PASSIVE BUILDING CASE STUDIES

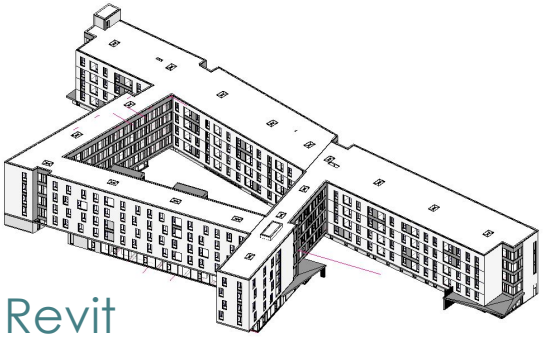
NAPHC 2016

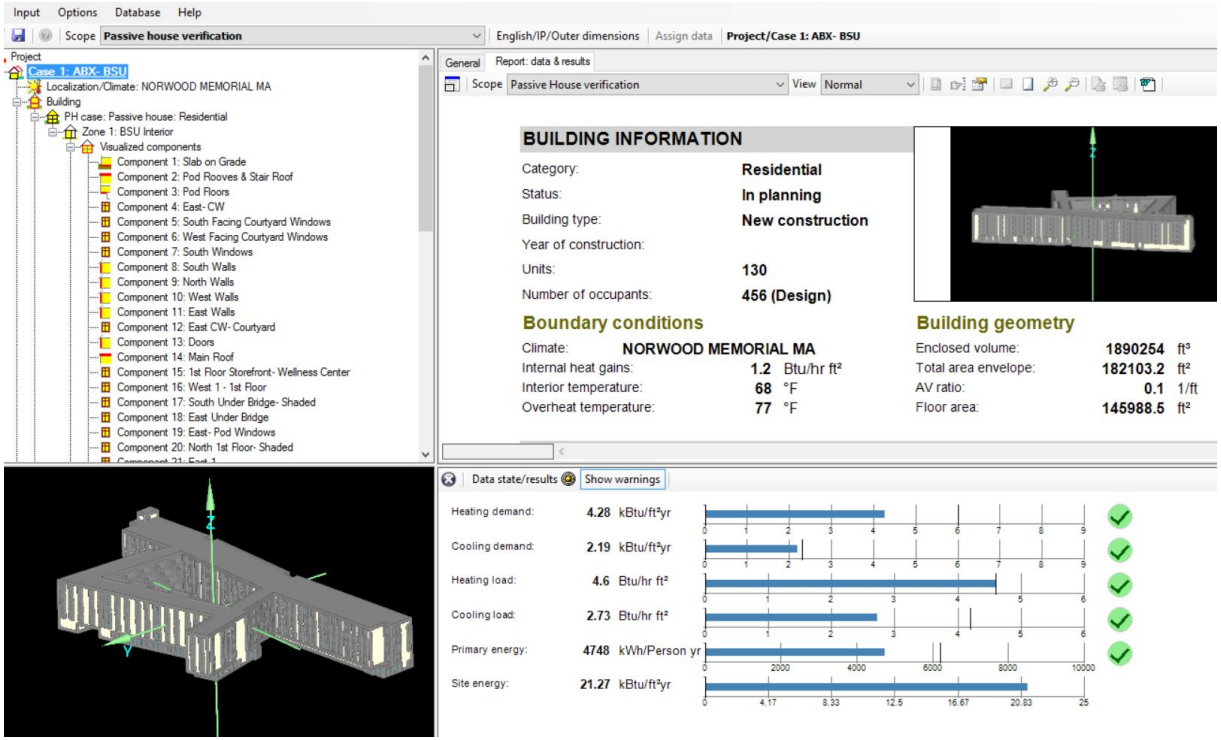
PHILADELPHIA, PA / SEPTEMBER 23, 2016

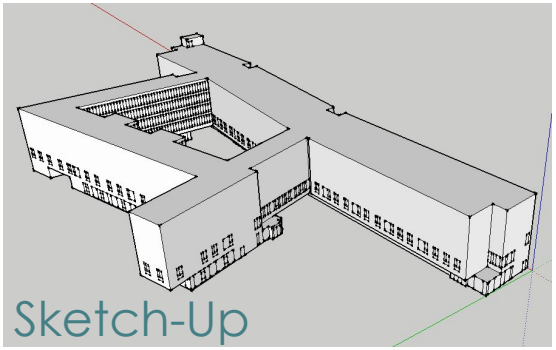
PERKINS+WILL

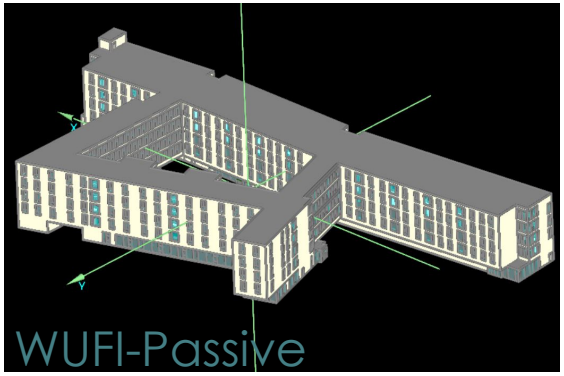
PHIUS Feasibility Study

- What is it?
  - Preliminary Assessment
  - Preliminary Energy Model
  - Envelope Performance
  - Stepping Stone



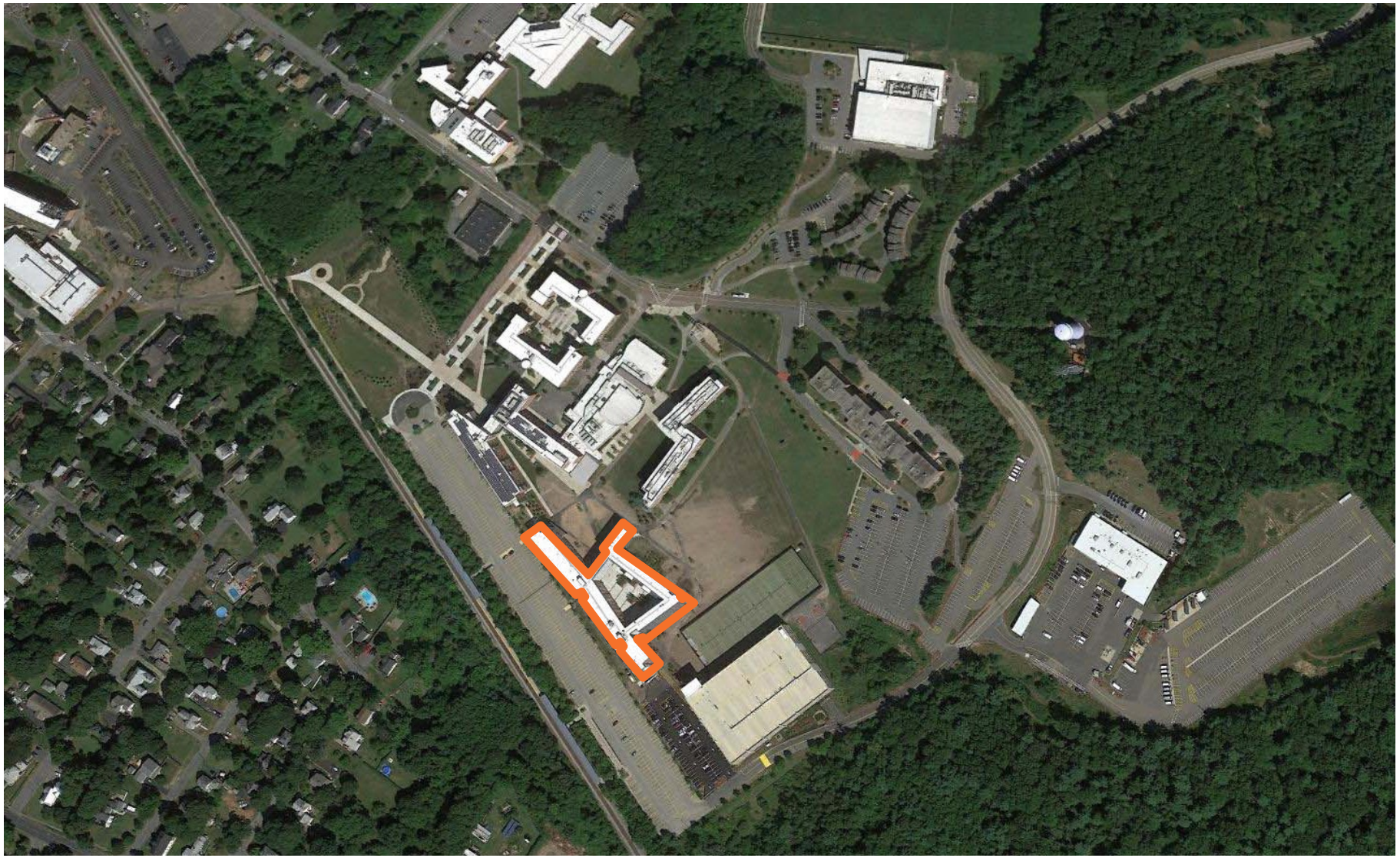




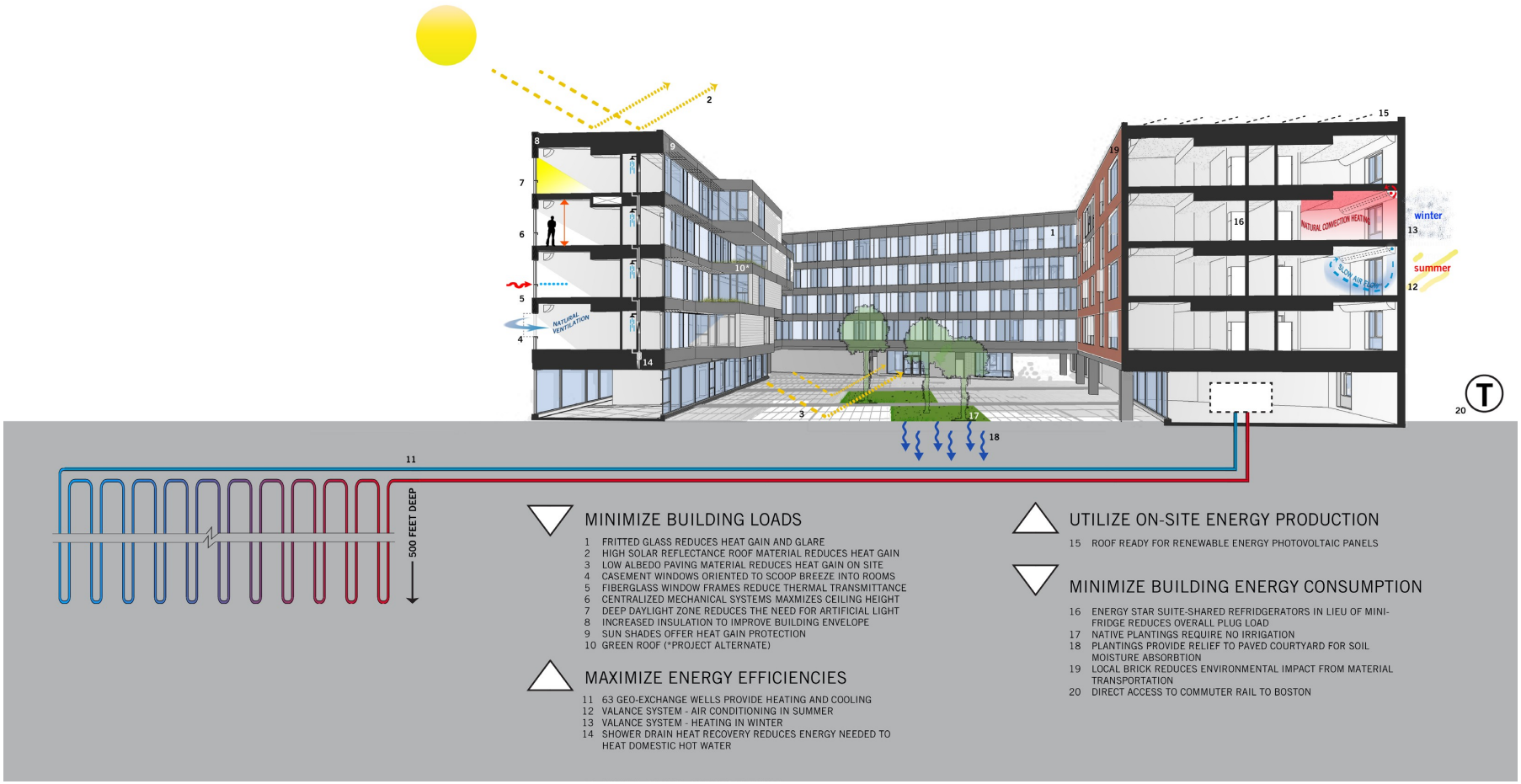


GEORGE WEYGAND HALL

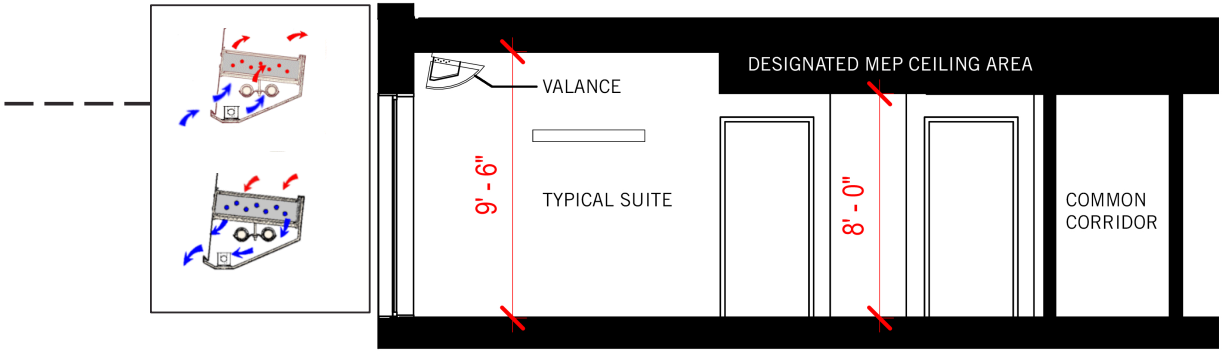
BRIDGEWATER STATE UNIVERSITY, BRIDGEWATER, MA

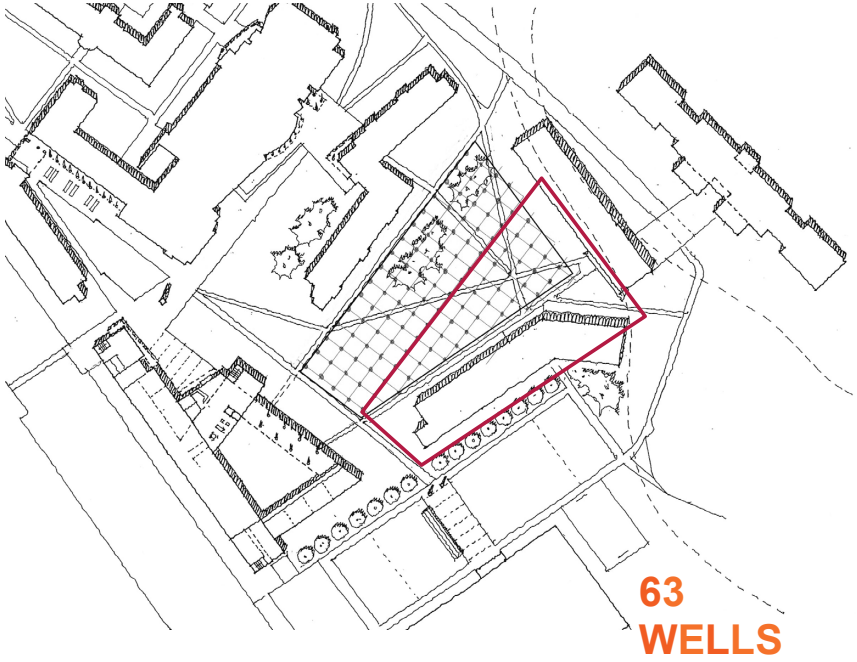


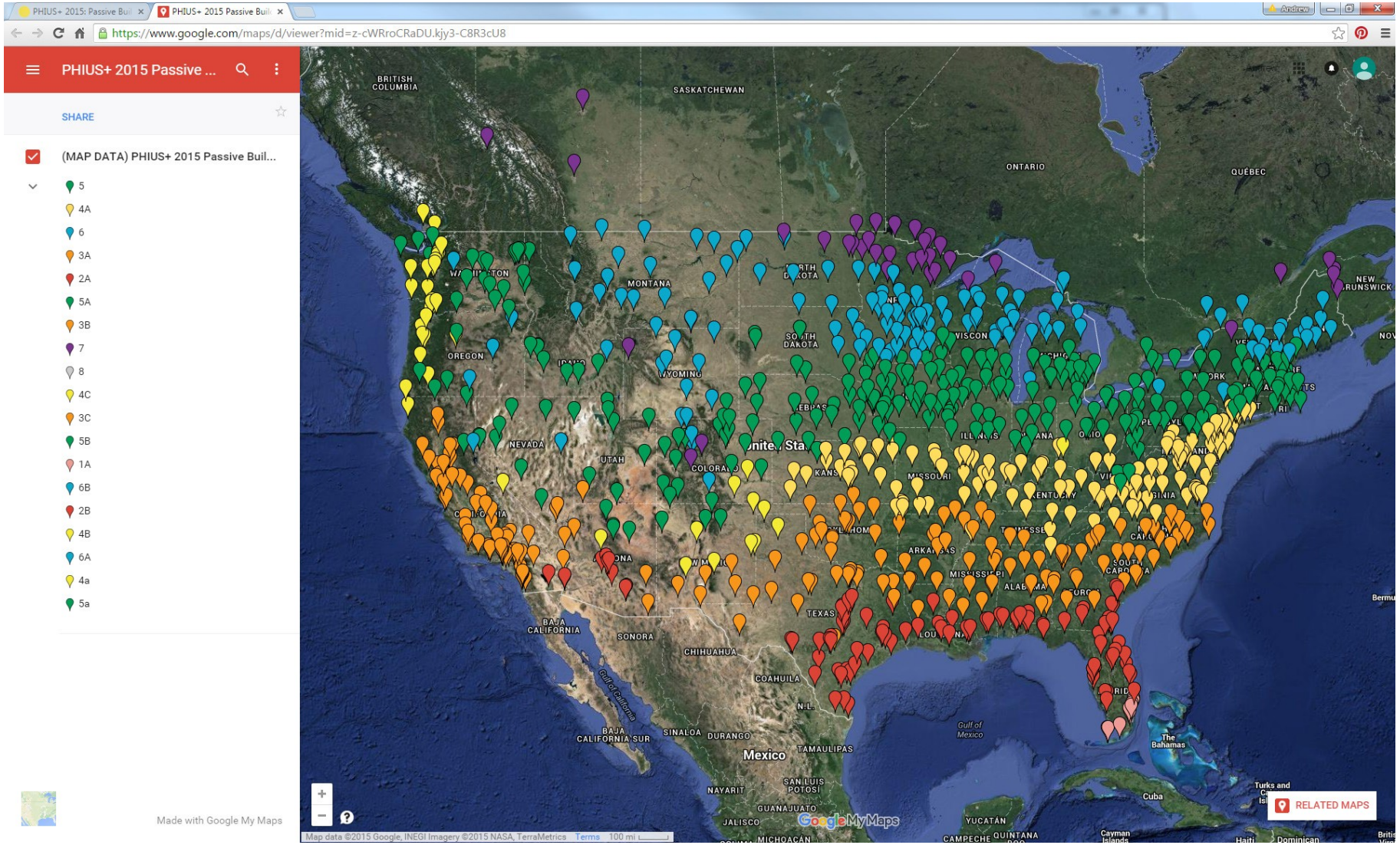

FIRE LANE ACCESS
Transformer
Generator
(8' x 16')


500 FEET DEEP
NATURAL VENTILATION
NATURAL CONVECTION HEATING
winter
summer
MINIMIZE BUILDING LOADS
1 FRITTED GLASS REDUCES HEAT GAIN AND GLARE
2 HIGH SOLAR REFLECTANCE ROOF MATERIAL REDUCES HEAT GAIN
3 LOW ALBEDO PAVING MATERIAL REDUCES HEAT GAIN ON SITE
4 CASEMENT WINDOWS ORIENTED TO SCOOP BREEZE INTO ROOMS
5 FIBERGLASS WINDOW FRAMES REDUCE THERMAL TRANSMITTANCE
6 CENTRALIZED MECHANICAL SYSTEMS MAXMIZES CEILING HEIGHT
7 DEEP DAYLIGHT ZONE REDUCES THE NEED FOR ARTIFICIAL LIGHT
8 INCREASED INSULATION TO IMPROVE BUILDING ENVELOPE
9 SUN SHADES OFFER HEAT GAIN PROTECTION
10 GREEN ROOF (*PROJECT ALTERNATE)
MAXIMIZE ENERGY EFFICIENCIES
11 63 GEO-EXCHANGE WELLS PROVIDE HEATING AND COOLING
12 VALANCE SYSTEM - AIR CONDITIONING IN SUMMER
13 VALANCE SYSTEM - HEATING IN WINTER
14 SHOWER DRAIN HEAT RECOVERY REDUCES ENERGY NEEDED TO HEAT DOMESTIC HOT WATER
UTILIZE ON-SITE ENERGY PRODUCTION
15 ROOF READY FOR RENEWABLE ENERGY PHOTOVOLTAIC PANELS
MINIMIZE BUILDING ENERGY CONSUMPTION
16 ENERGY STAR SUITE-SHARED REFRIDGERATORS IN LIEU OF MINI-FRIDGE REDUCES OVERALL PLUG LOAD
17 NATIVE PLANTINGS REQUIRE NO IRRIGATION
18 PLANTINGS PROVIDE RELIEF TO PAVED COURTYARD FOR SOIL MOISTURE ABSORBTION
19 LOCAL BRICK REDUCES ENVIRONMENTAL IMPACT FROM MATERIAL TRANSPORTATION
20 DIRECT ACCESS TO COMMUTER RAIL TO BOSTON

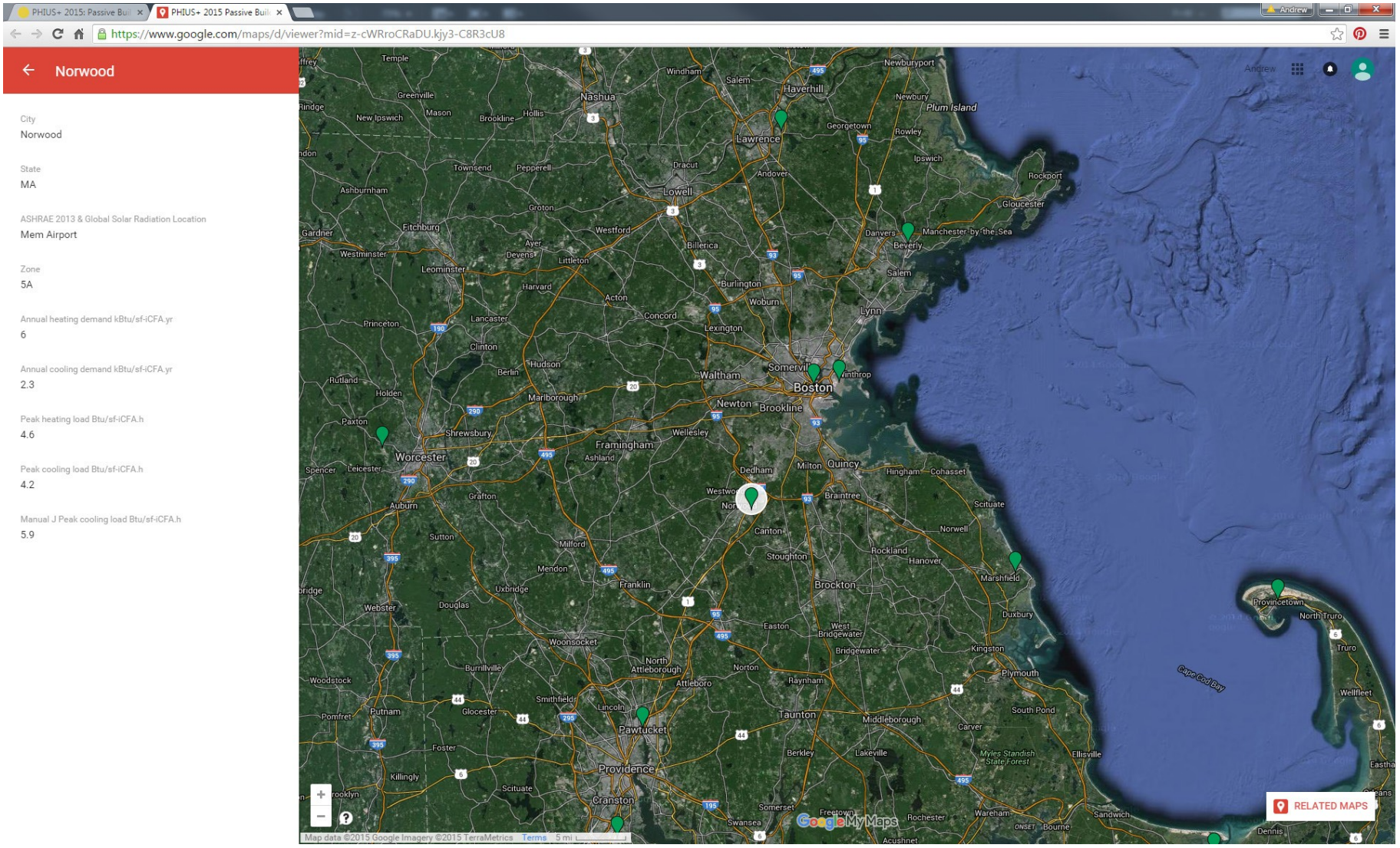
- Geo-exchange Heating & Cooling
- **Valance Suite Heating & Cooling**
- Shower Drain Heat Recovery
- Ventilation Energy Recovery
- Efficient Lighting
- Enhanced Commissioning






PHIUS+ 2015 Passive ...
SHARE
(MAP DATA) PHIUS+ 2015 Passive Buil...
5
4A
6
3A
2A
5A
3B
7
8
4C
3C
5B
1A
6B
2B
4B
6A
4a
5a
Made with Google My Maps
https://www.google.com/maps/d/viewer?mid=z-cWRroCRaDU.kjy3-C8R3cU8
BRITISH COLUMBIA
SASKATCHEWAN
ONTARIO
QUÉBEC
MONTANA
OREGON
WYOMING
NEVADA
UTAH
COLORADO
TEXAS
BAJA CALIFORNIA
SONORA
CHIHUAHUA
COAHUILA
SINALOA
DURANGO
TAMAULIPAS
Mexico
Gulf of Mexico
Cuba
The Bahamas
RELATED MAPS
Map data ©2015 Google, INEGI Imagery ©2015 NASA, TerraMetrics Terms 100 mi

PHIUS + 2015


PHIUS+ 2015: Passive Buil
PHIUS+ 2015 Passive Buil
https://www.google.com/maps/d/viewer?mid=z-cWRroCRaDU.kjy3-C8R3cU8
Norwood
City
Norwood
State
MA
ASHRAE 2013 & Global Solar Radiation Location
Mem Airport
Zone
5A
Annual heating demand kBtu/sf-iCFA.yr
6
Annual cooling demand kBtu/sf-iCFA.yr
2.3
Peak heating load Btu/sf-iCFA.h
4.6
Peak cooling load Btu/sf-iCFA.h
4.2
Manual J Peak cooling load Btu/sf-iCFA.h
5.9
Boston
Worcester
Framingham
Lowell
Lawrence
Haverhill
Nashua
Brockton
Quincy
Newton
Brookline
Waltham
Somerville
Pawtucket
Providence
Cranston
Taunton
Plymouth
Provincetown
Marshfield
Beverly
Manchester-by-the-Sea
Gloucester
Rockport
Ipswich
Newburyport
Plum Island
Cape Cod Bay
RELATED MAPS
Google My Maps
Map data ©2015 Google Imagery ©2015 TerraMetrics
Terms
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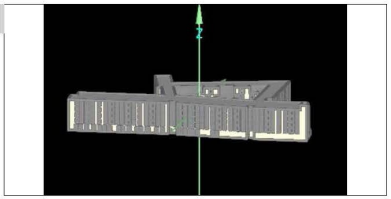
PHIUS + 2015

WUFI®Passive Passive

BUILDING INFORMATION

Category:	**Residential**
Status:	**In planning**
Building type:	**New construction**
Year of construction:	
Units:	**130**
Number of occupants:	**456 (Design)**



Boundary conditions

Climate:	**NORWOOD MEMORIAL MA**	
Internal heat gains:	**1.1**	Btu/hr ft²
Interior temperature:	**68**	°F
Overheat temperature:	**77**	°F

Building geometry

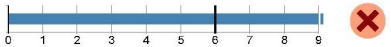
Enclosed volume:	**1890254**	ft³
Total area envelope:	**182103.2**	ft²
AV ratio:	**0.1**	1/ft
Floor area:	**145988.5**	ft²

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **PHIUS+ 2015 Standard**

Heating demand

specific:	**20.89**	kBtu/ft²yr
target:	**6**	kBtu/ft²yr
total:	3048814.43	kBtu/yr



Cooling demand

specific:	**2.51**	kBtu/ft²yr
target:	**2.3**	kBtu/ft²yr
total:	366980.62	kBtu/yr
latent:	0.82	kBtu/ft²yr

Heating load

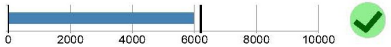
specific:	**13.58**	Btu/hr ft²
target:	**4.6**	Btu/hr ft²
total:	1982877.3	Btu/hr

Cooling load

specific:	**2.69**	Btu/hr ft²
target:	**4.2**	Btu/hr ft²
total:	392391.8	Btu/hr

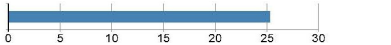
Primary energy

specific:	**5981**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	9304738.23	kBtu/yr



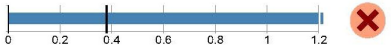
Site energy

total:	25.27	kBtu/ft²yr
building systems:	102.3	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**3**	1/hr
target:	**0.38**	1/hr
CFM50 per envelope area:	**0.39**	cfm/ft²
target:	**0.05**	cfm/ft²



AS BUILT

WALLS: R22

ROOF: R48

SLAB: R15

WINDOWS: R3 (INSTALLED)

CURTAINWALL: R1.78 (INSTALLED)

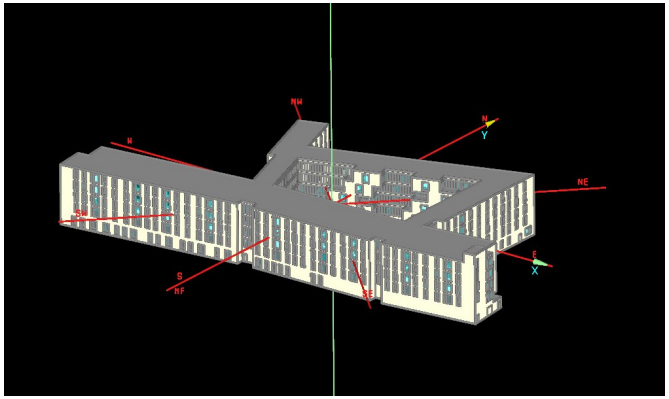
-HEATING DOMINATED

-ASSUMES AIR INFILTRATION

OTHER FACTORS:

BUILDING FORM (SURFACE TO VOLUME)

CURTAIN WALL (LOSS THROUGH ENVELOPE)



US+11.3.mwp

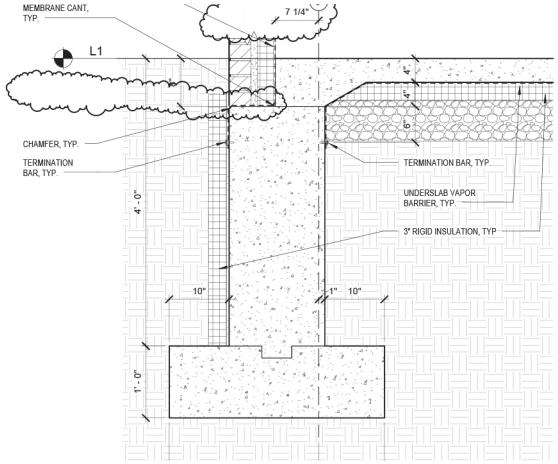
Outer dimensions | Assign data | **Project/Case 1: ABX- BSU/Building/PH case: Passive house: Residential/Zone 1: BSU Interior/Thermal bridges**

Linear thermal bridges

Nr	Name	Linear thermal transmittance [Btu/hr ft °F]	Length [ft]	Attachment
1	Estimated Perimeter T.B.	0.4	1830	Perimeter

New
Delete
Copy
Insert
New/Insert:
after

THERMAL BRIDGING (MINOR)



WUFI®Passive Passive

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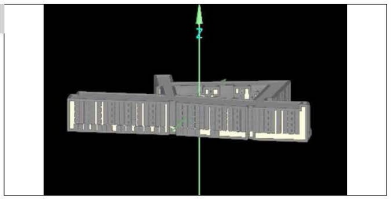


Boundary conditions

Climate:	**NORWOOD MEMORIAL MA**	
Internal heat gains:	**1.1**	Btu/hr ft²
Interior temperature:	**68**	°F
Overheat temperature:	**77**	°F

Building geometry

Enclosed volume:	**1890254**	ft³
Total area envelope:	**182103.2**	ft²
AV ratio:	**0.1**	1/ft
Floor area:	**145988.5**	ft²

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **PHIUS+ 2015 Standard**

Heating demand

specific:	**5.81**	kBtu/ft²yr
target:	**6**	kBtu/ft²yr
total:	847433.56	kBtu/yr

Cooling demand

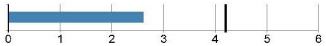
specific:	**2.17**	kBtu/ft²yr
target:	**2.3**	kBtu/ft²yr
total:	316506.9	kBtu/yr
latent:	0	kBtu/ft²yr

Heating load

specific:	**4.58**	Btu/hr ft²
target:	**4.6**	Btu/hr ft²
total:	668962.34	Btu/hr

Cooling load

specific:	**2.61**	Btu/hr ft²
target:	**4.2**	Btu/hr ft²
total:	381549.55	Btu/hr

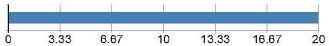


Primary energy

specific:	**4382**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	6818038.05	kBtu/yr

Site energy

total:	19.98	kBtu/ft²yr
building systems:	43.54	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.05**	1/hr
target:	**0.38**	1/hr
CFM50 per envelope area:	**0.01**	cfm/ft²
target:	**0.05**	cfm/ft²

MODIFIED TO PH STANDARD

WALLS: R30 (+R8)

ROOF: R48 (SAME)

SLAB: R15 (SAME)

WINDOWS: R5(INSTALLED) (+R2)

CURTAINWALL: R5 (INSTALLED) (+R3.22)

-ASSUMES PH AIRTIGHTNESS

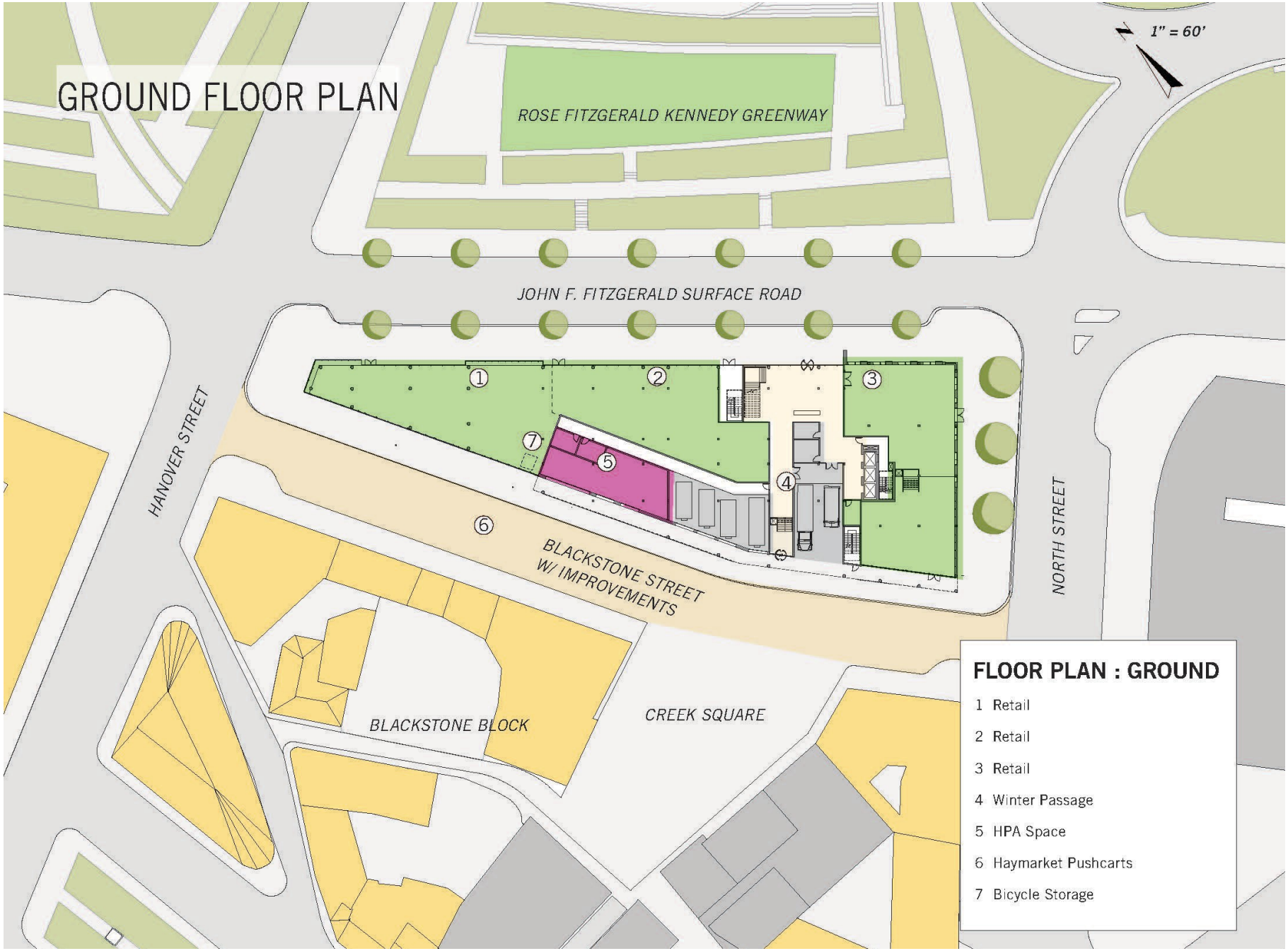
-SHGC FROM 0.27 TO 0.35 ON S. GLASS (INCREASE SOLAR GAINS)

PARCEL 9

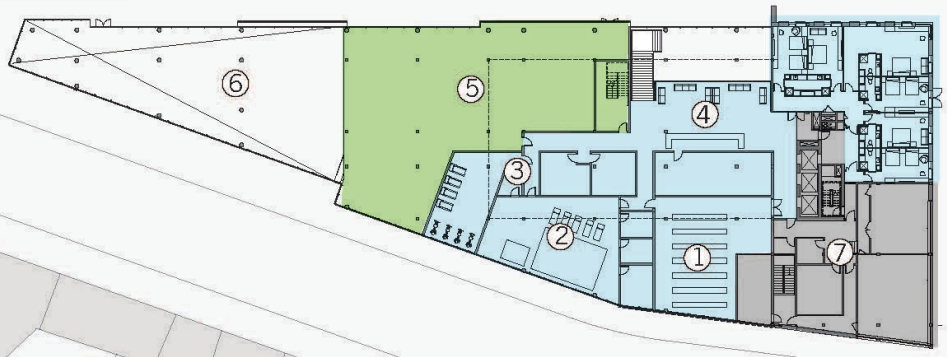
HOTEL AND MARKET, BOSTON, MA


HAYMARKET


HAYMARKET


GROUND FLOOR PLAN
ROSE FITZGERALD KENNEDY GREENWAY
1" = 60'
JOHN F. FITZGERALD SURFACE ROAD
HANOVER STREET
NORTH STREET
BLACKSTONE STREET
W/ IMPROVEMENTS
BLACKSTONE BLOCK
CREEK SQUARE
FLOOR PLAN : GROUND
1 Retail
2 Retail
3 Retail
4 Winter Passage
5 HPA Space
6 Haymarket Pushcarts
7 Bicycle Storage

SECOND FLOOR PLAN



FLOOR PLAN : SECOND

1 Community Room

2 Pool

3 Fitness

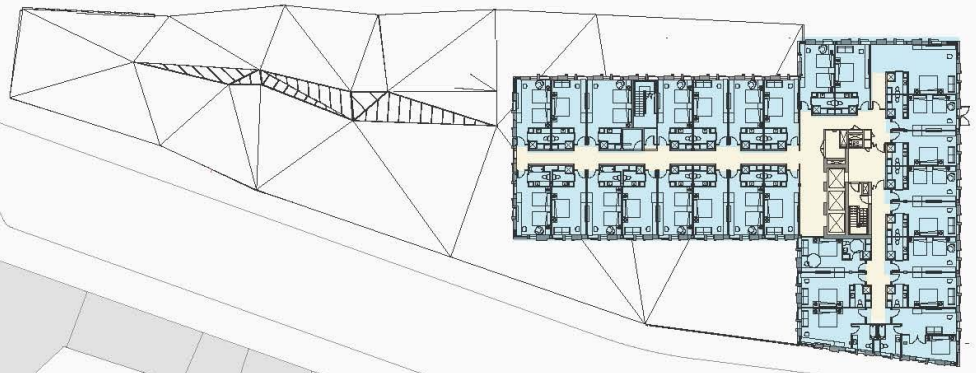
4 Hotel Lobby

5 Retail

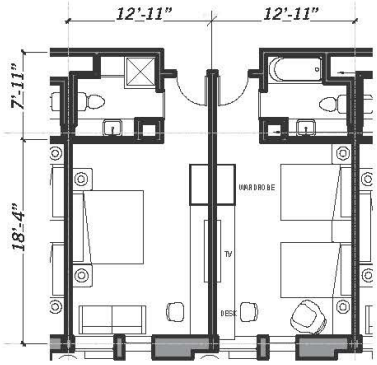
6 Market Below

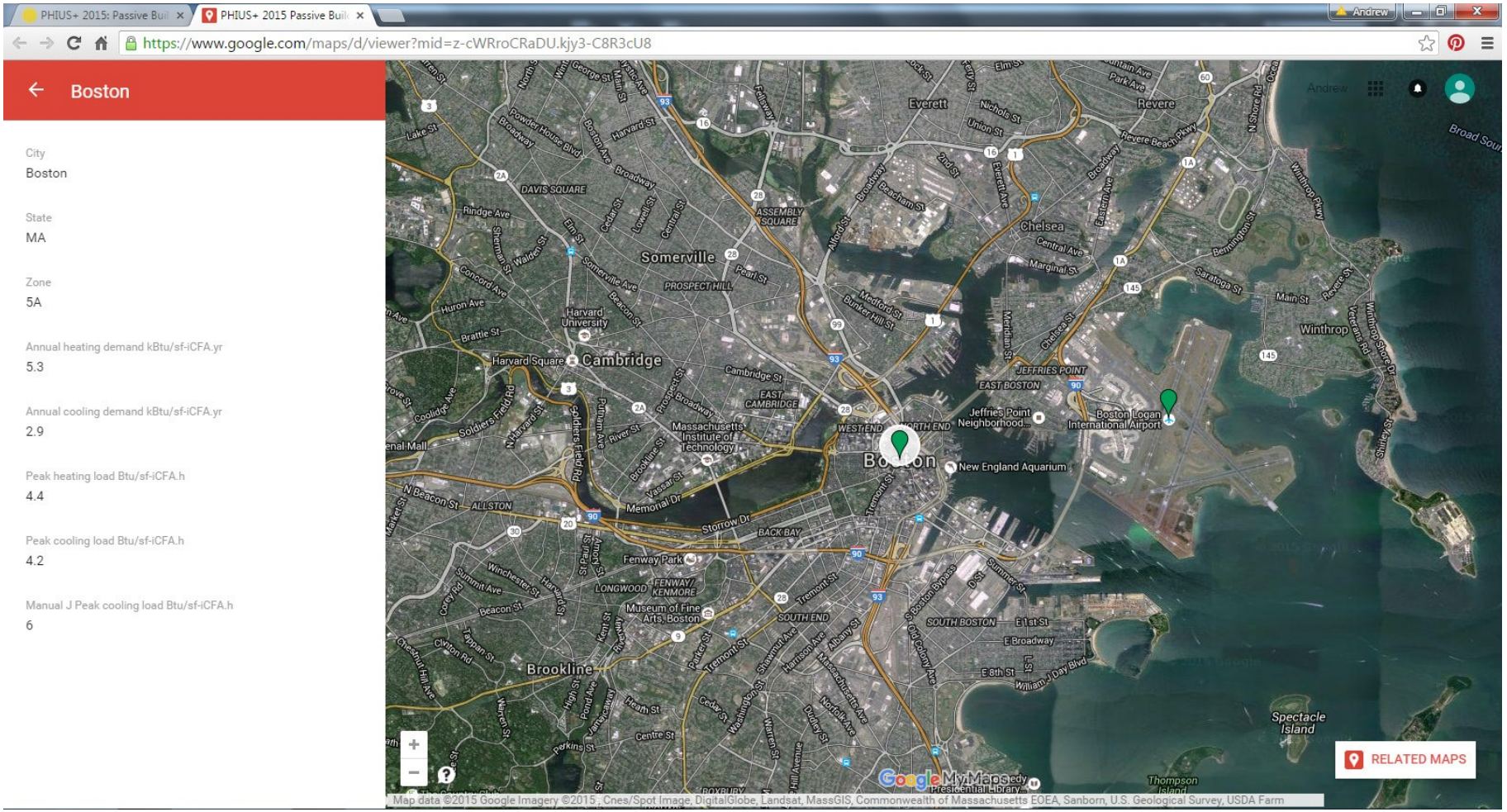
7 MEP

UPPER FLOOR PLAN



ROOM MODULE




PHIUS+ 2015: Passive Buil
PHIUS+ 2015 Passive Buil
https://www.google.com/maps/d/viewer?mid=z-cWRroCRaDU.kjy3-C8R3cU8
Boston
City
Boston
State
MA
Zone
5A
Annual heating demand kBtu/sf-iCFA.yr
5.3
Annual cooling demand kBtu/sf-iCFA.yr
2.9
Peak heating load Btu/sf-iCFA.h
4.4
Peak cooling load Btu/sf-iCFA.h
4.2
Manual J Peak cooling load Btu/sf-iCFA.h
6
Somerville
Cambridge
Harvard Square
Harvard University
Massachusetts Institute of Technology
Boston
Chelsea
Everett
Revere
Winthrop
Brookline
Fenway Park
New England Aquarium
Boston Logan International Airport
Jeffries Point Neighborhood
Spectacle Island
Thompson Island
RELATED MAPS
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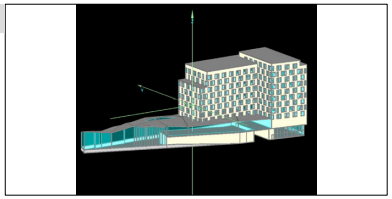
WUFI®Passive Passive

BUILDING INFORMATION

Category:	Residential
Status:	In planning
Building type:	New construction
Year of construction:	
Units:	224
Number of occupants:	448 (Design)



Boundary conditions

Climate:	BOSTON LOGAN INT ARPT MA		
Internal heat gains:	1.5	Btu/hr ft²	
Interior temperature:	68	°F	
Overheat temperature:	77	°F	

Building geometry

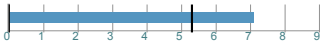
Enclosed volume:	1268254.8	ft³
Total area envelope:	80022.1	ft²
AV ratio:	0.1	1/ft
Floor area:	99533	ft²

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2015 Standard

Heating demand

specific:	7.1	kBtu/ft²yr
target:	5.3	kBtu/ft²yr
total:	706524.07	kBtu/yr

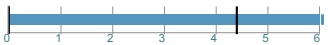


Cooling demand

specific:	3.95	kBtu/ft²yr
target:	2.9	kBtu/ft²yr
total:	392712.11	kBtu/yr
latent:	0	kBtu/ft²yr

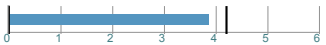
Heating load

specific:	6.83	Btu/hr ft²
target:	4.4	Btu/hr ft²
total:	679533.72	Btu/hr



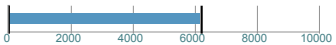
Cooling load

specific:	3.85	Btu/hr ft²
target:	4.2	Btu/hr ft²
total:	383236.55	Btu/hr



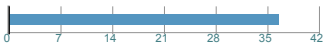
Primary energy

specific:	6132	kWh/Person yr
target:	6200	kWh/Person yr
total:	9373365.81	kBtu/yr



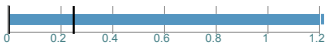
Site energy

total:	36.44	kBtu/ft²yr
building systems:	43.36	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	2	1/hr
target:	0.25	1/hr
CFM50 per envelope area:	4.	cfm/ft²
target:	5.	cfm/ft²



AS PROPOSED (HOTEL ONLY)

WALLS: R25

ROOF: R48

SLAB: R15

WINDOWS: R4(INSTALLED)

-COOLING DOMINATED

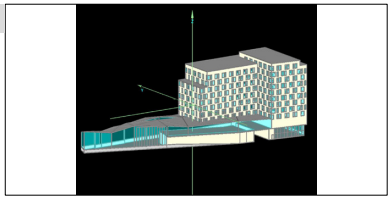
-ASSUMES AIR INFILTRATION

NAPHC 2016 - P+W CASE STUDIES - PARCEL 9

WUFI®Passive Passive

BUILDING INFORMATION

Category:	Residential
Status:	In planning
Building type:	New construction
Year of construction:	
Units:	224
Number of occupants:	448 (Design)



Building geometry

Enclosed volume:	1268254.8	ft³
Total area envelope:	80022.1	ft²
AV ratio:	0.1	1/ft
Floor area:	99533	ft²

Boundary conditions

Climate:	BOSTON LOGAN INT ARPT MA	
Internal heat gains:	1.5	Btu/hr ft²
Interior temperature:	68	°F
Overheat temperature:	77	°F

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2015 Standard

Heating demand

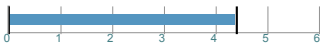
specific:	4.65	kBtu/ft²yr
target:	5.3	kBtu/ft²yr
total:	463261.75	kBtu/yr

Cooling demand

specific:	2.74	kBtu/ft²yr
target:	2.9	kBtu/ft²yr
total:	273020.53	kBtu/yr
latent:	0	kBtu/ft²yr

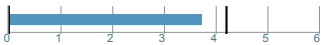
Heating load

specific:	4.37	Btu/hr ft²
target:	4.4	Btu/hr ft²
total:	434872.12	Btu/hr



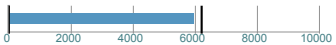
Cooling load

specific:	3.73	Btu/hr ft²
target:	4.2	Btu/hr ft²
total:	370831.17	Btu/hr



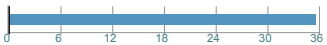
Primary energy

specific:	5956	kWh/Person yr
target:	6200	kWh/Person yr
total:	9103364.49	kBtu/yr



Site energy

total:	35.6	kBtu/ft²yr
building systems:	34.03	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	0.4	1/hr
target:	0.25	1/hr
CFM50 per envelope area:	0.08	cfm/ft²
target:	0.05	cfm/ft²

MODIFIED TO PH STANDARD (HOTEL ONLY)

WALLS: R25 (SAME)

ROOF: R48 (SAME)

SLAB: R15 (SAME)

WINDOWS: R4(INSTALLED)

-ASSUMES PH AIRTIGHTNESS

-NIGHT FLUSHING @ .05 ACH50

(TO BRING DOWN COOLING DEMAND)

EVEN WITH CONVENTIONAL SYSTEMS LIKE CHILLERS/BOILERS

THIS IS OK (.08 CFM/FT2 FOR NON-COMBUSTIBLE BUILDINGS OVER 5 STORIES)

NAPHC 2016 - P+W CASE STUDIES - PARCEL 9

1600 Wall Systems

Thermal Transmittance [1] (BTU/hr • ft [2] • °F)

Glass U-Factor [3]	Overall U-Factor [4]
0.48	0.61
0.46	0.60
0.44	0.58
0.42	0.56
0.40	0.55
0.38	0.53
0.36	0.51
0.34	0.50
0.32	0.48
0.30	0.47
0.28	0.45
0.26	0.43
0.24	0.42
0.22	0.40
0.20	0.38

1" GLAZING WITH ALUMINUM PRESSURE PLATE

NOTE: For glass values that are not listed, linear interpolation is permitted.

1. U-Factors are determined in accordance with NFRC 100.
2. SHGC and VT values are determined in accordance with NFRC 200.
3. Glass properties are based on center of glass values and are obtained from your glass supplier.
4. Overall U-Factor, SHGC, and VT Matricies are based on the standard NFRC specimen size of 2000mm wide by 2000mm high (78-3/4" by 78-3/4").

CURRENT CURTAINWALL SYSTEMS

HP-Wall™ Series

Allowable Air	Water	NFRC U-Factor	CRF_{frame}	STC
0.06 cfm/sqft at 6.24 psf	15 psf	0.18 to 0.52 BTU/hr.sqft.°F	78 to 83	31 to 49 (est.)

Test results may vary

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1600UT System™1 Curtain Wall

THERMAL PERFORMANCE MATRIX (NFRC SIZE)

Thermal Transmittance [1] (BTU/hr • ft [2] • °F)

Glass U-Factor [3]	Overall U-Factor [4]
0.47	0.53
0.46	0.52
0.44	0.50
0.42	0.49
0.40	0.47
0.38	0.45
0.36	0.44
0.34	0.42
0.32	0.40
0.30	0.39
0.28	0.37
0.26	0.35
0.24	0.34
0.22	0.32
0.20	0.31
0.18	0.28
0.16	0.27
0.14	0.25
0.12	0.23
0.10	0.22

TRIFAB® VG 451 (CENTER – Non-Thermal)

Thermal Transmittance [1]

Glass U-Factor [3]	Overall U-Factor [4]
0.48	0.63
0.46	0.61
0.44	0.60
0.42	0.58
0.40	0.57
0.38	0.55
0.36	0.53
0.34	0.52
0.32	0.50
0.30	0.49
0.28	0.47
0.26	0.45
0.24	0.44
0.22	0.42
0.20	0.41

TRIFAB® VG 451T (CENTER – Thermal)

Thermal Transmittance [1]

Glass U-Factor [3]	Overall U-Factor [4]
0.48	0.55
0.46	0.54
0.44	0.52
0.42	0.51
0.40	0.49
0.38	0.47
0.36	0.46
0.34	0.44
0.32	0.43
0.30	0.41
0.28	0.39
0.26	0.38
0.24	0.36
0.22	0.34
0.20	0.33

1600UT System™1 Curtain Wall

THERMAL PERFORMANCE MATRIX (NFRC SIZE)

Thermal Transmittance [1] (BTU/hr • ft [2] • °F)

Glass U-Factor [3]	Overall U-Factor [4]
0.10	0.22

R-10 R-4.5

TRIFAB® VG 451T (CENTER – Thermal)

Thermal Transmittance [1]

Glass U-Factor [3]	Overall U-Factor [4]
0.28	0.39

R-3.6 R-2.6

1600UT System™1 Curtain Wall

THERMAL PERFORMANCE MATRIX (NFRC SIZE)

Thermal Transmittance [1] (BTU/hr • ft [2] • °F)

Glass U-Factor [3]	Overall U-Factor [4]
0.28	0.37

R-3.6 R-2.7

TRIFAB® VG 451 (CENTER – Non-Thermal)

Thermal Transmittance [1]

Glass U-Factor [3]	Overall U-Factor [4]
0.28	0.47

R-3.6 R-2.1

1600 Wall System™1 Curtain Wall

THERMAL PERFORMANCE MATRIX (NFRC SIZE)

Thermal Transmittance [1] (BTU/hr • ft [2] • °F)

Glass U-Factor [3]	Overall U-Factor [4]
0.28	0.45

R-3.6 R-2.2

CONCLUSIONS:

-AIRTIGHTNESS THROUGH DETAILING AND CONSTRUCTION IS CRITICAL TO ACHIEVING STANDARD

-BUILDING MASSING (SURFACE TO VOLUME RATIO) MUST BE CAREFULLY CONSIDERED

-PERCENTAGE AND R-VALUE OF GLAZING MUST BE CAREFULLY CONSIDERED

-SOME FLEXIBILITY ON MECHANICAL SYSTEMS POSSIBLE (WATCH OUT FOR PRIMARY ENERGY)

-FRAME PERMFORMANCE OF CURTAIN WALLS COULD BE IMPROVED

-PASSIVE BUILDING STANDARD IS ACHIEVABLE FOR LARGE PROJECTORS, LET'S GO!

THANK YOU!

NAPHC 2016

PHILADELPHIA, PA / SEPTEMBER 23, 2016

ANDREW STEINGISER, RA, LEED AP, CPHC

PERKINS+WILL

PHIUS

Passive House Institute US