

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. CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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

This course is registered with AIA

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.

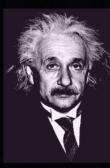
Making the Financial Case for Net Zero

BuildingEnergy 15

"Cropped Earth with Sunburst" by NASA

We shape our buildings; thereafter they shape us. -Winston Churchill





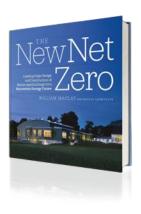
"The world we have created today as a result of our thinking thus far has problems that cannot be solved by thinking the way we thought when we created them."

-Albert Einstein



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

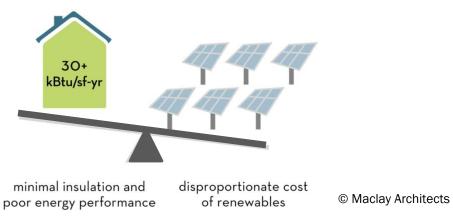


RENEWABLE ENERGY LABORATORY

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?





Key Elements to Achieve Net Zero

Conservation +

ר (

High-Efficient + Renewables Systems



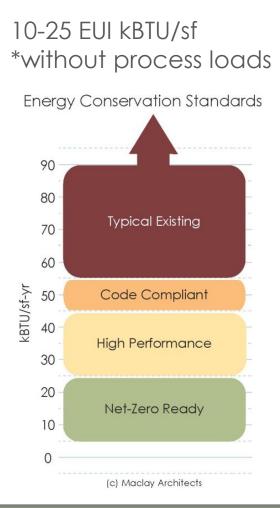


Usually Photovoltaics (sized for annual load)

Heat Pumps (COP 2.3-3.0)

Net Zero Building Metrics

Performance Metrics



R-60 R-5 Windows 14940496 <u>R-20</u>

Prescriptive Measures

NET ZERO READY

0.1 cfm50/sf above grade surface area@ 50 Pascals

NET ZERO Add renewables

Climate Change









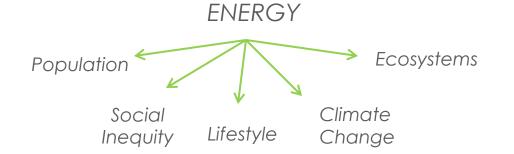




Why is Net Zero Important?





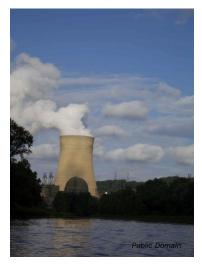




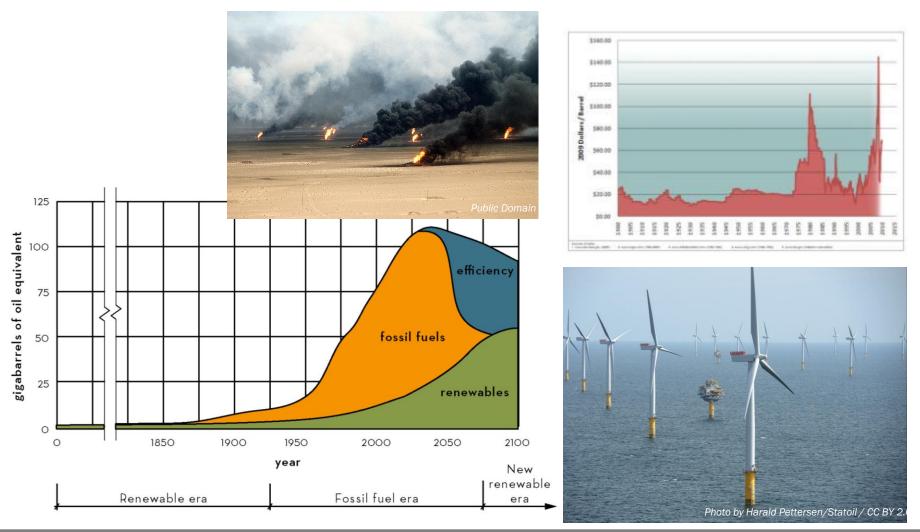








Energy Transition: Net Zero is the Least Operating Cost Today



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 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 Net Zero Related Programs

High Performance Homes

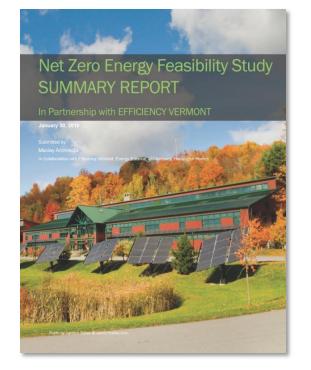
- Prescriptive: R-30/40/60, ≤1ACH50, Energy Star, HRV, etc.
- Efficiency Vermont provides incentives and technical assistance

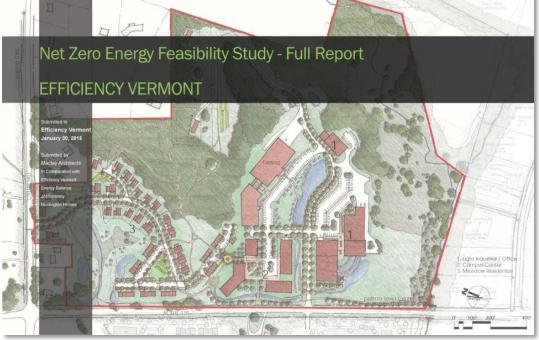
Deep Energy Retrofit Pilot (R&D for 2015 only)

- 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



Net Zero Energy Feasibility Study





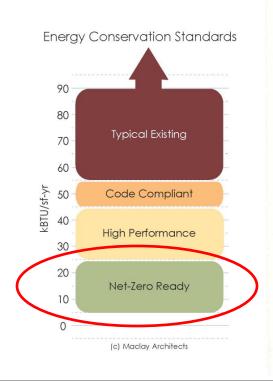
In partnership with

MaclayArchitects CHOICES IN SUSTAINABILITY

Energy Balance, Inc. Efficiency Vermont

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

T

11-4

M

T

• 214,000 sf proposed office and office/manufacturing

~ U

M

T

IT



1. Light Industrial / Office 2. Campus Center 3. Meadow Residenfia





Building Overview

Six typical new construction buildings were analyzed

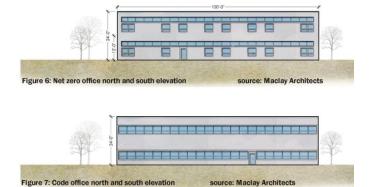
- •Single Family
- •Multifamily Duplex
- •Multifamily Quadplex
- •Office Open
- •Office Closed
- Office/Manufacturing

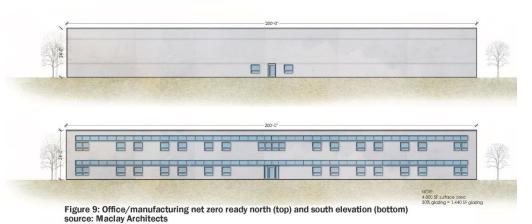


Figure 3: Residential single family home source: Huntington Homes



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

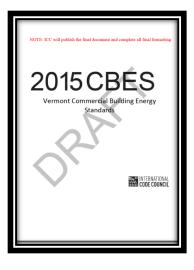


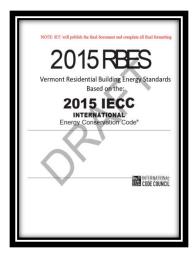


Code Standard

- 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

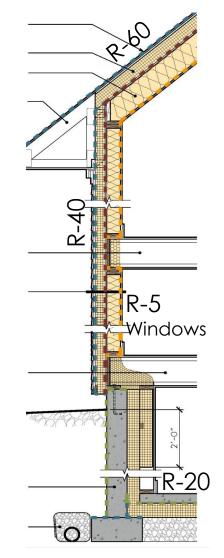




Net Zero Ready Standard

• 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



INPUTS

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

3	A Cut	Calibri	• 11 • A *		P- ∰Wap	Text	Number	- 1	e Can	vre 2 Ci	imency 2	Nernal 2	- 3	- 🛪 🔟	X Adalam -	- A
ele	-ia Crev	8/2	- B + A + A +		R (R 🖃 Merg	e & Center -	8 - % + 1	14 4% Can	Itenal Format Nor	mal Re	d	Good	1 20	of Delete Formal	2 Cear - Filter	& Find &
	lipboard		Fort 5		Alignment		Natiber			Styles				Cells	Editing	· 28.84
Sec.	ally Marring	Automatic update a	d links has been cloable	a Cations												
	14	• (*)	AD4/D4													
	M	N	0	P	O R	c	т	U	v	W	AA	AB	AC	AD	AE	AI AG
	141		0	,		erev Con	sumed (effic		sumed in model		101	740	PRV	no	76,	FINANCE
											_					
T	otal EUI							Electric	Electric ASHP					Total kBTU of	watts	Loan Payr
0	wh/s.	EPA Median			Electric	Electric		ASHP	included in total		Propan	Propane		all energy	required to	per year n
2 11	n-yr)	Site EUI			(kWh)	kBTU	Source:	(kWh)	kBTU	Source:	e (gal)	kBTU	Source:	sources	be Net Zero	solar
3	195	52.9			4463	15228	E10 Model	0	0.0000	E 10 Model	926	84865.7	E 10 Model	100094		5
4	60	52.9			6538		E10 Model	2406		E 10 Model	0		E 10 Model	30517		\$1,5
5	203	77.6			4444		E10 Model	0		E 10 Model	623		E 10 Model	72260		1
6	75	77.6					E10 Model	1302		E 10 Model	0		E 10 Model	26687		\$95
7	176	77.6			4444		E10 Model	0		E 10 Model			E 10 Model	62637		
3	70	77.6			6269	21391	E10 Model	1043	3560.4935	E 10 Model	0	0	E 10 Model	24951	6359	\$8
9		*CBECS 2009	Chart 2.1.10													
0																
1																
12																
3																
4																
6																
7					Total En		rumed from	Summanı	Spreadsheet							
					TOTAL CI	city con			Electric ASHP					Total kBTU of	watts	
						Electric			included in tota			Propane		all energy	required to	Loan Pave
8		Fuel -Solar Pla	teau for Fossil F	Fuels	0	kBTU	Source:	(kWh)	kBTU	Source:	0	kBTU	Source:	sources	be Net Zero	Opt A per
			w/													
		w/out	efficiencies													
		efficiencies of	of heat													
9		heat source	source		4463	15228	E10 Model	0	0.0000	E 10 Model	925		E 10 Model	100002		1
0		0.309	0.134		6538		E10 Model	2406		E 10 Model	0		E 10 Model	30517		1
1		12.324	6.304		4444		E10 Model	0		E 10 Model	646		E 10 Model	74368		1
2		8.301	4.246		6519		E10 Model	1302		E 10 Model	0		E 10 Model	26687	6801	1
3					4444		E10 Model	0		E 10 Model	537		E 10 Model	64378		
\$					6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	
5																
6									aws tot 2 com							

OUTCOMES

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

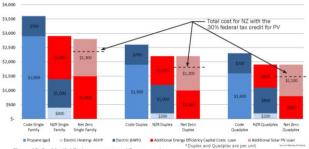


Figure 12: Residential first year energy and finance costs *Duplex and Qua *In 2014 dollars

Cumulative energy costs and financing costs for net zero ready residential buildings *in 2014 dollars \$140,000 Single Family Cumulative Savings of NZR above code - \$31, \$120.000 Duplex Cumulative Savings of NZR above code - \$20,00 \$100.000 £ \$80,000 \$40.000 \$20.000 20 25 Years NZR Single elex --- NZR Duplex --- Code Quadplex -- NZR Quadple Duplex and Quadplex are per

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

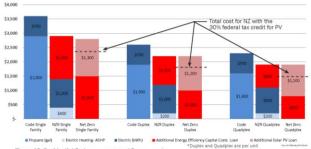
INPUTS

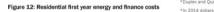
- Energy consumption
- Capital costs for energy efficiency
- Capital costs for PV
- Financing assumptions

r	A Cat	Calibri	• 11 • A *		P- SWip	Text	Number	- 1	e Com	vre 2 O	imency 2	Nernal 2	- B	- 🛪 🔟	X Autofum . A	C AB
e.t.	Tarmet P	B / U	• · · · · · · ·		R BR 3 Merg	e & Center -	8 - 16 +	14 28 Sand	Itenal Format Non	nal Bi	d	Good	2 20	of Delete Formal	2 Cear - Soft	& Field
	Clipboard		Fort 5		Alignment		Natiber			Styles				Cells	Editing	
	na ile Manine	Automatic sandates	d links has been disabl	a Defines												
	14		AD4/D4													
	M	N	0		O B		T	U	v	W	AA	AB	AC	AD	AF	AI AG
	101		0			erev Con	sumed leffic		sumed in model)		701	740	PR.	no	PR.	FINANCE
				Total cit	CIBY CON	James ferrie	circles of	onieu in nouei,		_					Therefore	
	Total EUI							Electric	Electric ASHP					Total kBTU of	watts	Loan Payr
	(kWh/s.	EPA Median			Electric	Electric		ASHP	included in total		Propan	Propane		all energy	required to	per year n
2	m-yr)	Site EUI			(kWb)	kBTU	Source:	(kWh)	kBTU	Source:	e (gal)	kBTU	Source:	sources	be Net Zero	solar
3	195	52.9			4463	15228	E10 Model	0	0.0000	E 10 Model	926	84865.7	E 10 Model	100094		5
4	60	52.9			6538	22309	E10 Model	2406	8208.4220	E 10 Model	0	0	E 10 Model	30517	7777	\$1,51
5	203	77.6			4444		E10 Model	0		E 10 Model	623		E 10 Model	72260		\$
6	75	77.6					E10 Model	1302		E 10 Model	0		E 10 Model	26687	6801	\$95
7	176	77.6			4444	15164	E10 Model	0		E 10 Model			E 10 Model	62637		1
3	70				6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	\$8
)		*CBECS 2009	Chart 2.1.10													
10																
11																
12																
3																
15																
6																
7					Total Fo	erev Con	sumed from	Summary	Spreadsheet							
									Electric ASHP					Total kBTU of	watts	
						Electric		ASHP	included in total			Propane		all energy	required to	Loan Payr
8		Fuel -Solar Pla	teau for Fossil	Fuels	0	kBTU	Source:	(kWh)	kBTU	Source:	0	kBTU	Source:	sources	be Net Zero	Opt A per
			w/													
		w/out	efficiencies													
		efficiencies of	of heat													
9		heat source			4463		E10 Model	0		E 10 Model	925		E 10 Model	100002		
0		0.309	0.134		6538		E10 Model	2406		E 10 Model	0		E 10 Model	30517		
1		12.324	6.304		4444		E10 Model	0		E 10 Model	646		E 10 Model	74368		
2		8.301	4.246		6519		E10 Model	1302		E 10 Model	0		E 10 Model	26687		
3					4444		E10 Model	0		E 10 Model	537		E 10 Model	64378		
4					6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	
5																
6		Profile Contain						_	11/05 110 C CONTRA		_					_

OUTCOMES

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





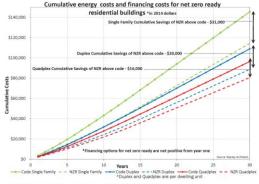


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

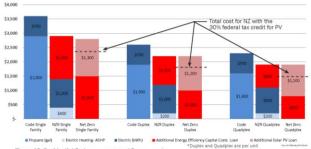
INPUTS

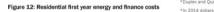
- Energy consumption
- Capital costs for energy efficiency
- Capital costs for PV
- Financing assumptions

ñ	A Cut	Calibri	• 11 • A *		P- ∰Wap	Text	Number	- 1	e Com	me 2 G	mency 2	Nernal 2	- B	- 泽 🔟	X Autofum . A	- A
ele	-La Crev	8/2	- 🗉 - 🖄 - 🚣 -		R (R 🖃 Merg	e & Center -	8 - 16 + 1	14 4% Can	Itenal Format Non	nal R	đ	Good	1 10	of Delete Pornal	Con Sof	& Find &
	Sphoard		Fort 5		Algoment				ating * at table *	Shire				Cells	Editing	* 5492 *
10	offer Warning	Automatic sandate a	d links has been disabl	a Dening												
-	14		AD4/D4													
	M	N	0		O B		T	U	v	W	AA	AB	AC.	AD	AE	AS AG
	rvn	n	0	r -		erev Con	sumed (effic		sumed in model)	w	101	AD	PR.	NO	AC	FINANCE
•					Total El	ergy con	someo (emo	rencies as	somed in model)		_					FINANCE
1	otal FUI							Electric	Electric ASHP					Total kBTU of	watts	Loan Payr
- 6	kWh/s	FPA Median			Electric	Electric		ASHP	included in total		Propan	Propane		all energy	required to	per year n
	n-vr)	Site FUI			(kWb)	kBTU	Source:	(kWh)	kBTU	Source:		kBTU	Source:	sources	be Net Zero	solar
3	195	52.9					E10 Model	0	0.0000	E 10 Model	926		E 10 Model	100094		5
4	60	52.9			6538		E10 Model	2406		E 10 Model	0		E 10 Model	30517	7777	\$1.51
5	203	77.6			4444	15164	E10 Model	0	0.0000	E 10 Model	623	57096.5	E 10 Model	72260		5
6	75	77.6			6519	22244	E10 Model	1302	4443.1997	E 10 Model	0		E 10 Model	26687	6801	\$95
7	176	77.6			4444	15164	E10 Model	0	0.0000	E 10 Model	518	47473.5	E 10 Model	62637		
3	70	77.6			6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	\$8
		*CBECS 2009 -	Chart 2.1.10													
0																
1																
12																
3																
4																
5																
6																
7					Total En	ergy Con	sumed from		Spreadsheet							
									Electric ASHP					Total kBTU of		
						Electric			included in total			Propane		all energy	required to	Loan Payr
8		Fuel -Solar Pla	iteau for Fossil	Fuels	0	KBTU	Source:	(kWh)	kBTU	Source:	0	kBTU	Source:	sources	be Net Zero	Opt A per
			w/ efficiencies													
		w/out														
9		efficiencies of heat source	source		4463		E10 Model	0		E 10 Model	925	0.077.0	E 10 Model	100002		
9		0.309	0.134		4463		E10 Model E10 Model	2406		E 10 Model E 10 Model	925		E 10 Model E 10 Model	30517	7777	-
1		12.324	6.304		6538		E10 Model	0		E 10 Model E 10 Model	646		E 10 Model E 10 Model	30517 74368	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	-
2		8.301	4.246		6519		E10 Model	1302		E 10 Model	040		E 10 Model	26687	6801	
23		8.301	4.240		4444		E10 Model	0		E 10 Model	537		E 10 Model	64378	0801	-
4					6269		E10 Model	1043		E 10 Model	557		E 10 Model	24951	6359	
5					0203	22331	cao informer	1043	0000.4909	C 10 10000			C 10 10000	24951	0000	
6																

OUTCOMES

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





Cumulative energy costs and financing costs for net zero ready residential buildings *in 2014 dollars \$140,000 Single Family Cumulative Savings of NZR above \$120.000 Duplex Cumulative Savings of NZR above code - \$20,00 \$100.000 2 \$80,000 \$40.000 \$20.00 20 25 Vears NZR Single ex - - - NZR Duplex ---- Code Quadplex - - NZR Quadplet Duplex and Quadplex are per Figure 7.3: Cumulative energy costs and finance costs for net zero ready

INPUTS

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

• Financing assumptions

r	A Cat	Calibri	• 11 • A *		P- SWip	Text	Number	- 1	e Com	vre 2 O	imency 2	Nernal 2	- B	- 🛪 🔟	X Autofum . A	C AB
e.t.	Tarmet P	B / U	• · · · · · · ·		R BR 3 Merg	e & Center -	8 - 16 +	14 28 Sand	Itenal Format Non	nal Bi	d	Good	2 20	of Delete Formal	2 Cear - Soft	& Field
	Clipboard		Fort 5		Alignment		Natiber			Styles				Cells	Editing	
	na ile Manine	Automatic sandate a	d links has been disabl	a Defines												
	14		AD4/D4													
	M	N	0		O B		T	U	v	W	AA	AB	AC	AD	AF	AI AG
	101		0			erev Con	sumed (effici		sumed in model)		701	740	PR.	no	PR.	FINANCE
				Total cit	CIBY CON	James ferrie	circles of	onica in novely		_					Therefore	
	Total EUI							Electric	Electric ASHP					Total kBTU of	watts	Loan Payr
	(kWh/s.	EPA Median			Electric	Electric		ASHP	included in total		Propan	Propane		all energy	required to	per year n
2	m-yr)	Site EUI			(kWb)	kBTU	Source:	(kWh)	kBTU	Source:	e (gal)	kBTU	Source:	sources	be Net Zero	solar
3	195	52.9			4463	15228	E10 Model	0	0.0000	E 10 Model	926	84865.7	E 10 Model	100094		5
4	60	52.9			6538	22309	E10 Model	2406	8208.4220	E 10 Model	0	0	E 10 Model	30517	7777	\$1,51
5	203	77.6			4444		E10 Model	0		E 10 Model	623		E 10 Model	72260		\$
6	75	77.6					E10 Model	1302		E 10 Model	0		E 10 Model	26687	6801	\$95
7	176	77.6			4444	15164	E10 Model	0		E 10 Model			E 10 Model	62637		1
3	70				6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	\$8
)		*CBECS 2009	Chart 2.1.10													
10																
11																
12																
3																
15																
6																
7					Total Fo	erev Con	sumed from	Summary	Spreadsheet							
									Electric ASHP					Total kBTU of	watts	
						Electric		ASHP	included in total			Propane		all energy	required to	Loan Payr
8		Fuel -Solar Pla	teau for Fossil	Fuels	0	kBTU	Source:	(kWh)	kBTU	Source:	0	kBTU	Source:	sources	be Net Zero	Opt A per
			w/													
		w/out	efficiencies													
		efficiencies of	of heat													
9		heat source			4463		E10 Model	0		E 10 Model	925		E 10 Model	100002		
0		0.309	0.134		6538		E10 Model	2406		E 10 Model	0		E 10 Model	30517		
1		12.324	6.304		4444		E10 Model	0		E 10 Model	646		E 10 Model	74368		
2		8.301	4.246		6519		E10 Model	1302		E 10 Model	0		E 10 Model	26687		
3					4444		E10 Model	0		E 10 Model	537		E 10 Model	64378		
4					6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	
5																
6		Profile Contain						_	11/05 110 C CONTRA		_					_

OUTCOMES

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

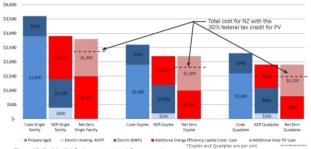


Figure 12: Residential first year energy and finance costs *In 2014 dollars

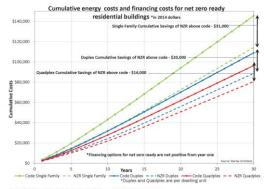


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

INPUTS

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

C	A Cut	Calibri	• 11 • A 4				Number				unency 2	Normal 2	1 3	- ⊁ 🗊	T Adalan - Z	° #3
ele ,	💚 Format Pa								Albanal Format N atting * as Table *		ad	Good	2 20	of Delete Formal	2 Otar * Filte	& Red &
	Clipboard		fort		Algement		Nation			Shiri				Criti	Editing	
5	ecurity Marning	Automatic update	et links has been disa	aled Options												
	64	• (0)	6 =AD4/D4													
	M	N	0	P	QR	S			v	W	AA	AB	AC	AD	AE	AF AG
					Total	Energy Cor	isumed (effic	lencies as	sumed in mode	el)	_					FINANCE
	Total FUI							The state	Electric ASHP					Total kBTU of		
		EPA Median			0	c Electric		ASHP	included in tot		0	Propane		all energy	required to	Loan Pays per year r
		Site EUI					Source:		kBTU	Source:	e (gal)		Source:	sources	be Net Zero	solar
2	195	52.9					E10 Model	(KWII)		0 E 10 Model			E 10 Model			solar
	60	52.9			65		E10 Model	2406		0 E 10 Mode			E 10 Model	30517		\$1.5
5	203	77.6					E10 Model	0		0 E 10 Mode			E 10 Model	72260		33,5
6	75	77.6			65		E10 Model	1302		7 E 10 Model			E 10 Model	26687		\$99
7	176	77.6			44	4 15164	E10 Model	0		0 E 10 Mode		47473.5	E 10 Model	62637		-
3	70	77.6			628	59 21391	E10 Model	1043	3560.493	9 E 10 Mode		0	E 10 Model	24951	6359	\$8
,		*CBECS 2009	- Chart 2.1.10								_					
0																
1																
2																
3																
4																
5																
6								-	Spreadsheet							
7					Iotal	Energy Col	isumed from		Electric ASHP					Total kBTU of		
						Electric		ASHP	included in tot			Propane		all energy	required to	Loan Pave
8		Eval - Colar Di	ateau for Fossi	I Suele		0 kBTU	Sourcer	(kWh)	kRTU	Source:		kBTU	Source	sources	he Net Zero	Opt A per
		Total Solar Pa	w/			U KUTU		(kuni)	RD10			KUTO			De Het Lero	openaper
		w/out	efficiencies													
		efficiencies of	of heat													
9		heat source	source		444	53 15228	E10 Model	0	0.000	0 E 10 Mode	925	84774	E 10 Model	100002		
0		0.309	0.134		653	38 22309	E10 Model	2406	8208.422	E 10 Model	1 0	0	E 10 Model	30517	7777	
1		12.324			44		E10 Model	0		E 10 Mode			E 10 Model	74368		
2		8.301	4.246		65		E10 Model	1302		7 E 10 Mode			E 10 Model	26687		
3					444		E10 Model	0		E 10 Mode			E 10 Model	64378		
4					620	59 21391	E10 Model	1043	3560.493	89 E 10 Mode	1 0	0	E 10 Model	24951	6359	
5																
6		malile Centai O							100 x 101					_		

OUTCOMES

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

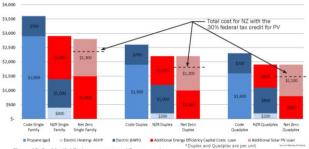
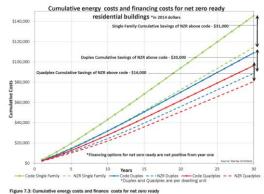


Figure 12: Residential first year energy and finance costs *In 2014 dollars



Energy Consumption

•Residential annual energy per dwelling unit

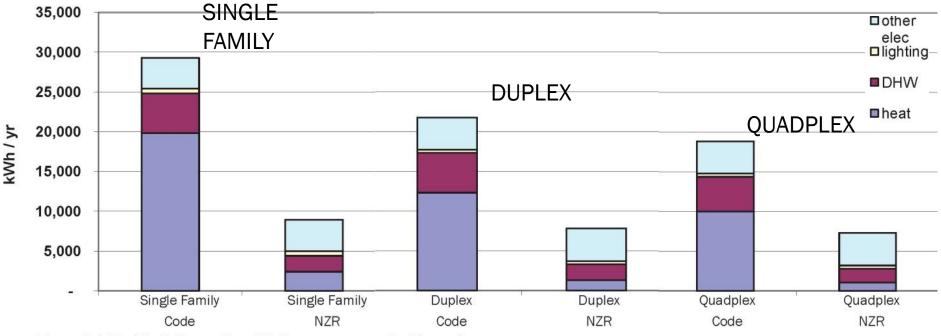


Figure 5.1: Residential annual modeled energy use per dwelling unit

Energy Consumption

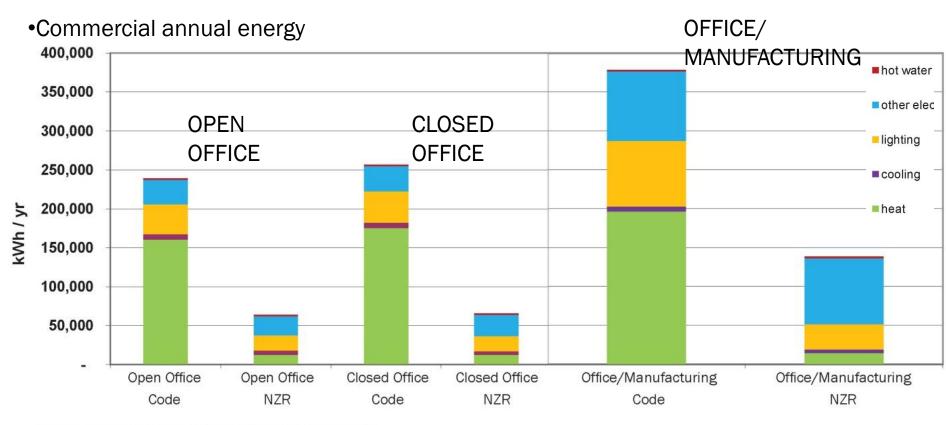


Figure 5.2: Commercial annual modeled energy use

Energy Use Intensity (EUI)

	2					
		C	ode [2]	Net Zei	ro Ready	
						% energy
		(kBTU/	(kWh/	(kBTU/	(kWh/	savings
Building Type	SF	sf-yr)	sq.m-yr)	sf-yr)	sq.m-yr)	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%
		207				

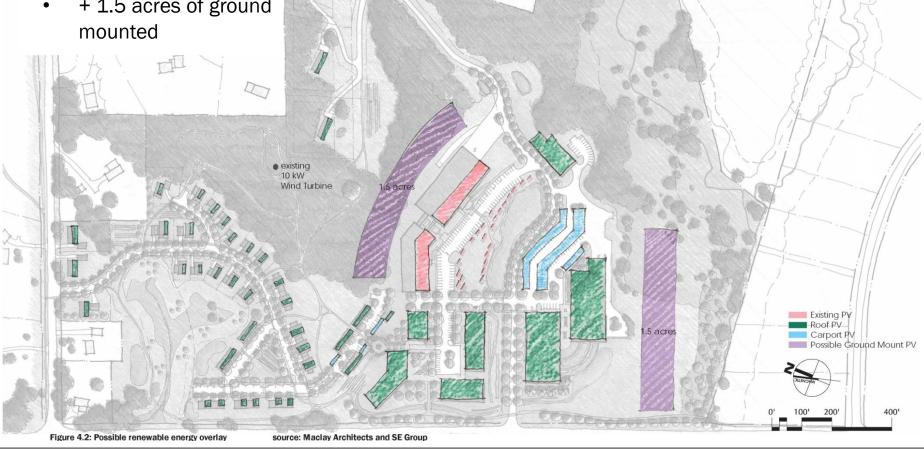
Community Energy

	SQUA	ARE FOOTAGE	(SF)		DDE EUI STU/sf-yr)		RO READY BTU/sf-yr)	тс	TAL				
Туре		Manufacturing Residential	total building	Office	Manufacturing Residential		Manufacturing	Total Code Energy (kBTU/yr)	Total Net Zero Ready Energy (kBTU/yr)				
Commercial													
Office		0 0	160000	62		17		9,900,000	2,700,000				
Office/manufacturing	10000 17	000 0	54000	62	49		17	2,900,000	900,000				
СО	OMMERICAL	SUBTOTAL SF:	214000		COMMERI	CAL TOTA	L 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 SUBTOTAL SF:	34,000 86,000		56		24	1,900,000	800,000 1,980,000				
				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	
						CC	MM	UNIT	Y TOT	AL SF	300,	000	
				COMMUNITY TOTAL kBTU							18,000,000	5,600,000	
					1	Annı	ual D	eman	d (kW	h/yr)	5,000,000	2,000,000	
							PV S	Syster	n Size	(kW)	5,750	2,300	
							PV S	ystem	Size (MW)	5.8	2.3	
			L										-

Renewable Energy Overlay

2.3 MW of PV to be NZ

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



Cost Estimate - Residential

						% of project
				C	ost	cost for
				ab	ove	additional
				Co	ode	energy
		Cos	t / sf	\$	/sf	upgrades
	Code Single Family	\$	120	1	VA	0
	NZR Single Family	\$	136	\$	16	12%
	NZ Single Family	\$	151	Ś	31	20%
	Code Duplex	\$	120	1	٨N	0
	NZR Duplex	\$	135	\$	15	11%
1	NZ Duplex	\$	153	\$	33	22%
1	Code Quadplex	\$	120	1	٨	0
	NZR Quadplex	\$	133	\$	13	10%
	NZ Quadplex	\$	150	\$	30	20%

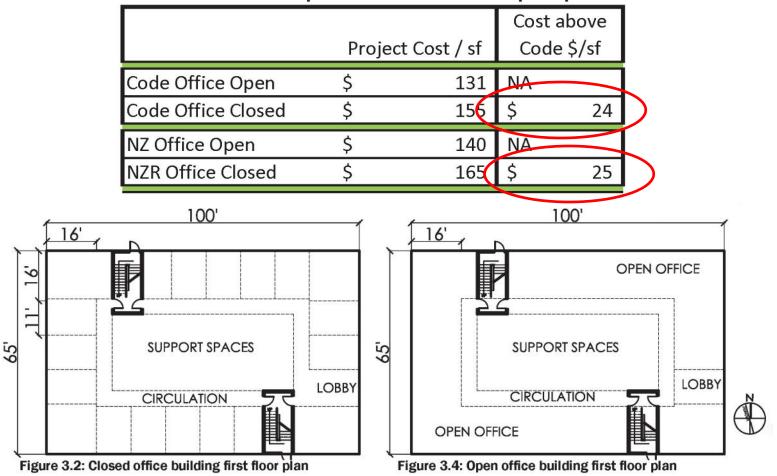
Cost Estimate - Commercial

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

	Bu	otal ilding st / sf	ab Co	ost ove ode /sf	% of project cost for additional efficiency upgrades	
Code Office Open	\$	131	NA	4	0%	
NZR Office Open	\$	140	\$	9	7%	
NZ Office Open	\$	153	\$	22	16%	
Code Office Closed	\$	154	NA	ł	0%	
NZR Office Closed	\$	164	\$	10	6%	
NZ Office Closed	\$	178	\$	24	14%	
Code Manufacturing	\$	107	NA	A	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



Financial Analysis

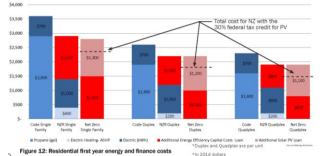
INPUTS

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

	A Cut	Calibri	• 11 • A a	=== = २	- SWap	Test	Number	- 1	e Car	vra 2 Qu	imency 2	Nernal 2	- B	- 🛪 🔟	X Autofum . A	C AB
	-ia Crev	8/2	- B - A -		t 🕸 🗄 Merg	di Center -	8 - 16 + 1	14 4% Can	Itenal Format Nor	mai Ba	d	Good	1 20	of Delete Formal	Cent - Sof	& Field
	lipboard		Fort 5		Lignment		Natiber			Styles				Cells	Editing	·
Sec	ally Marring	Automatic update i	d links has been disables	a Cutions.												
	14	• (*)	AD4/D4													
7	M	N	0	P	O B	c	т	U	v	W	AA	AB	AC	AD	AE	AS AG
	141		0	,		erev Con	sumed (effic		sumed in model)		101	740	PRV	no	HL.	FINANCE
											_					
T	otal EUI							Electric	Electric ASHP					Total kBTU of	watts	Loan Payr
0	wh/s.	EPA Median			Electric	Electric		ASHP	included in total		Propan	Propane		all energy	required to	per year n
2 m	n-yr)	Site EUI			(kWh)	k8TU	Source:	(kWh)	kBTU	Source:	e (gal)	kBTU	Source:	sources	be Net Zero	solar
3	195	52.9			4463	15228	E10 Model	0	0.0000	E 10 Model	926	84865.7	E 10 Model	100094		5
1	60	52.9			6538	22309	E10 Model	2406	8208.4220	E 10 Model	0	0	E 10 Model	30517	7777	\$1,51
5	203	77.6			4444		E10 Model	0		E 10 Model			E 10 Model	72260		\$
6	75	77.6			6519		E10 Model	1302		E 10 Model		0	E 10 Model	26687	6801	\$95
7	176	77.6			4444		E10 Model	0		E 10 Model			E 10 Model	62637		1
5	70				6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	\$8
		*CBECS 2009	Chart 2.1.10													
0																
1																
2																
3																
4																
6																
ь 7					Total Co		sumed from									
·					TOLATEN	ergy con	sumed from		Electric ASHP					Total kBTU of		
						Electric		ASHP	included in total			Propane		all energy	required to	Loan Payr
8		Eval -Solar Pla	iteau for Fossil F	inale	0		Source:		kBTU	Source:		kBTU	Source:	sources	be Net Zero	Opt A per
-		Contraction of the	w/													
		w/out	efficiencies													
		efficiencies of														
9			source		4463	15228	E10 Model	0	0.0000	E 10 Model	925	84774	E 10 Model	100002		
0		0.309	0.134		6538	22309	E10 Model	2406	8208.4220	E 10 Model	0	0	E 10 Model	30517	7777	
1		12.324	6.304		4444	15164	E10 Model	0	0.0000	E 10 Model	646	59204.3	E 10 Model	74368		-
2		8.301	4.246		6519	22244	E10 Model	1302	4443.1997	E 10 Model	0	0	E 10 Model	26687	6801	
3					4444	15164	E10 Model	0	0.0000	E 10 Model	537	49214.8	E 10 Model	64378		
1					6269	21391	E10 Model	1043	3560.4939	E 10 Model	0	0	E 10 Model	24951	6359	
5																
6																

OUTCOMES

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



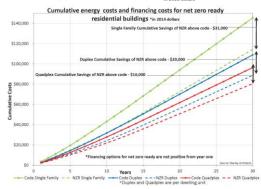
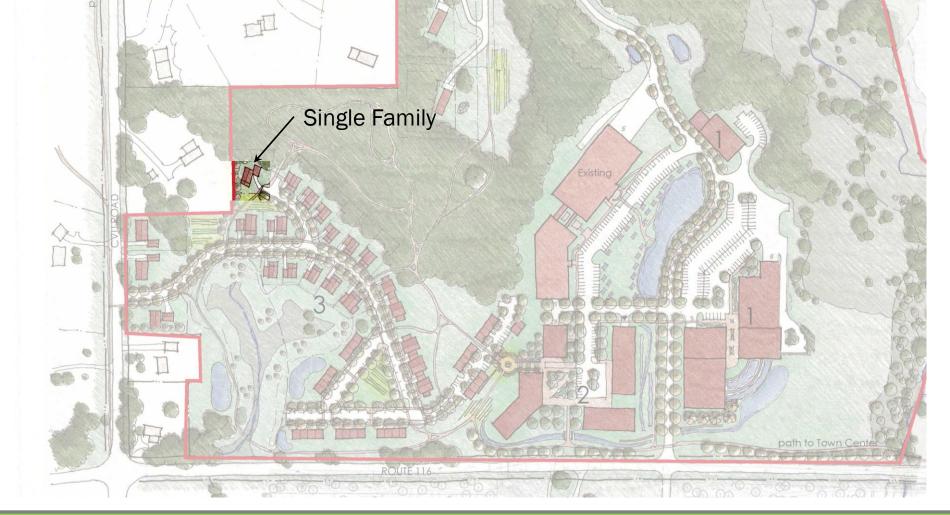


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

• 32,000 sf proposed single family residential

-

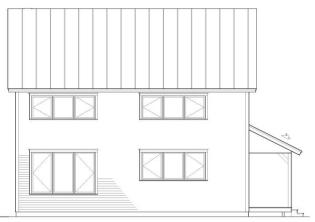


Single Family Residential



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 ٠
- 3 bedroom ٠
- 2.5 bath ٠
- 4 occupants ٠

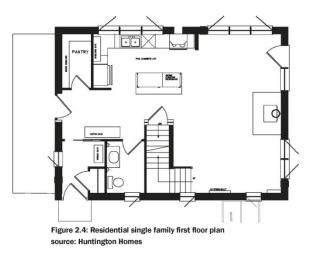
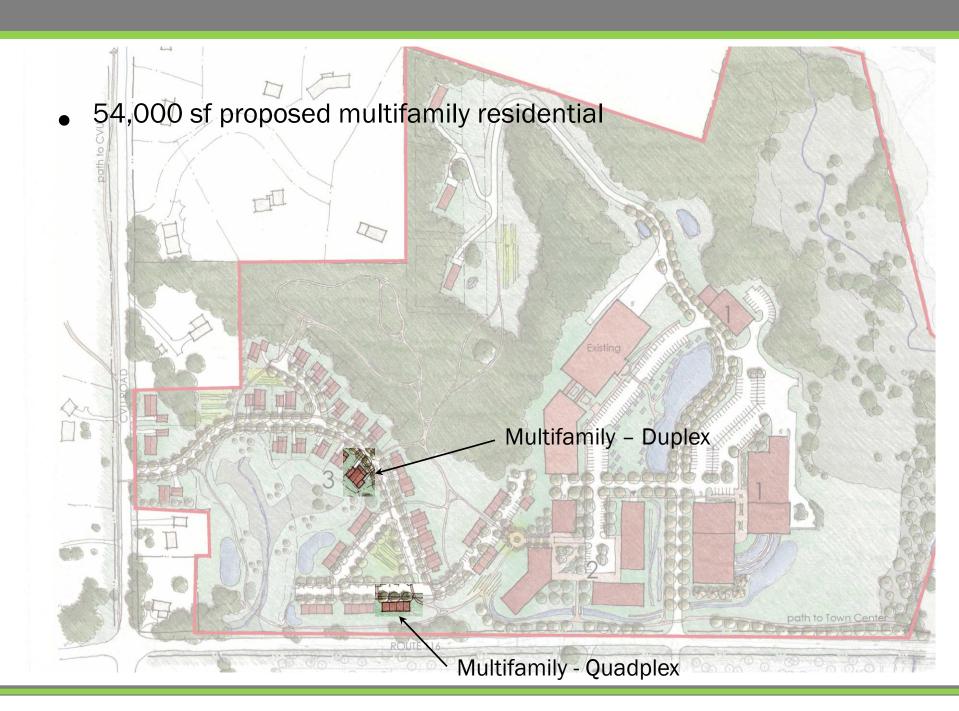


Figure 2.5: Residential single family second floor plan source: Huntington Homes



Multifamily Residential



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



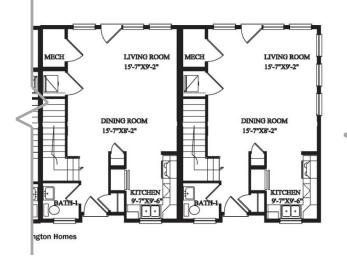
Figure 2.11: West elevation of the multifamily building source: Huntington Homes

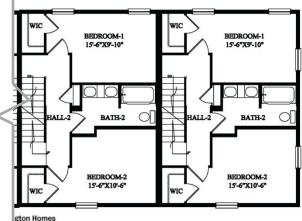


Figure 2.12: South elevation of the multifamily building

source: Huntington Homes

- 1,100 sf ٠
- 2 bedroom ٠
- 1.5 bath ۲
- 3 occupants ٠



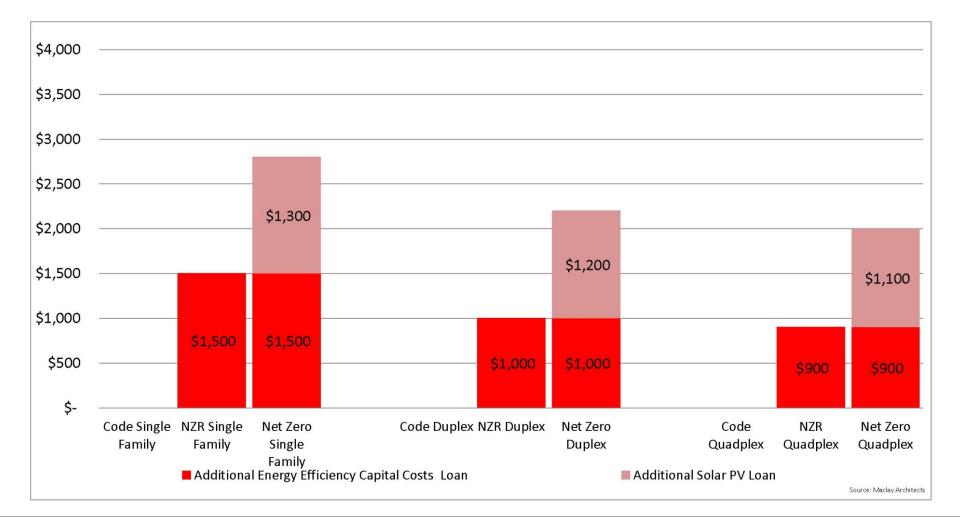


- Financing 30-year loan
- 4% fixed interest

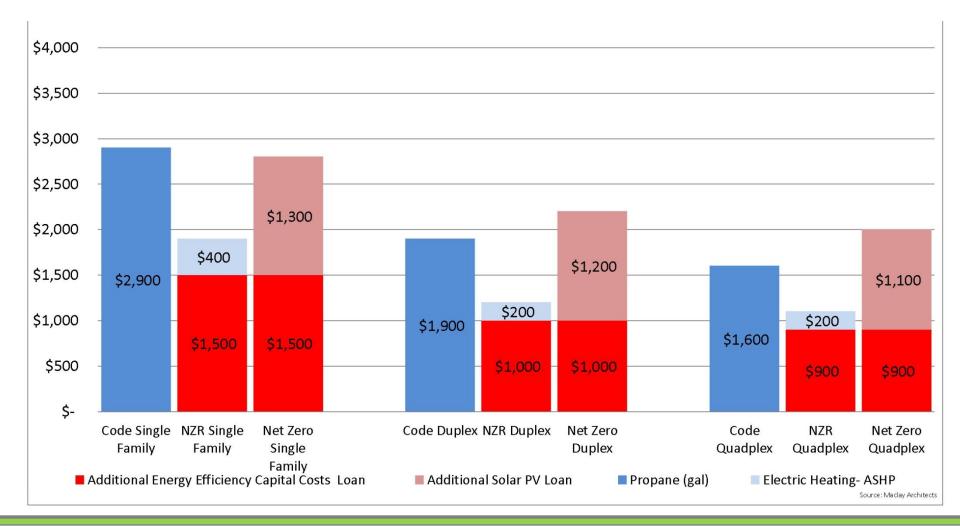
Finance cost for energy efficiency



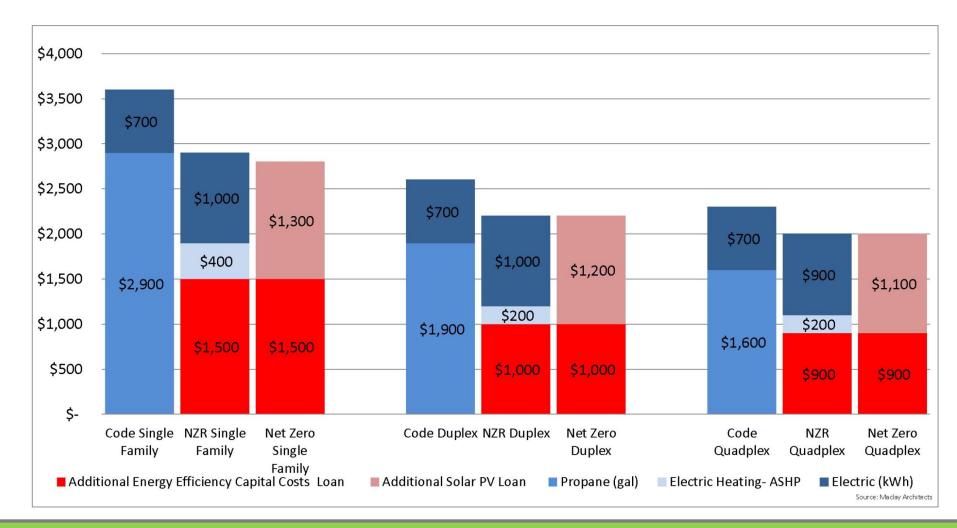
• Finance costs for PV



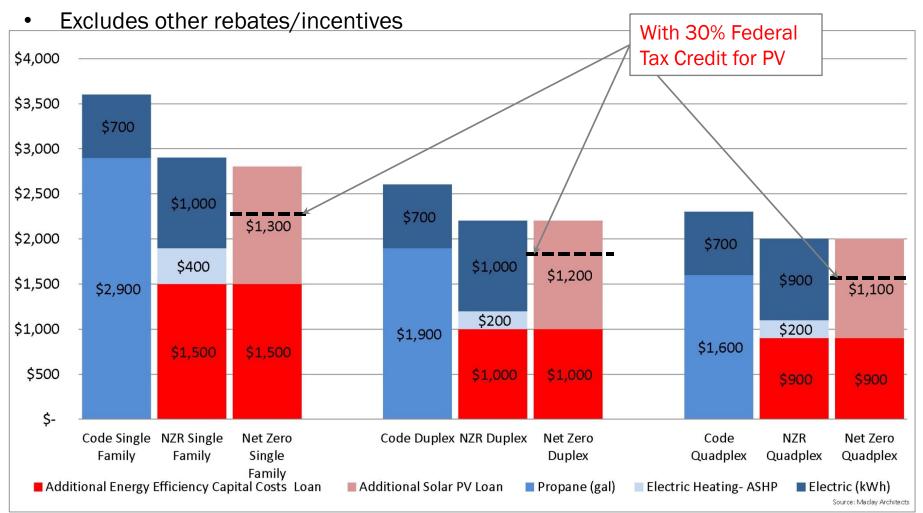
Heating Costs



• 1st year operating costs



• 30% Federal tax credit for PV



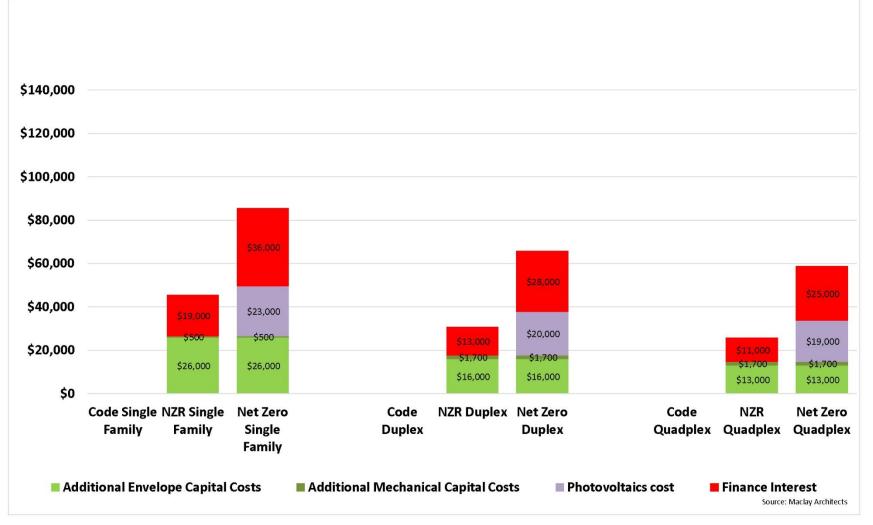
• Additional energy efficiency capital costs

\$140,000										
\$120,000										
\$100,000										
\$80,000										
\$60,000										
\$40,000										
\$20,000		\$500 \$26,000	\$500 \$26,000		\$1,700	\$1,700		\$1,700	\$1,700	
\$0					\$16,000	\$16,000		\$13,000	\$13,000	
	Code Single Family	NZR Single Family	Net Zero Single Family	Code Duplex	NZR Duplex	Net Zero Duplex	Code Quadplex	NZR Quadplex	Net Zero Quadplex	
		Additional E	invelope Capital Cost	ts	Additional Mechanical Capital Costs Source: Maclay Archite					

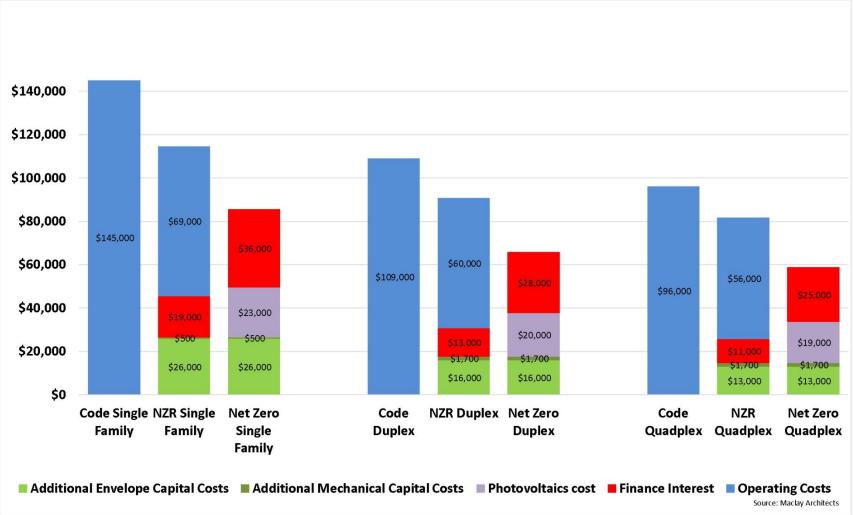
PV capital costs

\$140,000											
\$120,000											
\$100,000											
\$80,000											
\$60,000											
\$40,000			\$23,000								
\$20,000		\$500	\$500		\$1,700	\$20,000 \$1,700		\$1,700	\$19,000		
\$0		\$26,000	\$26,000		\$16,000	\$16,000		\$13,000	\$13,000		
	Code Single Family	NZR Single Family	Net Zero Single Family	Code Duplex	NZR Duplex	Net Zero Duplex	Code Quadplex	NZR Quadplex	Net Zero Quadplex		
	Additional Envelope Capital Costs			Addition	al Mechanical	Capital Cos	sts Photov	Photovoltaics cost Source: Maclay Architects			

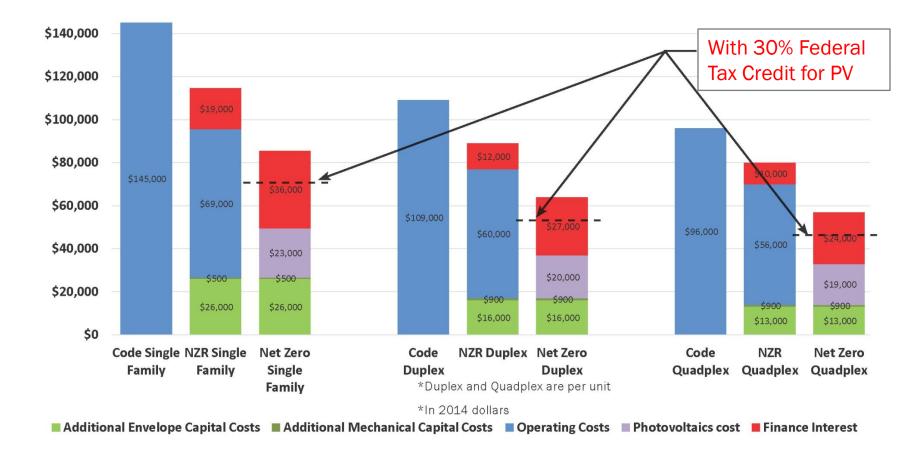
30-year cumulative financing interest



• Operating costs

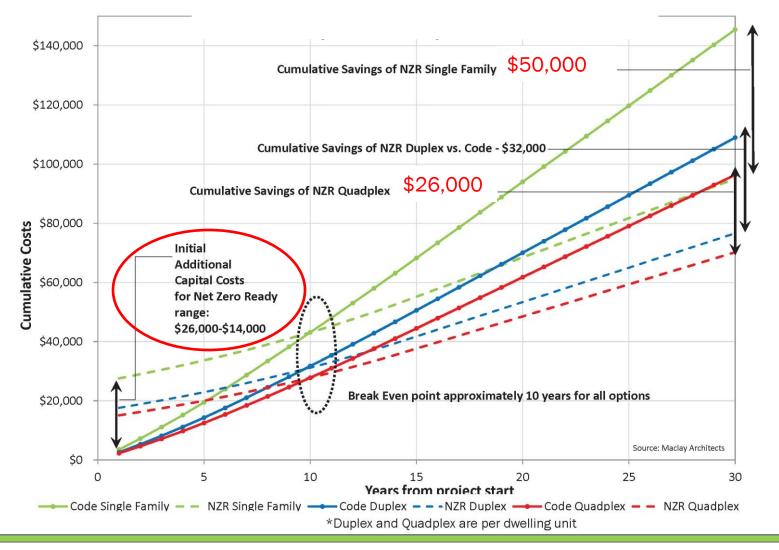


- 30% Federal tax credit for PV
- Excludes other rebates/incentives



Residential Financial Analysis

Net Zero Ready Not Financed



Residential Finance Options

- Efficiency Vermont Database:
 - <u>(https://www.efficiencyvermont.com/For-My-Home/Financing/Financing/Financing-Overview)</u>
- Northfield Savings Bank Energy Improvement Loans (<u>https://www.nsbvt.com/borrow/energy-improvement-loans/</u>)
- VSECU Vgreen Energy Savings Loan Program (<u>www.vsecu.com/vgreen</u>) 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

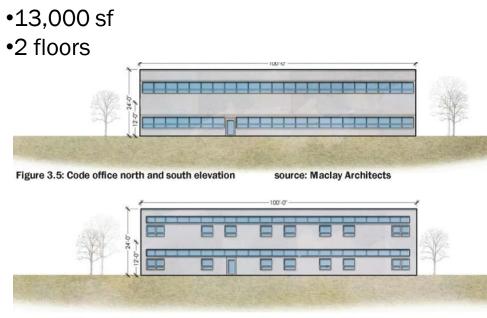


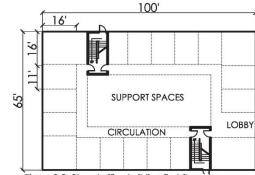


Figure 3.6: Net Zero office north and south elevation

source: Maclay Architects

Four office configurations:

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



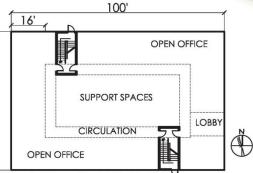


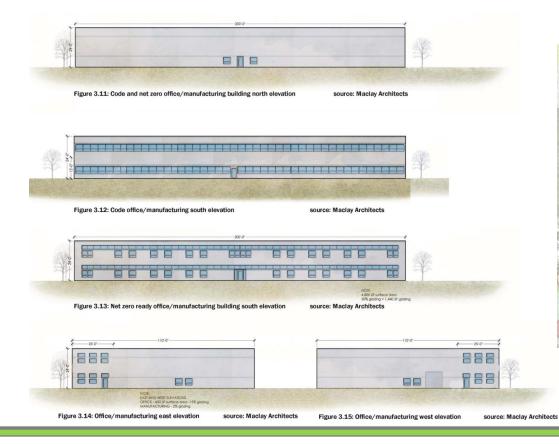
Figure 3.2: Closed office building first floor plan

Figure 3.4: Open office building first floor plan

651

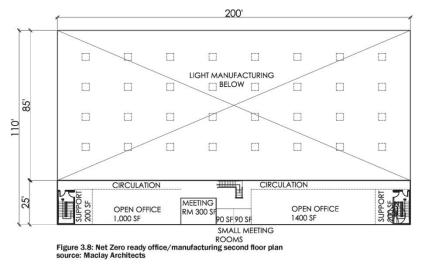
Office/Manufacturing Building

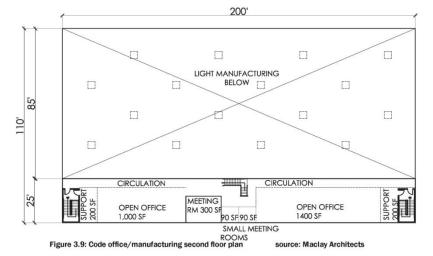
- 27,000 sf total
- 1st floor manufacturing/ warehouse space 17,000 sf
- 2 floors of office along the south 10,000 total sf





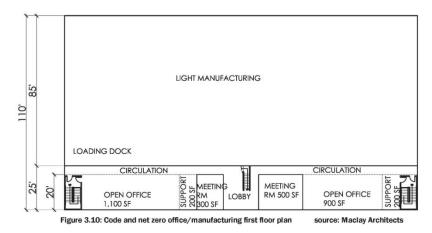
Office/Manufacturing Building





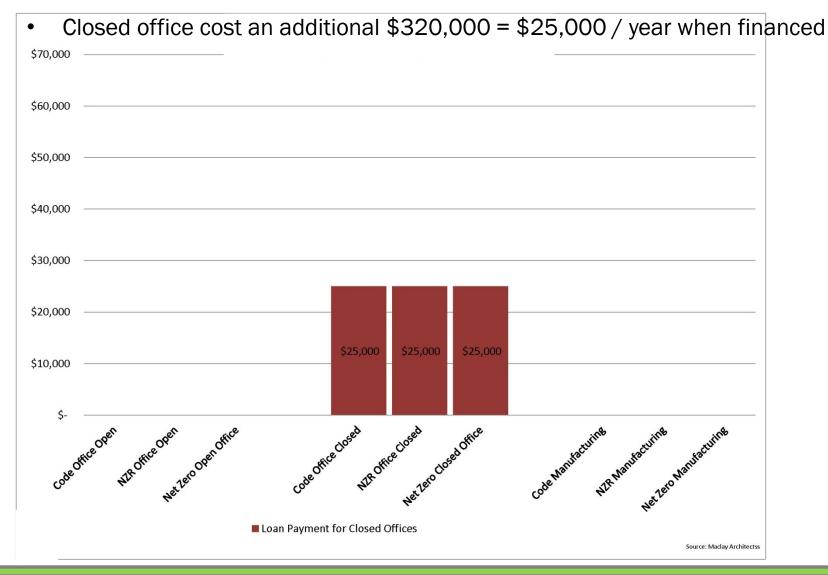
NZR

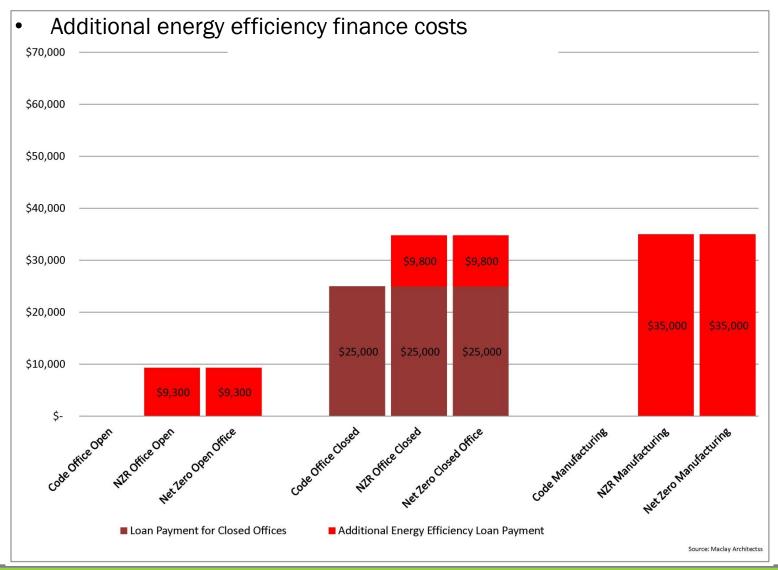
- 3% skylights in the NZR manufacturing area
- Lighting 0.5- 0.6 watts/sf CODE
- 1.5% skylights in the code manufacturing area
- Lighting 0.9 1.01 watts/sf

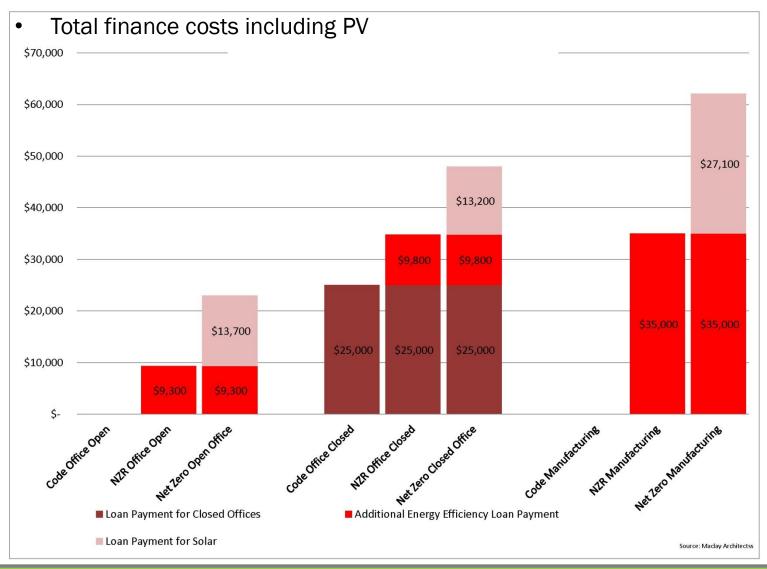


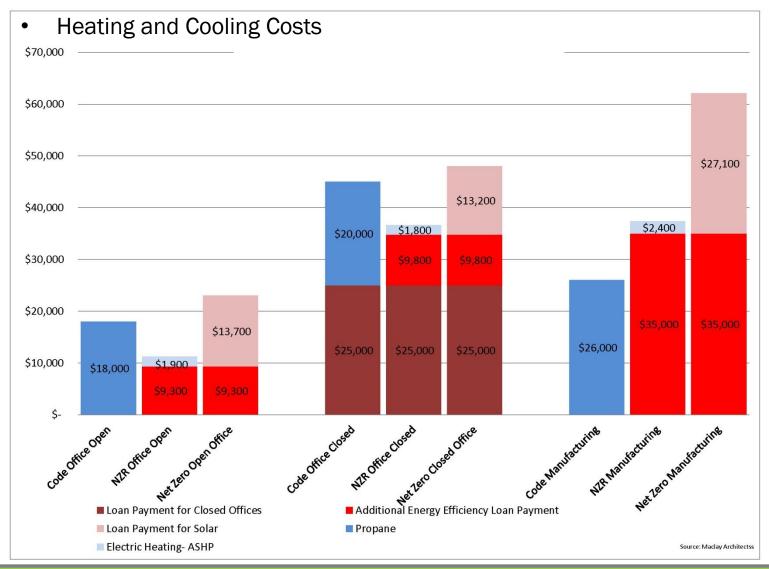
Commercial Finance Assumptions

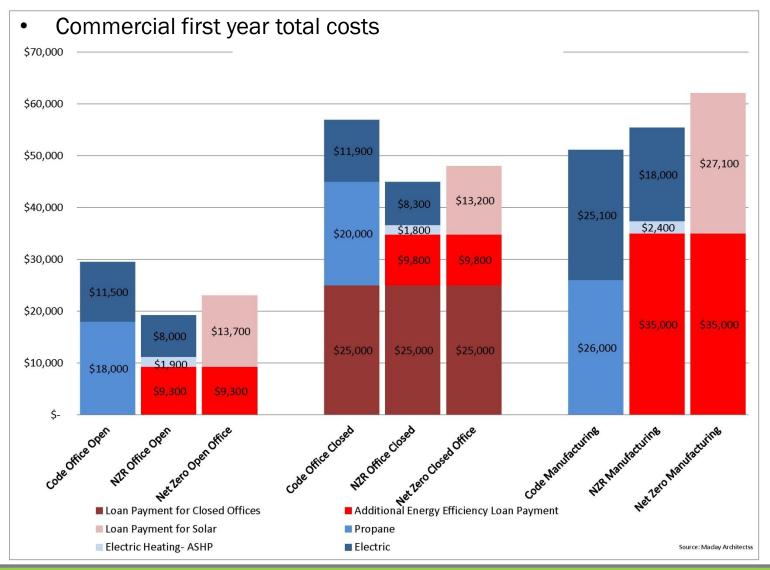
- 20-year variable loan rate to finance the incremental capital costs
- Starting at 4.61% and increases by 2% every 5 years









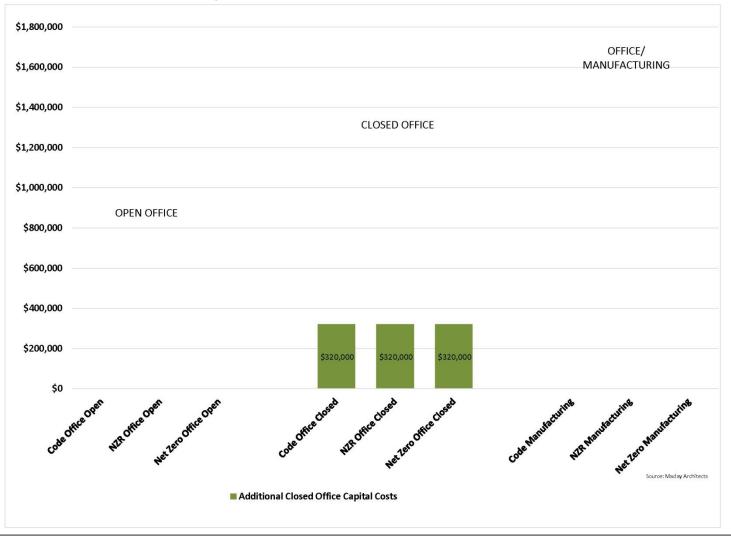


Federal Tax Credit for PV

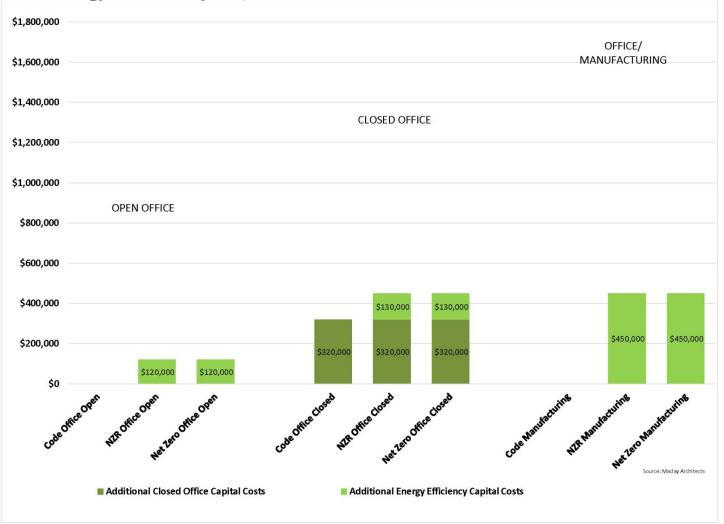
٠

\$70,000 OFFICE/ With 30% Federal MANUFACTURING CLOSED OFFICE \$60,000 Tax Credit for PV \$11,900 \$50,000 \$27,100 \$18,000 \$13,200 \$8,300 \$40,000 \$25,100 \$2,400 \$1,800 \$20,000 **OPEN OFFICE** \$30,000 \$11,500 \$20,000 \$13,700 \$8,000 \$25,000 \$25,000 \$25,000 \$26,000 \$10,000 \$1,900 \$18,000 \$codeOfficectosed NR Manufacturing codeomiceOpen NIR Office closed cole Manufacturne Net leo Manufactuine NIR Office Open Net leo Open Office Additional Energy Efficiency Loan Payment Loan Payment for Closed Offices Loan Payment for Solar Propane Electric Heating- ASHP Electric Source: Maclay Architectss

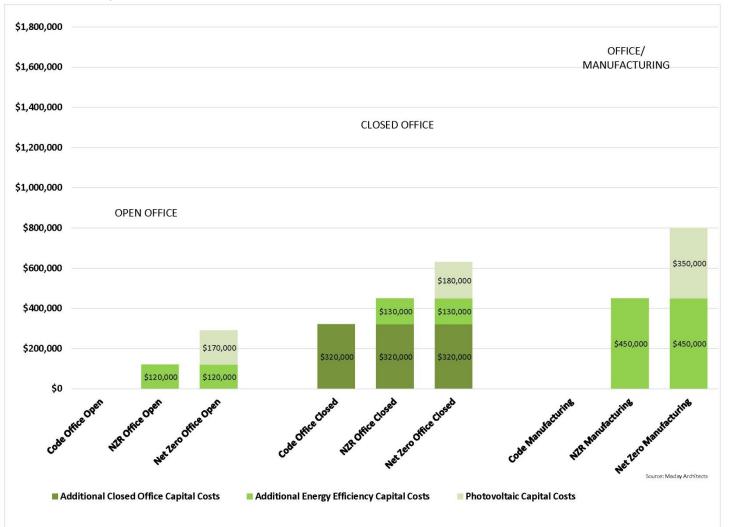
Closed office capital costs



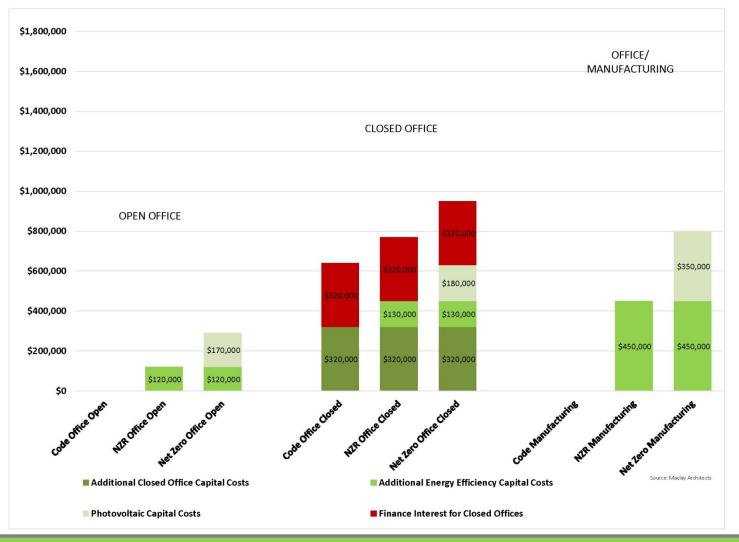
• Energy efficiency capital costs



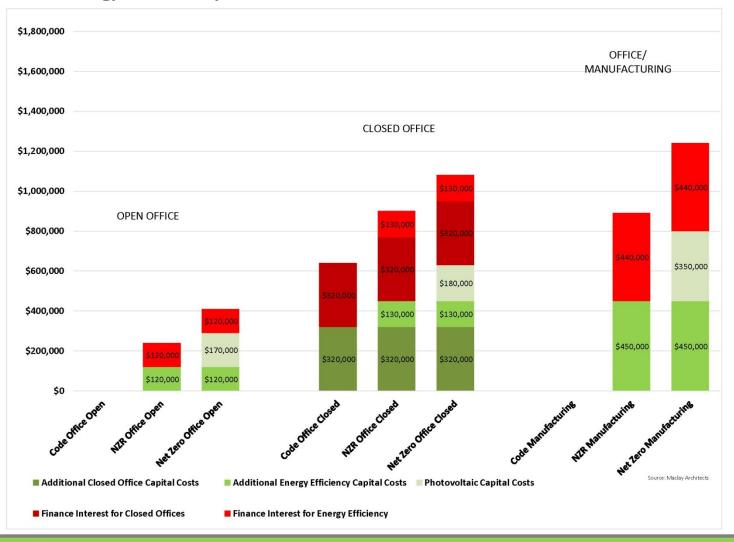
• PV capital costs



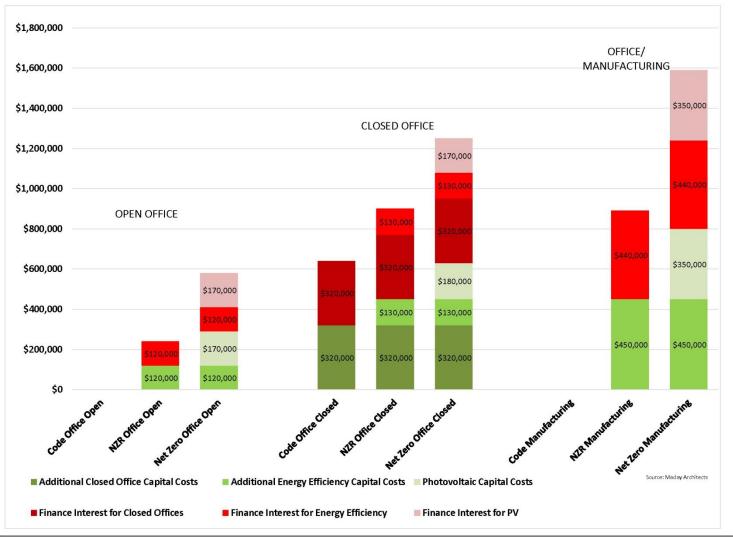
Closed office finance costs



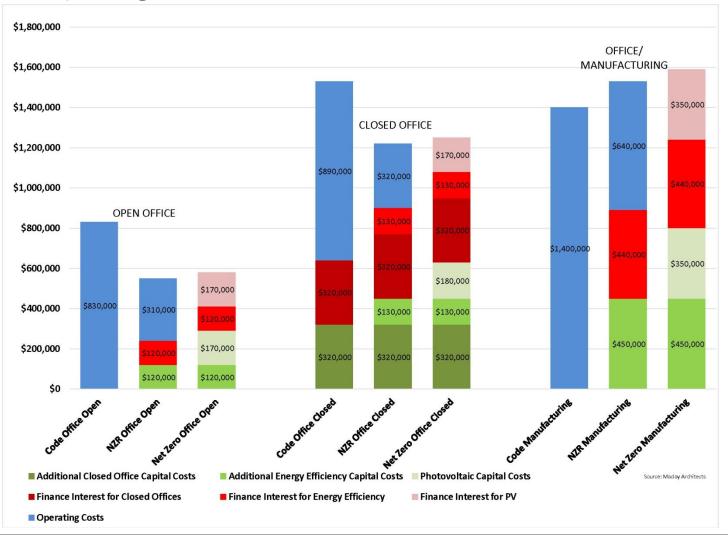
Energy Efficiency finance costs

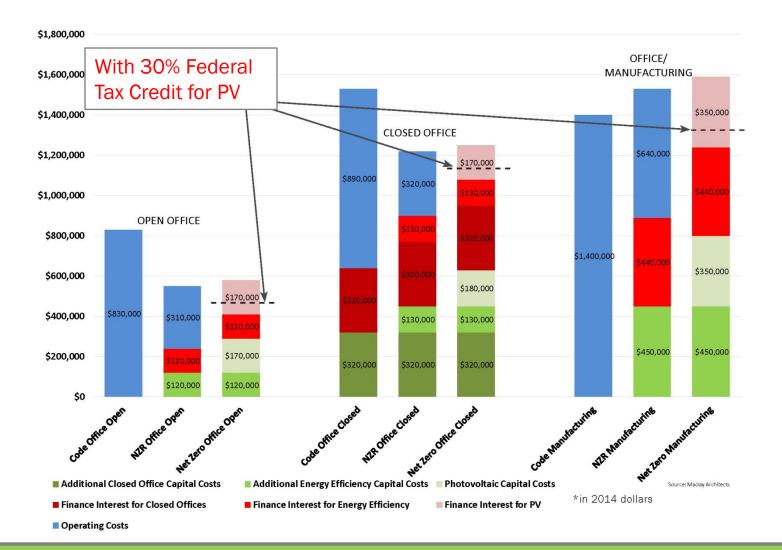


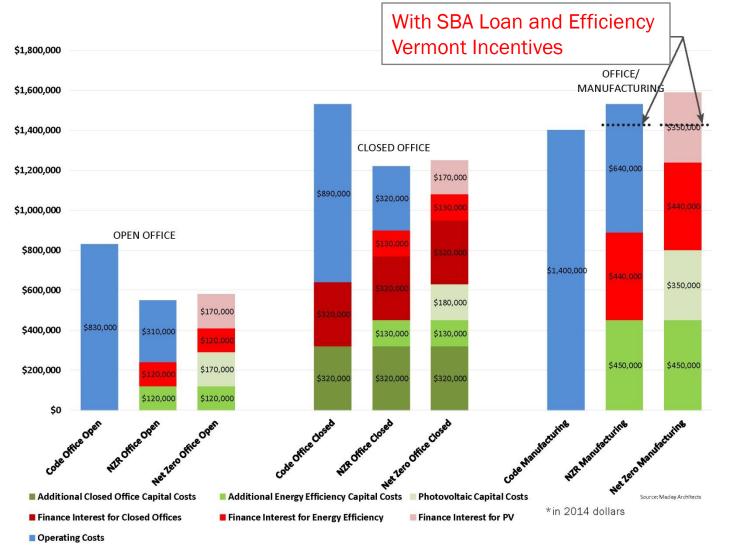
• PV finance costs

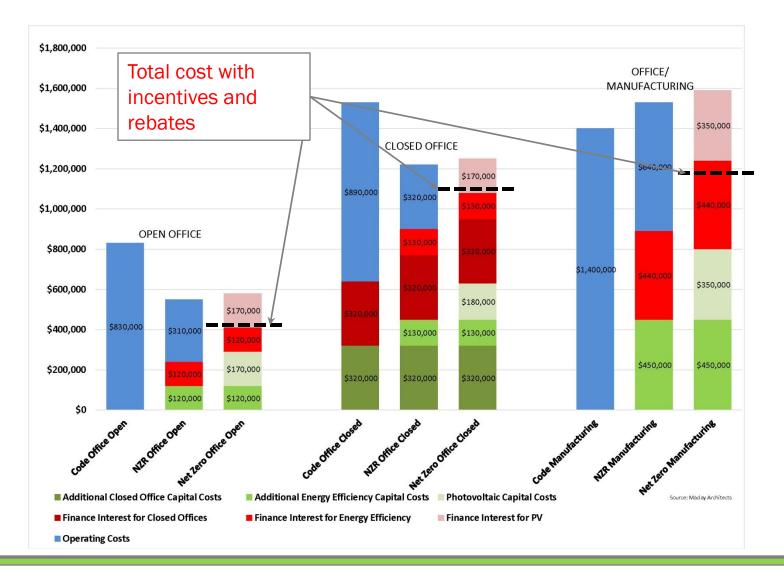


• Operating costs

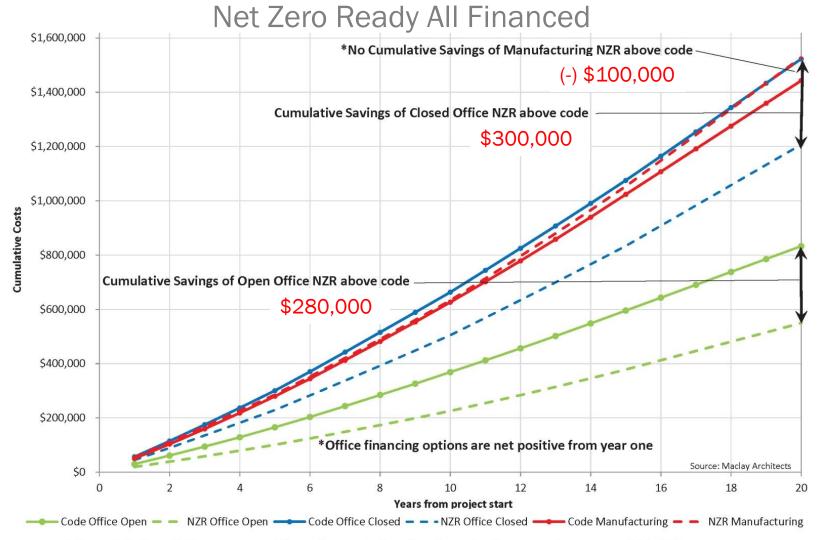








Commercial Financial Analysis





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

(<u>https://www.sba.gov/</u>)

(<u>http://www.vtsbdc.org/</u>)

Community

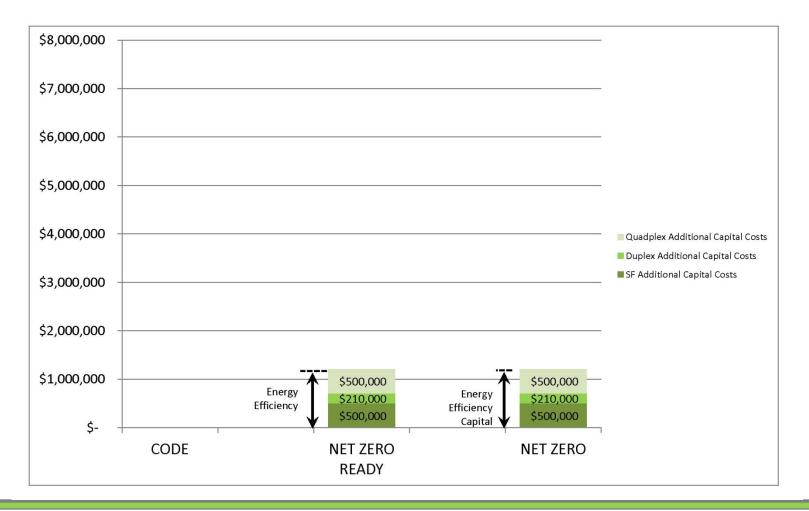
Proposed masterplan on the land of Wind Energy Associates in Hinesburg, VT

EXISTING

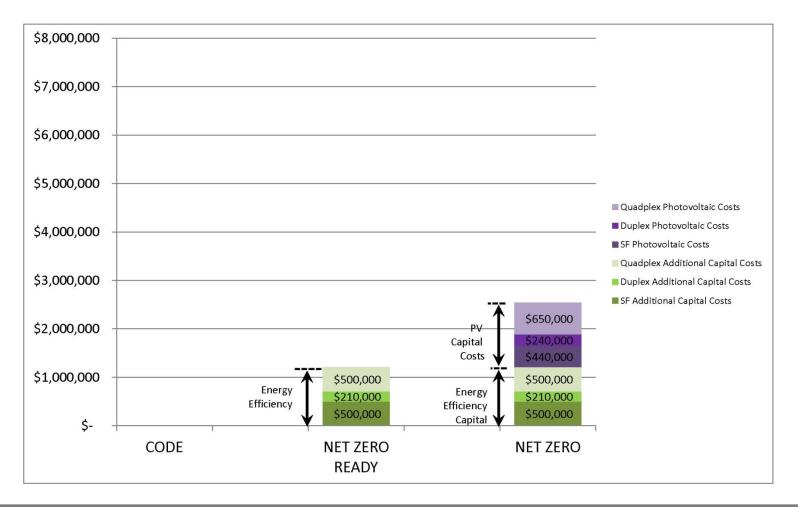
- ٠ office/manufacturing **PROPOSED ADDITIONAL**
- 214,000 sf commercial



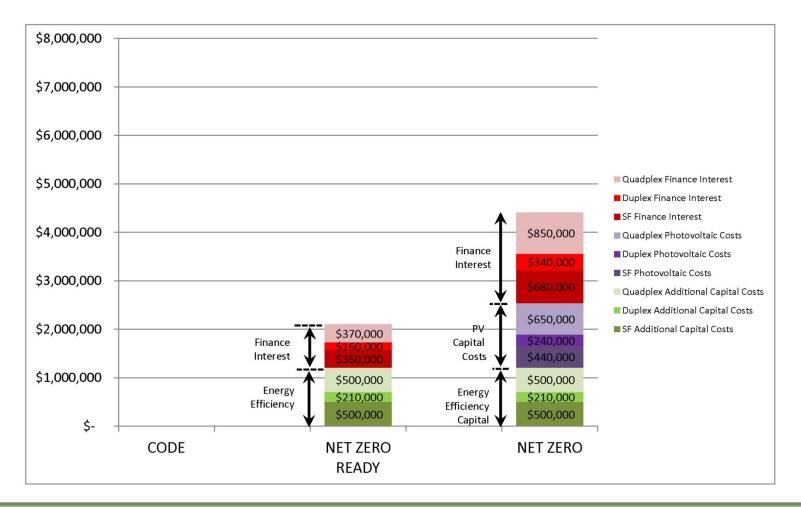
Additional Capital Costs



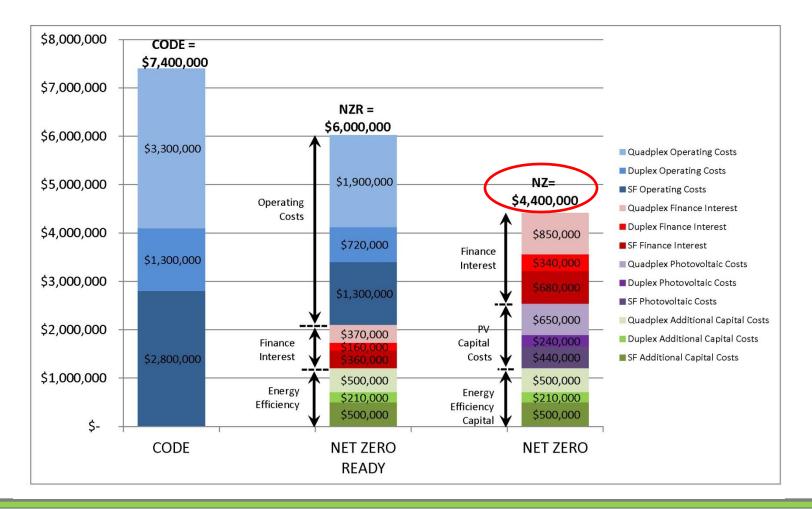
• PV Capital Costs



Cumulative 30-year Finance Interest



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



• NZ cumulative savings of \$3.8 million including PV tax credits

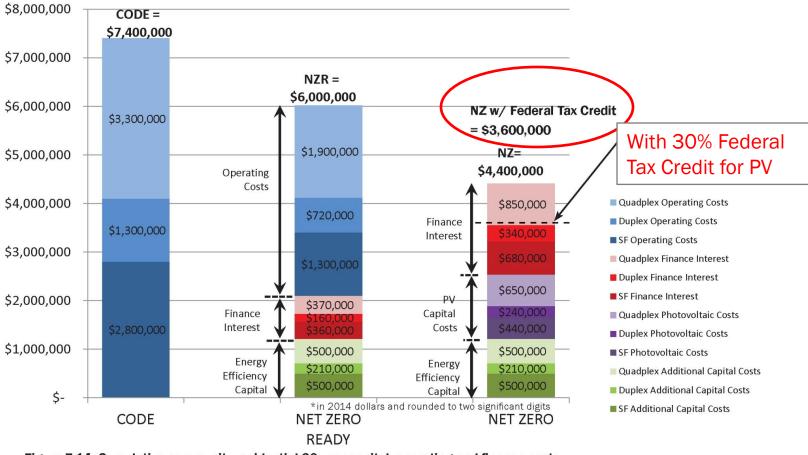


Figure 7.14: Cumulative community residential 30 year capital, operating and finance costs

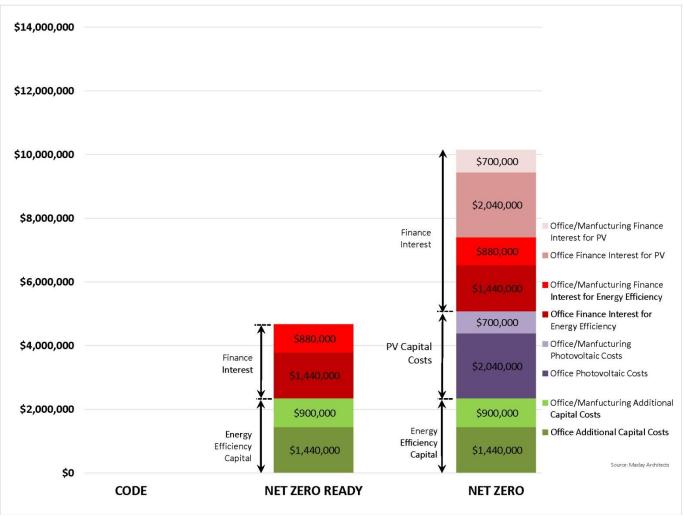
• Energy efficiency capital costs

\$14,000,000				
\$12,000,000				
\$10,000,000				
\$8,000,000				
\$6,000,000				
\$4,000,000				
\$2,000,000		Energy Efficiency \$1,440,000	Energy Efficiency Capital \$1,440,000	 Office/Manfucturing Additional Capital Costs Office Additional Capital Costs
\$0	CODE	Capital V NET ZERO READY	Capital V S1,440,000	Source: Madey Architects

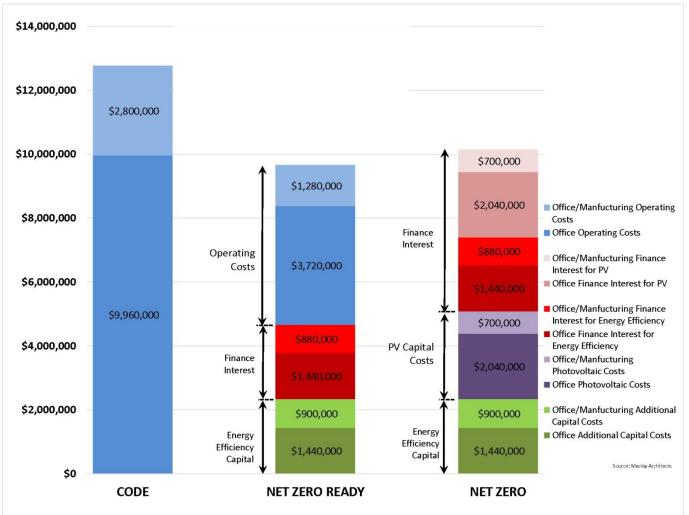
• PV capital costs

\$14,000,000						
\$12,000,000						
\$10,000,000						
\$8,000,000						
\$6,000,000						
\$4,000,000				PV Capital Costs	\$700,000	Office/Manfucturing Photovoltaic Costs
\$2,000,000		T	\$900,000	×	\$2,040,000 \$900,000	Office Photovoltaic Costs Office Photovoltaic Costs Office/Manfucturing Additional Capital Costs
ćo		Energy Efficiency Capital	\$1,440,000	Energy Efficiency Capital	\$1,440,000	Office Additional Capital Costs Scurce: Maday Architects
\$0	CODE	N	IET ZERO READY		NET ZERO	

Finance interest



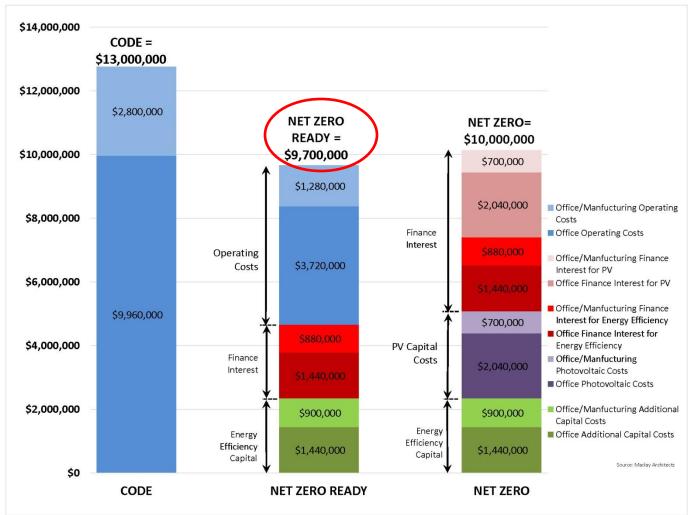
• Operating costs



Community

Commercial 20-Year Costs

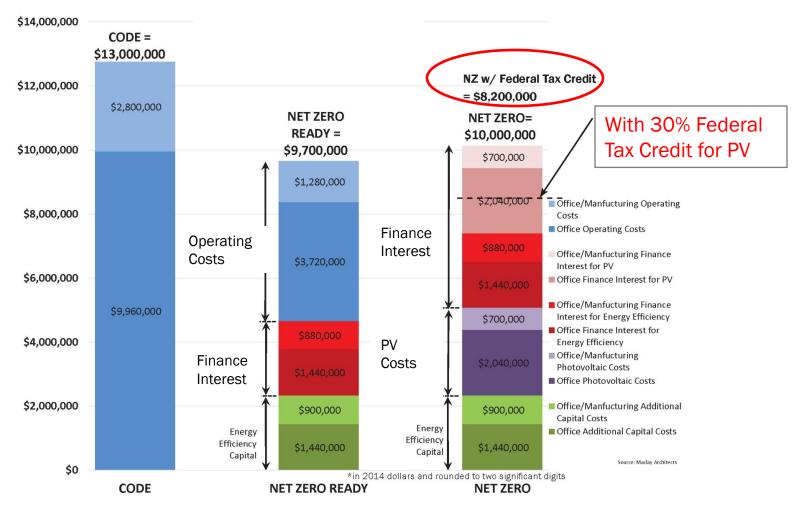
• NZR commercial buildings saves \$3.3 million over 20 years



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

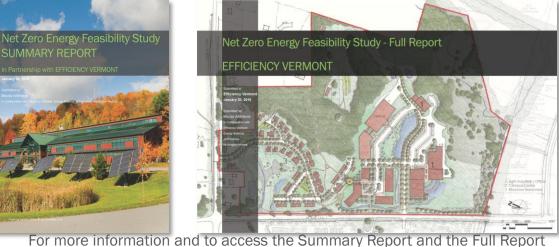
Outcome – Net Zero is Cost Effective

- 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

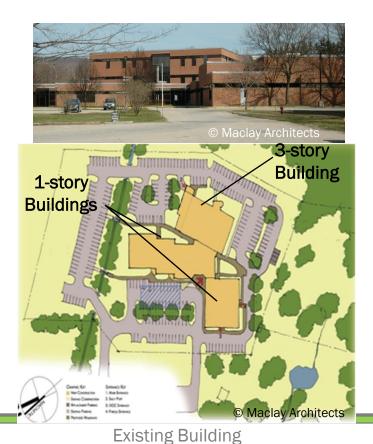
Share the Feasibility Study:



contact: laura@maclayarchitects.com



Integrated Building design -massing -orientation



New Option: Surface Area Reduction:

31% on 5 sides 45% on 6 sides

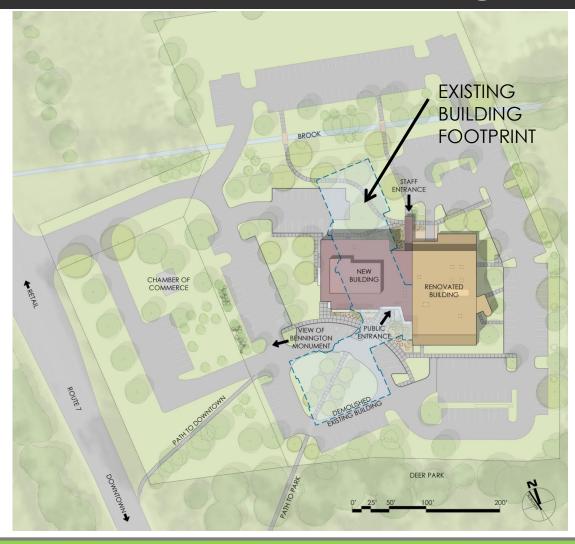
Cost: No increased cost

Massing Savings:

Infinite Return on Investment



Renovated Building

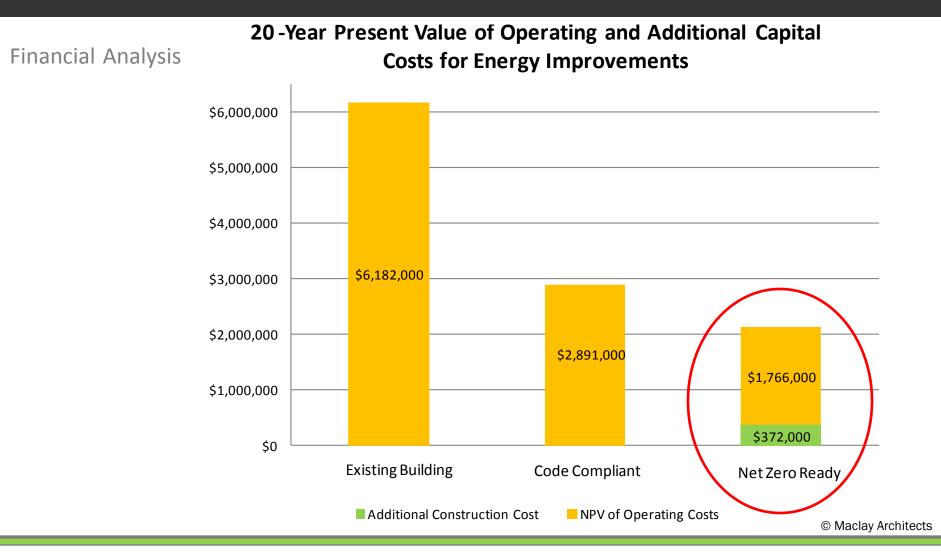


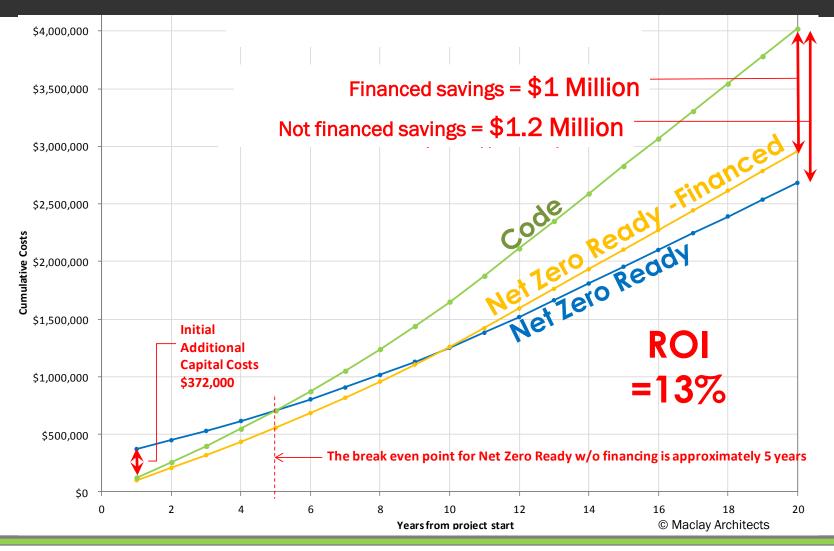
Project Goals and Metrics

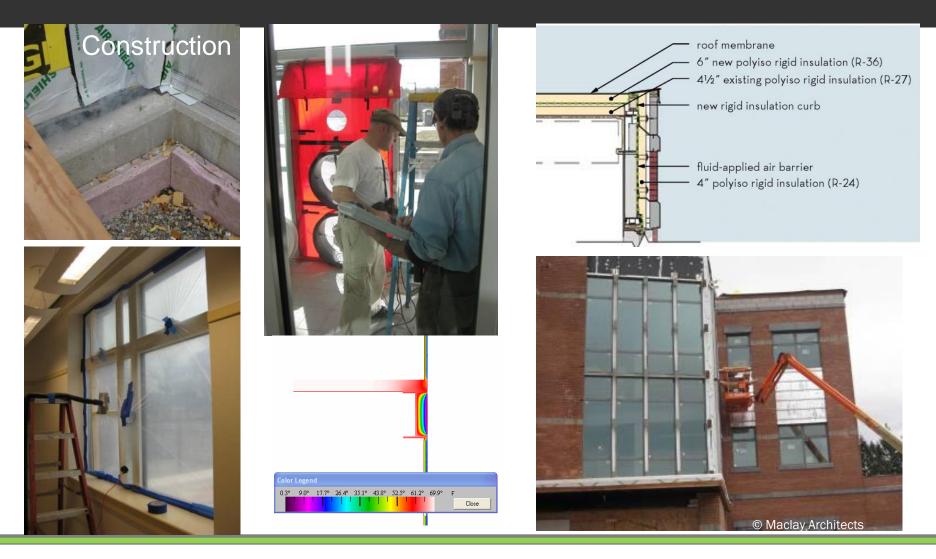
Energy Usage Intensity Comparison									
		Net Zero Ready (modeled as built)		Code Compliant		Existing Facility		EIA National Ave. Existing Office	
EUI	kBtu/sf-yr	(24) (39		113) (92
		Perc	Percent better than existing EUI:						
			79%	E	56%		0%)	
		Source: Maclay Architects' File "BldgEnergyFinance"							

Cost Estimate	Building Component	1. Code Compliant Building	2. Net Zero Ready building/GSHP	Added Cost	Added Cost			
	Windows	Double-glazed windows	Triple-glazed windows	\$30,557				
<u>م</u>	Air/Vapor Barrier	Varor barrier only	Combined air barrier and drainage plane	\$39,000	\$209,097			
Envelope		Install 2" of rigid insulation under slabs	Install 4" of rigid insulation on exterior face of wall framing	\$32,500				
Ň		Install 3" of rigid insulation on exterior face of wall framing	Install 4" of rigid insulation under slabs	\$22,500				
	Insulation	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	1			
	mounderon	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				
Mechanica	Commissioning	2	Full envelope commissioning & blower door testing	\$27,000				
cha	Solar Hot Water	Not a required system	Solar Hot Water System installed	\$31,000	\$163,000			
Me	HVAC	Stendard HVAC Replacement	High-efficiency Ground Source Heat Pump HVAC replacement	\$105,000				
	Total Added Cost \$372,097							
	Added Envelope Cost Per Square Foot S Added Mechanical Cost Per Square Foot S Total Added Cost Per Square Foot S Total Added Cost Per Square Foot S Total Added Cost Per Square Foot S							
	Source: Maclay Architects' File "BldgEnergy							

© Maclay Architects





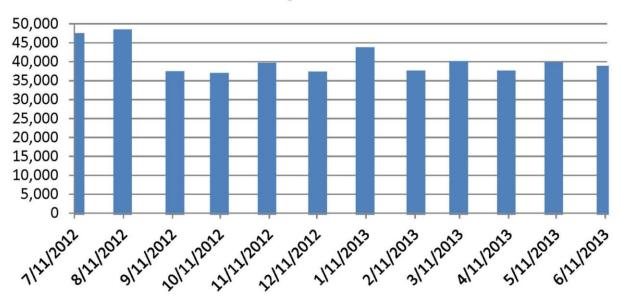


Actual Energy Data

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

Total = 1,664,715 kBtu/year

EUI = 25.6 kBtu/sf-



kWh per month

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

TEAM MEMBERS

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

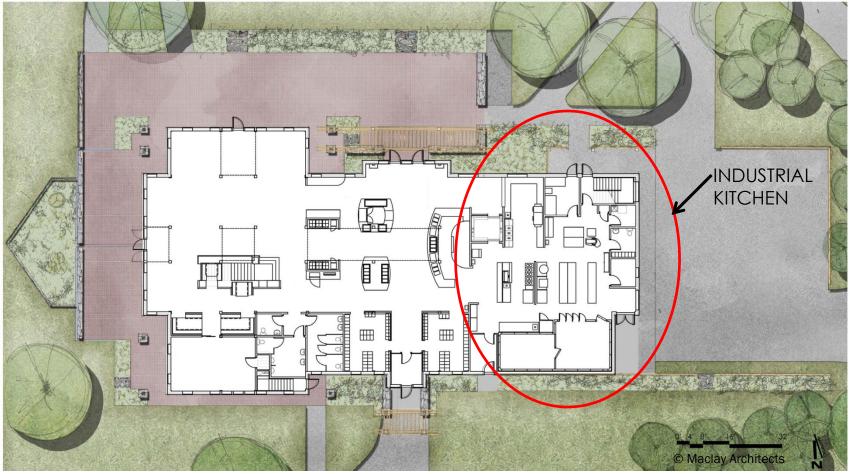


Proctor Academy Dining Hall

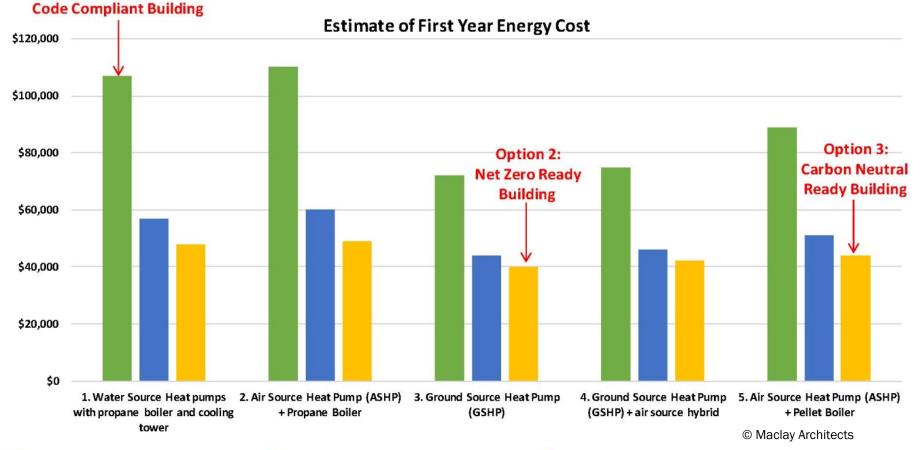




• First floor plan

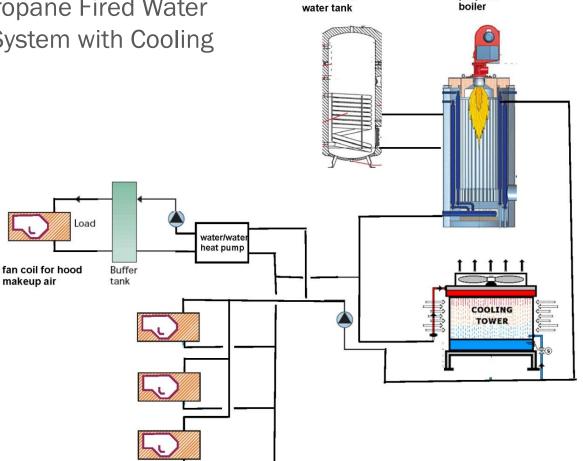


5 Mechanical systems + 3 kitchen hood options
 Option 1:



Code Complaint building with fixed speed hood Net Zero Ready building with variable speed hood

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

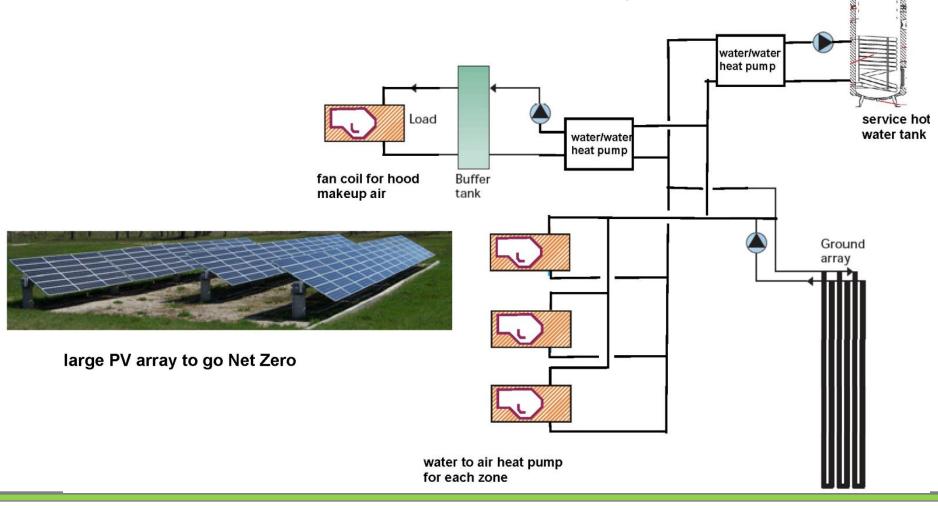


service hot

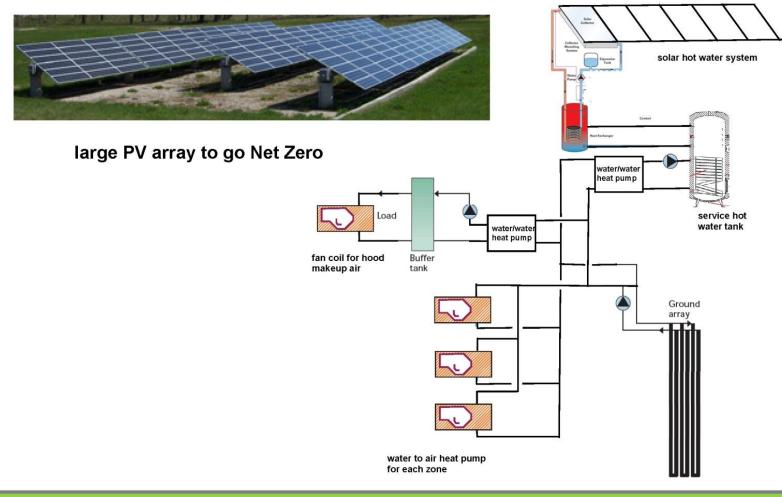
propane

water to air heat pump for each zone

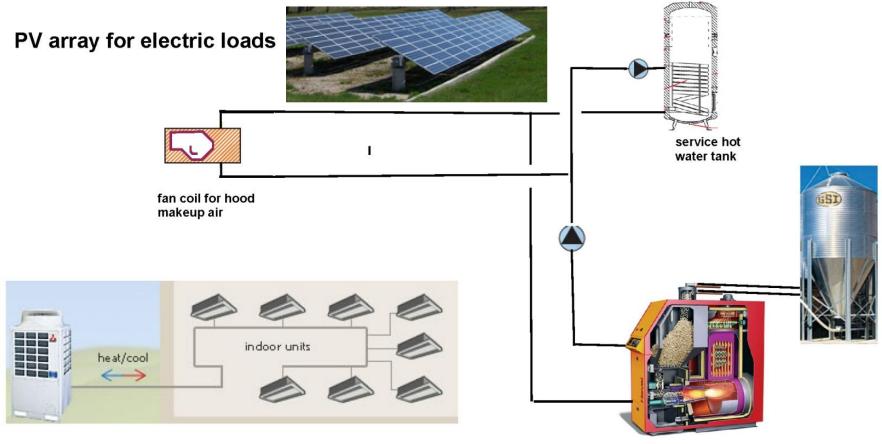
OPTION 2: NET ZERO - Ground Source Heat Pump



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



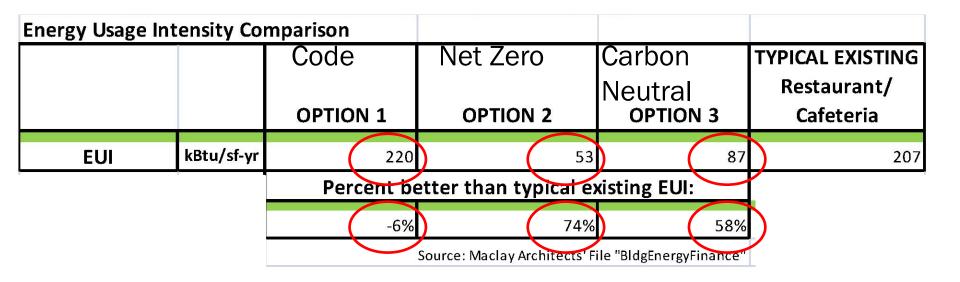
• OPTION 3: CARBON NEUTRAL - Air Source Heat Pump + Pellet Boiler



air to air heat pump with indoor unit for each zone

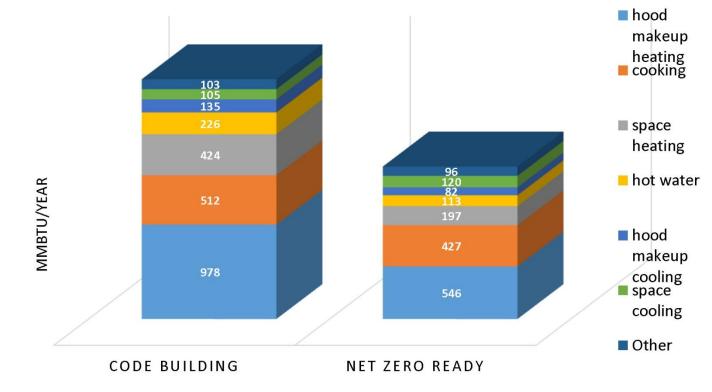
Pellet boiler and outdoor pellet silo

• EUI comparison



• Energy Use

PROCTOR DINING HALL -- CODE VS NET ZERO READY ANNUAL LOADS



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

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

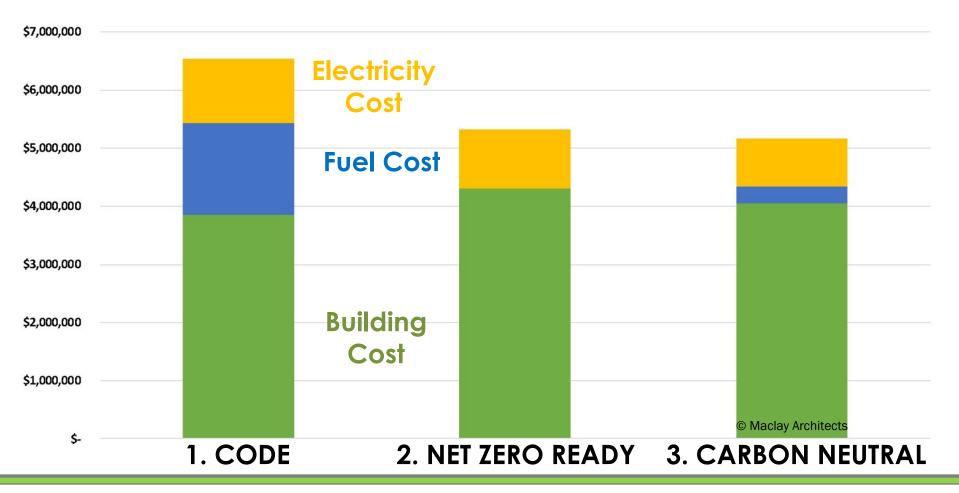
Source: Maclay Architects' File "BldgEnergyFinance"

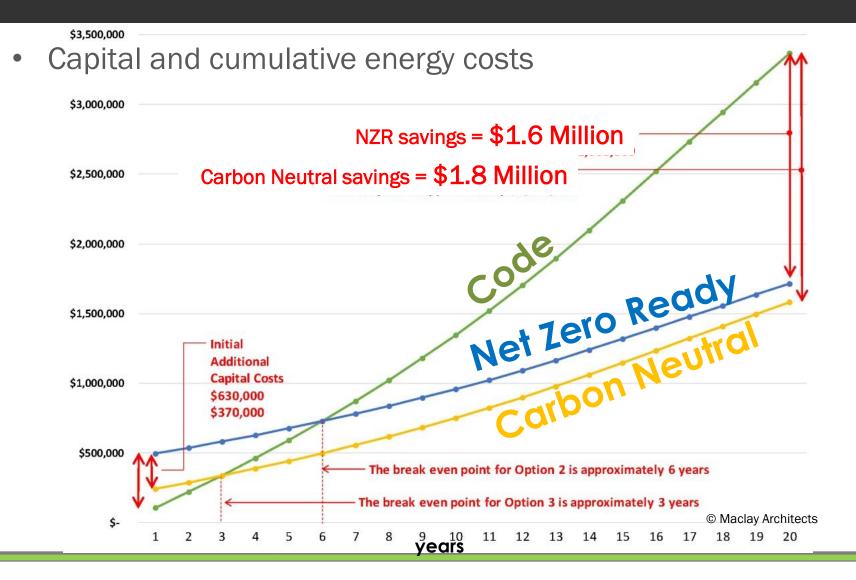
- Comparative cost analysis during Schematic Design for mechanical systems
- Option 1: Code v. Option 3: Carbon Neutral

Building		3. Carbon Neutral Ready Building/	Added
Component	1. Code Compliant Building	ASHP + Pellet Boiler	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	
	Walls: R-20 cavity insulation	Walls: R-40	
Insulation F	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
нуас	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%

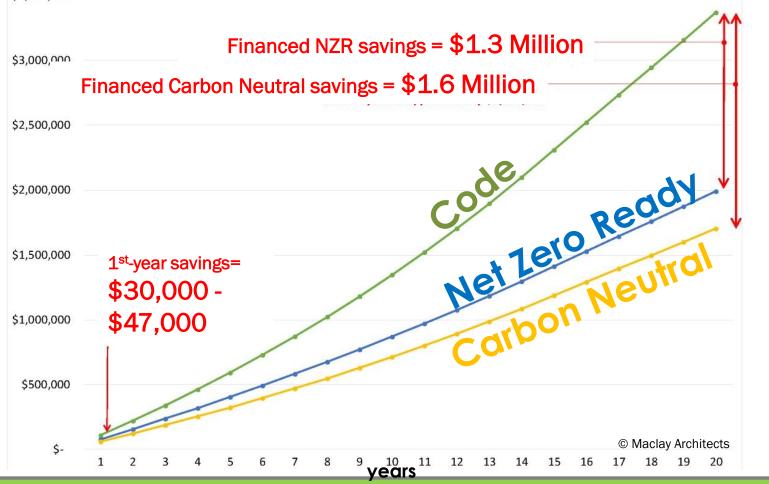
Source: Maclay Architects' File "BldgEnergyFinance"

• 20-year construction and energy costs





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

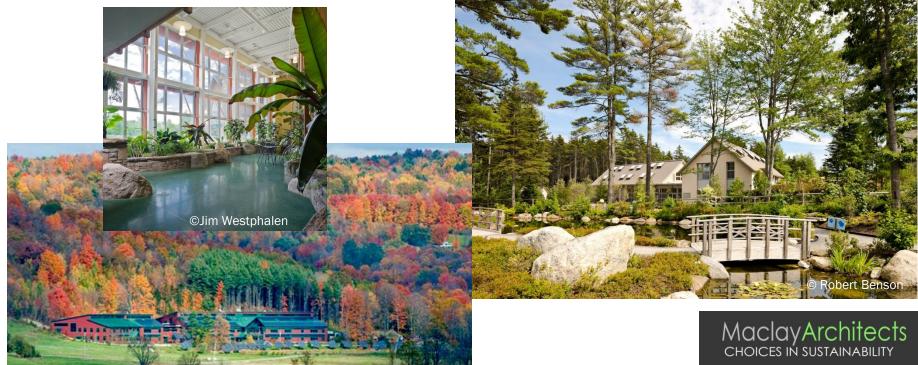


- Next Steps:
 - Add renewable energy on adjacent site
 - 200 kW PV system needed
 - PPA and retain RECs

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



This concludes The American Institute of Architects Continuing Education Systems Course

