

Net Zero Energy Feasibility Study Summary Report



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In Collaboration with:
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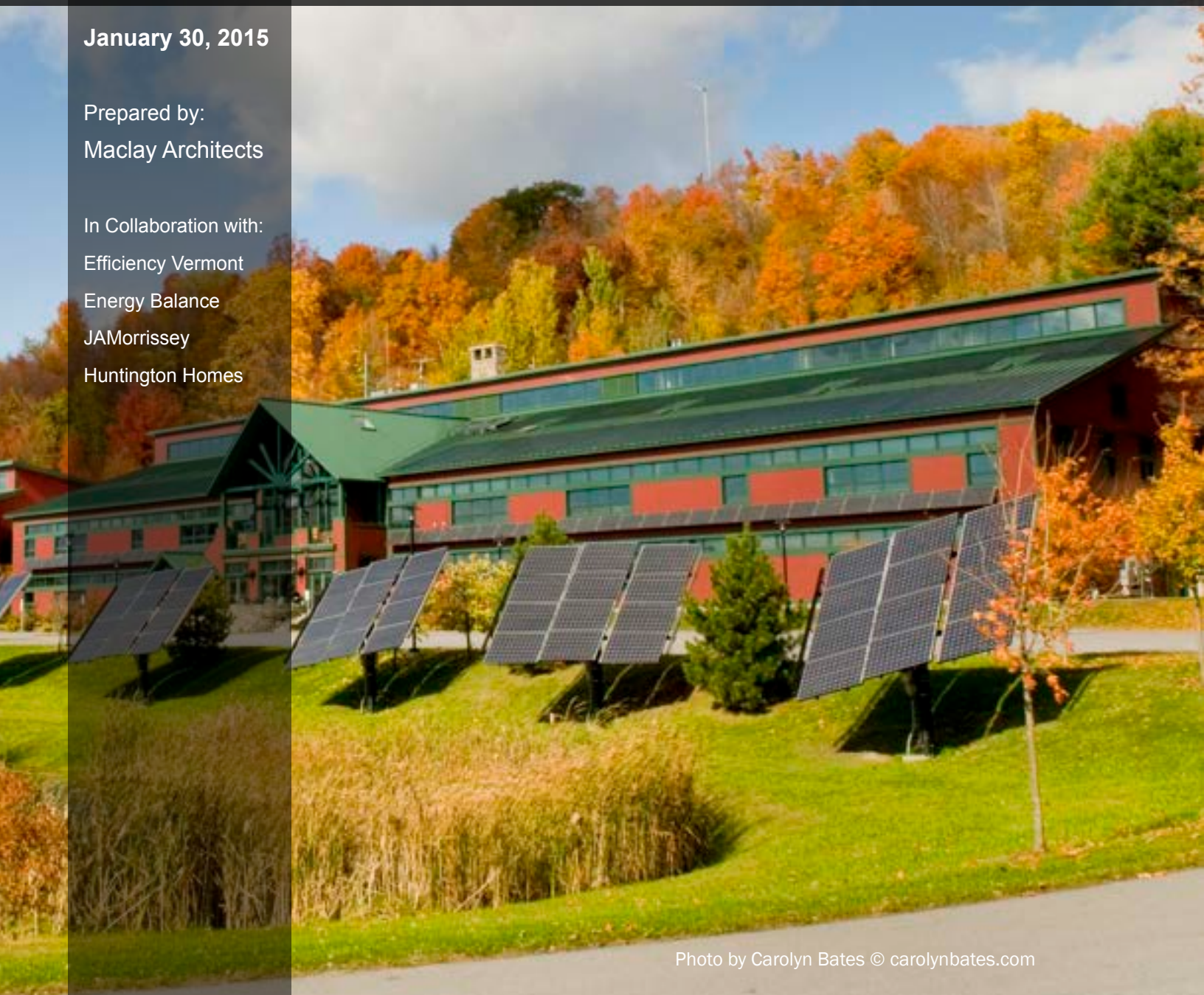


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EXECUTIVE SUMMARY

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).

Table 1: Energy Use Intensity (EUI) for each building type

Building Type		Code [2]		Net Zero Ready		% energy savings above code
	SF	(kBTU/sf-yr)	(kWh/sq.m-yr)	(kBTU/sf-yr)	(kWh/sq.m-yr)	
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/Manufacturing	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). 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.

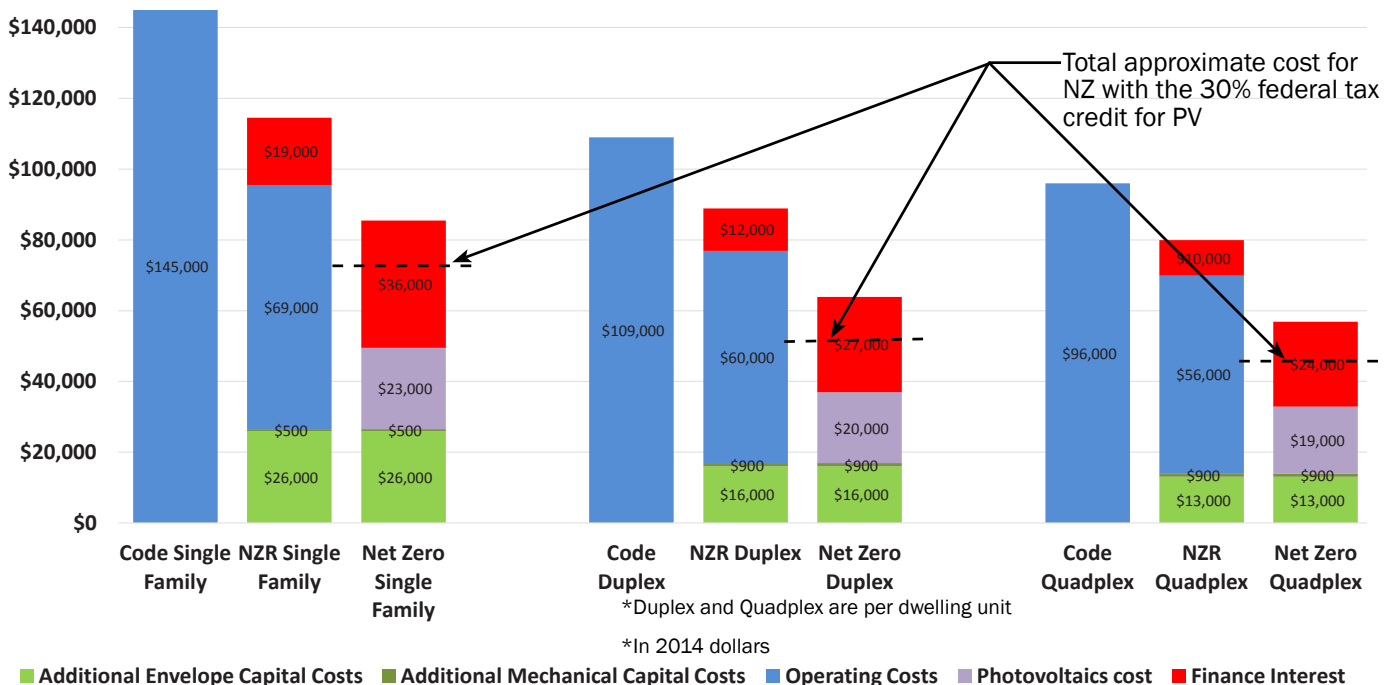


Figure 1: Residential 30-year capital, operating, and finance costs

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 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 2). Efficiency Vermont is currently running a Net Zero Energy Pilot Program that has additional incentives for the design process, metering, and commissioning.

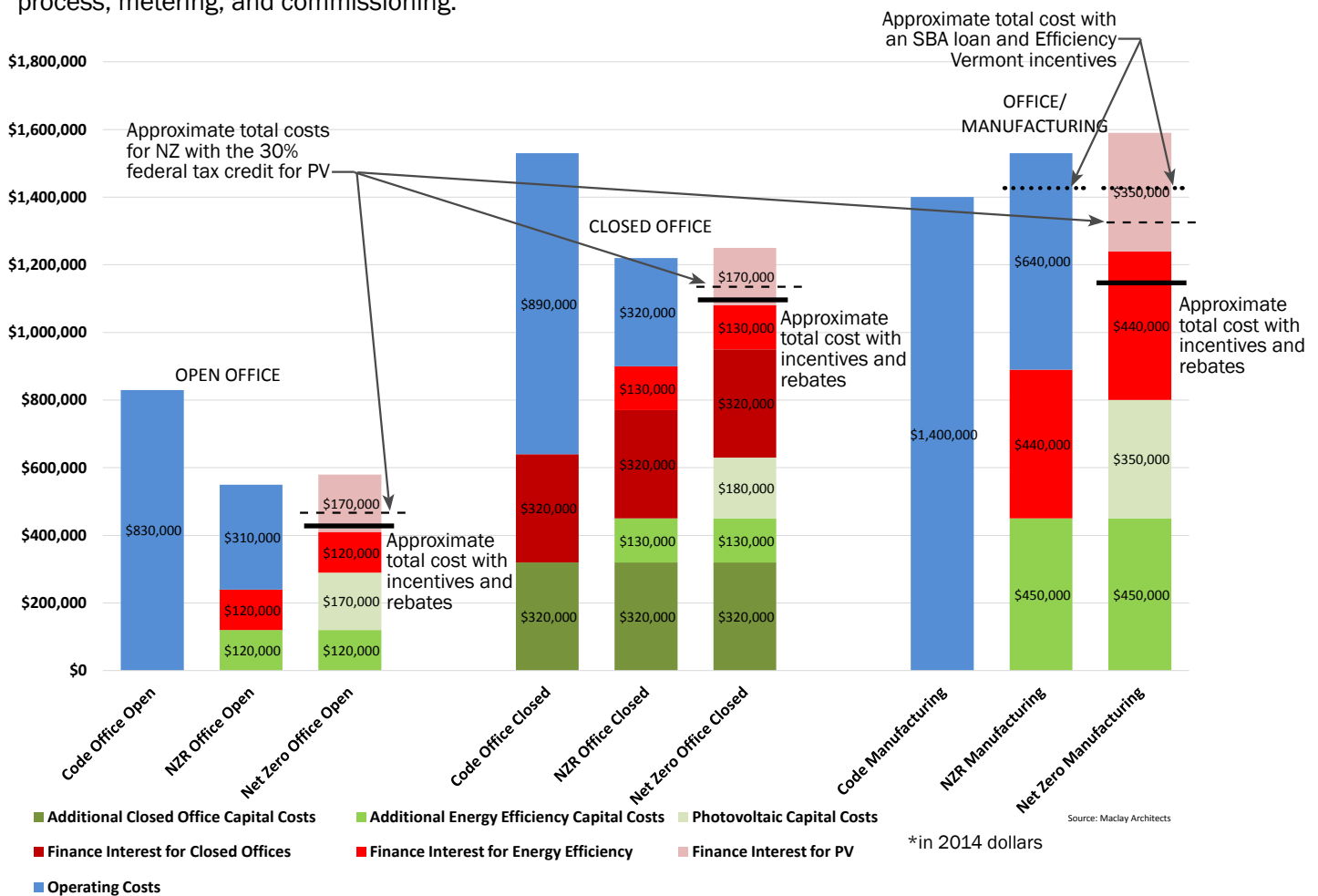


Figure 2: Commercial 20-year capital, operating, and finance costs

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.

STUDY BACKGROUND

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 in the full report.

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 SINGLE FAMILY

A 1,600 sf, 3 bedroom, 2.5 bathroom, single family home from Huntington Homes, was used for energy modeling and cost estimating.



Figure 3: Residential single family home
source: Huntington Homes

RESIDENTIAL 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 4), the design was adapted to duplex and quadplex options in this study.



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

OFFICE BUILDING

The 13,000 sf two-story office building schematic open and closed office floor plans are shown in Figure 5. 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. For additional commercial building information see the full report Section IV.

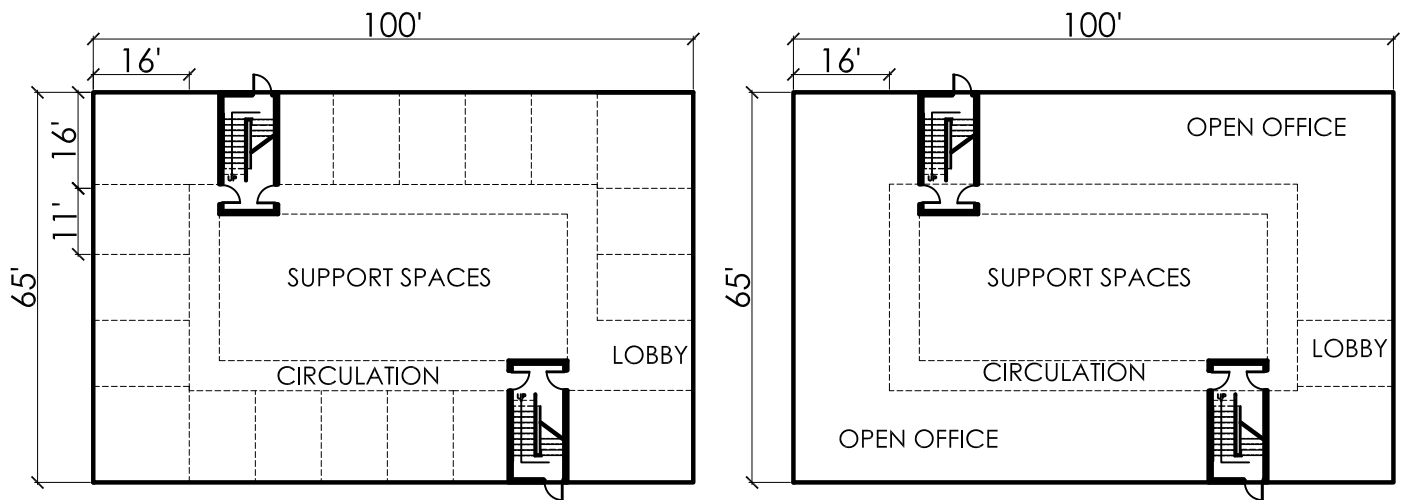


Figure 5: Closed office first floor plan on left, and open office first floor plan on the right

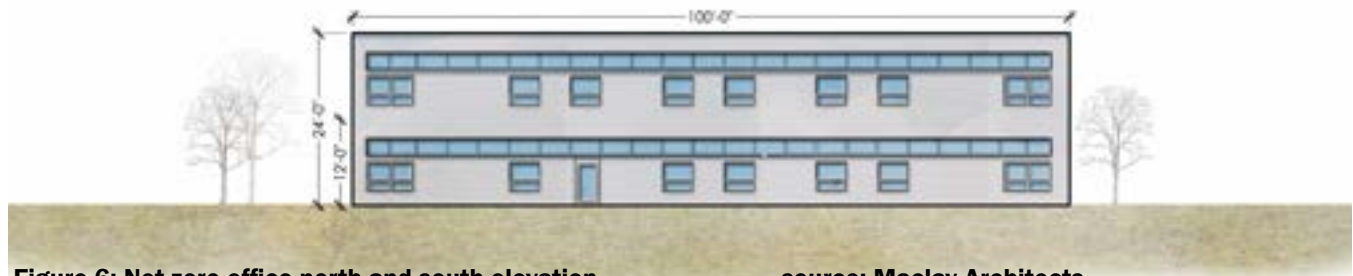


Figure 6: Net zero office north and south elevation

source: Maclay Architects

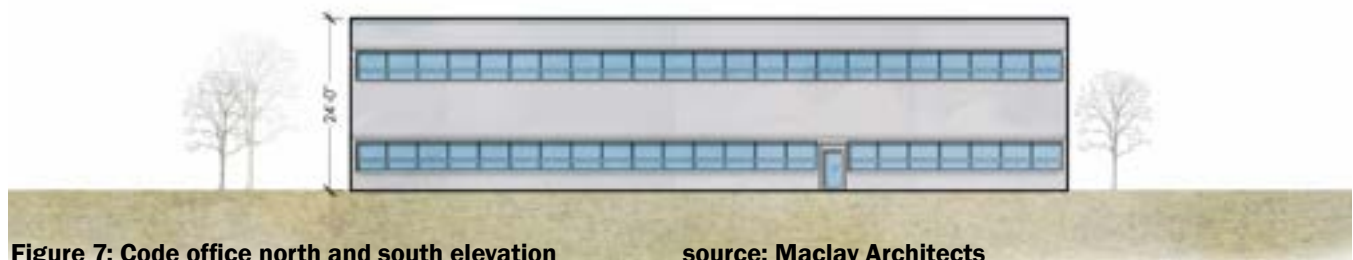


Figure 7: Code office north and south elevation

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 net zero and code building have the same overall glazing areas on each elevation. 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.

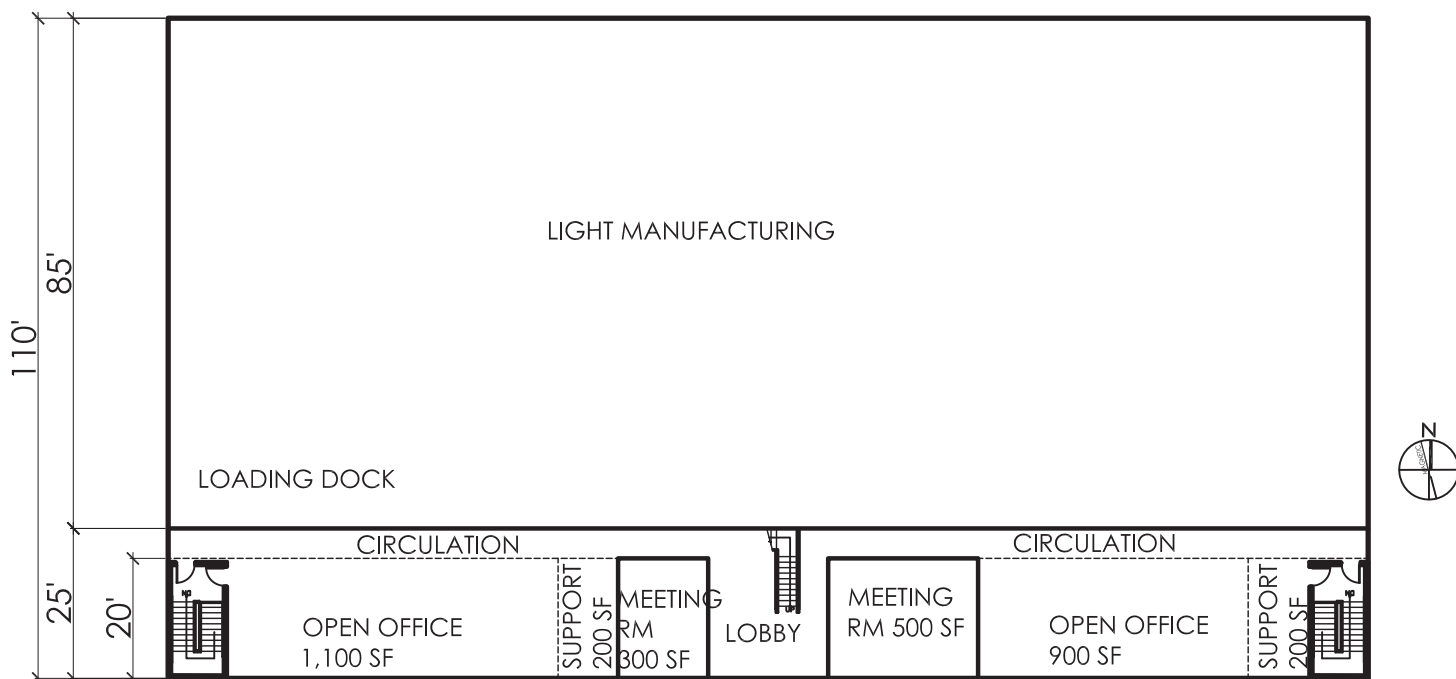


Figure 8: Office/manufacturing first floor plan

source: Maclay Architects

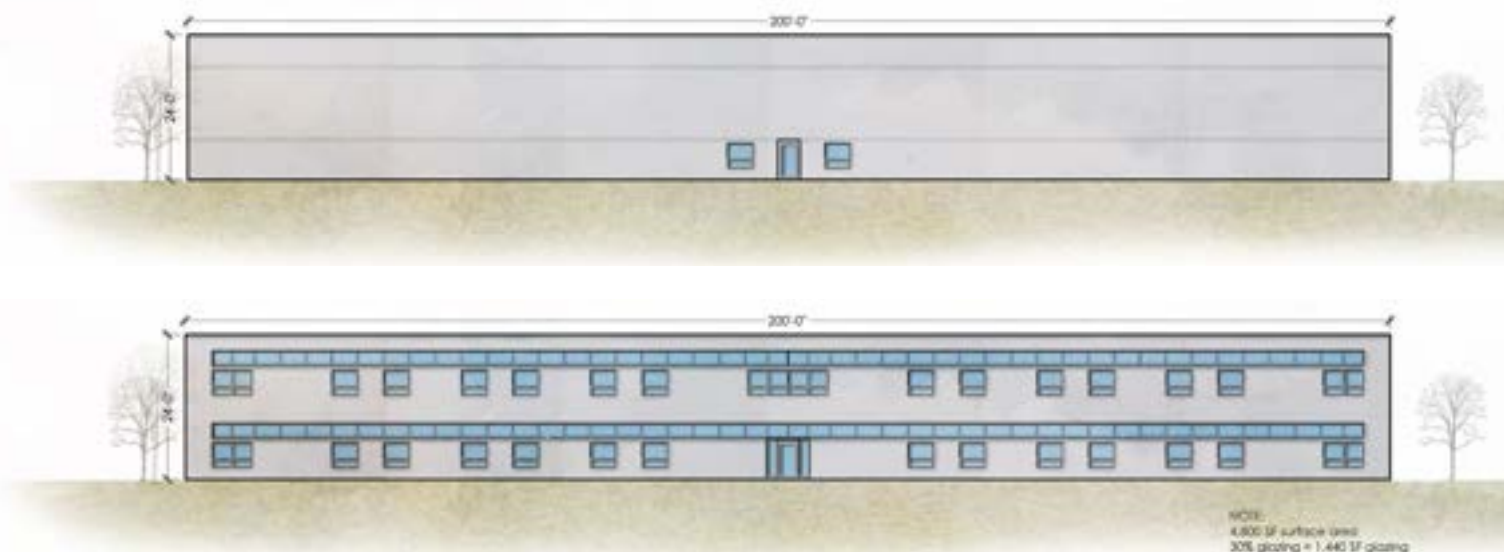


Figure 9: Office/manufacturing net zero ready north (top) and south elevation (bottom)

source: Maclay Architects

ENERGY MODEL SUMMARY

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 section of the full report.

Each building type has an overall Energy Use Intensity (EUI) in kBtu/sf-yr and kWh/sq.m-yr, (Table 1, page 3). 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 2).

Reducing energy consumption provides financial benefit to the building owner, but it also reduces the impact of carbon emissions in the atmosphere. Table 4 shows the carbon dioxide emissions assumptions for each building. Building to net zero standards saves operating costs and reduces CO2 emissions each year.

Table 2: Energy usage breakout for each building type

Building Type	Energy Usage, kWh/yr [4]												% energy savings above code
	Code						Net Zero Ready						
	heat [2]	hot water	cooling [5]	lighting	other elec	Total	heat [3]	hot water [4]	cooling [6]	lighting	other elec	Total	
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/Manufacturing	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%

Table 3: CO2 emissions per year

Building Type	Code	Net Zero Ready
	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/Manufacturing	128	61

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 value converted to kWh 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

COMMUNITY OVERVIEW

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 10) leased to Renewable NRG Systems, in Hinesburg, VT. The proposed community square footage is broken out by building type and number of units.

Table 4: 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 10: Community masterplan

source: Maclay Architects and SE Group

COMMUNITY ENERGY MODEL SUMMARY

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 11) shows rooftop, carport, and two possible ground mounted PV locations on site.

Table 5: Community energy consumption

Type	SQUARE FOOTAGE (SF)				CODE EUI (kBtu/sf-yr)			NET ZERO READY EUI (kBtu/sf-yr)			TOTAL	
	Office	Manufacturing	Residential	total building	Office	Manufacturing	Residential	Office	Manufacturing	Residential	Total Code Energy (kBtu/yr)	Total Net Zero Ready Energy (kBtu/yr)
Commercial												
Office	31200	0	0	160000	62			17			9,900,000	2,700,000
Office/manufacturing	10000	17000	0	54000	62	49		17	17		2,900,000	900,000
COMMERCIAL SUBTOTAL SF: 214000											COMMERCIAL 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
(all final numbers have two significant digits)												
COMMUNITY TOTAL SF: 300,000											COMMUNITY TOTAL kBtu/yr: 18,000,000	5,600,000



Figure 11: Possible renewable energy overlay

source: Maclay Architects and SE Group

COST ESTIMATE SUMMARY

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 in the full report). 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

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, which were then 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). The net zero building has the same additional envelope and mechanical costs plus additional costs for the PVs. See the full report for a detailed breakout of additional capital costs.

Table 6: 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

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 7) 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. A detailed capital cost comparison is included in the Cost Estimate Section of the full report.

Table 7: 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%

FINANCIAL ANALYSIS SUMMARY

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. The duplex and quadplex are analyzed on a per dwelling unit basis, and all financial analysis is in 2014 dollars with no inflation and a discount rate of 0%. Fuel rates start at the October 2014 Vermont rates of \$0.15/kWh and \$3.08/gal of propane. Fuel escalation is assumed to be 5% per year until they reach a solar plateau discussed in the Appendix of the Full Report.

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 there are many variables and local rebates, tax credits, grants, and solar installer financing that should be examined on a case by case basis.

Figure 12 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 13 and 14).

Rebates, tax credits, or incentives for residential NZR construction are not included in the total costs in Figure 12 and 13, 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.

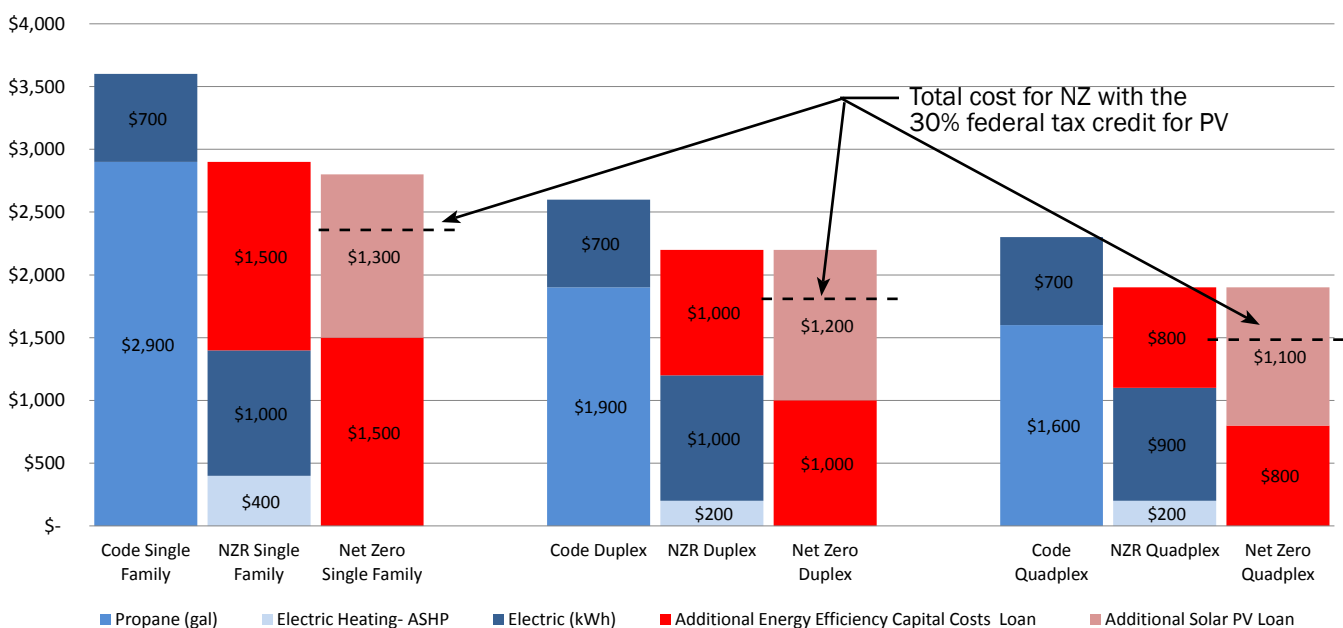


Figure 12: Residential first year energy and finance costs

Figure 13 shows the cumulative 30-year capital (green and purple), operating (blue), and finance (red) costs, indicating that net zero residential options are a very good investment today and provide cumulative savings ranging from \$59,000 to \$39,000 over code buildings (Figure 14).

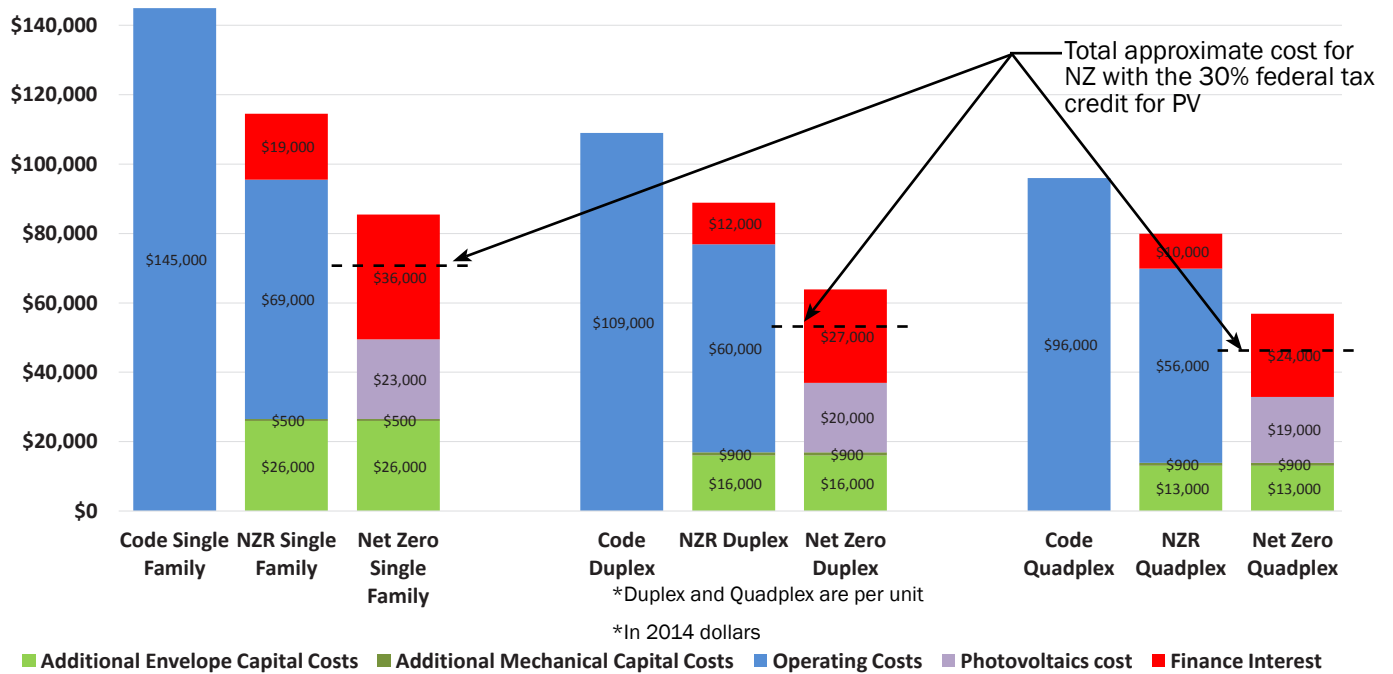


Figure 13: Residential 30-year capital, operating, and finance costs

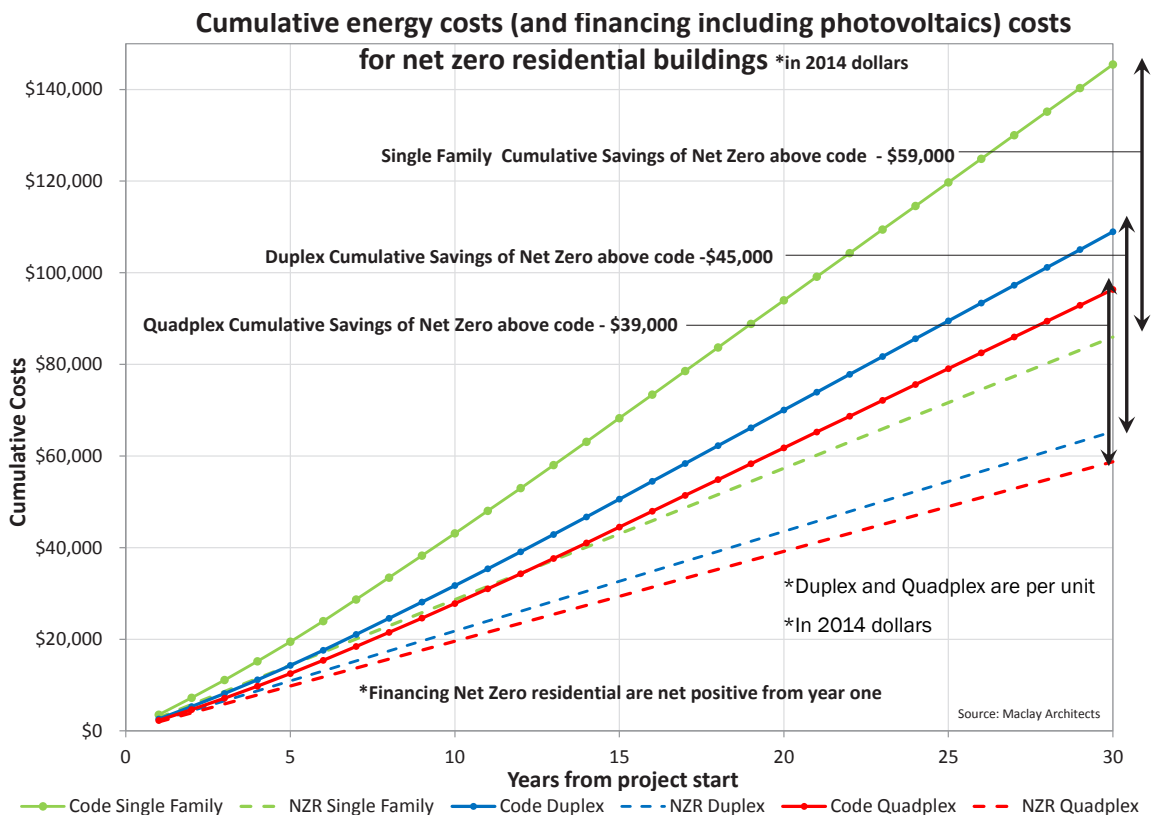


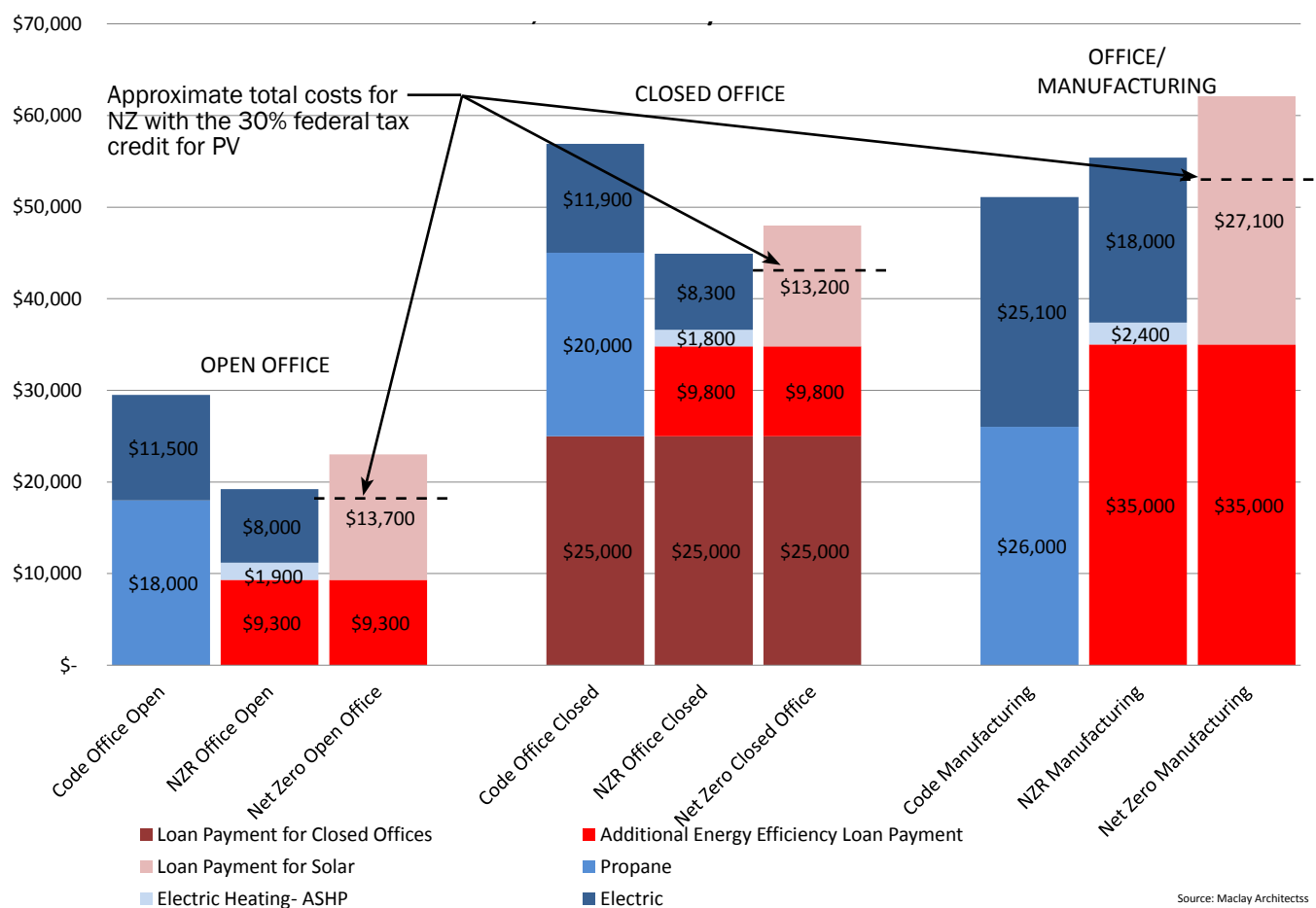
Figure 14: Cumulative residential 30-year capital, operating, and finance costs

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 15 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 15.

The office/manufacturing building on the right side of Figure 15, 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.



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 (solid line in Figure 16). This is due in part from the conservative commercial financing rates used in the analysis.



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 17. 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.

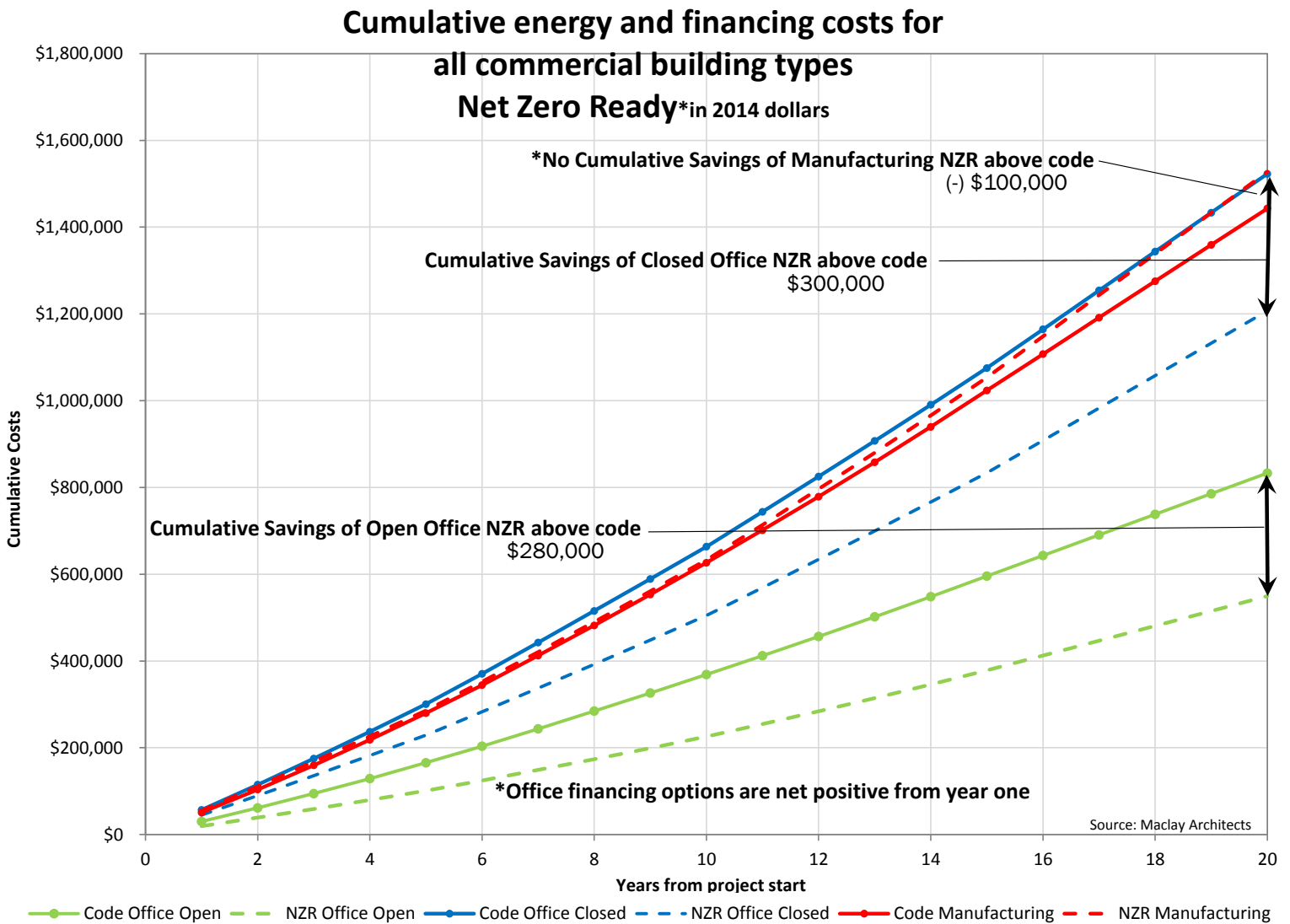


Figure 17: Cumulative energy and financing costs for all code and net zero ready commercial buildings

OPEN VERSUS CLOSED OFFICE ANALYSIS

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.

OPEN VERSUS CLOSED OFFICES FIRST YEAR ENERGY AND FINANCE COSTS

The open office buildings return 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.

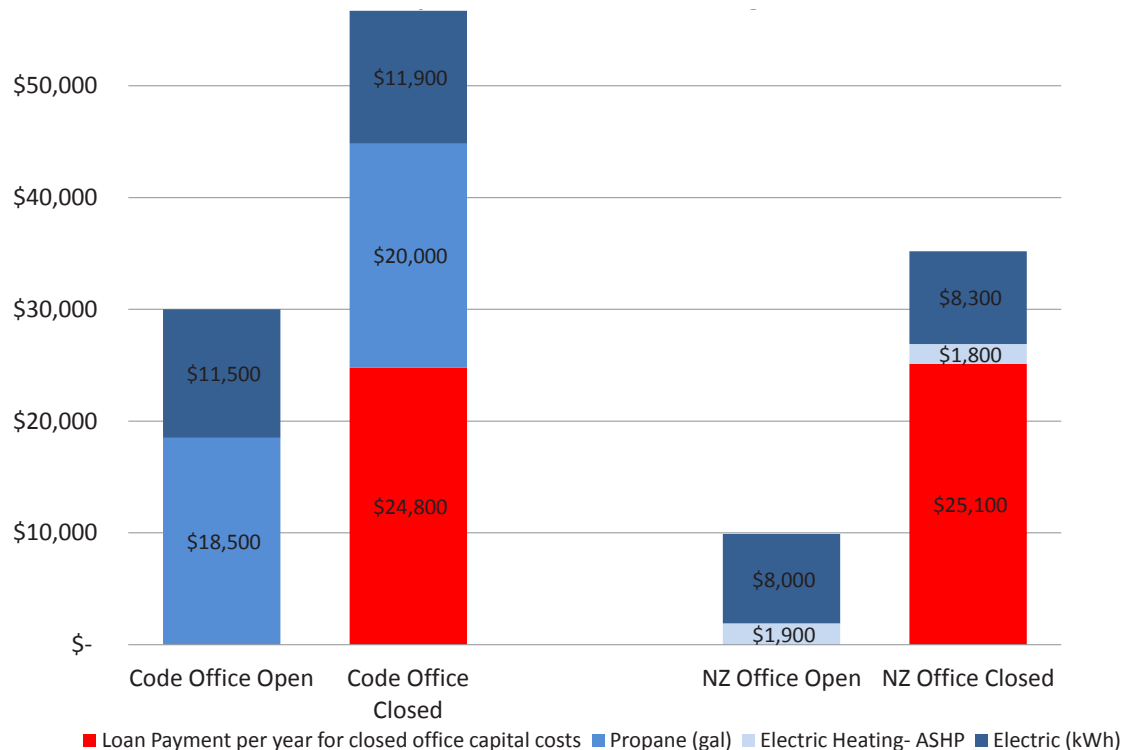


Figure 18: First year operating and finance costs for open and closed offices

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 19). The NZR open office building (dashed green line in Figure 20) shows significant savings above NZR closed office (solid green line) and code open and closed offices (blue lines).

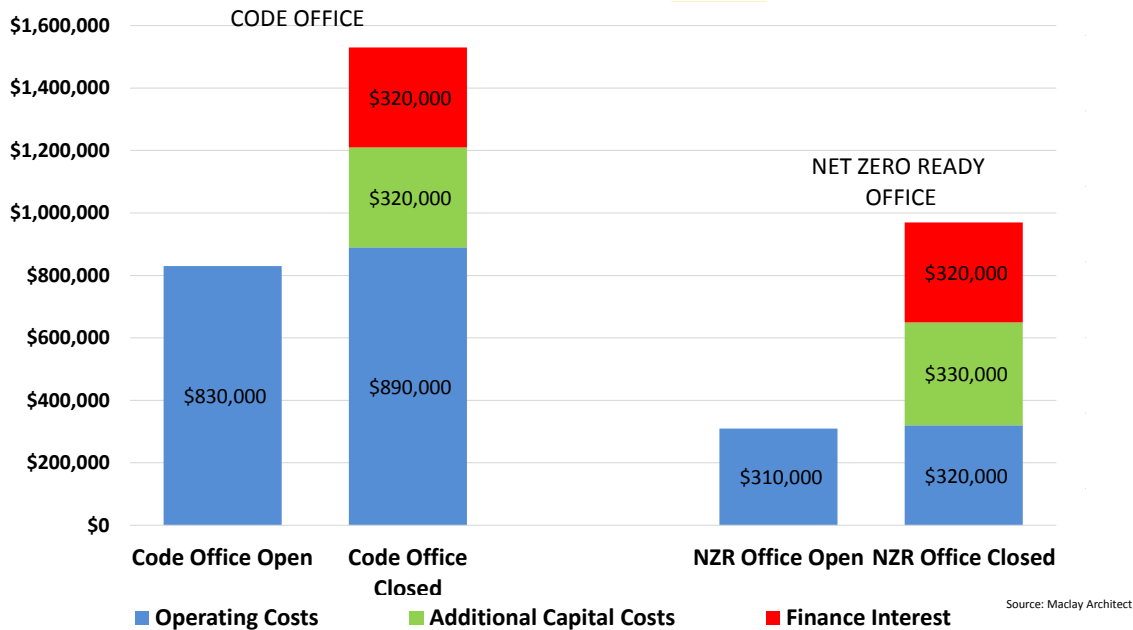


Figure 19: Twenty year cumulative capital, operating and finance costs for open and closed offices

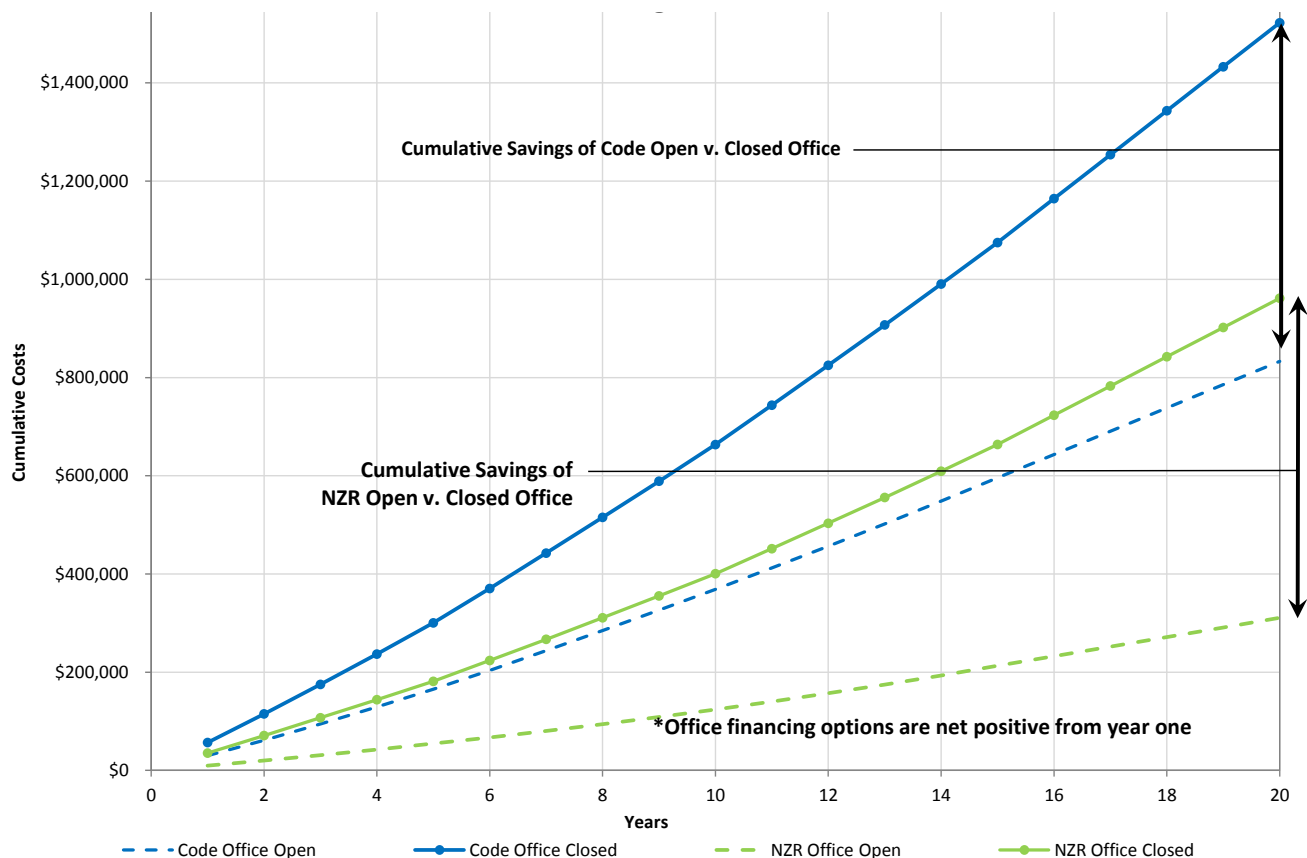


Figure 20: Cumulative 20-year capital, operating and finance costs for open and closed offices

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 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 21 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 only cost \$6 million to operate and own, 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.

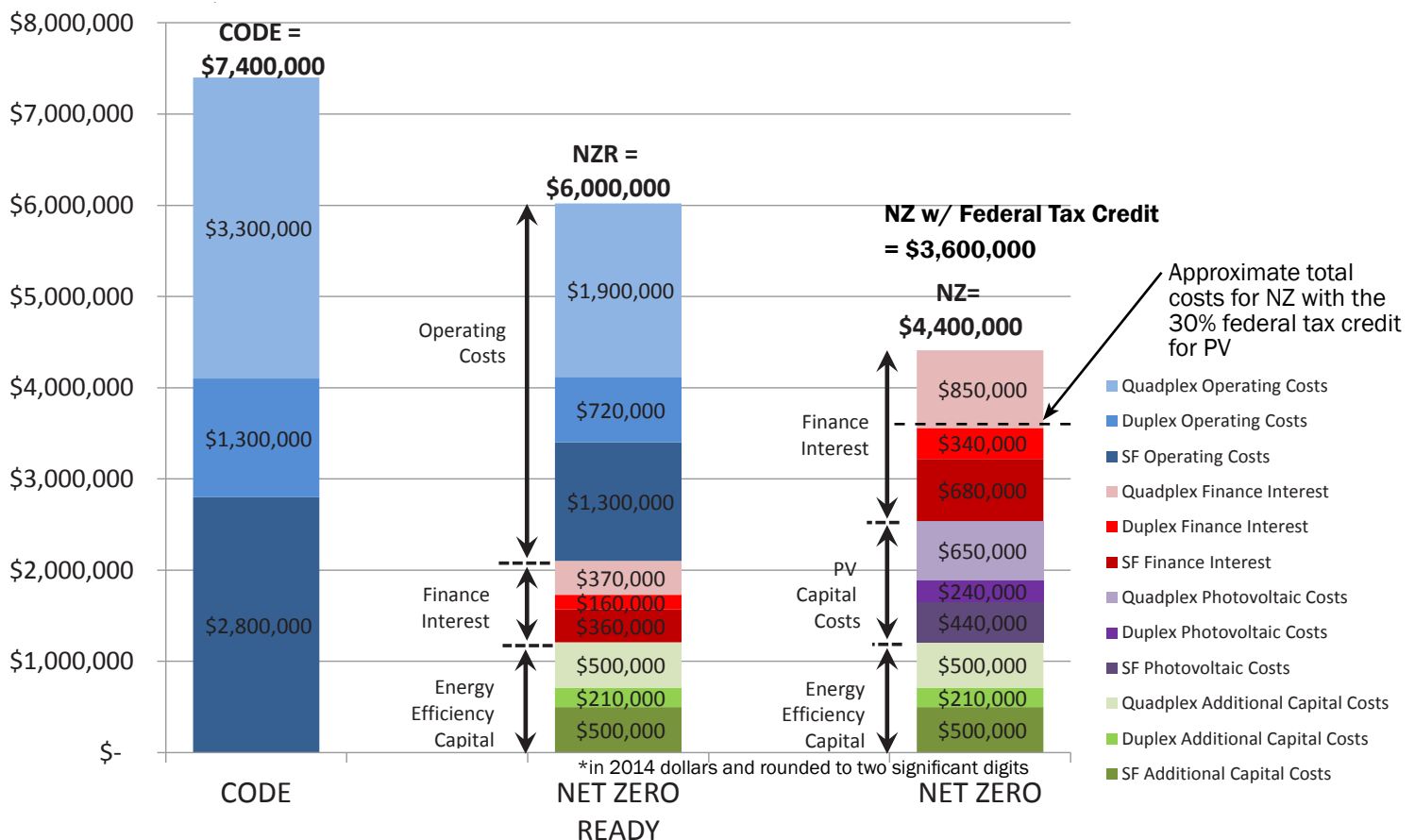


Figure 21: Cumulative community residential 30-year capital, operating and finance costs

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 22.

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.

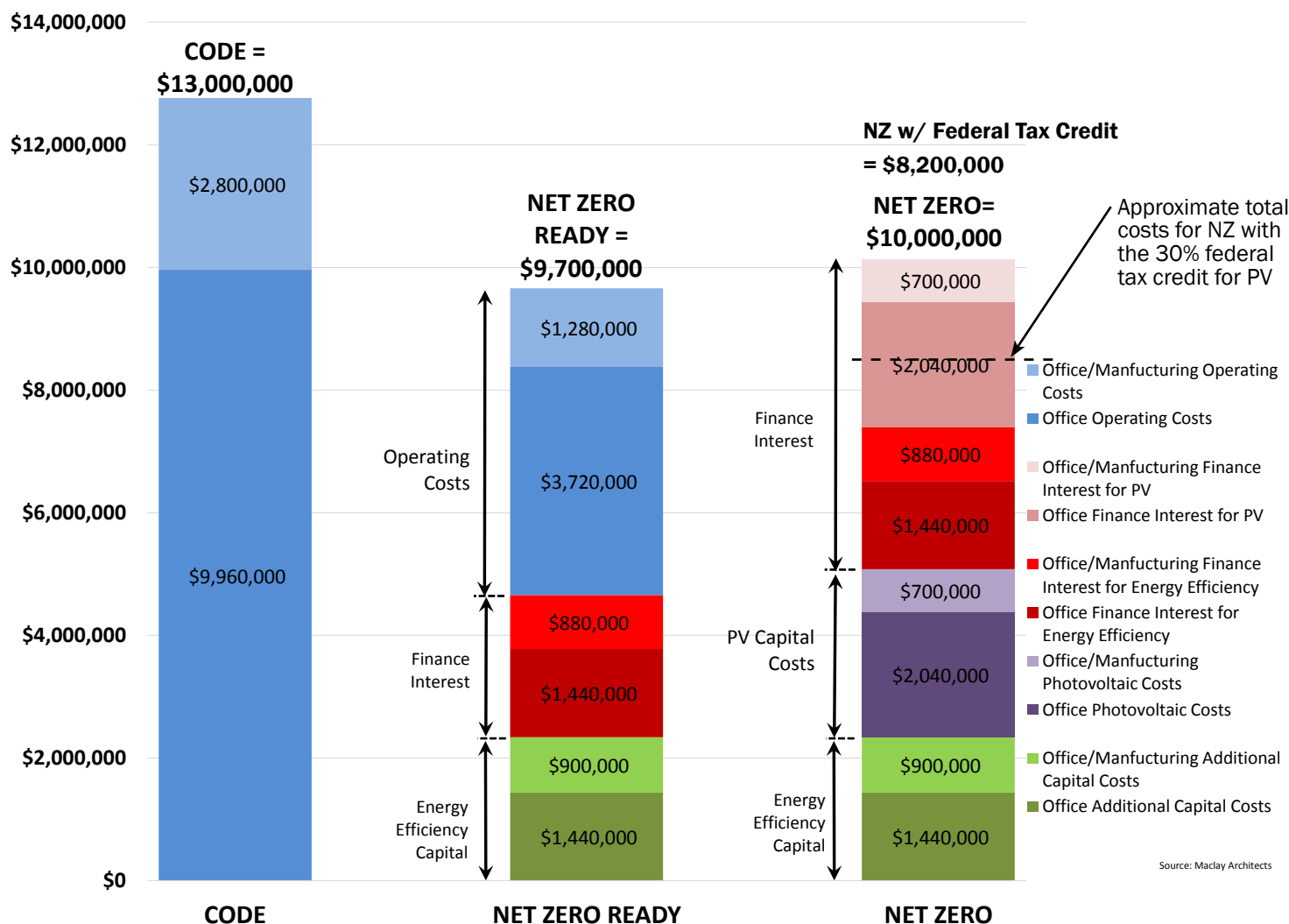


Figure 22: Cumulative community commercial 20-year capital, operating and finance costs

ADDITIONAL INFORMATION

For additional information please see the Net Zero Feasibility Full Report and Appendix,
or you can contact Laura Bailey at Maclay Architects (www.maclayarchitects.com)
or Paul Duane at Efficiency Vermont (<https://www.efficiencyvermont.com/About-Us/White-Papers>)

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

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