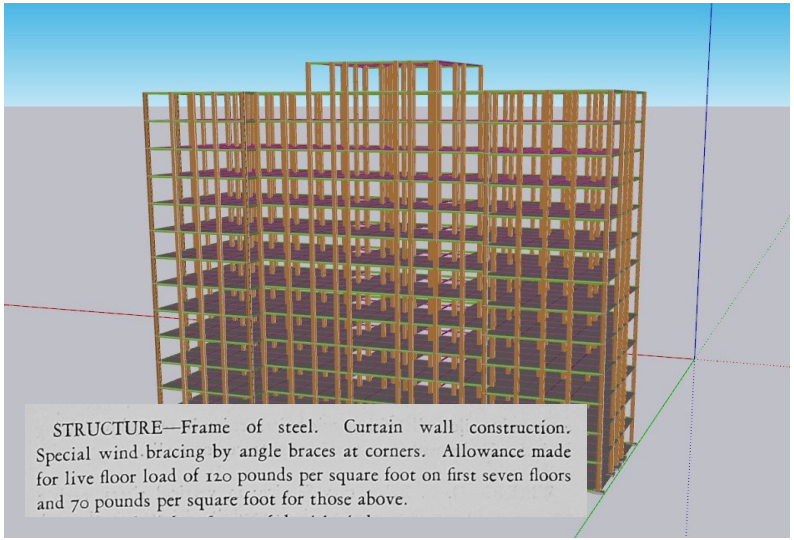
PUPIN HALL

STUDIO II CASE STUDIES

STRUCTURAL MATERIALS: STEEL

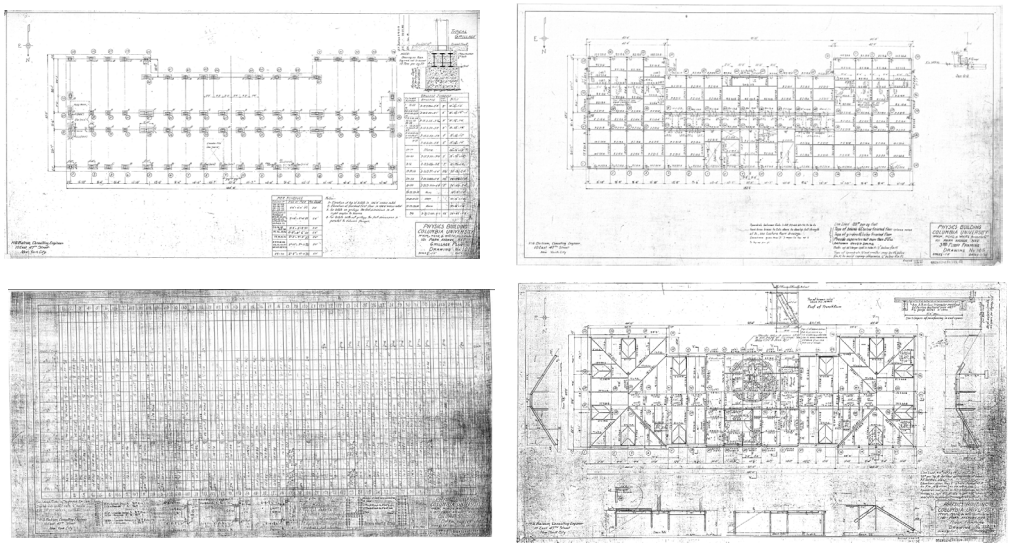
EMBODIED CARBON ANALYSIS

EMBODIED



PUPIN HALL STRUCTURAL STEEL SYSTEM

Pupin Hall Case Study



PUPIN HALL STRUCTURAL DRAWINGS

Columbia Facilities & Operations

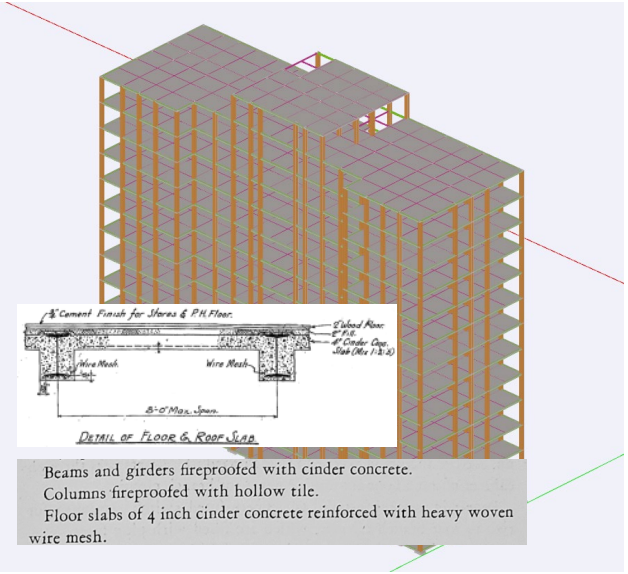
Material	Ext. or New	Volume (m3)	Density kg/m3	Mass (kg)	Embodied Carbon Factor (kgCO2e/kg)	Replacement Cycle (year)	Total Material EC tCO2e
Steel Grillage	Existing	-	7850	88000	1.74	200	155
Steel Columns	Existing	-	7850	1600000	1.74	200	2,800
Steel Floor Framing	Existing	-	7850	2900000	1.74	200	5050
Steel Roof Framing	Existing	-	7850	170000	1.74	200	295
						Total EC on Structural Steel	8,300

PUPIN HALL STRUCTURAL STEEL TOTAL EMBODIED CARBON

STRUCTURAL MATERIALS: CONCRETE

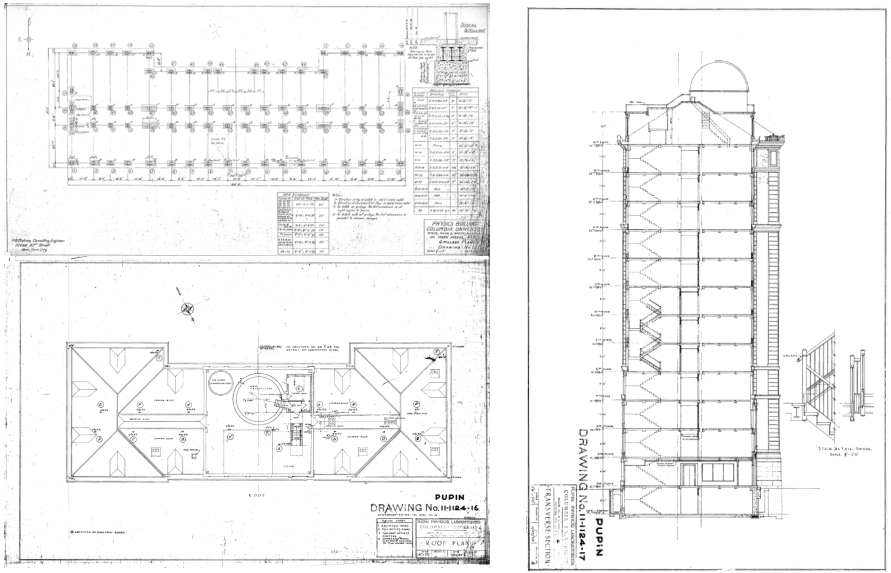
EMBODIED CARBON ANALYSIS

EMBODIED



PUPIN HALL STRUCTURAL CONCRETE SYSTEM

Pupin Hall Case Study



PUPIN HALL STRUCTURAL DRAWINGS

Columbia Facilities & Operations

Material	Ext. or New	Volume (m3)	Density kg/m3	Mass (kg)	Embodied Carbon Factor (kgCO2e/kg)	Replacement Cycle (year)	Total Material EC tCO2e
Concrete Pier	Existing	95	2400	228000	0.126	200	30
Concrete Floor Slabs	Existing	18000	2400	43200000	0.126	200	5450
Concrete Floor Footing	Existing	190	2400	456000	0.126	200	58
						Total EC on Structural Concrete	5,500

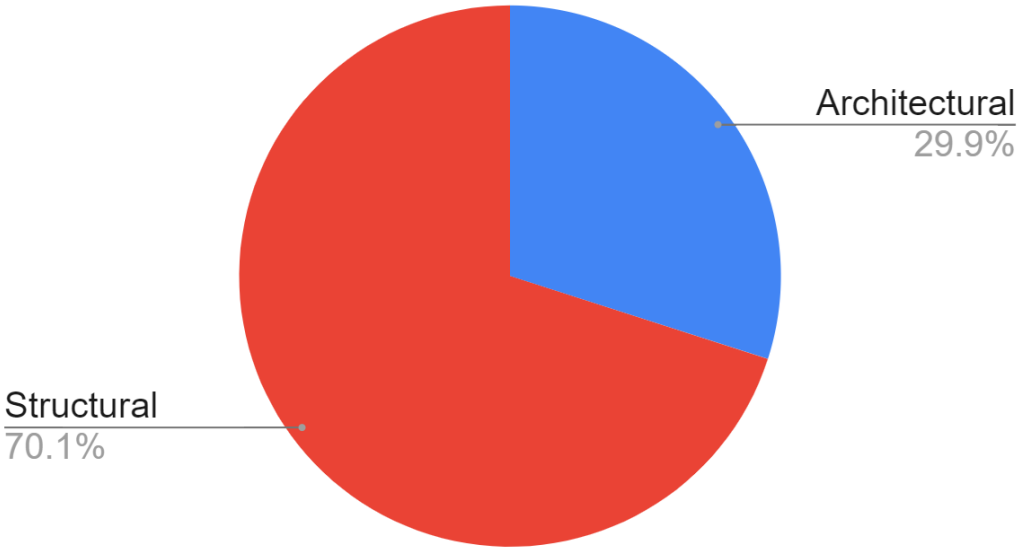
PUPIN HALL STRUCTURAL CONCRETE TOTAL EMBODIED CARBON

TOTAL EMBODIED CARBON OF PUPIN HAL19,700 tCO2e

EMBODIED CARBON ANALYSIS

EMBODIED

Total Architectural & Structural Material EC tCO2e



THIS IS EQUIVALENT TO CO2/GHG EMISSIONS FROM:

50,384,080 miles driven by an average gasoline-powered passenger vehicle

2,569 homes' energy use for one year

THIS IS EQUIVALENT TO GHG EMISSIONS AVOIDED FROM:

5.2 wind turbines running for a year

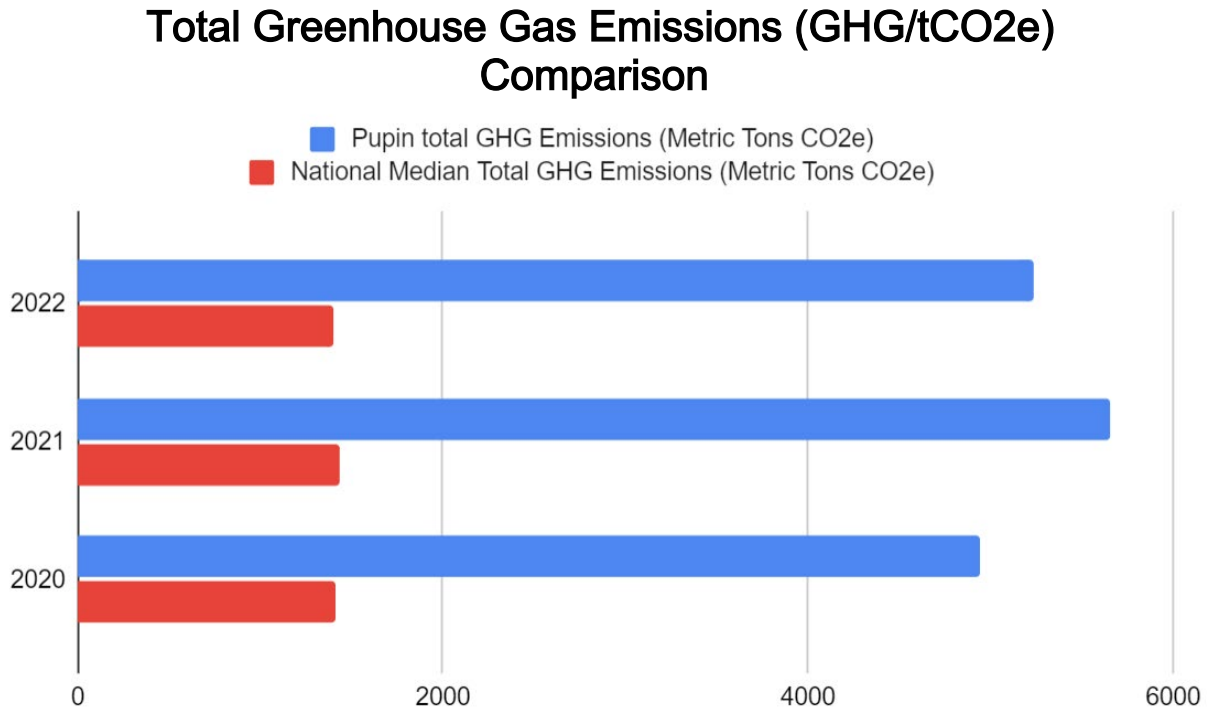
PUPIN HALL ARCHITECTURAL + STRUCTURAL MATERIALS EMBODIED CARBON

Pupin Hall Case Study

OPERATIONAL CARBON ANALYSIS FROM 2022

GREENHOUSE GAS (GHG) AS INDICATOR

OPERATIONAL



GHG COMPARISON GRAPH

Data sourced from NYC Open Data

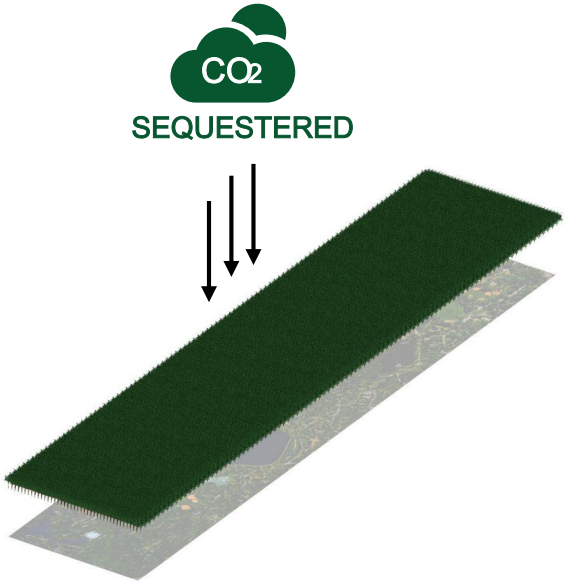
SCHAPIRO HALL
Photo by Charlotte Crum

SCHAPIRO HALL

STUDIO II CASE STUDIES

SCHAPIRO OPERATIONAL CARBON: 816 tCO_2e PER YEAR

=



SCHAPIRO HALL

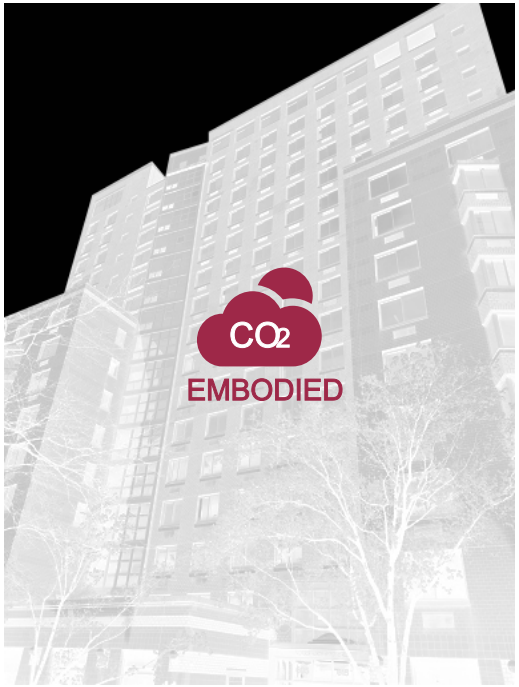
Photo by Charlotte Crum

FOREST THE SIZE OF CENTRAL PARK

CO_2 SEQUESTERED PER YEAR

SCHAPIRO EMBODIED CARBON: 2,300 tCO_2e

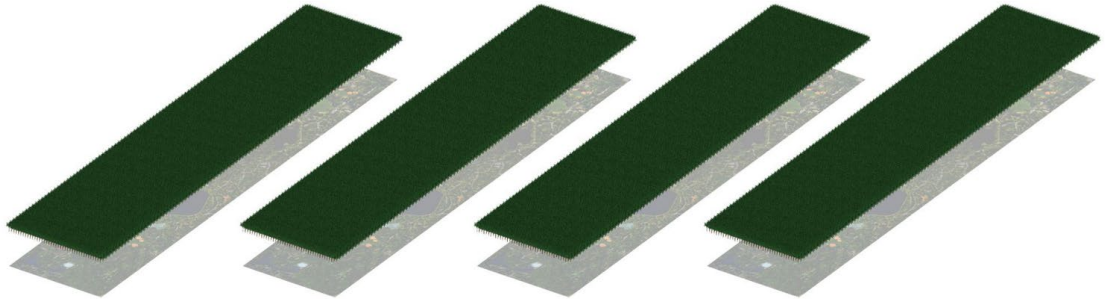
A LOT OF CO_2 FOR 160 MORE BEDS!



SCHAPIRO HALL

Photo by Charlotte Crum

=

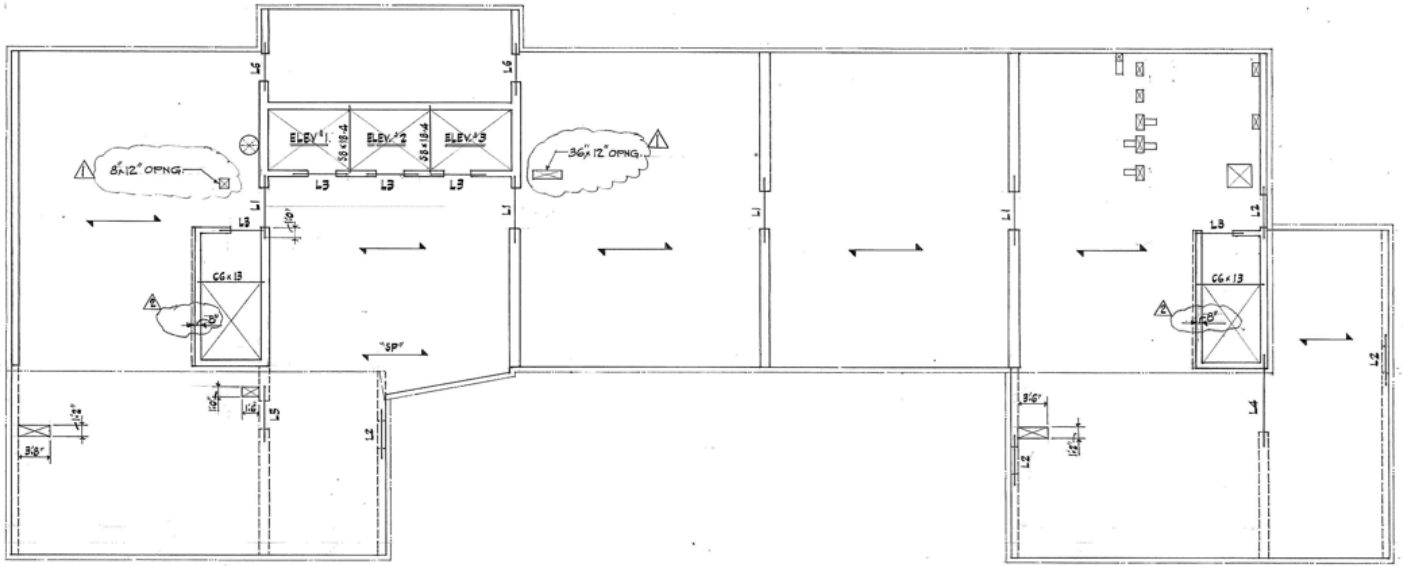


(NEARLY) FOUR FORESTS THE SIZE OF CENTRAL PARK

CO_2 SEQUESTERED IN ONE YEAR

CONCRETE = 50% OF SCHAPIRO'S EMBODIED CARBON

EMBODIED



10TH FLOOR FRAMING PLAN

NOTES: 1. ALL SLABS ARE 8" THICK HOLLOW CORE PRECAST CONCRETE PLANKS. THE DIRECTION OF SPAN IS SHOWN THUS ⟵ ON PLAN.

2. TOP OF CONCRETE PLANK ELEVATION = 192'-8½"

3. CONCRETE PLANKS SHOWN THUS ⟵"SP"⟶ ARE SPECIAL PLANKS THAT SHALL BE FABRICATED AS SOLID UNITS CONFORMING TO THE CONFORMING TO THE CONFIGURATION AND DIMENSIONS SHOWN ON ARCHITECTURAL DRAWING A-14.

TYPICAL UPPER FLOOR FRAMING PLAN

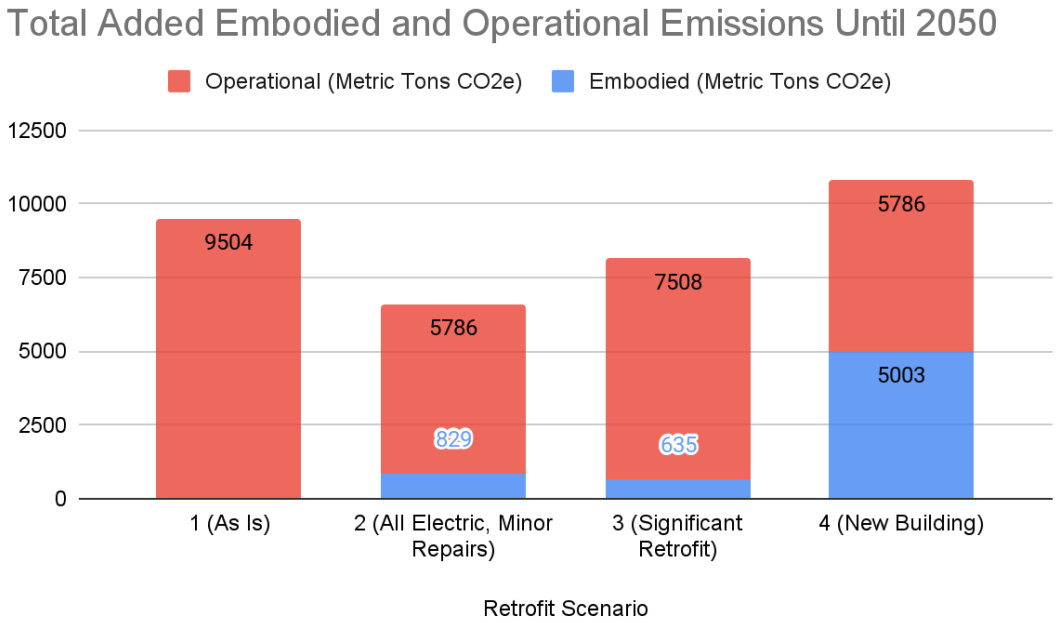
Robert Rosenwasser Associates (Structural Engineers), Morris A. Schapiro Residence Hall (Sheet no. S)

SCHAPIRO'S FUTURE

CARE TOOL ANALYSIS OF RETROFIT OPTIONS

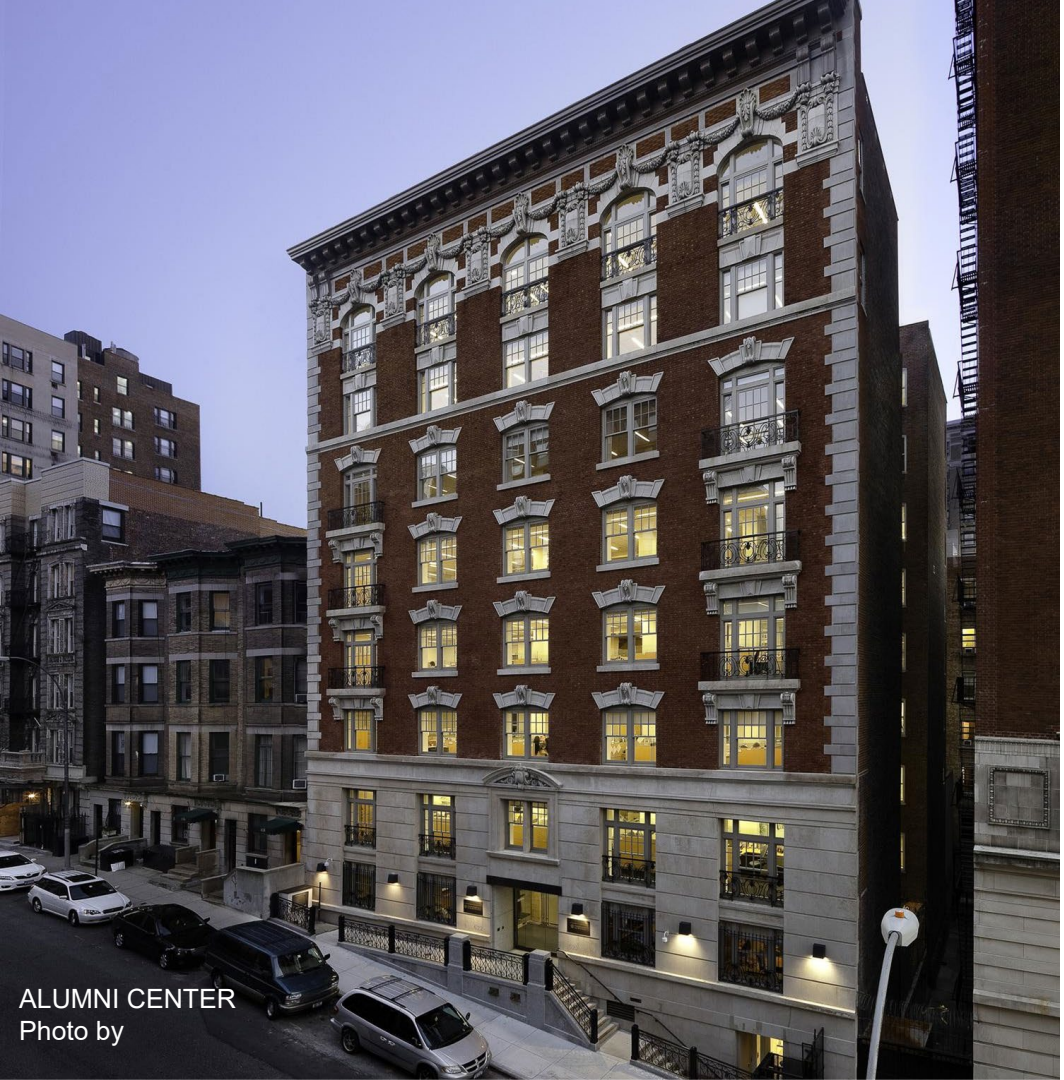
ENERGY OPERATIONAL EMBODIED

- Scenario 1: Leave Schapiro Hall as is
- Scenario 2: All electric systems running from clean grid by 2040-> large energy efficiency retrofit **not required** to meet NYC targets
- Scenario 3: Conversion to electric systems has NOT happened by 2050-> large energy efficiency retrofit **required** to meet NYC targets
- Scenario 4: New building



CARE Tool Retrofit Comparison

Chart by Schapiro Group, with data from CARE Tool

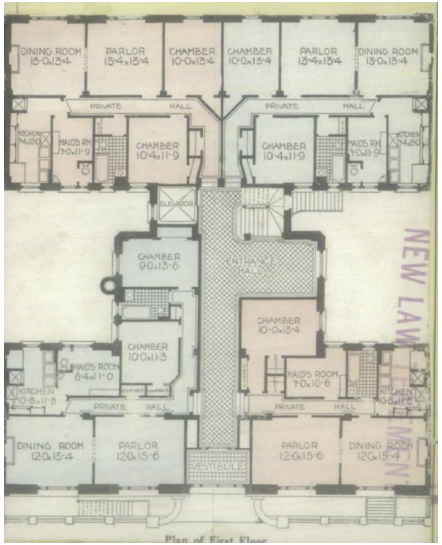


ALUMNI CENTER

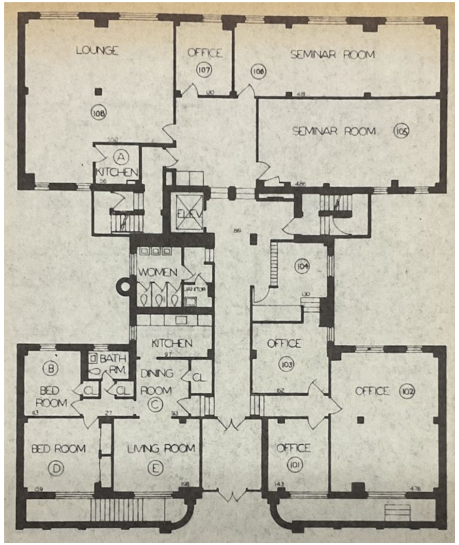
STUDIO II CASE STUDIES

BUILDING INTERVENTIONS

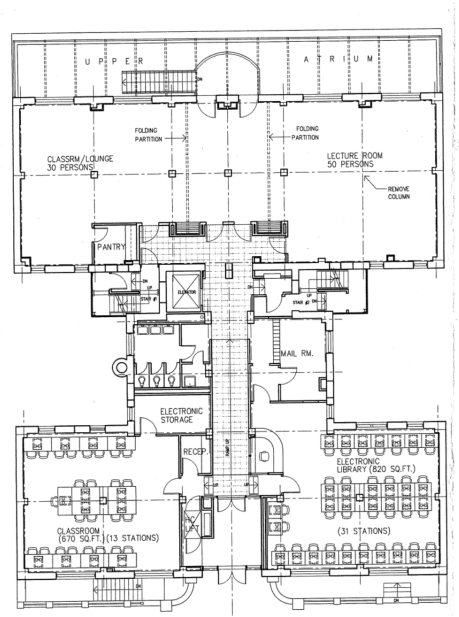
1st FLOOR PLANS: ORIGINAL CONSTRUCTION, 1969, 1996, 2009 RENOVATIONS



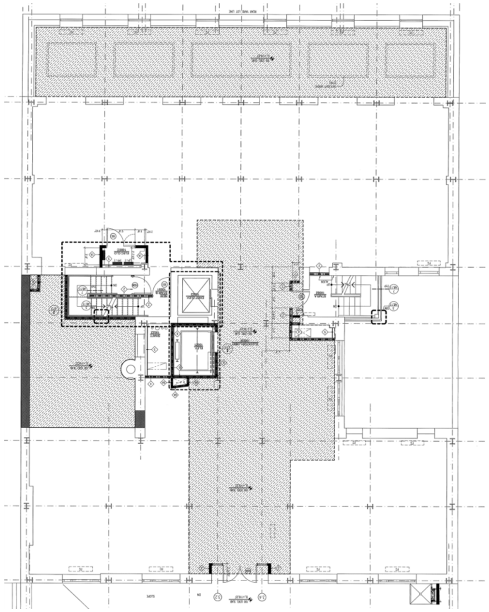
“VICTOR HALL”
FIRST FLOOR PLAN, 1908
Image: iCard



“McVICKAR HALL”
FIRST FLOOR PLAN, 1969
Image: Columbia University Archives



“McVICKAR HALL”
FIRST FLOOR PLAN, 1996
Image: Columbia University Facilities

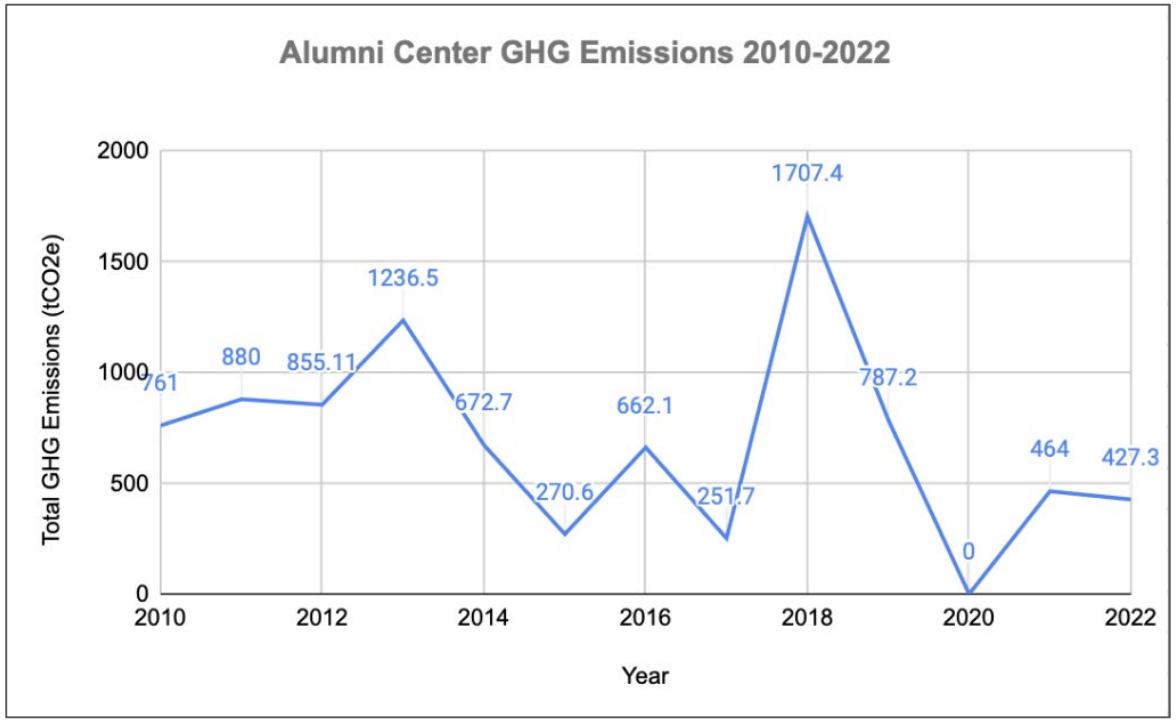


“ALUMNI CENTER”
FIRST FLOOR PLAN, 2009
Image: Columbia University Facilities

OPERATIONAL EMISSIONS ANALYSIS

FOLLOWS A SIMILAR TRAJECTORY TO EUI

OPERATIONAL



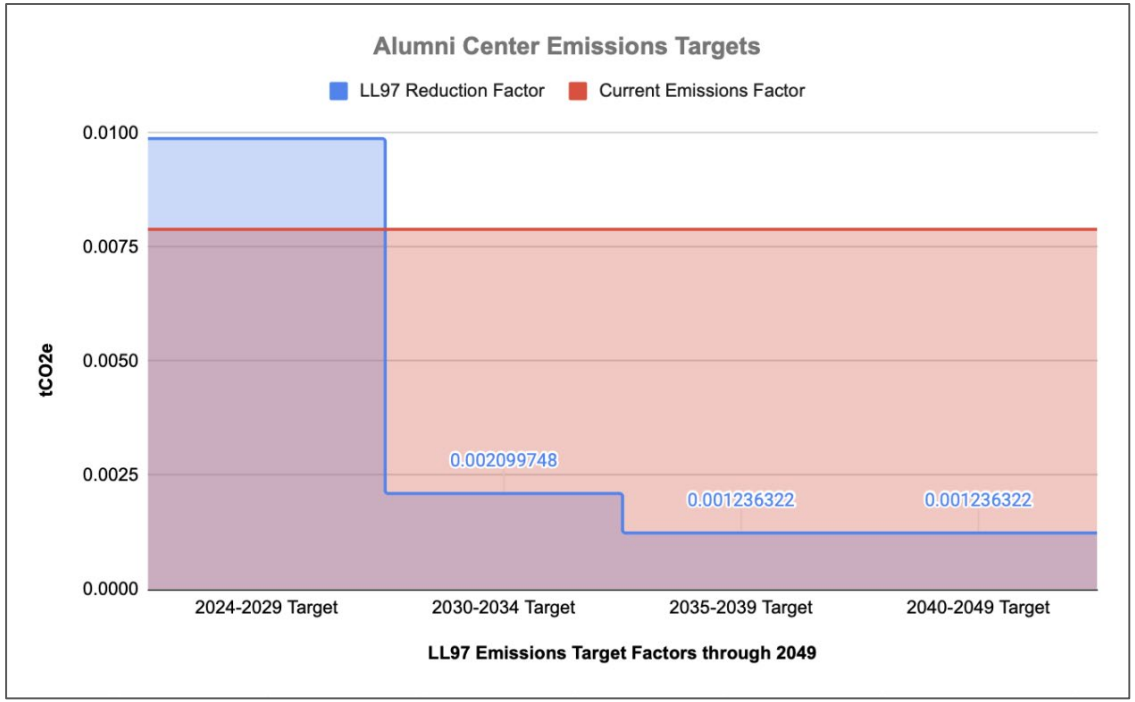
ALUMNI CENTER'S ANNUAL GHG EMISSIONS, 2010-2022, PER LL97.

Graph by Cecelia Halle

PROJECTED LL97 PENALTIES

CONSEQUENCES OF OVER EMITTING

OPERATIONAL



TARGET EMISSIONS FACTORS FOR ALUMNI CENTER PER LOCAL LAW 97.

Graph by Cecelia Halle

PENALTIES:

$84,000

MINIMUM ANNUAL FINE

OR

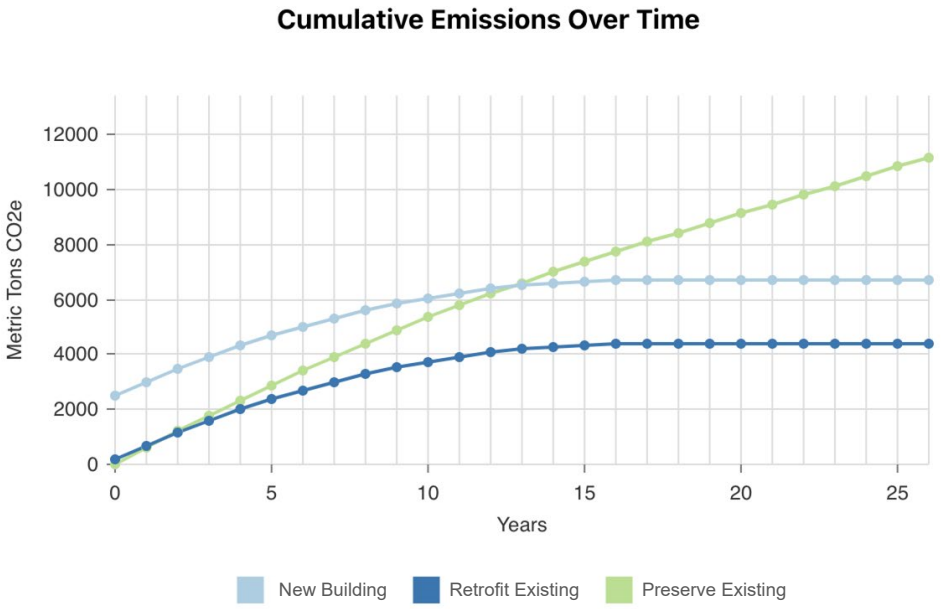
$2,136,273

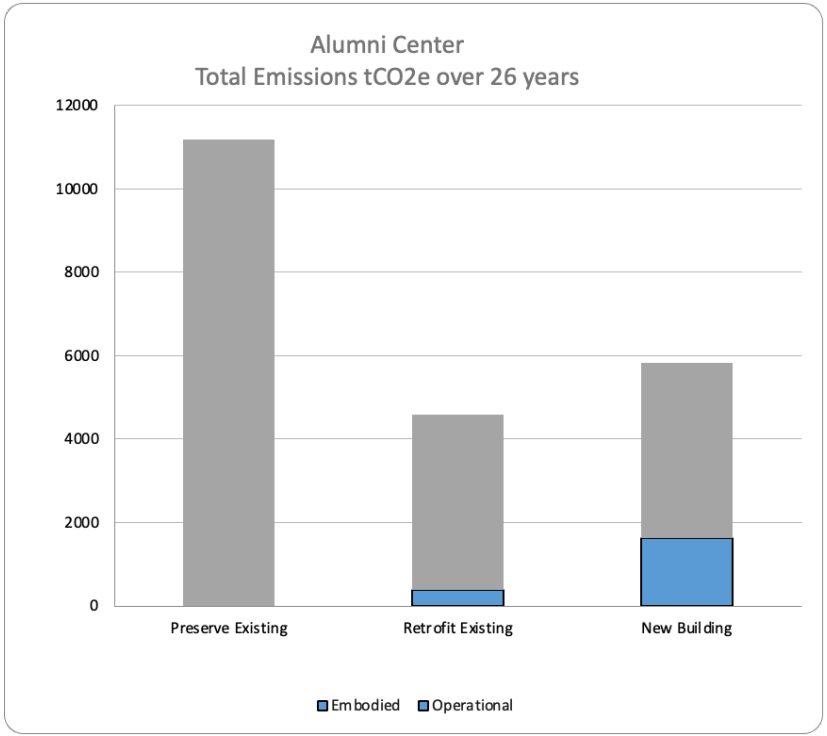
MINIMUM CUMULATIVE FINE BY 2050

DECARBONIZING TO REACH NET ZERO

PRESERVE EXISTING, REUSE AND NEW BUILDING PROJECTED EMISSIONS BY 2050

OPERATIONAL EMBODIED





ST PAUL'S CHAPEL

STUDIO II CASE STUDIES

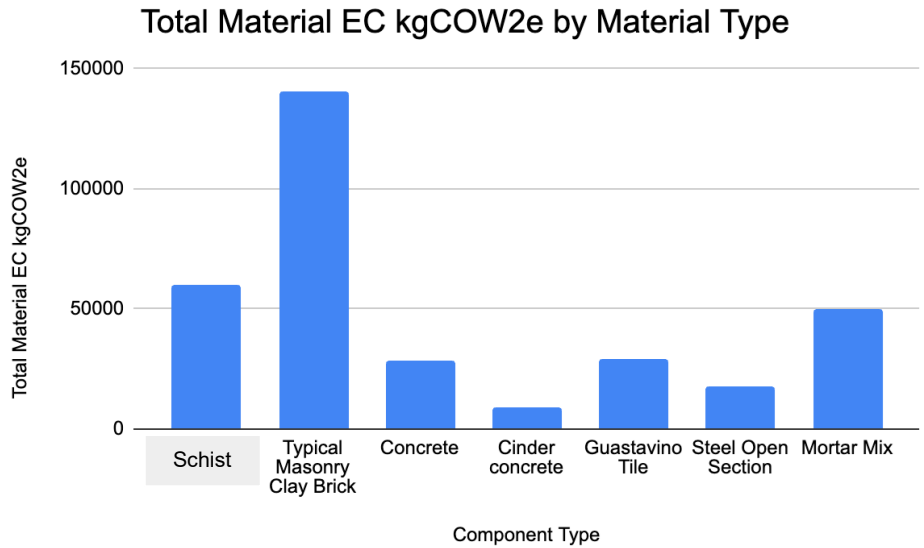
REPLACEMENT EMBODIED CARBON CALCULATION

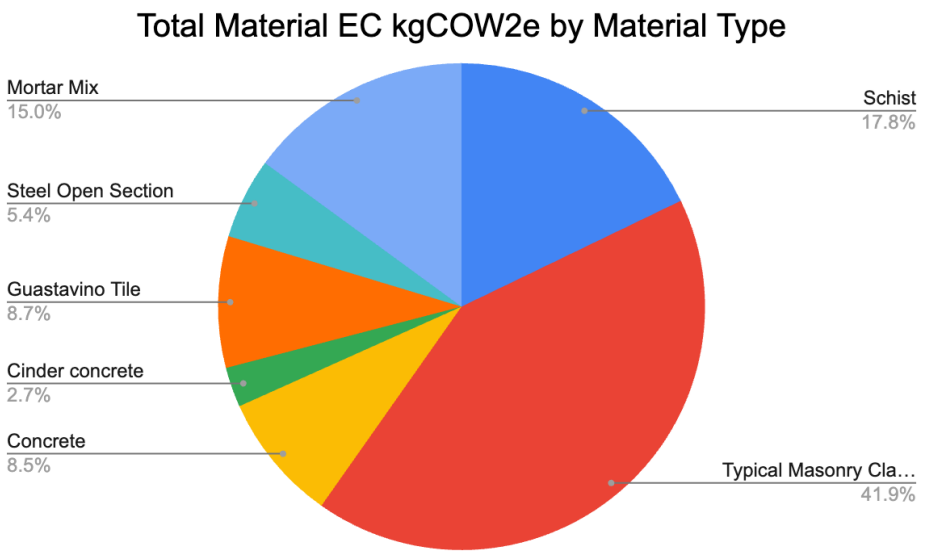
ST. PAUL'S CHAPEL

EMBODIED

TOTAL REPLACEMENT EMBODIED CARBON: 335 tCO2e

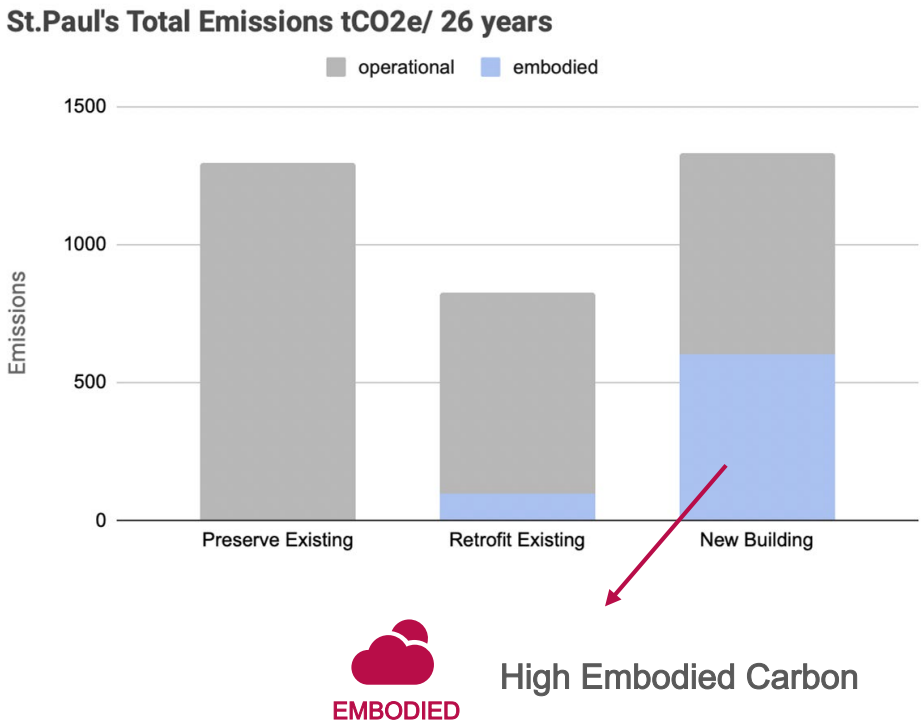
335 TONS = DRIVING AROUND THE EQUATOR 35 TIMES!





HIGH EMBODIED CARBON COST OF NEW ST. PAUL'S?

SIDE PERSPECTIVE OF ST. PAUL'S CHAPEL
Wurts Bros. (New York, N.Y.) ca. 1905



CARE TOOL: EMBODIED & OPERATIONAL EMISSIONS
OVER NEXT 26 YEARS

ST. PAUL'S IS EXCEEDING ITS OPERATIONAL TARGETS

OPERATIONAL

- Total GHG Emissions = 84 Metric Tons CO2e

- Among historic religious structures, reducing EUI is often a challenge because of existing high floor to ceiling area

NYC ENERGY CONSERVATION CODE NOTE - 2016

TO THE BEST OF MY KNOWLEDGE, BELIEF, AND PROFESSIONAL JUDGEMENT, ALL WORK UNDER THIS APPLICATION IS EXEMPT FROM THE NYCECC BECAUSE THE WORK IS AN ALTERATION OF A STATE AND/OR NATIONAL HISTORIC BUILDING (NYCECC SECTION 101.4.2 HISTORIC BUILDINGS).

ST. PAUL'S CHAPEL RENOVATION REPORT

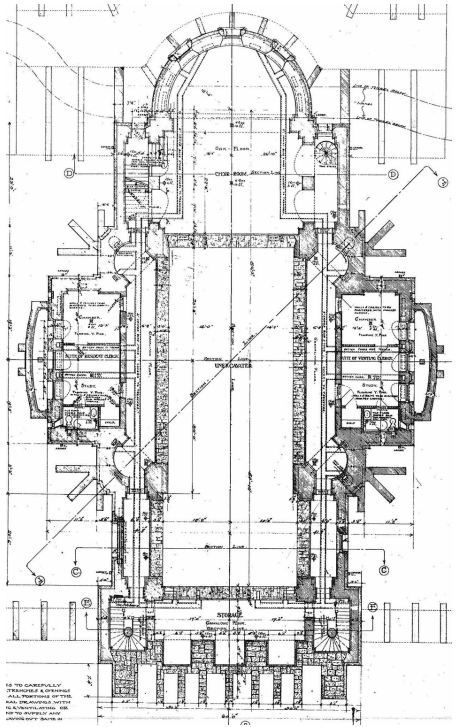
WBMA, 2019

DOMESTIC HOT WATER HEATER

Photo by James Oberting

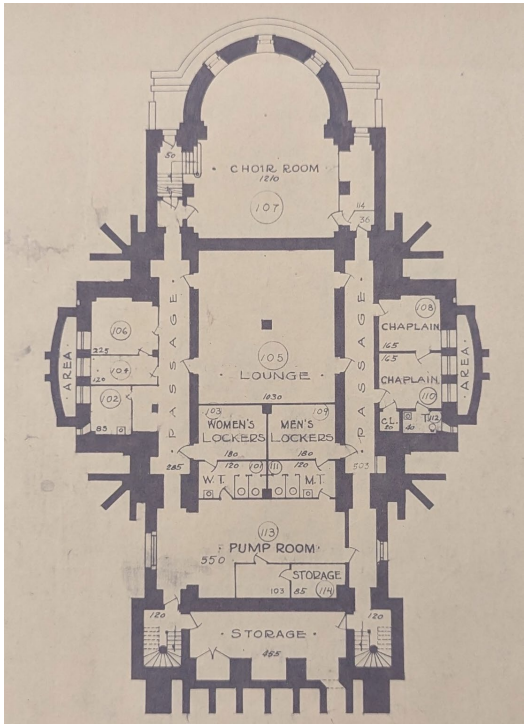
RETROFIT POTENTIAL

ST. PAUL'S CHAPEL



BASEMENT FLOOR PLAN, 1907

Image courtesy Avery D&A



BASEMENT FLOOR PLAN, 1968

Image courtesy Avery D&A

BUELL HALL
Photo by

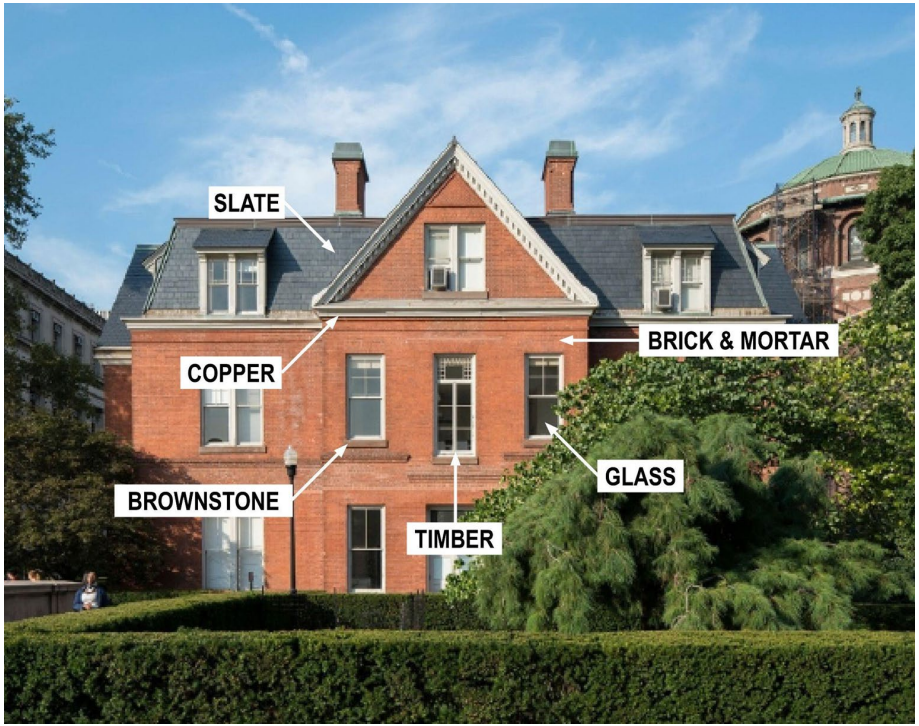
BUELL HALL

STUDIO II CASE STUDIES

CONSTRUCTION TYPOLOGY & MATERIALS

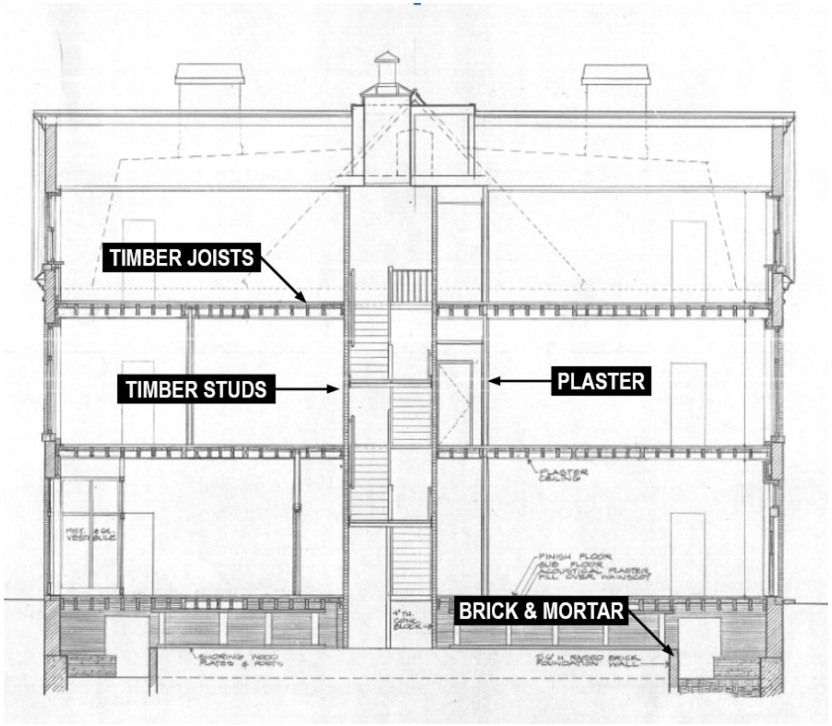
QUANTIFYING OUR MATERIALS

EMBODIED



IDENTIFIED FACADE MATERIALS

Courtesy of GSAPP Columbia



BUELL FRAMING PLAN

Columbia Facilities

HISTORIC EMBODIED CARBON

HOW DOES *THIS* BECOME *THAT*?

EMBODIED

NORTH CAROLINA LOGGING OPERATION

Via Moving North Carolina

POST CARD WITH BUELL HALL, 1900

Columbia University Archives

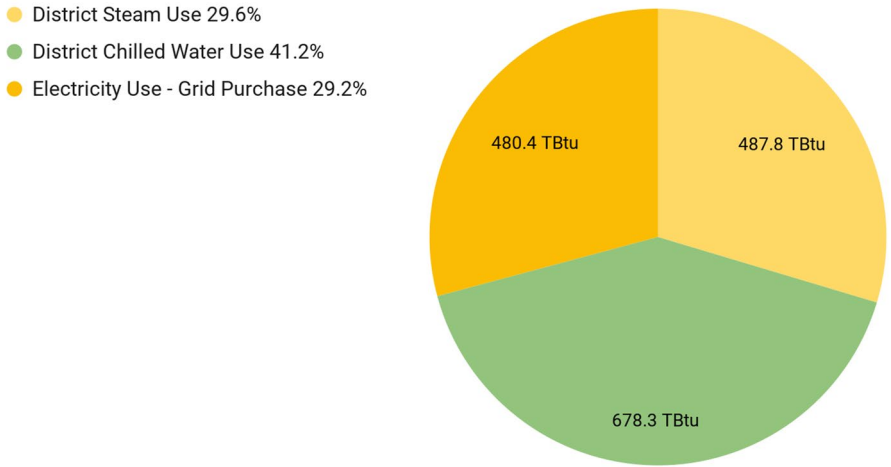
OPERATIONAL CARBON ANALYSIS

ENERGY CONSUMPTION AND EMISSION TARGETS

ENERGY OPERATIONAL

BUELL HALL ENERGY CONSUMPTION

LL84 DATA

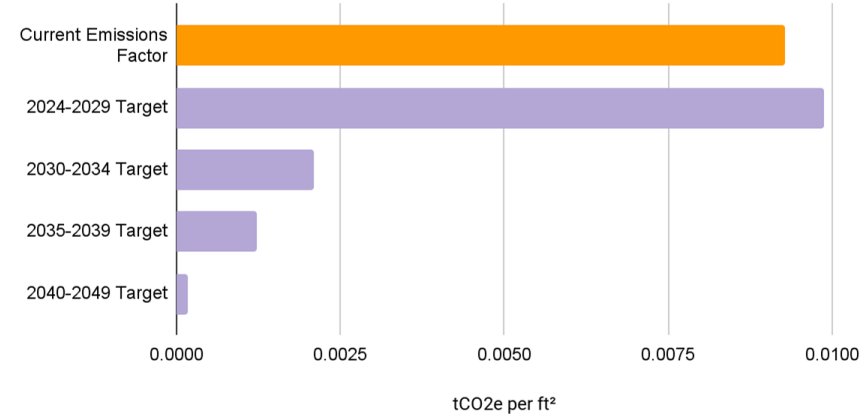


BUELL HALL BREAKDOWN OF ENERGY USE IN Tons Btu

Using LL84 Data

BUELL EMISSIONS FACTOR & FUTURE TARGETS

LL84 DATA



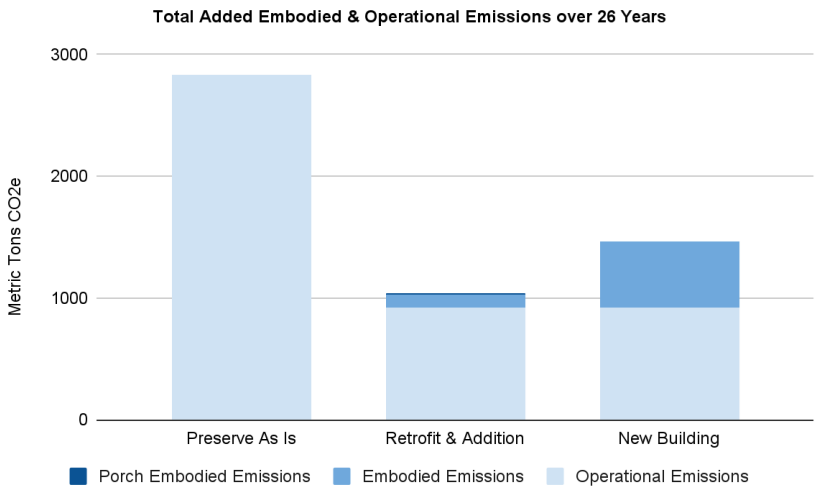
BUELL HALL CURRENT AND FUTURE EMISSIONS TARGETS

Using LL97 Data

OPERATIONAL & EMBODIED CARBON IMPACT

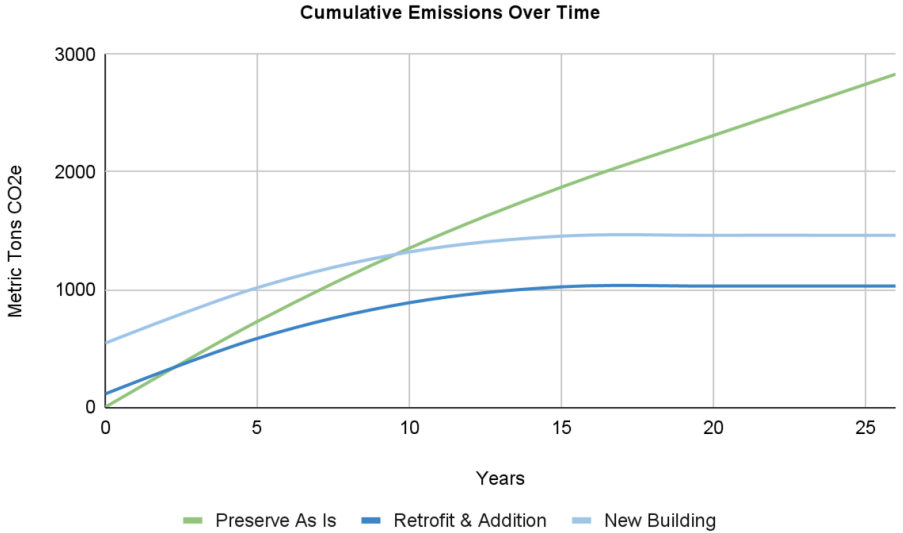
RETROFIT VS RECONSTRUCT

EMBODIED OPERATIONAL



RETROFITTING VS NEW BUILDING CARBON EMISSIONS

caretool.org



RETROFITTING VS NEW BUILDING CARBON OFFSET

caretool.org

KEY FINDINGS THEMES

EMPHASIS ON OPERATIONAL CARBON

EMBODIED CARBON IS UNDERVALUED

EMBODIED CARBON IS UNDERREGULATED

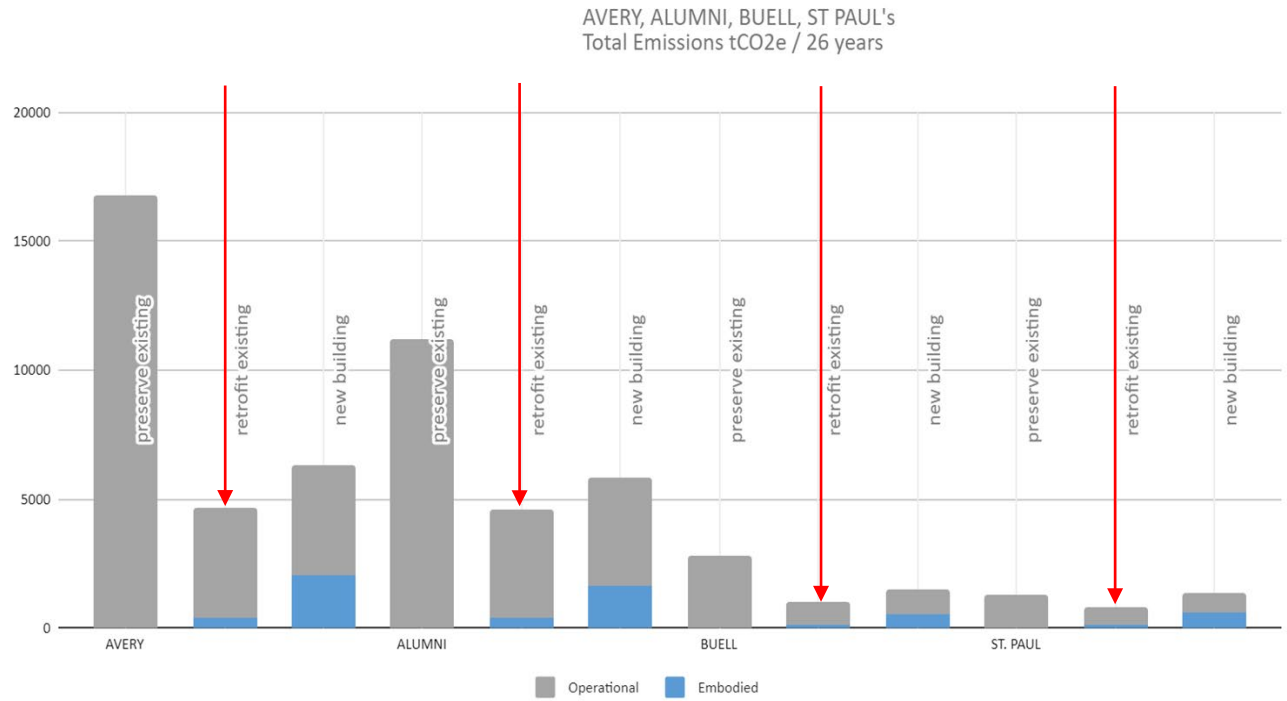
INSUFFICIENT EMBODIED CARBON DATA AND TOOLS

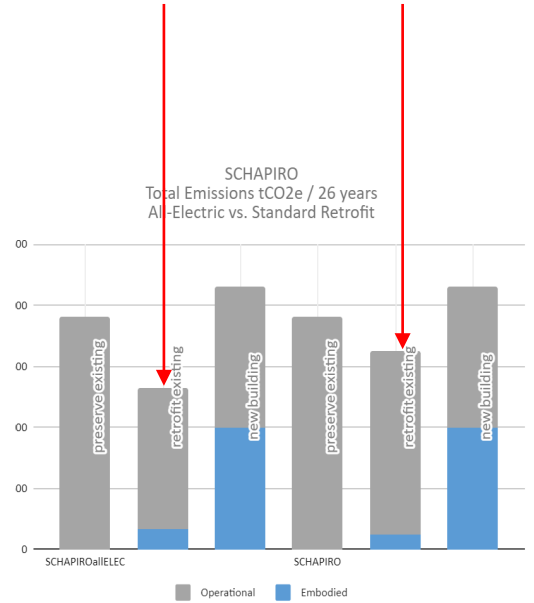
DECARBONIZATION CHALLENGES AT COLUMBIA

DECARBONIZATION CHALLENGES FOR PRESERVATION

OUR CASE STUDIES AND RETROFITTING

CARE TOOL RESULTS: RETROFITTING VS NEW CONSTRUCTION



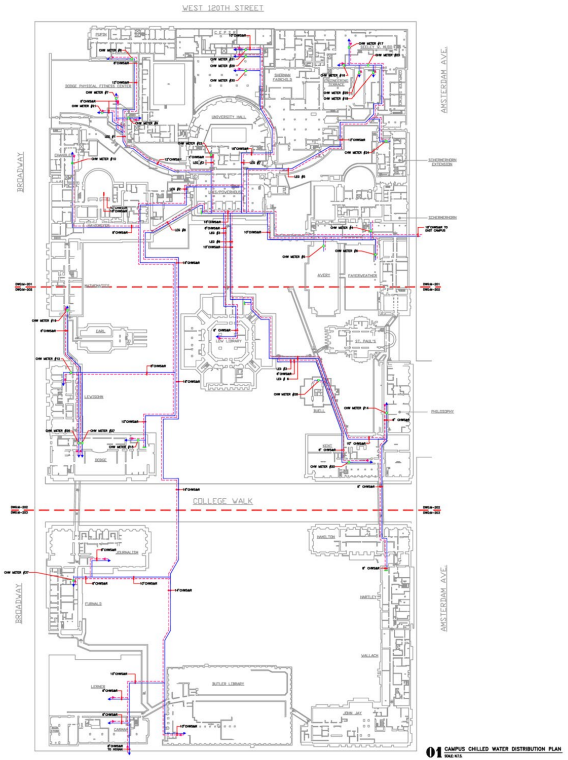


BUILDING RETROFITTING PRE-VISUALIZATION

Calculations done by Studio II students

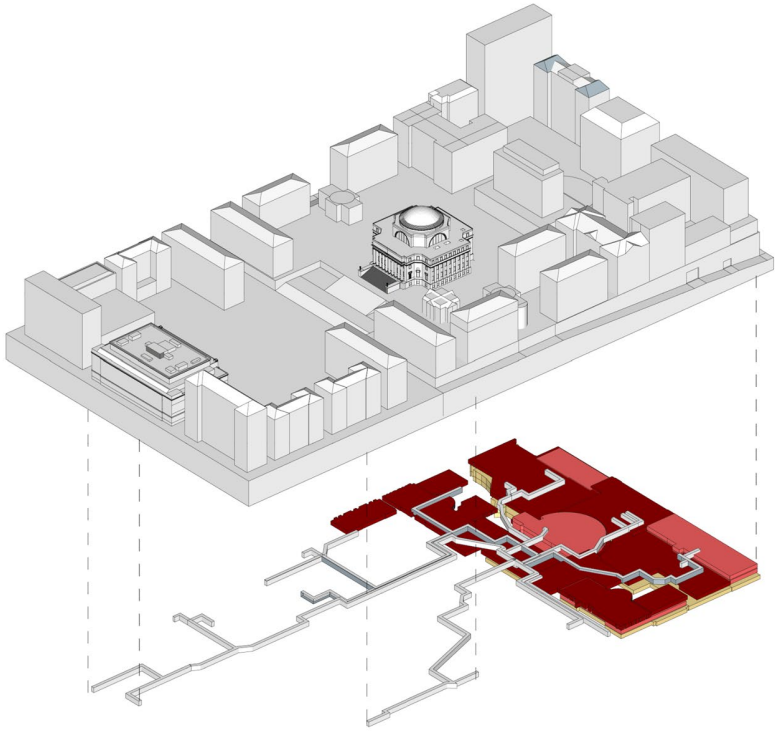
STEAM LOOP CONVERSION IS MASSIVE AND COMPLEX

UNDERGROUND INFRASTRUCTURE REACHING ALL CORNERS OF MAIN CAMPUS



COLUMBIA CHILLED WATER AND STEAM DISTRIBUTION PLAN

Courtesy of Columbia Facilities and Operations

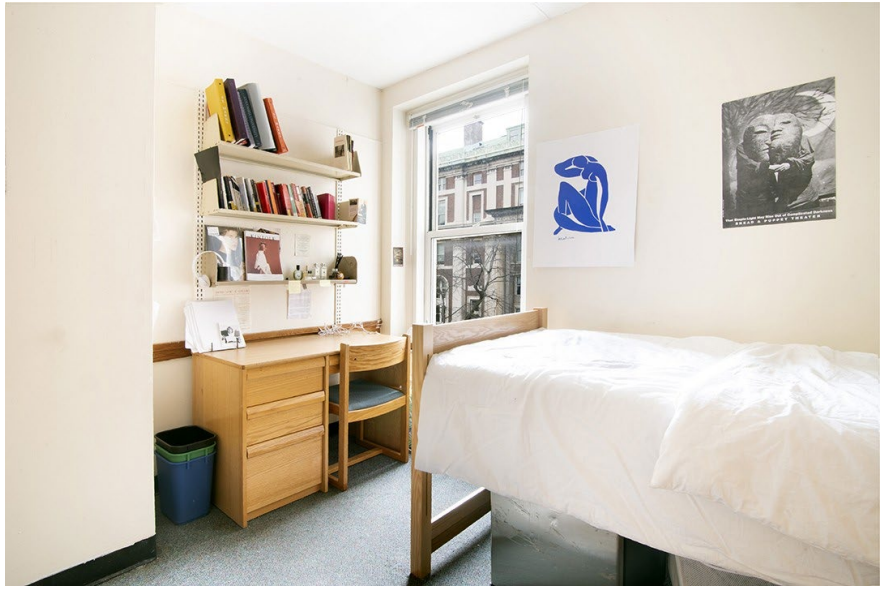


STEAM SYSTEM, 3D DIAGRAM

Courtesy of Columbia Facilities and Operations

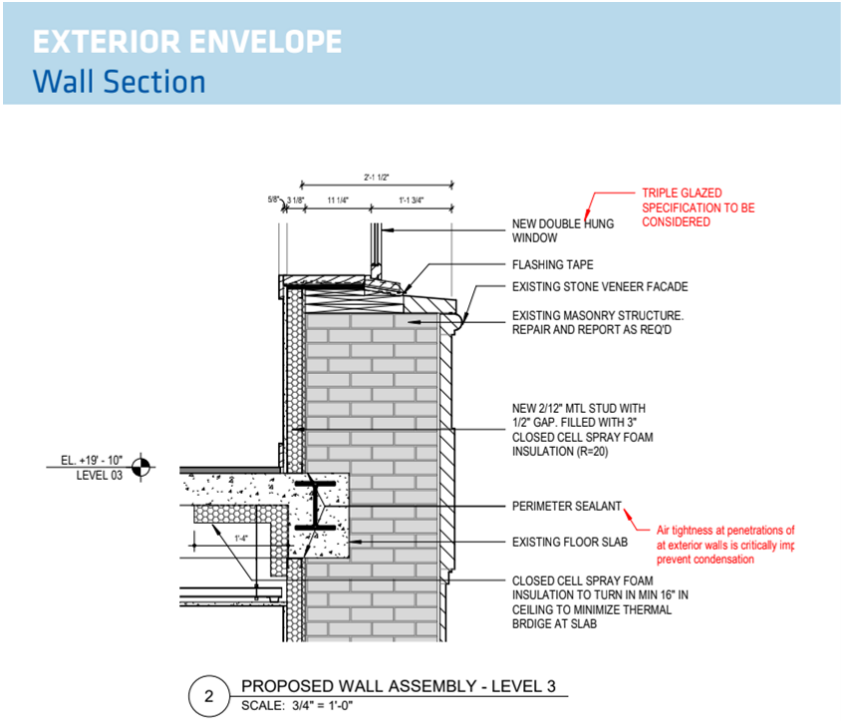
CONFLICTING INTERESTS IN BUILDING RETROFITS

THE CASE OF HARTLEY HALL



HARTLEY HALL, TYPICAL BEDROOM

Columbia Housing



PROPOSED RENOVATION WALL SECTIONS

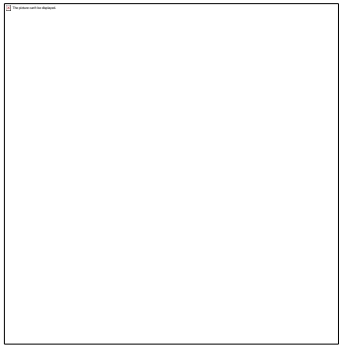
Hartley Hall Exteriors Review, 2021

CUMULATIVE LL97 FINES BY 2050

OUR SIX BUILDINGS

AVERY HALL
$8,234,558

PUPIN HALL
$34,825,161



SCHAPIRO HALL
$1,358,761

ALUMNI HALL
$2,136,273

ST. PAUL'S CHAPEL
$388,530

BUELL HALL
$553,732

OPERATING CARBON OF HISTORIC BUILDINGS ALSO MATTERS

AN URGENT NEED TO ADDRESS THESE HEAD-ON IN THE FIELD WITH ACTION

The greenest building is the one that is already built AND UNDERGOES A DEEP RETROFIT.

SAVE OUR HERITAGE ORGANISATION'S PRESIDENT'S MONTHLY MESSAGE

Save Our Heritage Organisation