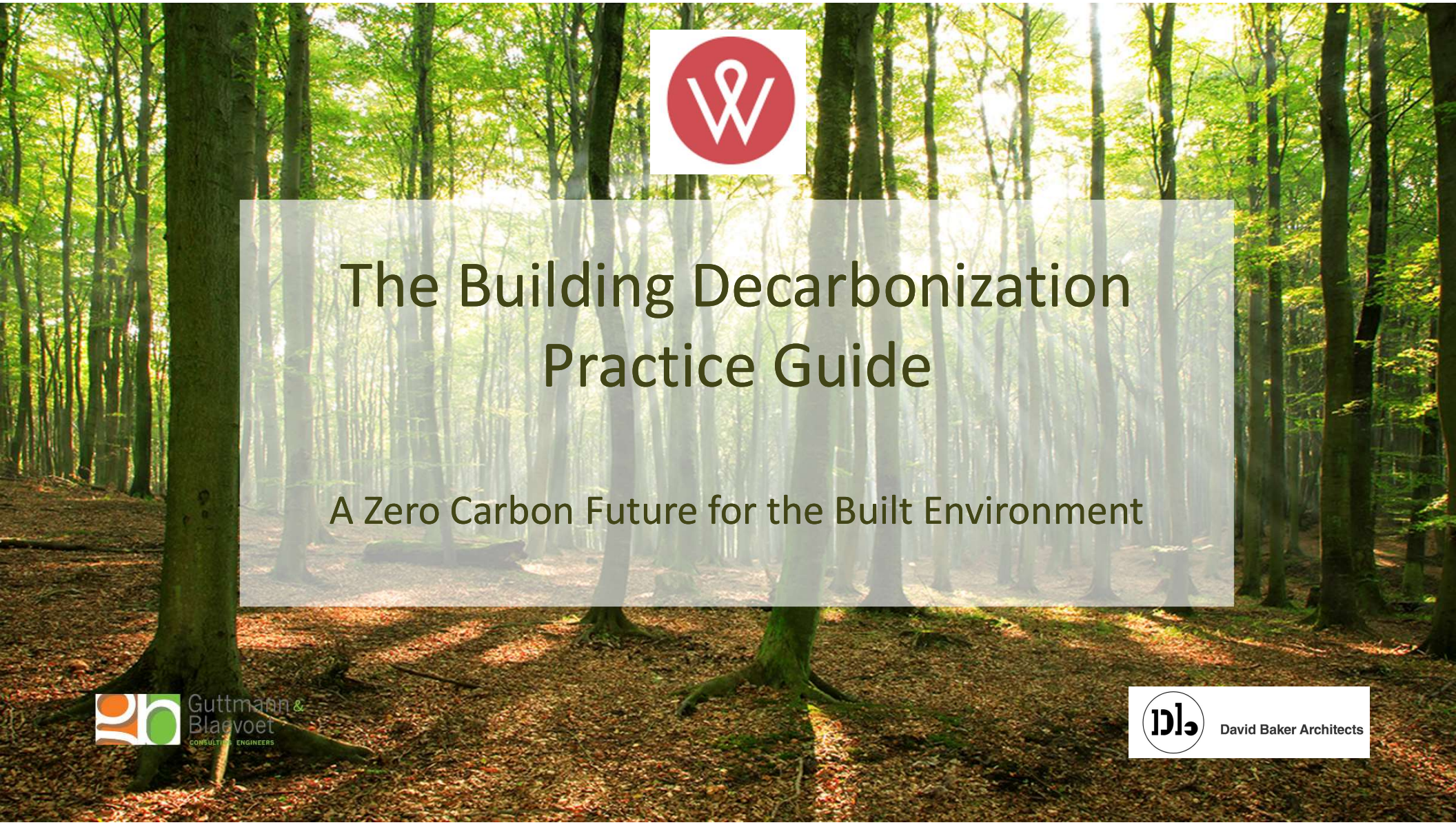


The Building Decarbonization Practice Guide

A Zero Carbon Future for the Built Environment

Guttmann & Blaevoet
CONSULTING ENGINEERS

David Baker Architects

Agenda

- Why Are We Transitioning from a ZNE to a ZNC mindset?
- Where Does this Transition Lead Us?
- How does a ZNC Mindset Play Out in Multifamily Housing Projects

The Building Decarbonization Practice Guide

Released in September, 2021

Released in October, 2021

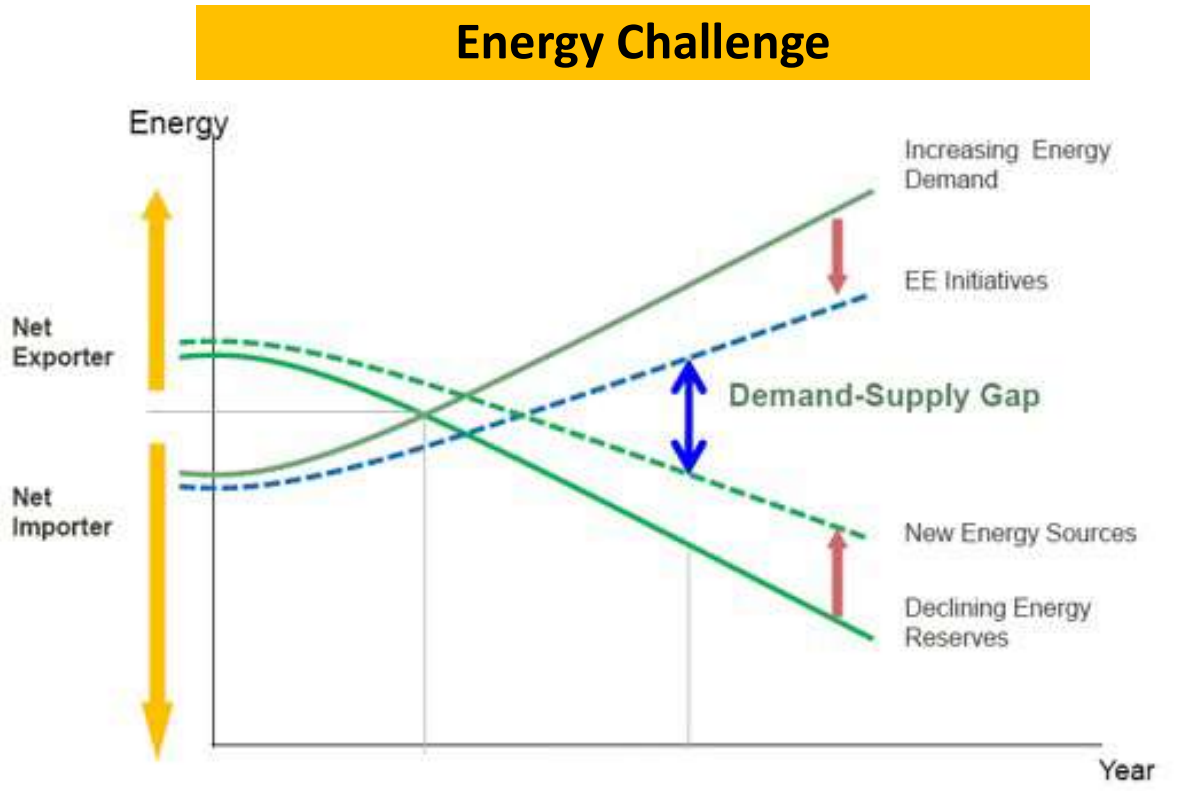
- **Volume 4**: Commercial Buildings
- **Volume 5**: All-Electric Kitchens – Residential and Commercial
- **Volume 6**: Embodied Carbon
- **Volume 7**: Policy and Code Context

Scheduled for Release in 1st Quarter, 2022

Why Are We Transitioning from a ZNE to a ZNC Mindset?

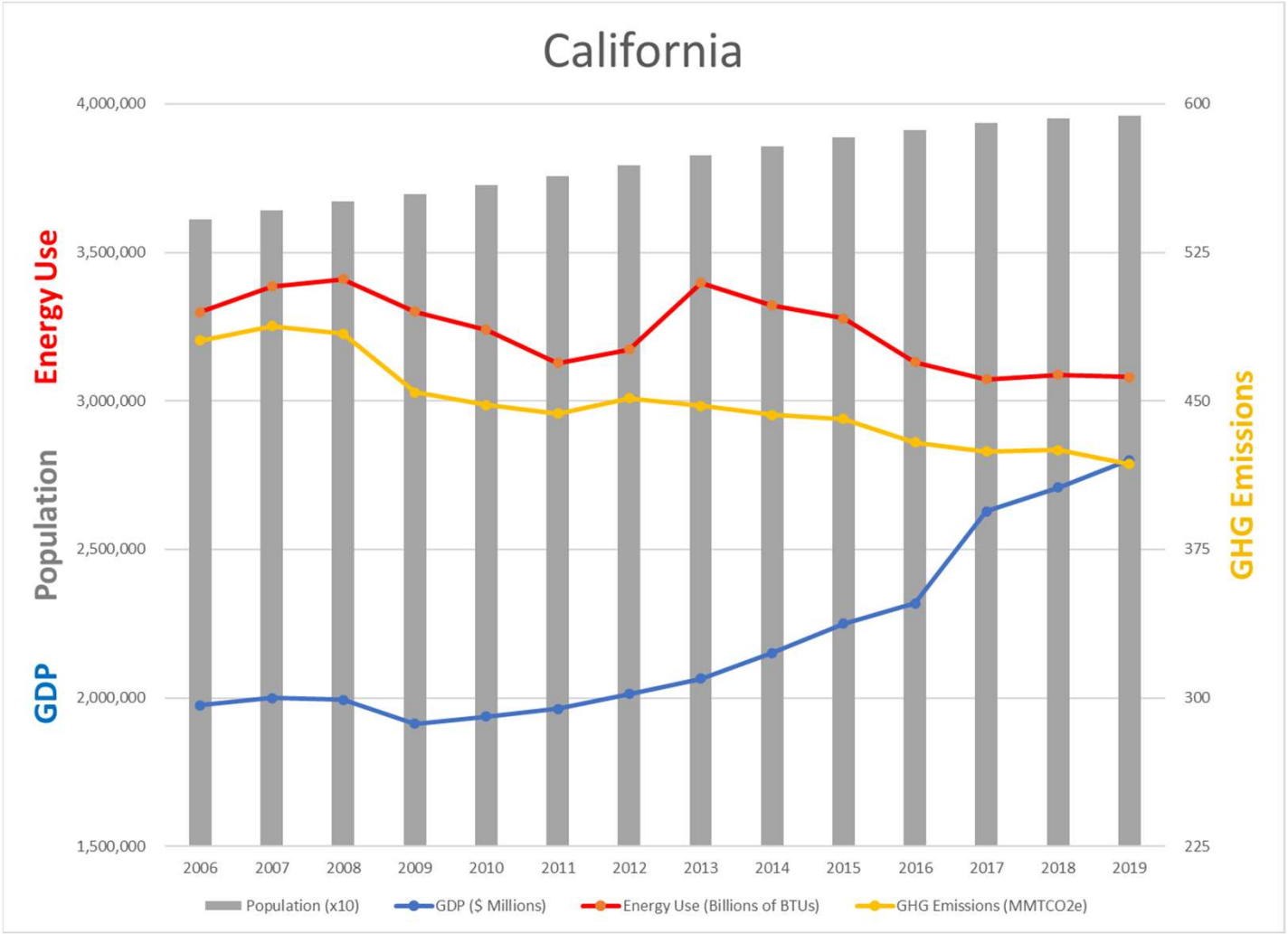
The Journey from Energy Efficiency to Carbon Neutrality

Focused on energy efficiency



- Energy demand is projected to increase from 2,000 PJ in 2009 to 4,013 PJ in 2030
- Average rate of 3.6% p.a.

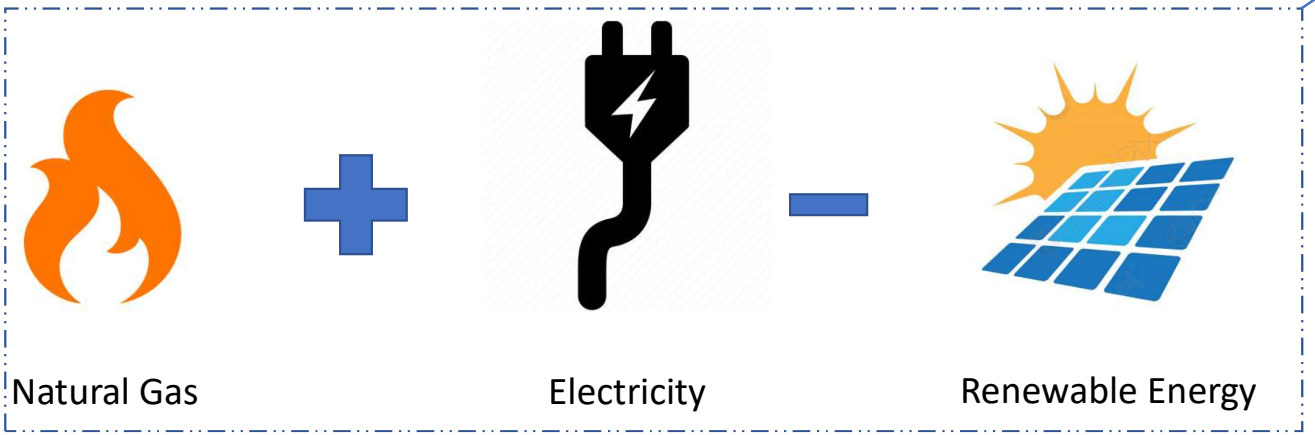
Decades of Effort in Energy Efficiency



SOURCES:

(1) https://www.statista.com/statistics/187834/gdp-of-the-us-federal-state-of-california-since-1997/
(2) California Natural Gas Total Consumption, Energy Information Administration (https://www.eia.gov/dnav/ng/hist/na1490_sca_2a.htm)
(3) State Electricity Profiles, Energy Information Administration (https://www.eia.gov/electricity/state/archive/2016/california/)
(4) State of California Department of Finance (http://www.dof.ca.gov/Forecasting/Demographics/Estimates/)
(5) (5) California Air Resources Board (https://www.arb.ca.gov/cc/inventory/data/data.htm)

TOTAL ANNUAL CONSUMPTION OF IMPORTED ENERGY



Natural Gas + Electricity − Renewable Energy

Gross Building Area

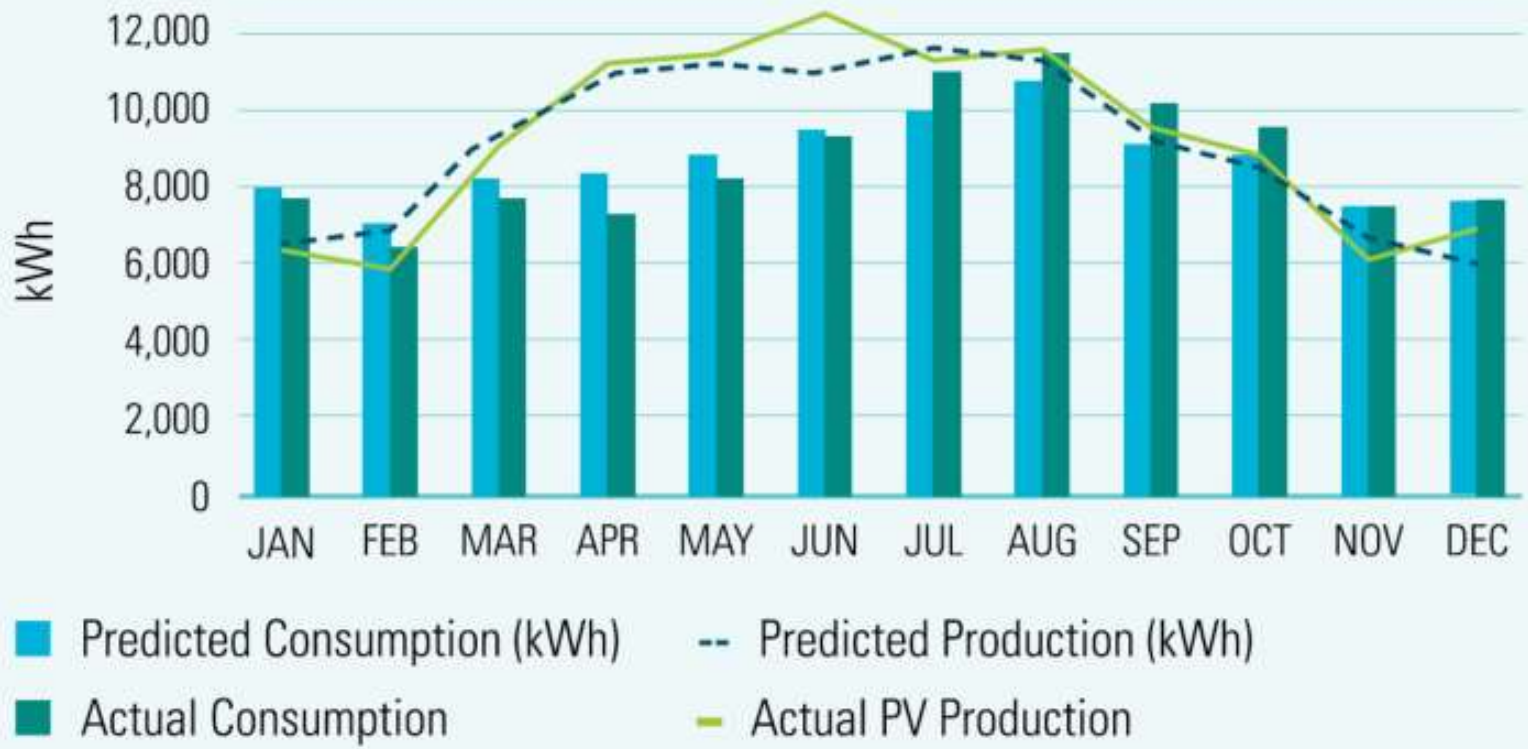
= **E**nergy **U**se **I**ntensity

EUI

kBTU/SF/ Year

Zero Net Energy (ZNE) Paradigm

FIGURE 2.23: ALPINE BRANCH LIBRARY YEAR ONE ZNE



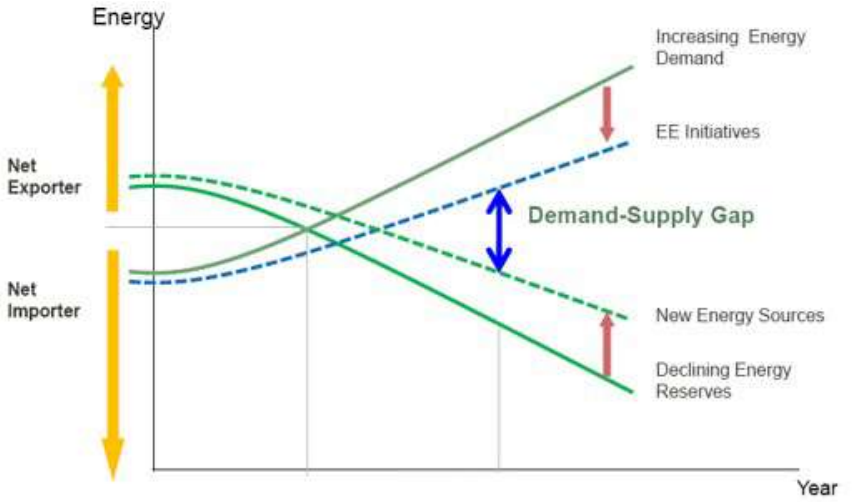
Source: Courtesy of Energy & Sustainability Program, County of San Diego

2018

THE GLOBAL CLIMATE ACTION SUMMIT

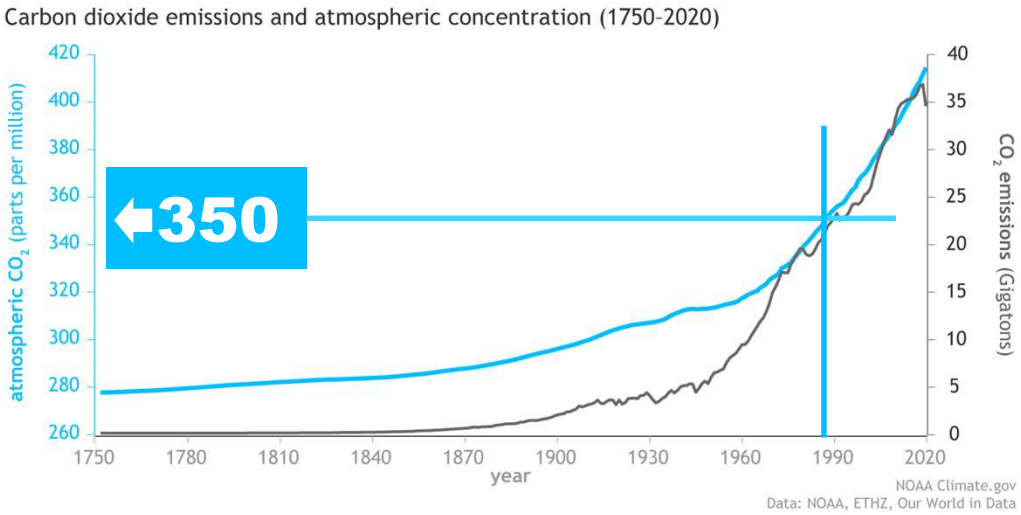
Focused on the wrong thing?

Energy Challenge



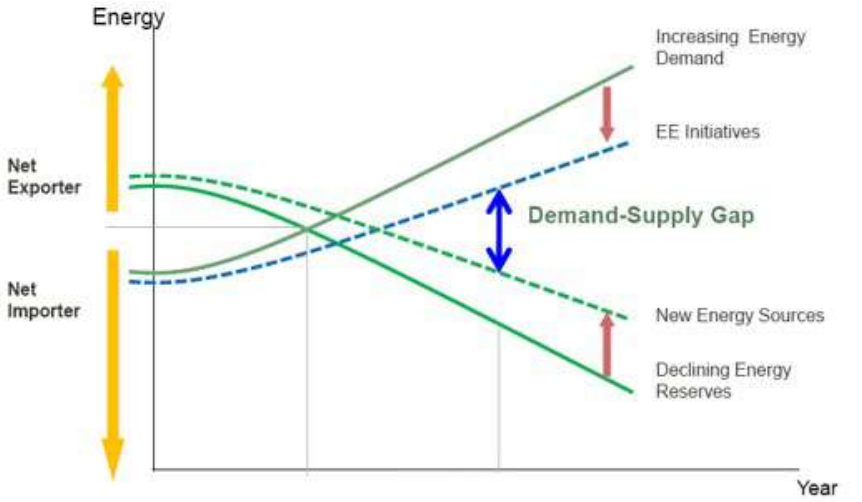
- Energy demand is projected to increase from 2,000 PJ in 2009 to 4,013 PJ in 2030
- Average rate of 3.6% p.a.

Carbon Dioxide Problem



Focused on the wrong thing?

Energy Challenge



- Energy demand is projected to increase from 2,000 PJ in 2009 to 4,013 PJ in 2030
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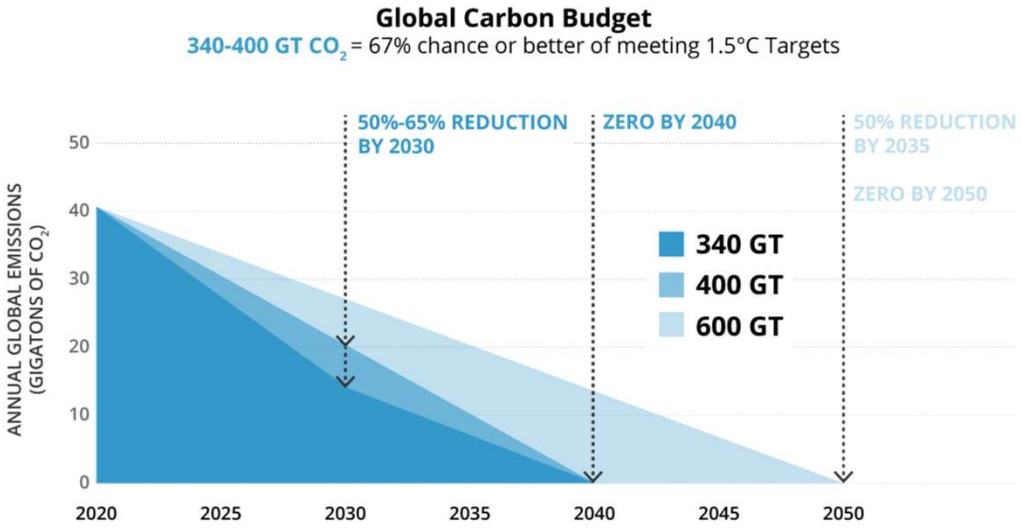
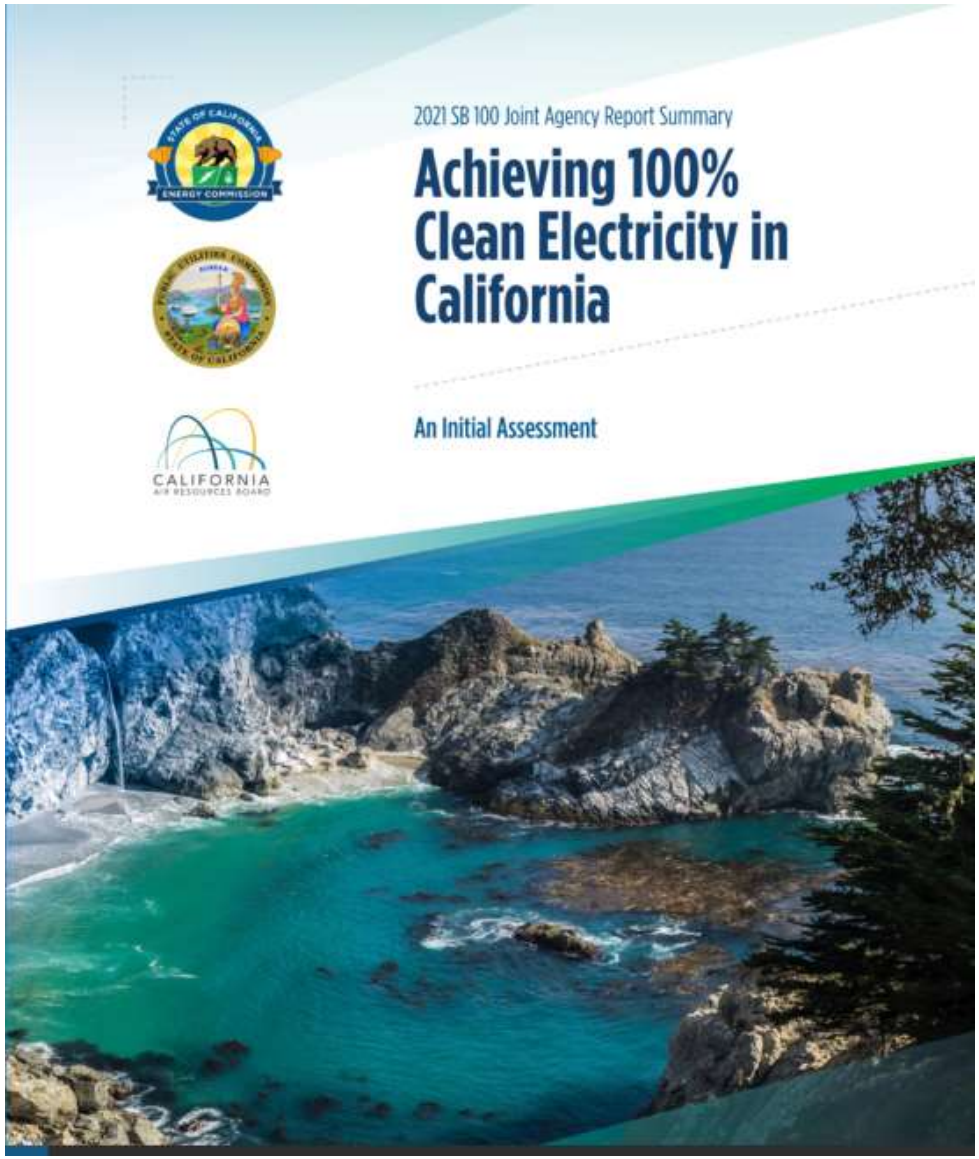
Carbon Dioxide Problem



Data Sources: UN IPCC AR6

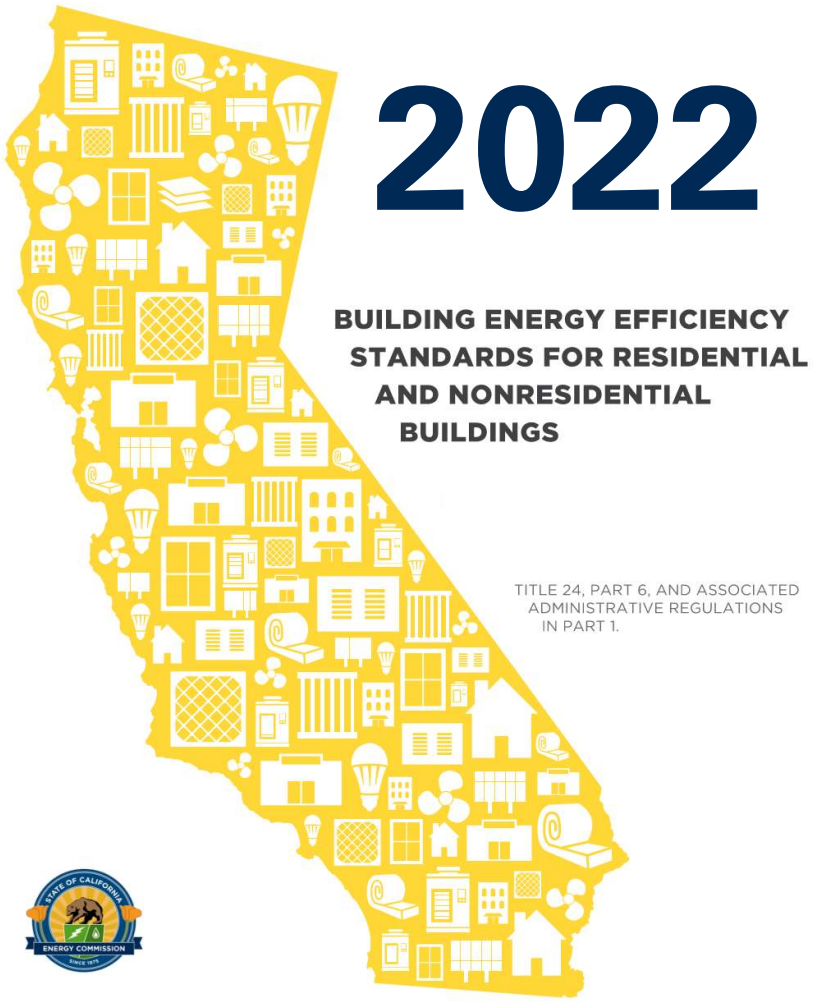
Factors Supporting the Transition from a ZNE to a ZNC Mindset

- Decarbonization of the Utility Grid
  - 100% renewable energy by 2045



Factors Supporting the Transition from a ZNE to a ZNC Mindset

- Decarbonization of the Utility Grid
- **Regulatory Landscape Support**
  - 2022 California Energy Code
    - Heat pump baseline **OR** increased efficiency requirements



Factors Supporting the Transition from a ZNE to a ZNC Mindset

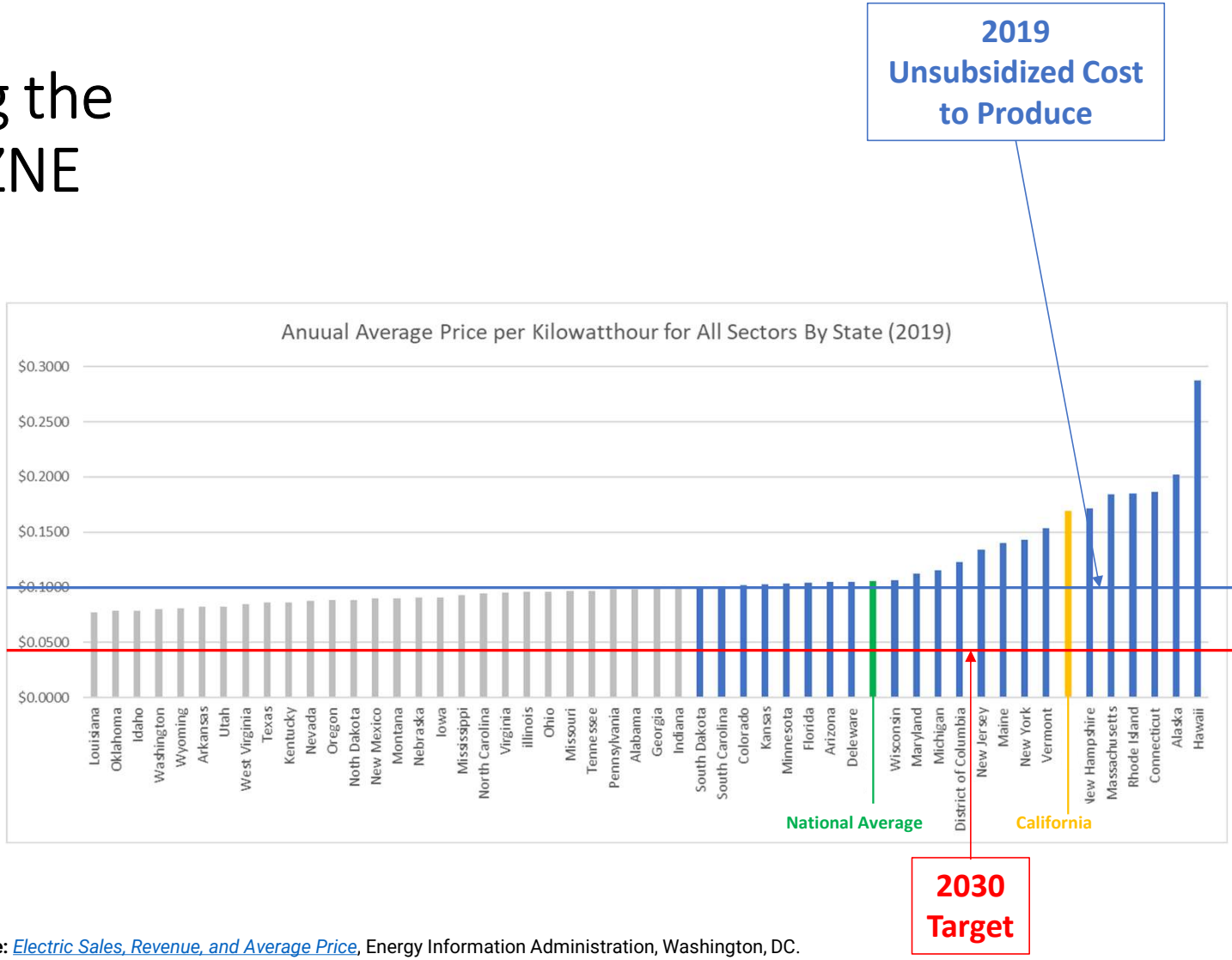
- Decarbonization of the Utility Grid
- **Regulatory Landscape Support**
  - *54* ~~*49*~~ California Cities/Counties
    - *11* Outright NG Moratoriums
    - *11* Electric-Preferred Ordinances
    - *35* All-Electric Reach Codes

More on Reach Codes at *https://localenergycodes.com*

Source: Sierra Club

Factors Supporting the Transition from a ZNE to a ZNC Mindset

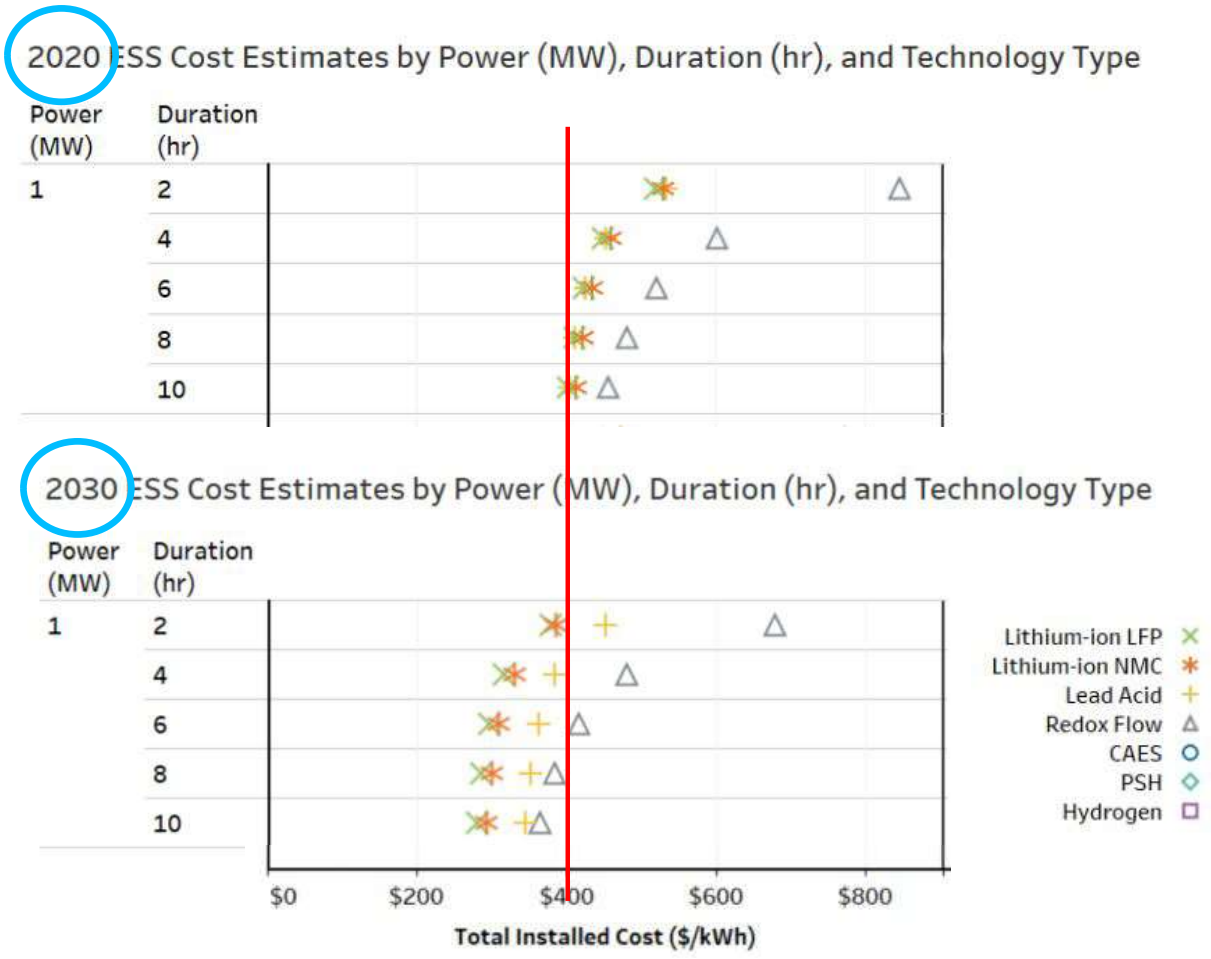
- Decarbonization of the Utility Grid
- Regulatory Landscape Support
- **Cheap Solar Energy**



Source: *Electric Sales, Revenue, and Average Price*, Energy Information Administration, Washington, DC.

Factors Supporting the Transition from a ZNE to a ZNC Mindset

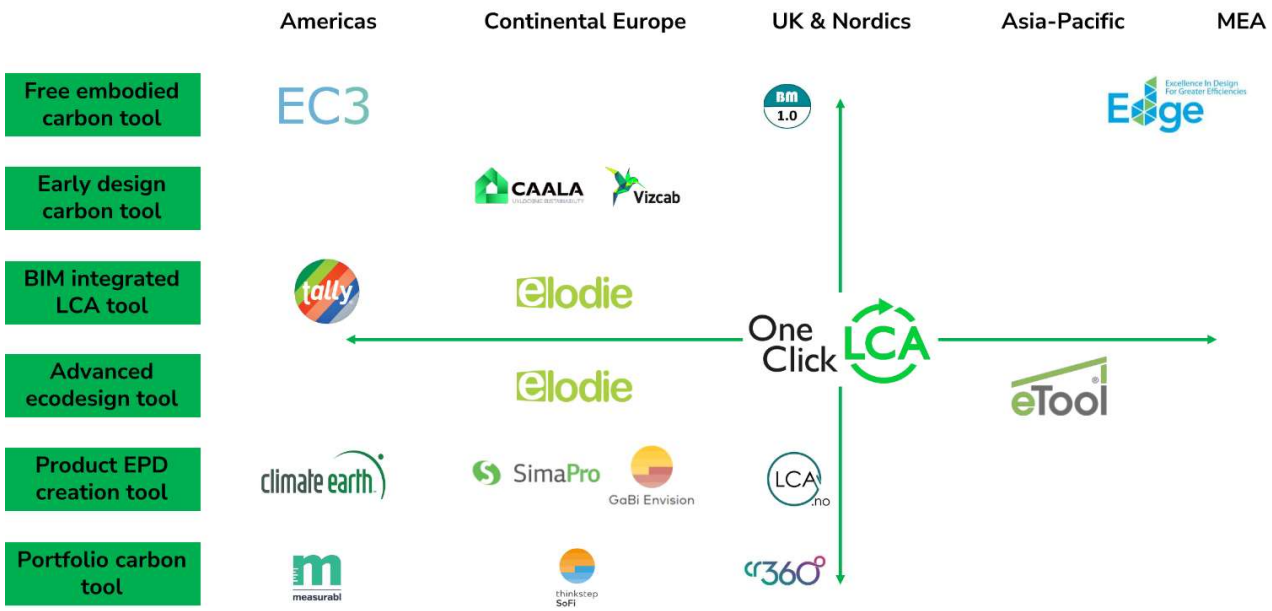
- Decarbonization of the Utility Grid
- Regulatory Landscape Support
- Cheap Solar Energy
- **Decreasing cost of battery energy storage**



Source: 2020 Grid Energy Storage Technology Cost and Performance Assessment, PNNL, December, 2020.

Factors Supporting the Transition from a ZNE to a ZNC Mindset

- Decarbonization of the Utility Grid
- Regulatory Landscape Support
- Cheap Solar Energy
- Decreasing cost of battery energy storage
- **Proliferation of WBLCA tools and expertise**



Where Does this Transition Lead Us?

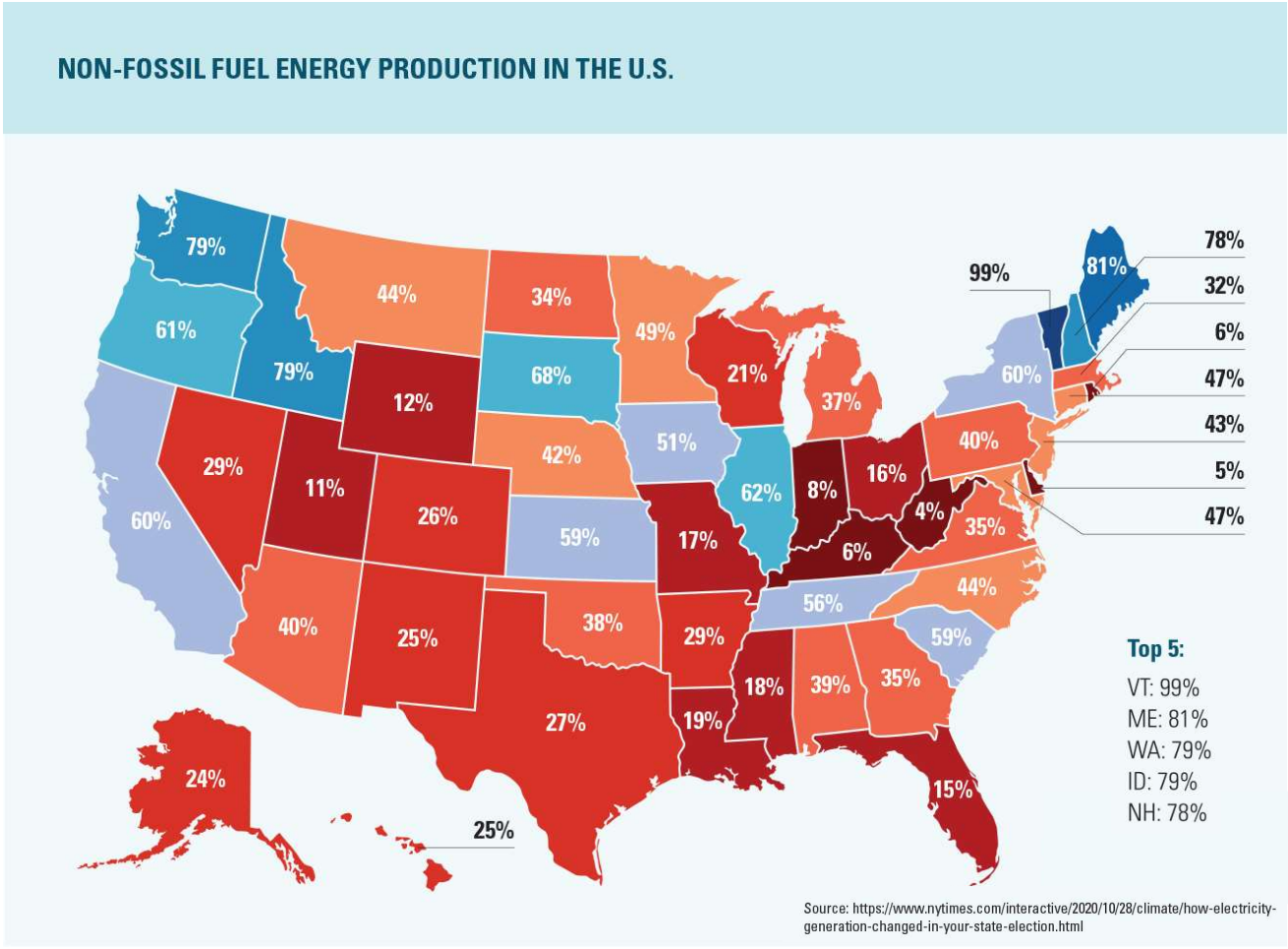
Adopting a Zero Net Carbon (ZNC) Design Paradigm

Zero Net Carbon (ZNC) Paradigm

- **All-Electric Buildings Powered by 100% Renewable Energy**
- Heat Pumps!
- Heat Recovery from Everything
- High Performance Envelopes
- Elimination of Reheat
- Grid Responsive Design
- Energy Storage
- Onsite Renewable Energy Generation
- Hot Water Use Reduction
- Monitoring Based Commissioning and Advanced Fault Detection and Diagnostics

Zero Net Carbon (ZNC) Paradigm

- **All-Electric Buildings Powered by 100% Renewable Energy**



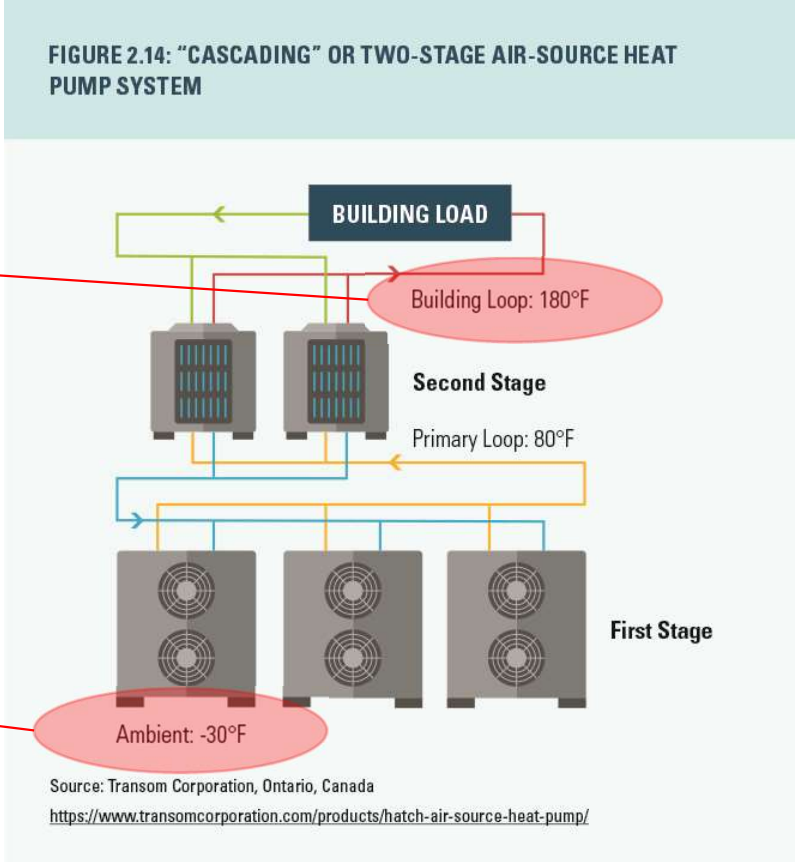
Zero Net Carbon (ZNC) Paradigm

- **Heat Pumps and Heat Recovery**

Building Loop: **180 ºF**

Ambient: **-30 ºF**

No Significant Cold Climate Limitations



Zero Net Carbon (ZNC) Paradigm

- **Grid Responsive Design**
  - Microgrids (energy generation plus energy storage)

Energy *Generation*

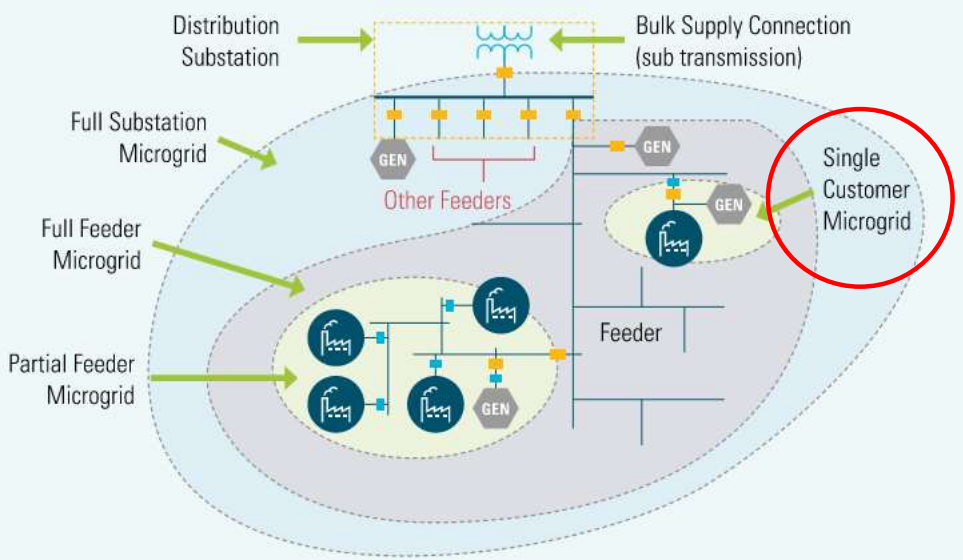
+

Energy *Storage*

+

Energy *Controls*

FIGURE 2.40: MICROGRIDS AT DIFFERENT SCALES



Source: https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/role-microgrids-helping

Grid Responsive Design

Marginal Emission Rates vis-à-vis Utility Rates

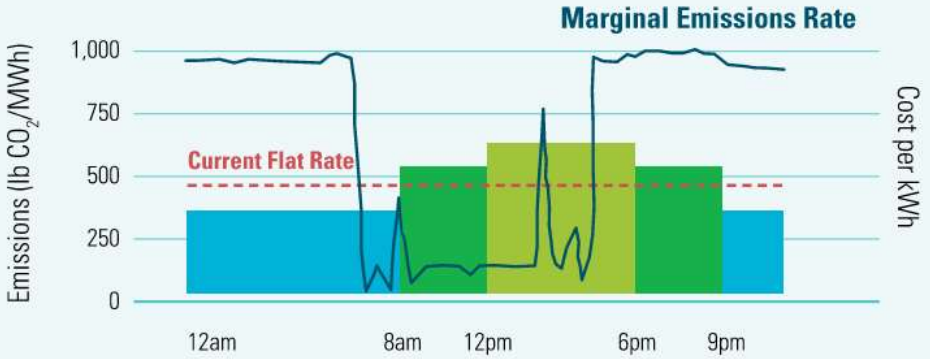
Grid Responsive Design

Marginal Emission Rates vis-à-vis Utility Rates

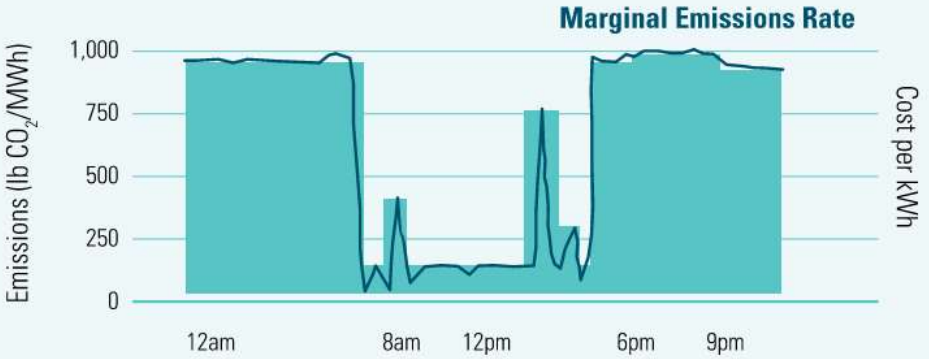
Grid Responsive Design

Marginal Emission Rates vis-à-vis Utility Rates

FIGURE 2.9: UTILITY COSTS ARE NOT ALIGNED WITH GRID EMISSIONS



Example above is what it looks like to have a tariff schedule that does not align with grid emissions



Example above is what it looks like to have a tariff schedule that perfectly aligns with grid emissions

Off-peak Partial-peak On-peak

Rate varies continuously throughout the day based on current marginal emissions rate

Source: Developed by Steve Guttmann, Guttmann & Blaevoet

Sonoma Clean Power Headquarters

Santa Rosa, CA

- Building Electrification Retrofit
- 15,000 SF Two Story Office
- High Efficiency Variable Speed Rooftop Heat Pumps
- Smart VAV diffusers
- On-site Solar
- 120 kWh Stationary Battery storage
- 23 Electric Car Charging Stations
- Automatic, grid-signaled HVAC, lighting and plug load demand reduction
- Estimated completion early 2022

Sonoma Clean Power

GRIDOPTIMAL™ BUILDINGS INITIATIVE

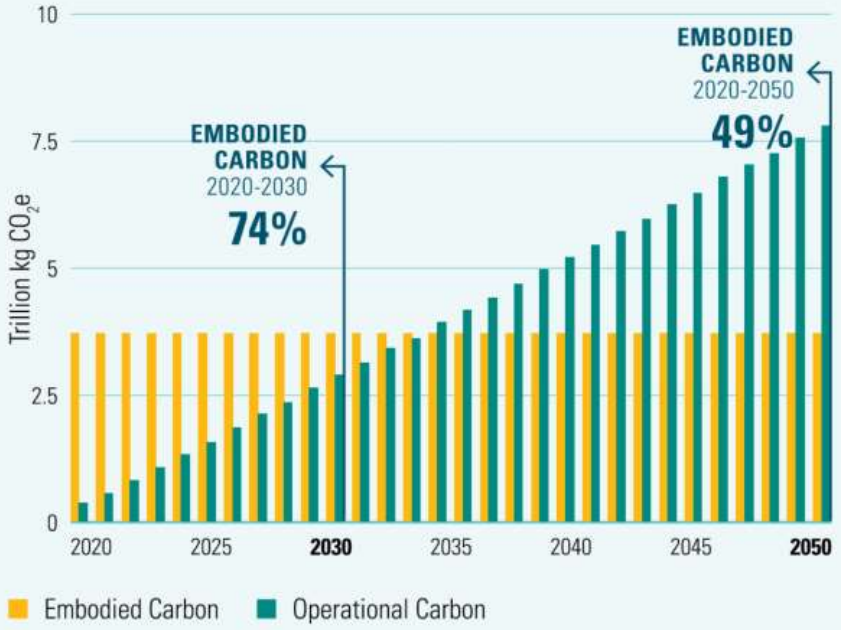
Zero Net Carbon (ZNC) Paradigm

- Low **embodied carbon** construction
  - Materials and methods

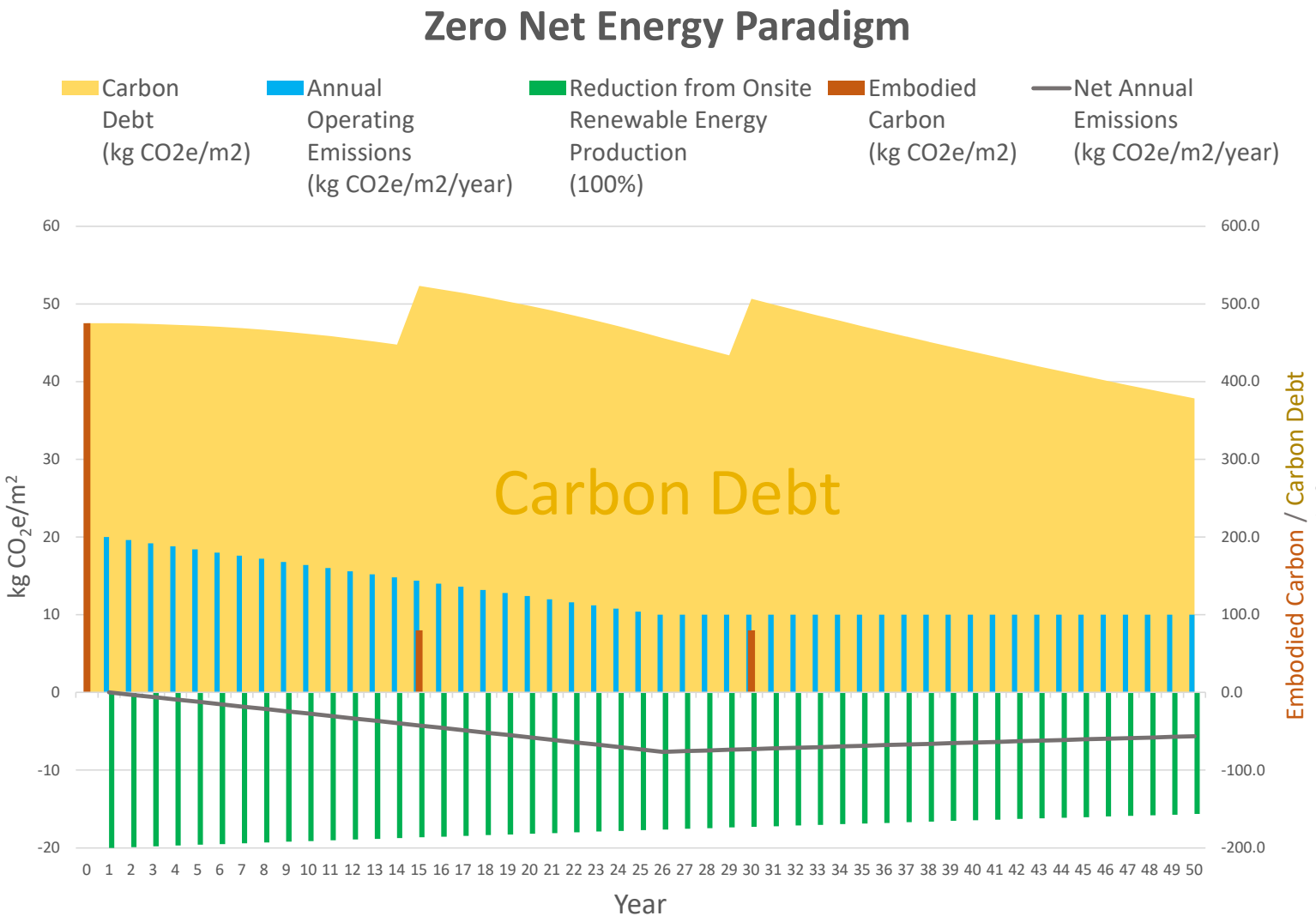
Buildings and Infrastructure Category Interventions	GHG Emission Reduction Potential
+ material efficiency + enhance building utilization + material switching + low-carbon cement + reuse building components	44%

Source: "Building and Infrastructure Consumption Emissions," August 2019

FIGURE 1.5: TOTAL CARBON EMISSIONS OF GLOBAL CONSTRUCTION (2020–2050)

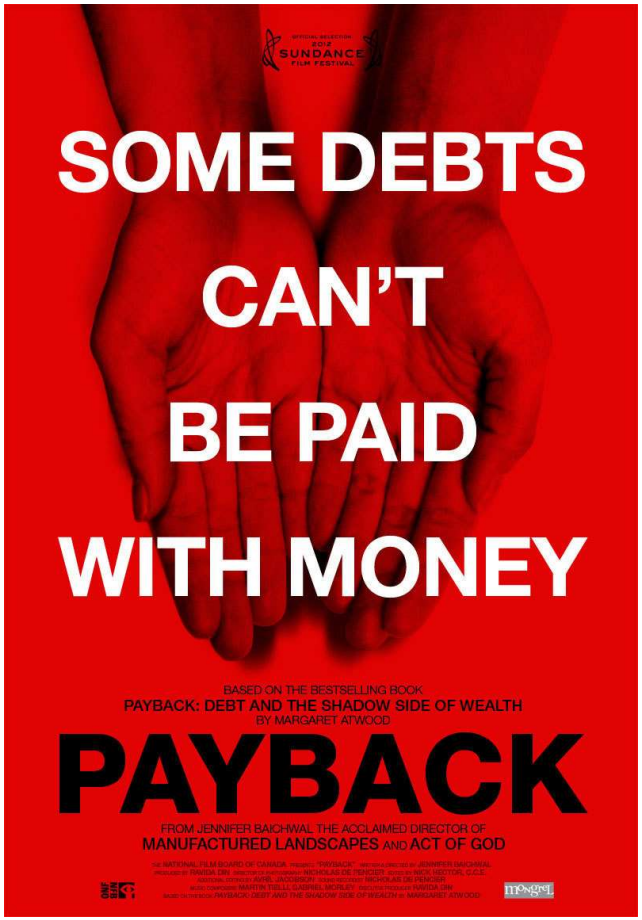


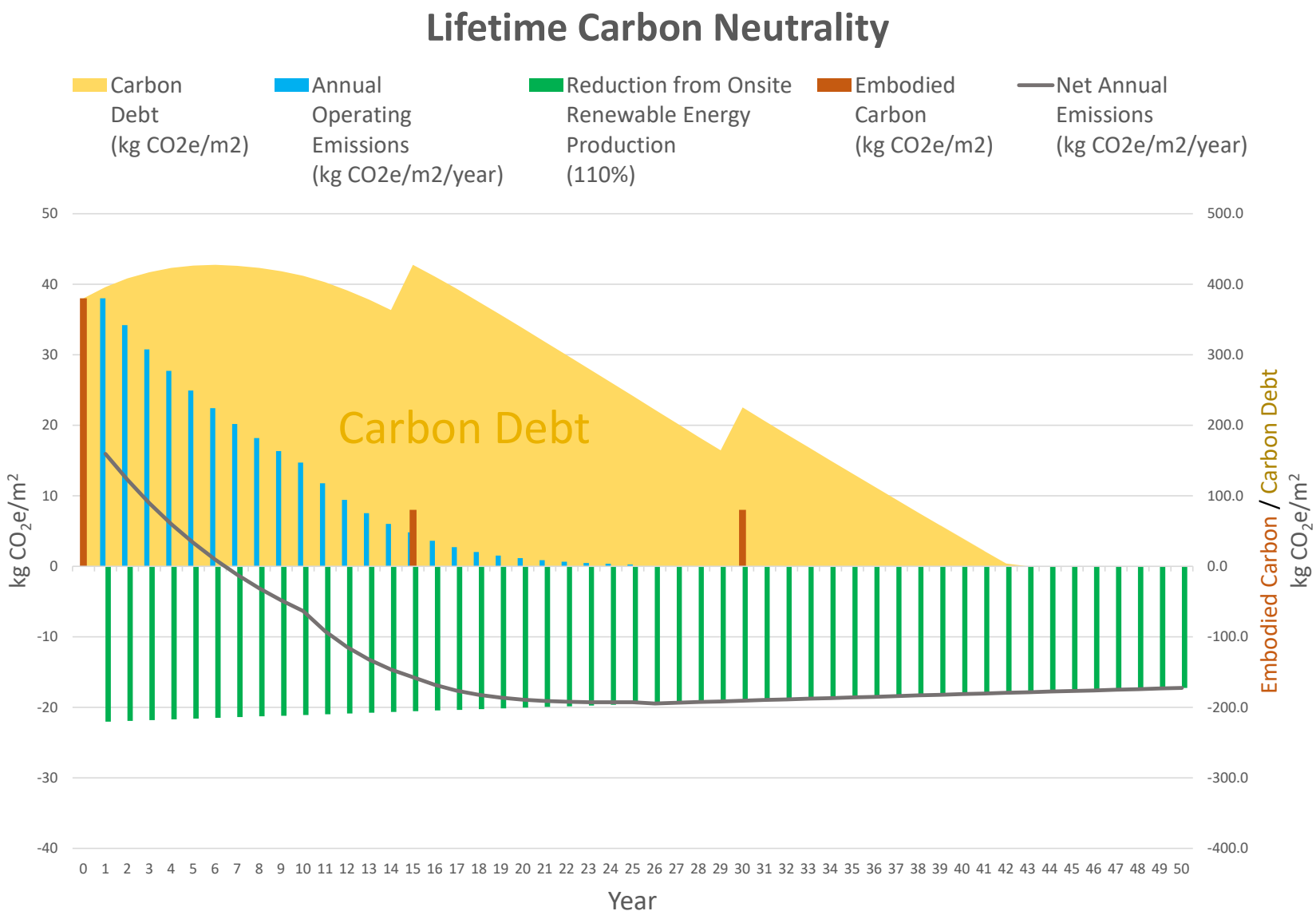
Source: Architecture 2030 (https://architecture2030.org/new-buildings-embodied/), using data from the U.N. Environment Global Status Report 2017: EIA International Energy Outlook 2017


Zero Net Energy Paradigm
Carbon Debt (kg CO2e/m2)
Annual Operating Emissions (kg CO2e/m2/year)
Reduction from Onsite Renewable Energy Production (100%)
Embodied Carbon (kg CO2e/m2)
Net Annual Emissions (kg CO2e/m2/year)
Carbon Debt
kg CO2e/m2
Embodied Carbon / Carbon Debt kg CO2e/m2
Year
60
50
40
30
20
10
0
-10
-20
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

Zero Net Carbon (ZNC) Paradigm

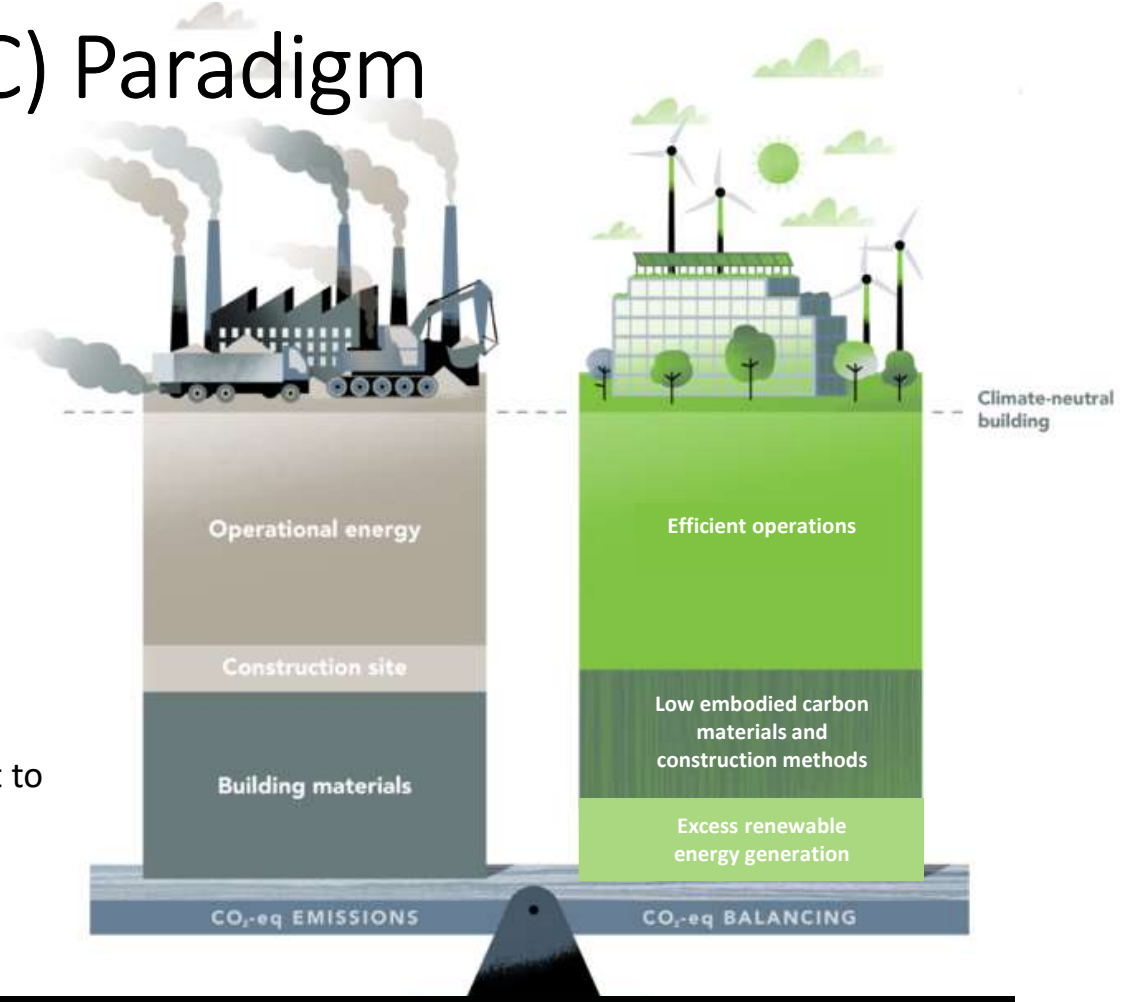
- Beyond ZNE
  - Overproduction of renewable energy (relative to ZNE)
  - Sufficient to pay back the **embodied carbon debt**




Lifetime Carbon Neutrality
Carbon Debt (kg CO2e/m2)
Annual Operating Emissions (kg CO2e/m2/year)
Reduction from Onsite Renewable Energy Production (110%)
Embodied Carbon (kg CO2e/m2)
Net Annual Emissions (kg CO2e/m2/year)
Carbon Debt
kg CO2e/m2
Embodied Carbon / Carbon Debt kg CO2e/m2
Year
50
40
30
20
10
0
-10
-20
-30
-40
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
-400.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

Zero Net Carbon (ZNC) Paradigm

- All-electric buildings
- Grid responsive design
- Low embodied carbon construction
  - Materials and construction methods
- Beyond ZNE
  - Overproduction of renewable energy sufficient to pay back the *embodied carbon debt*



The Only Realistic Path to Carbon Neutrality

How does ZNC Play Out in Multifamily Housing Projects?

Real-life Examples from California-based Project Experiences

Katie Ackerly
David Baker Architects
katieackerly@dbarchitect.com

THE BUILDING DECARBONIZATION PRACTICE GUIDE

A Zero Carbon Future for the Built Environment

Available for free download at https://www.collaborativedesign.org/get-the-guide-bdpg

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