nbi new buildings institute

Culture Over Carbon

Understanding the Impact of Museums' Energy Use

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Field Museum. Chicago, IL | Photo Credit: Chris Nguyen on Unsplash

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Acronyms and Definitions

BAS	Building Automation System
BMS	Building Management System
CO_2e	Carbon dioxide equivalent
COP	Coefficient of Performance
DOE	Department of Energy
ESPC	Energy Savings Performance Contract
EUI	Energy Use Intensity
F	Fahrenheit
GHG	Greenhouse Gas (Emissions)
GWP	Global Warming Potential
HVAC	Heating Ventilation Air Conditioning
ICC	International Code Council
RH	Relative Humidity
sf	Square Feet
T	Temperature
24/7	24 Hours a Day/Seven Days a Week

Benchmarking: The practice of comparing measured energy performance (of a building or facility) to itself, similar buildings, or established norms (such as a simulated reference building), with the goal of informing and motivating performance improvements.

Building decarbonization: Activities and programs that reduce carbon and other GHG emissions from buildings.

Building envelope: The component that separates the exterior of the building from the interior; can be thought of as the "shell" of the building.

Carbon intensity: Measure of carbon dioxide and other greenhouse gases (CO_2e), divided by the floor area of the building. This number is helpful when comparing buildings because it normalizes consumption by building size. A building could have high Total GHG Emissions, but a low carbon intensity if they are using a relatively low amount of energy or cleaner energy sources for the size of their building.

Cultural institution: Institutions that have an acknowledged mission to engage in the conservation, interpretation, and dissemination of cultural, scientific, and environmental knowledge, and promote activities meant to inform and educate visitors on associated aspects of culture, history, science, and the environment. Cultural institutions play a pivotal role in the maintenance, conservation, revitalization, interpretation, and documentation of, and public engagement with, natural and cultural heritage.[1]

Electric baseload: Year-round energy use like lights and plug loads that are independent of the weather.

Greenhouse Gas Emissions: Greenhouse Gas (GHG) emissions are the carbon dioxide (CO_2), methane (CH4), and nitrous oxide (N_2O) gases released into the atmosphere from energy consumption at the property. GHG emissions are often expressed in carbon dioxide equivalent (CO_2e), a universal unit of measure that combines the quantity and global warming potential of each greenhouse gas. Throughout this report, we will use the terms "GHG" and "carbon" interchangeably to refer to these emissions.

Model building code: A building code that is developed and maintained by a standards organization independent of the jurisdiction responsible for enacting the code. Local governments adopt a model building code and modify the code to meet local needs.

Process loads: Building loads that are not related to lighting, heating, ventilation, cooling, and water heating, and typically do not provide comfort to the occupants.

Thermal baseload: A measure of year-round energy use primarily attributable to fossil fuel-based loads such as water heating, cooking, reheating air for humidity control.

1 RICHES Project. (2014). *Cultural institutions.* https://resources.riches-project.eu/glossary/cultural-institutions/#:~:text=Cultural%20institutions%20are%20institutions%20with,history%2C%20science%20and%20the%20environment.

Executive Summary

This report shares the first in depth review of energy use patterns in cultural institutions across the United States and creates a roadmap for energy reductions based on best practices from this sector.

Cultural institutions play a crucial role in valuing and sharing local, regional, national, and global knowledge and expression. Increasingly, these institutions are taking responsibility for contributing to the well-being of the communities they serve.

In recent years, discussion around cultural institutions' sustainability and energy use has become of interest. Cultural institutions have different building use patterns and characteristics, which can present energy challenges not often encountered in other public buildings. This can include high occupancy levels, blends of both indoor and outdoor spaces, large open interiors that require conditioning, and intricate professional expectations such as strict operational temperature and humidity requirements.

Few cultural institutions have the ability or resources to monitor and assess their energy use, despite the increasing availability of tools and software and the many awareness-raising efforts by professional groups. The need to track this information is becoming critical as more building codes and policies are enacted that will require compliance from buildings in the cultural sector.

This project sought to conduct the sector's first in-depth review of the energy use patterns of cultural institutions and develop a roadmap for energy reduction at individual institutions and the sector. New Buildings Institute (NBI), Environment and Culture Partners, and the New England Museum Association were funded by the Institute of Museum and Library Services (IMLS) to study the energy consumption of cultural institutions, recommend key energy efficiency and decarbonization actions, and help cultural institutions prepare for expected building code and policy changes that may impact them.

Working with expert advisors, the project team conducted outreach across the cultural sector to recruit participants throughout the United States, capturing a variety of building sizes, cultural institution types, and building uses (e.g., office vs. collection storage). Ultimately, the outreach resulted in 133 institutions providing energy data for inclusion in the analysis. NBI also identified other cultural institutions for which annual public benchmarking data was available and included this data in the portfolio-level analysis. To complement the analysis findings, NBI conducted targeted interviews with a small subset of participants.

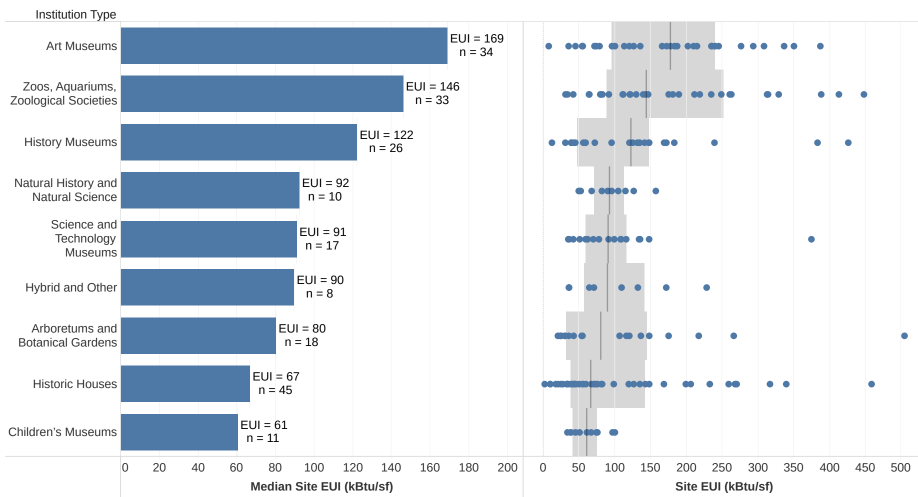
Courtesy of the La Plata County Historical Society, Animas Museum

Key Findings

The research uncovered a variety of insights related to the energy consumption of cultural institutions. The key findings are summarized below:

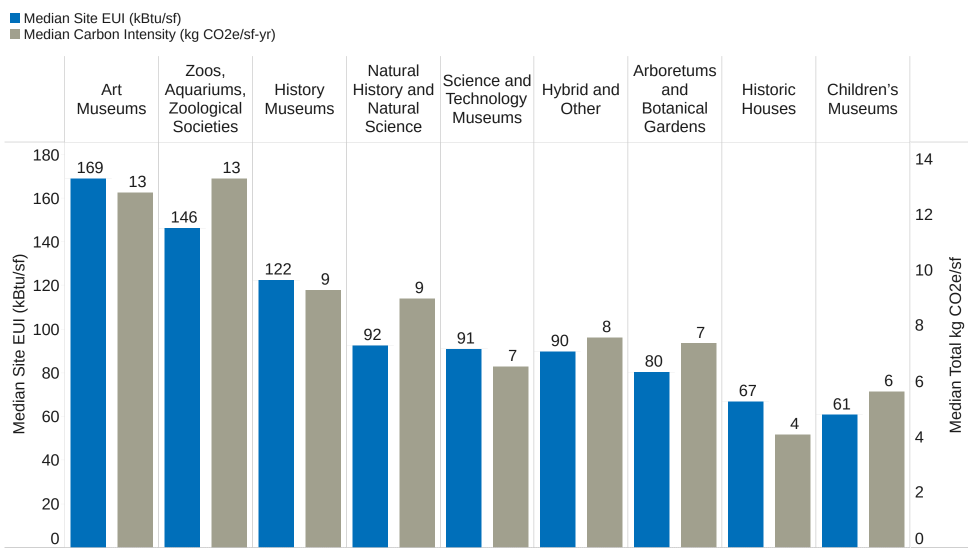
- **The median energy use intensity (EUI) of the cultural institutions studied varies greatly by institution type and is not directly correlated to building age.** Art museums, zoos, and history museums have the highest EUIs of all building types evaluated.

FIGURE 1. MEDIAN SITE EUI BY CULTURAL INSTITUTION TYPE (LEFT) AND INDIVIDUAL BUILDING EUI BY INSTITUTION TYPE (RIGHT).



- **Building energy intensity is not a consistent proxy for greenhouse gas (GHG) intensity at the building level.** While higher EUIs usually mean higher GHG emissions, building-specific factors including equipment efficiency, what fuels are used on site,[2] and the local electricity grid mix[3] drive wide variability in GHG emissions intensities.

FIGURE 2. SITE EUI AND CARBON INTENSITY BY CULTURAL INSTITUTION TYPE.



2 Fuel oil has a higher emissions intensity than gas; gas is often but not always higher emissions than electricity.

3 GHG emissions from electricity generation vary by region, by time of day, and by season. Achieving annual net zero energy performance in a grid-connected building does not guarantee 24/7 zero carbon operation.

- **The primary drivers of energy use vary by institution type.** Historic houses use a high amount of energy for space heating when compared to other end uses. Art museums have a high thermal baseload, meaning that they use fossil gas or another fuel such as chilled water or district steam year-round.
- **The number of annual visitors is not predictive of annual energy consumption.** Zoos and aquariums reported the most daily visitors yet had some of the lowest average energy use per visitor, meaning that each's visitor's theoretical impact on energy use is low. Conversely, history museums reported lower visitation rates but had a higher average energy per visitor. The energy per visitor per year ranged from 1 to 1,375 kBtu, excluding major outliers, signaling the importance for individual institutions to implement the energy reduction strategies that are most applicable to their specific institution.
- **Cultural institutions often have high thermal baseloads and poor heating and ventilation efficiency.** Half of all buildings analyzed as part of the individual building analysis were flagged as having high thermal baseloads. Thermal baseload is a measure of year-round energy use primarily attributable to fossil fuel-based loads such as water heating, or reheating air for humidity control. Several buildings had unexpectedly high gas use in the summer. In one case, a cultural institution reported that heaters run year-round to maintain the appropriate humidity for their collection. About one-third of the buildings analyzed were flagged for poor heating and ventilation efficiency. Because most of the heating systems observed in our sample are fossil fuel-fired, the combination of these two issues can significantly increase the GHG emissions of the building.

Recommendations

Recommendations are broken into four categories: establishing an energy baseline, identifying support and sharing findings, recommendations to reduce carbon through energy efficiency, and targeted carbon reduction recommendations.

UNDERSTAND YOUR ENERGY BASELINE

Tracking energy consumption can provide multiple benefits to cultural institutions, such as improving the understanding of energy consumption patterns and drivers, identifying the most efficient buildings in a campus, pinpointing the most effective performance improvements, and tracking the resulting energy savings from improvements. To better understand their energy use patterns and develop a consistent tracking mechanism, cultural institutions are encouraged to:

- **Find and use sustainability synergies.** Many institutions do not have a designated sustainability team or the necessary resources allotted to energy tracking and sustainability efforts. However, there may be people who are willing to help as well as energy tracking mechanisms that already exist within your institution. For example, the financial department will likely be monitoring energy bills. In this scenario, streamlining energy data tracking into existing financial monitoring may provide easy entry to tracking energy consumption (e.g., add a column for kWh in an existing spreadsheet instead of starting from scratch). Persistence is often required. Keeping the institution's overall goals in the forefront will help staff make decisions that will ensure success.
- **Use ENERGY STAR Portfolio Manager® to collect and review energy data in one place.** ENERGY STAR Portfolio Manager is a free tool that can help cultural institutions reap the benefits of energy tracking. Use of the tool can help institutions develop an improved understanding of energy consumption patterns and drivers, identify the most efficient

buildings on a campus, pinpoint the most effective performance improvements, and track the resulting energy savings from improvements. The tool includes guidance on issues cultural institutions commonly face such as tracking onsite renewable energy and delivered fuels.

- **Get a detailed building energy audit (ASHRAE Level 2 recommended).** An ASHRAE Level 2 audit examines building energy systems, analyzes consumption, assesses conditions that affect energy performance and occupant comfort, and may include a performance simulation. Auditors work closely with the building owner and management to understand problem areas, financial constraints, and overall goals. Level 3 audits may be desired for those seeking cost estimates.

IDENTIFY SUPPORT AND SHARE FINDINGS

The institutions that participated in our research and have successfully implemented energy efficiency and/or decarbonization measures shared helpful tips on how to gather momentum to tackle projects and the importance of sharing findings:

- **Look everywhere for ways to fund energy-saving projects.** Incentives and grants can come from a variety of sources. Talking to the utility, monitoring other energy projects in your city, and identifying new funders are starting points. Energy Service Companies (ESCOs) offer efficiency-as-a-service financing solutions that remove upfront cost barriers. Allocate staff time to research options and apply for incentives and grants as part of your continual fundraising efforts. Prioritize implementation of these upgrades when funding is awarded so that your savings can begin immediately, and then be channeled to other efficiency projects.
- **Identify a sustainability “champion” and create a compelling case.** Finding an influential “champion” on a Board of Directors or other governing body can help to move energy-saving projects forward. Ensure that the value of proposed projects is clearly communicated, including the return on investment. Projects that provide multiple benefits (e.g., financial savings, alignment with the mission, carbon emission reduction, educational opportunity) are more compelling than those with a single benefit. Taking action to address improvements related to energy use will have the most success when all levels of the organization are involved: executives prioritize energy savings, implementation staff are motivated to find opportunities to save, and facilities/maintenance staff are provided training to operate systems most efficiently.
- **Share lessons learned.** Remember that you are not alone. Network and share your findings with similar institutions to understand all available options and explore alternatives. Everyone must start somewhere; your experience can kick-start someone else’s path. The best first step is to start trying to collect building energy data, even if it is messy. It will become better and easier with more practice and experience.

REDUCE CARBON EMISSIONS THROUGH ENERGY EFFICIENCY

Building energy efficiency is the most cost-effective way to meet climate objectives to reduce carbon emissions, minimize stress on our electricity grid, reduce operation costs, and limit dependence on fossil fuels. Increasing the energy efficiency of cultural institutions will contribute to the climate fight by lowering energy demand and the related carbon emissions from energy production and use. Cultural institutions will also benefit from lower utility expenses, which can be reinvested into programs as well as healthier and more comfortable spaces for visitors and employees.

Recommended strategies in this category can be found in the bulleted list below. More detailed information on each of them is provided in the Recommended Strategies to Reduce Carbon Through Energy Efficiency section.

- ❑ Invest in ongoing commissioning and training.
- ❑ Use efficient lighting and harvest free daylight.
- ❑ Replace inefficient heating, cooling, and domestic water heating equipment.
- ❑ Install and maintain automatic building system controls.
- ❑ Decouple ventilation from heating and cooling.
- ❑ Add an energy-efficient humidity control solution.
- ❑ Evaluate ways to partition spaces and invest in zonal sensors where possible.
- ❑ Optimize the building envelope (e.g., walls, windows, and doors).
- ❑ Promote energy efficiency activities through visual tools.

PRIORITIZE CARBON-REDUCING STRATEGIES

Reducing on-site carbon emissions through electrification (replacing gas equipment) and procuring low embodied carbon products are priorities for driving down the built environment's impact on climate change. While the strategies bulleted below provide guidance on the most effective ways to reduce carbon, institutions will need to understand what works best for their goals, budget, and staff.

Recommended strategies in this category can be found in the bulleted list below. More detailed information on each of them is provided in the Targeted Carbon Reduction Strategies section.

- ❑ Create short- and long-term carbon reduction plans.
- ❑ Work towards electrification and minimizing on-site fossil fuels.
- ❑ Choose low global warming potential refrigerants.
- ❑ Seek low embodied carbon materials.
- ❑ Prioritize on-site renewables and utilize off-site renewables.
- ❑ Build resiliency through building-grid integration and on-site energy storage.

CONSIDER POLICY RECOMMENDATIONS

Building codes, policies, and programs will continue to be critical for federal, states, and cities (also referred to as jurisdictions) to meet their climate goals, and jurisdictional policies will increasingly impact cultural institutions' day-to-day practices. Cultural institutions will be called to reduce energy and water consumption, limit carbon emissions, or achieve net zero status.

Recommended strategies in this category can be found in the bulleted list below. More detailed information on each of them is provided in the section.

- Prepare for coming benchmarking policies that will require measurement and tracking of energy performance and carbon emissions over time.
- Proactively consider building labeling to show your commitment toward limiting the impacts of climate change.

- Understand how changes to energy performance requirements in the building code will impact renovations, additions, and construction of a new building.
- Understand current decarbonization goals of your state and city and plan for electrification mandates by phasing out gas equipment as they reach end-of-life.
- Look for products with ENERGY STAR or WaterSense ratings and low-GWP refrigerants to stay ahead of federal regulations.

Embrace the Opportunity

Cultural institutions have a great opportunity to reduce energy consumption and GHG emissions. The 133 participating institutions use an estimated one billion kWh per year, which is equivalent to 120 wind turbines running for a year. Through energy efficiency upgrades, a decrease in annual energy use by 20% would be possible for many institutions without impacting staff or visitor comfort. If all the cultural institutions that participated in Culture Over Carbon decreased their energy use by 20%, the energy saved would translate to $24 million in operational energy savings per year.[4]

Cultural institutions are urged to take action to make their buildings more efficient and decarbonized. This report seeks to provide a summary of where the industry stands today, and steps that even the smallest cultural institutions can take to make a difference. By implementing energy efficiency upgrades and decarbonizing their operations, cultural institutions can benefit from cost savings, improved building performance, and show their commitment to sustainability to their visitors and communities.

4 Assuming a $0.12 per kWh commercial rate. EIA (2023). *Electric Power Monthly: Table 5.6.A. Average Price of Electricity to Ultimate Customers by End-Use Sector.* https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

Introduction

Cultural institutions play a crucial role in preserving local culture, brining communities together, and preserving history. According to UNESCO, the United States (U.S.) is home to the highest number of museums globally, with over 33,000 institutions (as of March 2019) and supporting over 726,000 jobs.[5, 6] This document will provide staff and leaders of cultural institutions with relevant information about new code and policy requirements, as well as a roadmap to decarbonize their facilities.

Climate change represents a significant threat to life on Earth—as GHG emissions are released by human activities, the average global temperature increases and changes the ecological context. Impacts include rising sea levels, worsening extreme weather events, food and water shortages, and animal migration and extinction, among others. The most recent assessment by the Intergovernmental Panel on Climate Change (IPCC) estimates that we will reach the ecological tipping point of 1.5°C average warming within the next two decades unless dramatic action is taken to reduce emissions.[7]

Building design and construction produce around 40% of GHG emissions, representing a significant opportunity to contribute to the solution.[8] Cities and states have begun passing requirements for new construction and existing buildings to decarbonize, creating a patchwork of policies.

In recent years, discussion around cultural institutions' sustainability and energy use has become of interest. Cultural institutions have different building use patterns and characteristics, which can present challenges compared with other public buildings. This can include high occupancy levels, blend of both indoor and outdoor spaces, large open spaces that require conditioning, and strict temperature and humidity requirements.

Other, more general challenges include:

- Overburdened facility staff or inadequate budget to handle aging infrastructure or maintenance
- Lack of understanding of the benefits of energy and water efficiency
- Lack of awareness of current and emerging building decarbonization codes and policies and how they apply to cultural institutions
- Inconsistent adoption of updated recommendations for temperature (T) and relative humidity (RH) conditions for the care of collections

Building codes, policies, and programs continue to be a crucial lever for jurisdictions to increase the adoption of high-performance buildings. Unfortunately, some policies exclude cultural

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5 United Nations Educational, Scientific and Cultural Organization (UNESCO). (2019). *Report on the implementation of the UNESCO 2015 Recommendation on Museums & Collections: Recommendation concerning the Protection and Promotion of Museums and Collections, their Diversity and their Role in Society.* https://unesdoc.unesco.org/ark:/48223/pf0000371549

6 American Alliance of Museums. *Museums Facts & Data.* https://www.aam-us.org/programs/about-museums/museum-facts-data/#_ednref5

7 The Intergovernmental Panel on Climate Change. (2022). *Climate Change 2022: Impacts, Adoption, and Vulnerability — Working Group II Contribution to the IPCC Sixth Assessment Report.* www.ipcc.ch/report/sixth-assessment-report-working-group-ii/#:~:text=The%20IPCC%20has%20finalized%20the,55th%20Session%20of%20the%20IPCC

8 International Energy Agency (IEA). *Global CO2 emissions from buildings, including embodied emissions from new construction, 2022 (2023).* https://www.iea.org/data-and-statistics/charts/global-co2-emissions-from-buildings-including-embodied-emissions-from-new-construction-2022

institutions because some sensitive artifacts and materials they preserve can require relatively strict indoor environmental conditions. As a result, very few cultural institutions measure energy use despite the increasing availability of tools and software and the many awareness-raising efforts by professional groups.

As public benefit organizations, cultural institutions have a mission-driven responsibility to limit negative impacts while modeling thoughtful, responsible behavior. Additionally, society needs all buildings, no matter their potentially sensitive profiles, to identify ways to reduce energy demand and GHG emissions to avoid catastrophic climate change. There is opportunity for the cultural sector to create a great impact—**if all of the 30,000+ cultural institutions in the U.S. reduced their energy use by 20%, the estimated annual carbon and other GHG emission reduction would be the equivalent of two gas-fired power plant's annual emissions or taking around 180,000 cars off the road.** This would also provide direct cost savings for cultural institutions; for the participants in this study, a 20% reduction in energy consumption would translate to $24 million in annual operational energy savings, with a median energy cost savings of around $14,000 per year.[9]

Cultural institutions are urged to take action to make their buildings more efficient and decarbonized. This report provides a summary of where the industry stands today, and steps that even the smallest cultural institutions can take to make a difference. By implementing energy efficiency upgrades and decarbonizing their operations, cultural institutions can benefit from cost savings, improved building performance, and show their commitment to sustainability to their visitors and communities.

The Culture Over Carbon project sought to inspire cultural institutions to take action by conducting the sector's first in-depth review of their energy use patterns and delivering recommendations for key efficiency and decarbonization strategies. Data-driven insights were provided to help inform decision-making about investments and strategic planning and prepare institutions for expected building code and policy changes that may impact them.

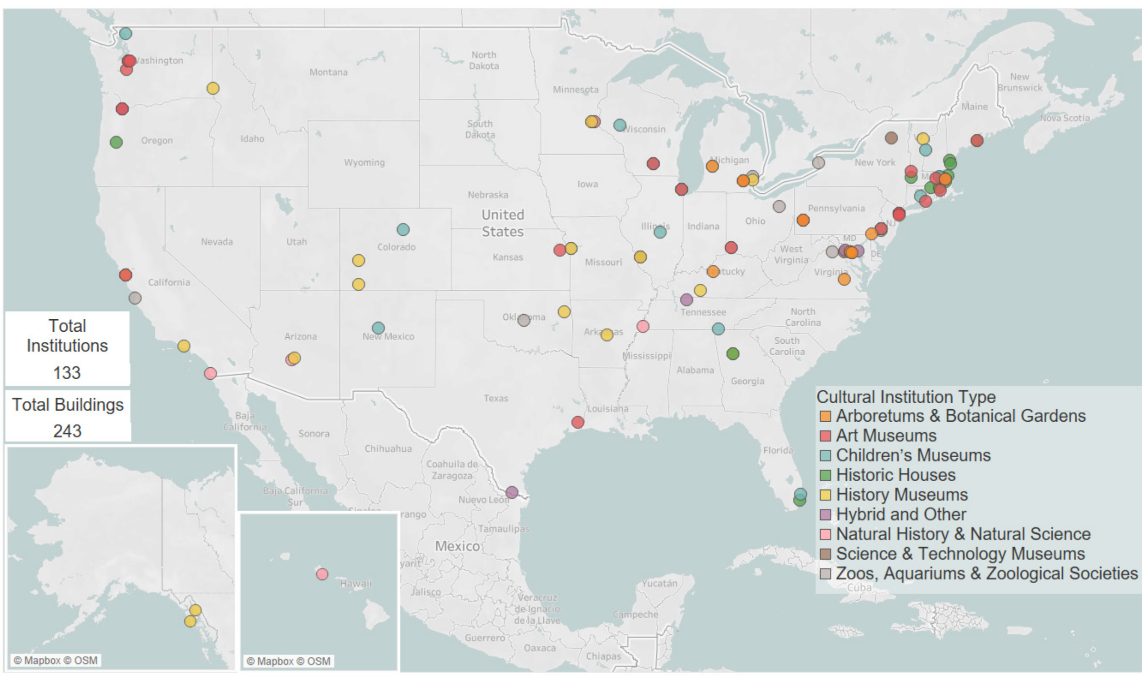
9 Assuming average dollar per square foot energy costs from the 2018 Commercial Building Energy Consumption Survey (CBECS). https://www.eia.gov/consumption/commercial/data/2018/

Energy Data Collection Approach

Over 130 cultural organizations participated and provided energy data presented in this report. These participants cover all major US Census regions, nearly every US climate zone, and represent all major cultural institution types.

The Culture Over Carbon team worked with a group of advisors in the cultural institution sector to recruit study participants. Working with the advisors, the team conducted targeted outreach to peer institutions and organizations through the six regional museum organizations' newsletters, and through social media for all regional and national museum associations. Stipends were offered to participants that completed a data collection sheet and provided sufficient energy data. Ultimately, the outreach resulted in more than 150 institutions expressing interest and 133 ultimately participating by providing energy data.[10] Figure 3 shows the institutions that elected to participate.

FIGURE 3. PARTICIPATION BY INSTITUTION TYPE.



Participants were asked to complete a data collection sheet with basic information about their institution. Some institutions submitted data for multiple buildings (e.g., zoos, who have many buildings with a distinct purpose). Demographic information included topics such as ownership, annual visitors, occupancy, year built, and building certifications. Data was also collected on energy-related details such as thermal and humidity set points, major mechanical systems, and number of energy meters. Participants with unusual buildings such as zoos and greenhouses were asked to provide information specific to their cultural institution type, such as total energy

10 There were 22 institutions that indicated interest and then did not ultimately participate. A reason was not given by all. However, the reasons included lack of bandwidth, staff turnover, and lack of access to the details needed to complete the data collection sheet.

use, campus size, number of buildings, and total greenhouse area. The data collection sheet provided a pathway for participants to provide monthly energy data. Participants could also share energy data through ENERGY STAR® Portfolio Manager.[11]

NBI utilized publicly available annual energy data from jurisdictions with benchmarking requirements for commercial buildings. This data is typically collected annually and includes basic information about the building such as square footage and vintage, as well as annual energy consumption details, which can be reported by fuel type, or the overall annual consumption of all fuels used by the building. NBI identified cultural institutions for which this public benchmarking data was available and included this data in the portfolio-level analysis.

NBI conducted targeted interviews with a small group of participants after the FirstView reports were delivered to complement the energy analysis and provide additional insight into how cultural institutions manage energy use. Additional information can be found in the Interview Findings section.

NBI analyzed the data using both the qualitative and quantitative data to draft the findings. Table 1 summarizes the total number of institutions and buildings used to inform the energy portion of the study. "Institution" refers to the overarching organization, while "buildings" refer to the individual structures owned by the institution. This includes the institutions that provided building-level monthly energy data for detailed analysis and institutions for which annual building energy data was collected.

TABLE 1. SUMMARY OF INSTITUTIONS AND BUILDINGS USED TO INFORM THE STUDY.

	Institutions	Buildings
Submitted monthly energy data for individual building analysis	92	200
Annual energy data from benchmarking data	41	43
Total	**133**	**243**

The number of buildings to receive individual building energy reports was slightly lower than the number that submitted data due to data issues, as described in the Individual Building Analysis—Participants section.

The carbon analysis considered each individual building's fuel type(s) and location to estimate the building's GHG emissions intensity measured in CO_2e per square foot. Electricity consumption was converted to carbon using eGrid[12] factors for the building's region. For non-electric fuel use, NBI referred to PortfolioManager[13] emissions rates for fossil fuels, district steam, district chilled water, district hot water, and/or other fuels. The carbon analysis did not factor in renewable energy generation, power purchase agreements, or other "green" electricity procured from the building's utility.

11 U.S. Environmental Protection Agency and U.S. Department of Energy. *Benchmark Your Building Using ENERGY STAR® Portfolio Manager®.* https://www.energystar.gov/buildings/benchmark

12 U.S. Environmental Protection Agency. *Emissions & Generation Resource Integrated Database (eGRID).* https://www.epa.gov/egrid

13 U.S. Environmental Protection Agency. (2022). *ENERGY STAR® Portfolio Manager® Technical Reference: Greenhouse Gas Emissions.* https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf

Key Findings and Recommendations

The research uncovered a variety of insights related to the energy consumption of cultural institutions. The key findings are summarized below:

Key Findings

- **The median EUI of the cultural institutions studied varies greatly by institution type** and is not directly correlated to building age. Art museums, zoos, and history museums have the highest EUIs of all building types evaluated.
- **Building energy intensity is not a consistent proxy for GHG intensity.** While higher EUIs usually mean higher GHG emissions, building-specific factors including equipment efficiency, which fuels are used on site,[14] and the local electricity grid mix[15] drive wide variability in GHG emissions intensities.
- **The primary drivers of energy use vary by institution type.** Historic houses use a high amount of energy for space heating when compared to other end uses. Art museums have a high thermal baseload, meaning that they use fossil gas or another fuel such as chilled water or district steam year-round.
- **Cultural institutions often have high thermal baseloads.** Half of all buildings analyzed as part of the individual building analysis were flagged as having high thermal baseloads. Thermal baseload is a measure of year-round energy use primarily attributable to fossil fuel-based loads such as reheating air for humidity control or water heating. Several buildings had unexpectedly high gas use in the summer. In one case, the cultural institution reported that heaters run year-round to maintain the appropriate humidity for their collection.
- **Cultural institutions often have poor heating and ventilation efficiency.** The second most common diagnostic flag, occurring in about one-third of the buildings analyzed, was heating and ventilation efficiency. Because most of the heating systems observed in our sample are fossil fuel-fired, this can significantly increase the GHG emissions of the building, especially when there is also a high thermal baseload as described above.
- **Cultural institutions have a valuable opportunity to reduce energy consumption and GHG emissions.** Collectively, the participating institutions use an estimated one billion kWh per year. This amount of energy is equivalent to 25% of the power produced at Hoover Dam. Through energy efficiency upgrades, a 20% decrease in annual energy use would be possible for many institutions without impacting staff or visitor comfort. If all the cultural institutions that participated in Culture Over Carbon decreased their energy use by 20%, the energy saved would be enough to power over 6,000 homes a year and would translate to $24 million in operational energy savings per year.[16] When extrapolating a 20% reduction in energy use to the more than 30,000 cultural institutions in the U.S., the estimated annual carbon and other GHG emissions reduction would be the equivalent of removing approximately 180,000 cars off the road.

14 For example, fuel oil has a higher emissions intensity than gas; gas usually has higher emissions than electricity. This is especially true when comparing high efficiency heat pumps to standard efficiency gas fueled equipment.

15 GHG emissions from electricity generation vary by region, by time of day, and by season. Achieving annual net zero energy performance in a grid-connected building does not guarantee 24/7 zero carbon operation.

16 Assuming a $0.12 per kWh commercial rate.

Recommendations

Recommendations by cultural institution type are summarized in Table 2. These recommendations are largely focused on energy reduction strategies (which also reduce carbon emissions) and are heavily informed by virtual energy audits performed with FirstView, an individual building analysis software tool. Additional strategies for cultural institutions are summarized in the following sections. These recommendations are grouped into categories, though will all reduce the carbon footprint of a building. In all cases, we recommend working with qualified professionals to ensure proper execution and maximum savings.

TABLE 2. ENERGY REDUCTION RECOMMENDATIONS BY BUILDING TYPE.

Institution Type	Recommendation
Multi-building campuses	For multi-building campuses, especially those lacking individual energy meters for each building, investing in submetering equipment can help to identify the buildings that are the largest contributors to overall energy use and carbon footprint. Meters can be expensive, so participants in our study suggested trying to incorporate them as part of the capital expenditure budget or including them in the scope of renovation projects.
Aquariums, Zoos & Zoological Societies	Zoos tend to have high electrical usage, which may be due to pumping, treating, and heating water for animal enclosures across a large campus and animal hospitals. High efficiency heat pumps and water pumps could provide energy and cost benefits, especially for the multiple zoos in our sample with mechanical systems that are original to the buildings.
Arboretums and Botanical Gardens	Arboretums and botanical gardens tended to have a high heating load, with unique requirements like root zone heating. Arboretums and botanical gardens in our sample were also likely to have old and inefficient natural gas boilers or steam systems providing heating. Investigating heating system improvements and/or envelope upgrades would be a good starting point, while being mindful of the variety of building uses (e.g., educational buildings, greenhouses) and unique greenhouse characteristics. Electrification of heating systems can yield significant carbon emission reductions as electric utility companies move toward cleaner generation sources.
Art Museums	Art museums often have the strictest temperature humidification requirements that result from having to maintain collections' environmental conditions. High-efficiency ventilation, which can also dehumidify the air, could also be an energy and cost saver in this institution type. Investing in a dedicated dehumidification system may be more efficient than relying on the HVAC system to regulate humidity. Desiccant-based or energy recovery ventilation systems (e.g., enthalpy wheels) may offer humidity control with significant energy, cost, and carbon savings. Art museums frequently mention the need to regulate the amount of light in their spaces to protect the art. Retrofitting lights with museum-quality LEDs can provide energy savings. Where daylight is acceptable, using clerestories or light shelves high on the walls that bounce light off the ceiling may bring in free daylight without impacting the art.

Institution Type	Recommendation
Children's Museums	This cultural institution type was the lowest overall energy user per square foot, on average, in our sample. Compared to collections-based museums, temperature and humidity requirements are looser. Children's museums may also include fewer energy-intensive displays in deference to hands-on exhibits. We suggest that individual institutions seek incremental improvements that will further decrease their electric and thermal baseload, and generally follow the energy efficiency and targeted carbon reduction recommendations outlined in the Recommendations section. Children's museums may also have more strict ventilation requirements. Scoping a heat recovery system when adding or modifying the ventilation system may provide energy, cost, and carbon emission savings.
Historic Houses	Historic houses tend to have little or no insulation and sometimes cannot insulate due to preservation guidelines. These buildings tend to use more heat, so an HVAC retrofit using high efficiency heat pumps might be a big energy and cost saver, where possible and feasible. Additionally, climate control within historic houses is typically used to benefit the objects on display, not occupant comfort. Humidistat controls that allow temperature to float while controlling relative humidity are one example of a potential energy saver.
History Museums	Depending on the collection, history museums may have similar humidity, temperature, and lighting needs as art museums and should consider similar strategies. History museums in our sample tended to have a variety of mechanical systems serving multiple thermal zones and were installed at different times all within the same building. In these cases, it is important for museums to ensure that the systems are not working against each other.
Hybrid and Other	Due to the small sample size, we suggest following the findings for the most similar institution type.
Natural History and Natural Science	Natural history and science institutions had similar results to science and technology museums, with middle of the pack EUIs. In our sample, most of these institutions had a central chilled water plant as the primary mechanical system.[17] Consider increasing the efficiency and/or scheduling of these loads if present. This institution type also had the largest average square footage per building, making rooftop solar more feasible, once efficiency is addressed.
Science and Technology Museums	We recommend a similar approach to natural history and natural science museums, given the similar performance, presence of research spaces, and large square footage (second highest of all institution types).

17 National Renewable Energy Laboratory (NREL). Defined as building electrical loads that are not related to lighting, heating, ventilation, cooling, and water heating, and typically do not provide comfort to the occupants. https://www.nrel.gov/docs/fy13osti/54175.pdf

PRIORITIZING STRATEGIES

Building energy efficiency is the most cost-effective way to meet climate objectives, minimize stress on our electricity grid, reduce operation costs, and limit dependence on fossil fuels. Increasing the energy efficiency of cultural institutions will contribute to the climate solution by lowering energy demand and the related carbon emissions from energy production and use. Cultural institutions will also benefit from lower utility expenses, which can be reinvested in programs as well as healthier and more comfortable spaces for visitors and employees.

Institutions in this study could use their customized FirstView building analysis report to guide their decision-making on prioritizing energy efficiency measures that will also yield carbon emission reductions. Cross-team collaboration can ensure existing knowledge and expertise about the building(s) is used to better understand issues and how to implement solutions.

Two additional steps that can help all cultural institutions as they consider energy efficiency upgrades include:

Use ENERGY STAR Portfolio Manager to set a baseline and track energy.

- ENERGY STAR Portfolio Manager (ESPM) is a free online resource management tool used for benchmarking building energy use. By inputting basic information about the building and at least 12 months of energy data, facility managers can track energy demand (and production) over time and monitor for abnormalities. ESPM can also help building owners and facility managers make informed choices about energy efficiency upgrades. The total annual GHG emissions and emissions intensity of the property are automatically calculated so that users can understand their carbon footprint and see how it changes year-over-year. The dashboards in Portfolio Manager can be used as a helpful reminder of everyone's role in energy efficiency and carbon reduction. A public-facing version of the dashboard can also engage the community in a conversation about energy and provide an opportunity to share the institution's sustainability story.

Perform a detailed building energy audit (ASHRAE Level 2 recommended).[18]

- An ASHRAE Level 2 audit examines building energy systems, analyzes consumption, assesses conditions that affect energy performance and occupant comfort, and may include a performance simulation. Auditors work closely with the building owner and management to understand problem areas, financial constraints, and overall goals. Level 3 audits may be desired for those seeking cost estimates. Asking the auditor to calculate the potential carbon savings from suggested measures can help institutions prioritize strategies.

RECOMMENDED STRATEGIES TO REDUCE CARBON THROUGH ENERGY EFFICIENCY

The following general recommendations are common energy efficiency best practices for cultural institutions to consider. All of these strategies will save carbon by reducing energy use, though some will have a bigger impact than others for the related cost and/or effort. It is up to each individual organization to evaluate which strategies are most accessible. These recommendations are not an exhaustive list and should be considered strategically. For example, upgrading the envelope would make the most sense as part of a major renovation as opposed to routine maintenance and upgrades.

18 For more information, see ASHRAE Technical FAQ 95, https://www.ashrae.org/File%20Library/Technical%20Resources/Technical%20FAQs/TC-07.06-FAQ-95.pdf

Invest in ongoing commissioning and training.

- Commissioning involves working with a professional to fine-tune building systems and controls to ensure a building is running at its optimal performance. As equipment is updated or replaced, the initial sequence of events may have been altered, or may not have been properly programmed in the beginning. Commissioning agents will confirm the equipment is operating as intended and will make recommendations if not. The lighting controls, HVAC controls, and schedules will be evaluated to ensure that they are programmed and functioning as intended. Evaluation of the security and submeters may also be included in the process if they are associated with the building automation system. Building operators (e.g., facilities/maintenance staff) that are trained to identify energy efficiency issues and opportunities when conducting building maintenance can catch potential issues and commissioning opportunities early.

Use efficient lighting and harvest free daylight.

- Upgrading lighting is typically very cost effective and a good first step to capture more accessible energy savings. Energy efficient lighting can provide the same amount of light for less money; LEDs are more efficient than incandescent and fluorescent lighting, are longer lasting, and generate less heat, which saves money by reducing cooling needs.
- Bring daylight into appropriate spaces as much as possible with daylight controls. Reflective surfaces and light shelves can bring light deeper into spaces, reduce the need for electrical lighting, and lead to better light quality. Use shades to control glare, heat gain, and to protect artifacts.

Select efficient hot water heating.

- Water heating accounts for 19-32% of typical building energy. Electric heat pump water heaters can create significant energy and cost savings as they are 2-4 times more efficient than conventional electric resistance water heaters.
- Central heat pump water heater systems are an option for buildings with existing boiler plants for domestic hot water. Transitioning water heating from a fossil fuel-based system to electric can yield significant carbon savings, and the large storage tanks associated with heat pump systems can support load shifting to save money during peak utility cost periods.

Replace inefficient heating & cooling equipment.

- Efficient electric heat pumps for heating and cooling provide operational cost savings. Heat pumps can be up to four times more efficient when compared to gas heat or electric resistance heat and can deliver plenty of heat even in very cold outside air conditions. Air source heat pumps, the most common type found today, work like an air conditioner in reverse, harvesting heat from outside air and using it to heat the building.

Install and maintain automatic building system controls.

- Automated controls for heating, cooling, lighting, and other building systems allow the systems to work together and create efficiencies. For example, daylight sensors can save energy by automatically turning off the lights when there is adequate sunlight in a room.
- System controls may need to be updated as seasons and exhibit needs change.

Decouple ventilation from heating and cooling.

- Separating ventilation from the heating and cooling systems that regulate temperature and humidity in a building can optimize the control of each system. A high efficiency dedicated outside air system (DOAS) uses fresh air directly from the outside and conditions it to be used in the building with little-to-no mechanical heating or cooling, providing energy, cost, and carbon savings while improving indoor air quality. Energy recovery systems are an important part of a high efficiency ventilation system, as they recapture energy from heated or cooled exhaust air.

Energy Recovery Success Story: Seattle Asian Art Museum

Location: Seattle, WA

The Seattle Asian Art Museum (SAM) highlights the potential for energy efficient upgrades in existing buildings. In 2016, SAM commissioned upgrades to a variety of HVAC and lighting systems within the 14,000 square foot museum, including a heat recovery chiller (HRC) alongside a water-to-water heat pump. These systems work in tandem to capture waste heat and reuse it within the museum rather than simply letting it escape into the atmosphere. This configuration not only helps SAM decarbonize; it also saves money by increasing the efficiency of the heat pump system.

Photo by Tyler Menezes on Unsplash

Add an energy-efficient humidity control solution.

- Traditional HVAC systems that remove moisture from the air by cooling it below the dew point use a significant amount of energy to meet the strict humidity requirements in galleries, storage spaces, and other tightly controlled zones in a building using. Adding other dehumidification technologies, such as desiccant or enthalpy wheels, can save energy by using a chemical process to remove and control moisture that does not rely on energy-intensive cooling, particularly in humid climates. An HVAC professional can aid in evaluating the best option.

Consider improvements to the building envelope (e.g., walls, windows, and doors).

- The envelope should help optimize the other building systems. For example, air sealing and insulating walls and windows keeps energy from moving from one side to the other, minimizing the need for heating and cooling. High efficiency windows and trees or shade structures can control the amount of heat gain into the conditioned space due to sunlight, minimizing the energy needed for heating, cooling, and lighting.
- Upgraded envelopes may also facilitate cost savings when HVAC equipment is replaced at the same time or later. Downsizing the HVAC system capacity may be possible due to the reduced overall heating and cooling needs of the building.

Photo Credit: Denmarsh Photography, Inc.

Efficient Envelope Success Story: Phipps Tropical Forest Conservatory

Location: Pittsburgh, PA

In 2006, Phipps Conservatory completed their 12,000 square foot, state-of-the-art Topical Forest Conservatory, incorporating envelope design elements and envelope efficiency measures with the goal of eliminating the need for any active HVAC system. First, the roof was designed to slope in a way that allowed for the use of insulated, double-pane glass on the roof, which saves energy while still maintaining proper light levels for growing plants. This energy efficient choice is typically not an option for glasshouses because it blocks solar radiation that the plants need. Additionally, half of the roof opens through an automated control system, which eliminates the need for energy-intensive exhaust fans. In the winter, automated energy blankets deploy on the roof to provide thermal insulation. Additionally, the western and northern walls, which are made from concrete, are insulated on the outside to achieve thermal mass, collecting heat during the day and releasing it at night as temperatures fall. Through these and other measures, the building uses 40% less energy than traditional glasshouses.

Promote energy efficiency activities with visual tools.

- An energy dashboard is a great opportunity to visually present building energy consumption and production and the associated GHG emissions. Interactive displays can be integrated into exhibits in an educational or motivating way, depending on the audience and the data available. Some energy tracking programs allow occupants to track energy use from a website or on their smartphones, will send educational messages and reminders about energy reduction at peak hours, and provide a comparison to peer buildings' use to encourage savings.

TARGETED CARBON REDUCTION STRATEGIES

Reducing on-site carbon emissions through electrification (replacing gas fueled equipment) and procuring low embodied carbon products are priorities for driving down the built environment's impact on climate change. As electric grids rely on more renewables, all-electric buildings will have carbon neutral operations. While the strategies bulleted below provide guidance on the most effective ways to reduce carbon, institutions will need to understand what works best for their goals, budget, and staff. Cultural institutions should consider the following ways to reduce the carbon emissions of their buildings:

Create short- and long-term carbon reduction plans.

- Carbon reduction plans set goals to phase out operational carbon and meet specific building and/or portfolio needs. Understanding the context of the existing fuel types, building location(s), and planned improvements can help cultural institutions achieve incremental carbon reductions over time. Having a plan helps staff prioritize activities such as tracking carbon emissions and then identifying and budgeting for the next step when equipment fails. A carbon reduction plan is a significant part of a larger climate action plan.

Work towards electrification and minimizing on-site fossil fuels.

- Electric building technologies deliver the same thermal comfort as traditional gas fueled equipment with lower emissions and more efficiently than their counterparts. Cultural institutions should consider heat pumps for space and water heating, and consider pursuing high-capacity electrical panels, electrical chases and conduit runs, and locate electrical outlets near gas equipment for future equipment conversion (e.g., electric vehicle charging, on-site solar, domestic hot water) to be "electrification-ready."

Choose low global warming potential refrigerants.

- Most refrigerants are high global warming potential (GWP) chemicals that can be thousands of times more polluting than carbon dioxide alone. Refrigerant leak detection systems can improve a system's performance and minimize the release of high GWP chemicals directly into the environment. Leaks require more refrigerants to recharge the system, releasing even more potent emissions. Cultural institutions should consider refrigerants when upgrading cooling systems as well as other systems such as refrigeration and freezer units, chillers, and fire extinguishing systems.

Seek low embodied carbon materials.

- Building construction materials alone are responsible for about 11% of all global carbon emissions.[19] As cultural institutions consider renovations and expansions to their buildings, thoughtful material selection can easily change a buildings' embodied carbon and reduce global climate emissions. Strategies may include reducing the number of materials overall, reusing materials where possible, selecting materials that will minimize product replacement, and choosing low embodied carbon materials (e.g., wood and bio-based materials, local materials, high recycled content). More information can be found in the Insider's Guide to Talking About Carbon Neutral Buildings.

19 IEA. (2019). *Global Status Report for Buildings and Construction 2019.* https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019.

Prioritize on-site renewables and utilize off-site renewables.

- Incorporate on-site renewables to produce emission-free energy, which offsets operational emissions. Note that this strategy is best implemented in tandem with or following energy efficiency upgrades—decreasing overall energy consumption will decrease the size of the renewable system needed. Solar photovoltaics (PV) is a typical option for creating energy on-site. For cultural institutions with a large floor area, roof mounting may be the most viable option. Smaller institutions can consider ground-mounted arrays or installations on top of parking structures or over open-air parking. If on-site energy generation is not an option, off-site renewables can be pursued through a power purchase agreement, community solar program, or opting into utility-delivered renewables.

Renewables Success Story: Monterey Bay Aquarium

Location: Monterey, CA

In 2018, the Monterey Bay Aquarium enrolled in Central Coast Community Energy's (CCCE's) community choice aggregation program. CCCE is committed to achieving 100 percent renewable energy procurement by 2030, allowing its customers—like the aquarium—to decarbonize their electricity supply. Monterey Bay Aquarium further demonstrated its commitment to clean energy through the construction of the Bechtel Family Center. Completed in 2019, the four-story, 25,000 square foot educational facility is equipped with nearly 7 kW of solar capacity paired with on-site battery storage. The Bechtel Center was also designed with conservation in mind; it takes advantage of the abundant natural light pouring through its many-windowed façade to reduce the need for artificial illumination. This reduction in lighting load allows generation from the solar array to meet a more substantial portion of the aquarium's electricity demand.

Build resiliency through building-grid integration and on-site energy storage.

- Building-grid integration allows buildings and the electrical grid to coordinate energy supply and demand to optimize energy consumption, reduce peak demand, offer more clean energy, and provide a reliable electricity supply. Cultural institutions can implement strategies to adjust their use (e.g., heating, cooling, lighting) to reduce consumption, minimize community-wide service impacts, and avoid peak energy rates. Strategies may include installation of smart controls and utilizing thermal energy storage (e.g., ice storage) and/or batteries.

Prepare for coming policies—benchmarking

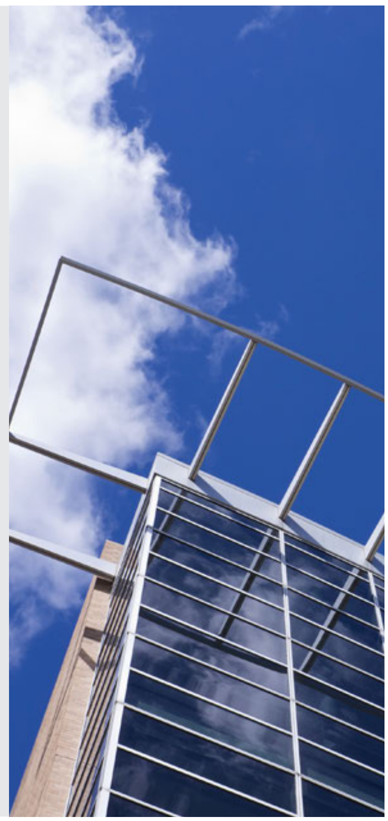
- Building benchmarking policies requires that public and private businesses measure and track energy performance and carbon emissions over time. Some policies may require public reporting (such requirements supported the data collection for this study). The intent is that when owners are armed with information about building performance, they can confidently implement efficiency improvements, ultimately reducing carbon and supporting jurisdictional climate goals.

  See the Codes & Policies Context for Cultural Institutions section of this report for more information about the importance of preparing for carbon reduction policies.

Benchmarking and Carbon Reduction Success Story: Science Museum of Minnesota

Location: Saint Paul, MN

The Science Museum of Minnesota began tracking its energy use and associated carbon emissions in 2013. In May 2019, benchmarking results through a combination of ENERGY STAR Portfolio Manager and the museum's internal tracking tools revealed that the museum's carbon emissions had declined by 43% since peaking in 2014. At this time, the museum committed to reducing its remaining emissions by another 50% by 2030 (if not sooner), and to achieve 100% carbon neutrality by 2050. By December 2021, ongoing energy efficiency efforts combined with agreements with two utilities for carbon-neutral energy resources had achieved an 86% reduction in carbon emissions since 2014. Equipped with this new information as a result of benchmarking, in March 2022 the museum upped its commitment to carbon neutrality, with its goal now being to achieve 100% carbon neutrality by 2030.



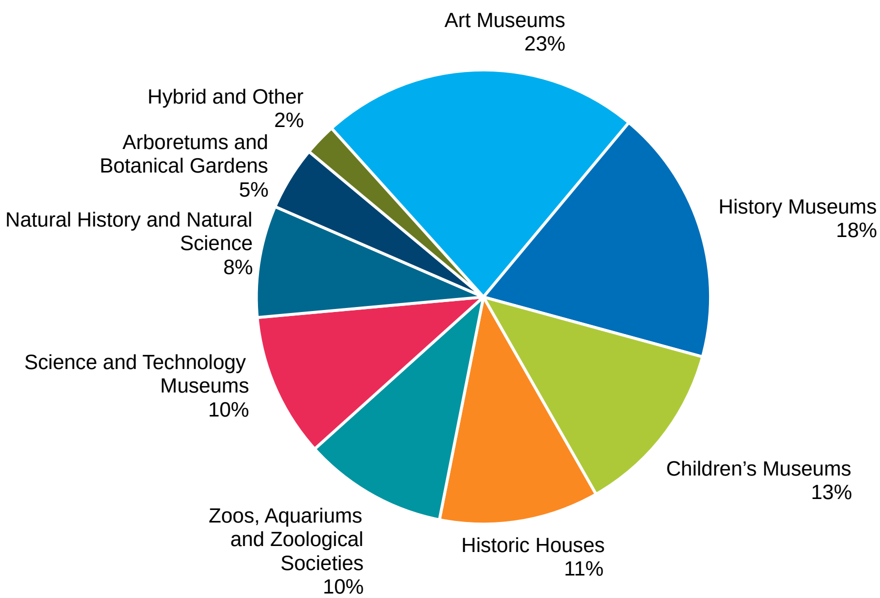
A quick guide summarizing these recommendations can be found in the Recommendations Factsheet.

Cultural Institution Performance Analysis

The research into the energy performance of cultural institutions started with building-level analysis and led to a portfolio-level analysis of all participating institutions.

Buildings were categorized into one of nine institution types Figure 4 shows the breakdown of participating institutions by type, representing all of the major museum types that align with the Institute of Museum and Library Services' Museum Data Universe.[20] The building-level analysis was primarily quantitative, based on energy consumption data, and the portfolio analysis included both quantitative and qualitative components.

FIGURE 4. FIRSTVIEW REPORTS BY INSTITUTION TYPE.



Individual Building Analysis

To conduct the individual building analysis, NBI used its in-house program called FirstView, a software tool that creates a simplified building energy model that can quickly diagnose opportunities for improvement in energy use and automatically compare a building's performance against peers. FirstView enables building owners and designers to extract targeted and useful energy performance information from basic energy data inputs.

HOW FIRSTVIEW WORKS

FirstView[21] takes in basic building demographic information and at least one year's energy usage to create a model of the building. The simulation model is weather-normalized for the location, meaning the energy a building would have used under average conditions, to create an energy signature that compares monthly energy use to monthly average outside temperature.

20 Institute of Museum and Library Services. (2018). *Museum Data Files.* https://www.imls.gov/research-evaluation/data-collection/museum-data-files

21 New Buildings Institute (NBI). (2018). *FirstView.* https://newbuildings.org/resource/firstview/.

The energy signature is also used for a diagnostic analysis that compares the building performance to pre-determined diagnostic thresholds in six areas: occupant load, heating and ventilation, reheat, cooling efficiency, system energy controls, and gas baseload. High energy use is expected during summer and winter months when heating and cooling systems are used more frequently. Milder "shoulder" seasons typically show lower energy use.

The FirstView outputs are simple but powerful. FirstView allows for disaggregation of energy end uses (heating, cooling, electric baseload, and gas/steam baseload), provides diagnostic building energy performance recommendations for those end-use categories, and compares a building's energy performance to benchmark values or to previous years' performance. This analysis goes beyond basic site energy per square foot, or energy use intensity (EUI), comparisons to help building owners and managers prioritize energy audit efforts and focus on the best retrofit opportunities.

In addition to an individual building's diagnostic comparison, the FirstView software allows for a building to be compared to a group of peer buildings. For this project, the custom comparison is based on the 189 Culture over Carbon participant buildings that provided adequate data to run a FirstView report.

USING FIRSTVIEW RESULTS

FirstView results provide an initial diagnostic look at how a building uses energy. Building owners, operators, and designers can use FirstView results and diagnostic recommendations to make more informed decisions about how to prioritize the next steps for their building. FirstVew can be a powerful tool to use prior to an on-site building energy audit to understand where the audit should focus.

Many of the Culture over Carbon participants found the FirstView content helpful to understand how their building compared to their peers' and prioritize energy efficiency projects. The graphic format of the outputs was reported by participants as being powerful in illustrating the need to address high thermal baseload and justify the investment in energy efficiency upgrades:

> "Having this data has provided the information and graphics that the managers need to show that energy updates are needed."

FirstView reports were also reported as useful for managers of a building within a larger portfolio:

> "This will be helpful to take to upper administration on our University campus to get changes made."

PARTICIPANTS

92 institutions expressed interest in participating in the FirstView analysis and provided energy use data for their buildings. FirstView reports could not be generated for buildings at all of these institutions due to data-related issues. This included complications due to delivered fuels (e.g., fuel oil or propane) and lack of building-level data for sites with district energy or multiple buildings sharing one meter. There were also issues unique to cultural institutions: historic homes with unique occupancy schedules and setpoints, museums with humidification requirements resulting in heating year-round, and atypical energy consumption due to COVID-19 protocols.

This resulted in a final total of 189 buildings analyzed through FirstView and receiving output reports.

Some institutions submitted data for multiple buildings. Examples include multiple historic houses on the same site, a large institution that owns and manages multiple distinct museum buildings in varying geographical locations, and multiple buildings at a zoo. The number of institutions by type and number of buildings within these institutions is provided in Table 3. For example, 20 institutions that identified as art museums shared data for 32 buildings (some institutions encompassed multiple buildings).

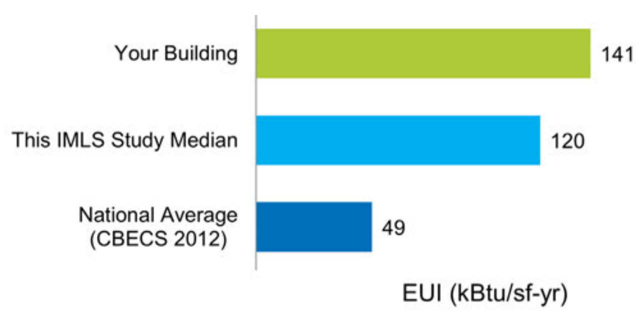
TABLE 3. NUMBER OF INSTITUTIONS AND BUILDINGS BY TYPE, FOR BUILDINGS THAT RECEIVED FIRSTVIEW REPORTS.

Museum Type	Institutions	Buildings
Art Museums	20	32
History Museums	16	24
Children's Museums	11	10
Historic Houses	10	39
Zoos, Aquariums and Zoological Societies	9	30
Science and Technology Museums	9	18
Natural History and Natural Science	7	10
Arboretums and Botanical Gardens	4	18
Hybrid and Other	2	8
Total	**88**	**189**

ENERGY USE INTENSITY

Each FirstView report includes the building's annual EUI, which is calculated by dividing the total annual energy use by the size of the building (kBtu/sf-yr). The EUI is compared to the median EUI for buildings in the IMLS study as well as the national median for Public Assembly buildings from the 2012 Commercial Buildings Energy Consumption Survey (CBECS).[22] Note that CBECS' public assembly buildings includes theaters, libraries, and convention centers which do not have the same occupancy data and use patterns as the cultural institutions in this study. An example of a history museum's FirstView report EUI comparison is shown in Figure 5. In this example, the building's EUI is 141, indicating that it uses more energy per square foot than the median for this IMLS study and the national CBECS average.

FIGURE 5. EUI COMPARISON FOR A PARTICIPATING BUILDING, THE STUDY MEDIAN, AND CBECS MEDIAN.

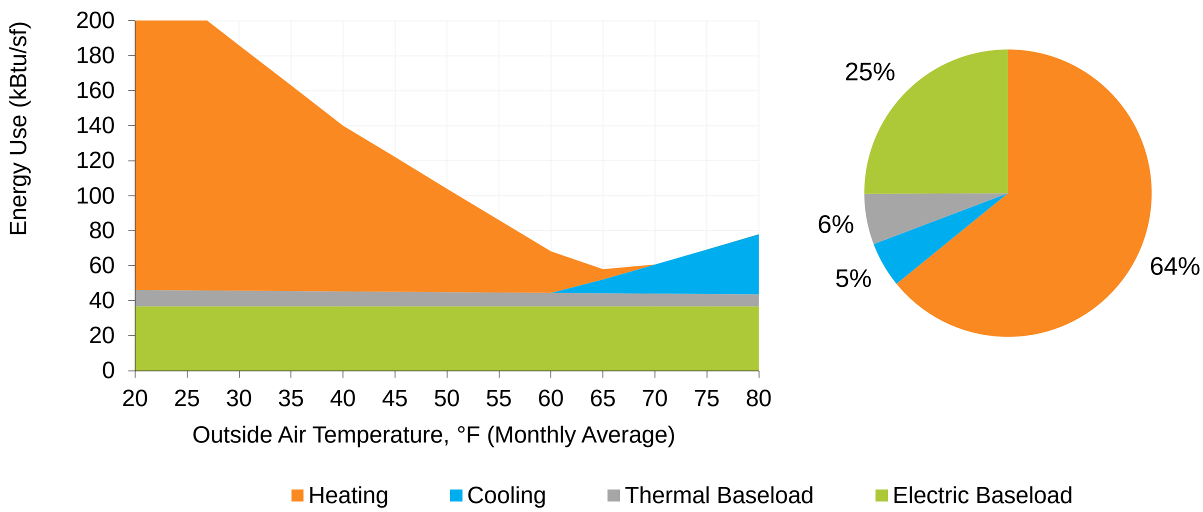


22 U.S. Energy Information Administration. *2018 Commercial Buildings Energy Consumption Survey final results.* https://www.eia.gov/consumption/commercial/

END USE CATEGORIES

FirstView reports also provide disaggregated end-use category information. An example of the end-use energy breakdown for the same history museum in Figure 5 is shown in Figure 6. The height of the yellow area indicates the electric baseload, which includes year-round energy use like lights and plug loads that are independent of the weather. For institutions that have server rooms, this can also increase the electric baseload. The height of the gray area indicates thermal baseload, which includes year-round energy used for loads such as water heating or cooking, coming from a fuel such as fossil gas, propane or fuel oil, district hot water, or steam. The red area indicates the energy used for space heating, and the blue area indicates the energy used for space cooling. The steepness of each slope and the overlap between the two are indicators of envelope, system loads, and controls.

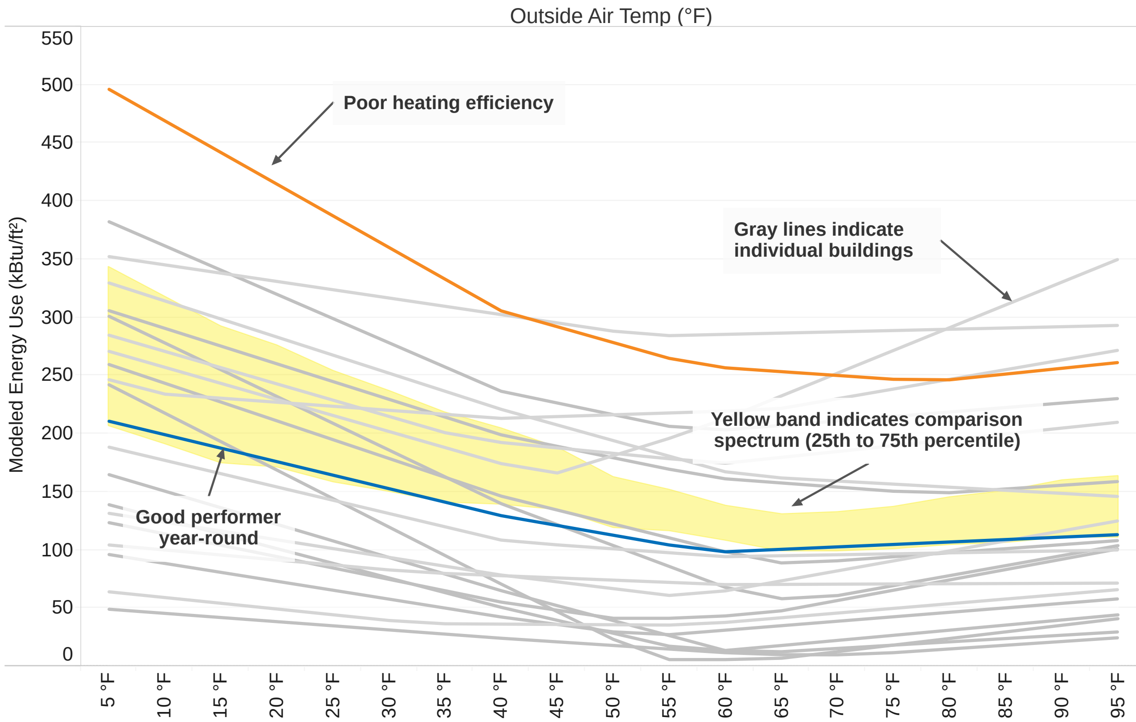
FIGURE 6. EXAMPLE SINGLE-BUILDING ENERGY USE BY END-USE CATEGORY.



To help building representatives assess their building's performance against peer buildings, the FirstView analysis includes generation of a comparison spectrum (reference band). This spectrum shows where most (25th to 75th percentile) of the institutions' energy use intensity falls, as a function of average monthly outside air temperature.

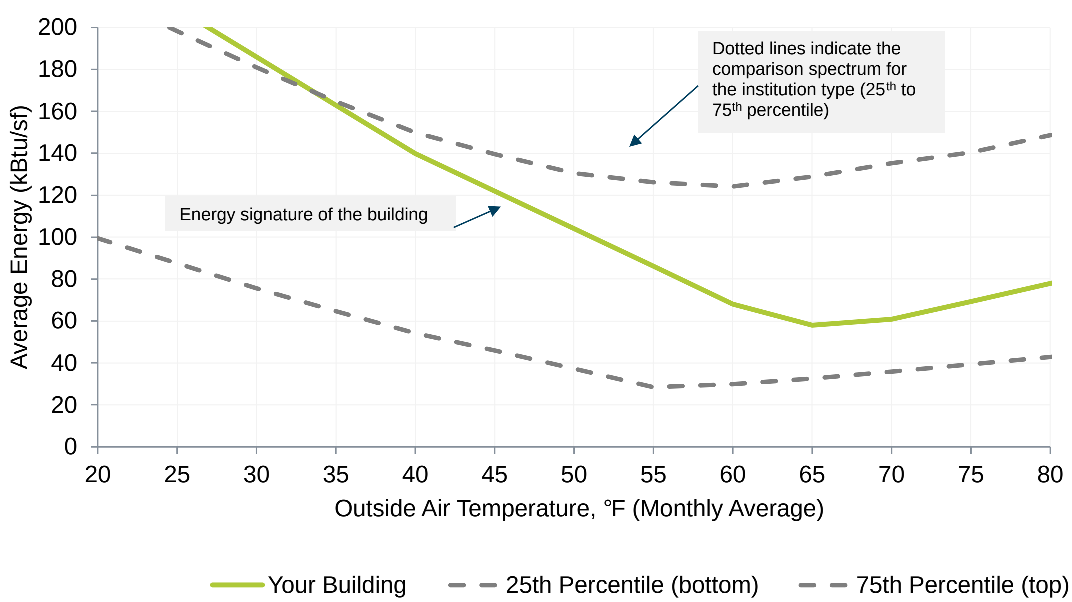
NBI generated and tailored a comparison spectrum for each cultural institution type. Figure 7 shows an example energy signature spectrum. The yellow band illustrates the 25th–75th percentile of annual energy consumption for peer buildings. Each grey line is the energy signature for one analyzed building. The orange line shows a building with a very steep slope, which means that the energy use increases rapidly as temperature decreases. This indicates a poor heating efficiency and envelope. The blue line calls out a building with good year-round performance. Since it is on the lower end of the yellow band, it has slightly better-than-average performance.

FIGURE 7. FIRSTVIEW COMPARISON SPECTRUM (ENTIRE IMLS COHORT).



The comparison spectrums specific to each cultural institution type were used in the FirstView reports to show how the building's energy signature compared to the reference spectrum. Figure 8 shows an example from a FirstView report. The comparison spectrum (bounded by the dotted grey lines) is for the specific cultural institution type this building falls within. The building's energy signature (green line) mostly falls within the comparison spectrum. However, when the temperature drops below 35°F, the building begins to use more energy than its peers.

FIGURE 8. BUILDING ENERGY SIGNATURE (GREEN) WITH COMPARISON SPECTRUM (DOTTED LINES) FOR THE APPLICABLE INSTITUTION TYPE.



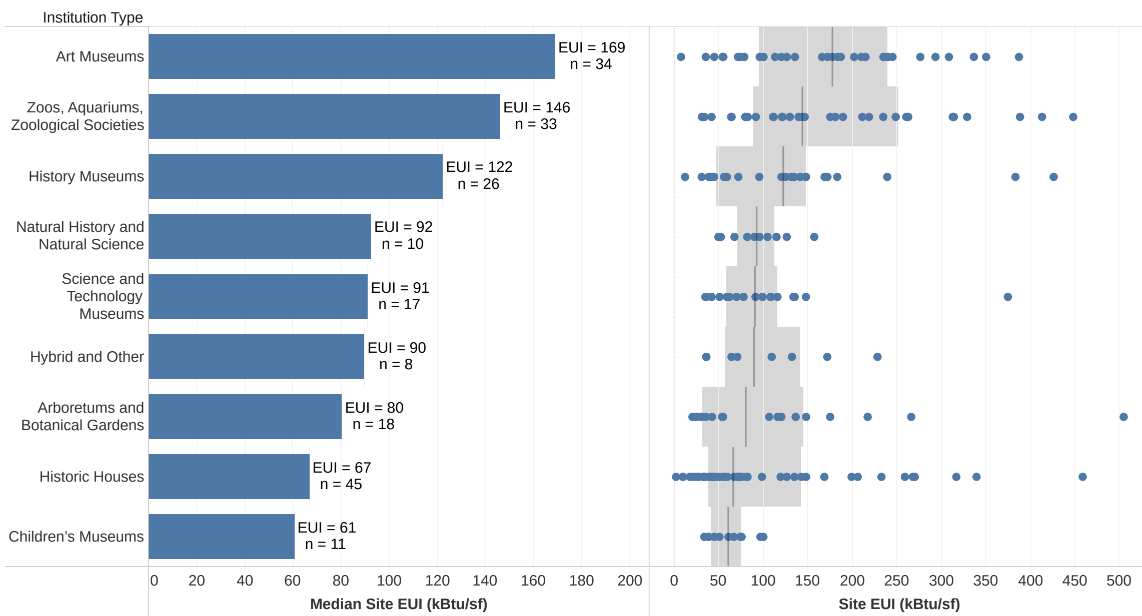
Portfolio-Level Analysis

In addition to the building-level FirstView analysis, NBI conducted an overall portfolio assessment to help understand what is "typical" for cultural institutions and specific sub-types such as art museums or historic houses. These insights were taken from the cohort that received FirstView reports.

EUI AND CARBON INTENSITY

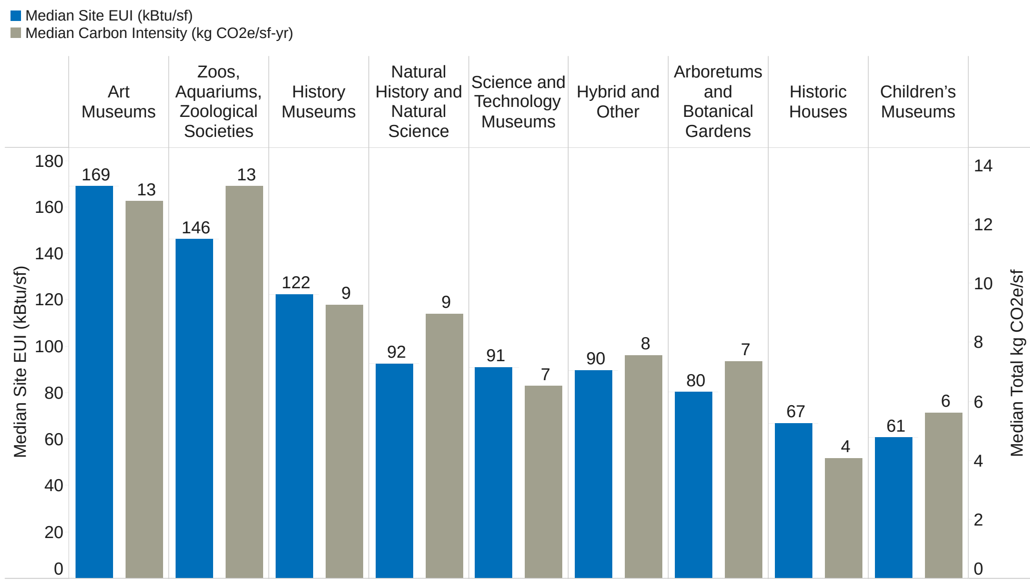
The median EUI of the cultural institutions studied vary greatly by institution type. The range of EUI by cultural institution type is shown in Figure 7. The number of buildings included in the median calculation is shown as data labels. Although we were able to determine a median EUI by institution type, some institution types, such as historic houses, have a large spread of individual building EUI (individual points in right panel). Others, such as Science and Technology museums, are closely clustered. This is likely indicative of the variation in individual building characteristics within the institution type.

FIGURE 9. MEDIAN SITE EUI BY CULTURAL INSTITUTION TYPE (LEFT) AND INDIVIDUAL BUILDING EUI BY INSTITUTION TYPE (RIGHT).



Building energy intensity is not directly related to carbon intensity. While the carbon intensity by institution type trends similarly to the EUI, there were a few minor differences, due to the types of fuel consumed on-site and the location of the building, which affects the carbon intensity of the grid-delivered electricity. Note that our analysis focused on the total energy consumption of buildings, rather than net consumption after renewables. Buildings with on-site renewable energy that offsets 100% of the energy use have a "real-world" carbon intensity of nearly zero. However, to understand the total energy consumed by the building, we included the consumption of on-site solar and/or other on-site renewable energy.

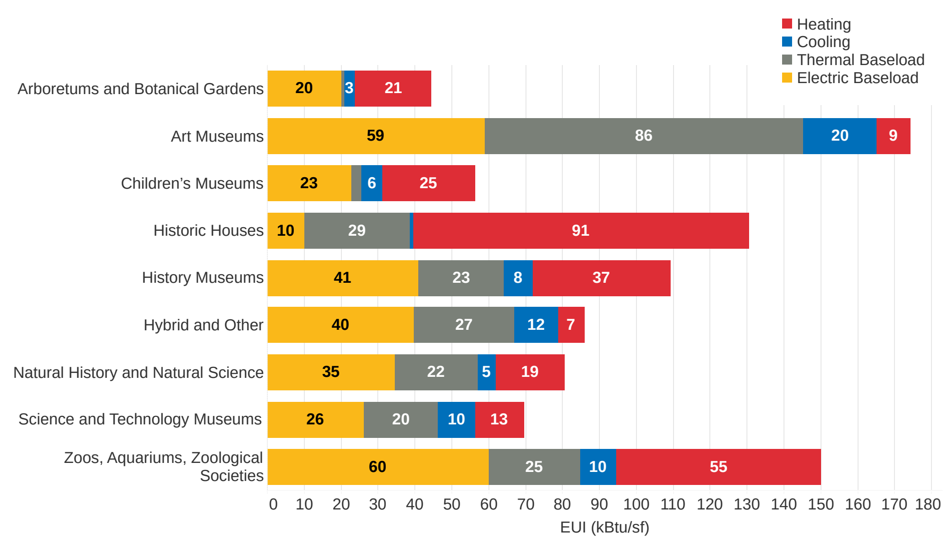
FIGURE 10. SITE EUI AND CARBON INTENSITY BY CULTURAL INSTITUTION TYPE.



END-USE ANALYSIS

Digging deeper into what drives the EUI for each institution type, we analyzed the EUI by end use. **The primary drivers of energy use vary by institution type,** as shown in Figure 11. Historic houses use a high amount of energy for seasonal space heating as compared to other end uses (such as seasonal cooling or electric baseload). This is most likely due to a combination of leaky windows and envelopes, little-to-no insulation, and/or inefficient heating systems—issues that may be difficult to resolve while maintaining historic building status. Art museums have a high thermal baseload, meaning that they use fossil gas or another fuel such as chilled water or district steam year-round. The high thermal baseload for art museums is most likely due to the strict humidification requirements needed to maintain collections.

FIGURE 11. AVERAGE WEATHER-NORMALIZED EUI BY END USE AND INSTITUTION TYPE.



Thermal baseload (gray) refers to the year-round energy used for loads such as water heating or cooking, coming from a fuel such as fossil gas, propane or fuel oil, district hot water, or steam, and is shown distinctly from space heating (shown in red). Electric baseload (yellow) refers to year-round energy use like lights and plug loads that are independent of the weather, and excludes space cooling, which is shown in blue.

The end-use analysis illuminated two key trends related to common issues for cultural institutions. First, cultural institutions have high thermal baseloads overall. **Half of all buildings analyzed were flagged for high thermal based loads** (see Table 4). This could be caused by high domestic hot water use, poor water heater efficiency, high water heating setpoints, gas process loads, and/or year-round HVAC reheat, typically associated with humidity control. Several buildings had unexpectedly high gas use in the summer. In one case, the cultural institution reported that heaters run year-round to maintain the appropriate humidity for their collection.

About **one-third of the buildings analyzed were flagged for inefficient heating and ventilation.** This may be due to excess outside air rates (i.e., bringing in more outdoor air than is necessary to maintain the air quality of the building), high outside air infiltration, poor control settings, and/or issues with the fan schedule. These issues can be mitigated through heating system upgrades including improved control strategies. Envelope improvements such as increased insulation levels and weatherization can be especially effective to mitigate infiltration issues in older buildings.

TABLE 4. MOST COMMON DIAGNOSTIC FLAGS FOR BUILDINGS WITH FIRSTVIEW ANALYSIS.

Diagnostic	Percent of buildings flagged (number of buildings)
High thermal baseload	52% (104)
Poor heating & ventilation efficiency	32% (62)
High light/plug load use	27% (55)
Poor cooling efficiency	22% (44)
High external/process load	21% (43)
Apparent excessive reheat	6% (12)

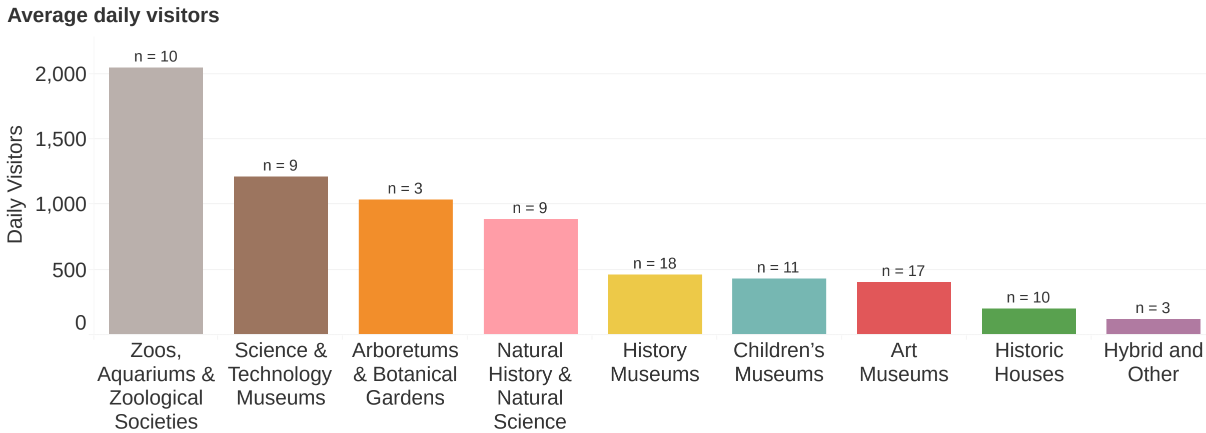
BUILDING OCCUPANCY

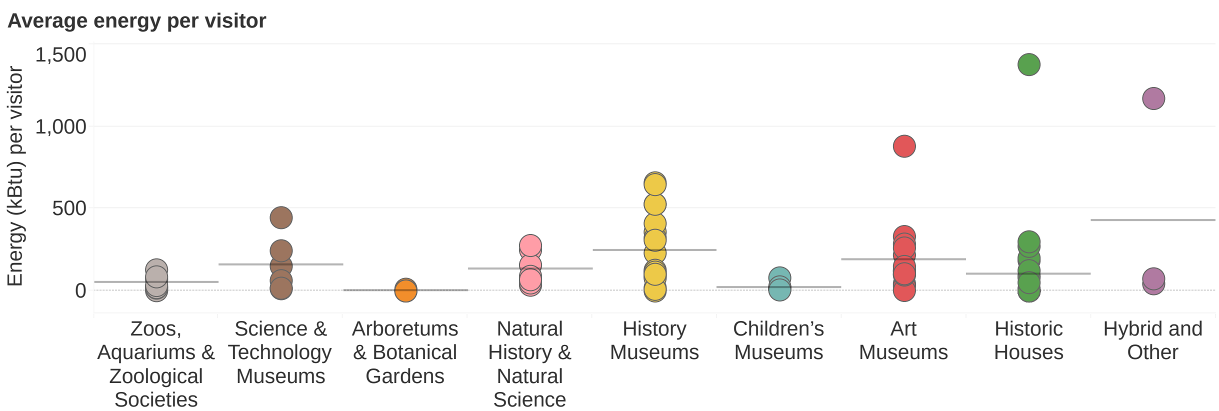
The occupancy of most cultural institutions is fairly consistent throughout the day or week, unlike the CBECS "public assembly" building group which includes convention centers that have large swings in occupants across a week or month. There are some exceptions—for example, historic sites may rent out their properties for weddings and some museum types host private events that could cause a short-term increase in energy use. However, these are typically isolated events that would account for a small share of the overall annual energy consumption. Cultural institutions' energy demand is often set by 24/7 temperature and relative humidity setpoint requirements dictated by the needs of the artifacts, animals, or plants. This contrasts with other public assembly buildings' energy demand, which is based on heating and cooling to maintain comfort for the occupants that come and go over the day and/or week.

Visitation is not predictive of annual energy consumption for the participants in this study, as shown in Figure 12. Zoos and aquariums reported the most daily visitors (top panel). However, this cultural institution type had some of the lowest average energy use per visitor, meaning that each visitor's theoretical impact on energy use is low. Conversely, history museums reported lower visitation rates but this institution type had a higher average energy per visitor.

As previously described in the EUI analysis, some institution types have a broader spread than others. Seven historical houses were excluded from Figure 12 as their annual energy use per visitor exceeds the energy/visitor axis values.

FIGURE 12. AVERAGE DAILY VISITORS AND ENERGY PER VISITOR INTENSITY BY INSTITUTION TYPE.



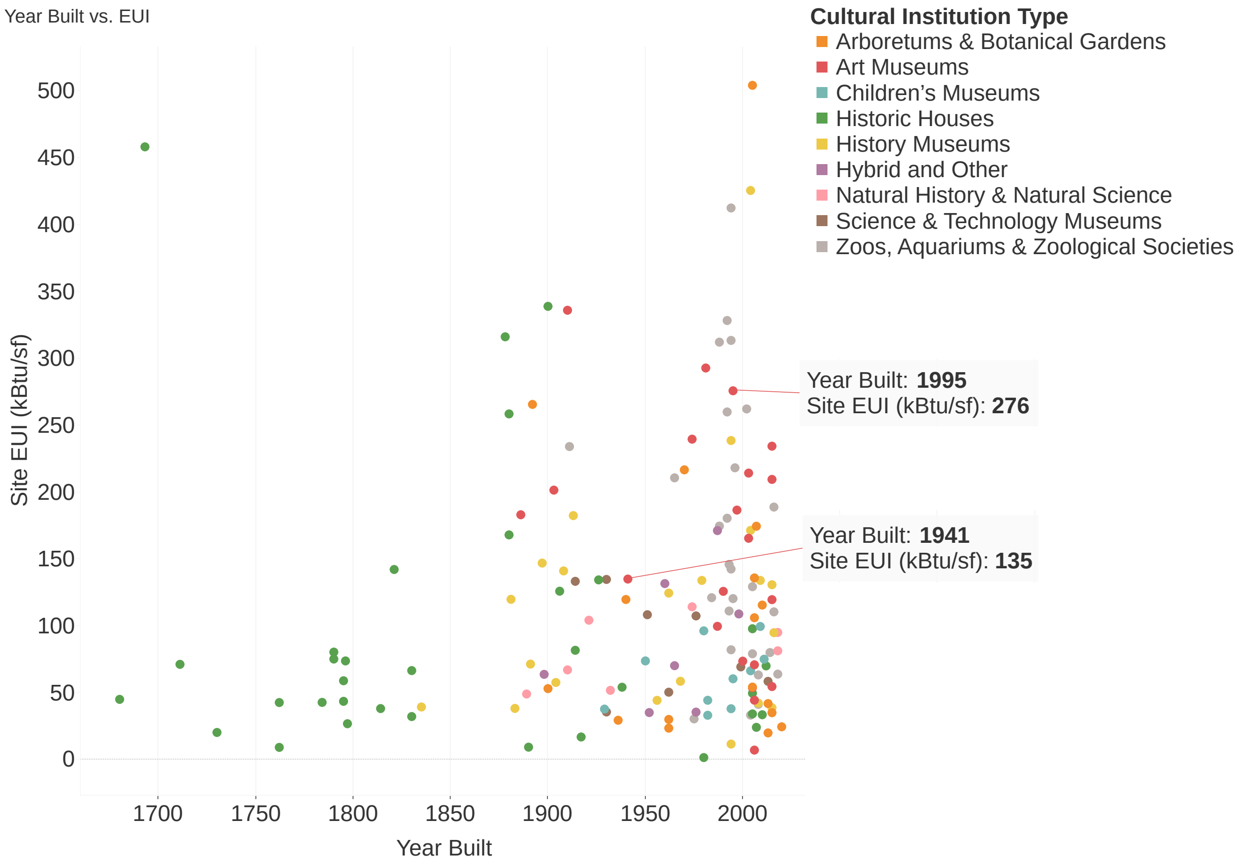


Overall, the energy per visitor per year ranged from 1 to 1,375 kBtu, excluding major outliers. This speaks to the importance of individual institutions implementing the energy reduction strategies that are most applicable to their specific institution, and it should empower institutions of all sizes to see that increases in occupancy do not necessarily correlate to a higher energy burden. A potential pathway to lowering the energy consumption per visitor is to study if temperature and/or relative humidity ranges can be adjusted or a separate dehumidification system installed.

BUILDING AGE AND EUI

Studying the possible correlation of EUI and building vintage (i.e., year of construction), provided unique results with a portfolio of buildings spanning over 300 years. As shown in Figure 13, some of the participating buildings are more than 300 years old. However, most of the participating buildings were built after 1900. Year of construction does not appear to be correlated with the site's EUI. For example, art museums (red dots) built between the early 1900s to 2015 have EUIs ranging from less than 50 to more than 300.

FIGURE 13. YEAR BUILT VS. SITE EUI, BY CULTURAL INSTITUTION TYPE.



FUEL TYPES

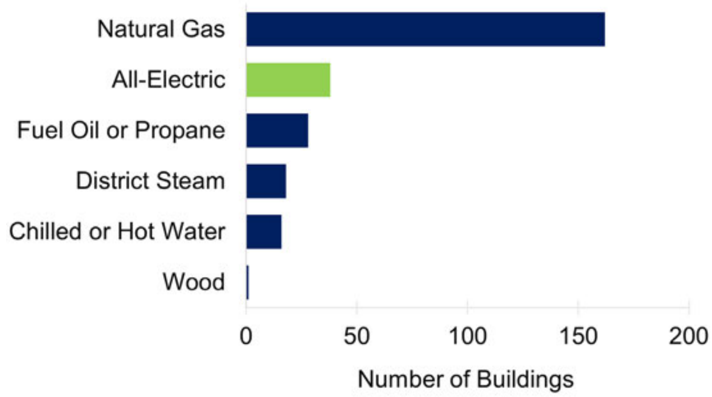
Most of the buildings studied were dual-fuel buildings using electricity and fossil gas or oil (see Figure 14). 20% of the buildings are all-electric, meaning they have no on-site combustion.

For dual-fuel buildings, gas appliances such as water heaters and other fossil fuel-burning heating devices generate air pollutants that pose health risks to occupants (and to nonhuman animals, for zoos). Using systems that burn natural gas in buildings can contribute to indoor/local air pollution via unvented or inadequately vented products of combustion and from leakage of unburned fuels. Gas exhaust has many pollutants including particulates, formaldehyde, methane, volatile organic compounds (VOCs), nitrogen oxides (Nox), and sulfur oxides (Sox). It is relevant to note that children are especially vulnerable to these pollutants. Children breathe more air pound-for-pound of body weight compared with adults, and their immune system and lungs are not fully developed, which can cause their bodies to react differently to airborne pollutants—most commonly manifesting in asthma.[23] Transitioning to electric building technologies usually saves energy, lowers emissions, and will deliver the same thermal comfort as traditional gas equipment, all at lower risk to occupants, including the children in the communities that cultural institutions serve. Planning ahead to make the building "electrification ready" can ease the decarbonization process. The first steps include making a plan to

23 Landrigan, Philip J. et al. (2004). *Children's Health and the Environment: Public Health Issues and Challenges for Risk Assessment.* Environmental Health Perspectives. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241836/pdf/ehp0112-000257.pdf and Schwartz, Joel. (2004). *Air Pollution and Children's Health.* Pediatrics. https://publications.aap.org/pediatrics/article-abstract/113/Supplement_3/1037/66815/Air-Pollution-and-Children-s-Health?redirectedFrom=fulltext

electrify gas equipment, checking your electrical panel capacity, talking with an electrician about electrification, and installing additional outlets near existing gas equipment. Additional recommendations related to carbon reduction strategies can be found in the [Targeted Carbon Reduction Strategies] section.

FIGURE 14. FUEL TYPES IN BUILDINGS ANALYZED WITH FIRSTVIEW.



Sector-Level Analysis: The Carbon Inventory Project

Culture Over Carbon's results highlight the cultural sector's potential to greatly impact overall GHG emissions by reducing energy consumption in buildings. When the initial research process revealed the difficulty of collecting energy data as the most common barrier to participation, the project team created the Carbon Inventory Project (CIP). The CIP goals were to help staff at cultural institutions build capacity to monitor and report their own energy use, familiarize them with ENERGY STAR® Portfolio Manager® to provide aggregate data to raise awareness about the impacts of energy-use carbon emissions, and use their knowledge to advance environmental leadership in the U.S. cultural sector.

Calculating a sector-wide carbon footprint, as CIP did, allows for increased accountability and transparency of the sector's emissions, and opportunity for:

- Quantitative tracking of progress to decrease the sector's carbon footprint
- Setting a carbon footprint reduction goal
- Holding the sector accountable for their emissions
- Better recognition of existing carbon footprint reduction activities in the sector
- Inclusion in reports and studies, including the U.S. National Determined Contributions[24]
- Easier reporting of energy and carbon data to jurisdictions or for future research on the sector

Over an eight-month period, the project team delivered seven webinars providing training and resources on Portfolio Manager and developed a spreadsheet tool that would allow institutions using a method other than Portfolio Manager for measuring/tracking energy consumption to participate in CIP. Participants used either the spreadsheet tool or Portfolio Manager to report their 2022 total greenhouse gas (GHG) emissions (in metric tons) and GHG emissions

24 United National Climate Change. *Nationally Determined Contributions (NDCs).* https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

intensity (in kg CO_2e/sf) associated with energy use. Anecdotally, participants reported using their experience with benchmarking, and their data, to respond more easily to requests for information and to craft stronger applications to fund capital projects.

PARTICIPANTS

80 cultural institutions submitted their 2022 total GHG emissions and GHG emissions intensity based on their energy consumption from January 1, 2022, to December 31, 2022. Some cultural institutions that did not use Portfolio Manager provided annual data over time periods that varied slightly from the calendar year due to their utility billing cycles (e.g., January 7, 2022 to January 7, 2023), but this is not expected to have a significant impact on the results.

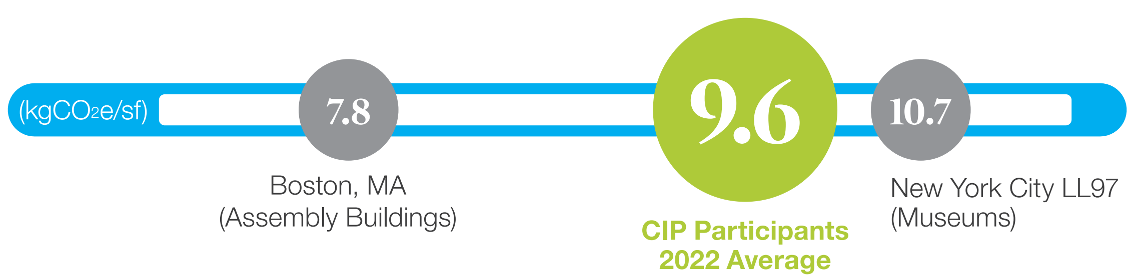
Participating facilities ranged in size and type; from small historic houses around 2,000 square feet, up to a natural history museum greater than 700,000 sf, located across 28 states. The participating institutions manage a combined 20 million sf of conditioned space which is the equivalent of more than 450 acres. To put that number in perspective, that's about the size of Disneyland in Anaheim, CA.

RESULTS

The collective GHG emissions associated with the 2022 energy consumption of Carbon Inventory Project participants were more than 187,000 metric tons CO_2e. This is equivalent to the annual emissions of over 41,000 gasoline-powered passenger cars. Our sample shows that generally, the larger the building, the higher the GHG emissions. Many of the CIP participants manage buildings less than 50,000 square feet and estimate their total emissions at less than 1,000 metric tons of CO_2e, but we also saw organizations managing 500,000+ square foot buildings with estimated 2022 emissions totaling 10,000 metric tons or more.

CIP participants reported an average GHG intensity ranging from less than zero (due to on-site renewables) to approximately 49 kgCO_2e/sf, with an overall average of around 9.6 kgCO_2e/sf. This metric will become increasingly important as more local jurisdictions adopt benchmarking requirements. New York City, NY and Boston, MA currently require commercial buildings (which includes museums) to meet emissions intensity limits starting in 2024 and 2025, respectively. The limits shown below are for the most similar building type through 2029 (shown in parentheses). Limits will become more stringent in future years.

FIGURE 15. GHG EMISSIONS INTENSITY LIMITS FOR TWO (SAMPLE) LOCAL BENCHMARKING MANDATES AND THE 2022 AVERAGE FOR CIP PARTICIPANTS.



About one quarter of all CIP respondents were art museums, representing more than 3 million square feet of conditioned space with an average GHG Intensity of around 11.8 kgCO_2e/sf, two points higher than the overall average in our sample. This emphasizes the findings from the Culture Over Carbon portfolio analysis, which found that art museums had some of the highest GHG emissions. Art museums frequently have the strictest temperature and humidity requirements for maintaining the environmental conditions of their collections which may contribute to higher GHG emissions.

Much like our findings from the Culture Over Carbon project, we heard that energy accounting was challenging for participants at the outset. The variety of monitoring techniques, including the availability and accessibility of building specifics and energy use information contributed to challenges. However, those with up-to-date data found it highly actionable. Some institutions, with updated Portfolio Manager data, reported that Portfolio Manager is an easy way to use energy data for capital planning work and funding applications. Quarterly updates appeared to be the most successful approach to maintain data.

CIP is a critical step in building awareness in the cultural sector about the importance and urgency of energy and carbon benchmarking. As we learned in the Culture Over Carbon project, the cultural sector has the opportunity to create meaningful reductions in GHG emissions. **The total GHG emissions of CIP participants accounts for about 5% of the estimated 4 million metric tons of CO_2e emitted by the entire cultural sector in 2022.** If the entire sector made the effort to reduce their annual energy consumption by 30%, the related GHG emissions reductions would be equivalent to eliminating the annual emissions of three fossil gas-fired power plants. Every additional 10% reduction in emissions from the sector's 2022 total equates to negating the annual emissions of one more fossil gas fired powered plant (e.g., a 40% reduction = 4 plants).

More information about CIP and the project results including a summary factsheet, can be found on Environment & Culture Partners' website.


The Carbon Inventory Project 2023
Cultivating the U.S. Cultural Sector's Commitment to Understanding and Reducing Energy-Use Carbon Emissions
Energy Data Supports the Sector's Carbon Impact Accounting

Operational Insights for Cultural Institutions

In addition to the quantitative individual building and portfolio analysis described above, we utilized information from all the institutions that submitted a data collection sheet, publicly available information from institutions are required to participate in benchmarking due to jurisdictional mandates, and a series of targeted interviews were conducted to gather additional insights into the operational trends of the cultural institution sector.

A Note About the COVID-19 Pandemic

Because this project began data collection in 2021, many institutions were only able to share annual energy data for 2020 or 2021, which may not be indicative of typical occupancy due to the COVID-19 pandemic. As discussed in the Building Occupancy section, occupancy is not the prime indicator for energy consumption, and we do not expect this to impact the applicability of the project findings. However, it is worth summarizing the impact of the COVID-19 pandemic due to the serious impact it had on cultural institutions of all types and in all geographic regions.

Participants reported many impacts of the pandemic, these included: cancelled events, moving to a remote staffing model, letting go of staff, mask requirements for patrons, and enhanced cleaning protocols. Institutions such as zoos and botanical gardens, which have outdoor spaces, and must maintain critical operations such as animal care, reported that the primary impact was a decrease in visitor capacity.

Museums with indoor collections and hands-on exhibits such as children's museums were hit hardest. Exhibits were reconfigured or removed and some objects could only be accepted via mail. School programs and other public programming as well as private event rentals, an important source of income for many institutions, were cancelled. One art museum reported that even after reopening, they only received 16%, or 30,000 visitors in 2021, compared to an annual average of 190,000 visitors pre-pandemic.

Despite this loss of revenue and massive change in occupancy, several institutions reported that they needed to continue to run the HVAC system 24/7 to preserve the collection—meaning that despite the significant loss of revenue, energy bills did not decrease. Some institutions also had increased expenses due to investing in upgrades to the HVAC system that would provide additional outside air circulation, installation of ultraviolet filters, and increased energy consumption to circulate air through finer filters.

This information is important to keep in mind while considering how COVID-induced protocols and spending may continue to impact the operational trends of the sector.

Sustainability and Renewable Energy

15% of participants reported that they receive power through a community solar program, power purchase agreement, or another mechanism to obtain energy from renewable sources. When including the additional 25 buildings that were reported to source energy from on-site photovoltaics, this accounts for a little **over one-quarter (29%)** of participants.

Of the 88 institutions that submitted a data collection sheet, more than **40%** reported that they had an energy or sustainability team or manager, and nearly **70%** reported that they have sustainability goals or are working toward developing sustainability goals.

A common thread in participant responses was the tension between energy efficiency, collections preservation, and funding availability:

> "We end up limiting our HVAC use because of the high cost of electricity but realize we really should be upgrading to a more energy efficient model so that we can protect our collections better."

Another participant described their struggle with rising energy costs, underlining the importance of implementing energy efficiency measures:

> "The rising cost of energy is hitting us hard. Our utility costs are $30,000 ahead of budget in the first six months of this fiscal year."

Despite the interest in limiting energy use, for many of the participants at smaller cultural institutions, financial means and staff bandwidth to track energy consumption and prioritize energy efficiency upgrades are limited. Lack of procedures and documentation can make it challenging in the case of staff turnover:

> "We are a small museum that is self-funded, that is to say we don't rely on grant money to stay open, so we try to stay as lean as possible. Every dollar we spend on un-fun things is a dollar we can't spent on exhibits, so we are very interested in cutting down on our utility bills."

Operating Conditions and Major Mechanical Systems

Cultural institutions often navigate complexities related to the conditions that artifacts must maintain, multiple zones, and a variety of mechanical equipment.

103 of the 243 buildings studied provided details about their temperature and/or humidity settings. **87%** of respondents shared that they have some sort of humidity controls. For those with humidity controls, the typical setting is 35 to 55% relative humidity (RH). However, many institutions reported multiple zones with varying humidification requirements. For instance, one museum reported humidification setpoints ranging from 20 to 75% RH and dehumidification setpoints ranging from 60 to 99% RH. Typical temperature setpoints ranged from 69 to 73 degrees Fahrenheit (F). Several institutions noted the use of refrigeration units used to kill pests before adding to their collection and freezers to maintain sensitive items such as photo negatives. Restaurant or café equipment reported in buildings also add substantial energy loads and a very different operating protocol than collections preservation.

In terms of mechanical equipment, larger cultural institutions noted the requirement for multiple air handling units or chillers for providing heating, cooling, and ventilation to the entire building. Beyond that, there is much variation in size and age. One institution reported that their heating, ventilation, and air conditioning (HVAC) equipment is still the original equipment installed in 1962. Other institutions described a rolling update schedule for their equipment, with some

30-year-old units in use alongside equipment newly installed in 2021. This emphasizes how important it is for cultural institutions to consider their individual building needs when creating an energy efficiency and/or carbon reduction strategy; a building with brand new HVAC equipment will have different needs than a building with older equipment and less sophisticated ventilation.

Only **one third** of buildings were reported to use a building management system (BMS) to automatically control the lighting, temperature, and RH. Studies in commercial buildings have found that building management systems, when optimized, can reduce building energy consumption by as much as 30%.[25] Cultural institutions with a BMS may be able to realize energy savings with minimal effort, just by optimizing their existing controls. For cultural institutions that are not using a BMS, this may be a strategy to prioritize.

Interview Findings

To better understand the nuances of cultural institution operation, the Culture Over Carbon team conducted interviews with select participants, aiming to gather perspectives from a variety of cultural institution types and sizes, across the country. The Culture Over Carbon team interviewed individuals representing nine institutions, with three additional institutions taking an online survey version of the interview questions. Most of the interview participants have been with their institution for at least five years, (14 years on average), so they were able to provide both depth and breadth of experience. Most of the participants indicated that they knew the basics of sustainability and energy efficiency practices at their institution.

WOW! Children's Museum. Lafayette, CO

25 Pacific Northwest National Laboratory. (2017). *Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction.* https://buildingretuning.pnnl.gov/publications/PNNL-25985.pdf

COMMON CHALLENGES

Interview respondents noted several common challenges both to energy tracking and to implementing energy efficiency or sustainability measures. A summary of the challenges and associated suggested solutions are provided below.

TABLE 5. COMMON ENERGY-RELATED CHALLENGES AND SOLUTIONS.

Type of challenge	Description of challenge	Suggested solutions
Energy data collection	Tracking solar generation	Take stock of the data available to you and understand how your utility bills track generation and consumption. ENERGY STAR offers a helpful training[26] on how to track on-site renewable energy.
	Tracking delivered fuels (e.g., fuel oil, propane)	Request both the gallons delivered and the cost when deliveries happen and maintain a tracking spreadsheet. Consumption estimations can be generated by checking tank gauges monthly.
	Getting energy data from a different department or parent organization*	Many institutions do not have a designated sustainability team and resources allotted to this kind of effort. However, there may be people who are willing to help with existing energy tracking mechanisms within the institution. For example, the financial department will likely be monitoring energy bills. In this scenario, streamlining energy data tracking into existing financial monitoring may provide easy entry to tracking energy consumption (e.g., add a column for kWh in an existing spreadsheet instead of starting from scratch).
Implementing energy efficiency/ sustainability measures	Funding constraints	See detailed recommendations that follow
	Stakeholder buy-in	See detailed recommendations that follow
	Limitations due to ownership structure or historic building status	Utilize a network of similar institutions to understand all the options that are available and explore alternatives.
	Challenges controlling temperature and/or humidity in large, open spaces	Evaluate ways to partition spaces, limit solar heat gain from large windows, and invest in zonal sensors where possible. Consider the challenges of large, open spaces when developing renovation plans.

*applies primarily to cultural institutions on university campuses or operating in a municipal-owned building

26 U.S. Environmental Protection Agency. *How to Track Onsite Renewable Energy in Portfolio Manager.* https://www.youtube.com/embed/L9pvzTeruZM?width=640&height=480&iframe=true

RECOMMENDATIONS FROM INTERVIEWS

The recommendations below represent key concepts that come directly from interviewees. While every cultural institution is unique, there are certain tactics and concepts that will aid all cultural institutions as they work to benchmark their buildings and consider energy efficiency and decarbonization efforts.

Look for cost savings opportunities everywhere

Interview respondents shared a variety of strategies to reduce cost barriers to energy-saving projects. Most respondents emphasized the importance of taking advantage of incentives and grants, which may come from a variety of sources, including the local utility, the city, county, state, federal programs, and foundations. Interviewees did mention that applying for grants, especially, requires dedicating staff time not just to the application process, but implementing the work if it is funded. One interviewee shared that they won a grant that allowed them to employ a sustainability coordinator for a two-year contract, which will go a long way to accomplishing their goal of establishing an energy baseline.

Being open-minded and looking at operations as a whole can yield savings. For example, one interviewee was able to secure sponsorship with a local company to install an educational exhibit about solar energy. This furthers the museum's mission, and the exposure benefits the company. While not directly related to energy savings, one museum noted that they were able to save a significant amount of money on their annual operating costs simply by reviewing their insurance policy—they (a children's museum) found that they were being insured as an art museum with much higher protections than were actually required.

As described above (see Prioritizing Strategies), an energy audit is a relatively small investment that can uncover no- or low-cost changes that can result in energy savings. For example, one institution found that although they needed to maintain temperature and humidity conditions 24/7, they did not need to be ventilating 24/7. Reducing their ventilation requirements allowed them to save energy. Going through the audit process may also help encourage staff to think ahead—interviewees noted that emergency replacements don't allow time to research energy efficient alternatives, and such alternatives may not be stocked and immediately available. Having a proactive replacement plan for major mechanical systems and ensuring budget is set aside for their replacement can avoid stressful decision-making and funding constraints in the future. Energy Service Companies (ESCOs) offer efficiency-as-a-service financing solutions that remove upfront cost barriers and help with creating replacement plans.

Get stakeholder buy-in with a "champion" and a compelling case

Cultural institutions reach a diverse audience and can make a big impact on their local communities. Prioritizing energy and carbon reductions is an opportunity to engage and inspire visitors, including future generations, and an opportunity to entice donors. The most impact will be realized when executives prioritize energy savings, implementation staff are motivated to find opportunities to save, and facilities/maintenance staff are provided training to operate systems most efficiently. Interview respondents noted that finding a "champion" on the Board or other governing body that has influence and can move things forward will go a long way. One participant noted the struggles they faced to provide energy data without this upper-level buy-in:

> "We lost a lot of traction due to short-staffing of key decision-making positions. The museum was without a CEO for one year. The COO and Facility Manager were both on extended leaves, then the Facilities Manager permanently left."

The other key to successful buy-in is ensuring that the value of proposed projects is clearly communicated. Cultural institutions have a lot of competing priorities, so showing how a proposed change can benefit multiple values streams (e.g., financial savings, alignment with mission, carbon emission reduction, educational opportunity) can make a more compelling case than a single benefit. If financial savings are a primary value stream, clearly communicating the return on investment is important. Some institutions noted that investments will only be approved if they will provide a return on investment within a certain time period, so evaluating this when completing initial project scoping can be important.

Remember that you are not alone

One of the key points emphasized by all interview respondents was the importance of not feeling alone—institutions of all sizes and budget amounts struggle with energy tracking, efficiency upgrades, and reducing carbon emissions. One interviewee noted that through recent sustainability efforts and conversations, they learned that their facilities director was unaware of what zones each rooftop HVAC unit was serving, despite having been with the organization for 25 years! This emphasizes the importance of not making assumptions, being willing to ask questions, and utilizing as many departments/resources as possible. While setting aside funding for a dedicated energy or sustainability manager will provide great value, this isn't possible for every institution. In these cases, encouraging a spirit of teamwork and taking a group effort approach makes the work more manageable without it becoming a single person's full-time job. Even though it may be daunting, everyone must start somewhere. The best first step is to start collecting data, even if it is messy. It will get better and easier with more practice and experience.

Keep the benefits of your efforts in sight

Tracking energy consumption can provide multiple benefits to cultural institutions. Establishing a baseline energy use pattern and benchmarking this use against other buildings or year-over-year performance can improve understanding of energy consumption patterns and drivers, identify the most efficient buildings in a campus, pinpoint the most effective performance improvements, and track the resulting energy savings from improvements. ENERGY STAR has found that the act of benchmarking alone can reduce annual energy consumption by 2.4%.[27]

Proactive benchmarking can also ensure cultural institutions are prepared for future local jurisdiction mandates. Energy tracking is especially important for cultural institutions that display objects; the owners of certain objects may require proof of temperature and humidity maintenance or other energy-related metrics before agreeing to put an object on loan.

Keeping your overall goals in mind will help staff make decisions along the way that will ensure success. For example, installing a BAS/BMS would be helpful to understanding savings opportunities, and is one of the first steps to take before adding energy efficiency upgrades.

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27 U.S. Environmental Protection Agency. (2012). *ENERGY STAR PortfolioManager Data Trends – Benchmarking and Energy Savings.* http://www.energystar.gov/sites/default/files/buildings/tools/DataTrends_Savings_20121002.pdf

Codes & Policies Context for Cultural Institutions

With buildings producing 40% of global GHG emissions and upwards of 80% of emissions in large cities, it's no wonder that climate policies focus on new construction and existing buildings.

Building codes, policies, and programs will continue to be critical for federal, states, and cities (also referred to as jurisdictions) to meet their climate goals. Cultural institutions will also be called to reduce energy and water consumption, limit carbon emissions, or achieve net zero status.

As more jurisdictional policies impact public and private buildings alike, these policies increasingly impact cultural institutions' day-to-day practices. Therefore, the new construction and existing building policies outlined in this section are important for cultural institutions to understand whether they are currently being asked to comply or will be in the future.

Next to jurisdictions, cultural institutions are uniquely positioned to lead the climate effort as civil society actors. As public institutions, reaching millions of visitors annually, cultural institutions have a mission-driven responsibility to limit their negative impacts while modeling thoughtful, responsible behavior, and sharing these actions with patrons; proving what is possible.

Jurisdictions will use building codes, policies, and programs to drive practices that ensure that we meet climate goals through reduced GHG emissions. Building energy codes will only require interaction a few times in a building's lifetime, building policies, focused primarily on existing buildings, may interplay with institutions annually. To date, most of these policies and programs have focused on new construction energy efficiency or zero energy goals. Still, with an evolving understanding of the broad climate impacts of the built environment, jurisdictions are now looking to account for the full carbon impact of the new and existing building stock, turning to goals and policies that achieve zero emissions.

FIGURE 16. COMMON BUILDING CODES AND POLICIES BY THE PHASES OF A BUILDING'S LIFECYCLE.

Operational policies often require reporting on a specific component during building operations, continuous monitoring of building performance, and some will require building or system level upgrades to remain in compliance.

These policies apply with new construction, renovations, or procurement requiring designers or owners to meet a specific standard or report the purchase or buy a product that meets certain specifications.

Some regulations do not require specific action by building decision-makers, but they could impact facilities and operations through the supply chain and product availability.

The following sections provide guidance, examples, and additional resources to leadership in cultural institutions. This resource is intended to aid decision-makers in cultural institutions in understanding how current and future codes and policies may directly or indirectly impact the operational practices of their buildings immediately or in the near future. The specific legal landscape of a given jurisdiction will vary broadly, and readers of this document should consider this high-level guidance as a first step in understanding the laws and programs that might apply. Cultural institutions should work with their local government to gain better guidance on specific climate action regulations and begin measuring their energy use to make informed decisions around their institutional needs.

The policies in this document are grouped into three different categories. The codes and policies are organized by the "point" when cultural institutions are more likely to intersect with the three phases of a building's lifecycle, focusing on building operations first, construction and remodels, followed by federal regulations. The "operations" policies are the policies most likely to be action taken by cultural institutions. Facility managers should become familiar with building benchmarking, building labeling, commissioning, and building performance standards. When fundraising for developing new buildings, facility managers should rely on the expertise of the design professional's deep knowledge of energy code, but familiarity with the context will allow deeper discussions around sustainable institutions. Finally, federal regulations will impact cultural institutions through different avenues, but being aware of the trending building topics is important to understand the supply chain.

A quick guide to the information contained below can be found in the Codes & Policies Factsheet.

Operations

Operational policies often require reporting on a specific component during building operations, continuous monitoring of building performance, and some will require building or system level upgrades to remain in compliance. Key policy mechanisms include: energy benchmarking, building labeling, energy audits and retro-commissioning, and building performance standards

ENERGY BENCHMARKING

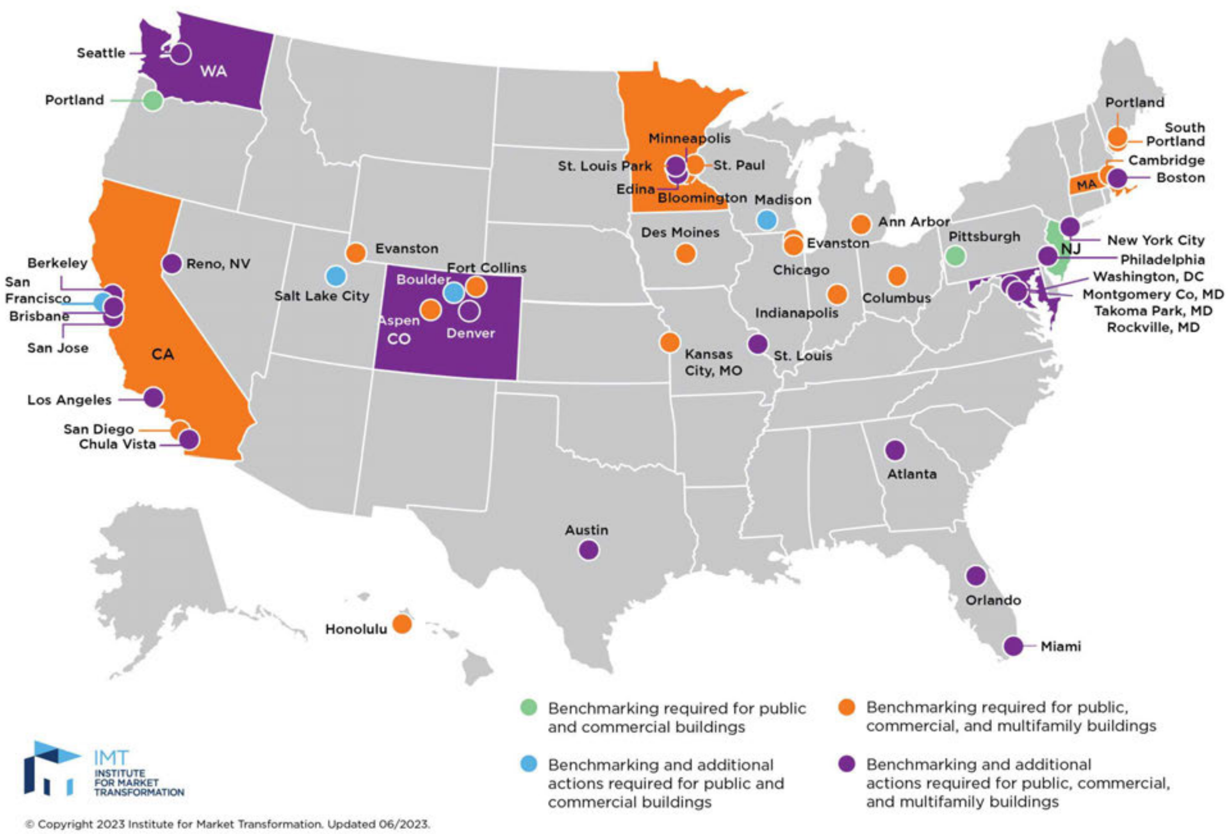
Building benchmarking serves as a mechanism to measure and track a single building's energy performance and carbon emission over time. Cultural institutions can benefit from consistently tracking energy consumption and carbon emissions, even if they are not in jurisdictions with a benchmarking policy. Armed with information about building performance, owners and occupants can understand their building's energy performance and carbon emissions relative to similar buildings over time to help identify opportunities to reduce energy use.[28] The Carbon Inventory Project (see description starting on page 33)

28 Hart, Zachary. (2015). *The Benefits of Benchmarking Building Performance.* IMT and the Pacific Coast Collaborative. https://www.imt.org/wp-content/uploads/2018/02/PCC_Benefits_of_Benchmarking.pdf

was conceptualized as a way to encourage the cultural sector to reap these benefits by helping them develop the necessary skillset for energy tracking.

When facility managers and owners understand their energy use and their facility operations, they can use benchmarking to guide and support continued maintenance and investment. Benchmarking encourages owners and operators to invest in energy efficiency and carbon reduction upgrades and lower buildings' energy use and GHG emissions. Performance information can be factored into transactional decisions like purchasing or leasing space. In addition, data can help to identify building inefficiencies, detect malfunctioning equipment through spikes in usage, and determine cost-effective retrofits.[29] A common tool that most policies use is ENERGY STAR PortfolioManager. It is a free energy management tool that allows owners to measure and track their building's energy and water consumption, identify investment priorities, and verify improvements over time. As of the publishing of this report, 39 cities and 13 states have implemented benchmarking policies (see Figure 17).

FIGURE 17: U.S. CITY, COUNTY, AND STATE POLICIES FOR EXISTING BUILDINGS BENCHMARKING, TRANSPARENCY, AND BEYOND.



29 National Apartment Association. *Energy Benchmarking and Building Energy Labeling: Policy Issue.* https://www.naahq.org/energy-policy

Example: Chicago's Energy Use Benchmarking Ordinance

The City of Chicago, Illinois, passed its Energy Use Benchmarking Ordinance in 2013, requiring all residential, commercial, and government buildings larger than 50,000 square feet (sf) to track their energy use and report it to the City annually.[30] The ordinance aims to "raise awareness of energy performance through information and transparency, to unlock energy and cost savings opportunities for businesses and residents."[31]

Building owners receive a compliance notification letter from the City every March, after which they must report their energy use by June 1 using EPA's ENERGY STAR PortfolioManager reporting platform. Building owners can also check the Covered Buildings Portal to confirm if they are required to report their energy data.[32] Furthermore, building owners must have an in-house or verified third-party verify the building's energy data every three years. Building owners are not required to reduce energy usage as part of the benchmarking ordinance.

Building owners may apply for a limited, one-year exemption in the case of financial duress, low occupancy rates, or if the building is newly constructed or has been acquired by a new owner within the past year.[33] Buildings covered by the ordinance that do not comply must pay a one-time $100 fine and a $25 fine for each additional day of noncompliance.[34, 35]

Chicago's ordinance covers less than 1% of all buildings but accounts for about 20% of the total energy used by Chicago's buildings.[32]

Benchmarking & Cultural Institutions

Cultural institutions may benefit from consistently tracking energy consumption, even if they are not in jurisdictions with a benchmarking policy. Facilities that are required to comply with a benchmarking regulation will be required to collect and report energy from electricity, fossil gas, steam, and other energy sources. Data reporting typically requires entering data into ENERGY STAR Portfolio Manager and sharing it with city staff. Some jurisdictions offer exceptions to some building types, like churches and museums.

BUILDING LABELING

Building labeling policies increase consumer awareness about building energy performance and create market signals by making energy performance information visible to the market. Building labeling is the physical public display of a building's energy efficiency or carbon emission grade, score, or certification. Examples include the building label of ENERGY STAR, LEED, or DOE's Asset Score green building certification or other energy performance information put into the local context, as seen in Figure 18. Building labeling may be a simple certification, tiered system, letter grade, numerical score, or some combination of these. Labeling can shift behavior without

30 Maximum Energy Professionals. *US Benchmarking Laws: Where Do YOUR City and State Stand?.* http://www.mep-llc.com/US-Benchmarking-Laws-Where-Do-YOUR-City-and-State-Stand.html

31 City of Chicago. *Chicago Energy Benchmarking Overview.* https://www.chicago.gov/city/en/depts/mayor/supp_info/chicago-energy-benchmarking/ChicagoEnergyBenchmarkingOverview.html#Requirements

32 City of Chicago. *Chicago Energy Benchmarking – Covered Buildings, Chicago Data Portal.* https://data.cityofchicago.org/Environment-Sustainable-Development/Chicago-Energy-Benchmarking-Covered-Buildings/g5i5-yz37/data

33 City of Chicago. (2021). *Chicago Energy Benchmarking: Frequently Asked Questions.* https://www.chicago.gov/content/dam/city/progs/env/EnergyBenchmark/2021_Chicago_Benchmarking_FAQs

34 Georgetown Climate Center Adaptation Clearinghouse. *Chicago's Energy Benchmarking Ordinance.* https://www.adaptationclearinghouse.org/resources/chicago-s-energy-benchmarking-ordinance.html?preview=true

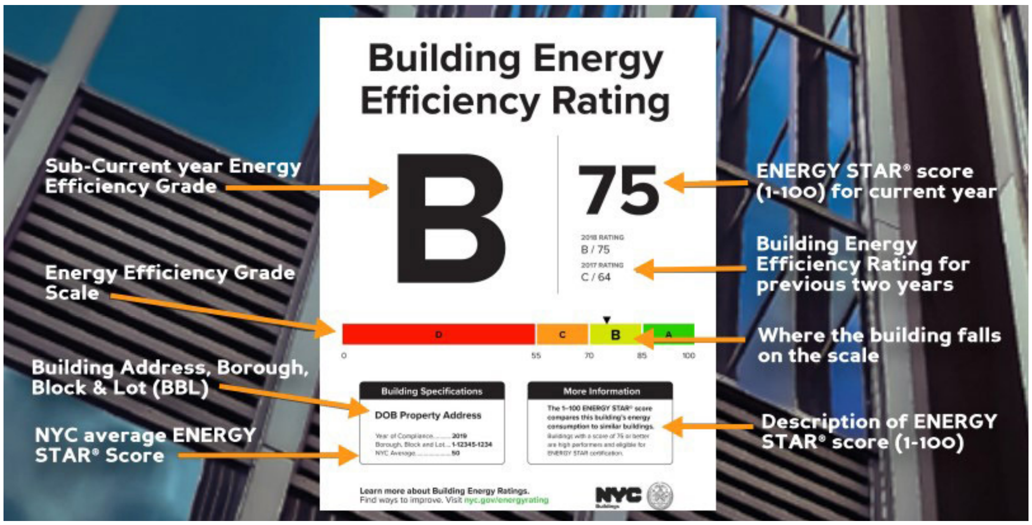
35 City of Chicago. (2013). *Benchmarking Ordinance, Office of City Clerk.* https://www.chicago.gov/content/dam/city/progs/env/EnergyBenchmark/BenchmarkingOrdinance11SEP2013.pdf

changing the price, value, or freedom of choice as facility managers become aware of the performance and building efficiency, while increasing visitors' and occupants' awareness about building energy performance.

Example States/Cities: New York City, NY; Chicago, IL

FIGURE 18: NEW YORK CITY'S BUILDING ENERGY EFFICIENCY LABEL INCLUDES BOTH A LETTER GRADE AND THE ENERGY EFFICIENCY SCORE FOR THE BUILDING.

Source: NYC Buildings, https://www.nyc.gov/assets/buildings/pdf/ll33_compliance_steps.pdf



Example: New York City's Building Energy Efficiency Rating Labels

New York City's 2018 Local Law 33, Building Energy Efficiency Rating Labels (as amended by the 2019 Local Law 95), requires all properties over 25,000 sf to calculate and display their energy consumption data on the exterior of the building with a Building Energy Efficiency Rating label.[36] Every year, building owners must calculate and report their energy use data using the ENERGY STAR Portfolio Manager tool, which outputs a 1-100 ENERGY STAR rating for the building. After that, the NYC Department of Buildings provides an energy label to each building owner, which displays the ENERGY STAR label and an A-D letter grade that coincides with the number rating.[34]

The energy rating must be displayed in a public, visible location close to the entrance of the building. The legislation's goal is to encourage visibility on energy performance and encourage actions that reduce energy and water consumption.

Buildings exempt from the rating requirement include multifamily housing with fewer than 20 units, enclosed parking, certain mixed-use buildings, museums, and other property types that are not eligible to receive a 1-100 ENERGY STAR rating.[37] In addition to facilities that contain a data center, television studio, and/ or trading floor that together exceed 10% of the gross floor area (GFA). Properties not eligible for the 1-100 ENERGY STAR rating receive an "N" grade and are exempted

36 NYC Buildings. *Local Law 33 as Amended by LL95 of 2019: New York City Steps to Compliance.* https://www1.nyc.gov/assets/buildings/pdf/ll33_compliance_steps.pdf

37 U.S. Environmental Protection Agency. (2020). *Is there a score for museums?* https://energystar-mesa.force.com/PortfolioManager/s/article/Is-there-a-score-for-museums-1600088528787#:~:text=No%2C%20there%20currently%20isn%E2%80%99t%20a%20score%20for%20museums.,building%20characteristics%20and%20actual%20energy%20consumption%20for%20museums.

from the benchmarking and posting requirement.[38] Furthermore, properties with a new building or demolition permit and no temporary certificate of occupancy (TCO) in a reporting year or properties with an ownership change in a reporting year may be eligible for a temporary exemption.[39]

Building owners that fail to display the energy rating by the deadline are fined $1,250 annually.[36] Noncompliant buildings will also be given a violation that could potentially prevent the owner from selling or refinancing the building.

Building Labeling & Cultural Institutions

Building labeling increases awareness, builds momentum for investment in energy efficiency, and create market signals. Cultural institutions in jurisdictions required to implement and enforce building labeling will benefit from monitoring, reporting, and displaying the building's energy efficiency grade, score, or certification, showing their commitment toward limiting the impacts of climate change. Institutions that are not currently in a jurisdiction requiring building labeling can lead by example by creating public displays showcasing energy and sustainability attributes of their facilities as educational and awareness tools.

ENERGY AUDIT AND RETRO-COMMISSIONING

Energy audit and retro-commissioning policies require actions that identify building energy improvement opportunities, presenting operational cost savings and payback opportunities. Energy audits identify baseline building energy performance characteristics and energy consuming devices and systems, while retro-commissioning requires addressing system inefficiencies. Building energy audits and retro-commissioning are critical tools for assessing where building equipment and systems are not operating as designed and often using more energy than designed.

An energy audit is completed by a registered energy advisor or energy auditor. Auditors conduct all three parts of an energy audit: evaluation, testing, and efficiency recommendations. Once the building audit is complete, the auditor will provide the owner with a report outlining energy consumption, grading, and suggestions to improve system operating performance and reduce energy costs. Findings may include low-cost recommendations to fix a leaky hot water faucet or more extensive recommendations to replace all ventilation damper controls. The types of audits differ, but the most commonly referred to audits in building energy policymaking are ASHRAE Level 1 and Level 2.[40] These standards are summarized below:

- **ASHRAE Level 1:** A preliminary, high-level facility walk-through analysis identifies low-cost, easily visible energy conservation opportunities. It typically uncovers major problem areas in system operation. The approximate cost is $0.12 per sf, which varies based on size and complexity.
- **ASHRAE Level 2:** Expanding on ASHRAE Level 1 findings, auditors look more closely at building heating and cooling systems and their controls. The more detailed data collection and analysis allows for better energy end-use breakdown. The approximate cost is $0.20 per sf and varies based on size and complexity.

38 NYC Buildings. (May 2021). *Frequently Asked Questions, Local Law 33/18 as Amended by Local Law 95/19.* https://www1.nyc.gov/assets/buildings/pdf/ll33_faqs.pdf

39 NYC Buildings. *Local Law 33 as Amended by LL95 of 2019: New York City Steps to Compliance.* https://www1.nyc.gov/assets/buildings/pdf/ll33_compliance_steps.pdf

40 Beddingfield, Erin and Hart, Zachary. (2019). *Using Data From Action-Oriented Energy Efficiency Programs and Policies. Institute for Market Transformation (IMT).* https://www.imt.org/wp-content/uploads/2019/11/IMT-PuttingDatatoWork-Using-Audit-Data.pdf

- **ASHRAE Level 3:** Also referred to as an "investment Grade audit," includes ASHRAE 1 and 2, with comprehensive analysis of building energy demands and inefficiencies, often done as part of an Energy Savings Performance Contract (ESPC). The detailed analysis allows for cost estimation of recommended energy conservation measures (ECMs). Focus on return on investment (ROI) for recommended ECMs. The approximate cost is $0.50 per sf and varies based on size and complexity.

Retro-commissioning policies require building owners to implement portions of the audit recommendations and restore facility operations to their design intent. Actions may include reprogramming lighting controls to align with operating hours, adjusting temperature set points to eliminate concurrent heating and cooling, or replacing a dead motor on a fan. Deferred maintenance leads to small inefficiencies in buildings, and over time the inefficiencies add up, and correcting the issues can pay for themselves. As encouragement, many utility incentive programs offer discounted or free energy audits and retro-commissioning support.

Example States/Cities: Austin, TX; New York City, NY; San Francisco, CA; Los Angeles, CA

Example: Los Angeles' Existing Buildings Energy and Water Efficiency Program

In 2016, the City of Los Angeles, California, passed the Existing Buildings Energy and Water Efficiency Program (EBEWE). The program is two-fold—it includes annual energy and water benchmarking requirements for buildings, and an energy/water audit and retro-commissioning provision every five years. The audit and retro-commissioning requirement applies to all commercial and multifamily buildings over 20,000 sf, and all city-owned buildings over 15,000 sf.[41] While benchmarking provides an overview of how much energy the building is wasting overall, an audit and retro-commissioning highlights specific strategies the building owner can take to achieve maximum energy and cost savings.

Every five years, owners must hire a Licensed Professional Engineer to audit the building and provide a report that lists specific actions and retrofits they can take to reduce water and energy use. The report includes estimated implementation costs, savings of the energy efficiency measures, and a list of which energy efficiency measures would provide the greatest ROI. While the report aims to inform building owners about their options to increase energy and water efficiency in their buildings, it is up to the building owners to decide whether to implement any of the measures.[39]

Exemptions to the energy audit and retro-commissioning policy requirements include but are not limited to: buildings that are less than five years old, buildings that have ENERGY STAR certification, or buildings that do not have a central cooling system and have four of the following six measures implemented: common area and exterior lighting meet the Title 24 Building Code, pipe insulation, cool roof, demand response, solar thermal, and domestic hot water meets the Title 24 Building Code.

The annual non-compliance fee is $202 (plus late charges) and is subject to increases and interest rates after 30 and 60 days of non-compliance. It is important to note that paying the fine does not result in compliance.[42]

41 Vert Energy Group. *LA EBEWE: Existing Buildings Energy and Water Efficiency Ordinance.* https://www.ebeweordinance.com/

42 City of Los Angeles Department of Building and Safety. (2022). *EBEWE Audits & Retro-Commissioning FAQs: Existing Buildings Energy & Water Efficiency Program.* https://www.ladbs.org/docs/default-source/forms/ebewe/arcx-faqs-020322.pdf?sfvrsn=487fcd53_76

Energy Audit and Retro-commissioning & Cultural Institutions

Nearly all buildings can benefit from energy audits and retro-commissioning, especially larger buildings with many visitors and guests, like cultural institutions. Energy audits identify baseline building energy performance characteristics and energy consuming devices and systems while retro-commissioning requires addressing the system inefficiencies. Audits may recommend system replacement or improvements to building operations, components and energy consumption and prioritize these energy reduction opportunities to cost effectiveness. They also present the opportunity for building owners to lead by example and find areas where building energy performance and energy savings can be improved without codes and policies forcing it.

BUILDING PERFORMANCE STANDARDS

A building performance standard (BPS) requires building owners to meet performance energy or carbon targets by improving their buildings over time. For existing buildings, a BPS commits buildings within a city, state, or agency to a long-term, high-performance standard (i.e., energy or carbon intensity), with interim targets increasing stringency over time.[43] BPS allows for more powerful carbon reductions across a broader set of existing buildings while allowing flexibility and predictability for owners and industry players. Jurisdictions carbon-free goals can be achieved over time using market forces' power. The private sector can enact carbon neutral solutions on a practical timeline to meet the city's goals.

BPS and building energy codes complement one other and enhance each other's benefits. Even if construction is not occurring or a building permit is pulled, BPS still applies to the building. It allows the owner to choose the technology and operational approaches they believe to be the most beneficial and cost-effective for achieving the target.

Several cities and states have implemented BPS policies. To date, the states of Colorado, Maryland, and Washington, and the cities of Denver, CO, Chula Vista, CA, Washington, DC, St. Louis, MO, Montgomery County, MD, New York City, NY, and Boston, MA, have implemented BPS policies. In addition, Council on Environmental Quality is launching an interagency Federal sustainability effort with the General Services Administration (GSA), Department of Energy (DOE), and Environmental Protection Agency (EPA) to develop a BPS for federal government buildings to reach federal carbon emissions goals.[44]

Pending states/cities include Massachusetts, Cambridge, MA; Reno, NV; and Los Angeles, CA.

Example: St. Louis' Building Energy Performance Standard

The City of St. Louis, Missouri passed its Building Energy Performance Standard (BEPS) in 2020, setting energy use intensity (EUI) targets for all buildings over 50,000 sf.[45] EUI is a commonly used measure of energy efficiency that refers to the average amount of energy used per sf of a building. Different types of buildings are given unique EUI targets due to their building

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43 NBI. 2020. *Implementing Building Performance Standards: Consistency is Key.* https://newbuildings.org/implementing-building-performance-standards-consistency-is-key/

44 The White House. (2021). *Fact Sheet: Biden Administration Accelerates Efforts to Create Jobs Making American Buildings More Affordable, Cleaner, and Resilient.* https://www.whitehouse.gov/briefing-room/statements-releases/2021/05/17/fact-sheet-biden-administration-accelerates-efforts-to-create-jobs-making-american-buildings-more-affordable-cleaner-and-resilient/

45 City of St. Louis. *Building Energy Performance Standard Targets.* https://www.stlouis-mo.gov/government/departments/public-safety/building/building-energy-improvement-board/beps-targets.cfm

energy needs. For example, museums have an EUI target of 118.4 kBtu/sf, while a grocery store may have an EUI target of 256.5 kBtu/sf, and a school at 30 kBtu/sf2.[46] The goal of the ordinance is "to reduce greenhouse gas emissions, drive energy efficiency improvements, and boost economic growth in St. Louis."[47]

The City set BEPS standards in May 2021, and most buildings have until May 2025 to reduce their energy use. After that, the City will update the BEPS standard every four years to increase energy performance and efficiency thresholds. Building owners can choose the method they take to achieve compliance, whether adding insulation or replacing inefficient gas furnaces with electric heat pumps.

Since 2017, due to the Building Energy Awareness Ordinance, a building benchmarking policy, buildings over 50,000 sf in St. Louis must annually report their EUI data via the online ENERGY STAR PortfolioManager tool. If building owners believe that due to unique circumstances, they will not be able to achieve the required BEPS standard by the given date, they can propose an alternative compliance plan and timeline for consideration by the Building Energy Improvement Board.

If a building owner fails to report adequate energy performance data, they will receive a written warning. Data reported 60 days after the warning, will receive an annual fine of up to $500, or imprisonment of up to 90 days.[48]

Building Performance Standards & Cultural Institutions

Moving beyond building energy benchmarking, BPS can be a catalyst for cultural institutions to reduce energy and water consumption and limit building GHG emissions. Meeting energy and carbon targets that incrementally become more stringent drives long-term improvement in the building stock to reduce emissions. BPS are important for cultural institutions because they allow for continuous improvement over time. It allows building staff to improve energy efficiency in their buildings, which comes with the added benefit of improving the health and wellbeing of their occupants and saving money for their organizations. This should be especially important to cultural institutions as they have a high influx of different visitors each day along with many staff.

Construction and Remodel

New construction, renovations, or procurement related policies require designers or owners to meet a specific standard or report the purchase or buy a product that meets certain specifications. Building codes are often the most common type of construction requirement, other policies such as electrification mandates and procurement policies can impact the equipment selected or other products purchased.

46 City of St. Louis. *BEPS by Property Type.* https://www.stlouis-mo.gov/government/departments/public-safety/building/building-energy-improvement-board/documents/upload/ApprovedBEPS_05-03-21.pdf

47 City of St. Louis. *Ordinance 71132: Building Energy Performance Standard (BEPS).* https://www.stlouis-mo.gov/government/city-laws/ordinances/ordinance.cfm?ord=71132

48 City of St. Louis. (2020). *Ordinance 71132.* https://www.stlouis-mo.gov/government/city-laws/upload/legislative/Ordinances/BOAPdf/71132%20Combined.pdf

MODEL BUILDING CODES

A set of fifteen national model building codes set minimum requirements for new construction and major renovations. These codes are then adopted by local jurisdictions. The International Code Council (ICC) develops model codes and standards used in the design, build, and compliance process to construct safe, sustainable, affordable, and resilient structures in the built environment. Every three years, the ICC develops and maintains this set of codes. Cyclical updates avoid big jumps or changes in technology or building practices that would occur if they were updated less frequently.

Codes primarily impact cultural institutions when it's time to build or renovate, and they are being asked to comply. Requirements are often based on the type of occupancy, addressing the unique nature of cultural institutions being places of gathering, along with retail, office, chemical storage, and even medical facilities. Knowing that codes are focused on energy allows institutions the opportunity to plan for and consider better practices to improve building performance. Addressing fire hazards, energy efficiency or resilience now can limit learning curves and upfront construction costs.

Model Codes include, but are not limited to:

- International Building Code (IBC)
- International Energy Conservation Code (IECC)
- International Plumbing Code (IPC)
- International Mechanical Code (IMC)

MODEL BUILDING ENERGY CODES

National model building energy codes set minimum energy efficiency requirements for new construction and major renovations. The International Energy Conservation Code (IECC) addresses energy efficiency through "cost savings, reduced energy usage, conservation of natural resources and the impact of energy usage on the environment." The code adopts frequently updated standards like ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, to provide steady progress toward increased energy efficiency. Advances from the most recent IECC cycle (2019 to 2021) delivered approximately 9% energy savings.

The jurisdictional authority for energy code adoption varies state by state—some states adopt an energy code at the state level and do not allow jurisdictions to adopt more stringent codes. Some states adopt a statewide model code and allow local jurisdictions to adopt a "reach code," which is developed at the state level. Meanwhile, other states have no statewide energy code but enable jurisdictions to adopt their own. Figure 19 illustrates the version of ASHRAE 90.1 each state has adopted. States with more recent versions adopted have more stringent energy requirements.

States are not federally required to adopt the newest codes on the same three-year schedule they are developed, and many states have their schedule based on past precedent or, in a few cases, state legislation mandating updates. Therefore, energy savings may not be realized equally for all new construction buildings across all states. State adoption occurs through either legislative or regulatory agency actions. While individual states set code adoption procedures, federal stature provides specific timelines for states to review the most recent energy codes and submit a notification to the Department of Energy (DOE).[49]

49 U.S. Department of Energy. (2022). *How Are Building Codes Adopted.* https://www.energy.gov/eere/buildings/articles/how-are-building-codes-adopted.

Buildings comply with the energy code either by meeting specific prescriptive energy efficiency measures, such as an R-22 insulated exterior wall, or meeting a particular performance target as documented through an energy model. Smaller buildings often opt to comply by following prescriptive measures rather than using targets set through modeling because of the cost; energy modeling is more common in larger buildings. Renovations also tend to follow prescriptive measures when they are smaller in scale, such as equipment replacements or small remodeling projects, and employ modeling when they are more substantial both by area being renovated and the overall cost of the project.

Enforcement and compliance strategies often include:

- Assessment of building plans
- Evaluation of materials and equipment being used
- Examination of the building during construction
- Inspection post construction

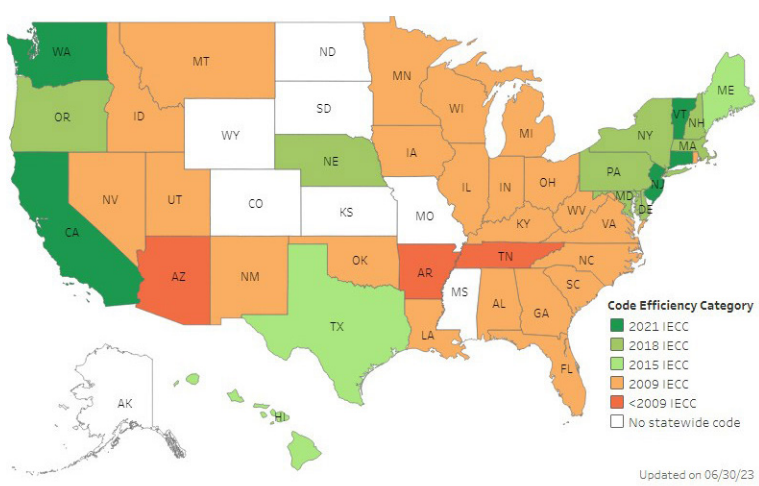
The IECC has been focused on energy. However, building code committees are considering GHG emissions of specific building materials. Similar to product procurement policies, some states require that common materials like concrete, structural steel, flat glass, insulation, and other materials meet low-carbon requirements.

Model Building Energy Codes & Cultural Institutions

When planning a new building, addition, or renovation, model building energy code requirements will likely be directed by the project architect. Institutions should be aware that in jurisdictions with an energy code, there will be energy performance requirements for design and construction, such as insulation, window and door designs, HVAC equipment, and lighting fixtures. Energy codes indicate the minimum performance legally allowable, and institutions can exceed the requirements for a more efficient building. Enforcement and compliance include building plan review and evaluation of materials and equipment before receiving the building permit, examination of the structure during construction, and inspection post construction.

FIGURE 19: STATUS OF STATE ENERGY CODE ADOPTION FOR COMMERCIAL BUILDINGS.

Source: Department of Energy (DOE)

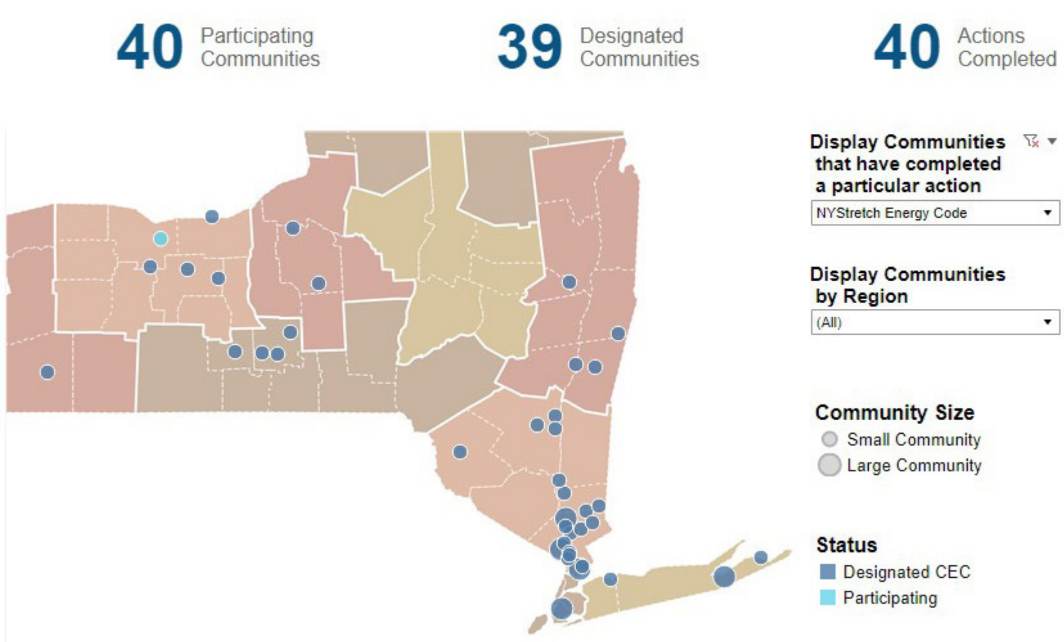


STRETCH BUILDING ENERGY CODES

A stretch code, also sometimes referred to as a reach code, is a locally mandated code or alternative compliance path with more stringent requirements than the base code, resulting in buildings that achieve higher energy savings than those subject to the base code alone. Stretch codes offer jurisdictions a pathway to achieve more ambitious energy or carbon targets through building construction and renovation. Depending on local laws, stretch codes may be developed by the municipality or as part of the state energy code adoption process, as described in the Massachusetts example below. In another example, New York State Energy Research and Development Authority (NYSERDA) led an effort to develop NYStretch-Energy. NYStretch-Energy is a voluntary locally adopted stretch energy code that offers municipalities a more energy-efficient alternative to the minimum state energy code. As indicated in Figure 20, 40 jurisdictions in the state have adopted the stretch code. The base code outlines the minimum energy performance for a building in a jurisdiction. When the base code is not keeping up with advances in technology and design practices, stretch codes provide an opportunity to train the design, construction, and development communities in advanced practices before the underlying energy code is improved. Stretch codes help accelerate market acceptance and adoption of more stringent energy efficiency codes in the future and require buildings to achieve even greater energy efficiency.[50]

FIGURE 20: NEW YORK COMMUNITIES THAT HAVE ADOPTED NYSTRETCH-ENERGY, THE STATE'S STRETCH CODE.

Source: NYSERDA, https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Communities/Tracking-Progress/CEC-Map



The metrics and compliance can vary based on each stretch code. Stretch codes have the same or similar reporting metrics as the energy code—they either meet specific prescriptive energy efficiency measures or meet performance targets through energy modeling.

Example states with stretch codes include Massachusetts, New York, California, Vermont, and Maine.

50 NBI. *Stretch Codes.* https://newbuildings.org/code_policy/utility-programs-stretch-codes/stretch-codes/

Example: Massachusetts Stretch Code

Massachusetts is a "Home Rule" state, meaning that the state grants local jurisdictions the authority to pass laws that are not preempted at the state level. Like NYStretch-Energy, Massachusetts develops a stretch code that can be optionally adopted at the local level. Due to jurisdictional interest in a stretch code, Massachusetts became the first state in the country to develop and offer an energy stretch code as an appendix to its statewide building energy code in 2009.[51] The Massachusetts Stretch Code aims to "lower consumption requirements, modernize building envelope, ventilation, insulation systems, and other measures, and promote cost savings for builders, owners, and residents through offsets and improved efficiency."[52] Any jurisdiction can adopt the state stretch code but may not amend it. As of Summer 2023, 311 (82%) state municipalities have adopted the state stretch energy code, while 52 municipalities (14%) only use the base energy code. The remaining 18 municipalities (5%) use aspecialized code in lieu of the stretch code.[53]

The Massachusetts stretch code provides a solution for two challenges: First, the stretch code supports jurisdictions that have more stringent GHG emission goals than the state and want a faster transition to decarbonized new construction buildings. Second, the regulation limits the different building codes building professionals would need to learn while working in the 311 unique state municipalities.

Stretch Building Energy Codes & Cultural Institutions

Stretch codes give jurisdictions the ability to familiarize the design and construction communities in advanced practices before the base energy code (which is updated every 3 years) is improved. Cultural institutions will be alerted by their design team if their project would be affected by a stretch code. Key improved changes in a stretch code typically include improved window performance, air-barrier commissioning, air leakage testing, reduced interior and exterior power and lighting controls, whole building energy monitoring, renewable and electrical vehicle readiness.

ELECTRIFICATION MANDATES

State and city electrification mandates encourage transitioning away from fuel oil, propane, and natural gas (also known as fossil gas)-fired systems to all electric buildings, which can quickly curb regional GHG emissions in new construction. As electric grids offer more clean energy, all-electric buildings can approach zero emissions. Electrification mandates prevent the use of fossil fuels primarily for water heating, space heating, and cooking applications.

City and state electrification mandates encourage all-electric buildings and can quickly curb regional GHG emissions in new construction. As electric grids offer more clean energy, all-electric buildings can approach zero emissions. 80% of building emissions, according to the EPA, are from the combustion of fossil gas used primarily for water heating, space heating, and cooking applications.[54] The International Energy Agency recommends policymakers around

51 Commonwealth of Massachusetts. (2022). *Building Energy Code: Summary of State Building Energy Codes including the Stretch Code.* https://www.mass.gov/info-details/building-energy-code

52 Commonwealth of Massachusetts. (2016). *Chapter 115 AA: Stretch Energy Code 2016 Amendment.* https://www.mass.gov/doc/chapter-115-aa-stretch-energy-code-2016-amendment/download

53 Massachusetts Department of Energy Resources (DOER). (2023). *Stretch Code Adoption by Municipality.* https://www.mass.gov/doc/building-energy-code-adoption-by-municipality/download

54 United States Environmental Protection Agency. *Sources of Greenhouse Gas Emissions.* https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#commercial-and-residential

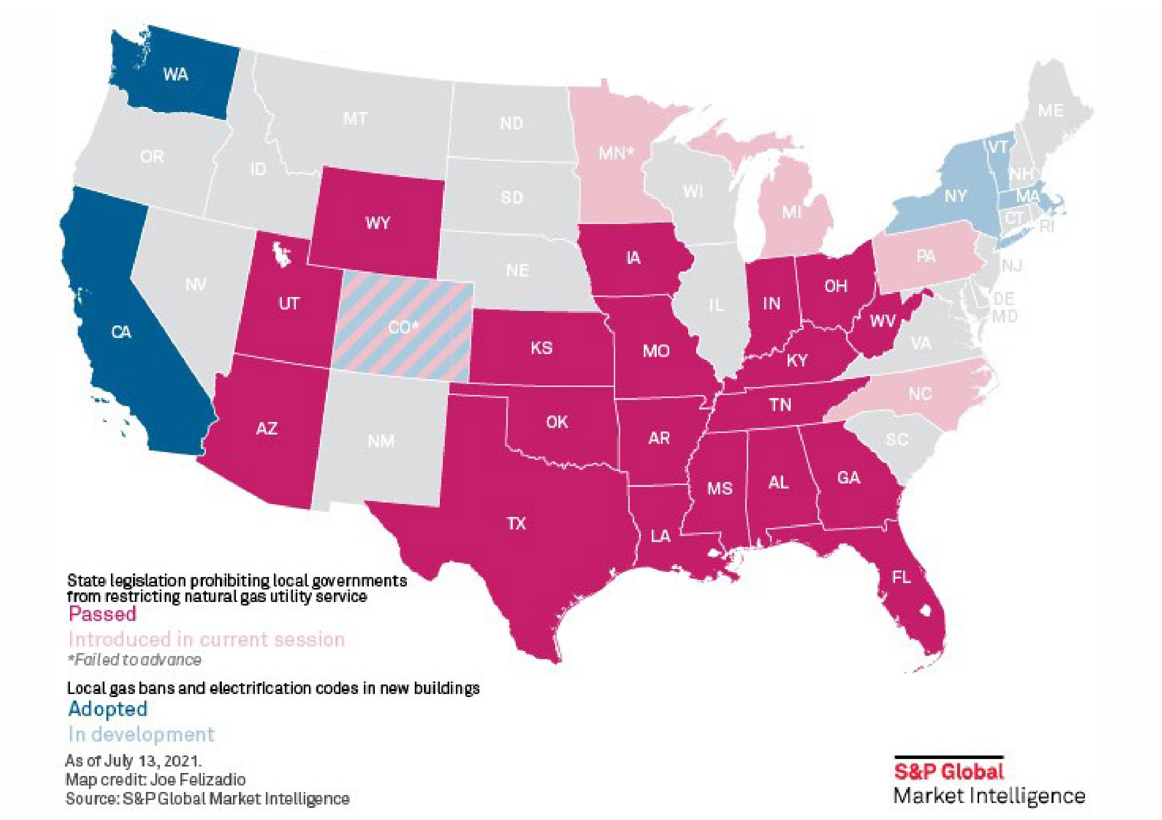
the world ban fossil fuel furnace sales by 2025 and adopt building codes that would largely phase out fossil gas use in buildings.[55] Due to this recommendation, states like California and Washington are now adopting electrification mandates.[56]

Electrification mandates not only impact outdoor air but indoor air as well. Researchers from the UCLA Fielding School of Public Health indicate that indoor gas cooking equipment and heating emit pollutants that impact kitchen staff and patrons, even when assumed to be ventilated. In addition, the combustion of fossil fuels can release carbon monoxide, formaldehyde, and other harmful pollutants into the air, which are toxic to people and animals.

On the other hand, several states have passed or introduced measures that would prevent local measures from blocking access to utility services based on fuel type. Fifteen states have successfully passed bills that prevent local municipalities from limiting fossil fuel hookups. Additionally, at least seven other states seek to prevent a ban on electrification policies before passing them. Figure 21 shows the states advancing or prohibiting building gas bans and all-electric building codes.

FIGURE 21: STATES ARE ADVANCING AND PROHIBITING BUILDING FOSSIL GAS BANS AND ELECTRIFICATION CODES.

Source: S&P Global Market Intelligence



55 IEA. (2021). *Net Zero by 2050: A Roadmap for the Global Energy Sector.* http://www.iea.org/reports/net-zero-by-2050

56 S&P Global Market Intelligence. (2021). *Gas Ban Monitor: Building electrification evolves as 19 states prohibit bans.* http://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/gas-ban-monitor-building-electrification-evolves-as-19-states-prohibit-bans-65518738

Example: Berkeley's Prohibition of Natural Gas Infrastructure in New Buildings

In 2019, Berkeley, California, became the first city in the U.S. to ban fossil gas hookups in new construction. The prohibition on fossil gas infrastructure in new buildings applies to all new buildings that apply for land use permits or zoning certificates.[57] In fact, gas-free construction is a condition of approval in land-use permits. Still, it does not impact existing buildings, retrofits, or portable propane appliances for outdoor cooking or heating.[55] Gas is typically used for space and water heating, cooking, and other miscellaneous uses such as fireplaces or decorative lighting. The fossil gas prohibition allows case-by-case exceptions for buildings that are impossible to construct without gas, such as those requiring high water temperatures for medical facilities or high temperatures needed for specific manufacturing processes. Further, the ordinance includes a public interest exemption if the City deems that gas infrastructure is an ideal solution for a building after considering the currently available technology and the public's health, safety, or welfare.[55] If an exemption is given to a particular building, it must still be constructed with adequate electric capacity, wiring, and conduit for full-building electrification in the future.

Berkeley is in an area that is very susceptible to wildfires, earthquakes, and rising sea levels, which can damage gas infrastructure and lead to dangerous gas leaks and fires. In addition, gas is mainly made of methane, a GHG over 80 times more potent than CO_2 over a 20-year period.[58] As a result, the City of Berkeley banned gas in new construction to speed up the City's transition to efficient, fossil-fuel-free buildings while protecting the health and wellbeing of the region's residents.

Electrification Mandates & Cultural Institutions

Electrification mandates may limit the type of equipment that can be purchased and installed when institutions are building new or adding additions on their buildings, in some states. Cultural institutions should be aware of the current decarbonization goals of their state and city as these measures will impact future renovations and equipment replacements. Institutions can be proactive by transitioning away from gas and making a plan to phase out common gas equipment, such as heating, water heating, cooking, drying and lighting. It is most effective to switch to all-electric equipment and appliances as equipment reaches end of life and needs to be replaced.

LOW ENERGY AND CARBON PROCUREMENT POLICIES

State and local government procurement and construction policies incorporate energy efficiency and decarbonization into everyday purchasing decisions. These policies help to institutionalize energy efficiency and decarbonization across all state or local government departments. Thoughtfully procuring products supports the development of a low-carbon future and encourages market innovation to support low-carbon products on the market. Four topic areas that state and local governments are adopting into policy for their jurisdictionally owned and/or leased assets include:

- **Fleet efficiency and vehicle infrastructure:** Fuel efficiency or fuel-efficient vehicle type requirements for public fleet vehicles; Fleet right-sizing policy or vehicle culling requirements; anti-idling policies for government vehicles or other programs to encourage efficient vehicle behavior.

57 Berkeley Municipal Codes. *Chapter 12.80: Prohibition of Natural Gas Infrastructure in New Buildings.* https://berkeley.municipal.codes/BMC/12.80

58 Deaton, Jeremy. (2020). *Methane Levels Reach an All-Time High. Scientific American.* https://www.scientificamerican.com/article/methane-levels-reach-an-all-time-high

- **Public lighting:** Efficiency requirements or upgrade of programs for outdoor lighting (e.g., streetlights); Use of photosensors or scheduling for outdoor lighting; Adoption of the Illuminating Engineering Society and the International Dark-Sky Association's Model Lighting Ordinance, participating in U.S. Department of Energy's (DOE) High Performance Outdoor Lighting Accelerator, or other relevant policy.
- **New buildings and equipment:** Energy efficiency or green building requirements for new public buildings or major renovations; Energy efficiency or lifecycle cost considerations integrated into procurement policies.
- **Low-carbon procurement policies** set specific standards for specific materials and projects. Purchasing lower-carbon products requires engaging suppliers to target a net-zero supply chain. Products may include structural materials (concrete, steel, and wood), building envelope materials (insulation, aluminum, glass, and cladding), and finishes (ceiling tile, gypsum board, and flooring).

Procurement policies, like Buy Clean, aim to fill a gap in climate policy. The carbon associated with the development of building materials accounts for over 11% of global GHG emissions.[59] Purchasing requirements use a combination of disclosure, incentives, and standards to leverage the significant purchasing-power of public agencies to encourage a shift toward lower-carbon options in the broader construction materials market. Low-carbon procurement is an approach that can be applied at the federal, state, or local level and used by private building owners.[60]

At the federal level, a procurement program was drafted in the Clean Future Act in 2020,[61] and clean manufacturing programs and incentives are included in Biden's Climate Action Plan.[62] At the state level, Washington state introduced a Buy Clean bill in 2017[63] and passed a Buy Clean pilot study in 2021,[64] and Oregon passed a Buy Clean policy for infrastructure projects in March 2022.[65] In 2021, Minnesota added a Buy Clean study and a Buy Clean/Buy Fair pilot program,[66] and Colorado passed a Buy Clean legislation into law.[67] New York state passed a material-specific variation of Buy Clean that focused on low-carbon concrete incentives in 2020.[68] At the local level, cities like Portland, Oregon, and Marin County in California are adopting regional or material-specific variations of the policy.[69]

Example: Portland, Oregon Low-Carbon Concrete Initiative

In 2016, the City of Portland, Oregon, conducted a supply chain analysis and found that construction was the top spending category contributing to the City's supply chain GHG

59 IEA. (2018). *2018 Global Status Report.* https://www.iea.org/reports/2018-global-status-report
60 Carbon Leadership Forum. (2020). *Carbon Leadership, What is Buy Clean Policy?* https://carbonleadershipforum.org/what-is-a-buy-clean-policy/
61 Committee on Energy & Commerce. (2021). The CLEAN Future Act — Updates to Discussion Draft Based on Feedback from Stakeholders & Committee Testimony. https://tonko.house.gov/uploadedfiles/clean_future_act_fact_sheet_final.pdf
62 Biden | Harris. (2022). *The Biden Plan for A Clean Energy Revolution and Environmental Justice.* https://joebiden.com/climate-plan/
63 Washington State Legislature. (2018). *HB 2412 – 2017-18: Creating the buy clean Washington act.* https://app.leg.wa.gov/billsummary?BillNumber=2412&Year=2017
64 Carbon Leadership Forum. (2021). *Buy Clean Buy Fair Washington Project.* https://carbonleadershipforum.org/bcbf-project/
65 Oregon State Legislature. (2022). *2022 Regular Session: HB 4139 Enrolled.* https://olis.oregonlegislature.gov/liz/2022R1/Measures/Overview/HB4139
66 Minnesota Legislature Office of the Revisor of Statutes. (2021). *HF 2110: Omnibus energy bill.* https://www.revisor.mn.gov/bills/bill.php?b=House&f=HF2110&ssn=0&y=2021
67 Colorado General Assembly. (2021). *HB21-1303: Global Warming Potential for Public Project Materials.* leg.colorado.gov/bills/HB21-1303
68 The New York State Senate. (2019) *Senate Bill S8965: Relates to "The New York State Low Embodied Carbon Concrete Leadership Act".* http://www.nysenate.gov/legislation/bills/2019/s8965
69 County of Marin. (2022). *Low-Carbon Concrete Requirements.* https://www.marincounty.org/depts/cd/divisions/sustainability/low-carbon-concrete

emissions.[70] Further, it was found that concrete was one of the highest-emitting products used in City construction projects.

Therefore, in 2019, the City established its Low-Carbon Concrete Initiative, which included three phases:

- **Creating Standards:** The City required product-specific Environmental Product Declarations (EPDs) for concrete used in City projects where at least 50 cubic yards are expected to be used. This step helped increase the available data on the embodied carbon of concrete used in City projects.
- **Piloting Standards:** The City conducted a pilot study with concrete mixes with lower cement percentages and lower amounts of embodied carbon and measured their performance and strength with regular, 100% cement mixes.
- **Wide-Scale Adoption of Standards:** After the pilot program showed that lower-carbon concrete mixes achieve satisfactory performance and strength while being cost-neutral or less expensive than the 100% cement mixes, the City of Portland created GWP limits for concrete used in City construction.[68]

In May 2022, the concrete low-GWP requirements in City construction were announced, and they will go into effect in January 2023 for all City projects that use at least 50 cubic yards of Portland Cement Concrete (PCC). The GWP of concrete mixes will be validated by verified, third-party EPDs. In addition, temporary exemptions may be granted when supply chain constraints are outside the producer's control.[71]

Low Energy and Carbon Procurement Policies & Cultural Institutions

Purchasing and construction policies impact everyday government funded projects—cultural institutions have the opportunity to lead by example and mirror leading governments' procurement policies within their own operations. Additionally, if a government with such a policy is funding site work, cultural institutions may find new requirements for replacing a city sidewalk or other infrastructure. Additionally, as government funding drives the market adoption of electric vehicles, LED lighting, and other environmentally preferred products, they may become feasible options for institution purchases.

Federal Regulations

Some regulations do not require specific action by building decision-makers, but they could impact facilities and operations through the supply chain and product availability. Policies in this category may include appliance and equipment standards and refrigerant regulations.

70 City of Portland. *Current Sustainable Procurement Initiatives; Low-Carbon Concrete Initiative.* https://www.portland.gov/omf/brfs/procurement/sustainable-procurement-program/sp-initiatives#toc-low-carbon-concrete-initiative

71 City of Portland. *Current Sustainable Procurement Initiatives; Embodied Carbon Thresholds for Concrete Mixes on City Projects.* https://www.portland.gov/omf/brfs/procurement/sustainable-procurement-program/sp-initiatives#toc-embodied-carbon-thresholds-for-concrete-mixes-on-city-projects

APPLIANCE AND EQUIPMENT STANDARDS

Appliance and equipment standards set requirements for the minimum energy efficiency of specific products sold or purchased within a jurisdiction. These successful policies save energy and water on products such as water heaters and cooking equipment. When the federal or state government establishes appliance and equipment standards, they set the bar for the minimum energy efficiency of specific products sold or purchased within their jurisdiction. Standards require products, such as refrigerators or air conditioners, to meet minimum efficiency requirements, thereby reducing energy use and consequently saving building operators money on energy bills while limiting GHG emissions. Product manufacturers are incentivized to meet the standards since jurisdictions prohibit the production and sale of products less efficient than the minimum requirements. Manufacturers focus on quickly developing least-cost, energy-efficient products that can compete with other high-performance products. Federal appliance standards are usually updated on a two-year cycle, while state adoption updates vary.[72]

Example: California Appliance Energy Efficiency Standards

Appliances account for more than half of all the electricity used in California buildings.[73] In 1977, the California Energy Commission (CEC) created the Appliance Energy Efficiency Standards to address the issue. The standards set minimum levels of operating energy efficiency and other cost-effective measures for all appliances sold or offered for sale in California.[74] The Appliance Energy Efficiency Standards were developed to save energy and water, reduce air pollution, and GHG emissions while saving building owners money. The California standards cover a variety of appliances, including, but not limited to: air conditioners and heat pumps, landscape irrigation equipment, lighting products, water heater products, general pumps, computers, and fans and dehumidifiers.72 The CEC continues to develop the standards through a transparent and public process with the help of stakeholder feedback. Once the CEC adopts a certain standard, the CEC informs all stakeholders and manufacturers on how to comply with it. Manufacturers confirm compliance by testing their product at a CEC-approved laboratory and receiving a third-party certification for standard compliance. Certification documents are submitted to the CEC in the agency's online Appliance Database. In instances of noncompliance, the CEC has the authority to penalize and fine retailers and manufacturers for violating the standards.[71]

Appliance and Equipment Standards & Cultural Institutions

Facility managers do not interact with appliance standards since the product efficiency will be filtered at the manufacturer level. Products that do not meet the appliance standards will not be available for purchase in the jurisdiction setting the standard (either nationally or at the state level). Cultural institutions should be aware of the policy since newer products are likely to be more efficient and save operating income by using less water and energy. Look for products with ENERGY STAR or WATER SENSE ratings. These programs work toward market enhancement and public recognition of energy and water efficiency through the labeling of their products and programs.

72 Appliance Standards Awareness Project. (2022). *National Standards.* https://appliance-standards.org/national
73 California Energy Commission. (2015). *The California Energy Commission Appliance Energy Efficiency Standards.* https://www.energy.ca.gov/sites/default/files/2019-06/EE-Appliance_Energy_Efficiency_Standards.pdf
74 California Energy Commission. *Appliance Efficiency Program: Outreach and Education.* https://www.energy.ca.gov/programs-and-topics/programs/appliance-efficiency-program-outreach-and-education

REFRIGERANT REGULATIONS

To limit potent GHG emissions, refrigerants are regulated at the federal and state level. Fluorinated gases (F-gas) associated with refrigerants are responsible for 2% of total global GHG emissions, making controlling these potent products essential to limit their climate impacts. The U.S. Environmental Protection Agency (EPA) began phasing down the supply of hydrofluorocarbons (HFC) in January 2022 and will essentially ban R-410A (a common refrigerant) for use in new equipment by January 2025. Other policies are aligned with the HFC phase-down based on international treaties.

Because many refrigerants have high global warming potential (GWP), some states, such as California, require refrigerant management plans. Properly managing and maintaining refrigerants leads to promptly repairing leaks from equipment, and adequately collecting, recycling, or disposing of refrigerants during maintenance and when equipment is retired.

According to the International Energy Agency, global refrigerant demand is expected to grow four-fold by 2050 because of the increased adoption of highly efficient heat pumps and the increased demand for cooling, especially as global temperatures rise.[75] If unregulated, this expansion in refrigerant use would lead to refrigerants making up a greater percentage of total GHG emissions. While refrigerant management is not required in all states, cultural institutions can limit GHG emissions simply by monitoring and maintaining refrigerants and promptly fixing leaks.

States requiring a transition to low-GWP refrigerants include California, Washington, Texas, New York, and Colorado.

Example: California Air Resources Board (CARB)

California Air Resources Board (CARB) was directed by the state legislature to issue rules to reduce HFC emissions by 40% below 2013 levels by 2030.[76] CARB adopted EPA's Significant New Alternatives Policy (SNAP) Rule 20, prohibiting higher GWP HFC-based refrigerants. As of January 2022, CARB finalized their HFC regulations limiting refrigerants' GWP, including:

- Refrigerants used in most refrigeration equipment not to exceed 150 GWP by January 1, 2022.
- Air conditioning (A.C.) manufacturers must use 10% reclaimed refrigerant annually for 2023 and 2024 through the Refrigerant Recovery, Recycle, and Reuse (R4) Program, which requires refrigerant recovery at the end of equipment life.
- Residential and light commercial stationary A.C. refrigerants not to exceed 750 GWP by January 1, 2025, excluding variable refrigerant flow (VRF) equipment which must convert in 2026, and small equipment in 2023.[77]

75 International Energy Agency. (2018). *The Future of Cooling: Opportunities for energy-efficient air conditioning.* http://www.iea.org/reports/the-future-of-cooling

76 California Legislature. (2016). *Senate Bill 1383 Short-lived Climate Pollutants: Methane Emissions: Diary and Livestock: Organic Waste: Landfills.* leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1383

77 California Air Resources Board. *California Significant New Alternatives Policy (SNAP).* ww2.arb.ca.gov/our-work/programs/california-significant-new-alternatives-policy-snap

Refrigerant Regulations & Cultural Institutions

Nearly all institutions use refrigerants. They are in space cooling equipment, drinking fountains, walk-in freezers, refrigerators, heat pumps, and more. As high-GWP refrigerants are phased out, HVAC service technicians may not be able to use the same refrigerants, and equipment adjustments or replacements may be necessary. Policies may require increased maintenance of systems to limit leaks and eliminate emissions. Monitor and maintain systems that use refrigerants and ask service technicians about options to phase into using lower-GWP refrigerants.

Call to Action

Jurisdictions, Federal agencies, and even private institutions are using building policies to reduce energy, water, and carbon emissions at different phases of buildings' lifecycle. It's rare that all policies will have an impact on one building type, but facility staff should be aware of these policies. Preparing for future policies can identify needs for long-term strategic plans, capital budgets, and staff training.

Even when exempt from local policies, institutions should be aware of and make a good faith effort to meet the requirements. Institutions can take advantage of the available resources like training and support lines to collect, organize, and internally report energy savings. Develop long-term operational plans to reduce energy and carbon emissions. Plans can help meet long-term goals by identifying when to commission the building systems, test for refrigerant leaks, or what should replace old or failing equipment. Preparing for pending policies not only limits last-minute documentation collection, but it leads to immediate energy cost savings, which can be put toward essential patron programs and services.

Building and energy policies affect the financial and physical roles of cultural institutions as individual entities and as contributors to their communities. As charitable institutions responsible for husbanding financial, staff, material, and natural resources, and as community-focused institutions operating a social and physical infrastructure, their buildings represent, simultaneously, public and private investments and public contributions. By attending to building and energy policies as they affect the institution and the community, facilities managers and owners demonstrate responsible stewardship.

The policies, practices, and standards described here will continue to change based on new laws and regulations, and the availability and affordability of new technologies. Cultural institutions are rarely exempt from these changes. The staff and consultants with cultural institutions can use these tools and strategies to their advantage as responsible facilities managers, advisors, and owners. They can use these to model stewardship of their own resources and their communities'.

The Culture Over Carbon team assembled a suite of Messaging Resources that can be used to communicate the importance of this work.

The materials can be accessed on the Culture Over Carbon Participation web page.

Energy Benchmarking Next Steps for the Sector

The Culture Over Carbon project provided data-driven insights to help inform decision-making about investments and strategic planning and prepare cultural institutions for expected building code and policy changes. Cultural institutions are taking action to make their buildings more efficient and decarbonized. In this report we shared their efforts to make a difference. By implementing energy efficiency upgrades and decarbonizing their operations, cultural institutions benefit from cost savings, improved building performance, and show their leadership and commitment to sustainability to their visitors and communities.

The Culture Over Carbon project seeks to ease the struggle that museum staff experience with lack of “like” comparisons for building energy use in the cultural sector. However, we recognize the limitations of our sample in comparison to a nationally recognized program like the 1–100 ENERGY STAR score.

This 1–100 ENERGY STAR score is based on the actual, measured energy use of a building and is calculated within EPA’s ENERGY STAR Portfolio Manager tool. The score accounts for differences in operating conditions, regional weather data, and other important considerations. This rating program exists for other building types, but there are too few museum-user entries to create appropriate comparisons for the cultural sector. To address this gap, the CIP Team and EPA are collaborating on a survey to create a building performance category for museums in Portfolio Manager.

To develop an ENERGY STAR score for museums and other cultural institutions, EPA requires significant data collection. A large representative sample of cultural institutions is needed for statistical analysis of the sector and understanding predictive energy drivers in buildings.

In collaboration with the EPA, the CIP team has developed a carefully designed cultural-sector-specific survey with input from museum stakeholders. Based on the total size of the cultural sector (estimated at over 30,000 institutions), a survey sample size of at least 200 properties is needed to establish the required representative samples for EPA to develop the ENERGY STAR score. Approximately 1,000 active properties of this type already exist in Portfolio Manager that could be candidates for the score, but completion of the survey will still be required to ensure accurate score development.

To accomplish a museum ENERGY STAR score, a large-scale, coordinated outreach effort to museums and other cultural institutions is needed to gather responses to the survey and provide ample time for data collection. The CIP team recognizes the importance of providing technical assistance and stipends as necessary to ensure accurate, complete responses for enough properties, and will be seeking funding to accomplish this goal.

Thank You to the Culture over Carbon Participants

The list below contains the names and location of the institutions that participated in Culture Over Carbon and provided data for the project. The list does not include the names of institutions whose data was procured from public benchmarking data and excludes any participants who indicated they wished to remain anonymous.

Institution Name	City, State
Adler Planetarium	Chicago, IL
Akron Zoological Park	Akron, OH
Alaska State Libraries, Archives, & Museums	Sitka, AK
American Swedish Institute	Minneapolis, MN
Ann Mary Brown Memorial, Brown Univ.	Providence, RI
Aquarium of Niagara	Niagara Falls, NY
Art Museum of Southeast Texas	Beaumont, TX
Asia Society	Brooklyn, NY
Atlanta History Center	Atlanta, GA
Bell Museum	St. Paul, MN
Bellevue Arts Museum	Bellevue, WA
Berkshire County Historical Society at Herman Melville's Arrowhead	Pittsfield, MA
Bernheim Arboretum and Research Forest	Clermont, KY
Bernice Pauahi Bishop Museum	Honolulu, HI
Burke Museum of Natural and Cultural History	Seattle, WA
Carnegie Museums of Pittsburgh	Pittsburgh, PA
Center for Arts & History, Lewis-Clark State College	Lewiston, ID
Chicago Children's Museum	Chicago, IL
Children's Museum of Eau Claire	Eau Claire, WI
Children's Museum of Illinois	Decatur, IL
Chumash Indian Museum	Thousand Oaks, CA
Cincinnati Art Museum	Cincinnati, OH
Cincinnati Contemporary Arts Center	Cincinnati, OH
Cincinnati Zoo & Botanical Garden	Cincinnati, OH
Clark Art Institute	Williamstown, MA
Creative Discovery Museum	Chattanooga, TN
Customs House Museum and Cultural Center	Clarksville, TN
Detroit Zoological Society	Royal Oak, MI
Discovery Museum	Acton, MA
Dumbarton Oak Research Library and Collections	Washington, DC
Explora	Albuquerque, NM
Exploratorium	San Francisco, CA

Institution Name	City, State
Farnsworth Art Museum	Rockland, ME
Field Museum	Chicago, IL
Florence Griswold Museum	Old Lyme, CT
Frye Art Museum	Seattle, WA
Henry Vilas Zoo	Madison, WI
Hillwood Estate, Museum & Gardens	Washington, DC
Historic New England	South Berwick, ME
International Museum of Art & Science	McAllen, TX
John Ball Zoo	Grand Rapids, MI
John F. Kennedy Presidential Library and Museum	Boston, MA
John Hair Cultural Center	Tahlequah, OK
Kansas City Zoo	Kansas City, MO
Kelsey Museum of Archaeology	Ann Arbor, MI
Kentucky Museum at Western Kentucky University	Bowling Green, KY
KidCity Children's Museum	Middletown, CT
KidsQuest Children's Museum	Bellevue, WA
La Plata County Historical Society / Animas Museum	Durango, CO
Madison Children's Museum	Madison, WI
Madison Museum of Contemporary Art (MMoCA)	Madison, WI
Memphis Museum of Science & History	Memphis, TN
Missouri History Museum	St. Louis, MO
Monterey Bay Aquarium	Monterey, CA
Mount Auburn Cemetery	Cambridge, MA
Mt. Cuba Center	Hockessin, DE
Museum of Contemporary Art, Chicago	Chicago, IL
Museum of Discovery and Science	Ft. Lauderdale, FL
Museum of Russian Icons	Clinton, MA
Museum of Science/Boston	Boston, MA
National Gallery of Art	Washington, DC
Oklahoma City Zoo	Oklahoma City, OK
Oregon Museum of Science and Industry (OMSI)	Portland, OR
Pacific Science Center	Seattle, WA
Paul Revere Memorial Association	Boston, MA
Phipps Conservatory and Botanical Gardens	Pittsburgh, PA
Pueblo Grande Museum and Archaeological Park	Phoenix, AZ
San Diego Natural History Museum	San Diego, CA
San Francisco Museum of Modern Art (SFMOMA)	San Francisco, CA
Science Museum of Minnesota	Saint Paul, MN

Institution Name	City, State
Seattle Art Museum	Seattle, WA
Shedd Aquarium	Chicago, IL
Shelton McMurphy Johnson House	Eugene, OR
Smithsonian	Suitland, MD
Spencer Museum of Art, U. of Kansas	Lawrence, KS
St. Louis Science Center	St. Louis, MO
Strawbery Banke	Portsmouth, NH
Tacoma Art Museum	Tacoma, WA
The Bakken Museum	Minneapolis, MN
The Henry Ford	Dearborn, MI
The Montshire Museum of Science	Norwich, VT
The Wild Center	Tupper Lake, NY
Thoreau Farmhouse	Concord, MA
Univ. Michigan Museum of Art	Ann Arbor, MI
Ute Indian Museum	Montrose, CO
Vermont History Center	Barre, VT
Vizcaya Museum & Gardens	Miami, FL
Western Spirit: Scottsdale's Museum of the West	Scottsdale, AZ
William J. Clinton Presidential Library	Little Rock, AR
WOW! Children's Museum	Lafayette, CO

Henry Vilas Zoo. Madison, WI | Photo courtesy of Henry Vilas Zoo

About Culture Over Carbon

The Culture Over Carbon project provides cultural institutions actionable data and recommendations to understand how their buildings use energy, help create roadmaps to reduce energy at individual institutions and the sector as a whole, and lower carbon and other greenhouse gas (GHG) emissions to reduce their impacts on climate change.

Under the project, over 130 cultural institutions from across the country provided energy use data for over 240 buildings. Analysts evaluated the data, looking for field-wide use patterns, and provided recommendations for key efficiency actions. The analysts provided recommendations to prepare institutions for expected building code and policy changes that may impact them.

This project is funded by a National Leadership grant (2021-2023) from the Institute of Museum and Library Services (IMLS) and supported by these organizations.

nbi new buildings institute | INSTITUTE of Museum and Library SERVICES | Environment & Culture Partners | nema NEW ENGLAND MUSEUM ASSOCIATION