

Reducing Greenhouse Gas Emissions From Building Operation – Guidance Document

**Report prepared by
City and County of Honolulu Climate Change Commission**

**Funded by
State of Hawai‘i
Energy Systems Development Special Fund (ESDSF)**

via

**Hawai‘i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai‘i**

July 2022



REDUCING GREENHOUSE GAS EMISSIONS FROM BUILDING OPERATION – GUIDANCE DOCUMENT

City and County of Honolulu Climate Change Commission

July 2022

PURPOSE

Pursuant to the Revised Charter of Honolulu (RCH) Section 6-107(h), the City and County of Honolulu (City) Climate Change Commission (Commission) is charged with gathering the latest science and information on climate change impacts to Hawai'i. The Commission also provides advice and recommendations to the mayor, City Council, and executive departments as they look to draft policy and engage in planning for future climate scenarios and reducing Honolulu's contribution to global greenhouse gas (GHG) emissions.

This guidance document provides potential actions for the City's consideration in order to mitigate climate change through reduction of GHG emissions from buildings' operational energy use and to adapt to climate change through the implementation of sustainable and resilient development policies and design strategies. This paper supports implementation of the Honolulu Climate Action Plan and Hawaii Clean Energy Initiative and informs the upcoming Honolulu Climate Adaptation Plan.

The body of the paper discusses key factors that shape the built environment, including objectives, context, and potential actionable steps. These key design influences include codes, policies, incentives, and education. The paper then addresses the need for future research in climate change and summarizes a discussion with an industry focus group. The appendix includes specific design strategies for passive and energy-efficient building design.

RECOMMENDATIONS

Based on current trends and studies of Honolulu and other U.S. cities, the Commission suggests the following for the City & County of Honolulu.

1. Adopt the following targets modified from the 2030 Challenge¹ to mitigate the building sector's contribution to climate change.
 - a. All new buildings, developments, and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% below the regional average/median for that building type in the 2003 Commercial Building Energy Consumption Survey (CBECS)².
 - b. At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% of the regional average/median for that building type.
 - c. The fossil fuel reduction standard for all new buildings and major renovations shall be increased as follows.
 - i. 80% in 2025
 - ii. 90% in 2030
 - iii. Carbon neutral in 2040 (using no fossil fuel GHG emitting energy to operate)
2. Convene a task force to advise the City on creating a roadmap that identifies actions and timelines to meet GHG emissions reduction targets in the Honolulu Climate Action Plan (strategy 5), the Hawaii Clean Energy Initiative, and the 2030 Challenge. This roadmap could include the following recommendations.
3. Support the adoption of the most recent building energy codes and stretch/reach codes to require and motivate best practices.
4. Require building energy benchmarking and disclosure for buildings over 25,000 sf.
5. Encourage existing buildings to improve energy efficiency over time.
 - a. Investigate energy auditing, building commissioning, and cost-effective energy-efficient retrofits.

- b. Investigate building performance standards.
- 6. Incentivize building owners, occupants, designers, and builders to adopt practices to reduce GHG emissions from building operation through financial incentives, energy efficiency standards, tax benefits, loans, grants, expedited permitting, and new financial tools.
- 7. Support education and ongoing training of professional designers, builders, and code enforcement officials to meet the goals of the 2030 Challenge, the AIA's Framework for Design Excellence, and the previously mentioned codes, policies, practices, and incentives.

TABLE OF CONTENTS

1	INTRODUCTION.....	6
1.1	National and International GHG Emissions Reductions Targets	6
1.2	The Hawai'i and O'ahu Context.....	6
2	CODES.....	7
2.1	Objectives.....	7
2.2	Context	7
2.3	Potential Actions.....	8
2.3.1	Adopt the most recent energy code	8
2.3.2	Adopt stretch/reach codes.....	8
2.3.3	Seek technical assistance for energy codes	9
2.3.4	Fund staff for the State Building Code Council.....	10
2.3.5	Improve competitiveness for FEMA BRIC funding	10
3	POLICIES AND PRACTICES.....	10
3.1	Objectives.....	10
3.2	Context	10
3.3	Potential Actions.....	11
3.3.1	Require building energy benchmarking.....	11
3.3.2	Require energy audits and commissioning	12
3.3.3	Implement building performance standards	13
4	INCENTIVES.....	18
4.1	Objectives.....	18
4.2	Context	18
4.3	Potential Actions.....	18
4.3.1	Create comprehensive programs for new and existing buildings	18
4.3.2	Link city-funded programs to GHG emissions reduction	19
4.3.3	Expand tax benefits.....	20
4.3.4	Expand loans and grants.....	21
4.3.5	Expedite building permitting	22
4.3.6	Access additional financing	23
5	EDUCATION	24
5.1	Objectives.....	24
5.2	Context	24
5.3	Potential Actions.....	24
5.3.1	Support AIA 2030 Commitment training.....	25
5.3.2	Support AIA Framework for Design Excellence training and awards	25

5.3.3	Host training on new codes, policies, and incentives	25
5.4	Next Steps	26
6	FUTURE RESEARCH NEEDS.....	26
6.1	Roadmap	26
6.2	Embodied and Sequestered Carbon	26
6.3	Grid-Interactive Efficient Buildings.....	28
6.4	Affordable, Equitable Housing	28
6.5	Adaptation to Climate Change.....	28
6.6	Zoning.....	28
6.7	Energy Code Compliance.....	29
7	O’AHU DESIGN AND CONSTRUCTION STAKEHOLDER FOCUS GROUP.....	29
8	CONCLUSION	30
9	ACKNOWLEDGEMENTS	30
	APPENDIX A—SUSTAINABLE AND RESILIENT DESIGN STRATEGIES	31
	REFERENCES	36

List of Abbreviations

ACEEE—American Council for an Energy-Efficient Economy
AIA—American Institute of Architects
AMI—area median income
ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers
BCEGS—Building Code Effectiveness Grading Schedule
BPS—building performance standards
CAP—Climate Action Plan
CBECs—Commercial Building Energy Consumption Survey
CDBG—Community Development Block Grant
CFC—Codes for Climate
DAGS—State of Hawai'i Department of Accounting and General Services
DDx—Design Data Exchange
DPP—Department of Permitting and Planning
EO—executive order
ESDS—Evergreen Sustainable Development Standard
EUI—energy use intensity, (i.e., unit of energy per unit of area)
FEMA BRIC—Federal Emergency Management Agency Building Resilient Infrastructure and Communities
GHG—greenhouse gas
HBCC—Hawai'i State Building Code Council
HCEI—The Hawai'i Clean Energy Initiative
HIB—Hawai'i Insurance Bureau
HRS—Hawai'i revised statute
HSEO—Hawai'i State Energy Office
HUD—Housing and Urban Development
IBC—International Building Code
ICC—International Code Council
IECC—International Energy Conservation Code
IMT—Institute for Market Transformation
IRC—International Residential Code
LED—light emitting diode
LEED—Leadership in Energy and Environmental Design
NYSERDA—New York State Energy Research and Development Authority
PG&E—Pacific Gas & Electric
PV—photovoltaic
RCH—Revised Charter of Honolulu
RPS—Renewable Portfolio Standard
sf—square feet
tCO₂e—metric tons of carbon dioxide, equivalent among greenhouse gases
UH—University of Hawai'i
USEPA—United States Environmental Protection Agency
USGBC—United States Green Building Council
yr—year

1 INTRODUCTION

1.1 National and International GHG Emissions Reductions Targets

Buildings generate nearly 40% of global annual greenhouse gas (GHG) emissions³ and are a “central solution to the climate crisis”.⁴ Of the annual global GHG emissions, building operations are responsible for 28%.⁵ A building's operational GHG emissions are from a building's energy consumption, such as heating, cooling, and lighting. About 10% of annual global GHG emissions are from building materials and construction, typically referred to as embodied carbon.⁶ A building's embodied carbon refers to the emissions generated from the manufacturing, transporting, and installation of construction materials⁷.

Global building stock is expected to double by 2060.⁸ With current trends in urban growth, over six billion people will live in cities within 40 years. This will require 2.48 trillion square feet of newly constructed floor area, in addition to the current global building stock.⁹ This is equivalent to adding an entire New York City every month for 40 years.¹⁰ In addition, approximately 2/3 of the global building area that exists today will still exist in 2040, making existing building decarbonization imperative.¹¹ The construction industry has an opportunity to change its adverse impact on the climate through new and renovated buildings.

To meet the United Nations 2015 Paris Agreement's 1.5°C carbon budget, all new buildings and major renovations must be designed to be carbon neutral *today*.¹² The knowledge and technology needed to reduce carbon emissions from buildings is available in all climates, and the health, economic, and environmental benefits are well documented.¹³ Policy-makers and professionals must act quickly to accelerate the pace of GHG emissions reductions¹⁴. Over 200 cities have made pledges to achieve 100 percent clean energy, or “net-zero” emissions.¹⁵ In addition, some companies are motivated to design and operate sustainable buildings because their environmental, social, and governance (ESG) reporting addresses building energy costs and climate change risks¹⁶.

Unfortunately, business-as-usual is a scenario which creates a negative feedback loop. As our planet is getting warmer, and weather patterns more irregular, the need for space cooling is projected to increase 300% from 2016 to 2050.¹⁷ This growing energy use, fueled in many communities by fossil fuels and natural gas, is adding to the amount of GHG emissions in Earth's atmosphere. It is increasingly important to recognize the role of the built environment in this context. The construction, use, and location of buildings are all factors that can influence climate change.¹⁸ Various stakeholders have identified opportunities that position the design and construction industry as pivotal, as we collectively address the climate and energy crisis.

1.2 The Hawai'i and O'ahu Context

Hawai'i's unique geographic location results in increased challenges and current reliance on imported fossil fuels and building materials. At the same time, as inhabitants of a tropical climate, we see the positive outcomes of good design within a geographically isolated ecosystem and enjoy the benefits of the community-oriented culture of 'ohana and mālama honua. This section describes Hawai'i's energy efficiency goals, energy costs, and the relationship between climate change and affordability.

The Hawai'i Clean Energy Initiative (HCEI) sets bold clean energy goals that include achieving the nation's first-ever 100 percent renewable portfolio standards (RPS) by the year 2045.¹⁹ It includes a separate goal for energy efficiency, establishing an energy efficiency portfolio standard²⁰ that calls for 4,300 GWh reduction in electricity use via efficiency measures by 2030.²¹ The Honolulu Climate Action Plan (CAP) Strategy 5 is to “Reduce Energy Demand by Increasing Energy Efficiency”.²² The Hawai'i 2050 Sustainability Plan Strategy 11 promotes energy conservation and efficiency.²³ “Each dollar spent on efficiency generally saves ten times that amount on energy bills. The Hawai'i energy savings multiplier for

program year 2020 was eleven to one. Energy efficiency is also important as a means of reducing the overall amount of land and resources necessary for meeting Hawai'i's energy needs."²⁴

Electricity costs in Hawai'i in 2020 were 2.6 times the national average²⁵, partially because 75.2% of our energy is generated by burning fossil fuels.²⁶ Other disadvantages of petroleum-based energy include: increasing our reliance and, therefore, vulnerability in the limited global fuel supply and its fluctuations; environmental pollution through GHG emissions; and exposure to hazardous substances from the manufacturing process.²⁷ Both embodied carbon and operational carbon contribute to the design and construction industry's share of GHG emissions. To address the high amount of operational carbon coming from buildings, Honolulu's City Council adopted Bill 58 in December 2020, which streamlines permitting for projects with residential clean energy and electric vehicle charging to increase access to renewable energy.²⁸

Two of the projected impacts of climate change on Hawai'i include warming air temperature and decreased prevailing trade winds. The negative impacts of climate change, including high energy costs and increased heat, are disproportionately borne by vulnerable communities.²⁹ Frontline communities, who are "geographically, physically, socially, or economically at-risk due to climate change impacts" most often face the worst consequences of climate impacts due to systemic injustices and lack the resources to build their adaptive capacity.^{30 31} Vulnerable communities are often comprised of a higher proportion of elderly (>65 years), children, low-income individuals, and ethnic minorities.³² As an example of the severity of the potential for the physical environment to impact vulnerable populations, the urban heat island impact on O'ahu on August 31, 2019 was 107.3°F (the maximum heat index recorded across Honolulu County) with the highest differential being 22.3°F.^{33 34} The lack of adequate green space, elevation, prevailing winds, and proximity to large bodies of water increases the heat island effect. Concrete, which absorbs heat, is widely used in the construction of roads and buildings. This typically causes them to soak up, rather than reflect, heat from the sun's radiation. Rising environmental temperatures and energy bills can both impact populations. This underscores the need for effective heat island mitigation, passive cooling strategies, and efficient air conditioning systems, particularly in underserved communities. On the other hand, green buildings "are healthier, perform better, last longer, and are easier to maintain. In the long run, owners of green homes in Hawai'i save energy, save money, preserve the environment, and help improve the state's economy, all at the same time."³⁵

2 CODES

2.1 Objectives

Accelerate adoption of the most recent international building and energy codes. This will reduce carbon emissions from the energy used in building operations and provide safer and more sustainable environments.

2.2 Context

The International Code Council (ICC) creates model codes and standards for buildings. It updates their International Building Code (IBC), International Residential Code (IRC), and International Energy Conservation Code (IECC) every three years.

The State of Hawai'i adopted the 2018 IBC/IRC codes in April 2021. Historically, Hawai'i has been two iterations behind the most recently updated international codes. The 2018 ICC codes are only one iteration

behind the latest, which are the 2021 versions. Historically, the counties automatically adopt a code two years after the state adopts it.

The IECC is a model code that regulates minimum energy conservation requirements for new buildings.³⁶ The State of Hawai'i adopted the IECC 2018 in December 2020 and counties must amend/adopt the IECC 2018 by December 2022.³⁷ The IECC 2021 framework is available online and requires buildings to be about 10% more energy efficient than the previous edition and includes an appendix with voluntary guidelines, including the renewable energy portions of the Zero Code. The IECC 2021 framework is available online and requires buildings to be about 10% more energy efficient than the previous edition and includes an appendix with voluntary guidelines, including the renewable energy portions of the Zero Code.³⁸

2.3 Potential Actions

2.3.1 Adopt the most recent energy code

Additional Context: The Hawai'i 2050 Sustainability Plan Strategy 23 states, "Update building codes and standards in a timely manner." The Honolulu CAP Strategy 5 states, "The most important long-term measure is to influence new construction by regularly updating building energy codes to the highest national and state standards." The Honolulu CAP Action 5.1 states, "Put in place a system to regularly update relevant building codes ..."

Best Practices: Seven states adopted newer commercial building energy codes and ten states adopted newer residential building energy codes, as compared to Hawai'i.³⁹

Next Steps: Establish a new maximum duration between model code releases and state and county adoption, in order to reference the highest national and state standards soon after they are released. Consult the State Building Code Council and county officials to create a timeline that will meet the State Sustainability Plan and Honolulu CAP goals.

Related Sections: Coordinate building energy code updates with the evaluation and adoption of stretch/reach codes and professional education.

2.3.2 Adopt stretch/reach codes

Additional Context: The building energy code establishes baseline standards for energy efficiency but does not push the latest design strategies and technology application. By adopting forward-looking stretch building codes, jurisdictions can increase the rate at which advances in building energy performance are incorporated into the building stock to meet policy goals.⁴⁰ Stretch codes integrate with the national model energy codes (e.g., IECC). The Hawai'i State Building Code Council may choose to adopt stretch codes or parts of them to allow the market to prepare and gain experience with new efficiency practices and technologies. State and local governments can also make stretch code adoption voluntary and incentivize owners and builders to follow the code.⁴¹

Best practices:

Zero Code: The Zero Code provides code-adaptable language defining the energy efficiency and renewable energy requirements (on-site and/or off-site) for zero carbon⁴² new buildings.⁴³ The Zero Code can be implemented through building codes, zoning regulations, municipal codes, incentive programs, or other means. The Zero Code appendix was formally adopted by the ICC in 2020 and is included in the new 2021 IECC⁴⁴. Zero Code may be used with earlier versions of the IECC⁴⁵, therefore, Hawai'i may adopt the Zero Code language and framework before updating to the IECC 2021. There are Zero Code versions for commercial⁴⁶ and residential⁴⁷ buildings. The Zero Code

can be tailored to geographic locations, such as the 2022 Zero Code for California, which will be the upcoming 2022 California Building Energy Efficiency Standards (BEES).⁴⁸

Building Decarbonization Code: The Building Decarbonization Code⁴⁹ from the New Buildings Institute is a code language overlay to the 2021 IECC that is designed to help states and cities working to mitigate carbon resulting from energy use in the built environment. Version 1.2 currently focuses on residential and commercial new construction with the potential to address existing buildings in a future version. While not an all-electric code, it prioritizes efficient electric equipment and covers all-electric and mixed-fuel options. Jurisdictions may use any section of the overlay in its entirety or use portions of these sections.

Most current IECC: If a newer version of the IECC is available, the state or city and county may adopt it as a stretch/reach code prior to its adoption as the required code. For example, Maine's stretch code uses the 2021 IECC, whereas their base energy code is the 2015 IECC⁵⁰. The cities of Portland and South Portland have adopted this stretch code⁵¹.

Stretch/reach codes on specific topics. Adopting an original or amended version of the Zero Code or Building Decarbonization Code as a stretch code, appears more straightforward than cobbling together reach codes on specific topics. That said, if the state or counties wish to adopt a reach code on a specific topic, the California Energy Codes and Standards website provides useful examples and categories: 1) energy efficiency and renewables/photovoltaics (PV); 2) electric ready; 3) energy plus water; 4) energy auditing and benchmarking; and 5) process loads. For example, at the time of writing, over 50 cities in California have passed building electrification reach codes⁵², some of which require all-electric new construction. Other reach codes require mixed-fuel buildings or certain building types to achieve energy savings beyond the state energy code. Honolulu's residential energy code requires renewable water heating⁵³ and solar conduit and electrical panel readiness⁵⁴. Some California cities' reach codes set a minimum capacity or area for on-site PV systems in residential and commercial buildings and could be an example for Honolulu.

Next Steps:

- Evaluate, amend, and consider for adoption one of the stretch/reach codes described previously.
- Determine if future iterations of the Zero Code, Building Decarbonization Code, or next version of IECC need to be adopted as a mandatory building code to meet the Hawai'i State Sustainability Plan, Honolulu CAP, and HCEI targets. Assign responsibility for adoption and updates.
- If the Zero Code or Building Decarbonization Code do not sufficiently address certain specific topics, identify and adopt reach codes to address those topics.
- Include incentives for adopting stretch codes (see Section 4).

2.3.3 Seek technical assistance for energy codes

Additional Context: The Codes for Climate (CFC) program from New Buildings Institute and Rocky Mountain Institute works with cities to provide the technical assistance needed to adopt climate-sensitive codes.⁵⁵ The CFC also offers support for stakeholder engagement and outreach. Support format can include email, calls, formal memos, and guidance.

Next Steps: The Honolulu Department of Climate Change, Resiliency, and Sustainability and Hawai'i State Energy Office (HSEO) may work with CFC and similar organizations, for technical assistance and support to evaluate, amend, and adopt building energy codes and stretch codes that will meet the State Sustainability Plan and Honolulu CAP goals

2.3.4 Fund staff for the State Building Code Council

Additional Context: The Hawai'i State Building Code Council⁵⁶ (SBCC) consists of 11 volunteer seats and is administered by the State of Hawai'i Department of Accounting and General Services (DAGS) and new permanent staff are desired. Funding the SBCC is a critical need in order to support expedited adoption of recent codes. At minimum, one full-time (1.0 FTE) program director position and one additional 1.0 FTE staff member position, and costs to train staff and establish a full-time office are needed.

Next Steps: Pass the above or similar bill to fund SBCC staff.

2.3.5 Improve competitiveness for FEMA BRIC funding

The Federal Emergency Management Agency (FEMA) offers the Building Resilient Infrastructure and Communities (BRIC)⁵⁷ program, which funds hazard mitigation projects to reduce the risks communities face from disasters and natural hazards, making them more resilient and sustainable. Energy is listed as one of the FEMA community lifelines that can be addressed in a project proposal.⁵⁸ Counties in Hawai'i submitted a total of 13 applications to the national competition for this funding in January 2021 and none were funded⁵⁹. To be competitive for BRIC funding, counties needed to have updated IBC and IRC building codes and Building Code Effectiveness Grading Schedule (BCEGS)⁶⁰, issued by the Hawai'i Insurance Bureau (HIB) with rating of one to five. The BCEGS questionnaire asks which edition of energy code is in use. In January of 2021, the counties did not meet these FEMA 2020 requirements, which were worth 35 of a total 100 points for technical criteria used to evaluate proposed projects. According to the FEMA 2021 guidelines, they are worth 40 out of 115 points. The 2018 and 2021 IBC/IRC code versions both qualify for 20 points for the applications that were due in January 2022. The deadline for applications is the end of January each year.

Next Steps:

- The state and counties adopt one of the latest two iterations of the IBC/IRC by December of each year.
- Counties file BCEGS paperwork with HIB until they achieve a rating of five or lower.

3 POLICIES AND PRACTICES

3.1 Objectives

Codify policies to reduce carbon emissions from existing buildings' operational energy use.

3.2 Context

Approximately two-thirds of existing buildings will still be operating in 2040.⁶¹ According to the International Energy Agency, to reach net-zero by 2050, one in five existing buildings worldwide will need to be retrofitted to be zero-carbon-ready by 2030. Retrofits would need to continue after 2030, in order to retrofit 85% of the global building stock by 2050.⁶² To reach that goal, Honolulu must do its part. The Honolulu CAP Actions 5.2 and 5.3 address the use of benchmarking, building performance standards, and transparent reporting to improve the energy efficiency of buildings. There are a series of increasingly stringent policies that can be implemented in sequence. This allows building owners and the regulatory authority to adapt to each new requirement before implementing the next.

3.3 Potential Actions

3.3.1 Require building energy benchmarking

Additional Context: Building energy use benchmarking measures energy performance of a single building over time relative to other similar buildings and is useful in assessing opportunities for improvement.⁶³ Benchmarking helps identify buildings that are in the greatest need for energy retrofits, and raises a building owner’s awareness about the energy use of their buildings. When energy efficiency information is publicly disclosed, the transparency provides an incentive for the building owner to improve the energy performance of the building. The data can provide market pressure and also inform other policy decisions (e.g., incentives, energy use intensity (EUI) limits, etc.).

Disclosure of energy performance makes efficient buildings more marketable and serves as customer protection for prospective renters or buyers. This market transformation will precede actual energy savings.⁶⁴ A controlled study conducted by researchers at the Massachusetts Institute of Technology determined that benchmarking and disclosure policies enacted by New York City resulted in decreasing energy use in buildings by 9% in three years, and 13% in four years.⁶⁵ Owners of buildings in the rental market have little incentive to improve the energy efficiency of their rental units if the tenants pay the utility bills. Some jurisdictions require disclosure of energy use costs before a lease is signed.⁶⁶ Research using a control group (no disclosure) has shown that prospective tenants are willing to pay more in rent for a more energy efficient unit.^{67 68} How the energy cost information was displayed affected their decision: including it in context of other rental units, e.g., on a scale from one to ten, was more effective than just stating the energy cost. RentLab is an example of an online tool that some cities are using to disclose energy use on listings for rental units.⁶⁹ Analysis of the data collected by RentLab supports the previous research that found energy disclosure affects the choices of prospective tenants.⁷⁰

Action 5.2 in Honolulu’s 2020–25 CAP⁷¹ called for the development of a “lead by example” municipal energy and water benchmarking program, and Action 5.3 called for building benchmarking to be extended to large covered commercial and multifamily buildings. In 2020, Honolulu committed⁷² to benchmarking energy and water use data for all city buildings over 10,000 sf and is working towards establishing a U.S. Department of Energy Better Buildings⁷³ benchmarking program to expand benchmarking to commercial and multi-unit residential buildings on O’ahu (Bill 22 (2022)).⁷⁴ Bill 22 passed in 2022⁷⁵ and requires a first phase of reporting to apply to buildings over 100,000 sf and second and third phases to apply to all buildings over 50,000 and 25,000 sf, respectively⁷⁶.

Best Practices

Example: New York City

New York City started benchmarking city-owned buildings over 10,000 sf in 2010.⁷⁷ One year later, it required all buildings over 50,000 sf to be benchmarked. In 2016, this requirement was extended to buildings over 25,000 sf.⁷⁸ Data is submitted using the USEPA Energy Star Portfolio Manager⁷⁹, which generates an Energy Star Rating. There is a benchmarking help center⁸⁰ with staff that provide group presentations, training, and one-on-one assistance. The fines for not submitting benchmarking data can add up to \$2,000/year and failure to display an energy efficiency rating label (a letter grade based on the Energy Star Rating) at the entrance to the building is \$1,250.⁸¹ There is an energy and water performance map online⁸² with six years of data that makes the benchmarking data publicly available.

Example: Seattle

Seattle requires benchmarking of non-residential and multifamily buildings that are larger than 20,000 sf.⁸³ Penalties for noncompliance are \$4,000 per year for buildings that are 50,000 sf or larger, and \$2,000 per year for smaller buildings. Six years of energy benchmarking data is publicly available on a website map.⁸⁴

Example: Minneapolis

Minneapolis has a “truth in sale of housing” ordinance that requires the seller to provide an energy report at the time of sale. The report is prepared by an inspector and includes an energy performance score based on the insulation, windows, and heating system.⁸⁵ Benchmarking and public disclosure of energy use is required for all buildings >50,000 sf, including multifamily buildings.⁸⁶ As of September 2021, there is a requirement for “time-of-rent” disclosure of energy consumption of rental units to prospective tenants⁸⁷. Utilities provide information based on metered energy use per square foot, or per bedroom.⁸⁸ They are working towards creating a publicly available comparison of buildings’ energy costs.

Next steps:

- Honolulu passes the proposed benchmarking bill.
- Provide training and technical assistance for compliance.
- Consider requiring public disclosure of energy performance.

3.3.2 Require energy audits and commissioning

Additional Context: An energy audit is an assessment of the energy efficiency of a building and identifies potential improvements, known as energy efficiency measures, which can be implemented. Retro-commissioning is like a tune-up for a building and involves assessing the energy systems, identifying maintenance issues, and adjusting controls and operating schedules. Energy audit and retro-commissioning policies are a middle ground between benchmarking and mandated energy use or GHG emissions reduction.⁸⁹ Typically the owners of buildings covered by the policy need to have their facilities audited periodically (every five or ten years) unless the building already meets a certain efficiency standard. Most policies require the audit to comply with standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and be conducted by a qualified contractor. There are different levels of audits. Some policies will require only a basic audit (ASHRAE level 1) for smaller buildings and a more detailed audit with a financial analysis of potential improvements (ASHRAE level 2) for larger buildings.

In 2009, the Lawrence Berkeley National Laboratory studied commissioning projects from 643 buildings. This study found that commissioning resulted in 16% median energy savings in existing buildings and 13% savings in new construction, with payback periods of 1.1 and 4.2 years, respectively.⁹⁰ The retro-commissioning policies are usually phased in over time, either by building size or randomly by a digit in the building ID. This practice spreads out the number of buildings needing services evenly over the years and does not overwhelm service providers or the regulatory agency in any one year.

Best Practices

Example: New York City

New York City mandates that all buildings over 50,000 sf undergo an energy audit and retro-commissioning and submit a report to the city every ten years.⁹¹ The required content of the report is clearly specified.⁹² The year it is due depends on a digit of the tax block number. The fine for violation is \$3,000 for the first year, and \$5,000 for every year thereafter.

Example: San Francisco

San Francisco requires that all non-residential buildings over 50,000 sf undergo an ASHRAE level 2 energy audit. Non-residential buildings over 10,000 sf and up to 49,999 sf must undergo an ASHRAE level 1 energy audit every five years.⁹³ Buildings that are large or have complex central systems are encouraged to consider retro-commissioning as an alternative way to meet the audit requirement.⁹⁴ To sell a residence, the owner needs to have the residence inspected, install basic energy and water conservation devices or materials, and obtain a certificate of compliance.⁹⁵

Example: Los Angeles

Los Angeles requires buildings >20,000 sf (>7,500 sf for city buildings) to achieve certain energy efficiency targets or perform audits and retro-commissioning every five years.⁹⁶ This includes commercial, residential, industrial buildings, structured parking, and condominiums.⁹⁷

Example: Austin

Austin requires energy audits for residential buildings (four dwellings or fewer) that are more than ten years old and are being sold.⁹⁸ The results need to be disclosed to the prospective buyer. Multifamily buildings must have an energy audit conducted every ten years. The owner must post and provide the results of the audit to current tenants. In both cases, the auditor must be certified by the Residential Energy Services Network or Building Performance Institute and provide a copy of the energy audit to the Austin Electric Utility within 30 days. Commercial buildings >10,000 sf are only required to benchmark their energy.

Next step:

- Create a task force or designate a city entity to develop requirements for energy audits and retro-commissioning.

3.3.3 Implement building performance standards

Additional Context: Building performance standards (BPS) are state and local laws that require existing buildings to achieve minimum levels of energy or climate (e.g., GHG emissions) performance.⁹⁹ The BPS establish long-term standards with interim targets that change over time (e.g., every five years) to achieve the city or state's GHG emission reduction goal. Building owners achieve the BPS targets by actively improving their buildings over time to reduce emissions across a building's life cycle.^{100 101} Most BPS policies to date cover existing commercial and multifamily properties.¹⁰² In the U.S., three states (Washington, Colorado and Maryland) and five cities (Boston, New York City, Washington D.C., St. Louis, Denver, and Chula Vista) passed BPS policies¹⁰³ but as of February 2021, none have been fully implemented.¹⁰⁴ Many more jurisdictions also demonstrated a commitment to implementing BPS policies. As of May 2022, 32 cities and two states joined the new National Building Performance Standards Coalition.^{105 106}

Table 1 shows the years that benchmarking and BPS policies were adopted by several jurisdictions in the U.S. An early adopter of a BPS policy was Tokyo, which enacted a law in 2010 with an initial year of compliance of 2015.¹⁰⁷

Table 1. Examples of jurisdictions that implemented benchmarking and building performance standards, year each law was passed, and year(s) compliance is required.

Jurisdiction	Benchmarking		BPS	
	Law	Compliance year(s)	Law	Compliance year(s)
New York City ^{108 109}	2009	2008 some city buildings 2010 for city buildings 2011 for other buildings	2019	2024
Washington D.C. ^{110 111}	2008	2009 city buildings > 10,000 sf 2010 all buildings > 200,000 sf 2011 all buildings > 150,000 sf 2012 all buildings > 100,000 sf 2013 all buildings > 50,000 sf	2018	2021 private buildings > 50,000 sf and city buildings > 10,000 sf 2023 private buildings >25,000 sf 2026 private buildings >10,000 sf
Washington State ^{112 113}	2009	2010 for city buildings 2011 for nonpublic nonresidential buildings	2019	2026
St. Louis ^{114 115}	2017	2017 city buildings 2018 private buildings	2020	2025
Denver ^{116 117}	2016	2017 buildings > 25,000 sf	2021	Performance: 2024 all buildings >25,000 sf Prescriptive only: 2025 all buildings 15,0001–24,999 sf 2026 all buildings 10,001–15,000 sf 2027 all buildings 5,000–10,000 sf

The BPS is a more powerful regulatory tool for driving down energy use of existing buildings than either benchmarking or voluntary incentive programs. To achieve climate goals, swift and decisive action is needed, especially considering that between now and 2050 there are only one to three opportunities to replace most equipment at the end of its useful life.¹¹⁸ Action 5.2 and 5.3 in Honolulu’s CAP¹¹⁹ calls for the development of building performance standards for municipal facilities, and large covered commercial and multifamily buildings, respectively.

Best Practices

Targets: Specific performance targets are developed for different building occupancy types, locations, and climates. Benchmarking and BPS apply to buildings based on the minimum gross square footage with exceptions (e.g., places of worship). The policy is often developed using data from building energy models, a previously implemented building energy benchmarking program, or national existing building energy data. The policy is typically phased in over time starting with larger buildings. Targets are set for building energy use or GHG emissions for various building types over a set period (e.g., five years). For example, targets could be based on intensity values (e.g., energy per square foot or GHG emissions per square foot) or absolute values (e.g., total energy use or total GHG emissions). Other variations for energy metrics include site or source energy use.¹²⁰

Example: Denver

Denver scored the highest in the ACEEE “2021 City Clean Energy Scorecard” for building policies.¹²¹ The city and county of Denver has ambitious climate goals: 80% reduction in GHG emissions by 2050.¹²² Denver codified its BPS in 2021,¹²³ covering buildings over 25,000 sf. Target EUIs (kBtu/sf/yr) are set for all building types, with the goal to achieve an overall 30% energy reduction by 2030, from a 2019 baseline. An analysis, based on maximum efficiency using current

technologies (without renewables), was completed for each building type to set the EUI targets.¹²⁴ Buildings will need to meet interim energy targets in 2024 and 2027. The interim targets are formulated using a trajectory approach¹²⁵ by graphically drawing a straight line from a building’s 2019 baseline EUI to the final EUI target for that building type. Interim targets will be set in 2022. Owners of smaller buildings (5,000–25,999 sf; phased in from 2025–2027) will need to comply with a prescriptive requirement of certifying they have installed all LED lights (or an equivalent lighting power density), installed solar panels, or purchased solar electricity produced off-site to meet 20% of the building’s annual energy use.

Example: New York City

New York City has an overall goal to reduce emissions from covered buildings by 40% by 2030 and 80% by 2050 (relative to 2005).¹²⁶ Emissions limits were codified in 2019 and buildings need to be in compliance by 2024.¹²⁷ Target annual emission limits in tons of CO₂ equivalent per square foot (tCO₂e/sf) of gross area are set for each building occupancy group¹²⁸ for 2024–2029 and reduced for 2030–2034 (Table 2). Building energy modeling was used to set emissions limits for each building type. The law provided GHG coefficients in tCO₂e per unit of energy for each type of energy consumed (e.g., grid electricity, natural gas, fuel oils) and updated coefficients would be available by 2023. The city will set building emission limits for 2035–2039 and 2040–2049 by 2023. “Such limits shall be set to achieve an average building emissions intensity for all covered buildings of no more than 0.0014 tCO₂e/sf/yr by 2050.”¹²⁹

Table 2. Greenhouse gas emission limits (tCO₂e/sf/yr) by occupancy group for New York City buildings in 2024 and 2030.

Occupancy Group Description	tCO ₂ e/sf/yr Limits	
	2024	2030
A: assembly	0.01074	0.0042
B: civic administration, emergency response, ambulatory health care, H: high hazard, I-2: hospitals, nursing homes, etc., I-3: correctional centers	0.02381	0.01193
B (others not specified above): business	0.00846	0.00453
E: educational, I-4: institutional, custodial care (day nursery)	0.00758	0.00344
I-1: institutional, supervised residential (assisted living, rehabilitation)	0.01138	0.00598
F: factory/industrial	0.00574	0.00167
M: mercantile	0.01181	0.00403
R-1: transient residential (hotels, rooming houses, etc.)	0.00987	0.00526
R-2: dormitories	0.00675	0.00407
S: storage, U: utility and miscellaneous	0.00426	0.00110

Compliance pathways: If buildings do not meet the building performance targets, the owners are usually offered several compliance pathways.

- Performance: reduce building energy usage or GHG emissions by a certain percentage.
- Prescriptive: implement cost-effective building efficiency measures.
 - Denver requires only prescriptive measures for smaller buildings (5,000–25,000 sf) but has EUI targets for larger buildings.¹³⁰
 - Washington D.C. has a four-phase option that includes an energy audit, list of energy efficiency measures, implementation of those measures, and a monitoring and verification report.¹³¹
- Alternative:
 - Washington D.C. allows building owners to propose a plan that is designed to achieve energy savings comparable to the requirements in the performance pathway. Such plans need to be approved by the District’s energy department.¹³²

- Longer compliance periods are allowed for specific building types. St. Louis BPS has a six-year compliance cycle for affordable housing, vs. a four-year compliance cycle for their standard building stock.¹³³
- NY City considers GHG purchase offsets, renewable energy credits, and adjustments for special categories of buildings.¹³⁴

Development and Implementation: A task force (e.g., Washington D.C.¹³⁵) or board (e.g., St. Louis¹³⁶) can develop or support the development of a BPS program adapted to local conditions. Alternatively, BPS hosting departments could conduct their own stakeholder engagement to determine initial BPS program (e.g., Washington State¹³⁷). In a summary by the American Cities Challenge¹³⁸, BPS stakeholder groups usually include: city government; utilities; labor; various building owners; building associations; tenants and tenant groups; design professionals; contractors and service providers; community-based organizations; racial and social groups; and citizen groups. New offices could be created to implement building performance laws and policies (e.g., New York¹³⁹) or be housed in existing local administrative bodies (e.g., Washington State¹⁴⁰). Future advisory boards may provide advice and recommendations on reducing greenhouse gas emissions from buildings (e.g., New York City¹⁴¹).

Example: Washington D.C.

Washington D.C.'s BPS task force¹⁴² advised the District's Department of Energy and Environment on the creation of an implementation plan for their BPS program, recommended amendments to proposed regulations, and recommended complementary programs or policies. The task force was established by the mayor and composed of 17 representatives: five from relevant District Departments; one from a green building council; one from the District's sustainable energy utility; three from different building types (rent-controlled apartment, market-rate apartment, commercial building); one from an apartment and building association; one from a university consortium; one from an affordable housing operator; one from an affordable housing developer; one from a nonprofit or professional association advocating for energy efficient building or a low-carbon built environment; one from a provider of energy efficiency or renewable energy services to large buildings or affordable housing; and one from the District's Green Finance Authority.

Reporting requirements: The most common reporting approach under existing benchmarking requirements is for the state or local government to set up a custom reporting template in EPA's ENERGY STAR Portfolio Manager and to publish it as a Data Request.¹⁴³

Penalties: Penalties for noncompliance should be high enough to make it more attractive to improve the building than to pay the penalty. It can be structured based on building size or excess GHG gas emissions. New York City fines \$268 per ton of carbon equivalent emissions.¹⁴⁴ Washington State may assess a maximum amount of \$5,000 plus an additional amount based on the duration of any continuing violation, which may not exceed more than \$1 per year per gross square foot of floor area¹⁴⁵.

Tenants and leases: Tenants are not necessarily incentivized to contribute towards BPS goals. Building owners may pass along BPS fines and incentives to their tenants, though additional support to reduce tenant's cost burden may be considered by state and local governments for certain building types¹⁴⁶ (e.g., affordable housing). The Institute for Market Transformation (IMT) and the New York City Climate Action Alliance are experimenting with Performance Based Leases to align tenants with building BPS goals¹⁴⁷. Internationally, some BPS programs target building users rather than building owners (e.g., the Netherlands) or treat certain tenants as building owners¹⁴⁸ (e.g., Tokyo).

Affordable housing: Some cities provide additional support on BPS to affordable housing. Washington D.C.'s Affordable Housing Retrofit Accelerator program is a five-year program that offers training and support on BPS compliance pathways, support for building audits and assessing building opportunities, and financial assistance to owners and managers of qualifying affordable multifamily buildings (see the Incentives section of this document). Qualifying buildings are those over 50,000 square feet, meet D.C.'s affordable housing criteria (50% of dwelling units are occupied or affordable to households with incomes less than or equal to 80% of AMI), and currently do not meet D.C.'s BPS¹⁴⁹. It is important to support tenants, small landlords, and under-resourced building types. Stakeholder engagement should include housing advocates and tenant representatives to help shape the policy, target funding, and provide supportive programs and resource hubs for those who need it most.

Lead by Example:

Example: On December 8, 2021, President Biden signed Executive Order 14057¹⁵⁰, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. EO 14057 sets a net-zero emissions goal for federal buildings by 2045, including a 50% reduction in building emissions by 2032 from 2008 levels, and establishes the first ever Federal Building Performance Standard. Guidance for the Federal BPS will be provided to federal agencies by the Chair of the Council on Environmental Quality, in consultation with the Director of the Office of Management and Budget.

Example: The National BPS Coalition¹⁵¹ was launched by President Biden on January 21, 2022, with 33 inaugural participants. These state and local governments have “committed to inclusively design and implement equitable building performance standards and complementary programs and policies, working to advance legislation and/or regulation, with a goal of adoption by Earth Day, 2024.” Federal agencies (e.g., U.S. Department of Energy and Environmental Protection Agency) provide technical assistance and funding programs, while non-governmental and labor organizations offer complementary resources to Coalition members.

Example: Washington D.C. leads in the implementation of their BPS by requiring that District buildings meet BPS before private buildings. Washington D.C.'s BPS applies to District buildings with at least 10,000 sq ft by January 1, 2021, and to privately-owned buildings with at least 10,000 sq ft by January 1, 2026¹⁵².

Next Steps:

- Consider joining the National BPS Coalition¹⁵³ to access Federal and other Coalition resources for designing and implementing BPS.
- Create a task force or designate a city entity to develop city building performance standards. This task force or entity should consider the following:
 - Coordinate to determine if the BPS should be created at the state, city, or county level;
 - A model ordinance drafted by the IMT can be used as a starting point and customized for Honolulu's needs;¹⁵⁴
 - Study the building stock, available benchmarking data, and building owners' needs and resources available for compliance. Determine properties to which the BPS will apply;¹⁵⁵
 - Conduct stakeholder engagement to align policy objectives with priorities from the community, individuals directly affected, and underserved groups;
 - Using stakeholder feedback, set the timeline, energy or GHG reduction targets and appropriate compliance pathways, and reporting requirements, and
 - Provide support to building owners (further discussed in the education section).

4 INCENTIVES

4.1 Objectives

Incentivize building owners, occupants, designers, and builders to adopt practices to reduce GHG emissions from building operation that otherwise would not take place. Incentives may be used to motivate early adopters of previously mentioned topics (e.g., stretch/reach codes, benchmarking, audits, building performance standards) before they are required by code. Utilize financial incentives to enable people to adopt those practices in a fiscally responsible manner.

4.2 Context

Various incentive programs currently operate in Hawai'i at both the state and city/county level. Incentive programs include tax credits (reduction of tax burden), tax abatements (reduction in assessed value of a property), expedited permitting, loans, and grants. Rebates are a specific type of grant, available after the purchase of energy efficient or renewable products, such as the State's Weatherization Assistance Program with the Department of Energy.¹⁵⁶ In order to extend these programs, increased funding and innovative financial instruments are necessary.

4.3 Potential Actions

4.3.1 Create comprehensive programs for new and existing buildings

Additional Context: Hawai'i Energy, the public benefits fee administrator¹⁵⁷, currently offers rebates for energy-efficient residential and commercial upgrades to a building.¹⁵⁸ There is also periodic funding available for energy audits and re-commissioning.¹⁵⁹ Rebates offered include funding for solar hot water heaters (\$750), heat pump water heaters (\$500), and refrigerators (\$150).

Best Practices

Example: California

The utility provider, PG&E, runs the California Advanced Homes¹⁶⁰ program, which offers design assistance and a suite of financial incentives for single-family, low-rise and high-rise multifamily residential new construction with better-than-code energy performance. Financial incentives are based on an overall performance rating and issued after construction and inspection. The performance rating is established by California's Building Energy Efficiency Standards (Energy Code).

Example: Washington D.C.

The DC Sustainable Energy Utility runs the Affordable Housing Retrofit Accelerator Program, which is designed for existing multifamily buildings not meeting citywide building performance standards (which are based on an Energy Star rating). Eligibility is based on a metric of housing affordability. The program combines financing (through the DC Green Bank¹⁶¹), guidance, and technical assistance¹⁶². The program provides building owners with an energy audit and financial and contractor support to make energy efficiency upgrades.¹⁶³

Example: New York City & State

The New York State Energy Research and Development Authority's (NYSERDA) Assisted Home Performance with ENERGY STAR provides funding for energy improvements to a building (up to \$5,000 for single-family and \$10,000 for two–four unit).¹⁶⁴ NYSERDA is a public benefit corporation

funded through several sources including a system benefits charge, sale of renewable energy credits, and sale of carbon emission allowances.¹⁶⁵ Within New York City, the NYC Accelerator program provides assistance for new construction and existing buildings larger than 5,000 square feet. This assistance includes education, technical knowledge, and connections to financing options.¹⁶⁶

Next Steps:

Honolulu Office of Climate Change, Sustainability, and Resiliency can work with State entities, utilities, and Hawai'i Energy to create new integrated energy efficiency programs for new construction and building retrofits. These programs can be based on improvement relative to stretch codes, recommendations from energy audits, and incorporation of future building performance standards. They can incorporate programs already in place, such as Hawai'i Energy rebates and the recently passed Bill 22, which requires covered buildings to benchmark energy use¹⁶⁷. Existing measures can be combined with new strategies, such as incentives based on performance tracking.¹⁶⁸ Technical assistance and education can also be provided to assist buildings with benchmarking and meeting performance requirements. For single family homes, program registration could be combined with HSEO (Hawaii State Energy Office)'s Clean Energy Wayfinders outreach program, which shares training and resources for energy conservation with under-resourced schools, community organizations, and households in Hawaii¹⁶⁹. Over time, this program can identify which incentives are most beneficial based on overall GHG reduction, and future resources can be directed to these areas.

Implementation: The Office of Climate Change, Sustainability, and Resiliency can work with the HSEO, Hawaiian Electric (HECO) and Hawai'i Energy, to create and expand programs that help buildings meet energy efficiency and performance standards. Coordination is necessary with applicable city agencies (Department of Planning and Permitting, Department of Budget and Fiscal Services, etc.), to ensure that these comprehensive programs will be integrated with current agency activities.

4.3.2 Link city-funded programs to GHG emissions reduction

Additional Context: The City and County of Honolulu Department of Community Services currently funds a host of programs related to affordable housing, however, they do not currently incorporate building energy or GHG emissions standards beyond complying with the building energy code.¹⁷⁰

Best Practices

Example: Washington State

The Evergreen Sustainable Development Standard (ESDS) applies to affordable housing projects, receiving funding through the State's Housing Trust Fund. The ESDS looks comprehensively at integrated design, energy performance, materials, and other aspects of sustainable building.¹⁷¹ The maximum award for multifamily buildings is \$5 million.¹⁷² In 2021 the Housing Trust Fund awarded \$40 million in grants for property acquisition.¹⁷³ Funding is made possible through the National Housing Trust Fund, a HUD grant.¹⁷⁴ The ESDS is based on the Green Communities standard from Enterprise Community Partners.¹⁷⁵

Example: Portland, OR

The Portland Housing Bureau (PHB) oversees 15,000 regulated housing units throughout the city.¹⁷⁶ Both new construction and renovation projects receiving funding from the PHB are required to follow Green Affordable Housing guidelines. These guidelines cover areas such as energy, water, and material conservation. Typical energy efficiency measures include EnergyStar appliances, high efficiency windows, advanced framing techniques, increased insulation, and high

efficacy lighting. A 2009 study found that these requirements did not increase construction cost.¹⁷⁷ In FY 20–21, the PHB created or preserved 654 units with affordability standards and awarded 518 Home Repair Grants.¹⁷⁸

The Portland Clean Energy Community Benefits Fund provides additional support for sustainable development, which advances racial and social justice. For large projects, funding awards of between \$200,000 and \$1 million are available. Projects can include energy efficiency and renewable energy improvements to both single and multifamily residential properties, with an emphasis on deep energy retrofits.¹⁷⁹ This program is funded by the Clean Energy Surcharge, a tax on large retailers.¹⁸⁰

Next Steps:

Funding for affordable housing may incorporate new criteria for energy performance, creating more equitable and sustainable housing. The Honolulu Department of Community Services, Community Based Development Division can incorporate standards for energy performance into the selection criteria for the award of Community Development Block Grant (CDBG)¹⁸¹ and HOME Investment Partnerships Program (HOME) funding¹⁸² for affordable housing projects. These projects can be new construction, or renovation.¹⁸³ Energy performance standards can also be developed and incorporated into zoning districts for transit-oriented development.¹⁸⁴ Standards can be similar to the State’s Low Income Housing Tax Credit Qualified Allocation Plan, which awards points for buildings that meet EPA Energy Star, Enterprise Green Communities, LEED Certification, or National Green Building Standard criteria.¹⁸⁵

Implementation: The Department of Community Services can make development funds available for energy efficient projects under the proposed programs. The Department of Land Management can incorporate integrated programs and performance standards into their sponsored projects.

4.3.3 Expand tax benefits

Additional Context: The State currently offers a Renewable Energy Technologies Income Tax Credit for installation of renewable energy systems in both residential and commercial buildings. For single-family home PV Systems, 35% of the cost is covered (with a cap of \$5,000).¹⁸⁶ Honolulu currently offers a 25-year property tax abatement, covering the cost of energy efficient improvements to a building. While the Honolulu program does not cover home solar, coverage of wind or ocean energy production is possible.¹⁸⁷

Best Practices

Example: Baltimore, MD

Baltimore County offers a property tax credit for up to 50% of the cost of installing a renewable energy system for single and multifamily residential properties.¹⁸⁸

Example: Cleveland, OH

Cleveland offers a 15-year tax abatement for new construction or improvements to single or multifamily residential buildings¹⁸⁹. Applicants must follow one of three compliance paths based on the Enterprise Green Communities Criteria¹⁹⁰, National Green Building Standard Certification¹⁹¹, or LEED Silver Certification¹⁹².

Next Steps:

Honolulu can expand on the State Renewable Energy Technologies Income Tax Credit program, by offering an additional City property tax credit for renewable energy production in a building. For solar energy systems, a Honolulu tax credit of 15% of system cost could be added to the 35% provided as a tax credit by the State. The City can also further tax abatements for energy efficiency in order to cover more categories of renewable systems. This program could remain a 25-year abatement or be scaled based on tax structure. Both tax credits and abatements, can also be linked to building performance and affordability standards.

Implementation: The Honolulu Department of Budget and Fiscal Services can determine the overall feasibility of tax programs, based on the city budget. The Honolulu Office of Climate Change, Sustainability, and Resiliency may assist in identifying which tax incentives would result in the greatest reduction of GHG emissions and should therefore be prioritized. The Honolulu Real Property Assessment Division, of the Department of Budget and Fiscal Services, can implement tax programs, as well as graduation based on savings beyond energy code (new construction), or building performance standards (existing buildings).

4.3.4 Expand loans and grants

Additional Context: The Hawai'i Green Infrastructure Authority offers loans for residential and commercial buildings' renewable systems such as solar hot water and PV. Repayment occurs through electricity billing (payments, including system financing, must be 10% lower).¹⁹³ Both existing and new buildings are eligible.¹⁹⁴ The City of Honolulu offers a Solar Loan Program for home installation of solar hot water and PV systems, charging 0% interest on a 10–20 year loan.¹⁹⁵ There is also a Rehabilitation Loan Program that can be used for energy-efficient improvements to owner-occupied residential properties, offering 0% interest loans, with a cap of \$300,000.¹⁹⁶

Best Practices

Example: Washington State

The Washington State Housing Finance Commission offers low-interest loans (2–4%) for energy efficiency improvements to multifamily residential buildings. Loan amount is up to \$1 million.¹⁹⁷ Washington State's Early Adopter Incentive Program provides an incentive for building owners who demonstrate early compliance, relative to building performance targets. A one-time base incentive payment of \$0.85 per square foot of eligible floor area is available for qualified buildings. The program will award \$75 million in incentive funds.¹⁹⁸

Example: New York State

The NYSERDA's Energy Efficiency for Commercial Tenants program provides grants and technical assistance in energy efficiency to commercial tenants. They provide a 75% cost share towards hiring a full-time, on-site energy manager for commercial and industrial buildings.¹⁹⁹ NYSERDA also has a Buildings of Excellence program, which provides project funding for the construction of multifamily residential buildings with low or net-zero carbon emissions. The maximum award given is \$1 million.²⁰⁰

Next Steps:

The City of Honolulu can evaluate expanding the Rehabilitation Loan Program, to cover energy-efficient improvements to multifamily residential and commercial buildings. The potential loan amount could be expanded from the current cap of \$300,000 to \$1 million (or more). Honolulu might also consider offering businesses cost matching for energy consulting, providing 50–75% of the cost of hiring an energy consultant. This incentive could be provided to individual buildings, developers, or design teams. In addition, Honolulu could offer a "buildings of excellence" program with grant funding for exceptional buildings, that are built or retrofitted to net-zero or carbon-

negative standards. Funding can also be given for early adoption of building performance standards.

Implementation: The Honolulu Office of Climate Change, Sustainability, and Resiliency and the State Public Utilities Commission (along with other agencies and commissions) can prioritize which loans and grants to implement first, based on climate impact. Coordination is necessary regarding which programs will be implemented by the City and which by the Hawai'i State Energy Office (HSEO) and Hawai'i Energy. The Department of Hawaiian Home Lands is involved in outreach and implementation for home land residents.

Within Honolulu City and County, the Department of Community Services implements changes to building-related loan programs. The Department of Budget and Fiscal Services determines overall feasibility of loan and grant programs, based on the current city reserves and liquidity.

4.3.5 Expedite building permitting

Additional Context: The City of Honolulu currently has a policy for expedited permitting for alternative energy systems (Bill 58)²⁰¹, but this legislation does not cover the buildings themselves. Hawai'i statute (HRS §46-19.6) directs each county to have a procedure for priority processing of permits for LEED silver/green globe rated buildings.²⁰² Currently, the Honolulu Department of Planning and Permitting (DPP) is in the process of updating its permit system,²⁰³ so the time is opportune for incorporating expedited permitting pathways.

Best Practices

Example: Miami

Miami-Dade County has a Green Building Expedited Plan Review program, which expedites the plan review of energy efficient and environmentally friendly buildings. Newly constructed residential, commercial, and industrial buildings are eligible, and must be certified as a green building by the Florida Green Building Coalition, or the U.S. Green Building Council (USGBC). The program is limited to projects valued at \$50,000 or more.²⁰⁴

Example: San Diego, CA

San Diego has a Sustainable Buildings Expedite Program, which provides for permit processing at least 25% faster than conventional review, 80% of the time. This expedited pathway is available for any development project incorporating sustainable design and materials, which exceeds the requirements in the CA state code.²⁰⁵

Next Steps:

The DPP can create an expedited permitting pathway for projects that demonstrate savings beyond energy code (new construction) or adoption of building performance standards (existing buildings). Once the DPP has restructured their permitting system, a 90-day review window could be applied to projects that meet energy efficiency and green building standards. For residential projects, one-time initial review could ideally be conducted within 60 days, similar to the one-time review process extended to one- and two-family projects in 2018.²⁰⁶

Housing affordability standards can be incorporated as well, similar to Bill 7 (Relating to Affordable Rental Housing). This legislation requires permit review within 90 days, for buildings where 80% of units are rented to households earning 100% or less of the HUD Area Median Income.²⁰⁷

Expedited permitting could also incorporate approval of renewable systems with Hawaiian Electric.²⁰⁸ Ideally, these expediting programs could be implemented without requiring additional

funding. Expedited permitting should not restrict opportunities for community input, which should be inclusive of multiple engagement methods and times.

Implementation: The DPP can create an expedited pathway for sustainable buildings. The guidelines should follow the LEED silver/green globe rating system in order to satisfy Hawai'i statute (HRS §46-19.6). If city legislation is required, it could be combined with a permanent version of Bill 7, which is set to expire in 2024.²⁰⁹

4.3.6 Access additional financing

Additional Context: We recognize that there is a severe funding shortage for these types of initiatives. Therefore, we encourage the City and State to advocate for increased federal funding in order to meet the Honolulu Climate Action Plan and HCEI goals.

The U.S. Department of Energy has several funding streams that can be accessed. The Building Codes Implementation for Efficiency and Resilience²¹⁰ grant program is a competitive award, and applications are expected to be open by the end of 2022. The funding enables sustained, cost-effective implementation of updated building energy codes. Also covered are trainings and materials for builders and code officials, and addressing implementation needs in rural, suburban, and urban areas. The Energy Efficiency Revolving Loan Fund Capitalization Grant Program²¹¹ provides capitalization grants to states to establish a revolving loan fund under which the state shall provide loans and grants for energy efficiency audits, upgrades, and retrofits. The overall goal is to increase energy efficiency and improve the comfort of building occupants. Applications are sent to open in the fourth quarter of 2022. The Energy Efficiency and Conservation Block Grant Program²¹² provides funding for state and local governments to act on improving energy efficiency, using tools such as strategy and programs, energy audits, financial incentives, building codes and inspections, energy distribution technologies, and on-site renewable energy.

In addition, The Hawai'i State Department of Economic Development and Tourism (DBEDT) currently issues green infrastructure bonds, in order to provide low-cost financing for renewable energy and energy efficiency measures.²¹³

Best Practices

Example: Berkeley, California

Berkeley is implementing microbond financing to increase community investment. Bond offerings will be priced at \$100 or less.²¹⁴ The funds will be used to raise money for public projects.²¹⁵

Example: Vancouver, Canada

Vancouver has a 3% tax on properties considered "vacant". Typically, these are non-primary residences that are not rented for at least six months out of the year.²¹⁶ From 2017–2020, the first three years of the tax, vacant homes decreased from 2,193 to 1,627. This was accomplished with only a 1% vacancy tax.²¹⁷

Example: Connecticut

Since 2011, the Connecticut Green Bank has directed \$2.14 billion in capital to clean energy projects.²¹⁸ One recent project was the Gateway at 570 State Street, Bridgeport, a mixed-use building with 30 residential units. This project received \$500,00 in funding, via a two-year loan at 2% interest. The building is owned by a non-profit neighborhood trust and is the first Energy Star Multifamily High Rise in CT.²¹⁹

Next Steps:

The City and County of Honolulu, alone or in conjunction with the State of Hawai'i, may apply for U.S. Department of Energy grants. To provide liquidity for retrofit and new construction loans that promote energy efficient and renewable practices, Honolulu can also create low-cost municipal "green" or "carbon" bonds. By decreasing bond prices from the typical level of \$1,000 to \$100, citizens that would not normally invest in bonds are given this opportunity. Using social media could allow this program to reach a new generation of investors.

Green banking is another initiative that can provide capital funding for sustainable projects. Loans can be provided to cover the cost of a building's renewable energy system or efficiency improvements, with a loan period that allows the system to pay for itself in energy savings. Capital can be provided from investors and mission driven funds,²²⁰ and be directed to both private and non-profit developers.

An additional source of funding can be a vacancy tax. Thousands of housing units in Honolulu are used only seasonally or as an investment property. Four percent of all housing units in Oahu were considered "seasonal" in 2017.²²¹ Honolulu can create a "pied-a-terre" tax that recovers revenue for grant programs based on taxing non-primary residences. To this effect, a Honolulu City Council bill,²²² active as of June 2022, would make "vacant residential" (properties unoccupied for six months of the year) a tax category.

Implementation: The Honolulu Office of Climate Change, Sustainability, and Resiliency, in coordination with the Hawai'i State Energy Office and the State Building Code Council, can apply for federal programs. The Department of Budget and Fiscal Services (BFS) is responsible for new municipal bond offerings for the City and would determine the appropriate tax rate for vacant properties. Together with the State Department of Economic Development and Tourism, BFS can also assist in implementation of green banking. Within BFS, the Real Property Assessment Division may identify vacant properties through the assessment process. The DPP may assist in vacancy compliance through its Short Term Rentals Division.

5 EDUCATION

5.1 Objectives

Identify opportunities and encourage design professionals, contractors, and developers to utilize policies, national frameworks, and opportunities to reduce buildings' operational energy use.

5.2 Context

During the development of this guidance document, stakeholders from the design and construction community communicated strong support for professional education. Potential training actions listed below may build upon existing training approaches in Hawai'i. For example, the HSEO and Hawaii Energy currently host training on the building energy code²²³ and the Honolulu Resilience Office hosts community meetings on their programs²²⁴. Professional organizations (e.g., ASHRAE Hawai'i²²⁵, American Institute of Architects (AIA) Honolulu²²⁶, USGBC Hawai'i²²⁷, American Planning Association Hawaii Chapter²²⁸, Building Commissioning Association²²⁹) regularly host presentations and architects are motivated to attend to complete continuing education requirements for licensure²³⁰. The UH Outreach College holds a few short courses for architects and engineers with course fees subsidized by Hawai'i Energy.²³¹ Conversation with stakeholders indicated a need for training for decision makers on the need for climate action, financing energy efficiency retrofits, particularly in commercial buildings.

5.3 Potential Actions

5.3.1 Support AIA 2030 Commitment training

The AIA 2030 Commitment²³² is a set of standards and goals for reaching net-zero emissions by 2030 for buildings in design. Coordinate with the AIA Hawai'i and AIA Honolulu to determine highest priority training subjects and relevant format in conversation with design firms. Training subjects may include: signing the 2030 Commitment Letter; creating a sustainability action plan; recording and tracking predicted energy use intensity data in the national online reporting system, the Design Data Exchange (DDx); utilizing the webinars and guides, and office hours offered by AIA National. To minimize planning time and expedite training implementation, consider creating a curriculum based on existing webinars from AIA COTE chapters around the country or from AIA University (AIAU)²³³ followed by local live discussions. The AIA 2030 Commitment is further described in the appendix of this document.

Best practice: Utilize existing educational resources from AIA National 2030 Commitment website online training and guides²³⁴. The AIA Philadelphia 2030 Working Group²³⁵ hosts webinars on meeting the 2030 Commitment including energy modeling processes and contracts, integrated design, environmental design tools, collaborating with building performance specialists, simplifying solar energy analysis, and more.

5.3.2 Support AIA Framework for Design Excellence training and awards

Support AIA Framework for Design Excellence training and align architecture awards with the values in the AIA Framework for Design Excellence.

Best Practice: The Common App²³⁶ is used nationally to simplify multiple award submissions with one set of data fields for performance metrics that reinforce the Framework for Design Excellence.

5.3.3 Host training on new codes, policies, and incentives

5.3.3.1 Host professional training on new building energy codes. The HSEO should continue to regularly offer training sessions²³⁷ on upcoming or newly adopted energy codes.

5.3.3.2 Host professional training on new stretch codes to garner support for adoption and train design, construction, and reviewing professionals.

Best Practice: Architecture 2030 Webinar on Zero Code²³⁸; AIA Central Valley 2020 webinar on "ZERO Code for California"²³⁹.

5.3.3.3 Provide ongoing professional training and assistance on building energy benchmarking. The City and County of Honolulu Office of Climate Change, Sustainability, and Resilience should continue to host informational sessions on building energy benchmarking for the various audiences as the program expands.

Best Practice: The New York City Benchmarking Help Center²⁴⁰ provides free training and one-on-one help navigating the ENERGY STAR Portfolio Manager to meet Local Law 84.

5.3.3.4 Provide ongoing professional training and assistance on building energy auditing. The list of Hawaii Energy Clean Energy Allies²⁴¹ may help locate energy auditing and commissioning professionals. Conversation with stakeholders identified a need for training for professionals who evaluate the energy efficiency of detached houses, such as raters for Home Efficiency Rating System²⁴² and Building Performance Institute Certified Energy Auditors²⁴³.

Best Practice: The New York City Retrofit Accelerator²⁴⁴ provides free, personalized guidance

to make cost-saving, energy-efficiency, and water-efficiency upgrades to comply with Local Law 87 and Local Law 97.

5.3.3.5 Provide ongoing professional training and assistance on building (energy) performance standards.

Best Practice: The New York City Retrofit Accelerator²⁴⁵ provides technical assistance on LL97 information and GHG emission calculator, technical primers, case studies, financing, and training²⁴⁶.

The Urban Sustainability Directors Network hosted webinars on building performance standards with targets for existing buildings to reduce energy use, or GHG emissions. Target audiences included local governments, community, and industry professionals.²⁴⁷ The webinars and framework were developed for the American Cities Climate Challenge²⁴⁸.

5.3.3.6 Provide training to officials (DPP) who review for compliance with the building energy code at the time of permitting, on using the building energy code performance path.

5.4 Next Steps

The Honolulu Office of Climate Change, Sustainability, and Resiliency may coordinate with the HSEO, Hawai'i Energy, State Building Code Council, AIA Hawai'i and AIA Honolulu, ASHRAE Hawai'i, USGBC Hawai'i, American Planning Association Hawaii Chapter, Building Commissioning Association and other professional organizations to determine highest priority training subjects including Architecture 2030, new codes, policies, and incentives. Together, they can determine relevant training formats, responsibilities, and schedules.

6 FUTURE RESEARCH NEEDS

The following section lists future research needs regarding climate change mitigation and adaptation in the built environment.

6.1 Roadmap

A roadmap is needed to meet the goals of Honolulu's Climate Action Plan²⁴⁹, HCEI²⁵⁰, and the AIA 2030 Challenge. This will project and benchmark progress toward targeted, incremental reductions in GHG emissions, from existing and new building operation and renewable energy production. A roadmap should build upon the Energy Efficiency Portfolio Standard requiring 4300 GWh of electricity savings by 2030 (Act 155)²⁵¹ and Transcending Oil report²⁵², and quantify and provide guidance on strategies for emissions reductions over time from codes, energy conservation measures, retrofits, and renewable energy. A relevant example is New York City's Roadmap to 80x50²⁵³. A recent study²⁵⁴ of multifamily housing in Honolulu establishes energy use intensity targets, identifies effective energy efficiency measures, and achieves net-zero energy. Its information and replicable methods may be duplicated in a roadmap for Honolulu.

6.2 Embodied and Sequestered Carbon

Embodied carbon in the built environment is generated during the process of manufacturing, transporting, and installing construction materials. With increased operational energy efficiency, the impact of embodied carbon emissions in buildings becomes progressively more important. Currently nearly all of

building materials in Hawaii are shipped long distances, creating a large carbon footprint²⁵⁵. Data is needed on the embodied carbon due to transportation of materials to Hawaii, which is not currently included in the continental US data referenced by lifecycle analysis tools and environmental product declarations. Embodied carbon can be decreased through a variety of different design and construction decisions: material selection (type and sourcing); project delivery method; on-site construction and installation methods; and project end of life outcome. Future research is needed on lowering embodied carbon, in both new construction and renovation projects.

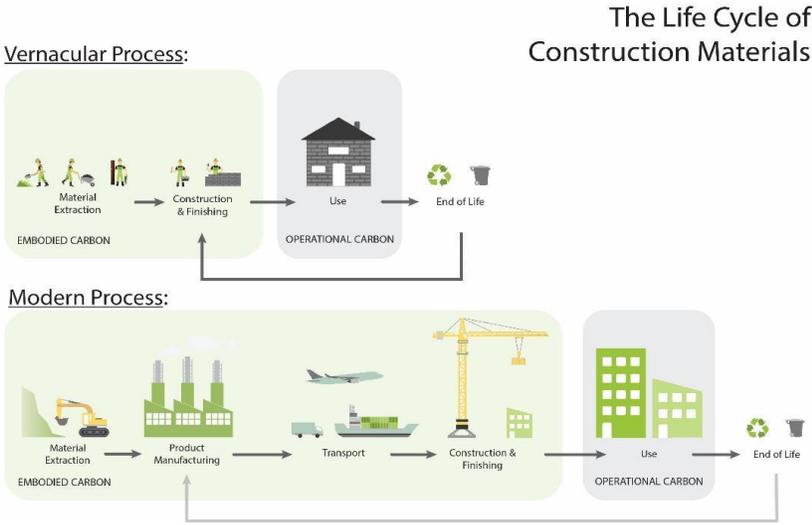
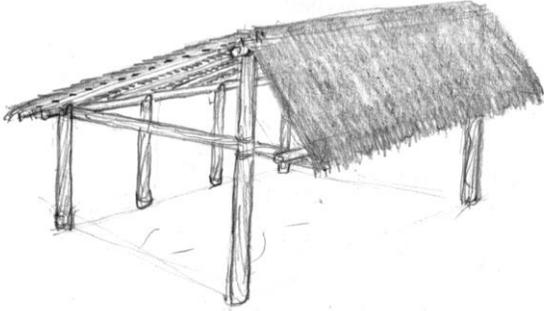


Figure 1. Embodied and operational carbon. Source: Created by AHL and used with permission.

Sequestered carbon, conversely, is carbon that is removed from the environment through its presence in building materials. Using biogenic materials such as wood helps to remove carbon dioxide from the atmosphere.²⁵⁶ Implementation could involve versions of the traditional hale ku'ai (shed or gable style), using guidance from the "Indigenous Architecture" section of the Honolulu Building Code.²⁵⁷



HALE KU'AI
GABLE STYLE

Figure 2. Hale Ku'ai Gable Style typology. From the Honolulu Building Code, ROH Section 16-12.9(b)2.

Please see the green concrete section of the appendix for more discussion on carbon sequestering materials.

6.3 Grid-Interactive Efficient Buildings

Rather than focusing on an insular goal of creating net-zero buildings, grid-interactive efficient buildings serve the collective goal of decarbonizing the electric grid.²⁵⁸ More research is needed to determine how buildings in Honolulu can be used as grid assets, to help manage the bidirectional flow of energy. This will shift loads to match generation, reduce peak grid loads (thus reducing the need for larger infrastructure), and support grid stability and resilience.^{259 260}

6.4 Affordable, Equitable Housing

Single family homes represent the largest housing segment (number of households) on O'ahu²⁶¹. However, O'ahu's single family homes are also the largest average consumers of residential energy (both in total kwh and kwh per household)²⁶², and continue to increase in price²⁶³. This brings about concerns over the affordability and carbon intensity of single family homes. In 2011, Kaupuni Village in Waianae became Hawaii's first net-zero, affordable housing project²⁶⁴. This project serves 19 Native Hawaiian families through a partnership between federal, state, and local stakeholders, and assistance from federal and state agencies.

In line with the Honolulu Climate Change Commission's focus on social equity, research is needed to establish criteria for energy efficiency, to reduce energy bills for the residents of subsidized housing. In 2008 Ameresco was selected by the Hawaii Public Housing Authority to provide energy services and efficiency-related capital improvements, at 67 sites throughout the state. Efficiency measures include high-efficiency water and lighting fixtures, and renewable technologies. Increased funding is necessary, to encourage implementation of energy efficiency and renewable measures, with cost premiums in subsidized housing.

6.5 Adaptation to Climate Change

Research is needed on adapting Honolulu's built environment for projected climate change impacts, including rising sea levels, hotter temperatures, changing rainfall patterns, and tropical cyclones shifting northward.²⁶⁵ The AIA requires members to incorporate adaptation strategies to anticipate extreme weather events and minimize adverse effects on the environment, economy, and public health.²⁶⁶ Hydrologic engineering studies, such as the U.S. Army Corps of Engineers' flood risk study in Honolulu²⁶⁷, utilize rainfall intensity-duration-frequency (IDF) curves in their model analysis. Projected future climate-change shifted IDF curves and weather files (for simulating building energy requirements) are available through databases, such as Arup WeatherShift²⁶⁸, and were used in a Kapalama Canal study²⁶⁹. In addition, adaptation and resiliency plans from New York²⁷⁰, Boston²⁷¹, and Chicago²⁷² are references that can inform Honolulu's forthcoming Climate Adaptation Plan.

If the design and construction industry incorporate long-term climate projections, whether through standards, licensing, education, building codes, or zoning, critical infrastructure and community assets can become more resilient against climate hazards.²⁷³ Building energy modelers typically use weather files from 1976–2005 to project energy use²⁷⁴. There is a need for design and construction industries, academia, and professional licensing boards to reach a consensus on how to create and use future weather data. This data is used in simulations to size heating and cooling systems, or estimate annual energy use and thermal comfort²⁷⁵.

6.6 Zoning

Additional research is needed on zoning-related incentives for energy performance and sustainable design. Seattle's Living Building Pilot program provides additional height and floor area ratio in exchange

for meeting the Living Building Challenge,²⁷⁶ and allows requests for additional departures from the Seattle Land Use Code through Design Review. Honolulu's Land Use Ordinance already allows some energy-saving features to extend above the district height limit.²⁷⁷ Resolution 21-136, active in the Honolulu City Council as of June 2022, allows solar panels to extend 10 feet above the height limit of a building in zoning districts with a height limit of 60 feet or more. This can allow for useable shaded space for occupants, which does not add to the floor area of the building.²⁷⁸ Honolulu's Transit Oriented Development program²⁷⁹, allows for zoning plans around HART stations that can incorporate biogenic carbon and the shaded areas described in Appendix A.

6.7 Energy Code Compliance

To demonstrate compliance with the Honolulu building energy conservation code, the licensed project design professional provides signature certification²⁸⁰, although more extensive requirements may be considered. Best practices that go beyond Honolulu's current energy code compliance practices include air barrier testing, mandatory commissioning, performance testing, and staff dedicated solely to energy code compliance reviews²⁸¹. A city may also contract a consultant to review plans. The City of Santa Clara, CA, Building Division uses consultants to assist with reviews for 25–50% of their workload.²⁸² Resources and training would be needed to increase the capacity of DPP, and may be funded by a federal grant (see section 4.3.6 of this paper).

7 O'AHU DESIGN AND CONSTRUCTION STAKEHOLDER FOCUS GROUP

Objectives

The Honolulu Climate Change Commission pledged to center social equity in its recommendations and processes, and to engage with diverse voices in meetings and reports. This includes focused outreach, co-development, and assessment of Commission products with organizations and communities that are disproportionately impacted by the topic. The emphasis is on engaging with frontline communities and underserved populations. To this effect, a virtual stakeholder discussion was held on May 14, 2021 to accomplish the following: (1) listen to diverse sectors in the development and review of this guidance document; (2) get feedback on the key recommendations; and (3) expand the Hawai'i and O'ahu context with local experience and expertise. A follow up internet survey was administered to gather additional input from those who could not attend the virtual discussion. A second-round of virtual stakeholder discussions were held between July 7 and July 13, 2022 to provide written input to the revised guidance document.

Identification of stakeholders. Stakeholders representing eight broad sectors on O'ahu were identified: non-profits; developers; construction industry; labor unions; architecture; government; academia; and community/advocacy. A total of 20 people attended the virtual discussion (six non-profit, one labor union, six government/academia, five developers, two construction). The survey was opened for one week and received 12 additional responses (three labor union, three construction, two government, two developer, one community/advocacy, one architecture). After revisions, a selection of stakeholders from a few sectors were individually consulted to get additional feedback. A total of nine people, representing the government, non-profit, architecture, and construction sectors, attended the second round of stakeholder discussions.

Discussion and survey themes and recommendations. The climate-related risks that most concerned stakeholders included: impacts of sea level rise on infrastructure; hurricane planning and response; heatwaves and corresponding energy use; flooding and wastewater management; and the unintended consequences of climate policies. Themes that emerged from the discussion and survey responses included: concerns about social and financial costs, and the associated challenge of limited resources; the importance of combining new development with infrastructure upgrades; the value of studies that determine the impact of new potential code requirements on different building types; mitigating energy costs for building operations; and the need for iterative evaluation and discussion of changes. Direct recommendations include: the need for disclosure of

emission and energy performance in the current building stock; common and transparent building standards; avoiding mandates and encouraging incentives; evaluation of recommended policies' impact on low-income populations; and continuing education in construction sectors to support new standards and policies. With these considerations in mind, the guidance document was heavily revised to incorporate: (1) an assessment of operational carbon emission reduction policies from other cities; (2) guidance on creating policies and incentives to reduce embodied carbon from building construction; and (3) resources and recommendations for professional education on embodied and operational carbon emission reductions.

8 CONCLUSION

The urgent need to reduce and eliminate greenhouse gas emissions from buildings' operation may be addressed through codes, policies, practices, incentives, and education. This paper provides potential actions and examples of best practices for consideration and possible implementation, by the City and County of Honolulu and its collaborators.

9 ACKNOWLEDGEMENTS

Funding for the completion of this project was provided by the Hawai'i Natural Energy Institute with resources allocated to them from the State of Hawai'i Energy Systems Special Fund §304A-C, and the Healy Foundation via the Institute for Sustainability and Resilience. Additional support was provided by Hawai'i Sea Grant and the UH School of Architecture.

The commission thanks Wendy Meguro, Eileen Peppard, Felix Gottdiener, Ryan Ringuette (University of Hawai'i at Mānoa) for leading the grounded academic and field research; Bettina Mehnert and Raffie Lee (AHL) for the initial draft guidance document paper for stakeholder feedback; and to Jim Maskrey of the Hawai'i Natural Energy Institute for his guidance.

The commission thanks the following people for providing valuable input: Ben Sullivan and Matthew Gonser (Honolulu Office of Climate Change, Sustainability, and Resiliency), Harrison Rue (Honolulu Department of Planning and Permitting), Charles Chaleiocheep (WSP), Howard Wiig (Hawaii State Energy Office), Ramona Mullahey (Federal Department of Housing and Urban Development), Anton Krucky (Honolulu Department of Community Services), Katia Chikasuye (Hawai'i Emergency Management Agency), Erik Kolderup (Kolderup Consulting), Ross MacWhinney (New York City Mayor's Office). The commission thanks the many stakeholders from different sectors across O'ahu who provided their feedback during the virtual focus group and survey.

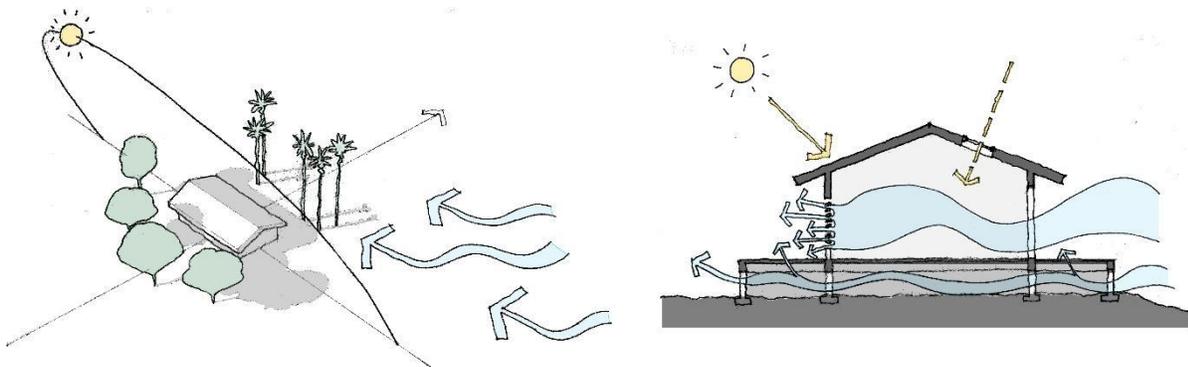
APPENDIX A—SUSTAINABLE AND RESILIENT DESIGN STRATEGIES

The adoption of collective values in the design and construction of the built environment, driven by energy efficient design strategies, will support the climate and energy crisis solution. As architects, engineers, contractors, municipalities, nonprofits, community members, and neighbors, we have a collective responsibility to create the new norm of efficient energy usage. Its impact is directly related to the consequences of climate change, that affects the natural and built environment we inhabit.

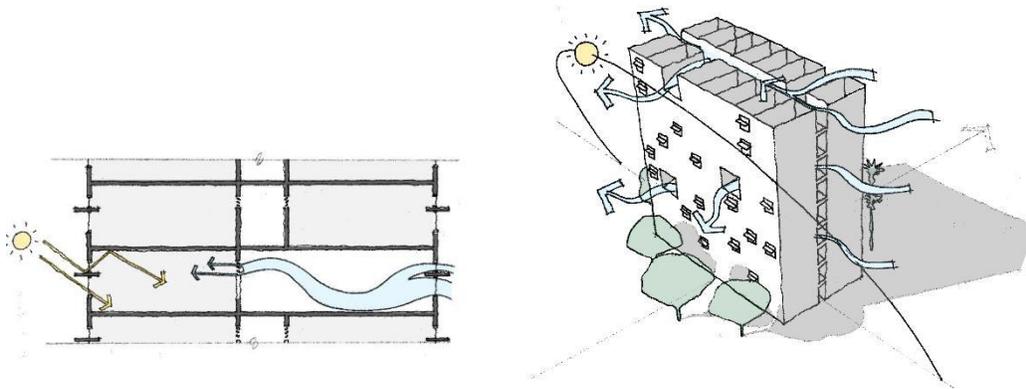
The prioritization of energy efficiency in the built environment works across many industries, to slow the effects of the climate crisis. Buildings with integrated passive and renewable energy systems will decrease operational costs. Low-cost passive design allows inhabitants of the space to experience thermal comfort, as well as utilizing ecosystem services. Design that responds to both expected and unexpected conditions increases resilience, and provides a safer, more sustainable, and cost-effective built environment.

Implement Sustainable Design Strategies on O‘ahu

Implementation of sustainable design strategies will increase energy efficiency through no or low-cost passive strategies. Climatic specific design looks to the site of the project to take advantage of simple concepts such as natural lighting, ventilation, and elevation benefits. This decreases the space’s reliance on fossil fuel based energy, and reduces demand on the electricity grid. Vernacular architectural techniques, especially in Hawai‘i, can also be used to inspire innovative passive strategies as well as acting as a form of cultural preservation. Open houses promote convective airflow, which works to remove humidity from the skin through evaporative cooling, decreasing the need for electrically powered cooling devices. Lighter weight materials and thoughtful building designs store less heat, allowing houses to cool quickly after the sun sets. Common design elements with energy efficient drivers include deep overhangs that wrap and shade homes, louvered windows that allow for views while promoting air movement, large surrounding shade trees, raised homes that can be situated on steep slopes and take advantage of trade winds, and large windows and lānais for increased daylighting and natural ventilation.²⁸³



Figures 2 and 3. Tropical design strategies for low rise typology. Source: Created by AHL and used with permission.



Figures 3 and 4. Tropical design strategies for mid to high-rise typology. Source: Created by AHL and used with permission.

Site orientation maximizes the environmental services of natural daylighting and trade winds. Minimizing east and west facing walls decreases sun exposure, and the consequent heat gain. Maximizing the south facing roof increases possible photovoltaic exposure. Canopy trees positioned on the south filter the summer sun and tall, narrow trees in the north filter the high morning sun and help to buffer wind. Raised buildings allow for increased ventilation throughout, and create a separation from the wet ground (depending on the microclimate). Solar heat gain may be blocked by large roof overhangs that shade low rise buildings, and awnings or sunshades on high rise buildings. Operable windows and louvered doors on at least two elevations create cross ventilation. In larger scaled buildings, open corridors and lounges are important for maintaining ventilation.

Prioritize Shading for Community Gathering Spaces

The built environment has a responsibility to its occupants to provide inhabitable areas that offer thermal comfort, clean air, and physical space conducive for community engagement. Embodied carbon from building materials can be partially offset with increased habitation of flora, and biogenic carbon. Reactivating spaces in existing structures can be done through adaptive reuse focused on providing shade and open, covered, gathering spaces for building occupants.

Outdoor shading strategies, especially in our tropical climate, allow for more adaptable flex space within buildings, campuses, neighborhoods, and city centers. Shaded areas not only decrease the heat island effect but also encourage outdoor activities that lend to community participation, engagement, and stewardship.

Creative shaded areas can be designed on various scales and levels of permanency. Using traditional typologies such as the Hale Ku'ai gable and shed style (see section 6.2) can promote Hawaiian cultural identity.

Two important strategies for increasing shading on both existing and newly developed sites include plants and vegetation, and tensile shading structures. Proper location and selection of flora surrounding the built environment can reduce up to 25% of the cooling costs of the building's operational loads. Branches and leaves provide shade, leaves help filter air pollution, and evapotranspiration from leaves cools surrounding air.²⁸⁴ The installation of tensile structures also can help create shading in outdoor areas. Their flexibility is enabled by the type of material used, adaptable anchor points, and the potential for adjustment during different times of the year. These types of shading structures can be installed on existing projects, but can also be fully integrated as a potential design feature of the site, with upfront planning during the design process.

Material Selection and Construction Strategies

These sustainable design strategies exist for the physical design of the building and also in the material selection and project delivery method. Materials with inherently lower embodied carbon can be substituted for the traditional and, in many instances, can be of comparable price and availability. Utilizing local materials helps promote circular economies, and reduces transportation impacts.

One-time use materials have an abrupt end of life, that results in their disposal into waste streams. In 2017, the U.S. generated 569 million tons of construction and demolition (C&D) debris. Redirection of this material decreases the environmental impact associated with the extraction and consumption of natural resources. Sustainable materials management (SMM)²⁸⁵ can help to divert C&D materials out of waste streams by redefining them as new commodities. Additional benefits of SMM include decreased project expenses, decreased environmental impacts from waste disposal facilities and virgin material extraction, conservation of landfill space, increased employment opportunities, and economic activity. Sustainable material use can be exercised through source reduction, salvaging, or the recycling and reusing of existing material.²⁸⁶

Source reduction prevents waste from being generated in the beginning of the life cycle of a building. Examples of this approach include preserving existing buildings over new construction, designing adaptable buildings to extend their lifetime, utilizing construction methods that facilitate the reuse of materials, applying alternative framing techniques, and reducing interior finishes. Purchasing agreements with suppliers can also be adapted to prevent excess material and packaging, during transportation and site arrival.²⁸⁷

Green Concrete

Concrete is the second most used material on the planet after water,²⁸⁸ and is the second largest industrial source of carbon dioxide in the world.²⁸⁹ In addition to its extractive manufacturing process, its transportation to site is another source of carbon emissions, adding to the material's embodied energy.²⁹⁰ This distance is increased by the geography of our island state.

Carbon-sequestering concrete is an opportunity to redefine the procurement of raw material extraction required for concrete. Hawai'i and New York²⁹¹ implemented requirements for procuring low-carbon or carbon-sequestering concrete for state projects. In Hawai'i, Section 601: Structural Concrete of the DOT/State Projects Special Provisions 2005 Standard Specifications²⁹² was updated on July 10th, 2020. Revisions to the section included the requirement to reduce the embodied carbon footprint of concrete, through carbon dioxide mineralization technology, supplementary cementitious materials (SCMs), or other methods.

Carbon-sequestering concrete demonstrations include a 2019 HDOT pour of 150 cubic yards of concrete by CarbonCure Technologies Inc., which showed a reduction of 1,500 pounds of carbon dioxide, offsetting the emissions from 1,600 miles of highway driving.²⁹³ The injection of waste carbon dioxide, usually from a gas company or power plant, is injected into a wet concrete mix, forms calcium carbonate, and replaces some of the cement while maintaining strength requirements.²⁹⁴ The carbon-injected concrete is projected to reduce embodied carbon by 25 pounds per cubic yard.²⁹⁵

Use of iterative embodied energy tools are encouraged to inform decision making throughout the entire design process. Building information modeling (BIM) techniques and lean construction methods can detect and reduce material waste in projects. Better visualization increases accurate estimations of material use and cost, while reducing the number of errors made on site.

Generate On-site (and Off-site) Renewable Energy

In addition to sustainable design strategies, which help to satisfy a low energy budget while preserving comfort, the generation of on-site renewable energy furthers the impact of the building from energy efficient to zero-net-energy (ZNE). Some forms of renewable energy being generated on the Island of O'ahu include solar, wind, ocean, biofuel, and waste-to-energy.²⁹⁶

Resilient Design for O'ahu's Buildings

Resilience is defined by the O'ahu Resilience Strategy as "the ability to survive, adapt, and thrive regardless of what shocks or stressors come our way". These shocks ("events which occur rapidly and unexpectedly") and stressors

(“on-going strains on society that gradually sap community strength”) create vulnerabilities that detract from strong community culture, values, and experiences.²⁹⁷

The top identified shocks on O’ahu in 2019 include the following.²⁹⁸

1. Hurricanes
2. Tsunamis
3. Infrastructure Failure
4. Rainfall Flooding
5. External Economic Crisis
6. Heat Waves

The top five identified stressors on O’ahu in 2019 include the following.²⁹⁹

1. Cost of Living
2. Aging Infrastructure
3. Climate Change Impacts
 - a. Rising Heat
 - b. Sea Level Rise
4. Lack of Affordable Housing
5. Overreliance on Imports

New builds and existing retrofits must look at these challenges in order to help increase the resiliency of O’ahu. Design and selected materials can help coastal areas be better prepared for sea level rise, flooding during heavy rain showers, increased threat of hurricanes, and extreme summer heat. A more equitable distribution of affordable housing in urban regions can decrease the cost of living for many residents, while offering increased public transportation options and shorter commutes to work. Prioritizing the use of local building materials, local AEC businesses, and SMM cuts back on the industry’s contribution to GHG emissions and reduces our reliance on imported goods.

Regenerative Buildings

Regenerative architecture is the “practice of engaging the natural world as the medium for and generator of the architecture focused on: conservation and performance through decreased environmental impacts of a building”.³⁰⁰ A refocus on the place and site of the specific built project allows designers and stakeholders to understand the natural and living systems in the design. A regenerative practice follows the approach that the production output is “greater than the net input of resources into the system”.³⁰¹ In terms of architecture it means a surplus of food, clean water, and energy post consumption as well as a richer diversity than was there previously.

Preparing to adapt both new and existing spaces, aftershocks and stressors, is especially important. Exploring questions such as “What can be done differently?” and “How do we want to rebuild?” can be a great exercise, in beginning to examine both mitigation and resilient strategies. Regenerative buildings are inherently more self-sustaining and resilient, because of their formation from mutually supportive relationships. A dependence on the landscape and biosphere of the site, and a core belief in recycling resources, helps to create a circular process loop. This type of process contrasts strongly with the traditional degenerative process, where energy and resources are taken from the outside environment and produce a large waste output.

In recognition of the gravity of the architects’ opportunity, the AIA issued a “Framework for Design Excellence”, which outlines the defining principles of good design in the 21st century. Comprised of ten concepts and accompanied by searching questions, the framework seeks to inform progress toward a zero-carbon, equitable, resilient, and healthy built environment. These principles are meant to be carefully considered by designers and architects at the initiation of every project and incorporated into the work as appropriate to the project scope. The framework is intended to be accessible and relevant for every architect, client, and project, regardless of size, typology, or aspiration.

Response to New Water Challenges

The average Hawaiian resident uses 144 gallons of water per day at home.³⁰² Here in Hawai'i, this valuable resource has been filtered through porous volcanic rock for up to 25 years and is held in aquifers.³⁰³ In light of the Red Hill crisis, the protection of Hawaii's wai must be acknowledged and addressed.³⁰⁴ For more information, please refer to the "One Water" document that "promotes the management of all water within a specific geography—drinking water, wastewater, stormwater, greywater—as a single resource".³⁰⁵

REFERENCES

- ¹ https://architecture2030.org/2030_challenges/2030-challenge/
- ² <https://architecture2030.org/about/faq/#toggle-id-8>
- ³ “Why the Building Sector? – Architecture 2030”. Architecture2030.org, 2021, architecture2030.org/buildings_problem_why
- ⁴ <https://architecture2030.org/new-building-actions/>
- ⁵ “Frequently Asked Questions (FAQs)—U.S. Energy Information Administration (EIA)”. Eia.gov, 2018, www.eia.gov/tools/faqs/faq.php?id=86&t=1.
- ⁶ “Frequently Asked Questions (FAQs)—U.S. Energy Information Administration (EIA)”. Eia.gov, 2018, www.eia.gov/tools/faqs/faq.php?id=86&t=1.
- ⁷ Carbon Leadership Forum <https://carbonleadershipforum.org/the-carbon-challenge/>
- ⁸ “Why the Building Sector? – Architecture 2030”. Architecture2030.org, 2021, architecture2030.org/buildings_problem_why/.
- ⁹ “Why the Building Sector? – Architecture 2030”. Architecture2030.org, 2021, architecture2030.org/buildings_problem_why
- ¹⁰ “Why the Building Sector? – Architecture 2030”. Architecture2030.org, 2021, architecture2030.org/buildings_problem_why
- ¹¹ “Why the Building Sector? – Architecture 2030”. Architecture2030.org, 2021, architecture2030.org/buildings_problem_why
- ¹² <https://architecture2030.org/accelerating-the-2030-challenge-to-2021/>
- ¹³ <https://architecture2030.org/accelerating-the-2030-challenge-to-2021/>
- ¹⁴ <https://architecture2030.org/1-5c-cop26-communique/>
- ¹⁵ https://newbuildings.org/wp-content/uploads/2021/08/CfC_Bldg-Decarb-Code_FS_commercial.pdf
- ¹⁶ Melton, P. “Will ESG Move the Green Building Needle?”. BuildingGreen. January 20, 2022. <https://www-buildinggreen-com.eres.library.manoa.hawaii.edu/news-analysis/will-esg-move-green-building-needle>
- ¹⁷ International Energy Agency (IEA), The Future of Cooling, https://iea.blob.core.windows.net/assets/0bb45525-277f-4c9c-8d0c-9c0cb5e7d525/The_Future_of_Cooling.pdf Accessed 6/27/22.
- ¹⁸ Budds, D. “How Do Buildings Contribute to Climate Change?” Curbed, 19 Sept. 2019, www.curbed.com/2019/9/19/20874234/buildings-carbon-emissions-climate-change.
- ¹⁹ <https://energy.hawaii.gov/hcei>
- ²⁰ https://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0096.htm
- ²¹ <https://energy.hawaii.gov/wp-content/uploads/2021/01/HCEI-10Years.pdf>
- ²² <https://www.resilientoahu.org/climate-action-plan>
- ²³ <https://hawaii2050.hawaii.gov/wp-content/uploads/2021/07/FINAL-Hawaii-2050-Sustainability-Plan-web-1.pdf>
- ²⁴ https://energy.hawaii.gov/wp-content/uploads/2022/01/HSEO_2021_Annual_Report_1.4-3.pdf
- ²⁵ USEIA Electricity Data Browser [https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g000000000008&endsec=vg&linechart=ELEC.PRICE.US-ALL.A&columnchart=ELEC.PRICE.US-ALL.A&map=ELEC.PRICE.US-ALL.A&freq=A&ctype=linechart&itype=pin&rtype=s&mptype=0&rse=0&pin=\[https://energy.hawaii.gov/wp-content/uploads/2020/11/HSEO_FactsAndFigures-2020.pdf\]\(https://energy.hawaii.gov/wp-content/uploads/2020/11/HSEO_FactsAndFigures-2020.pdf\)](https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g000000000008&endsec=vg&linechart=ELEC.PRICE.US-ALL.A&columnchart=ELEC.PRICE.US-ALL.A&map=ELEC.PRICE.US-ALL.A&freq=A&ctype=linechart&itype=pin&rtype=s&mptype=0&rse=0&pin=https://energy.hawaii.gov/wp-content/uploads/2020/11/HSEO_FactsAndFigures-2020.pdf)
- ²⁶ https://energy.hawaii.gov/wp-content/uploads/2020/11/HSEO_FactsAndFigures-2020.pdf
- ²⁷ “Field Guide for Energy Performance, Comfort, and Value in Hawai‘i Homes”. State of Hawai‘i, Department of Business, Economic Development and Tourism, Energy, Resources and Technology Division, 2001.
- ²⁸ <https://hnlidoc.ehawaii.gov/hnlidoc/document-download?id=8821>
- ²⁹ <https://www.resilientoahu.org/what-we-do>
- ³⁰ Greenlining Institute. “Making Equity Real in Climate Adaptation and Community Resilience Policies and Programs: A Guidebook”. Greenlining Institute, 2019, <https://greenlining.org/publications/2019/making-equity-real-in-climate-adaption-and-community-resilience-policiesand-programs-a-guidebook>.
- ³¹ “Climate Change and Social Equity Guidance Document”. Climate Change Commission, City and County of Honolulu, Dec. 2020, static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/5feb95d232da5052ae2fb8da/1609274837864/Climate_Change_Social_Equity_Guidance_Document_FINAL.pdf.
- ³² Hudson, S. W. “Insights in Public Health: Climate Change: A Public Health Challenge and Opportunity for Hawai‘i”. Hawai‘i Journal of Medicine & Public Health: a Journal of Asia Pacific Medicine & Public Health, Aug. 2016, 75(8), 245-50, <http://search.proquest.com/docview/1814670706/>.
- ³³ “O‘ahu Community Heat Map”. City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, 2019. Retrieved from <http://bit.ly/oahuheatmap>.
- ³⁴ O‘ahu Community Heat Map by the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency **(Error! Hyperlink reference not valid.**
- ³⁵ “Field Guide for Energy Performance, Comfort, and Value in Hawai‘i Homes”. State of Hawai‘i, Department of Business, Economic Development and Tourism, Energy, Resources and Technology Division, 2001.

-
- 36 <https://codes.iccsafe.org/content/IECC2018P4/effective-use-of-the-international-energy-conservation-code>
- 37 <https://ags.hawaii.gov/wp-content/uploads/2019/08/SBCC2018CodeCycleCriticalDates.pdf>
- 38 https://www.architectmagazine.com/practice/what-architects-need-to-know-about-iecc-2021_o and https://newbuildings.org/code_policy/2021-iecc-base-codes/
- 39 <https://www.energycodes.gov/status/residential>
- 40 <https://newbuildings.org/news/new-stretch-code-helps-cities-states/>
- 41 <https://newbuildings.org/news/new-stretch-code-helps-cities-states/>
- 42 <https://architecture2030.org/zero-net-carbon-a-new-definition/>
- 43 <https://zero-code.org/>
- 44 https://zero-code.org/wp-content/uploads/2021/05/RM_What-Is-Zero-Code_Final.pdf
- 45 https://zero-code.org/wp-content/uploads/2021/05/RM_What-Is-Zero-Code_Final.pdf
- 46 <https://zero-code.org/new-model-building-code-empowers-local-jurisdictions-to-require-zero-net-carbon-operations/>
- 47 https://newbuildings.org/wp-content/uploads/2020/05/2021_IECC_ZEAppendix_202006.pdf
- 48 <https://zero-code.org/>
- 49 <https://newbuildings.org/resource/building-decarbonization-code/>
- 50 Maine Energy code <https://www.maine.gov/dps/fmo/sites/maine.gov.dps.fmo/files/inline-files/Chapter6.pdf>
- 51 <https://www.oneclimatefuture.org/initiatives/stretch-code/>
- 52 <https://localenergycodes.com/content/map>
- 53 https://energy.hawaii.gov/wp-content/uploads/2021/05/Checklist_2018_IECC_Residential_2021-05-11.pdf
- 54 https://energy.hawaii.gov/wp-content/uploads/2020/06/2015-IECC-Honolulu-Amendments-Webinar_6.19.20.pdf
- 55 “Codes For Climate”. Codes for Climate, <https://www.codesforclimate.org/>. Accessed 5/18/22.
- 56 <https://ags.hawaii.gov/bcc/>
- 57 FEMA Building Resilient Infrastructure and Communities (BRIC) <https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities> accessed 5/18/22.
- 58 FEMA Community lifelines <https://www.fema.gov/emergency-managers/practitioners/lifelines>. Accessed 5/18/22.
- 59 Chikasuye, K. A. Disaster Assistance Mitigation Planner, Hawai'i Emergency Management Agency, personal communication via email, 12/28/21.
- 60 Verisk, Building Code Effectiveness Grading Schedule (BCEGS) <https://www.isomitigation.com/bcegs/>. Accessed 5/18/22.
- 61 Architecture2030. “Existing Buildings”. <https://architecture2030.org/why-the-building-sector/>. Accessed 2/9/22.
- 62 Pales, A. F., S. Bouckaert, T. Abergel, and T. Goodson. “Net-zero by 2050 Hinges on a Global Push to Increase Energy Efficiency”. International Energy Agency, 2021, <https://www.iea.org/articles/net-zero-by-2050-hinges-on-a-global-push-to-increase-energy-efficiency>.
- 63 <https://www.energy.gov/eere/slsc/building-energy-use-benchmarking>
- 64 “U.S. Department of Energy Benchmarking & Transparency Policy and Program Impact Evaluation Handbook”. 2015, <https://www.energy.gov/sites/prod/files/2015/05/f22/DOE%20Benchmarking%20and%20Transparency%20Policy%20and%20Program%20Impact%20Evaluation%20H....pdf>.
- 65 Meng, T., D. Hsu, and A. Han. “Estimating Energy Savings from Benchmarking Policies in New York City”. Energy, 2017, 133, 415-423, <https://doi.org/10.1016/j.energy.2017.05.148>.
- 66 ACEEE Energy Equity for Renters Policy Tracker <https://www.aceee.org/energy-equity-renters-policy-map>. Accessed 5/23/22.
- 67 Susman, R., H. Bastian, S. Conrad, E. Cooper, E. Tong, A. Sherpa, and S. Pourfalamatoun. Energy labels affect behavior on rental listing websites: a controlled experiment. May 2022 ACEEE Report <https://www.aceee.org/sites/default/files/pdfs/b2204.pdf>. Accessed 5/23/22.
- 68 ACEEE Webinar May 18, 2022. Empowering Renters Through Energy Efficiency Labels in Rental Listings. Video <https://www.youtube.com/watch?v=2ZywgB4Eqo> ACEEE research 02:00, RentLab 18:06, Minneapolis 32:35. Accessed 5/23/22.
- 69 RentLab <https://www.rentlab.org/>. Accessed 5/23/22.
- 70 ACEEE Webinar May 18, 2022. “Empowering Renters Through Energy Efficiency Labels in Rental Listings”. Video <https://www.youtube.com/watch?v=2ZywgB4Eqo> ACEEE research 02:00, RentLab 18:06, Minneapolis 32:35. Accessed 5/23/22.
- 71 Honolulu CAP <https://static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/6080c33e91bbf23a20b74159/1619051381131/2020-2025+Climate+Action+Plan.pdf>.
- 72 City and County of Honolulu, Ordinance 20-47. <https://hnlidoc.hawaii.gov/hnlidoc/document-download?id=9213>.

-
- ⁷³ U.S. Department of Energy Better Buildings Program. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Benchmarking_Transparency_Resource_PDF_Final_2.14.pdf.
- ⁷⁴ City and County of Honolulu BILL022(22) Relating to Building Benchmarking, <https://hnlidoc.hawaii.gov/hnlidoc/measure/2121>. Accessed 5/17/22.
- ⁷⁵ Honolulu City Council Bill 022(22), CD1 Ordinance 22-17. "Relating to Building Benchmarking." <https://hnlidoc.hawaii.gov/hnlidoc/measure/2121>
- ⁷⁶ Honolulu Benchmarking & Transparency FAQ <https://static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/62046c1e859dc337c1e15f85/1644456991614/Benchmarking+FAQ.pdf>. Accessed 4/22/22.
- ⁷⁷ NYC LL84 https://www1.nyc.gov/assets/buildings/local_laws/ll84of2009.pdf. Accessed 4/22/22.
- ⁷⁸ NYC LL133 https://www1.nyc.gov/assets/buildings/local_laws/ll133of2016.pdf. Accessed 4/22/22.
- ⁷⁹ USEPA Energy Star Portfolio Manager. <https://www.energystar.gov/buildings/benchmark>.
- ⁸⁰ New York City Benchmarking Help Center. https://www1.nyc.gov/html/gbee/html/plan/ll84_help_center.shtml.
- ⁸¹ New York City Benchmarking. <https://www1.nyc.gov/site/buildings/codes/benchmarking.page>.
- ⁸² NYC Energy & Water Performance Map <https://energy.cusp.nyu.edu/#/>. Accessed 4/22/22.
- ⁸³ Seattle Municipal Code 22.920 Energy Use Benchmarking https://library.municode.com/wa/seattle/codes/municipal_code?searchRequest=%7B%22searchText%22:%22Chapter%2022.920%22,%22pageNum%22:1,%22resultsPerPage%22:25,%22booleanSearch%22:false,%22stemming%22:true,%22fuzzy%22:false,%22synonym%22:false,%22contentType%22:%5B%22CODES%22%5D,%22productIds%22:%5B%5D%7D&nodeId=TIT22BUCOCO_SUBTITLE_XMIRURE_CH22.920ENUSBE. Accessed 4/22/22.
- ⁸⁴ Seattle Energy Benchmarking Map http://www.seattle.gov/energybenchmarkingmap/#seattle/2020?layer=total_ghg_emissions&sort=total_ghg_emissions&order=desc&lat=47.61&lng=-122.33&zoom=14. Accessed 4/22/22.
- ⁸⁵ Minneapolis Renter Energy Disclosure <https://www2.minneapolismn.gov/government/programs-initiatives/environmental-programs/energy/disclosure/>. Accessed 5/23/22.
- ⁸⁶ Minneapolis Code of Ordinances 47.190. Commercial and Multifamily Residential Building Rating and Disclosure. https://library.municode.com/mn/minneapolis/codes/code_of_ordinances?nodeId=COOR_TIT3AIP0ENPR_CH47ENAIP0_47.190COMUREBURADI. Accessed 5/23/22.
- ⁸⁷ Minneapolis Truth in Sale of Housing <https://www.minneapolismn.gov/resident-services/property-housing/buying-selling/tish/>. Accessed 5/23/22.
- ⁸⁸ ACEEE Webinar May 18, 2022. "Empowering Renters Through Energy Efficiency Labels in Rental Listings". Video <https://www.youtube.com/watch?v=2ZywqgB4Ego> ACEEE research 02:00, RentLab 18:06, Minneapolis 32:35. Accessed 5/23/22.
- ⁸⁹ Gahagan, R. "IMT Implementing Energy Audit and Tune-Up Policies". 2021, <https://www.imt.org/resources/implementing-energy-audit-and-tune-up-policies/>. Accessed 3/15/22.
- ⁹⁰ Mills, E. "Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse-Gas Emissions". 2009, <https://cx.lbl.gov/2009-assessment.html>.
- ⁹¹ "LL87: Energy Audits & Retro-commissioning". New York City, <https://www1.nyc.gov/html/gbee/html/plan/ll87.shtml>. Accessed 2/9/22.
- ⁹² "Energy Efficiency Report". New York, https://www1.nyc.gov/html/gbee/html/plan/ll87_eer.shtml. Accessed 2/9/22.
- ⁹³ "Environment Code Chapter 20: Existing Buildings Energy Performance". San Francisco, https://codelibrary.amlegal.com/codes/san_francisco/latest/sf_environment/0-0-0-1758 accessed 2/9/22.
- ⁹⁴ "Confirmation of Energy Audit Guidelines". SF Environment, https://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_cea_guidelines.pdf.
- ⁹⁵ "Residential Energy Conservation Ordinance". SF Environment, <https://sfenvironment.org/residential-energy-conservation-ordinance>. Accessed 2/10/22.
- ⁹⁶ "The City of Los Angeles Existing Buildings Energy and Water Efficiency Ordinance". L.A. Energy and Water Efficiency, https://www.betterbuildingsla.com/images/content/EBEWE_Ordinance_Brochure.pdf. Accessed 2/9/22.
- ⁹⁷ "Who is Covered". L.A. Energy and Water Efficiency, <https://www.betterbuildingsla.com/whos-covered>. Accessed 2/10/22.
- ⁹⁸ Austin Energy Conservation Code <https://austinenergy.com/wcm/connect/c8814cf7-e1a4-4d6f-8257-88445444f40c/ECADChap6-7EnergyConservation.pdf?MOD=AJPERES&CVID=mNOa26F>. Accessed 4/22/22.
- ⁹⁹ National Building Performance Coalition <https://nationalbpscoalition.org/>
- ¹⁰⁰ National Building Performance Coalition **Error! Hyperlink reference not valid.**
- ¹⁰¹ https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf

-
- ¹⁰² https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf
- ¹⁰³ IMT, Map: Building Performance Standards updated April 2022 <https://www.imt.org/resources/map-building-performance-standards/>. Accessed 4/18/22.
- ¹⁰⁴ https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf
- ¹⁰⁵ National Building Performance Coalition <https://nationalbpscoalition.org/>. Accessed 5/23/22.
- ¹⁰⁶ White House Fact Sheet: Biden-Harris Administration Launches Coalition of States and Local Governments to Strengthen Building Performance Standards, Jan 21, 2022, <https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/21/fact-sheet-biden-harris-administration-launches-coalition-of-states-and-local-governments-to-strengthen-building-performance-standards/>. Accessed 4/18/22.
- ¹⁰⁷ Nadel, S. and A. Hinge. “2020 Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals”. ACEEE white paper https://www.aceee.org/sites/default/files/pdfs/buildings_standards_6.22.2020_0.pdf, Table 2, p. 24. Accessed 4/12/22.
- ¹⁰⁸ NYC LL84 NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/ll97of2019.pdf. Accessed 4/12/22.
- ¹⁰⁹ NYC LL84 https://www1.nyc.gov/assets/buildings/local_laws/ll84of2009.pdf. Accessed 4/12/22.
- ¹¹⁰ Washington DC Law 17-250 <https://code.dccouncil.us/us/dc/council/laws/docs/17-250.pdf>. Accessed 4/18/22.
- ¹¹¹ Washington DC Law 22-257 <https://code.dccouncil.us/us/dc/council/laws/22-257>. Accessed 4/12/22.
- ¹¹² Washington State SB 5854 <https://apps.leg.wa.gov/documents/billdocs/2009-10/Pdf/Bills/Senate%20Passed%20Legislature/5854-S2.PL.pdf>. Accessed 4/12/22.
- ¹¹³ Washington State HB1257 <http://www.commerce.wa.gov/wp-content/uploads/2019/06/HB1257.pdf>. Accessed 4/12/22.
- ¹¹⁴ St. Louis Ordinance 70474 <https://www.stlouis-mo.gov/government/city-laws/upload/legislative//Ordinances/BOAPdf/BB205CSAA-wd7--Ord.%2070474.pdf>. Accessed 4/12/22.
- ¹¹⁵ St. Louis Ordinance 71132 <https://www.stlouis-mo.gov/government/city-laws/upload/legislative//Ordinances/BOAPdf/71132%20Combined.pdf>. Accessed 4/12/22.
- ¹¹⁶ Denver 2016 Energy Benchmarking Ordinance <https://betterbuildingssolutioncenter.energy.gov/implementation-models/denvers-energy-benchmarking-ordinance#:~:text=Denver%27s%20Energy%20Benchmarking%20Ordinance%20requires.resources%20to%20improve%20energy%20efficiency>. Accessed 4/12/22.
- ¹¹⁷ Denver 2021 Ordinance 202113310 https://www.denvergov.org/files/assets/public/climate-action/documents/energize-denver-hub/21-1310_recorded_bill_energize_denver.pdf, p. 15–17. Accessed 4/11/22.
- ¹¹⁸ Urban Sustainability Directors Network, July 2021, Building Performance Standards: A Framework for Equitable Policies to Address Existing Buildings https://www.usdn.org/uploads/cms/documents/bps-framework_july-2021_final.pdf. Accessed 3/8/22.
- ¹¹⁹ Honolulu Climate Action Plan <https://static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/6080c33e91bbf23a20b74159/1619051381131/2020-2025+Climate+Action+Plan.pdf>
- ¹²⁰ USEPA Building Performance Standards: Overview for State and Local Decision Makers https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf Accessed 6/24/22.
- ¹²¹ ACEEE. “The 2021 City Clean Energy Scorecard”. <https://www.aceee.org/sites/default/files/pdfs/u2107.pdf>, p. 55–58. Accessed 4/12/22.
- ¹²² Denver July 2018, 80 x 50 Climate Action Plan, https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/80x50/DDPHE_80x50_ClimateActionPlan.pdf. Accessed 4/18/22.
- ¹²³ Denver 2021, Ordinance 20211310, https://www.denvergov.org/files/assets/public/climate-action/documents/energize-denver-hub/21-1310_recorded_bill_energize_denver.pdf pages 15-16. Accessed 4/12/22.
- ¹²⁴ Denver, Jan 2021, Denver’s Net Zero Energy (NZE) New Buildings & Homes Implementation Plan, https://denvergov.org/files/assets/public/climate-action/documents/denver-nze-implementation-plan_final_v1.pdf, p. 19. Accessed 4/18/22.
- ¹²⁵ Hart, A. “Institute for Market Transformation, Denver’s Building Performance Standard and the Trajectory Approach”. Nov 23, 2021, <https://www.imt.org/denver-passes-building-performance-standard/>. Accessed 4/18/22.
- ¹²⁶ NYC’s Roadmap to 80 x 50, https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%2050_Final.pdf
- ¹²⁷ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/ll97of2019.pdf. Accessed 4/6/22.
- ¹²⁸ NYC Use and Occupancy Classification https://up.codes/viewer/new_york_city/nyc-building-code-2014/chapter/3/use-and-occupancy-classification#3. Accessed 4/18/22

-
- ¹²⁹ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/l197of2019.pdf. Accessed 4/6/22.
- ¹³⁰ Denver, Energize Denver Hub <https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directories/Climate-Action-Sustainability-Resiliency/High-Performance-Buildings-Homes/Energize-Denver-Hub>. Accessed 3/30/22.
- ¹³¹ Washington DC, Building Innovation Hub, BEPS Standards and Compliance Rules Finalized <https://buildinginnovationhub.org/news/special-update-beps-rules-released/#:~:text=The%20maximum%20penalties%20are%20set,relative%20to%20its%20pathway%20target>
- ¹³² Washington DC, Building Innovation Hub, BEPS Standards and Compliance Rules Finalized. Alternative compliance pathways. <https://buildinginnovationhub.org/news/special-update-beps-rules-released/#:~:text=The%20maximum%20penalties%20are%20set,relative%20to%20its%20pathway%20target>.
- ¹³³ St. Louis Building Energy Performance Standard (BEPS) Ordinance 71131. <https://www.stlouis-mo.gov/government/city-laws/ordinances/ordinance.cfm?ord=71132>. Accessed 3/30/22.
- ¹³⁴ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/l197of2019.pdf. Accessed 4/6/22.
- ¹³⁵ Washington DC, D.C. Law 22-257. CleanEnergy DC Omnibus Amendment Act of 2018, <https://code.dccouncil.us/us/dc/council/laws/22-257>. Accessed 3/31/22.
- ¹³⁶ St. Louis BPS ordinance <https://www.stlouis-mo.gov/government/city-laws/ordinances/ordinance.cfm?ord=71132>.
- ¹³⁷ WA State BPS website <https://www.commerce.wa.gov/growing-the-economy/energy/buildings/clean-buildings-standards/>.
- ¹³⁸ American Cities Challenge Appendix A https://www.usdn.org/uploads/cms/documents/bps-framework_july-2021_final.pdf.
- ¹³⁹ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/l197of2019.pdf.
- ¹⁴⁰ WA State legislation <http://www.commerce.wa.gov/wp-content/uploads/2019/06/HB1257.pdf>.
- ¹⁴¹ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/l197of2019.pdf.
- ¹⁴² DC Law 22-257 <https://code.dccouncil.us/us/dc/council/laws/22-257>.
- ¹⁴³ https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf
- ¹⁴⁴ NYC LL97 https://www1.nyc.gov/assets/buildings/local_laws/l197of2019.pdf.
- ¹⁴⁵ WA state legislation <http://www.commerce.wa.gov/wp-content/uploads/2019/06/HB1257.pdf>.
- ¹⁴⁶ U.S. EPA Building Performance Standards Policy Toolkit https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf. Accessed 3/31/22.
- ¹⁴⁷ Institute for Market Transformation, “Why Traditional Leases Don’t Measure Up and What We Need Instead”, <https://www.imt.org/why-traditional-leases-dont-measure-up-and-what-we-need-instead/>. Accessed 3/31/22.
- ¹⁴⁸ ACEEE Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals https://www.aceee.org/sites/default/files/pdfs/buildings_standards_6.22.2020_0.pdf.
- ¹⁴⁹ DC Sustainable Energy Utility, Affordable Housing Retrofit Accelerator <https://www.dcseu.com/retrofitaccelerator>. Accessed 3/31/22.
- ¹⁵⁰ EO <https://www.federalregister.gov/presidential-documents/executive-orders>.
- ¹⁵¹ National BPS <https://nationalbpscoalition.org/#about>.
- ¹⁵² DC law <https://code.dccouncil.us/us/dc/council/laws/22-257>.
- ¹⁵³ National BPS Coalition <https://nationalbpscoalition.org/>.
- ¹⁵⁴ IMT Model Ordinance for a Building Performance Standard <https://www.imt.org/resources/model-ordinance-for-building-performance-standards/>. Accessed 5/23/22.
- ¹⁵⁵ https://www.epa.gov/sites/default/files/2021-02/documents/benchmarking_building_performance_standards_section2.pdf
- ¹⁵⁶ “Weatherization Assistance Program”. Honolulu Community Action Program, <https://www.hcapweb.org/weatherization-assistance-program/>. Accessed 5/19/22.
- ¹⁵⁷ <https://hawaiienergy.com/about/82-about>
- ¹⁵⁸ “Hawai’i Energy”. Hawai’i Energy, <https://www.hawaiienergy.com/>.
- ¹⁵⁹ “Audits and Retro-Commissioning”. Hawai’i Energy, <https://hawaiienergy.com/for-business/rebates/audits-retro-commissioning>.
- ¹⁶⁰ “California Advanced Homes”. Pacific Gas and Electric Company, <https://cahp-pge.com>.
- ¹⁶¹ “DC Green Bank”. DC Green Bank, <https://dcgreenbank.com>.
- ¹⁶² “Affordable Housing Retrofit Accelerator”. DC Sustainable Energy Utility, <https://www.dcseu.com/RetrofitAccelerator>.
- ¹⁶³ “Affordable Housing Retrofit Accelerator”. DC Sustainable Energy Utility, <https://www.dcseu.com/RetrofitAccelerator>.
- ¹⁶⁴ “Assisted Home Performance with Energy Star FAQs”. New York State Energy Research and Development Authority, <https://www.nyserda.ny.gov/All-Programs/Assisted-Home-Performance-with-ENERGY-STAR/FAQs#assisted-home-performance>.
- ¹⁶⁵ <https://www.nyserda.ny.gov/About/Funding>
- ¹⁶⁶ “NYC Accelerator”. NYC Mayor’s Office of Climate and Environmental Justice, <https://accelerator.nyc>. Accessed 6/18/22.

-
- 167 "Bill 22 (2022) Related To Building Benchmarking", Honolulu City Council, <https://hnlodoc.ehawaii.gov/hnlodoc/document-download?id=13412>, Accessed 7/7/2022.
- 168 "EnergyPlus". EnergyPlus, <https://energyplus.net>. Accessed 6/18/22.
- 169 "Clean Energy Wayfinders", Hawaii State Energy Office, <https://energy.hawaii.gov/get-engaged/clean-energy-wayfinders/>, Accessed 7/15/22.
- 170 "Department of Community Services". City and County of Honolulu, <https://www.honolulu.gov/dcs/default.html>. Accessed 5/19/22.
- 171 "ESDS v4.0". Washington State Department of Commerce, <https://deptofcommerce.app.box.com/s/qn5q15au8qInp655a9vrub7w38211vgr/file/805323628342>. Accessed 5/27/22.
- 172 "HTF Handbook Version 3-4-2021". Washington State Housing Trust Fund, <https://deptofcommerce.app.box.com/s/f89ytc0qtime7dl6wpgke5h2zl1jwzlm>. Accessed 5/27/22.
- 173 "2021 Rapid Capital Housing Acquisition". Washington State Housing Trust Fund, <https://deptofcommerce.app.box.com/s/1s8r5su9i1e0whkkce18r6botooiqjk>.
- 174 "National Housing Trust Fund Program". Washington State Department of Commerce, <https://www.commerce.wa.gov/building-infrastructure/housing/national-housing-trust-fund/>. Accessed 5/27/22.
- 175 "Evergreen Sustainable Development Standard". Washington State Department of Commerce, <https://www.commerce.wa.gov/building-infrastructure/housing/housing-trust-fund/housing-trust-fund-evergreen-sustainable-development>.
- 176 "Portland Housing Bureau". Portland.gov, <https://www.portland.gov/ryan/portland-housing-bureau>.
- 177 Langdon, D. "Cost of Green Analysis for Affordable Housing in Seattle and Portland", July 2009. <https://www.seattle.gov/Documents/Departments/OSE/Cost-of-Green-AffordHousing.pdf>. Accessed 3/15/22.
- 178 "Data Window". Portland Housing Bureau, https://www.portland.gov/sites/default/files/2021/phb-data-window-2020-2021_1.pdf. Accessed 5-8-2022.
- 179 "PCEF Inaugural Fund Announcement FAQ". City of Portland, <https://www.portland.gov/bps/cleanenergy/inaugural-fund-faq>. Accessed 5/27/22.
- 180 "About PCEF". City of Portland, <https://www.portland.gov/bps/cleanenergy/about>. Accessed 5/27/22.
- 181 <https://www.hudexchange.info/programs/cdbg/>
- 182 https://www.hud.gov/program_offices/comm_planning/home
- 183 "Development, Acquisition, Construction and Fair Housing (DACFH) Branch Programs". Honolulu Department of Community Services, <https://www.honolulu.gov/cms-dcs-menu/site-dcs-sitearticles/40161-cbdd-dacfh-branch.html>. Accessed 5/27/22.
- 184 "Transit-Oriented Development". City of Honolulu, <https://www.honolulu.gov/tod/>. Accessed 5/27/22.
- 185 "State of Hawai'i Low-Income Housing Tax Credit Program 2022/2023 Qualified Allocation Plan". Hawai'i Housing Finance & Development Corporation, <http://dbedt.hawaii.gov/hhfdc/files/2021/12/2022-2023-Qualified-Allocation-Plan-12-17-21.pdf>. Accessed 6/3/2022.
- 186 "Instructions for Form N-342, Renewable Energy Technologies Income Tax Credit". State of Hawai'i, <https://files.hawaii.gov/tax/forms/2021/n342ins.pdf>.
- 187 "Claim for Exemption, Alternate Energy Improvements". Revised Ordinances of Honolulu Sec 8-10.15, <https://www.realpropertyhonolulu.com/media/1403/bfsrpp5d.pdf>.
- 188 "Energy Tax Credits". Baltimore County Government, <https://www.baltimorecountymd.gov/departments/budfin/taxpayerservices/taxcredits/energy.html>.
- 189 "Tax Abatement". City of Cleveland, Ohio, <https://www.clevelandohio.gov/CityofCleveland/Home/Government/CityAgencies/CommunityDevelopment/TaxAbatement>.
- 190 "Green Communities Criteria & Certification". Enterprise Green Communities, <https://www.greencommunitiesonline.org/>. Accessed 5/27/22.
- 191 "National Green Building Standard Certification". National Association of Home Builders, <https://www.nahb.org/advocacy/industry-issues/sustainability-and-green-building/national-green-building-standard-certification>. Accessed 5/27/22.
- 192 "LEED Rating System". U.S. Green Building Council, <https://www.usgbc.org/leed>. Accessed 5/27/22.
- 193 "GEMS Financing Program". Hawai'i Green Infrastructure Authority, <https://gems.hawaii.gov>. Accessed 5/27/22.
- 194 "Residential/Non-Residential FAQ". Hawai'i Green Infrastructure Authority, https://gems.hawaii.gov/wp-content/uploads/2019/08/Residential-Non-Residential-FAQs_rev-8-2019.pdf. Accessed 5/27/22.
- 195 "Solar Loan Application". City and County of Honolulu Department of Community Services, <https://www.honolulu.gov/cms-dcs-menu/site-dcs-sitearticles/1852-cad-solar-loan.html>.
- 196 "Rehabilitation Loan Program". City and County of Honolulu Department of Community Services, <https://www.honolulu.gov/cms-dcs-menu/site-dcs-sitearticles/1851-cad-home-repair-loan.html>. Accessed 5/29/22.

-
- ¹⁹⁷ “Clean Energy Financing for Multifamily Housing”. Washington State Housing Finance Commission, <https://www.wshfc.org/energy/SETmf.pdf>.
- ¹⁹⁸ “Early Adopter Incentive Program”. Washington State Department of Commerce, <https://www.commerce.wa.gov/growing-the-economy/energy/buildings/early-adopter-incentive-program>.
- ¹⁹⁹ “Energy Efficiency for Commercial Tenants”. New York State Energy Research and Development Authority, <https://www.nyserda.ny.gov/All-Programs/Energy-Efficiency-for-Commercial-Tenants>.
- ²⁰⁰ “Buildings of Excellence”. New York State Energy Research and Development Authority, <https://www.nyserda.ny.gov/All-Programs/Multifamily-Buildings-of-Excellence>.
- ²⁰¹ “Bill 58 (2020) Related to Clean Energy Projects”. Honolulu City Council, <https://hnlidoc.hawaii.gov/hnlidoc/document-download?id=7334>.
- ²⁰² “HRS §46-19.6”. State of Hawai‘i House Bill, https://www.capitol.hawaii.gov/hrscurrent/Vol02_Ch0046-0115/HRS0046/HRS_0046-0019_0006.htm.
- ²⁰³ “Permitting Overhaul May Mean Faster Build Times for Homeowners”. KITV [Honolulu], 4/21/22, https://www.kitv.com/news/local/permitting-overhaul-may-mean-faster-build-times-for-homeowners/article_84469aca-c1d9-11ec-8576-ab5d128d2588.html.
- ²⁰⁴ “Green Building Expedited Plan Review”. Miami-Dade County, <https://www.miamidade.gov/permits/home.asp?cat=build&subcat=plan&filter1=green>. Accessed 5/29/22.
- ²⁰⁵ “Affordable and Sustainable Development”. City of San Diego, California, https://docs.sandiego.gov/councilpolicies/cpd_600-27.pdf. Accessed 5/29/22.
- ²⁰⁶ “Bill 64 (2018) Related to Building Permits”. Honolulu City Council, [http://www4.honolulu.gov/docushare/dsweb/Get/Document-208546/DOC004%20\(6\).PDF](http://www4.honolulu.gov/docushare/dsweb/Get/Document-208546/DOC004%20(6).PDF). Accessed on 6/11/22.
- ²⁰⁷ “Bill 7 (2019) Related to Affordable Rental Housing”. Honolulu City Council, <https://hnlidoc.hawaii.gov/hnlidoc/document-download?id=2>. Accessed on 4/28/22.
- ²⁰⁸ “Private Rooftop Solar”. Hawaiian Electric, <https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/rooftop-solar>. Accessed 6/18/22.
- ²⁰⁹ “Bill 7 (2019) Related to Affordable Rental Housing”. Honolulu City Council, <https://hnlidoc.hawaii.gov/hnlidoc/document-download?id=2>, p.23. Accessed on 4/28/22.
- ²¹⁰ “Building Codes Implementation for Efficiency and Resilience”. U.S. Department of Energy, <https://www.energy.gov/bil/building-codes-implementation-efficiency-and-resilience>.
- ²¹¹ U.S. Department of Energy. “Energy Efficiency Revolving Loan Fund Capitalization Grant Program”. <https://www.energy.gov/bil/energy-efficiency-revolving-loan-fund-capitalization-grant-program>. Accessed 6/20/22.
- ²¹² U.S. Department of Energy. “Energy Efficiency and Conservation Block Grant Program”. <https://www.energy.gov/eeere/wipo/energy-efficiency-and-conservation-block-grant-program-bipartisan-infrastructure-law-2021>. Accessed 6/20/2022.
- ²¹³ “DBEDT Announces Details of Bond Issue to Support Green Energy Market Securitization Program”. Hawai‘i State Energy Office, <https://energy.hawaii.gov/dbedt-announces-details-of-bond-issue-to-support-green-energy-market-securitization-program>.
- ²¹⁴ Armstrong, A. “Berkeley to Adopt Blockchain Technology for Microbond Financing Program”. The Daily Californian [Berkeley], 12/30/21, <https://www.dailycal.org/2021/12/30/berkeley-to-adopt-blockchain-technology-for-microbond-financing-program>.
- ²¹⁵ “Berkeley City Council Moves To Enable Blockchain Microbond Financing Program”. Mayor Jesse Arreguin, n.d. City of Berkeley, <https://www.jessearreguin.com/press-releases/2021/12/23/berkeley-city-council-moves-to-enable-blockchain-microbond-financing-program>. Accessed 5/29/22.
- ²¹⁶ “Empty Homes Tax”. City of Vancouver, <https://vancouver.ca/home-property-development/empty-homes-tax.aspx>.
- ²¹⁷ “Empty Homes Tax Annual Report”. City of Vancouver, <https://vancouver.ca/files/cov/vancouver-2021-empty-homes-tax-annual-report.pdf>. Accessed 5/8/22.
- ²¹⁸ “Changing Connecticut For The Greener”. Connecticut Green Bank, <https://www.ctgreenbank.com/about-us/>. Accessed 6/18/22.
- ²¹⁹ “What Is A Green Bank?” AIA Philly COTE, <https://www.youtube.com/watch?v=TZg4Rfhzicl>. Accessed 6/18/22.
- ²²⁰ “How We Work—FAQs”. Ulupono Initiative, <https://www.ulupono.com/how-we-work/faqs/>. Accessed 6/18/22.
- ²²¹ http://dbedt.hawaii.gov/hhfdc/files/2020/02/State_HHPS2019_Report-FINAL-Dec.-2019-Rev.-02102020.pdf
- ²²² “Bill 76 (2020) Related to Real Property Taxation”. Honolulu City Council, [http://www4.honolulu.gov/docushare/dsweb/Get/Document-277489/BILL076\(20\).htm](http://www4.honolulu.gov/docushare/dsweb/Get/Document-277489/BILL076(20).htm). Accessed 6/11/22.
- ²²³ <https://energy.hawaii.gov/building-code-training>
- ²²⁴ <https://resilientoahu.org/sustainability-report>
- ²²⁵ American Society of Heating, Refrigerating and Air-Conditioning Engineers Hawaii <https://ashraehawaiichapter.info/>
- ²²⁶ American Institute of Architects Honolulu https://www.aiahonolulu.org/events/event_list.asp

-
- 227 US Green Building Council Hawaii <https://www.usgbc.org/chapters/usgbc-hawaii>
- 228 American Planning Association Hawaii Chapter <https://hawaii.planning.org/>
- 229 Building Commissioning Association Northwest Region <https://www.bcxa.org/about-us/chapters/northwest-region.html>
- 230 <https://cca.hawaii.gov/pvl/boards/engineer/architects-continuing-education-requirements/>
- 231 UH Outreach College, Engineering & Architecture, <https://www.outreach.hawaii.edu/areas-of-study/engineering-architecture/>. Accessed 4/22/22.
- 232 <https://www.aia.org/pages/6464938-the-aia-2030-commitment>
- 233 <https://aiou.aia.org/aia2030-online-series>
- 234 <https://www.aia.org/pages/6464938-the-aia-2030-commitment>
- 235 <https://www.aiaphiladelphia.org/search/content/2030%20working%20group>
- 236 <https://network.aia.org/viewdocument/evolving-design-awards-the-common?CommunityKey=3b790506-aca5-4eff-aaf6-8a7b553dc0ef&tab=librarydocuments>
- 237 <https://energy.hawaii.gov/building-code-training>
- 238 <https://zero-code.org/zero-code-webinar/>
- 239 Calendar, AIA East Bay, <https://aiaeb.org/calendar/webinar-transforming-how-we-build-zero-code-for-california/>. Hosted by AIA Central Valley, https://aiacv.org/wp-content/uploads/2020/01/Transforming-How-We-Build_FINAL.pdf.
- 240 NYC Benchmarking Help Center https://www1.nyc.gov/html/gbee/html/plan/l184_help_center.shtml.
- 241 Hawaii Energy Clean Energy Allies <https://hawaiienergy.com/clean-energy-allies>
- 242 Home Energy Rating System (HERS) Index <https://www.hersindex.com/hers-index/what-is-the-hers-index/>
- 243 Home Energy Professional (HEP) Energy Auditor <https://www.bpi.org/certified-professionals/energy-auditor>
- 244 https://www1.nyc.gov/html/gbee/html/plan/l187_help.shtml and <https://www1.nyc.gov/site/nycaccelerator/index.page>
- 245 https://www1.nyc.gov/html/gbee/html/plan/l187_help.shtml and <https://www1.nyc.gov/site/nycaccelerator/index.page>
- 246 https://www1.nyc.gov/assets/nycaccelerator/downloads/pdf/NYCA_Program_Handout.pdf
- 247 <https://www.usdn.org/projects/building-performance-standards.html>
- 248 <https://www.bloomberg.org/environment/supporting-sustainable-cities/american-cities-climate-challenge/>
- 249 <https://static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/6080c33e91bbf23a20b74159/1619051381131/2020-2025+Climate+Action+Plan.pdf>
- 250 <https://energy.hawaii.gov/hcei>
- 251 “Act 155 Relating to Energy Resources”. State of Hawai‘i, 2009, https://www.capitol.hawaii.gov/slh/Years/SLH2009/SLH2009_Act155.pdf.
- 252 <https://elementalexcelerator.com/transcending-oil/>
- 253 NYC’s Roadmap to 80x50 https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City%27s%20Roadmap%20to%2080%20x%2050_Final.pdf.
- 254 Meguro, W., and E. J. Glassman. “Evaluating Energy Targets and Efficiency Measures in Multifamily Subtropical Buildings through Automated Simulation”. *Technology|Architecture + Design*, 2021, 5(1), 82–95. doi: 10.1080/24751448.2021.1863676.
- 255 “The 21st Imperative”, Living Building Challenge, <http://www.livingbuildingchallengehawaii.com/projects>, Accessed 7/17/2022.
- 256 “Can Timber Construction Be a Significant Carbon Sink?”, *Architect Magazine*, https://www.architectmagazine.com/technology/can-timber-construction-be-a-significant-carbon-sink_o, Accessed 7/17/2022.
- 257 “Article 12. Indigenous Hawaiian Architecture”. Revised Ordinances of Honolulu, n.d., Vol. 16-12.9(b)2, <https://www.honolulu.gov/rep/site/ocs/roh/ROHChapter16a12.pdf>. Accessed 5/29/22.
- 258 Pearson, C., and N. Malin. “Net-Zero Energy Isn’t the Real Goal: 8 Reasons Why”. *BuildingGreen*, May 18, 2021, <https://www-buildinggreen-com.eres.library.manoa.hawaii.edu/feature/net-zero-energy-isn-t-real-goal-8-reasons-why>. Accessed 5/23/22.
- 259 “The GridOptimal Buildings Initiative”. New Buildings Institute, October 2021, <https://newbuildings.org/resource/gridoptimal/>. Accessed 5/23/22.
- 260 Holland, C., and J. Homer. “Pilot Considerations for Grid-Interactive Efficient Buildings in Hawai‘i”. Pacific Northwest National Laboratory Report PNNL-32353, <https://connectedcommunities.lbl.gov/resources/general-information/grid-interactive-efficient-buildings-gebs/pilot-considerations-grid-0>. Accessed 5/23/22.
- 261 AEG Group for the Hawaii Public Utilities Commission. “State of Hawaii Market Potential Study” Excel Appendix. July 27, 2020. <https://puc.hawaii.gov/wp-content/uploads/2021/02/Hawaii-2020-Market-Potential-Study-Final-Report.pdf>
- 262 AEG Group for the Hawaii Public Utilities Commission. “State of Hawaii Market Potential Study” Excel Appendix. July 27, 2020. <https://puc.hawaii.gov/wp-content/uploads/2021/02/Hawaii-2020-Market-Potential-Study-Final-Report.pdf>
- 263 SMS for the Hawaii Housing Finance and Development Corporation, DBEDT. “Hawaii Housing Planning Study.” 2019. https://dbedt.hawaii.gov/hhfdc/files/2020/02/State_HHPS2019_Report-FINAL-Dec.-2019-Rev.-02072020-FINAL.pdf

- 264 US DOE Kaupuni <https://www.energy.gov/sites/default/files/2014/05/f15/53401.pdf>
- 265 <https://www.resilientoahu.org/climate-action-plan>
- 266 https://content.aia.org/sites/default/files/2020-12/2020_Code_of_Ethics.pdf
- 267 “Ala Wai Canal Flood Risk Management Study, Oahu, Hawai‘i, Final Feasibility Study Report with Integrated Environmental Impact Statement, Appendix A—Hydrology and Hydraulic Engineering”. U.S. Army Corps of Engineers, Honolulu District, <https://www.poh.usace.army.mil/Portals/10/docs/projectreviewplans/Appendix%20A%20-%20H-H.pdf?ver=2017-05-24-120452-233>. Accessed 6/10/22.
- 268 <https://www.weathershift.com/>
- 269 “Flexible Adaptation Pathways—An Approach to Coastal Flooding and Extreme Heat”. ARUP (for the Hawai‘i State Climate Change Commission), October 28, 2020, <https://climate.hawaii.gov/wp-content/uploads/2020/10/Item-4b-Adaptation-Planning-Arup-1.pdf>. Accessed 6/11/22.
- 270 “Creation of a Citywide Climate Adaptation Plan”. The New York City Council, Int 1620-2019, <https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3996243&GUID=8BA20DCE-2975-4E72-A812-0320EE34B96C>. Accessed 6/20/22.
- 271 “Boston Climate Action”, City of Boston, <https://www.boston.gov/departments/environment/boston-climate-action>, Accessed 6/25/22.
- 272 “2022 Climate Action Plan”, City of Chicago, <https://www.chicago.gov/city/en/sites/climate-action-plan/home.html>, Accessed 6/25/22.
- 273 Maxwell, K., S. Julius, A. Grambsch, A. Kosmal, L. Larson, and N. Sonti. “Built Environment, Urban Systems, and Cities”. In “Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment”, Volume II, Reidmiller, D.R., et al. (eds.), U.S. Global Change Research Program, Washington, DC, USA, 2018, pp. 438–478. doi: 10.7930/NCA4.2018.CH11.
- 274 Melton, P. “The Future of Designing with Future Weather Data”. December 21, 2021. Retrieved from <https://www-buildinggreen-com.eres.library.manoa.hawaii.edu/news-analysis/future-designing-future-weather-data>.
- 275 Melton, P. (2021, December 21). “The Future of Designing with Future Weather Data”. December 21, 2021. Retrieved from <https://www-buildinggreen-com.eres.library.manoa.hawaii.edu/news-analysis/future-designing-future-weather-data>.
- 276 <https://www.seattle.gov/sdci/permits/green-building/living-building-pilot>
- 277 “Land Use Ordinance, Section Sec. 21-2.140-1 (b)”. City of Honolulu, https://www.honolulu.gov/rep/site/ocs/roh/Chapter_21_Art_1-3.pdf, p.22. Accessed 5/27/22.
- 278 “Proposing an Amendment to Chapter 21, Revised Ordinances of Honolulu 1990 (The Land Use Ordinance), Relating to Height Limits for Rooftop Structures”. Honolulu City Council, <https://hnlodoc.ehawaii.gov/hnlodoc/document-download?id=11048>. Accessed 6/3/22.
- 279 “TOD Zoning”, City and County of Honolulu, <https://www.honolulu.gov/tod/zoning-policies/zoning-special-district/tod-zoning.html>, Accessed 7/18/2022.
- 280 “Relating to the Adoption of the State Energy Conservation Code”. City and County of Honolulu. Bill 25, 2019, https://energy.hawaii.gov/wp-content/uploads/2020/07/HonoluluCounty_EnergyCode.pdf. Accessed 6/20/22.
- 281 ACEEE State and Local Policy Database <https://database.aceee.org/city/energy-code-compliance>. Accessed 6/7/22.
- 282 Lobao, A., Building Official, City of Santa Clara, CA, personal communication via email 6/14/22.
- 283 “Field Guide for Energy Performance, Comfort, and Value in Hawai‘i Homes”. State of Hawai‘i, Department of Business, Economic Development & Tourism, Energy, Resources & Technology Division, 2001.
- 284 Lechner, N. M. “Heating, Cooling, Lighting: Sustainable Design Methods for Architects”. John Wiley, 2020.
- 285 <https://www.epa.gov/smm/sustainable-materials-management-basics>
- 286 “Sustainable Management of Construction and Demolition Materials”. Environmental Protection Agency, 26 May 2020, <https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials#WYCD>.
- 287 Ibid.
- 288 Gagg, C. R. “Cement and Concrete as an Engineering Material: An Historic Appraisal and Case Study Analysis”. Engineering Failure Analysis, 2014, 40, 114–140, <https://doi.org/10.1016/j.engfailanal.2014.02.004>.
- 289 “HDOT Tests Sustainable Concrete Mix Designed to Reduce Carbon Footprint of Road Construction”. 16 May 2019, hidot.hawaii.gov/blog/2019/05/16/hdot-tests-sustainable-concrete-mix-designed-to-reduce-carbon-footprint-of-road-construction/.
- 290 Matayoshi, K. P. “Greening the Concrete Jungle”. Hawaii Business Magazine, 11 Sept. 2019, www.hawaiibusiness.com/greening-the-concrete-jungle/.
- 291 <https://www.greenbiz.com/article/how-ny-could-become-model-green-concrete-policy>
- 292 <https://hidot.hawaii.gov/highways/s2005-standard-specifications/special-provisions-for-2005-standard-specifications/dot-federal-projects-special-provisions-for-2005-standard-specifications/>
- 293 “HDOT Tests Sustainable Concrete Mix Designed to Reduce Carbon Footprint of Road Construction”. 16 May 2019, hidot.hawaii.gov/blog/2019/05/16/hdot-tests-sustainable-concrete-mix-designed-to-reduce-carbon-footprint-of-road-construction/.

-
- ²⁹⁴ Matayoshi, K. P. "Greening the Concrete Jungle". Hawaii Business Magazine, 11 Sept. 2019, www.hawaiibusiness.com/greening-the-concrete-jungle/.
- ²⁹⁵ "The Technology". CarbonCure Technologies Inc., <https://www.carboncure.com/technology/>.
- ²⁹⁶ "Hawai'i Clean Energy Leaders and Renewable Energy Projects". Hawai'i Renewable Energy Projects, energy.ehawaii.gov/epd/public/energy-projects-map.html.
- ²⁹⁷ "Ola: O'ahu Resilience Strategy". Resilience Office, City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, 2019, static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/5f10eaf7cb44284ef9c93e4d/1594944287505/Ola_Oahu_Resilience_Strategy.pdf.
- ²⁹⁸ "Ola: O'ahu Resilience Strategy". Resilience Office, City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, 2019, static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/5f10eaf7cb44284ef9c93e4d/1594944287505/Ola_Oahu_Resilience_Strategy.pdf.
- ²⁹⁹ "Ola: O'ahu Resilience Strategy". Resilience Office, City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, 2019, static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/5f10eaf7cb44284ef9c93e4d/1594944287505/Ola_Oahu_Resilience_Strategy.pdf.
- ³⁰⁰ Littman, J. A. "Regenerative Architecture: A Pathway Beyond Sustainability". Masters Theses 1911, February 2014, 303, 2009, <https://scholarworks.umass.edu/theses/303>.
- ³⁰¹ Ibid.
- ³⁰² "Home Water Use In The United States", The National Environmental Education Foundation, <https://www.neefusa.org/weather-and-climate/weather/home-water-use-united-states#Hawaii>, Accessed 7/17/2022.
- ³⁰³ "Hawai'i's Water Cycle". Honolulu Board of Water Supply, www.boardofwatersupply.com/water-resources/the-water-cycle.
- ³⁰⁴ "Drinking Water Emergency at Joint Base Pearl Harbor-Hickam, Honolulu, Hawaii (November 2021-March 2022)", U.S. Environmental Protection Agency, <https://www.epa.gov/red-hill/drinking-water-emergency-joint-base-pearl-harbor-hickam-honolulu-hawaii-november-2021>, Accessed 7/17/2022.
- ³⁰⁵ Richards, S. "Texas Swimming Holes Need One Water". Texas Living Waters Project, The Cynthia and George Mitchell Foundation, 28 Mar. 2018, texaslivingwaters.org/one-water-blog/.