AIA 1 LU/HSW

Energy Decarbonization Blueprint

AIA LA – July 2024

Speaker

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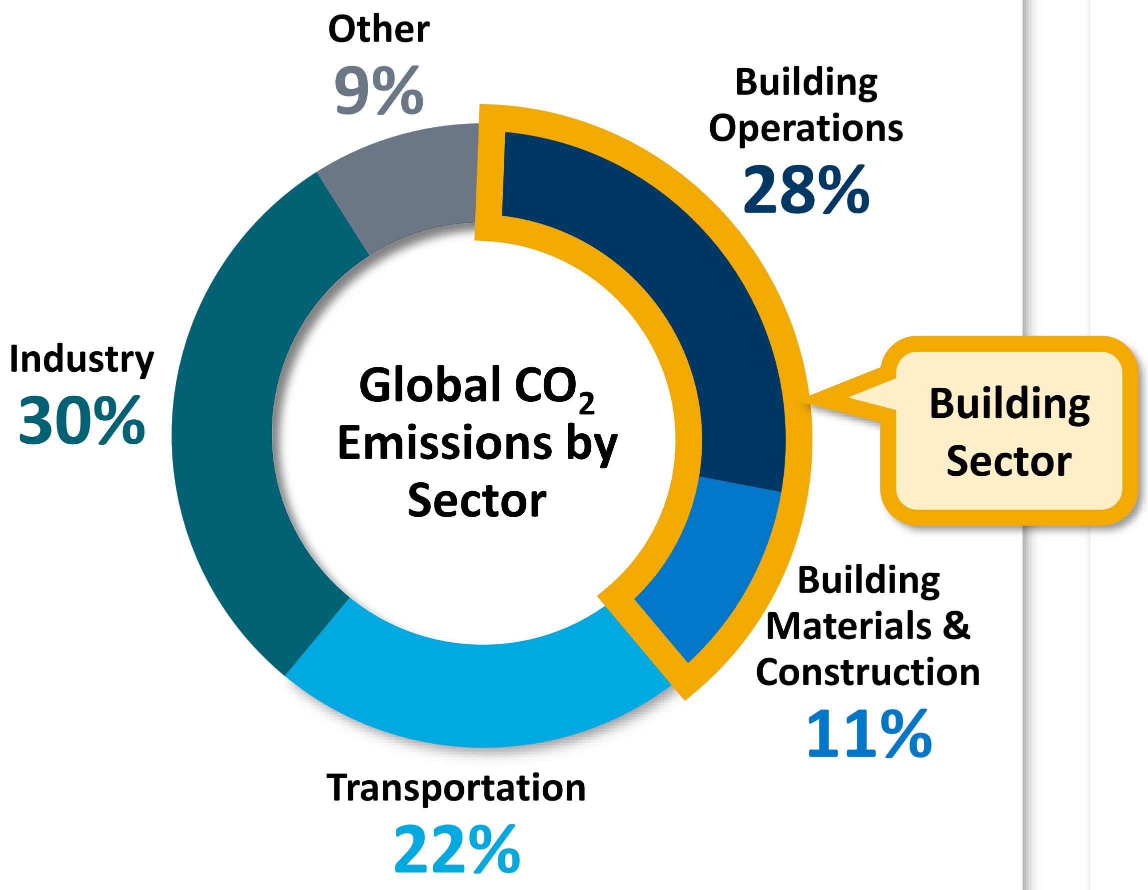
Abstract and Learning Objectives

Utilizing **four case studies**, this course explores how to create a new blueprint for energy decarbonization that aligns with the changing electric grid. An overview of energy infrastructure changes that are taking place in the state of California will be provided alongside how these changes impact the types of building systems being considered for a multi-family building, a school, a healthcare project, and an office building. The course will explore the carbon impacts of each case study both today and in the future as the electric grid continues to decarbonize utilizing expected average carbon emissions for 2030 and 2050.

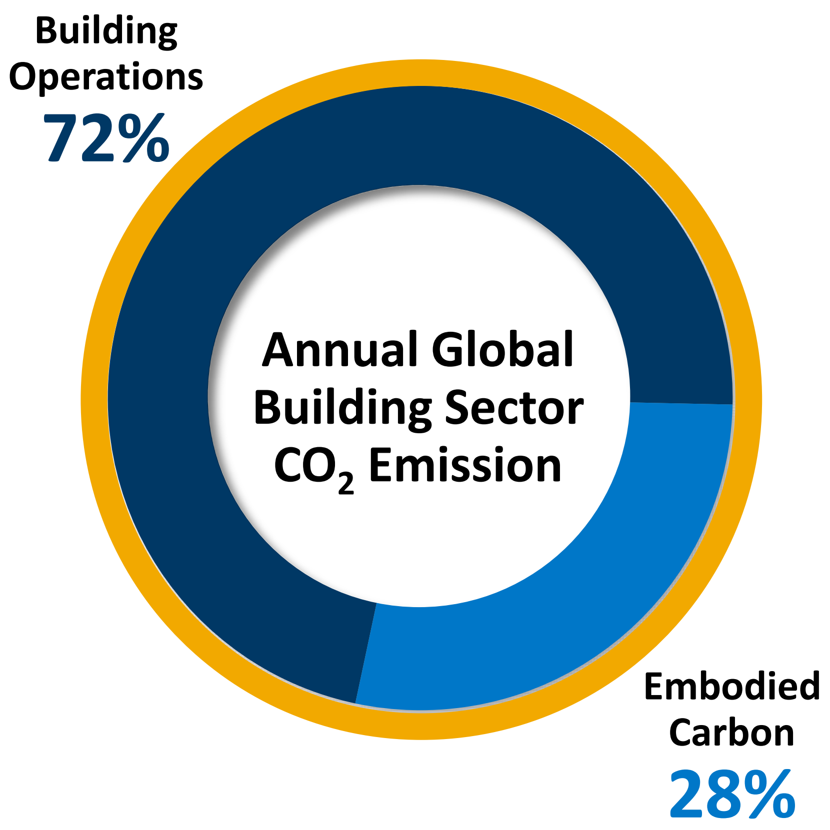
Learning Objectives:

1. Identify how the decarbonization of the CA electric grid impacts the built environment
2. Describe challenges and opportunities in decarbonizing typical project types from an energy standpoint
3. Describe the difference in decarbonization impacts between today's grid and the expected grid in 2030 and 2050
4. Create an energy decarbonization blueprint for your firms' projects

Buildings’ Contribution to Carbon Emissions



Source: Architecture 2030, Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017



Source: Architecture 2030, EPA International Energy Outlook

Architects Value Sustainable Design But...

- Clients aren't interested or asking for it
- Budgets are too tight
- Developers don't care about ongoing maintenance and energy costs
- Paybacks are too long
- Timeline is too short to consider options
- Contractors or Facility Managers aren't comfortable with it
- Measures just get removed in value engineering
- Not in our scope of work
- It's the engineer's problem to solve
- Not required by code

Buildings with high operating carbon

- Slow the transition to clean energy
- Are less adaptable and resilient, causing…
  - Faster depreciation
  - Decreased profits
- Vulnerable to future policy changes
  - Higher utility rates
  - Carbon taxes
- Potential to become stranded assets

Electricity as a power source is relatively young

Electricity installed in childhood home

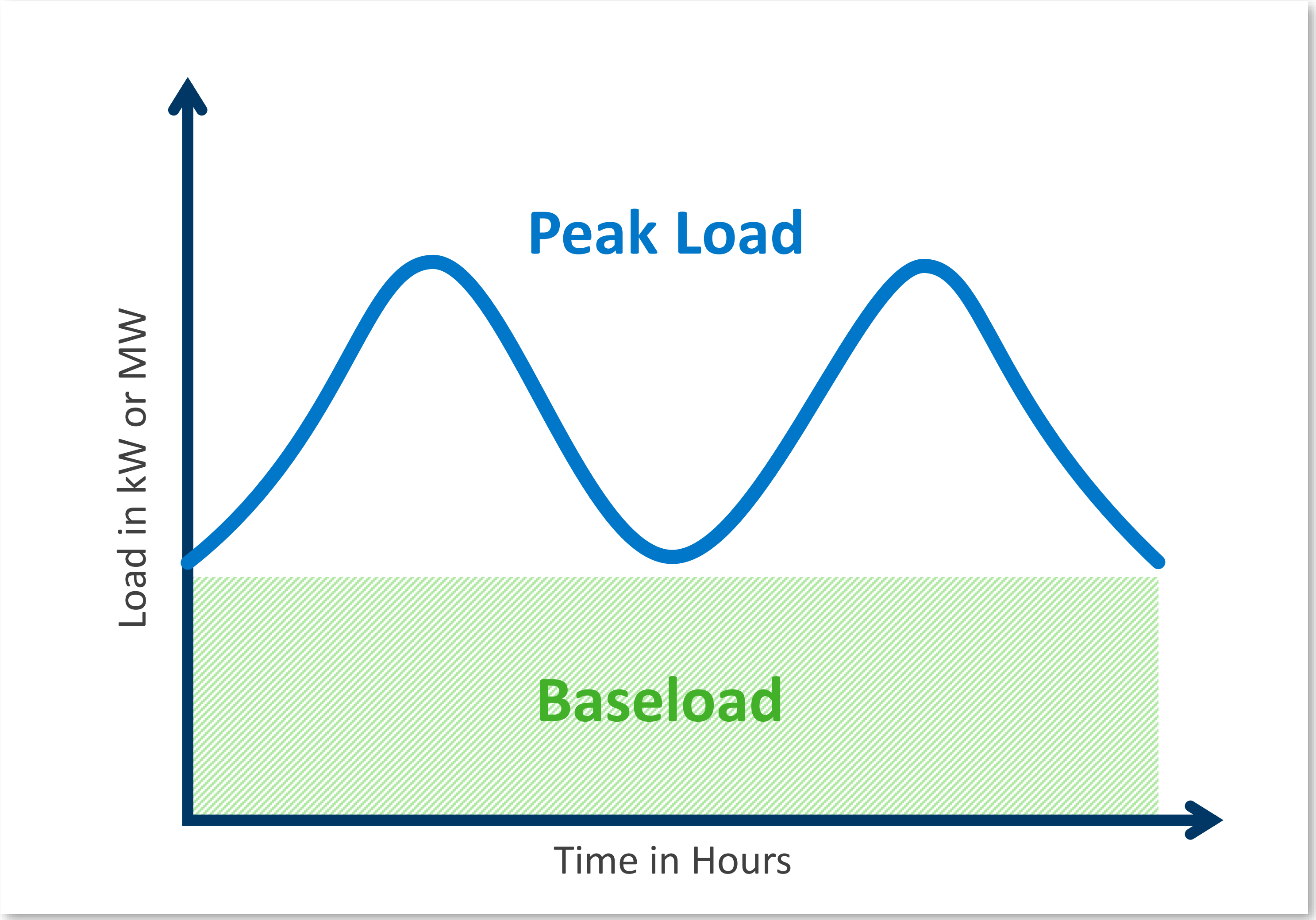
This home had an electric washing machine and refrigerator

Cable TV just in time for retirement

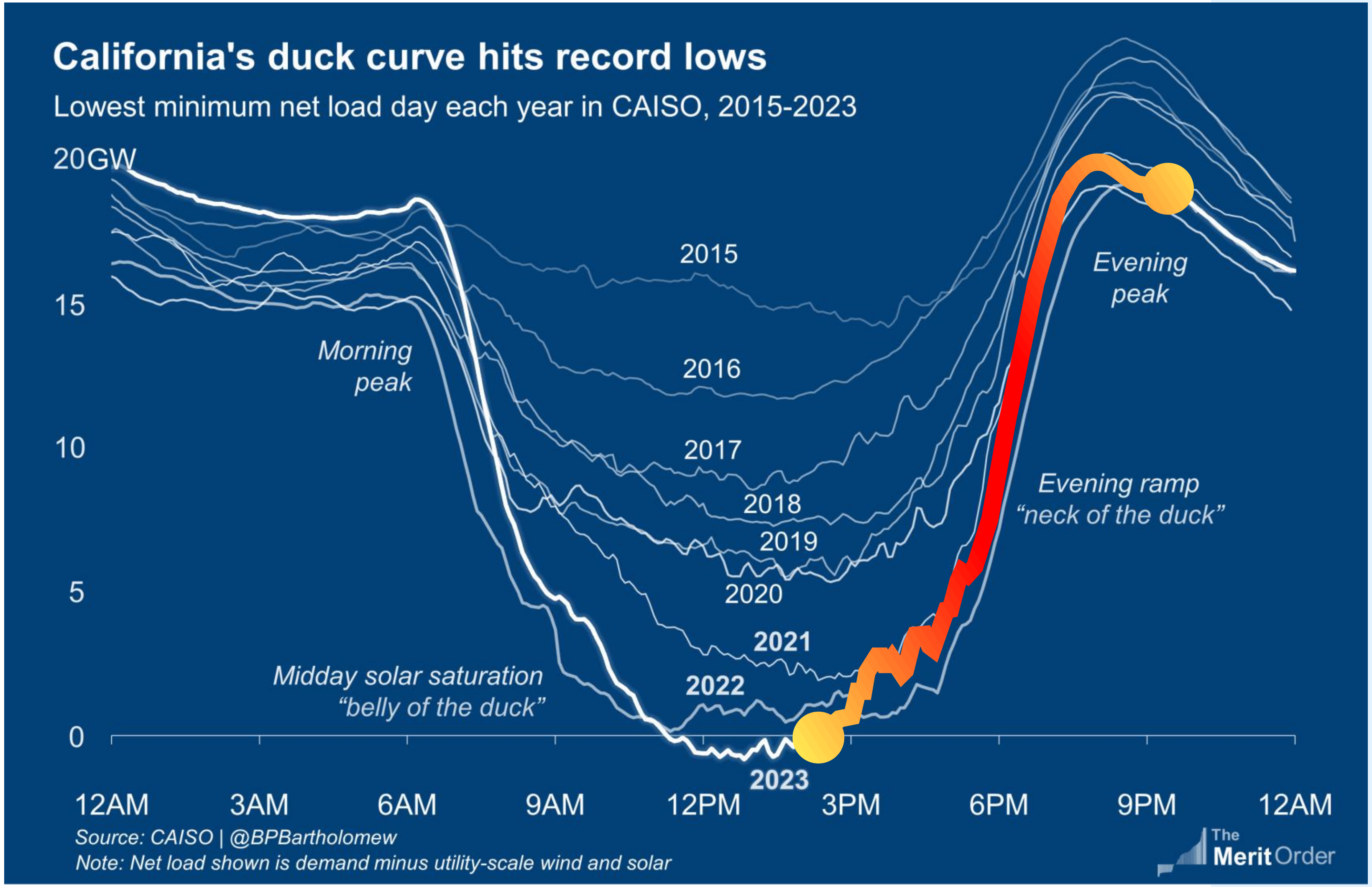
Keeps in touch with great-grand children via FaceTime

- Electricity is a luxury for the privileged few
- In 1925, only 50% of homes had electricity
- "Electricity is a modern necessity of life." (Franklin Roosevelt, at Rural Electrification Administration celebration, 1938)
- Electricity becomes affordable, reliable, and accessible
- Electricity is fundamental human right

Electricity Production



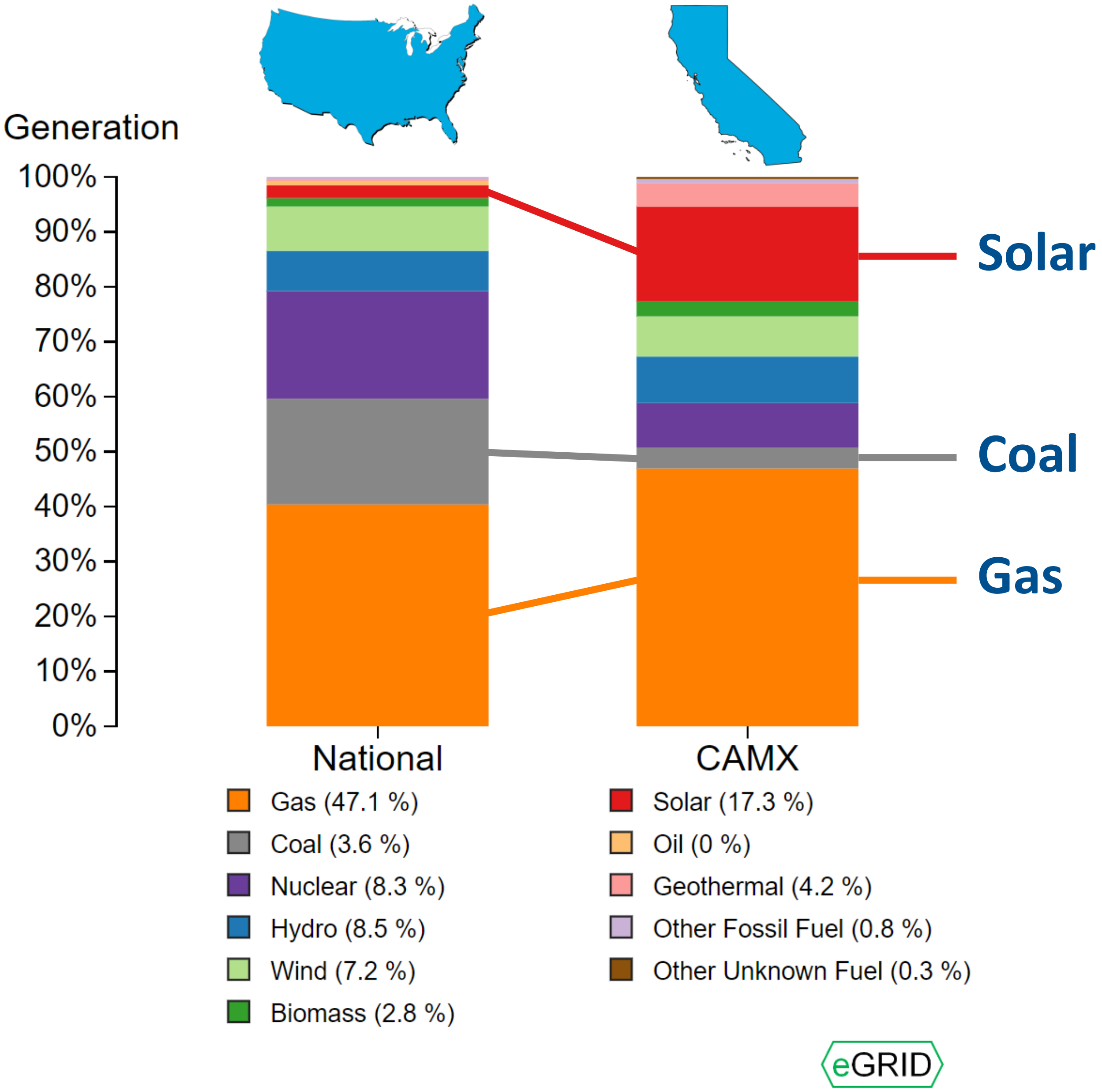
Widespread Solar Impact on Grid



- Significant reduction in net demand during the day
- Steep ramp-up of demand between 4 pm and 7 pm

Variable renewable production needs to be balanced with dispatchable power or demand.

California's Grid Mix in 2020



- Compared to National Average
  - More renewables
  - Much less coal
  - More natural gas
- Grid continues to decarbonize with non-dispatchable solar and wind
- Duck curve is going to continue to grow

Electric Grid is Getting Cleaner

- Reduction in coal power plants replaced with renewables and natural gas plants
- City bans on new natural gas hook-ups
- California Public Utility Commission retired subsidies on new natural gas connections
- States and local governments encouraging all-electric power in new buildings
- Renewables are becoming more cost effective
- Testing utility grade battery storage

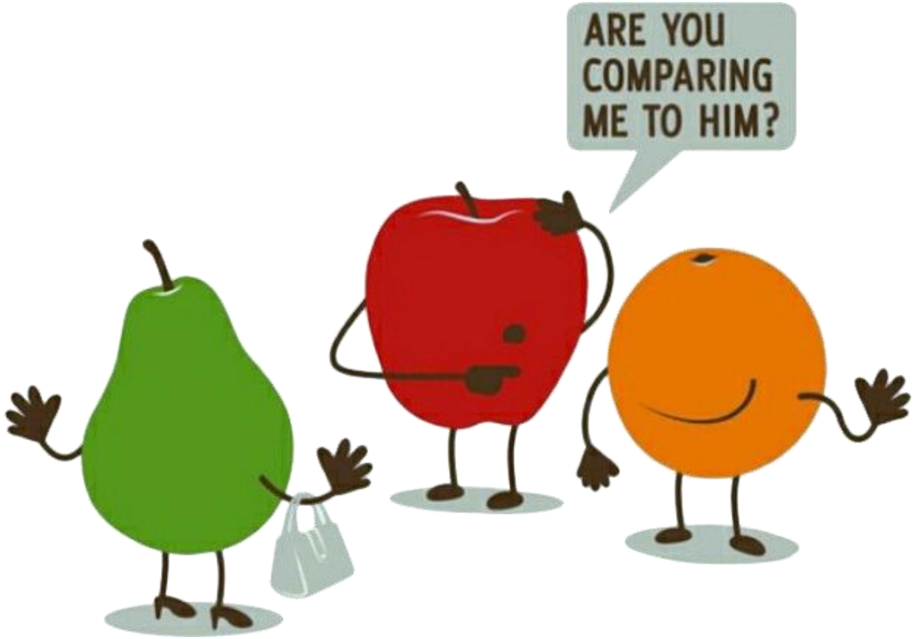
Demand Response and Time-of-Use Rate Structures

- **Demand Response:** Financial incentives to reduce energy consumption during peak incidents

- **Time-of-Use Rate Structure:** Rate per kilowatt hour changes throughout the day

Variables Impacting Energy Analysis Results

- Climate
- Building type/function
- Building form/size
- Window to wall area ratio
- Hours of operation/usage



Architectural

- Roof R-Value
- Wall R-Value
- Glass U-Value
- Glass SHGC

Lighting

- Occupancy Sensors
- Lighting Power Density
- Dimming Daylighting Control

Mechanical

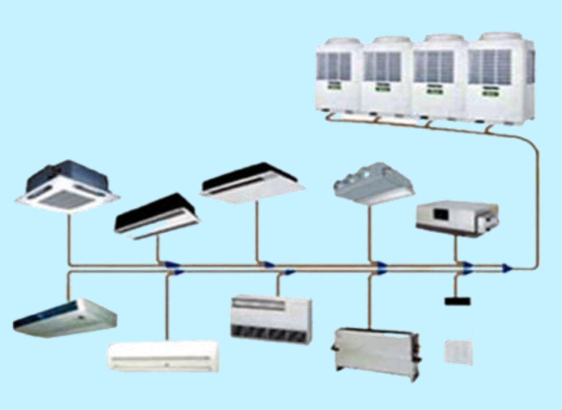
- HVAC System Types
- Heating Efficiency
- Heat Recovery
- Cooling Efficiency

Building Decarbonization Toolkit

Heat Pumps

- High efficiency air source heat pumps
- High efficiency ground coupled heat pumps

VRF Systems



- Variable refrigerant flow
- Simultaneous heating and cooling

Water Heating

- Heat pump water heater

Kitchen Equipment

- Electric fryer
- Electric ovens
- Electric griddle
- Induction Cooktops

Recap - Rules Of Thumb *Alone* Won't Solve This Challenge

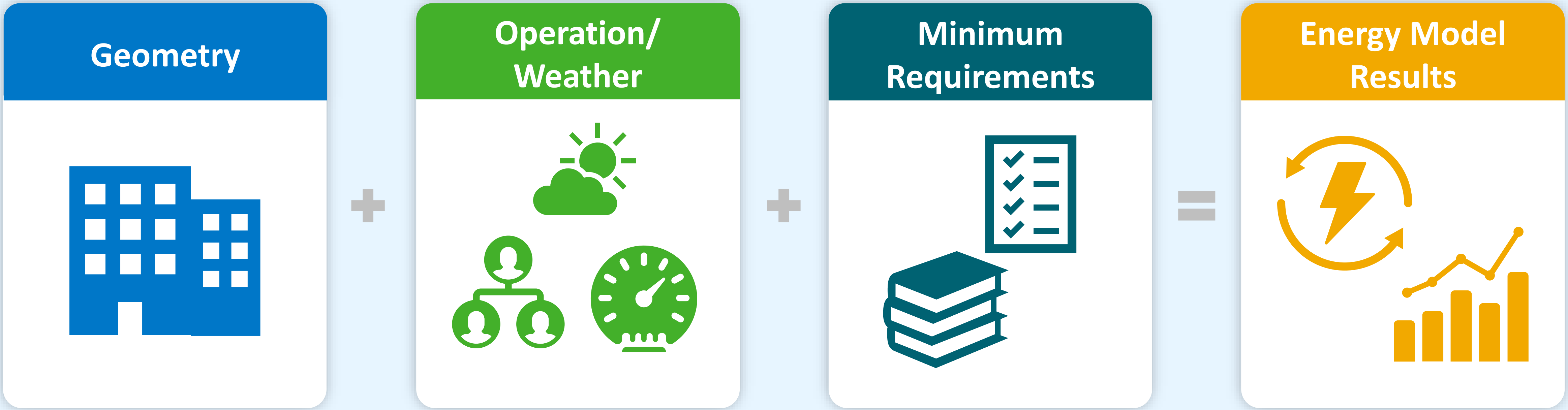
1. Electricity is a relatively young technology
2. The energy grid is continuously evolving
3. Our current structure is not a sustainable business model and rates keep changing
4. There are too many variables that impact energy use in a building for a one-size-fits-all solution
5. Building system technology keeps evolving and improving

Decarbonization Methodology

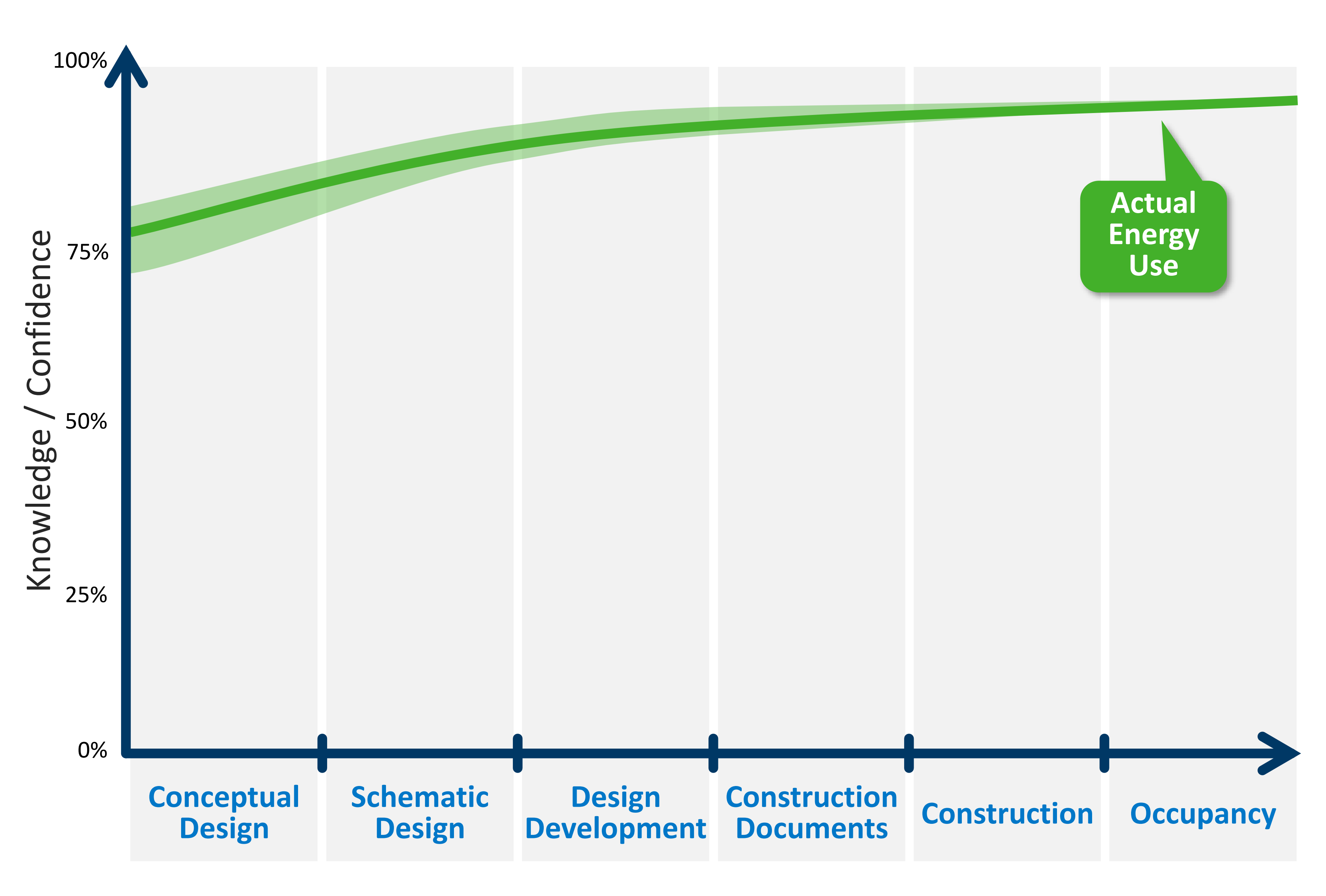
Energy Modeling Tool Advancement

- Faster
- Accurate
- Versatile
- Easier
- Affordable

Comparative Analysis



Models Are Perfect … Right?



Energy models are nearly 100% accurate … provided you can accurately predict the three main variables:

- Human behavior
- Climate and Weather
- Energy prices

The Method: Start Early, Stay at It

20-70 Year Lifespan
Massing
Glazing
Insulation
HVAC Concept

Minimize load first priority

5-15 Year Lifespan
HVAC Design
Lighting
Daylighting
Controls

Simple, cost-effective systems

20-30 Year Lifespan
Solar
Wind
Co-Gen

Appropriate energy source

Rapid Change
Schedules
Controls
Training
Maintenance
Ongoing M&V

Operate the building well

Case Studies

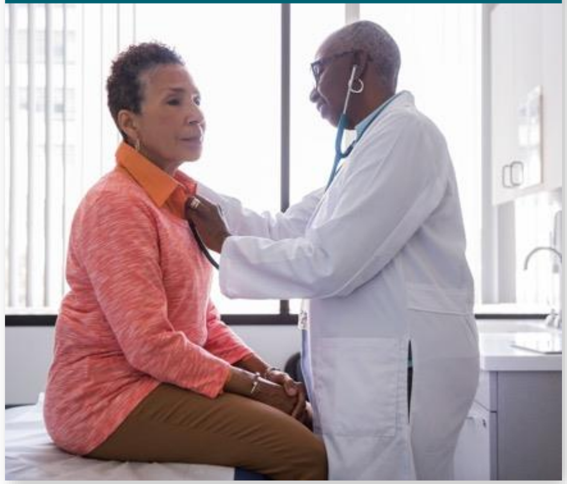
Case Study Building Types

Apartment

School

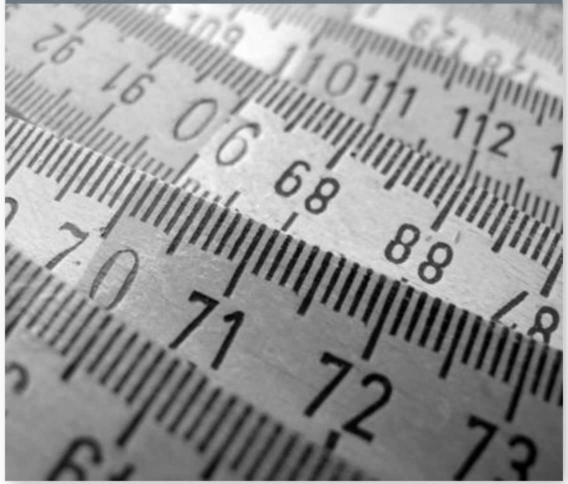
Office

Clinic



Typical Space Types

100,000 SF Program



Typical Hours of Operation

Case Study Locations

Mechanical Systems for Case Studies

Natural Gas

- VAV System with Air Cooled Chiller and Gas Boiler
- Gas fired VTACs in apartments with packaged rooftop units for common spaces
- Gas fired water heaters

All-Electric

- Air Source Heat Pumps with electric back up
- Electric resistance water heaters

Sustainable

- Ground coupled water loop heat pumps
- Heat pump water heaters

System Assumptions

Mechanical Assumptions

- **Chiller:** 1.12 kW/ton
- **Condensing Boiler:** 95% efficient
- **Gas furnace:** 95% efficient
- **DX cooling:** 12.1 EER
- **Air Source Heat Pump:** 12.1 EER/ 3.63 COP
- **Water Loop Heat Pump:** 16.9 EER/ 3.84 COP
- Demand control ventilation included where applicable

Architectural Assumptions

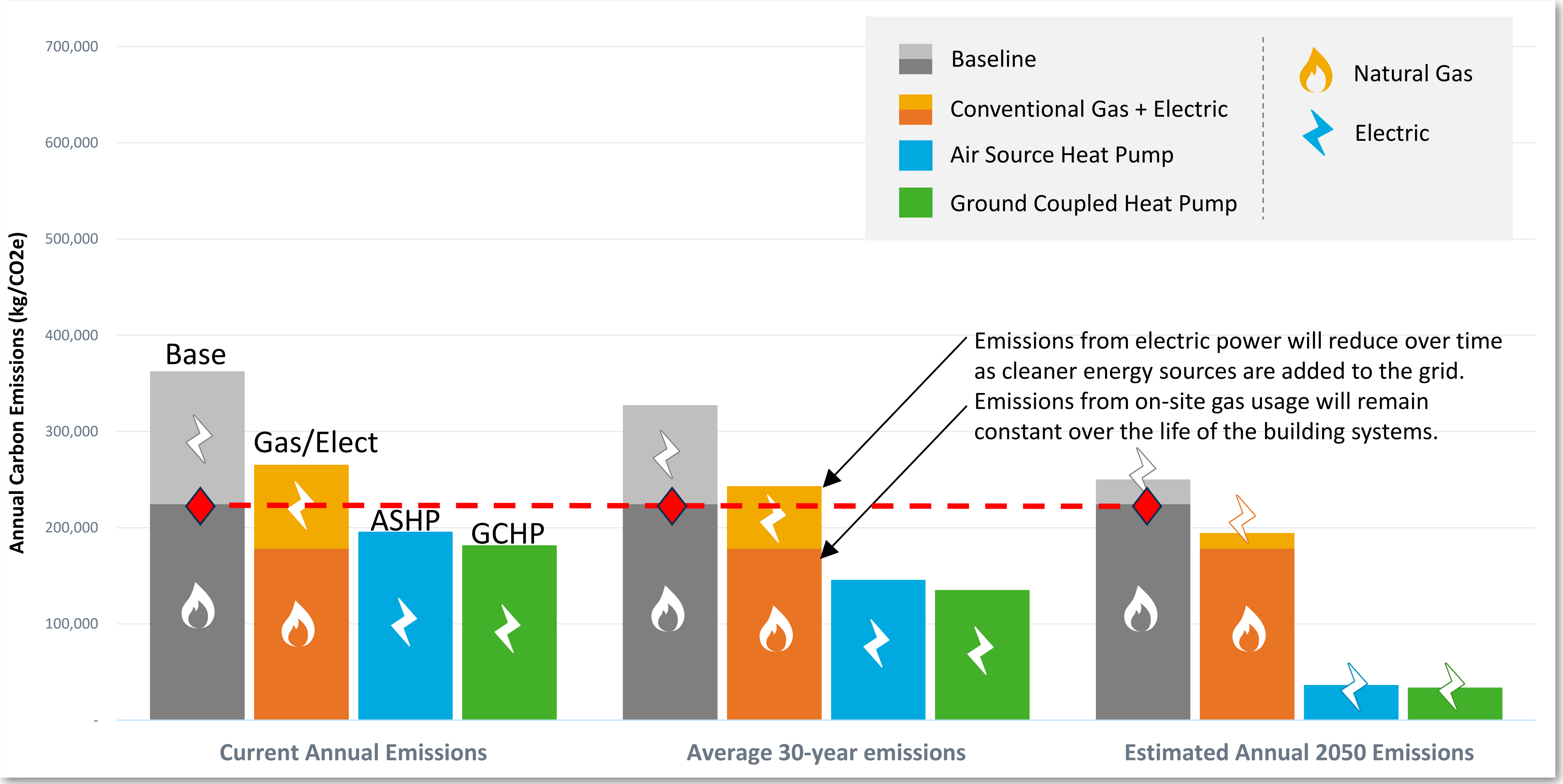
- Slightly above code minimums
- Aluminum windows with slightly above code minimums for U-factor and Solar heat gain coefficient
- Vinyl windows in apartments

Lighting Assumptions

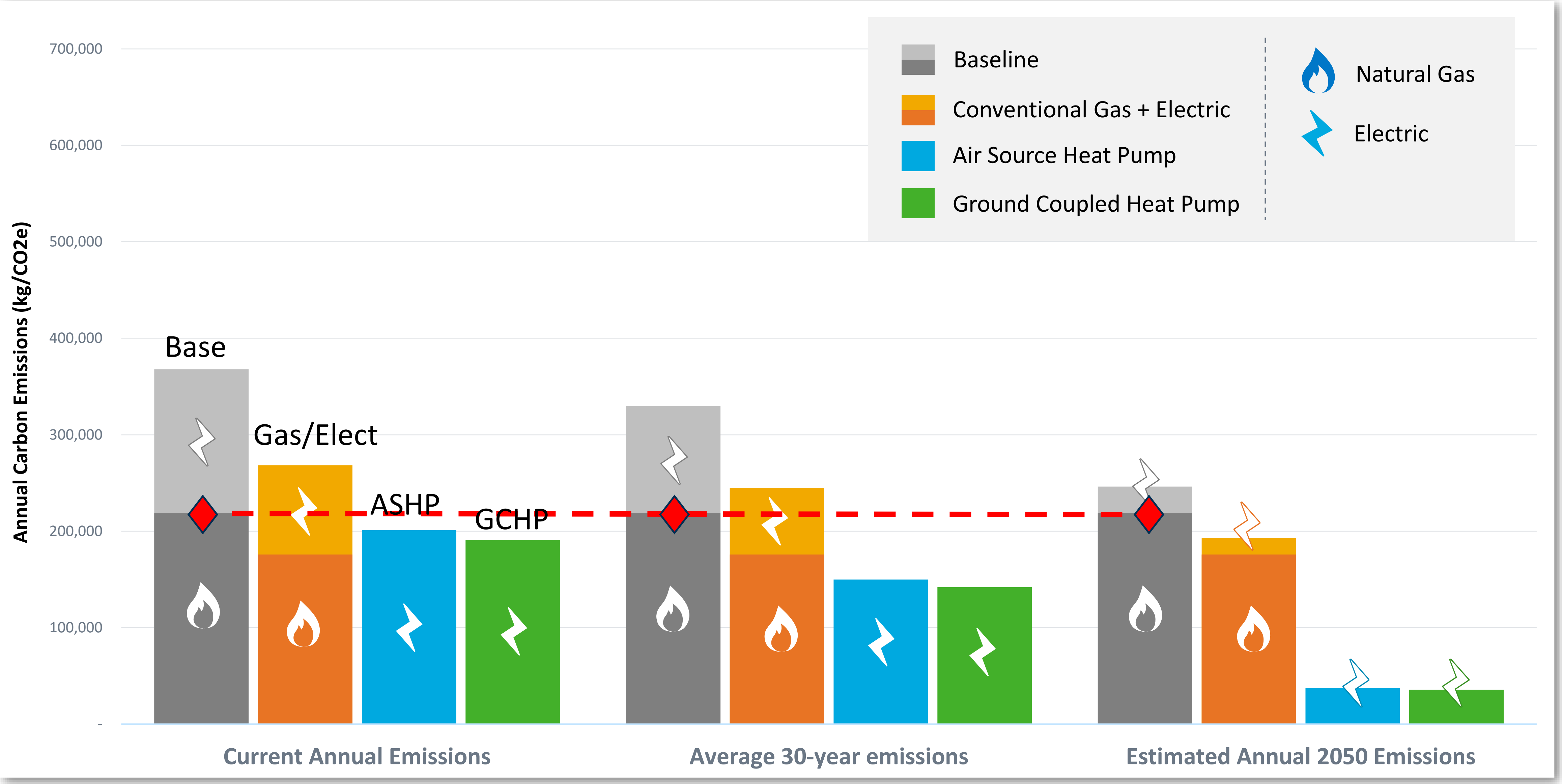
- LED Lights throughout
- Lighting controls as required by code

Carbon Impact by System

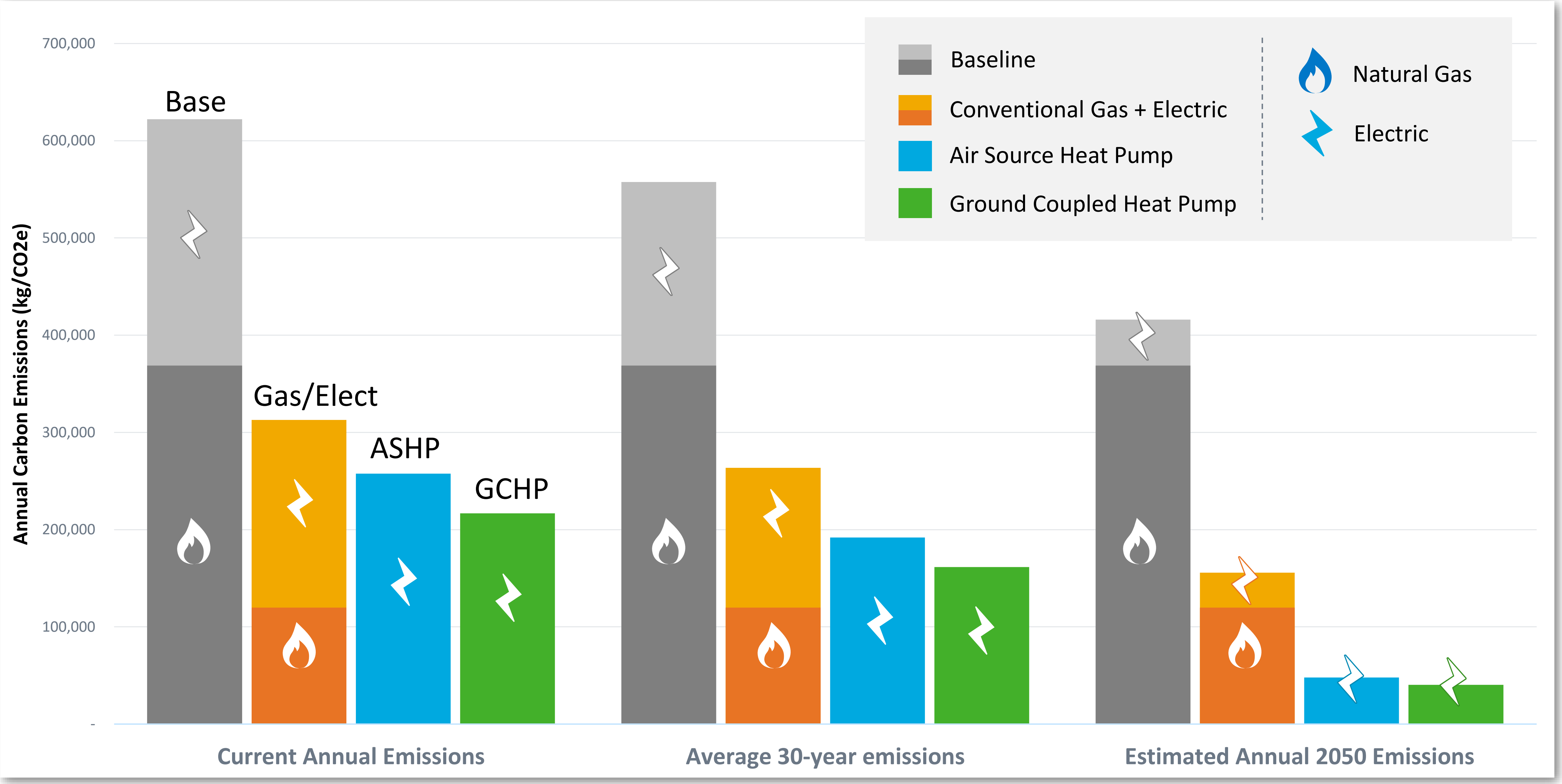
Annual Carbon Emissions by Energy Source - Multifamily (NorCal)



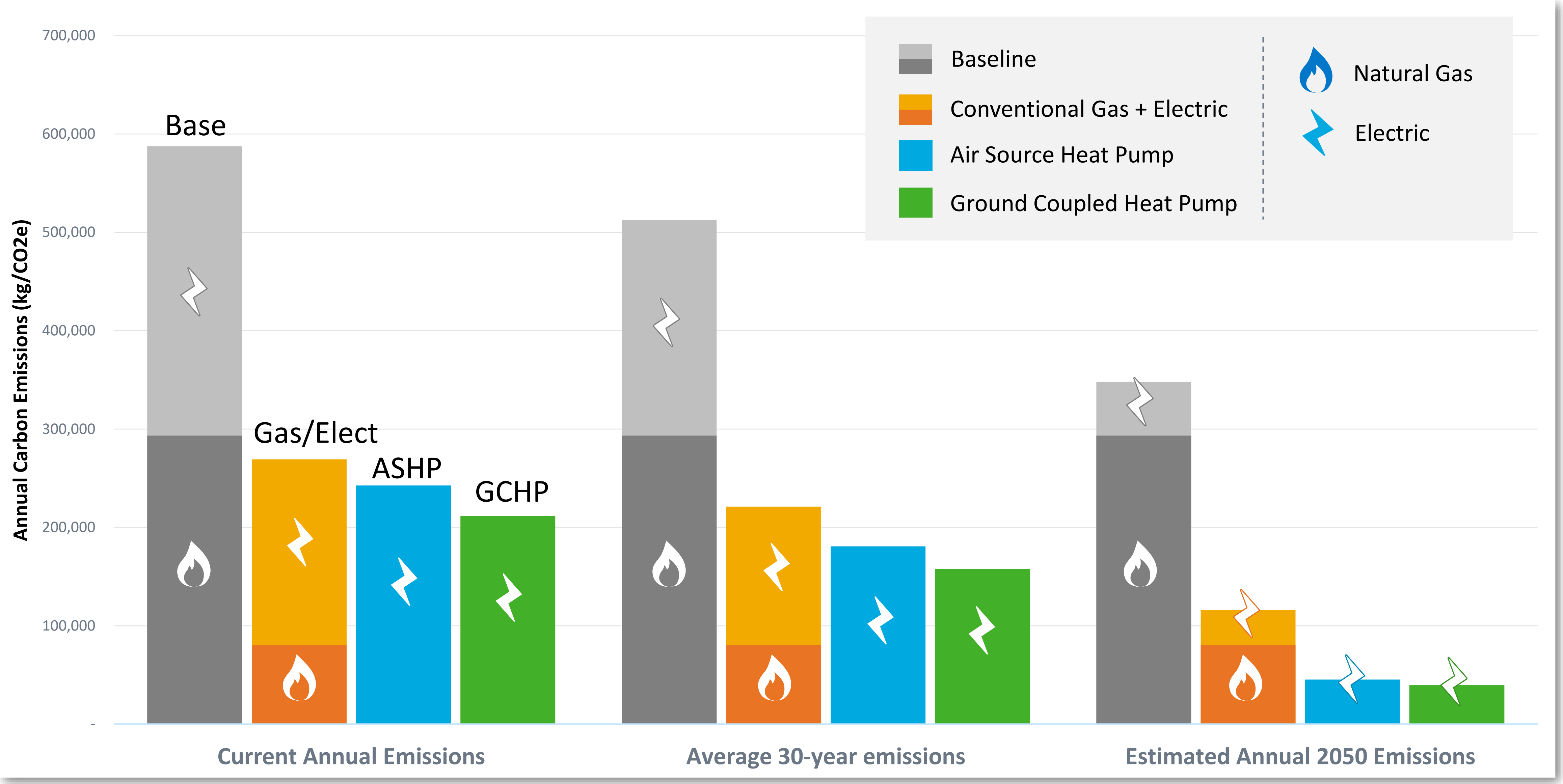
Annual Carbon Emissions by Energy Source - Multifamily (SoCal)



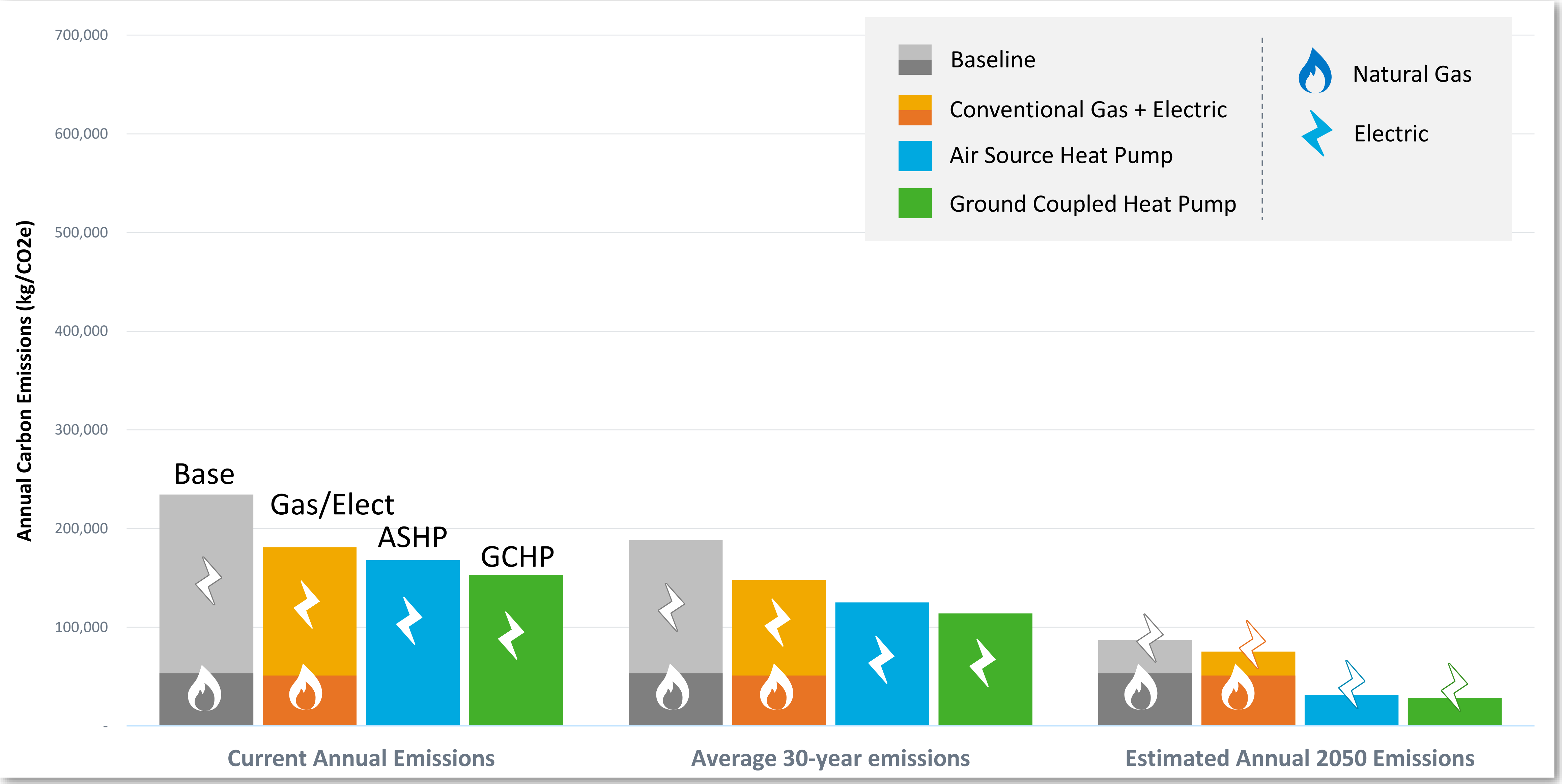
Annual Carbon Emissions by Energy Source - K12 (NorCal)



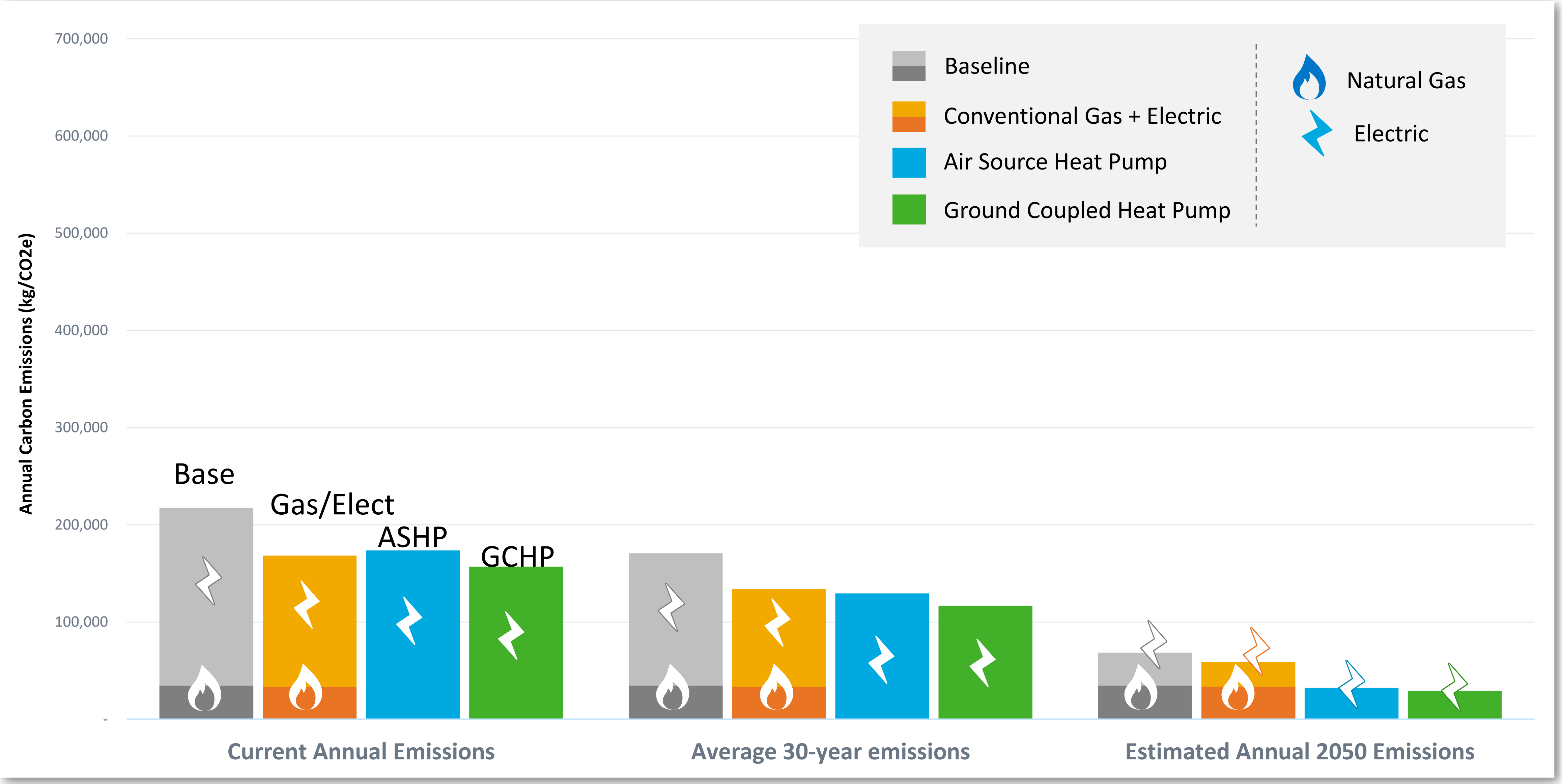
Annual Carbon Emissions by Energy Source - K12 (SoCal)



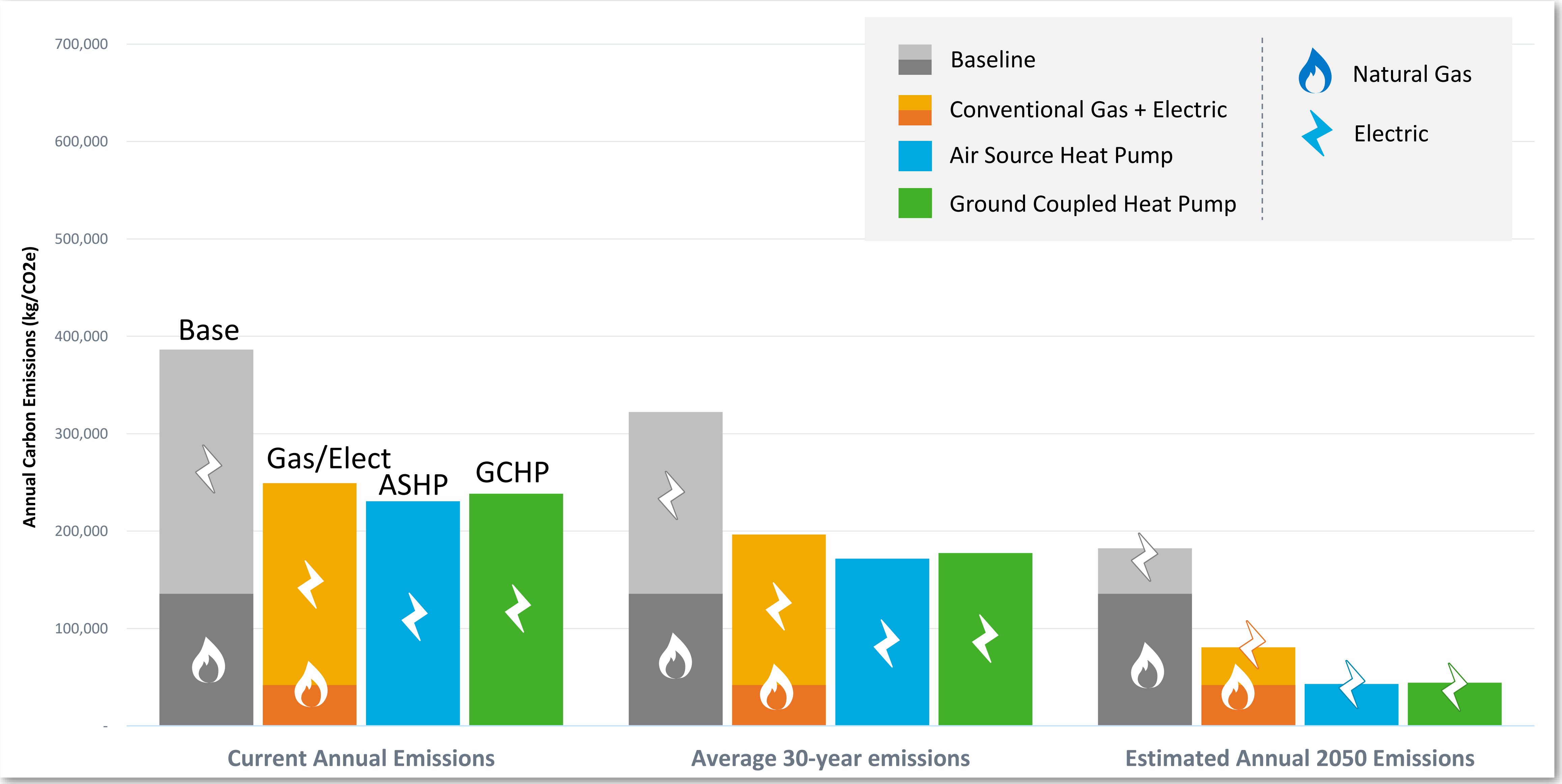
Annual Carbon Emissions by Energy Source - Office (NorCal)



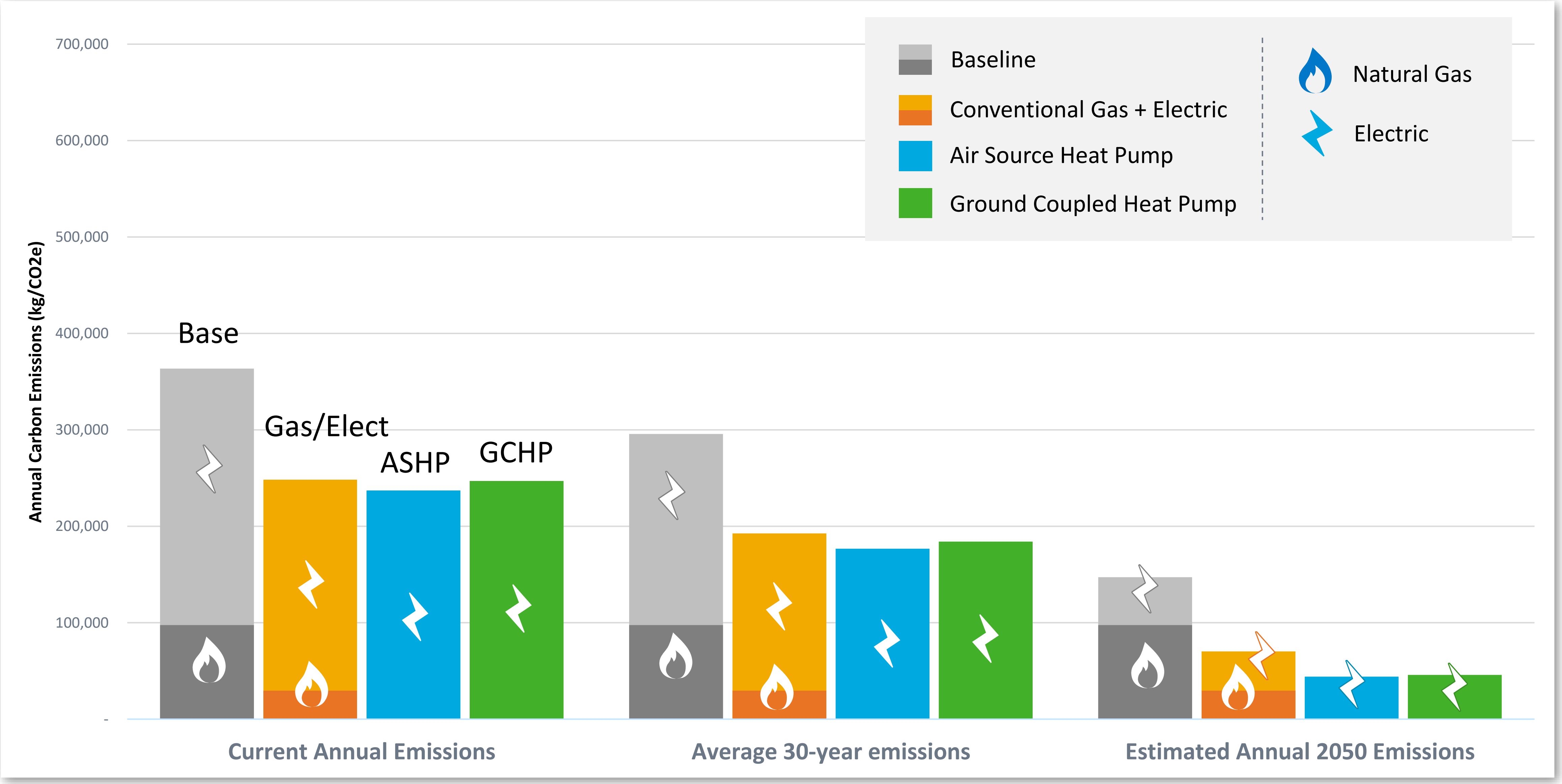
Annual Carbon Emissions by Energy Source – Office (SoCal)



Annual Carbon Emissions by Energy Source – Healthcare Clinic(NorCal)



Annual Carbon Emissions by Energy Source – Healthcare Clinic(SoCal)



Key Takeaways

Installing natural gas equipment in new buildings locks in those carbon emissions for the life of the equipment

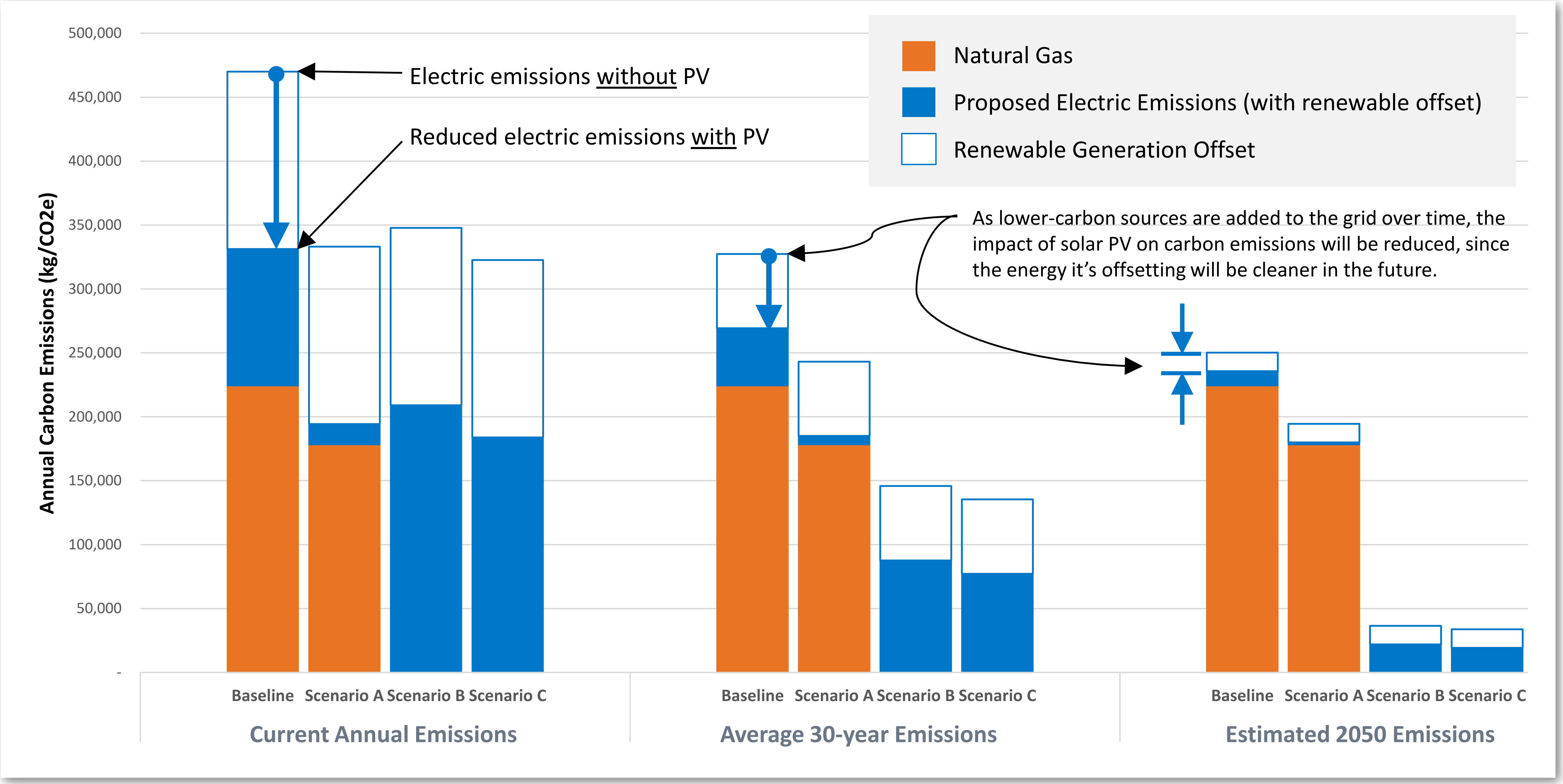
The electric grid is getting cleaner each year - which has a profound impact on carbon emissions of the built environment

Installing efficient electric equipment will allow the building to decarbonize along with the electrical grid

Electrifying buildings is key to decarbonizing the built environment

Impact of Solar Energy

Annual Carbon Emissions by Energy Source (w/ PV roof coverage) – Multifamily (NorCal)



Key Takeaways

There is a diminishing return on solar from a carbon standpoint as the grid gets cleaner.

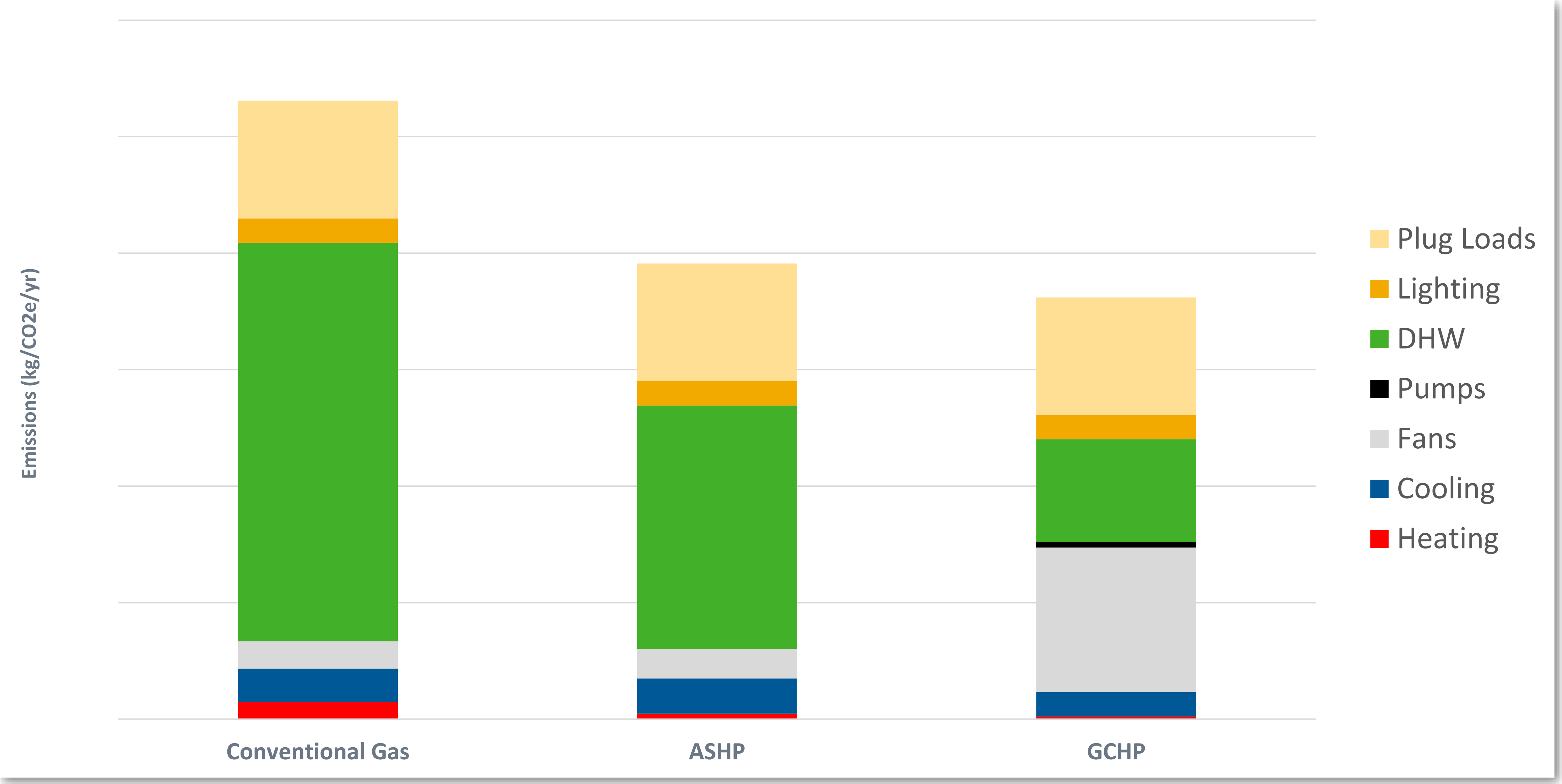
Solar is a key strategy for reducing annual energy costs and is required by code for certain building uses

Electrify as many end uses as possible first to receive the maximum benefit of solar

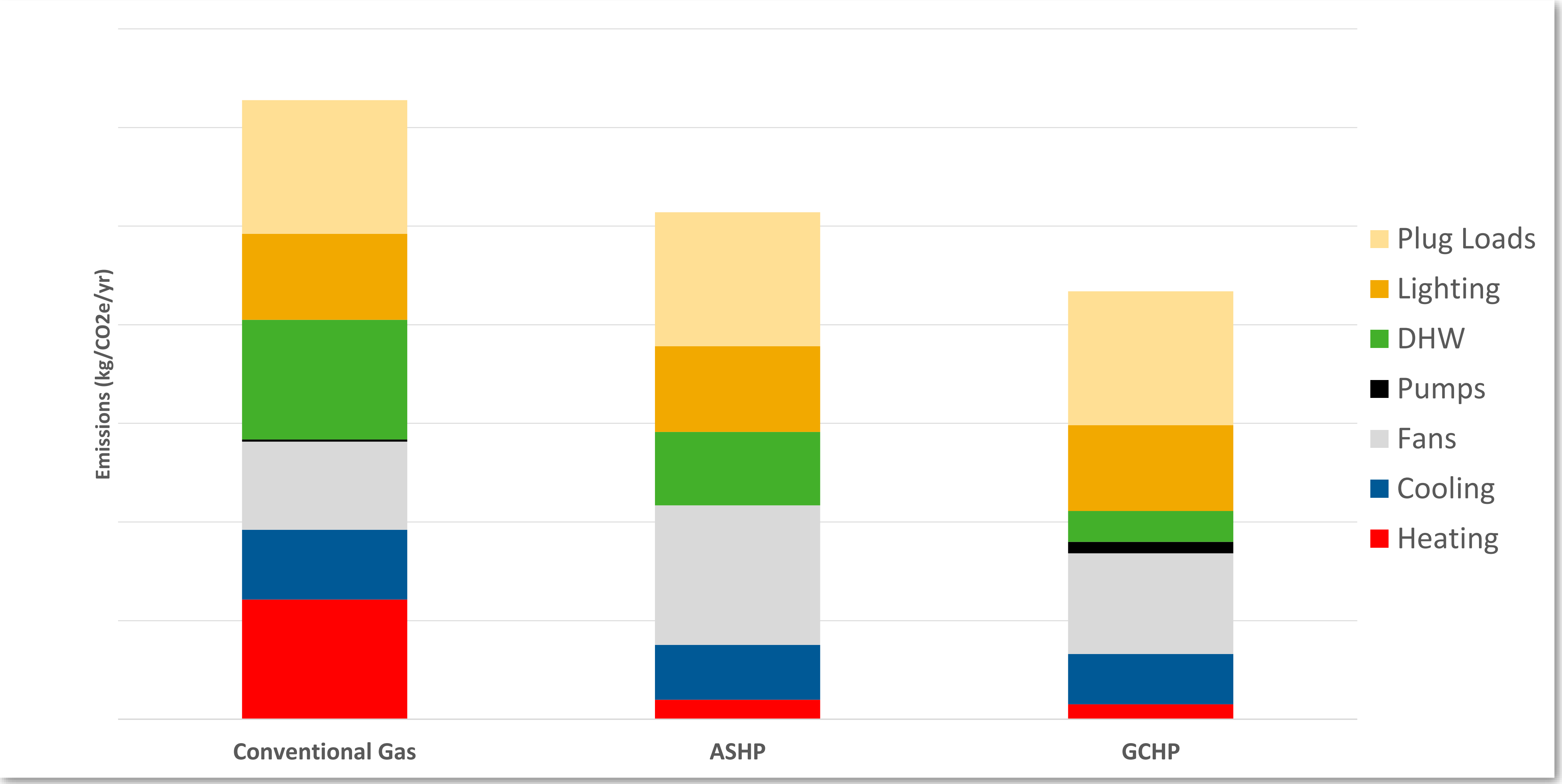
Battery storage paired with solar will be an important strategy for operating cost reduction in the future

Carbon by End Use

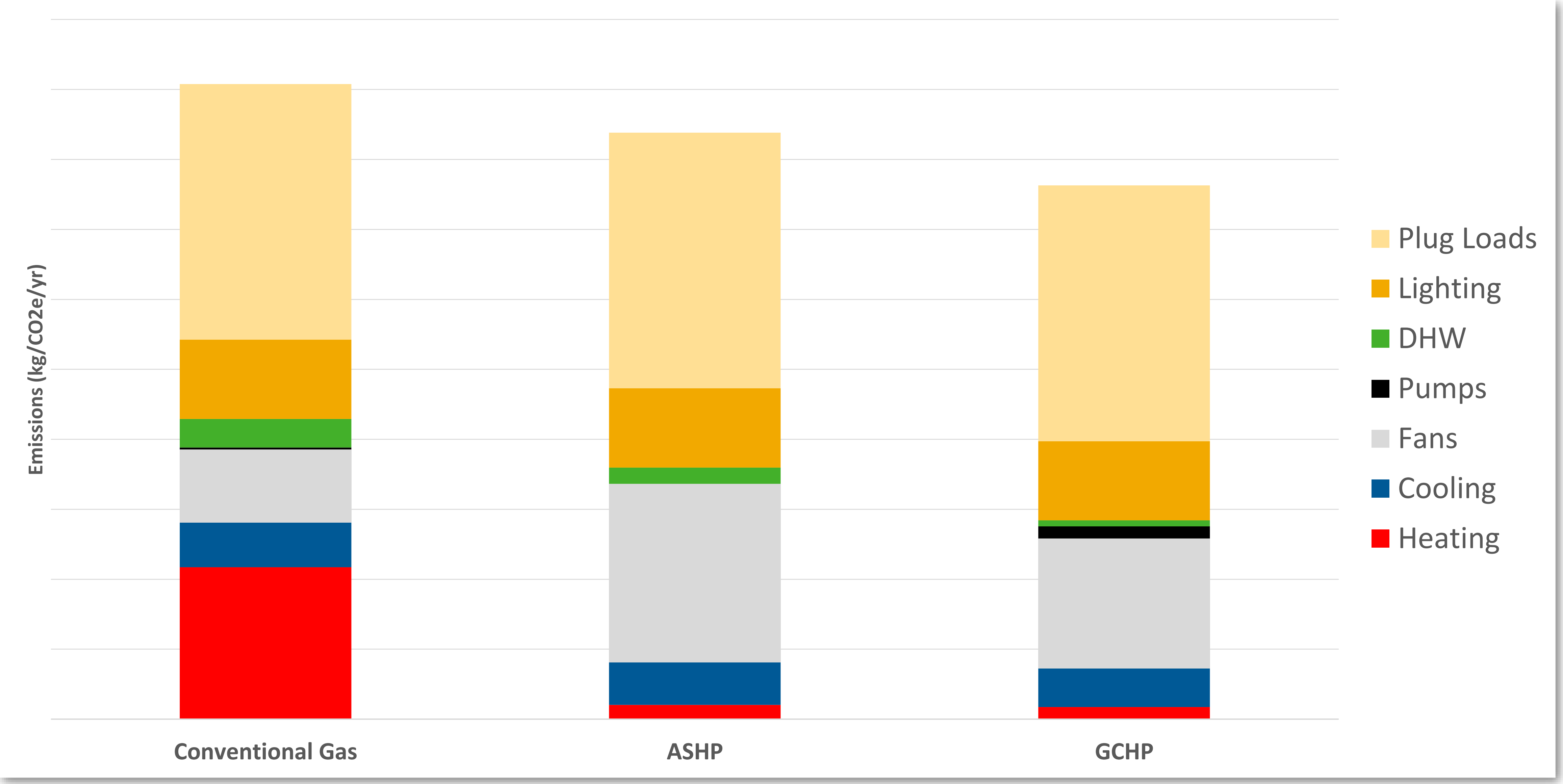
2026 Carbon Emissions by End Use - Multifamily (NorCal)



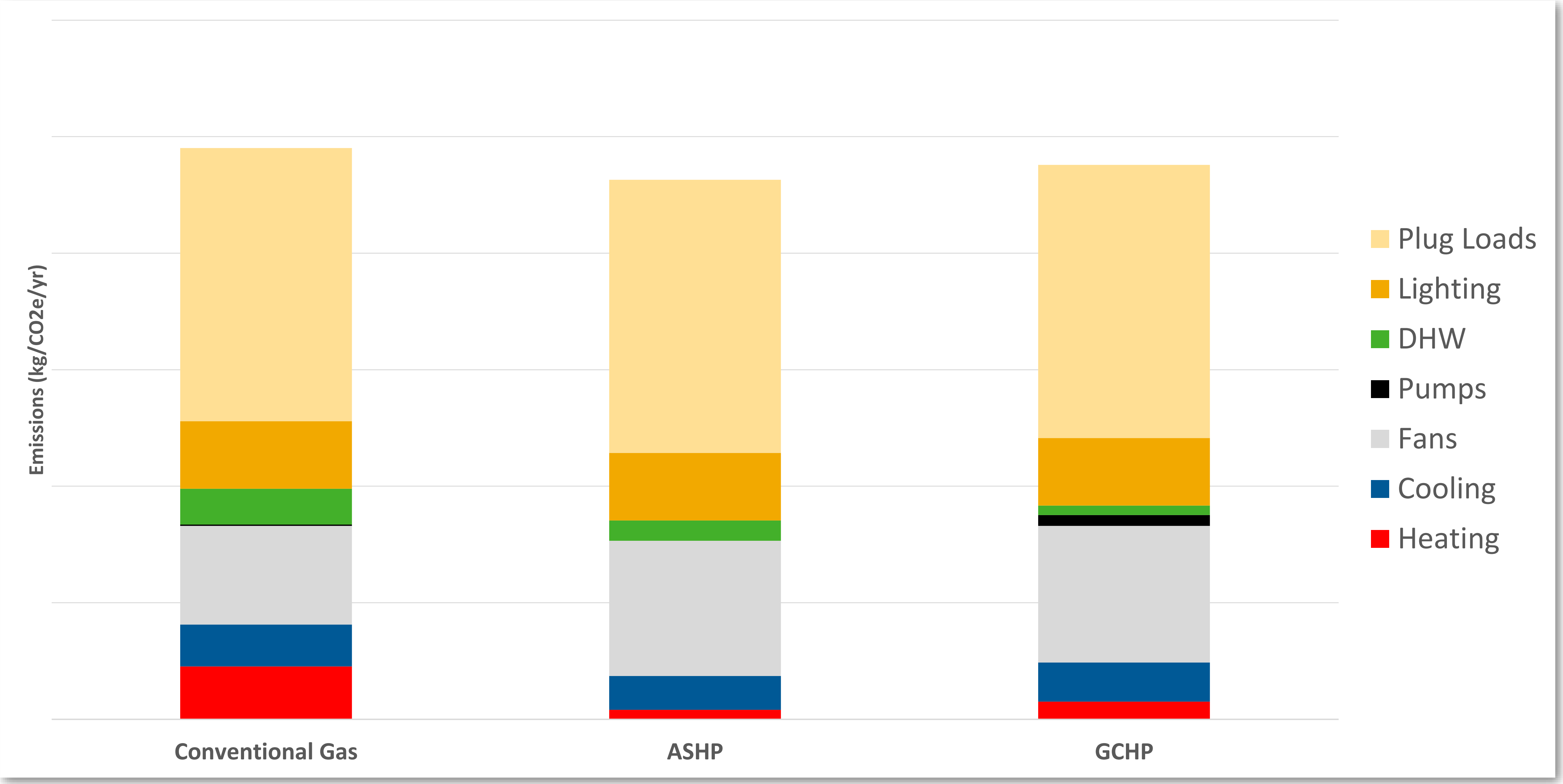
2026 Carbon Emissions by End Use - K12 (NorCal)



2026 Carbon Emissions by End Use - Office (NorCal)



2026 Carbon Emissions by End Use - Healthcare (NorCal)



Key Takeaways

Water heating is the biggest carbon usage in apartments and school facilities

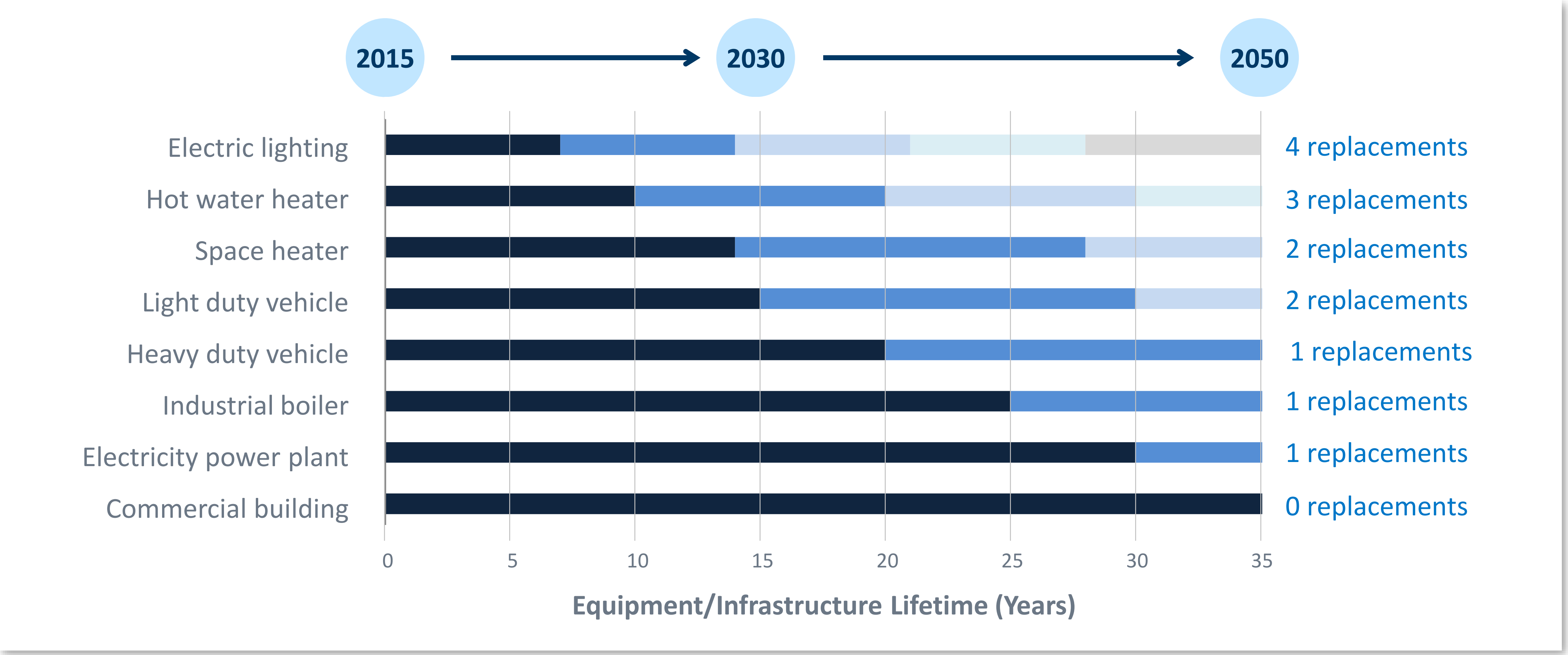
Plug loads and fan energy in offices and healthcare are opportunities for carbon reduction

Minimal savings impact is left from lighting -- LEDs have made electric lights very efficient

In the next 5 years 460 Million Square Feet of new construction apartments are expected to be built in California

Other Considerations

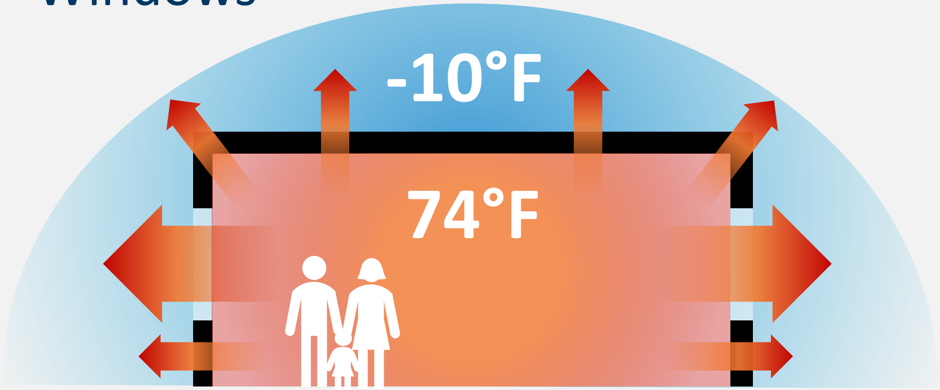
Equipment Life



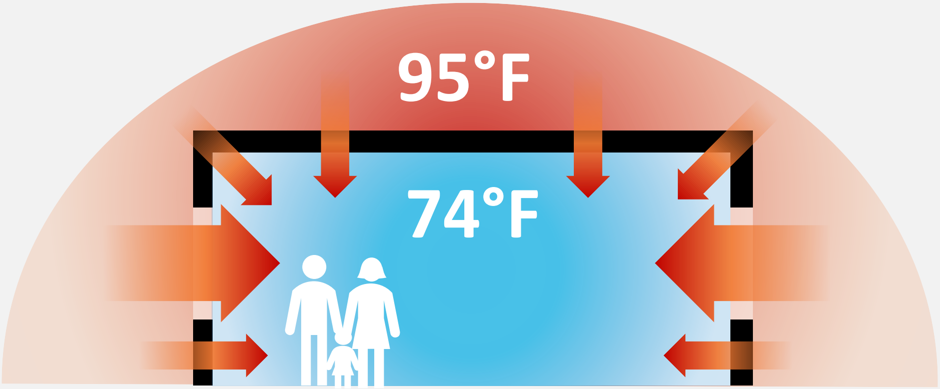
Building Loads

EXTERNAL

- Wall/Roof (including infiltration)
- Windows



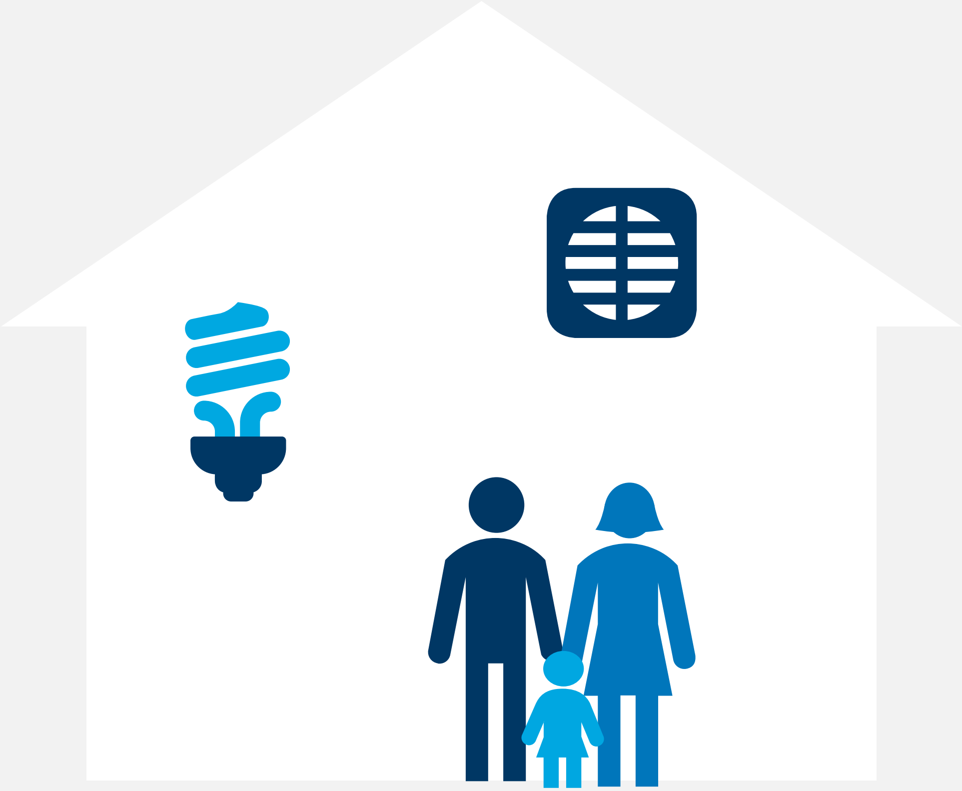
Winter Mode



Summer Mode

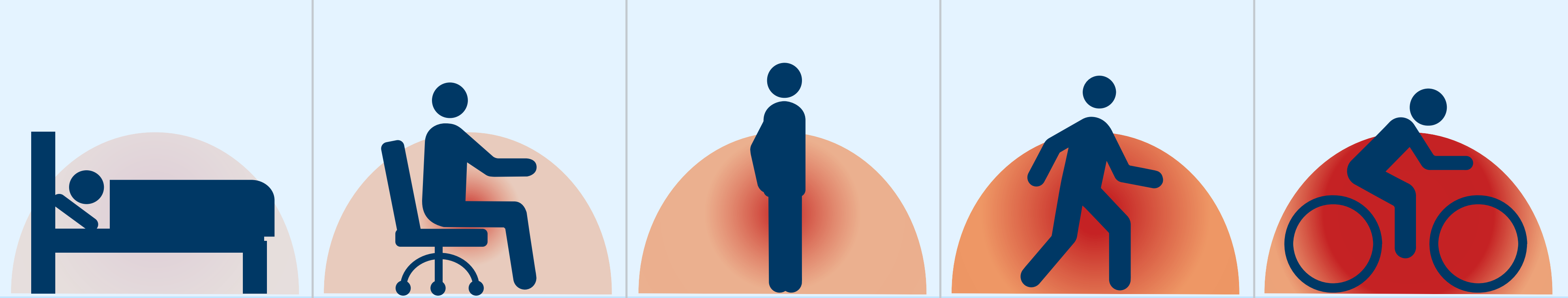
INTERNAL

- Occupants
- Lighting/Equipment
- Ventilation



Internal Loads – Occupant Activity

Building types house different activities that influence heating and cooling loads



Activity	Sleeping	Sitting	Standing	Walking	Exercise
Heat Output	76W	103W	126W	212W	370W

Key Takeaways

Building envelope impacts heating and cooling loads and has a life-long impact on carbon reduction

Additional carbon reductions can be found by balancing envelope strategies, building systems, and project budget/goals

More carbon reductions can be found when we analyze impacts of internal loads

Decarbonization analysis can help identify areas where additional savings can be found

04

Conclusions and Discussion

Start in SD and DD

20-70 Year Lifespan
Massing
Glazing
Insulation
HVAC Concept

Minimize load first priority

5-15 Year Lifespan
HVAC Design
Lighting
Daylighting
Controls

Simple, cost-effective systems

20-30 Year Lifespan
Solar
Wind
Co-Gen

Appropriate energy source

Rapid Change
Schedules
Controls
Training
Maintenance
Ongoing M&V

Operate the building well

Key Takeaways

The landscape of power generation is changing and contributes significantly to carbon reduction.

Utilize energy modeling to explore load balancing and carbon emissions.

Assess carbon reduction, with today and future emission rates, to design buildings for the future.

Make a commitment to include low carbon design strategies in the development of every project.

Thank you!

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