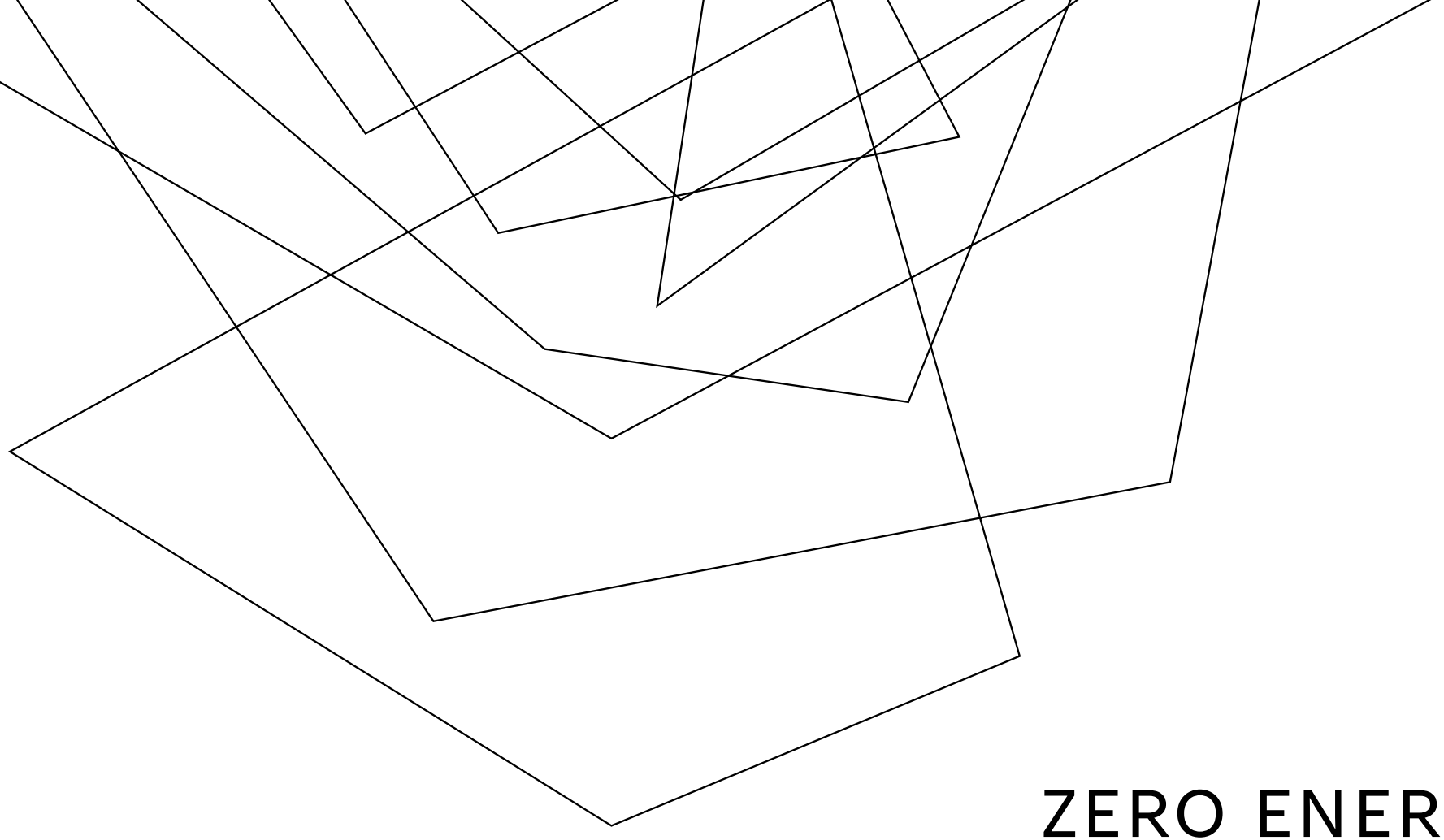
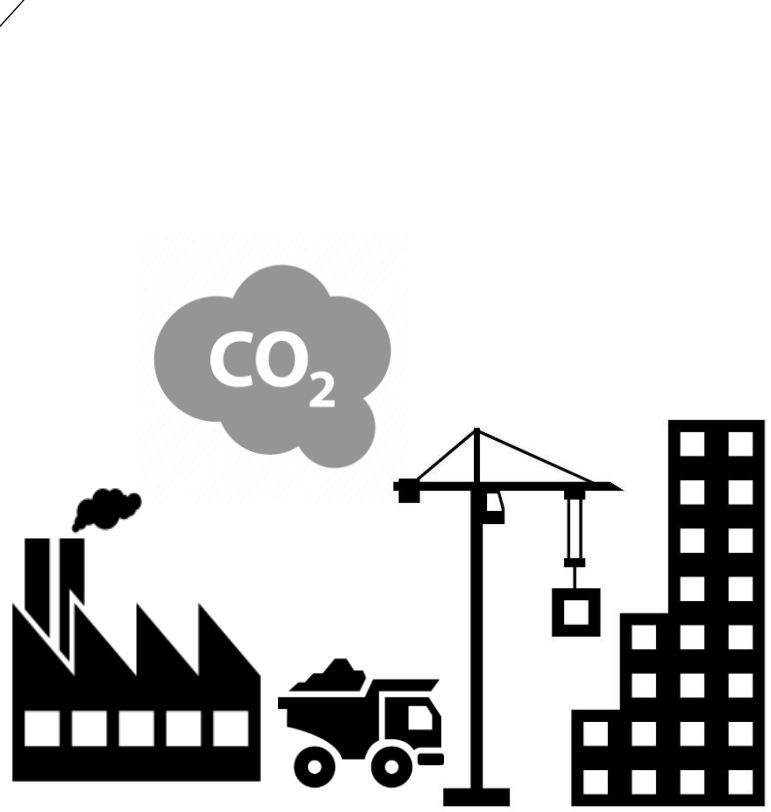


ZERO ENERGY TARGETS IN PRACTICE

Jamy Bacchus

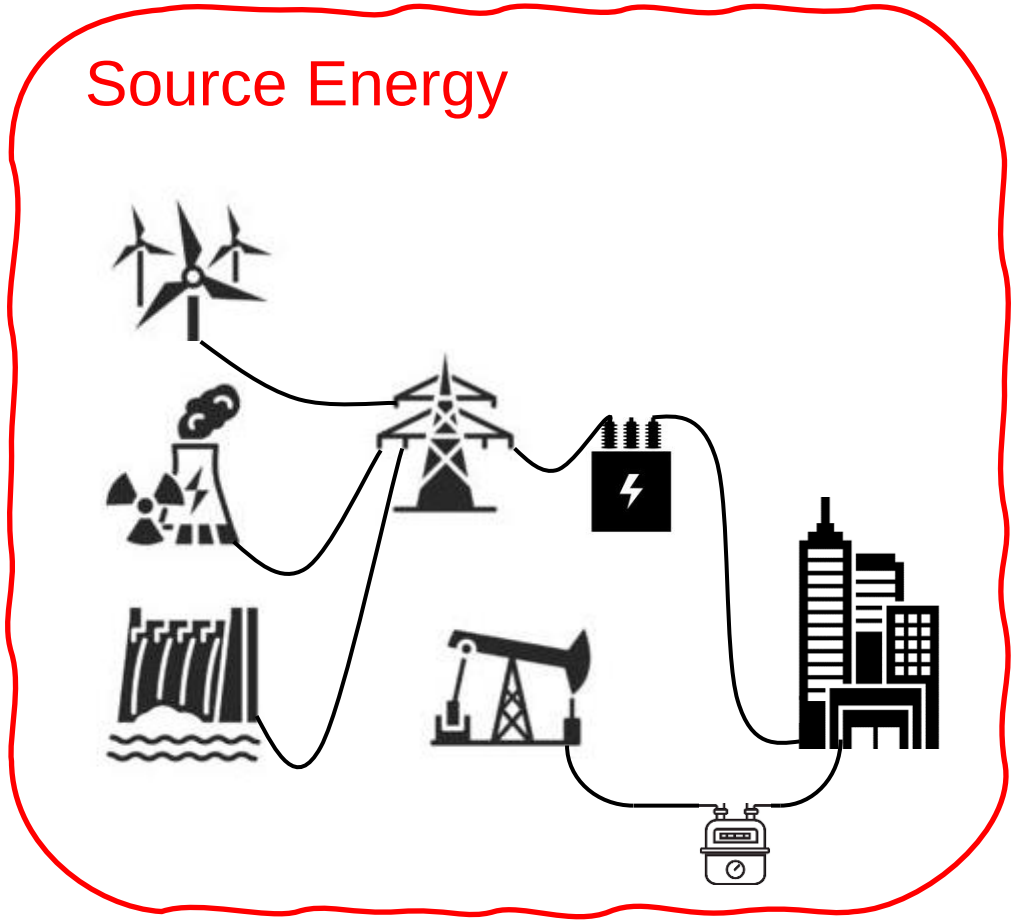
ME Engineers

TOTAL CARBON



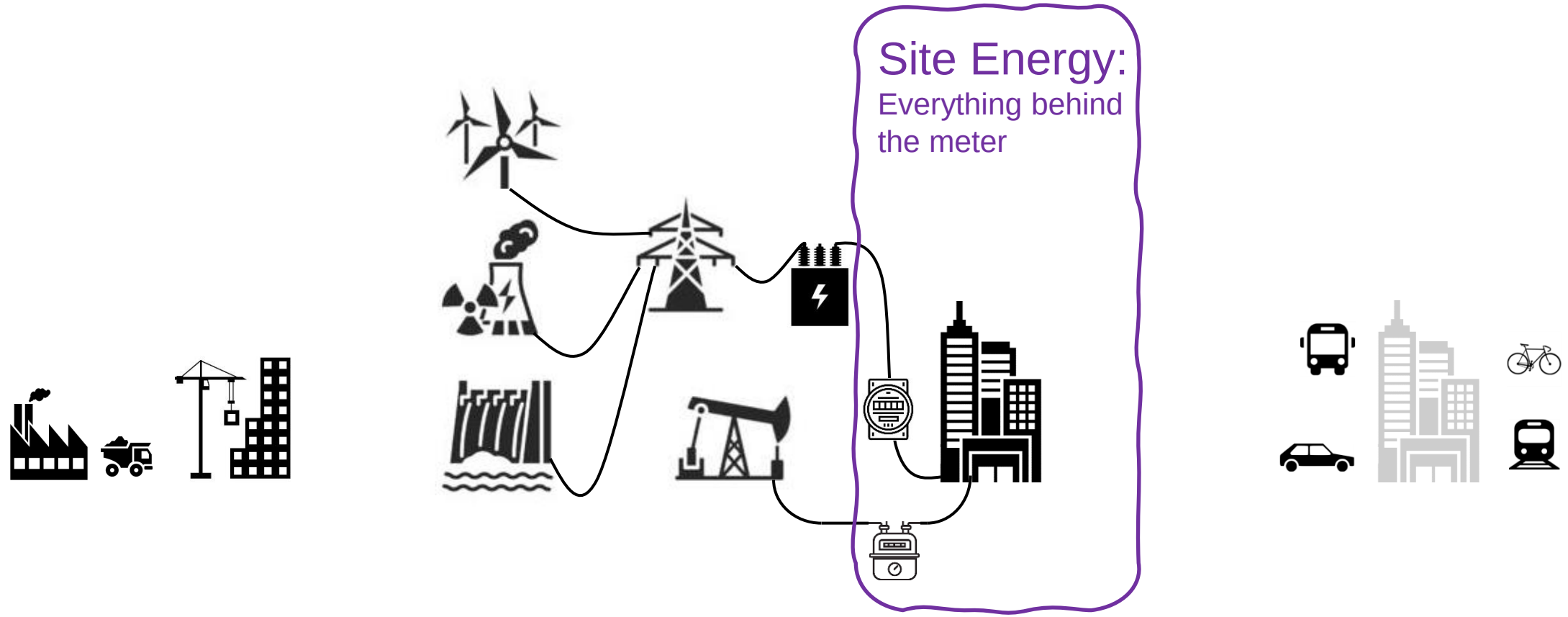
Embodied + **Operational** + Transportation

TOTAL ENERGY



Embodied + **Operational** + Transportation

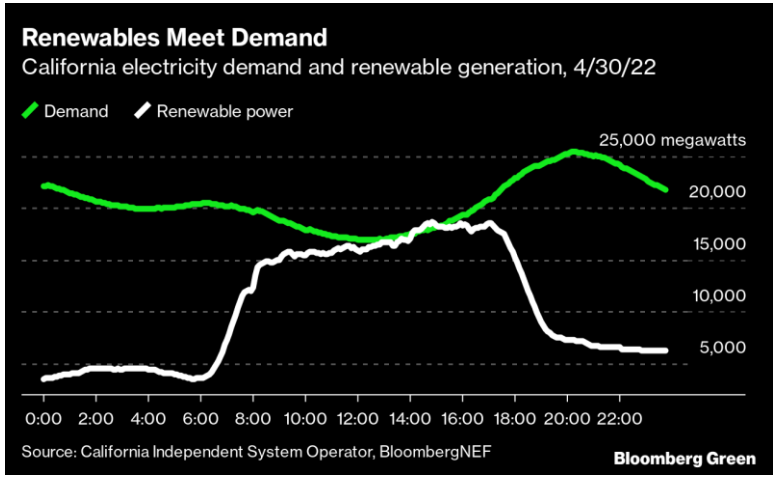
TOTAL ENERGY



Embodied + **Operational** + Transportation

NEW SCHOOL C. 2020 NREL NET ZERO DEFINITION

- 100% Renewables, 100% of the time!
- It's a tall order for most regions with variable grid renewables and intermittent non-dispatchable on-site renewables.
- But people should know old school net zero generally uses the grid as your battery and that "battery" isn't always providing clean energy in return when you need it.



The Future of Zero Energy Buildings: Produce, Respond, Regenerate

Preprint

Paul A. Torcellini, Sammy Houssainy, Shanti D. Pless, William Livingood, and Ben Polly

National Renewable Energy Laboratory

Presented at the 2020 ACEEE Summer Study on Energy Efficiency in Buildings
August 17-21, 2020

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Conference Paper
NREL/CP-5500-77415
September 2020

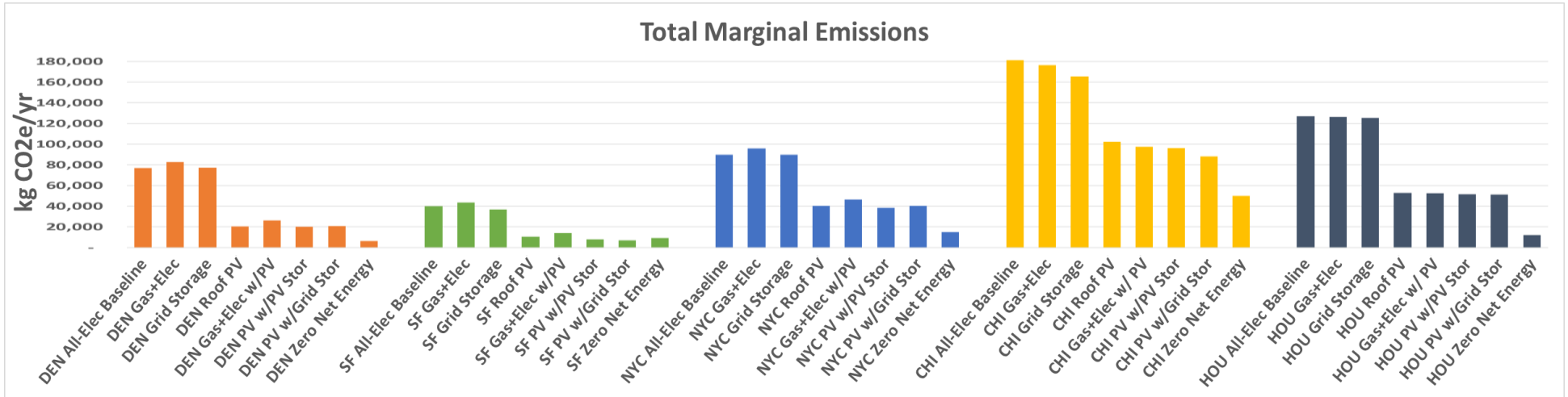
DEFINITION CHOICES AND PITFALLS

Net Zero Energy

- Energy is “somewhat” easy to measure
- Site vs source requires evaluation for consistency with AHJ’s goals
- Source energy conversions are often historical vs forecasted

Net Zero Carbon

- Not constant as electrical grid emissions are likely to decrease over time
- Will favor electrification in regions with clean grids
- Will favor on-site renewables in regions with dirty grids and gas



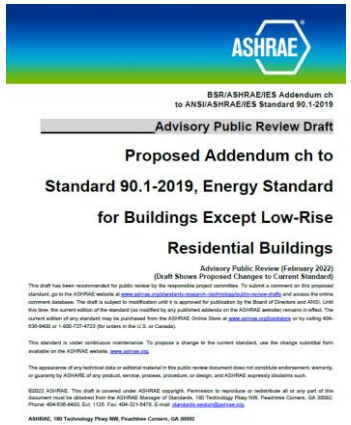
DON'T GO IT ALONE

DOE, EPA and federal level sources

- Leverage national resources

REEOs and NGOs

- Regional and national resources are available


ASHRAE

BSR/ASHRAE/IES Addendum ch to ANSI/ASHRAE/IES Standard 90.1-2019

Advisory Public Review Draft

Proposed Addendum ch to Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings

Advisory Public Review (February 2022)
(Draft Shows Proposed Changes to Current Standard)

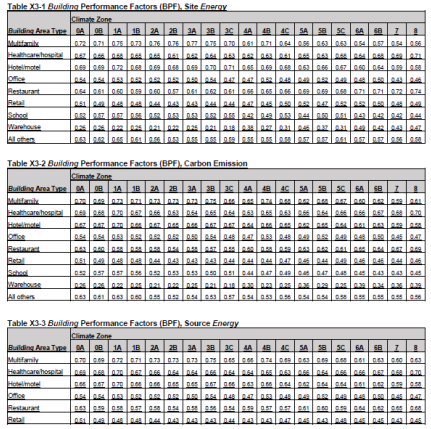


Table X3-1 *Building* Performance Factors (BPF), Site *Energy*

Building Area Type	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.72	0.71	0.75	0.73	0.76	0.76	0.77	0.75	0.70	0.61	0.71	0.64	0.66	0.63	0.63	0.54	0.57	0.54	0.56
Healthcare/hospital	0.67	0.66	0.68	0.66	0.61	0.62	0.64	0.63	0.62	0.63	0.61	0.66	0.63	0.66	0.64	0.66	0.69	0.71
Hotel/motel	0.69	0.69	0.72	0.68	0.69	0.68	0.69	0.70	0.71	0.65	0.69	0.68	0.63	0.66	0.67	0.60	0.64	0.69	0.68
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.52	0.54	0.47	0.47	0.53	0.48	0.49	0.52	0.49	0.48	0.50	0.43	0.46
Restaurant	0.64	0.61	0.60	0.59	0.60	0.57	0.61	0.62	0.61	0.66	0.66	0.66	0.69	0.69	0.69	0.71	0.71	0.72	0.74
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.44	0.44	0.47	0.45	0.50	0.52	0.47	0.52	0.52	0.50	0.48	0.49
School	0.59	0.57	0.57	0.56	0.52	0.53	0.53	0.52	0.55	0.49	0.49	0.53	0.44	0.50	0.51	0.43	0.43	0.43	0.44
Warehouse	0.26	0.26	0.22	0.23	0.21	0.22	0.23	0.21	0.18	0.28	0.27	0.31	0.48	0.37	0.31	0.49	0.45	0.43	0.47
All others	0.63	0.62	0.65	0.61	0.56	0.53	0.55	0.59	0.55	0.55	0.58	0.57	0.57	0.61	0.57	0.57	0.56	0.56	0.58

Table X3-2 *Building* Performance Factors (BPF), Carbon Emission

Building Area Type	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.70	0.69	0.73	0.71	0.73	0.73	0.73	0.75	0.66	0.65	0.74	0.68	0.62	0.66	0.67	0.60	0.62	0.59	0.61
Healthcare/hospital	0.69	0.68	0.70	0.67	0.66	0.63	0.64	0.65	0.64	0.63	0.65	0.63	0.66	0.64	0.66	0.66	0.67	0.69	0.70
Hotel/motel	0.67	0.67	0.70	0.66	0.67	0.65	0.66	0.67	0.67	0.64	0.66	0.65	0.62	0.66	0.64	0.61	0.63	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.47	0.53	0.48	0.49	0.52	0.49	0.48	0.50	0.46	0.47
Restaurant	0.63	0.60	0.58	0.58	0.58	0.54	0.58	0.57	0.55	0.60	0.58	0.59	0.63	0.62	0.61	0.65	0.64	0.67	0.69
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.44	0.44	0.47	0.46	0.44	0.49	0.46	0.46	0.44	0.46
School	0.52	0.51	0.51	0.50	0.50	0.53	0.53	0.50	0.51	0.44	0.47	0.49	0.46	0.47	0.48	0.45	0.43	0.43	0.45
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.19	0.30	0.23	0.25	0.36	0.29	0.25	0.39	0.34	0.36	0.39
All others	0.63	0.61	0.63	0.60	0.56	0.52	0.54	0.53	0.57	0.54	0.53	0.56	0.54	0.54	0.56	0.59	0.56	0.55	0.56

Table X3-3 *Building* Performance Factors (BPF), Source *Energy*

Building Area Type	Climate Zone 0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.70	0.69	0.72	0.71	0.73	0.73	0.73	0.75	0.65	0.66	0.74	0.69	0.63	0.69	0.66	0.61	0.63	0.60	0.63
Healthcare/hospital	0.66	0.66	0.70	0.67	0.66	0.64	0.64	0.66	0.64	0.64	0.66	0.62	0.66	0.64	0.66	0.66	0.67	0.66	0.70
Hotel/motel	0.66	0.67	0.70	0.66	0.66	0.65	0.65	0.67	0.66	0.63	0.66	0.64	0.62	0.64	0.64	0.61	0.62	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.47	0.53	0.48	0.49	0.52	0.54	0.48	0.50	0.46	0.47
Restaurant	0.63	0.59	0.58	0.57	0.58	0.54	0.58	0.56	0.54	0.59	0.57	0.57	0.61	0.60	0.59	0.64	0.63	0.65	0.66
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.44	0.43	0.43	0.47	0.45	0.43	0.45	0.45	0.45	0.43	0.43	0.45

CONSIDERATION	ENERGY EFFICIENCY METRIC					
	Site EUI	Site EUI – normalized for business characteristics	Source EUI – regional factor	Source EUI – regional factor, normalized for business characteristics	Source EUI – national factor	ENERGY STAR Score
Simple	√	X	X	X	√	√
Within control of building owner	√	√ Energy use X Normalization factors may change over time	√ Energy use X Source factor changes over time	√ Energy use X Source and normalization factors change over time	√ Energy use X Source factor changes over time	√ Energy use X Source and normalization factors change over time
Favors electrification	√ Always, regardless of whether most efficient	√ Always, regardless of whether most efficient	√ Impact depends on regional grid fuel mix	√ Impact depends on regional grid fuel mix	√ Only when most efficient	√ Only when most efficient
In Portfolio Manager	√	X Would need to be developed	X Would need to be developed	X Would need to be developed	√	√
Available for all buildings	√	X Would need to be developed for business characteristics	X Would need to be developed by region	X Would need to be developed by region, incl normalization for business characteristics	√	X Available for 22 building types
Standard normalization approach exists	√ Weather	√ Weather X Business characteristics	√ Weather	√ Weather X Business characteristics	√ Weather	√ Weather and business characteristics
Data requiring verification	Meter data for all energy sources Building size	Meter data for all energy sources Building size + business characteristics	Meter data for all energy sources Building size	Meter data for all energy sources Building size + business characteristics	Meter data for all energy sources Building size	Meter data for all energy sources Building size + business characteristics

Source: EPA Understanding and Choosing Metrics for Building Performance Standards and Zero-Carbon Recognition - 5.14.2021

YOU'VE CHOSEN A METRIC, BUT THERE'S STILL MORE

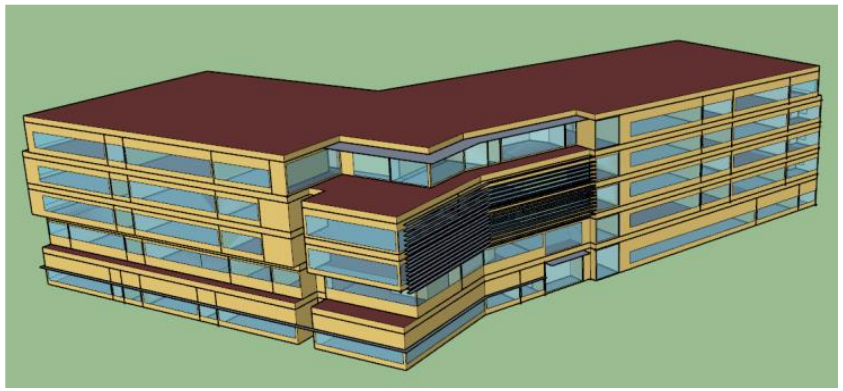
Are you requiring the documentation at time of construction permit?

- This is synonymous with traditional "performance-based" compliance

...Or are you asking for proof after the building is operating?

- This is termed "outcome-based" compliance

Actual Site EUI = TBD kBTU/sf-yr



Predicted Site EUI = 29.8 kBTU/sf-yr

POLICY CONSIDERATIONS

- If you have a lot of existing buildings, then weighing embodied carbon encourages reuse over new construction
- If you have a lot of varied car-dependency within your jurisdiction you should likely consider transportation. If everything thing is equal, you might justify excluding it
- If you have high rises, then on-site solar requirements are tricky if not impractical

ABOVE CODES HAVE DIFFERING BOUNDARIES

	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 CERTIFICATION					Highest efficiency	Yes, must be local. 75% of roof for solar.	
ZERO CARBON CERTIFICATION					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

OLD SCHOOL C. 2006 NREL NET ZERO DEFINITION

- Energy used = energy produced
- Charles Eley published an ASHRAE Journal Article reviewing building heights, building types, climate zones and likelihood for readily being net zero
- For many low-rise buildings, max tech isn't necessary
- Off the shelf products will get you there

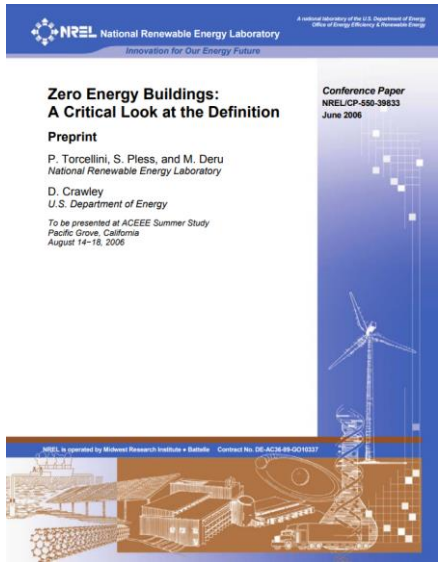
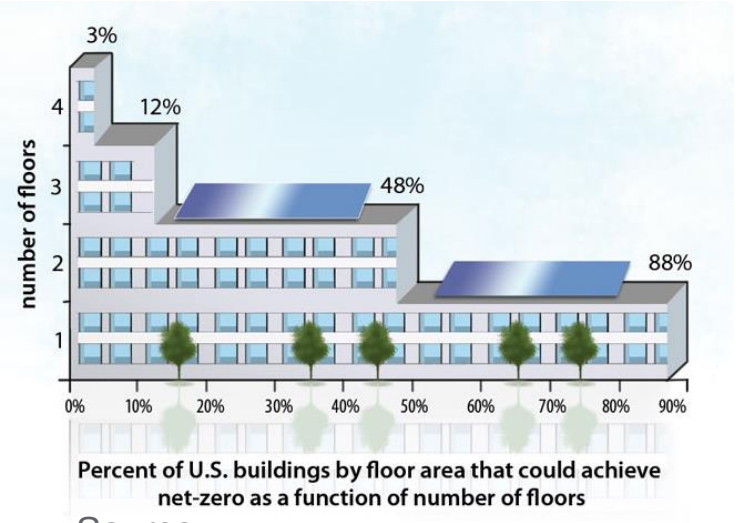


TABLE 6 Minimum CFA ratio needed for ZNE, compliance with Standard 90.1-2013.

	PACIFIC COAST	WARM AND DRY	HOT AND HUMID	WARM AND HUMID	COLD AND DRY	COLD AND HUMID	ARCTIC
Warehouses	0.22	0.21	0.17	0.24	0.28	0.44	0.84
Offices	0.30	0.42	0.46	0.46	0.45	0.56	1.04
Retail	0.49	0.66	0.67	0.72	0.77	0.98	2.07
Schools	0.48	0.62	0.68	0.69	0.69	0.84	1.72
Apartments	0.49	0.64	0.67	0.74	0.76	1.02	1.93
Offices/Data Center	0.85	0.94	0.99	1.02	1.05	1.29	2.25
Hotels	0.78	1.01	1.12	1.13	1.12	1.38	2.55
Health Care	1.40	1.45	1.64	1.68	1.61	2.01	3.57
Restaurants	4.97	5.80	5.81	6.82	7.46	9.60	19.34

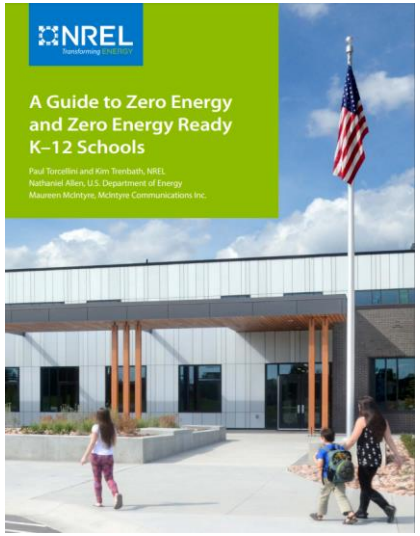
Source: Charles Eley

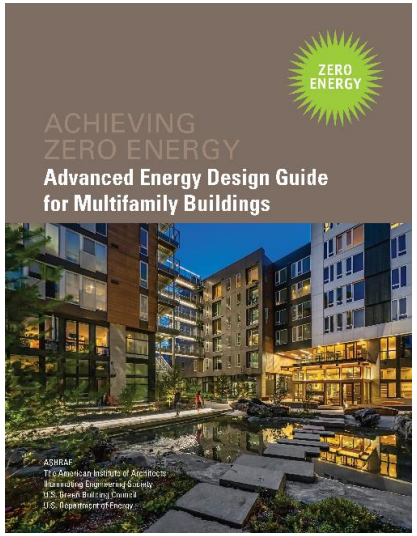


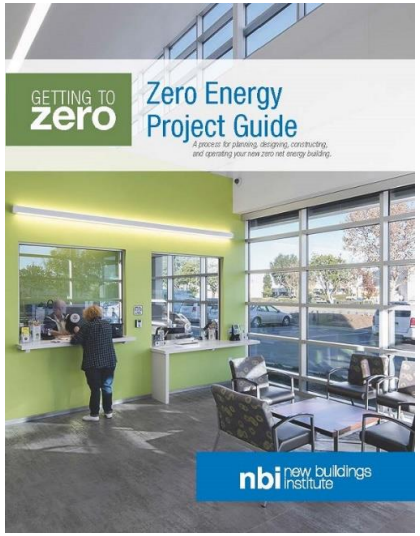
Source: BuildingGreen

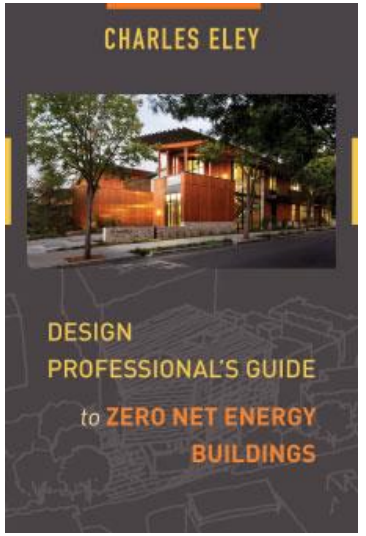
LOTS OF RESOURCES

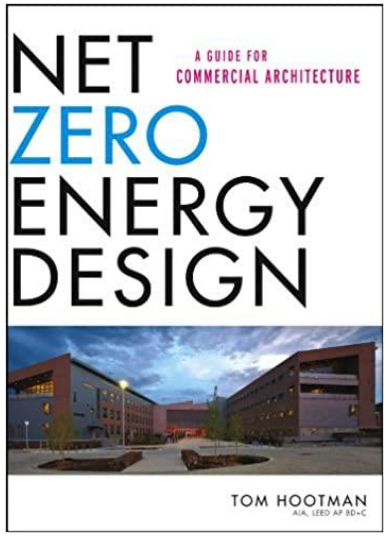
- Prescriptive resources exist
  - For specific building types
    - Schools
    - Multifamily
    - Office Buildings
  - Covering most US climate zones







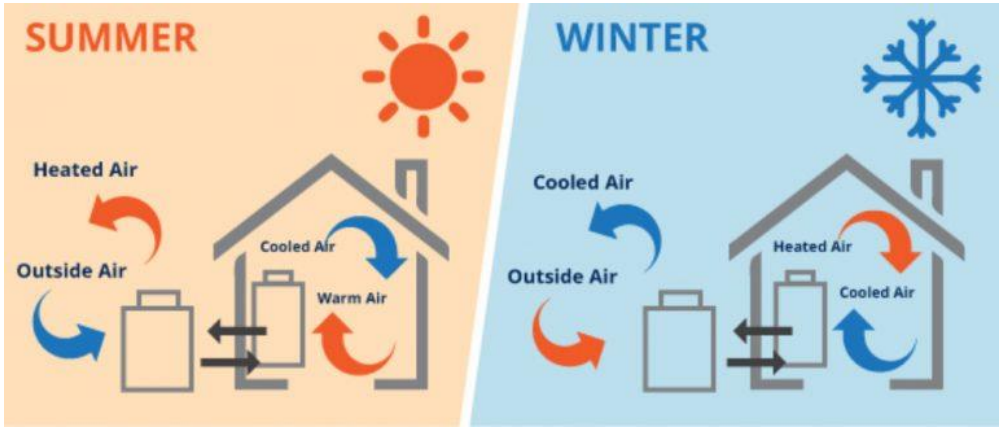


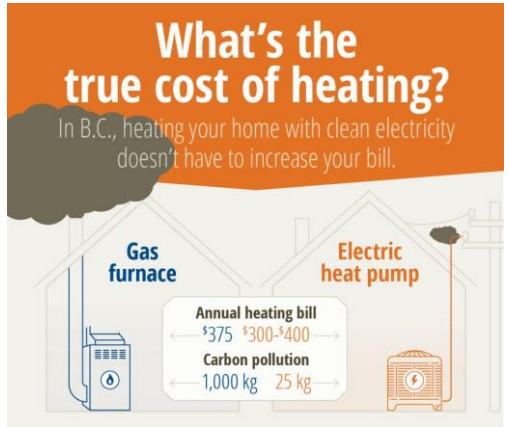


TECHNOLOGIES

- Space Heating and Domestic Hot Water
  - You can burn gas at ~80% thermal efficiency
  - You can burn gas at ~95% thermal efficiency with condensing flue gases
  - You can run electricity through a resistance heater at ~100% efficiency
  - You can run electricity through a heat pump at ~200-400% efficiency

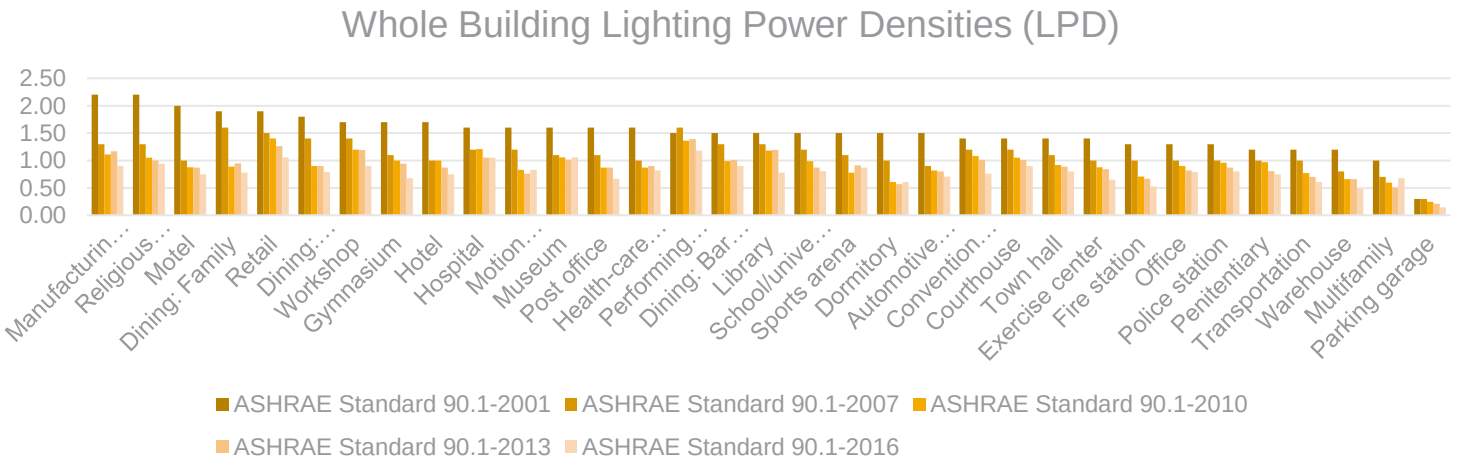
Note: electric resistance has its place but should generally be used sparingly





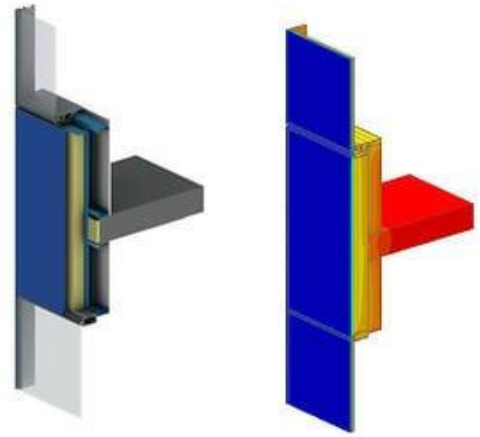
LIGHTING

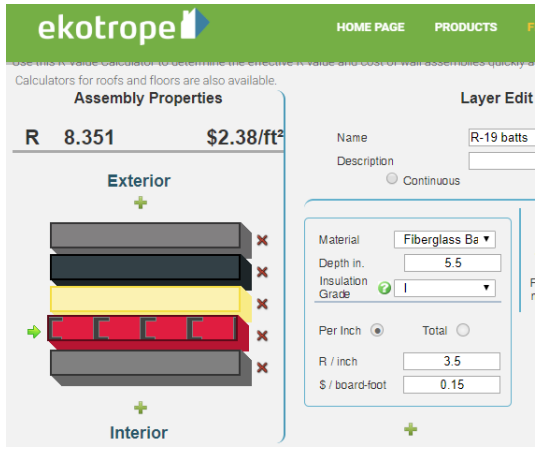
- LEDs have replaced virtually everything
  - We use them in world class venues
- Lighting controls
  - Will help with demand response, daylight dimming, occupancy/vacancy and setback modes
  - Energy codes are getting more and more complicated on control requirements

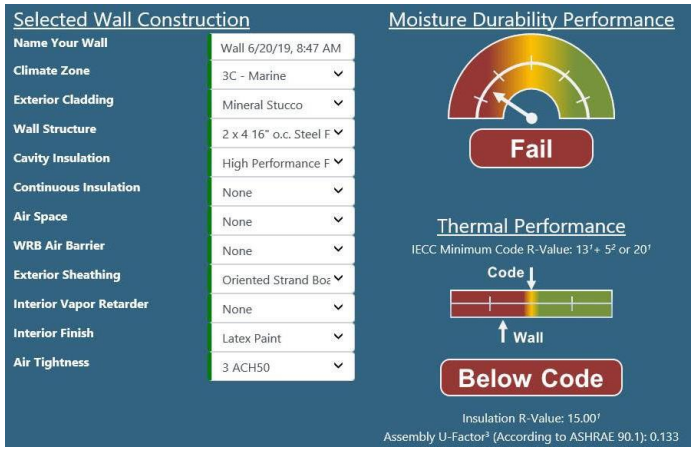


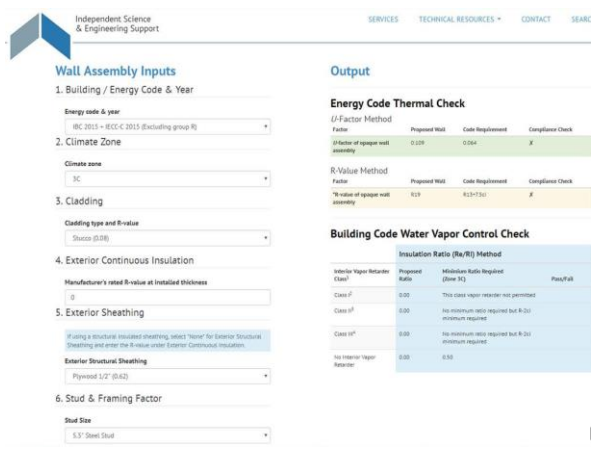
ENVELOPE

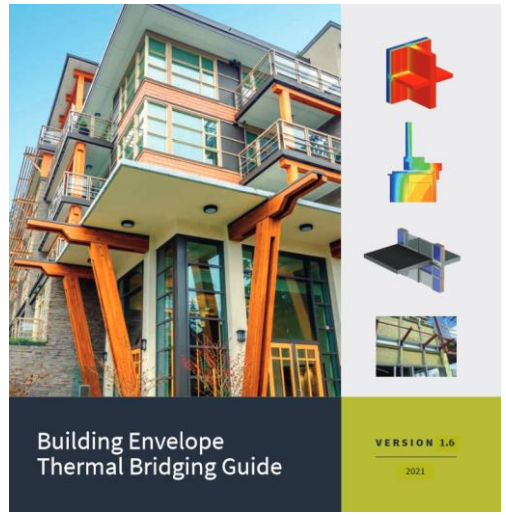
- Good thermal envelope
  - There are now many online tools to calculate assembly U-factors or R-values
- Use glass wisely and perhaps sparingly
- Avoid thermal bridges
- Install an air barrier
- Add a vapor barrier if you're humidifying spaces or have pools





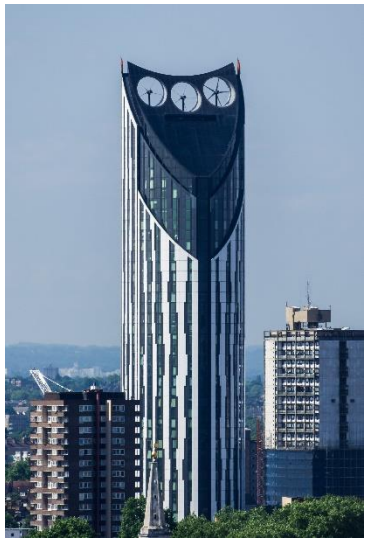






ADD ON-SITE RENEWABLES

- For almost all projects this will mean PV (photovoltaic) panels
- Some might find biomass or small-scale wind
- Micro-hydro is an option and has been around for millennia
- True geothermal, i.e., not ground source



ZE METRICS APPLICATION SUMMARY

- Many definitions exist for ZE
- ZE metric definition is only part of ZE policy
- Don’t go it alone – use available resources
- ZE is achievable with available technologies
- ZE may require max tech or off-site renewable energy procurement for some building types
- **Inconsistencies or competing requirements across national, state, and local jurisdictions can make compliance challenging**

ENERGY TARGETS
GETTING TO ZERO ENERGY CODES OR CARBON OVER TIME

Session Summary

- Many definitions exist for ZE and associated system boundaries
- “Step” ZE codes support achieving zero energy and carbon over time
- Technologies that support ZE are available on the market and are being installed in buildings
- ZE achievement may require max tech or off-site renewable energy procurement for some building types
- Variations in requirements across national, state, and local jurisdictions can make compliance challenging
- ZE target enablers include utilization of published resources, strong stakeholder engagement, a step code approach, adoption of stretch codes, and project incentives

Pacific Northwest
NATIONAL LABORATORY

Questions and Discussion