GETTING TO zero

Thank you to our Getting to Zero sponsors who make these educational opportunities possible:

nbi new buildings institute · RMI · NEW YORK STATE OF OPPORTUNITY. NYSERDA · TRANE · NEW YORK STATE OF OPPORTUNITY. NY Power Authority · nationalgrid · BETTERBRICKS · DAIKIN AIR INTELLIGENCE · enVerid · legrand · NREL · ASHRAE · ENERGY FOUNDATION · Opinion Dynamics · Pacific Northwest NATIONAL LABORATORY · BREEAM USA delivered by bre · NORESCO · PGE · P2S INC · ARUP · Brightcore BUILDING ENERGY PERFORMANCE · CMTA · DNV · EXCEL · EVERSOURCE · mass save · INTEGRAL · LinkedIn · PAE · POINTENERGY INNOVATIONS · Rheem · slipstream · SOUTHERN CALIFORNIA EDISON Energy for What's Ahead · Steven Winter Associates, Inc. · TRC

1

Center for Sustainable Landscapes | Pittsburgh, PA *Photo: Paul G. Wiegman*

nbi new buildings institute

Insiders Guide to Talking about Carbon Neutral Buildings

September 23, 2021

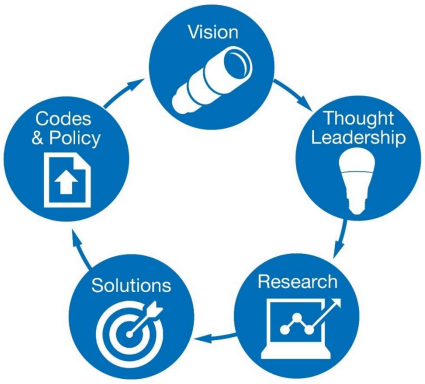
© New Buildings Institute 2021

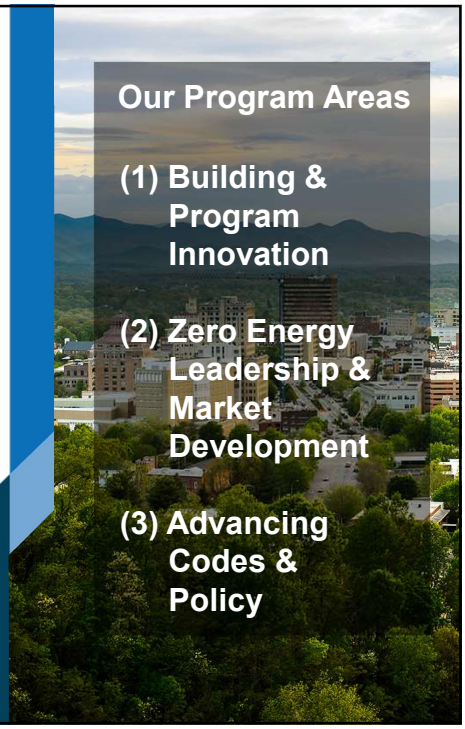
2

Efficiency delivered.

NBI is responding to increasing urgency to reduce carbon emissions and increased demand for improved energy performance of new and existing buildings.

NBI's Theory of Market Change:





3

Frick Environmental Center | Pittsburgh, PA *Photo:Ed Massey*

Today's panel:

Narada Golden
Vice President
WSP

Webly Bowles
Project Manager
New Buildings Institute

Mischa Egolf
Project Analyst
New Buildings Institute

Jonathan Heller
President
Ecotope

© New Buildings Institute 2021

4

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Defining Net Zero

This project needs to be **Net Zero**!

I hope they've all read **NBI's Insider Guide to Carbon Neutral Buildings**!

What does that mean exactly? Net Zero **energy** or **carbon**?

How are we measuring success? **Prescriptive Measures** or real-world **Performance**

Phew! That just means buying offsets. **We don't have to do anything!**

Are we talking about the **SBTi**, **ILFI**, **LEED, WGBC, Zero Code, 2030** or **NREL** definition?

Are we including **Embodied Carbon** or just **Operational Carbon**?

We'll need to prioritize **energy efficiency** and **load reductions**.

5

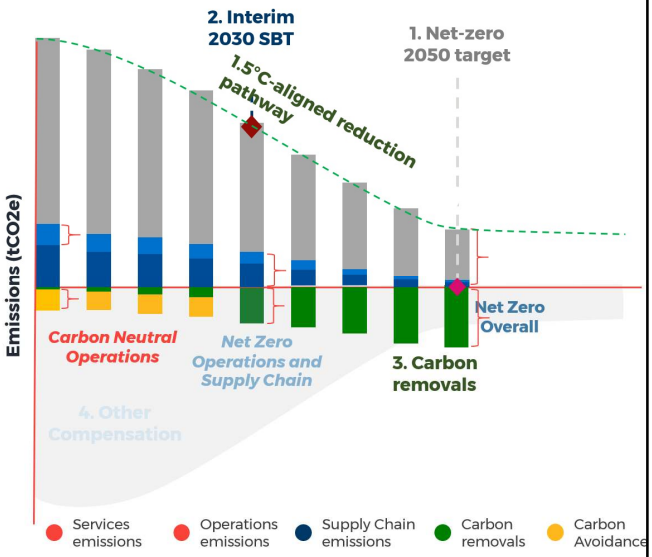
5

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Defining Net Zero in Companies and Institutions

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

- Science-Based Targets align Net Zero plans with climate science
- Details of Net Zero requirements will be published later this year
- WSP is involved in developing these criteria



6

6

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Defining Net Zero in Companies and Institutions

Science-Based Targets Framework

Foundations for net-zero target-setting in the corporate sector

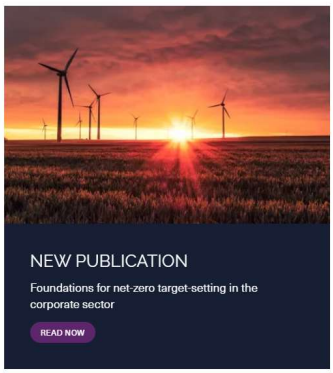
We've launched a process to develop the first science-based global standard for corporate net-zero targets, to ensure that companies' net-zero targets translate into action that is consistent with achieving a net-zero world by no later than 2050.

Our new paper lays out the conceptual foundations for credible, science-based net-zero targets for the corporate sector:

- Full Report
- Executive Summary
- Blog post on Net-Zero
- Press release

Additional languages:

- Executive Summary - Japanese
- Executive Summary - Portuguese from Brazil
- Paper - Portuguese from Brazil
- Paper - Portuguese from Portugal

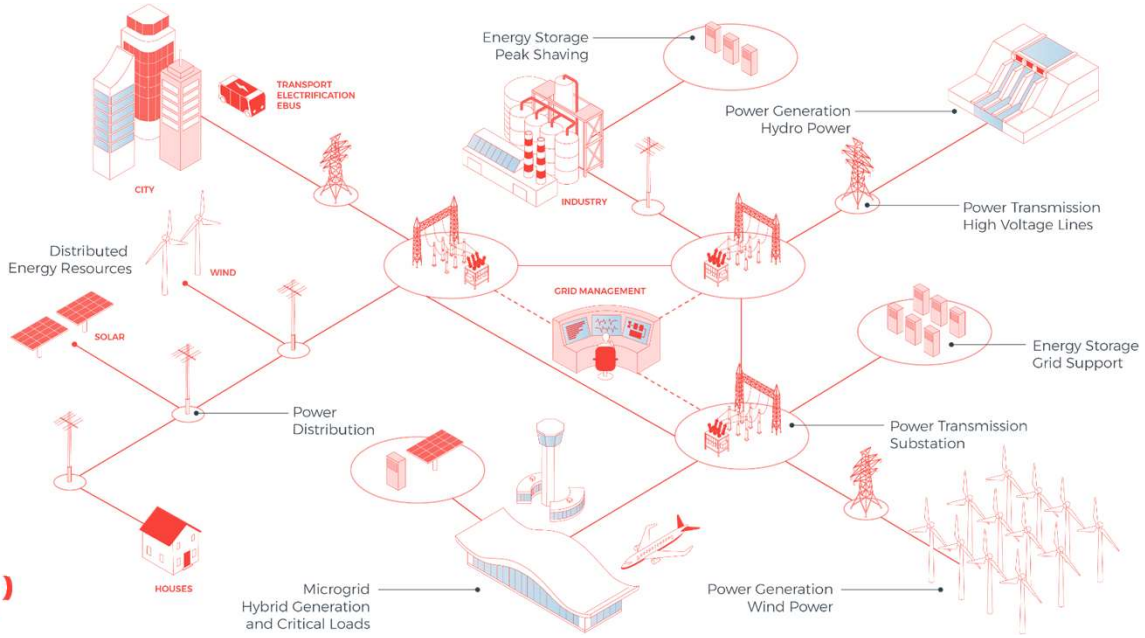


7

7

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Defining Net Zero Carbon Cities

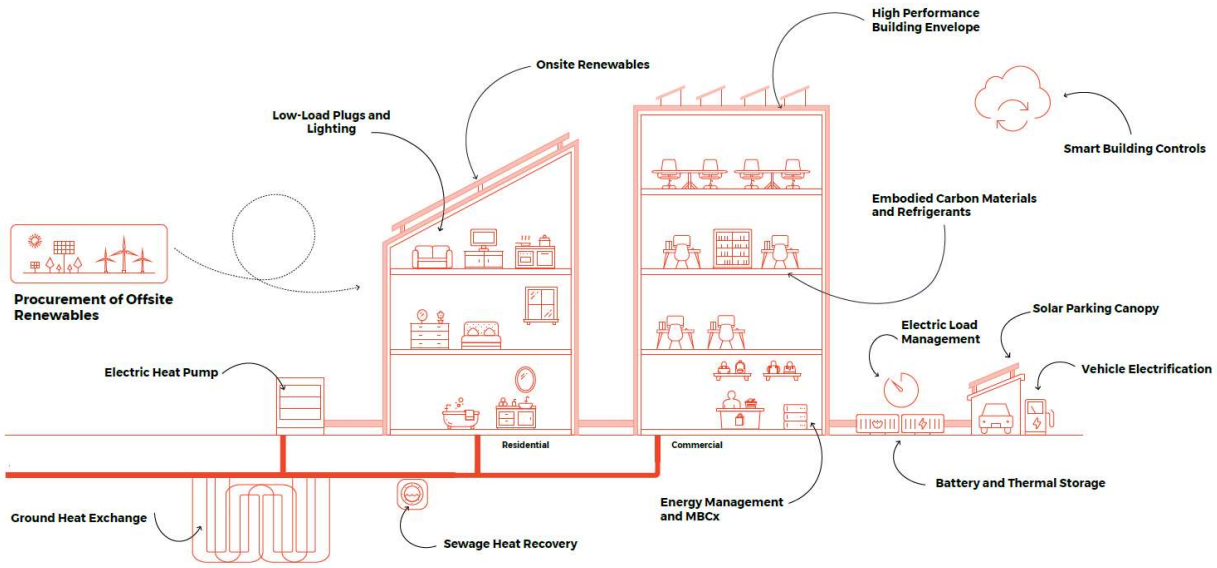


8

8

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Defining Net Zero Carbon and Energy Buildings



9

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Carbon neutral definitions vary

Review of over 15 organizational definitions of carbon neutral building operations found a number of aspects that varied in how they were represented including embodied carbon, on-site combustion, how renewables were defined and counted, etc.

10

The good news? There are more commonalities across the definitions. The divergence is often in the details.

This chart represents a few carbon neutral definitions from programs and shows the commonalities and variances.

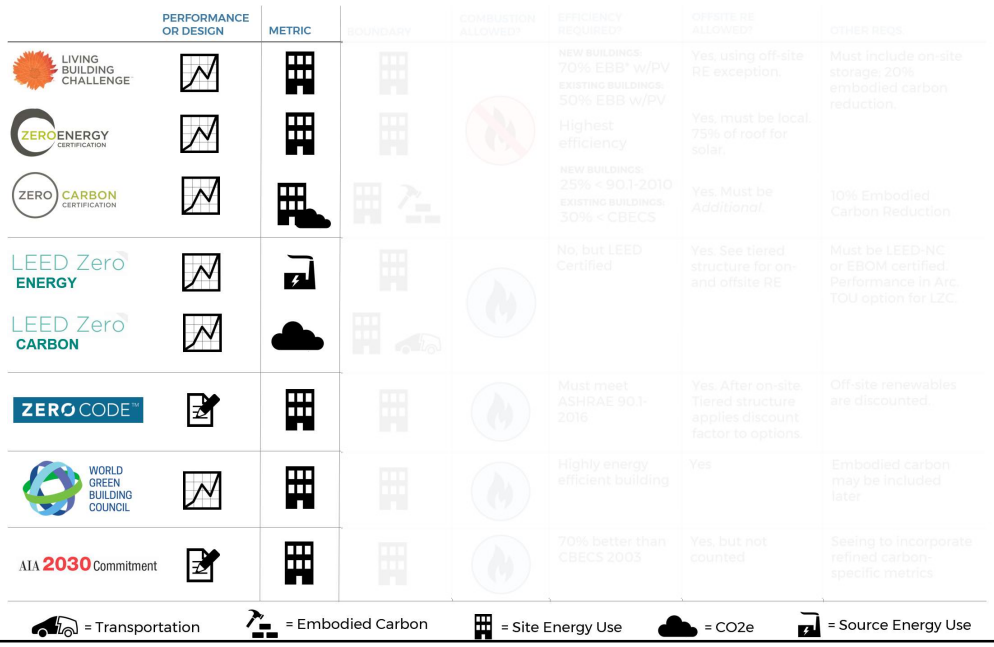
	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					NEW BUILDINGS: 70% EBB* w/PV EXISTING BUILDINGS: 50% EBB w/PV	Yes, using off-site RE exception.	Must include on-site storage; 20% embodied carbon reduction.
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON CERTIFICATION					NEW BUILDINGS: 25% < 90.1-2010 EXISTING BUILDINGS: 30% < CBECS	Yes. Must be *Additional*.	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified. Performance in Arc. TOU option for LZC.
LEED Zero CARBON							
ZERO CODE					Must meet ASHRAE 90.1-2016	Yes. After on-site. Tiered structure applies discount factor to options.	Off-site renewables are discounted.
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

10

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

How is it measured?



11

11

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

What emissions are included?

12

12

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Is the combustion of fossil fuels allowed?

	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					NEW BUILDINGS: 70% EBB* w/PV EXISTING BUILDINGS: 50% EBB w/PV	Yes, using off-site RE exception	Must include on-site storage; 20% embodied carbon reduction
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local; 75% of roof for solar	
ZERO CARBON CERTIFICATION					NEW BUILDINGS: 25% < 90.1-2010 EXISTING BUILDINGS: 30% < CBECS	Yes, Must be Additional	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes, See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified; Performance in Arc. TOU option for LZC
LEED Zero CARBON							
ZERO CODE					Must meet ASHRAE 90.1-2016	Yes, After on-site, Tiered structure applies discount factor to options	Off-site renewables are discounted
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

13

13

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Does the building have to be energy efficient?

	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					NEW BUILDINGS: 70% EBB* w/PV EXISTING BUILDINGS: 50% EBB w/PV	Yes, using off-site RE exception	Must include on-site storage; 20% embodied carbon reduction
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local; 75% of roof for solar	
ZERO CARBON CERTIFICATION					NEW BUILDINGS: 25% < 90.1-2010 EXISTING BUILDINGS: 30% < CBECS	Yes, Must be Additional	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes, See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified; Performance in Arc. TOU option for LZC
LEED Zero CARBON							
ZERO CODE					Must meet ASHRAE 90.1-2016	Yes, After on-site, Tiered structure applies discount factor to options	Off-site renewables are discounted
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

14

14

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Can off-site renewables be counted?

	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?
LIVING BUILDING CHALLENGE					**NEW BUILDINGS:** 70% EBB* w/PV **EXISTING BUILDINGS:** 50% EBB w/PV	Yes, using off-site RE exception.
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.
ZERO CARBON CERTIFICATION					**NEW BUILDINGS:** 25% < 90.1-2010 **EXISTING BUILDINGS:** 30% < CBECS	Yes. Must be *Additional.*
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and offsite RE
LEED Zero CARBON						
ZERO CODE					Must meet ASHRAE 90.1-2016	Yes. After on-site. Tiered structure applies discount factor to options.
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

15

15

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Are there other requirements?

	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					**NEW BUILDINGS:** 70% EBB* w/PV **EXISTING BUILDINGS:** 50% EBB w/PV	Yes, using off-site RE exception.	Must include on-site storage; 20% embodied carbon reduction.
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON CERTIFICATION					**NEW BUILDINGS:** 25% < 90.1-2010 **EXISTING BUILDINGS:** 30% < CBECS	Yes. Must be *Additional.*	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified. Performance in Arc. TOU option for LZC.
LEED Zero CARBON							
ZERO CODE					Must meet ASHRAE 90.1-2016	Yes. After on-site. Tiered structure applies discount factor to options.	Off-site renewables are discounted.
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

16

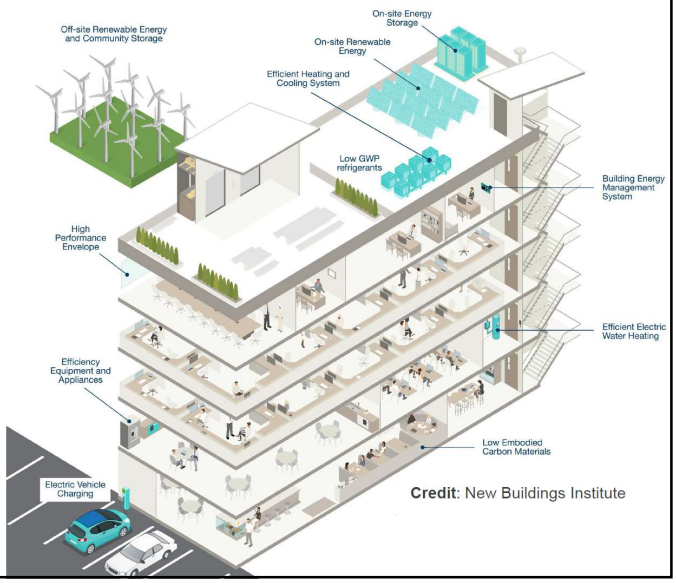
16

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

The Guide defines core and additional components

In addition to the Core Components, **carbon neutral buildings** should incorporate as much as possible the additional components listed below. As grid-supplied resources get cleaner, **building-grid integration** will become necessary to address peak demand and enable load shifting. Reducing onsite GHG emissions through **electrification** and **embodied carbon** will become priorities for driving down the climate changing impacts of the built environment.

Core Components:	Additional Components:
Maximize energy efficiency	Electrification-ready and minimize/eliminate on-site fossil fuels
Prioritize on-site renewables	Optimize building-grid integration and on-site storage
Utilize off-site renewables	Specify low GWP refrigerants
Measure and manage net zero operations	Select low embodied carbon materials



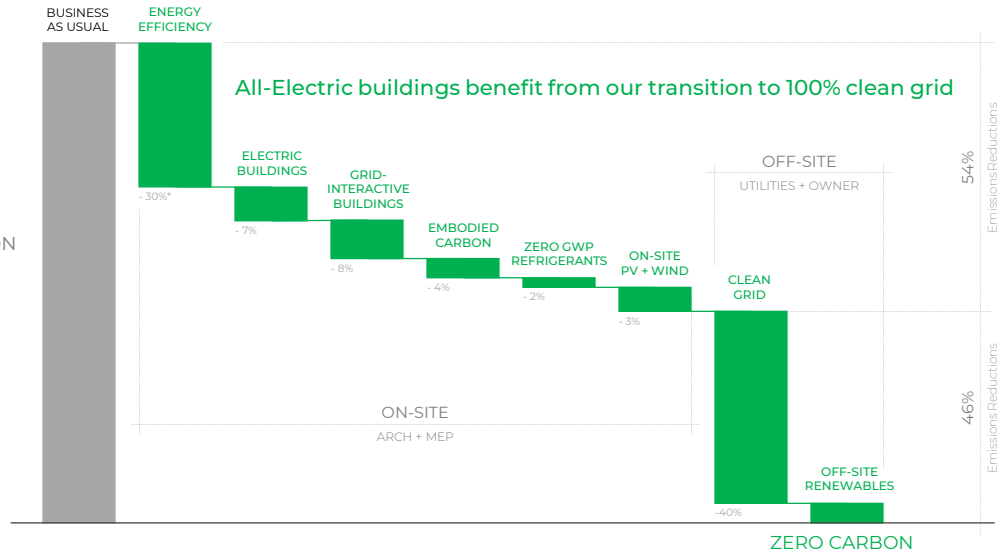
Credit: New Buildings Institute

17

A1

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Pathway to Net Zero Carbon Buildings



18

* Percentages vary depending on building type, systems, structure, grid, and more

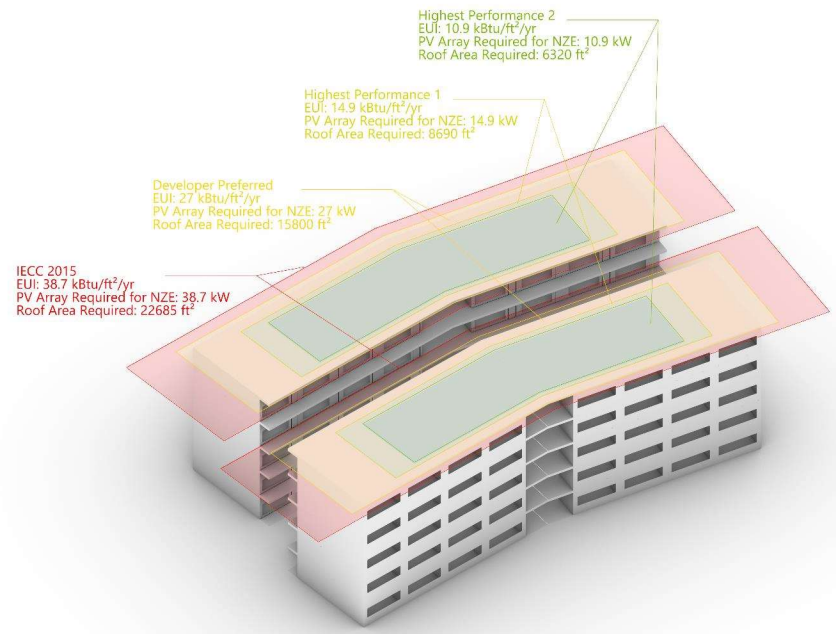
18

Slide 18

A1 Add slide to prompt questions
Author, 9/22/2020

INSIDER'S GUIDE TO C02e NEUTRAL BLDGS.

Net-Zero Energy optimization



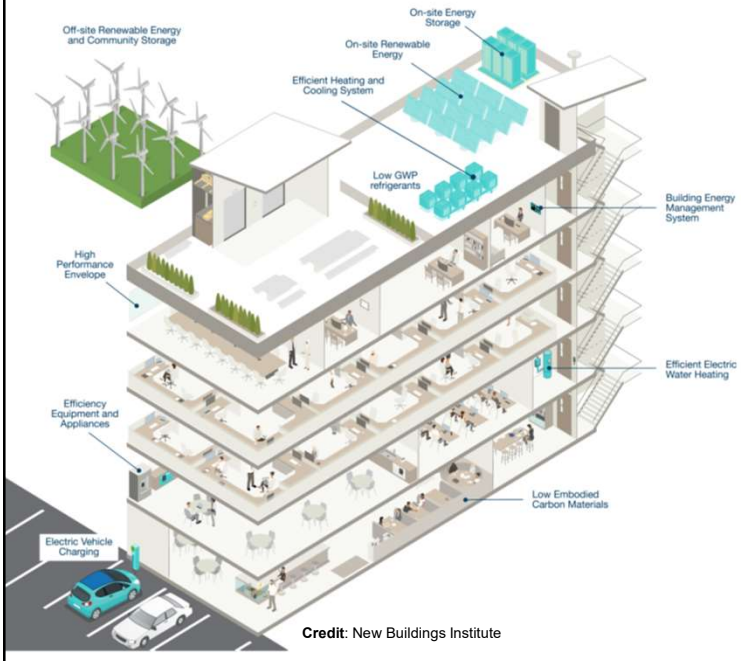
19

19

	PERFORMANCE OR DESIGN	METRIC	BOUNDARY	COMBUSTION ALLOWED?	EFFICIENCY REQUIRED?	OFFSITE RE ALLOWED?	OTHER REQS.
LIVING BUILDING CHALLENGE					**NEW BUILDINGS:** 70% EBB* w/PV **EXISTING BUILDINGS:** 50% EBB w/PV	Yes, using off-site RE exception.	Must include on-site storage; 20% embodied carbon reduction.
ZERO ENERGY CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON CERTIFICATION					**NEW BUILDINGS:** 25% < 90.1-2010 **EXISTING BUILDINGS:** 30% < CBECS	Yes. Must be *Additional.*	10% Embodied Carbon Reduction
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and offsite RE	Must be LEED-NC or EBOM certified. Performance in Arc. TOU option for LZC.
LEED Zero CARBON							
ZERO CODE™					Must meet ASHRAE 90.1-2016	Yes. After on-site. Tiered structure applies discount factor to options.	Off-site renewables are discounted.
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment					70% better than CBECS 2003	Yes, but not counted	Seeing to incorporate refined carbon-specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

20



Credit: New Buildings Institute

An insider's guide to talking about carbon neutral buildings

CC BY

This document was developed by New Buildings Institute in collaboration with a number of professional trade groups and other nonprofits.

© New Buildings Institute 2021

21

Energy to Carbon

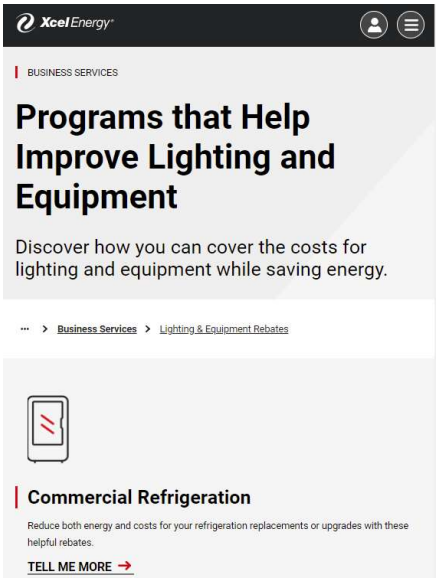


Figure 1: Climate Recovery Thermometer

© New Buildings Institute 2021

22

How to define carbon?!

© New Buildings Institute 2021

23

Carbon neutral definitions vary

	Performance or Design	Metric	Boundary	Combustion Allowed?	Efficiency Required?	Off-site RE Allowed?	Other Reqs.
LIVING BUILDING CHALLENGE					NC: 70% EBB* EB: 50% EBB (both w/ PV)	Yes. Using the off-site RE exception.	Must include on-site storage; 20% embodied carbon reduction.
ZERO ENERGY					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON					NC: 25% < 90.1-2010 EB: 30% < CBECS	Yes. Must be *additional*.	10% Embodied Carbon Reduction + Carbon offsets for the remainder
LEED Zero ENERGY					No, but LEED Certified	Yes. See tiered structure for on- and off-site RE	Must be LEED-NC or EBOM certified. Performance in Arc. TOU option for LZC.
LEED Zero CARBON							
ZERO CODE					Must meet ASHRAE 90.1-2019	Yes. After on-site. Tiered structure applies discount factor to various	Off-site renewables are discounted
WORLD GREEN BUILDING COUNCIL					Highly energy efficient building	Yes	Embodied carbon may be included later
AIA 2030 Commitment				Not allowed in 2030	70% better than CBECS 2003	Yes, but not counted	Seeking to incorporate refined carbon specific metrics

= Transportation = Embodied Carbon = Site Energy Use = CO2e = Source Energy Use

Credit: WSP with NBI additions

© New Buildings Institute 2021

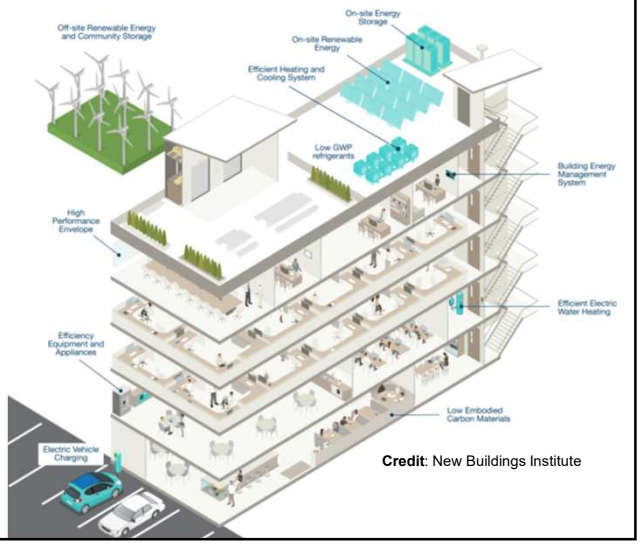
24

Core components of net zero energy building versus carbon neutral buildings

A **net zero energy building** is a highly **energy efficient** building that maximizes on-site **renewables** and **procures off-site renewables**. For the most part, so too are the components of a carbon neutral building operations. However, to achieve carbon neutral operations, any carbon produced from grid- or on-site-supplied energy must be offset through additional renewable energy procurement.

Core Components:	Additional Components:
Maximize energy efficiency	Electrification-ready and minimize/eliminate on-site fossil fuels
Prioritize on-site renewables	Optimize building-grid integration and on-site storage
Utilize off-site renewables	Specify low GWP refrigerants
Measure and manage net zero operations	Select low embodied carbon materials

nbi new buildings institute



Credit: New Buildings Institute

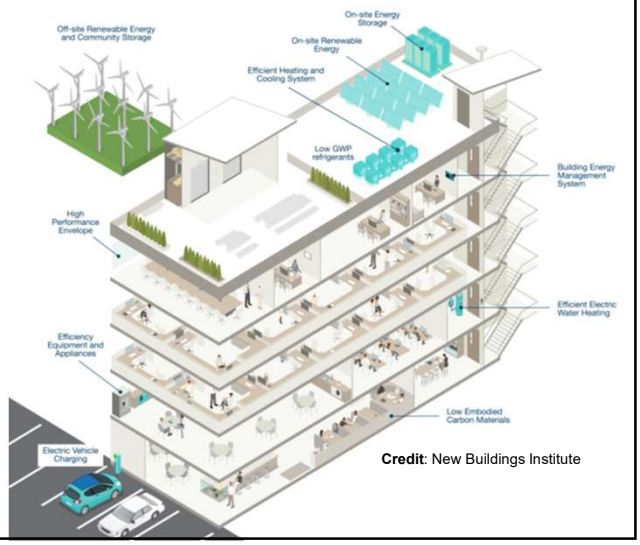
25

Additional components of net zero energy building versus carbon neutral buildings

In addition to the Core Components, **carbon neutral buildings** should incorporate as much as possible the additional components listed below. As grid-supplied resources get cleaner, **building-grid integration** will become necessary to address peak demand and enable load shifting. Reducing onsite GHG emissions through **electrification** and **embodied carbon** will become priorities for driving down the climate changing impacts of the built environment.

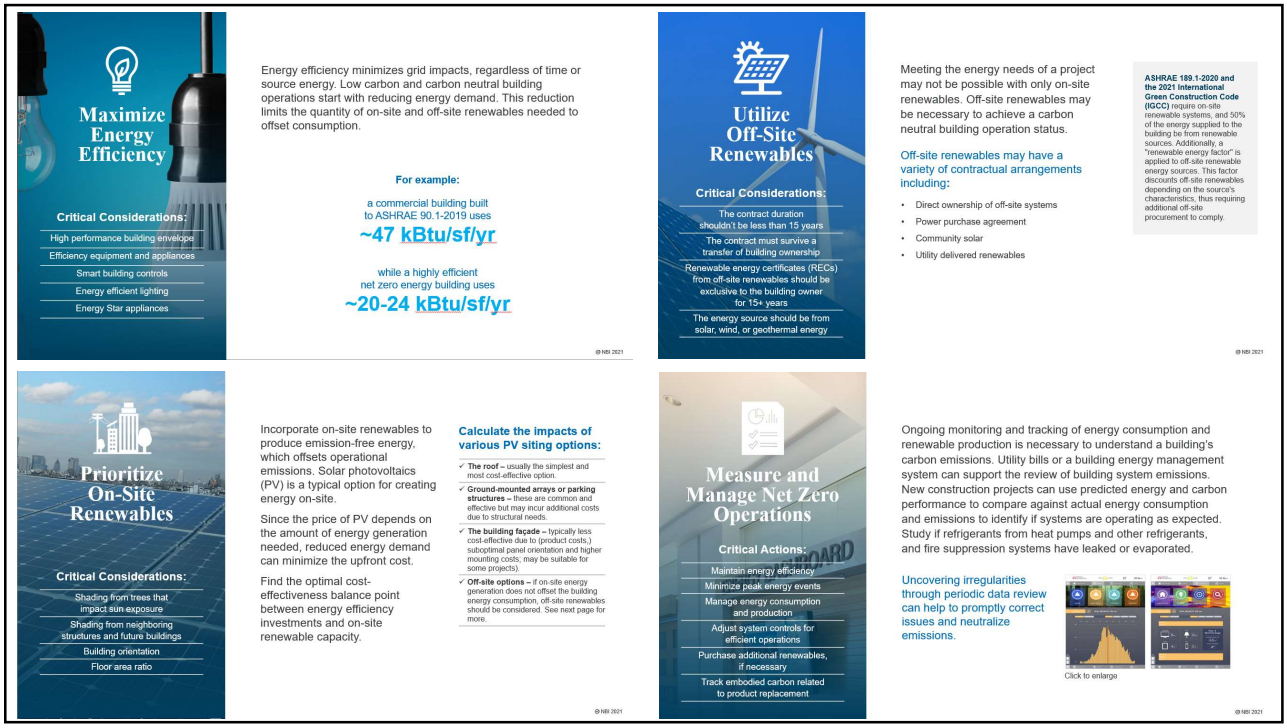
Core Components:	Additional Components:
Maximize energy efficiency	Electrification-ready and minimize/eliminate on-site fossil fuels
Prioritize on-site renewables	Optimize building-grid integration and on-site storage
Utilize off-site renewables	Specify low GWP refrigerants
Measure and manage net zero operations	Select low embodied carbon materials

nbi new buildings institute



Credit: New Buildings Institute

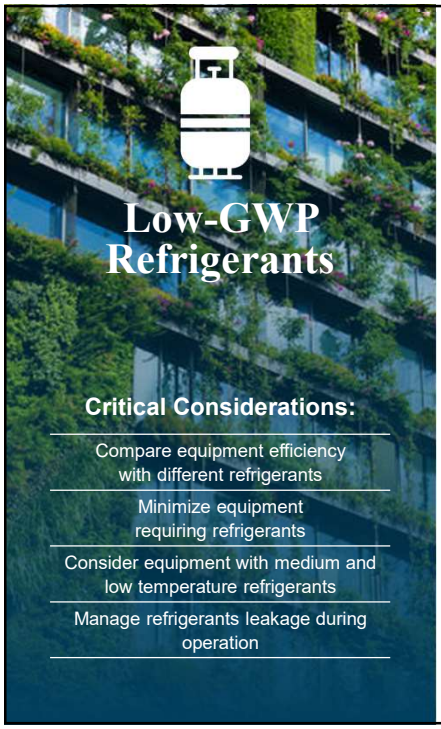
26


Maximize Energy Efficiency
Critical Considerations:
High performance building envelope
Efficiency equipment and appliances
Smart building controls
Energy efficient lighting
Energy Star appliances
Energy efficiency minimizes grid impacts, regardless of time or source energy. Low carbon and carbon neutral building operations start with reducing energy demand. This reduction limits the quantity of on-site and off-site renewables needed to offset consumption.
For example:
a commercial building built to ASHRAE 90.1-2019 uses
~47 kBtu/sf/yr
while a highly efficient net zero energy building uses
~20-24 kBtu/sf/yr
Utilize Off-Site Renewables
Critical Considerations:
The contract duration shouldn't be less than 15 years
The contract must survive a transfer of building ownership
Renewable energy certificates (RECs) from off-site renewables should be exclusive to the building owner for 15+ years
The energy source should be from solar, wind, or geothermal energy
Meeting the energy needs of a project may not be possible with only on-site renewables. Off-site renewables may be necessary to achieve a carbon neutral building operation status.
Off-site renewables may have a variety of contractual arrangements including:
Direct ownership of off-site systems
Power purchase agreement
Community solar
Utility delivered renewables
ASHRAE 189.1-2020 and the 2021 International Green Construction Code (IGCC) require on-site renewable systems, and 50% of the energy supplied to the building be from renewable sources. Additionally, a "renewable energy factor" is applied to off-site renewable energy sources. This factor discounts off-site renewables depending on the source's characteristics, thus requiring additional off-site procurement to comply.
Prioritize On-Site Renewables
Critical Considerations:
Shading from trees that impact sun exposure
Shading from neighboring structures and future buildings
Building orientation
Floor area ratio
Incorporate on-site renewables to produce emission-free energy, which offsets operational emissions. Solar photovoltaics (PV) is a typical option for creating energy on-site.
Since the price of PV depends on the amount of energy generation needed, reduced energy demand can minimize the upfront cost.
Find the optimal cost-effectiveness balance point between energy efficiency investments and on-site renewable capacity.
Calculate the impacts of various PV siting options:
The roof – usually the simplest and most cost-effective option.
Ground-mounted arrays or parking structures – these are common and effective but may incur additional costs due to structural needs.
The building façade – typically less cost-effective due to (product costs,) suboptimal panel orientation and higher mounting costs; may be suitable for some projects).
Off-site options – if on-site energy generation does not offset the building energy consumption, off-site renewables should be considered. See next page for more.
Measure and Manage Net Zero Operations
Critical Actions:
Maintain energy efficiency
Minimize peak energy events
Manage energy consumption and production
Adjust system controls for efficient operations
Purchase additional renewables, if necessary
Track embodied carbon related to product replacement
Ongoing monitoring and tracking of energy consumption and renewable production is necessary to understand a building's carbon emissions. Utility bills or a building energy management system can support the review of building system emissions. New construction projects can use predicted energy and carbon performance to compare against actual energy consumption and emissions to identify if systems are operating as expected. Study if refrigerants from heat pumps and other refrigerants, and fire suppression systems have leaked or evaporated.
Uncovering irregularities through periodic data review can help to promptly correct issues and neutralize emissions.
Click to enlarge

27

Electrification-Ready, Electrification, and Minimization of On-Site Fossil Fuel Combustion
Critical Considerations:
Energy efficient equipment
High-capacity electrical panels
Electrical chases and conduit runs for future renewables and electric vehicles
Electrical outlets near gas equipment
Carbon neutral buildings minimize or eliminate on-site natural gas and other fossil fuels because fossil fuel combustion (i.e., propane and gas) directly contributes to GHG emissions. Building electrification combined with energy efficiency can reduce air pollution, assist with better grid management, and permanently lower utility expenses.
Electric-powered building technologies deliver the same thermal comfort of traditional gas equipment with lower emissions, and they are often more efficient than their counterparts. These include heat pump water heaters and space heating, induction stoves, fireplaces, etc. As the grid becomes cleaner, building technologies that don't rely on gas fuel will become more important to mitigate carbon and other GHG emissions.
"Electrification-ready" buildings incorporate high-capacity electrical panels, electrical chases and conduit runs, and locate electrical outlets near gas equipment for future equipment conversion (EV, solar, DHW, etc.) All-electric buildings support a clean energy future as operational GHG emissions will be eliminated when the grid supplies 100% renewables.
Natural gas combustion emits approximately 0.4 lbs of CO2e per kWh of energy consumed, or 28% more than the national electric emission rate.
CO2e per kBtu delivered:
Natural Gas = 0.117 lbs
Electricity = 0.279 lbs
Source: EIA
Click to enlarge
Building-Grid Integration and Energy Storage
Critical Considerations:
Energy efficiency
Shift peak energy loads
Design for flexible loads
Allow for dispatchable energy storage
Building-grid integration allows buildings and the electrical grid to coordinate energy supply and demand to optimize energy consumption, reduce peak demand, offer more clean energy, and provide a reliable electricity supply.
Smart design, distributed energy resources (DER), and demand response allow grid operators to adjust building heating, cooling, lighting, etc., to reduce power consumption and minimize community-wide service impacts. Building operators can adjust when grid energy is consumed to avoid peak energy rates. The balance of energy resources will improve how we use energy and support a modern grid that is capable of supplying more renewable energy.
Distributed Energy Resources:
Solar photovoltaics
Wind turbines
Energy storage
Electric Vehicles
Combined heat and power plants
How buildings support a reliable grid
Grid-friendly Building Strategies:
Permanent Efficiency
Efficient systems
Peak Shifting and Flexible Loads
Smart controls
Thermal mass
Energy storage / batteries
Dispatchable Energy Storage
Intelligent, grid-integrated communication
Smart systems and devices for HVAC, water heating, lighting, and electric vehicles, can align building energy
Low-GWP Refrigerants
Critical Considerations:
Compare equipment efficiency with different refrigerants
Minimize equipment requiring refrigerants
Consider equipment with medium and low temperature refrigerants
Manage refrigerants leakage during operation
Most refrigerants are high global warming potential (GWP) chemicals that can be up to thousands of times more polluting than carbon dioxide alone. Fire suppression systems and heat pumps are common sources of refrigerants. They may also be sources of emissions from leakage or evaporation.
Choosing a 20-year GWP rather than a 100-year GWP will place more emphasis on reducing emissions of short-term, climate-changing gases (methane and refrigerants) relative to reducing emissions that contribute COze.
Refrigerant leak detection systems can improve a system's performance and minimize the release high GWP chemicals directly into the environment. Leaks require more refrigerants to recharge the system, releasing even more potent emissions.
Link to refrigerant GWP table
Consider refrigerants outside of the main cooling systems. Refrigerants are used in many different systems:
Refrigeration
Freezers
Air-conditioning
Heat pumps
Chillers
Fire extinguishing systems
Aerosols
Low-GWP refrigerants include:
Ammonia
CO2
Propane
Low-Embodied Carbon Materials
Critical Considerations:
Reduce the number of materials
Reuse materials
Select materials that sequester carbon
Prioritize durable materials to minimize product replacement
Design for deconstruction
As building energy efficiency increases and more buildings eliminate fossil fuels in building operations, the impact of upfront embodied carbon emissions in building materials is becoming increasingly significant. Construction materials alone are responsible for about 11% of all global carbon emissions. Embodied carbon refers to the total impact of all human induced greenhouse gases emitted from material extraction through the end of its useful life. Thoughtful material selection can easily change a buildings' embodied carbon and reduce global climate emissions.
Low embodied carbon materials include:
Low-Portland cement concrete
Wood and bio-based
Reuse/reclaim
High recycled content
Local
Unfinished materials (polished concrete)
Embodied carbon is calculated by summing all emissions emitted from non-renewable energy sources resulting from sourcing raw materials, manufacturing, transporting, construction and installation activities, ongoing material/product energy use, maintenance, repair, and finally, disposal.
Link to graph of carbon reduction during construction phases

28



Low-GWP Refrigerants

Critical Considerations:

- Compare equipment efficiency with different refrigerants
- Minimize equipment requiring refrigerants
- Consider equipment with medium and low temperature refrigerants
- Manage refrigerants leakage during operation

Most refrigerants are high global warming potential (GWP) chemicals that can be up to thousands of times more polluting than carbon dioxide alone. Fire suppression systems and heat pumps are common sources of refrigerants. They may also be sources of emissions from leakage or evaporation.

Choosing a 20-year GWP rather than a 100-year GWP will place more emphasis on reducing emissions of short-term, climate-changing gases (methane and refrigerants) relative to reducing emissions that contribute CO_2e.

Refrigerant leak detection systems can improve a system's performance and minimize the release high GWP chemicals directly intro the environment. Leaks require more refrigerants to recharge the system, releasing even more potent emissions.

Consider refrigerants outside of the main cooling systems. Refrigerants are used in many different systems:

- Refrigeration
- Freezers
- Air-conditioning
- Heat pumps
- Chillers
- Fire extinguishing systems
- Aerosols

Low-GWP refrigerants include:

- Ammonia
- CO_2
- Propane

© New Buildings Institute 2021
© NBI 2021

29

Low-Embodied Carbon Materials

Critical Considerations:

- Reduce the number of materials
- Reuse materials
- Select materials that sequester carbon
- Prioritize durable materials to minimize product replacement
- Design for deconstruction

As building energy efficiency increases and more buildings eliminate fossil fuels in building operations, the impact of upfront embodied carbon emissions in building materials is becoming increasingly significant. Construction materials alone are responsible for about 11% of all global carbon emissions. Embodied carbon refers to the total impact of all human induced greenhouse gases emitted from material extraction through the end of its useful life. Thoughtful material selection can easily change a buildings' embodied carbon and reduce global climate emissions.

Low embodied carbon materials include:

- Low-Portland cement concrete
- Wood and bio-based
- Reuse/reclaim
- High recycled content
- Local
- Unfinished materials (polished concrete)

Embodied carbon is calculated by summing all emissions emitted from non-renewable energy sources resulting from sourcing raw materials, manufacturing, transporting, construction and installation activities, ongoing material/product energy use, maintenance, repair, and finally, disposal.

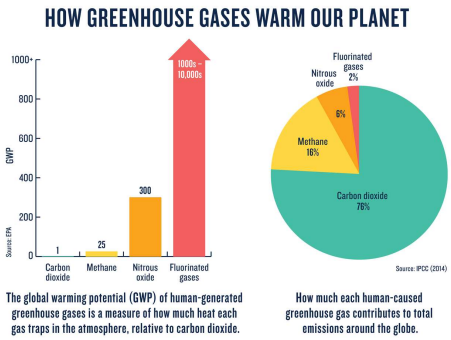
© New Buildings Institute 2021
© NBI 2021

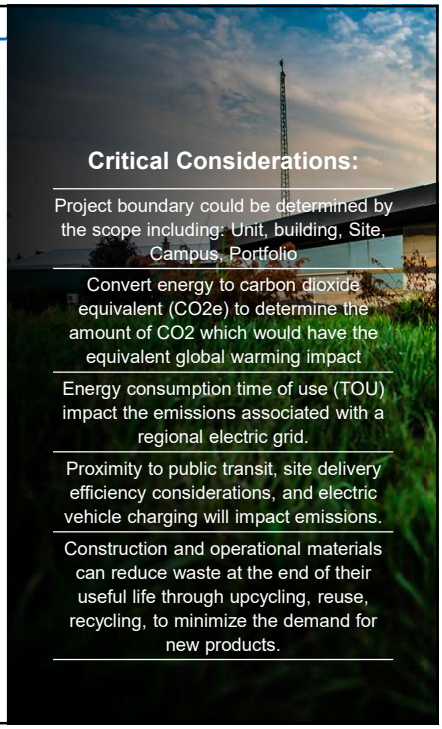
30

Additional considerations

Program details include specific requirements to determine carbon neutral compliance. Incorporating common program elements can help clarify how carbon neutral is understood in the market. Variations are inevitable. The more insight users have into why specific elements are included or not, they can compare carbon neutral buildings.

Measuring building GHG emissions depends on project goals. Buildings may only calculate operational emissions from energy consumption and production, while others consider the whole life of embodied carbon from materials through end of life. There are several considerations on the right.





Critical Considerations:

- Project boundary could be determined by the scope including: Unit, building, Site, Campus, Portfolio
- Convert energy to carbon dioxide equivalent (CO_2e) to determine the amount of CO_2 which would have the equivalent global warming impact
- Energy consumption time of use (TOU) impact the emissions associated with a regional electric grid.
- Proximity to public transit, site delivery efficiency considerations, and electric vehicle charging will impact emissions.
- Construction and operational materials can reduce waste at the end of their useful life through upcycling, reuse, recycling, to minimize the demand for new products.

31

Additional components of net zero energy building versus carbon neutral buildings

In addition to the Core Components, **carbon neutral buildings** should incorporate as much as possible the additional components listed below. As grid-supplied resources get cleaner, **building-grid integration** will become necessary to address peak demand and enable load shifting. Reducing onsite GHG emissions through **electrification** and **embodied carbon** will become priorities for driving down the climate changing impacts of the built environment.

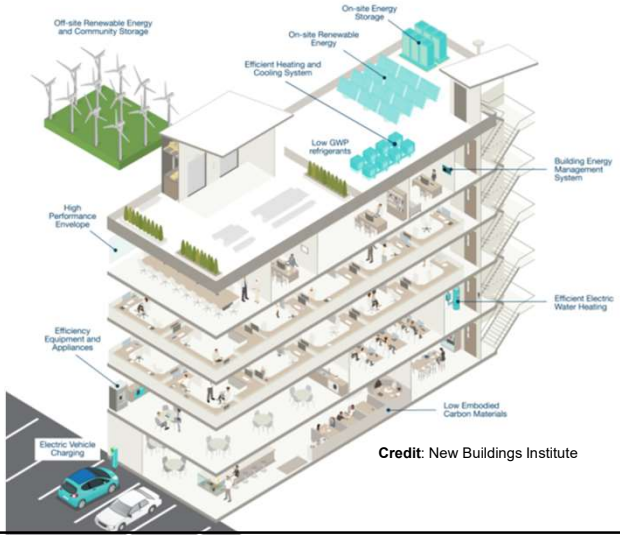
Core Components:

- Maximize energy efficiency
- Prioritize on-site renewables
- Utilize off-site renewables
- Measure and manage net zero operations

Additional Components:

- Electrification-ready and minimize/eliminate on-site fossil fuels
- Optimize building-grid integration and on-site storage
- Specify low GWP refrigerants
- Select low embodied carbon materials

nbi new buildings institute



Credit: New Buildings Institute

32

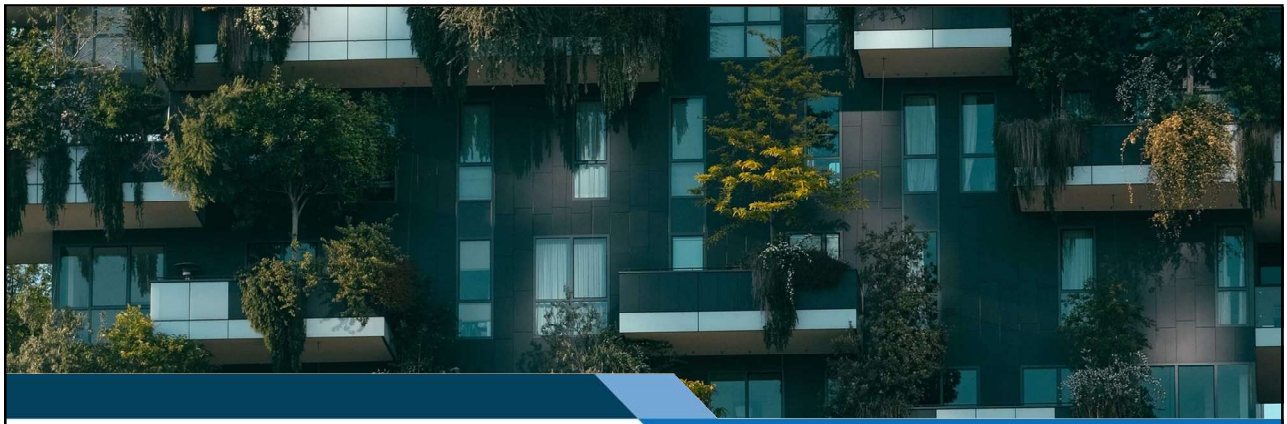
Thank you!

Webly Bowles, Project Manager
webly@newbuildings.org

nbi new buildings institute
www.newbuildings.org

© New Buildings Institute 2021

33



nbi new buildings institute

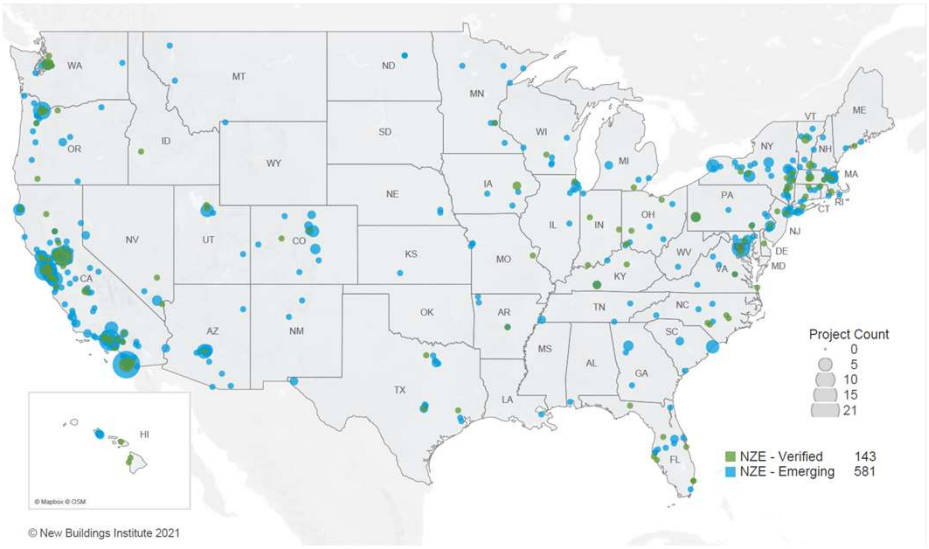
Zero Carbon vs. Zero Energy Buildings

Mischa Egolf, NBI

© New Buildings Institute 2021

34

NBI Getting to Zero Buildings Database



nbi new buildings institute

© New Buildings Institute 2021

35

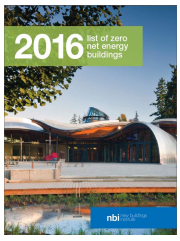
Zero Energy Building Counts

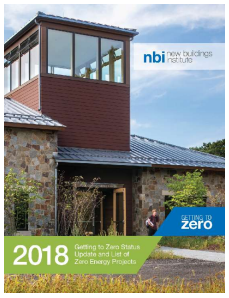
12x Growth since 2012

60 (2012)

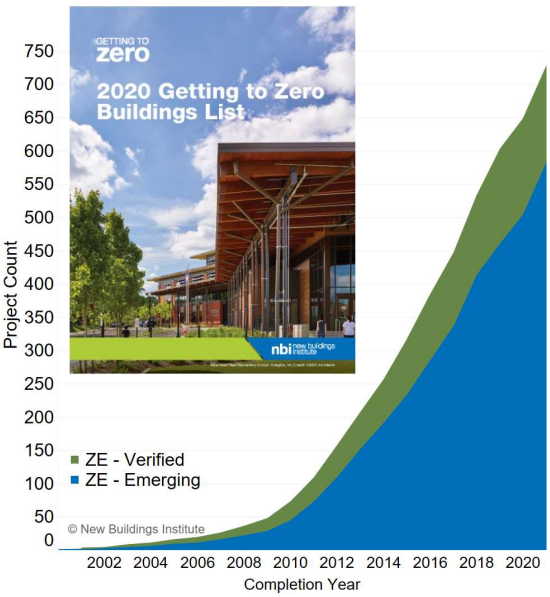
160

332





720+



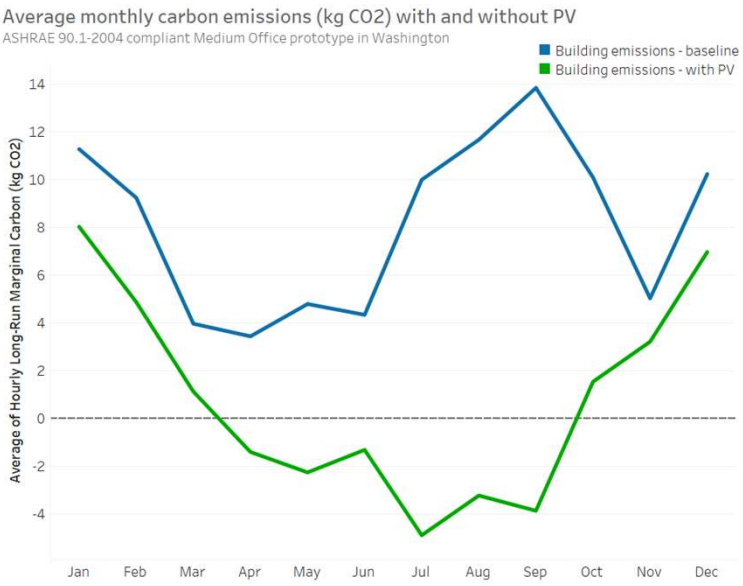
nbi new buildings institute

© New Buildings Institute 2021

36

Zero Energy ≠ Zero Carbon

- In this example, the building reaches zero energy through PV but not quite zero carbon operations (although it gets very close!)



nbi new buildings institute

© New Buildings Institute 2021

37

Zero Carbon: Beyond Zero Energy

Zero Energy Components
Maximizing energy efficiency
On-site and off-site renewables
Site operations

+

Zero Energy + Carbon Components
Onsite fossil fuels (combustion)
Grid integration and on-site storage
Low GWP refrigerants
Embodied carbon

+

Additional Considerations
Project boundary
Energy to carbon methodology
Transportation
Full lifecycle of materials
Time of energy use & impact to regional grid

nbi new buildings institute

© New Buildings Institute 2021

38

Zero Carbon: Additional Considerations

Project Boundary	Energy to carbon methodology	Transportation	Full lifecycle of materials	Time of energy use and regional impact to grid
• How is the physical boundary defined (unit, building, site, campus, portfolio)? • Does the project boundary account for embodied carbon? Transportation?	• Calculation requirements vary by program and jurisdiction • Is energy predicted, or performance based?	• Does the site include EV charging? • What is the proximity to public transit?	• How will construction and operational materials be handled at the end of their useful life? Upcycling, reuse, recycling?	• When the building is consuming the most energy, how "clean" is the regional grid?

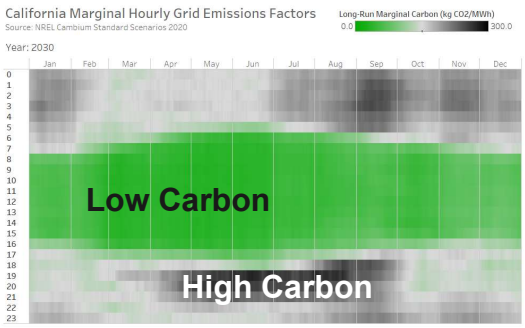
nbi new buildings institute

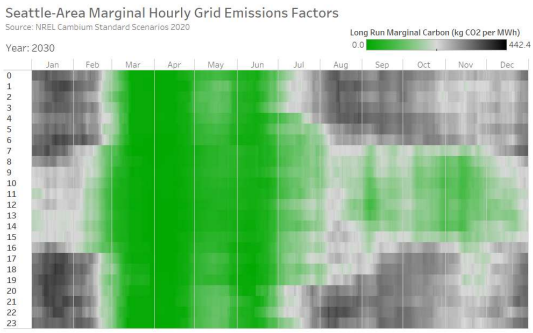
© New Buildings Institute 2021

39

GHG Intensity Varies Temporally and Regionally

- GHG intensity (CO2e/MWh) varies widely from hour to hour, day to day, season to season
  - This variability will grow as more wind and solar go online



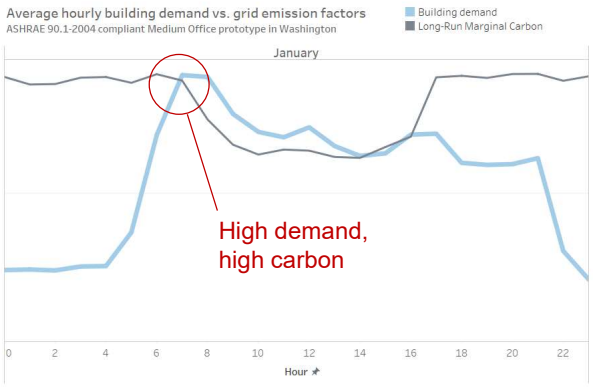


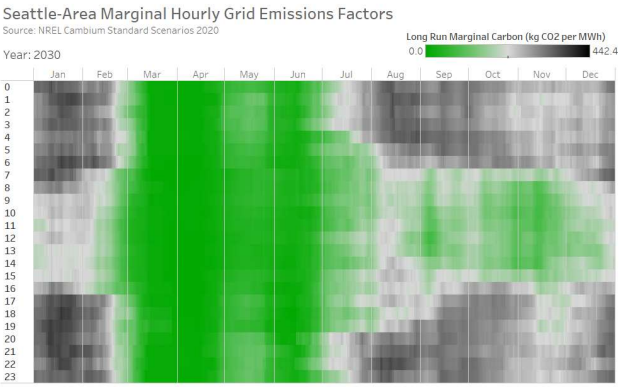
nbi new buildings institute

© New Buildings Institute 2021

40

Building energy use vs. grid carbon



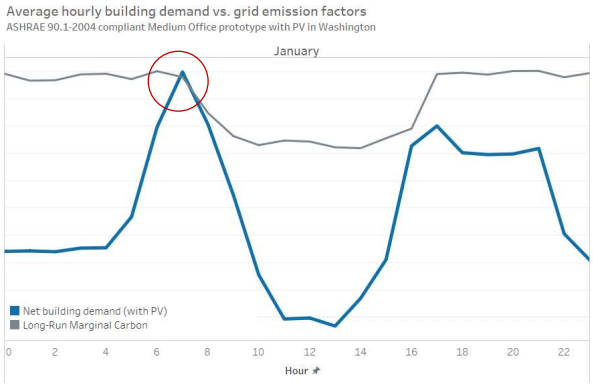


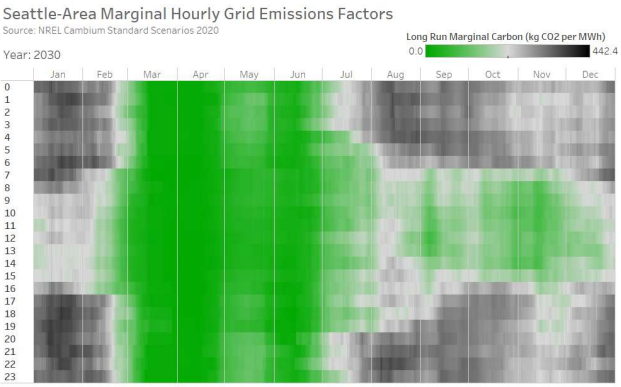
nbi new buildings institute

© New Buildings Institute 2021

41

Building energy use with PV vs. grid carbon





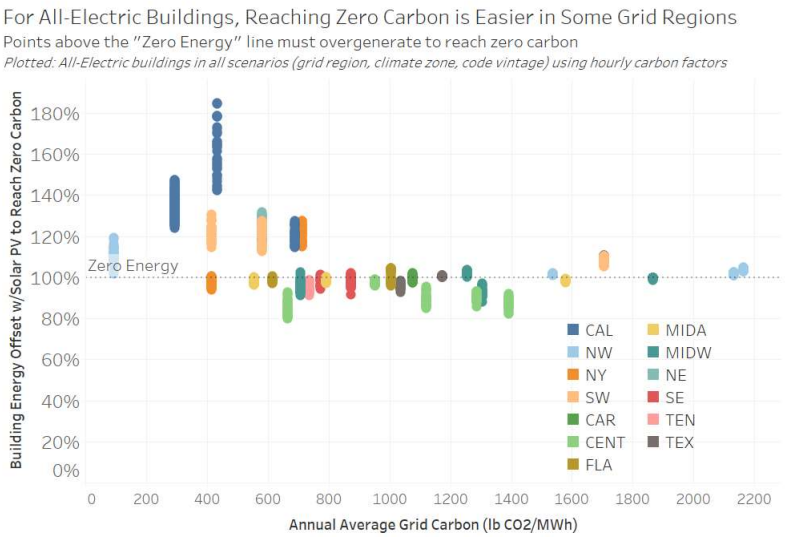
nbi new buildings institute

© New Buildings Institute 2021

42

Zero Energy ≠ Zero Carbon

- The average PV offset needed to reach zero carbon varies by climate zone, building type, and code vintage
- Points below the dotted line demonstrate that zero carbon can be achieved, even if the building has not reached zero energy

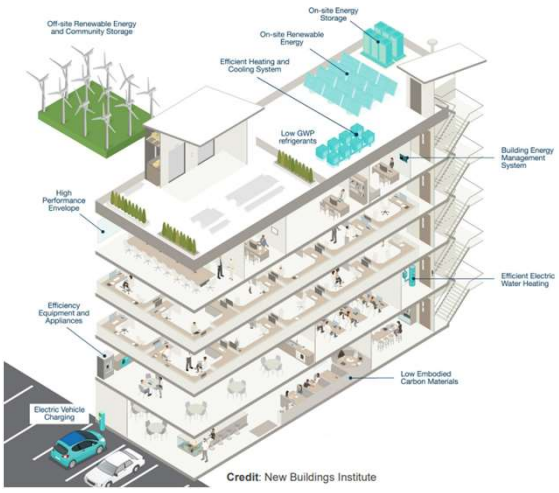


© New Buildings Institute 2021

43

Reaching Zero Carbon

- Zero carbon is possible!
  - Many solutions to get there
- Flexibility and ease to serve with renewables is key, especially as the electric grid transforms to more wind and solar



© New Buildings Institute 2021

44

Thank you!

nbi new buildings institute

www.newbuildings.org

© New Buildings Institute 2021

45

46

PURPOSE

Leading transformation of the building industry to energy efficient carbon neutral buildings

Technology Transformation

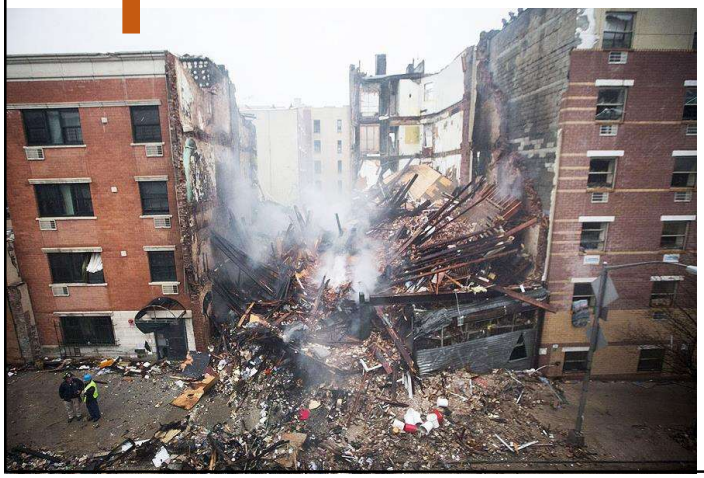
Design & Engineering

Grid Integration & Policy

47

BUILDING INDUSTRY **RESPONSE TO THE CLIMATE CRISIS**

1 Electrify Everything: Technology Transformation



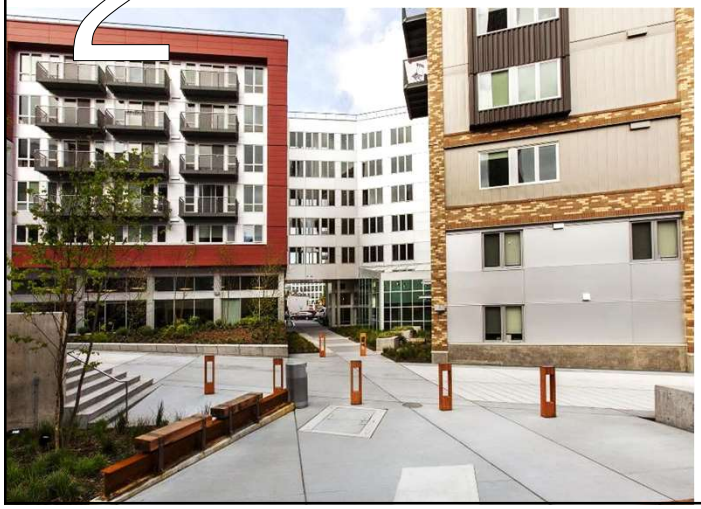
Sitka Apartments / Runberg Architecture Group

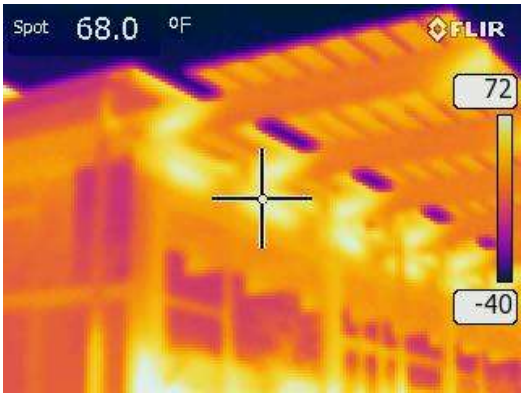
48

BUILDING INDUSTRY **RESPONSE TO THE CLIMATE CRISIS**

2

Efficiency is Energy: Design and Engineering





Stackhouse Apartments / Runberg Architecture Group

49

BUILDING INDUSTRY **RESPONSE TO THE CLIMATE CRISIS**

3

When Matters: Grid Integration

50

51

Vision for Market Transformation

- Heat Pumps are Standard Practice for Water Heating
- Average System COP of 3.0 or better
- Use Low-GWP Refrigerants (GWP<750)
- Plug-and-Play
- Affordable
- Reliable and Redundant systems
- Ability to Load Shift

ECOTOPE

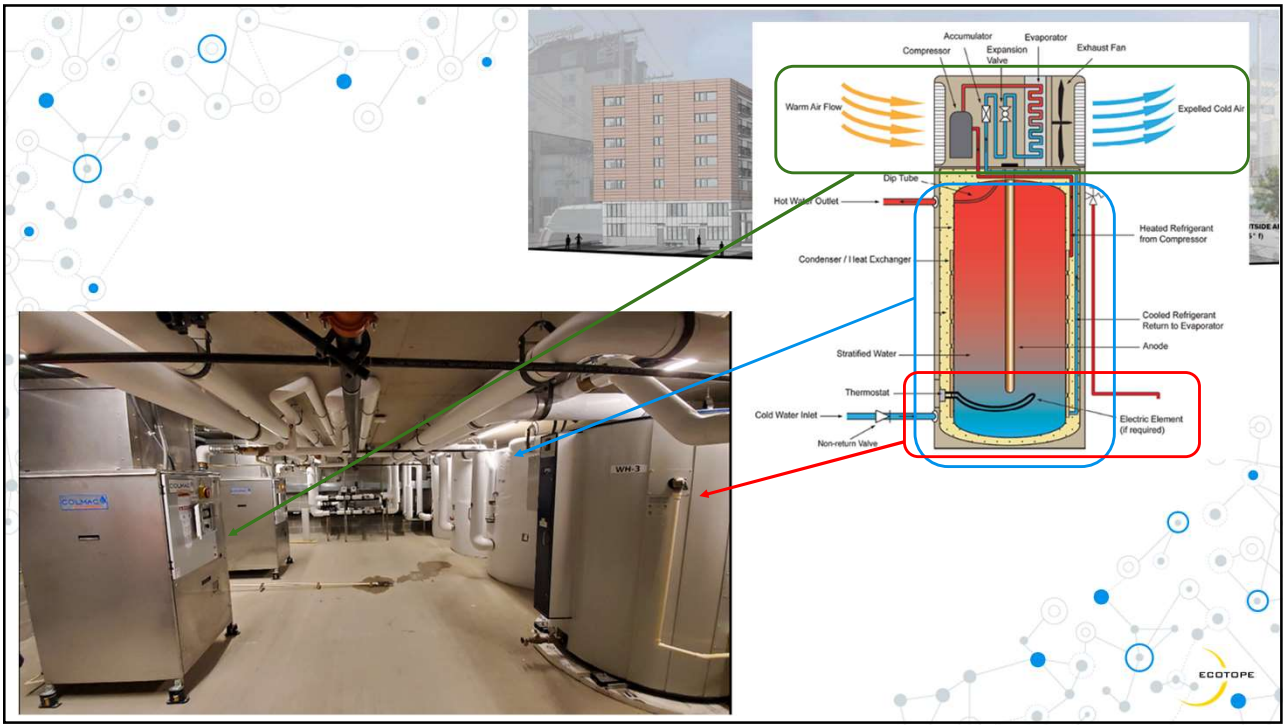
52

PLUG-AND-PLAY SYSTEMS

- A ***system*** of components
  - Compressor, Storage Tanks, Temperature Maintenance, Conrols
- Purchased pre-packaged on a skid or individual components with assembly instructions
  - Easy install, single point of contact
- Reduced risk
  - Reduce need for custom design solutions
  - Reliable repeatable results
  - Reduced pricing over time
  - Single warranty

ECOTOPE

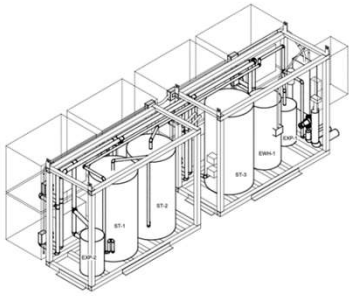
53

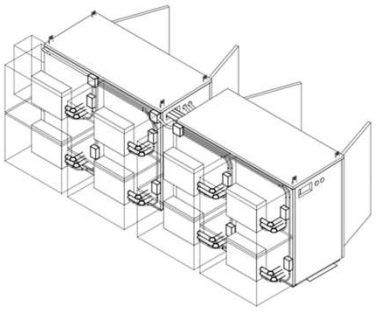


54

Fully Packaged
Skid-Mounted
Plug-and-Play

50-100 People

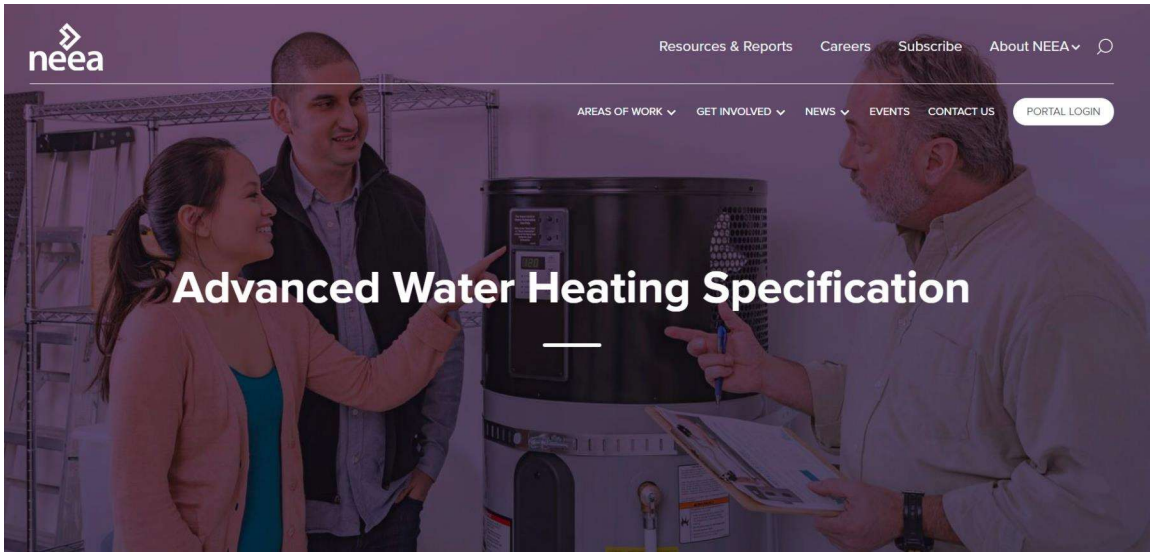




WATER DROP
Powered By SANCO2

ECOTOPE

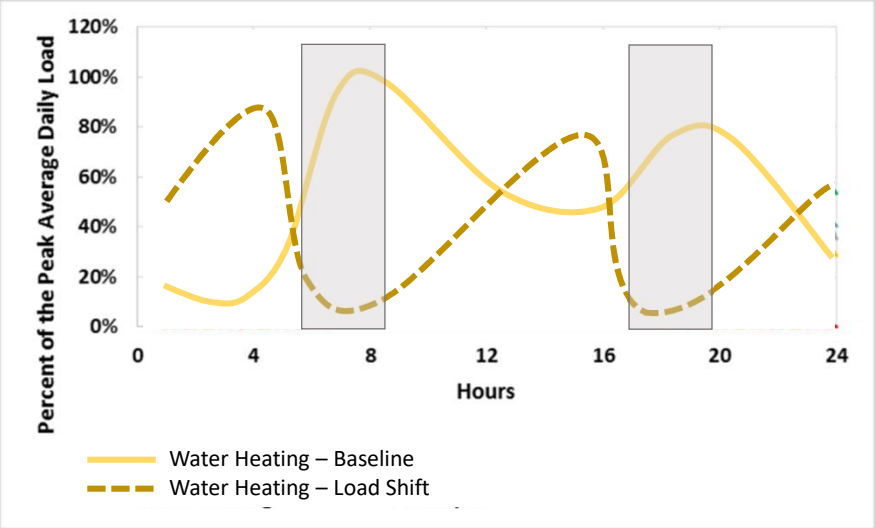
55



ECOTOPE

56

Load Shifting Water Heating



57

Seattle Housing Authority Bayview Tower Retrofit

- 100-unit multifamily building
- High-rise construction
- Existing electric resistance
- Fully occupied
- Tight urban setting

58

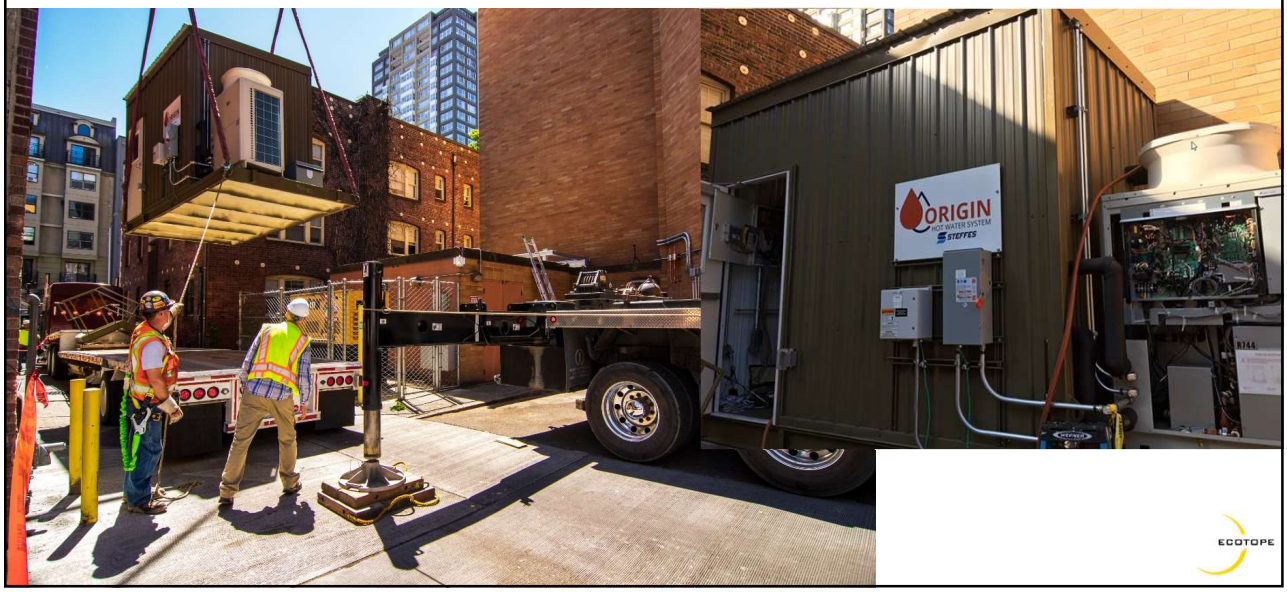
Origin by Steffes: Mitsubishi Engine

59

Fully-Packaged CHPWH Product Delivered

60

And Installed



61

GETTING TO zero FORUM 2021

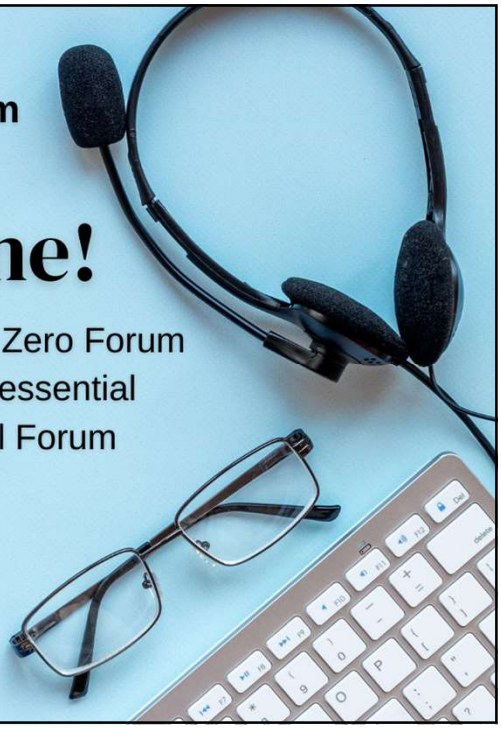
October 27-29, 2021
New York City

@GTZForum

Join Us Live or Online!

We want to see you in person at the Getting to Zero Forum but know some folks can't travel. To make this essential material widely available, we've added a Virtual Forum Pass and On-Demand viewing options.
Learn more and register today!

gettingtozeroforum.org/registration



62

Access case studies, research, guidance, models and more

The **Getting to Zero Resource Hub** is an open-source collection of over 300 zero energy and zero carbon resources across six different topic areas:

gettingtozeroforum.org/resource-hub

GETTING TO zero | nbi new buildings institute

The Getting to Zero Resource Hub was developed and delivered by New Buildings Institute with ongoing support from our sponsors and partners.

63

Find out first!

Follow NBI on your favorite social media platform, including our new Instagram account

ZeroEnergyBuildings | **@newbldgsinst** | New Buildings Institute | NewBuildingsInstitute

Find us online at: nbi new buildings institute www.newbuildings.org

© New Buildings Institute 2021

64

Thank you!

You will receive an email tomorrow with links to the on-demand recording and a PDF of the slides.

© New Buildings Institute 2021

65