High-Performance Building Standards

Version 1.0
December 31, 2025

Section 1 **Introduction**

1.1 What is High-Performance Building?

Charlottesville's *High-Performance Building Standards* define the City's expectations for its new and existing buildings, including its school facilities. So, what are "high-performance," "green," or "sustainably designed" buildings? Precise definitions vary, but this document reflects an understanding that high-performance buildings are designed, constructed, and operated to optimize occupant health and comfort, maximize building longevity, reduce annual operating costs, and minimize environmental impacts. These benefits and outcomes are directly supported by a firmly established and growing base of evidence developed by industry experts across many disciplines. The reduced operating costs and many of the reduced environmental impacts of high-performance buildings are attributable to substantial decreases in energy use and significant reductions of the building practices that contribute to greenhouse gas emissions (GHG).

According to the Intergovernmental Panel on Climate Change (IPCC) in their 2023 *Sixth Assessment Report*, the building sector was responsible for 21% of 2019's global GHG emissions. In Charlottesville, the building sector accounts for over 50% of emissions. Charlottesville's residents and leaders have affirmed that the reduction of emissions is a critical goal, and the City's expectations for building-related GHG reductions are further characterized in Charlottesville's 2023 *Climate Action Plan*.

The practices associated with high-performance building are best delivered in a multi-disciplinary and integrated fashion. Collectively, the synergies of interconnected building practices multiply the benefits of an isolated strategy or intervention. Put another way, "green" or "high-performance" buildings must not be imagined as conventional buildings with an added set of features. High-performance buildings are fundamentally grounded in an altogether unique approach to project delivery.

1.2 High-Performance Building Standards Purpose

The City of Charlottesville has long been an advocate and leader in the construction of high-performance public buildings. However, subject matter expertise historically resided in the various city staff members charged with project delivery and facility operations, without systematically formalized guidance. Responsibility for construction, renovation, operation, and maintenance practices was somewhat de-centralized, leading to inconsistencies in standards and expectations across departments, across project scales (major new construction projects compared to small renovations), and across activity types (new construction compared to maintenance projects).

The main goal of the *High-Performance Building Standards* (*HPBS*) is to establish a central repository for the best practices recognized by those engaged in delivering buildings and building systems. It brings these practices into alignment with City commitments to climate and sustainability. The *HPBS* also captures current mandates established by the Commonwealth of Virginia and translates these into actionable guidelines for users.

The *HPBS* is a tool to effectively guide the design, construction, and operation of City buildings by codifying and consolidating an already robust set of best practices and standard operating procedures. As the Owner and operator of a large building portfolio, standardizing high-performance practices is an investment in the City's defined goals—benefiting each building's occupants and the environment. The HPBS also models facility design and performance for local building owners, operators, and builders.

1.3 Financial Implications

A full discussion of the cost implications of high-performance building is beyond the scope of this document, but numerous in-depth studies explore the cost of achieving explicit milestones such as Leadership in Energy and Environmental Design (LEED) certification or Zero Energy Buildings. In many cases, the differential costs are minimal or negligible.

Some key concepts help to characterize the costing approach to high-performance buildings.

- High-performance building costs should be compared to the baseline building costs of the municipality (to what level of quality the municipality builds), and not to a minimally code-compliant building. Such a comparison reflects the broad spectrum of decision-making relative to other goals and constraints including building programming, planned longevity, physical context, aesthetics, local construction costs, and other factors.
- High-performance buildings reduce the cost of operations and maintenance, and when appropriate, costs can be shifted from an ongoing Operational Expense budget to a Capital Expense budget.
- Building teams should deploy a life-cycle cost analysis to major building systems that directly affect operational costs, ensuring that the payback period of an investment aligns with current municipal leadership goals.
- Project teams should always use an integrated design process to ensure that methods and systems are being conceived and deployed in a synergistic fashion to maximum efficiencies in first costs and operational costs.
- The construction team should be engaged as early as possible in the process to ensure accurate costing and constructability review.
- Environmental costs are exceedingly difficult to monetize in the context of a specific building project. New strategies are emerging for building teams, including full Carbon Life Cycle Assessments (CLCA).
- The landscape for grants and incentives is continually changing, but significant opportunities exist for municipalities to offset a portion of their costs. Examples include negotiated re-allocations of Section 179D Energy Efficient Commercial Buildings Tax Deduction and elective pay of available tax credits for renewable energy generation, clean vehicles, and alternative refueling systems.

1.4 Policy Background

In the early 2000's, the city's attention began to coalesce around impacts associated with the built environment. In 2006, the Charlottesville City Council unanimously endorsed the U.S. Conference of Mayors Climate Protection Agreement. Shortly thereafter, planning began for the Downtown Transit Station, which was certified LEED Gold by the United States Green Building Council (USGBC) after its opening in 2008. The commitment to sustainable building efforts was affirmed with the first

Charlottesville Green Building Resolution which was adopted by the City Council the same year.

From 2008 to 2020, the City achieved certification of seven projects across the building portfolio, with two additional projects to be completed in 2025 and 2026 (Bypass Fire Station and Charlottesville Middle School.) To date, all projects have been certified at the Gold or Platinum levels (Downtown Transit Center, ecoREMOD house, Smith Aquatic Center, Charlottesville Area Transit Operations Center, Facilities Maintenance Facility, Fontaine Fire Station, and Circuit Court.) The projects collectively demonstrate decades of commitment to the construction and operation of high-performing buildings in the City of Charlottesville. The highest-level certifications were achieved on buildings that were simultaneously quite technical in nature, with both the Fontaine Fire Station and the Smith Aquatic Center reaching LEED Platinum status.

The City's Comprehensive Plan contains various statements and strategies that support high performance, sustainable, and energy-efficient buildings, both in the community as well as in the municipal portfolio. Chapter 9 (Community Facilities) includes as specific strategy to "Employ innovative technology and green building practices for all eligible capital construction and renovation projects and in routine maintenance program efforts."

Previously, the City Council Vision for 2025 (established in 2007) provided nine ways that the governing body would focus on making Charlottesville "a great place to live for all [its] citizens." One method was to ensure that Charlottesville be known as a Green City.

> *Charlottesville citizens live in a community with a vibrant urban forest, tree-lined streets, and lush green neighborhoods. We have an extensive natural trail system, along with healthy rivers and streams. We have clean air and water, we emphasize recycling and reuse, and we minimize stormwater runoff. Our homes and buildings are sustainably designed and energy efficient.*

The 2025 subfocus on being a green city articulates the City of Charlottesville's long-standing dedication to human and environmental wellness. For over twenty years, the City has been committed to reducing and minimizing the impact of its construction activities and building operations.

The commitment to environmental protection was re-affirmed by City Council's 2017 commitment to the *Global Covenant of Mayors for Climate & Energy* and a 2019 commitment to 45% greenhouse gas reductions by 2030 and carbon neutrality by 2050. Following these renewed commitments, two significant documents were developed. In 2023, the City issued its *Climate Risk and Vulnerability Assessment* and its *Climate Action Plan*—documents which together point to the local implications of a changing climate and anticipate city-wide strategies for mitigating climate impacts. A *Climate Adaptation Plan* is currently in development and will include strategies for increasing climate resilience in the built environment.

At the state level, the regulatory environment has been steadily evolving since the Governor's *Order #48* in 2007, which instituted efficiency requirements for state facilities. With the *High-Performance Buildings Act of 2021*, the General Assembly established green building requirements for all municipalities in the Commonwealth of Virginia. For localities planning new construction or renovation activities, state law now requires that localities perform the following:

- Achieve LEED certification (or a comparable high-performance building certification)
- Install sources of renewable energy production
- Provide electric vehicle charging stations

1.5 *High-Performance Building Standards* Scope

The breadth and depth of the *HPBS* was intentionally framed to best support the priorities of the City of Charlottesville. These priorities include:

- Codification of internal best practices for high-performance building standards developed over 20+ years of commitment to human and environmental wellness
- Alignment with recent changes to state law, including but not limited to *the Code of Virginia §15.2-1804.1*, originally known as the *High-Performance Buildings Act*
- Alignment with the 2023 *Charlottesville Climate Action Plan*
- Alignment and re-alignment with established City of Charlottesville policies, resolutions, and guides
- Alignment of internal best practices across City departments, project scales, building types, and construction activity types
- Anticipation of future environmental conditions as identified in the *Climate Risk and Vulnerability Assessment*

The current Standards are conceived to be generalized and broadly applicable to City buildings, and it stops short of offering detailed suggestions for new or recently emergent green building practices that have not yet been incorporated in the City's portfolio. Many of these emergent concepts or practices are briefly included as "Stretch Goals". A summary of future opportunities to expand the *HPBS* is included as Appendix D.

As a guide for high-performing buildings, the document generally avoids the recitation of current building code requirements. It is assumed that the user is familiar with (or understands how to identify) current code regulations.

1.6 Document Structure and Use

The *HPBS* is intended to be used by a wide variety of building project constituents including City project managers, maintenance staff, and building operators, as well as contracted designers, builders, vendors, tradespeople, and even building users.

While the document is lengthy in its entirety, it is conceived to be concise, readily accessible, and user-friendly. The Table of Contents lists all subsections in the document, and the subsection list is hyperlinked directly to the applicable content, making the document easy to navigate. In addition, cross-references within the document are linked directly to the referenced subsection. Many subsections include references to additional resources, for the user who wants or needs a more detailed explanation or information.

Sustainable Design Procedures and Activities (Section 2) outlines the procedures that apply broadly to the design and construction of high-performance buildings. This section also includes a matrix to assist project managers and designers in assessing requirements for specific projects.

Building Planning (Section 3) describes a wide range of issues that apply to the planning and scoping phases of a building project. Within each subsection, guidance is generally organized into Current Practices, Opportunities, and Stretch Goals. The Current Practice paragraphs codify existing methods. The Opportunities paragraphs offer guidance for projects seeking to go beyond current best practice or needing to focus their performance in specific areas. The Stretch Goals paragraphs provide additional suggestions for projects seeking the highest levels of performance or piloting new or emerging practices.

Technical guidance sections (Sections 4 through 11) explore an array of topics organized into broad categories. These sections utilize the same organizational structure as Section 3, for Current Practices, Opportunities, and Stretch Goals.

Referenced Requirements and Standards (Section 12) offers standards for Building Operations, including standard operating procedures.

The Appendices offer additional supporting information.

Section 2 **Sustainable Design Procedures and Activities**

Embarking on a building project with high-performance vision and shared sustainability goals is unlike any conventional design and construction effort. This section highlights many of the unique procedures and activities that help ensure completed projects meet the original project goals.

2.1 Procedures and Activities Generally

The *High-Performance Building Standards* are conceived as a guide and tool to be used by City project managers, buyers, maintenance staff, contractors, consulting building industry professionals, and others. The Standards, as may be expected, include standards for materials and products. They also include standards for activities and procedures that collectively help project teams deliver high-performing buildings.

A detailed articulation of the design and delivery process is beyond the scope of the Standards, but they offer a guide to the procedures and activities that collectively, and in combination with effective project management, contribute to higher-performing and more sustainable buildings in the City's portfolio.

Some activities in this section reflect new mandates from the Commonwealth of Virginia. Therefore, the procedures and activities outlined in this section may be new or unfamiliar to some stakeholders, depending on their specific experiences. Generally, these activities are common in the high-performance building community, and most have been implemented for one or more City projects over the last twenty years (most commonly on the City's major LEED-certified new construction projects.)

Project managers and project teams should consult the Project Requirements by Type (Section 2.3) to understand the high-level project requirements stipulated by the Commonwealth and the City.

Project teams will be asked to establish *Building Performance Targets*, defined in Building Energy and Water Performance Targets (Section 2.4). To meet these targets with a judicious use of project funds, project teams can use Life-Cycle Cost Analysis (Section 2.5) to assess the value of a proposed building measure.

In most cases, project teams will be required to pursue LEED Certification (Section 2.6) or ENERGY STAR Certification (Section 2.7) for buildings to demonstrate successful implementation of the requirements.

This chapter also includes information on Post-Occupancy Evaluations (Section 2.8), which will help City staff continue to refine the ever-evolving set of building construction and operations best practices.

2.2 Waiver Process

When compliance with a *Current Practice* is technically infeasible, the City's Project Manager or Project Leader may apply for a waiver from Current Practice as outlined below.

2.2.1 Current Practice

2.2.1.1 When Applicable

Waivers from Current Practices will generally be evaluated for technical infeasibility. Waivers will not be approved for inadequate project planning or scheduling.

As stipulated in Project Requirements by Type (Section 2.3), the HPBS recommends that Emergency Maintenance repairs adhere to Current Practices; however, this is not strictly required. As used in the HPBS, "Emergency Maintenance" is intended to apply to situations immediately threatening to health, safety, welfare, or property. Minor or short-term inconvenience of users or occupants is not intended to justify relief from Current Practices.

2.2.1.2 Waiver Protocol

To apply for a waiver, the City's Project Manager of Project Leader shall complete the *High Performance Building Standards Waiver Application*, included herein as Appendix C and available on the City's intranet site.

The application shall clearly indicate the following information, as well as any other information requested on the Waiver Application form.

- The applicant and applicant's contact information
- The relevant building or site, by name and address
- The specific Current Practice in question, including the HPBS section number (one Current Practice per application)
- The justification for technical infeasibility
- The proposed alternative approach, if applicable
- The date of application

The Waiver Application shall be submitted to the Office of Sustainability, who will arrange for the *High Performance Building Standards Committee*'s initial consideration of the Waiver Application within five business days. Upon initial consideration, the committee will approve the Waiver Application, deny the Waiver Application, request additional information from the Applicant, or make a recommendation to the City Manager, when warranted.

For waivers requesting relief from LEED Certification, from any HPBS practice that is stipulated by the Code of Virginia §15.2-1804.1, or from any practice the committee deems critical, the committee shall review the application and make a recommendation to the City Manager for final determination.

Applicants should understand that relief from HPBS practices that are stipulated in the Code of Virginia requires a resolution by City Council.

2.2.1.3 Committee Structure

The *High Performance Building Standards Committee* shall consist of the following representatives appointed by the respective Director, unless otherwise established by the City Manager.

- A designee from the Department of Public Works
- A designee from the Office of Sustainability
- A designee from the Department of Parks and Recreation

2.2.2 Opportunities

None identified.

2.2.3 Stretch Goals

None identified.

2.2.4 Resources

None identified.

2.3 Project Requirements by Type

The following tables indicate the basic green building requirements for project types most frequently pursued by the City of Charlottesville. The tables include high performance standards from the Code of Virginia (originally conceived as the Virginia High-Performance Buildings Act) as well as requirements of the City of Charlottesville, although the source of the requirements is not indicated. In some cases, the Code of Virginia recognizes an alternative compliance method, and these are also indicated in the tables below. Where LEED certification is required, the project shall be certified to Certified level or above using the most recent version of the applicable LEED Rating System.

All work is expected to follow Virginia Uniform Statewide Building Code (USBC).

2.3.1 Requirements

2.3.1.1 New Construction

Refer to the table below for compliance methods for new construction.

	Referenced Section	New Construction Project Description			
		Over 20k SF	**5k to 20k SF**		**Under 5k SF**
			Conditioned Structures	Unconditioned Structures	
Primary Compliance Method					
Certify to most recent version of LEED NC	Section 2.6	Certified+	Certified+		
Has sufficient ZEV charging and fueling infrastructure	Section 9.4	Required	Required		
Metering of all electricity, gas, and water	Section 9.5	Code Required	Code Required		
Incorporates appropriate onsite renewable energy generation + energy storage	Section 3.11	Required	Required		
Incorporates appropriate resilience features	Section 3.4	Required	Required		
Fundamental Commissioning (LEED Definition)	Section 10.1	LEED Prerequisite	LEED Prerequisite		
Enhanced Commissioning	Section 10.2	LEED Required	LEED Recommended		
Building Envelope Commissioning	Section 10.3	Recommended	Recommended		
Meet *HPBS* as applicable		Required	Required		
Alternative Compliance Method					
ENERGY STAR Certification	Section 2.7			Required	
Fundamental Commissioning (LEED Definition)	Section 10.1			Required	
Building Envelope Commissioning	Section 10.3			Required	
Meet *HPBS* as applicable				Required	Required

** Shaded cells indicate no requirement.

2.3.1.2 Renovations

Refer to the table below for compliance methods for renovation projects.

	Referenced Section	Renovation Project Description			
		Over 20k SF		Under 20k SF	
		Major Renovations			
		Reno Cost > 50% of Bldg. Value	Reno Cost < 50% of Bldg. Value	Reno Cost > 50% of Bldg. Value	Reno Cost < 50% of Bldg. Value
Primary Compliance Method					
Certify to most recent version of LEED NC	Section 2.6	Certified+		Certified+	
Has sufficient ZEV charging and fueling infrastructure	Section 9.4	Required	Recommended	Required	
Metering of all electricity, gas, and water	Section 9.5	Required	Recommended	Required	
Incorporates appropriate onsite renewable energy generation + energy storage	Section 3.11	Required	Recommended	Required	
Incorporates appropriate resilience features	Section 3.4	Required	Recommended	Required	
Fundamental Commissioning (LEED Definition)	Section 10.1	Required	Recommended	Required	
Building Envelope Commissioning	Section 10.3	Recommended	Recommended	Recommended	
Meet *HPBS* as applicable		Required	Required	Required	
Alternative Compliance Method					
ENERGY STAR Certification	Section 2.7			Required	
Fundamental Commissioning (LEED Definition)	Section 10.1			Required	
Building Envelope Commissioning	Section 10.3			Required	
Meet *HPBS* as applicable				Required	Required

** Shaded cells indicate no requirement.

2.3.1.3 Other Project Types

Refer to the table below for compliance methods for other project types.

	Referenced Section	Other Project Type Description			
		Energy Performance	Retro Commissioning	Maintenance	Emergency Maintenance
Compliance Method					
ENERGY STAR Certification	Section 2.7	Recommended	Recommended		
Fundamental Commissioning (LEED Definition)	Section 10.1	Required	Required		
Meet *HPBS* as applicable		Required	Required	Required	Recommended

** Shaded cells indicate no requirement.

2.4 Building Energy and Water Performance Targets

Energy and water performance targets are a key component of sustainable building design and operations. All projects, including new construction, renovations, and equipment replacements, should prioritize strategies that reduce overall energy use, improve system efficiency, lower Energy Use Intensity (EUI), and lower Water Use Intensity (WUI).

2.4.1 Current Practice

2.4.1.1 Energy Performance Targets by Project Type

- New Construction
  New buildings offer the greatest opportunity for energy efficiency, as they are not constrained by existing conditions. Projects should be designed to meet all applicable requirements in these standards while integrating additional recommended strategies unless otherwise constrained. High-performance envelopes, efficient HVAC systems, and other strategies listed below should be incorporated to set aggressive, but realistic EUI energy goals.
- Major Renovations
  Renovation projects should focus on improving the energy efficiency of existing buildings by upgrading the envelope and building systems. Where feasible, outdated mechanical, electrical, and plumbing systems should be replaced with high-efficiency, all-

electric alternatives. Renovations should aim for substantial reductions in energy use compared to pre-renovation baselines.

- Equipment Replacements
  When replacing building systems or components, priority should be given to energy-efficient solutions that align with long-term sustainability goals while meeting the needs of the building currently served by the existing equipment being replaced. All new equipment should meet or exceed the highest industry efficiency standards, with a focus on electrification and compatibility with renewable energy sources.
- Building Operations and Controls
  Operational strategies play a critical role in maintaining and improving energy performance over time. Building automation systems, advanced controls, and continuous commissioning should be used to ensure energy systems operate as efficiently as possible throughout the building's lifecycle.

2.4.1.2 Energy Use Intensity Targets by Building Type

Energy Use Intensity is a measure of energy per square foot (kBtu/sf) that a building consumes in one calendar year. This is a standard unit that helps compare energy use between buildings of various types and sizes. EUI targets help define performance expectations and ensure consistency across new construction and major renovation projects. The table below provides baseline ENERGY STAR averages for comparison, current Citywide performance, and recommended EUI targets by building type. These targets are intended to guide design teams in developing high-performance buildings that significantly reduce operational energy use.

Projects should use these EUI values as performance benchmarks during early design and energy modeling phases, tailoring strategies such as improved envelope design, high-efficiency mechanical systems, and optimized controls to achieve or exceed the recommended targets.

Building Type	National EUI Average 2024*	Current City EUI Average 2024	% Above/Below National Average	New Construction	Major Renovation	
				EUI Target	% Energy Reduction	EUI Target
Aquatics Facility	123	265	-116%	100	40%	159.1
Athletic Facility	50	87	-74%	35	40%	52.2
Court House	101.2	61.7	39%	30	30%	43.2
Fire/Rescue Station	63.5	56.4	11%	35	30%	39.5
Library	71.6	58.3	19%	30	30%	40.8
Office	52.9	50.1	-5%	25	30%	35.1
Parking Garage	15	24.5	-63%	10	30%	17.2
Police Station	63.5	56.4	11%	30	30%	39.5
Schools	48.5	53.6	-11%	20	30%	37.5
Transit Center	56.2	49.1	13%	20	30%	49.2
Warehouse	20.2	22.7	-12%	15	15%	19.3

* EUI numbers listed are site EUI (kBtu/ft2) values listed by ENERGY STAR

2.4.1.3 Net Zero Energy Ready Infrastructure

All projects should strive to achieve Net Zero Energy (NZE) if possible; and should be designed, at a minimum, to be Net Zero Energy Ready to align with long-term decarbonization goals of the City. While immediate on-site renewable energy production may not be feasible for every project, all new construction and major renovations are required to include the necessary infrastructure—such as roof load capacity and electrical conduit routing to support future photovoltaic (PV) system installation. Additional infrastructure such as space for inverters or battery storage should be considered and included if there is deemed to be minimal cost to the project. See Roof Planning and Design (Section 3.10), Electrical Equipment Space Planning & Renewable Energy Ready Design (Section 3.11), and Photovoltaics (PV) (Section 9.3) for more information.

Design teams and project managers should embrace the following principle: "Reduce a watt before you produce a watt." This means prioritizing energy efficiency strategies that significantly lower building energy demand before investing in renewable generation. Right-sizing PV systems become more cost-effective and achievable when energy loads are minimized through passive design, efficient systems, and advanced controls.

Additionally, design teams and project managers should consider the cost benefits of energy efficiency measures against the potential cost of production that would be otherwise needed if a measure was not enacted. In projects constrained by first-cost, it may at times be more beneficial and practical to plan for slightly more production if energy efficiency measures are proving too costly.

2.4.1.4 Water Use Intensity Targets by Building Type

Water Use Intensity (WUI) is a measure of a building's annual water consumption relative to its size, typically expressed in gallons per square foot per year (gal/sf/yr). WUI typically does not include water that is used for site purposes and only measures processes used for indoor purposes like sinks, restrooms, cooling, etc. It provides a useful benchmark for comparing water performance across different building types and identifying opportunities for conservation.

All projects should aim to reduce both indoor and outdoor potable water use through strategies such as high-efficiency plumbing fixtures, low-flow appliances, native or adaptive landscaping, and smart irrigation systems. These efforts help lower operating costs, conserve resources, and support the City's long-term sustainability goals.

The table below provides WUI targets by building type, based on national ENERGY STAR data and current City benchmarks. These targets should guide design decisions for new construction and major renovations.

Building Type	National WUI Average 2024*	Current City WUI Average 2024	% Below National Average	New Construction	Major Renovation	
				WUI Target	% WUI Reduction	WUI Target
Aquatics Facility	Not Listed	181.12	Not Listed	125	15%	154.0
Athletic Facility	Not Listed	86.99	Not Listed	50	15%	73.9
Court House	14.48	7.09	51%	7	15%	6.0
Fire/Rescue Station	28.9	8.59	41%	15	15%	7.3
Library	14.48	7.37	49%	5	15%	6.3
Office	14.48	9.72	33%	10	15%	8.3

Parking Garage	3.43	4.61	-34%	<5	15%	3.9
Police Station	14.48	8.59	41%	10	15%	7.3
School	10.84	10.43	4%	10	15%	8.9
Transit Center	14.48	19.76	-36%	12	15%	16.8
Warehouse	3.43	4.06	-18%	<5	15%	3.5

*ENERGY STAR median (gal/sf) for 2024

2.4.2 Opportunities

None identified.

2.4.3 Stretch Goals

None identified.

2.4.4 Resources

For additional guidance on energy performance best practices and stretch goals, projects are encouraged to reference:

- (Leadership in Energy and Environmental Design) LEED
  Industry-standard certification system for energy-efficient and high-performance buildings
  https://www.usgbc.org/leed
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Advanced Energy Design Guides
  Best practices for reducing energy use and improving building efficiency
  https://www.ashrae.org/technical-resources/aedgs
- Passive House Design
  A rigorous standard for ultra-low energy buildings that emphasizes airtightness, superinsulation, and balanced ventilation strategies
  https://www.phius.org/
- Living Building Challenge
  A holistic sustainability framework that encourages regenerative design, net-positive energy, and ultra-efficient building performance
  https://living-future.org/lbc/

These frameworks can serve as targets for projects seeking to push beyond minimum efficiency requirements.

2.5 Life-Cycle Cost Analysis

Life-cycle cost analysis (LCCA) is an essential practice for evaluating the long-term financial impacts of design decisions. By considering both upfront costs and long-term operational expenses, projects can optimize investments in energy efficiency, material durability, and system performance. LCCA's should be incorporated into major project decisions to ensure that sustainability goals align with budgetary constraints while delivering the best long-term value.

LCCA is best suited to design decisions that have measurable effects on utility costs, maintenance needs, or replacement cycles—such as energy-efficient envelope assemblies, high-performance HVAC systems, and advanced lighting or controls. It is not typically used for comparing purely aesthetic or material choices that do not significantly affect operational cost, such as finishes or facade treatments.

While environmental impact is an important factor in sustainable design, LCCA by itself does not capture these effects.

2.5.1 Current Practice

2.5.1.1 When Applicable

Life-cycle cost analysis should be conducted for major design decisions that have significant budgetary impacts, such as the selection of building envelope systems, HVAC strategies, and primary structural materials. The analysis should cover a time frame sufficient to reflect the expected life of the system or material being evaluated, but ensure analysis covers a minimum of 30 years in all cases.

2.5.1.2 Analysis Scope

- Conduct LCCA for major design decisions, including building envelope and mechanical system selection.
- Ensure analysis covers a minimum of 30 years, reflecting the expected lifespan of the component or system.
- Utilize architects and engineers to develop LCCA models that provide accurate long-term cost projections.
- Capture estimates for all major maintenance and replacement costs due to expected life and operation.

2.5.1.3 Return on Investment

Energy-saving measures should be evaluated based on their payback period and overall return on invested funds, ensuring that projects invest in strategies that offer substantial long-term benefits. The most optimal payback period will need to be determined on a case-by-case basis. Priority should be given to measures that align with energy performance targets, reduce greenhouse gas emissions, and contribute to overall sustainability goals. In cases where measures have a longer payback period but offer significant environmental benefits, supplemental funding sources or incentives (including external ones) should be explored.

2.5.2 Opportunities

- Conduct a Carbon Life Cycle Assessment (CLCA) to supplement LCCA in evaluating materials and systems.

2.5.3 Stretch Goals

- For projects seeking to address embodied carbon, see Embodied Carbon (Section 5.1.2.1) or broader environmental outcomes, a more specific Life Cycle Assessment (LCA) may be used to supplement LCCA in evaluating materials and systems that weigh these specific criteria.

2.5.4 Resources

- ASHRAE Standard 189.1
  Provides guidance on high-performance green building design, including life-cycle considerations
  https://store.accuristech.com/standards/ashrae-icc-usgbc-ies-189-1-2023?product_id=2576090 (Costs associated)
- ENERGY STAR Portfolio Manager
  Offers frameworks for evaluating energy efficiency investments
  https://portfoliomanager.energystar.gov/pm/login?testEnv=false
- National Institute of Standards and Technology (NIST) Life-Cycle Costing Manual
  A key reference for conducting LCCA in construction projects

https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program

- Tally
  An LCA app that lets you calculate the environmental impacts of your building material selections directly in an Autodesk® Revit® model
  https://choosetally.com/
- Anthena Impact Estimator for Buildings
  A whole-building tool is used by design teams to explore the environmental footprint of different material choices and core-and-shell system options, applicable for new construction, renovations and additions
  https://www.athenasmi.org/our-software-data/impact-estimator/
- Embodied Carbon in Construction Calculator (EC3)
  A tool that helps building designers, construction companies, and material suppliers can directly measure, compare, and reduce the embodied carbon of their products and projects
  https://www.buildingtransparency.org/tools/ec3/

2.6 LEED Certification

Leadership in Energy and Environmental Design (LEED) is a highly regarded standard across the industry for green building design, construction, operations and performance. The standard and certification are maintained by the United States Green Building Council (USGBC). Projects can be certified at four levels of achievement: Certified, Silver, Gold, or Platinum.

The City of Charlottesville *High-Performance Building Standards* (HPBS) are not strictly aligned with LEED credit requirements, and LEED credit language changes over time. In many cases, however, there is a significant overlap between the two standards.

2.6.1 Current Practice

2.5.1.1 Where Applicable

Reference Project Requirements by Type (Section 2.3) for more information about when LEED certification is required.

2.6.1.2 Certification Level

Where LEED Certification is required, projects should achieve a minimum certification level of "Certified" using a current version of the Building Design and Construction framework (LEED BD+C).

The City does not require achievement of specific LEED credits, although project teams should strive to align their certification efforts with current practices represented in the HPBS and with those credits that directly support the City's *Climate Action Plan*.

2.6.2 Opportunities

Achieve LEED Silver, Gold, or Platinum Certification using a current version of LEED BD+C.

2.6.3 Stretch Goals

None identified.

2.6.4 Resources

- USGBC's LEED Reference Guide for Building Design and Construction https://www.usgbc.org/guide/bdc

2.7 ENERGY STAR

ENERGY STAR, operated by the US Environmental Protection Agency (EPA), is a voluntary program that rates appliances, electronics, lighting fixtures, and more in addition to building certifications for residential, commercial, and industrial plants.

2.7.1 Current Practice

2.7.1.1 Where Applicable—Pursuit

Pursue the ENERGY STAR Building Certification for all project types that are recognized by the certification program.

2.7.1.2 Where Applicable--Certification

The Commonwealth recognizes ENERGY STAR Building Certification as an alternative compliance method to state-level mandates in some instances. The City has defined the building types for which the alternative compliance method will be utilized. In such instances, the applicable building must earn the ENERGY STAR Building Certification. Reference Project Requirements by Type (Section 2.3).

2.7.1.3 Commercial Building Certification

To earn the ENERGY STAR, eligible commercial buildings must earn an 1–100 ENERGY STAR score of 75 or higher—indicating that they operate more efficiently than at least 75% of similar buildings nationwide. Before applying, a building's application must be verified by a Professional Engineer or Registered Architect. This licensed professional must verify that all energy use is accounted for accurately, the building characteristics have been properly reported, and that building operates in accordance with industry standards for indoor environmental quality.

2.7.1.4 Additional Building Type Certifications

To earn the ENERGY STAR, a new home or apartment must undergo a rigorous process of third-party inspections and testing to verify that all applicable program requirements are met. Requirements differ between single family homes, multifamily buildings, and manufacturer homes. Consult the ENERGY STAR website for resources detailing requirements and eligibility.

2.7.2 Opportunities

None identified.

2.7.3 Stretch Goals

None identified

2.7.4 Resources

- ENERGY STAR Building Certification
  https://www.energystar.gov/buildings/building-recognition/building-certification

2.8 Post-Occupancy Evaluation

A Post Occupancy Evaluation (POE) is a systematic review to measure the quality of the design and functionality of a building, after it has been occupied for some time, with the goal of fully understanding how the building is working for those who use the space daily. POEs offer the opportunity to fine-tune building operations and collect lessons learned which can be applied to future building projects. These efforts are intended to result in increased productivity, improved performance, and greater efficiency. POEs are distinct and separate from one-year warranty reviews. Activities typically include data analysis, walk-throughs/observations, interviews with key stakeholders, and surveys of building occupants.

POE stakeholders should include representatives from the design and construction teams, building management, building operations, and building occupants.

2.8.1 Current Practice

None identified.

2.8.2 Opportunities

Perform POE activities on recently completed building projects. POE's are recommended after one year (one heating and cooling season) and after two years (two heating and cooling seasons).

2.8.3 Stretch Goals

None identified.

2.8.4 Resources

- Post Occupancy Evaluations, Whole Building Design Guide
  https://stg.wbdg.org/resources/post-occupancy-evaluations
- Center for the Built Environment (CBE) Occupant Survey
  https://cbe.berkeley.edu/resources/occupant-survey/

2.9 Codes and Standards

The following codes and standards are applicable to projects in the City of Charlottesville and Albemarle County. The lists are not intended to be comprehensive. Dates are current as of July 2025. All documents are readily available online, at no cost.

2.9.1 Primary Code Requirements

The Code of Virginia contains enabling regulations and state mandates which underly much of the High-Performance Building Standards.

- Code of Virginia

A partial list of the building codes currently adopted by the Commonwealth of Virginia is indicated below.

- 2021 Virginia Construction Code
- 2021 Virginia Existing Building Code
- 2021 Virginia Energy Conservation Code
- 2020 NFPA 70, National Electric Code
- 2021 Virginia Plumbing Code
- 2021 Virginia Mechanical Code
- 2021 Virginia Statewide Fire Prevention Code

2.9.2 Primary Accessibility Requirements

The two most frequently referenced accessibility standards are indicated below. The Americans with Disabilities Act (ADA) is federal civil rights law. The ICC A117.1 document is the adopted code standard in the Commonwealth of Virginia. These standards vary slightly and are both applicable to City projects.

- 2010 ADA Standards for Accessible Design
- 2017 ICC A117.1 Accessible and Usable Buildings and Facilities

2.9.3 Principal Sustainability Reference

The LEED program is a nationally recognized standard for green building and is maintained by the US Green Building Council. Projects are assessed by building type and project type and are certified to the Certified, Silver, Gold and Platinum levels.

- LEED v4.1 Building Design + Construction
- LEED v4.1 Interior Design + Construction
- LEED v4.1 Operations + Maintenance

2.10 Facility Systems Manual

The first months and years of a building's operation are critical to achieving long-term performance goals. This period allows verification of the system functionality, optimization of settings, and ensures that operational knowledge is transferred effectively from the designers and installers. Establishing consistent guidance for building handoff and post-occupancy support ensures new buildings perform as intended.

2.10.1 Current Practice

2.10.1.1 Where Applicable

Turnover procedures and operational readiness protocols should be implemented for all new construction and major renovation projects.

2.10.1.2 Project Operations Manual

All projects shall include a concise but thorough operations manual developed by the design team, including the engineer and architect of record. This manual shall contain:

- HVAC system schedules and sequences
- Recommended setpoints
- Seasonal changeover procedures
- Typical equipment maintenance
- Basic troubleshooting guidance
- Controls and BAS narrative

This manual should be provided in a user-friendly digital format for facilities staff and handed off at the time of commissioning closeout.

2.10.1.3 Training and Commissioning

Operational staff shall receive training from the commissioning and construction team along with support from the design team. Refer to Section 10 Commissioning.

2.10.2 Opportunities

- Conduct a joint workshop after initial occupancy to review the commissioning report, unresolved issues, and ongoing optimization strategies.
- Enhanced Staff Training: Provide phased or follow-up training after occupancy to address real-world operating conditions and evolving staff needs.

2.10.3 Stretch Goals

None identified.

2.10.4 Resources

- ASHRAE Guideline 1.4P – Procedures for Preparing Facility Systems Manuals https://www.eeperformance.org/uploads/8/6/5/0/8650231/systemsmanualsgdl1_4-201x__chair_approved.pdf

Section 3 **Building Planning**

Buildings designed, planned, and constructed with sustainability and durability in mind lead to longer use and a lower environmental and economic impact. Thoughtful design creates a well-maintained, meaningful, and enduring built environment.

3.1 Development and Permitting Requirements

A full discussion of the development and permitting processes is beyond the scope of this document. The City Project Manager and the design team should be in close communication relative to the entitlement and permitting processes.

3.1.1 Requirements

3.1.1.1 Development Requirements

The City of Charlottesville maintains a webpage outlining the full development review process, with links to additional resources. See the Resources section below.

3.1.1.2 Building Permits

The Virginia Construction Code (VCC) Section 108 outlines all scenarios when a building permit is required. Project managers shall ensure that all construction activities are properly permitted in accordance with the most recent edition of the VCC.

3.1.1.3 Construction Documents

Construction documents shall be developed and submitted to the Building Official in accordance with VCC Section 109.

3.1.2 Opportunities
None identified.

3.1.3 Stretch Goals
None identified.

3.1.4 Resources
- Development Requirements and Processes
  Development Requirements and Processes | Charlottesville, VA
- *The Development Code and Procedures Manual*
  Microsoft Word - 2025_Edits_Charlottesville_NDS_Admin-Manual_FINAL
- *Development Code* (5.2.9)
  34_529_Development_Review

3.2 Design Professional Requirements
The following requirements generally describe when a registered design professional is needed.

3.2.1 Requirements

3.2.1.1 When an Architect or Engineer is Required
A Registered Design Professional (architect or engineer, typically) is required to provide sealed construction documents under any of the circumstances below. The occupancies indicated are defined in the Virginia Construction Code.

- Assembly Group A Occupancies (areas where occupants gather)
- Business Group B Occupancies over 5,000 SF or over 3 stories
- Schools and Daycare Centers Group E Occupancies
- Factory and Industrial Group F Occupancies over 15,000 SF or over 3 stories
- High Hazard Group H Occupancies
- Institutional Group I Occupancies
- Mercantile Group M Occupancies over 5,000 SF or over 3 stories

- For Residential Group R Occupancies, consult the Authority Having Jurisdiction
- Storage Group S Occupancies over 15,000 SF or over 3 stories
- Utility and Miscellaneous Occupancies over 15,000 SF or over 3 stories
- Remodeling or interior design which involves a change to the occupancy classification, occupant load, structural system, access pattern, or exit pattern, or which involves an increase in fire hazard

For Mechanical, Electrical, Plumbing (MEP), and Fire Protection (FP) systems and components, consult the Authority Having Jurisdiction.

3.3 Accessibility Features

The City strives to provide facilities which offer equivalent access to people of all abilities.

3.3.1 Current Practice

Projects shall meet the Virginia Construction Code and the ADA. No additional requirements have been identified.

3.3.2 Opportunities

3.3.2.1 Ramps

Ramps with a slope of 1:20 are recommended where feasible. Ramps with lower gradients are easier for differently abled users to navigate.

3.3.2.2 Entrance Operators

Automatic door operators are recommended at the primary entrances of new buildings. Operators should control one door of the inner and outer enclosure of vestibules. Ensure that the door operator does not override any access control features.

3.3.2.3 Employee Work Areas

Current standards do not require employee work areas to be fully accessible. Consider opportunities to exceed current standards by increasing accessibility in work areas or designing work areas to be fully accessible.

3.3.2.4 Universal Design

Consider a universal design approach which provides facilities and features that are fully accessible to all. This approach also avoids the segregation of facilities into accessible and non-accessible components.

3.3.3 Stretch Goals

None identified.

3.3.4 Resources

None identified.

3.4 Resilience Features

The Commonwealth of Virginia, per the Code of Virginia §15.2-1804.1, requires municipalities to prepare for acts of nature, failures of systems, or adversarial acts that could cause a major disruption to building functionality, by reducing risk or enabling recovery. The City has considered emergency preparedness on a City-wide level, and no requirements have been identified relative to the *High-Performance Building Standards*. The City has also completed a *Climate Risk & Vulnerability Assessment* which identifies long-term risks which may be ameliorated by prudent building planning decisions.

3.4.1 Current Practice

Building systems for new construction and major renovations should always consider resilience as a key design consideration. Systems should be sized and designed for energy efficiency, but project teams should also evaluate project and site-specific vulnerabilities to major disruption.

3.4.1.1 Prohibited Development Locations

Do not locate buildings, hardscapes, or systems in the following sensitive locations:

- Within the 100-year flood plain or within any legally adopted flood hazard area
- Within 100′ of a water body
- Within 50′ of a wetland
- On land identified as habitat for the following:

- Species listed as threatened or endangered under the U.S. Endangered Species Act or the state's endangered species act
- Species or ecological communities classified by NatureServe as GH (possibly extinct), G1 (critically imperiled), or G2 (imperiled)

3.4.2 Opportunities

3.4.2.1 Plumbing Systems

Plumbing (Section 7) includes water conservation strategies that demonstrate the City's commitment to protecting limited water resources.

3.4.2.2 Mechanical Systems

Mechanical (Section 8) includes recommendations for demand response strategies which can reduce stressors on the power grid in times of regional demand peaks.

3.4.2.3 Site Design

Several opportunities for mitigating climate risk are included in Site Design (Section 11), including:

- Maximizing the City's tree canopy
- Restoring streams and establishing riparian buffers
- Optimizing stormwater strategies for on-site management
- Protecting and increasing areas of native habitat

3.4.2.4 Resilience Hubs

Plan for community-serving facilities to function as Resilience Hubs. Hubs shall be designed to be usable in a crisis, but they are not intended to be designated emergency shelters and are not conceived to serve emergency preparedness functions or emergency response functions.

Locate buildings in areas that equitably serve the needs of disadvantaged Charlottesville communities.

Resilience Hubs should include the following features:

- Energy Production
- Emergency Power
- Showers, see Showers and Changing Facilities (Section 3.13)
- Redundancy of systems to reduce single point failures which can adversely affect an entire facility's operation

Resilience Hubs are anticipated to serve as:

- An operations base for the delivery and distribution of food and water
- A place for charging phones and other personal devices
- A place for refrigeration of personal pharmaceuticals
- Cooling and heating centers

3.4.3 Stretch Goals

None identified.

3.4.4 Resources

- *Charlottesville Climate Risk & Vulnerability Assessment* https://www.charlottesville.gov/DocumentCenter/View/8902/Adaptation-Planning---Charlottesville-VA---Climate-Risk-and-Vulnerability-Assessment-PDF

3.5 Building Reuse

Architecture 2030, a non-profit, non-partisan and independent organization established in 2002 in response to the ongoing climate emergency, reports that the built environment accounts for 40% of global carbon emissions, and of that, approximately one-third is attributable to the embodied carbon of building construction. See Embodied Carbon (Section 5.1.2.1). Re-purposing and extending the useful life of existing buildings is one of the most important and effective actions that building owners and green building practitioners can take.

3.5.1 Current Practice

Fully assess opportunities for building renovation, rehabilitation, or re-purposing before demolishing and replacing any existing building.

3.5.2 Opportunities
None identified.

3.5.3 Stretch Goals
None identified.

3.5.4 Resources
None identified.

3.6 Salvaged Materials
Salvaging construction materials and used furnishings from existing buildings helps divert waste from landfills and incinerators. Additionally, recycling and salvaging materials often require less energy compared to manufacturing products from raw materials.

3.6.1 Current Practice

3.6.1.1 Salvage Assessment
Prior to renovation, assess building materials and furnishings for potential salvage, re-use, and re-purposing. Develop a plan to avoid sending materials to landfills.

3.6.1.2 Furnishings
Retired furnishings with useful life remaining shall be salvaged for re-use.

Surplus furniture from non-school facilities can be delivered to the Procurement Division at the City Warehouse (PWD) and re-sold via the City's *Public Surplus* online auction. The City Warehouse has limited space so deliveries to the warehouse should be coordinated in advance by the City's Project Manager.

Surplus furniture from school facilities can be re-purposed through *The Reuse Network* listed below. The Reuse Network charges a fee for their collection.

Furnishings that cannot be accepted by the city warehouse or *The Reuse Network* should be repurposed via used furniture aggregators or distributors who may also be able to facilitate collection. Aggregators may charge a modest fee for pick-up. See Resources below.

3.6.1.3 Refrigerants

Refrigerants that are phasing out but are still used elsewhere in the City shall be recovered and stored for re-use. Obsolete refrigerants must be legally disposed of. Contact PWD or Facilities Maintenance for more information.

3.6.1.4 Plumbing Items

Do not reclaim faucets and pipes with unknown levels of lead in the brass of the items.

3.6.2 Opportunities

None identified.

3.6.3 Stretch Goals

None identified.

3.6.4 Resources

- City of Charlottesville Surplus Property Sales
  https://www.charlottesville.gov/946/Warehouse-Operations
- Office Products, Harrisonburg
  Buys and sells used furnishings
  https://www.furniture-systems.com/
- Richmond Office Interiors
  Buys and sells used furnishings
  https://richmondofficeinteriors.com/
- The Reuse Network
  An established company that facilitates furniture collection and re-distributes products to non-profit and disaster relief efforts around the world.
  https://www.irnsurplus.com/

3.7 Construction and Demolition Debris

Reducing the amount of Construction and Demolition (C&D) waste materials disposed of in landfills or incinerators can create employment and economic activities in recycling industries and provide increased business opportunities within the local community while reducing overall building project costs and environmental impacts.

The following requirements and opportunities are for City projects generally. LEED projects will need to follow more specific requirements from United States Green Building Council (USGBC).

3.7.1 Current Practice

3.7.1.1 General Requirements

Except on small projects, implement a C&D waste recovery program.

3.7.1.2 Required Items

Waste streams that must be diverted from landfills include aluminum, steel, glass, cardboard, wood, paper, films, and carpet.

3.7.1.3 On Site Containers

Use a single stream co-mingled recycling container OR deploy multiple recycling containers for on-site separation.

3.7.1.4 Carpet Take Back Programs

Carpet scheduled for removal must be processed through a manufacturer take-back program. Major carpet manufacturers with take-back programs include, but are not limited to:

- Shaw Contract
  Shaw will pick up any Shaw product at no cost to the project. A replacement order with Shaw is not required. The minimum quantity is 100 cubic yards.
- Interface
  Interface will pick up any Interface product at no cost to the project. A replacement order with Interface is not required. Minimums apply but salvaged products can frequently be aggregated by the distributor or vendor.

- Mohawk Group
  Mohawk accepts any manufacturer's carpet in their recycling program, if the carpet meets the recycling type and condition requirements. Recycling and landfill diversion fees are assessed on a project-by-project basis. A quote can be obtained within 48 hours by contacting Mohawk's ReCover Carpet Recycling Program.

3.7.2 Opportunities

3.7.2.1 Small Projects

For small projects that do not justify on-site containers or separation, City staff should deposit C&D waste in the designated container at the City Yard. Contact the Capital Development Division with any questions. Contractors working on small projects may be given access to the container on a project-by-project basis.

3.7.2.2 Other Flooring Types

Other flooring scheduled for removal should be evaluated for take-back by the new flooring manufacturer or the original flooring manufacturer. Major manufacturers of other flooring types with take-back programs include but are not limited to:

- Shaw Contract
- Interface
- Tarkett
- Forbo

3.7.2.3 Ceiling Tile Take Back

Major ceiling tile manufacturers with take-back programs include, but are not limited to:

- Armstrong
  The Armstrong Ceilings Recycling Program focuses on recycling and reusing mineral fiber ceilings. Armstrong recycles CertainTeed, USG, and other mineral fiber ceilings in addition to Armstrong ceiling material. The minimum amount recyclable is 5,000 square feet but can vary depending on location and proximity. Start ceiling recycling by filling out the ceiling recycling contact form at Armstrong's website.

https://www.armstrongceilings.com/commercial/en/performance/sustainable-building-design/ceiling-recycling-program.html

- United States Gypsum (USG)
  USG recycles mineral fiber ceilings. Consult USG's Take-Back Recycle Program brochure to view the list of accepted ceiling products.
  https://www.usg.com/content/usgcom/en/sustainability/ceilings-recycling-program.html

3.7.2.4 Gypsum Board Take Back

Gypsum board recycling is not widely available in Charlottesville and the surrounding area at this time. The following programs accept gypsum for recycling with the stipulations described.

- USG
  USG enables customers with clean construction, new, non-decorated drywall waste discarded on the jobsite to recycle all standard USG Sheetrock® Brand gypsum panel products. Other manufacturers clean scrap cannot be accepted.

3.7.2.5 Emerging Take Back Streams

The materials market is rapidly evolving and expanding. Project teams should be aware of emerging manufacturer take back streams and strive to recycle or divert as much material as is practicable.

3.7.3 Stretch Goals

None identified.

3.7.4 Resources

None identified.

3.8 Construction Materials and Methods

Fundamental decisions about construction methods can have outsized impacts on a building's (and in turn the City's) carbon footprint. It is important to understand and vet these big-picture decisions early in the design process, while plans are still malleable.

According to *Architecture 2030*, concrete, steel, and aluminum are collectively responsible for 23% of total global emissions, and most of these emissions are attributable to the built environment. These materials are ubiquitous in the contemporary building industry, and in most cases cannot be entirely eliminated. Strategic decision-making, however, can significantly reduce the embodied carbon of a construction project. See Embodied Carbon (Section 5.1.2.1).

Wood building products are generally recognized as having much lower embodied energy than concrete and steel and should therefore be preferred in many instances.

3.8.1 Current Practice

All new construction projects shall carefully evaluate and consider the materials and methods used for a building's primary structural frame, walls, and partitions.

In many cases, the building code permits buildings with wood structures or buildings otherwise made of wood elements and materials. Even larger buildings, including high-rise structures, can now be constructed of wood frame elements such as heavy timber or cross-laminated timber (CLT).

3.8.2 Opportunities

Project teams should strive to reduce the effects of the building sector's high-impact structural materials. Specify low-impact building materials as often as possible.

3.8.2.1 Concrete

Reduce the use and impact of concrete. See Concrete (Section 5.9) for more information.

3.8.2.2 Steel

Specify structural steel with high-recycled content manufactured in a plant with electric arc furnaces (EAF) operated on high percentages of renewable energy. The specified steel should therefore have a lower Global Warming Potential (GWP).

3.8.3 Stretch Goals

None identified.

3.8.4 Resources

- Architecture 2030
  https://www.architecture2030.org/

3.9 All-Electric Buildings

The transition to all-electric buildings is a crucial strategy for reducing carbon emissions and improving building performance. As the electrical grid continues to incorporate higher levels of renewable energy, all-electric buildings will see increasing environmental and financial benefits. Unlike fossil fuel-based systems, which lock in emissions for decades, electric systems allow buildings to take full advantage of grid decarbonization over time.

Beyond environmental benefits, electrification also enhances building resilience and operational efficiency. Gas heated systems lose controllability and would fully shutdown in most power loss situations with modern controls, thus electrified buildings do not expose a new risk to losing heat during power outage. Modern electric systems, particularly heat pumps, also offer higher energy efficiency, lower maintenance costs, and greater flexibility in responding to demand. Additionally, all-electric buildings are better positioned to integrate with on-site renewable energy, battery storage, and demand response programs, making them more adaptable to future energy trends.

3.9.1 Current Practice

3.9.1.1 New Construction and Major Renovations

Generally, all projects in this category shall be designed as fully electric unless site specific limitations, such as utility service constraints, make this infeasible. Consult Project Requirements by Type (Section 2.3) for the full extents of requirements by size of construction. Other possible exceptions include generators and science labs.

Electrical infrastructure must be sized to accommodate all-electric systems, including space heating, domestic water heating, cooking, electrical vehicle (EV) charging, and other major loads.

- Heating and domestic hot water systems shall use heat pump technology wherever possible to maximize efficiency and reduce carbon emissions. See Equipment (Section 6) and Domestic Water Heating Systems (Section 7.8).
- Cooking equipment in commercial and institutional kitchens should transition to induction or other high-efficiency electric alternatives. See Commercial Kitchens (Section 6.7).

In cases where backup power is required, battery energy storage should be evaluated as an alternative to diesel or natural gas generators.

3.9.1.2 Avoid Fossil Fuels

No new fossil fuel-based heating systems shall be installed with the exception of when service upgrades would make the conversion cost-prohibitive. Where existing fossil fuel equipment must remain due to these limitations, a transition plan should be developed to support future electrification.

Use of heat pumps for space and water heating shall be prioritized unless infeasible for some reason. Where it is infeasible to completely transition to all-electric look at hybrid systems as an additional option.

3.9.2 Opportunities

None identified.

3.9.3 Stretch Goals

None identified.

3.9.4 Resources

- Advanced Energy Design Guides by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IES Standard 90.1.
  https://aedg.ashrae.org/
- Rocky Mountain Institute (RMI) Building Electrification Program
  https://rmi.org/our-work/building-electrification/
- New Buildings Institute, The Building Electrification Technology Roadmap
  https://newbuildings.org/resource/the-building-electrification-technology-roadmap/
- New Buildings Institute, The Building Electrification Technology Roadmap for Schools
  https://newbuildings.org/resource/the-building-electrification-technology-roadmap-for-schools/

3.10 Roof Planning and Design

In almost all cases, rooftop solar will be the most viable renewable energy strategy for a new construction project and will prove viable for many renovation projects. The following planning strategies are all fundamental to maximizing the amount of energy that can be produced on site. This section also includes planning strategies relevant to green roofs.

3.10.1 Current Practice

3.10.1.1 Where Applicable

Rooftop solar production shall be anticipated and planned for every project. See Electrical Systems (Section 9) for electrical information and Photovoltaics (PV) (Section 9.3) for anchorage requirements.

Green roofs shall be considered for low-slope, or flat, roofs that are not otherwise viable for rooftop solar production.

3.10.1.2 Roof Planning and Design

The project team shall consider all aspects defined below, recognizing that roof designs cannot fully satisfy all roof optimization considerations. Roofing performance requirements can be found in Building Envelope (Section 4). Roofing material requirements can be found in Building Materials (Section 5).

3.10.1.2.1 Structural Capacity

Where solar arrays are anticipated, new roofs shall be designed to accommodate a minimum of 8 psf, in addition to other code-required structural loads. Where green roofs are anticipated, new roofs shall be designed to accommodate the superimposed loads anticipated by the specifier, in addition to other code-required structural loads.

3.10.1.2.2 Roof Form

Consider the building's roof form with respect to the energy production goals. As the City moves towards net zero energy (NZE) buildings, the production goals will exceed the roof capacity, so maximizing the rooftop production is even more critical.

Pitched roofs, especially shed roof forms, roof forms with ribs or battens, and roof forms with overhanging eaves, can make installation easier and can offer larger areas for solar production.

Low-slope, or flat, roofs are acceptable but can present greater limitations on production capacity. Solar arrays on low-slope roofs can be mounted at angles to maximize the production from each panel but tilted panels will cast shade and reduce the number of panels that can be deployed. Panels can also be mounted flat, which typically maximizes the production capacity of the array (i.e. lower production per panel, with more panels).

Absent other criteria, the ideal slope for solar panels in the central Virginia climate is 30 to 45 degrees, which equates to pitches between 7:12 and 10:12.

3.10.1.2.3 Orientation

Orient roofs to avoid shade created or anticipated by nearby buildings or landscape features. Roofs should be oriented within 10 degrees of south to maximize sunlight for PV installation when possible. When a south-facing roof is not possible or is limited, the preference is for west-facing roof to maximize hours of sunlight on the PV array.

3.10.1.2.4 Fall Protection

On low-slope roofs, provide parapet walls. Parapets can reduce wind pressures, serve as fall protection, and provide better aesthetics to the building facade. When PV is installed on the roof, anticipate projected shadows and code-required clearances. Use rails or screen walls as a secondary option if parapets are not possible. Tie-offs for fall protection are the least preferable option.

3.10.1.2.5 Roof Access

On low-sloped roofs, provide a roof access hatch. Consider stair access to the roof hatch depending on the intended use case and building code requirements. Place roof access near rooftop equipment. If equipment is located on the ground or in a dedicated mechanical space, place the roof access near other roof penetrations to avoid interruptions in the PV layout.

3.10.1.2.6 Rooftop Equipment

When possible, avoid placing equipment on the roof. Equipment should be located on the ground or in a dedicated mechanical space inside the building. This allows for increased service life and efficiency while leaving the roof available for PV production. This is also a preferred solution for maintenance personnel regarding serviceability. Consider that placing equipment inside requires additional square footage. When equipment is located on the roof, consolidate and align the equipment and prefer locations on the north side of the roof or in areas where shadows are cast from adjacent buildings or trees.

3.10.1.2.7 Daylighting

Maximize daylighting through roof monitors rather than skylights. Skylights increase the cooling load while roof monitors can increase the amount of natural light while still incorporating shading on the glass. Consider north-facing glass for the monitors to maximize the roof area facing south for PV installation. Monitors should be used sparingly and for the most interior impact.

Consider tubular daylighting systems rather than traditional skylights. Tubular daylighting systems minimize the heat gain of typical skylights by using a smaller roof penetration and filtering out infrared wavelengths. Carefully coordinate locations to avoid interruptions to the PV production.

3.10.1.2.8 Rooftop Penetrations

Aggregate rooftop penetrations when possible. For tubular daylighting penetrations, consider grouping the roof penetrations together and using the flexibility of the tube to distribute lighting throughout the spaces. Avoid placing intakes and exhausts on the roof; relocate to walls when possible.

3.10.1.2.9 Rooftop Coordination Drawings

Require rooftop coordination drawings from the construction team. These include solar shop drawings, rooftop equipment, penetrations, roof drains, and other items on the rooftop. Drawings should be adjusted as needed for the maximization of PV production.

3.10.2 Opportunities

None identified.

3.10.3 Stretch Goals

None identified.

3.10.4 Resources

- The Virginia Statewide Fire Prevention Code (VSFPC) contains code requirements for access, perimeter and interior pathways, and setbacks in relation to Solar Photovoltaic Power Systems.
- The Occupational Safety and Health Administration (OSHA) Regulations, *1926.502 – Fall Protection Systems Criteria and Practices* contains minimum fall protection requirements.

3.11 Renewable Energy Ready Design & Electrical Equipment Space Planning

The following strategies are fundamental to maximizing space efficiency and preparing for renewable energy integration.

3.11.1 Current Practice

3.11.1.1 Where Applicable

Electrical equipment space planning and renewable energy ready design are expected for all new construction, major roofing replacements, and major building renovations, except where technically infeasible. Consult Project Requirements by Type (Section 2.3) for exceptions.

3.11.1.2 Renewable Energy Ready Definition

When applicable, renewable energy ready design shall include the following:

- Space in the building for needed electrical equipment such as panels, inverters, etc., see Electrical Room Design (Section 3.11.1.3).
- Conduit pathways with pull strings to locations serving future energy systems (Section 3.11.1.5)
- Coordination with the electrical utility to ensure transformers are sized for the planned renewable energy capacity.
- Adequate structural capacity to locate photovoltaics, and their associated mounting equipment, on the roof, see Photovoltaics (PV) (Section 9.3).
- Clean roofs with any roof mounted equipment minimized to the maximum extent possible, see Roof Planning and Design (Section 3.10).
- OSHA requirements for fall protection on the roofs, see Fall Protection (Section 3.10.1.2.4).
- See Roofing (Section 4.3) for more information on roofing material selection in regard to photovoltaics.
- Determination of where renewables will tie-in to the overall electrical distribution system.
    - The location of a tie-in to the electrical distribution system is specific to the individual building circumstances. The design team should evaluate project needs, indicate whether this tie-in will be before or after the main building breaker, and ensure all requirements of NEC 705 are met.

3.11.1.3 Electrical Room Design

Electrical Rooms shall be designed to meet the requirements of the proposed building and building systems. In addition, the rooms shall be designed to accommodate the installation, or future installation, of a photovoltaic system. Construction documents shall clearly indicate the building and electrical equipment spaces reserved for future breakers, panels, inverters and other required system components. The City requires all inverters to be inside the building.

3.11.1.4 Energy Storage Planning

The City anticipates a move to battery back-up or hybrid battery and natural gas back-up. Construction documents shall clearly indicate the proposed location for battery storage and how it integrates into the overall building/site electrical distribution system. In a hybrid back-up scenario, the City anticipates that both an exterior natural gas genset and battery back-up system may be located outside the building.

3.11.1.5 PV Panel Placement Other than Roofs

Where the new roof is not large enough to support zero net energy, the project should consider alternatives for supplemental production in the following order of preference:

- PV on parking canopies or other site canopy structures
- Building-integrated PV (BIPV)
- Ground-mounted PV
- Other renewable strategies
- Off-site PV

3.11.1.6 Pathways

Conduit shall be installed between the roofs where photovoltaic array(s) are planned and the proposed interior photovoltaic equipment location(s). Conduit shall be extended through the roof and capped. Conduit pathways shall also be identified from the interior photovoltaic equipment location and any anticipated exterior battery storage when they are to be integrated directly. Underground conduit shall be installed from the interior photovoltaic equipment location through the exterior foundations and beyond any anticipated hardscape elements. Conduit shall be terminated in an underground pullbox or handhole. All conduits installed for future use shall include pull-strings.

3.11.2 Opportunities

A renewable energy system that offsets at least 50% of the building's energy use shall be provided as part of the project that will be installed as soon as possible, via direct purchase or through Power Purchase Agreement (PPA).

3.11.3 Stretch Goals

Include a renewable energy system that offsets 100% of the building's energy use with a 15% safety factor. Refer to Photovoltaics (PV) (Section 9.3) for additional requirements.

3.11.4 Resources

None identified.

3.12 Lactation Rooms

Providing a private room for expressing breastmilk meets federal law per the Fair Labor Standards Act (FLSA). To meet the requirements of the law, the employer must ensure that all nursing employees, including employees who telework, are shielded from view and free from intrusion when pumping. This includes being shielded from the view of and free from intrusion by members of the public and co-workers, including any co-workers who are also pumping. An employee must also be free from observation by any employer-provided or required video system, including a computer camera, security camera, or web conferencing platform, when she is expressing breast milk, regardless of her location. Also see the City of Charlottesville's current policy on lactation requirements or consult with the Human Resources Department.

3.12.1 Current Practice

3.12.1.1 Where Applicable

A permanent room for the purpose of breast-feeding is required in new construction and major renovations with more than 20 regular building occupants. Lactation rooms should not be in or accessed through bathrooms. Lactation rooms should be private spaces shielded from view. Facilities may have a larger lactation room with multiple stations, but the station must be separated by a privacy curtain or other screening device.

3.12.1.2 Minimum Size

A lactation room should be 7 feet by 10 feet minimum, measured to the interior face of the wall, and include a 24" deep counter and turning space, as required by code.

3.12.1.3 Minimum Elements

Where a lactation room is required, provide the following elements.

- Provide a user-operated locking door.
- Provide storage for cleaning supplies.
- Provide a trash can.

- Provide a comfortable chair with arms. Avoid sofas.
- Provide power within reach of the chair.
- Provide dimmable lights.
- Provide a refrigerator (an undercounter refrigerator is acceptable).
- Provide a counter.
- Provide a sink with hot and cold water.

3.12.1.4 Counter

The required counter should be 24 inches deep and long enough to accommodate the sink and a clear counter area 18" long.

3.12.1.5 Sink

The required sink should be large enough to wash bottles and breast pump parts. Gooseneck or kitchen-type faucets are recommended. The sink shall have the required knee and toe clearance.

3.12.2 Opportunities

Evaluate the need for a lactation room in all projects. Develop a plan for temporary lactation space, including a counter or tabletop, that could be made available for up to one year where permanent lactation spaces are not provided.

3.12.3 Stretch Goals

None identified.

3.12.4 Resources

- The Virginia Pregnant Workers Fairness Act, *Code of Virginia* § 2.2-3905 https://law.lis.virginia.gov/vacode/2.2-3905/
- Fact Sheet #73A: Space Requirements for Employees to Pump Breast Milk at Work under the FLSA, Department of Labor, 2025 https://www.dol.gov/agencies/whd/fact-sheets/73a-flsa-nursing-mothers-at-work-general-guidance
- Recommendations for designing lactation/wellness rooms, American Institute of Architects (AIA), 2023 https://www.aia.org/resource-center/recommendations-for-designing-lactation-wellness%20rooms

- *Lactation Room Requirements*, National Institutes of Health, 2016 https://orf.od.nih.gov/TechnicalResources/Documents/News%20to%20Use%20PDF%20Files/2016%20NTU/Lactation%20Room%20Requirements%20-%20June%202016%20News%20to%20Use_508.pdf

3.13 Showers and Changing Facilities

Availability of showers in City buildings play a crucial role in encouraging employees to bike, run, or walk to work. Access to showers allows individuals to freshen up after their commute, making active and eco-friendly travel options more practical and appealing. Providing showers not only promotes healthier lifestyles but also reduces reliance on cars, helping to lower traffic congestion and carbon emissions.

3.13.1 Current Practice

3.13.1.1 Where Applicable

Showers are required in buildings that support 24-hour operations.

3.13.1.2 Number of Fixtures

One ADA compliant shower is required where showers are required. One ADA compliant sink with floor clearances is required near or within the shower room. Additional fixtures shall be provided where required by code or certification body.

3.13.1.3 Plumbing Fixtures

See Plumbing (Section 7) for more information.

3.13.2 Opportunities

Shower and changing facilities should be considered in all City facilities with more than 20 full-time equivalent staff regularly present.

Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter, up to 999 occupants.

3.13.3 Stretch Goals

None identified.

3.13.4 Resources
None identified.

3.14 Restroom Planning
Utilize the following strategies for inclusive restroom planning. A single strategy may not be best for all City building types.

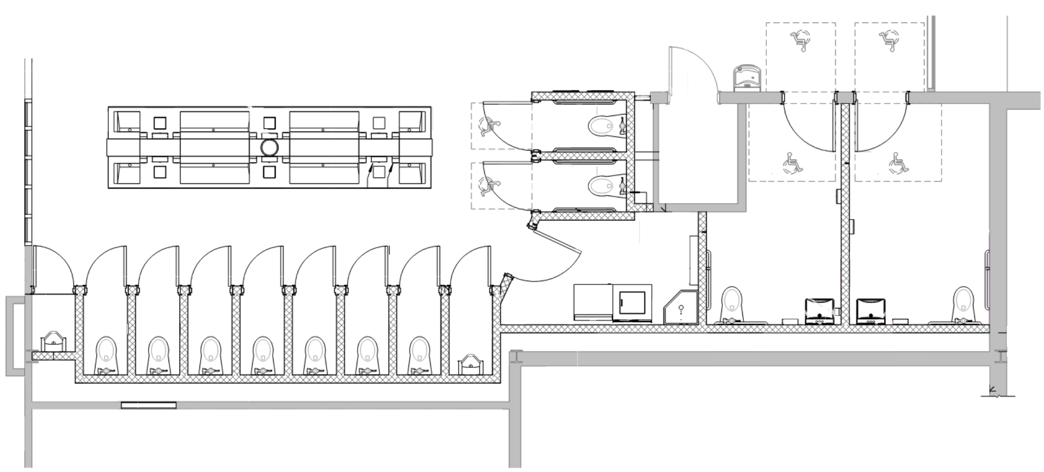
3.14.1 Current Practice
Utilize inclusive restroom strategies. Use approved naming and pictograms. Accessible restrooms and water closets are required. For information about efficient fixtures, see Plumbing (Section 7).

3.14.2 Opportunities

3.13.2.1 Strategy A
All restrooms are individual or family restrooms.

3.14.2.2 Strategy B
Restrooms are multi-user men's restrooms and multi-user women's restrooms. In addition, there shall be at least 1 or 10%, whichever is greater, of the water closets designated as all-user or family restrooms.

3.14.2.3 Strategy C
Utilize common use restrooms with water closets in fully enclosed partitions. Utilize shared lavatories. See an example below.



Source: CHS Restroom Renovations, Wiley Wilson, 2024

3.14.3 Stretch Goals
None identified.

3.14.4 Resources
None identified.

3.15 Bicycle Storage
Cycling reduces vehicular traffic and pollution while contributing to a healthy lifestyle. Providing secure storage ensures that cyclists can leave their bicycles unattended for extended periods.

3.15.1 Current Practice

3.15.1.1 Short-Term Bicycle Storage
Secure short-term bicycle storage is required for all new construction and major renovations over 5,000 gross square feet. Short-term bicycle storage is not required to be covered.

Short-term bicycle storage is required to be within 200 feet of the primary or public entrance of the building. Provide bicycle storage spaces for 2.5% of peak visitors, and no fewer than 4 storage spaces per building.

The provision of power for bicycle charging is not recommended.

3.15.2 Opportunities

3.15.2.1 Long-Term Bicycle Storage
Secure long-term bicycle storage is recommended for all new construction and major renovations over 5,000 gross square feet. Long-term bicycle storage is required to be covered and may be located inside the building.

Long-term bicycle storage is required to be within 300 feet of the primary or public entrance of the building. Provide bicycle storage spaces for at least 5% of regular building occupants, and no fewer than 4 storage spaces per building.

The provision of power for bicycle charging is not recommended.

3.15.2.2 Bicycle Storage in Other Facilities

A bicycle storage area should be considered for all new construction and renovations, including those with fewer than 5,000 gross square feet.

3.15.3 Stretch Goals

None identified.

3.15.4 Resources

None identified.

3.16 Waste Recycling

Due to shifts in waste management systems in the region, the collection of recyclables from City facilities was terminated several years ago. At that time, a material recovery facility had been established that could receive "all-in-one" waste that they separated. In 2018, that facility abruptly ceased accepting municipal solid waste. The re-establishment of the former single-stream collection of recyclable materials has not occurred as a standard program in City facilities.

3.16.1 Current Practice

3.16.1.1 Waste Recycling/Reuse

Single stream recycling is currently provided in a limited number of facilities that are (or are pursuing) LEED certification as this practice is a prerequisite credit. Disposition of City surplus property is handled through the Procurement Division's Warehouse.

3.16.2 Opportunities

- Re-establish waste recycling throughout City facilities.
- Provide collection for food scraps and other organics in accordance with the City's composting program.

3.16.3 Stretch Goals

- Establish a formalized program of expanded materials that are collected for recycling or reuse.

3.16.4 Resources

The University of Virginia operates a comprehensive waste management program and could provide some transferable programs or systems.

3.17 Smoking & Vaping

Smoking has long been known to cause health problems to both individuals who do and do not smoke. The same is true for the use of Electronic Nicotine Delivery Systems (ENDS), which includes vaping.

Smoking can also affect a building over time, because smoke can linger in walls, carpets, furniture, HVAC systems, and even structure in some cases. Lingering chemicals from smoking can reduce indoor air quality and lead to additional exposure to secondhand and thirdhand smoke.

For this section, smoking includes tobacco smoke, as well as smoke produced from the combustion of cannabis and controlled substances and the emissions produced by ENDS.

3.17.1 Current Practice

3.17.1.1 Prohibitions

Smoking and vaping are prohibited inside all buildings. Smoking is prohibited outside of buildings apart from designated smoking areas, and is specifically prohibited within 25 feet, measured horizontally, from entrances, operable windows, and air intakes on any level. Designated smoking areas may not be located within 25 feet of exterior places of respite.

3.17.1.2 Signage

No smoking signage shall be posted around the exterior of the building where smoking is specifically prohibited. Signage shall describe the prohibition of smoking and shall not stipulate which building element is in immediate proximity (i.e. do not call attention to building intakes). Signage shall be posted at designated smoking areas.

3.17.2 Opportunities

None identified.

3.17.3 Stretch Goals
None identified.

3.17.4 Resources
- Code of Virginia, Virginia Clean Indoor Air Act
  https://law.lis.virginia.gov/vacodepopularnames/virginia-indoor-clean-air-act/
- National Institute of Health, National Library of Medicine
  https://www.nlm.nih.gov/

3.18 Vehicle Idling
Reduction of vehicle idling is cost efficient, reduces emissions, and increases indoor air quality by minimizing emissions near building air intakes.

3.18.1 Current Practice

3.18.1.1 Motor Vehicles for Commercial or Public Service
Per Virginia's *Administrative Code*, motor vehicles licensed for commercial or public service may not idle for more than 3 minutes in commercial or residential urban areas, unless the engine is providing auxiliary power for purposes other than heating or air conditioning. Tour buses and diesel vehicles are not permitted to idle for more than 10 minutes.

Reference the *City of Charlottesville Standard Operating Procedure*, Idling Reduction Policy for Motor Vehicles and Equipment for further requirements.

3.18.1.2 Signage
Signage prohibiting vehicular idling shall be posted near all entrances, operable windows, and air intakes, and near loading and delivery zones.

3.18.2 Opportunities
None identified.

3.18.3 Stretch Goals
None identified.

3.18.4 Resources

- Administrative Code 9VAC5-40-5670. Motor vehicles. https://law.lis.virginia.gov/admincode/title9/agency5/chapter40/section5670/
- *City of Charlottesville Standard Operating Procedure*, Idling Reduction Policy

3.19 Elevators

Electric elevators offer increased efficiency, while avoiding the use and management of hydraulic fluids.

3.19.1 Current Practice

Provide electric Machine Room-less (MRL) elevators, without the use of hydraulic systems.

3.19.2 Opportunities

None identified.

3.19.3 Stretch Goals

None identified.

3.19.4 Resources

None identified.

Section 4 **Building Envelope**

In new construction projects, designing a resilient building envelope is a key factor in reducing energy consumption. The requirements for opaque envelope elements, fenestration, air tightness, and performance testing will be further defined in this section. For renovations, the City of Charlottesville will focus on air tightness and fenestration improvements rather than insulation improvements. Specific Leadership in Energy and Environmental Design (LEED) requirements for certification or rating may supersede the requirements in this section.

4.1 Opaque Thermal Envelope Insulation Values

The opaque sections of the building envelope are those parts that do not transmit light, such as walls, roofs, foundations, and doors without windows. These envelope sections shall achieve the thermal values established below. See insulation requirements in Section 5 Building Materials for more information on insulation materials.

4.1.1 Current Practice

4.1.1.1 Energy Modeling

Project teams should rely on energy modeling to optimize the building design and to demonstrate compliance with code requirements, LEED requirements, energy goals, and zero energy building planning. Performance values of the thermal envelope should meet or exceed the prescriptive requirements of the Virginia Energy Conservation Code (VECC) currently in effect.

4.1.1.2 New Construction and Renovations

For new construction projects where the development of an energy model is impractical, exceed prescriptive VECC requirements by 15%. For renovation projects, project teams shall meet the prescriptive requirements of the VECC currently in effect and need not exceed the requirements. Teams shall concentrate envelope efforts on air tightness and fenestration improvements.

4.1.2 Opportunities

None identified.

4.1.3 Stretch Goals

None identified.

4.1.4 Resources

None identified.

4.2 Fenestration

Fenestration is crucial for natural lighting and ventilation but can also be a point of significant energy loss from a building. This energy loss is because windows allow for greater heat transfer into the building through solar gain and convection. Windows are also points of high leakage potential. Therefore, great care should be taken to replace existing fenestration with units offering greater performance values and to ensure new construction makes the most strategic use of fenestration space.

4.2.1 Current Practice

4.2.1.1 Energy Modeling

Project teams should rely on energy modeling to optimize the building design and to demonstrate compliance with code requirements, LEED requirements, energy goals, and zero energy building planning. Performance values of the fenestration should meet or exceed the prescriptive requirements of the VECC currently in effect.

4.2.1.2 New Construction

For new construction projects where the development of an energy model is impractical, exceed prescriptive VECC requirements by 15%.

4.2.1.3 Existing Single Pane Exterior Glass

For renovation projects where single pane exterior glass exists, project teams should focus on efforts to replace windows or glazing units. If replaced, exterior windows or glazing must be replaced with materials complying with the requirements for new construction currently in effect.

For renovations of historic buildings or buildings in design control districts, window replacement should be approached with caution. The fenestration project scope will be evaluated on a case-by-case basis and should be coordinated with the City's Historic Preservation and Design Planner. Options for improving building performance include interior storm windows.

4.2.1.4 Existing Insulating Glass

For renovation projects where insulating glass is in place but demonstrates a poor Solar Heat Gain Coefficient (SHGC), provide a neutral color solar control film on exterior windows to remain. Maintain a Visible Transmittance of 0.50 or greater. The assembly should strive for an SHGC of 0.3 or less wherever possible, and a U-factor of 0.35 or less.

4.2.1.5 Glare Control

Provide interior solar control in all offices and in other spaces anticipated to be adversely affected by undesirable solar glare. Roller shades are preferred. Mini blinds may be acceptable for some projects. Use only GREENGUARD Gold certified products. Ensure devices are ADA compliant, where required. Evaluate choking risk, especially in schools, where chain operators are used.

4.2.2 Opportunities

4.2.2.1 Shading Devices

For new construction, the use of exterior shading devices is preferred for their ability to reduce solar heat gain in the space. Consider shading where possible on existing buildings as well.

For interior spaces, consider motorized shades in public or shared-use spaces or where two or more devices are adjacent.

4.2.2.2 Bird Collision Deterrence

Avoid reflective glass types and utilize bird-friendly glass on large expanses of glass. Project teams can use the LEED Bird Collision Deterrence Innovation in Design (ID) credit as a framework.

4.2.3 Stretch Goals

None identified.

4.2.4 Resources

- Charlottesville Development Code, Chapter 34 Zoning & Subdivision https://charlottesville.gov/DocumentCenter/View/11104/Development-Code-PDF?bidId=
- LEED Bird Collision Deterence ID Credit https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-75

4.3 Roofing

Roofing is the part of the building envelope that is exposed to the most direct sunlight and has the highest requirements for insulation according to the VECC. Roofing design decisions are important for reducing the heat island effect. An additional consideration when selecting a roofing material is the volatile organic compound (VOC) content. Conscious choices of roofing products lead to a more sustainable building.

4.3.1 Current Practice

4.3.1.1 Pitched Roofing Materials

Steep-slope roofs are defined as a roof with a slope greater than 2:12. For steep-slope roofs, use materials with a minimum initial solar reflectance index (SRI) of 39 and a minimum aged SRI of 32.

4.3.1.2 Low-Sloped Roofing Materials

Low-slope roofs are defined as roofs with a slope less than or equal to 2:12. For low-slope roofs in new construction, use white Thermoplastic Polyolefin (TPO) with a minimum initial SRI of 82 and a minimum aged SRI of 64. If aged SRI is not available, the roofing material shall have an initial SRI equal to or greater than 82. The TPO shall be minimum 60 mil with a fully adhered membrane. All low-slope roofing assemblies shall include a high-density cover board.

For re-roofing, the membrane type will be evaluated on a case-by-case basis and is generally expected to be EPDM or white TPO.

4.3.1.3 Manufacturer Warranty

The Contractor shall furnish a manufacturer's 20 year minimum total system material and labor warranty or guarantee with no monetary limitations from the final completion date of the entire project and no less than the expected life of any anticipated rooftop photovoltaic installation. Ensure warranty acknowledges renewable energy system installation. Coordinate the roof design with any roof manufacturer requirements relative to the renewable energy system. Associated roofing metals shall be covered under the manufacturer's warranty.

4.3.1.4 Contractor's Warranty

The Contractor shall furnish a workmanship warranty agreeing to maintain the entire roof system(s) in a completely watertight condition at no cost to the Owner for 2 years from the final completion date of the entire project. Ensure the warranty acknowledges photovoltaic installation and coordinates the roof design with any roof manufacturer requirements relative to the photovoltaics (PV).

4.3.1.5 Roof Adhesive and Sealant VOC Limits

Reference the following chart for the maximum VOC limits in each category of roofing adhesives and sealants.

Category	VOC Limit (g/L)
EPDM/TPO Single Ply Roof Membrane Adhesive	250
All Other Roof Adhesives	250
Single Ply Roof Membrane Sealant	450
Cut Edge Single Ply Roof Membrane Sealant	450
Roof Adhesive Primers	250

4.3.1.6 Additional Roofing Assemblies

See Opaque Thermal Envelope Insulation Values (Section 4.1) and Insulation (Section 5.9) for insulation types and for the performance requirements of insulation.

4.3.2 Opportunities

None identified.

4.3.3 Stretch Goals

None identified.

4.3.4 Resources

None identified.

4.4 Vegetated Roofs

Vegetated roofs are an excellent option for reducing the heat island effect, increasing the insulation on a roof, and extending the life of a roof. Vegetated roofs also reduce stormwater runoff and decrease the demand on storm water infrastructure.

4.4.1 Current Practice

None identified.

4.4.2 Opportunities

Vegetated roofs are a great alternative when the characteristics of the roof are not ideal for a solar array. Vegetated roofs are acceptable for roofs of lower floors, small roofs, roofs outside of windows, and roofs where PV is not practicable.

4.4.2.1 Leak Detection

Vegetated roofs are required to include leak detection.

4.4.2.2 Irrigation

Coordinate with a landscape architect or green roof vendor to optimize substrate depth and materials to avoid permanent irrigation. Provide a water source for establishment and temporary irrigation within 100 feet of all roof areas.

4.4.2.3 Maintenance

Establish an annual maintenance contract. See the Virginia Statewide Fire Prevention Code (VSFPC), Section 317, for more information about maintenance of vegetated roofs.

4.4.3 Stretch Goals

None identified.

4.4.4 Resources

None identified.

4.5 Air Barriers

Air barriers control the movement of air through the building envelope, reducing energy losses due to uncontrolled air infiltration and exfiltration. They play a critical role in the energy efficiency, durability, and indoor air quality of buildings.

4.5.1 Current Practice

- Continuous Air Barrier: All new construction and major renovation projects shall include a continuous air barrier system that is properly detailed and installed to minimize air leakage.
- Air Barrier Permeability: Air barriers shall be vapor-permeable.
- Fluid-Applied Barrier: Fluid applied barriers should always be used, unless specific cases do not allow. Fluid applied barriers provide greater seal and durability than sheet applied barriers.

4.5.2 Opportunities

None identified.

4.5.3 Stretch Goals

None identified.

4.5.4 Resources

None identified.

4.6 Envelope Pressure Testing

A well-sealed building envelope is essential for energy efficiency, occupant comfort, and indoor air quality. Air leakage through the building envelope can lead to increased energy consumption, moisture infiltration, and difficulty maintaining stable indoor humidity levels. Envelope pressure testing, commonly performed using blower door testing, helps quantify air leakage and identify deficiencies that can be corrected to improve overall building performance.

4.6.1 Current Practice

Envelope pressure testing shall be used where required by code and where stipulated in this document. Small scale renovation projects may not have enough scope or budget to financially support full pressure testing. These projects should perform a comprehensive visual inspection to identify envelope air-sealing project scope.

4.6.1.1 Baseline Testing for Renovations

For major renovation projects, a baseline blower door test should be conducted prior to major envelope modifications to establish existing air leakage conditions.

- This data will inform the design and scope of necessary air-sealing improvements and what strategies might be the best use of a project's funds.
- A post-renovation test should be performed to verify the effectiveness of envelope upgrades. The target for this reduction should be a minimum of 50% reduction in test performance, or a total of 0.20 cfm per square foot of envelope at 75 Pascals, whichever is more stringent.
- Focus should be given to window and door replacements, roof-wall connections, and mechanical penetrations, as these are common areas of air leakage.

4.6.1.2 Testing Targets for New Construction

New construction projects should target air leakage rates that meet or exceed industry best practices.

- The recommended air leakage rate should be less than 0.15 CFM per square foot of envelope area at 75 Pascals.

- Testing shall occur during construction as soon as the air barrier system is complete and well before planned building occupancy to allow time to address any discrepancies found. Testing shall be clearly indicated in the contractor's project schedule.

4.6.2 Opportunities

None identified.

4.6.3 Stretch Goals

None identified.

4.6.4 Resources

None identified.

Section 5 **Building Materials**

According to United Nations (UN) Environment Programme in "Building Materials And The Climate: Constructing A New Future," historically, much of the building sector's progress in lowering greenhouse gas (GHG) emissions has centered around reducing the operational emissions of buildings (heating, cooling, lighting, etc.) rather than the embodied carbon of the materials used in constructing a building. Using the current practices in this section reduces the City's contribution to GHG emissions and leads to a safer and healthier built environment.

5.1 Environmentally Preferable Purchasing of Building Products, Generally

5.1.1 Current Practice

None identified.

5.1.2 Opportunities

The following subsections describe building material criteria that offer opportunities to reduce a building's environmental footprint and safeguard the wellness of building occupants.

5.1.2.1 Embodied Carbon

Embodied carbon is the quantity of carbon emissions released during the lifecycle of building materials, including raw material extraction, manufacturing, transport, construction, and demolition and disposal. Building materials, especially concrete and steel, contribute to a significant percentage of global greenhouse gas emissions. Prioritizing materials with lower embodied carbon is essential to reducing the overall carbon footprint of the building industry and the City.

Project teams should preference materials which sequester carbon or otherwise demonstrate very low embodied carbon. Embodied carbon is typically measured by a product's Global Warming Potential (GWP) which is measured in kilograms of CO_2 equivalent per cubic meter (kg CO_2/m^3). These values are typically found in a product's environmental product declaration (EPD).

5.1.2.2 Recycled Content
Higher recycled content is generally preferable for all building materials. Post-consumer recycled content should be preferred over pre-consumer recycled content.

5.1.2.3 Recyclable
Preference products that are recyclable, and which have a demonstrated recycling mechanism in the marketplace. Some products, such as items made from polyvinyl chloride (PVC), are recyclable but not in our region.

5.1.2.4 Local & Regional Sourcing
Preference locally quarried, produced, and manufactured items. For the purpose of the *High-Performance Building Standards*, local is defined as a 300-mile radius. Consider the transportation method when considering local and regional building materials. The mode of transportation can greatly affect the embodied carbon of a product. Long distance trucking, for example, may adversely affect the desired goal.

One key to a higher utilization of local materials is an understanding of locally available materials. Project leaders should familiarize themselves with the marketplace and specify materials accordingly.

5.1.2.5 Bio-Based
Preference natural and bio-based materials. A bio-based product is one made with a significant portion of natural and naturally-derived materials. This can include agricultural materials, forestry materials, and others.

Strive to understand the extent of the bio-based content to guard against exaggerated or misleading marketing claims.

5.1.2.6 Rapidly Renewable

Preference rapidly renewable building materials. Rapidly renewable materials must have a harvest cycle of 10 years or less. A few examples include mineral fiber, clay, bamboo, hemp, cork, and natural rubber.

Strive to understand the extent of the rapidly-renewable content to guard against exaggerated or misleading marketing claims.

5.1.2.7 Reclaimed and Reused Materials

Preference reclaimed or reused materials. Reclaiming and reusing building materials is an effective strategy for minimizing additional carbon spent. Strive to identify opportunities to integrate reclaimed and reused materials.

5.1.2.8 Forest Certification

Preference forest products from sustainably managed forests. The Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and American Tree Farm all have forest certifications for building materials. FSC is generally recognized for having the highest available standard for forest certification.

5.1.2.9 Manufacturer Transparency

Products and manufacturers which fully disclose product ingredients and product impacts are preferrable. Common tools for disclosure include EPDs and Health Product Declarations (HPDs).

5.1.2.10 General Product Certifications

Preference and utilize certified products as often as possible. The following list is not all-inclusive of certifications that are widely regarded by the green building community.

- ENERGY STAR, operated by the US Environmental Protection Agency, a voluntary program that rates appliances, electronics, lighting fixtures, and more

- WaterSense, a label issued by the US Environmental Protection Agency for products that are 20% more water efficient than average products in the same category
- Cradle to Cradle, a certification that vets products for environmental criteria across a product's full life cycle.
- Climate Neutral Certified, a certification given by Climate Change Project for brands that are actively working toward net-zero carbon and implement efficiency measures and offsets
- Certified B Corp, a "benefit" corporation means a company has been third-party evaluated for environmental performance and social responsibility
- GREENGUARD, a certification that ensures a product has met a comprehensive and rigorous standard for low emissions of volatile organic compounds (VOCs)
- USDA Biopreferred, a label from the US Department of Agriculture for biobased products

5.1.2.11 Low-Emitting Products

Prefer low-emitting products and materials. Widely regarded indications of low emissions include:

- GREENGUARD Gold certified products—tested for a wide range of chemical emissions
- CARB Phase II compliant products—tested for formaldehyde emissions
- Certified Ultra Low-Emitting Formaldehyde (ULEF) products
- No Added Formaldehyde (NAF) products
- Zero VOC products
- Low VOC products
    - Be wary of uncertified or self-reported claims

5.1.2.12 Red-List Free

Products that are red-list-free are preferrable in all cases. The Red List is a collection of the "worst in class" chemicals prevalent in building materials. The list was created in 2006 by the International Living Future

Institute. A majority of the chemicals listed are technical in nature. Some of the most common chemicals are as follows:

- Antimicrobials (marketed with a health claim), can be found in solid surface & simulated stone countertops, acoustical ceiling panels and tiles, acoustical sealant, batt or blanket insulation, carpet adhesive and backing, and more
- Bisphenol A (BPA), can be found in epoxy grouting, epoxy paint or coatings, epoxy resinous flooring, high pressure laminate, high performance coatings, grouting and mortar, resilient flooring, white board paint or dry erase paint and more
- Chemicals with Arsenic, Cadmium, Hexavalent Chromium, Lead, and Mercury (CASRMs), can be found in acoustical ceiling panels and tiles, carpet backing, cast-in-place and precast concrete, concrete masonry units (CMU), fluid-applied flooring, gypsum board, mineral board insulation, membrane roofing, porcelain tile and thin-set porcelain, spray applied insulation, and more
- Formaldehyde, can be found in adhesives and binders for MDF and wood decorative wall treatment, wood floor adhesive, plywood siding and sheathing, mineral board insulation, spray applied insulation, and more
- Halogenated Flame Retardants (HFRs) can be found in batt insulation, board and foam board insulation, carpet, exterior metal panels, spray applied insulation, upholstery foam, and more
- Phthalates can be found in adhesives and binders for casework, floor sealant and coatings, carpet, resilient flooring, vinyl composition flooring, PVC membrane roofing and more
- Polyvinyl Chloride (PVC), can be found in pipes and fittings, window and door profiles, roof membranes, and more
- Styrene and Polystyrene, can be found in board and foam insulation, fluid applied roofing, expanded polystyrene or closed cell insulation, membrane roofing, and more
- Volatile Organic Compounds (VOCs) can be found in wet-applied products, such as paint, sealants, and coatings

5.1.2.13 Durable Materials

Durable and readily-maintained materials which can withstand the use-case of the building and will last for the lifetime of the structure are preferable.

5.1.3 Stretch Goals

None identified.

5.1.4 Resources

- UN Environment Programme, "Building Materials And The Climate: Constructing A New Future" https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future
- Red-list free products are searchable on the ILFI's Declare website. https://declare.living-future.org/
- Additional lists of chemicals to avoid can be found on the Perkins + Will Precautionary List. https://transparency.perkinswill.com/lists/precautionary-list

5.2 Paints and Coatings

Paints and coatings with high levels of VOCs contribute to poor indoor air quality, pollution, and smog. Prolonged exposure to VOCs can lead to health problems. Choosing zero- or low-VOC paints and coatings are better for people and for the environment.

5.2.1 Current Practice

5.2.1.1 Low-VOC Primers and Paints

For typical conditions, zero-VOC primers and paints are required. When zero-VOC primers and paints are not available, use the table below.

Category	VOC Limit (g/L)
Flat Coatings	50
Nonflat Coating	50
Fire Resistive Coatings	150
Primers, Sealers, and Undercoaters	100
Stains (Interior)	250
Wood Coatings	275
Architectural Coatings, excluding Industrial Maintenance Coatings	50

5.2.1.2 Standard Colors

In all City buildings, including schools, non-accent walls shall be painted with Sherwin Williams Pure White, SW 7005, in Low Sheen Eg-Shel, or a color-matched product from an equivalent manufacturer.

5.2.1.3 Coatings for Steel

Coat ferrous exterior steel with a high-performance coating system. High-performance coatings are a product category offered by all major paint and coating manufacturers.

5.2.1.4 Additional Materials

No spare or extra primers, paints, or coatings for “attic stock” should be ordered as they will not be stored.

5.2.2 Opportunities

None identified.

5.2.3 Stretch Goals

None identified.

5.2.4 Resources

None identified.

5.3 Adhesives and Sealants

VOCs are prevalent in construction adhesives and sealants, such as adhesives for flooring and wall coverings, bonds used for decorative material applications, various structural adhesives, and foam and high-pressure foam sealants. This section is inclusive of all adhesives and sealants in construction.

5.3.1 Current Practice

5.3.1.1 VOC Limits

Reference the following chart for the VOC limits in each category of adhesive or sealant, if zero-VOC is not available.

Category	VOC Limit (g/L)
Contact Adhesive	80
Bond Breakers	350
Dry Wall and Panel Adhesive	50
Multipurpose Construction Adhesives	70
Subfloor Adhesive	50
One-Component Foam Sealant	250
High-Pressure Two-Component Foam Sealant	250

5.3.2 Opportunities

None identified.

5.3.3 Stretch Goals

None identified.

5.3.4 Resources

None identified.

5.4 Wood Products

This section is inclusive of all solid wood products used as building materials.

5.4.1 Current Practice

5.4.1.1 Wood Species

Do not use tropical hardwoods or rainforest species. Evaluate wood products harvested and produced domestically as an alternative to imported wood.

5.4.1.2 VOC Limits

For site-finished wood products, utilize zero or low-VOC finishes, where available. Reference the following chart for the VOC limits in each category of adhesive or coating, if zero-VOC is not available.

Category	VOC Limit (g/L)
Wood Floor Coatings	100
Wood Flooring Adhesive	100
Stains (Interior)	250
Wood Coatings	275
Wood Substrate Adhesive	30

5.4.2 Opportunities

5.4.2.1 Sustainable Forests Certifications

Consider wood products that are from certified, sustainably managed forests. Certifications could include The Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and American Tree Farm.

5.4.2.2 Wood Product Sourcing

Evaluate opportunities for salvaged, locally milled, or site-harvested wood products.

5.4.3 Stretch Goals

None identified.

5.4.4 Resources

None identified.

5.5 Composite Wood Products

This section is inclusive of all composite wood products used as building materials, including but not limited to particleboard, medium density fiberboard (MDF), hardwood plywood with veneer cores, composite cores, or combination cores, wood structural panels, composite structural wood products. This also includes products assembled from composite wood products, such as millwork, cabinetry, and doors. Composite wood products are frequently manufactured with binders and adhesives containing formaldehyde resins.

5.5.1 Current Practice

For all composite wood products inside the building envelope, provide products certified for low formaldehyde emissions. The composite wood product must meet one of the following criteria:

- GREENGUARD Gold Certified
- California Air Resources Board (CARB) Phase II Compliant
- Certified as ULEF under the Environmental Protection Agency (EPA) Toxic Control Act or California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM)
- Certified as NAF product under EPA TSCA Title VI
- CARB ATCM wood structural panel manufactured according to PS 1-09 or PS 2-10 (or one of the standards considered by CARB to be equivalent to PS 1 or PS 2) and labeled bond classification Exposure 1 or Exterior
- Structural wood product manufactured according to American Society for Testing and Materials (ASTM) D 5456 (for structural composite lumber), American National Standards Institute (ANSI) A190.1 (for glued laminated timber), ASTM D 5055 (for I-joists), ANSI PRG 320 (for cross-laminated timber), or PS 20-15 (for finger-jointed lumber)

5.5.2 Opportunities

None identified.

5.5.3 Stretch Goals

None identified.

5.5.4 Resources

None identified.

5.6 Flooring

This section is inclusive of all flooring.

5.6.1 Current Practice

5.6.1.1 Prohibited Flooring Materials

Vinyl composite tile is prohibited.

5.6.1.2 Low-Emitting Flooring

Low-emitting flooring products are required. Compliant products shall bear at least one of the following certifications:

- Compliance with California Department of Public Health (CDPH) Standard Method v1.2-2017 and with VOC limits in Table 4-1
- GREENGUARD Gold certified products
- Floorscore certified products
- Products meeting composite wood product requirements
- Products which are inherently non-emitting such as stone, ceramic, concrete, or brick and having no binders, coatings, or sealants that include organic chemicals
- Salvaged or re-used materials more than one year old at the time of use

5.6.1.3 VOC Limits for Adhesives and Coatings

Preference low-VOC (or zero VOC) adhesives, coatings, and sealants. Reference the following chart for the maximum allowable VOC limits in each product category, if zero-VOC is not available. For sealants used in floorings, see VOC Limits in Adhesives and Sealants (Section 5.3).

Category	VOC Limit (g/L)
Floor Coatings	100
Carpet Pad Adhesive	50
Ceramic Glass, Porcelain, & Stone Tile Adhesive	65
Cove Base Adhesive	50
Grout	65
Rubber Floor Adhesive	60
Wood Floor Adhesive	100
Waterproofing Membranes	250
All Other Indoor Floor Covering Adhesives	50

5.6.1.4 Carpet

Among interior finishes, carpet is one of the most carbon-intensive building materials. The embodied energy of carpeting varies among manufacturers and product lines.

Utilize the following strategies:

- Reduce the use of carpet.
- Specify lower impact carpet products.
- Specify carpet products that can and will be taken back by the manufacturer at the end of the product's useful life. See Carpet Take Back Programs (Section 3.7.1.4).

5.6.2 Opportunities

5.6.2.1 PVC-free Flooring

Consider using flooring that does not contain PVC, which occurs on the Red List and many precautionary lists.

5.6.2.2 Carpet Selection

Consider carpet products that are Red List-free, PVC-free, or Cradle-to-Cradle certified.

Preference carbon-neutral carpet tiles that are solution-dyed, as a low-carbon strategy.

5.6.2.3 Sealed Concrete

Consider sealed concrete as an alternative to traditional flooring. See Concrete (Section 5.9) for requirements for sealed concrete.

5.6.2.4 Bio-Based flooring Products

Consider natural bio-based flooring products such as cork or linoleum as an alternative to resilient flooring products containing vinyl and other synthetic ingredients.

5.6.3 Stretch Goals

None identified.

5.6.4 Resources

None identified.

5.7 Gypsum Board

According to *Architecture 2030*, gypsum board is an energy-intensive product to manufacture.

5.7.1 Current Practice

Where used, ensure that lightweight gypsum board satisfies all other technical requirements for the intended application.

5.7.2 Opportunities

None identified.

5.7.3 Stretch Goals

None identified.

5.7.4 Resources

- Carbon Smart Materials Palette
  https://www.materialspalette.org/gypsum-board/

5.8 Ceiling Products

This section is inclusive of all ceiling products. There is a vast array of ceiling products in the marketplace. Products should be selected that meet the project requirements including but not limited to aesthetics, durability, fire resistance, and ability to be cleaned.

5.8.1 Current Practice

5.8.1.1 GREENGUARD Gold

Specify products with no added formaldehyde or certified GREENGUARD Gold or otherwise certified to be low-emitting or inherently non-emitting.

5.8.1.2 Noise Reduction

Specify ceiling products with high Noise Reduction Coefficient (NRC) ratings (.70+) and high Articulation Class (AC) ratings (180+), where noise reduction is necessary and where speech intelligibility is a priority, as in classrooms and open office environments.

5.8.1.3 Sound Transmission

Specify ceiling products with high Ceiling Attenuation Class (CAC) ratings (35+), where sound transmission is an issue, as between offices.

5.8.2 Opportunities

5.8.2.1 Red List

Consider ceiling products to be Declare-labeled, or otherwise free of red-listed chemicals of concern.

5.8.2.2 Life Cycle

Consider specifying ceiling products that can and will be taken back by the product's manufacturer at the end of the product's useful life.

5.8.3 Stretch Goals

None identified.

5.8.4 Resources

None identified.

5.9 Concrete

Concrete is a building material that has high embodied carbon but is often necessary for the stability and longevity of a building.

5.9.1 Current Practice

Civil-related concrete should follow the *City of Charlottesville City Standards and Design Manual*. For projects pursuing LEED certification, coordinate the solar reflectance values with the project goals for heat island reduction.

The following practices are standard for building-related concrete.

5.9.1.1 Minimize Concrete Use

Minimize the use of concrete when possible. Right-size all concrete elements and utilize concrete strengths that do not significantly exceed the structural requirements. Consider alternative materials with lower embodied carbon/lower GWP.

5.9.1.2 Reduce Cement Content

Project teams shall specify low-GWP concrete mixes. At local ready-mix providers, low-GWP concrete mixes are generally designed with fly ash as a cement replacement. Slag, CarbonCure, and other cement replacement products are not generally available. GWP reductions of approximately 25%-30% are possible, when reductions are averaged across all concrete in a project. Mixes for some building elements will demonstrate more or less savings than other elements.

Greater GWP reductions are possible when the project team can prepare for and accommodate concrete pours that reach design strength at the 56-day break.

5.9.1.3 VOC Limits

Reference the following chart for the maximum VOC limits in each category of concrete sealers and accessory compounds.

Category	VOC Limit (g/L)
Concrete Curing Compounds	350
Concrete & Masonry Sealers	100
Form-Release Compounds	250

5.9.2 Opportunities

None identified.

5.9.3 Stretch Goals

None identified.

5.9.4 Resources

- *City of Charlottesville City Standards and Design Manual* https://charlottesville.gov/DocumentCenter/View/1040/Standards-and-Design-Manual-PDF

5.10 Insulation

The selection and specification of building insulation is a complex subject with many variables and factors to consider. In all cases, it is paramount to understand moisture dynamics and moisture control in the building envelope. It is beyond the scope of this guide to recommend insulation for all conditions. This section addresses some common conditions found in the City's various structures.

5.10.1 Current Practice

Insulation products used inside the building envelope must contain no added formaldehyde or be certified GREENGUARD Gold or otherwise be certified as low-emitting. In general, preference insulation products with the following characteristics:

- Products with moisture characteristics appropriate to the building envelope
- Products with low embodied energy and embodied carbon characteristics (low Global Warming Potential (GWP))
- Products which are naturally fire-resistant and do not require added flame retardants
- Products that do not contain styrene (Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) foams contain styrene)

5.10.2 Opportunities

5.10.2.1 Cavity Fill

For commercial stud cavity fill, prefer Spray-Applied Fiberglass or Mineral Wool Batts with no added formaldehyde. For stud cavities in wood-framed or "residential-type" structures, Dense-Packed Cellulose or Spray-Applied Fiberglass or Mineral Wool Batts with no added formaldehyde is preferred.

5.10.2.2 Exterior Insulation

For wall exterior insulation, prefer high-density mineral wool board or when unavailable, expanded polystyrene (XPS) board. XPS presents challenges for installation and continuity.

5.10.2.3 Exterior Foundation Insulation

For exterior foundation wall insulation, prefer mineral wool board or when unavailable, XPS board.

5.10.2.4 Interior Foundation Insulation

For interior foundation walls, continuous mineral wool board or polyisocyanurate board, with mineral wool batts filling the inboard stud cavity, is preferred.

5.10.2.5 Slab Insulation

For sub-slab insulation, high density mineral wool boards or XPS boards or high-density EPS boards are preferred. Always coordinate with the project's structural engineer.

5.10.2.6 Attic Insulation

For attic floor insulation, in wood-framed or "residential-type" structures, prefer loose-fill cellulose.

5.10.2.7 Low-Slope Roof Insulation

For low-slope roof insulation, prefer polyisocyanurate board or high-density rigid mineral wool board.

5.10.3 Stretch Goals

None identified.

5.10.4 Resources

None identified.

5.11 Furniture

Furniture is part of the building environment people directly interact with the most. Furniture with red list chemicals can have negative effects on health. It’s important to consider this factor, as well as the life cycle of the items, when purchasing new furniture.

5.11.1 Current Practice

Ensure that 75% of new furniture in the project scope of work, by cost, is certified to Business and International Furniture Manufacturers Association (BIFMA) level 2.

5.11.2 Opportunities

5.11.2.1 Certifications

Consider using furniture that is Cradle to Cradle Certified.

5.11.2.2 Reuse and Re-Manufactured

Consider gently used or re-manufactured office furnishings when appropriate.

5.11.3 Stretch Goals

None identified.

5.11.4 Resources

The following companies offer used or re-manufactured commercial office furnishings:

- Richmond Office Interiors, Richmond
  https://richmondofficeinteriors.com/
- Office Products, Harrisonburg
  https://www.furniture-systems.com/
- Davies Office, Albany NY
  https://www.daviesoffice.com/
- Building + Institutional Furniture Manufacturers Association (BIFMA)
  https://www.bifma.org/

Section 6 **Equipment**

Energy-efficient equipment can conserve natural resources and reduce carbon footprints in buildings while lowering costs for consumers. In aggregate, smart selection and conscious management of equipment items can contribute to significant energy savings.

6.1 Office Equipment

More conscious use of energy efficient office equipment has the potential to not only be a cost savings but also creates healthier indoor work environments and encourages local businesses to use energy efficient equipment.

6.1.1 Current Practice

6.1.1.1 Printers and Copiers

Printers and copiers are required to be in shared spaces or common use areas. Printers and copiers for individual use are prohibited. All printers and copiers are required to be ENERGY STAR certified. Printers and copiers shall have a built-in "energy saver" mode or hibernation mode. This feature is required to be enabled.

6.1.1.2 Space Heaters

Space heaters are prohibited, except when issued by Facilities Maintenance for temporary use.

6.1.1.3 Space Dehumidifiers

Space dehumidifiers are prohibited, except if issued by Facilities Management for special circumstances.

6.1.1.4 Room Air Purifiers

Room air purifiers are prohibited as a primary means of indoor air quality improvement. These purifiers should only be utilized in time of need and issued by Facilities Maintenance.

6.1.2 Opportunities

None identified.

6.1.3 Stretch Goals

None identified.

6.1.4 Resources

None identified.

6.2 Break Room Equipment and Appliances

Appliances are a part of almost every project type. The following items define environmentally friendly requirements and opportunities for appliances within all projects.

6.2.1 Current Practice

6.2.1.1 Accessibility Compliance

All appliances are to be ADA compliant. This will limit the options in some ENERGY STAR product categories.

6.2.1.2 Appliance Locations

All appliances are to be located in shared or common-use spaces. Appliances for individual use are prohibited.

6.2.1.3 ENERGY STAR Certification

The following appliance types are to be ENERGY STAR certified:

- Cooktops
- Ovens
- Dishwashers
- Refrigerators, including undercounter

- Freezers

6.2.1.4 Ice Makers

Only batch type ice makers are allowed for bulk ice machines. Icemakers on refrigerators are acceptable.

6.2.1.5 Prohibited Appliances

The following appliances are prohibited:

- Pod-type coffee makers. Airpots, insulated coffee carafes, or insulated beverage dispensers are encouraged.
- Hot plates
- Personal refrigerators
- Personal microwaves

6.2.1.6 Drinking Water

Drinking water is required to be made available by tap, by dispensers in refrigerators, direct water line dispensers, or by drinking fountains with bottle fillers. Using 5-gallon water bottles and their dispensers is prohibited.

6.2.1.7 Cooking Equipment

New propane and natural gas equipment is prohibited for all cooking and warming in new construction and major renovations. As much as possible, utilize enclosed cooking equipment that does not produce grease laden vapors, such as convection ovens. Where open cooktops are required, utilize induction type heating.

6.2.2 Opportunities

- Special use kitchens such as those in 24/7 emergency operations facilities and fire stations should follow the same standards.
- Prefer toasters over toaster ovens when the use case allows.
- For drinking water from the tap, consider sink- or counter-mounted bottle fillers.
- Avoid garbage disposals and opt for composting instead.

6.2.3 Stretch Goals
None identified.

6.2.4 Resources
None identified.

6.3 Vending
Vending machines are provided in various spaces in the City of Charlottesville. Vending machines are typically owned by vendors.

6.3.1 Current Practice

6.3.1.1 Power Control Technology
Power control technology is required at all locations. Provide *Vending Miser* or similar products at all vending machines.

6.3.1.2 City Owned Vending Machines
All vending machines are required to be ENERGY STAR certified.

6.3.2 Opportunities
None identified.

6.3.3 Stretch Goals
None identified.

6.3.4 Resources
None identified.

6.4 Concessions
Concession stands will generally offer snacks and food that has been warmed or re-heated.

6.4.1 Current Practice
Utilize ENERGY STAR certified appliances where the product category is available.

6.4.2 Opportunities
Avoid or minimize fossil fuel use for concession stands. Avoid direct cooking that requires additional equipment, energy use, and ventilation.

6.4.3 Stretch Goals
None identified.

6.4.4 Resources
None identified.

6.5 Laundry Equipment
The following section is limited to localized and residential type units. Using efficient clothes washers and dryers can reduce energy and water consumption.

6.5.1 Current Practice

6.5.1.1 Washers
Washers are required to be ENERGY STAR certified.

6.5.1.2 Dryers
Dryers are required to be ENERGY STAR certified. Ensure that the manufacturer's indicated drying time is compatible with the use case. Natural gas dryers are prohibited. Investigate whether a heat pump dryer is appropriate due to its energy efficiency and reduced needs for ventilation.

6.5.1.3 Industrial and Commercial Units
Industrial and commercial type units represent special cases and project managers should strive to optimize selections for water and energy efficiency.

6.5.2 Opportunities
None identified.

6.5.3 Stretch Goals
None identified.

6.5.4 Resources
None identified.

6.6 AV and IT Equipment
Audio and visual (AV) and information technology (IT) equipment are an important part of energy reduction in the workplace. Energy saver modes are designed to enhance battery life of devices and reduce power consumption. Reduced power consumption leads to reduced heat generation which lengthens the lifespan of the technology.

6.6.1 Current Practice

6.6.1.1 Screens and Monitors
All display screens, televisions, and monitors are required to be ENERGY STAR. All installed products shall be reverted to an energy-saver or hibernation mode after normal operating hours.

6.6.1.2 Data Center Equipment
All data center equipment, including but not limited to data center storage, enterprise servers, large network equipment, and uninterruptable power supplies, is required to be ENERGY STAR certified where available.

6.6.2 Opportunities
Provide equipment that is Electronic Product Environmental Assessment Tool (EPEAT) certified. EPEAT is a widely regarded global standard that certifies products to Bronze, Silver, and Gold standards.

6.6.3 Stretch Goals
None identified.

6.6.4 Resources

- Electronic Product Environmental Assessment Tool (EPEAT)
  https://www.epeat.net/

6.7 Commercial Kitchens

Commercial kitchens are among the most energy-intensive spaces in a building, with an Energy Use Intensity (EUI) reaching up to 250 kBtu/sf. A significant portion of this energy demand comes from the large amounts of exhaust required, which results in substantial heating and cooling losses. Implementing energy reduction strategies in these areas can have a major impact on overall building performance.

6.7.1 Current Practice

6.7.1.1 Electric Kitchens

- ENERGY STAR or equivalent high-efficiency appliances shall be specified for all major kitchen equipment, including ovens, refrigerators, dishwashers, and ice machines.
- Kitchens shall be fully electric unless infeasible due to project or site-specific constraints such as inadequate infrastructure or programmatic requirements.
- All open ranges shall use induction cooking technology, which offers high efficiency, rapid response, and improved occupant safety due.

6.7.1.2 Ventilation

- Minimize equipment requiring Type I hoods and fully eliminate such equipment where possible. Only place necessary equipment under a Type I hood. This includes any equipment that will produce grease laden vapors.
- Type II hoods should be used for all other applicable equipment to reduce exhaust requirements.
- Ensure that makeup air systems are as efficient as possible, with appropriate setpoints, efficiency ratings, and controls so that they only operate when needed by the hood(s).
- Demand-controlled kitchen ventilation (DCKV) systems should be used to reduce fan energy and conditioned air losses when cooking appliances are idle.

6.7.1.3 Cold Food Storage

- ENERGY STAR Certification – All walk-in coolers, freezers, and refrigeration units shall be ENERGY STAR certified to ensure high efficiency and lower energy costs.

- Single-Entry with Pass-Through Design – Cold storage areas shall be designed with a single point of entry for staff that allows freezer access through the cooler section to reduce energy loss.
- High-Performance Insulation & Seals – Freezers and refrigerators must utilize high R-value insulation and tight-sealing doors to prevent unnecessary cooling loss.
- Where the HVAC systems allow, condensers shall be water-cooled to allow for more efficient operation.

6.7.1.4 Dishwashing Equipment

- ENERGY STAR Certification – dishwashing equipment shall be ENERGY STAR certified, where applicable, to ensure high efficiency and lower energy costs.
- Ventless Dishwashing Systems – Where possible, ventless dishwashers should be used to eliminate the need for dedicated exhaust hoods, reducing total HVAC demand and improving kitchen efficiency.

6.7.2 Opportunities

6.7.2.1 Controls

- Hoods shall include temperature-based demand exhaust controls in addition to manual on/off switches to optimize ventilation. This will adjust exhaust and makeup air rates based on cooking activity.
- Dishwashing hoods shall be sure to operate only when demand is generated by the operation of the dishwashing equipment. The system shall not be allowed to remain on indefinitely.
- Staff should be trained in the energy impact of kitchen hoods and the cost-saving benefits of reducing unnecessary hood operation.

6.7.2.2 Cooking Equipment

- Investigate induction cooktops with integral vapor removal to potentially eliminate the need for overhead hoods.
- Utilize packaged ventless cooking equipment, such as combi ovens, wherever possible to reduce space exhaust requirements.

6.7.3 Stretch Goals

None identified.

6.7.4 Resources

None identified.

6.8 Lab Equipment

Laboratories should utilize equipment that consumes fewer resources and minimizes hazardous waste to minimize environmental impact and operational costs. Labs should consider the full "life cycle" when selecting new equipment. Most laboratory equipment in buildings or projects is located within schools.

Specialty laboratories, such as law enforcement laboratories, are not specifically addressed by this document.

6.8.1 Current Practice

Laboratory hoods shall be compatible with the educational specifications and intended curriculum for the spaces in which they are located.

6.8.1.1 Air Flow

- Fume hoods and ventilation systems shall be designed to minimize airflow demand while ensuring safety.
- The sash opening should be kept as low as possible which will allow for adequate operation to maintain efficiency and reduce total airflow needed.
- System design must be based on anticipated processes and chemical usage, ensuring proper containment and exhaust requirements.

6.8.1.2 Recirculation

- Where feasible, recirculating hoods (ductless fume hoods) should be considered for low-risk experiments to reduce energy loss associated with exhaust systems.
- These hoods filter and recirculate air instead of exhausting it outdoors, reducing heating and cooling loads.

- Recirculating hoods are only appropriate for certain applications and must be matched to allowable chemical usage (e.g., may be appropriate for middle school science labs but may not be appropriate for high school chemistry labs).

6.8.1.3 Timers

- Constant operation of fume hoods leads to excessive energy waste. Exhaust and airflow systems should be connected to local timer controls to automatically shut off when not needed.
- Timers should allow operation for preset durations (typically 1–2 hours) to provide adequate ventilation while preventing unnecessary energy use.
- Laboratory exhaust control systems shall be integrated with building HVAC controls to ensure:
    - Proper air pressure balance within the lab space.
    - Sufficient makeup air to replace exhausted air, maintaining indoor air quality.
    - Compatibility with demand-controlled ventilation (DCV) systems for further energy savings.

6.8.2 Opportunities
None identified.

6.8.3 Stretch Goals
None identified.

6.8.4 Resources
None identified.

Section 7 **Plumbing**

Plumbing plays a crucial role in water conservation, energy efficiency, and reducing environmental impact. Sustainable plumbing focuses on efficient water use through low-flow fixtures, rainwater harvesting, and greywater recycling. It also promotes energy-efficient water heating solutions like solar or tankless water heaters. Eco-friendly plumbing practices contribute to a more sustainable built environment by conserving natural resources and lowering carbon footprints.

7.1 Lavatory Faucets

Efficient lavatory fixtures are essential to reducing indoor water use. This section focuses on selecting low-flow, durable, and hygienic faucet systems for public and private restrooms.

7.1.1 Current Practice

7.1.1.1 Maximum Flowrate

Provide fixtures with a maximum of 0.5 gallons per minute (GPM) at 60 PSI for flow rate.

7.1.1.2 Materials

Use only lead-free brass materials for all buildings.

7.1.1.3 Metering and Sensors

Utilize the following sensors and metering practices for lavatory faucets:

- Install metered sensor-activated faucets in all facilities (unless valid reason is given to have manual operating faucets for process or use) to improve hygiene and reduce water waste.
- Hard-wired sensors are preferred for reliability and reduced maintenance. Required for all new construction.
- Battery-powered sensors are acceptable where hard-wired connections are not feasible, such as in retrofit applications
- Faucets must be metered with a maximum of 0.25 gallons per cycle (GPC) flow, with a maximum runtime of 30 seconds before timeout.

7.1.2 Opportunities

7.1.2.1 Public-Facing Restrooms

Install metered faucets, either electronically or mechanically controlled, when replacing fixtures in public-facing restrooms with a 0.25 GPC flow.

7.1.2.2 Lavatory Replacement

During partial lavatory renovations or fixture replacements, evaluate adjacent fixtures for material quality and wear to determine if comprehensive replacement is recommended.

7.1.3 Stretch Goals

7.1.3.1 Drainage Capture

Utilize drainage capturing strategies shown below for reuse:

- Capture lavatory drainage for reuse via a greywater filtration system for non-potable use.
- Capture lavatory drainage for reuse in non-potable applications by integrating a greywater filtration system, supporting broader water conservation goals. Prioritize large volume use spaces and grouped fixtures with heavy hot water consumption

7.1.4 Resources

None identified.

7.2 Showerheads

Showerheads represent a major opportunity for water conservation, particularly in athletic facilities, dormitories, and community centers. Showerheads are defined as a component or set of components distributed in commerce for attachment to a single supply fitting, for spraying water onto a bather, typically from an overhead position, excluding safety shower showerheads. This section outlines best practices for fixture selection, water use reduction, and advanced reuse systems.

7.2.1 Current Practice

7.2.1.1 Maximum Flowrate

Provide showerheads with a maximum of 1.5 GPM at 60 PSI flow rate to reduce water consumption.

7.2.1.2 WaterSense Certification

Showerheads shall have WaterSense certification to ensure high efficiency.

7.2.1.3 Decontamination Showers

Decontamination showers shall not be held to these requirements, though design and signage shall make clear that this shower type is for emergency purposes intended by design.

7.2.2 Opportunities

High use installations shall investigate the potential for heat recovery drainage systems.

7.2.3 Stretch Goals

Capture of shower drainage for reuse via a greywater filtration system for non-potable use.

7.2.4 Resources

None identified.

7.3 Toilets

Toilets represent a significant portion of a building's water use. High-efficiency fixtures, paired with appropriate infrastructure evaluation and strategic upgrades, can drive meaningful reductions in water consumption without compromising performance.

7.3.1 Current Practice

7.3.1.1 Maximum Flowrate

Provide toilets with a maximum of 1.28 gallons per flush (GPF) volume for all installations and WaterSense certified.

7.3.1.2 Pipe Condition Assessment

Coordinate with PWD and Facilities Maintenance to review waste pipe conditions for renovation projects to ensure compatibility with low-flow fixtures.

7.3.2 Opportunities

7.3.2.1 Pressure-Assisted Flushing

- Prioritize pressure-assisted flushing systems to achieve 1.1gallons per flush (GPF) performance where feasible

7.3.2.2 Dual-Flush Capability

- Install Dual-flush capable fixtures abiding by WaterSense certification (Version 2.0) wherever possible and have a maximum GPF of 1.28.

7.3.2.3 Scoping

- Conduct sanitary line scoping prior to installation to confirm infrastructure suitability for ultra-low-flow operation

7.3.2.4 Bowl Design

- Select low-friction bowl designs to improve efficiency and reduce water usage per flush

7.3.3 Stretch Goals

Explore composting toilet systems to eliminate water use and convert waste into usable fertilizer for non-edible plant applications. Composting toilet systems are best suited for remote or intermittently used facilities and should be evaluated alongside nutrient recovery urinals

7.3.4 Resources

None identified.

7.4 Urinals

Urinals offer significant water savings when low-flow or waterless models are used. This section addresses fixture performance, odor control, and advanced sustainability strategies like nutrient recovery.

7.4.1 Current Practice

7.4.1.1 Max Flowrate

Provide urinals with a maximum 0.125 GPF for all new or replacement urinals.

7.4.1.2 Sealing

Maintain proper trap seals through regular inspection and maintenance to prevent odors and ensure hygiene.

7.4.2 Opportunities

7.4.2.1 Waterless Urinals

Investigate the use of waterless urinals where possible.

7.4.2.2 Model Preference

Prefer models with automated or periodic water pulses to maintain seal integrity and minimize odors.

7.4.3 Stretch Goals

Explore nutrient recovery technologies that capture nitrates from urine for conversion into fertilizer. Nutrient recovery systems will be considered alongside composting toilet systems for facilities with strong sustainability goals.

7.4.4 Resources

None identified.

7.5 Kitchen Sinks

Kitchen sinks, especially in cafeterias, break rooms, and teaching kitchens, should be equipped with efficient, high-performing fixtures. This section focuses on water savings through reduced flow rates and smart fixture selection.

7.5.1 Current Practice

7.5.1.1 Max Flowrate

Provide kitchen sinks with a maximum of 1.5 GPM at 60 PSI flow rate to ensure water efficiency without compromising functionality.

7.5.1.2 Flexible Sprayer Head

Provide a flexible sprayer head for pre-rinse and cleaning purposes, optimizing water use during meal preparation and dishwashing.

7.5.1.3 WaterSense Certification

Fixtures must have WaterSense certification to guarantee high efficiency in line with environmental goals.

7.5.1.4 Aerators

Install water saver aerators to further reduce water flow while maintaining spray coverage and pressure.

7.5.2 Opportunities

7.5.2.1 Material

Use stainless steel or durable materials for sinks to ensure long-term performance, particularly in institutional or commercial settings.

7.5.3 Stretch Goals

7.5.3.1 Water Reuse

Water reuse from different applications are shown below:

- Integrate greywater recycling for non-potable applications, such as irrigation or toilet flushing, to drastically reduce overall water consumption
- Implement water reuse systems like pre-rinse spray systems or water-efficient dishwashing equipment to reduce overall water demand

7.5.4 Resources
None identified.

7.6 Utility Sinks
Utility sinks in janitor closets, maintenance areas, and other service spaces must balance functionality with water efficiency. This section outlines minimum performance and conservation standards.

7.6.1 Current Practice

7.6.1.1 Max Flowrate
For utility sinks, if large flow is not needed, provide a maximum of 1.5 GPM flow rate to ensure water efficiency without compromising cleaning and operational effectiveness.

7.6.1.2 Material
Select durable materials—sink materials should withstand frequent use and exposure to cleaning chemicals, ensuring longevity.

7.6.2 Opportunities
Install drain screens or catch baskets to capture debris, preventing clogs and reducing the need for frequent maintenance

7.6.3 Stretch Goals
Integrate water recovery systems such as a drain heat recovery system to capture and reuse warm water from washing processes for future cleaning or heating needs

7.6.4 Resources
None identified.

7.7 Drinking Fountains and Bottle Fillers
Drinking fountains, bottle fillers, and direct line water dispensers offer opportunities to reduce single-use plastics and support occupant hydration. Prioritizing efficient, low-

maintenance equipment contributes to overall building sustainability and energy goals.

7.7.1 Current Practice

7.7.1.1 ENERGY STAR Rated

All fountains, bottle fillers, and direct line water dispensers shall be ENERGY STAR rated for efficiency.

7.7.1.2 Bottle Fillers

All fountains shall include integrated bottle fillers to encourage reusable bottle use and reduce plastic waste.

7.7.1.3 ADA Compliance

All fountains and bottle fillers to be ADA type with dual height and fully accessible.

7.7.2 Opportunities

- Coordinate recessed wall boxes and plumbing rough-ins to accommodate direct-plumbed bottle fillers, minimizing installation complexity, and improving aesthetics.
- Specify non-refrigerated fountains in facilities where cooling is not critical, to reduce energy consumption and ongoing maintenance.

7.7.3 Stretch Goals

None identified.

7.7.4 Resources

None identified.

7.8 Domestic Water Heating Systems

Water heating is a key contributor to a building's energy use and carbon footprint. This section focuses on improving energy efficiency, reducing fossil fuel dependency, and increasing system longevity through the selection of efficient, right sized, and electrified water heating solutions.

7.8.1 Current Practice

7.8.1.1 Electric Hot Water Generation

Utilize electric hot water generation wherever possible, except in renovations that do not have adequate electrical capacity for these upgrades. Gas-fired systems shall have a minimum 95% thermal efficiency rating for systems that remain in use.

7.8.1.2 Electric Tankless Water Heaters

For systems serving only a few fixtures or will only see intermittent use (e.g. remote restroom facilities), utilize electric tankless water heaters to minimize energy waste and reduce standby losses.

7.8.1.3 Equipment Design

All water heaters and storage tanks must include sufficient insulation and demonstrate low standby heat loss.

7.8.2 Opportunities

7.8.2.1 Heat Pump Water Heaters

Prioritize heat pump water heaters for new designs and electrification replacements; utilize water-source heat pump wherever possible, and air-source heat pumps elsewhere.

7.8.2.2 Design Considerations

Size storage tanks to account for slower heat pump recovery times and ensure hot water availability during all normally occupied hours. Air-source heat pumps also require adequate space, ventilation, and ambient temperatures to operate correctly.

7.8.2.3 Minimum Coefficient of Performance

Minimum Coefficient of Performance (COP) for water-source systems should be COP=3 while air-source units might be as low as COP=2 in some installation types.

7.8.2.4 Solar Hot Water Generation

Solar thermal hot water generation should be limited to systems that have a near constant need for water heating. Priority for roof space should also generally be given to photovoltaic panels for electricity generation.

7.8.2.5 Pool Heating

Pool heating is one of the few applications where solar thermal remains viable.

7.8.3 Stretch Goals

Where large volumes of hot water or regular use allow, investigate the potential for installation of drain heat recovery systems that can preheat incoming domestic water and lessen the burden of hot water generation.

7.8.4 Resources

None identified.

7.9 Pipe Materials

Piping systems must be designed for durability, safety, and sustainability. Selecting the appropriate materials enhances water quality, minimizes maintenance, and ensures long-term performance. This section outlines required practices, recommended alternatives, and goals for more sustainable material selection.

7.9.1 Current Practice

7.9.1.1 Piping Construction

- All plumbing materials to have low-lead content required by code
- Utilize Type L copper for domestic water standard construction
- Corrosion-resistant materials shall be used to increase system longevity

7.9.1.2 Prohibited Materials

Prohibited materials for pipes are as follows:

- Lead-based solder
- Galvanized steel
- Unlined cast iron

7.9.1.3 Minimum Service Life

Minimum 50-year expected service life for all piping systems

7.9.1.4 Dissimilar Metals
Utilize dielectric unions for connection of dissimilar metals to avoid risks of galvanic corrosion.

7.9.2 Opportunities

7.9.2.1 PVC Piping
Utilize PVC where feasible for sanitary piping to reduce cost and increase sanitary flow capabilities.

7.9.2.2 Polyethylene Piping
Utilize crosslinked polyethylene (PEX) where significant savings can be achieved for a project.

7.9.2.3 Stainless Steel Piping
Utilize stainless steel piping for critical applications and applications in highly corrosive environments (such as natatoriums).

7.9.2.4 Sustainable Materials
Prioritize materials with environmental product declarations (EPDs) and health product declarations (HPDs) to support transparency and sustainability

7.9.3 Stretch Goals
Evaluate alternatives to PVC by referencing current Red List materials

7.9.4 Resources
None identified.

7.10 Water Treatment/Cleaning Systems
Proper water treatment extends equipment life and improves performance. Filtration should be included in humidification, boiler make-up, and process water applications. Greywater treatment can provide additional water reuse opportunities.

7.10.1 Current Practice

7.10.1.1 Where Applicable

Use water treatment where specific water conditions are required for certain processes purposes, or where hard mineral deposits are a risk due to incoming water hardness levels.

7.10.1.2 Water Filtration

Wherever humidification systems might be installed, install local water filtration to prevent scaling, microbial growth, and premature equipment failure utilizing one of the processes below:

- Multi-stage physical filtration to reduce large particulates and sediment
- Activated carbon treatment to reduce organic and chemical compounds
- Reverse osmosis filtration where applicable

7.10.2 Opportunities

7.10.2.1 Water Treatment

- Water treatment strategies are shown below for enhanced water quality:
- Utilize ultraviolet sterilization for effective disinfection of microorganisms.
- Utilize membrane micro/ultra-filtration to reduce microorganisms.

7.10.3 Stretch Goals

7.10.3.1 Greywater Treatment and Reuse

- Buildings should consider capture, treatment, and reuse of greywater from lavatories, showers, etc. for filtration and non-potable reuse such as toilet flushing, irrigation, and cooling tower makeup water.
- Greywater filtration shall pass through Ultraviolet Sterilization, Membrane filtration, and potentially Reverse Osmosis Filtration before being reused in the building

7.10.4 Resources
None identified.

7.11 Rainwater Harvesting
Rainwater harvesting systems offer a sustainable strategy for reducing potable water demand and minimizing stormwater runoff. When designed and maintained properly, these systems can supply non-potable water for uses such as irrigation, flushing fixtures, and mechanical systems. This section outlines key requirements and opportunities for safe and effective system implementation, with stretch goals to further enhance water quality, reduce maintenance, and expand indoor use.

7.11.1 Current Practice

7.11.1.1 Where Applicable
Rainwater harvesting should be evaluated on all new construction and major renovation projects. It should be implemented where the harvested rainwater will be able to offset regular water use that would otherwise come from the municipality, or if a lifecycle analysis proves a significant ROI.

7.11.1.2 First Flush System
Always include a first-flush diversion mechanism to remove large particles and debris.

7.11.1.3 Filtration
Small particle filtration to remove sediment and debris shall be implemented before any indoor use of the rainwater system.

7.11.1.4 Storage Strategy
Separate potable/non-potable storage for code purposes and to avoid higher levels of filtrations and chemical treatment. These different systems should be clearly labeled to avoid confusion.

7.11.1.5 UV Disinfection
Include an ultraviolet disinfection system to kill biological growth in the storage tank.

7.11.2 Opportunities

7.11.2.1 Condensate Capture

Include the capture of condensate from HVAC equipment runoff wherever layouts and unit locations allow. Condensate capture would be a bonus to rainwater harvesting.

7.11.2.2 Water Use Reduction

Provide separate supply line to water closet flush fixtures to reduce overall building water use. This will incur more in-depth filtration and chemical treatment requirements.

7.11.3 Stretch Goals

7.11.3.1 Multi-Stage Filtration

Investigate the use of multi-stage filtration (such as reverse osmosis) to improve water quality to allowable levels.

7.11.3.2 Water Quality Testing

Investigate the use of automated water quality testing to reduce maintenance burden.

7.11.3.3 Water Quality Control

Include pH and mineral balance control to improve water quality and reduce corrosion.

7.11.4 Resources

None identified.

7.12 Plumbing Meters

Effective water management requires visibility into how water is being used throughout a building. In addition to the utility-provided main water meter, projects shall provide BAS connected plumbing sub-meters to monitor key water end uses. This supports leak detection, maintenance, water conservation, and performance benchmarking over time.

7.12.1 Current Practice

7.12.1.1 Where Applicable

Sub-meters will be installed in the applications listed below:

- Domestic hot water systems serving 80% or more of the building's floor area
- All irrigation systems on site and within the building
- Cooling towers, evaporative condensers, or other process water systems
- Laundry systems with commercial or multi-unit capacity
- Meter all pool water use, indoor or outdoor.

7.12.1.2 Meter Reporting

Submetering strategies shall align with LEED BD+C v4 WE Credit: Water Metering. Meters shall report back to the building automation or energy management system for central monitoring and alarm to assist with leak detection and curtailment of excessive water use. If no BAS exists at the site, the meter shall be ready for future connection.

7.12.2 Opportunities

7.12.2.1 Alerts

- Automated alerts for unusual consumption patterns or excessive use, supporting proactive leak detection and faster response

7.12.2.2 Water Use Feedback

- Integration of water use dashboards or reporting tools to support staff engagement and transparency in sustainability reporting

7.12.3 Stretch Goals

None identified.

7.12.4 Resources

- LEED BD+C v4 WE Credit: Water Metering.

Section 8 **Mechanical**

Mechanical systems are used to provide comfortable working conditions through heating, cooling, and fresh air. Systems are designed to be efficient to minimize energy use and water use. Certain systems are designed to reduce greenhouse gas emissions and fossil fuel use for sustainability and enhance efficiency. Noise mitigation for mechanical systems will abide by LEED requirements for acoustical treatment within the building.

8.1 Boilers

Boilers play a crucial role in generating and providing hot water to mechanical equipment throughout the building to maintain comfort. Maintaining efficiencies is important for overall system operation and sustainability.

8.1.1 Current Practice

8.1.1.1 Electrification

Evaluate the feasibility of replacing gas fired boilers with electric or heat pump technology for end-of-life replacements or major renovations. The goal being the reduction or removal of on-site combustion where possible.

8.1.1.2 Thermal Efficiency

Boilers will be selected at a minimum 95% thermal efficiency for condensing and high efficiency boilers to maximize heat capture from combustion.

8.1.1.3 Right Sizing

Right size boilers appropriately for building load. Oversizing will short cycle the boiler and turn the boiler on/off excessively.

8.1.1.4 Turndown

All new and replacement boilers to have a minimum 15:1 turndown to reduce excess gas consumption.

8.1.1.5 Emissions

Ensure low NOx emitting boilers are specified to reduce environmental and health impacts.

8.1.1.6 Venting

Boilers are to be vented in accordance with the manufacturer's instructions, local building codes, and applicable national standards.

8.1.2 Opportunities

8.1.2.1 Heat Pump Water Heating

Prioritize the use of heat pump technology to reduce or remove the need for both gas and electric boilers. Storage shall be sized for slower regeneration rate of heat pumps.

8.1.3 Stretch Goals

8.1.3.1 Heat Pump Water Heating

Utilize geothermal heating systems in lieu of boilers. Geothermal heating systems have higher efficiency, lower operating costs, and zero onsite emissions. (For new construction, geothermal will often prove most advantageous in lifecycle cost analysis)

8.1.4 Resources

None identified.

8.2 Cooling Towers

Cooling towers can be utilized to efficiently dissipate heat from the building’s cooling system, reducing energy consumption and maintaining optimal indoor temperatures. This section also refers to packaged fluid coolers as cooling towers.

8.2.1 Current Practice

8.2.1.1 Where Applicable

Cooling towers are efficient cooling mechanisms, best used where geothermal exchange is not possible or feasible for central cooling.

8.2.1.2 Water Treatment

Implement automated water treatment to minimize corrosion, scale buildup, and biological growth. Maximize cycles of concentration (COC) to manufacturer's highest recommendation for safe long-term use.

8.2.1.3 Drift Eliminators

Install drift eliminators to minimize water loss and reduce contaminant spread.

8.2.1.4 Fill Media

Use high-efficiency fill media to improve cooling performance.

8.2.1.5 Noise Mitigation

Install with manufacturer's low-noise options to mitigate sound impacts that towers often generate.

8.2.1.6 Metering

Directly meter all cooling tower water use to track consumption, detect leaks, and optimize efficiency while also deducting from the overall utility meter to reduce overall sewer charge.

8.2.1.7 Smart Monitoring

Integrate with BAS for real-time monitoring, including chemical makeup and blowdown notifications for trending.

8.2.1.8 Variable Speed Drives

Utilize variable frequency drives (VFDs) on tower fans and pumps to optimize system operation and modulate to the systems real-time needs, allowing for cost savings and extended equipment life.

8.2.1.9 Cooling Tower Flow

Cooling towers shall not be single-pass or once-through cooling systems.

8.2.2 Opportunities

Increase tower COC to ≥ 10 for LEED compliance. Minimize the need for frequent blowdown. As building layout and orientation allows, capture nearby condensate and rainwater to be used as tower makeup water source. Refer to LEED credit – Optimize Process Water Use.

8.2.3 Stretch Goals

Utilize hybrid fluid cooler technologies. These towers can operate as a fluid cooler or dry cooler depending on ambient conditions in order to prioritize energy or water savings.

8.2.4 Resources

None identified.

8.3 Chillers

Chillers play a crucial role in generating and providing chilled water to mechanical equipment throughout the building to maintain cooling comfort.

8.3.1 Current Practice

8.3.1.1 Minimum Efficiency

Utilize high-efficiency equipment exceeding Air-Conditioning, Heating, and Refrigeration Institute (AHRI) part-load efficiency standards by 15% where possible to optimize performance and reduce operational costs.

8.3.1.2 Refrigerant Requirement

Use only low global warming potential (GWP) refrigerants to reduce greenhouse emissions while maintaining system efficiency and performance. Refer to LEED prerequisite – Fundamental Refrigerant Management.

8.3.1.3 Variable Speed Compressors

Utilize variable speed compressors to modulate cooling output, extending equipment life and lowering energy use.

8.3.2 Opportunities

8.3.2.1 Chiller Configuration

Utilize centrifugal chillers with magnetic bearings to reduce friction, enhance compressor performance, and lower operational costs.

8.3.2.2 Smart Monitoring

Implement smart monitoring systems to provide real-time data on performance, efficiency and potential issues, allowing for proactive maintenance and optimized operation.

8.3.3 Stretch Goals

8.3.3.1 Heat Recovery

- Wherever possible, integrate heat recovery into the chiller to capture waste heat for simultaneous heating and cooling.
- For 4-pipe chilled/hot water systems, provide heat recovery chiller with ability to simultaneously heat and cool these loops for maximum energy efficiency.

8.3.3.2 Heat Pump Integration

For condenser loops or 2-pipe systems, provide a chiller with heat pump operation to integrate electric heating and reduce boiler reliance.

8.3.3.3 Refrigerant Alternative

Investigate the use of chillers with Carbon-neutral refrigerants such as carbon dioxide (CO_2) that will eliminate or greatly reduce greenhouse gas emissions from the refrigeration fluid.

8.3.4 Resources

None identified.

8.4 Air Handling Units (AHUs) / Rooftop Units (RTUs)

AHUs/RTUs will be responsible for conditioning and circulating air throughout the building. These systems have several variations that can increase energy efficiency while improving indoor air quality.

8.4.1 Current Practice

8.4.1.1 Housing Construction

AHUs/RTUs to be constructed with double-wall casing to reduce thermal bridging and minimize operational noise. Foil face insulation should be avoided for all rooftop units.

8.4.1.2 Minimum Efficiency

Maintain 15% better than code required minimum efficiency values to maximize system performance.

8.4.1.3 Minimum Filter Grade

Utilize MERV 13 filters at a minimum for enhanced pollutant removal and indoor air quality, unless existing fans do not have adequate static pressure for these filters.

8.4.1.4 Heat Recovery

Utilize heat recovery systems (enthalpy wheel or plate heat exchanger) to reduce heating and cooling energy demand.

8.4.1.5 Demand Control Ventilation

Utilize demand control ventilation to modulate outdoor air intake based on real-time occupancy for all multi-occupant spaces (classroom, conference, etc.). CO_2 level management to maintain cognitive function in critical thinking spaces (like offices and classrooms). Demand control ventilation and air quality monitoring should ensure optimal CO_2 levels without compromising indoor air quality. This is current practice for new construction and renovation, but should be evaluated as feasible for unit replacements in-kind.

8.4.1.6 Variable Frequency Drives

Install VFDs on fans to optimize airflow based on demand, improving efficiency.

8.4.1.7 Bipolar Ionization

Include needlepoint bipolar ionization in the supply airstream after the fan to reduce pathogens, increase filter efficiency, and reduce VOC particles in the space.

8.4.2 Opportunities

8.4.2.1 Alternative Fan Drives

Direct-drive fans should be considered in place of belt-driven systems where feasible to improve efficiency and reduce maintenance. Fan walls should also be considered in these scenarios to improve both resiliency and energy efficiency.

8.4.2.2 Refrigerant Requirement

Utilize low-GWP refrigerants in direct expansion (DX) packaged units to minimize greenhouse gas emissions. Refer to the LEED prerequisite – Fundamental Refrigerant Management.

8.4.2.3 Indoor Air Quality

Include advanced levels of air filtration like upper room ultraviolet lighting, hydrogen peroxide generation, or similar strategies with proven results that will improve improved indoor air quality by reducing pollutants like VOCs, pathogens, and particulates.

8.4.2.4 Pool Dehumidification

Utilize dehumidification heat recovery for pool areas to reclaim rejected heat from the dehumidification process in order to heat the pool with waste heat.

8.4.2.5 Condensate Recovery

Install air handler condensate recovery systems to divert water back to a cooling tower or rainwater collection system.

8.4.3 Stretch Goals

8.4.3.1 Air Quality Monitoring

Utilize advanced air quality monitoring allows for real-time tracking of indoor air conditions resulting in optimal ventilation and control for the AHU on adjusting airflow and filtration.

8.4.3.2 Indoor Air Quality

Consider ASHRAE 62.1 Indoor Air Quality (IAQ) Procedure for ventilation code compliance to optimize outside air intake via integration of advanced air cleaning technologies, reducing energy use while maintaining indoor air quality. Only use in appropriate places where CO_2 levels are not a driving factor of design (e.g. gymnasiums, cafeterias, auditoriums, etc.).

8.4.4 Resources

None identified.

8.5 Dedicated Outside Air System (DOAS)

DOAS systems increase energy efficiency while improving indoor air quality by separating the ventilation load from the space heating and cooling loads. DOAS systems can provide fresh air directly to spaces improving indoor air quality. They are also imperative to increase the health of the building occupants and to reduce the total energy costs of the facility.

8.5.1 Current Practice

8.5.1.1 Where Applicable

DOAS systems will be installed in new construction and major renovations. Only smaller renovations should not consider the implementation of DOAS units into the design in some capacity.

8.5.1.2 Alternative Fan Drives

Direct-drive fans should be considered in place of belt-driven systems where feasible to improve efficiency and reduce maintenance. Fan walls should also be considered in these scenarios to improve both resiliency and energy efficiency.

8.5.1.3 Housing Construction

Utilize double wall casing to mitigate thermal bridging and minimize noise during operation.

8.5.1.4 Minimum Efficiency Grade

Install MERV 13 filters for enhanced indoor air quality and capturing incoming particulate from the environment.

8.5.1.5 Environmental Control Measures

Provide control measures via the BAS to turn the DOAS unit off during smoke events to stop smoke particulates from entering the building.

8.5.1.6 Energy Recovery Systems

Utilize energy recovery systems (enthalpy wheel or plate heat exchanger) to reduce heating and cooling loads while maintaining ventilation effectiveness.

8.5.1.7 CO_2 Sensors

Utilize CO_2 sensors in variable occupancy spaces for air quality monitoring and demand control ventilation.

8.5.1.8 Bipolar Ionization

Include needlepoint bipolar ionization in the supply airstream after the fan to reduce pathogens, increase filter efficiency, and reduce VOC particles in the space.

8.5.2 Opportunities

8.5.2.1 Indoor Air Quality

Include advanced levels of air filtration like upper room ultraviolet lighting, hydrogen peroxide generation, or similar strategies with proven results that will improve improved indoor air quality by reducing pollutants like VOCs, pathogens, and particulates.

8.5.3 Stretch Goals

8.5.3.1 Air Quality Monitoring

Utilize integrated air quality sensors connected to the building management system for real-time monitoring and optimization. Monitor for tVOCs, PPM_{10}, $PPM_{2.5}$, CO_2, and Ozone at a minimum, and consider best industry practices for additional measures.

8.5.3.2 Code Compliance

Consider ventilation and filtration strategies aligned with ASHRAE 241 ; Control of Infectious Aerosols (Section 8.5) to enhance air quality and occupant health.

8.5.4 Resources

- ASHRAE 241 – Control of Infectious Aerosols https://www.ashrae.org/about/news/2023/ashrae-publishes-standard-241-control-of-infectious-aerosols

8.6 Heat Pumps

Heat pumps utilize a refrigeration cycle, rejecting heat to the atmosphere or a condenser water loop to efficiently heat and cool spaces. These systems, whether air-source or water-source, help reduce energy consumption and improve operational efficiency.

8.6.1 Current Practice

8.6.1.1 Where Applicable

These systems are extremely flexible and should be considered in all new construction projects and major renovations.

8.6.1.2 Low Ambient Package

Utilize heat pumps with low-ambient rating, such as NEEP Cold Climate Air Source Heat Pump Specification V4.0 or equivalent to ensure efficient operation in colder temperatures.

8.6.1.3 Minimum COP

Maintain 15% better than code required minimum COP/EER values to maximize system performance where feasible.

8.6.1.4 Heat Pump Sizing

Right size heat pumps for space load to prevent short-cycling and improve longevity for the system while reducing energy consumption.

8.6.1.5 Multi-Stage Compressors

Provide with multi-staged compressors whenever option is present for modulating operation to increase comfort and efficiency of the system.

8.6.1.6 Refrigerant Requirement

Low global warming potential (GWP) refrigerants to reduce greenhouse gas emissions. Refer to LEED prerequisite – Fundamental Refrigerant Management.

8.6.2 Opportunities

8.6.2.1 Water-Source Configuration

Utilize ground/water-source options to provide higher efficiency due to stable temperature conditions, offering a longer system life and lower maintenance needs.

8.6.2.2 Scheduling

Integrate setback temperatures when spaces become unoccupied for extended periods of time.

8.6.3 Stretch Goals

8.6.3.1 Hybrid Systems

Consider dual-source hybrid systems to combine traditional cooling equipment like cooling towers and geothermal exchange fields in projects that do not have adequate space for a full geothermal wellfield. This will result in reduced first cost and year-round energy savings.

8.6.3.2 Demand Usage

Implement peak demand management via a building management system to shift heating/cooling to off-peak hours, reducing grid strain and lowering electricity costs.

8.6.4 Resources

- NEEP Cold Climate Air-Source Heat Pump Standard
  https://neep.org/heating-electrification/ccashp-specification-product-list

8.7 Split Systems

Split systems provide flexible heating and cooling solutions for individual zones, offering efficiency and adaptability for various building applications.

8.7.1 Current Practice

8.7.1.1 Where Applicable

In new construction and major renovation, split systems shall only be installed to serve critical infrastructure zones with backup needs such as MDF rooms, dry food storage, etc.

8.7.1.2 Minimum Efficiencies

Utilize high efficiency models 15% above the minimum SEER and HSPF requirements by code where feasible.

8.7.1.3 Low Ambient Package

Utilize heat pumps with low-ambient rating, such as NEEP Cold Climate Air Source Heat Pump Specification V4.0 or equivalent, to ensure efficient operation in colder temperatures.

8.7.2 Opportunities

8.7.2.1 Inverter Compressors

Utilize inverter compressors that provide higher energy efficiency, precise temperature control, longer design life and quieter operation.

8.7.2.2 Simultaneous Heating & Cooling

Design systems with simultaneous heating and cooling for systems with multi- split units where possible to greatly improve energy efficiency.

8.7.2.3 Low Noise Operation

Ensure low noise operation to ensure comfort for occupants

8.7.3 Stretch Goals

Investigate the use of carbon-neutral refrigerant systems that have little to no GWP resulting in less emissions of greenhouse gases.

8.7.4 Resources

- NEEP Cold Climate Air-Source Heat Pump Standard
  https://neep.org/heating-electrification/ccashp-specification-product-list

8.8 Fan Coils and Unit Vents

Fan coils and unit ventilators are commonly used for zone-level temperature control in individual rooms or spaces. Their performance and efficiency are highly dependent on proper design, installation, and integration with the building automation system.

8.8.1 Current Practice

8.8.1.1 Motor Type

Utilize electronically controlled motors (ECM) to reduce energy use, extend equipment life, and enhance control precision.

8.8.1.2 Condensate Management

Incorporate reliable condensate management including sloped drain pans and properly routed drain lines to prevent water accumulation and potential damage. Gravity drain wherever possible.

8.8.2 Opportunities

8.8.2.1 Noise Constraints

Quiet operation standards should meet or exceed building acoustical requirements like LEED – Acoustic Performance through design features such as vibration isolation, sounds blankets, and fan modulation.

8.8.2.2 Variable Speed Fans

Utilize variable speed operation via the ECM fans to enable improved comfort, energy savings, and equipment longevity. Integration with BAS allows dynamic fan speed control based on occupancy or temperature.

8.8.2.3 Indoor Air Quality

Utilize bipolar ionization and other IAQ strategies to reduce outside air in non-critical spaces via the ASHRAE IAQ ventilation compliance and improve indoor air quality overall.

8.8.3 Stretch Goals

8.8.3.1 Controls

Utilize smart room-level controls offering personalized environmental control, energy tracking, and integration with occupant schedules.

8.8.4 Resources

None identified.

8.9 Pumps

Pumps play a critical role in circulating water for heating and cooling of the facility. Optimizing pump performance can lead to substantial energy savings and increased system reliability.

8.9.1 Current Practice

8.9.1.1 Energy Performance

High-efficiency pump models must be selected to meet or exceed current energy performance standards, ensuring reduced operating costs and reliable service.

8.9.1.2 Variable Frequency Drives

Variable frequency drives (VFDs) shall be installed to modulate water flow based on system demand, improving energy efficiency and extending pump life

8.9.2 Opportunities

8.9.2.1 Low-Flow Design

Low-flow system design strategies should be considered, particularly for larger systems, to reduce pump load, save energy, and extend maintenance intervals. This can include pumps that are sized to operate more efficiently a part-load, or inclusion of a low-flow pump for these conditions.

8.9.2.2 Pump Construction

Consider corrosion-resistant materials (e.g., stainless steel or composite housings) are recommended for long-term durability and reduced maintenance in demanding environments.

8.9.2.3 Redundancy

N+1 redundancy should be considered in critical applications to ensure continuous operation during maintenance or failure, improve reliability, and reduce stress on individual pumps.

8.9.3 Stretch Goals

None identified.

8.9.4 Resources

- ASHRAE 90.1 – Energy Standard for Buildings https://store.accuristech.com/standards/ashrae-90-1-2022-i-p?product_id=2522082

8.10 Variable Frequency Drives (VFD)

VFDs regulate the speed and torque of electric motors by adjusting the frequency and voltage of the electrical supply. Integrating VFDs enhances energy efficiency, extends equipment life, and allows for precise control of motor-driven systems.

8.10.1 Current Practice

8.10.1.1 Where Applicable

Include on all new motors, pumps, compressors, etc. that do not have inherent variable operation and turndown ability.

8.10.1.2 Harmonic Mitigation

Harmonic mitigation strategies (e.g., filters, reactors) shall be implemented to prevent electrical disturbances, reduce the risk of overheating, and maintain power quality.

8.10.2 Opportunities

8.10.2.1 Motor Control

Consider advanced motor control capabilities to allow for more responsive and energy-efficient operation across HVAC, pumping, and process systems.

8.10.2.2 Power Quality Improvements

Power quality improvements can be achieved by aligning motor speeds with actual load demands, minimizing wasted energy and reducing mechanical wear.

8.10.3 Stretch Goals

Utilizing integrated energy monitoring features can provide real-time data on performance, enabling users to identify inefficiencies, implement corrective actions, and optimize energy use over time.

8.10.4 Resources

- ASHRAE 90.1 – Energy Standard for Buildings
  https://store.accuristech.com/standards/ashrae-90-1-2022-i-p?product_id=2522082

8.11 Variable Refrigerant Flow (VRF)

VRV/VRF systems are all-electric, HVAC solutions that support building decarbonization goals through inverter-driven compressors, zoned control, and potential for simultaneous heating and cooling. While VRV/VRF has potential for improved efficiency over existing dated systems, this system type requires large amounts of refrigerant and operation is extremely reliant on the installer's skill level. For these reasons, this system type is not preferred by the City unless it is clearly shown through an LCCA analysis to be the better long-term solution. If determined to be so, the following requirements should be met.

8.11.1 Current Practice

8.11.1.1 Where Applicable

VRV/VRF systems shall primarily be considered in renovations without space for larger ducts and more efficient systems. Smaller systems might be appropriate for small zone control, such as admin offices or small office buildings.

8.11.1.2 Refrigerant Management

Low global warming potential (GWP) refrigerants shall be specified to reduce greenhouse gas emissions.

8.11.1.3 Temperature Control

Zoned temperature control must be provided to allow for individualized heating or cooling in response to varying thermal loads throughout the building.

8.11.2 Opportunities

8.11.2.1 Heat Recovery

Consider heat recovery functionality enables simultaneous heating and cooling by redirecting thermal energy from zones in cooling mode to zones in heating mode via branch controllers or dedicated recovery units.

8.11.2.2 Hybrid System

Utilizing hybrid VRF systems with water-based distribution can reduce overall refrigerant volume, offering enhanced safety and potential LEED or WELL credit advantages.

8.11.3 Stretch Goals

Strategic integration of VRF systems may be considered in spaces or buildings targeted for all-electric operation and rapid decarbonization, especially in retrofit scenarios.

8.11.4 Resources

- Compliance with ASHRAE 15 is required, including refrigerant concentration monitoring and safety protocols in occupied spaces. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

8.12 Geothermal Exchange HVAC Systems

Geothermal exchange systems are systems that utilize the nearly constant underground temperatures of the Earth as a heating and cooling source to provide building conditioning. They can offer a long-lasting, energy-efficient solution with extended lifespans which results in less maintenance burden. These systems contribute significantly to energy savings and support LEED certification across multiple categories. The existence of grants, tax credits (such as the ITC tax credits for geothermal), and other funding mechanisms at the state and federal levels can be used to alleviate the initial financial burden on geothermal systems.

8.12.1 Current Practice

8.12.1.1 Where Applicable

Geothermal systems will be installed in major renovations and new construction wherever site space is adequate. A lifecycle analysis should be performed to verify that a geothermal system will be the most advantageous long-term solution.

8.12.1.2 System Sizing

System sizing must align with building heating and cooling loads to ensure optimal performance, avoid short-cycling, and protect the geothermal wellfield. A test well scope shall be performed before full installation to ensure accurate sizing of the system.

8.12.1.3 Monitoring

Monitor the wellfield temperature regularly via the BAS and trend this data consistently to monitor performance and ensure long-term wellfield integrity.

8.12.2 Opportunities

For restricted sites or budgets, hybrid system configurations (e.g., geothermal with supplemental boilers or cooling towers) can improve cost-effectiveness and enhance performance in variable climate conditions.

8.12.3 Stretch Goals

Open-loop geothermal systems utilizing groundwater may be considered where conditions allow, offering enhanced efficiency and reduced infrastructure cost for well fields while balancing some additional maintenance requirements.

8.12.4 Resources

None identified.

8.13 Thermal Energy Storage

Thermal energy storage systems improve energy efficiency by storing heating or cooling for use during peak demand, reducing operational costs, alleviating grid strain, and maximizing renewable energy benefits. These systems are most effective for facilities subject to demand-driven energy rates and should be prioritized for such applications. While the City's portfolio may have limited opportunities for thermal storage, the following guidelines outline where implementation can be considered. It is important to note that while these systems offer long-term savings, they may require increased maintenance and oversight compared to conventional HVAC solutions.

8.13.1 Current Practice

8.13.1.1 Where Applicable

Thermal energy storage should be implemented primarily as an energy and utility savings measure. Where metering agreements use time-of-day rates to set price on billing cycles, these systems can help alleviate price variability and realize savings. Systems must be designed to integrate with renewable energy sources (e.g., solar thermal, geothermal), allowing stored energy to be deployed during peak load conditions.

8.13.1.2 Design Criteria

Right-size heating and cooling equipment to reflect the increased capacity and load-shifting potential of the thermal storage system. Reducing equipment size can lower capital costs and improve overall system efficiency.

8.13.2 Opportunities

Storage tanks should be highly insulated to minimize heat loss and prevent thermal bridging, ensuring stored energy remains effective and efficient.

8.13.3 Stretch Goals

None Identified.

8.13.4 Resources

None identified.

8.14 Energy Recovery Systems

Energy recovery systems capture and reuse energy that would otherwise be lost from exhaust air or mechanical processes, improving overall HVAC system efficiency and reducing energy consumption.

8.14.1 Current Practice

Include energy recovery on all Dedicated Outdoor Air Systems (DOAS) to reduce ventilation-related heating and cooling loads. Dedicated energy recovery systems should also be considered for buildings with large exhaust air needs such as warehouses, shops, garages, etc.

8.14.2 Opportunities

Utilize waste heat recovery from mechanical systems (e.g., chillers, compressors, data centers) to preheat domestic hot water or support space heating loads.

8.14.3 Stretch Goals

Where the systems exist, integrate energy recovery with thermal storage systems to capture and reuse heat or cooling during peak periods or when renewable generation is available.

8.14.4 Resources

None identified.

8.15 Economizers

Economizers are designed to reduce energy usage by utilizing outdoor air conditions to assist in heating/cooling when the environment provides favorable conditions. Utilizing outdoor conditions improves system efficiency and will lengthen the expected life of equipment.

8.15.1 Current Practice

8.15.1.1 Installation

Incorporate airside economizers on all applicable air handling and rooftop units where local climate supports energy savings.

8.15.1.2 BAS Integration

Ensure economizer controls are integrated with the BAS for automatic operation based on outdoor air temperature, humidity, and enthalpy.

8.15.2 Opportunities

8.15.2.1 Economizer Longevity

Where energy recovery exists, incorporate controls to expand the economizer operation to a larger outdoor conditions range.

8.15.2.2 Economizer Controls

The following economizer controls should be considered to maintain efficiency

- Use comparative enthalpy logic instead of dry-bulb temperature only, to maximize economizer hours and improve performance in Charlottesville's humid climate.
- Add fault detection and diagnostics (FDD) to monitor damper performance and ensure the economizer is functioning as intended.
- Utilize economizer mode to assist with precooling/heating of the building and thermal storage systems where they exist, thus reducing peak load and shifting cooling to off-peak hours.

8.15.2.3 Energy Recovery Integration

Energy recovery systems will help improve the function of economizers wherever they exist. These components can passively or actively increase the outdoor enthalpy ranges that makes economizing viable. Improving the time each year that free heating/cooling can be accomplished.

8.15.3 Stretch Goals

None identified.

8.15.4 Resources

None identified.

8.16 Building Automation Systems (BAS)

The Building Automation System (BAS) is central to a high-performance building, integrating and controlling HVAC, lighting, and other critical systems for optimized energy efficiency, indoor air quality (IAQ), and occupant comfort. A well-designed BAS reduces energy use, supports sustainability goals, helps reduce carbon footprints, and extends the life of building equipment through real-time monitoring and adaptive control strategies.

8.16.1 Current Practice

8.16.1.1 Where Applicable

BAS systems are critical for accurate control and energy conservation and should be installed in all major renovations and new construction.

8.16.1.2 Sensors

Provide the following sensors to maximize the BAS system

- Utilize occupancy sensors for lighting, ventilation, and temperature control to reduce energy use in unoccupied spaces.
- Integration of room sensors for Demand Control Ventilation (DCV) to adjust ventilation rates based on actual occupancy and CO_2 levels, improving efficiency without compromising IAQ.
- Integrated temperature, humidity, and CO_2 sensors in each thermal zone for precise environmental control and real-time IAQ management.

8.16.1.3 BAS Interface

Centralized control through a web-based BAS interface to enable remote monitoring, trend analysis, and scheduling.

8.16.1.4 BAS Alarms

Integrate alarms and fault detection protocols for HVAC system components to improve response time and minimize downtime.

8.16.1.5 Metering

Water sub-meters will be integrated into the BAS system to monitor water usage.

8.16.2 Opportunities

8.16.2.1 Miscellaneous Sensors

- Vape detection sensors should be installed in areas of concern (e.g., restrooms, locker rooms, student spaces) to support health, safety, and compliance with no-smoking/vaping policies.

- Where applicable, implement smart sensors and adaptive learning controls that optimize setpoints and schedules based on historical data and usage patterns.

8.16.2.2 Energy Consumption

Integration of standalone lighting controls, plug load management, and daylight harvesting into the BAS platform to reduce total building energy consumption.

8.16.3 Stretch Goals

8.16.3.1 Indoor Air Quality

- Local IAQ sensors monitoring fine and coarse particulate matter (PM1.0, PM2.5, PM10), ozone (O_3), total volatile organic compounds (TVOCs), and other relevant air quality indicators, allowing the BAS to respond to dynamic environmental conditions.
- Advanced indoor air quality dashboards accessible to occupants and facility staff, providing transparency and empowering data-driven ventilation decisions.

8.16.4 Resources

None identified.

8.17 Scheduling

Scheduling is an essential aspect of building operations that focuses on optimizing system performance and energy efficiency based on occupancy patterns and time-of-day variations. Proper scheduling helps minimize energy waste, reduces operational costs, and ensures that building systems are operating only when needed.

8.17.1 Current Practice

8.17.1.1 Building Operation

Scheduling building operation times based on typical occupancy patterns to optimize energy use.

8.17.1.2 Optimum Startup

Include optimal startup with slow warmup/cooldown to minimize equipment wear and ensure highest energy efficiency.

8.17.2 Opportunities

8.17.2.1 Occupancy Scheduling

Implement occupancy-based scheduling with sensors to adjust systems based on real-time occupancy (e.g., lighting, HVAC, and ventilation).

8.17.2.2 Flexible Scheduling

Include flexible scheduling for different building zones, with varying operational hours, to ensure resources are allocated effectively such as: publicly accessible areas, gymnasiums, etc.

8.17.2.3 Adaptive Scheduling

Integrate adaptive scheduling that accounts for changes in building usage, including weekends, holidays, and off-hours and allows for easy adjustments in schedule for non-typical operations during these times.

8.17.3 Stretch Goals

None identified.

8.17.4 Resources

None identified.

8.18 Grid Optimization

Grid optimization involves managing and balancing energy consumption within the building in a way that aligns with the local electrical grid's capacity and efficiency. This approach is crucial in supporting grid stability, especially during high-demand periods, while also contributing to sustainability goals through optimized energy use.

8.18.1 Current Practice

8.18.1.1 Where Applicable

Grid optimization to be used to meet LEED requirements and achieve credits, or when battery storage is present on the project

8.18.1.2 Compliance
Comply with local utility regulations and participation in demand response programs for buildings without critical operation needs.

8.18.1.3 BAS Integration
Integrate grid-responsive systems into the building's BAS for automatic adjustments based on grid signals or conditions.

8.18.2 Opportunities

8.18.2.1 Controls
Utilize smart thermostats and BAS controls that adjust space setpoints based on grid signals or time-of-use pricing.

8.18.2.2 Optimum Start
Incorporate staging and optimum starts of systems (e.g., HVAC, elevators) based on grid conditions and occupancy to reduce peak load and optimize energy consumption.

8.18.3 Stretch Goals

8.18.3.1 Electric Vehicles
Utilize vehicle-to-grid (V2G) integration for electric vehicles (EVs) to provide backup power to the grid during peak demand, creating a potential revenue stream and supporting energy resilience.

8.18.3.2 Energy Storage Systems
Integrating energy storage systems (e.g., batteries) for load shifting, storing excess energy when demand is low, and using it during high-demand periods to reduce the building's reliance on the grid.

8.18.4 Resources
None identified.

8.19 Indoor Air Quality
Indoor Air Quality (IAQ) is fundamental to occupant health, comfort, and cognitive performance. As buildings become tighter and more energy efficient, ensuring adequate ventilation and air cleaning becomes more critical. Prioritizing IAQ will

support public health goals, reduce long-term operational burdens, and reinforce the city's leadership in sustainable building practices.

8.19.1 Current Practice

8.19.1.1 Where Applicable

IAQ measures shall be incorporated into all new construction, major renovations, and significant HVAC system upgrades. Projects should integrate IAQ design considerations early in the process to optimize system selection and ensure sufficient monitoring and control.

8.19.1.2 Minimum Filter Grade

- MERV 13 filters are required on all outdoor air intakes and in systems where fan performance can support the added pressure drop.
- MERV 11 is the minimum acceptable filter rating for all new and replacement systems where MERV 13 is not feasible.
- Filter upgrades should be verified for fan capacity and pressure drop before implementation.

8.19.1.3 CO_2 Sensors

All thermostats should be supplied with CO_2 sensors to monitor indoor pollutant levels and enable demand control ventilation strategies.

8.19.1.4 Air Flushing

Schedule air flushing during off-peak hours (e.g., early mornings or late evenings) to reduce accumulated indoor pollutants and refresh the indoor air quality. This can also help reduce heating and cooling loads during peak demand times by utilizing natural ventilation when outdoor temperatures are more favorable, thereby improving overall energy efficiency.

8.19.1.5 Air Purifiers

Room air purifiers should be prohibited as a primary means of indoor air quality improvement. These purifiers should only be utilized in time of need and distributed by the facilities department.

8.19.2 Opportunities

Supplemental strategies: Where budget allows, utilize advanced air treatment methods, such as upper room UV systems, bi-polar ionization, and hydrogen peroxide generation for additional air purification and to complement HVAC filtration.

8.19.3 Stretch Goals

Integrating continuous IAQ monitoring systems, which measure parameters such as particulate matter (PM), ozone, and total volatile organic compounds (TVOCs), ensure long-term air quality maintenance and improve overall efficiency.

8.19.4 Resources

- ASHRAE 241 https://www.ashrae.org/technical-resources/bookstore/ashrae-standard-241-control-of-infectious-aerosols

8.20 Simple Equipment Replacements

Simple equipment replacements are essential to maintain and improve the performance of HVAC systems while enhancing energy efficiency and occupant comfort. This section outlines the minimum requirements for replacing outdated or inefficient equipment, opportunities for improving system functionality and performance, and stretch goals that aim to further optimize energy usage and sustainability. By addressing these key aspects, buildings can achieve immediate improvements in operational efficiency and long-term environmental benefits.

8.20.1 Current Practice

8.20.1.1 Energy Compliance

Ensure all HVAC equipment meets energy efficiency standards, including high-efficiency motors, variable frequency drives, and minimum efficiency ratings for heat pumps and chillers.

8.20.1.2 Refrigerant Requirement

Use low GWP refrigerants in all applicable systems (chillers, heat pumps, VRF, etc.) to reduce environmental impact.

8.20.1.3 Occupancy Scheduling

Incorporate occupancy sensors and demand control ventilation to optimize energy use based on real-time building occupancy.

8.20.1.4 BAS Compatibility

Ensure compatibility with BAS for monitoring and control integration to maximize energy performance.

8.20.1.5 Variable Frequency Drives

Utilize variable speed pumps, fans, and compressors (through VFDs where necessary) to ensure efficient operation and extended life of equipment through minimizing short cycling.

8.20.1.6 Electrification

Fossil-fueled equipment should be replaced with electric alternatives wherever possible. Only replace with in kind fossil-fueled equipment where electrification is not possible. Consider more energy efficient replacements like heat pumps to reduce need for increase electrical infrastructure upgrades.

8.20.1.7 Minimum Efficiency

Maintain 15% better than code required minimum COP and energy efficiency values to maximize equipment performance where feasible.

8.20.2 Opportunities

8.20.2.1 Upgrades

Upgrade to inverter-driven or variable speed systems (e.g., chillers, air handling units, fan coils) for better efficiency and longer system life.

8.20.2.2 Energy Recovery

Consider energy recovery options for systems such as DOAS and AHUs to recover waste heat or minimize cooling loads.

8.20.2.3 Energy Saving Features

Incorporate energy-saving features such as economizers to reduce energy consumption during operation.

8.20.3 Stretch Goals

8.20.3.1 Refrigerant Design

- Investigate the use of and adopt carbon-neutral refrigerants and systems with minimal environmental impact to align with sustainability goals.
- Install refrigerant leak detection to ensure system longevity and efficiency and to notify of leaks as soon as possible to minimize environmental impact.

8.20.3.2 Indoor Air Quality

Implement advanced air quality monitoring systems to ensure continuous IAQ optimization in conjunction with ventilation systems.

8.20.4 Resources

- Virginia Energy Conservation Code (VECC) https://www.energycodes.gov/status/states/virginia

Section 9 **Electrical Systems**

Electrical systems are implemented to provide reliable power to buildings and comfortable working conditions through lighting, generators, photovoltaic systems, EV charging, and metering systems. Systems should be designed to be efficient, minimize energy use, and provide reliable power even in the event of utility power loss.

References to Code:

- Virginia Energy Efficiency Code 2021
- LEED v4.1

9.1 Lighting

Lighting and their associated lighting controls should be designed to minimize energy use, provide comfortable spaces, offer flexibility, and save energy when spaces are unoccupied.

9.1.1 Current Practice

9.1.1.1 Where Applicable

Lighting design will be applicable in all new projects and any renovation requiring new ceilings.

9.1.1.2 Light Emitting Diode (LED) Lighting

All lighting shall be LED.

9.1.1.3 Color Rendering Index (CRI)

All lighting CRIs should be 80 at a minimum.

9.1.1.4 Correlated Color Temperatures (CCT)

Correlated Color Temperatures of fixtures shall be appropriate for the space being lit. See below for requirements by occupancy type.

- 3000K CCT for buildings that will be regularly occupied at hours exceeding 8 AM-6 PM.
- 4000K CCT for buildings that will be regularly occupied at typical operating hours (roughly 8 AM-6 PM).

9.1.1.5 Lighting Controls

Lighting for all regularly occupied spaces shall have the ability to be dimmed from a control station within the space being controlled. Where a control station is not advisable to be located within the space itself it should be in an adjacent space with visibility to the space being controlled.

9.1.1.6 Lighting Controls

Utilize lighting controls as required by the Virginia Energy Conservation Code (VECC).

9.1.1.7 Fixture Certification

All fixtures shall be DesignLights Consortium (DLC) certified.

9.1.2 Opportunities

9.1.2.1 Minimum Lumens Per Watt (LPW)

All fixtures should be greater than 100 LPW.

9.1.2.2 Maximum Unified Glare Rating (UGR)

Provide calculations to show all regularly occupied spaces have a UGR of less than 19.

9.1.2.3 Lighting Power Density (LPD)

Building LPD should be 30% better than code.

9.1.2.4 Improved CRIs

All light fixture CRI values shall be 90 where they do not significantly reduce the efficacy (LPW) of the fixture.

9.1.3 Stretch Goals

9.1.3.1 Minimum LPW

All fixtures for primary spaces should be greater than 140 Lumens Per Watt.

9.1.3.2 LPD

Building lighting power density should be 50% better than code.

9.1.4 Resources

None identified.

9.2 Generators

Generators provide reliable back-up power in the event of utility power loss.

9.2.1 Current Practice

9.2.1.1 Where Required

Generators shall be considered on all major renovations and new projects or where code requires emergency power supply and battery storage is not viable.

9.2.1.2 Power Requirement

All generators shall be powered by natural gas.

9.2.1.3 Generator Enclosure

All generators shall be provided with weatherproof enclosures and Level 2 sound attenuation at a minimum.

9.2.1.4 Resilience Hub

Where any parts of a building or campus are to be used as a resilience hub provide additional loads within the hub such as HVAC, power, and lighting on the generator. This applies to code required and non-code required structures.

9.2.1.5 Generator Loads

Loads on the generator shall be as follows:

- Emergency Lighting
- Optional Standby Lighting
- Fire Alarm
- Intercom Head-End
- Security Systems
- Kitchen Coolers/Freezers
- IT Equipment

9.2.2 Opportunities

Analyze the use of battery energy storage systems (BESS) in lieu of generators. Where full replacement of the generator with a BESS is not possible look at hybrid solutions.

9.2.3 Stretch Goals

None identified.

9.2.4 Resources

None identified.

9.3 Photovoltaics (PV)

Photovoltaics, or solar panel arrays, provide clean on-site renewable energy to offset a building or sites energy use. Equipment includes inverters, PV panels, optimizers, racking and other equipment. The existence of grants, tax credits (such as the Investment Tax Credit (ITC) for PV), and other funding mechanisms at the state and federal levels can be used to alleviate the initial financial burden on solar panel installation.

9.3.1 Current Practice

9.3.1.1 Where Applicable

Provide PV on major renovation and new construction projects where the project budget allows. Refer to Electrical Equipment Space Planning & Renewable Energy Ready Design (Section 3.11) for required PV system design requirements.

9.3.1.2 Tier 1 Panels

Provide Tier 1 panels (where panels are included as part of the project).

9.3.1.3 Roof Penetrations

Minimize any required roof penetrations for racking, conduit, etc.

9.3.1.4 Minimum Warranty

All equipment should be provided with a minimum 5-year parts and labor warranty.

9.3.1.5 BAS Integration

Connect all inverters to the BAS for monitoring. Provide alarms if production falls below production thresholds for any given month. Coordinate exact requirements with controls and solar contractors.

9.3.1.6 Acceptable Inverter Manufacturers

Acceptable inverter manufacturers are as follows:

- SolarEdge
- SMA
- Enphase

9.3.1.7 Mounting Options

Provide appropriate mounting solution(s) for the roof where solar is being installed. Provide structural reports to the structural engineer to confirm the roof has been designed with the appropriate capacity based on the mounting solution selected. Mounting options are as follows:

- Rack mounted Systems which would be ballasted, attached, or hybrid. These systems are typically used on flat roofs.
- Railed mounted system. These systems are typically used on sloped roofs.
- Curb mounted systems

9.3.1.8 Maintenance Plans

- All projects should have a maintenance protocol in place for the photovoltaic system. Coordinate with the owner for implementation of the maintenance protocol on a project-by-project basis.

9.3.2 Opportunities

9.3.2.1 Roof Penetrations

Eliminate all roof penetrations other than conduit feeding panels/inverters.

9.3.2.2 Target AC:DC Ratio

Target 1.3 AC:DC ratio. Utilize larger ratios where utility interconnection or other factors make them beneficial.

9.3.2.3 Mounting Options

Look at mounting panels on parking canopies or building attached canopies where additional photovoltaic capacity is needed. Refer to PV Panel Placement Other than Roofs (Section 3.11.1.4) for additional options where additional capacity is needed.

9.3.2.4 PV Inclusion

Preference for PV to be included in the project. Look at bidding these systems as add or deduct alternates to get pricing and allow a decision to be made.

9.3.2.5 Buy American Act Compliance

All panels shall be Buy American Act Compliant.

9.3.2.6 Bifacial Panels

Evaluate the feasibility and suitability of bifacial panels, especially when using building integrated PV or PV parking canopies.

9.3.3 Stretch Goals

None identified.

9.3.4 Resources

None identified.

9.4 EV Charging

As zero-emissions vehicles become more prevalent it is important that projects plan for infrastructure to support current and future charging needs.

9.4.1 Current Practice

9.4.1.1 Where Applicable

Provide sufficient zero-emissions vehicle charging infrastructure as indicated in the relevant chart in Project Requirements by Type (Section 2.3). Where infrastructure (or chargers) is required, refer to the Charlottesville Zoning Ordinance for projects within city limits, and the LEED Electric Vehicles credit for projects located in the county.

9.4.1.2 Required Infrastructure

Where zero-emissions vehicle charging is required, plan for space in all panelboards for future breakers and EV charging ampacity. Install EV charging electrical capacity and pre-wiring sufficient to meet the projected demand for such infrastructure ten years after building occupancy. Meter EV charging separately to track energy usage.

9.4.1.3 Required Level 2 Charging

Where zero-emissions vehicle charging is required, provide sufficient chargers to satisfy EV charging requirements two years after building occupancy. Provide a minimum of one Level 2 dual pedestal charging station. All chargers shall comply with NEC Article 625, UL 2594, UL 2231-1, and UL 2231-2.

9.4.1.4 Fleet Charging

Where fleet level charging is provided, chargers shall be compatible with dynamic load management to limit required electrical upgrades. Load management shall be employed at sites serving a minimum of 8 charging stations, or as needed at smaller sites to avoid electrical service upgrades.

9.4.2 Opportunities
Consider providing EV charging and infrastructure when recommended in the relevant chart in Project Requirements by Type (Section 2.3).

9.4.3. Stretch Goals
None identified.

9.4.4 Resources
None identified.

9.5 Metering
The movement towards more energy efficient and electrified buildings requires the gathering and assessment of information about how energy is used throughout the property. Metering Systems give us the ability to observe electricity usage of our buildings, and specific load categories, to better understand how and when energy is consumed.

9.5.1 Current Practice
Provide metering and sub-metering as required in the VECC. In addition, provide sub-metering for EV charging facilities.

9.5.1.1 BAS Integration
All meters shall be tied into and monitored by the BAS. The following items shall be trended at a minimum:

- Peak demand (kW)
- Total usage (kWH)

9.5.2 Opportunities

9.5.2.1 Load Submetering
For new construction and major renovations sub-metering shall cover the following loads (where applicable):

- Lighting
- Exterior Lighting
- HVAC
- Plug Loads
- Kitchen

- Elevators
- All emergency power branches
- Large IT loads

9.5.3 Stretch Goals
Track metering for all metering and sub-metering systems and cross compare sub-loads of similar building types. Monitor all buildings and make adjustments based on historical energy usage by sub-loads.

9.5.4 Resources
None identified.

Section 10 **Commissioning**

Commissioning (Cx) ensures that building systems are designed, installed, and operated as intended. It enhances performance, reduces operational issues, and supports energy efficiency goals. The Virginia Building Code mandates commissioning for some projects. LEED also sets requirements for Fundamental and Enhanced Commissioning, emphasizing system verification, performance testing, and long-term optimization.

Commissioning is a critical process for both new construction and major renovations, ensuring that mechanical, electrical, plumbing, and envelope systems function correctly before occupancy. It can be a process that helps building owners and operators understand their building systems so they can be maintained and operated for maximum performance over the life of the facility. The scope and level of commissioning vary depending on project size and complexity.

Commissioning is one of the last lines of defense against improper installation or incorrect operation of system components. Thus, the commissioning agent should be a separate entity from the contractor that purchases and installs the equipment.

References to Code:

- Virginia Energy Efficiency Code 2021
- LEED v4.1
- *Code of Virginia § 2.2-1182*, High Performance Building Act

10.1 Fundamental Commissioning

Fundamental Commissioning (FCx) is essential to ensure that a building's systems function as intended and deliver on the Owner's Project Requirements (OPR). It involves verifying and documenting that building systems are designed, installed, tested, and capable of being operated and maintained to meet the operational needs of the building.

10.1.1 Current Practice

10.1.1.1 Where Applicable

Per the VECC, fundamental commissioning (Cx) is required for all new construction and renovation projects per Section 2 of this document, as well as for any project pursuing LEED certification. It is also mandated by the VECC for projects with:

- More than 480,000 Btu/h of cooling capacity
- More than 600,000 Btu/h combined water-heating and space-heating capacity

10.1.1.2 Agent

Commissioning shall be conducted by a qualified independent party. A registered design professional is required to lead or oversee the commissioning process.

10.1.1.3 Timing

- Develop the commissioning plan early in the design process, prior to equipment procurement.
- Testing and verification must occur well before project closeout, allowing time to resolve deficiencies before occupancy.
- Perform functional performance testing of all commissioned systems prior to substantial completion.

10.1.1.4 Training and Building Turnover

A minimum of 8 hours of operations and maintenance training shall be provided to facility staff, covering major systems and controls to ensure smooth turnover and ongoing system performance. Smaller renovations and equipment replacements may require less time for training. The engineer of record for new construction and major renovations shall also generate a building operation manual that describes building operations as they were designed. Also include setpoints, schedules, and other important design and operation factors that will affect the future energy use and operation of the building.

10.1.2 Opportunities

10.1.2.1 IT/AV Commissioning

Expand the commissioning scope to include IT, security, audiovisual, and non-regulated systems to ensure coordinated, functional integration at occupancy.

10.1.2.2 Additional Training

Provide an additional 8+ hours of advanced training for large facilities or projects with new or complex technologies. Consider inviting key maintenance staff to observe functional performance testing of complex systems as a learning opportunity to support future O&M.

10.1.3 Stretch Goals

None identified

10.1.4 Resources

- LEED v4/v4.1 Enhanced Commissioning Guidelines
- ASTM E2947 / ASHRAE Guideline 0.2
- Refer to Section 2 of this standard

10.2 Enhanced Commissioning

Enhanced Commissioning (ECx) extends beyond the baseline commissioning process by engaging the Commissioning Authority (CxA) earlier in the design process and continuing commissioning activities after occupancy. This deeper level of involvement helps optimize building performance, reduce operational issues, and ensure long-term success in meeting energy and sustainability goals. Enhanced Commissioning is recognized by LEED and other sustainability frameworks as a key strategy for improving outcomes, and it is essential for high-performing buildings.

10.2.1 Current Practice

10.2.1.1 Where Applicable

Enhanced Commissioning shall be a baseline requirement for all new buildings and major renovations over 20,000 SF. Enhanced commissioning is recommended for buildings between 5,000 to 20,000 SF.

10.2.1.2 Early Design Involvement

Include the Commissioning Authority (CxA) during early design phases to review OPR, Basis of Design (BoD), design documentation, and sequences of operation for major systems.

10.2.1.3 Seasonal Performance Testing

Schedule seasonal performance testing to validate operation during both heating and cooling seasons, helping identify latent issues not revealed during standard testing.

10.2.2 Opportunities

10.2.2.1 Occupant Feedback

Incorporate occupant feedback loops (e.g., surveys, post-occupancy evaluations) to inform commissioning outcomes and identify user comfort or performance issues. Refer to Post-Occupancy Evaluation (Section 2.8) for protocols.

10.2.2.2 Warranty-Phase Reviews

Engage the CxA in warranty-phase reviews (10–12 months post-occupancy) to assess system performance and identify deferred maintenance or corrective action needs.

10.2.3 Stretch Goals

None identified.

10.2.4 Resources

- LEED v4/v4.1 Enhanced Commissioning Guidelines

10.3 Building Envelope Commissioning

Building envelope commissioning (BECx) is a critical process for ensuring that a building's enclosure meets performance expectations for energy efficiency, durability, and occupant comfort. Unlike traditional commissioning, which primarily focuses on mechanical, electrical, and plumbing (MEP) systems, envelope commissioning evaluates air, water, thermal, and vapor control layers to reduce energy losses, prevent moisture-related issues, and improve indoor environmental quality. It is particularly beneficial for energy-efficient buildings, reducing infiltration and ensuring long-term durability.

10.3.1 Current Practice

10.3.1.1 Where Applicable

BECx shall be included in major new construction projects and major renovations that touch the building envelope for changes and improvements and in all instances where it is required by Project Requirements by Type (Section 2.3).

10.3.1.2 Scope of work

The commissioning authority (CxA) shall be involved during early design to review envelope detailing, and shall coordinate with the design and construction teams through completion. Visual inspections, air barrier verification, and installation checklists shall be part of the standard process.

10.2.1.3 Envelope Testing

Testing shall include thermal imaging and whole-building air leakage testing (blower door testing) where applicable, in accordance with ASTM and ASHRAE guidelines.

10.3.2 Opportunities

10.3.2.1 Multi-Seasonal Testing

Incorporate seasonal performance evaluations to understand enclosure performance under various climate conditions.

10.3.3 Stretch Goals

None identified.

10.3.4 Resources

- LEED v4/v4.1 Enhanced Commissioning Guidelines
- ASTM E2947 / ASHRAE Guideline 0.2

10.4 Monitoring-Based Commissioning

Monitoring-based Commissioning (MBCx) extends traditional commissioning by continuously tracking building performance post-occupancy. It leverages data analytics to identify system inefficiencies and ensure long-term optimization. Monitoring-based commissioning should be implemented when a project is attempting to achieve net zero energy certification. This is important as the first year of operation will set the trend for the building and will be when most deficiencies or operations issues are found.

10.4.1 Current Practice

10.4.1.1 Where Applicable

MBCx should be considered for all new construction, major renovations, and existing buildings seeking ongoing performance verification or additional LEED points. The project manager should determine if it is advantageous to implement MBCx on a case-by-case basis.

10.4.1.2 Data Infrastructure

Install a network of metering, sensors, and data collection tools that can feed into the building automation system or standalone MBCx platform.

10.4.1.3 Analytics and Reporting

Use logging of trends and software analytics to perform trend analysis, fault detection, and diagnostics. Develop dashboards and automated reporting to alert staff to abnormal conditions.

10.4.1.4 Monitoring

Engage the commissioning agent to continuously monitor energy and system performance data post-occupancy.

10.4.2 Opportunities

10.4.2.1 Staff Analysis Training

Engage facility personnel in regular review of performance dashboards and data insights. Allocate time for training of the staff to interpret data trends, identify performance inefficiencies, and coordinate actions to alleviate system abnormalities.

10.4.3 Stretch Goals

None identified.

10.4.4 Resources

- LEED v4/v4.1 Enhanced Commissioning Guidelines

10.5 Retro-Commissioning

Retro-commissioning (RCx) is the process of evaluating and optimizing the performance of existing building systems to improve efficiency, occupant comfort, and system reliability. Unlike fundamental or enhanced commissioning, which applies to new construction, RCx is performed on existing buildings to identify operational inefficiencies and restore systems to their optimal performance.

10.5.1 Current Practice

10.5.1.1 Where Applicable

Retro-commissioning should be considered for existing buildings undergoing renovations, buildings and systems with 10 years of operation or more, or when persistent operational issues such as occupant discomfort or excessive energy consumption are reported. The following guidelines are included for projects which strive to pursue retro-commissioning.

10.5.1.2 Data Infrastructure

Engage a commissioning agent to conduct a thorough review of control sequences, equipment functionality, setpoints, and occupancy patterns. Develop findings report that includes quick wins and long-term improvement recommendations.

10.5.1.3 Testing

Perform functional performance testing on HVAC, lighting, and controls systems to uncover inefficiencies. Prioritize improvements that do not require major equipment replacement.

10.5.2 Opportunities

10.5.2.1 Incentives and Rebates

Consult with local utility provider and the Cx agent to find and apply for utility incentives and rebates to reduce project cost and improve return on investment.

10.4.3 Stretch Goals

None identified.

10.4.4 Resources

- ENERGY STAR Building Upgrade Manual – Retro-Commissioning Chapter
- ASHRAE Guideline 0.2 and 1.2

Section 11 **Site Design**

The way the built environment interacts with the natural environment is a critical component of a site's sustainability. For all projects, consider how site design and design decisions minimize environmental impact. Site design should be restorative and include native vegetation as often as possible.

11.1 Outdoor Spaces

Outdoor spaces can reduce stress, improve employee mental health, foster better social interactions, and increase employee physical activity.

11.1.1 Current Practice

None identified.

11.1.2 Opportunities

Plan and design outdoor spaces that invite building occupants and visitors to the outdoors. Anticipate the need for sunny places and shady places to maximize year-round enjoyment of the local climate.

11.1.3 Stretch Goals

None identified.

11.1.4 Resources

None identified.

11.2 Hardscaping and Paving

Hardscape and paving are necessary for accessing buildings. However, minimizing both can allow for the opportunity to create additional inhabitable outdoor spaces and planting areas. Minimizing impermeable surfaces allows for more water infiltration.

11.2.1 Current Practice

None identified.

11.2.2 Opportunities

11.2.2.1 Minimize Paving and Hardscaping

Minimize paving and hardscape extents to the extent practicable. Utilize permeable surfaces to maximize infiltration when possible.

11.2.2.2 Paving Materials

Use light-colored paving and hardscape materials when possible. Use paving materials with an initial solar reflectance (SR) value of at least 0.33. Evaluate alternatives to asphalt paving.

11.2.2.3 Shade Structures

Consider light-colored shade structures over hardscaping, especially over darker paving materials.

11.2.2.4 Future PV

Anticipate Photovoltaic (PV) locations or future PV locations placed over parking areas to shade parking surfaces and vehicles.

11.2.3 Stretch Goals

None identified.

11.2.4 Resources

None identified.

11.3 Landscaping

Interaction with plants improves moods, reduces stress, and enhances productivity. Tying the built environment and nature together offers improved aesthetics, increased physical and psychological benefits for employees, increased land value, and can positively impact the environment. Shading from trees can reduce the heat island effect and create a cooler area surrounding the building. Also, permeable areas can benefit stormwater management and increase the local biodiversity.

11.3.1 Current Practice

Utilize drought-tolerant plants native to the Piedmont region of Virginia. Prefer plant ecotypes from the City of Charlottesville, Albemarle County or the immediately surrounding counties.

11.3.2 Opportunities

11.3.2.1 Pollinator Species

Utilize native and drought-tolerant plant species which are beneficial to pollinator species.

11.3.2.2 Canopy Coverage

Design landscaping to improve tree canopy coverage and shade all hard surfaces.

11.3.2.3 Mosquito Predators Shelters

Provide shelters and habitat for mosquito predators such as bats, swallows, martins, and bluebirds.

11.3.2.4 Lawn Size

Minimize or reduce lawn and site areas that require regular mowing. For open areas, native warm season grasses and native flowering species which require only annual or semi-annual mowing, or which can be maintained with other low-impact management practices, are preferred.

11.3.3 Stretch Goals

None identified.

11.3.4 Resources

None identified.

11.4 Stream Restoration and Riparian Buffers

Riparian buffers are the natural habitats between terrestrial and aquatic ecosystems. There are two approaches to stream and riparian buffer restoration: passive and active. A passive approach is the reduction of human-induced disturbances and restoration of boundary conditions for native riparian species to flourish. An active approach is the removal of invasive species and the planting of natives for the establishment of a buffer.

11.4.1 Current Practice

None identified.

11.4.2 Opportunities

11.4.2.1 Stream Restoration

Where streams are piped or in poor condition, consider stream daylighting or restoration. Repair stormwater outfalls that are damaged or eroded.

11.4.2.2 Riparian Buffers

Where a property includes a stream, implement best practices for riparian buffers.

11.4.3 Stretch Goals

None identified.

11.4.4 Resources

None identified.

11.5 Outdoor Water Use

When workplaces have an outdoor space that needs supplemental watering, utilize water saving practices to help reduce water waste. Monitoring water usage outdoors through metering and smart sensors can significantly reduce water waste. For example, in the case of a week with rain, a smart sensor can monitor the dampness of the soil and make it easier to determine the necessary amount of watering needed. Another key way to minimize water waste is to closely monitor sprinklers and hose adapters for leaks.

11.5.1 Current Practice

11.5.1.1 Irrigation

For irrigation, use Smart Controls, such as WaterSense labeled weather-based smart irrigation controls, drip systems, rain sensors, and weather tracking. Irrigation needs can be complicated and bringing in an expert can be a great way to make sure irrigation systems are set up correctly and perform effectively and efficiently. WaterSense certifies irrigation professionals and has a database for searching for a professional in the area.

Coordinate with Charlottesville Parks & Recreation for irrigation systems and controls management.

11.5.1.2 Metering

Meter outdoor potable water uses including, but not limited to, irrigation, spray grounds, ornamental water features, pools, gardening, and equipment washing. Consider metering on less intensive uses as appropriate.

Metering may be omitted when the only potable outdoor fixtures are hose bibs and the bibs are not expected to be regularly used.

11.5.2 Opportunities

Utilize non-potable water where the use-case does not necessitate potable water. Such uses include, but are not limited to, gardening, irrigation, and equipment washing. Non-potable sources include rainwater, condensate recovery, and direct sourcing from the Rivanna River, where allowed by regulators.

11.5.3 Stretch Goals

None identified.

11.5.4 Resources

- Water & Efficiency Guide for Purchasing, WISE Program Resource

11.6 Site Lighting

Lighting and their associated lighting controls should be designed to minimize energy use, provide comfortable spaces, offer flexibility, and save energy when spaces are unoccupied.

11.6.1 Current Practice

The following items are required for site lighting:

- All lighting shall be LED.
- All fixtures shall be provided with integral motion sensors when the option is available.
- Fixtures shall dim down to a lower lighting level but not turn completely off.
- All fixtures shall be DesignLights Consortium (DLC) certified.
- Correlated Color Temperatures (CCT) should be 3000K or lower.
- Color Rendering Index (CRI) shall be 80 or higher.
- All fixtures should be DarkSky compliant, full cut-off, aimed away from adjacent properties, and provided with appropriate Backlight, Uplight, and Glare (BUG) Ratings.
- Where fixtures are located near the property line consider changes in grade and location of adjacent buildings, trees, etc. when placing fixtures.
- Lighting levels at the property line should not be greater than 0.1 FC when measured on both the horizontal and vertical planes.
- Comply with any additional requirements listed in The City of Charlottesville Code Chapter 34 Division 4.12 (Outdoor Lighting).

11.6.2 Opportunities

- All fixtures should be greater than 100 Lumens Per Watt (LPW).
- Exterior lighting power density (LPD) should be 30% better than code.

11.6.3 Stretch Goals

- All fixtures should be greater than 130 Lumens Per Watt (LPW).
- Exterior lighting power density (LPD) should be 50% better than code.

11.6.4 Resources

None identified.

11.7 Bicycle Storage

See Bicycle Storage (Section 3.15) for more information.

11.8 Vehicle Charging

See EV Charging (Section 9.4) for more information.

11.9 Sidewalks

See Concrete (Section 5.9) for more information.

Appendix A - **Resources**

Code References

- Code of Virginia
- 2021 Virginia Construction Code
- 2021 Virginia Existing Building Code
- 2021 Virginia Energy Conservation Code
- 2020 NFPA 70, National Electric Code
- 2021 Virginia Plumbing Code
- 2021 Virginia Mechanical Code
- 2021 Virginia Statewide Fire Prevention Code

Accessibility Standards

- 2010 Standards for Accessible Design
- 2017 ICC A117.1 Accessible and Usable Buildings and Facilities

Sustainable Design Standards

- USGBC's LEED v4 Reference Guide for Building Design and Construction
  https://www.usgbc.org/guide/bdc
- USGBC's LEED-EBOM (Existing Buildings: Operations and Maintenance)
  https://www.usgbc.org/leed/rating-systems/existing-buildings

- ENERGY STAR Building Certification
https://www.energystar.gov/buildings/building-recognition/building-certification
- IAPMO Water Efficiency and Sanitation Standard (WE-Stand\) 2017
https://iapmo.org/we-stand

Other Resources (alphabetical)

- Administrative Code 9VAC5-40-5670. Motor vehicles.
https://law.lis.virginia.gov/admincode/title9/agency5/chapter40/section5670/
- Advanced Energy Design Guides by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
https://aedg.ashrae.org/
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) High-Performance Design Guidelines
- Anthena Impact Estimator for Buildings
https://www.athenasmi.org/our-software-data/impact-estimator/
- Architecture 2030
https://www.architecture2030.org/
- Armstrong Ceilings Recycling Program
https://www.armstrongceilings.com/commercial/en/performance/sustainable-building-design/ceiling-recycling-program.html
- ASHRAE 90.1, DOE
https://store.accuristech.com/standards/ashrae-90-1-2022-i-p?product_id=2522082 (Cost associated)
- ASHRAE Standard 189.1
https://store.accuristech.com/standards/ashrae-icc-usgbc-ies-189-1-2023?product_id=2576090 (Costs associated)
- Building + Institutional Furniture Manufacturers Association (BIFMA)
https://www.bifma.org/
- Carbon Smart Materials Palette
https://www.materialspalette.org/gypsum-board/
- Center for the Built Environment (CBE) Occupant Survey
https://cbe.berkeley.edu/resources/occupant-survey/

Appendix A **Resources**

- Charlottesville Climate Action Plan
  https://climateaction.charlottesville.gov/action-plan
- Charlottesville Climate Risk & Vulnerability Assessment
  https://www.charlottesville.gov/DocumentCenter/View/8902/Adaptation-Planning---Charlottesville-VA---Climate-Risk-and-Vulnerability-Assessment-PDF
- Charlottesville Development Code, Chapter 34 Zoning & Subdivision
  https://charlottesville.gov/DocumentCenter/View/11104/Development-Code-PDF?bidId=
- City of Charlottesville Standard Operating Procedure, Idling Reduction Policy
  See Appendix
- City of Charlottesville Surplus Property Sales
  https://www.charlottesville.gov/946/Warehouse-Operations
- Code of Virginia, Virginia Clean Indoor Air Act
  https://law.lis.virginia.gov/vacodepopularnames/virginia-indoor-clean-air-act/
- Davies Office, Albany NY
  https://www.daviesoffice.com/
- Electronic Product Environmental Assessment Tool (EPEAT)
  https://www.epeat.net/
- Embodied Carbon in Construction Calculator (EC3)
  https://www.buildingtransparency.org/tools/ec3/
- Fact Sheet #73A: Space Requirements for Employees to Pump Breast Milk at Work under the FLSA, Department of Labor, 2025
  https://www.dol.gov/agencies/whd/fact-sheets/73a-flsa-nursing-mothers-at-work-general-guidance
- Global Covenant of Mayors for Climate & Energy
  https://www.globalcovenantofmayors.org/who-we-are/
- Lactation Room Requirements, National Institutes of Health, 2016
  https://orf.od.nih.gov/TechnicalResources/Documents/News%20to%20Use%20PDF%20Files/2016%20NTU/Lactation%20Room%20Requirements%20-%20June%202016%20News%20to%20Use_508.pdf
- LEED and ENERGY STAR Portfolio Manager
  https://portfoliomanager.energystar.gov/pm/login?testEnv=false
- LEED Bird Collision Deterence ID Credit
  https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-75

- Living Building Challenge
  https://living-future.org/lbc/
- National Institute of Health, National Library of Medicine
  https://www.nlm.nih.gov/
- National Institute of Standards and Technology (NIST) Life-Cycle Costing Manual
  https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program
- New Buildings Institute, The Building Electrification Technology Roadmap
  https://newbuildings.org/resource/the-building-electrification-technology-roadmap/
- New Buildings Institute, The Building Electrification Technology Roadmap for Schools
  https://newbuildings.org/resource/the-building-electrification-technology-roadmap-for-schools/
- Office Products, Harrisonburg
  https://www.furniture-systems.com/
- Passive House Design
  https://www.phius.org/
- Perkins + Will Precautionary List
  https://transparency.perkinswill.com/lists/precautionary-list
- Post Occupancy Evaluations, Whole Building Design Guide
  https://stg.wbdg.org/resources/post-occupancy-evaluations
- Recommendations for designing lactation/wellness rooms, American Institute of Architects (AIA), 2023
  https://www.aia.org/resource-center/recommendations-for-designing-lactation-wellness%20rooms
- Red-list free products are searchable on the ILFI's Declare website.
  https://declare.living-future.org/
- Richmond Office Interiors, a furniture aggregator
  https://richmondofficeinteriors.com/
- Richmond Office Interiors, Richmond
  https://richmondofficeinteriors.com/
- Rocky Mountain Institute (RMI) Building Electrification Program
  https://rmi.org/our-work/building-electrification/

- Tally
  https://choosetally.com/
- The Occupational Safety and Health Administration Regulations, 1926.502 – Fall Protection Systems Criteria and Practices
  https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.502
- The Reuse Network
  https://www.irnsurplus.com/
- United Nations (UN) Environment Programme, "Building Materials And The Climate: Constructing A New Future"
  https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future
- United States Gypsum (USG)
  https://www.usg.com/content/usgcom/en/sustainability/ceilings-recycling-program.html
- USGBC's LEED-EBOM (Existing Buildings: Operations and Maintenance)
  https://www.usgbc.org/leed/rating-systems/existing-buildings

Appendix B - **Acronyms**

Acronyms

AC - Articulation Class
AHRI - Air-Conditioning, Heating, and Refrigeration Institute
AHU – Air Handling Unit
ANSI - American National Standards Institute
ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM - American Society for Testing and Materials
AV – Audio and visual
BECx - Building Envelope Commissioning
BIFMA - Business + International Furniture Manufacturers Association
BIPV - Building-Integrated Photovoltaics
BOD -Basis of Design
BPA – Bisphenol A
CAC – Ceiling Attenuation Class
CARB - California Air Resources Board
CARB ATCM - California Air Resources Board Airborne Toxic Control Measure
CBE - Center for the Built Environment (at the University of California, Berkley)
CDPH - California Department of Public Health
CLCA - Carbon Life Cycle Assessment
CLT - Cross-Laminated Timber
CO_2 – Carbon Dioxide
CxA – Commissioning Authority
DLC - DesignLights Consortium
DOAS – Dedicated Outdoor Air System
DOE - Department of Energy

Appendix B **Acronyms**

DX - Direct Expansion
EAF - Electric Arc Furnaces
ECM - Electronically Controlled Motors
ECx - Enhanced Commissioning
EPA - Environmental Protection Agency
EPD - Environmental Product Declaration
EPEAT - Electronic Product Environmental Assessment Tool
EUI - Energy Use Intensity
FCx – Fundamental Commissioning
FSC - Forest Stewardship Council
GHG – Greenhouse House Gas
GPC - Gallons Per Cycle
GPF – Gallons Per Flush
GWP - Global Warming Potential
HFRs - Halogenated Flame Retardants
HPBS – City of Charlottesville High-Performance Building Standards
HPD - Health Product Declarations
HVAC - Heating, Ventilation, and Air Conditioning
IAQ - Indoor Air Quality
ID - Innovation in Design (credit)
IPCC - Intergovernmental Panel on Climate Change
IT – Information Technology
ITC - Investment Tax Credit
LCA - Life Cycle Assessment
LCCA – Life-Cycle Cost Analysis
LED - Light Emitting Diode
LEED – Leadership in Energy and Environmental Design
LEED BD+C – LEED Building Design and Construction
LEED-EBOM – LEED Existing Buildings: Operations and Maintenance
MBCx - Monitoring-Based Commissioning
NAF - No Added Formaldehyde
NIST - National Institute of Standards and Technology
NRC – Noise Reduction Coefficient
NZE - Net Zero Energy
OPR – Owner's Project Requirements
OSHA - Occupational Safety and Health Administration
POE - Post Occupancy Evaluation
PV – Photovoltaics

PVC – Polyvinyl Chloride
PWD - Procurement Division at the City Warehouse
RCx - Retro-Commissioning
RMI - Rocky Mountain Institute
RTU – Roof Top Unit
SFI - Sustainable Forestry Initiative
SHGC - Solar Heat Gain Coefficient
SRI - Solar Reflectance Index
TPO - Thermoplastic Polyolefin
ULEF - Ultra Low-Emitting Formaldehyde
UN - United Nations
USBC – (Virginia) Uniform Statewide Building Code
USG - United States Gypsum
USGBC - United States Green Building Council
VCC – Virginia Construction Code
VECC - Virginia Energy Conservation Code
VOC – Volatile Organic Compound
VRF – Variable Refrigerant Flow
VRV – Variable Refrigerant Volume
VSFPC - Virginia Statewide Fire Prevention Code
WUI - Water Use Intensity

Appendix C – **HPBS Waiver Application**

High Performance Building Standards Waiver Application

Use this form to apply for a waiver from the City's High Performance Building Standards. Refer to Waiver Process (Section 2.2) of the document for more detailed information about the process. Waiver requests from the Current Practices established in the standards will be evaluated for technical infeasibility. Waivers will not be approved for inadequate project planning or scheduling.

NOTE: Each waiver application covers a single Current Practice. Once complete, please send this form to sustainability@charlottesville.gov. Within five business days, the HPBS Committee will meet to discuss the waiver request and issue a response, request for further information, or make a recommendation to the City Manager's Office, when warranted.

Date:	
Name:	
Email:	
Phone:	
Project Name:	
Site Address:	

1. **Specify the project type using the following criteria (refer to Project Requirements by Type (Section 2.3) for more detailed information):**

- ☐ New construction
  - ☐ Over 20,000 SF
  - ☐ 5,000 to 20,000 SF, Conditioned
  - ☐ 5,000 to 20,000 SF, Unconditioned
  - ☐ Under 5,000 SF

- ☐ Renovation
  - ☐ Over 20,000 SF, Reno $ > 50% Building Value
  - ☐ Over 20,000 SF, Reno $ < 50% Building Value
  - ☐ Under 20,000 SF, Reno $ > 50% Building Value
  - ☐ Under 20,000 SF, Reno $ < 50% Building Value

☐ Energy Performance Project

☐ Retro Commissioning Project

☐ Maintenance Project

☐ Emergency Maintenance Project

2. **What specific Current Practice is a waiver being sought for? Include the HPBS section number and a detailed description.**

3. **Please provide justification of why the Current Practice cannot be met. Why is it technically infeasible?**

4. **Please propose an alternative solution, if applicable.**

Appendix D – **For Future Study**

Opportunities for Emerging Standards

The City recognizes that many aspects of the design, construction, and operational processes are not addressed by the *HPBS*, and the City expects that the breadth of the HPBS will be expanded in future versions. Aspects that were not addressed in the initial version of the HPBS may be developed or expanded in future iterations.

The *HPBS* applies generally to buildings that are developed, owned, occupied, and managed by the City of Charlottesville. The *HPBS* does not apply perfectly to all ownership structures.

Future opportunities for focus and customization include:

- Application of the HPBS to City-owned, tenant-occupied facilities
- Application of the HPBS to properties the City leases from others
- Alignment with the activities of quasi-governmental agencies and authorities serving the City of Charlottesville

The *HPBS* applies to the most common building types in the City's portfolio. The *HPBS* does not include specificity for some less common project types.

Future opportunities for particularization include:

- Application of the HPBS to Historic Rehabilitation projects
- Application of the HPBS to residential properties

- Application of the HPBS to building-specific technical standards (as would be required for aquatics buildings or fire stations)

The *HPBS* include the core aspects of a building project defined by architects and by mechanical, electrical and plumbing engineers. Within this realm, the *HPBS* focus on those aspects most directly affecting building performance.

Future opportunities for expansion of the *HPBS* include:

- Site design and infrastructure, generally, including the possible integration of the Institute for Sustainable Infrastructure's Envision Sustainable Infrastructure Framework
- Horizontal projects
- Expanded building structural standards
- Specialty consulting disciplines such as audio-visual and technology requirements
- Acoustical standards
- City standards that are not directly tied to building performance

The *HPBS* primarily includes best practices already established by the City of Charlottesville or mandated by the Commonwealth of Virginia. The *HPBS* does not provide detailed requirements for emerging best practices or for practices not yet regularly used by the City of Charlottesville.

Future opportunities for the expansion of best practices include:

- Emerging best practices for embodied carbon accounting
- Comprehensive integration with Universal Design principles
- Comprehensive integration with inclusive design and equitable development standards
- Comprehensive application of Resilient Design principles
- Comprehensive avoidance of red- or precautionary-listed building materials and ingredients