zero net energy

Getting to Zero:
ZNE Project Guide

Getting to Zero: ZNE Project Guide

ZNE is possible for many buildings and this Getting to Zero: ZNE Project Guide *can help you on the path to zero energy. A zero net energy (ZNE) building is an extremely energy efficient building that is designed and operated to produce as much energy as it consumes over the course of the year. ZNE buildings are no longer solely demonstration projects and market outliers. NBI's* List of ZNE Buildings *includes a wide-range of mainstream building and ownership types that reflect a universal trend toward ZNE adoption.*

ZNE is feasible in both new construction and existing building renovation. Teams have found that ZNE buildings do not always cost more to build, especially when ZNE is a goal from the start. Plus, they provide exemplary spaces for their occupants. ZNE buildings are thermally and acoustically comfortable and offer glare-free daylighting, which creates a highly productive environment. They also have significantly lower operations and maintenance costs.

A zero net energy (ZNE) building is an extremely energy efficient building that is designed and operated to produce as much energy as it consumes over the course of the year.

The steps to achieve ZNE are different from a traditional building development process. This Getting to Zero: ZNE Project Guide explains those differences and provides a framework for planning any ZNE project. It provides resources, checklists, and worksheets to inform a process of gaining stakeholder support, selecting a qualified design team, managing the design and construction process, occupying a ZNE building, and verifying a ZNE result.

Stakeholder Awareness

One of the key ingredients to success in developing a ZNE project is an internal champion, or someone who is fully committed to the ZNE vision and goal. This may be a staff member, city manager, superintendent, architect, engineer, or committed individual. The ZNE champion often raises awareness and educates other stakeholders and decision-makers to gain widespread support for a ZNE project.

The ZNE Communications Toolkit identifies likely stakeholders, their drivers, and compelling messages to build support for a ZNE project. There may be others that are important to include. In addition, case studies and factsheets may be helpful to share with stakeholders to build momentum for ZNE, as are tours of nearby ZNE buildings. Resources include a communications toolkit with factsheets and a current list of ZNE projects across the United States, can support your efforts.

435 Indio Way | Sunnyvale, CA
Credit: Bruce Damonte

Resources

- ZNE Frequently Asked Questions and Terminology
- ZNE Case Studies
- ZNE Communications Toolkit
- The Vocabulary of ZNE
- 2016 Getting to Zero List
- ZNE Stakeholder Worksheet

California State Lottery Santa Fe Springs District Office | Santa Fe Springs, CA
Credit: LPAS Architecture + Design

Successful ZNE champions and project managers have clear energy and sustainability goals for their project, even before design begins.

Energy Goals and Targets

Successful ZNE champions and project managers have clear energy and sustainability goals for their project early, even before design begins. Instead of "percent better than code" goals, ZNE projects use an absolute energy target—called an Energy Use Intensity (EUI) commonly expressed in kBtu/square foot per year. Energy targets vary slightly depending on building type and climate. They are a fraction of the average building energy consumption as defined by Commercial Building Energy Consumption Survey (CBECS) or the California Energy Use Survey (CEUS). For example, CBECS 2012 suggests that an average EUI for school buildings is 53 kBtu/square foot per year while a ZNE school is about 20-24 kBtu/square foot per year. Resources in this section include tables of typical EUIs for common building types as well as low-energy targets as suggested by the National Renewable Energy Lab and ASHRAE.

Beyond new construction, existing buildings offer many opportunities for deep energy reduction and ZNE. By measuring the energy performance with benchmarking tools like EnergyStar® Portfolio Manager, owners can better understand their building's EUI. NBI's FirstView® Software Tool then uses this benchmarking data to remotely diagnose both capital and operational opportunities across the portfolio. This process can help target limited resources for a walkthrough audit on those with the most potential for improvement.

After using remote diagnostics, assessments (or audits) for ZNE may be broader than a typical building assessment. Instead of only looking for the energy efficiency "low hanging fruit," ZNE assessments leave no stone unturned in their search for energy efficiency opportunities. They focus attention on ways to reduce building loads with envelope sealing, lighting, HVAC and other energy using systems such as server closets. In addition, ZNE assessments include detailed information about solar access, roof condition, warranty, and structural capacity necessary for additional weight associated with solar installations.

Also, ZNE assessments should pay careful attention to the operational characteristics and behaviors that drive energy consumption. Conversations with facility staff and building occupants are critical to understanding how the building actually works. This information about temperature set points, behavior and occupancy patterns, plug load energy use, etc. can be incorporated into the Owners Project Requirements (OPR) which are covered in the next section.

Resources

- Commercial Building Energy Consumption Survey (CBECS)
- California Energy Use Survey (CEUS)
- Energy Targets
  - NREL Setting WholeBuilding Absolute Use Targets for the K-12 SchoolRetail and Health Care Sectors
  - ASHRAE Standard 100-2015 Energy Efficiency in Existing Buildings Table 7-2
- EnergyStar® Portfolio Manager
- FirstView®

Team Selection

Design and construction team commitment is essential for ZNE project success. Owners should be clear about their ZNE aspirations in their Request for Proposals (RFP), Owners Project Requirements (OPR) and contract documents. Since energy consumption in a building is a function of both design and operations, discussion about ZNE and the EUI target with the design team is a critical part of the team selection and contracting process. Consideration should be given to the contractual approach selected, whether it be design-build, design-bid-build, lease-leaseback, energy service company, or integrated project delivery. Each has its own unique set of benefits and drawbacks for a ZNE project.

Just like many owners include LEED goals in their Request for Proposals, a ZNE goal can be added to the RFP. For example, the RFP might simply ask for a LEED Gold building that achieves ZNE. This puts teams on notice of the goal and encourages them to think about energy performance even before putting pen to paper.

Although not all teams have ZNE experience, those that are committed to low-energy buildings should know the EUI of other buildings that they have designed. During the team interviews, consider asking for information about sustainable design goals, predicted EUIs and actual performance in completed projects. The ZNE team interview questions below offer examples of questions for the prospective design teams to gauge their experience and fit for the project.

Another tool in the team selection and contracting process is called the Owners Project Requirements (OPR). OPR define project goals, the building program, operational parameters, sustainability and energy goals, and financial expectations. Most of the time OPR are done in layman's terms for individual building projects. However, ZNE OPR can be more sophisticated and can detail the requirements of envelope; lighting, heating, cooling, and ventilation; hot water; controls; and other energy using systems. OPRs should be clear about specific programmatic requirements, operational patterns and schedules, plug load assumptions, and other activities in the building that influence the energy consumption. "Template" language in an OPR can be modified for individual projects, and teams should carefully track changes over time.

Environmental Innovation Center | San José, CA
Credit: City of San José

Design and construction team commitment to ZNE is essential for ZNE project success.

Once a team has been selected and is committed to a ZNE result, consider incorporating an EUI target range into the contractual documents. This "performance-based procurement" approach sets a clear expectation with the design team and the building occupants on how the building should perform once it is occupied.

- What architectural, engineering, and construction principles do you suggest to reach ZNE performance? When do you consider them in the design process?
- How are your past ZNE or low-energy use building performing? What are their EUIs? What have you learned from these buildings?
- What tools or processes do you use when estimating energy consumption?
- Are you aware of grants and incentives that may be available for the project?
- Have you stayed involved with previous projects after they were occupied? If so, how?
- How would you work with us to resolve a higher-than-designed EUI?

Resources

San Diego County ZNE RFP

SFUSD Project Requirements

How to Guide for Energy Performance Based Procurement, National Renewable Energy Laboratory

Finance and Incentives

ZNE buildings have been built for the same first costs as comparable buildings.[1] Other studies suggest that zero energy is a cost effective investment.[2] Success requires a committed team, a clear energy goal, and integrated building system design. ZNE teams manage costs by first drastically reducing energy consumption and then serving the remaining loads with renewable energy. These energy and financial cost control strategies along with financial incentives are key to making the business case for ZNE, as outlined in by the National Renewable Energy Lab in their Cost Control Best Practices for ZNE study.

Energy efficient and ZNE buildings can unlock financial incentives not available to other projects. Sources of additional funding may include utility energy efficiency programs, Community Choice Aggregator (CCA) programs, tax credits, low-interest loans, or commercial Property Assessed Clean Energy (PACE). Financial incentives constantly evolve so every project team should investigate the opportunities to can capture as many as possible.

Utilities are one important source of funding for ZNE projects. The Database of State Incentives for Renewables and Efficiency® (DSIRE) database can help policies, tax credits, and financial incentives by state. Often utility programs must be involved early in design in order to qualify for financial incentives. Even if they do not have ZNE specific programs, other programs may be available for the project. Savings by Design is an example of a program in California, though there are others. Utilities may also have on-bill financing options that can help by repaying the loan on a monthly utility bill.

CCAs combine the buying power of many customers to allow cities, counties, and other qualifying governmental entities to purchase electricity for their residents and businesses. They offer different rate structures for customers, although the utility continues to deliver the energy and provide meter reading, billing, and maintenance. Many CCAs have financial incentives for both efficiency and solar.

Solar installations have other financial incentives. The federal government provides a 30% tax credit for renewable energy (including photovoltaics, wind, geothermal), although public buildings and schools may need to partner with a tax-paying entity through a Power Purchase Agreement in order to capture these benefits. (Caution, PPAs may create complications with Renewable Energy Certificates as the U.S. Department of Energy explains in the Federal On-Site Renewable Power Purchase Agreements.) Other states, including California, have specific incentives for solar.

Finally, commercial PACE is a mechanism for energy efficiency and renewable energy financing. It allows local and state governments to fund the up-front cost of energy improvements on commercial properties and allow repayment by the property owners over time as part of the tax bill. This addresses an owner's need to finance large upfront costs and allows the cost of the investment to transfer with the property owner.

Resources

- NREL Cost Control Best Practices for Net Zero Energy Building Projects
- DSIRE
- Federal solar tax credits
- California Solar Initiative
- Accelerating the Commercial PACE Market

1 http://eecoordinator.info/california-zero-net-energy-buildings-cost-study/
2 https://www.efficiencyvermont.com/Media/Default/docs/white-papers/efficiency-vermont-net-zero-energy-feasibility-study-final-report-white-paper.pdf

Bishop O'Dowd Catholic High School | Oakland, CA
Credit: David Wakely

Early Design/Pre design

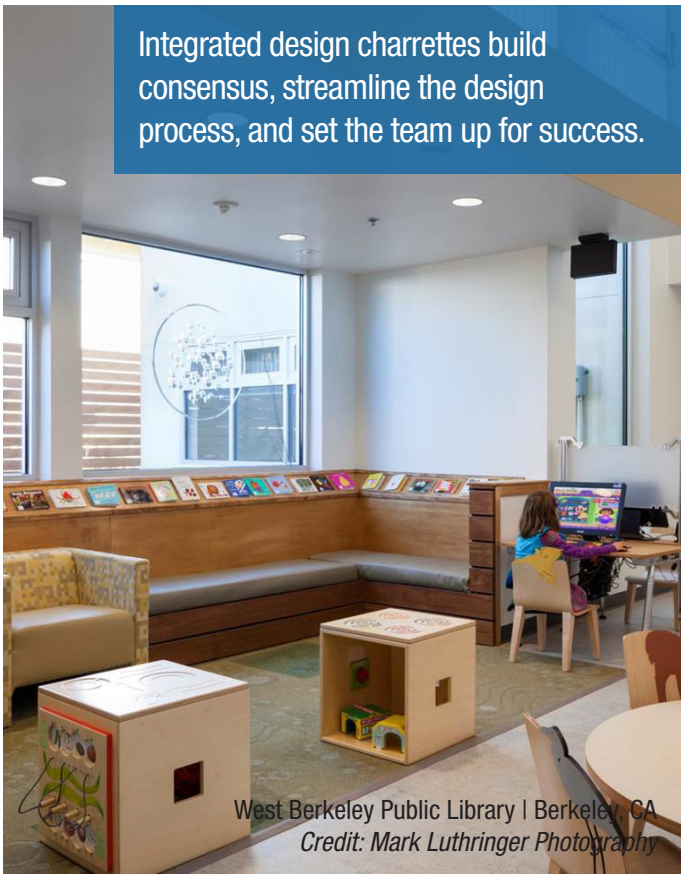
Shortly after the project team has been selected, an integrated design charrette is essential to align the ZNE vision among all stakeholders. A charrette is an interactive, facilitated discussion where relevant team members, including owners, architects, engineers, contractors, building occupants, and facility maintenance staff, review priorities and agree on shared project goals. Time on the agenda should allow for a focused discussion about achieving ZNE and energy targets.

NBI's Integrated Design Charrette Toolkit includes an explanation of the charrette process, a list of preferred charrette participants, planning checklists, sample agendas, presentations, and reports for the team to use and modify as necessary.

Early design is the appropriate time for the design team to calculate the solar potential on the site.

Integrated design charrettes build consensus, streamline the design process, and set the team up for success. They are most effective when they happen early in Schematic Design. This allows key stakeholders like owners, facility managers, and building occupants to share their perspective and ideas about the project at a time when their feedback can still be easily—and inexpensively—incorporated into the design. The charrette also provides design team members an opportunity to share their early design schematics and experiences on other projects. Post charrette, the facilitator should provide a summary of the event, including next steps. At that time, the owner may want to update the OPR with new performance goals or include additional details such as thermal comfort ranges that might have been agreed to during the charrette.

Early design is also the appropriate time for the design team to calculate the solar potential on the site. This is a function of the location, available space on the site for a photovoltaics, and the production capability of the system. PV Watts© is a tool from the National Renewable Energy Lab that helps define the solar potential on a particular site.



West Berkeley Public Library | Berkeley, CA
Credit: Mark Luthringer Photography

Another important step early in design is the finalization of the Basis of Design (BOD). The BOD is the primary document that translates an owner's needs into specific building approaches such as building envelope, mechanical, electrical, plumbing, security systems, building automation system, etc. Essentially, this is the design team's response to how the details in the OPR will be achieved. The commissioning agent will use these documents to ensure the building will meet the owner's expectations. (See more about commissioning in the next section.)

Resources

PV Watts©solar calculator

Integrated Design Charrette Toolkit

Design and Construction

Achieving a ZNE goal for any new construction or deep renovation project requires a design team commitment to a fully integrated process where the interrelationships between the building and its systems, surroundings, and occupants make efficient and effective use of resources. Teams should carefully consider climate as a resource, taking advantage of free daylighting, cooling, and other passive strategies as appropriate. New construction projects can take advantage of building orientation—elongating buildings along an East-West axis if possible—as a way to manage energy loads like lighting and heat gain.

The complimentary elements of a ZNE building are ultra-low energy use, energy demand stability and renewable energy. Incremental levels of efficiency or on-site generation are case-specific, and relative to a building's capability to maximally reduce energy consumption coupled with the site-availability of renewable energy resources. ZNE buildings should consider energy storage, electric vehicle facilitation, and/or demand response to reduce grid impact.

Designers should focus on a sealed envelope to manage infiltration loads. In net zero buildings, the level of envelope performance goes well beyond code requirements. Programs and standards such as a Passive House Institute can lead to significant mechanical load reductions.

Once loads have been reduced with passive strategies, carefully investigate the occupancy and use patterns to ensure that electrical and mechanical equipment is sized appropriately. Plug loads in ZNE buildings represent 30-50% of the load, so these should be carefully considered and managed. Reducing loads leads to smaller mechanical systems which can save first costs and ongoing operational costs. Once all loads have been reduced and served with high-performance equipment, remaining loads can be offset with renewable energy, also managing the first costs of the photovoltaic system.

Bacon Street Offices | San Diego, CA
Credit: ARCHITECTS hannah gabriel wells

Teams should carefully consider climate as a resource, taking advantage of free daylighting, cooling, and other passive strategies as appropriate.

Buildings that have been commissioned have been found to operate more efficiently, are more comfortable, and have lower operations and maintenance costs.

ZNE projects often use iterative energy modeling throughout the design process to estimate the building loads and energy efficiency measures. This can begin early in the Schematic Design phase with climate, site, and solar simulations to provide feedback which can be incorporated into fundamental design decisions. Iterative energy models can then begin to factor in building systems. These "shoebox" energy models are different. They compare relative savings associated with big design options to uncover which is more advantageous in a particular building. They may also help prevent oversizing mechanical systems, reducing upfront costs. This can be distinguished from other energy models that are focused more on documenting design decisions or code compliance. Iterative models can help prompt integrated design conversations early on in the process. Some utilities offer incentives for energy modeling, which can then be used to help identify first cost savings in a project.

The design of controls and systems for easy metering are other important considerations during design. Some ZNE teams hire a "controls integrator" to improve operational efficiencies and on-the-ground diagnostic capabilities through the proper inclusion of energy sub-meters. This professional can assist with the layout, access, and format of the lighting, HVAC, plug load meters, and control considerations.

"Building systems commissioning" is a process to ensure that a building is delivered according to the OPR. It can streamline the design and construction process, leading to fewer change orders. Buildings that have been commissioned operate more efficiently, are more comfortable, and have lower operations and maintenance costs. Bringing a commissioning agent on board to review the drawings for agreement between

the OPR, BOD, and design documents before construction begins, is worth the investment. The Building Commissioning Association can help you find a qualified professional and understand best practices.

Commissioning can also extend throughout construction and into post-occupancy. During construction, the controls integrator and/or commissioning agent will test the installed systems to ensure they are working together correctly according to the OPR. This can help identify any operational issues, hopefully before occupancy. The commissioning agent can also assist in resolving any issues uncovered in this process. Lastly, this individual can help train owners and occupants to properly use the systems for maximum efficiency. Post-occupancy commissioning can identify and resolve any unexpected operational issues after move-in.

It is important for the design team to keep the project goals and OPR in mind throughout the entire design and construction process. When project finances get tight or not everyone is familiar with the ZNE goal, efficiency strategies can be "value engineered" out of the final design, because they may have a long-term payback period and comparatively high first cost. However, this method often has unexpected consequences in building performance. When systems are properly integrated, each component is critical to achieving the ZNE goal so both first costs and ongoing lifecycle costs should be considered during value engineering.

Resources

- ZNE Design Fundamentals Fact Sheet
- Deep Savings in Existing Buildings
- NBI Technical Resource Guides:
  - Daylighting Pattern Guide
  - Daylighting Guide for Office Interiors
  - Plug Load Guide
  - Indirect Evaporative Cooling
  - Luminaire Level Lighting Control
  - Radiant Heating and Cooling + Dedicated Outdoor Air Systems
  - ZNE Building Controls: Characteristics, Energy Impacts and Lessons
- Passive House Institute (International)
- Passive House Institute (United States)
- Whole Building Design Guide Building Commissioning
- Building Commissioning Association

The David and Lucile Packard Foundation Headquarters | Los Altos, CA
Courtesy: Jeremy Bitterman

When systems are properly integrated, each component is critical to achieving the ZNE goal so both first costs and ongoing lifecycle costs should be considered during value engineering.

Project Hand off

While design characteristics have a significant impact on long-term building energy use; building maintenance, operation, and occupancy strategies are absolutely critical to the long-term ZNE result. An NBI Sensitivity Analysis shows that occupancy characteristics impact energy just as much as many design decisions on building energy use. This confirms just how critical it is to engage building operators, occupants, and tenants in any long-term strategy to manage and improve building energy performance.

Turning the project over to the owner is a critical point in a ZNE project. Building occupants and facility staff may not be familiar with passive approaches or new equipment, yet these individuals must understand the systems – and how their interaction with these systems drives energy consumption – in order to achieve a ZNE result. For example, if the building is naturally ventilated, the occupants should know when to open or close windows. The same holds true for daylighting strategies that can easily be disabled by occupants. Cleaning crews should also be trained to turn off systems, such as lighting, when their work is done.

Interactive energy data displays can help familiarize occupants with the impacts of their behaviors on energy use.

Zero Net Energy Center | San Leandro , CA
Credit: Chad Ziemendorf

Interactive energy data displays can help familiarize occupants with the impacts of their behaviors on energy use. Touchscreen dashboards displayed in the building can educate occupants and help inform visitors of sustainability interests. Similarly, online platforms allow occupants to see, in real-time, the effects their behaviors have on building energy consumption. Such tools can help engage occupants and remind them to use building systems as designed.

Turning the project over to the owner is a critical point in a ZNE project.

Facility operations and maintenance staff should meet with the design team and commissioning agent to learn about the building systems, controls, and automation systems before taking over maintenance responsibilities. It may be helpful for the design team to develop an operations manual that includes equipment data forms and warranty information.

The contractor, architect and/or engineer can also assist the building operator in troubleshooting performance issues early in occupancy. They should provide as-built drawings that show changes that may have been made during the construction process. These will be helpful during future remodels to know where ducts, pipes, wires, etc. are located.

Finally, recapping successes and challenges at a close-out meeting can be valuable for everyone to reflect on the development process through the lens of ZNE. This is an opportunity to note what was different from a conventional design and construction approach. Lessons learned and case studies can influence future projects, for this team and for others, if the ideas are presented in papers or at conferences with a larger audience.

Resources

- Sensitivity Analysis: Comparing the Impact of Design Operations, and Tenant Behavior on Building Energy Performance
- Using Key Performance Indicators for Energy Performance

Operation and Verification

ZNE buildings are not just designed to ZNE standards, they are operated at ZNE.

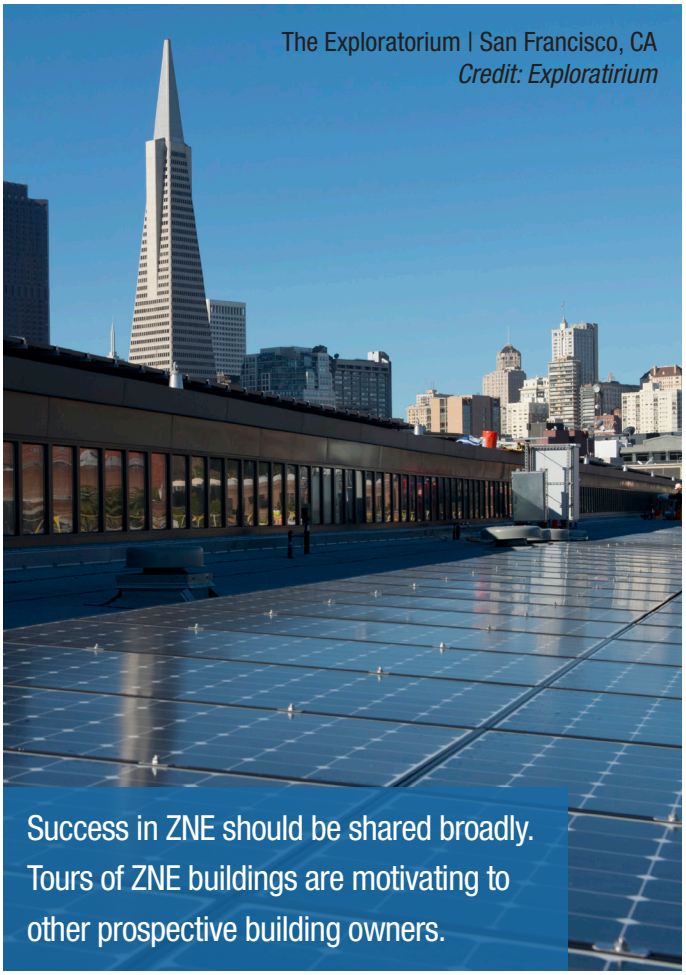
Ongoing tracking and review of energy performance with a building management system, energy dashboard, or EnergyStar® Portfolio Manager is helpful to understand energy performance and renewable energy production. Facility staff can compare actual energy consumption to predicted performance to identify if systems are operating as expected. Uncovering irregularities through frequent data review can help to promptly correct issues.

One full year of energy consumption and production data is necessary to verify ZNE performance. Research has shown that some ZNE buildings may not operate at ZNE during the first twelve months of operation, instead, it takes longer to meet the target. After one year of ZNE performance, energy data can be submitted to NBI or the International Living Future Institute (ILFI) for third-party review.

ZNE buildings are not just designed to ZNE standards, they are operated at ZNE.

If the building is not meeting the target, the design team, building operators, and commissioning agent should coordinate to review the data, calibrate the equipment, and engage the occupants to ensure the performance meets ZNE goals.

Success in ZNE should be shared broadly. Tours of ZNE buildings are motivating to other prospective building owners. Some ways to share your story might be by speaking at conferences, publishing case studies, and/or explaining lessons learned.



The Exploratorium | San Francisco, CA
Credit: Exploratirium

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Resources

- Getting to Zero Registry, Buildings List and Database FAQ
- NBI Getting to Zero Database and Registry
- ILFI Net Zero Certification
- NEEP Regional Operations and Maintenance Guide
- The Path to Net Zero: A Shout Out to Building Operators
- Discovery School (Arlington, VA) Energy Dashboard by VMDO and CMTA

ZNE Project Checklist

This Getting to Zero: ZNE Project Guide *can help lead your ZNE project to success with information and links to resources to support your path to zero. The checklist below outlines some of the key action items for easy reference.*

Stakeholder Awareness:

- ☐ Identify a ZNE Champion
- ☐ Identify stakeholders, drivers, and messaging
- ☐ Distribute case studies
- ☐ Schedule tours

Energy Goals and Targets:

- ☐ Benchmark existing building performance
- ☐ Evaluate building pipeline for ZNE opportunities
- ☐ Use remote analytics to prioritize assessments
- ☐ Conduct onsite assessments
- ☐ Draft Owners Project Requirements (OPR)
- ☐ Set energy target EUI

Team Selection:

- ☐ Address ZNE in Request for Proposal
- ☐ During team interviews, ask about ZNE
- ☐ Understand ZNE implications of various contractual structures (design-build, lease-leaseback, integrated project delivery, etc.)
- ☐ Incorporate ZNE and energy targets into the RFP, OPR, and contract documents

Finance and Incentives:

- ☐ Connect with efficiency program administrators to identify available incentives
- ☐ Evaluate On Bill Repayment options
- ☐ If tenants will be in the building, consider a green lease with energy targets
- ☐ Consider tax credits

Early Design/Pre Design:

- ☐ Host an integrated design charrette
- ☐ Conduct early design phase modeling
- ☐ Develop and update the OPR and BOD
- ☐ Evaluate building orientation options for passive opportunities

Design and Construction:

- ☐ Review passive and active technologies:
  - ☐ Envelope and sealing
  - ☐ Heating and cooling
  - ☐ Ventilation
  - ☐ Lighting, daylighting, and controls
  - ☐ Design for ease of metering
- ☐ Evaluate onsite renewables
  - ☐ Location
  - ☐ Structure
  - ☐ Pre-wiring for future installation
- ☐ Conduct iterative energy modeling
- ☐ Identify how energy data will be shared with tenants
- ☐ Engage a commissioning agent and controls integrator
- ☐ Ensure the contractor understands the project goals and coordinates with the commissioning agent
- ☐ Conduct envelope and systems commissioning

Project Hand Off:

- ☐ Train facility and operations staff
- ☐ Provide as-built drawings
- ☐ Conduct close out meeting
- ☐ Conduct occupant training

Operations and Verification:

- ☐ Benchmark energy performance
- ☐ Share energy use with occupants
- ☐ Commission the building systems
- ☐ Create a project case study
- ☐ Celebrate!

Cover Image: Stevens Library at Sacred Heart School | Atherton, CA

Administered by California utilities, Savings By Design encourages high-performance, non-residential building design and construction, and a variety of solutions to building owners and design teams. More information at: savingsbydesign.com.

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