Presentation

More Renewables, Less Carbon: How Fast, How Far, and at What Cost?

Harvard Electricity Policy Group

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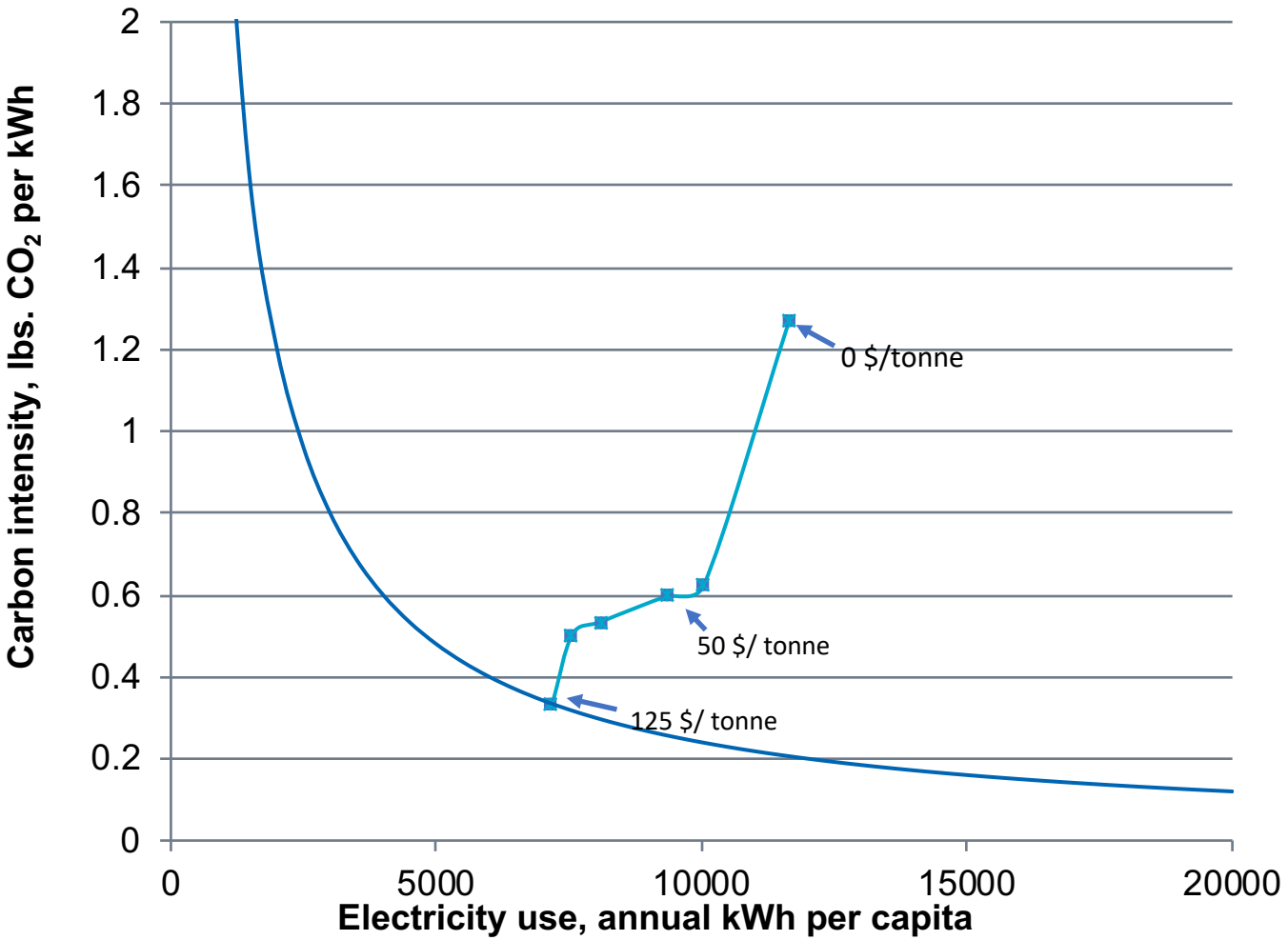
Overview

- Renewables are a means to an end, rather than an end themselves. Therefore, climate policy goals and approaches determine how far, how fast, and what cost more renewable deployment can result in less CO_2 emissions.

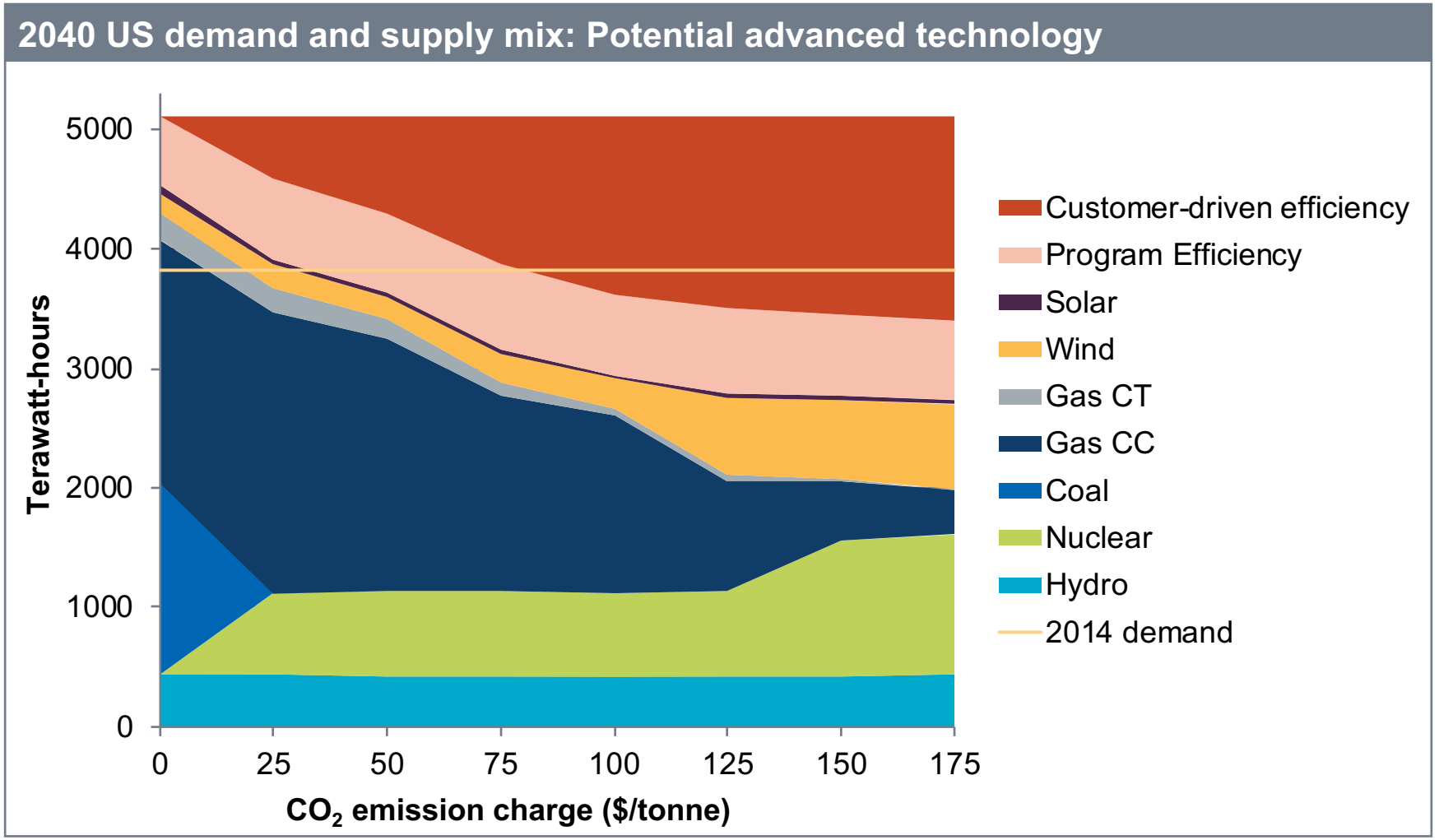
- A US electric supply portfolio that cost-effectively internalizes a real 50 dollars per metric tonne charge for CO_2 emissions, or cost-effectively achieves a sustainable per capita CO_2 emission profile, likely involves a US wind and solar generation share of between 6 and 25 percent by the year 2040 based on expected grid-based electricity demand and supply conditions, including the cost and performance characteristics of the current and advanced state of electricity production technologies. Under these conditions, cost-effective wind and solar resource expansions contribute to the overall grid-based electricity system integrated average real cost increases of 23 and 41 percent respectively for the 53 and 80 percent reductions in the annual electricity CO_2 emissions per capita from 2018 levels.

- Accumulating experience in the California electricity system illustrates the impact of key factors determining the cost-effective expansion of wind and solar electricity supply resources, the unintended consequences of renewable policy approaches, and the impact on electricity sector CO_2 emissions.

Potential advanced technology US electricity CO_2 emission per capita, 0 to 125 $/tonne: 2040



Source: Makovich, Lawrence, *Tilting at Windmills: Making a case for reframing electric sector climate policies*, June 2017, available at https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/78_tilting%40windmills.pdf



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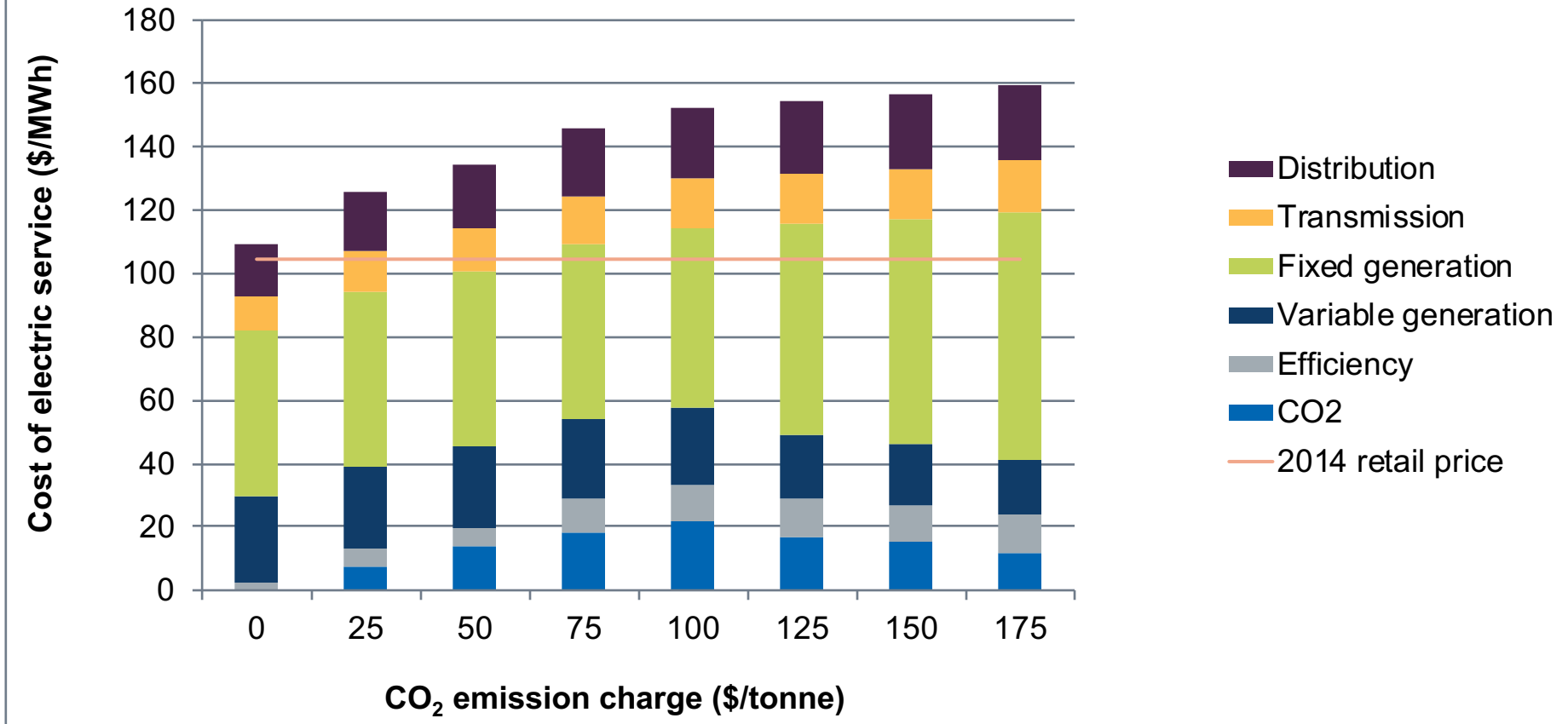
Potential advanced technology real average retail prices



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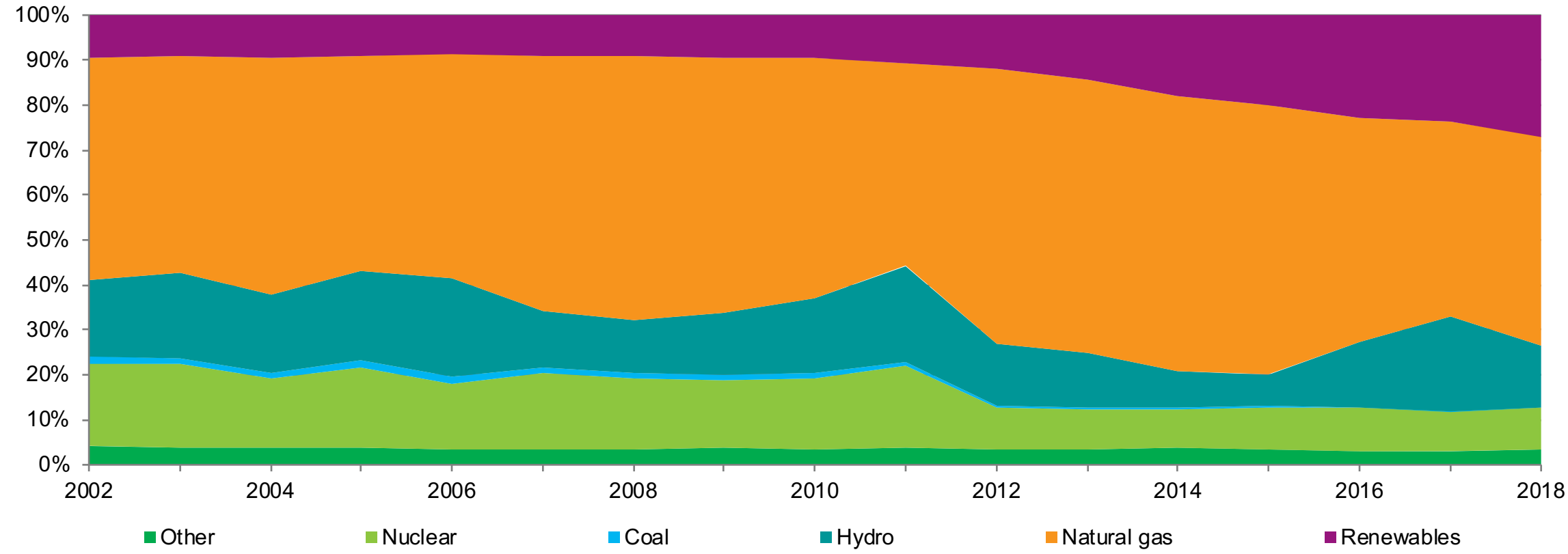
California in-state power generation by fuel type

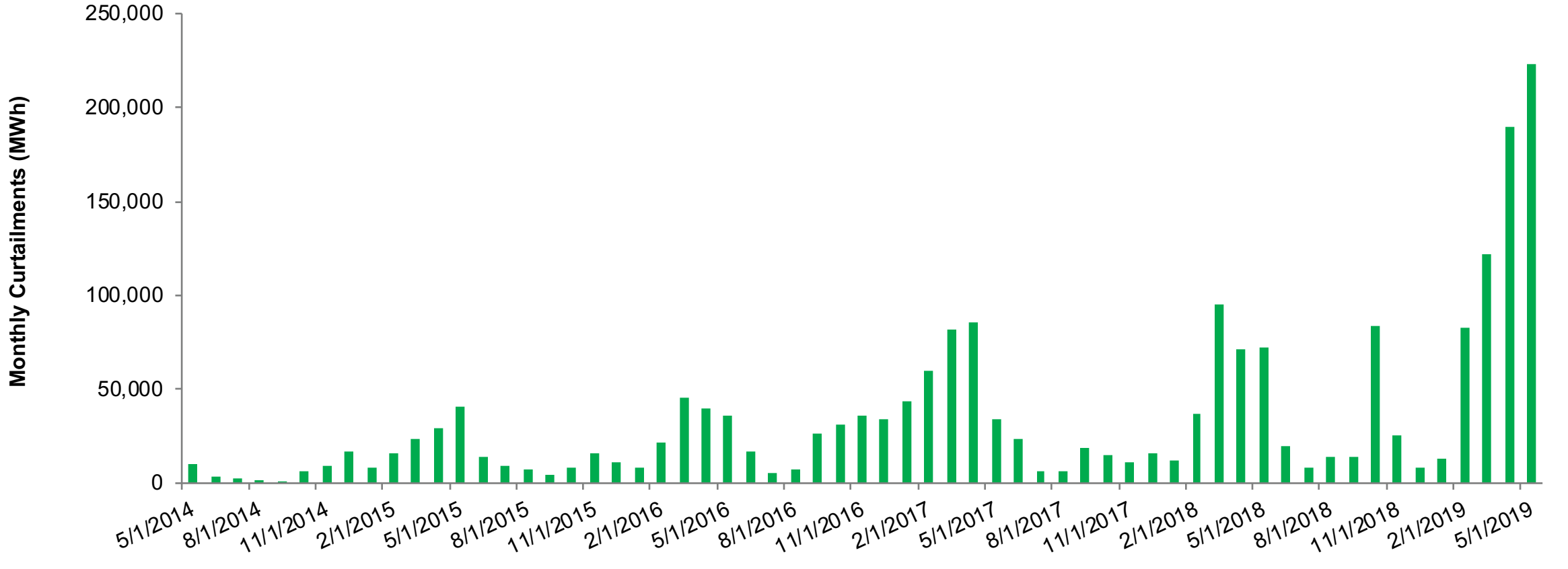
California in-state power generation: Shares by fuel, 2002–2018



Notes: Other includes biomass, waste heat, oil and pet coke
Source: IHS Markit, California Energy Commission

California ISO monthly wind and solar curtailments

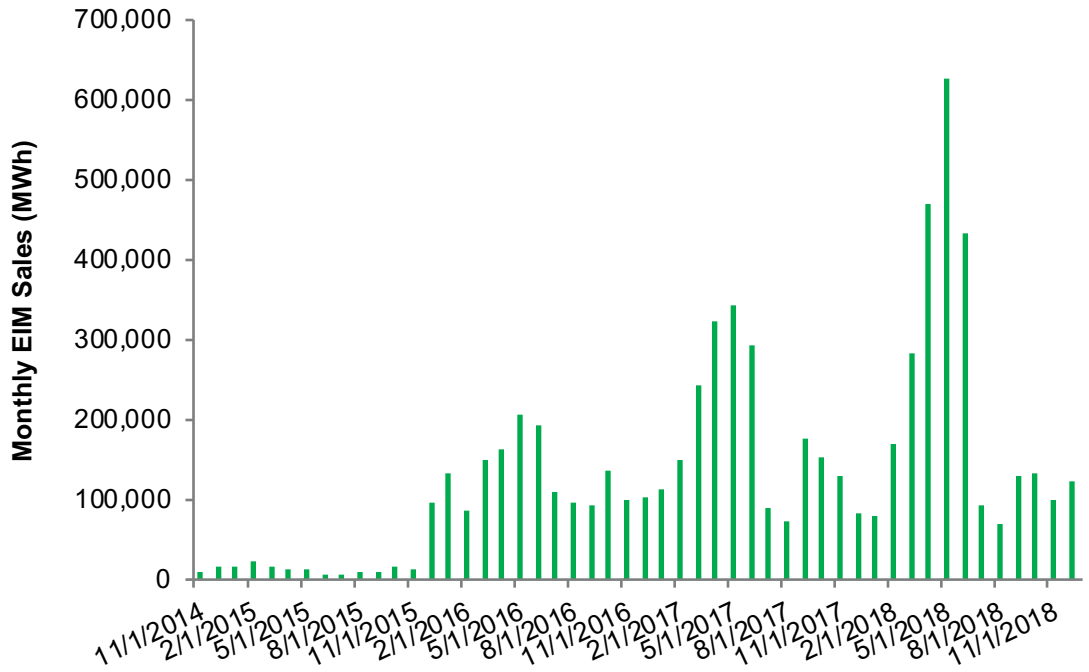
CAISO monthly solar and wind curtailments, May 2014 - May 2019



Source: IHS Markit, CAISO

California ISO monthly sales and average price into the Western Energy Imbalance Market

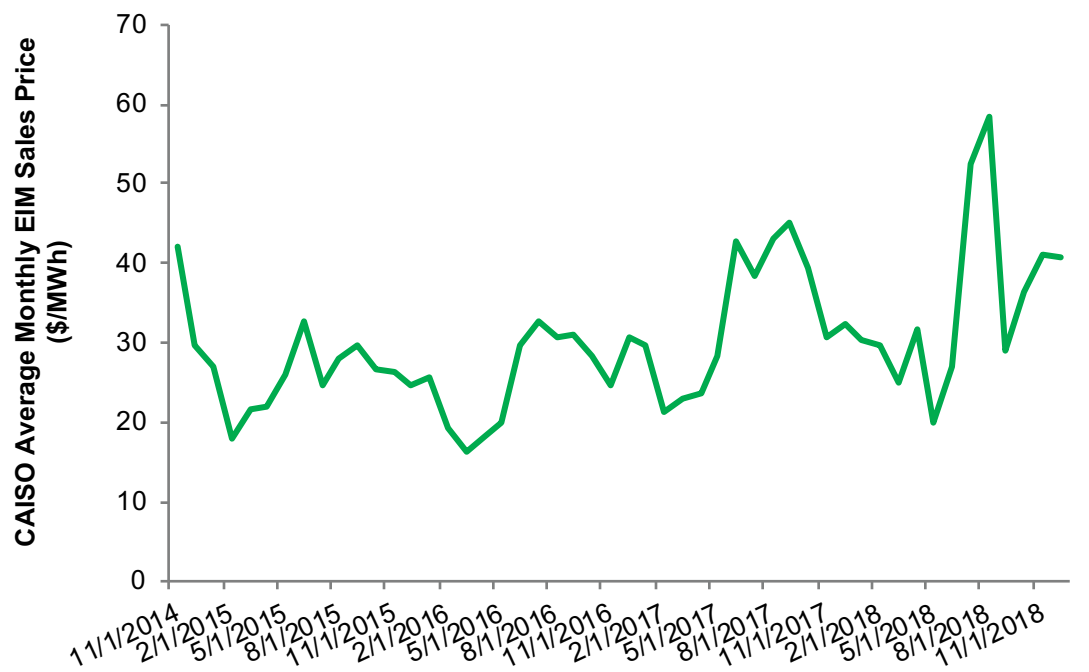
CAISO monthly sales in the Western Energy Imbalance Market, November 2014 - December 2018



Notes: CAISO monthly EIM sales includes sales to PACW, NEVP, AZPS and PWRX load aggregation points

Source: IHS Markit, Western Energy Imbalance Market

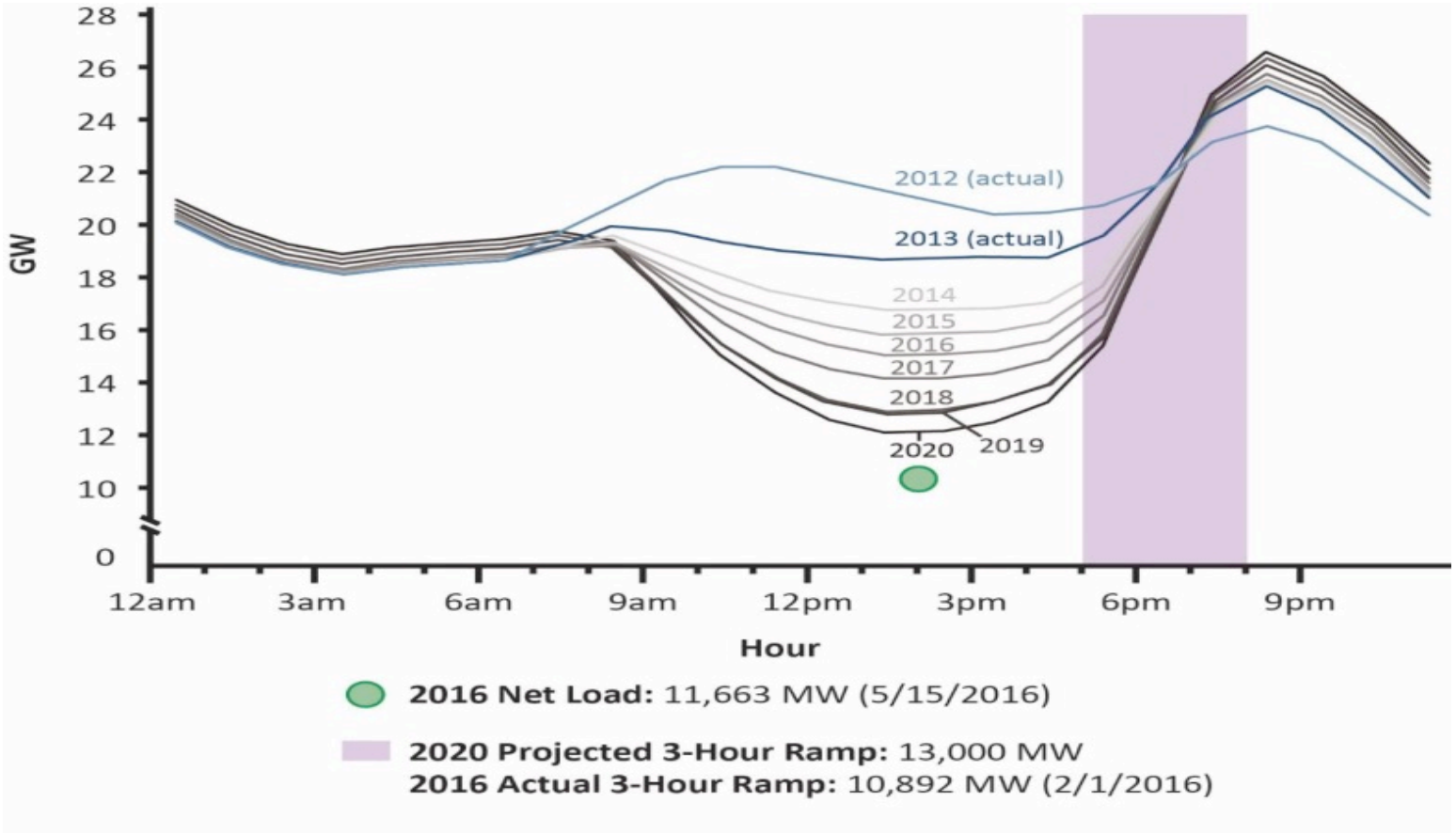
CAISO average monthly Western Energy Imbalance Market sales price, November 2014 - December 2018



Source: IHS Markit, Western Energy Imbalance Market

California ISO net load

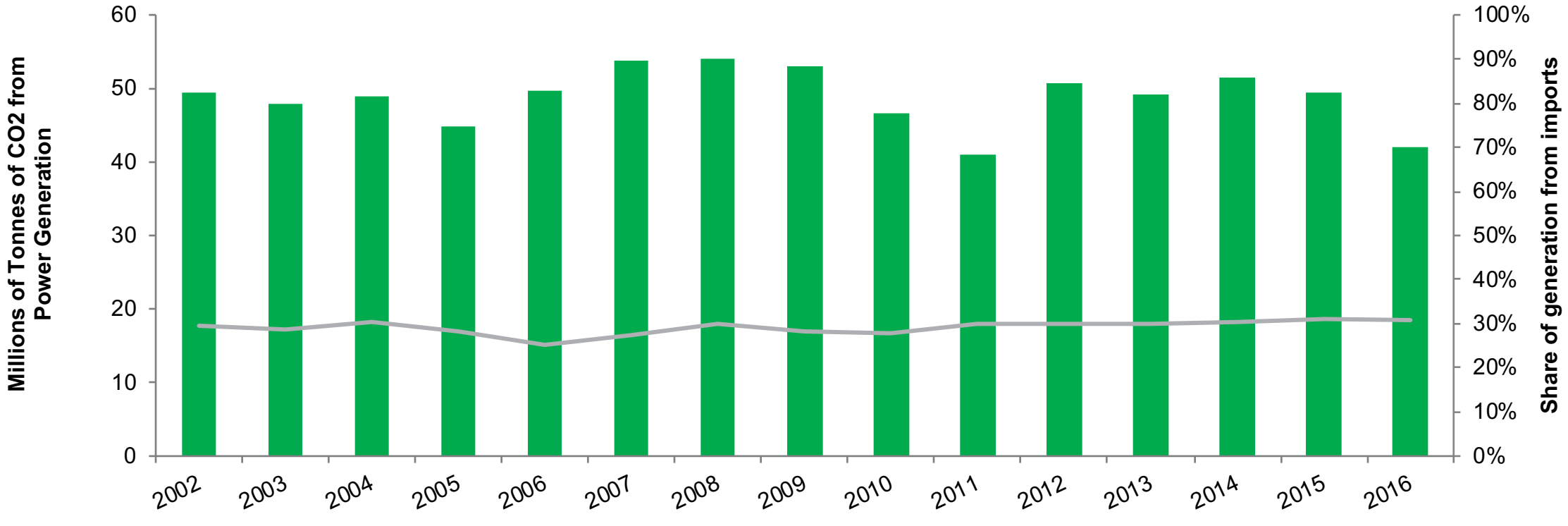
CAISO representative spring net load curves, 2012 – 2013 (actual) and 2014 – 2020 (projected)



Source: California ISO, http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf accessed October 2, 2017.

California in-state CO_2 emissions from power generation and electricity imports

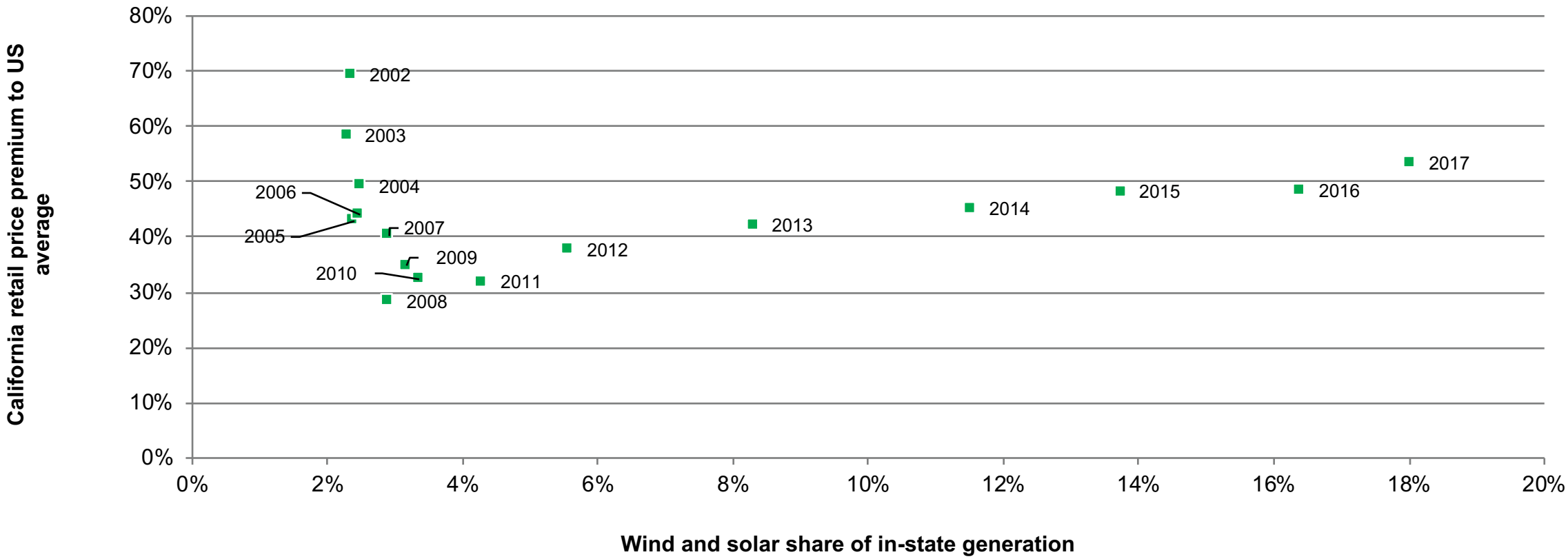
California in-state power generation CO2 emissions and out-of-state electricity imports, 2002-2016



Source: IHS Markit, EIA, California Air Resources Board

California wind and solar in-state generation shares and retail price premium to US average

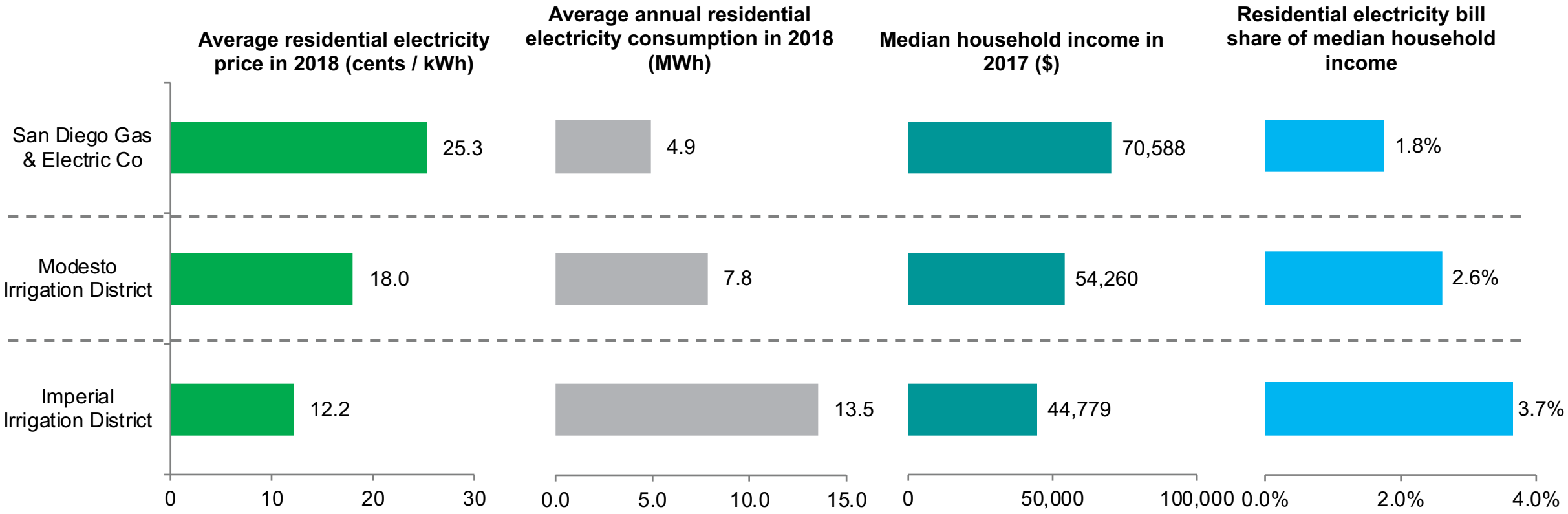
California generation share of wind and solar and retail price premium to US average, 2002-2017



Source: IHS Markit, EIA

Average residential electricity price, annual bill and income data for select counties in California

Average residential electricity price, consumption, and household income data for select counties in California



Source: EIA (Form 861M), US Census Bureau, 2013-2017 American Community Survey, IHS Markit

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