

# A Tech Rescue for Tired Buildings

Moderator:

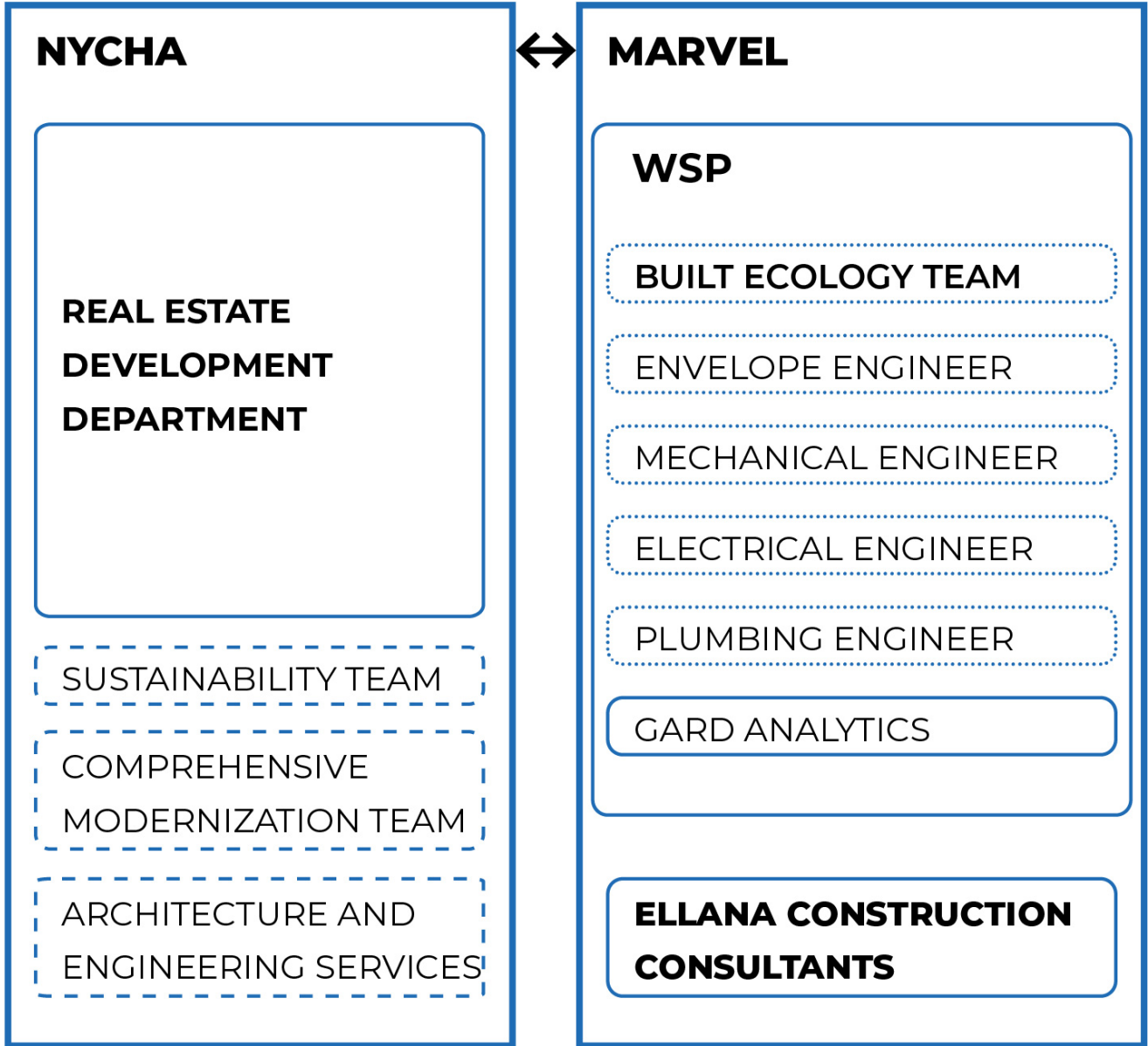
**Steve Jones**, *Sr. Director, Industry Insights Research,*  
Dodge Data & Analytics

**Rebecca Fitzgerald**, *Sr. Design Program Manager, Asset & Capital  
Management/Real Estate Development, New York City Housing Authority*

**Narada Golden**, *Sr. Vice President, WSP*

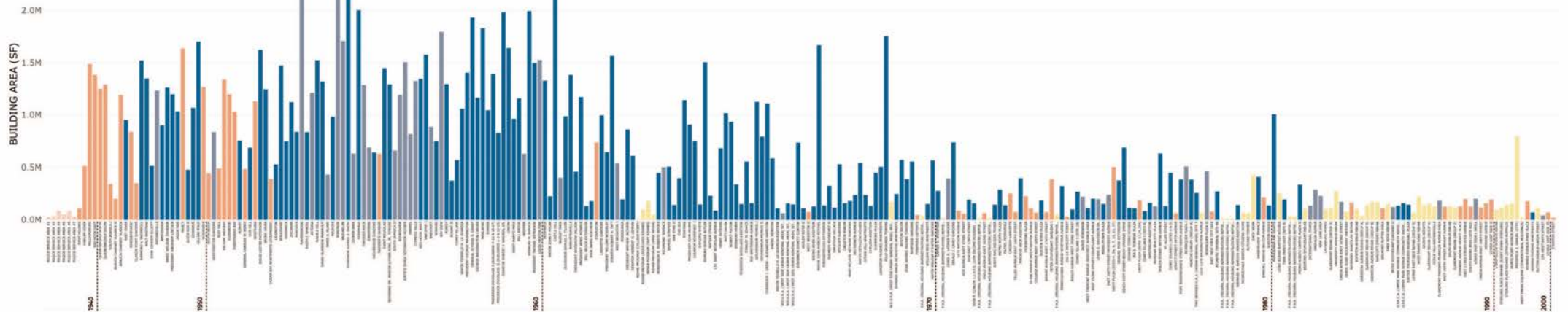
**Luba Valkova**, *Architect, MARVEL*

# Meet the Team



# THE CHALLENGE

The New York Housing Authority (NYCHA) manages **335 developments**, housing over **530,000 residents** - a population larger than that of Sacramento or Atlanta.



NYCHA sites classified by building floor area

# Chelsea Houses, Manhattan

High Rise



# Stebbins Ave-Hewitt Place, Brooklyn

Low Rise

## ✘ Watertightness



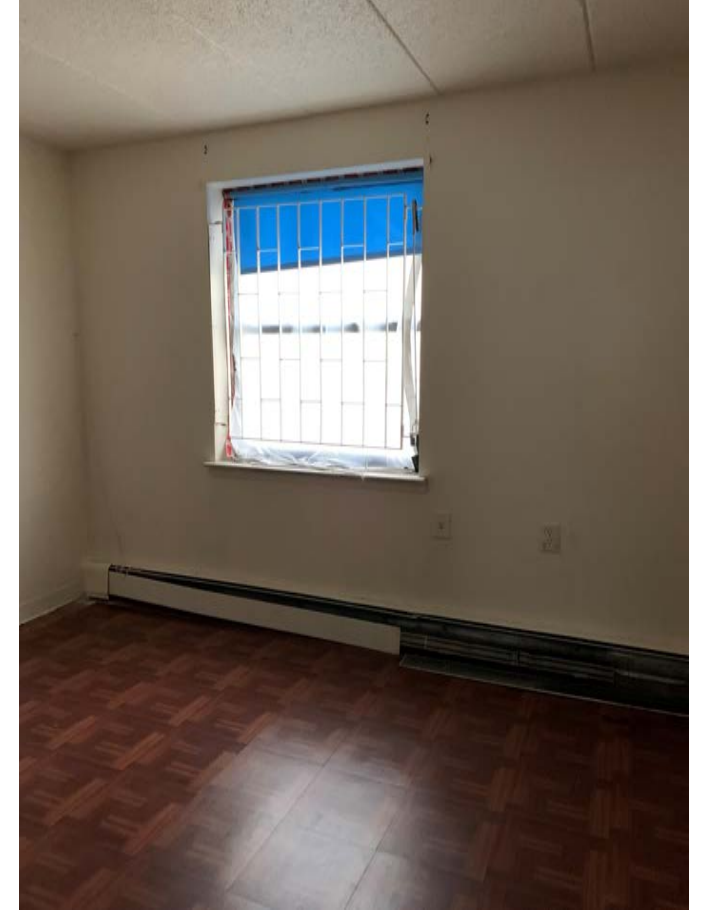
Recurrent water infiltration damage and repairs, particularly at acquired buildings

## ✘ Airtightness



Leaky windows exacerbated by unused, unsealed through-wall AC penetrations

## ✘ Durability



Maintenance difficulties with typical fin-tube radiators

## ✘ Monitoring



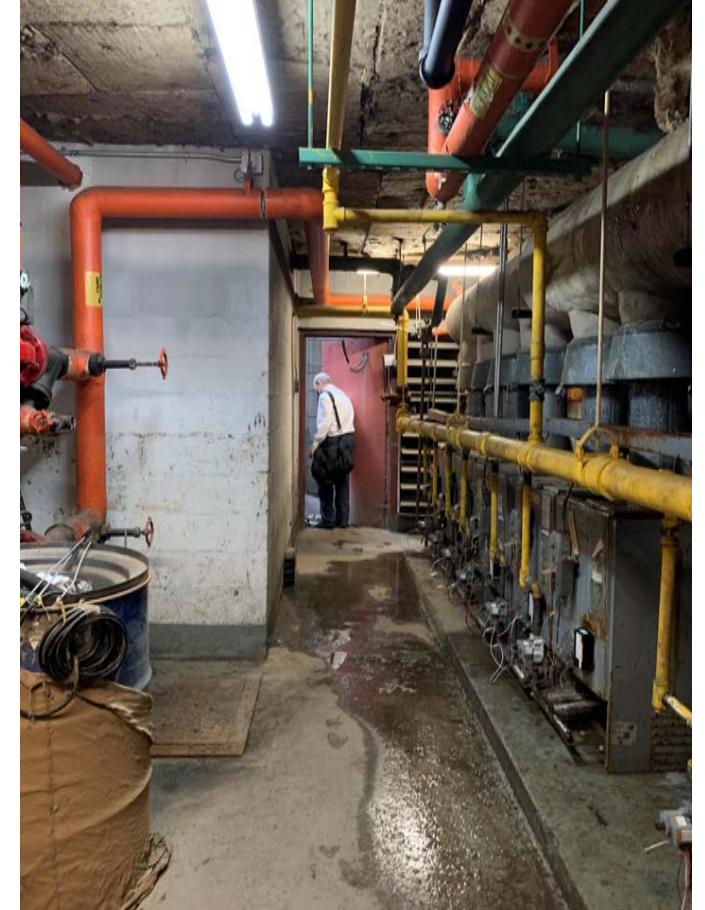
Exposed bus bars with risers arranged to serve multiple apartments preclude submetering

## ✘ Control



Steam boiler system runs year-round to provide hot water in addition to seasonal heating

## ✘ Resiliency



Evidence of major flooding on wall adjacent to open flame gas-fired boilers

As of 2017, the Physical Needs Assessment conducted by NYCHA estimated **\$45.2 billion** in costs for **repair needs**.

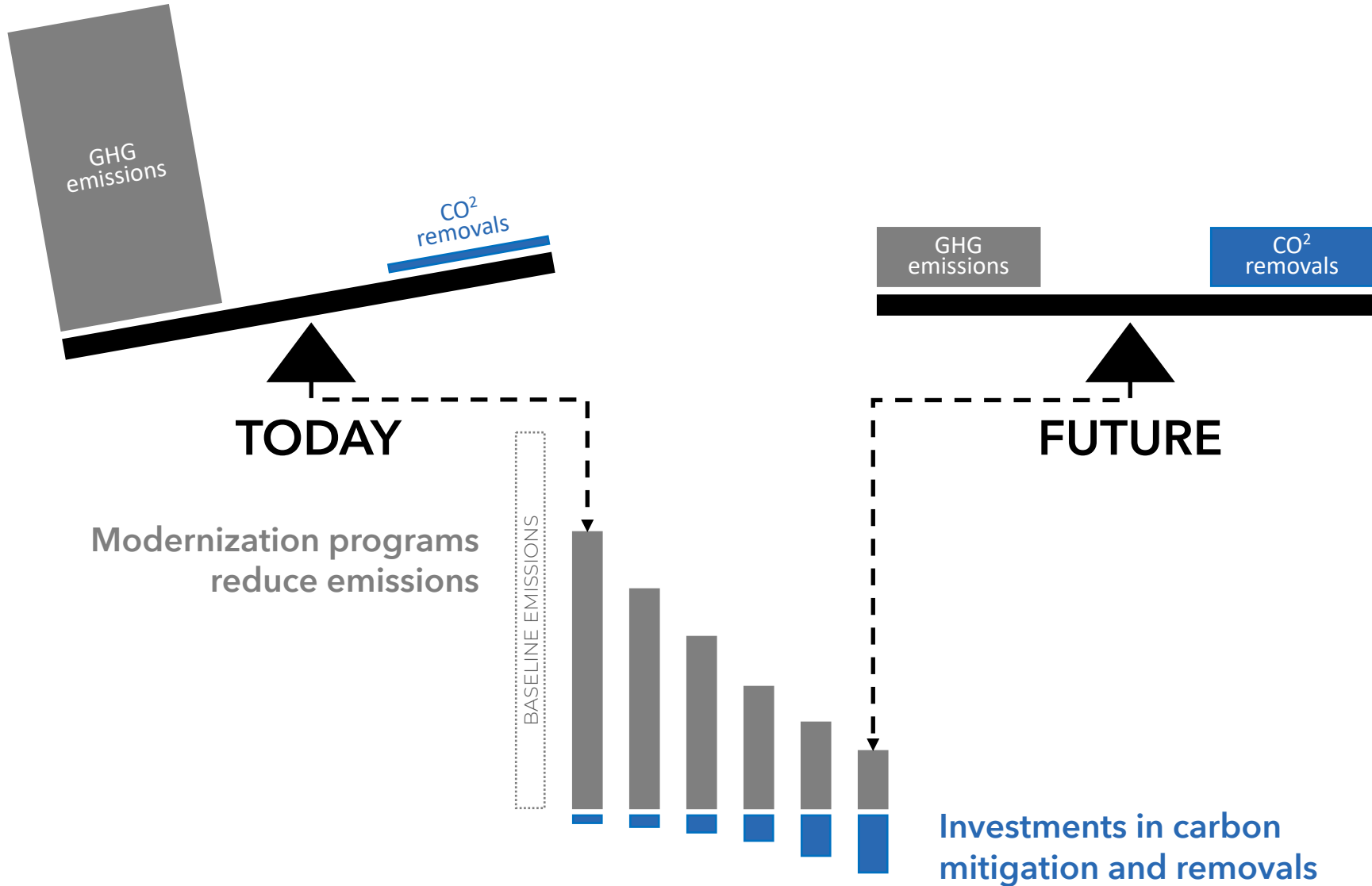


NYCHA is on the path to taking on one of the biggest **decarbonization initiatives** in the country.

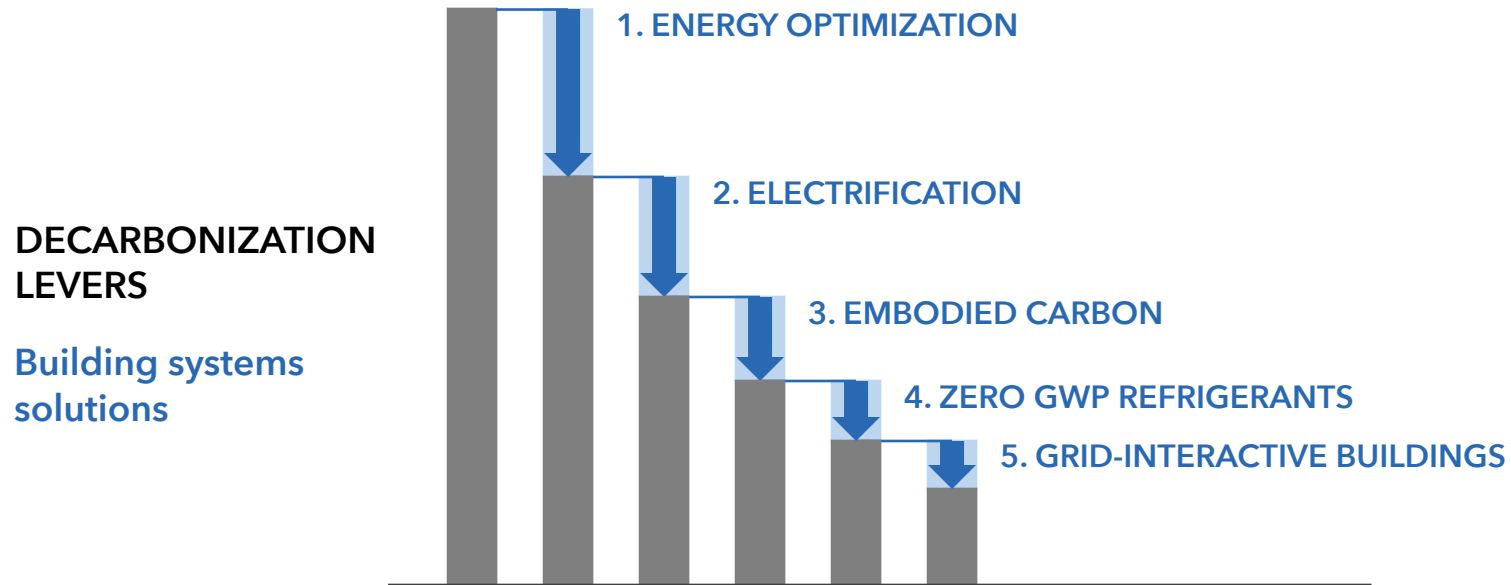
There are several Departments that work to implement decarbonization efforts across various programs: including **Real Estate, Comprehensive Modernization, Sustainability, and Architecture & Engineering Services.**



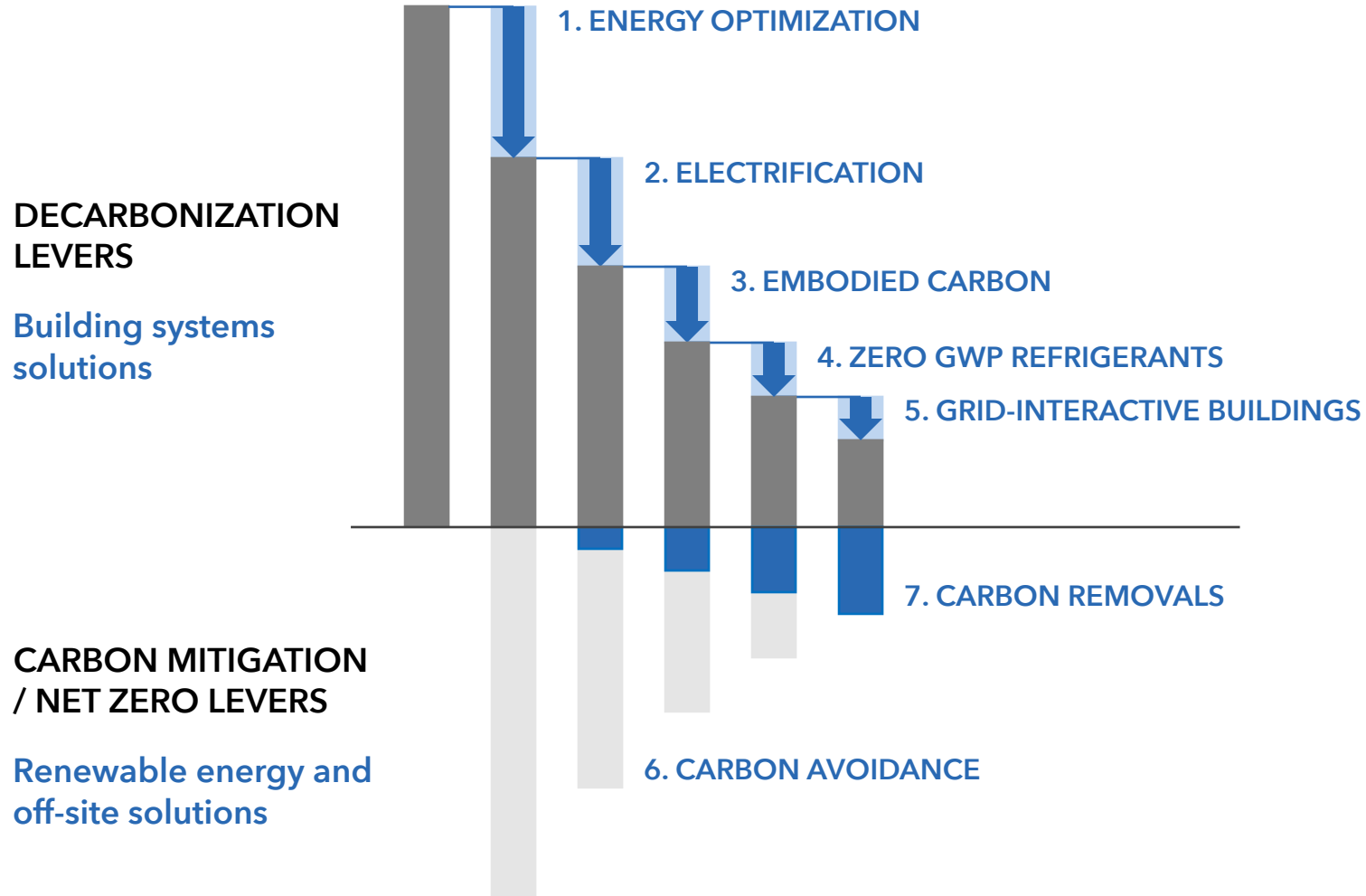
Investments in **long-term building decarbonization** are important for **achieving interim targets** and advancing the journey to Net Zero emissions.



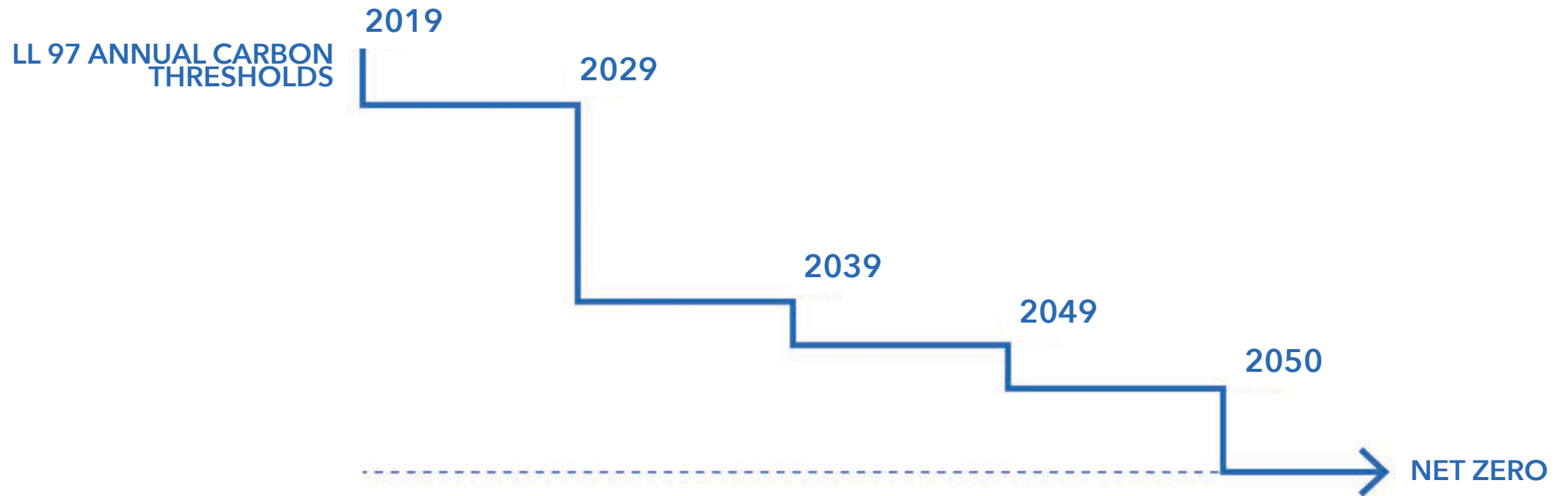
# The five levers for decarbonizing buildings start with energy optimization and electrification.



The five levers for decarbonizing buildings start with **energy optimization and electrification**. Additional off-site solutions are required to achieve Net Zero carbon.



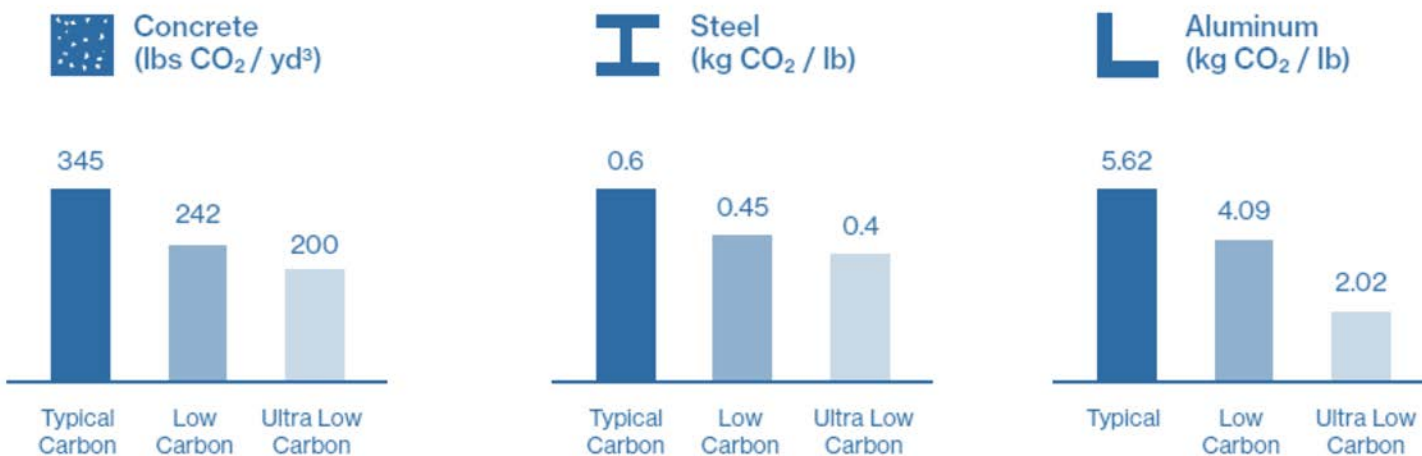
New York City's **Local Law 97** of 2019 is one of the first laws of its kind to require existing buildings to measure and reduce carbon emissions.



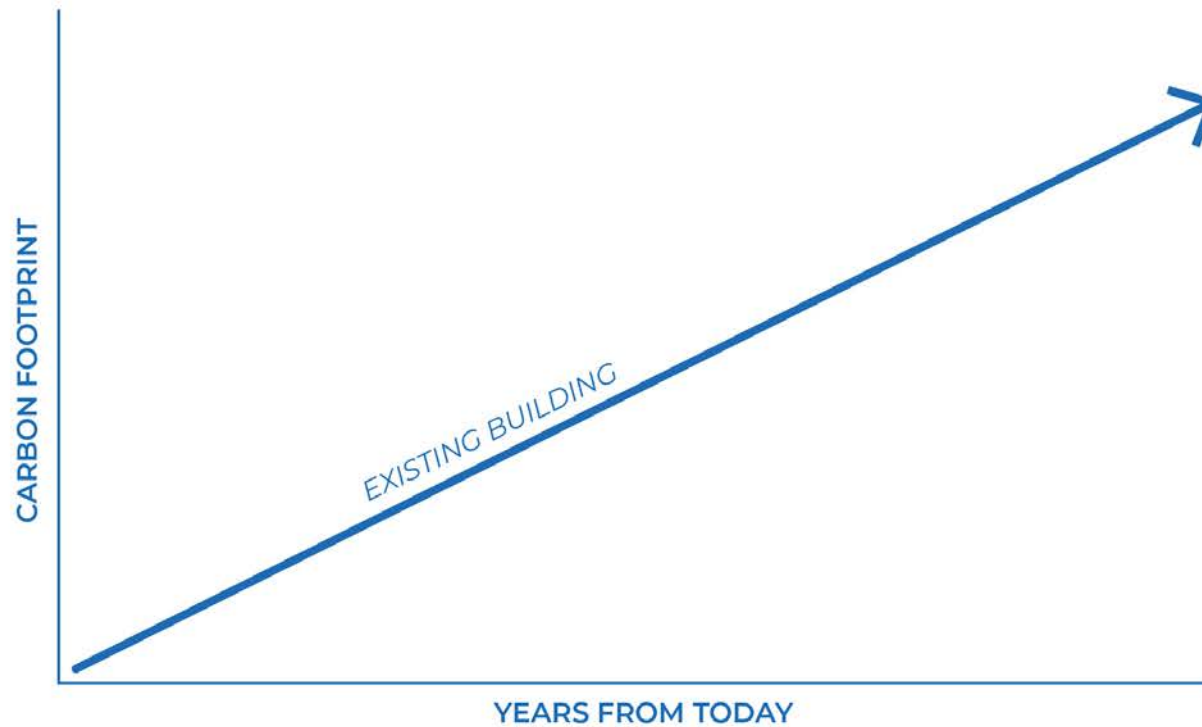
Other cities with Building Performance Standards include Boston, Washington DC, Seattle, Denver, St. Louis, and more.

As part of its **2023 Sustainability Action Plan: PlaNYC**, New York City adopted embodied carbon targets in addition to the operational carbon targets.

#### EMBODIED CARBON RANGES FOR SELECTED CONSTRUCTION MATERIALS

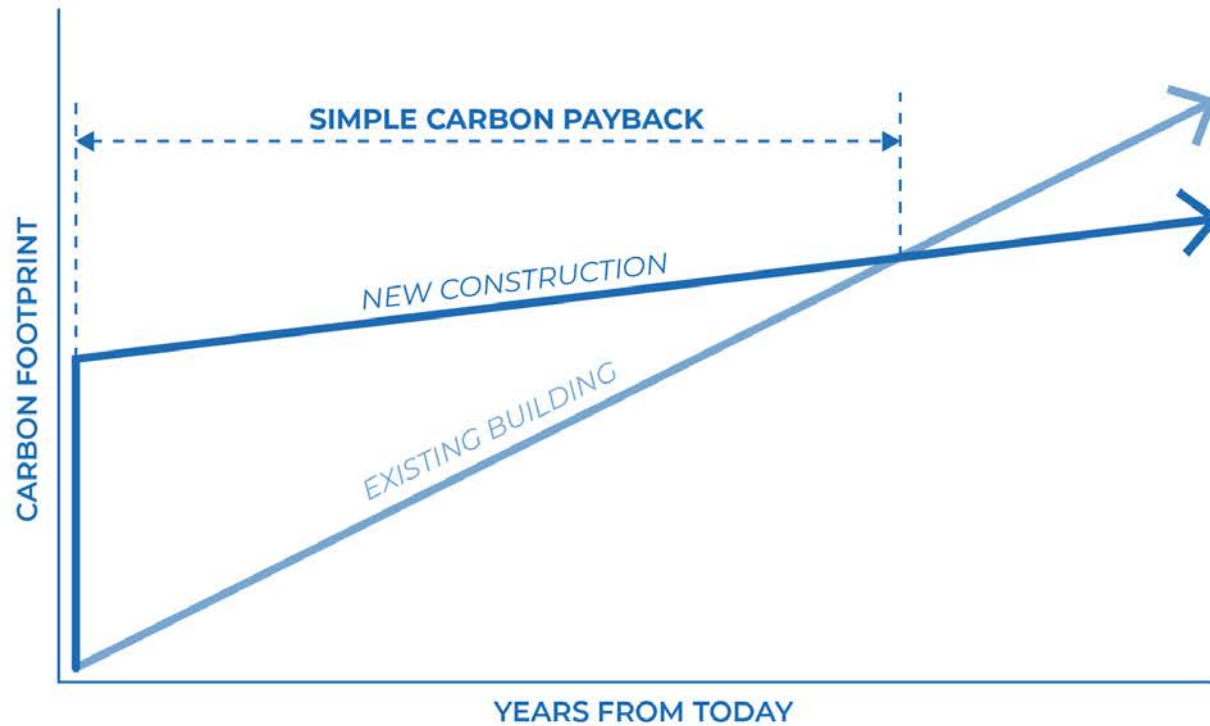


Building retrofits are the only path forward that meet both operational and embodied carbon targets.

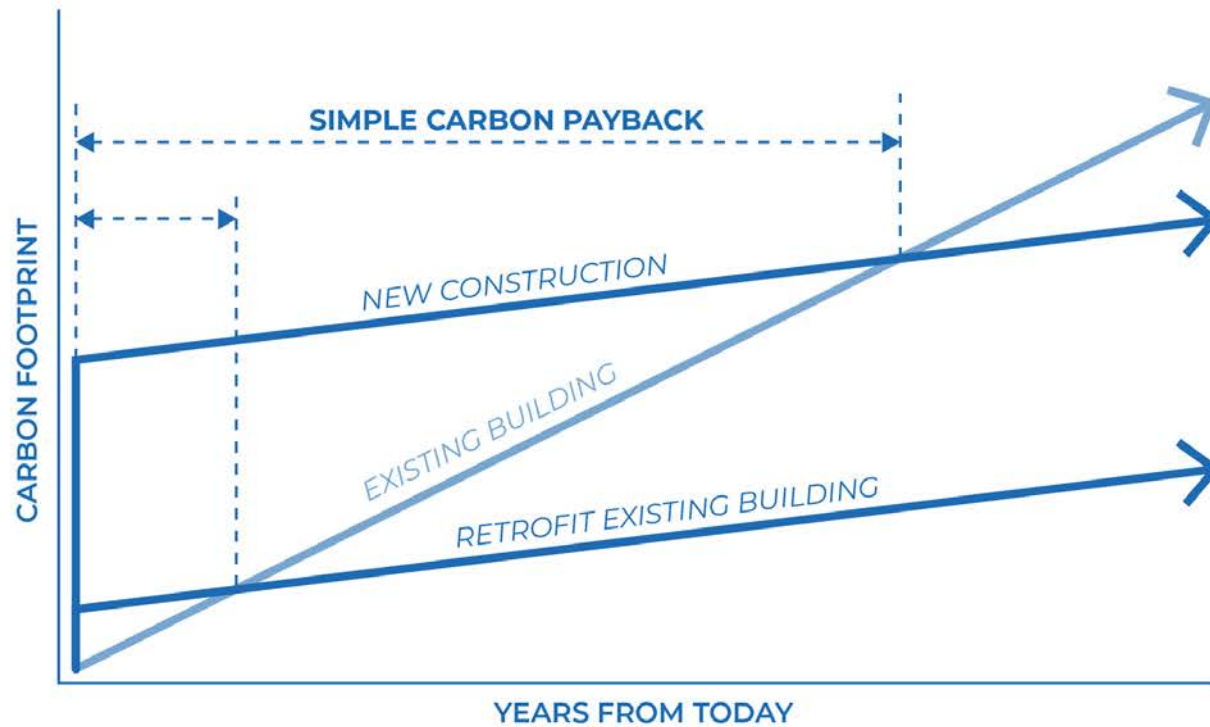




Building retrofits are the only path forward that meet both operational and embodied carbon targets.



Building retrofits are the only path forward that meet both operational and embodied carbon targets.



This boiler upgrade is **34% more costly** than upgrading all apartments to PTHP units and consumes up to **82% more energy**.

*Our data shows that NYCHA can't afford to replace in kind. Every dollar spent on critical repairs can double as an energy conserving measure.*



Example of existing boilers at Chelsea Houses



Example of upgraded boilers at Baychester Houses

What does **whole building energy modeling** look like **today**?

- ✘ Complicated process led by consultants
- ✘ Each building analyzed individually
- ✘ Limited opportunity for iteration
- ✘ Results take too long to generate

**335 developments**

x **100+ days** traditional energy modeling per building

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**171.8 years** to evaluate the NYCHA portfolio  
using a traditional approach

When owners ask “what would it take to model this project” the answer is often something like...

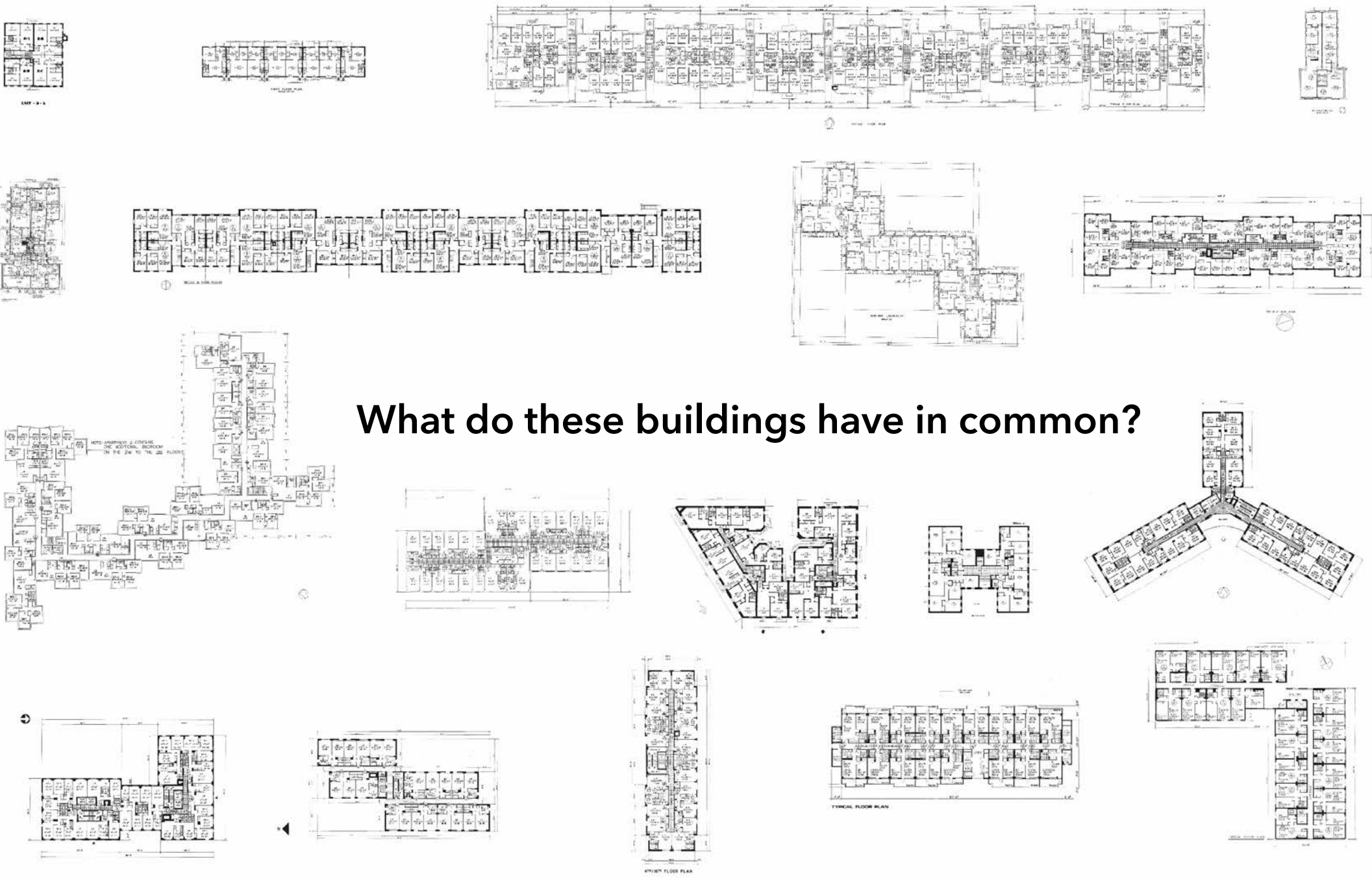
**“Eight weeks and \$80,000”**

*Owners and developers need another way to make smart decisions about building performance.*



A blue-tinted photograph of a building facade. The image is slightly out of focus. In the center, the words "THE PROCESS" are written in white, bold, uppercase letters. Above and below the text are two rectangular windows with white frames. To the right, a dark doorway is visible. The overall mood is calm and professional.

# THE PROCESS



What do these buildings have in common?

## Source Data:

### 18 Case Study Developments

- Construction drawings
- Documentation of replacements and upgrades
- Utility usage data
- Site visits

### NYCHA Property Directory

- Data such as height, number of buildings, floor area, construction year, etc.



# We studied two types of parameters:

Those which may impact **energy performance**

Those which may impact **feasibility of various interventions**

Parameters

Sort	Name of Development	NYCHA Typology Designation	Geometry Type	Geometry Notes	Development Uniformity	Stacked Geometry	Stories	Overall Building Height (ft)	Typ. Floor to Floor Height (ft)	Building Area (sf)	Typ. Floor Plate Area (sf)	Floor Plate Depth (ft)	Perimeter (ft)	Perimeter Irregularity	Envelope Area (sf)	Typ. Floor Window Area (sf)	Total Window Area (sf)	Approx. Total Window Area (sf)	Window Area Approximation Error	IWR at Typ. Floor	IWR	IWR Approximation Error	Typ. Window Area to Floor Area	Envelope Area to Building Area	Roof Area to Envelope Area	Volume (cu ft)	Median EUI (kBtu/sf)
1	Manhattanville	High-Rise	Tower	Tower, (3) linear bars radiating from axis	Y	Y	20	172	8.58	202,250	10,113	37.25	769.33	125%	142,437	1,343	27,051	26,854	-0.73%	20%	20%	-0%	13%	70%	7%	1,739,350	122.55
2	Chelsea Houses	High-Rise	Tower	Tower	N	Y	21	180	8.58	193,893	9,233	53.00	505.00	111%	100,133	990	20,521	20,793	1.32%	23%	23%	1%	11%	52%	9%	1,661,940	137.93
3	Boston Road Plaza	High-Rise	Tower	Tower with cantilevers at top	Single Building	N	20	171	8.56	165,796	7,451	51.70	465.50	119%	97,875	1,016	23,835	20,316	-14.76%	25%	27%	-7%	14%	59%	8%	1,371,074	148.25
4	Corsi Houses	High-Rise	Tower	Tower on a base	Single Building	N	16	146	8.54	105,560	6,921	45.16	407.65	103%	77,697	738	11,662	11,807	1.24%	21%	20%	4%	11%	74%	9%	923,067	177.96
5	Twin Parks East	High-Rise	Linear	Linear with balconies	Single Building Stacked	Y	14	124	8.67	158,603	11,329	56.33	526.42	102%	76,605	1,030	14,423	14,423	0.00%	23%	22%	2%	9%	48%	15%	1,404,765	74.04
6	Upaca (Site 5)	High-Rise	Tower	Tower, L-shaped	Single Building Stacked	Y	11	100	8.88	151,547	13,777	60.83	662.00	115%	79,977	1,300	14,302	14,302	0.00%	22%	22%	2%	9%	53%	17%	1,377,700	83.84
7	Breukeien	Slab	Linear	Linear, zig zag	Y	Y	7	60	8.63	60,938	8,705	30.88	668.00	107%	49,006	1,196	8,336	8,372	0.43%	21%	21%	0%	14%	80%	18%	525,197	28.56
8	Metro North Plaza	Slab	Linear	Linear	N	Y	11	97	8.58	123,937	11,267	53.50	651.00	123%	74,629	1,285	13,203	14,131	7.03%	23%	21%	10%	11%	60%	15%	1,096,617	129.69
9	Davidson	Slab	Irregular	Irregular	Single Building	N	8	70	8.54	181,350	24,125	50.00	1556.25	146%	103,548	3,227	23,254	25,816	11.02%	24%	21%	14%	13%	57%	23%	1,572,976	149.43
10	Garvey (Group A)	Slab	Linear	Linear, staggered	N	Y	6	53	8.58	59,441	9,907	52.67	489.00	102%	35,946	839	4,681	5,035	7.57%	20%	18%	11%	8%	60%	28%	527,539	31.61
11	First Houses	Low-Rise	Linear	Detached cubes	N	Y	5	47	9.33	14,070	2,814	55.00	212.00	100%	12,831	431	2,155	2,155	0.00%	22%	22%	1%	15%	91%	22%	132,962	99.33
12	Clason Point Gardens	Low-Rise	Linear	Linear with pitched roofs	Y	Y	2	21	8.25	7,068	3,534	26.00	324.00	100%	10,338	-	770	-	-	-	14%	-	11%	146%	34%	74,214	188.45
13	Stuyvesant Gardens I	Low-Rise	Irregular	Linear, irregular	Y	Y	4	36	9.00	124,676	31,169	53.50	1788.00	141%	95,233	3,020	12,080	12,080	0%	19%	19%	-0%	10%	76%	33%	1,116,785	52.3
14	Stebbins Avenue-Hewitt Place	Low-Rise	Linear	Linear	Y	Y	3	27	8.75	72,507	24,169	54.33	1153.50	116%	55,314	2,569	7,109	7,707	8.41%	25%	23%	12%	10%	76%	44%	652,563	115.42
15	Hunts Point Ave Rehab	Acquired Low-Rise	Tenement	Tenement with airwells, attached, T-shape	Y	Y	4	39	9.66	9,592	2,398	NA	229.00	117%	11,253	424	1,649	1,694	2.76%	19%	19%	3%	18%	117%	21%	92,731	215.84
16	West Farms Square Conventional	Acquired Low-Rise	Tenement	Tenement with airwells, attached, O-shaped	Y	Y	5	50	10.00	17,365	3,473	NA	305.75	130%	18,761	423	2,115	2,114	-0.06%	14%	14%	-0%	12%	108%	19%	173,650	146.96
17	Taft Rehab	Acquired Low-Rise	Tenement	Tenement with airwells, corner lot	Y	Y	7	79	10.67	75,226	10,747	NA	725.00	175%	68,022	1,401	8,957	9,809	9.51%	18%	16%	16%	13%	90%	16%	848,980	118.29
18	Bedford-Stuyvesant Rehab	Acquired Low-Rise	Tenement	Tenement with airwells, attached, I-shape	Y	Y	6	62	10.00	31,434	5,239	NA	405.00	140%	30,349	671	3,987	4,026	0.98%	17%	16%	4%	13%	97%	17%	324,818	103.44

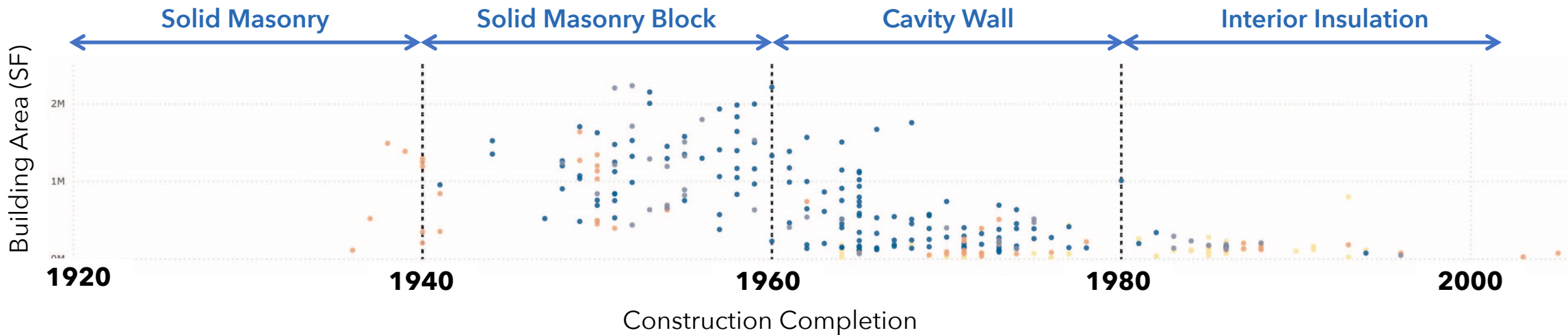
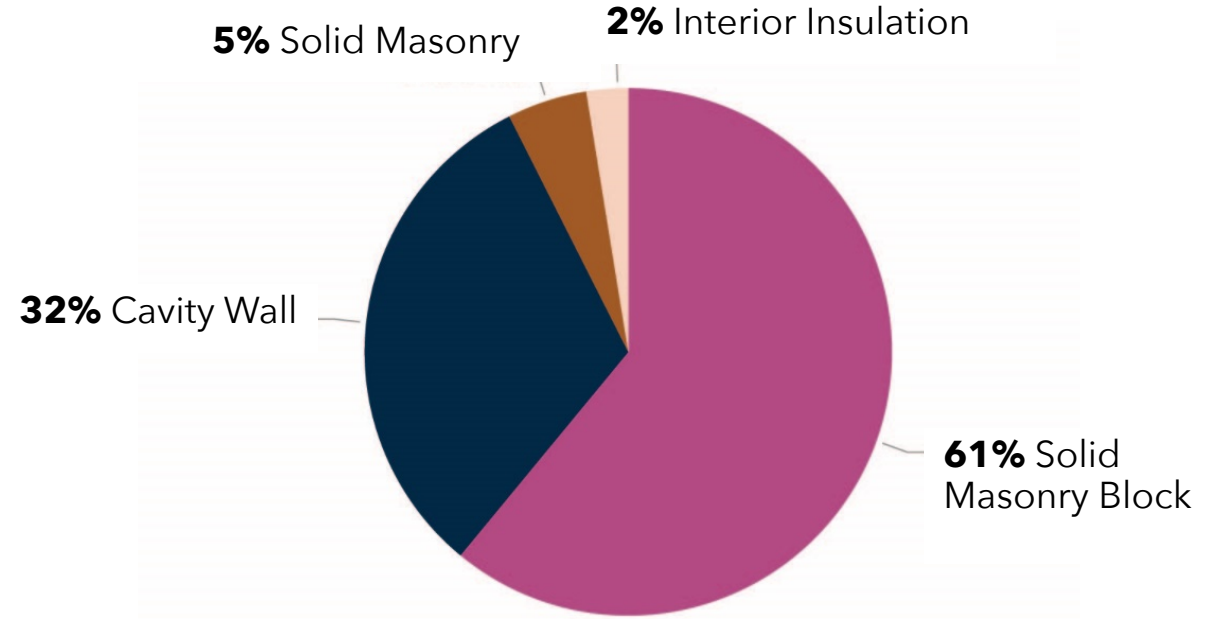
Developments

One of a few analysis tables generated from the 18 case studies.

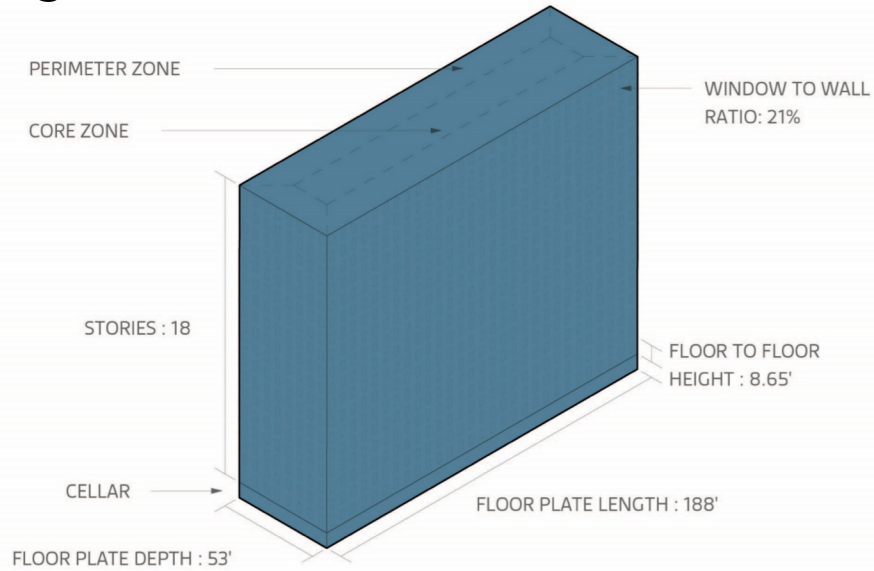
For example, 98% of NYCHA building stock has uninsulated wall construction.

**TPOLOGY**

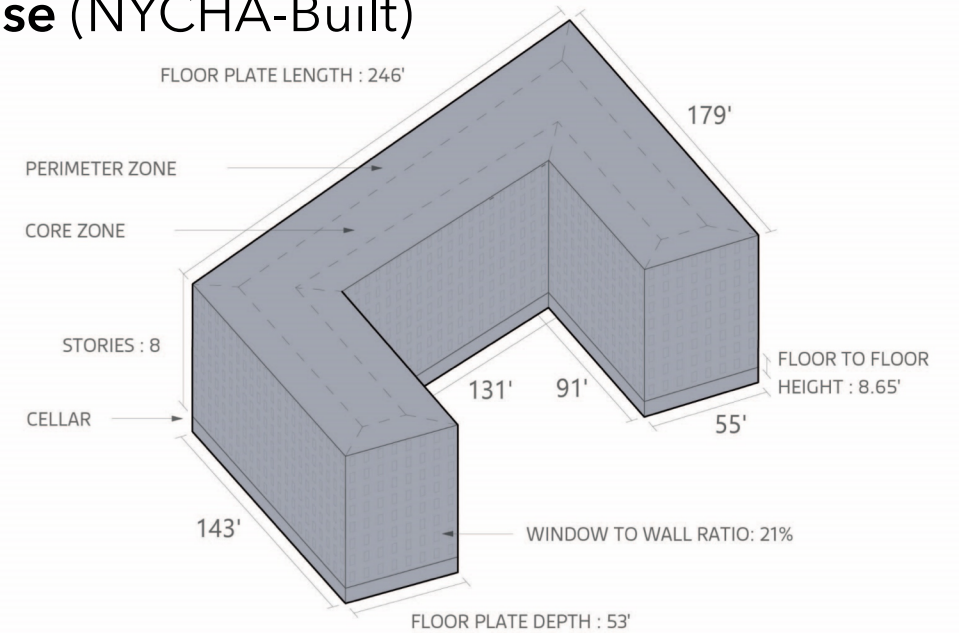
- High-Rise
- Slab
- Low-Rise
- Acquired Low-Rise



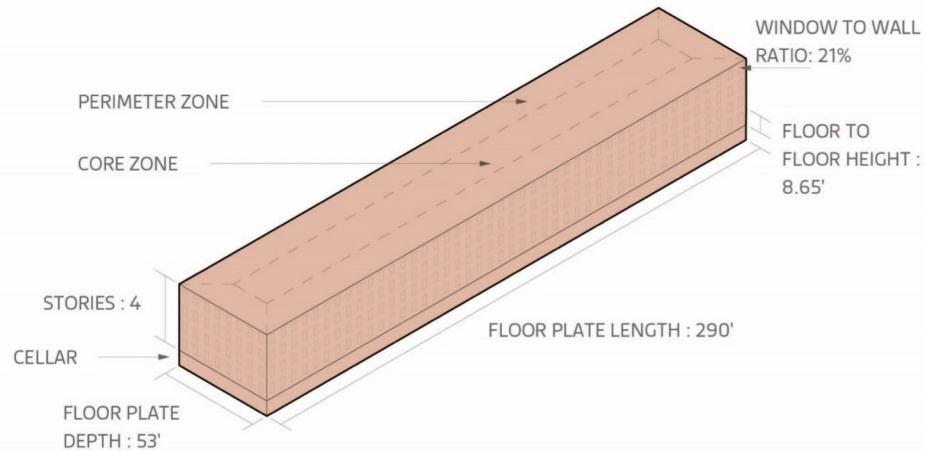
## High Rise (NYCHA-Built)



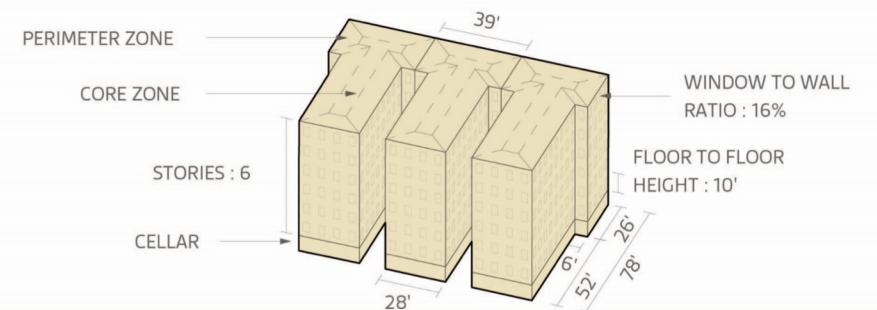
## Mid Rise (NYCHA-Built)



## Low Rise (NYCHA-Built)

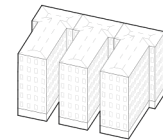
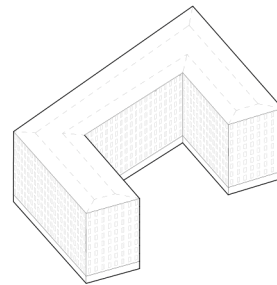
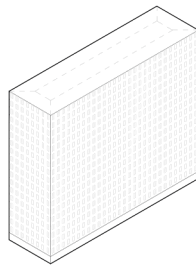
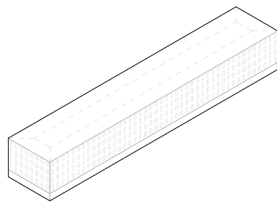
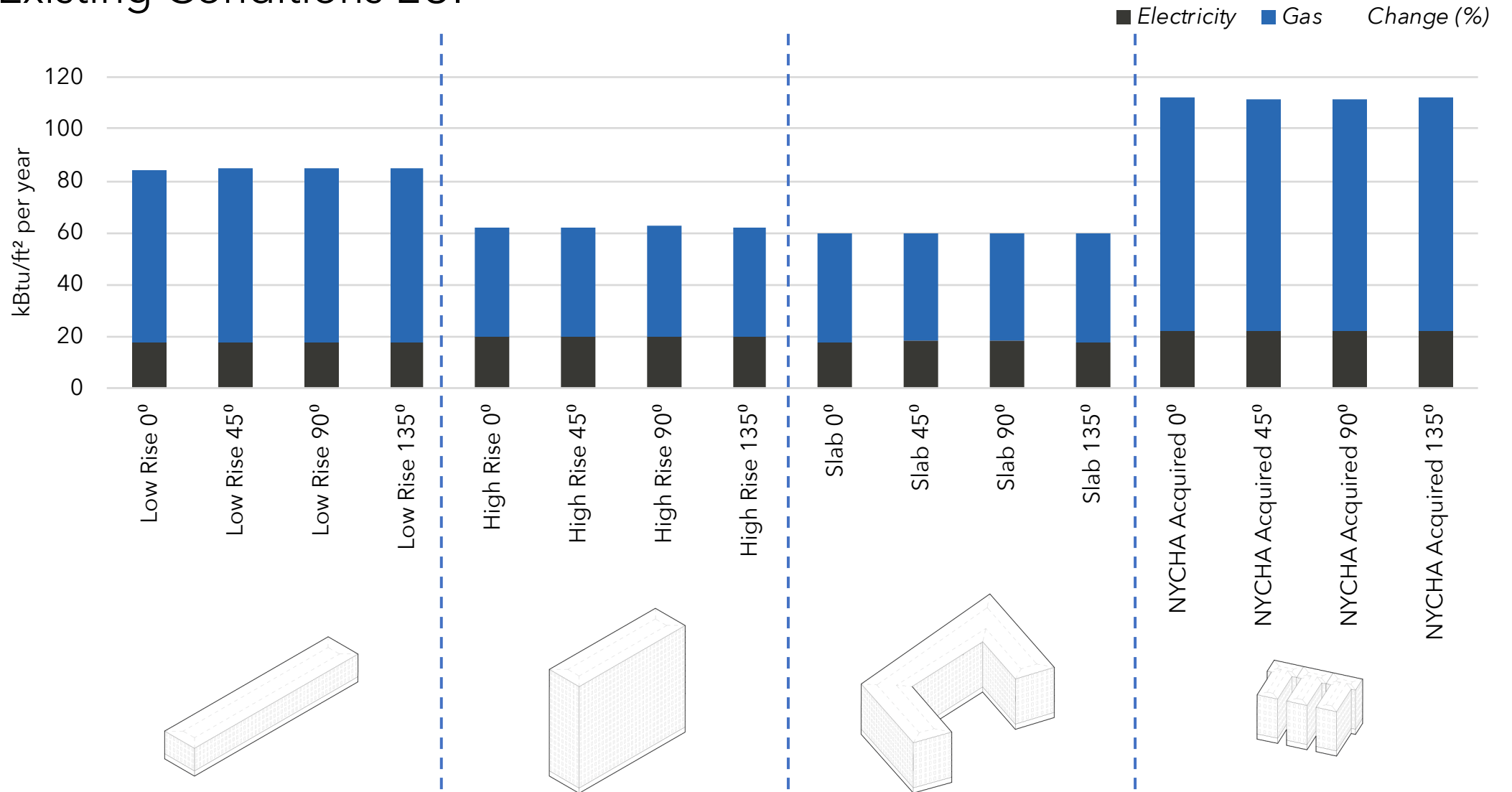


## Low Rise (Acquired)



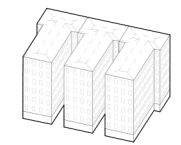
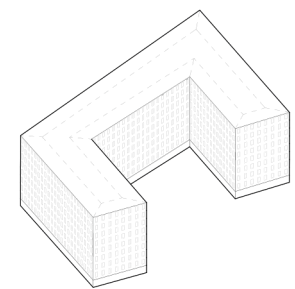
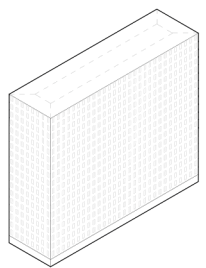
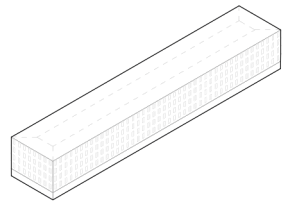
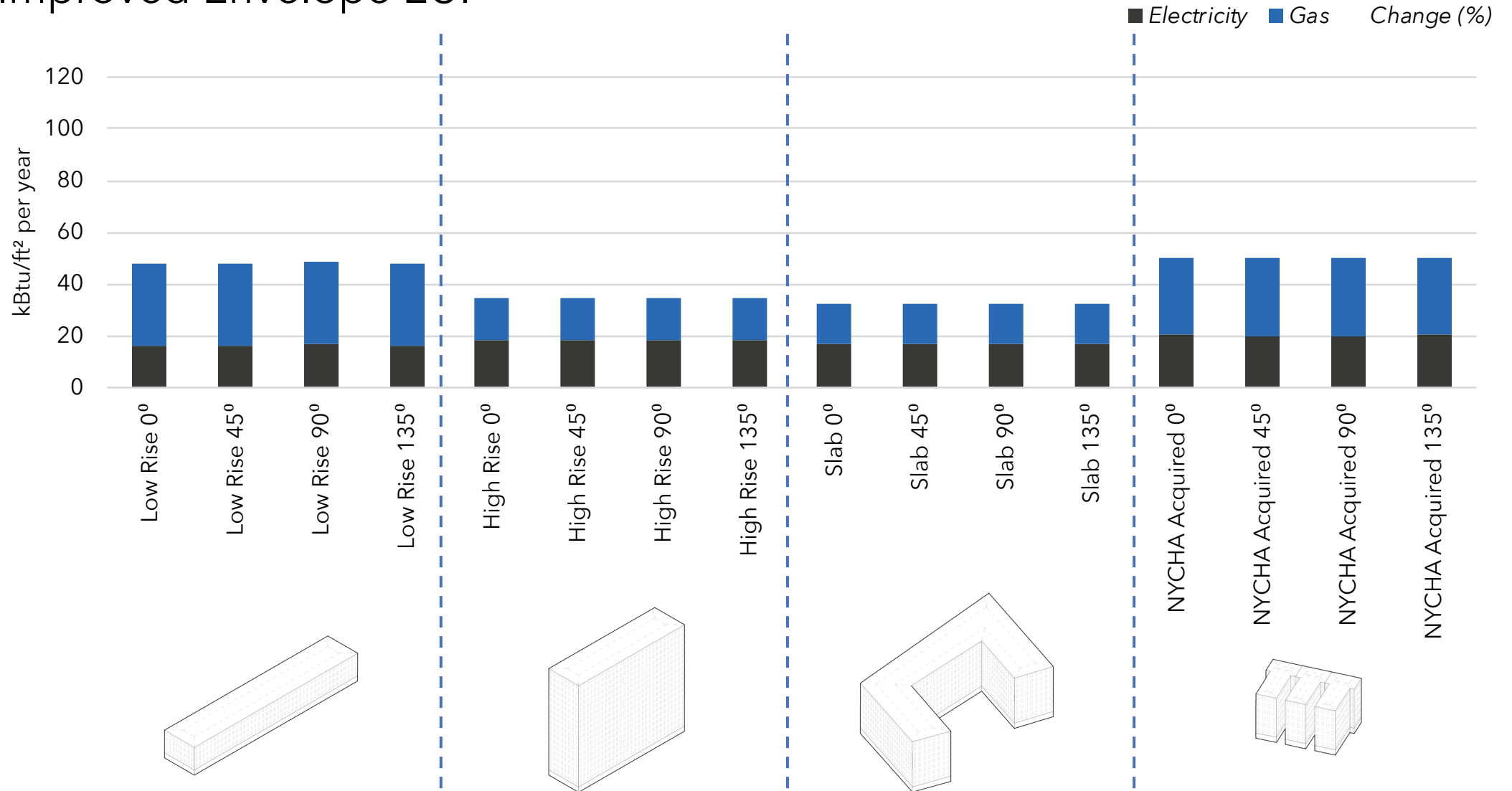
# Typology Sensitivity Study

## Existing Conditions EUI

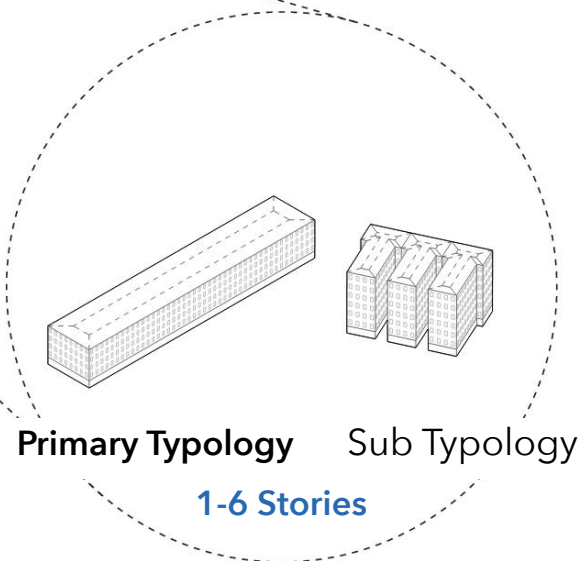
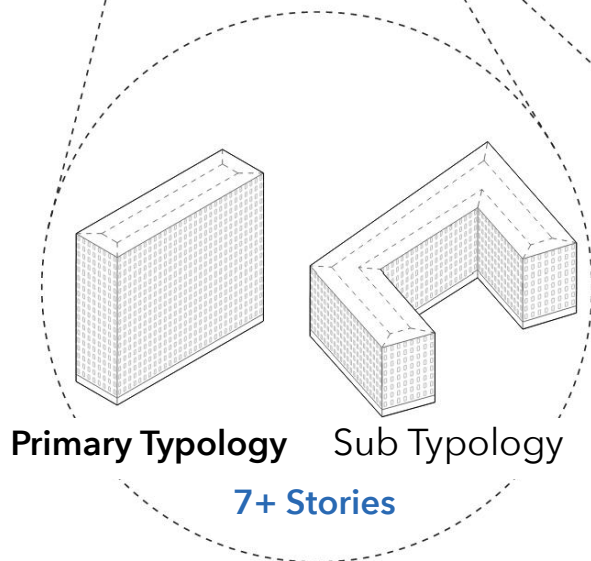
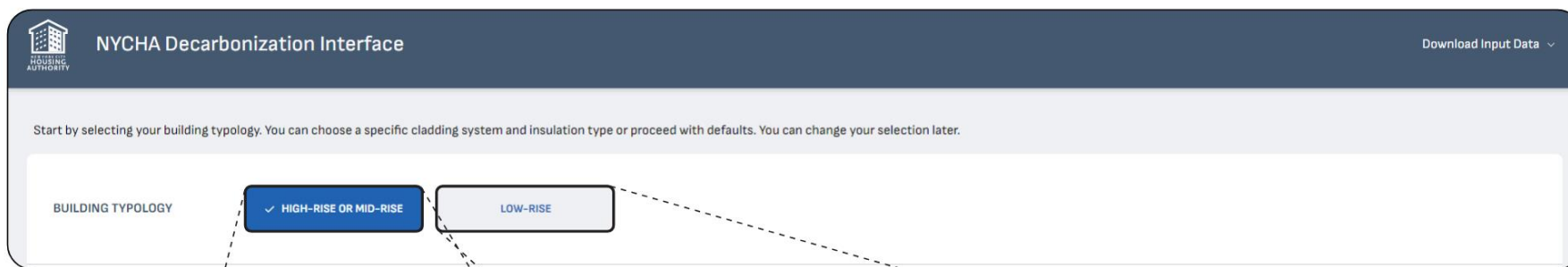


# Typology Sensitivity Study

## Improved Envelope EUI



Every one of NYCHA's buildings can be organized into **two primary typologies** and two sub-types.



# Interventions included in the study:

## Envelope

### WALL

- Existing Wall
- ~~R-4 exterior c.i.~~
- ~~R-8 exterior c.i.~~
- R-12 exterior c.i.
- ~~R-16 exterior c.i.~~
- EIFS
- Cement Board Panels
- Insulated Metal Panel
- Modular Metal Panel
- Dextall D-Wall
- ~~R-4.5 effective interior ins.~~
- R-10.5 effective interior ins.

### ROOF

- Keep Current Roof
- ~~Improve solar reflectance index (SRI) only~~
- ~~Below deck insulation~~
- Above deck insulation + improve SRI

### GLAZING

- Keep current glazing
- ~~Window insert over existing windows~~
- Dual-pane IGU
- Triple-pane/Heat mirror IGU

### WINDOW FRAMES

- Keep current frames
- Aluminum double hung
- ~~Aluminum casement~~
- Fiberglass/PVC casement\*
- ~~Fiberglass/PVC double hung~~

## SHADING

- No external shading
- ~~1 ft overhang~~
- ~~2 ft overhang~~
- ~~3 ft overhang~~

## Building Systems

### HEATING & COOLING

- Do nothing
- Boiler VFD & oxygen trim
- ~~Boiler blow-down heat recovery~~
- ~~Boiler stack economizer~~
- 100% AC
- Electric boilers
- Central VRF
- PTHP
- HPAC 2.0
- Dedicated mini-split VRF system
- Water source HP
- Ground source HP

### DOMESTIC HOT WATER

- Use building heating source for DHW
- Central fossil fuel DHW
- Central electric DHW
- Central DHW heat pump
- ~~Dedicated DHW heat pumps~~
- Dedicated electric instantaneous heaters
- ~~DHW pre-heating with condenser loop~~
- ~~Local DHW heat exchanger~~

## ON-SITE GENERATION

- No on-site generation
- Rooftop PV
- Rooftop solar hot water
- South wall BiPV
- ~~Combined heat & power (CHP)~~
- ~~Microgrid with heat recovery~~
- ~~Microturbine with heat recovery~~

## VENTILATION

- Rely on infiltration
- Central make-up air no heat recovery (HR)
- ~~Central make-up air no HR + air curtains~~
- ~~Rooftop ERV~~
- Rooftop ERV + air curtains
- ~~Façade ERV~~
- ~~Façade ERV + air curtains~~

## Fixtures/Appliances

### PLUMBING

- ~~Keep plumbing fixtures~~
- Water conserving fixtures
- VFD Pumps
- ~~Wastewater heat recovery system~~

### COOKING

- Gas range cooking
- Electric range cooking

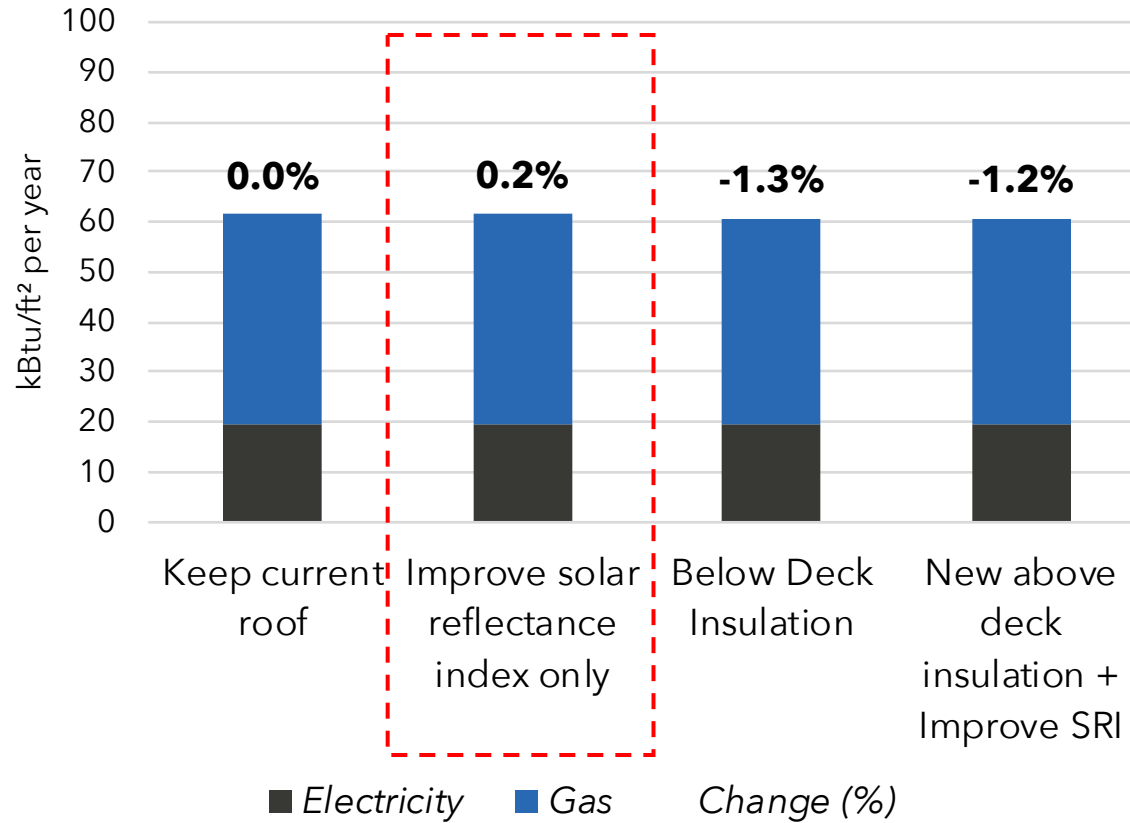
**Magenta text** = eliminated through sensitivity study results

**Orange text** = not recommended by engineering team due to feasibility and ease of implementation issues

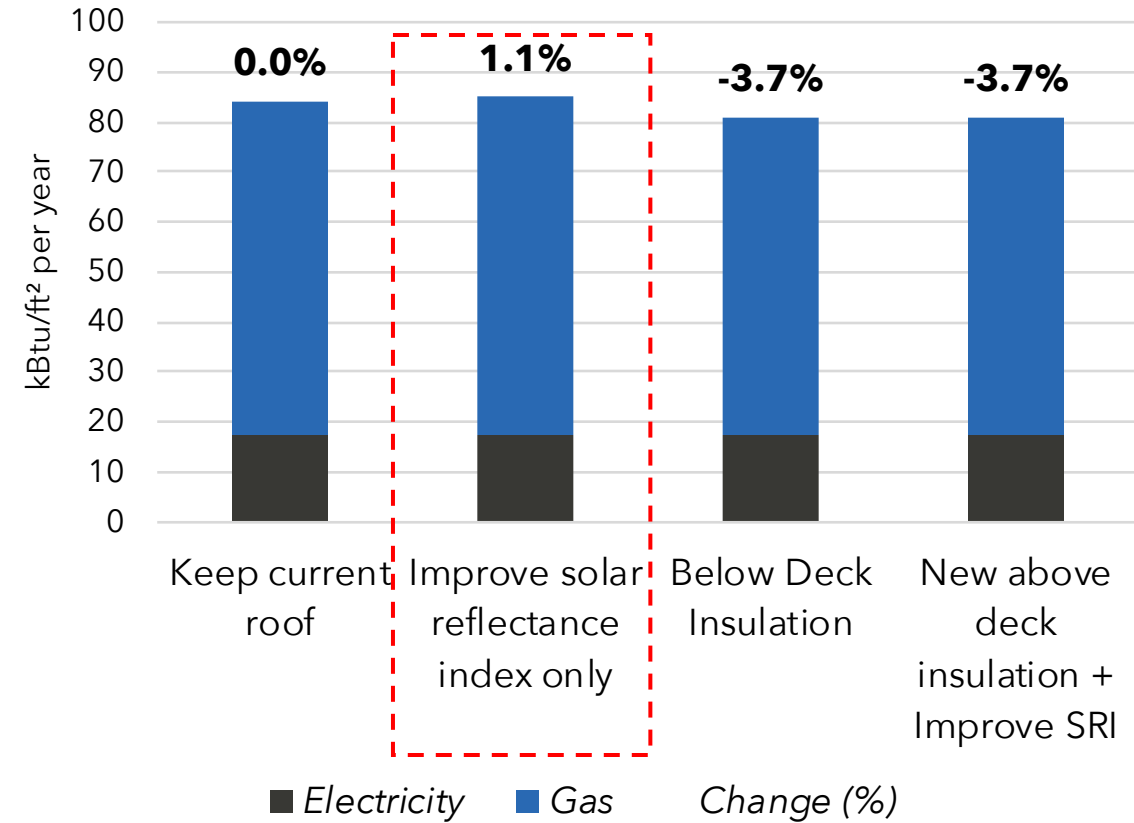
**Gray text** = "base case" (existing conditions)

# Example Sensitivity Study: Roof Interventions

## High Rise EUI



## Low Rise EUI





# Interventions Included in the NYCHA Decarbonization Interface:

## Envelope

### WALL

Existing Wall  
R-12 exterior c.i.  
EIFS  
Cement Board Panels  
Insulated Metal Panel  
Modular Metal Panel  
Dextall D-Wall  
R-10.5 effective interior ins.

### ROOF

Keep Current Roof  
Above deck insulation + improve SRI

### GLAZING

Keep current glazing  
Dual-pane IGU  
Triple-pane/Heat mirror IGU

### WINDOW FRAMES

Keep current frames  
Aluminum double hung  
Fiberglass/PVC casement\*

**Blue text** = cladding sub-options,  
web app does not support energy  
model results for these sub-  
options

**Gray text** = "base case" (existing  
conditions)

## Building Systems

### HEATING & COOLING

Do nothing  
Boiler VFD & oxygen trim  
100% AC  
Electric boilers  
Central VRF  
PTHP  
HPAC 2.0  
Dedicated mini-split VRF system  
Water source HP  
Ground source HP

### DOMESTIC HOT WATER

Use building heating source for DHW  
Central fossil fuel DHW  
Central electric DHW  
Central DHW heat pump  
Dedicated electric instantaneous heaters

### ON-SITE GENERATION

No on-site generation  
Rooftop PV  
Rooftop solar hot water  
South wall BiPV

### VENTILATION

Rely on infiltration  
Central make-up air no heat recovery (HR)  
Rooftop ERV + air curtains

## Fixtures/Appliances

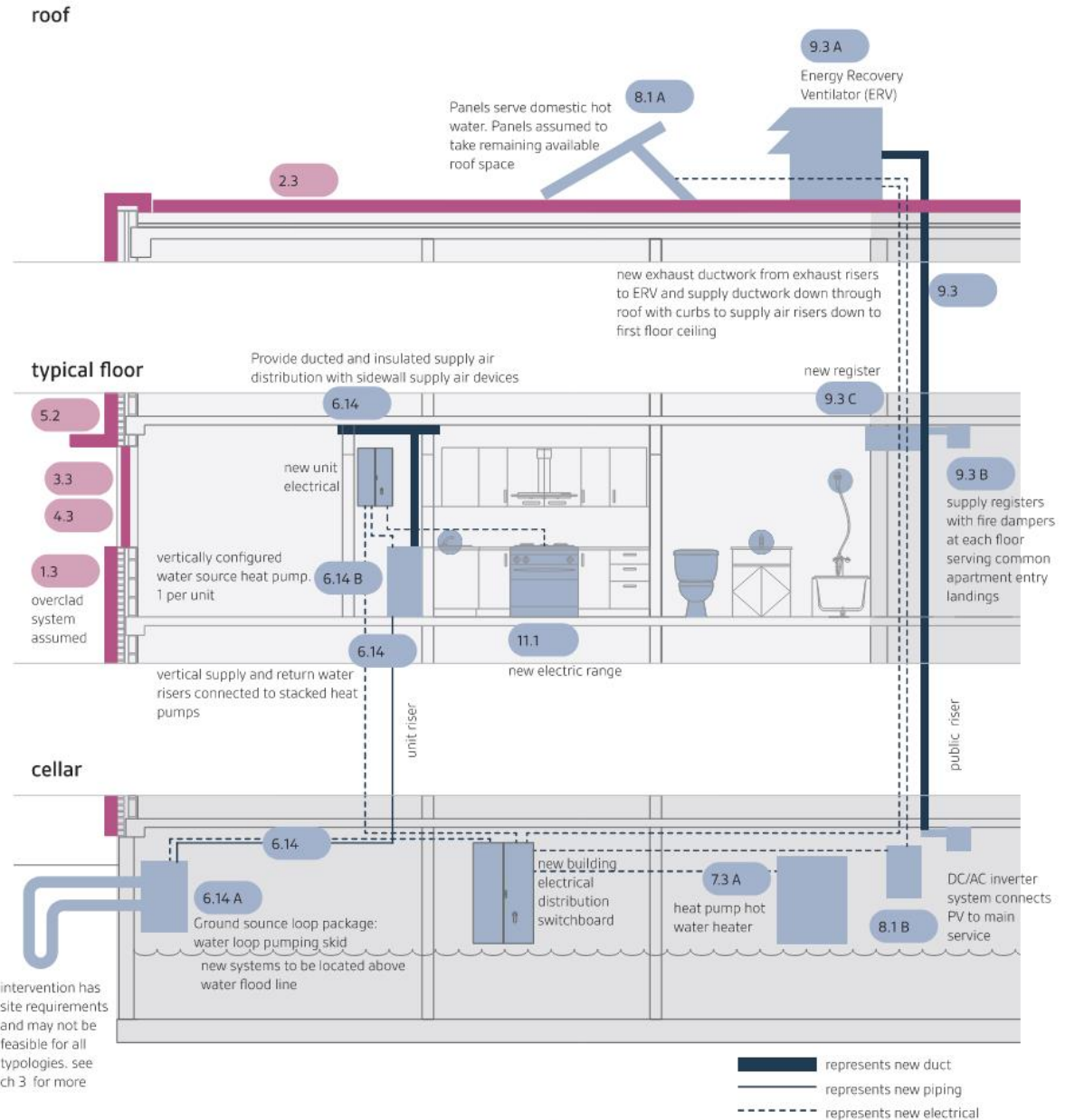
### PLUMBING

Water conserving fixtures

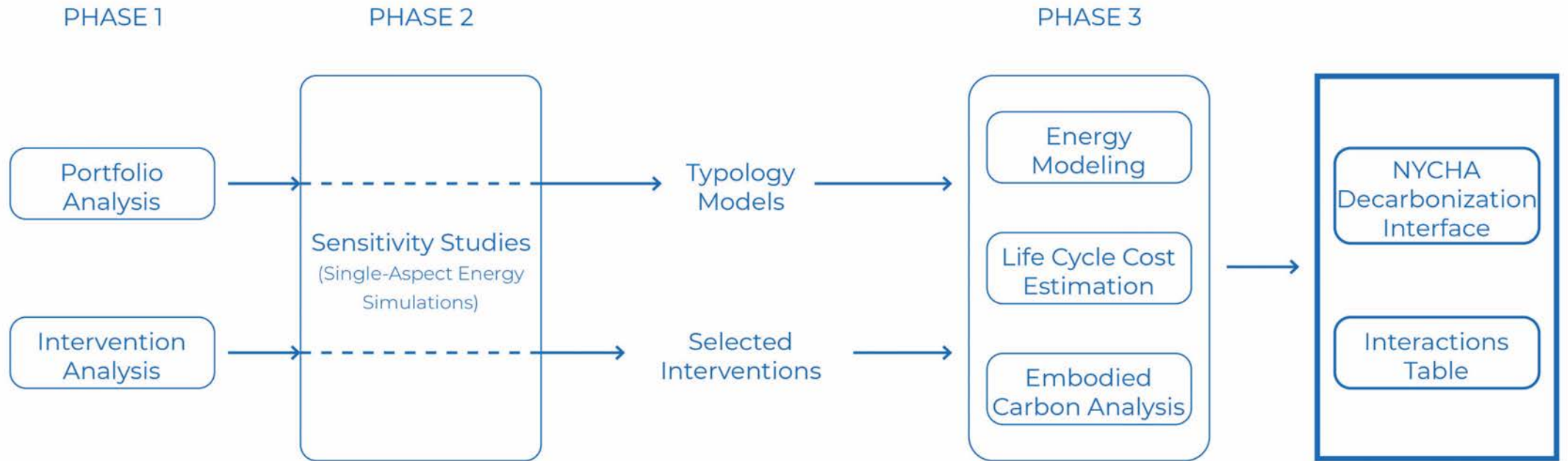
### COOKING

Gas range cooking  
Electric range cooking

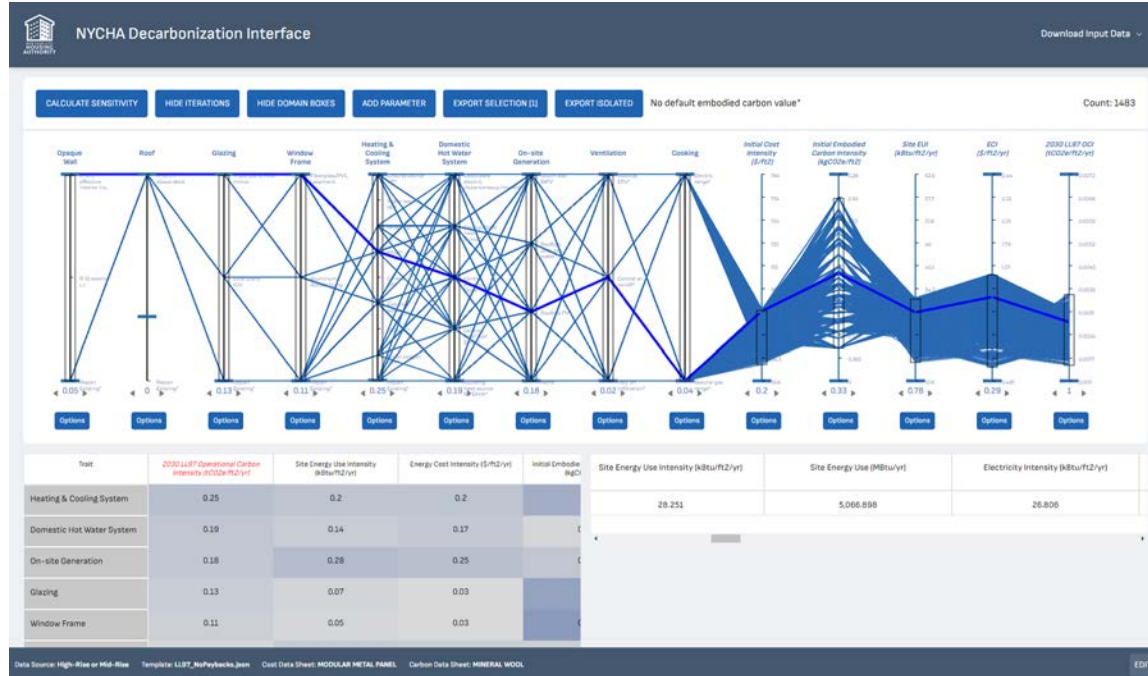
A **deep energy retrofit** with 10 energy conserving measures can lower a high-rise building's EUI from **60 kBtu/ft<sup>2</sup>/yr** to **16 kBtu/ft<sup>2</sup>/yr**.



# How did we get here?



# The Web App



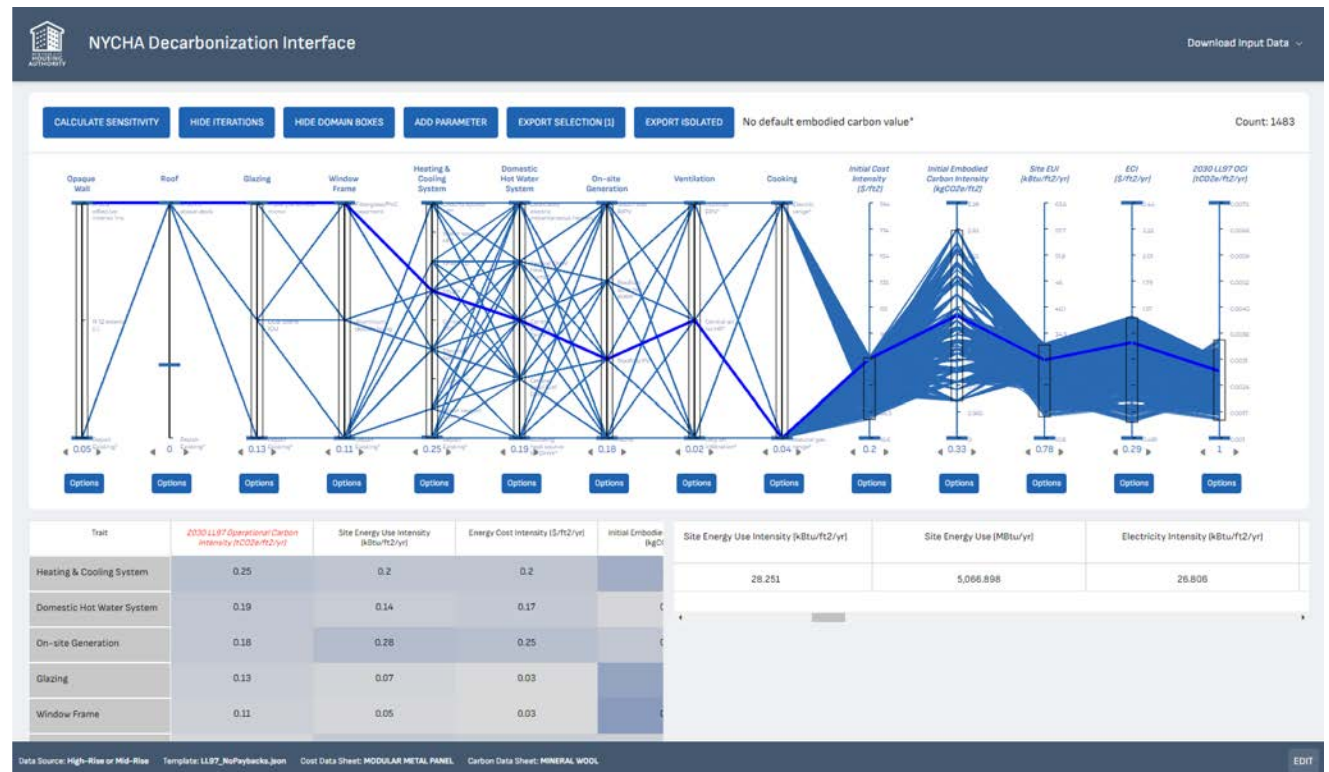
# The Interactions Table

Category	Measure/Requirement	Interaction Matrix (Color-coded: Blue for positive, Orange for negative, Grey for neutral)	
TYPOLGY	Compatibility with high-rise typology	[Grey]	
	High Lot Coverage*	[Grey]	
	Landmark* or National Register Status*	[Grey]	
	Flood Plain*	[Grey]	
	Low Typ. Floor to Floor Height*	[Grey]	
	Cavity Wall Type*	[Grey]	
	High Typ. Floor Efficiency Ratio*	[Grey]	
	High Density*	[Grey]	
	Limited dwelling unit closet area	[Grey]	
	Limited mechanical room area	[Grey]	
EXISTING BUILDING CRITICAL REPAIR NEED	Low roof area to floor area ratio	[Grey]	
	Superstructure load capacity	[Grey]	
	Resident remediation - Tenant required to vacate	[Grey]	
	Boiler replacement	[Grey]	
	Domestic water piping replacement	[Grey]	
	Brick repair	[Grey]	
	COORDINATED BUILDING INFRASTRUCTURE IMPROVEMENTS	Electrical upgrade	[Grey]
		Submetering	[Grey]
		Electrification	[Grey]
		BMS	[Grey]
CODE & REGULATIONS COMPLIANCE		NYCEC 2020	[Grey]
		NYC BC 2022	[Grey]
		Emissions Reductions per LIIF** - High Rise	[Grey]
		Emissions Reductions per LIIF** - Low Rise	[Grey]
		Local Law 96 of 2019	[Grey]
		Local Law 97 of 2019	[Grey]
	Local Law 98 of 2019	[Grey]	
	ASLA Guidelines 2018	[Grey]	
	RESILIENCE AND CLIMATE ADAPTATION	Conservation and electrification	[Grey]
		Expand access to reliable, efficient cooling	[Grey]
Protect critical infrastructure from coastal flooding		[Grey]	
Provide resilient back-up power		[Grey]	
Prepare for additional hazards		[Grey]	
ENERGY CONSERVING MEASURES		Existing wall	[Grey]
		EIFS exterior c.i.	[Grey]
		EIFS effective interior ins.	[Grey]
		EIFS	[Grey]
		Equibone Cement Board Panels	[Grey]
	Insulated Metal Panel - Corins 3" Thick	[Grey]	
	Modular Metal Panel - Trepsa	[Grey]	
	Convital D Wall	[Grey]	
	Keep current roof	[Grey]	
	Above deck + improve IRI	[Grey]	
Keep current glazing	[Grey]		
Over panel IGU	[Grey]		
Triple-pane heat mirror	[Grey]		
Keep current frames	[Grey]		
Aluminum double hung	[Grey]		
Fiberglass/PCU casement	[Grey]		
No external shading	[Grey]		
Do nothing	[Grey]		
Boiler oxygen trim	[Grey]		
COX AC	[Grey]		
Electric boilers	[Grey]		
Central VRF	[Grey]		
VRP	[Grey]		
HPAC 2.0	[Grey]		
Dedicated mini-split VRF system	[Grey]		
Water source HP	[Grey]		
Ground source HP	[Grey]		
Use building heating source for DHW	[Grey]		
Central fuel fuel DHW	[Grey]		
Central electric DHW	[Grey]		
Central DHW heat pump	[Grey]		
Dedicated electric instantaneous heaters	[Grey]		
No on-site generation	[Grey]		
Boothup PV	[Grey]		
Boothup solar hot water	[Grey]		
South wall BIPV	[Grey]		
Rely on infiltration	[Grey]		
Central air no HR	[Grey]		
Boothup EHV	[Grey]		
Water Conserving	[Grey]		
Low range cooking	[Grey]		
Electric Range	[Grey]		



# THE APPROACH AND TOOLS

The **NYCHA Decarbonization Interface** is a web-based platform that allows NYCHA project teams and program managers to interact with a **wide variety of building retrofit scenarios** and explore the operational carbon, embodied carbon, first costs, and life cycle costs of each.



## Parallel Coordinates Graph

A graph that visualizes the relationship between multiple input and output parameters

All parameters are visualized as columns, and individual entries are displayed as lines connecting the columns

## Input Parameter

An input variable used to simulate different retrofit projects

## Output Parameter

A variable calculated either through EnergyPlus (energy model simulation engine) or the web app

## Intervention

A single building improvement

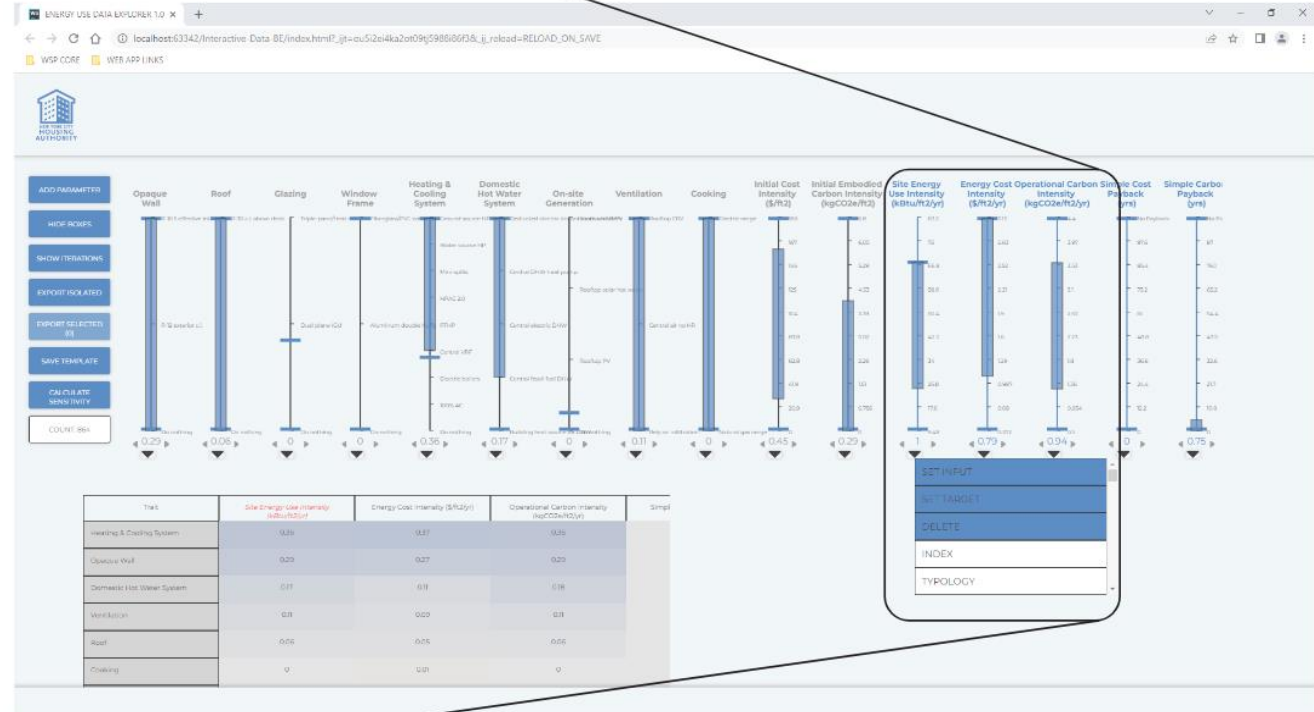
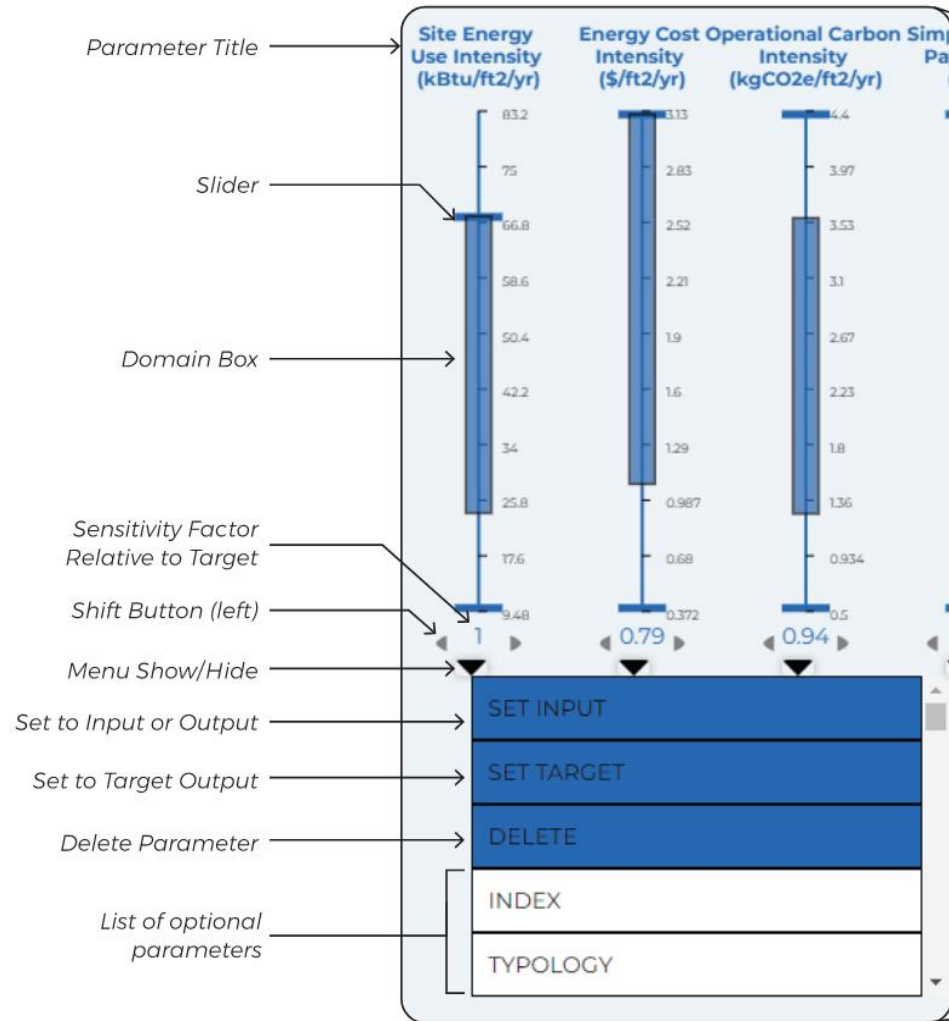
## Intervention Type

An input parameter that contains a category of interventions considered for every project (e.g., Wall cladding, Heating and Cooling systems, etc.)

## Iteration

A unique set of interventions representing a single retrofit project

# Interface Structure:







## How to start:

1. Know your site
2. Know your limitations
3. Determine your targets

*You can use any of these parameters to begin using the Decarbonization Interface.*

# 1. Use the Interactions Table to identify compatible interventions for a high rise building with desired submetering in a flood zone.

## WHAT IS THIS?

This workbook is a tool intended to supplement the web app in the process of decision-making. The web app is a repository of quantitative data including operational and embodied carbon, as well as initial and life cycle cost. While this information may guide a deep-energy retrofit, there are qualitative design interactions that should be considered concurrently. Existing conditions pose many physical and logistical challenges to potential designs, regulations and guidance pertaining to alterations may pose questions of interpretation in unique cases, and interventions should be selected to work cohesively as a system. There are numerous interactions, and the traditional process relies on professional expertise during the design phase to work through them. The Interactions Table has been assembled as a live document to catalog key knowledge that NYCHA can use in pushing forward a wider range of ideas at different stages in the process and with any team.

## HOW DO I USE IT?

1. Consider a list of interventions that might be of interest
2. Go to the Interactions Table TOC sheet. You can click on the "GO>" link below. Use Ctrl+Shift+F1 to view in full screen.
3. Find the columns corresponding to the interventions of interest. A quick scan of the colors of cells in that column can give a general idea of how many positive or negative interactions that intervention might cause.
4. To read about specific interactions, click on the corresponding cell in the matrix. It will take you to the full text. You may easily return to the Interactions Table TOC by clicking the link at the top left corner.
5. To find additional information about the range of interventions, refer to one of the supplementary sheets listed below. Return here by clicking the link at the top.

NOTE: Rather than starting with an intervention of interest, you may also look up a specific existing condition, resiliency concern, etc. on the left side of the TOC.

EDITS: Building technologies are evolving fast, particularly for retrofit applications. This tool is meant to remain live and editable as a way of staying up to date and maximally useful. To make any additions or edits to the interactions table, enter text directly into the "Interactions Table" sheet. Manually use "paste special" to copy formatting only to the "Interactions Table TOC" sheet after editing. Note rows 26 and 27 of the TOC are conditionally formatted based on the values in the Interactions Table - avoid copying formatting to those rows.

## SHEETS IN THIS WORKBOOK:

START (this page)

- GO> INTERACTIONS TABLE TOC
- GO> INTERACTIONS TABLE
- GO> ENVELOPE INTERVENTIONS
- GO> BUILDING SYSTEMS INTERVENTIONS
- GO> EMISSIONS REDUCTIONS (LL97) - HIGH RISE
- GO> EMISSIONS REDUCTIONS (LL97) - LOW RISE

## SECTIONS OF THE INTERACTIONS TABLE:

### TYPOLOGY

Interventions may be more or less compatible with different building typologies, and some may be entirely incompatible. This section outlines the main typological considerations for each intervention identified during the course schematic design studies applied to representative buildings of the High-Rise and Low-Rise types.

## 2. In the web app, select the High Rise typology



Start by selecting your building typology, then select from the options for over-cladding systems and insulation types. You can change your selections later.

BUILDING TYPOLOGY	HIGH-RISE OR MID-RISE	<input checked="" type="checkbox"/> LOW-RISE				
CLADDING SYSTEM	<input checked="" type="checkbox"/> EIFS	INSULATED METAL PANEL	EQUITONE CEMENT BOARD	MODULAR METAL PANEL	DEXTALL D-WALL PREFAB	
INSULATION TYPE	MINERAL WOOL	<input checked="" type="checkbox"/> EPS/XPS FOAM				

LOAD INTERFACE

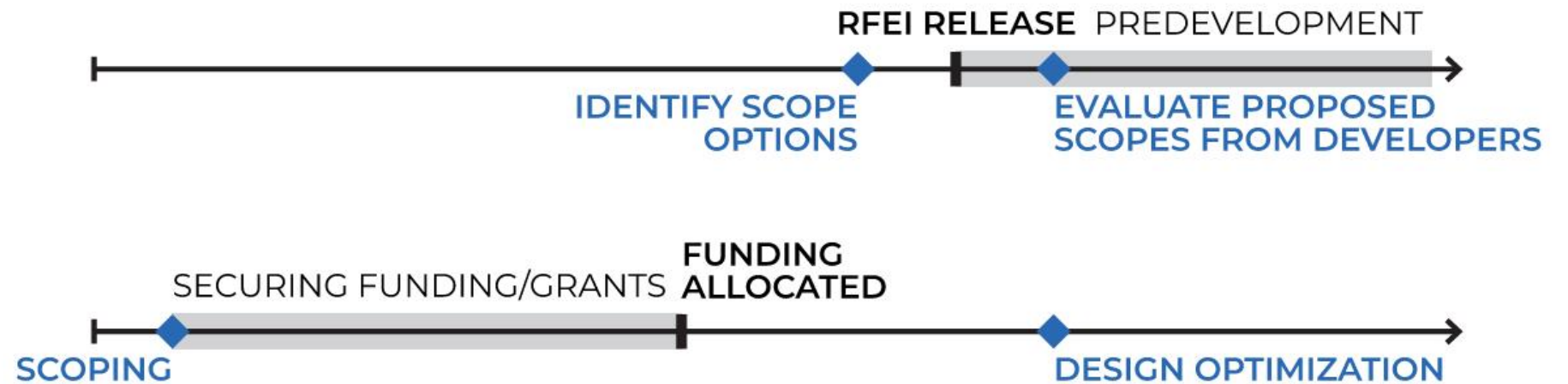


**WHAT'S NEXT?**



This tool allows portfolio managers to make **data-driven decisions** and **anticipate key scope impacts** before a full design team can be onboarded onto the project.

*An integrated design process can begin on day one.*



## Project level

- Identify scope options
- Securing finding/grants
- Back up cost and scope negotiations
- Design optimization

## Program Level





- Inform R&D projects
- Advocate for gap financing
- Establish design standards

## Policy Level

- Inform inter-agency coordination
- Make recommendations for affordable housing city-wide



## Where do we go from here?

-  **Closing the gap** between simulated and real-world performance
-  **Tracking** project improvements at the portfolio scale
-  **Feedback** on why specific options are not recommended
-  **Evolving to reflect the market** and **drive R&D** of new options





**THANK YOU**



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