Zero Net Energy Guidebook

This guidebook provides the full spectrum of Zero Net Energy (ZNE) guidance. It aids in defining ZNE goals, engaging and aligning the entire project team, selecting energy conservation measures, coordinating pre-construction preparation, and delivering a verifiable, efficient ZNE building. This guidebook outlines the requirements for each Consumers Energy ZNE Companion Program deliverable and provides resources for renewable energy options and building certifications.

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Executive Summary

The Zero Net Energy (ZNE) Companion Program educates on the importance of an integrated design process in achieving ZNE buildings. This program promotes ZNE as post-occupancy, measurable goal, by providing incentive payments to fund a portion of the added costs to reach a ZNE-Ready target (i.e. engineering support, energy modeling, cost-benefit analysis, commissioning, equipment costs and post-occupancy measurement & verification) and the energy savings associated with it.

The ZNE Companion Program is set up in five phases from early schematic design through 12 months of post-occupancy with 15 deliverables along the way. Using this guidebook and completion of each deliverable sequentially, customer projects are setup to stay on track to achieving their high-performance energy goals. The flowchart on the next page lays out each phase and deliverable, indicating how this program lines up with a typical design and construction timeline.

The intent of this guidebook is to aid the project team through this extensive ZNE process. Each of the 15 deliverables are thoroughly described throughout this document with clear explanations of intent, program requirements, responsible parties, congruity amongst deliverables, examples, and additional resources. Here are a handful of ways each deliverable guide can be used:

- To help the owner understand each deliverable's scope of work.
- As a basis for a request for proposal (RFP).
- As a how-to guide for the responsible party completing the deliverable.
- As a resource for the entire project team to keep on track to achieve ZNE.
- To help with renewable energy options and building certifications.
- As a ZNE refresher for experienced professionals or those new to the field.

This guidebook is by no means an exhaustive list of resources nor is it the only possible process of achieving ZNE. However, based on extensive experience, this process has proven to be ideal for Consumers Energy's ZNE Companion Program, a tried-and-true way of successfully achieving ZNE.

This guide was developed by DNV GL on behalf of Consumers Energy's Zero Net Energy program. This document is intended to be used by project teams needing assistance in developing this deliverable for their project. This document is for informational purposes and is not intended to represent a complete deliverable document or constitute legal advice. Consumers Energy reserves the right to modify or cancel the Zero Net Energy program at any time at its discretion.


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Zero Net Energy Companion Program Flowchart
Preliminary Design
Advanced Design
Construction
Measurement
Verification
Schematic Design
Design Drawings, Energy Modeling & ECMs
100% CDs
Kickoff Meeting
Construction & Commissioning
Occupy Building
M&V Testing
12-Month Performance Period
Customer Project Team
Phase 1
Deliverables:
1.1 Preliminary Energy Model
1.2 Design Charrette
1.3 OPR
Phase 2
Deliverables:
2.1 Energy Model
2.2 Cost-Benefit Analysis
2.3 Basis of Design
2.4 Submetering & CDs
Phase 3
Deliverables:
3.1 Construction Kickoff
3.2 M&V Plan
3.3 Circuiting Inspection
3.4 Envelope Cx
3.5 System-Level Cx
Phase 4
Deliverables:
4.1 Monitoring Equipment
4.2 Performance Testing
Phase 5
Deliverables:
5.0 Verification: 12 months of energy data
ZNE Team
Coordinate meetings, review deliverables and provide technical assistance and guidance throughout the project

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Project Initiation

Intent: Assess project eligibility, ZNE feasibility and start building a team. The Project Initiation period occurs during the application process to the Consumers Energy ZNE Companion Program. At this time, extensive building data is also collected to support future analysis and savings estimates. This is where the foundation is set for the ZNE work to come.

Coordination: Occurs prior to the start of Phase 1

- Program Application Questionnaire
- Data Collection
- ZNE Feasibility Study
- Hire Design Team
- Kickoff Meeting
- Schedule Reoccurring Monthly Meetings

Project Initiation

Eligibility

The following is a list of eligibility requirements for the Consumers Energy ZNE Companion Program.

- Commercial buildings only.
- New construction, major renovation, or a deep retrofit project upgrading a minimum of two whole building energy systems.
- Must be in early stage schematic design (i.e. no late "on-ramping").
- Must be in an electric-only or in a combination of natural gas and electric Consumers Energy service area.
- Proposed project must use 100% electricity (i.e. no natural gas, district heating, etc. used onsite).
- All deliverables are required for payment (i.e. no skipping of deliverables or associated requirements).
- Owners are limited to two enrolled projects (or one campus, up to four adjacent buildings).

As part of the Consumers Energy Business Energy Efficiency Programs, the ZNE Companion Program's incentives and requirements are based on energy reduction efforts to reach an EUI (kBtu/sf/yr) goal for ZNE-Ready status. Renewable energy generation for true ZNE is not required but highly encouraged and is further explained in the appendix. Below are the different definitions related to ZNE buildings for this program's purposes:

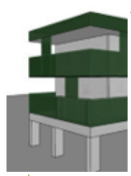
- **ZNE:** A building that generates as much energy as it uses annually.
- **ZNE-Ready:** A building that has reduced its energy use to meet the program's EUI goal requirements.
- **EUI Goal:**
    - 25 kBtu/sf/yr and 20% reduction in regulated whole building energy, or
    - If 25 kBtu/sf/yr cannot be reached:
        - 30% for existing buildings (compared to existing energy use).
        - 40% for new construction (over Michigan adopted American Society of Heating, Refrigerating and Air-Conditioning Engineers® ASHRAE® 90.1 Table G3.1).

Technical Assistance throughout the Program

The Consumers Energy ZNE team will be there to support business owners throughout their ZNE journey. Below is a list of some of the technical assistance they will provide.

Phase 1

- Aid in charrette coordination
- Review and recommend energy efficiency technologies



Phase 2

- Review energy model and help with troubleshooting
- Review economic analysis

Phase 3

- Aid in construction kickoff meeting coordination
- Review Cx documentation

Phase 4

- Review monitoring data
- Help troubleshoot any errors in the monitoring data

Phase 5

- Verify whole building savings based on building's 12 month performance

Project Initiation

Steps to Project Enrollment

1. **Application Questionnaire** – Complete interactive application questionnaire (available online at ConsumersEnergy.com/pilots). Once complete, please submit to ZeroNetEnergy@cmsenergy.com to assess eligibility and ZNE feasibility.

2. **Data Collection** – Submit drawings, schedules, occupancy count, building program, site conditions, and other relevant documents or analysis to the ZNE team (ZeroNetEnergy@cmsenergy.com), as well as 3 years of energy bills and building audit reports if an existing building.

3. **ZNE Feasibility Study** – Performed by Consumers Energy during the application process as an initial assessment of the project's baseline energy use, viable ECM opportunities, EUI goal feasibility and solar sizing to achieve true ZNE.

4. **Design Team Procurement** – Gather the team to support the Integrated Design Process from the start and prepare for Step 5. Kickoff Meeting
    a. Design Architect
    b. Mechanical, Electrical and Plumbing (MEP) and Civil Engineers
    c. Energy Modeler
    d. Lighting Designer
    e. Contractor
    f. Commissioning Agent
    g. Green Building and Solar/Renewable Energy Consultants (optional)

5. **Kickoff Meeting** – Initiate the project by hosting a walkthrough of building and/or site with the owner, design team (see above), Consumers Energy representative and additional stakeholders. This meeting will also include a review of program requirements and deliverables and a discussion about the ZNE vision for the project.

6. **Reoccurring Monthly Meetings** – Schedule reoccurring monthly meetings with the customer, design team and Consumers Energy representative throughout the project. The first topic will be assigning actionable tasks to project team members in preparation for the upcoming Design Charrette.

Phase 1: Preliminary Design

Intent: Establish project owner's energy efficiency and sustainability goals and expectations and align the team through the preliminary energy model results and a ZNE charrette brainstorming session to assess project limitations and opportunities.

Coordination: Occurs during Schematic Design or early Design Development (DD).

- 1.1 Preliminary Energy Model
- 1.2 ZNE Design Charrette
- Owner's Project Requirements

Phase 1: Prelim. Design | Phase 2: Adv. Design | Phase 3: Construction | Phase 4: Measurement | Phase 5: Verification

1.1 Preliminary Energy Model

Summary

Intent

The intent of the preliminary energy model is to provide an evaluation of baseline conditions and feasibility of conceptual design to facilitate discussions during the ZNE Design Charrette around Energy Conservation Measures (ECMs) for energy savings and determine an energy use index (EUI) goal. Therefore, the Preliminary Energy Model must be completed prior to the ZNE Design Charrette. There is a wide variety of acceptable content for this deliverable based on the stage of design, information available and preferred calculations. The results should reflect the current design and incorporate ECMs to meet the EUI goal. This deliverable is required to take place early in the conceptual process to inform design decisions for the owner and design team.

Primary Responsibility: Design Team/Energy Modeler
Secondary Responsibility: Owner (data collection)

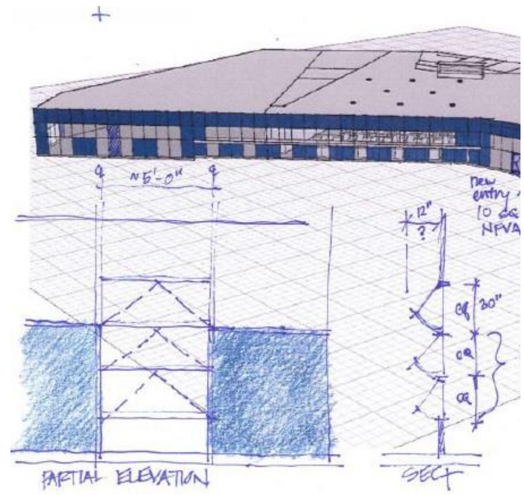
Program Requirements

For the ZNE Companion Program, the Preliminary Energy Model must include the following:

☐ Estimated baseline EUI for the project

☐ Preliminary list of ECMs and preliminary energy savings calculations for each ECM

☐ A proposed ZNE-Ready EUI goal based on initial results



Cross-Deliverable Consistency

The data collection and design parameters explored during the preliminary model analysis should be used to inform the next three deliverables for the program, though changes and adjustments to the original EUI estimates are expected throughout the design.

- 1.2 ZNE Design Charrette
- 1.3 Owner's Project Requirement (OPR)
- 2.1 Energy Model

Since the 2.1 Energy Model deliverable can build upon the 1.1 Preliminary Energy Model, please refer to the 2.1 guide for additional information on requirements (e.g. software, calibration, weather files, input data and assumptions) for the final energy model deliverable.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• **1.1 Preliminary Energy Model** • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

1.1 Preliminary Energy Model

Deliverable Description

Program Requirements

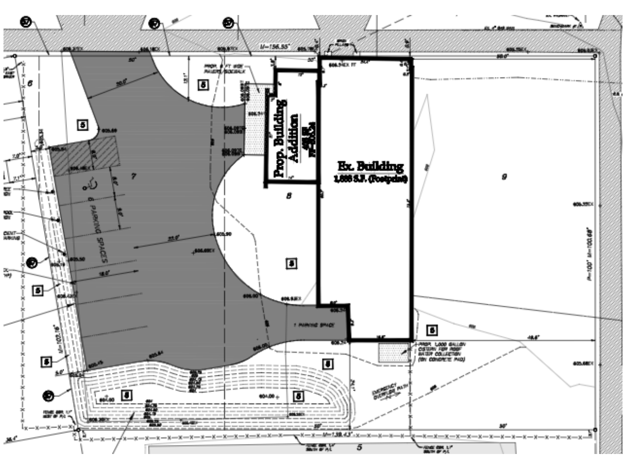
The Preliminary Energy Model analysis is needed to support productive decision-making during the upcoming design charrette. The four most important components to this deliverable are data collection, baseline EUI calculations, ECM assessments and ZNE EUI goal estimations. The design team should conduct an evaluation of the concept design and discuss possible site and building specific sustainable strategies, including building orientation (for new construction projects), passive design optimization and preliminary ECMs. The EUI can be estimated from the Preliminary Energy Model and should be calculated as annual energy use per square foot. The EUI will be further defined during the 1.2 ZNE Charrette.

Data Collection

The first step is data collection – most of which should have been collected during the Project Initiation. The following documentation/information will be required to perform an accurate analysis:

- Site conditions and climate data
- Building use type(s)
- Building area
- Drawings
- Schedules
- Occupancy and building program information
- Three years of energy bills for existing buildings
- Benchmark data for new construction
- Project timelines/deadlines
- Potential ECMs

The availability of this information will vary depending on the stage of design, existing building versus new construction, etc., but gather as much as possible.



Baseline EUI

Using the collected information, the next step is to calculate the baseline EUI, which is annual energy use per square foot. This is typically represented in kBtu per square foot per year (kBtu/sf/yr).

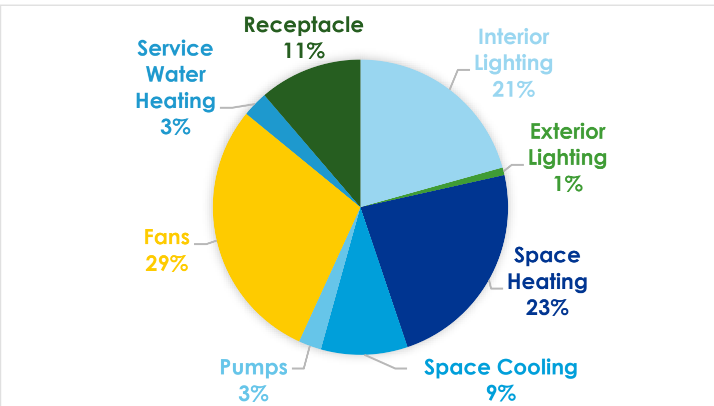
Existing Building: To account for variations in weather and occupant use, it is recommended to use the annual energy use averaged over the past three years, unless there is a major discrepancy in occupancy or if any ECMs have been implemented during that time. In which case, only use the energy use data that reflects the full occupancy post renovations. If this is less than 12 months, extrapolate and modify accordingly.

New Construction: For new construction projects, there are a variety of methods for estimating the baseline EUI. The most accurate method is to build an all-electric preliminary energy model using code minimum input values. The baseline model should denote the baseline design prior to incorporation and implementation of specific ECMs for the project. Benchmarking data available for the project's region is also very valuable in this process in terms of cross-checking the Baseline building energy use and helping with projections for the EUI target. Data by building type is available from Energy Star or the Commercial Building Energy Consumption Survey (CBECS) for a variety of use types and vintages.

1.1 Preliminary Energy Model
Deliverable Description (cont.)

ECM Assessment

After creating a preliminary energy model that roughly meets the baseline EUI, the project team can assess the end use breakdown of the building.



A breakdown of energy into the different end-uses provides an insight into what is driving the energy load and potential energy savings for the project. The savings per ECM can be estimated using the energy model. Manual forms of calculations can also be a good quality check. The results should be used to prioritize ECMs moving into the Advance Design Phase as well as to justify the EUI goal selection. The following is an example list of ECMs:

- Massing and orientation for passive strategies
- Natural ventilation and operational controls
- Natural daylighting and controls
- Improved thermal properties of the envelope
- Reduced lighting power densities (e.g. LED upgrade) and occupancy controls
- Increase thermal comfort ranges
- Reduce plug and process loads
- Fine-tune operations parameters
- BMS controls
- High efficiency HVAC equipment

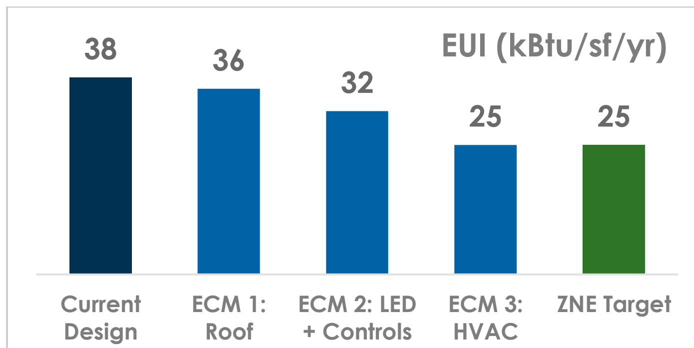
Note: Some measures such as massing, and orientation will not be feasible for existing buildings.

Proposed EUI Goal

To comply with the program, the proposed EUI goal must meet one of the following requirements (percent savings are per regulated loads only):

- 25 kBtu/sf/yr and 20% energy savings, or
- 30% energy savings for existing buildings, or
- 40% energy savings for new construction

Based on estimated energy savings associated with each ECM, a proposed EUI can be estimated (see the below graph as an example). This will be an extremely valuable point of discussion during the design charrette to help justify and verify the ZNE EUI goal.



As this analysis occurs during the very early stages of the project, it should be approximate but detailed enough to inform the discussions during the design charrette to answer these questions:

- For new construction, what building orientation optimizes roof PV generation and passive design strategies (natural ventilation and daylighting) while minimizing unwanted heat gain and loss?
- What is the baseline and/or current energy use of the building (including estimates of end use breakdown)?
- Based on the preliminary list of ECMs, what proposed EUI could be achieved?
- If the program EUI goal requirements cannot be reached based on preliminary design decision, what other ECMs can be included?

1.1 Preliminary Energy Model

Resources

The following is a list of resources that are valuable during the Preliminary Energy Model process.

- ASHRAE Standard 209 describes a methodology to apply building energy modeling to the design. The standard was created to define reliable and consistent procedures that advance the use of timely energy modeling to quantify the impact of design decisions at the point in time at which they are being made.
- ENERGY STAR® Benchmarking Data.
- Commercial Building Energy Consumption Survey (CBECS).
- US Green Building Council®, LEED® Building Design and Construction Version 4, Integrative Process Credit.

1.2 ZNE Design Charrette

Summary

Intent

The intent of the ZNE Design Charrette is to initiate the integrative design process (IDP), introduce project team members, review project expectations, and explore design strategies. Throughout the charrette, the preliminary energy model analysis should be used to inform the discussions on the baseline energy use intensity (EUI), energy conservation measures (ECM), and the zero net energy (ZNE) EUI goal. Based on the discussions and brainstorming, a path to ZNE will be formed which sets the team up for success by building consensus, formalizing the project vision, streamlining the design process and establishing project goals.

Primary Responsibility: Facilitator and Design Team
Secondary Responsibility: Owner/Consumers Energy

Program Requirements

For the ZNE Companion Program, the charrette deliverable must include the following:

- ☐ Comprehensive attendee list including representatives from all design disciplines
- ☐ Agenda that includes but is not limited to: program overview, ZNE goals, and ECM brainstorming
- ☐ An agreed upon EUI goal
- ☐ A list of initial ECMs to achieve EUI goal

Cross-Deliverable Consistency

The following program deliverables must be consistent with the Design Charrette.

- 1.1 Preliminary Energy Model
- 1.3 OPR
- 2.1 Energy Model

The results from the Preliminary Energy Model must be presented during the charrette. After the charrette, the agreed upon EUI goal must be included in the OPR and the ECM list will be further analyzed during energy modeling. These will be checked by project team for consistency before submittal. Please note, if true ZNE is a goal of the owner, renewable energy would also need to be factored into the design at this stage. If not, at a minimum, wiring for future PV is required.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • **1.2 ZNE Design Charrette** • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

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1.2 Design Charrette

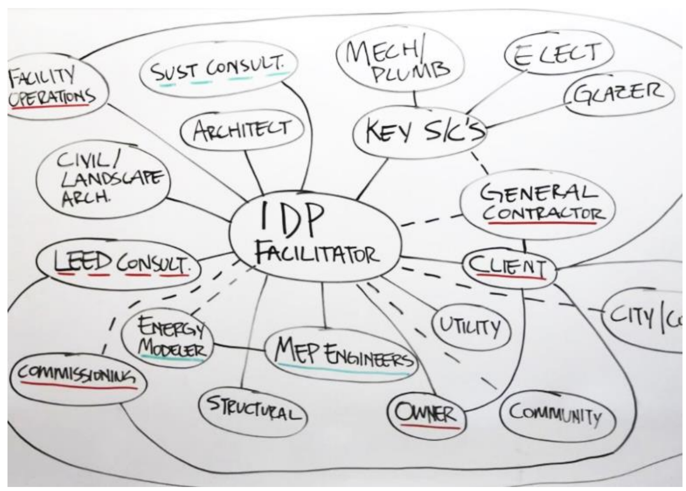
Deliverable Description

Program Requirements

The key to a successful charrette is to prepare in advance so time during the charrette is used wisely and the main outcomes and objectives are achieved. It is the responsibility of the design team to lead the Design Charrette. Therefore, the design team should have a presentation prepared (e.g. slide deck, handouts, etc.) and have identified other members of the design team to speak about their own discipline's role in the project (e.g. specific sustainable, high performance building strategies). As part of the program deliverable, a comprehensive attendee list with representatives from all design disciplines is required, along with an agenda that covers an overview of the ZNE Companion Program, preliminary energy model results, ZNE goals, ECM brainstorming, and next steps. The design team must complete their preliminary energy model analysis ahead of time and present the results during the charrette to establish a baseline EUI and discuss energy savings per ECM to reach a ZNE-ready EUI goal.

Potential Attendee List

- Owner/Owner's Representative
- Facilities Director/Building Operator
- Charrette Facilitator
- Design Architect
- Mechanical, Electrical and Plumbing (MEP) and Civil Engineers
- Energy Modeler
- Lighting Designer
- Contractor
- Energy Provider Representative
- Commissioning Agent
- Green Building Consultant
- Solar/Renewable Energy Consultant



Sample Agenda

The following is a sample agenda for the design charrette; content can be added/adjusted to meet the attendees' needs. It is important to schedule at least a half-day, in-person charrette to cover all topics.

Time	Content	Who
30 min	Introduction (purpose, agenda and expectations)	Facilitator
15 min	Project updates, goals and schedules	Owner
15 min	Icebreaker: What does ZNE mean to you?	All
30 min	Overview of ZNE, IDP and the Consumers Energy ZNE Companion Program	Consumers Energy Rep.
30 min	Baseline conditions and EUI calculations	Energy consultant
30 min	Break	All
30 min	Preliminary model results	Energy consultant
30 min	Brainstorming ECM list for both passive (e.g. orientation, daylighting, natural ventilation, etc.) and active (e.g. lighting, HVAC equipment, etc.) measures	All
10 min	Set EUI goal for the program	Consumers Energy Rep.
10 min	Discuss renewable energy system options and goals for ZNE	Facilitator/Owner
10 min	Review of action items, timelines and next steps	Facilitator/All

1.2 Design Charrette

Deliverable Description (cont.)

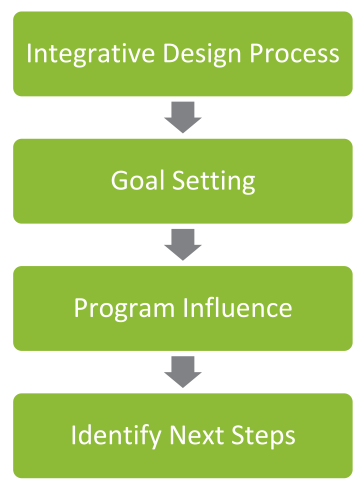
ZNE Strategies to Consider during the Charrette

Below is a potential list of questions to discuss during the charrette to facilitate ECM brainstorming.

- What are the sustainable design goals for the building?
- What is the energy target?
- What green building standard or certification will be used/pursued for the project and what elements of the standard are most important to address in the design?
- How will the building design take advantage of climatic factors and passive systems (building orientation, daylighting, solar tubes/skylights, natural ventilation, operable windows, etc.)?
- What are the baseline envelope construction assemblies? What types of opportunities are available for improved thermal properties?
- What high performance, all-electric HVAC systems might be considered? How will they be controlled?
- What size renewable energy system(s) will you need and where might they be located?
- If renewable energy is not part of the current design, how will the project meet the program requirements of wiring for future PV (detailed in the deliverable guide section 2.4).
- What are the lighting needs for the space? How will daylighting be utilized? How will lighting be controlled?
- What is the inventory of plug load equipment for this building and how can we optimize plug load energy use?
- Are there any biases for or against particular system types?
- What low water use fixtures will be used in the plumbing system?
- How will the design promote high standards in indoor air quality, thermal comfort, and glare?
- How can nature be incorporated into the building?
- Will the proposed ECMs have an impact on maintenance and/or maintenance staff?

Charrette, Vision, Goals, and Objectives

- Provide an overview: the project vision, goals, timeline, and green building approaches.
- Foster teamwork and an integrated design process.
- Examine constraints and identify possible synergies and solutions.
- Clarify ZNE energy targets and anticipated Energy Use Intensity (EUI) outcome.
- Identify and engage stakeholders in the process of ZNE.
- Define next steps and a path forward.
- Identify energy and water saving opportunities.



Anticipated Charrette Outcomes

- The owner, design team and all stakeholders understand and are committed to project vision and goals.
- ZNE EUI energy target is set.
- A list of ECMs is created and assigned to team members for further analysis and information gathering.
- All team members understand that there will be post-construction measurement and verification of performance.
- Action items for the project are defined and assigned to each team member.

1.2 Design Charrette

Resources

Getting to Zero: Zero Energy Integrated Design Charrette Toolkit for Schools. New Buildings Institute. https://newbuildings.org/wp-content/uploads/2017/10/ZEProjectGuide_NBI.pdf.pdf

Sample Integrated Design Charrette Checklist

Prior to the Event:

- ☐ Preliminary meeting/prep call
- ☐ Team members identified and invited
- ☐ Venue arranged
- ☐ Verify that venue has projector, easels, wall charts
- ☐ Arrange meals/snacks
- ☐ Agenda distributed to participants
- ☐ Assign pre-work for team
- ☐ Owner prepared for brief introduction
- ☐ Design team prepared for project overview
- ☐ Prepare presentations
- ☐ Make name tags
- ☐ Prepare sign in sheet (sample one attached to this list)
- ☐ Make copies of agenda
- ☐ Pack pens, name tags, tape, etc.
- ☐ Travel Research & Reservations
- ☐ Other:

Items to Bring:

- ☐ Copies of agenda
- ☐ Copies of other documents:
  ____
  ____
  ____
- ☐ Attendee list
- ☐ Sign in sheet
- ☐ Pens, markers, voting dots, name tags & business cards
- ☐ Wall charts for brainstorming: 3M-type poster-size sticky backed easel pad & easel if needed
- ☐ Laptop with PowerPoint, power and extension cords
- ☐ Digital Projector and extension cords
- ☐ ZE/eco materials: case studies, fact sheets, articles, etc.
- ☐ Resources: Living Building Challenge, CHPS, etc.
- ☐ Directions (map, driving directions), parking pass
- ☐ Other: ____________________
  ____

Day of Event:

- ☐ Set-up attendee list & name tags
- ☐ Set-up projector and computer
- ☐ Arrange for coffee, snacks
- ☐ Greetings & introduction
- ☐ Distribute handouts
- ☐ Facilitate meeting
- ☐ Clarify next steps
- ☐ Say thank you!

Post Event:

- ☐ Next day: thank you email
- ☐ Following week: draft report and distribute
- ☐ Continue follow up with team as process continues

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1.3 Owner's Project Requirement (OPR)

Summary

Intent

The intent of the Owner's Project Requirement (OPR) is to identify and describe the owner's energy efficiency and sustainability goals and expectations for the project. The OPR is used to clearly communicate the required outcomes and goals to the entire project team to ensure alignment around the goals. For the purposes of completing a ZNE-Ready project, the OPR must clearly state the commitment to a ZNE-Ready EUI, all-electric design, and wiring for future PV.

Primary Responsibility: Owner
Secondary Responsibility: Design Team

Program Requirements

For the ZNE Companion Program, the OPR must include the following:

- ☐ ZNE EUI goal for the project (25 kBtu/sf/yr and 20% regulated energy savings) or a modified EUI goal (30% energy savings for EB) or 40% energy savings for NC
- ☐ A list of initial ECMs to further analyze
- ☐ An owner's signature committing to the goals stated in the OPR (including an all-electric design and wiring for future PV)

Cross-Deliverable Consistency

The following design deliverables must be consistent with the OPR.

- 2.1 Energy Model
- 2.3 Basis of Design

2.1 and 2.3 must be based on the energy conservation measures (ECM) and EUI goal stated in the OPR. These will be checked by project team for consistency before submittal.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • **1.3 OPR**	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

1.3 Owner's Project Requirement (OPR)

Deliverable Description

Program Requirements

The OPR must include a ZNE EUI goal for the project and a commitment to an all-electric design and wiring for future PV. The EUI is calculated as annual energy use per square foot and is a metric for the project that is selected by the team during 1.2 ZNE Design Charrette. The nationwide EUI target for a ZNE project is 25 kBtu/sf/year; however, for this program the 25 EUI must also yield a regulated energy savings of at least 20%. If 25 EUI cannot be reached, a modified goal can be established, but must achieve at least 30% energy savings for existing buildings or 40% energy savings for new construction. Additionally, the OPR must include a list of clearly defined proposed energy conservation measures for further analysis, such as LED lighting and sensors, increased roof insulation, optimization of window orientation for daylighting, or ground source heat pumps with a COP of 4 or higher. The following sections provide examples of possible questions to answer in the document while defining these measures.

Note: Each project will be unique and not all these topics are required. In general, OPR documents typically range from one to five pages in length, depending on detail and complexity of goals and must be signed by the owner.

Owner and User Requirements

- What is the primary and secondary use type of this building (i.e. office, retail, etc.)?
- Will the potential to sell or lease parts of the building in the future be a consideration in the design?
- What are the financial metrics and acceptable payback period to be used to determine feasibility of an ECM? (e.g. Simple Payback, Return on Investment, Total Cost of Ownership, etc.)

Environmental and Sustainability Goals

- What are the sustainability or certification goals for the project separate from this program? (e.g. LEED Zero Energy, ILFI Zero Energy, etc.)
- Are there any funding sources whose program requirements should be considered as part of design? What are those requirements?
- What are the priorities regarding first costs, operational costs, and maintenance costs and management?
- What are the priorities regarding the characteristics of the building materials (e.g. high-recycled content, sustainably harvested, locally manufactured, low off-gassing)?
- What are the priorities regarding company exposure and marketing related to green design and construction?

Water and Landscaping

- What are the project's water reduction goals?
- What is the source of water? Is there access to reclaimed water on-site?

Energy Use and Building Component Efficiency

- What is the ZNE EUI goal that has been mutually agreed upon by the team?
- Any established operational energy cost concerns or budgets?
- What are the ideal performance characteristics of the thermal envelope (exterior), glass and glazing and roof?
- What are the thermal comfort parameters for occupants in the building?
- How much access should the building occupants be given over controls?

Renewables, Battery Storage, and Backup Power

- Does the building have on-site renewable energy? What type and preliminary capacity calculated (in kW)?
- Is there battery storage to cover peak load?
- Is backup generation needed? What systems will an emergency generator power?

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1.3 Owner's Project Requirement (OPR)

Resources

Owner's Project Requirements Example

1. **Owner and User Requirements**
   A. [PROJECT NAME] will serve as [building uses i.e. headquarter for company, office building, distribution center, etc.]. [OWNER] is a [DESCRIPTION OF OWNER/COMPANY]. The employee's and client's comfort is the number one priority and [OWNER] would like to provide a healthy, energy-efficient working environment through the use of carefully chosen building and finish materials and equipment.
   B. [OWNER] estimates to break ground by [DATE] and complete by [DATE]. The current size parameter for the building is [#] story(ies) and approximately [#] square feet of gross space.

2. **Certification Goals**
   A. Project shall meet [LEED-NC v4, LEED-CS v4, or LEED-CI v4] requirements at the [Certified, Silver, Gold or Platinum] performance level.

3. **Energy Efficiency Goals**
   A. Project shall reduce energy use in order to meet or exceed a ZNE EUI goal of [#] kBtu/sf/yr.
   B. Project shall comply with [ASHRAE, ICC, OR OTHER LOCAL STANDARDS] building energy efficiency standards.
   C. Lighting systems offer cost effective energy savings potential, and lighting fixtures and/or controls shall be selected to exceed minimum efficiency requirements by [#]% or greater.
   D. High efficiency HVAC equipment offers cost effective energy savings, and HVAC equipment shall be selected that exceeds minimum efficiency requirements by [#]% or greater.
   E. Additional energy efficiency measures that provide cost effective energy savings shall be included wherever feasible.

4. **Indoor Environmental Quality Requirements**
   A. Indoor lighting requirements: Use high efficiency luminaries (T5 or better) for all lighting, maximize use of daylighting (minimum of 75% of regularly occupied spaces), and all lighting shall be Energy Star compliant when applicable.
   B. Occupant lighting control requirements: Lighting controls will be provided for at least 90% of occupants and all shared multi-occupant spaces.
   C. Minimum ventilation requirements outlined in ASHRAE Standard 62-2010 shall be met or exceeded while maintaining thermal comfort requirements as listed in ASHRAE Standard 55-2010.
   D. All regularly occupied areas of tenant space provided with new air filtration media prior to occupancy that provides a MERV of 13 or better.

5. **Building Occupant and O&M Personnel Expectations**
   A. [OWNER] staff will occupy 100% of this building. Operations and maintenance staff will be employed by [OWNER]. [OWNER] requires operations and maintenance staff be trained on all systems including but not limited to, mechanical, electrical, plumbing, and fire alarm systems by installing contractors.

Owner Signature:

[DATE]

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Phase 2: Advanced Design

Intent: Ensure the final list of ECMs yields enough energy savings to meet the EUI goal cost-effectively, and that they are designed to satisfy monitoring and verification requirements.

Coordination: Occurs during early Construction Drawings (CDs).

- 2.1 Energy Model
- 2.2 Cost-Benefit Analysis
- 2.3 Basis of Design
- 2.4 Submetering and CDs

Phase 1: Prelim. Design | **Phase 2: Adv. Design** | Phase 3: Construction | Phase 4: Measurement | Phase 5: Verification

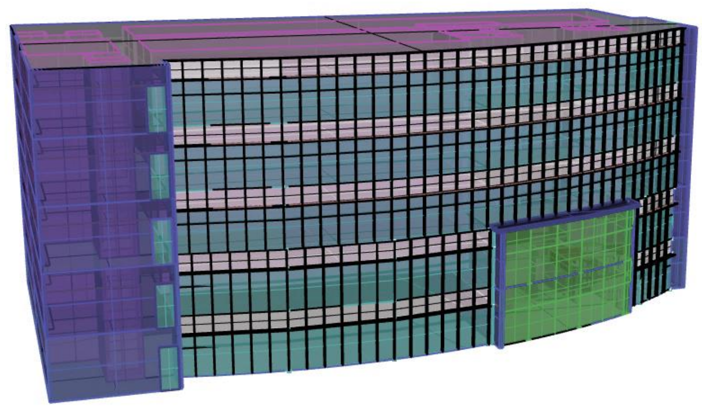
2.1 Energy Model

Summary

Intent

The intent of the energy model is to predict the annual energy use of the proposed design and the savings associated with each individual energy conservation measure (ECM). These results are used to verify that the EUI goal can be met with the proposed ECMs, and the associated energy savings are used to assess feasibility through the cost-benefit analysis and the M&V plan.

Primary Responsibility: Energy Modeling Consultant
Secondary Responsibility: Design Team



Program Requirements

For the ZNE Companion Program, the energy model deliverable must include the following:

- ☐ Baseline and proposed energy model output reports and executable files from approved software (to limit rework, submit the baseline model for initial review prior to working on the proposed model).
- ☐ Incorporated ECMs, adding them to the model cumulatively.
- ☐ The proposed model must meet the EUI goal (within 5% deviation).

Cross-Deliverable Consistency

The following program deliverables must be consistent with the energy model:

- 1.3 OPR
- 2.2 Cost Benefit Analysis
- 2.3 Basis of Design
- 3.2 M&V Plan

The proposed model EUI must meet or exceed the EUI goal stipulated in the signed OPR. All ECMs incorporated into the final proposed model must be assessed for economic feasibility in cost-benefit analysis, described in detail in the BOD, and measured in the M&V plan.

Phase 1: Prelim. Design
- 1.1 Preliminary Energy Model
- 1.2 ZNE Design Charrette
- 1.3 OPR

Phase 2: Adv. Design
- **2.1 Energy Model**
- 2.2 Cost-Benefit Analysis
- 2.3 Basis of Design
- 2.4 Submetering & 100% CDs

Phase 3: Construction
- 3.1 Construction Kickoff
- 3.2 M&V Plan
- 3.3 Circuiting Inspection
- 3.4 Envelope BCx
- 3.5 System-level Cx

Phase 4: Measurement
- 4.1 Monitoring Equipment
- 4.2 Performance Testing

Phase 5: Verification
- 5.0 Verification of ZNE EUI goal

2.1 Energy Model

Deliverable Description

Program Requirements

The energy model or whole building interactive energy simulation, aids in the design efforts by predicting the interactive energy and energy savings associated with each Energy Conservation Measure (ECM). This supports the ECM optimization and decision-making process. The analysis involves evaluating the performance of a given climate, building envelope, occupants, equipment, heating, cooling and ventilation loads hourly over a year (8,760 hours) to determine energy use. Reasonable occupancy schedules and equipment usage schedules should be used consistently for the baseline and proposed models to compare the energy use of the building over time. To accurately assess the annual energy savings, a realistic baseline model must be created using ASHRAE 90.1 Appendix G protocol and calibrated using past energy use data or using code minimum inputs. Building off that model, the ECMs are then cumulatively added to the model until the proposed design is complete and the EUI goal has been reached. For the program deliverable, the energy model deliverable must include both baseline and proposed energy model output reports from approved software and the executable files, incorporate ECMs for at least two whole building systems, and meet the EUI goal (within 5% deviation).

Software:
There are many options for energy modeling software that quantitatively predict a building's annual energy use. The software must be capable of simulating hourly energy use for all energy specific components (e.g. air conditioning, lighting, etc.) by evaluating the building against the weather conditions of an entire year. The model simulates the interactive effects of the of the building envelope, internal loads, and capabilities of the mechanical equipment. The table on the right includes a list of accepted energy modeling software for the ZNE Companion Program with varying capabilities, limitations and costs.

Weather file:
Typical meteorological year (TMY) weather data is the commonly used type of weather file in energy modeling software. TMY is a collation of selected weather data for a specific location, collected for a minimum of ten-years and then averaged for an annual period. TMY weather file is acceptable to use in the energy model for the ZNE Companion Program; however, the use of "actual meteorological year" (AMY) weather data is required for models calibrated to a specific year.

Accepted Energy Modeling Software	
Free	• Energy Plus • eQUEST • Open Studio
Not Free	• Integrated Environmental Solutions Virtual Environment (IES-VE) • Trace 700 • Trane 3D + • Design Builder • Carrier HAP • Autodesk • EnergyPro • Sefaira

(This list does not constitute an endorsement from Consumers Energy.)

Input data and assumptions:
Input data used in the model should represent the best available information about the design of the building and if the building is already existing, actual performance data from key components in the facility. Using actual collected data is preferred for occupancy and schedules as opposed to using the ASHRAE defaults, unless actual data is unavailable.

2.1 Energy Model

Deliverable Description (cont.)

Baseline Model

The baseline model should denote the baseline design prior to incorporation and implementation of specific ECMs for the project.

Baseline Model Inputs and Assumptions

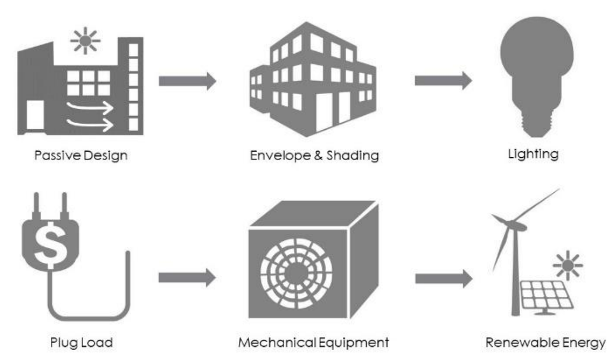
	Existing Building	New Construction
Calibration	Calibrated using actual energy data	No calibration
Occupancy	Existing occupancy (or close to)	Predicted actual use
Schedules	Existing schedule	Predicted actual use
Envelope	Existing assemblies and thermal properties	Code minimum assemblies and thermal properties
Lighting	Existing wattage by lighting zone	Code minimum LPD using space-by-space method
Mechanical Equipment	Existing systems installed (if all-electric, otherwise use all-electric code minimum)	All-electric code minimum equipment and efficiencies

Calibration:

Calibrating a model is a process that aligns the theoretical model with the actual building performance to more reliably test ECM. A tolerance or deviation to the historical data due to software limitations and unknown usage factors is expected. The ZNE Companion Program encourages following the calibration procedure set out in the International Performance Measurement & Verification Protocol (IPMVP) Option D. However, this program's accepted tolerances are within 10% of monthly and 5% of annual energy use. Another option for calibration compliance is through the industry accepted ASHRAE Guideline 14. This calibration guidance targets compliance based on less than 15% coefficient of variations of the root mean square CV(RMSE) and less than 5% when calibrating a model to monthly data.

Proposed Model

The proposed model should be a representation of the final building design energy use that must be equal or less than the ZNE design EUI set by the customer and team. Once the baseline model is complete, the ECMs need to be cumulatively added onto the model in the appropriate loading order (see below image). Most importantly, the mechanical ECMs must be last to ensure proper equipment sizing based on the reduced load from the other measures.



With each ECM addition, the model must be saved and simulated to identify the energy savings associated with each measure. Also keep in mind that some ECMs will have multiple options (e.g. varying R-values for the roof, different HVAC equipment, etc.), but only one option will continue into the final design.

The final, all-electric proposed energy model will then include all ECMs that the project is moving forward with. This final selection will likely be modified based on the economic analysis results.

The purpose of this energy modeling analysis is to answer the following questions:

- Can we reach our EUI goal?
- How much energy does each measure save? (This is then used for the cost benefit analysis).
- If there are multiple options for an ECM (roof A vs roof B), which one has the better results?
- Which ECMs are selected for the final design?

2.1 Energy Model

Resources

There is no example document for this deliverable, since the required deliverable is simply the output reports and/or the executable model file. However, to expedite the review process, putting together an energy model report can be beneficial to compile the model results, explain assumptions, workarounds and any troubleshooting issues. The following is a list of resources to help during the energy modeling process.

ASHRAE 90.1-2013 Appendix G

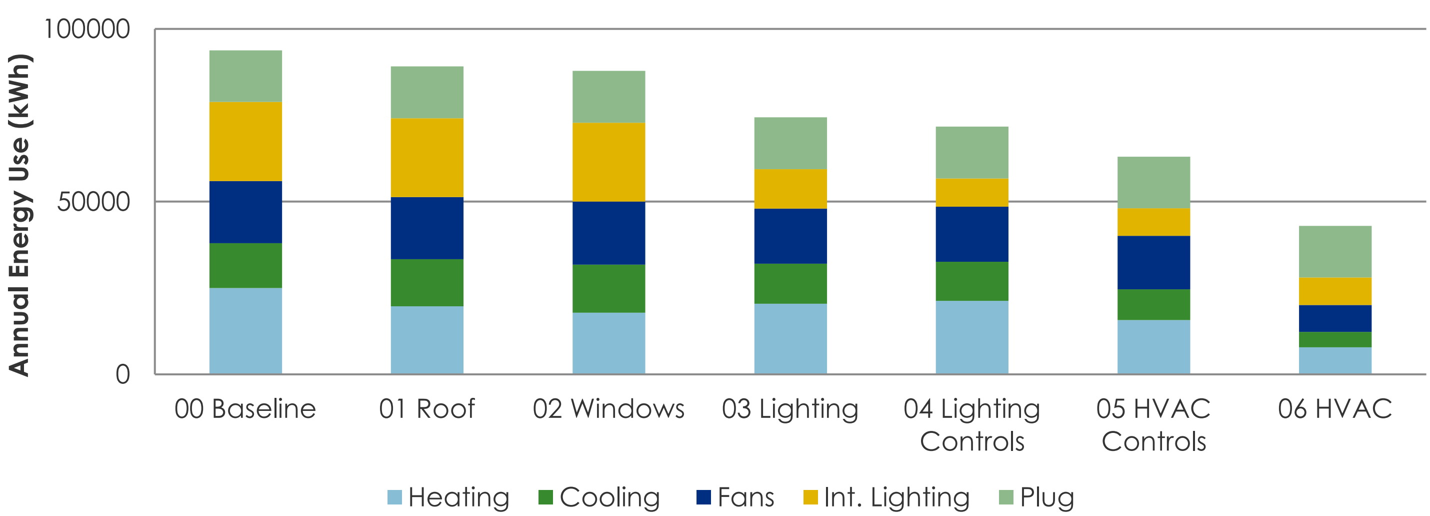
2015 Michigan Building Code

ASHRAE Guideline 14

International Performance Measurement & Verification Protocol (IPMVP) Option D

As previously stated, it is required that the ECMs are cumulatively added to the baseline model. The following is an example of the saved model iterations and a sample graph of the results. The actual selected ECMs may vary per project.

- 00 Baseline model
- 01a Baseline + roof upgrade A (ECM not selected, does not carry forward)
- 01b Baseline + roof upgrade B (selected ECM)
- 02 Baseline + roof B + window upgrade (selected ECM)
- 03 Baseline + roof B + window + LED upgrade (selected ECM)
- 04 Baseline + roof B + window + LED + LED controls (selected ECM)
- 05 Baseline + roof B + window + LED + LED controls + HVAC controls (selected ECM)
- 06a Baseline + roof B + window + LED + LED controls + HVAC controls + HVAC upgrade A (selected ECM)
- 06b Baseline + roof B + window + LED + LED controls + HVAC Controls + HVAC upgrade B (ECM not selected)
- 06c Baseline + roof B + window + LED + LED controls + HVAC Controls + HVAC upgrade C (ECM not selected)
- 07 Proposed model = Baseline + roof B + window + LED + LED controls + HVAC Controls + HVAC A



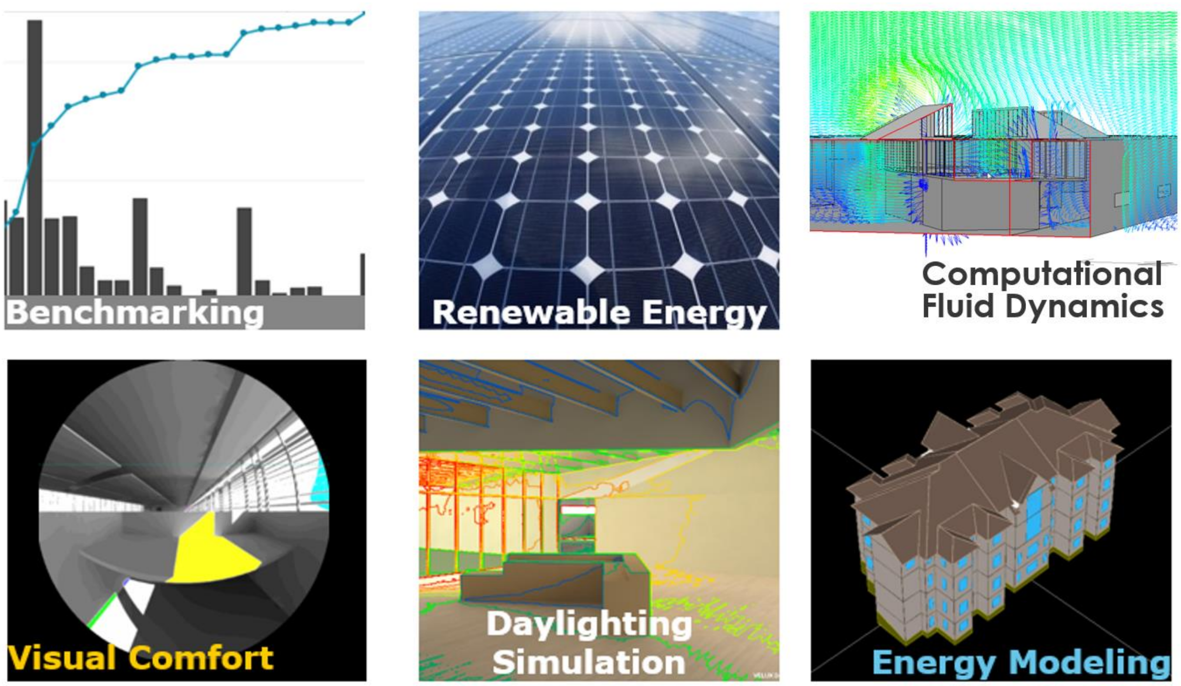
2.1 Energy Model

Resources (cont.)

The following is a list of acceptable output reports required for this deliverable.

DOE2, eQUEST & Visual DOE	EnergyPlus & Open Studio	Carrier HAP	Trane TRACE
Building Energy Performance (BEPS)	Annual Building Utility Performance Summary (ABUPS)	Annual Cost Summary	Energy Cost Budget/PRM Summary
Building Utility Performance (BEPU)	System Summary (showing the unmet load)	Unmet Load Report (for all plants and systems)	Energy Use Summary Reports
Energy Cost Summary (ES-D)	Report that shows energy cost	Systems Energy Budget	Performance Rating Method Details
System Design Parameters (SV-A)	Equipment Summary & System Summary	System Input Data Reports	Equipment Energy Use
Summary of Exterior Surfaces (LV-D)	Envelope Summary	Wall Constructions	Entered Values Report (for all rooms and systems)

This image includes additional types of advanced modeling and analysis that may be relevant to the project depending on the ECMs being pursued.



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2.2 Cost-Benefit Analysis

Summary

Intent

The intent of the cost-benefit analysis is to determine the cost and savings of each ECM. The energy cost savings per ECM should be predicted using the energy model results and energy cost data. Some common metrics used for this analysis include simple payback, return on investment (ROI), internal rate of return (IRR), or life-cycle assessment (LCA). The cost-benefit analysis results are then used to inform ECM decision-making for the final design, typically approved by the owner and/or owner's representative for the project. This analysis is especially important when comparing multiple options for a single building system (e.g. assessing various insulation thicknesses for the roof or HVAC system options). The final ECM list approved for the project must still meet the agreed upon ZNE EUI goal for the program.

Primary Responsibility: Design Team
Secondary Responsibility: Owner / Owner's Rep.

Program Requirements

For the ZNE Companion Program, the Cost-Benefit Analysis deliverable must include the following:

- ☐ Cost-benefit analysis calculation inputs and resulting metrics for each individual ECM.
- ☐ An updated list of approved ECMs for the final design (the proposed energy model must be updated with these ECMs to ensure the EUI goal can still be met).

Cross-Deliverable Consistency

The following program deliverables must be consistent with the Cost-Benefit Analysis.

- 1.3 Owner's Project Requirements
- 2.1 Energy Model
- 2.3 Basis of Design

All ECMs in the 2.1 energy model must be assessed in the cost-benefit analysis. The final ECM list approved after the cost-benefit analysis must still meet the agreed upon ZNE EUI goal stipulated in the 1.3 OPR. All ECMs in the final design must be described in the 2.3 BOD. These will be checked by the project team for consistency before submittal.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • **2.2 Cost-Benefit Analysis** • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

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2.2 Cost-Benefit Analysis

Deliverable Description

Program Requirements

The objective of developing a cost-benefit analysis is to financially assess ECMs and design alternatives. This is a necessary step in any design construction process but especially when evaluating the cost benefit of ECMs to achieve a certain EUI goal. Cost-benefit calculations can follow different methodologies (e.g. simple payback, ROI, IRR, LCA, NPV, etc.). This guide uses simple payback as an example for the deliverable; however, the Consumers Energy ZNE Companion Program does not limit which calculation can be used if it meets the needs of the financial decision-makers and helps to inform their process.

Inputs and Calculations

The cost-benefit analysis is typically summarized in a spreadsheet (e.g. Microsoft Excel, energy model software output tables, etc.). The equation below is how to calculate simple payback. Keep in mind that not all input values may be needed, and other inputs could be added depending on the needs of the project. Since the annual energy savings from the energy model is calculated as the difference between a baseline design and a proposed design, the savings are incremental between the two. Therefore, it is helpful to use incremental comparisons for all the other input values. For example, if the code minimum HVAC system costs $10,000 and the higher efficiency version costs $15,000, the added cost for this ECM would be stated as $5,000. In new construction projects or existing buildings with systems that are at the end of their life and require replacement, the cost would be the incremental cost between the baseline system and the more efficient one. However, if the baseline condition requires no added cost then the incremental costs would be equal to the full cost of the proposed ECM (e.g. baseline = no building controls; proposed = full cost of adding a building automation system).

$$\text{Simple Payback (years)} = \frac{[(\Delta\, capital\ cost) - (utility\ incentives) - (reduced\ cost\ of\ PV\ for\ ZNE)]}{[(annual\ energy\ savings) + (\Delta\, annual\ maintenance\ costs)]}$$

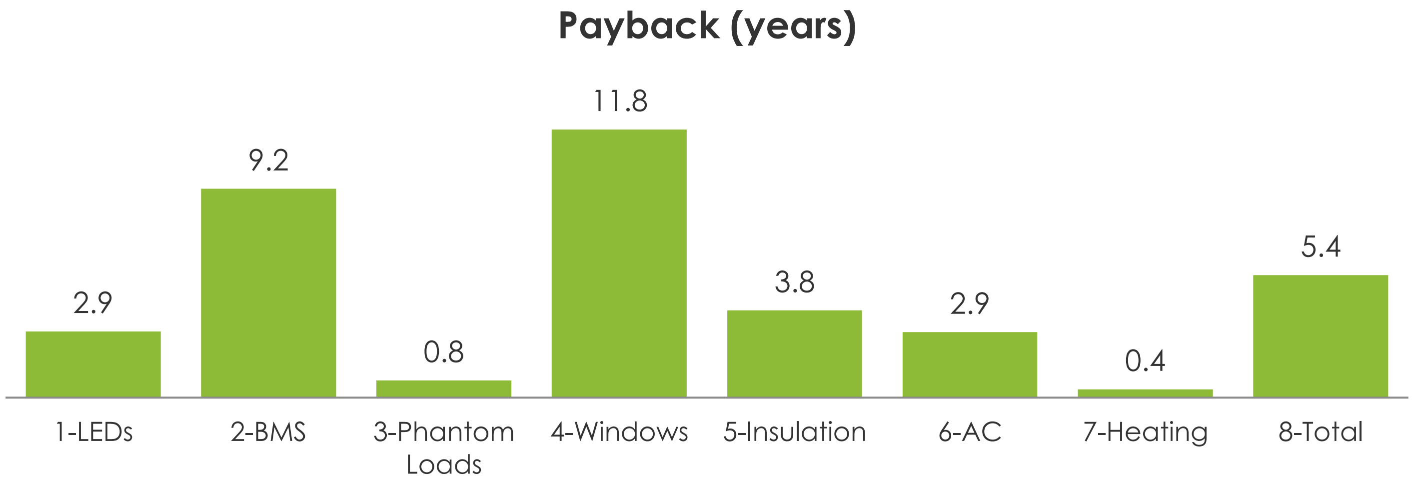
∆ capital costs	The capital costs are the incremental costs (compared to a baseline design) to purchase and install the ECM.
Energy provider incentives	Any added rebates or incentives (if applicable).
Reduced cost of PV for ZNE	Although generating enough energy to meet 100% of the annual energy use of the building with renewable energy is not a set requirement of the program, it may be a goal of the project owner. In which case, it is important to calculate the cost savings associated with reducing the PV array size needed, since less annual energy use means less PV installed.
Annual energy savings	The annual energy savings taken from the energy model must reflect the total energy savings for each ECM as an interactive savings. (Reminder: the ECMs must be cumulatively added to the model; therefore, the savings for each ECM is the difference in energy use each time an ECM is added to the model).
∆ annual maintenance	The typical annual maintenance cost is the difference between a baseline maintenance and the maintenance required with the new ECM system. This value may be positive or negative.

Cost-benefit is one way of assessing ECMs for viability; however, it is not uncommon for ZNE buildings to select ECMs based on energy reduction or added qualitative value (e.g. improved thermal comfort, reduced glare, educational aspects, marketing potential, etc.) regardless of a longer payback. The ECM should be selected based on the owner's financial commitment and sustainability goals established in the OPR.

2.2 Cost-Benefit Analysis

Resources

The following is an example of a payback graph and a cost-benefit analysis table. Note: when calculating the total payback for the project, each ECM's payback cannot simply be averaged together. They are not evenly weighted percentages of the total cost of the proposed design; therefore, the total payback must be calculated using the sum of each of the input values per ECM.



Energy Conservation Measures	Capital Cost	Energy Provider Incentives Available	Reduced PV Costs for ZNE	Δ Maintenance Cost	Annual Electric Cost Savings ($/year)	System Life (years)	Payback (years)
ECM 1							
ECM 2							
ECM 3							
ECM 4							
ECM 5							
ECM 6							
ECM 7							
Total							

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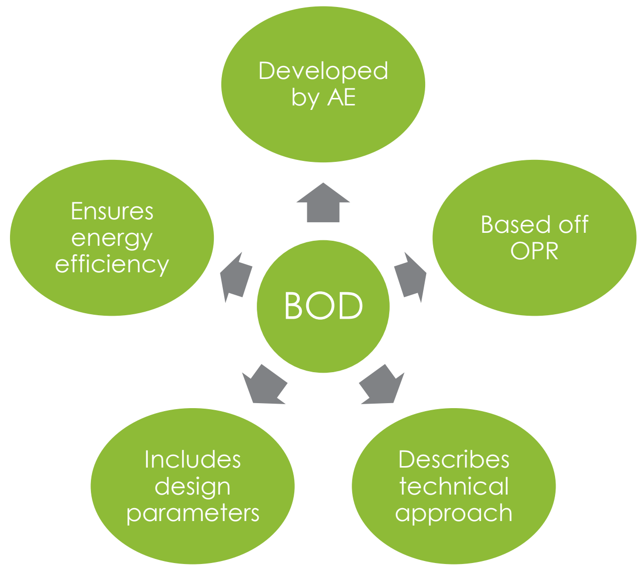
2.3 Basis of Design (BOD)

Summary

Intent

The intent of the Basis of Design (BOD) is to describe the technical approach to achieving the goals set in the Owner's Project Requirement through various energy efficiency and sustainability measures. The BOD must include the design parameter details for each of the ECMs in the final design. This document is then used as a reference guide by the design, construction and commissioning teams to ensure the appropriate materials, equipment and installation methods are implemented during construction. The BOD should be completed and reviewed prior to the 50% CD mark to ensure there is enough time to implement changes to the design.

Primary Responsibility: Design team (architect/engineers)



Program Requirements

For the ZNE Companion Program, the BOD must include the following:

- ☐ The ZNE EUI goal for the project
- ☐ A detailed description for each of the ECMs selected for the final design (i.e. description of building envelope, HVAC and lighting systems with performance efficiencies, wiring for future PV or current renewable design, etc.)

Cross-Deliverable Consistency

The following program deliverables must be consistent with the BOD.

- 1.3 Owner's Project Requirements
- 2.1 Energy Model
- 2.2 Cost Benefit Analysis
- 3.1 Construction Kickoff Meeting
- 3.4 Envelope Cx
- 3.5 System-level Cx

The BOD must include all ECMs used in 2.1 and 2.2 to meet the EUI goal stated in the OPR. The BOD will be reviewed during the construction kickoff meeting and used during commissioning.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • **2.3 Basis of Design** • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

2.3 Basis of Design (BOD)

Deliverable Description

Program Requirements

The BOD should establish the multidisciplinary framework needed to meet the goals and objectives set forth in the OPR. Specifically, for this program, the BOD must expand upon the selected ECMs needed to achieve the ZNE EUI goal for the project. The BOD is the primary document that provides a detailed description of each individual building systems such as heating, ventilating and air conditioning (HVAC) systems, electrical, building envelope, building automation system, etc. The BOD describes the technical approach planned for the project as well as the design parameters to be used. The BOD is typically developed by the design team (led by the architect), and each building section is completed by that specific discipline (i.e. lighting systems section would be completed by the electrical designer/engineer on the project). As a result, it is written in technical terms; whereas the OPR document is developed by the owner and is more of a summary document expressed in layman's terms.

The following is an example excerpt of language that is found in a typical BOD when defining the technical approach to a ZNE-Ready project. A BOD outline is presented in the Resources section; however, each project will be unique and not all sections may be required. In general, a concise BOD document is typically four or more pages in length, depending on detail and complexity of technical specifications and approaches.

Example HVAC Section

HVAC Equipment

The list for major mechanical and plumbing equipment is described below. In addition, all exposed equipment shall have proper coating for a marine environment.

1. 234 two-ton vertical (VTAC) AC-units, 24,000 BTU/HR (One per unit)
2. MAU-1 through MAU-4, 100% outside air AC units, 15,000 CFM, 20 HP, VFD, heating & cooling, etc.
3. EF-1 thru EF-6, typical toilet and general exhaust for living modules, 10,000 CFM, 7.5 HP, roof mounted, VFD
4. Misc. split system for NMCI/telecom room, elevator room, etc.
5. Misc. fan coil split system units for common areas, lobby, etc.

HVAC Control System

The following controls shall be provided for the HVAC equipment:

1. Vertical AC-units (VTAC) shall operate on local, non-DDC thermostatic control.
2. MUA units shall be controlled by JCI Metasys Bacnet DDC controls per UFGS 23 09 23.13 20.
3. Exhaust fans shall be controlled by JCI Metasys Bacnet DDC controls per UFGS 23 09 23.13 20.
4. Split systems shall be controlled by Bacnet DDC network thermostat controllers.
5. Two ATFP shut down buttons shall be provided per floor. MUA units and EFs shall be shut down via DDC network.
6. DHW system shall be controlled by the JCI Metasys Bacnet DDC controls system per UFGS 23 09 23.13 20.
7. JCI Metasys NAE55 (Network Automation Engine) shall be provided with industry standard JCI graphics.

2.3 Basis of Design (BOD)

Resources

The following is an example outline for a BOD with program-specific items highlighted in green. A typical BOD includes details for the entire project (even items outside the scope of the Consumers Energy ZNE Companion Program). The layout, structure and content of the BOD deliverable can be modified to best meet the needs of the design team.

Basis of Design Example Outline

I. Project Summary
II. Architectural
  A. Referenced Standards
  B. Space Usage & Functions
  C. Structure & Interior
  D. **Envelope materials – assemblies and thermal properties for exterior walls, roof, doors, glazing, etc.**
  E. Preliminary Color & Finishes Scheme (and Furniture, if applicable)
  F. Circulation & Egress
  G. Accessibility and Other Considerations
III. Structural
  A. Referenced Standards
  B. Foundation
  C. Structural Floor & Roof Systems, including materials and loads
  D. Other Considerations
IV. Civil
  A. Referenced Standards
  B. Site & Soil Conditions
  C. Demolition
  D. Environmental Pollution / Erosion & Sedimentation Control
  E. Water & Sewage Systems
  F. Drainage
  G. Existing & Planned Utilities
  H. Other Considerations
V. Landscaping
  A. Referenced Standards
  B. Existing & Planned Landscaping
  C. Irrigation
  D. Other Considerations
VI. Plumbing
  A. Referenced Standards
  B. Existing & Planned Systems
  C. Water Demand
  D. Fixtures
  E. **Domestic Hot Water & Distribution – design specifications of equipment including efficiencies**
  F. Piping Materials
  G. Other Considerations
VII. Heating, Ventilation & Air-Conditioning (HVAC)
  A. Referenced Standards
  B. Design Conditions
  C. Heating
    1. Source
    2. **Heating Medium & System(s) – design specifications of equipment including efficiencies**
    3. **Control System**

2.3 Basis of Design (BOD)

Resources (cont.)

- D. Ventilation
  1. **Outside Air Requirements & Control**
  2. **Exhaust Requirements**
  3. **Modes of Operation**
- E. Air Conditioning
  1. **AC System – design specifications of equipment including efficiencies**
  2. Conditioned Areas
  3. Humidification, Dehumidification & Filtration Requirements
  4. **Features to Reduce Cooling Loads**
- F. Refrigeration
  1. Areas to be Refrigerated
  2. **Refrigeration System**
- G. Central Plants & Special Mechanical Equipment
  1. **Energy Analysis**
  2. Environmental Constraints
  3. **New Boilers – design specifications of equipment including efficiencies**
  4. **Control System**
  5. New Auxiliaries & Power Source
- H. Other Considerations

VIII. Electrical
- A. Referenced Standards
- B. Characteristics
- C. Load Breakdown
- D. **Wiring & Circuiting – submeter set up to measure per end use and/or per tenant**
- E. **Lighting Systems – details on selected fixtures, sensors and wattage**
- F. **Electronic Systems**
- G. **Renewable Energy Systems**
- H. Special Systems
- I. Other Considerations

IX. Fire Protection
- A. Referenced Standards
- B. Fire-Rated Assemblies
- C. Detection and Alarm Systems
- D. Extinguishing Systems
- E. Other Considerations

X. Sustainable Design
- A. Referenced Standards
  1. **Green Code Requirements**
  2. Building Rating Systems
- B. **Design Features**
- C. **Sustainability Goals & Objectives**
- D. Other Considerations

2.4 Submetering & Construction Documents

Summary

Intent

The intent of submitting the construction documents is to ensure that the project is set up for end-use or tenant-level submetering, as well as wiring for future or current renewable systems. The data collected from the submeters is required for successful commissioning, measurement and verification, performance testing and case study data sharing. Real-time data monitoring is also vital for tenant involvement in energy conservation by use of dashboards throughout the building. Submetering makes it possible for the owners, tenants, and building managers to identify abnormalities in the buildings systems and/or their usage during the measurement phase and for years to come.

Primary Responsibility: Electrical & HVAC Engineers
Secondary Responsibility: Design Team

Program Requirements

For the ZNE Companion Program, the Construction Plan must include:

- ☐ Submetering plan and list of end-uses or tenant spaces to be monitored per circuit (per the intended M&V option).
- ☐ Electrical drawings of wiring and connections to designated areas for (future or current) renewable systems.
- ☐ 100% CDs, including circuiting plan.

Cross-Deliverable Consistency

The following program deliverables must be consistent with the circuiting plan.

- 2.3 BOD
- 3.2 M&V Plan
- 3.3 Circuiting Inspection
- 3.5 System-Level Cx
- 4.1 Monitoring Equipment
- 4.2 Performance Testing
- 5.0 Verification

Moving forward, the construction documents and submeter data will be referenced for almost every remaining deliverable. They are key components to ensuring proper installation of ECMs during construction, testing of equipment and monitoring energy use. Reference 3.2 for M&V option selection details.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • **2.4 Submetering & 100% CDs**	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

2.4 Submetering & Construction Documents

Deliverable Description

Program Requirements

Each project must submit construction documents developed by an electrical engineer that include a circuiting diagram (aka: one-line diagram), setup requirements for submetering building end-uses and/or tenant-level usage, as well as wiring and connections to designated areas for (future or current) renewable systems. Confirm which IPMVP Option has been selected for the future M&V Plan deliverable and ensure that the submetering plan and selected monitoring points line up with the required data collection.

New Construction Versus Existing Buildings
For new construction projects, the level of detail and precision that can go into isolating end-uses is extremely high and is therefore required. Existing buildings, on the other hand, are limited based on existing conditions and potentially cost-prohibitive re-wiring. Therefore, the Consumers Energy ZNE team will work with existing building project teams to come up with a submetering solution that maximizes disaggregation of energy use without breaking the bank.

What to Measure – Monitoring Point Selection
Before coming up with a submeter plan, the project team must first decide what kind of data is needed and how it will be used. This program recommends disaggregation of energy use down to lighting, plug load and HVAC (preferably down to specific HVAC equipment as it is installed). If the building has tenants, it may also be beneficial to the owner to submeter per tenant. Here are some examples of questions to ask while creating the submetering plan and selecting monitoring points and logging periods:

- ECMs: Based on selected ECMs is there specific equipment that needs monitoring?
- Dashboards: What data do we want to show the tenants to increase education, gamification, and overall energy savings?
- M&V Plan: What loads need to be isolated based on the IPMVP Option selected for deliverable 3.2? (This is why it is important to bring the commissioning agent on to the project during the design phases.)
- Setup: What should the sequence of operation be for the monitoring systems?

Types of Monitoring Equipment
There are many types of monitoring equipment to choose from (i.e. HOBO data loggers, DENT meters, whole building monitoring systems, submeters, etc.). Consumers Energy does not require a specific brand or type of equipment if it meets the needs of the project.

Responsible Parties
It is the business owner's responsibility to purchase and install all the monitoring equipment and maintain monitoring operations for the duration of the program's post-occupancy performance testing and 12-month performance period.

2.4 Submetering & Construction Documents

Deliverable Description (cont.)

Wiring and Connections for Future PV

Being a ZNE-Ready program, it is a requirement to install wiring and connections to designated areas for future renewable system installations. Including on-site renewable energy in the current design is not officially required, but highly recommended.

This program requires projects to be 'solar ready' unless certain exceptions are met (listed below). Projects are required to include the following information on their construction drawings to be considered solar ready and in compliance with the program:

- The project's construction drawings must include information on structural loads and plans for connecting a photovoltaic system to the electrical systems of the building.
- The structural design loads shall be clearly indicated on the construction drawings so that the loads are known for a future photovoltaic system. Structural design load requirements apply for any roof mounted photovoltaic systems.
- A plan for connecting the photovoltaic system to the electrical system of the building must be included in the construction drawings, as well as a location for inverters and metering equipment for the future solar electrical systems.
- There is no requirement to install conduit. Rather, the drawings must show where the conduit would be installed if a system were installed at a future date.

Exceptions:

- Photovoltaic system is already permanently installed.
- Solar access at the building site is limited due to adjacent shading (e.g. from neighboring buildings, vegetation).
- Existing conditions (i.e. building's age) prevent installation of the photovoltaic system. Project team must provide documentation of a compelling justification for their exemption from this requirement.

2.4 Submetering & Construction Documents

Resources

The below tables are examples of monitoring lists determining submeter placement for systems and sub systems.

	Hardware (data logger provides information for remote access)	Initial Field Requirements	Analysis	Manual Calculations and Inputs by Operation & Maintenance Staff
Building Water	Flow meter trended via software	On-site calibration required	Analyze and compile data, calculate use and provide monthly report	Review and provide flow meter outputs
Building Electrical	Main meter trended via software			
Building Plug/ Process kWh	Sub-meter trended via software	On-site calibration required for sub-meter on main electrical board		
Building Interior Light kWh				

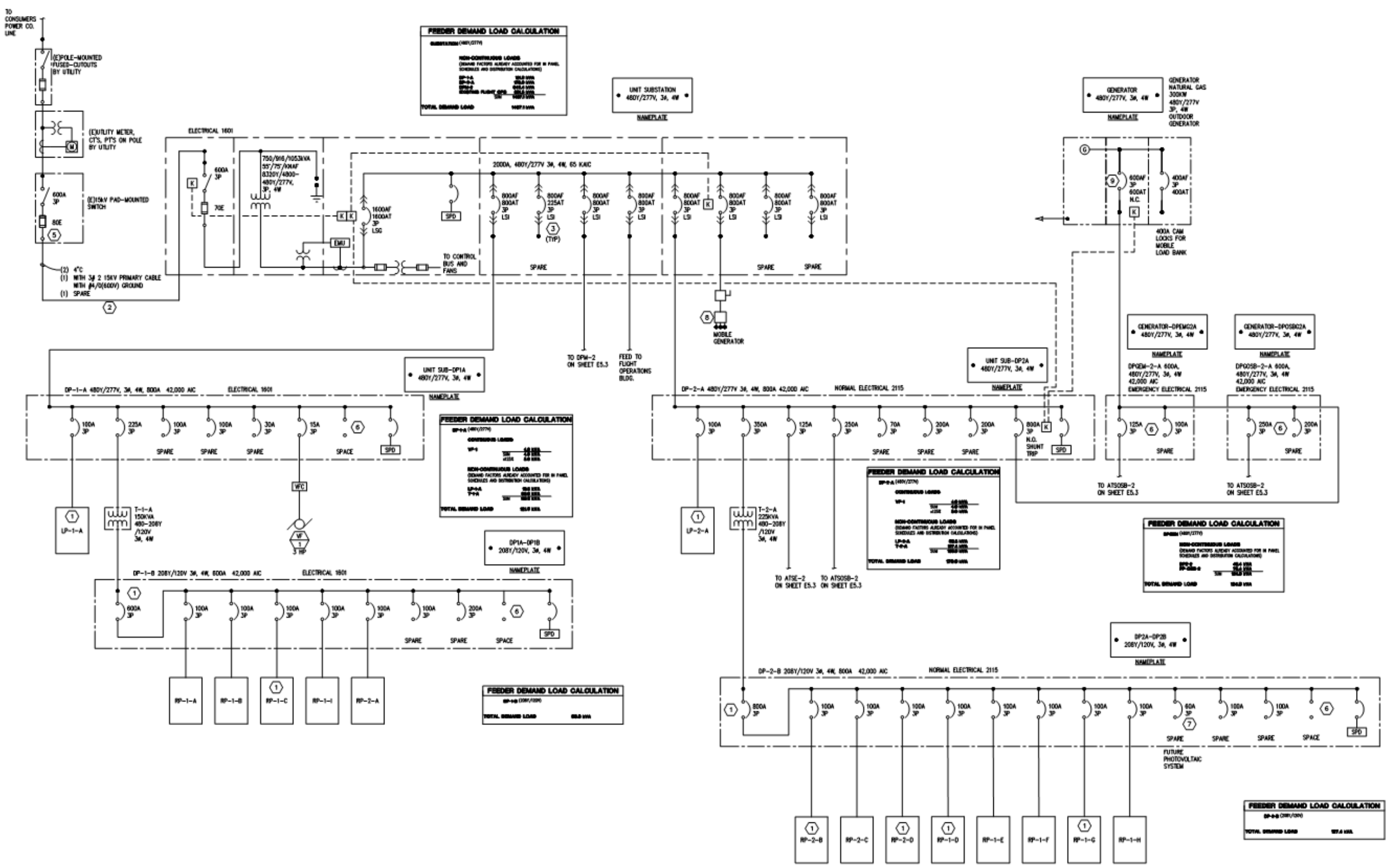
	Sub System	Hardware	Initial Field Requirements	Energy Calculations	Manual Calculations and Inputs by Operation & Maintenance Staff
HVAC system operation and thermal trending	HVAC system operation and thermal trending	Externally located temperature and humidity sensor(s)	On-site calibration required	Analyze and compile hourly temperature and humidity level data	Use outputs from internal space sensors and the system sensors to calculate hourly thermal load and building load profile
HVAC system operation and thermal trending	Internal space temperature and humidity sensor(s)	Internally located temperature and humidity sensor(s)			
Geo-power System	Geo-power fan inlet temperature and humidity sensor	Duct located temperature and humidity sensor(s)			Use geo-exchange usage data to estimate the hourly ground temperature and energy exchange
Geo-power System	Geo-power supply fan volume	Air flow meter/ fan motor speed monitoring		Analyze and compile hourly supply volume	Use geo-power supply fan usage data to modulate supply volumes
Geo-power System	Geo-power supply fan outlet temperature and humidity sensor	Duct located temperature and humidity sensor(s)		Analyze and compile hourly temperature and humidity level data	Use supply volume monitoring to calculate load capacity and total thermal energy supply to the space

2.4 Circuiting Plan

Resources (cont.)

Sample Diagram

Below is a sample circuiting plan (also known as a “one-line diagram”).



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Phase 3: Construction

Intent: Ensures the project will be properly constructed and circuited to achieve the anticipated energy savings, as well as reduce maintenance issues and provide ongoing accountability of building energy use and data collection over time.

Coordination: Occurs before, during and after building construction.

- 3.1 Construction Kickoff Meeting
- 3.2 Measurement & Verification Plan
- 3.3 Circuiting Inspection
- 3.4 Envelope Commissioning
- 3.5 System Level Cx

Phase 1: Prelim. Design | Phase 2: Adv. Design | **Phase 3: Construction** | Phase 4: Measurement | Phase 5: Verification

3.1 Construction Kickoff Meeting

Summary

Intent

The intent of the construction kickoff meeting is to review ECM specifications from the BOD to identify specific requirements for installation and O&M goals for the building systems, as well as coordinate the commissioning (Cx) and construction schedules. This meeting must occur prior to the start of construction. This will help the construction team members identify specific requirements unique to the construction process for a ZNE building. ZNE buildings often include new technologies, abnormal installations, and more vigorous operations and maintenance goals for building systems.

Primary Responsibility: Cx Agent and GC
Secondary Responsibility: Design Team/Owner

Program Requirements

For the ZNE Companion Program, the Construction Kickoff Meeting must include the following.

- ☐ On-site meeting with third party Cx Agent, Consumers Energy representative, contractor and construction team.
- ☐ Pre-review of agenda with Consumers Energy prior to the kickoff.

Cross-Deliverable Consistency

The following design deliverables must be consistent with the construction kickoff meeting:

- 2.3 Basis of Design
- 3.4 Envelope Cx
- 3.5 System-level Cx

All relevant requirements for installation included in 2.3 must be discussed in the construction kickoff meeting. Agenda of this meeting shall be provided to the Consumers Energy Team one-week prior to the meeting. ECMs discussed will be commissioned during 3.4 and 3.5.

Phase 1: Prelim. Design	Phase 2: Adv. Design	**Phase 3: Construction**	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• **3.1 Construction Kickoff** • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

3.1 Construction Kickoff Meeting

Deliverable Description

Program Requirements

This construction kickoff meeting allows crucial information about installation and/or operations and maintenance requirements to be reviewed before the construction of the project begins. At this face-to-face on-site meeting, the team members also discuss how to deal with pressing issues. The importance of the EUI goal, established because of the Energy Modeling and Cost Benefit Analysis, will be addressed and reaffirmed as the reason for the list of energy conservation measures for the project. Each discipline will be made aware of their respective equipment and/or materials being installed and how it is to be operated according to program requirements.

The design team must address the following issues during the kickoff to ensure the proper installation and an uninterrupted construction schedule:

What is the final list of ECMs?

- Each ECM must be confirmed along with associated responsible sub-contractors.

Are there any unforeseen conditions that change the expected installation schedule?

- If there is a known schedule change (due to weather delay, delivery issues, labor schedule, etc.), the construction kickoff is the appropriate time to discuss it.

Are all subcontractors and necessary trades engaged on the project?

- When each system installation is discussed, the subcontractor responsible should be identified and confirm their responsibility.

Per system or equipment, what operating requirements are necessary to meet the established Basis of Design (BOD)? The Cx agent may lead this discussion to confirm:

- Is there a manufacturer's warranty?
- Are there temperature or ventilation restrictions for the product or system?
- Are there any other operations or maintenance requirements to ensure proper use of system or equipment?

Are there any non-traditional constructions measures included?

- Any new or uncommon technologies to the design team (e.g. Solatubes) should be flagged for discussion to confirm any additional installation or operation requirements.

What are the monitoring points for submetered equipment?

When applicable, ensure responsible subcontractors are aware what equipment is to be sub-metered.

3.1 Construction Kickoff Meeting
Deliverable Description (cont.)

Construction Kickoff Attendees (at a minimum):

Consumers Energy Representative

Commissioning Agent

General Contractor

Subcontractors

Architect/Designer

Production Manager

Job Superintended/Foreman

Suggested Agenda for Ongoing Meetings

Moving forward through the construction phase, it is highly recommended that ongoing meetings continue after the kickoff. This will help ensure that the project stays on track. Below is a suggested agenda for the ongoing meetings.

Encourage regular visits to the job site → Verify construction is advancing per drawings → Discuss any issues as they arise → Come up with agreeable solutions → Try to not deter from project goals

3.1 Construction Kickoff Meeting

Resources

Sample Agenda:

1. Identify EUI goal and ECMs in OPR and BOD
2. Confirm 100% CDs reflect final decisions
3. Prioritize items that differ from traditional construction
4. Confirm requirements for systems installation and operations
5. Identify monitoring points on circuiting plans
6. Review job schedule and coordinate Cx

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3.2 Measurement and Verification (M&V) Plan

Summary

Intent

The intent of an M&V plan is to ensure the ECMs achieve the anticipated energy savings, as well as reduce maintenance issues and provide ongoing accountability of building energy use over time. Advanced M&V planning confirms that all data needed to verify savings will be available after the project has been completed and that all records are prepared in an easily accessible and cohesive manner.

Primary Responsibility: Mechanical Engineer / CxA
Secondary Responsibility: Electrical Engineer / Owner

Program Requirements

For the ZNE Companion Program, the M&V Plan must include the following.

- ☐ M&V Plan per the International Performance Measurement & Verification Protocol (IPMVP) complying with one of the following options (agreed upon with Consumers Energy's input).
  - Option B: Retrofit Isolation
  - Option C: Whole Facility
  - Option D: Calibrated Simulation

Cross-Deliverable Consistency

The following program deliverables must be consistent with the M&V Plan.

- 1.3 OPR
- 2.1 Energy Model
- 2.3 Basis of Design
- 4.2 Performance Testing
- 5.0 Verification of ZNE EUI Goal

The M&V plan must identify systems to be measured and verified which should include performance of all ECMs identified in the energy model under the operating conditions detailed in the BOD. The M&V plan needs to include verification that the building meets the EUI goal from the OPR. It will then be followed for deliverables 4.2 and 5.0. These consistencies should be confirmed by the project team prior to submission.

Phase 1: Prelim. Design
- 1.1 Preliminary Energy Model
- 1.2 ZNE Design Charrette
- 1.3 OPR

Phase 2: Adv. Design
- 2.1 Energy Model
- 2.2 Cost-Benefit Analysis
- 2.3 Basis of Design
- 2.4 Submetering & 100% CDs

Phase 3: Construction
- 3.1 Construction Kickoff
- **3.2 M&V Plan**
- 3.3 Circuiting Inspection
- 3.4 Envelope BCx
- 3.5 System-level Cx

Phase 4: Measurement
- 4.1 Monitoring Equipment
- 4.2 Performance Testing

Phase 5: Verification
- 5.0 Verification of ZNE EUI goal

3.2 M&V Plan

Deliverable Description

Program Requirements

For the evaluation of the building's performance, a M&V plan should be developed during the construction phase to outline the series of action items required for the operation of the monitoring system and post-processing procedures required for calculating and verifying the EUI goal. The plan must define approaches to solve for missing or inaccurate data, including procedures for erroneous recorded data. Additionally, the plan should list maintenance actions and time schedules to guarantee the correct operation of the monitoring equipment. The M&V period must cover at least one year of postconstruction occupancy. It should provide a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved. Here are the M&V options to choose from:

Calibrated Simulation – Option D: The proposed energy model is calibrated to at least 12-months of measurement building energy use and verification of savings is done compared to the already established baseline energy model. The M&V plan describes the process of obtaining any measured data and the simulation software used.

Whole Facility – Option C: Savings are based on the meter readings (and sub-meter reading if available) pre- and post-retrofit.

Retrofit Isolation – Option B: This option is for projects with less complex ECMs that are easily isolated. Savings are individually assessed.

M&V plans must include the following:

- Details of the baseline building conditions and how existing data will be collected.
- Description of each ECM.
- Include a clear and concise guide to what the M&V process will involve for the project.
- Identify systems to be measured and verified which should include performance of all ECMs.
- Discuss instrumentation testing and diagnostic methodology.
- Provide a setup of metering points for each system component.
- Identification of responsible parties for each of the M&V roles (i.e. facility management, M&V agent, investor, quality assurance provider).
- Schedule for all M&V activities.
- Details on the method of engineering analysis and how savings will be determined.
- Define Operations & Maintenance process and reporting responsibilities.
- Verification that the building meets the EUI goal.
- If Option D is being followed:
    - Details of the calibration process and identification of the error tolerance in calibration calculation.
    - Documentation of the calibration software used, including the facility's base-year conditions and resultant base-year energy data.
    - Describe how exactly the baseline and proposed energy model will be altered to align with the energy provider and/or measured energy use.
- If Option C is being followed:
    - List of the main building energy meters.
    - Description of the baseline performance period dates (12 months).
    - Basis for any adjustments to the baseline period energy use.
- If Option B is being followed:
    - List of equipment and loads that will be isolated and measured over a 12-month performance period compared to a described baseline year.

3.2 M&V Plan

Resources

The following is a list of resources that will aid in the process of creating an M&V plan.

- International Performance Measurement & Verification Protocol (IPMVP), Volume 1 (Option B, C or D)
- LEED User's Sample M&V Plan for Option D: https://leeduser.buildinggreen.com/sites/default/files/credit_documentation/Sample%20MV%20Plan_Option%20D.pdf
- Investor Confidence Project, M&V Plan Template for Option C: http://www.eeperformance.org/uploads/8/6/5/0/8650231/icp_option_c_m_v_plan_v1.0_-_template.docx

The information in the table below is taken from *IPMVP Volume 1, Table 1: Overview of M&V Options*

M&V Option	***How Savings are Calculated***	***Typical Applications***
B. Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements.	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the baseyear this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
C. Whole Facility *Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.*	*Analysis of whole facility energy meter or sub-meter data using techniques from simple comparison to regression analysis.*	*Multifaceted energy management program affecting many systems in a building. Energy use is measured by the natural gas and electric meters for a 12-month baseyear period and throughout the post-retrofit period.*
D. Calibrated Simulation *Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.*	*Energy use simulation calibrated with hourly or monthly energy billing data and/or end-use metering.*	*Multifaceted energy management program affecting many systems in a building but where no baseyear data is available. Post-retrofit period energy use is measured by the natural gas and electric meters. Baseyear energy use is determined by simulation using a model calibrated by the post-retrofit period energy use data.*

3.2 M&V Plan

Resources (cont.)

Sample Outline

I. PROJECT OBJECTIVES AND DESCRIPTION
   a. Design intent of pertinent ECMs or energy performance strategies.
   b. Statement of M&V objectives and description of the project context of the M&V program.
   c. Technical identification of the boundaries of savings determination. The nature of any energy effects beyond the boundaries may be described and their possible impacts estimated.
   d. Clear statement describing M&V period.

II. BASELINE DETERMINATION
   a. Documentation and specification of the baseline including a listing of all important assumptions and supporting rationale.
   b. References to relevant sections of any energy efficiency standard or guide used in setting the baseline.

III. M&V OPTIONS
   a. Specification of the M&V Option or combination of Options used to determine savings. Include a rationale for the choice.
   b. For Option D, Calibration Simulation:
      i. Savings with Option D are estimated by one of two methods:
         1. Method 1 – Subtract the energy use of the calibrated as-built model from the energy use of the calibrated baseline model.
         2. Method 2 – Subtract the metered post-construction energy use from the energy use of the calibrated baseline model.
   c. Refer to IPMVP Volume III: Concepts and Options for Determining Energy Savings in New Construction, April 2003, Page 30, Section 4.5.8 Option D: Savings Estimation.
   d. Specification of analytical techniques, algorithms and/or software tools (name and version number), including any stipulated parameters or operating conditions and the range of conditions to which the techniques, algorithms and/or software tools apply.
   e. Ensure appropriate weather data is used.

IV. METERING REQUIREMENTS
   a. Final input/output files for software tools, including important assumptions and any unusual modeling techniques employed during the development of the model.
   b. Specification of metering points, equipment, equipment commissioning and calibration and measurement protocols, including expected accuracy.
   c. Specification of the methods to be used to deal with missing or lost metered data.
   d. Identification of operational conditions that are to be monitored, and methods for monitoring and data collection.
   e. For Option D, specification of simulation calibration procedures, calibration parameters, frequency of measurement of calibration parameters, and calibration accuracy objectives.
   f. Specification of the set of conditions used for weather adjustments, including the period and/or weather data used, and any assumptions or interpolations made in the case of missing or incomplete data.
   g. Expected overall M&V accuracy and anticipated areas of error susceptibility and magnitude of the sensitivity.

V. IMPLEMENTATION METHODOLOGIES
   a. Description of Quality Assurance procedures.
   b. Specification for reporting format of the results.
   c. Specification of the information and data that will be available for third party verification, if required.
   d. Budget and resources for the entire M&V program, including long term costs, broken out into major categories.

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3.3 Circuiting Inspection

Summary

Intent

The intent of the circuiting inspection is to identify and confirm that the system controls and wiring design are being built to the100% Construction Drawing's specifications. Compare actual installed electrical circuiting and wiring to the submetering plan to ensure the setup is appropriate for monitoring before the walls are closed.

Primary Responsibility: Electrical Engineer
Secondary Responsibility: Owner and Design team

Program Requirements

For the ZNE Companion Program, the Circuiting Inspection must include the following.

- ☐ Filled out checklist (provided by Consumers Energy) confirming the controls and submetering design requirements.
- ☐ The responsible party must sign the checklist confirming the as-built meets design intent.

Cross-Deliverable Consistency

The following design deliverables must be consistent with the Circuiting Inspection checklist.

- 2.4 Submetering & 100% CDs
- 3.2 M&V Plan

The above submittals will be checked by the Consumers Energy representative for consistency before submittal.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • **3.3 Circuiting Inspection** • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

3.3 Circuiting Inspection

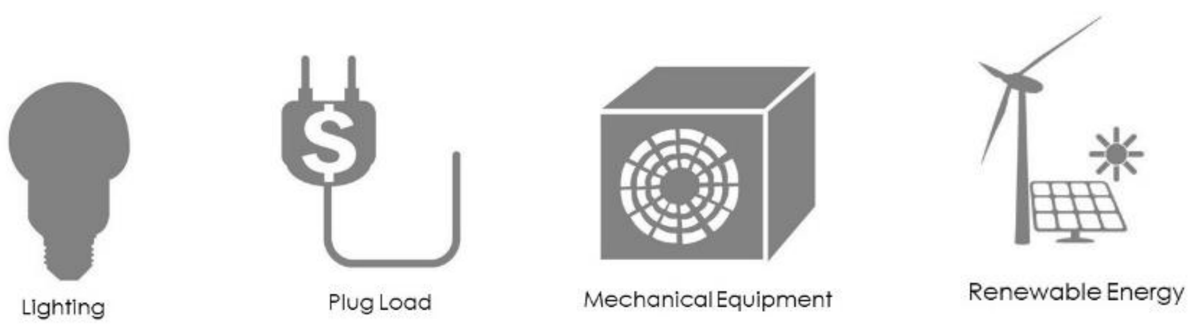
Deliverable Description

Program Requirements

The Circuiting Inspection determines the building's ability to disaggregate energy (per end use or per tenant). The electrical engineer will perform the self-inspection and will confirm that they have observed the work and it substantially meets the intent of the design documents via signature.

The inspection should confirm the following:

- Details on facility operation and how the individual systems will operate. If applicable, what is under owner control versus tenant control? (i.e. 24 hour indoor lighting circuit for security versus tenant indoor lighting circuit).
- Wiring disaggregation per the submetering plan ZNE Deliverable 2.4.
- Identification of any inconsistencies with 100% CD's ZNE Deliverable 2.4.
- Labeling of all points that are to be monitored on the circuiting diagram and listing of their installation type (e.g. Panel, rack-mount or meter base).
- Listing of estimated maximum power/amperage for each submeter on the plan.
- Instructions on how the meters will report the data (e.g. Network connection or building management system).
- Installed infrastructure for future renewable systems.



3.4 Envelope Commissioning (BECx)

Summary

Intent

The intent of building envelope commissioning (BECx) is to verify that the installed envelope meets capabilities of the design and thermal criteria described in the BOD, therefore ensuring the energy performance targets of the building can be met. An assigned commissioning agent (CxA) begins the commissioning process before construction to coordinate with the construction team. Throughout construction, the CxA inspects, tests and documents the envelope assemblies and finalizes the reports post-construction. Any identified issues must be remedied during the BECx process.

Primary Responsibility: Commissioning Agent (CxA)
Secondary Responsibility: Construction Team

Program Requirements

For the ZNE Companion Program, Envelope Commissioning must include the following:

☐ Inspection and testing of the envelope assemblies documenting the results and remedies of all identified issues during the BECx process.

☐ Submission of a completed envelope BECx report for each envelope assembly effected by an ECM in the BOD.

Cross-Deliverable Consistency

The following program deliverables must be consistent with envelope commissioning.

- 1.3 Owner's Project Requirements
- 2.3 Basis of Design
- 3.1 Construction kickoff Meeting

The OPR and BOD should be used as a guide by the CxA to ensure that the envelope specifications described in the document are being met. The construction kickoff meeting is when the CxA reviews the envelope requirements and the commissioning process with the construction team.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • **3.4 Envelope BCx** • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

3.4 Envelope Commissioning (BECx)

Deliverable Description

Program Requirements

The primary objective of the envelope commissioning process is to confirm that the building envelope meets the specifications and performance expectations described in the OPR and the BOD, including materials, durability, energy efficiency, sustainability goals, life cycle of the building and facility interior conditions. Envelope Cx begins with early design and continues through completion of construction. The commissioning agent is responsible for coordinating with the construction team during the construction and BECx processes to ensure the envelope inspection can occur while the building materials are still exposed. Then the infiltration testing will occur after the envelope is closed. The CxA must also coordinate the envelope Cx so that the envelope is complete prior to beginning the system-level Cx testing. Envelope Cx reports are typically very long reports (40-100 pages) and include a multitude of pictures taken of the envelope assemblies and the tests performed and often include action item logs (including resolution of unresolved items), testing results, and remediation of problems encountered.

Pre-Construction	•When: CxA meets with the team at the construction kickoff meeting. •What: CxA reviews materials/specifications in the BOD for each envelope ECM. •Coordination: CxA coordinates timelines w/construction team and system-level CxA.
Material Inspection	•When: During construction while building materials are still exposed. •What: CxA measures insulation thicknesses, confirms material selection, inspects joint connections, etc. of each ECM envelope system. •Coordination: CxA coordinates with the construction team to correct any issues.
Infiltration Tests	•When: Once the envelope construction is complete. •What: Test may include blower door/air leakage, water leakage, thermal leakage tests. •Coordination: CxA coordinates with the construction team to correct any issues and then coordinates with the system-level CxA to begin work.

Envelope Cx Components

ZNE program requires envelope Cx for all envelope systems effected by the ECMs. Typical building envelope Cx components/systems may include:

- Roof construction, systems and openings
- Sunshades, louvers and vents
- Connections to existing building components or existing adjacent structures
- Exterior walls – masonry, stone, metal panel, stucco, EIFS, curtain wall, parapets, sheet metal, etc.
- Exterior windows
- Exterior doors

Envelope Cx Scope

It is up the CxA (with Consumers Energy approval) to select the types of testing to perform on the building based on the ECM's selected for the project. At a bare minimum, this would include field QA testing of building exterior enclosure materials, components, systems, and assemblies during initial installation, and at various stages throughout construction. However, due to the complexity of the envelope system, project-specific, pre-construction laboratory mock-up testing of building exterior enclosure materials, components, systems and assemblies may also be warranted.

3.4 Envelope Commissioning (BECx)

Resources

There are a handful of envelope commissioning codes, standards, procedures and guides on the market; however, the Consumers Energy ZNE Companion Program does not require any one specifically to be followed. The following are some examples to use as references.

American Society of Heating, Refrigerating and Air-Conditioning Engineers® (ASHRAE®) - *ASHRAE Guideline 0-2005: The Commissioning Process*

American Society for Testing and Materials (ASTM) E 1105 - *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, By Uniform or Cyclic Static Air Pressure Difference*

American Architectural Manufacturers Association® (AAMA®) 501.1-17 - *Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure*

American Architectural Manufacturers Association (AAMA) 1503 - *Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections*

National Institute of Building Science (NIBS) NIBS Guideline 3-2012 - *Building Enclosure Commissioning Process BECx*

US Green Building Council - LEED version 4, *LEED Reference Guide for Building Design and Construction,* Energy and Atmosphere, Enhanced Commissioning credit, Option 2

3.5 System-Level Commissioning (Cx)

Summary

Intent

The intent of System-Level Commissioning (Cx) is to ensure that all systems affected by the project ECMs are installed per their specification and operation requirements as indicated in the BOD. The Cx processes and subsequent report must be completed by an assigned Commissioning Agent (CxA). The full scope of Cx begins during design and continues into the occupancy phase. During the Cx process, all identified issues or anomalies must be remedied. The final submission is a commissioning report that includes the Cx process, collected data, performance testing results and corrective action.

Primary Responsibility: Commissioning Agent
Secondary Responsibility: Construction Team

Program Requirements

For the ZNE Companion Program, System-Level Cx must include the following:

- ☐ Inspection and testing of the building systems documenting the results and remedies of all identified issues during the BECx process.
- ☐ Submission of a completed system-level commissioning report demonstrating that equipment and revised operating procedures conform with design intent.

Cross-Deliverable Consistency

The following program deliverables must be consistent with the system-level commissioning.

- 1.3 OPR
- 2.3 Basis of Design
- 3.1 Construction Kickoff Meeting
- 3.4 Envelope Commissioning

The OPR and BOD should be used as a guide by the CxA to ensure that the system specifications described in the document are being met. The construction kickoff is when the CxA reviews the system-level requirements and the commissioning process with the construction team. The system-level Cx must coordinate schedules with envelope commissioning.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • **3.5 System-level Cx**	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

3.5 System-level Commissioning (Cx)

Deliverable Description

Program Requirements

System-level Cx "is a quality-focused process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet the defined objectives and criteria," (ASHRAE Guidelines 0-2005 and 0-2013, The Commissioning Process). The primary objective of the Cx process is to confirm the delivery of a building that meets the Owner's Project Requirements, Basis of Design, and performance expectations. For the ZNE Companion Program, this includes meeting the ZNE EUI goal for the project. The specific tasks to be conducted during each phase verify that design, construction, and training meet the OPR and BOD. Cx verifies that the building systems perform as expected. System-level Cx at a minimum coordinates system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training, as well as all administrative and quality control documentation.

Benefits to System-Level Commissioning:

- Quality assurance process for evaluating a building
- Improves building/individual system O&M
- Identifies inefficiencies
- Increases equipment life and lowers maintenance costs
- Improves building documentation
- Results in optimal building and system performance

System-Level Cx Team Responsibilities:

- Project owner or manager
  - Ensures CxA is assigned before construction begins.
  - Provides the OPR and BOD to the CxA and contractor.
- Contractor
  - Integrate and coordinate Cx process activities with construction schedule.
  - Provide O&M manuals and other supporting documentation necessary for CxA to develop Functional Testing and compile Systems Manual.
- CxA
  - Must be an objective third party.
  - Organize and lead the Cx team.
  - Develop and circulate Cx Plan.
  - Facilitate Cx team meetings.
  - Provide Cx process text procedures
  - Prepare and maintain issues log and construction checklist log.
  - Supervise component, assembly, equipment and systems startup/testing.
  - Compile test data, inspection reports and certificates for the System Manual and Cx process reports.

3.5 System-level Commissioning (Cx)

Deliverable Description (cont.)

Design Specification Cx Scope

The Cx scope should include the building systems to be commissioned, which includes, but is not limited to, the following MasterFormat Spec Divisions:

- Division 23: HVAC
    - HVAC equipment and fans
    - HVAC ducts and casings
    - Air terminal units
    - Particulate air filtration
    - Heating boilers
    - Solar energy heating equipment
    - Compressor and condenser units
    - Packaged water chillers
    - Cooling towers
    - Packaged outdoor HVAC equipment
    - Evaporative air-cooling equipment
    - Radiant heating units
- Division 22: Plumbing
    - Domestic hot water heater system and associated controls (temp. and flow)
    - Recirculation pumps
- Division 25: Integrated Automation
    - All associated HVAC controls
- Division 26: Electrical
    - Lighting systems, controls, and sensors
    - Photovoltaic units

Construction Kickoff Meeting	During Construction	Post-Construction
☐ CxA presents the Cx process to the group	☐ Review Submittals for Performance Parameters	☐ Perform Differed and Seasonal Testing
☐ Project Manager & Construction Manager must attend	☐ Develop and Utilize Construction Checklists	☐ Reinspect/Review Performance (before warranty period)
☐ Each Sub related to systems to be commissioned must attend	☐ Oversee and Document Functional Performance Testing	☐ Complete Report
☐ Review of Cx requirements and responsible parties	☐ Hold Cx Team Meetings and Report Progress	☐ Final Satisfaction Review
☐ Review of management protocols and required submittals	☐ Conduct Owner Training	
☐ Review of sequence of Cx activities and training	☐ Deliver Commissioning Record	

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3.5 System-level Commissioning (Cx)
Deliverable Description (cont.)

Commissioning Plan and Expected Deliverables

The Cx Plan is a stand-alone document that will be updated as the project progresses. It should outline, but is not limited to:

- Roles/responsibilities for building systems.
- Communication processes defined for reviewing designs, resolving issues, and obtaining documentation.

Expected deliverables include:

- Commissioning plan and schedule detailing each step of the commissioning process and each team member's role and responsibilities.
- A diagnostic and functional test plan detailing how each test will be accomplished and noting expected performance parameters.
- A list of findings and potential improvements identified by the CxA for construction activities.
- A training plan recommending specific topics and training schedules.
- At the completion of the project, a final commissioning report detailing all the findings and recommendations including copies of all functional performance testing data.
- Energy savings and implementation cost estimates for recommendations developed in the process.
- A systems concepts and operations manual which gives a description of each system with specific information about how to optimally operate and control the system during all modes of operation such as during fire, power outage, shutdown, etc., including special instructions for energy efficient operation and recommissioning.

The following is a sample table of contents for a system-level Cx report.

TABLE OF CONTENTS

1.0 INTRODUCTION ....
1.1 PURPOSE OF THE COMMISSIONING PLAN ....
1.2 OVERVIEW OF COMMISSIONING PLAN ....
1.3 DEFINITIONS AND ABBREVIATIONS ....
1.4 COMMISSIONING TEAM MEMBER ROSTER ....
2.0 SCOPE OF COMMISSIONING ....
2.1 PROJECT OVERVIEW ....
2.2 PROJECT DOCUMENTS RELATED TO COMMISSIONING ....
2.2.1 Owners Project Requirements (OPR) ....
2.2.2 Basis of Design (BOD) ....
2.2.3 Construction Documents ....
2.3 SCOPE OF COMMISSIONING REQUIREMENTS ....
2.3.1 Overview of LEED® Fundamental Commissioning ....
2.3.2 Overview of LEED® Enhanced Commissioning ....
2.4 OVERVIEW OF COMMISSIONED SYSTEMS AND EQUIPMENT ....
2.4.1 Systems Included in this Commissioning Plan ....
2.4.2 Systems NOT Included in this Commissioning Plan ....
2.5 DETAILED DESCRIPTION OF COMMISSIONED SYSTEMS AND EQUIPMENT ....
2.5.1 Heating, Ventilating and Air Conditioning Systems (LEED System) ....
2.5.2 Central Building Automation System (LEED System) ....
2.5.3 Lighting Controls (LEED System) ....
2.5.4 Domestic Hot Water Systems (LEED System) ....
2.5.5 Building Enclosure (LEED System) ....
2.6 EQUIPMENT LIST ....
3.0 COMMISSIONING PROCESS & ACTIVITIES ....
3.1 GENERAL COMMISSIONING PROCESS ....
3.1.1 Pre-construction Design Phase ....
3.1.2 Construction and Acceptance Phases ....
3.2 CONSTRUCTION PHASE COMMISSIONING ACTIVITIES ....
3.2.1 Commissioning Issues List ....

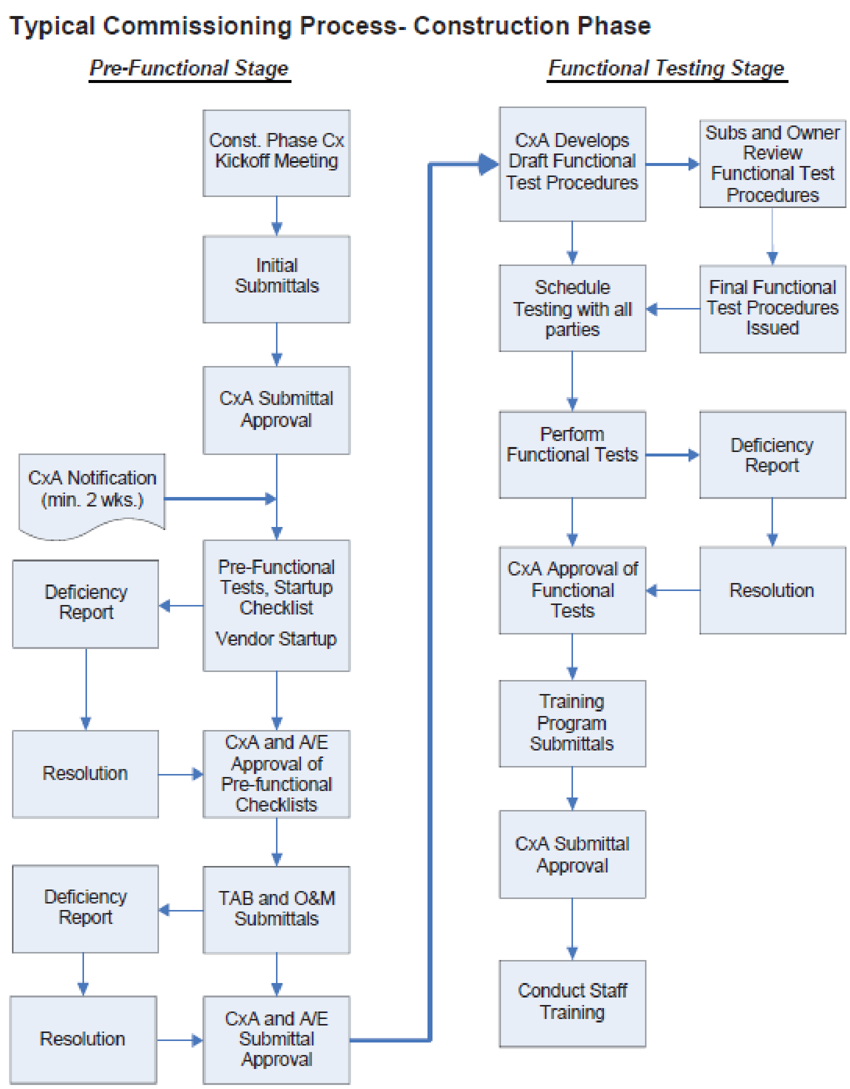
3.5 System-level Commissioning (Cx)

Resources

The following list is of resources to aid the in system-level commissioning process.

- ASHRAE® Guideline 0-2005: The Commissioning Process: https://www.ashrae.org/File%20Library/Technical%20Resources/Standards%20and%20Guidelines/Standards%20Addenda/G0_2005_a_b_c_d_FINAL.pdf
- Energy Design Resources, Commissioning Handbook: https://energydesignresources.com/media/2296/EDR_CommissioningHandbookComplete.pdf
- 2005 edition of the GSA commissioning guide

The following is a diagram/flowchart of a typical Cx process during the construction phase.



This guide was developed by DNV GL on behalf of Consumers Energy's Zero Net Energy program. This document is intended to be used by project teams needing assistance in developing this deliverable for their project. This document is for informational purposes and is not intended to represent a complete deliverable document or constitute legal advice. Consumers Energy reserves the right to modify or cancel the Zero Net Energy program at any time at its discretion.

Phase 4: Measurement

Intent: Ensure energy monitoring is functioning properly and providing ongoing accountability of building energy use and data post-occupancy.

Coordination: Occurs after the building has been occupied (minimum of 80% per building area).

- 4.1 Monitoring Equipment
- 4.2 Performance Testing

Phase 1: Prelim. Design | Phase 2: Adv. Design | Phase 3: Construction | **Phase 4: Measurement** | Phase 5: Verification

4.1 Monitoring Equipment

Summary

Intent

The intent of the Installation of Monitoring Equipment is to confirm the monitoring equipment is installed and set up in accordance with submetering and M&V plans (i.e. metering points, reading protocols, period(s), characteristics, Cx procedures and calibration). An inspection checklist will be filled out by Consumers Energy to ensure monitoring is ready for post-occupancy measurement, which can only occur once the building is occupied (minimum of 80% per building area).

Primary Responsibility: Consumers Energy Rep. or CxA
Secondary Responsibility: Facility Manger / Electrician

Program Requirements

For the ZNE Companion Program, Installation of Monitoring Equipment must include the following.

- ☐ Inspection of the monitoring equipment and process by Consumers Energy.
- ☐ Fill out the inspection checklist deliverable.
- ☐ Remedy any identified issues.

Cross-Deliverable Consistency

The following design deliverables must be consistent with the Installation of Monitoring Equipment.

- 2.4 Submetering & Construction Documents
- 3.2 M&V Plan
- 3.3 Circuiting Inspection

Above listed deliverables will be checked by project team for consistency before submittal.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	**Phase 4: Measurement**	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• **4.1 Monitoring Equipment** • 4.2 Performance Testing	• 5.0 Verification of ZNE EUI goal

4.1 Monitoring Equipment

Deliverable Description

Program Requirements

The Monitoring Equipment Inspection confirms that the monitoring equipment is installed and set up in accordance with submetering and M&V plans. A Consumers Energy representative will perform the on-site inspection and will confirm that they have observed the work and it substantially meets the intent of the design documents via signature.

The inspection should confirm the following:

- The submetering method and approaches for this building (i.e. per tenant, per end-use, other, etc.) compared to the 2.4 and 3.3 deliverables.
- The current building occupancy percentage and/or the anticipated "full occupancy" date.
- If the building is not fully occupied, identification of adjustments to energy use/demand during the post-retrofit period and occupancy variations that are to be expected.
- Isolated energy systems that have submeters installed (i.e. HVAC, lighting, hot water and renewable energy systems), as well as types of monitoring equipment installed (i.e. current transducers connected to power meter).
- Installation, calibration and functionality of all meters.
- Excluded energy systems from measurement and verification and why.
- Instructions on how the meters will report the data (e.g. Network connection or building management system).
- Time intervals for the submeters matching the energy provider billing meter (i.e. 15 minute periods). If not, identify method to match recorded data with the billing period.
- Guidelines for metering system maintenance per meter type.

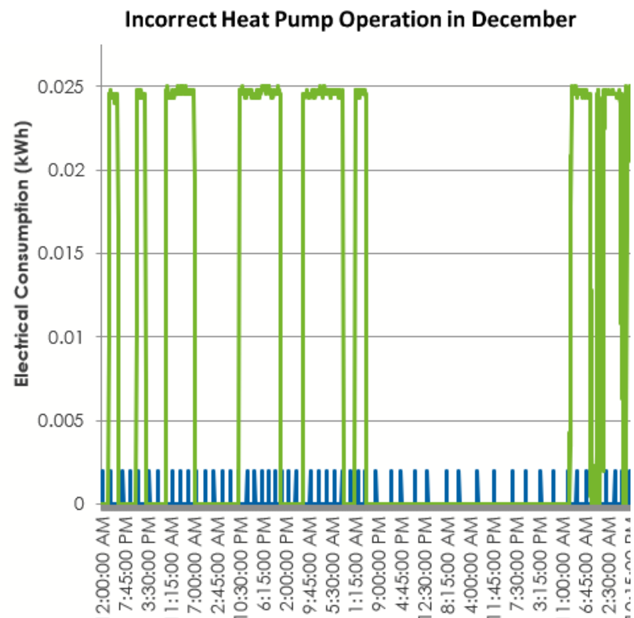
4.2 Performance Testing

Summary

Intent

The intent of Performance Testing in the first three months of occupancy is to verify the building equipment and data collection is operating per design by following the M&V Plan created in Phase 3. This is done by testing that the meters and monitoring equipment have been installed correctly, testing the instrumentation diagnostics, identifying any abnormalities in data, analyzing, tuning and resetting equipment (if necessary) and avoiding repetition of error in data. Most importantly, it allows the facility manager to make any required changes or adjustments to the metering and monitoring equipment prior to the start of the 12-month performance period.

Primary Responsibility: Facility Manger or CxA
Secondary Responsibility: Mech. or Electrical Engineer



Program Requirements

For the ZNE Companion Program, Performance Testing must include the following.

- ☐ Sample of the output data verifying testing results, signed by the responsible party.
- ☐ If needed, list of adjustments incorporated and secondary data output after any issues have been mitigated.

Cross-Deliverable Consistency

The following design deliverables must be consistent with Performance Testing during the first three months.

- 3.2 Measurement & Verification Plan

Performance testing during the first three months must be consistent with the M&V plan.

Phase 1: Prelim. Design
- 1.1 Preliminary Energy Model
- 1.2 ZNE Design Charrette
- 1.3 OPR

Phase 2: Adv. Design
- 2.1 Energy Model
- 2.2 Cost-Benefit Analysis
- 2.3 Basis of Design
- 2.4 Submetering & 100% CDs

Phase 3: Construction
- 3.1 Construction Kickoff
- 3.2 M&V Plan
- 3.3 Circuiting Inspection
- 3.4 Envelope BCx
- 3.5 System-level Cx

Phase 4: Measurement
- 4.1 Monitoring Equipment
- **4.2 Performance Testing**

Phase 5: Verification
- 5.0 Verification of ZNE EUI goal

Phase 5: Verification

Intent: Ensure the ZNE goal has been met.

Coordination: Occurs after the 12-month performance period.

- 5.0 Verification

Phase 1: Prelim. Design | Phase 2: Adv. Design | Phase 3: Construction | Phase 4: Measurement | **Phase 5: Verification**

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5.0 Verification

Summary

Intent

The intent of this deliverable is to verify whether the project has met its ZNE EUI goal established in the OPR. This will be determined by confirming that the whole-building's annual energy use is within 10% of its goal (or less). Verification is in the form of a standard report that includes the building's use (at least 12-month period) and/or energy bills for same period.

Throughout the 12-month performance period, the Consumers Energy team will review data collected at incremental periods to ensure the building is tracking correct performance target over various weather periods and building operation schedules.

Primary Responsibility: Facility Manager
Secondary Responsibility: Owner

Program Requirements

For the ZNE Companion Program, Verification must include the following.

- ☐ Twelve months of energy use data per submeter for whole building energy use compared to EUI goal.

Cross-Deliverable Consistency

The following design deliverables must be consistent with 5.0 Verification.

- 1.3 OPR
- 2.1 Energy Model

Verification must include a comparison of actual EUI and the EUI goal set in 2.1 Energy Model prior to submittal.

Phase 1: Prelim. Design	Phase 2: Adv. Design	Phase 3: Construction	Phase 4: Measurement	Phase 5: Verification
• 1.1 Preliminary Energy Model • 1.2 ZNE Design Charrette • 1.3 OPR	• 2.1 Energy Model • 2.2 Cost-Benefit Analysis • 2.3 Basis of Design • 2.4 Submetering & 100% CDs	• 3.1 Construction Kickoff • 3.2 M&V Plan • 3.3 Circuiting Inspection • 3.4 Envelope BCx • 3.5 System-level Cx	• 4.1 Monitoring Equipment • 4.2 Performance Testing	• **5.0 Verification of ZNE EUI goal**

Appendices

Appendix: Renewable Energy Generation and ZNE

ZNE-Ready vs ZNE Buildings

A zero net energy (ZNE) building is one where the amount of the energy produced by on-site renewable energy resources is equal to the amount of the energy used annually by the building. First, ZNE buildings use energy conservation measures (ECMs) to reduce energy use, at which stage the building is being prepared to become ZNE-Ready. Then, to become a true ZNE building, renewable energy systems must be included on-site (with some exceptions), which will offset the remaining energy use. While the on-site renewable energy component is not a requirement of the Consumers Energy ZNE Companion Program[1], it is highly recommended for all ZNE-Ready buildings as a final step that should be vetted in the early design phases.

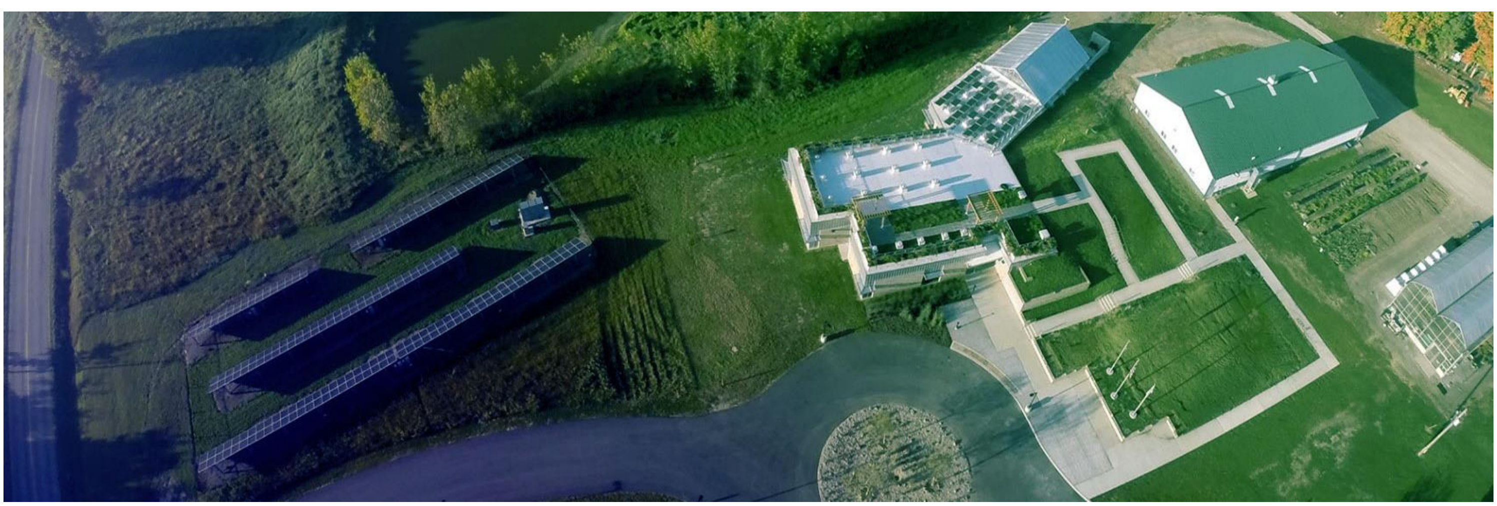
The most common renewable energy in ZNE buildings is on-site solar, as seen below at the Lenawee Intermediate School District's Center for a Sustainable Future.

ZNE buildings are designed and operated at maximum efficiency so that the on-site renewable energy can easily meet any remaining energy needs (as calculated on an annual basis for each building).

ZNE buildings have efficient systems and are also comfortable and healthier inside due to passive design strategies such as natural ventilation and daylighting. They also have the benefit of lower operational and maintenance costs and reduced greenhouse gas emissions.

Furthermore, some ZNE buildings choose to add energy storage to capture any excess renewable energy generated onsite. Energy storage options include batteries (both conventional and advanced), electrochemical capacitors, flywheels, power electronics, control systems and software tools used for storing generated electricity, energy, optimization and sizing. Energy storage devices can manage the amount of power required to supply during peak demand. These devices can also help make renewable energy, whose power output cannot be controlled by grid operators, smooth and dispatchable.

If the project goal is to go beyond ZNE-Ready and become a ZNE building, the Integrated Design Process (IDP) should factor in some sort of renewable energy, and possibly energy storage into the design, construction, operation and occupancy planning for the building. If the site limitations restrict full on-site renewable energy capacity, other offsite renewable options can be explored.



[1] Due to a legal restriction on incentivizing renewable energy technologies through the energy efficiency programs.

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Consumers Energy Renewable Energy Options

Once energy use has been minimized, installing on-site renewable energy systems can be sized to meet the ZNE goal of the building. The less energy the building uses, the fewer solar PV panels (or other renewable option) are required, and the lower the price. Matching energy use with renewable energy using an energy provider program or installing a renewable resource onsite are two means of offsetting remaining energy use with green energy. Solar panels can be purchased or leased. Purchasing panels allows the builder/owner to receive available incentives and/or tax credits. Leasing reduces the upfront cost of the panels and maintenance costs. Below is a list of renewable energy and electric vehicle program options available through Consumers Energy.

Solar Gardens

Consumer Energy's Solar Gardens allow business owners to power their buildings with renewable solar energy, without owning the solar panels. Consumers Energy owns, operates and maintains several large solar garden facilities like Grand Valley State University, and this one (pictured below) at Western Michigan University, and others.

Net Metering Program

Consumers Energy has a Net Metering Program which allows business owners who install solar panels to earn credit on each monthly energy bill for any excess energy generated that is not used on site. Net metering is an enabling contract which can tip the financial scales for the benefit of the building owners and operators, while also enabling the ZNE goal to be reached.

In some cases, however, onsite renewables are not an option. For example, if there is not enough unshaded south or west facing roof or carport space, then other renewable energy options must be considered.

PowerMIDrive™

PowerMIDrive™ is a new program designed to get more electric vehicles on the roads. The program offers up to $5,000 for commercial entities installing a public Level 2 Charger or up to $70,000 for commercial entities installing a public DC Fast Charger (based on availability).

Renewable Energy Financing

There are numerous benefits of including renewable energy in your project, and typically it has an agreeable payback period. However, coming up with the upfront capital for such a large investment is not always easy. Here is a list of other options for financing renewable energy for your project.

Power Purchase Agreement (PPA)

Solar gardens are sometimes privately developed through a Power Purchase Agreement (PPA). PPAs are contracts used where a third party owns the renewable energy asset and sells the power generated back to the energy provider or other business owners.

Green Bank Financing: Michigan Saves

Michigan Saves is a nonprofit that operates as a green bank to make energy improvements easy and affordable for home and building owners. Michigan Saves finances energy efficiency and renewable energy projects.

PACE Financing: Lean and Green Michigan

Property Assessed Clean Energy (PACE) is a financing tool that enables investment in comprehensive energy efficiency, water efficiency and renewable energy projects. By financing such projects through PACE, businesses can eliminate the need for upfront capital and spread the costs over 15, 20, or 25 years so that the savings generated from the project are greater than the annual PACE loan repayment – generating immediate positive cash flow.

Lean & Green Michigan PACE financing allows a property owner to use the local government's taxing authority to the property owner's advantage. The property owner voluntarily enters into a special assessment agreement, which it pays off as part of its property tax bill over the next 15 to 25 years.

Renewable Energy Certificates (RECs)

RECs can be purchased through a third party but are not advisable or available through Consumers Energy because there are so many good local renewable energy options. RECs are supported by several different levels of government, regional electricity transmission authorities, nongovernmental organizations (NGOs), and trade associations, and where on-site renewable energy is not possible, RECs can be purchased as an offsite option, like offsets.

Appendix: Building Certifications

ZNE Certifications

Congratulations! If you are reading this, perhaps you are ready for your ZNE Building Certification. Zero Net Energy buildings are the way of the future. The convergence of state and local policies, building codes, energy provider programs and renewable energy trends, along with large climatic shifts all point toward ZNE buildings as the building stock of the future across the world. Certification is a great way to get recognized and to help educate and inspire others wishing to build or retrofit to ZNE. Here are some resources to help you decide which option is best for you.

International Living Future Institute (ILFI)

Zero energy is recognized worldwide as one of the highest aspirations in energy performance in the built environment. The International Living Future Institute's (ILFI) Zero Energy Building (ZEB) Certification™ was created to allow projects to demonstrate zero energy performance, building an advanced cohort of projects with the integrity of third-party performance certification. This program, the only international zero energy certification, certifies that the building is truly operating as claimed, harnessing energy from the sun, wind or earth to produce net annual energy demand through a third-party audit of actual performance data. This certificate celebrates a significant accomplishment and differentiates both the building and those responsible for its success in this quickly evolving market.

The ILFI Zero Energy Standard is as follows:
"One hundred percent of the building's energy needs on a net annual basis must be supplied by on-site renewable energy. No combustion is allowed. "

There are four certifications offered by ILFI in increasing levels of difficulty to achieve, Zero Carbon, Zero Energy, Petal and Living Building Challenge.

New Buildings Institute (NBI) – ZE Verified

NBI releases a list each year of ZE Verified, ZE Emerging and Ultra-Low Energy (ULE) Buildings.:

- **Verified projects** have been reviewed by NBI or another third-party as having achieved ZE performance.
- **Emerging** projects are those that have a stated ZE goal but have not yet been verified with 12 months of energy use and generation data.
- **Ultra-Low Energy (ULE)** buildings are reaching similar levels of energy performance without adding renewables or an official ZE goal. These buildings are also often referred to as near net zero, zero energy capable or zero energy ready. ULE projects are no longer included in NBI's list but the data is still being gathered.

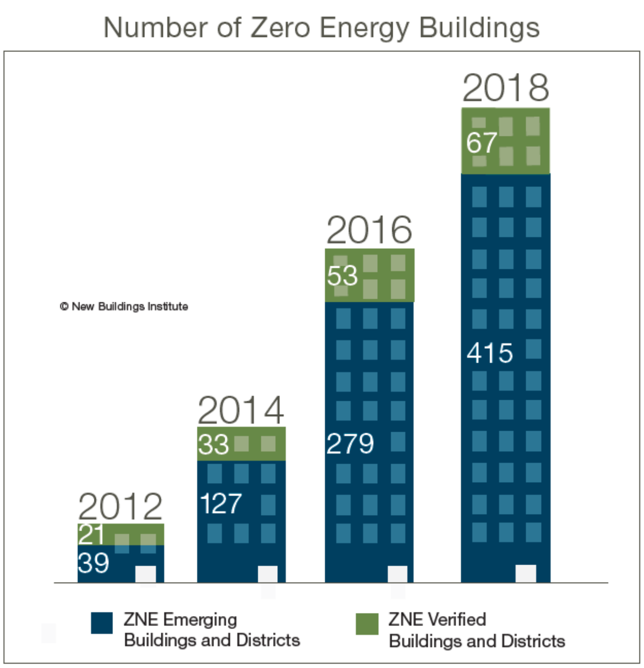

Fig 2. There are now 67 ZE Verified and 415 ZE Emerging projects documented by NBI.

USGBC LEED Zero

The importance of LEED as an energy and green building platform that drives higher goals of zero energy cannot be understated; the majority of ZE buildings are LEED certified as well. USGBC staff confirmed that on NBI's 2018 list, over one-third of the ZE Emerging projects (36%, or 174 projects) and 70% of the ZE Verified projects are LEED registered or certified. Three-quarters of these LEED projects are at the Platinum or Gold certified level.

The U.S. Green Building Council has now developed **LEED Zero**, a complement to LEED that verifies the achievement of net zero goals and signals market leadership in the built environment. LEED Zero includes energy, water and waste.

Carbon recognizes buildings or spaces operating with net zero carbon emissions from energy use and occupant transportation to carbon emissions avoided or offset over a period of 12 months.

Energy recognizes buildings or spaces that achieve a source energy use balance of zero over a period of 12 months.

Water recognizes buildings that achieve a potable water use balance of zero over a period of 12 months.

Waste recognizes buildings that achieve GBCI's TRUE Zero Waste certification at the Platinum level.

Other ZNE Resources

- EnergyStar.gov
- USGBC LEED v4
- Well Building Standard
- ZNE Reach Code Compliance: Example ZNE New Building Guidelines from City of Santa Monica
- Passive Haus Standard
- Build it Green; Green Point Rated
- Zero Energy Project
- Energy Design Resources
- Energy Code Ace

Appendix: Typical ZNE Project Overview

Below is a list of each of the Consumers Energy ZNE Companion Program deliverables, along with descriptions and notes to coordinate with typical project schedules and milestones. For full deliverable requirements, please reference the supplemental Consumers Energy ZNE Deliverable Guidebook.

Project Initiation		**Coordination**
Data Collection	The following documents and information must be provided to Consumers Energy as well as the design team to ensure accurate baseline conditions and energy savings estimations. - Drawings (current schematic or early design development sets, as-builts for existing buildings, etc.) - Schedules (occupancy, HVAC, lighting, etc.) - Occupancy count and building program information - Three years of energy bills for existing buildings - Site conditions - Building audit reports - Other relevant documents and analysis	ASAP
ZNE Feasibility Study	The ZNE feasibility study will be performed by Consumers Energy as an initial assessment of the project's baseline energy use, viable ECM opportunities, EUI goal feasibility, and solar sizing to achieve true ZNE.	Data Collection items and Application Questionnaire answers inform this study.
Design Team Procurement	Procuring design team must occur prior to the kickoff meeting so that the entire team can be in attendance and align project goals and visions from the start. The following is a list of required members: - Design Architect - Mechanical, Electrical and Plumbing (MEP) and Civil Engineers - Energy Modeler - Lighting Designer - Contractor - Commissioning Agent - Green Building and Renewable Energy Consultants (optional)	Prior to the Kickoff Meeting.
Kickoff Meeting	Kickoff meeting should occur onsite and include a walkthrough of the building and/or site. The owner, design team, Consumers Energy representative and additional stakeholders must be in attendance to review the integrated design process, program requirements and deliverables and discuss ZNE vision for the project.	Assign actionable tasks to project team members in preparation for the Phase 1 Design Charrette.
Monthly Meetings	Reoccurring monthly meetings must be scheduled for the customer, design team and Consumers Energy representative throughout the project.	

Phase 1: Preliminary Design		Coordination
1.1 Preliminary Energy Model	This initial energy analysis is meant to inform the Design Charrette. This will include an evaluation of the concept design and possible site and building specific ECMs, including building orientation, and passive design optimization.	Schematic Design or early Design Development (DD).
1.2 Design Charrette	The owner, design team, Consumers Energy representative, and any additional stakeholders are required to attend the Design Charrette to facilitate ZNE brainstorming. The design team presents the preliminary analysis and research along with performance targets and suggested systems. Based on decisions made during the charrette, the team must submit list of ECMs showing incremental savings to achieve the zero net energy ready EUI target.	
1.3 Owner's Project Requirements	Owner's Project Requirements (OPR) document which must include a statement of commitment to achieving the ZNE-Ready goal and the minimum total building energy reduction requirements applicable for the all-electric, solar ready project and be signed by the project owner.	
Phase 2: Advanced Design		**Coordination**
2.1 Energy Model	Energy Model (executable file and output reports from an approved energy modeling software) must demonstrate the incremental improvement of the Baseline design to the targeted Proposed design over the course of a year. The proposed model should be a representation of the final building design energy use that reaches the EUI goal set by the Customer in the OPR. The Baseline model should represent the Baseline design before the implementation of project specific ECMs. Input data should represent the best available information including, as much as possible, actual performance data from key components in the facility.	Early Construction Drawings (CDs). To limit reworking, submit the baseline model for initial review prior to working on the proposed model.
2.2 Cost-Benefit Analysis	Generate a Cost-Benefit Analysis of the proposed building systems using savings results from the energy modeling. The results of this analysis will influence the final ECM selection.	Upon completion, update the proposed model with the final ECMs to ensure the EUI goal is still being met.
2.3 Basis of Design	Formulate a Basis of Design (BOD) that includes a statement on the project's ZNE performance target and all ECM design and construction specifications across building systems. This will be used in the field by the construction manager and commissioning agent (CxA) to ensure proper installation and operation. The BOD is also used throughout the Phase 3 deliverables.	Submit 2.1, 2.2 and 2.3 for initial review prior to 50% CDs to ensure there is enough time to implement changes.
2.4 Submetering and 100% CDs	Submetering and Construction Documents (CDs) to be shared at 100% CDs that include specific circuiting diagram, setup requirements for sub-metering building energy uses, as well as wiring and connections to designated areas for future renewable system installations. Consumers Energy's desired submetering plan is per energy end use (i.e. HVAC, lighting, plug load, etc.) or per tenant space. Customized submetering plans will be allowed for existing buildings with circuiting layouts that are non-conforming. Extensive re-wiring is not required.	At this point, projects typically submit for permits.

Phase 3: Construction		Coordination
3.1 Construction Kickoff Meeting	Construction kickoff meeting must be held at the project site, and a Consumers Energy representative and third party CxA must be present along with the contractor and construction team. The agenda must include a review of the commissioning (Cx) and construction schedules, as well as a review of ECM specifications from the BOD to identify specific requirements for installation and O&M goals for the building systems.	Prior to the start of construction.
3.2 Measurement & Verification Plan	An M&V Plan should be developed for the evaluation of the building's ZNE performance (per IPMVP Options B, C or D) outlining steps/aspects required for the operation of the monitoring system and post-processing procedures for calculating and verifying the energy target. The plan should include approaches to solve missing/inaccurate data, as well as maintenance actions and time schedules to guarantee correct operation of monitoring equipment.	Developed during construction but implemented during Phase 4.
3.3 Circuiting Inspection	The circuiting inspection checklist will be cross-checked versus the submetering plan to ensure that the electrical circuiting and wiring is set up appropriately for monitoring purposes, as well as M&V.	Before the walls are closed to inspect the wiring.
3.4 Envelope Commissioning	Commissioning of the building envelope is required for ECMs that involve the building shell. Envelope construction and insulation should be inspected once installed to ensure capabilities of the design and thermal criteria. The envelope commissioning and subsequent report should be completed by a third party CxA.	This occurs before, during and after envelop construction.
3.5 System-Level Commissioning	Depending on the project and the ECMs employed, commissioning of the building systems may be required. The system-level Cx and subsequent reporting must demonstrate that equipment and revised operating procedures conform with design intent in the BOD and is completed by a third party CxA.	First incentive payment occurs once Phase 3 is complete.
Phase 4: Measurement		**Coordination**
4.1 Monitoring Equipment	Monitoring system is to be installed and set up in accordance with submetering and M&V plans. An inspection checklist of the metering points, reading protocols, period(s), characteristics, Cx procedures, and calibration is meant to ensure end-use monitoring is ready for post-occupancy measurement.	Occupy building (minimum of 80% per building area) before 4.2 can begin.
4.2 Performance Testing	Performance testing of the equipment is implemented according to the M&V Plan (deliverable 3.2). This 3-month period is used to ensure the building equipment and data collection is operating per design. The Consumers Energy team will review data collected at incremental periods during the monitoring year to ensure that the building is tracking correct performance target over the various weather periods and building operation schedule.	After the M&V Plan is implemented, the 12-month performance period can begin.
Phase 5: Verification		**Coordination**
5.0 Verification	To verify the ZNE EUI goal has been met, submit at least 12-months of post-occupancy building energy use data from the monitoring system.	Final incentive payment occurs once Phase 5 is complete.

Glossary

Acronyms

AE – Architect & Engineer

AHU – Air Handling Unit

AMY - "Actual Meteorological Year" Weather Data

ASHRAE – American Society of Heating, Refrigeration, And Air-Conditioning Engineers, Inc.

BECx – Building Envelope Commissioning

BMP – Best Management Practice

BOD – Basis of Design

Btu – British Thermal Unit

CBECS – Commercial Building Energy Consumption Survey

CEC – California Energy Commission

COP – Coefficient of Performance

Cx – Commissioning

CxA – Commissioning Agent/Authority

ECM – Energy Conservation Measure

EER – Energy Efficiency Rating

EUI – Energy Use Intensity

GWP – Global Warming Potential

HVAC – Heating, Ventilation, and Air Conditioning

IAQ – Indoor Air Quality

IDP – Integrated Design Process

IPLV – Integrated Part Load Value

IPMVP – International Performance Measurement & Verification Protocol

IRR – Internal Rate of Return

kBtu/sf/year – 1000 British thermal units per square foot per year; annual energy use per area

kW – kilowatt (unit of electric power)

LCA – Life Cycle Assessment

LCC – Life Cycle Cost

LEED – Leadership in Energy and Environmental Design

M&V – Measurement & Verification

MEP – Mechanical, Electrical, and Plumbing

MERV – Minimum Efficiency Reporting Value

O&M – Operations and Maintenance

OPR – Owner's Project Requirements

ROI – Return on Investment

SEER – Seasonal Energy Efficiency Rating

SRI – Solar Reference Index

TMY – "Typical Meteorological Year" Weather Data

VAV – Variable Air Volume

ZNE – Zero Net Energy

Definitions

Baseline Building Performance - the annual energy use for a building design, based on either current building code or existing conditions.

British Thermal Unit (Btu) - unit of energy; one Btu is the amount of heat required to raise the temperature of one pound of water by one-degree Fahrenheit.

Basis of Design (BOD) - the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations and guidelines.

Charrette - an intensive, multiparty workshop that brings people from different disciplines and backgrounds together to explore, generate, and collaboratively produce design options.

Commissioning (Cx) - the process of verifying and documenting that a building and all its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner's project requirements.

Commissioning Agent (CxA) – the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

Energy Conservation Measure (ECM) – a process or technology incorporated into building design or building operations and management to reduce the energy use of a piece of equipment or overall building energy use.

Energy Use Intensity (EUI) – a building's annual energy use per unit area; typically measured in thousands of BTU per square foot per year (kBtu/ft^2/yr) or kWh/m^2/yr.

Energy storage – devices, such as batteries, that manage the amount of power required to supply during peak demand by storing energy during off-peak hours.

Integrated Design Process (IDP) – a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. This approach requires the entire project team to emphasize communication among professionals and stakeholders throughout the life of a project.

Internal Rate of Return (IRR) – a measure of an investment's rate of return to the internal organization. The term internal refers to the fact that the internal rate excludes external factors, such as inflation, the cost of capital, or various financial risks.

International Performance Measurement & Verification Protocol (IPMVP) – defines standard terms and suggests best practice for quantifying the results of energy efficiency investments and increase investment in energy and water efficiency, demand management and renewable energy projects.

Occupant Control – a system or switch that a person in the space can directly access and use. Examples include a task light, an open switch, and blinds. A temperature sensor, photo sensor or centrally controlled system is not occupant controlled.

Operations and Maintenance Plan – a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system.

Owner's Project Requirements (OPR) – a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project.

Peak Demand – the maximum electricity load at a specific point in time or over a period of time.

Plug Load – the electrical current drawn by all equipment that is connected to the electrical system via a wall outlet (aka receptacle load).

Process Load – the load on a building resulting from the energy use for processes (i.e. manufacturing load).

Regulated Load – any building end use that has either a mandatory or a prescriptive requirement in ANSI/ASHRAE/IES Standard 90.1–2010.

Renewable Energy – energy sources that are not depleted by use (solar, wind, hydropower, geothermal and wave and tidal systems).

Return on Investment (ROI) – a ratio between the net profit and cost of investment resulting from an investment of a resource. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment.

Simple Payback – the length of time required to recover the cost of an investment.

Zero Net Energy (ZNE) – a ZNE building produces enough renewable energy to meet its own annual energy use requirements, thereby reducing the use of non-renewable energy. ZNE buildings use all cost-effective measures to reduce energy use through energy efficiency and include renewable energy systems that produce enough energy to meet remaining energy needs.

ZNE-Ready – a building that has reduced its energy use as low as possible and can become true ZNE once renewable energy is added.

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