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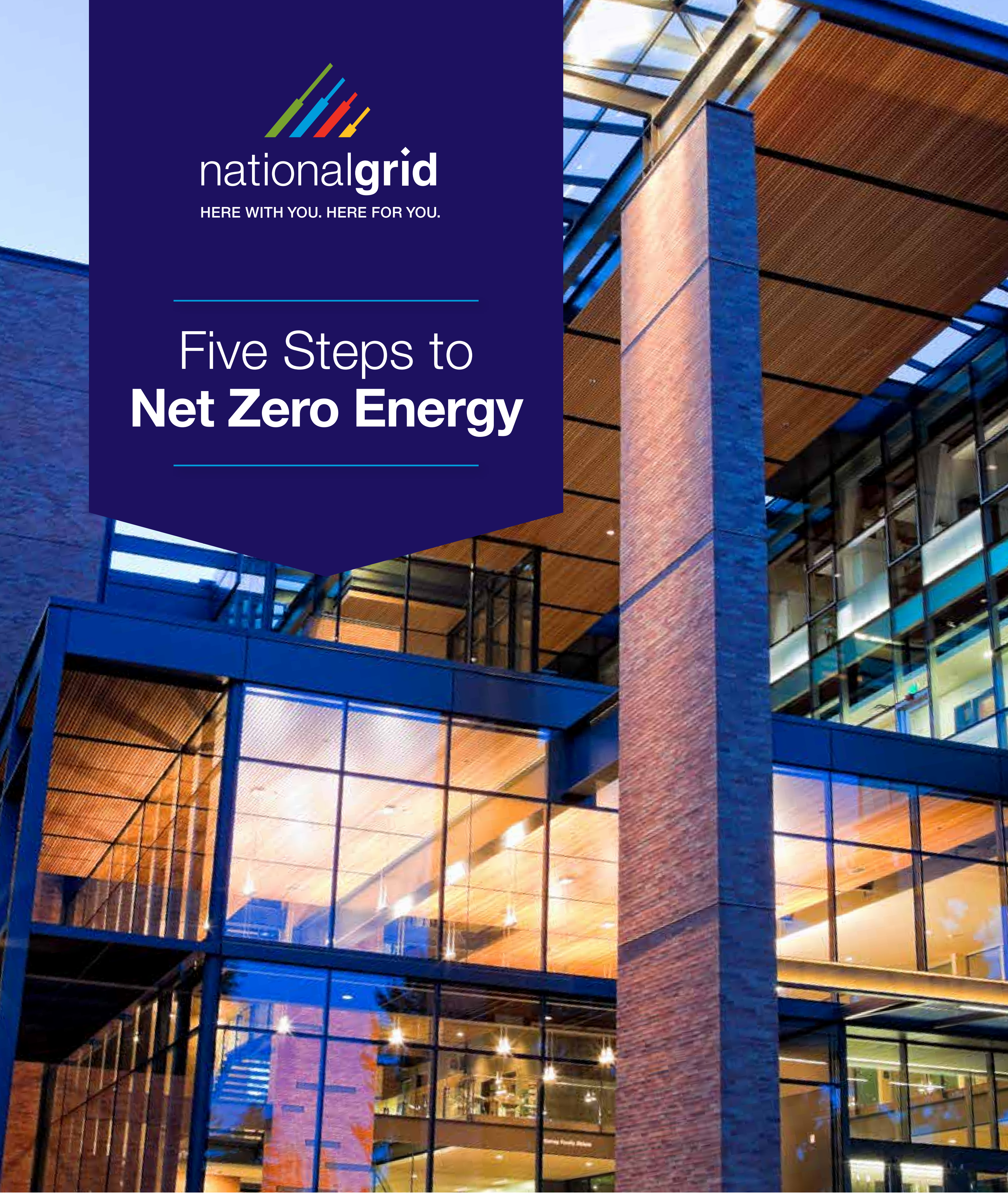
Five Steps to **Net Zero Energy**



nbi new buildings institute

INTRODUCTION

Zero net energy buildings are emerging as the premium standard of energy efficiency in the green architecture world. A zero net energy (ZNE) building combines high levels of efficiency, good operations, and on-site renewable energy (such as photovoltaic panels) in order to produce as much energy on-site as the building consumes in a year.

And what about existing buildings? Deep Energy Retrofits have received increased attention, but can a retrofit go all the way to zero? The answer is yes; nearly a third of the buildings in the New Buildings Institute's (NBI's) **database of ZNE buildings** are retrofits of existing buildings.

This guide is an introduction to how architects and engineers can help clients upgrade their existing buildings to be ZNE through a Deep Energy Retrofit combined with renewable energy sources. A Deep Energy Retrofit is an existing building retrofit that improves building performance by at least 30%. Deep Energy Retrofits increase the value of buildings, lower utility bills, improve occupant comfort, and reduce maintenance needs. They can be key to improving a building for occupants and improving the investment value of a building for owners.

A ZNE Deep Energy Retrofit is possible for a large number of existing buildings in the market today. These five steps can help ensure your project's success:

1. **ASSESS THE BUILDING**
2. **SET GOALS FOR PERFORMANCE**
3. **SCOPE THE PROJECT**
4. **IMPLEMENT THE RETROFIT**
5. **OPERATE THE BUILDING**

1 ASSESS THE BUILDING

A successful ZNE retrofit must start with a thorough assessment of the building. In new construction, the building is shaped by the design. But in retrofits, the design is shaped by the building to a much greater extent. Changing the features of an existing building requires a lot more than moving lines in a drawing. Therefore, a retrofit project needs to begin with a thorough assessment of the building, including current energy performance, weaknesses, and strengths.

Analyze Energy Performance

This assessment starts with analyzing energy performance and energy benchmarking. The energy performance of buildings is often expressed in energy use intensity (EUI) or kBTU/square foot. However, knowing what EUI is appropriate for your building type is a challenge. Different buildings use energy differently. For example, a fast food restaurant or a lab uses much more energy per square foot than an office or a church. Plus, the same building in different climates will use energy differently. So how do we assess a building's performance? How do we move beyond benchmarking to a deeper understanding of the meaning of energy performance?

There are several tools and rating systems that contextualize energy performance:

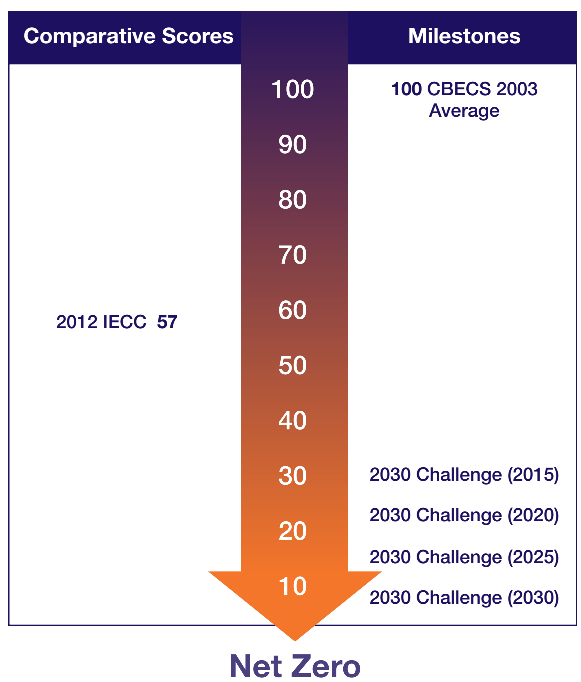
- ENERGY STAR® scores
- The zEPI Scale
- The ASHRAE Building Energy Quotient
- ASHRAE Standard 100

These kinds of tools allow a project team to turn gross energy consumption into meaningful information about energy performance, how certain buildings compare to other buildings, and, especially in the case of the zEPI scale, how they compare to ZNE. Once the building's starting energy performance is understood, the project team can see how much improvement achieving ZNE will require.

zEPI

The Zero Energy Performance Index (zEPI) is particularly well suited to assessing buildings for ZNE. zEPI is a scale: 100 represents the average performance of the American building stock from the turn of the millennium (as represented by data in the Energy Information Administration's 2003 Commercial Building Energy Consumption Survey), and 0 represents ZNE. Scores are normalized by building type, square footage, and climate so that any buildings, no matter how different, can be evaluated side by side. zEPI offers a clear picture of where a building's performance currently is and how far it will need to go to get to ZNE.

zEPI Scale to ZNE



An assessment does not have to be limited to a single building. It can be applied to entire portfolios of buildings, or even entire building stocks. Using context provided by tools such as zEPI, a whole group of buildings can be assessed together in order to identify the best candidates for a ZNE retrofit. A government entity does this with its collection of public buildings in order to identify the best building to pilot the retrofits necessary to meet aspirational carbon reduction goals. Property management companies might conduct this type of analysis as a value-added offering to their clients in order to identify good candidates to reposition in a burgeoning green building market. Or a corporate real estate portfolio might be looking to decide which buildings to take to ZNE first.

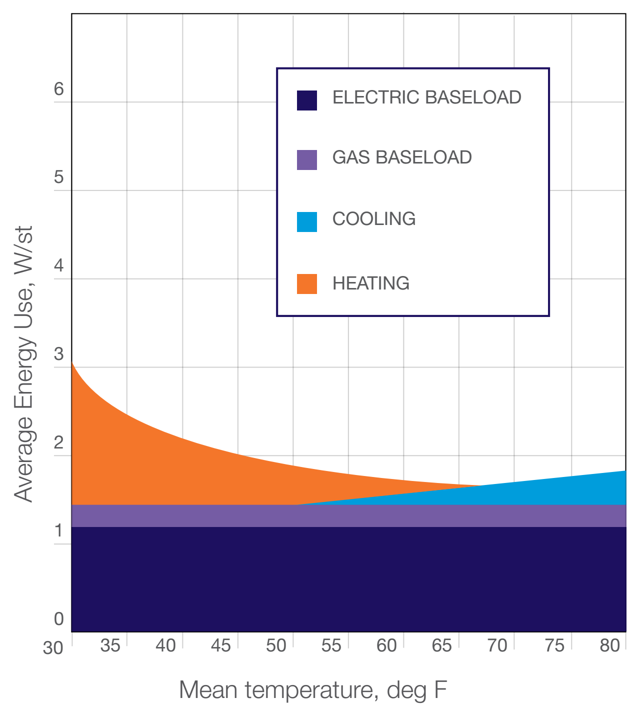
Identifying good candidate buildings for ZNE retrofits doesn't just mean seeking the best performers or the ones closest to ZNE. The worst performing buildings may offer the greatest opportunity for savings. As a comparison, improving the gas mileage of a new hybrid won't save nearly as much energy as the same percentage of savings in gas mileage in an old beat-up truck. Those worst performers may have systems that need to be replaced or may have the greatest need for a retrofit or market repositioning.

Examine Weaknesses and Strengths

Assessing a building goes beyond understanding energy performance. The project team needs to investigate further in order to understand *why* the building is performing as it is. This requires assessing the building's condition and its energy efficiency weaknesses and strengths. Normally, project teams do this with an on-site energy audit. ASHRAE defines a set of three increasingly thorough levels of audits for buildings. These and other energy audit protocols provide a way to physically examine the building in order to understand its performance.

However, there may be factors that impact a building's energy performance that can't be seen or with which the auditor is unfamiliar. This is where remote auditing tools like FirstView™ and FirstFuel™ can play a role. By combining simple physical information about the building with monthly data (such as energy use) and weather data, these "inverse modeling" tools can reveal details about a building's performance, all without ever going on-site.

FirstView Software Tool Access



These details include the electric baseload from lighting and plugs, gas loads from water heating, and heating and cooling performance.

These kinds of tools can supercharge an on-site audit and give auditors information about which systems to investigate further, where to spend extra time, and what particular performance issues to understand.

Often, when project teams assess a building, they look only for weaknesses or problems that need to be solved. However, an assessment needs to also focus on strengths. For example, windows are often seen as a weak point in the thermal envelope, yet these same openings are essential for daylight and natural ventilation. Masonry walls might be poor insulators, but they also provide thermal mass that can naturally even out temperature swings. Since ZNE is such an aggressive goal, teams need to take advantage of strengths present in their existing building to ensure success.

2 SET GOALS FOR PERFORMANCE

After a comprehensive assessment of the building, the project team can set goals for the retrofit. Even after the goal of ZNE has been chosen, there are other targets to set.

The assessment will provide information about how much each aspect of building performance–thermal performance, ventilation, lighting, water heating, process loads, plug loads–will need to be improved to meet that ZNE goal. This is another reason a full assessment is necessary. This is also the time to consider the production side of ZNE. Every building and site has only so much potential for renewable energy production.

For example, there is only so much roof and site square footage that can be devoted to photovoltaics. Local climate and shading will determine how much solar energy actually reaches that area, and more efficient PV panels are costlier. Therefore, the total renewable energy potential of the building and site provides a maximum level of energy consumption for the building and a minimum level of efficiency for the building.

3 SCOPE THE PROJECT

Once you have set performance goals for building, the project team can scope the retrofit. New Buildings Institute maintains a database of buildings that have achieved ZNE or similar levels of ultra-low energy. Examining these ZNE precedents can help project teams evaluate a ZNE retrofit for their own building.

The body of ZNE precedents provides source of guidance for ZNE retrofit projects. NBI's database of ZNE buildings includes case studies and project details. Project teams can look at other ZNE buildings that are similar to their project to see how other project teams have addressed similar circumstances and issues, benefiting from their experience. They can look at what it takes to get to zero in a school, an office, or a multifamily building. They can also look for buildings with similar characteristics, construction types, configurations, and size to see how those characteristics were accommodated in a ZNE building.

Combined with a comprehensive building assessment, these precedents provide the project team with a basis for choosing measures to pursue to reach both individual goals for parts of the building and the overall goal of ZNE.

This set of common retrofit technologies also reveals a set of measures that will be part of nearly every ZNE retrofit. Because not all of the systems in a building are likely to be replaced, those that remain will need to be retro-commissioned in order to maximize their performance. Even the systems that remain will most likely need an upgrade in order to provide more advanced control capabilities. In addition, a key element of recent gains in energy performance has been controlling infiltration, so some level of infiltration reduction will probably be necessary.

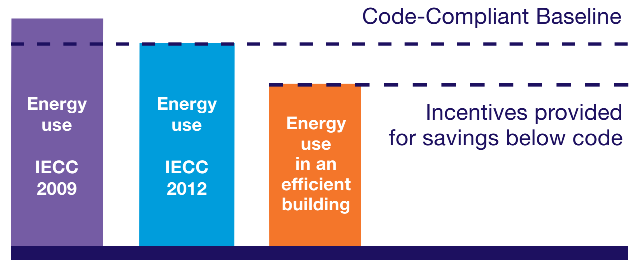
ZNE buildings tend to have a certain suite of features and technologies in common

1. **Lighting:** Daylighting as the primary source of illumination, plus LED lighting and vacancy controls
2. **HVAC:** variable capacity heat pumps, ground source heat pumps, and radiant systems; technologies such as packaged roof top units are almost totally absent
3. **Ventilation:** Variable flow fans, advanced controls like demand control ventilation, and energy recovery ventilation
4. **Envelope:** High insulation levels, high-performance windows, and conscious efforts to reduce thermal bridging and infiltration
5. **Plug load:** Attention to plug load equipment like high-efficiency appliances and computers, and plug load controls

Exceeding Building Code

Whatever the approaches or technologies chosen, one common theme is the importance of exceeding code wherever possible. It isn't only about trying to maximize performance or making the most of every intervention; utilities are allowed to offer incentives only for exceeding code minimums. Therefore, the assistance that utilities have to offer with technical issues and cost is available only when the project goes beyond code.

And that code is moving. The federal efficiency standards for HVAC equipment are lower than what is available in the market. LEDs are transforming the lighting world, but code requirements are still based on less efficient technologies. With rising code baselines, today's efficient technologies will be tomorrow's code minimums.

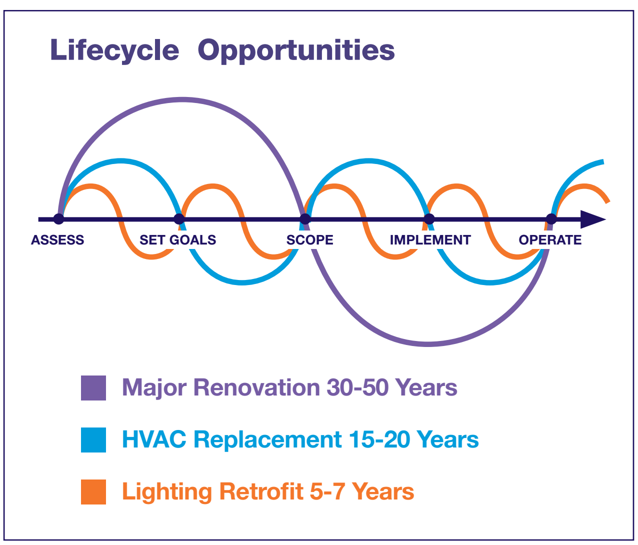


4 IMPLEMENT THE RETROFIT

The next step is to implement the retrofit measures. A big retrofit project can be disruptive; therefore, the success of the ZNE project requires good timing and accounting for the realities of the building, ownership, tenants, and markets.

Building Considerations

Buildings have a natural life cycle. Major renovations usually come around only every 30-50 years, HVAC replacements every 15-30 years, and lighting retrofits every 5-7 years. Lease renewals in commercial buildings come along every 2-5 years, and other real estate transactions like sale, mortgage refinance, or market repositioning can come along at any time. And of course, unexpected repairs due to everything from equipment failure to a natural disaster can appear without warning.



All of these events in the life of a building create an "inflection point," an opportunity that can be exploited for a Deep Energy Retrofit. The more significant the inflection point, the bigger the opportunity to pursue energy improvements, especially ZNE.

Ownership and Tenants

Ownership also affects the way that a ZNE retrofit can be implemented. Owner-occupied buildings are a good match for ZNE retrofits because the owner is the occupant and therefore has control over every aspect of the building, including operations. Additionally, when the owner pays the utilities, they benefit directly from energy performance improvements and there is no split incentive between capital and operating costs. Budget may determine whether the retrofit is executed in stages or all at once, but coordination with occupancy is simplified significantly.

The more institutional MUSH (Municipal, University, School, and Hospital) market lends itself to whole building retrofits. These institutions typically also have a high

degree of control over building occupancy and are more likely to fund projects through lump sums like endowments, capital campaigns, and bonds.

Conversely, the tenant-based occupancy, often involving multiple tenants, that characterizes commercial real estate imposes certain limitations. Unless the building is undergoing a major renovation or market repositioning in which the entire building is going to be vacant, a ZNE retrofit may need to be undertaken in stages to minimize tenant disruption.

This might include staging the retrofit around vacancies, lease renewals, or tenant improvements. The cash-flow basis for that market also means that retrofits may need to be staged as capital reserves are replenished by rents, or whole building retrofits timed to coincide with a new or refinanced mortgage.

Market Positioning

Finally, implementing the retrofit measures means looking beyond just energy. Sometimes retrofits create a non-energy opportunity. This goes beyond the opportunity to reposition a building in the market. For instance, an insulation upgrade can also provide the opportunity to give the building façade a facelift. In older buildings with historic character that have suffered from previous retrofits–such as the introduction of drop ceilings to reduce the conditioned volume, or the installation of ductwork through spaces and architectural detail–a system replacement with more advanced equipment can provide the opportunity to restore obscured architectural detail. One advantage to building envelope and lighting improvements is that they can also allow HVAC equipment to be downsized, sometimes substantially. That can create the opportunity to reclaim building area that was previously occupied by HVAC equipment.

For example, improvements made as part of the Deep Energy Retrofit to the Edith Green—Wendell Wyatt Federal Building allowed for the majority of the machine penthouse to be converted to office space, freeing up some of the most valuable square footage in the building for people to use.

The Edith Green—Wendell Wyatt Federal Building before and after achieving ZNE

Photography provided by SERA Architects

5 OPERATE THE BUILDING

Ultimately, ZNE must be proven by actual performance and occupation of the building. A successful ZNE building needs to go beyond design, technologies, and strategies. A ZNE building needs to be operated to achieve zero, and good operations start with design.

Begin With Design

Users, operators, and contractors can and should be brought into the design process early to help designers understand how the building and its individual spaces will actually be used. The building can be organized to align uses as much as possible. Spaces with similar schedules, lighting, and/or space conditioning can be grouped together. This allows systems to be more effectively zoned and configured to only provide as much lighting, heating, cooling, ventilation, or hot water as is necessary to those common uses, rather than being tuned to the most demanding use in the zone. With grouped schedules, zones can be turned off or down rather than being kept on for partial occupancy.

The design team can also specify technologies and incorporate design features to support good operations. This means specifying controls that are easy to use and adjust. Sophisticated controls can be a powerful tool, but sometimes a simple solution can be powerful too. For example, DPR Construction's Phoenix office includes a big red button by the door; this "vampire switch" shuts down the power to 95% of the nonessential plug loads. The last one out of the building hits the vampire switch. That approach cuts the plug loads by about 37%. It also provides users with easy-to-understand feedback about building performance so that they have the information they need to adjust their day-to-day behavior, and operators can identify when something is going wrong with the building's performance and address it early.

Vampire switch at DPR Construction's Phoenix office

Photography provided by DPR Construction

Reconsider Operations

Effective operation of ZNE goes beyond design. Owners might decide to jettison the traditional design-bid-build approach and opt for contracts that better support the integration of the design, alteration, and operation of the building. ZNE buildings benefit from a tighter integration of the design and build phases, as well as the introduction of a new category to maintain and/or operate.

Owners might find that it makes sense to hire a resource conservation manager, a consulting entity that will monitor the building performance, identify and remedy issues early–whether those issues are with the building or with the users –ensure that proper maintenance is being performed, check that equipment is being recalibrated to changing needs, and help the owner make long-term decisions about the building. Owners may need to enter into "green leases" with tenants in order to clearly define the tenants' responsibilities to operate the building efficiently.

Above all, everyone involved will need to stay engaged with the building to ensure that ZNE is not just an aspiration or an intention, but a reality.

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Do you have a building and want to go deep with your retrofit, all the way to ZNE? Watch our net zero webinar to learn more. Or contact us to find out how our incentives and design assistance can help you achieve that goal.

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This publication has been developed in collaboration with New Buildings Institute (NBI), a nonprofit organization working to improve the energy performance of commercial buildings. NBI works collaboratively with commercial building market players—governments, utilities, energy efficiency advocates and building professionals—to help remove barriers to energy efficiency, including promoting advanced design practices, improved technologies, public policies and programs that improve energy efficiency. | newbuildings.org

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