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### **Title**

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## **Greenhouse Gas Abatement with Distributed Generation in California's Commercial Buildings**

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Gonçalo Cardoso, and Olivier Mégel**

**Environmental Energy  
Technologies Division**

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*<http://eetd.lbl.gov/EA/EMP/emp-pubs.html>*

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# Greenhouse Gas Abatement with Distributed Generation in California's Commercial Buildings

**Keywords:** carbon emissions, climate change, combined heat and power, commercial buildings, distributed generation, microgrids



**Project started:** January 2009  
**Team:** Chris Marnay, Michael Stadler, Tim Lipman, Judy Lai, Gonçalo Ferreira Cardoso, Olivier Mégel  
**Project partner:** University of California, Berkeley

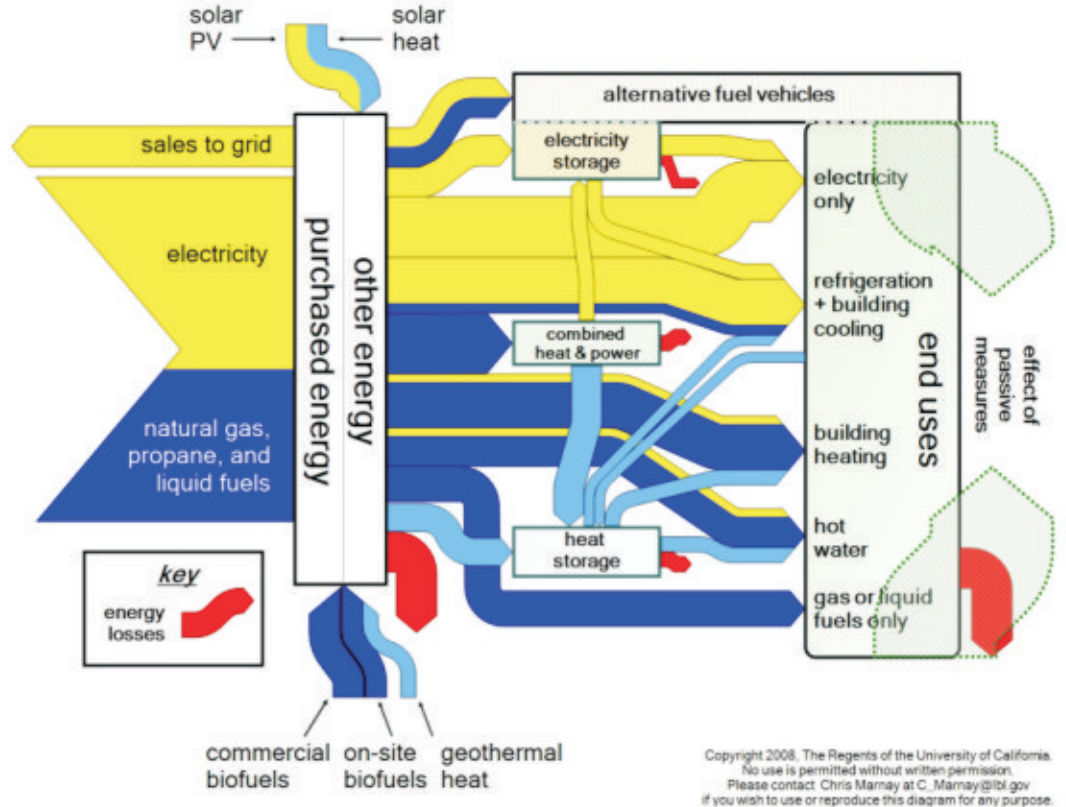
## Motivation & Objective for this Research

- to determine the role of distributed generation (DG) in greenhouse gas reductions by
- applying the Distributed Energy Resources Customer Adoption Model (DER-CAM)
  - using the California Commercial End-Use Survey (CEUS) database for commercial buildings
  - selecting buildings with electric peak loads between 100 kW and 5 MW
  - considering fuel cells, micro-turbines, internal combustion engines, gas turbines with waste heat utilization, solar thermal, and PV
  - testing of different policy instruments, e.g. feed-in tariff or investment subsidies

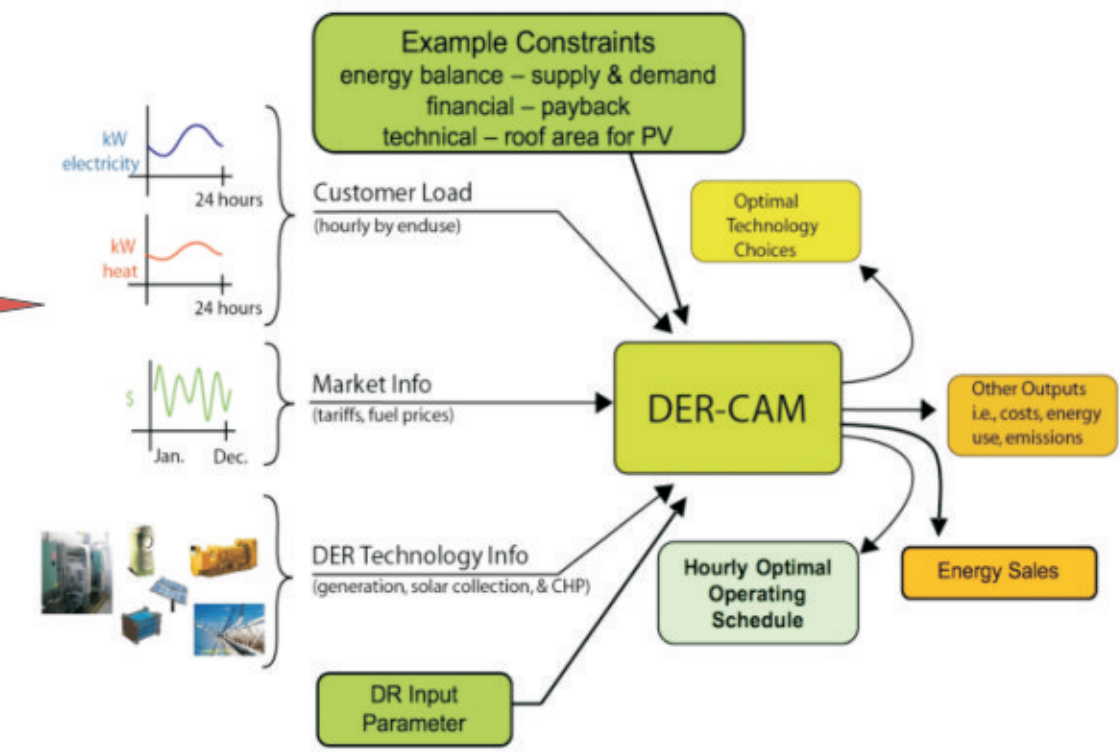
## Distributed Energy Resources Customer Adoption Model (DER-CAM)

- DER-CAM optimization techniques find both the combination of equipment and its operation over a typical year that minimizes the site's total energy bill, including amortized capital costs, or CO<sub>2</sub> emissions by considering
- hourly load profiles for electric, heating, cooling, and natural gas loads
  - any onsite technology that can be described by capital costs, O&M costs, efficiency, etc.
  - building / microgrid energy balance
  - operating constraints, e.g. solar radiation
  - regulatory constraints, e.g. CO<sub>2</sub> prices / taxes or zero-net energy buildings

## Schematic of the Energy Flow in a Building - Global Concept



## High Level Schematic of DER-CAM



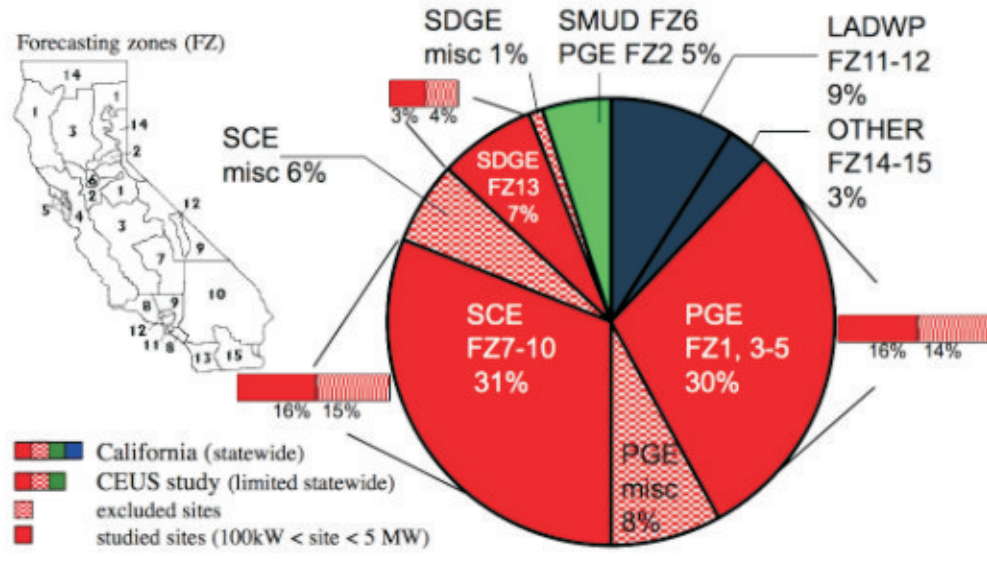
## California Commercial End-Use Survey (CEUS) database

CEUS database contains 2790 premises from PG&E, SMUD, SCE, and SDG&E service territories:

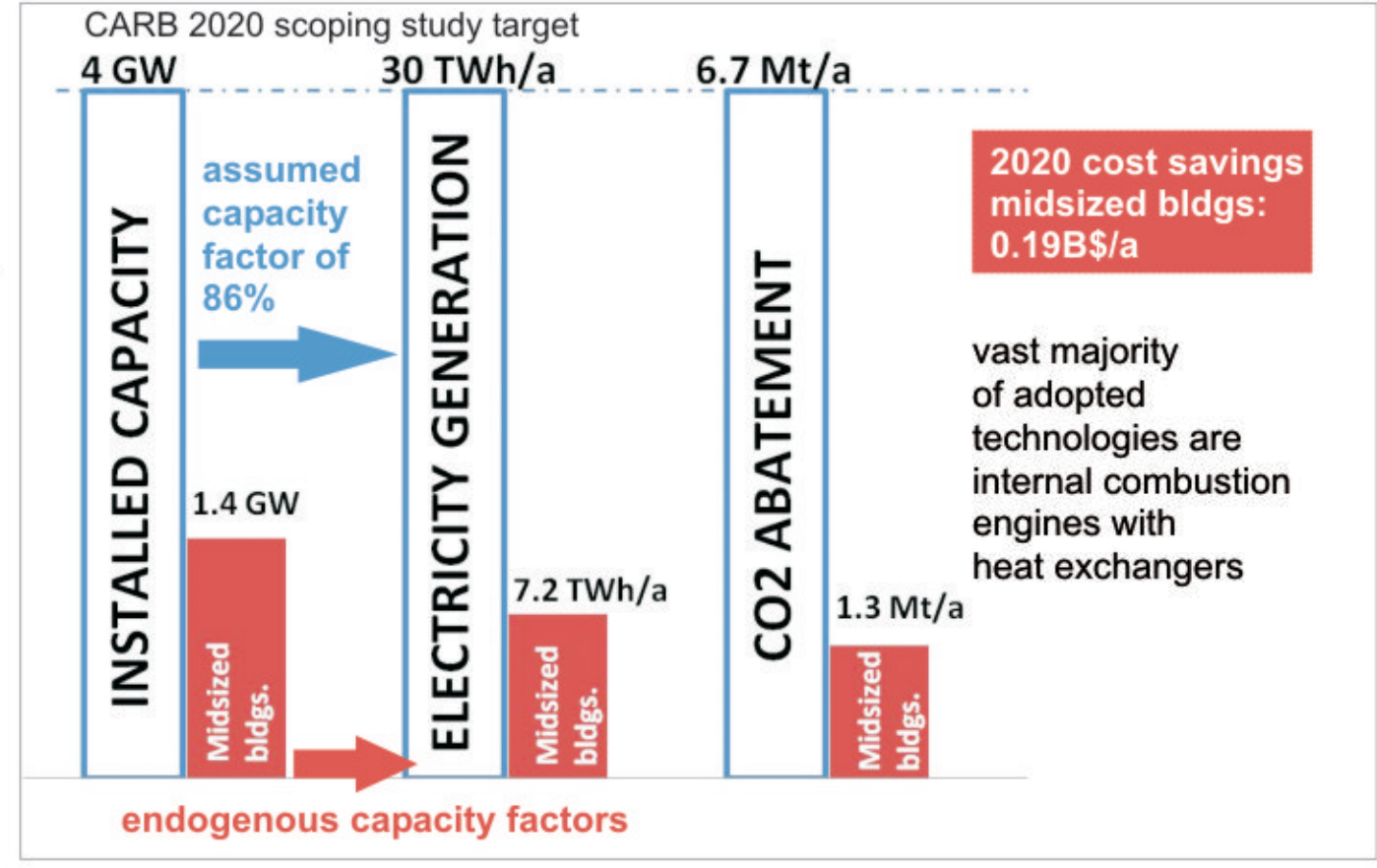
- 12 building types, e.g. schools, colleges, hotels, warehouses, etc.
- 12 forecasting Climate Zones (FZ); using 10 year normalized weather sample; containing simulated hourly estimates of end-use electricity and natural gas consumption
- eQUEST simulations (frontend tool for DOE2)

35% of commercial electric demand considered

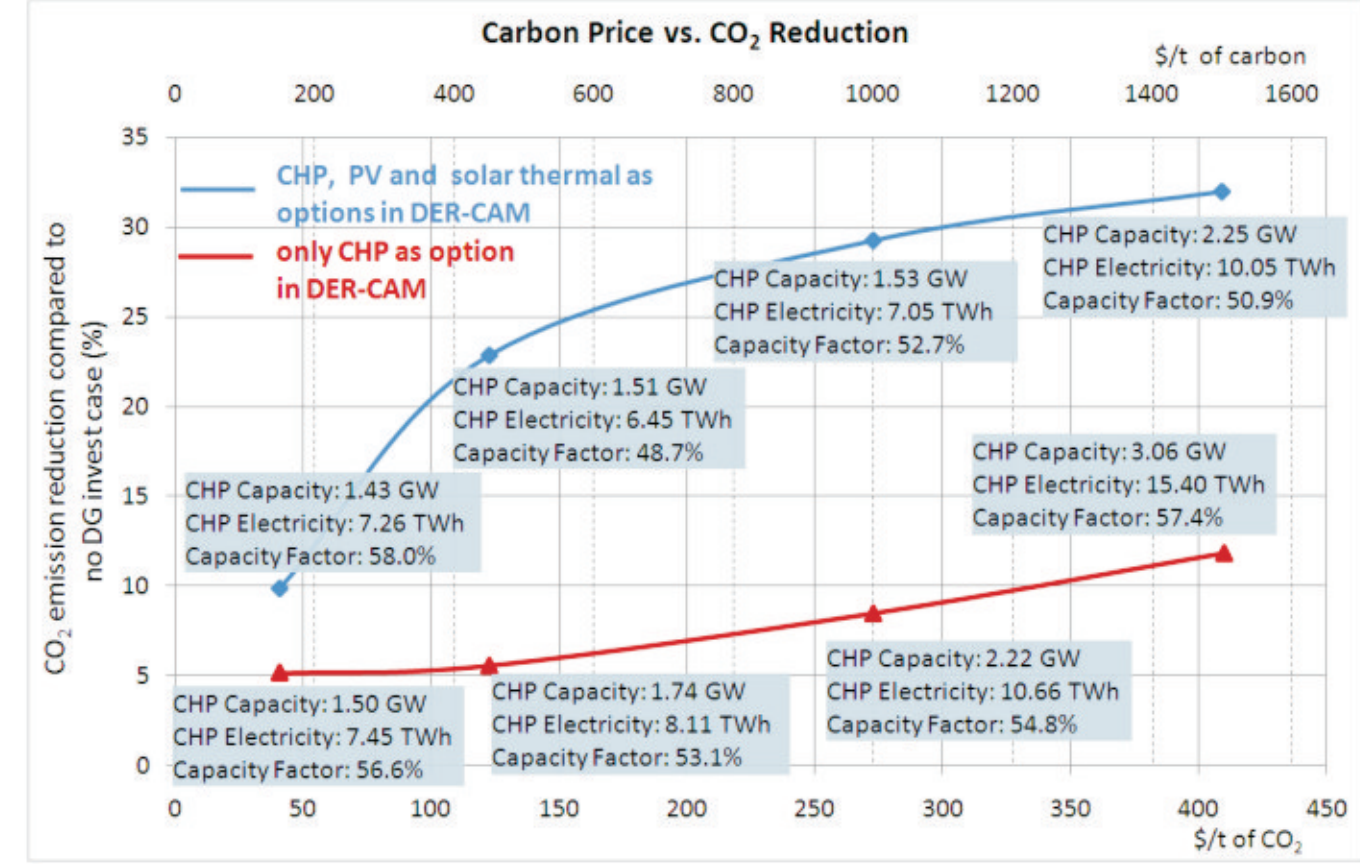
- buildings between 100 kW and 5 MW electric peak load are considered
- no miscellaneous building types
- SMUD and LADWP are not considered



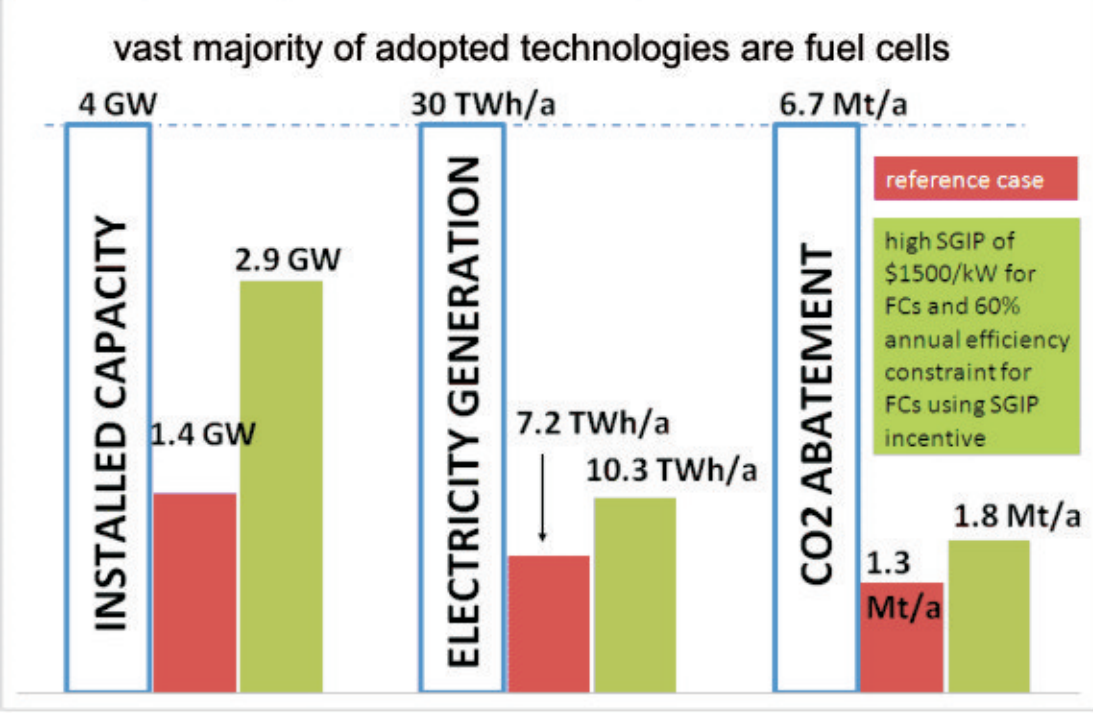
## Result: Reference Case in Comparison to California Air Resources Board's (CARB) 2020 Goal



## Result: Influence of a CO<sub>2</sub> Pricing Scheme



## Result: Influence of Investment Incentives for Fuel Cells in 2020



# Greenhouse Gas Abatement with Distributed Generation in California's Commercial Buildings

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