Zero Net Energy, Flexible Loads *and* The Biggest Machine in the World

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Carbon Smart Buildings

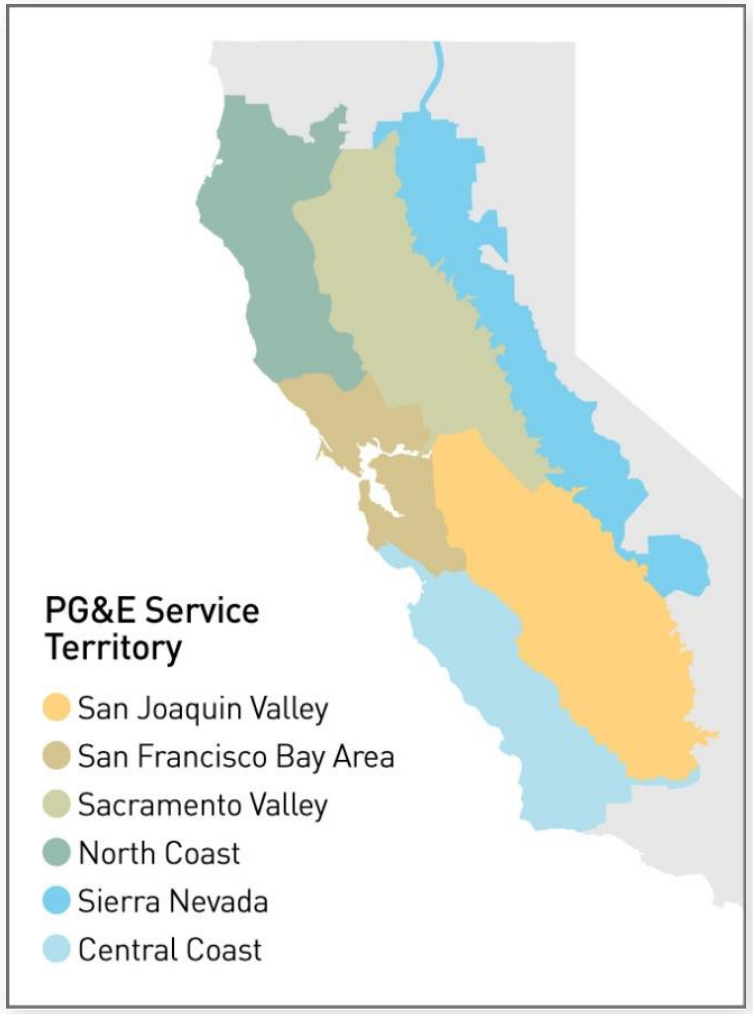
Together, Building a Better California

Pacific Gas and Electric Company

Our mission:

To safely and reliably deliver clean energy to our customers and communities every single day while building the energy network of tomorrow

- Service area population of ~16,000,000
- ~110,000 miles of distribution grid
- ~1,000,000 distribution transformers



A Little Review . . . Why "Zero Net Energy"?

AB 32: "The Global Warming Solutions Act" . . . 2006

Chief requirement AB 32—GHG emissions 20% below 1990 levels by 2020

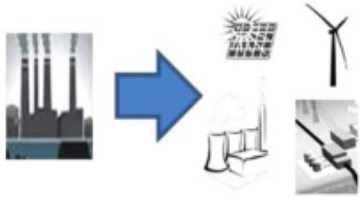
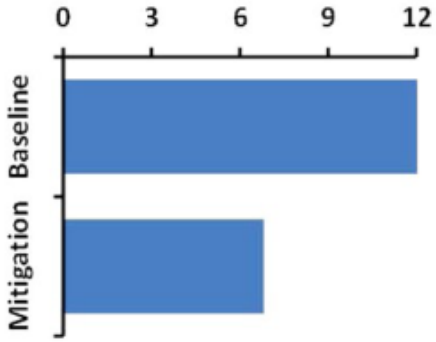
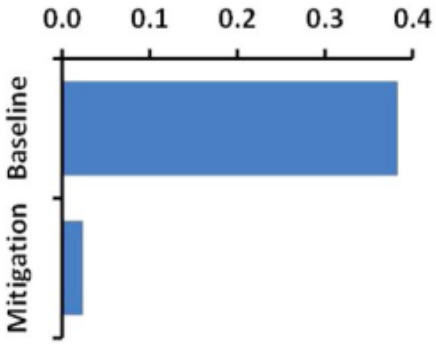
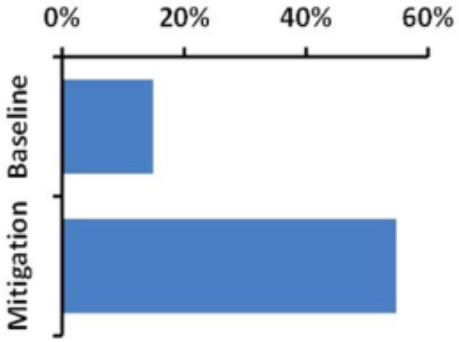
SB 32: An extension and expansion of the AB 32 legislation, 2016

Chief requirement SB 32: GHG emissions 40% below 1990 levels by 2030

Long term goal:

GHG emissions 80% below 1990 levels by 2050

2012 Science Paper: "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050" (From E3, San Francisco)

Wedge	ENERGY EFFICIENCY	GENERATION DECARBONIZATION	ELECTRIFICATION
			
Key Metric in 2050	End Use Energy Consumption (Quads)	Electric Generation GHG Intensity (Mt CO2e/GWh)	Electricity Share of Total End Use Energy (%)
			
Constraints	• Max feasible rate of improvement: 1.3% y^{-1} • Fundamental changes in the built environment • Limitations on changes in human behavior	• Grid operability requires some natural gas usage • Large infrastructure investment required • Facility and transmission siting challenges	• Smart charging • Battery technology and cost • Low-carbon source of electricity

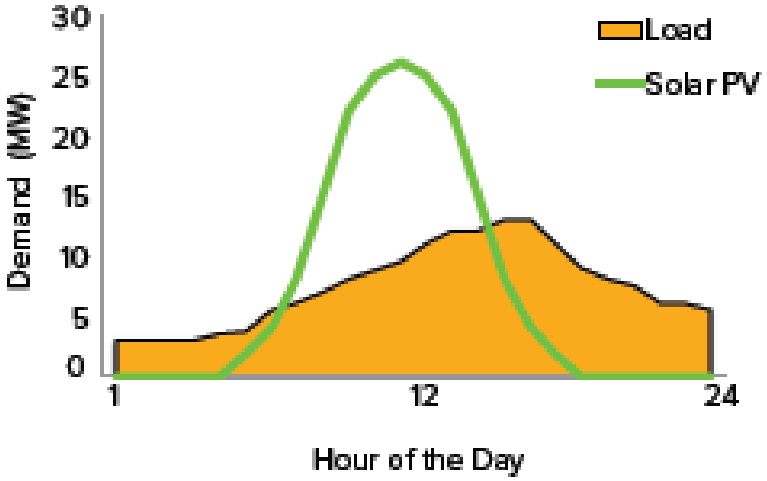
A California Utility's Perspective on ZNE . . .

What Does a Utility Want?

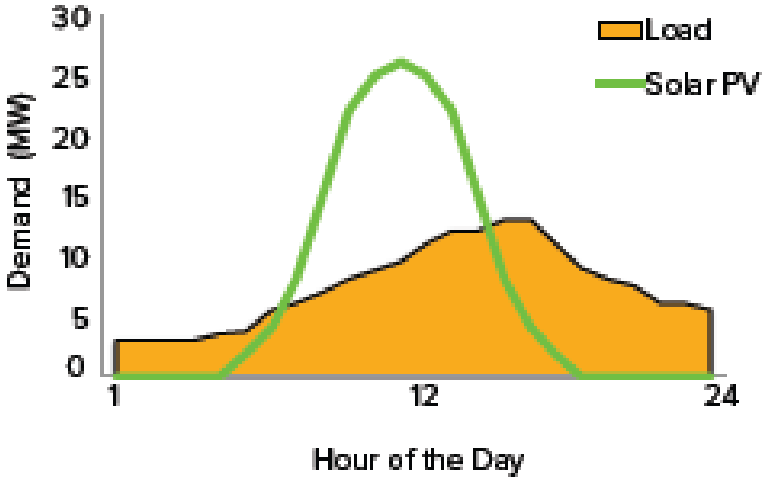
- *To be responsive to policy and regulatory initiatives and to be perceived as such by the public—GHG reduction is front and center*
- *To have satisfied customers who believe they receive good value for what they pay for*
- *Financial perspective: To collect sufficient revenue to "run the business" and meet investor earning expectations—the basic regulatory compact*
- *Operational Perspective: To have tools, equipment and processes to "run the grid" effectively*

A Tale of 2 Buildings . . . Both ZNE

Solar PV



Solar PV



A Tale of 2 Buildings . . . Both ZNE

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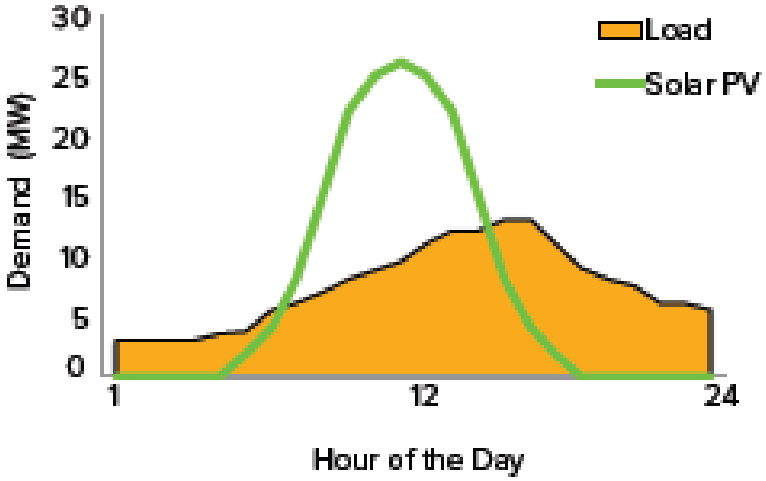
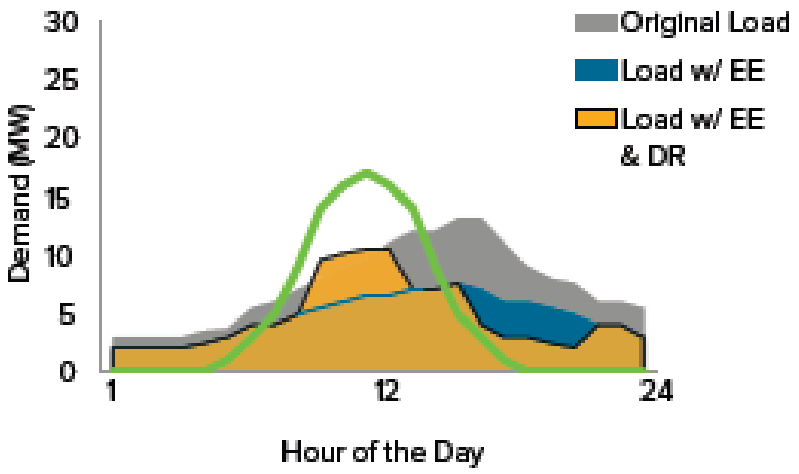
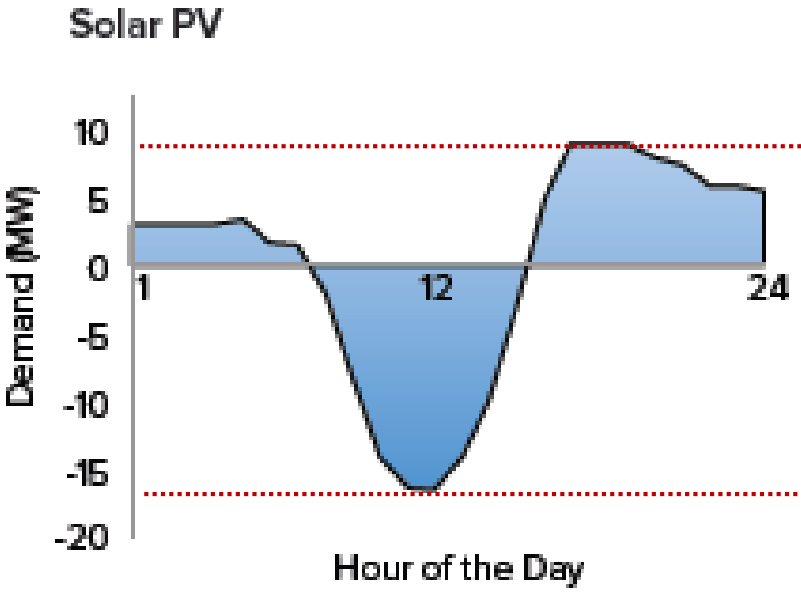
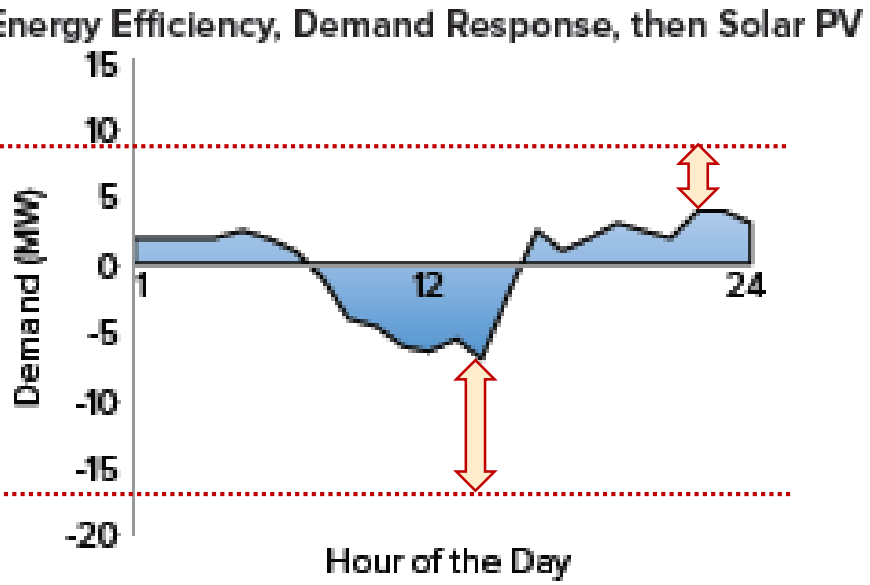


Energy Efficiency, Demand Response, then Solar PV



A Tale of 2 Buildings



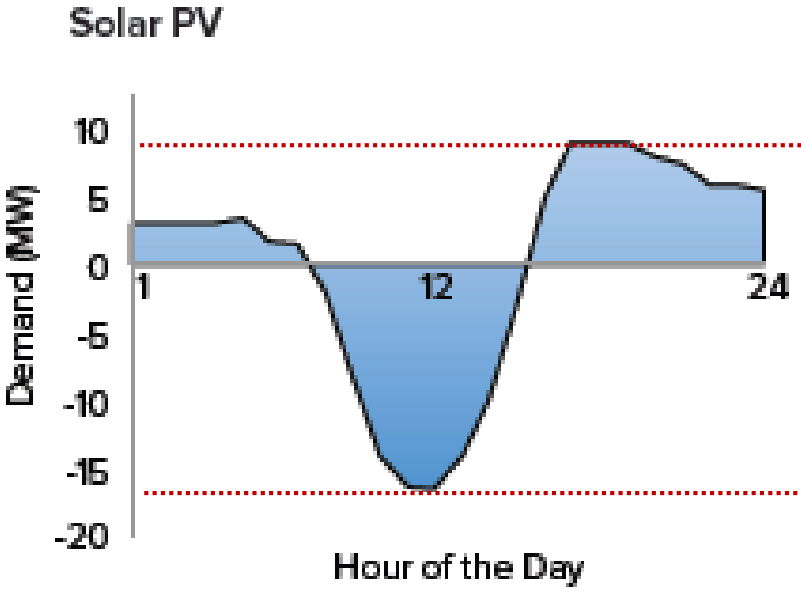


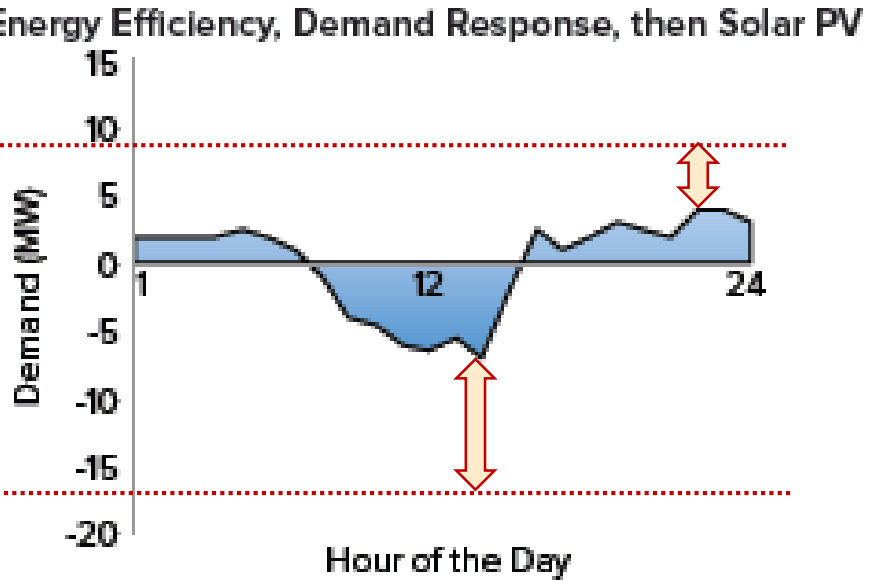
A Tale of 2 Buildings

Which is the easier, less costly building to serve for a utility?

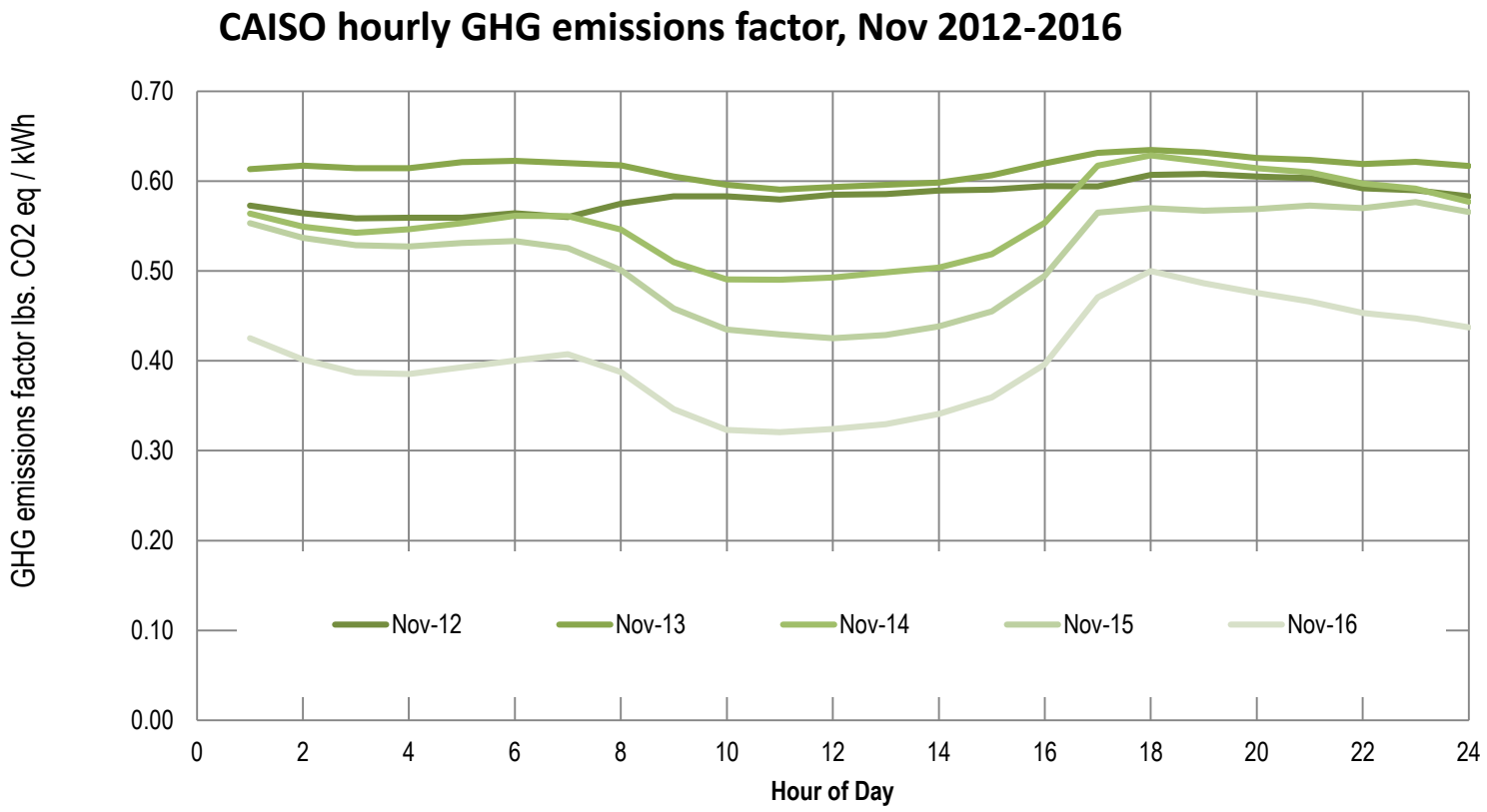
- *Infrastructure build-out*
- *Purchased or generated power*

For the customer: which building would have the lower bill?





GHG Emissions Perspective



Note degree of change in just five years

Dynamic quality of change—we would expect change to continue

- In 2012, it looks fine to charge your car at night
- In 2016, not so much!
- Under NEM, no incentive to charge your car in the afternoon

Thank you!

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What Does This Mean for ZNE?

Questions to consider . . .

- Is grid connectivity essential to take ZNE “to scale”?
- If we could instantly (tomorrow) make half of all buildings ZNE, would it reduce utility grid costs?
- At scale, what is a fair and reasonable method of
  (1) determining and calculating, and
  (2) collecting utility costs to serve ZNE customers?
- Is “Net Positive” always “good”? Is it ever “good”?
- Is incremental energy savings ever “bad”?
- Who should pay for microgrids?
- How should we handle storage?