THE BUSINESS CASE FOR PASSIVE HOUSE

What is the Passive House (Cost) Difference?

A. Envelope

B. Quality Control / Engineering / Testing

C. HVAC Systems

Envelope

COMPONENT	BASELINE (ENERGY CODE)	PH DESIGN	INSTALLED / TESTED
ROOF	R-30	R-30	R-30
ABOVE-GRADE WALLS	R-11.4	R-20	R-18.4
BELOW-GRADE WALLS	R-7.5	R-10	R-10
WINDOWS – INSTALLED EFFECTIVE U-VALUE	0.45	0.25	0.28 (Frame) 0.21 (Glazing)
GLAZING SHGC	0.40	0.27	0.25
FAÇADE AIR TIGHTNESS	0.31 cfm50	0.08 cfm50	0.035 cfm50 (Taped) 0.055 cfm50 (Un-Taped)

Envelope


High-Performance Windows

High-Performance Glazing

Air Barrier Seal

High Quality Air Barrier

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Envelope

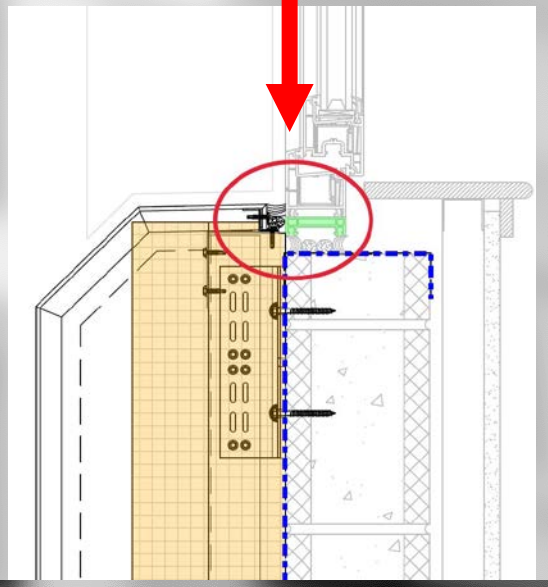
Thermal Separation at Dunnage

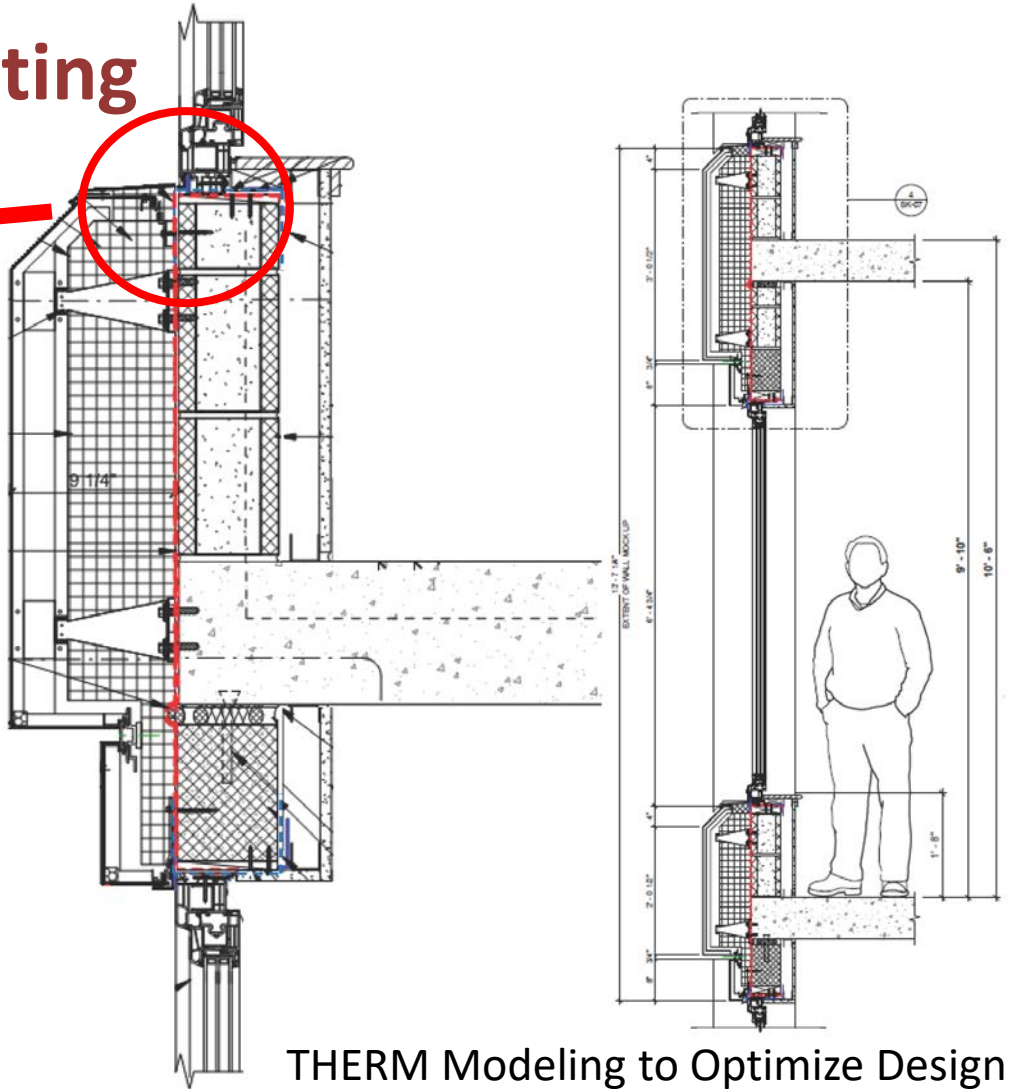
Thermal Separation with AAC

Thermal Break at Sunshades

Thermal Breaks of Roof Structure

Quality Control / Engineering / Testing





THERM Modeling to Optimize Design

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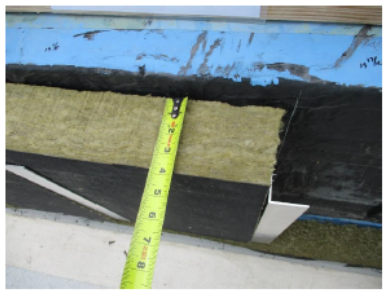
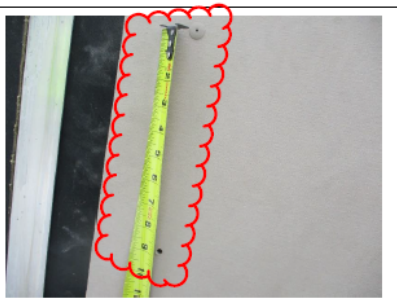
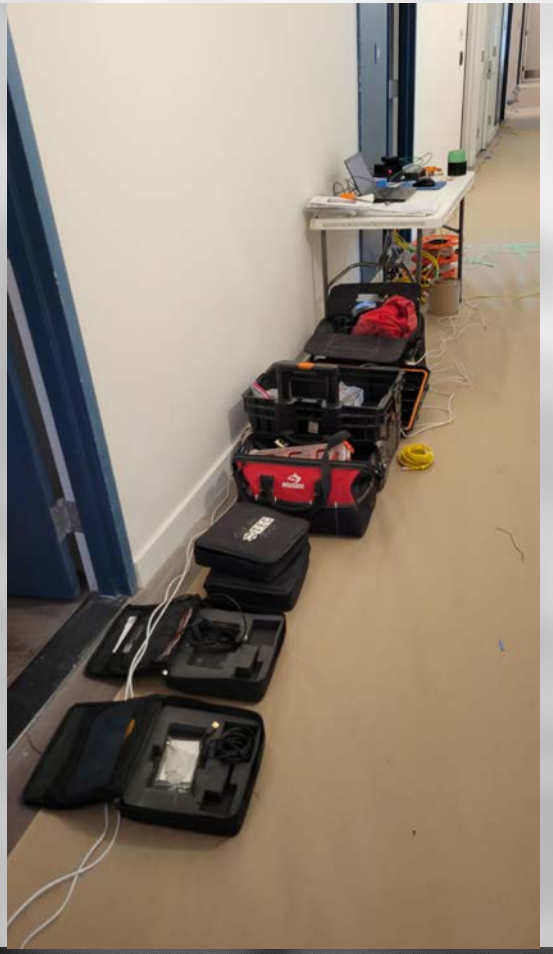
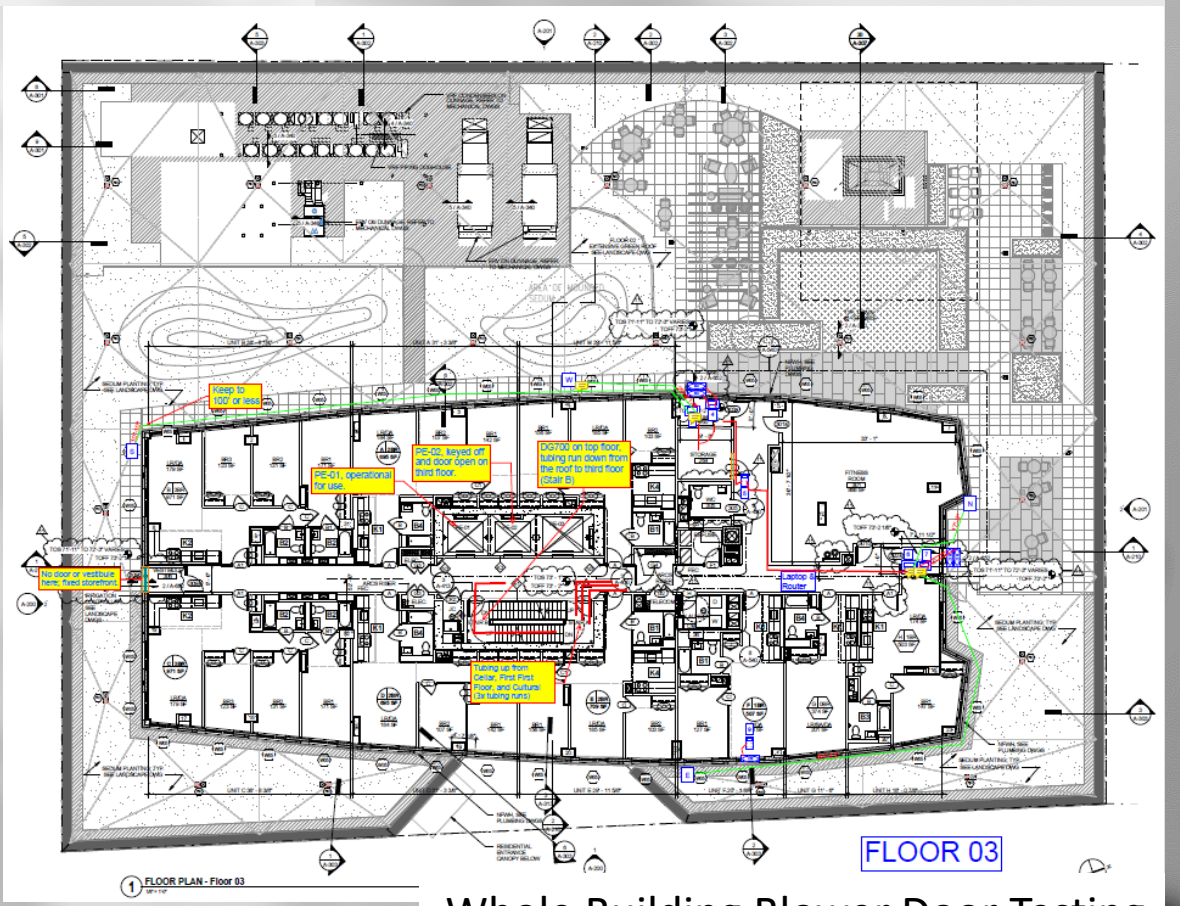
Quality Control / Engineering / Testing

253	Metal Panels: Screws Engaged to the Wrong Slots for Vertical Framing Supports
	**Photo #253.01** • Multiple screws on the metal panel support bracket were observed engaged in the wrong slots at noted locations. Instead of engaging in live load connections, screws were observed engaged in deadload load connections at the bottom of the vertical framing supports.
	**Photo #253.02** • Multiple screws on the metal panel support bracket were observed engaged in the wrong slots at noted locations. Instead of engaging in live load connections, screws were observed engaged in deadload load connections at the bottom of the vertical framing supports.
	**Photo #253.03** • PGNY relocated screws installed in dead load connections to live load connections in accordance with approved as noted shop drawings.

255	Metal Panels: Spot Check of Equitone Panel Installation at FL 27 Parapet
	**Photo #255.01** • Rockwool Cavityrock Black mineral wool insulation, noted to be 4" thick, was set in place at the interior face of the parapet between vertical aluminum framing angles.
	**Photo #255.02** • The Equitone panel was spot checked to be 3/8" thick and was observed attached to the vertical framing supports using color matched Equitone Uni-rivet.
	**Photo #255.03** • The rivets have a spacing of approximately 9" on-center vertically.

Quality Control / Engineering / Testing





Whole Building Blower Door Testing

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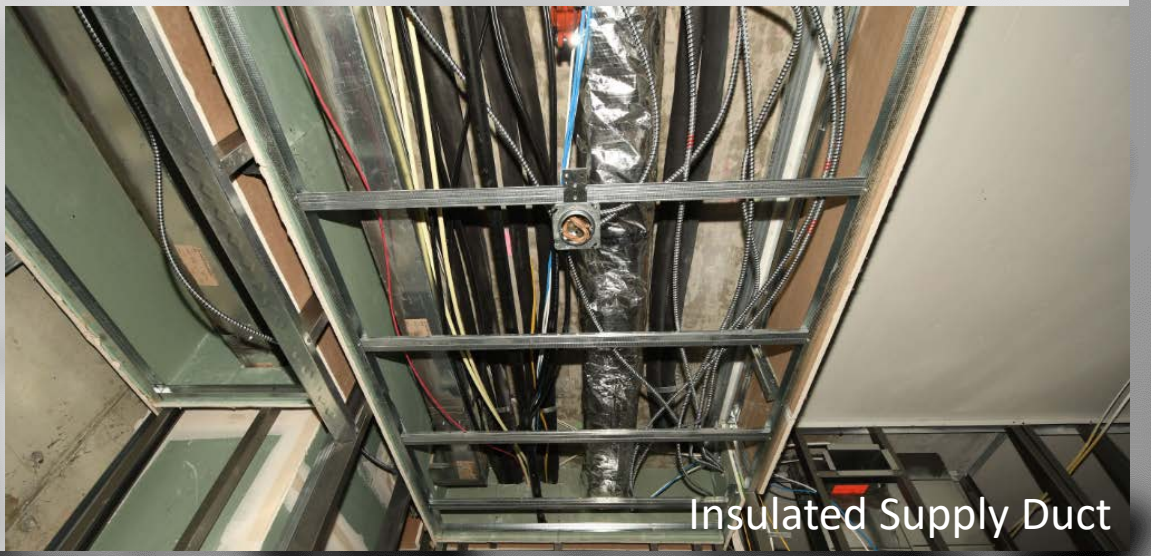
HVAC

ERV

Constant Air Regulating Dampers

ERV Components



Insulated Supply Duct

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HVAC


VRF Branch Controller


VRF Roof Condenser


VRF Indoor Evaporator

What is the Passive House (Cost) Difference?

	Baseline Design	Passive House Improvement	Passive House "Cost Premium"
Envelope	▪ Double Hung Aluminum Windows ▪ 1 Wet Seal at Openings / Sporadic Discontinuity of Air Seal ▪ Occasional / Common Thermal Breaks	▪ UPVC Casement Windows ▪ 2 Wet Seals at Openings / Full Continuity of Air Seals ▪ No Thermal Breaks	**$ 1,200,000**
Quality Control / Engineering / Testing	▪ Façade Design QC focused on Water Infiltration only ▪ Standard, Prescriptive Modeling / Design ▪ Correct Materials are used, often installed correctly, usually in correct places. ▪ Blower Door Test at 0.40 cfm75 or 0.31 cfm50	▪ Façade Design QC on Water and Air Infiltration ▪ Focus on Modeling of Thermal / psi and humidity ▪ Correct Materials are used, installed correctly in correct places. ▪ Blower Door Test at 0.08 cfm50	**$ 1,150,000**
HVAC	▪ Hydronic PTAC Heating / Cooling ▪ Exhaust only Ventilation / Unconditioned Make-Up Air	▪ Energy Recovery VRF Heating / Cooling ▪ Balanced Energy Recovery Ventilation	**$ 1,800,000**
Total Dev. Cost	$ 186,930,000 or $ 603 / sf	$ 191,080,000 or $ 616.35 / sf	**$ 4,150,000 or $ 13.35 / sf**

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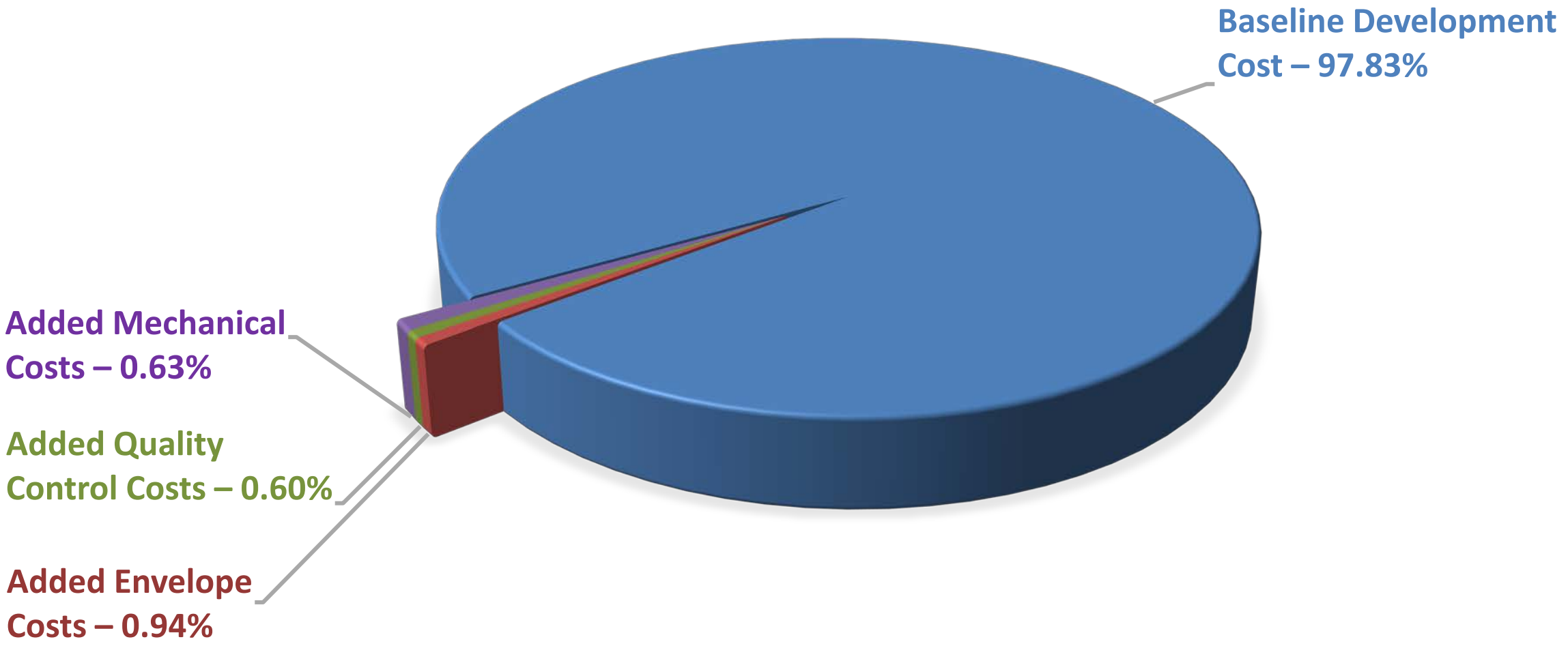
What is the Passive House (Cost) Difference?



Building Operating Costs

		Average NYC MF	425 Grand Concourse
Source EUI [kBtu/(sf x a)]		154[2]	76[2]
Space Heating	38%[1]	Gas[1]	Elec
Domestic Hot Water	15%[1]	Gas[1]	Gas
Plug Loads / Misc.	15%[1]	Elec[1]	Elec
Lighting	10%[1]	Elec[1]	Elec
Space Cooling	8%[1]	Elec[1]	Elec
Conveyance	2%[1]	Elec[1]	Elec
Ventilation	2%[1]	Elec[1]	Elec
Process Loads	2%[1]	Elec[1]	Elec
Other	8%[1]	Elec[1]	Elec
Site EUI [kBtu/(sf x a)]		82[1]	32[3]
2022 Operating Cost[4] [$ / (sf x a)]		**$ 3.46**	**$ 1.91**

2022 Cost per kBtu Electricity[4]: $ 0.0663

2022 Cost per kBtu Gas[4]: $ 0.0209

Notes:

[1] "New York City's Energy and Water Use Report", published December 2020 by UGC and the City of New York. The report is based on over 16,000 multifamily buildings.

[2] Calculated per EPA conversion table Site-to-Source Ratio of 2.80 for Electricity (Grid Purchased) and 1.05 for Natural Gas.

[3] Per SWA utility analysis for 425 Grand Concourse, dated 10/7/22, factored up by average difference between SWA's ASHRAE energy model and actual readings of Trinity's existing NYC portfolio.

[4] Commercial Electrical Rate EL9 and Gas Rate from 425 Grand Concourse August 2022 .

Annual Utility Savings
$ 1.55 / sf
or $482,824 for Building

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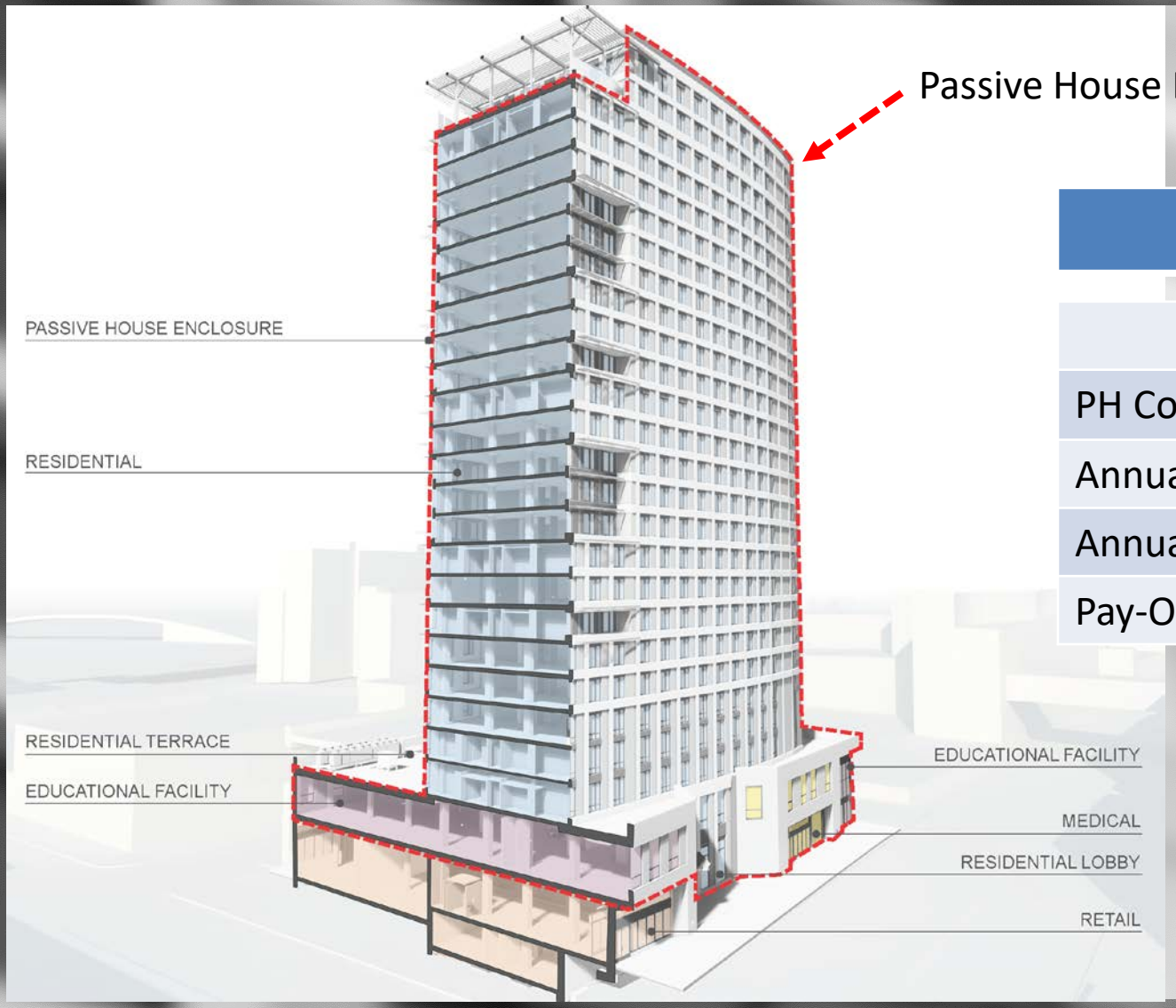

Passive House Financing

	per SF	Building
PH Cost over Baseline [$]	13.35	4,150,000
Annual Interest [%]	6.00	
Annual Payment [$]	1.55	482,824
Pay-Off Period [Years]	12	

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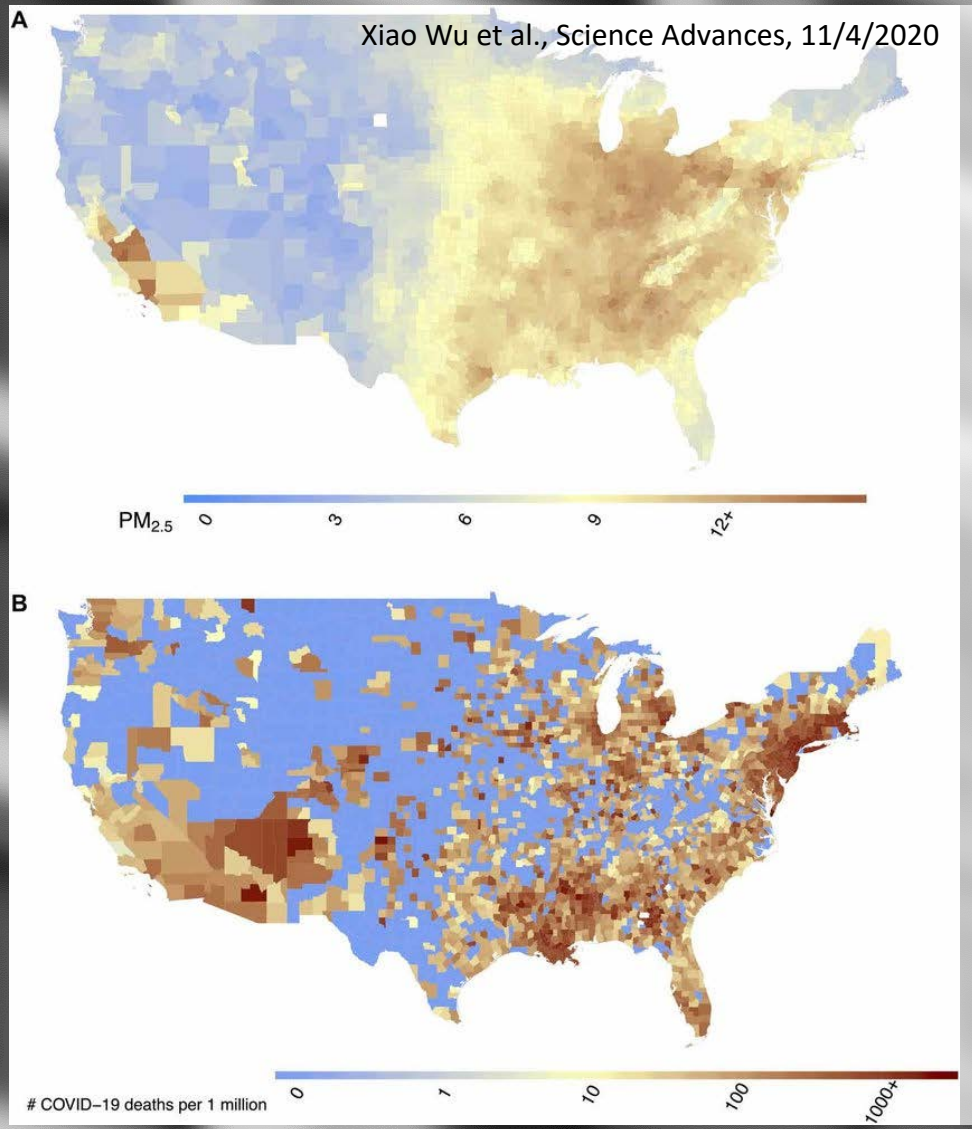
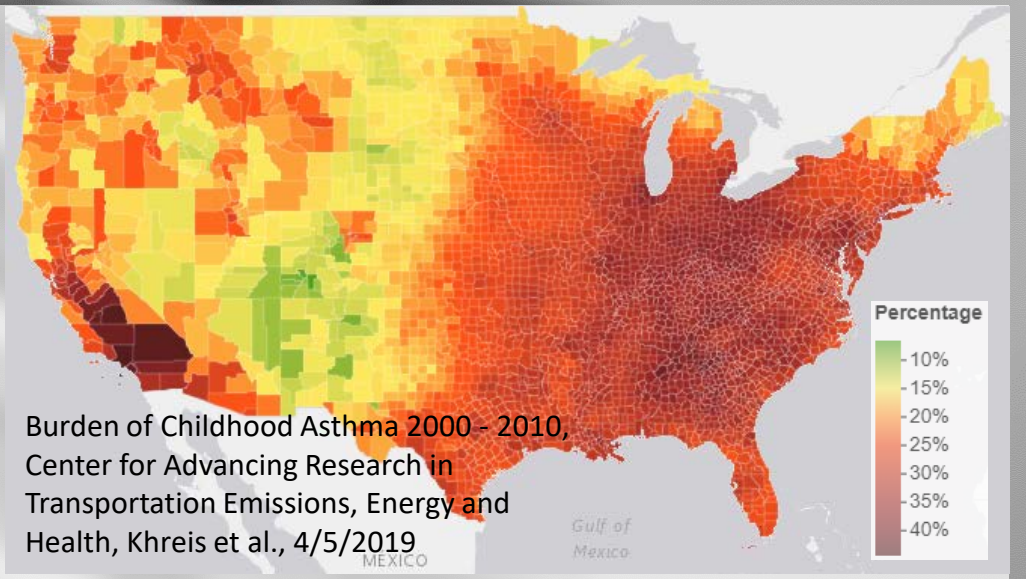
Not included in this Cost Analysis:

Health- and labor-related **cost reductions** of avoided risk of

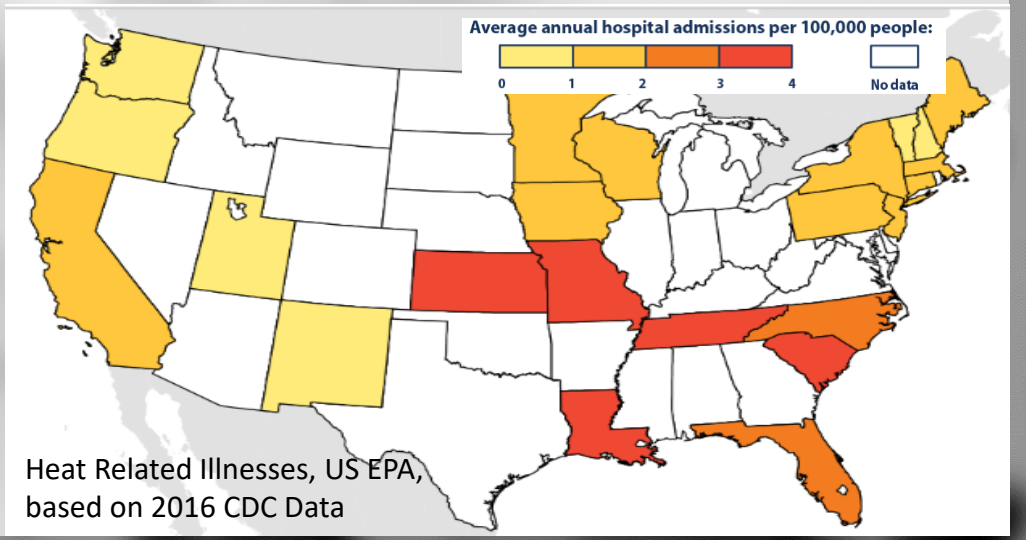
- Heat-related illness
- Respiratory illness
- Noise-related illness



Xiao Wu et al., Science Advances, 11/4/2020



Burden of Childhood Asthma 2000 - 2010, Center for Advancing Research in Transportation Emissions, Energy and Health, Khreis et al., 4/5/2019



Heat Related Illnesses, US EPA, based on 2016 CDC Data

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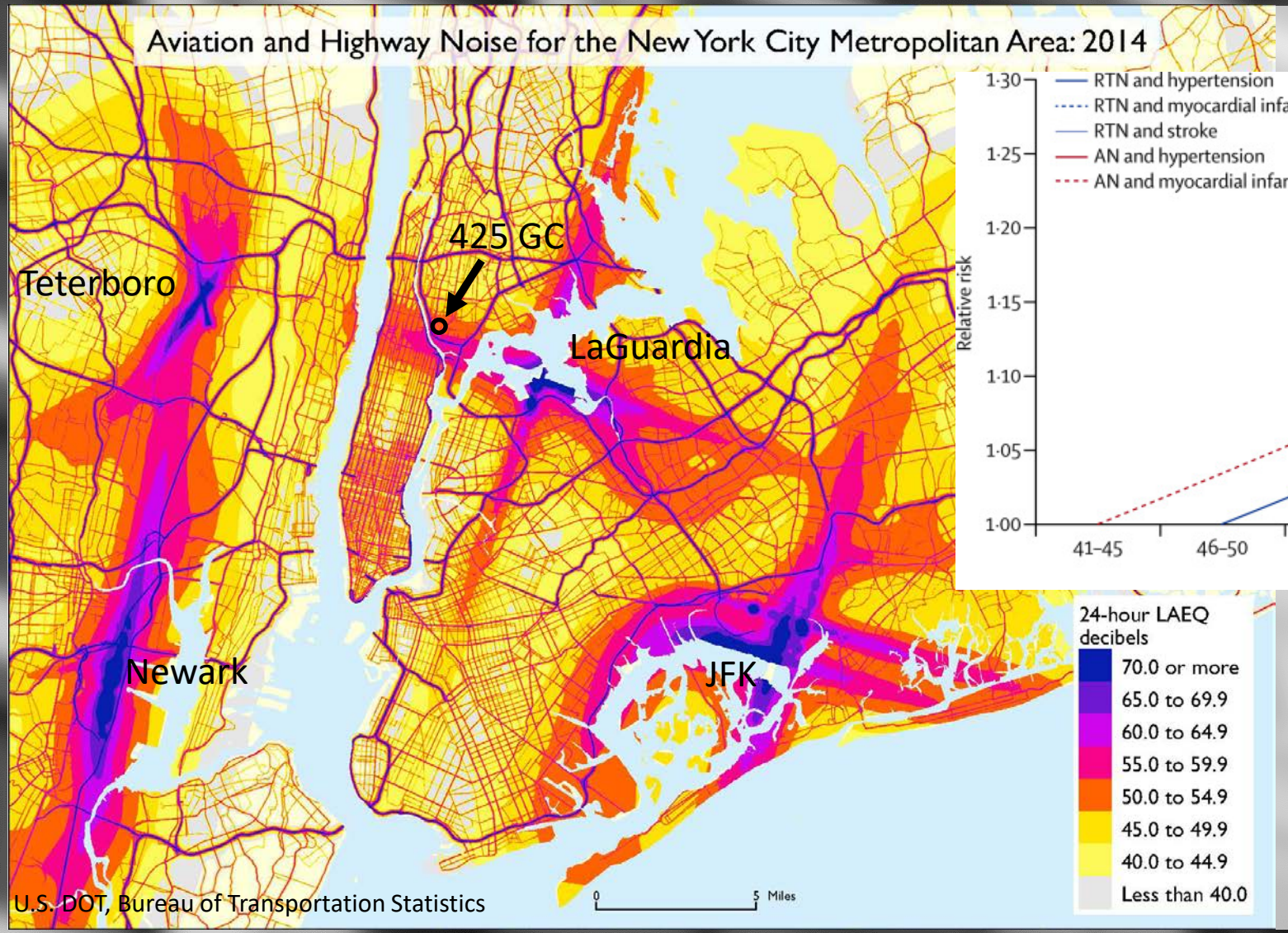

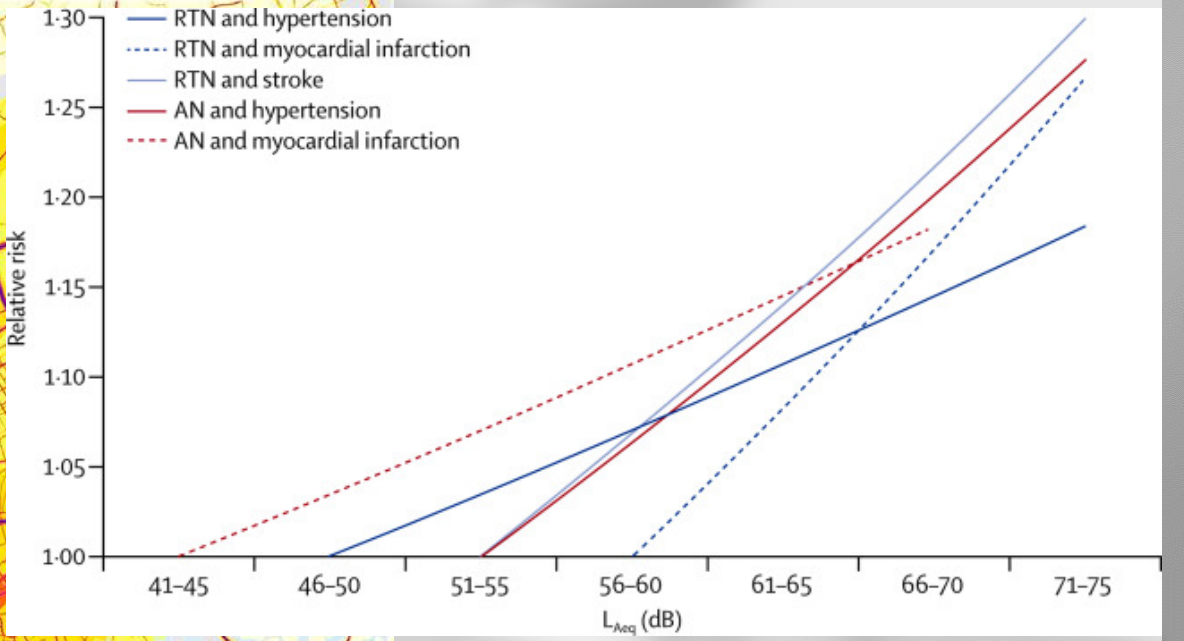

Exposure-response curves of road traffic [RTN] and aircraft noise [AN] and cardiovascular endpoints. Basner et al., Lancet, 2013

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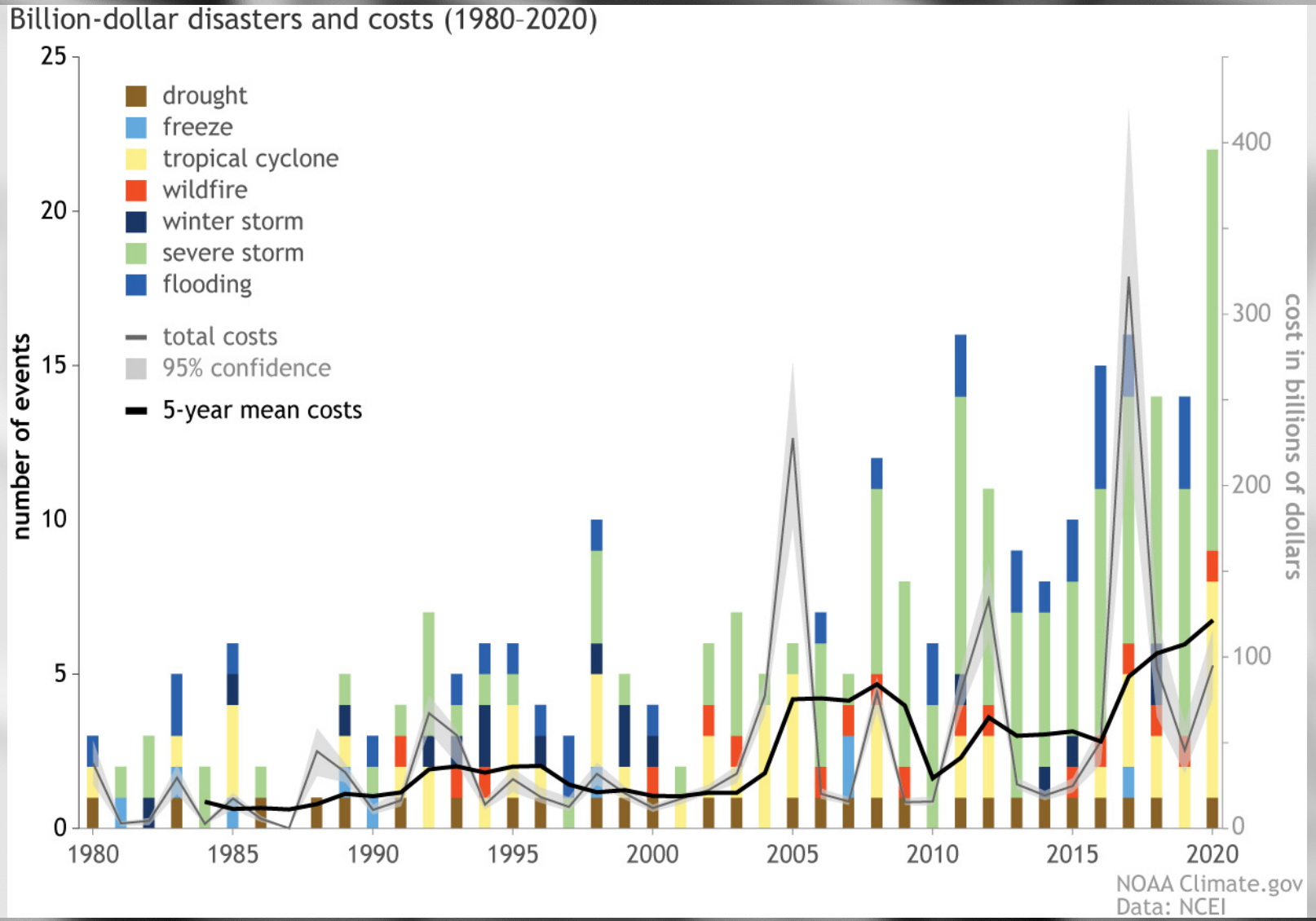
Also not included in this Cost Analysis:

Climate-related **cost reductions** of avoided risk to

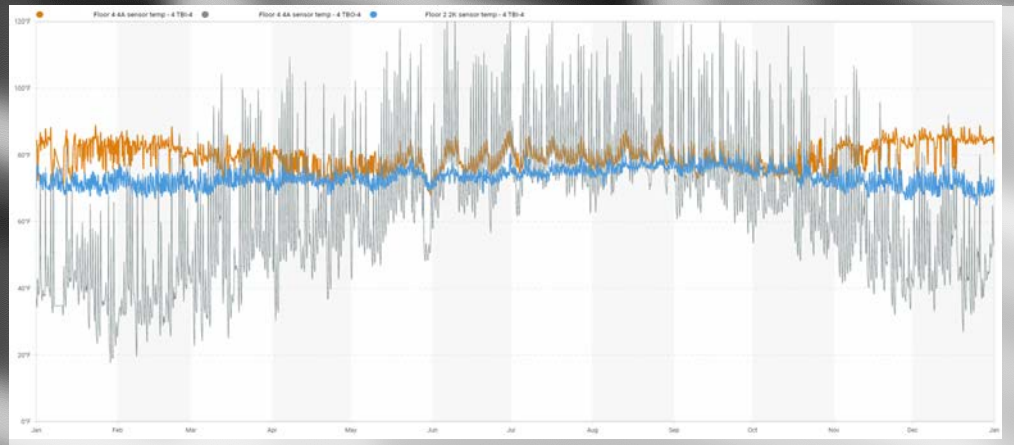
- Buildings and infrastructure
- Agriculture and food security
- Overall utility- and specifically peak demand
- Climate-migration

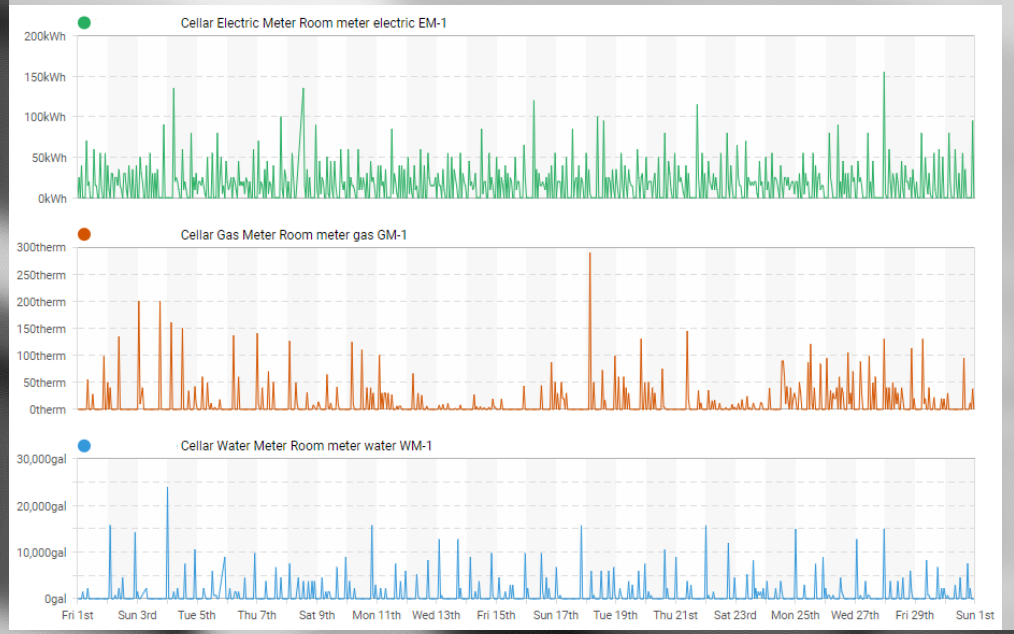

Billion-dollar disasters and costs (1980-2020)
drought
freeze
tropical cyclone
wildfire
winter storm
severe storm
flooding
total costs
95% confidence
5-year mean costs
number of events
cost in billions of dollars
0
5
10
15
20
25
0
100
200
300
400
1980
1985
1990
1995
2000
2005
2010
2015
2020
NOAA Climate.gov
Data: NCEI

Notes on Passive House Data:

Cost and Operating data on highly energy efficient buildings is currently sparse, but urgently needed for:

- better design and systems selection (e.g. when is dehumidification needed)
- better understanding energy recovery / redistribution with simultaneous heating and cooling in different spaces.
- finetuning energy / utility modeling (assumptions on occupancy / usage)
- better underwriting





Monitoring Data at 425 Grand Concourse

- energy consumption by
  - Apartments
  - House meter
  - Equipment (pumps, fans, elevators, lighting, etc.)
- temperature and temperature settings in apartments and common spaces
- relative humidity levels in 1/4 of apartments

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HELP COLLECT AND SHARE YOUR DATA