NET-ZERO ENERGY & NET-ZERO CARBON

DESIGN STRATEGIES TO REACH BUILDING PERFORMANCE GOALS

As the effects of climate change intensify across the world, the AEC industry is shifting toward green building to effectively address the climate crisis. In 2020, members of The American Institute of Architects (AIA) overwhelmingly approved a resolution making environmental stewardship the organization's top priority and since then, steady progress has been achieved to develop a Climate Action Plan, evolve the Framework for Design Excellence, and increase participation in the 2030 Commitment. The building and construction sector is responsible for 36% of energy consumption, 38% of energy related carbon emissions, and 50% of resource consumption globally. These percentages are expected to double in total footprint by 2060, exacerbating the negative effects of climate change on the environment. The Intergovernmental Panel on Climate Change (IPCC) 2021 Report warns of increasingly extreme heatwaves, droughts and flooding, and a key temperature limit being broken in just over a decade. The world must act fast to avoid these catastrophic events, and decarbonizing the built environment is a major step in the right direction.

Many government organizations and climate-conscious entities are pushing for all new buildings, developments, and renovations to achieve carbon-neutrality by 2040. Architects, engineers, and all parties involved in the building design process must begin implementing sustainable strategies into their workflows to achieve these goals and make a significant impact in the fight against climate change. In this e-book, we outline the differences between net-zero energy and net-zero carbon and provide key design strategies to help architects and engineers meet performance targets.

What is Net-Zero Energy (NZE)?

Net-Zero Energy refers to the ability of a building to offset the amount of energy required to operate throughout its lifetime. A building can be designed toward net-zero and offset its energy use in three ways:

1. Producing energy onsite via equipment like solar panels or wind turbines.
2. Accounting for its energy use through clean energy production offsite.
3. Reducing the amount of energy required through design and system optimization.

These are typically complementary strategies with the first option directly linked to the initial costs of the building design. Achieving NZE is not technically dependent on the building being efficient, but the most effective and cost-efficient strategy to achieve NZE is reducing the energy load and then utilizing renewable energy to offset the remaining energy use requirements. Optimizing the energy requirements of a properly designed building exponentially helps reduce power demand and the amount of power to produce or offset.

What is Net-Zero Carbon (NZC)?

Net-Zero Carbon refers to the ability of a building to offset the operational carbon and the amount of embodied carbon from the process of creating a building. Embodied Carbon (kgCO2e) refers to the Greenhouse Gases (GHGs) emitted during the extraction, manufacture, transportation, construction, replacement, and deconstruction of building materials, together with the end-of-life emissions. Building materials currently account for nearly 40% of the world's carbon emissions, making carbon neutrality a top priority for architectural projects. Below are the main stages of carbon emissions for a building with highlights of who is most or least responsible for each one as published by the World Green Building Council (WGBC).

With the world quickly shifting towards focusing on reducing carbon for economic stability, large investment firms are changing their stance and efforts towards achieving net-zero carbon. The news about Blackstone, one of the largest real estate groups in the world, doubling down on their environmental, social, and governance (ESG) commitments is just one example amongst many that showcases the shifting trend. Achieving NZC requires the reduction and offsetting of non-sustainable building materials and construction practices that cause high carbon emissions, like specifying building materials with low kgCO2e values. Similar to achieving NZE, the reduction of carbon has an exponential effect on a building design that is net-zero carbon.

	Construction	Use stage		End of life
	Upfront carbon	Operational carbon	Use stage embodied carbon	End of life carbon
Architects	High	Low	Medium	High
Engineers	Low	High	Medium	Low
Cities, States and Regional Authorities	Low	High	Low	Low
Construction Product Manufacturers	High	Low	Low	High
Contractors	High	Low	Low	Low
Property Developers[4]	High	Low	Low	Medium
Property Owners and Investors[4]	Low	High	High	Low
Property Managers, Agents and Advisors[4]		Medium	High	
Tenants/Occupiers		High	Medium	

Figure 5 - Influence of stakeholders across the building lifecycle (new construction and renovation)

Certification Requirements

There are now multiple certifications available for recognizing NZE and NZC buildings. Carbon neutrality is the key initiative for climate change to support the survival of cities as outlined by Architecture 2030, who has established a goal to achieve a carbon-neutral built environment by 2040. Certifications help incentivize this goal. It's important to identify key design requirements early in the design process to help predict if a building is on track to be net-zero and determine optimization strategies to reach this goal. Multiple organizations offer certifications for NZE and NZC buildings, and the requirements for each certification differ slightly.

Not every building will apply for certification, but design strategies toward net-zero buildings are simply good design. The lower the energy demand upfront, the less energy needed to make up later. This **energy/carbon in = energy/carbon out** is the neutral balance and net result of zero energy/carbon wasted for net-zero strategies. Good design strategies working toward net-zero are beneficial to the architecture even without certification, and it is possible to achieve without high-priced products. Designers can use predictive tools to automate the insight of design decisions and get a clear understanding of how to design for better building performance.

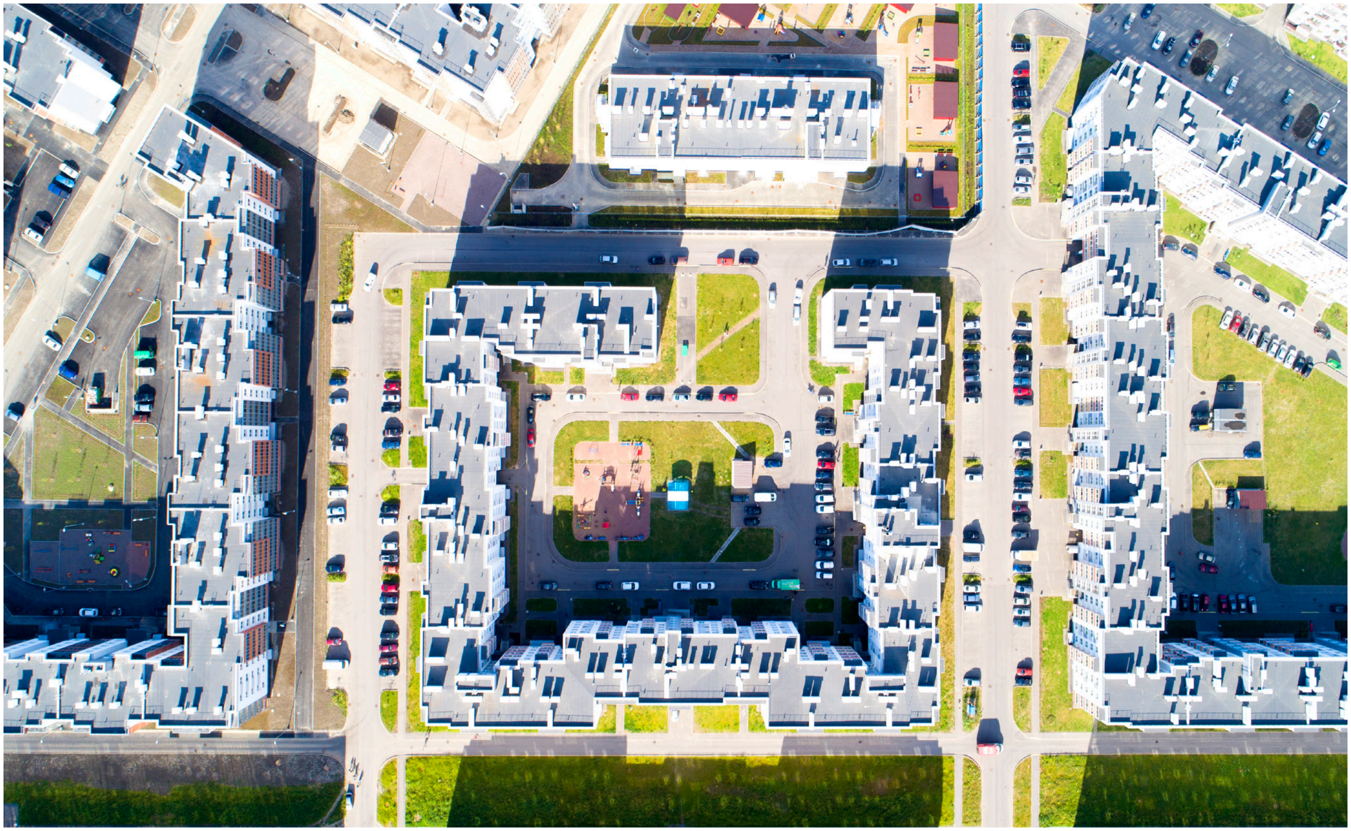
Design Strategies

Reduction is the over-arching design approach for all net-zero strategies as it directly affects the energy/carbon required to offset later. Reducing the energy demand on a building provides the appropriately sized system for building operations and can lead to large cost savings. Reducing embodied carbon through material decisions often results in enhanced occupant experience by decreasing harmful off-gassing from chemicals that affect the occupants' productivity.

It's important to note that rule-of-thumb concepts are not enough to make a net-zero building as each building and its conditions are unique and optimization is the key to striking the neutral-balance. However, there are common design strategies that help teams understand the impact of their decisions. Applying any number of the below strategies during your design process will guide your work toward energy and embodied carbon reduction and keep your project on track toward net-zero.

1. PASSIVE STRATEGIES

Designing with passive strategies is about understanding the environmental constraints of the site and designing a response that does not require active mechanical systems. Examples include using ambient energy sources to cool, heat, shade, or ventilate a building space. Working with the natural conditions without requiring added electrical load helps decrease the energy required to offset for a net-zero building. Environmental qualities have a critical role in design to know what is specifically needed to minimize heat transfer through the building envelope (exterior walls), which will then rely less on mechanical systems to maintain occupant comfort levels. The challenge with designing for passive strategies is that they must be incorporated in the early stages of the process to be effective.



2. SOLAR SHADING

Solar shading is a form of solar control that can be used to optimize the amount of solar heat gain and visible light that is admitted into a building. Solar Shading is a powerful passive strategy that if fully utilized can have a massive impact on a building's overall performance and space quality. A good way to think about this is to consider that the heat added to the inside of your building has to be adjusted to stay at set temperature levels, typically by an HVAC system. The less the mechanical system has to work, the less energy you need to use, and the more likely your design will reach net-zero. Solar shading encompasses a large scope of design strategies.

- Building Massing
- Orientation
- WWR (Window to Wall Ratio)
- Glazing Placement
- Envelope Properties
- Fenestration Performance
- Traditional Shading Elements (fins and overhangs, light shelves, shadow boxes, and cantilevers)
- Modern Shading Elements (frit, interior shades, dynamic glass).

Using this strategy, designers can reduce energy use and have a strong impact on the thermal and visual comfort of the occupants by preventing overheating and glare during sunny seasons in the year. However, the effectiveness of the shading strategy is dependent on multiple factors, including shading device type, depth, context, and building program.

3. ACTIVE STRATEGIES

A building's energy use refers to the energy required to operate and sustain the project once it's occupied. The metric is expressed as the energy per square foot per year (kBtu/ft²/yr) or as it is more commonly known as the EUI or energy use intensity. By calculating the energy, a building consumes annually, designers can better predict the projects' cost as it is directly linked to a building's energy consumption.

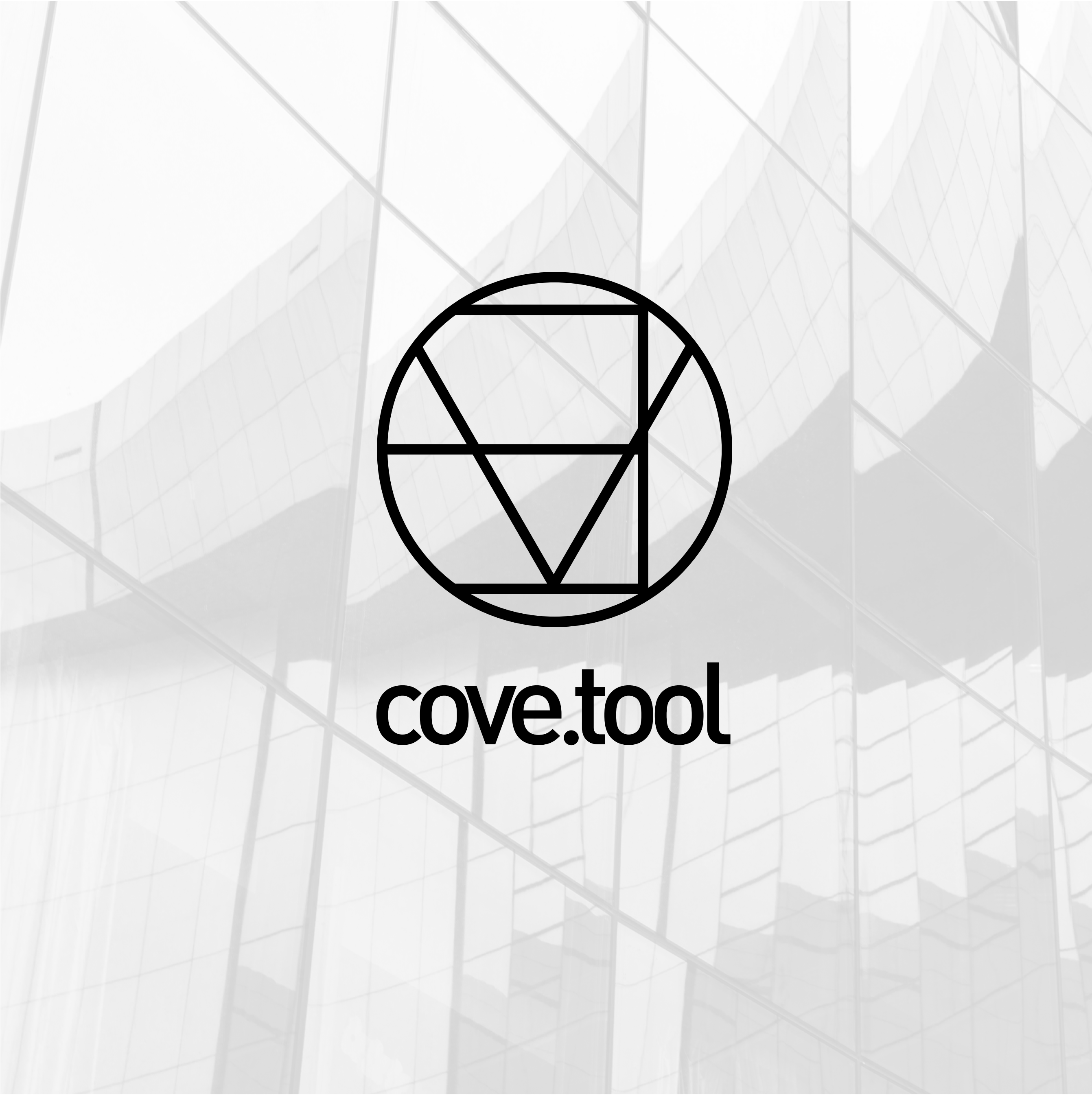
EUI breakdown includes heating, cooling, lighting, equipment, fans, pumps, and hot water that represents the mechanical system of a functional building. A more detailed overview of what is covered in these categories can be found here.

The goal is to increase the efficiency of the active system to decrease the demand for energy overall. Showing a reduction of energy use is helpful, but to reach net-zero energy the optimal overall solution is crucial as every project has many variables and entities involved that don't all have net-zero as the top priority. Optimizing for energy reduction and initial cost helps the whole team quickly reach an informed decision on the best route forward with the best performing options at the table. Optimization is the core powerhouse of reaching net-zero building design.

4. RENEWABLE ENERGY

On-site renewable energy is another essential tool for reaching net-zero. Off-site renewable energy is essential as well but requires live operational data from the source energy (power plant) and is thus outside the scope of building design. Providing energy generation is the final tool for net-zero energy design and is possible through technologies that produce electricity, like wind or photovoltaic "solar" panels. The strategy is simple. Use natural energy sources like the wind or the sun to generate electricity.

For a building to reach net-zero, this strategy must produce enough electricity as what it uses annually. For example, solar panels are an assembly of silicon cells mounted in a frame with wiring that helps absorb and convert sunlight into usable electricity. By calculating the total square feet of panels and the type of panels used, designers can calculate the annual power generation the building project. Power generation is the final piece of building design to reach both net-zero-energy and net-zero-carbon status.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