Affordable Multifamily Housing: Net Zero and Passive House? Challenges, Opportunities, Mistakes, and Solutions

NESEA BE March 14, 2019

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TWIN PINES HOUSING

VEIC

MaclayArchitects
CHOICES IN SUSTAINABILITY

Learning Objectives

1. Participants will identify cost effective envelope enclosures and mechanical systems for multi-family net zero projects.
2. Participants will understand and use a proven, replicable energy modeling and financial analysis methodology for determining the most cost effective high-performance strategies and what level of energy performance is the most cost effective for building owners and managers.
3. Participants will understand the differences in NZE and Passive House Certification and the applicability, including benefits and liabilities, for multifamily housing projects.
4. This session will increase participants ability to select and successfully pursue and achieve NZE and Passive House

Project Team

- Twin Pines Housing - Owner
- Maclay Architects - Architect
- Engineering Services of Vermont - MEP
- Engineering Ventures – Civil, Structural
- GPI – Landscape Architects
- Estes & Gallup – Contractor
- Eco Houses of Vermont – PHIUS modeler
- Norwich Solar – Solar installer/consultant
- VEIC – Karen Bushy PHIUS rater

TWIN PINES HOUSING

MaclayArchitects
CHOICES IN SUSTAINABILITY

Engineering Services of Vermont, LLC
Mechanical-Electrical Consulting Engineers

ENGINEERING VENTURES PC

GPI

E&G
ESTES&GALLUP
INCORPORATED

VEIC

NORWICH SOLAR TECHNOLOGIES

ECO HOUSES OF VERMONT, LLC

Who is Twin Pines Housing?

- Upper Valley's leading developer and provider of Affordable Housing.
  - 417 Rentals at 19 Properties
    - 161 in VT
    - 256 in NH
  - 48 Homeownership Properties
    - Twin Pines is permanent steward
  - Over 1,000 people are housed
- 20-member staff with expertise in project development, property management, and resident support services.

Twin Pines Team at Safford Commons
Woodstock, VT

Serving the Upper Valley since 1990

Tracy Community Housing

West Lebanon, NH

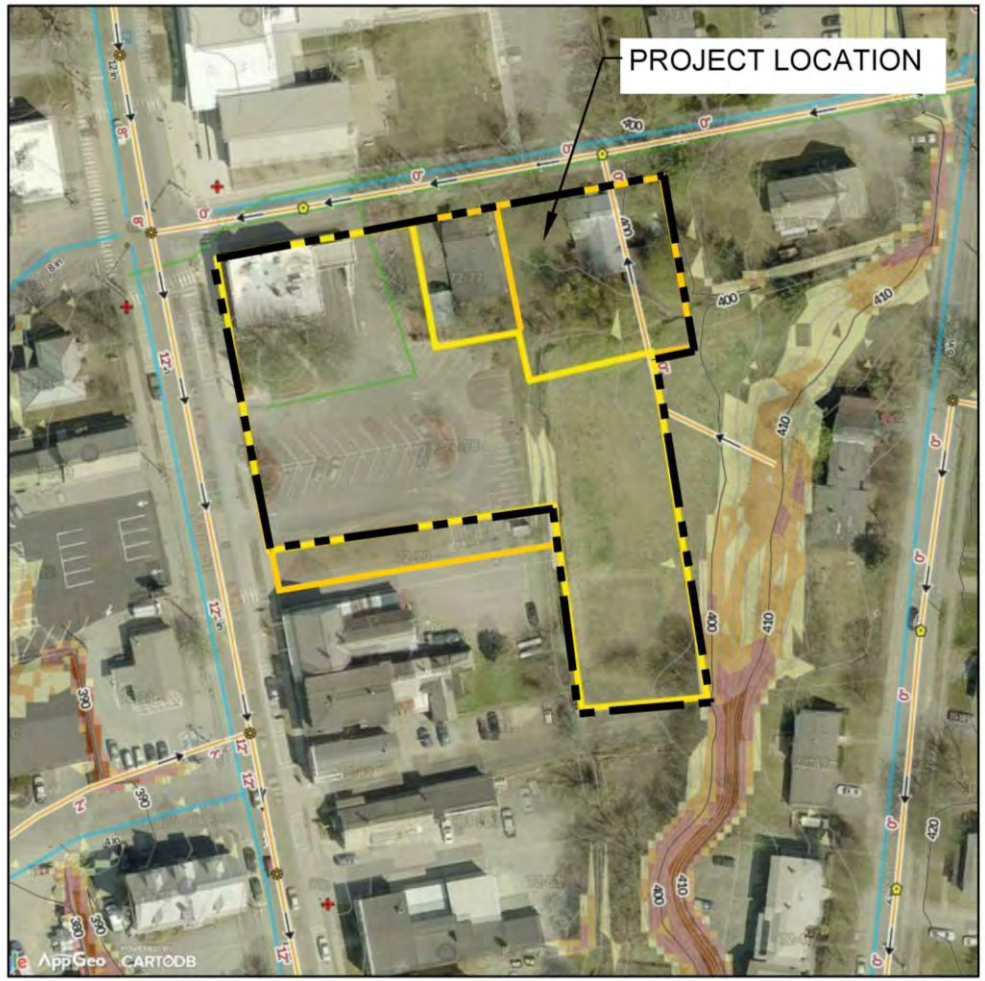
A new 3-story, net-zero, passive house, residential building to include:

- 29 one- and two-bedroom units for all ages and incomes.
- 18 units for households below 50% of AMI, 11 units for households below 60% of AMI.
- Building adjacent to Kilton Library, on Advance Transit bus line.

Site Plan

TWIN PINES HOUSING

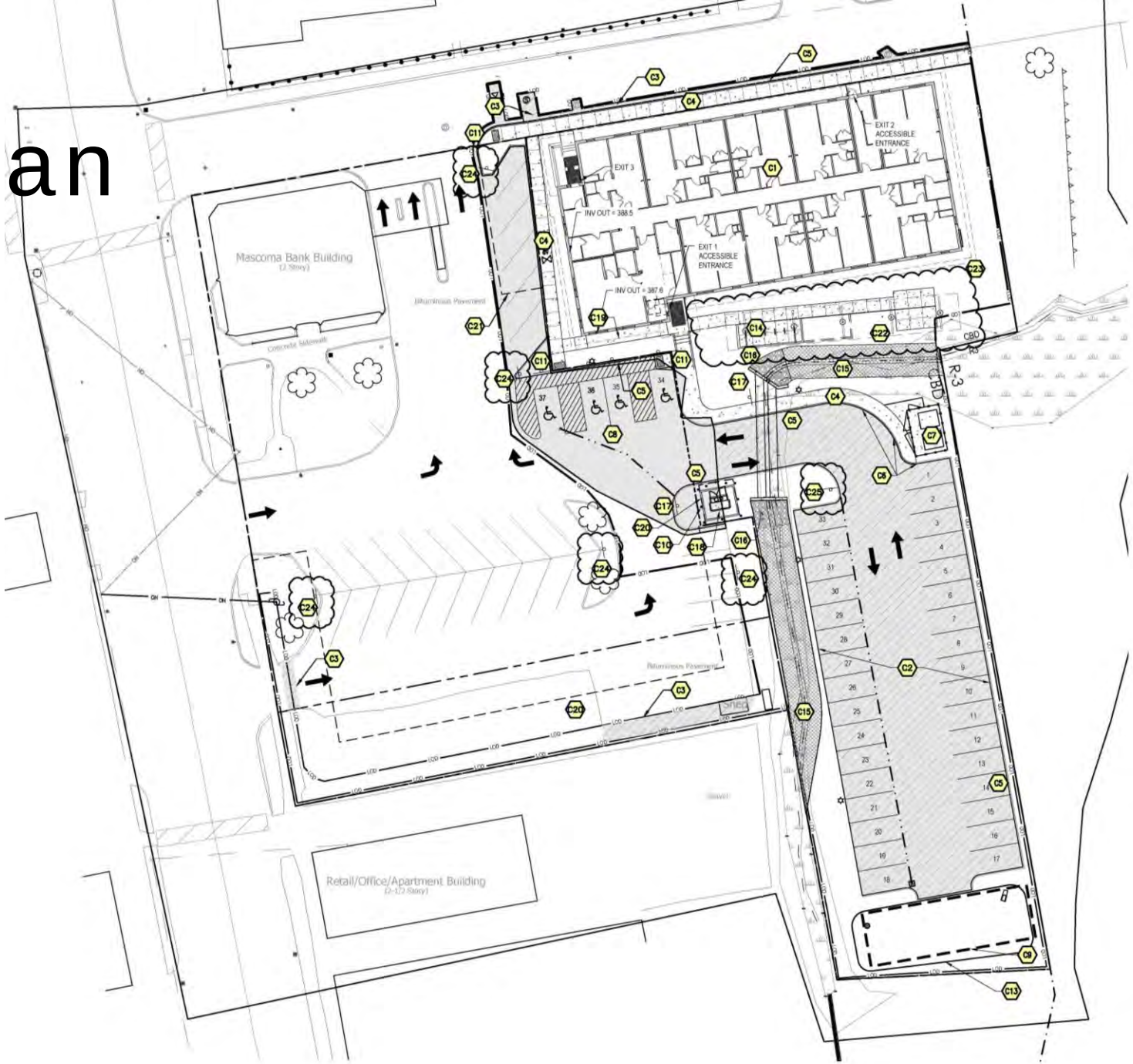
- Infill



ORTHO MAP
1"=200'

ZONING MAP
1"=200'

Site Plan



TWIN PINES HOUSING

PROPO

100

98

PROPERTY LINE
LOD LIMIT OF DISTURBANCE
EDGE OF PAVEMENT
EDGE OF GRAVEL
CURB
DITCH/SWALE
TREE LINE
STONE WALL

ST STORM LINE
UD UNDER DRAIN
FD FOUNDATION DRAIN
UT TELECOMM
UE UNDERGROUND ELECTRIC
W WATER LINE
G GAS LINE

PROPOSED SITE FEATURES

C1 BUILDING.
C2 PAVED DRIVES, SURFACE PARKING AND STRIPING. REFER TO DETAIL 4/C3.3
C3 PAVED UTILITY TRENCHES AND CURB PATCHES. REFER TO DETAIL 9/C3.3
C4 SIDEWALK. SEE PLAN FOR WIDTH. REFER TO DETAILS 1,2/C3.3
C5 7" GRANITE CURB. REFER TO DETAIL 5/C3.3
C6 FLUSH GRANITE CURB. REFER TO DETAIL 5/C3.3
C7 ENCLOSED DUMPSTER/RECYCLING AREA. REFER TO DETAILS 3/C3.3, 2/C3.4
C8 ADA PARKING (STANDARD AND VAN ACCESSIBLE). SIGN AND STRIPING
C9 SNOW STORAGE
C10 BOLLARD. REFER TO DETAIL 1/C3.4
C11 DETECTABLE WARNING PLATES (TYP.). REFER TO DETAIL 6/ C3.3
C12 GRAVEL WALK AND BENCHES. REFER TO LA PLANS.
C13 GRAVEL WETLAND. REFER TO DETAIL 6/C3.2
C14 BIKE RACK/STORAGE
C15 STABILIZED CHANNEL. REFER TO DETAIL 4/C3.2
C16 CLASS C STONE RIP-RAP. REFER TO DETAIL 4/C3.2
C17 "NO PARKING" SIGN
C18 CONCRETE TRANSFORMER PAD. REFER TO DETAIL 3/C3.3
C19 30 LF ACCESSIBLE RAMP AT 1:12 WITH HANDRAILS.
C20 ELECTRIC EASEMENT
C21 WATER EASEMENT
C22 PV ARBOR BY PV DESIGN
C23 PV ROOF PANELS. REFER TO ARCHITECTURAL DRAWINGS.
C24 SIGN "BANK PARKING ONLY BETWEEN SIGNS - 14 TRACY STREET HOUSING PARKING IN REAR LOT"
C25 SIGN "14 TRACY STREET HOUSING PARKING ONLY"

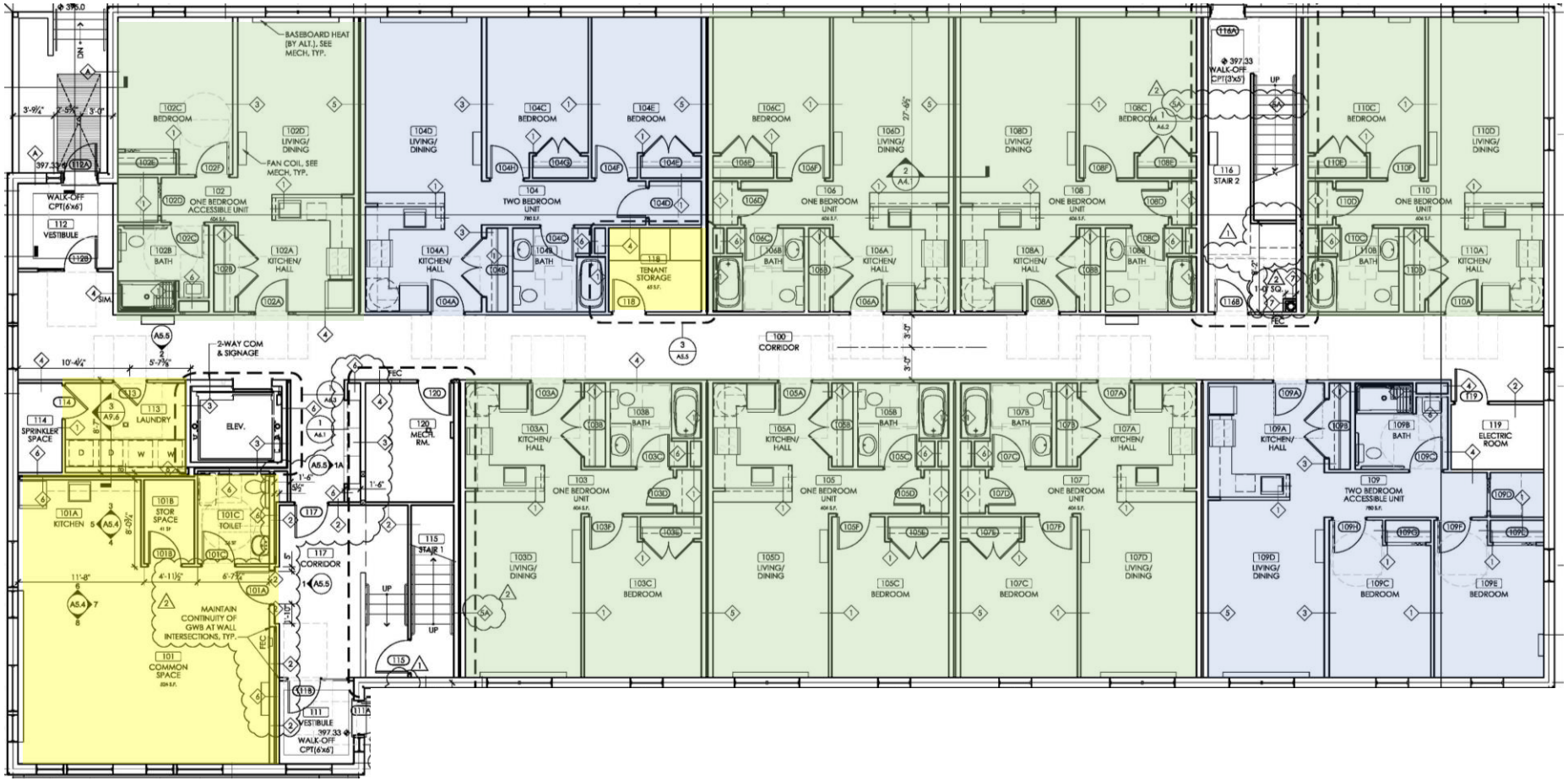
N

GRAPHIC SCALE

1 inch = 20 ft.
for sheet size 24" x 36"

1st Floor Plan

- 1 and 2 bedroom units
- Community room
- Tenant Storage
- Shared Laundry



2nd/3rd Floor Plan

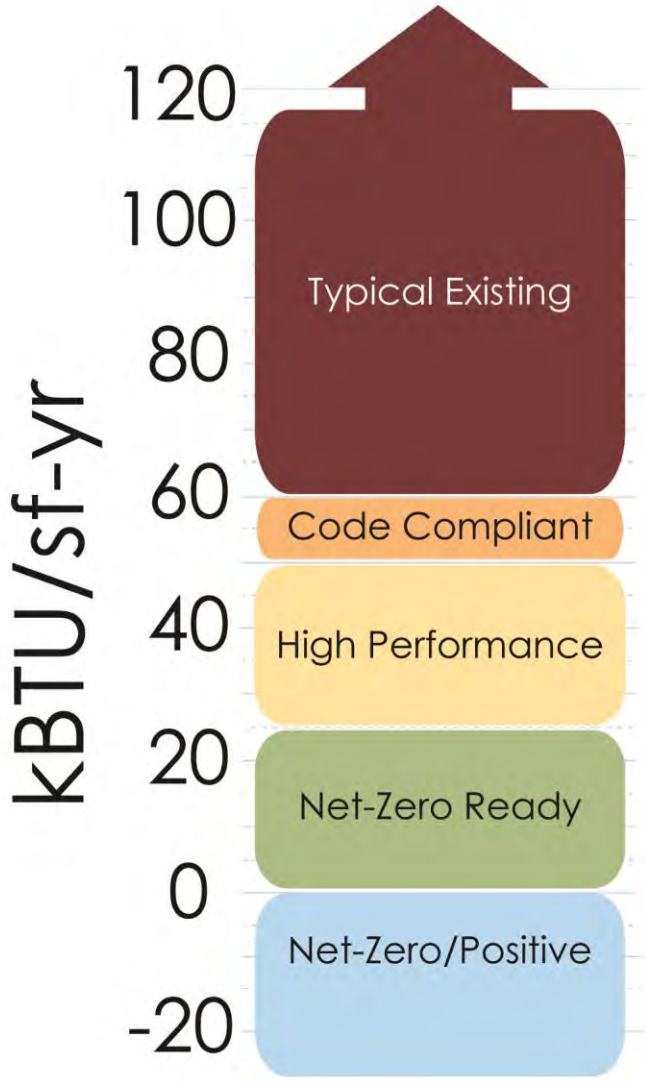
- 1 and 2 bedroom units

Why Net Zero and Passive House?

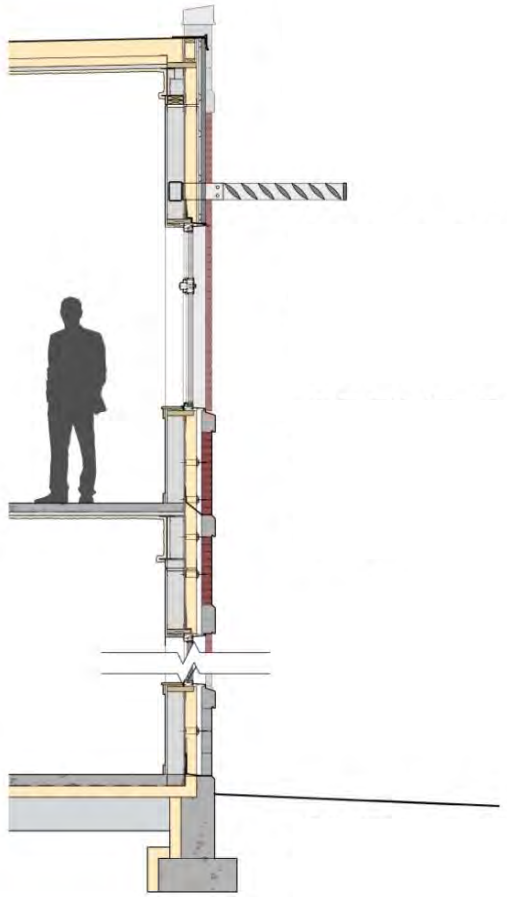
- As an organization, we are striving to develop a more energy efficient portfolio;
- Our housing typically includes heat and hot water in the rent. Controlling energy costs benefits our organization and our residents;
- Serves as model for future development
- Extra funding points for NZ or PH

Net Zero Building Metrics

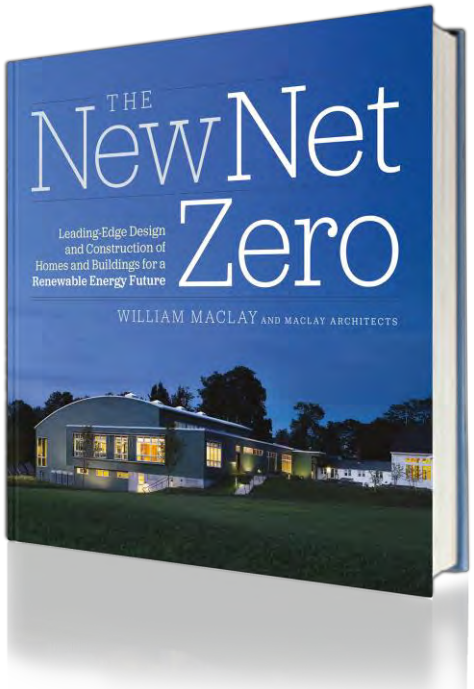
PERFORMANCE METRICS
(without process loads)



PRESCRIPTIVE METRICS



Air Infiltration - Maximum 0.05 cfm/sf @ 50 Pascals



Key Elements

Conservation + High-Efficient Systems + Renewables

Energy Use Intensity (EUI)

Heat Pumps (COP 2.3-3.0)

Usually Photovoltaics (sized for annual load)

Passive House Metrics

Energy Model Targets:
Annual Heating
Peak Heating
Annual Cooling
Peak Cooling
Source Energy / person for residential
PHIUS review

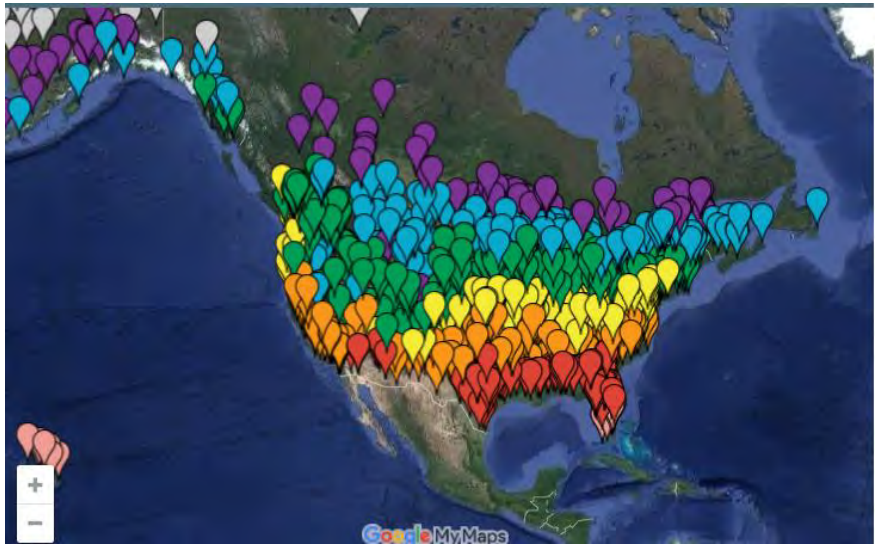
Construction:
3rd party verified built as constructed
0.05 cfm50/sf gross envelope
Interior containment between apartments

Why PHIUS?

Climate Specific Targets

Lebanon Municipal Airport, NH

Climate Zone	6
Annual Heating Demand	6.9 kBtu/sf-iCFA-yr
Annual Cooling Demand	1.8 kbtu/sf-iCFA-yr
Peak Heating Load	5.2 Btu/sf-iCFA-h
Peak Cooling Load	4 Btu/sf-iCFA-h
Manual J Peak Cooling Load	5.7 Btu/sf-iCFA-h



Key Decision Timeline

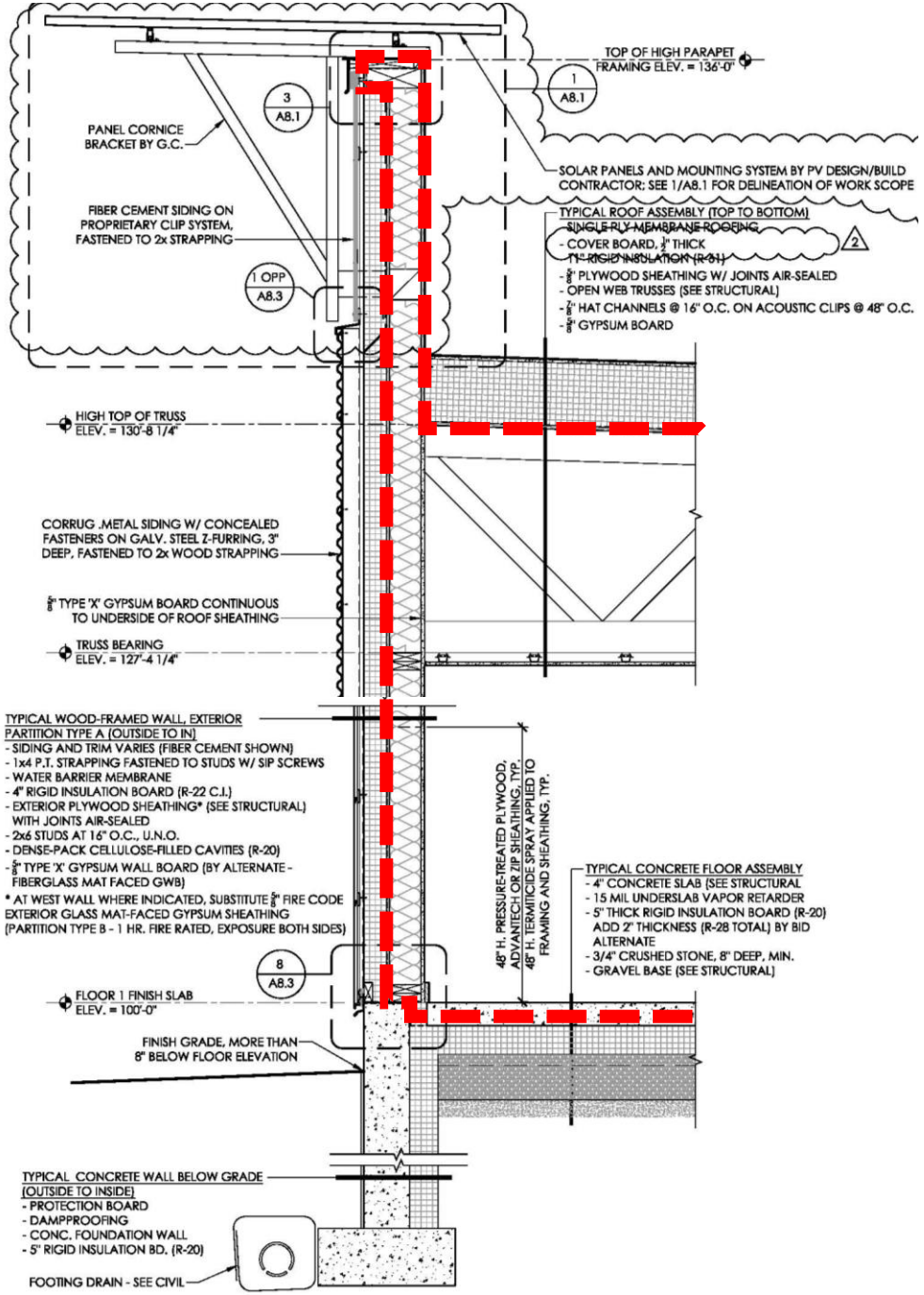
- Site Identification — Spring 2016
- 1st Funding application — Summer 2016- not funded
- Revised Site — Winter 2017
- 2nd Funding application — Summer 2017
  - NZE target for additional funds
  - Financing enabled extra $10,000/unit adjusted for NZ or PH
- Construction Manager hired — Winter 2017
- Solar Coordination/Consultation — Summer 2017
- Funding Secured — Winter 2018
- Construction begins — Summer 2018
- PHIUS exploratory model — Summer 2018
- PHIUS Certification pursued — Fall 2018

Why NZ first then PH?

- NZ Energy conservation is almost passive house
- NZ further reduces operational costs compared to code
- Minimal certification fees for same funding incentives

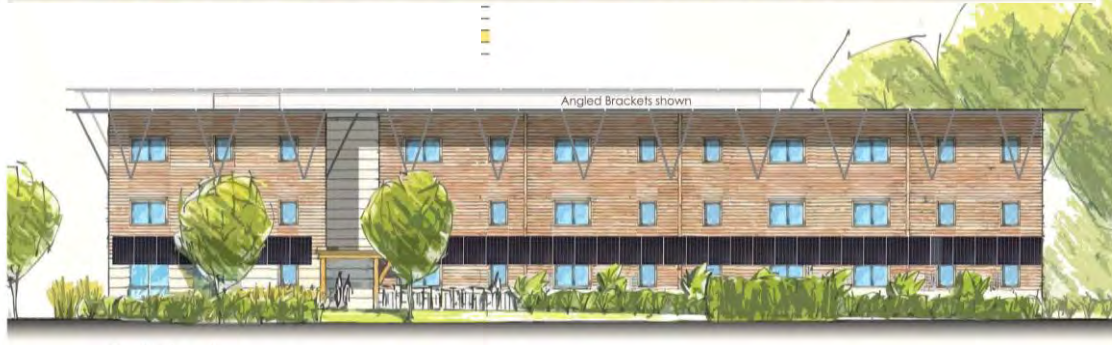
Design for Net Zero

- Wall – 2x6 cellulose +4” polyiso (R38)
- Roof – 11” polyiso (R60)
- Sub-slab – 5” rigid insulation (R20)
- Windows – U-value 0.22, SHGC 0.41
- Air infiltration - 0.05 cfm50/sf gross envelope
- Air Source Heat Pumps
- Electric hot water



Design for Net Zero

- Solar system size – 110% predicted
- Solar location –
  - Roof
  - Cornice
  - Façade
  - Arbors
  - Carports

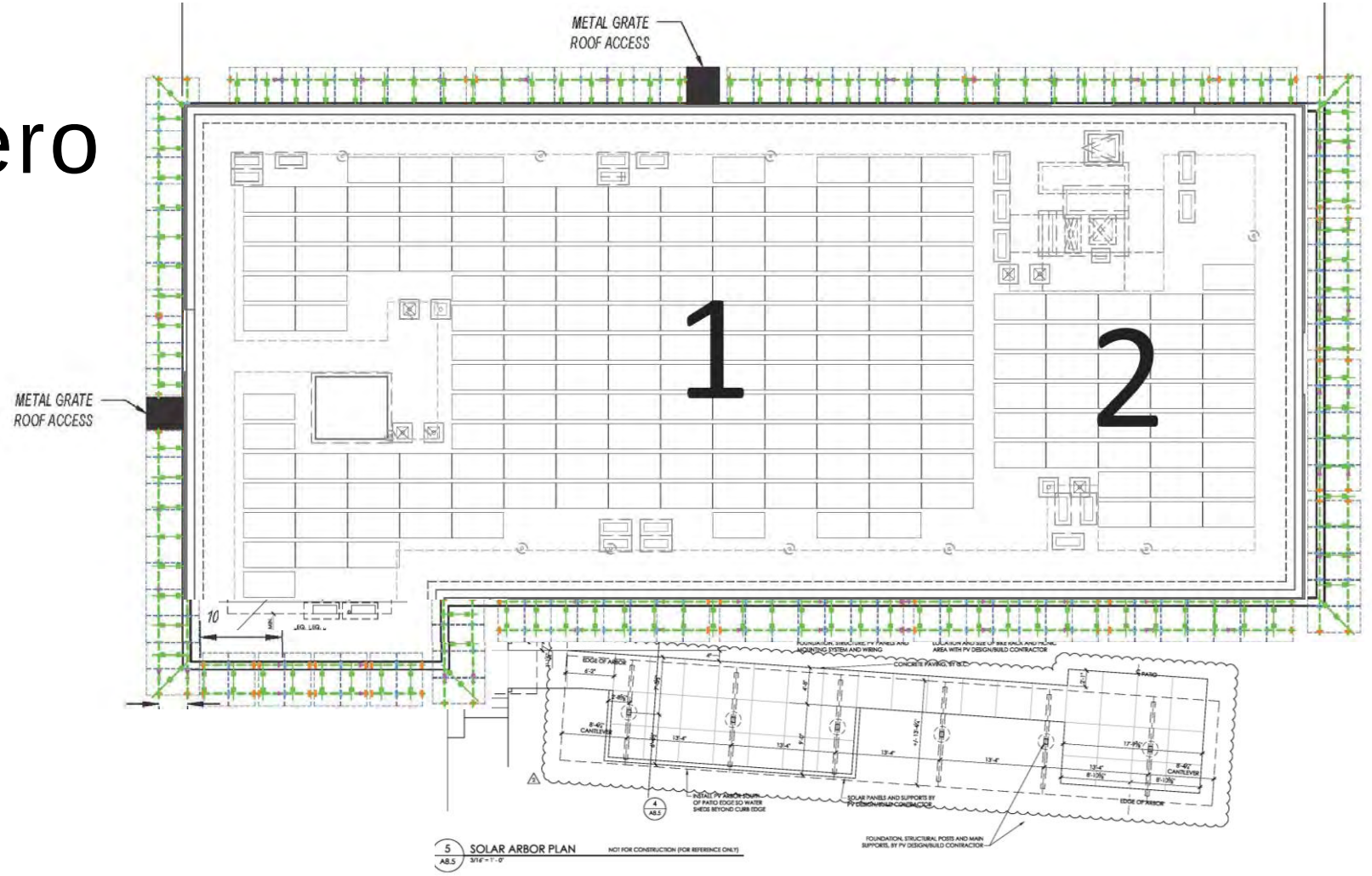


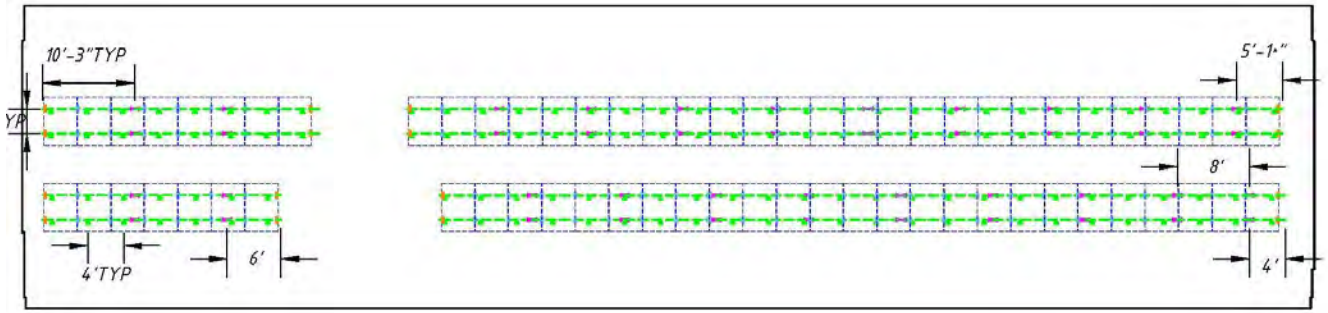
NORWICH SOLAR TECHNOLOGIES

Design for Net Zero

- 180 kW DC solar
  - Roof - 85 kW, ballasted system
  - Cornice – 50 kW - structure
  - South Façade- 24 kW conduit, penetrations
  - Arbor – 20 kW

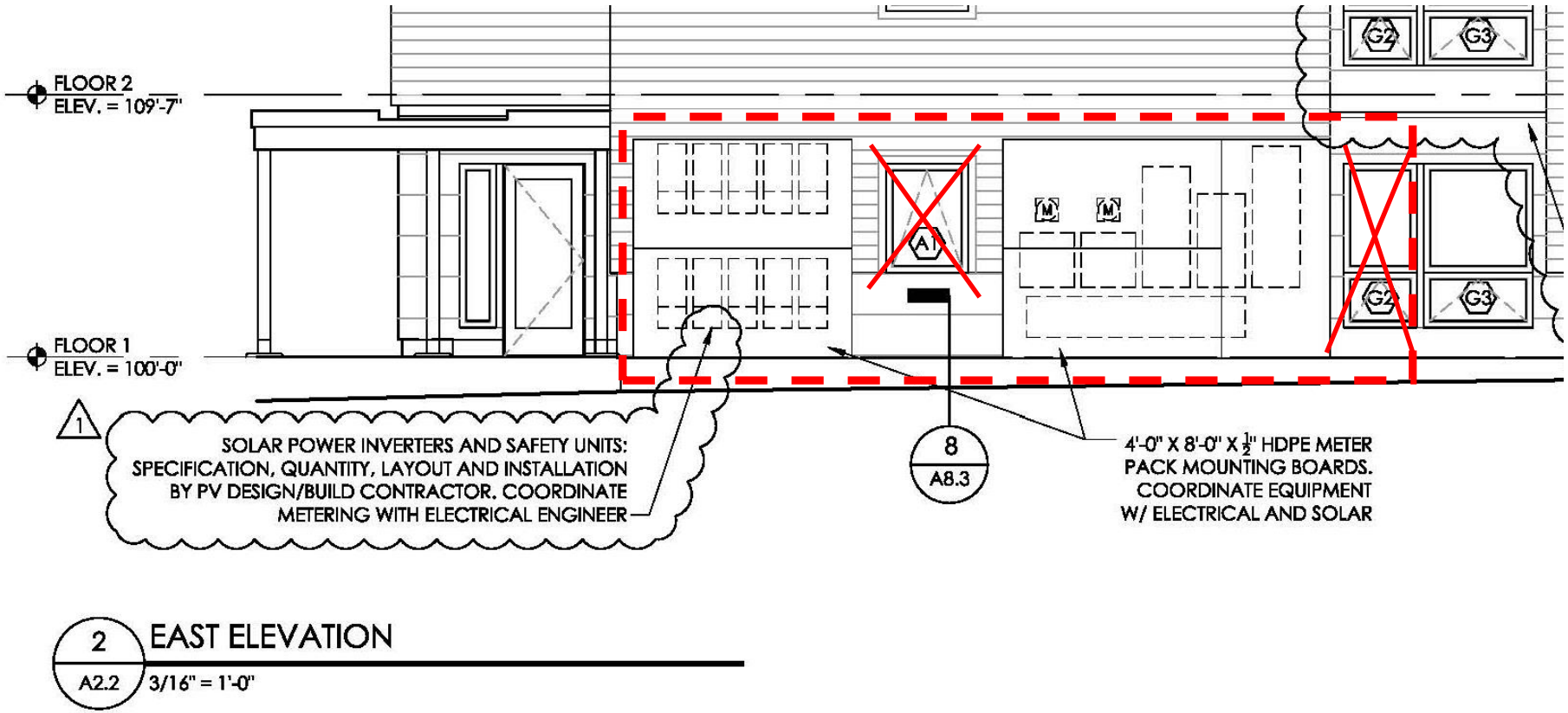
Estimated production
196,000 kWh/yr





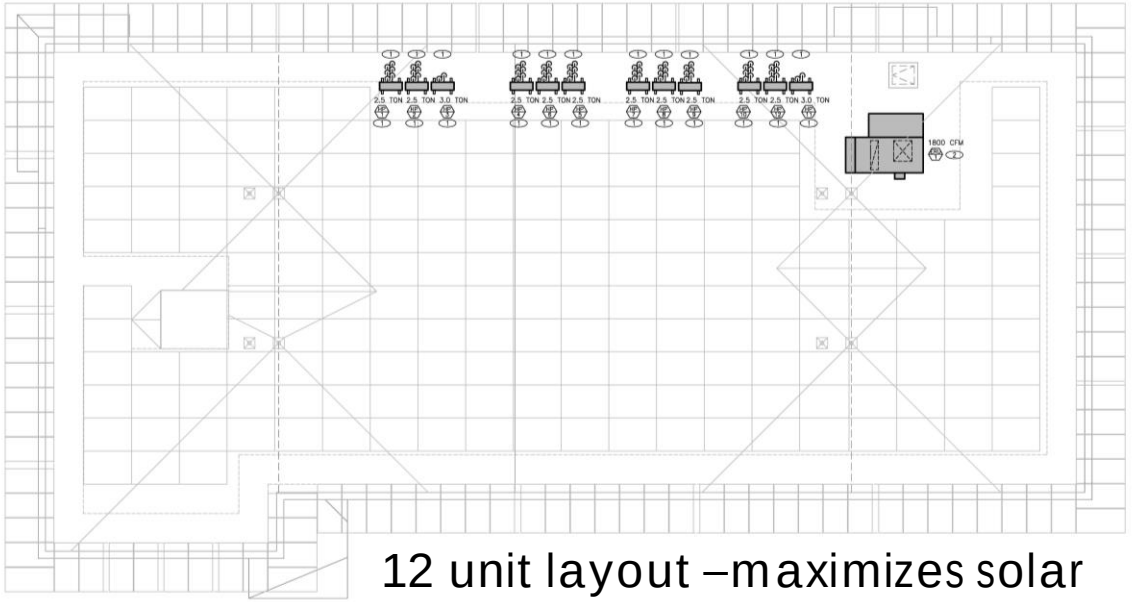
Design for Net Zero

- Solar Inverter and electrical panel size needs

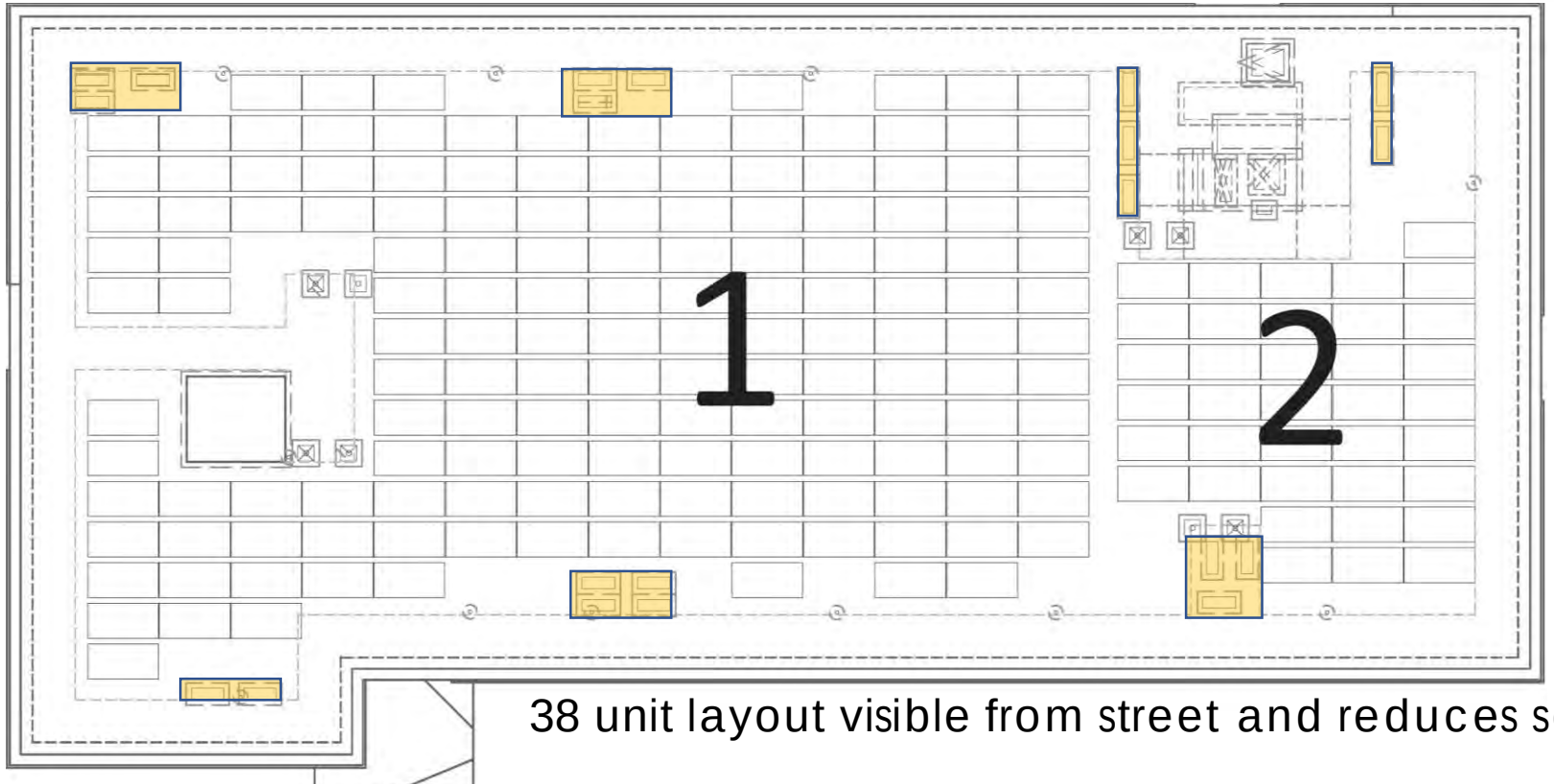


Design for Net Zero

- Heat Pump changes 12 to 38 rooftop units



12 unit layout –maximizes solar



38 unit layout visible from street and reduces solar area

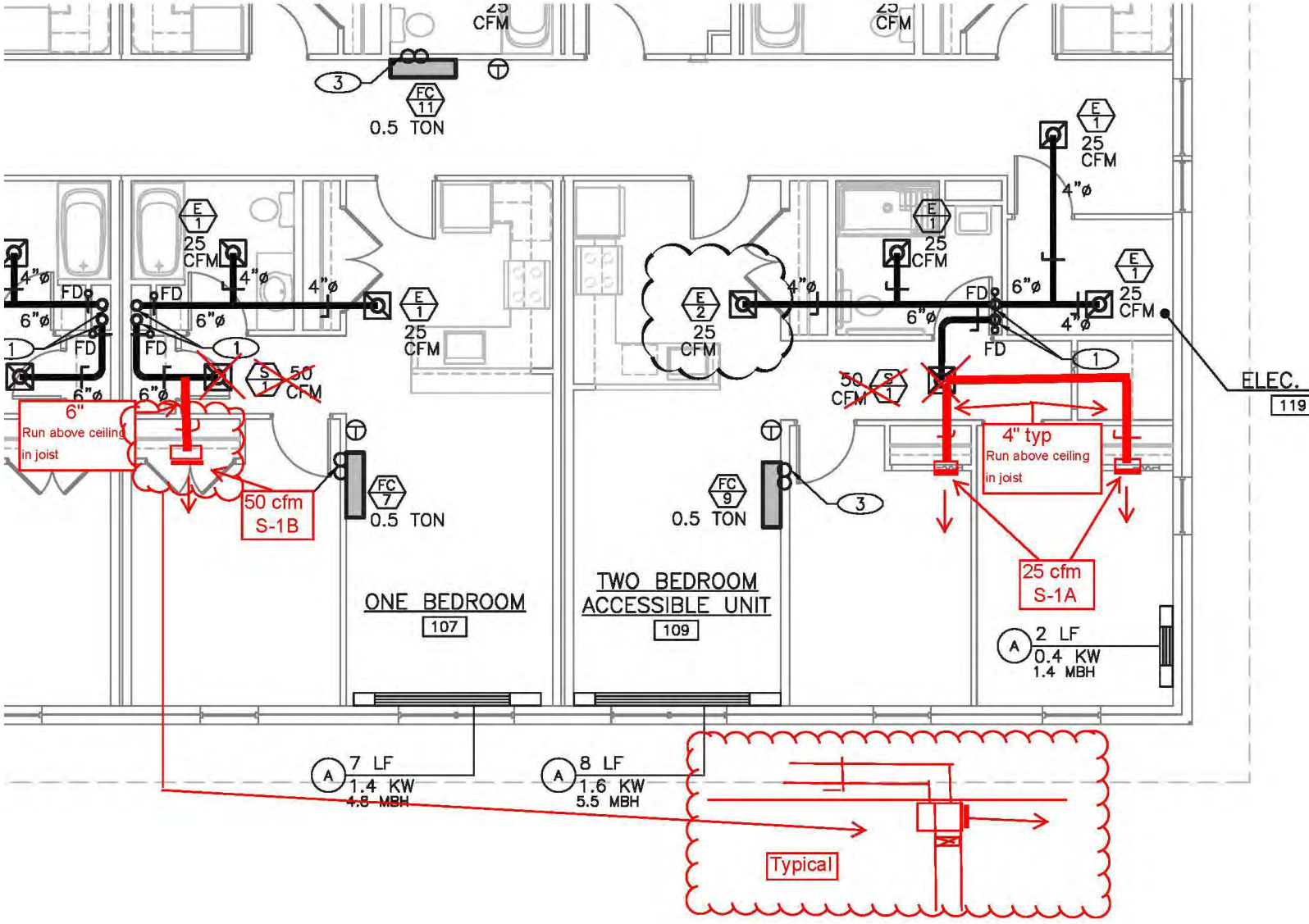
Design for Passive House

ADDITIONAL COSTS ASSOCIATED WITH PASSIVE HOUSE CERTIFICATION

DESCRIPTION	COST	NOTES
CONSTRUCTION COSTS:		
Extend Ventilation (includes CM Fee)	$6,240	Improves Indoor Air Quality/Health acutal was $60,000!
Window Upgrade (includes CM Fee)	$0-$7280	~~Very likely~~ windows ~~will~~ not need to be upgraded
PHIUS RELATED FEES:		
PHIUS modeling	$5,000-$9,000	Eco Houses of VT
PHIUS Certification Fee	$7,336	
PHIUS Rater Fee	$12,000	VEIC; $11,000 in project for BE Commissioning
TOTAL POTENTIAL COST	**$27,440 - 38,720**	
POTENTIAL REBATES:		
LU Potential Custom Incentive Rebate	$33,000	Unknown amount until built
Solar Rebate	$52,000	Total solar cost $450,000
TOTAL POTENTIAL REBATES	**$85,000**	

Design for Passive House

- Ventilation-same equipment, extension needed to bedrooms
- Window SHGC increase to 0.41 from 0.2 – No cost change



Financial Analysis Methodology

INPUTS

- Energy Consumption
- Increased Capital Costs for Efficiency
- Capital Cost for PV
- Financing Assumptions

	Code [2]		Net Zero Ready		
SF	(kBTU/ sf-yr)	(kWh/ sq.m-yr)	(kBTU/ sf-yr)	(kWh/ sq.m-yr)	% energy savings above code
27,000	49	156	17	54	65%

OUTCOMES

- Capital and operating costs over time

Energy Consumption

		code	ESVT energy model (Carrier HP)	EHVT Wufi Passive	REGIONAL AVERAGE (CBECS)
Total Electric	kBtu/yr	974,000	527,000	425,254	
Total BuildingEUI	kBtu/sf-yr	35	19	16	69

Code: Really that low? No air barrier testing required

Actual: ???

Capital Costs for NZ Over Code

under $8/sf

	Building Component	code	net zero ready	Added Cost	Category Added Cost
Envelope	Windows	U 0.35 min., SHGC max. 0.40	U 0.21awning, U0.22 casement	$15,447	$120,000
	Doors	U 0.50, R2	U 0.31 (glazed doors)	Above	
	Air/Vapor Barrier	Continuous air barrier required, but not tested - Infiltration ~0.40 CFM75/sf gross envelope	Infiltration 0.065 CFM75/sf gross envelope (=0.05 cfm50/sf) ~additional $1/sf of floor area to achieve	$27,000	
	Insulation	Roof R-20 ci entirely above deck	Roof R-61 ci entirely above deck	$38,380	
		Floor R-30	Floors - R-60 + R-33 ci	$200	
		Walls above grade, wood framed R 20 or R13 +R5 ci	Walls above grade, wood framed - R 20 +R22 ci	$12,168	
		Walls below grade - R 19 or R15 ci	Walls below grade - R 20	$1,053	
		Slab R-15 for 24" bel.	slab R-20 contin.	$4,570	
	Envelope Cx	none	full envelope commissioning	$23,000	
Mech	Heating	direct resistant electric baseboard	ASHPs	$37,300	$88,000
	Cooling	Wall mounted units for each apartment	ASHPs provide included above	-$9,425	
	Ventilation	Direct exhaust ventilation with passive intake	Rooftop heat recovery unit, Daikin DPS 007A	$60,500	

Total Added Cost without PV	**$210,000**
Added Envelope Cost Per Square Foot	$4.60
Added Mechanical Cost Per Square Foot	$3.40
Total Added Cost Per Square Foot	**$7.90**

Increased Net Zero Cost

PV	Solar PV	180 kW roof, façade and arbor, includes brackets ($52K and rebate $52K) $450k - $135	$315,000	$315,000

Total Added Cost with PV	**$520,000**
Added Envelope Cost Per Square Foot	$4.60
Added Mechanical Cost Per Square Foot	$3.40
Added PV Cost Per Square Foot	$12.00
Total Added Cost Per Square Foot	**$20.00**

Financial Analysis – Financial Assumptions

INPUTS

- Interest Rate - varies
- Loan Duration – 20 years
- Fuel Escalation Rate – 5%
  - "solar plateau" at year 13
  - (0% escalation from yr 13-20)
- Nominal Inflation rate equals the nominal discount rate therefore 0% used

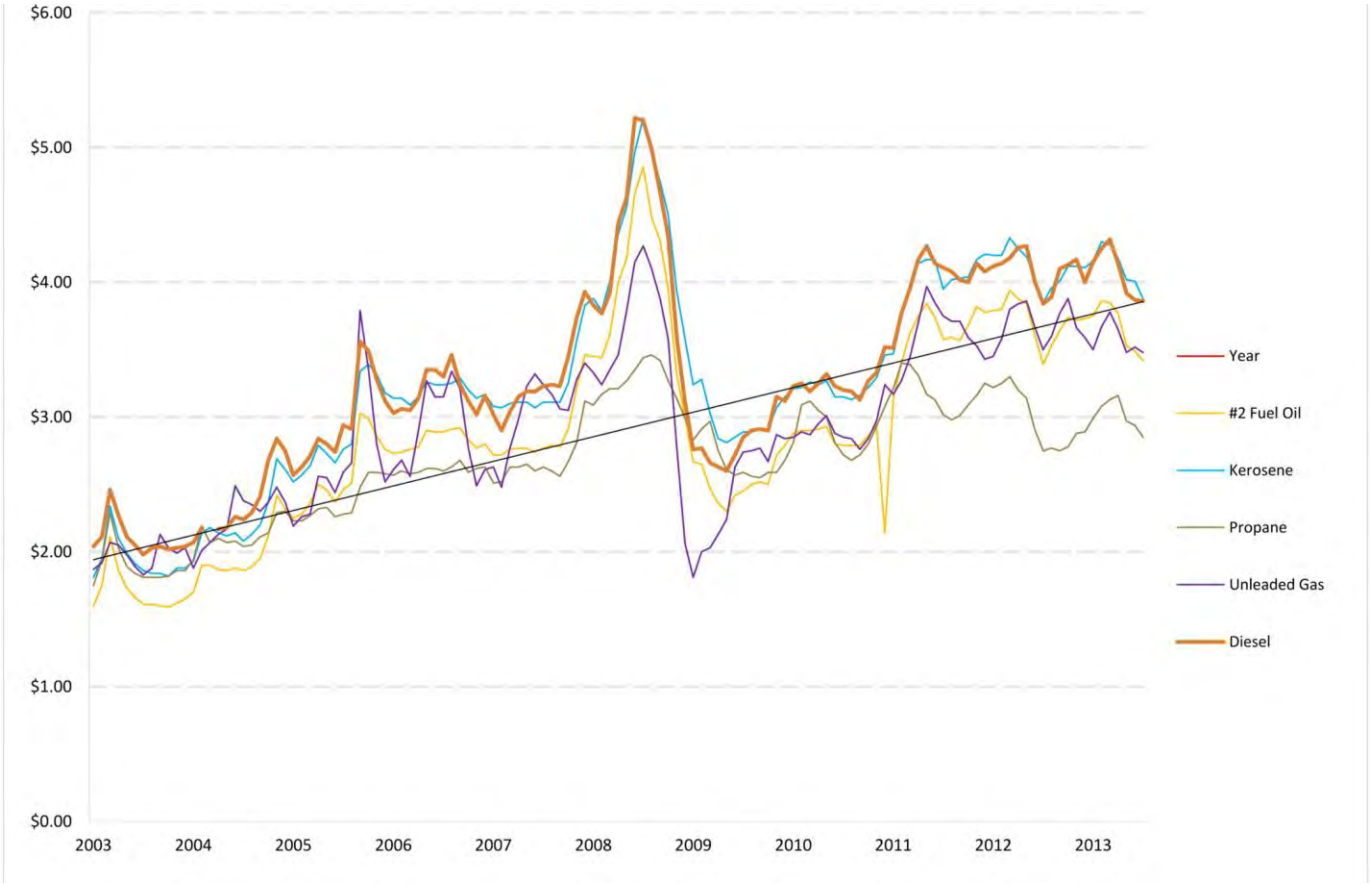
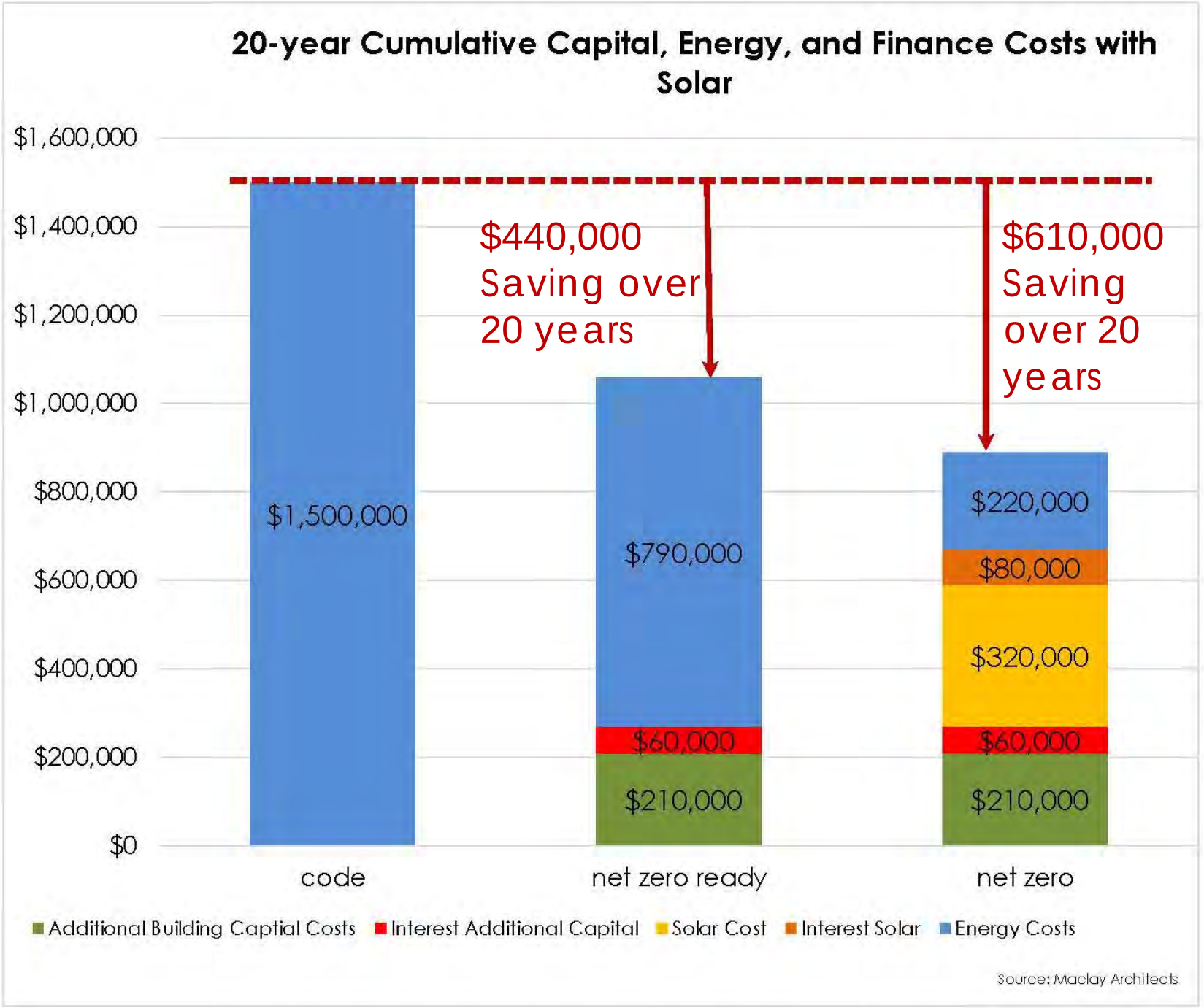


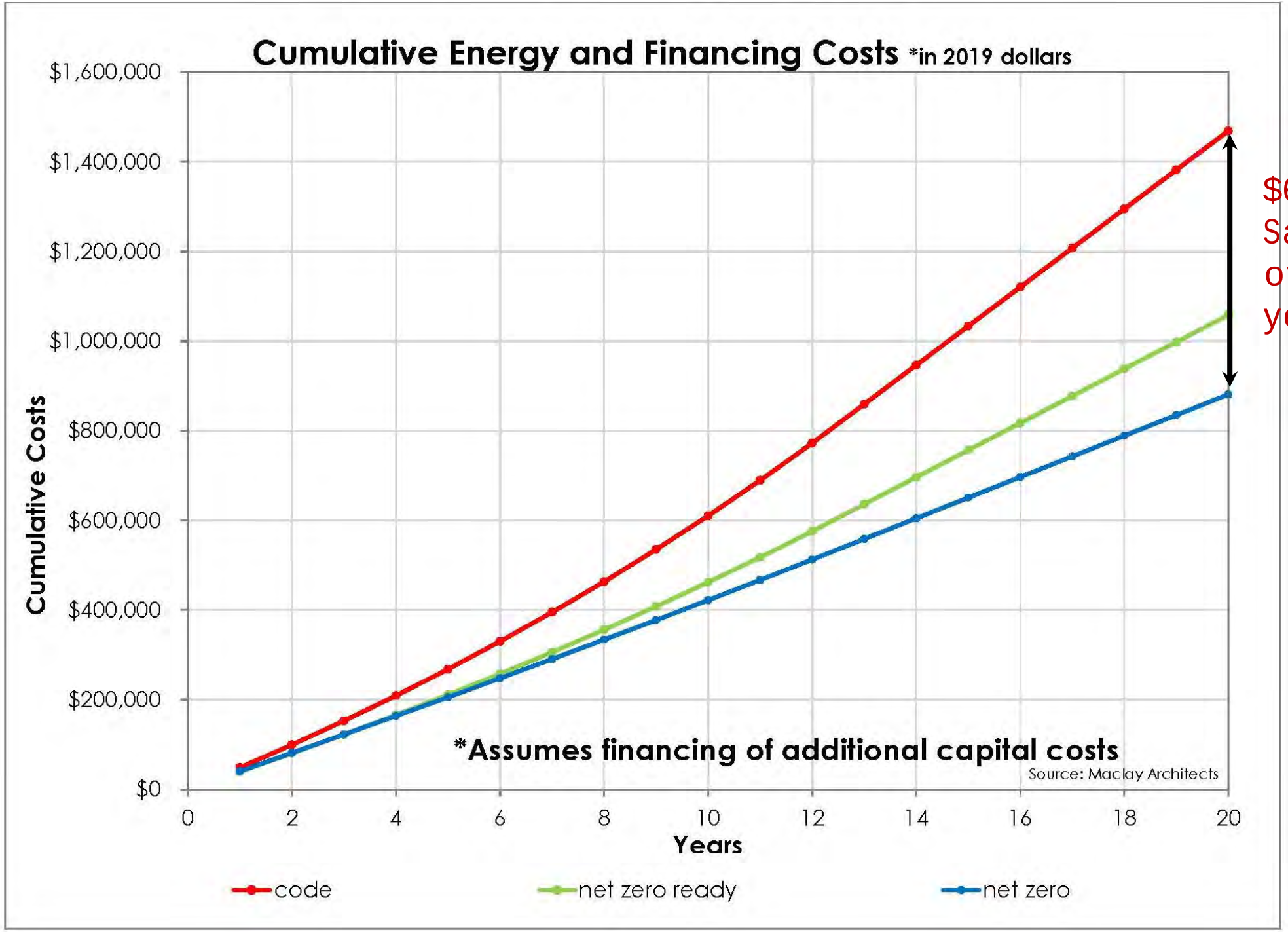
Image: Vermont Fuel Price 2003-2014

1. TPH Scenario (financed)

2.375% interest rate

- 20-year loan
- Weighted average of TPH loans for $1M of project cost
- Assume all additional capital is loaned
- Solar same loan

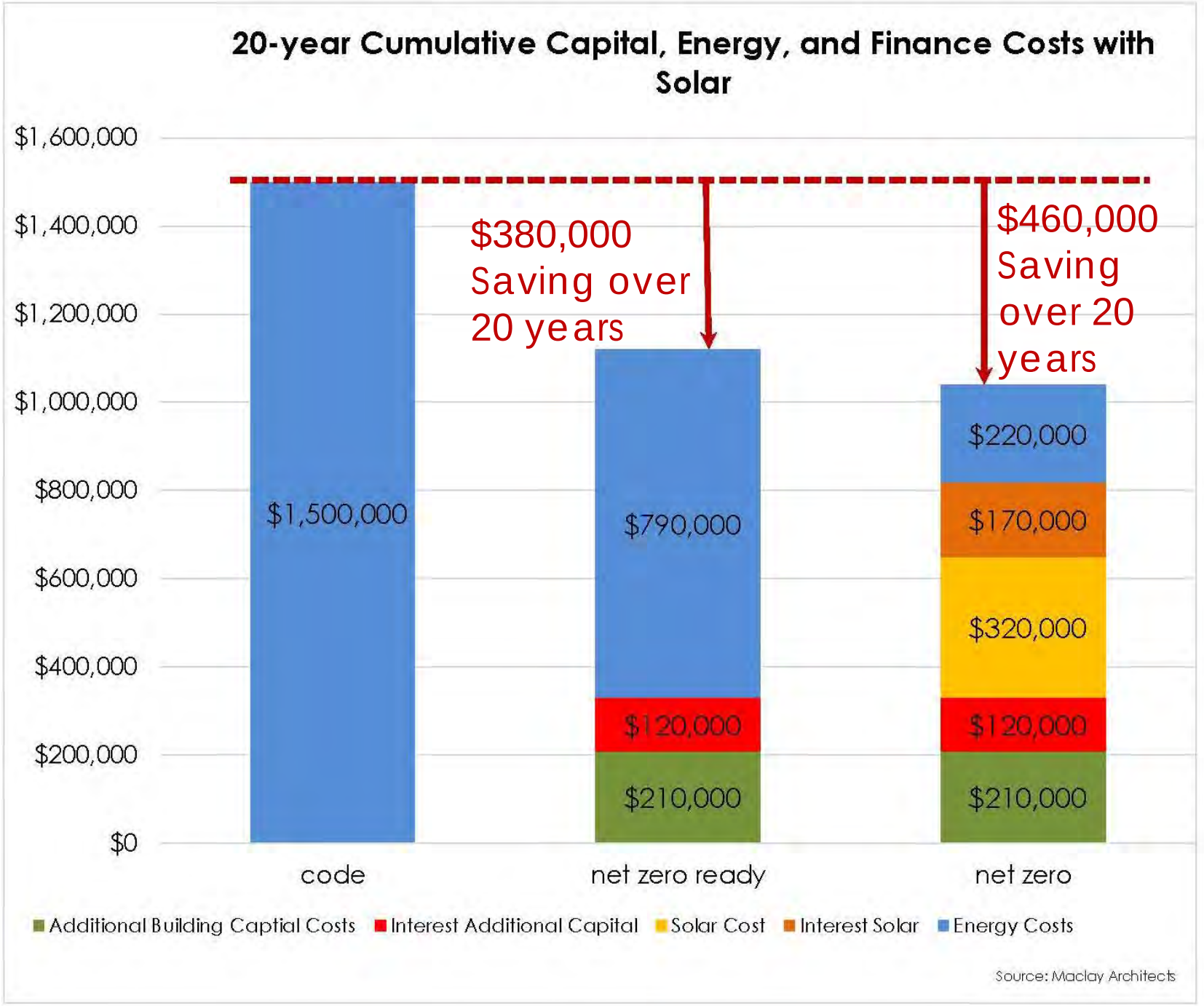


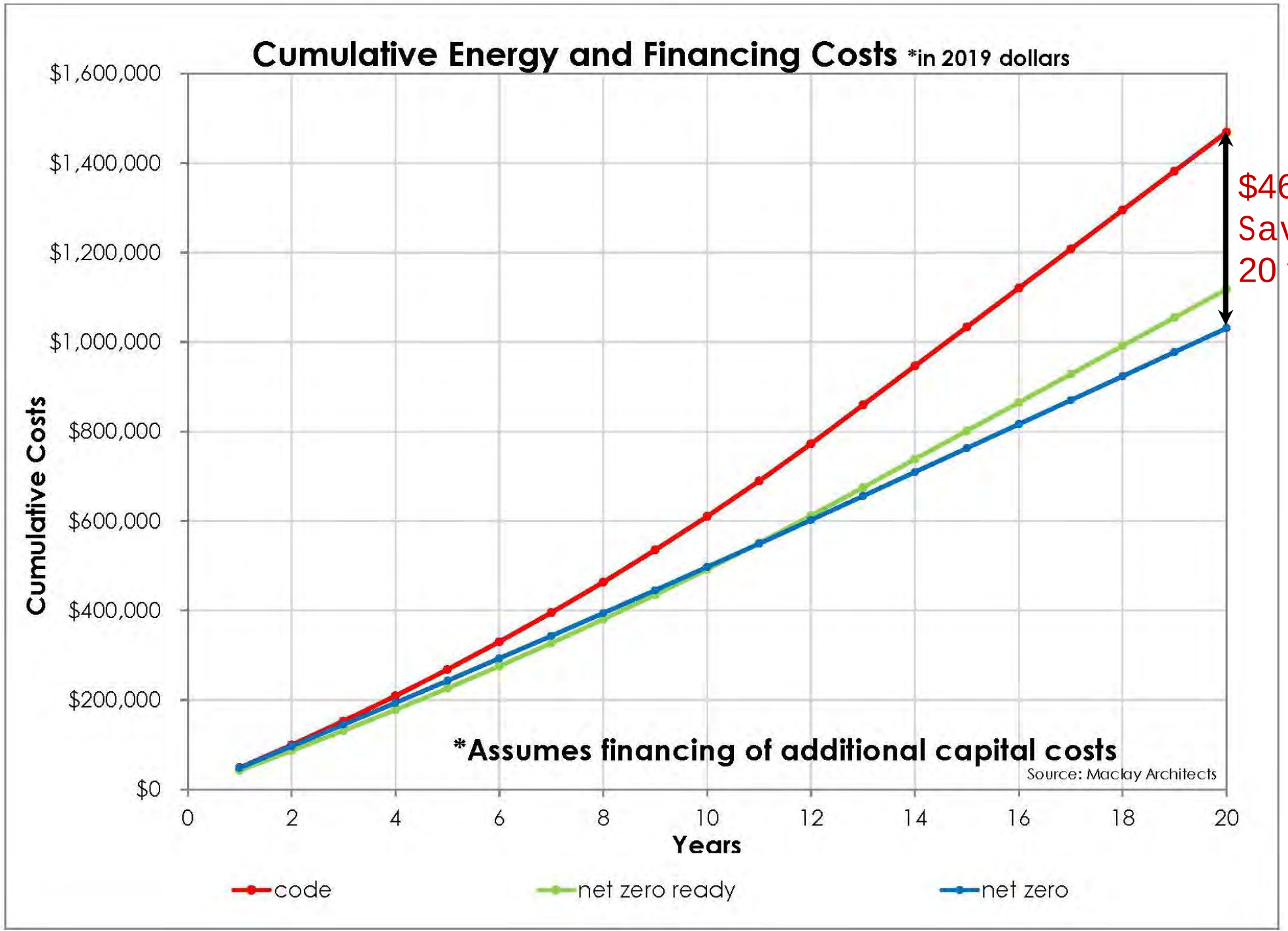

Cumulative Energy and Financing Costs *in 2019 dollars
$1,600,000
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
Cumulative Costs
0
2
4
6
8
10
12
14
16
18
20
Years
*Assumes financing of additional capital costs
Source: Maclay Architects
code
net zero ready
net zero
$610,000 Saving over 20 years

2. Typical Construction (financed)

4.625% interest rate

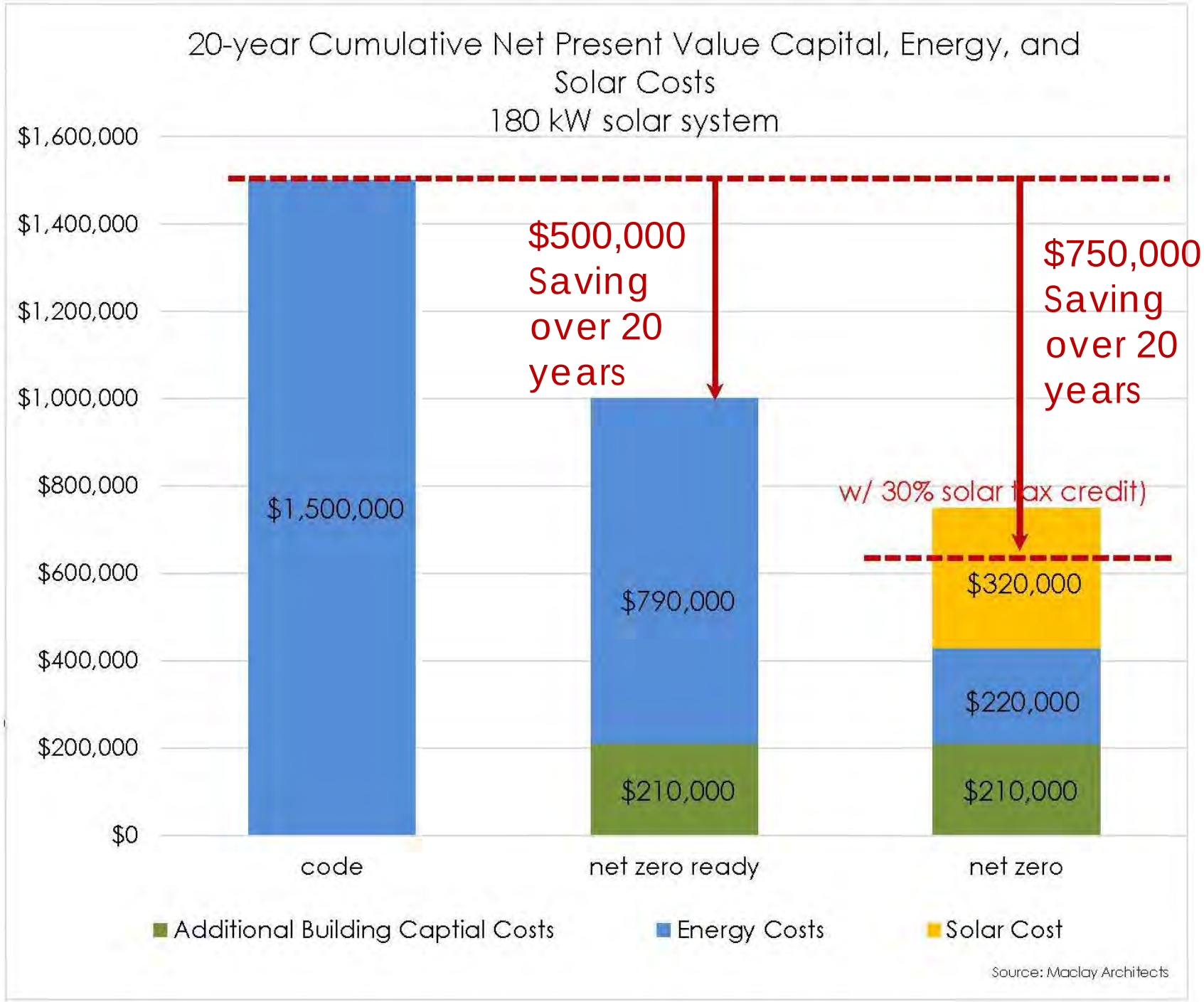
- 20-year loan
- Assume all additional capital is loaned
- Solar same loan

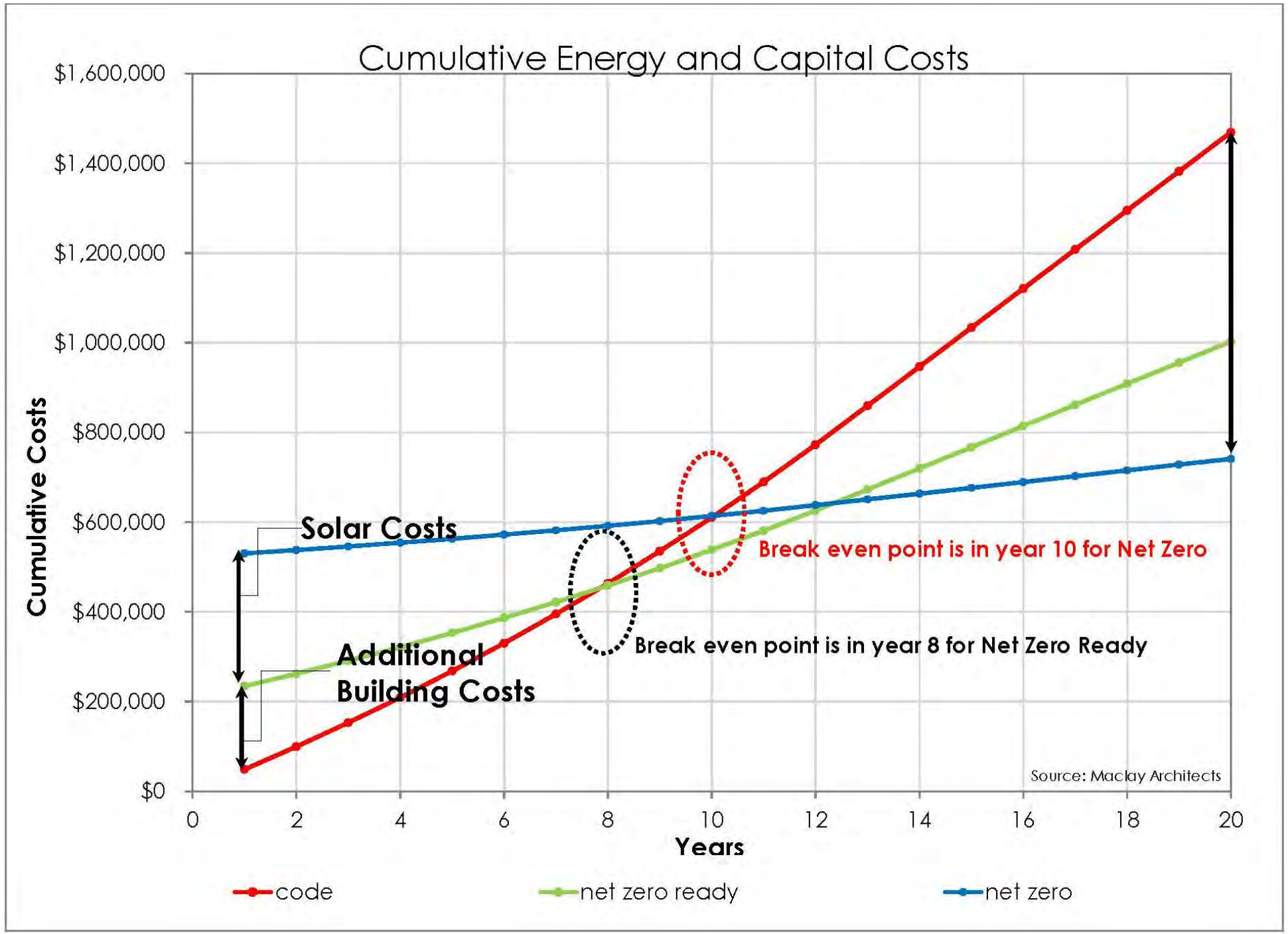



Cumulative Energy and Financing Costs *in 2019 dollars
$1,600,000
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
Cumulative Costs
0
2
4
6
8
10
12
14
16
18
20
Years
$460,000
Saving over
20 years
*Assumes financing of additional capital costs
Source: Maclay Architects
code
net zero ready
net zero

3. No Financing

0% interest rate

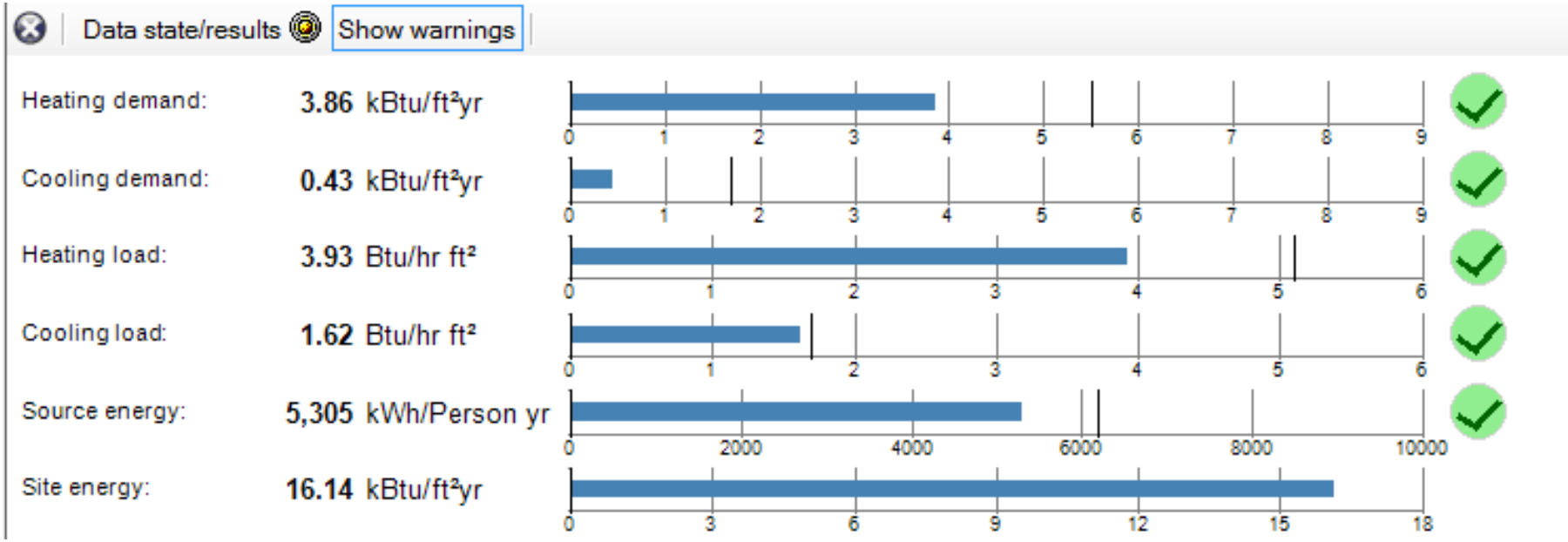




$730,000 Saving over 20 years

PHIUS Certification Status

- Model completed – Eco Houses of Vermont January 2019
- Round 1 PHIUS - 2 months
- Revisions to model based on feedback
- Round 2 PHIUS - 6 weeks
- Revisions to model based on feedback
- Round 3 PHIUS
  - 4 weeks



Passive House Rater/ Verifier

- Goal is to start early – not always possible
- Certification often does NOT work out* if CPHC and/ or Rater are not involved early (before DD)
  - Exceptional case with exceptional team
  - Net Zero design made it possible
- NH vs. VT - able to provide Rater services through VEIC outside of VT

* or results in higher cost