

TO Travis Anderson (Boston Planning & Development Agency)

FROM Thornton Tomasetti

DATE February 22, 2024

RE MA Stretch and Specialized Code Projects and BERDO 2.0

NOTE: Project names in this document have been made anonymous and withheld for confidentiality purposes.

This memo summarizes the analysis to quantify the financial cost of meeting the Building Emissions Reduction and Disclosure Ordinance (BERDO) 2.0 emissions targets (Appendix A) for projects that are designed to meet the 225 CMR 23 Massachusetts Stretch Energy Code and Specialized Opt-in Code.

There are three ways projects can meet BERDO 2.0 if they are over the emissions limits: purchase Massachusetts Class 1 Renewable Energy Certificates (RECs), install on-site renewable photovoltaic (PV) energy, or pay the BERDO Alternative Compliance Payment. Mixed fuel projects can also fully electrify to reduce emissions.

This study aims to answer the following questions:

1. How do the case studies' energy usage compare to the BERDO 2.0 emissions limits over time?
2. What is the financial cost of complying with BERDO 2.0 via RECs, on-site renewables and Alternative Compliance Payments over time?
3. Which BERDO 2.0 compliance method provides the least financial burden?

Executive Summary

- Most projects, except for some multifamily residential, healthcare and technology/science projects, will comply with BERDO 2.0 until 2045. Once a project exceeds the BERDO emissions limit, it will be required to offset emissions by selecting one of the three compliance methods.
- To comply with BERDO Zero in 2024 (i.e. offsetting 100% of annual operating carbon emissions), Massachusetts Class 1 RECs is the least expensive compliance method. To meet the emissions targets in 2040 to 2050, Alternative Compliance Payments is the least expensive compliance method.
- Electrifying buildings to comply with BERDO is financially prohibitive compared to other compliance methods.

The case study data included in this study are provided by Thornton Tomasetti, BR+A and the Boston Planning & Development Agency (BPDA). To capture a variety of sample projects for different building types, we included projects both located within Boston and from other Massachusetts communities. While they are not all subject to BERDO requirements, the projects included in this analysis are designed in accordance with the 225 CMR 23 Massachusetts Stretch Energy Code or Specialized Opt-in Code. As more Boston-based projects are designed to meet the new energy code, we recommend expanding this analysis to include them.

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Carbon Emissions Over Time

Figures 1 to 7 present case study carbon emissions and the BERDO 2.0 emissions targets for each project type from 2024 to 2050. Projects will exceed the BERDO 2.0 emissions limits when their emissions lines cross above the red dashed line. The grid electricity emissions factors are based on the *BERDO Policies and Procedures* and they are given in Appendix B.

Most projects (except some multifamily residential, healthcare and technology/science projects) will comply with the BERDO 2.0 emissions targets until 2045, at which point, the projects will need to offset their emissions with one of the three methods mentioned previously.

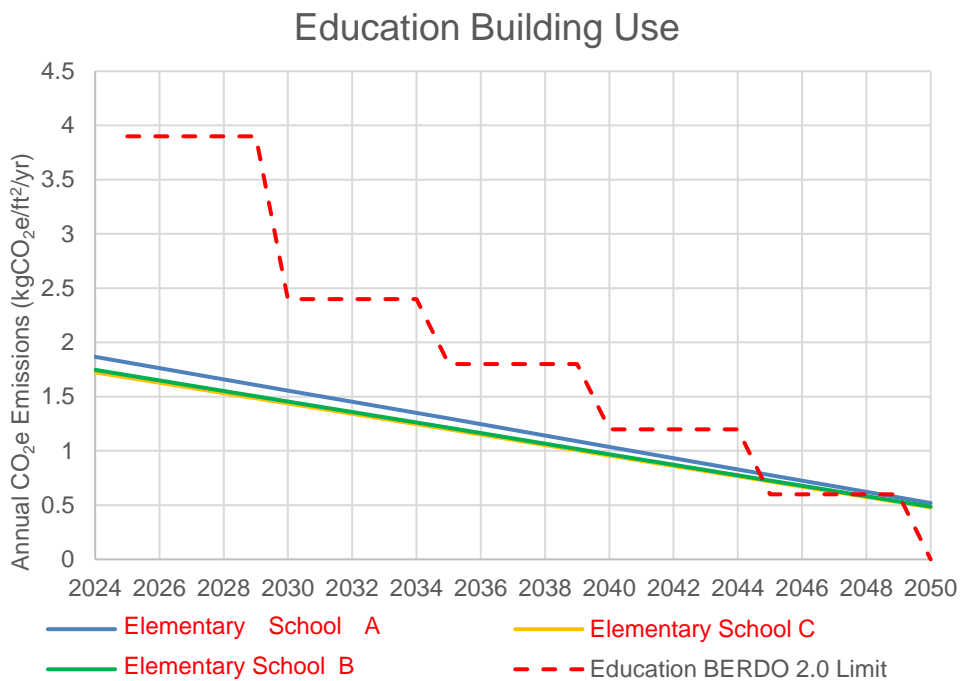


Figure 1: Education Project Type Emissions Graph

NOTE: Names and locations have been withheld

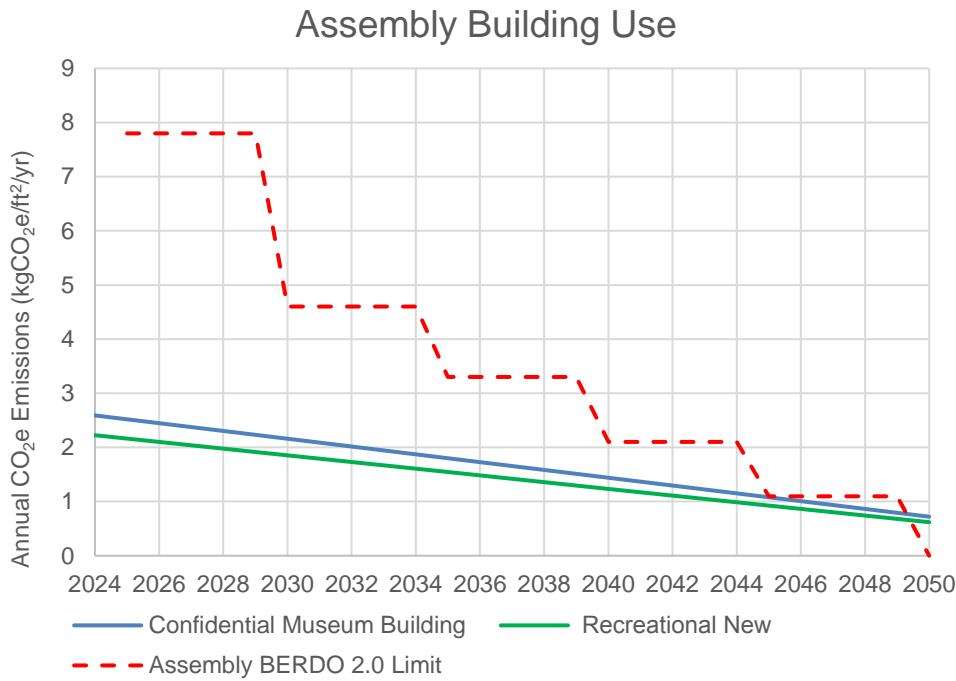


Figure 2: Assembly Project Type Emissions Graph

NOTE: Names and locations have been withheld

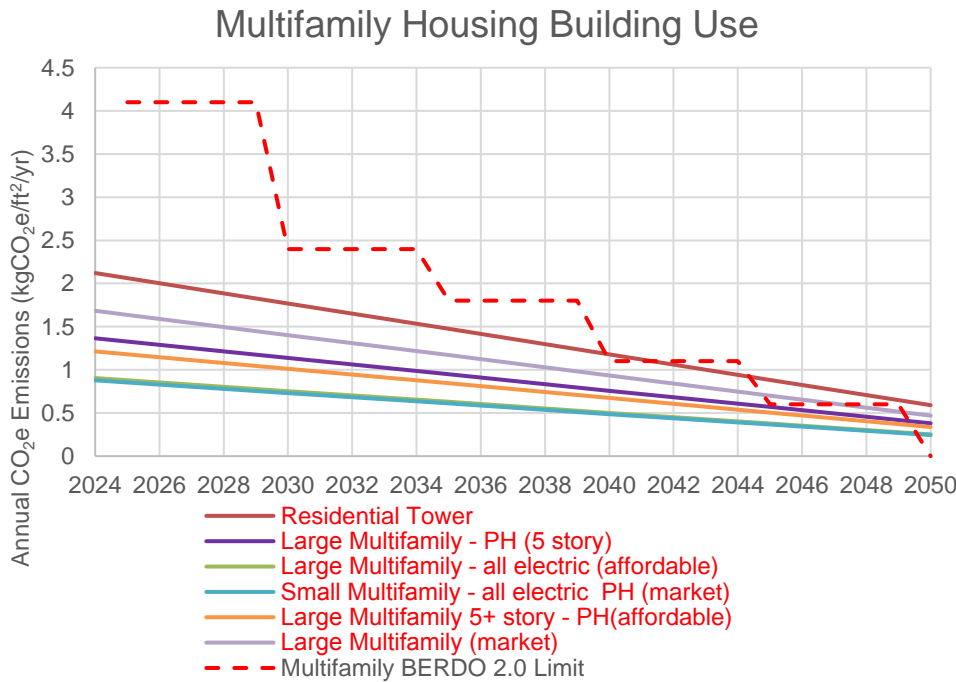


Figure 3: Multifamily Project Type Emissions Graph

NOTE: Names and locations have been withheld

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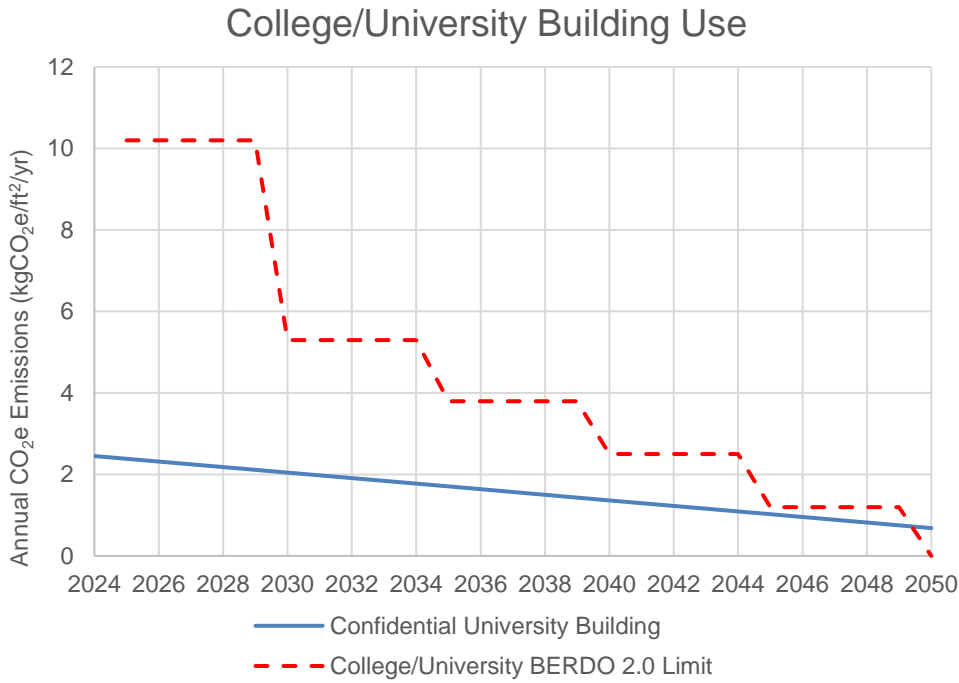


Figure 4: College/University Project Type Emissions Graph

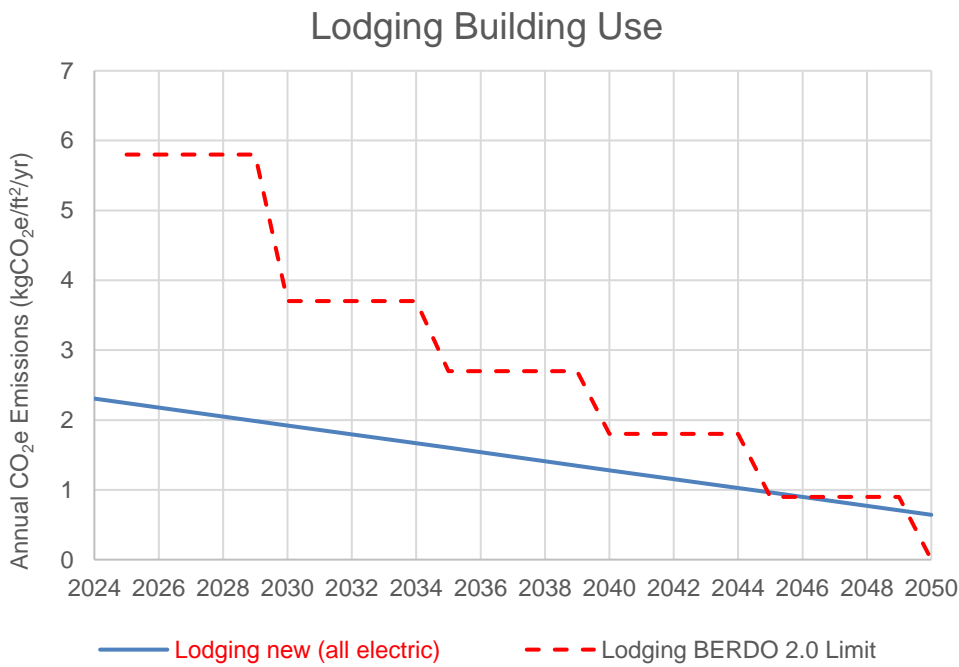


Figure 5: Lodging Project Type Emissions Graph

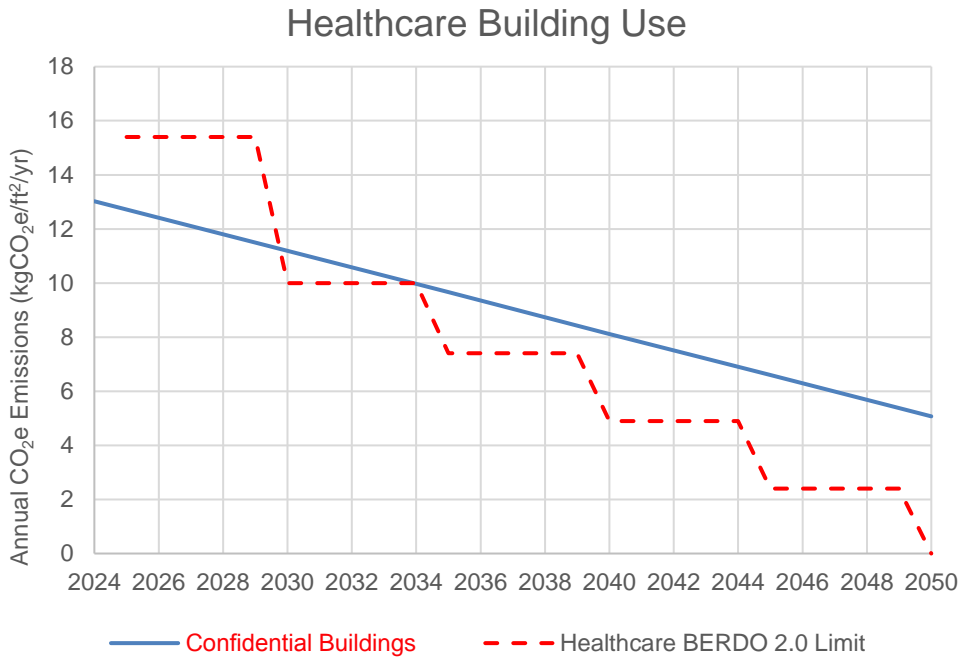


Figure 6: Healthcare Project Type Emissions Graph

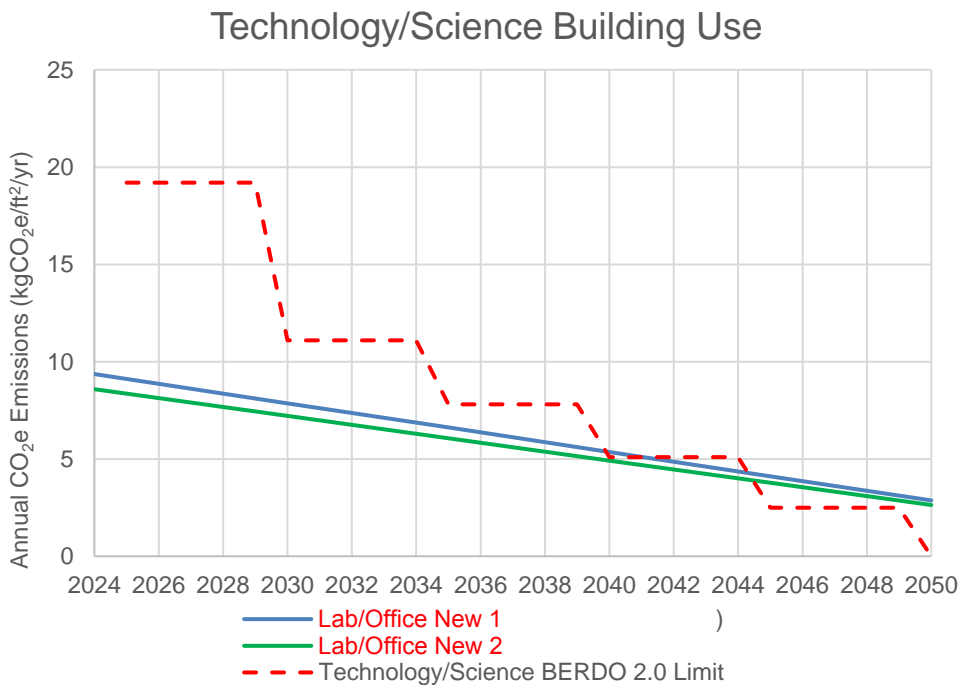


Figure 7: Technology/Science Project Type Emissions Graph

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Financial Cost of Meeting BERDO 2.0 Emissions Limits

The financial cost of complying with BERDO 2.0's emissions limits via each method is shown in Tables 1 to 3. The cost of Massachusetts Class 1 RECs of \$40/MWh is provided by the BPDA. The cost of PV of \$3,150/kW (including the 30% tax credit from the Inflation Reduction Act) is provided by Turner Construction. The cost of the BERDO 2.0 Alternative Compliance Payment of \$234 per metric ton is from the *Ordinance Amending City of Boston Code, Ordinances, Chapter VII, Sections 7-2.1 and 7-2.2, Building Energy Reporting and Disclosure (BERDO)*.

The BERDO Zero 2024 column presents the cost of meeting BERDO Zero in 2024 by offsetting 100% of annual operating carbon emissions. The 2040, 2045 and 2050 columns show the financial cost of meeting BERDO 2.0 for those years, when the operating emissions exceed the BERDO limits.

For mixed-fuel projects, the 2050 REC and PV costs are different from the BERDO Zero 2024 cost because the grid electricity emissions factor decreases in the future whereas the gas emissions factor remains constant.

Figures 8, 9 and 10 graphically compares the cost of the three methods for three representative projects: Elementary School, Residential Tower, and P [•] Buildings. The figures illustrate the significant additional cost of utilizing on-site PVs compared to Mass Class 1 RECs and the BERDO 2.0 Alternative Compliance payments. They further illustrate how the cost of Mass Class 1 RECs and the BERDO 2.0 Alternative Compliance payments compare over time for each project.

Across all project types, Mass Class 1 RECs is the most economical option to achieve BERDO Zero in 2024. As the grid emissions factor reduces in the future, the most economical option to comply with BERDO 2.0 between 2040 and 2050 is via Alternative Compliance Payments.

Mixed fuel projects can also fully electrify to reduce emissions. The only projects that are mixed fuel in this analysis are S [•] G. At the cost of \$5,000 per ton for air source heat pumps (provided by Turner Construction), it will cost approximately \$3 to \$4 million each to fully electrify these projects. With much cheaper alternatives like Mass Class 1 RECs and Alternative Compliance Payment, fully electrifying projects to meet BERDO 2.0 is a significant financial burden.

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Table 1: Financial Analysis of BERDO – Mass Class 1 RECs

Project Name	Mass Class 1 RECs (\$) (BPDA: \$40/MWh)			
	BERDO Zero 2024	2040	2045	2050
Elementary School A	\$ 30,868	\$ -	\$ 7,058	\$ 30,868
Elementary School B	\$ 19,946	\$ -	\$ 3,285	\$ 19,946
Elementary School C	\$ 23,823	\$ -	\$ 4,187	\$ 23,823
Confidential Museum Building	\$ 11,243	\$ -	\$ -	\$ 11,243
Residential Tower	\$ 67,657	\$ 4,435	\$ 21,726	\$ 67,657
Recreation Center	\$ 10,857	\$ -	\$ -	\$ 10,857
Confidential University Building	\$ 40,634	\$ -	\$ -	\$ 40,634
Large Multifamily - PH (5 story)	\$ 13,063	\$ -	\$ -	\$ 13,063
Large Multifamily - PH (affordable)	\$ 8,139	\$ -	\$ -	\$ 8,139
Small Multifamily PH (market)	\$ 5,110	\$ -	\$ -	\$ 5,110
Large Multifamily 5+ PH(affordable)	\$ 60,747	\$ -	\$ -	\$ 60,747
Large Multifamily 5+ PH (market)	\$ 79,472	\$ -	\$ 11,485	\$ 79,472
Lodging Confidential(all electric)	\$ 22,200	\$ -	\$ 1,404	\$ 22,200
Hospital Buildings Confidential	\$ 2,324,885	\$ 1,035,461	\$ 1,797,279	\$ 3,251,934
Lab / Office 1	\$ 424,607	\$ 21,231	\$ 175,799	\$ 467,662
Lab/ Office 2	\$ 577,243	\$ -	\$ 205,827	\$ 636,464

Table 2: Financial Analysis of BERDO – PV

Project Name	Owner-owned PV (\$) (PV: \$3,150/kW)			
	BERDO Zero 2024	2040	2045	2050
Elementary School A	\$ 1,869,902	\$ -	\$ 427,571	\$ 1,869,902
Elementary School B	\$ 1,208,290	\$ -	\$ 199,000	\$ 1,208,290
Elementary School C	\$ 1,443,131	\$ -	\$ 253,614	\$ 1,443,131
Confidential Museum Building	\$ 681,088	\$ -	\$ -	\$ 681,088
Residential Tower	\$ 4,098,458	\$ 268,628	\$ 1,316,091	\$ 4,098,458
Recreation Center	\$ 657,654	\$ -	\$ -	\$ 657,654
Confidential University Building	\$ 2,461,461	\$ -	\$ -	\$ 2,461,461
Large Multifamily - PH (5 story)	\$ 791,337	\$ -	\$ -	\$ 791,337
Large Multifamily - PH (affordable)	\$ 493,032	\$ -	\$ -	\$ 493,032
Small Multifamily PH (market)	\$ 309,562	\$ -	\$ -	\$ 309,562
Large Multifamily 5+ PH(affordable)	\$ 60,747	\$ -	\$ -	\$ 3,679,864
Large Multifamily 5+ PH (market)	\$ 4,814,177	\$ -	\$ 695,713	\$ 4,814,177
Lodging Confidential(all electric)	\$ 1,344,805	\$ -	\$ 85,047	\$ 1,344,805
Hospital Buildings Confidential	\$ 140,834,370	\$ 62,725,023	\$ 108,873,647	\$ 196,992,178
Lab / Office 1	\$ 25,721,405	\$ 1,286,130	\$ 10,649,376	\$ 28,329,497
Lab/ Office 2	\$ 34,967,628	\$ -	\$ 12,468,374	\$ 38,555,058

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Table 3: Financial Analysis of BERDO – Alternative Compliance Payment

Project Name	BERDO Alternative Compliance Payment (\$) (\$234 per metric ton)			
	BERDO Zero 2024	2040	2045	2050
Elementary School A	\$ 46,197	\$ -	\$ 4,401	\$ 12,860
Elementary School B	\$ 29,851	\$ -	\$ 2,049	\$ 8,310
Elementary School C	\$ 35,653	\$ -	\$ 2,611	\$ 9,925
Confidential Museum Building	\$ 16,827	\$ -	\$ -	\$ 4,684
Residential Tower	\$ 101,255	\$ 3,683	\$ 13,548	\$ 28,186
Recreation Center	\$ 16,248	\$ -	\$ -	\$ 4,523
Confidential University Building	\$ 60,812	\$ -	\$ -	\$ 16,928
Large Multifamily - PH (5 story)	\$ 19,550	\$ -	\$ -	\$ 5,442
Large Multifamily - PH (affordable)	\$ 12,181	\$ -	\$ -	\$ 3,391
Small Multifamily PH (market)	\$ 7,648	\$ -	\$ -	\$ 2,129
Large Multifamily 5+ PH(affordable)	\$ 60,747	\$ -	\$ -	\$ 25,307
Large Multifamily 5+ PH (market)	\$ 118,937	\$ -	\$ 7,162	\$ 33,108
Lodging Confidential(all electric)	\$ 33,224	\$ -	\$ 875	\$ 9,249
Hospital Buildings Confidential	\$ 3,479,386	\$ 860,003	\$ 1,120,742	\$ 1,354,764
Lab / Office 1	\$ 635,461	\$ 17,634	\$ 109,624	\$ 194,829
Lab/ Office 2	\$ 863,893	\$ -	\$ 128,349	\$ 265,153

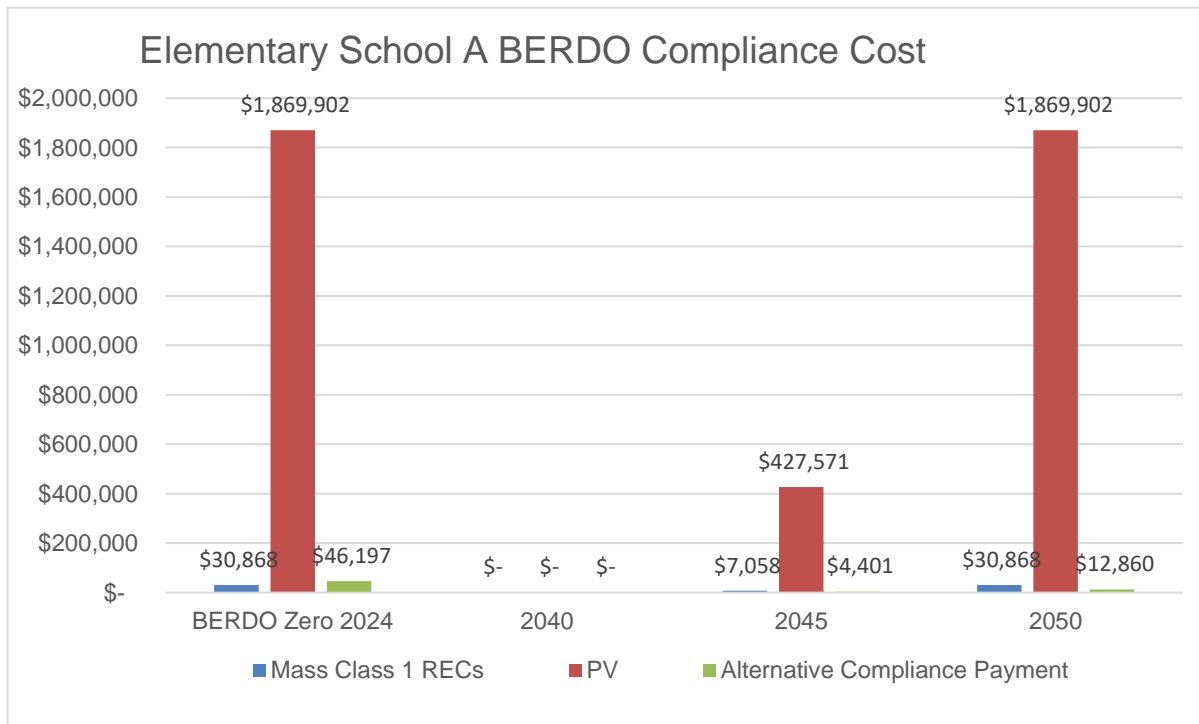


Figure 8: Elementary School iA BERDO Compliance Cost Comparison

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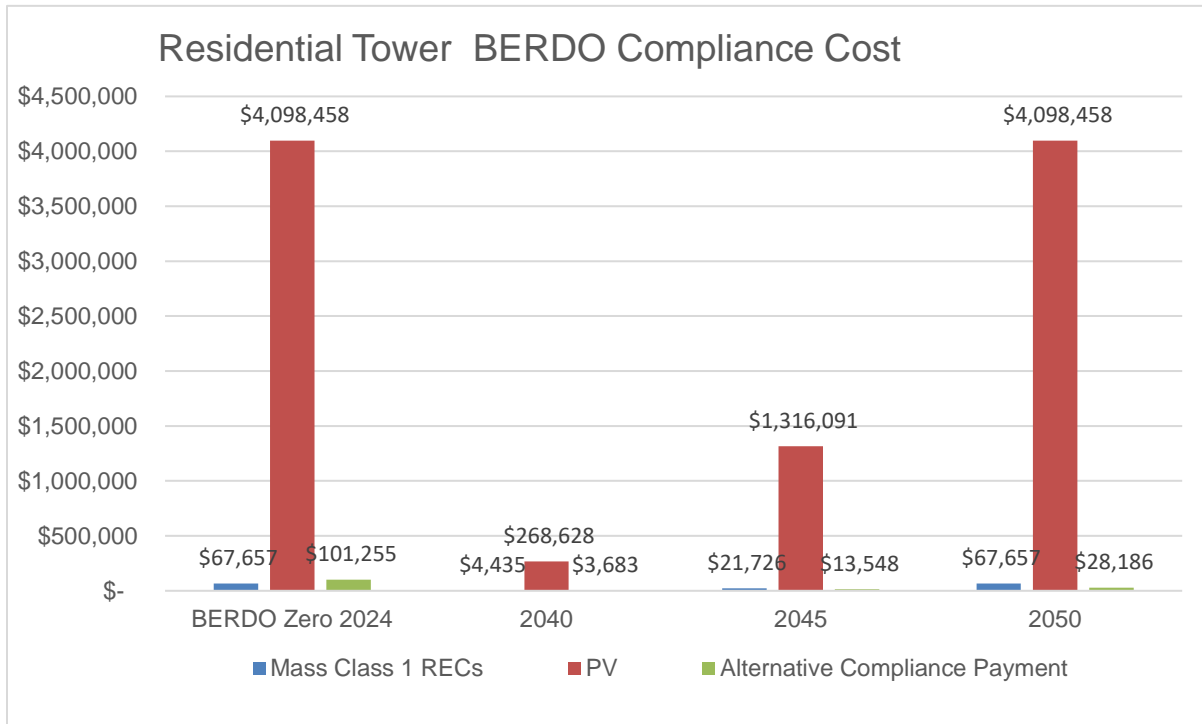


Figure 9: Residential Tower in Everett BERDO Compliance Cost Comparison

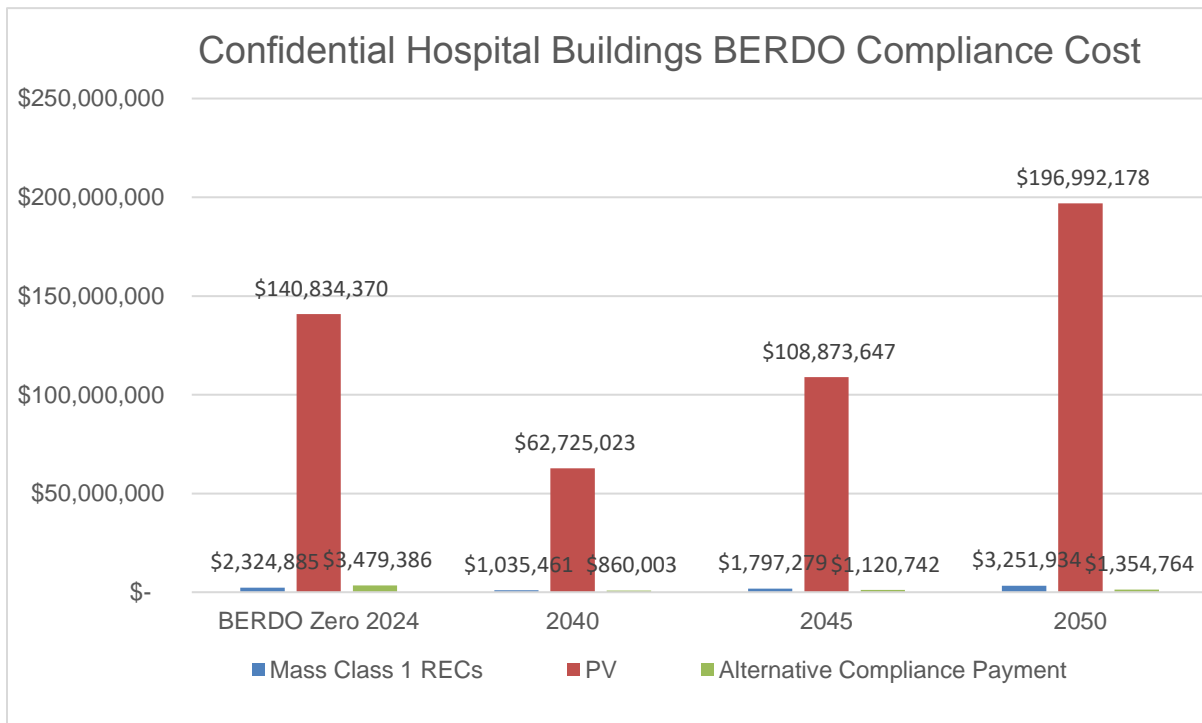


Figure 10: Confidential Hospital Buildings BERDO Compliance Cost Comparison

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Study Assumptions and Limitations

All projects included in the analysis are currently in design. Thus, the operational energy usage for each project used in this analysis is modeled and not measured usage. This analysis assumes that the operational energy usage is constant across the years. The analysis further assumes constant costs for the RECs, PV, and Alternative Compliance Payments over time. Discount rates and escalation rates are not included in this analysis. Should further analysis take place, we recommend taking into account the changes in energy usage, costs, discount and escalation rates over time.

Conclusions

This analysis shows that most projects that are designed to meet the 225 CMR 23 Massachusetts Stretch Energy Code and Specialized Opt-in Code will comply with the BERDO 2.0 emissions limits through the year 2045. Some multifamily residential, healthcare and technology/science projects included in the study exceed the emissions limits prior to 2045.

For most projects, Mass Class 1 RECs is the least expensive method of complying with BERDO Zero for 2024, offsetting 100% of the project's energy usage. Alternative Compliance Payments become the least expensive method for complying from 2040 to 2050.

The cost of installing on-site PVs far exceeds the cost of the other two alternative methods of compliance. Similarly, for buildings with mixed fuel usage, the cost of electrification far exceeds the cost of the alternative compliance methods.

Appendices

- Appendix A – BERDO 2.0 Emissions Targets
- Appendix B – Projected Grid Emissions Factors
- Appendix C – Raw Analysis Data

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Appendix A – BERDO 2.0 Emissions Targets

Building use	Emissions standard (kgCO ₂ e/SF/yr.)					
	2025 - 2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-
<u>Assembly</u>	7.8	4.6	3.3	2.1	1.1	0
<u>College/ University</u>	10.2	5.3	3.8	2.5	1.2	0
<u>Education</u>	3.9	2.4	1.8	1.2	0.6	0
<u>Food Sales & Service</u>	17.4	10.9	8.0	5.4	2.7	0
<u>Healthcare</u>	15.4	10.0	7.4	4.9	2.4	0
<u>Lodging</u>	5.8	3.7	2.7	1.8	0.9	0
<u>Manufacturing/</u>	23.9	15.3	10.9	6.7	3.2	0
<u>Industrial</u>						
<u>Multifamily housing</u>	4.1	2.4	1.8	1.1	0.6	0
<u>Office</u>	5.3	3.2	2.4	1.6	0.8	0
<u>Retail</u>	7.1	3.4	2.4	1.5	0.7	0
<u>Services</u>	7.5	4.5	3.3	2.2	1.1	0
<u>Storage</u>	5.4	2.8	1.8	1.0	0.4	0
<u>Technology/Science</u>	19.2	11.1	7.8	5.1	2.5	0

(Source: Ordinance Amending City of Boston Code, Ordinances, Chapter VII, Sections 7-2.1 and 7-2.2, Building Energy Reporting and Disclosure (BERDO))

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Appendix B – Projected Grid Emissions Factors

PROJECTED GRID EMISSIONS FACTORS

Year	Projected Grid Emissions Factor (lb/MWh)
2022	595
2023	580
2024	564
2025	548
2026	533
2027	517
2028	501
2029	486
2030	470
2031	454
2032	439
2033	423
2034	407
2035	392
2036	376
2037	360
2038	345
2039	329

Year	Projected Grid Emissions Factor (lb/MWh)
2040	313
2041	298
2042	282
2043	266
2044	251
2045	235
2046	219
2047	204
2048	188
2049	172
2050	157

Source: These projected Emissions Factors were prepared by Synapse as part of the development process of the BERDO Emissions standards. See complete report [here](#).

(Source: *BERDO Policies & Procedures – Air Pollution Control Commission Adopted December 20, 2023 Version 2.5*)

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Appendix C – Raw Analysis Data

Project Name	Building Use	Location	Heating Type	Project Area (ft²)	Phase	Data Source	Code	Annual Electricity Usage (kWh)	Annual Gas Usage (MMBtu)	For projects NOT all-electric...					Annual CO ₂ e Emissions (kgCO ₂ e/ft²/yr)					Annual GHG over BERDO 2.0 Limit (kgCO ₂ e/ft²/yr)				Mass Class 1 RECs (\$) (BPDA: \$40/MWh)				Owner-owned PV (\$) (PV: \$3.150/kW)				BERDO Alternative Compliance Payment (\$) (\$234 per metric ton)			
										Peaking Heating (MBH)	Heat Pump heating capacity (MBH)	Upgrade to 100% Heat Pump cost (\$)	2024	2030	2035	2040	2045	2050	2040	2045	2050	BERDO Zero 2024	2040	2045	2050	BERDO Zero 2024	2040	2045	2050	BERDO Zero 2024	2040	2045	2050		
																																		2024	2030
Education			GSHP	105,750	CD	TT	Specialized	771,707	0	1.866881	1.555734	1.297548	1.036053	0.777867	0.519681	0	0.177866937	0.519681315	\$ 30,868	\$ -	\$ 7,058	\$ 30,868	\$ 1,869,902	\$ -	\$ 427,571	\$ 1,869,902	\$ 46,197	\$ -	\$ 4,401	\$ 12,860					
Education			GSHP	74,000	DD	TT	Specialized	498,660	0	1.723922	1.436602	1.198187	0.956716	0.718301	0.479886	0	0.118301009	0.479886206	\$ 19,946	\$ -	\$ 3,285	\$ 19,946	\$ 1,208,290	\$ -	\$ 199,000	\$ 1,208,290	\$ 29,851	\$ -	\$ 2,049	\$ 8,310					
Education			GSHP	87,214	SD	TT	Stretch	595,579	0	1.747019	1.455849	1.21424	0.969534	0.727925	0.486316	0	0.127924747	0.486315682	\$ 23,823	\$ -	\$ 4,187	\$ 23,823	\$ 1,443,131	\$ -	\$ 253,614	\$ 1,443,131	\$ 35,653	\$ -	\$ 2,611	\$ 9,925					
Assembly			VRF	27,756	DD	TT	Specialized	281,084	0	2.590744	2.158953	1.800659	1.437771	1.079477	0.721182	0	0.721182277	\$ 11,243	\$ -	\$ -	\$ 11,243	\$ 681,088	\$ -	\$ -	\$ 681,088	\$ 16,827	\$ -	\$ -	\$ 4,684						
Multifamily housing			VRF	204,000	DD	TT	Stretch	1,691,431	0	2.121136	1.767613	1.474265	1.177155	0.883807	0.590458	0.077155201	0.283806621	0.59045804	\$ 67,657	\$ 4,435	\$ 21,726	\$ 67,657	\$ 4,098,458	\$ 268,628	\$ 1,316,091	\$ 4,098,458	\$ 101,255	\$ 3,683	\$ 13,548	\$ 28,186					
Assembly			VRF	31,200	CD	TT	Stretch	271,413	0	2.225465	1.854554	1.546777	1.235054	0.927277	0.6195	0	0.619500018	\$ 10,857	\$ -	\$ -	\$ 10,857	\$ 657,654	\$ -	\$ -	\$ 657,654	\$ 16,248	\$ -	\$ -	\$ 4,523						
College/University			ASHP	106,000	SD	TT	Specialized	1,015,843	0	2.451688	2.043073	1.79401	1.3606	1.021537	0.692473	0	0.692473458	\$ 40,634	\$ -	\$ -	\$ 40,634	\$ 2,461,461	\$ -	\$ -	\$ 2,461,461	\$ 60,812	\$ -	\$ -	\$ 16,928						
Multifamily housing	Boston, MA		BPDA	61,204				326,584	0	1.365085	1.137571	0.948782	0.757574	0.568785	0.379997	0	0.379996972	\$ 13,063	\$ -	\$ -	\$ 13,063	\$ 791,337	\$ -	\$ -	\$ 791,337	\$ 19,550	\$ -	\$ -	\$ 5,442						
Multifamily housing	Boston, MA		BPDA	57,576				203,474	0	0.904091	0.753409	0.628375	0.501738	0.376704	0.251671	0	0.251670593	\$ 8,139	\$ -	\$ -	\$ 8,139	\$ 493,032	\$ -	\$ -	\$ 493,032	\$ 12,181	\$ -	\$ -	\$ 3,391						
Multifamily housing	Boston, MA		BPDA	37,232				127,756	0	0.877828	0.731523	0.610122	0.487163	0.365762	0.24436	0	0.244359922	\$ 5,110	\$ -	\$ -	\$ 5,110	\$ 309,562	\$ -	\$ -	\$ 309,562	\$ 7,648	\$ -	\$ -	\$ 2,129						
Multifamily housing	Boston, MA		BPDA	320,279				1,518,677	0	1.213058	1.010881	0.843118	0.673204	0.505441	0.337677	0	0.337677396	\$ 60,747	\$ -	\$ -	\$ 60,747	\$ 3,679,864	\$ -	\$ -	\$ 3,679,864	\$ 90,913	\$ -	\$ -	\$ 25,307						
Multifamily housing	Boston, MA		BPDA	301,961				1,986,807	0	1.683253	1.402711	1.16992	0.934146	0.701355	0.468565	0.101355287	0.468565021	\$ 79,472	\$ -	\$ 11,485	\$ 79,472	\$ 4,814,177	\$ -	\$ 695,713	\$ 4,814,177	\$ 118,937	\$ -	\$ 7,162	\$ 33,108						
Lodging	Boston, MA		BPDA	61,576				555,000	0	2.305823	1.921519	1.602629	1.27965	0.96076	0.641869	0.060759656	0.641869217	\$ 22,200	\$ -	\$ 1,404	\$ 22,200	\$ 1,344,805	\$ -	\$ 85,047	\$ 1,344,805	\$ 33,224	\$ -	\$ 875	\$ 9,249						
Healthcare	Boston, MA		BPDA	1,141,734				49,182,000	43,064	13.02333	11.18664	9.662584	8.118987	6.59493	5.070873	3.21898747	4.194930364	5.070873258	\$ 2,324,885	\$ 1,035,461	\$ 1,797,279	\$ 3,251,934	\$ 140,834,370	\$ 62,725,023	\$ 108,873,647	\$ 196,992,178	\$ 3,479,386	\$ 860,003	\$ 1,120,742	\$ 1,354,764					
Technology/Science	Boston, MA		ASHP+gas fir	290,000	SD	BR+A	Stretch	10,200,000	2,000	9.36429	7.864621	6.620215	5.359855	4.115448	2.871042	0.259854549	1.615448359	2.871042168	\$ 424,607	\$ 21,231	\$ 175,799	\$ 467,662	\$ 25,721,405	\$ 1,286,130	\$ 10,649,376	\$ 28,329,497	\$ 635,461	\$ 17,634	\$ 109,624	\$ 194,829					
Technology/Science	Boston, MA		ASHP+gas fir	430,000	SD	BR+A	Stretch	13,860,000	2,751	8.585703	7.211383	6.079889	4.915975	3.775582	2.635188	0	1.275581659	2.635188079	\$ 577,243	\$ -	\$ 205,827	\$ 636,464	\$ 34,967,628	\$ -	\$ 12,468,374	\$ 38,555,058	\$ 863,893	\$ -	\$ 128,349	\$ 265,153					