



# DENVER INTERNATIONAL AIRPORT

## DESIGN STANDARDS MANUAL

### Sustainability

Design, Engineering and Construction

Revised: Q4 2023



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## Summary of Revisions

The following tables list the revisions made in the past year to the Sustainability DSM.

### 2023 Revisions

#### *Fourth Quarter*

Reference	Revision Description
Throughout	Minor grammatical corrections
1.6.6 Waste No More Ordinance	Added new section
1.7.1 New Construction or Major Renovation – Heavy Civil	Added information on construction cost using the Envision rating system
5.3.8 Conduct Site Visits and Issue Site Observation Reports	Updated information from BIM 360 to Autodesk Construction Cloud (ACC)

#### *Second Quarter*

Reference	Revision Description
Throughout	Minor grammatical corrections
1.3 Vision 100	Updated language
1.6.4 Environmental Permits & Guidelines	Added guideline reference
3.3.5 Commissioning Plans (Cx Plans)	Revised content
4.3.6 Provide IECC Cx Permit Letter	Clarification on IECC Cx permit letter
5.3.1 Update Construction-Phase Cx Plan	Revised content
5.3.11 Monitoring-Based Commissioning (MBCx) Implementation & Coordination	Update on MBCx implementation
5.4 Net Zero	Removed QA content
Chapter 7- Monitoring-Based Commissioning (MBCx)	Added chapter on MBCx
9.3 Commissioning	Removed BIM 360 Field references

### 2022 Revisions

#### *Fourth Quarter*

Reference	Revision Description
Entire Sustainability DSM	Format update to fit sustainability goals

**Revision Notation:** Revisions made to this Manual during this revision cycle are annotated as shown in the example below:

A vertical line in the left-hand margin is used to annotate paragraphs that have been added or revised in the current publication. Revisions may include items such as new requirements, clarification of existing requirements, or removal of requirements that no longer apply to projects. Revision annotation is applied to each publication individually; revisions made in past publications are not annotated in subsequent publications.

## Purpose of Design Standards Manuals

The DEN Design Standards have been developed to ensure a unified and consistent approach to the thematic and technical design for DEN. These standards are for use and strict implementation by all consultants under contract to DEN, to tenants, and all other consultants under contract to any other entity for the design of projects at DEN.

The Standards Manuals are working documents, which will be revised and updated, as required, to address the general, conceptual, design, and technical standards for all areas of design for DEN.

This Design Standards Manuals (DSM) for DEN has been prepared for use by competent, professionally licensed architectural and engineering consultants under the direction of DEN Maintenance and Engineering or tenants of DEN.

The Design Standards shall not be quoted, copied, or referenced in any bidding or construction contract documents. Content contained in this Manual shall not be copied in any bidding or construction documents, except where specifically instructed to do so. All information contained in these standards must be fully explained and shown in all bidding and contract documents.

The Design Standards Manuals are intended to be used as a whole, as each manual is complimentary to the other DSMs. To understand the overall thematic and design standards for DEN, the applicable manuals must be utilized together and not separated from the Design Standards Manuals.

The Consultant shall not reproduce, duplicate in any manner, transmit to other consultants or other entities, or use in conjunction with other projects without the express written consent of DEN.

**NOTE:** This document is optimized for duplex (double-sided) printing.

### VARIANCE FROM DEN DESIGN STANDARDS MANUALS

Requests for non-conformance or variance from DEN Design Standards manuals, for any DEN or Tenant Projects, must be formally submitted using the online DSM Variance Request form at the following website:



<https://tinyurl.com/DENDSMVariance>

Variance requests may or may not be approved by DEN and response will be communicated to the requestor.

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# Chapter 1 - Background and Introduction

## 1.0 Purpose and Background

### 1.0.1 Intended User

Airports are designed to exist for generations. The development decisions made today directly impact DEN's viability and success for decades to come. As a process, sustainability is about considering relevant economic, environmental, and social criteria in all decision-making. It does not prescribe a specific outcome or mandate that every project has certain environmental attributes. Understanding that all projects have inherent constraints, sustainable criteria need to be built-in from the earliest stages of design to ensure that decisions are made in a systematic and holistic way to stay within project constraints while meeting the sustainability goals of the airport. The key is to balance short and long-term costs in such a way as to minimize negative impacts and maximize benefits. By achieving this, DEN will continue to be a global leader in airport sustainability and our projects will perform to the highest sustainability standards in the aviation industry.

This DSM assists planning, design, and construction teams with integrating sustainability, certification, and commissioning into their project processes and deliverables. It provides guidelines for project teams to deliver sustainable projects through an integrated stakeholder engagement process. It sets the expectations for sustainable development at DEN.

With new design strategies and technologies becoming available at a rapid pace, it is the expectation of the airport that project teams develop designs and proposals that deliver innovative approaches and maximize the sustainable outcomes of the project. These strategies and their total costs should be included in the base design, clearly indicated in the budget for all project proposals and presented in terms of capital investment as well as total costs over the life of the project.

### 1.0.2 Summary

DEN has a longstanding commitment to advancing sustainability in our facilities and operations and improving the standard for sustainability in the aviation industry. This commitment is rooted in our Strategic Objectives and aligns with other City and County of Denver (CCD) principles, best-practices, and requirements.

This Design Standard Manual reinforces that commitment and formally defines the sustainability requirements that all new building construction, major facility renovation projects, and non-building landside and airside projects shall meet. The manual directly aligns with the CCD Executive Order Number 123 (XO123), Denver Green Building Ordinance, Energize Denver Ordinance, Denver One Water Plan, Net Zero, and DEN's continued commitment to sustainable development and operations.

### 1.0.3 Scope

The scope of coverage of this manual includes all processes related to the certification of any project under various rating and certification bodies; the validation of performance of a project during design, construction, acceptance, turnover, and operation; and the development of high-performance design criteria to support those certification and validation efforts.

## 1.1 Environmental Policy

Denver International Airport (DEN) is dedicated to working with our partners to promote strong environmental performance. Our organization and employees are committed to business practices, policies, actions, and programs that enhance our performance by:

- A. Protecting the environment
- B. Conserving energy and natural resources
- C. Preventing pollution
- D. Meeting or exceeding all compliance obligations and voluntary commitments

- E. Continually improving the Environmental Management System (EMS)

## 1.2 Sustainability Policy

DEN is committed to strategically considering the long-term economic, social, and environmental impacts of all airport activities in order to maximize long-term benefits and ensure that our success strengthens our community stakeholders.

## 1.3 Vision 100

Vision 100 is DEN's strategic plan that will enable DEN to prepare for and reach 100 million annual passengers. The strategic plan will serve as a blueprint to align decision-making and enable accountability so together we can thoughtfully prepare to serve 100 million passengers in the next 8-10 years. This plan will guide our work over the next 3-5 years, the first phase of reaching Vision 100.

DEN's strategic plan is centered around four pillars of Vision 100 and under each pillar are strategic objectives, which are goals for the next 3-5 years.

### 1.3.1 Empowering Our People

This about the people who work at DEN and those who want to be part of DEN today or in the future. DEN's success relies on its people and partners.

To ensure we have a strong workforce, we must provide opportunities for employees to develop and grow so we can retain our talent and knowledge. We also need to prepare future employees by providing training and opportunities. We want Denver to become THE place for aviation talent. We will also create more opportunities for minority, women-owned, and veteran-owned businesses to do business at DEN and grow to become prime contractors or full concession owners. By taking care of our people, we can ensure DEN is prepared today and in the future.

### 1.3.2 Growing Our Infrastructure

We must continue to invest and grow our facility by completing key projects such as Great Hall and others, continuing improvements to Peña Boulevard and exploring options- for a 7th and even 8th runway. We will continue to focus on projects in our Capital Improvement Plan to ensure we can build a facility to accommodate 100 million annual passengers.

### 1.3.3 Maintaining What We Have

We must continue to take care of what we currently have. The airport is more than 27 years old and is experiencing a great deal of wear and tear due to increasing passenger volumes. Projects such as Concourse Renewal, which will upgrade our restrooms, wayfinding, hold rooms and flooring, will make a tremendous improvement. We will replace aging conveyances, replace and add train cars and ensure our asset management system is efficient and effective. As employees, we help by reporting maintenance or cleanliness issues so they can be resolved quickly.

### 1.3.4 Expanding Our Global Connections

A competitive advantage of DEN includes our vast amount of land and the fact that we are centrally located in the United States with easy access to the coasts. This allows us to expand our air service network and grow our cargo operations. Our DEN Real Estate program will be essential for this pillar as we open up about 16,000 acres for commercial use. This will generate additional revenue, keep costs down for airlines, and lead to more flights, more passengers and more business opportunities.

## 1.4 DEN Community Demographics

Section in development.



## 1.5 Equity, Diversity, and Inclusion

In alignment with the City & County of Denver's Race & Social Justice (RSJ) goals the DEN Equity, Diversity, and Inclusion (EDI) team designed three pillars of focus with interconnected strategies. The three pillars of People (Employees), Operations (Customers), and Community (Internal & External) make up the DEN Equity Plan and have wide-reaching tactics aimed to drive innovative change and build sustainable outcomes.

## 1.6 Codes, Regulations, and Ordinances

This section describes key sustainability regulations and ordinances that apply to DEN projects. Project teams are expected to understand how these apply to their specific projects and include a plan for compliance in their proposals and designs. Refer to the code, regulation, or ordinance language for comprehensive information.

### 1.6.1 City and County of Denver Executive Order 123 (XO123)

XO123 was originally issued in 2013 and has been subsequently amended multiple times. The current version of XO123 is available for review online from CCD. Under XO123, all new City funded building and major building renovation projects over 5,000 square feet are required to achieve a minimum of LEED® Gold certification. Projects under the 5,000 square foot threshold are expected to meet the intent of the green building rating systems but are not required to pursue formal certification.

The most current version of the LEED® reference manuals for New Construction, Commercial Interiors, Core and Shell, and Airports shall be used. Where contradictions exist between the LEED® reference manual and any CCD or DEN document or standard, the more stringent requirement shall apply.

### 1.6.2 City and County of Denver Green Building Ordinance

A Green Buildings Ordinance (GBO) was approved by Denver City Council on October 29, 2018, and took effect, November 2, 2018. It is available for review on Denver's Green Buildings Ordinance site from the CCD.



<https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Community-Planning-and-Development/Green-Buildings-Ordinance>

The GBO applies to the following:

- A. New buildings 25,000 square feet or larger.
- B. Roof permits for existing buildings 25,000 square feet or larger.
- C. Additions of 25,000 square feet or larger.

### 1.6.3 Building Codes and Amendments

The Denver Building and Fire Code establishes the minimum, mandatory standards for building construction in Denver. Denver's code is based on international standards for safe, habitable structures. It is available for review from CCD:



<https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Community-Planning-and-Development/Building-Codes-Policies-and-Guides>

### 1.6.4 Environmental Permits & Guidelines

Review relevant DEN Technical Specifications, DEN Environmental Guidelines and local, state and federal permitting requirements. All applicable specifications, guidelines and permits must be adhered to. Refer to the DEN Environmental Management website for additional guidelines.



[https://www.flydenver.com/about/administration/environmental\\_management](https://www.flydenver.com/about/administration/environmental_management)

### 1.6.5 Energize Denver Ordinance

The Energize Denver ordinance establishes energy use intensity targets for buildings over 25,000 sq. ft. It is available online at the Energize Denver Hub from the CCD.



<https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directories/Climate-Action-Sustainability-Resiliency/High-Performance-Buildings-and-Homes/Energize-Denver-Hub>

### 1.6.6 Waste No More Ordinance

This ordinance requires nearly all construction and demolition projects to separate and recycle, at a minimum, all readily recyclable concrete, asphalt, clean wood, scrap metal, and corrugated cardboard. Projects are required to submit a recycling and reuse plan to the city to confirm compliance with the ordinance prior to obtaining a construction or demolition permit. The compliance form can be found on the City's Waste No More C&D webpage.



<https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directories/Community-Planning-and-Development/Waste-No-More-Recycling-and-Reuse-Plan>

### 1.6.7 Denver One Water Plan

The One Water approach promotes coordination and collaboration among various city departments, organizations, and agencies in charge of managing all aspects of the urban water cycle including: water supply, wastewater, storm and flood protection, water quality, watersheds and waterways. The plan requirements are available for review from CCD.



<https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directories/Department-of-Transportation-and-Infrastructure/Programs-Services/One-Water>

### 1.6.8 NET ZERO

DEN is continuously updating the guiding principles for Net Zero implementation at the airport. Contact the DEN project manager or DEN Environmental for current requirements. A link to the City and County of Denver's Net Zero website is found:



<https://www.denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directories/Climate-Action-Sustainability-Resiliency/High-Performance-Buildings-and-Homes/Net-Zero-Energy-Hub-Codes-and-Resources>

## 1.7 Applicability

DEN is owned and operated by the City and County of Denver and subject to applicable Executive Orders issued by the Mayor, Ordinances and City Policies. For instance, Executive Order 123 (XO 123) directly addresses the sustainability expectations for all City projects. All DEN funded projects must comply with XO 123 requirements in addition to following the expectations outlined in this DSM. For clarification on specific project application, contact the DEN Project Manager.

### 1.7.1 New Construction or Major Renovation – Heavy Civil

All DEN horizontal infrastructure projects over \$10M total construction cost shall utilize the Envision® third-party sustainability rating system and achieve at a minimum the Verified level using the Envision® self-assessment tool, unless otherwise specified. Projects will seek third-party verification and certification through the Institute for Sustainable Infrastructure on a case-by-case basis.

All DEN horizontal infrastructure projects over \$1M but less than \$10M total construction cost shall utilize the Envision rating system to the extent practicable and complete the Envision self-assessment tool.

Non-DEN horizontal infrastructure projects that meet the above construction costs are encouraged to utilize the Envision rating system, including the self-assessment tool and seek verification.

### 1.7.2 New Construction – Buildings

Any new building construction project which totals over 5,000 square feet of enclosed space is subject to the requirements in this manual.

### 1.7.3 Major Renovation – Buildings

Any major renovation or re-model of an interior space wherein over 50% of the gross floor area is being renovated and mechanical, electrical, plumbing, and life-safety systems are modified, deleted, or added shall comply with the requirements in this manual.

### 1.7.4 Commissioning Projects

Projects of any size which include building systems are subject to the requirements of Commissioning. This includes new systems, modifications to existing systems, and removal of systems. Applicable systems include any of the following:

- A. Mechanical systems
- B. Electrical systems
- C. Plumbing systems
- D. Life safety systems
- E. Building Enclosures/envelope
- F. Other systems, as directed by the DEN Project Manager

## 1.8 Definitions, Abbreviations, and Terminology

Table 1-1: [Definitions](#) lists common terms associated with this DSM.

**Table 1-1: Definitions**

Term	Definition
Sustainability	DEN is committed to strategically considering the long-term economic, social, and environmental impacts of all airport activities in order to maximize long-term benefits and ensure that our success strengthens our community stakeholders.
Certification	Third party verification and certification of design and construction practices by an entity approved by DEN.
Validation	The action of making or declaring something legally or officially acceptable.
High-Performance Design	An approach to the design of a project where it is required to meet certain performance requirements, such as energy efficiency, without a specific prescribed method by which to attain those requirements.
Integrative Process	The integrative process engages all stakeholders through an iterative process to design and construct projects that achieve the desired level of high-performance design.
Life Cycle Assessment (LCA)	Framework to quantify the environmental impacts of a product or service across all stages of its life cycle.
Life Cycle Cost Analysis (LCCA)	The process for evaluating the total financial cost of an asset or investment over its service life.
Design Analysis Report (DAR)	A report to present a clear, complete, and concise picture of the design of the facilities and systems. See Chapter 3 of the Standards and Criteria Design Standards Manual for more information.

Table 1-2: [Abbreviations and Terminology](#) lists abbreviations and terminology used throughout this manual.

**Table 1-2: Abbreviations and Terminology**

Term	Definition
AOB	Airport Office Building
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BTU	British Thermal Unit
CCD	City and County of Denver
CFM	Cubic feet per minute
CUP	Central Utility Plant
Cx	Building equipment and systems commissioning
CxA	Building equipment and systems commissioning agent

**Table 1-2: Abbreviations and Terminology (Continued)**

Term	Definition
DDS	Denver Development Services. DDS is the Denver Building Department
DEC	Design, Engineering, and Construction. DEC is a division within DEN.
DEN	Denver International Airport
DEN PM	DEN Project Manager. The DEN PM is the CCD representative.
DFD	Denver Fire Department
ECS	Emergency Communication System
EMCS	Energy Management Control System
GPM	Gallons per minute
HTC	Hotel and Transit Center
HVAC	Heating, Ventilating, Air Conditioning systems
ISI	Institute for Sustainable Infrastructure
LEED®	Leadership in Energy and Environmental Design
NFPA	National Fire Protection Association
OPR	Owner’s Project Requirements
SSI	Sensitive Security Information
Tenant	Lessee to CCD and DEN, including the Tenant's Architectural/Engineering Consultants.
XO123	The CCD Executive Order Number 123. This Executive Order and the applicable memoranda establish key sustainability policies for CCD.

Table 1-3: Project Personnel lists typical team members and their level of engagement on DEN project teams.

**Table 1-3: Project Personnel**

Personnel	Definition
Core Team Members	Core members typically include the project manager, sponsor, contract administrator, designer, and contractor. This is the team that is ultimately responsible for making final decisions about the project.
DEN Project Stakeholders	A stakeholder is someone who will be affected by the project and who has a vested interest in the project's success. Typical stakeholders include the project sponsor, facilities and operations staff, design consultants, construction vendors, concessionaries, fire safety staff, IT staff, airline representatives, and even travelers who might visit or use the space.

**Table 1-3: Project Personnel (Continued)**

Personnel	Definition
Key Stakeholders	Key stakeholders may include individuals representing both DEN and the customer who have special expertise in certain areas essential to the project, such as fire, life safety, sustainability, airport security, finance, the FAA, and many more.
Periphery Stakeholder	Periphery stakeholders may include design consultants, construction subs, and customer representatives whose expertise is needed at critical points in the project.
Project Teams	Project team members are project dependent. It is essential to think critically about each project and determine who needs to be at the table at these various levels.

Table 1-4: [Cx Terms](#) provides a list of terms, abbreviations (abbr.) and definitions as they relate to this Cx Program.

**Table 1-4: Cx Terms**

Term	Abbr.	Definition
Basis of Design	BOD	A document that records concepts, calculations, decisions, and product selections used to meet the requirements of the Contract and to satisfy applicable regulatory requirements.
Building Envelope Commissioning	BECx	Quality-based process for evaluating the performance of a facility envelope to determine if a project is meeting the defined objectives, standards, and requirements of the owner.
Commissioning	Cx	The process of assuring that all systems and components of a project are designed, installed, tested, and operated according to the operational requirements of the airport.
Cx Plan	N/A	The formal document which defines the commissioning process for each project, including key stakeholders, activities, and milestones. A Cx plan shall be developed for each project.
DEN Contract Administrator	CA	The DEN PMO will provide a Contract Administrator to support the execution of all Cx tasks.
DEN Cx Program	N/A	A program within the DEN Systems Group, charged with the mission of providing commissioning services for DEN projects, as further described in this program definition.
DEN Cx Program Manager	Cx PGM	The individual responsible for the overall governance of the DEN Cx Program.
DEN Cx Agent	CxA	The individuals contracted by DEN for the purposes of providing Cx services for DEN projects and programs, or the DEN Systems Commissioning Engineer for in-house commissioning.
DEN Project Manager	PM	The individual responsible for the management and execution of the project being commissioned.

**Table 1-4: Cx Terms (Continued)**

Term	Abbr.	Definition
Existing Building Commissioning	EBCx	A systematic process for improving an existing building's performance by identifying and implementing relatively low-cost operational and maintenance improvements, helping to ensure that the building's performance meets owner expectations.
Monitoring Based Commissioning	MBCx	Integration of the components of permanent energy monitoring systems, real-time energy analysis, and ongoing commissioning. This provides the building operator a continual stream of information that helps identify operational issues as they occur to save energy consumption over the life of the building.
New Construction Commissioning	NCCx	A process that ensures that a new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.
Ongoing Commissioning		This is an extension of LEED Enhanced Cx and is a repetition of the functional performance testing and reporting procedures performed during the acceptance phase. The ongoing Cx may occur twice per year to coincide with summer and winter seasons.
Owner's Project Requirements	OPR	A written document that details the requirements of a project and the expectations of how it will function. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This will be in agreement with the DSMs and may be referred to as DEN's Project Requirements (DPR).
Pre-Functional Checklist	PFC	Checklist(s) executed by the contractor(s) to represent completion of system readiness for functional testing.
Project Management Office	PMO	The DEN Project Management Office defines and maintains standards for project management.
Subject Matter Expert	SME	Individuals with deep understanding of a discipline, subject or process, assigned to a project to assist the DEN Project Manager with reviews, scoping, problem-solving and decision-making.
TAB	TAB	Testing, adjusting and balancing.

## 1.9 Compliance Paths

There are a range of compliance pathways to achieve Envision and LEED certification. Relevant stakeholders must be engaged early to determine the most feasible path, while considering the project scope, budget and organizational priorities.

## End of Chapter

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## Chapter 2 - Pre-Define

### 2.0 Stakeholder Identification/Engagement

#### 2.0.1 Define the Stakeholder Engagement

Review the applicable credits in the sustainability frameworks to determine the elements to incorporate in the project’s engagement strategy and plans.

##### 2.0.1.1 Stakeholder Mapping

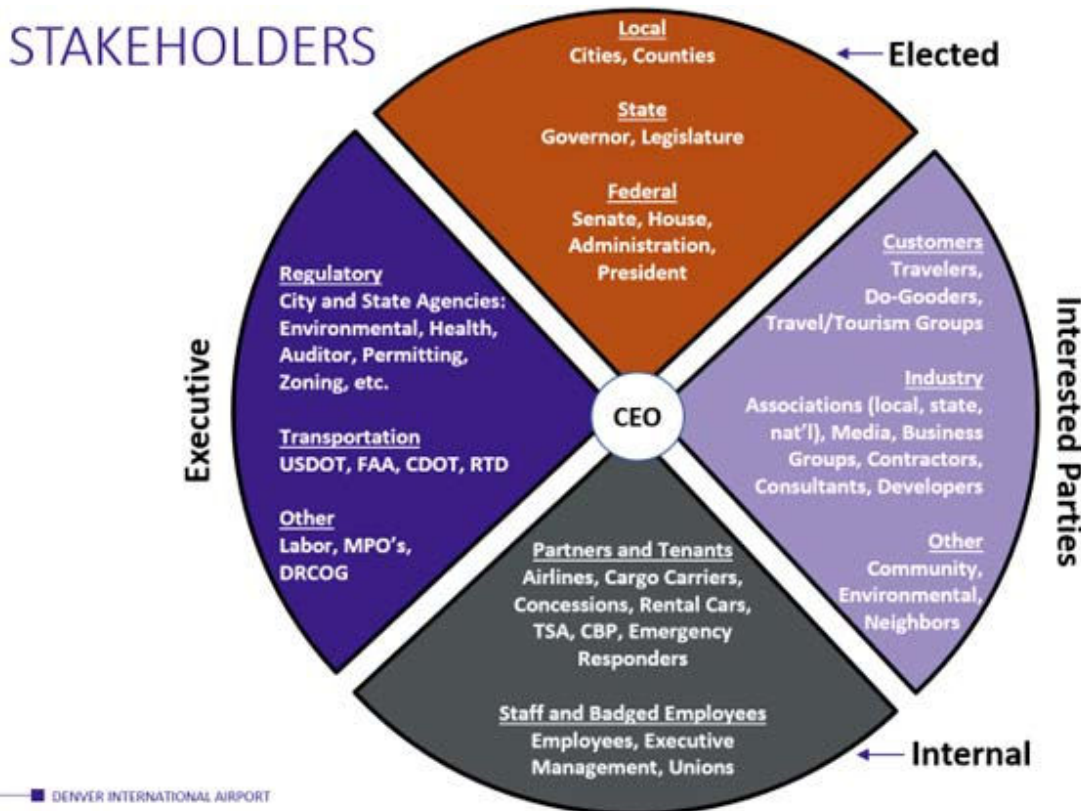


Figure 2-1: Stakeholder Mapping

##### 2.0.1.2 How to Engage with Stakeholders

Review the applicable credits in the sustainability frameworks to determine the elements to incorporate in the project’s engagement strategy.

### 2.1 Project Charter

Review the applicable credits in the sustainability frameworks to determine the elements to incorporate in the project’s charter.

#### 2.1.1 Goals/OPR

During the pre-design phase, initial project parameters are being developed. The goal is to set the design intent and Owner Project Requirements (OPR) for the duration of the project. The design intent and OPR’s may be developed through engagement of a Sustainability Consultant to conduct a pre-define charrette or other pre-define activities.

## 2.1.2 Energy and Utility Goals

During the pre-design phase, project energy and utilities goals are developed for use in the OPR for the duration of the project. Utilities rebates, energy efficiency, renewable energy, and utilities availability to the project are some of the goals and requirements to be considered.

## 2.1.3 LEED and Envision Credit Assessment

Complete a LEED® Checklist and Envision® Pre-assessment Checklist to determine the baseline for the project and identify potential gaps.

## 2.2 Risk Assessment

### 2.2.1 Environmental

Content under development.

### 2.2.2 Climate

Content in development – Review the applicable credits to determine elements needed for a Climate Change risk assessment.

## 2.3 Sustainability Elements of the DEN Business Case

### 2.3.1 LCA

A listing of all major materials to be procured for the subject building or construction project should be developed and alternative choices should be identified. The choices should then be ranked based on lifecycle environmental impacts and economic cost. Recommendations should be developed for the optimum material selection to meet technical, environmental, and economic requirements for the project. Examples of such materials include concrete mixes, exterior cladding and roofing, floor coverings, and indoor furniture.

Life Cycle Assessment (LCA) encompasses the evaluation of the potential environmental impacts of a given product, process, or service over the course of its lifetime. Also known as life cycle analysis, eco-balance, cradle-to-grave and cradle-to-cradle analysis, LCA is a technique used to quantify the impacts from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling and reuse. LCA can be applied at the component, process, product, and system scale, including buildings.

DEN recognizes that construction projects create life cycle impacts on the environment by using materials, equipment, energy, and other resources. Therefore, DEN encourages Consultant Teams to incorporate LCA into the planning, design, and construction process with the objective of identifying and then minimizing or eliminating such impacts. This process can assist teams in making informed choices on the selection of a design element, a piece of equipment or construction practice.

### 2.3.2 LCCA

Life-Cycle Cost Analysis (LCCA) takes into account all costs of acquiring, owning, and disposing of infrastructure, building or building systems at DEN. The LCCA is conducted on the whole project to identify the total economic impacts of the project. The comprehensiveness of the economic analyses used to determine the net impacts of the project, and their use in assessing alternatives to inform decision making. The business case should include consideration of whether a Life-Cycle Cost Analysis should be completed at the Define Phase.

### 2.3.3 Envision®

Envision was designed to help infrastructure stakeholders implement more sustainable, resilient, and equitable projects. Envision helps communities cut greenhouse gas (GHG) emissions, create good-paying “green” jobs, address environmental justice, and meet climate-change targets. Infrastructure owners and design teams,

community and environmental groups, constructors, regulators, and policymakers can all benefit from using Envision. Download the Envision Brochure or more detailed Envision Packet for more information. See Envision links below:



<https://sustainableinfrastructure.org/envision/use-envision/>



<https://sustainableinfrastructure.org/wp-content/uploads/2021/03/Final-Envision-3-17-21.pdf>



<https://sustainableinfrastructure.org/wp-content/uploads/2021/11/Envision-Packet-Final.pdf>

### 2.3.4 LEED®

Under XO123, all new, DEN-funded building and major building renovation projects over 5,000 square feet are required to achieve a minimum of LEED® Gold certification. Projects under the 5,000 square foot threshold are expected to meet the intent of the green building rating systems but will not be required to pursue formal certification.

### 2.3.5 Project Location

Select locations of the project components to minimize or avoid environmental impacts and maximize efficiency.

## 2.4 Net Zero

Under development - Contact DEN PM for guidance.

## End of Chapter

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## Chapter 3 - Define

### 3.0 Stakeholder Engagement

#### 3.0.1 Identify Stakeholders

The define phase begins before the designer and contractor are hired. This phase focuses on internal stakeholder engagement to further define the project goals, objectives, and budget. DEN project managers engage a team of stakeholders in the development of the project requirements, which helps to inform the design phase. The stakeholder requirements are outlined in an engagement strategy and/or plans.

##### 3.0.1.1 Project Management Team

The DEN project manager will work with the DEN project sponsor, design team, DEC tactical planning, and sustainability to define the stakeholders that should be engaged in the project.

##### 3.0.1.2 Envision® Professional

For infrastructure projects, a credentialed ENV SP preferably with airport experience shall be engaged to facilitate the Envision® process. Follow the requirements as outlined in the engagement strategy and/or plans or as defined by the Envision framework (see e.g., Envision credit LD1.3).

##### 3.0.1.3 LEED® Professional

For building projects, a credentialed LEED® AP professional shall be engaged to facilitate the LEED® process.

##### 3.0.1.4 Commissioning Agent

For building projects, a Commissioning Agent (CxA) is engaged not only as a technical advisor but as an Owners Representative through the define, design, build, and closeout process.

### 3.1 LEED®

#### 3.1.1 General

LEED is a widely accepted standard for green building that has been vetted and implemented on a global scale. However, it is understood that some LEED criteria are impractical or impossible to implement on certain projects at DEN. For this reason, only certain criteria are required for all projects with all other criteria being left optional. The minimum required criteria were based on lessons learned from previous LEED projects and existing best management practices in place at the airport.

Project managers, designers, and contractors are expected to refer to the LEED v4 Reference Guide for specific definitions and instructions on compliance and documentation for each of the project criteria. Projects will continue to be required to comply with all local, state, and federal code requirements.

#### 3.1.2 Goals

Development of Owner's Project Requirements (OPR). The OPR includes evaluation of required and optional goals along with the LCA/LCCA for the project.

#### 3.1.3 Project Requirements

See [Table 3-1: Project Requirements for New Construction and Major Renovations](#) give Required (R) and Optional (O) requirements.

**Table 3-1: Project Requirements for New Construction and Major Renovations**

		New Construction	Major Renovation	Equivalent LEED Points
Credit	Integrative Process	R	R	1
Location and Transportation				
Credit	LEED for Neighborhood Development Location	O	O	16
Credit	Sensitive Land Protection	O	O	1
Credit	High Priority Site	O	O	2
Credit	Surrounding Density and Diverse Uses	O	O	5
Credit	Access to Quality Transit	O	O	5
Credit	Bicycle Facilities	O	O	1
Credit	Reduced Parking Footprint	O	O	1
Credit	Green Vehicles	O	O	1
Sustainable Sites				
Prereq	Construction Activity Pollution Prevention	R	R	req
Credit	Site Assessment	R	R	1
Credit	Site Development - Protect or Restore Habitat	O	O	2
Credit	Open Space	O	O	1
Credit	Rainwater Management	O	O	3
Credit	Heat Island Reduction	R	R	2
Credit	Light Pollution Reduction	R	R	1
Water Efficiency				
Prereq	Outdoor Water Use Reduction	R	R - at least 50%	req
Prereq	Indoor Water Use Reduction	R	R	req
Prereq	Building-Level Water Metering	R	R	req
Credit	Outdoor Water Use Reduction	R	R	2
Credit	Indoor Water Use Reduction	R	R - at least 40%	4
Credit	Cooling Tower Water Use	O	O	2
Credit	Water Metering	R	R	1

**Table 3-1: Project Requirements for New Construction and Major Renovations (Continued)**

		New Construction	Major Renovation	Equivalent LEED Points
Energy and Atmosphere				
Prereq	Fundamental Commissioning and Verification	R	R	req
Prereq	Minimum Energy Performance	R	R	req
Prereq	Building-Level Energy Metering	R	R	req
Prereq	Fundamental Refrigerant Management	R	R	req
Credit	Enhanced Commissioning	R	R	6
Credit	Optimize Energy Performance	R - at least 32%	R - at least 32%	13-18
Credit	Advanced Energy Metering	R	R	1
Credit	Demand Response	O	O	2
Credit	Renewable Energy Production	O	O	3
Credit	Enhanced Refrigerant Management	R	R	1
Credit	Green Power and Carbon Offsets	O	O	2
Materials and Resources				
Prereq	Storage and Collection of Recyclables	R	R	req
Prereq	Construction and Demolition Waste Management Planning	R	R	req
Credit	Building Life-Cycle Impact Reduction	O	O	5
Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	O	O	2
Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	O	O	2
Credit	Building Product Disclosure and Optimization - Material Ingredients	O	O	2
Credit	Construction and Demolition Waste Management	R - at least 75%	R - at least 75%	2
Indoor Environmental Quality				

**Table 3-1: Project Requirements for New Construction and Major Renovations (Continued)**

		New Construction	Major Renovation	Equivalent LEED Points
Prereq	Minimum Indoor Air Quality Performance	R	R	req
Prereq	Environmental Tobacco Smoke Control	R	R	req
Credit	Enhanced Indoor Air Quality Strategies	O	O	2
Credit	Low-Emitting Materials	R	R	3
Credit	Construction Indoor Air Quality Management Plan	R	R	1
Credit	Indoor Air Quality Assessment	O	O	2
Credit	Thermal Comfort	O	O	2
Credit	Interior Lighting	R	R	2
Credit	Daylight	R	O	3
Credit	Quality Views	O	O	1
Credit	Acoustic Performance	O	O	1

## 3.2 High-Performance Design Requirements

### 3.2.1 Design Assessment

Designer shall assess the project according to the following procedure:

- A. Design at least two conceptual options, layouts, equipment procedures or design solutions.
- B. Calculate the rough order of magnitude total cost of ownership for all project components, including equipment, operation and maintenance, carbon emissions, and end-of-life deconstruction.
- C. Quantify climate impact of options, including constructability, equipment, and operation and maintenance activities.
- D. Quantify alternatives for building materials with lower impacts, and document the impacts of end-of-life deconstruction/deconstructability.
- E. Select the final design based on conceptual options, and Design-in-a-day priorities.

### 3.2.2 Siting and Orientation

The building should be sited and oriented to support passive energy savings strategies and the use of on-site renewable energy. Reduce solar heat gain to the occupied spaces in the summer and maximize solar thermal heating in southern occupied spaces in the winter. The final design solution should use orientation, shading and glazing types to support the desired energy flows in the building. All buildings and roofs should be designed to be solar ready.



### 3.2.3 Energy Modeling

Building projects in excess of 5,000 square feet and/or where required by the DEN Mechanical Engineer shall have a computer energy model (the Energy Analysis) performed to establish baseline and design energy performance according to the methodology established in the most current version of ASHRAE Standard 90.1.

### 3.2.4 Simulation Elements

Energy Analyses shall simulate performance of all relevant building spaces, components, systems, and subsystems and shall produce aggregate building energy performance estimates for both peak demand and consumption of all sources of energy to the designed building (primary and secondary) for a full year. Energy Analyses shall also include economic analyses of energy costs based upon current DEN utility rates and rate structures, and account for expected future rate instability. Energy cost budgets shall be established and shall meet the requirements of ASHRAE 90.1. This standard allows tradeoffs between mechanical and electrical systems and the building envelope. These tradeoffs shall supersede specific requirements presented only with written approval by DEN Mechanical Engineer or Energy Manager.

### 3.2.5 Software

The consultant will develop design strategies for maximizing the project's energy efficiency. An energy model shall be used to evaluate the energy performance of building systems. The following software is acceptable. Select the correct tool to meet the project needs:

- A. EnergyPlus is the required platform for the Xcel Energy, Energy Design Assistance (EDA) rebate and incentive program. This is the required modeling platform unless otherwise approved by the DEN Mechanical Engineer.
- B. Trane TRACE
- C. eQUEST

### 3.2.6 Criteria

The Energy Analysis will meet the requirements detailed in the following:

- A. International Building Code, as adopted and amended by CCD
- B. International Energy Conservation Code, as adopted and amended by CCD
- C. ASHRAE 90.1 (latest version at time of NTP)
- D. LEED Requirements (latest version at time of NTP)

Where the requirements of this chapter or the Codes and Standards themselves deviate from one another, the more stringent of the two shall apply.

For the purposes of analysis associated with existing facility systems the following sections of the Mechanical DSM shall be used for historical reference of component performance:

- A. Existing Facility Design and Analysis Conditions
- B. Building Envelope Evaluation
- C. U Values
- D. Building Components
- E. Air Leakage – All Buildings
- F. HVAC Systems
- G. HVAC Equipment
- H. Insulation
- I. Plumbing Systems

### 3.2.7 Energy Performance Criteria

The designer should utilize industry resources to identify the Energy Use Intensity (EUI) target for each specific project. Utilize the resource and building type that best fits the project use. The EUI target should exceed any code or LEED requirements, as applicable, and be coordinated with the larger project stakeholder group. The final project target will need to be approved by the DEN Project Manager, Mechanical Engineer and Energy Manager.

The following resources may be useful in identification of an EUI target:

- A. ASHRAE Advanced Energy Design Guidelines (AEDG)
- B. Architecture 2030 Zero Tool ([www.zerotool.org](http://www.zerotool.org))
- C. Energy Star Portfolio Manager

### 3.2.8 Energy Efficiency

Energy efficiency is an important consideration in the design of the mechanical systems for all DEN facilities.

### 3.2.9 Mechanical Equipment

Heating, ventilating, and air conditioning systems are to be designed to meet or exceed the requirements of the latest version of ASHRAE standard 90.1- Energy Efficient Design of New Buildings except Low-Rise Residential Buildings, and the CCD building code. Projects seeking LEED certification must meet all requirements to achieve LEED Gold certification or higher as defined by CCD Executive Order 123. Heating, Ventilation, and Air Conditioning Systems are a major consumer of energy in buildings, in most cases, and contribute a significant portion of the building's footprint at DEN. Improved design of these systems with emphasis on outside air economizing for cooling purposes or energy recovery, and for controlling the temperature of conditioned air should be thoroughly evaluated at the design stage. Key issues include coordination of the HVAC design with the building envelope, insulation and glazing properties, connection to the Central Utility Plant or alternative sources of heating and cooling, and energy management systems.

System design should favor the use of electric devices or electrically driven prime movers. The reduction of natural gas in favor of electrical appliances is desired by DEN, and integration with renewable energy sources such as on-site photovoltaics is desired where feasible.

Refer to the Mechanical DSM for additional performance requirements for mechanical equipment.

### 3.2.10 Electrical Equipment

Lighting systems shall meet or exceed the power density requirements set forth in ASHRAE 90.1 and the International Energy Conservation Code, as applicable to the project. Electrical appliances shall be Energy Star rated.

Refer to the Electrical DSM for additional performance requirements for electrical equipment.

### 3.2.11 Water Efficiency

In addition to the minimum requirements under the sustainability certification frameworks applicable to each project, the design will also incorporate additional water efficiency measures as outlined in this manual.

### 3.2.12 Water Management Plan

Develop a water plan to evaluate the water and wastewater supply and demand of the project to understand and coordinate any synergistic opportunities to reduce and/or reuse water.

### 3.2.13 Water Metering

Install permanent water meters that measure the total potable water use for the building and associated grounds. Meter data must be compiled into monthly and annual summaries; meter readings can be manual or automated.

### 3.2.14 Indoor Water Use Reduction

Reduce indoor water use by 40% from baseline using low-flow fixtures and water efficient equipment. Follow the process outlined in the US Green Building Council's LEED guidance manual on how to achieve and document compliance.

### 3.2.15 Indoor Environmental Performance

Occupant comfort and health are priorities for DEN. All projects should take measures to ensure the highest level of indoor air quality during and after construction. This should be achieved by focusing on pollutant control by creating and following a construction indoor air quality management plan, specifying low emitting materials for finishes and furnishings, and using low VOC products.

### 3.2.16 Innovation

Project teams are encouraged to propose and pursue innovative solutions to create more sustainable outcomes on DEN projects. These solutions may include advances in technology or the incorporation of art to create a sense of place. Innovative solutions should be clearly described in project proposals and designs and include information on budget implications as well as costs and benefits over the life of the asset.

## 3.3 Commissioning

Commissioning at DEN generally consists of two categories of activities related to vertical construction: New Construction commissioning (NCCx) and Existing Building Commissioning (EBCx). Throughout the project lifecycle, the DEN Cx program reviews, observes, documents and tests systems to ensure that they meet the requirements of the airport. By implementing the commissioning process, DEN can be confident that project results align with operational and sustainability goals, and that DEN assets achieve and maintain consistently high levels of performance and efficiency.

The Commissioning Agent (CxA) shall be retained by DEN to execute commissioning (Cx) activities according to this DSM. In some cases, the General Contractor may be required to designate a Commissioning Coordinator to actively participate in the planning and execution of Cx activities. All project stakeholders should be familiar with these requirements as they relate to their discipline and understand individual roles and responsibilities.

### 3.3.1 Commissioning Scope of Work

The commissioning scope of work will be developed by the DEN PM, using DEN standard on-call professional services forms and templates. The DEN Cx Program Manager will aid in determining the extent of commissioning scope for the project and shall make recommendations to the DEN PM based on the project scope to maximize the value of the commissioning process. The Commissioning Activities in this DSM are representative of the desired DEN best practices that may be included in the scope of work for a given project. Refer to the project scope of work for direction on which activities are included in a particular project.

### 3.3.2 Milestones

Key project milestones will be identified and coordinated with the CxA, DEN PM, and the DEN Cx Program Manager at task kickoff. The milestones will be included in the Cx Plan.

The services described below may be included as part of the commissioning Scope of Work in the Define phase of the project.

### 3.3.3 Design Intent Review

The CxA will review the design intent of the project, to ensure that owner's requirements are clearly defined. The provider will review the most recent design submission based on the timing of CxA involvement. Provide feedback to the DEN PM of any recommendations to clarify project requirements.

### 3.3.4 Owner's Project Requirements

The OPR shall be developed for each specific project per the DSM by the DEN PM with assistance from the CxA. Assistance may include facilitating an OPR workshop or drafting the OPR. The DEN PM shall identify the Project Sponsor and the appropriate stakeholders and include them in the OPR development.

### 3.3.5 Commissioning Plans (Cx Plans)

The Cx Plan shall be developed by the CxA and submitted to the DEN PM and DEN Cx Program Manager for review and approval using DEN standard professional services submittal procedures. The DEN SMEs shall be included in the review process.

Upon review, the DEN PM may direct the CxA to revise and resubmit the Cx Plan to incorporate any comments. The CxA shall revise and resubmit the Cx Plan as needed until it is accepted by the DEN PM.

The standard Cx plan will include a design and construction phase for the project. The Cx Plan should at a minimum contain the following items per the IECC and will likely include more content to meet the expectations for LEED:

- A. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
- B. A listing of the specific equipment, appliances, or systems to be tested and a description of the tests to be performed (assumptions should be made if specific information is not known at the time of the report).
- C. Functions to be tested including, but not limited to, calibrations and economizer controls.
- D. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
- E. Measurable criteria for performance.
- F. Commissioning Schedule (based on Owner or Contractor provided schedule)

For large projects, it may be necessary to develop separate Cx Plans for the design and construction phase of the project, or to develop separate plans for other phases of work as deemed necessary by the DEN PM. The construction phase Cx Plan shall be updated after the completion of construction documents.

### 3.3.6 NCCx

DEN's NCCx is a process to ensure that systems and equipment are designed, installed, functionally tested, and validated as capable of being operated and maintained according to the DEN's operational needs.

### 3.3.7 EBCx

DEN's EBCx consists of two distinct processes for investigating, analyzing, and optimizing an existing building's performance.

### 3.3.8 Reporting and Documentation

The project Cx deliverables shall be determined during project scoping. All deliverables shall be submitted in accordance with the DEN standard professional services submittal process.

### 3.3.9 Targeted Audits

By identifying and implementing relatively low-cost operational and maintenance improvements through targeted audits or assessments of building systems and controls, the CxA can help to ensure that the building's performance meets DEN's expectations on previously commissioned facilities or systems (re-commissioning).

### **3.3.10 Retro Commissioning**

Retro commissioning is a process similar to NCCx for existing buildings that never completed initial commissioning. It is usually triggered by a change in building use or occupancy, the onset of operational problems, or some other need.

## **3.4 Net Zero**

### **3.4.1 Goals**

Section under development.

**End of Chapter**

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## Chapter 4 - Design

### 4.0 Stakeholder Engagement

Follow the requirements as outlined in the engagement strategy and/or plans.

The design phase consists of translating the project requirements into detailed plans and specifications that are incorporated into construction documents. These design documents can be developed in-house or by a consultant. The design phase is the ideal time to align the project with the airport's sustainability goals. The team should evaluate energy efficiency, indoor water efficiency, and outdoor environmental concerns, at a minimum.

#### 4.0.1 Initial Project Concept Review Meeting

Through the Initial Project Concept Review meeting and design document reviews, the input from these stakeholders reveals how the project will impact other projects and systems. This is when the team identifies potential risks and opportunities and ensures that the projects stays in-line with its goals. Another key focus is ensuring that the design is maintainable and meets standard operating procedures. As design documents unfold, the team will have a clearer idea of the physical design. For example, using 3D modeling software, the team can see how systems and components overlap, which ideally supports catching oversights.

#### 4.0.2 30/60/90 Design Review

Stakeholders should be engaged at 30/60/90 percent design reviews. Early engagement is imperative since it is easier and more cost effective to make changes earlier in the design. Project teams may also have to have page-turn meetings for key design features that impact varied stakeholders to ensure that all participants fully understand the design and its implications.

### 4.1 Envision®

The ENV SP facilitates the inclusion of project updates and any additional credits discovered during the design. All applicable credits requirements must be incorporated into the design in order to meet the targeted level of achievement.

### 4.2 LEED®

Updates discovered from the define phase are updated in the OPR by the LEED® AP. Updates may need to define project submittals for the build phase that the construction phase will need to perform.

### 4.3 Commissioning

The services described below may be included as part of the commissioning Scope of Work in this phase of the project.

#### 4.3.1 Review Basis of Design

The BOD is represented by the DEN DSMs and the Designer of Record (DOR) Design Analysis Report (DAR). The CxA reviews the OPR and BOD documents to ensure that the BOD reflects the desired outcomes represented in the OPR.

#### 4.3.2 Design Reviews

The CxA shall perform design reviews based on milestones defined by the DEN PM as part of the task order RFP process. The design packages will be reviewed with respect to completeness in all areas relating to the commissioning process and to confirm compliance with the OPR and DSM. The CxA shall identify any design-related issues that may hinder the commissioning of systems, such as access restrictions, missing test ports, missing devices, etc. The CxA will be expected to back check their previous design review comments at each

subsequent design review. The CxA shall attend design review comment resolution meetings in person for each design package review.

### 4.3.3 Commissioning Meetings – Design

Regular meetings will be held with the DEN Cx Program Manager and CxAs, to maintain consistent application and interaction for commissioning services across multiple contracts and projects.

A project-specific kickoff meeting should be conducted by the CxA to introduce the Cx team to the project team and review the preliminary Cx Plan. The CxA may need to resubmit the Cx Plan with updates based on the kickoff meeting.

Additional project-specific commissioning meetings will be as defined in the scope of work for the project. The CxA will provide recommendations for meeting frequency and agenda, subject to review by the DEN PM. The general recommendation is bi-weekly meetings during design and weekly meetings during construction (see Pre-Construction Phase Activities: Conduct Cx Meetings for additional information).

### 4.3.4 Integration Meetings

Additional meetings may be required for integration of controls, MBCx, envelope Cx, etc. and will be coordinated with the DEN PM. These meetings should be conducted by the design team and attended by the CxA.

### 4.3.5 Commissioning Specifications

The CxA will develop commissioning requirements and incorporate them into the construction documents (i.e. specifications). The CxA develops a comprehensive commissioning specification based on the DEN standard specifications and works with the DOR to incorporate into the construction documents.

### 4.3.6 Provide IECC Cx Permit Letter

For compliance with CCD IECC requirements, submit a letter to the electrical or mechanical/plumbing reviewer as part of the permit submission. The letter is drafted by the CxA and executed by DEN. The letter documents the CxA assigned to the project and represents the qualifications required by the code.

Confirm that the letter is required with the specific DEN Project Manager.

### 4.3.7 Develop Systems Manual Scope and Format

The systems manual contains all of the information necessary to operate, maintain, and recommission energy-consuming systems within the project. The systems manual should include, at a minimum, the following to satisfy both IECC and LEED requirements:

- A. Executive summary
- B. Owner's project requirements
- C. Basis of Design
- D. System single-line diagrams
- E. Construction record documents and specifications
- F. Approved submittals
- G. Equipment operations and maintenance manuals (O and Ms)
- H. System balancing reports
- I. Final commissioning report

### 4.3.8 Develop Training Requirements

The CxA should confirm the development of training requirements in coordination with the DEN PM.



### 4.3.9 Develop Monitoring Based Commissioning (MBCx) Plan

The CxA will incorporate MBCx requirements and activities into the preliminary Cx Plan previously developed. The DEN PM will work with the DEN Cx Program Manager to determine if MBCx will be part of the project scope. This may be required by LEED depending on the credits pursued by the project.

### 4.4 Net Zero

This section is under development.

**End of Chapter**

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## Chapter 5 - Build

### 5.0 Stakeholder Engagement

Continue to follow the requirements as outlined in the engagement strategy and/or plans.

#### 5.1 Envision®

All applicable credit requirements must be incorporated into the build phase in order to meet the targeted levels of achievement.

#### 5.2 LEED®

All applicable credit requirements must be incorporated into the build phase in order to meet the targeted levels of achievement.

### 5.3 Commissioning

The services described below may be included as part of the commissioning Scope of Work in the Build phase of the project.

#### 5.3.1 Update Construction-Phase Cx Plan

The CxA will update the Cx Plan to reflect any design changes and update/add any team members that may have occurred during the design phase. If the Cx Plan was not previously developed the CxA shall develop a construction commissioning plan. This document shall outline the commissioning process throughout the construction phase. Include the following for the construction phase:

- A. General project information and overview
- B. Commissioning goals and objectives
- C. Commissioning team information
- D. Construction team information
- E. Roles and responsibilities during construction
- F. Commissioning scope
- G. Commissioning process
  - 1. Meetings
  - 2. Site observation
  - 3. Documentation
  - 4. Pre-functional checklists, tests, and startup
  - 5. Functional testing and verification
  - 6. Owner training
  - 7. O&M manuals & warranties
- H. Commissioning schedule (based on Contractor provided schedule)
- I. Site specific safety plan

#### 5.3.2 Coordinate Cx Activities (Scheduling)

The CxA will work with the contractor to integrate the Cx activities into the master construction schedule as well as the 3-week lookahead schedule. This may include participation in pull planning sessions if that effort is conducted by the GC.

### 5.3.3 Commissioning Meetings - Construction

The CxA is responsible for setting up and facilitating recurring Cx meetings to coordinate construction activities. The CxA will work with the DEN PM to define the frequency of meetings. There should be a construction phase Cx kickoff meeting prior to the start of major construction activities. Meetings should be weekly once commissioned systems are being installed.

### 5.3.4 Review Submittals

The CxA reviews submittals of commissioned systems concurrently with the design team to ensure ongoing compliance with the OPR, BOD and Cx requirements. The CxA review comments should be documented and addressed. Submittal(s) may include but not be limited to:

- A. HVAC sequences of operation
- B. Lighting control sequences
- C. Controls, controls graphics and programming

### 5.3.5 Develop Construction Checklists

The CxA prepares construction checklists (also known as pre-functional checklists (PFCs) or installation verification checklists (IVCs)). The checklists should be prepared utilizing the approved submittals and be specific to the installed systems. The checklist is intended to verify that each piece of equipment has been installed, started up, programmed, tested, and balanced, and that functional testing is ready to proceed. PFCs should be provided to the contractor prior to beginning installation to ensure they are completed by the installing contractor.

Note that the PFCs do not take the place of manufacturer's start-up procedures and documentation.

### 5.3.6 Prepare Functional Performance Tests (FPTs)

The functional test procedures are developed by the CxA after the submittal review process for commissioned systems is complete (especially the controls and sequence of operations). The FPTs are provided to the contractors and design team for the opportunity to review, verify proper operating modes, and comment on any desired modifications. FPTs should identify parties responsible for carrying out each activity.

### 5.3.7 Identify and Track Issues

The CxA will track any deficiencies discovered throughout construction, acceptance, and occupancy/operation phases. The issues will be shared with the design and construction team through a collaborative platform that identifies the responsible party for corrective action. The DEN instance of BIM 360 Field platform may be used for this reporting or another platform approved by the DEN PM. The CxA will work with the DEN PM to verify resolution of all issues.

### 5.3.8 Conduct Site Visits and Issue Site Observation Reports

The CxA will conduct regularly scheduled site visits to verify completion of PFCs and review systems installations. Field observation reports will be issued to document observations and issues will be added as needed. If the project is using the DEN instance of Autodesk Construction Cloud (ACC) during construction the CxA may enter Daily Reports in ACC as the observation reports and will enter issues separately. Other Cx collaboration platforms may be used for this purpose when approved by the DEN PM. When properly executed this effort may identify and prevent early systemic installation issues that will reduce rework by the contractors. The task required quantity of site observation reports will be coordinated with the DEN PM and the reports will be submitted in Unifier. The site observation reports will be included in the final Cx Report, which is also submitted in Unifier. The following activities would be expected to be included, at a minimum:

- A. Witness sub-contractor pre-testing
- B. Verify/witness point verification testing

C. Witness equipment startup

### 5.3.9 Review Requests for Information

The CxA will review and provide responses to Requests for Information (RFIs) pertaining to commissioning activities, documentation, and processes. Additional RFIs may be provided to the CxA throughout construction for informational purposes.

### 5.3.10 Coordination and Shop Drawing Review

The CxA will review and comment on the contractor's coordination and shop drawings for conformance with the commissioning plan.

### 5.3.11 Monitoring-Based Commissioning (MBCx) Implementation & Coordination

Per the LEED v4 Enhanced Credit requirements, the CxA will develop monitoring-based commissioning procedures and identify points to be measured and evaluated to assess performance of energy and water consuming systems. Procedures and measurement points will be included in the MBCx of the Cx Plan.

Currently DEN utilizes an instance of SkySpark as the Energy Management Information System (EMIS) platform for the implementation of MBCx. The DEN MBCx process and requirements are continuously evolving and should be coordinated for each project.

See [Chapter 7: Monitoring-Based Commissioning \(MBCx\)](#) for implementation standards.

### 5.3.12 Building Enclosure Commissioning (BECx) Mock-Up Testing

The CxA should observe third-party testing (e.g. builder sub-contractor) and review test reports. Provide documentation in site observation reports.

### 5.3.13 Power Systems – NETA Testing

The CxA should observe and report any NETA testing performed by others, if part of the project.

## 5.4 Net Zero

This section is under development.

**End of Chapter**

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## Chapter 6 - Closeout

### 6.0 Stakeholder Engagement

Follow the requirements as outlined in the engagement strategy and/or plans.

#### 6.1 Envision®

All applicable credit requirements must be incorporated into the closeout phase in order to meet the targeted levels of achievement.

The project team will complete and submit all required Envision templates and documentation through ISI if the project is pursuing Envision certification. Additional information, project support and appropriate contracts will be necessary to achieve third-party verification. Project teams should consider the best approach for continuing support in these areas to completion, including award.

#### 6.2 LEED®

The CxA will complete and submit all required LEED® templates and documentation through LEED® Online if the project is pursuing LEED® certification.

### 6.3 Commissioning

The services described below may be included as part of the commissioning Scope of Work in this phase of the project.

#### 6.3.1 Commissioning Meetings – Acceptance

The CxA is responsible for setting up and facilitating recurring Cx meetings to coordinate acceptance phase activities. The CxA will work with the DEN PM to define the frequency of meetings. There should be an acceptance phase Cx kickoff meeting prior to the start of major acceptance phase activities. Meetings should be weekly once commissioned systems are being installed.

#### 6.3.2 Verify PFCs and Point Verification Tests (PVTs)

The CxA will collect and review the PFCs and PVTs documentation and checks for completeness. Any review comments are recorded as issues and provided to the construction and design team for resolution.

#### 6.3.3 Review Completed Start-Up and TAB Reports

The CxA will collect and review the start-up and TAB reporting documentation to confirm readiness of systems for functional testing. Any review comments are recorded as issues and provided to the construction and design team for resolution. The CxA may be asked to perform a sampling of the TAB work to provide on-site verification.

#### 6.3.4 Execute Functional Tests

The CxA will perform (direct and witness) on-site functional testing of all systems to be commissioned in accordance with the FPTs. The executed functional test reports signed by the CxA will be submitted in Unifier and included in the final Cx Report, which is also submitted to Unifier. The documentation will include the following as appropriate for each piece of equipment:

- A. Basic information (Project name, building, system, equipment ID)
- B. System description
- C. Operational assumptions
- D. Listing of test participants
- E. Listing of test status for each test

- F. System readiness checklist summary
- G. Required testing supplies
- H. Required trend data
- I. Parameters and set points
- J. Functional performance test data and checklist
- K. CxA Signature Line (Sign-off)
- L. Reference information (as appropriate)

Retesting will be conducted based on sampling rate and failure percentage.

### **6.3.5 Review Operation & Maintenance Manuals**

The CxA will conduct a summary review of the operation and maintenance (O&M) manuals for compliance with the project specifications. Any comments are recorded as issues and provided to the construction and design team for resolution.

### **6.3.6 Verify Completion of Training**

The CxA will confirm the training program has been completed according to the owner's requirements. The contractor develops, schedules, and conducts the training. The CxA reviews the training agenda and attendance documentation, and attends a portion of the training sessions per the owner's requirements as directed by the DEN PM.

### **6.3.7 Complete IECC Cx Compliant Checklist**

Per IECC, all preliminary commissioning reports must include the commissioning compliance checklist as required by the IECC. Refer to the current version of the City & County of Denver Submittal Requirements for the IECC Commercial Provisions for the checklist.

### **6.3.8 Prepare Preliminary Cx Report**

The CxA will prepare a preliminary Cx report after installation inspections and FPT verification, but before final City inspection (per IECC requirements). The preliminary report will detail all commissioning activities carried out during the project and include at a minimum:

- A. Describe all activities performed during pre-design, design, construction, and closeout.
- B. Include projected activities related to ongoing commissioning and seasonal testing of systems included in the project.
- C. Provide any recommendations for future projects which could improve the commissioning process.
- D. IECC Commissioning Compliance Checklist.

### **6.3.9 Compile Systems Manual**

The CxA will compile the documents defined in the systems manual scope and format developed during the design phase.

### **6.3.10 Compile Current Facility Requirements and O&M Plan**

The CxA will prepare and maintain the CFR and O&M Plan through the completion of the acceptance phase. These documents contain the information necessary to operate the building efficiently. Specific information included within the CFR and O&M Plan include sequence of operations, building occupancy schedule, equipment run-time schedule, setpoints for all HVAC equipment, lighting levels throughout the building, minimum outside air requirements, systems narratives, a preventative maintenance plan, and periodic commission requirements.



### 6.3.11 Deliver Post Construction Documents

The CxA will complete and deliver the necessary operating documents and reports to DEN before building occupancy but no later than 90 days of the date of receipt of the certificate of occupancy for IECC compliance. The final package must include the following:

- A. Up-to-date systems manual.
- B. Documentation of operator training.
- C. Complete functional performance test reports.
- D. Up-to-date issues log detailing closed and open issues.
- E. Updated Cx Plan that outlines commissioning completed to date, plan for seasonal testing, plan for 10-month operational/warranty review, and plan for addressing open issues identified after the initial round of commissioning.
- F. For FAA projects, equipment commissioning documents are required as a condition of final payment. See Section 90-11.I of the Standard Specifications for Construction of Airports AC no. 150/5370-10.

### 6.3.12 LEED Submissions

The CxA will complete and submit all required LEED® templates and documentation through LEED® Online if the project is pursuing LEED accreditation.

## 6.4 Net Zero

This section is under development.

**End of Chapter**

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## Chapter 7 - Monitoring-Based Commissioning (MBCx)

### 7.0 MBCx Goals and Objectives

- A. Ensure consistent SkySpark deployment across the airport owned and managed by DEN for the long term.
- B. Shift to Design, Engineering, and Construction (DEC) after project turnover completion.
- C. DEC will become the main point of contact and have responsibility for MBCx during warranty.

### 7.1 MBCx System Description

#### 7.1.1 IT and SkySpark Configuration

- A. SkySpark is installed on a DEN virtual machine on the DEN network.
- B. Remote access is through Citrix.
- C. DEN will manage SkySpark user access.
- D. Each Site will use SkySparkConnectors to integrate data on the same network:
  - 1. SQL
  - 2. Niagara Supervisor/JACEs
  - 3. BACnet connectors
  - 4. Modbus
  - 5. Energy Star integration
  - 6. Web API to Power Takeoff, etc

### 7.2 Planning

#### 7.2.1 Design Coordination and Reviews

Review design documents to confirm monitoring points, sequences for rules, and integration of systems such as lighting controls

#### 7.2.2 MBCx Plan

- A. Confirm planned equipment for monitoring.
- B. Determine the points to include MBCx.
- C. Review available SkySpark points with DEN.
- D. Plan for the purchase of additional points as needed.

#### 7.2.3 Contractor Coordination

- A. Coordinate with the controls contractor to request and confirm trend setup.
- B. Coordinate integration details such as the server for the trend storage or BACnet controller information.

#### 7.2.4 User Access Setup

Remote access through Citrix:

- A. Set up DEN/Citrix account by submitting User Agreement and Cyber Security forms to access DEN's network and SkySpark project.
- B. Send Access request list to DEC and DEN BT.

- C. Citrix Login: Log in using your DEN credentials and multi-factor authentication (MFA) token received by text or other means.



<https://citrix.flydenver.com>

- D. SkySpark Application: From the Citrix home page, double-click the “SkySpark Web Client” Google Chrome icon to open the SkySpark homepage at skyspark/user/login in a new tab. Access to SkySpark requires a username and password.

**Note:** Once logged in, the URL will show as skyspark/ui/denverIntAirport.

- E. BAS link also available on the Citrix homepage. Login credentials are the same as FlyDenver.

SkySpark user access:

- A. DEN will set up users and manually email passwords.
- B. Reset password on first use.
- C. Include email tag (external access not set up at this time).
- D. Include custom tag for companies.
- E. Teams may request the inclusion of a funAccessFilter to limit accessible code to code with the respective team’s tag.
- F. User template available through Prototype.

## 7.3 Acceptance — Integration and Initial Commissioning

### 7.3.1 Project/Site Setup

- A. All DEN work will be consolidated under one combined SkySpark “Project” to provide a unified access point for the airport operations team.
- B. “Sites” will be configured within the overall Project, representing specific areas of the airport such as concourses, the terminal, and central plant.
- C. Each provider will focus on the area and equipment they are responsible for configuring.

### 7.3.2 Equipment Setup and Naming

- A. Equipment will be organized by Concourse, Floor, and Module.
- B. SkySpark point will include these elements in the display name (e.g. CCB 04 08W AHU\_B displays with each point on this AHU). Refer to Appendix # for DEN Equipment Navigation Setup.

### 7.3.3 Points and Tagging

- A. SkySpark Point names will generally follow EMCS names based on DEN standards. Teams can provide feedback if EMCS names don’t follow standards.
- B. Tagging will follow consistent Haystack 4 standards, and the names will facilitate automated tagging.
- C. Integrated equipment will be tagged with a key-value tag designating the provider (e.g. team: “CompanyXYZ”). This allows each team’s rules and dashboards to only apply to the equipment they are responsible for integrating.
- D. DEN tagging standards will be developed for points and equipment types not covered by Haystack. Refer to Appendix A for a tagging template for equipment not covered by Haystack 4 standards
- E. .Code Repository

- A. Code will be tagged with a marker tag referencing the team name (e.g. “CompanyXYZ”). The funAccessFilter on each User will reference the team name.

### 7.3.4 Rules

- A. MBCx provider will deploy rules to automatically detect issues and opportunities for the monitored equipment.
- B. Rules may be deployed as pods and can be applied to specific equipment in an area of work or across similar types of equipment.
- C. Rules and applications will be separate for each provider.
- D. Rules will be tagged with a key-value tag designating the provider (e.g., team: “CompanyXYZ”). This ensures that each team’s rules and dashboards only apply to the equipment they integrated. See APPENDIX A for Rule examples.

### 7.3.5 Dashboards

- A. Energy dashboards will be configured to monitor the whole building and energy end-uses where applicable. This may include:
  1. Site/meter energy monitoring dashboard to display monthly and annual energy data, costs, EUIs, etc.
  2. Campus-wide energy dashboard to compare energy use across Sites and identify changes.
  3. Energy end-use dashboard to evaluate the breakdown of energy for major loads (greater than 10% of annual energy use).
- B. Operator dashboard will provide equipment operating details and key metrics. Heat maps can visually display data over time. Each integration team will create their own dashboards. See APPENDIX A for dashboard examples.

### 7.3.6 Key Performance Indicators (KPIs)

- A. KPIs can be configured at the meter level and/or the equipment level and may include energy use/costs, energy/cost intensities, and equipment-level metrics.
- B. KPIs will be tagged with a key-value tag designating the provider (e.g. team: “CompanyXYZ”). This ensures that each team’s rules and dashboards only apply to the equipment they integrated. See APPENDIX A for KPI examples.

### 7.3.7 Automated Tests and TAB Verification

- A. SkySpark will monitor real-time equipment operation to verify the sequence of operations.
- B. Issues found through SkySpark will be added to the construction commissioning issues log.
- C. Automated scripts can be used to drive the operation of devices, and SkySpark can identify issues from the automated test.

### 7.3.8 Contractor Coordination for Issue Resolution

- A. The construction team will generate MBCx or SkySpark issues in the construction commissioning issues log and the construction team will respond accordingly.

## 7.4 Ongoing Monitoring and Maintenance

### 7.4.1 Ongoing Issues Tracking Process

DEN currently has various methods of ongoing issue tracking processes. CxA should coordinate with the DEN PM and DEN SkySpark Super User to verify what is best for their project.

CxA may use the ARC app in SkySpark to track issues.

### **7.4.2 Issue Resolution Mapping, Roles, and Responsibilities**

Section under development. Coordinate with DEN PM for issue resolution mapping, roles, and responsibilities.

### **7.4.3 Warranty Management Process**

Issues identified by the Commissioning team that were turned over to the owner/GC for warranty review will be monitored over the first year of operation.

### **7.4.4 Quarterly Checkups**

CxA shall provide quarterly checkups for two years after substantial completion of the project, unless otherwise specified in contract documents.

At a minimum, the Quarterly Checkup shall include any issues being currently tracked, new issues, seasonal testing reports, and recommendations for issue correction.

### **7.4.5 Energy Monitoring/Measurement and Verification (M&V)**

Section under development.

**End of Chapter**

## Chapter 8 - Turnover

### 8.0 Stakeholder Engagement

Follow the requirements as outlined in the engagement strategy and/or plans.

### 8.1 Commissioning

The services described below may be included as part of the commissioning Scope of Work in this phase of the project.

#### 8.1.1 Review As-Built Drawings

The CxA will review the as-built drawings received from the contractor. As-built drawings include redline mark-ups, electronic construction models, Revit models, etc. See the Digital Facilities and Infrastructure DSM for DEN as-built model development process.

#### 8.1.2 Troubleshooting/Optimization

The CxA will execute a certain number of hours troubleshooting systems as defined by the DEN PM and identify any optimization opportunities.

#### 8.1.3 Develop Ongoing Cx Plan

The CxA will develop and issue an ongoing Cx plan before or as part of the 10-month warranty review. The plan should provide the building's operating staff with procedures, blank test scripts, and a schedule for ongoing Cx activities.

#### 8.1.4 Finalize Cx Report

The CxA will update the preliminary Cx report issued during the acceptance phase to document additional activities and findings during the occupancy and operations phase. The final report will detail all commissioning activities carried out during the project and will include at a minimum:

- A. Description of all activities performed during pre-design, design, construction, and closeout.
- B. Include projected activities related to ongoing commissioning and seasonal testing of systems included in the project.
- C. Provide any recommendations for future projects which could improve the commissioning process.

The provider should issue the final Cx Report within 30 days of the substantial completion of the total project.

### 8.2 Net Zero

This section is under development.

## End of Chapter

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## Chapter 9 - Acceptance Phase

### 9.0 Stakeholder Engagement

Follow the requirements as outlined in the engagement strategy and/or plans.

#### 9.1 Envision®

All projects intending to pursue Envision® verification will submit a verification plan for approval by DEN PM and DEN Sustainability. The project team will determine the best approach for continuing support in these areas to completion, including award. Any additional Envision® templates and project support will continue as necessary to achieve third-party verification. Acceptance phase will be complete upon receipt of final certification.

#### 9.2 LEED®

All projects intending to pursue LEED® verification will submit a verification plan for approval by DEN PM and DEN Sustainability. The project team will determine the best approach for continuing support in these areas to completion, including award. Any additional LEED® templates and project support will continue as necessary to achieve required third-party verification. Acceptance phase will be complete upon receipt of accreditation.

### 9.3 Commissioning

The services described below may be included as part of the commissioning Scope of Work in this phase of the project.

#### 9.3.1 Execute Seasonal Testing

The CxA will perform seasonal testing on systems that require testing of loading, staging, and capacities that were not completed during the initial functional testing. The results of seasonal testing and the issues identified must be included in the final commissioning report.

#### 9.3.2 Update/Resolve Cx Issues Log

The CxA will continually update and support resolution of issues. Effort should be made to have all issues resolved prior to the 10-month warranty review.

#### 9.3.3 Conduct MBCx Quarterly Checks

The CxA will conduct quarterly reviews of metering and trend logs defined in the MBCx Plan. This should also include verification of any alerts that the operator should receive when equipment, systems and the building are not performing to energy expectations. Any issues will be logged in the approved Cx platform.

Submit Quarterly Check-In Reports in Unifier.

#### 9.3.4 Conduct Operations and Warranty Review

The CxA will participate in 10-month operations and warranty walkthrough, to ensure that all equipment associated with systems to be commissioned is operating properly. A 22-month operations and warranty walkthrough may be required and should be confirmed by the DEN PM when developing the scope of services.

- A. Not less than four weeks prior to scheduled warranty walkthrough, provide a checklist to the DEN PM for review. The checklist will include any outstanding issues from the (DEN approved Cx platform) that should be checked during the walkthrough.
- B. Checklist will include a section for each individual piece of equipment, expected attendees and responsibilities, and field or checkboxes for each individual inspection procedure or measurement as directed by the DEN PM.

- C. Provide copies of the checklist on-site during the warranty walkthrough for use in inspecting the equipment.

## 9.4 Net Zero

This section is under development.

**End of Chapter**