Guidelines: Zero-Emission Cost-Benefit Analysis Report

As part of the Phase II application package, this document provides guidelines for the required analysis of the estimated cost difference between the zero-emission build-out compared to standard building design, construction, and operations. Standard building design refers to the design that achieves minimum requirements on energy savings according to California's 2022 Building Energy Efficiency Standards (Title 24, Part 6), effective January 1, 2023.

Applicants are required to report two categories of costs for the **residential units** of the mixed-use developments: **incremental first cost** and **lifecycle cost from the residents' perspective.** Incremental first costs represent the additional costs for building features and energy equipment of the proposed design relative to the 2022 Title 24 minimum requirements. Lifecycle cost from the residents' perspective represents the net present value of the building, experienced by the residents over its 30-year lifetime. And finally, the project team may elect to analyze lifecycle cost from a societal perspective to account for the benefits of carbon emissions avoidance, which results from advanced building design and operation. The results from this analysis can be shown in the following table format:

Table 1: Comparison of Three Cost Categories

	Incremental First Cost per Unit ($/Unit)			Residents' Lifecycle cost (based on utility rates) ($)			**[Optional]** Societal Lifecycle cost (based on carbon emissions avoidance) ($)		
	Standard	Proposed	Savings	Standard	Proposed	Savings	Standard	Proposed	Savings
Purchase									
Rental									

1. **Incremental First Costs**

   This section will provide the estimates of the incremental first costs of the standard and proposed building and explanation of goals and challenges that the project experienced to reach the final design. Only the costs that increase or decrease due to proposed designs should be reported. The cost for each building element should include materials, labor, and installation. Indirect costs – such as overhead, profit, project/construction management, commissioning, should not be included in the first cost analysis.

   a) Provide a comparison of the first cost of **building features and construction method** for the standard vs. proposed building. The comparison may include, but is not limited to, number of stories, type of foundation, aspect ratio, window-to-wall ratio, framing material, conditioned and unconditioned areas, type of insulation, etc.

   Table 2: Sample comparison of the incremental first costs of **building features and construction methods**, standard vs. proposed design

Examples of Energy Features	Standard Design and Cost	Proposed Design and Cost	Incremental First Cost Increase (+) or Savings (-)
Exterior Wall Construction and Insulation	2x6 R-19 16" OC	2x6 R-21 16"OC	$6,686
	$21,435	$28,121	

Foundation type and insulation			
Glazing			
Other energy features			
Total Incremental Cost Increase (+) or Savings (-) for the development			
Incremental cost per residential unit ($/sf)			

Source of examples: Klammer, Noah, et al. (2021). Decarbonization During Predevelopment of Modular Building Solutions. NREL/TP-5500-81037. National Renewable Energy Laboratory. December 2021

Discussion: Provide comments on how the design teams arrived at the proposed design features and construction methods, what compromises have been made with respect to costs and other considerations.

b) Provide a comparison of the first costs of **energy features** for the standard vs. proposed building in the following format. Only energy features with incremental first costs or savings should be listed. See examples below from Denniston et al. (2022).

Table 3: Sample comparison of the incremental first costs of energy features, standard vs. proposed design

Examples of Energy Features	Standard Design and Cost ($/sf)	Proposed Design and Cost ($/sf)	Incremental First Cost Increase or Savings ($/sf) + means higher cost of proposed design -means cost savings
Electric service, Main breaker, and Main Panel	400 A Main panel	800 A main panel	$0.17/sf
	$0.18/sf	$0.35/sf	
Service water heating	Central gas boiler with storage tank and recirculation loop	Central heat pump water heater with recirculation loop	$0.48/sf
	$0.08/sf	$0.56/sf	
Fossil fuel infrastructure	Gas piping, values, meter, and venting	No gas infrastructure	($0.23)/sf
	$0.23/sf	$0/sf	
On-site renewable energy (RE) system	No on-site RE system	13 kW solar, including solar	$0.40/sf

		panels, BOS, and meter	
	$0/sf	$0.40/sf	
EV charging infrastructure (EVCI)	No EVCI	30 EVSE spaces+80 EV capable spaces, supporting electricity system	$10.70/sf
	$0/sf	$10.70/sf	
Total Incremental Cost Increase (+) or Savings (-) for the development ($/sf)			

Source: Denniston S., Burk Diana, et al., 2022. "Cost Study of the Building Decarbonization Code." New Buildings Institute and Natural Resources Defense Council, https://newbuildings.org/resource/cost-study-of-the-building-decarbonization-code/

Discussion: Provide comments on how the design teams arrived at the proposed energy features, what compromises have been made with respect to costs and other considerations.

2. Lifecycle Costs Analysis: Residents' Perspective

As the market for zero-emission buildings is still in its early stage, builders may experience a high incremental first cost, which is passed down to the residents, but the energy-efficient construction and equipment help lower the energy costs for the residents over the years. A lifecycle cost analysis provides a full picture of how energy savings are balanced against the initial cost and operation cost over the 30-year period.

This section will provide the lifecycle cost of the proposed development from the residents' perspectives. Net Present Value is used as the metric for measuring lifecycle cost, as detailed in the CEC's and DOE's methodologies. The net present value (NPV) metric is calculated from the sum of the discounted yearly net values over the 30-year lifetime of the property according to Equation 1.

$$\text{Lifecycle Cost} = \text{Net Present Value} = \sum_{t=0}^{30} \frac{(Cost-Benefit)_t}{(1+r)^t} \qquad \text{Equation 1}$$

where r is equal to the discount rate, and t (the analysis year) runs for 30 years

The lifecycle cost, or the net present value, of the proposed design is then compared with the net present value of the standard design. Because the initial cost of electrification may be high, compared to the Title 24-compliant design, the cost of the proposed design can be high in initial years. But high efficiency of the design, the use of DERs, and demand response measures can result in electricity cost savings over time. When the proposed design is more cost-effective than the standard design, the lifecycle cost of the proposed design will be negative.

Annual costs include the cost of owning the residential units for 30 years (if applicable), the cost of renting the residential unit (if applicable), capital cost of equipment, maintenance cost, replacement cost, utility bill payments for electricity (and natural gas cost for the standard case), payment to a third-party provider (if applicable).

Annual benefits include utility bill savings caused by the proposed design, the use of DERs for load serving and load shifting, demand response measures, tax deduction from mortgage interest payment and property tax payment (if applicable), and other incentives (if applicable).

For developments that have units available for both purchases and rentals, please provide the lifecycle cost analysis for both the representative owner and tenant of the residential units.

3) [Optional] Lifecycle cost from a societal perspective: Carbon Emissions Avoidance

To calculate the lifecycle cost of the proposed design from a societal perspective, the project team may elect to quantitatively estimate the value of carbon emissions saving over a 30-year period of the building lifetime. The sources of emission savings may come from embodied emissions avoidance and operational emissions avoidance. This monetization will provide an additional benefit on top of the utility bill savings.

The project team may refer to the societal cost of carbon ($/metric ton) for each analysis year as proposed by the Interagency Working Group on Social Cost of Greenhouse Gases (Whitehouse.gov, 2021)[1].

It should be noted that work is under way to account for a broader range of societal impacts of energy efficiency, DERs, and demand response measures. Societal costs of electricity consumption, which includes not only the climate change impacts of carbon emissions but also health impacts from air pollution, are currently proposed to be incorporated into Integrated Resource Planning for California (CPUC, 2022). However, the monetization of societal cost using carbon emission avoidance alone has shown to improve the economics of building electrification measures (Denniston et al., 2022; CPUC, 2022).

Applicants are encouraged to compare the lifecycle costs from the residents' perspectives vs. lifecycle costs from the societal perspective, as shown in Table 1.

Assumptions

To ensure consistency across applications, the following assumptions must be used in the calculation of the Net Present Value

Table 4: Required Assumptions

Item	Assumption	Explanation
Building lifetime	30 years	Assumed lifetime of buildings according to 2022 Title 24 code cycle.
Inflation rate	3%	Same as the discount rate required below.

[1] See the Appendix of this report for the carbon cost in 2020 dollars per metric tons of CO_2; More updated CO_2 costs are being considered by the EPA in this draft report, but these costs are not officially published yet.

Discount rate	3%	Same as the discount rate used in Interagency Working Group on Social Cost of Greenhouse Gases (2022).
Electricity rate escalation	Yearly rate from 2023 to 2052 Refer to Appendix 7.2.7 in California Energy Codes and Standards (2022)	California Energy Codes and Standards (2022), based on assumptions from CPUC 2021 En Banc hearings on utility cost (through 2030) and assumptions within 2022 TDV factors (after 2030).
Financing the residential units		
Down payment	10% of the incremental cost of the proposed design	Taylor et al. (2015) and Denniston et al. (2022)
Mortgage Fee	0.6% of the total mortgage amount	Taylor et al. (2015) and Denniston et al. (2022)
Mortgage interest rate	5% per year	Taylor et al. (2015) and Denniston et al. (2022), based on the average historical interest rate for 30-year mortgage loans
Property tax	Use the property tax rate of the city in which the property is located. Apply a home price escalation rate of 1.6%	
Tax credit		Denniston et al. (2022)
Net Energy Metering (if applicable)	NEM 3.0	

Other assumptions that are not listed in the Table above should be included in an attachment with explanations why they are chosen, along with cited sources.

References

California Energy Codes and Standards (2022). 2022 Cost-Effectiveness Study: Single Family New Construction. Revision 1.0. Prepared by Frontier Energy, Inc. and Misri Bruceri & Associates, LLC. for PG&E, SCE, and SDG&E. https://localenergycodes.com/download/1240/file_path/fieldList/2022%20Single%20Family%20NewCon%20Cost-eff%20Study.pdf

CEC (2020a). Final 2022 TVD Methodology Report. California Energy Commission. https://efiling.energy.ca.gov/getdocument.aspx?tn=233345

CEC (2020b). TDV 2022 Updated Model. California Energy Commission https://www.energy.ca.gov/files/tdv-2022-update-model

CPUC. (2022). Societal Cost Test Impact Evaluation. CPUC Staff Report on the Impact of a Societal Cost Test on Resource Procurement (January 2022), https://www.ethree.com/wp-content/uploads/2022/01/CPUC-SCT-Report-FINAL.pdf

Denniston S., Burk Diana, et al., 2022. Cost Study of the Building Decarbonization Code. New Buildings Institute and Natural Resources Defense Council, https://newbuildings.org/resource/cost-study-of-the-building-decarbonization-code/

Klammer, Noah, et al. (2021). Decarbonization During Predevelopment of Modular Building Solutions. NREL/TP-5500-81037. National Renewable Energy Laboratory. December 2021

Taylor, ZT, et al., 2015. Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes. U.S. DOE. Prepared by Pacific Northwest Laboratory, https://www.energycodes.gov/methodology

Wei, Max, et al., 2021. Approaches to Zero Net Energy Cost Effectiveness for New Homes. Final Project Report CEC-500-2021-025, https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2021-025.pdf

https://eta-publications.lbl.gov/sites/default/files/77._approaches_to_zne_cost_effective_homes.pdf

Whitehouse.gov. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates under Executive Order 13990. Interagency Working Group on Social Cost of Greenhouse Gases (February 2021), https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf