Net Zero Energy Feasibility Study
Full Report

Efficiency Vermont

January 30, 2015

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In Collaboration with:
Efficiency Vermont
Energy Balance
JAMorrissey
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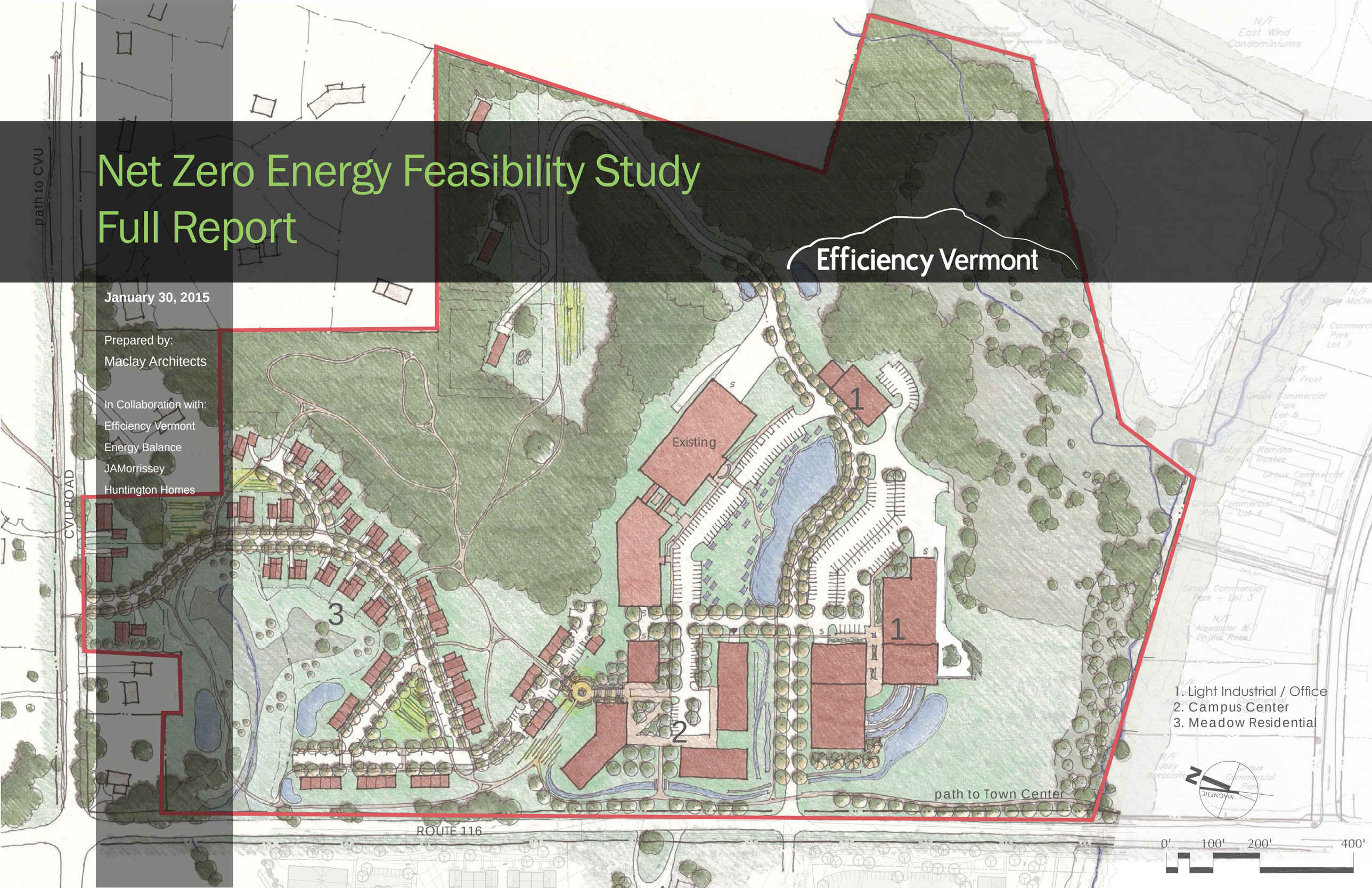

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PROJECT TEAM

Efficiency Vermont

Architecture and Finance Analysis- Maclay Architects

Energy Analysis - Energy Balance

Residential Design and Cost Estimate - Huntington Homes

Finance Review - Renaissance Development Corp.

Commercial Cost Estimate - JAMorrissey

- Avonda Air
- LN Consulting
- Peck Electric
- Northeast Electrical Distributors

SOURCES CONSULTED

Huntington Homes Home Designs
http://huntingtonhomesvt.com/

Wind Energy Associates, LLC Masterplan

Cover photo and all section photos by Maclay Architects unless otherwise noted

Net Zero Energy Feasibility Study

I. EXECUTIVE SUMMARY

Photo by Carolyn Bates © carolynbates.com

EXECUTIVE SUMMARY

PURPOSE

The purpose of this study **is to explore the financial feasibility of net zero energy buildings.** The analysis provided here demonstrates that net zero and net zero ready buildings are a viable and cost effective investment, as compared to code compliant buildings. Using financing for the additional capital costs to build a net zero building, there are net savings from year one for all building types in this study without applying any rebates or incentives except for the office/manufacturing building. By using a SBA secured loan for lower financing rates, Efficiency Vermont incentives, and the federal solar tax credit, the net zero office/manufacturing building is also a better investment than a code building (Figure 2) and will provide cumulating saving beyond the 20 years shown in this analysis. When considering energy cost volatility, health, and other environmental benefits the office/manufacturing building is even more of a prudent investment.

This study provides a body of work and background justification that developers, contractors, designers, consultants, and clients can use to show the relevance and financial benefit of building beyond code standards to net zero energy standards. It is intended to advance net zero buildings in Vermont and beyond.

SCOPE

This study examines the energy and financial implications of building to net zero ready and net zero standards compared to code for six new construction building types.

- Single family residential
- Duplex residential
- Quadplex residential
- Open office
- Closed office
- Office and light manufacturing

Additionally, the study examines the feasibility of a net zero community on the property of Wind Energy Associates, LLC in Hinesburg, VT, demonstrating the viability of net zero construction on a campus scale. Proposed and analyzed for this 60 acre property are 300,000 sf of new buildings added to the 77,000 sf of existing near net zero buildings. This analysis is intended to encourage the planning and construction of net zero ready and/or net zero buildings as the property is developed.

PROCESS

Energy modeling and cost estimating were used to determine the incremental capital cost and annual energy use differences between a code compliant building and a net zero ready building. These results were then analyzed to determine first year operating costs and cumulative capital, operating, and finance costs.

OUTCOME

This analysis shows that new construction of residential and office net zero energy buildings is a cost effective investment. These buildings cost less to own and operate than code buildings from the first year into the long term. The net zero office/manufacturing building is a better investment than code when incentives and rebates are applied.

ENERGY SAVINGS

Energy savings range from 57% to 74% annually for net zero ready buildings as compared to code buildings due to the increased envelope insulation, air sealing, and air source heat pumps (Table 1.1).

Table 1.1: Energy Use Intensity (EUI) for each building type

		Code [2]		Net Zero Ready		
Building Type	**SF**	**(kBTU/ sf-yr)**	**(kWh/ sq.m-yr)**	**(kBTU/ sf-yr)**	**(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%

[1] Duplex and Quadplex are analyzed per unit

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

RESIDENTIAL COST SAVINGS

The residential analysis shows that net zero is the best investment before rebates or incentives are applied, both in year one and over the 30-year loan period (Figure 1.1). When additional energy efficiency capital costs and photovoltaics are financed (cumulative interest is shown in red) net zero ready and net zero residential buildings are cheaper to own and operate (operating costs are shown in blue) than code buildings for single family, duplex and quadplex units.

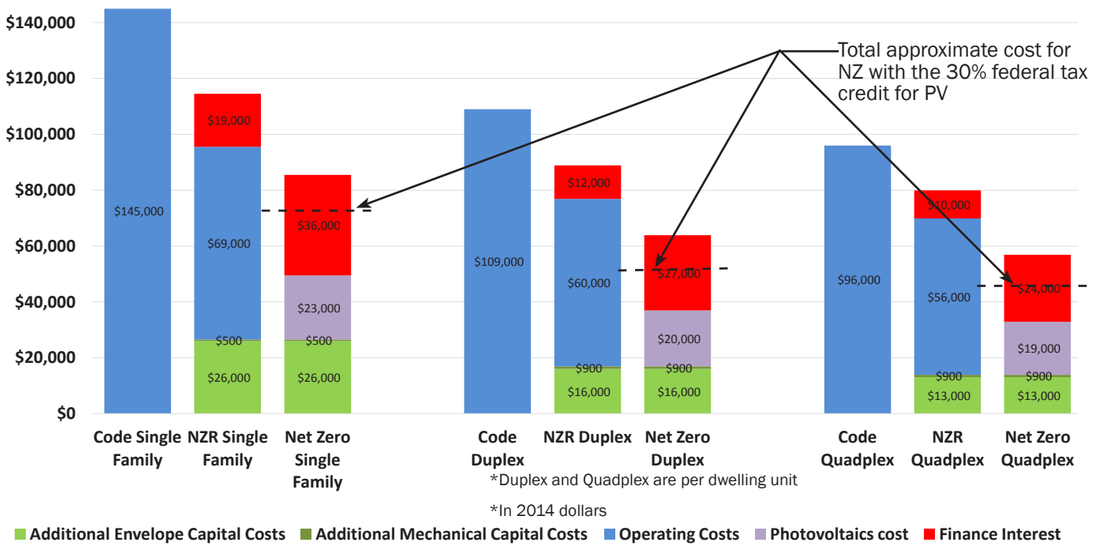

Figure 1.1: Residential 30-year capital, operating, and finance costs

COMMERCIAL COST SAVINGS

The commercial analysis shows that net zero ready office buildings are a better investment than code buildings before rebates or incentives. The open offices cost less to build and operate than closed offices due to reduced materials, finishes, controls, and mechanical systems. For the office/ manufacturing building, the large envelope requirements of the manufacturing area increase the incremental capital costs beyond the savings from reduced operating costs when financed with current commercial financing rates and without applying incentives or rebates (Figure 1.2). Incentives available from Efficiency Vermont would be provided on a custom basis for each project, but they are likely to be in the range of $1/sf for these types of building designs. This incentive level would provide the office buildings with an additional $13,000, and the office/manufacturing building with an additional $27,000. Combining this incentive with the 30% federal tax credit for PV and reduced finance interest with a SBA loan, all of the net zero ready and net zero buildings would each cost less than the code building to own and operate (solid black lines in Figure 1.2). Efficiency Vermont is currently running a Net Zero Energy Pilot Program that has additional incentives for the design process, metering, and commissioning.

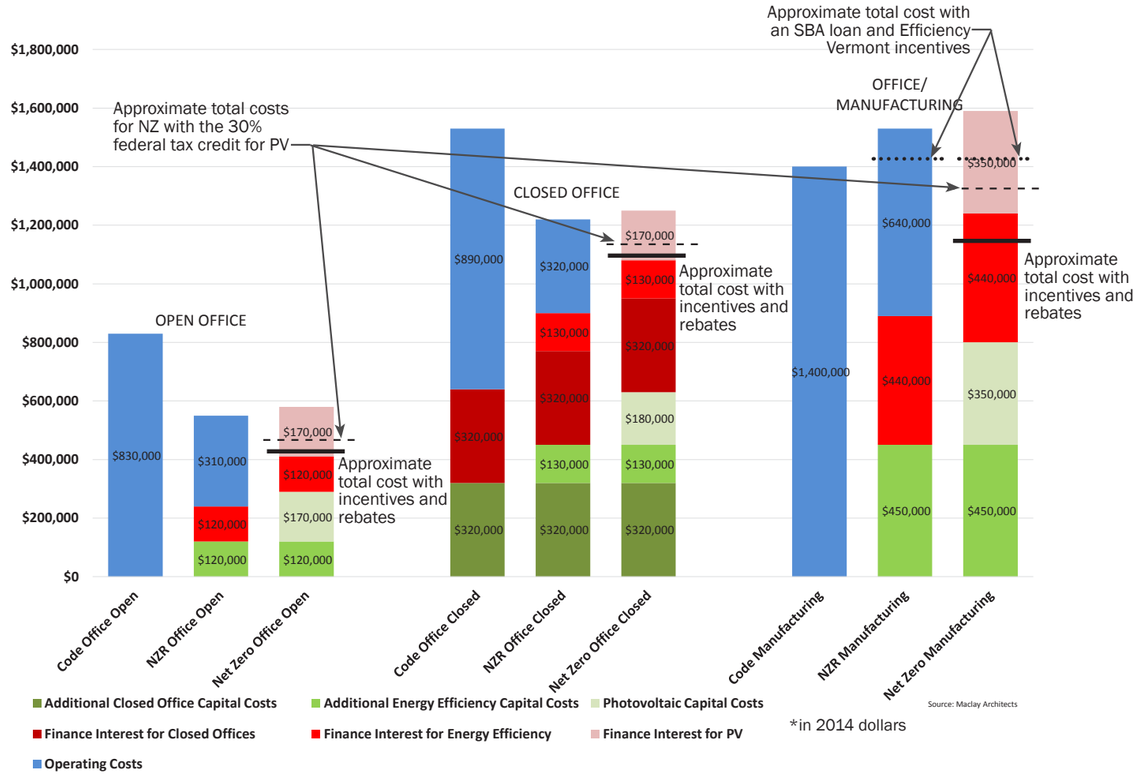

Figure 1.2: Commercial 20-year capital, operating, and finance costs

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ASSUMPTIONS

Assumptions about building design and construction and energy costs were chosen to most accurately reflect the current building climate and financing options today. The financial analysis assumes 4% fixed interest for 30 years for the residential buildings and variable interest rates over 20 years for the commercial buildings. The same financing terms are used for the PV.

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Net Zero Energy Feasibility Study

II. RESIDENTIAL

Photo and project by Huntington Homes, Inc ©

BUILDING TYPE OVERVIEW

This study examined three residential building types and three commercial building types. The residential designs were developed by Huntington Homes and adapted for this study, and the commercial building designs were developed by Maclay Architects to reflect typical commercial buildings.

CODE COMPLIANT BUILDINGS

The code compliant buildings meet the 2015 Vermont Residential Building Energy Standards (RBES) and the 2015 Vermont Commercial Building Energy Standards (CBES) draft dated 11/24/2014. The heating and DHW for the residential buildings are propane-fired furnaces. The mechanical systems for the commercial buildings are rooftop propane-fired heating and cooling units with demand controlled outside air. Ventilation requirements are met without any heat recovery. Additional building modeling information is located in Section V Energy Consumption.

NET ZERO READY BUILDINGS

The net zero buildings are based on the recommended envelope specifications of R20 below grade, R40 walls, R60 roof, R5 windows and air infiltration of less than 0.1cfm50 per sf of above grade surface area. The increased envelope insulation and airtightness enables the heating and cooling system to be air source heat pumps. The tight envelope also provides interior comfort and building resiliency. Ventilation occurs through energy recovery ventilators (ERV), that provide demand-controlled, tempered 100% outside air. Heating and cooling are provided by variable volume cold-climate air source heat pumps, and DHW is provided by a heat pump unit located in the basement.

RESIDENTIAL OVERVIEW

The residential building design for this study is from Montpelier-based modular construction company, Huntington Homes. They currently provide upgrade options to customers that reach the net zero ready level of performance at less that $20/sf additional cost, which includes additional windows on the south elevation. For this analysis the windows were kept the same for both the code and NZR buildings. Huntington Homes also has a variety of multifamily residential building options so the project team adapted an existing Huntington Homes triplex design to become the duplex and quadplex unit layouts for this study. Throughout the study the duplex and quadplex analysis is per dwelling unit.

The envelope and mechanical descriptions are shown in Table 2.3 for the code and net zero ready buildings. There is no cooling for any of the residential buildings, and it is assumed basements will be semi-conditioned for this analysis.

Table 2.1: Residential building configuration parameters

Building configuration	RBES 2015 Code Compliant	Net Zero
Basement	Full basement, semi-conditioned	Full basement, semi-conditioned
# of floors	2 floors	2 floors
Roof/attic	flat attic	flat attic
Orientation	Single Family, duplex, quadplex, has S.facing façade; 0-30% shading no significant impact on model	Single Family, duplex, quadplex, has S.facing façade; 0-30% shading no significant impact on model

Table 2.2: Residential building occupants

Building Occupants	Single Family	Duplex	Quadplex
# bedrooms	3	2	2
Total SF	1,600 sf excluding basement	two floors 560 sf each, total 1,100 sf excluding basement	two floors 560 sf each, total 1,100 sf excluding basement
# bathrooms	2.5	1.5	1.5
# occupants	**4**	**3**	**3**

RESIDENTIAL ENERGY MODEL

The residential energy model is based on the information outlined in Table 2.1 through Table 2.3. Additionally, modeling showed that up to 30% shading on the south side did not significantly change the heating requirements for the residential units, therefore no shading is assumed. The attic is flat and outside of the thermal envelope. Four occupants were modeled in the single family home and three in the duplex and quadplex units.

Table 2.3: Single family building code and net zero specifications

SINGLE FAMILY

	Building Component	Code Single Family	NZR Single Family
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20
		Rim insulation R21	Rim insulation R42
		Walls: R-25	Walls: R-40
		Attic R-49	Attic R-60
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3
PV	Solar PV	none	7.7 kW system

[1] DHW net COP considers some supplemental heat supplied by the ASHP and considering in place performance measurement analysis by Steven Winters Associates

SINGLE FAMILY

The 1,600 sf, 3 bedroom, 2.5 bathroom, single family residential building from Huntington Homes, was used for energy modeling and cost estimating. It is an elongated rectangle with the long axis facing north and south.

Figure 2.1: Residential single family home
source: Huntington Homes

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

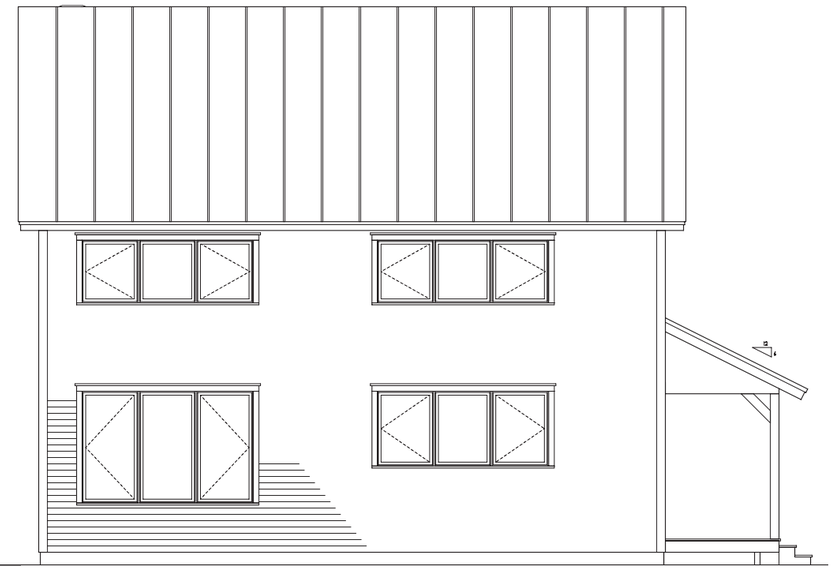


Figure 2.3: Residential single family south elevation
source: Huntington Homes

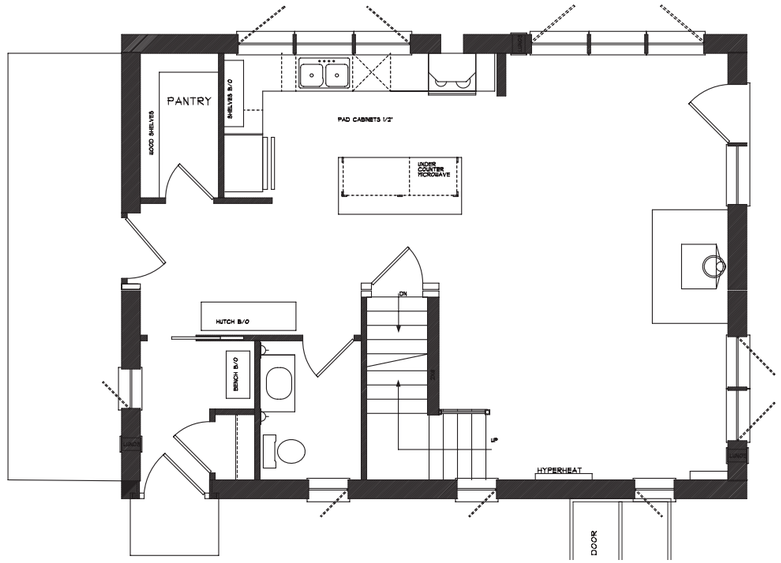


Figure 2.4: Residential single family first floor plan
source: Huntington Homes

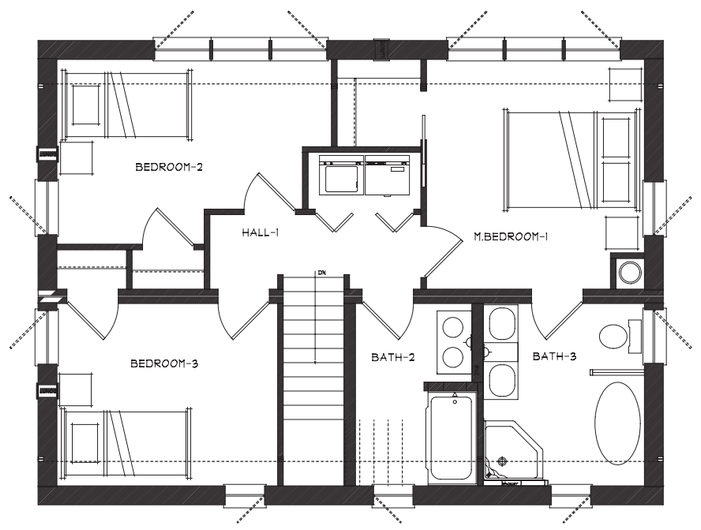


Figure 2.5: Residential single family second floor plan
source: Huntington Homes

Figure 2.6: Residential single family east elevation
source: Huntington Homes

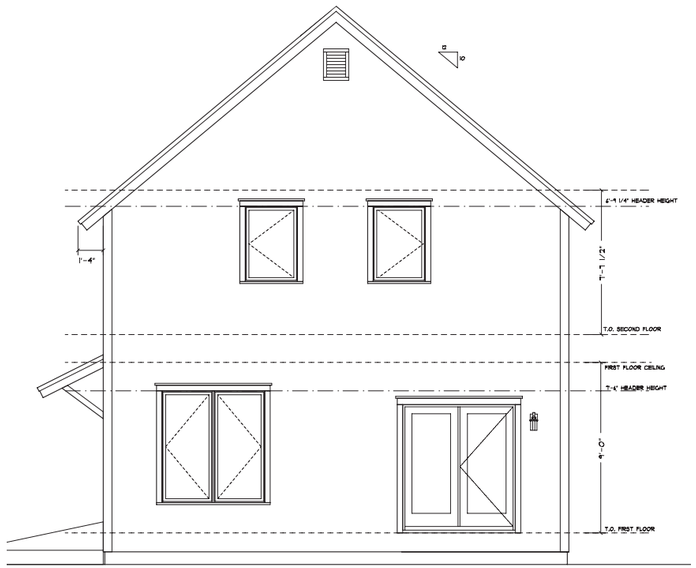


Figure 2.7: Residential single family west elevation
source: Huntington Homes

MULTIFAMILY

A 1,100 sf, 2 bedroom, 1.5 bathroom, multi family residential unit from Huntington Homes was used for the duplex and the quadplex design. Originally for a triplex (shown in Figure 2.8), the design was adapted to duplex and quadplex options in this study.

Table 2.4 and 2.5 detail the specifics of the envelope and mechanical systems.

Figure 2.8: Rendering of the multifamily building
source: Huntington Homes

Table 2.4: Duplex building code and net zero specifications

DUPLEX

	Building Component	Code Duplex	NZR Duplex
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20
		Rim insulation R21	Rim insulation R42
		Walls: R-25	Walls: R-40
		Attic R-49	Attic R-60
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3
	Solar PV	none	6.8 kW system

Table 2.5: Quadplex building code and net zero specifications

QUADPLEX

	Building Component	Code Quadplex	NZR Quadplex
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20
		Rim insulation R21	Rim insulation R42
		Walls: R-25	Walls: R-40
		Attic R-49	Attic R-60
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3
	Solar PV	none	6.3 kW system

[1] DHW net COP considers some supplemental heat supplied by the ASHP and considering in place performance measurement analysis by Steven Winters Associates

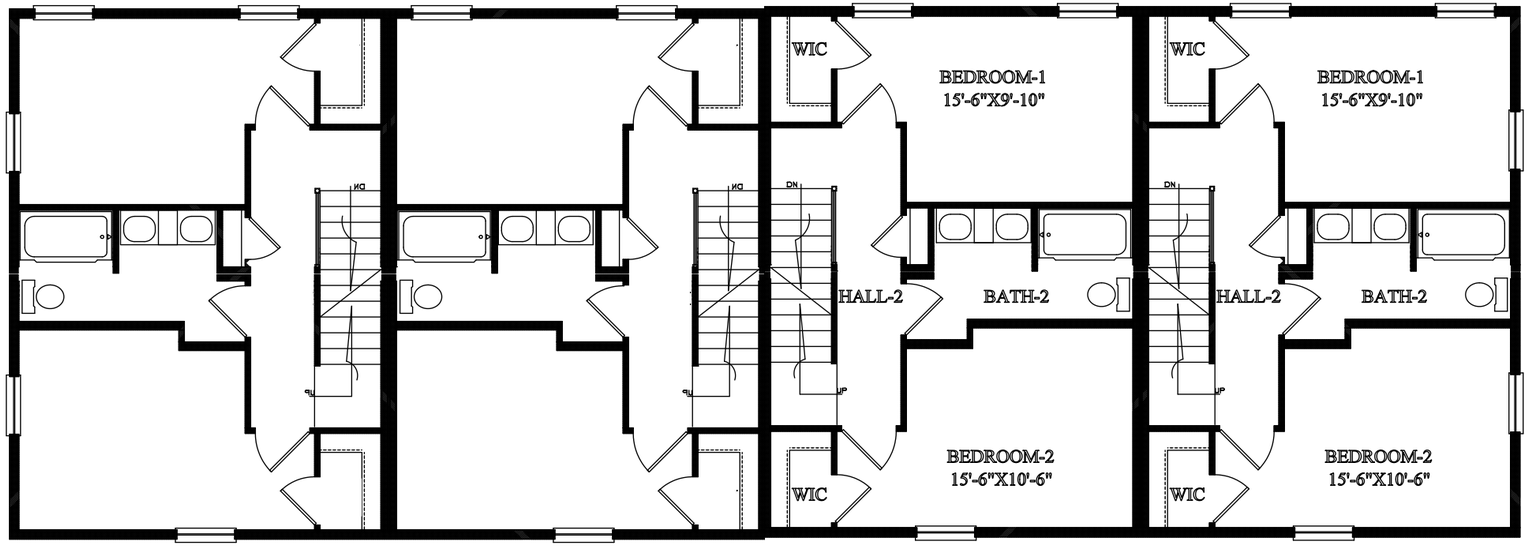


Figure 2.9: Quadplex (and Duplex) second floor plan **source: Huntington Homes**

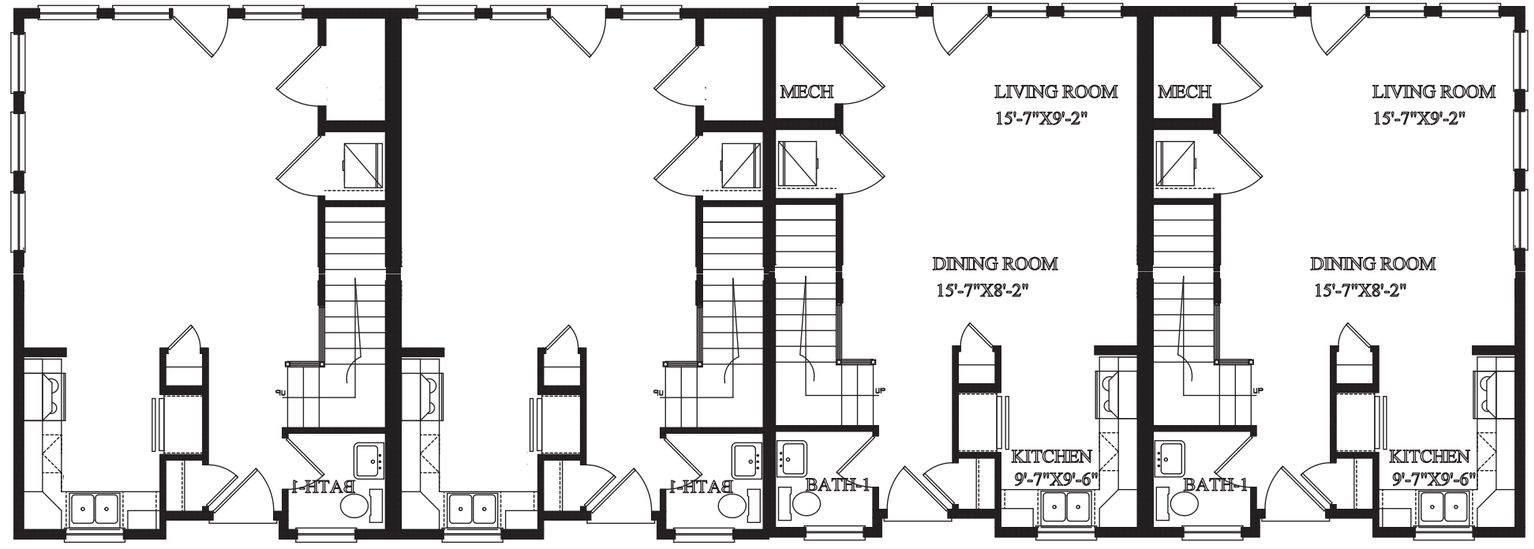


Figure 2.10: Quadplex (and Duplex) first floor plan **source: Huntington Homes**

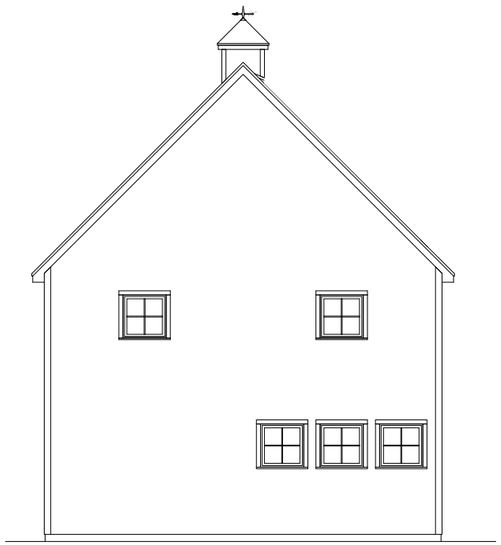


Figure 2.11: West elevation of the multifamily building
source: Huntington Homes

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

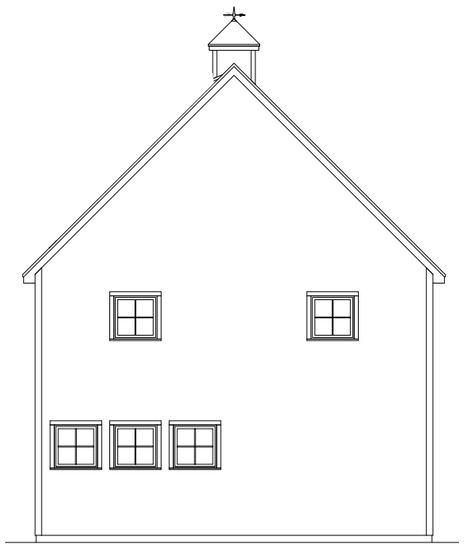


Figure 2.13: East elevation of the multifamily building
source: Huntington Homes

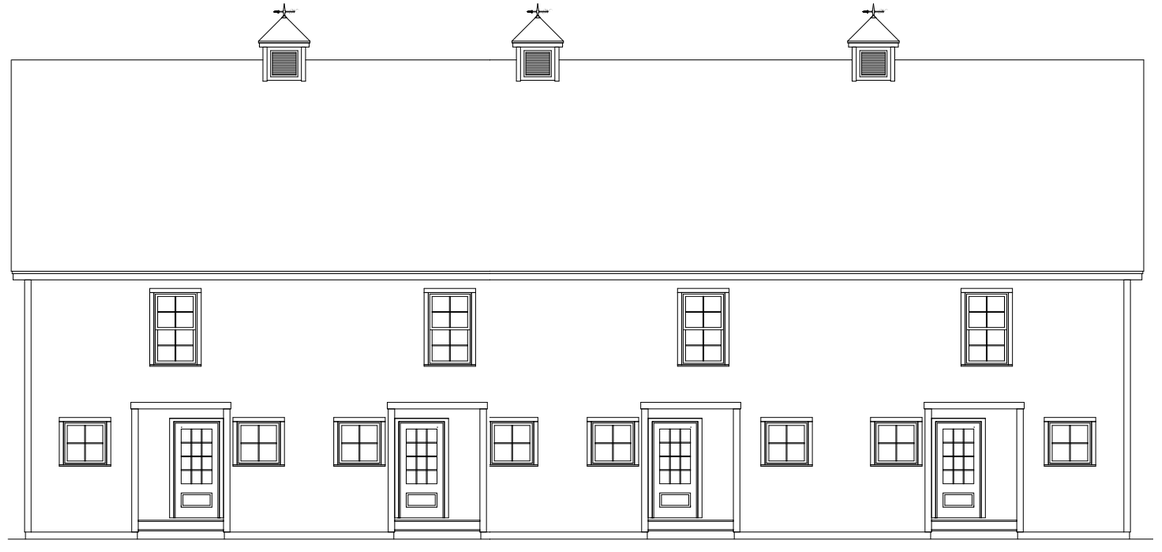
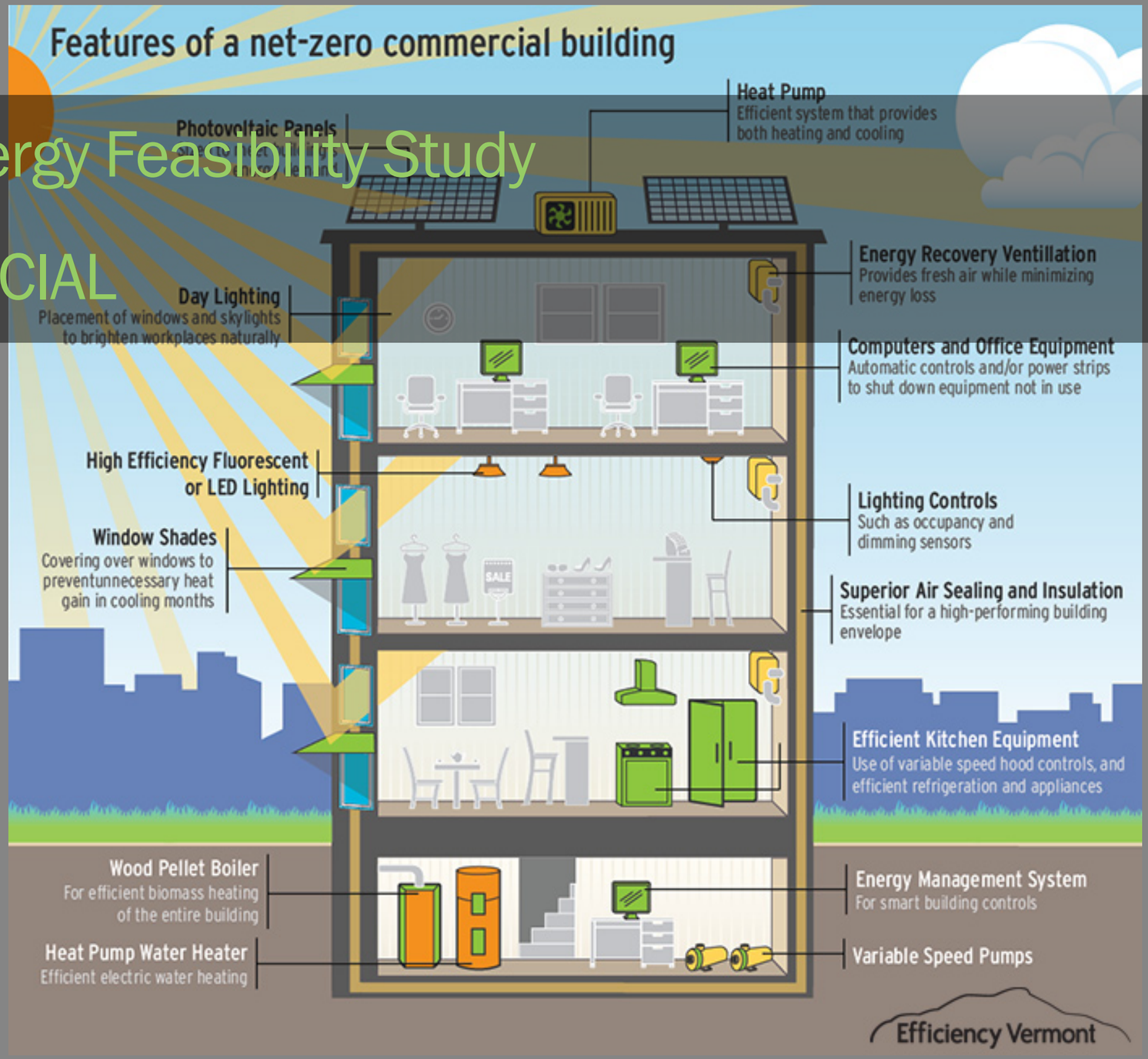


Figure 2.14: Residential duplex and quadplex north elevation **source: Huntington Homes**

Net Zero Energy Feasibility Study

III. COMMERCIAL



COMMERCIAL OVERVIEW

The commercial buildings include a two-story office building totalling 13,000 sf, and a 27,000 sf office and light manufacturing building. The buildings assume a flat site and slab-on-grade construction. The building, plans, elevations, sections, and envelope and mechanical systems are shown for each building type.

OFFICE BUILDING

The 13,000 sf two-story office building schematic open and closed office floor plans are shown in Figure 3.1-3.4. The closed offices require additional mechanical ducting, interior partitions and finishes, and additional controls, resulting in an additional $24/sf capital cost. The net zero and code compliant buildings have the same overall glazing areas on each elevation.

The office building has two 65 ft x 100 ft levels. The size of the floor plate was designed to accommodate the possibility of underground parking. Four office configurations were modeled and cost estimated:

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

This breakout enabled analysis of the energy savings of net zero ready above code compliant, as well as energy and cost savings that open office configurations provide compared to closed offices.

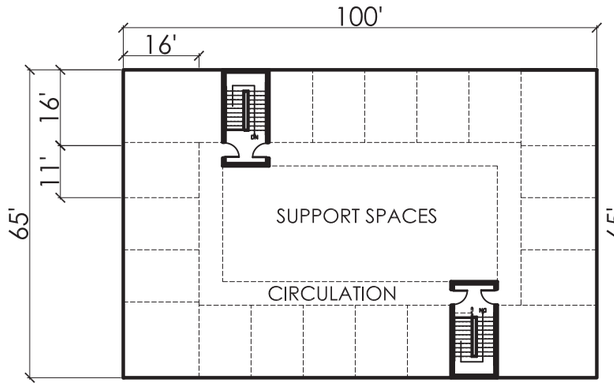


Figure 3.1: Closed office building second floor plan

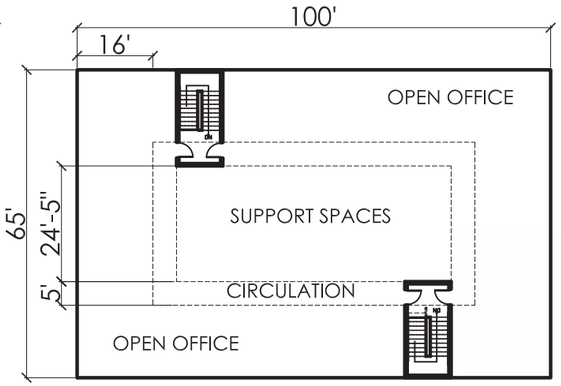


Figure 3.3: Open office building second floor plan

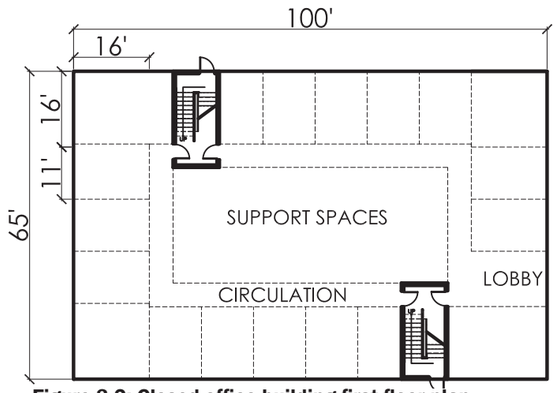


Figure 3.2: Closed office building first floor plan

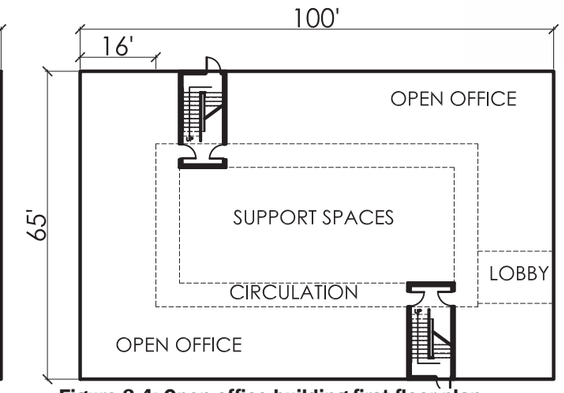


Figure 3.4: Open office building first floor plan

NOTES OFFICE:
6,500 SF PER FLOOR
13,000 SF TOTAL
64% OFFICE
22% SUPPORT
14% CIRCULATION

OFFICE ELEVATIONS

The net zero and code compliant buildings have the same overall glazing areas on each elevation. While the net zero building provides high daylighting windows and the code elevations have only a continuous band of view windows on the north and south, no energy savings were taken for the optimized window placement in the net zero buildings.

The overall percentage of glazing to wall area is 30% for the north and south elevations. The east and west elevations have 15% glazing to reduce overheating from the low sun angles. The open and closed offices have the same exterior elevations.

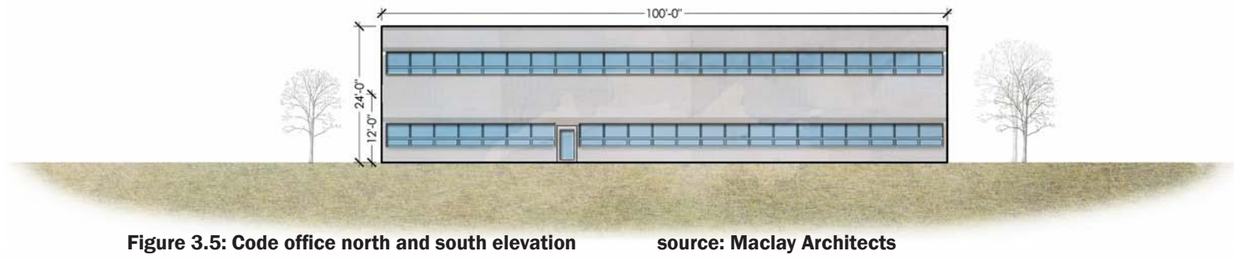


Figure 3.5: Code office north and south elevation **source: Maclay Architects**

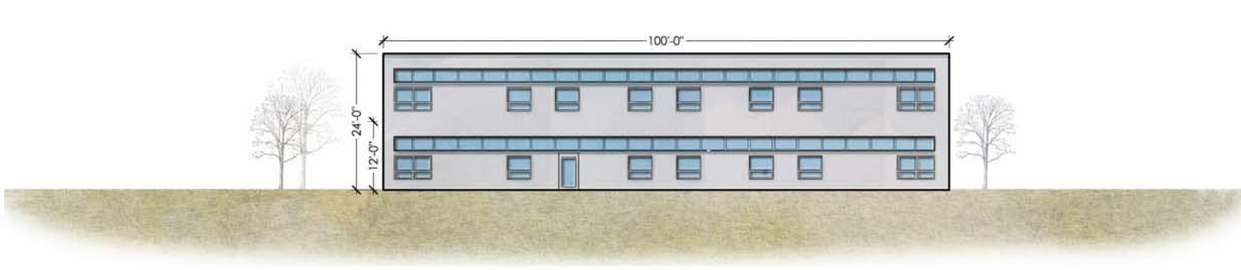


Figure 3.6: Net Zero office north and south elevation **source: Maclay Architects**

Figure 3.7: Code and Net Zero office east and west elevation
source: Maclay Architects

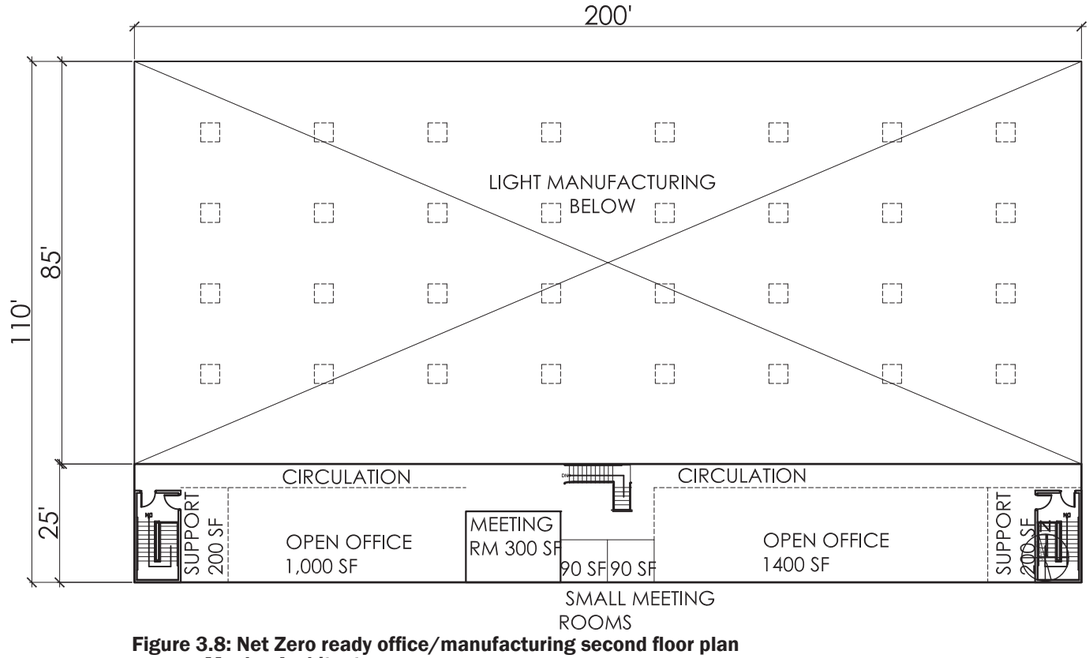


Figure 3.8: Net Zero ready office/manufacturing second floor plan
source: Maclay Architects

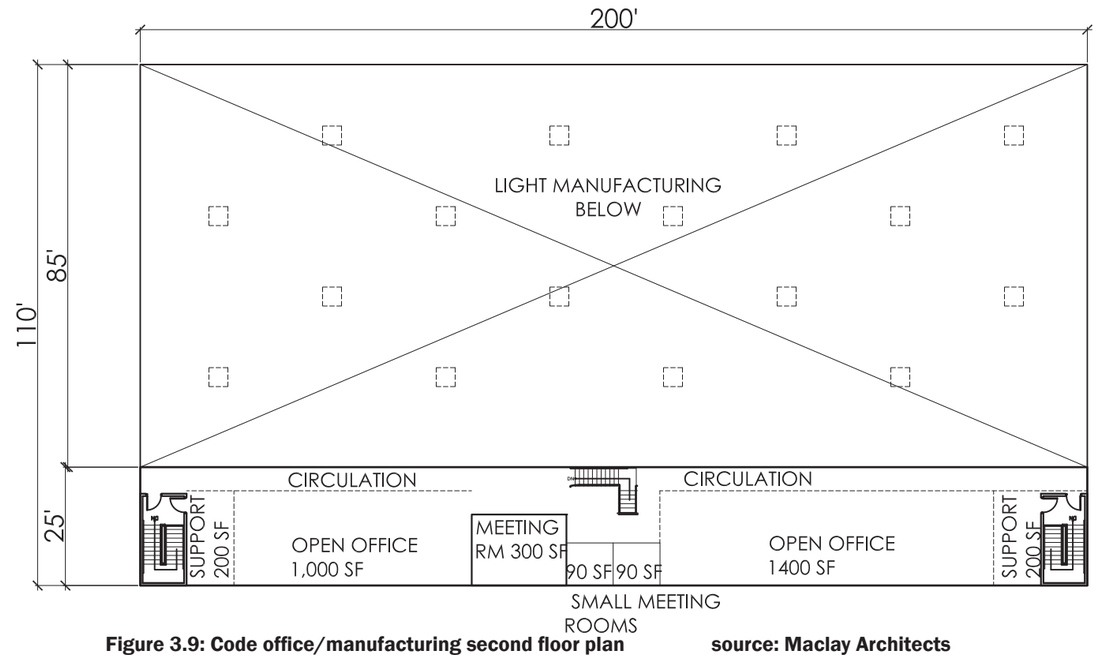


Figure 3.9: Code office/manufacturing second floor plan **source: Maclay Architects**

OFFICE/MANUFACTURING BUILDING

The 27,000 sf office/manufacturing building is designed with a two story elongated open office configuration along the south of the building, with circulation between the offices and the light manufacturing area to the north. The manufacturing area has skylights providing daylight to approximately 3% of the floor area in the net zero building and 1.5% of the floor area in the code building (as per requirements of the 2015 draft Energy Code) with automatic daylight responsive controls in both. See Table 3.2 for skylight specifications.

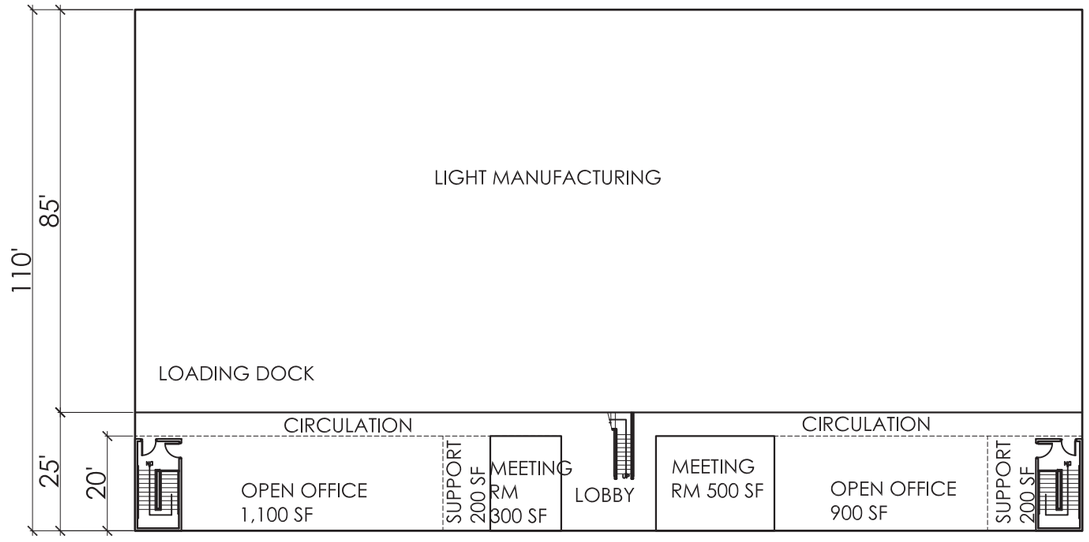


Figure 3.10: Code and net zero office/manufacturing first floor plan **source: Maclay Architects**

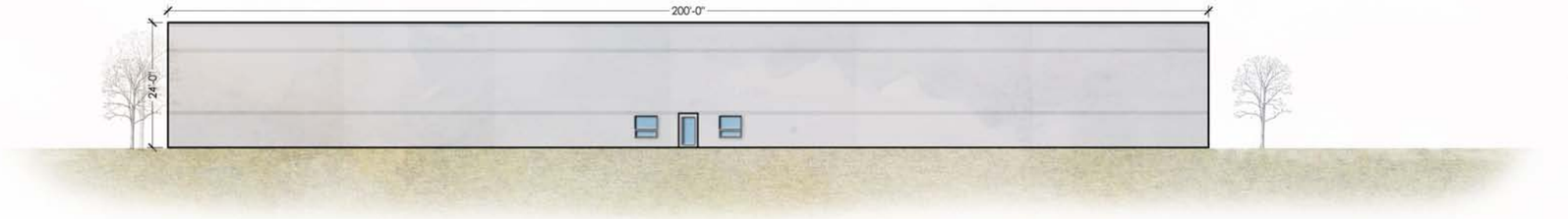


Figure 3.11: Code and net zero office/manufacturing building north elevation **source: Maclay Architects**

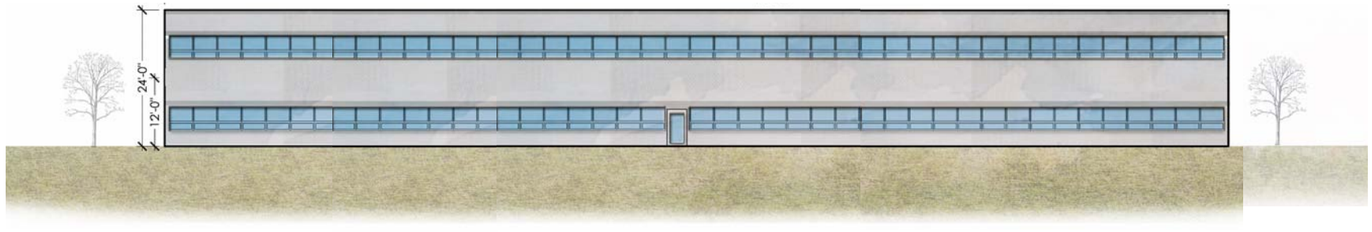


Figure 3.12: Code office/manufacturing south elevation **source: Maclay Architects**

OFFICE/MANUFACTURING ELEVATIONS

The office/manufacturing elevations differ in window placement for the code and net zero options along the south elevation adjacent to the office area. The overall percentage of glazing to wall area is 30% for both south elevations. While the net zero building provides high daylighting windows and the code elevations have only a continuous band of view windows on the north and south, no energy savings were taken for the optimized window placement in the office area of the NZR building.

The east and west elevations have 15% glazing in the office area and less than 2% glazing in the manufacturing area to reduce overheating from the low sun angles and direct sun in the manufacturing area. The north elevation also has less than 2% glazing in the manufacturing area.

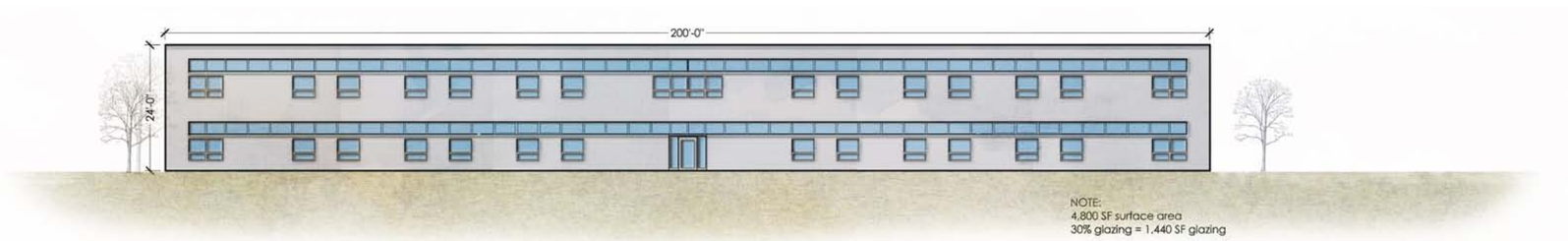


Figure 3.13: Net zero ready office/manufacturing building south elevation **source: Maclay Architects**

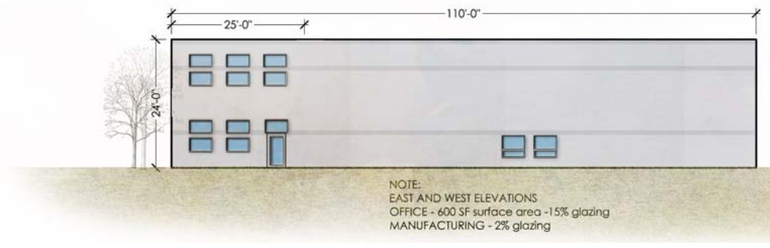


Figure 3.14: Office/manufacturing east elevation **source: Maclay Architects**

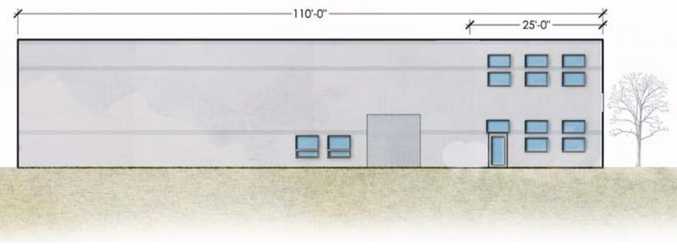


Figure 3.15: Office/manufacturing west elevation **source: Maclay Architects**

COMMERCIAL BUILDING SYSTEMS

The building configurations and occupant assumptions are the same for the code and net zero ready buildings and are broken out in Table 3.1. The office and manufacturing spaces are assumed to be occupied for 10 hours per day 5 days per week, which equates to 2,600 operating hours per year.

The envelope specifications for the commercial buildings are shown in Table 3.2, which are the same for the office building and office/manufacturing building.

The energy model reports used to generate building energy consumption are located in the Appendix.

Table 3.1: Commercial building configuration and occupants

	Offices (Closed and Open Offices same, except interior layout)		Light Manufacturing/Warehouse Space	
BUILDING CONFIGURATION	**CBES 2015 Code Compliant**	**Net Zero**	**CBES 2015 Code Compliant**	**Net Zero**
# of floors	2 floors	2 floors	1 floor	1 floor
Roof/attic	flat/low slope roof	flat/low slope roof	flat/low slope roof	flat/low slope roof
Orientation	Offices have S.facing façade for daylighting	Offices have S.facing façade for daylighting	North facing minimal N,E and W facing windows	North facing minimal N,E and W facing windows
Fenestration	see exterior elevations	see exterior elevations	see exterior elevations	see exterior elevations
Daylighting (see also Lighting Control Strategy matrix below)	side lighting + daylighting controls	side lighting + daylighting controls	skylights on roof 1.5% of floor area + daylighting controls (very few windows so no daylighting contribution)	skylights on roof 3% of floor area + side lighting + daylighting controls (very few windows so no daylighting contribution)
Occupants	one per 200 sq.ft. = 65	one per 200 sq.ft. = 65	20 occupants in Manufacturing area, 32 occupants in the office area	20 occupants in Manufacturing area, 32 occupants in the office area
Plug loads	0.3 watts/sf	0.3 watts/sf	0.55 watts/sf	0.55 watts/sf
Occupied Hours	all spaces Monday -Friday 8-6	all spaces Monday -Friday 8-6	all spaces Monday -Friday 8-6	all spaces Monday -Friday 8-6

Table 3.2: Commercial envelope specifications

	Offices (Closed and Open Offices same) and Light Manufacturing/Warehouse	
BUILDING ENCLOSURE	**CBES 2015 Code Compliant**	**Net Zero**
Foundation	slab on grade R-10 insulation @ below grade walls slab on grade F-factor = 0.48 which is R-10 for 48"	slab on grade R-20 insulation @ below grade walls R-20 under slab and slab edge; slab edge F-factor =0.16
Above grade walls continuous insulation	structural steel frame with horizontal wall girts interior GWB on cold-formed steel studs, no cavity insulation R-16.8 insulated metal panels (3" thick)	structural steel frame with horizontal wall girts interior GWB on cold-formed steel studs, no cavity insulation R-33.6 insulated metal panels (6" thick)
Windows	Double-glazed windows U= 0.35 whole unit SHGC = 0.40 whole unit	Triple-glazed windows U=.2, whole unit SHGC=.33, whole unit
Doors	solid swinging, U=.37 sectional R-10 entrances U=0.8	solid swinging, U=.37 sectional R-10 entrances U=0.5
Roof continuous insulation	tapered polyiso and TPO on metal deck R-33.6 insulation (6" thick, minimum)	tapered polyiso and TPO on metal deck R-61.6 insulation (11" thick, minimum)
Skylights	none in office manufacturing area: U=0.6; SHGC = 0.4	none in office manufacturing area: U=0.2; SHGC=0.5; Tv=0.5
Air/Vapor Barrier	Vapor barrier only	Combined air barrier and drainage plane
Air leakage rate	.50 cfm50/sq.ft. above grade shell	Tested 0.10 cfm50/sq.ft. above grade shell

COMMERCIAL HVAC SYSTEMS

Heating, Ventilation, and Air Conditioning (HVAC) specifications are located in Table 3.3. The net zero option uses air source heat pumps for heating and cooling, and energy recovery ventilation (ERV) units that supply 100% tempered outside air to meet required ventilation rates. The code building uses a rooftop propane furnace for heating with an electric AC unit and a rooftop ventilation unit that draws in some fresh air to meet required ventilation rates. The code ventilation is comprised of a number of small units providing a portion of the ventilation requirements and does not employ energy recovery. The manufacturing area does not have mechanical cooling and air leakage is sufficient to provide the required ventilation rates in both the code and NZR buildings.

Table 3.3: Commercial HVAC specifications

	Offices		Light Manufacturing/Warehouse Space	
MECHANICAL	**CBES 2015 Code Compliant**	**Net Zero**	**CBES 2015 Code Compliant**	**Net Zero**
Commissioning	Not Included	Not Included	Not Included	Not Included
Ventilation	% OA from rooftop unit	ERV, one per floor	Air leakage sufficient for ventilation requirements	Air leakage sufficient for ventilation requirements
Hot Water	Elec resistance	Elec resistance	N/A	N/A
Heat	rooftop unit AFUE=0.8, propane fired	ASHP, annual heating COP=2.3	Modine, propane fired	ASHP, annual heating COP=2.3
Set points	70/65 heat; 74/78 cool	70/65 heat; 74/78 cool	65/60 heat	65/60 heat
Cooling	rooftop unit SEER 13	ASHP SEER 16	No cooling	No cooling

Mechanical Program

Space type	Control program	Temp Schedule
Circulation	one temperature zone per floor	1
Offices, open	one temperature control per room	1
Offices, closed	one temperature zone for 3 or 4 offices	1
Mechanical room	one temperature zone per room	2
Stairwells	one temperature zone per stairwell	2
Manufacturing Warehouse	one temperature zone	2
Vestibule	one temperature zone	3

	Offices		Light Manufacturing/Warehouse Space	
VENTILATION SYSTEM	**CBES 2015 Code Compliant**	**Net Zero**	**CBES 2015 Code Compliant**	**Net Zero**
Circulation space	%OA from rooftop unit	dedicated OA	%OA from rooftop unit	dedicated OA
Offices, Open	%OA from rooftop unit	dedicated OA	%OA from rooftop unit	dedicated OA
Offices, Closed	%OA from rooftop unit	dedicated OA	%OA from rooftop unit	dedicated OA
Mechanical Room	none	none	none	none
Stairwells	none	none	none	none
Vestibule	none	none	none	none
Factory / Warehouse	NA	NA	Air leakage sufficient for ventilation requirements	Air leakage sufficient for ventilation requirements

NOTE:
% OA: rooftop unit draws in some fresh air to meet required ventilation rate
dedicated OA: energy recovery ventilation unit that supplies 100% tempered outside air to meet required ventilation rate

	Offices	
VENTILATION RATES	**CBESC 2015 Code Compliant**	**Net Zero**
Circulation space volume: note [1]	control: clock set point: per sq.ft & # people	control: clock set point: per sq.ft & # people
Offices, Open volume: note [1]	control: clock set point: per sq.ft & # people	control: modulated Set point: 1200 ppm
Offices, Closed volume: note [1]	control: clock set point: per sq.ft & # people	control: occupancy set point: per sq.ft & # people

[1] .06 cfm/sq.ft + 5 cfm/person; minimum of 30 cfm per closed office

COMMERCIAL LIGHTING

The lighting calculations used in the energy models assume the same fixture count and installation labor for the code and net zero ready buildings. The code buildings use fluorescent fixtures and the net zero ready buildings use LED fixtures. No rebates or incentives were applied to the cost of the LED fixtures. The controls are the same for the code and net zero ready buildings, but differ for the closed and open offices.

Table 3.4: Commercial building lighting watt assumptions

W/SF MAXIMUM	CBES 2015 Code Compliant and Net Zero watts/sq.ft.	Open Office		Closed Office		Manufacturing/ Warehouse	
		% of floor area	sq.ft	% of floor area	sq.ft	% of floor area	sq.ft
Circulation ambient	0.66	20%	2,600	20%	2,600	10%	2,700
fc: 10-20							
Open Offices	0.98	70%	9,100		-	16%	4,320
fc: 30							
Closed office	1.11		-	70%	9,100	6%	1,700
fc: 30							
Mechanical room	0.95	5%	650	5%	650	2%	540
fc: 50							
Stairwells	0.69	5%	650	5%	650	3%	800
fc: 10-20							
Mfg. / Warehouse avg [1]	1.07		-		-	63%	17,000
fc: 10-20							
Modeled Area Weighted Avg watts/sf							
Code		**0.90**		**0.99**		**1.01**	
Net Zero Ready		**0.50**		**0.50**		**0.60**	

[1] assumes half warehouse/half manufacturing

Mfg/Warehouse	Mfg Facility – "In a low bay area"	1.19
Mfg/Warehouse	Warehse- storage –" smaller items"	0.95
	average	1.07

COMMERCIAL DAYLIGHTING

Daylight savings from vertical fenestration were assumed to be the same for both the code and net zero ready office buildings and not included in this analysis. The 2015 CBES code requires daylight controls that are also used for the NZR office buildings.

For the manufacturing area of the office/manufacturing building daylight savings were calculated from skylights in both the code and net zero ready buildings. The net zero manufacturing area has skylights covering 3% of the floor area and the code building has skylights covering 1.5% of the floor area. Skycalc, from Energy Design Resources, was used to estimate energy savings and heating and cooling energy penalties, which are reflected in Section V. Energy Consumption for the office/ manufacturing building.

Table 3.5: SkyCalc for the manufacturing area of the office/manufacturing building

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: Energy Balance
Project Description: NZ manufacturing

Electric Lighting Usage	**kWh/yr**		
Ltg. Energy without Skylights	79,033	Lighting Fraction Saved	30%
Lighting Energy w/ Skylights	54,999	Full daylighting (h/yr)	624

Savings from Design Skylighting System

Savings		**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting		24,034	$0
Cooling		0	$0
Heating		-5,591	-$656
Total		**18,443**	**$2,949**

Skylighting System Description		Site Description	
Skylight unit size (ft2)	16	Climate Location	Burlington, VT
Number of Skylights	32	Climate Zone	ASHRAE B-19
Total Skylight Area (ft2)	512	Building Type	Warehouse
Skylight to Floor Ratio (SFR)	3%	Building Area	17000 (ft2)
Effective Aperture	1%		
Floor Area per Skylight	531.25	Elecric Lighting System Description	
Skylight U-value	0.3	Lighting Ty Industrial fluorescent	
Skylight SHGC	0.51	Lighting Cc Dimming min 10% light	
Skylight Tvis	0.50	Light Level Setpoint	25 fc
Well Efficiency (WF)	0.82	Lighting Density	1.05 W/ft2
Dirt and Screen Factor	0.80	Connected Load	17.85 kW
Overall Skylight System Tvis	0.33	Fraction Controlled	0.9
Skylight CU	0.39		

OFFICE SECTION

The office building wall assembly is comprised of insulated metal panels. This decision was based on information from the NFPA 285 that states exterior rigid foam is not permitted unless specifically tested on this building type and size. In order to reach the net zero ready envelope R-values a number of wall assembles were investigated. Metal panel manufacturers undergo the required testing for their products to pass the NFPA 285 testing requirements, so were used for the walls wrapping a steel structure for the office and office/manufacturing building.

The building section shows the same components for both the code and net zero buildings, with the difference in insulation thickness shown as the dotted line.

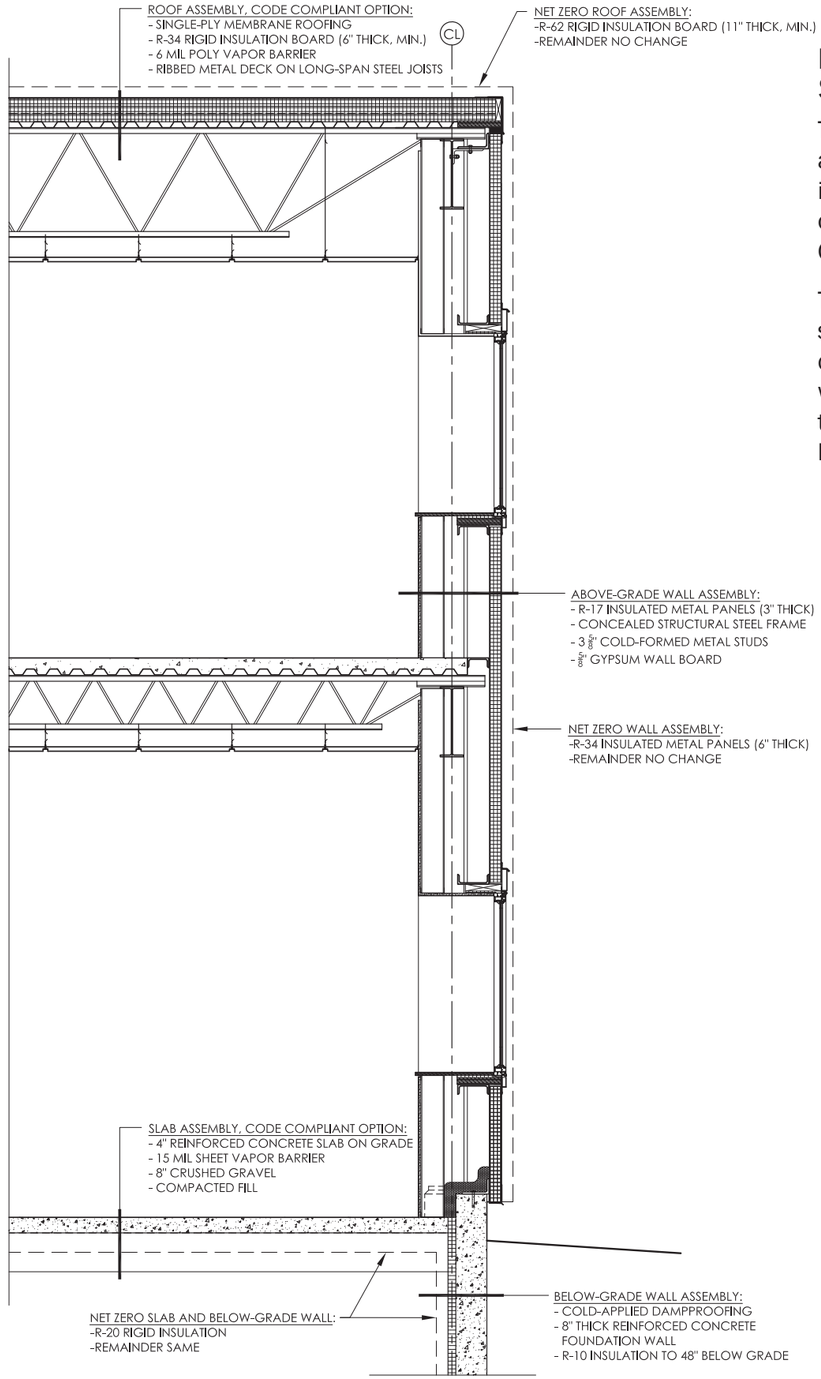


Figure 3.16: Office wall section **source: Maclay Architects**

MANUFACTURING SECTION

The manufacturing building wall assembly also is comprised of insulated metal panels based on the discussion outlined in the Office Section.

The building section shows the same components for both the code and net zero buildings, with the difference in insulation thickness shown as the dotted line.

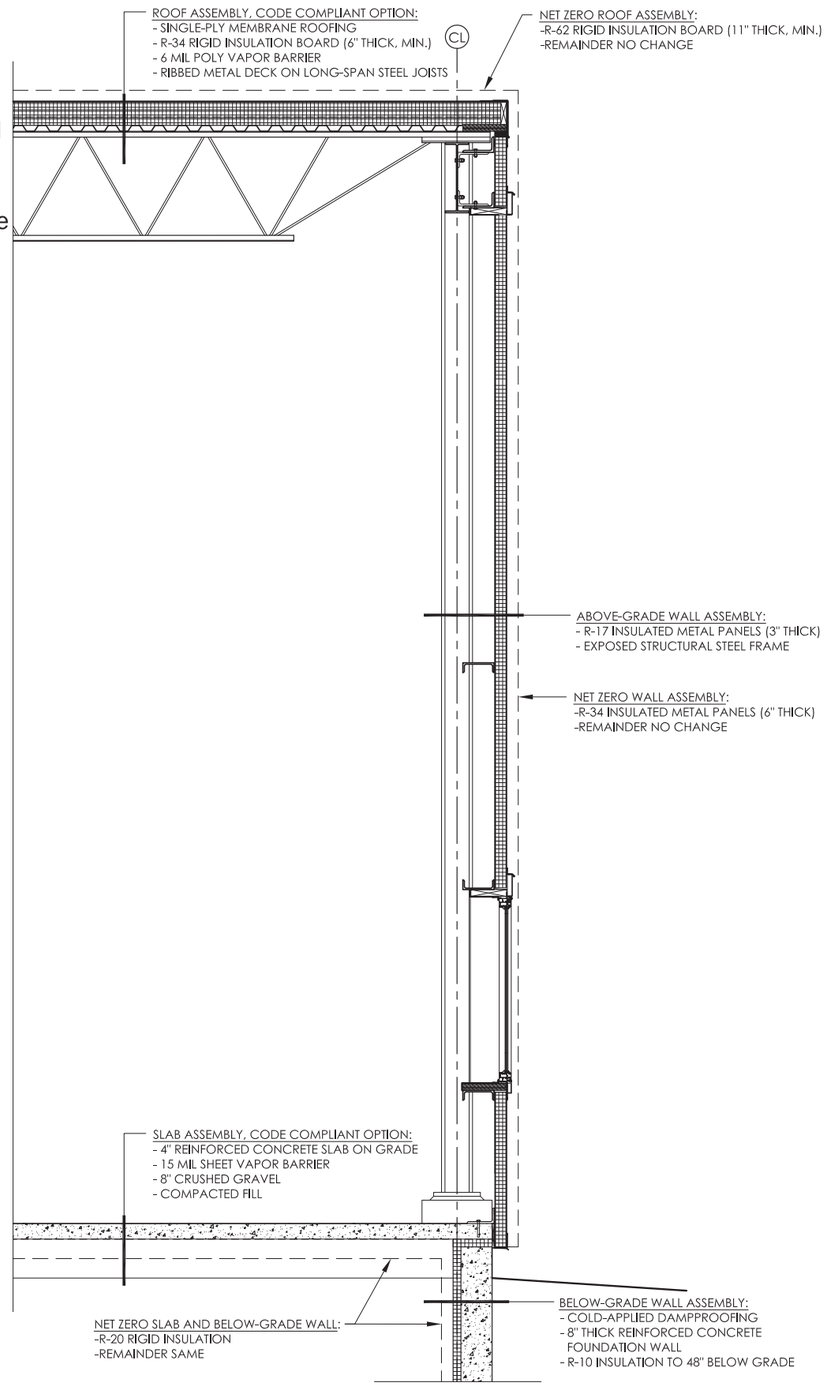


Figure 3.17: Manufacturing wall section **source: Maclay Architects**

Net Zero Energy Feasibility Study

IV. COMMUNITY

COMMUNITY

To evaluate and encourage net zero ready, net zero, and high performance buildings on a campus scale in Vermont, a 300,000 sf mixed use community on Wind Energy Associates property was analyzed to show the total energy requirements for a code compliant community and a net zero community. The land contains two existing office and light manufacturing buildings (indicated in the center of Figure 4.1) leased to Renewable NRG Systems, in Hinesburg, VT. The proposed community square footage is broken out by building type and number of dwelling units. The total energy consumption for a code compliant and a net zero community were analyzed based on the EUIs generated for each building type and located in Section V.

Table 4.1: Net zero community square footage calculation

	Office (SF)	Manu-facturing (SF)	Total building (SF)	Number of Bldgs/ Units	Community (SF)
Office	13,000 - 48,000	0	varies	5	160,000
Office/manufacturing	10,000	17,000	27,000	2	54,000
			Total commercial SF:		**214,000**
Single Family			1,617	19	32,000
Duplex			1,120	12	20,000
Quadplex			1,120	34	34,000
			Total residential SF:		**86,000**
			Community Total:		**300,000**

Figure 4.1: Community masterplan source: Maclay Architects and SE Group

RENEWABLE ENERGY OVERLAY

This community is oriented and planned to optimize renewable energy production on site. The design considerations include rooftops and carports that are within 20 degrees of due south with minimal shading by existing or proposed trees. The renewable energy overlay shows the existing 150 kW of PV in pink, the existing 10 kW wind turbine, proposed PV areas on south-facing or flat rooftops in green, carports in blue, and possible ground-mounted PV on the flat meadow or south facing slope to make the community net zero.

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

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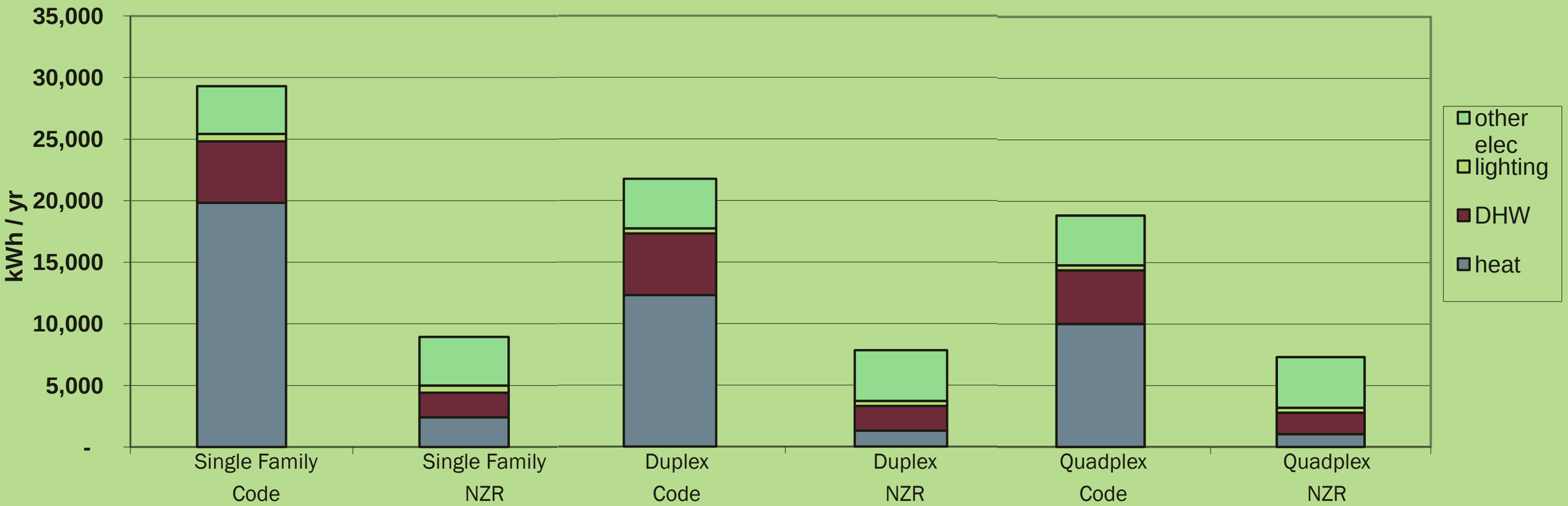
Net Zero Energy Feasibility Study

V. ENERGY CONSUMPTION



Efficiency Vermont · Huntington Homes · JAM · Energy Balance · MaclayArchitects

ENERGY CONSUMPTION

ENERGY MODEL APPROACH

The building load energy modeling was performed by Energy Balance using Energy10, an hourly building energy simulation model. Each building type was modeled to determine code and net zero ready energy consumption per year. The building parameters and mechanical assumptions are listed in the residential and commercial sections of this report.

SUMMARY OF BUILDING ENERGY USE

Each building type has an overall Energy Use Intensity (EUI) in kBtu/sf-yr and kWh/sq.m-yr, (Table 5.1).The overall energy savings of the net zero ready building above the code building for each building type ranges from 57% to 74% better than 2015 code. This shows substantial savings even with the high energy standards of the 2015 code.

The annual energy consumption for each building type is broken out into heat, hot water, cooling, lighting and other electric (Table 5.2 and Figure 5.1-5.2).

Reducing energy consumption provides financial benefit to the building owner, but it also reduces the impact of carbon emissions in the atmosphere. Table 5.2 shows the carbon dioxide emissions assumptions for each building. Building to net zero standards saves operating costs and reduces CO2 emissions each year.

For additional energy modeling summaries for each building see the Appendix.

Table 5.1: Energy Use Intensity (EUI) for each building type

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

[1] Duplex and Quadplex are analyzed per dwelling unit

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

Table 5.2 Energy usage breakout for each building type

	Energy Usage, kWh/yr [4]												
	Code						Net Zero Ready						
Building Type	**heat [2]**	**hot water**	**cooling [5]**	**lighting**	**other elec**	**Total**	**heat [3]**	**hot water [4]**	**cooling [6]**	**lighting**	**other elec**	**Total**	**% energy savings above code**
Single Family	19,826	5,000	-	585	3,878	29,289	2,406	2,667	-	585	3,953	9,610	67%
Duplex [1]	12,316	4,375	-	407	4,037	21,135	1,302	2,333	-	407	4,112	8,155	61%
Quadplex [1]	9,525	4,375	-	407	4,037	18,344	985	2,333	-	407	4,112	7,837	57%
Open Office	160,366	2,000	6,879	35,963	31,500	236,708	12,381	2,000	6,922	19,832	24,656	65,792	72%
Closed Office	175,015	2,000	6,987	37,965	32,258	254,225	12,232	2,000	6,096	19,882	27,141	67,351	74%
Office/Manfuacturing	223,689	2,000	6,607	69,632	88,990	390,918	16,166	2,000	4,564	27,532	84,738	135,001	65%

Notes
[1] Duplex and Quadplex energy use on a per-unit basis.
[2] Propane usage in code buildings accounts for 80% efficient boiler for heating and 80% efficient for hot water -energy calculation of EUIs: kBtu/sq.ft-yr x 1 kWh/3.412kBtu X 10.76 sq.m./sq .ft
[3] ASHP have a heating COP of 2.3
[4] NZR domestic hot water uses DWH heat pump in basement at net COP of 1.5 for NZR
[5] Propane AC unit with SEER rating of 13 has a COP of 3.8
[6] ASHP for cooling have a COP of 4.7

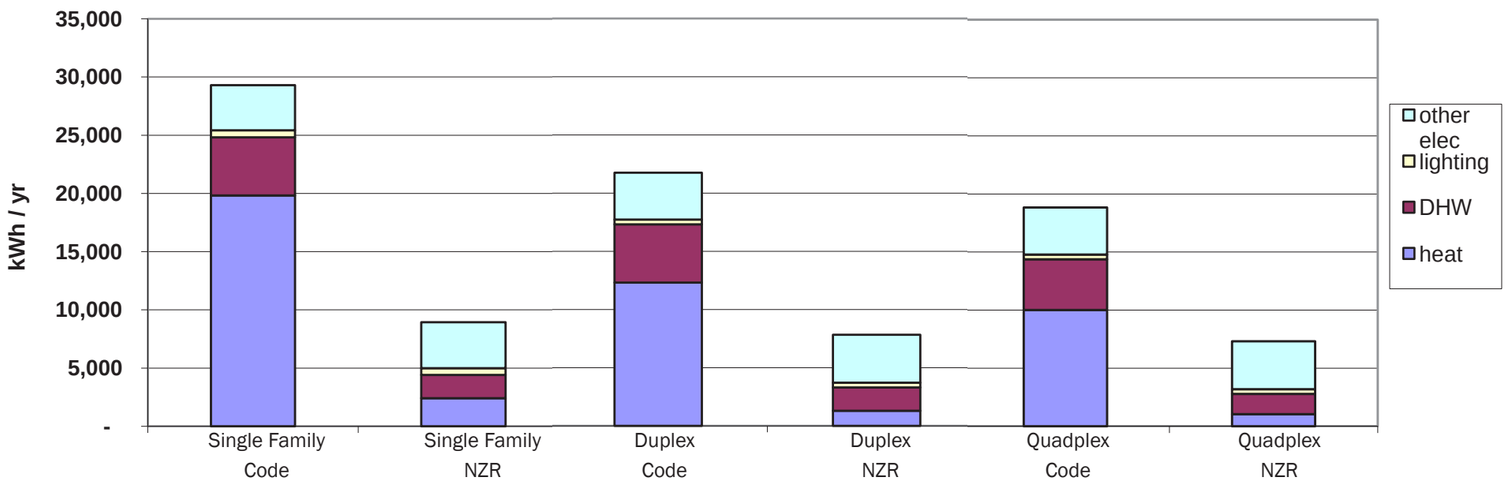


Figure 5.1: Residential annual modeled energy use per dwelling unit

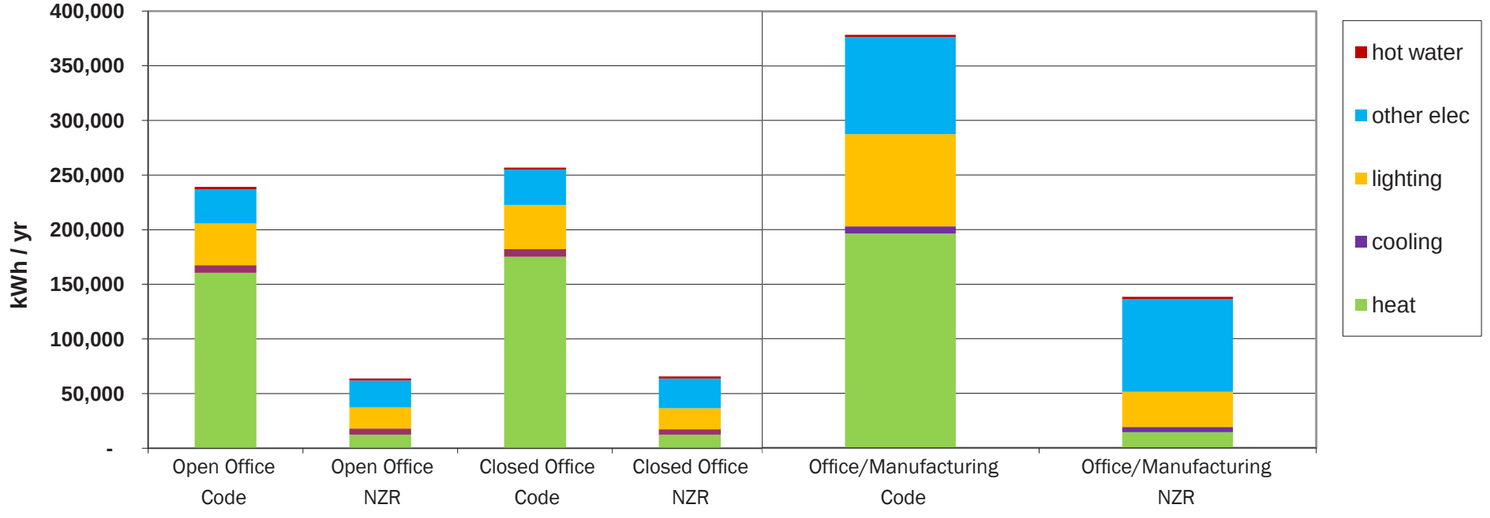


Figure 5.2: Commercial annual modeled energy use

Table 5.3: CO2 emissions per year for each building type

	Code	Net Zero Ready
Building Type	**CO2 tons/yr with no PV**	**CO2 tons/yr with no PV**
Single Family	7.7	3.7
Duplex [1]	5.7	3.7
Quadplex [1]	5.1	3.6
Open Office	72	30
Closed Office	77	30
Office/Manfuacturing	128	61

[1] Duplex and Quadplex are analyzed per unit

COMMUNITY ENERGY USE

Based on the energy modeling and EUI for each building type, the community energy requirements were determined for a code compliant community and a net zero ready community. The code compliant community would use 18,000,000 kBtu/yr and require 5.8 Megawatts of installed photovoltaics to offset the entire community energy load annually. The net zero ready community would use 5,600,000 kBtu/yr and require 2.3 Megawatts of installed photovoltaics to offset the entire community energy load annually. 60% of the net zero communities 2.3 MW of PV could be located on roofs and carports, with the remainder ground mounted on site on approximately 1.5 acres. The renewable energy overlay (Figure 4.2 on page 23) shows rooftop, carport, and two possible ground mounted PV locations on site.

The rooftop area calculations assume 50% of the residential and commercial building footprint would be available for PV. Garages are excluded from this calculation and would provide additional rooftop PV area. The energy requirements of the community are rounded to two significant digits.

Table 5.4 Community annual energy usage

	SQUARE FOOTAGE (SF)				CODE EUI (kBTU/sf-yr)			NET ZERO READY EUI (kBTU/sf-yr)			**TOTAL**	
Type	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

NOTE: (area is PV surface area Assumes 1.15 kWh/yr - Wp, 205 watt high efficiency panel)

Net Zero Community PV Area **requirements:**

Available sf rooftop for PV:	71,000
Available sf Carport for PV:	25,000
Ground sf needed for PV:	64,000 ~ 1.4 acres

Net Zero Energy Feasibility Study

VI. COST ESTIMATE

Photo and project by Huntington Homes, Inc ©

COST ESTIMATE

Reflecting the assumptions used in the energy modeling, cost estimates were generated for each building type. Capital costs for energy efficiency upgrades to build a net zero ready building compared to a code building were broken out for each building type, (see Table 6.3 and 6.4). Additional capital costs to add photovoltaics (PV) make the net zero ready buildings net zero. The cost for PVs was calculated using $3/watt installed cost and 1.15 kWh generated per year per peak watt installed (kWh/yr-Wp). The PV output is based on Vermont's solar radiation available and documented system performance. The installed cost for a PV system is based on an estimate provided in the fall of 2014 for a roof-mounted system. The PV system was sized for each building type to produce enough energy on an annual basis to offset the entire energy use of the NZR buildings.

RESIDENTIAL COST ESTIMATE SUMMARY

The initial residential cost estimate numbers were provided by Huntington Homes for houses they built in 2014. Huntington Homes offers standard building packages and options for upgrades to net zero ready standards. The cost estimates were for both a code and NZR single family home. These were broken out based on building takeoffs to apply the same incremental costs to the duplex and quadplex residential units. Each additional energy efficiency capital cost is an incremental cost per dwelling unit, not per building. The total additional energy capital costs range from $13 to $16 / sf for net zero ready construction and are 10 to 12% of the total construction costs (Table 6.1). The net zero building has the same additional envelope and mechanical costs with additional costs for the PVs. See the Table 6.3 for a breakout of additional capital costs.

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%

COMMERCIAL COST ESTIMATE SUMMARY

A detailed cost estimate was provided for the commercial buildings by JA Morrissey, enabling incremental costs to be determined for the net zero ready buildings compared to code compliant buildings. The additional energy efficiency capital costs for the net zero ready buildings add $9 to $17 /sf (Table 6.2) and are 6 to 13% of the total construction costs.

The NZR closed offices average $24 /sf additional cost above open offices. The savings of constructing closed versus open offices can pay for the increased cost of a net zero office building. See the Table 6.4 for a breakout of additional capital costs.

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 ASSUMPTIONS AND EXCLUSIONS

- The code lights are fluorescent fixtures, and the net zero ready lights are LED fixtures. The breakout of these costs are located in the Appendix.
- Commissioning is recommended for all buildings but is not required by code for these buildings based on size. Commissioning is assumed to be the same cost for the code and net zero ready buildings and not included in this analysis.

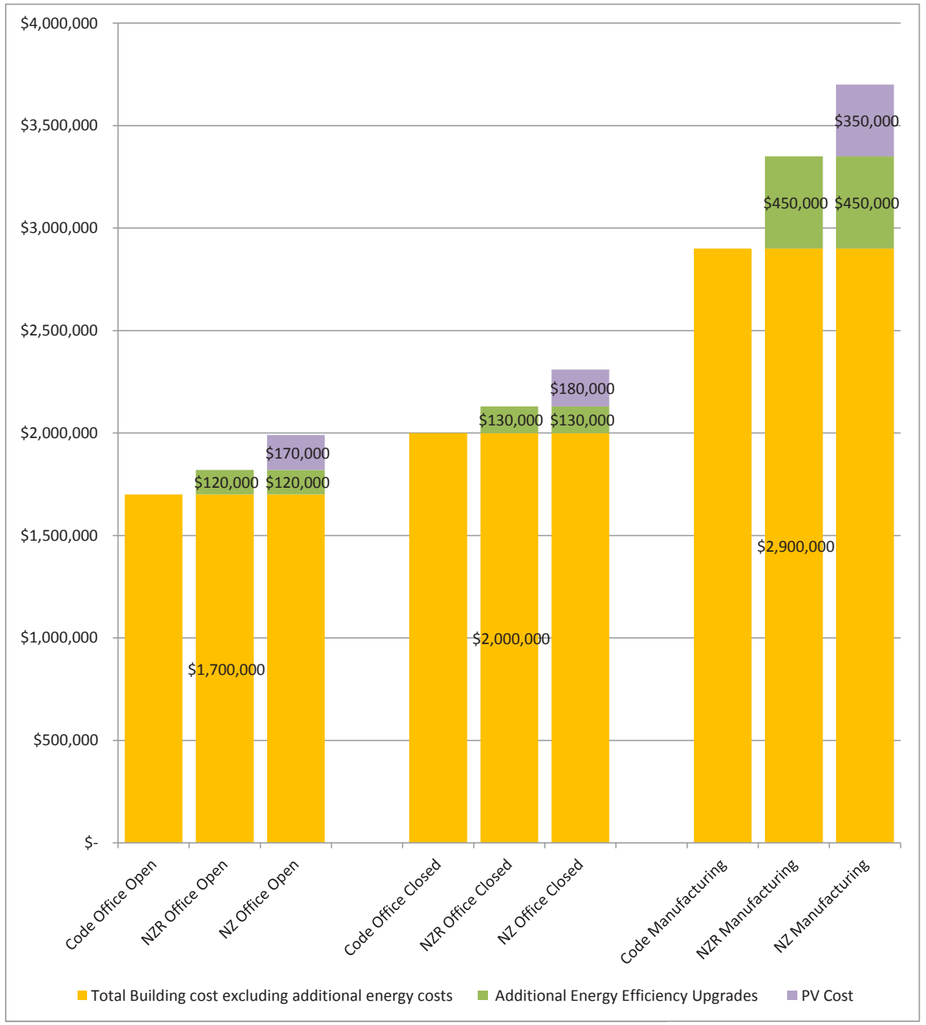


Figure 6.1: Total Commercial Building Costs

ADDITIONAL RESIDENTIAL CAPITAL COSTS

The items identified in Table 6.3 have been incorporated into the additional energy efficiency capital costs that are required to build to net zero ready standards. Huntington Homes provided cost information for a single family home, which has been adjusted here to fit the feasibility study assumptions as well as the duplex and quadplex options. A breakout of takeoffs that generated the duplex and quadplex areas, to apply the incremental costs, is located in the Appendix. The total cost per square foot is listed inTable 6.3 and ranges from $13 to $16/ sf for net zero ready construction. The cost is also broken out into Additional Envelope cost / sf and Additional Mechanical cost/ sf. Note that the mechanical systems for the net zero ready buildings provide a credit as the systems are overall smaller and utilize an efficient air source heat pump. For the net zero building option, the same additional envelope and mechanical costs apply in addition to costs for the Photovoltaics that range from $14 to $18 / sf.

Table 6.3: Residential capital costs

SINGLE FAMILY

	Building Component	Code Single Family	NZR Single Family	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20	$6,792	$25,724
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area	$2,172	
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	$6,176	
		Rim insulation R21	Rim insulation R42	$696	
		Walls: R-25	Walls: R-40	$8,064	
		Attic R-49	Attic R-60	$1,824	
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted	$3,800	$500
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]	$2,600	
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3	-$5,900	
PV	Solar PV	none	7.7 kW system	$23,332	$23,332

*All totals have been rounded to two significant digits

Total Added Cost without PV	**$26,000**
Added Envelope Cost Per Square Foot	$16.00
Added Mechanical Cost Per Square Foot	$0.30
Total Added Cost Per Square Foot	**$16.00**

DUPLEX

	Building Component	Code Duplex	NZR Duplex	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20	$4,800	$15,508
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area	$1,406	
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	$3,652	
		Rim insulation R21	Rim insulation R42	$412	
		Walls: R-25	Walls: R-40	$3,971	
		Attic R-49	Attic R-60	$1,267	
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted	$2,682	$1,749
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]	$1,950	
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3	-$2,883	
	Solar PV	none	6.8 kW system	$20,404	$20,404

*All totals have been rounded to two significant digits

Total Added Cost without PV	**$17,000**
Added Envelope Cost Per Square Foot	$14.00
Added Mechanical Cost Per Square Foot	$1.60
Total Added Cost Per Square Foot	**$15.00**

QUADPLEX

	Building Component	Code Quadplex	NZR Quadplex	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows; U=0.32	Triple-glazed windows; U=0.20	$4,248	$13,044
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	Air infiltration is 0.1 cfm50/sf above grade surface area	$1,211	
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	$2,900	
		Rim insulation R21	Rim insulation R42	$327	
		Walls: R-25	Walls: R-40	$3,091	
		Attic R-49	Attic R-60	$1,267	
Mech	Ventilation	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted	$2,682	$1,749
	Domestic Hot Water	From boiler	ASHP with a net COP of 1.5 [1]	$1,950	
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3	-$2,883	
	Solar PV	none	6.3 kW system	$19,077	$19,077

*All totals have been rounded to two significant digits

Total Added Cost without PV	**$15,000**
Added Envelope Cost Per Square Foot	$12.00
Added Mechanical Cost Per Square Foot	$1.60
Total Added Cost Per Square Foot	**$13.00**

SINGLE FAMILY WITH SOLAR

Total Added Cost	**$50,000**
Added Envelope Cost Per Square Foot	$16.00
Added Mechanical Cost Per Square Foot	$0.00
Added PV Cost Per Square Foot	$14.00
Total Added Cost Per Square Foot	**$31.00**

DUPLEX WITH SOLAR

Total Added Cost	**$38,000**
Added Envelope Cost Per Square Foot	$14.00
Added Mechanical Cost Per Square Foot	$2.00
Added PV Cost Per Square Foot	$18.00
Total Added Cost Per Square Foot	**$34.00**

QUADPLEX WITH SOLAR

Total Added Cost	**$34,000**
Added Envelope Cost Per Square Foot	$12.00
Added Mechanical Cost Per Square Foot	$2.00
Added PV Cost Per Square Foot	$17.00
Total Added Cost Per Square Foot	**$30.00**

ADDITIONAL COMMERCIAL CAPITAL COSTS

The additional energy efficiency commercial capital costs are broken out in Table 6.4 for each variable building feature. The office/manufacturing building does not have cooling in the manufacturing area, hence the minimal credit to the office/manufacturing net zero ready mechanical system. The closed offices add $25/ sf, highlighted in orange. This cost includes interior partitions and finishes and is explained in the Open Versus Closed Office Analysis. The additional $320,000 capital cost of the closed office is included as a portion of the capital costs to be financed and is broken out further in Table 6.5 and Table 6.6. The additional costs for photovoltaics to make the building net zero range from $13 to $14 / sf.

Table 6.4: Additional commercial capital costs

OPEN OFFICE

	Building Component	Code Office Open	NZR Office Open	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows, U=0.35 whole unit SHGC= 0.40 whole unit	Triple-glazed windows; U=0.20 whole unit SHGC = 0.33 whole unit	$34,995	$186,401
	Doors	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.8	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.5	$585	
	Skylights	None	None	$0	
	Air/Vapor Barrier	Vapor Barrier only, Air infiltration of 0.5 cfm50/sf above grade surface area	Combined Air and Vapor barrier, Air infiltration is 0.1 cfm50/sf above grade surface area	$5,938	
	Insulation	R-10 insulation at below grade walls -slab on grade F-factor = 0.48 which is R-10 for 48"	R-20 under slab and slab edge; slab edge factor =0.16	$32,368	
		R-16.8 insulated metal panels (3" thick)	R-33.6 insulated metal panels (6" thick)	$93,600	
		Tapered Polyiso and TPO on metal deck, R 33.6 insulation (6" minimum)	Tapered Polyiso and TPO on metal deck, R 61.6 insulation (11" minimum)	$18,915	
Mech	Electrical	NA	Reduced mechanical controls	-$1,363	-$66,409
	Lights	Fluorescent fixtures	LED fixtures	$15,684	
	Domestic Hot Water	Elect resistance	Elect resistance		
	HVAC/ Ventilation	Rooftop unit for heating, cooling, and ventilation	ASHP, annual heat COP 2.3, cooling ASHP SEER 16, one	-$80,730	
PV Office Layout	Interior Partitions	none	none	$0	
PV	Solar PV	none	61 kW system	$171,630	$171,630

**All totals have been rounded to two significant digits*

Total Added Cost	**$120,000**
Added Envelope Cost Per Square Foot	$14.00
Added Mechanical Cost Per Square Foot	-$5.00
Total Added Cost Per Square Foot	$9.00

CLOSED OFFICE

	Building Component	Code Office Closed	NZR Office Closed	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows, U=0.35 whole unit SHGC= 0.40 whole unit	Triple-glazed windows; U=0.20 whole unit SHGC = 0.33 whole unit	$34,995	$189,616
	Doors	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.8	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.5	$585	
	Skylights	None	None	$0	
	Air/Vapor Barrier	Vapor Barrier only, Air infiltration of 0.5 cfm50/sf above grade surface area	Combined Air and Vapor barrier, Air infiltration is 0.1 cfm50/sf above grade surface area	$5,938	
	Insulation	R-10 insulation at below grade walls -slab on grade F-factor = 0.48 which is R-10 for 48"	R-20 under slab and slab edge; slab edge factor =0.16	$32,368	
		R-16.8 insulated metal panels (3" thick)	R-33.6 insulated metal panels (6" thick)	$93,600	
		Tapered Polyiso and TPO on metal deck, R 33.6 insulation (6" minimum)	Tapered Polyiso and TPO on metal deck, R 61.6 insulation (11" minimum)	$22,131	
Mech	Electrical	NA	Reduced mechanical controls	-$1,363	-$62,899
	Lights	Fluorescent fixtures	LED fixtures	$15,684	
	Domestic Hot Water	Elect resistance	Elect resistance		
	HVAC	Rooftop unit for heating, cooling, and ventilation	ASHP, annual heat COP 2.3, cooling ASHP SEER 16, one	-$77,220	
	Interior Partitions	Closed office additional interior wall partitions relative additional cost above open offices	Closed office additional interior wall partitions relative additional cost above open offices	$320,000	$320,000
PV	Solar PV	none	66 kW system	$175,697	$175,697

**All totals have been rounded to two significant digits*

Total Added Cost	**$450,000**
Added Envelope Cost Per Square Foot	$15.00
Added Mechanical Cost Per Square Foot	-$5.00
Added closed office costs	$25.00
Total Added Cost Per Square Foot	**$35.00**

OFFICE/MANUFACTURING

	Building Component	Code Manufacturing	NZR Manufacturing	Added Cost	Category Added Cost
Envelope	Windows	Double-glazed windows, U=0.35 whole unit SHGC= 0.40 whole unit	Triple-glazed windows; U=0.20 whole unit SHGC = 0.33 whole unit	$12,411	$429,175
	Doors	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.8	Solid swinging, U 0.37, Sectional R-10, Entrances U - 0.5	$2,340	
	Skylights	U=0.2; SHGC=0.5; VT=0.5 1.5% of manufacturing area has skylights	U=0.2; SHGC=0.5; VT=0.5 3% of manufacturing area has skylights	$40,693	
	Air/Vapor Barrier	Vapor Barrier only, Air infiltration of 0.5 cfm50/sf above grade surface area	Combined Air and Vapor barrier, Air infiltration is 0.1 cfm50/sf above grade surface area	$15,102	
	Insulation	R-10 insulation at below grade walls -slab on grade F-factor = 0.48 which is R-10 for 48"	R-20 under slab and slab edge; slab edge factor =0.16	$103,779	
		R-16.8 insulated metal panels (3" thick)	R-33.6 insulated metal panels (6" thick)	$179,946	
		Tapered Polyiso and TPO on metal deck, R 33.6 insulation (6" minimum)	Tapered Polyiso and TPO on metal deck, R 61.6 insulation (11" minimum)	$74,903	
Mech	Electrical	NA	Reduced mechanical controls	-$2,340	$18,161
	Lights	Fluorescent fixtures	LED fixtures	$29,861	
	Domestic Hot Water	Elect resistance	Elect resistance		
	HVAC	Rooftop unit for heating, cooling, and ventilation	ASHP, annual heat COP 2.3, cooling ASHP SEER 16, one	-$9,360	
PV Office Layout	Interior Partitions	Open office configuration	Open office configuration	$0	
PV	Solar PV	none	127 kW system	$352,175	$352,175

**All totals have been rounded to two significant digits*

Total Added Cost	**$450,000**
Added Envelope Cost Per Square Foot	$16.00
Added Mechanical Cost Per Square Foot	$0.67
Total Added Cost Per Square Foot	$17.00

OPEN OFFICE WITH SOLAR

Total Added Cost	**$290,000**
Added Envelope Cost Per Square Foot	$14.00
Added Mechanical Cost Per Square Foot	-$5.00
Added PV Cost Per Square Foot	$13.00
Total Added Cost Per Square Foot	**$22.00**

CLOSED OFFICE WITH SOLAR

Total Added Cost	**$620,000**
Added Envelope Cost Per Square Foot	$15.00
Added Mechanical Cost Per Square Foot	-$5.00
Added closed office costs	$25.00
Added PV Cost Per Square Foot	$14.00
Total Added Cost Per Square Foot	**$49.00**

MANUFACTURING WITH SOLAR

Total Added Cost	**$800,000**
Added Envelope Cost Per Square Foot	$16.00
Added Mechanical Cost Per Square Foot	$0.67
Added PV Cost Per Square Foot	$13.00
Total Added Cost Per Square Foot	**$29.67**

ADDITIONAL COMMERCIAL CAPITAL COSTS

CLOSED VERSUS OPEN OFFICE

The comparison of capital costs for closed versus open offices reveals that closed offices cost $320,000 more for the 13,000 sf office building. This averages to an additional $25/ sf, with the majority of costs ($23/sf) attributed to interior finishes.

The rounded total capital costs is the same for code and net zero ready closed offices, but there are cost differences in the increased mechanical system of the code and NZR buildings.

Table 6.5: Additional open v. closed office capital costs

CODE

	Building Component	Code Office Closed	Added Cost	Category Added Cost
Envelope	Thermal	Additional interior insulation for sound	$3,861	$296,548
Envelope	Doors and Windows	Interior Doors	$40,037	
Envelope	Finishes	Additional interior walls and finishes	$252,650	
Mech	Sprinkler	additional system components	$6,096	$23,268
Mech	Electrical	Additional controls	$8,982	
Mech	HVAC/ Ventilation	Additional mechanical	$8,190	

All totals have been rounded to two significant digits

Total Added Cost	**$320,000**
Added Envelope Cost Per Square Foot	$23.00
Added Mechanical Cost Per Square Foot	$2.00
Total Added Cost Per Square Foot	**$25.00**

NET ZERO READY

	Building Component	NZR Office Closed	Added Cost	Category Added Cost
Envelope	Windows	Additional interior insulation for sound	$3,861	$296,548
Envelope	Doors and Windows	Interior Doors	$40,037	
Envelope	Interior Partitions	Additional interior walls and finishes	$252,650	
Mech	Sprinkler	additional system components	$6,096	$26,778
Mech	Electrical	Additional controls	$8,982	
Mech	HVAC	Additional mechanical	$11,700	

All totals have been rounded to two significant digits

Total Added Cost	**$320,000**
Added Envelope Cost Per Square Foot	$23.00
Added Mechanical Cost Per Square Foot	$2.00
Total Added Cost Per Square Foot	**$25.00**

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

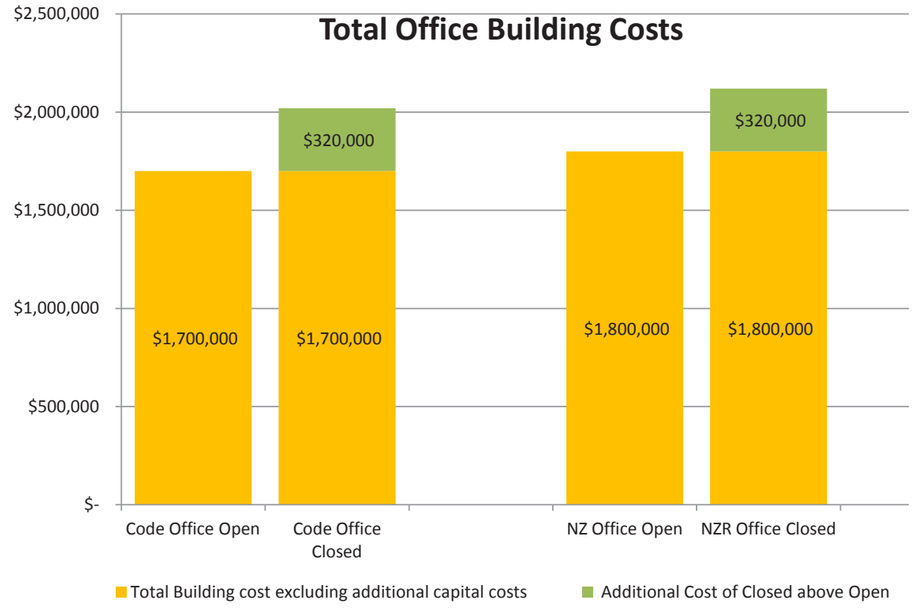


Figure 6.2:Total office building costs

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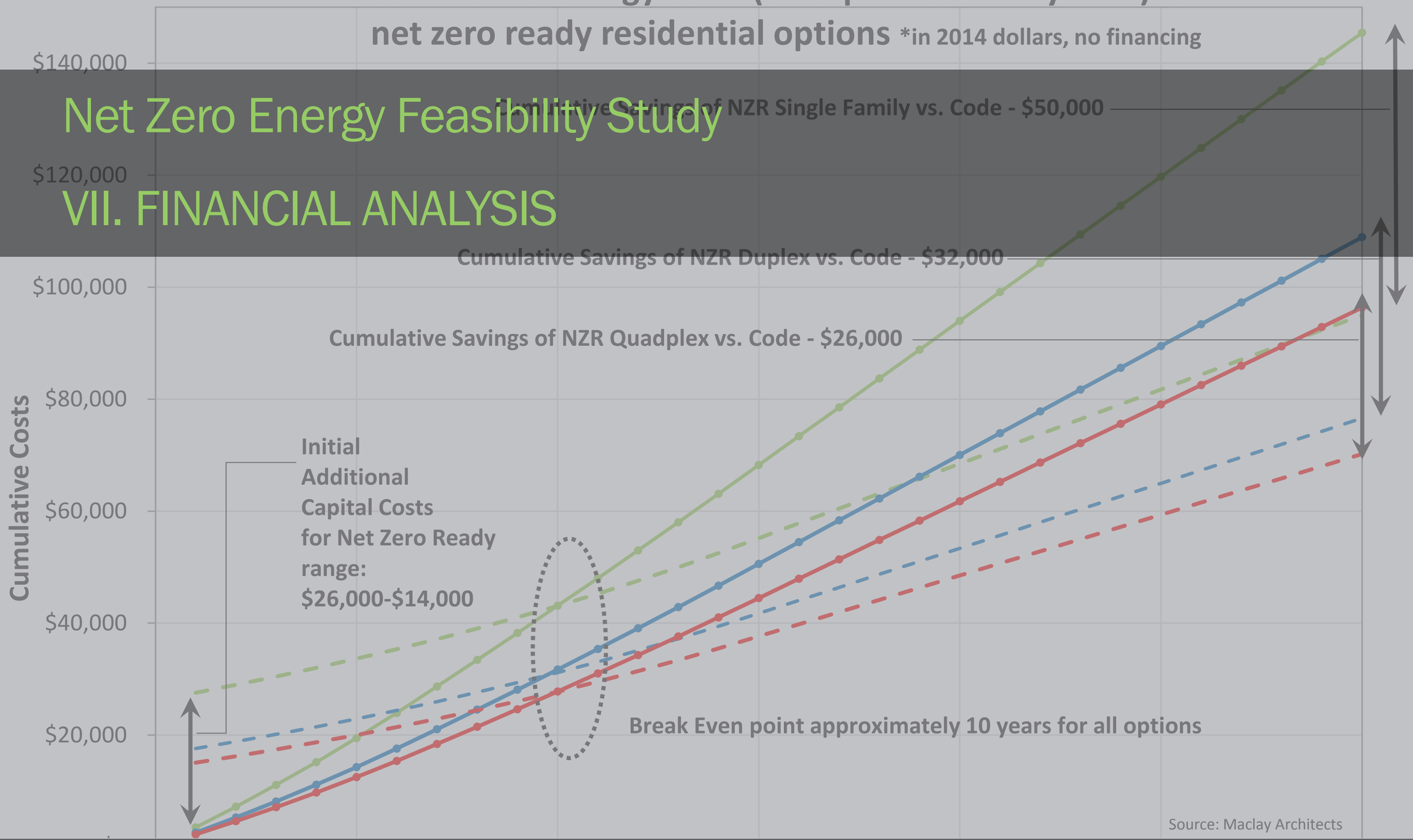
Net Zero Energy Feasibility Study

VII. FINANCIAL ANALYSIS

Cumulative energy costs (all capital costs in year 1) for net zero ready residential options *in 2014 dollars, no financing



Source: Maclay Architects

Efficiency Vermont · Huntington Homes · JAM · Energy Balance · MaclayArchitects

FINANCIAL ANALYSIS

APPROACH

For each building type, the annual energy consumption, financing assumptions, and additional capital costs for bringing a code building to net zero ready and net zero standards were input into a financial analysis tool to generate first year ownership and operating costs and cumulative capital, operating, and finance costs. This analysis shows that net zero ready (NZR) and net zero (NZ) construction is a cost effective investment from year one without rebates or incentives, except with the office/manufacturing building.

ASSUMPTIONS AND EXCLUSIONS

- All final numbers have been rounded to two significant digits
- All duplex and quadplex analysis is per dwelling unit
- Code baseline is based on the Draft 2015 Vermont Residential Building Energy Standards (RBES) and the 2015 Vermont Commercial Building Energy Standards (CBES) draft dated 11/24/2014.
- Fuel escalation rates are modeled at 5% with a "solar plateau" which assumes that once energy from solar PV costs half that of fossil fuel energy, people will shift their use to renewable energy and the price of fossil fuels will plateau. For additional explanation see the Appendix.
- Energy costs are based on the Vermont Fuel Price Report for October 2014. (http://publicservice.vermont.gov/publications/fuel_report)

  Electricity = $0.15/ kWh

  Propane = $3.08 / gallon
- No rebates or incentives are included in the total costs of the financial analysis. Some incentives are included within the narrative and notes on the graphs. The approximate location of the 30% federal PV tax credit is represented in the bar graphs with dashed lines and the approximate finance interest reduction using a SBA loan is represented with dotted lines for the office/manufacturing building. Efficiency Vermont incentives are not included on the graphs, but are available for residential and commercial buildings and should be looked into on a project by project basis.

RESIDENTIAL FINANCIAL ANALYSIS

The residential financial analysis uses a 30-year fixed mortgage rate of 4% for financing the additional capital costs. The additional photovoltaic costs for the net zero buildings assumes the same 30-year loan with 4% interest. This assumption does not fully reflect loans for energy efficiency, and these should be looked into for each project. This study also did not explore renewable energy financing options, as their are many variables and local rebates, tax credits, grants, and solar installer financing that should be examined on a case by case basis.

Figure 7.1 shows energy costs in blue and financing costs in red for year one. Purchasing photovoltaics, financed as an additional capital cost, provides additional savings for single family homes and has the same costs in year one for the Duplex and Quadplex. Over 30 years the net zero residential options provide significant savings (Figure 7.2 to 7.6).

Rebates, tax credits, or incentives for residential NZR construction are not included in the total costs in Figure 7.1 and 7.2, and would reduce the cost of NZR and NZ further. Efficiency Vermont currently offers a one time rebate of $2,000 when a residential building meets their High Performance Building Standards but this is not included in this analysis. The federal tax credits for solar, currently 30% of the total solar photovoltaics cost, is shown with the dashed line.

RESIDENTIAL FIRST YEAR ENERGY AND FINANCE COSTS

The first year costs for operating and financing the additional capital costs are shown in the Table 7.1 and the Figure 7.1. The graph shows operating costs in blue and the financial costs in red. The NZR and NZ buildings provide net savings compared to the code building from the first year.

Table 7.1: First year energy and finance costs with solar

	Electric (kWh)	Electric Heating-ASHP	Propane (gal)	Additional Energy Efficiency Capital Costs Loan	Additional Solar PV Loan	Total
Code Single Family	$ 700	$ -	$ 2,900	$ -		$ 3,600
NZR Single Family	$ 1,000	$ 400	$ -	$ 1,500		$ 2,900
Net Zero Single Family	$ -	$ -	$ -	$ 1,500	$ 1,300	$ 2,800
Code Duplex	$ 700	$ -	$ 1,900	$ -		$ 2,600
NZR Duplex	$ 1,000	$ 200	$ -	$ 1,000		$ 2,200
Net Zero Duplex	$ -	$ -	$ -	$ 1,000	$ 1,200	$ 2,200
Code Quadplex	$ 700	$ -	$ 1,600	$ -		$ 2,300
NZR Quadplex	$ 900	$ 200	$ -	$ 800		$ 1,900
Net Zero Quadplex	$ -	$ -	$ -	$ 800	$ 1,100	$ 1,900

*Cooling is included in Electric kWh

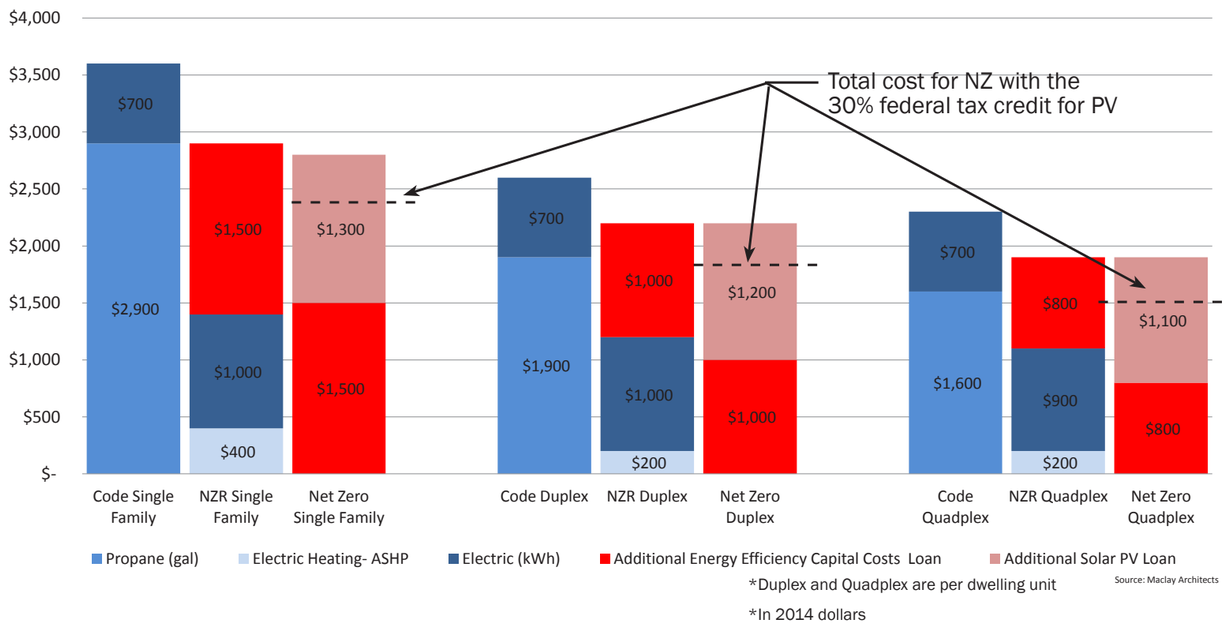


Figure 7.1: Residential first year energy and finance costs

RESIDENTIAL 30-YEAR CUMULATIVE COSTS

The thirty-year financial analysis reveals significant savings for the net zero residential options. Figure 7.2 shows the cumulative 30-year capital (green and purple), operating (blue), and finance (red) costs. The dashed line shows the approximate cost for a net zero building with a 30% federal tax credit for the PV system. Net zero residential options are a cost effective investment today and provide substantial savings over code buildings.

Table 7.2: Residential 30 year capital, operating, and finance costs chart

	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	$ -	$ 26,000	$ 26,000	$ -	$ 16,000	$ 16,000	$ -	$ 13,000	$ 13,000
Additional Mechanical Capital Costs	$ -	$ 500	$ 500	$ -	$ 900	$ 900	$ -	$ 900	$ 900
Photovoltaics cost			$ 23,000			$ 20,000			$ 19,000
Finance Interest	$ -	$ 19,000	$ 36,000	$ -	$ 12,000	$ 27,000	$ -	$ 10,000	$ 24,000
Operating Costs	$ 145,000	$ 69,000	$ -	$ 109,000	$ 60,000	$ -	$ 96,000	$ 56,000	$ -
30 Year Total	**$ 145,000**	**$ 114,000**	**$ 86,000**	**$ 109,000**	**$ 89,000**	**$ 64,000**	**$ 96,000**	**$ 80,000**	**$ 57,000**

*in 2014 dollars

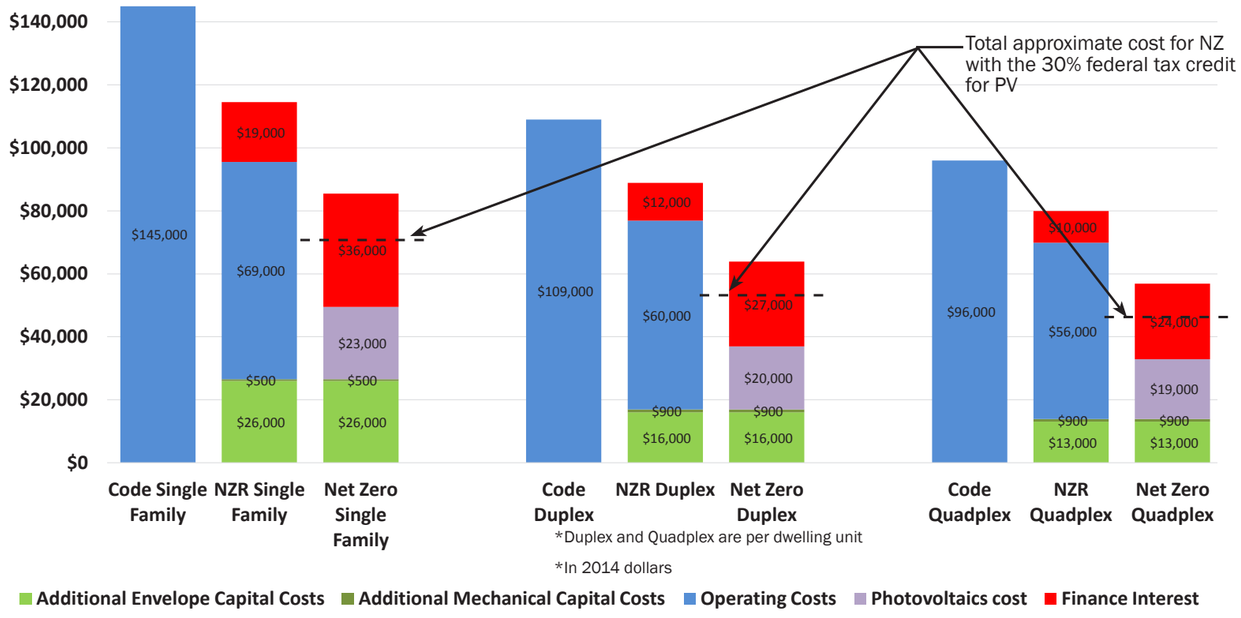


Figure 7.2: Residential 30 year capital, operating, and finance costs graph

RESIDENTIAL 30-YEAR CUMULATIVE COSTS - NET ZERO READY

Figure 7.3 shows the cumulative operating and financing costs for code and net zero ready buildings. The total savings are indicated at year 30 for each building type. The cumulative savings range from $31,000 for the single family home to $16,000 for the quadplex.

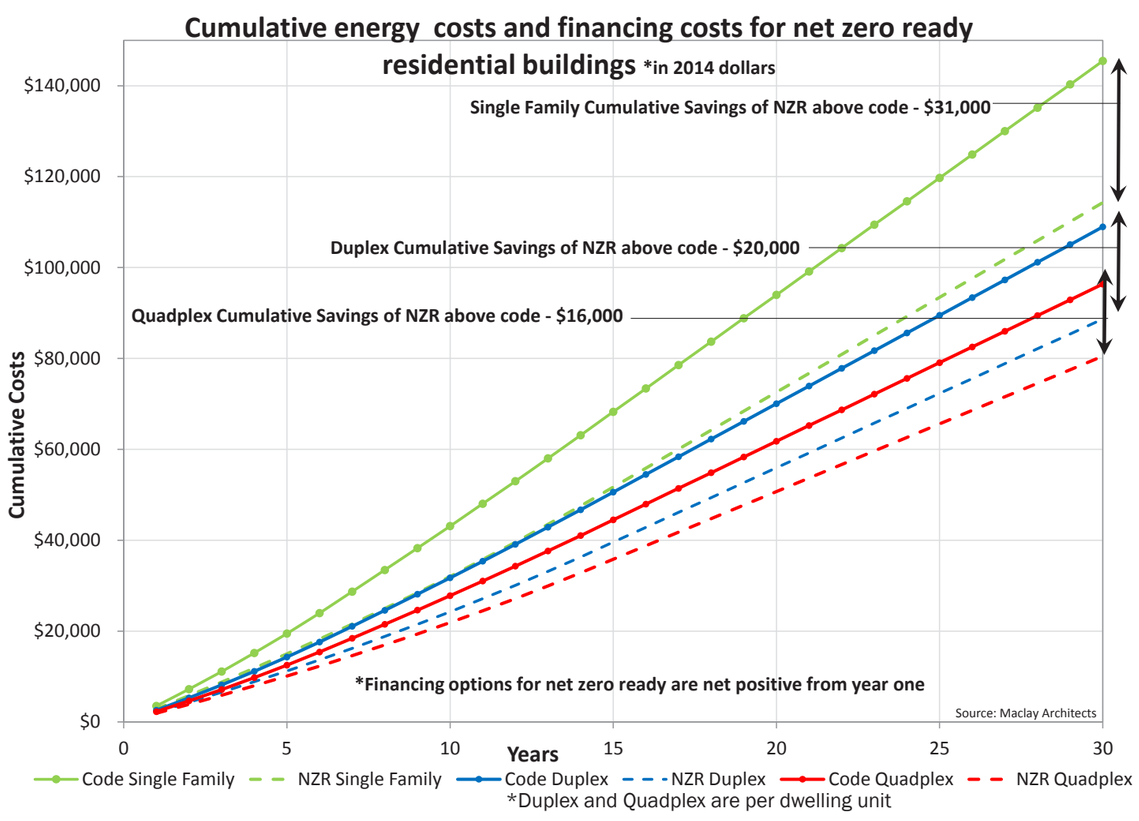


Figure 7.3: Cumulative energy costs and finance costs for net zero ready

RESIDENTIAL 30-YEAR CUMULATIVE COSTS - NET ZERO

Photovoltaics are added to the financed additional capital costs to make the building net zero from year one. Figure 7.4 shows the cumulative operating and financing costs for code buildings and cumulative financing costs for net zero buildings. The total cumulative savings are indicated at year 30 for each building type. The savings range from $59,000 with the single family home to $39,000 with the quadplex. Since financing photovoltaics is not always available, alternative models for paying for energy efficiency and PV are shown in Figure 7.5 and Figure 7.6.

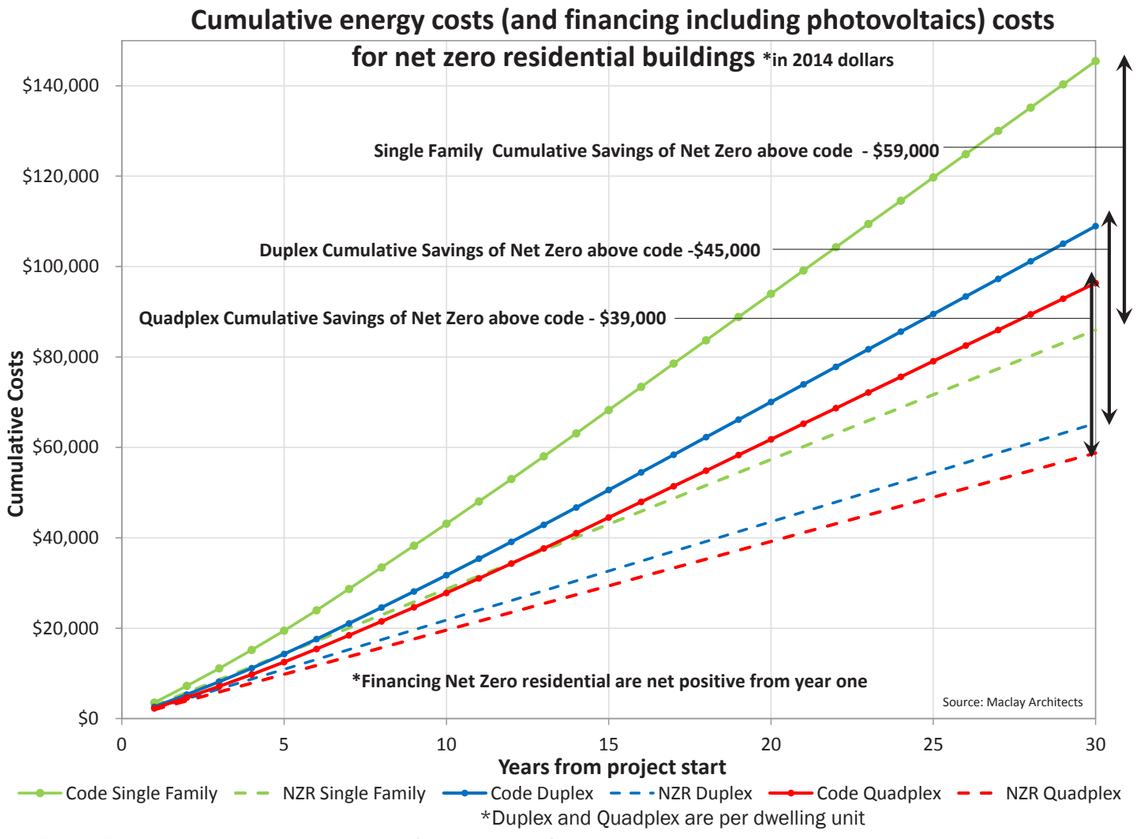


Figure 7.4: Cumulative energy costs and finance costs for net zero

RESIDENTIAL 30-YEAR CUMULATIVE COSTS - NO FINANCING

As financing energy efficiency and renewable energy systems can be tricky, Figure 7.5 shows the capital costs for net zero ready paid in year one and therefore do not require any financing. All of the residential net zero ready options pass the “break even” point with the code building at year ten, after which time the net zero ready building has recouped the initial capital costs through energy savings.

If the additional capital costs for energy improvements, as well as the cost of the photovoltaics, are paid in full in year one, the operating costs are reduced to zero and show a “break even” point with the code buildings around year twelve (Figure 7.6). The cumulative savings of a net zero building with no financing is $95,000 for a single family home and $63,000 for a quadplex unit.

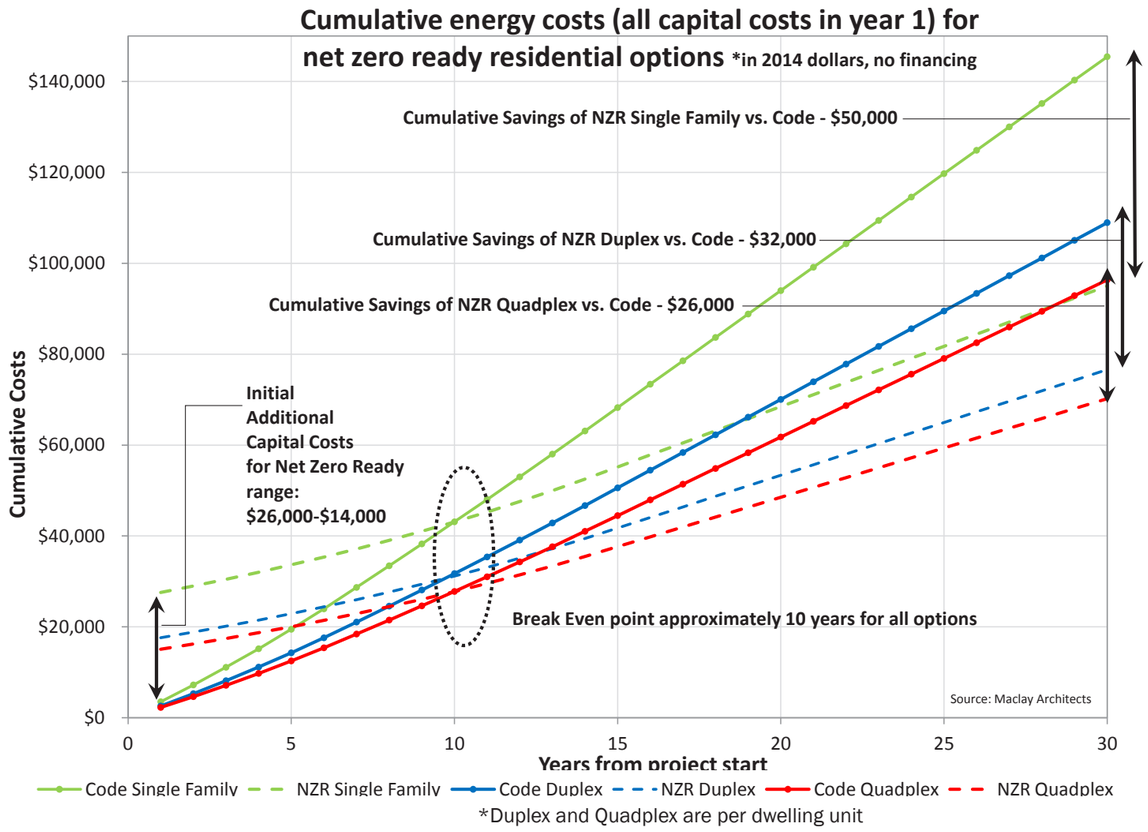


Figure 7.5: Additional capital cost in year one, plus cumulative energy costs for net zero ready and code

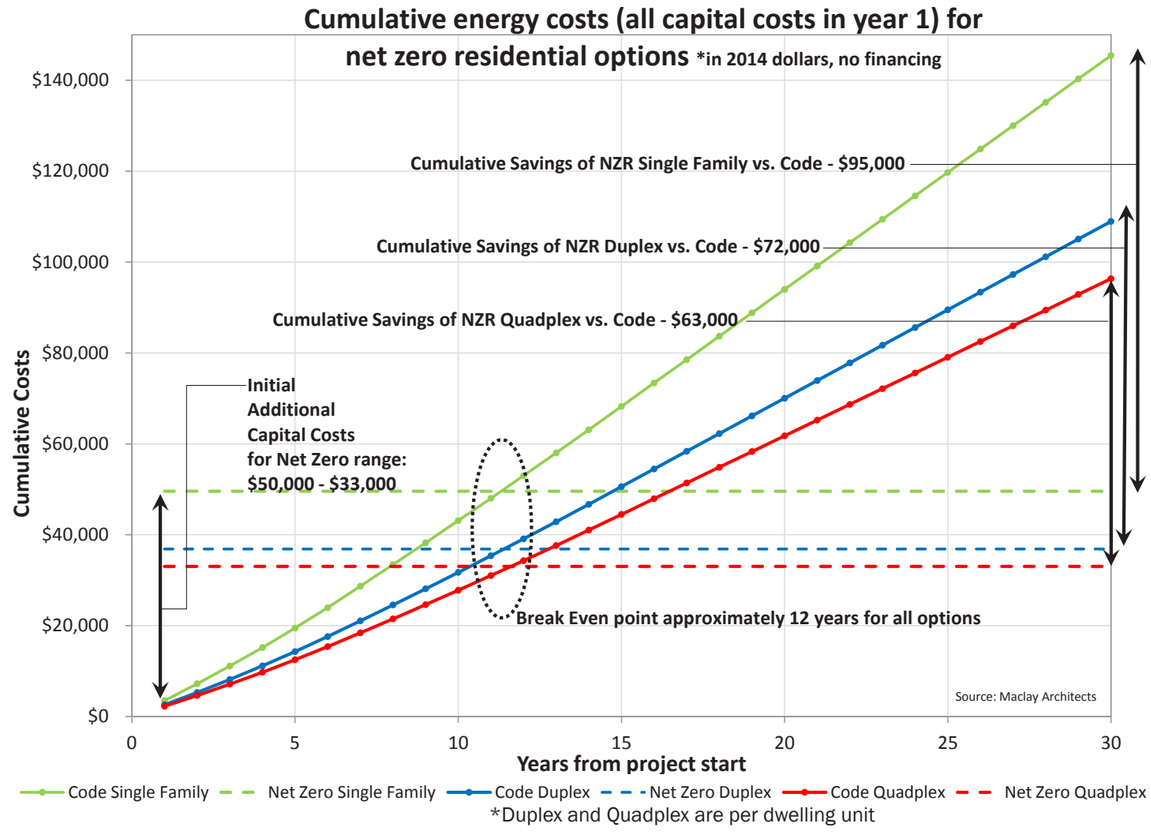


Figure 7.6 - Additional capital cost in year one for net zero, plus cumulative energy costs for code

COMMERCIAL FINANCIAL ANALYSIS

The commercial financial analysis uses a 20-year variable loan rate to finance the incremental capital costs. The rate starts at 4.61% and increases by 2% every 5 years. Year 15-20 has a rate of 10.61%, which is a conservative estimated projection of rates. The discount rate and inflation are assumed to be zero. These financial terms are used for this analysis as commercial lending rates are typically not available beyond seven years. However, if the office building is owned by the tenant, SBA secured loans could improve the financial performance.

Figure 7.7 shows that for the office buildings, net zero ready (NZR) construction is a cost effective investment from year one, and that open offices are significantly cheaper to build and operate than closed offices. Photovoltaics purchased as an additional capital cost for the net zero options, will be financed with the same assumptions. The NZ buildings do not return savings above NZR buildings unless federal tax credits or other rebates are applied as shown with the dashed lines indicating the 30% federal tax credit. Grants, accelerated depreciation, and rebates have not been included in the total costs. The code building operating costs are more than double the NZR operating costs, as shown in the blue bars in Figure 7.7.

The office/manufacturing building on the right side of Figure 7.7, shows that the financed additional capital cost for energy improvements in the NZR or NZ building do not provide savings in year one above the code building. This result is due in part by the large volume in the manufacturing area that increases the capital cost from $9/sf (office only building) to $17/sf (office/manufacturing building) in order to make the envelope net zero ready. If the office and manufacturing building is owned by the tenant, a SBA secured loan could reduce the 20-year interest by $70,000, but does not change the year one costs. Efficiency Vermont incentives would be available to further reduce the NZR and NZ building costs.

Table 7.3: Commercial first year energy cost

	Electric	Electric Heating-ASHP	Propane	Additional Energy Efficiency Loan Payment	Loan Payment for Solar	Loan Payment for Closed Offices	Total
Code Office Open	$ 11,500	$ -	$ 18,000	$ -	$ -	$ -	$ 29,500
NZR Office Open	$ 8,000	$ 1,900	$ -	$ 9,300	$ -	$ -	$ 19,200
Net Zero Open Office	$ -	$ -	$ -	$ 9,300	$ 13,700	$ -	$ 23,000
Code Office Closed	$ 11,900	$ -	$ 20,000	$ -	$ -	$ 25,000	$ 56,900
NZR Office Closed	$ 8,300	$ 1,800	$ -	$ 9,800	$ -	$ 25,000	$ 44,900
Net Zero Closed Office	$ -	$ -	$ -	$ 9,800	$ 13,200	$ 25,000	$ 48,000
Code Manufacturing	$ 25,100	$ -	$ 26,000	$ -	$ -	$ -	$ 51,100
NZR Manufacturing	$ 18,000	$ 2,400	$ -	$ 35,000	$ -	$ -	$ 55,400
Net Zero Manufacturing	$ -	$ -	$ -	$ 35,000	$ 27,100	$ -	$ 62,100

COMMERCIAL FIRST YEAR ENERGY AND FINANCE COSTS

Net zero ready (NZR) construction is a cost effective investment from year one for office buildings. Figure 7.7 shows the operating costs in blue and finance costs in red.

Purchasing photovoltaics as an additional capital cost to be financed for the NZ commercial buildings do not return savings beyond the NZR building unless federal tax credits or other rebates are applied in the analysis. This is due in part from the conservative commercial financing rates used in the analysis.

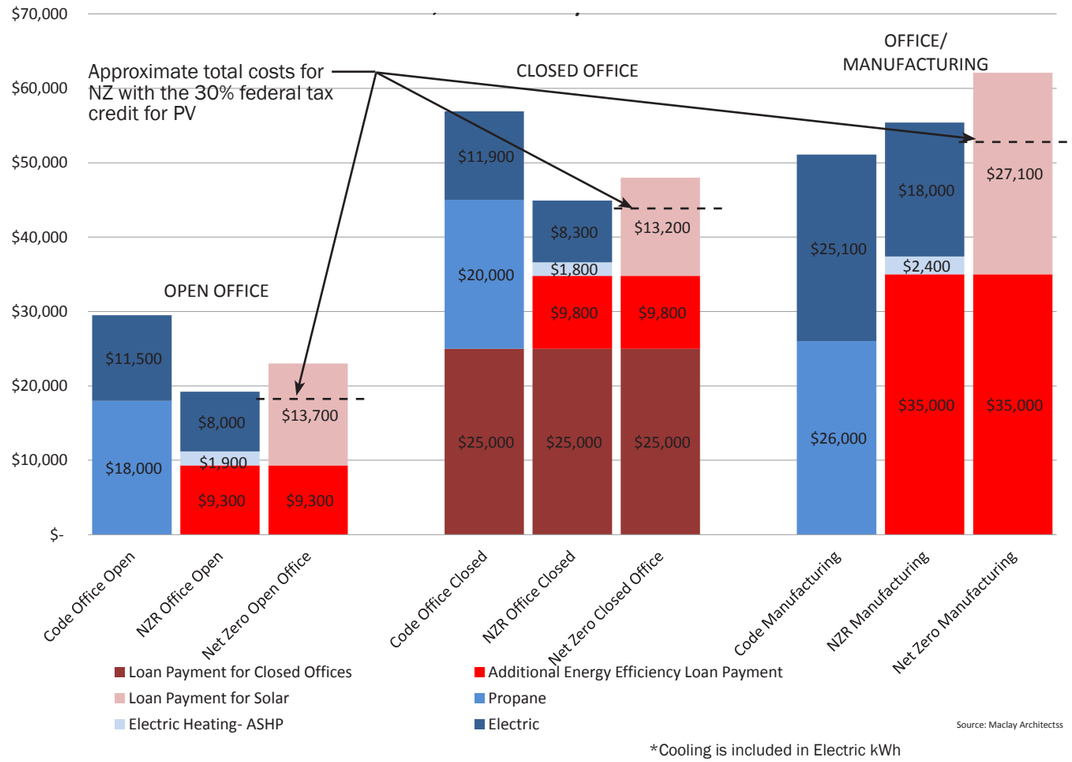


Figure 7.7: Commercial first year energy cost graph

COMMERCIAL 20-YEAR CUMULATIVE COSTS

The total 20-year capital (green), operating (blue), and finance (red) costs are shown in Figure 7.8 for the commercial buildings. The 30% federal tax credit for PV is shown with the dashed lines and is a 30% reduction on the PV capital costs and the accumulated interest for financing the PV over 20 years. The net zero ready open office is the best investment if you do not include any rebates or tax credits. The closed office shows an additional $320,000 capital costs associated with interior walls, finishes, and mechanical distribution requirements (highlighted in orange in Table 7.4), which is more than the added costs to make the building net zero. All of the capital costs (green) are financed over 20 years. The accumulated interest for each capital cost is shown in red in Table 7.4 and Figure 7.8. An analysis of the closed versus open office is shown without the energy efficiency capital costs in the next section.

Table 7.4: Commercial cumulative capital, finance, and operating costs

	Code Office Open	NZR Office Open	Net Zero Office Open	Code Office Closed	NZR Office Closed	Net Zero Office Closed	Code Manufacturing	NZR Manufacturing	Net Zero Manufacturing
Additional Envelope Capital Costs	$ -	$ 190,000	$ 190,000	$ -	$ 190,000	$ 190,000	$ -	$ 420,000	$ 420,000
Additional Mechanical Capital Costs	$ -	$ (66,000)	$ (66,000)	$ -	$ (63,000)	$ (63,000)	$ -	$ 18,000	$ 18,000
Additional Energy Efficiency Capital Costs	$ -	$ 120,000	$ 120,000	$ -	$ 130,000	$ 130,000	$ -	$ 440,000	$ 440,000
Additional Closed Office Capital Costs	$ -	$ -	$ -	$ 320,000	$ 320,000	$ 320,000	$ -	$ -	$ -
Photovoltaic Capital Costs			$ 170,000			$ 180,000			$ 350,000
Finance Interest for Energy Efficiency	$ -	$ 120,000	$ 120,000	$ -	$ 130,000	$ 130,000	$ -	$ 430,000	$ 430,000
Finance Interest for Closed Offices	$ -	$ -	$ -	$ 320,000	$ 320,000	$ 320,000	$ -	$ -	$ -
Finance Interest for PV	$ -	$ -	$ 170,000	$ -	$ -	$ 170,000	$ -	$ -	$ 350,000
Operating Costs	$ 830,000	$ 310,000	$ -	$ 890,000	$ 320,000	$ -	$ 1,400,000	$ 640,000	$ -
Total Cost over 20 years	$ 830,000	$ 550,000	$ 580,000	$ 1,500,000	$ 1,200,000	$ 1,200,000	$ 1,400,000	$ 1,500,000	$ 1,600,000

*in 2014 dollars

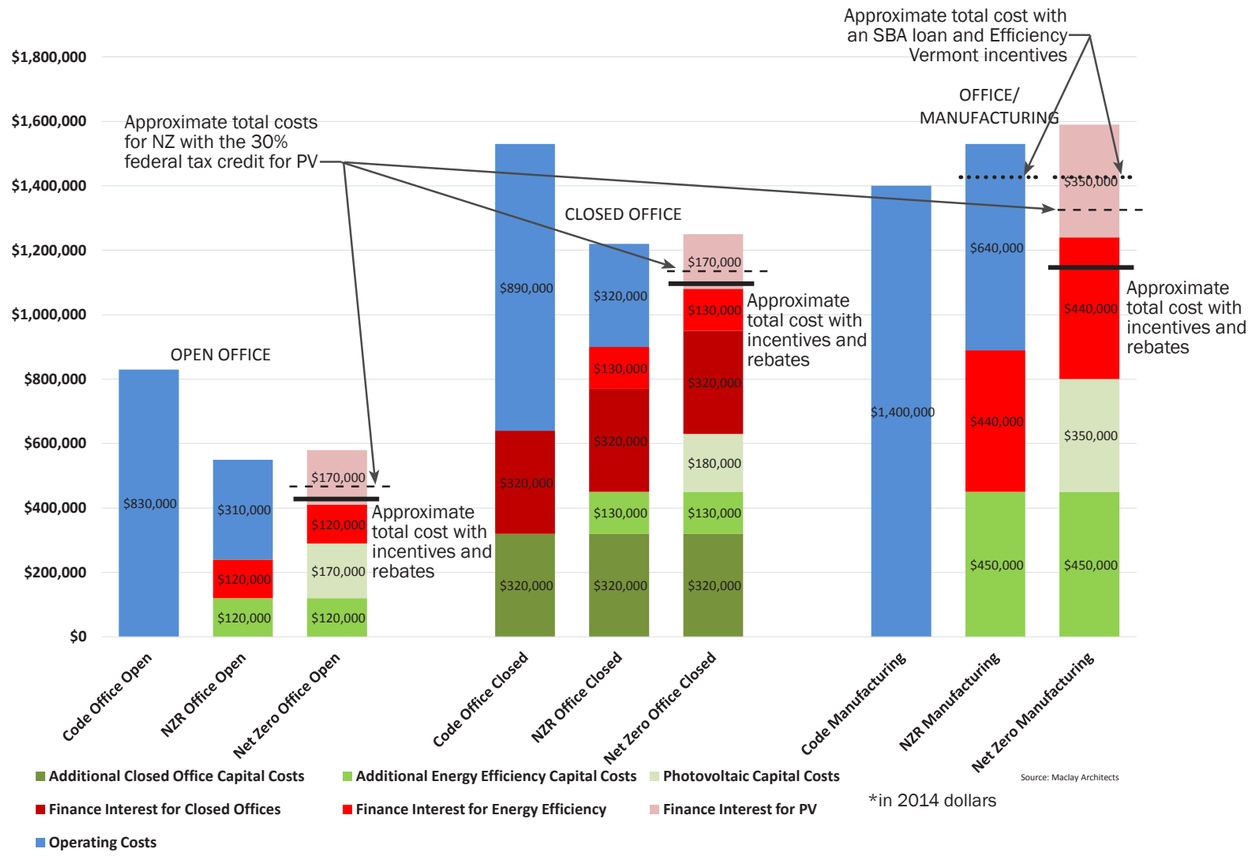


Figure 7.8: Commercial 20-year capital, operating, and finance costs

COMMERCIAL 20-YEAR CUMULATIVE COSTS NET ZERO READY

The costs to own and operate the commercial buildings cumulate each year from the project start and are shown in Figure 7.9. The NZR open office building (dashed green line) shows significant savings above code (solid green line) and closed offices (blue lines). The office/manufacturing building does not show cumulative savings without incentives or tax credits.

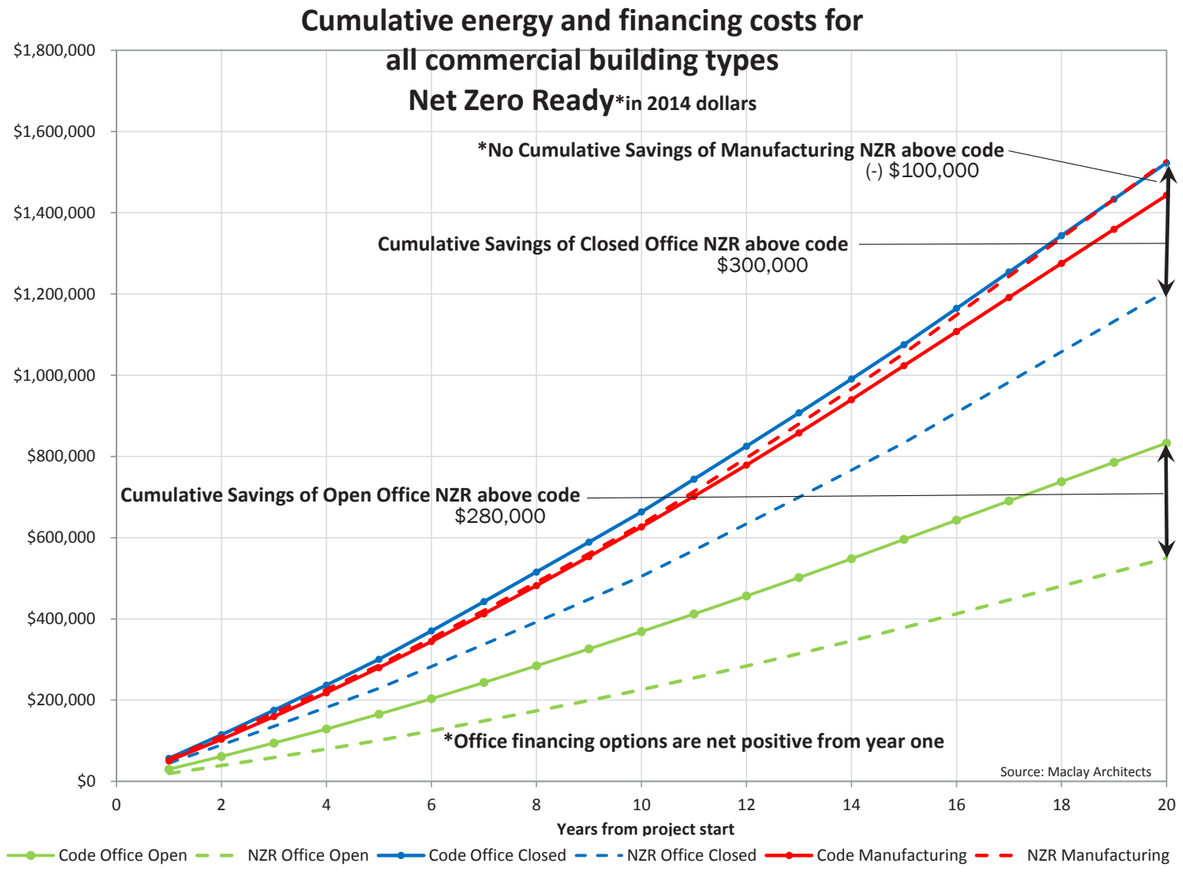


Figure 7.9: Cumulative energy and financing costs for all code and net zero ready commercial buildings

COMMERCIAL 20-YEAR CUMULATIVE COSTS NET ZERO

Figure 7.10 graphically displays the cumulative energy and finance costs over the 20-year loan period for the net zero commercial options, which includes financing the PV costs, but does not include any incentives or rebates.

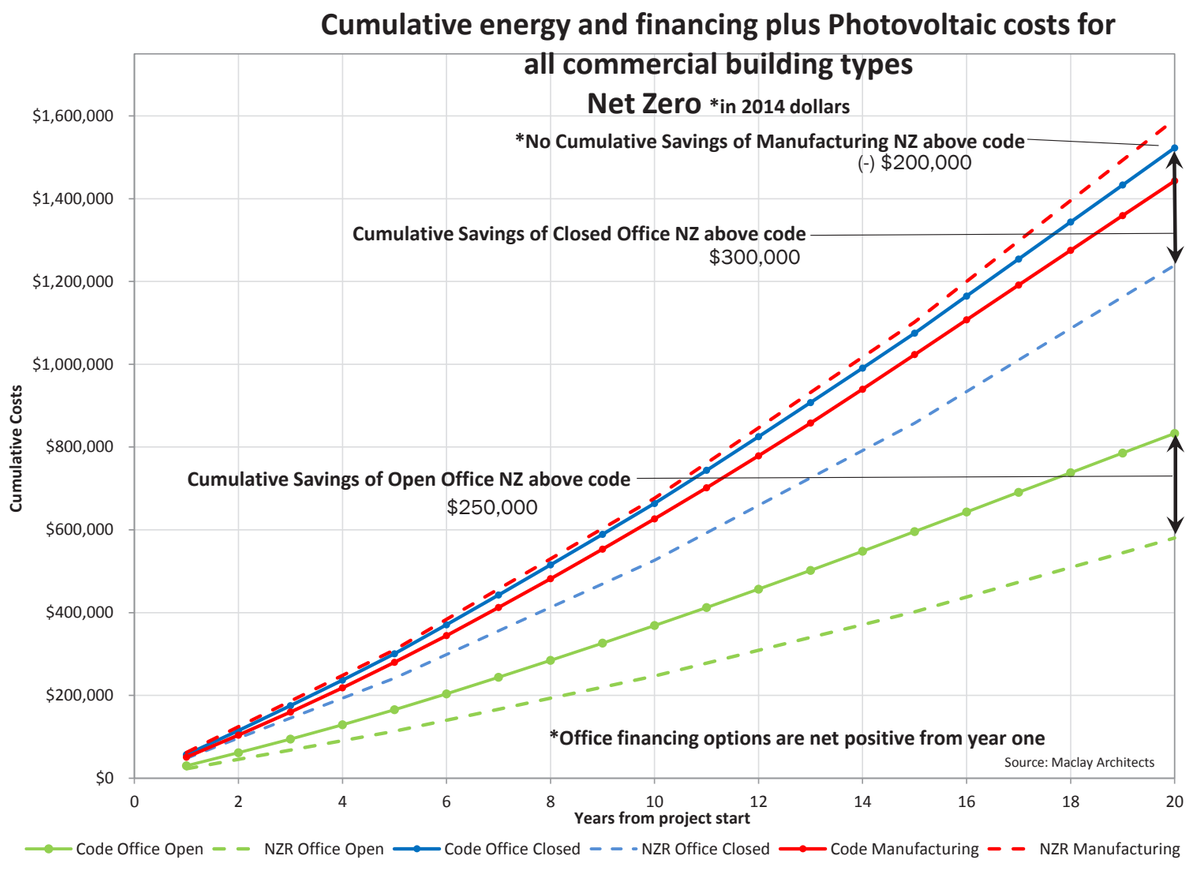


Figure 7.10: Cumulative energy and financing costs for all code and net zero commercial buildings

OFFICE/MANUFACTURING FINANCING OPTIONS

The net zero ready and net zero office/manufacturing building is not cost effective over a code compliant building before applying incentives and rebates (using the financing assumptions for the commercial buildings- Option 1). The large envelope requirements of the manufacturing area increase the incremental capital costs beyond the savings from reduced operating costs when financed. Incentives available from Efficiency Vermont would be provided on a custom basis for each project, but they are likely to be in the range of $1/sf for these types of building designs. This incentive level would provide the office/manufacturing building with an additional $27,000. Combining this incentive with the 30% federal tax credit for PV and reduced finance interest with an SBA loan (Option 4 in Table 7.5), the net zero ready and net zero office/manufacturing buildings would each cost less than the code building.

Other financing options were explored that made the net zero ready office/ manufacturing building a better investment than the code building over 20 years. The financing approaches included:

- Option 2: Less conservative 5 year rate increases of 1.5% versus 2%
- Option 3: Fixed commercial rate of 6.61% over 20 years
- Option 4: SBA 504 loan for 40% of the total cost at a fixed rate of 4.77% (current rate for December 2014) The remaining 60% would be financed through a lending institution
- Option 5: VEDA loan provides a similar structure to the SBA 504, but has a variable rate that changes quarterly. Currently the VEDA rate would start around 3% but change each quarter. The remaining 60% would be financed through a lending institution. This option is the same format as option 4, but with a variable VEDA loan instead of the fixed SBA loan. Due to the multiple variable rate assumptions needed the project team did not include this in the 20-year analysis. This would be an option that building owners should explore.

The accumulated interest for the manufacturing building over 20 years is $440,000, as shown in Table 7.5 in the red box. The total accumulated interest for the other 20-year financing Options 2 through 4 are subtracted from the base interest costs to determine the additional savings in the office/manufacturing analysis (highlighted in yellow). The SBA-secured loan (Option 4) shows that $70,000 could be subtracted from the net zero ready and net zero buildings total costs over 20 years (dotted lines in Figure 7.8).

These alternative financing options provide additional avenues for commercial building owners to explore when looking to finance their building, and should be pursued on a project by project basis to determine the best rates. It was beyond the scope of this study to further analyze other options for the office/manufacturing building.

Table 7.5: Office/manufacturing financing options analysis

1 Option

Capital cost financed: $447,335

VAIRABLE INTEREST 2% INCREASE EVERY 5 YRS
***Jeff Glassberg**

Year	VAIRABLE INTEREST 2% INCREASE EVERY 5 YRS *Jeff Glassberg	interest rate per year
1	$34,718	4.61%
2	$34,718	4.61%
3	$34,718	4.61%
4	$34,718	4.61%
5	$34,718	4.61%
6	$40,954	6.61%
7	$40,954	6.61%
8	$40,954	6.61%
9	$40,954	6.61%
10	$40,954	6.61%
11	$47,650	8.61%
12	$47,650	8.61%
13	$47,650	8.61%
14	$47,650	8.61%
15	$47,650	8.61%
16	$54,748	10.61%
17	$54,748	10.61%
18	$54,748	10.61%
19	$54,748	10.61%
20	$54,748	10.61%
Total	$890,349	

INTEREST ONLY COST OVER 20 YRS
$440,000

Better than current analysis

2 Option

Capital cost financed: $ 447,335

VARIABLE INTEREST 1.5% INCREASE EVERY 5 YRS
***Jeff Glassberg**

VARIABLE INTEREST 1.5% INCREASE EVERY 5 YRS *Jeff Glassberg	interest rate per year
$34,718	4.61%
$34,718	4.61%
$34,718	4.61%
$34,718	4.61%
$34,718	4.61%
$39,350	6.11%
$39,350	6.11%
$39,350	6.11%
$39,350	6.11%
$39,350	6.11%
$44,248	7.61%
$44,248	7.61%
$44,248	7.61%
$44,248	7.61%
$44,248	7.61%
$49,389	9.11%
$49,389	9.11%
$49,389	9.11%
$49,389	9.11%
$49,389	9.11%
$838,522	

$390,000
-$50,000

3 Option

Capital cost financed: $ 447,335

FIXED INTEREST RATE OF 6.61%
***Jeff Glassberg**

FIXED INTEREST RATE OF 6.61% *Jeff Glassberg	interest rate per year
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
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$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$40,954	6.61%
$819,080	

$370,000
-$70,000

4 Option

Capital cost financed SBA FIXED: $ 178,934
Capital cost financed VARIABLE: $ 268,401

40% LOAN FIXED WITH SBA - OTHER 60% VARIABLE
EXCLUDES ALL SBA FEES, THAT CAN BE SUBSTAINTIAL
***source: NSB Commercial lending program**

SBA portion of the loan	SBA fixed 4.77% loan for 40% of the total cost	VAIRABLE INTEREST 2% INCREASE EVERY 5 YRS *Jeff Glassberg	interest rate per year
$14,079	4.77%	$20,831	4.61%
$14,079	4.77%	$20,831	4.61%
$14,079	4.77%	$20,831	4.61%
$14,079	4.77%	$20,831	4.61%
$14,079	4.77%	$20,831	4.61%
$14,079	4.77%	$24,572	6.61%
$14,079	4.77%	$24,572	6.61%
$14,079	4.77%	$24,572	6.61%
$14,079	4.77%	$24,572	6.61%
$14,079	4.77%	$24,572	6.61%
$14,079	4.77%	$28,590	8.61%
$14,079	4.77%	$28,590	8.61%
$14,079	4.77%	$28,590	8.61%
$14,079	4.77%	$28,590	8.61%
$14,079	4.77%	$28,590	8.61%
$14,079	4.77%	$32,849	10.61%
$14,079	4.77%	$32,849	10.61%
$14,079	4.77%	$32,849	10.61%
$14,079	4.77%	$32,849	10.61%
$14,079	4.77%	$32,849	10.61%
$281,589		$534,209	
	Total	$815,799	

$370,000
-$70,000

OPEN VERSUS CLOSED OFFICE

An analysis was performed comparing the cost of code-compliant open and closed offices, and NZR open and closed offices. The additional capital costs for the closed offices is $320,000, because of additional partitions, interior doors, sound insulation, sprinkler system configuration, mechanical ducts, and controls.

While closed versus open offices does not necessarily connect to the evaluation of code versus net zero buildings, net zero buildings particularly benefit from an open office layout as daylighting, lighting, and HVAC systems can be simplified and reduce capital and operating costs. Switching from a closed office to an open office can more than offset the additional net zero costs.

Closed offices require slightly more energy to operate per year, with an additional 5 kBtu/sf-yr for code compliant buildings and 0.5 kBtu/sf-yr for net zero ready buildings shown in Table 7.6.

Table 7.6: Open and closed office EUI comparison

		Code Office Open	Code Office Closed	NZR Office Open	NZR Office Closed
Electricity	**kBtu/yr**	260000	270000	182000	188000
Electricity-ASHP	**kBtu/yr**	0	0	42000	42000
Fossil Fuels	**kBtu/yr**	550000	595000	0	0
Total	**kBtu/yr**	810000	866000	224000	230000
Total BuildingEUI	**kBtu/sf-yr**	62	67	17.2	17.7
% Better than Closed		7%	N/A	3%	N/A

OPEN VERSUS CLOSED OFFICE FINANCIAL ANALYSIS

The closed v. open financial analysis uses a 20 year variable loan rate starting at 4.61%, and increasing by 2% every 5 years to finance the incremental capital costs. Year 15-20 has a rate of 10.61%, which is a conservative estimated projection of rates. The discount rate and inflation are assumed to be zero.

OPEN VERSUS CLOSED OFFICES FIRST YEAR ENERGY AND FINANCE COSTS

The open office building returns significant savings in year one compared to the code building when the additional capital costs for closed offices are financed. The additional closed office capital cost of $320,000 requires a first year financed payment of $24,800-$25,100.

Table 7.7: First year operating and finance costs for open and closed offices

	Electric (kWh)	Electric Heating-ASHP	Propane (gal)	Loan Payment per year for closed office capital costs	Total
Code Office Open	$ 11,500	$ -	$ 18,500	$ -	$ 30,000
Code Office Closed	$ 11,900	$ -	$ 20,000	$ 24,800	$ 56,700
NZ Office Open	$ 8,000	$ 1,900	$ -	$ -	$ 9,900
NZ Office Closed	$ 8,300	$ 1,800	$ -	$ 25,100	$ 35,200

*2014 dollars

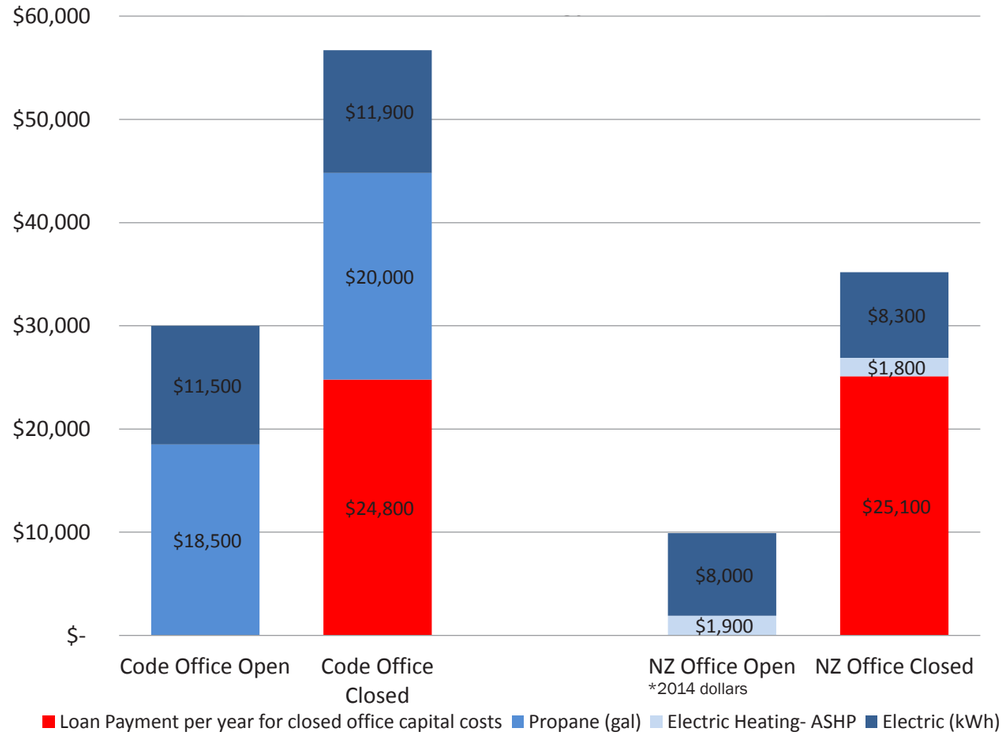


Figure 7.11: First year operating and finance costs for open and closed offices

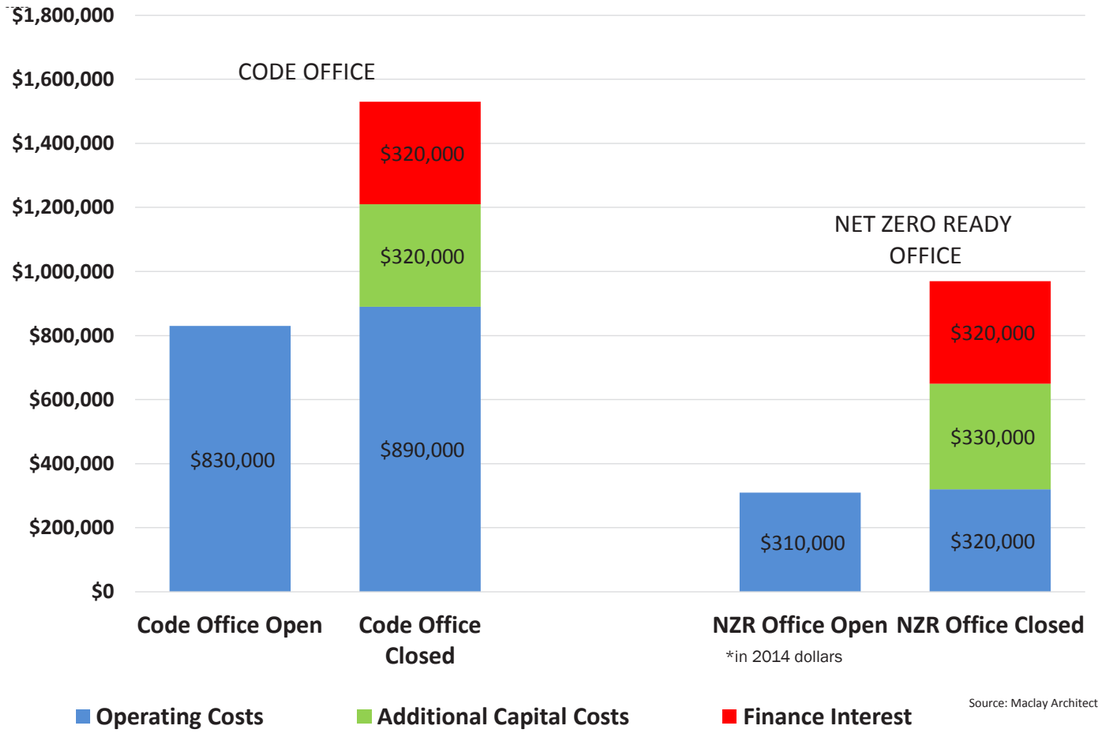
OPEN VERSUS CLOSED OFFICES 20-YEAR CUMULATIVE COSTS

Over 20 years the open offices cost slightly less to operate and require significantly lower financing costs compared to the closed offices (Figure 7.12).

Table 7.8: Twenty year cumulative capital and operating costs

	Code Office Open	Code Office Closed	NZR Office Open	NZR Office Closed
Additional Envelope Capital Costs	$ -	$ 300,000	$ -	$ 300,000
Additional Mechanical Capital Costs	$ -	$ 23,000	$ -	$ 27,000
Additional Capital Costs	$ -	$ 320,000	$ -	$ 330,000
Finance Interest	$ -	$ 320,000	$ -	$ 320,000
Operating Costs	$ 830,000	$ 890,000	$ 310,000	$ 320,000
Total Cost over 20 years	**$ 830,000**	**$ 1,520,000**	**$ 310,000**	**$ 960,000**

*2014 dollars



Source: Maclay Architect

Figure 7.12: Twenty year cumulative capital, operating and finance costs for open and closed offices

OPEN VERSUS CLOSED OFFICES 20-YEAR CUMULATIVE COSTS

The NZR open office building (dashed green line in Figure 7.13) shows significant savings above NZR closed office (solid green line) and code open and closed offices (blue lines).

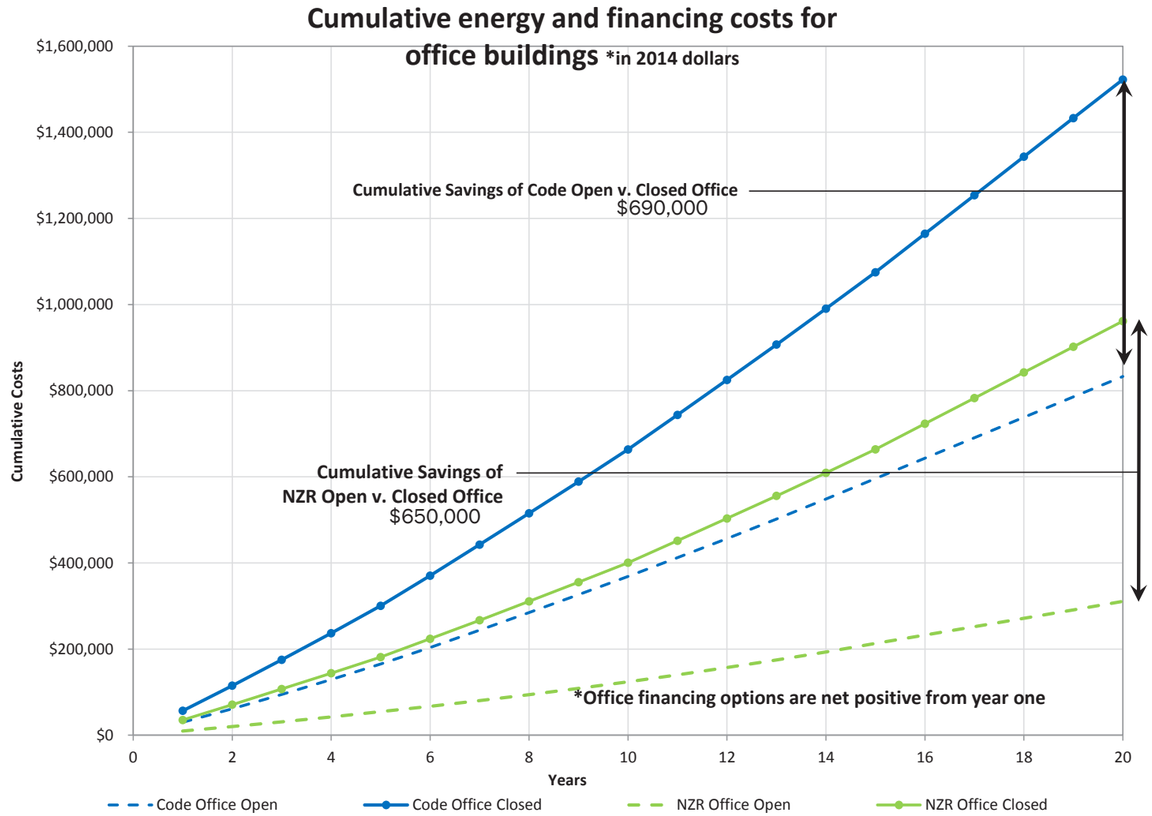


Figure 7.13: Twenty year capital, operating and finance costs for open and closed offices

COMMUNITY FINANCIAL ANALYSIS

To determine the total financial impact of a code versus net zero community the building analyses described in the proceeding sections was applied to the masterplan for the land of Wind Energy Associates. The proposed community contains 19 Single family homes, 12 duplexes, 34 quadplexes, 160,000 sf of office space, and 54,000 sf of office/manufacturing space. This analysis shows that both the residential and commercial portions of the community are cash flow positive.

Figure 7.14 shows that for the residential portion of the community, code buildings would cost $7.4 million to operate over 30 years; the net zero ready buildings would cost $6 million to own and operate; and the net zero buildings would cost $4.4 million. If the federal tax credit for PV is applied to the NZ buildings the total cost to own and operate would be $3.6 million. **The net zero residential community shows cumulative savings of $3 million compared to a code built community over 30 years of operation, and $3.8 million including tax credits.** These savings are incurred by the homeowners, while the developer can market the buildings as providing reduced owning and operating costs from the first year, and significant cumulative savings in the long term.

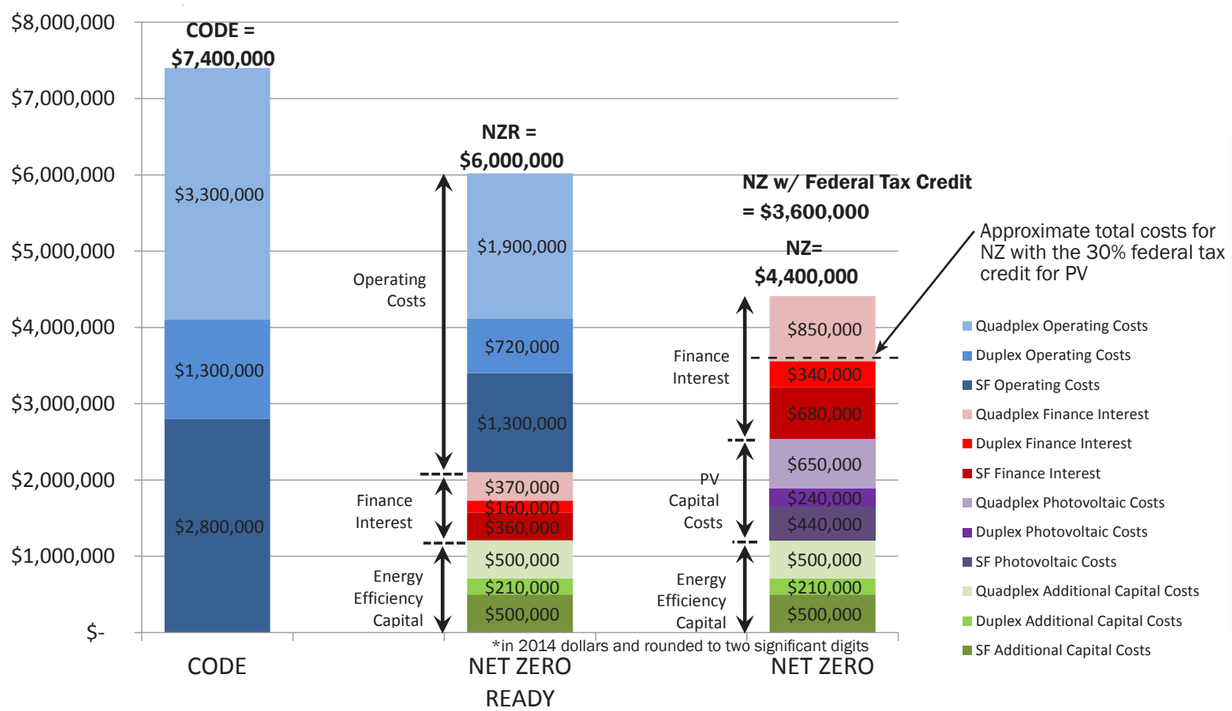


Figure 7.14: Cumulative community residential 30 year capital, operating and finance costs

Table 7.9 Cumulative community residential 30 year capital, operating and finance costs

# of units		CODE	NET ZERO READY	NET ZERO
19	SF Additional Capital Costs	$ -	$ 500,000	$ 500,000
	SF Photovoltaic Costs	$ -	$ -	$ 440,000
	SF Finance Interest	$ -	$ 360,000	$ 680,000
	SF Operating Costs	$ 2,800,000	$ 1,300,000	$ -
12	Duplex Additional Capital Costs	$ -	$ 210,000	$ 210,000
	Duplex Photovoltaic Costs	$ -	$ -	$ 240,000
	Duplex Finance Interest	$ -	$ 160,000	$ 340,000
	Duplex Operating Costs	$ 1,300,000	$ 720,000	$ -
34	Quadplex Additional Capital Costs	$ -	$ 500,000	$ 500,000
	Quadplex Photovoltaic Costs	$ -	$ -	$ 650,000
	Quadplex Finance Interest	$ -	$ 370,000	$ 850,000
	Quadplex Operating Costs	$ 3,300,000	$ 1,900,000	$ -
	total rounded (to the two significant digits)	$ 7,400,000	$ 6,000,000	$ 4,400,000

For the commercial portion of the community, code buildings would cost $13 million to operate over 20 years, the net zero ready buildings would only cost $9.7 million to operate and own, and the net zero buildings would cost $10 million before tax credits and $8.2 million after federal tax credits for PV, as shown in Figure 7.15.

Operating and owning all of the NZR commercial buildings saves $3.3 million over 20 years. Operating and owning net zero commercial buildings and using the federal tax credit for 30% of the PV costs saves $4.8 million over 20 years. The savings are to the building owner/operator. If the developer maintains ownership of the buildings they could pass through the energy savings to their tenants or charge higher rents for stable energy costs over time. Overall, investing in net zero buildings has financial benefits for developers, building owners, or tenants.

This study shows that NZR and NZ construction reduces costs to own and operate buildings and reduces CO2 emissions. The financial savings are realized by building owners over time, but the benefits of NZR and NZ buildings go beyond the monetary savings by reducing CO2 emissions, creating resilient buildings, minimizing impact from fuel cost volatility, and providing healthier places for people to live and work.

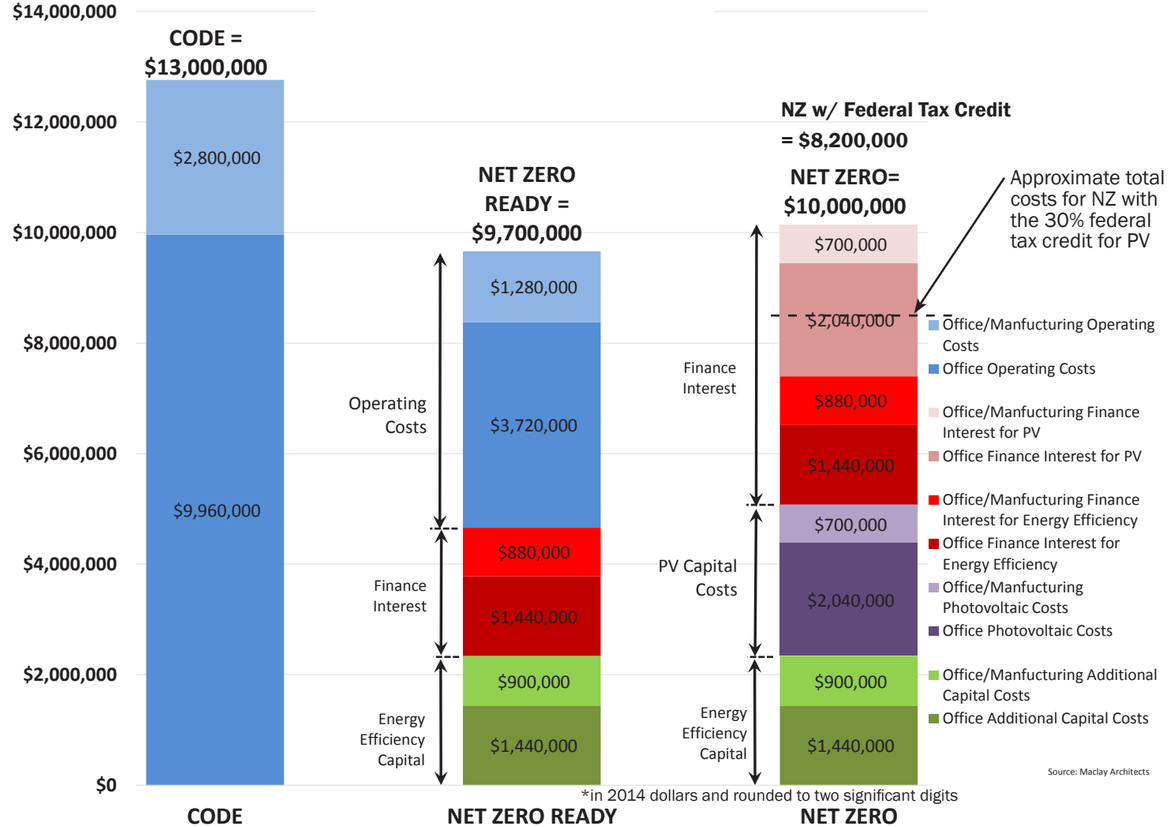


Figure 7.15: Cumulative community commercial 20 year capital, operating and finance costs

Table 7.10: Cumulative community commercial 20 year capital, operating and finance costs

	CODE	NET ZERO READY	NET ZERO
Office Additional Capital Costs	$ -	$ 1,440,000	$ 1,440,000
Office Photovoltaic Costs	$ -	$ -	$ 2,040,000
Office Finance Interest for Energy Efficiency	$ -	$ 1,440,000	$ 1,440,000
Office Finance Interest for PV	$ -	$ -	$ 2,040,000
Office Operating Costs	$ 9,960,000	$ 3,720,000	$ -
Office/Manufacturing Additional Capital Costs	$ -	$ 900,000	$ 900,000
Office/Manufacturing Photovoltaic Costs	$ -	$ -	$ 700,000
Office/Manufacturing Finance Interest for Energy Efficiency	$ -	$ 880,000	$ 880,000
Office/Manufacturing Finance Interest for PV	$ -	$ -	$ 700,000
Office/Manufacturing Operating Costs	$ 2,800,000	$ 1,280,000	$ -
Total Rounded (to the two significant digits)	$ 13,000,000	$ 9,700,000	$ 10,000,000

ADDITIONAL INFORMATION

For additional information please contact a project team member:

Maclay Architects - contact Laura Bailey www.maclayarchitects.com
Efficiency Vermont - contact Paul Duane www.efficiencyvermont.com
Energy Analysis - Energy Balance, Andrew Shapiro
Residential Cost Estimating - Huntington Homes, Jason Webster www.huntingtonhomesvt.com
Commercial Cost Estimating - JAMorrissey, John Atherton www.jamteam.com

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Net Zero Energy Feasibility Study

APPENDIX

Photo by Jim Westphalen ©

Efficiency Vermont · Huntington Homes · JAM · Energy Balance · MaclayArchitects

APPENDIX

Residential Cost Estimate Parameters and Assumptions
Commercial Variable Interest Rate Cost per year
NFPA 285 Wall Assembly Narrative
Energy 10 Models
E10 Analysis Summary
SkyCalc Reports for Manufacturing area in Office/Manufacturing Building
Mechanical System Description
Commercial Cost Estimates
Electrical Cost Breakout
Electrical Lighting Budgets
Historical Fuel Rates and Escalation Narrative
Solar Plateau Explanation

RESIDENTIAL COST ESTIMATE PARAMETERS AND ASSUMPTIONS

Residential Capital Costs

	Building Component	Code	Net Zero Ready	Price / unit	Single Family Added Cost	Single Family Takeoffs (SF, LF, or ft^3)	Duplex Added Cost	Duplex Takeoffs (SF, LF, or ft^3)	Quadplex Added Cost	Quadplex Takeoffs (SF, LF, or ft^3)	Notes
Envelope	**Windows**	Double-glazed windows; U=0.32, SHGC =0.35	Triple-glazed windows; U=0.20 SHGC=0.50 on south; 0.35 other orientations	$24.00	$6,792	283	$4,800	200	$4,248	177	All buildings are modeled with the same number and size of window openings for both the NZR and Code buildings. NZR windows will be Integrity tri pane (and Alpine on south with higher SHGC) as they are the same price as of 2014. Code buildings uses Anderson 400 series windows. The price for the Integrity tri pane over Anderson is a 32% increase, which is equivalent to $24/sf more for NZR windows.
	Air/Vapor Barrier	Vapor Barrier only - Air infiltration of 0.5 cfm50/sf above grade surface area	Combined air barrier and drainage plane - Air infiltration is 0.1 cfm50/sf above grade surface area	$0.76	$2,172	2842	$1,406	1840	$1,211	1584	Tescon Vana Tape and installation cost $672, we added $1,500 to the single family home for additional air sealing
	Insulation	Basement Walls, R-15; R-15 slab edge; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	$53.70	$6,176	115	$3,652	68	$2,900	54	Huntington Homes cost: Under slab insulation actual = R15 ($2,426), and Foundation ICF R21 ($3,750)
		Rim insulation R21	Rim insulation R42	$6.05	$696	115	$412	68	$327	54	
		Walls: R-25	Walls: R-40	$3.82	$8,064	1708	$3,982	1042	$3,099	811	We had to add 1" rigid foam to exterior above the Huntington Homes estimate to comply with 2015 code -subtracted $0.90 sf/ material as this is now required by code. Inside foil faced rigid on inside. (R20 was Huntington Homes code wall)
		Attic R-49	Attic R-60	$2.26	$1,824	806	$1,267	560	$1,267	560	*Actual insulation in Huntington Homes NZR building was R-70
Mech	**Ventilation**	Rate: (# BR's + 1) *25 cfm, exhaust only	Rate: (# BR's + 1) *25 cfm, heat recovery ducted	$0.21	$3,800	18337	$1,857	8960	$1,857	8960	Panasonic Fans w/ timer v. LUNOS and panasonic fans - Used Ducted Venmar for NZR that has approximately the same cost
	Domestic Hot Water	From boiler	ASHP located in basement	$650.00	$2,600	4	$1,950	3	$1,950	3	Huntington Homes used the propane furnace Triangle Tube Boiler for code and a State Hybrid REEM for the single family home. DHW net COP considers some supplemental heat supplied by the ASHP and considering in place performance measurement analysis by Steven Winters Associates. The Single Family occupancy of 4 people is prorated for the assumed multifamily occupancy of 3 people to prorate the additional costs.
	HVAC	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3	-$0.32	-$5,900	18337	-$2,883	8960	-$2,883	8960	Code has a propane fired furnace Triangle Tube (95% AFUE) Boiler ($10,800), which is replaced with Mitsubishi MSZFE/MUZFE ($4,900) ASHP for a net saving.

NOTES:
Basement take off is linear feet of foundation perimeter
Air infiltration based on above grade surface area
Ventilation based on volume
DHW based on kWh use/year of NZR above code
HVAC based on volume

The residential net zero hot water average COP for the heat pump water heater was estimated at 1.5, which is a conservative estimate given current studies.

July 2011
Steven Winters Associates for
CONSORTIUM FOR ADVANCED RESIDENTIAL BUILDINGS

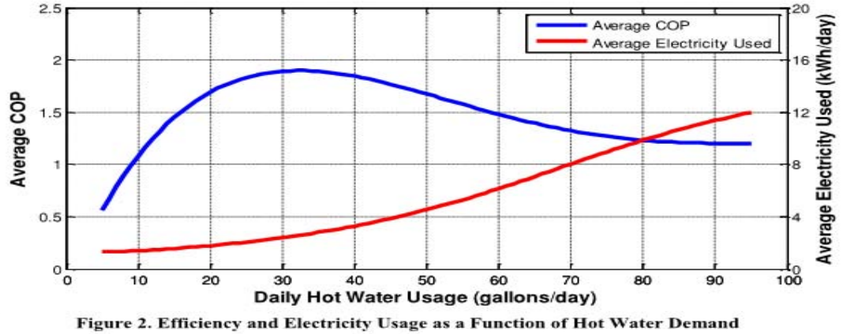


Figure 2. Efficiency and Electricity Usage as a Function of Hot Water Demand

source:
http://www.swinter.com/Collateral/Documents/English-US/Heat%20Pump%20Water%20Heater%20Draft%20Measure%20Guideline.pdf
Heat Pump Water Heaters in New and Existing Homes

COMMERCIAL VARIABLE FINANCE COSTS PER YEAR

Commercial variable interest loan of the NZR and NZ capital costs over 20 years, and the closed office capital costs financed.

Captial cost financed: $ 119,991

NZR Office Open

Year	Loan Payment for additional energy costs per year
1	$9,313
2	$9,313
3	$9,313
4	$9,313
5	$9,313
6	$10,985
7	$10,985
8	$10,985
9	$10,985
10	$10,985
11	$12,781
12	$12,781
13	$12,781
14	$12,781
15	$12,781
16	$14,685
17	$14,685
18	$14,685
19	$14,685
20	$14,685
Total	$238,823

Captial cost financed: $ 126,717

NZR Office Closed

Year	Loan Payment for additional energy costs per year
1	$9,835
2	$9,835
3	$9,835
4	$9,835
5	$9,835
6	$11,601
7	$11,601
8	$11,601
9	$11,601
10	$11,601
11	$13,498
12	$13,498
13	$13,498
14	$13,498
15	$13,498
16	$15,509
17	$15,509
18	$15,509
19	$15,509
20	$15,509
Total	$252,209

Captial cost financed: $ 447,335

NZR Manufacturing

Year	Loan Payment for additional energy costs per year
1	$34,718
2	$34,718
3	$34,718
4	$34,718
5	$34,718
6	$40,954
7	$40,954
8	$40,954
9	$40,954
10	$40,954
11	$47,650
12	$47,650
13	$47,650
14	$47,650
15	$47,650
16	$54,748
17	$54,748
18	$54,748
19	$54,748
20	$54,748
Total	$890,349

Captial cost financed: $ 291,622

Net Zero Open Office

Year	Loan Payment for additional energy capital cost plus solar
1	$22,633
2	$22,633
3	$22,633
4	$22,633
5	$22,633
6	$26,698
7	$26,698
8	$26,698
9	$26,698
10	$26,698
11	$31,063
12	$31,063
13	$31,063
14	$31,063
15	$31,063
16	$35,691
17	$35,691
18	$35,691
19	$35,691
20	$35,691
Total	$580,426

Captial cost financed: $ 302,414

Net Zero Closed Office

Year	Loan Payment for additional energy capital cost plus solar
1	$23,471
2	$23,471
3	$23,471
4	$23,471
5	$23,471
6	$27,686
7	$27,686
8	$27,686
9	$27,686
10	$27,686
11	$32,213
12	$32,213
13	$32,213
14	$32,213
15	$32,213
16	$37,012
17	$37,012
18	$37,012
19	$37,012
20	$37,012
Total	$601,907

Captial cost financed: $ 799,511

Net Zero Manufacturing

Year	Loan Payment for additional energy capital cost plus solar
1	$62,051
2	$62,051
3	$62,051
4	$62,051
5	$62,051
6	$73,196
7	$73,196
8	$73,196
9	$73,196
10	$73,196
11	$85,163
12	$85,163
13	$85,163
14	$85,163
15	$85,163
16	$97,850
17	$97,850
18	$97,850
19	$97,850
20	$97,850
Total	$1,591,297

Captial cost financed: $ 320,000

Closed Office

Year	Loan Payment for Closed Office Capital Costs
1	$24,835
2	$24,835
3	$24,835
4	$24,835
5	$24,835
6	$29,296
7	$29,296
8	$29,296
9	$29,296
10	$29,296
11	$34,086
12	$34,086
13	$34,086
14	$34,086
15	$34,086
16	$39,164
17	$39,164
18	$39,164
19	$39,164
20	$39,164
Total	$636,908

	interest rate per year
1	4.61%
2	4.61%
3	4.61%
4	4.61%
5	4.61%
6	6.61%
7	6.61%
8	6.61%
9	6.61%
10	6.61%
11	8.61%
12	8.61%
13	8.61%
14	8.61%
15	8.61%
16	10.61%
17	10.61%
18	10.61%
19	10.61%
20	10.61%

NFPA 285 TESTING ASSEMBLIES ASSUMPTIONS

NFPA 285 TESTING OF ASSEMBLIES

The International Building Code 2012 (incorporated into and amended by the VT Fire and Building Safety Code) includes several references to wall assembly testing per NFPA 285. In brief, the requirement for NFPA 285 testing is triggered by:

Foam plastic insulation on buildings of any height, which are categorized as construction types I-IV (this is generally cavity insulation, but insulated metal panels are also required to undergo NFPA 285 testing);

Air and water barriers on buildings taller than 40 feet above grade, which are categorized as construction types I-IV; and

Combustible cladding (EIFS, MCM, FRP, and HPL) on buildings taller than 40 feet above grade, which are categorized as construction types I-IV.

Buildings using noncombustible wall assembly materials are not subject to NFPA 285 testing. (There is also an exception for one-story buildings that are fully sprinklered - IBC 2603.4.1.4 - but plastic foam thickness is limited to 4 inches and foam must be covered with .032" aluminum or .016" corrosion-resistant steel.)

NFPA 285 is a full assembly test. This means that all of the wall components need to be tested together and then the entire assembly is given credit for passing the test. Even the noncombustible components in the wall assembly—including the base wall structure, interior drywall, and exterior sheathing—are not test triggers, but they must be considered as part of the complete wall assembly.

While some manufacturers and associations have been proactive in terms of testing their wall assemblies in-house to ensure NFPA 285 compliance (insulated metal panel manufacturers, for instance), other products have only begun showing up in wall assemblies in recent years and have not been tested together with many component variations or with the insulation thicknesses that would typically be used with high-performance buildings.

Some assembly issues to be aware of:

- Some assemblies need to have a certain amount of rock wool or mineral wool at the window head in order to pass.
- If a 1" cavity behind a veneer is called out, it is not necessarily the case that the cavity width can be increased. (A wider air space may provide enough oxygen to fuel a fire where 1" width wouldn't.)
- Combustible detail membranes can be used around openings in tested assemblies as long as they are within certain widths around the perimeters.

There is a partial workaround to full assembly testing in the 2012 Vermont Fire & Building Safety Code which allows a 3rd party engineering analysis that may permit the use of foam insulation in a cavity wall:

-delete & replace- IBC 2603.5.5 **Vertical and lateral fire propagation**: The exterior wall assembly shall have an evaluation report which provides details of the assemblies tested, in accordance with NFPA 285 and/or NFPA 285 test results extended via a third-party engineering analysis. Exception: One-story buildings complying with Section 2603.4.1.4.

These reports may be available or can be requested from the manufacturers' engineering departments. Most will allow for 2½-3" of the tested insulation product. Air and water barrier manufacturers may offer a similar service (such as Tremco - see Resources below.)

RESOURCES

Libraries:

SBC Research Institute (testing lab)
http://www.sbcri.info/content/2/icc-es-reports-approving-products-used-nfpa-285-tested-assemblies

Pace Representatives
http://www.pacerepresentatives.com/nfpa-285-wall-section-details/

Manufacturers:

Atlas EnergyShield Pro CI Board
www.atlasroofing.com/download.php?uid=569

Carlisle Fire Resist Air and Vapor Barriers
http://www.carlisleccw.com/?page=template&mode=product&category=198

Dow Tech Solutions 514.0
http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_08dd/0901b803808dd414.pdf?filepath=styrofoam/pdfs/noreg/179-04502.pdf&fromPage=GetDoc

Kingspan Shadowline metal panels
http://www.kingspanpanels.us/kingspanunitedstatesmain/media/pdfDownloads/Insulated%20Roof%20and%20Wall%20Panels/Insulated%20Metal%20Wall%20Panels/Data%20Sheets/KS-Shadowline-Data-Sheet.pdf

Owens Corning CommercialComplete Wall System
http://www.foamular.com/assets/0/144/172/174/d7a8d35c-e330-491c-b876-9ff0c8af5c55.pdf

Tremco, Inc.
https://www.tremcosealants.com/technical-resources/nfpa-285-air-barrier-engineering-judgment-request.aspx for engineering judgement request form
http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=FWFX.R27656&ccnshorttitle=Exterior+Wall+System+Components&objid=1082999775&cfgid=1073741824&version=versionless&parent_id=1082761881&sequence=1 for UL directory listing of tested exterior wall assemblies using Tremco products.

Roxul mineral fiber insulation
http://www.rspec.com//uploads/default/files/tb-noncombustible-construction.pdf

Miscellaneous:

Maclay server
P:\Projects\Resources\Codes and Standards\NFPA\NFPA 285

ENERGY 10 MODELS

Energy-10 Summary Page Jan 06, 2015
Project: NRG NZ Single FamilyProject Directory: C:\Program Files\Energy-10\Version 1.8\Projects \NRGSF

Description:	Reference Case code	NZR Case
Scheme Number:	1 / Saved	3 / Saved
Library Name:	Local Only	Local Only
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	1612.0	1612.0
Surface Area, ft²	3648.0	3648.0
Volume, ft³	12695.0	12695.0
Total Conduction UA, Btu/h-F	239.8	181.5
Average U-value, Btu/hr-ft²-F	0.066	0.050
Wall Construction	2 x 6 frame poly, R=23.1	pv_wall_r40, R=40.0
Roof Construction	pv_roof_r50, R=50.0	pv_roof_r60, R=60.0
Floor type, insulation	Basement, Reff=15.9	Basement, Reff=20.3
Window Construction	3040 dbl low-e lo shgc, U=0.32,etc	3040 super, hi shgc, U=0.27,etc
Window Shading	None	None
Wall total gross area, ft²	2036	2036
Roof total gross area, ft²	806	806
Ground total gross area, ft²	806	806
Window total gross area, ft²	276	276
Windows (N/E/S/W:Roof)	2/2/12/7:0	2/2/12/7:0
Glazing name	double low-e, U=0.26	triple low-e 88, U=0.23
Operating parameters for zone 1		
HVAC system	Baseboard Electric Heat	Baseboard Electric Heat
Rated Output (Heat/SCool/TCool),kBtu/h	31/0/0	17/0/0
Rated Air Flow/MOOA,cfm	0/0	0/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	76.0 °F, no setup	76.0 °F, no setup
Heat/cool performance	eff=100,EER=1.0	eff=100,EER=1.0
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.10/0.00/0.50/0.40	0.10/0.00/0.50/0.40
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.6	ACH=0.2
Results:		
Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	83702	47067
Energy cost, $	1611	919
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	24530	13793
(** less Sellback, if any)		
Internal/External lights, kWh	585/0	585/0
Heating/Cooling/Fan+Aux, kWh	15952/0/0	5216/0/0
Hot water/Other, kWh	4214/3778	4214/3778
Peak Electric, kW	10.7	6.6
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	32968/194/101	18538/109/57
Construction Costs	245708	245401
Life-Cycle Cost	297148	274641

Photovoltaics System Summary:

Description:	Reference Case code	NZR Case
PV System Definition Status:	Undefined	Undefined
Total PV Array Area, ft² / m²	--	--
Total PV Rated Output, kW	--	--
Total Inverter Rated Capacity, kW	--	--
Total PV System First Cost, $	--	--

(See Menu "Reports\Perf. Summary Reports\PV Summary" for additional details.)

Solar Hot Water System Summary:

Energy-10 Summary Page Jan 06, 2015
Project: NRGDUP Project Directory: C:\Program Files\Energy-10\Version 1.8\Projects \NRGDUP

Description:	Baseline 30% shaded	NZEB
Scheme Number:	4 / Not Saved	2 / Not Saved
Library Name:	ARCHIVELIB	ARCHIVELIB
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	1120.0	1120.0
Surface Area, ft²	2400.0	2400.0
Volume, ft³	8960.0	8960.0
Total Conduction UA, Btu/h-F	161.5	115.6
Average U-value, Btu/hr-ft²-F	0.067	0.048
Wall Construction	2 x 6 frame poly, R=23.1	pv_wall_r40, R=40.0
Roof Construction	pv_roof_r50, R=50.0	pv_roof_r60, R=60.0
Floor type, insulation	Basement, Reff=18.7	Basement, Reff=23.8
Window Construction	3040 dbl low-e lo shgc shaded 30%, U=0.32,etc	3040 super, hi shgc 30% shaded, U=0.20,etc
Window Shading	None	None
Wall total gross area, ft²	1280	1280
Roof total gross area, ft²	560	560
Ground total gross area, ft²	560	560
Window total gross area, ft²	204	204
Windows (N/E/S/W:Roof)	3/4/10/0:0	3/4/10/0:0
Glazing name	double low-e, U=0.26	triple low-e 88, U=0.23
Operating parameters for zone 1		
HVAC system	Baseboard Electric Heat	Baseboard Electric Heat
Rated Output (Heat/SCool/TCool),kBtu/h	21/0/0	12/0/0
Rated Air Flow/MOOA,cfm	0/0	0/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	76.0 °F, no setup	76.0 °F, no setup
Heat/cool performance	eff=100,EER=1.0	eff=100,EER=1.0
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.10/0.00/0.50/0.60	0.10/0.00/0.50/0.60
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.6	ACH=0.2
Results:		
Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	58684	34735
Energy cost, $	1123	666
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	17198	10179
(** less Sellback, if any)		
Internal/External lights, kWh	407/0	407/0
Heating/Cooling/Fan+Aux, kWh	9926/0/0	2908/0/0
Hot water/Other, kWh	2928/3937	2928/3937
Peak Electric, kW	7.4	4.7
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	23114/136/71	13681/80/42
Construction Costs	170693	170495
Life-Cycle Cost	206535	191681

Photovoltaics System Summary:

Description:	Baseline 30% shaded	NZEB
PV System Definition Status:	Undefined	Undefined
Total PV Array Area, ft² / m²	--	--
Total PV Rated Output, kW	--	--
Total Inverter Rated Capacity, kW	--	--
Total PV System First Cost, $	--	--

(See Menu "Reports\Perf. Summary Reports\PV Summary" for additional details.)

ENERGY 10 MODELS

Energy-10 Summary Page Jan 06, 2015
Project: NRG NZEB Quadplex Project Directory: C:\Program Files\Energy-10\Version 1.8\Projects\NRGQUAD

Description:	Reference Case	NZEB
Scheme Number:	1 / Saved	2 / Saved
Library Name:	ARCHIVELIB	ARCHIVELIB
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	1120.0	1120.0
Surface Area, ft²	2144.0	2144.0
Volume, ft³	8960.0	8960.0
Total Conduction UA, Btu/h-F	137.6	107.2
Average U-value, Btu/hr-ft²-F	0.064	0.050
Wall Construction	2 x 6 frame poly, R=23.1	pv_wall_r40, R=40.0
Roof Construction	pv_roof_r50, R=50.0	pv_roof_r60, R=60.0
Floor type, insulation	Basement, Reff=23.6	Basement, Reff=30.0
Window Construction	3040 dbl low-e lo shgc, U=0.32,etc	3040 super, hi shgc, U=0.27,etc
Window Shading	None	None
Wall total gross area, ft²	1024	1024
Roof total gross area, ft²	560	560
Ground total gross area, ft²	560	560
Window total gross area, ft²	180	180
Windows (N/E/S/W:Roof)	3/2/10/0:0	3/2/10/0:0
Glazing name	double low-e, U=0.26	triple low-e 88, U=0.23
Operating parameters for zone 1		
HVAC system	Baseboard Electric Heat	Baseboard Electric Heat
Rated Output (Heat/SCool/TCool),kBtu/h	19/0/0	11/0/0
Rated Air Flow/MOOA,cfm	0/0	0/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	76.0 °F, no setup	76.0 °F, no setup
Heat/cool performance	eff=100,EER=1.0	eff=100,EER=1.0
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.10/0.00/0.50/0.60	0.10/0.00/0.50/0.60
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.6	ACH=0.2
Results:		
Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	52438	32541
Energy cost, $	1010	627
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	15367	9536
(** less Sellback, if any)		
Internal/External lights, kWh	407/0	407/0
Heating/Cooling/Fan+Aux, kWh	8096/0/0	2265/0/0
Hot water/Other, kWh	2928/3937	2928/3937
Peak Electric, kW	6.8	4.5
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	20654/121/63	12817/75/39
Construction Costs	170653	170480
Life-Cycle Cost	202882	190413

Photovoltaics System Summary:

Description:	Reference Case	NZEB
PV System Definition Status:	Undefined	Undefined
Total PV Array Area, ft² / m²	--	--
Total PV Rated Output, kW	--	--
Total Inverter Rated Capacity, kW	--	--
Total PV System First Cost, $	--	--

(See Menu "Reports\Perf. Summary Reports\PV Summary" for additional details.)

Solar Hot Water System Summary:

Energy-10 Summary Page Jan 06, 2015
Project: NRGMANUF **Project Directory:** C:\Program Files\Energy-10\Version 1.8\Projects\NRGMANUF

Description:	Reference Case	NZEB-r30walls
Scheme Number:	1 / Saved	3 / Saved
Library Name:	ARCHIVELIB	ARCHIVELIB
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	27000.0	27000.0
Surface Area, ft²	58880.0	58880.0
Volume, ft³	528000.0	528000.0
Total Conduction UA, Btu/h-F	2721.2	1517.8
Average U-value, Btu/hr-ft²-F	0.046	0.026
Wall Construction	steelstud 6 poly, R=16.0	pv_wall_r30, R=28.5
Roof Construction	pv_roof_r30, R=30.5	pv_roof_r60, R=60.0
Floor type, insulation	Slab on Grade, Reff=95.7,etc	Slab on Grade, Reff=287.2,etc
Window Construction	3040 low-e code com, U=0.35,etc	3040 super lo shgc, U=0.19,etc
Window Shading	None	None
Wall total gross area, ft²	14880	14880
Roof total gross area, ft²	22000	22000
Ground total gross area, ft²	22000	22000
Window total gross area, ft²	2376	2760
Windows (N/E/S/W:Roof)	25/28/117/28:0	20/33/117/28:24
Glazing name	double low-e, U=0.26	quad low-e 88, U=0.12
Operating parameters for zone 1		
HVAC system	DX Cooling with Elect Furn	DX Cooling with Elect Furn
Rated Output (Heat/SCool/TCool),kBtu/h	254/150/199	108/95/126
Rated Air Flow/MOOA,cfm	6956/0	4585/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	74.0 °F, setup to 78.0 °F	74.0 °F, setup to 78.0 °F
Heat/cool performance	eff=100,EER=3.4	eff=100,EER=3.4
Economizer?/type	yes/fixed dry bulb, 65.0 °F	yes/fixed dry bulb, 65.0 °F
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.95/0.05/0.05/0.55	0.42/0.05/0.05/0.55
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.7	ACH=0.2
Operating parameters for zone 2		
HVAC system	Baseboard Electric Heat	Baseboard Electric Heat
Rated Output (Heat/SCool/TCool),kBtu/h	246/0/0	91/0/0
Rated Air Flow/MOOA,cfm	0/0	0/0
Heating thermostat	65.0 °F, setback to 60.0 °F	65.0 °F, setback to 60.0 °F
Cooling thermostat	74.0 °F, setup to 78.0 °F	74.0 °F, setup to 78.0 °F
Heat/cool performance	eff=100,EER=1.0	eff=100,EER=1.0
Economizer?/type	no/NA	no/NA
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.95/0.05/0.00/0.55	0.42/0.05/0.00/0.55
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.2	ACH=0.0
Results:		
Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	1292903	612905
Energy cost, $	24564	11642
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	378895	179616
(** less Sellback, if any)		
Internal/External lights, kWh	77891/5519	34436/5519
Heating/Cooling/Fan+Aux, kWh	178951/25262/10324	31191/21451/6072
Hot water/Other, kWh	2281/78666	2281/78666
Peak Electric, kW	185.3	84.7
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	509235/2993/1553	241404/1419/736
Construction Costs	4207796	4187466
Life-Cycle Cost	5067071	4620409

Energy-10 Summary Page Jan 06, 2015
Project: NRG Office Closed **Project Directory:** C:\Program Files\Energy-10\Version 1.8\Projects\NRGOffcl

Description:	Reference Case	NZEB
Scheme Number:	1 / Not Saved	4 / Not Saved
Library Name:	ARCHIVELIB	ARCHIVELIB
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	13000.0	13000.0
Surface Area, ft²	20920.0	20920.0
Volume, ft³	156000.0	156000.0
Total Conduction UA, Btu/h-F	1467.3	731.3
Average U-value, Btu/hr-ft²-F	0.070	0.035
Wall Construction	steelstud 6 poly, R=16.0	pv_wall_r40, R=40.0
Roof Construction	pv_roof_r30, R=30.5	pv_roof_r60, R=60.0
Floor type, insulation	Slab on Grade, Reff=41.0,etc	Slab on Grade, Reff=123.1,etc
Window Construction	3040 low-e code com, U=0.35,etc	3040 super lo shgc, U=0.19,etc
Window Shading	None	None
Wall total gross area, ft²	7920	7920
Roof total gross area, ft²	6500	6500
Ground total gross area, ft²	6500	6500
Window total gross area, ft²	1920	1920
Windows (N/E/S/W:Roof)	60/20/60/20:0	60/20/60/20:0
Glazing name	double low-e, U=0.26	quad low-e 88, U=0.12

Operating parameters for zone 1

HVAC system	DX Cooling with Elect Furn	DX Cooling with Elect Furn
Rated Output (Heat/SCool/TCool),kBtu/h	163/92/123	61/56/75
Rated Air Flow/MOOA,cfm	4199/0	2657/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	74.0 °F, setup to 78.0 °F	74.0 °F, setup to 78.0 °F
Heat/cool performance	eff=100,EER=3.4	eff=100,EER=3.4
Economizer?/type	yes/fixed dry bulb, 65.0 °F	yes/fixed dry bulb, 65.0 °F
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.99/0.05/0.05/0.30	0.50/0.05/0.05/0.30
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.7	ACH=0.2

Operating parameters for zone 2

HVAC system	DX Cooling with Elect Furn	DX Cooling with Elect Furn
Rated Output (Heat/SCool/TCool),kBtu/h	160/77/103	59/47/62
Rated Air Flow/MOOA,cfm	3444/0	2196/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	74.0 °F, setup to 78.0 °F	74.0 °F, setup to 78.0 °F
Heat/cool performance	eff=100,EER=3.4	eff=100,EER=3.4
Economizer?/type	yes/fixed dry bulb, 65.0 °F	yes/fixed dry bulb, 65.0 °F
Duct leaks/conduction losses, total %	0/0	2/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.99/0.05/0.05/0.30	0.50/0.05/0.10/0.30
Added mass?	none	none
Daylighting?	no	no
Infiltration, in²	ACH=0.7	ACH=0.2

Results:

Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	831547	359746
Energy cost, $	16052	7065
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	243691	105426
(** less Sellback, if any)		
Internal/External lights, kWh	39082/2657	19739/2657
Heating/Cooling/Fan+Aux, kWh	140012/26716/11598	28133/23308/6481
Hot water/Other, kWh	2966/20660	4449/20660
Peak Electric, kW	112.5	51.0
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	327521/1925/999	141693/833/432
Construction Costs	2052335	2031502
Life-Cycle Cost	2621342	2298642

Energy-10 Summary Page Jan 06, 2015
Project: NRG open office Project Directory: C:\Program Files\Energy-10\Version 1.8\Projects\NRG2

Description:	Reference Case	Low-Energy Case
Scheme Number:	1 / Saved	2 / Saved
Library Name:	ARCHIVELIB	ARCHIVELIB
Simulation status, Thermal/DL	valid/NA	valid/NA
Weather file:	Burlingt.et1	Burlingt.et1
Floor Area, ft²	13000.0	13000.0
Surface Area, ft²	20920.0	20920.0
Volume, ft³	156000.0	156000.0
Total Conduction UA, Btu/h-F	1347.3	735.2
Average U-value, Btu/hr-ft²-F	0.064	0.035
Wall Construction	2 x 6 frame, R=16.0	r-33.6, R=33.6
Roof Construction	pv_roof_r30, R=30.5	pv_roof_r60, R=60.0
Floor type, insulation	Slab on Grade, Reff=41.0	Slab on Grade, Reff=123.1
Window Construction	3040 double, lshgc, U=0.30,etc	3040 super lshg, U=0.19
Window Shading	None	<none>
Wall total gross area, ft²	7920	7920
Roof total gross area, ft²	6500	6500
Ground total gross area, ft²	6500	6500
Window total gross area, ft²	1920	2016
Windows (N/E/S/W:Roof)	60/20/60/20:0	60/20/60/20:8
Glazing name	double lshgc, U=0.26	quad low-e 88, U=0.12

Operating parameters for zone 1

HVAC system	DX Cooling with Elect Furn	DX Cooling with Elect Furn
Rated Output (Heat/SCool/TCool),kBtu/h	303/160/214	124/104/139
Rated Air Flow/MOOA,cfm	7181/0	5058/0
Heating thermostat	70.0 °F, setback to 65.0 °F	70.0 °F, setback to 65.0 °F
Cooling thermostat	74.0 °F, setup to 78.0 °F	74.0 °F, setup to 78.0 °F
Heat/cool performance	eff=100,EER=3.4	eff=100,EER=3.4
Economizer?/type	yes/fixed dry bulb, 65.0 °F	yes/fixed dry bulb, 60.0 °F
Duct leaks/conduction losses, total %	0/0	0/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.90/0.05/0.05/0.30	0.50/0.05/0.05/0.30
Added mass?	none	none
Daylighting?	no	yes, continuous dimming
Infiltration, in²	ACH=0.7	ACH=0.2

Results:

Energy cost	0.400$/Therm,0.054$/kWh,2.470$/kW	0.400$/Therm,0.054$/kWh,2.470$/kW
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec
Energy use, kBtu	775464	358156
Energy cost, $	14984	7044
Saved by daylighting, kWh	-	NA
Total Electric (**), kWh	227255	104960
(** less Sellback, if any)		
Internal/External lights, kWh	35529/2657	19739/2657
Heating/Cooling/Fan+Aux, kWh	128293/26310/10840	28477/26466/3996
Hot water/Other, kWh	2966/20660	2966/20660
Peak Electric, kW	105.5	50.9
Fuel, hw/heat/total, kBtu	0/0/0	0/0/0
Emissions, CO2/SO2/NOx, lbs	305431/1795/932	141067/829/430
Construction Costs	2023445	2193758
Life-Cycle Cost	2535282	2425895

Photovoltaics System Summary:

Description:	Reference Case	Low-Energy Case
PV System Definition Status:	Undefined	Applied
Total PV Array Area, ft² / m²	--	1588 / 148
Total PV Rated Output, kW	--	17.4
Total Inverter Rated Capacity, kW	--	20.0
Total PV System First Cost, $	--	130388

(See Menu "Reports\Perf. Summary Reports\PV Summary" for additional details.)

Solar Hot Water System Summary:

E10 ANALYSIS SUMMARY

NRG NZEB Single Family House
Summmary of energy modeling results

07-Jan-15

	Peak heat, kBtu/hr		Propane	Elec Use	EUI	
	heating	cooling	Gallons	kWh/yr [3]	kBtu/sq.ft.-yr	kWh/sq.m.-yr
Baseline	32	0	926	4,463	62	196
NZEB	18	0		9,229	20	62

Operating Cost [2]	PV's needed kW-p [1]	CO2 tons/yr with no PV
$ 3,500	4.1	7.7
$ 1,400	8.4	3.7

Notes
[1] fixed array, to equal annual electricity consumption,and does not cover propane use for base building
[2] energy cost at current rates -- assuming no PV -- to nearest $100

	per unit	efficiency	$$/MMBtu deliv'd heat	lbs CO2/unit	# CO2/MMBtu delivered	
propane	$ 3.08	0.8	$ 42.08	12.7	139	
kWh electricity	$ 0.15	2.3	$ 19.11	0.8	234	without PV's

[3] Energy from all fuel sources, in kWh

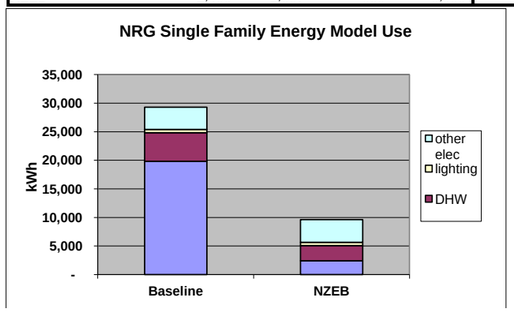
195.50
64.15

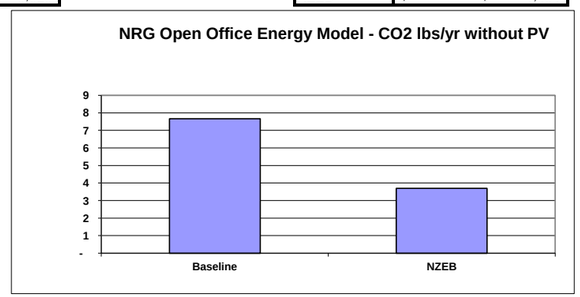
	CO2 lbs/yr with no PV
Baseline	8
NZEB	4

Energy Usage in kWh

	heat	DHW	lighting	other elec	Total
Baseline	19,826	5,000	585	3,878	29,289
NZEB	2,406	2,667	585	3,953	9,610

Cost	Propane	Electricity
Baseline	$ 2,852	$ 669
NZEB	$ -	$ 1,384





NRG NZEB Duplex
Summmary of energy modeling results

07-Jan-15

	Peak heat, kBtu/hr		Propane	Elec Use
	heating	cooling	Gallons	kWh/yr [3]
Baseline	21	0	623	4,444
NZEB	12	0		9,321

Operating Cost [2]	PV's needed kW-p [1]	CO2 tons/yr with no PV
$ 2,600	4.0	5.7
$ 1,400	8.5	3.7

Notes
[1] fixed array, to equal annual electricity consumption,and does not cover propane use for base building
[2] energy cost at current rates -- assuming no PV -- to nearest $100

	per unit	efficiency	$$/MMBtu deliv'd heat	lbs CO2/unit	# CO2/MMBtu delivered	
propane	$ 3.08	0.8	$ 42.08	12.7	139	
kWh electricity	$ 0.15	2.3	$ 19.11	0.8	234	without PV's

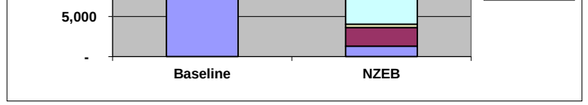
[3] Energy from all fuel sources, in kWh

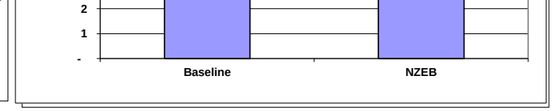
	CO2 lbs/yr with no PV
Baseline	6
NZEB	4

Energy Usage in kWh

	heat	hot water	lighting	other elec	Total
Baseline	12,316	4,375	407	4,037	21,135
NZEB	1,302	2,333	407	4,112	8,155

Cost	Propane	Electricity
Baseline	$ 1,918	$ 667
NZEB	$ -	$ 1,398





E10 ANALYSIS SUMMARY

NRG NZEB Quadplex
Summmary of energy modeling results

07-Jan-15

	Peak heat, kBtu/hr		Propane	Elec Use
	heating	cooling	Gallons	kWh/yr [3]
Baseline	19	0	518	4,444
NZEB	11	0		9,004

Operating Cost [2]	PV's needed kW-p [1]	CO2 tons/yr with no PV
$ 2,300	4.0	5.1
$ 1,400	8.2	3.6

Notes
[1] fixed array, to equal annual electricity consumption,and does not cover propane use for base building
[2] energy cost at current rates -- assuming no PV -- to nearest $100

	per unit	efficiency	$$/MMBtu deliv'd heat	lbs CO2/unit	# CO2/MMBtu delivered	
propane	$ 3.08	0.8	$ 42.08	12.7	139	
kWh electricity	$ 0.15	2.3	$ 19.11	0.8	234	without PV's

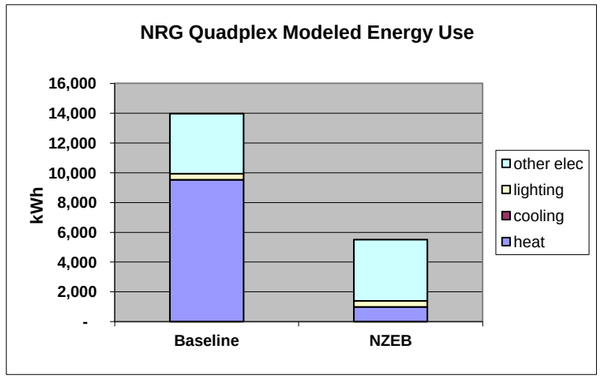
[3] Energy from all fuel sources, in kWh

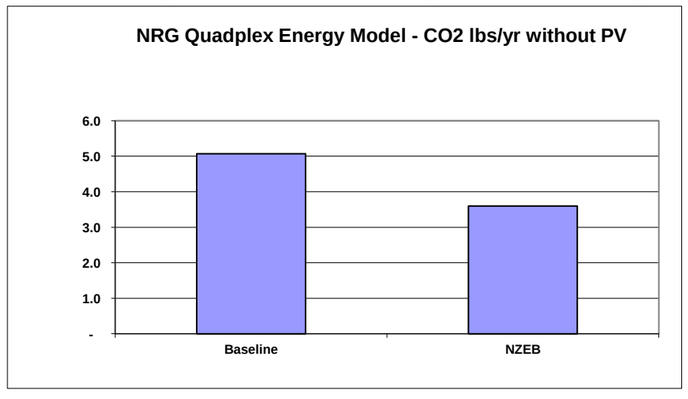
	CO2 lbs/yr with no PV
Baseline	5.1
NZEB	3.6

Energy Usage in kWh

	heat	cooling	lighting	other elec	hot water	Total
Baseline	9,525	-	407	4,037	4,375	18,344
NZEB	985	-	407	4,112	2,333	7,837

Cost	Propane	Electricity
Baseline	$ 1,597	$ 667
NZEB	$ -	$ 1,351





E10 ANALYSIS SUMMARY

NRG Offices
Summmary of energy modeling results

05-Jan-15

	Peak heat, kBtu/hr		Propane	Elec Use
	heating	cooling	Gallons	kWh/yr [3]
NRG Open Office Baseline	303	214	6,000	76,300
NRG Open Office NZEB	124	139		65,800
NRG Closed Office Baseline	323	226	6,500	79,200
NRG Closed Office NZEB	120	137		67,400

First Year Operating Cost	PV's needed kW-p [1]	CO2 tons/yr with no PV
$ 29,900	66	72
$ 9,900	57	30
$ 31,900	69	77
$ 10,100	59	30

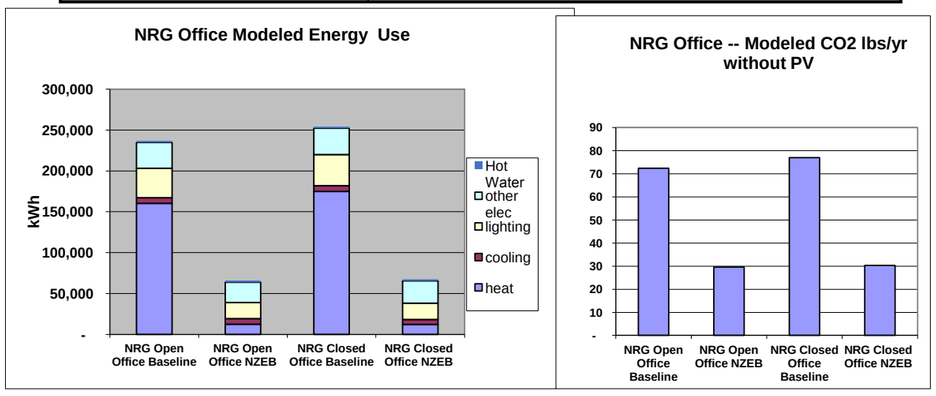
Notes
[1] fixed array, to equal annual electricity consumption,and does not cover propane use for base building, with 1 Wp installed producing 1.15kWh/yr
[2] energy cost at October 2014 rates -- assuming no PV

	per unit	efficiency	$$/MMBtu delvd heat	lbs CO2/unit
propane	$ 3.08	0.8	$ 38.50	12.7
kWh electricity	$ 0.15	2.3	$ 19.11	0.9

Tables below are for graphing

Energy Usage in kWh

	heat	cooling	lighting	other elec	Hot Water	Total
NRG Open Office Baseline	160,366	6,879	35,963	31,500	2,000	236,708
NRG Open Office NZEB	12,381	6,922	19,832	24,656	2,000	65,792
NRG Closed Office Baseline	175,015	6,987	37,965	32,258	2,000	254,225
NRG Closed Office NZEB	12,232	6,096	19,882	27,141	2,000	67,351



NRG Manufacturing
Summmary of energy modeling results

05-Jan-15

	Peak heat, kBtu/hr		Propane	Elec Use
	heating	cooling	Gallons	kWh/yr [3]
NRG Manuf/Office Baseline (w/code daylighting)	500	199	8,300	167,200
NRGManuf/Office NZEB (w/ added daylighting)	199	126		135,000

First Year Operating Cost	PV's needed kW-p [1]	CO2 tons/yr with no PV
$ 51,000	145	128
$ 20,000	117	61

Notes
[1] fixed array, to equal annual electricity consumption,and does not offset propane use for base building, with 1 Wp installed producing 1.15kWh/yr
[2] energy cost at current rates -- assuming no PV

	per unit	efficiency	$$/MMBtu del'v'd heat	lbs CO2/unit [3]
propane	$ 3.08	0.80	$ 39	12.7
kWh electricity	$ 0.15	2.3	$ 19	0.9

0.9lbs CO2/kWh is average ISO-NE value

Tables below are for graphing only

Energy Usage in kWh

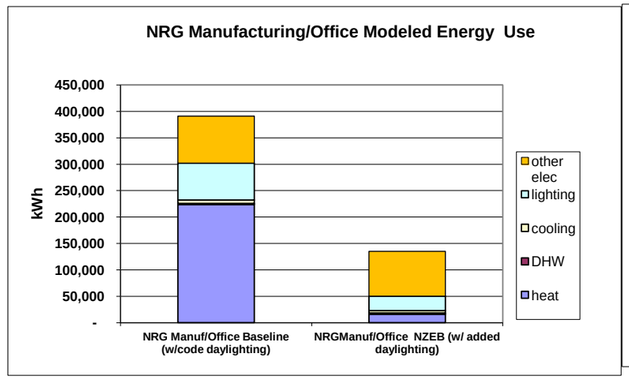
	heat	DHW	cooling	lighting	other elec	Total
NRG Manuf/Office Baseline (w/code daylighting)	223,689	2,000	6,607	69,632	88,990	390,918
NRGManuf/Office NZEB (w/ added daylighting)	16,166	2,000	4,564	27,532	84,738	135,001

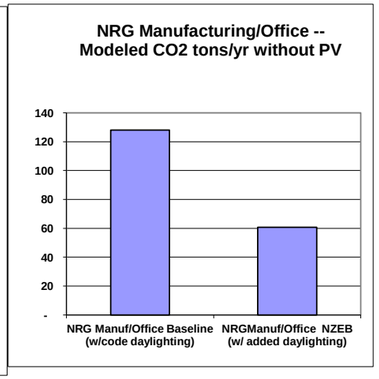
Energy Usage in kWh/sq.ft.-yr

	heat	DHW	cooling	lighting	other elec	Total
NRG Manuf/Office Baseline (w/code daylighting)	8.28	0.07	0.24	2.58	3.30	14.48
NRGManuf/Office NZEB (w/ added daylighting)	0.60	0.07	0.17	1.02	3.14	5.00

total sq.ft. 27,000

NRG Actual kWh/sq.ft-yr -- all but heat are usage; heat is load					
heat load	DHW	cooling	lighting	other elec	
2.33	0.04	0.24	0.89	2.17	4.354
with COP =2.3 1.01	<<NRG usage if heat pump were used for heat				





SKYCALC DAYLIGHT SUMMARY

Company Name: Energy Balance
Project Description: NZ manufacturing

Select Location
Climate data loaded = Burlington, VT
Climate data for location is already loaded

Building

Building type	Warehouse	
Bldg area	17,000	ft^2
Ceiling height	24	ft
Wall color	off white	

Shelving/Racks or Partitions?

No data required	14	ft
No data required	4	ft
No data required	6.5	ft
No data required	1	ft

Electric Lighting

Lighting system	fluorescent	
Fixture height	20	ft
Lighting control	dimming to 10%	

Lighting Control Graph - Lighting Setpoint = 0 fc

Skylights:

Number of skylights	32	
Skylight width	4	ft
Skylight length	4	ft

Current Skylight to Floor Ratio = 0.0%

Skylight Description

Glazing type	polycarb
Glazing layers	triple
Glazing color	clear

Skylight Well

Light well height	2	feet
Well color	white	
Safety grate or screen		

Heating and Air Conditioning Systems

Air Conditioning	none
Heating System	electric

Utilities

Average Elec Cost	$0.150	kWh
Heating Fuel Units	kwh	
Heating Fuel Cost	$0.060	/kwh

SkyCalc: Skylight Design Assistant - Optional I

Company Name: Energy Balance
Project Description: NZ manufacturing

Skylights	Default	User Revisions	Design Input
Visible transmittance	50%		50%
Solar heat gain coefficient	51%		51%
Curb type	Wood	#VALUE!	#VALUE!
Frame type	Metal w/ thermal brk	#VALUE!	#VALUE!
Unit U-value (Btu/h•°F•ft^2)	0.406	0.300	0.300
Dirt light loss factor	70%	80%	80%
Screen or safety grate factor	100%		100%
Light well reflectance	80%	85%	85%
Well factor (WF)	82%		82%
Bottom of light well:			
Width (ft)	4.00	4.00	4.00
Length (ft)	4.00	4.00	4.00
Diffuser on bottom of well?	No	○ Yes,	◉ No

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: Energy Balance
Project Description: NZ manufacturing

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	79,033	Lighting Fraction Saved	30%
Lighting Energy w/ Skylights	54,999	Full daylighting (h/yr)	624

	Savings from Design Skylighting System		
Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		24,034	$0
Cooling		0	$0
Heating		-5,591	-$656
Total		**18,443**	**$2,949**

Skylighting System Description		Site Description	
Skylight unit size (ft2)	16	Climate Location	Burlington, VT
Number of Skylights	32	Climate Zone	ASHRAE B-19
Total Skylight Area (ft2)	512	Building Type	Warehouse
Skylight to Floor Ratio (SFR)	3%	Building Area	17000 (ft2)
Effective Aperture	1%		
Floor Area per Skylight	531.25	Elecric Lighting System Description	
Skylight U-value	0.3	Lighting Ty Industrial fluorescent	
Skylight SHGC	0.51	Lighting Cc Dimming min 10% light	
Skylight Tvis	0.50	Light Level Setpoint	25 fc
Well Efficiency (WF)	0.82	Lighting Density	1.05 W/ft2
Dirt and Screen Factor	0.80	Connected Load	17.85 kW
Overall Skylight System Tvis	0.33	Fraction Controlled	0.9
Skylight CU	0.39		

Offices Only

Daylighting from sidelighting - E10	
	E-10 shoebox
wsf	1.0
no daylight, kWh/yr	39,477
daylight, kWh/yr	38,242
savings from E-10	1,235
% savings [1]	3.1%
Annual kWh factor	97%

[1] savings applied to E-10 lighting for daylighting savings

Manufacturing/warehouse space only

Skycalc skylighting	
Partial inputs	
3%	of floor area in skylights
17,000	floor area (whole space)
510	skylight area, sq.ft.
16	skylight area each, sq.ft.
32	number skylights in fullly daylit space
4	rows
8	number in row
28	row spacing, ft.
Results	
30%	% savings from Skycalc
15%	% savings if half implemented (code)

Estimation of Interior Lighting with Daylighting

code	NZEB	
77,891	34,436	E-10 interior lighting total
63%	63%	fraction of area in maufacturing warehouse
28,849	12,754	annual kWh offices only, E-10 model
49,042	21,682	annual kWh manuf/warehouse only, E-10 model
27,946	12,355	offices annual kWh with code required daylighting
41,686	15,177	manuf/warehouse with daylighting -- half area for code, all for NZEB
69,632	27,532	Total interior lighting, kWh/yr

L. N. CONSULTING INC.
P. O . BOX 65178
BURLINGTON, VT 05406-5178
TELEPHONE (802) 655-1753
FAX: (802) 655-7628

November 20, 2014

Bob Avonda
Avonda Air Systems
1879 Williston Rd.
South Burlington, VT 05403

Re: NRG Master Plan – Mechanical System Info

Manufacturing Building:

CBEC 2015 Code Compliant

Manufacturing Space
(2) Propane Fired Unit Heaters 150,000 btu/hr each.

Office Space
Level One: 8 ton roof top unit with (5) VAV zones and 300 cfm of ventilation air
Zone 1 – Open Office – 1300 s.f. – 800 cfm
Zone 2 – Meeting Room – 300 s.f – 250 cfm
Zone 3 – Lobby & Circulation – 1000 s.f. – 800 cfm
Zone 4 – Meeting – 500 s.f. – 400 cfm
Zone 5 – Open Office – 1100 s.f. – 600 cfm

Level Two: 9 ton roof top unit with (4) VAV zones and 300 cfm of ventilation air
Zone 1 – Open Office & Circulation – 1700 s.f. – 900 cfm
Zone 2 – Meeting Room – 300 s.f – 250 cfm
Zone 3 – Small Meeting Rooms – 300 s.f. – 250 cfm
Zone 4 – Open Office & Circulation – 2100 s.f. – 1200 cfm

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

Bathrooms
Assume (1) bath exhaust fan ducted to all bathrooms. Fan rated at 600 cfm.

This system will provide poor performance for the meeting rooms as they might have cooling load in winter time due to occupant density and the roof top unit is only operating in heating mode. One option is to fit the meeting rooms with air to air heat pumps to meet these cooling conditions. This can create the heating and cooling systems fighting each other in some instances. Other option is to support these spaces with dedicated roof top unit.

Net Zero

Manufacturing Space
(4) Air Source Heat Pump Units 4 tons (48,000 btu/hr) each.

Office Space
Level One: 6 ton outdoor unit rated for minus 14 degress F.
Zone 1 – Open Office – 1300 s.f. – Fan Coil Indoor Unit 1.5 tons
Zone 2 – Meeting Room – 300 s.f – Fan Coil Indoor Unit 0.75 ton
Zone 3 – Lobby & Circulation – 1000 s.f. – (2) Fan Coils Indoor Units rated at 1.0 ton each
Zone 4 – Meeting – 500 s.f. – Fan Coil Indoor Unit 1.0 ton
Zone 5 – Open Office – 1100 s.f. – Fan Coil Indoor Unit 1.5 tons

Level Two: 6 ton outdoor unit rated for minus 14 degress F.
Zone 1 - Open Office & Circulation – 1700 s.f. – Fan Coil Indoor Unit 2.0 tons
Zone 2 – Meeting Room – 300 s.f – Fan Coil Indoor Unit 0.75 ton
Zone 3 – Small Meeting Rooms – 300 s.f. – (2) Fan Coils Indoor Units rated at 0.5 ton each
Zone 4 – Open Office & Circulation – 2100 s.f. – Fan Coil Indoor Unit 3.0 tons

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

ERV rated at 600 cfm with exhaust air duct from bathrooms and supply air ducting to each occupied space fan coil unit.

Office Building (Closed Office Plan):

CBEC 2015 Code Compliant

Level One: (2) roof top units with one rated for 3.5 tons fitted with (3) VAV units and one rated for 12 tons fitted with (6) VAV units.

Two Ton Roof Top Unit with 200 cfm of ventilation air:
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – 350 cfm per zone
Zone 3: Circulation Space – 910 s.f. – 450 cfm

Twelve Ton Roof Top Unit with 450 cfm of ventilation air:
Zones 4 through 8: One large office and three small offices – 780 s.f. each – 475 cfm each
Zones 9 through 10: Three small offices – 370 s.f. each – 225 cfm each

MECHANICAL SYSTEM DESCRIPTION

Level Two: (2) roof top units with one rated for 3.5 tons fitted with (3) VAV units and one rated for 12 tons fitted with (6) VAV units.

Two Ton Roof Top Unit with 200 cfm of ventilation air:
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – 350 cfm per zone
Zone 3: Circulation Space – 910 s.f. – 450 cfm

Twelve Ton Roof Top Unit with 450 cfm of ventilation air:
Zones 4 through 8: One large office and three small offices – 780 s.f. each – 475 cfm each
Zones 9 through 10: Three small offices – 370 s.f. each – 225 cfm each

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

Bathrooms
Assume (1) bath exhaust fan ducted to all bathrooms. Fan rated at 600 cfm.

Net Zero

Level One: 8 ton outdoor unit rated for minus 14 degress F.
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – Each Fan Coil Indoor Unit rated at 1.0 ton
Zone 3: Circulation Space – 910 s.f. – Fan Coil Indoor Unit 1.0 ton
Zones 4 through 8: One large office and three small offices – 780 s.f. each – Each Fan Coil Indoor Unit rated at 1.0 ton
Zones 9 through 10: Three small offices – 370 s.f. each – Each Fan Coil Indoor Unit rated at 0.75 ton

Level Two: 8 ton outdoor unit rated for minus 14 degress F.
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – Each Fan Coil Indoor Unit rated at 1.0 ton
Zone 3: Circulation Space – 910 s.f. – Fan Coil Indoor Unit 1.0 ton
Zones 4 through 8: One large office and three small offices – 780 s.f. each – Each Fan Coil Indoor Unit rated at 1.0 ton
Zones 9 through 10: Three small offices – 370 s.f. each – Each Fan Coil Indoor Unit rated at 0.75 ton

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

ERV rated at 1300 cfm with exhaust air duct from bathrooms and supply air ducting to each occupied space fan coil unit.

Office Building (Open Office Plan):

CBEC 2015 Code Compliant

Level One: (2) roof top units with one rated for 3.5 tons fitted with (3) VAV units and one rated for 12 tons fitted with (4) VAV units.

Two Ton Roof Top Unit with 200 cfm of ventilation air:
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – 350 cfm per zone
Zone 3: Circulation Space – 910 s.f. – 450 cfm

Twelve Ton Roof Top Unit with 500 cfm of ventilation air:
Zones 4 through 8: Open Office Quadrant – 1500 s.f. each – 1200 cfm each

Level Two: (2) roof top units with one rated for 3.5 tons fitted with (3) VAV units and one rated for 12 tons fitted with (4) VAV units.

Two Ton Roof Top Unit with 200 cfm of ventilation air:
Zones 1 & 2: Core Area Support Space – 1475 s.f. per zone – 350 cfm per zone
Zone 3: Circulation Space – 910 s.f. – 450 cfm

Twelve Ton Roof Top Unit with 500 cfm of ventilation air:
Zones 4 through 8: Open Office Quadrant – 1500 s.f. each – 1200 cfm each

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

Bathrooms
Assume (1) bath exhaust fan ducted to all bathrooms. Fan rated at 600 cfm.

Net Zero

Level One: 8 ton outdoor unit rated for minus 14 degress F.
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – Each Fan Coil Indoor Unit rated at 1.0 ton
Zones 4 through 8: Open Office Quadrant – 1500 s.f. each – Each Fan Coil Indoor Unit rated at 1.75 tons

Level Two: 8 ton outdoor unit rated for minus 14 degress F.
Zones 1 & 2: Core Area Support Space – 715 s.f. per zone – Each Fan Coil Indoor Unit rated at 1.0 ton
Zones 4 through 8: Open Office Quadrant – 1500 s.f. each – Each Fan Coil Indoor Unit rated at 1.75 tons

Stairwells
(2) air to air heat pumps sized at 12,000 btu/hr and rated for minus 14 deg F.

ERV rated at 1400 cfm with exhaust air duct from bathrooms and supply air ducting to each occupied space fan coil unit.

If you have any questions or require additional information please contact our office.

Sincerely,

L.N. Consulting, Inc Wayne Nelson, President

COMMERCIAL CAPITAL COSTS

Summary of Commercial Capital Costs

		Office Open plan Code Compliant	Office Open plan Net Zero	Office closed plan Code Compliant	Office closed plan Net Zero	Office/ Manufacturing Code	Office/ Manufacturing Net Zero
	DIVISION / WORK ITEM	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL
1000	GENERAL CONDITIONS	$0	$0	$0	$0	$0	$0
2000	SELECTIVE DEMO/PROTECTION	$0	$0	$0	$0	$0	$0
2000	SITEWORK	$83,688	$83,688	$83,688	$83,688	$127,260	$127,260
3000	CONCRETE	$94,500	$94,500	$94,500	$94,500	$248,300	$248,300
4000	MASONRY	$0	$0	$0	$0	$0	$0
5000	STEEL	$195,500	$195,500	$195,500	$195,500	$418,000	$418,000
6000	ROUGH CARPENTRY	$2,670	$2,670	$2,670	$2,670	$2,670	$2,670
6200	FINISH CARPENTRY	$5,875	$5,875	$5,875	$5,875	$5,875	$5,875
7000	THERMAL & MOISTURE PROTECTION	$538,993	$681,603	$542,293	$684,903	$1,067,145	$1,438,284
8000	DOORS AND WINDOWS	$141,202	$171,112	$175,422	$205,332	$207,457	$257,571
9000	FINISHES	$172,600	$172,600	$388,540	$388,540	$174,800	$174,800
10000	SPECIALTIES	$2,780	$2,780	$2,780	$2,780	$2,780	$2,780
11000	EQUIPMENT	$0	$0	$0	$0	$0	$0
12000	FURNISHINGS	$0	$0	$0	$0	$0	$0
13000	SPRINKLER	$26,300	$26,300	$31,510	$31,510	$45,275	$45,275
14000	CONVEYING SYSTEMS	$0	$0	$0	$0	$0	$0
15000	MECHANICAL	$185,000	$116,000	$192,000	$126,000	$123,000	$115,000
16000	ELECTRICAL	$126,817	$139,057	$134,494	$146,734	$197,425	$220,946
	VERT. TOTALS	$1,575,924	$1,691,684	$1,849,271	$1,968,031	$2,636,574	$3,122,440
	HORIZ. TOTALS	$1,449,107	$1,552,627	$1,714,777	$1,821,297	$2,439,149	$2,901,493
	Overhead and Fee - 7%	$101,437	$108,684	$120,034	$127,491	$170,740	$203,105
	General Conditions 10 %	$155,054	$166,131	$183,481	$194,879	$260,989	$310,460
	BASE ESTIMATE - CONSTRUCTION COSTS	**$1,705,599**	**$1,827,442**	**$2,018,293**	**$2,143,667**	**$2,870,878**	**$3,337,754**

Summary of Open v. Closed Capital Cost Summary

		Office closed plan Code Compliant	Office Open plan Code Compliant	Office closed plan Net Zero	Office Open plan Net Zero	Difference of Closed to Open Code	Difference of Closed to Open Net Zero	
	DIVISION / WORK ITEM	TOTAL	TOTAL	TOTAL	TOTAL			
1000	GENERAL CONDITIONS	0	0	0	0	0	0	
2000	SELECTIVE DEMO/PROTECTION	0	0	0	0	0	0	
2000	SITEWORK	83687.5	83687.5	83687.5	83687.5	0	0	
3000	CONCRETE	94500	94500	94500	94500	0	0	
4000	MASONRY	0	0	0	0	0	0	
5000	STEEL	195500	195500	195500	195500	0	0	
6000	ROUGH CARPENTRY	2670	2670	2670	2670	0	0	
6200	FINISH CARPENTRY	5875	5875	5875	5875	0	0	
7000	THERMAL & MOISTURE PROTECTION	542292.5	538992.5	684902.75	681602.75	3300	3300	Additional sound insulation
8000	DOORS AND WINDOWS	175422	141202	205332	171112	34220	34220	Additional interior doors
9000	FINISHES	388540	172600	388540	172600	215940	215940	Interior finishes
10000	SPECIALTIES	2780	2780	2780	2780	0	0	
11000	EQUIPMENT	0	0	0	0	0	0	
12000	FURNISHINGS	0	0	0	0	0	0	
13000	SPRINKLER	31510	26300	31510	26300	5210	5210	
14000	CONVEYING SYSTEMS	0	0	0	0	0	0	
15000	MECHANICAL	192000	185000	126000	116000	7000	10000	
16000	ELECTRICAL	134493.56	126816.56	146734.04	139057.04	7677	7677	
	HORIZ. TOTALS	1714777	1449107	1821297.25	1552627.3	265670	268670	
	Overhead and Fee - 7%	120034.39	101437.49	127490.8075	108683.91	18596.9	18806.9	
	General Conditions 10 %	183481.139	155054.45	194878.8058	166131.12	28426.69	28747.69	
	BOND -				0	0	0	
	BASE ESTIMATE - CONSTRUCTION COSTS	2018292.529	1705598.9	2143666.863	1827442.3	312693.59	316224.59	

The lighting analysis was adjusted to incorporate Fluorescent fixtures for the code building and LED fixtures for the net zero ready building. The differences in the Lighting budget are shown in orange. The differences are highlighted in yellow that are reflected in the Commercial Capital Cost analysis.

Revised Lighting Capital costs

	Open Office Code	Open Office NZ	Closed Office Code	Closed Office NZ	Manufacturing Code	Manufacturing NZ	NOTES
A. Original Lighting Budget	$ 47,250	$ 47,250	$ 50,200	$ 50,200	$ 67,750	$ 67,750	
A1. Added hallway lighting	$ 3,327	$ 1,372	$ 3,327	$ 1,372	$ 3,025	$ 1,248	*double hallway lighting to reach watt/sf required *added 6% to original lighting budget for installation of double the number of hallway lights to reach the target W/sf
A1.1 Added hallway lighting installation	$ 2,835	$ 2,835	$ 3,012	$ 3,012	$ 4,065	$ 4,065	
A2. Credit for Fluorescent lights	$ (7,211)		$ (7,211)		$ (12,515)		
A3. Addition for higher output LEDs		$ 8,150		$ 8,150		$ 14,784	
A. Revised Lighting Budget	$ 46,202	$ 59,607	$ 49,329	$ 62,734	$ 62,325	$ 87,846	
Difference of NZR v. Code		**$ 13,405**		**$ 13,405**		**$ 25,522**	
B. Distribution	$ 14,050	$ 14,050	$ 14,050	$ 14,050	$ 21,300	$ 21,300	
C. Branch Wiring	$ 12,000	$ 12,000	$ 14,400	$ 14,400	$ 18,400	$ 18,400	
D. Mechanical	$ 6,265	$ 5,100	$ 6,265	$ 5,100	$ 10,600	$ 8,600	
E. Fire Alarm	$ 23,500	$ 23,500	$ 23,500	$ 23,500	$ 35,000	$ 35,000	
F. Data	$ 18,500	$ 18,500	$ 19,100	$ 19,100	$ 40,400	$ 40,400	
G. Electrical Permit	$ 800	$ 800	$ 850	$ 850	$ 1,200	$ 1,200	
H. Fire alarm permit	$ 500	$ 500	$ 500	$ 500	$ 1,000	$ 1,000	
I. Lighting Controls	$ 5,000	$ 5,000	$ 6,500	$ 6,500	$ 7,200	$ 7,200	
Total	**$ 126,817**	**$ 139,057**	**$ 134,494**	**$ 146,734**	**$ 197,425**	**$ 220,946**	
Difference of NZ above Code costs		$ 12,240		$ 12,240		$ 23,522	

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: **11.25.14**
GC **J.A. Morrissey, Inc.** **OWNER:**
Ph. : (802) 863-1717

Office plan **Closed** **Code Compliant**

DIVISION: 01000 GENERAL CONDITIONS

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SELECTIVE DEMO/PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SITE WORK

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	14,700	sf							$4,000	$4,000
	Excavate for footings 330 ln ft	310	yds	28	40	$1,120	$15.00	$250		$4,650	$6,020
	backfil	100	yds	24	40	$960	$25.00	$2,500		$5,000	$8,460
	grading and compaction	260	yds	64	40	$2,560	$25.00	$6,500		$10,000	$19,060
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$4,000	$4,000
	Interior for plumbing									$2,500	$2,500
	site control									$4,000	$4,000
	SUBTOTAL					$4,640		$9,250	$0	$69,150	$83,040
	LABOR, TAXES, INSURANCE							$648	$0	$0	$648
	TOTAL					$4,640		$9,898	$0	$69,150	$83,688

DIVISION: 03000 CONCRETE

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	30	yds				$350.00			$10,500	$10,500
										$0	$0
	walls	70	yds				$350.00			$24,500	$24,500
										$0	$0
	slab	85	yds				$300.00			$25,500	$25,500
										$0	$0
	elevated slab	85	yds				$400.00			$34,000	$34,000
		0	ea	0	40	$0	$0.00	$0		$0	$0
			sf			$0	$1.00	$0		$0	$0
	SUBTOTAL					$0		$0	$0	$94,500	$94,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$94,500	$94,500

DIVISION: 04000 MASONRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 05000 STEEL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	24					$500.00	$0		$12,000	$12,000
	Bar joists for 2nd floor	6500	sf				$5.00	$0		$32,500	$32,500
	roof joist	6500	sf				$6.00	$0		$39,000	$39,000
	metal deck second floor	6500	sf				$3.00	$0		$19,500	$19,500
	roof decking	6,500	sf				$4.00	$0		$26,000	$26,000

	sets of stairs	2					$5,000.00	$0		$10,000	$10,000
	Structral steel	7500	lf				$7.00	$0		$52,500	$52,500
						$0		$0		$0	$0
	Metal hand rails	80	lf	0	40	$0	$50.00	$0		$4,000	$4,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$195,500	$195,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$195,500	$195,500

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	slab insulation	0	sf	0	40	$0		$0			$0
	concrete wall insulation R 10	1650	sf			$0	$2.25	$0		$3,713	$3,713
	vapor barrier for slab	6500	sf		40	$0	$2.25	$0		$14,625	$14,625
	wall vapor barrier	1650	sf			$0	$4.00	$0		$6,600	$6,600
	sound insulation	12000	sf			$0	$0.30	$0		$3,600	$3,600
						$0		$0		$0	$0
	Roofing R 34	6500	sf			$0	$6.27	$0		$40,755	$40,755
						$0		$0		$0	$0
	Metal wall panels R 21	8000	sf	0	40	$0	$50.00	$400,000		$45,000	$445,000
						$0		$0		$0	$0
					40	$0		$0			$0
	SUBTOTAL					$0		$400,000	$0	$114,293	$514,293
	LABOR, TAXES, INSURANCE							$28,000	$0	$0	$28,000
	TOTAL					$0		$428,000	$0	$114,293	$542,293

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0		$0	$0
	Main entrance	1	ea	8	40	$320	$3,000.00	$3,000			$3,320
	exterior doors	2	ea	16	40	$640	$2,000.00	$4,000			$4,640
	interior doors	50	ea	200	40	$8,000	$650.00	$32,500			$40,500
						$0		$0			$0
	Windows Marvin	54	ea	162	40	$6,480	$400.00	$21,600			$28,080
		90	ea	270	40	$10,800	$600.00	$54,000			$64,800
		0	ea	0	40	$0	$0.00	$0			$0
	Interior finish of windows and doors	150	ea	450	40	$18,000	$50.00	$7,500			$25,500
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$44,240		$122,600	$0	$0	$166,840
	LABOR, TAXES, INSURANCE					$0		$8,582	$0	$0	$8,582
	TOTAL					$44,240		$131,182	$0	$0	$175,422

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	45840	sf			$0	$6.00	$0		$275,040	$275,040
						$0		$0			$0
	Ceilings	15000	sf			$0	$3.50	$0		$52,500	$52,500
						$0		$0			$0
	Flooring	14000	sf			$0	$4.00	$0		$56,000	$56,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$388,540	$388,540
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$388,540	$388,540

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
		0	sf	0	40	$0		$0		$31,510	$31,510
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$31,510	$31,510
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$31,510	$31,510

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$192,000	$192,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$192,000	$192,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$192,000	$192,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
	See electrical cost analysis					$0		$0			$134,494
						$0		$0			
						$0		$0			
						$0		$0			
						$0		$0			
	SUBTOTAL					$0		$0	$0	$0	$134,494
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$134,494

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: **11.25.14**
GC **J.A. Morrissey, Inc.** **OWNER:**
Ph. : (802) 863-1717

Office plan **Closed** **Net Zero**

DIVISION: 01000 GENERAL CONDITIONS

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SELECTIVE DEMO/PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SITE WORK

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	14,700	sf							$4,000	$4,000
	Excavate for footings 330 ln ft	310	yds	28	40	$1,120	$15.00	$250		$4,650	$6,020
	backfil	100	yds	24	40	$960	$25.00	$2,500		$5,000	$8,460
	grading and compaction	260	yds	64	40	$2,560	$25.00	$6,500		$10,000	$19,060
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$4,000	$4,000
	Interior for plumbing									$2,500	$2,500
	site control									$4,000	$4,000
	SUBTOTAL					$4,640		$9,250	$0	$69,150	$83,040
	LABOR, TAXES, INSURANCE							$648	$0	$0	$648
	TOTAL					$4,640		$9,898	$0	$69,150	$83,688

DIVISION: 03000 CONCRETE

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	30	yds				$350.00			$10,500	$10,500
										$0	$0
	walls	70	yds				$350.00			$24,500	$24,500
										$0	$0
	slab	85	yds				$300.00			$25,500	$25,500
										$0	$0
	elevated slab	85	yds				$400.00			$34,000	$34,000
		0	ea	0	40	$0	$0.00	$0		$0	$0
			sf			$0	$1.00	$0		$0	$0
	SUBTOTAL					$0		$0	$0	$94,500	$94,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$94,500	$94,500

DIVISION: 04000 MASONRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 05000 STEEL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	24					$500.00	$0		$12,000	$12,000
	Bar joists for 2nd floor	6500	sf				$5.00	$0		$32,500	$32,500
	roof joist	6500	sf				$6.00	$0		$39,000	$39,000
	metal deck second floor	6500	sf				$3.00	$0		$19,500	$19,500
	roof decking	6,500	sf				$4.00	$0		$26,000	$26,000

	sets of stairs	2					$5,000.00	$0		$10,000	$10,000
	Structral steel	7500	lf				$7.00	$0		$52,500	$52,500
						$0		$0		$0	$0
	Metal hand rails	80	lf	0	40	$0	$50.00	$0		$4,000	$4,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$195,500	$195,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$195,500	$195,500

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	Slab insulation R 20	6500	sf	0	40	$0	$3.85	$0		$25,025	$25,025
	concrete wall insulation R20	1650	sf			$0	$3.85	$0		$6,353	$6,353
	vapor barrier for slab	6500	sf		40	$0	$2.25	$0		$14,625	$14,625
	wall vapor barrier	1650	sf			$0	$4.00	$0		$6,600	$6,600
	sound insulation	12000	sf			$0	$0.30	$0		$3,600	$3,600
						$0		$0		$0	$0
	Roofing R 60	6500	sf			$0	$9.18	$0		$59,670	$59,670
						$0		$0		$0	$0
	Metal wall panels R 35.7	8000	sf	0	40	$0	$60.00	$480,000		$50,000	$530,000
						$0		$0		$0	$0
	Air Barrier ($0.35/sf based on the incremental cost of better installation of metal panels, 1/2 the cost of the fluid applied membrane)	14500	sf		40	$0	$0.35	$5,075			$5,075
	SUBTOTAL					$0		$485,075	$0	$165,873	$650,948
	LABOR, TAXES, INSURANCE							$33,955	$0	$0	$33,955
	TOTAL					$0		$519,030	$0	$165,873	$684,903

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0		$0	$0
	Main entrance	1	ea	8	40	$320	$3,500.00	$3,500			$3,820
	exterior doors	2	ea	16	40	$640	$2,000.00	$5,000			$5,640
	interior doors	50	ea	200	40	$8,000	$650.00	$32,500			$40,500
						$0		$0			$0
	Windows Marvin	146	ea	438	$40	$17,520	$480.00	$70,080			$87,600
		22	ea	66	$40	$2,640	$720.00	$15,840			$18,480
		8	ea	24	$40	$960	$960.00	$7,680			$8,640
	Interior finish of windows and doors	180	ea	540	40	$21,600	$50.00	$9,000			$30,600
						$0		$0			$0
	SUBTOTAL					$51,680		$143,600	$0	$0	$195,280
	LABOR, TAXES, INSURANCE					$0		$10,052	$0	$0	$10,052
	TOTAL					$51,680		$153,652	$0	$0	$205,332

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	45840	sf			$0	$6.00	$0		$275,040	$275,040
						$0		$0			$0
	Ceilings	15000	sf			$0	$3.50	$0		$52,500	$52,500
						$0		$0			$0
	Flooring	14000	sf			$0	$4.00	$0		$56,000	$56,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$388,540	$388,540
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$388,540	$388,540

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
		0	sf	0	40	$0		$0		$31,510	$31,510
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$31,510	$31,510
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$31,510	$31,510

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$126,000	$126,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$126,000	$126,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$126,000	$126,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			
						$0		$0			$146,734
	See electrical cost analysis					$0		$0			
						$0		$0			
						$0		$0			
						$0		$0			
	SUBTOTAL					$0		$0	$0	$0	$146,734
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$146,734

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: **11.25.14**
GC **J.A. Morrissey, Inc.** **OWNER:**
Ph. : (802) 863-1717

Office Plan **Open** **Code Compliant**

DIVISION: **01000 GENERAL CONDITIONS**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: **02000 SELECTIVE DEMO/PROTECTION**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: **02000 SITE WORK**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	14,700	sf							$4,000	$4,000
	Excavate for footings 330 ln ft	310	yds	28	40	$1,120	$15.00	$250		$4,650	$6,020
	backfil	100	yds	24	40	$960	$25.00	$2,500		$5,000	$8,460
	grading and compaction	260	yds	64	40	$2,560	$25.00	$6,500		$10,000	$19,060
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$4,000	$4,000
	Interior for plumbing									$2,500	$2,500
	site control									$4,000	$4,000
	SUBTOTAL					$4,640		$9,250	$0	$69,150	$83,040
	LABOR, TAXES, INSURANCE							$648	$0	$0	$648
	TOTAL					$4,640		$9,898	$0	$69,150	$83,688

DIVISION: **03000 CONCRETE**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	30	yds				$350.00			$10,500	$10,500
										$0	$0
	walls	70	yds				$350.00			$24,500	$24,500
										$0	$0
	slab	85	yds				$300.00			$25,500	$25,500
										$0	$0
	elevated slab	85	yds				$400.00			$34,000	$34,000
		0	ea	0	40	$0	$0.00	$0		$0	$0
			sf			$0	$1.00	$0		$0	$0
	SUBTOTAL					$0		$0	$0	$94,500	$94,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$94,500	$94,500

DIVISION: **04000 MASONRY**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: **05000 STEEL**

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	24					$500.00	$0		$12,000	$12,000
	Bar joists for 2nd floor	6500	sf				$5.00	$0		$32,500	$32,500
	roof joist	6500	sf				$6.00	$0		$39,000	$39,000
	metal deck second floor	6500	sf				$3.00	$0		$19,500	$19,500
	roof decking	6,500	sf				$4.00	$0		$26,000	$26,000

	sets of stairs	2					$5,000.00	$0		$10,000	$10,000
	Structral steel	7500	lf				$7.00	$0		$52,500	$52,500
						$0		$0		$0	$0
	Metal hand rails	80	lf	0	40	$0	$50.00	$0		$4,000	$4,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$195,500	$195,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$195,500	$195,500

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	slab insulation	6500	sf	0	40	$0	$0.00	$0		$0	$0
	concrete wall insulation R 10	1650	sf			$0	$2.25	$0		$3,713	$3,713
	vapor barrier for slab	6500	sf		40	$0	$2.25	$0		$14,625	$14,625
	wall vapor barrier	1650	sf			$0	$4.00	$0		$6,600	$6,600
	sound insulation	1000	sf			$0	$0.30	$0		$300	$300
						$0		$0		$0	$0
	Roofing R 34	6500	sf			$0	$6.27	$0		$40,755	$40,755
						$0		$0		$0	$0
	Metal wall panels R 21	8000	sf	0	40	$0	$50.00	$400,000		$45,000	$445,000
						$0		$0		$0	$0
					40	$0		$0			$0
	SUBTOTAL					$0		$400,000	$0	$110,993	$510,993
	LABOR, TAXES, INSURANCE							$28,000	$0	$0	$28,000
	TOTAL					$0		$428,000	$0	$110,993	$538,993

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0		$0	$0
	Main entrance	1	ea	8	40	$320	$3,000.00	$3,000			$3,320
	exterior doors	2	ea	16	40	$640	$2,500.00	$4,000			$4,640
	interior doors	10	ea	40	40	$1,600	$650.00	$6,500			$8,100
						$0		$0			$0
	Windows Marvin	54	ea	162	40	$6,480	$400.00	$21,600			$28,080
		90	ea	270	40	$10,800	$600.00	$54,000			$64,800
		0	ea	0	40	$0	$0.00	$0			$0
	Interior finish of windows and doors	150	ea	450	40	$18,000	$50.00	$7,500			$25,500
						$0		$0			$0
	SUBTOTAL					$37,840		$96,600	$0	$0	$134,440
	LABOR, TAXES, INSURANCE					$0		$6,762	$0	$0	$6,762
	TOTAL					$37,840		$103,362	$0	$0	$141,202

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	9850	sf			$0	$6.00	$0		$59,100	$59,100
						$0		$0			$0
	Ceilings	15000	sf			$0	$3.50	$0		$52,500	$52,500
						$0		$0			$0
	Flooring	14000	sf			$0	$4.00	$0		$56,000	$56,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$172,600	$172,600
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$172,600	$172,600

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
		0	sf	0	40	$0		$0		$26,300	$26,300
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$26,300	$26,300
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$26,300	$26,300

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$185,000	$185,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$185,000	$185,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$185,000	$185,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
	See electrical cost comparison					$0		$0			$126,817
						$0		$0			
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$126,817
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$126,817

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: **11.21.14**
GC **J.A. Morrissey, Inc.** **OWNER:**
Ph. : (802) 863-1717

Office Plan **Open** **Net Zero**

DIVISION: 01000 GENERAL CONDITIONS

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SELECTIVE DEMO/PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SITE WORK

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	14,700	sf							$4,000	$4,000
	Excavate for footings 330 ln ft	310	yds	28	40	$1,120	$15.00	$250		$4,650	$6,020
	backfil	100	yds	24	40	$960	$25.00	$2,500		$5,000	$8,460
	grading and compaction	260	yds	64	40	$2,560	$25.00	$6,500		$10,000	$19,060
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$4,000	$4,000
	Interior for plumbing									$2,500	$2,500
	site control									$4,000	$4,000
	SUBTOTAL					$4,640		$9,250	$0	$69,150	$83,040
	LABOR, TAXES, INSURANCE							$648	$0	$0	$648
	TOTAL					$4,640		$9,898	$0	$69,150	$83,688

DIVISION: 03000 CONCRETE

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	30	yds				$350.00			$10,500	$10,500
										$0	$0
	walls	70	yds				$350.00			$24,500	$24,500
										$0	$0
	slab	85	yds				$300.00			$25,500	$25,500
										$0	$0
	elevated slab	85	yds				$400.00			$34,000	$34,000
		0	ea	0	40	$0	$0.00	$0		$0	$0
			sf			$0	$1.00	$0		$0	$0
	SUBTOTAL					$0		$0	$0	$94,500	$94,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$94,500	$94,500

DIVISION: 04000 MASONRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 05000 STEEL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	24					$500.00	$0		$12,000	$12,000
	Bar joists for 2nd floor	6500	sf				$5.00	$0		$32,500	$32,500
	roof joist	6500	sf				$6.00	$0		$39,000	$39,000
	metal deck second floor	6500	sf				$3.00	$0		$19,500	$19,500
	roof decking	6,500	sf				$4.00	$0		$26,000	$26,000

	sets of stairs	2					$5,000.00	$0		$10,000	$10,000
	Structral steel	7500	lf				$7.00	$0		$52,500	$52,500
						$0		$0		$0	$0
	Metal hand rails	80	lf	0	40	$0	$50.00	$0		$4,000	$4,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$195,500	$195,500
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$195,500	$195,500

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	slab insulation R 20	6500	sf	0	40	$0	$3.85	$0		$25,025	$25,025
	concrete wall insulation R 20	1650	sf			$0	$3.85	$0		$6,353	$6,353
	vapor barrier for slab	6500	sf		40	$0	$2.25	$0		$14,625	$14,625
	wall vapor barrier	1650	sf			$0	$4.00	$0		$6,600	$6,600
	sound insulation	1000	sf			$0	$0.30	$0		$300	$300
						$0		$0		$0	$0
	Roofing R 60	6500	sf			$0	$9.18	$0		$59,670	$59,670
						$0		$0		$0	$0
	Metal wall panels R 35.7	8000	sf	0	40	$0	$60.00	$480,000		$50,000	$530,000
						$0		$0		$0	$0
	Air Barrier ($0.71/sf based on Maclay work of incremental cost for fluid applied air and vapor me	14500	sf		40	$0	$0.35	$5,075			$5,075
	SUBTOTAL					$0		$485,075	$0	$162,573	$647,648
	LABOR, TAXES, INSURANCE							$33,955	$0	$0	$33,955
	TOTAL					$0		$519,030	$0	$162,573	$681,603

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0		$0	$0
	Main entrance	1	ea	8	40	$320	$3,500.00	$3,500			$3,820
	exterior doors	2	ea	16	40	$640	$2,500.00	$5,000			$5,640
	interior doors	10	ea	40	40	$1,600	$650.00	$6,500			$8,100
						$0		$0			$0
	Windows Marvin	146	ea	438	40	$17,520	$480.00	$70,080			$87,600
		22	ea	66	40	$2,640	$720.00	$15,840			$18,480
		8	ea	24	40	$960	$960.00	$7,680			$8,640
	Interior finish of windows and doors	180	ea	540	40	$21,600	$50.00	$9,000			$30,600
						$0		$0			$0
	SUBTOTAL					$45,280		$117,600	$0	$0	$162,880
	LABOR, TAXES, INSURANCE					$0		$8,232	$0	$0	$8,232
	TOTAL					$45,280		$125,832	$0	$0	$171,112

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	9850	sf			$0	$6.00	$0		$59,100	$59,100
						$0		$0			$0
	Ceilings	15000	sf			$0	$3.50	$0		$52,500	$52,500
						$0		$0			$0
	Flooring	14000	sf			$0	$4.00	$0		$56,000	$56,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$172,600	$172,600
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$172,600	$172,600

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
		0	sf	0	40	$0		$0		$26,300	$26,300
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$26,300	$26,300
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$26,300	$26,300

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$116,000	$116,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$116,000	$116,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$116,000	$116,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
	See electrical cost analysis					$0		$0			$139,057
						$0		$0			
						$0		$0			
						$0		$0			
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$139,057
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$139,057

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: 11.25.14
GC J.A. Morrissey, Inc. **OWNER:**
Ph. : (802) 863-1717

Office Manufacturing

DIVISION: 01000 GENERAL CONDITIONS

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SELECTIVE DEMO/PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SITE WORK

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	36,000	sf							$8,000	$8,000
	Excavate for footings 820 ln ft	760	yds	40	40	$1,600	$15.00	$250		$10,000	$11,850
	backfil	100	yds	32	40	$1,280	$25.00	$2,500		$10,000	$13,780
	grading and compaction	850	yds	80	40	$3,200	$25.00	$21,250		$20,000	$44,450
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$5,000	$5,000
	Interior for plumbing									$2,500	$2,500
	site control									$5,000	$5,000
	SUBTOTAL					$6,080		$24,000	$0	$95,500	$125,580
	LABOR, TAXES, INSURANCE							$1,680	$0	$0	$1,680
	TOTAL					$6,080		$25,680	$0	$95,500	$127,260

DIVISION: 03000 CONCRETE

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	95	yds				$350.00			$33,250	$33,250
										$0	$0
	walls	155	yds				$350.00			$54,250	$54,250
										$0	$0
	slab	420	yds				$300.00			$126,000	$126,000
										$0	$0
	elevated slab	32	yds				$400.00			$12,800	$12,800
		0	ea	0	40	$0	$0.00	$0		$0	$0
	Concrete seal	22000	sf			$0	$1.00	$0		$22,000	$22,000
	SUBTOTAL					$0		$0	$0	$248,300	$248,300
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$248,300	$248,300

DIVISION: 04000 MASONRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 05000 STEEL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	50					$500.00	$0		$25,000	$25,000
	Bar joists for 2nd floor	5000	sf				$5.00	$0		$25,000	$25,000
	roof joist	22000	sf				$6.00	$0		$132,000	$132,000
	metal deck second floor	5000	sf				$3.00	$0		$15,000	$15,000
	roof decking	22,000	sf				$4.00	$0		$88,000	$88,000

	sets of stairs	3					$5,000.00	$0		$15,000	$15,000
	Structral steel	16000	lf				$7.00	$0		$112,000	$112,000
						$0		$0		$0	$0
	Metal hand rails	120	lf	0	40	$0	$50.00	$0		$6,000	$6,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$418,000	$418,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$418,000	$418,000

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	slab insulation	22000	sf	0	40	$0		$0			$0
	concrete wall insulation	2500	sf			$0	$2.25	$0		$5,625	$5,625
	vapor barrier for slab	22000	sf		40	$0	$2.25	$0		$49,500	$49,500
	wall vapor barrier	2500	sf			$0	$4.00	$0		$10,000	$10,000
	sound insulation	10000	sf			$0	$0.30	$0		$3,000	$3,000
						$0		$0		$0	$0
	Roofing R 34	22000	sf			$0	$6.27	$0		$137,940	$137,940
						$0		$0		$0	$0
	Metal wall panels	14880	sf	0	40	$0	$50.00	$744,000		$65,000	$809,000
						$0		$0		$0	$0
					40	$0		$0			$0
	SUBTOTAL					$0		$744,000	$0	$271,065	$1,015,065
	LABOR, TAXES, INSURANCE							$52,080	$0	$0	$52,080
	TOTAL					$0		$796,080	$0	$271,065	$1,067,145

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	OH doors	1	ea		40	$0	$5,000.00	$0		$5,000	$5,000
						$0		$0			$0
	exterior doors	4	ea	24	40	$960	$2,500.00	$10,000			$10,960
	interior doors	20	ea	80	40	$3,200	$750.00	$15,000			$18,200
						$0		$0			$0
	Windows	54	ea	563.2	40	$22,528	$400.00	$21,600			$44,128
		90	ea	76.8	40	$3,072	$600.00	$54,000			$57,072
		0	ea	19.2	0	$0	$800.00	$0			$0
	Interior finish of windows and doors	261	ea	500	40	$20,000	$30.00	$7,830			$27,830
						$0		$0			$0
	Skylights 1.5 % of area	255	sf	20	40	$800	$100.00	$25,500			$26,300
	Roofing curbs	16	ea	32	40	$1,280	$100.00	$1,600			$2,880
	Additional roofing	16	ea			$0	$350	$0		$5,600	$5,600
	SUBTOTAL					$51,840		$135,530	$0	$10,600	$197,970
	LABOR, TAXES, INSURANCE					$0		$9,487	$0	$0	$9,487
	TOTAL					$51,840		$145,017	$0	$10,600	$207,457

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	15800	sf			$0	$6.00	$0		$94,800	$94,800
						$0		$0			$0
	Ceilings	10000	sf			$0	$3.50	$0		$35,000	$35,000
						$0		$0			$0
	Flooring	10000	sf			$0	$4.00	$0		$40,000	$40,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$174,800	$174,800
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$174,800	$174,800

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
		0	sf	0	40	$0		$0		$45,275	$45,275
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$45,275	$45,275
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$45,275	$45,275

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$123,000	$123,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$123,000	$123,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$123,000	$123,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
	See electrical cost analysis					$0		$0			$197,425
						$0		$0			
						$0		$0			
						$0		$0			
						$0		$0			
	SUBTOTAL					$0		$0	$0	$0	$197,425
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$197,425

PROJECT ESTIMATE **PROJECT: Net Zero**
DATE: **11.25.14**
GC **J.A. Morrissey, Inc.** **OWNER:**
Ph. : (802) 863-1717

Office Manufacturing **Net Zero Building**

DIVISION: 01000 GENERAL CONDITIONS

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	PERMITS & FEES :										
	TOWN BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STATE BUILDING PERMIT	0	ls	0	60	$0	$8.50	$0			$0
	STREET PERMIT										$0
	EXCAVATION PERMIT FEES										$0
	ZONING PERMIT										$0
	SEWER/WATER HOOK-UP/IMPACT FEES										$0
	BUILDERS RISK INSURANCE										$0
	ADDITIONAL INSURANCE										$0
	SITE SURVEY - LAYOUT										$0
	TESTING- Compaction, Concrete, Thermal, Waterproofing										$0
	RECYCLE PLAN DOCUMENTATION										$0
											$0
	CONTRACTOR'S GENERAL CONDITIONS										$0
	SUPERINTENDENT	0	mo	0	60	$0					$0
	PROJECT MANAGER/ESTIMATING	0	mo	0	65	$0					$0
	FOREMAN										$0
	VEHICLE EXPENSE	0	mo				$750.00	$0	$0		$0
	OFFICE/STORAGE TRAILER (one)	0	mo				$250.00		$0		$0
Owner	TEMPORARY ELECTRICITY/WATER										$0
	DRINKING WATER	0	mo				$50.00	$0			$0
	TELEPHONE/INTERNET	0	mo				$100.00	$0			$0
	TOILETS	0	mo				$110.00	$0			$0
	PERSONAL PROTECTION	0	ls				$350.00	$0			$0
	TEMPORARY HEAT/PROTECTION & NEGATIVE AIR	0	ls				$510.00		$0		$0
	BARRICADES/FENCING/TRAFFIC CTR.	0	mo								$0
	TOOLS	0	ea				$500.00	$0			$0
	EQUIPMENT RENTAL	0	ls								$0
	STAGING/TEMPORARY STRUCTURES	0	mo				$500.00	$0			$0
	RUBBISH REMOVAL/CLEAN-UP	0	ls	0	38	$0		$0			$0
	DUMPSTERS	0	ea				$750.00	$0			$0
	FINAL CLEANING	0	sf	0	40	$0	$0.50	$0		$0	$0
	PUNCH LIST	0	ls	0	40	$0	$0.00	$0			$0
	AUTOCAD AS-BUILT DRAWINGS										$0
	MEETING MINUTES										$0
	SPECIAL WARRANTIES or EXTRA MATERIAL										$0
	EXTRA BLUEPRINTS	1	ls							$0	$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SELECTIVE DEMO/PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
	NIC				40	$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 02000 SITE WORK

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Strip site	36,000	sf							$8,000	$8,000
	Excavate for footings 820 ln ft	250	yds	40	40	$1,600	$15.00	$250		$10,000	$11,850
	backfil	100	yds	32	40	$1,280	$25.00	$2,500		$10,000	$13,780
	grading and compaction	850	yds	80	40	$3,200	$25.00	$21,250		$20,000	$44,450
	waterline	1	ls							$20,000	$20,000
	electric line	1	ls							$5,000	$5,000
	sewer line	1	ls							$10,000	$10,000
NIC	parking	1	ls	0	40	$0		$0		$0	$0
NIC	paving.					$0		$0			$0
											$0
	Final grading	1	ls							$5,000	$5,000
	Interior for plumbing									$2,500	$2,500
	site control									$5,000	$5,000
	SUBTOTAL					$6,080		$24,000	$0	$95,500	$125,580
	LABOR, TAXES, INSURANCE							$1,680	$0	$0	$1,680
	TOTAL					$6,080		$25,680	$0	$95,500	$127,260

DIVISION: 03000 CONCRETE

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	footings	95	yds				$350.00			$33,250	$33,250
										$0	$0
	walls	155	yds				$350.00			$54,250	$54,250
										$0	$0
	slab	420	yds				$300.00			$126,000	$126,000
										$0	$0
	elevated slab	32	yds				$400.00			$12,800	$12,800
		0	ea	0	40	$0	$0.00	$0		$0	$0
	concrete sealer	22000	sf			$0	$1.00	$0		$22,000	$22,000
	SUBTOTAL					$0		$0	$0	$248,300	$248,300
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$248,300	$248,300

DIVISION: 04000 MASONRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	NIC			0	40	$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 05000 STEEL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Steel columns	50					$500.00	$0		$25,000	$25,000
	Bar joists for 2nd floor	5000	sf				$5.00	$0		$25,000	$25,000
	roof joist	22000	sf				$6.00	$0		$132,000	$132,000
	metal deck second floor	5000	sf				$3.00	$0		$15,000	$15,000
	roof decking	22,000	sf				$4.00	$0		$88,000	$88,000

	sets of stairs	3					$5,000.00	$0		$15,000	$15,000
	Structral steel	16000	lf				$7.00	$0		$112,000	$112,000
						$0		$0		$0	$0
	Metal hand rails	120	lf	0	40	$0	$50.00	$0		$6,000	$6,000
						$0		$0		$0	$0
	SUBTOTAL					$0		$0	$0	$418,000	$418,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$418,000	$418,000

DIVISION: 06000 ROUGH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
					40	$0		$0			$0
					40	$0		$0			$0
					40	$0		$0	$0		$0
	Misc	1	ls	40	40	$1,600		$1,000			$2,600
					40	$0		$0			$0
	SUBTOTAL					$1,600		$1,000	$0	$0	$2,600
	LABOR, TAXES, INSURANCE					$0		$70	$0	$0	$70
	TOTAL					$1,600		$1,070	$0	$0	$2,670

DIVISION: 06200 FINISH CARPENTRY

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
					40	$0		$0	$0		$0
	Misc.	1	ea	80	40	$3,200		$2,500			$5,700
					40	$0		$0			$0
	SUBTOTAL					$3,200		$2,500	$0	$0	$5,700
	LABOR, TAXES, INSURANCE					$0		$175	$0	$0	$175
	TOTAL					$3,200		$2,675	$0	$0	$5,875

DIVISION: 07000 THERMAL & MOISTURE PROTECTION

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	slab insulation R 20	22000	sf	0	40	$0	$3.85	$0		$84,700	$84,700
	concrete wall insulation R 20	2500	sf			$0	$3.85	$0		$9,625	$9,625
	vapor barrier for slab	22000	sf		40	$0	$2.25	$0		$49,500	$49,500
	wall vapor barrier	2500	sf			$0	$4.00	$0		$10,000	$10,000
	sound insulation	10000	sf			$0	$0.30	$0		$3,000	$3,000
						$0		$0		$0	$0
	Roofing R 64	22000	sf			$0	$9.18	$0		$201,960	$201,960
						$0		$0		$0	$0
	Metal wall panels R .35.7 5 inch	14880	sf	0	40	$0	$60.00	$892,800		$70,000	$962,800
						$0		$0		$0	$0
	Air Sealing all above grade surface area	36880	sf			$0	$0.71	$26,185		$26,185	$52,370
	SUBTOTAL					$0		$918,985	$0	$454,970	$1,373,955
	LABOR, TAXES, INSURANCE							$64,329	$0	$0	$64,329
	TOTAL					$0		$983,314	$0	$454,970	$1,438,284

DIVISION: 08000 Doors and Windows

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	OH doors	1	ea		40	$0	$5,000.00	$0		$5,000	$5,000
						$0		$0			$0
	exterior doors	4	ea	24	40	$960	$3,000.00	$12,000			$12,960
	interior doors	20	ea	80	40	$3,200	$750.00	$15,000			$18,200
						$0		$0			$0
	Windows	140	ea	563.2	40	$22,528	$480.00	$67,200			$89,728
		20	ea	76.8	40	$3,072	$720.00	$14,400			$17,472
		4	ea	19.2	40	$768	$960.00	$3,840			$4,608
	Interior finish of windows and doors	261	ea	500	40	$20,000	$30.00	$7,830			$27,830
						$0		$0			$0
	Skylights 3 % of area	510	sf	40	40	$1,600	$100.00	$51,000			$52,600
	Roofing curbs	32	ea	64	40	$2,560	$100.00	$3,200			$5,760
	Additional roofing	32	ea			$0	$350	$0		$11,200	$11,200
	SUBTOTAL					$54,688		$174,470	$0	$16,200	$245,358
	LABOR, TAXES, INSURANCE					$0		$12,213	$0	$0	$12,213
	TOTAL					$54,688		$186,683	$0	$16,200	$257,571

DIVISION: 09000 Finishes

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Metal framing , sheet rock, tape and paint	15800	sf			$0	$6.00	$0		$94,800	$94,800
						$0		$0			$0
	Ceilings	10000	sf			$0	$3.50	$0		$35,000	$35,000
						$0		$0			$0
	Flooring	10000	sf			$0	$4.00	$0		$40,000	$40,000
						$0		$0			$0
	Misc painting					$0		$0		$5,000	$5,000
	SUBTOTAL					$0		$0	$0	$174,800	$174,800
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$174,800	$174,800

DIVISION: 10000 Specialties

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	bath specialties	4	ea	16	40	$640	$500.00	$2,000			$2,640
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$640		$2,000	$0	$0	$2,640
	LABOR, TAXES, INSURANCE					$0		$140	$0	$0	$140
	TOTAL					$640		$2,140	$0	$0	$2,780

DIVISION: 11000 Equipment

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
	NIC			0	40	$0		$0			$0
											$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 12000 Furnishings

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
											$0
	NIC	1	ls	0	40	$0		$0			$0
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 13000 Sprinkler

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
	Sprinkler	27000	sf	0	40	$0		$0		$45,275	$45,275
						$0		$0			$0
						$0		$0			$0
						$0		$0			$0
	SUBTOTAL					$0		$0	$0	$45,275	$45,275
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$45,275	$45,275

DIVISION: 14000 Conveying Systems

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0					$0
		0	ea	0	40	$0		$0		$0	$0
						$0					
	SUBTOTAL					$0		$0	$0	$0	$0
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$0

DIVISION: 15000 MECHANICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
			sf			$0		$0			$0
			ea			$0	$0.00	$0		$115,000	$115,000
						$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
			ls			$0		$0			$0
	SUBTOTAL					$0		$0	$0	$115,000	$115,000
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$115,000	$115,000

DIVISION: 16000 ELECTRICAL

	DESCRIPTION	QUANTITY	UNIT	LABOR HOURS	PER HOUR	TOTAL LABOR	UNIT COST	MATERIAL TOTAL	EQUIP. TOTAL	SUB TRADES	TOTAL COST
						$0		$0			$0
						$0		$0			$0
	See Lighting analysis					$0		$0			$220,946
						$0		$0			
						$0		$0			
						$0		$0			
						$0		$0			
	SUBTOTAL					$0		$0	$0	$0	$220,946
	LABOR, TAXES, INSURANCE							$0	$0	$0	$0
	TOTAL					$0		$0	$0	$0	$220,946

4050 Williston Road
So. Burlington, Vt. 05403

Peck Electric Company

December 1, 2014

Subject: NZ FEASIBILITY STUDY

See budgetary scope detail below. All lighting packages have been design to meet net zero wattages per square ft. With current efficiency Vermont rebates a code compliant design offers no savings.

MANUFACTURING NOT ZERO

54,700

1. MANUFACTURING BUILDING

A. Lighting Budget	$67,750.00
B. Distribution	$21,300.00
C. Branch Wiring	$18,400.00
D. Mechanical	$10600.00
E. Fire Alarm	$35,000.00
F. Data	$40400.00
G. Electrical Permit	$1200.00
H. Fire alarm Permit	$1000.00
TOTAL	$195,650.00
Option#1 Lighting Controls. add daylight harvesting controls	$7200.00

8,600

$180,600
+ 9200.00

2. OPEN OFFICE

NET ZERO
41,250

A. Lighting Budget	$47,250.00
B. Distribution	$14,050.00
C. Branch Wiring	$12,000.00
D. Mechanical	$6265.00
E. Fire Alarm	$23,500.00

5100

Peck Electric Company
Telephone: 802-658-3378
Fax: 802-658-3527

F. Data	$18,500.00
G. Electrical Permit	$800.00
H. Fire alarm Permit	$500.00
TOTAL	$122,865.00
Option#1 Lighting Controls. add daylight harvesting controls	$5000.00

115,700
+ 5000

3. CLOSED OFFICE

NET ZERO
44,200

A. Lighting Budget	$50,200.00
B. Distribution	$14,050.00
C. Branch Wiring	$14,400.00
D. Mechanical	$6265.00
E. Fire Alarm	$23,500.00
F. Data	19,100.00
G. Electrical Permit	$850.00
H. Fire alarm Permit	$500.00
TOTAL	$128,865.00
Option#1 Lighting Controls. add daylight harvesting controls	$6500.00

5100

121,700
+ 6500

If you have any questions or would like to modify the scope of work, please give me a call at 658-3378 ext. 232.

Thanks,

Tylor Thibault

Project Manager

By signing below, you accept the conditions and terms listed above.

Customer _____ Date _____

Equipment and materials supplied by the contractor are warranted only to the extent that the same are warranted by the manufacturer. The contractor shall not be held liable for errors or omissions in designs by others, nor inadequacies of materials and equipment specified or supplied by others.

John Atherton

From: Tylor Thibault <Tylor@peckelectric.com>
Sent: Monday, December 01, 2014 4:02 PM
To: John Atherton
Subject: Bid Proposal NZ feasibility Study
Attachments: Bid Proposal NZ feasibility Study.pdf

John,

See budget details below. Give me a call after you review with any question you have

Tylor Thibault
Project Manager
Peck Electric
658-3378 ext 232

1. MANUFACTURING BUILDING

A. Lighting Budget . NEED budget attached

B. Distribution 800 amp service 120/208 volt 3 phase 100 ft. from utility. (1) 400 amp, (2) 200 amp distribution panels

C. Branch Wiring (30) receptacles. Circuits for (66) furniture cubicles

D. Mechanical (2) 80 amp rtus, (4) 30 amp units

E. Fire Alarm Fully automatic addressable system based on a sprinkled building

F. Data (88) 2 cable drops. Rack and demark. (4) wifi

2. OPEN OFFICE

A. Lighting Budget NEED budget attached

B. Distribution 400 amp 3 phase 120/208 volt (2) 200 amp, (1) 100 amp distribution panels

C. Branch Wiring (75) receptacles, Circuits for (50) furniture cubicles

D. Mechanical (2) 30 amp rtus, (2) 60 rtus

E. Fire Alarm Fully automatic addressable system based on a sprinkled building

F. Data (50) 2 wire drops for cubicles, (2) wifi

3. CLOSED OFFICE

A. Lighting Budget NEED budget attached

B. Distribution 400 amp 3 phase 120/208 volt (2) 200 amp, (1) 100 amp distribution panels

C. Branch Wiring 150 receptacles for offices and support spaces

D. Mechanical (2) 30 amp rtus, (2) 60 rtus

E. Fire Alarm Fully automatic addressable system based on a sprinkled building

F. Data (40) 2 wire drops for offices, (2) wifi

ELECTRICAL LIGHTING BUDGETS

NorthEast Electrical DISTRIBUTORS
340 Avenue D, Williston VT 05495
phone: 802-658-1625 Fax: 802-658-5962
e-mail: stephen.beard@needco.com

QUOTED BY: Steve Beard

JOB NAME: NRG NZ Feasibility Study **DATE:** 11/24/2014
LOCATION: Open Office and Closed Office
100' x 65' Building **DUE DATE:** 11/24/2014

ATTN:

ENGINEER:

QTY	TYPE	NO. LAMPS	LAMP TYPE	MFG CODE		UNIT SELL W / LAMP	UNIT EXTENDED
					Open Office and Support Spaces		
96	LED 2x4			**LITH**	**2FSL4-40L-EZ1-LP835**	$ 125.84	$ 12,080.64
4	DH			**LEV**	**PCC1D-00W / PCC2D-OOW / ODC**	$ 610.63	$ 2,442.52
					Circulation		
44	HALL			**LITH**	**FMML-7-840**	$ 31.19	$ 1,372.36
8	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 1,280.00
					Lobby		
2	LED 2x4			**LITH**	**2FSL4-40L-EZ1-LP835**	$ 125.84	$ 251.68
					Stairwells		
6	STAIRWELL			**P2**	**LED stairwell fixture with integral**	$ 500.00	$ 3,000.00
1	TC			**HBA**	**Lighting control panel with photoc**	$ 1,500.00	$ 1,500.00
					Subtotal - Open Office layout:		$ 21,927.20
					Closed Plan and Support Spaces		
96	LED 2x4			**LITH**	**2FSL4-40L-EZ1-LP835**	$ 125.84	$ 12,080.64
38	W-OCC/DAY			**WATT**	**DW-200-W**	$ 101.87	$ 3,871.06
					Circulation		
44	HALL			**LITH**	**FMML-7-840**	$ 31.19	$ 1,372.36
8	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 1,280.00
					Lobby		
2	LED 2x4			**LITH**	**2FSL4-40L-EZ1-LP835**	$ 125.84	$ 251.68
					Stairwells		
6	STAIRWELL			**P2**	**LED stairwell fixture with integral**	$ 500.00	$ 3,000.00
1	TC			**HBA**	**Lighting control panel with photoc**	$ 1,500.00	$ 1,500.00
					Subtotal - Open Office layout:		$ 23,355.74

NorthEast Electrical DISTRIBUTORS
340 Avenue D, Williston VT 05495
phone: 802-658-1625 Fax: 802-658-5962
e-mail: stephen.beard@needco.com

QUOTED BY: Steve Beard

JOB NAME: NRG NZ Feasibility Study **DATE:** 12/12/2014
LOCATION: Open Office and Closed Office
100' x 65' Building **DUE DATE:** 12/12/2014
Fluorescent alternate

ENGINEER:

QTY	TYPE	NO. LAMPS	LAMP TYPE	MFG CODE		UNIT SELL W / LAMP	UNIT EXTENDED
					Open Office and Support Spaces		
96	2X4	3	F32T8TL8	**LITH**	**GT3-MV**	$ 50.82	$ 4,878.72
4	DH			**LEV**	**PCC1D-00W / PCC2D-OOW / ODC**	$ 610.63	$ 2,442.52
					Circulation		
44	HALL	1	PLT26W	**LIL**	**1101F2642U / 1176WH**	$ 75.62	$ 3,327.28
8	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 1,280.00
					Lobby		
2	2X4	3	F32T8TL8	**LITH**	**GT3-MV**	$ 50.82	$ 101.64
					Stairwells		
6	STAIRWELL	2	F32T8TL8	**COL**	**BIL-232-EPU**	$ 197.72	$ 1,186.32
1	TC			**HBA**	**Lighting control panel with photoc**	$ 1,500.00	$ 1,500.00
					Subtotal - Open Office layout:		$ 14,716.48
					Closed Plan and Support Spaces		
96	2X4	3	F32T8TL8	**LITH**	**GT3-MV**	$ 50.82	$ 4,878.72
38	W-OCC/DAY			**WATT**	**DW-200-W**	$ 101.87	$ 3,871.06
					Circulation		
44	HALL	1	PLT26W	**LIL**	**1101F2642U / 1176WH**	$ 75.62	$ 3,327.28
8	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 1,280.00
					Lobby		
2	2X4	3	F32T8TL8	**LITH**	**GT3-MV**	$ 50.82	$ 101.64
					Stairwells		
6	STAIRWELL	2	F32T8TL8	**COL**	**BIL-232-EPU**	$ 197.72	$ 1,186.32
1	TC			**HBA**	**Lighting control panel with photoc**	$ 1,500.00	$ 1,500.00
					Subtotal - Open Office layout:		$ 16,145.02

NorthEast Electrical DISTRIBUTORS
340 Avenue D, Williston VT 05495
phone: 802-658-1625 Fax: 802-658-5962
e-mail: stephen.beard@needco.com

QUOTED BY: Steve Beard

JOB NAME: NRG NZ Feasibility Study **DATE:** 11/24/2014
LOCATION: Office / Manufacturing
200' x 110' building **DUE DATE:** 11/24/2014
ATTN: Tylor Thibault

ENGINEER:

QTY	TYPE	NO. LAMPS	LAMP TYPE	MFG CODE		UNIT SELL W / LAMP	UNIT EXTENDED
					Code Compliant / Net Zero base pricing		
					(fixtures and motion control)		
					200' x 85' Light Manufacturing		
55	LED HI-BAY			**LITH**	**IBH12L**	$ 222.07	$ 12,213.85
55	HB-MOTION			**SSW**	**CMRB-6P / FB3**	$ 86.25	$ 4,743.75
					Circulation		
40	HALL			**LITH**	**FMML-7-840**	$ 31.19	$ 1,247.60
4	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 640.00
					Stairwells		
6	STAIRWELL			**P2**	**LED stairwell fixture with integral OCC**	$ 500.00	$ 3,000.00
					Support and Janitor's Closets		
12	CEILING			**ETI**	**LED surface mount 22w LED fixture**	$ 56.25	$ 675.00
5	W-OCC			**WATT**	**WS-250**	$ 34.65	$ 173.25
					Offices, Meeting Rooms, and Lobby		
92	LED 2x4			**LITH**	**2FSL4-40L-EZ1-LP835**	$ 125.84	$ 11,577.28
7	C-OCC			**SSW**	**1200 SQ FT DT CEILING OCC SENSOR**	$ 160.00	$ 1,120.00
4	DH			**LEV**	**PCC1D-00W / PCC2D-OOW / ODC20-M**	$ 610.63	$ 2,442.52
1	TC			**HBA**	**Lighting control panel with photocell**	$ 1,500.00	$ 1,500.00
					Subtotal:		$ 39,333.25

NorthEast Electrical DISTRIBUTORS
340 Avenue D, Williston VT 05495
phone: 802-658-1625 Fax: 802-658-5962
e-mail: stephen.beard@needco.com

QUOTED BY: Steve Beard

JOB NAME: NRG NZ Feasibility Study **DATE:** 12/12/2014
LOCATION: Office / Manufacturing
200' x 110' building **DUE DATE:** 12/12/2014
Fluorescent alternate

ENGINEER:

QTY	TYPE	NO. LAMPS	LAMP TYPE	MFG CODE		UNIT SELL W / LAMP	UNIT EXTENDED
					Code Compliant / Net Zero base pricing		
					(fixtures and motion control)		
					200' x 85' Light Manufacturing		
55	T5HO hi-bay		INCL	**LITH**	**IBZT5-4L**	$ 122.50	$ 6,737.50
55	HB-MOTION			**SSW**	**CMRB-6P / FB3**	$ 86.25	$ 4,743.75
					Circulation		
40	HALL	1	PLT26W	**LIL**	**1101F2642U / 1176WH**	$ 75.62	$ 3,024.80
4	HALL-OCC			**SSW**	**CM-11 / PP20**	$ 160.00	$ 640.00
					Stairwells		
6	STAIRWELL	2	F32T8TL8	**COL**	**BIL-232-EPU**	$ 197.72	$ 1,186.32
					Support and Janitor's Closets		
12	CEILING	2	F32T8TL8	**LITH**	**SB232-MVOLT**	$ 47.88	$ 574.56
5	W-OCC			**WATT**	**WS-250**	$ 34.65	$ 173.25
					Offices, Meeting Rooms, and Lobby		
92	2X4	3	F32T8TL8	**LITH**	**GT3-MV**	$ 50.82	$ 4,675.44
7	C-OCC			**SSW**	**1200 SQ FT DT CEILING OCC SENSOR**	$ 160.00	$ 1,120.00
4	DH			**LEV**	**PCC1D-00W / PCC2D-OOW / ODC20-M**	$ 610.63	$ 2,442.52
1	TC			**HBA**	**Lighting control panel with photocell**	$ 1,500.00	$ 1,500.00
					Subtotal:		$ 26,818.14

Standard terms and conditions apply.Partial releases, including pre-shipment of anchor bolts, may incur freight charges. Quotation is subject to approval, based on material shown only, valid for 30 days.

NorthEast Electrical DISTRIBUTORS

Quotation

NORTHEAST ELECTRICAL DISTRIBUTORS
340 AVENUE D SUITE 10
WILLISTON,VT 05495
802-658-1625 *Fax* 802-658-5962

stephen.beard@needco.com

QUOTE DATE	QUOTE NUMBER
12/17/14	S020857042

PAGE NO
1 of 1

QUOTE TO:
PECK ELECTRIC CO
4050 WILLISTON RD
SUITE 511
S BURLINGTON, VT 05403-6068
802-658-3378

SHIP TO:
PECK ELECTRIC CO
4050 WILLISTON RD
SUITE 511
S BURLINGTON, VT 05403-6068
802-658-3378

CUSTOMER NUMBER	CUSTOMER ORDER NUMBER	JOB NAME	QUOTED TO
78234	NRG		Tylor

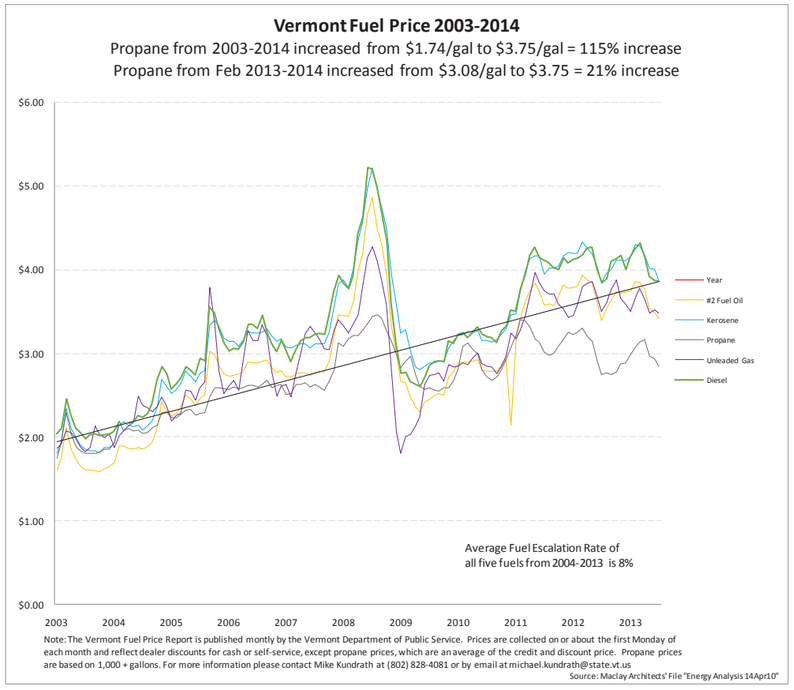
SALESPERSON	SHIP VIA	FREIGHT ALLOWED	EXPIRATION DATE
STEPHEN BEARD	BID	Yes	01/31/15

ORDER QTY	UPC	DESCRIPTION	UNIT PRICE	U	EXT PRICE
1ea		LITH IBH-18000LM-SD080-MD-MVOLT-GZ10-40K -70CRI-WH	351.760	e	351.76
1ea		^Lithonia 2FSL4 60L EZ1 LP835	209.000	e	209.00

HISTORIC FUEL RATES AND ESCALATION TRENDS

Historic Fuel Rate Trends and Escalation Rate Justification

The following graph summarizes actual fuel prices per gallon for five types of fuel from 2003 to 2013 in Vermont. The data in the graph is from the Vermont Fuel Price Report. We utilized this data to formulate reasonable assumptions related to probable fuel escalation rates in the coming years.



Taking a closer look at the Vermont Fuel Price Report data, we also generated the percent change of each fuel cost from the year prior. The annual rates of escalation are shown in the chart to the right and the average fuel escalation rate for each fuel is shown below for the past nine years. The fuel escalation rates vary from as low as 5% for propane to 11% for #2 Fuel Oil. The average fuel escalation rate of all fuels was 8% over this 9 year period.

Based on this information we have assumed conservative 5% fuel escalation rates for our analysis which follows.[1]

Vermont Fuel Escalation Rates

Percent Change in Fuel Cost from Previous Year

	Fuel Type				
	#2 Fuel Oil	Kerosene	Propane	Unleaded Gas	Diesel
2004	41%	39%	24%	17%	35%
2005	19%	22%	12%	6%	13%
2006	1%	0%	2%	4%	1%
2007	24%	21%	19%	30%	24%
2008	-13%	-7%	-4%	-39%	-21%
2009	-7%	-12%	-10%	38%	0%
2010	-23%	10%	15%	14%	13%
2011	77%	22%	6%	6%	16%
2012	-1%	-2%	-11%	5%	-2%
2013	-2%	-1%	-3%	-5%	-2%
Average Fuel Escalation Rate from 2004-2013	11%	9%	5%	8%	8%

Source: Maclay Architects' File "Energy Analysis 14Apr10"

[1] We also assumed that when fuel prices reach 2.5 times the current cost of energy from renewable fuels, either conventional fuel prices will level off and/or one would switch to a renewable fuel source. At that point, we do not escalate fuel prices further in our analysis.

SOLAR PLATEAU EXPLANATION

EXCERPTS FROM *THE NEW NET ZERO*

THE RENEWABLE COST PLATEAU: ENERGY PARITY

From 2008 to 2013 the cost of solar PV dropped significantly, from over $6/peak watt installed to $4/peak watt installed for small installations and roughly $2/peak watt for large utility installations. It is likely renewable energy will continue to decrease so that the cost of energy produced from renewables will at some point equal the cost of energy produced from fossil fuels. Then, as fossil-fuel prices continue to rise, the cost of energy from renewables will become the least expensive energy source, and energy investments will be based on renewable energy costs, not fossil-fuel costs.

So when we use the term "new net zero," we are saying that future buildings will be based on a renewable energy economy, not a fossil-fuel economy. We will eventually reach what we call the renewable solar cost plateau, where fossil-fuel and PV costs equalize and PV then becomes more cost effective (see

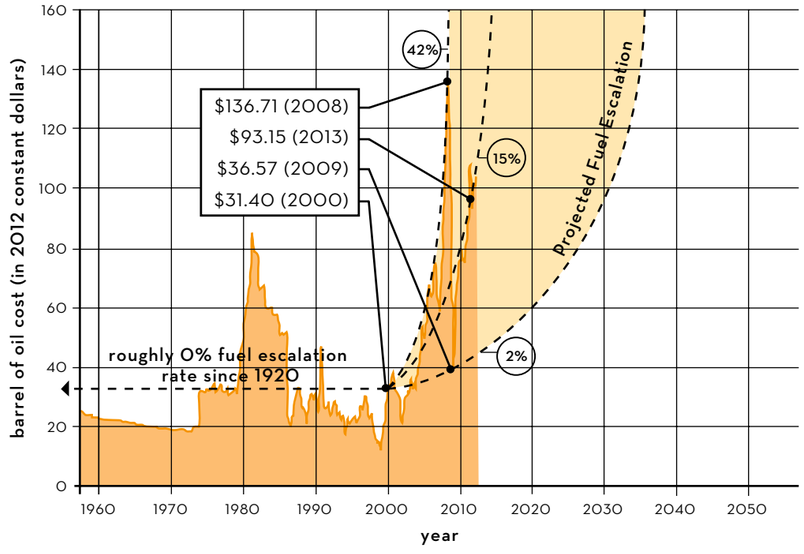


FIGURE 17.2. The average oil price from 1920 to 2000 was $25.14 a barrel. The current fuel cost volatility is evident when we look at the high and low prices between 2000 and 2013. The cost of oil in 2000 was $31.40. The highest oil price, recorded in July 2008, was $136.71, with an annual fuel escalation rate of 42 percent. The lowest oil price since 2000 was recorded in February 2009, at $36.57, with a resulting annual fuel escalation rate of only 2 percent. The price of oil was $93.15 in January 2013, which gives an annual fuel escalation rate of 15 percent.[3]

SOLAR PLATEAU EXPLANATION

EXCERPTS FROM *THE NEW NET ZERO*

figure 17.3). We have projected this renewable energy plateau by estimating future market rates for different energy sources and estimating when renewable and fossil-fuel energy prices equalize, the point of grid parity. This may sound simple, but in reality it is a complex projection.

Energy produced by renewables has already reached grid parity in some nations, but the real tipping point will not occur until a certain "pain factor" is reached with their existing fuel prices, causing the majority of people to shift to renewable energy. The delay in reaching grid parity is caused by numerous factors connected to changing from fossil fuels to renewables. For existing buildings, these factors include owners' prior investments in fossil-fuel heating and cooling equipment, as well as time needed for shifts in perception and buying habits. For new buildings, this transition will happen sooner, as their owners do not face the cost and complexity of replacing an existing system. However, the fact that consumers resist change and uncertainty will slow advances even in new buildings.

Yet the plateau brought on by price parity may not be enough, right away, to force a swift transition. To understand why, we can first look at our current options and practices when purchasing energy to meet our electricity needs. In Vermont, due to power purchase agreements, all homeowners and most businesses can purchase their electricity for the same price or less from solar developers and companies typically with a guaranteed rate for 5 years. This would seem to indicate that the solar plateau has arrived for solar PV in Vermont. And yet most people have not switched. Why? First, this is not as easy as just asking your power company to change their billing procedure. You need to call the solar developer company to determine if your site is feasible. You have to switch providers and engage in a seemingly complicated agreement, new and different in the marketplace. You need to put the solar on your home or your land, or on other land in the territory of your utility. All of this takes effort and causes resistance by the consumer. Thus, the effective solar plateau happens after the theoretical solar plateau.

If you do not have easy solar access to make this change, you have to wait until your utility switches from fossil fuels to renewables, and this is likely to be much later. Utilities will probably wait until there is a greater price difference between renewables and fossil fuels, because utility companies already have major investments in fossil-fuel generating plants. So, while a homeowner may arrive at the solar plateau when fossil fuels are slightly more expensive than renewables, say 1.25 times PV prices, a utility likely won't change until energy from fossil fuels is closer to twice the cost of energy from renewables. The utilities will also change more slowly as net-metering laws mandate that utilities pay net-metered users the retail price for renewable power, which is not the typical purchase price for utilities.

While the theoretical solar plateau is when grid parity occurs, our estimate is that people will switch at varying times from when renewable energy and fossil-fuel energy cost the same to when fossil fuel energy is twice as expensive as renewable energy. This variance is based on multiple factors, including viability of PV on-site or off-site, existing systems, utility company decisions, and each individual's or organization's environmental mission.

So let's look in greater detail to figure out the plateau for building owners, managers, and users, as well as the best time to convert to renewables. Our interest lies in determining when PV will reach the tipping point in the United States, by determining for our clients the financial analysis of an installed PV system in relation to traditional fossil-fuel options. We use PV in our analysis because it is the most common renewable technology for electrical needs, and so, the most likely candidate for net zero energy construction.

All of our estimates of the renewable solar plateau are based on 2013 PV costs and use $4/watt for installation costs of small- and medium-size installations of a durable, high-efficiency module. We chose a thirty-year lifetime of the PV panels (although they will likely last longer), a panel degradation of 0.5 percent per year, one inverter replacement in the thirty years (which is not discounted), a fixed-tilt array, and 1.1 kWh/yr-Wp peak rating (typical of New England). Drawing on these assumptions, we would expect the PVs to produce energy for a price of $0.14/kWh for typical electric uses without any incentives in New England.

If we made the same assessment for Colorado Springs, Colorado, with a 1.5 kWh/yr-Wp peak rating, the PV system would produce energy for a price of $0.10/kWh (without incentives) because of the increased solar radiation of Colorado. Depending on your location and incentives available, the costs for energy from PV are better than, or are approaching, the 2013 national residential electric rate of $0.12/kWh. When PV systems are paid for up front by the owner, it seems as if the cost is much higher than using grid electricity, but over the lifetime of the system the cost is in fact lower.

So far we have discussed the solar plateau in relation to an existing user's electricity bill. What if we want to use renewable energy for heating or cooling? Does this change? Likely it does, because of the efficiency of all-electric heating using heat pumps. Ground-source and air-source heat pumps are 2.3 to 3 times more efficient than electricity used for direct resistant heating. With heat pumps the relative efficiency of electricity increases, making it more cost effective as a heating source. In other words, it lowers the solar plateau by roughly 60 percent compared to electricity for other typical uses. However, if you are switching from an existing fossil-fuel heating system to a heat pump you will be less eager to change because you have a functioning system, and you may wait until fossil-fuel energy moves well beyond the cost of renewable energy.

In table 17.1 and figure 17.3, we converted each energy source to cost per MMBtu in order to compare the cost of fossil fuels and electricity from PV. Table 17.1 indicates that PV electricity for our general use or for direct-resistance electric heat is equal to propane at $3.76/gal, oil at $5.58/gal, or natural gas at $4.10/therm. However, we do not use fossil fuels directly for typical electrical uses so we need to incorporate heating efficiencies into the analysis.

The range of heat pump efficiencies is typically between 2.3 and 3 in cold climates. Our analysis assumes a heating COP of 2.3 for air-source heat pumps, meaning they are 230 percent efficient (based on a high-efficiency, variable-refrigerant-flow heat pump operating in a cold climate). Using electricity from PV at a cost of $0.14/kWh, the heat delivered is $0.06/kWh ($17.58/MMBtu), which is equivalent to fossil fuels if you are paying $1.61/gal for propane, $2.39/gal for oil, or $1.76/therm for natural gas (see table 17.1). These costs are well below 2013 oil and propane rates in Vermont as shown in table 17.2. If you have an existing building, the renewable solar cost plateau would occur at double these rates, as shown in table 17.1, at $35.17 /MMBtu.

Table 17.2 shows heating comparisons from various fuel sources with their adjusted efficiencies in Vermont from December 2013. The cost per MMBtu and heating efficiencies reported by the Vermont Public Service Department for each

SOLAR PLATEAU EXPLANATION

EXCERPTS FROM *THE NEW NET ZERO*

TABLE 17.1. HEATING COSTS COMPARING SOLAR PV TO FOSSIL FUELS

	ELECTRIC (kWh)	PROPANE (GAL)	OIL (GAL)	NATURAL GAS (THERM)	$/MMBtu
2013 cost of heat comparing direct electric resistance and PV	$0.14	$3.76	$5.58	$4.10	$41.03
Plateau for heating sources, when retrofitting with heat pumps	$0.12	$3.22	$4.78	$3.52	$35.17
2013 cost of heat comparing heat pumps and PV	$0.06	$1.61	$2.39	$1.76	$17.58
2013 cost of heat pumps and PV with 30 percent federal tax credit for PV	$0.04	$1.07	$1.59	$1.17	$11.72

Source: Analysis completed with the assistance of Andy Shapiro, Energy Balance.

TABLE 17.2. COST COMPARISON OF HEATING FUELS IN VERMONT

TYPE OF ENERGY	Btu/UNIT	ADJUSTED EFFICIENCY	PRICE PER UNIT	COST PER MMBTU
Fuel oil, gallon	138,200	80%	$3.77	$34.09
Kerosene, gallon	136,600	80%	$4.19	$38.36
Propane, gallon	91,600	80%	$2.91	$39.75
Natural gas, therm	100,000	80%	$1.46	$18.28
Electricity, kWh (resistive heat)	3,412	100%	$0.15	$43.46
Electricity, kWh (cold climate heat pump)	3,412	300%	$0.15	$14.49
Wood, cord (green)	22,000,000	60%	$193.33	$14.65
Pellets, ton	16,400,000	80%	$247.00	$18.83

Source: Vermont Department of Public Service, *Vermont Fuel Price* (December 2013), 3, http://publicservice.vermont.gov/publications/fuel_report

fuel source confirms our assumptions and are the starting point for the fuel prices in figure 17.3.

We prepare a customized financial analysis for projects, and assume fuel escalation rates for energy that are discussed and agreed upon with our clients. In figure 17.3, we offer an example of this analysis. We begin with the costs for different energy sources without tax credits. In this case we used residential energy costs in Vermont in December 2013 as the starting point, but these costs should be adjusted to each individual project. In this example we use $3.77/gal for oil, $2.91/gal for propane, and $1.46/therm for natural gas. We used an annual fuel escalation rate of 4 percent. Once the renewable cost plateau is reached, we assume fuel escalation rates are zero and the only cost increases are due to inflation, which we have disregarded in this analysis. For PV electric rates we show three alternative solar plateaus: electricity from PV and direct resistance heat, retrofitting heat pumps for fossil fuels, and heat pumps in new installations. In order to account for delivered energy per fuel type, efficiencies of heating systems are taken into account. Heat pumps have a COP of 2.3, while other fuel sources have an efficiency of 0.8. Heat pumps in new installations are already at the solar plateau for all fossil fuel sources (with natural gas reaching it by 2014). If you are retrofitting your existing heating system the plateau is at $35.17/MMBtu or $0.12/kWh. Propane is already above this plateau, oil will likely reach this solar plateau in 2015, and natural gas will reach it in 2027. If local PV incentives of federal tax credits are included, the solar plateau decreases by 30 percent, making the transition sooner. And if a business is undertaking these improvements, depreciation and other benefits may further expedite the solar plateau.

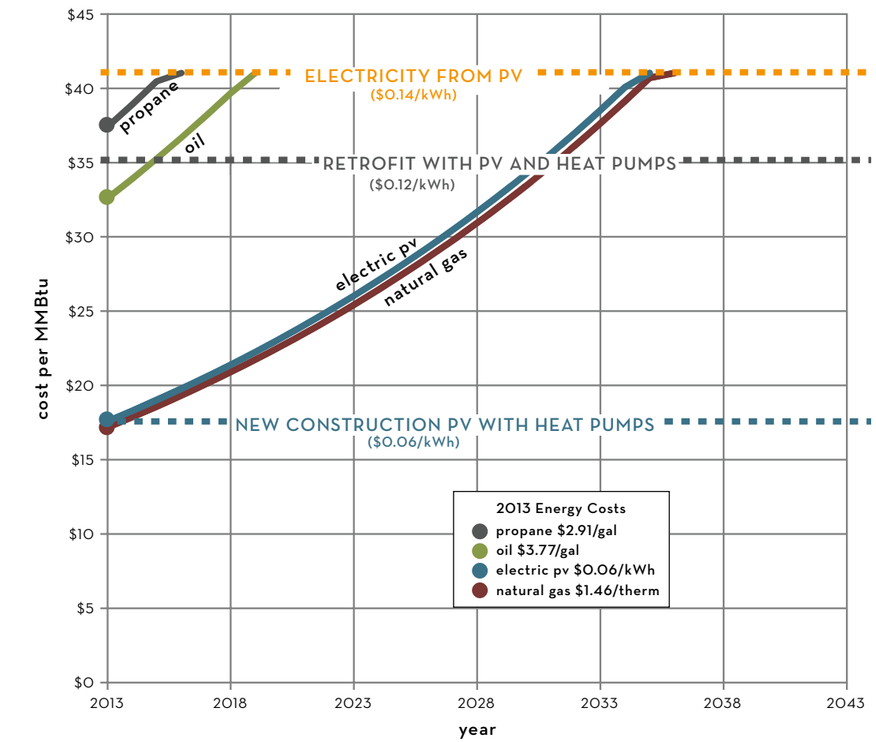


FIGURE 17.3. This example of the renewable solar cost plateau when heating efficiencies are used shows three plateaus: new construction with PV electric and heat pumps, retrofitting using PV and heat pumps, and electricity from PV. This graph confirms that heat pumps in new construction are already cost effective for all fuel sources, and even retrofits will become cost effective by 2027, depending on fuel prices and options.

Fuel Cost with the Solar Plateau

	w/o efficiencies of heat source	w/ efficiencies of heat source
Electric (kWh)	$ 0.31	$ 0.13
Oil (gal)	$ 12.32	$ 6.30
Propane (gal)	$ 8.30	$ 4.25

Maximum fuel prices once they reach the solar plateau used in this report

Efficiency Vermont

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