BUILDINGENERGY BOSTON

Affordable Housing: Saving Energy & Money While Addressing Climate & Equity Goals

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Prudence Ferreira (BR+A Consulting Engineers)
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Curated by Danny Veerkamp (Thoughtforms Corporation)

Northeast Sustainable Energy Association (NESEA)
February 28, 2022

Massachusetts Buildings: Energy and Carbon

27% — **MA emissions from buildings' onsite fuels**

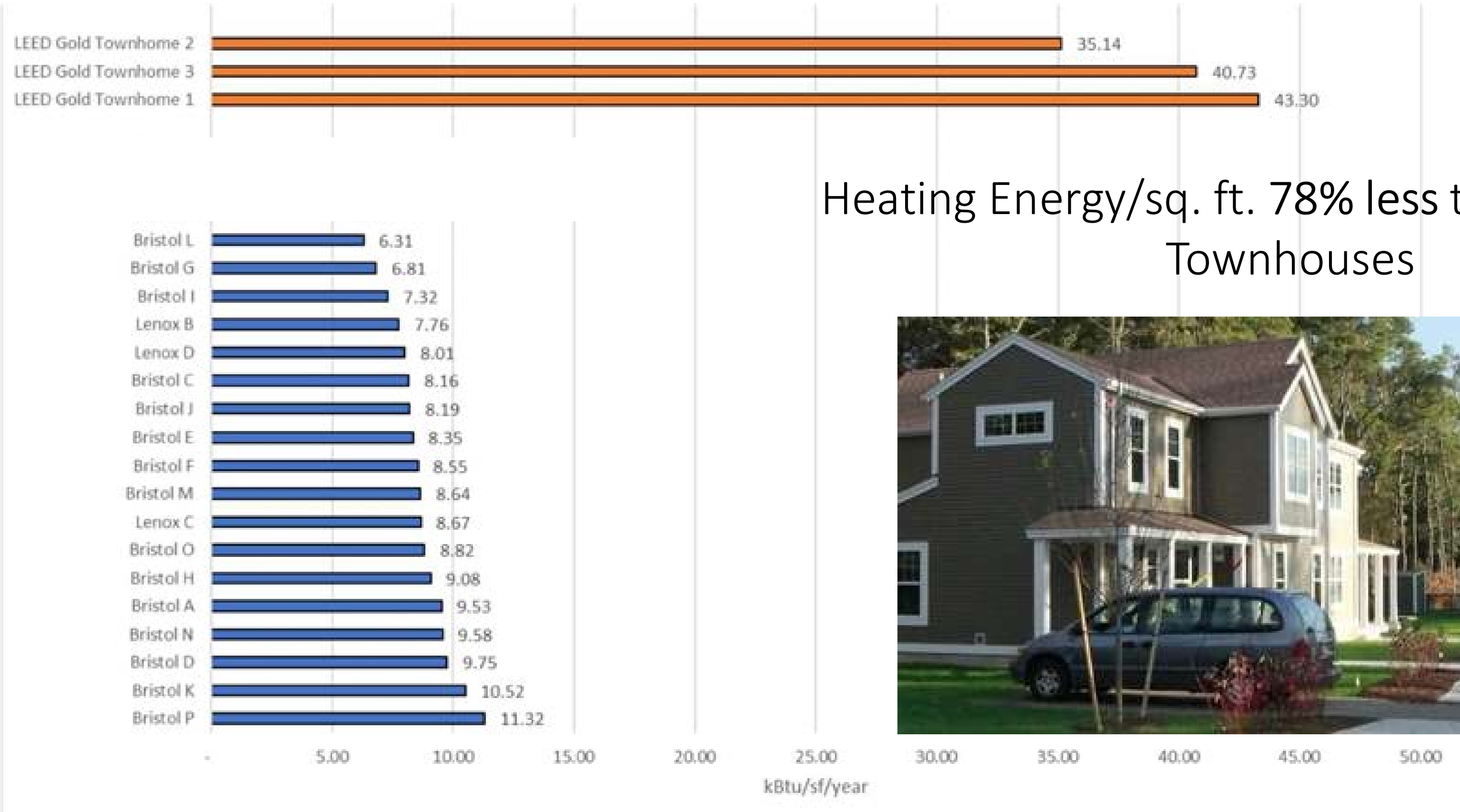
2.0 million — **Number of existing buildings in MA that will exist in 2050**

500,000 — **Number of new buildings expected in MA by 2050**

PASSIVE HOUSE:
WHAT A TERRIBLE NAME!

Performance: Bristol Commons, Taunton 2014

16 Affordable 2-8 unit “stealth passive all electric”



Heating Energy/sq. ft. **78% less** than LEED Gold Townhouses

New Ecology Study excerpt. 5 Years of performance monitoring reports available.

Passive House Skepticism

Passive House Design Challenge

MASSACHUSETTS CLEAN ENERGY CENTER®

- Up to $4,000 per unit incentive
- 8 Affordable Projects: 540 Units
- 5 Occupied; 3 Under Construction

Incremental Cost of Passive House Standard: 2.4% average

Does not include final change orders for Kenzi and Mattapan Station; incentives not included

What are the biggest incremental costs?

- **Much better ventilation**
- **Windows and Doors**
- Efforts to reduce thermal bridging
- Higher level of construction verification

Heating and Cooling Equipment Cost Decrease:

• 6 out of 8 projects have **significantly lower size and cost for heating and cooling** equipment

• Window premium is coming way down. In some cases, cost neutral

LESSONS

- Architects with more PH training and experience had lower cost; better outcomes
- Decide early if you are seeking PH certification- if whole team on board coming out of charrette, more will go more easily
- There is a large learning curve on first PH project – expect it
- Give yourself plenty of room in PH model for things to go wrong
- All 7 of 8 projects likely to get PH certification successfully, MassSave fallback incentives still reward trying and above code outcome
- More complex roofline= more expensive

mass save®

Savings through energy efficiency

Passive House Multifamily Incentives

- 100% of feasibility study cost up to $5,000
- 75% of PH modeling cost up to $20,000
- $3,000 per unit for PH certification

Current PH Enrollment Stats

- 116 buildings enrolled for PH incentives
- Represents 6,500+ units
- 70 buildings have completed PH feasibility studies

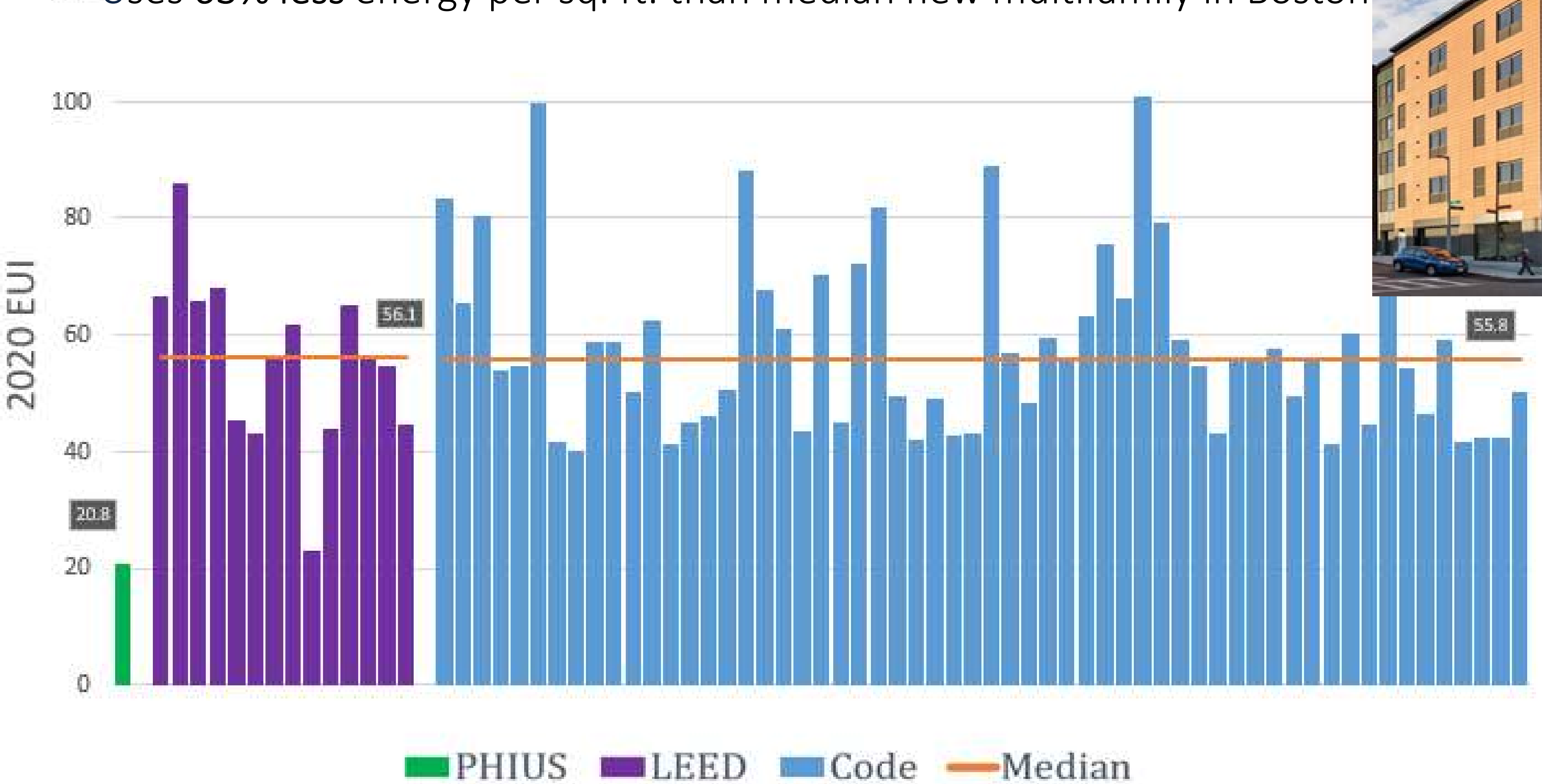
Passive House Education

- PH Lunch & Learns/Workshops: 59
- Total Attendees: 2,497
- PHIUS/ PHI Accreditation Reimbursements: 107

- **See phmass.org video library for free recordings**

PH Performance: Distillery, Boston 2020

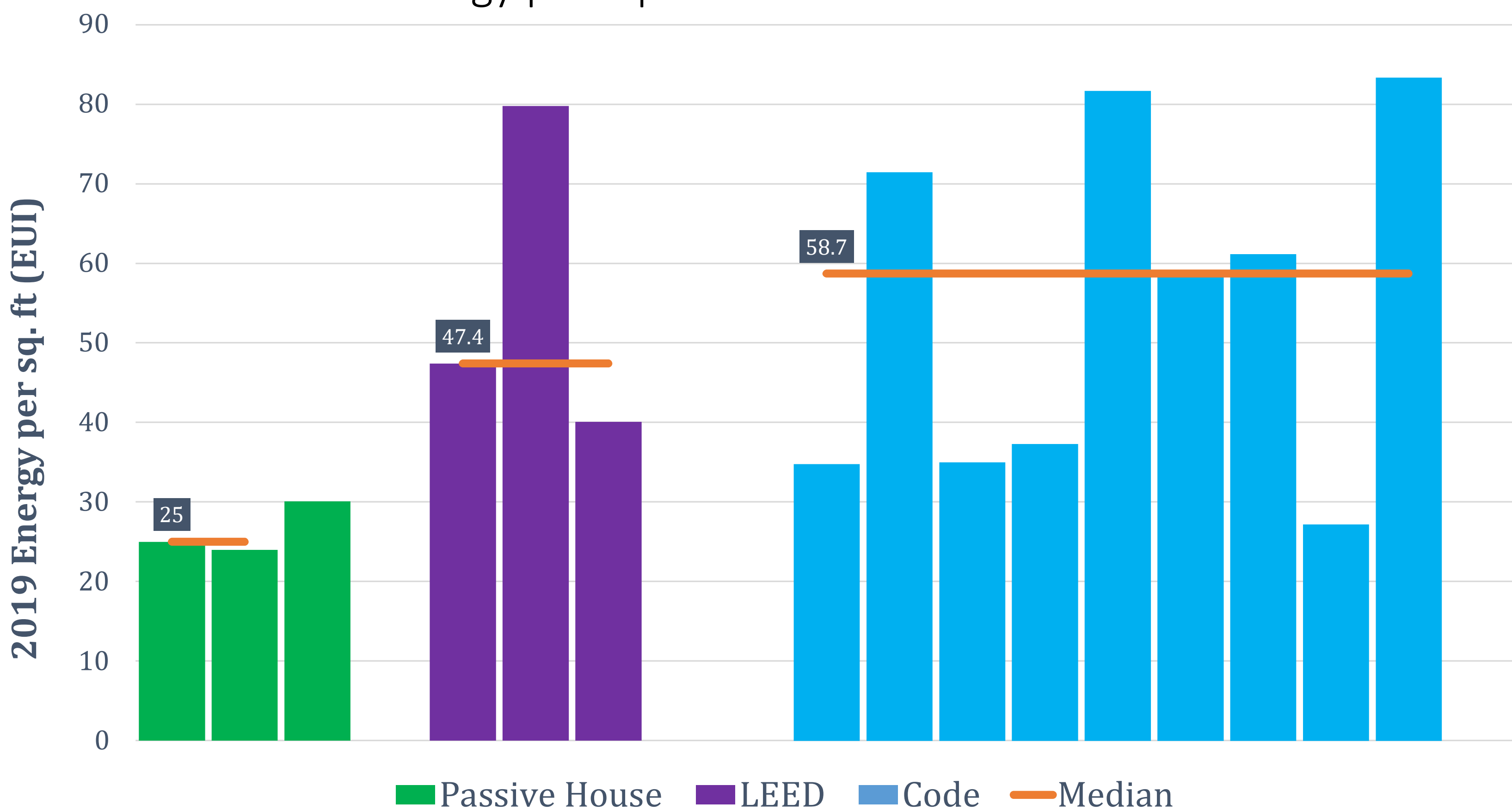
Uses 63% less energy per sq. ft. than median new multifamily in Boston



Data from Boston Energy Disclosure 2020 sorted for new construction multifamily built since 2010; Cross checked for LEED certification; Credit to Jayne Lino, MassCEC

PH Performance: Philadelphia 2019 Affordable

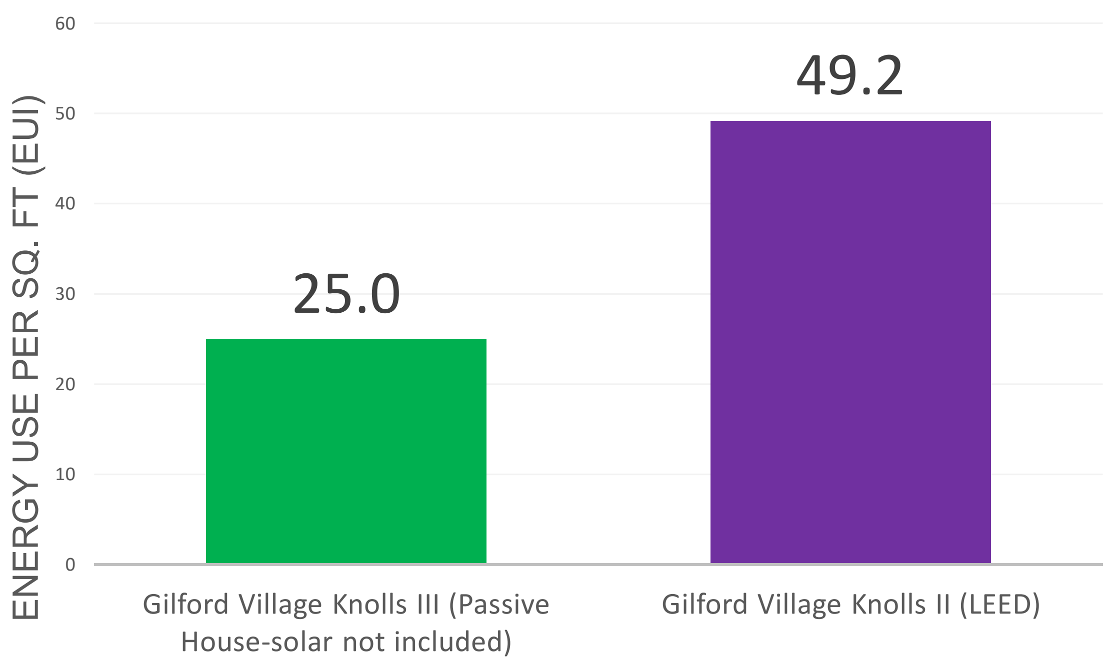
57% less energy per sq. ft. than Median Code Built



Data from Philadelphia Energy Disclosure 2019 cross checked for LIHTC multifamily; Credit to Green Building United, Katie Bartolotta

PH Performance 2019: Gilford Village Knowles III, NH

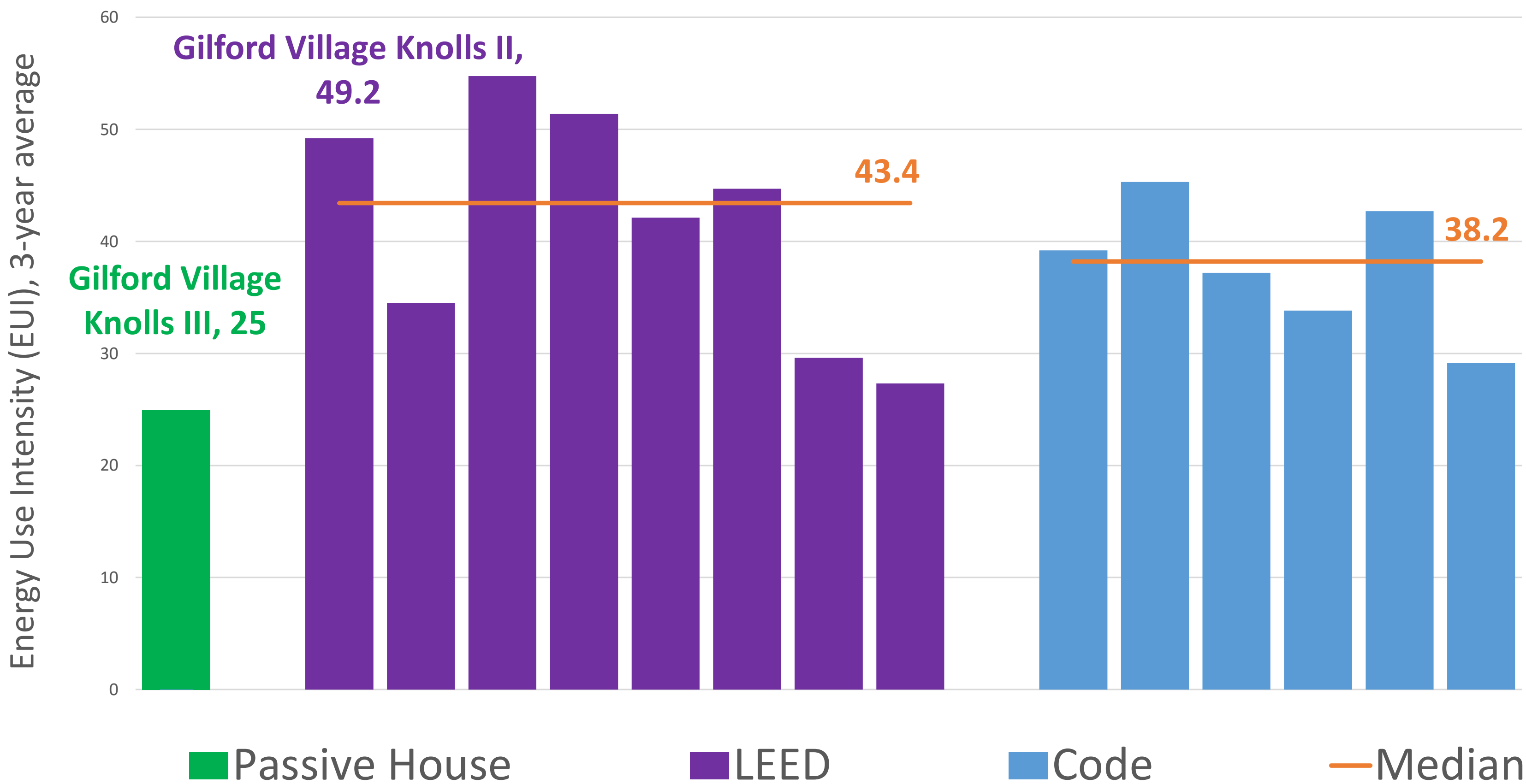
PH uses 49% less energy per sq. ft. than Gilford Village Knowles II LEED built 2008 (same building, different standard)



Graphic representation of study by Resilient Building Group (2020 Report of average 3 year energy usage data ending in 2019)

New Hampshire Affordable Multifamily

42% less energy per sq. ft than Median LEED



Graphic representation of study by Resilient Building Group (2021), New Construction 2006+, LIHTC

MA Low Income Housing Tax Credits (QAP Scoring draft)

- Two paths now for energy performance: New Construction and Rehab (Preservation)
- 5 points more for new construction Passive proposal
- Rehab now must meet Enterprise Green Communities mandatory requirements
- 3 points for reduced embodied carbon

TRIPLE DECKER DESIGN CHALLENGE GOALS

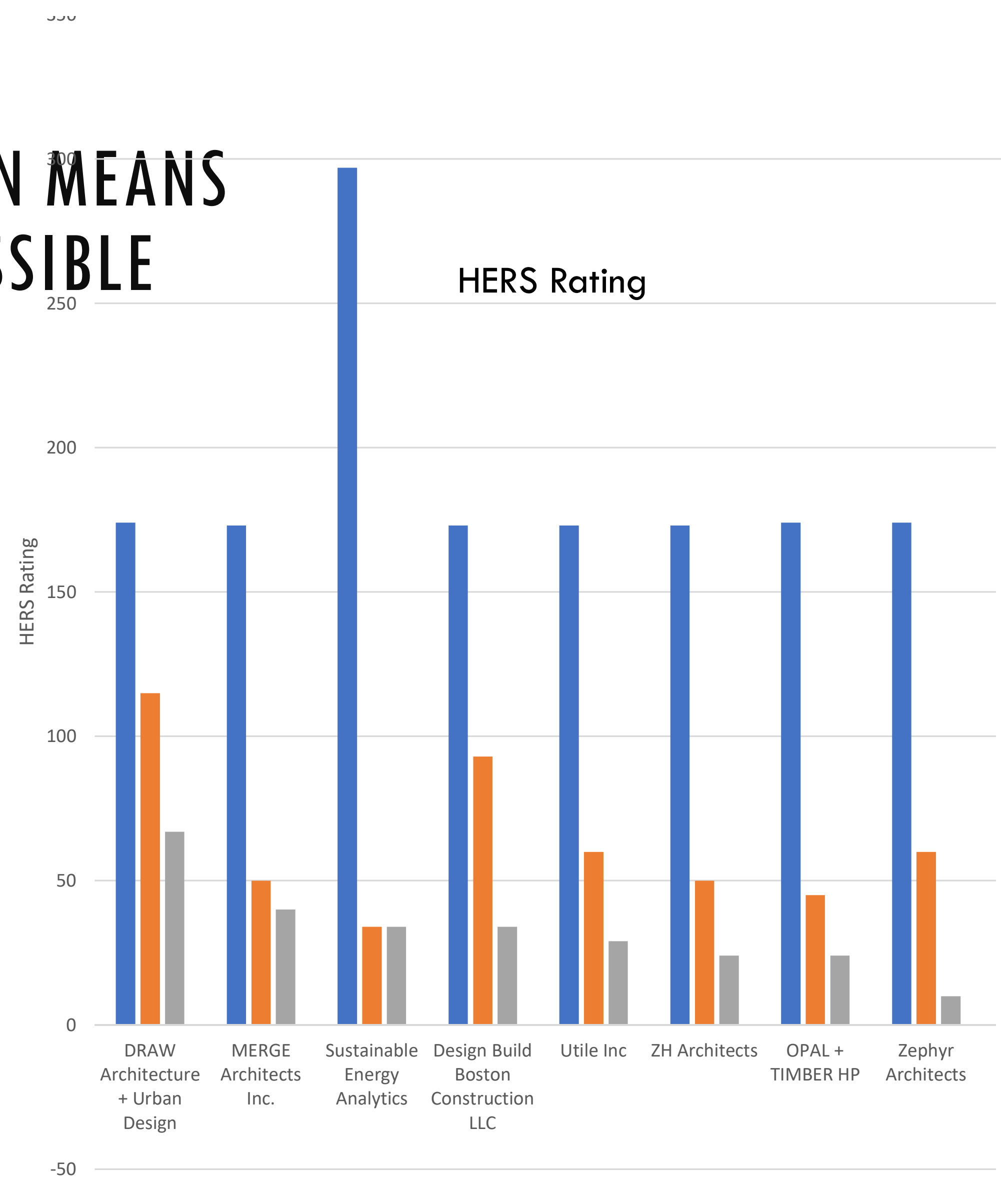
- Identify scalable and replicable system designs for triple decker energy fossil fuel free retrofits
- Assess opportunity to add additional unit during the energy retrofit process
- Consider the full carbon impact of retrofit options including embodied carbon

Bit.ly/3Decker

Poster	Project Name and Summary	Description
	**Winner: Triple Decker Retrofit Design** TDC Retrofit Toolkit: by Zephyr Architects Design Drawing Narrative Video	• This Triple Decker Retrofit Design provides a series of tools to help home the most effective ways to renovate their buildings, balancing immediate • Estimated construction cost: $152,149 (and $16,700 Solar PV) • 94% decrease in annual energy use; HERS rating change: 174 to 11 • 3,500 kgCO2e embodied carbon emissions in proposed building material • Solar PV: 5.6kW • Heating & Cooling: Air-source heat pumps (ducted), Hot Water: Hybrid he
	**Winner: 3+ Retrofit Design** The Back Stack: by MERGE Architects Inc. Design Drawing Narrative Video	• This 3+ Retrofit Design adds an additional 3 story unit (of 1,100 sq. ft.) an existing tenants at the rear of the building. • Estimated construction cost: $620,010 ($288,210 to retrofit the existing s additional unit) • 80% decrease in annual energy use; HERS rating change: 173 to 34 • 3,900 kgCO2e embodied carbon emissions in proposed building material • Solar PV: 4kW • Heating & Cooling: Air-source heat pumps (ductless), Hot Water: Heat pu

POOR EXISTING CONDITION MEANS DEEP ENERGY SAVINGS POSSIBLE

- 3 to 5 times more energy use than similar new construction
  - HERS ratings started between 170 and 297
- Proposals reduced energy usage from 61% to 104%
- Cost w/o solar ranged from $150,000 to $530,000



ON-SITE SOLAR PV

- All but one of the Triple Decker Design Challenge submissions installed Solar PV
- Solar PV was always a good investment with a payback of ~8 years
- What areas should the solar PV power?

Making Cents of Carbon, DiMella Shaffer

WHY ADD AN ADDITIONAL UNIT?

- Adding an additional unit could change the economics of the project if the revenue from the additional unit could pay for the retrofit of the existing building
- Way to add gentle density to a city

AFFORDABLE RFP NOW OPEN

- 10 pilot buildings will get up to $120,000 of additional incentive above MassSave low income incentives.

The Back Stack: MERGE Architects, Inc.

Fort Hill Triple Decker: West Faulkner & Placetailor

Boston HiP: ZH Architects

AI INFORMED SUSTAINABLE DESIGN

Faster,
Smarter,
More Sustainable,
Design + Design Process

NESEA, February 28, 2022

Presented by Prudence Ferreira, Sr Associate, BR+A Consulting Engineers
Prepared by Trevor Fedyna, Principal, Unconstrained Development LLC

BR+A


BR+A


CONSTRUCTION COST PREMIUM
<1%
<1%
<1%
<1%
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Evolutionary Optimization

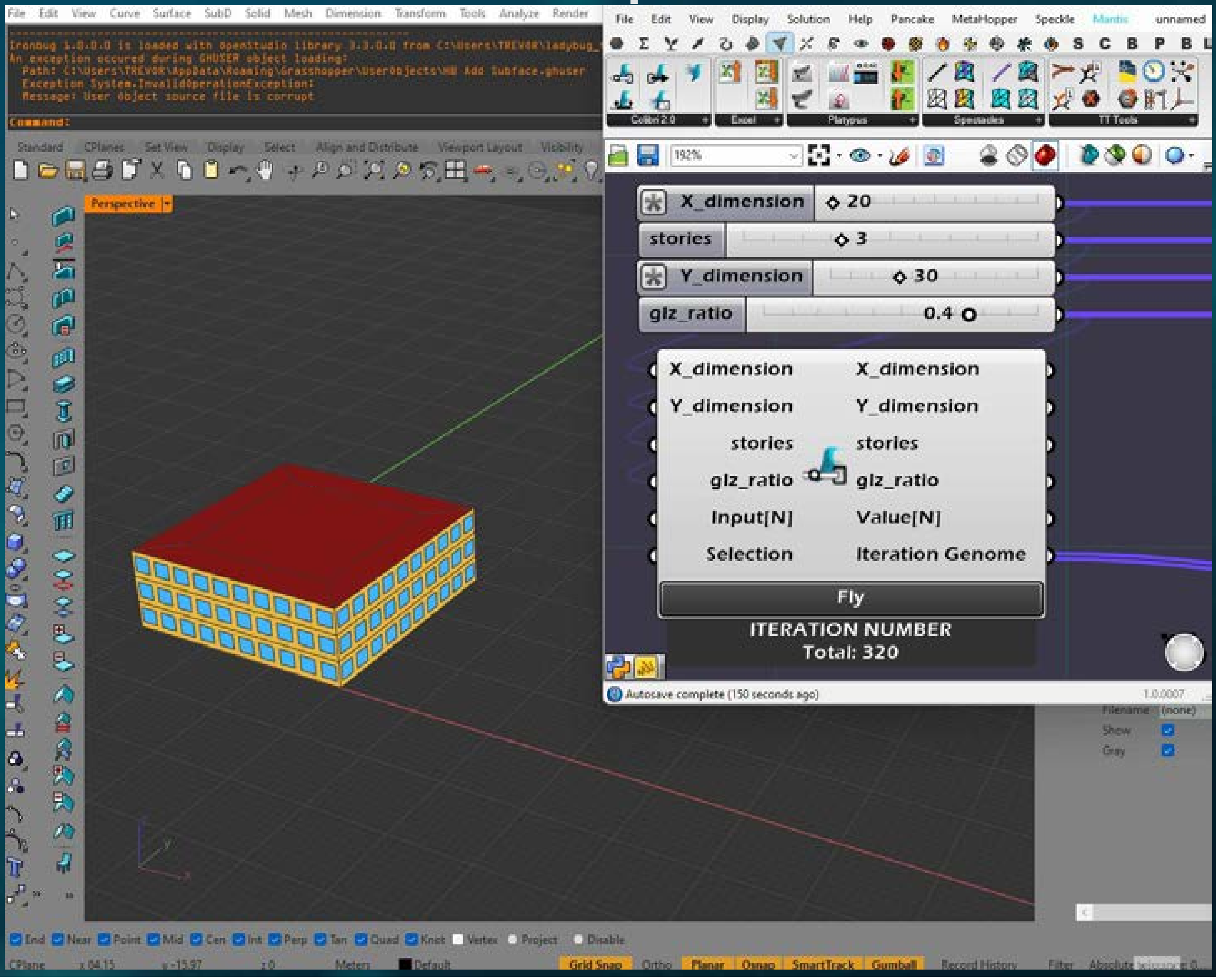
Neuro-Evolution of Augmenting Topologies

Brute Force Iteration

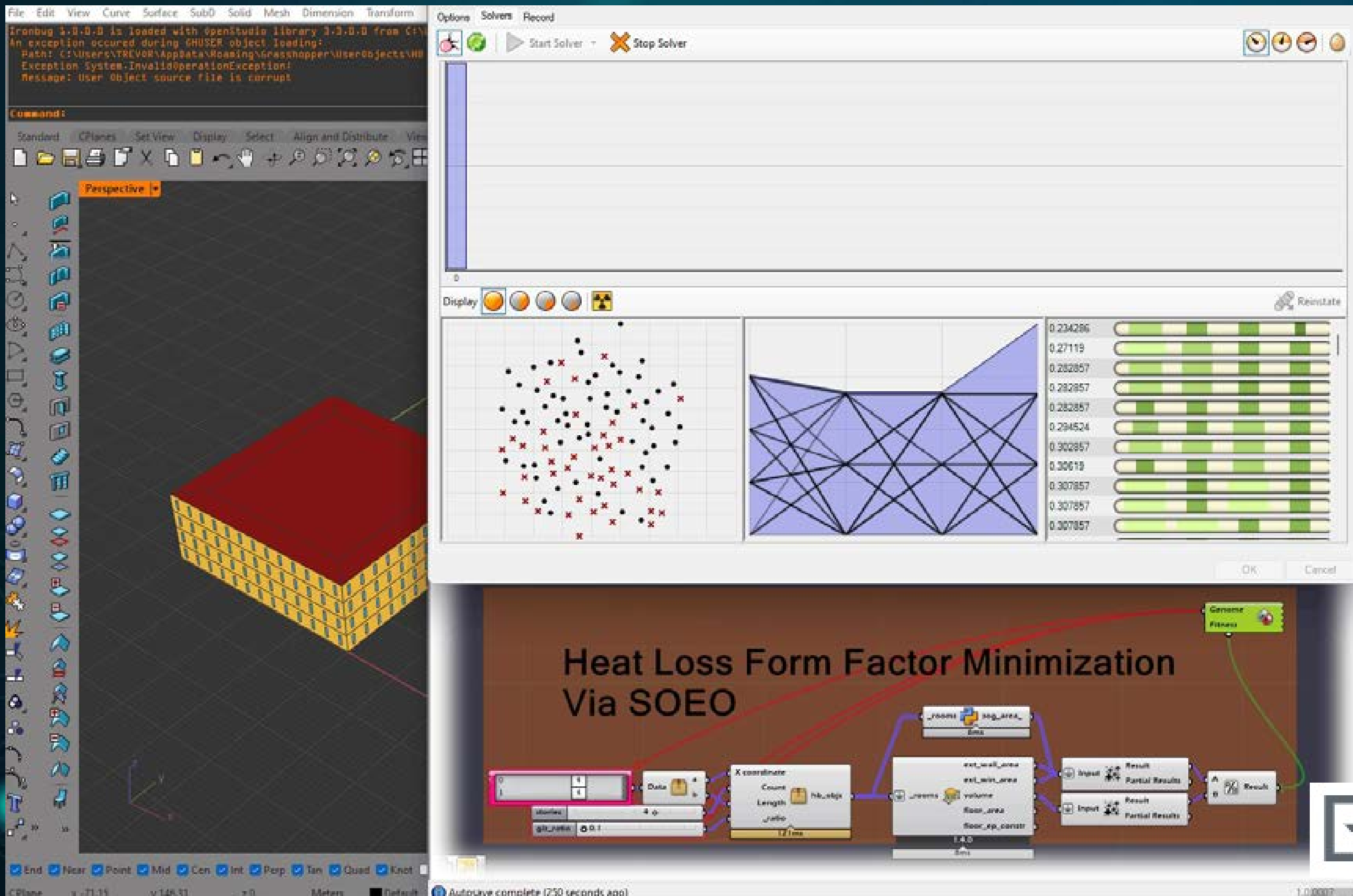
How to Apply Them?

Physics Informed Neural Network

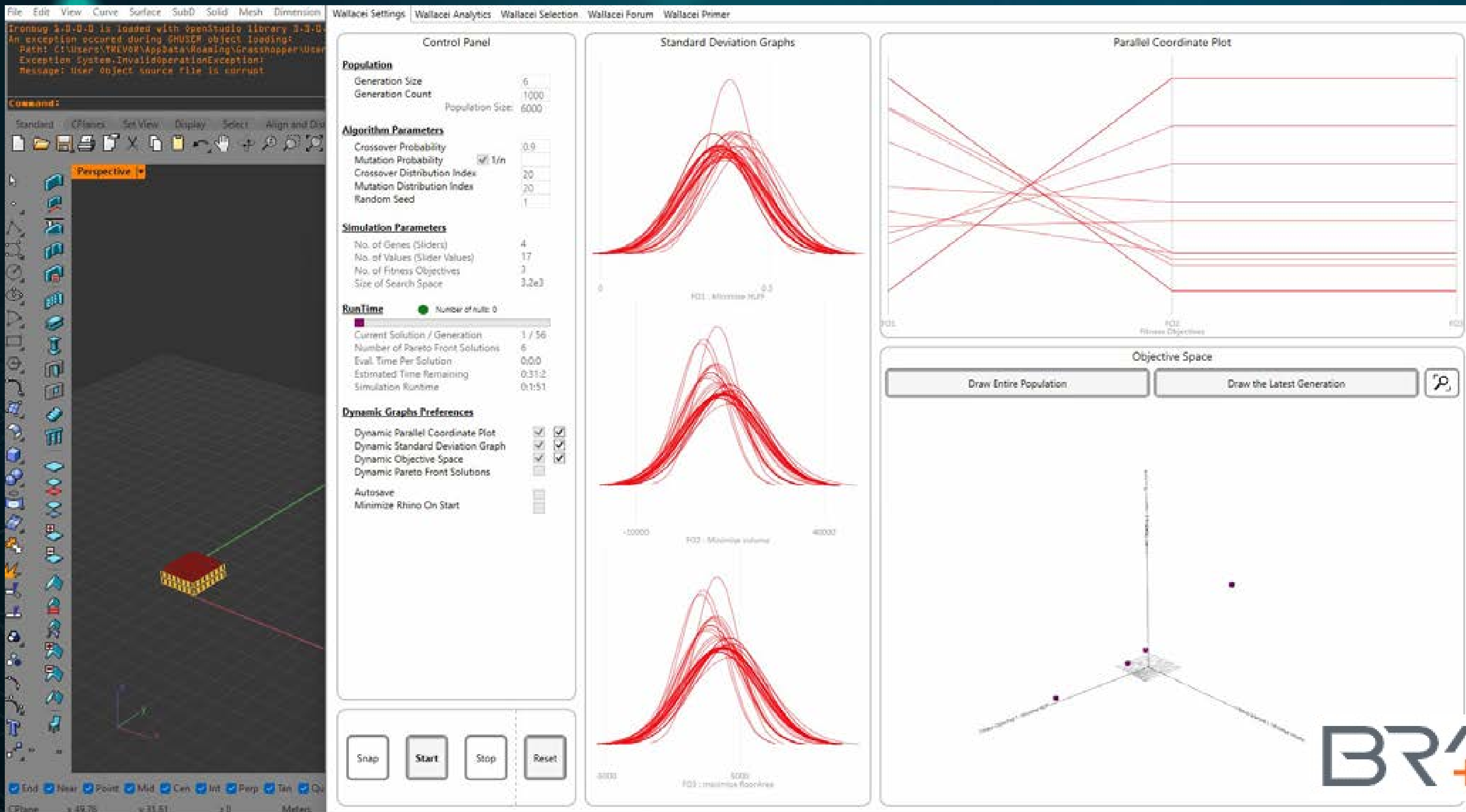
Brute Force Iteration Example



Single Objective Evolutionary Optimization



MULTI-OBJECTIVE EVOLUTIONARY OPTIMIZATION



THE ELEPHANT IN THE ROOM

1% Of world energy use is cloud computing

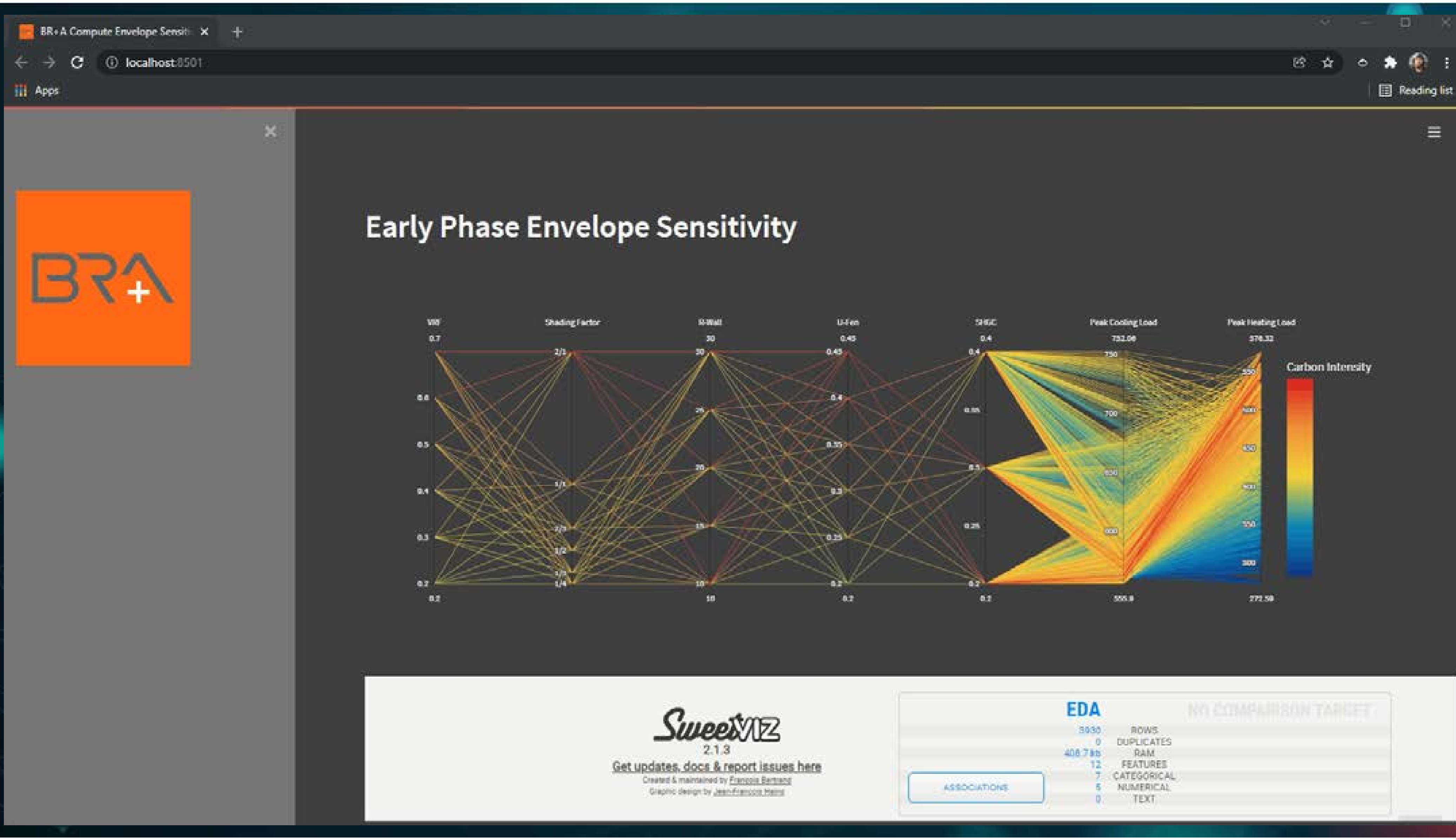
Cloud computing is accepted as ~50% more energy efficient than local server farms.

+1 for cloud compute! But we can do better still, we can utilize a "sustainable data recycling ecosystem" and further minimize the impact of computational design and engineering.

02

Importance of Persuasive, Accurate, Informed Early Phase Design

Setting the Tone, Leading the Charge With Confidence and Precision

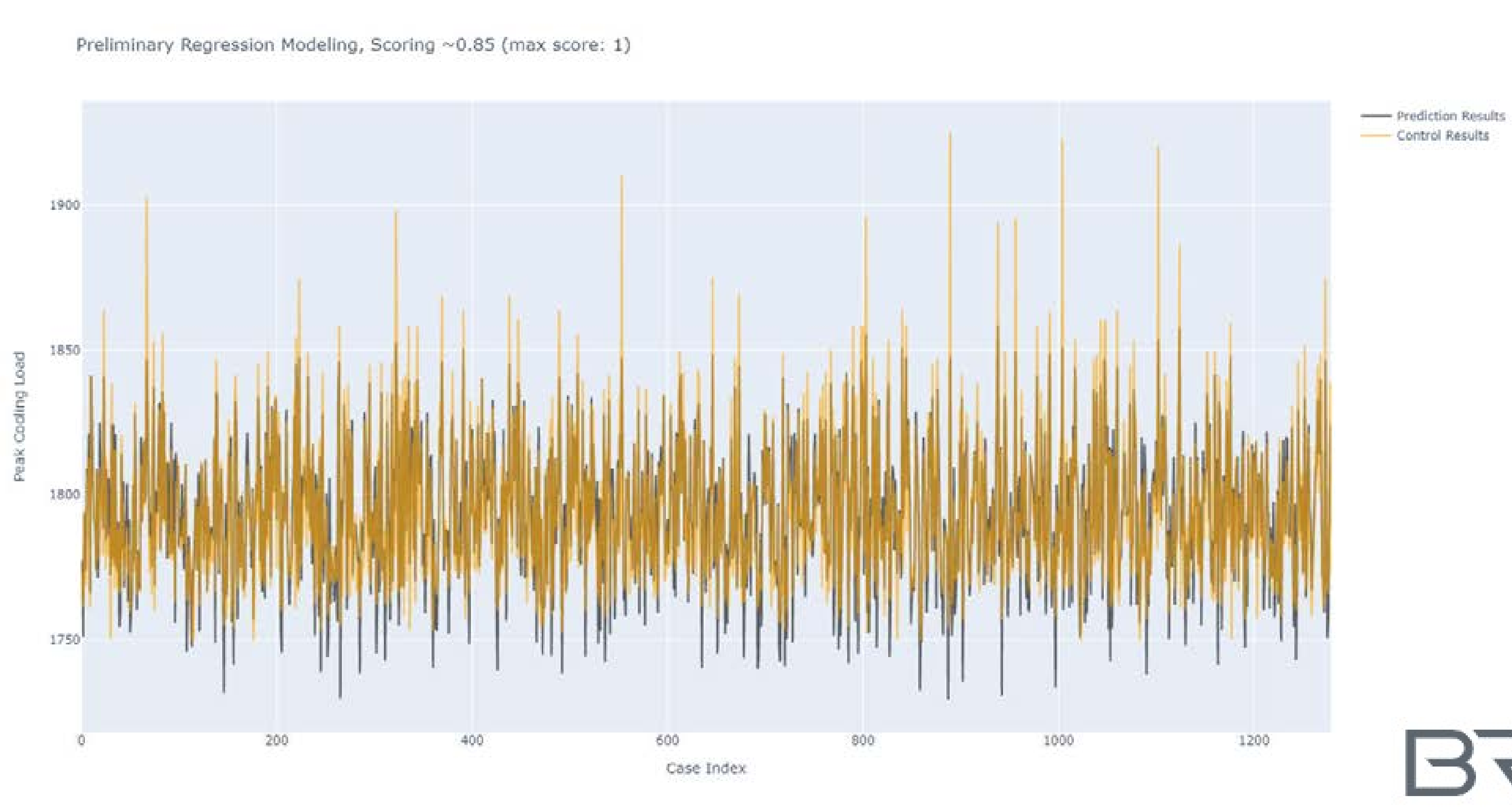


BR+A Compute Envelope Sensiti
localhost:8501
Apps
Reading list
Early Phase Envelope Sensitivity
Shading Factor
R-Wall
U-Fen
SHGC
Peak Cooling Load
Peak Heating Load
Carbon Intensity
2.1.3
Get updates, docs & report issues here
EDA
ROWS
DUPLICATES
RAM
FEATURES
CATEGORICAL
NUMERICAL
TEXT
ASSOCIATIONS


03
Human Expertise
PINN
Data-Reuse
Proj_LrAx
Min-GHG
Min-$$$
Max-Effi

04

THE ROAD AHEAD



NEXT STEPS

- Create initial proof-of concept PINN using the $Q_H = Q_T + Q_V - [\eta \times (Q_S + Q_I)]$ Family of equations

- Continue Parametric studies, utilizing in-house data schema for uniformed training materials

- Learn, Do, Teach, Share

THANK YOU!

Prudence Ferreira, CPHC
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BR+A Consulting Engineers
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PLACETAILOR

Urban
Design
Build

Occupy
the Future.

Agenda

1. MISSION FIRST
2. MODEL SECOND
3. WHAT WE’VE MADE
4. LESSONS LEARNED

1. MISSION FIRST

ACTI VISM ARCH ITECTURE

PT's mission is to facilitate Boston's rapid transition to Future Housing; healthy for the person, healthy for the community, healthy for the planet.

4 CRISES IN BOSTON

Climate crisis

Housing crisis

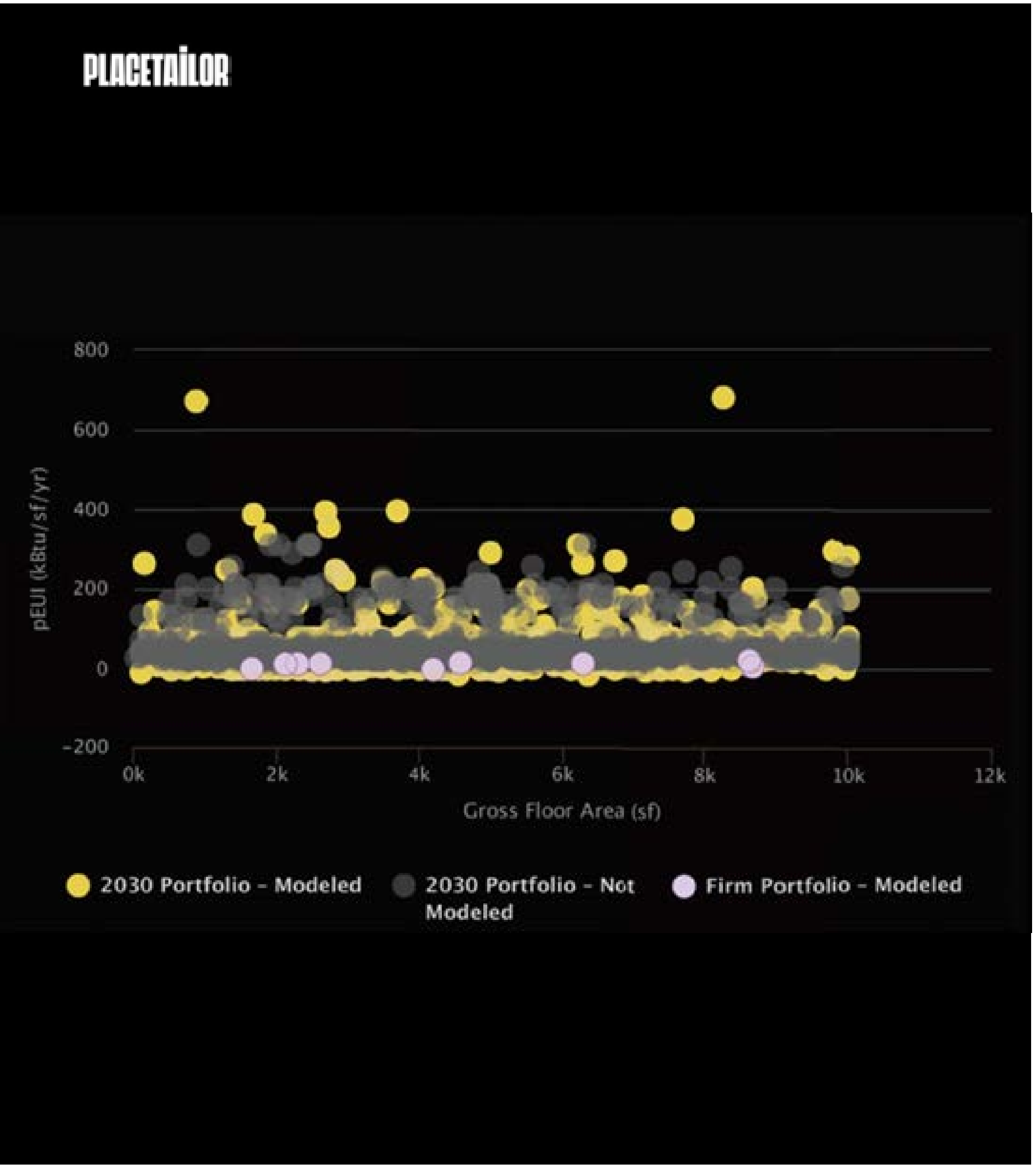
Community / Gentrification crisis

Health crisis

WHAT WE DO:

Design, development and innovation for hyper-sustainable urban housing.

Placetailor is transforming Boston into the ultimate **practice-based R&D** project. Through solving the challenge of Boston, the blueprint to reforming the planet's cities will be cast, and shared.

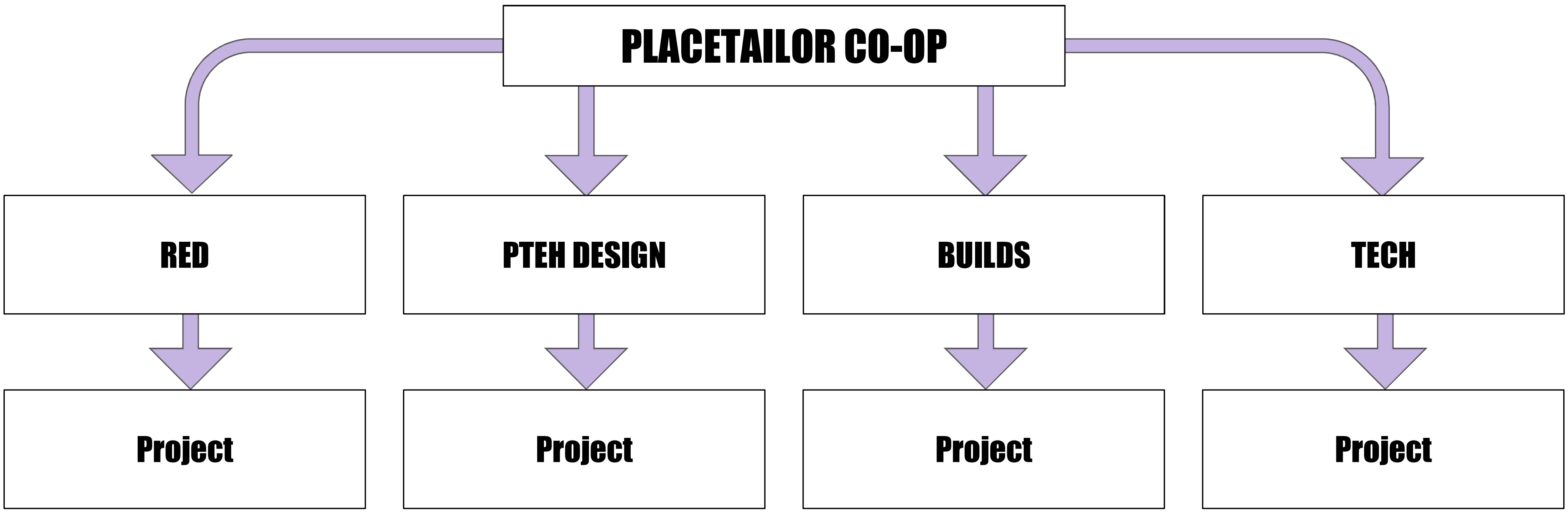


AIA 2030

Every project we've designed or built since founding in 2008 has been Passive House or Zero Net Energy.

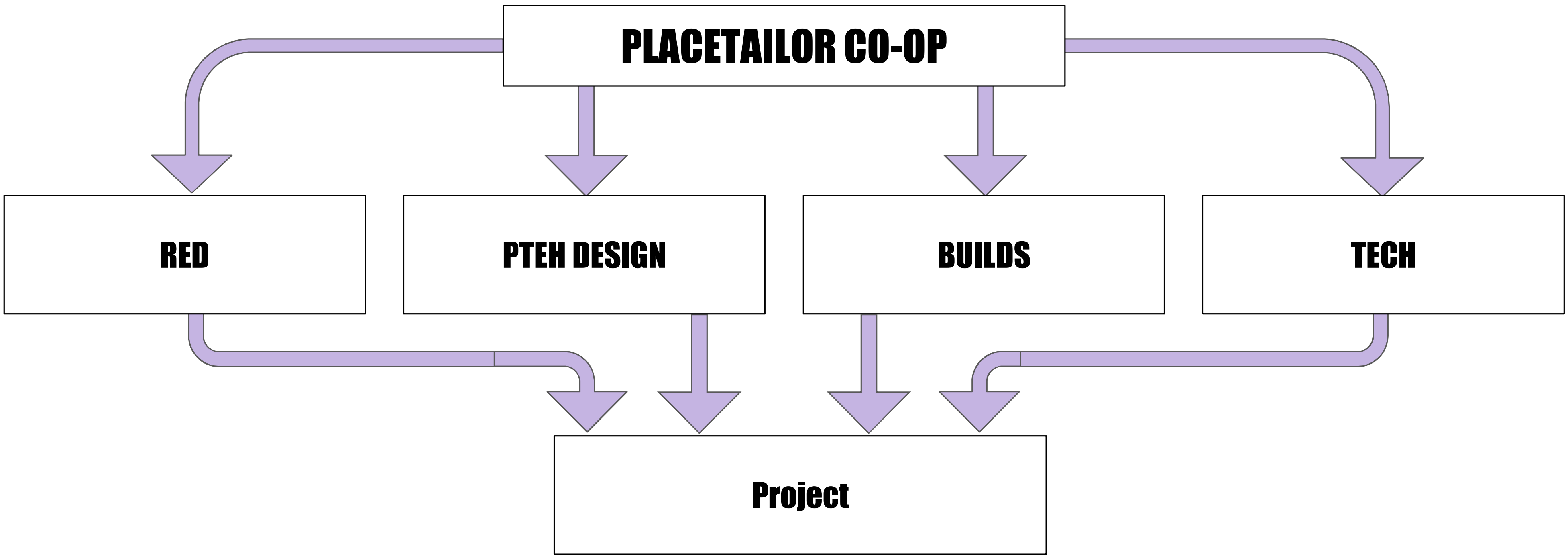
Every project has exceeded the AIA 2030 goals.

2. MODEL SECOND



Each division shares common management resources, such as marketing, accounting, etc.

Each division can work independently on their own projects.



Each division can collaborate with one another on a specific project.

Nick Elton, RA
Principal, PTEH Design

Juliet Borja, RA, LEED AP
Senior Project Manager, PTEH Design

Katherine Faulkner, FAIA
Director of Technologies, PT Tech

Elizabeth Hauver, CP
Energy Design Manager PTEH Design

Minkoo Kang
Design & Development Manager, PT RED

Brad Prestbo, FAIA
Director of Operations, Placetailor

Bruce Hampton, AIA
Principal, PTEH Design

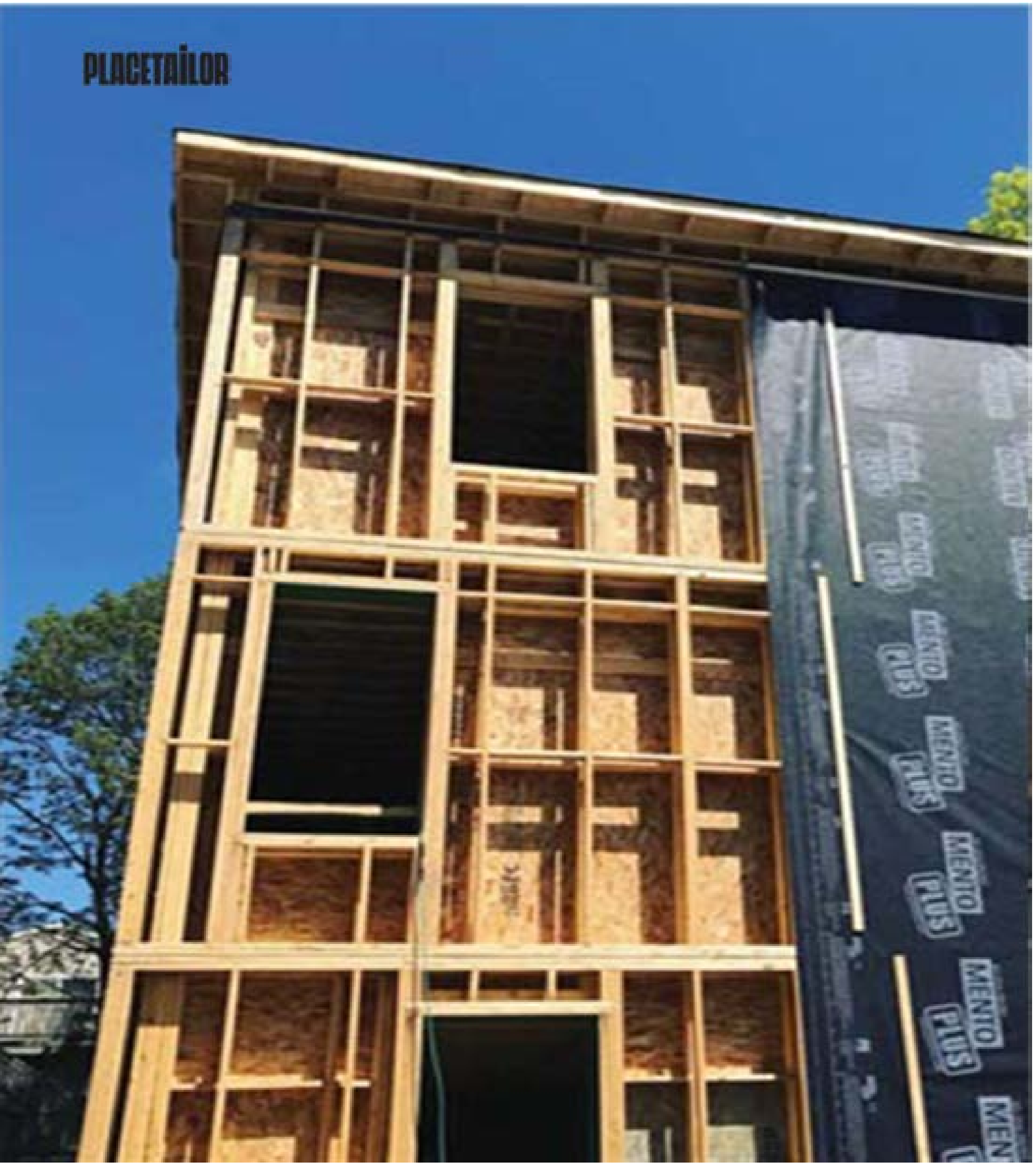
Colin Booth
Managing Director, Placetailor

Evan Smith
Director of Real Estate Development, PT RED

3. WHAT WE'VE MADE

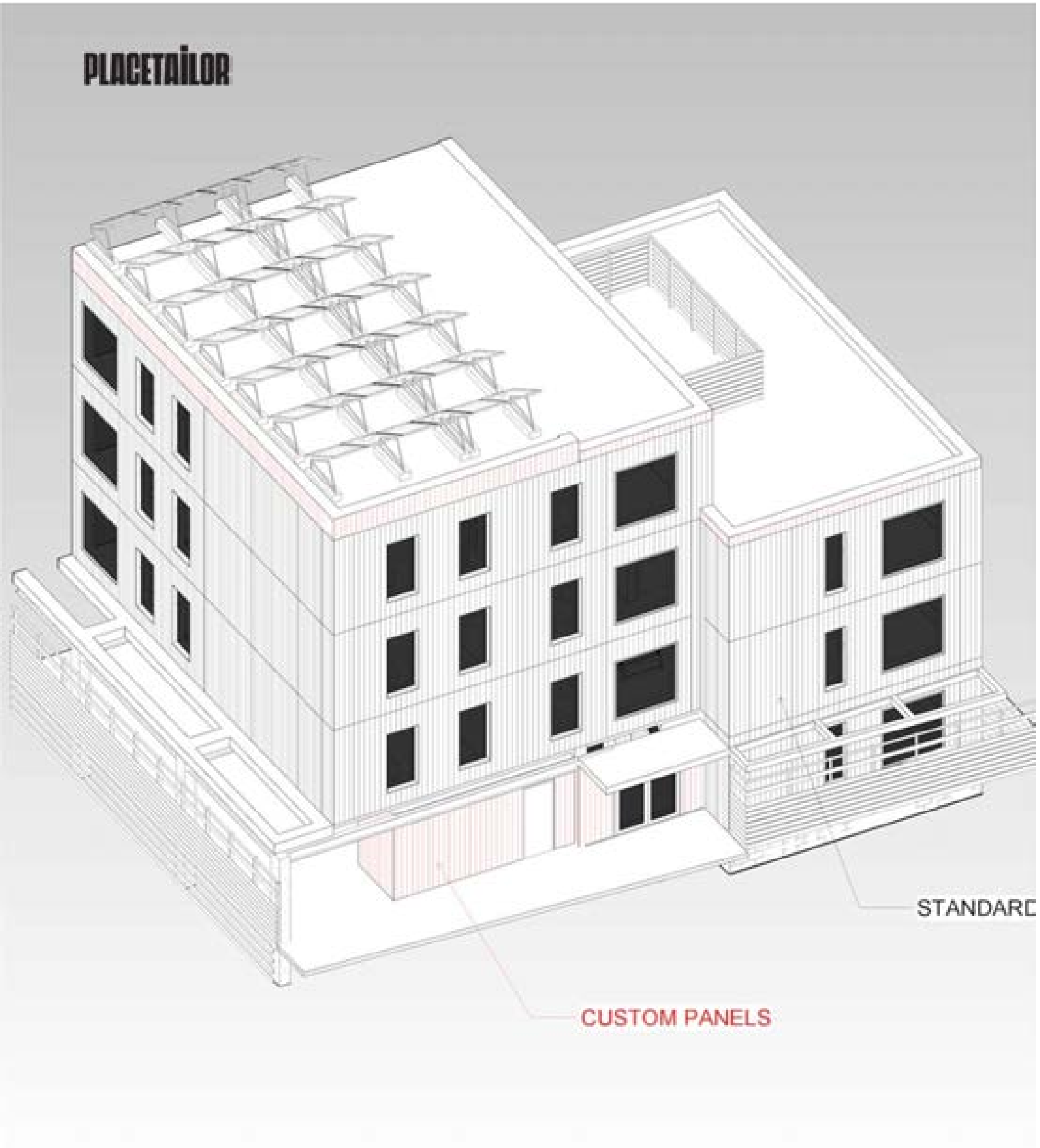
P-B R&D DNA

- 100% commitment to mission
- Model follows the mission
- IP value is captured
- R&D master plan
- R&D on every project
- Culture of DO LEADERSHIP



MODEL A

R and D in various high performance
stick-built assemblies

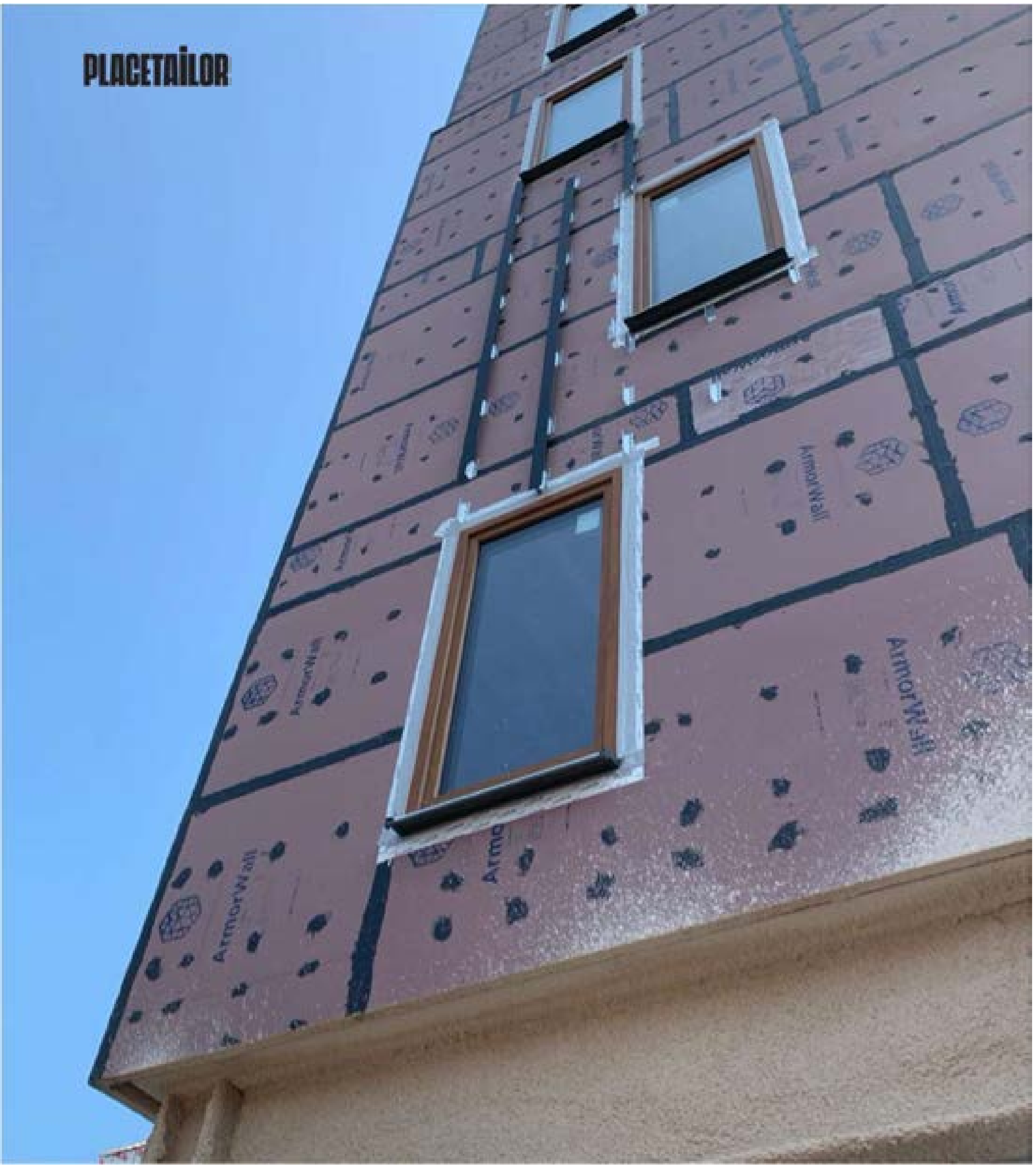


MODEL B

Innovations in delivery model for high performance panelized prefab

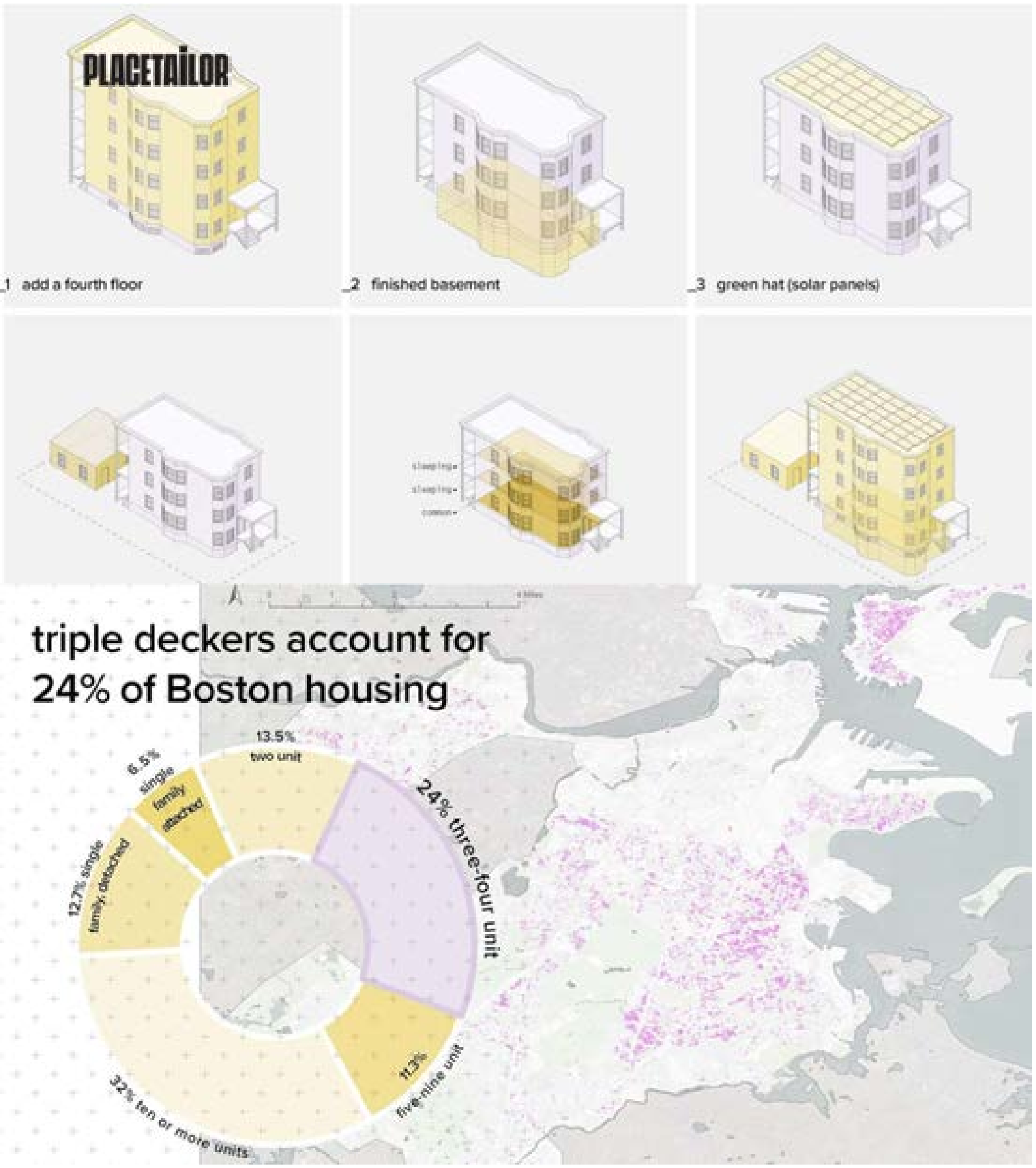
MODEL C

First Boston full CLT
MIT R and D meets mission-first PT



PRODUCT R&D

Integrated analysis from perspectives of energy design, constructability, and development bottom-line



DECARB'ING THE TRIPLE DECKER

Prefab retrofit panel system
+ scalable delivery model

lowered with application of insulating envelope; gas-fired boilers are replaced with Energy Recovery Ventilators and mini-split Heat Pumps.


SCAN
DESIGN
CUT
FINISH
DELIVER
PREP
INSTALL

	Site Built-Up Siding w/ Insulation	Nail Built Insulated Panel	Exterior Insulation and Finish System	PT Panel
Carbon Neutral Product	○	○	○	●
Low Waste Production	○	◒	○	●
Minimized On-Site Labor	○	◒	○	●
Customized Patterns + Textures	○	◒	◒	●
OSHA Friendly Install	○	●	○	●
Cost Competitive vs. Traditional Siding	●	○	●	●

Melnea Cass

- 200 Units
- LEED Platinum
- 100% Affordable

Castle Square

- 500 Units
- In-Place Deep Energy Retrofit
- LEED Silver

63 Moreland

- 7 Unit
- Model B
- Net Zero Ready

31 Tufts

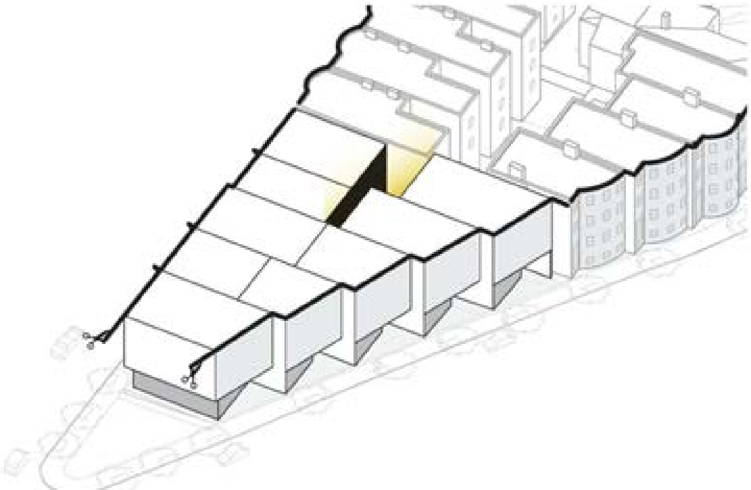
- 15 Units
- Model A
- ILFI zero carbon cert pilot
- Pursuing PHIUS Cert

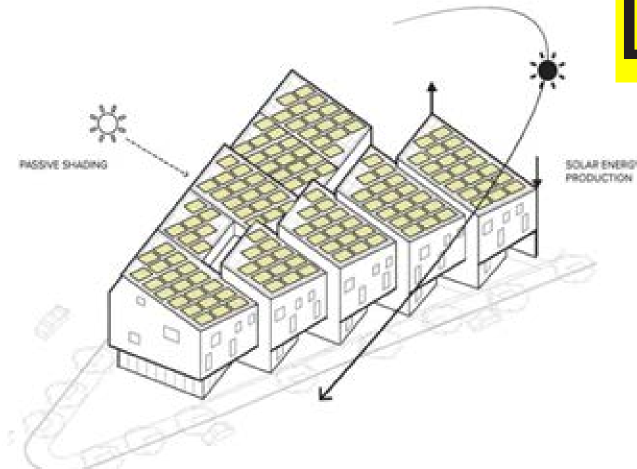
201 Hampden

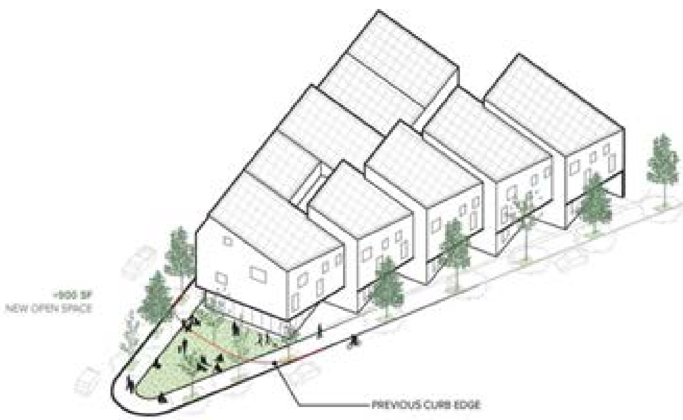
- 14 Units
- First full CLT in Boston
- Affordable commercial ground
- Pursuing PHUIS Certification

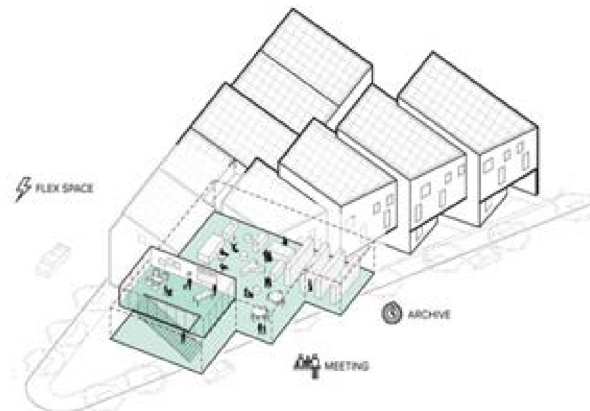
Dudley St.

- 22 Units
- Model B
- Community Space
- HNEF II Fund



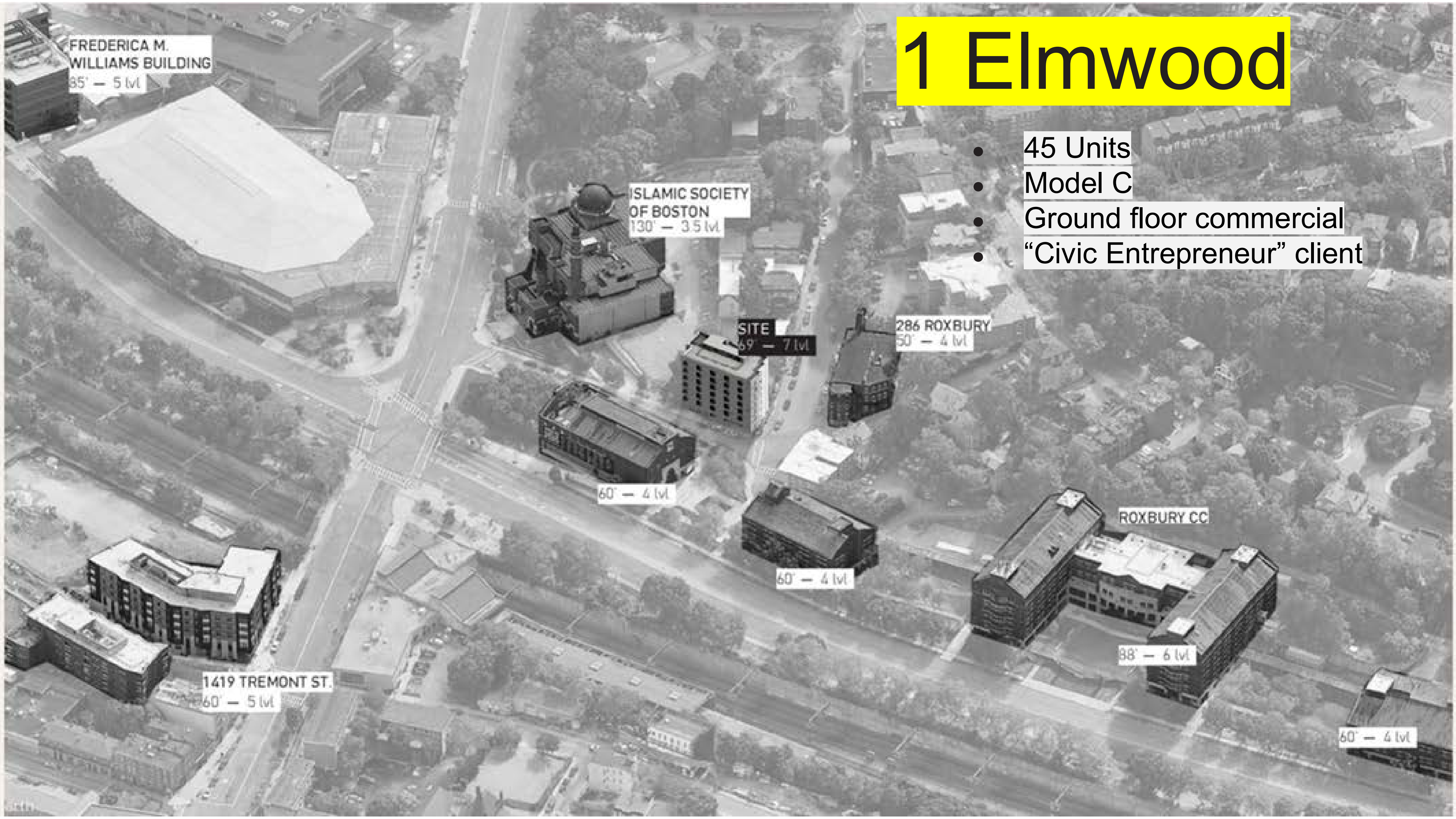






1 Elmwood

- 45 Units
- Model C
- Ground floor commercial
- “Civic Entrepreneur” client



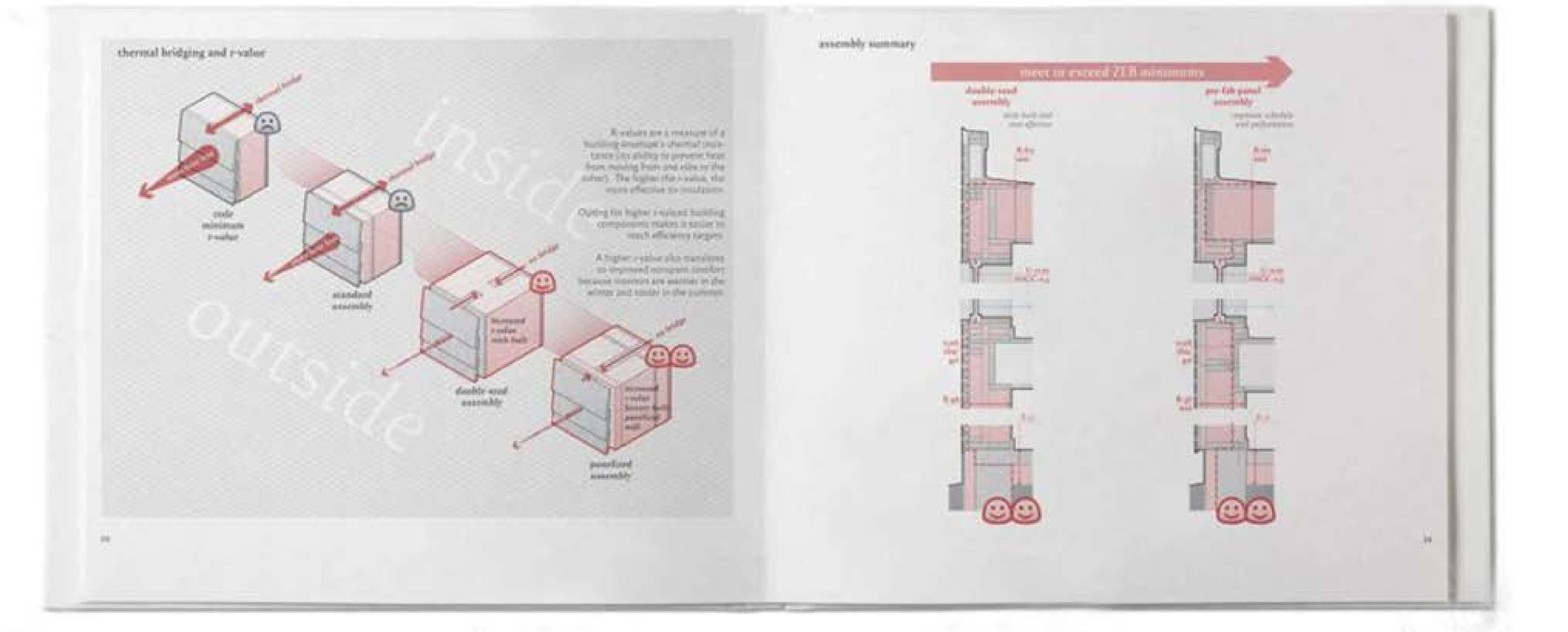

STOP

City of Boston - Department of Neighborhood Development

2020

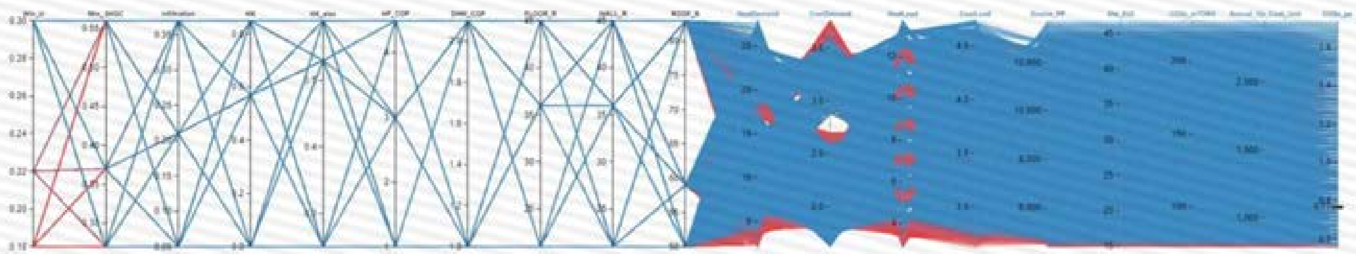
guidebook for Zero Emission Buildings (ZEBs)

City of Boston - DND PLACETAILOR / elton+hampton architects Thornton Tomasetti Bensonwood


thermal bridging and r-value
inside
outside
assembly summary
meet or exceed ZEB minimums

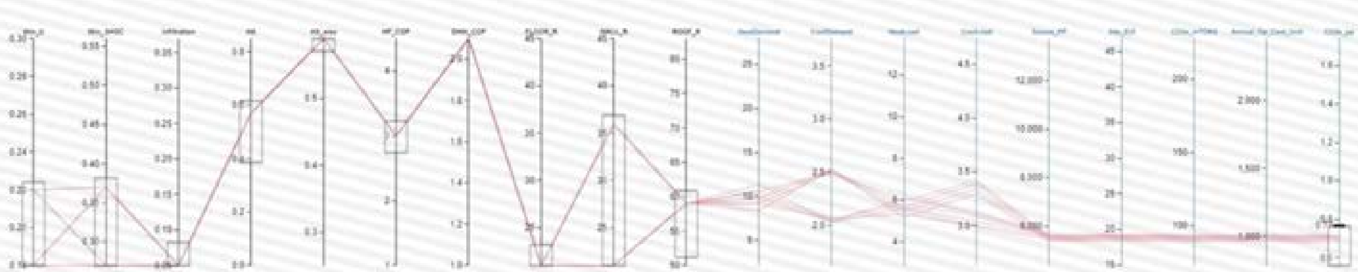
parametric energy modeling

To perform the analysis the team utilized parametric energy modeling, where many combinations of building approaches and features are rapidly and automatically tested by computer programs in order to help find the most energy-efficient and cost-effective combined strategies. Each typology was simulated with approximately 38,000 combinations of variables including envelope air-tightness, opaque envelope R-Values, window and glazing properties, ventilation system alternatives, heating/ cooling systems, and domestic hot water systems. The large-batch optimization studies used WUFI-Plus from Fraunhoffer IBP, with the results post-processed and analyzed using Thornton Tomasetti's Design Explorer, an interactive and multi-dimensional data visualization tool that allowed the team to filter iterations for specific outcomes such as Co2e footprint per person and operational utility cost.



Each vertical line on the left in the image above represents a building characteristic (i.e. window u-value, air-tightness, heat pump C.O.P., wall R-value etc.)

Each vertical line on the right in the image above represents building energy use and CO2 emission based on each building characteristic (i.e. heat demand, cooling demand, site EUI, and CO2e per person)



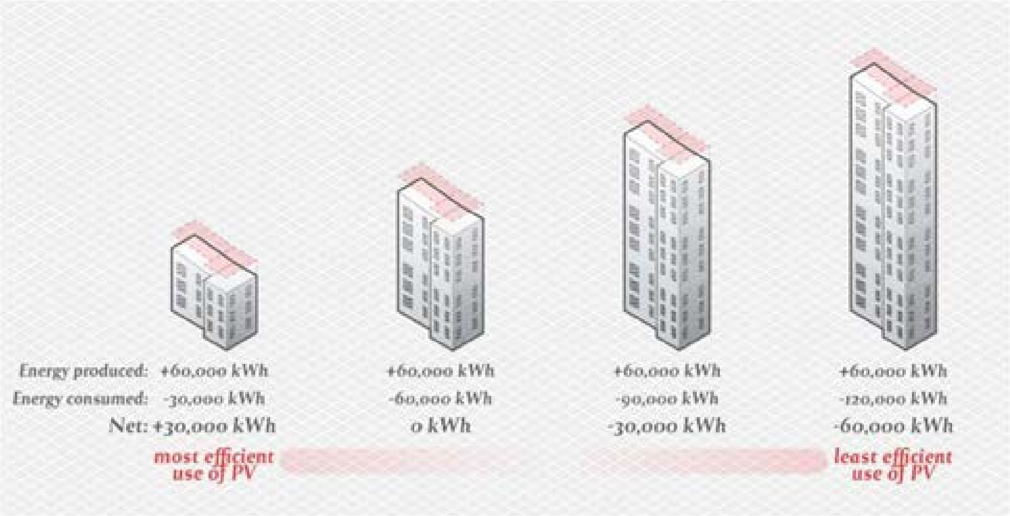
In the image above the CO2 emission for the building has been set to the 0.77 Co2e per person target. The matrix above is generated and a series of building characteristics are selected based on cost and performance. The end result is the optimimal combination of building charaterisics to produce a Zero Emission Building.

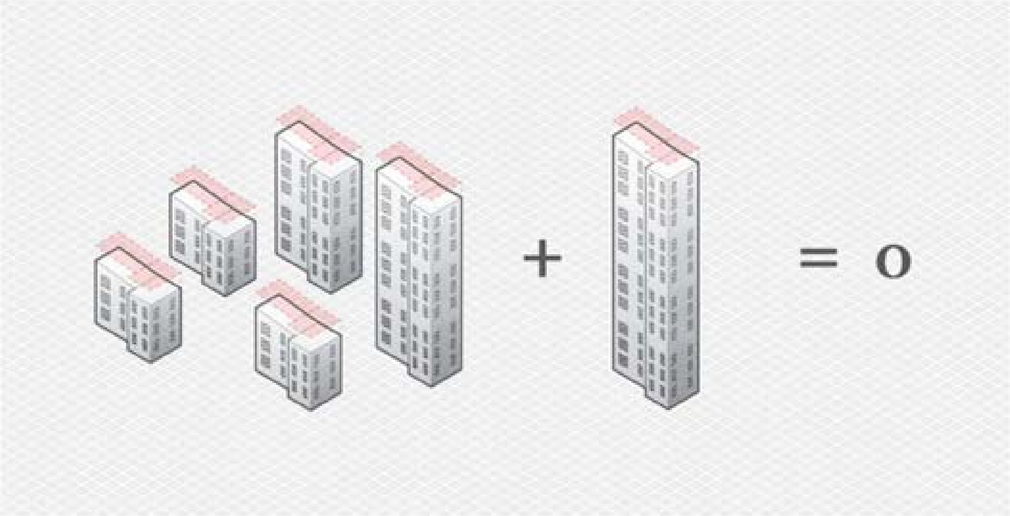
building v portfolio

Further supporting the portfolio approach to reaching zero emissions, the top diagram shows how important it is for smaller buildings to actually be net energy positive. They generate excess power that larger buildings can not. The lower diagram illustrates the portfolio concept. Not all the buildings need to be Zero Emissions, but as a community of buildings are measured together the same outcome is reached.

Applying this approach of a carbon budget per person to existing buildings would be the first step in generating a Zero Emissions plan for the City as a whole.

In cities like Boston with dense housing, there is more opportunity for increasing efficiency when accounting for the entire urban fabric. Zero Emission Buildings are a key component to implementing a clean energy future.





building elements and operation - cost analysis

	Small Multifamily 6 unit bldg	3 Story Multifamily 14 unit bldg	4 - 5 Story Multifamily 50 unit bldg	6 Story Multifamily 51 unit bldg
Stretch Code Baseline Building				
Stretch Code EUI (kBtu/sf/yr)	24	34.2	25.5	26.8
CO2e / per person baseline Stretch Code (mTons/kwh)	0.86	1.19	0.8	0.82
Annual Utility Cost per living unit - 1.52 (dollar / therm)**	$1,820	$1,211	$1,368	$1,481
Stretch Code Baseline Build cost ($)*	**$358,766**	**$387,988**	**$1,298,574**	**$1,464,522**
Zero Emission Building				
ZEB EUI (kBtu/sf/yr)	18	26	21	18
CO2e / per person ZEB (mTons/kwh)	0.77	0.77	0.77	0.77
Annual Operational Cost per Unit ZEB - 22.61 (cents/kWh)	$1,450	$1,200	$1,100	$1,100
ZEB Baseline build cost ($)*	**$361,913**	**$390,312**	**$1,310,419**	**$1,496,920**
Stretch Code vs ZEB				
Incremental Cost difference to ZEB ($) Total project cost	$3,148	$2,324	$11,845	$32,398
Incremental Cost to ZEB (% increase)	0.88%	0.60%	0.91%	2.21%
Incremental change per person CO2e ZEB (% decrease)	**-25%**	**-24%**	**-18%**	**-33%**
Incremental Cost difference to ZEB (% decrease) operational cost	**-20%**	**-1%**	**-20%**	**-26%**
Renewables - Rebates and Incentives are not included				
Solar PV size (kW) - 75% of Roof Areas	37 KW	40 KW	156 KW	104 KW
PV cost installed (Average $3.16 / watt)	$117,000	$126,000	$492,000	$328,000

** Baseline cost is per modeled building component only (U-value, SHGC, Air-Tightness, Heat Recovery efficiency, Domestic Hot Water, Heating, Roof R, Walls R, Floor R)*

*** Stretch code operating cost - Operating costs based on 2018/2019 and 2019/2020 Mass DOER heating cost data*
Plug loads were normalized based on DND occupant criteria (2 people per bedroom) for both Stretch code and ZEB operating costs

How to use this table:
Modeled categories are compared across each typology using stretch code as a baseline standard for energy use, carbon emissions and construction cost. The table highlights the benefits associated with Zero Emissions Buildings, energy and carbon reductions. The table also displays the incremental change associated with operational cost, construction cost and carbon reduction for the modeled building elements.

4. LESSONS LEARNED

Cost Offsets

1. Operational Costs

2. Zoning Approval Process

3. Incentives / Rebates / Grants

4. Sales / Rental Prices

PLACETAILOR

Thank you.

Colin Booth
booth@placetailor.com