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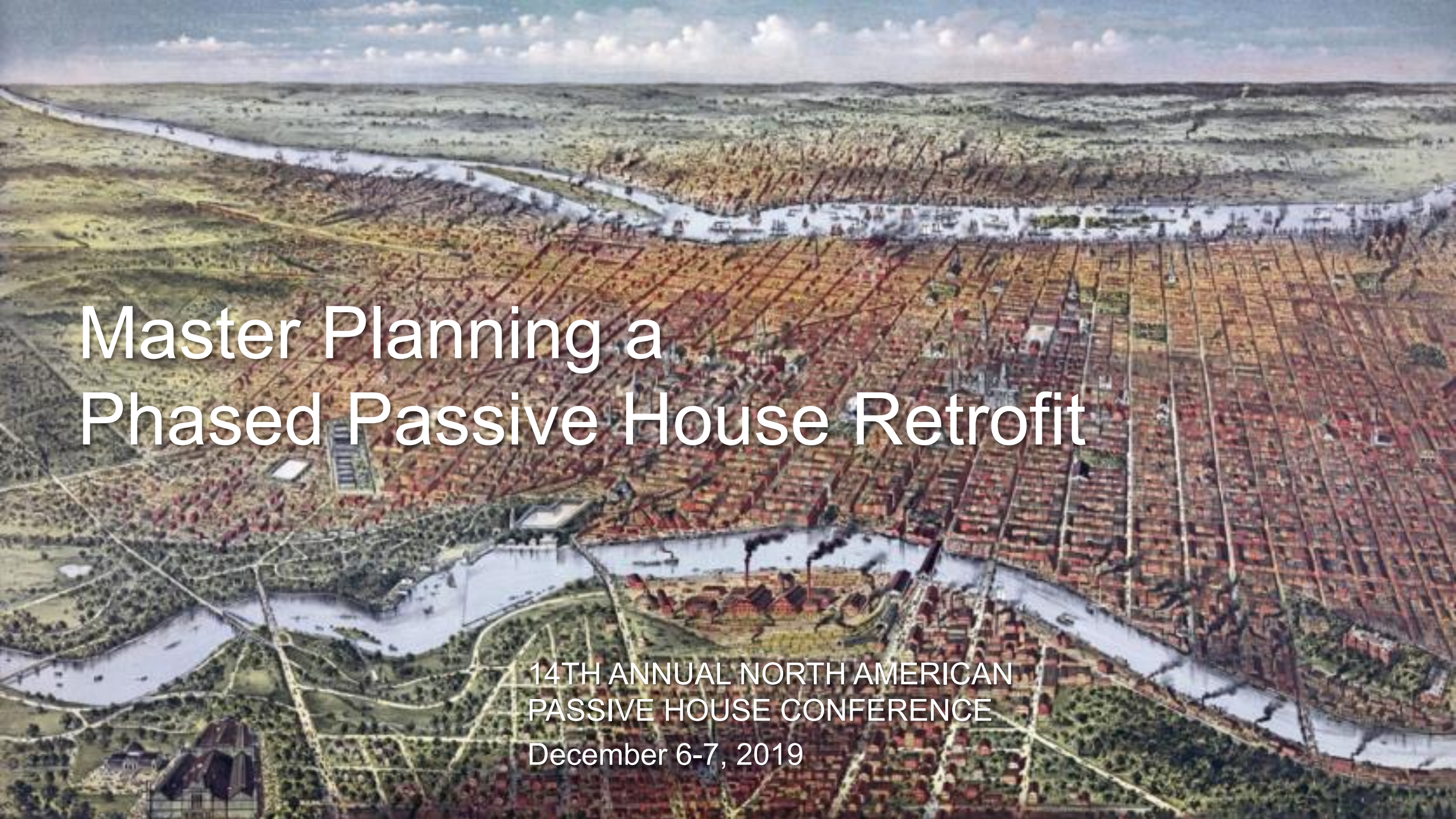


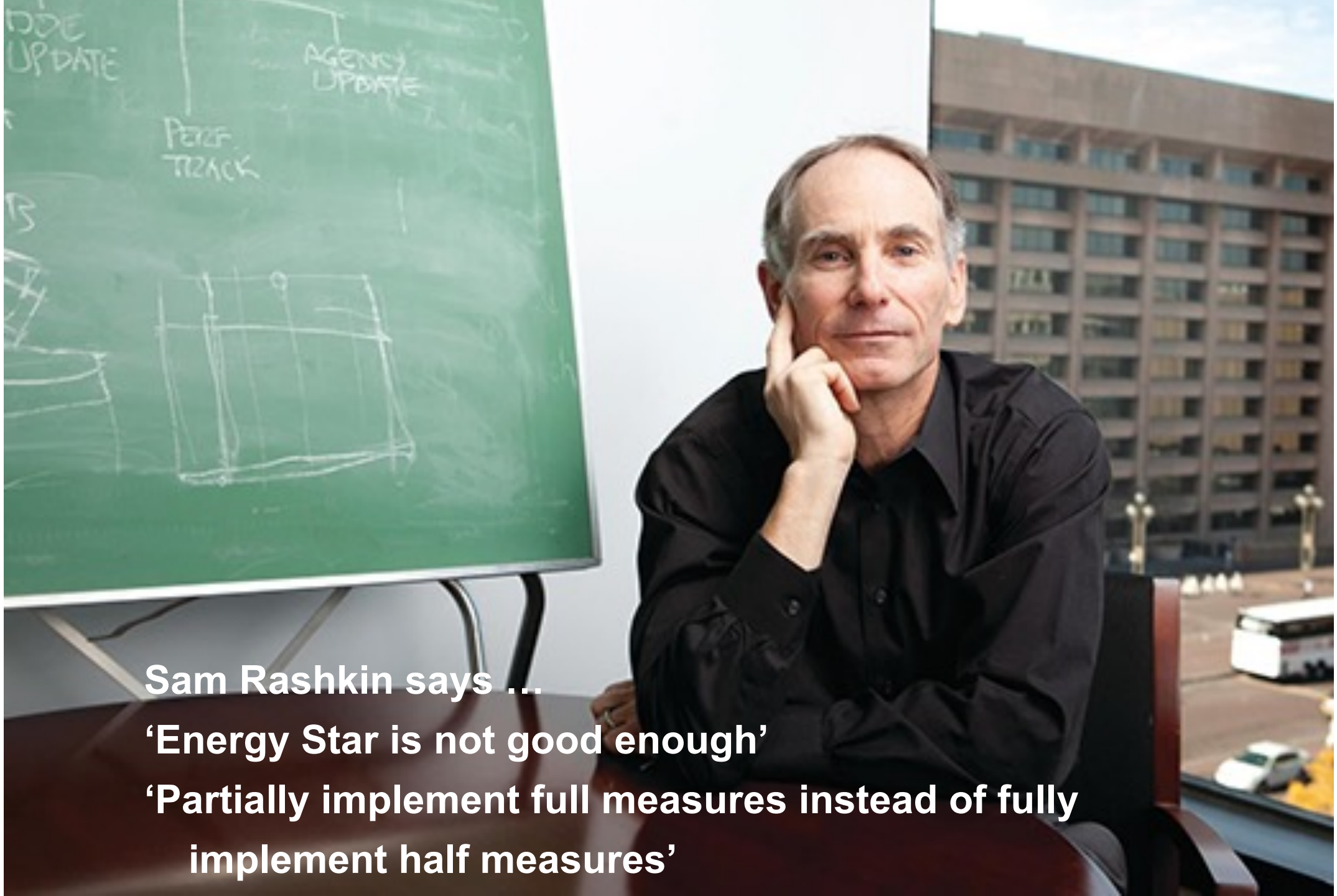
Master Planning a Phased Passive House Retrofit

14TH ANNUAL NORTH AMERICAN
PASSIVE HOUSE CONFERENCE
December 6-7, 2019

Presenters

Laura Blau AIA, CPHC, Certified Passive House Builder
BluPath Design Inc, GreenSteps LLC

Paul Thompson AIA, LEED BD+C, CPHC, NCIDQ
IEI Architects


Sam Rashkin says …
‘Energy Star is not good enough’
‘Partially implement full measures instead of fully implement half measures’

Master Planning Process

1. Establish Goals
2. Collect and Analyze Facts
3. Uncover and Test Concepts
4. Determine Needs
5. State the Problem

We add this task

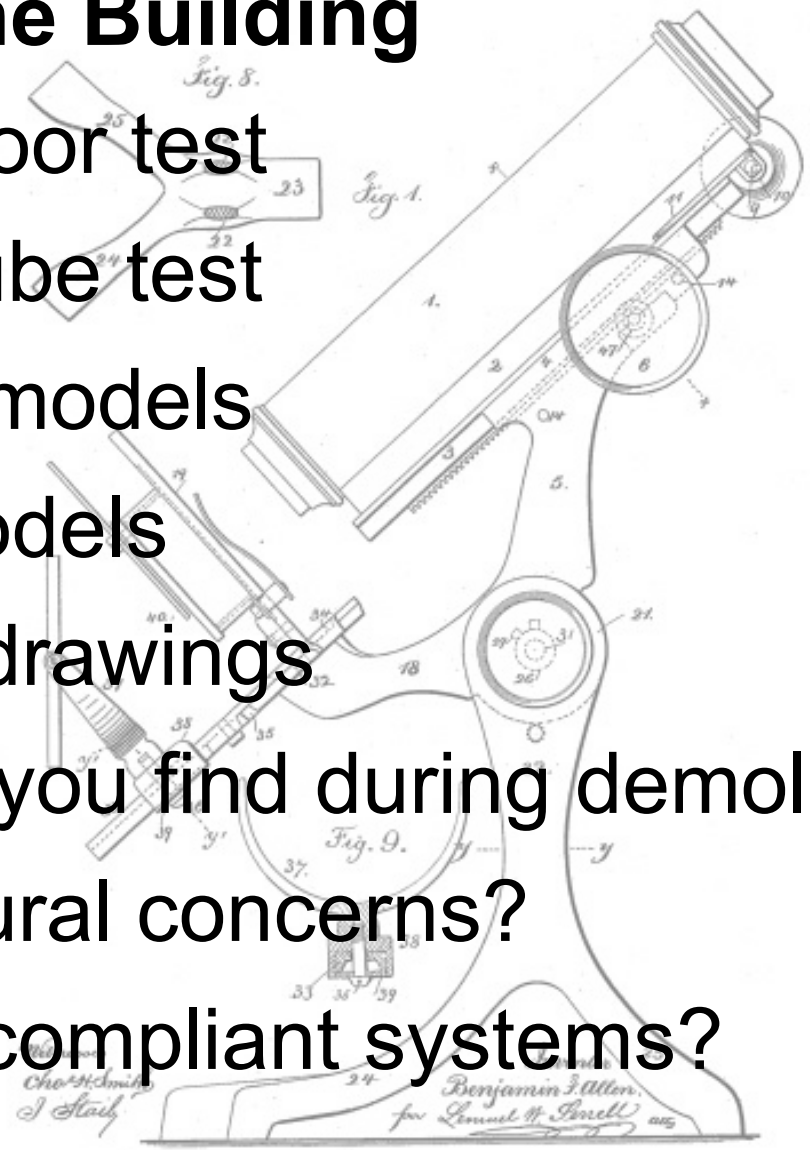
6. Develop a Comprehensive Plan, including Phased Construction

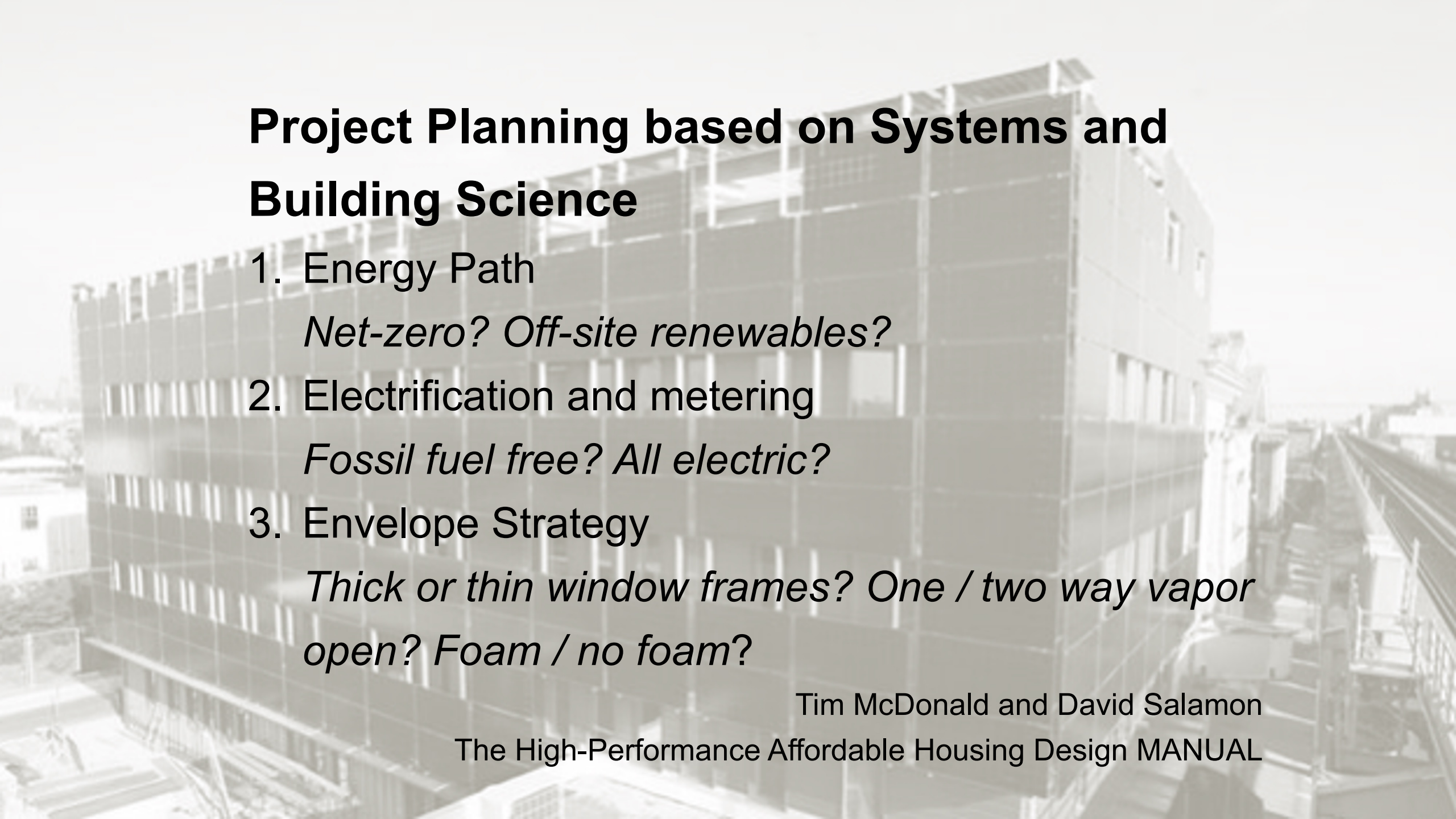
Establish Goals

- Fossil fuel free?
- Net-zero?
- Passive House principles or PH certified?
- Health issues? Indoor air quality?
- Programmatic requirements
  - Age-in-place?
  - Expanding family?
  - Income producing?
  - Limited budget?
  - Establish pro-forma?

Evaluate the Building

- Blower door test
- RILEM tube test
- THERM models
- WUFI models
- Existing drawings
- What do you find during demolition?
  - Structural concerns?
  - Code compliant systems?





Project Planning based on Systems and Building Science

1. Energy Path

   Net-zero? Off-site renewables?

2. Electrification and metering

   Fossil fuel free? All electric?

3. Envelope Strategy

   Thick or thin window frames? One / two way vapor open? Foam / no foam?

Tim McDonald and David Salamon

The High-Performance Affordable Housing Design MANUAL

Site Analysis

Developing a Quasi-Quantifiable Tool

PROJECT OPPORTUNITY AND CONSTRAINT WORKSHEET

Building Address		**Building Description**	Building age	
	Street Number and Name	Building Description	Bldg Age?	years
	City, State, ZIP			
Date	January 1, 2010			

				points
General				
G.1	Climate zone		Climate Zone?	
G.2	Cost of acquisition			
G.3	Project budget			
G.4	PH Certification?		Certification?	
G.5	Gut rehab	If gut rehab, then Yes	Yes or No?	0
G.6	Partial renovation	If partial renovation, then Yes	Yes or No?	0
G.7	Program requirements	If improves energy use, then Yes	Yes or No?	0
G.8	New Addition solves problems?	If improves energy use, then Yes	Yes or No?	0
Site Constraints				
S.1	Zoning constraints and Property line location	If constraints, then Yes	Yes or No?	1
S.2	Building Code restrictions	If restrictions, then Yes	Yes or No?	1
S.3	Adjacent buildings, vegetation and obstructions	If obstructions, then Yes	Yes or No?	1
S.4	Orientation for passive solar access	If good solar orientation, then Yes	Yes or No?	0
S.5	Orientation for solar access for energy generation	If good solar access, then Yes	Yes or No?	0
S.6	Future solar access restrictions	If future solar restrictions, then Yes	Yes or No?	1
S.7	Storm water management, drainage, flooding	If poor drainage, then Yes	Yes or No?	1
S.8	Soil type, Wet lands, Brownfield, Sink holes, Radon	If difficult soil, then Yes	Yes or No?	1
Building History				
H.1	Historic designation	If historically designated, then Yes	Yes or No?	1
H.2	Cultural significance to be preserved	If culturally signifiant, then Yes	Yes or No?	1
H.3	Architectural features to be preserved	If has arch. features, then Yes	Yes or No?	1
H.4	Recent additions that preclude optimal solutions	If recent addition, then Yes	Yes or No?	1
H.5	Recent renovations or replacements	If recent renovation, then Yes	Yes or No?	1

Building Envelope				
E.1	Aesthetics	If an Ugly Duck, then Yes	Yes or No?	0
E.2	Simple form	If simple form, then Yes	Yes or No?	0
E.3	Complex form	If complex form, then Yes	Yes or No?	0
E.4	Very complex form	If very complex form, then Yes	Yes or No?	0
E.5	Construction type		Const. Type?	0
E.6	Roof form		Roof Form?	0
E.7	Slab on grade foundation	If slab on grade, then Yes	Yes or No?	1
E.8	Basement	If there is a basement, then Yes	Yes or No?	0
E.9	Exposed rubble foundation	If rubble basement, then Yes	Yes or No?	0
E.10	Exposed concrete foundation	If concrete basement, then Yes	Yes or No?	0
E.11	Moisture issues	If basement is wet, then Yes	Yes or No?	1
E.12	Structural issues	If structural problems, then Yes	Yes or No?	1
E.13	Opportunity for exterior insulation? EIFS, rainscreen, other	If possible exterior insulation, then Yes	Yes or No?	0
E.14	Ease of interior insulation	If easy interior insulation, then Yes	Yes or No?	0
Building Systems				
SY.1	Heating system type		Furnace	0
SY.2	Heating fuel		Natural gas	0
SY.3	Heating system at end of useful life?	If system will be replaced, then Yes	Yes or No?	0
SY.4	Air conditioning system		A/C System?	0
SY.5	AC system at end of useful life?	If system be replaced, then Yes	Yes or No?	0
SY.6	Hot water system		HW System?	0
SY.7	Hot water fuel		HW Fuel?	0
SY.8	HWH at end of useful life?	If system will be replaced, then Yes	Yes or No?	0
SY.9	Plumbing system materials		Plumb. Mat'l?	0
SY.10	Plumbing system at end of useful life?	If system will be replaced, then Yes	Yes or No?	0
SY.11	Plumbing access	If easily accessible, then Yes	Yes or No?	0
SY.12	Plumbing location	If plumbing areas are close, then Yes	Yes or No?	0
SY.13	Plumbing fixture efficiency	If fixtures are WaterSense, then Yes	Yes or No?	0
SY.14	Electrical service size		Service Size?	0
SY.15	Electrical system condition		Condition?	0
SY.16	LED light fixtures	If LED fixtures, then Yes	Yes or No?	0
SY.17	CFL or incandescent light fixtures	If CFL or incandescent fixtures, then Yes	Yes or No?	0
SY.18	Appliance efficiency	If Energy Star appliances, then Yes	Yes or No?	0
SY.19	Replace appliances?	If appliances to be replaced, then Yes	Yes or No?	0
		Score	**14**	14
		CHALLENGING CANDIDATE		

SITE OPPORTUNITY AND CONSTRAINT WORKSHEET

Building Address		**Building Description**	Building age	
	1722 Pine St.	4 story, 4 unit historic rowhome	170	years
	Philadelphia PA 19103			
Date	July 1, 2016			

				points
General				
G.1	Climate zone		Zone 4A Phila	
G.2	Cost of acquisition		$450,000	
G.3	Project budget		$1,300,000	
G.4	PH Certification?		EnerPHit	
G.5	Gut rehab	If gut rehab, then Yes	Y	3
G.6	Partial renovation	If partial renovation, then Yes	Y	2
G.7	Program requirements	If improves energy use, then Yes	Y	1
G.8	New Addition solves problems?	If improves energy use, then Yes	N	0
Site Constraints				
S.1	Zoning constraints and Property line location	If constraints, then Yes	Y	0
S.2	Building Code restrictions	If restrictions, then Yes	Y	0
S.3	Adjacent buildings, vegetation and obstructions	If obstructions, then Yes	Y	0
S.4	Orientation for passive solar access	If good solar orientation, then Yes	N	0
S.5	Orientation for solar access for energy generation	If good solar access, then Yes	Y	2
S.6	Future solar access restrictions	If future solar restrictions, then Yes	Y	0
S.7	Storm water management, drainage, flooding	If poor drainage, then Yes	Y	0
S.8	Soil type, Wet lands, Brownfield, Sink holes, Radon	If difficult soil, then Yes	N	1
Building History				
H.1	Historic designation	If historically designated, then Yes	Y	0
H.2	Cultural significance to be preserved	If culturally signifiant, then Yes	Y	0
H.3	Architectural features to be preserved	If has arch. features, then Yes	Y	0
H.4	Recent additions that preclude optimal solutions	If recent addition, then Yes	N	1
H.5	Recent renovations or replacements	If recent renovation, then Yes	N	1

Building Envelope				
E.1	Aesthetics	If an Ugly Duck, then Yes	N	0
E.2	Simple form	If simple form, then Yes	Y	3
E.3	Complex form	If complex form, then Yes	N	0
E.4	Very complex form	If very complex form, then Yes	N	0
E.5	Construction type		Mixed	0
E.6	Roof form		Flat	0
E.7	Slab on grade foundation	If slab on grade, then Yes	N	1
E.8	Basement	If there is a basement, then Yes	Y	2
E.9	Exposed rubble foundation	If rubble basement, then Yes	Y	1
E.10	Exposed concrete foundation	If concrete basement, then Yes	N	0
E.11	Moisture issues	If basement is wet, then Yes	Y	-1
E.12	Structural issues	If structural problems, then Yes	N	1
E.13	Opportunity for exterior insulation? EIFS, rainscreen, other	If possible exterior insulation, then Yes	Y	5
E.14	**Ease of interior insulation**	If easy interior insulation, then Yes	Y	3
Building Systems				
SY.1	Heating system type		Boiler	0
SY.2	Heating fuel		Natural gas	0
SY.3	Heating system at end of useful life?	If system will be replaced, then Yes	Y	3
SY.4	Air conditioning system		Window Units	0
SY.5	AC system at end of useful life?	If system be replaced, then Yes	Y	3
SY.6	Hot water system		Tank	0
SY.7	Hot water fuel		Natural Gas	0
SY.8	HWH at end of useful life?	If system will be replaced, then Yes	N	0
SY.9	Plumbing system materials		Copper	0
SY.10	Plumbing system at end of useful life?	If system will be replaced, then Yes	N	0
SY.11	Plumbing access	If easily accessible, then Yes	N	0
SY.12	Plumbing location	If plumbing areas are close, then Yes	Y	1
SY.13	Plumbing fixture efficiency	If fixtures are WaterSense, then Yes	N	0
SY.14	Electrical service size		200A	0
SY.15	Electrical system condition		Mixed	0
SY.16	LED light fixtures	If LED fixtures, then Yes	N	0
SY.17	CFL or incandescent light fixtures	If CFL or incandescent fixtures, then Yes	Y	1
SY.18	Appliance efficiency	If Energy Star appliances, then Yes	N	0
SY.19	Replace appliances?	If appliances to be replaced, then Yes	[illegible]	2
		Score	**36**	36
		LIKELY CANDIDATE		

Developing a Comprehensive Retrofit Plan

EnerPHit Retrofit Plan (ERP)

- Describes the overall concept for step-by-step, phased improvements to a building.
- Phased improvements are documented as ‘variants’ in a single PHPP version 9.7 (imperial units).
- Input Existing Conditions, Schedule and Cost for each Retrofit Phase in Variants page.
- Input phased / future renewable primary energy.
- Outputs show the improving energy efficiency for each phase, including the primary energy (PER) and economic results / feasibility of each proposed improvement.

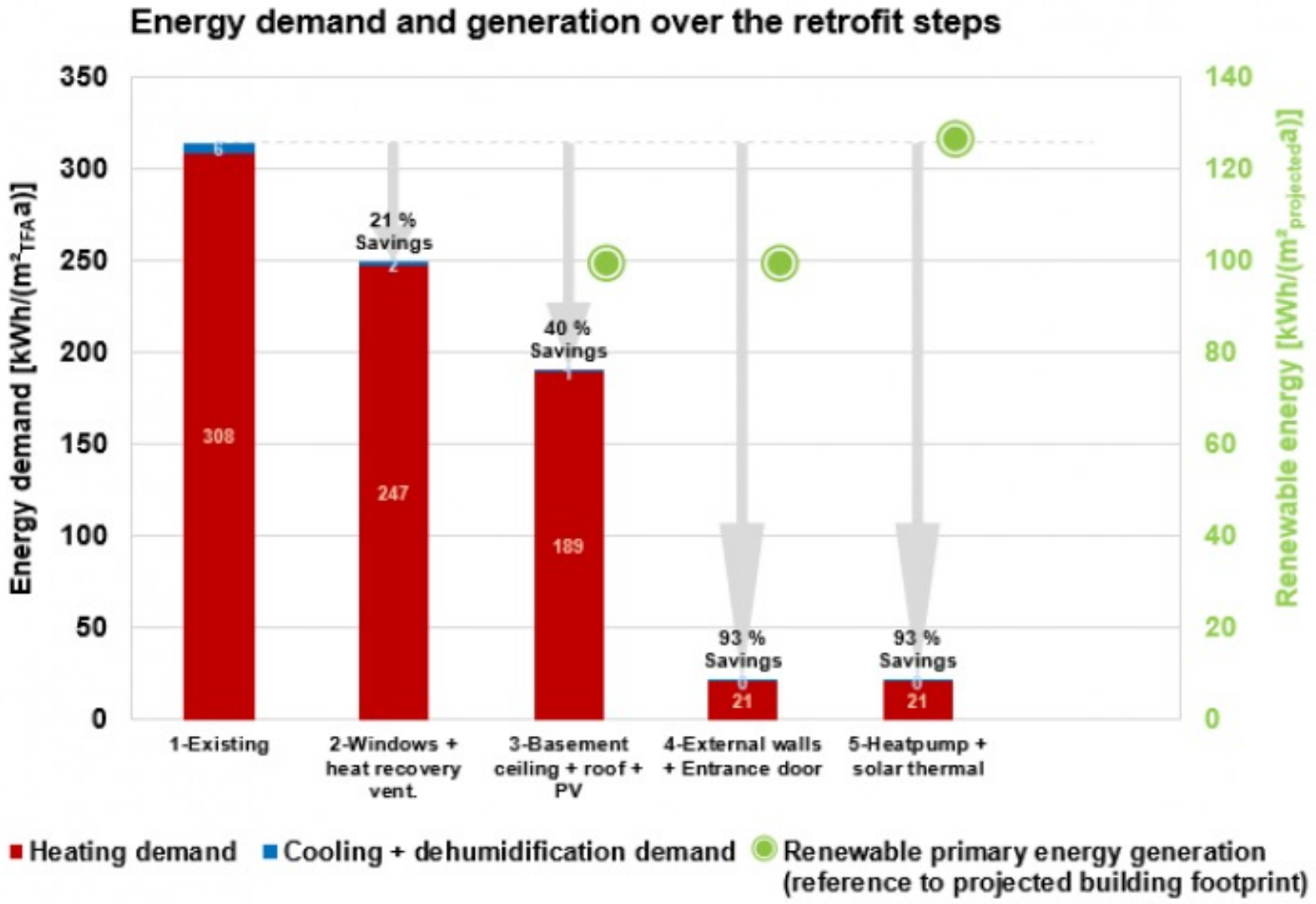
	Select the active variant here >>>>>>>	Active 1-Existing	Existing	Windows + heat recovery vent.	Basement ceiling + roof + PV	External walls + Entrance door	Heatpump + solar thermal
	Units	1	1	2	3	4	5
Heating demand	kWh/(m²a)	246,7	279,7	246,7	189,0	20,6	20,6
Heating load	W/m²	100,0	129,2	100,0	79,8	15,6	15,6
Cooling & dehum. demand	kWh/(m²a)	2,3	6,2	2,3	1,1	0,3	0,1
Cooling load	W/m²	18,2	31,9	18,2	12,8	5,8	4,0
Frequency of overheating (> 25 °C)	%						
PER demand	kWh/(m²a)	770,4	855,8	770,4	624,9	203,0	36,7
EnerPHit Plus?	yes / no	no	no	no	no	no	yes

PHPP ‘Variant’ worksheet shows the results for each phase

d-Windows in first step	Frame list			
Active variant: g-Value:0,52 U-Value: 0,63 W/(m²K)	09ud-EnerPHit window	93ud-Double glazing 4/12mm air /4	09ud-EnerPHit window	09ud-EnerPHit window
U-Value [W/(m²K)]: left: 0,9 right: 0,9 bottom: 0,9 top: 0,9 Width [m]: left: 0,12 right: 0,12 bottom: 0,12 top: 0,12	09ud-EnerPHit window	53ud-EXISTING: timber 45 mm	09ud-EnerPHit window	09ud-EnerPHit window
e-Windows in later step	Frame list			
Active variant: g-Value:0,77 U-Value: 2,9 W/(m²K)	93ud-Double glazing 4/12mm air /4	93ud-Double glazing 4/12mm air /4	93ud-Double glazing 4/12mm air /4	09ud-EnerPHit window
U-Value [W/(m²K)]: left: 2,5 right: 2,5 bottom: 2,5 top: 2,5 Width [m]: left: 0,14 right: 0,14 bottom: 0,14 top: 0,14	53ud-EXISTING: timber 45 mm	53ud-EXISTING: timber 45 mm	53ud-EXISTING: timber 45 mm	09ud-EnerPHit window

d-Windows in first step	09ud-EnerP	South
d-Windows in first step	09ud-EnerP	South
d-Windows in first step	09ud-EnerP	South
e-Windows in later step	93ud-Doubl	North
e-Windows in later step	93ud-Doubl	West
e-Windows in later step	93ud-Doubl	North

PHPP Windows ‘Variant’ worksheet for different specifications



ERP title page shows the results of each Retrofit phase.

Owner’s Project Requirements

A Case Study


1722 Pine Street, Philadelphia PA

BUILDING DESCRIPTION

Built 1845, Major renovation 1922 (77 yrs), 2018 (96 yrs)
4 floor with basement; 4 unit townhouse
Lot: 20ft x 90ft = 1,800sf
Open Area: 331sf

Basement:	1,225sf	Unit A, Common storage
1st Floor:	1,469sf	Unit A, Unit A yard
2nd Floor:	1,499sf	Unit B
3rd Floor:	1,499sf	Unit C, Unit D
4th Floor:	801sf	Unit D, Unit D deck, Common deck
Total:	6,493sf	

Unit A: 3 BR, 3 Bath
Unit B: 2 BR, 2 Bath
Unit C: 2 BR, 2 Bath
Unit D: 2 BR, 1 Bath, Deck

MAJOR WORK

Phase 1

Underpin basement, insulated slab, perimeter drain

All new windows

New MEP, ventilation, fire sprinkler system

Phase 2

New exterior insulation at rear

New fire escape

Phase 3

Renewable energy + growing carbon

Basement,1st and 2nd Floor: Gut rehab

3rd Floor: Partial rehab - Add bathroom

4th Floor: Major rehab - New kitchen, New bathroom

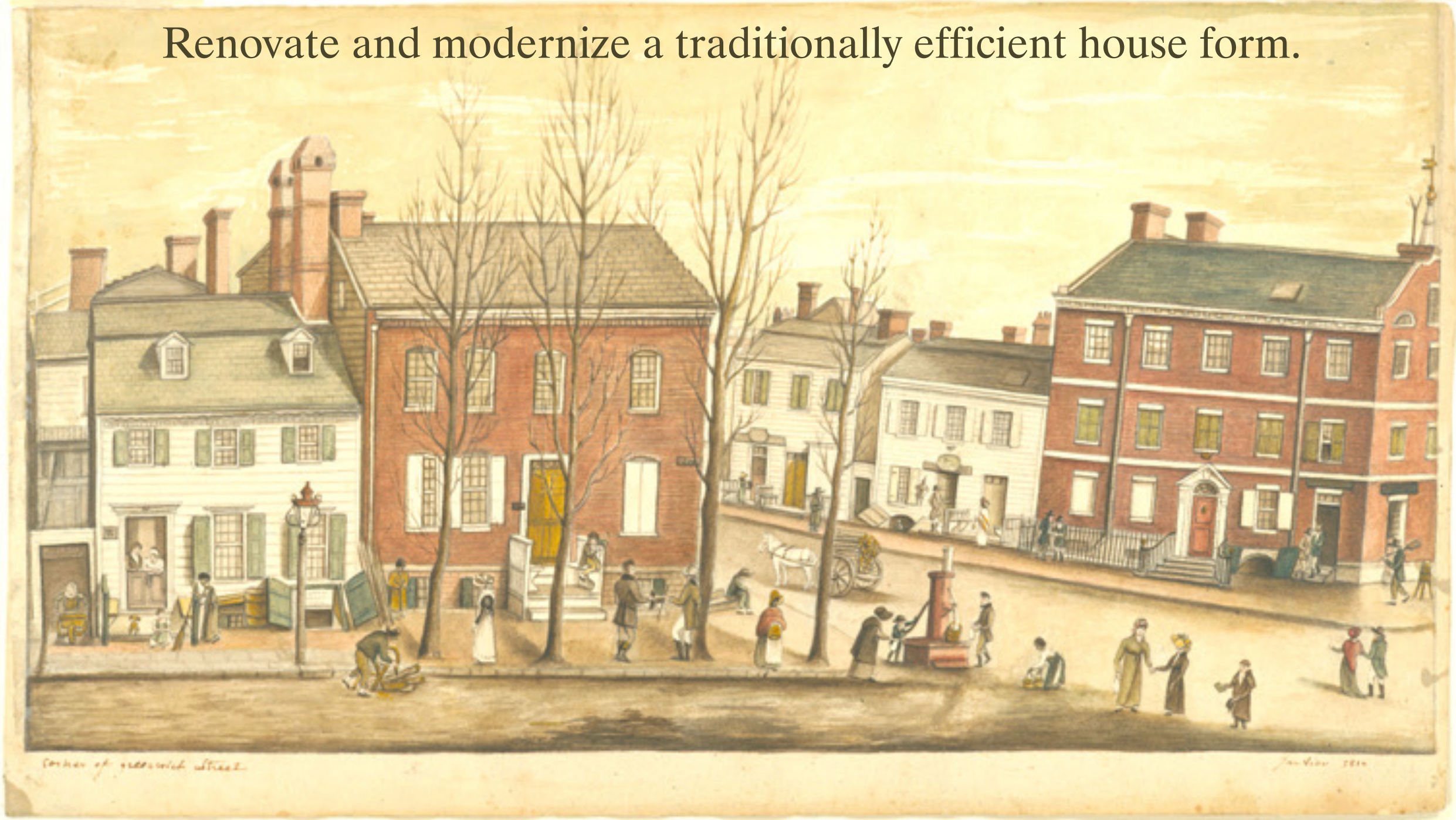
OWNER PROJECT REQUIREMENTS

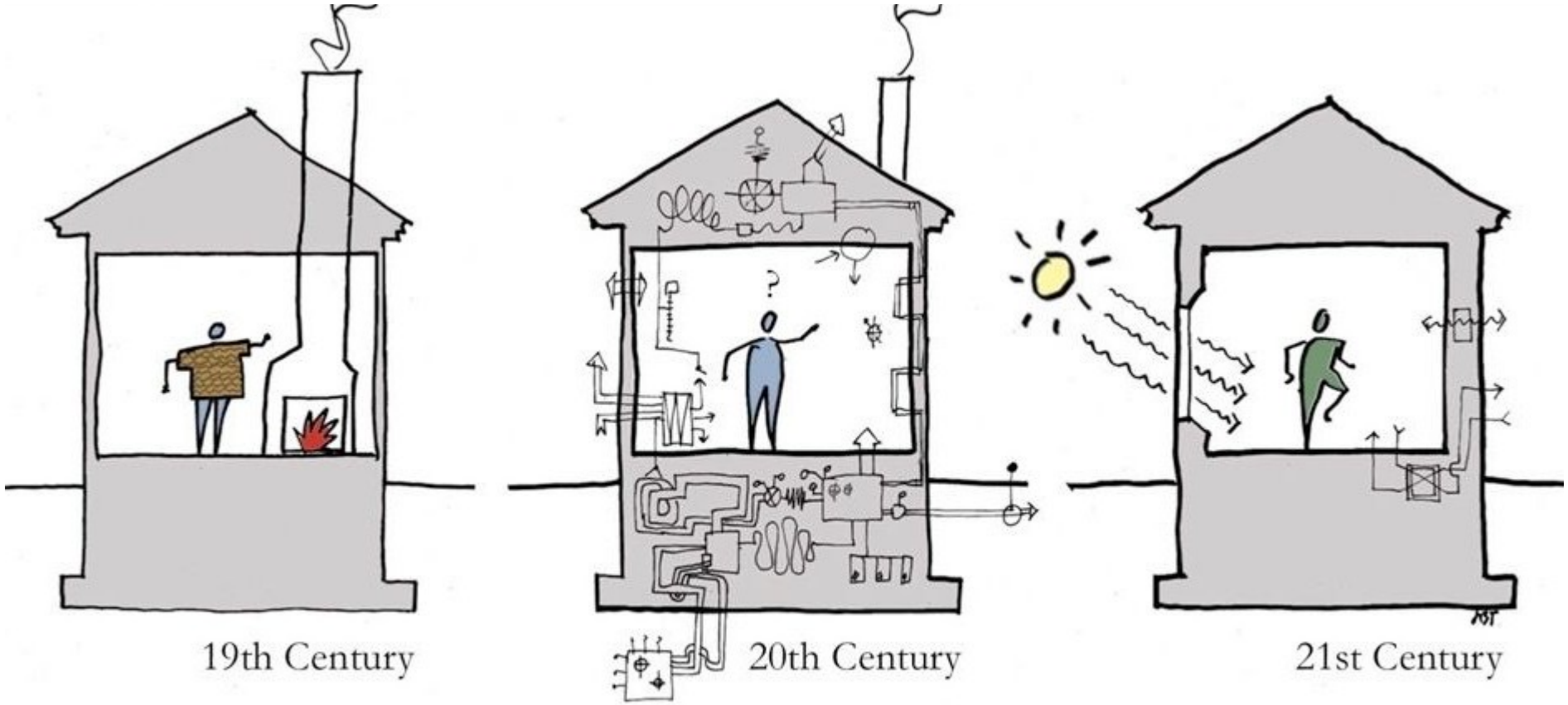
1. Renovate and modernize a traditionally efficient house form.
2. Get rid of all natural gas and make the building all-electric.
3. Maintain the building's historical character and support a wonderful neighborhood.
4. Demonstrate that renovating existing building stock can meet sustainability goals AND create beautiful, livable cities while retaining the embodied carbon.
5. Set a precedent for renovating historic rowhomes.
6. Engage the municipal approvals process to set precedent for future projects in Philadelphia.

OWNER PROJECT REQUIREMENTS

7. Adhere to building science based construction.
8. Meet Passive House standard by incorporating PH principles and achieve Certification.
9. Lead by example and set sustainability goals.
10. Make zero-energy ready design decisions.
11. Meet personal financial goals by achieving acceptable pro-forma results.
12. Live in a Passive House!

Renovate and modernize a traditionally efficient house form.





HOUSE HEATING SYSTEMS: A BRIEF HISTORY

ALBERT, RIGHTER & TITTMANN ARCHITECTS, INC.

Whale oil lamps


Get Rid of the Gas!!


2nd Floor
SmartWater
SmartSHIELD
SENSOR SYSTEM
We're Here To Help!
1-800-431-1549
ENERGYGUIDE
WEIL-MCLAIN
SPARCO
Get Rid of the Gas!!


(fancy) Delancey Place


Rittenhouse Square


Done in NY

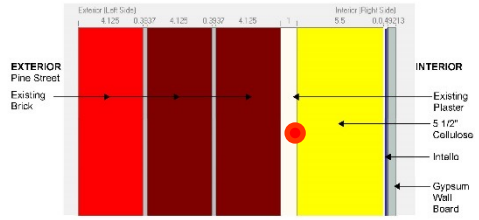

Why not Philadelphia?

Pine Street façade:
Contributor to the culture of historic Philadelphia.

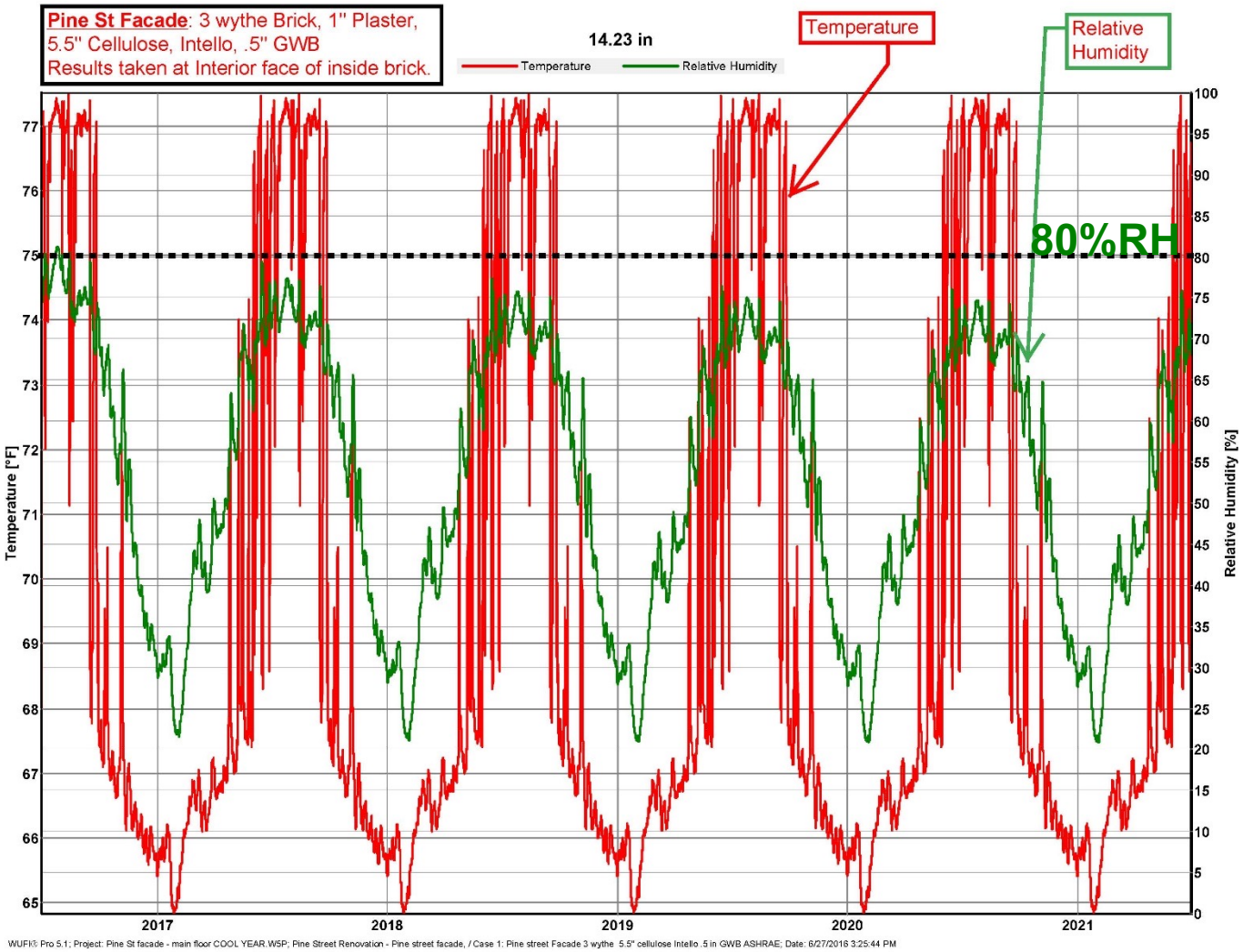
Waverly Street elevations:
Car parkers, dog walkers and trash pickers.

The Building Science Story

RILEM (AKA Karsten) tube moisture absorption test



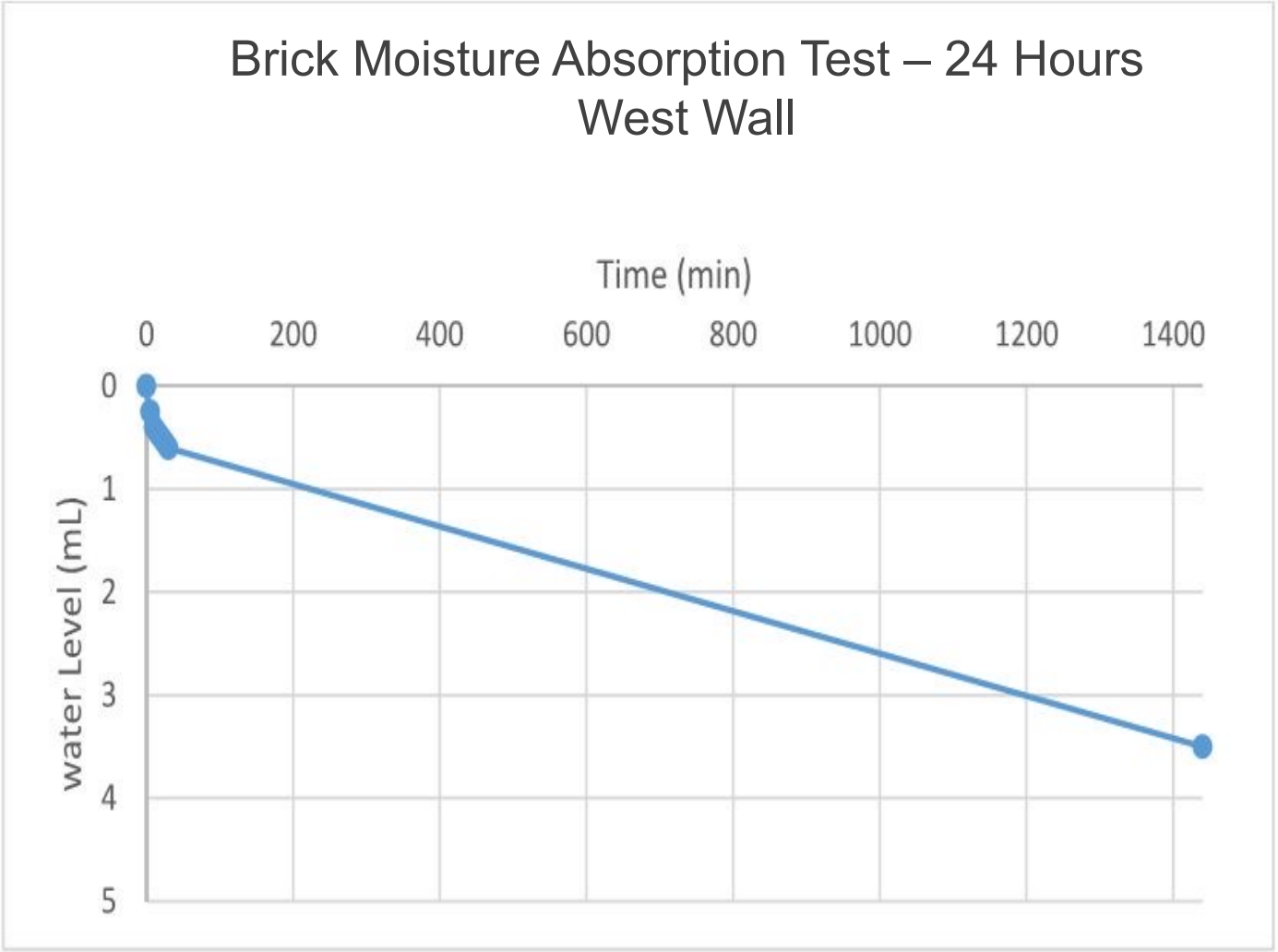
Pine Street Wall Section post Renovation



Pine Street Facade - WUFI, Hygrothermal Analysis

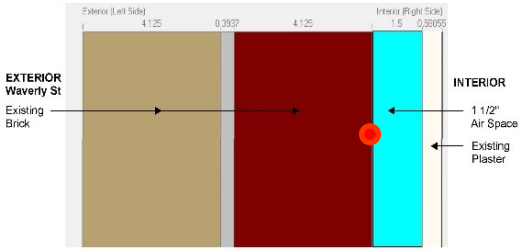
Option 1: Add 5.5” Cellulose with smart vapor retarder

Result: Acceptable mold risk (R19)

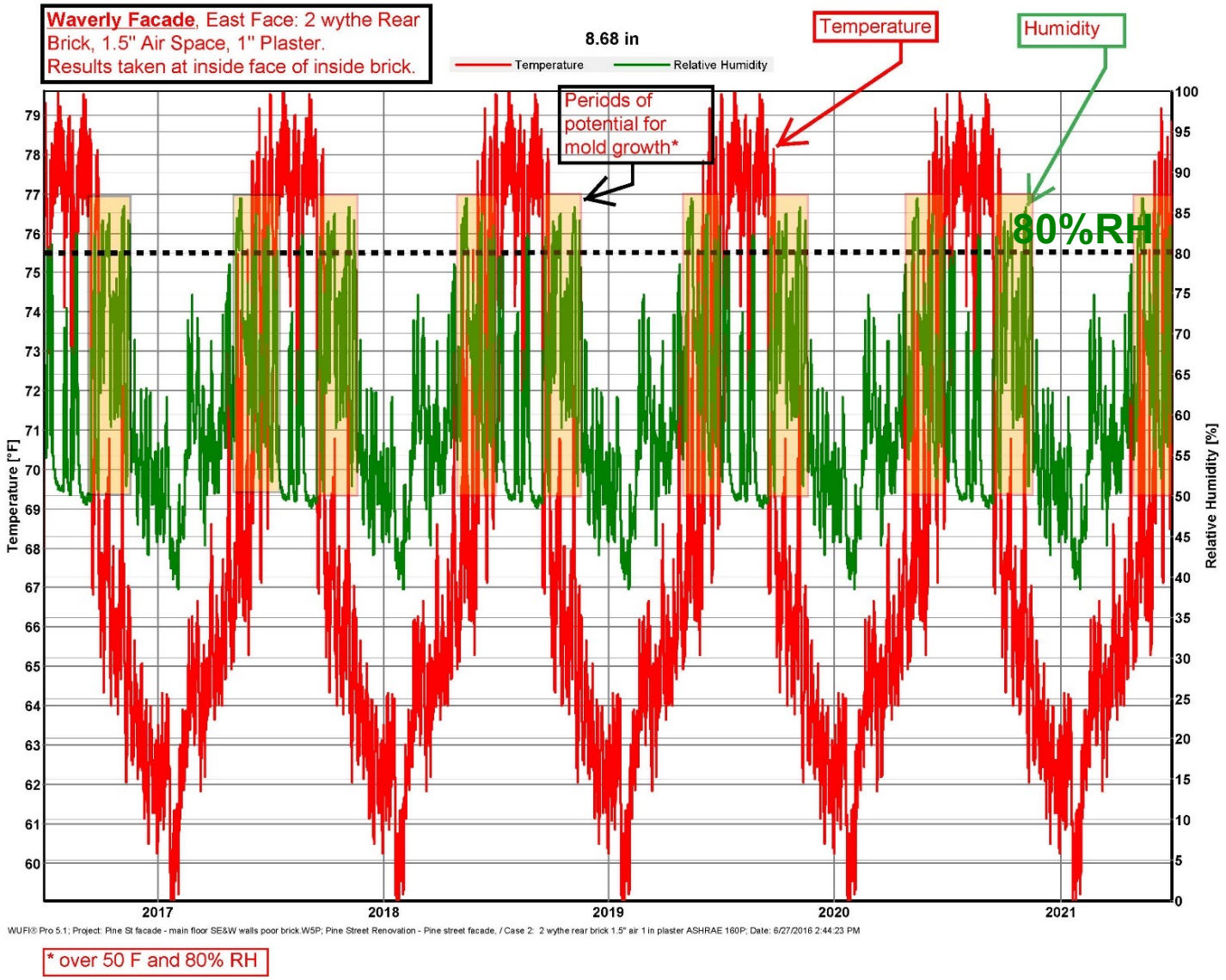


Pine Street Facade – Moisture Absorption Test

Result: High absorption rate



Waverly St Wall Section - Existing Conditions

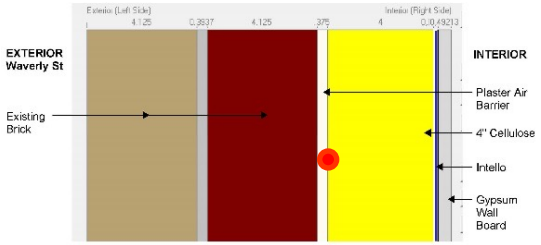


Waverly Street East Facade - WUFI, Hygrothermal Analysis

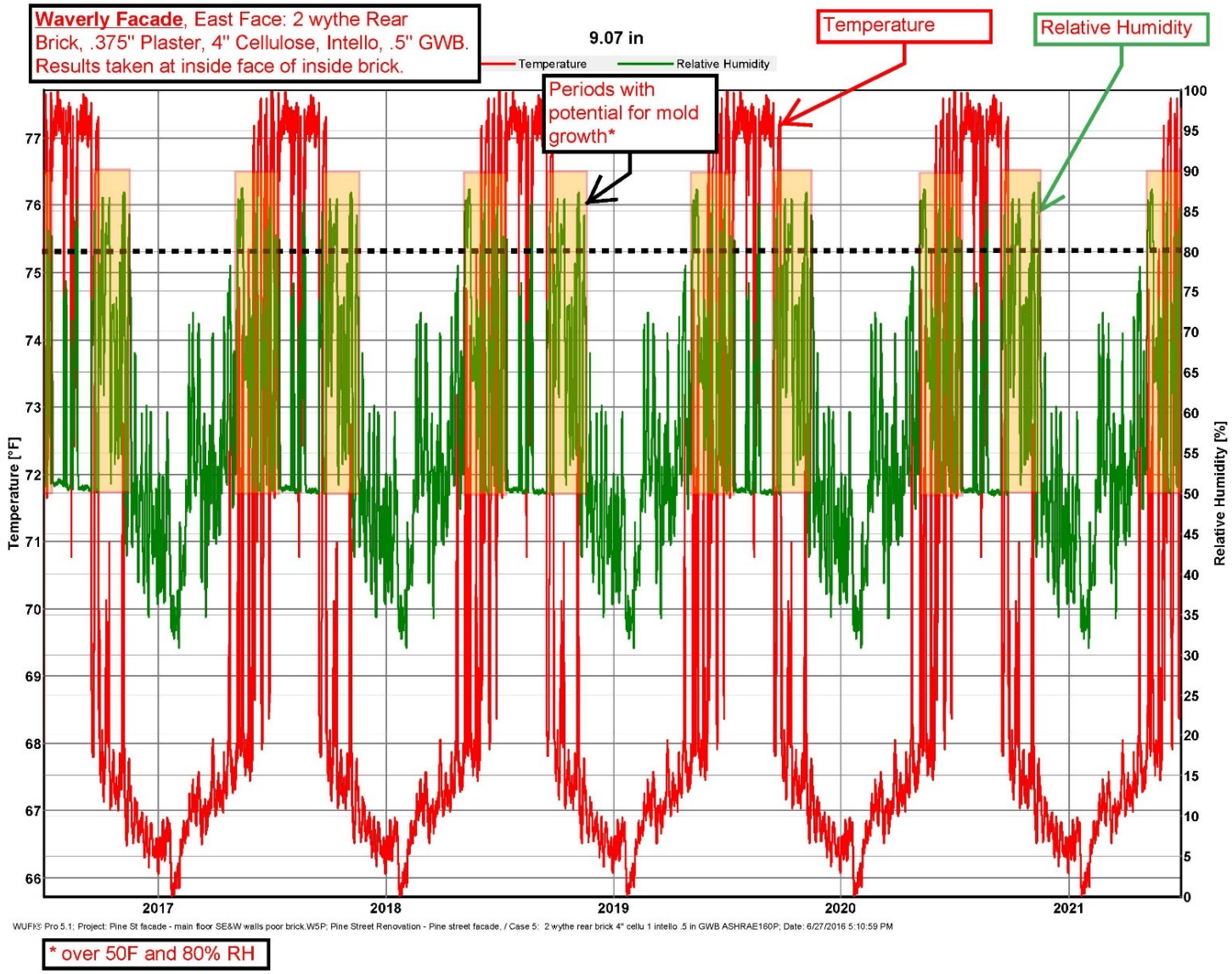
Existing Condition

Result: Unacceptable mold risk

Interior (after pointing) 1ST FLOOR WEST WALL Exterior



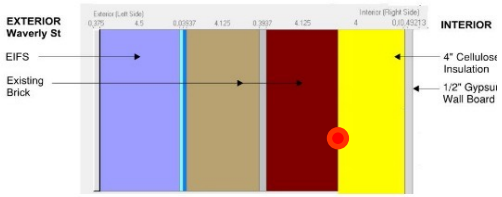
Waverly St Wall Section - *not successful*



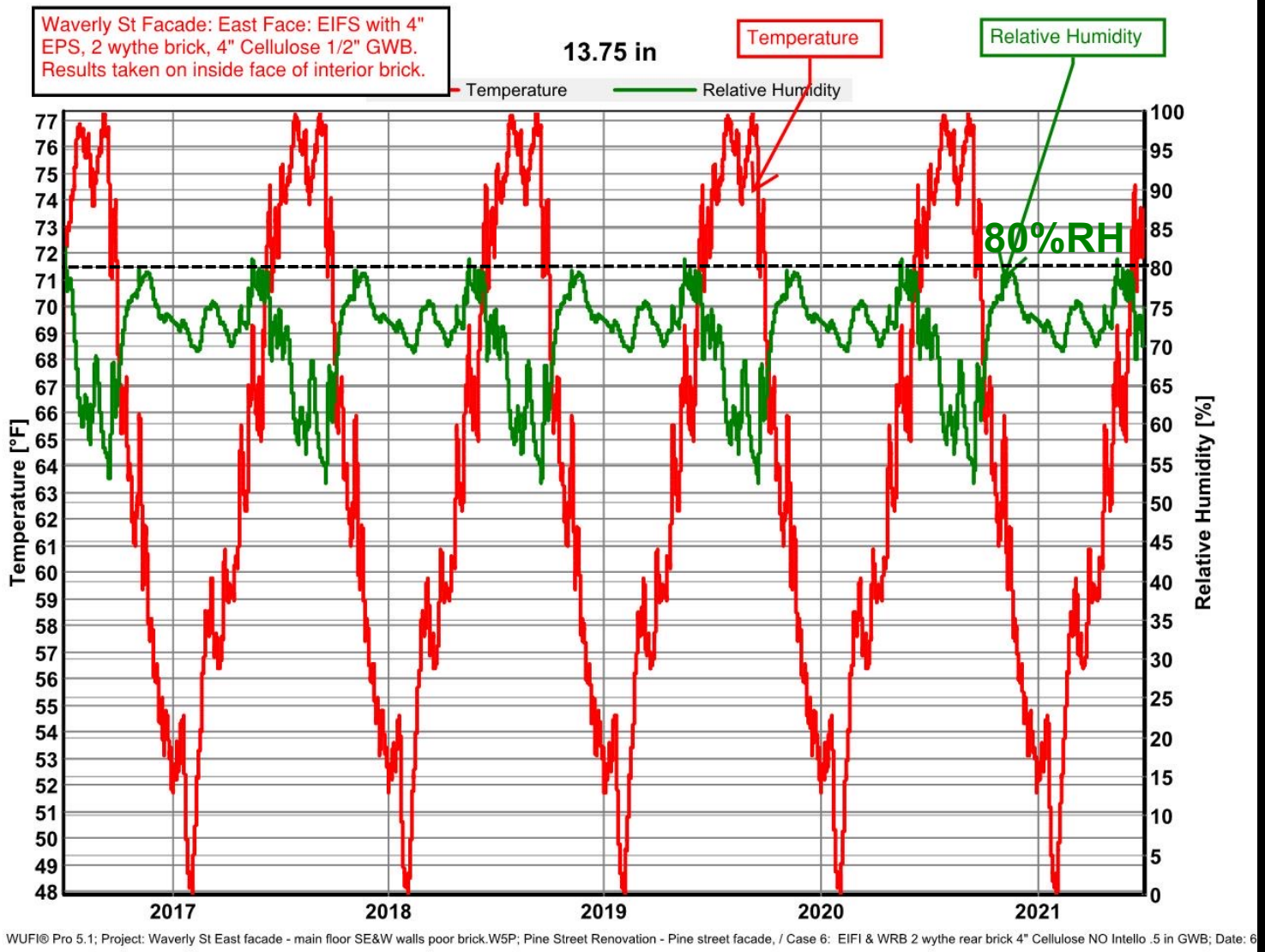
Waverly Street East Facade - WUFI, Hygrothermal Analysis

Option 2: Add interior partition with 4” cellulose with smart vapor retarder

Result: Unacceptable mold risk



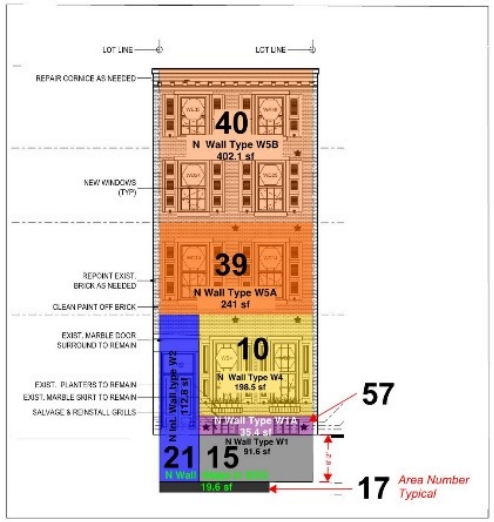
Waverly St Wall Section Option 4



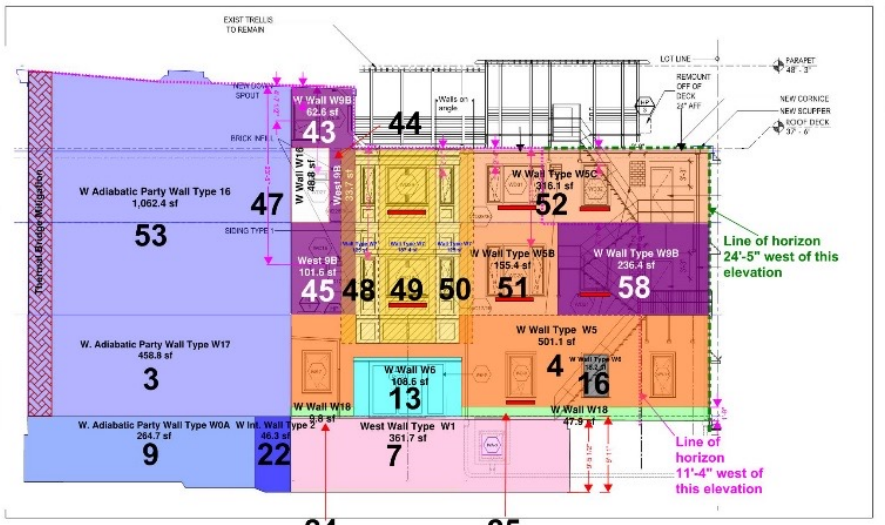
Waverly Street East Facade - WUFI, Hygrothermal Analysis

Option 4: Add drainage plane system EIFS with 4” EPS and 4” Cellulose

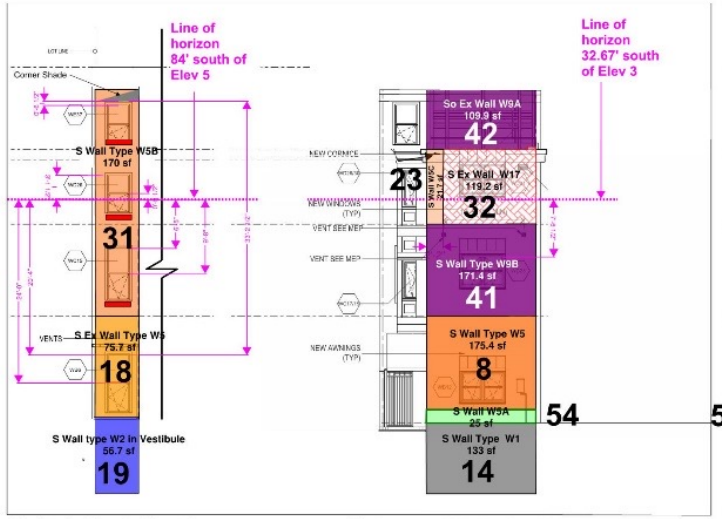
Result: Acceptable mold risk



1 Proposed North Elevation

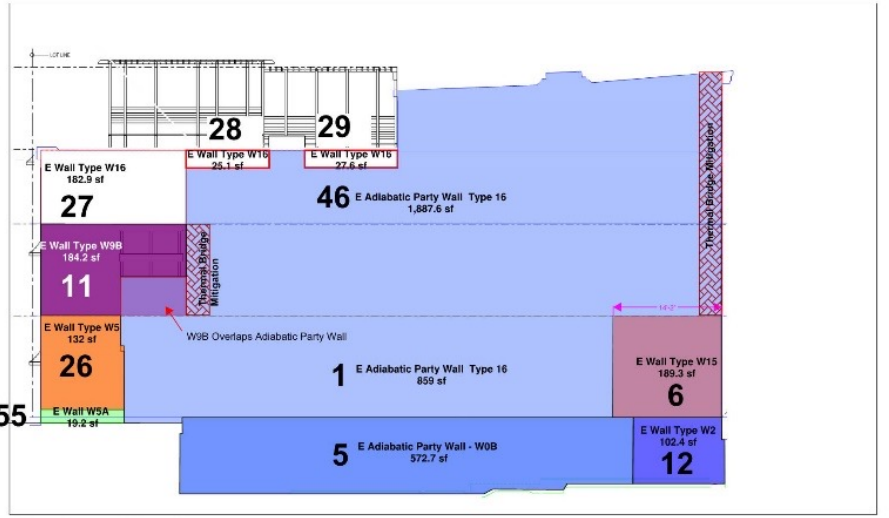


2 Proposed West Elevation



5 Partial South Elevation

3 Proposed South Elevation



4 Proposed East Elevation

Wall Area Take-off for PHPP model: Apartments 1 thru 4

Includes silhouette of neighboring building for solar shading input

Pine Street PHPP – Exterior Elevations w/ Wall Types

30 different assemblies for walls, floors and roof

EnerPHit Verification *without Cork EIFS*

Photo or Drawing

Building:	1722 Pine Street Renovation - Historic building
Street:	1722 Pine St
Postcode/City:	19103 Philadelphia
Province/Country:	Pennsylvania USA
Building type:	Historic Brick Rowhome
Climate data set:	US0064a-Philadelphia
Climate zone:	4: Warm-temperate — Altitude of location: 35 ft
Home owner / Client:	Laura Blau & Paul Thompson
Street:	1005 S 7th St
Postcode/City:	19147 Philadelphia
Province/Country:	Pennsylvania USA

Architecture:	BluPath Design Inc
Street:	1005 S 7th St
Postcode/City:	19147 Philadelphia
Province/Country:	Pennsylvania USA
Energy consultancy:	BluPath Design Inc
Street:	
Postcode/City:	
Province/Country:	

Mechanical engineer:	
Street:	
Postcode/City:	
Province/Country:	
Certification:	
Street:	
Postcode/City:	
Province/Country:	

Year of construction:	1845	Interior temperature winter [°F]:	68.0
No. of dwelling units:	4	Internal heat gains (IHG) heating case [BTU/(hr.ft²)]:	0.81
No. of occupants:	10.1	Specific capacity [BTU/F per ft² TFA]:	10.6
Interior temp. summer [°F]:	77.0		
IHG cooling case [BTU/(hr.ft²)]:	1.23		
Mechanical cooling:	x		

Specific building characteristics with reference to the treated floor area

						Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	ft²	4734					
Space heating	Heating demand	kBTU/(ft²yr)	6.64	≤		6.34	-	no
	Heating load	BTU/(hr.ft²)	5.70	≤		-	-	
Space cooling	Cooling & dehum. demand	kBTU/(ft²yr)	5.22	≤		5.71	5.71	yes
	Cooling load	BTU/(hr.ft²)	5.64	≤		-	3.31	
	Frequency of overheating (> 77 °F)	%	-	≤		-		-
	Frequency of excessively high humidity (> 0.012 lb/lb)	%	0.0	≤		10		yes
Airtightness	Pressurization test result n_{50}	1/hr	0.6	≤		1.0		yes
Non-renewable Primary Energy (PE)	PE demand	kBTU/(ft²yr)	32.78	≤		40.31		yes
Primary Energy Renewable (PER)	PER demand	kBTU/(ft²yr)	16.59	≤		-	-	-
	Generation of renewable energy (in relation to projected building footprint area)	kBTU/(ft²yr)	0.00	≥		-	-	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

EnerPHit Classic? no

Task:	First name:	Surname:	Signature:
1-Designer	Laura	Blau	

Issued on: City:

EnerPHit Verification *with 3" Cork EIFS*

Photo or Drawing

Building:	1722 Pine Street Renovation - Historic building
Street:	1722 Pine St
Postcode/City:	19103 Philadelphia
Province/Country:	Pennsylvania USA
Building type:	Historic Brick Rowhome
Climate data set:	US0064a-Philadelphia
Climate zone:	4: Warm-temperate — Altitude of location: 35 ft
Home owner / Client:	Laura Blau & Paul Thompson
Street:	1005 S 7th St
Postcode/City:	19147 Philadelphia
Province/Country:	Pennsylvania USA

Architecture:	BluPath Design Inc
Street:	1005 S 7th St
Postcode/City:	19147 Philadelphia
Province/Country:	Pennsylvania USA
Energy consultancy:	BluPath Design Inc
Street:	
Postcode/City:	
Province/Country:	

Mechanical engineer:	
Street:	
Postcode/City:	
Province/Country:	
Certification:	
Street:	
Postcode/City:	
Province/Country:	

Year of construction:	1845	Interior temperature winter [°F]:	68.0
No. of dwelling units:	4	Internal heat gains (IHG) heating case [BTU/(hr.ft²)]:	0.81
No. of occupants:	10.1	Specific capacity [BTU/F per ft² TFA]:	10.6
Interior temp. summer [°F]:	77.0		
IHG cooling case [BTU/(hr.ft²)]:	1.23		
Mechanical cooling:	x		

Specific building characteristics with reference to the treated floor area

						Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	ft²	4734					
Space heating	Heating demand	kBTU/(ft²yr)	4.82	≤		6.34	-	yes
	Heating load	BTU/(hr.ft²)	4.88	≤		-	-	
Space cooling	Cooling & dehum. demand	kBTU/(ft²yr)	5.04	≤		5.71	5.71	yes
	Cooling load	BTU/(hr.ft²)	5.37	≤		-	3.31	
	Frequency of overheating (> 77 °F)	%	-	≤		-		-
	Frequency of excessively high humidity (> 0.012 lb/lb)	%	0.0	≤		10		yes
Airtightness	Pressurization test result n_{50}	1/hr	0.6	≤		1.0		yes
Non-renewable Primary Energy (PE)	PE demand	kBTU/(ft²yr)	30.49	≤		38.12		yes
Primary Energy Renewable (PER)	PER demand	kBTU/(ft²yr)	15.24	≤		-	-	-
	Generation of renewable energy (in relation to projected building footprint area)	kBTU/(ft²yr)	0.00	≥		-	-	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

EnerPHit Classic? yes

Task:	First name:	Surname:	Signature:
1-Designer	Laura	Blau	

Issued on: City:

Pine Street PHPP Verification Sheet

With and without Cork Exterior Insulating System


Ready to Harvest Carbon and Reduce Carbon Emissions


Be the Snowflake that becomes the Snowball that starts the Avalanche

Why Zero: Path to Better Future

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

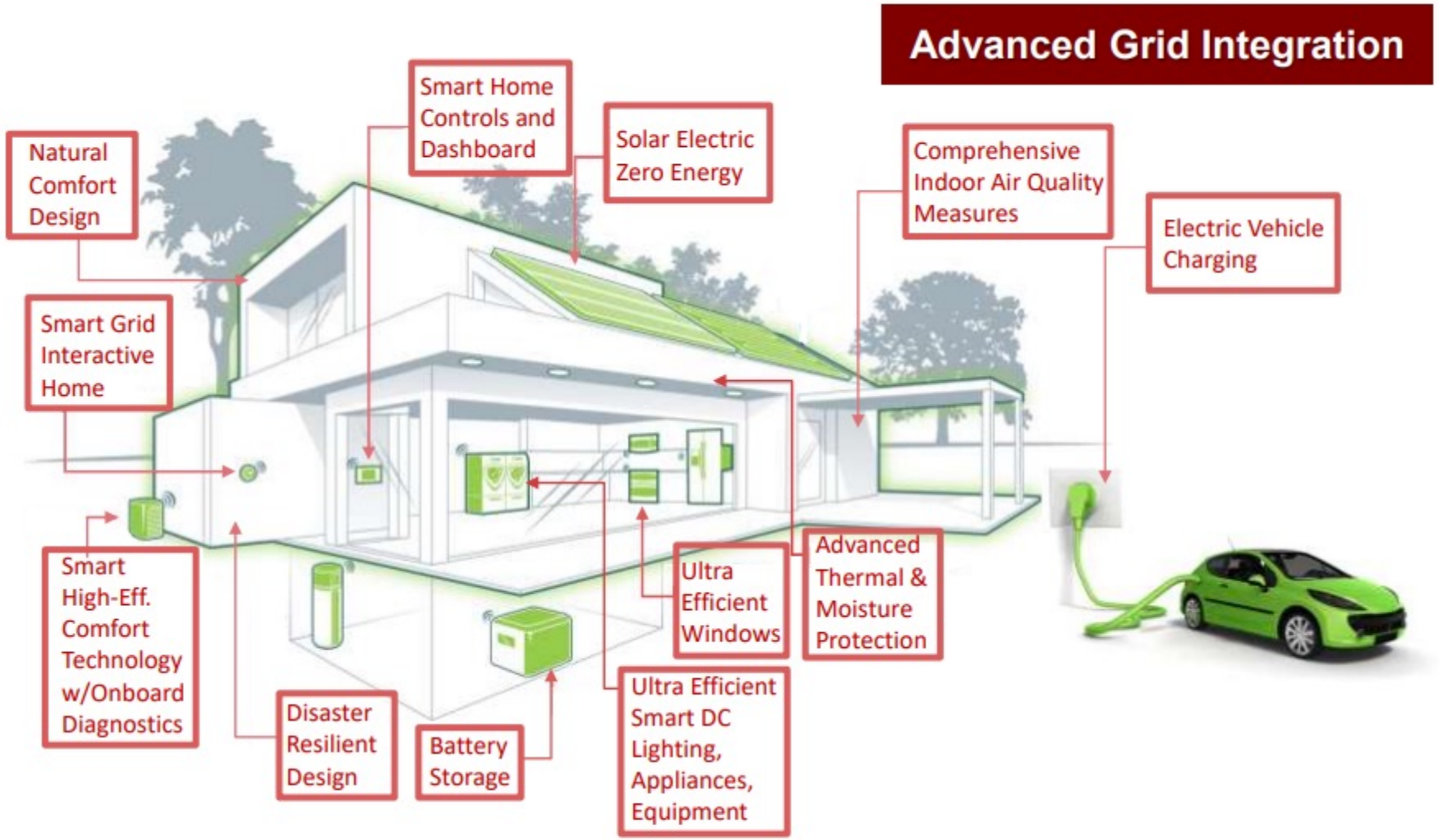


Image Source: http://www.santamonicapropertyblog.com/more-green-building-codes-in-january/


Can you find the Passive House?

Conclusion

1. Renovations take planning
2. Building science is an active part of the process
3. Values, Mission and Vision are the alpha and omega

Next Steps

1. Finish the f@#$%&g project
2. Get it rented
3. Get the certification
4. Share lessons learned
5. Install solar panels
6. Start growing carbon!


We are stardust, we are golden …
Joni Mitchell, 1970