BUILDING ENERGY 15

MARCH 3-5, 2015 AT THE SEAPORT WORLD TRADE CENTER

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Making the Financial Case for Net Zero Buildings

Why it is free now, how to do it, and how to create success with your clients

Course Number:

Bill Maclay, Maclay Architects
Andy Shapiro, Energy Balance
Laura Bailey, Maclay Architects
Craig Simmons, Efficiency Vermont

Course Date: *March 4, 2015*

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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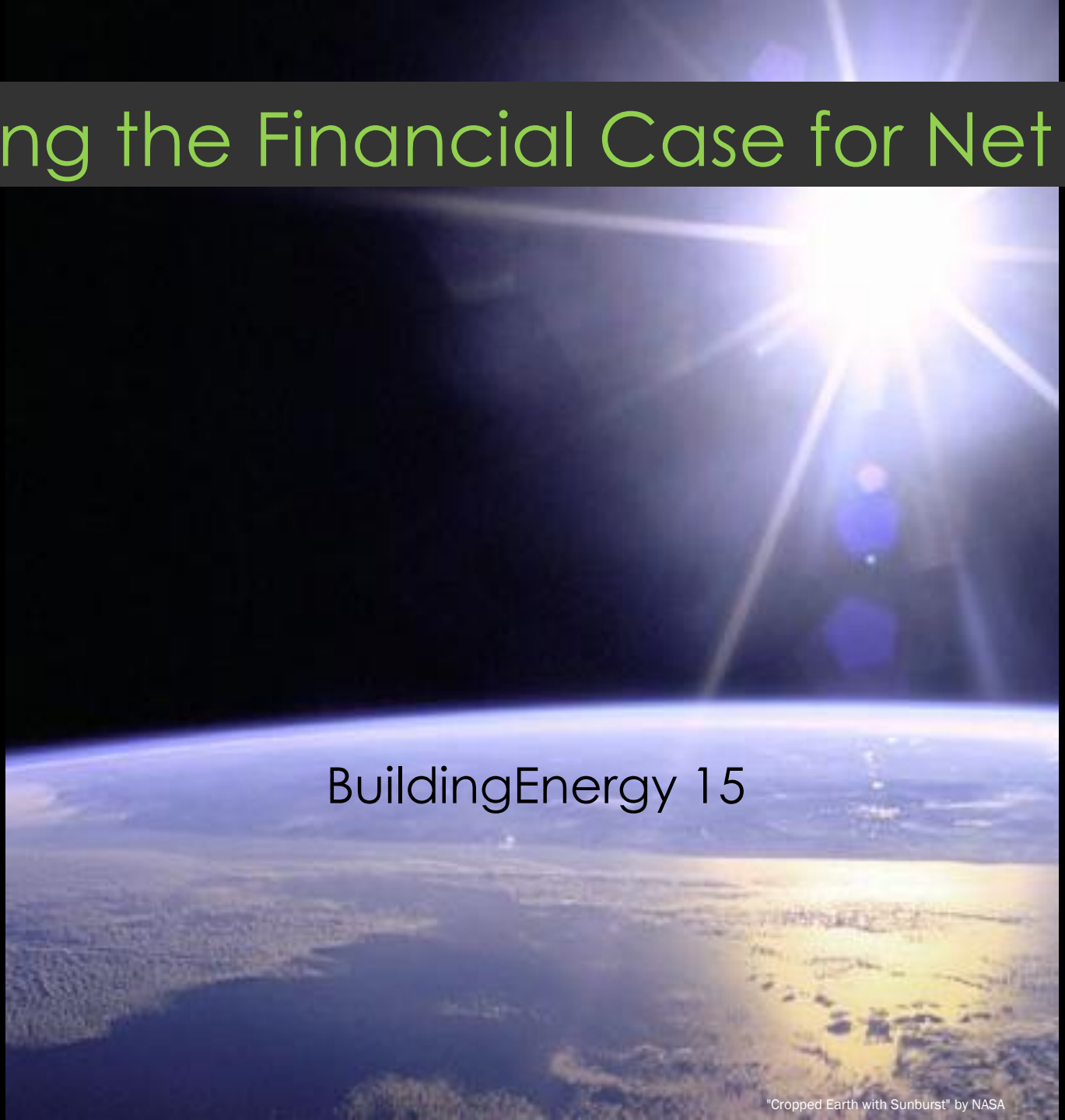
Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Energy Balance, Inc

Course Description

This presentation illustrates the financial prudence of net zero buildings today. From the outset of design through construction and operation, Maclay Architects and Energy Balance utilize comparative energy modeling and cost estimating to determine financial benefits of net zero buildings compared to code compliant or intermediate building solutions. Commercial and Institutional case studies illustrate the detailed and interwoven financial/energy analysis process, metrics, and templates used to guide net zero projects from initiation to completion.

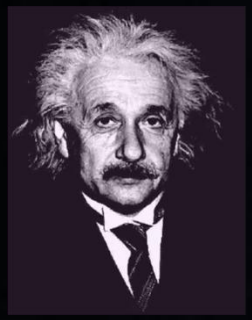
Making the Financial Case for Net Zero



BuildingEnergy 15

"Cropped Earth with Sunburst" by NASA


We shape our buildings; thereafter they shape us.
-Winston Churchill
"Cropped Earth with Sunburst" by NASA



"The world we have created today as a result of our thinking thus far has problems that cannot be solved by thinking the way we thought when we created them."

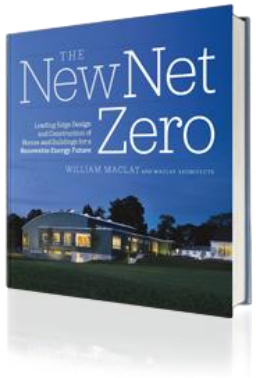
-Albert Einstein

"Cropped Earth with Sunburst" by NASA

What is Net Zero?

The Simplicity of Net Zero

The New Net Zero Definition



A building, a community, a country, or a planet—is simple: it produces more energy than it consumes on an annual basis using only renewable energy in the process.

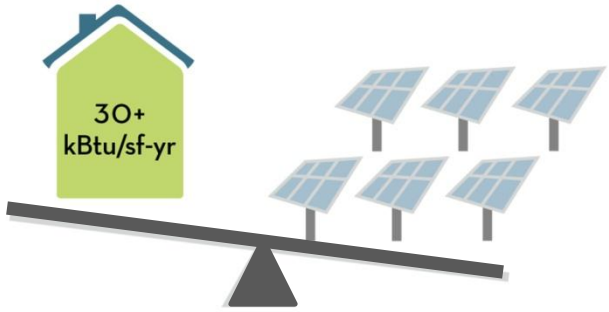
The Subtleties of Net Zero

NREL Definition

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Option Number	ZEB Supply-Side Options
0	Reduce site energy use through low-energy building technologies
On-Site Supply Options	
1	Use renewable energy sources available within the building's footprint
2	Use renewable energy sources available at the site
Off-Site Supply Options	
3	Use renewable energy sources available off site to generate energy on site
4	Purchase off-site renewable energy sources

Is this Net Zero?

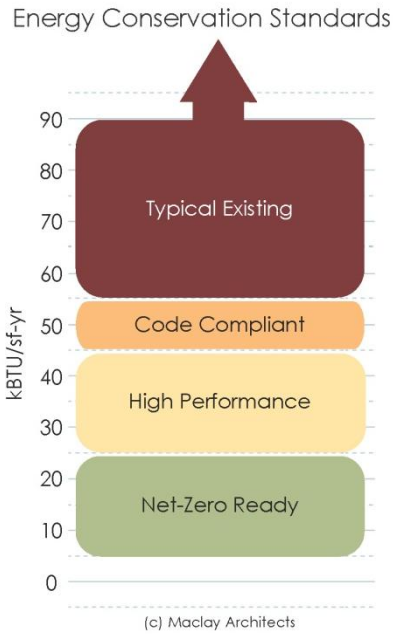


minimal insulation and poor energy performance

disproportionate cost of renewables

Key Elements to Achieve Net Zero

Conservation + High-Efficient Systems + Renewables



Energy Use Intensity (EUI)

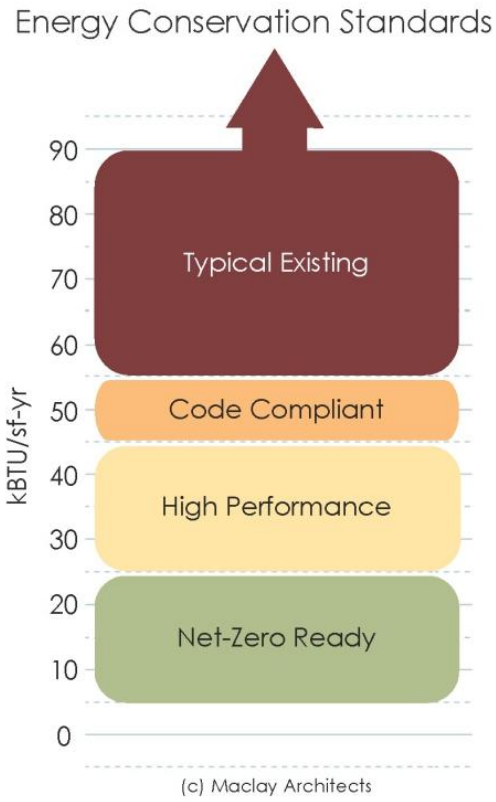
Heat Pumps (COP 2.3-3.0)

Usually Photovoltaics (sized for annual load)

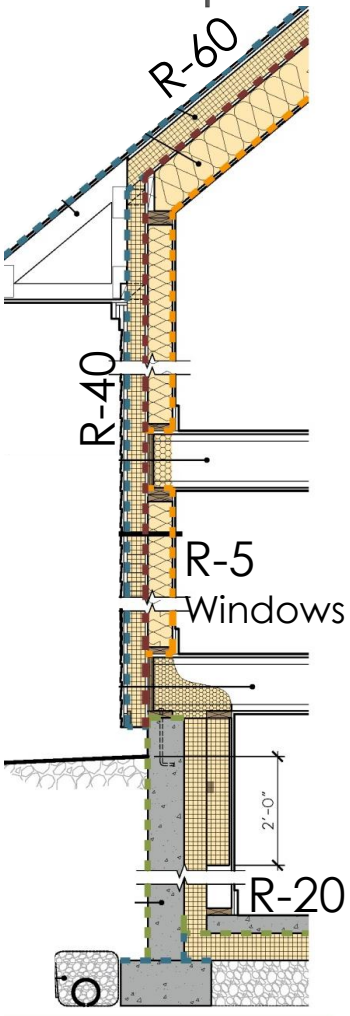
Net Zero Building Metrics

Performance Metrics

10-25 EUI kBTU/sf
*without process loads



Prescriptive Measures



NET ZERO READY

0.1 cfm50/sf above grade surface area@ 50 Pascals

NET ZERO
Add renewables

Climate Change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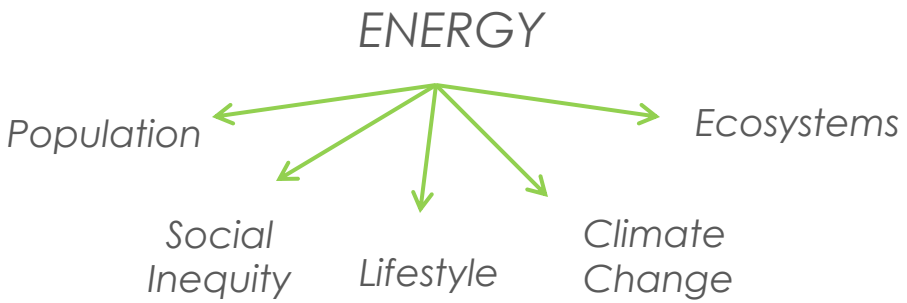
Why is Net Zero Important?

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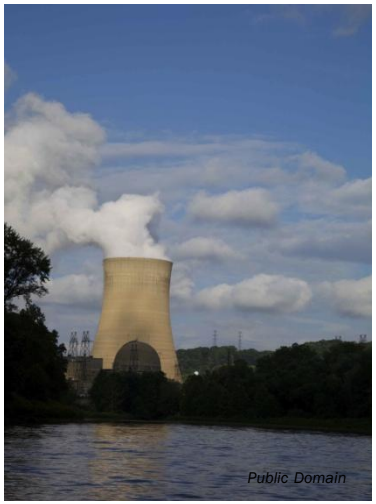
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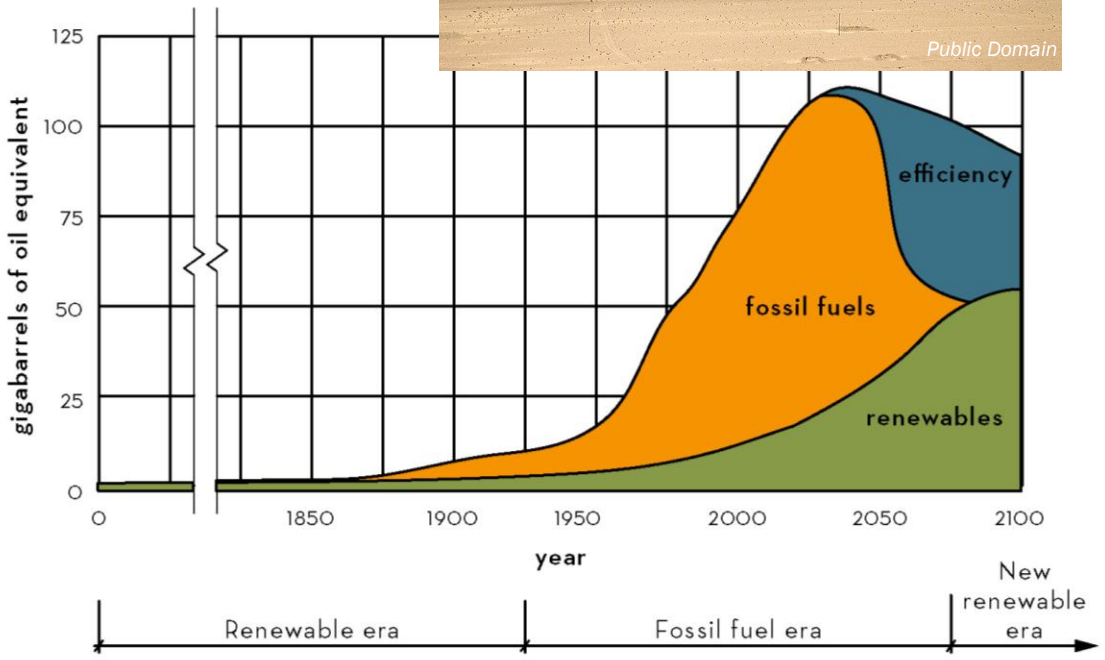
Energy Transition:

Net Zero is the Least Operating Cost Today



EFFICIENCY VERMONT
Net Zero Feasibility Study

Reasons for Efficiency Vermont's Involvement

- Owners' concerns
- Vermonters want VT data
- Gap in actual VT project data
- Inform early cost analysis
- Education and outreach

Efficiency Vermont

EFFICIENCY VERMONT
Net Zero Related Programs

Net Zero Energy Pilot Program

- 50% site energy performance (modeling per 90.1, App G)
- Commissioning & Energy Monitoring per 189.1
- Added incentives for Charette, Modeling, Commissioning, & Metering
- 1-yr performance bonus

Efficiency Vermont

EFFICIENCY VERMONT
Net Zero Related Programs

High Performance Homes

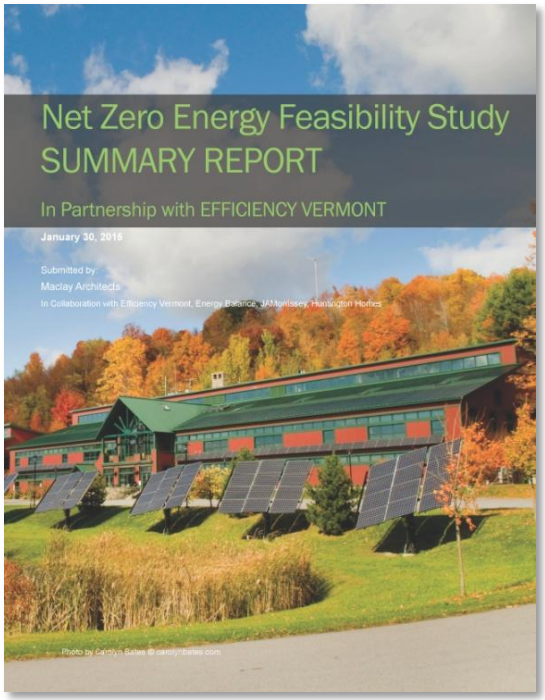
- Prescriptive: R-30/40/60, ≤1ACH50, Energy Star, HRV, etc.
- Efficiency Vermont provides incentives and technical assistance

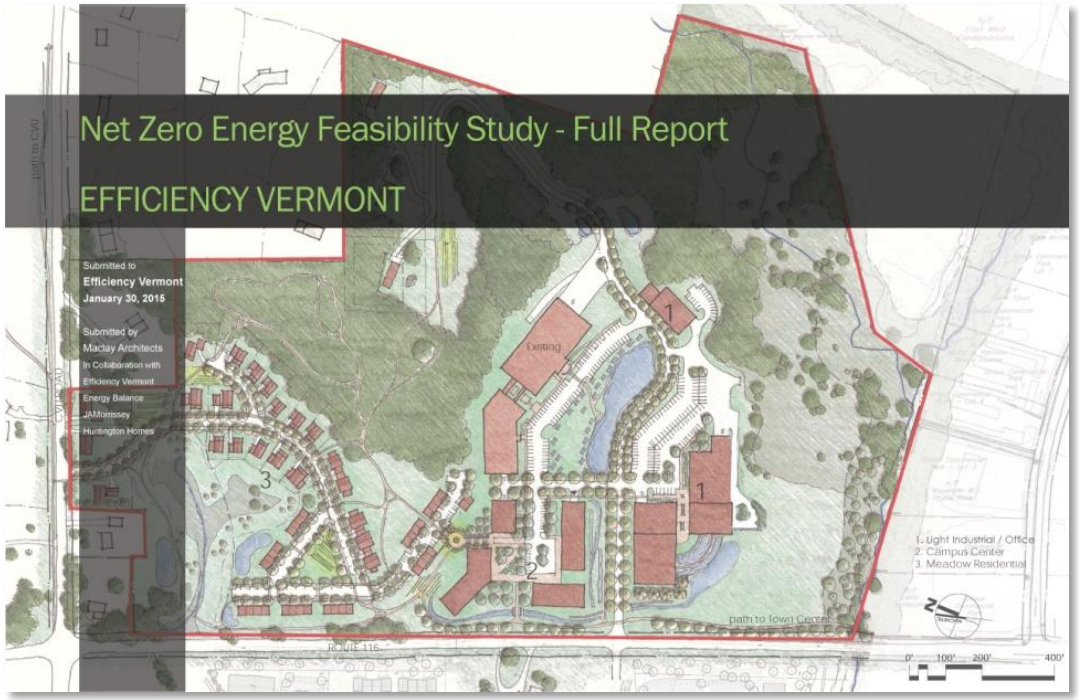
Deep Energy Retrofit Pilot (R&D for 2015 only)

- 50% EUI improvement
- Up to $10/sf incentives (simplified, staged incentive approach)
- 4,000 to 25,000 sf; 1-yr pre-occupancy; 1-yr performance period

Efficiency Vermont

Net Zero Energy Feasibility Study





In partnership with

MaclayArchitects
CHOICES IN SUSTAINABILITY

Energy Balance, Inc.

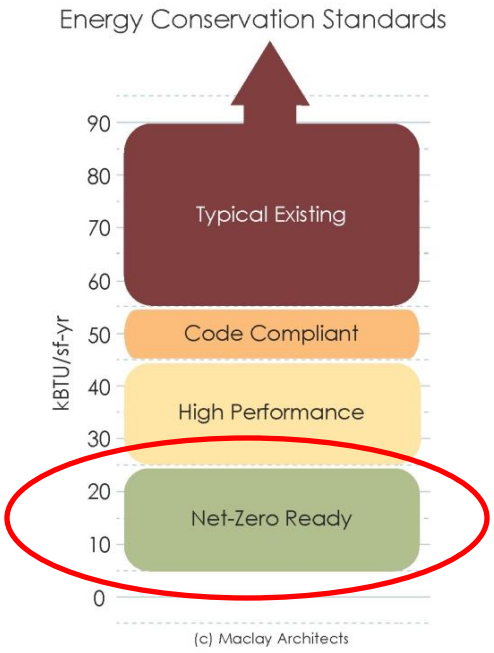
Efficiency Vermont

JAM

HUNTINGTON HOMES SINCE 1978

Purpose

- Explore the financial feasibility of net zero energy buildings above code buildings
- Examine the feasibility of a net zero community



- 77,000 sf existing office/manufacturing

- 214,000 sf proposed office and office/manufacturing

- 86,000 sf proposed residential


path to CVU
CVU ROAD
ROUTE 116
path to Town Center
Existing
1
2
3
1. Light Industrial / Office
2. Campus Center
3. Meadow Residential
0'
100'
200'
400'

Building Overview

Six typical new construction buildings were analyzed

- Single Family
- Multifamily – Duplex
- Multifamily - Quadplex
- Office – Open
- Office - Closed
- Office/Manufacturing

Figure 3: Residential single family home
source: Huntington Homes

Figure 4: Rendering of the multifamily housing
source: Huntington Homes

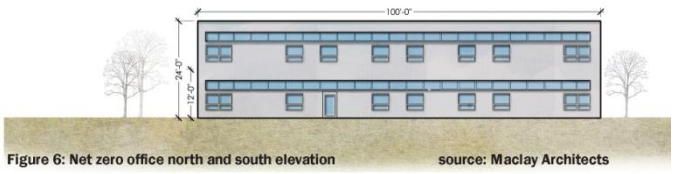


Figure 6: Net zero office north and south elevation source: Maclay Architects

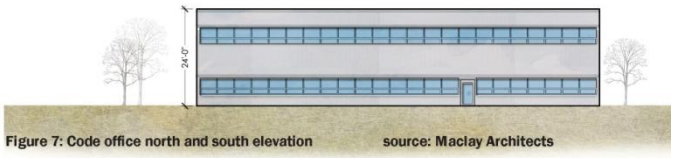


Figure 7: Code office north and south elevation source: Maclay Architects

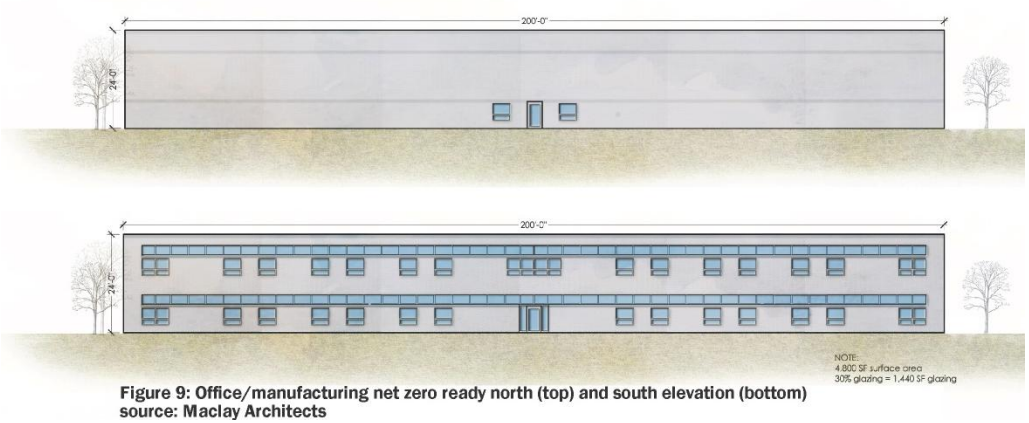


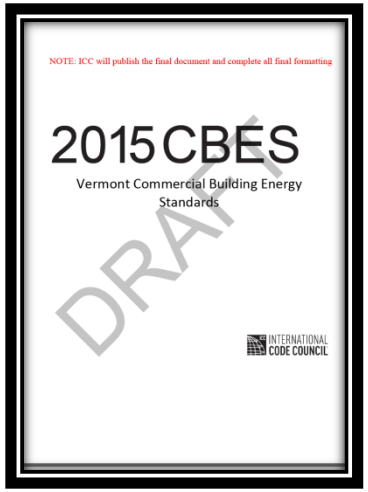
Figure 9: Office/manufacturing net zero ready north (top) and south elevation (bottom)
source: Maclay Architects

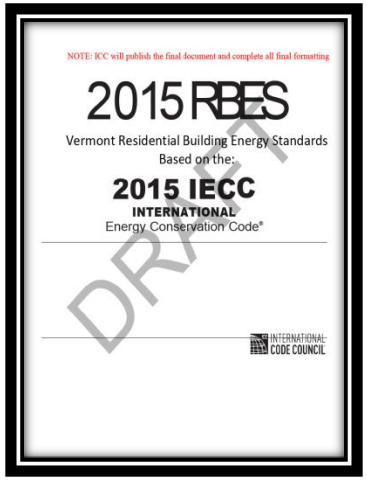
Code Standard

- Mechanical: Residential -Propane-fired furnaces for heating and DHW, Commercial -Rooftop propane-fired heating and cooling units with demand controlled outside air

- Ventilation: no heat recovery

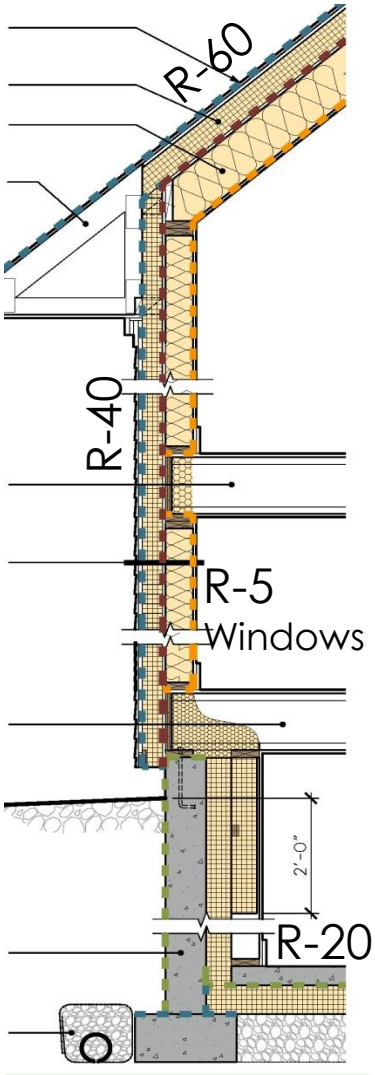
Code Used: 2015 Vermont Residential Building Energy Standards (RBES) and the 2015 Vermont Commercial Building Energy Standards (CBES) draft dated 11/24/2014





Net Zero Ready Standard

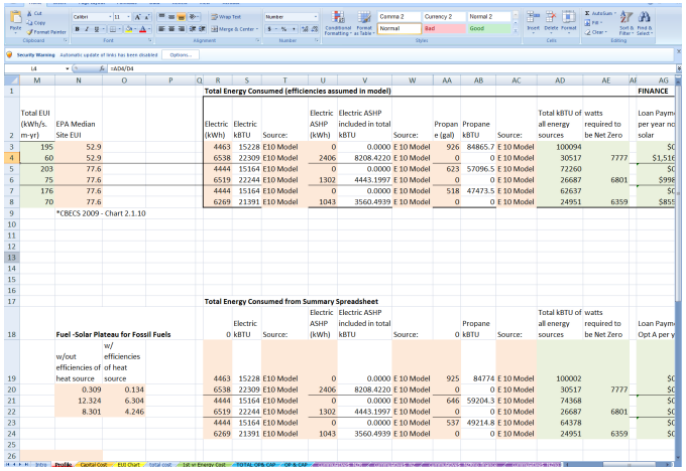
- Envelope:
  - R60, R40, R20, R5
  - 0.1 cfm50/sf above grade surface area@ 50 Pascals
- Mechanical: Air source heat pumps
- Ventilation: Residential –HRV, Commercial -ERV
- DHW: Residential -heat pump unit, Commercial - electric resistance
- PV: sized to be net zero on an annual basis



Financial Analysis

INPUTS

- Energy consumption
- Capital costs for energy efficiency
- Capital costs for PV
- Financing assumptions



OUTCOMES

- 1st year ownership and operating costs
- Cumulative capital, operating, and finance costs

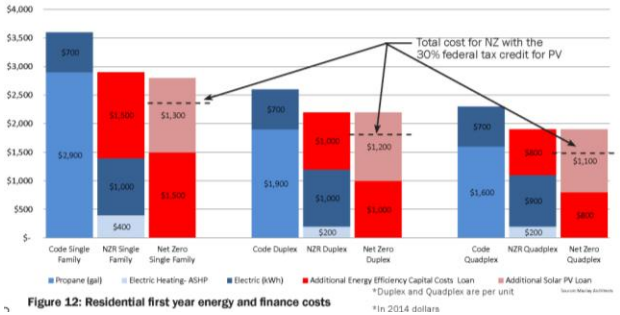


Figure 12: Residential first year energy and finance costs

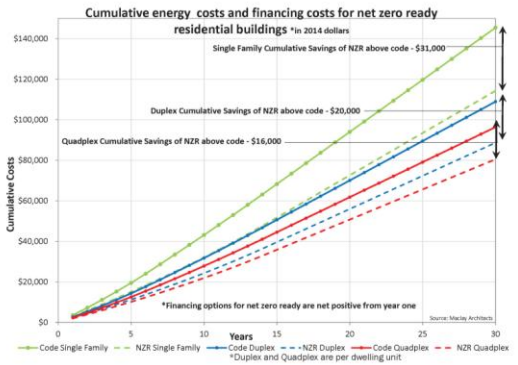


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

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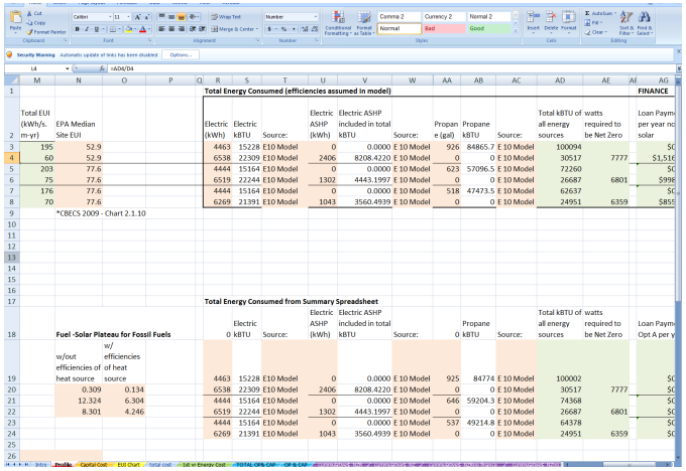

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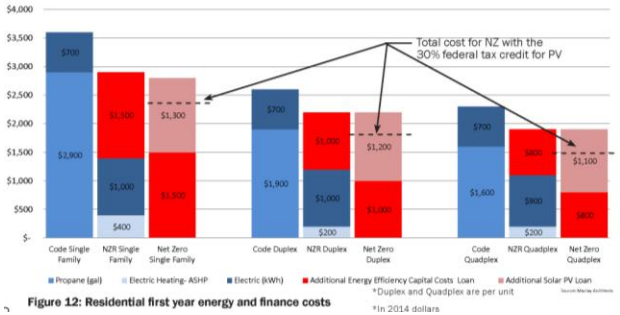

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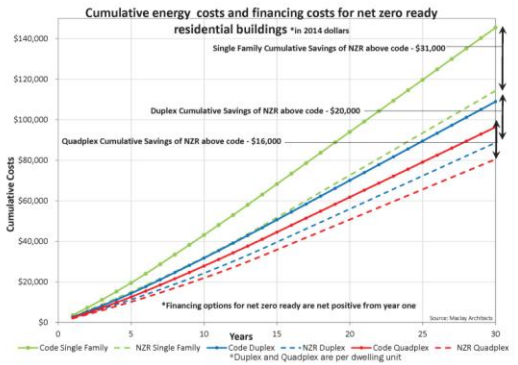

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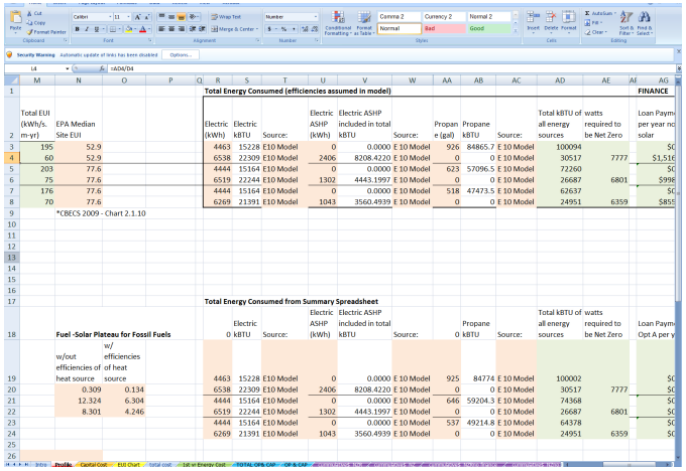

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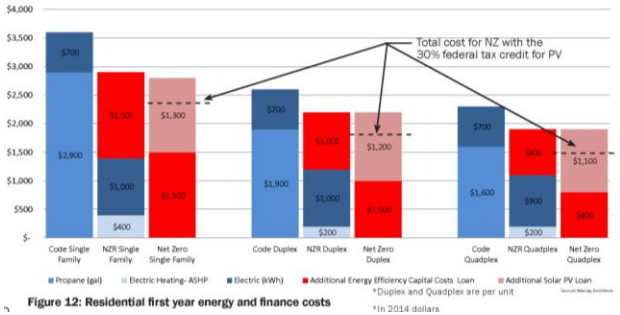

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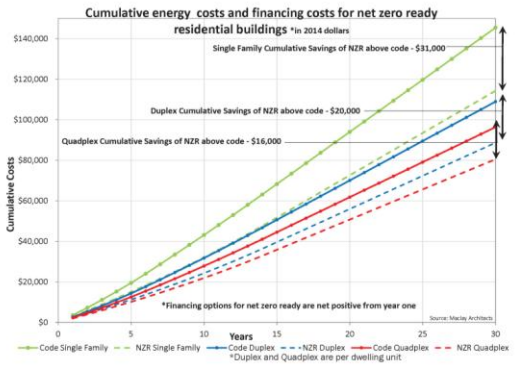

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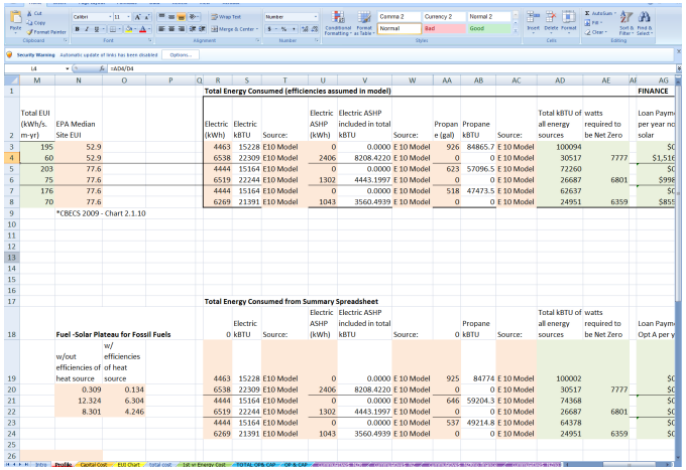

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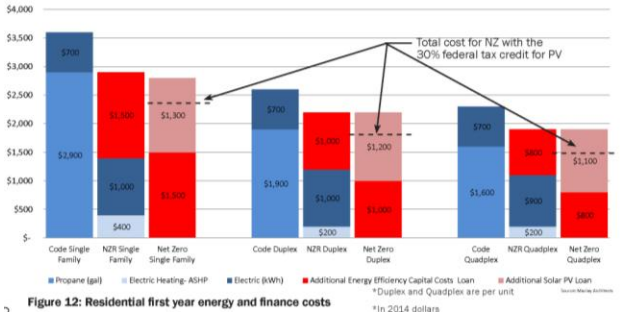

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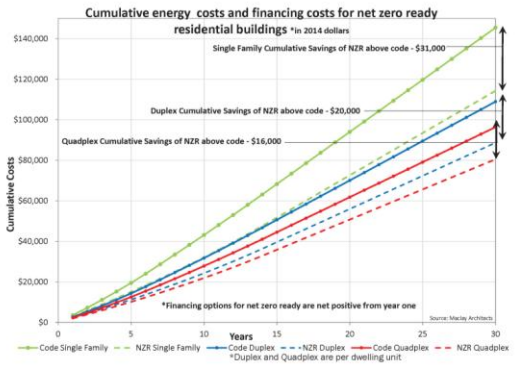

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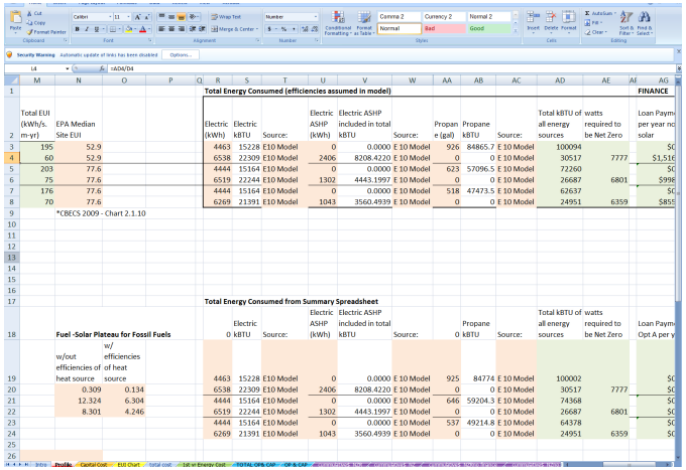

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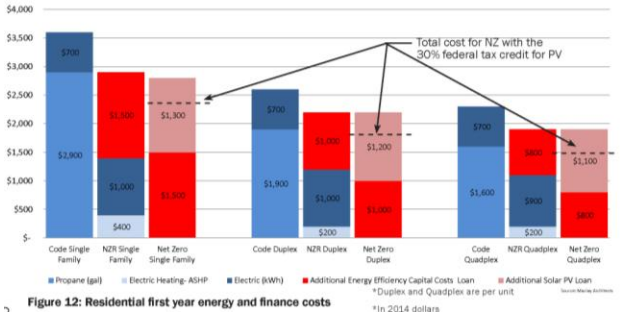

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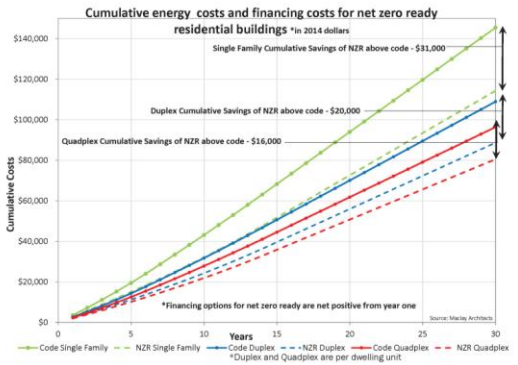


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

Energy Consumption

- Residential annual energy per dwelling unit

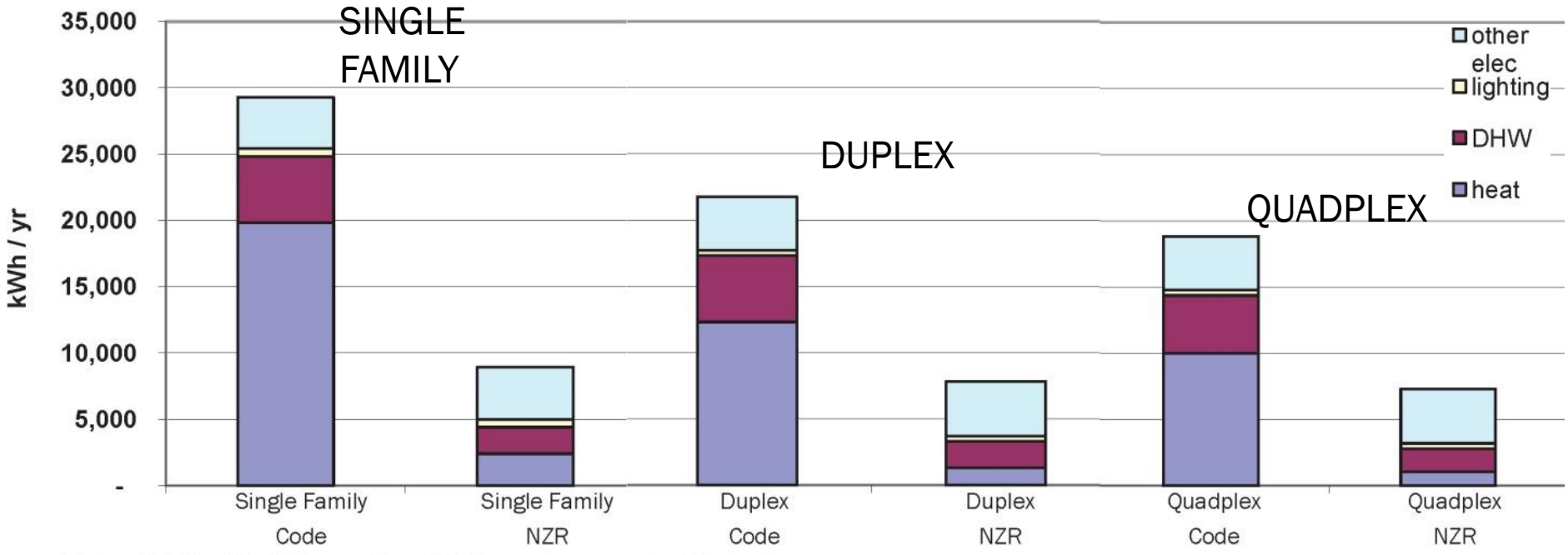


Figure 5.1: Residential annual modeled energy use per dwelling unit

Energy Consumption

- Commercial annual energy

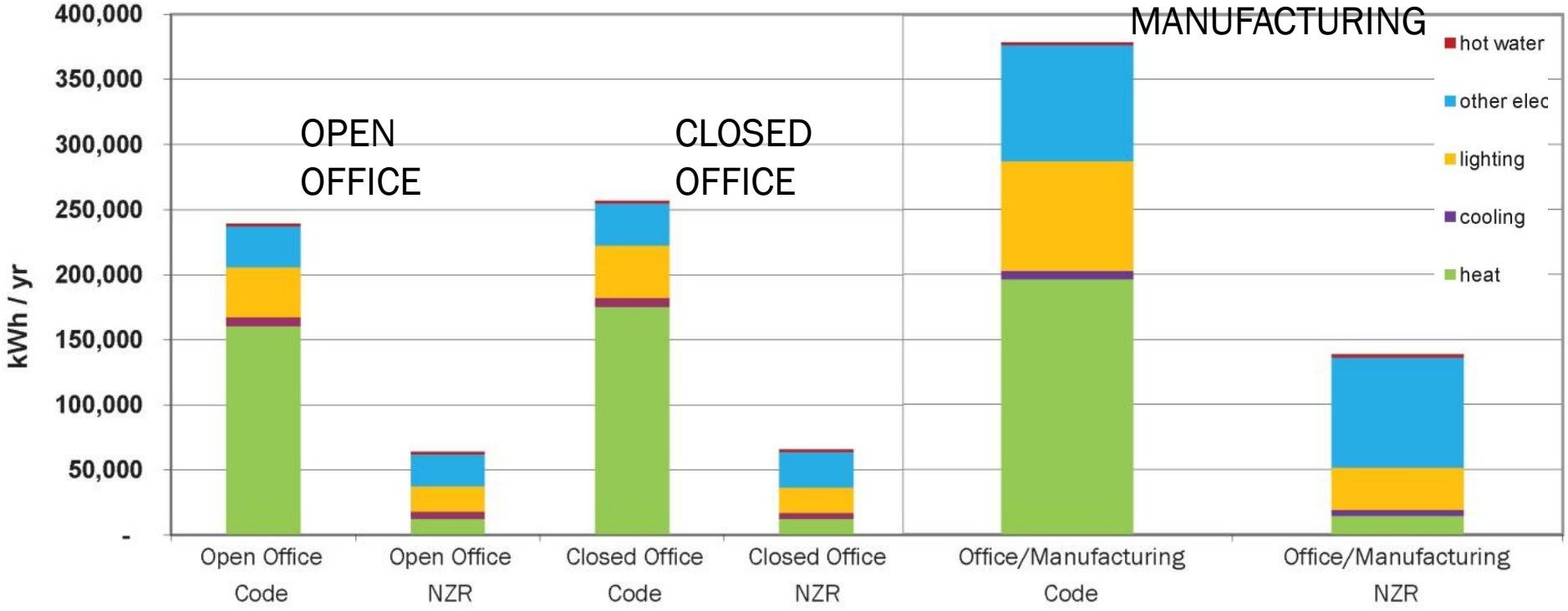


Figure 5.2: Commercial annual modeled energy use

Energy Use Intensity (EUI)

Building Type	SF	Code [2] (kBTU/ sf-yr)	Code [2] (kWh/ sq.m-yr)	Net Zero Ready (kBTU/ sf-yr)	Net Zero Ready (kWh/ sq.m-yr)	% energy savings above code
Single Family	1,612	62	196	20	64	67%
Duplex [1]	1,120	64	203	25	78	61%
Quadplex [1]	1,120	56	176	24	75	57%
Open Office	13,000	62	196	17	54	72%
Closed Office	13,000	67	210	18	56	74%
Office/Manfuacturing	27,000	49	156	17	54	65%

Community Energy

Type	SQUARE FOOTAGE (SF)				CODE EUI (kBTU/sf-yr)			NET ZERO READY EUI (kBTU/sf-yr)			TOTAL	
	Office	Manufacturing	Residential	total building	Office	Manufacturing	Residential	Office	Manufacturing	Residential	Total Code Energy (kBTU/yr)	Total Net Zero Ready Energy (kBTU/yr)
Commercial												
Office	31200	0	0	160000	62			17			9,900,000	2,700,000
Office/manufacturing	10000	17000	0	54000	62	49		17	17		2,900,000	900,000
	COMMERICAL SUBTOTAL SF:			**214000**			**COMMERICAL TOTAL kBTU/yr:**				**12,800,000**	**3,600,000**
Residential												
Large Single Family			2,200	15,000		62			20		900,000	300,000
Small Single Family			1,600	18,000		62			20		1,100,000	400,000
Duplex			1,100	19,000		64			25		1,200,000	480,000
Quadplex			1,100	34,000		56			24		1,900,000	800,000
	RESIDENTIAL SUBTOTAL SF:			**86,000**			**RESIDENTIAL TOTAL kBTU/yr**				**5,100,000**	**1,980,000**

COMMUNITY TOTAL SF	**300,000**	
COMMUNITY TOTAL kBTU/yr	**18,000,000**	**5,600,000**
Annual Demand (kWh/yr)	5,000,000	2,000,000
PV System Size (kW)	5,750	2,300
PV System Size (MW)	5.8	2.3
Target Area of PV (SF)	390,000	160,000

	CODE	NZR
COMMUNITY TOTAL SF	**300,000**	
COMMUNITY TOTAL kBTU/yr	**18,000,000**	**5,600,000**
Annual Demand (kWh/yr)	5,000,000	2,000,000
PV System Size (kW)	5,750	2,300
PV System Size (MW)	5.8	2.3

Renewable Energy Overlay

2.3 MW of PV to be NZ

- Rooftops and carports maximized
- + 1.5 acres of ground mounted

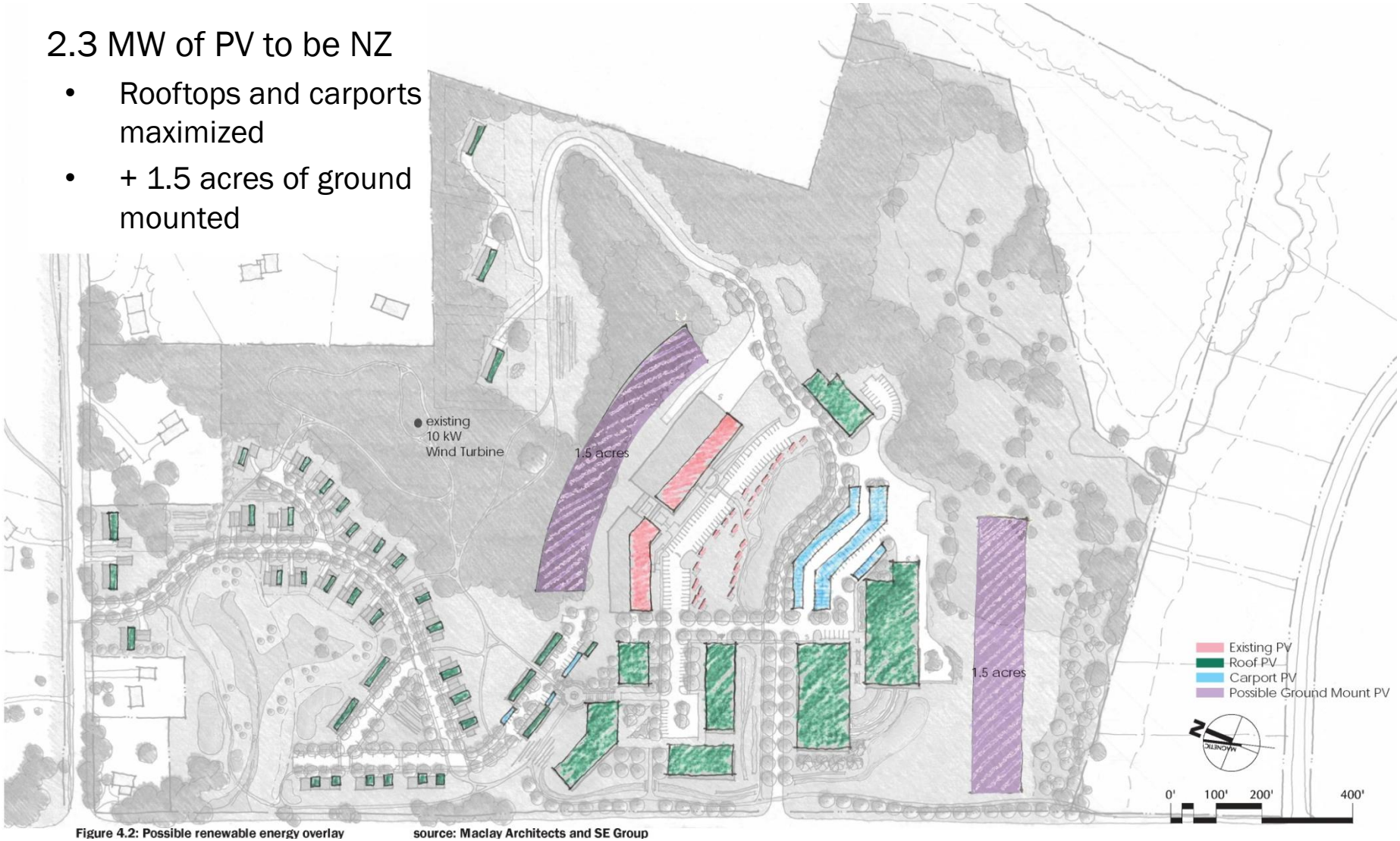


Figure 4.2: Possible renewable energy overlay source: Maclay Architects and SE Group

Cost Estimate - Residential

Table 6.1: Residential cost per square foot for each building type

	Cost / sf	Cost above Code $/sf	% of project cost for additional energy upgrades
Code Single Family	$ 120	NA	0
NZR Single Family	$ 136	$ 16	12%
NZ Single Family	$ 151	$ 31	20%
Code Duplex	$ 120	NA	0
NZR Duplex	$ 135	$ 15	11%
NZ Duplex	$ 153	$ 33	22%
Code Quadplex	$ 120	NA	0
NZR Quadplex	$ 133	$ 13	10%
NZ Quadplex	$ 150	$ 30	20%

Cost Estimate - Commercial

Table 6.2: Commercial cost per square foot for each building type

	Total Building Cost / sf	Cost above Code $/sf	% of project cost for additional efficiency upgrades
Code Office Open	$ 131	NA	0%
NZR Office Open	$ 140	$ 9	7%
NZ Office Open	$ 153	$ 22	16%
Code Office Closed	$ 154	NA	0%
NZR Office Closed	$ 164	$ 10	6%
NZ Office Closed	$ 178	$ 24	14%
Code Manufacturing	$ 107	NA	0%
NZR Manufacturing	$ 124	$ 17	13%
NZ Manufacturing	$ 137	$ 30	24%

Cost Estimate – Commercial Open Versus Closed Office

Table 6.6: Additional open v. closed office costs per square foot

	Project Cost / sf	Cost above Code $/sf
Code Office Open	$ 131	NA
Code Office Closed	$ 155	$ 24
NZ Office Open	$ 140	NA
NZR Office Closed	$ 165	$ 25

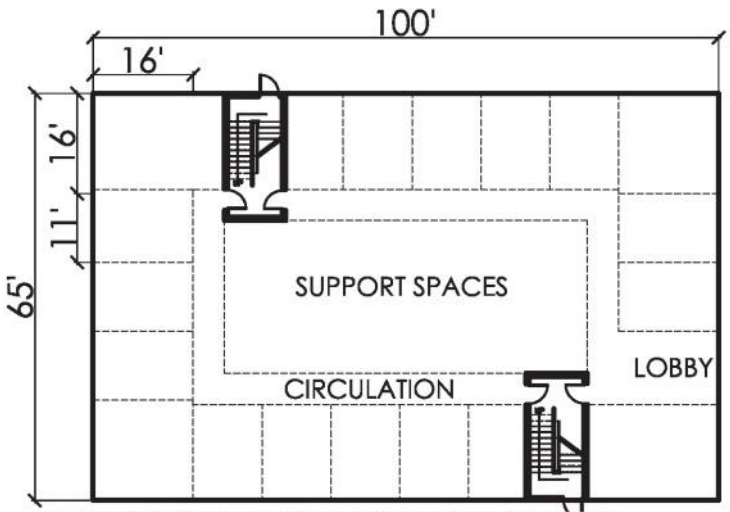


Figure 3.2: Closed office building first floor plan

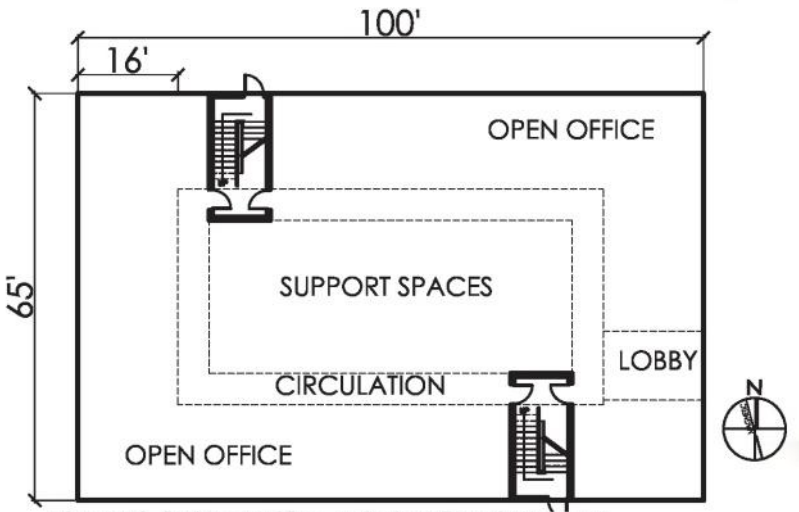
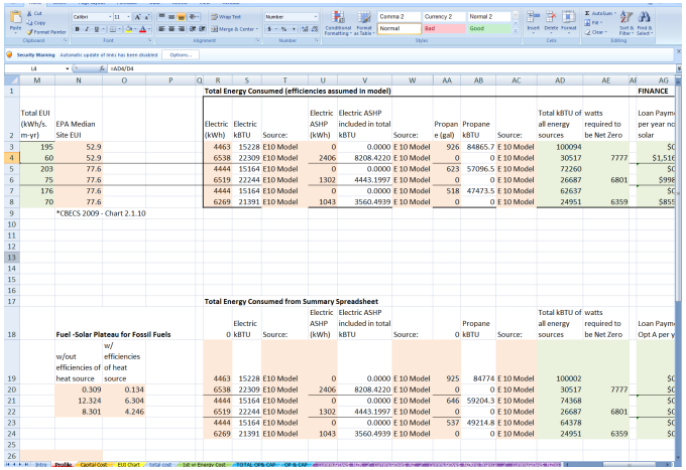


Figure 3.4: Open office building first floor plan

Financial Analysis

INPUTS

- Energy consumption
- Capital costs for energy efficiency
- Capital costs for PV
- Financing assumptions



OUTCOMES

- 1st year ownership and operating costs
- Cumulative capital, operating, and finance costs

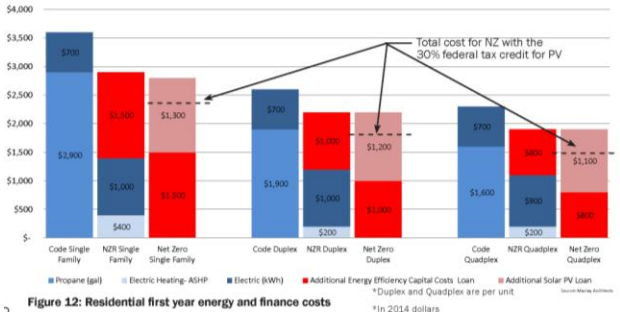


Figure 12: Residential first year energy and finance costs

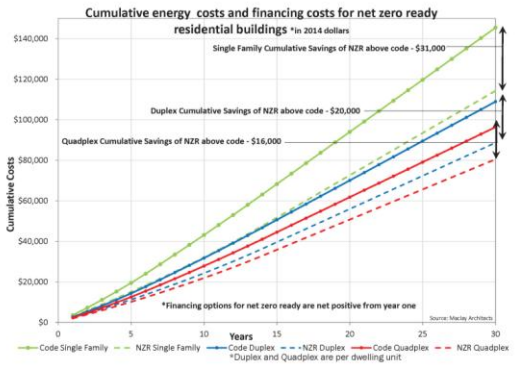
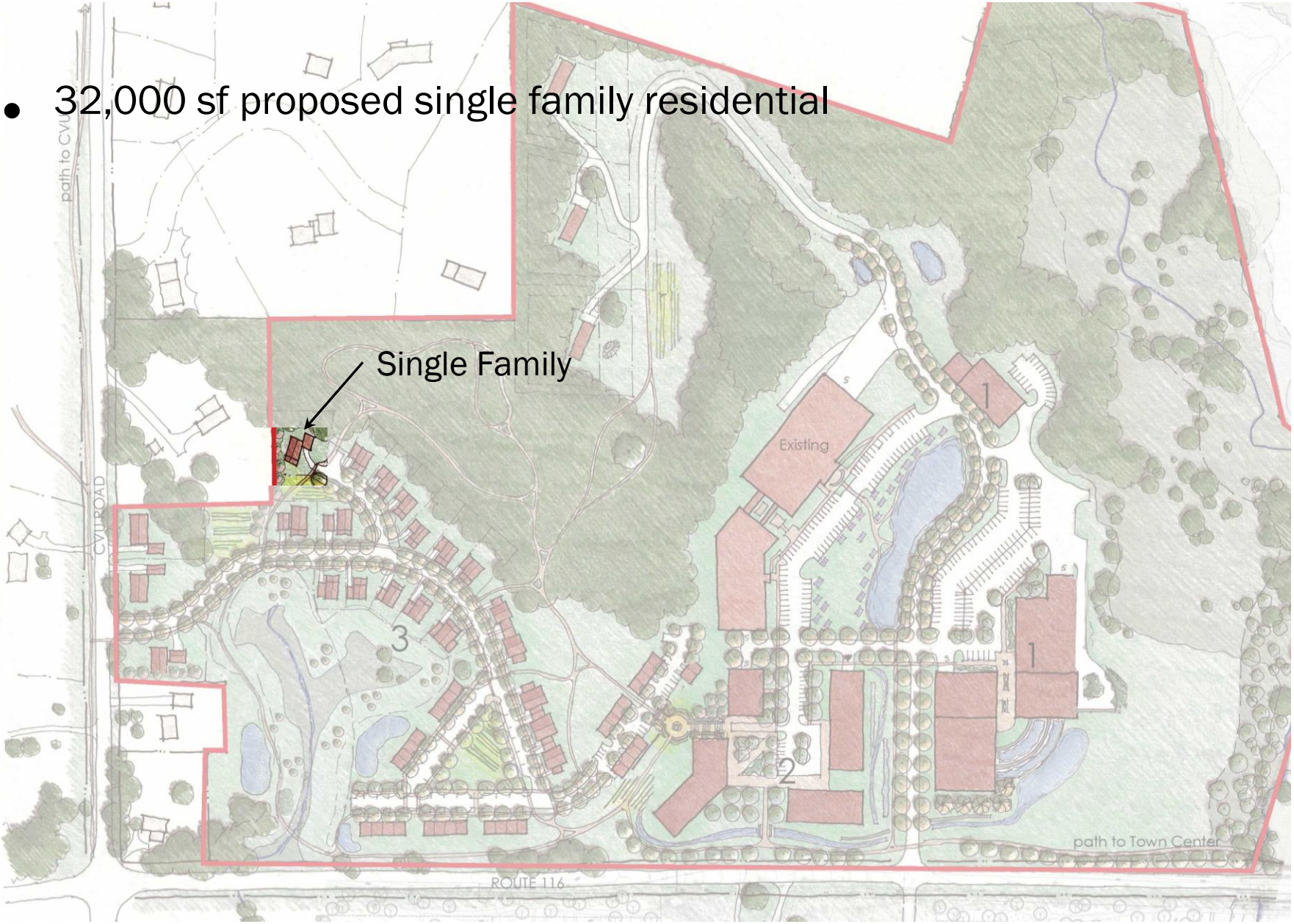


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

- 32,000 sf proposed single family residential



Single Family Residential

Figure 3: Residential single family home
source: Huntington Homes

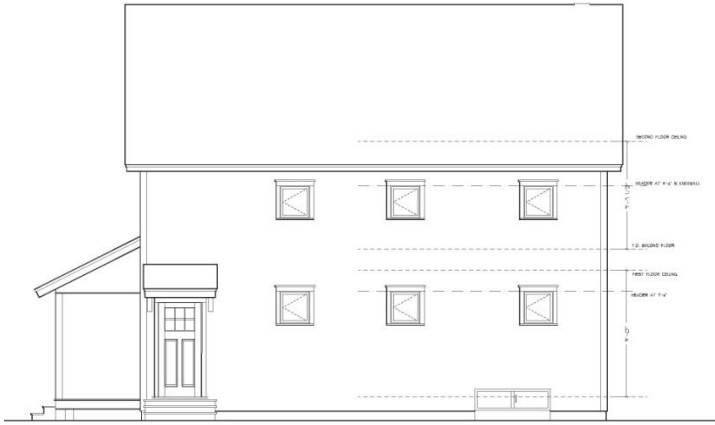


Figure 2.2: Residential single family north elevation
source: Huntington Homes

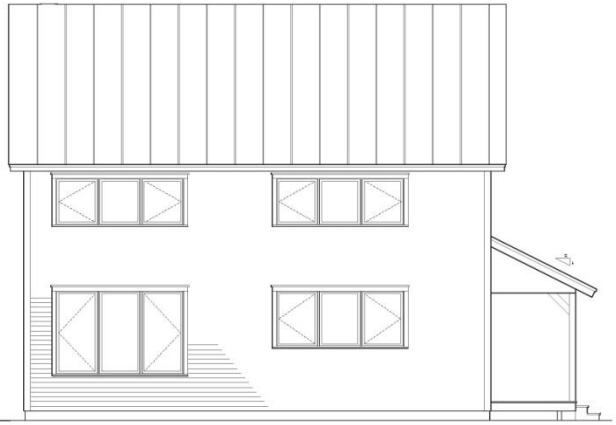


Figure 2.3: Residential single family south elevation
source: Huntington Homes

- 1,600 sf
- 3 bedroom
- 2.5 bath
- 4 occupants

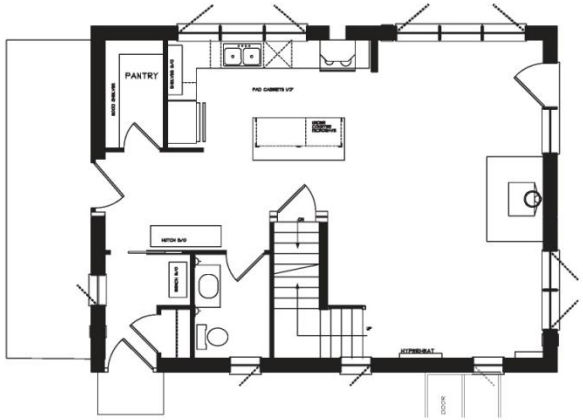


Figure 2.4: Residential single family first floor plan
source: Huntington Homes

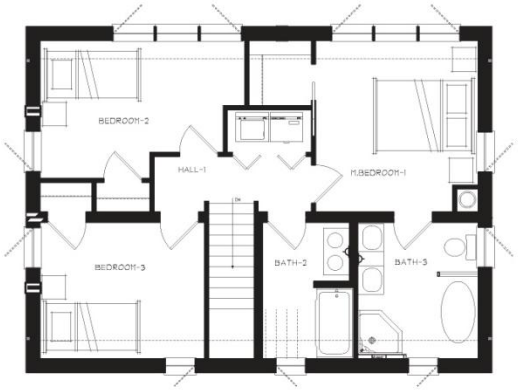
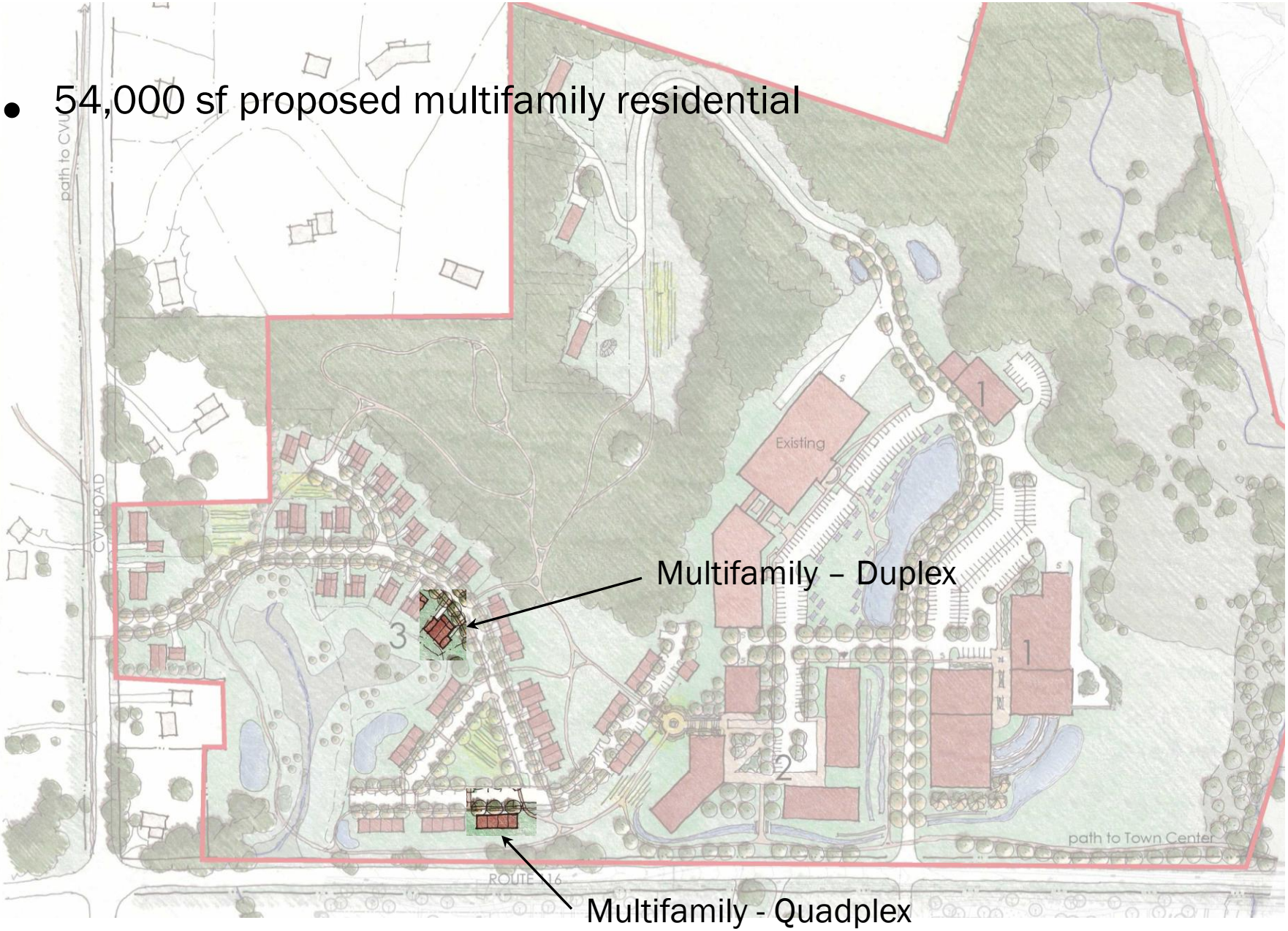


Figure 2.5: Residential single family second floor plan
source: Huntington Homes

- 54,000 sf proposed multifamily residential



Multifamily Residential

Figure 4: Rendering of the multifamily housing
source: Huntington Homes

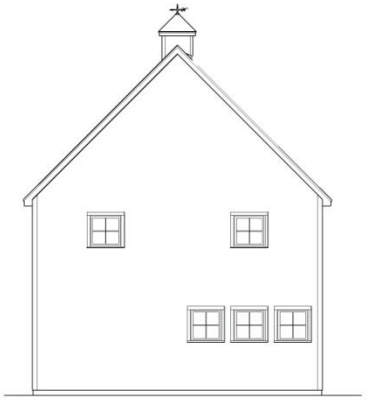
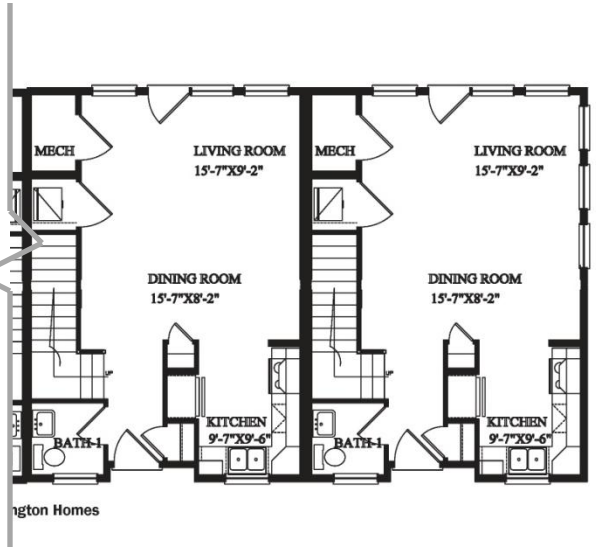


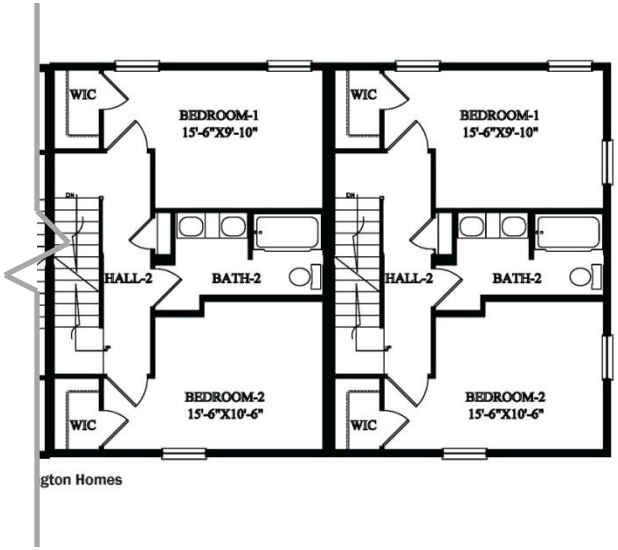
Figure 2.11: West elevation of the multifamily building
source: Huntington Homes

Figure 2.12: South elevation of the multifamily building source: Huntington Homes

- 1,100 sf
- 2 bedroom
- 1.5 bath
- 3 occupants



ngton Homes



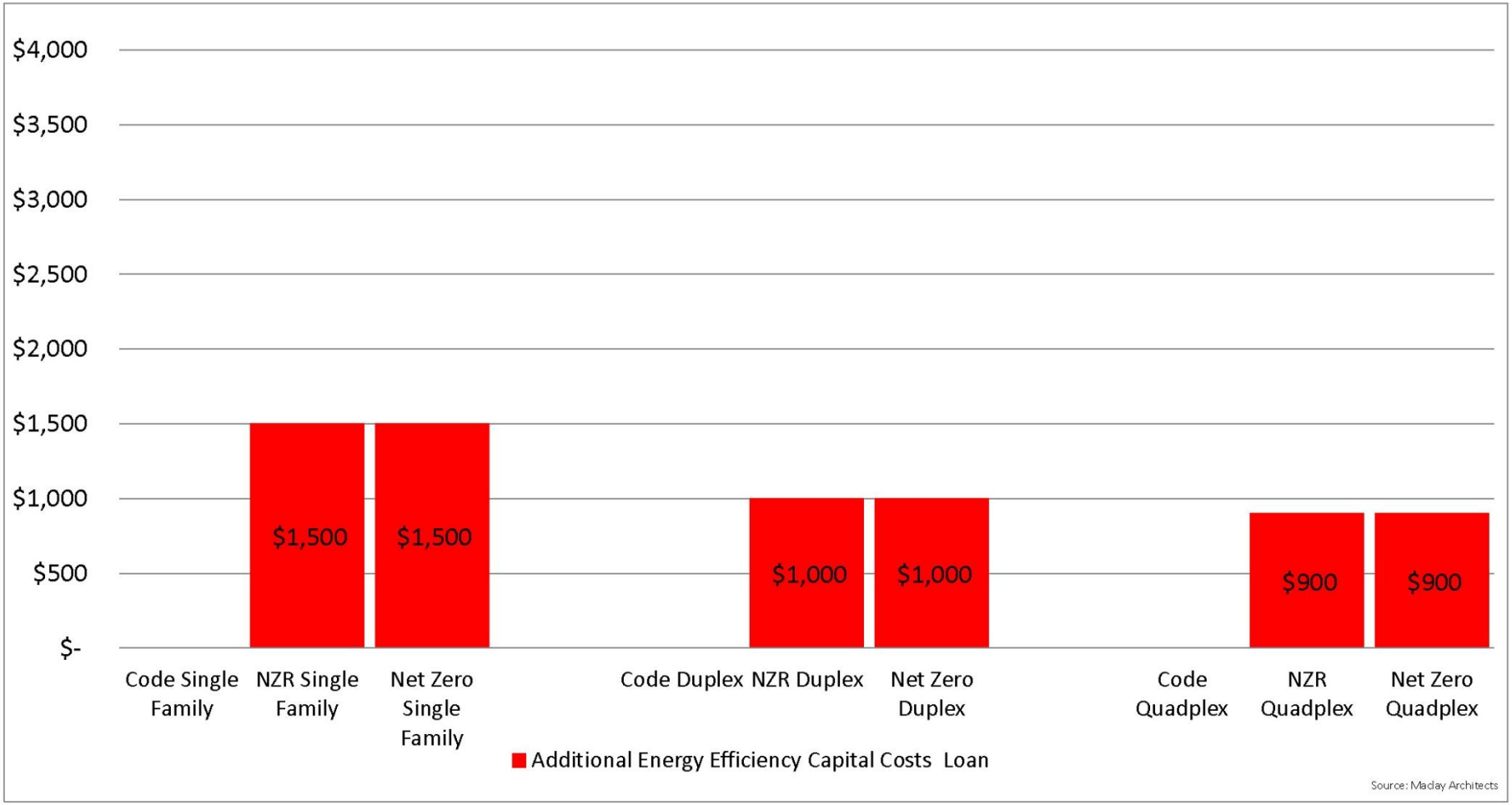
gton Homes

Residential 1st Year Costs

- Financing 30-year loan
- 4% fixed interest

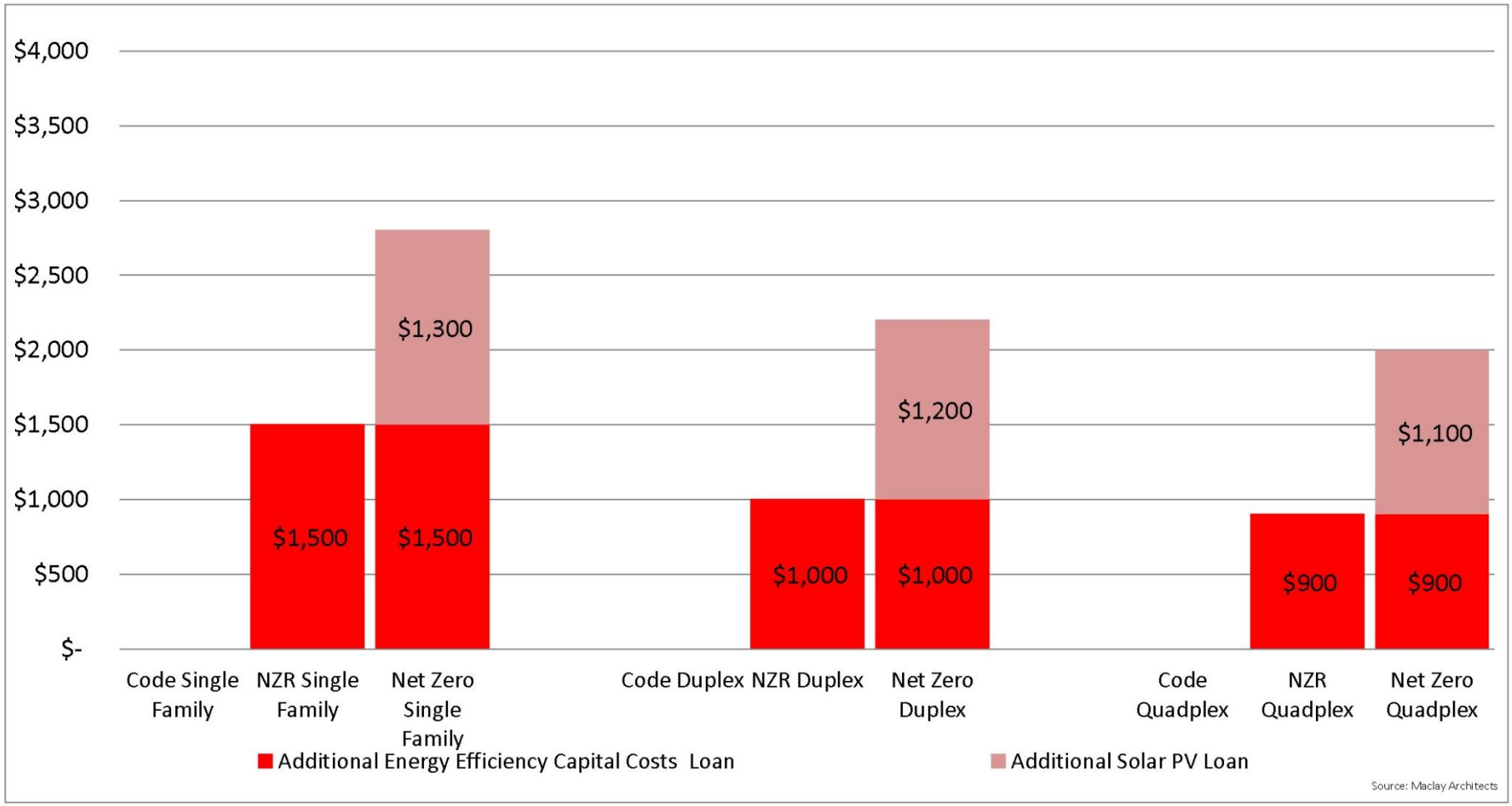
Residential 1st Year Costs

- Finance cost for energy efficiency



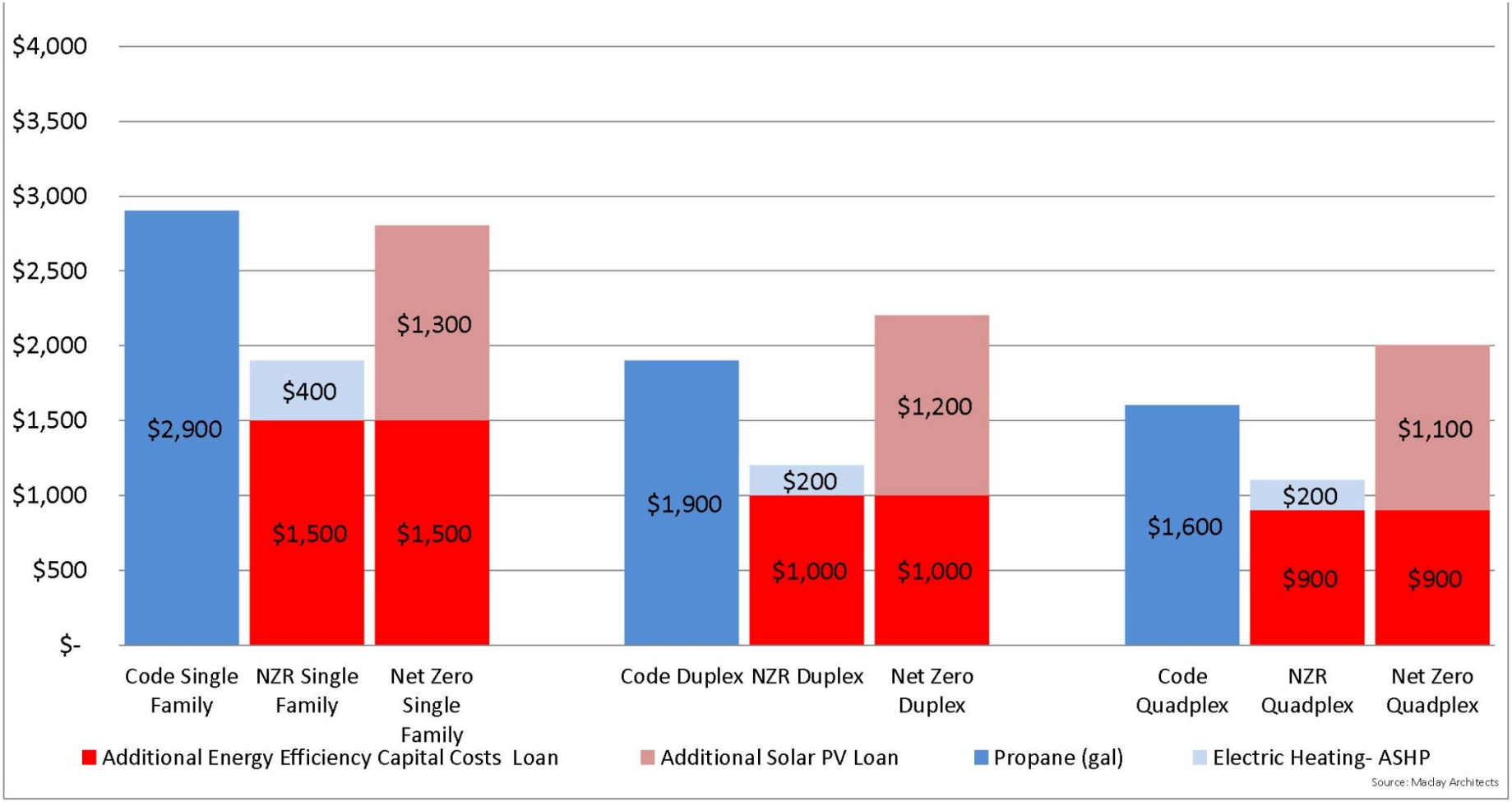
Residential 1st Year Costs

- Finance costs for PV



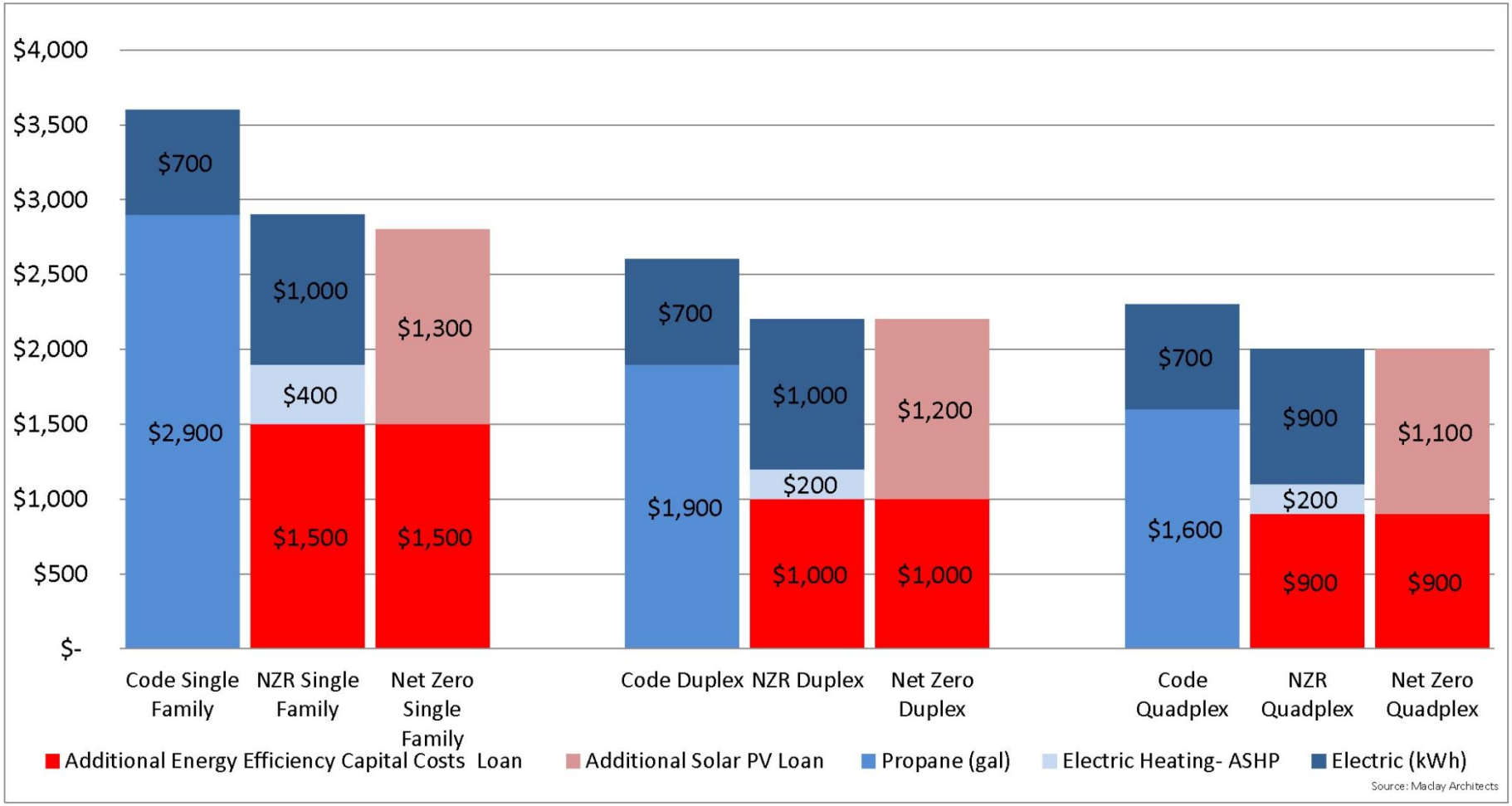
Residential 1st Year Costs

- Heating Costs



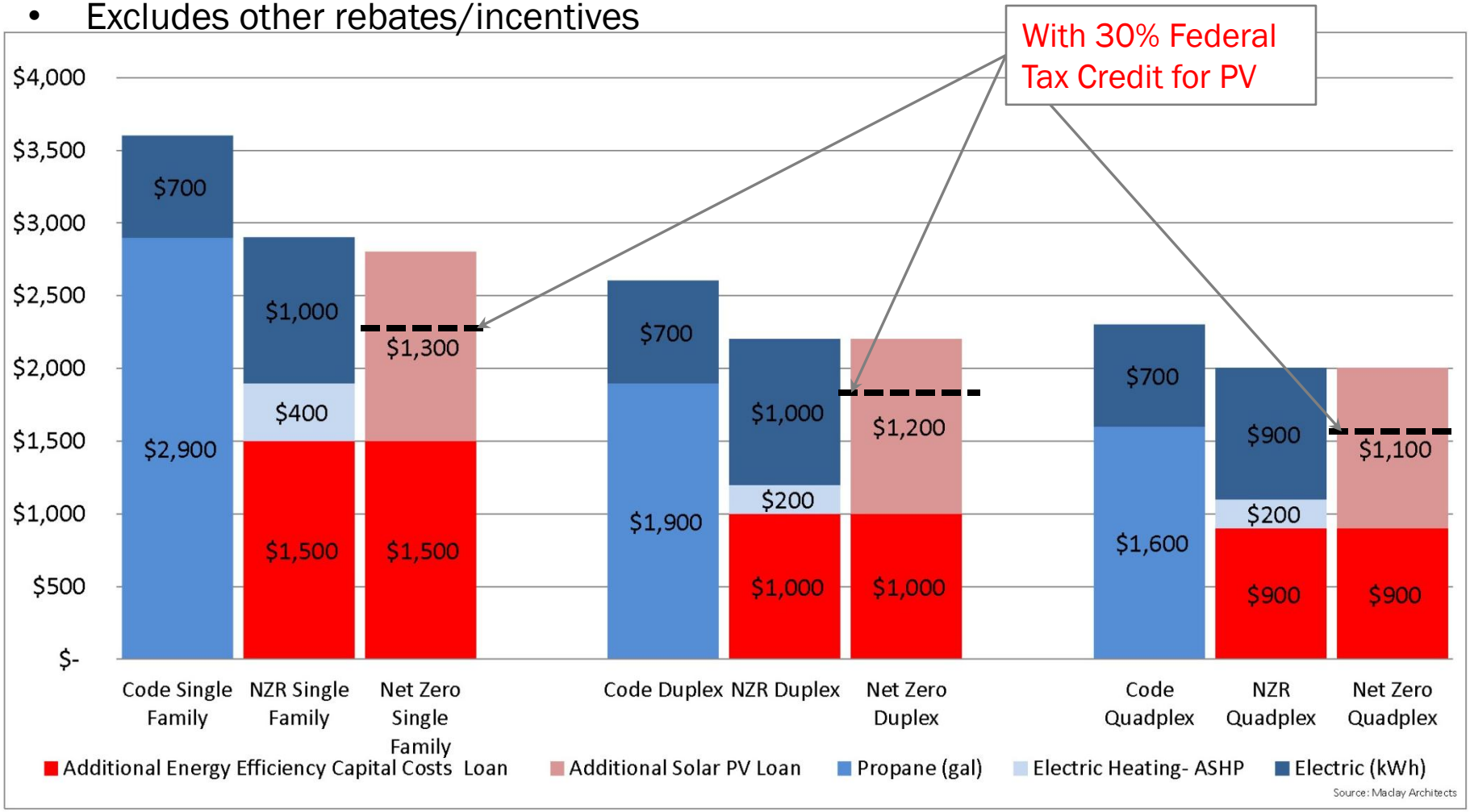
Residential 1st Year Costs

- 1st year operating costs



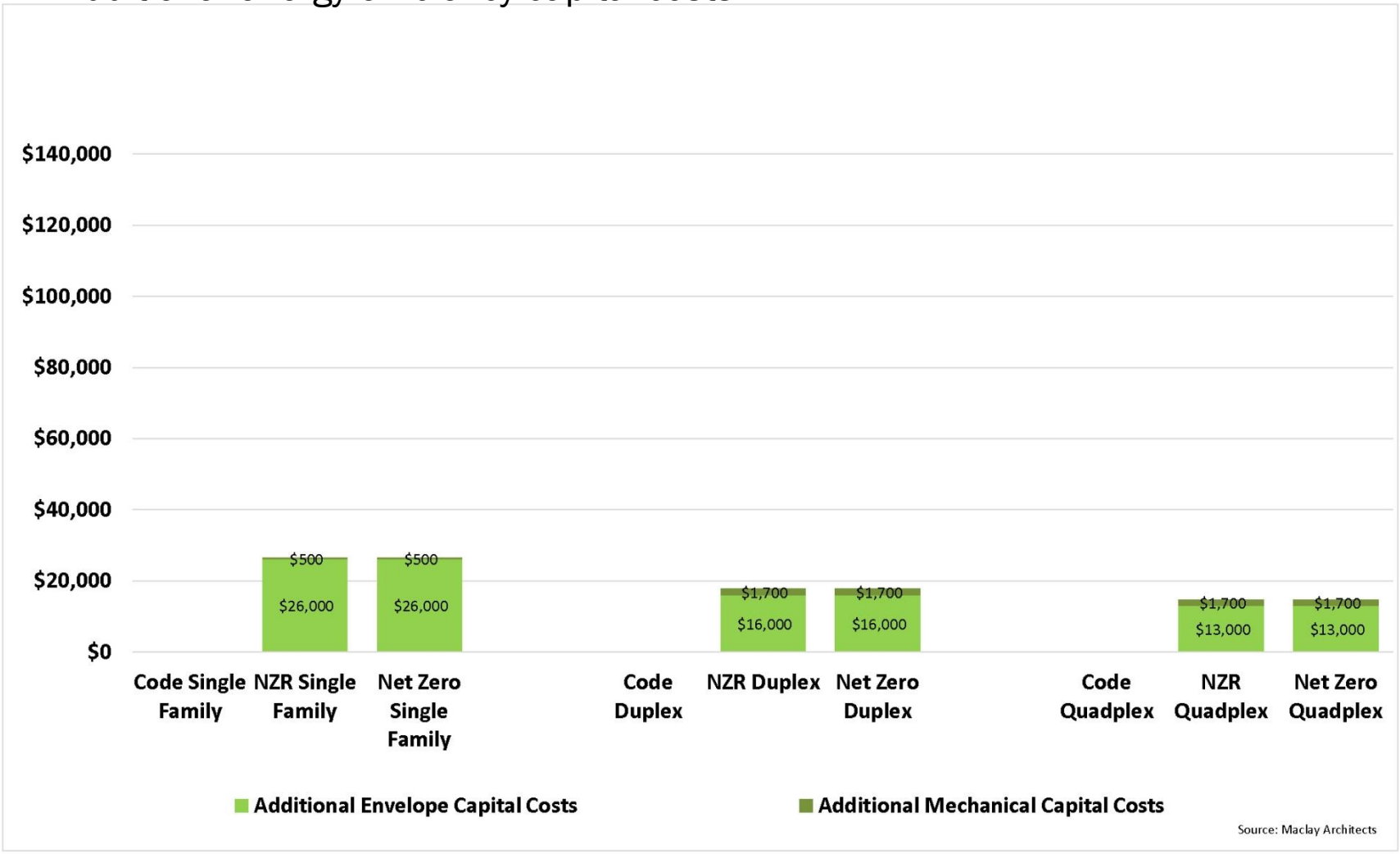
Residential 1st Year Costs

- 30% Federal tax credit for PV
- Excludes other rebates/incentives



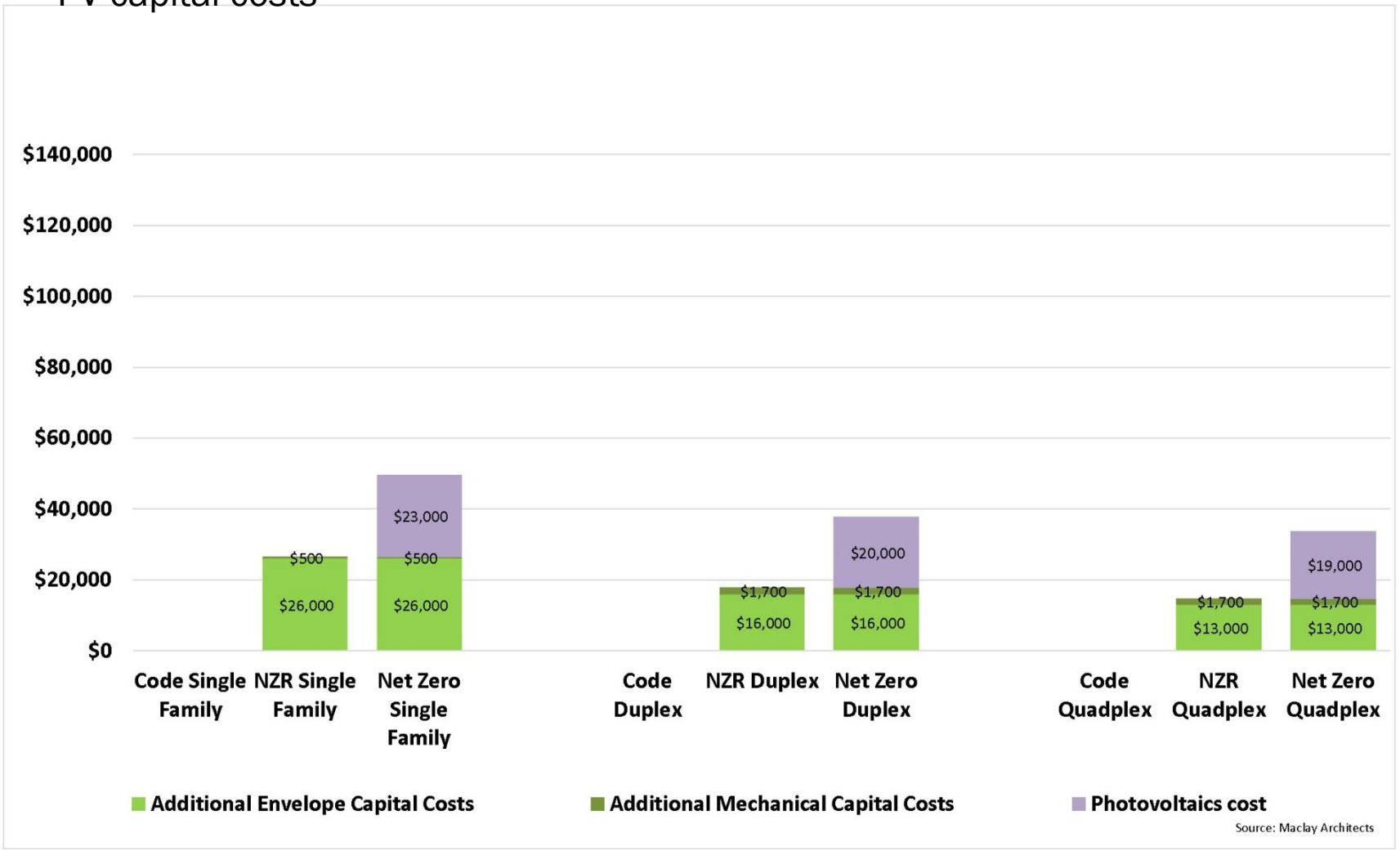
Residential 30-year Costs

- Additional energy efficiency capital costs



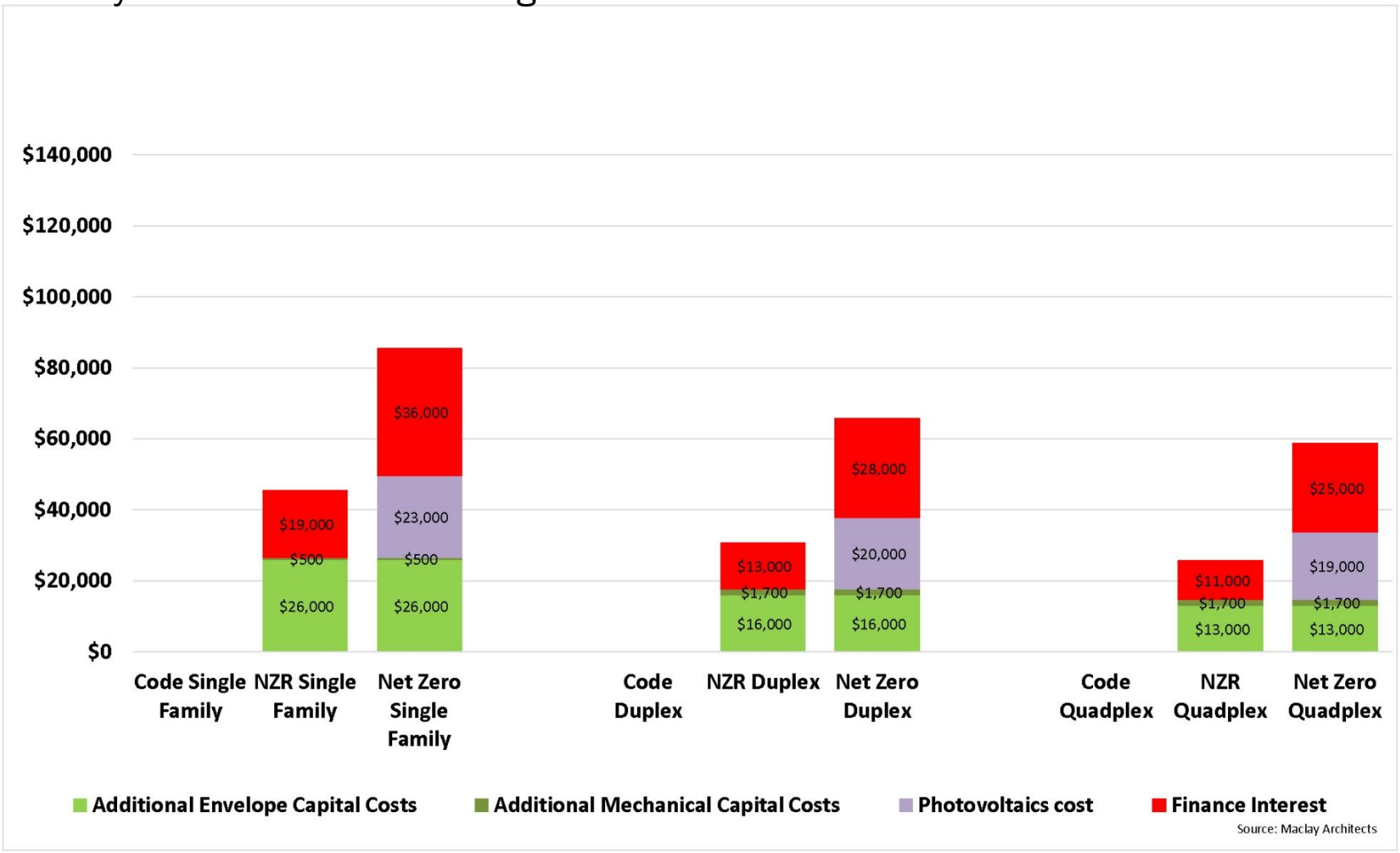
Residential 30-year Costs

- PV capital costs



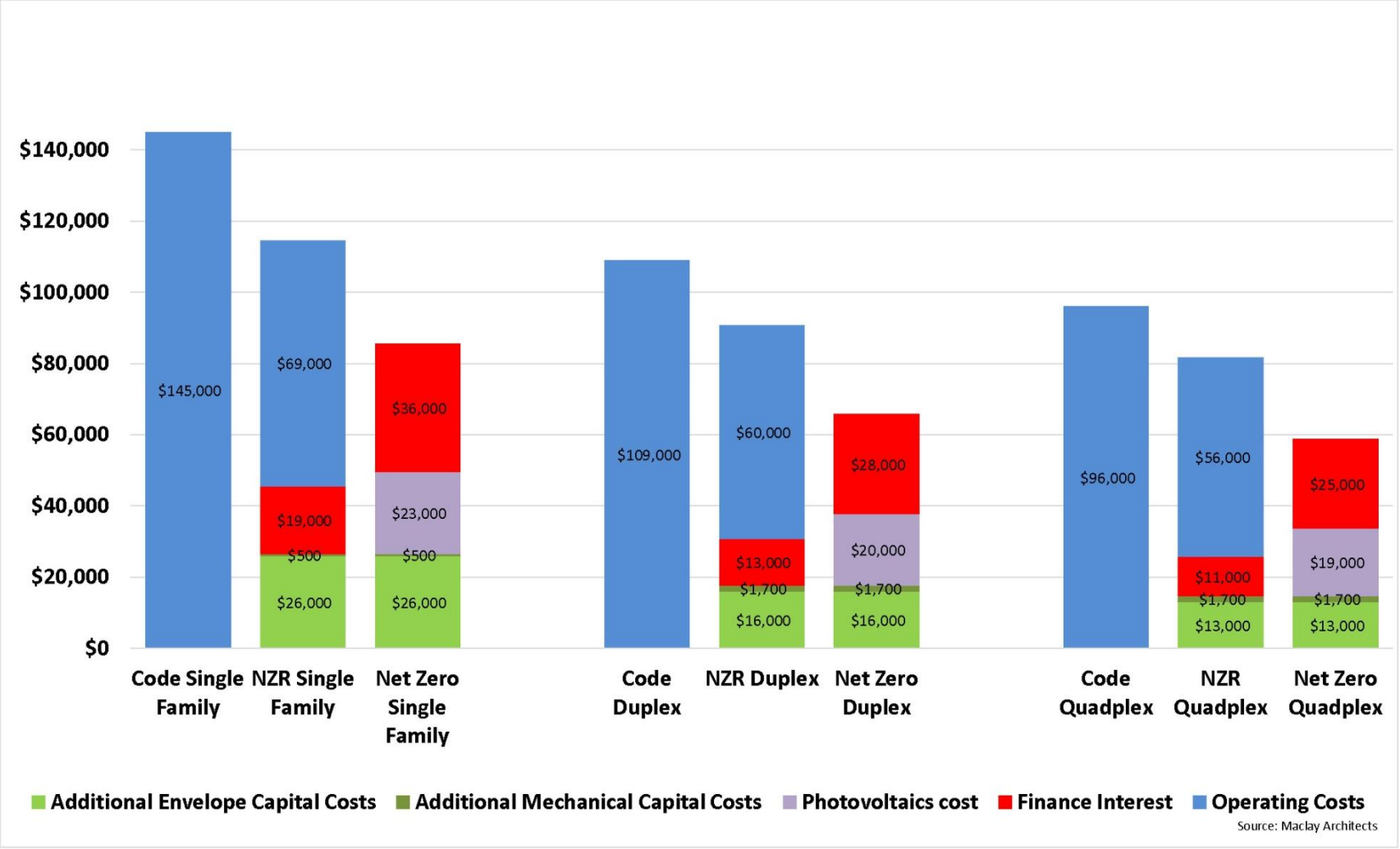
Residential 30-year Costs

- 30-year cumulative financing interest



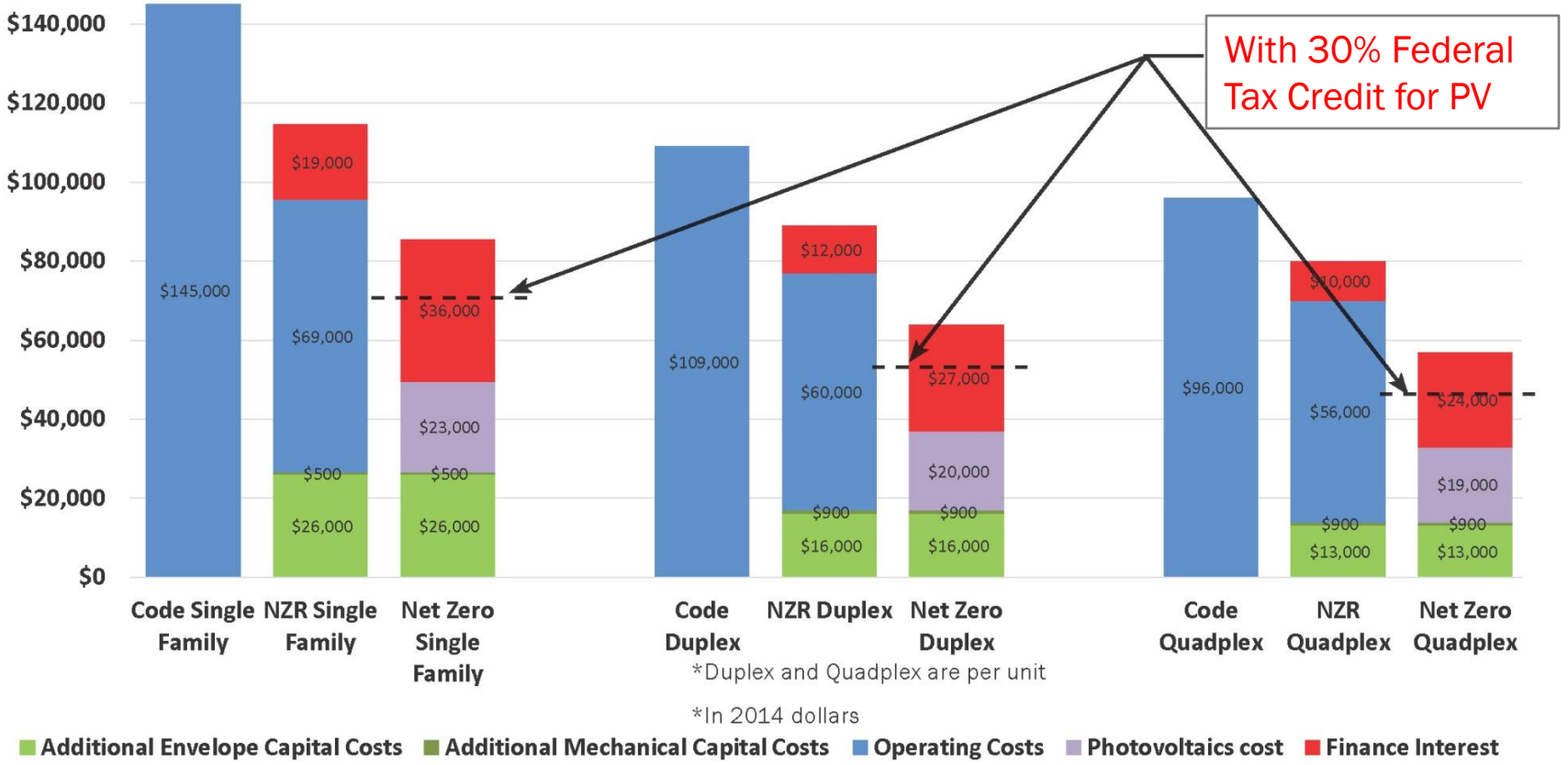
Residential 30-year Costs

- Operating costs



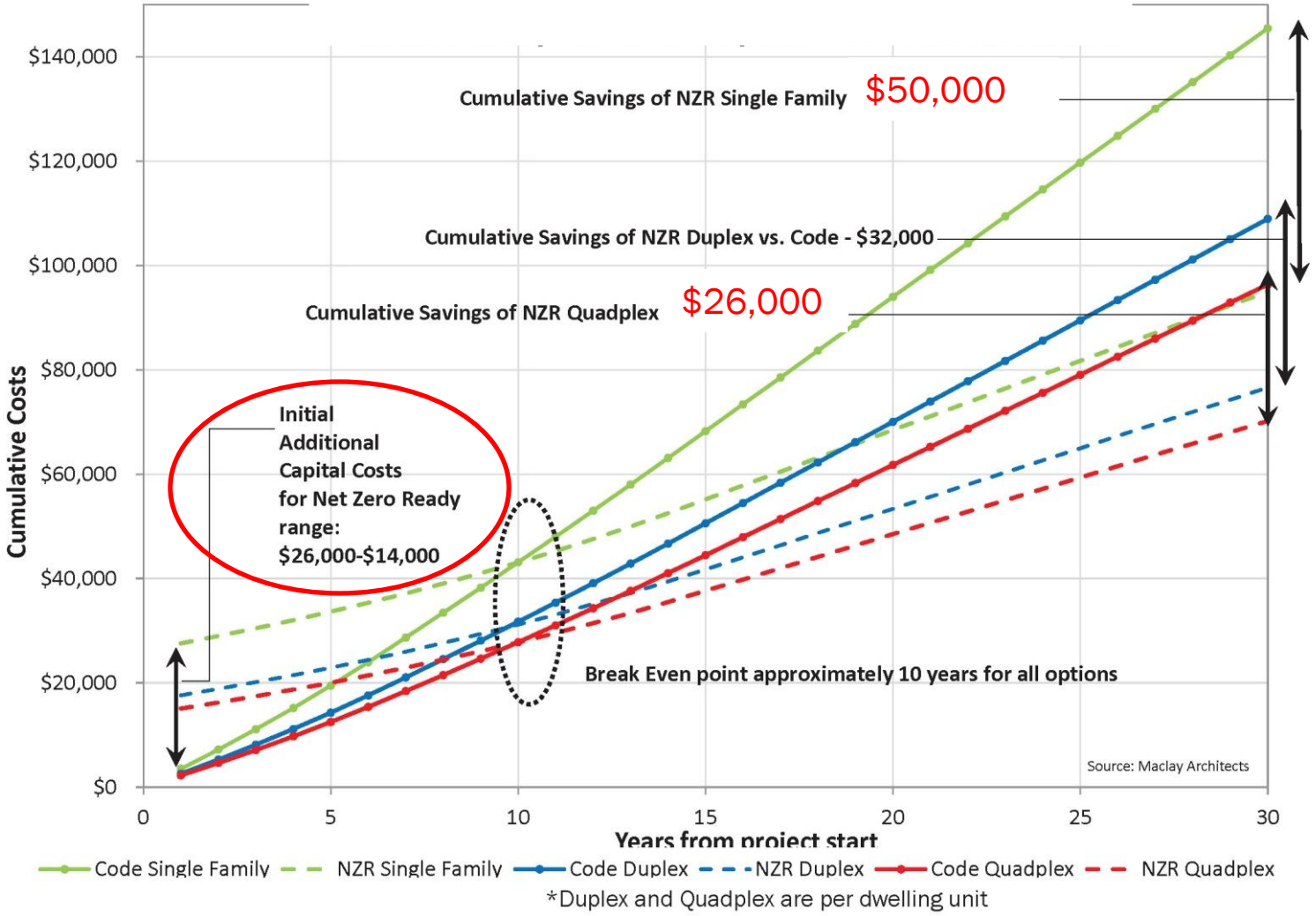
Residential 30-year Costs

- 30% Federal tax credit for PV
- Excludes other rebates/incentives



Residential Financial Analysis

- Net Zero Ready Not Financed



Residential Finance Options

- Efficiency Vermont Database:
  - (https://www.efficiencyvermont.com/For-My-Home/Financing/Financing/Financing-Overview)

- Northfield Savings Bank – Energy Improvement Loans (https://www.nsbvt.com/borrow/energy-improvement-loans/)
- VSECU – Vgreen – Energy Savings Loan Program (www.vsecu.com/vgreen) Unsecured and Home Equity Loans
  - Unsecured:
    - 5 yr fixed 4.9% maximum $10,000
    - 15 yr fixed 5.9% maximum $30,000
  - Home Equity Loans:
    - 5 yr fixed 2.74%
    - 15 yr fixed 4.5%

Office Building

- 13,000 sf
- 2 floors

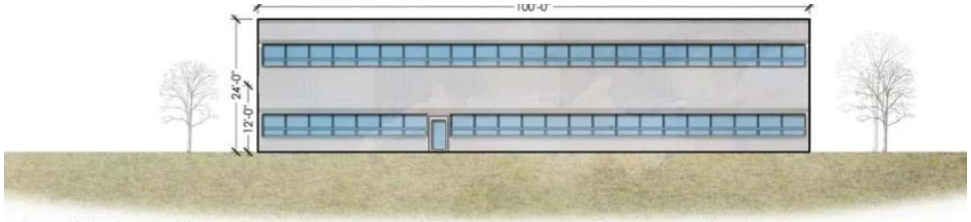


Figure 3.5: Code office north and south elevation source: Maclay Architects

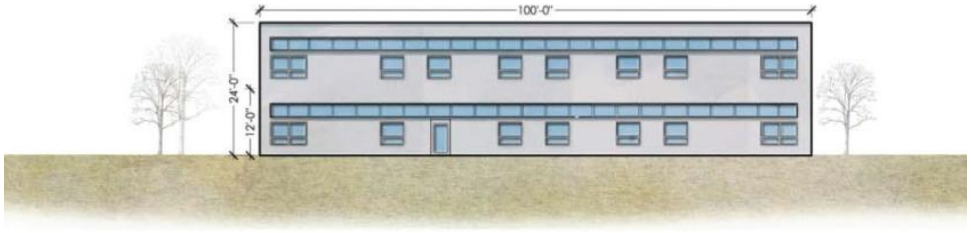


Figure 3.6: Net Zero office north and south elevation source: Maclay Architects

Four office configurations:

- Net Zero Ready open office
- Net Zero Ready closed office
- Code open office
- Code closed office

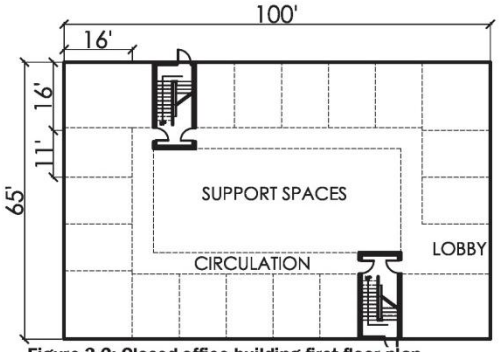


Figure 3.2: Closed office building first floor plan

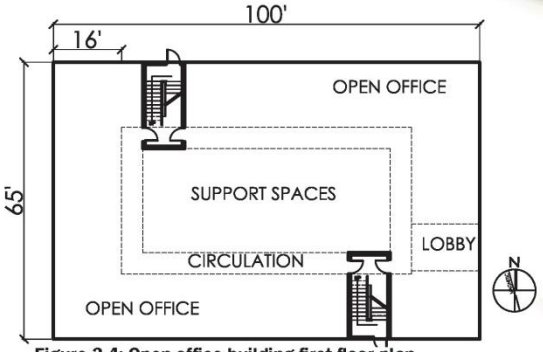


Figure 3.4: Open office building first floor plan

Office/Manufacturing Building

- 27,000 sf total
- 1st floor manufacturing/ warehouse space 17,000 sf
- 2 floors of office along the south 10,000 total sf

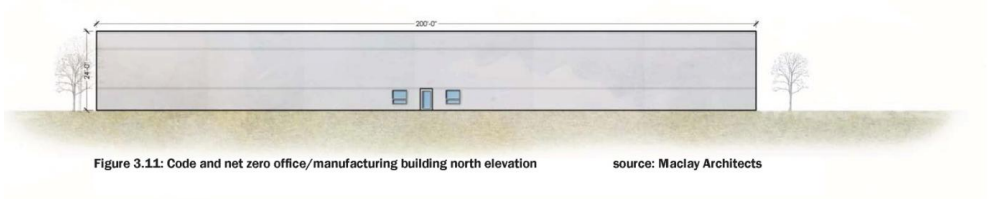


Figure 3.11: Code and net zero office/manufacturing building north elevation source: Maclay Architects

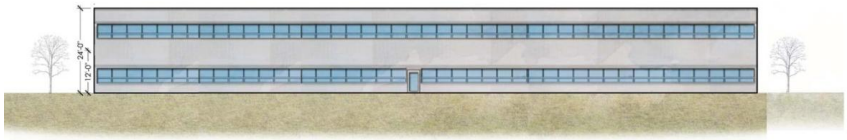


Figure 3.12: Code office/manufacturing south elevation source: Maclay Architects

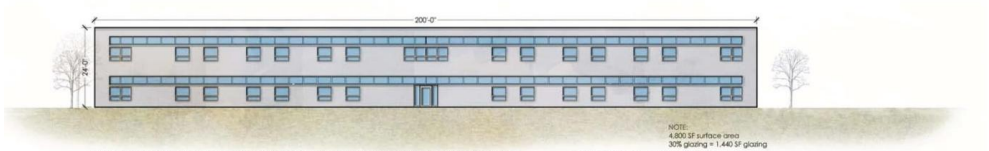


Figure 3.13: Net zero ready office/manufacturing building south elevation source: Maclay Architects

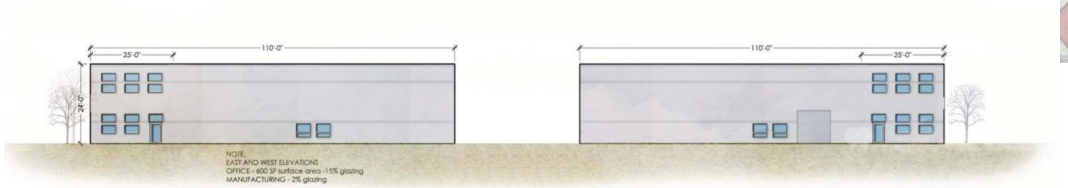


Figure 3.14: Office/manufacturing east elevation source: Maclay Architects

Figure 3.15: Office/manufacturing west elevation source: Maclay Architects

Office/Manufacturing Building

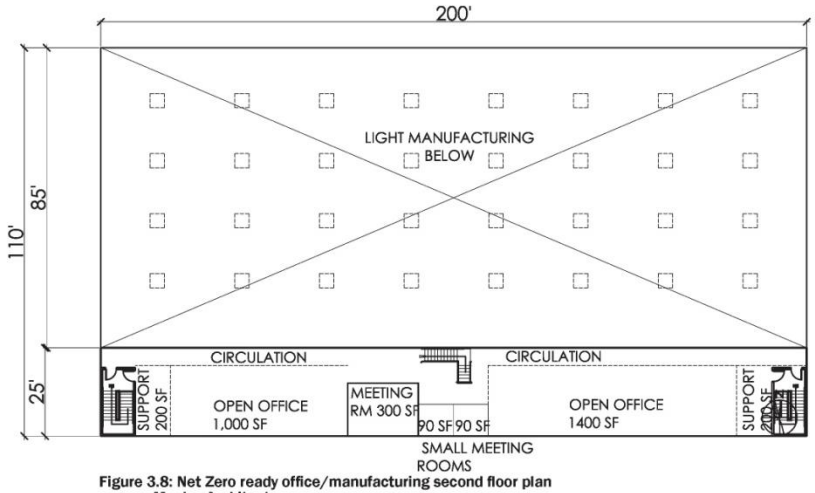


Figure 3.8: Net Zero ready office/manufacturing second floor plan
source: Maclay Architects

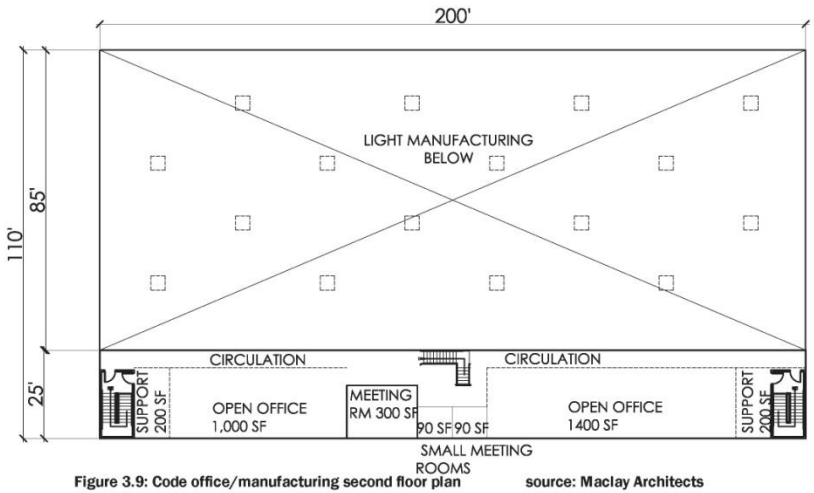


Figure 3.9: Code office/manufacturing second floor plan **source: Maclay Architects**

NZR

- 3% skylights in the NZR manufacturing area
- Lighting 0.5- 0.6 watts/sf

CODE

- 1.5% skylights in the code manufacturing area
- Lighting 0.9 – 1.01 watts/sf

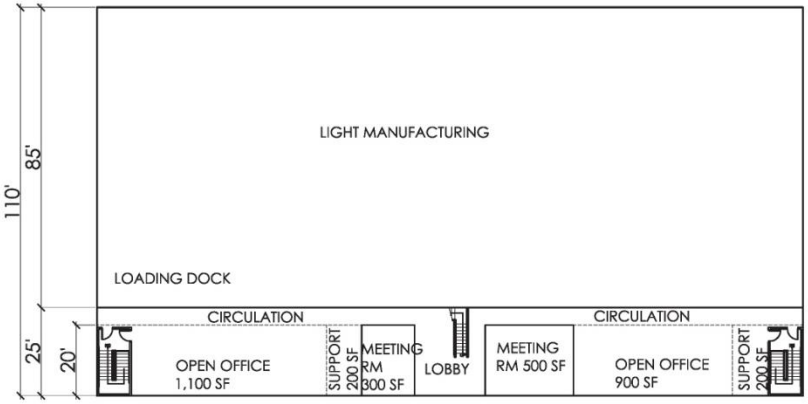


Figure 3.10: Code and net zero office/manufacturing first floor plan **source: Maclay Architects**

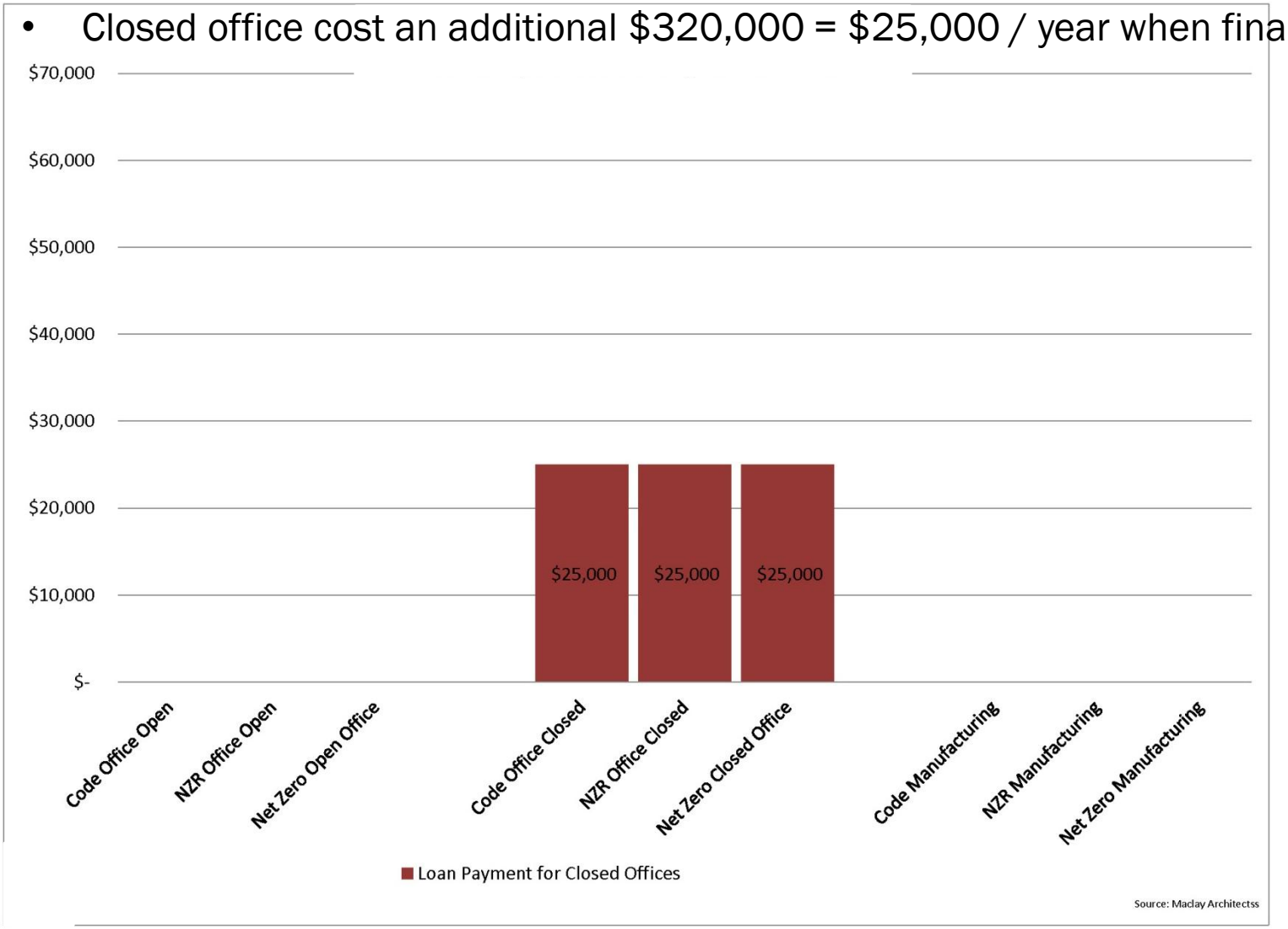
*Other Assumptions the same for both

Commercial Finance Assumptions

- 20-year variable loan rate to finance the incremental capital costs
- Starting at 4.61% and increases by 2% every 5 years

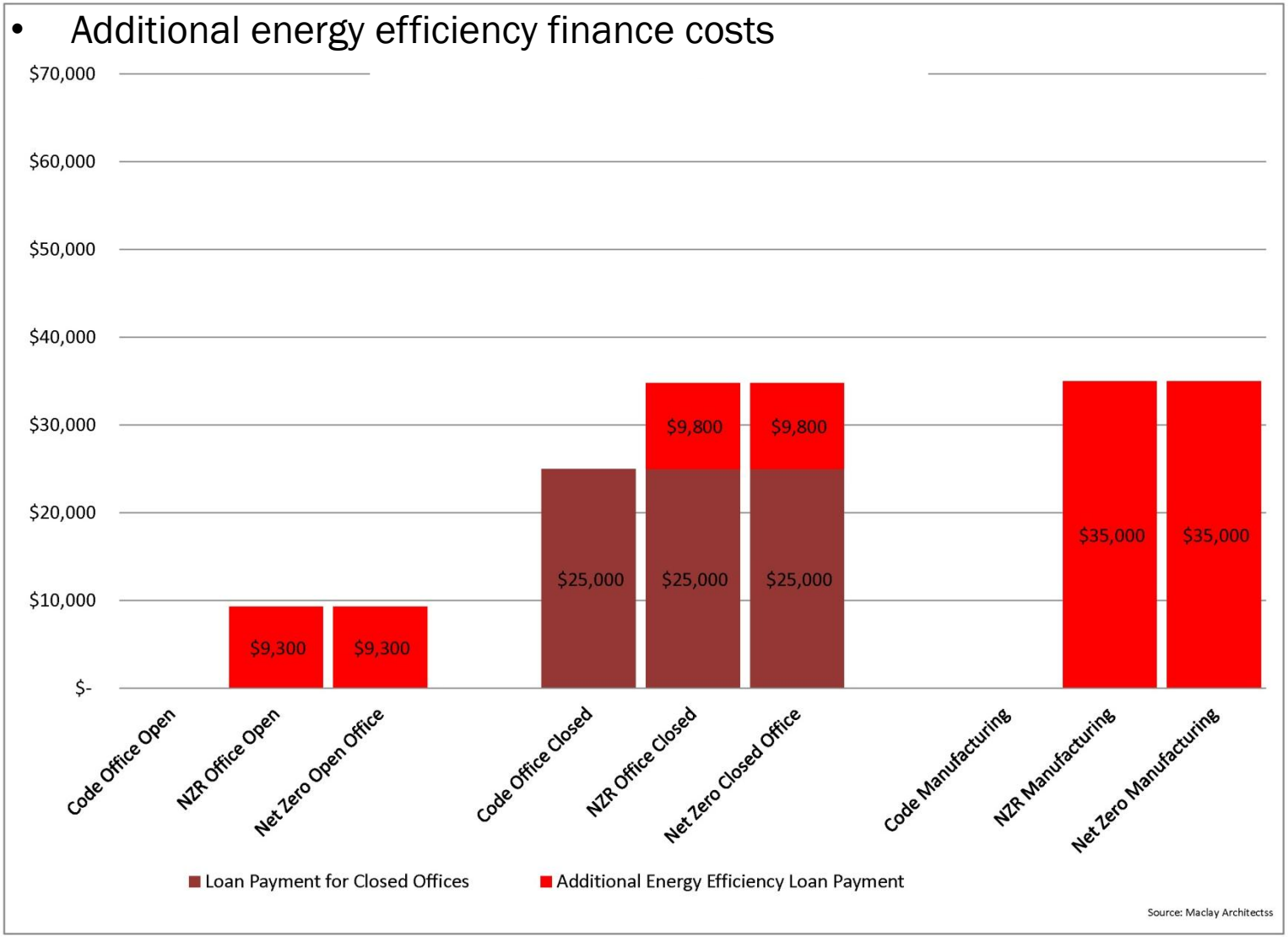
Commercial 1st Year Costs

- Closed office cost an additional $320,000 = $25,000 / year when financed



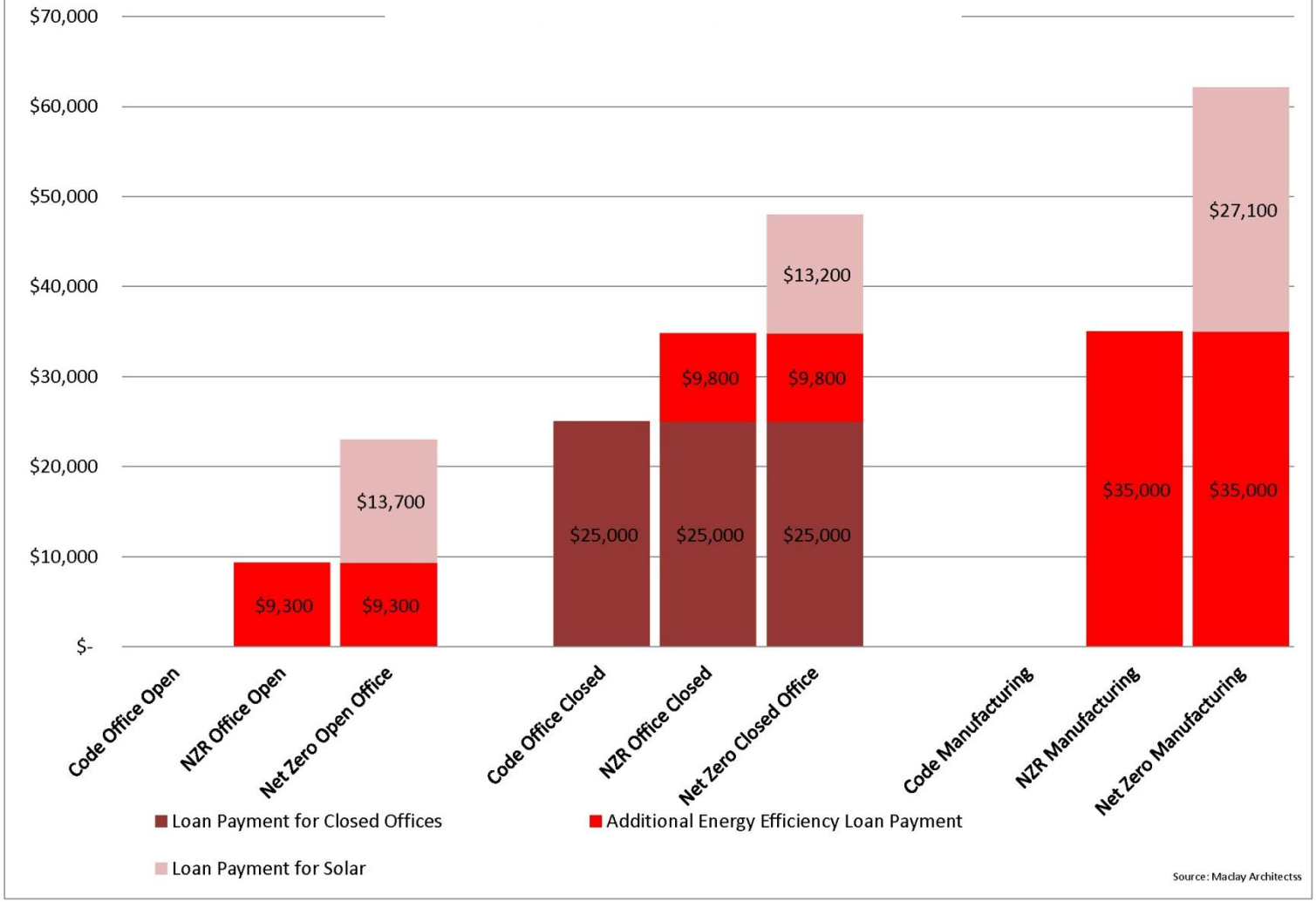
Commercial 1st Year Costs

- Additional energy efficiency finance costs



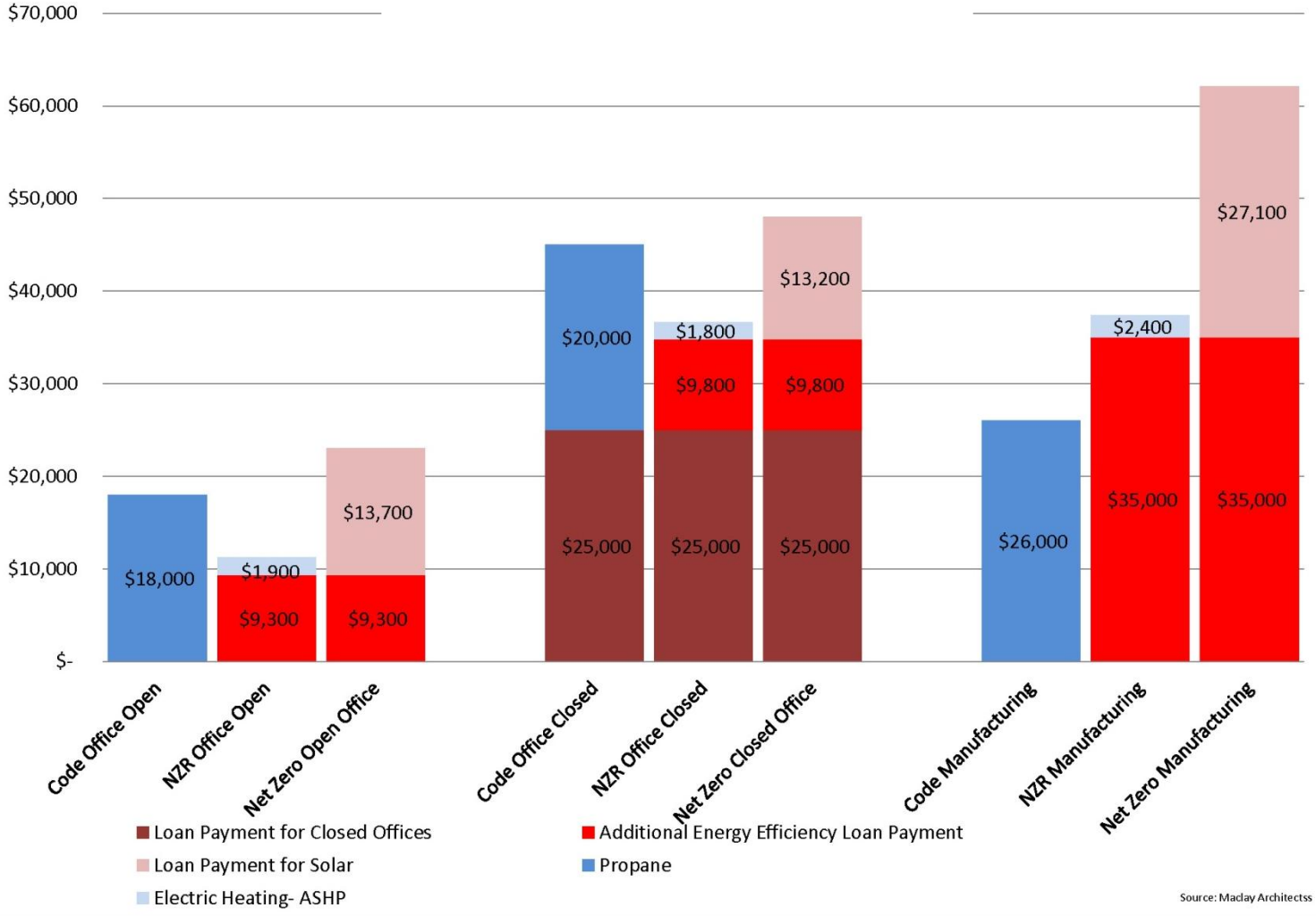
Commercial 1st Year Costs

- Total finance costs including PV



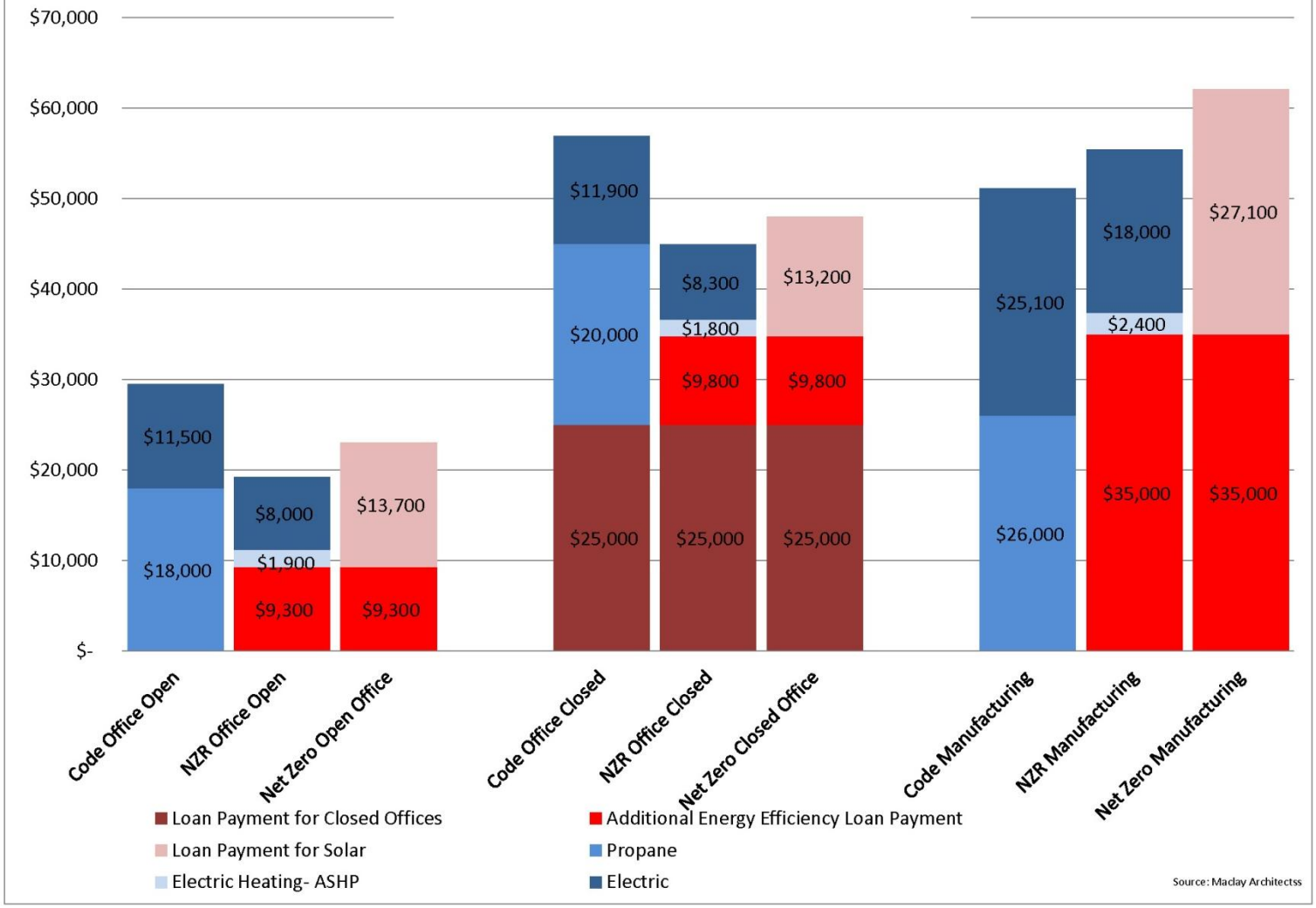
Commercial 1st Year Costs

- Heating and Cooling Costs



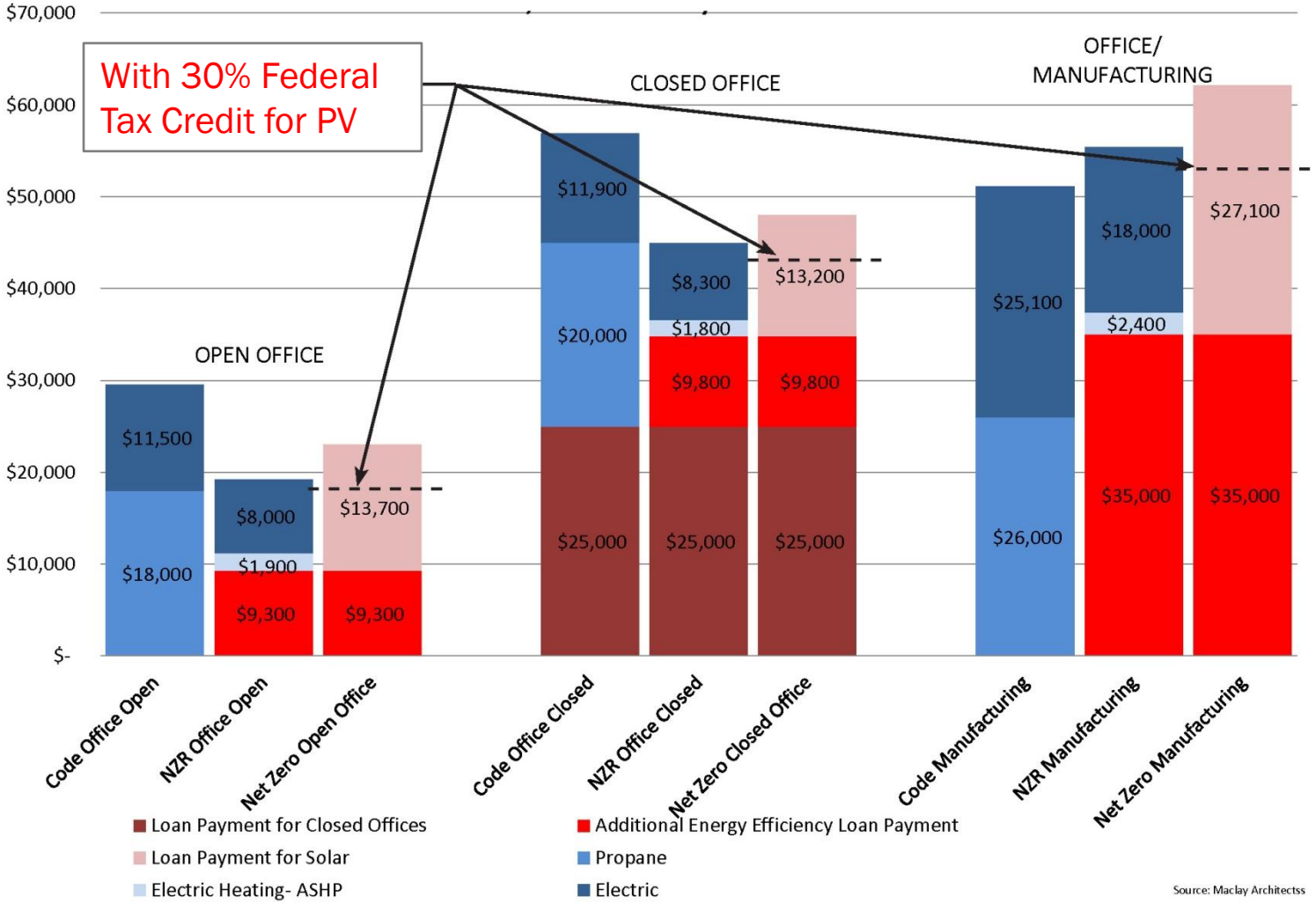
Commercial 1st Year Costs

- Commercial first year total costs



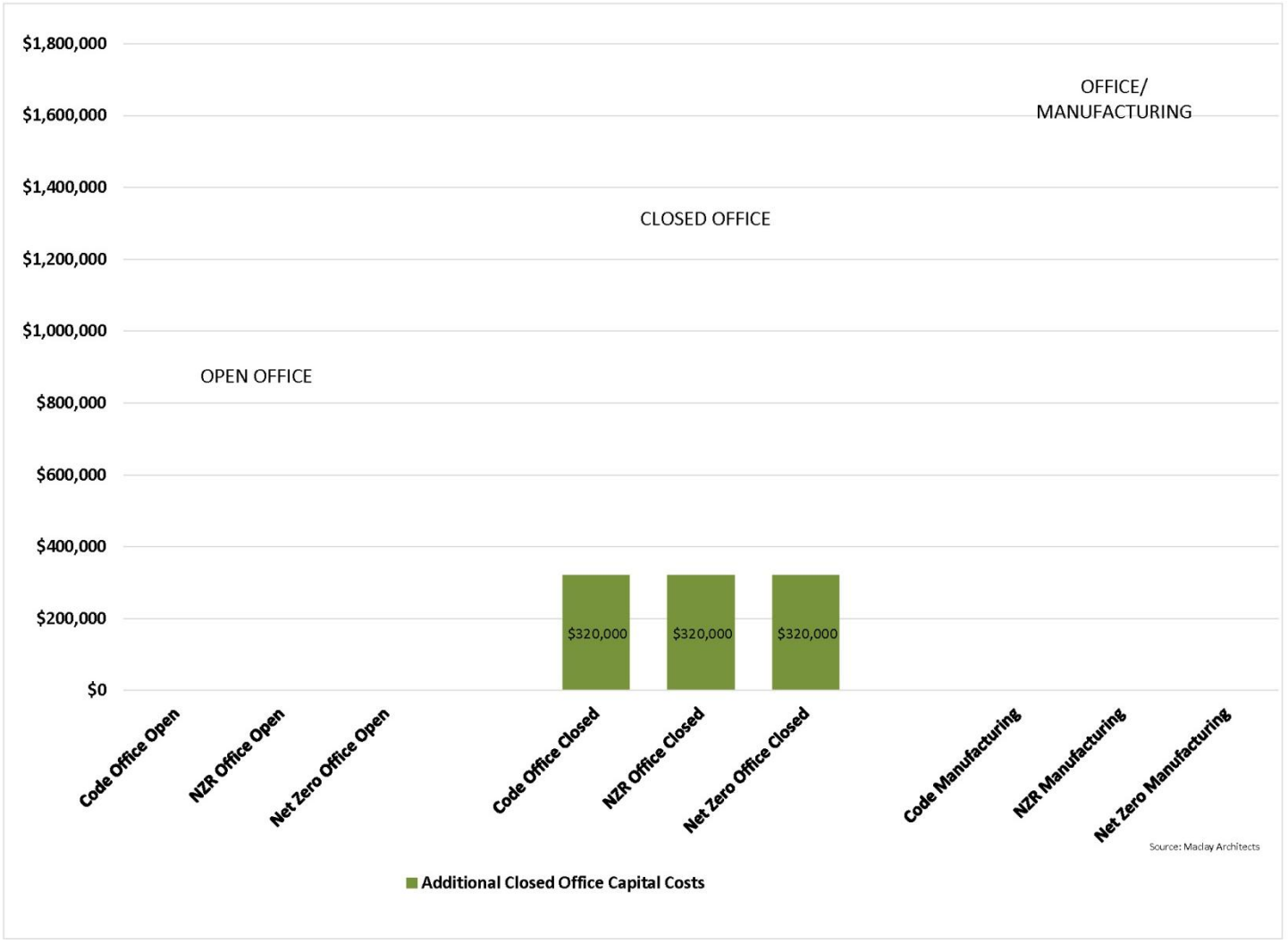
Commercial 1st Year Costs

- Federal Tax Credit for PV



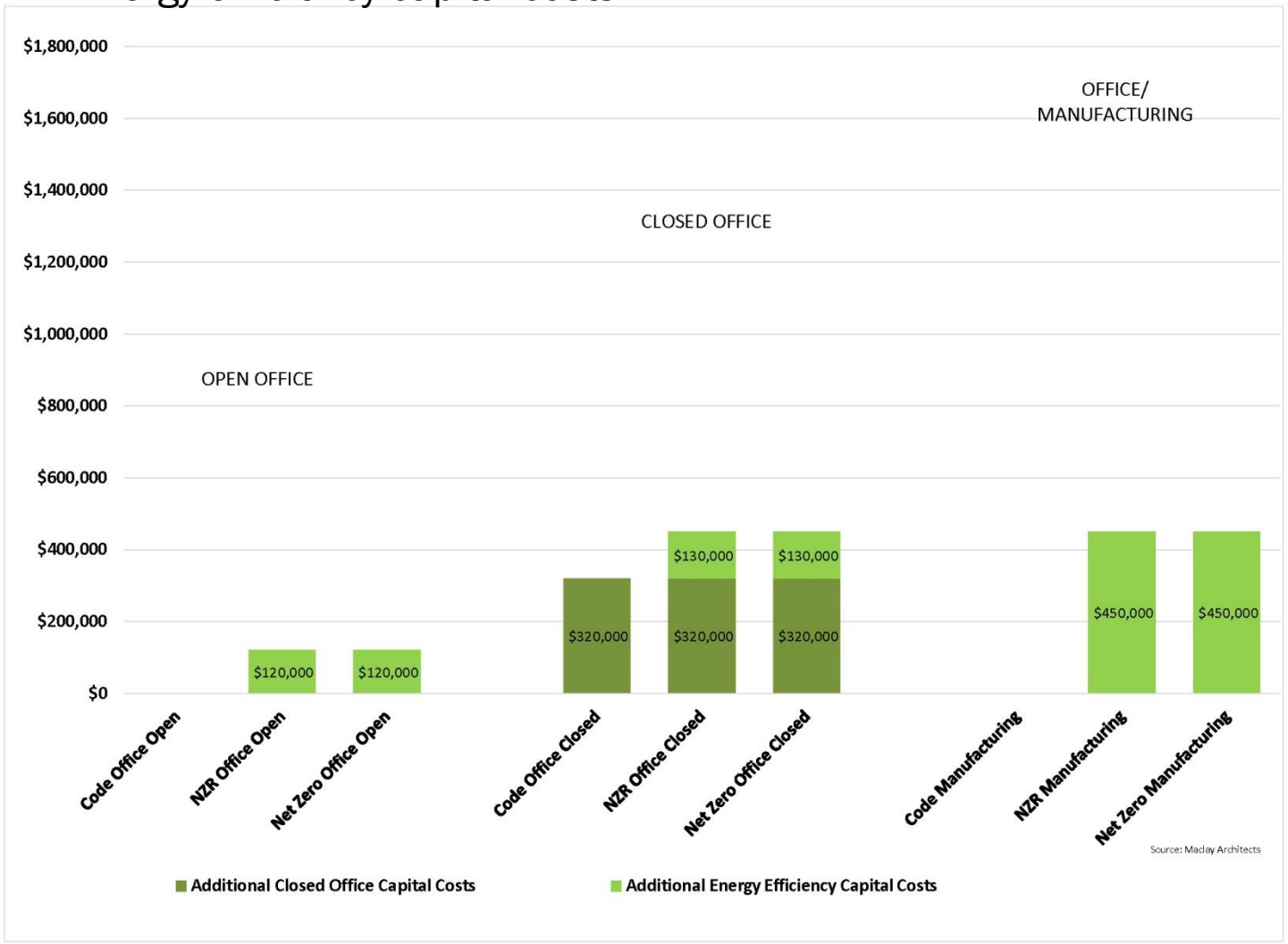
Commercial 20-year Costs

- Closed office capital costs



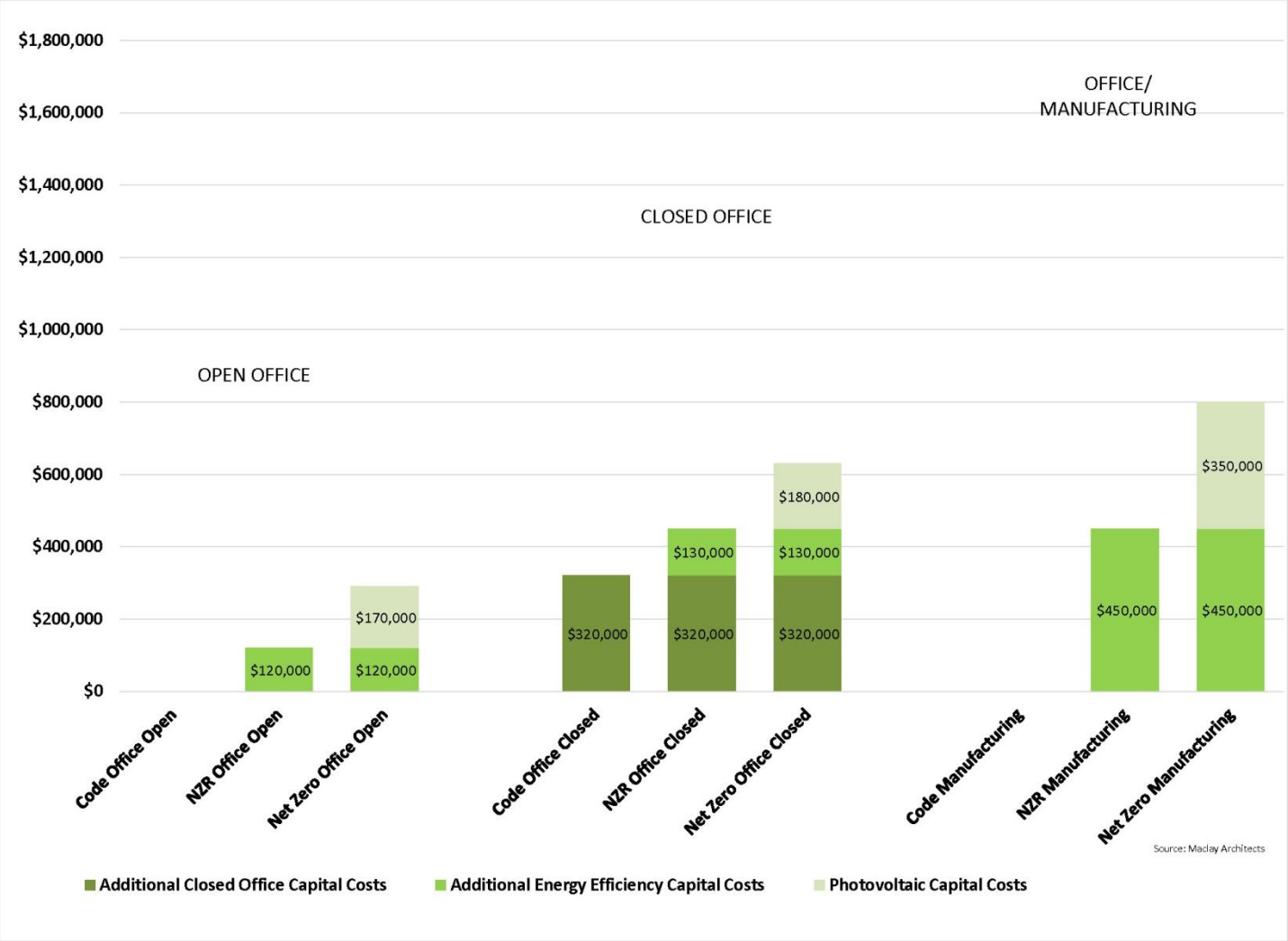
Commercial 20-year Costs

- Energy efficiency capital costs



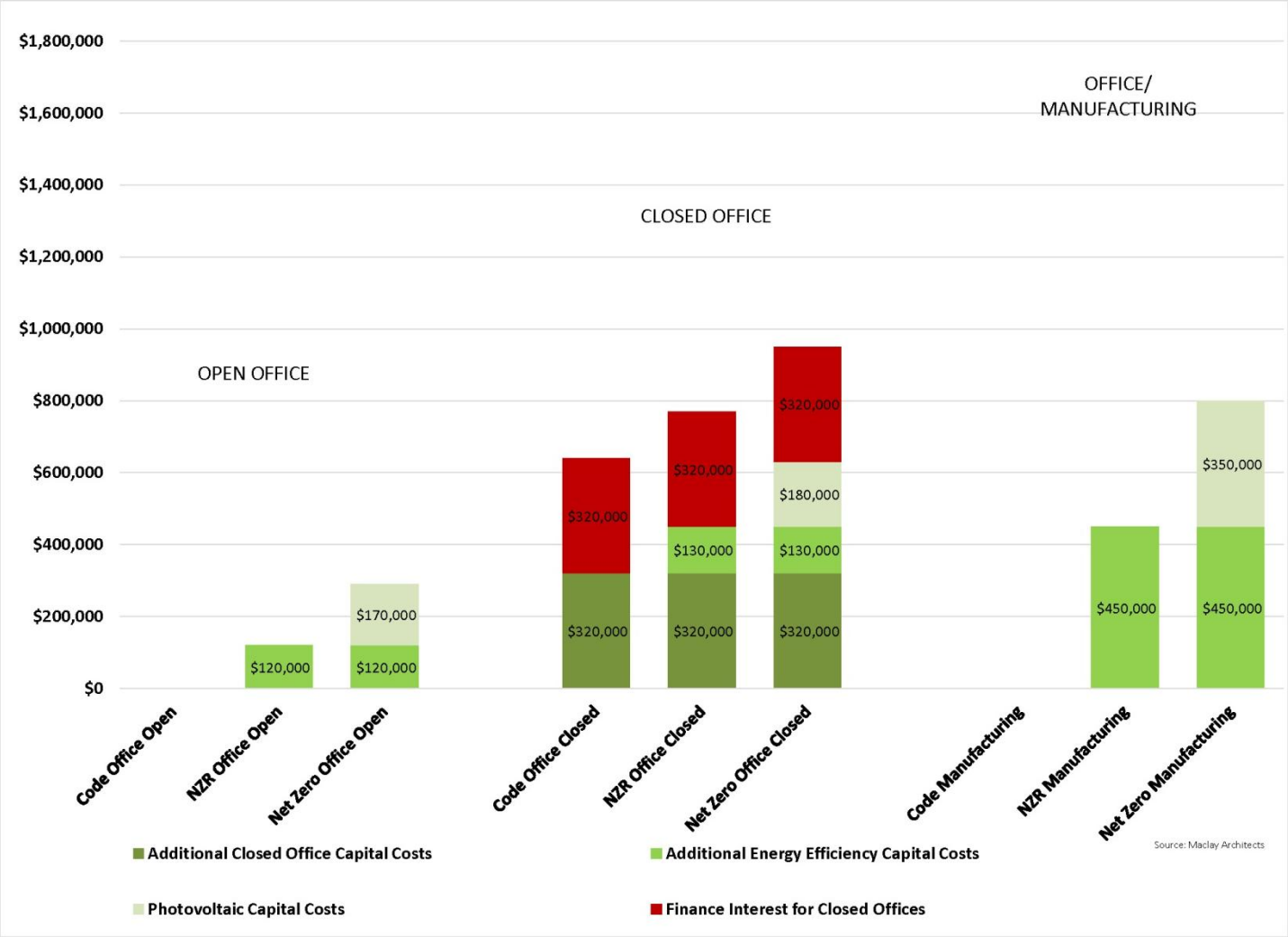
Commercial 20-year Costs

- PV capital costs



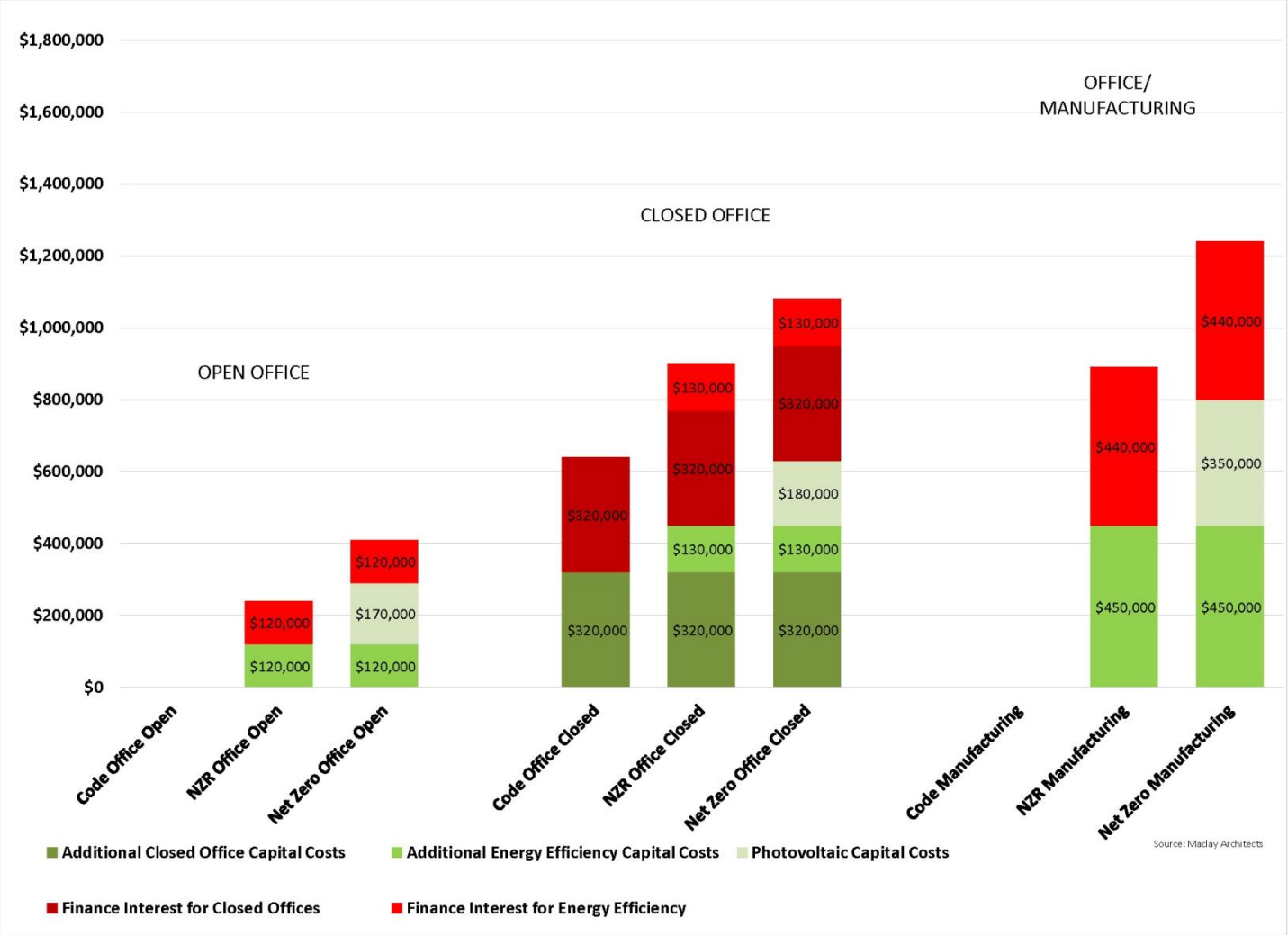
Commercial 20-year Costs

- Closed office finance costs



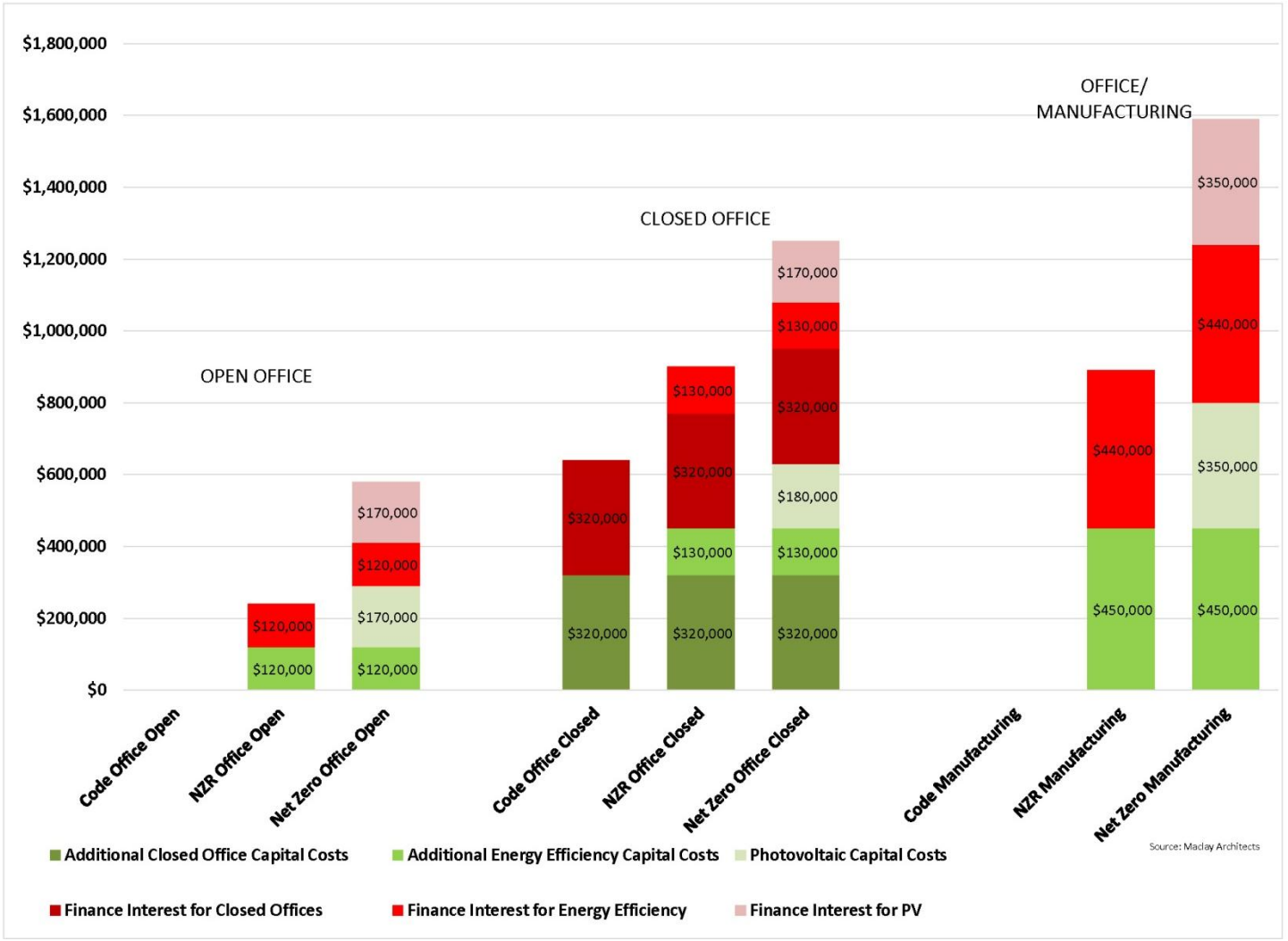
Commercial 20-year Costs

- Energy Efficiency finance costs



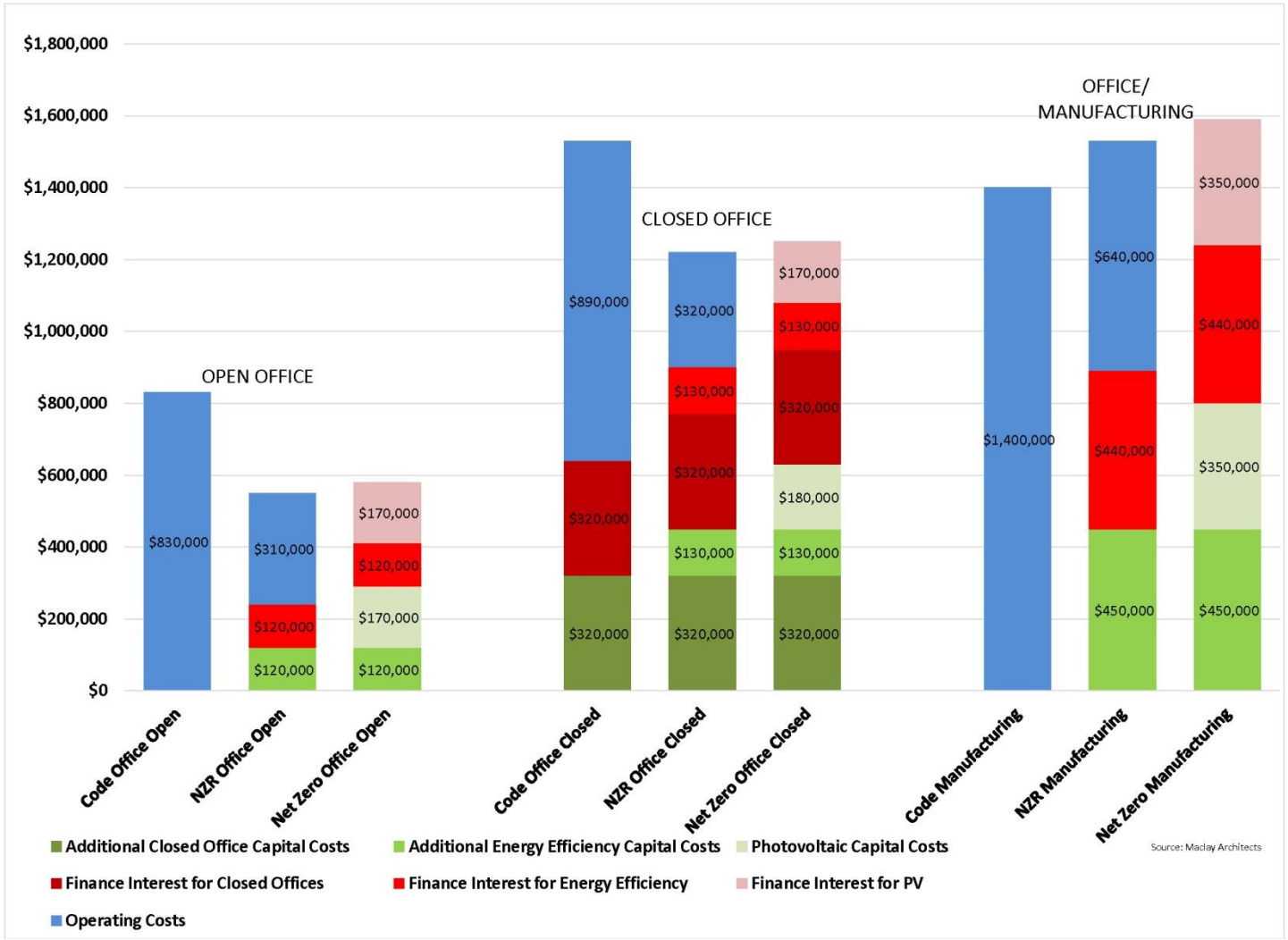
Commercial 20-year Costs

- PV finance costs

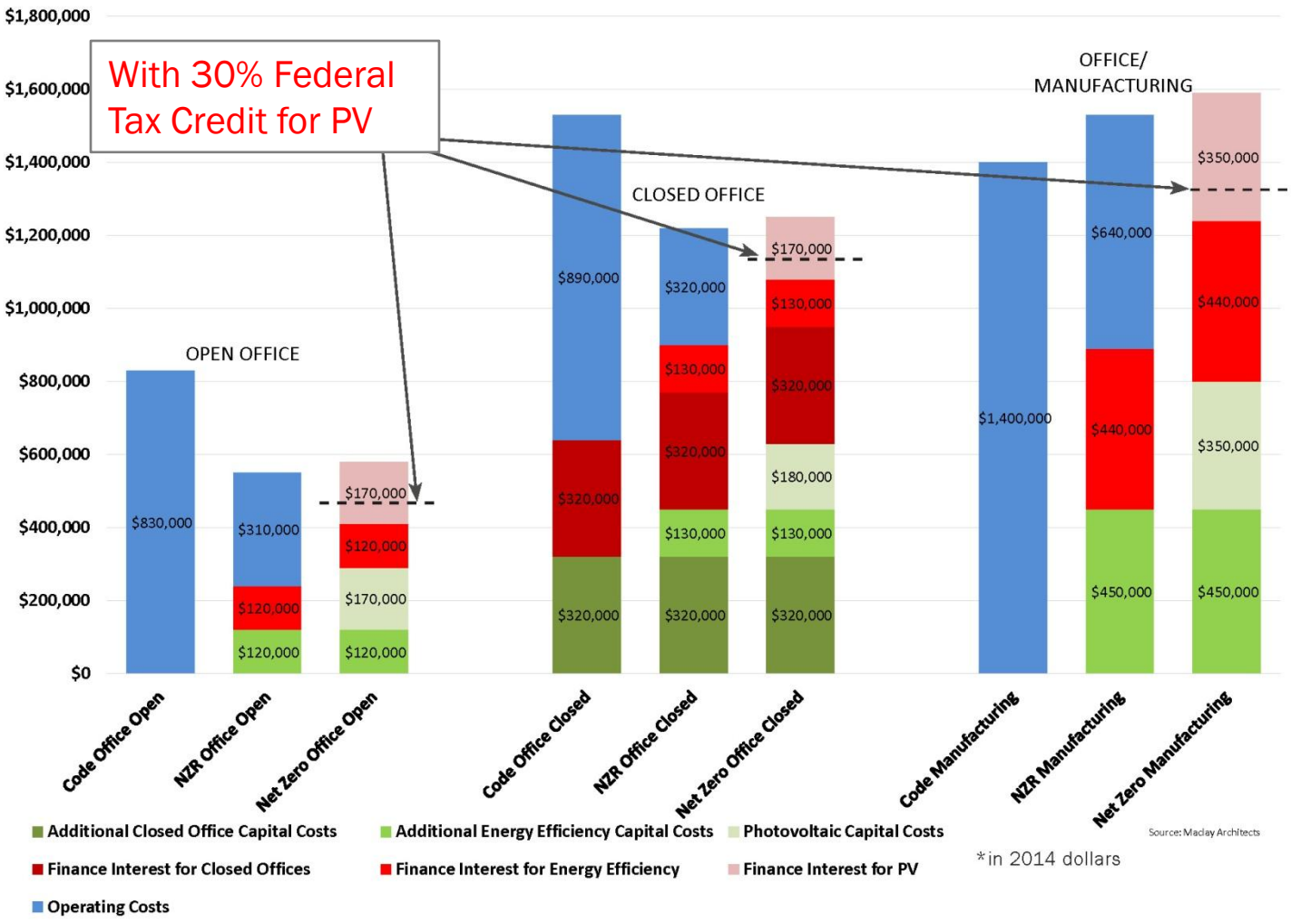


Commercial 20-year Costs

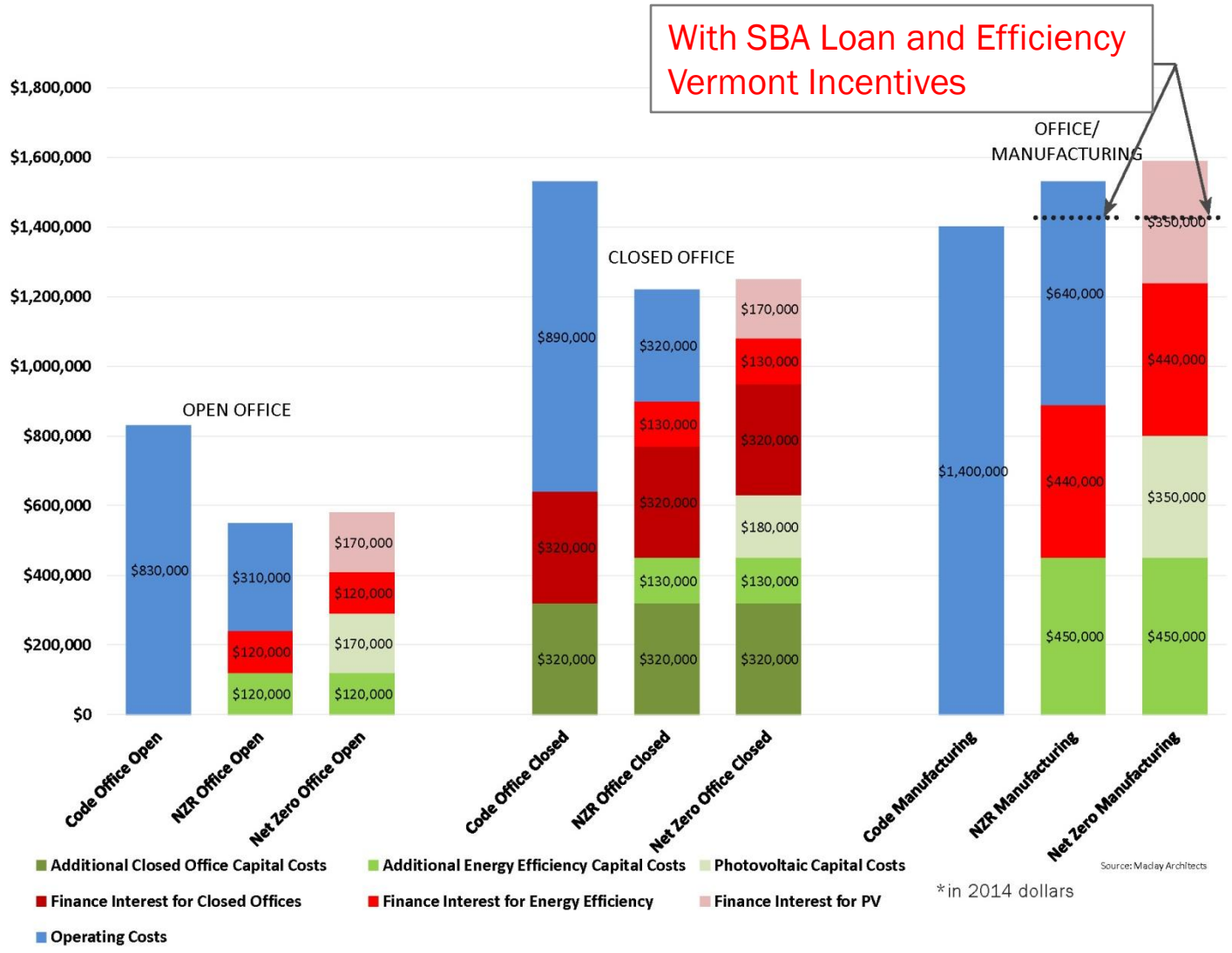
- Operating costs



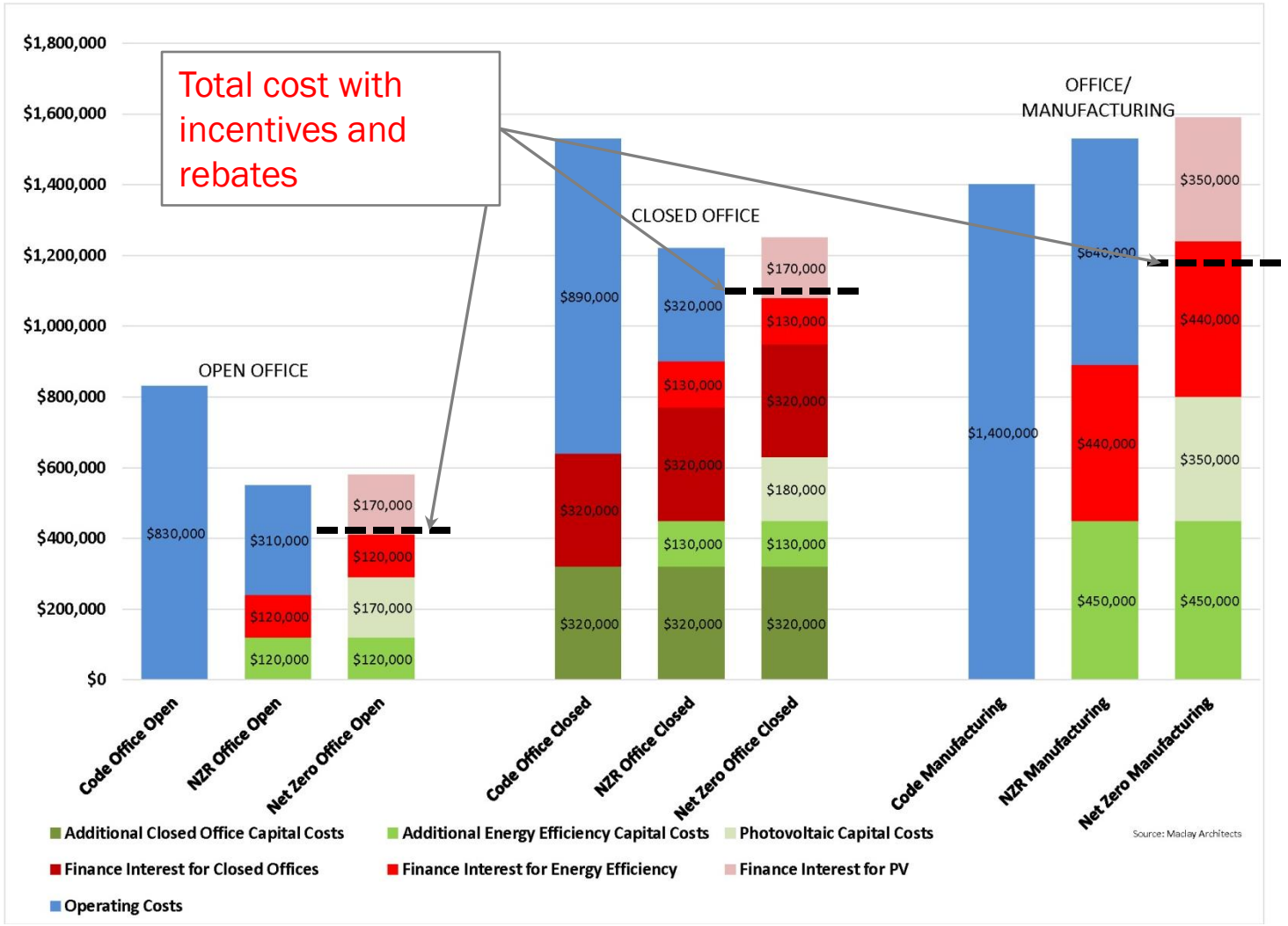
Commercial 20-year Costs



Commercial 20-year Costs



Commercial 20-year Costs



Commercial Financial Analysis

Net Zero Ready All Financed

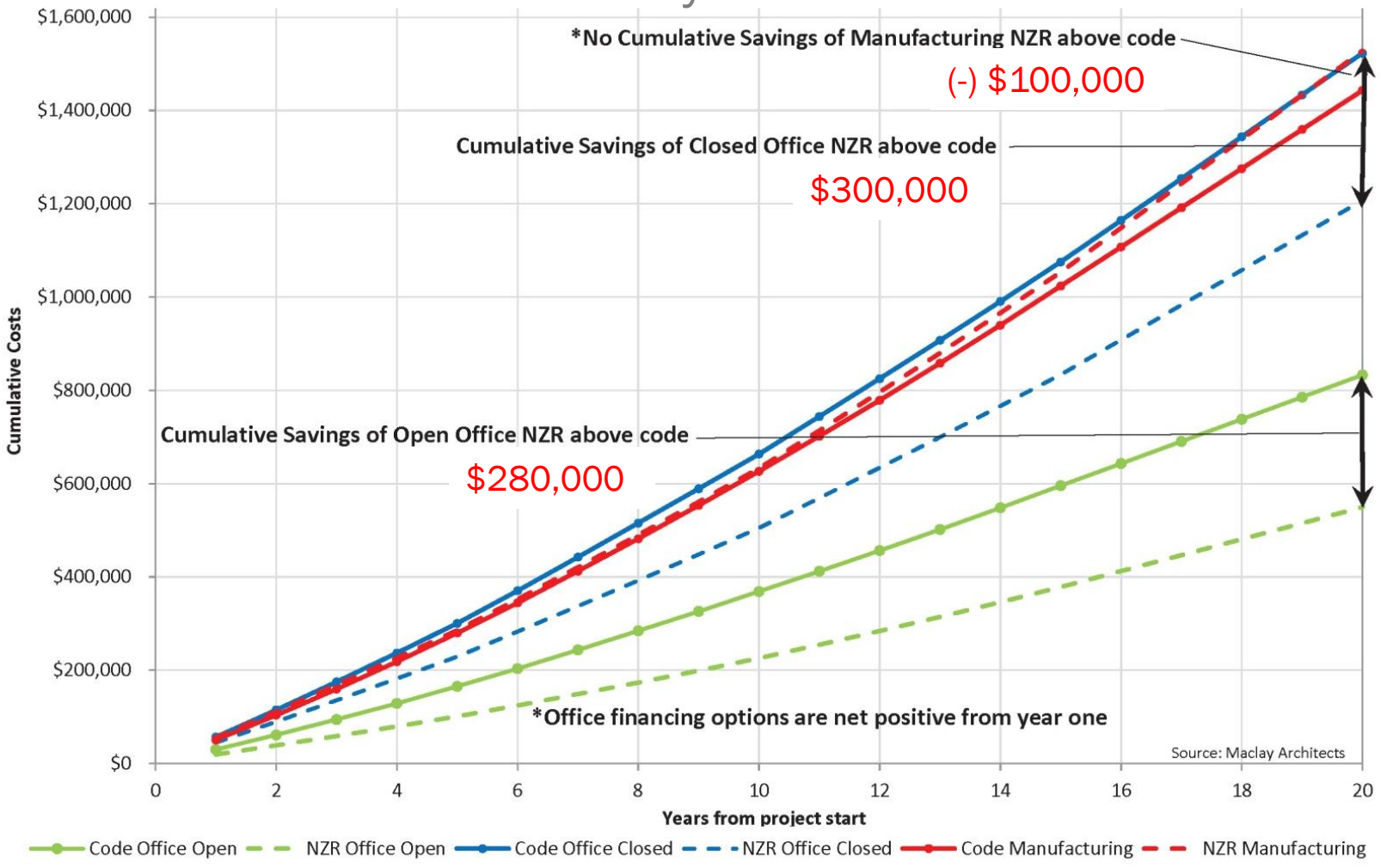


Figure 7.9: Cumulative energy and financing costs for all code and net zero ready commercial buildings

Commercial Finance Options

- VEDA
  - 20% down payment
  - Finance 40% at low variable interest rates
  - Finance 40% with lending institution

  (http://www.veda.org/commercial-loan-rates-fees/#vermont)
- Small Business Administration (SBA 504 Loan through local bank)
  - 20% down payment
  - Finance 40% fixed interest rate ~4.77%
  - Finance 40% with lending institution

  (https://www.sba.gov/)

  (http://www.vtsbdc.org/)

Community

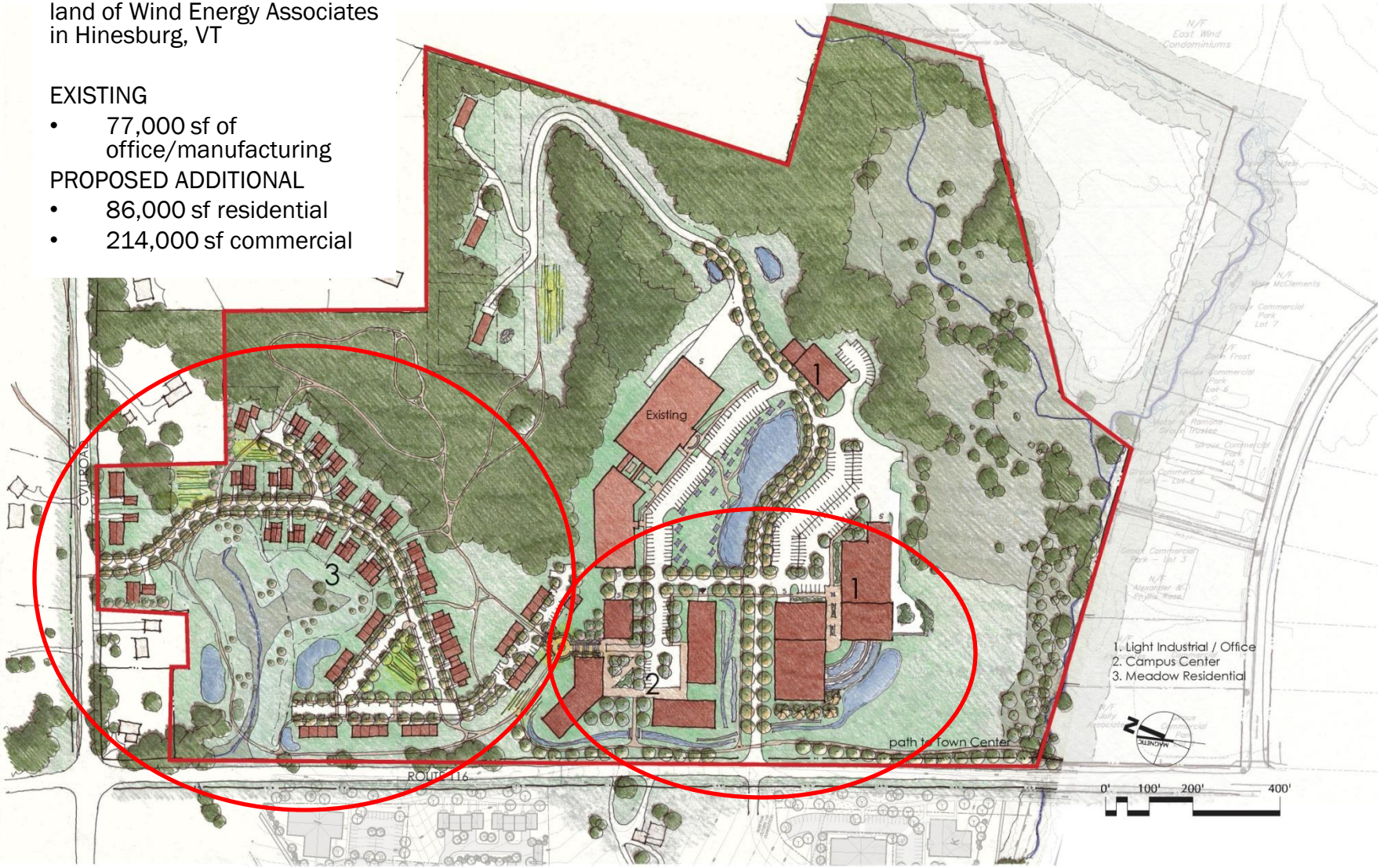
Proposed masterplan on the land of Wind Energy Associates in Hinesburg, VT

EXISTING

- 77,000 sf of office/manufacturing

PROPOSED ADDITIONAL

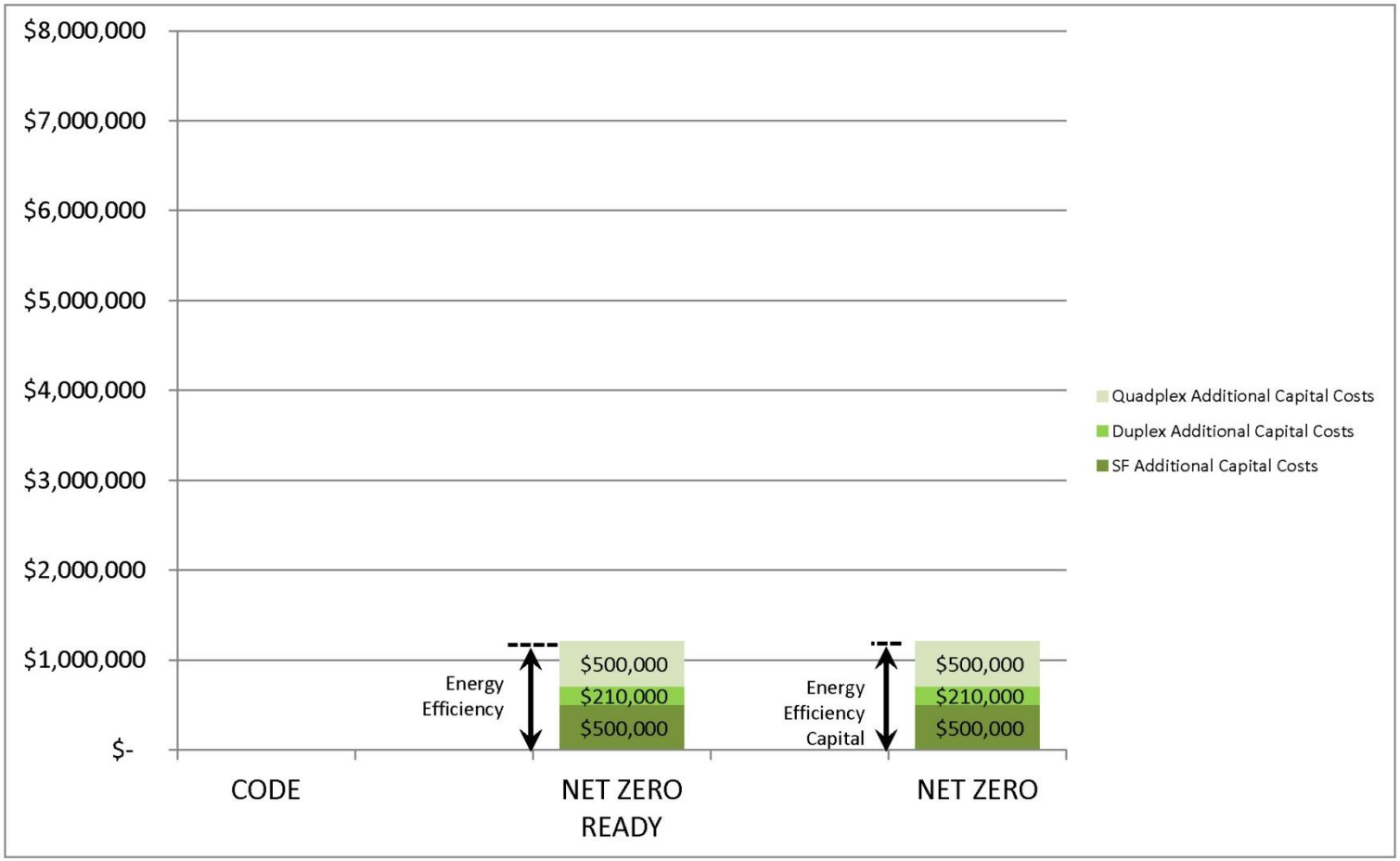
- 86,000 sf residential
- 214,000 sf commercial



Community

Residential 30-Year Costs

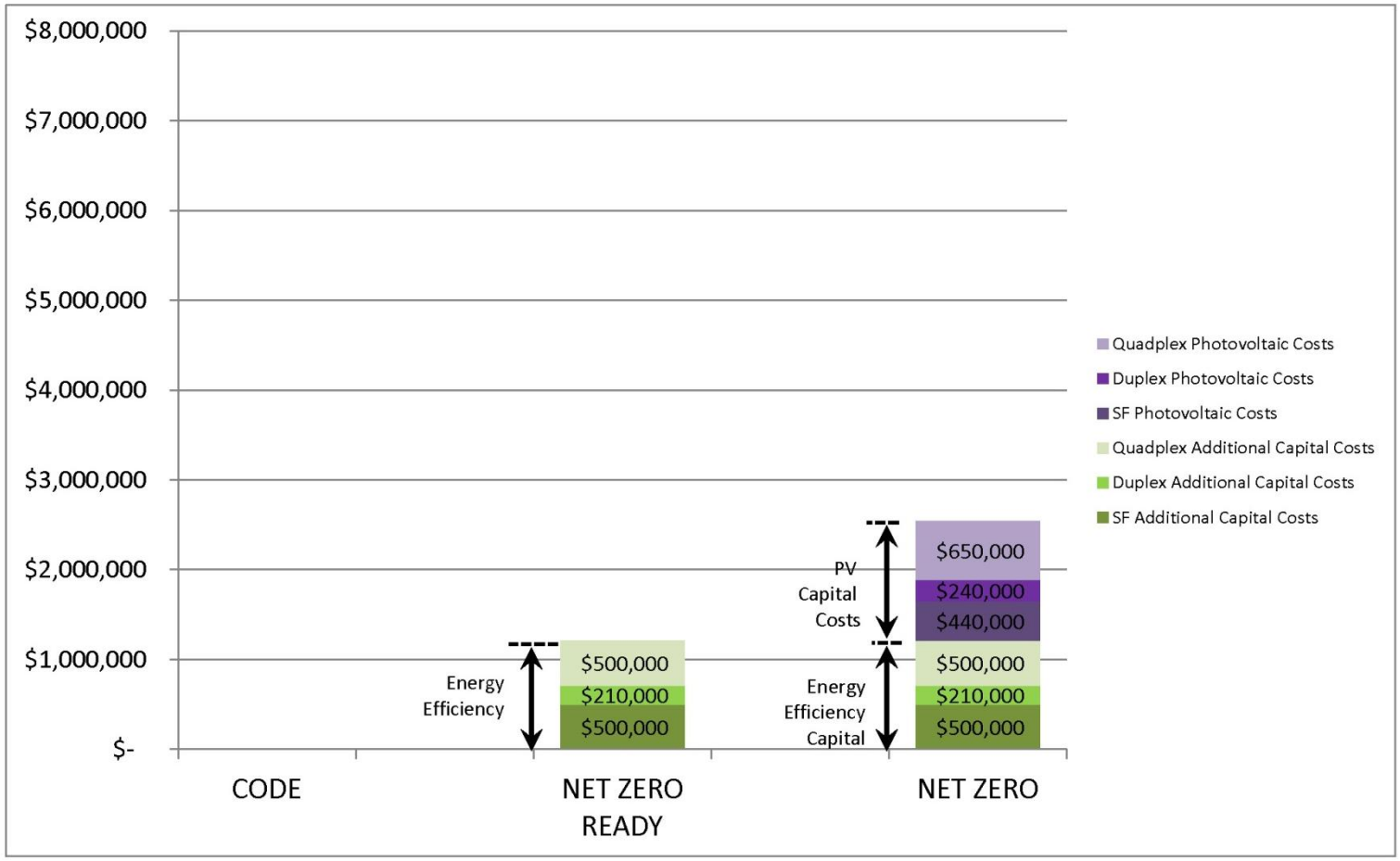
- Additional Capital Costs



Community

Residential 30-Year Costs

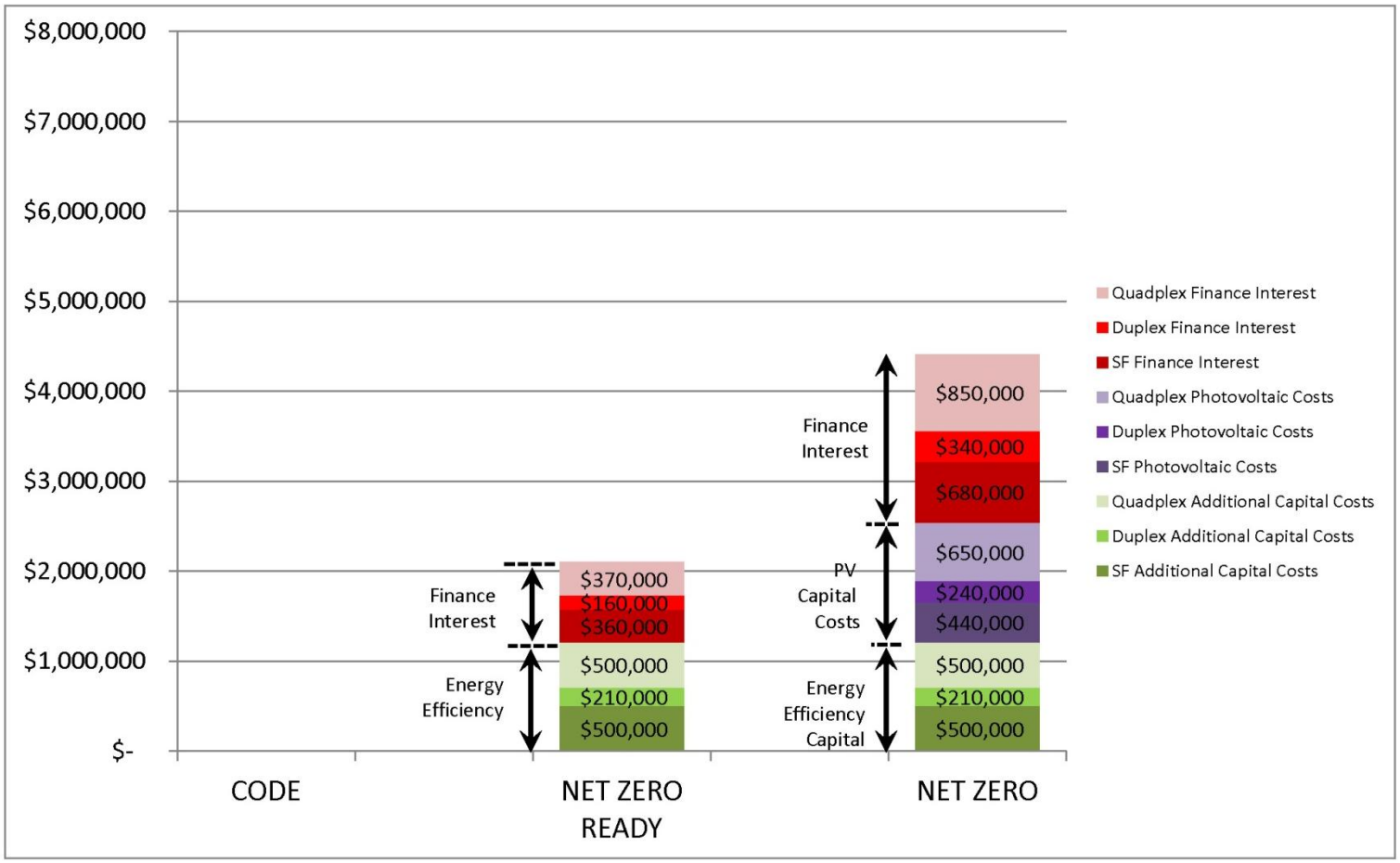
- PV Capital Costs



Community

Residential 30-Year Costs

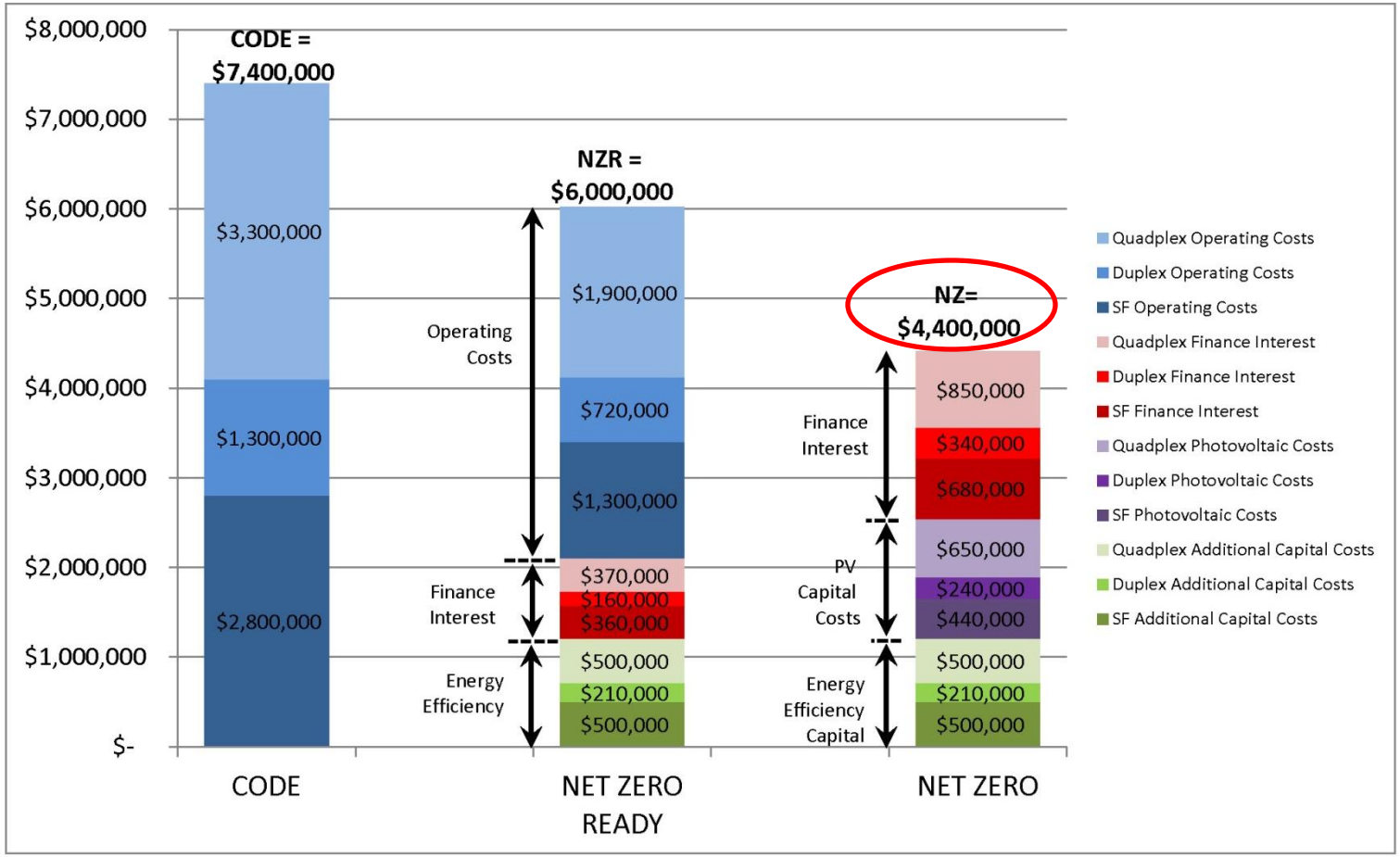
- Cumulative 30-year Finance Interest



Community

Residential 30-Year Costs

- NZ cumulative savings of $3 million compared to a code and savings



Community

Residential 30-Year Costs

- NZ cumulative savings of $3.8 million including PV tax credits

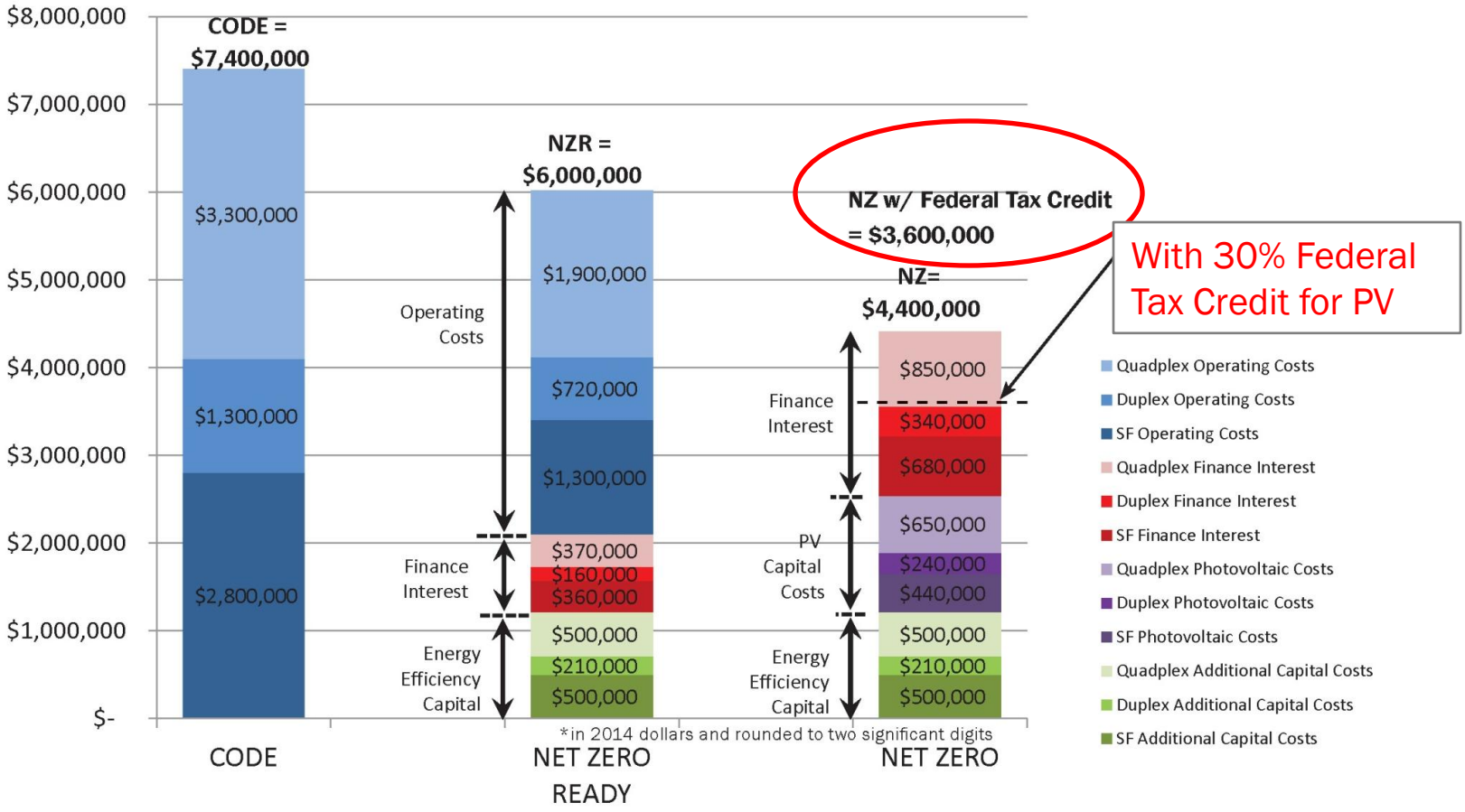
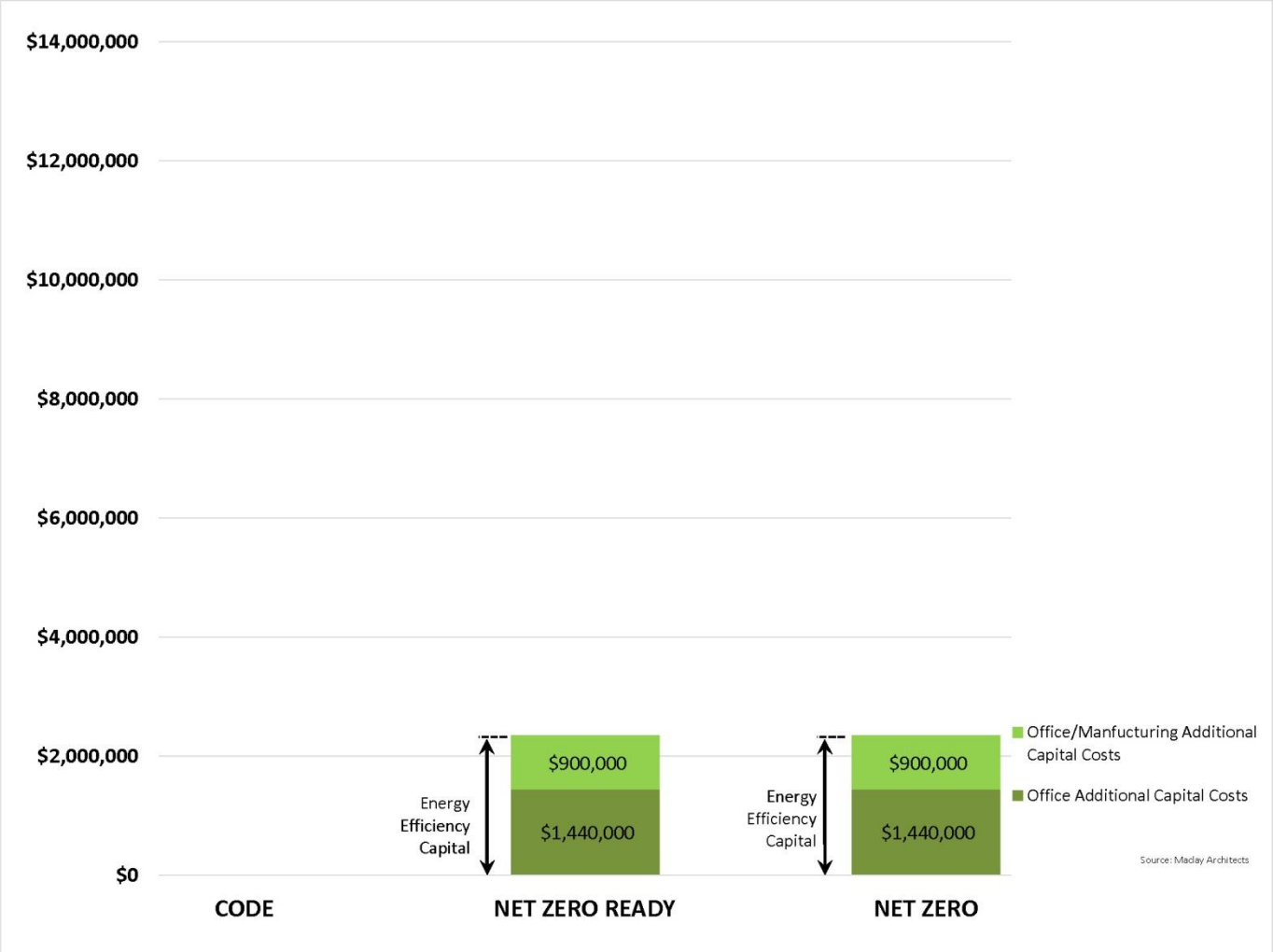


Figure 7.14: Cumulative community residential 30 year capital, operating and finance costs

Community

Commercial 20-Year Costs

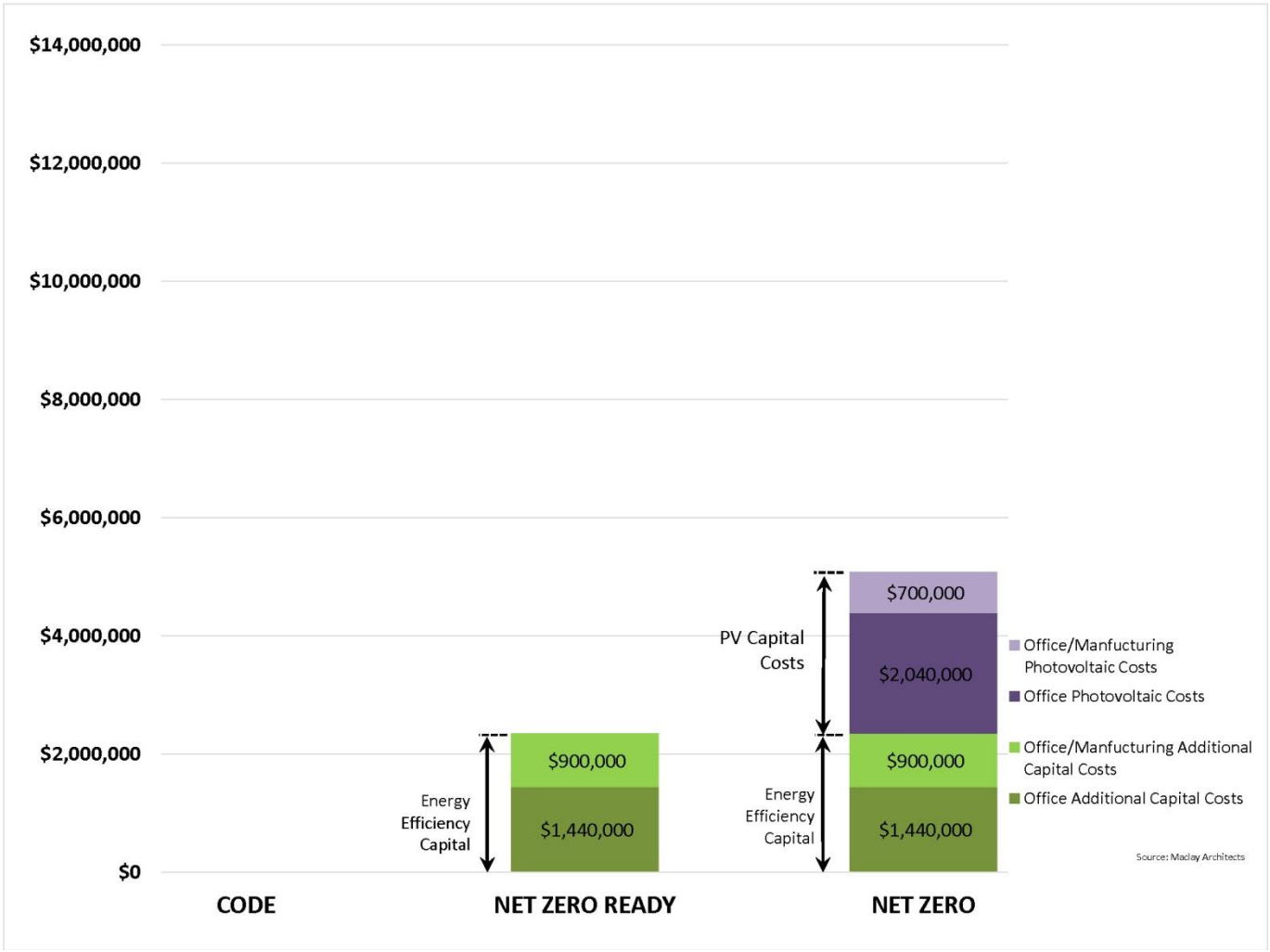
- Energy efficiency capital costs



Community

Commercial 20-Year Costs

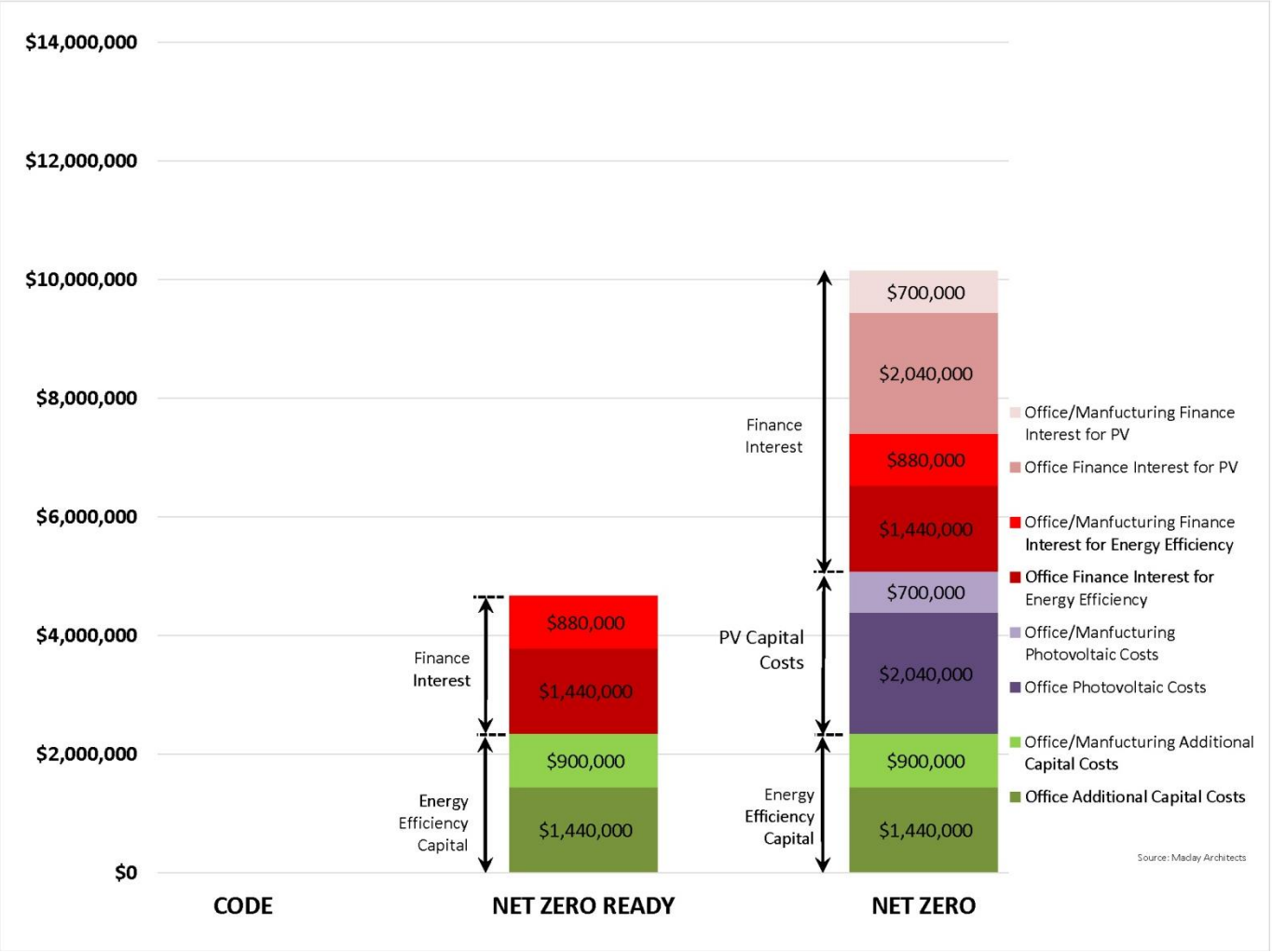
- PV capital costs



Community

Commercial 20-Year Costs

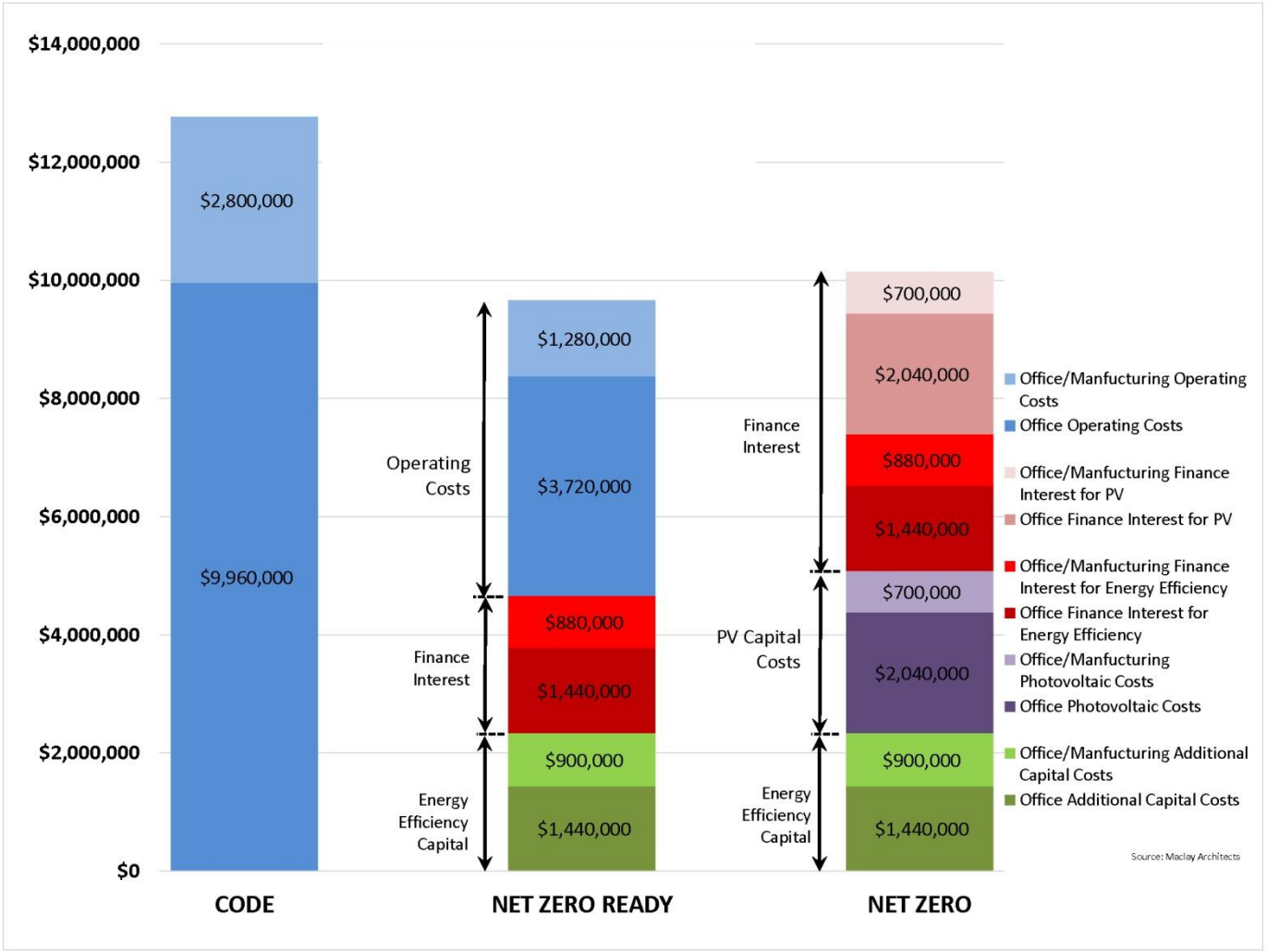
- Finance interest



Community

Commercial 20-Year Costs

- Operating costs



Community

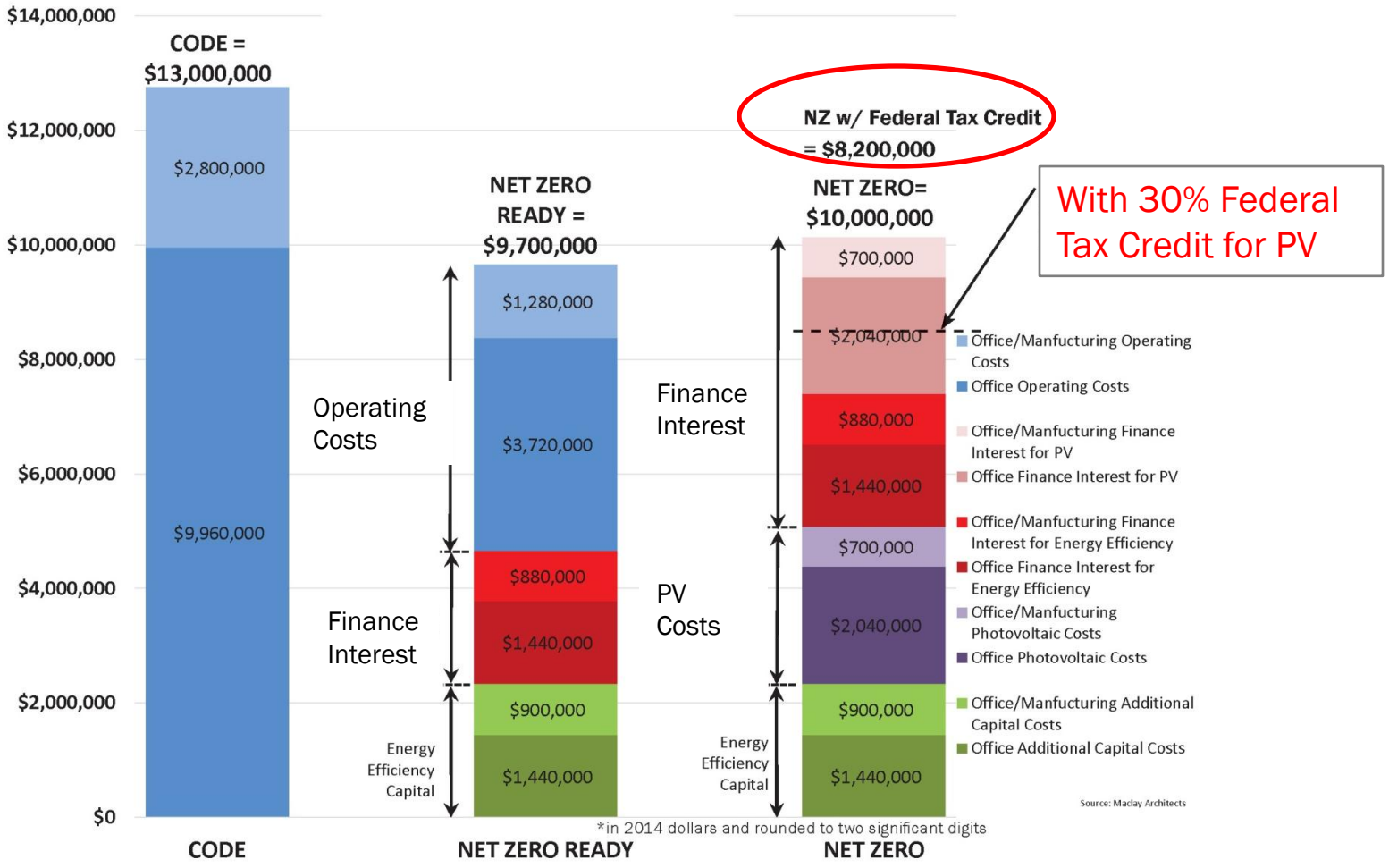
Commercial 20-Year Costs

- NZR commercial buildings saves $3.3 million over 20 years

Community

Commercial 20-Year Costs

- NZ with the federal tax credit saves $4.8 million over 20 years



Community

Saves over $8 million in 30 years

Outcome –
Net Zero is Cost Effective

- Building Type is a factor

Outcome –
Net Zero is Cost Effective

- Building Type is a factor
- Financing is a factor

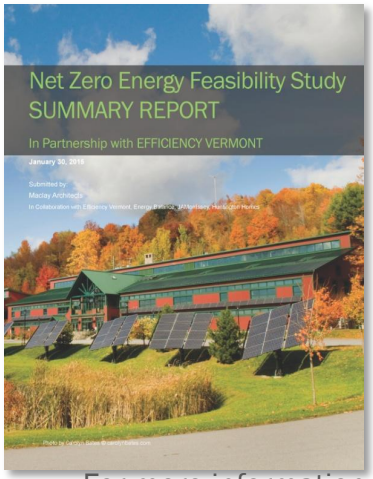
Outcome –
Net Zero is Cost Effective

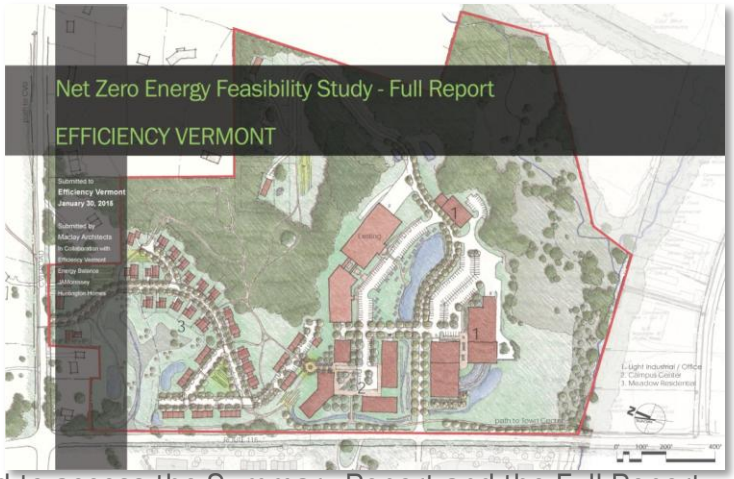
- Building Type is a factor
- Financing is a factor
- Rebates and incentives are a factor

Implement

- Net zero is cost effective today
- Design to net zero standards
- Look at financing options
- Build net zero projects and communities

Share the Feasibility Study:





For more information and to access the Summary Report and the Full Report contact: laura@maclayarchitects.com

Bennington Superior Courthouse and State Office Building

Bennington Superior Courthouse and State Office Building

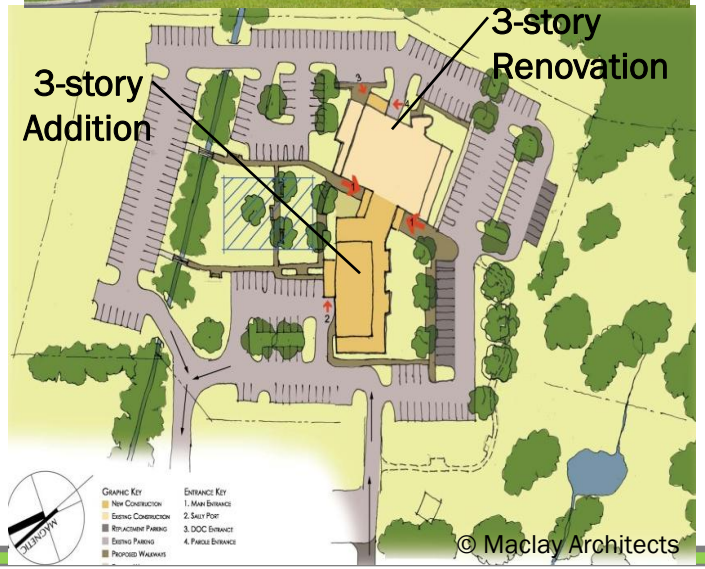
Integrated Building design
- -massing
- -orientation

New Option: Surface Area Reduction: 31% on 5 sides
45% on 6 sides

Cost: No increased cost

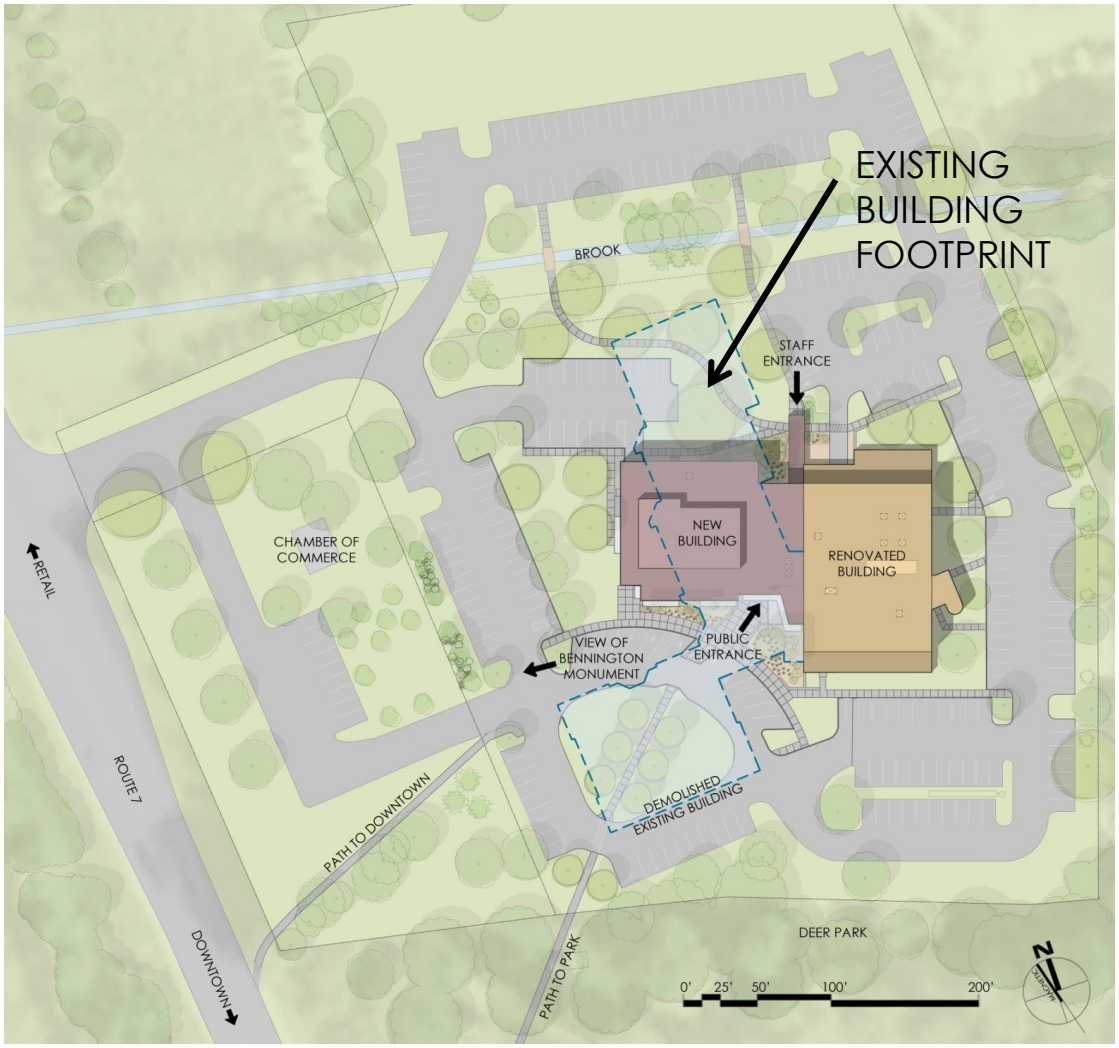
Massing Savings: Infinite Return on Investment

Existing Building



Renovated Building

Bennington Superior Courthouse and State Office Building



Bennington Superior Courthouse and State Office Building

Project Goals and Metrics

Energy Usage Intensity Comparison

		Net Zero Ready (modeled as built)	Code Compliant	Existing Facility	EIA National Ave. Existing Office
EUI	**kBtu/sf-yr**	24	39	113	92
		Percent better than existing EUI:			
		79%	66%	0%	

Source: Maclay Architects' File "BldgEnergyFinance"

Bennington Superior Courthouse and State Office Building

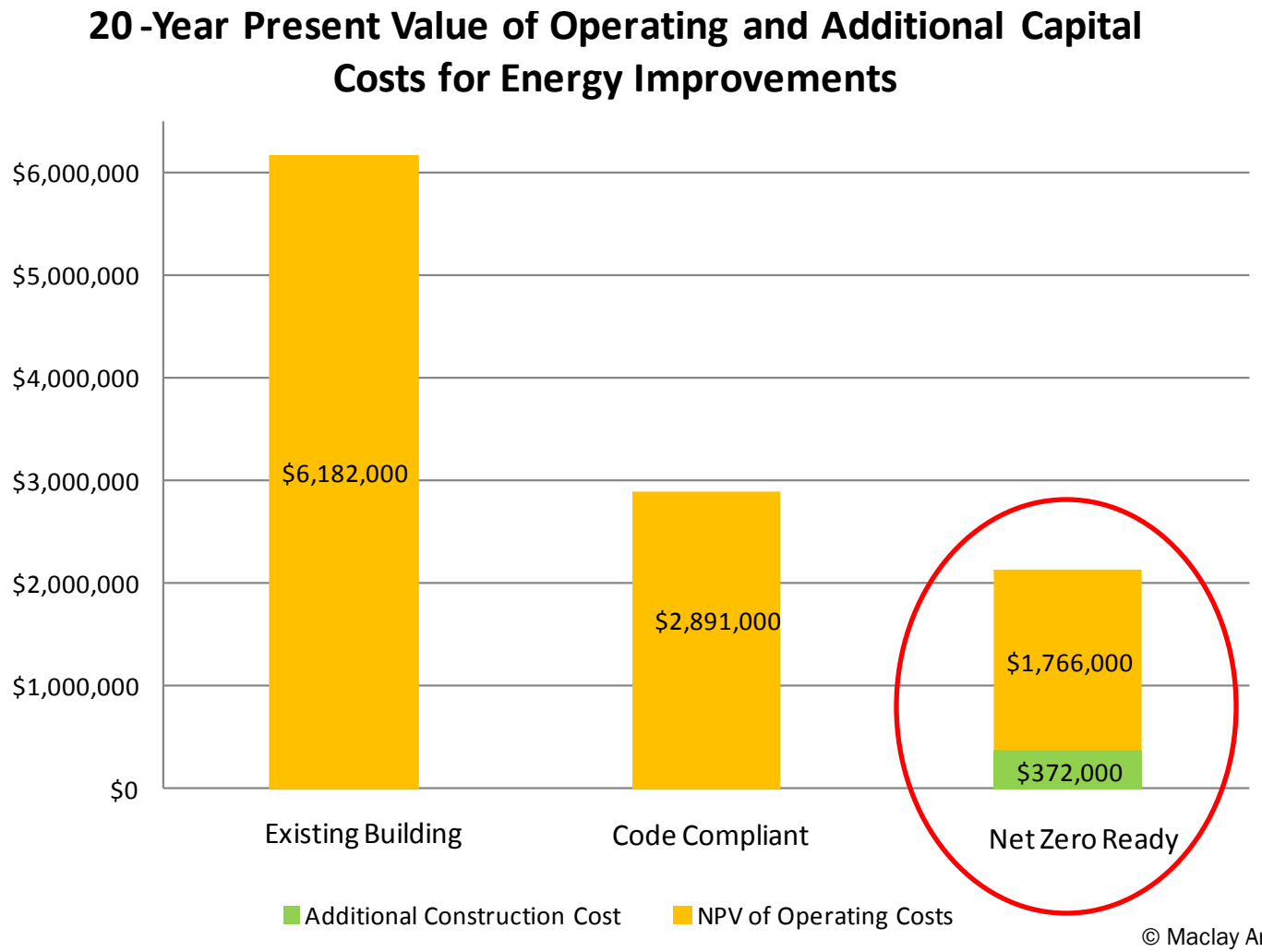
Cost Estimate

	Building Component	1. Code Compliant Building	2. Net Zero Ready building/GSHP	Added Cost	Added Cost
Envelope	Windows	Double-glazed windows	Triple-glazed windows	$30,557	$209,097
	Air/Vapor Barrier	Vapor barrier only	Combined air barrier and drainage plane	$39,000	
	Insulation	Install 2" of rigid insulation under slabs	Install 4" of rigid insulation on exterior face of wall framing	$32,500	
		Install 3" of rigid insulation on exterior face of wall framing	Install 4" of rigid insulation under slabs	$22,500	
		Insulate seismic joint between new and existing wings to to R-9	Insulate seismic joint between new and existing wings to maximum R-value	$22,500	
		Standard detailing of steel support for exterior sun shades	Custom detailing of steel support for exterior sun shades to minimize thermal bridging	$8,000	
		Standard detailing of steel relieving angles for brick veneer	Custom detailing of steel relieving angles for brick veneer to minimize thermal bridging	$14,000	
		6" isocyanurate on the roof	9" minimum isocyanurate on the roof	$40,040	
Mechanical	Commissioning	NA	Full envelope commissioning & blower door testing	$27,000	$163,000
	Solar Hot Water	Not a required system	Solar Hot Water System installed	$31,000	
	HVAC	Standard HVAC Replacement	High-efficiency Ground Source Heat Pump HVAC replacement	$105,000	
				Total Added Cost	**$372,097**
				Added Envelope Cost Per Square Foot	$3.22
				Added Mechanical Cost Per Square Foot	$2.51
				Total Added Cost Per Square Foot	**$5.72**
				Total Added Cost As A Percentage Of Total Construction Cost	**2.76%**

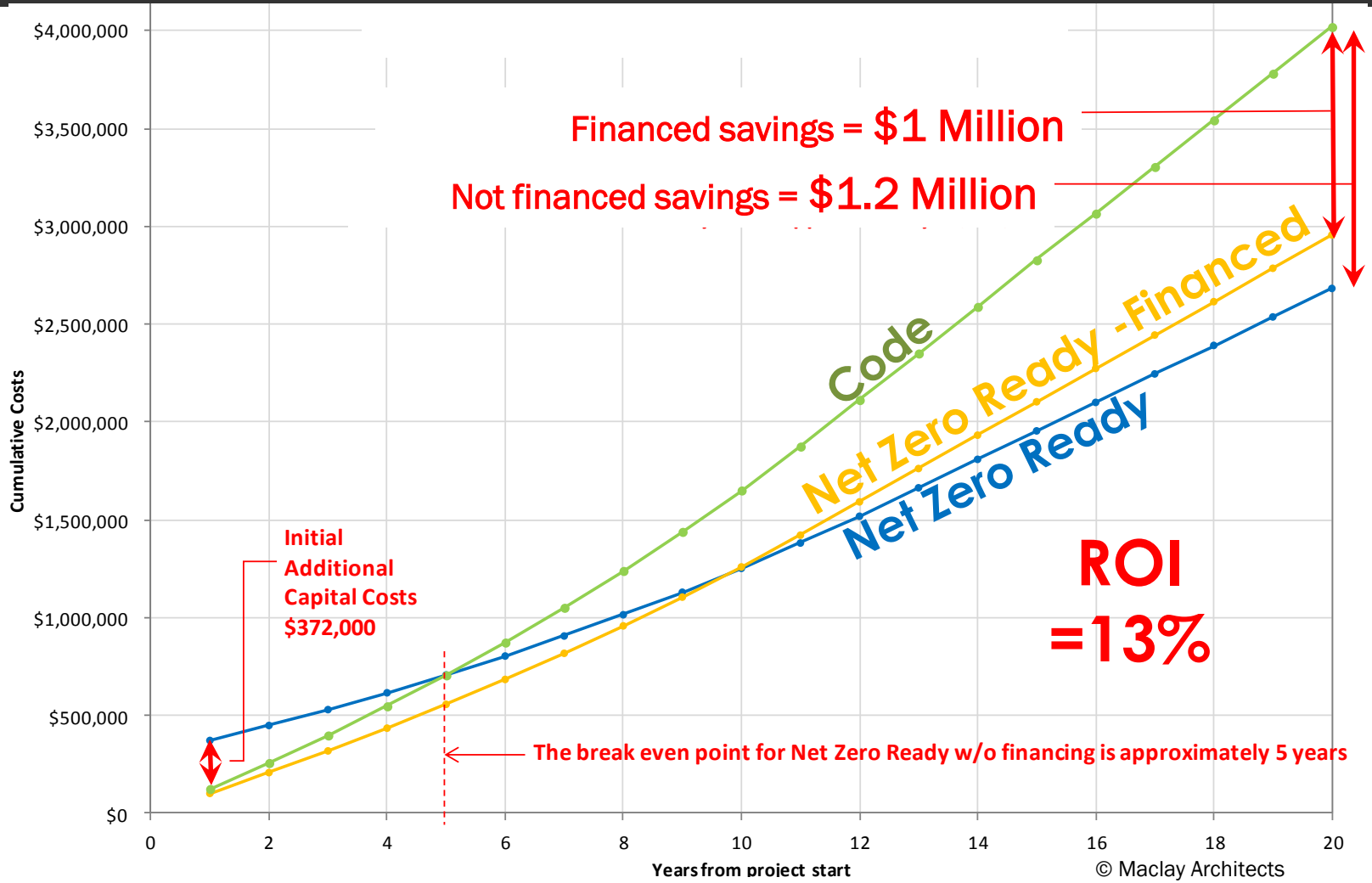
Source: Maclay Architects' File "BldgEnergyFinance"

Bennington Superior Courthouse and State Office Building

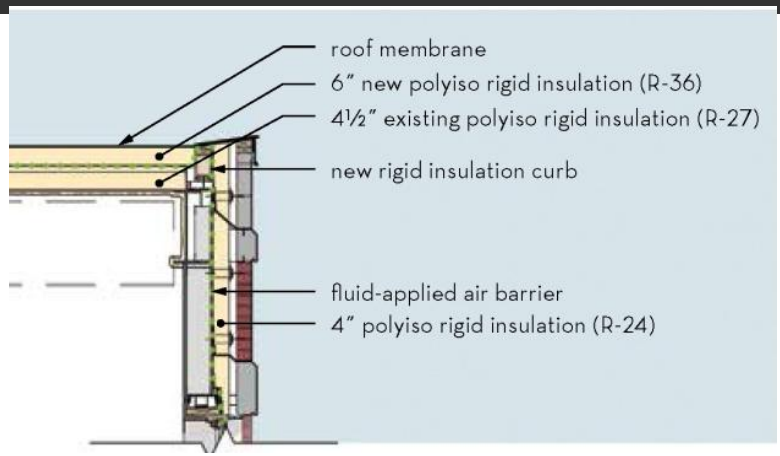
Financial Analysis

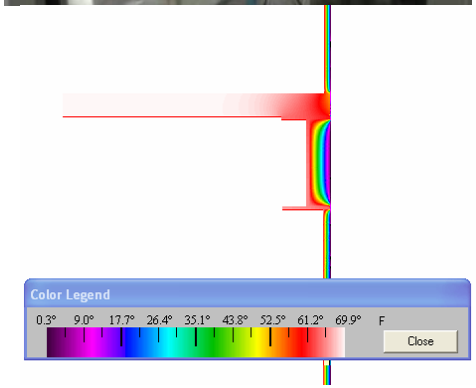


Bennington Superior Courthouse and State Office Building



Bennington Superior Courthouse and State Office Building





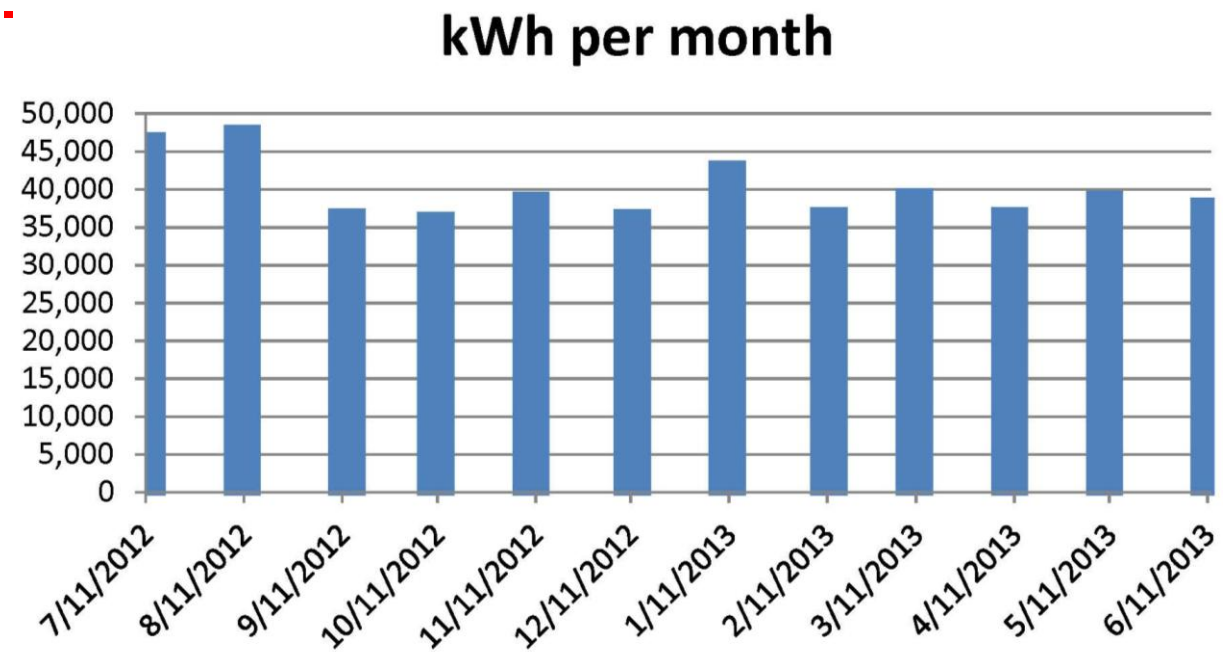
Bennington Superior Courthouse and State Office Building

Actual Energy Data

July 2012-June 2013 = 459,052 kWh and 1,084 gallons of propane

Total = 1,664,715 kBtu/year

EUI = 25.6 kBtu/sf-



Future steps: Propane converts to electric and becomes net zero with a 20 yr PPA

Bennington Superior Courthouse and State Office Building

TEAM MEMBERS

OWNER TEAM

State of Vermont
- Mike “Obie” Obuchowski, BGS Comissioner
- Dave Burley, P.E. BGS Director, Facilities Operations -- West Region
- Peter Hack, P.E. BGS Project Engineer
- Mike McArdle, P.E. BGS Mechanical Engineer
- Debra M. Baslow, BGS Environmental Engineer
- Bob Greemore, Vermont Court Administrator

Clerk of the Works
- Zollie Horvath, LLC Construction Consultant

CONSTRUCTION TEAM

DEW Construction Corporation, General Contractor
- Jeff Davis, Executive Management
- Rich Leclerc, Project Manager
- Jon Lamb, Superintendent

Electrical Contractor
- F.H. Hamblet Inc.

Plumbing & HVAC
- Thomas Mechanical Inc.

Structural Steel Supplier / Erector
- Reliance Steel, Inc.

Masonry Contractor
- Moulton Masonry & Construction

Millwork
- Amoskeag Woodworking

DESIGN TEAM

Maclay Architects
- Bill Maclay, Principal
- Bill Gallup, Project Manager
- Cam Featherstonhaugh, Job Captain

Ricci Greene Associates, Court Design Consultant
- Ryan Critchfield

Energy Balance, Energy Consultant
- Andy Shapiro

Kohler Lewis, Mechanical and Plumbing Engineers
- Joe Kohler
- Roy Swain
- Dan Lewis
- Adam Kohler

Haley & Aldrich, Geo-thermal Engineers
- John Berry

EDM Services, Inc., Electrical Engineers
- Al Marino

Engineering Ventures, Inc., Structural Engineers
- David Boehm

Engineering Ventures, Inc., Civil Engineers
- Kevin Worden

Chase Engineering, Fire Protection Engineer
- Matt Chase

Cx Associates, Commissioning Consultants
- Jennifer Chiodo
- Matt Napolitan

DEW Construction Corporation, Cost Consultant
- Scott Carter

Proctor Academy Dining Hall

- 16,000 sf dining hall
- 350 seats
- Net Zero

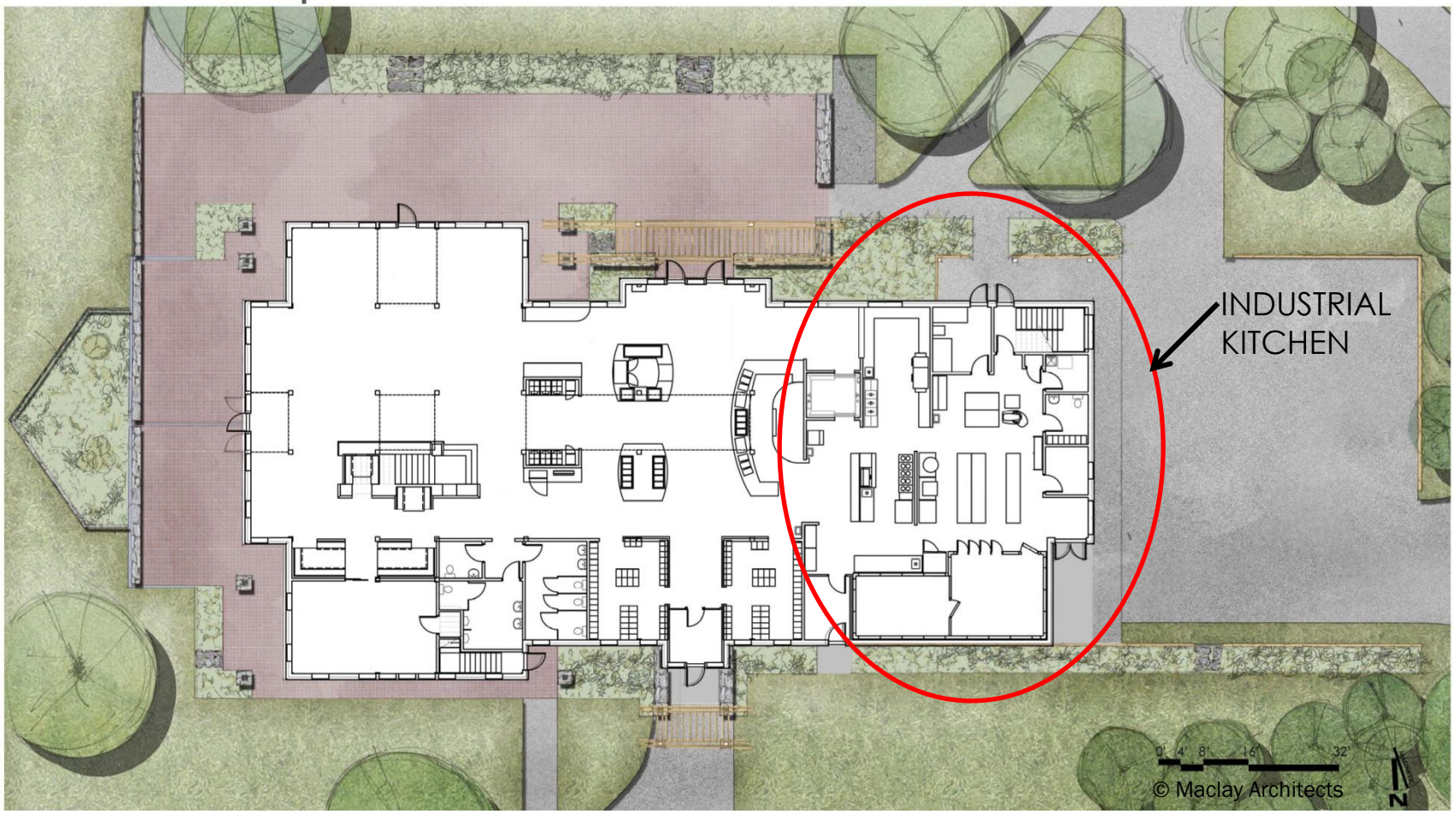
View from entry drive

Proctor Academy Dining Hall

- Building Section

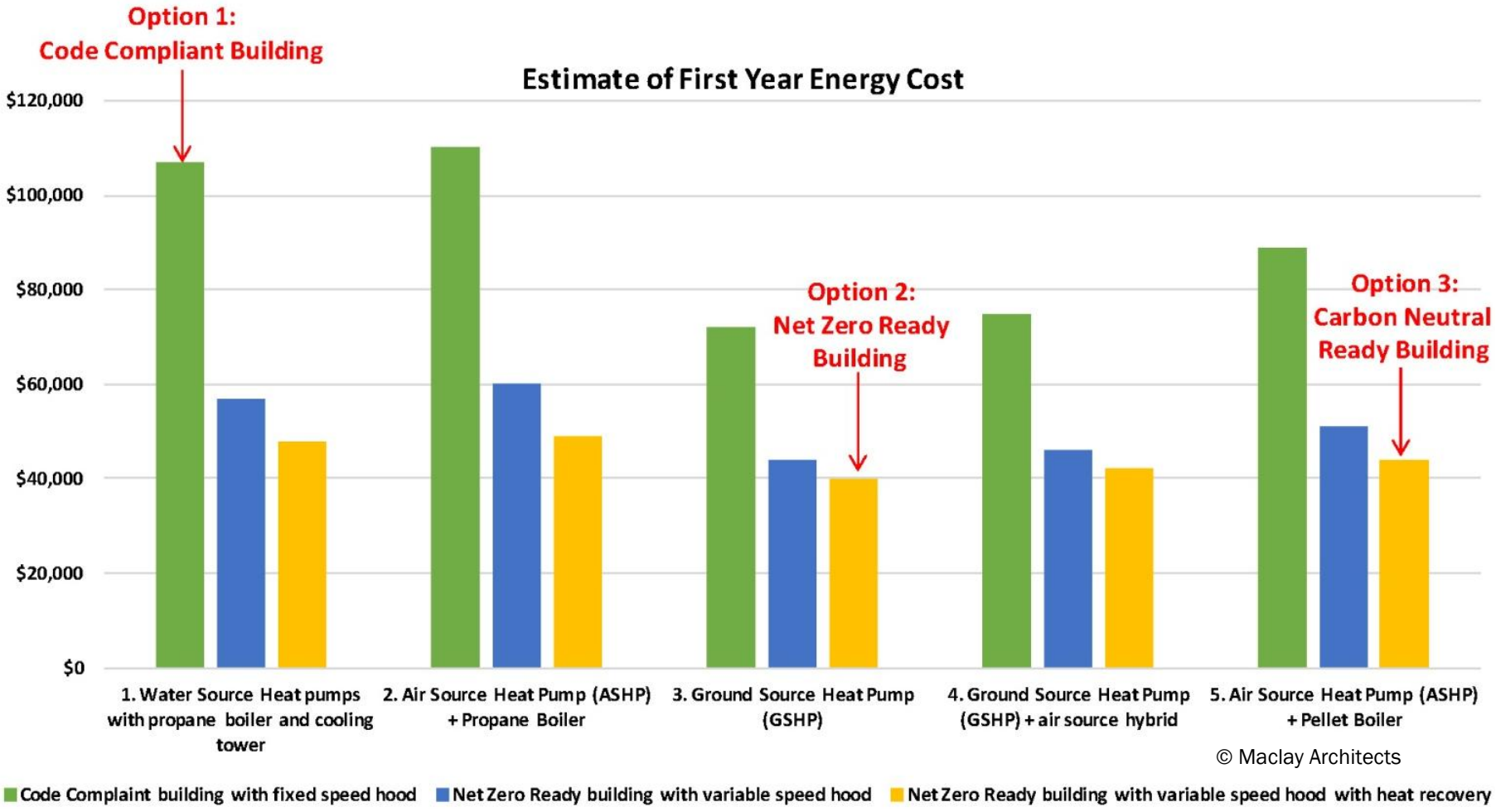
Proctor Academy Dining Hall

- First floor plan



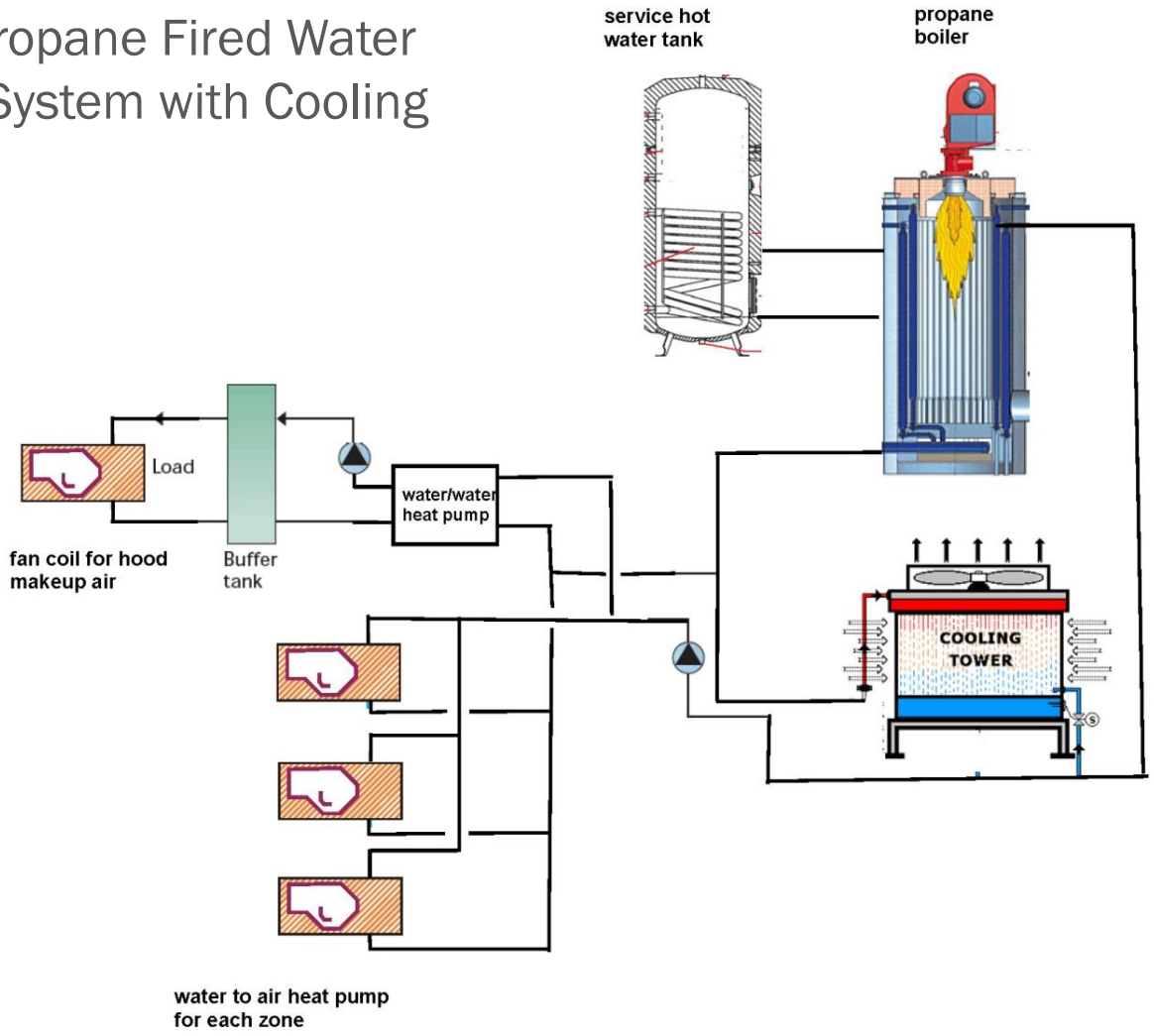
Proctor Academy Dining Hall

- 5 Mechanical systems + 3 kitchen hood options



Proctor Academy Dining Hall

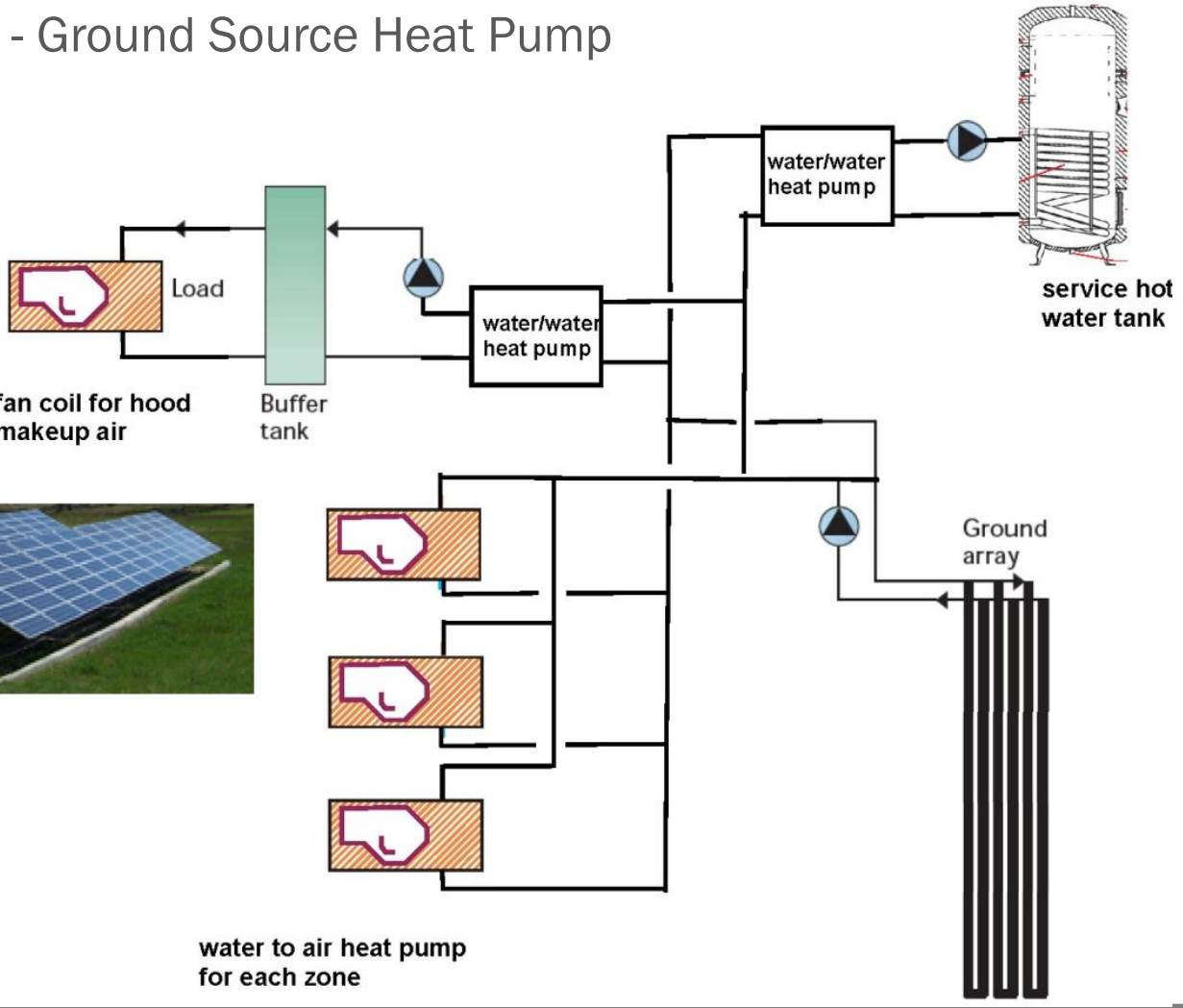
- OPTION 1: CODE - Propane Fired Water Source Heat Pump System with Cooling Tower



Proctor Academy Dining Hall

- OPTION 2: NET ZERO - Ground Source Heat Pump

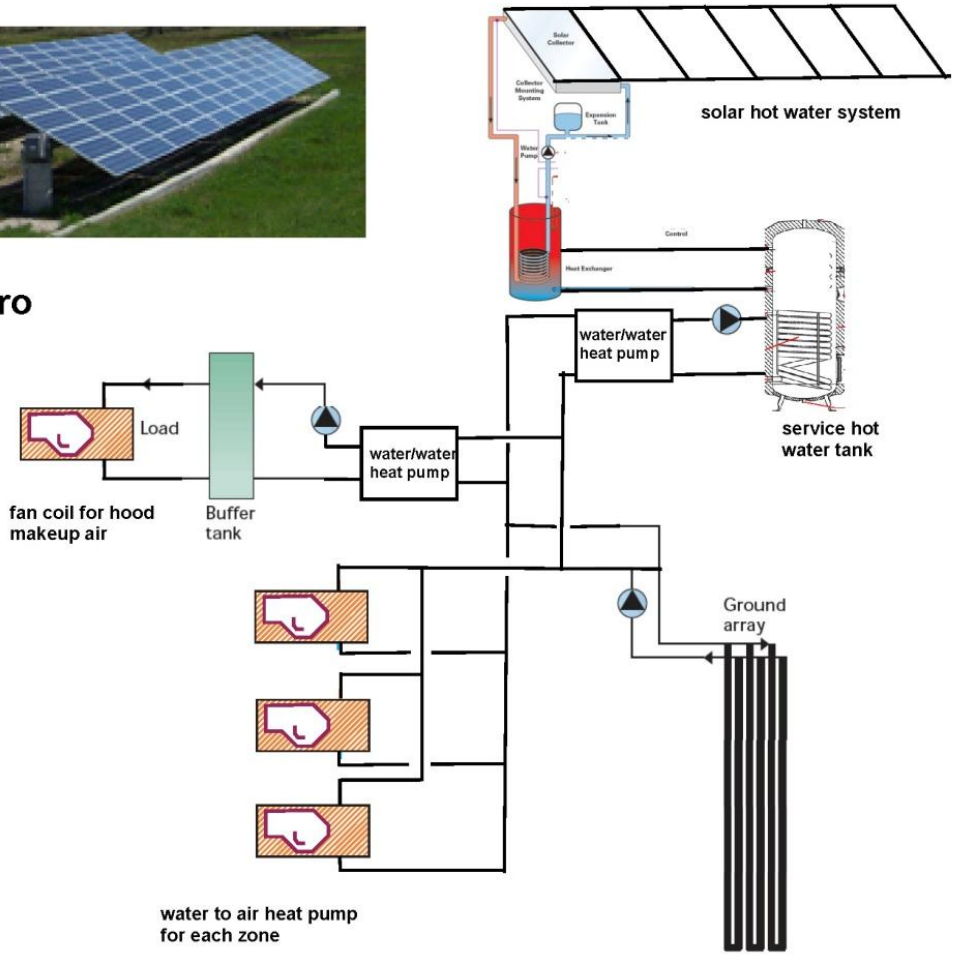
large PV array to go Net Zero



Proctor Academy Dining Hall

- OPTION 2b: NET ZERO Ground Source Heat Pump + Solar Hot Water

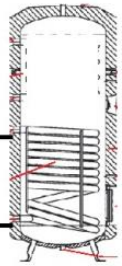
large PV array to go Net Zero



Proctor Academy Dining Hall

- OPTION 3: CARBON NEUTRAL - Air Source Heat Pump + Pellet Boiler

PV array for electric loads



service hot water tank

fan coil for hood makeup air

air to air heat pump with indoor unit for each zone

Pellet boiler and outdoor pellet silo

Proctor Academy Dining Hall

- EUI comparison

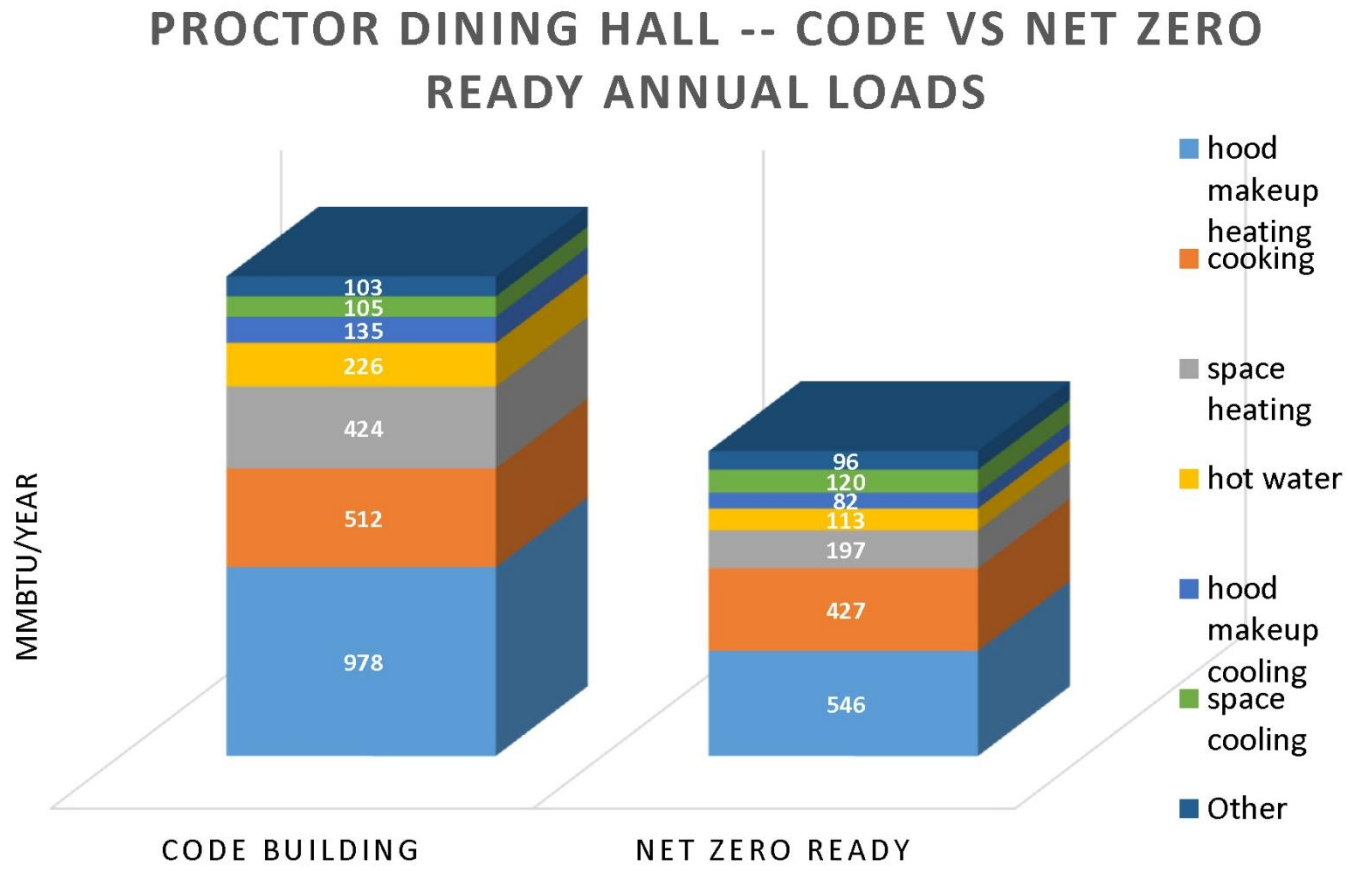
Energy Usage Intensity Comparison

		Code OPTION 1	Net Zero OPTION 2	Carbon Neutral OPTION 3	TYPICAL EXISTING Restaurant/ Cafeteria
EUI	**kBtu/sf-yr**	220	53	87	207
		Percent better than typical existing EUI:			
		-6%	74%	58%	

Source: Maclay Architects' File "BldgEnergyFinance"

Proctor Academy Dining Hall

- Energy Use



Proctor Academy Dining Hall

- Comparative cost analysis during Schematic Design for mechanical systems
- Option 1: Code v. Option 2: Net Zero Ready

Building Component	1. Code Compliant Building	2. Net Zero Ready building/GSHP	Added Cost
Windows	double glazed argon filled Marvin Ultimate Windows	triple glazed argon filled Marvin Ultimate Windows	
Air/Vapor Barrier	Infiltration is 0.2 CFM50/sf	Infiltration is 0.1 CFM50/sf	
Insulation	Walls: R-20 cavity insulation	Walls: R-40	
	Roof: R-49	Roof: R-60	
			$95,153
Kitchen	Convential Kitchen with fixed speed exhaust hood	All electric kitchen with variable speed heat recovery hood	$59,550
Commissioning	Envelope and Mechanical Systems	Envelope and Mechanical Systems	-
Solar Hot Water	None	Included	$60,000
HVAC	Water Source Heat Pump with propane boiler and cooling tower	Ground Source Heat Pump (GSHP)	$412,654
		Total Added Cost	**$627,357**
		Added Envelope Cost Per Square Foot	**$6.29**
		Total Added Cost Per Square Foot	**$41.46**
		Total Added Cost As A Percentage Of Total Construction Cost	**16.70%**

Source: Maclay Architects' File "BldgEnergyFinance"

Proctor Academy Dining Hall

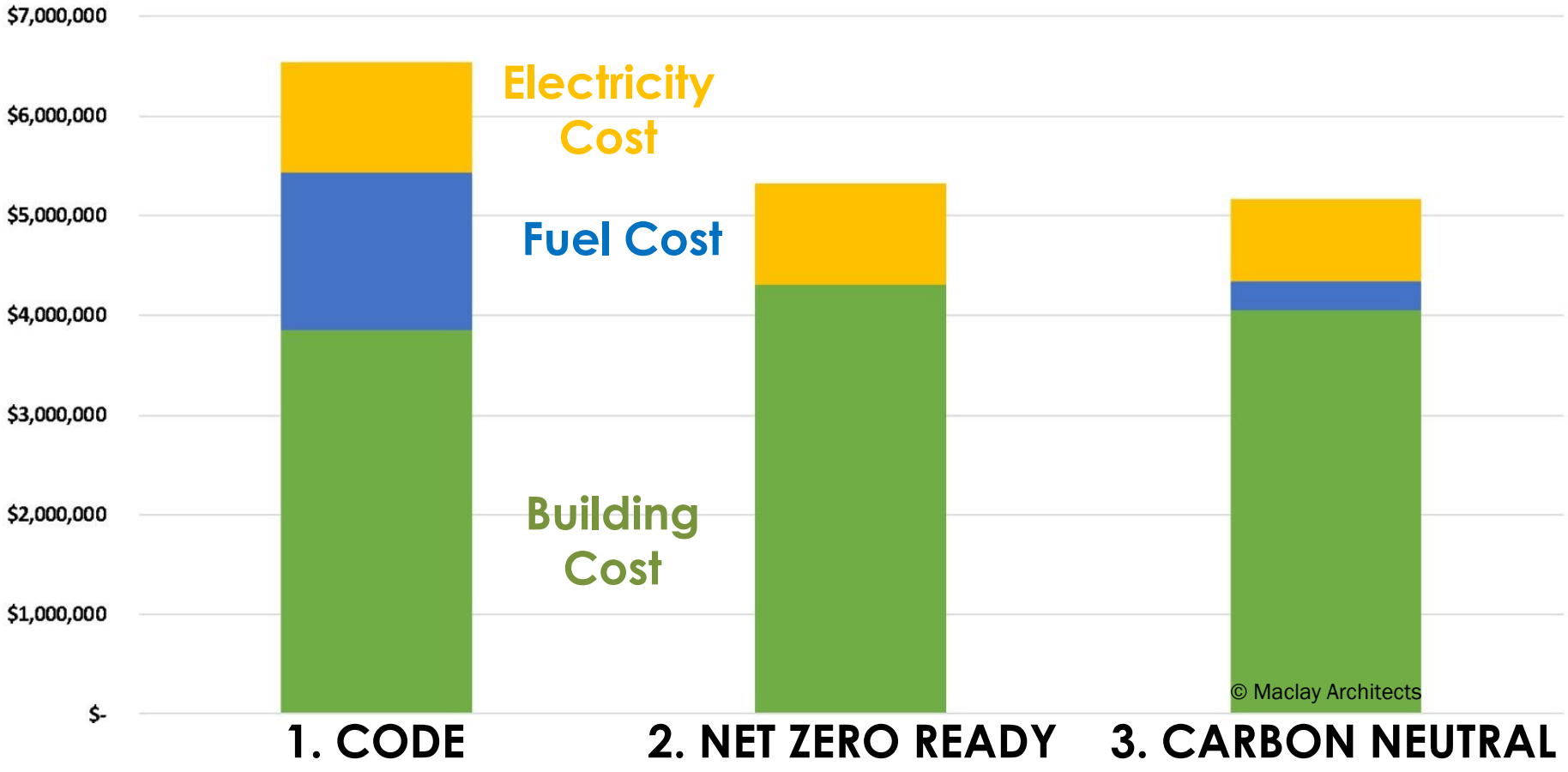
- Comparative cost analysis during Schematic Design for mechanical systems
- Option 1: Code v. Option 3: Carbon Neutral

Building Component	1. Code Compliant Building	3. Carbon Neutral Ready Building/ ASHP + Pellet Boiler	Added Cost
Windows	double glazed argon filled Marvin Ultimate Windows	triple glazed argon filled Marvin Ultimate Windows	
Air/Vapor Barrier	Infiltration is 0.2 CFM50/sf	Infiltration is 0.1 CFM50/sf	
Insulation	Walls: R-20 cavity insulation	Walls: R-40	
	Roof: R-49	Roof: R-60	
			$95,153
Kitchen	Convential Kitchen with fixed speed exhaust hood	All electric kitchen with variable speed heat recovery hood	$59,550
Commissioning	Envelope and Mechanical Systems	Envelope and Mechanical Systems	-
Solar Hot Water	None	Included	$60,000
HVAC	Water Source Heat Pump with propane boiler and cooling tower	Ground Source Heat Pump (GSHP)	$155,074
		Total Added Cost	**$369,777**
		Added Envelope Cost Per Square Foot	**$6.29**
		Total Added Cost Per Square Foot	**$24.44**
		Total Added Cost As A Percentage Of Total Construction Cost	**9.84%**

Source: Maclay Architects' File "BldgEnergyFinance"

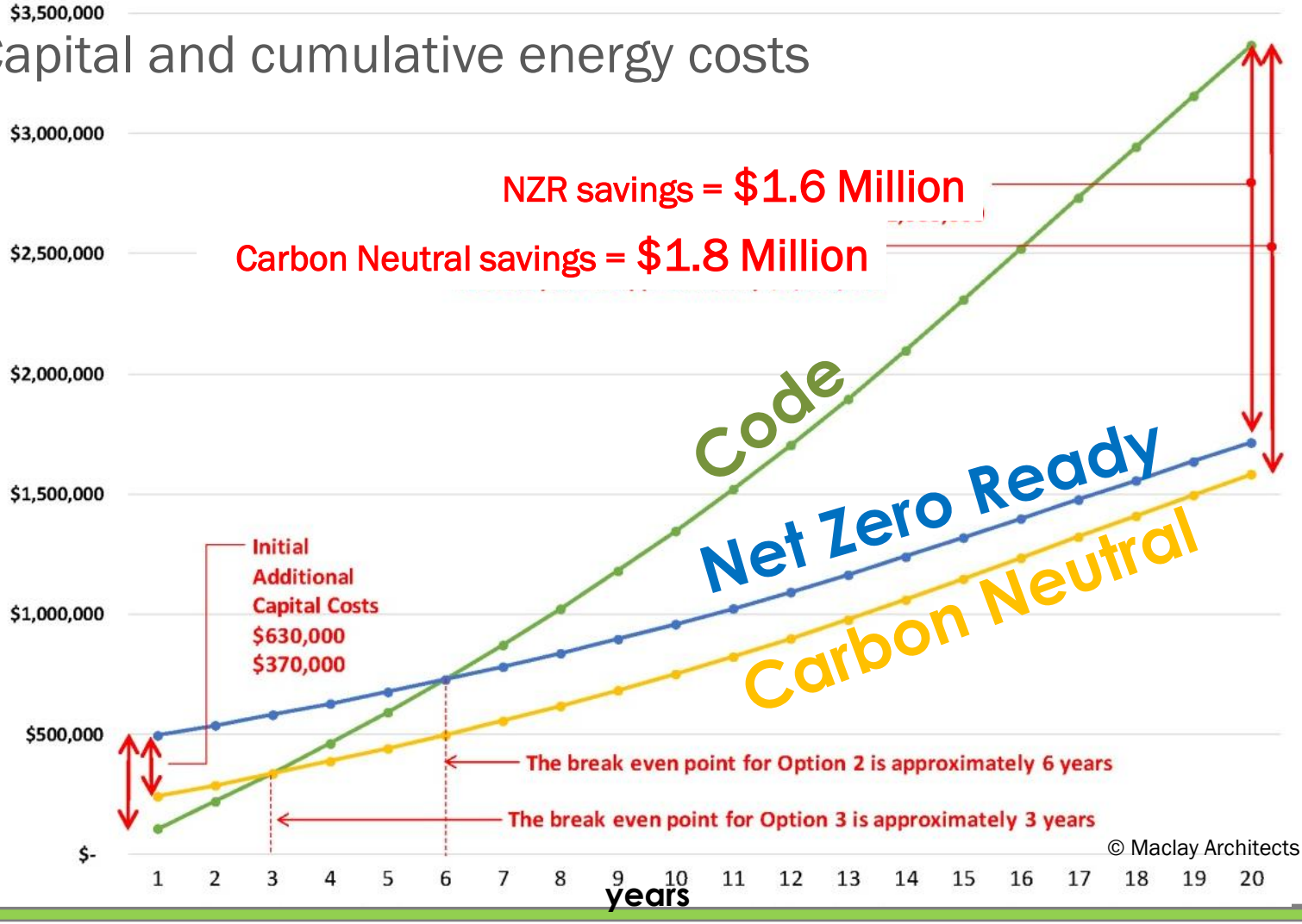
Proctor Academy Dining Hall

- 20-year construction and energy costs



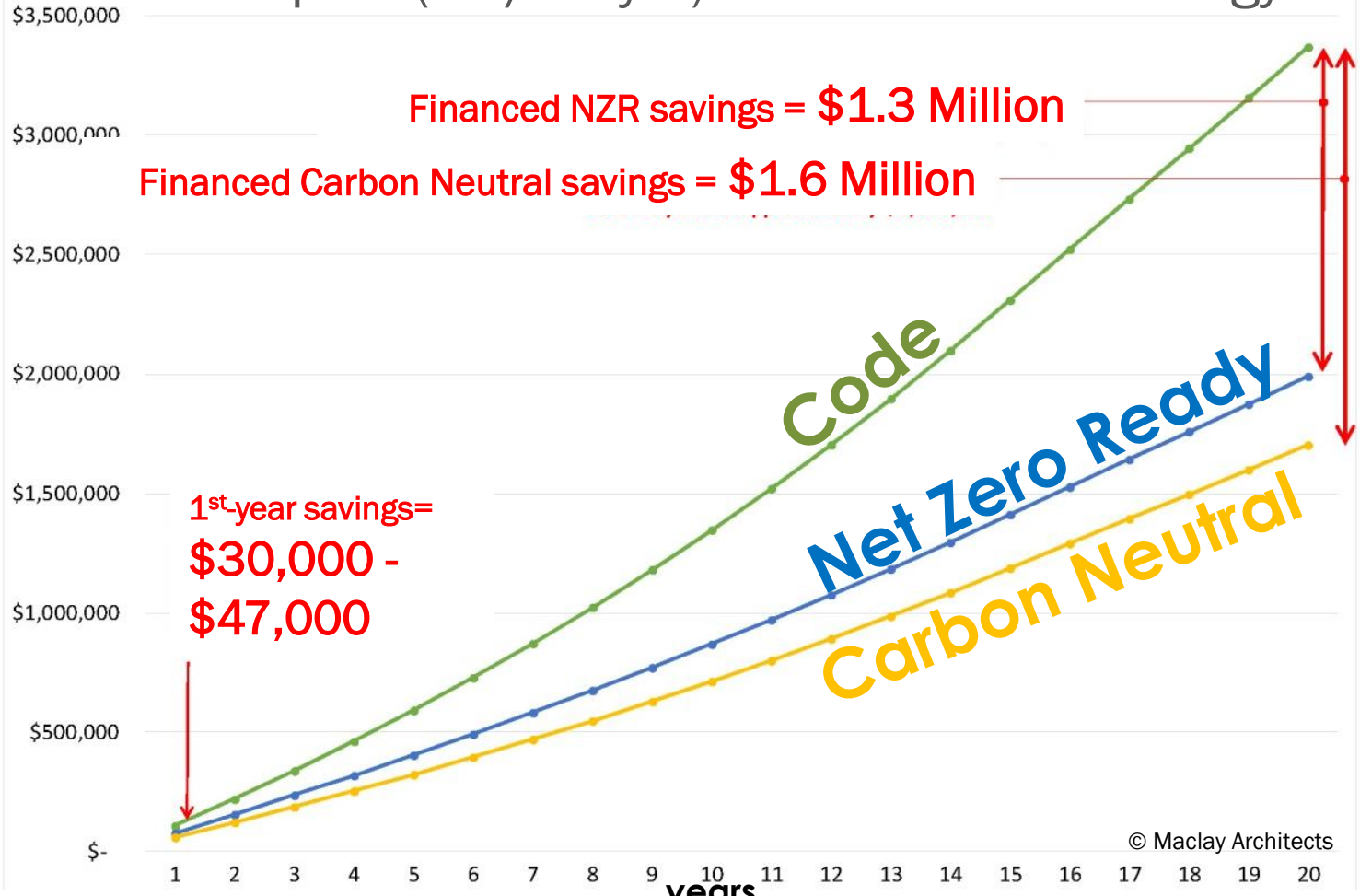
Proctor Academy Dining Hall

- Capital and cumulative energy costs



Proctor Academy Dining Hall

- Financed capital (5%/20 yrs) and cumulative energy costs



Proctor Academy Dining Hall

- Next Steps:
  - Add renewable energy on adjacent site
    - 200 kW PV system needed
    - PPA and retain RECs

Net Zero is the Best Investment Today

- $6-17/sf additional cost
- Heat Pumps
- Renewables
- Health and Beauty
- ALL COMBINE FOR POSITIVE RETURN ON INVESTMENT

MaclayArchitects
CHOICES IN SUSTAINABILITY

This concludes The American Institute of Architects
Continuing Education Systems Course

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NORTHEAST SUSTAINABLE ENERGY ASSOCIATION