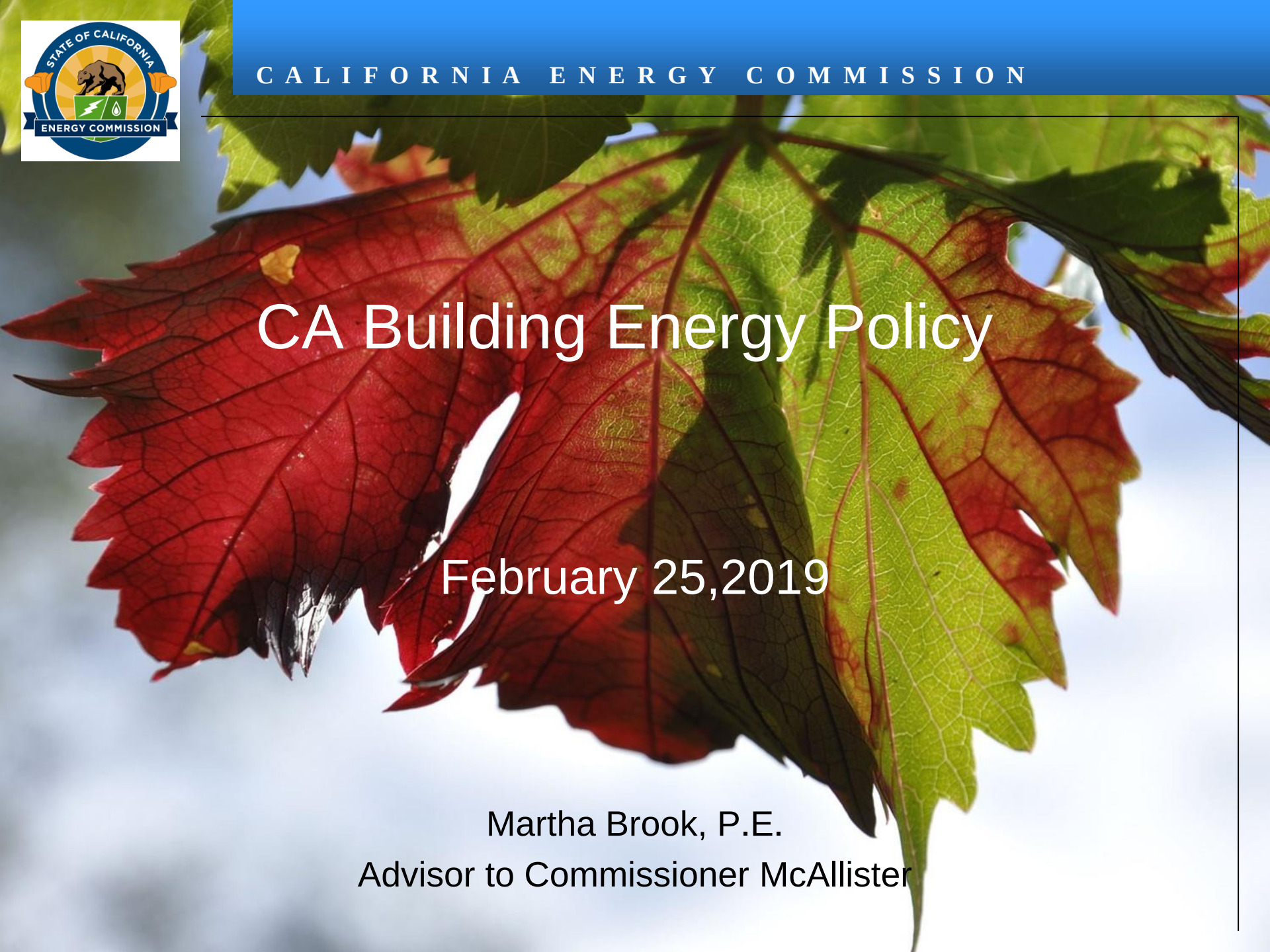
From Zero Energy to Zero Emissions

The Transition to Carbon as an Efficiency Metric

2019 RESNET Building Performance Conference

New Orleans, LA

February 25, 2019



CALIFORNIA ENERGY COMMISSION

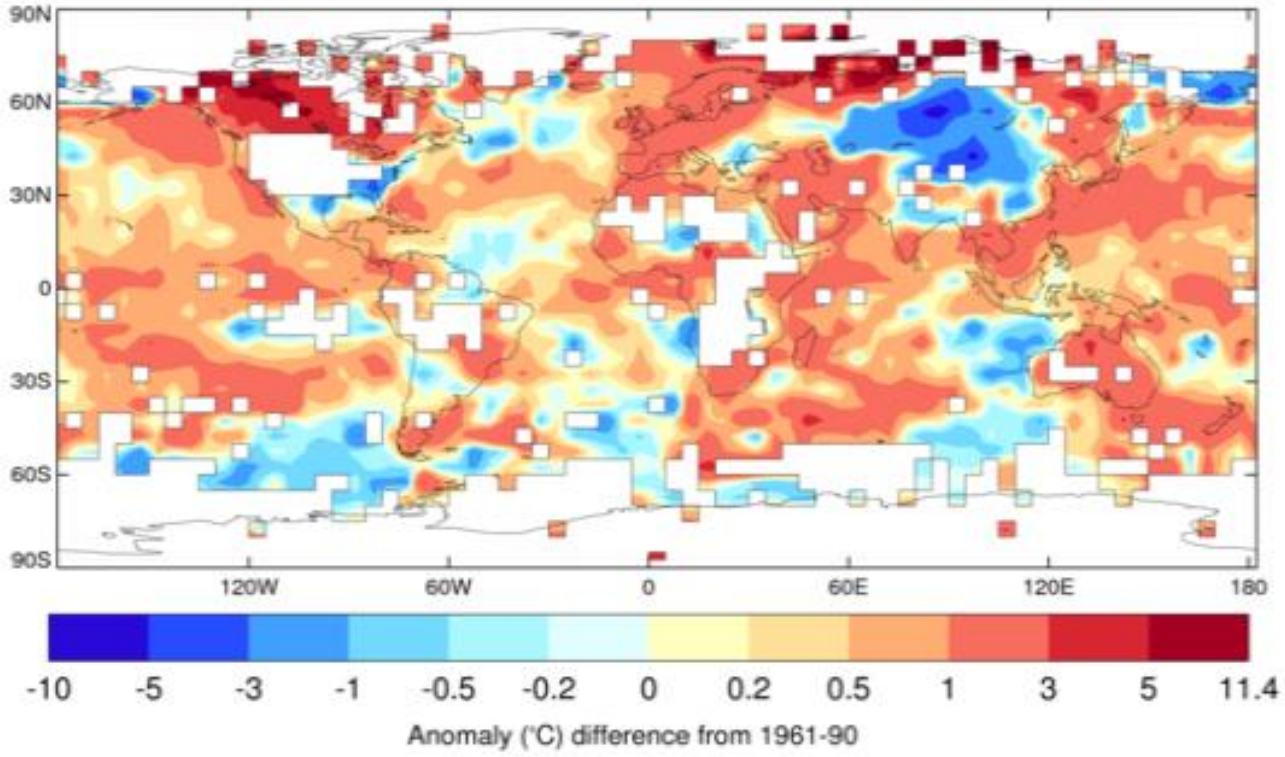
CA Building Energy Policy

February 25,2019

Martha Brook, P.E.
Advisor to Commissioner McAllister

2018 Global Surface Temperature Anomalies

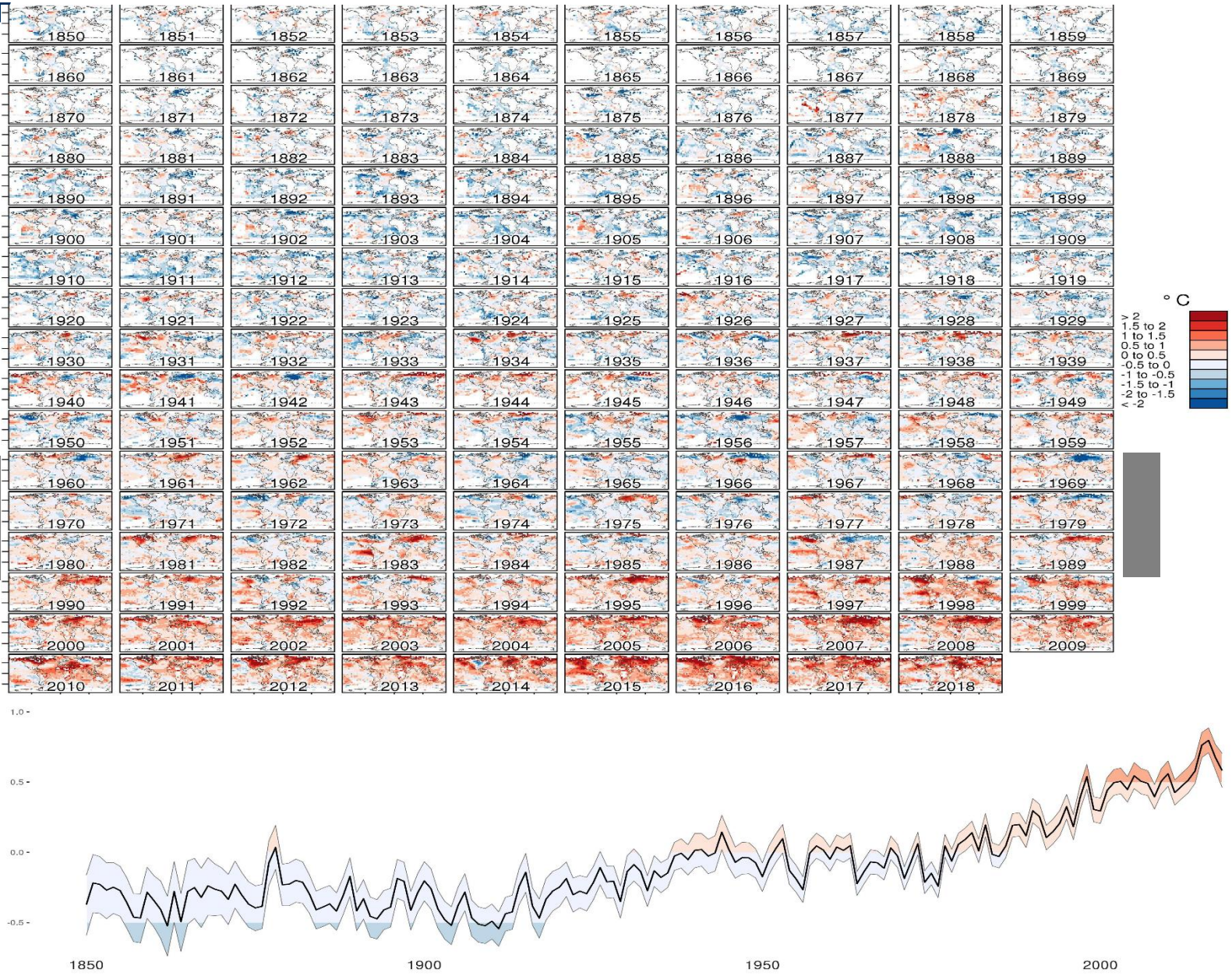
Relative to 1961-1990 Average



1850-2018 Global Surface Temperature Anomalies

relative to 1961-1990 average

reddit/dataisbeautiful/neilrkaye



Senate Bill 350

The Clean Energy and Pollution Reduction Act of 2015

- EE: Double energy efficiency savings by 2030
- Renewables: 50% renewable energy by 2030
- Equity: Address barriers for low-income residents & disadvantaged communities
- EVs: Encourage widespread transportation electrification
- IRPs: Integrated resource planning to reduce greenhouse gas emissions



Senate Bill 100

The 100 Percent Clean Energy Act of 2018

- RPS:
  - 33% by 2020
  - 50% by 2025
  - 60% by 2030
- Zero-carbon resources supply 100 percent of all retail sales of electricity to California end-use customers

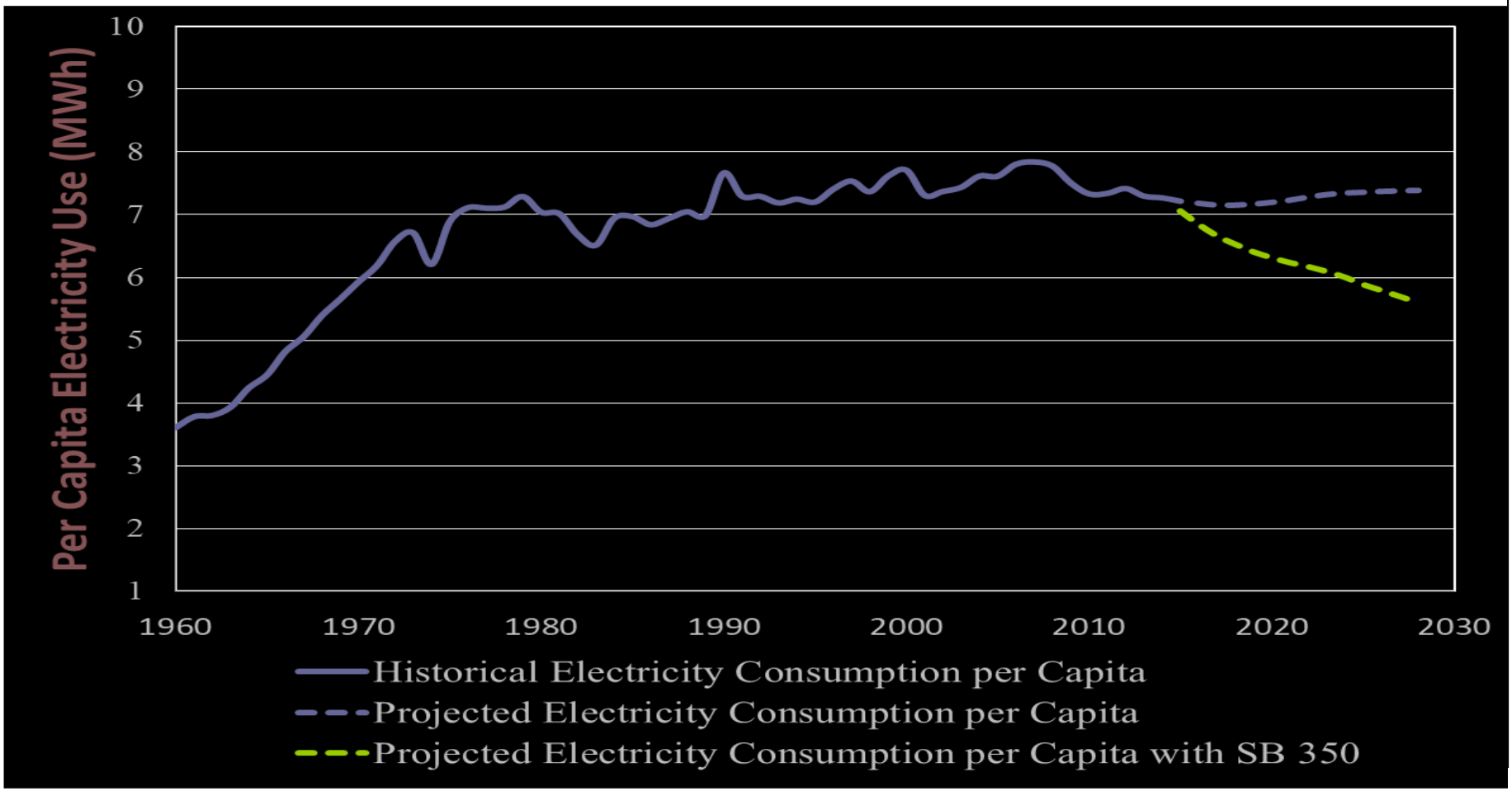
Executive Order B-55-18

To Achieve Carbon Nutrality

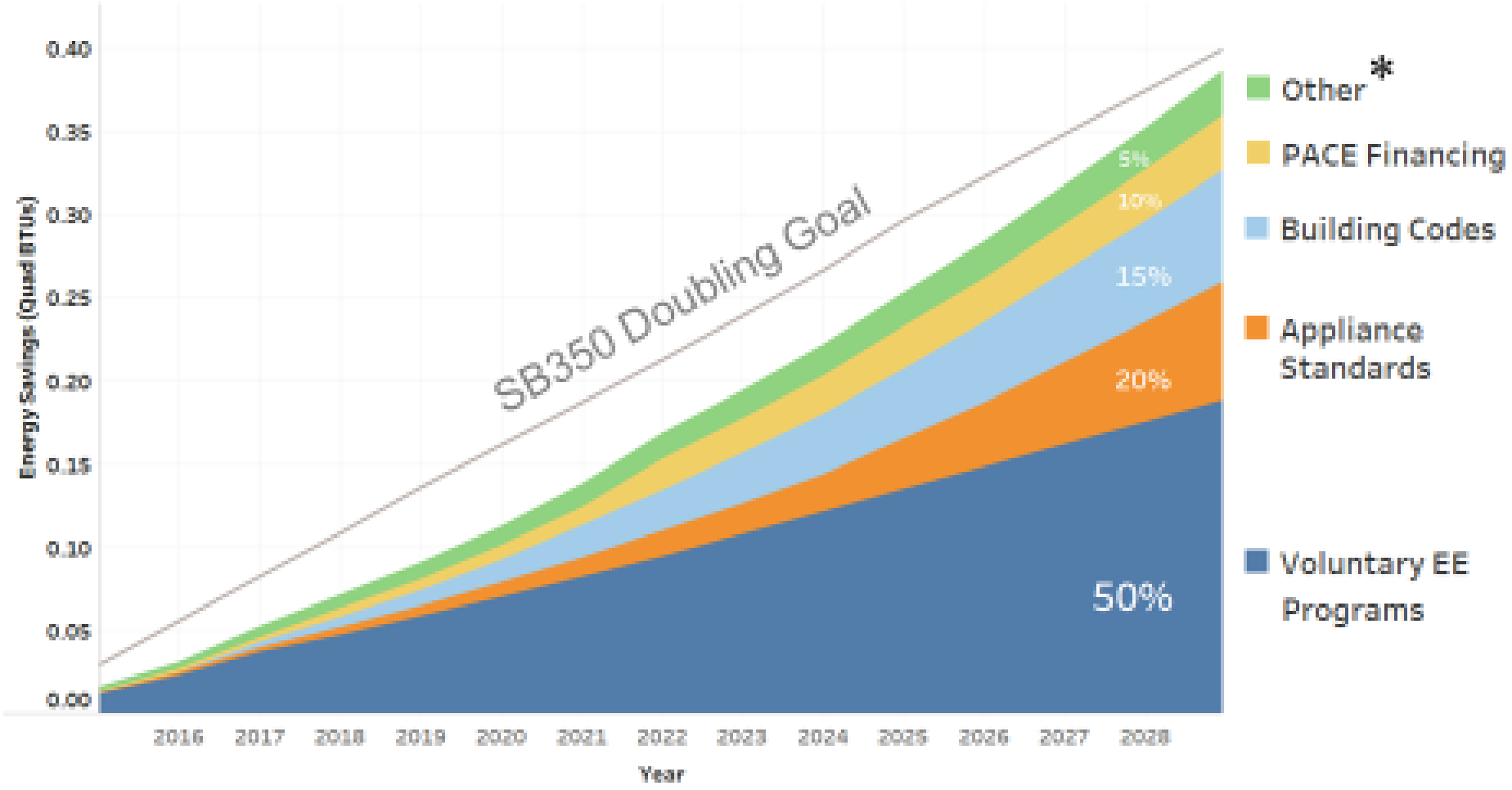
- Carbon Neural as a State Across all Sectors by 2045



Energy Use Reductions needed to meet SB 350

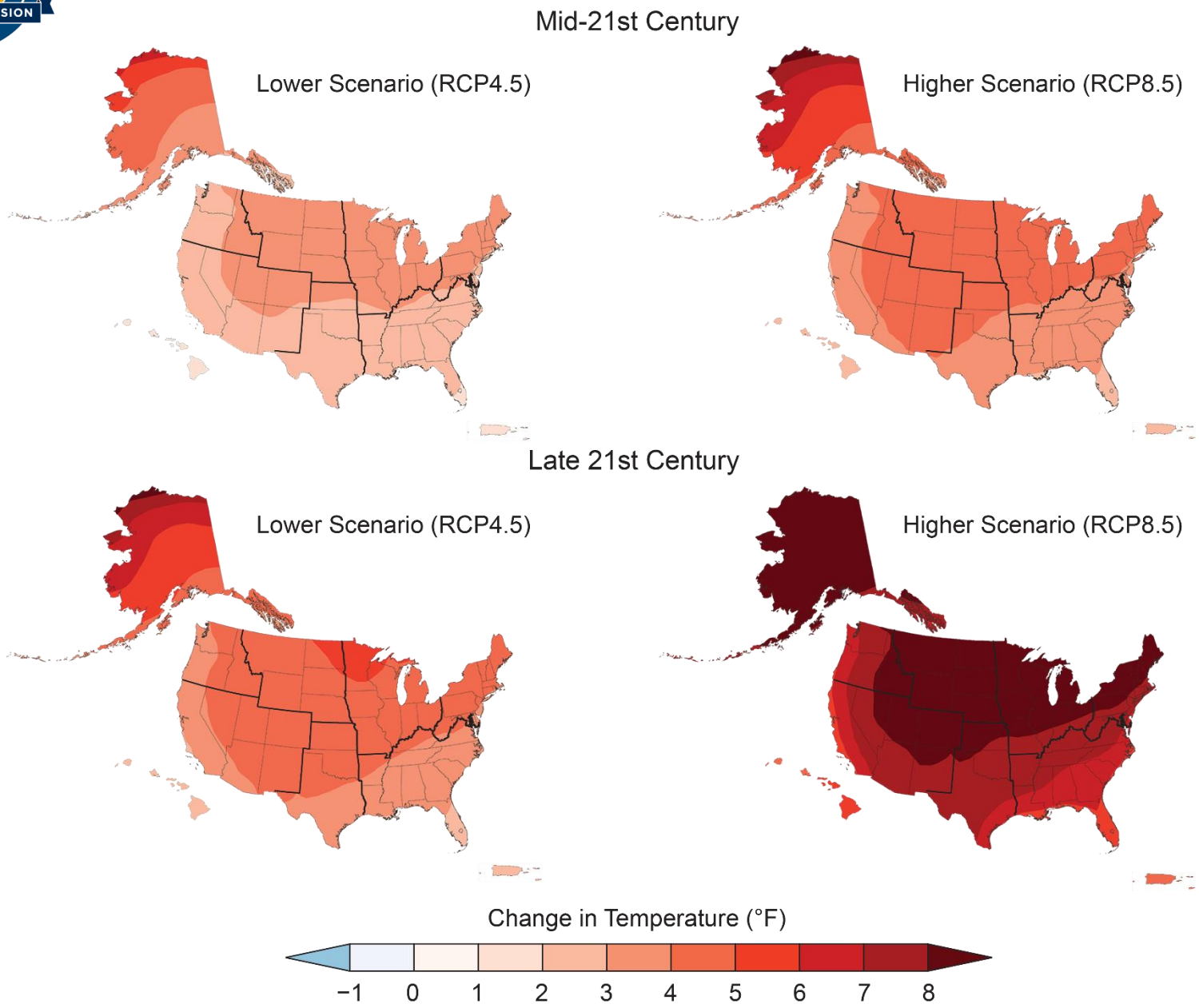


Energy Savings (Quad BTUs)

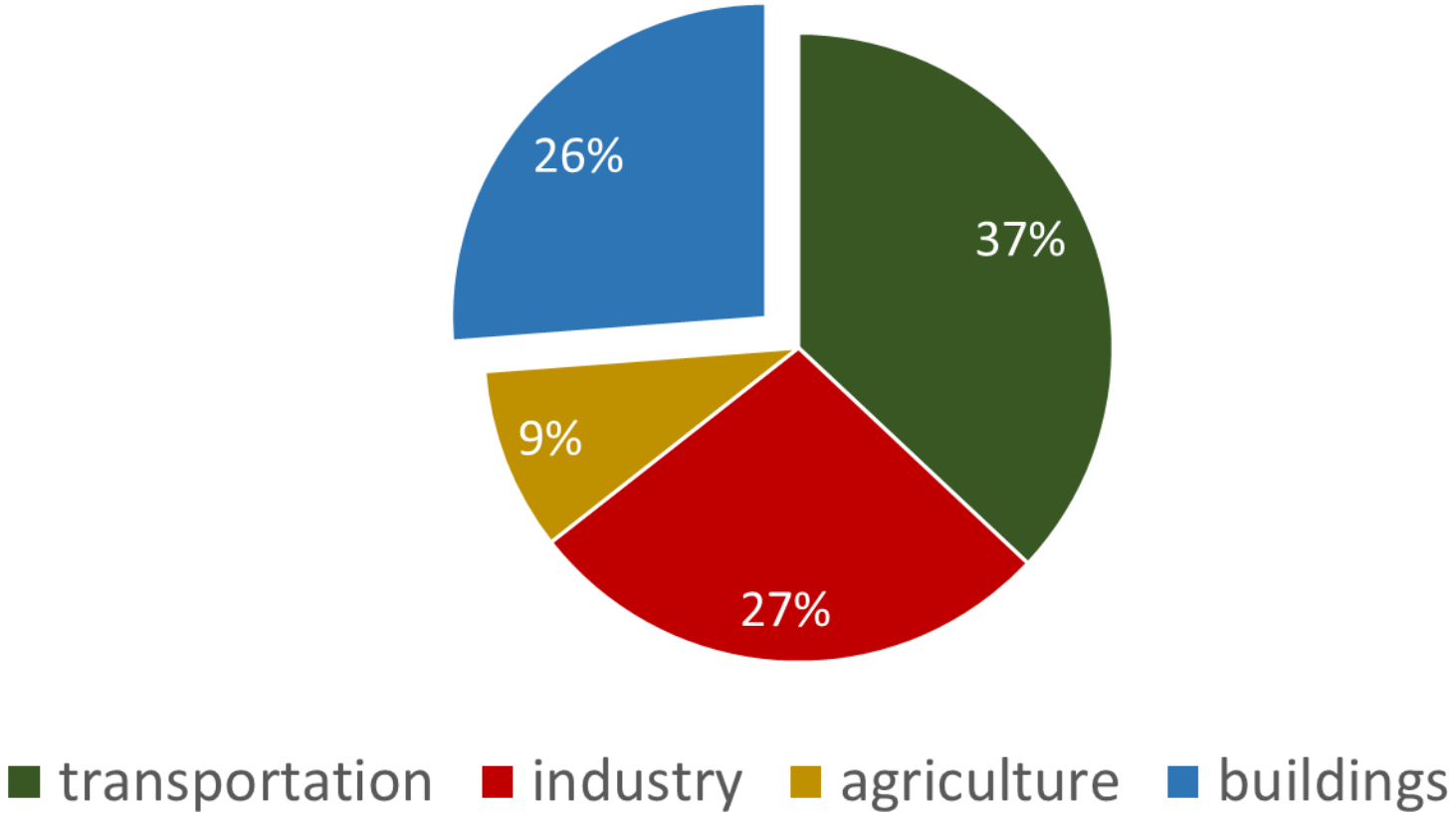


*"Other" includes federal appliance standards; local government ordinances; air quality districts; Proposition 39; industrial and agricultural sectors; Behavioral, Retrocommissioning, Operational Energy Efficiency (BROs); benchmarking; energy asset rating; smart meter and controls; & electrification.

Impacts, Risks, and Adaptation in the United States:
Fourth National Climate Assessment



CA GHG Emissions

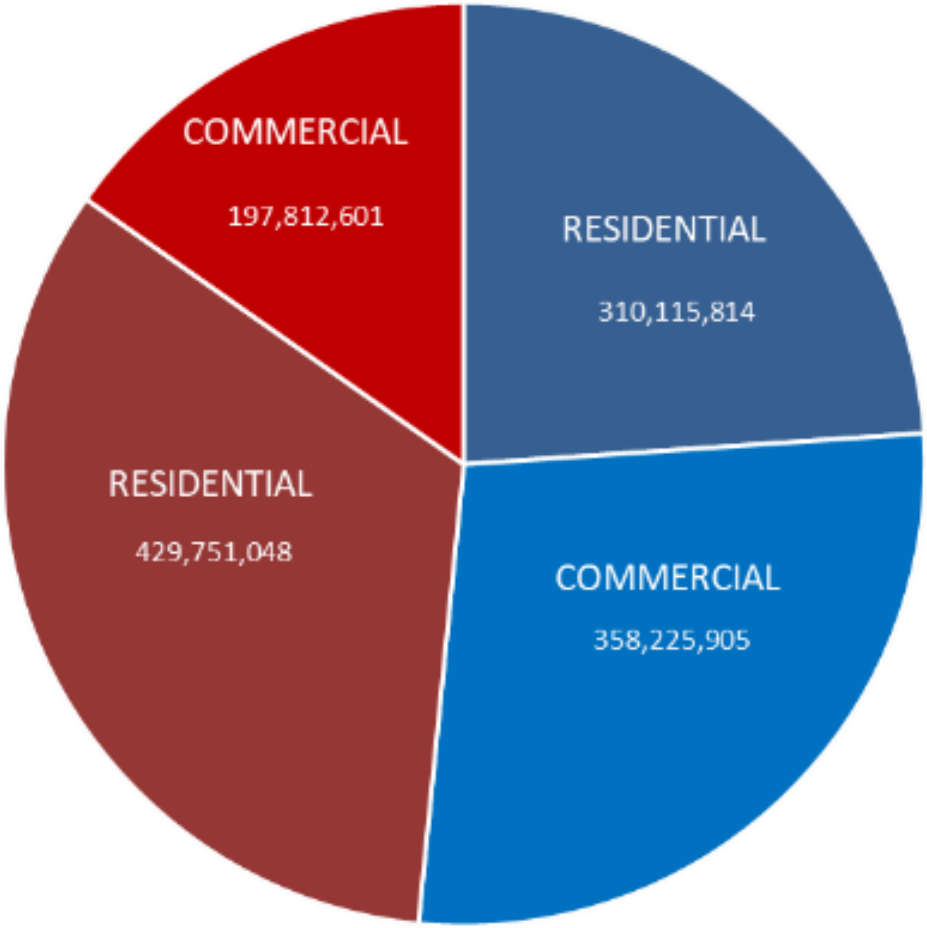


Policy Direction: Building Decarbonization

- First significant policy discussion - *2018 Integrated Energy Policy Report Update* *(see Decarb Docket Log)*
  - *Zero Emission Buildings policy goals, rather than ZNE*
- *2018 legislation:* new construction & upstream product incentives (SB 1477), plans to meet statewide building decarb targets (AB 3232), 100% RPS (SB 100)
- *Governor Brown Executive Order:* Carbon Neutrality by 2045
- Several cities working on decarbonization reach codes for 2020

2016 Energy Use in California Buildings (MMBtu)

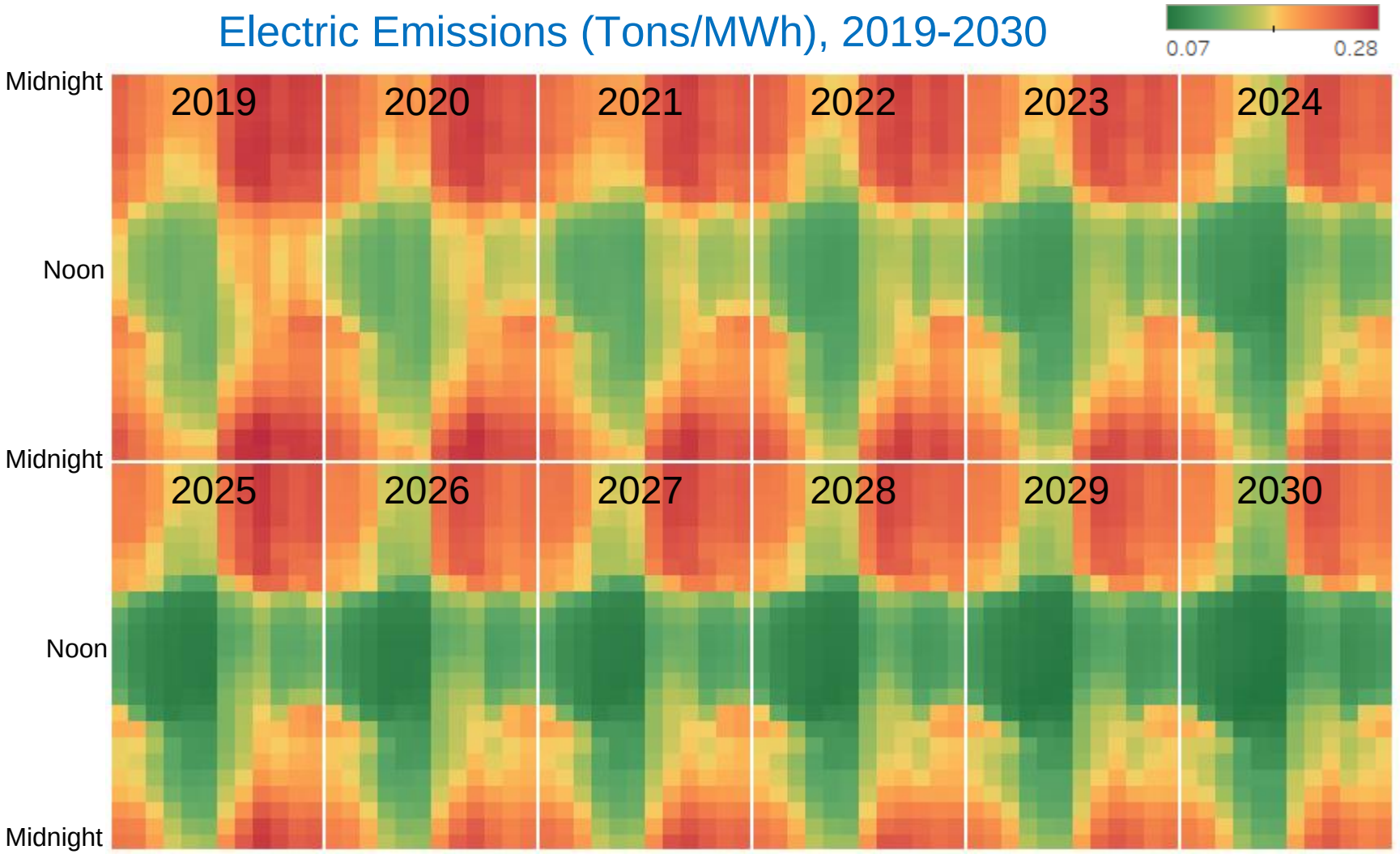
NATURAL GAS (48%)



ELECTRICITY (52%)

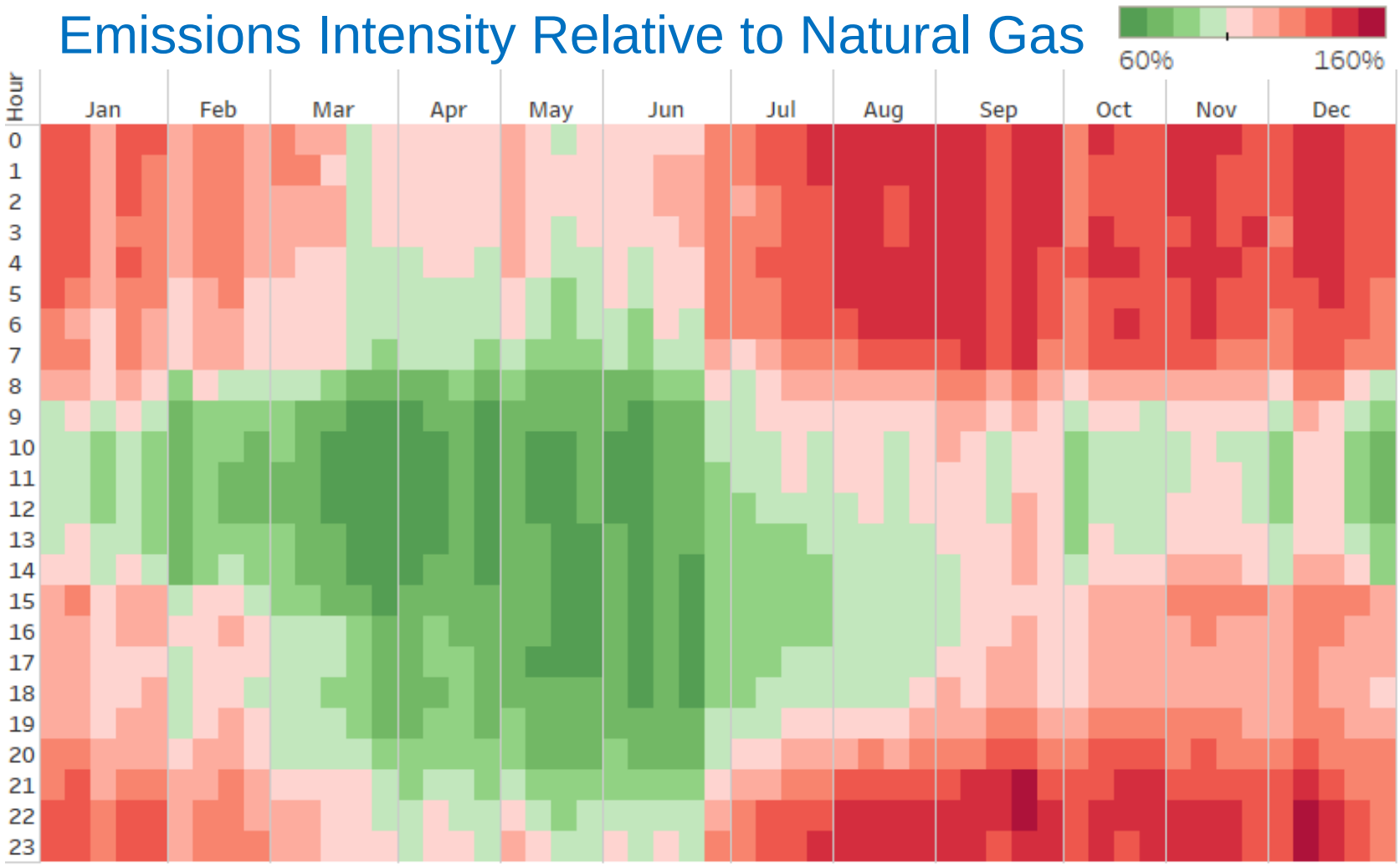
Electricity CO_2 Intensity

Electric Emissions (Tons/MWh), 2019-2030



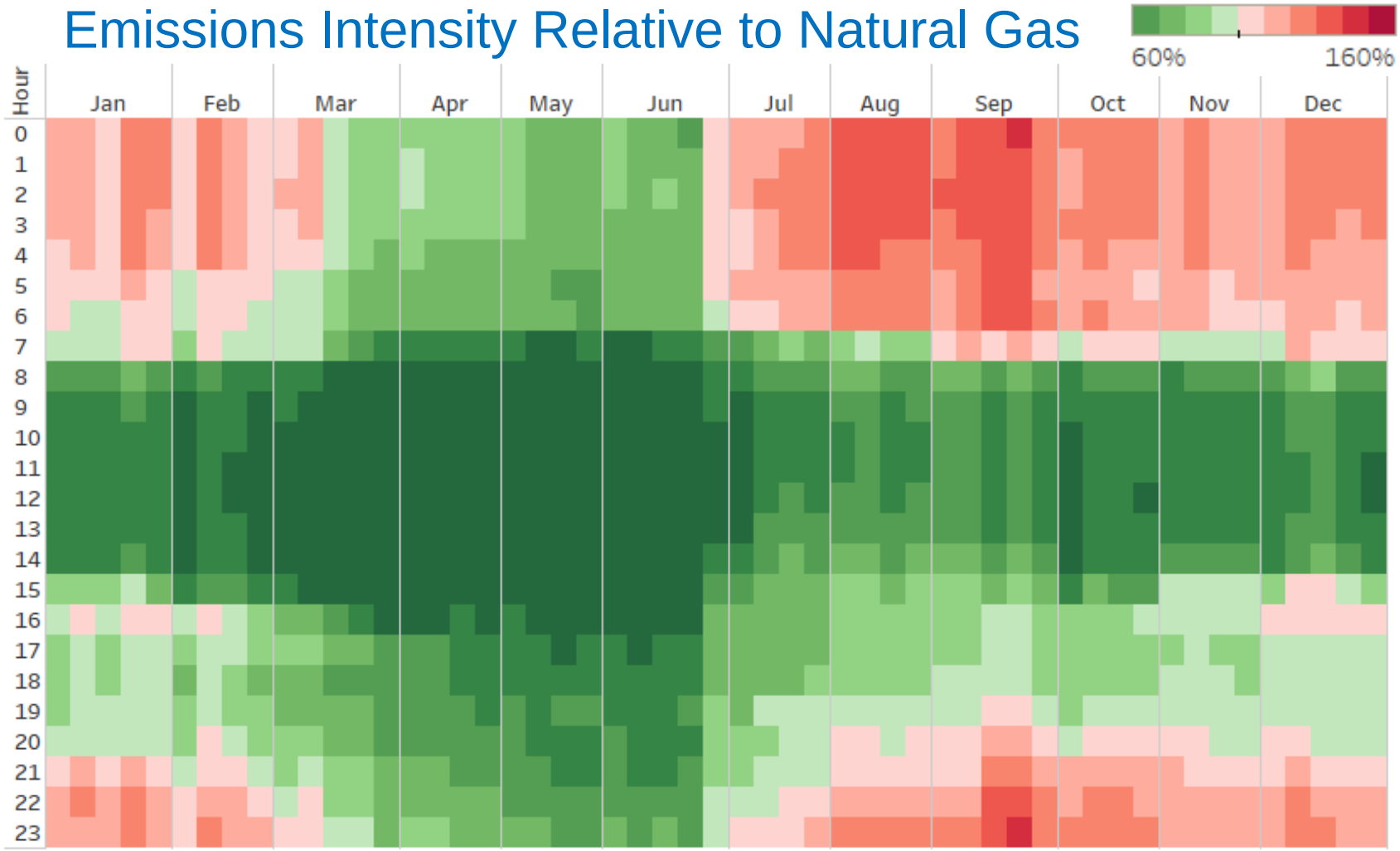
Buildings Perspective: 2019

Emissions Intensity Relative to Natural Gas

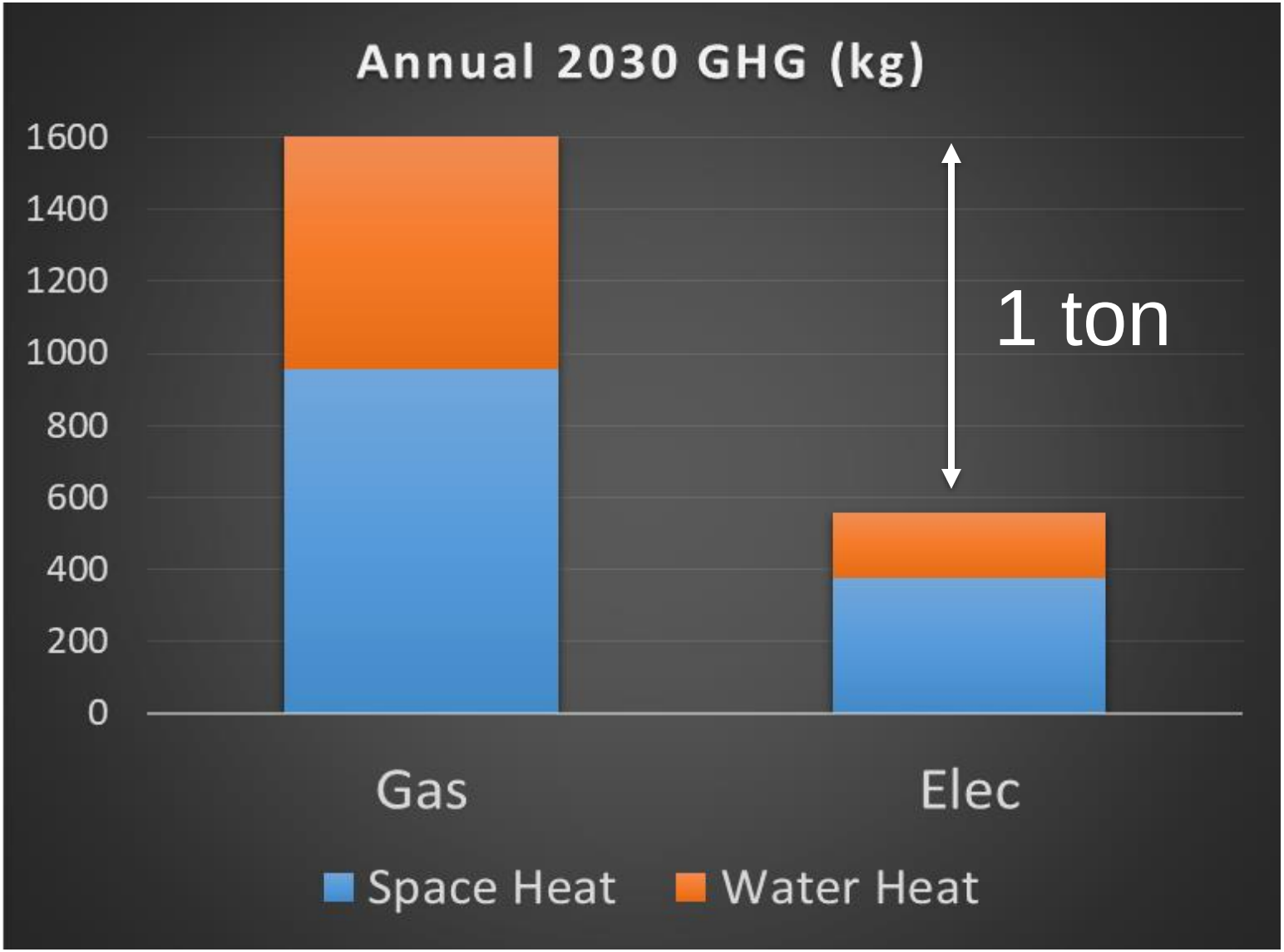


Buildings Perspective: 2030

Emissions Intensity Relative to Natural Gas

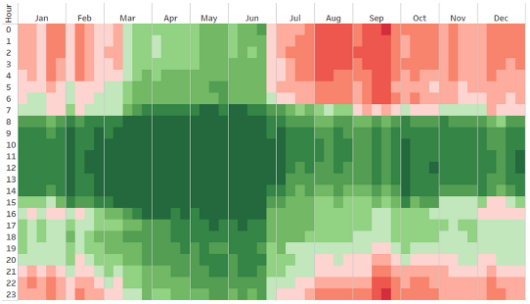


CZ 3 2019 Std – 2100 sf

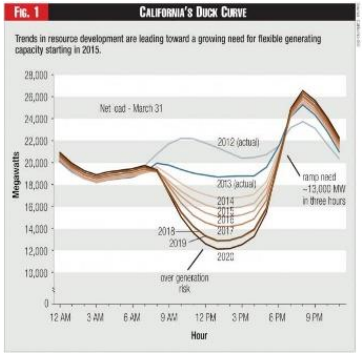


Policy Direction: Building Standards

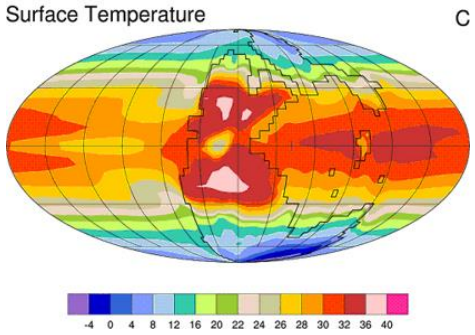
- Adopt an energy metric that aligns with GHG emissions (applied to all fuel types)



- Adopt a secondary demand flexibility metric (applied only to electricity)



- Implement performance trade-offs that prioritize & protect the building envelope



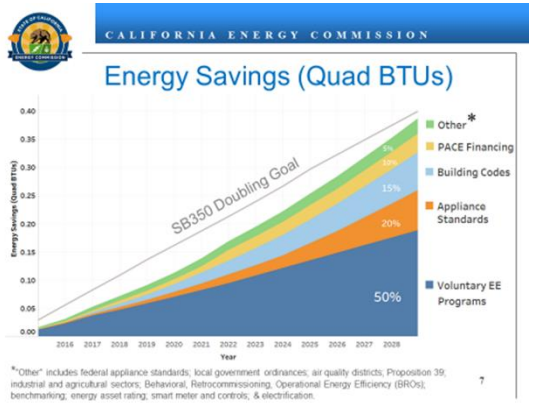
- Address refrigerant leakage emissions

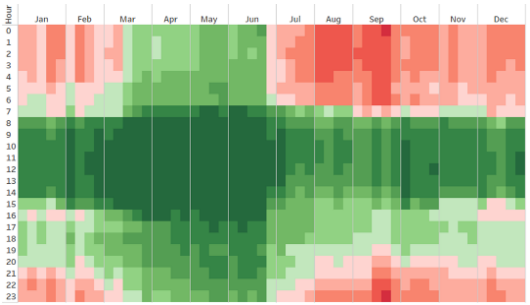
Policy Direction: Existing Buildings

- SB 1477: Low-emissions buildings and sources of heat energy

- AB 3232 building decarbonization focus will be prevalent in 2019 existing building action plan update

- Identify where code can be leveraged





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Nic Dunfee

Senior Project Manager

www.trcsolutions.com

Agenda

- **Keys to Decarbonization**
- **On-Site Combustion:**
  It's Not What It Used to Be
- **Renewable Portfolio Standards:**
  The Future of the Grid
- **Decarbonization in the Home**

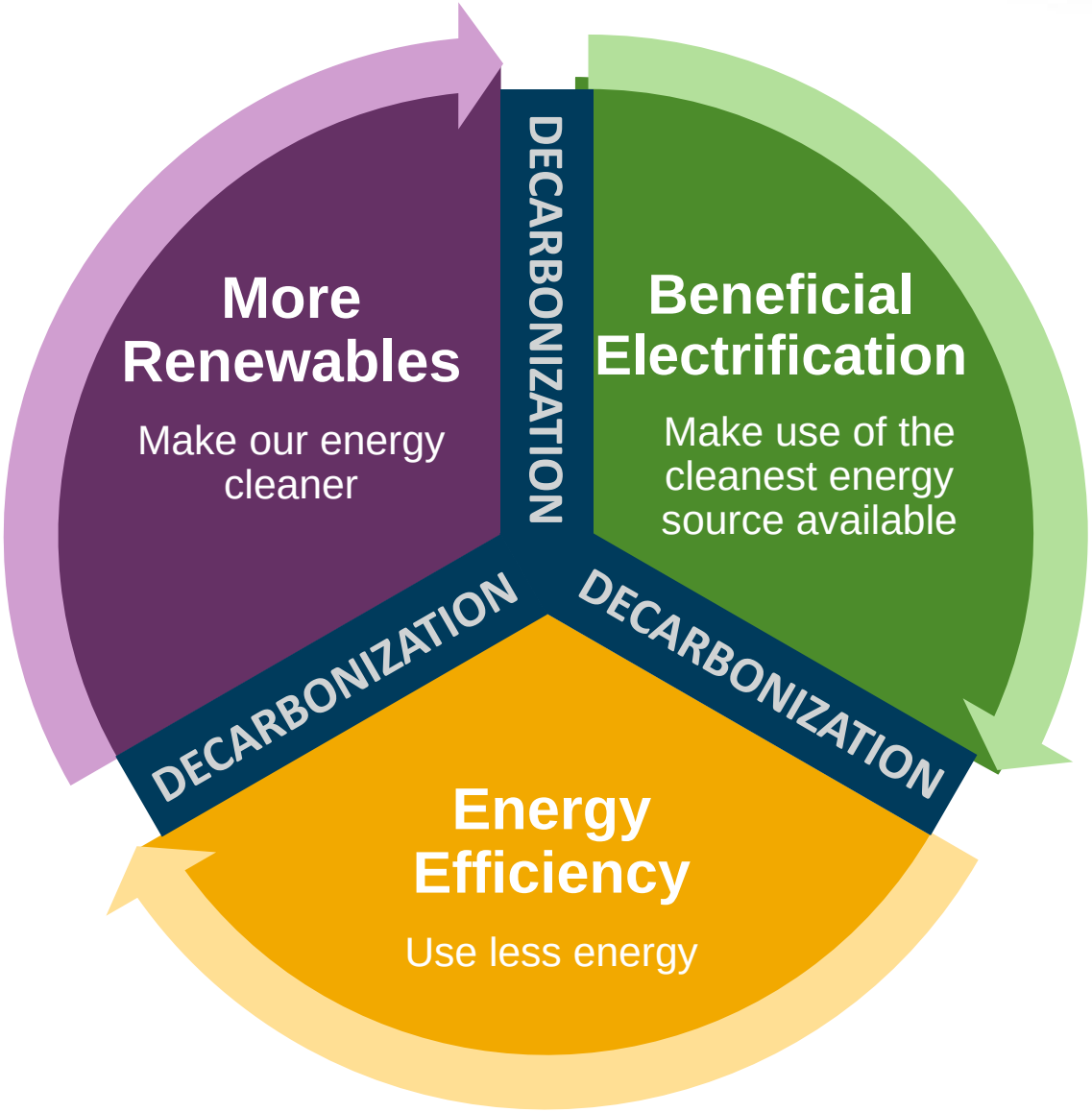
The Need to Decarbonize

"Pathways limiting global warming to 1.5°C with no or limited overshoot would **require rapid and far-reaching transitions** in energy, land, urban and infrastructure (including transport and buildings), and industrial systems."

"**These systems transitions are unprecedented in terms of scale**, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, **a wide portfolio of mitigation options and a significant upscaling of investments** in those options."

"Avoiding overshoot and reliance on future large-scale deployment of carbon dioxide removal (CDR) can only be achieved **if global CO2 emissions start to decline well before 2030**"

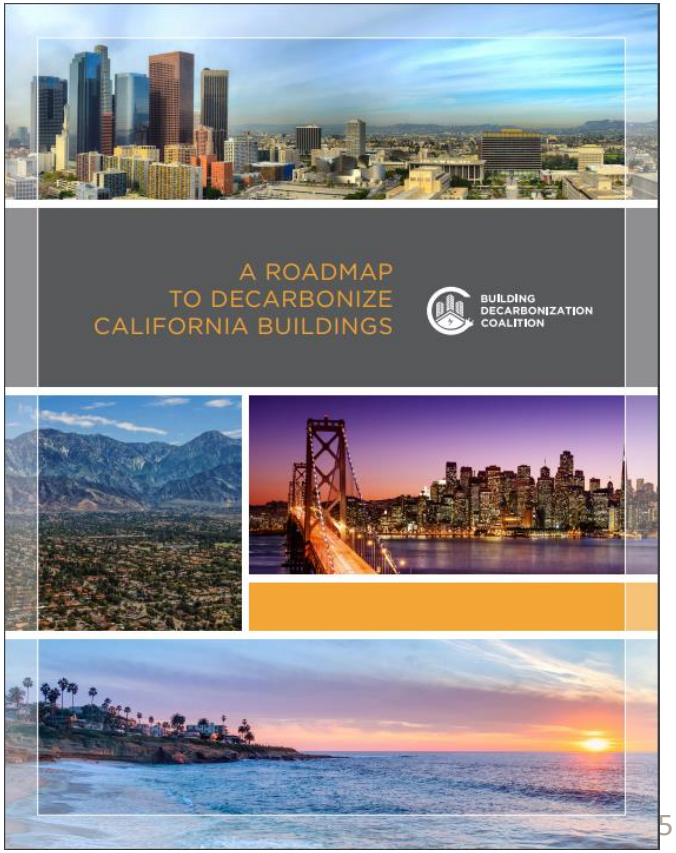
Three Keys to Decarbonization



Building Decarbonization Coalition (BDC)

BUILDING DECARBONIZATION COALITION

The Building Decarbonization Coalition is a 501(c)(3) nonprofit organization whose mission is to convene the stakeholders necessary to drive the conversation around building decarbonization at the state level. The Coalition brings together industry, advocacy, government experts, and the private sector to develop integrated and effective approaches to make decarbonization a reality.



http://www.buildingdecarb.org/

BDC Road Map Recommendations

California should adopt a Zero Emission Building Code as a State

California should set greenhouse gas emission reduction standards for the overall building stock that account for emissions lock-in from fossil fuel-powered appliances

California should build the market share for underlying technologies

BDC Recommendations

California should adopt a Zero Emission Building Code as a State

2025

All Residential New Construction

2028

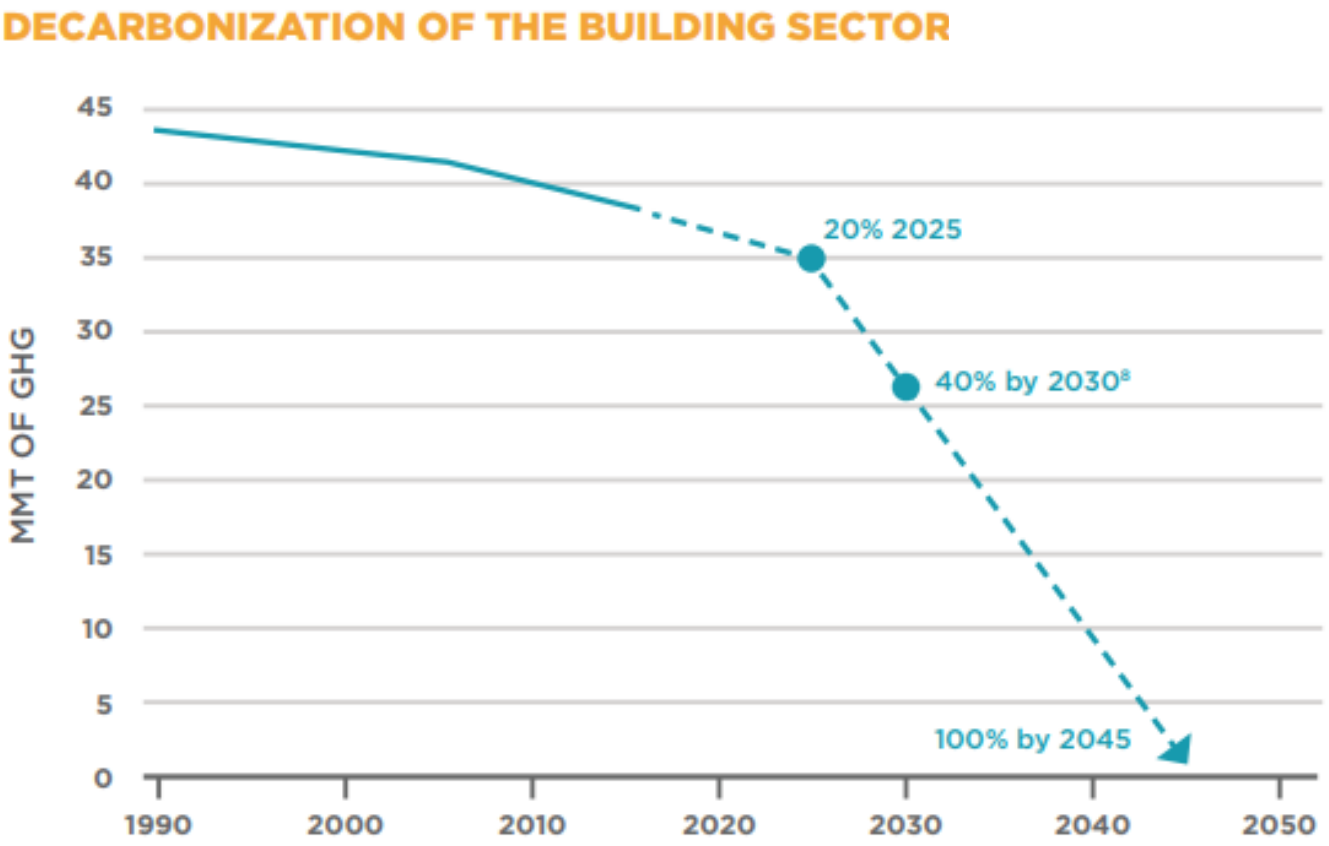
All Commercial New Construction

BDC Recommendations

California should set greenhouse gas emission reduction standards for the overall building stock that accounts for emissions lock-in from fossil fuel-powered appliances

2025	2030	2045
20% GHG reductions from building sector	40% GHG reductions from building sector	100% GHG reductions from building sector

BDC Recommendations

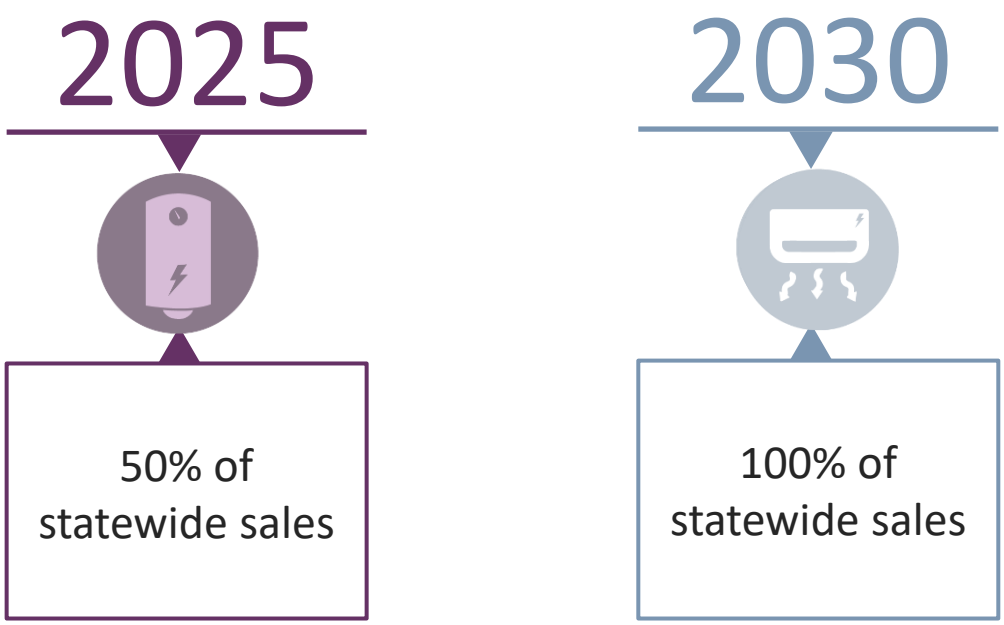


http://www.buildingdecarb.org/resources/a-roadmap-to-decarbonize-californias-buildings

BDC Recommendations

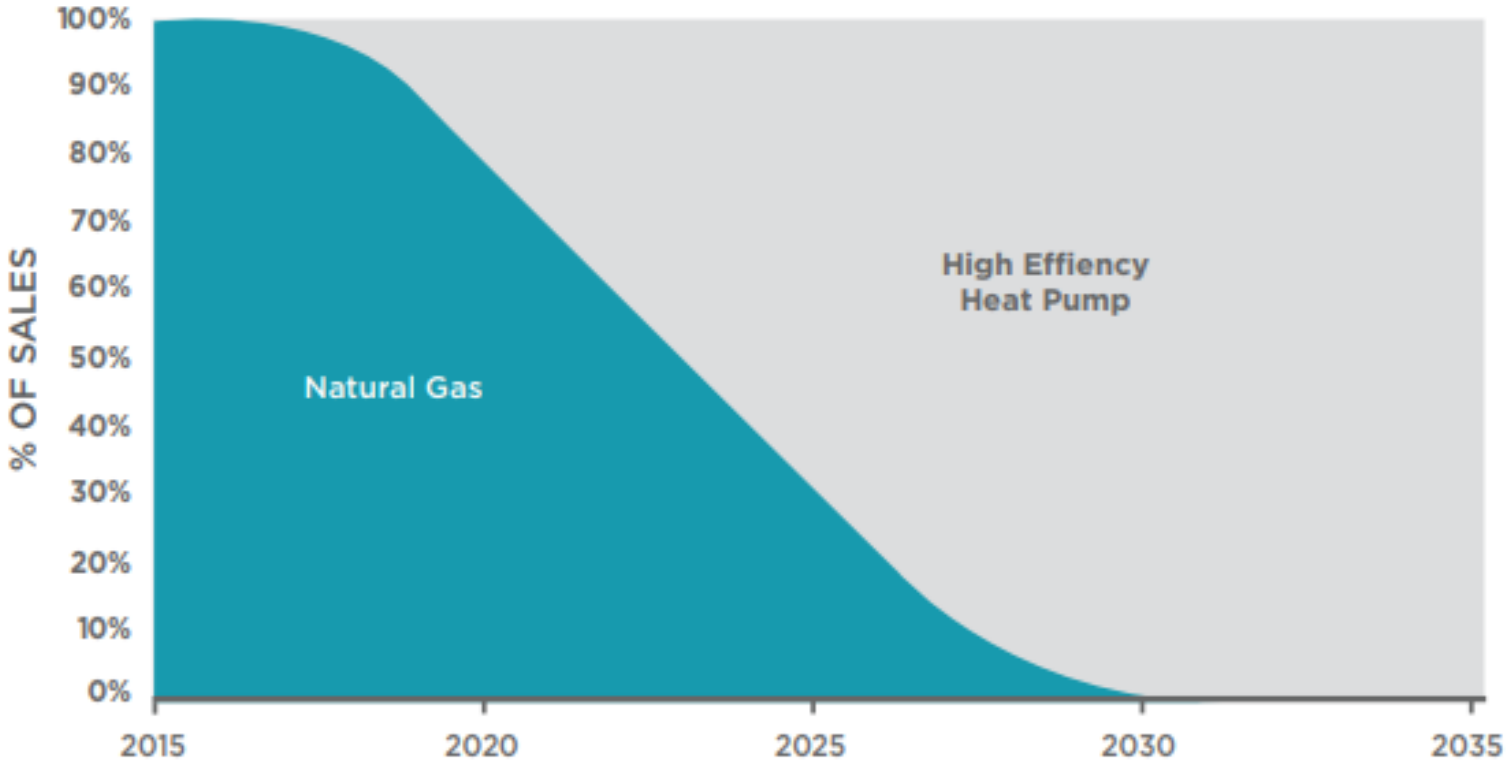
California should build the market share for underlying technologies:

Heat Pump Space and Water Heating



Water Heating

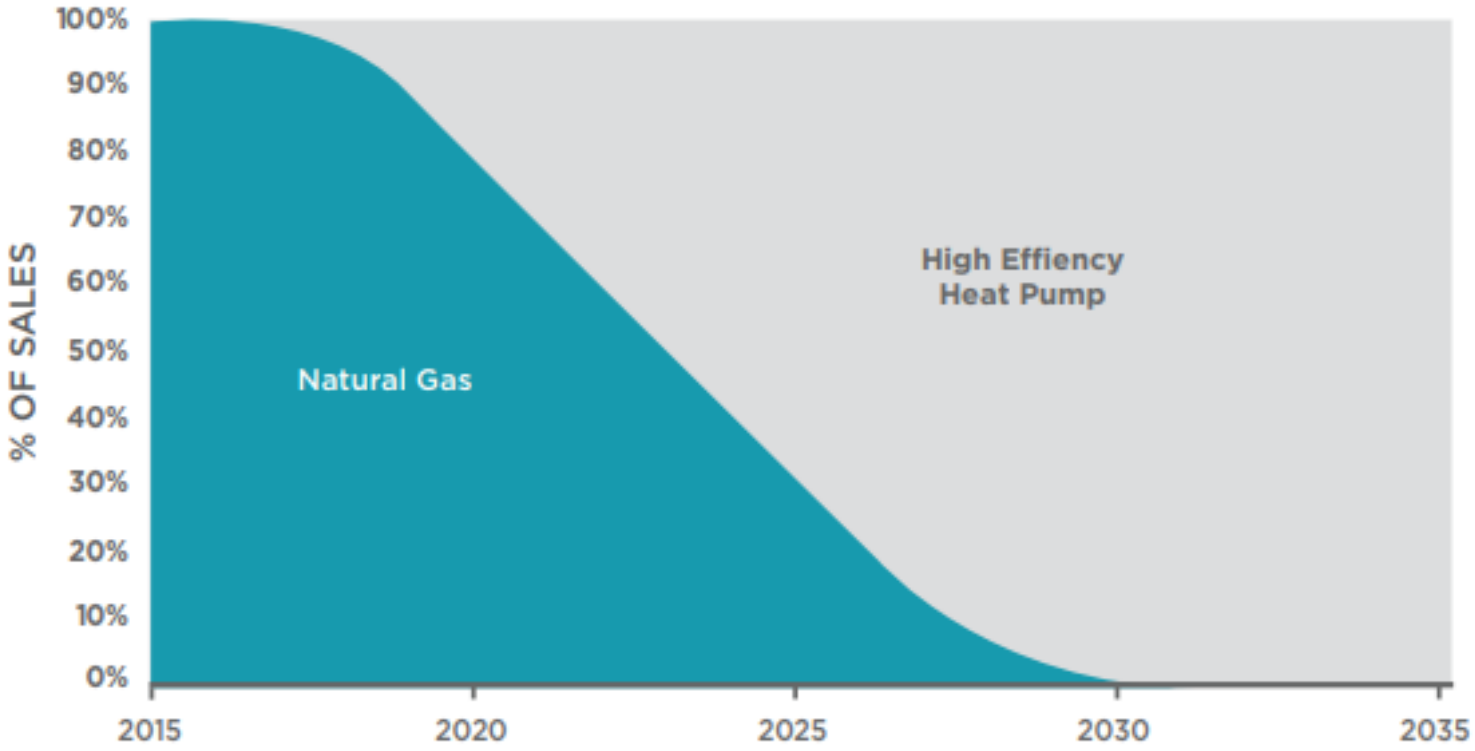
Increase the share of high efficiency heat pumps for water heating from 1% of sales in 2018, to 50% in 2025 and 100 % in 2030.



http://www.buildingdecarb.org/resources/a-roadmap-to-decarbonize-californias-buildings

Space Heating

Increase the share of high efficiency heat pumps for space heating from 5% of sales in 2018, to 50% in 2025 and 100 % in 2030.



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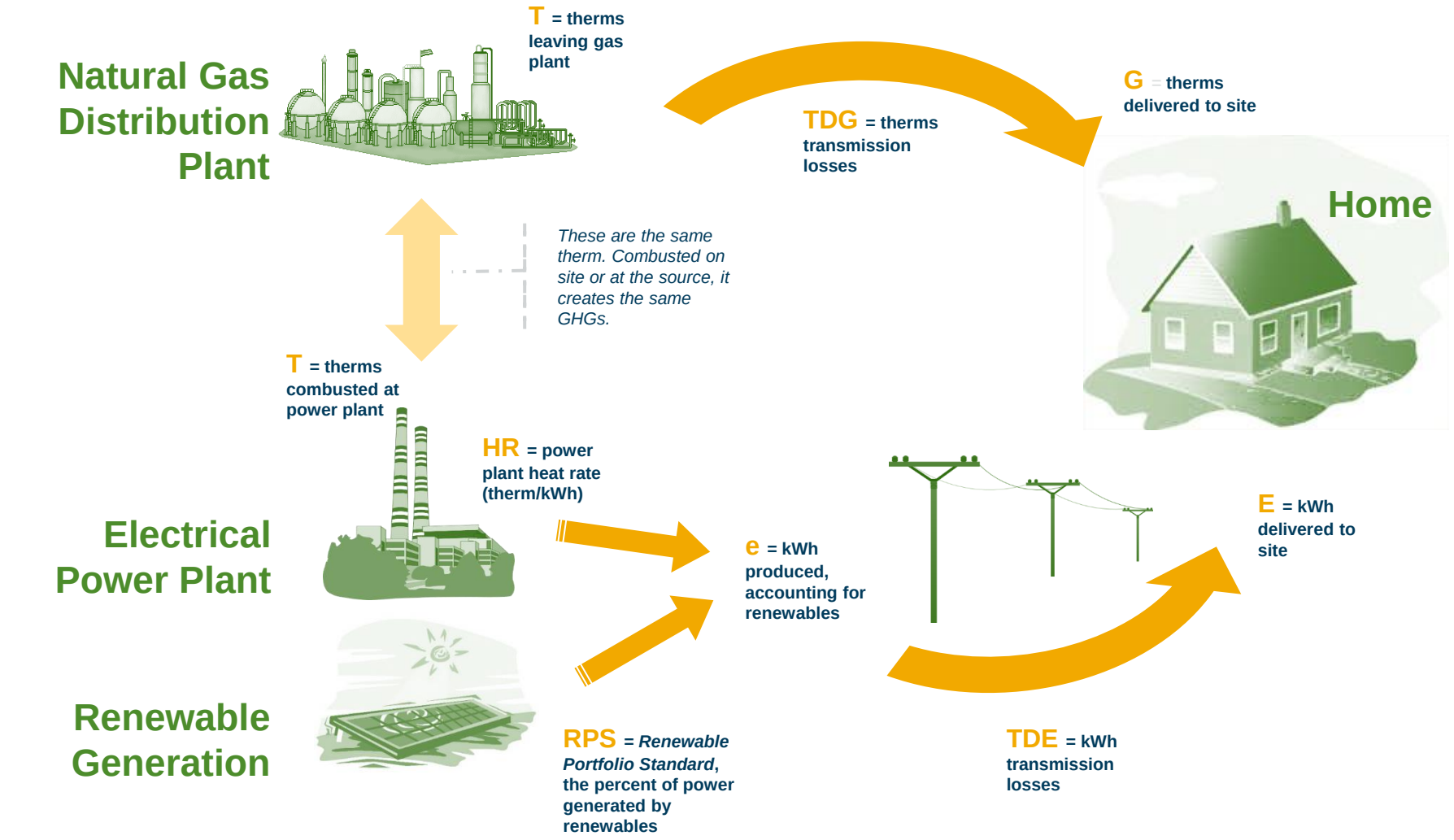
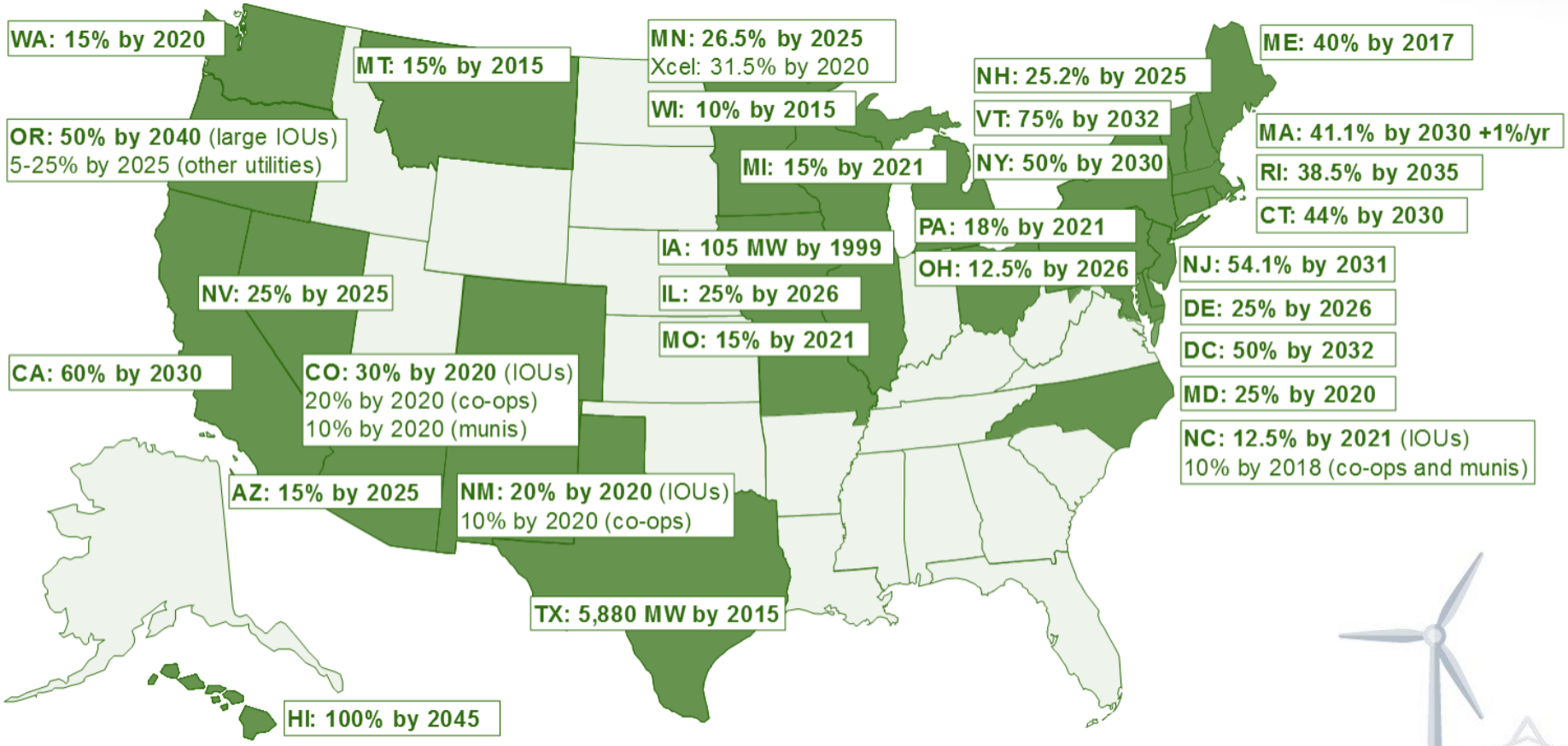
On-Site Combustion:
It's Not What It Used to Be



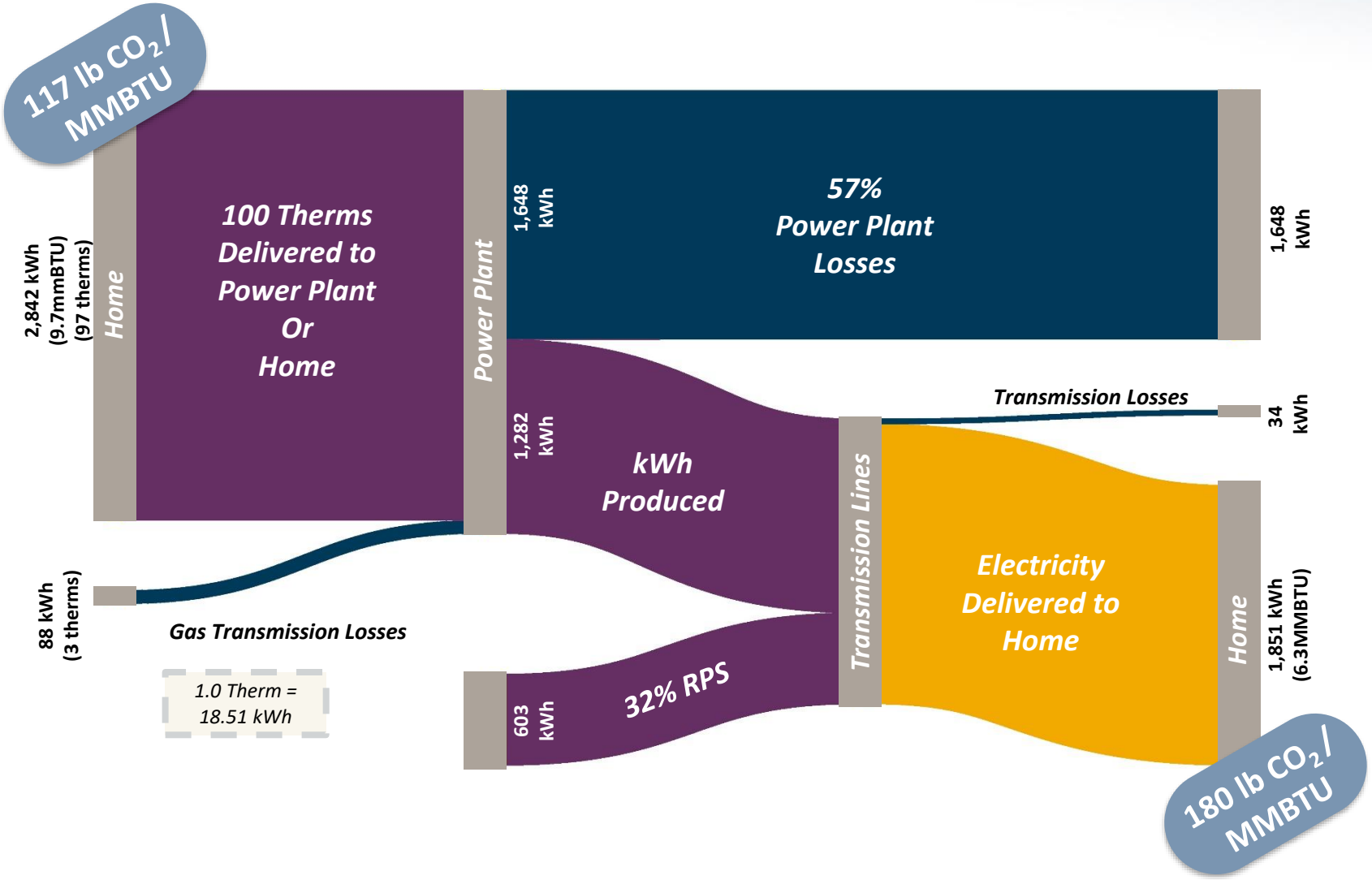
Renewable Portfolio Standards



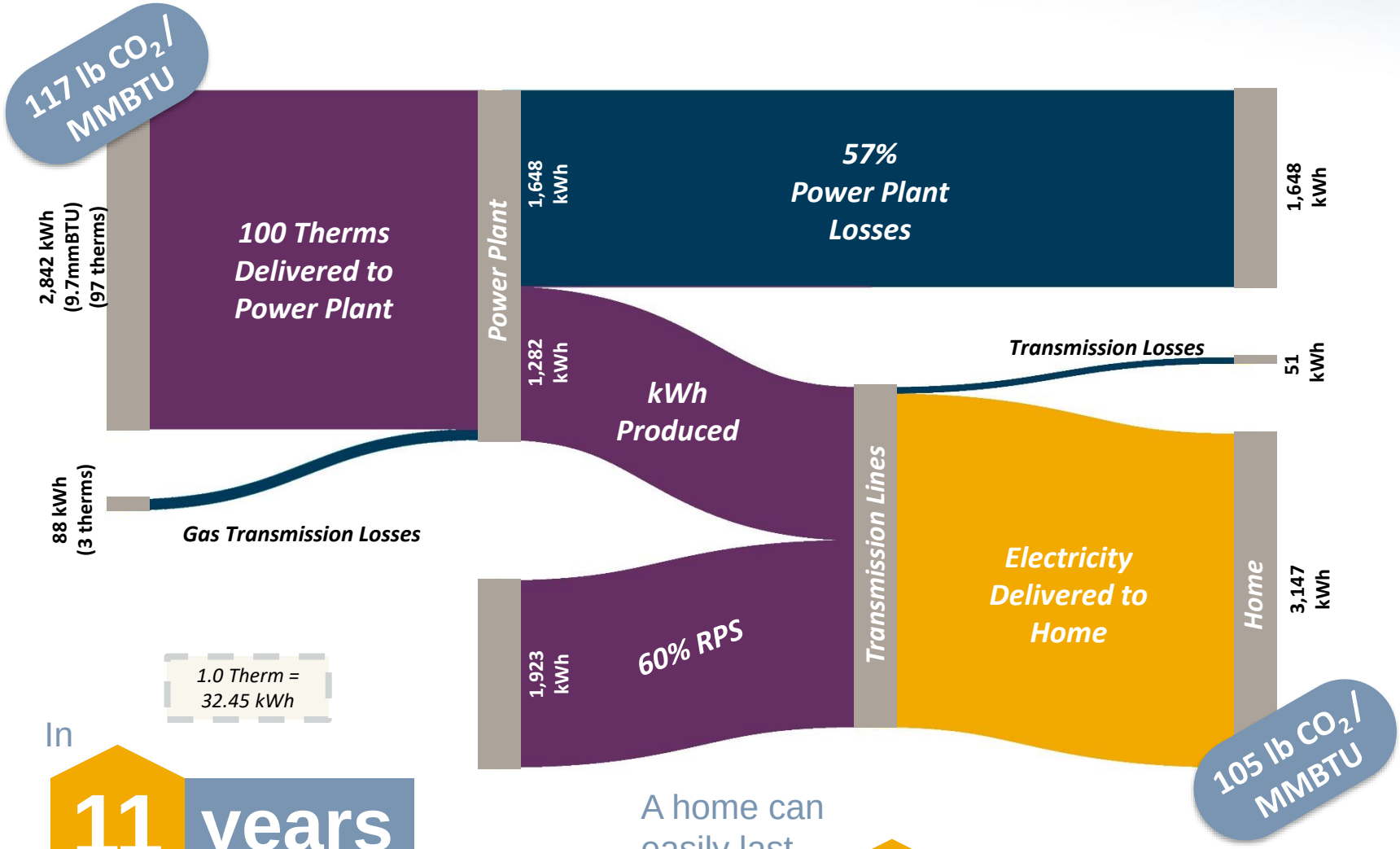
Source: Berkeley Lab (November 2018)

29 states currently have RPS regulations or mandates

Source Carbon Content: 2018



Source Carbon Content: 2030

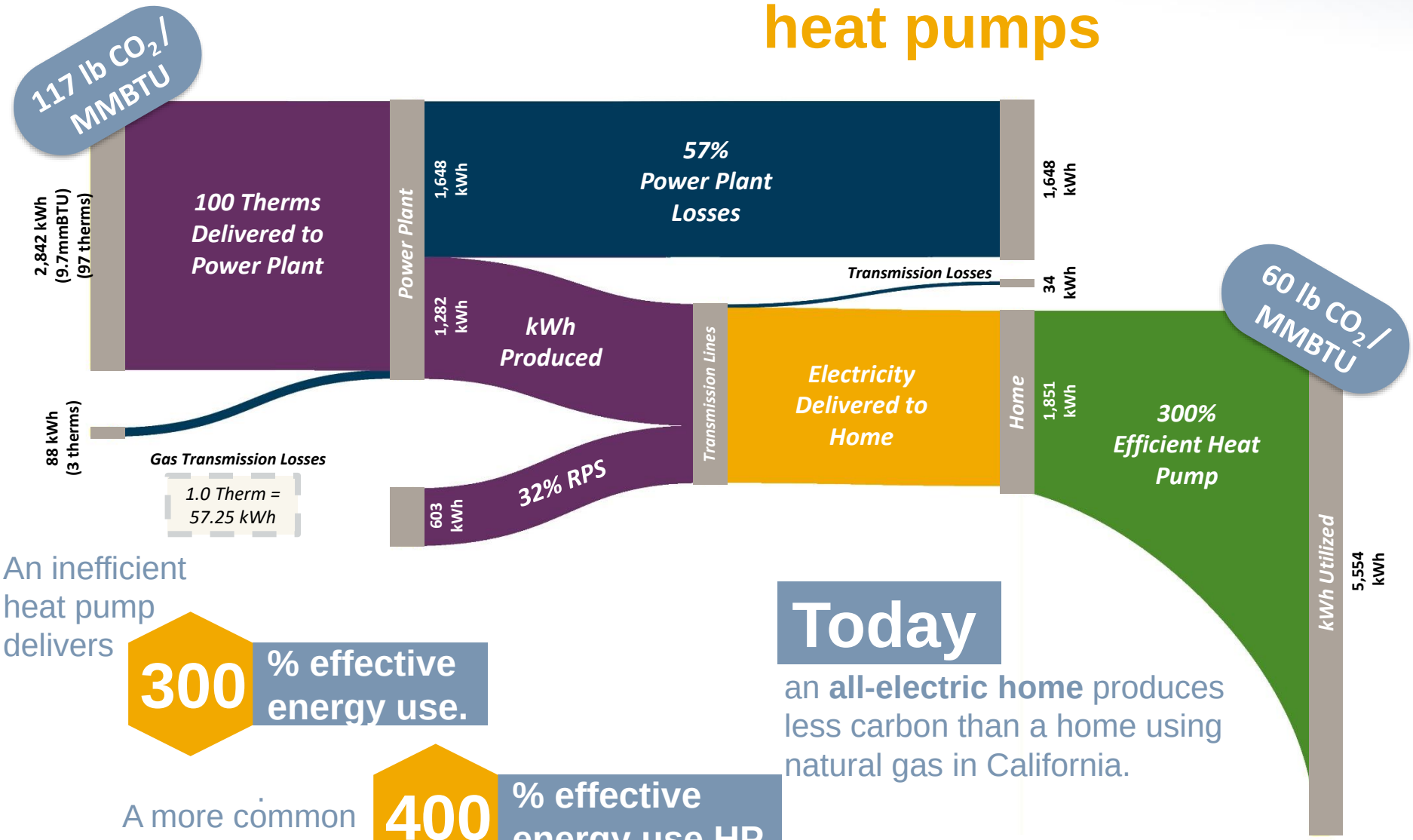


1.0 Therm = 32.45 kWh

In **11 years** the **electric grid** will be cleaner than using natural gas in California.

A home can easily last is well over **100 years**

Source Carbon Content: 2018 with heat pumps



An inefficient heat pump delivers

300 % effective energy use.

A more common

400 % effective energy use HP

= 44 lb CO_2 / MMBTU

Today

an **all-electric home** produces less carbon than a home using natural gas in California.

The Hardest Habits to Break

People care that they are comfortable and have hot water, they don't care what fuel source makes these happen

The only place most people interact with their fuel source is cooking – it is the hardest for them to give up.

Gas burners were estimated to add 25–33% to the week-averaged indoor NO_2 concentrations during summer and 35–39% in winter… For CO, gas stoves were estimated to contribute 30% and 21% to the indoor air concentration in summer and winter, respectively.

LBNL

Carbon monoxide is a deadly toxin. In one study, 51 percent of kitchen ranges tested raised CO concentrations in the room above the EPA standard of 9 parts per million. Five percent had carbon monoxide levels above 200 parts per million

Iowa State

The Hardest Habits to Break

Induction cooking is the future!

- ❑ No combustion
- ❑ Cooking surface is not directly heated
- ❑ Better temperature
- ❑ Faster cooking
  (95% effective; natural gas only 35% effective)
- ❑ Easy to clean

Thank You

Nic Dunfee,
Senior Project Manager

Ndunfee@trcsolutions.com

CALIFORNIA DREAMIN'
PATH TO NET ZERO ENERGY HOMES
CALIFORNIA ZERO-NET-ELECTRICITY NEW HOMES ENERGY CODE

RESNET CONFERENCE
FEBRUARY 2019
NEW ORLEANS, LOUISIANA

PIERRE DELFORGE AND DAVID B. GOLDSTEIN, PH.D.

NATURAL RESOURCES DEFENSE COUNCIL

PDELFORGE@NRDC.ORG AND DGOLDSTEIN@NRDC.ORG

CA has ambitious climate goals, but no explicit policy pathway to zero-emissions buildings yet

- 40% GHG reduction by 2030

SB 32 (2016)

Electric sector:
- 60% renewable / 2030
- 100% carbon-free / 2045

NEW!

SB 100 (2018)

- Carbon neutrality by 2045

NEW!

Gov. Exec Order (2018)

- 40% GHG reductions in buildings / 2030 (assessment)

NEW!

AB 3232

- $200M incentives for low-emissions buildings and equipment

NEW!

SB 1477

Regulators Have Agreed on Zero Energy Goals and Timetables

- Back in 2008 the California Energy Commission and the California Public Utilities Commission agreed to a goal of Zero Net Energy (ZNE) buildings:
  - Residential by 2020
  - Commercial by 2030
- This agreement spurred the Energy Commission to achieve greater reductions in energy use in the last four code cycles than had been the case before.
- Most recent (2019) residential code requires “zero net electricity”.
  - Solar is part of the prescriptive requirements

“Nothing is Better Than Zero”

- Zero Net Energy (ZNE) does not necessarily mean zero energy bills
- After Zero Net Energy facilities--or even stand-alone solar and wind energy--become common, Zero Net Energy does not mean zero emissions from the grid
- But the 2019 Title 24 takes steps in the direction of zero emissions

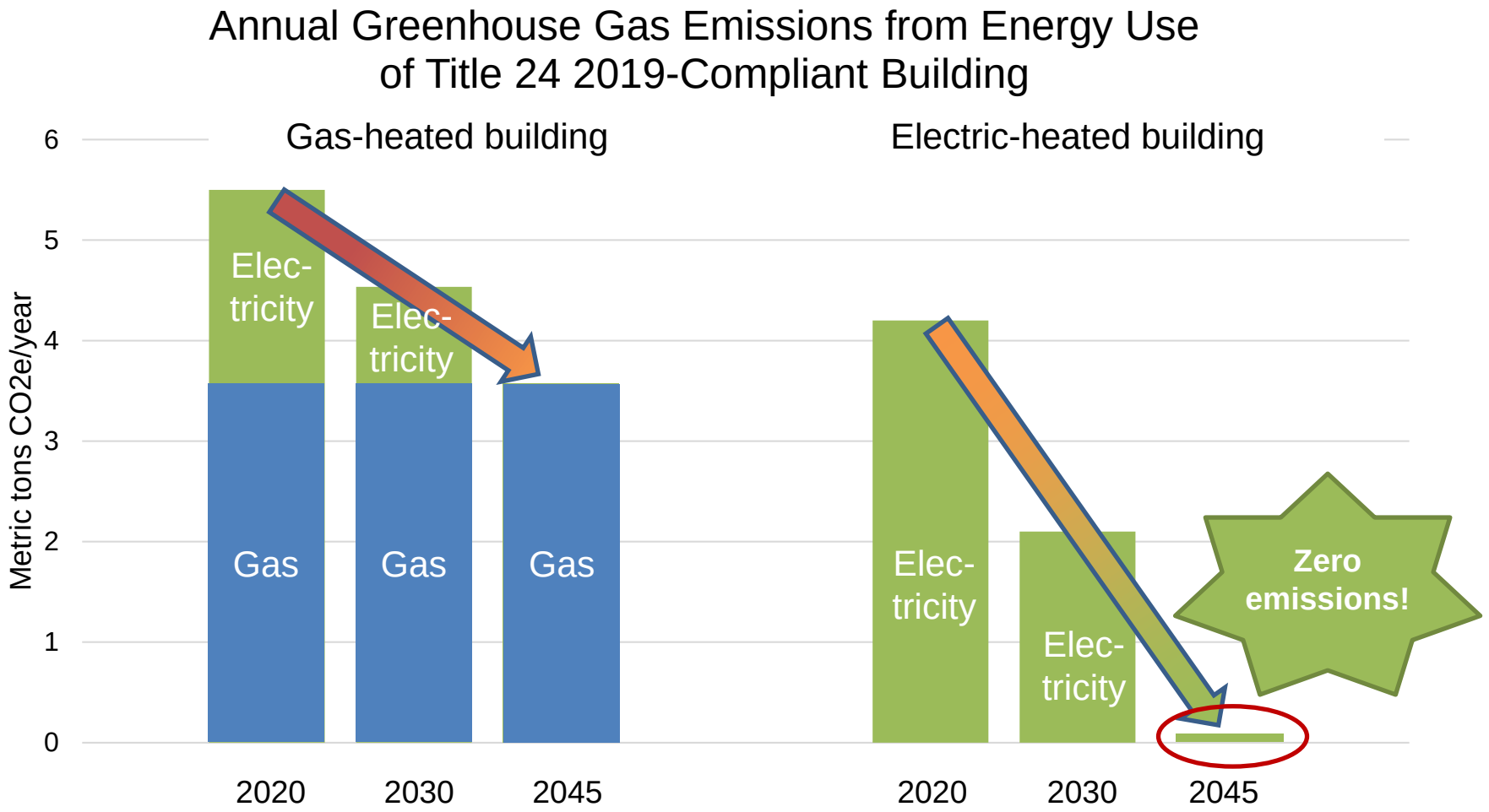
Title 24 2019 Residential: Key Advances

- Energy Efficiency
  - ✓ Solar/EE tradeoff now only for solar+battery. EE tradeoff limited to 2016 code EE requirements
  - ✓ High-performance walls, attics, windows, QII
- Independent gas and electric baselines for low-rise residential (similar to RESNET)
  - ✓ Level-playing field electric vs. gas
- Electric water heating ready
  - ✓ 240V dedicated outlet + breaker space in panel
- Variable capacity heat pumps
  - ✓ More favorable modeling in software (work-in-progress ACM)
- Heat pump water heater thermal storage
  - ✓ Credit for load shifting capability (work-in-progress ACM)

“Zero Net Electricity”

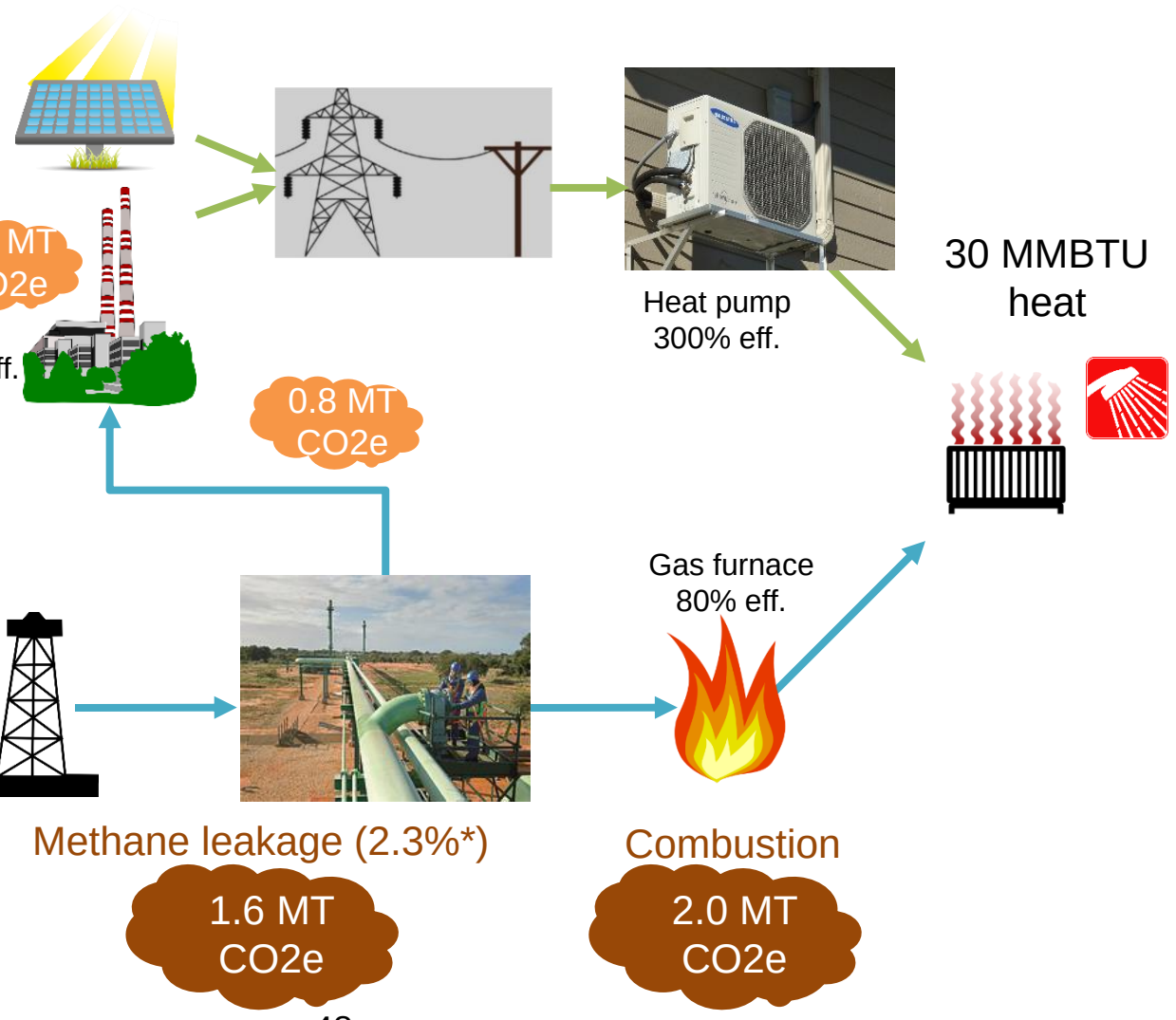
- Code only requires solar to offset as much electricity use (TDV) as mixed-fuel prototype
- Same for all-electric buildings (no solar “penalty” for going all-electric)
- Does NOT offset gas use (cost-effective constraints)
- Can add more solar than code minimum, but no compliance credit for the extra
- Also limited by CPUC connection rule
- Flexibility for solar: purchased, PPAs, lease, community solar

Electric Heat Offers Pathway To Zero Emissions



NRDC analysis, climate zone 13 (Fresno)
with rooftop solar. Including methane leakage

How about power plant emissions: Is electric heat really cleaner than gas heat?



NRDC calculations, climate zone 13 Fresno

* Alvarez A. et al, Science, 2018

Title 24 2019 Residential: Remaining Issues

- No longer penalizes all-electric, but still does not encourage it as the lowest emissions option
  - Still gas baseline for multi-family with central DHW and recirc.
- No standards for air-tightness (now different than RESNET)
- Inability to model central HPWH

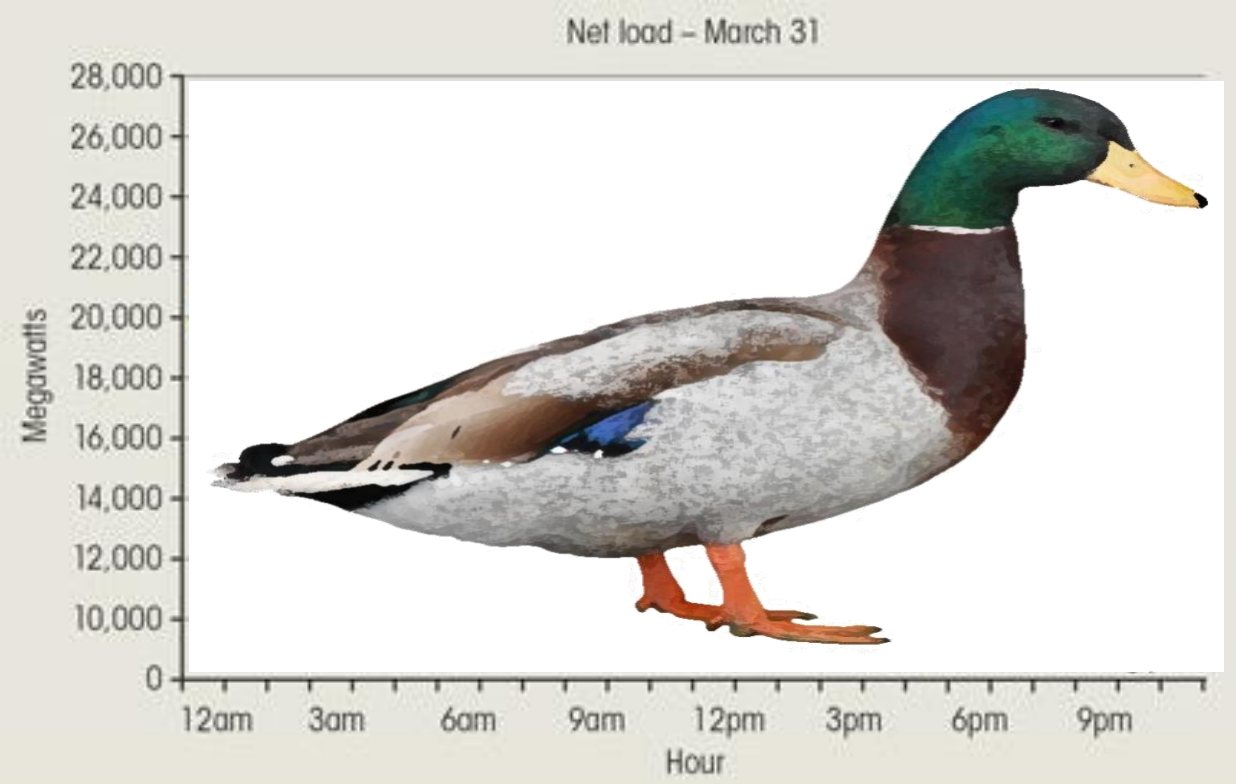
Title 24 2019 Non-Residential: Remaining Issues

- No mid-/high-rise multi-family prototype
- Same-fuel baseline for HVAC and DHW
- Issues with temperature maintenance in water heating loop modeling
- Heat loss from recirc not captured
- Return water temperature effect on COP/AFUE not captured
- DHW thermal storage modeling capability
- Inability to model air-tightness

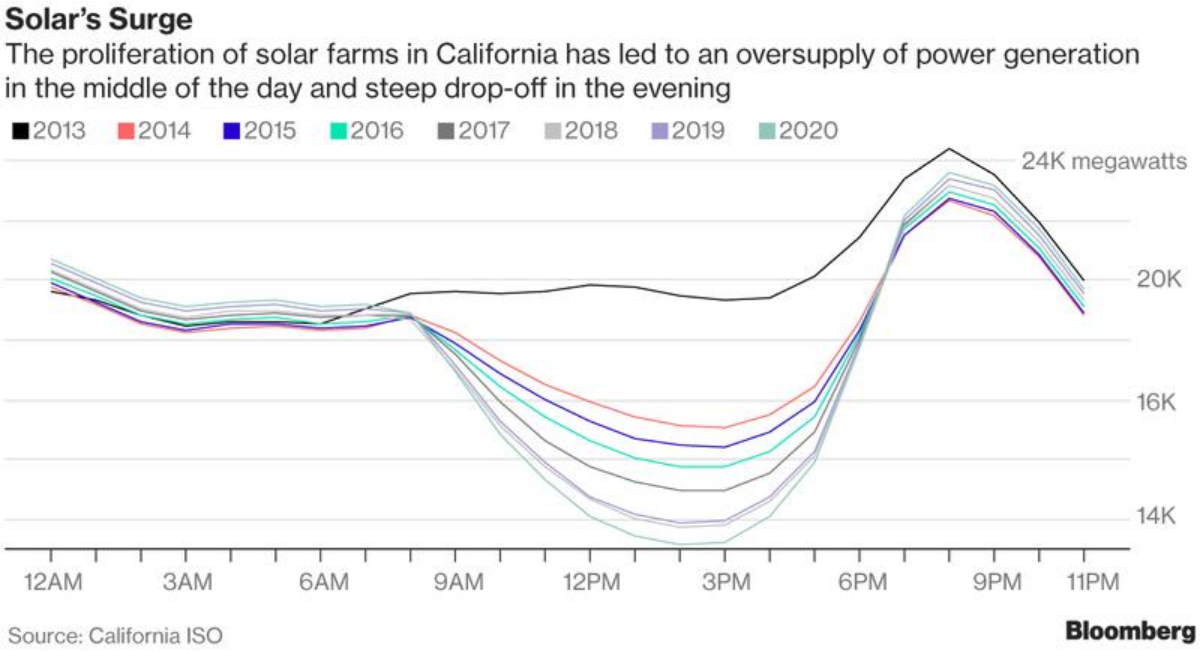
What about net zero emissions?

- As noted net zero energy equals net zero carbon only for a grid with minimal variable-output renewable energy sources. If most facilities achieve ZNE, this equality ceases to be the case:
  - Energy produced when the sun is shining is hard to use; and
  - Energy consumed after the sun goes down is more problematic
- There are two dimensions to this mismatch: Diurnal and Seasonal
  - Energy storage is not difficult (but not cheap) on a diurnal basis
  - but storage more challenging on a seasonal basis

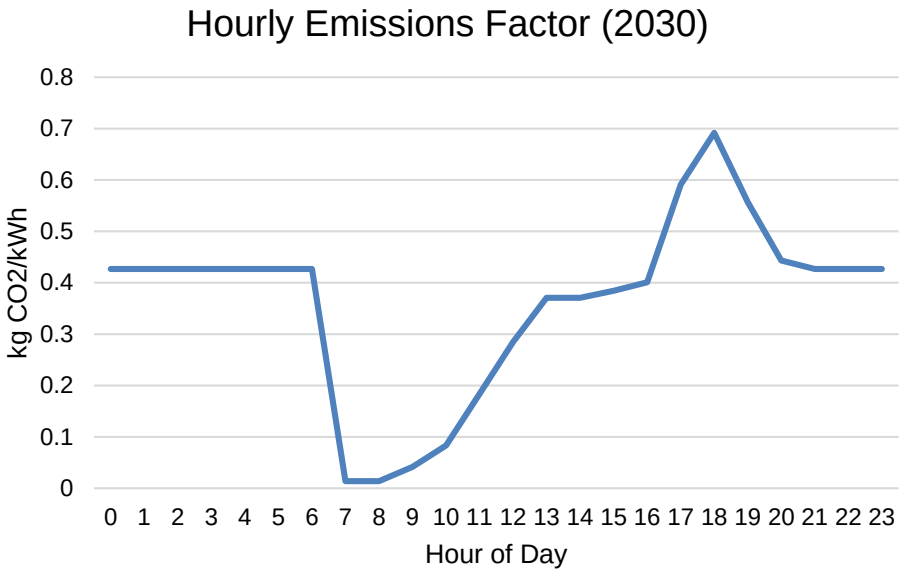
Diurnal Variation: the “Duck Curve”



This is the duck (net electricity loads in California vs. time of day)



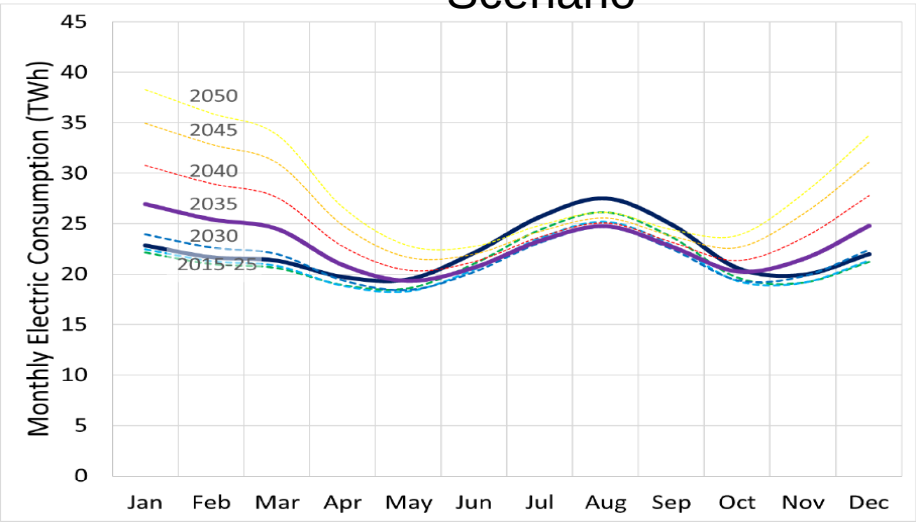
California GHG Emissions Factors 2018



* CPUC Avoided Cost Model 2018: http://www.cpuc.ca.gov/General.aspx?id=5267

Energy efficiency remains essential to address annual variation

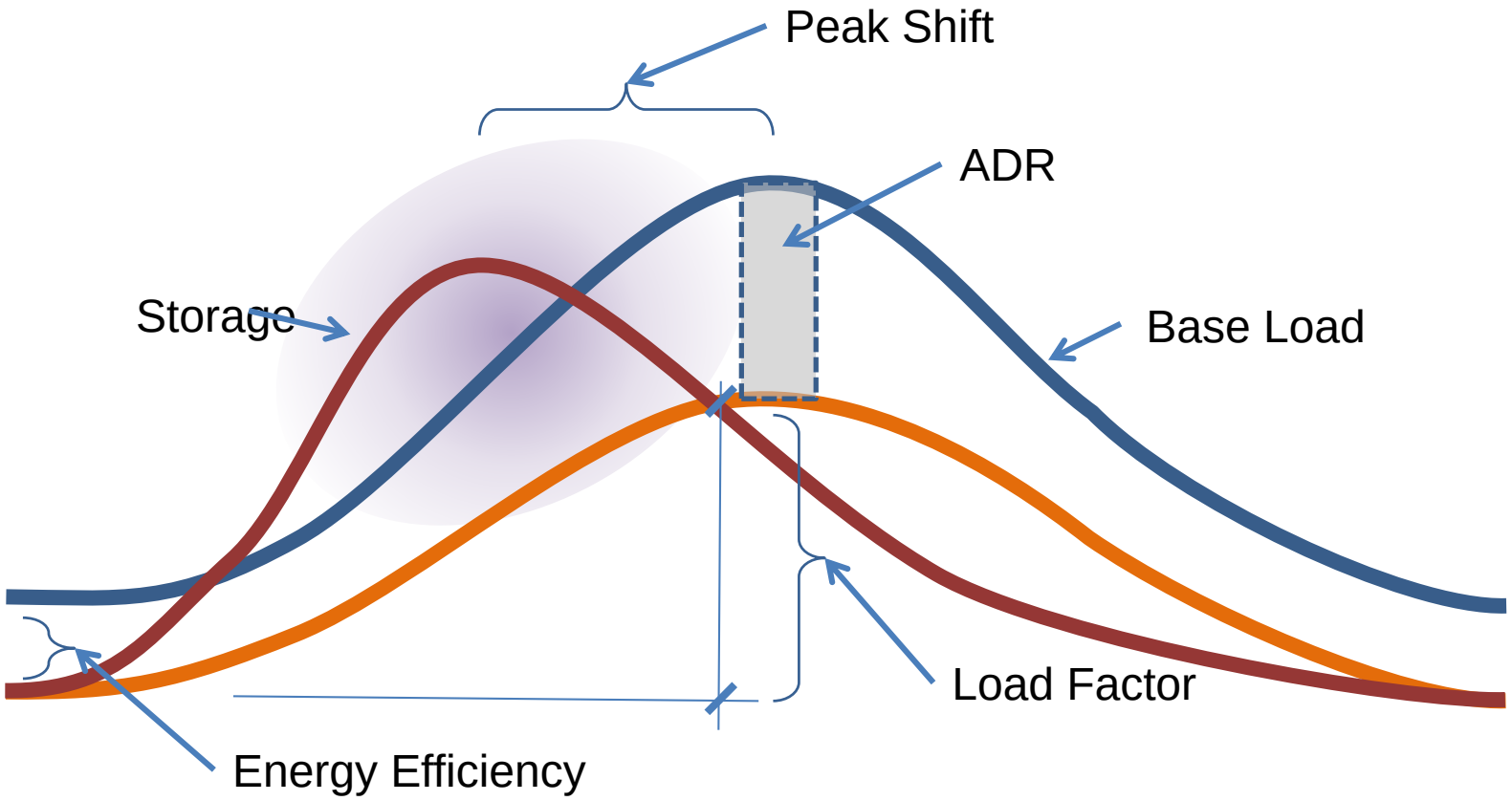
Potential Shift to Winter Peak Under High Electrification Scenario



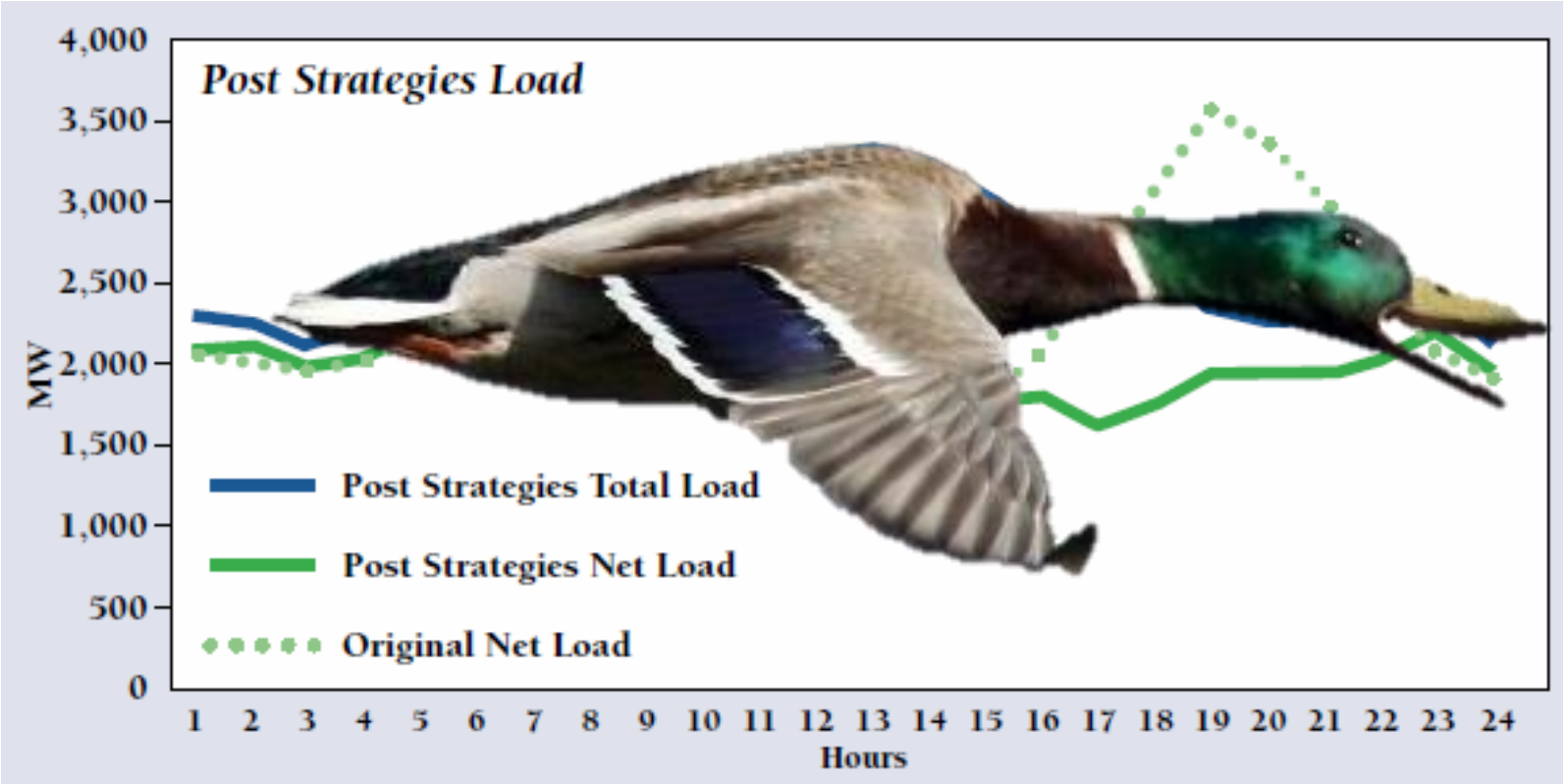
NEEP: Northeastern Regional Assessment of Strategic Electrification, July 2017

https://neep.org/strategic-electrification-regional-assessment

Building Load Curve



Teaching the Duck to Fly”



But these methods are not recognized in Title 24 or RESNET 301

- They would require weighting energy use by an hourly “source multiplier”
- They would require algorithms for modeling user-controlled or grid-controlled actions to shift time of use
  - Running water heater only when factors are low
  - Charging and discharging batteries, both standalone and in cars
  - Slowing down air conditioner/heat pump when factors are high
  - Postponing appliance use, refrigerator defrost, etc., subject to user override
  - Dimming lights or turning them off automatically

Conclusions

- ZNE goal led to major improvements in residential Title 24
  - Even though the 2019 code is not all the way there, it is far stronger than it would have been otherwise
- The code should evolve toward Zero Emissions Buildings (ZEB)
  - When coupled with future changes to encourage electrification, Title 24 methods could accommodate time of use emissions factors to provide Zero Emissions

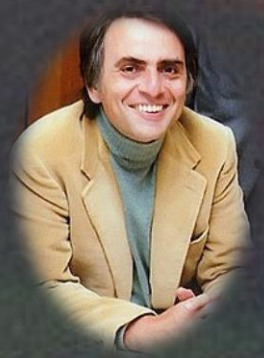
California Hourly Site-to-Source Energy Conversion Factors and GHG Emissions

Charles Kim, P.E.

Southern California Edison

2019 RESNET

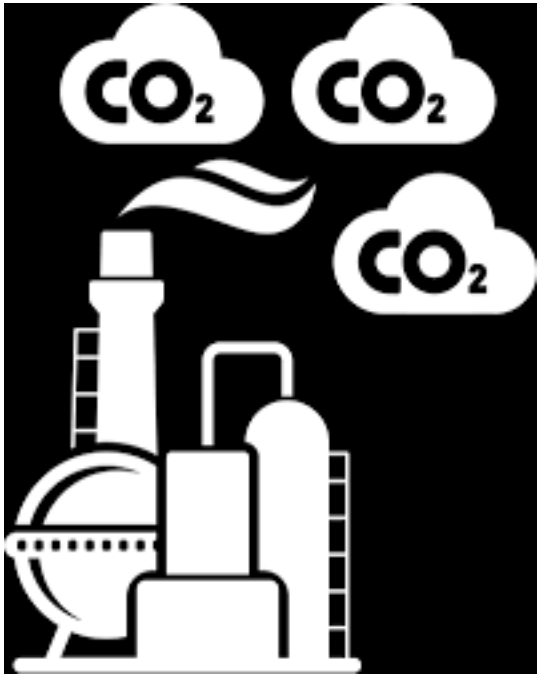
Blue Pale Dot



- "… In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves…. *To my mind, there is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly and compassionately with one another and to preserve and cherish that pale blue dot, the only home we've ever known*." --- *Carl Sagan*

How to Count for GHG from the Use of Energy?

Counting: Δ GHG emission / Δ Generation



- Non-Renewable Generators
  - EPA monitors emissions continuously
  - CA ISO records MW and MWh
    - Imports
    - Exports
    - Curtailment

How about from My Home?

- Data Source:
  - Electric Bill
  - Gas Bill
- How much GHG emissions from my energy use?
  - *Simply multiply by the EPA's GHG emission factor to your energy usage?*

Energy: From *[Generation]* Source to *[Building/Home]* Site

Heat Rate

CO_2

T&D Loss

CO_2

1

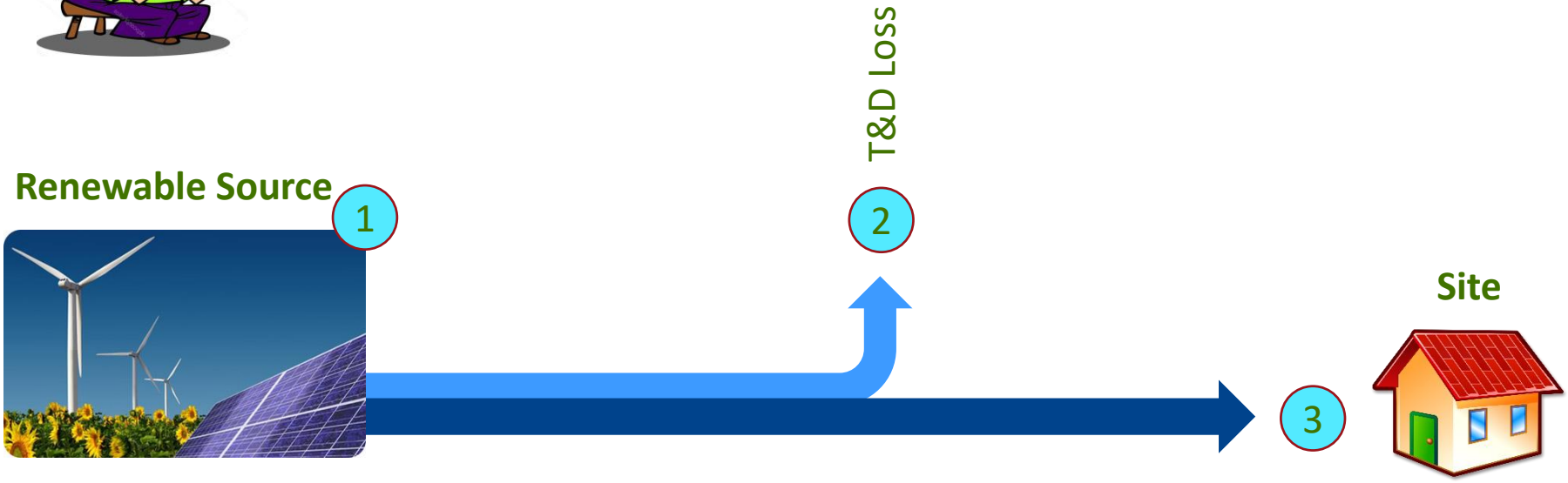
2

3

Non-Renewable Source

Site

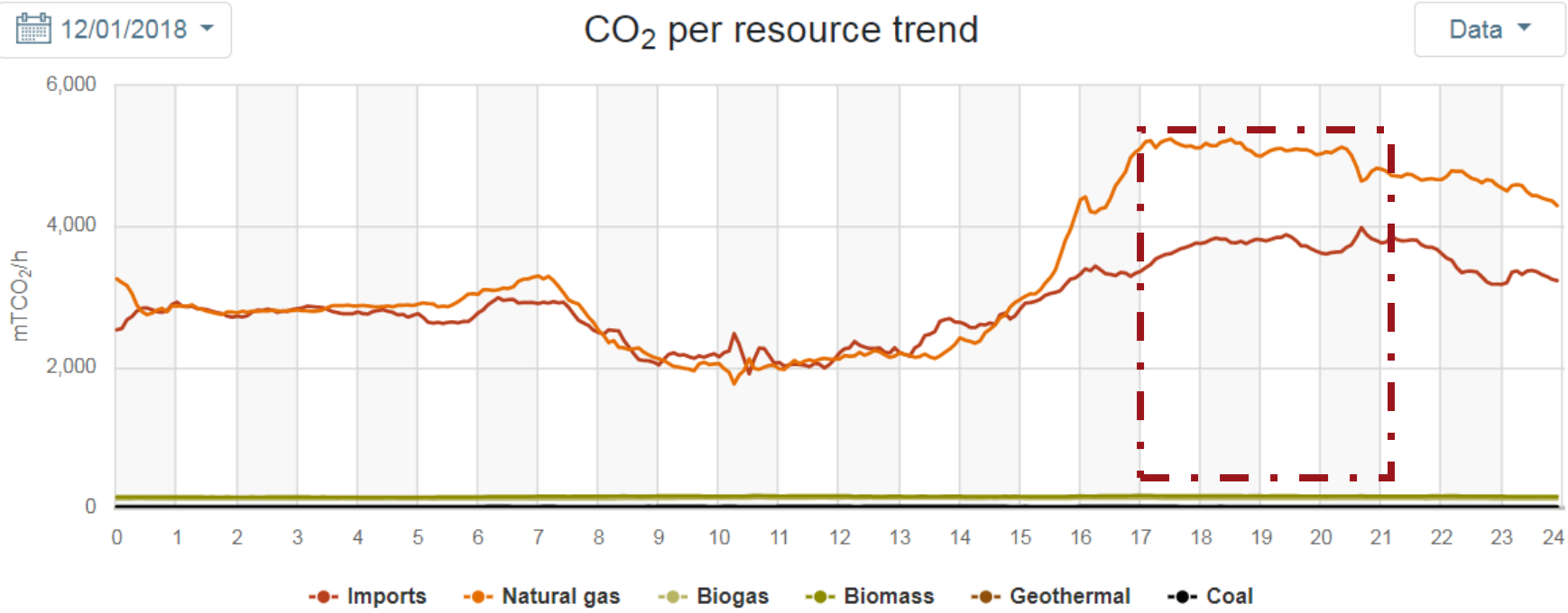
Energy: From *[Generation]* Source to *[Building/Home]* Site



Does GHG emission rate change over a day?

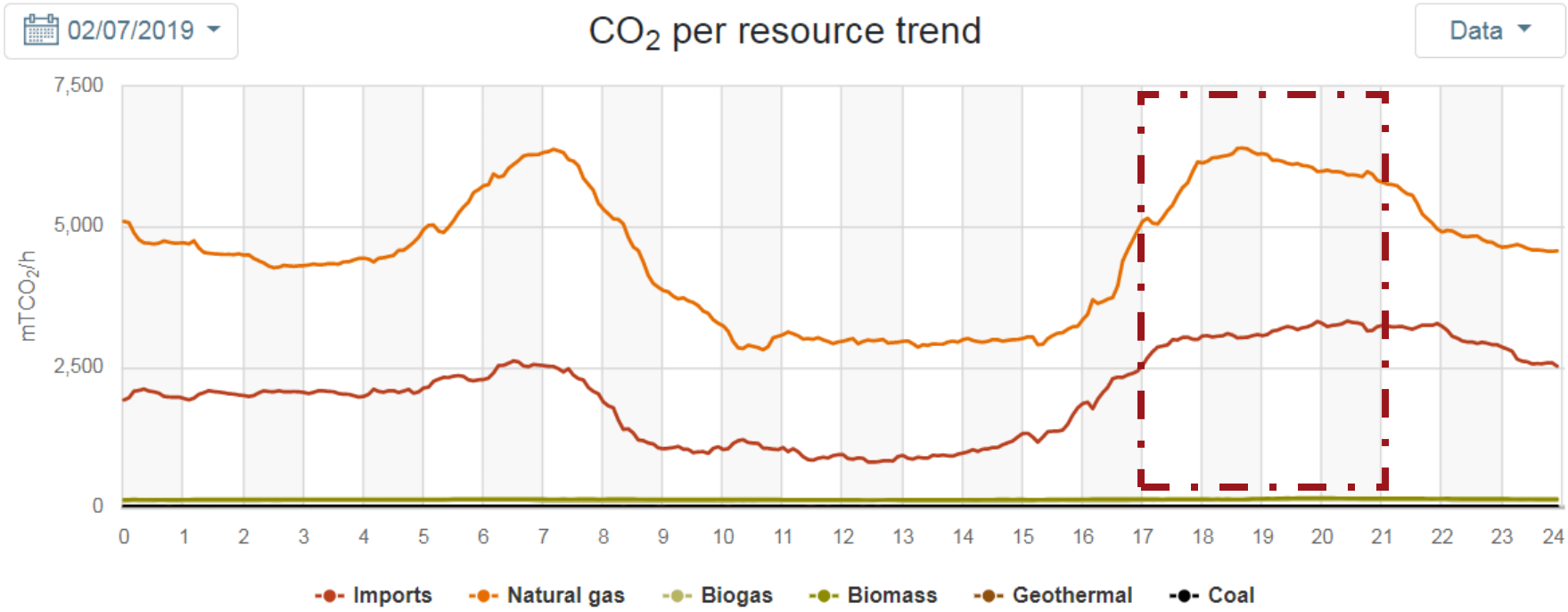
GHG Emissions per Fuel Type

Today's Outlook | Demand | Supply | Prices | Emissions | AS OF 08:35 12/04/2018

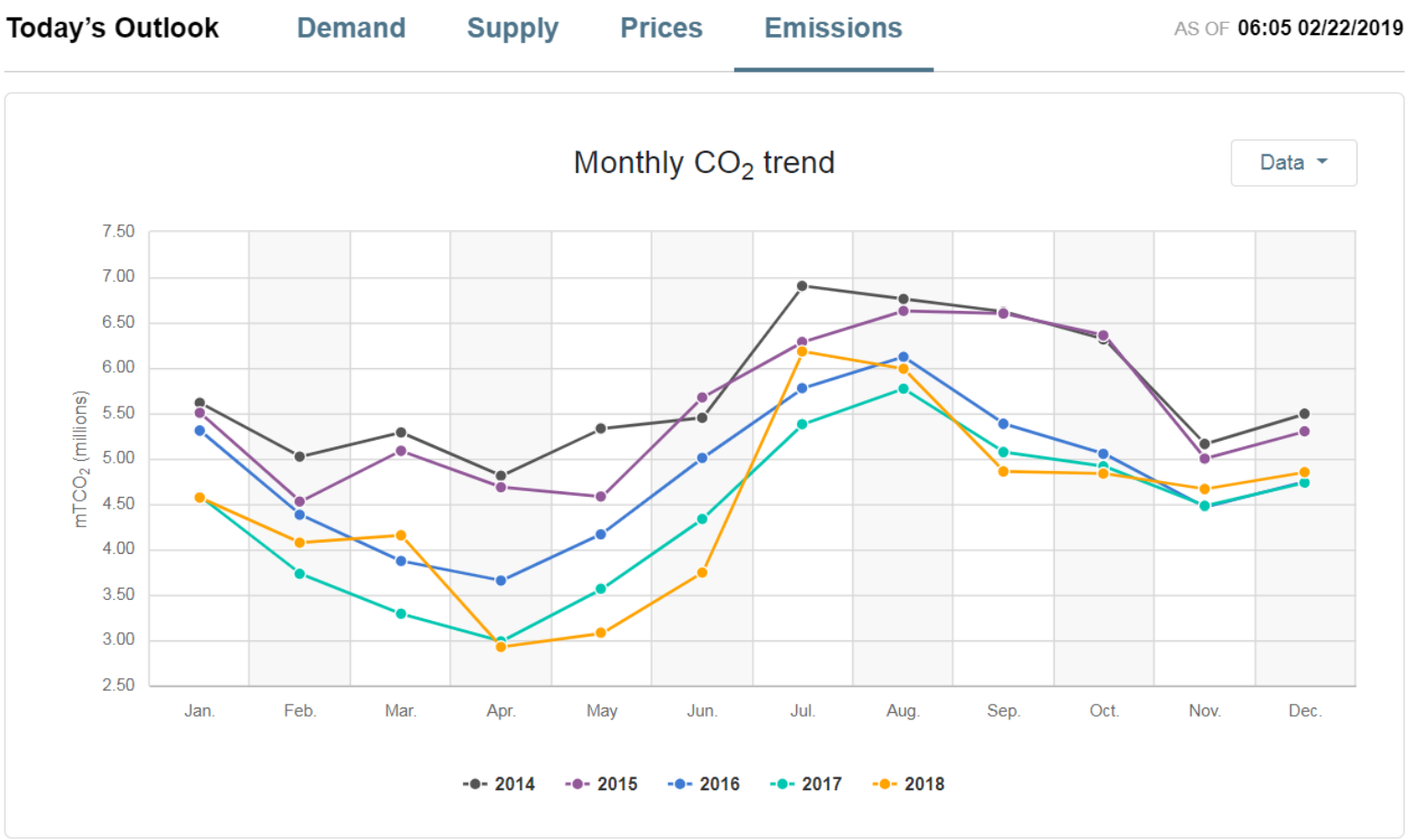


[Source: California ISO, http://www.caiso.com/TodaysOutlook/Pages/Emissions.aspx]

GHG Emissions per Fuel Type



Impacts of CA Renewable Portfolio Standard



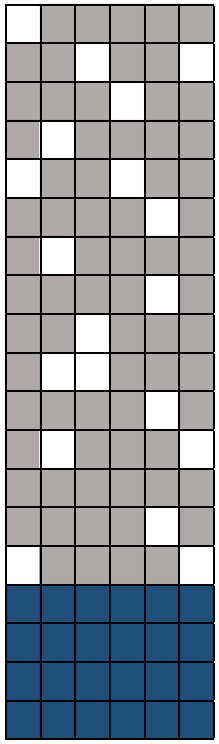
[Source: California ISO]

Site Energy Needs from GHG Perspective

Determine/Estimate Site Energy Needs

How much energy does this building need?

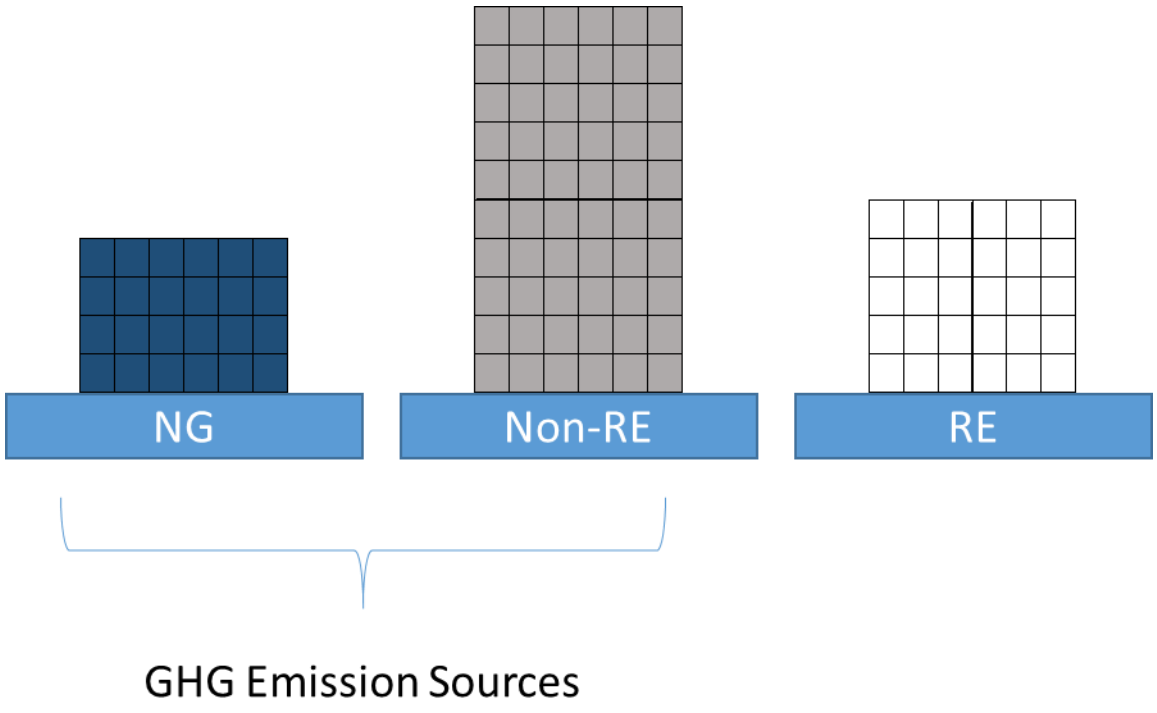
Suppose these boxes represent hourly site energy needs by fuel types



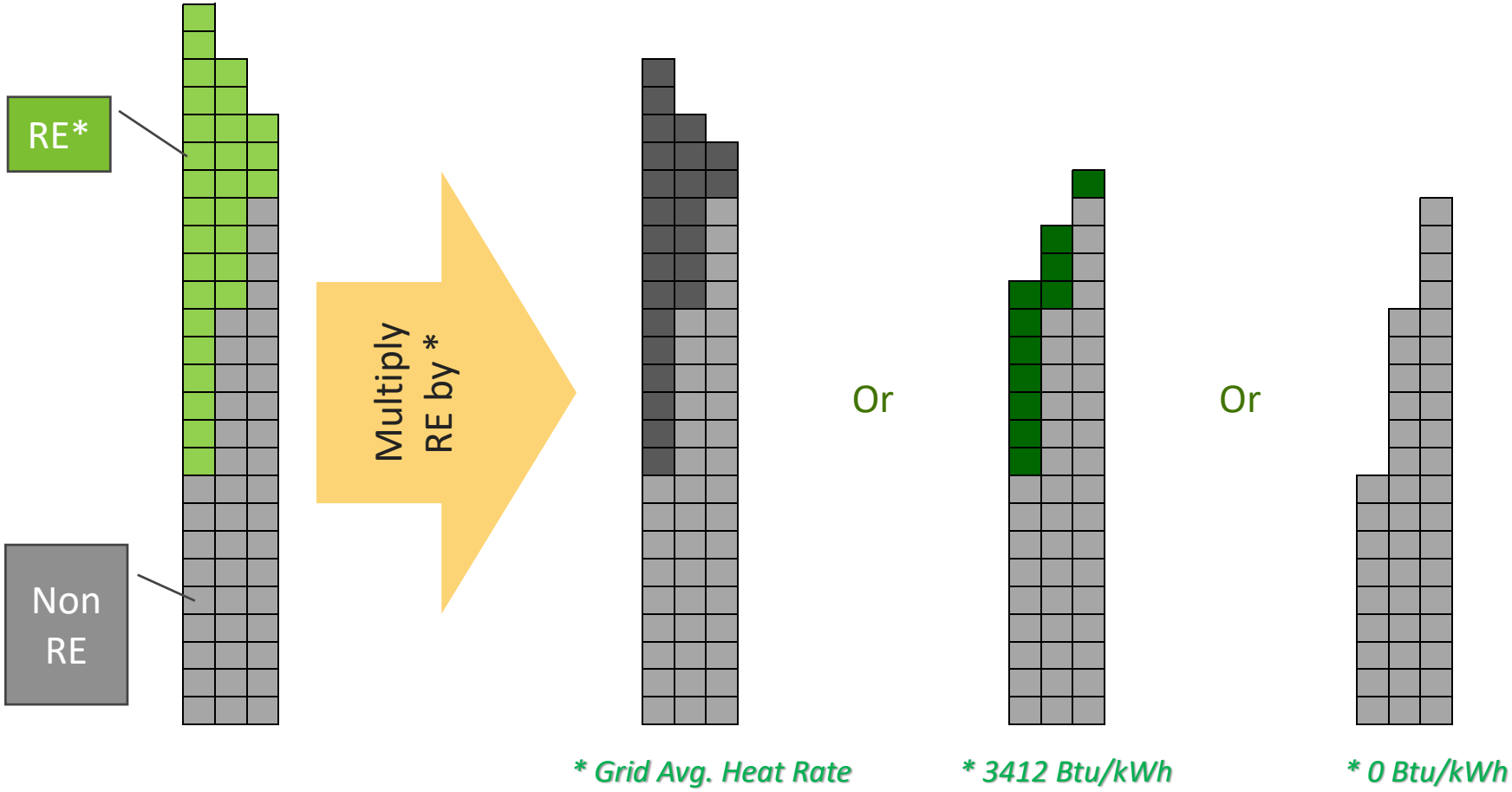
Electricity
RE and Non-RE

Natural Gas (NG)

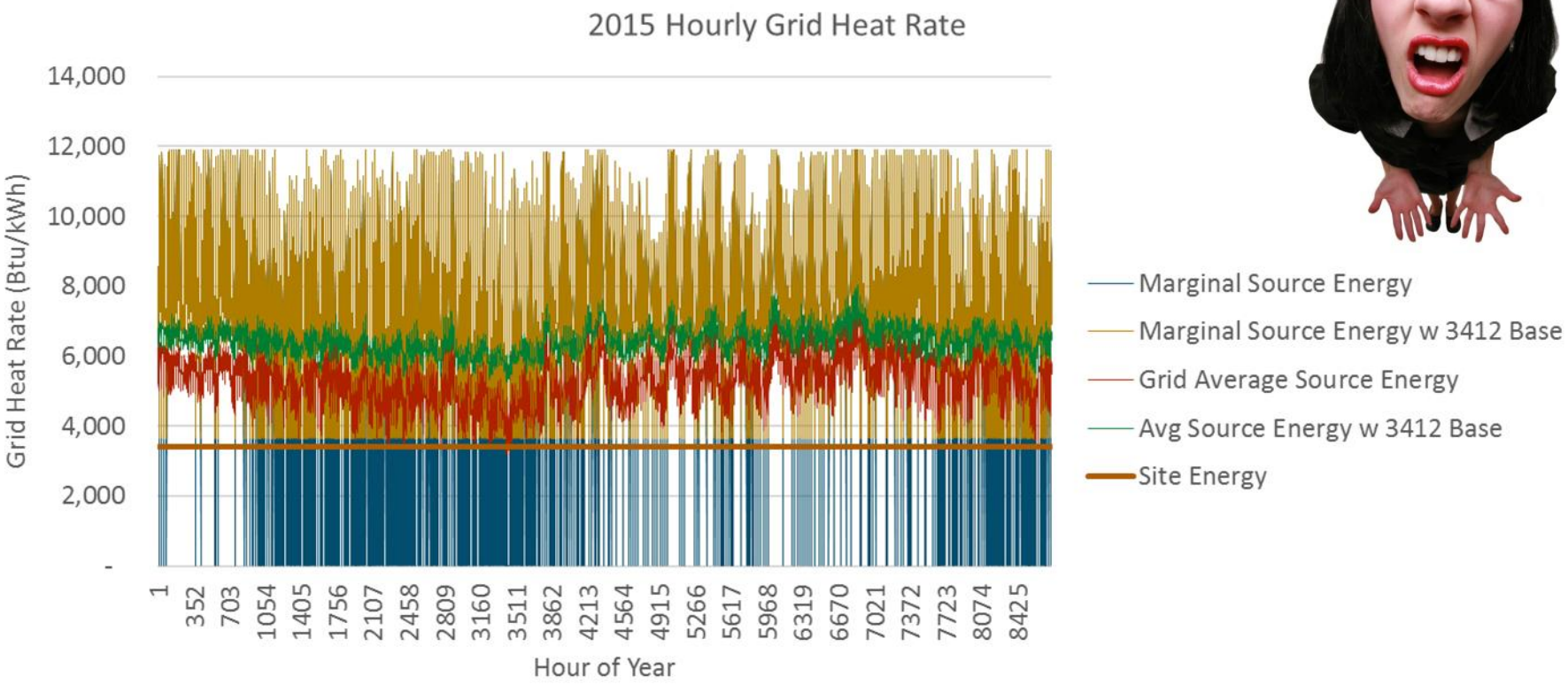
How to Separate Non-RE from RE?



How to Calculate “Non-RE” from Grid?

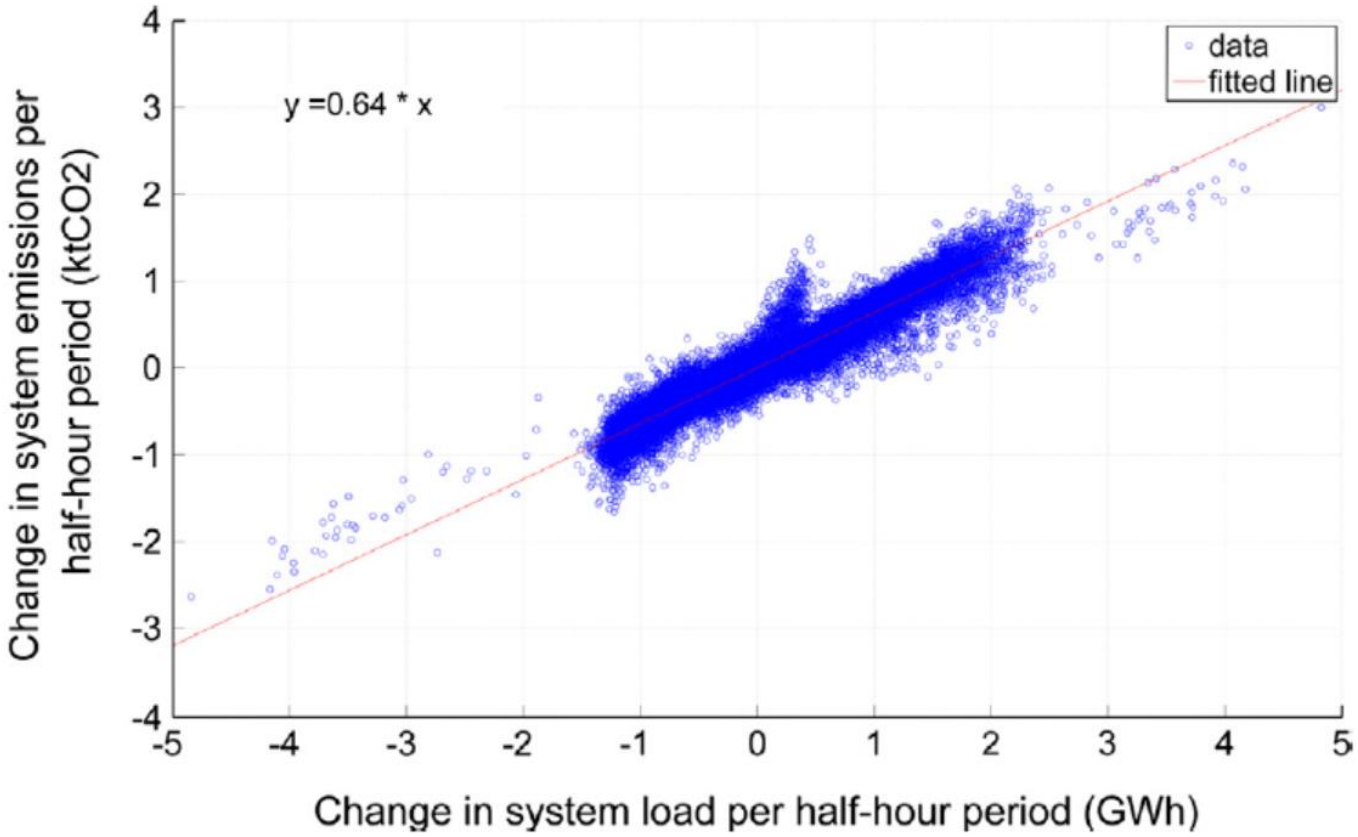


Why not apply “Heat Rates” to Non-RE?



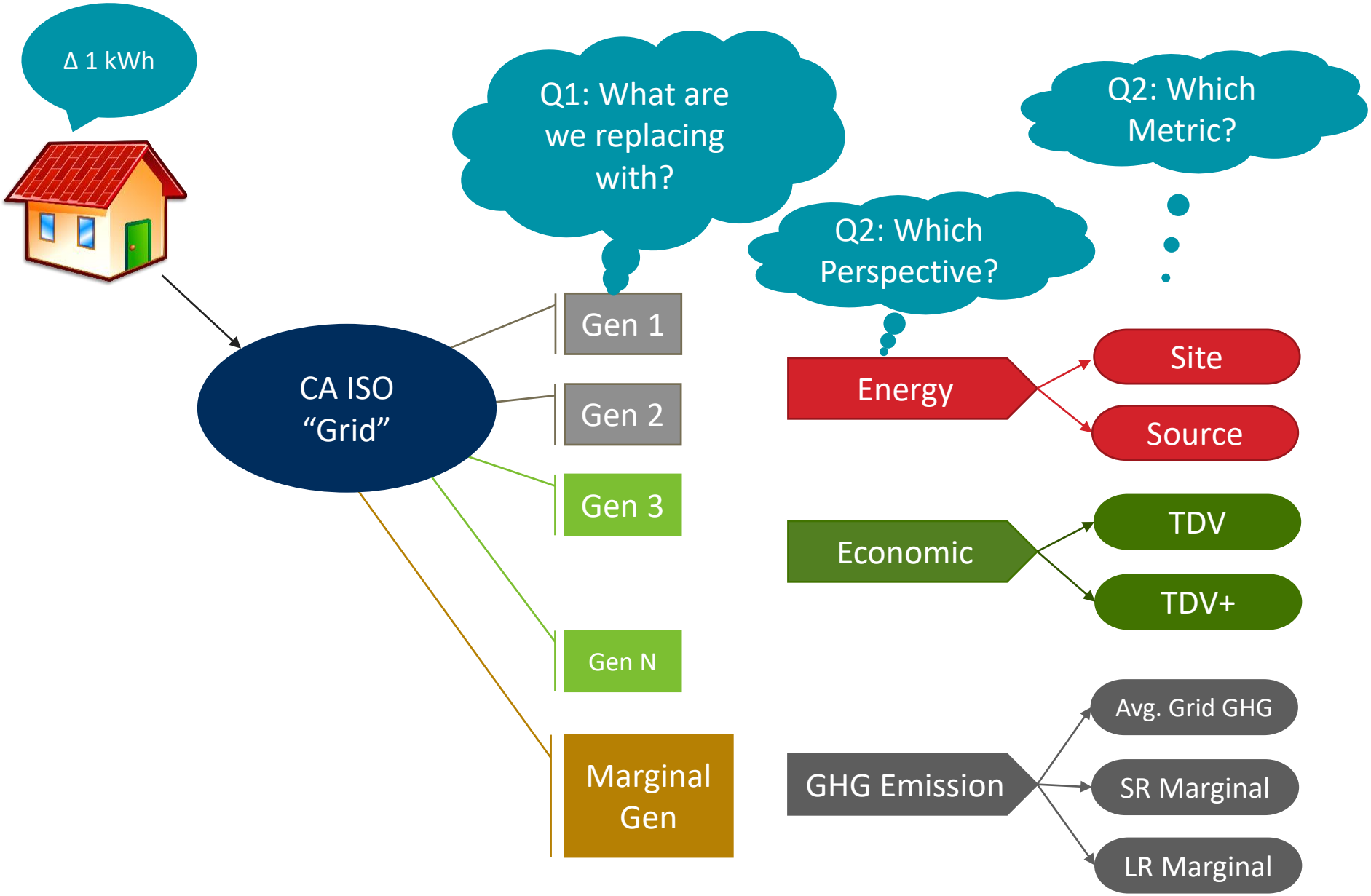
Can we correlate Electricity to GHG?

Presumption Valid? – Yes.



Ref: "Long-run marginal Co2 emissions factors in national electricity system," A.D. Hawkes, Applied Energy, 2013

Which generators are we replacing when DMS occurs at a site?


Δ 1 kWh
Q1: What are we replacing with?
Q2: Which Metric?
Q2: Which Perspective?
CA ISO "Grid"
Gen 1
Gen 2
Gen 3
Gen N
Marginal Gen
Energy
Site
Source
Economic
TDV
TDV+
GHG Emission
Avg. Grid GHG
SR Marginal
LR Marginal

How to give various credits to building designers/owners?

Energy Needs

From the Grid
60 kWh (Non-RE)
40 kWh (RE)

Choice

R.E. Generated

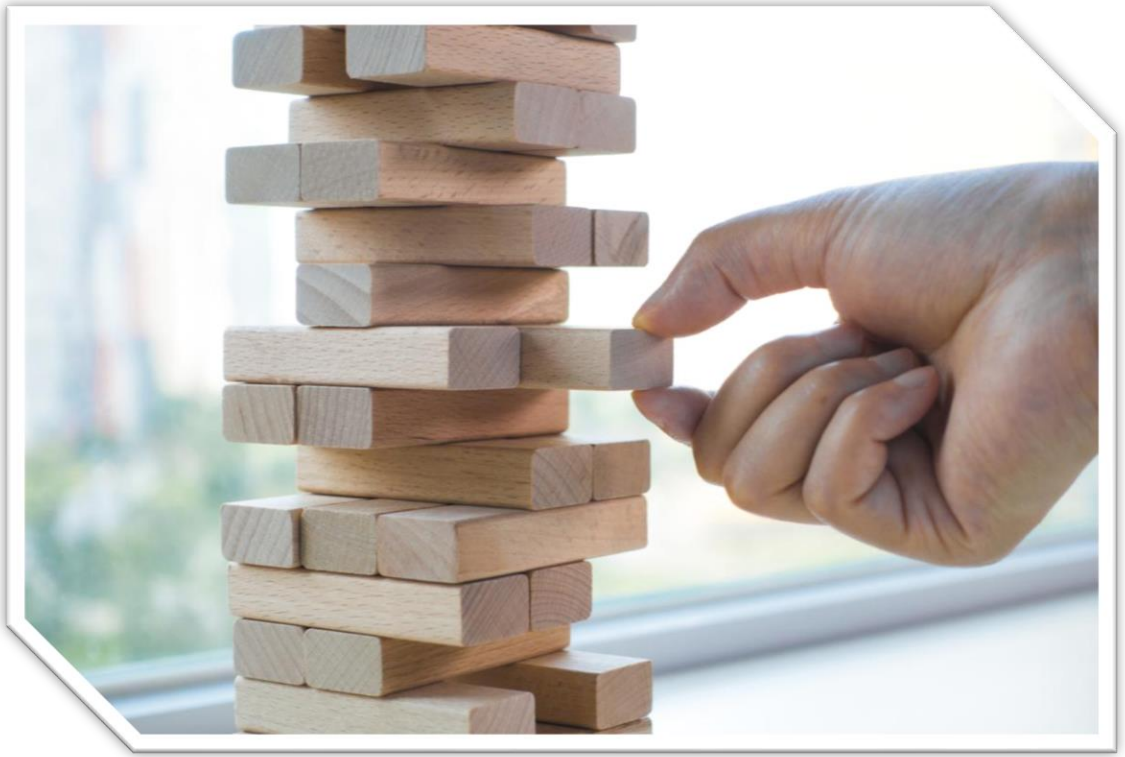
Site PV
50 kWh (RE)

How to
Credit the PV
for Site Energy Need?

Credit Method 1

Credit Method 2

Unintended Consequences?



Issues/Challenges/Opportunities

- Challenge: How should we account for energy efficiency, energy conservation, and renewable generation efforts at a site and reflect them at the generation source?
- How do we treat EE, Renewable Energy, and Bldg. Controls? Equally???
- Some measures/appliances can reduce more GHG than others; therefore, hourly schedules for building simulation become critical.
- WIP – Impacts on Building Simulation Results by new metrics…