Design Guideline 3.2
Carbon Reduction and Energy and Water Conservation

Summary

This Design Guideline applies to new buildings, building additions, building alterations and capital equipment replacements at the Ann Arbor, Dearborn and Flint campuses. Contact the Project Design Manager to determine when it applies to leased properties.

Consider carbon reduction and energy and water conservation in all aspects of project design. Incorporate conservation measures as described herein and as requested by the Design Manager.

Throughout the design process, meetings shall be held to evaluate how the project is meeting the project's maximum carbon emissions and conservation targets and to review the conservation measures specific to the project.

Related Sections

U-M Design Guideline Sections:
1.0 Codes and Regulatory Agencies (for energy code requirements)
2.1 Owner's Project Requirements and Basis of Design Documents
230030 Laboratory Ventilation Design

Related Documents:
Energy and Water Conservation Report Format-Projects $2M to $10M Construction Cost
Energy and Water Conservation Report Format-Projects Over $10M Construction Cost
Energy Impact Statement Format and Examples
LCCA and Carbon Worksheet

Reference Documents:
ASHRAE 90.1-2019, "Energy Standard for Buildings Except Low-Rise Residential Buildings" ASHRAE 189.1-2023, "Standard for the Design of High-Performance Green Buildings" ASHRAE 189.3-2021 Design, Construction, and Operation of Sustainable High-Performance Health Care Facilities
ASHRAE Handbook-2023, "HVAC Applications"

Carbon Reduction Compliance

New buildings and building additions as well as major renovation projects over $10 million construction cost

(a) Comply with project-specific Building Maximum Emissions Target. Targets to be determined as described in DG 3.6 Carbon Maximum Emissions Targets.
(b) Calculate an annual energy consumption by utility type for an ASHRAE baseline and alternative design options being considered.
(c) Calculate project cost premium of each design option. Provide all applicable calculations.
(d) Estimate the embodied carbon of structural systems and enclosures associated with the ASHRAE baseline and each design option.
(e) Provide a LCCA & Carbon Input Worksheet as described herein.

Energy Conservation Compliance

All projects

(a) Incorporate the Mandatory Energy Conservation Measures (ECMs) listed herein.
(b) Evaluate the Potential ECMs listed herein and incorporate as appropriate.
(c) Incorporate the Water Conservation Measures listed herein.

Projects between $2M and $10M construction cost

In addition to the requirements applicable to all projects, perform the following:

(a) Utilize the United States Department of Energy's (DOE) COMcheck software to demonstrate compliance.
(b) Document the impact of the ECMs in accordance with the Documentation Requirements listed herein.
(c) Provide an Energy Impact Statement as described herein.

Projects over $10M construction cost

In addition to the requirements applicable to all projects, perform the following:

(a) Exceed ASHRAE 90.1 baseline requirements by the percentage established for the project.
(b) Utilize the United States Department of Energy's (DOE) COMcheck software to demonstrate compliance.
(c) In accordance with Appendix G: Performance Rating Method of ASHRAE 90.1, use a computer energy simulation program to establish a baseline energy consumption for the entire building and to calculate the percentage energy cost saved above the baseline.
(d) Document the impact of the ECMs in accordance with the Documentation Requirements listed herein.
(e) Provide an Energy Impact Statement as described herein.

Mandatory Energy Conservation Measures

The following ECMs shall be incorporated into every project as applicable to the project's scope.

(a) Building Envelope: At a minimum, envelope systems on new construction projects to meet the ASHRAE 90.1, 5.5 Prescriptive Building Envelope Compliance Path. (Design Professional (DP) to work with Design Managers to determine when exceptions to Minimum Skylight Requirements can be considered.)
(b) Window-to-Wall Ratio: Design building envelope on new construction projects are not to exceed the window-to-wall ratio indicated in ASHRAE 90.1- Appendix G table for Baseline Building Vertical Fenestration Percentage of Gross Above-Grade Wall Area.
(c) Window Blinds/Shades: Provide interior blinds/shades on south and west facing windows.
(d) Occupancy Schedules: Determine anticipated occupancy schedules in consultation with the Users and indicate these in the OPR/BOD Document, in the Energy Impact Statement, and in the energy simulation software output. Based on these schedules, indicate on the project control drawings the initial operating schedule for all mechanical and electrical systems and equipment.
(e) Part Load Efficiency: Design mechanical and electrical systems to run efficiently at partial loads.
(f) HVAC System Zoning: Zone HVAC systems by occupancy type, ventilation rate, and operating schedule to allow shutdown or setback during no/reduced occupancy. Utilize zoned shutdown for sections of systems where occupancy schedules vary widely and separate systems are not feasible.
(g) DDC VAV Control: Control room air volume and temperature with direct digital controlled variable air volume (VAV) assemblies.
(h) Standalone HVAC Systems: Provide standalone HVAC systems for areas that require 24/7 operation, to allow central systems to be shut down.
(i) Laboratories: See U-M Design Guideline 230030 Laboratory Ventilation Design for information regarding ECMs in labs.
(j) Building Envelope Thermal Scanning: For projects over $10M construction cost, perform infrared thermal scans of any existing envelope during design to identify areas needing improvement. Perform scans of the new building envelope during construction. Correct deficiencies found.
(k) Incandescent Lighting: Limit incandescent lighting to accent or special use.
(l) Lighting and Power Justification: Provide justification for any area that exceeds ASHRAE 90.1 lighting or electrical power limits.

Mandatory Evaluations of Potential Energy Conservation Measures

Evaluate the following ECMs in accordance with the Economic Evaluation of Energy Conservation Measures section of this Design Guideline. Incorporate any ECM into the project that meets the maximum payback criterion.

(a) Below-Grade Insulation: Improve the below-grade insulation R-value above the ASHRAE 90.1 required minimum.
(b) Wall Insulation: Improve the wall insulation R-value above the ASHRAE 90.1 required minimum.
(c) Roof Insulation: Improve the roof insulation R-value above the ASHRAE 90.1 required minimum.
(d) Glazing: Provide glass with reduced solar heat gain coefficients and fenestration systems with lower U values than the ASHRAE 90.1 required maximums.
(e) Server Rooms: Instead of electronic data server rooms located inside the project building, consolidate servers into data centers located outside of the project building.
(f) Chillers: Exceed ASHRAE 90.1 chiller efficiency. Include the impact of pump power reductions.
(g) Free Cooling: Where there is a year-around chilled water load in the building, use “Free Cooling”

as part of the chilled water system. Free Cooling shall utilize an evaporative cooling tower coupled with a heat exchanger, closed circuit evaporative fluid coolers, or dry coolers to produce chilled water when seasonal temperatures permit. Evaporative towers should be separate or be able to be decoupled from the main cooling tower array.

(h) Heat Recovery: Where an air handling system's minimum outside air percentage is greater than 40 percent, use a heat recovery system to transfer heat from exhausted air to the outside air entering the system. Evaluate heat recovery (enthalpy) wheels, flat plate air-to-air heat exchangers, heat pipes (including pumped type), and run-around coils. Include the impact of additional pressure drop through each device type.
(i) Envelope Inspections: Increase the inspection of the exterior wall insulation and exterior fenestration systems. Energy savings evaluation to be based on a percentage reduction of the estimated annual energy consumed due to infiltration and thermal conduction through the building envelope.
(j) Lighting Controls: Where occupancy in auditoriums, classrooms, conference rooms and offices varies with time of day, provide occupancy sensing and day-lighting control to achieve minimum space lighting times and ventilation rates, and close VAV boxes to zero position if no occupancy is detected.
(k) Boilers: Exceed ASHRAE 90.1 boiler efficiency.
(l) HVAC: Exceed ASHRAE 90.1 mechanical cooling and heating equipment efficiencies.
(m) Kitchen Hoods: Provide variable volume kitchen exhaust hood systems.

Additional Energy Conservation Opportunities

Consider additional energy conservation opportunities including those listed below for application on the project.

(a) Optimum building aspect ratios (squareness and roof area vs. total area).
(b) Optimum building siting to respond to the climate. Minimize west and south facing windows. Optimize glass orientation and area. Consider double glass wall systems for south or west facades with large areas.
(c) Fenestration overhangs, setbacks, fins, or similar exterior shading devices.
(d) Light shelves to promote day lighting.
(e) Clerestories to reduce energy use while providing day-lighting, in lieu of horizontal glass surfaces or large windows.
(f) Fritted glass, in particular for atriums, winter gardens, and similar type spaces with roofs containing a large percentage of glass.
(g) For renovation projects where fenestration or glazing will not be replaced, consider window films to improve energy performance.
(h) Vegetated roofs.
(i) Improved ventilation air flow efficiency by reducing the pressure drop of air system components and ductwork. In particular, consider air systems that run continuously 24/7.
(j) Chilled beams for areas with large sensible loads and moderate ventilation air requirements.
(k) Displacement/impingement ventilation systems for large spaces with high ceilings.
(l) Heat recovery systems that recover heat from heat rejection equipment or from other available "waste" heat in the building.

Economic Evaluation of Energy Conservation Measures

It is the intent that ECMs incorporated by the project will have payback periods less than the maximum payback periods stated below.

ECM Simple Payback Calculations and Criterion

Evaluate the financial metrics of each ECM.

(a) Calculate the simple payback period of each ECM using:

$$\text{Simple Payback Period} = \frac{\text{Incremental Capital Cost of the ECM}}{\text{Annual Energy Savings} - \text{Incremental Maintenance Costs of the ECM}}$$

(b) Determine the service life of each ECM in accordance with the ASHRAE Handbook Chapter 36, "Costs of Owning and Operating Equipment." For ECMs not covered in the ASHRAE Handbook, contact the Design Manager for U-M input on their service lives.

(c) Where the service life of two alternative systems is significantly different from each other, include the replacement cost of the shorter lived system in the analysis.

(d) Use the following table to determine whether each ECM meets the maximum simple payback criterion and should or should not be incorporated.

Service Life of ECM (years)	Maximum Simple Payback Period (years)
15	6
20 or More	8

(e) For fenestration and glazing, use a maximum simple payback period of 10 years. For membrane roof insulation, use 12 years. For all other insulation, use a maximum simple payback period of 30 years.

Energy Calculations

Utilize a computer energy simulation program for energy use calculations that meets the requirements of ASHRAE 90.1. Acceptable simulation programs include, but are not limited to, Trane Trace, Carrier HAP, IES Virtual Environment, and eQuest.

Energy Costs

When evaluating ECMs, use the current utility costs.

Maintenance Costs

Include significant maintenance cost impacts if anticipated as a result of an ECM. Submit a comparative equipment list detailing the two options being analyzed to the Design Manager and request the necessary maintenance unit and annual costs.

Water Conservation Compliance

All projects

(a) Incorporate water conservation measures that in aggregate use 20 percent less water than a baseline water use (not including irrigation) based on Energy Policy Act of 1992 fixture performance requirements (which are incorporated into the Michigan Plumbing Code).
(b) Incorporate the following mandatory water conservation measures:
- Dual flush water closets.
- Waterless or 1/8 gallon per flush urinals.
- 1.5 GPM shower heads.

(c) Incorporate additional measures as required to meet the 20 percent water conservation target. (1/2 GPM aerators for lavatory faucets are required by the plumbing code and thus may not be used as a credit toward the 20 percent target.)
(d) Document the impact of the Water Conservation Measures in accordance with the Documentation Requirements listed below.
(e) Projects unable to meet this requirement shall obtain approval through use of the U-M Building Design Sustainability - Exemption Request Form.

Documentation Requirements

Provide documentation in accordance with Design Guideline 2.1, the Design Deliverables and as follows.

When using the Life Cycle Cost Analysis (LCCA) and Carbon Input Worksheet, carefully review both the Intro and Assumptions Tab and the Instructions/Notes included in the far right column of the Input tab.

When using the Energy and Water Conservation Report Format form, assure hidden text is turned “on” and carefully review additional information and guidance notes.

New buildings and building additions as well as major renovation projects over $10 million construction cost

Starting at Pre-Design and expanding during the Schematic Design (SD), Design Development (DD) and Construction Documents (CD) phases, provide the following information.

(a) A completed Life Cycle Cost Analysis (LCCA) & Carbon Input Workbook, provided as a Related Document.
(b) Calculations of cost premiums for each design option.
(c) Calculations of the embodied carbon of structural systems and enclosures associated with an

ASHRAE baseline and each design option.

Update and submit the CD phase Life Cycle Cost Analysis (LCCA) & Carbon Input Workbook after project award to reflect accepted Alternates and Owner's Options.

In addition, projects are to provide documentation requirements listed below based on project construction cost.

Projects between $2M and $10M construction cost

Starting at the Schematic Design (SD) phase and expanding during the Design Development (DD) and Construction Documents (CD) phases, provide the following information utilizing the Energy and Water Conservation Report Format form provided as a Related Document.

(a) A copy of a completed COM*check* compliance report. Confirm that all mandatory requirements are met. Identify prescriptive measures that are non-compliant due to trade-offs.
(b) If an energy model is run, provide complete data files (including all executable files necessary to allow U-M to “run” the energy model) from the energy simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps).
(c) Explanation of all ECMs evaluated for the project. Provide summary calculations demonstrating the simple payback period of each measure.
(d) Explanation of all Water Conservation Measures applied to the project and their predicted results.
(e) Explanation of which Mandatory Energy Conservation Measures and Mandatory Energy Evaluations apply to the project and how they will be implemented.

Update and submit the CD phase report after project award to reflect accepted Alternates and Owner's Options, including updated executable energy model files if an energy model was used.

Projects over $10M construction cost

As part of the program and concept design report, identify the architectural, mechanical, and electrical energy conservation technologies specific to the project that will be utilized to provide an energy efficient building.

Provide the following information utilizing the Energy and Water Conservation Report Format form provided as a Related Document.

During the Schematic Design Phase, provide:

(a) A copy of the completed COM*check* compliance report. Confirm that all mandatory requirements are met. Identify prescriptive measures that are non-compliant due to trade-offs.
(b) Explanation of all Water Conservation Measures applied to the project and their predicted results.
(c) Explanation of which Mandatory Energy Conservation Measures and Mandatory Energy Evaluations apply to the project and how they will be implemented.
(d) Explanation of any other ECMs to be applied to the project. Include summary calculations demonstrating the simple payback period of each measure (see the "Economic Evaluation of Energy Conservation Measures" section of this Guideline).

When an energy goal above the ASHRAE 90.1 baseline requirements has been established for the project, also provide the following:

(a) Calculated values for the *baseline building performance*. The *proposed building performance*, and the percentage improvement is also strongly preferred but is not required at SD Phase.
(b) Complete data files (including all executable files necessary to allow U-M to "run" the energy model) from the energy simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for the *baseline building design* and the *proposed building design*. The proposed building design shall not have more "unmet hours" than the baseline building.
(c) An explanation of any error messages noted in the simulation program output.
(d) List ECMs planned for the *proposed building design* and indicate the relative contribution each will make toward exceeding ASHRAE 90.1. This list shall document all energy features that differ between the *baseline building performance* and the *proposed building performance* calculations.

During the Design Development and Construction Document phases, provide:

(a) Calculated values for the baseline building performance, the proposed building performance, and the percentage improvement, when applicable.
(b) Updates of all the energy and water conservation documentation required to be submitted at the SD phase.

Update and submit the CD phase reports after project award to reflect accepted Alternates and Owner's Options, including updated executable energy model files.

Energy Impact Statement

For projects over $2M construction cost, provide an Energy Impact Statement. Utilize the form provided as a Related Document.