Challenges to the Electricity Sector: California's Efforts at Long-term Decarbonisation

14th IEA-IETA-EPRI Annual Workshop on Greenhouse Gas Emission Trading

October 8, 2014

Pacific Gas and Electric Company®

Agenda

- California's Long-Range GHG Reduction Goals
- Modeling Pathways to Achieve California's Long-Range GHG Reduction Goals
- Existing and Post-2020 Policy Framework
- California and 111(d)

Setting California's Long-Range GHG Reduction Goals

- The UN Intergovernmental Panel on Climate Change (IPCC) identified the need to stabilize global carbon dioxide concentrations to avoid risk of large-scale, irreversible changes in the global environment
  - 450 parts per million (ppm) selected as upper bound to limit temperature increases to 2° Celsius and sea level rise to 0.4 meters
- To achieve climate stabilization, the UN IPCC recommended*:
  - 80% reduction in GHG emissions below 1990 levels by 2050 for developed countries
- In 2005, Governor Schwarzenegger issued an Executive Order adopting this goal for California
- Assembly Bill 32 requires California achieve 1990 levels by 2020
  - Statewide GHG emissions limit shall remain in effect unless otherwise amended or repealed
  - Post-2020 targets now under discussion

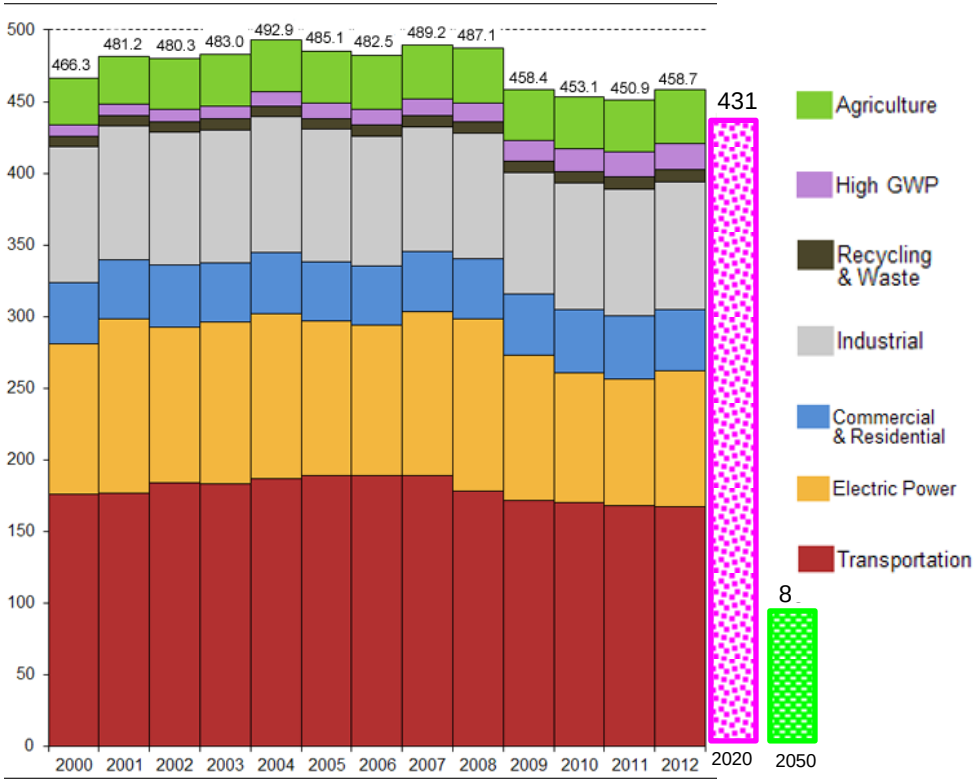
* Source: IPCC Fourth Assessment Report (2007).
IPCC Fifth Assessment Report expected in October, 2014

Making Progress Towards California's GHG Reduction Goals

California is on track to achieve its 2020 target, but the pace of emissions reductions will need to accelerate to reach the 2050 goal

- According to ARB, "California is on track to meet the near-term 2020 greenhouse gas limit and is well positioned to maintain and continue reductions beyond 2020 as required by AB 32" (ARB's First Update to the Climate Change Scoping Plan)
- Achieving an 80% reduction will require substantial reductions from every sector
- The pace of GHG reductions will need to accelerate to achieve the 2050 target
- In California, the transportation and electric sectors are the focus of GHG policy

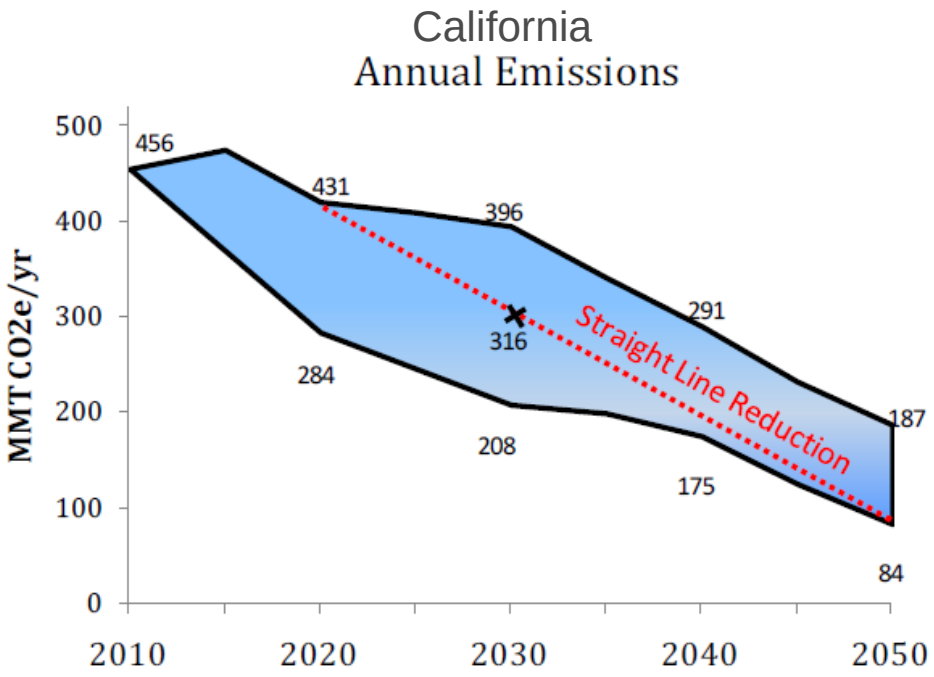
California's GHG Emissions by Scoping Plan Category

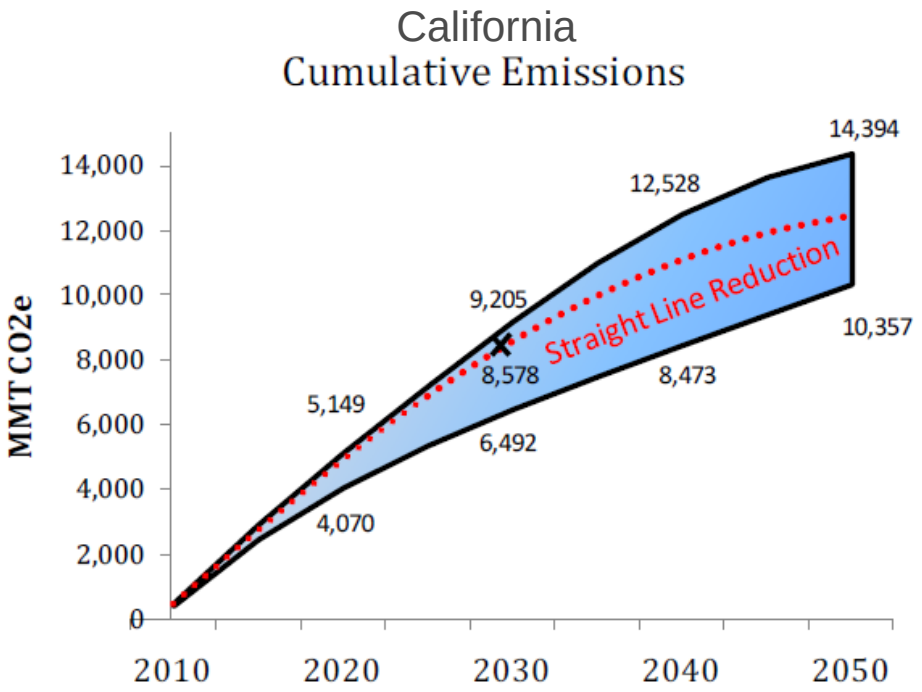


Source: ARB: California GHG Inventory for 2000 to 2012 — by Scoping Plan Category

What's Next: California's Path to 2050 GHG Reductions

- A number of models have been built to study strategies for reducing California's GHG emissions to 80% below 1990 levels in 2050
  - Emissions trajectories vary across models
  - Contributions of technologies and fuels vary across models





Source: Long-term Energy Planning In California: Insights and Future Modeling Needs, UC Davis: http://policyinstitute.ucdavis.edu/initiatives/ccpm/

Strategies to Reduce Emissions

Primary strategies to reduce GHG emissions:

1) Increase efficiency

- Electric and Natural Gas
  - Increase energy efficiency of buildings and appliances
- Transportation
  - Improve vehicle efficiency to increase miles per gallon equivalent (MPGe)

2) Reduce demand for energy services

- Electricity and Natural Gas
  - Change behavior to reduce consumer demand for electricity and natural gas
- Transportation
  - Change behavior and land-use planning to decrease vehicle miles traveled (VMT)

3) Reduce carbon intensity of energy

- Transition to zero and low-carbon electric generation, pipeline gas, and transportation fuels

California's Post-2020 GHG Reduction Policy

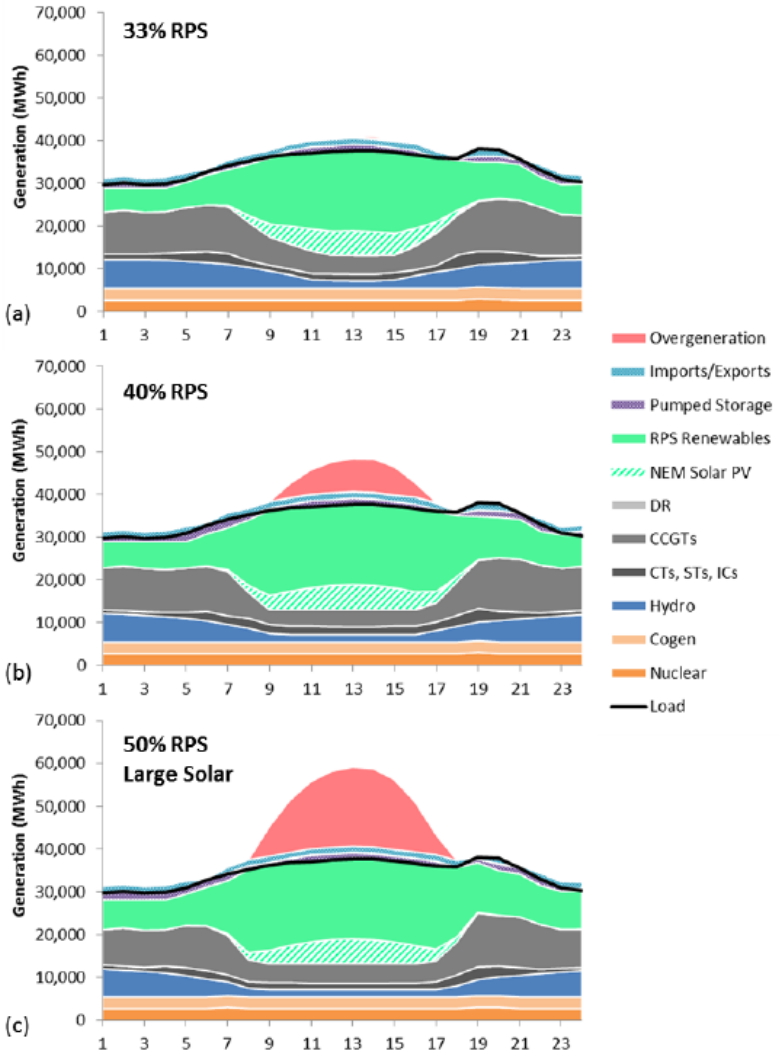
Post-2020 GHG reduction policy in California remains undefined:

- Mid-term target (2030) between 2020 and 2050 likely
- Rate of emissions reduction needed to achieve the mid-term and 2050 goals has yet to be determined
- Strategies to meet these goals have not been put into place
  - Most existing GHG reduction programs target 2020 (e.g., Cap-and-Trade, LCFS, RPS etc.)
- US EPA 111(b) and (d) draft power sector regulations issued

Overgeneration is the Most Significant Integration Challenge

- **Chart shows increasing overgeneration above 33%**
  - Overgeneration is very high on some days under the 50% Large Solar case
  - Fossil generation is reduced to minimum levels needed for reliability
- **Renewable curtailment is a critical strategy to maintain reliability**
  - Reduces overgeneration
  - Mitigates ramping events

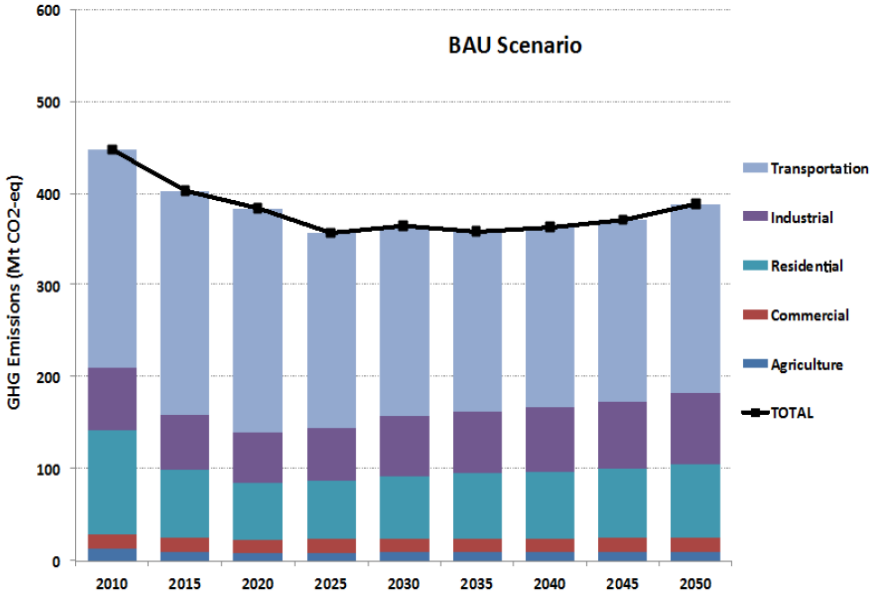
Example April Day



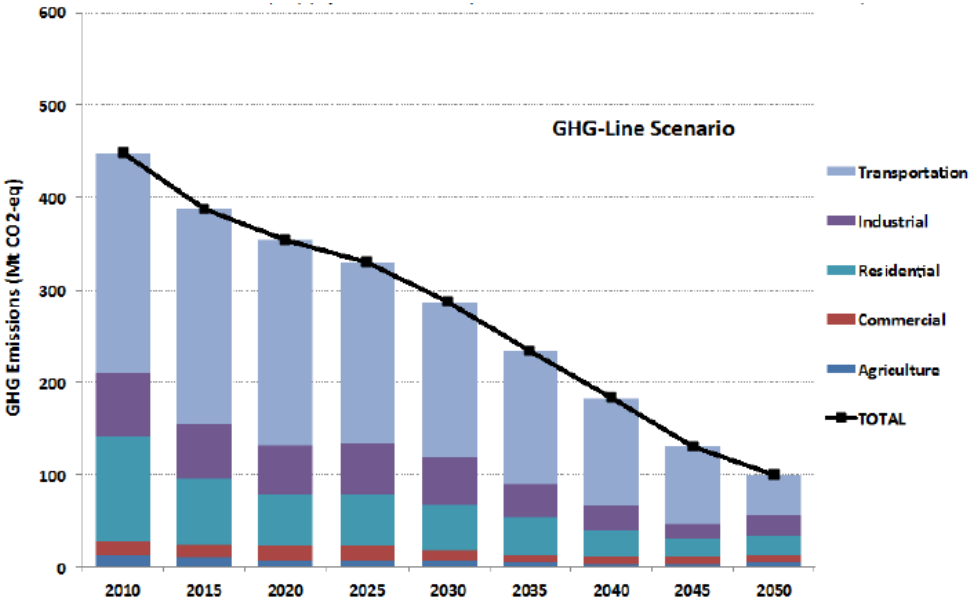
UC Davis "CA-Times": Trajectory to 2050

- "BAU" Scenario, or the Reference Case: Represents a vision of the state GHG trajectory with the current state and federal policies in place
- "GHG-Line" Scenario: Places a declining carbon cap constraint on roughly a linear trajectory

BAU Statewide Emissions by End-use



GHG-Line Statewide Emissions by End-use

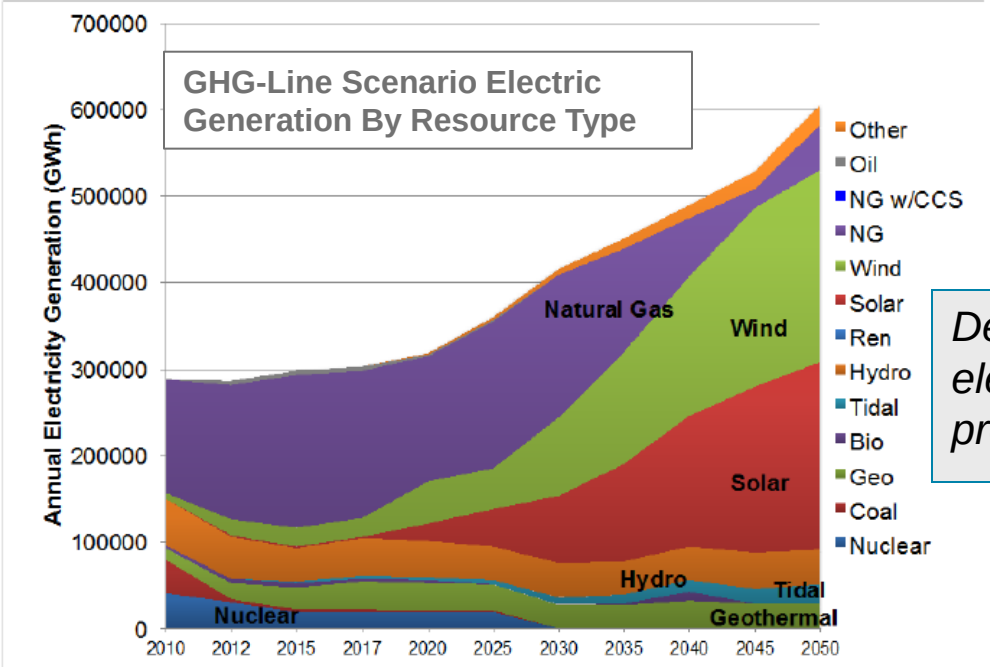


Despite substantial reductions across all sectors, 2050 emissions are only 75% below 1990 levels.

Pacific Gas and Electric Company®

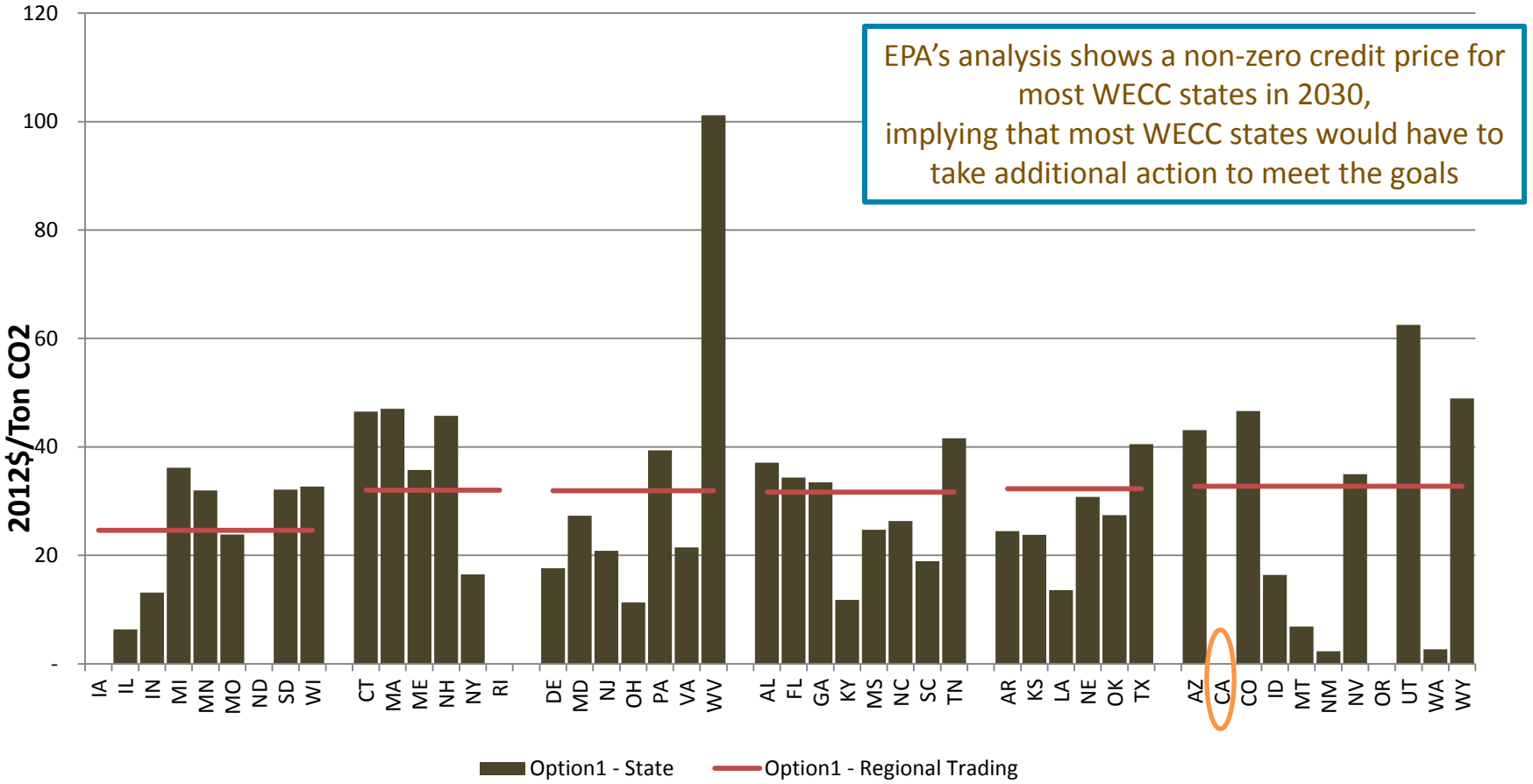
UC Davis "CA-Times" Model: Reducing Carbon Intensity of Electricity

- BAU: Electricity generation increases 41% in BAU, with natural gas representing the largest contribution to the state's electricity mix
- GHG-Line: *Energy efficiency gains are substantial, but demand for electricity doubles*
  - Electrification of industrial sector drives approximately half of this growth
  - Electric vehicle charging, creation of hydrogen, and population growth are other drivers
- GHG-Line: *Carbon intensity of electricity declines from 440 lbs/MWh in 2020 to 66 lbs/MWh in 2050*
  - Non-carbon generation climbs to 60% in 2030 (of 400,000 GWh, or 54% RPS equivalent) and 88% in 2050 (of 600,000 GWh, or 81% RPS equivalent)
  - Remaining emissions result from continued use of natural gas generation for load balancing



Decarbonization of electric supply and electrification of end-uses are key strategies to progress toward 2050 target.

EPA's Projected State 111(d) Credit Prices in 2030



- Credit prices are a measure of the stringency of EPA's proposed goals for each state
- *For CA, extending current policy appears sufficient to meet EPA's proposed goals*
- Only four other states are in this position

Source: U.S. EPA. Data compiled by ICF

Key 111(d) Issues

1. Best System of Emission Reduction (BSER) Goal-Setting and Compliance
    - Desirable Outcomes:
        - *General equivalence between goal-setting and compliance counting*
        - *Broad compliance flexibility*
2. Conversion of state goals from intensity (lbs/MWh) to mass (tons)
    - Desirable Outcomes:
        - *Ensure goal is achievable after conversion*
        - *Adjustments built-in for key external drivers; for example:*
            - *Transport electrification*
            - *Economic/demographic growth*
            - *Level of imports*
3. Multi-state coordination to avoid a patchwork of state approaches that raise costs and emissions relative to efficient approaches
    - Desirable Outcome:
        - *May be difficult to achieve alignment across WECC given disparate starting points*
        - *Efficient siting and dispatch in the WECC, with beneficial impacts on wholesale prices and emissions levels*

APPENDIX

EPA's Best System of Emission Reduction (BSER)

EPA uses four building blocks to determine each state's **emission rate** goals:

1. Heat Rate Improvements at Existing Coal-Fired Power Plants

2. Increased Utilization of Existing NGCC

3. Operation of Zero-Emitting Generation

4. Increased Demand-Side Energy Efficiency

Emission rate: lbs of CO_2 per megawatt hour (lbs/MWh)

The relative impact of each building block on individual state goals varies substantially

Calculating Each State's Goal under 111(d)

Adjusted Emissions Rate

$$\frac{\text{2012 Fossil } CO_2 \text{ Emissions (after coal heat rate improvements and redispatch)}}{\text{Fossil MWhs generated} + \text{At Risk Nuclear (5.8\%)} + \text{Projected RE MWhs} + \text{EE Savings}} = \text{California's 2030 Goal: 537 lbs/MWh}$$

California's Existing Policy Map

GHG Reduction Strategy	Electric Sector	Natural Gas Sector	Transportation Sector	All Energy Sectors
Increase Efficiency	Energy Efficiency Programs • 3,000 GWhs of savings for 2014-15 statewide Codes and Standards • 1,200 GWhs of savings for 2014-15 statewide	Energy Efficiency Programs • 80+ MMTherms of savings for 2014-15 statewide Codes and Standards • 4.5 MMTherms of savings for 2014-15 statewide	Pavley Fuel Efficiency Standards • Average of 30% reduction in GHG emissions by 2016 Advanced Clean Cars (e.g., Zero Emission Vehicles)	Cap-and-Trade
Reduce Demand for Energy Services	Behavioral programs • Captured under energy efficiency programs above	Behavioral programs • Captured under energy efficiency programs above	SB 375 • Long-run land use planning by Municipal Planning Organization	
Reduce Carbon Intensity of Energy	Renewable Portfolio Standard • 33% by 2020 GHG Rate Standards: • SB 1368 • US EPA 111(b) proposal	AB 1900 • Requires CPUC to adopt programs to promote in-state production and distribution of biomethane	Low Carbon Fuel Standard • 10% reduction (from 2010) in carbon intensity of fuels by 2020	

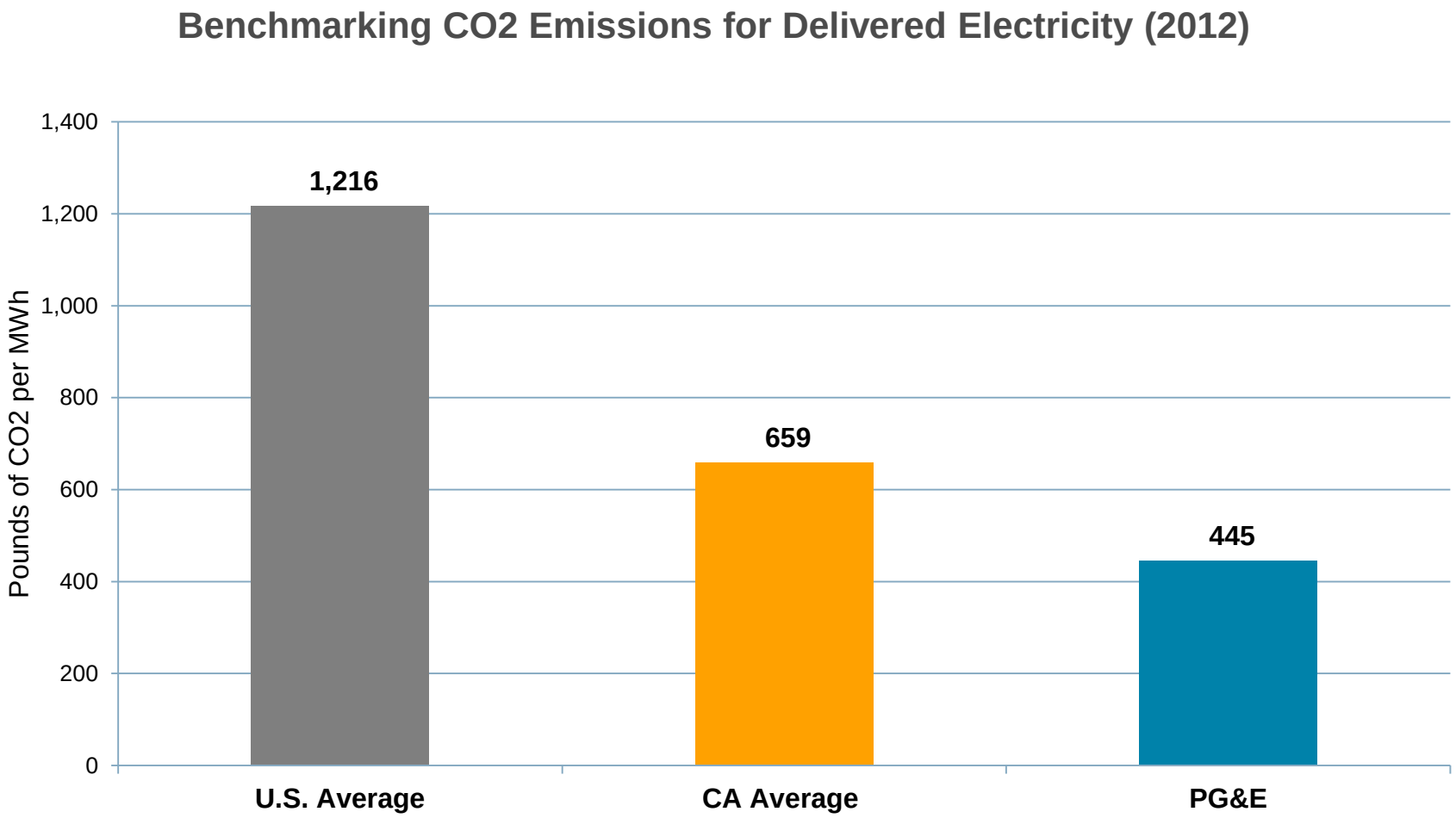
- *All three GHG reduction strategies are reflected in California's existing clean energy policies*

EPA's Adjusted Emission Rate Goals for States

California's Final State Goal

537 lb/MWh

PG&E's Progress: Emissions Rate



***Sources:** US/CA averages – US Environmental Protection Agency eGRID2012 Version 1.0, which contains year 2009 information configured to reflect the electric power industry's current structure as of May 10, 2012. PG&E – The Climate Registry, a third-party verification of greenhouse gas emissions data.*