A **Benefit-Cost Analysis of the Energy Efficiency and Renewable Energy Standards** in the Washington State Housing Finance Commission's Bond / 4% Low-Income Housing Tax Credit Program

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WASHINGTON STATE HOUSING FINANCE COMMISSION

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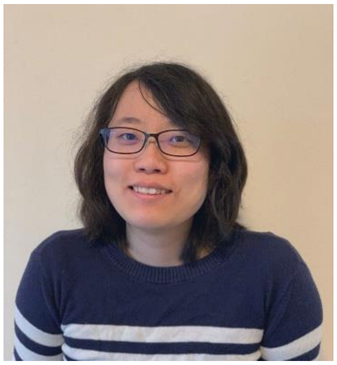
About the Authors



Victoria Chow grew up in Southern California and attended University of California, Riverside for her BA in economics. After three years as an accountant at a community-based non-profit, she decided to pursue an MPA at UW's Evans School of Public Policy. Her interest in housing policy drove her to join the 2020-21 cohort of HDC interns, with Plymouth Housing as her host organization. After graduation, she hopes to continue working in the housing and homelessness sphere to do her part in solving one of our most pressing public policy challenges.

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Acronyms

AMI	Area Median Income
BCA	Benefit-Cost Analysis
CDFI	Community Development Finance Institution
EE	Energy Efficiency
EEB	Energy Efficient Building
EERE	Energy Efficiency and Renewable Energy
ELI	Extremely Low Income
EPA	US Environmental Protection Agency
ESA	Energy Service Agreement
ESDS	Evergreen Sustainable Development Standard
ESPC	Energy Service Performance Contract
GHG	Greenhouse Gas
GSEs	Government Sponsored Entities
HFAs	Housing Finance Agencies
HUD	US Department of Housing and Urban Development
HVAC	Heating, Ventilation, and Air Conditioning
IRR	Internal Rate of Return
IRS	Internal Revenue Service
kWh	Kilowatt-hour
LIHTC	Low-Income Housing Tax Credit
MadBoy	Madison & Boylston
MF	Multifamily
NEB	Non-Energy Benefits
NPV	Net Present Value
NYGB	New York Green Bank
OBF	On-Bill Financing
PACE	Property Assessed Clean Energy
PBRA	Project-Based Rental Assistance
QAP	Qualified Allocation Plan
RE	Renewable Energy
RLF	Revolving Loan Fund
SEO	State Energy Office
WSEC	Washington State Energy Code
WSHFC	Washington State Housing Finance Commission
WTP	Willingness to Pay

Key Terminology

Cost-Burdened Renters - Cost-burdened renters are defined as those spending 30% or more of their income on rent.

Extremely Low-Income Renters - Those with household incomes are at or below the poverty guideline or 30% of their area median income.

Qualified Allocation Plan (QAP) - Defines the state Housing Financing Agencies' (HFAs) priorities and criteria to allocate low-income housing tax credits to eligible developers.

Low Income Housing Tax Credits - These are available through two different programs. The **9% Low Income Housing Tax Credit Program** gives an affordable housing project access to equity through partnerships, in which one partner typically buys the tax credits, putting equity in the project; the other partner(s) typically own and develop the project. The **Bond / 4% Tax Credit Program** provides fewer tax credits and can only be accessed through using tax-exempt bonds.

Benefit-Cost Analysis (BCA) - This is an economic tool to evaluate the social benefits and costs of a governmental policy or program. This type of analysis places a monetary value on all impacts from a given policy.

Standing - In a BCA, it's important to define whose benefits and costs count. Often programs and policies expand further than city, state, or even national boundaries. Therefore, for a BCA it is necessary to define the population of people that are impacted through the program or policy.

Willingness to pay (WTP) - This is the maximum price a customer or consumer is willing to pay for a product or service. They may be willing to pay less but it is unlikely that they would pay more.

Discount Rate - Money today has more value than it does tomorrow. This value of time in the context of money is measured by the discount rate. Individuals, businesses, and governments all use discount rates to valuate short- and long-term investments.

Net Present Value (NPV) - The NPV looks at all of the money you expect to make from an investment and translates those returns into today's dollars. This metric supports the decision-making process for long-term investments.

Internal Rate of Return (IRR) - This is a metric used in capital budgeting when calculating the NPV. It is the discount rate that makes the NPV of all cash flows from a project equal to zero. This is used in a financial analysis to estimate the profitability of a potential investment.

Sensitivity Analysis - A sensitivity analysis, through the application Crystal Ball, gives a probability distribution of potential outcomes (NPVs), allowing for variation in input parameters.

Residual Value - This is the estimated value of a fixed asset, i.e. housing, at the end of its useful life. As the Commission's bond contract is for 30 years, this study will assess the value of the property at the end of the bond's contract.

Kilowatt hour (kWh) - A kilowatt hour is a unit of energy that equates to one kilowatt of power sustained for one hour. Kilowatt hours are generated from a variety of energy sources (coal, nuclear, hydro, wind, solar, geothermal) and are then transmitted regionally to homes, businesses, and schools. Electric utilities, such as Seattle City Light, use this form of measurement to price electricity in units of dollars per kWh.

Therm - A therm is a measurement of the amount of heat energy in natural gas and is the standard unit of measurement for residential, commercial, and industrial natural gas usage in the United States. Natural gas is extracted from shale and other sedimentary rock formations through the process called hydraulic fracturing or fracking. On a utility bill, natural gas is priced in units of dollars per therm.

Energy Efficiency (EE) - Energy efficiency means using less energy to perform the same task. For buildings, it can include installing more efficient equipment including, but not limited to, lighting, insulation, windows, and building materials.

Renewable Energy (RE) - Renewable energy comes from natural sources, like solar, wind, hydro, tidal, geothermal, and biomass, that are constantly replenished. Each of these natural sources can be converted into energy and transmitted from central or decentralized sources to power homes, businesses, and schools.

Non-Energy Benefit (NEB) - These benefits, often hard to quantify, are in addition to the energy savings from energy efficiency infrastructure. They are often separated between participant, utility, and societal benefits.

Greenhouse Gas (GHG) Emissions - GHG emissions include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6), that all trap heat in the atmosphere.[1] They are caused by burning fossil fuels (i.e. coal, petroleum, and natural gas) to produce energy to fuel our vehicles, power our homes, and industry.

Carbon Dioxide Equivalent (CO_2e) - This is a metric used to compare all the GHG emissions named above based on their global warming potential (GWP). The CO_2e for each greenhouse gas is calculated by converting the amount of their greenhouse gas to the equivalent amount of carbon dioxide using their GWP. For example, the GWP for methane and nitrous oxide is 25 and 298, respectively.

Note: The terms 'renters' and 'renter households' are used interchangeably to mean renter households in this document.

[1] U.S. Environmental Protection Agency (EPA). (2018). Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy. Washington D.C. From https://www.epa.gov/sites/production/files/2018-07/documents/epa_slb_multiple_benefits_508.pdf

Executive Summary

Our client, the Washington State Housing Finance Commission (the Commission), contracted our team to analyze the costs and benefits of the energy efficiency and renewable energy standards in the Bond / 4% Low Income Housing Tax Credit (LIHTC) Program. The federal LIHTC program is the largest funder of affordable housing in the United States and is administered in Washington State by the Commission. In recent years, the Bond / 4% Tax Credit Program has become highly competitive, where developers are maximizing the number of points in their applications to increase the likelihood of securing funding. Earning energy efficiency and renewable energy points includes implementing new technology and building measures that are known to have higher upfront costs. Through this study, the Commission was interested to understand how the benefits of these energy efficiency and renewable energy points weighed against those increased costs.

We conducted a literature review, stakeholder interviews, and a benefit-cost analysis (BCA) to answer the following research question; ***do the benefits of higher energy efficiency and renewable energy standards, which are prioritized in the Commission's Bond / 4% Tax Credit Program, outweigh the higher project costs?*** In addition to synthesizing the literature and interviews, our BCA sought to monetize the social benefits of these sustainable building investments in affordable housing and weigh them against their costs.

Literature: We reviewed existing literature, data, policies, and case studies to build an understanding of the intersection of the affordable housing and climate crises. The literature showed an immense need for affordable housing in the US and Washington State. Researchers also pointed out disproportionate impacts of climate change on low-income communities due to lack of affordable housing, high energy burden, and health impacts such as indoor air pollution. Further, researchers theorized how energy efficient or sustainable building could price out certain populations from affordable housing using the term "green gentrification". However, researchers also noted that investing in energy efficiency and renewable energy technologies is a critical pathway to reduce greenhouse gas emissions and combat climate change impacts. Lastly, the literature suggested that with the right tools and targeted approaches, Housing Financing Agencies (HFAs), such as the Commission, are the best suited to address the intersection of the affordable housing and climate crises.

Stakeholder Interviews: Interviews were conducted with energy consultants and affordable housing developers. The intent to these interviews were to determine the attitudes of developers regarding the Commission's energy efficiency and renewable energy standards and to gain an energy consultant's technical expertise to support the development of our benefit-cost analysis methodology. These interviews found that developers prioritize building as many units as possible to increase housing stock and energy efficient buildings increase upfront costs, but also provide developers and/or tenants with benefits through utility savings.

Benefit-Cost Analysis: We analyzed two Bond / 4% Tax Credit Program projects, the Maddux and Madison & Boylston (MadBoy), that were approved in 2020 as case studies to understand how the application's energy efficiency and renewable energy standards weighed against their costs. For each project, we analyzed two scenarios named the first and final submittal, against the status quo. The status quo assumes the project will be built with the Commission's minimum energy efficiency and renewable energy standards. Both their first submittals were rejected before reapplying with additional energy efficiency and renewable energy points in their final submittals, which allowed us to analyze the incremental benefits and costs. Cost-related data was supplied by the Commission and housing developers, while the benefits were calculated with the support of peer-reviewed academic studies and governmental reports.

Findings: The net present value for both projects and all four scenarios were positive. This finding demonstrates that the benefits of the energy efficiency and renewable energy standards were greater than the costs. View Table 1 and 2 for the Maddux and MadBoy's total project benefits and costs for their first and final submittal.

Table 1: The Maddux's discounted benefits and costs ($2021)

The Maddux	First Submittal	Final Submittal
Total Discounted Benefits	$359,100	$860,576
Total Discounted Costs	$263,787	$781,541
Net Present Value (NPV)	$95,313	$79,035

Table 2: MadBoy's discounted benefits and costs ($2021)

MadBoy	First Submittal	Final Submittal
Total Discounted Benefits	$908,514	$1,370,567
Total Discounted Costs	$91,469	$1,038,415
Net Present Value (NPV)	$817,046	$332,152

The implications of these findings show the Commission is heading in the right direction in terms of combining both their goals of funding affordable housing and building more sustainable properties. However, it is clear from conversations with stakeholders, that the Commission's point system can further evolve to mitigate the impact development has on the environment and upfront costs.

Recommendations: With this in mind, we propose a series of recommendations that will maintain the positive benefits the case studies suggest, and address areas of improvement when supporting housing development.

1. Maintain the energy efficiency and renewable energy standards in the Bond / 4% Tax Credit Program.
2. Identify opportunities to lower high-efficiency heat pump water heater costs.
3. Provide more support to developers.
4. Develop more engaging and collaborative statewide partnerships.

Overall, our findings suggest there is a path forward for housing development that is affordable, safe, and sustainable for Washingtonians.

Chapter 1: Introduction

The Washington State Housing Finance Commission (the Commission) serves the people of Washington State through its mission of expanding housing access and affordability.

To combat both the climate change crisis and reduce the energy burden faced by renters in Washington, the Commission recently implemented policies to incentivize energy efficiency (EE), including the use of renewable energy (RE) for affordable housing projects. While these measures can save money on utility bills and reduce greenhouse gas emissions, the cost of building such energy efficient buildings may reduce the number of affordable units built. This project evaluates the Commission's energy efficiency and renewable energy (EERE) efforts through a Benefit-Cost Analysis (BCA) to understand the Bond / 4% Tax Credit Program's long-term implications for sustainability and affordable housing in Washington State.

We are a team of Master of Public Administration students from the University of Washington completing our Capstone project, which is a body of work that serves as a culminating academic experience. For this project, our BCA of the Commission's Bond / 4% Tax Credit Program was conducted over the course of five months and represents a case study of two buildings funded in the 2020 application cycle.

1.1 The Commission's LIHTC Program

The Commission is the state agency responsible for allocating the federal Low-Income Housing Tax Credits (LIHTC) program in Washington State. Enacted in 1986 as part of Tax Reforms Act[2], LIHTCs are issued by the Internal Revenue Service (IRS) to state housing finance agencies to fund affordable housing projects. The Commission allocates low-income housing tax credits through two different programs. In the Bond / 4% Tax Credit Program, developers apply to use tax-exempt bonds; tax credits come automatically with those bonds. In the 9% Program, developers apply only for tax credits. The Commission's tax credits and bonds are awarded to developers through a competitive process according to the Commission's policies and procedures.

The LIHTC program is an indirect subsidy program in the US for building affordable housing. The IRS and state housing finance agencies work together to give proportional (either 9% or 4% depending on the application) tax credits for eligible housing developers. Developers sell the tax credits to investors for equity. A detailed explanation of the LIHTC mechanism is in Chapter 2.3. Due to data availability and timing, our study only assessed the Bond / 4% Tax Credit Program. These projects generally serve populations earning 30 - 60% of the area median income using tax-exempt bonds as a key source of financing. The application process has become highly competitive in recent years, with two application periods a year and only the highest scoring applications being considered. The EERE points are only a portion of the application but provide an avenue for developers to maximize the chance their application is approved. In the past three years, the EERE points were restructured by the Commission to incentivize developers to improve the sustainability of new and retrofitted housing developments. However, the

[2] LIHTC, Key Elements of the US Tax System, https://www.taxpolicycenter.org/briefing-book/what-low-income-housing-tax-credit-and-how-does-it-work

technology and building measures used to meet these energy standards can be cited as cost prohibitive. This tradeoff between increasing the energy efficiency of affordable housing and using more bond cap is the basis of Commission's BCA request.

1.2 The Commission's Bond / 4% Tax Credit Program Energy Efficiency and Renewable Energy (EERE) Standards

The Commission's Bond / 4% Tax Credit Program application includes points for renewable energy and energy efficiency measures in sections 4.19 'Solar Options' and 4.20 'Energy Efficient Building', respectively (View Appendix A).[3] As applications become more competitive each year, getting awarded a tax credit often relies on developers earning most of these energy-related points. The Commission is aware that achieving these points and their corresponding environmental benefits come at higher cost and they wish to better understand the impacts of these standards on environmental and other benefits such health, living conditions, education outcomes.

For the 4.20 Energy Efficient Building (EEB) points, the Bond / 4% Tax Credit Program application references the criteria of Evergreen Sustainable Development Standards (ESDS)[4] 5.1A and 5.2A, which describes mandatory and optional requirements in terms of sections C406 and C407 of the 2015 Washington State Energy Code (WSEC). The Commission awards 3 or 6 points for achieving 5 or 10 ESDS 5.2A points. The C406 method is the most common method for achieving the additional ESDS points, and is what was utilized by the case studies, so that is the focus of this discussion. Of the eight C406 energy efficiency (EE) options, the Bond / 4% Tax Credit Program application's minimum standard requires developers to comply with ESDS 5.1A, which minimally requires incorporation of three C406 EE options. To earn three or six Bond / 4% Tax Credit Program application points requires developers to incorporate one or two additional C406 EE options, for a total of four or five options, respectively.[5]

Energy Efficient Building Options

1. More efficient HVAC performance in accordance with section C406.2.[6]
2. Reduced lighting power in accordance with section C406.3.
3. Enhanced lighting controls in accordance with section C406.4.
4. On-site supply of renewable energy in accordance with section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with section C406.6.
6. High-efficiency service water heating in accordance with section C406.7.
7. Enhanced envelope performance in accordance with section 406.8.
8. Reduced air infiltration in accordance with section C406.9.

Additionally, for 4.19 Solar Options points, the Commission awards developers three and five points to install onsite renewable energy with a certain threshold of annual energy production per

[3] Washington State Housing Finance Commission. (2021). Bond / Tax Credit Program Policies. Olympia.
[4] ESDS v3.0.1 https://deptofcommerce.app.box.com/s/ble9p0n7cu4osxgn8v0rjqbtesnr10hb
[5] Washington State Housing Finance Commission. (2021). Bond / Tax Credit Program Policies. Olympia.
[6] View the 2015 Washington Commercial Energy Code (WESC) section C406 (multifamily over three stories) for greater detail to each of these energy efficiency options.

square foot of total (residential & nonresidential) conditioned floor area of the building. The specific requirements for each threshold are listed below.

Solar Options

- 3 points = Annual energy production between 0.15 – 0.27 kWh/SF/Year
- 5 points = Annual energy production greater than or equal to 0.28 kWh/SF/Year

1.3 Our Research Question

Using the data provided by the Commission, stakeholder insight, and information from an in-depth literature review, we have answered the following question in a benefit-cost analysis study:

- *Do the benefits of higher energy efficiency and renewable energy standards, which are prioritized in the Commission's Bond / 4% Tax Credit Program, outweigh the higher project costs?*

To answer this question, we analyzed two projects, The Maddux and Madison & Boylston (MadBoy), as case studies to understand how the application's solar and energy points affected developer costs. These projects were approved by the Commission in 2020. Both these projects were useful in that their initial applications did not score high enough to be awarded bond cap before reapplying with additional solar and energy points, allowing us to analyze the incremental benefits and costs of these points.

1.4 The Maddux and MadBoy

We employed a case study approach, where we analyzed the costs and benefits of two Bond / 4% Tax Credit projects, the Maddux and MadBoy. Both these projects submitted multiple rounds of applications with varying levels of EERE measures. Due to these multiple submittals, we were able to analyze the incremental costs and benefits of a variety of sustainable building investments. The section below includes a description of each project and the EERE technology included per submittal.

1.4.1 The Maddux

The Mt. Baker Housing Association (MBHA) successfully won Bond / 4% Tax Credit Program funding in 2020 to construct a two-building mixed-use affordable housing project named the Maddux in Seattle's Mt. Baker neighborhood. It will be located a quarter mile from the light rail station and will serve as a resident thoroughfare to connect Mt. Baker's residential area to its commercial district. The Maddux North building will be 5 floors that will include a mix of studios, one bedroom, two bedrooms, three bedrooms units, along with two future retail tenant spaces, a community room, onsite parking, and a rooftop terrace for residents. The Maddux South building will be 6 floors that will include mostly studios and a few one-bedroom units, along with one future retail tenant space and common laundry spaces. The design has 29% of the project's units able to serve larger household sizes and all of the units will target households earning at or below 60% AMI with half of the units at or below 50% AMI. Construction began in late 2020 with an anticipated completion by mid-2022. View Figure 1 for a before and after rendering of the Maddux.

Figure 1: A before and after rendering of the Maddux[7]

A unique element to this affordable housing project is that it's located on environmentally contaminated sites from the historical land use of a gas station, auto repair shop, and dry cleaner. All of these sites released a significant amount of dry-cleaning solvents and petroleum waste into the soils and groundwater. For most private and nonprofit developers, remediating these contaminants would be too costly to consider for this type of project. However, MBHA developed several local and state partnerships to fund this cleanup, including with Aspect Consulting, and the Department of Ecology's Healthy Housing Remediation Program to fund this cleanup effort prior to construction.[8] Seattle's City Council also rezoned this area as a 'Redevelopment Opportunity Zone' to allow Ecology's funds to be quickly accessible for the cleanup.[9]

We compared the incremental benefits and costs from going above the minimum EERE standards in the Bond / 4% Tax Credit Program, also known as the status quo. For the Maddux, the two submittals we analyzed utilize several types of EERE technology. The first submittal differed from the status quo with additional solar panels and an enhanced building envelope primarily using triple-pane vinyl windows on the residential floors of the building. The final submittal differed from the status quo by adding more solar panels from the first submittal, maintaining the triple-pane vinyl windows, and investing in a high-efficiency heat pump water heater.

1.4.2 MadBoy

Bellwether Housing successfully won Bond / 4% Tax Credit Program funding in 2020 to construct a 17-story building in Seattle's First Hill neighborhood named MadBoy. This was a joint venture with Plymouth Housing Group. Upon completion, there will be 365 new affordable rental units, with 250 homes for individuals and families operated by Bellwether. These units are studio and one, two, and three-bedroom apartments. The Bellwether portion of the building will also include a community room, onsite fitness center, business/learning center, media room, playground, bicycle storage, as well as space for Bellwether's Resident Services Coordinator.

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[7] Aspect Consulting. (n.d.). Restoring Land, Creating Affordable Housing Gateways. Retrieved March 10, 2021, from Affordable Housing: https://www.aspectconsulting.com/affordablehousing

[8] Aspect Consulting. (2020). Construction Begins on Aspect's Innovative Affordable Housing Project. Retrieved March 10, 2021, from Affordable Housing: https://www.aspectconsulting.com/blog/tag/Affordable+Housing

[9] Mt. Baker Housing (n.d.). The Mt. Baker Gateway Project. Retrieved March 10, 2021, from Mt. Baker Housing: http://mtbakerhousing.org/coming-soon/

This building will serve large households and disabled populations. Construction began in October of 2020 and is scheduled to last 22 months, ending in August 2022. View Figure 2 for an architectural rendering of MadBoy.

Figure 2: An architectural rendering of MadBoy[10]

Unique to this property is that it is a joint venture between Plymouth Housing and Bellwether. Although the Bond / 4% Tax Credit Program application is through Bellwether, Plymouth Housing utilized 9% LIHTC funding for a portion of the project. Plymouth's 115 units provide homes for formerly homeless seniors. This joint development aims to address the challenges of large-scale development by leveraging Bellwether and Plymouth's respective expertise, diverse relationships, and collective resources. Seattle's First Hill neighborhood is a "high opportunity" area rich with public transit, employment opportunities and human services which make this location ideal for Madison/Boylston's combination of supportive and workforce housing.

Similarly, to the Maddux, we compared the incremental benefits and costs from going above the minimum EERE standards in the Bond / 4% Tax Credit Program, also known as the status quo. For the MadBoy, the first submittal differed from the status quo with the implementation of heat pumps with Energy Recovery Ventilation (ERV) and Variable Refrigerant Flow (VRF) in the property's amenities. The final submittal differed from the status quo by adding more solar panels, heat pumps with ERVs, VRFs, and investing in a high-efficiency service water heater.

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[10] DEI Creative in Seattle. (2021, April 08). 1400 Madison. Retrieved May 10, 2021, from https://www.weberthompson.com/project/1400-madison/

Chapter 2: Literature Review

In our research, we incorporated three methodologies to answer our research question. They include a literature review, stakeholder interviews, and a benefit-cost analysis (BCA). The literature review is presented in this chapter with the other two methods described in Chapter 3. We conducted this literature review to present the existing knowledge in the field of research. Besides, it helps to discover additional related and uncovered areas for further study and understand limitations in the research. With our literature review, we present a holistic view of the intersectionality of affordable housing, climate change, and their effects on low-income households. We intend to use these insights from the literature review to develop an understanding of the field to answer our research question and also provide recommendations to the Commission.

In this chapter, we review the existing literature, data, policies and practices, and case studies to build an understanding of the intersection of affordable housing and the climate crisis. The sources include academic and journal articles, articles from policy advocacy groups, think tanks, and government data. Section 2.1 details the affordable housing and climate crisis in the US and Washington State. Section 2.2 focuses on the disproportionate impact of these twin crises on people of color and low-income communities in the US and in Washington. Section 2.3 explains the low-income housing tax credits available in the US for developing affordable housing. Section 2.4 highlights the increased cost of building affordable housing while 2.5 states that progressive policies can help protect affordable housing and also tackle challenges of climate change. In section 2.6, we introduce the concept of energy efficiency and renewable energy (EERE) for affordable housing and in section 2.7, we highlight some of the applications of EERE in affordable housing. As for the next two sections, 2.8 discusses the benefits of EERE in affordable housing, while 2.9 presents an understanding of the benefits from energy savings and reduced emissions due to the implementation of EERE standards. Section 2.10 provides an overview of common barriers for implementing EERE standards and opportunities to overcome such barriers. It also covers unintended consequences of improving energy efficiency standards such as green gentrification. The final section 2.11 concludes the chapter with suggested policies proposed in the literature for solving the affordable housing and climate change crisis.

2.1 The Affordable Housing and Climate Crisis in the US and in Washington

Homelessness and the affordable housing crisis have been critical social problems experienced in the US for more than 70 years.[11] According to the National Low Income Housing Coalition, in the U.S., there is a shortage of seven million rental homes affordable and available to extremely low-income (ELI) renters[12,13] and only 36 affordable rental homes are available for every 100 extremely low-income renter households across the nation.[14] The improvements in the American economy as indicated by increased weekly earnings for full-time employment in the recent years

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[11] According to Freeman (2002), the Housing Act 1949 mentioned the “realization as soon as feasible of the goal of a decent home and suitable living environment for every American family”. Although this societal contract may not be binding now, increasingly many state and local governments’ polity still view a decent and affordable home as a minimal right in America. (Freeman L. (2002). America's affordable housing crisis: a contract unfulfilled. *American journal of public health*, *92*(5), 709–712. https://doi.org/10.2105/ajph.92.5.709)

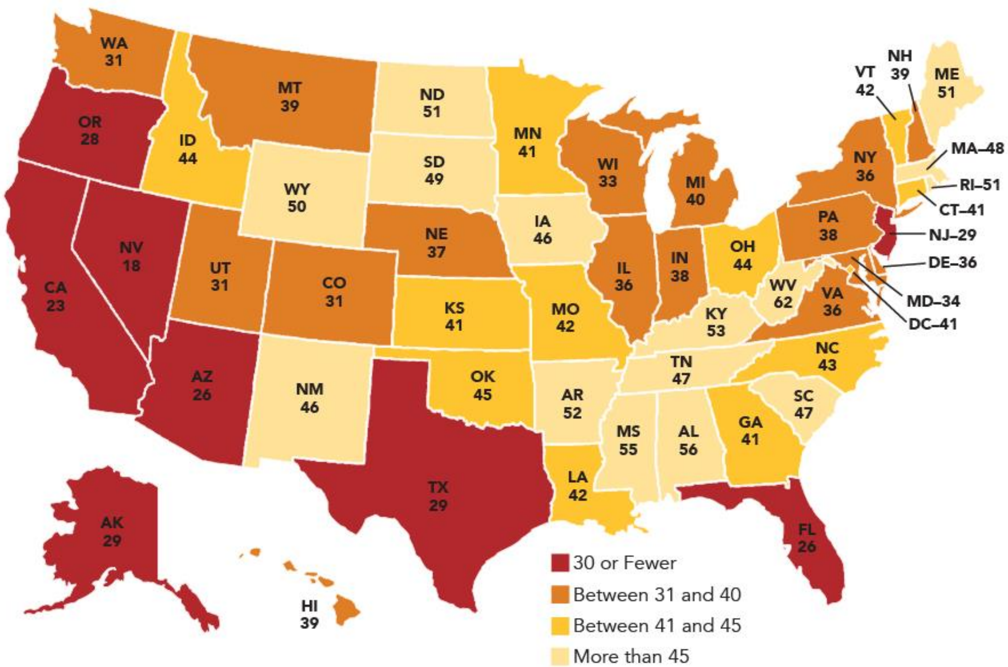
[12] The terms ‘renters’ and ‘renter households’ are used interchangeably to mean renter households in this chapter.

[13] Extremely low-income renters are those with household incomes are at or below the poverty guideline or 30% of their area median income.

[14] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

and increased housing construction since 2008[15], did not result in better housing outcomes for all sections of the society.[16] For instance, supply of affordable housing for the nation's lowest-income families and individuals remains inadequate across the country (View Figure 3).[17]

Figure 3: Rental homes affordable and available per 100 ELI renter households by state[18]



As the above graphic demonstrates, Washington has only 31 affordable homes available for Extremely Low Income (ELI) households, making Washington one of the least affordable states in the country.

2.1.1 Widening Inequality and Increasingly Unaffordable Rents

In the housing sector, the "filtering down" process[19] did not produce a sufficient supply of rental homes that were inexpensive enough for the lowest-income renters to afford.[20] While this is primarily due to the absence of adequate public subsidy and a strong reliance on the private market for housing[21], the severe shortage of affordable homes for extremely low-income renters

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[15] Sisson,P., Andrews,J., and Bazeley, A., (2020). The affordable housing crisis, explained. Curbed. https://archive.curbed.com/2019/5/15/18617763/affordable-housing-policy-rent-real-estate-apartment

[16] *Ibid.*

[17] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

[18] Taken directly from Source: Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

[19] "Filtering down" process states that as high-income groups move into new luxury buildings, the old buildings will be available to the low-income groups at lower rents. Zonta, M. (2018). *Homes for All*. Center For American Progress. https://www.americanprogress.org/issues/economy/reports/2018/07/24/452645/homes-for-all/

[20] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

[21] *Ibid.*

is systemic, and is seen in every state and metropolitan area in the US.[22] Figure 4 explains the divergent housing trends seen in the US over the years.

Figure 4: Divergent housing trends in the US[23]

BETWEEN 1960-2016, COST-BURDENED SHARE OF RENTERS DOUBLED FROM 23.8% TO 47.5% , WITH THE LARGEST INCREASES OCCURRING IN THE 2000S

MEDIAN RENT PAYMENT ROSE 61% BETWEEN 1960-2016 WHILE THE MEDIAN RENTER HOUSEHOLD INCOME GREW ONLY 5%, ADJUSTING FOR INFLATION

BETWEEN 2006 AND 2016, THE TOTAL NUMBER OF OCCUPIED RENTALS WAS UP BY 21%, BUT THOSE RENTING FOR UNDER $650 IN REAL TERMS FELL BY 5%

The trends observed in various states of the US regarding inadequate affordable housing supply is true in Washington State as well. Washington State has the 8th-highest housing shortage in the US, despite having steady economic and population growth in recent years.[24]

Figure 5: Housing trends in Washington[25]

AS OF 2018, FOR 221,795 EXTREMELY LOW-INCOME RENTER HOUSEHOLDS, ONLY 68,535 AFFORDABLE RENTAL HOMES WERE AVAILABLE, MEETING ONLY 30% OF THE DEMAND

MEDIAN RENT PAYMENT ROSE 42% SINCE 2014 WHILE THE MEDIAN RENTER HOUSEHOLD INCOME GREW ONLY 23%,

WASHINGTON HAS A DEFICIT OF 153,260 AFFORDABLE UNITS ANNUALLY

OVER 50% OF EXTREMELY LOW-INCOME RENTER HOUSEHOLDS IN WASHINGTON STATE ARE IN THE SEATTLE-BELLEVUE-TACOMA METROPOLITAN AREA

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[22] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

[23] Data Source: Joint Center For Housing Studies Of Harvard University. (2018). The State of the Nation's Housing 2018. https://www.jchs.harvard.edu/sites/default/files/Harvard_JCHS_State_of_the_Nations_Housing_2018.pdf

[24] Up for Growth. Housing Underproduction In Washington State. 2020. https://www.upforgrowth.org/sites/default/files/2020-01/HousingUnderproductionInWashingtonState2020-01-10.pdf

[25] Data Source: National Low-Income Housing Coalition. (2018). Housing Needs by State/Washington. https://nlihc.org/housing-needs-by-state/washington

From 2000 to 2015, Washington state underproduced housing by approximately 225,600 units, or roughly 7.5% of the total 2015 housing stock, leading to an unfavorable imbalance in demand and supply of housing impacting vulnerable communities across the state.[26] Research also shows among the kind of housing units that are missing in Washington, 80% of them are meant for families earning up to 80% of area median income (AMI), suggesting a disproportionate impact on low-income households.[27]

2.1.2 Climate Crisis Compounds Housing Unaffordability

Besides affordable housing crisis, changing weather patterns, frequent natural disasters, and natural disasters caused by climate change are compounding the affordable housing crisis in the US.[28] About 75% of properties damaged in natural disasters are rental homes and when residents scramble to find new places to live, they discover that rents are too high from the sudden supply shortage.[29]

Recent research suggests climate change events are also impacting affordable housing in low-lying areas in coastal states because of frequent flooding.[30] Residents in such low-lying areas are more likely to be low-income and living in old and poor-quality structures.[31] By 2050, most coastal states are estimated to have at least some affordable housing units at risk of flood at least four times per year. In Washington, approximately 100 affordable units will be exposed to frequent flooding by 2050, while zero units were exposed to such flooding in 2000; in Hoquiam, Washington, 72% of units are expected to be exposed to flooding by 2050.[32]

2.2 Disproportionate Effects of Climate Change on Low-Income Communities

According to the University of Washington Climate Impact Group (UW-CIG), by 2050, an average year in Washington will be warmer than the hottest year of the 20th century, if greenhouse gas emissions continue on their current pathway.[33] While everyone in Washington State will be affected by climate change, communities at most risk of experiencing negative impacts of climate change are often communities of color, indigenous people, and lower-income communities. UW CIG 's report emphasizes that lack of access to affordable housing, poor housing quality, or homelessness can significantly contribute to an individual's exposure to climate change-related hazards.[34] In addition, systemic disparities, income inequality, historical racist policies, and changing climate patterns have disproportionately affected people of color and dissuade them from owning housing assets. Figure 6 highlights this fact. While Black

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[26] Up for Growth. Housing Underproduction in Washington State. 2020. https://www.upforgrowth.org/sites/default/files/2020-01/HousingUnderproductionInWashingtonState2020-01-10.pdf

[27] *Ibid.*

[28] Ortiz, G., Schultheis, H., Novack, V., & Holt, A. (2019). A Perfect Storm: Extreme Weather as an Affordable Housing Crisis Multiplier. Center for American Progress. https://www.americanprogress.org/issues/green/reports/2019/08/01/473067/a-perfect-storm-2/

[29] *Ibid.*

[30] Buchanan, M.K.,Kulp,S., Cushing,L., l Morello-Frosch,R., Nedwick,T., Strauss, B., (2020).Sea level rise and coastal flooding threaten affordable housing. Environmental Resource Letters. https://iopscience.iop.org/article/10.1088/1748-9326/abb266/pdf

[31] *Ibid.*

[32] *Ibid.*

[33] Snover, A.K., C.L. Raymond, H.A. Roop, H. Morgan, 2019. No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State. Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. Updated 02/2019. https://cig.uw.edu/wp-content/uploads/sites/2/2019/02/NoTimeToWaste_CIG_Feb2019.pdf

[34] UW Climate Impacts Group, UW Department of Environmental and Occupational Health Sciences, Front and Centered and Urban@UW. (2018). An Unfair Share: Exploring the disproportionate risks from climate change facing Washington state communities. A report prepared for Seattle Foundation. University of Washington, Seattle. https://cig.uw.edu/wp-content/uploads/sites/2/2018/08/AnUnfairShare_WashingtonState_August2018.pdf

households account for 12% of all households (renters and owners), of which they represent 19% of all renters and 26% of all ELI renters.[35] Hispanic households account for 12% of all U.S. households (renters and owners), of which they represent 19% of all renters, and 21% of ELI renters.[36]

Figure 6: Racial composition by housing type in the US[37]

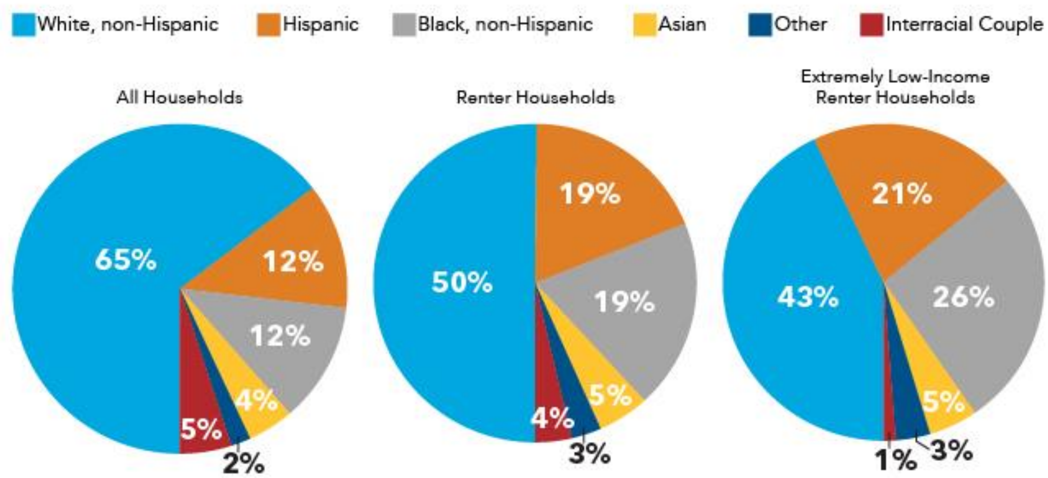
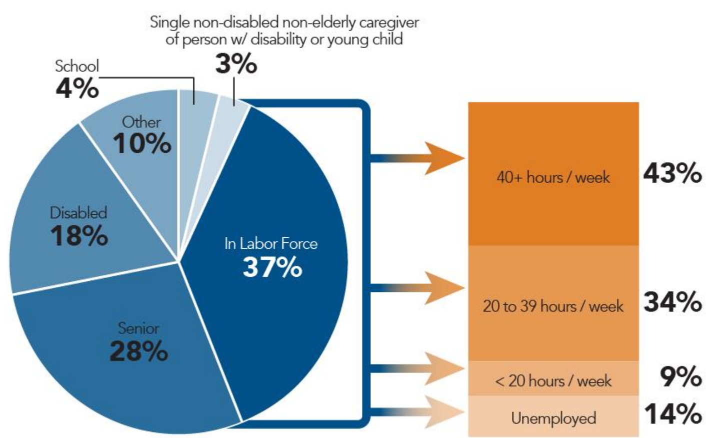


Figure 7: Composition of extremely low-income (ELI) renter households in the US[38]



From Figure 7, we can see that most of the low-income households in the US consist of seniors, people with disabilities, and adult caregivers who care for a child or a family member with disability and more than 50% of these caregivers are in the labor market. According to the

[35] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf
[36] *Ibid.*
[37] Taken directly from Source: Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf
[38] Taken directly from Source: Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

National Low-Income Housing Coalition, in the US, about 77% of extremely low-income households in the labor force work more than 20 hours per week, but their low-wage employment does not provide them with adequate income to afford housing.[39] The situation is similar in Washington as well. Table 3 provides an overview of prevailing wages and the estimated earnings needed to afford a 2-bedroom apartment at Fair Market Rent (FMR) in Washington state and the Seattle - Bellevue Metropolitan Area.

Table 3: Prevailing wages and estimated earnings needed to afford a 2-bedroom apartment at fair market rent in Washington State and the Seattle - Bellevue Metropolitan area[40]

Geography	Fair Market Rent (FMR) for 2-bedroom apartment	Average renter earnings per hour	Estimated hourly housing wage needed to afford 2-BR at FMR	Annual household earnings needed to afford the rent and utilities without cost burdening	Full-time jobs needed to afford 2-BR at FMR	
					At Minimum Wage	At Average Renter's
Washington State	$1,584	$21.90	$30.46	$63,352	2.3	1.4
Seattle-Bellevue Metropolitan Area	$2,099	$28.43	$40.37	$83,960	3	1.4

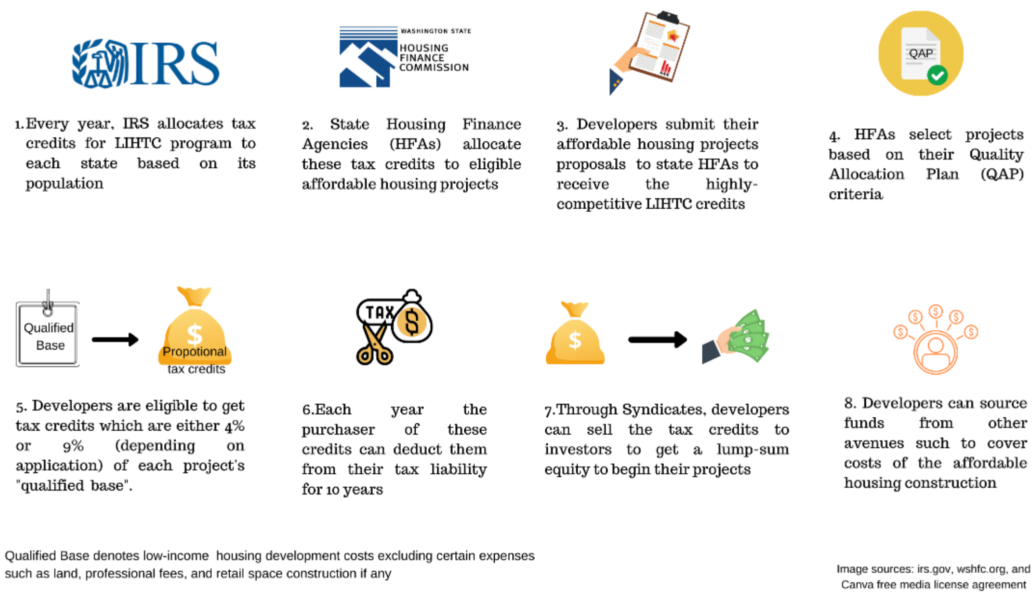
Therefore, low-income homes cannot afford rents without housing assistance or an increase in their hourly wage at 2020-wage levels. Additionally in 2020, the COVID induced economic crisis threatened the work of these low-wage earners. The Bureau of Labor Statistics estimated that the job sectors[41] most directly exposed to COVID-19 shutdowns account for more than 20% of all workers, and they have a disproportionate number of low-wage jobs.[42]

2.3 Low-Income Housing Tax Credits (LIHTC) for Affordable Housing

To encourage the development of affordable housing, the US federal government introduced Low-Income Housing Tax Credits (LIHTC), a subsidy given to developers who construct or rehabilitate rent-restricted housing units.[43] Figure 8 explains the mechanics of the program. Enacted in 1986, as part of the Tax Reforms Act, LIHTCs are issued by the Internal Revenue Service (IRS) to state housing agencies based on the state population for allocation to affordable housing projects across the U.S. The program cost the US Government over $8.4 billion in lost tax revenue in 2017 but there is bipartisan support to expand future allocations by up to 50%.[44] According to the US Department of Housing and Urban Development (HUD) 2014 report, nearly half (47%) of LIHTC households have annual incomes of less than thirty percent of the area median income (AMI).[45] Between 2011-15, about 25% of all low-income households in the US reside in multifamily housing units.[46]

[39] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf
[40] Data Source: National Low-Income Housing Coalition. (2020). Out of Reach. WA. Page 258. https://reports.nlihc.org/sites/default/files/oor/OOR_2020.pdf
[41] According to Bureau of Labor Statistics, these sectors include restaurants and bars, travel and transportation, entertainment, personal service (e.g., daycare providers and barbers), some retail (e.g., department stores), and some manufacturing (e.g., aircraft manufacturing).
[42] National Low-Income Housing Coalition. (2020). Out of Reach. https://reports.nlihc.org/sites/default/files/oor/OOR_2020.pdf
[43] Erickson, M. D., & Lang, B. J. (2018). Overview and Proposed Reforms of the Low-Income Housing Tax Credit Program. University of Cincinnati Lindner College of Business Research Paper. Retrieved from https://ssrn.com/abstract=3132493
[44] *Ibid.*
[45] US Department of Housing and Urban Development (2014). Understanding Whom the LIHTC Program Serves: Data on Tenants in LIHTC Units as of December 31, 2014. https://www.huduser.gov/portal/sites/default/files/pdf/LIHTC-TenantReport-2014.pdf
[46] US Department of Energy. Reducing Energy Burden for Low-income Residents in Multifamily Housing with Solar Energy. https://www.energy.gov/sites/prod/files/2019/05/f62/low-income-multi-family-solar_0506.pdf

Figure 8: How does the LIHTC Program work?[47]



Besides the tax credits, housing developers can also claim depreciation of the building asset every year for 10 years. LIHTC projects are expected to keep the houses affordable for 30 years. If the agreement is not honored within the initial 15 years, the IRS can take back the value of tax credits from the housing developers.[48]

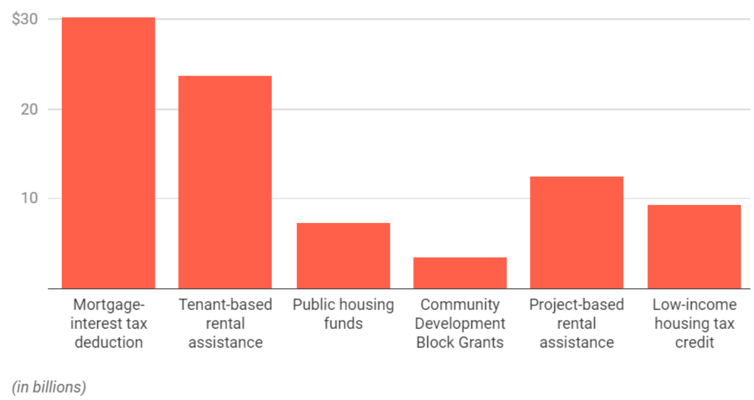
In the US, there are two types of LIHTCs available to developers. The 9% LIHTC Program gives an affordable housing project access to equity through a partnership, in which one partner typically buys the tax credits, putting equity in the project; the other partner(s) typically own and develop the project. The Bond / 4% Tax Credit Program provides fewer tax credits and can only be accessed through using tax-exempt bonds. In the Bond / 4% Tax Credit Program, developers apply to use tax-exempt bonds and tax credits come automatically with those bonds. In the 9% program, developers apply just for tax credits. In Washington, the Commission allocates most of Bond / 4% tax credits for new construction multifamily affordable housing projects compared to the rehabilitation projects.

The National Coalition for low-income Housing attributes the severe housing cost burdens for renters to the lack of subsidized affordable housing for extremely low-income households.[49] For instance, the Congressional Joint Committee on Taxation predicted that in 2020 the Mortgage Interest tax Deduction (MID), which provides tax deductions to homeowners is expected to cost the federal government $30.2 billion in lost revenue. This annual federal tax expenditure is more

[47] Information Source: Casey, A. (2017). *Low-Income Housing Tax Credits: Why They Matter, How They Work and How They Could Change*. Zillow Research. https://www.zillow.com/research/low-income-housing-tax-credits-15276/
[48] Casey, A. (2017). *Low-Income Housing Tax Credits: Why They Matter, How They Work and How They Could Change*. Zillow Research. https://www.zillow.com/research/low-income-housing-tax-credits-15276/
[49] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

than the funding of all rental subsidies and public housing and benefits mostly middle-class and wealthy homeowners (View Figure 9).[50]

Figure 9: Federal expenditures for various housing programs, fiscal year 2020[51]



2.4 Increased Costs for Affordable Housing Projects

University of California Berkeley's Terner Center for Housing Innovation states that in California, the cost of building a 100-unit affordable housing project increased from $265,000 per unit in 2000 to almost $425,000 in 2016.[52] This increase may be due to a number of costs associated with the construction of affordable housing with developers not able to cover them because the rent from the lowest-income households not covering the development and operating expenses of this new housing.[53] According to Bureau of Labor Statistics data, the cost of construction materials has risen by 24%, taking into account the producer price index[54] (PPI) for such raw materials, since the 2008 financial crisis.[55] About 5 - 10% of housing costs are accounted by the cost of lumber, which has doubled since 2008 in the US.[56] According to a 2018 survey by the National Association of Home Builders, 85% of its members believe the cost and availability of labor is their biggest issue, even with the industry adding roughly 12,000 new construction jobs per month in 2019.[57] In addition, undeveloped land prices in urban areas are higher[58], local government design requirements for affordable housing adds an average of 7% in total costs to construction, and community opposition (measured by holding four or more

[50] Sisson,P., Andrews,J., and Bazeley, A., (2020). The affordable housing crisis, explained. Curbed. https://archive.curbed.com/2019/5/15/18617763/affordable-housing-policy-rent-real-estate-apartment
[51] Taken directly from Source: Sisson,P., Andrews,J., and Bazeley, A., (2020). The affordable housing crisis, explained. Curbed. https://archive.curbed.com/2019/5/15/18617763/affordable-housing-policy-rent-real-estate-apartment
[52] *Ibid.*
[53] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf
[54] According to the Bureau of Labor Statistics, The Producer Price Index (PPI) program measures the average change over time in the selling prices received by domestic producers for their output. The prices included in the PPI are from the first commercial transaction for many products and some services
[55] Sisson,P., Andrews,J., and Bazeley, A., (2020). The affordable housing crisis, explained. Curbed. https://archive.curbed.com/2019/5/15/18617763/affordable-housing-policy-rent-real-estate-apartment
[56] *Ibid.*
[57] *Ibid.*
[58] *Ibid.*

community meetings) increased expenses by 5%.[59] All these factors mean that builders tend to take up projects that target high-income group renters for a high-profit margin, leading to home builders constructing fewer entry-level and starter homes for affordable housing.[60]

2.5 Progressive Policies Can Address the Affordable Housing and Climate Crises

With growing economic disparities, systemic racism, and environmental injustice affecting low-income communities, there is gaining momentum nationally and in states in the US to target the overall benefits from investing in a clean energy transformation, climate-resilient infrastructure, and affordable housing specifically to disadvantaged communities through bold, pathbreaking policies.[61] This is reflected in Washington State's Clean Energy Future[62], 2019 Clean Buildings Policy,[63] , and 2021 Energy Strategy for Buildings.[64] When coupled, these policies try to address the challenges associated with climate change through decarbonization, building and preserving affordable housing, increasing access to such constructions, implementing energy conservation measures, and enhancing public health with a targeted focus on delivering benefits to low-income communities through the lens of diversity, equity, and inclusion. According to the Center for American Progress, such progressive measures scaled at the state and national level can garner substantial new investment not only to expand access to renewable energy and energy efficiency improvements, but also provide pollution-free transportation and safe affordable housing in the communities that need it the most.[65]

2.6 Energy Efficiency and Renewable Energy (EERE) for Affordable Housing

Applying energy efficient measures in affordable housing is a progressive policy to mitigate challenges of climate change and help in preserving affordability of houses for low-income communities. In the literature, energy efficiency (EE) in housing is defined as the implementation of new technologies, retrofits, and infrastructure upgrades to reduce energy use, while providing the same level of service at a possible net low cost, upgrades and retrofitting measures include insulating, reducing air infiltration, and other approaches to weatherization; replacing or updating heating, ventilation, and air conditioning (HVAC) systems; replacing or updating water heaters; updating appliances like washing machines, clothes dryers, or dishwashers; and installing more energy-efficient lighting.[66] Efforts to modify the awareness or behavior of end users, such as energy-conservation programs.[67] On the other hand, renewable energy (RE) in housing refers to use of energy generated through renewable sources such as

[59] Claros, M., (2020). The Cost of Building Housing Series. Terner Center for Housing Innovation, UC Berkeley.https://ternercenter.berkeley.edu/research-and-policy/the-cost-of-building-housing-series/

[60]Sisson,P., Andrews,J., and Bazeley, A., (2020). The affordable housing crisis, explained. Curbed. https://archive.curbed.com/2019/5/15/18617763/affordable-housing-policy-rent-real-estate-apartment

[61] Kelly,C., & Reta,M., (2020).Building Equitable, Healthy, and Climate Change-Ready Communities in the Wake of COVID-19. https://www.americanprogress.org/issues/green/reports/2020/10/08/491371/building-equitable-healthy-climate-change-ready-communities-wake-covid-19/

[62] A plan by the Governor to reduce carbon emissions at least 25 percent below 1990 levels by 2035 and promote energy efficiency in buildings and utilities.

[63] Washington state Governor. Energy and Environment. https://www.governor.wa.gov/issues/issues/energy-environment

[64] Reduce Energy Consumption and Emissions in the Built Environment. (2021). Olympia: Washington Department of Commerce. Retrieved from https://www.commerce.wa.gov/wp-content/uploads/2021/01/WA_2021SES_Chapter-D-Buildings.pdf

[65] Kelly,C., & Reta,M., (2020).Building Equitable, Healthy, and Climate Change-Ready Communities in the Wake of COVID-19. https://www.americanprogress.org/issues/green/reports/2020/10/08/491371/building-equitable-healthy-climate-change-ready-communities-wake-covid-19/

[66] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

[67] *Ibid.*

resources such as solar, wind, geothermal, biomass, rather than using nonrenewable sources like fossil fuels such as natural gas, oil, and coal.

The existing research provides an insight to energy use in residential buildings across the nation. The energy used to heat, cool, and provide electricity accounts for about 20% of the total residential energy use in the United States and contributes about 20% of the greenhouse gas (GHG) emissions associated with fossil-fuel combustion.[68] Similar trends are seen in the Washington State. Buildings including residential are the most rapidly growing source of GHG and account for 27% of carbon pollution in Washington.[69] While the statewide emissions have grown 10% overall since 1990, building emissions have jumped by 50%, more than any other source in the state.[70] According to the Washington Clean Energy Strategy 2021, most of the building emissions are associated with the direct combustion of natural gas and other fossil fuels in buildings for space heating, water heating, and cooking.[71] To exasperate the problem, most of these appliances and technologies used in multifamily affordable housing tend to be old and less energy efficient.[72]

According to Pivo (2012), the energy expenditure[73] per square foot in a multifamily low-income rental property is about 37% higher than multifamily owner-occupied properties and 76% higher than single family owner-occupied properties.[74] When viewed through socio-economic profile, low-income renters and people of color[75] spent more for utilities per square foot than any average household, indicating that they reside in less efficient housing.[76] According to a 2013 American Council for an Energy-Efficient Economy (ACEEE), the median energy burden[77] for low-income households is more than twice that of the median household, 7.2% and 3.5%, respectively, and three times greater than higher income households (2.3%), while for African American households, the median energy burden is 5.4% and for Latino households, it is 4.1%.[78]. Figure 10 explains the energy burden of select socio-economic groups by region, ordered from highest to lowest, based on the average of the median energy burdens across all groups.[79] As indicated by the below graphic, low-income households have the highest energy burden across all the regions in the US.

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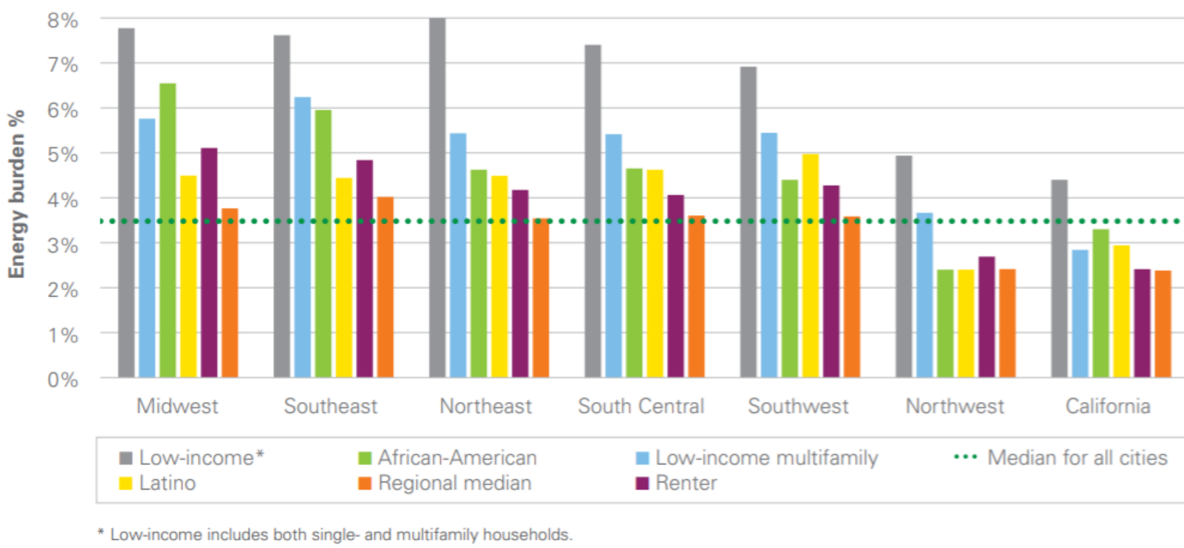
[68] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[69] Washington State Governor. (2019). Clean Buildings Policy Brief.https://www.governor.wa.gov/sites/default/files/documents/clean-buildings-policy-brief-bill-signing.pdf
[70] *Ibid.*
[71] Washington State Clean Energy Strategy. (2021). *Reduce Energy Consumption and Emissions in the Built Environment*. https://www.commerce.wa.gov/wp-content/uploads/2021/01/WA_2021SES_Chapter-D-Buildings.pdf
[72] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[73] Energy expenditure or Energy burden is the percentage of household income that is spent on energy bills
[74] Pivo, G., Energy Efficiency and Its Relationship to Household Income in Multifamily Rental Housing, Tucson: University of Arizona, School of Architecture, 2012. As of July 18, 2018: www.fanniemae.com/content/fact_sheet/energy-efficiency-rental-housing.pdf
[75] Includes African American and Latino households.
[76] Drehobl, A., and L. Ross, Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities, Washington, D.C.: Energy Efficiency for All, American Council for an Energy-Efficient Economy. 2013. https://assets.ctfassets.net/ntcn17ss1ow9/1UEmqh5l59cFaHMqVwHqMy/e81368fa10d39bbb4b114262aaee5be2/Lifting_the_High_Energy_Burden_0.pdf
[77] To calculate median energy burden, energy burden for all households is calculated and then the median is taken.
[78] Drehobl, A., and L. Ross, Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities, Washington, D.C.: Energy Efficiency for All, American Council for an Energy-Efficient Economy. 2013. https://assets.ctfassets.net/ntcn17ss1ow9/1UEmqh5l59cFaHMqVwHqMy/e81368fa10d39bbb4b114262aaee5be2/Lifting_the_High_Energy_Burden_0.pdf
[79] *Ibid.*

Figure 10: Energy burden of select socio-economic groups by region[80]



Several cities and states, including in Washington State, have embarked on complementary policies[81] to enhance energy efficiency in buildings as a means to cut carbon emissions[82] to tackle the challenges posed by the climate crisis, reduce the energy burden, transition to a promising clean energy economy, while also preserving the affordability of rental houses for low-income communities.[83,84,85,86] Implementing EE measures in residential buildings has been a policy priority at national level in the US since 2000 and the number of programs[87] and the money spent on EE programs for residential buildings have increased.[88]

2.7 Application of Energy Efficiency and Renewable Energy (EERE) in Affordable Housing

Most of the states in the US have used the LIHTC program, the largest affordable rental housing program, to prioritize implementing EE measures to increase the share of resources for EE within affordable multifamily rental houses since 2000.[89] The scoring systems of the state

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[80] *Ibid.*
[81] Washington Clean Buildings Policy, 2019 has new standards for buildings to increase building energy efficiency and efficiency standards for appliances. Washington State Energy Strategy 2021 has a decarbonization strategy to reduce carbon emissions from buildings.
[82] *Ibid.*
[83] Samarripas,S., & de Campos Lopes,C.,(2020).Taking Stock: Links between Local Policy and Building Energy Use across the United States. https://www.aceee.org/sites/default/files/pdfs/u2005.pdf
[84] Bartolomei, D. (2017). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. Energy Efficiency For All, National Housing Trust Retrieved from https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf
[85] United States Environmental Protection Agency. (2016). Energy Efficiency and Renewable Energy in Low-Income Communities: A Guide to EPA Programs. EPA. https://www.epa.gov/statelocalenergy/bringing-benefits-energy-efficiency-and-renewable-energy-low-income-communities
[86] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[87] Although the number of programs focusing on EE in residential buildings peaked in 2006, the money spent on them continues to increase.
[88] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[89] *Ibid.*

Housing Finance Agencies (HFAs) have incorporated energy codes and appliance energy standards for developers to obtain the highly competitive tax credits.[90]

Using LIHTCs, the Pennsylvania Housing Finance Agency (PHFA) was successful in incentivizing ultra-efficient low-income housing. Since 2002, PHFA focused on reducing energy costs in its buildings and began awarding points in the selection criteria for projects that met standards for better insulation, energy-efficient appliances, and renewable energy. This approach is followed by Housing Finance Agencies (HFAs) across the US.[91] Some existing evidence suggests that EE programs by HFAs and other public housing agencies have brought significant benefits to the residents such as the estimated reduction in total energy costs in Ann Arbor, Michigan by 20% (2014).[92] Additionally, in Kent, Washington, a deep energy retrofit to a multifamily housing complex reduced annual energy costs by 22% while improving comfort and air quality for residents (2016).[93] Many HFAs including the Commission include points/incentives for developers to include renewable energy systems in their projects.

2.8 Benefits of Energy Efficiency and Renewable Energy (EERE) in Affordable Housing

While the research explicitly concludes the benefits of energy efficiency and renewable energy (EERE) in affordable housing is evolving, the existing research does suggest that efficient affordable housing lowers the financial and social costs to tenants[94] by reducing operating costs, promoting resident health, and mitigating negative environmental impacts.[95] Below are some of the energy and non-energy benefits (NEBs) captured in the literature when EERE technologies and upgrades are deployed in affordable housing. A detailed methodology of how these benefits are incorporated in our study is explained in Chapter 3.

As low-income affordable housing properties have narrow operating margins with low or subsidized rents, the literature views deploying EE measures to reduce energy consumption and utility bills. These EE measures may provide an improved financial position for renters and developers to preserve their affordability. A 2016 ACEEE report estimated that if low-income housing were brought up to the efficiency level of an average home, it would cut the energy-cost burden on low-income families by one-third.[96]

In addition to the reduced energy use, financial savings from energy expenditure, the literature also studies the NEBs from EE upgrades. They include participant benefits (renters and

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[90] *Ibid.*

[91] Legere, L. (2019). How a Pa. affordable housing agency is making ultra-efficient buildings mainstream. Post-Gazette. Retrieved from: https://www.post- gazette.com/business/development/2018/12/31/pa-affordable-housing-tax-credits-pennsylvania-housing-finance-agency-passive-house-design/stories/201812190012

[92] United States Environmental Protection Agency. (2016). Energy Efficiency and Renewable Energy in Low-Income Communities: A Guide to EPA Programs. EPA. https://www.epa.gov/sites/production/files/2017-06/documents/epa_low_income_program_guide_508_2-29-16.pdf

[93] *Ibid.*

[94] McCabe, A., Pojani, D., & van Groenou, A. B. (2018). The application of renewable energy to social housing: A systematic review (Vol. 114). Energy Policy. Retrieved from https://www.sciencedirect.com/science/article/pii/S030142151730856X#!

[95] US Department of Housing and Urban Development (2014). Green Building in Low-Income Housing Tax Credit Developments. PD&R Edge. https://www.huduser.gov/portal/pdredge/pdr_edge_featd_article_061614.html

[96] Drehobl, A., and L. Ross, Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities, Washington, D.C.: Energy Efficiency for All, American Council for an Energy-Efficient Economy. 2013. https://assets.ctfassets.net/ntcn17ss1ow9/1UEmqh5l59cFaHMqVwHqMy/e81368fa10d39bbb4b114262aaee5be2/Lifting_the_High_Energy_Burden_0.pdf

owners/developers), utility company benefits, and societal benefits. Table 4 displays the varying benefits per category.

Table 4: Participant, utility company, and societal non-energy benefits (NEBs)[97,98,99]

Non-Energy Benefits	
Participant Benefits	Improved comfort for residents, improved indoor air quality, reduced noise, enhanced indoor aesthetics and appearances, improved building safety, better health and educational attainments, reduced stress and fear of eviction, losing utility (due to non-payment of bills), savings from fewer moves, reduced maintenance from increased durability of appliances, greater marketability, and fewer complaints from residents
Utility Company Benefits	Reduced emergency and safety calls, fewer notices for termination, lower bad debt write-offs, fewer shutoffs and reconnects
Societal Benefits	Economic development, supports breaking cycle of poverty, improved educational attainment, better public health, avoided greenhouse gas (GHG) emissions, reduced pollution, contributes to clean energy economy

Some research does exist to better understand the economic case of whether energy-efficient technology in affordable housing has more social benefits. For instance, a Cost-Benefit Analysis of energy efficiency in social housing in Northwest Mexico studied whether energy efficiency technology provided a positive net present value (NPV) for householders and developers. The researchers found that investing in low-energy design or upgrades always had a positive NPV but the payback period varied based on the financing.[100] A second study from South Africa, examining EE measures using thermal performance of ceilings, roof and wall insulation, windows and partitions in low-cost housing, found that EE measures have a net social benefit, however, concluded that these measures have high capital costs, while the benefits are spread over many years, implying that low-income residents cannot afford them.[101]

Another study examined the cost and benefits of green affordable housing to assess whether upfront costs of green certifications outweigh the expected social benefits associated with green building projects using construction cost and price data from 422 LIHTC properties and 11,000 Multiple Listing Service transactions in Virginia. The authors conclude that the initial investment

[97] Myers, J., & Skumatz, L. (2006). Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques. ACEEE Summer Study on Energy Efficiency in Buildings.
[98] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
[99] NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
[100] Preciado-Perez, O. A., & Fotio, S. (2017). Comprehensive cost-benefit analysis of energy efficiency in social housing. Case Study: Northwest Mexico. Energy and Buildings, 152, 279-289. https://www.sciencedirect.com/science/article/pii/S0378778816316577?via%3Dihub
[101] Winkler, H., Spalding-fecher, R., Tyani, L., & Matibe, K. (2002). Cost-benefit analysis of energy efficiency in urban low-cost housing. Development southern Africa, 19(5). https://www.tandfonline.com/doi/abs/10.1080/03768835022000019383

and social benefits that come from voluntary green building standards are justified as housing prices of those projects and the surrounding neighborhood will increase overtime.[102]

2.9 Understanding the Benefits of Energy Savings and Reduced Emissions

Studies have found that implementing policies and strategies focused on improving energy use and adopting EERE standards by all the stakeholders including governments, investors, housing developers, tenants, has the potential to cut US energy use and GHG emissions in half by 2050.[103] This would contribute to the US achieving its 2050 climate goals and earning about $700 billion savings.[104] Table 5 provides an insight to the estimated energy savings and reduced CO_2 emissions from identified opportunities related to homes and buildings in the US.

Table 5: Estimated energy savings and reduced CO_2 emissions from identified opportunities related to buildings in the US[105]

Identified Opportunities	Common Policies Adopted	Estimated energy savings (in quadrillion BTUs)	Estimated reduction in CO_2 emission (in million metric tons (MMT))	% reduction in energy use and CO_2 emissions by 2050*
Improved buildings design for New Constructions (including Zero Net Energy homes and buildings)	Building energy codes with high levels of EERE standards, voluntary LEED** certification	5.7	265	80%
Appliance and Equipment Efficiency	Department of Energy (DoE) appliance efficiency standards and voluntary Energy Star*** labeling	5.6	210	13%
Retrofits and upgrades	Home energy efficiency labeling and upgrade requirement for development	3.8	148	18% (in residential homes)
Electrification of home space heating and water heating	Incentives for electrification of homes and commercial buildings	0.9	76	13%

* The percentage reduction figures represent cumulative reduction of CO_2 emissions through various opportunities as compared to 2019 Baseline figures of the 2019 Annual Energy Outlook (AEO) released by the U.S. Energy Information Administration (EIA)

** Introduced by the US Green Building Council (USGBC) in 2000, LEED certification is a voluntary initiative that uses a series of performance metrics to guide businesses, governments, and individuals in improving their properties' energy and water efficiency, waste generation, and occupant comfort (Samarripas, S., & de Campos Lopes, C.,2020)

*** Energy Star symbol is introduced by the EPA for energy efficiency, providing simple, credible, and unbiased information that consumers and businesses rely on to make well-informed decisions (energystar.gov)

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[102] Yeganeh, A. J., McCoy, A. P., & Hankey, S. (2019). Green Affordable Housing: Cost-Benefit Analysis for Zoning Incentives. Sustainability, 11. https://ideas.repec.org/a/gam/jsusta/v11y2019i22p6269-d284800.html

[103] Nadel, S., & Ungar, L. (2019). *Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050*. American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/publications/researchreports/u1907.pdf

[104] *Ibid.*

[105] *Ibid.*

Translating the above table in other terms, we can understand that the estimated reduction in CO_2 emissions because of improved building design is equivalent to the avoided GHG emissions of recycling 12.8 million garbage trucks of waste instead of landfilling.[106] Similarly, by electrifying home space heating and water heating, the estimated reduction in CO_2 emissions is equivalent to the avoided GHG emissions of recycling 3.7 million garbage trucks of waste instead of landfilling.[107]

View **Appendix B** for the US's baseline GHG CO_2 estimate and potential reduction in CO_2 emissions from combined opportunities including the above mentioned.

<u>2.10 Common Barriers and Opportunities</u>

As many states in the US implement EERE standards in the affordable housing sector, state agencies, homeowners, developers, and tenants face multiple barriers. In this section, we present the common barriers and opportunities identified in the literature. These barriers are commonly observed across the country, while the opportunities listed in this section are not exhaustive.

The common barriers to implementing EERE standards include:

1. Financial Constraints
2. Regulatory Barriers
3. Split Incentives
4. Reluctance to Participate in Government Sponsored Programs
5. Lack of Coordination between Agencies
6. Constraints to Energy Data Access and Sharing
7. Green Gentrification and Double Injustice

Recent literature also noted a trend called "green gentrification" and "double injustice", which refers to social displacements and spatial inequalities experienced by low-income communities because of implementing EERE standards in affordable housing. Each of these identified barriers, along with the opportunities to overcome them, are presented below.

1. Financial Constraints[108,109,110,111]

Barriers	Access to capital is amplified by the lack of understanding of benefits of energy efficiency by the lender/underwriter/appraiser. Usually, they do not have data driven insights to invest in energy efficient projects.

[106] Using EPA's Greenhouse Gas Equivalence calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[107] *Ibid.*
[108] Peters, E. J. (2018). Bankable Savings: Analyzing New York's Green Bank. *Stanford Law Journal*, 457-469. https://law.stanford.edu/wp-content/uploads/2018/05/peters.pdf
[109] Henner, N. (2020). *Energy Efficiency Program Financing: Size of the Markets*. American Council for an Energy Efficient Economy. https://www.aceee.org/sites/default/files/pdfs/energy_efficiency_financing_-_the_size_of_the_markets.pdf
[110] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf
[111] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

	Investments and financial programs targeted specifically for multifamily programs are limited.
Opportunities	According to the 2020 ACEEE report on Energy Efficiency Financing, five major types of energy efficiency financing programs in the United States offer about $7 billion in lending annually, representing more than 40% growth since 2014. These models include Energy Service Performance Contract (ESPC),[112] Property Assessed Clean Energy (PACE),[113] State Energy Office (SEO) Revolving Loan Funds (RLFs),[114] On-Bill Financing (OBF),[115] Utility Financing Programs.[116] Some of the practices in states are described below: In New Jersey, **Residential Multifamily Housing Program** of the state Public Service Electric and Gas offers homeowners free investment-grade audits and subsidies for implementing cost-effective measures, allowing remaining costs to **be financed on the utility bill over a 10-year period.** In Tennessee, Pathway Lending, a **community development financial institution (CDFI)**, partnered with the state energy agency to provide a targeted multifamily option as part of its $50 million loan program, which includes state petroleum violation escrow funds, a Tennessee Valley Authority forgivable loan, and private capital from Pathway Lending and Pinnacle National Bank. Establishment of Government Sponsored Entities (GSEs) Fannie Mae[117] and Freddie Mac[118] in the last decade has expanded green loans to multifamily housing with a commitment to reduce energy use. According to ACEEE, in the US, **Green banks** have grown significantly in recent years, generating more than $5 billion in clean energy investment nationally since 2011, including $1.5 billion in 2019. In New York, state sponsored **New York Green Bank (NYGB)** offers submarket loans for clean energy projects, including energy efficiency measures. More details about this model are described in Chapter 5.

[112] An ESPC is a performance contract between an energy service company (ESCO) and a building owner/manager. A performance contract guarantees energy and/or dollar savings, and ESCO compensation is linked to the level of savings achieved. (Henner, 2020).
[113] PACE financing is a long-term loan instrument used for financing EE projects. PACE financing is attached to the property and not the property owner and the loan is repaid by customers as an assessment on their property tax bill. (Henner,2020).
[114] RLFs are offered to end users for eligible energy upgrades. RLFs are pools of capital from which funding is recycled via repayment of the loans by customers and then re-loaned for new projects. (Henner,2020).
[115] OBF financing for energy efficiency is returned to the utility on the customer's utility bill as an additional line item. (Henner, 2020).
[116] Offered by utility agencies or authorized third party agencies to lend capital to customers to fund energy efficiency projects. These programs are like traditional loan products and generally utilize funds provided by ratepayers to capitalize loans, provide credit enhancements, or offer interest rate buydowns to customers. (Henner,2020).
[117] Established by HUD to fund EE projects. Under Fannie Mae Green Mortgage Backed Securities, to access multifamily green financing, owner must either have green building certification or make property improvements to reduce energy or water consumption by 25 percent. (Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, L.,2018)
[118] Under Freddie Mac, to access Green Advantage loans, multifamily owner must do green assessment and commit to property improvements to reduce energy or water consumption by 25 percent. Freddie Mac will underwrite up to 50 or 75 percent of projected energy saving, depending on the type of green assessment done. (Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, L., 2018)

2. Regulatory Barriers[119,120,121]

Rules associated with federal subsidy programs including Section 8 and LIHTC properties have issues in calculating utility allowance.

Barriers	Utility allowances[122] published by a local Public Housing Authority (PHA) might not reflect actual usage at individual LIHTC properties as they base costs on a portfolio average of utility usage at typically older, energy-inefficient properties. These calculations may be higher, which do not incentivize developers to adopt energy efficient measures.
Opportunities	For new LIHTC constructions, HFAs including the Commission promote using either an Energy Consumption Model or an Actual Usage Estimate model for calculating the project's utility allowance. Section 8[123] and PHA properties may have limitations to adopt this model.

3. Split Incentives between Building Owners and Tenants[124,125]

Barriers	The lack of alignment of interests for utility benefits between the owners and tenants is called split incentive[126]. In federal subsidy programs such HUD's Section 8 Project-based Rental Assistance (PBRA), the landlords have no incentive to upgrade energy efficiency because those measures can potentially reduce the subsidy they may receive from the government.
Opportunities	In New York City, **"green lease"** or **energy efficient lease** allows commercial buildings' landlords to implement energy efficiency improvements and pass the costs to tenants based on projected savings. This can be a potential model for the residential sector. New York State Energy Research and Development Authority (NSERDA) provides 50% of costs of installing sub-meters in multifamily residential properties to overcome split incentives.

119 Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

120 Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

121 Washington State Housing Finance Commission. (2018). *Utility Allowance Procedures for LIHTC Properties*. Washington State Housing Finance Commission. https://www.wshfc.org/managers/ManualTaxCredit/290_AppendixOUtilityAllowanceProceduresForLIHTCProperties.pdf

122 Developers of LIHTCs must reduce rents by the amount of a resident "utility allowance," established in most places by local public housing authorities and in some areas by utility companies

123 HUD Project Based Section 8 property is a government-funded and provides rental housing to low-income households in privately owned and managed rental units.

124 Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

125 Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

126 Because of positioning of different metering systems, the owners and tenants do not have enough incentive to adopt energy efficient practices. In buildings with a master-meter, the owner pays the energy and water bills and passes it to the tenants in rents. Owners do not have incentive to implement energy efficient measures. In tenant-metered buildings, the tenant does not have control over energy-efficiency improvements that affect the entire property.

4. Reluctance to Participate in Government Sponsored Programs[127,128]

Barriers	Research found that many housing developers and owners are not comfortable being part of government utility programs focused on energy efficiency due to significant paperwork and bureaucratic hurdles.
Opportunities	Many non-governmental organizations provide "one-stop shopping" for building owners who need a simple guide to the various incentives and programs available focusing on energy efficiency, as well as financing to complete projects. One such example is **Chicago's Center for Neighborhood Technology (CNT) Energy Savers** working with Elevate Energy and Community Investment Corporation for energy upgrades and financing respectively and has retrofitted 32,000 units in Chicago. According to 2013 data, the retrofits have resulted in a 30% reduction in energy consumption; other benefits include a 5,000 metric ton reduction in GHG and 75 new jobs. The **National Housing Trust (NHT)** also leverages financing and incentives from various available programs to improve existing affordable rental homes.

5. Lack of Coordination between Agencies[129,130]

Barriers	Siloed policies of state agencies, utility, and decentralized policies at local, state, and federal levels on policies related to energy efficiency, climate goals, and affordable housing. This may lead to duplication of efforts and reduces efficiency of delivering targeted public programs.
Opportunities	Increase coordination between housing authorities, state utilities, and local governments have been observed in the last decade. Maryland Department of Housing and Community Development (MDHCD) also administers the state utility agency **EmPOWER Maryland's Multifamily Energy Efficiency and Housing Affordability (MEEHA) Program**, which is funded through the state's investor-owned utilities to provide rebates for energy-efficient constructions. **MassSave Multi-Family Retrofit Program**, an initiative sponsored by Massachusetts' gas and electric utilities and energy service providers along with the Massachusetts Department of Energy Resources, offers comprehensive energy efficiency services for multifamily owners and property managers with the help of a network of qualified Energy Specialists, who perform building assessments and identify available rebates, incentives, and financing.

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[127] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

[128] Center for Neighborhood Technology. (n.d.). *History and Accomplishments*. Retrieved 2021, from https://www.cnt.org/history-and-accomplishments

[129] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

[130] Bartolomei, D. (2017). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf

6. Constraints to Energy Data Access and Sharing[131,132,133]

Barriers	Without energy use data, insights about the impacts of implementing EERE standards remain unknown.
Opportunities	The EPA's Energy Star Portfolio Manager is a great tool to track and monitor a buildings energy use. Increasingly utilities provide energy use data uploaded on the Portfolio Manager to housing agencies and developers. In New York city, through an ordinance, **benchmarking and data disclosure about energy use was mandated**. Research has shown that the combination of disclosure of both energy use and Energy Star scores led to a 6% reduction in building energy-use intensity in three years and a 14% reduction in four years. **Georgia Power provides anonymized whole-building energy use** data uploaded on Energy Star Portfolio Manager to multifamily building owners and developers throughout the state. **Alaska Housing Finance Agency awards points to developers who commit to real-time energy data monitoring**. Energy and water audits and modeling analysis describing the energy and water use are mandated to track the use. However, water audits remain optional in many states. **Maryland Department of Housing and Community Development (MDHCD) requires an energy and water audit** for rehabilitation projects to identify all cost-effective energy conservation and water conservation measures that can be incorporated into the project's scope of work. In California, **California Tax Credit Allocation Committee (CTCAC) mandates rehabilitation projects to demonstrate a 10% improvement** above the building's modeled energy consumption based on CTCAC Existing Multifamily Assessment Protocols.

7. Green Gentrification and Double Injustice

While existing research suggests that affordable housing development can revitalize low-income communities[134], some of the research has observed adding climate change policies to existing housing policies has put a unique situation for low-income households. Investment in EERE technologies is seen as crucial for decarbonization and climate preparedness. However, these investments also add upfront costs, which push up prices affecting affordability leading to potential social displacements, which is what social scientists term *green gentrification.*[135]

[131] Bartolomei, D. (2017). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf
[132] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf
[133] American Council for an Energy-Efficient Economy. (n.d.). *Energy Data Access: State and Local Policies Database*. https://database.aceee.org/state/data-access
[134] Diamond, R & McQuade,T.(2019). "Who Wants Affordable Housing in Their Backyard? An Equilibrium Analysis of Low-Income Property Development," Journal of Political Economy, vol 127(3), pages 1063-1117. https://web.stanford.edu/~diamondr/LIHTC_spillovers.pdf
[135] Anguelovski,I., Connolly,J.J.T., Pearsall,H., Shokry,G., Checker,M., Maantay,J., Gould,K., Lewis,T., Maroko,A., Roberts,J.T.,Why green "climate gentrification" threatens poor and vulnerable populations. Proceedings of the National Academy of Sciences Dec 2019, 116 (52) 26139-26143; https://www.pnas.org/content/116/52/26139 DOI: 10.1073/pnas.1920490117

Emerging evidence suggests that assessing climate adaptation initiatives in eight cities worldwide can exacerbate socio-spatial inequalities across diverse developmental and environmental conditions.[136] This new form of climate injustice is termed "double injustice" because disadvantaged groups who contributed the least to global GHG emissions are bearing the brunt of the social costs of adaptation and, at the same time, are being excluded from the benefits of climate adaptation action.[137]

As a solution to these emerging barriers, when energy efficiency and green projects create new economic activities, researchers propose creating "green collar" jobs for low-income people who are impacted by green gentrification, especially in private sector projects, to reap the benefits of energy efficiency and sustainability.[138] Some promising practices are documented including the Latino neighborhood of Cully in Portland, Oregon, where Verde, a nonprofit organization, aims to train and hire local residents in building projects that improve social and environmental resilience. Similar examples are seen in Boston in groups such as GreenRoots and Boston Harborkeepers.[139]

2.11 Suggested Policy Options from the Literature

To overcome these unique socio-economic-environmental challenges and bring the benefits of affordable housing and energy efficiency to all, the suggested policy options demand a strong commitment of public sector leadership and private sector innovation.[140] Specifically, the public sector should address the roots of the housing affordability problem, through a significant and sustained commitment to rental housing programs.[141] For instance, the researchers highlight that the Congress should consider expanding LIHTCs to better target the housing needs of extremely low-income households. Although it is one of the largest federal subsidy programs given to low-income households, LIHTC rents, however, are not typically affordable to extremely low-income renters without additional rental assistance.[142] One suggested reform is, including a 50% basis boost in tax credits for developers that set aside at least 20% of their housing for extremely low-income renters through the proposed "Affordable Housing Tax Credit Improvement Act".[143]

An affordable and decent housing is important for stability in life. Along with energy efficiency measures, it provides a solid foundation for rejuvenating homes and lives and improves residents' social outcomes such as better health, nutrition, and educational outcomes. Researchers recommend continued support of public incentives for clean energy education and technology, while soliciting the involvement of nonprofit organizations for improving energy

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[136] Anguelovski,I., et al. (2016)., Equity impacts of urban land use planning for climate adaptation: Critical perspectives from the Global North and South. J. Plann. Educ. Res. 36, 333-348. https://journals.sagepub.com/doi/full/10.1177/0739456x16645166?casa_token=1M84DrzKovsAAAAA%3Au-eDiph0KPG6x177qRNAWcxqwRg4g7Af0c3idynI874oe1eN0xAhF6FMNH8NV28S3VAwBz_ZrFlDVwc

[137] *Ibid.*

[138] *Ibid.*

[139] Anguelovski,I., Connolly,J.J.T., Pearsall,H., Shokry,G., Checker,M., Maantay,J., Gould,K., Lewis,T., Maroko,A., Roberts,J.T.,Why green "climate gentrification" threatens poor and vulnerable populations. Proceedings of the National Academy of Sciences Dec 2019, 116 (52) 26139-26143; https://www.pnas.org/content/116/52/26139 DOI: 10.1073/pnas.1920490117

[140] Williams, Stockton. (2008). Bringing Home the Benefits of Energy Efficiency to Low-Income Households. Enterprise Community Partners.https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/paper-s-williams08.pdf

[141] National Low-Income Housing Coalition. (2020). Out of Reach. https://reports.nlihc.org/sites/default/files/oor/OOR_2020.pdf

[142] Aurand,A.,Emmanuel, D., Threet,D., Rafi,I., Yentel, D. (2020). THE GAP: The Affordable Housing Gap Analysis. National Low Income Housing Coalition. https://reports.nlihc.org/sites/default/files/gap/Gap-Report_2020.pdf

[143] *Ibid.*

efficiency in affordable housing.[144] With a more holistic approach, housing and energy efficiency can be integrated. It saves energy, improves indoor and outdoor air quality, supports natural resource conservation, and provides more equitable economic development for everyone, especially to low-income communities.[145]

[144] Hoye, Tim. (2013). Community Green: Sustainable Energy for Affordable Housing. College of Professional Studies Professional Projects. Paper 48. Retrieved from https://epublications.marquette.edu/cgi/viewcontent.cgi?article=1051&context=cps_professional
[145] Williams, Stockton. (2008). Bringing Home the Benefits of Energy Efficiency to Low-Income Households. Enterprise Community Partners. https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/paper-s-williams08.pdf

Chapter 3: Research Methods

Since our research needs an inter-disciplinary understanding, we utilized three research methods - a literature review, stakeholder interviews, and a benefit-cost analysis (BCA) - to address our research question of whether the Commission's Bond / 4% Low-Income Housing Tax Credit (LIHTC) Program's energy efficiency and renewable energy (EERE) standards outweigh the higher project costs. The stakeholder interviews aimed to better understand Bond / 4% Tax Credit Program stakeholder perceptions of the higher EERE standards. Then, the literature review dove deep into academic research that analyzed the relationship between the affordable housing and climate crises in the US and Washington State. Finally, the benefit-cost analysis was used to evaluate the social benefits and costs of two 2020 Bond / 4% Tax Credit Program-funded projects to identify whether the benefits of EERE standards were higher than their costs. The methodology to the stakeholder interviews, literature review, and benefit-cost analysis are described in greater detail below.

3.1 Stakeholder Interviews

Interviews were conducted in February 2021 with stakeholders identified by the Commission. The stakeholders were drawn from two groups: energy consultants and affordable housing developers. View Chapter 4 for the stakeholder interview key findings.

The purpose of these interviews was twofold:

- Determine the attitudes of developers with regard to the Commission's EERE points system, and allow them to voice concerns about the costs, advantages, and disadvantages of this system.
- Obtain an energy consultant's technical expertise on the energy efficiency code and gather any guidance to develop the benefit-cost analysis methodology.

Each interview was conducted through Zoom with a semi-structured format. The developers and energy consultants each had a separate list of prepared questions, as shown in the **Appendix C**. A selection of the interview questions are detailed below:

Developers:

- How does the environmental portion of the points system relate to your work?
- Should the Commission continue to emphasize environmental points or reprioritize its points to encourage more affordable housing units?

Energy Consultants:

- What's the best method for measuring energy use?
- What are the costs of the increased EERE technologies?

3.2 Literature Review

Our literature review in the Chapter 2 presented the existing knowledge in the field of research. With our literature review, we presented a holistic view of the intersectionality of affordable housing, climate change, and their effects of low-income households. We used insights from the literature review to develop an understanding of the field to answer our research question and also provide recommendations to the Commission.

3.3 Benefit-Cost Analysis

A benefit-cost analysis (BCA) is a useful economic tool to evaluate the social benefits and costs of a governmental policy or program. This type of analysis places a monetary value on all impacts from a given policy. Although a BCA should not be the only tool for decision-making, it can provide a valuable perspective on programmatic impacts. For this BCA, we evaluated the costs and benefits of the Commission's Bond / 4% Tax Credit Program EERE standards.

3.3.1 Standing

Determining standing, that is whose costs and benefits count, is one of the first considerations in a BCA. For this analysis, all residents in the United States have standing due to the Bond / 4% Tax Credit Program funding being issued from the federal government to state governments. State agencies (i.e., the Commission) then award the tax credits to private and nonprofit developers. However, Washington State residents and the Commission's project stakeholders will experience the greatest impacts from the construction and operation of these EERE standards.

3.3.2 The Commission's Energy Efficiency and Renewable Energy (EERE) Standards

The Commission's Bond / 4% Tax Credit Program includes EERE standards that enable a housing developer to earn additional points. It's important to understand these EERE standards as our BCA is focused on their incremental costs and benefits. View Chapter 1.2 and Appendix A for greater detail of the specific EERE standards in the Bond / 4% Tax Credit Program.

3.3.3 Utility Allowances

Utility allowances are an important aspect of the Commission's Bond / 4% Tax Credit Program and provide an important assumption to the BCA. The gross rent limit for a LIHTC affordable housing unit includes the cost of utilities. To determine the utility cost, a utility allowance analysis is conducted to estimate the utility usage for a given unit. The owner of a Commission-funded property must subtract the appropriate utility allowance to determine the maximum rent for tenants.[146] For all qualified low-income units, the tenant's rent plus utility costs should not exceed 30% of their actual income. One can assume that when a utility bill decreases from EERE improvements, rent may increase to make up the difference for the total gross rent. However, the building owner does not have to increase the gross rent when utility bills decrease. Due to this uncertainty and for the purposes of this BCA, we are assuming that there are benefits of lower utility bills to tenants, building managers, utilities, and society, regardless of utility allowances. Additionally, as this is a social BCA, we are measuring the net social benefits and costs, so even if the impacts aren't felt directly by tenants, then they can be assumed to benefit the utility or society as a whole.

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[146] Washington State Housing Finance Commission. (2021). Tax Credit Compliance Procedures Manual. Retrieved from http://www.wshfc.org/managers/ManualTaxCredit/40_Chap02FederalRequirements.pdf

3.3.4 Scenarios Explored

The first step to creating a BCA is to specify the project alternatives and the status quo. For this BCA, the status quo assumes that the property will be built, and the building will achieve the minimum EERE standards of the Bond / 4% Tax Credit Program. We employed a case study approach, where we analyzed two Bond / 4% Tax Credit projects, the Maddux and the Madison and Boylston (MadBoy), against the status quo. Both these projects submitted multiple rounds of applications with varying levels of EERE measures. By analyzing the same property against itself with greater degrees of sustainable building investments, we can identify the scale at which environmental benefits increase with those EERE measures. For both the projects, the first submittal was rejected, and the final submittal was approved. Therefore, our project alternatives were those first and final submittals. The following describes the Maddux and MadBoy's project alternatives and the status quo they are compared to.

Maddux:

- Status Quo: The building provided onsite renewable energy with no less than a peak system rating of 0.025 kWh/SF of conditioned floor area of the building. Additionally, for EE measures, the building completed at least three of the eight EE measures outlined in the 2015 Washington State Energy Code (WSEC).
- First Submittal: This first application was submitted December 9th, 2019. This application achieved three solar points with an annual energy production between 0.15-0.27 kWh/SF/year & three EE points by including four of the eight EE measures outlined in the 2015 WSEC.
- Final Submittal: This final application was submitted June 17th, 2020. This application achieved five solar points with an annual energy production greater than or equal to 0.28 kWh/SF/Year & six EE points by including five of the eight EE measures outlined in the 2015 WSEC.

View Table 6 for a breakdown of what was included in the Bond / 4% Tax Credit Program status quo and the first and final submittal for the Maddux's EERE measures.

Table 6: Maddux EERE measures per scenario

Status Quo	First Submittal	Final Submittal
C406.3 reduced lighting power	C406.3 reduced lighting power	C406.3 reduced lighting power
C406.9 reduced air infiltration	C406.9 reduced air infiltration	C406.9 reduced air infiltration
C406.5 renewable energy (0.15kWh/SF – res area only)	C406.5 renewable energy (0.15kWh/SF – res area only) Increase solar to 0.15kWh/SF-whole building	C406.5 renewable energy (0.15kWh/SF – res area only) Increase solar to 0.28kWh/SF-whole building
Gas water heating	Gas water heating	C406.7 High-efficiency service water heating - DHW Heat Pump
Double-pane windows	C406.8 enhanced envelope performance – triple-pane windows	C406.8 enhanced envelope performance – triple-pane windows

MadBoy:

- Status Quo: The building provided onsite renewable energy with no less than a peak system rating of 0.025 kWh/SF of conditioned floor area of the building. Additionally, for EE measures, the building completed at least three of the eight EE measures outlined in the 2015 WSEC.
- First Submittal: This first application was submitted December 9th, 2019. This application achieved three solar points with an annual energy production between 0.15-0.27 kWh/SF/year & zero EE points by including three of the eight EE measures outlined in the 2015 WSEC.
- Final Submittal: This final application was submitted June 17th, 2020. This application achieved five solar points with an annual energy production greater than or equal to 0.28 kWh/SF/Year & three EE points by including four of the eight EE measures outlined in the 2015 WSEC.

View Table 7 for a breakdown of what was included in the Bond / 4% Tax Credit Program status quo and the first and final submittal for the MadBoy's EERE energy measures.

Table 7: MadBoy EERE measures per scenario

Status Quo	First Submittal	Final Submittal
C406.3 reduced lighting power	C406.3 reduced lighting power	C406.3 reduced lighting power
C406.9 reduced air infiltration	C406.9 reduced air infiltration	C406.9 reduced air infiltration
C406.5 renewable energy (0.15kWh/SF – whole building)	C406.5 renewable energy (0.15kWh/SF – whole building)	C406.5 renewable energy (0.28kWh/SF – whole building)
C406.8 enhanced envelope performance – triple-pane windows	C406.8 enhanced envelope performance – triple-pane windows	C406.8 enhanced envelope performance – triple-pane windows
Gas water heating	Gas water heating	C406.7 High-efficiency service water heating - HPWH
	Energy Recovery Ventilation (ERV) in amenities	Energy Recovery Ventilation (ERV) in amenities
	Heat Pump with ERV for the corridor pressurization unit	Heat Pump with ERV for the corridor pressurization unit
	Variable Refrigerant Flow (VRF) in amenities	Variable Refrigerant Flow (VRF) in amenities

3.3.5 Impact Categories and Assumptions

The following sections describe each impact category and how they were measured. To monetize each cost and benefit, our sources include cost data from the Maddux and MadBoy's application materials, proxies from peer-reviewed academic studies, and price forecasts from governmental reports. We gathered additional data to model electricity and natural gas usage from the U.S. Department of Commerce's National Institute of Standards and Technology (NIST), Rushing, and O'Brien360. The NIST Energy Price Indices were used to escalate electricity and natural gas prices through 2050, while Rushing and O'Brien360 utilized building information modeling (BIM) technology to calculate annual energy usage per project and scenario.

We assumed a 30-year lifetime for each of the projects analyzed, as that is the amount of time the developers are contracted to keep the units as affordable housing. For our research, we applied a 3% discount rate, as that is the discount rate our social cost of carbon utilizes, as well as the rate the Congressional Budget Office uses.[147] We followed guidance from the Washington State Institute for Public Policy (WSIPP) when considering our discount rate range. WSIPP utilizes low and high values of 2% and 5% for their sensitivity analyses.[148] The Council of Economic Advisors recommended utilizing a 2% discount rate, while Moore et al. recommend using a 5% discount value.[149,150] Lastly, before each benefit and cost category was discounted, they were adjusted for inflation and measured in constant 2021 dollars.

3.3.6 Costs

The status quo assumes the project will be built with the minimum EERE standards. Therefore, we were only concerned with the higher project costs of each submittal.

Initial project investment costs

The initial project investment costs were the incremental costs that occurred in the construction period before the housing development was ready for tenants. These incremental costs included the planning, building material procurement, and construction costs for the specific EERE infrastructure in each submittal. These costs were supplied by the Commission and the housing developers directly. They are specific to the projects chosen. Both the Maddux and MadBoy stated construction would take around 1.5 years to complete. For the purposes of this BCA, we extended the construction period to 2 years. View Chapter 4 for a breakdown of costs per submittal and **Appendix D** for their integration into the full BCA.

Annual operation & maintenance (O&M) costs

Operation and maintenance costs are yearly incurred costs starting at the first year of operation. We only included the increased O&M costs from the EERE technology from each submittal, as we were only concerned with the incremental costs from higher EERE standards. These costs included the maintenance of the building and energy efficiency equipment and the other overhead costs associated with operations. Most of these costs were provided by the housing developers, while others like solar panel maintenance costs were calculated with the assumptions from the Cost of Renewable Energy Spreadsheet Tool (CREST) developed by the National Renewable Energy Laboratory (NREL).[151] The CREST tool states that the annual O&M for solar panels should be $6.50 / KW annually, with a 1.6% yearly increase. This cost covers the insurance, project management, property tax (or payment in lieu thereof), land lease, and royalty expenses.

It's important to note that these costs were the incremental costs from the status quo scenario. Therefore, for example, when the MadBoy final submittal installed a high efficiency water heater, rather than a natural gas water heater, we used the difference between their O&M costs

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[147] Congressional Budget Office. (2012). *The 2012 long-term projections for social security: Additional information.* Washington, DC.

[148] Washington State Institute for Public Policy. (December 2019). *Benefit-cost technical documentation*. Olympia, WA.

[149] Council of Economic Advisers. (2017). Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate. Council of Economic Advisers Issue Brief January 2017

[150] Moore, M.A., Boardman, A.E., & Vining, A.R., (2013) More appropriate discounting: the rate of social time preference the value of the social discount rate. Journal of Benefit-Cost Analysis, 4(1), 1-16.

[151] NREL. (n.d.). CREST: Cost of Renewable Energy Spreadsheet Tool. Retrieved April 17, 2021 from Energy Analysis: https://www.nrel.gov/analysis/crest.html

for the incremental costs. We applied this cost differential approach to all EERE infrastructure. For some technologies, like the Energy Recovery Ventilators (ERV) in the MadBoy submittals, where we did not have the various O&M costs available, we applied an O&M percentage proxy to develop each O&M cost differential.[152]

Equipment replacement costs
From solar panels to ERVs to high efficiency hot water heaters, each required replacement of certain equipment to maintain their effectiveness overtime. We utilized the NREL's CREST tool to develop the solar panels equipment replacement costs. This tool estimated a $0.235 / Watt for inverter equipment replacement that will occur in the year 10 & 20 of operations.[153] Similarly to the O&M costs, the Maddux and MadBoy housing developers provided estimates for the water heater and ERVs equipment replacement cost and when they would need to be replaced. When the status quo equipment replacement cost was not provided, we utilized an equipment replacement percentage proxy to develop the cost differential between the status quo and first or final submittal.[154]

3.3.7 Benefits

The energy efficiency and renewable energy (EERE) standards in the Commission's Bond / 4% Tax Credit Program are building properties with healthier living environments, cleaner air, better insulation to reduce noise levels, and more efficient equipment to lower utility bills. Residents, utilities, and society all benefit from these standards through public health, economic, and environmental outcomes. These benefits can be split into two categories: energy and non-energy benefits (NEBs). While energy benefits have a direct monetary value (i.e., electricity savings), all NEBs are hard-to-quantify and, therefore, have been historically left out of BCAs. Gudbjerg et al. found that if NEBs are included, the true value of the energy efficiency projects might be up to 2.5 times higher than if only assessing energy benefits.[155] Over the past twenty years, economists have used a variety of approaches to quantify these hard-to-quantify NEBs. Through our research, several types of proxies were identified to monetize NEBs.[156] Our BCA used the most conservative estimate of these proxies, the percentage adder proxy, as most NEB research develops percentage adders for each impact category. Additionally, Skumatz et al. recommended utilizing percentage adders as they offer an easier metric to scale to various EE programs, while other proxies are more subjective to the size, investment, or savings from individual programs.[157] This type of proxy is described in more detail below:

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[152] The O&M percentage proxy was developed based on a confidential Rushing and RMI Life Cycle Cost Analysis (LCCA) of water heaters. From their cost analysis, we calculated the ratio between the status quo equipment's O&M to the final submittal's O&M costs. This ratio of 0.29% was applied to other EE equipment when status quo cost estimates were unavailable.
[153] NREL. (n.d.). CREST: Cost of Renewable Energy Spreadsheet Tool. Retrieved April 17, 2021 from Energy Analysis: https://www.nrel.gov/analysis/crest.html
[154] The equipment replacement percentage proxy was developed based on a confidential Rushing and RMI Life Cycle Cost Analysis (LCCA) of water heaters. From their cost analysis, we calculated the ratio between the status quo equipment replacement costs to the final submittal equipment replacement costs. This ratio of 43.50% was applied to other EE equipment when status quo cost estimates were unavailable.
[155] Gudbjerg, E., Dyhr-Mikkelsen, K., Anderson, C. (2014). Spreading the word - an online non-energy benefit tool. *ECEEE Industrial Summer Study Proceedings*, 173.
[156] NESP. (2020). National Standard Practice Manual for Benefit-Cost Analysis for Distributed Energy Resources. National Energy Screening Project (NESP). From https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/08/NSPM-DERs_08-24-2020.pdf
[157] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

- Percentage Adder (% of energy savings): A percentage adder estimates the value of a non-monetized (i.e., comfort) impact by scaling up the utility savings impacts. This is known to be the simplest and most conservative approach for quantifying NEBs.[158]

There is substantial academic evidence to monetize NEBs for state and utility cost effectiveness testing. Cost-effectiveness tests are used to determine whether the benefits of utility investments of ratepayer funds in energy efficiency outweigh the costs.[159] Although our BCA is focused on two properties, rather than a utility portfolio, we applied these NEB values that were developed for statewide and utility cost-effectiveness tests. These cost-effectiveness tests define their NEBs into three categories: participant, utility, and societal benefits. The participant benefits are the effects of energy efficiency improvements that accrue to participants, in our case multifamily residents.[160] Utility benefits are the impacts that affect the utility company and its customers. When customers have lower utility bills, they are more likely to pay them on time, which allows utility administrators to spend less time managing bad debt and shutoffs.[161] Societal benefits are the impacts energy efficiency improvements have on the general public. When low-income multifamily residents spend less on utility bills, they can spend more elsewhere, which improves the local economy.[162] Additionally, research shows that low-income residents experience greater benefits from a more stable income.[163]

Most of the NEB research is focused on single-family weatherization and retrofit programs, with very limited research on quantifying market-rate and affordable multifamily housing NEBs.[164] While there are over 300 studies quantifying single-family NEBs, there are fewer than 6 quantifying multifamily NEBs.[165] For our research, we focused on three studies that quantified NEBs for low-income single and multifamily residents. For multifamily participant benefits, we used the Skumatz and Meyers 2006 study that aggregated participant NEBs from three low-income multifamily programs.[166] For multifamily building owner and management benefits, we used the NMR 2011 study that valued the impacts of energy efficiency improvements to building managers.[167] Lastly, due to the significant gap in multifamily NEB literature and, with the recommendation of Norton et al. and Cluett et al, our BCA utilized the Skumatz 2014 study approach to quantify societal and utility NEBs.[168,169] This Skumatz 2014 study conducted a

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[158] NESP. (2020). National Standard Practice Manual for Benefit-Cost Analysis for Distributed Energy Resources. National Energy Screening Project (NESP). From https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/08/NSPM-DERs_08-24-2020.pdf
[159] Cluett, R., & Amann, J. (2015). Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening. American Council for an Energy-Efficient Economy, 16. Retrieved from http://www.ourenergypolicy.org/wp-content/uploads/2015/06/a1502.pdf
[160] *Ibid.*
[161] *Ibid.*
[162] *Ibid.*
[163] NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
[164] Elevate Energy. (2014). Preserving Affordable Housing through Energy Efficiency. 13. Retrieved from https://www.elevatenp.org/wp-content/uploads/Preserving_Affordable_Multifamily_Housing_Through_Energy_Efficiency.pdf
[165] Skumatz, L. (2015). Considering the Inclusion of NEBs in IL TRM for Single and Multi-family Whole Building Retrofit Programs: The Issue of Measure-Based NEBs. Skumatz Economic Research Associates, Inc, 4-12. Retrieved from https://s3.amazonaws.com/ilsag/IL_NEBs_estimates_measures_Skumatz_for_NRDC_2015-08-03_Final.pdf
[166] Myers, Jody, and Lisa A. Skumatz, Ph.D. (2006). Evaluating Attribution, Causality, NEBs, and Cost-Effectiveness in Multifamily Programs: Enhanced Techniques. Proceedings from the ACEEE Study on Buildings, Asilomar, CA, August.
[167] Cluett, R., & Amann, J. (2015). Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening. American Council for an Energy-Efficient Economy, 16. Retrieved from http://www.ourenergypolicy.org/wp-content/uploads/2015/06/a1502.pdf \
[168] Norton, R., Brown, B., Lee, C., Malono-Paris, K., & Lewis, J. (n.d.). Achieving Health and Social Equity through Housing: Understanding the Impact of Non-Energy Benefits in the United States. Green & Healthy Homes Initiative, 116.
[169] Myers, Jody, and Lisa A. Skumatz, Ph.D. (2006). Evaluating Attribution, Causality, NEBs, and Cost-Effectiveness in Multifamily Programs: Enhanced Techniques. Proceedings from the ACEEE Study on Buildings, Asilomar, CA, August.

review of 20 single-family household weatherization programs to aggregate category NEBs.[170] All the hard-to-quantify NEBs were measured using contingent valuation, willingness to pay (WTP), and willingness to accept (WTA) surveys.[171] The following section outlines each energy and non-energy benefit's methodology to quantify their impacts, separated by participant, utility, and societal benefits.

3.3.8 Energy Benefits

Resource cost savings (a.k.a. energy savings)
The resource cost savings benefit is the reduced electricity and natural gas usage from more efficient building infrastructure, which includes efficient Heating, Ventilation, and Cooling (HVAC) systems, solar panels, and higher thermal envelope standards. We assumed a flat supply curve for the energy market, meaning that the supply of energy would not shift with a lower demand from these energy efficient projects. Therefore, if the price equals marginal cost, the change in energy prices overtime will represent the resource cost savings.

To calculate the resource cost savings, we modeled, with the support of Rushing and O'Brien360, the energy usage for the MadBoy and the Maddux for each project scenario. The energy savings was calculated by subtracting the first or final submittal by the status quo (minimum EERE standards). We then used the NIST pricing forecast for electricity (kWh) and natural gas (therms) rates until the end of the project to determine the savings on a year-to-year basis.[172] For our BCA, we calculated the kWh and therms savings separately for the status quo, first, and final submittal, as each energy source is priced differently and have varying global warming potentials (GWP) when converting to a carbon dioxide equivalence for the avoided greenhouse gas (GHG) emissions category. To monetize this category, the annual electricity and natural gas usage savings were applied to the yearly kWh and therms price.

3.3.9 Non-Energy Benefits (NEBs)

NEB research provides many types of participant, utility, and societal NEBs for cost-effectiveness tests and BCAs. As stated in section 3.3.7, our study was limited in the quantity and relevance of multifamily NEBs as there are so few multifamily studies. Therefore, with limited NEB categories that apply to multifamily housing, our study took the following approach to quantify NEBs,

For the participant benefits, we included all multifamily categories that were available to us, only excluding a few categories that were not relevant to these projects. For the utility and societal NEBs, we included single-family weatherization program proxies. There was no available multifamily study to address these utility and societal benefits. Future BCAs should develop project-specific NEBs to mitigate these limitations.

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[170] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
[171] *Ibid.*
[172] Lavappa, P., & Kneifel, J. (2019). Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis - 2019. U.S. Department of Commerce, National Institute of Standards and Technology. Retrieved from https://nvlpubs.nist.gov/nistpubs/ir/2019/NIST.IR.85-3273-34.pdf

Given these limitations, the overall impact of NEBs in this BCA is considered a conservative approach by researchers. The Midwest Energy Efficiency Alliance (MEEA) stated that 75% of the benefits from an EE project should come from NEBs.[173] Chapter 4 presents that the Maddux and MadBoy's NEBs contributed between 49% - 51% to the total project benefits for this BCA. Thus, even given the limitations outlined above, this lower NEB contribution to the total project's benefits confirms a conservative approach to quantifying NEBs.

View Table 8 for a breakdown of each NEB category and their proxy. Each category is described in greater detail following this table.

Table 8: Non-energy benefits (NEBs) and monetization proxy[174]

Non-Energy Benefit (NEB) Category	Annual % of Utility Bill Savings Range Low-High			Typical Value
Participant Benefits				
MF Residents				
Improved comfort	-		-	3.00%
Improved aesthetics & appearance	-		-	17.00%
Reduced noise	-		-	8.00%
Increased building safety	-		-	5.00%
Satisfaction from being env. responsible	-		-	27.00%
Fewer moves	-		-	5.00%
MF Building Owners & Managers				
Marketability of rental units	-1.00%	-	17.00%	8.00%
Reduced equipment maintenance	-1.00%	-	5.00%	3.00%
Greater durability	3.00%	-	17.00%	10.00%
Fewer tenant complaints	1.00%	-	7.00%	4.00%
Utility Benefits				
Reduced carrying cost on arrearages	0.60%	-	4.40%	2.00%
Lower bad debt write-offs	0.40%	-	2.00%	0.70%
Fewer shutoffs / reconnects	0.10%	-	4.40%	0.50%
Fewer notices	0.10%	-	1.80%	0.90%
Fewer customer calls / collections	0.20%	-	1.90%	0.60%
Reduction in emergency / safety	0.10%	-	2.70%	0.80%
T&D savings	0.09%	-	2.10%	1.20%
Societal Benefits				
Economic impacts	3%	-	237.60%	31.10%
Avoided GHG Emissions	See Avoided GHG Emissions methodology			

3.3.10 NEB Participant Benefits

As stated in section 3.3.3, for the purposes of this BCA, we are assuming that there are benefits of lower utility bills for tenants, regardless of utility allowances.

[173] Vijaykar, N. (n.d.). *Non-Energy Benefits of Energy Efficiency.* Chicago: Midwest Energy Efficiency Alliance (MEEA). Retrieved from https://www.mwalliance.org/sites/default/files/media/NEBs-Factsheet_0.pdf

[174] These NEB values were aggregated from 3 studies: Myers and Skumatz (2006), NMR (2011), and Skumatz (2014)

Improved comfort
The most commonly reported NEB for residents is from the additional perceived comfort. According to Skumatz et al, during a pre- and post-survey with a California Weatherization Program, 57% of survey participants experienced a positive change in comfort levels.[175] This could be caused by fewer drafts and more steady temperatures with highly efficient HVAC systems. Skumatz and Myers developed a proxy for comfort through a combination of open- and close-ended survey questions to gauge residents' value of comfort from energy efficiency programs. This study found the annual percentage of utility bills savings for comfort to be 3%.[176] We applied this percentage adder to the annual utility bill savings to calculate the increased comfort from the energy efficiency improvements.

Improved aesthetics and/or appearance
Skumatz and Myers utilized a labeled magnitude scaling technique when conducting their NEB WTP surveys.[177] This technique asked whether low-income renters experienced a positive, negative, or no effect with respect to each category, like improved aesthetics. They were then asked to value those benefits relative to the energy savings they experienced, which created the proxy percentage adders relative to utility bill savings. From thousands of surveys, Skumatz and Myers found the percentage adder for improved aesthetics was 17%.[178] We applied this percentage adder to the annual utility bill savings to calculate this improved aesthetics benefit.

Reduced noise
The reduced noise NEB stems from a buildings' tighter building envelope, better air filtration, and higher R-value insulation. This more efficient equipment reduces the outside noise that can be heard from inside a residence, providing mental health benefits. To monetize this category, we utilized Skumatz and Meyers percentage of bill savings proxy from multifamily retrofit programs. Skumatz found that noise reductions from more sustainable buildings were valued as 8% of annual utility bill savings.[179] We applied this percentage adder, 8%, to the annual utility bill savings from each submittal to quantify the noise reduction benefits.

Increased building safety
Faulty heating equipment is among the common causes of residential fires.[180] Low-income households are often impacted more when considering building safety, as they are less likely to afford their utility bills. Nonpayment of these bills may resort to alternative ways to heat their home (i.e., ovens, space heaters) that place those families at a greater risk of experiencing a fire.[181] This category was quantified using direct avoided costs estimates from reduced fires attributable to faulty equipment. Skumatz and Myers found this building safety benefit for

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175 TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf
176 Myers, J., & Skumatz, L. (2006). Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques. ACEEE Summer Study on Energy Efficiency in Buildings.
177 *Ibid.*
178 *Ibid.*
179 *Ibid.*
180 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
181 *Ibid.*

multifamily retrofit programs was valued at 5% of annual utility bill savings.[182] We applied this percentage adder, 5%, to the annual utility bill savings from each submittal to quantify the building safety benefits.

Satisfaction from being environmentally responsible
Multifamily residents are mostly aware that their energy consumption has an impact on the environment. Therefore, residents that live in more energy efficient housing can result in a sense of satisfaction from being environmentally responsible.[183] Skumatz and Myers study found that multifamily (MF) residents' value this doing good for the environment benefit at 27% of annual utility bill savings.[184] We applied this percentage adder, 27%, to the annual utility bill savings from each submittal to quantify this sense of environmental responsibility benefit.

Participant savings from fewer moves
Skumatz et al found in several of their low-income customer surveys that energy costs are often identified at the primary or a secondary reason why a renter elects to move.[185] Avoiding these move-outs provides an economic benefit to the residents and property managers. Lower energy use due to EERE equipment causes lower utility bills and allows the resident to avoid a variety of direct and indirect move costs. Direct costs include the time, effort, and expenses incurred with moving, while indirect costs include the disruption in children's education.[186] Skumatz and Myers valued this economic benefit for MF retrofit programs as 5% percentage adder to utility bill savings.[187] We applied the percentage adder to the annual utility bill savings to monetize the benefit.

Marketability of rental units
When NMR surveyed 27 low-income multifamily properties, 15% of building managers and owners found that building energy efficiency improvements led to better marketability of units.[188] Using the relative valuation method, low-income building owners valued NEBs as a percentage of energy savings. NMR then used a scaling method to aggregate the individual NEB values into individual benefit proxies. For the marketability of rental units, NMR estimated this benefit for low-income MF building managers as 8% of annual utility bill savings. To monetize this category, we applied this percentage adder to the annual utility bill savings.

Reduced equipment maintenance

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182 Myers, J., & Skumatz, L. (2006). Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques. ACEEE Summer Study on Energy Efficiency in Buildings.
183 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
184 Myers, J., & Skumatz, L. (2006). Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques. ACEEE Summer Study on Energy Efficiency in Buildings.
185 TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf
186 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
187 Myers, J., & Skumatz, L. (2006). Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques. ACEEE Summer Study on Energy Efficiency in Buildings.
188 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf

NMR's low-income multifamily housing survey found that 20% of building managers experienced an equipment maintenance benefit from energy efficiency improvements to their property.[189] Through the relative valuation method and NMR's scaling method, NMR developed an equipment maintenance proxy for low-income multifamily housing managers. NMR estimated this benefit for multifamily managers as 3% of annual utility bill savings.[190] We applied this percentage adder to annual utility bill savings to monetize this equipment maintenance benefit.

Greater durability
Single and multifamily households that are built with better quality HVAC systems, and structural materials are more durable.[191] Due to this durability, they require less maintenance. Thus, for energy efficiency programs, these durable improvements provide value to the multifamily housing managers in the form of avoided maintenance and transaction costs.[192] NMR, through the relative valuation method, estimated this benefit for MF retrofit programs as 10% percentage adder to utility bill savings.[193] To monetize this benefit, we applied this percentage adder to the annual utility bill savings.

Fewer tenant complaints
As tenants experienced the benefits of more reliable HVAC systems, longer lasting equipment, and lower energy bills, building managers received less complaints. When surveyed, 31% of multifamily building managers found that tenants were complaining less.[194] NMR then estimated this tenant complaint benefit as 4% of annual utility bill savings through the relative valuation method.[195] We applied this percentage adder to the annual utility bill savings to monetize this tenant complaint benefit.

3.3.11 NEB Utility Company Benefits

As stated in section 3.3.3, for the purposes of this BCA, we are assuming that there are benefits of lower utility bills for utilities, regardless of utility allowances. There is still a social benefit from customers in affordable multifamily housing paying utility bills on time and in full. Therefore, we included the following utility company benefits in the BCA.

Reduced carrying cost on arrearages
Arrearages are the costs accrued overtime when customers are unable to pay their bills. The "carrying cost" of this bad debt is borne by the utilities.[196] When buildings or households are more energy efficient, then low-income customers are more likely to pay for their utility bills, and less likely to be in arrears. This is the most widely studied NEB, and is measured as the utility's interest savings from the reduced arrearages carried.[197] Skumatz et al. valued this benefit

[189] NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
[190] *Ibid.*
[191] *Ibid.*
[192] *Ibid.*
[193] *Ibid.*
[194] *Ibid.*
[195] *Ibid.*
[196] *Ibid.*
[197] TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf

through multiple studies as 2% of annual utility bill savings.[198] To monetize this reduced carrying cost on arrearages benefit, we applied this percentage adder to the annual utility bill savings.

Lower bad debt write-offs

Bad debt write-offs, a.k.a. uncollectible, are when a utility is unable to collect payment from their customers who fail to pay their bills. Bad debt is accounted for separately from arrearages by utilities and represents a different cost.[199] Lower energy bills through low-income energy efficiency improvements can decrease these bad debt write-offs.[200] This category is measured through assumed rates of program-induced decreases in bad debt write-offs. Skumatz estimated this benefit as 0.70% of annual utility bill savings.[201] To monetize this bad debt write-off benefit, we applied this percentage adder to the annual utility bill savings.

Fewer shutoffs and reconnects

Low-income residents are disproportionately impacted by utility bills.[202] Installing more energy efficient equipment makes those utility bills more affordable and lessens the likelihood of service termination from non-payment.[203] Reduced shutoffs are measured in terms of the marginal cost from not sending staff out to disconnect the account, while the reconnect is measured in terms of the net marginal cost to the utility from the reconnect.[204] Skumatz measured the benefit from fewer shutoffs and reconnects as 0.50% of annual utility bill savings.[205] To monetize this fewer shutoff and reconnect benefit, we applied this percentage adder to the annual utility bill savings.

Fewer notices

Throughout NEB literature, a reduction in late payments and termination notices are widely recognized as a benefit to utilities.[206] Improved payment behavior leads to a reduction in utility costs and is measured in the reduced marginal cost from sending fewer notices to customers.[207]

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[198] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

[199] TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf

[200] *Ibid.*

[201] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

[202] Norton, R., Brown, B., Lee, C., Malomo-Paris, K., & Lewis, J. (n.d.). Achieving Health and Social Equity through Housing. 2018: Green & Healthy Homes Initiative. From https://www.greenandhealthyhomes.org/wp-content/uploads/AchievingHealthSocialEquity_final-lo.pdf

[203] NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf

[204] TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf

[205] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

[206] NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf

[207] TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf

Skumatz valued this benefit as 0.90% of annual utility bill savings.[208] We applied this percentage to the utility bill savings to monetize this benefit of fewer notices.

Fewer customer calls and collections
When low-income multifamily residents have lower energy bills, they are more likely to pay their utility bills in a timely manner. This can result in fewer customer calls and collection activities.[209] Improved payment behavior allows the utility to respond to fewer customers and fewer collection-related activities.[210] This benefit is valued by the marginal cost of fielding fewer calls and fewer collection-related activities. Skumatz valued this benefit as 0.60% of annual utility bill savings.[211] We applied this percentage to the utility bill savings to monetize this benefit of fewer customer calls and collections.

Reduced emergency and safety calls
Low-income homeowners or renters are more likely to live in a space with old or damaged HVAC systems, and therefore, more likely to experience fires from gas leaks.[212] Building energy efficient HVAC systems decrease the likelihood of an emergency call to the gas utility.[213] This benefit is quantified at the marginal staff and travel cost of addressing fewer gas emergency calls.[214] Skumatz valued this reduced emergency call benefit as 0.80% of annual utility bill savings.[215] We applied this percentage to the utility bill savings to monetize this benefit of reduced emergency and safety calls.

Deferred or avoided costs of expanding transmission and distribution (T&D) capacity:
Energy efficiency and distributed renewable energy generation capacity can delay, reduce, or avoid the need to build or upgrade T&D systems or reduce the size of needed additions as electricity demand increases.[216] Skumatz identified T&D savings with energy efficiency and renewable energy to be valued with a 1.20% percentage adder to annual utility bill savings.[217] We applied this percentage to the utility bill savings to monetize this benefit of avoided T&D capacity costs.

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208 Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
209 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
210 TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf
211 Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
212 NMR. (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Madison: Tetra Tech, Inc. Retrieved from https://ma-eeac.org/wp-content/uploads/Residential-and-Low-Income-Non-Energy-Impacts-Evaluation-1.pdf
213 *Ibid.*
214 TecMarket Works. (2001). The Low-Income Public Purpose Test (LIPPT). Oregon: Skumatz Economic Research, Inc. and Megdal and Associates. From https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/The-Low-Income-Public-Purpose-Test-LIPPT-May-25-2001.pdf
215 Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
216 U.S. Environmental Protection Agency (EPA). (2018). Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy. Washington D.C. From https://www.epa.gov/sites/production/files/2018-07/documents/epa_slb_multiple_benefits_508.pdf
217 Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf

3.3.12 NEB Societal Benefits

As stated in section 3.3.3, for the purposes of this BCA, we are assuming that there are benefits of lower utility bills for society, regardless of utility allowances.

Economic development
An ACEEE study focusing on U.S. metro areas found that overall the median energy burden for all households was 3.5%, whereas the energy burden for low-income households, low-income multifamily, renters, Latino and African-American households was 7.2%, 5.0%, 4.0%, 4.1% and 5.4%, respectively.[218] This study confirmed that there is a larger energy burden on low-income and racially diverse communities. While energy costs are not the only cost that can improve the livelihood of these vulnerable populations, reducing these costs through energy efficiency can help these residents pay for other bills (i.e. healthcare), and invest in the local economy. Additionally, this economic development category includes the direct and indirect impact to employment from the EERE investments. Skumatz monetized economic development benefits with a 31.10% percentage adder to utility bill savings.[219] To monetize this category, we applied the percentage adder to annual utility bill savings.

Avoided greenhouse gas (GHG) emissions
GHG emissions include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6), that all trap heat in the atmosphere, which is the primary reason for climate change.[220] With the reduction of natural gas infrastructure required to meet the Bond / 4% Tax Credit Program standards, these buildings will have extensive environmental benefits to Washington residents. This environmental benefit was captured through avoided GHG emissions by implementing higher EERE standards.

We calculated this impact by converting the natural gas and electricity usage into tonnes of CO_2e. by utilizing WA's OFM LCCA tool emission factor conversions of .00041184 CO_2e Tons/kWh and .00531148 CO_2e Tons/Therms, respectively.[221] To monetize avoided CO_2e emissions, we utilized the EPA's social cost of carbon (SCC) displayed in Table 9 through the project lifetime. We followed the guidance from the recent Interagency Working Group's publication on the social cost of greenhouse gases, where they recommended utilizing $52 per metric ton in 2021 with a 3% discount rate.[222] Essential to calculating the SCC is using Integrated Assessment Models (IAMs) that model the economic losses (via the GDP) from climate change impacts (i.e. sea level rise, extreme climate disasters, temperature rise).[223]

[218] Norton, R., Brown, B., Lee, C., Malomo-Paris, K., & Lewis, J. (n.d.). Achieving Health and Social Equity through Housing. 2018: Green & Healthy Homes Initiative. From https://www.greenandhealthyhomes.org/wp-content/uploads/AchievingHealthSocialEquity_final-lo.pdf
[219] Skumatz, L. (2014). Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and Their Role & Values in Cost-Effectiveness Test: State of Maryland. Skumatz Economic Research Associates, Inc, 27-30. Retrieved from https://sahlln.energyefficiencyforall.org/sites/default/files/2014_%20NEBs%20report%20for%20Maryland.pdf
[220] U.S. Environmental Protection Agency (EPA). (2018). Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy. Washington D.C. From https://www.epa.gov/sites/production/files/2018-07/documents/epa_slb_multiple_benefits_508.pdf
[221] Office of Financial Management. (2014). Life Cycle Cost Tool (LCCT) Instructions. Olympia: OFM. From: https://www.ofm.wa.gov/sites/default/files/public/budget/instructions/capital/LCCT_Instructions.pdf
[222] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. (2021). *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide*. Washington, D.C. Retrieved March 20, 2021 from https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf
[223] Liu, C., Zhang, H., & Wang, Z. (2019). Study on the Functional Improvement of Economic Damage Assessment for the Integrated Assessment Model. Sustainability, 1-8. doi:10.3390/su11051280

Table 9: Social cost of carbon from 2020 - 2050

EPA's Social Cost of Carbon per Metric Ton ($2021)						
2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
$52	$57	$63	$68	$74	$80	$86

3.3.13 Residual Value

The residual value is the remaining value of the project investment at the end of the project life that can be reused for another purpose. For this category, we considered the likely higher market value associated with increased EERE of housing at point of resale, as a function of the energy cost savings.

It can be difficult to isolate the specific benefit of the proportion of the market price that can be attributed to energy efficiency technology, however it is generally acknowledged that these energy efficient additions do add value to the property.[224] One method, a hedonic price regression analysis, can be used to assess the value of individual attributes of a property whose prices are not directly observed.[225] Most of these hedonic analyses have focused on the impacts of energy efficiency on single-family housing sales prices, whereas we only found one study that covers the EE impact on rental housing sales prices and rent payments.[226] This study from Hyland et al. analyzed how varying levels of the Building Energy Rating (BER) influenced housing sale prices and rent payments.[227] Similarly to the Bond / 4% Tax Credit Program EERE requirements, these BER certificates are assessed along the basis of the efficiency of the space and water heating, ventilation, insulation, and lighting fixtures in a building. Due to this similarity in building standards, we argue that Hyland et al.'s hedonic price analysis approach can be used to assess the varying resale price due to EERE improvements of the MadBoy and Maddux properties.

Through Hyland's analysis, they found EE improvements increase sales price by 64% - 79% of the NPV of energy cost savings.[228] To calculate the residual value for the Maddux and MadBoy's scenarios, we applied the average of this range, 72%, to each scenario's total resource cost NPV savings.

3.3.14 Omitted Impacts Categories

Our BCA assumes that these affordable housing projects will be built regardless of the EERE standards. In the Maddux and MadBoy's submittals, the higher EERE standards did not change the number of housing units per project. Therefore, we did not include the cost and benefits of increased affordable housing units. Nonetheless, detailed below are considerations for the Commission when developing future BCAs that aim to better understand the affordable housing impacts on Bond / 4% Tax Credit projects.

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[224] Hyland, M., Lyons, R., & Lyons, S. (2013). The value of domestic building energy efficiency - evidence from Ireland. Energy Economics, 40, 943-952. doi: http://dx.doi.org/10.1016/j.eneco.2013.07.020

[225] *Ibid.*

[226] Kholodilin, K., Mense, A., & Michelsen, C. (2017). The market value of energy efficiency in buildings and the mode of tenure. Urban Studies, 54(14), 3218-3238. doi:10.1177/0042098016669464

[227] Hyland, M., Lyons, R., & Lyons, S. (2013). The value of domestic building energy efficiency - evidence from Ireland. Energy Economics, 40, 943-952. doi: http://dx.doi.org/10.1016/j.eneco.2013.07.020

[228] *Ibid.*

People experiencing homelessness

We assume that a person experiencing homelessness will have some degree of benefit upon moving from a shelter, vehicle, tent, or other outdoor dwelling into a safe and affordable housing unit. This benefit would have come from the willingness to pay people to be in safe and affordable housing. There are relatively no peer-reviewed studies that fully capture the willingness to pay (WTP) for affordable housing. Other additional benefits of stable housing include general health, education (both for children in pre-k-12, but also in terms of secondary and post-secondary education for adults), and productivity loss.[229] There is also the impact on community engagement and safety. This includes voting, especially in a state that does exclusively mail in voting as Washington does, and overall agency in their communities.[230]

For the purposes of a BCA, productivity loss is defined as the economic impact that an individual has. This is often measured through earning potential, as BCA's frame these issues through an economist's lens. Specific to homelessness, and likely applicable to unstable housing as well, this not only includes individuals that do not work, but also do not perform at their full potential.

General health includes not only direct health outcomes and avoided medical costs for malnutrition, communicable diseases, and exposure, but it also encompasses violence, substance abuse, and other crimes (such as loitering) that ultimately cost society.[231] This can include productivity hours (a cost) but does not generally include fees (usually considered a transfer and not a true benefit, although there are ways to frame such fees as benefits depending on a particular BCA). It has been found that unhoused individuals utilize emergency services at a much higher rate than housed individuals.[232] With greater access to housing, this category can be monetized through the avoided costs from those individuals seeking emergency services.

Reduced work absences and sick days from school

Single and multifamily homes that have a tighter envelope, are less drafty, and offer a more efficient HVAC system that can result in fewer sick days for children and days off of work for adults. This category includes both direct costs for sick days lost from work and indirect costs from lower educational attainment from children losing days from school. This NEB was developed for single-family households, and therefore was not included in our participant NEBs as there is no multifamily study that quantifies this impact.

Indoor air quality

Criteria air pollutants, known as particulate matter or PM, ground-level ozone, carbon monoxide (CO), SO_2, NO, and lead (Pb) lower air quality and are harmful to human health. By reducing criteria air pollutants, it can have local and regional benefits to public health to reduce asthma,

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[229] Diamond, M. (2016). The Costs and Benefits of Affordable Housing: A Partial Solution to the Conflict of Competing Goods. *Georgetown Journal on Poverty Law & Policy*,, 27(2), 231-260.

[230] Manchester, N., & Ponsor, A. (2020). *The Impact of Home: Building to Opportunity, Health & Equity* (Rep.). Stewards of Affordable Housing for the Future.

[231] Diamond, M. (2016). The Costs and Benefits of Affordable Housing: A Partial Solution to the Conflict of Competing Goods. *Georgetown Journal on Poverty Law & Policy*,, 27(2), 231-260.

[232] Schanzer, B., Dominguez, B., Shrout, P. E., & Caton, C. L. (2007). Homelessness, health status, and health care use. *American Journal of Public Health, 97*(3), 464-469. doi:10.2105/ajph.2005.076190

lung damage, and other cardiovascular illnesses.[233] This impact was not included in our BCA due to limitations in previous research to quantify this impact.

Lighting quality
Lastly, we elected not to include lighting quality improvements as a NEB. This benefit is widely researched with multiple types of proxies available for cost-effectiveness testing and BCAs. However, as the quality of lighting did not change from the status quo to the first or final submittal, we elected to not include this NEB in our analysis.

3.3.15 Sensitivity Analysis

The NPV from this BCA was estimated based on input parameters from peer-reviewed academic literature, governmental resources, and developer projections. Most of these estimates were developed with varying levels of uncertainty. Our sensitivity analysis helps account for the uncertainty presented in the analysis. A Monte Carlo sensitivity analysis, through the application Crystal Ball, gives a probability distribution of potential outcomes (NPVs), allowing for variation in our input parameters. View the varied input parameters in Table 10.

Table 10: Input parameters and type of distribution

Normal Distribution	Triangular Distribution
Price of electricity	Fewer moves
Price of natural gas	Marketability of rental units
Annual electricity usage	Reduced equipment maintenance
Annual natural gas usage	Greater durability
Cost of carbon	Fewer tenant complaints
Annual avoided GHG emissions	Reduced carrying cost on arrearages
Improved comfort	Lower bad debt write-offs
Improved aesthetics & appearance	Fewer shutoffs / reconnects
Reduced noise	Fewer notices
Increased building safety	Fewer customer calls / collections
Satisfaction from being env. responsible	Reduction in emergency / safety
Project investment costs	T&D savings
O&M costs	Economic impacts
Equipment replacement costs	Discount rate
	Residual value

For the variables using a normal distribution we assumed a 10% standard deviation, which is the best practice for a Monte Carlo sensitivity analysis. For all other input parameters, we define the assumptions using a triangular distribution curve using minimum and maximum values. We limit our forecast to values between zero and infinity. The simulation results for both the Maddux and MadBoy are presented in Chapter 4.

[233] U.S. Environmental Protection Agency (EPA). (2018). Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy. Washington D.C. From https://www.epa.gov/sites/production/files/2018-07/documents/epa_slb_multiple_benefits_508.pdf

Chapter 4: Analysis

4.1 Overview

This chapter includes the results from our stakeholder interviews, as well as the benefit-cost analysis results for the Maddux and Madison and Bolyston (MadBoy) projects. View Chapter 3 for greater detail about how we arrived at the results from each research method.

4.2 Key Findings from Interviews

The stakeholder interviews presented us with three main findings, listed below. Specific feedback from developers and energy consultants are provided in section 4.2.1 and 4.2.2.

- A priority for developers is to build as many units as possible to increase the housing stock.
- While energy efficient building methods increase costs, they also provide an avenue to benefit developers and/or tenants through utility savings.
- There is an interest in seeing market rate developers be held to the same standards of energy efficiency as affordable housing developers.

4.2.1 Developers

We interviewed Jacob Gelb, a senior developer with Bellwether Development who manages the Bond / 4% Tax Credit Program development of a high-rise building on Madison and Boylston (MadBoy). The building is significant because of its use of both 4% and 9% tax credits, and that Bellwether and its partner developer applied for the credits twice before achieving a design with enough points to get funding. The MadBoy building became a key case study in the effects of how more energy efficiency points contribute to successful applications.

Gelb made clear that he saw the Commission's energy efficiency points as a key advantage for developers in Seattle applying for affordable housing funding through the Housing Trust Fund or the Commission. Both these agencies require buildings to be above the state's energy building code. He said that market rate developers should be held to the same higher standard, rather than allowing affordable housing more exemptions. Overall, he had a positive view of the energy requirements, and estimated that while earning energy points could lead to more development costs, it had a negligible effect on the number of units built.

We also interviewed Barry Baker of Mt. Baker Housing who is working on the Maddux project. Baker had a differing view from Gelb in that he believed it was most important to build as many units as possible to combat the housing crisis, and the increased costs associated with earning the energy points was a barrier to approving more projects.

4.2.2 Energy Consultants

We interviewed two energy consultants: Andi Burnham of Rushing and David Reddy of O'Brien360. Both had worked on buildings that were funded through the Commission's Bond / 4% Tax Credit Program. To improve their chances of maximizing energy points, Burnham stressed the importance of energy modeling at the beginning of the application process, which helped secure bond cap funding. The application process is highly competitive, and changes to the energy code are closely monitored by energy consultants that work with affordable housing developers.

While Burnham used modeling with her work on MadBoy, Reddy noted that whole building energy modelling is not a required component of the energy code in that increases soft costs and doesn't directly earn points, so it is not something that every developer does. He noted that the way points are weighed in the system tends to choose less costly methods of scoring points over more expensive ones and not always informed by in-depth analysis, and almost never using life-cycle cost analysis. However, he noted owners tend to adopt building envelope and other longer-lasting methods or less complicated energy efficiency measures due to concerns about newer technologies and maintenance. He also stressed the Commission should take long term policy goals into account when thinking of retrofits to improve sustainability. Burnham echoed his sentiment in that the energy points only tackled one portion of the various environmental considerations when building new housing, and that more can be done to ensure that overall life-cycle costs are considered.

4.3 Benefit-Cost Analysis (BCA) Results

We employed a case study approach to address our research question of whether the Commission's Bond / 4% Low-Income Housing Tax Credit (LIHTC) Program's energy efficiency and renewable energy (EERE) standards outweigh the higher project costs. Due to limitations in data availability and timing, we analyzed the benefits and costs of two Bond / 4% Tax Credit-funded projects, the Maddux and Madison and Boylston (MadBoy), rather than analyze all Bond / 4% Tax Credit-funded projects. Specifically, we compared both the Maddux and MadBoy's first and final submittals to the status quo. Both projects submitted a first application that was not selected for funding due to the limited EERE infrastructure presented in their Bond / 4% Tax Credit Program applications. Then each project resubmitted an application in the same funding cycle year, their final submittal, which was approved in part due to the greater EERE investments. We compared both these submittals to the status quo, which is the minimum EERE standards to receive Bond / 4% Tax Credit Program funding. By analyzing these two projects, we identified programmatic trends and provided a comprehensive framework for the Commission to use in future Bond / 4% Tax Credit Program BCAs.

In the below section, we separated the two projects to provide project-by-project differences in benefits and costs. Each section includes an overview of the project EERE technology per submittal, discounted benefits and costs table, and a sensitivity analysis. View Appendix D for the excel workbook that shows how these Net Present Values (NPVs) were calculated. The workbook includes the assumptions, parameters, discounting, and calculations.

4.3.1 The Maddux

The Maddux consists of two buildings, where all 203 units will serve households earning at or below 60% Area Median Income (AMI). This project is located in Seattle's Mt. Baker neighborhood on historically contaminated land due to the previous land use of a gas station, auto repair shop, and dry cleaner. View Chapter 1.4.1 for more detail about the Maddux's housing overview.

In this BCA, we compared the incremental benefits and costs from going above the minimum EERE standards in the Commission's Bond / 4% Tax Credit Program. For the Maddux, the two scenarios we analyzed utilize several EERE technology that reduced energy consumption and greenhouse gas (GHG) emissions, but in the process increased project costs. The first submittal differed from the status quo with additional solar panels and triple-pane windows. The additional renewable energy allows for less of a reliance on the energy grid, thus lowering utility costs overtime. Triple-pane vinyl windows are much more efficient for a home as they maintain indoor temperatures about 25% more efficiently than double-paned windows.[234] The final submittal differed from the status quo by adding more solar panels from the first submittal, maintaining the triple-pane windows, and investing in a high-efficiency heat pump water heater. The final submittal's greatest expense was the high-efficiency water heater, but also provided for the greatest energy savings of all the EERE infrastructure.

The project investment costs, especially the triple-pane windows and high-efficiency direct hot water heat pumps, provided the greatest costs for the Maddux's first and final submittals. Table 11 breaks down the project investment costs for the first and final submittal to contextualize their impact on the NPV.

Table 11: Maddux's project investment costs for the first and final submittal

First Submittal Project Investment Cost Deltas		**Final Submittal Project Investment Cost Deltas**	
EE and Renewable Energy Technology	Cost ($2021)	EE and Renewable Energy Technology	Cost ($2021)
Enhanced building envelope; Cost difference from status quo's double-pane to this submittal's triple-pane windows	$260,096	Enhanced building envelope; Cost difference from status quo's double-pane to this submittal's triple-pane windows	$260,096
Increased solar PV production; Cost difference from status quo's 20,076 kWh/yr to this submittal's 21,332 kWh/yr	$7,068	Increased solar PV production; Cost difference from status quo's 20,076 kWh/yr to this submittal's 39,821 kWh/yr	$105,289
		Enhanced hot water heater; Cost difference from status quo's natural gas water heater to this submittal's high-efficiency direct water heater (DHW) heat pump	$304,800

The O&M and equipment replacement costs were not as substantial than the project investment costs for the Maddux's first and final submittals. However, they do contribute to the NPV and are important to understand in this BCA. Table 12 breaks down these costs for the first and final submittal.

[234] American Vision Windows. (2016). Benefits of Triple-Pane Windows. Retrieved April 11, 2021, from: https://www.americanvisionwindows.com/benefits-triple-pane-windows/

Table 12: Maddux's O&M and equipment replacement costs for the first and final submittal

First Submittal O&M and Equip. Replacement Cost Deltas		**Final Submittal O&M and Equip. Replacement Cost Deltas**	
EE and Renewable Energy Technology	Cost ($2021)	EE and Renewable Energy Technology	Cost ($2021)
Increased solar PV maintenance costs from increased production. Cost difference from status quo and this submittal's annual maintenance costs	$8	Increased solar PV maintenance costs from increased production. Cost difference from status quo and this submittal's annual maintenance costs	$112
Increased solar PV equipment replacement costs from increased production. Cost difference from status quo and this submittal's equipment replacement in year 10 and 20 of operations	$275	Increased solar PV equipment replacement costs from increased production. Cost difference from status quo and this submittal's equipment replacement in year 10 and 20 of operations	$4,041
		Enhanced hot water heater; Annual maintenance cost difference from status quo's natural gas water heater to this submittal's high-efficiency direct water heater (DHW) heat pump	$2,864
		Enhanced hot water heater; Equipment replacement cost difference from status quo's natural gas water heater to this submittal's high-efficiency direct water heater (DHW) heat pump in year 20 of operations	$113,168

All the benefits were calculated from each submittal's reduced energy consumption and avoided GHG emissions compared to the status quo. To better understand this calculation, included below describes the energy savings and avoided GHG emissions for each submittal.

- For the first submittal, submitted on Dec. 9th, 2019, the increased renewable energy via solar panels and triple-pane windows led to an annual energy savings of 44,977 kWh, which equates to 18.52 metric tons of avoided GHG emissions. There was no change in the natural gas usage as the first submittal did not replace the gas water heating system.

- For the final submittal, submitted on June 17th, 2020, the additional solar panels, triple-pane windows, and high-efficiency water heating system led to an annual natural gas savings of 12,967 therms and an increase to the properties electricity usage by 38,665 kWh. The reason for the increase in kWh from the status quo is that the high-efficiency water heating system relies on electricity, rather than in the status quo the water heater relied on natural gas. As electricity in the Puget Sound area is generated mostly from hydroelectric power, it has a much lower carbon footprint than natural gas. Therefore, even with the increase in electricity, the natural gas reduction was large enough to avoid a cumulative 52.95 metric tons of GHG emissions.

Given the benefits and costs included in this analysis, the NPV of the first and final submittal would be $95,313.04 and $79,035.06, as shown in Table 13. Both the first and final submittal render a positive NPV, although the final submittal is a lower NPV. The additional investment and maintenance costs of the high efficiency water heating system are the reason for this lower NPV in the final submittal. The internal rate of return (IRR), or the discount rate at which the NPV would turn positive, in the first submittal is 1.81% and the final submittal is 0.63%.

Table 13: Maddux's discounted benefits and costs over the life of the project ($2021)

Category	First Submittal Discounted $2021	Final Submittal Discounted $2021
Benefits		
Energy Benefits		
Resource Cost Savings	$106,910.75	$250,170.63
Non-Energy Benefits		
Participant Benefits		
Improved Comfort	$3,207.32	$7,505.12
Improved Aesthetics & Appearance	$18,174.83	$42,529.01
Reduced Noise	$8,552.86	$20,013.65
Increased Building Safety	$5,345.54	$12,508.53
Doing Good for the Environment	$28,865.90	$67,546.07
Fewer Moves	$5,345.54	$12,508.53
Marketability of Rental Units	$8,552.86	$20,013.65
Reduced Equipment Maintenance	$3,207.32	$7,505.12
Greater Durability	$10,691.08	$25,017.06
Fewer Tenant Complaints	$4,276.43	$10,006.83
Utility Benefits		
Reduced carrying cost on arrearages	$2,138.22	$5,003.41
Lower bed debt write-offs	$748.38	$1,751.19
Fewer shutoffs / reconnects	$534.55	$1,250.85
Fewer notices	$962.20	$2,251.54
Fewer customer calls / collections	$641.46	$1,501.02
Reduction in emergency / safety	$855.29	$2,001.37
T&D savings	$1,282.93	$3,002.05
Societal Benefits		
Economic Impacts	$33,249.24	$77,803.07
Avoided GHG Emissions	$39,115.87	$111,815.33
Total Non-Energy Benefits	$175,747.82	$431,533.40
Residual Value	$76,441.19	$178,872.00
Total Discounted Benefits	**$359,099.76**	**$860,576.03**
Costs		
Initial Project Investment Costs	$263,273.57	$660,425.12
Equipment Replacement and Maintenance Costs	$513.15	$121,115.85
Total Discounted Costs	**$263,786.72**	**$781,540.97**
NPV	**$95,313.04**	**$79,035.06**

Looking at the composition of expected benefits for the first and final submittals, 49% and 50%, of the project's total benefits of came from NEBs, respectively. This is promising as the Midwest Energy Efficiency Alliance (MEEA) states that 75% of the benefits from an EE project come from NEBs, thus establishing our NEB analysis as a conservative approach.[235] Avoided GHG emissions and economic impacts were the largest NEBs for the first and final submittal. The resource cost savings benefit accounted for the remaining 30% and 29% of the benefits. The big driver on the cost side for the first submittal were initial project investment costs, while the

[235] Vijaykar, N. (n.d.). *Non-Energy Benefits of Energy Efficiency.* Chicago: Midwest Energy Efficiency Alliance (MEEA). Retrieved from https://www.mwalliance.org/sites/default/files/media/NEBs-Factsheet_0.pdf

equipment replacement and maintenance costs only make up a small fraction of total costs. However, the final submittal differed in that the replacement and maintenance costs were 15% of the total project costs, while the first submittal was only 0.20%. This is due to the increased replacement and maintenance costs for the high efficiency water heater system and the additional solar panels.

To account for the uncertainty in each of the above input parameters, we conducted a Monte Carlo sensitivity analysis for both the first and final submittal NPVs. View Chapter 3's sensitivity analysis section for a description of how we varied each parameter.

Figure 11: Maddux's first submittal sensitivity analysis

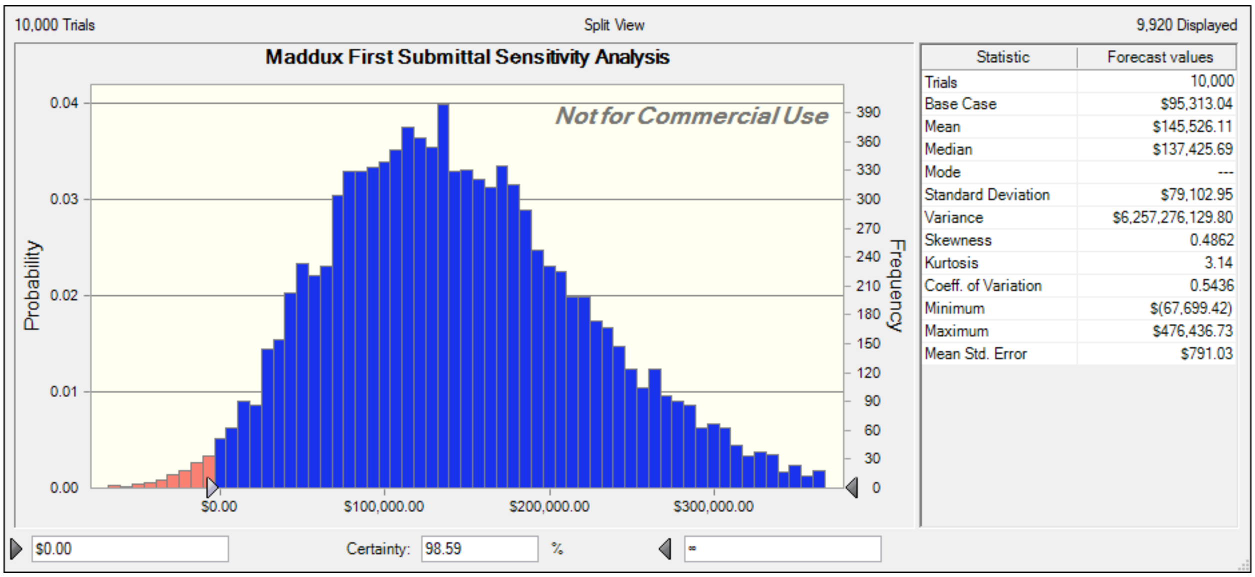

Figure 11 shows the results of the Maddux's first submittal Monte Carlo sensitivity analysis. There is an 98.59% chance that the Maddux's first submittal would result in a positive NPV, as indicated by the blue bars. The statistics on the right side of the graph show that the "Base Case" has a lower positive NPV than the average case, by approximately $50,000. The economic impact NEB contributes around 46% of the variation across simulations. While the kWh usage, capital costs, and real discount rate variations contribute 23%, 16%, and 12% to the variation, respectively.

Figure 12: Maddux's final submittal sensitivity analysis

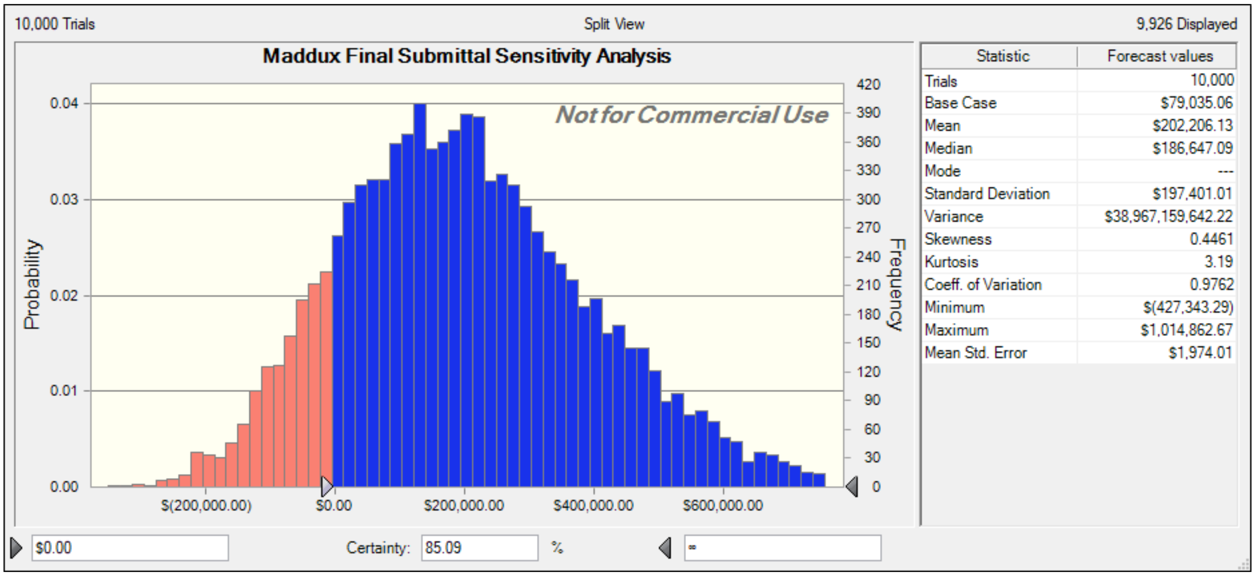

Figure 12 shows the results of the Maddux's final submittal Monte Carlo sensitivity analysis. There is an 85.09% chance that the Maddux's final submittal would result in a positive NPV, as indicated by the blue bars. The statistics on the right side of the graph show that the "Base Case" has a lower positive NPV than the average case, by more than $123,000. The economic impact NEB contributes around 39% of the variation across simulations. While the therms usage, capital costs, and real discount rate variations contribute 36%, 11%, and 9% to the variation, respectively.

Both the Maddux's first and final submittal's base case produced positive NPVs. These sensitivity analyses proved these submittals are very likely to produce positive NPVs even given the uncertainty of the benefit and cost input parameters.

<u>4.3.2 The Madison and Boylston (MadBoy)</u>

The MadBoy will be a 17-story building in Seattle's First Hill neighborhood with 365 affordable rental units. This property will serve large low-income families, disabled populations, and formerly homeless seniors. View Chapter 1.4.2 for more detail about the MadBoy's housing overview.

The MadBoy's first and final submittal utilize renewable energy and various EERE technology that reduces energy consumption and GHG emissions but in the process increases project costs. The first submittal differed from the status quo with the addition of an Energy Recovery Ventilation (ERV), heat pump, and Variable Refrigerant Flow (VRF) for the building's communal spaces. They did not increase their solar PV production in the first submittal. The ERV and VRF come at high costs but reduce energy consumption for a buildings HVAC system, as they use a heat exchanger to transfer hot and cold air more efficiently. Additionally, these EE technologies improve indoor air quality by flushing stale air out of the building. The final submittal differed from the status quo through additional solar panels and investing in an energy efficient heat pump water heater. As with the Maddux, the MadBoy's final submittal's greatest expense was the energy efficient heat pump water heater, but it also provided for the greatest energy savings.

The project investment costs provided the greatest costs for the MadBoy's first and final submittals. The largest initial expenditure was the high-efficiency service water heating system. Table 14 breaks down the project investment costs for the first and final submittal to contextualize their impact on the NPV.

Table 14: MadBoy's project investment costs for the first and final submittal

First Submittal Project Investment Cost Deltas		**Final Submittal Project Investment Cost Deltas**	
EE and Renewable Energy Technology	Cost ($2021)	EE and Renewable Energy Technology	Cost ($2021)
Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Cost difference is the total investment cost, as this was in addition to all other technology in the status quo scenario	$72,136	Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Cost difference is the total investment cost, as this was in addition to all other technology in the status quo scenario	$72,136
		Increased solar PV production; Cost difference from status quo's 47,723 kWh/yr to this submittal's 68,500 kWh/yr	$33,274
		Enhanced hot water heater; Cost difference from status quo's natural gas water heater to this submittal's high-efficiency service water heating (HPWH)	$714,248

The O&M and equipment replacement costs were not as substantial than the project investment costs for the Maddux's first and final submittals. However, they do contribute to the NPV and are important to understand in this BCA. Table 15 breaks down these costs for the first and final submittal.

Table 15: MadBoy's O&M and equipment replacement costs for the first and final submittal

First Submittal O&M and Equip. Replacement Cost Deltas		**Final Submittal O&M and Equip. Replacement Cost Deltas**	
EE and Renewable Energy Technology	Cost ($2021)	EE and Renewable Energy Technology	Cost ($2021)
Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Annual maintennce cost difference is the total annual maintenance cost for these technologies, as this was in addition to all other technology in the status quo scenario	$211	Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Annual maintennce cost difference is the total annual maintenance cost for these technologies, as this was in addition to all other technology in the status quo scenario	$211
Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Equipment replacement cost difference is the total replacement costs for these technologies in year 20 of operations, as this was in addition to all other technology in the status quo scenario	$31,379	Enhanced ventilation and HVAC equipment through ERV, heat pumps, and VRF; Equipment replacement cost difference is the total replacement costs for these technologies in year 20 of operations, as this was in addition to all other technology in the status quo scenario	$31,379
		Increased solar PV maintenance costs from increased production. Cost difference from status quo and this submittal's annual maintenance costs	$126
		Increased solar PV equipment replacement costs from increased production. Cost difference from status quo and this submittal's equipment replacement in year 10 and 20 of operations	$4,542
		Enhanced hot water heater; Annual maintenance cost difference from status quo's natural gas water heater to this submittal's high-efficiency service water heating (HPWH)	$2,085
		Enhanced hot water heater; Equipment replacement cost difference from status quo's natural gas water heater to this submittal's high-efficiency service water heating (HPWH) in year 20 of operations	$310,693

All the benefits were calculated from each submittal's reduced energy consumption and avoided GHG emissions compared to the status quo. To better understand this calculation, included below describes the energy savings and avoided GHG emissions for each submittal.

- For the first submittal, submitted on Dec. 9th, 2019, the addition of the ERV, VRF, and heat pump led to an annual energy savings of 12,403 kWh and 8,977 therms, which equates to 52.79 metric tons of avoided GHG emissions. In this submittal, those EE technologies reduced both the electricity and natural gas consumption.

- For the final submittal, submitted on June 17th, 2019, the additional solar panels, ERV, VRF, and high-efficiency heat pump water heating system led to an annual natural gas savings of 30,059 therms and an increase to the properties electricity usage by 167,829 kWh. Similarly, to the Maddux, the reason for the increase in kWh from the status quo is that the high-efficiency water heating system relies on electricity, rather than in the status quo the water heater relying on natural gas. As stated earlier, electricity has a much lower carbon footprint than natural gas, so even with the increase in electricity from the final submittal, the natural gas reduction was large enough to avoid a cumulative 90.54 metric tons of GHG emissions.

Given the benefits and costs included in this analysis, the NPV of the MadBoy's first and final submittal would be $817,045.76 and $332,152.35, as shown in Table 16. Both the first and final submittal render a positive NPV, although the first submittal is significantly more positive than the final. The additional investment and maintenance costs of the high efficiency water heating system and solar system are the reason for the decrease in the positive NPV in the final submittal. The IRR, or the discount rate at which the NPV would turn positive, in the first submittal is 32.79% and the final submittal is 2.06%.

Table 16: MadBoy's discounted benefits and costs over the life of the project ($2021)

Category	First Submittal Discounted $2021	Final Submittal Discounted $2021
Benefits		
Energy Benefits		
Resource Cost Savings	$266,301.01	$394,044.40
Non-Energy Benefits		
Participant Benefits		
Improved Comfort	$7,989.03	$11,821.33
Improved Aesthetics & Appearance	$45,271.17	$66,987.55
Reduced Noise	$21,304.08	$31,523.55
Increased Building Safety	$13,315.05	$19,702.22
Doing Good for the Environment	$71,901.27	$106,391.99
Fewer Moves	$13,315.05	$19,702.22
Marketability of Rental Units	$21,304.08	$31,523.55
Reduced Equipment Maintenance	$7,989.03	$11,821.33
Greater Durability	$26,630.10	$39,404.44
Fewer Tenant Complaints	$10,652.04	$15,761.78
Utility Benefits		
Reduced carrying cost on arrearages	$5,326.02	$7,880.89
Lower bed debt write-offs	$1,864.11	$2,758.31
Fewer shutoffs / reconnects	$1,331.51	$1,970.22
Fewer notices	$2,396.71	$3,546.40
Fewer customer calls / collections	$1,597.81	$2,364.27
Reduction in emergency / safety	$2,130.41	$3,152.36
T&D savings	$3,195.61	$4,728.53
Societal Benefits		
Economic Impacts	$82,819.62	$122,547.81
Avoided GHG Emissions	$111,475.43	$191,192.17
Total Non-Energy Benefits	$451,808.13	$694,780.92
Residual Value	$190,405.22	$281,741.75
Total Discounted Benefits	**$908,514.37**	**$1,370,567.07**
Costs		
Initial Project Investment Costs	$71,085.48	$807,721.23
Equipment Replacement and Maintenance Costs	$20,383.13	$230,693.49
Total Discounted Costs	**$91,468.60**	**$1,038,414.72**
NPV	**$817,045.76**	**$332,152.35**

Looking at the composition of expected benefits for the first and final submittals, 50% and 51%, of the project's total benefits of came from NEBs, respectively. As with the Maddux, the avoided GHG emissions and economic impacts were the largest NEBs for the first and final submittal. The resource cost savings benefit accounted for the remaining 29% of the benefits with $266,301 and $394,044 in savings for the first and final submittal. The big driver on the cost side for the first and final submittal were initial project investment costs. The first and final submittals equipment replacement and maintenance costs composed of 22% of the total project's costs.

To account for the uncertainty in each of the above input parameters, we conducted a Monte Carlo sensitivity analysis for both the MadBoy's first and final submittal NPVs. View Chapter 3's sensitivity analysis section for a description of how we varied each parameter.

Figure 13: MadBoy's first submittal sensitivity analysis

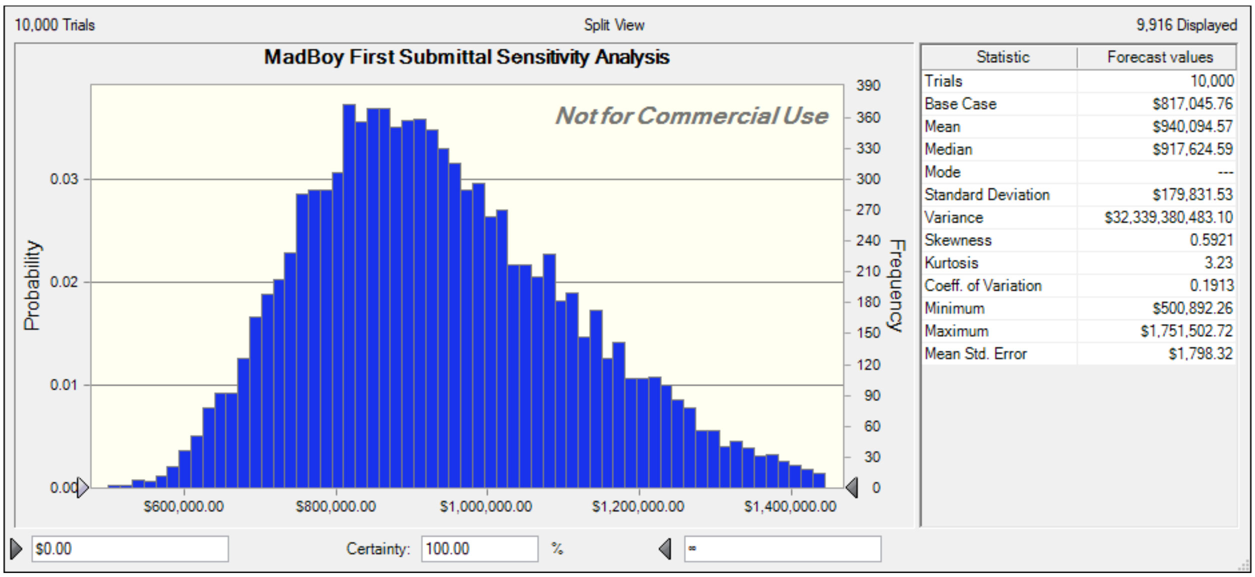

Figure 13 shows the results of the MadBoy's first submittal Monte Carlo sensitivity analysis. There is a 100.00% chance that the MadBoy's first submittal would result in a positive NPV, as indicated by the blue bars. The statistics on the right side of the graph show that the "Base Case" has a lower positive NPV than the average case, by approximately $123,000. The economic impact NEB contributes around 56% of the variation across simulations. While the real discount rate and therms usage variations contribute 21% and 19% to the variation, respectively.

Figure 14: MadBoy's final submittal sensitivity analysis

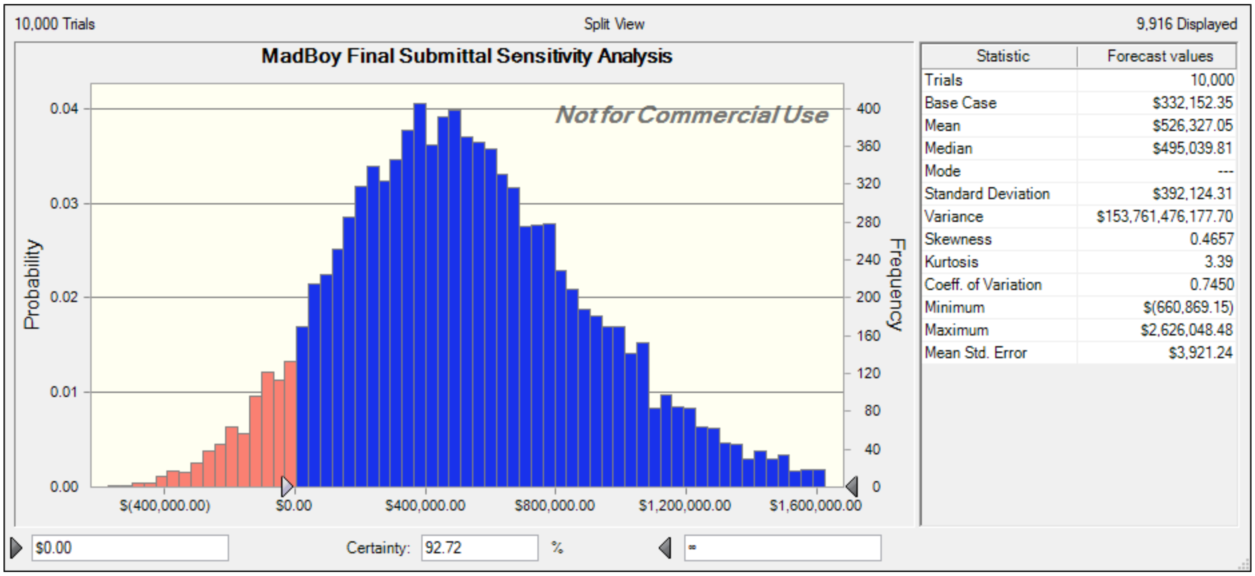

Figure 14 shows the results of the MadBoy's final submittal Monte Carlo sensitivity analysis. There is an 92.72% chance that the MadBoy's final submittal would result in a positive NPV, as indicated by the blue bars. The statistics on the right side of the graph show that the "Base Case" has a lower positive NPV than the average case, by approximately $200,000. The therms usage contributes around 50% of the variation across simulations. While the economic impacts, kWh usage, real discount rate, and capital cost variations contribute 26%, 12%, 5%, and 4% to the variation, respectively.

Both the MadBoy's first and final submittal's base case produced positive NPVs. These sensitivity analyses proved these submittals are very likely to produce positive NPVs even given the uncertainty of the benefit and cost input parameters.

Chapter 5: Conclusion and Next Steps

5.1 Conclusion of the Study

The Commission's objectives with this study were to determine how the benefits of the energy efficiency and renewable energy (EERE) points weighed against the increased costs to developers. Additionally, we weighed the benefits against the Commission's constraints, which include a limited pool of annual bond cap funding. More costly projects cause fewer affordable housing units to be built with the limited bond cap funding. Through this study, the Commission also wanted to assess how the Bond / 4% Tax Credit Program's point system can address the affordable housing crisis while also minimizing the impact of new buildings on the environment.

We adopted three approaches— Literature review, Stakeholder interviews, and a Benefit-Cost Analysis (BCA) to answer our research question: *whether the Bond / 4% Tax Credit Program's EERE standards outweigh the higher project costs in two projects (Maddux and MadBoy) funded by the Commission, to provide clarity to the Commission's policies*. Our literature review analyzed existing literature, data, policies and practices, and case studies to build an understanding of various facets that are at the intersection of affordable housing and climate change. This research identified integrated solutions to solve both the affordable housing crisis and the climate crisis. Through our stakeholder interviews, we heard how Washington developers and energy consultants viewed the Commission's policies, and how the policies can improve to solve the affordable housing and climate change crises. Lastly, in our BCA, we employed a case study approach of two Bond / 4% Tax Credit projects that monetized the incremental benefits and costs from going above the minimum EERE standards. View **Appendix E** for the limitations of this study.

Our results demonstrate that environmental benefits from EERE standards are greater than the costs. We believe there is a way for housing development to be affordable, safe, and sustainable for Washingtonians and recommend the following steps to improve the Commission's existing policies.

5.2 Recommendation #1: Maintain the Energy Efficiency and Renewable Energy (EERE) Standards in the Bond / 4% Tax Credit Program

From our study, we determined the environmental benefits of having EERE policies outweigh the additional cost burden to developers. This implies that the Commission is heading in the right direction to combine their goal of funding affordable housing development and building sustainable properties. Both the Maddux and MadBoy reduced their environmental impacts fairly substantially from these EERE investments. Table 17 displays the avoided GHG emissions from MadBoy and Maddux in their first and final submittal.

Table 17: Avoided GHG emissions from the Maddux and MadBoy in their first and final submittal (estimates)

Property	First Submittal Avoided GHG Emissions in Metric Tons (MT)	Final Submittal Avoided GHG Emissions in Metric Tons (MT)
Maddux	18.52	52.95
MadBoy	52.79	90.54

Another way to present this environmental impact is through the avoided GHG emissions in the MadBoy's final submittal which is equivalent to the avoided GHG emissions from recycling 30.8 tons of waste instead of landfilling or equivalent to carbon sequestered by 111 acres of US forests in one year.[236] For Maddux's final submittal, the avoided GHG emissions is equivalent to the avoided GHG emissions from recycling 18 tons of waste instead of landfilling or equivalent to carbon sequestered by 64.9 acres of US forests in one year.[237] By maintaining these EERE standards, the Commission has an opportunity to reduce energy use and carbon emissions, in alignment with Washington's Clean Energy Strategy 2021 for buildings.[238] These standards will also target benefits of higher quality of living for low-income communities in affordable housing.

Research observing the implementation of such standards find reduction in energy use and GHG emissions.[239] For instance, between 2013 and 2016, per capita building electricity and natural gas use declined at annual rates of approximately 1% and 4%, respectively, in mediumand large US urban municipalities.[240] Empirical evidence from California after implementing building energy codes showing that the compliance ensured 8-13% less electricity for cooling than homes built before 1978.[241] Similarly, the US Environmental Protection Agency's (EPA) Portfolio Manager tool data indicates that properties that are ENERGY STAR certified use 35% less energy and generate 35% fewer GHG emissions than similar noncertified facilities.[242] We also see the trend consistent with LEED certified properties showing lower GHG emissions from building energy use in buildings with higher certification levels.[243]

5.2.1 Limitations

Some of the limitations we observe for this recommendation include a) Application of the EERE standards to affordable housing and studying their impacts is an evolving field of research. Hence, we could not find comparable data and analysis representing the impacts of these standards on affordable housing, especially multifamily housing, energy use in these buildings, and those practices that can be readily applicable to Washington conditions. b) Scaling energy efficiency programs in multifamily housing has been difficult without adequate financing. Only a few energy efficiency programs in multifamily affordable housing have gone beyond their initial

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[236] Using EPA's Greenhouse Gas Equivalence calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[237] *Ibid.*

[238] Reduce Energy Consumption and Emissions in the Built Environment. (2021). Olympia: Washington Department of Commerce. Retrieved from https://www.commerce.wa.gov/wp-content/uploads/2021/01/WA_2021SES_Chapter-D-Buildings.pdf

[239] Samarripas, S., & de Campos Lopes, C. (2020). *Taking Stock: Links between Local Policy and Building Energy Use across the United States*. American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/pdfs/u2005.pdf

[240] *Ibid.*

[241] *Ibid.*

[242] *Ibid.*

[243] *Ibid.*

geographic area of implementation.[244] c) While per capita energy consumption in affordable housing is also declining, the pace of building new affordable housing is slow.[245] Between 2000 - 2018, the time between a multifamily project's permit application submission and completion increased by 47% from 9.8 to 14.4 months[246] which can impact the Commission's objectives. d) Another worrying trend is evidence from research suggests that while energy efficiency technologies in multifamily affordable housing leads to savings in utility bills for tenants, these savings can be used to buy new goods or services to support other economic activities, known as the "rebound effect". However, some scholars have questioned the longevity of such effects and have argued that if the savings from energy efficiency are used in buying new appliances that are not energy efficient or cannot be disposed sustainably, it erodes the net environmental effects achieved through these EERE standards.[247]

5.2.2 Next Steps

The Commission can utilize the same methodology used in this study to conduct BCAs for all Bond / 4% Tax Credit properties to better understand the full programmatic impacts these EERE standards have on the program. Additionally, we recommend utilizing the 2018 Washington State Energy Code (WSEC) as the baseline for these prospective BCAs. Table 18 displays an initial analysis to determine the variation between the 2015 and 2018 WSEC, and their impact on earning the maximum EERE points in the Bond / 4% Tax Credit Program. There is only one variation that developers can implement but is considered as a realistic option.[248] As highlighted in red text, the major differences between the 2015 and 2018 WSEC are due to the balanced ventilation & heat recovery (BV+HR) and a prescriptive envelope. For buildings that use electric resistance heating, the energy savings of BV+HR are expected to outweigh the savings of an enhanced envelope, therefore, a 2018 WSEC/ESDS v4 project will be more energy efficient than a 2015 WSEC/ESDS v3 project. That said, the cost for BV+HR is higher than the envelope, so the life-cycle costs may be similar or perhaps slightly worse for 2018 WSEC/ESDS v4 projects. Further analysis should be conducted to understand the true WSEC update implications to the Bond / 4% Tax Credit Program.

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[244] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

[245] Samarripas, S., & de Campos Lopes, C. (2020). Taking Stock: Links between Local Policy and Building Energy Use across the United States. American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/pdfs/u2005.pdf

[246] *Ibid.*

[247] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

[248] Reddy, D. (2021, April 27). 2015 and 2018 WSEC Code Variation for the Commission. (K. Johnson, Interviewer)

Table 18: Comparison of 2015 WSEC/ESDS v3 and 2018 WSEC/ESDS v4

WSEC and ESDS Code Variations	2015 WSEC/ESDS v3	2018 WSEC/ESDS v4
Using C406 to achieve ESDS 5.1 Minimum + ESDS 5.2 -> 10 pts	Exhaust ventilation Reduce lighting power Solar PV (Achieves both code C406 and bond pts) HPWH for 60% of annual load Reduced air leakage (0.25 cfm75/ft2) Enhanced envelope	Balanced ventilation + heat recovery (BV+HR) Reduced lighting power Solar PV (Achieves both code C406 and bond pts) HPWH for 60% of annual load Reduced air leakage (0.25 cfm75/ft2) Prescriptive envelope
Using C407 to achieve ESDS 5.1 Minimum + ESDS 5.2 -> 10 pts	Exhaust ventilation Reduce lighting power Solar PV HPWH for 100% of annual load	*Not enough data to determine how the new C407 might translate to the ESDSv4 criteria*

Going further, with adequate time and funding, the Commission should develop more robust and Commission-specific multifamily participant, utility, and societal non-energy benefits (NEBs) through willingness-to-pay (WTP) surveying. Developing unique NEBs for the Commission's properties will create more accurate and credible results, as the NEBs in our study were developed for utility and state cost-effectiveness testing. The largest omitted category from our study were the costs and benefits associated with people experiencing homelessness. We assume that a person experiencing homelessness will have some degree of benefit upon moving from a shelter, vehicle, tent, or other outdoor dwelling into a safe and affordable housing unit. This benefit would have come from the willingness to pay (WTP) for people to be in safe and affordable housing. However, there are relatively no peer-reviewed studies that fully capture the WTP for affordable housing. Future BCAs should incorporate those benefits and costs, provided that researchers have found a way to capture the social WTP of affordable housing, to fully understand the impacts of maintaining EERE standards.

Another practice can be incorporating benchmarking standards to monitor the energy and water use in the projects funded by the Commission. This will help the Commission monitor the application of EERE standards and take data-driven decisions on future investments. Housing Finance Agencies (HFAs) in New York City, Illinois, Pennsylvania, New Jersey, and Alaska incorporate benchmarking strategy in their awarding system. Some of these strategies requires commitment to data sharing with the Commission.[249]

The affordable housing markets should start to identify and implement methods to both scale housing investments while integrating energy efficiency benefits. This will speed up the pace of construction of achieving affordable housing and climate goals. The Commission can facilitate this scale of investments. There is no perfect model that works for all, but the literature presents

[249] Bartolomei, D. (2017). *State Strategies to Increase Energy and Water Efficiency In Low Income Housing Tax Credit Properties*. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf

emerging models of energy services and financing that show promise and offer hope in identifying creative ways to aggregate properties and standardize energy efficient upgrades to lower costs and risks.

As mentioned in Chapter 2, Maryland Department of Housing and Community Development (MDHCD) mandates developers to perform energy audits in buildings to receive tax credits.[250] To make these retrofits more feasible and energy efficient, MDHCD also administers EmPOWER Maryland's Multifamily Energy Efficiency and Housing Affordability (MEEHA) program, which is funded through the state's investor-owned utilities to provide rebates.[251] MDHCD also provides loans and grants for energy conservation measures through the MEEHA program, further incentivizing housing developers to implement building standards with higher levels of energy efficiency than required by the qualified allocation plans (QAP).[252]

A 2020 report of American Council of Energy Efficient Economy (ACEEE) noted cities that adopted climate goals are driving the trends in achieving EERE standards.[253] They have a number of the comprehensive energy service programs for multifamily housing available. Seattle and Washington are ahead in the US by implementing progressive policies focused on clean energy and climate goals. The Commission is well-placed to leverage the supportive policy and leadership environment to further its mission.

5.3 Recommendation #2: Identify Opportunities to Lower High-Efficiency Heat Pump Water Heater Costs

Although the NPVs in each scenario were positive, it is worth noting that for both the Maddux and MadBoy final submittals, the greatest cost and benefit were the high-efficiency heat pump water heaters. For both the Maddux and MadBoy, these EE technologies accounted for 54% and 99% of the total discounted costs, respectively. However, they were also responsible for the greatest environmental benefits as they transitioned each project from using natural gas to electricity. This transition to electricity is important as natural gas is primarily made up of methane, a strong greenhouse gas (GHG) that contributes to climate change. Electricity in the Puget Sound region is generated mostly from hydroelectric power, which has a much lower carbon footprint than natural gas. The Washington State's Deep Decarbonization Pathways (DDP) Study's Electrification Scenario indicated that when buildings are powered by electricity, there is a 26% drop in building energy use by 2050. When gas is retained in buildings, the drop in energy use in buildings is only 13%.[254] From our BCA, we found that the benefits of these high-efficiency heat pump water heaters as well as other EERE technologies, outweighed the higher costs. With these EERE technologies becoming more common, they are likely to pave the way for more affordable renewable energy implementation in the affordable housing sector.

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[250] Promising Practice: Incorporate Energy Efficiency and Renewable Energy Standards as a Criterion in Low-Income Housing Tax Credit Applications. (2020). US Environmental Protection Agency. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf
[251] *Ibid.*
[252] *Ibid.*
[253] Ribeiro, D., S. Samarripas, K. Tanabe, A. Jarrah, H. Bastian, A. Drehobl, S. Vaidyanathan, E. Cooper, B. Jennings, and N. Henner. 2020. *The 2020 City Clean Energy Scorecard.* Washington, DC: American Council for an Energy-Efficient Economy. www.aceee.org/local-policy/city-scorecard.
[254] Bansal, A. (2021). An Ambitious Clean Buildings Act for Washington State. Clean Energy Transition Institute. https://www.cleanenergytransition.org/post/an-ambitious-clean-buildings-act-for-washington-state

Additionally, as the state moves towards clean energy grid goals, the costs of renewable energy may continue to decrease, which in turn will reduce the costs of high efficiency heat pump water heaters. For now, as these high-efficiency heat pump water heaters represent most costs for developers seeking additional EERE points in the Bond / 4% Tax Credit Program, the Commission may want to explore opportunities or financial mechanisms to lower these costs for housing developers. Another observation from both the Maddux and MadBoy final submittals is that their high efficiency heat pumps are centralized. To achieve greater energy efficiency, in-unit or decentralized high efficiency heat pumps should be considered. As these decentralized heat pumps are more efficient, they are likely to save money overtime. However, without any data on their upfront or maintenance costs, we are unsure of how this will impact the lifecycle costs.

5.3.1 Limitations

Without state or federal action to place a price on carbon pollution, the price of natural gas will be lower than electricity. However, over the next 10 years, there will likely be a price increase to fossil-fuel based fuels, like natural gas with the passage of Washington State's GHG cap and invest legislation named the E2SSB 5126 Climate Commitment Act.[255] By January 1, 2023, the Department of Ecology may start to implement this cap-and-trade program to reach statewide goals of being net zero by 2050. This carbon pricing legislation will further incentivize energy efficiency in existing and new buildings, as it would increase the cost of energy.[256] Overtime, this may decrease the initial capital costs for high efficiency heat pump water heaters. Secondly, as with other recommendations, the Commission is constrained with the amount of financial support they can offer with limited bond cap support.

5.3.2 Next Steps

The Commission can collaborate and partner with manufacturers, local and statewide agencies, and housing developers to identify financial opportunities to lower these high efficiency heat pump water heater costs. One potential partner can be the Northwest Energy Efficiency Alliance (NEEA) which has successful working partnerships with manufacturers, retailers, and utilities that developed and deployed robust programs for installation of highly efficient Ductless Heat Pumps (DHPs) in the region since 2010.[257] Additionally, the Commission can consider a partnership with the Washington Utilities and Transportation Commission (UTC), who work closely with regulated energy utilities that offer a variety of energy efficiency incentives, including high efficiency heat pump water heaters.[258] Lastly, a partnership with the City of Seattle's Multifamily Weatherization Program to get energy efficiency grants may support lowering costs to heat pump water heaters by potentially covering up to 90% of the project

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[255] Senate Committee on Environment, Energy, & Technology; Senate Committee on Ways & Means; House Committee on Environment & Energy; House Committee on Appropriations. (2021). *Final Bill Report.* Olympia. Retrieved from http://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bill%20Reports/Senate/5126-S2.E%20SBR%20FBR%2021.pdf?q=20210505095512

[256] Hayes, K., & Hafstead, M. (2020, April 27). *Carbon Pricing 103: Effects across Sectors*. Retrieved from Resources for the Future: https://www.rff.org/publications/explainers/carbon-pricing-103-effects-across-sectors/#:~:text=A%20carbon%20price%20would%20make,cleaner%20sources%20more%20cost%2Dcompetitive.&text=Figure%201%20presents%20results%20from,a%20range%20of%20carbon%20prices.

[257] Nadel, S. (2018). *Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps*. American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/publications/researchreports/a1803.pdf

[258] Washington Utilities and Transportation Commission. (n.d.). Company Conservation Programs. Retrieved May 8, 2021, from https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/company-conservation-programs

costs[259]. The Commission can engage the above identified stakeholders individually or collectively to identify potential solutions and develop a plan to integrate these solutions into the Bond / 4% Tax Credit Program.

5.4 Recommendation #3: Provide More Support to Developers

Many community-based developers in Washington are small developers. The Commission can consider supporting those smaller developers through subsidies, grants, or other financial mechanisms, to reduce the increased cost of housing development to ensure equity in the affordable housing sector and the Commission's point system can evolve to address that.

Typically, the rate of participation of multifamily properties in state energy financing is significantly low in comparison to the level of investment made for single-family residential or commercial energy efficiency projects.[260] However, emerging practices captured in the literature offer some exciting insights in overcoming this barrier. One of the prospective ways the Commission can consider is engaging Community Development Finance Institutions[261] (CDFIs) to augment financing targeted for EERE projects in multifamily affordable housing projects. As mentioned in Chapter 2, in Tennessee, state agencies have partnered with Pathway Lending, a CDFI, to provide targeted retrofit loans for developers.[262] Other financial models include participation in energy efficiency projects in affordable housing and are practiced across the nation are: On-Bill Lending[263], Pay as You Save (PAYS)[264], Property Assessed Clean Energy (PACE)[265], and Energy Service Agreements (ESAs).[266]

In New York state, the state sponsored New York Green Bank (NYGB) was created to be a self-sustaining financial institution to fund clean energy projects. It charges interest rates below the market rate for loans and offers very long repayment periods, which may not likely be commercially available.[267] Considering the environmental benefits of EERE standards and emerging opportunities in clean energy housing, the Commission can build a financing model with no to low-interest loans for developers to cover the upfront costs of the EERE projects and

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[259] Seattle City Government. Multifamily Weatherization Program. https://www.seattle.gov/housing/housing-developers/multifamily-weatherization

[260] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

[261] CDFIs are private institutions dedicated to lending to help low-income and other disadvantaged households. They aim to expand economic opportunity in low-income communities through access to capital and services for local residents and businesses. CDFIs can be banks, credit unions, loan funds, microloan funds, or venture capital providers. (Johnson, K., & Mackres, E. (2013))

[262] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

[263] As per the US Department of Energy, **On-bill financing** allows the utility to incur the cost of the clean energy upgrade, which is then repaid on the utility bill. **On-bill repayment** options require the customer to repay the investment through a charge on their monthly utility bill as well, but with this option, the upfront capital is provided by a third party, not the utility. (https://www.energy.gov/eere/slsc/bill-financing-and-repayment-programs)

[264] In PAYS model, the utility invests in cost-effective energy upgrades at customer sites, such as building energy efficiency upgrades or rooftop solar. The customer pays nothing upfront for the upgrades they choose but pay back the costs through a fixed charge on the customer's monthly bill until the investment is recovered. (https://www.cleanenergyworks.org/about-pays-for-ee/)

[265] In PACE finance modeling, for energy efficiency and renewable energy projects, property owner can implement improvements without a large up-front cash payment for owners. They can raise private capital in this model and repay their improvement costs over a set time period - typically 10 to 20 years - through property assessments, which are secured by the property itself and paid as an addition to the owners' property tax bills. Nonpayment generally results in the same set of repercussions as the failure to pay any other portion of a property tax bill. (https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs)

[266] In ESAs, instead of securing a loan to finance capital improvement or new EE building technology, the owner enters into an agreement with a third party that installs and owns the EE improvements, and the building owner pays a service fee to the third party for ongoing use of those improvements.

[267] Peters, E. J. (2018). Bankable Savings: Analyzing New York's Green Bank. *Stanford Law Journal*, 457-469. https://law.stanford.edu/wp-content/uploads/2018/05/peters.pdf

then deduct that amount of financial support from their LIHTC funding once approved. A state backed effort may help the small developers overcome market barriers and provide flexibility[268] to the Commission's mission.

Another model that can be explored is providing financial incentives to developers based on their performance and achieving specific energy efficient outcomes. This provides an opportunity for making data-driven decisions and incentivize developers showing commitment to reduced energy use. One of the practices used by HFAs to track energy use and performance is by benchmarking energy and water use is currently followed at 10 states in 2020[269] as compared to 6 in 2017.[270]As mentioned in Chapter 2, utilities are increasingly sharing energy consumption data to multifamily property owners/developers for the purpose of benchmarking, and many utility systems upload data directly to the EPA's Energy Star Portfolio Manager[271]. In some states, WegoWise for benchmarking energy use.[272] The Commission can consider awarding points for developers adhering to benchmarking practices. **Appendix F** provides a list of emerging practices applied by HFAs across the nation for benchmarking energy and water use, according to their September 2020 QAPs.

Incorporating benchmarking practices along with energy audits requirements may lead to analyzing building energy performance and awarding points/incentives to the developers[273]. In Rhode Island, South Dakota, Wyoming, HFAs award points for developers[274] based on building energy performance using a nationally recognized system for calculating a home's energy performance[275] Home Energy Rating System (HERS), created by the Residential Energy Services Network (RESNET) and ENETGY STAR Certification. **Appendix G** provides a list of emerging practices applied by HFAs across the nation for building energy performance incentives, according to their September 2020 QAPs.

5.4.1 Limitations

The limitations we foresee with this recommendation include a) Mobilizing additional financial support for small developers can be constraining for the Commission with limited bond cap funds available each year. Hence, having a readily available capital pool for lending to cover upfront costs can be challenging. b) Additionally, the Commission may require gaining support from state's political leadership for building a new financial model, adding a layer of political

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[268] *Ibid*.
[269] Bartolomei, D. (2021). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. Report Update. https://www.novoco.com/sites/default/files/atoms/files/nht-report-energy-water-efficiency-lihtc-03292021.pdf. Based on 2020 QAPs of HFAs
[270] Bartolomei, D. (2017). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf. Based on 2016 QAPs of HFAs
[271] Bartolomei, D. (2021). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. Report Update. https://www.novoco.com/sites/default/files/atoms/files/nht-report-energy-water-efficiency-lihtc-03292021.pdf. Based on 2020 QAPs of HFAs
[272] *Ibid.*
[273]Bartolomei, D. (2021). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. Report Update. https://www.novoco.com/sites/default/files/atoms/files/nht-report-energy-water-efficiency-lihtc-03292021.pdf. Based on 2020 QAPs of HFAs.
[274] *Ibid.*
[275] Bartolomei, D. (2017). State Strategies to Increase Energy and Water Efficiency in Low Income Housing Tax Credit Properties. https://assets.ctfassets.net/ntcn17ss1ow9/7r1ftuS6Fp6ExJ09xGCSeN/6fa5b2b51a60a8dd024864a23d9f0eba/Energy_Efficiency_Strategies_in_LIHTC_properties.pdf. Based on 2016 QAPs of HFAs

and bureaucratic barrier. c) Other financial models practiced elsewhere in the US for EERE in affordable housing may be difficult to replicate in Washington. d) Operationally, small community developers may be inexperienced in handling large scale projects that may require additional training. e) Finding and engaging CDFIs can be challenging and adds additional administrative burden for the Commission. f) Lastly, for benchmarking practice, the Commission must engage with the developers and utility agencies and/or third-party agencies, the negotiations may be time-consuming and may increase the Commission's workload.

5.4.2 Next Steps

The Commission can identify developers based on the size of the organization and engage them in discussions to build more resources for supporting developers. To augment more financial resources, the Commission can explore the possibility of securing additional funds for small developers through programs targeted at EERE in affordable housing by other government agencies such as the US Department of Housing and Urban Development (HUD) and Department of Commerce's Housing Trust Funds. Moreover, the Commission can negotiate with the state energy offices to see the possibility of securing their funds from the Department of Energy (DoE) for developers to invest in multifamily affordable housing. Another option with the Commission can be expanding partnerships with energy efficiency non-profit organizations that have loan programs for EERE in affordable housing and leveraging philanthropic grants available for EERE upgrades in multifamily affordable housing. These sources can potentially form the capital pool for upfront lending for small developers discussed above. In NYGB, the ratepayer[276] funds from utilities are used for lending loans to green projects. In Tennessee's CDFI model, public and private capital are pooled and targeted for multifamily retrofits. [277]

For incorporating benchmarking practice, the Commission has many options:

1. Ask developers to benchmark energy and water consumption using Energy Star Portfolio Manager for a minimum of five years and make data available to the agency. This model is followed in South Carolina.
2. Only common area energy use data from Energy Star Portfolio Manager can be shared with the Commission, as practiced in New Jersey.
3. Alternatively, the Commission can work with a third-party entity to monitor the utility consumption of projects as in Pennsylvania.

While these partnerships and negotiations may take time to materialize, as a first step, the Commission can start building a repository with details of additional funding sources that can be shared with developers. This is important as the existing literature suggests many affordable housing developers and contractors lack information regarding the existing policies, governmental incentives. and non-governmental funding available to them for EERE upgrades.[278]

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[276] Refers to a customer of a public utility agency.

[277] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

[278] *Ibid.*

5.5 Recommendation #4: Develop More Engaging and Collaborative Statewide Partnerships

The Commission can consider collaborating with other state agencies, large nonprofit organizations, energy and environmental advocates, utility companies, and developers in Washington to work together to identify and propose solutions to the affordable housing and climate crises. These partnerships may identify crossover with existing agency outreach programs that can clearly target and achieve each partner's housing and climate goals. Besides, working with multiple partners with different expertise can help achieve the benefits of keeping housing occupied, as well as keeping them energy efficient. Building owners and operators in general, but of multifamily rental housing in particular, do not have the expertise or bandwidth to execute EE upgrades and retrofits.[279] Therefore, engaging, and educative partnerships are necessary to further the Commission's goal.

Although the list is not exhaustive, we recommend some of the potential partnerships that can be explored by the Commission below. These are:

1. Partnering with Energy Service Companies (ESCOs)

The Commission can build a framework to leverage its working partnership with Energy Consultants and Energy Service Companies (ESCOs) to provide Energy Service Performance Contracts (ESPCs) for Energy Efficient (EE) upgrades and retrofits. In the ESPCs, the Energy Service firms or ESCOs conduct energy audits for the housing projects and generally offer guaranteed minimal energy (or water) savings, arrange for up-front financing of capital costs to the housing owner that is designed to be paid for over time with the energy savings, initial monitoring and verification after installing, and long-term operations and maintenance.[280]

While ESPCs are not common for the multifamily housing sector as EE-retrofits in both smaller and larger projects have similar fixed costs. This prevents small Energy Service firms to engage in EE-retrofits for small multifamily housing projects due to the challenge of scale.[281] As the Commission has a large portfolio of affordable housing projects, the issue of economies of scale faced by ESCOs can be tackled. In Colorado, Denver Housing Authority (DHA) partnered with ESCO Honeywell to implement EE retrofits in its affordable housing portfolio in 2007. Following its success, DHA implemented a self-managed ESPC in the second phase. They implemented $14 million in capital improvements and Energy Conservation Measures (ECMs)[282] in 2,800 housing units across 14 properties with a 15-year payback from ECM-related utility savings. They estimated 17% electric savings, 35% natural gas savings, and 45% water and sewer savings.[283] Similarly, the Rockford Housing Authority (RHA) in Illinois entered a $7.5 million ESPC with an ESCO and realized about 13% savings in utility costs.[284]

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[279] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[280] *Ibid.*
[281] *Ibid.*
[282] The measures included new roofs, attic insulation, window replacement, efficient furnaces and water heaters, central plant upgrades, common and unit-level lighting retrofits, efficient appliances, ceiling fans, and thermostats.
[283] Applied Public Policy Research Institute for Study and Evaluation (APPRISE). (2017). *Low-Income Energy Efficiency: Opportunities Study*. https://www.edf.org/sites/default/files/APPRISE_Low-Income-Energy-Efficiency-Opportunities-Study-2017.PDF
[284] *Ibid.*

2. Partnering with Utility and Energy Agencies

State utility agencies have increased their focus on EERE programs. Spending on electricity EE programs by state utility agencies has risen from $900 million in 1998, $3.9 billion in 2010, to $6.3 billion in 2016.[285] These programs also include financial incentives, such as rebates, loans, and technical services such as audits, retrofits, and training for architects, engineers, and building owners through educational campaigns. Therefore, utilities have additional avenues for the Commission to explore for affordable housing EERE project incentives. Some of these successful partnerships between Housing Finance Agencies (HFAs) and state-utility agencies as mentioned in Chapter 2 are[286]: a) Maryland's MEEHA b) New Jersey Housing and Mortgage agency partnered with state's largest utility provider Public Service Electric & Gas (PSE&G) for Residential Multifamily Housing Program c) Michigan State Housing Development Authority's GREEN loan project for EE in multifamily housing.

The Commission can build a framework to deepen the existing partnerships with Seattle City Light and Puget Sound Energy to integrate their comprehensive programs for new construction EE into the Bond / 4% Tax Credit Program. Additionally, these utility agencies implement multifamily rebate programs for EE retrofits for existing buildings which researchers consider a new opportunity for retrofitting existing affordable housing in the Seattle area.[287] The Commission can also work with these utility agencies to get energy consumption data for benchmarking practices.

3. Partnering with residents and owners of the affordable housing projects

While the Commission leads the affordable space with financing, it can also take this opportunity to educate residents and owners of the multifamily affordable housing projects to advance its mission of achieving affordable housing with a minimal environmental impact. For example, the Denver Housing Authority (DHA) focused on getting feedback from residents of affordable housing projects during the design process to understand the resident's behaviors and preferences. Due to this, DHA installed ceiling fans, HVAC replacements, and building envelope improvements that enhanced climate control and had high resident satisfaction.[288]

Another way for the Commission to communicate with residents is by partnering with energy consulting firms, community organizations, and utility agencies to educate high-energy users during energy audits. An additional benefit to this communication is that the Commission can recruit these high-energy residents to test strategies that incentivizes energy conservation and identify potential EE solutions. Such analytics can also provide opportunities to expand the most successful strategies.

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[285] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf
[286] Johnson, K., & Mackres, E. (2013). *Scaling Up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment*. American Council for Energy-Efficient Economy (ACEEE). https://www.aceee.org/sites/default/files/publications/researchreports/e135.pdf
[287] *Ibid.*
[288] Applied Public Policy Research Institute for Study and Evaluation (APPRISE). (2017). *Low-Income Energy Efficiency: Opportunities Study*. https://www.edf.org/sites/default/files/APPRISE_Low-Income-Energy-Efficiency-Opportunities-Study-2017.PDF

5.5.1 Limitations

Researchers have pointed out that in many states, the LIHTC programs are often siloed approaches, which highlights a weak collaborative governance.[289] The above-mentioned partnerships demonstrate public-private partnerships that will only work when there is mutual support and coordination to achieve maximum program effectiveness. As multiple agencies are involved, the Commission should be aware of multiple operational barriers, dividing responsibilities, and accountability issues that may affect these partnerships. The Commission should be aware of these pitfalls and design their collaborative approach to avoid them. Additionally, the Commission should be cautious to join many agreements because of additional administrative capacity needed to manage these partnerships. Affordable housing owners and developers may be weary of entering into several government partnerships as well.

As for the ESCOs, they are standardized and guarantee a minimum savings. However, there are instances where ESCOs have been seen to be predatory in nature. For example, the New York Public Service Commission cited three energy-service companies in 2016 for deceptive practices like charging customers inflated rates for utilities, signing up customers who did not know what they were receiving, or falsely telling customers they were from the local utility.[290] ESPCs have long close times because of their complexity and can have high transactions costs.[291] Lastly, ESCOs can deliver better savings only for large scale or a large portfolio of projects and their business goals may not align with the Commission's mission.

5.5.2 Next Steps

The Commission can begin by identifying potential partners and deepen stakeholder engagement by discussing ways to improve existing relationships, develop new partnerships, and enhance expertise to achieve the integrated goal of achieving affordable housing with minimal environmental impacts. Since the affordable housing market is complex, experts believe that high specialization within the sector by compartmentalizing and providing complementing learning practices to the sector in terms of financing, policy areas, standardization, and benchmarking will lead to effective scaling of energy efficient affordable housing.[292]

5.6 Conclusion

While the pace and level of investment in multifamily energy efficiency has increased, experts in the field suggest that more is possible in terms of savings for building owners, tenants, society, and government[293] and the Commission is well-positioned to bring this change. The literature suggests that the evolving nature of work in affordable housing, utility sector, and state-level decision making around energy issues, and collaboration with private and non-profit agencies

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[289] Satio.B.(2020). Collaborative Governance and the Low Income Housing Tax Credit. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3601869

[290] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

[291] *Ibid.*

[292] *Ibid.*

[293] Energy Programs Consortium. (2013). *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices*. https://www.aceee.org/files/pdf/resource/epc_%20multifamily_housing_13.pdf

gives an opportunity to build policies at the intersection between housing and climate policies and efforts to address racial and economic inequality.[294]

[294] Schwartz, H. L., Curtright, A. E., Ogletree, C., Thornton, E., & Jonsson, ,. L. (2018). *Energy Efficiency as a Tool for Preservation of Affordable Rental Housing: Evaluation of the Efficiency Emphasis in the MacArthur Foundation's Window of Opportunity Initiative*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2293/RAND_RR2293.pdf

Appendix A: The Commission's Program Policies Excerpt

4.19 Solar Options

Points will be awarded for projects that install a solar system with an annual energy production per square foot of conditioned floor area of the building:

- 3 points: Annual energy production between 0.15-0.27 kWh/SF/year
- 5 points: Annual energy production greater than or equal to 0.28 kWh/SF/Year

Projects must submit with their application an architect's certification and a solar contractor's assessment attesting that the project can accommodate a compliant solar system.

As part of the Placed-in-Service package, the Applicant or the Applicant's solar contractor must submit documentation stating the size of the system installed. Failure to install a compliant solar system may result in a temporary suspension from the program. Such action will be considered on a case-by-case basis.

4.20 Energy Efficient Building

Points will be awarded for projects that score additional ESDS points in ESDS section 5.2a.

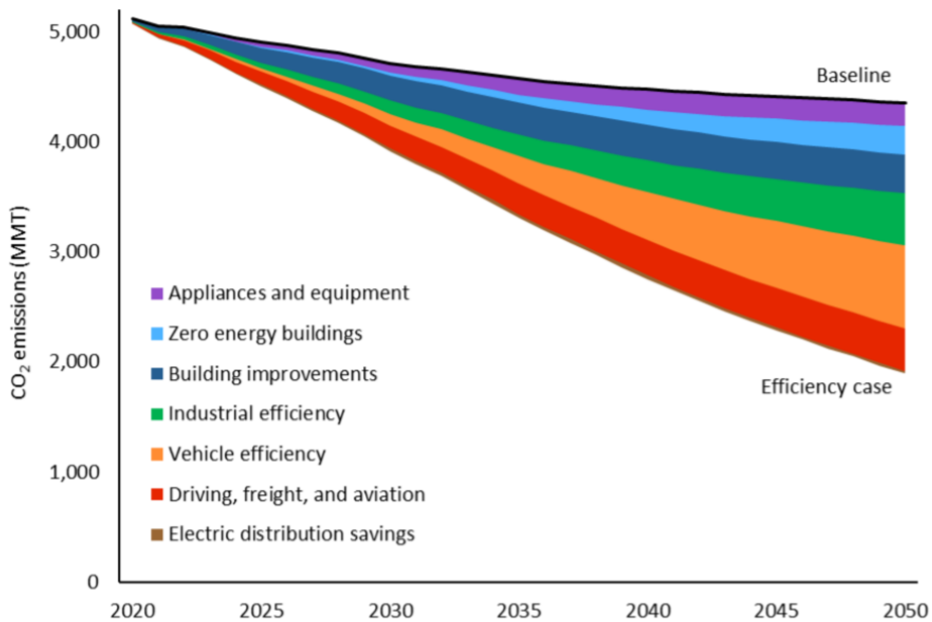
3 points: 5 ESDS points over mandatory in ESDS Section 5.2a

6 points: 10 ESDS points over mandatory in ESDS Section 5.2a

During submittal, the ESDS points used to comply with this section must be noted on the ESDS Checklist and Evergreen Owner Certification outlined in Section 3.5.

As part of the Placed-in-Service Package, the ESDS points used to comply with this section must be included in the Evergreen Project Implementation Plan and architect's certification outlined in Section 3.5.

Appendix B: Estimated Reduction in Carbon Dioxide Emissions from Combined Opportunities in the US



Taken from Source: Nadel and Ungar (2019)

Appendix C: Interview Questions

1. Please succinctly describe the application process for the Commission's Bond / 4% Tax Credit Program as you understand it.
2. Please describe the environmental standards and points system related to it.
3. How does the environmental portion of the points system relate to your work?
4. Do you think you would build more affordable housing units if the environmental point requirements were reduced?
    a. If so, if you're able to estimate, how many would you expect?
5. Does the Bond / 4% Tax Credit Program effectively address both sustainability and housing needs, or does it favor one over the other?
6. Given everything we spoke about, what do you think the Commission should do regarding the Bond / 4% Tax Credit Program?
    a. Should they continue to emphasize environmental points or reprioritize its points to encourage more affordable housing units?

Appendix D: BCA Workbook (attachment)

Appendix E: Other Limitations Identified in our Methodology

In this section, we list the limitations identified from our methodology to highlight the appropriate context and influences that may impact the findings of the study and generalization of the conclusions.

From the Stakeholder Interviews:

- We bring our own biases and experiences to the interviews with developers and energy consultants.
- While we prepared questions ahead of time and tried to standardize the interview process, we also allowed the interviewees to steer the interview because of their relative expertise on the topics we were covering.
- The buildings that use the Commission's funding are all unique, and developers run the gamut of sizes, experience levels, and from for-profit to nonprofit organizations. Our two interviews with developers of our case study buildings represent the views of just a small sample of the stakeholders.
- Time constraints and the busy schedule of developers with buildings in development made it difficult to have as many interviews as we intended to.
- Our interviews were with developers only from non-profit organizations, which likely limited the scope of the views expressed.

From the BCA:

- To calculate the NEBs, our BCA used utility/state cost-effectiveness testing methodology. This approach may not have been the perfect method to quantify NEBs as it is meant to measure an EE investment for an entire utility portfolio. Nonetheless, through their rigorous surveying methods, it seemed like the best approach to quantify NEBs for this study.
- The multifamily participant NEB methodology was derived from two studies (Skumatz 2006 & NMR 2011). Whereas there are hundreds of single-family NEB studies that have developed very robust methods to calculate each NEB.
- The utility and societal NEBs were developed from single-family weatherization programs. There was no available multifamily study to address these utility and societal benefits.
- The energy savings per scenario (status quo, first, and final submittal) were calculated from building modeling software that used assumptions to calculate the annual energy consumption. The actual energy savings may differ due to the tenant's behavior and the annual weather fluctuations.
- When developing the resource cost savings benefit, we used the NIST pricing forecast for electricity and natural gas. We did not have time to investigate the impacts of carbon pricing into our energy price forecasting.
- The first and final submittal cost differentials to the status quo were calculated by developers estimating the cost to EERE infrastructure. The estimates were broad in their scope and we used a variety of assumptions to breakdown the cost differences between the status quo and the first and final submittal.

- We utilized a proxy % of capital costs to forecast equipment replacement and maintenance costs for the increased EERE infrastructure in the Maddux and MadBoy’s first and final submittal. The proxy % of capital costs were developed by using a RMI and Rushing water heater system life-cycle cost analysis.

Appendix F: Energy and Water Benchmarking Requirements and Incentives across the US

States	Required	Points	Language
Alaska		X	The Alaska Housing Finance Corporation requires applicants awarded points for energy efficiency to respond to reasonable inquiries from AHFC regarding energy consumption at their properties throughout the term of the restrictive covenants recorded for the property
Colorado	X		The Colorado Housing Finance Agency requires all buildings, once constructed, to annually assess and report their energy performance using the free ENERGY STAR Portfolio Manager tool
Delaware	X		The Delaware State Housing Authority requires applicants to certify the use of a utility benchmarking service for all owner-paid utility accounts and a sample of tenant-paid utility accounts for a minimum of fifteen (15) years. Utility data shall be updated continuously and be no more than three (3)
Massachussets		X	The Massachusetts Department of Housing and Community Development awards points to projects that incorporate the following: Post construction energy use benchmarking -- for example, WegoWise, Energy Scorecards -- for a minimum of five years occupancy. Sponsors must commit to providing
New Jersey	X		The New Jersey Housing and Mortgage Finance Agency requires all new construction and rehabilitation projects to participate in the NJHMFA Energy Benchmarking Initiative. Common area and tenant utility data shall be uploaded to ENERGY STAR Portfolio Manager for a period of three years
New York State	X	X	New York State Homes and Community Renewal encourages all projects to track their utility usage as a tool to effectively manage energy efficiency. All projects financed through HCR tax-exempt bond and subsidy applications (4% LIHTC projects) are required to benchmark energy usage using ENERGY STAR Portfolio Manager and provide information annually to HCR
New York City Housing Preservation and Development (HPD)	X		New York City Department of Housing Preservation and Development requires applicants receiving allocations to agree to New York City's Local Law 84 and HPD's Benchmarking Protocol.
Pennsylvania	X		The Pennsylvania Housing Finance Agency contracts with a third-party entity to monitor the utility consumption of projects.
Rhode Island		X	Rhode Island Housing awards points to projects that sign up with a Utility Benchmarking Service (UBS) for all utilities including tenant paid utilities. The cost for the UBS should be reflected in the applicant's operating expenses. Tenant leases must be modified to allow owner's access to tenant utility information. The UBS must be made available to RI Housing
South Carolina	X		South Carolina Housing requires New Construction Multi Family Developments to use ENERGY STAR Portfolio Manager and must allow the SC Housing full access to this data for a minimum of five years.

Taken from Source: Bartolomei (2021); based on September 2020 QAPs and accompanying documents.

Appendix G: Building Energy Performance Requirements and Incentives across the US

	New Construction			Rehabilitation		
State	Required	Points	Standard	Required	Points	Standard
Rhode Island	X	X	Threshold: NGRID's RNC Tier 1 Standards Points: Up to 3 points for new construction developments that achieve NGRID's RNC Tier II and Energy Star 3.1 revision 8 standards to	X	X	Threshold: NGRID's RNC Tier 1 Standards. Points: Projects undertaking substantial rehabilitation rather than new construction will be awarded up to 3 points if they demonstrate an ability to
South Carolina	X		ENERGY STAR Multi Family New Construction or ENERGY STAR v. 3.0			
South Dakota		X	HERS rating of 60 or less or latest version of ENERGY STAR for New Homes or ENERGY STAR		X	HERS rating of 60 or less or latest version of ENERGY STAR for New Homes or ENERGY STAR for
Utah	X		ENERGY STAR Certification	X		ENERGY STAR Certification
Vermont	X		All new construction and substantial rehabilitation: Efficiency Vermont's (EVT) 2020 High-Performance Track	X		Efficiency Vermont's 2020 HighPerformance Track Standards to the extent possible
Virginia	X		ENERGY STAR Certification	X		Rehab: 30% post-rehabilitation decrease on the HERS Index or score HERS rating 80 or lower Adaptive Reuse: HERS rating 95 or lower
Wyoming		X			X	HERS Rating

Taken from Source: Bartolomei (2021); based on September 2020 QAPs and accompanying documents.

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