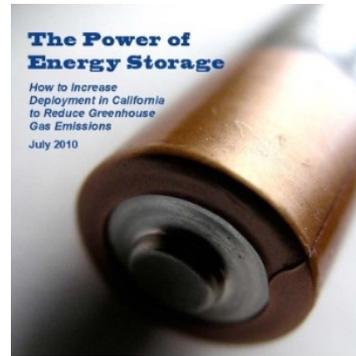


# Energy Storage in California:

## How Law & Policy Has Helped Create A Market



Bank of America  
BerkeleyLaw  
UCLA LAW

Ethan N. Elkind

Director of the Climate Program

Center for Law, Energy & the Environment (CLEE)

UC Berkeley School of Law

**BerkeleyLaw**  
UNIVERSITY OF CALIFORNIA  
Center for Law, Energy &  
the Environment

*Why Energy Storage?*

# SHIFTING PATTERNS



Image Credit: FEMA

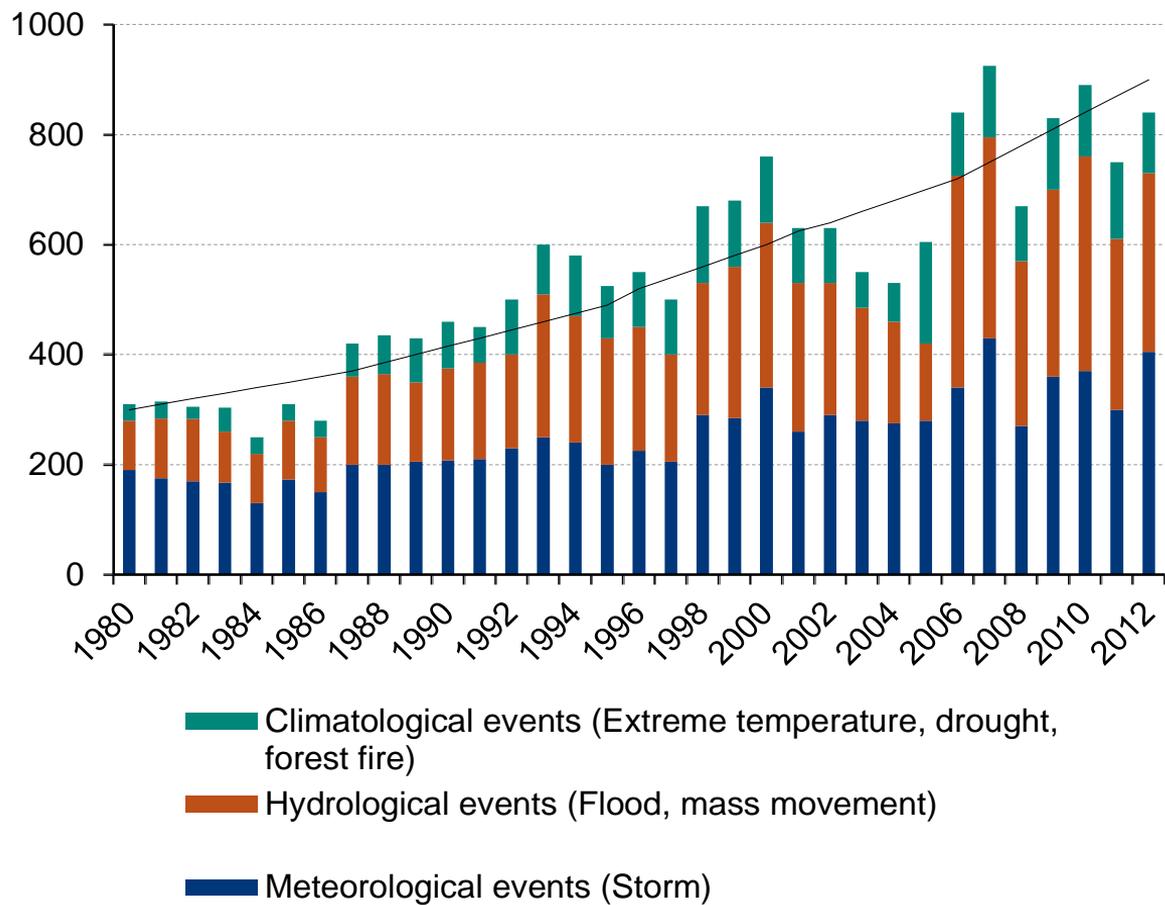


# SEA LEVEL RISE



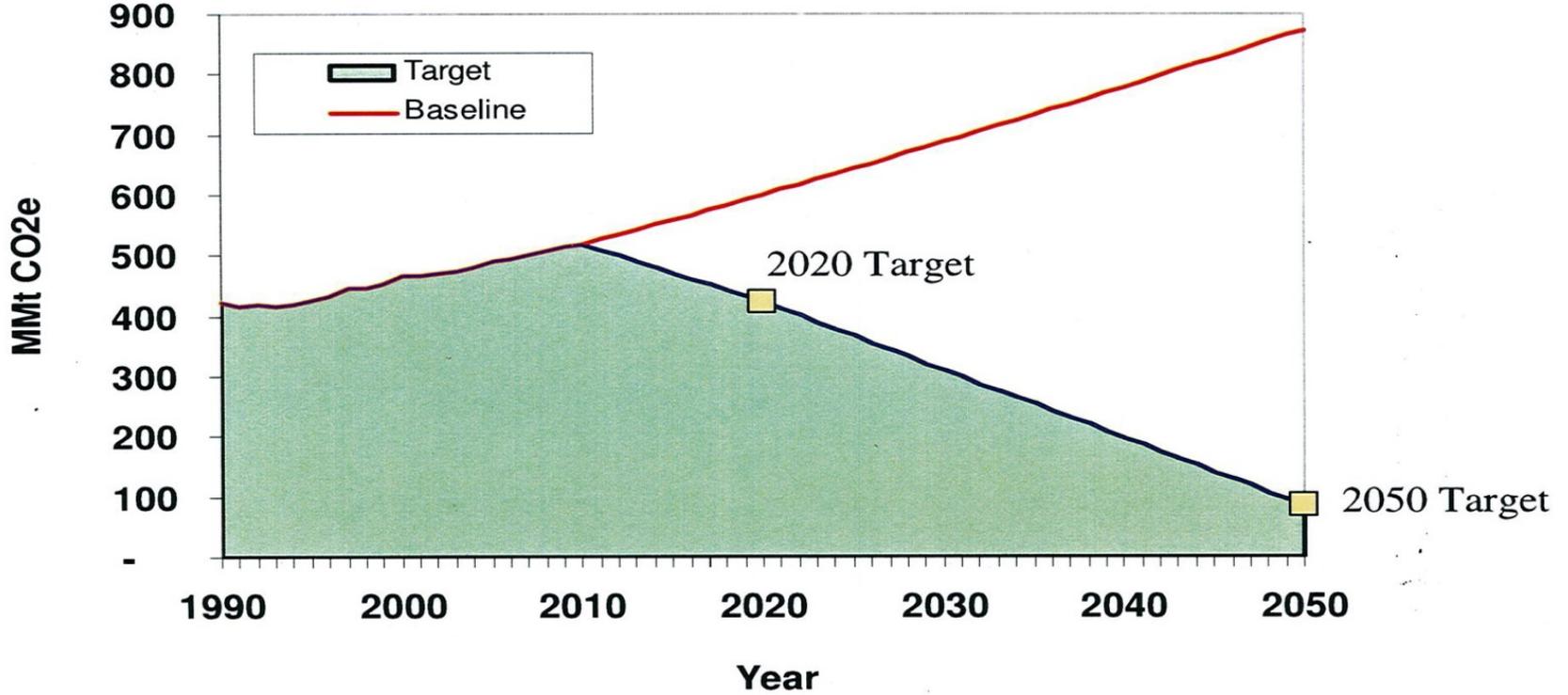
Chart 1: Weather catastrophes worldwide 1980-2012

RISING TEMPERATURES

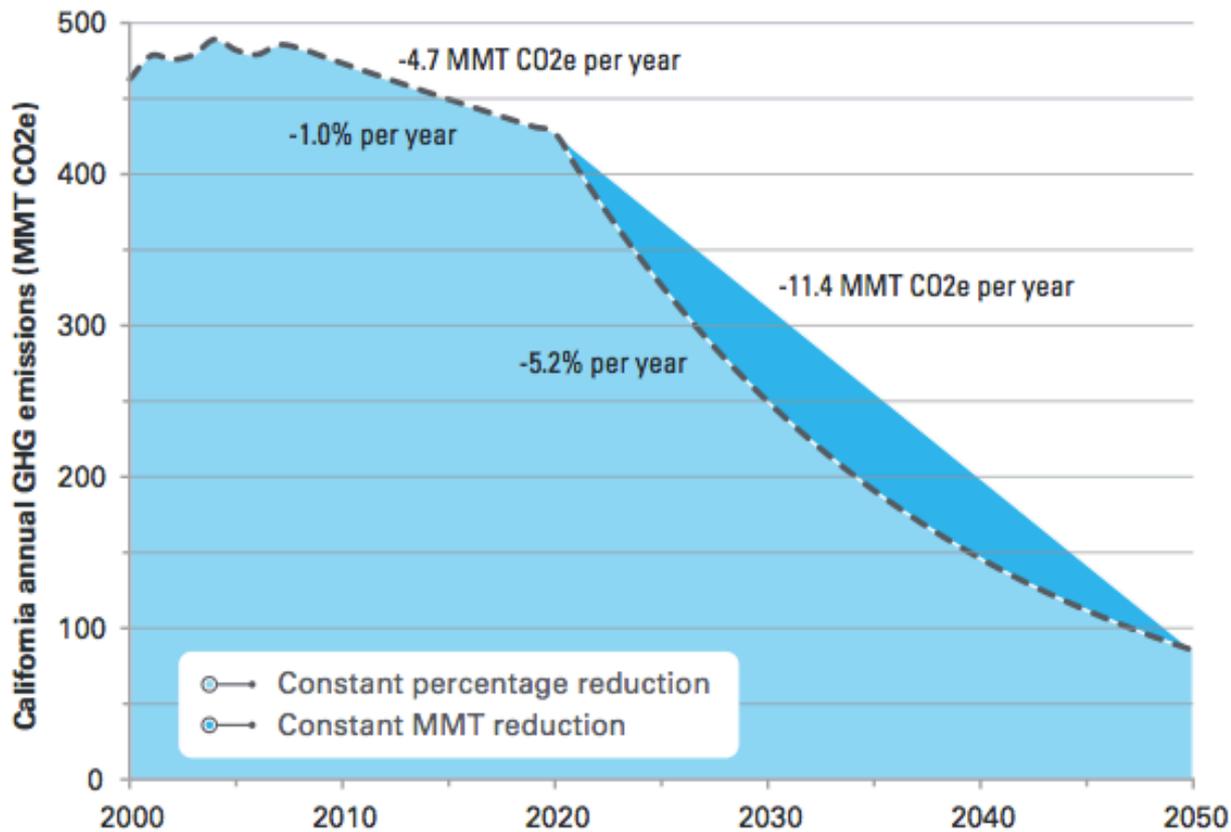


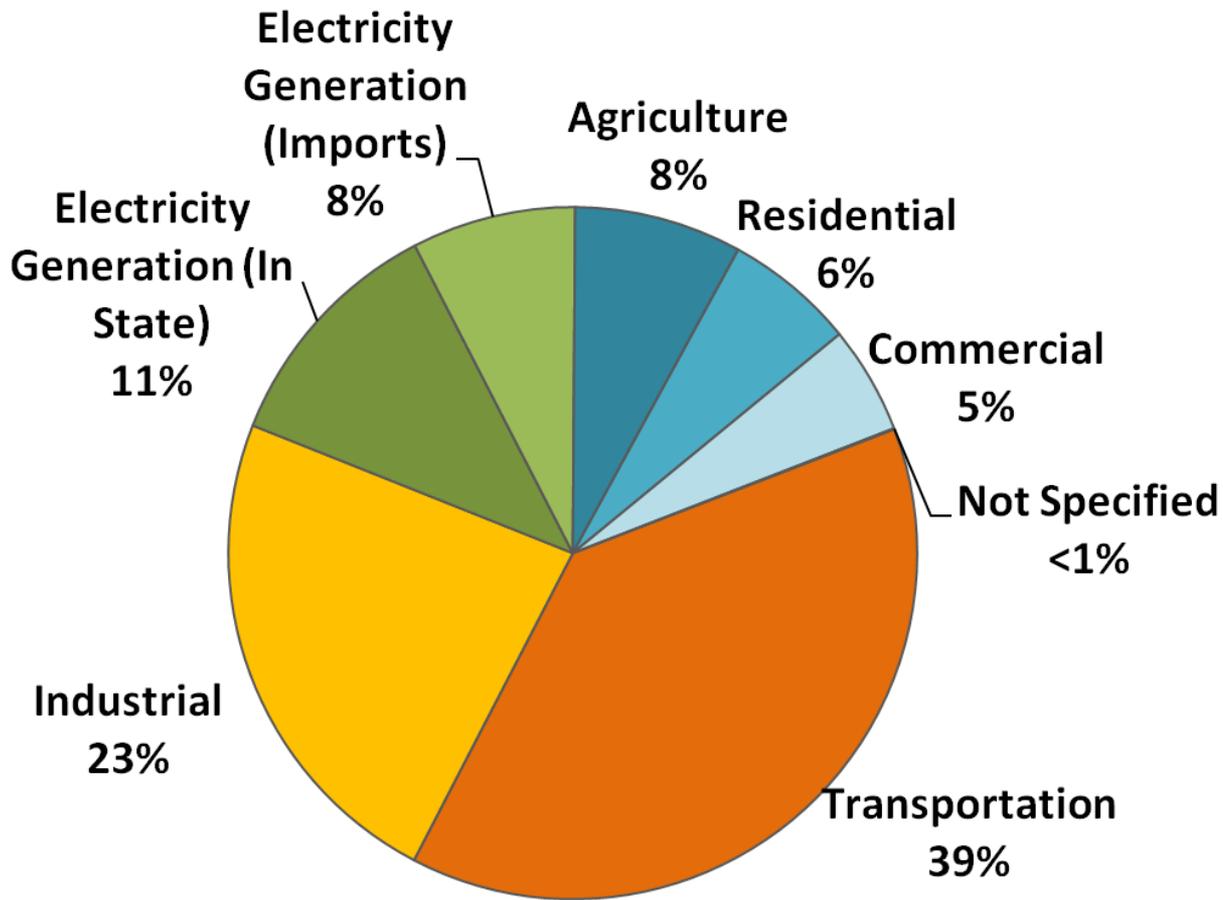
Source: Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – As at January 2013





Pre-2020 and Post-2020 emissions trajectories

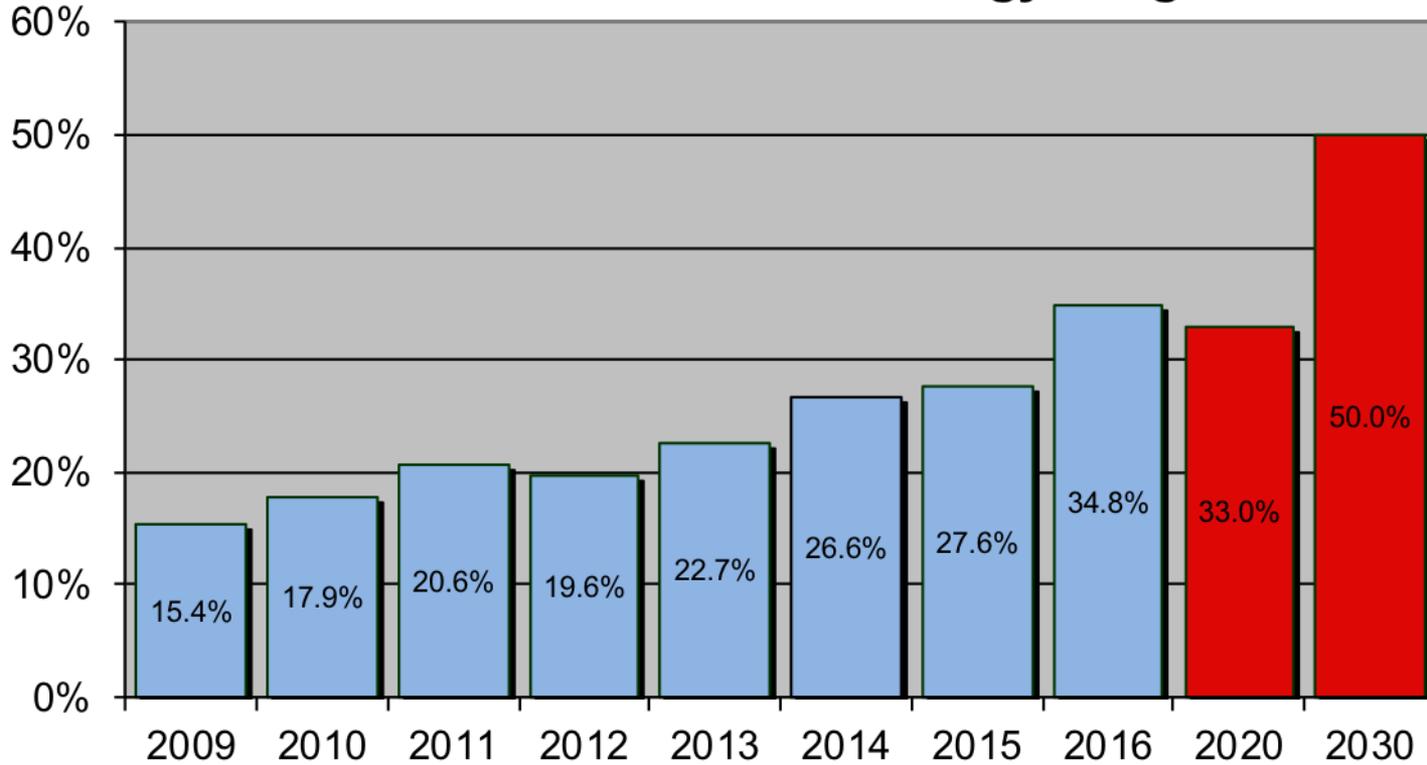




**2015 Total CA Emissions: 440.4 MMTCO<sub>2</sub>e**



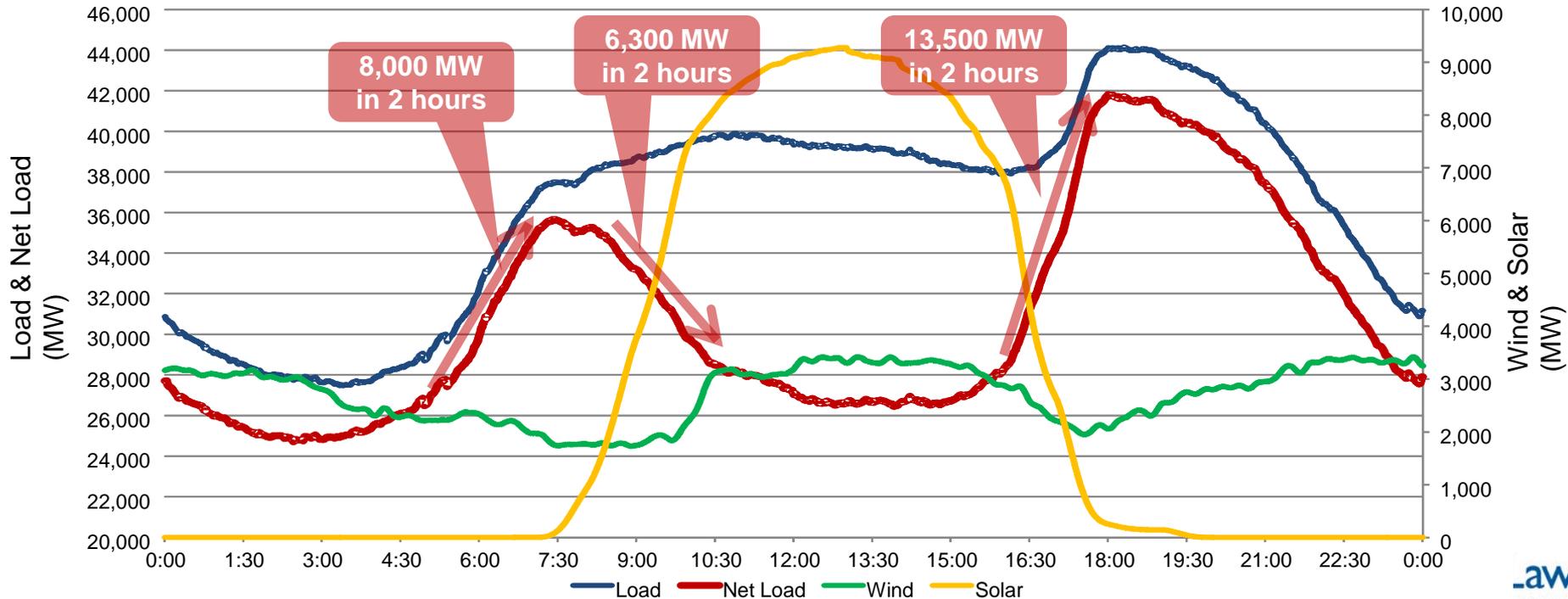
## California's Renewable Energy Progress



Source: California Public Utilities Commission

# 2020 High Net Load Demand Curve

Load, Wind & Solar Profiles – High Load Case  
Example: winter 2020



Source: California ISO

# *Energy Storage Law & Policy*

# Technology Overview

- Electrochemical – Promising Technologies:
  - Advanced lead-acid
  - Li-Ion
  - Flow batteries
- Mechanical – Promising Technologies:
  - Pumped hydro
  - Compressed air
  - Flywheels
- Thermal – Promising Technologies:
  - Solar thermal
  - HVAC applications
- Hydrogen, Ultracapacitors, Superconducting Magnetic Energy Storage

Definition: “A physical system with the ability to capture energy for dispatch or for displacement of electricity use at a later time”

# Mandates: AB 2514 (Skinner, 2010)

## Three Goals:

- 1) Grid optimization (including peak reduction, reliability improvement, or deferment of transmission and distribution upgrade investments)
- 2) Integration of Renewable Energy
- 3) Reduction of Greenhouse Gas Emissions

## Issues:

- Utility vs. Customer Owned
- Offramps & Flexibility
- Technological Innovation



# AB 2514 Targets: 1.325 GW by 2020

| Use case category, by utility       | 2014 | 2020 | Total* |
|-------------------------------------|------|------|--------|
| <b>Southern California Edison</b>   |      |      |        |
| Transmission                        | 50   | 110  | 310    |
| Distribution                        | 30   | 65   | 185    |
| Customer                            | 10   | 35   | 85     |
| <b>Pacific Gas and Electric</b>     |      |      |        |
| Transmission                        | 50   | 110  | 310    |
| Distribution                        | 30   | 65   | 185    |
| Customer                            | 10   | 35   | 85     |
| <b>San Diego Gas &amp; Electric</b> |      |      |        |
| Transmission                        | 10   | 33   | 80     |
| Distribution                        | 7    | 23   | 55     |
| Customer                            | 3    | 14   | 30     |
|                                     |      |      |        |
| <b>Total – all utilities</b>        | 200  | 490  | 1,325  |



# Progress to Date

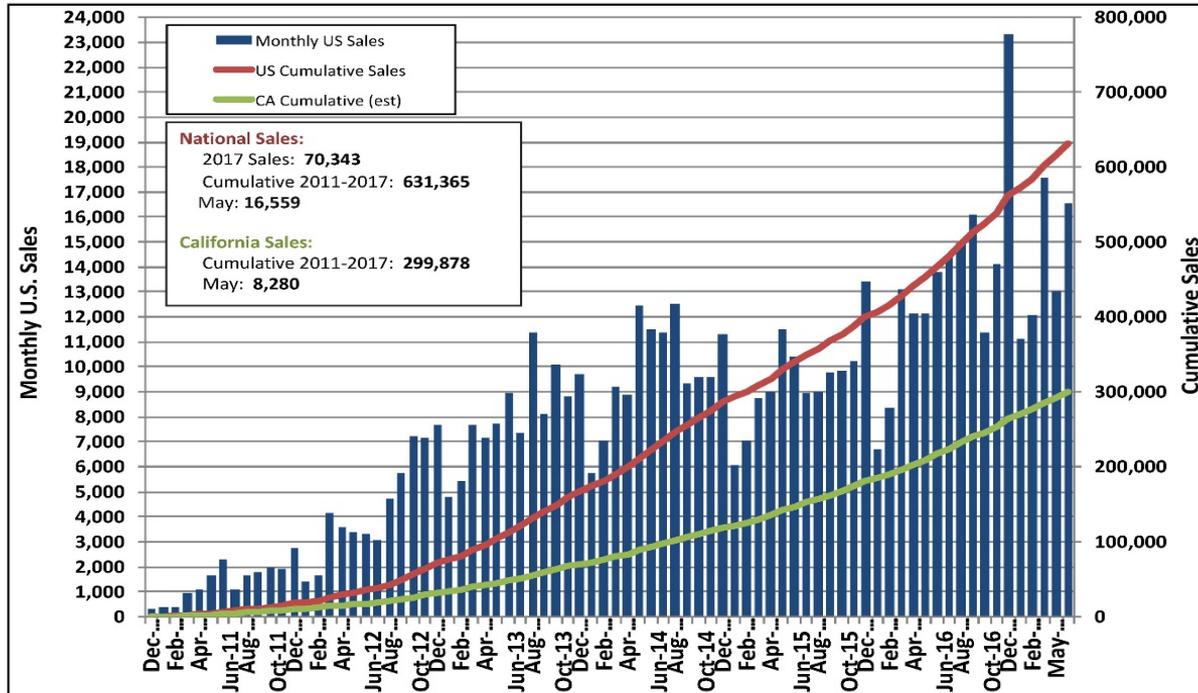
- Pumped hydro: 4,500 MW (2017)
- Thermal systems: 178 MW installed/1,371 MWh (as of Dec. 2016, up from 24 MW/150 MWh in 2014)
- Stationary batteries: 147 MW/401 MWh (as of Dec. 2016, up from 41 MW/117 MWh in 2014)
- Flywheels: few (June 2017)
- CAES: none



# Additional Mandates

- AB 2868 (2016): 500 MW additional behind-the-meter energy storage
- Nuclear & Natural Gas Plant Closures: replace with energy storage

# Zero-Emission Vehicle Mandate: EV Sales 2011-17

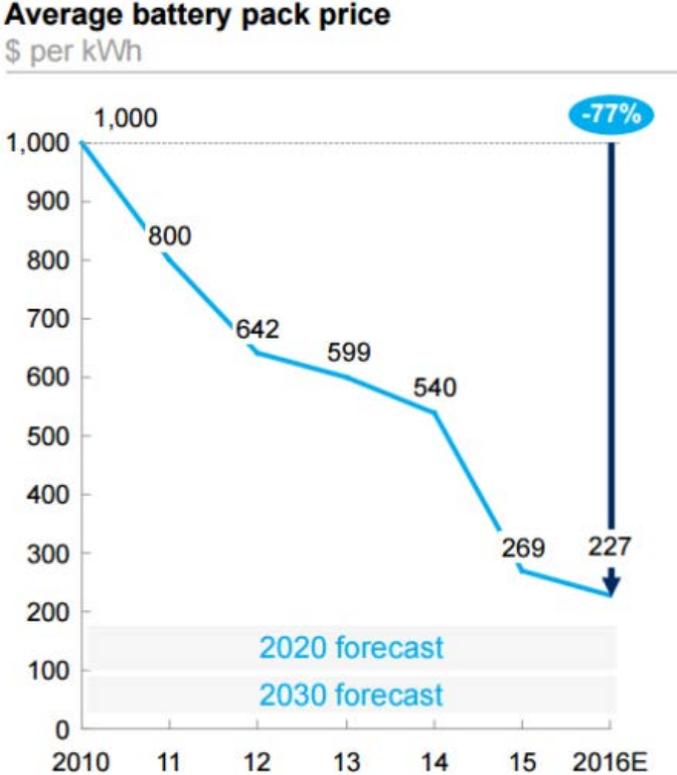


Note: Approximation assumes CA sales are 50% of national sales.  
 Reference: [www.hybridcars.com](http://www.hybridcars.com)

06/02/2017



# Battery Price Decreases



Source: McKinsey





# Incentives & R&D

- AB 1150 (2011): extended self-generating incentive program (SGIP) to energy storage
- Jan. 2018 CPUC Decision: allow "stacking" revenues (wholesale market, distribution grid, transmission system, resource adequacy requirements & customers)
- California Energy Commission research grants

# *Trends & Future Policy Needs*

# Trends: Renewables & Bulk Storage



# Trends: Microgrids & Resilience



# Trends: Backup Power

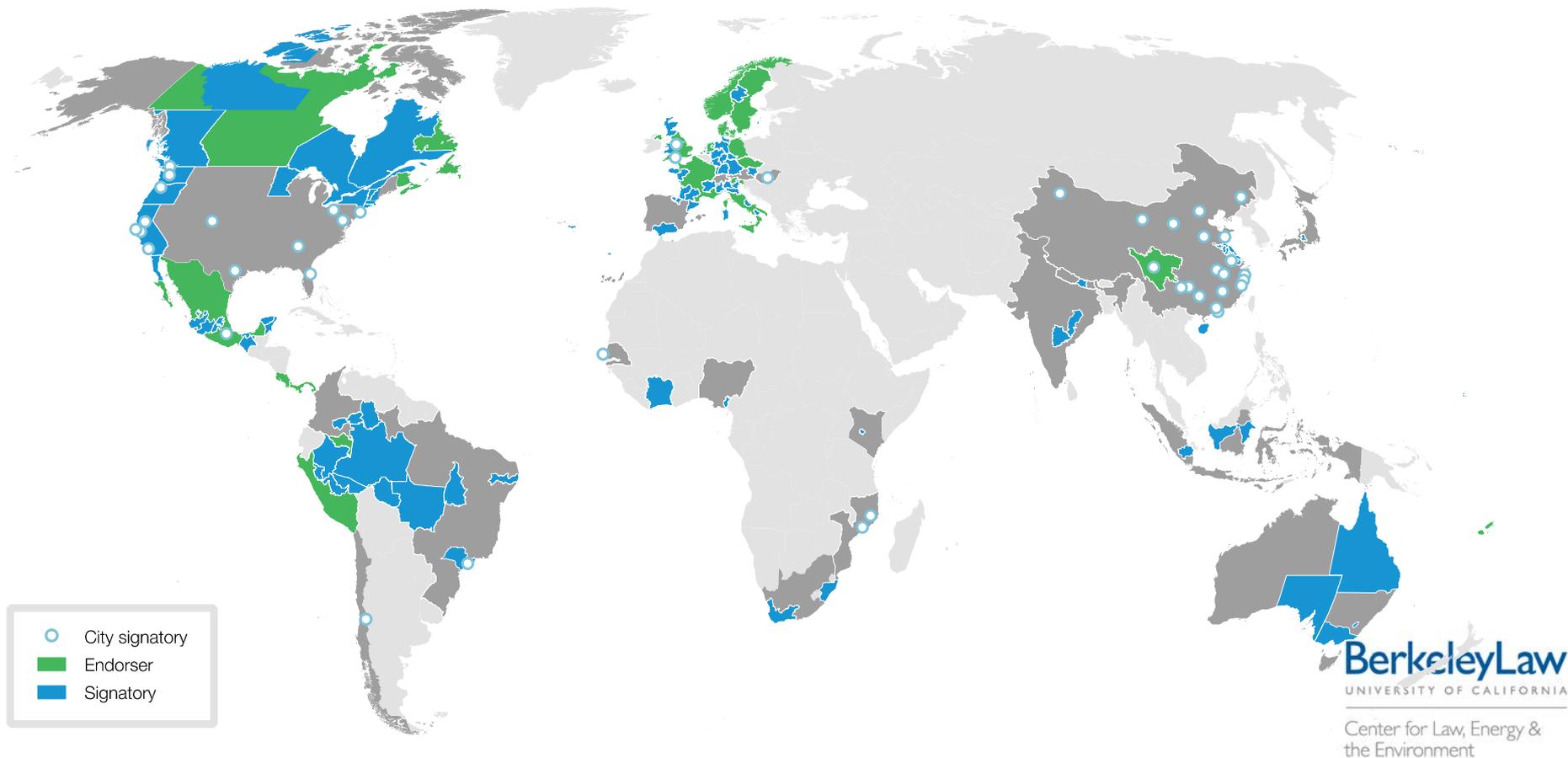


*Global Scale*





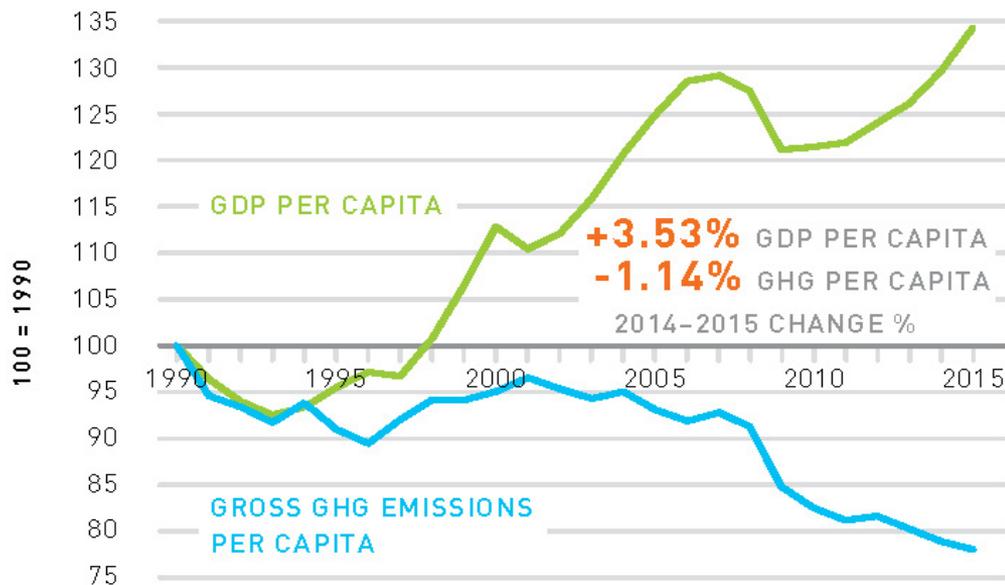
187 states, provinces, regions, cities, and nations have signed or endorsed the Under2 MOU – spanning six continents and 38 countries.



# Conclusion: Future of Energy Storage

## GDP & EMISSIONS

CALIFORNIA, IN 2015 \$



**NEXT 10 CALIFORNIA GREEN INNOVATION INDEX.** Data Source: California Air Resources Board, California Greenhouse Gas Inventory – by Sector and Activity; Bureau of Economic Analysis, U.S. Department of Commerce; U.S. Census Bureau. NEXT 10 / SF · CA · USA

# Ethan Elkind

eelkind@law.berkeley.edu

@BerkeleyLawCLEE

@ethanelkind

clee.berkeley.edu

legal-planet.org

ethanelkind.com

**BerkeleyLaw**

UNIVERSITY OF CALIFORNIA

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