Carbon Reduction through Building Electrification – Part 1: All-Electric Design and Construction Series

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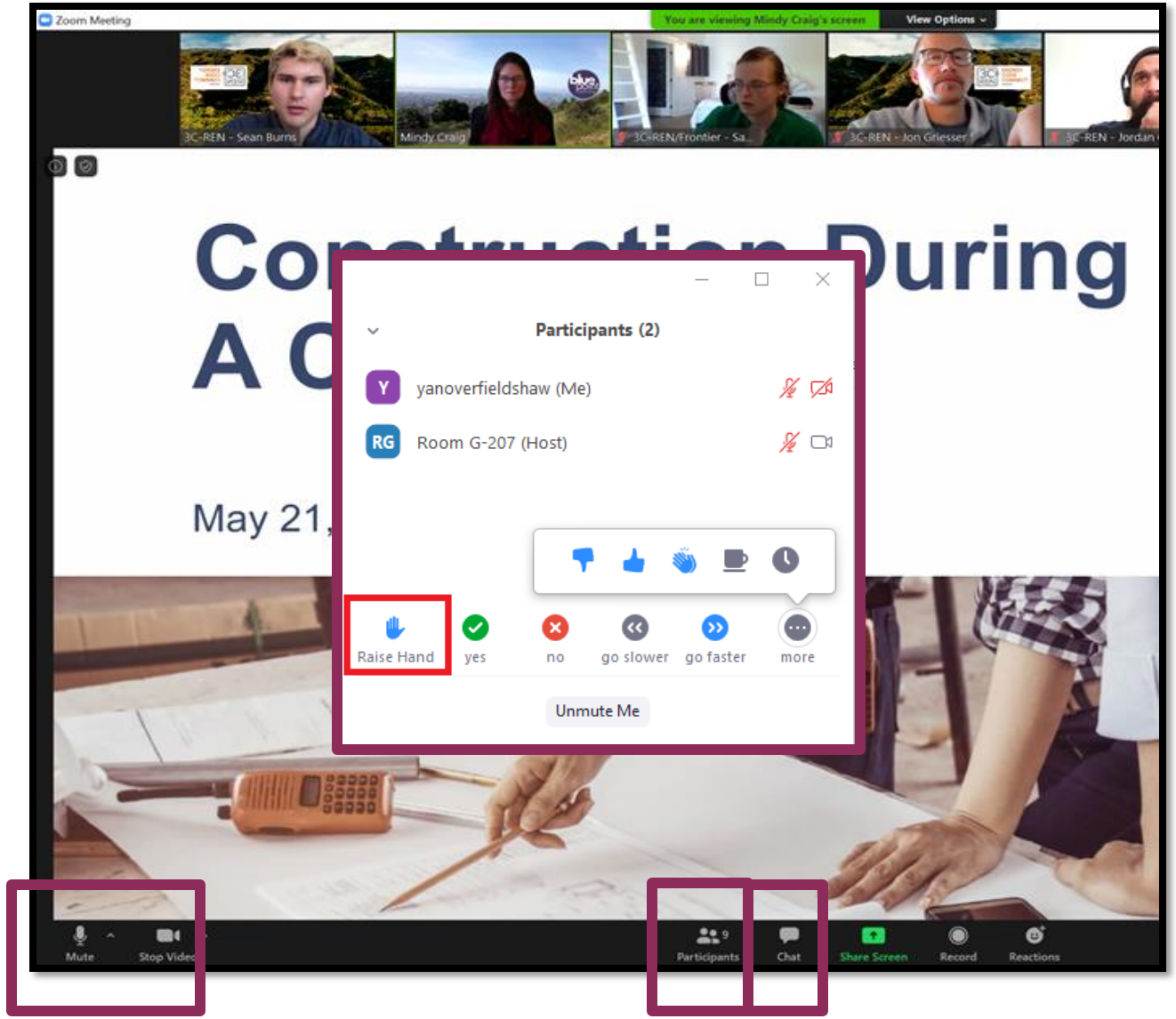
December 19, 2024

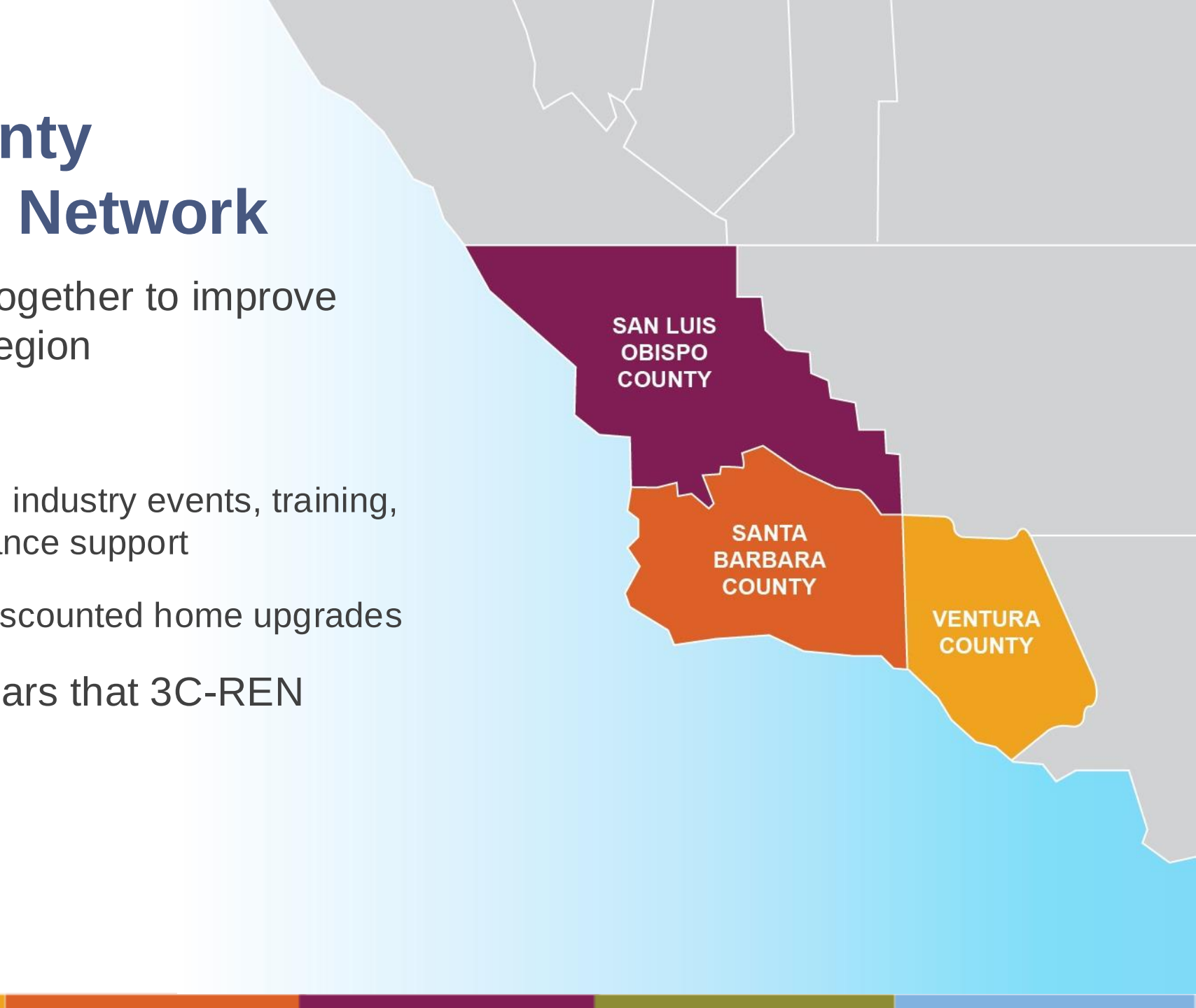
Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



3C-REN Programs

- Energy Code Connect (ECC)
  - Industry Trainings and Regional Forums
  - Energy Code Coach: Title 24 Compliance Support Hotline (805) 220-9991
- Building Performance Training (BPT)
  - Industry Trainings & Certification for current and perspective building professionals
  - Helps workers thrive in an evolving industry
- Home Energy Savings (HES)
  - Flexible Home Energy Upgrades
  - Multifamily (5+ units) & Single Family (up to 4 units)

California Licensure & AIA Learning Units

- Beginning in 2023 Licensed Architects are required by the State of California to take five (5) hours of Continuing Education (CE) coursework in Zero Net Carbon Design (ZNCD).
- This course is designed to count towards CA's ZNCD requirement **as well as** AIA's Health, Safety, Welfare (HSW) Learning Units.
- The whole series provides **5 AIA HSW / CA ZNCD** Learning Units
- For more information see https://www.cab.ca.gov/docs/misc/ab1010_zncdce_faq.pdf

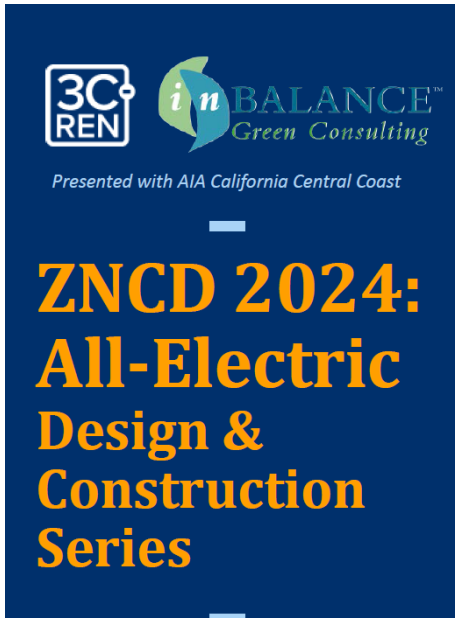
CALIFORNIA ARCHITECTS BOARD

AIA

inBALANCE™ Green Consulting

3C REN

Series Outline



1. Overview: Carbon Reduction through Building Electrification
2. ZNCD for Heat Pumps for heating and cooling
3. ZNCD for Domestic Hot Water
4. ZNCD for Ventilation and HRV
5. ZNCD for Appliances & Energy Storage

inBALANCE Green Consulting

3C REN

Today's Learning Objectives

- Learn the 'why' behind California's shift to building electrification and the link to Zero Net Carbon Design
- Learn the pros and cons of various products to help in selecting appropriate systems that meet electrification and carbon-reduction goals
- Learn critical installation details such as dimensions and venting to call out in plans and/or identify early in construction
- Understand the local market for specific all-electric/ZNCD equipment, including cost, availability and lead times.

Learning Units:

- 1.0 AIA HSW LU approved for this course

We'll send you the slides later!

Agenda

1. California’s Clean Energy Goals
2. ZNCD and the Electric Grid
3. ZNCD and Transportation
4. ZNCD Buildings

ZNCD and California's Clean Energy Goals

California Air Resources Board (CARB) - Mary D. Nichols Campus

Vocabulary Review

- ZNCD –Zero Net Carbon Design
- Operational Carbon

  CO_2e emissions related to building energy use
- Embodied Carbon

  CO_2e emissions related to building materials and construction
- Global Warming Potential (GWP)
  - Metric Using Carbon Dioxide Equivalent (CO_2e) as Baseline of 1
  - Common Metric for Refrigerants
- Decarbonization

  Elimination of CO_2e emissions as a method of mitigating climate change
- Fossil Fuels

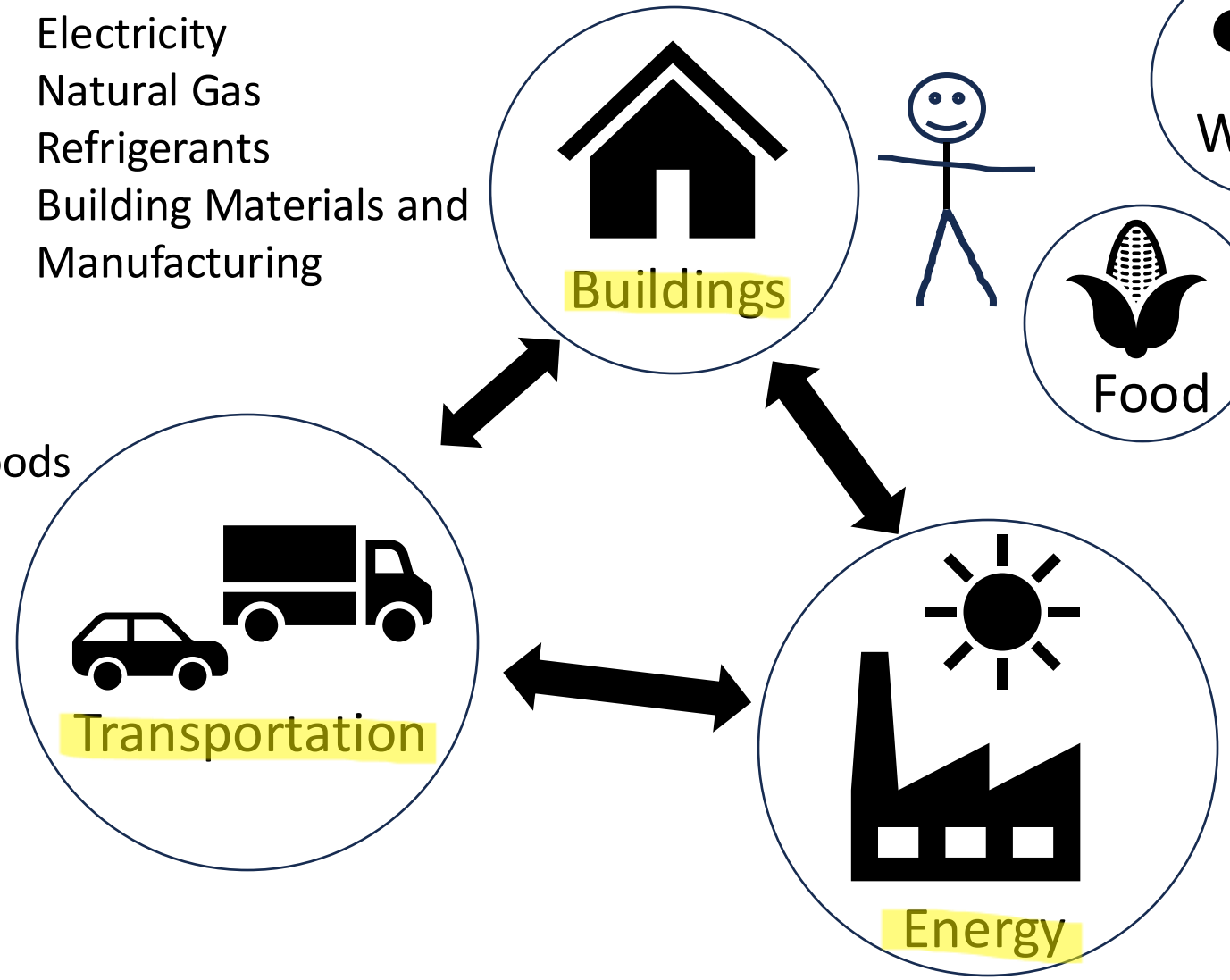
  Oil, Gasoline, Diesel, Natural Gas, Propane, etc.
- 'Non-Combustion' or High-GWP
  - Methane
  - Refrigerants
- Green House Gases (GHG):
  - CO_2 – Carbon Dioxide
  - CH_4 – Methane
  - N_2O – Nitrous Oxide
  - HFCs – Hydrofluorocarbons
  - PFCs – Perfluorocarbons
  - SF_6 – Sulfur Hexafluoride
  - NF_3 – Nitrogen Trifluoride
- Clean Energy / Electricity

  Energy Produced without Emissions
- Clean Fuel

  Hydrogen (H_2) Fuel Cells
- NOAA – National Oceanic and Atmospheric Administration
- DOE – Department of Energy
- EIA – Energy Information Administration
- CARB – California Air Resources Board
- CEC – California Energy Commission
- CAISO –California Independent Systems Operator

People, Buildings and Everything

Operational and Embodied Impacts
- Electricity
- Natural Gas
- Refrigerants
- Building Materials and Manufacturing



Water Energy Nexus
- Pumping
- Cleaning

Agriculture and Forestry
- Harvesting
- Processing
- Transporting

People and Goods
- Personal Vehicles
- Trucking
- Shipping

All Energy Types
- Gas, Diesel
- Natural Gas
- Nuclear
- Solar & Wind
- Hydroelectric

The Source of Our Energy Impacts Climate Change

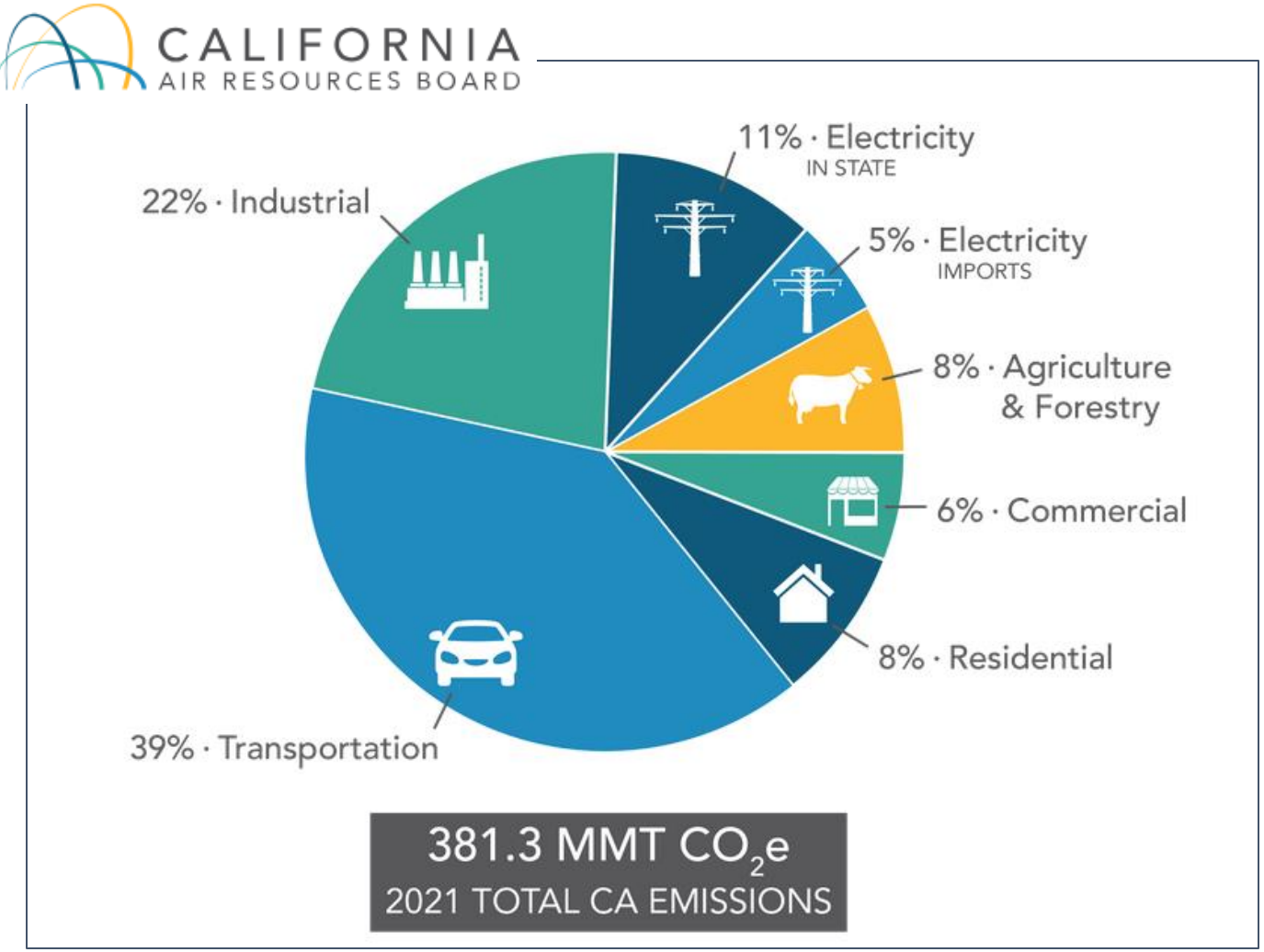
- Burning of Fossil Fuels is the Main Driver of CO2 Emissions
- CO2 Emissions is the largest contributor to Climate Change

Burning of Fossil Fuels is used for

- Transportation
- Industrial Processes
- Electricity Generation
- Equipment for Agriculture & Forestry
- Space Heating – Commercial and Residential
- Water Heating – Commercial and Residential

https://www.noaa.gov/news-release/greenhouse-gases-continued-to-increase-rapidly-in-2022

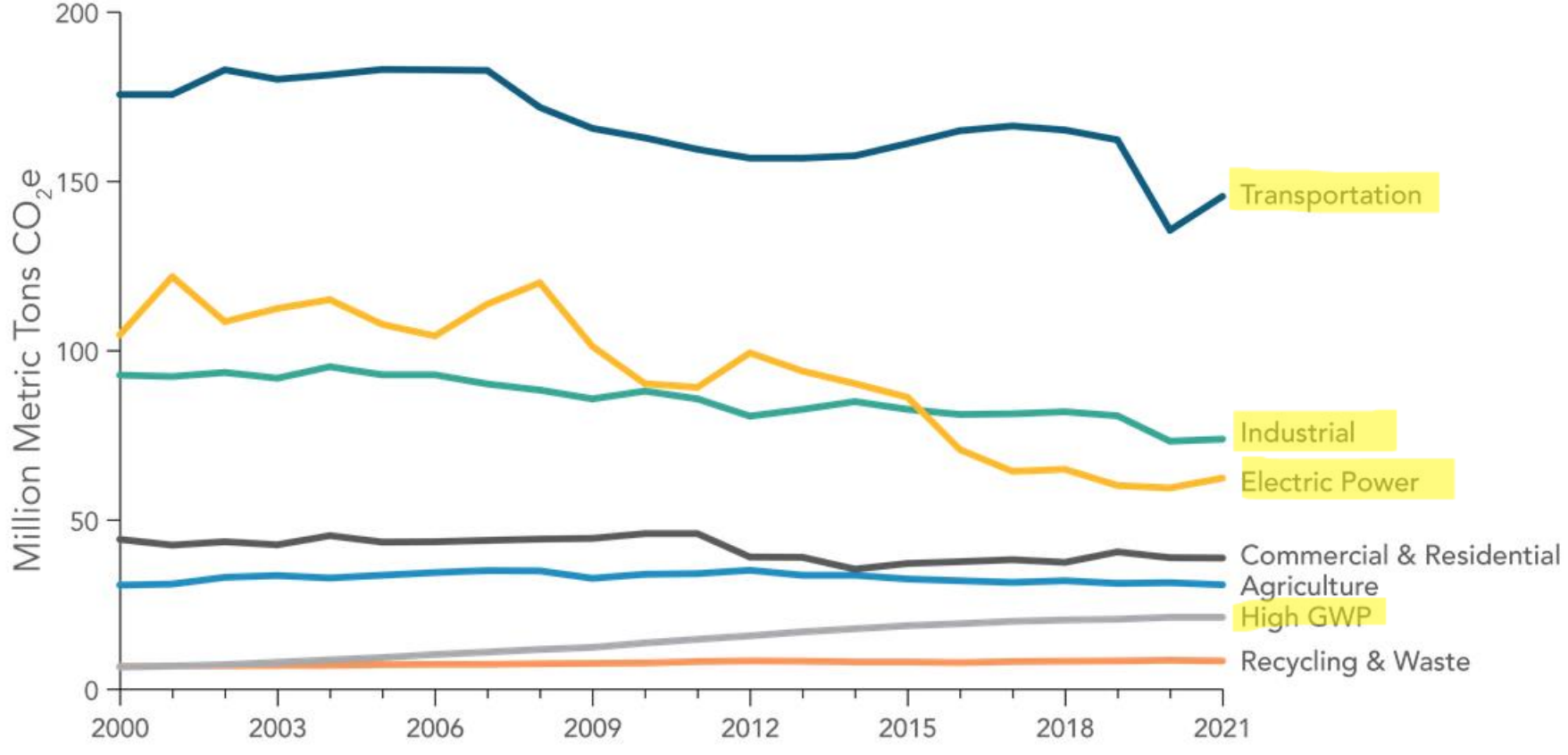
California GHG Emissions by Main Economic Sector



https://ww2.arb.ca.gov/ghg-inventory-data

- California has identified the primary sectors responsible for the majority of GHG Emissions
- Transportation is at the top

California GHG Emissions Trends

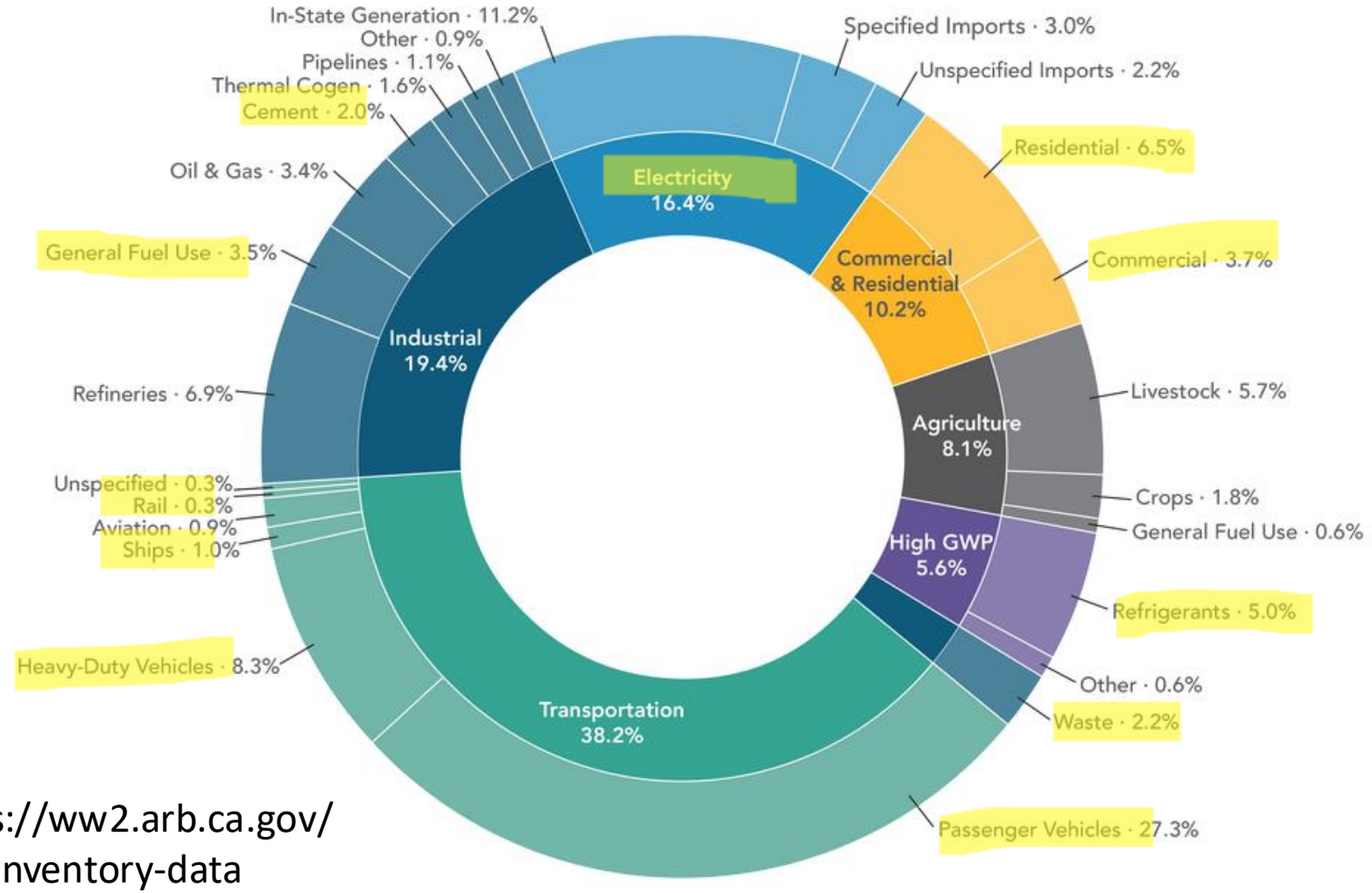


2000–2021 GHG Emissions by Category as Defined in the Scoping Plan

https://ww2.arb.ca.gov/ghg-inventory-data

- Transportation, Industrial, and Electric Power GHG Emissions have decreased even as California's population grow.
- High GWP (refrigerants) increased during the same time period.

Buildings and Construction GHG Emissions Cut Across Sectors



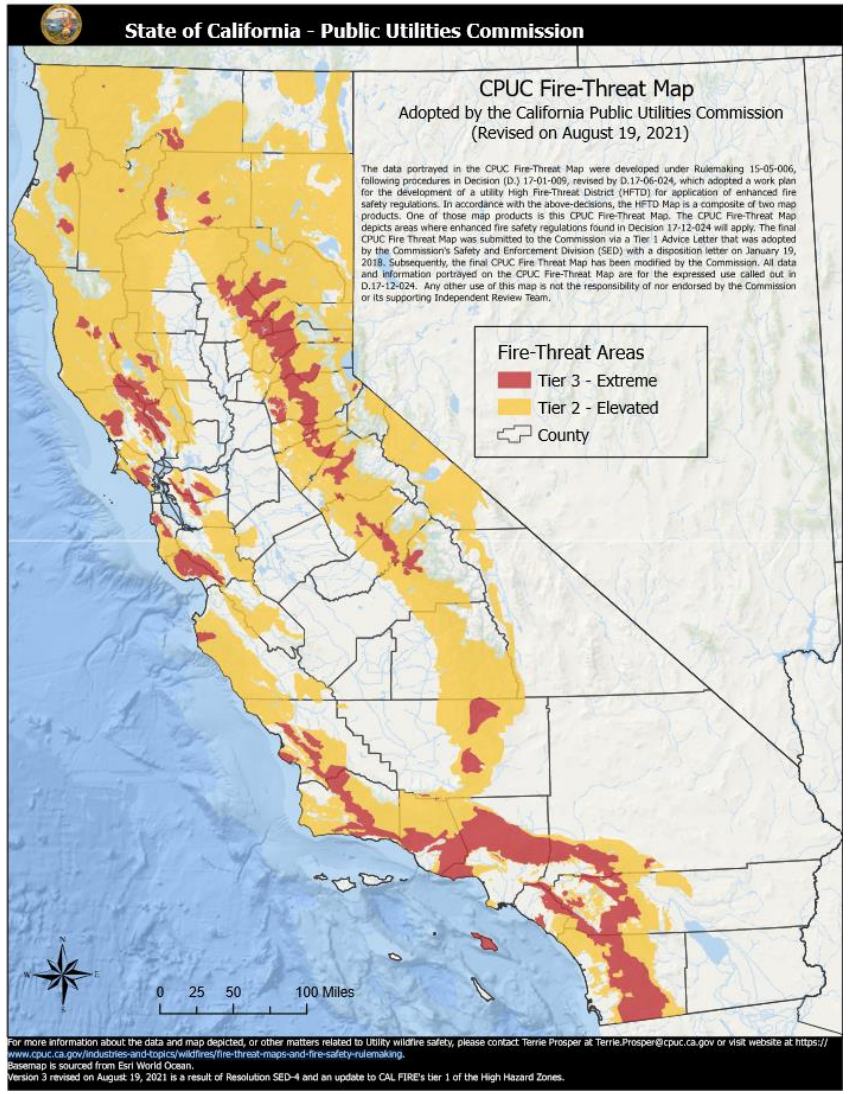
https://ww2.arb.ca.gov/ghg-inventory-data

- *'Buildings and Construction'* account for approx 25% of GHG Emissions in California
- The impact is likely much larger due to the emissions of materials manufactured out of state
- Project 2030 estimates Buildings account for 42% of global GHG emissions

ZNCD and The Electric Grid

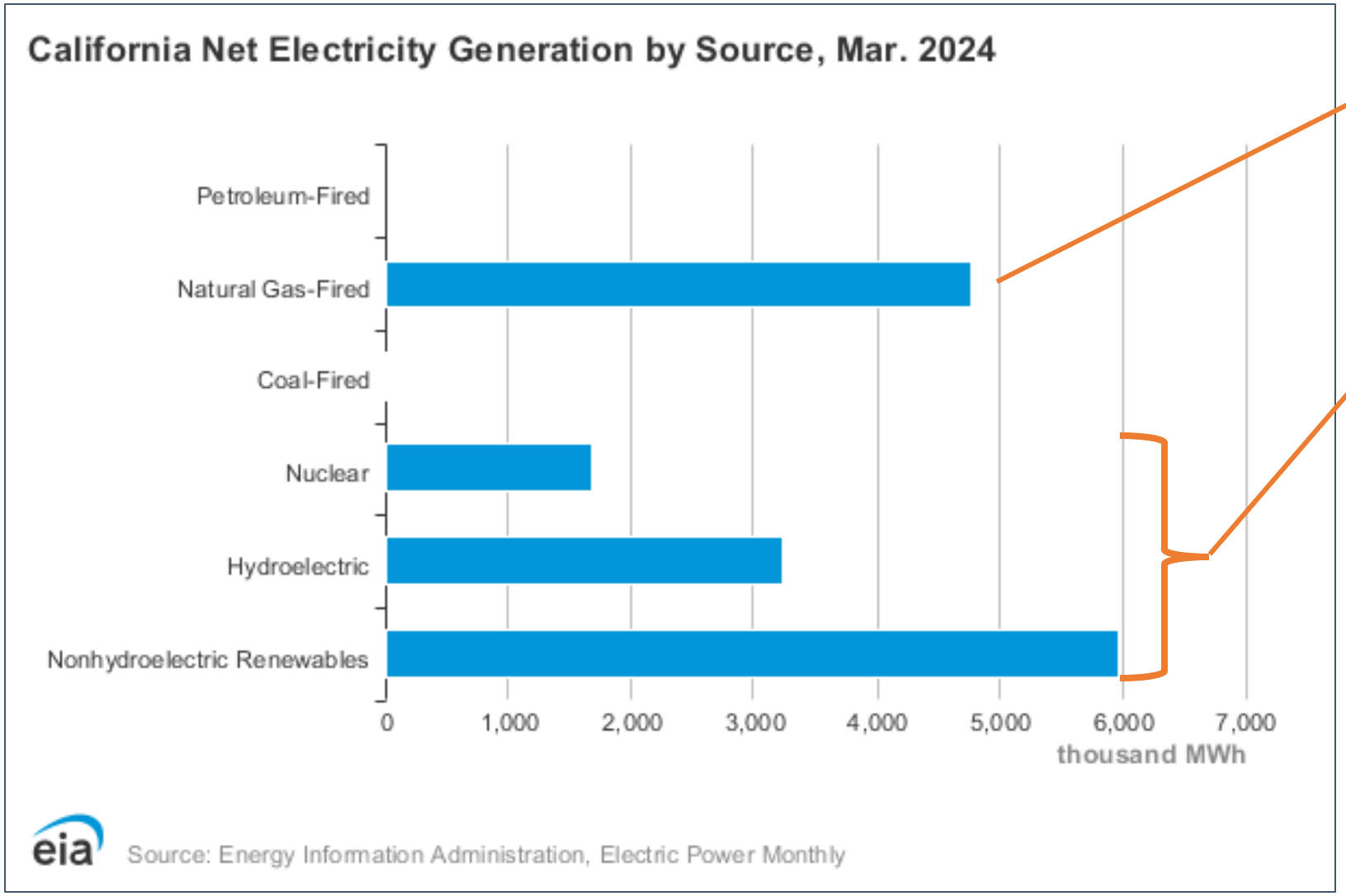
Key Concepts for ZNCD and our Electric Grid

- **Reliability** – is the power distribution and transmission steady and continuous
- **Adequacy** – do we have enough resource capacity to meet demand
- **Resiliency** – can we safely and efficiently power down and power off during Public Safety Power Shutoffs (PSPS) to prevent wild fire
- **Climate Action Goals** – can we *quickly* implement zero-net-carbon electricity production



https://www.cpuc.ca.gov/industries-and-topics/wildfires

California's Electricity Generation is Becoming Cleaner

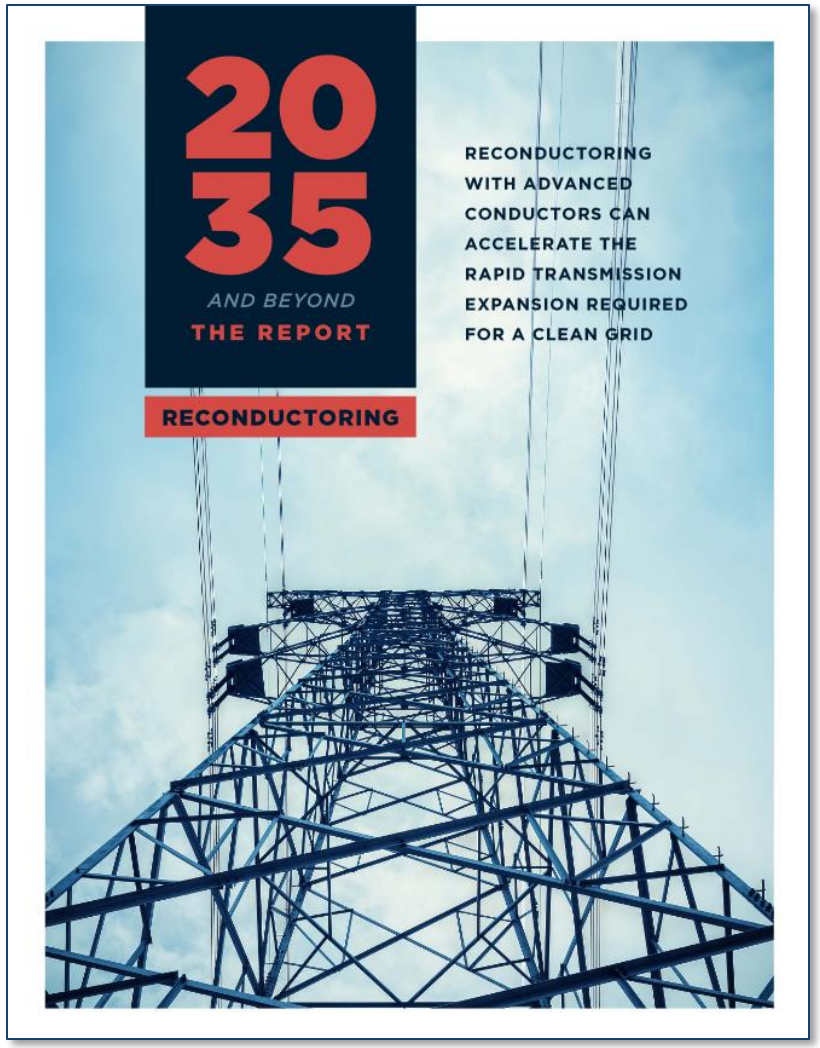


- Natural gas-fired fuel accounted for 31% of California's electricity generation
- Approx 69% came from non-fossil fuel sources
- Nonhydroelectric Renewables (mostly wind and solar) provided approx 38% of the total mix

https://www.eia.gov/state/?sid=CA#tabs-4

Strategies for Meeting the Increase in Energy Demand

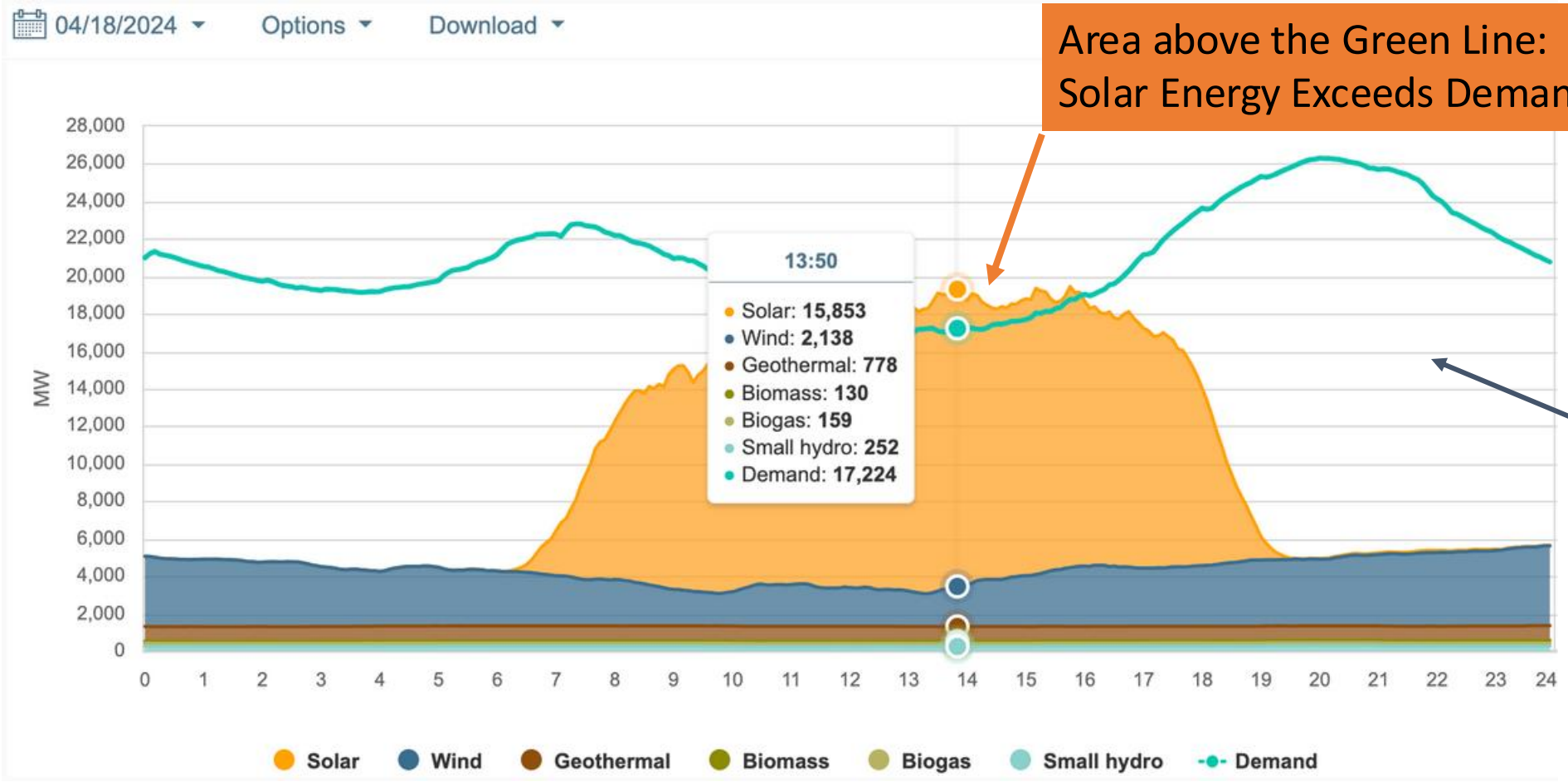
- Upgrades to the Grid – Improved wire types and transformers
- Energy Storage Expansion – Short Duration and Long Term
- Energy Resource Diversification
- Natural Gas Substitutions – Hydrogen and Biomethane



This study specifically addresses upgrading the electric grid with new 'advanced' conductors without the need to build new lines in California.

https://www.2035report.com/wp-content/uploads/2024/04/GridLab_2035-Reconductoring-Technical-Report.pdf

Solar Energy Exceeds Demand for Part of the Day



Area above the Green Line:
Solar Energy Exceeds Demand

White Areas:
Demand is Met by
Non-Renewables

https://www.gov.ca.gov/2024/04/19/californias-grid-keeps-setting-new-clean-energy-records/

Present Situation: When Solar Cannot Meet Demand, NG Peaker Plants Kick-in

- NG ‘Peaker’ Plants Provide Rapid Response Electricity
- Peaker plants help meet peak electricity demand, typically during 4 pm-9 pm.
- NG peaker plants provide energy when solar energy cannot meet demand

As we transition to a Clean Energy Grid, other technologies will be implemented to replace the heavy reliance on NG Peaker Plants.

KING CITY PEAKING ENERGY CENTER

The King City Peaking Energy Center is a “peaker” facility located in King City, California.

https://www.calpine.com/King-City-Peaking-Energy-Center

Alternative to Peaker Plants… Solar with Battery Storage

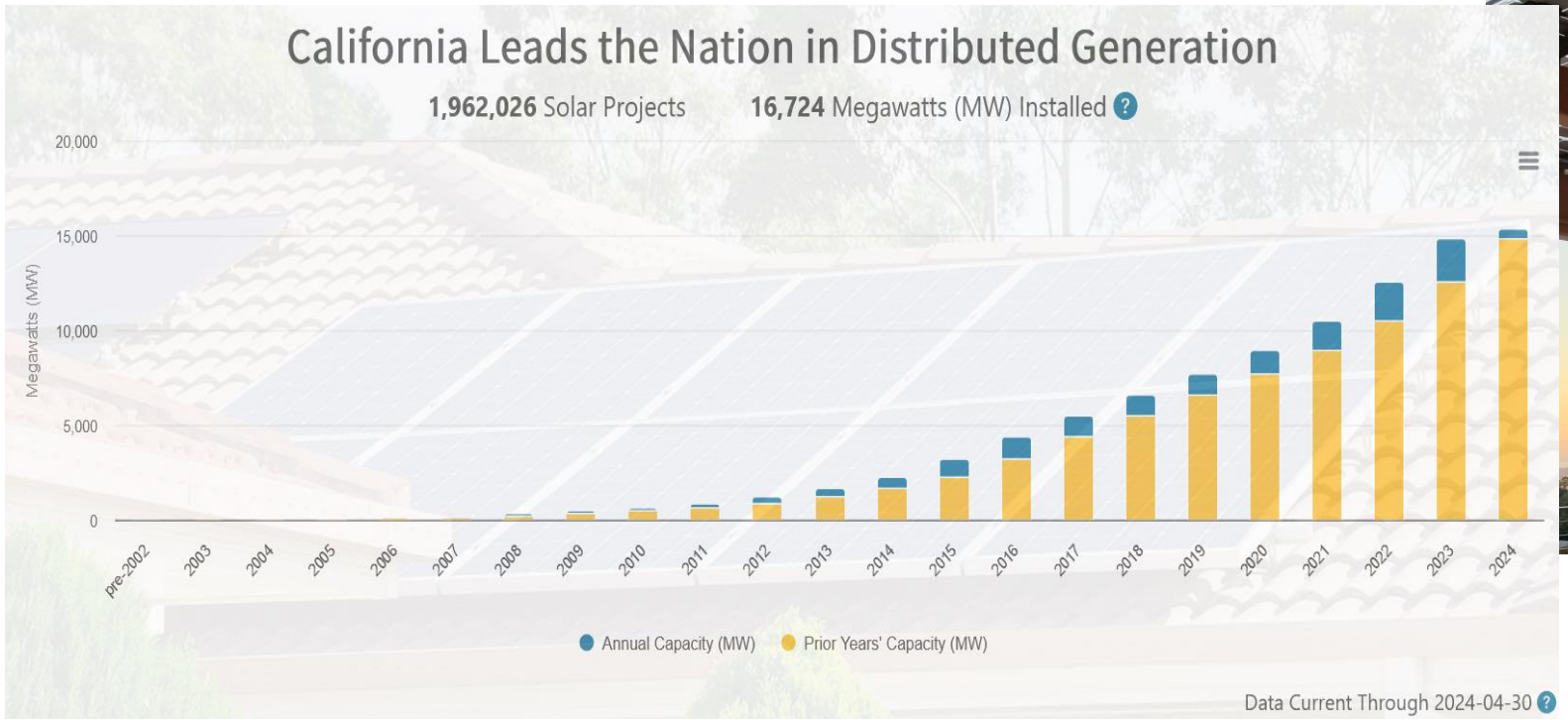
- Located in California –Largest single Solar plus Battery Storge facility in the US.
- Collaborative project with Edwards Air-Force Base.
- Projected Completed Jan 2024.

Edwards & Sanborn Solar and Energy Storage, Kern County, CA

https://www.mortenson.com/projects/edwards-sanborn-solar-plus-storage

California Continues to Add Distributed and Grid Scale Solar

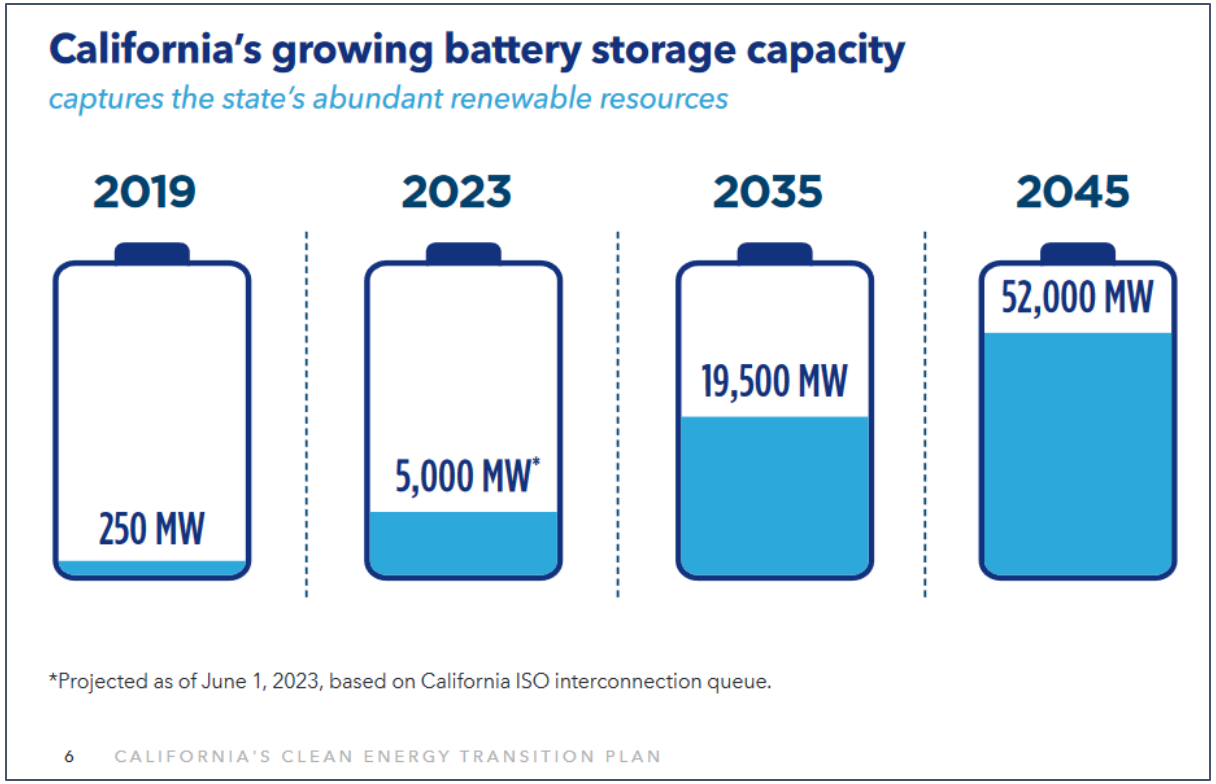
Cumulative growth in on-site (distributed) generation



https://www.californiadgstats.ca.gov/

Solar and Battery Storage –Rapid Expansion Predicted

Excerpts from California's Clean Energy Transition Plan for 2045:



https://www.gov.ca.gov/wp-content/uploads/2023/05/CAEnergyTransitionPlan.pdf

Other Infrastructure – Natural Gas and Hydrogen Blending

- Mar 1, 2024 SoCalGas, SDG&E, Southwest Gas, and PG&E submitted joint proposal to California Public Utilities Commission (CPUC) for hydrogen blending projects
- SoGalGas has shown successful pilot research at UC Irvine (2016);‘Real World’ Testing needed
- Effort to reduce carbon in the existing NG infrastructure
- Hydrogen would be created with excess solar energy that otherwise would be curtailed

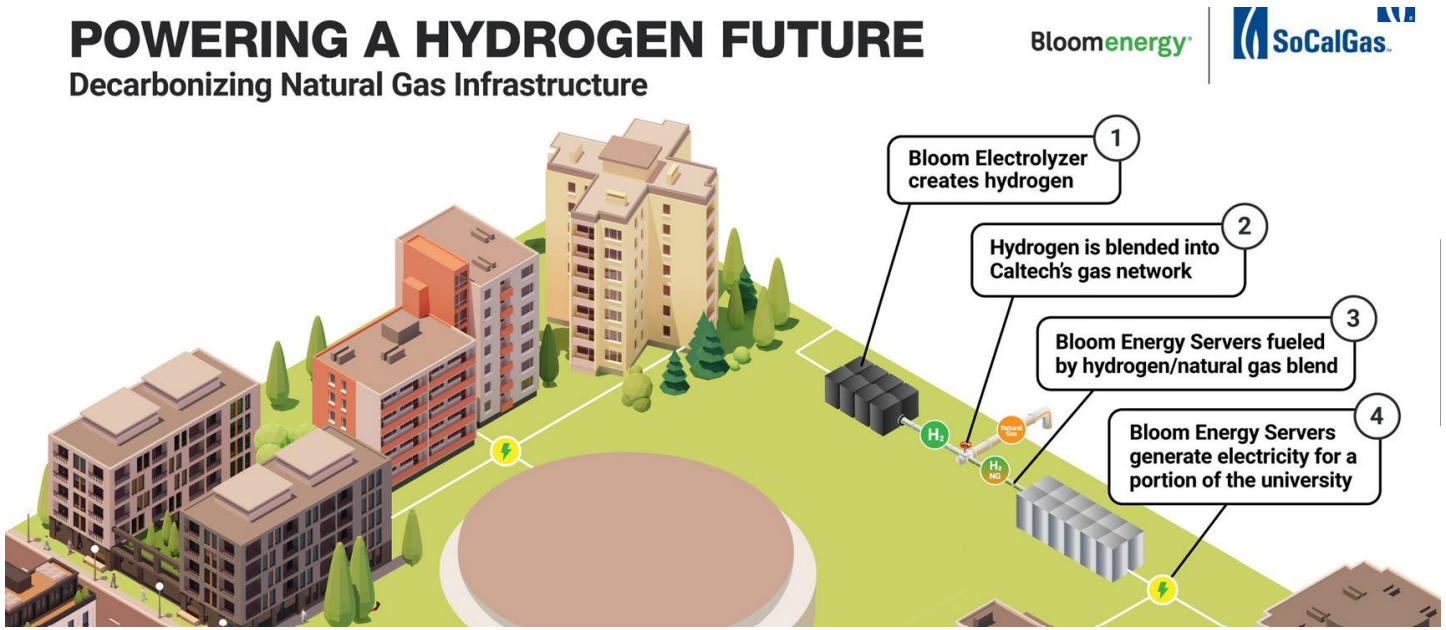


Image from SoCalGas Newsroom: 2021 Demonstration Project Proposal with CalTech, Pasadena.

H2 Fuel Cells –Marine Vessels and Trucking Vehicles

Zero Emissions Industry (ZEI):

- Received a $3 million grant from the California Air Resources Board (CARB)
- Built the first hydrogen fuel cell passenger ferry in the United States
- Proved that zero-emission hydrogen fuel cell technology works for commercial marine vessels
- The Sea Change utilizes 360kw of H2 Fuel Cells and 100 kWh Li-Ion batteries

https://zeroei.com/sea-change

AP SCIENCE

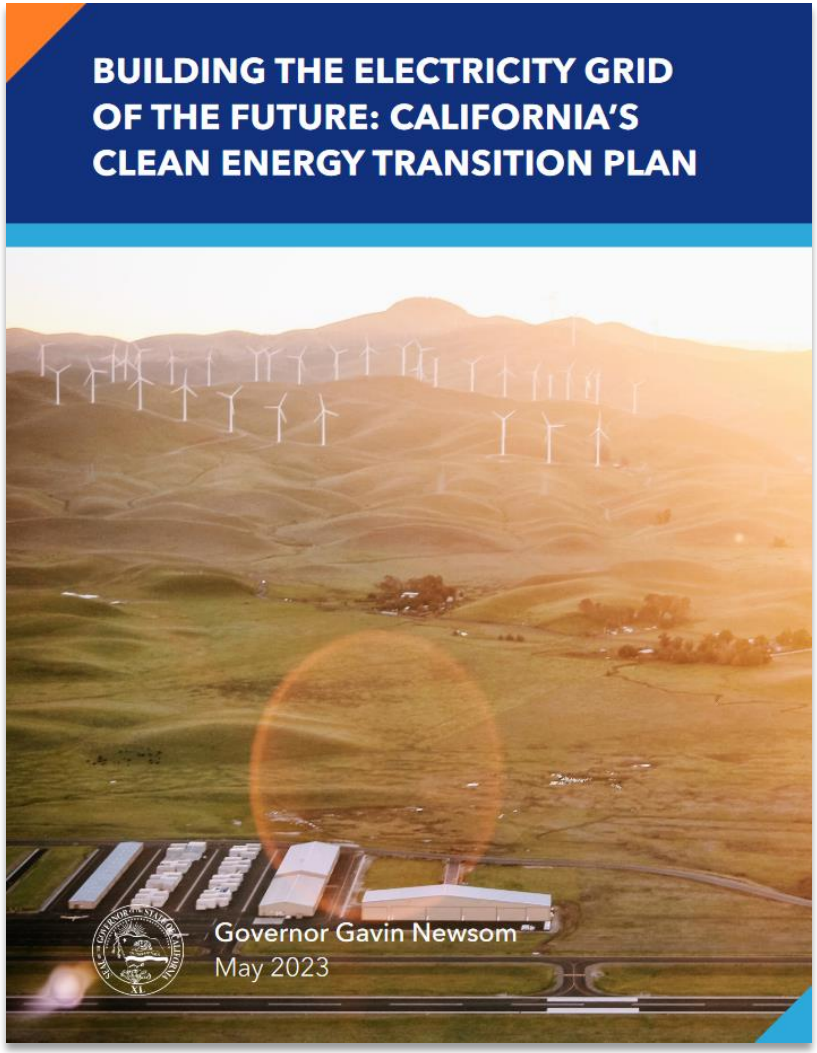
World's first hydrogen-powered commercial ferry to run on San Francisco Bay, and it's free to ride

by: TERRY CHEA, Associated Press
Posted: Jul 12, 2024 / 11:21 PM EDT
Updated: Jul 12, 2024 / 11:23 PM EDT

California's Plan for Grid Stability and Expansion

A carbon-free electric grid where:

- **Buildings** are increasingly decarbonized.
- **The Industrial Sector** is powered by clean electricity, and by clean fuels, such as green hydrogen.
- **Transportation** choices are zero-emission and able to plug into the electric grid at places of convenience for all customers



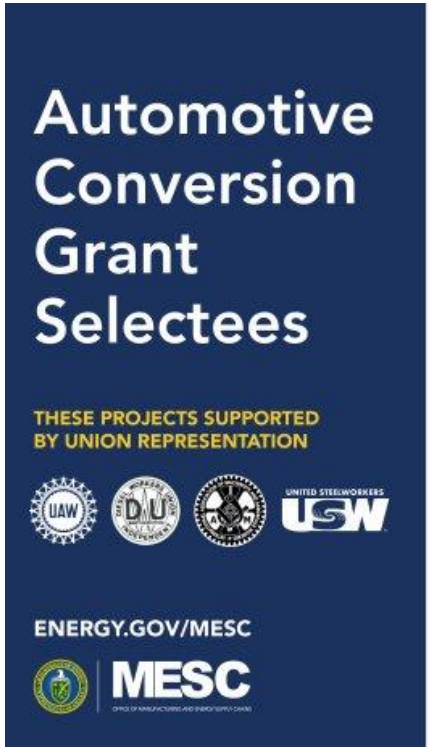
https://www.gov.ca.gov/wp-content/uploads/2023/05/CAEnergyTransitionPlan.pdf

ZNCD and Transportation

US Funds $1.7B for Electric Vehicle Manufacturing

DOE, Office of Manufacturing and Energy Supply Chains:

- $1.7 billion from the Inflation Reduction Act (IRA)
- Eleven (11) facilities will be converted to manufacture electric vehicles and their supply chain.
- Facility Locations:
  - Michigan
  - Ohio
  - Pennsylvania
  - Georgia
  - Illinois
  - Indiana
  - Maryland
  - Virginia



https://www.energy.gov/mesc

Transportation Electrification in California

- Electric Vehicles – Fastest Growing Electrification Sector
- 7.5 million EV's are expected on the road by 2030
- Approx 1.2 million Public Charges will be needed
- Bi-directional EV Charging may be part of the Energy Storage /Grid Stability Solution

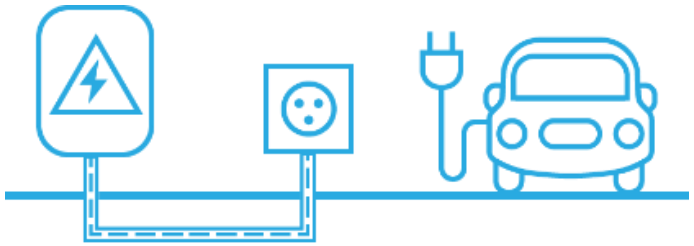
Electric Vehicle Charging in CALGreen

- EV Readiness Definitions
- Single Family
- Multi Family
- Non-Res
- Medium- & Heavy-Duty Charging
- Additions/Alterations

EV Readiness – 3 Types

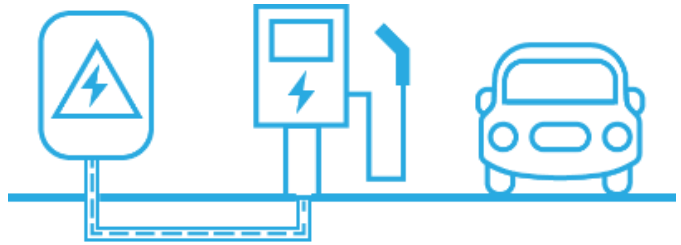
EV CAPABLE

Provide electrical panel space, conduit (no wire), and a termination box for a future 208/240--volt, 40-amp circuit



EV READY

Provide a space that is fully wired for 208/240 volt and has a receptacle, and is “ready” for a Level 2 Charger



EV CHARGING STATION

Provide Level 2 EVSE chargers. These should be stand-alone chargers in common-use parking areas

Types of Chargers

Level 1

120-volt, 16-amp commercial cable

Level 2

208/240-volt, 40-amp receptacle, or charge station

This is what is required of EVCS

Level 3 & DCFC

(Direct current Fast Charger)

480-volt, 80-amp charging station

Allowed but not required by code

Electric Vehicle Charging- New Single Family

- One- and two-family dwellings, townhouses with attached private garages
- Requires EV Capable
- Exception: Not required for ADUs/JADUs

4.106.4.1

EV Charging - Multifamily & Hotel/Motels

Mid-2024 WAS:

- ~~EV Capable~~
  - ~~10% of total spaces~~
- ~~EV Ready~~
  - ~~25% of total spaces~~

As of July 1, 2024:

- 40% low power Level 2 EV charging receptacles!
- 10% Level 2 EV chargers

4.106.4.2 / 4.106.4.3

Electric Vehicle Charging - Non-Res

TABLE 5.106.5.3.1

TOTAL NUMBER OF ACTUAL PARKING SPACES	NUMBER OF REQUIRED EV CAPABLE SPACES	NUMBER OF EVCS (EV CAPABLE SPACES PROVIDED WITH EVSE)[2, 3]
0–9	0	0
10–25	4	0
26–50	8	2
51–75	13	3
76–100	17	4
101–150	25	6
151–200	35	9
201 and over	20 percent of actual parking spaces[1]	25 percent of EV capable spaces[1]

1. Calculation for spaces shall be rounded up to the nearest whole number.
2. The number of required EVCS (EV capable spaces provided with EVSE) in column 3 count toward the total number of required EV capable spaces shown in column 2.
3. At least one Level 2 EVSE shall be provided.

Based off this table

- Note that the EVCS count towards the total number of EV Capable Spaces

Example:

If a project has 28 parking spaces, 8 total EV spaces are required. 2 are EVCS and other 6 are EV Capable

5.106.5.3

Alternative Approaches to EVCS

DC Fast Charger = 5 Level 2

Low-Power Level 2 =

½ regular Level 2

PARKING SPACES	6.6 kVA	LOW POWER LEVEL 2, LEVEL 2, OR DCFC
0–9	0	0
10–25	26.4	26.4
26–50	52.8	52.8
51–75	85.8	85.8
76–100	112.2	112.2
101–150	165	165
151–200	231	231
	20 percent of	Total required kVA = P × 20 × 6.6

Power Allocation Method

Medium- and Heavy-Duty Charging – and another thing…

TABLE 5.106.5.5.1
RACEWAY CONDUIT AND PANEL POWER REQUIREMENTS FOR MEDIUM- AND HEAVY-DUTY EVSE [N]

BUILDING TYPE	BUILDING SIZE (SQ. FT.)	NUMBER OF OFF-STREET LOADING SPACES	ADDITIONAL CAPACITY REQUIRED (KVA) FOR RACEWAY & BUSWAY AND TRANSFORMER & PANEL
Grocery	10,000 to 90,000	1 or 2	200
		3 or Greater	400
	Greater than 90,000	1 or Greater	400
Manufacturing Facilities	10,000 to 50,000	1 or 2	200
	10,000 to 50,000	3 or Greater	400
	Greater than 50,000	1 or Greater	400
Office Buildings	10,000 to 135,000	1 or 2	200
	10,000 to 135,000	3 or Greater	400
	Greater than 135,000	1 or Greater	400
Retail	10,000 to 135,000	1 or 2	200
		3 or Greater	400
	Greater than 135,000	1 or Greater	400
Warehouse	20,000 to 256,000	1 or 2	200
		3 or Greater	400
	Greater than 256,000	1 or Greater	400

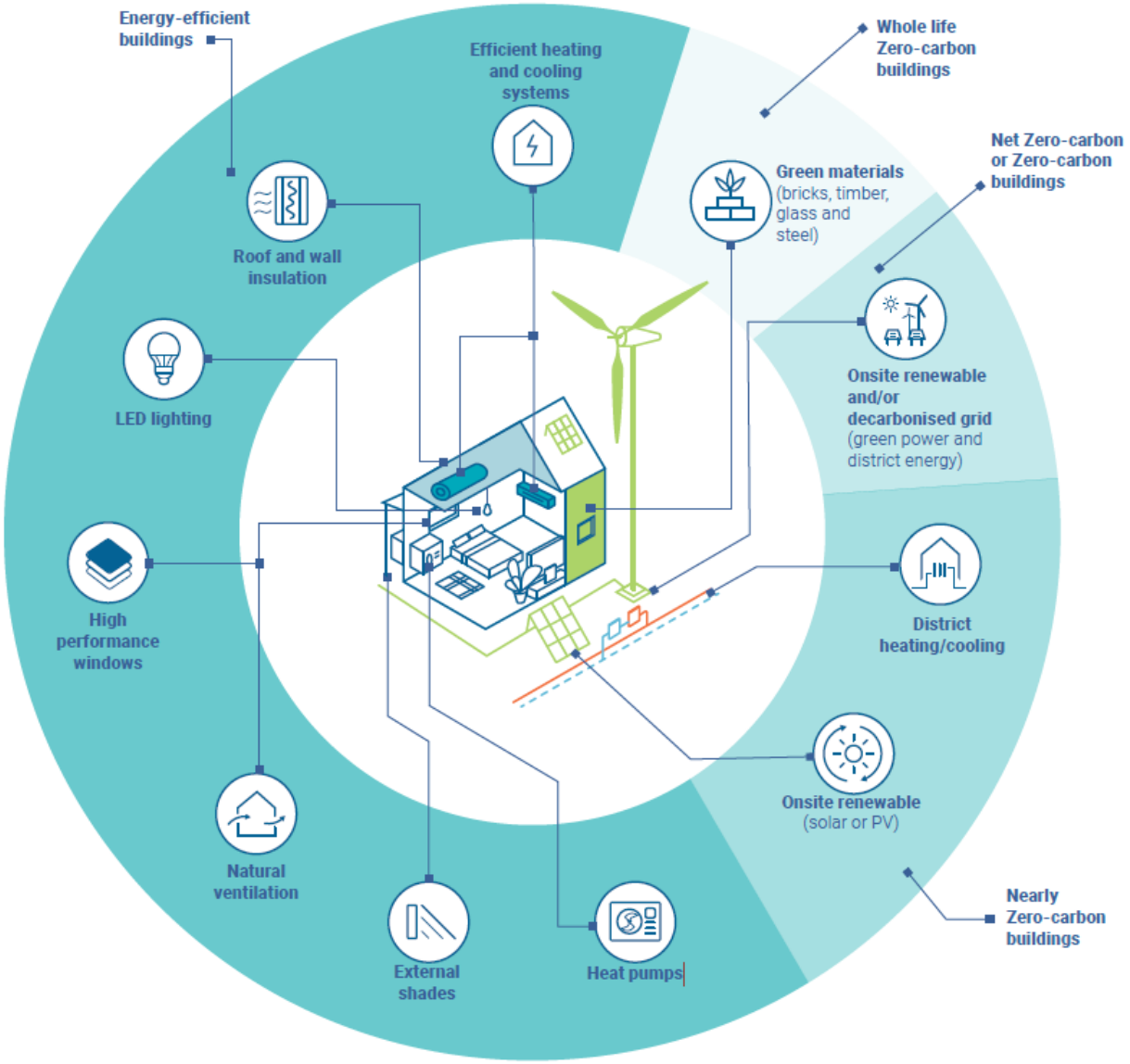
5.106.5.3

ZNCD Buildings

Forest Edge Elementary School, Fitchburg, WI

ZNC Buildings

- Choose materials with low embodied carbon footprint
- Supply Buildings with clean electric energy
  - On-site solar, wind, micro-hydro, etc
  - Decarbonized Grid
- Design Energy Efficient Buildings
- Use heat pumps –with low GWP refrigerants
  - Space Conditioning
  - Water Heating
  - Appliances



Source: UN Environment Programme, "2022 Global Status Report for Buildings and Construction"

Forest Edge Elementary School –ASHRAE Technology Award 2024

Architect: Bray Architects, HGA
Builder: J.H. Findorff & Son

- Largest net zero verified education project in the US
- Project incorporates geothermal heating and cooling, rooftop photovoltaic (500 kW) and 125 kVA battery storage system (expandable to 500 kVA)
    - Eliminates excess demand and provides power to the building during nighttime
    - Excess energy: returned to grid/sold back to electric utility company
- In one year, the solar panel system offsets CO2 emissions equivalent to: electrical usage of 96.4 homes, 1,403,553 miles driven, or 623,249 pounds of coal burned

https://www.msa-ps.com/our-experience/forest-edge-elementary-school/

ILFI Full Living Building Certification –PAE Living Building

Owner: First and Pine LLC
Architect: ZGF Architects
Builder: PAE

- 5-story mixed use project incorporates both air-source and ground-source heat pump systems
- Due to Historical District constraints, a 215 kW PV solar system is located on an affordable housing development a few miles down the road
  - Project donated 60% of the PV system, while retaining the Renewable Energy Credits
- Very low operating EUI: ~16.1 kBtu/sf/yr
- 25% less embodied carbon than a comparable concrete and steel building
  - The carbon footprint of construction was off-set with still purchased carbon credits

https://living-future.org/case-studies/pae-living-building/

ZNE - California Air Resources Board –Leading by Example

Architect: ZGF Architects
Builder: Hensel Phelps

- Largest Zero Net Energy (ZNE) building(402,000 sf) in the United States – producing as much energy as it uses
- 3500 kW Solar System –Estimated to produce 6,235,000 kWh/yr
- Leadership in Energy and Environmental Design (LEED) Platinum certification
- California Green Building Standards Code (CALGreen) Tier 2 standards

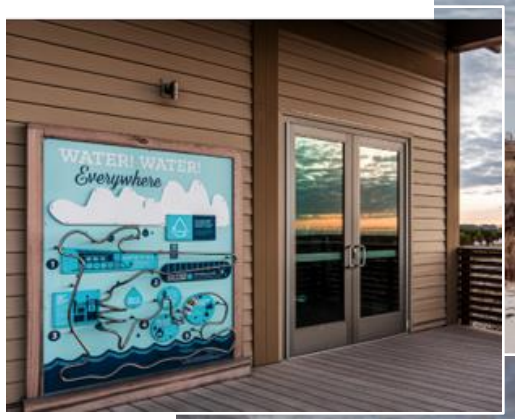
California Air Resources Board (CARB) - Mary D. Nichols Campus, Riverside, CA

https://ww2.arb.ca.gov/

ILFI Living Building –Gulf State Park Interpretive Center

Architect: ArchitectureWorks
Builder: Integral Group

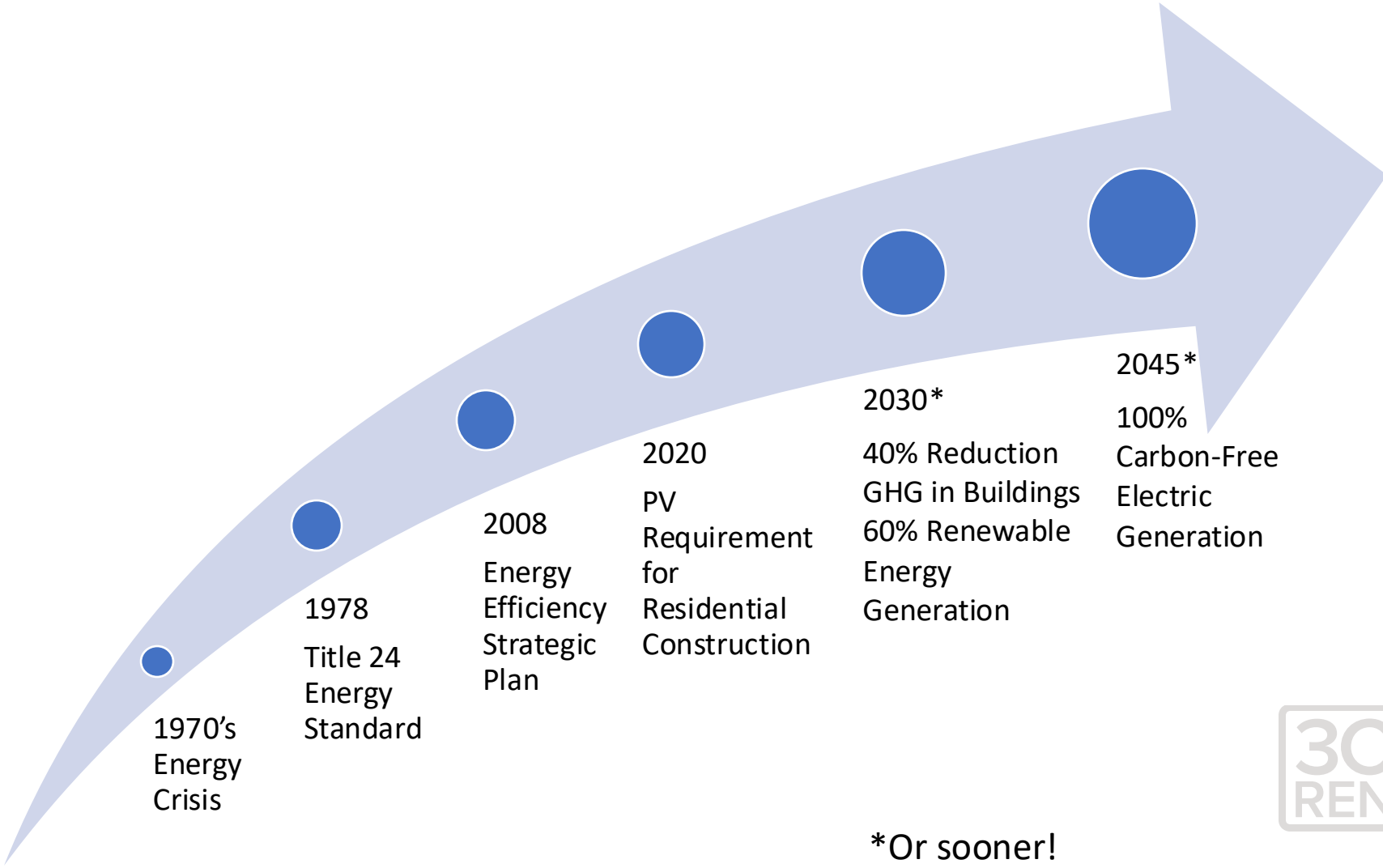
- LEED Certified and engineered to reduce harmful emissions and contribute lowest environmental impact
- ILFI Net Positive Energy – Carbon Positive Building
  - 18.14 kW solar array
  - 13.5 kW battery system
- Saved approx. 41,840 lbs in CO2 emissions since solar panel installation (2018) –Equivalent to 316 trees planted
- Purchased verified Carbon Emission Reductions (CERs) to offset that embodied carbon of construction



https://living-future.org/case-studies/gulf-state-park-interpretive-center/

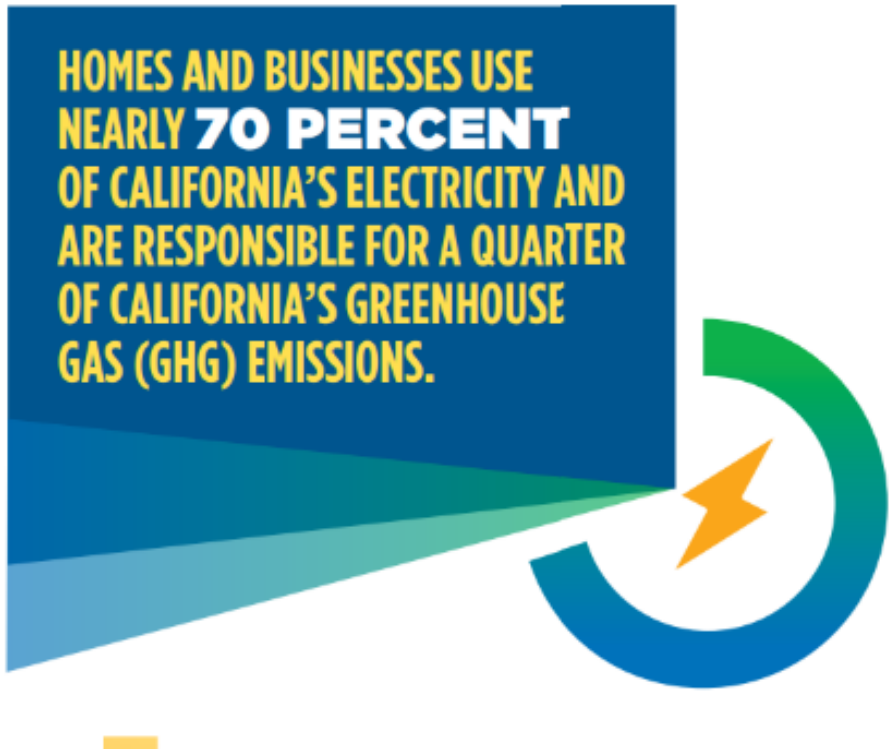
California Buildings: Pathway to Carbon Neutrality

Reminder:
Every 3 yrs, California Title 24 Building Codes are updated, furthering California's Clean Energy and Zero Net Carbon Goals.



*Or sooner!

Big Picture Goals for the 2022 Code (and 2025…)



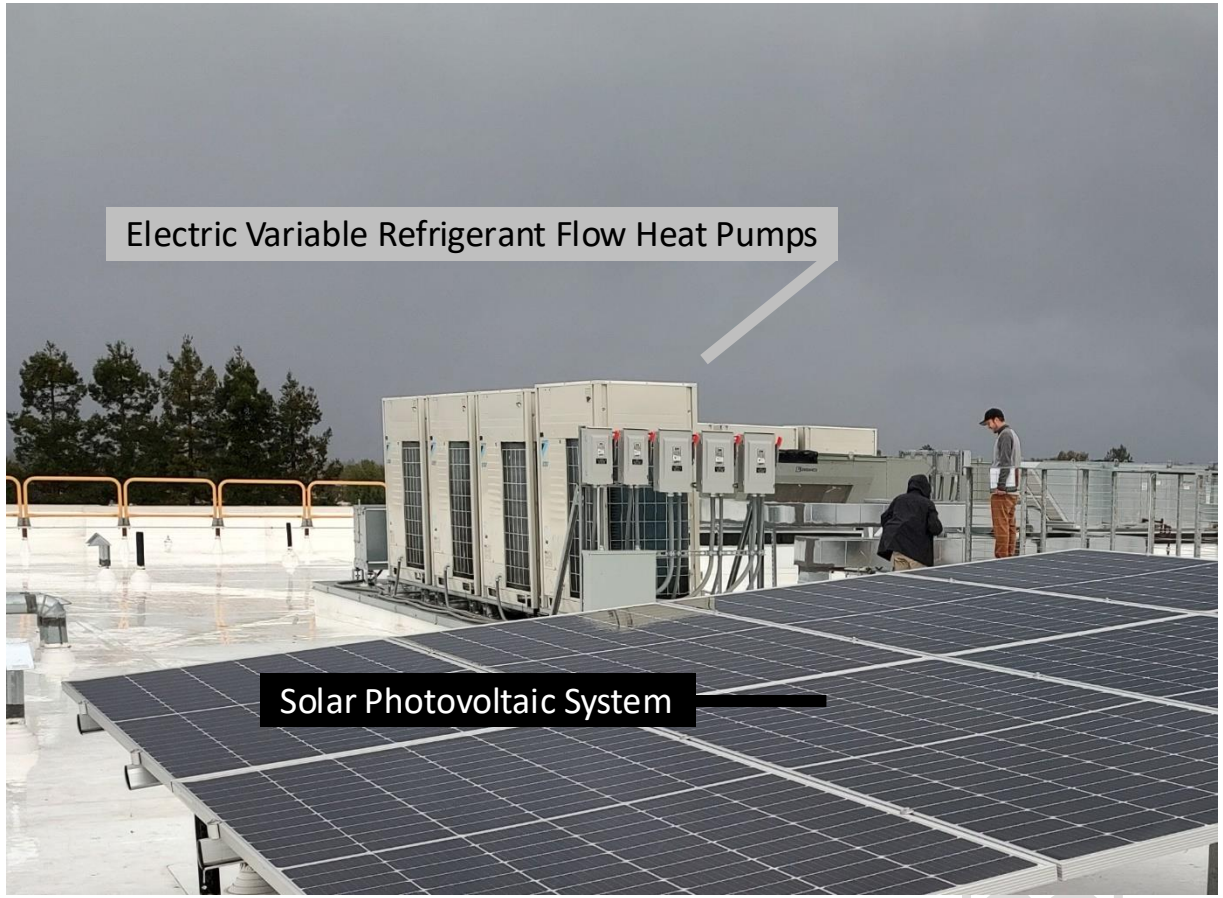
- Encourage heat pump technology for space and water heating
- Establish electric-ready requirements for single family homes
- Expand PV systems and battery storage standards

All-Electric (and *Nearly* All-Electric) Buildings

- **New Construction** All-Electric is relatively easy, with some exceptions for large scale buildings and industrial applications

- **Existing Buildings** – Incremental opportunities for
  - HVAC Replacement
  - Appliance Replacement
  - On-site Solar and Batteries
  - Envelope Improvements

- **Existing Communities** – Infrastructure Approach
  - Decarbonize the Grid
  - Reduce Natural Gas Carbon Footprint



Morning Star Senior Living, San Jose, CA

Expected Benefits of California's Climate Action Plan

- How we design and construct our buildings will have a large impact on reducing GHG emissions and mitigating climate change
- Not 'tree-hugger' fringe – it's just how we build now

Questions about Title 24?

Energy Code Coaches are local experts who can help answer your Title 24 questions. Coaches have decades of experience in green building and energy efficiency improvements. They can provide citations and offer advice for your project to help your plans and forms earn approval the first time.

Online:
3c-ren.org/codes

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  - 1/16: Domestic Hot Water – Part 3: All-Electric Design & Construction
  - 1/22: Introduction to the Energy Code
  - 1/23: Ventilation & HRV – Part 4: All-Electric Design & Construction
  - 1/30: Appliances & Energy Storage – Part 5: All-Electric Design & Construction Series
  - 2/6: Home Electrification Contractor Boot Camp
- For more information about upcoming events please visit: https://www.3c-ren.org/events

Thank you!

For more info:
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For questions:
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