DOCKETED	
Docket Number:	20-IEPR-01
Project Title:	General/Scope
TN #:	236902
Document Title:	Proposed Final 2020 Integrated Energy Policy Report Update Volume III California Energy Demand Forecast Update - TRACK CHANGES
Description:	Proposed Final 2020 Integrated Energy Policy Report Update Volume III: California Energy Demand Forecast Update - TRACK CHANGES
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	2/25/2021 2:30:17 PM
Docketed Date:	2/25/2021

CALIFORNIA
ENERGY COMMISSION

California Energy Commission

COMMISSION REPORT

Proposed Final~~Draft~~ 2020 Integrated Energy Policy Report Update

Volume III: California Energy Demand Forecast Update

Gavin Newsom, Governor
February 2021 | CEC-100-2020-001-V3-CMF

California Energy Commission

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ABSTRACT

The *2020 Integrated Energy Policy Report Update* provides the results of the California Energy Commission's assessments of a variety of energy issues facing California. Many of these issues will require action if the state is to meet its climate, energy, air quality, and other environmental goals while maintaining reliability and controlling costs.

2020 ~~has been~~was ~~an~~ unprecedented ~~year~~ as the state continues to face the impacts and repercussions of ~~multiple~~ several events including the COVID-19 pandemic, electricity outages, and ~~catastrophic~~ statewide wildfires. In ~~addition~~ response to these ~~devastating~~ challenging events, the *2020 Integrated Energy Policy Report Update* covers a broad range of topics, including transitioning to a zero-emission transportation sector, microgrids, and the *California Energy Demand Forecast*.

Keywords: California Energy Commission, electricity demand forecast, zero-emission vehicles

Please use the following citation for this report:

Bailey, Stephanie, Nicholas Fugate, and Heidi Javanbakht. 2021. *Proposed Final 2020 Integrated Energy Policy Report Update, Volume III: California Energy Demand Forecast Update*. California Energy Commission. Publication Number: CEC-100-2020-001-V3-CMF.

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EXECUTIVE SUMMARY

The year 2020 brought many challenges but also hopes for a better future. The *2020 Integrated Energy Policy Report (IEPR) Update* identifies actions the state and others can take to ensure a clean, affordable, and reliable energy system. California's innovative energy policies strengthen energy resiliency, reduce greenhouse gas (GHG) emissions that cause climate change, improve air quality, and contribute to a more equitable future.

The *2020 IEPR Update* is divided into three parts:

- **Volume I** focuses on California's transportation future and the transition to zero-emission vehicles (ZEVs). Volume I is the focus of the *2020 IEPR Update*.
- **Volume II** examines microgrids, lessons learned from a decade of state-supported research, and stakeholder feedback on the potential of microgrids to ~~exploring how they can~~ contribute to a clean and ~~more~~ resilient energy system.
- **Volume III** provides an update on California's energy demand outlook, updated to reflect the global pandemic and help plan for a growth in zero-emission plug in electric vehicles.

The following summarizes the results of Volume III~~3~~.

Updated Ten-Year Electricity Forecast

For the *2020 IEPR Update*, the California Energy Commission (CEC) updated its 10-year forecast of electricity demand that was developed for the *2019 IEPR*. The forecast is foundational to various statewide energy planning processes including the California Public Utilities Commission's (CPUC's) oversight of energy procurement and the California Independent System Operator's (California ISO's) transmission planning. The record west-wide heat storm in August 2020 that led to rotating power outages demonstrated that the severity of such extreme events are no longer within the realm of current planning contingencies. As detailed in the January 2021 *Final Root Cause Analysis*[1] submitted to the Governor, the CEC, CPUC, and California ISO are working to refine various elements of the state's electricity planning process in response to the increasing risk of extreme weather events. Consistent with previous forecasts, this forecast provides peak demand projections for a broad range of weather scenarios, to support these future planning improvements.

1 California ISO, CEC, and CPUC. *Final Root Cause Analysis: Mid-August 2020 Heat Storm*. January 13, 2021. http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf.

This update includes revising economic and demographic drivers used in the *2019 IEPR* forecast with current projections, including the impacts of COVID-19 on the economy. The update also adds one more year of historical energy data. Additionally, staff updated electricity rate projections, as well as forecasts of behind-the-meter photovoltaic (PV) system adoption and electric vehicle adoption. The forecast update includes high, medium, and low demand cases designed to capture a reasonable range of outcomes over the next 10 years.

The update presents scenarios that combine energy efficiency savings scenarios with the baseline forecast to create managed forecasts. These managed forecasts are options for a "single forecast set" to be used for planning purposes in CEC, CPUC, and California ISO proceedings. The report identifies which elements of the single forecast set the energy agencies and the California ISO have agreed to use in their energy planning efforts.

Electricity Demand in the Transportation Sector

Forecast results include electricity demand for light-duty, medium-duty, heavy-duty, and off-road ZEVs through 2030. In the mid demand case, the on-road transportation electricity consumption represents 4.5 percent of overall forecasted electricity consumption in 2030, and 1.9 percent of electricity demand during the peak hour in 2030.

The COVID-19 pandemic has impacted economic projections, resulting in a near-term decline in total new vehicle sales in 2020. Because ZEV sales track closely to total light-duty vehicle sales, ZEV sales in 2020 are projected to be lower than 2019, although the ZEV share of total sales has increased from 6.8 percent in 2019 to 7.7 percent through the third quarter of 2020. (Based on CEC staff analysis of the California Department of Motor Vehicles registration database.) The decline in ZEV sales may make it more difficult to reach the state's ZEV targets since there will be a corresponding decrease in the rate at which ZEVs are put on the road. In 2030, the forecast shows 3.3 million light-duty ZEVs in the mid case and 4.2 million in the high case. These numbers fall short of the target set by former Governor Edmund G. Brown Jr. (Executive Order B-48-18) for 5 million ZEVs on the road in California. The aggressive and bookend case result in 4.7 million and 4.8 million in 2030, respectively, just short of the 2030 target. The forecast indicates that additional market interventions will be needed to meet B-48-18 and to meet Governor Gavin Newsom's goal for ZEVs to comprise 100 percent of new vehicle sales starting in 2035 (Executive Order N-79-20).

The analysis also includes estimates of the number of medium-duty and heavy-duty ZEV buses and trucks in California by 2030. The results range from about 70,000 to more than 90,500 in the low- and high-electricity demand cases, respectively. In June 2020, the California Air Resources Board finalized the Advanced Clean Truck regulation that calls for truck manufacturers to sell an increasing proportion of zero-emission trucks in California starting in 2024. The mid- and high-electricity demand cases suggest that given the assumptions around economic conditions, total cost of ownership, and incentives, growth in the statewide fleet is on target to meet the rule.

Transportation Exploratory Analysis

Staff developed three sets of exploratory scenarios, in addition to the low-, mid-, and high-electricity demand cases. First, staff developed scenarios to analyze electricity system impacts by shifting the times when drivers recharge their plug-in electric vehicles. These scenarios highlight the potential effects of shifting this load, and the importance of managing plug-in electric vehicle (PEV) charging (such as through vehicle-grid-integration technologies) with respect to reducing system load and GHG emissions.

Second, staff developed an exploratory scenario to plan for potential electricity demand of medium-duty and heavy-duty vehicles to meet 2031 federal ozone standards in the South Coast Air Quality Management District. The increase in the number of battery-electric trucks resulted in 1,684 gigawatt hours (GWh) of added electricity consumption over the mid-electricity demand case in 2031. Of this, roughly 71 percent is attributed to Southern California Edison (SCE) and results in an additional 164 megawatts (MW) to SCE's summer peak in 2031.

Staff also developed a third set of exploratory scenarios to estimate the potential energy related impacts of an increase in telecommuting if it were to continue after COVID-19. Staff estimated that if single occupant vehicle commuters worked from home one, three, or five days per week, gasoline and GHG emissions could be reduced by 4 percent, 12 percent, or 21 percent, respectively.

Volume I, Chapter 4, of the *2020 IEPR Update* provides estimates of electricity demand from ~~unmanaged~~ PEV charging due to time-of-use pricing as modeled by EVI-Pro 2 and Road Trip models~~,~~ in relation to the availability of renewable energy.

California Energy Demand

Introduction

Planning for California's energy needs is a core role of the California Energy Commission (CEC) and planning for electricity demand is a fundamental part of this work. Such planning informs major energy infrastructure investments throughout the state in both the near- and long-term.

The many challenges of 2020 include a global pandemic that has killed tens of thousands of Californians, slowed economic activity, and increased unemployment. California also experienced a record west-wide heat storm in August 2020 that led to rotating power outages.[2] (See sidebar.) The forecast developed for the *2020 Integrated Energy Policy Report* (*IEPR*) *Update* includes adjustments to account for changes in demand due to climate change and resulting increases in temperature based on modeling conducted by Scripps. Consistent with previous forecasts, this forecast provides peak demand projections for a broad range of weather scenarios (1-in-2, 1-in-5, 1-in-10, and 1-in-20 probability weather scenarios). Furthermore, the forecast also includes a 1-in-30 peak forecast (a very low probability weather scenario similar to what was experienced in August 2020) for situational awareness and to help support future planning improvements. While the *2020 IEPR Update* robustly captures 1-in-2 probability weather scenarios (reflecting likely future climate change impacts), as part of the *2021 IEPR* proceeding, the CEC plans to further explore ways to better quantify and predict the likelihood, severity, and duration of future extreme heat events. This will help the CEC strengthen the assumptions undergirding forecasting using the lower-probability climate scenarios (such as 1-in-5 and 1-in-10 forecasts).

As the state grapples with the events of 2020, the need for long-term energy demand forecasts to be nimble is clear — to account for structural changes in California's economy and the effects of increasingly extreme weather events caused by climate change. The CEC is adapting its forecasting efforts to meet these challenges and this volume of the *2020 Integrated Energy Policy Report Update* (*2020 IEPR Update*) provides:

- Updates to the ten-year, end-user electricity forecast developed in the *2019 IEPR.*
- Updates to electricity demand in the transportation sector.

2 For more information on corrective actions the agencies are taking to address the August rolling outages, see the *Final Root Cause Analysis: Mid-August 2020 Heat Storm*. January 13, 2021. http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf.

- Exploratory analyses to assess the impacts of potential changes in the transportation sector.

The results of the forecast and exploratory scenarios are presented.

August 2020 Rolling Blackouts Highlight Planning Needs

On August 14 and 15, 2020, the state experienced rotating outages during an extreme heat storm that spread across the West. An analysis developed jointly by the California Independent System Operator (California ISO), California Public Utilities Commission (CPUC), and CEC found a series of factors contributed to the emergency:

- The extreme, climate change-induced heat storm resulted in electricity demand exceeding supply.
- Resource planners have not kept pace with the rapid rise of solar and wind power on the grid, resulting in insufficient supply to meet the high demand in the early evening in extreme conditions.
- Some practices in the day-ahead energy market exacerbate supply challenges when the grid is under high stress.

The heat storm brought temperatures 10 to 20 degrees Fahrenheit above average, with overnight temperatures remaining higher than normal and further driving up demand for air conditioning. Energy supply was also pinched. Natural gas power plants ran less efficiently, and fewer imports of electricity were available as other western states also endured the extreme heat. At the same time, high clouds covered parts of California, reducing solar generation.

Heats storms of such severity and compounding factors are no longer within the realm of current planning contingencies. The CEC, CPUC, and California ISO are working to ensure grid reliability in response to increasingly severe events related to climate change, such as the August 2020 extended heat storm. Grid reliability will be further discussed in the *2021 IEPR*.

Credit: CEC, CPUC, and California Air Resources Board. December 2020. *Draft 2021 SB 100 Joint Agency Report*. https://efiling.energy.ca.gov/getdocument.aspx?tn=235848.

California Energy Demand Forecast Update 2020

As part of the IEPR process, the CEC develops and adopts ten-year forecasts of end-user electricity demand every two years, in odd-numbered years. Recognizing the process alignment needs and schedules of the CPUC and California ISO planning work, the CEC provides an update to the IEPR forecast here and in even-numbered years in general.

The update includes revising economic and demographic drivers used in the *2019 IEPR* forecast with current projections, including the impacts of COVID-19 on the economy. The update also adds one more year of historical electricity consumption, peak demand, and self-generation technology adoption data, all of which are used to recalibrate the forecast to the most recent historical year. Additionally, staff updated electricity rate projections, as well as forecasts of behind-the-meter photovoltaic (PV) system adoption and electric vehicle adoption.

Consistent with the forecast developed for the *2019 IEPR*, the forecast update includes three electricity demand cases designed to capture a reasonable range of outcomes over the next 10 years:

- ***High-electricity demand case*** incorporates relatively high economic/demographic growth, relatively low electricity rates, high adoption of zero-emission vehicles (ZEVs), and relatively low efficiency program, self-generation, and climate change impacts.
- ***Low-electricity demand case*** includes lower economic/demographic growth, higher assumed rates, low adoption of ZEVs, and higher efficiency program and self-generation impacts.
- ***Mid-electricity demand case*** uses input assumptions at levels between the high and low cases.

In addition to the required forecast, this volume of the *2020 IEPR Update* also presents exploratory scenarios for transportation energy demand. As discussed in the *2020 IEPR Update, Volume I,* the state needs to reduce GHG emissions from the transportation sector. To this end, the state is actively supporting a transition to ZEVs, including both battery-electric and hydrogen-powered vehicles, as well as looking for ways to reduce vehicle miles traveled (VMT). To help the state plan for and identify the best path forward, staff developed illustrative scenarios for charging electric vehicles, increased adoption of medium- and heavy-duty ZEVs needed to meet air quality standards, and increased telecommuting.

The Forecast Is Foundational to Statewide Energy Planning

The CEC's ten-year forecast of end-use electricity demand informs the need for major infrastructure investments in California. It is used in various proceedings, including the CPUC's Integrated Resource Plan (IRP) process and the California ISO's Transmission Planning Process (TPP). IRPs are long-term plans outlining how load-serving entities (including investor- and publicly owned utilities, community choice aggregators, and private electricity suppliers) will meet demand reliably and cost-effectively while achieving state policy goals and mandates. The TPP is a roadmap for short- and long-term transmission infrastructure needs in the California ISO service territory. In addition, the CEC provides annual year-ahead peak demand forecasts for the resource adequacy process in coordination with the California ISO and the CPUC.

COVID-19 Impacts on Energy Demand

The COVID-19 pandemic and the corresponding halt to normal business activity has disrupted California's long period of low unemployment and steady economic growth following the Great Recession. After statewide shelter-in-place orders were announced on March 19, 2020, monthly statewide unemployment levels reached 16 percent, while statewide gross state product receded by 0.6 percent.[3] Additionally, limited federal response and stimulus, and the general unknowns and fears about virus transmission and impacts contributed to the state's initial rapid economic decline.

The COVID-19 pandemic will introduce additional uncertainty into economic forecasts particularly around the depth of the economic slowdown and the speed of recovery. All three economic scenarios used in the California Energy Demand Update (CEDU) 2020 will include varied assumptions for how the California economy will recover from this pandemic. In the short-term, the scenarios generally assume that midway through 2021 the California economy will begin to recover with decreased unemployment and positive growth in gross state product. In the long-term, scenarios will differ primarily due to assumptions regarding the availability of a vaccine that would allow a return to normal business activity and the likelihood and impact of federal economic stimulus. For example, high-electricity and mid-electricity demand cases assume a vaccine will be available at the end of 2020/early 2021 and varying impacts from federal stimulus. The low-electricity demand case assumes a reliable vaccine is not available until after the current expected timeframe of end of 2020/early 2021 and delays or limited positive impacts from federal stimulus.

Economic Outlook

The CEDU 2020 electricity demand cases use the June 2020 vintages of economic projections from Moody's Analytics (Moody's) and demographic projections from the California Department of Finance (DOF). The high-electricity demand case uses a custom economic scenario that Moody's developed for the CEC. It incorporates more optimistic assumptions, leading to a higher long-term growth trend. The low-electricity demand case uses Moody's slow long-term growth scenario. The mid-electricity demand case uses Moody's baseline scenario that is described as a "50/50" likelihood with assumptions between Moody's high and low scenarios.

Demographic assumptions are derived from forecasts of population and number of households developed by DOF. The population forecast is used in all three electricity demand cases while the household forecast is used for the mid and low cases. For the high case, CEC staff developed a more optimistic household growth projection using a combination of DOF and Moody's more optimistic forecast data.

3 Bureau of Labor Statistics, U.S. Department of Labor. Databases, Tables & Calculators by Subject. Retrieved September 24, 2020. https://www.bls.gov/data/.

U.S. Bureau of Economic Analysis. Total Gross Domestic Product by Industry for California. https://fred.stlouisfed.org/series/CANQGSP. Retrieved from Federal Reserve Bank of St. Louis, September 24, 2020.

Other drivers in electricity consumption forecasts are the retail cost of energy, adoption of self-generation and energy storage technologies, and vehicle electrification. Electricity rate scenarios for CEDU 2020 incorporate new data for actual rates from 2018/2019, publicly owned utility rate projections, current and prospective investor-owned utility (IOU) revenue requirements, and wholesale electricity prices. The retail rate scenarios are based on assumptions for natural gas and GHG allowance prices and distribution revenue requirements. A mid-electricity-rate forecast is used for the mid-electricity demand case while a low-electricity-rate forecast is used in the high-electricity demand case, and the high-electricity-rate forecast is used in the low-electricity demand case. The electricity rate assumptions are linked to assumptions used for the adoption of self-generation and storage technologies. These assumptions are linked in that high electricity rates should create a more economically favorable condition for self-generation technologies such as solar photovoltaic (PV) and energy storage, while a low-electricity-rate assumption would create a less favorable condition. Electric vehicles are discussed in detail in later sections of this report, but generally the low- and high-electricity demand cases include lower and higher vehicle adoption than the mid. Table 1 summarizes the electricity demand case assumptions for CEDU 2020.

Table 1: Summary of Electricity Demand Case Assumptions, CEDU 2020

Electricity Demand Case	Key Assumptions
High-Electricity Demand Case	• Higher economic and demographic projections • Lower electricity rates • Higher electric vehicle adoption • Lower self-generation and storage adoption
Low-Electricity Demand Case	• Lower economic and demographic projections • Higher electricity rates • Lower electric vehicle adoption • Higher self-generation and storage adoption
Mid-Electricity Demand Case	• Expected case with assumptions generally between the high and low electricity demand cases

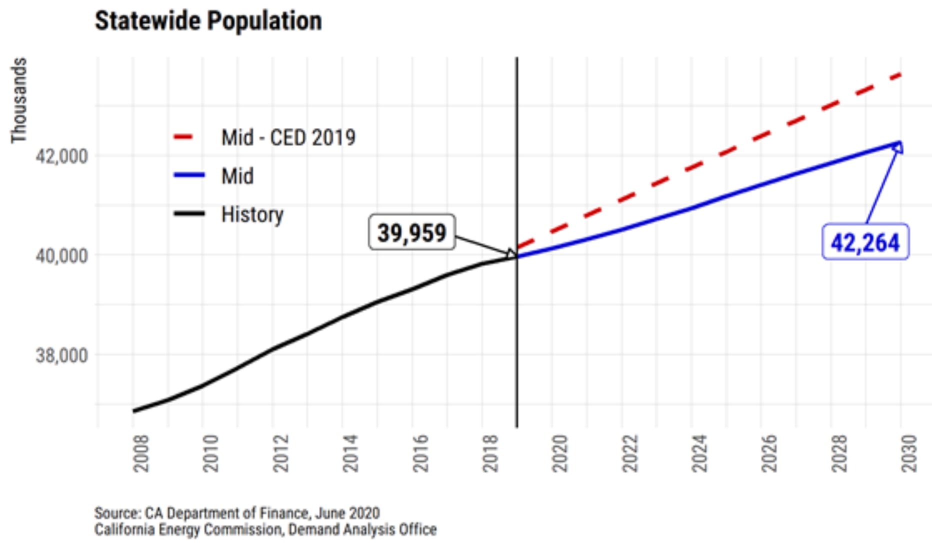
Credit: CEC

Summary of Key Drivers

Statewide population for CEDU 2020 is expected to grow at 0.5 percent annually from 2020 to 2030, as compared to 0.8 percent in the California Energy Demand 2019 forecast (CED 2019). This results in about 3 percent less total population by 2030 than the previous forecast. The reduction in population is due to several factors: lower starting population estimates since the

2010 Census, a reduction in net migration, declining birth rates, and slowing life expectancy. Figure 1 compares statewide population forecasts for CEDU 2020 and CED 2019.

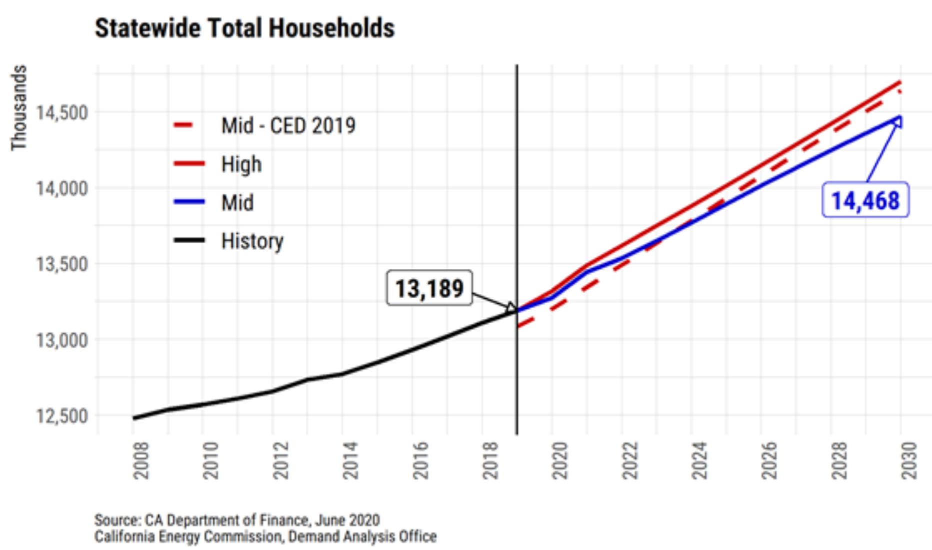
Figure 1: Statewide Population Comparison, CEDU 2020



Credit: CEC using data from DOF

The total household forecast for CEDU 2020 has a higher starting point but slightly lower 2020-2030 annual average growth compared to CED 2019 — 0.9 percent versus 1 percent, respectively. The new household forecast is driven by changes in the household formation rate, which is derived from underlying population segment forecasts — millennials are now reaching prime household formation years but are limited by affordability issues. Figure 2 compares total household forecast for CEDU 2020 and CED 2019.

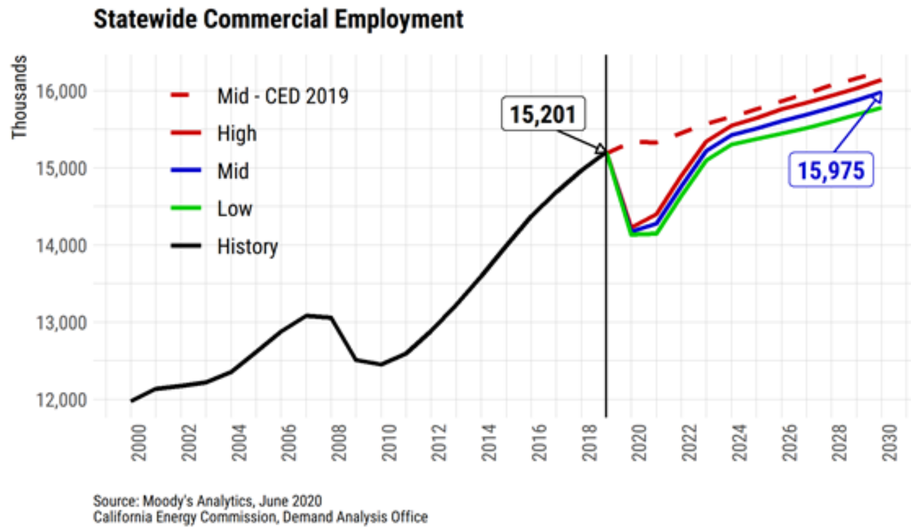
Figure 2: Statewide Total Household Comparison, CEDU 2020



Credit: CEC using data from DOF

Figure 3 compares California commercial employment scenarios against the mid case scenario from CED 2019 illustrating the expected rapid recovery in the near-term and variation in long-term recovery assumptions. Commercial employment grows at 1.2 percent annually from 2020-2030 compared to 0.6 percent in CED 2019 due to the recovery period in the early part of the forecast. Ultimately, commercial employment remains below the CED 2019 mid case — about 2 percent lower by 2030.

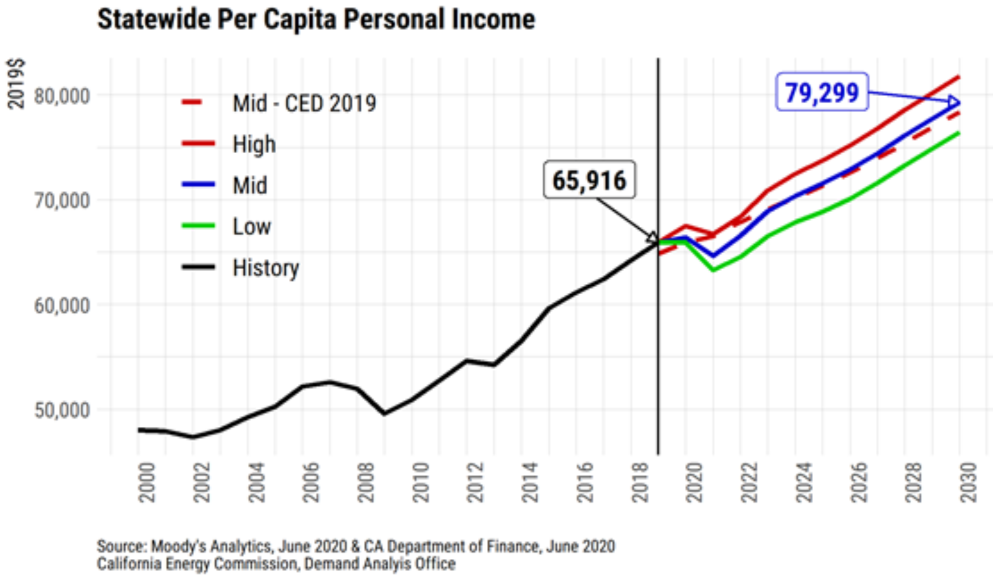
Figure 3: CEDU 2020 California Statewide Commercial Employment Scenario Comparison



Credit: CEC using data from Moody's Analytics

Figure 4 compares statewide per capita income scenarios against the mid case scenario from CED 2019. The per capita income scenarios show somewhat similar trends with the difference being that 2020 per capita income remains stable due to government income assistance programs. There is a deep decline in 2021 compared to the CED 2019 forecast but it reaches a relatively similar level by 2030. In the mid case, average annual growth from 2020-2030 is slightly higher at 1.8 percent versus 1.7 percent for CED 2019.

Figure 4: Statewide Per Capita Personal Income Comparison, CEDU 2020



Credit: CEC using data from Moody's Analytics and DOF

Overview of Methods

Baseline Forecast Update

The CEC uses detailed models for each economic sector (such as residential, commercial, industrial, and transportation) to project electricity consumption for each full IEPR demand forecast. In an update year, the CEC uses single-equation econometric models by sector, which typically yield similar results at a high level. Staff relied on these econometric models, re-estimated to incorporate historical data for 2019, for CEDU 2020.

To ensure a proper comparison to CED 2019, results from the econometric models are benchmarked to the earlier electricity demand forecast to isolate the effects from the revised set of economic and demographic drivers. Percentage changes in electricity demand caused by the updated drivers as estimated by the econometric models are then applied to CED 2019 results.

Forecasts for individual load modifiers such as PV and electric vehicle (EV) adoption are analyzed individually and updated separate from the general method described above. The EV forecast update is part of a broader transportation electrification forecast update discussed extensively later in this report.

Planning for Climate Change

The adopted *2019 IEPR* forecast includes estimated load impacts due to climate change based on projected increases in average temperatures developed for the CEC by Scripps Institute of Oceanography. These load impacts are carried over to the *2020 IEPR Update*. These same climate models that Scripps Institute uses to predict increasing average temperatures can also be used to predict increasing frequency of extreme heat events.[4] During the *2021 IEPR* cycle, staff will explore ways such additional data can inform the CEC's forecasts of peak load under critical planning contingencies — such as the type of extreme weather that should be expected once every ten years.

PV Interconnection Data and Revised Capacity Factors

The behind-the-meter (BTM) PV forecast update is relatively straightforward. The same PV adoption model used to inform CED 2019 is run with refreshed electricity rate, housing addition, commercial account, and commercial floor space projections. For CEDU 2020, however, staff examined two additional factors affecting the forecast.

The first is the historical record of system interconnections which serve both as the starting point for the forecast and as a means to calibrate the adoption model. In previous cycles, staff constructed this historical record using a combination of incentive program data, individual data requests to utilities, and more recently the net energy metering (NEM) interconnection data reported by the California Distributed Generation Statistics (DG stats) website.[5] This approach made it difficult for staff to properly classify systems and verify the accuracy of installation data, especially for data collected from incentive programs.

This year, staff will use interconnection data reported directly to the CEC by utility distribution companies under newly amended Title 20 data regulations.[6] Not only does this data provide a more complete and accurate historical record, it allows staff to classify systems into customer sectors consistent with CEC forecasts, and classify a greater number of systems into customer subsectors that can be used to inform other CEC forecast models. Figure 5 illustrates the significant improvement in system classification relative to CED 2019, with far more systems now classified by subsector (colored portions) as opposed to by customer sector only (gray portions.)

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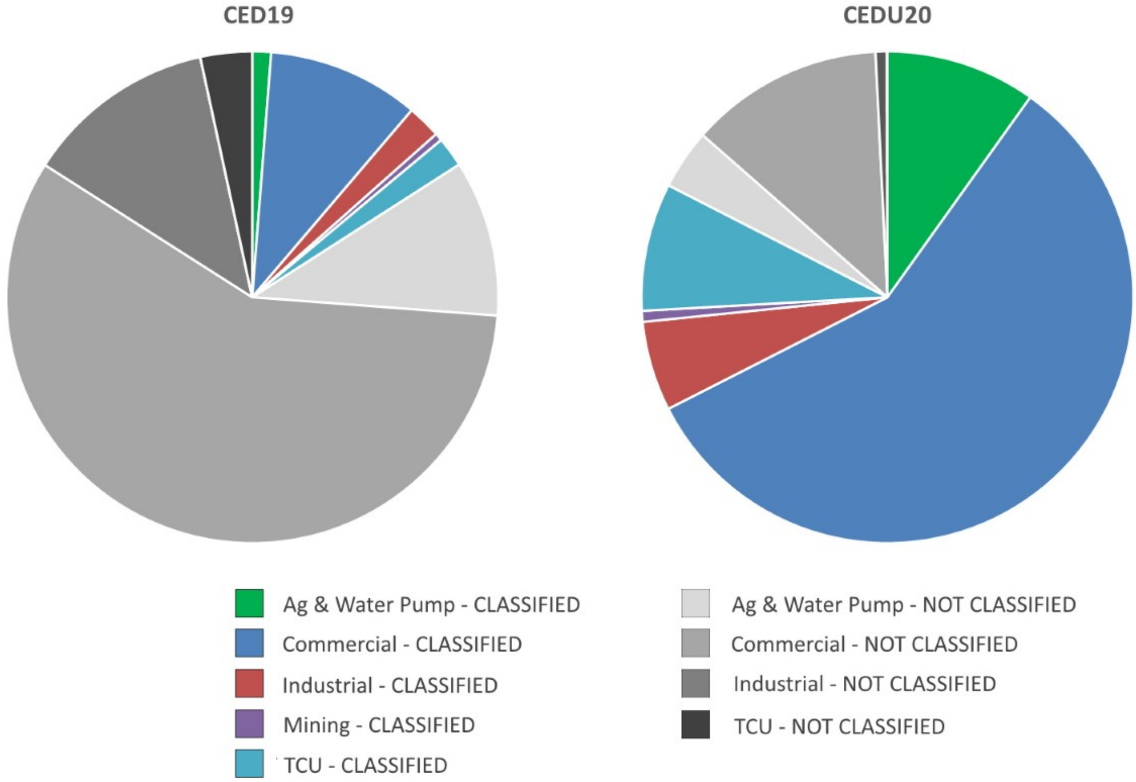
4 Cal Adapt web page. "Extreme Heat Days and Warm Nights." Accessed December 15, 2020. https://cal-adapt.org/tools/extreme-heat/.

5 California Distributed Generation Statistics web page. https://www.californiadgstats.ca.gov/downloads/.

6 California Code of Regulations Title 20, Public Utilities and Energy. Section 1304- Power Plant Reports. https://govt.westlaw.com/calregs/Document/IDBC468FEE44542FC80641F270F7AC6A5?transitionType=Default&contextData=%28sc.Default%29.

Figure 5: Nonresidential BTM PV by Customer Sector and Sub-Sector



Credit: CEC using data from DOF

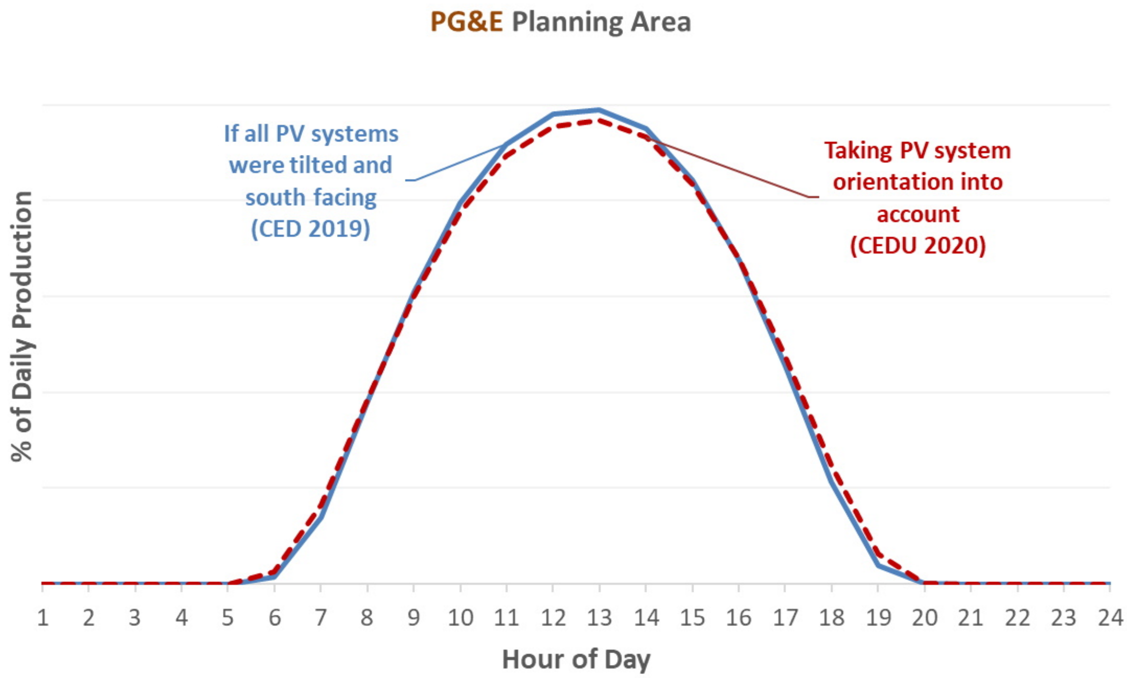
Secondly, staff reexamined the PV capacity factors used to estimate electricity production from BTM PV systems for historical and forecasted PV installations. In previous cycles, staff used a capacity factor for each region assuming a single orientation — a tilted, southward facing system — and applied this factor to all capacity installed in the region. For CEDU 2020, staff developed weighted average capacity factors reflecting the orientation of all PV systems in a region as reported by the NEM Interconnection Applications dataset.[7] The change resulted in capacity factors that were 2 to 3 percent lower than assumed in CED 2019.

Similarly, staff developed weighted average hourly generation profiles for each zone to account for actual system orientation. Figure 6 illustrates the resulting change in the hourly profile for systems installed in the Pacific Gas and Electric Company (PG&E) planning area for a specific day in July. Under the new profile, there is more generation expected in the early

7 California DG Stats web page. Accessed June 24, 2020. https://www.californiadgstats.ca.gov/archives/interconnection_rule21_applications/.

morning and evening hours, with slightly less production during mid-day. The pattern is similar for other planning areas.

Figure 6: PV Production for a Day in Early July



Credit: CEC using data from DOF

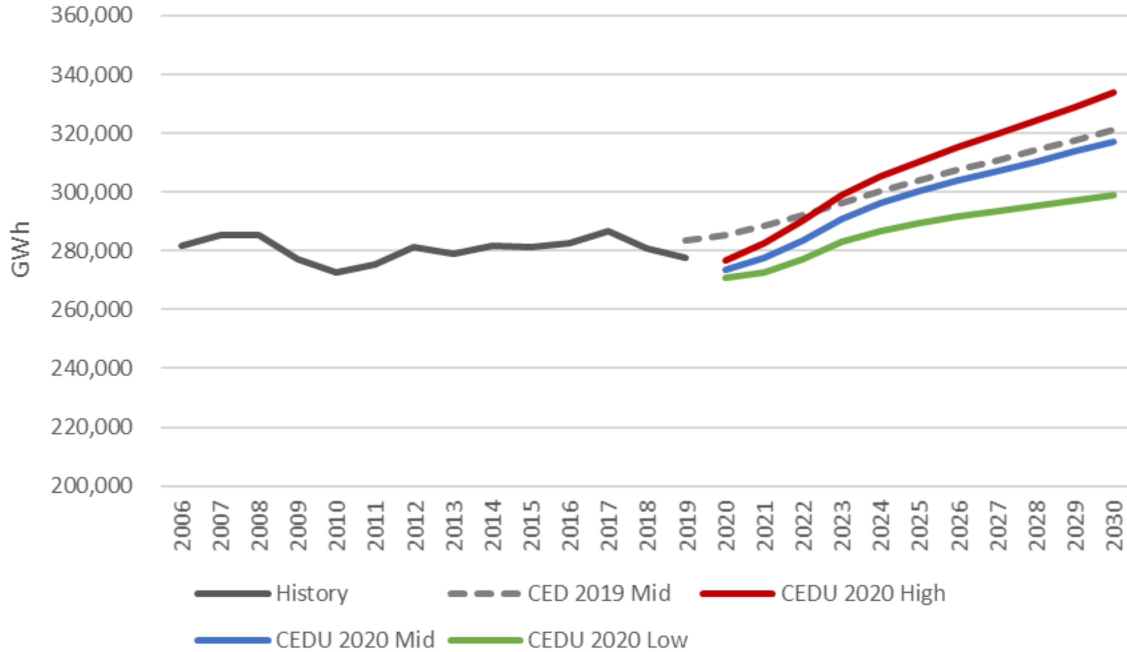
Forecast Results

CEC staff presented draft forecast results at an IEPR workshop on December 3, 2020. The public was invited to make verbal comments at the workshop or to submit written comments by December 17, 2020. After carefully considering public comments, staff developed a final set of forecast updates which the CEC adopted at its January 25, 2021, Business Meeting. The adopted forecast results are presented below.

Electricity Consumption, Sales, and Peak Demand

Statewide electricity consumption is estimated to have been 277,750 GWh in 2019 — nearly 2 percent lower than the CED 2019 forecast for that same year. Because CEDU 2020 incorporates 2019 historical loads, the updated consumption forecast is benchmarked to this lower level. From 2019 to 2020, the mid baseline electricity demand case declines another 1.5 percent reflecting a significant drop in projected commercial and industrial employment. From this low point, the mid electricity demand case grows at a rate just over 2 percent annually through 2024 as the economy recovers. Over the latter half of the forecast period, the mid case grows 1.1 percent annually, reaching 317,217 GWh by 2030 — about 1.3 percent lower than the CED 2019 mid baseline consumption forecast.

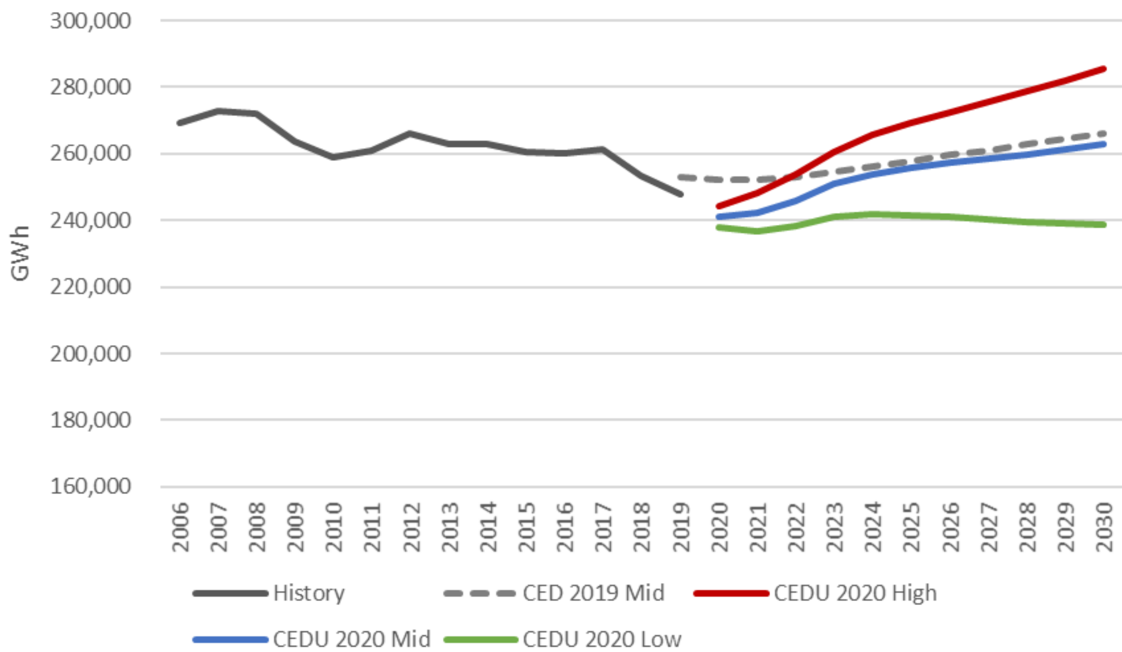
Figure 7: Baseline Electricity Consumption (Statewide)



Credit: CEC

The CEDU 2020 sales forecast represents the amount of electricity load-serving entities will need to provide to their customers and is derived by subtracting projected customer generation from the updated consumption forecast. As such, the statewide sales forecast update reflects many of the same characteristics as the consumption forecast, such as a lower starting point and initial decline followed by high growth in the near-term. In this case, however, substantial amounts of incremental PV generation (discussed in a later section) added each year reduce annual growth relative to consumption. Between 2024 and 2030, annual growth in the mid baseline case averages about 0.6 percent. By 2030, sales in the mid case reach 262,762 GWh — about 1.3 percent lower than the CED 2019 mid baseline sales forecast.

Figure 8: Baseline Electricity Sales (Statewide)



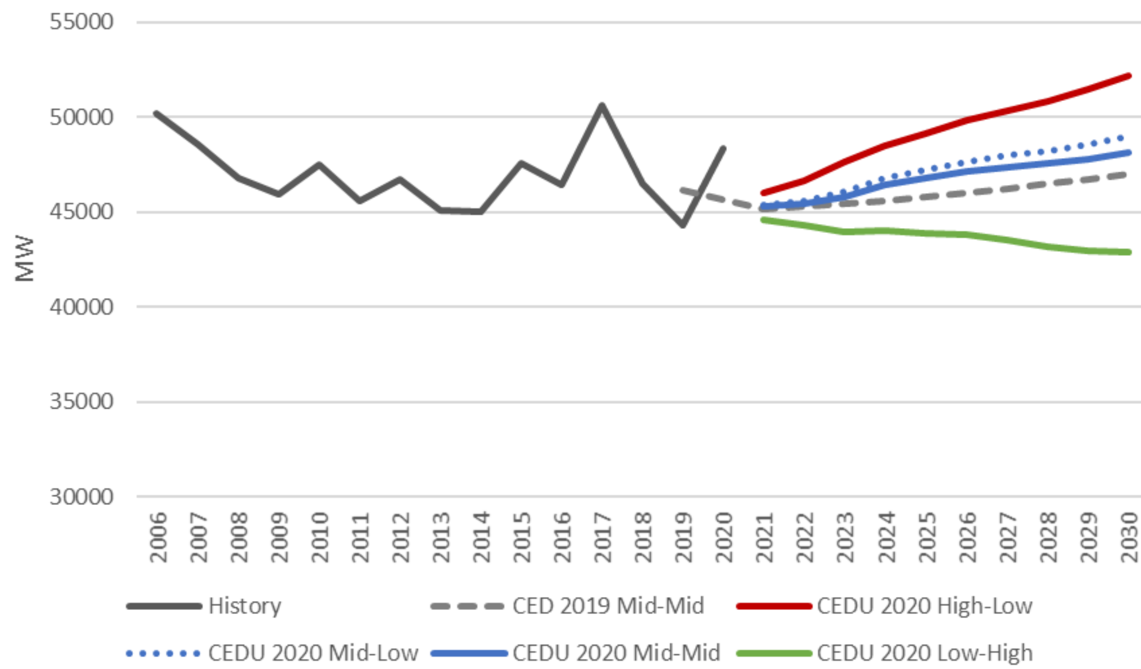
Credit: CEC

The peak demand forecast update is also derived from the updated consumption forecast — by applying hourly system load profiles to projected annual consumption. Ordinarily, CEC staff would benchmark the peak forecast to weather-normalized peaks from the most recent historical year — from summer 2020, in this case. However, due to widespread behavioral changes in response to the COVID-19 pandemic, system load profiles in 2020 exhibit a higher-than-usual ratio of peak demand to annual consumption. At the December 3, 2020, IEPR workshop, CEC staff noted that a profile benchmarked to 2020 may produce reasonable peak projections for the initial years of the forecast, but artificially high projections if applied to the latter years of the forecast. Instead, the CEDU 2020 begins with system load profiles benchmarked to 2020, but gradually transitions to a set of profiles benchmarked to 2019 levels of peak load and consumption by year 2023 of the forecast.

The baseline peak forecast updates can be combined with the same additional achievable energy efficiency scenarios developed and adopted as part of the *2019 IEPR* to create managed forecasts for use in planning studies. The CEDU 2020 mid baseline, mid additional achievable energy efficiency (AAEE) managed peak forecast for the California ISO control area grows at a rate of 0.7 percent annually, reaching 48,170 MW by 2030. This managed forecast is 2.5 percent higher than projected by CED 2019.

In part, the higher peak forecast is due to 485 MW of incremental load added to the PG&E planning area forecast to account for data centers expected to come online in the Silicon Valley Power service territory. Additionally, because historical consumption was about 2 percent lower in 2019 relative to the level forecast by CED 2019, the base-year ratio of peak demand to consumption is higher in CEDU 2020.

Figure 9: Managed System Peak Demand (California ISO)



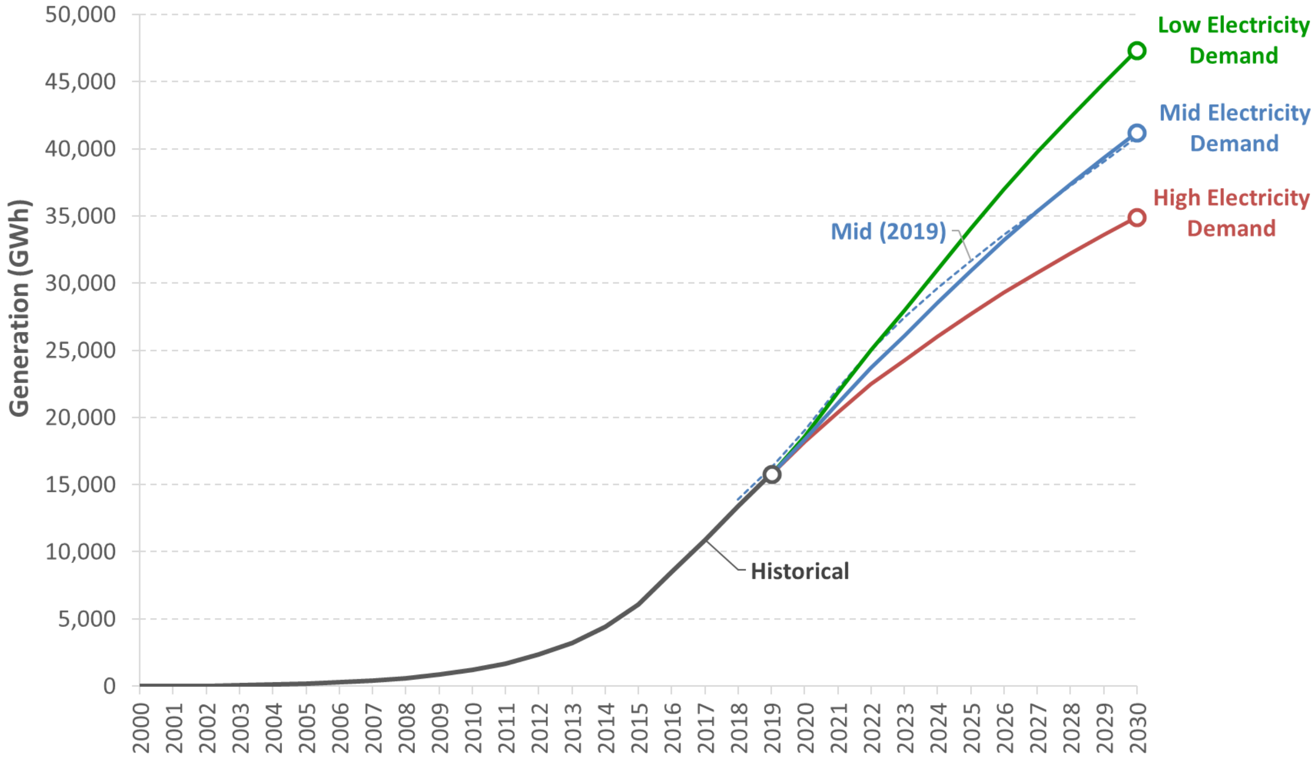
Credit: CEC

Self-Generation and Storage

Adoption of BTM PV systems is a key consideration in deriving retail sales from end-user consumption and analyzing the timing and magnitude of system peaks. Since 2016, California has added about 1,300 to 1,400 MW of new BTM PV capacity annually. By the end of 2019, there was more than 9,400 MW of installed BTM PV capacity in California.

The forecast of statewide BTM PV generation for the three CEDU 2020 baseline demand cases, as well as the CED 2019 mid case, are shown in the figure below.

Figure 10: Estimated Statewide Generation From Behind-The-Meter PV

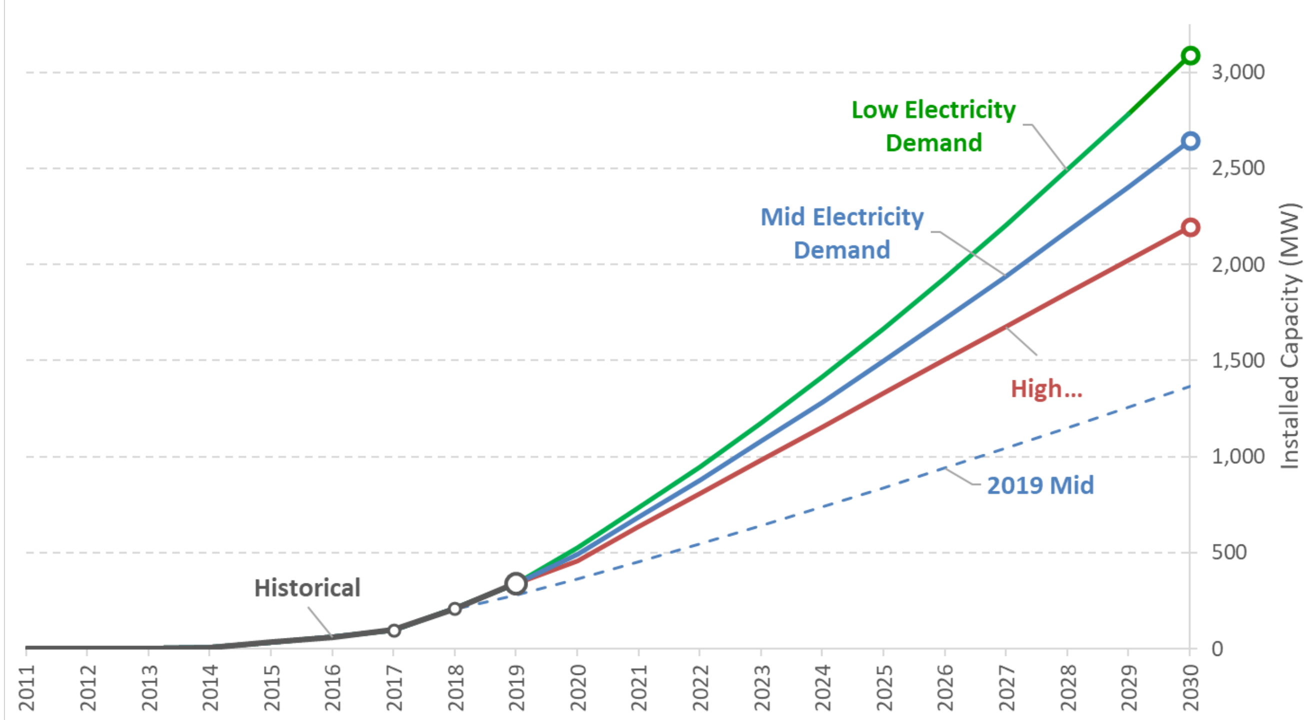


Credit: CEC

In 2019, an estimated 15,800 GWh of electricity was produced by BTM PV in California. By 2030, the CEDU 2020 forecast projects generation from PV to reach about 34,900 GWh, 41,200 GWh, and 47,300 GWh in the high, mid, and low electricity demand cases, respectively.

The adoption of BTM energy storage in California has grown tremendously in recent years. About 130 MW of BTM storage was installed in 2019. At the end of 2019, the CEC estimates that there is about 340 MW of BTM energy storage installed in California, up from about 100 MW in 2017. The forecast of statewide BTM energy storage for the three CEDU 2020 baseline demand cases, as well as the CED 2019 mid case, are shown in the figure below.

Figure 11: Statewide BTM Energy Storage Capacity



Source: CEC

By 2030, the CEDU 2020 forecast projects BTM energy storage capacity to reach about 2,200 MW, 2,600 MW, and 3,000 MW in the high, mid, and low electricity demand cases, respectively. The forecast is significantly higher than previous forecasts, accounting for higher than projected adoptions in 2019, as well as the significant year-over-year increase in reservations for funding for storage projects as reported by the Self-Generation Incentive Program.

Choice of Single Managed Forecast Set for Planning Purposes

The three updated baseline demand cases discussed above, when combined with six AAEE savings scenarios developed and adopted as part of the *2019 IEPR*, create managed forecasts that constitute options for a "single forecast set" to be used for planning purposes in CEC, CPUC, and California ISO (the Joint Agencies and California ISO) proceedings. The lead staff of the Joint Agencies and California ISO guiding the processes listed below have agreed that specific elements of this forecast set will be used for planning and procurement in the California ISO's TPP and the CPUC's IRP, resource adequacy, and other planning processes as outlined below. The details of this agreement will be adapted through time as the needs of planning and procurement evolve.

The term "single forecast set" is intended to clarify that what has commonly been called a "single forecast" is not a single number, but actually a set of forecast numbers adopted as part of the *IEPR*. This includes six managed scenarios which combine baseline forecasts using alternative weather variants and AAEE scenarios, and hourly load forecasts for transmission access charge (TAC) areas.[8] Agreement on a single forecast set includes specification on the use for each component of the set.

The single forecast set consists of three components of the IEPR demand forecast:

- Three baseline scenarios of annual energy and peak demand, each with three peak event weather variants (*for example*, 1-in-2, 1-in-5, and 1-in-10).
- Three scenarios of hourly loads for baseline forecasts for each of three IOU TAC areas.
- Six scenarios of AAEE described by annual energy and hourly load impacts.

The combination of a CEDU 2020 baseline forecast using a specific weather variant plus an AAEE scenario depends on their use. The selected CEDU 2020 baseline case will be the "mid demand" case for the combined IOU service areas that comprise the California ISO balancing area. The mid demand case includes variants for different weather conditions. To account for uncertainty, variations of IEPR CEDU outputs that diverge from the single forecast set may be used in CPUC IRP modeling sensitivities. However, lead CPUC staff agrees to ensure that adopted IRP portfolios will not deviate from the single forecast set.

The following list describes the current agreement among the lead staff of the Joint Agencies and California ISO:

- CPUC IRP Reference System Plan, Preferred System Plan, and California ISO economic studies[9]
    - Baseline mid-case annual energy and annual peak demand
    - AAEE mid-mid scenario annual energy and peak demand
    - 1-year-in-2 peak event weather conditions
- California ISO TPP policy studies and bulk system studies:
    - Baseline mid-case annual energy and annual peak demand
    - AAEE mid-mid scenario annual energy and peak demand

8 A TAC area denotes a portion of the California ISO balancing authority area that has been placed in the California ISO's operational control through an agreement with an electric utility or other entity operating a transmission system component. A TAC area typically consists of an IOU and multiple publicly owned utilities using the transmission system owned by the IOU.

9 In consultation with the CEC and California ISO, the CPUC may authorize procurement using an alternative weather variant.

- 1-year-in-5 peak event weather conditions
- Mid-mid hourly loads
- CEC Staff allocations of AAEE to load busses used in transmission studies

- California ISO TPP and resource adequacy local capacity studies:
  - Baseline mid-case annual energy and annual peak demand
  - AAEE mid-low scenario annual energy and peak demand
  - 1-year-in-10 peak event weather conditions
  - CEC Staff allocations of AAEE to load busses used in transmission studies
- California ISO Maximum Import Capability allocation for CPUC's system resource adequacy requirements for load-serving entities (LSEs)
  - Baseline mid-case monthly peak demand derived from the mid-mid managed demand forecast case of hourly loads
- CPUC resource adequacy LSE system requirements[10]
  - Baseline mid-case monthly peak demand derived from mid-case hourly loads
  - AAEE mid-mid annual and monthly peak demand
  - 1-year-in-2 peak event weather conditions
- CPUC IOU distribution planning requirements
  - Baseline peak demand (also known as the IEPR demand forecast) and AAEE scenarios (also known as "distributed energy resource growth forecasts")
  - Weather variants and AAEE scenario variants may differ by IOU as per CPUC D. 18-02-004[11]
- California ISO flexible capacity studies for resource adequacy:[12]

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10 In consultation with the CEC and California ISO, the CPUC may authorize procurement using an alternative weather variant.

11 Pursuant to a May 11, 2020, CPUC Distribution Resources Plan Ruling (R.14-08-013), the same IEPR datasets are used by each IOU. The IOUs meet and confer to establish which IEPR datasets to use and present a listing of the selected datasets to CPUC staff for approval. In all cases, IEPR datasets are used where feasible for disaggregation and forecasting, and the IOUs clearly state in their filings which datasets were used.

12 The methodology for assessing flexible capacity utilizing the hourly CEC Forecast was first used for flexible capacity resource adequacy planning for year 2020, and the Joint Agencies and California ISO are collaborating to evaluate this use case into the overall CEC demand forecasting work flow and the California ISO's flexible capacity

- Baseline mid-case hourly loads by California ISO area
- AAEE mid-mid scenario hourly loads by California ISO area
- 1-year-in-2 peak event weather conditions

Lead staff of the Joint Agencies and California ISO have developed a process by which the CPUC or California ISO can make a formal request to the CEC for a desired demand forecast variant or combination which is not yet produced. If the CEC does not have the resources to develop such a variant, then lead staff from the requesting agency may consider deviating from this agreement to independently develop and use such a variant for the period until the CEC is able to develop it. Such requests should also be made and approved using appropriate procedures of the requesting agency to ensure all interested stakeholders are aware of such a deviation.

Transportation Energy Demand Forecast

This section provides an overview of the CEC transportation energy demand forecast. The forecast reflects the implications of a mix of existing policies, consumer preferences, fuel price cases, and projected market and technological conditions. Consistent with prior forecast updates, staff focuses the updated forecast of electricity consumption for transportation but does not present results for other transportation fuels.

The CEC's *Transportation Energy Demand Forecast* uses a suite of models that incorporate consumer preferences, regulations, economic and demographic projections, projected improvements in technology, and other market factors to forecast transportation energy demand. The approach starts with current market conditions and forecasts transportation energy demand based on the projected inputs. No constraints are imposed for the forecast to meet a future target. In contrast, methods used by others for strategic planning begin with a target (such as a quantity of vehicles, fuels, or emissions goals to meet by a future year) and work backward to create intermediate goals for the intervening years. In this way, policy makers can use the forecast in conjunction with a corresponding strategic plan to assess progress toward statewide goals and determine whether further action is needed to meet the goals.

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projection methodology. The Joint Agencies and California ISO are actively working to evaluate and potentially modify the flexible capacity analysis going forward. Until finalization of evaluation and potential changes are made, the California ISO will continue to use the CEC's hourly forecast.

Method Overview for the Transportation Forecast Update

CEC staff designed different combinations of inputs and assumptions to create several plausible transportation demand cases. The low-, mid-, and high-electricity demand cases are consistent with the demand cases used for forecasting total electricity and natural gas demand. These three demand cases are based on different ZEV incentive scenarios, projected vehicle attributes, and economic, demographic, and fuel price inputs, varying in relative favorability for ZEV market penetration. The inputs and assumptions for these cases range from less favorable for ZEV adoption in the low-electricity-demand case to more favorable for ZEV adoption in the high-, aggressive-, and bookend-demand cases.

CEC staff developed all the forecast fuel price cases except for the hydrogen prices, which were developed by the National Renewable Energy Laboratory (NREL). The update to the California fuel price forecasts is primarily based on the United States Energy Information Administration's (U.S. EIA's) nationwide forecasts in its Annual Energy Outlook.[13] Fuel prices in California and the nation as a whole have been greatly impacted by COVID-19. While high uncertainty remains, the decline in price for gasoline and other fuels is not anticipated to last. The U.S. EIA publishes a short-term energy outlook every month that contains monthly forecasts of fuel prices for the current and following calendar years — currently through the end of 2021. These incorporate the effect of COVID-19 into the price forecasts and are incorporated directly into the California fuel price model. In California, an additional factor may contribute to a rebound in fuel prices: the Marathon Martinez refinery has closed this year, and the Phillips 66 refineries in Rodeo and Santa Maria are planning to do so in 2023. These closures will reduce the supply of fuel and could result in a faster return to pre-COVID-19 prices for gasoline and diesel.

Light-Duty ZEV Forecast Updates

Table 2 shows consumer preferences, vehicle attributes, ZEV incentives, and infrastructure availability assumptions for each electricity demand case. Staff updated ZEV vehicle attributed based on manufacturer vehicle announcements. The bookend electricity demand case incorporates makes and models in additional light-duty vehicle (LDV) size classes for fuel cell electric vehicles (FCEVs) and plug-in hybrid FCEVs (PHFCEVs).[14]

The inputs and assumptions for these scenarios range from less favorable for ZEV adoption in the low-electricity demand case to more favorable for ZEV adoption in the high-, aggressive-,

13 U.S. EIA. Annual Energy Outlook 2020. https://www.eia.gov/outlooks/aeo/.

14 An example of a plug-in fuel cell electric vehicle is the Mercedes-Benz GLC F-CELL, which is sold in Europe. https://www.daimler.com/products/passenger-cars/mercedes-benz/glc-f-cell.html.

and bookend-electricity demand cases. The aggressive- and bookend-electricity demand cases use the economic, demographic, and fuel price inputs from the high-electricity demand case.

For the 2020 forecast, staff modified the incentive forecast based on rebate announcements from CARB and IOUs. Staff also extended the high-occupancy-vehicle-lane-access incentive for ZEVs, based on discussions with CARB. Finally, staff added new ZEV classes to reflect new model announcements made by original equipment manufacturers (OEMs).

Table 2: Inputs and Assumptions for Light-Duty ZEV Scenarios

Electricity Demand Case	Low	Mid	High	Aggressive	Bookend
	Preferences	**Preferences**	**Preferences**	**Preferences**	**Preferences**
Consumers' ZEV Preference	Constant at 2017 Level	Increase With ZEV Market Growth	Increase With ZEV Market Growth	Increase With ZEV Market Growth	Increase With ZEV Market Growth
	Incentives	**Incentives**	**Incentives**	**Incentives**	**Incentives**
Federal Tax Credit	Eliminated after 2019	Decreasing	Decreasing	Decreasing	Decreasing
California Vehicle Rebate Project (CVRP)	To 2025	To 2025	To 2025	To 2030	To 2030
Clean Fuel Rewards Program	2021 to 2030	2021 to 2030	2021 to 2030	2021 to 2030	2021 to 2030
State Rebates	CA Vehicle Rebate Project To 2025; Clean Fuel Rewards 2021 to 2030	CA Vehicle Rebate Project to 2025; Clean Fuel Rewards 2021 to 2030	CA Vehicle Rebate Project to 2025; Clean Fuel Rewards 2021 to 2030	CA Vehicle Rebate Project to 2030; Clean Fuel Rewards 2021 to 2030	CA Vehicle Rebate Project to 2030; Clean Fuel Rewards 2021 to 2030
High Occupancy Vehicle Lane Access	To 2021	To 2023	To 2025	To 2030	To 2030
	Attributes in 2030	**Attributes in 2030**	**Attributes in 2030**	**Attributes in 2030**	**Attributes in 2030**
Number of LDV Classes with ZEVs Available in 2030 (out of 16 CEC LDV classes)	Battery Electric Vehicle (BEV): 10 Plug-in Hybrid Electric Vehicle (PHEV): 10 FCEV: 4 PHFCEV: 0	BEV: 16 PHEV: 14 FCEV: 6 PHFCEV: 2	BEV: 16 PHEV: 15 FCEV: 6 PHFCEV: 2	BEV: 16 PHEV: 15 FCEV: 6 PHFCEV: 2	BEV: 16 PHEV: 15 FCEV: 10 PHFCEV: 7
Vehicle/Battery Price	Plug-in Electric Vehicles (PEVs): Prices based on	PEVs: Prices based on battery price	PEVs: Prices based on battery price	PEVs: Prices based on battery price	PEVs: Prices based on battery price

Electricity Demand Case	Low	Mid	High	Aggressive	Bookend
	battery price declining to ~$120/kWh	declining to ~$100/kWh	declining to ~$80/kWh	declining to ~$70/kWh	declining to ~$62/kWh
Max Range for a Midsize Vehicle (Miles)	BEVs: ~385 FCEVs: ~460	BEVs: ~385 FCEVs: ~460	BEVs: ~385 FCEVs: ~460	BEVs: ~385 FCEVs: ~460	BEVs: ~385 FCEVs: ~460
Refuel Time (minutes)*	PEVs: 15-21 FCEVs: 5	PEVs: 15-21 FCEVs: 5	PEVs: 10-16 FCEVs: 5	PEVs: 10-16 FCEVs: 5	PEVs: 10-16 FCEVs: 5
	Forecast Results	**Forecast Results**	**Forecast Results**	**Forecast Results**	**Forecast Results**
2030 ZEV Population	1.9 Million	3.3 Million	4.2 Million	4.7 Million	4.8 Million

Credit: CEC *Refueling time for PEVs assumes use of a direct-current fast charger (DCFC).

Medium- and Heavy-Duty Vehicle Forecast Updates

Table 3 shows the key inputs and assumptions used for MD-HD vehicles. Some factors, like CARB regulations and South Coast Air Quality Management District (SCAQMD) rules requiring alternative fuels, apply to all the electricity demand cases, while others like fuel prices and battery costs are case-specific. Existing regulations are implicit, since staff estimates truck retirement rates from CARB's Emission Factor 2017 data, which includes regulatory effects.[15] The Advanced Clean Trucks (ACT) regulation was finalized in June 2020, because of the significant updates required to the forecasting model, truck class definitions, and input values, this regulation is not included in the 2020 forecast. For the *2021 IEPR*, staff will design all cases to comply with the ACT regulation. This report does, however, include a comparison of forecast results to the ACT regulation (see Figure 10).

Recent voucher amounts awarded by the CARB Hybrid and Zero-Emission Truck and Bus Incentive Program (HVIP), plus incentives from other entities, are the basis for incentives. The low-, mid-, and high-electricity demand cases use staff's commercial fuel price forecast, except for hydrogen where the fuel price forecast from NREL is used for the low- and mid-electricity demand cases. In the high-electricity demand case after 2021, staff assumed a dedicated fleet price for hydrogen. Battery-electric medium-duty (MD) and heavy-duty (HD) truck battery pack prices are based on the LDV battery pack prices plus 30 percent, to account for more cooling and higher power ratings to perform in the more intense drive cycles. Battery-electric

15 CARB. EMFAC2017 webpage. https://www.arb.ca.gov/emfac/2017/.

trucks are constrained to replacing existing trucks with a typical daily VMT under 150 miles.[16]

Table 3: Key Inputs and Assumptions for MD and HD Zero Emission Vehicles

Electricity Demand Case	Low	Mid	High
	California Regulations	**California Regulations**	**California Regulations**
California Air Resources Board (CARB) Regulations	Innovative Clean Transit Rule, Zero-Emission Airport Shuttle Regulation	Innovative Clean Transit Rule, Zero-Emission Airport Shuttle Regulation	Innovative Clean Transit Rule, Zero-Emission Airport Shuttle Regulation
SCAQMD Regulations	Implicit for refuse trucks and urban transit buses	Implicit for refuse trucks and urban transit buses	Implicit for refuse trucks and urban transit buses
	Incentives	**Incentives**	**Incentives**
HVIP (all years)*	Current HVIP voucher plus stacked incentives, 86.5 percent of vehicle incremental cost in all years	Current HVIP voucher plus stacked incentives, 86.5 percent of vehicle incremental cost in all years	Current HVIP voucher plus stacked incentives, 86.5 percent of vehicle incremental cost in all years
	Fuel Prices	**Fuel Prices**	**Fuel Prices**
Hydrogen Price	NREL high price	NREL mid price	Based on "right-sized dedicated fleet" fueling station
Electricity Rates	Commercial Rates, High	Commercial Rates, Mid	Commercial Rates, Low
	Attributes	**Attributes**	**Attributes**
Battery Electric Truck Prices Given Pack Price in 2030	BEV prices based on battery price declining to **~$120/kilowatt hour (kWh)**	BEV prices based on battery price declining to **~$100/kWh**	BEV prices based on battery price declining to **~$80/kWh**
Miles Per Gallon (MPG) (conventional/alternative fuels)	High / Low	Mid / Mid	Low / High
Truck Range of Operations	Battery electric range to 150 miles	Battery electric range to 150 miles	Battery electric range to 150 miles
Total ZEV stock 2030	**70,292**	**81,484**	**90,547**

Credit: CEC *The incremental cost is the difference between the purchased truck and the least expensive truck in the class.

16 Based on the length of typical daily trips reported by fleets in the Caltrans 2017 California Vehicle Use and Inventory Survey.

To calculate MD-HD truck retirements, staff used CARB's Emission Factor 2017 forecast of vehicle populations in each calendar year, by vehicle class and model year. Staff discussed this change in methodology in greater detail during the December 3, 2020, IEPR workshop.[17]

Furthermore, CEC staff calibrated the Freight Analysis Framework (FAF) forecast[18] to reflect Moody's gross domestic product forecast.

Transportation Electricity Demand Forecast Results

CEC staff presented ZEV forecast results at a workshop on December 3, 2020.[19] The transportation forecast is integrated into the larger California energy demand forecast. Results include electricity demand for light-duty, MD-HD, and off-road ZEVs through 2030, shown in Figure 12.[20] In the mid-electricity demand case, the transportation electricity consumption from on-road light-duty and MD-HD vehicles represents 4.5 percent of overall forecasted electricity consumption in 2030, and 1.9 percent of electricity demand during the peak hour in 2030.

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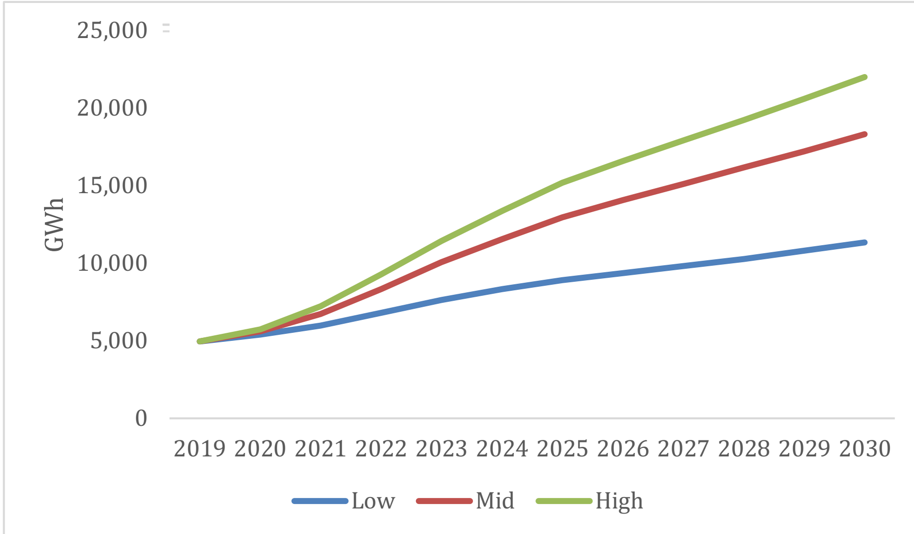
17 December 3, 2020, IEPR Workshop on Updates to the California Energy Demand 2019–2030 Forecast. Session 1: Transportation Energy Demand Forecast Update. Medium- and Heavy-Duty Trucks Forecast Update. https://www.energy.ca.gov/event/workshop/2020-12/session-1-transportation-energy-demand-forecast-update-commissioner-workshop.

18 U.S. Department of Transportation Federal Highway Administration Freight Analysis Framework. https://ops.fhwa.dot.gov/freight/freight_analysis/faf/.

19 Link to workshop documents for the December 3, 2020, workshop on the California Energy Demand Forecast. https://www.energy.ca.gov/event/workshop/2020-12/session-1-transportation-energy-demand-forecast-update-commissioner-workshop.

20 To be consistent with the ZEV action plan, ZEV vehicles in this report include both PEVs as well as FCEVs. PEVs include both BEVs and PHEVs. BEVs, FCEVs, and PHFCEVs are considered pure ZEVs, while PHEVs are considered transitional ZEVs.

Figure 12: Transportation Electricity Demand by Case, 2019–2030



Credit: CEC

Staff calculated tailpipe GHG emissions associated with the forecasted conventional-fueled vehicles by applying CARB's emission factors from the Emission Factor 2017 database.[21] In 2030 for the mid case, GHG emissions (in terms of carbon dioxide equivalent [CO_2e]) from on-road vehicles are estimated to be 140 million tons. This is a decrease from 173 million tons in 2019. The 19 percent decrease in GHG emissions is due to the higher percentage of ZEVs in the vehicle population in 2030.

ZEV Forecast Results

Forecast results for ZEVs are shown below, first for LDVs, and then for MD-HD vehicles.

LDV Results

The CEC's forecast shows an increase in light-duty ZEV population to more than 3.3 million vehicles on the road in 2030 in the mid-electricity demand case and more than 4.2 million in the high-electricity demand case, as shown in Figure 13. Of these, 3.1 million are PEVs, and the remainder are FCEVs and plug-in FCEVs. In 2030, light-duty ZEVs account for 9.6 percent of all LDVs on the road in the mid case and 11.9 percent in the high case. In the aggressive and bookend-electricity cases designed to reflect the most optimistic scenarios of the total LDV population, the light-duty ZEV stock is 13.2 percent (4.7 million) and 13.5 percent (4.8 million), respectively.

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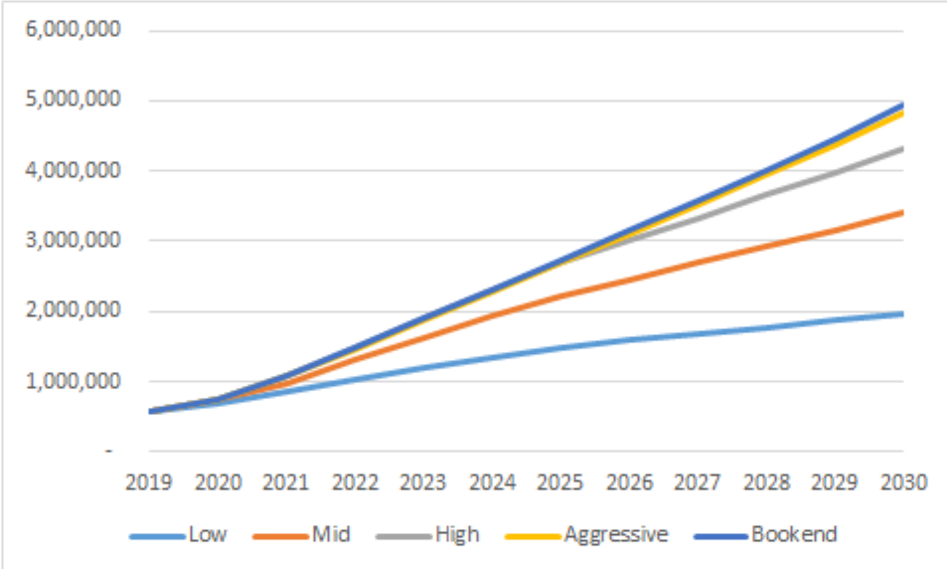
21 CARB. Emission Factor 2017 database. https://arb.ca.gov/emfac/.

Figure 13: Light-Duty ZEV Results by Electricity Demand Case, 2019–2030



Credit: CEC

In 2025, the forecast results in 2.2 million light-duty ZEVs in the mid-electricity demand case, surpassing the target set in Executive Order B-16-12 for 1.5 million ZEVs on the road in California.[22] In 2030, the forecast shows 3.3 million light-duty ZEVs in the mid-electricity demand case and 4.2 million in the high-electricity demand case. These numbers fall short of the target set in Executive Order B-48-18 for 5 million ZEVs on the road in California.[23] The aggressive and bookend-electricity demand cases result in 4.7 million and 4.8 million in 2030, respectively, just short of the 2030 target.

The forecasted decrease in per-capita income, due to the COVID-19 pandemic, could make it more difficult to reach the state's ZEV targets. This scenario could cause a decrease in overall new vehicle sales, which will reduce the rate at which ZEVs are put on the road. Although this income dip is not anticipated to extend throughout the entire 10-year span of the forecast, the effect will be enough to impact the total ZEV stock in 2030.

In 2030, 15.1 percent of new vehicle sales are forecasted to be ZEV in the mid-electricity demand case and 19.6 percent are ZEV in the high-electricity demand case. These results

22 Executive Order B-16-12. https://www.ca.gov/archive/gov39/2012/03/23/news17463/index.html.

23 Executive Order B-48-18. https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html.

show that additional market interventions will be needed to meet the Executive Order N-79-20 goal that 100 percent of new vehicle sales are ZEV starting in 2035.[24]

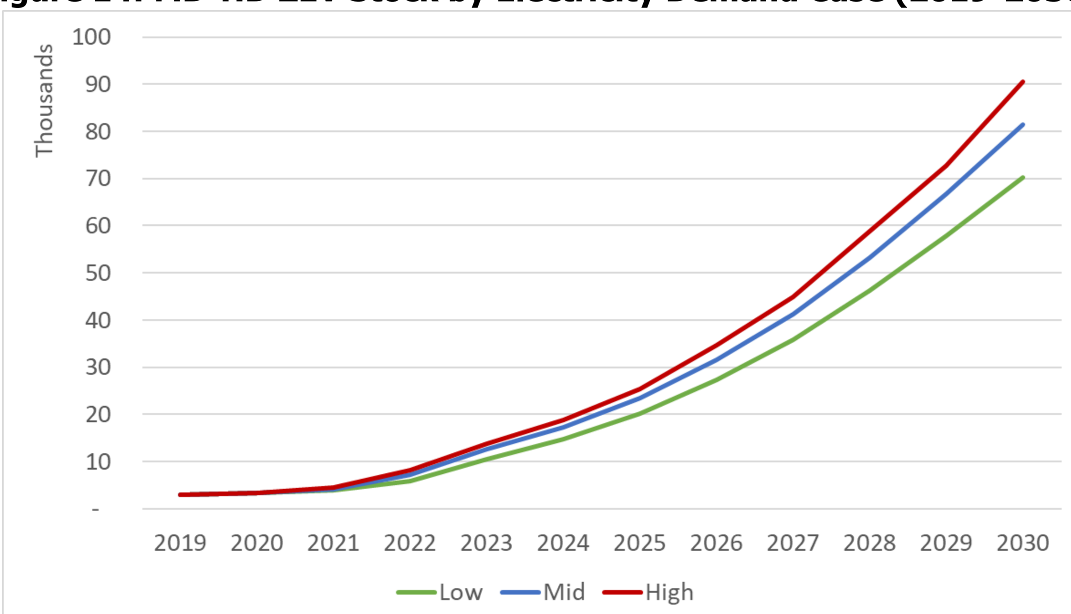
MD and HD ZEV Results

Figure 14 shows the forecast of MD and HD buses and trucks. The high-electricity demand case results in 90,547 MD and HD ZEVs by 2030, including:

- 85,606 battery-electric trucks and buses.
- 2,970 catenary-electric trucks (primarily port drayage trucks).
- 1,971 hydrogen fuel-cell Class 8 tractor-trailers and buses.

The mid-electricity demand case includes 81,484 MD and HD ZEVs. The low-electricity demand case results in 70,292 MD and HD ZEVs. The high-electricity demand case assumes more favorable truck purchase prices and fuel prices for ZEVs, leading to a lower cost of ownership and higher adoption rates than the low electricity demand case.

Figure 14: MD-HD ZEV Stock by Electricity Demand Case (2019-2030)



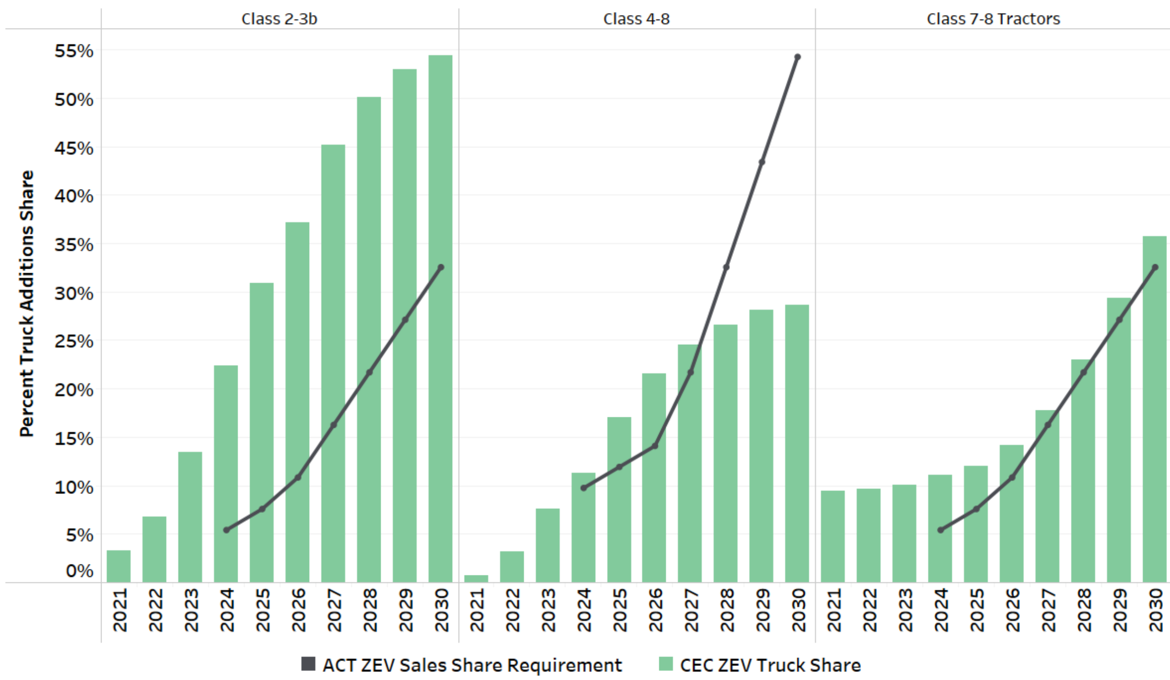
Credit: CEC

Figure 15 compares the ZEV market share in the mid-electricity demand with the adoption requirements of the ACT regulation. Credits are earned starting in 2021, but deficits are not

24 Executive Order N-79-20. https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf.

accrued until 2024. Credits can be applied up to five years in the future. Classes 2B, Class 7 and 8 trucks, and Class 7 tractor trucks[25] were not evaluated because these classes were not anticipated to electrify at the time that zero-emission truck attributes were developed, and therefore staff do not have zero-emission truck attributes for these classes. For the *2021 IEPR*, staff will update zero-emission truck attributes and include these classes.

Figure 15: Comparison of the Mid Electricity Demand Case Zero-Emission Truck Share with ACT Regulation Requirements

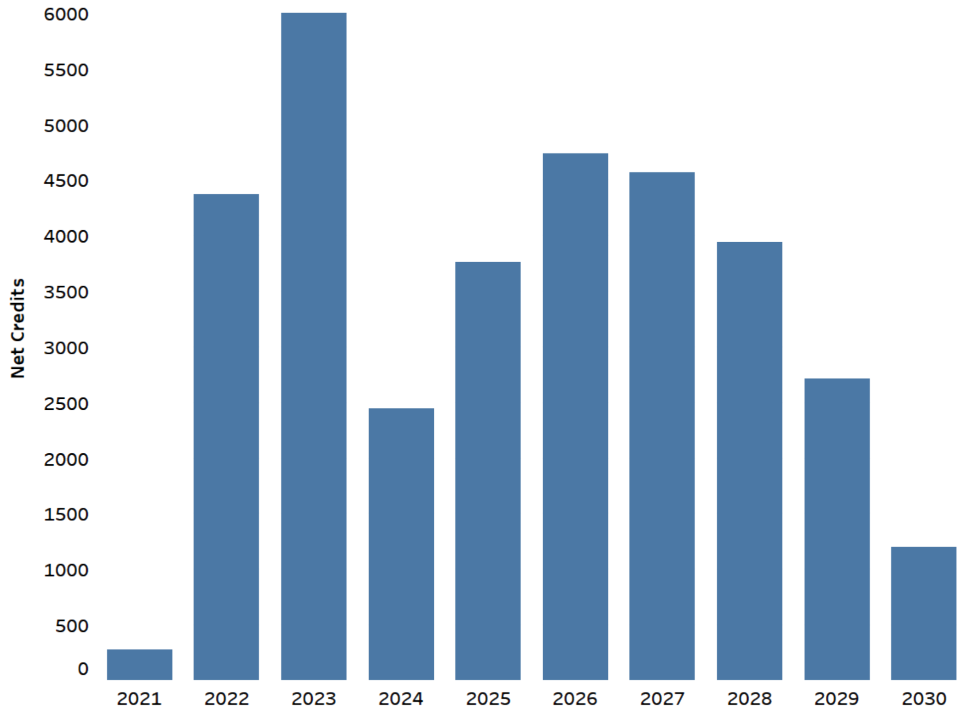


Credit: CEC

Figure 16 shows that despite the Classes 4-8 straight trucks falling short of the ACT targets for that class in 2028–2030, the overall statewide fleet has enough credits from the other classes to comply.

25 Straight trucks have a single frame, while a tractor truck (or articulated truck) consists of two or more separate frames and the tractor can be removed from the back of the truck.

Figure 16: Advanced Clean Truck Net Credits based on the Mid-Electricity Demand Case ZEV Adoption



Credit: CEC

Transportation Exploratory Scenarios

CEC staff developed exploratory scenarios to analyze the electricity demand impacts of 1) different PEV charging load shapes, 2) increased MD-HD adoption to meet federal ozone standards in the SCAQMD, and 3) increased telecommuting. These exploratory scenarios are intended to provide additional information for policymakers, regulators, or other stakeholders to consider for planning.

Exploratory PEV Charging Load Shape Scenarios

Staff developed charging load shape scenarios to analyze system impacts from shifting PEV charging load to different times during the day. These scenarios do not represent current or expected charging behavior that depends on PEV owners' driving patterns and influenced by utility time-of-use (TOU) rates. These scenarios highlight the potential effects of shifting this load and the importance of managing PEV charging (such as through vehicle-grid-integration technologies) with respect to reducing system load and GHG emissions.

GHG Emission Reduction Scenario

This scenario investigates impacts of shifting PEV charging to hours when GHG emissions from electricity generation are lowest. GHG emissions from electricity generation are lowest midday when solar PV systems are producing electricity. A PEV charging profile reflective of this scenario could be achieved by increasing access to workplace chargers or redesigning TOU rates so that mid-day rates are less expensive than nighttime rates.

Staff developed hourly statewide GHG emission intensity factors based on the projected generation mix in each hour of 2030[26] and used the analysis to design PEV charging profiles to reduce GHG emissions. This scenario uses statewide system average GHG emission intensity factors based on the *2019 IEPR* adopted mid-case statewide electricity sector projections. CEC staff combined forecasted electricity consumption in the mid case for 2030 by the vehicle categories included in the EV Infrastructure Load Model. CEC staff then used the EV Infrastructure Load Model to disaggregate, or break down, annual electricity consumption to daily electricity consumption. Then that daily electricity consumption was distributed across each hour of the day according to the load shape developed to reduce GHG emissions. This load shape was applied only to vehicle categories assumed to have to have the flexibility to shift charging times to the middle of the day. For example, it could be difficult for vehicles on scheduled fixed routes (such as transit buses) to charge at a different time. Table 4 shows which vehicle categories, as categorized in the EV Infrastructure Load Model, were considered to have flexible or inflexible charging times.

Table 4: Assumed Vehicle Categories With Flexible and Inflexible Charging Behavior

Assumed Flexibility	EV Infrastructure Vehicle Category
Flexible	Personal LDV (Single Family, Multi Family, Destination), Commercial LDV, Neighborhood EV, School Buses
Inflexible	Government/Rental LDV; Gross Vehicle Weight Rating (GVWR) classes 3, 4, 5, and 6; GVWR classes 7 and 8; Urban Buses

Credit: CEC

Results for an average summer weekday in 2030 for the GHG emission reduction scenario and EV Infrastructure Load Model are compared in Figure 17. The EV Infrastructure Load Model projects that PEVs contribute 1,384 MW to the system peak demand. In the GHG emission reduction scenario, PEVs contribute 2,046 MW to the system peak demand. Though the GHG emission reduction scenario increases load during peak hours, the annual GHG emissions from charging PEVs are decreased by 0.4 million metric tons of CO_2e. These results underscore the need to consider GHG emission intensity factors and grid conditions when considering load-shifting strategies to address climate change.

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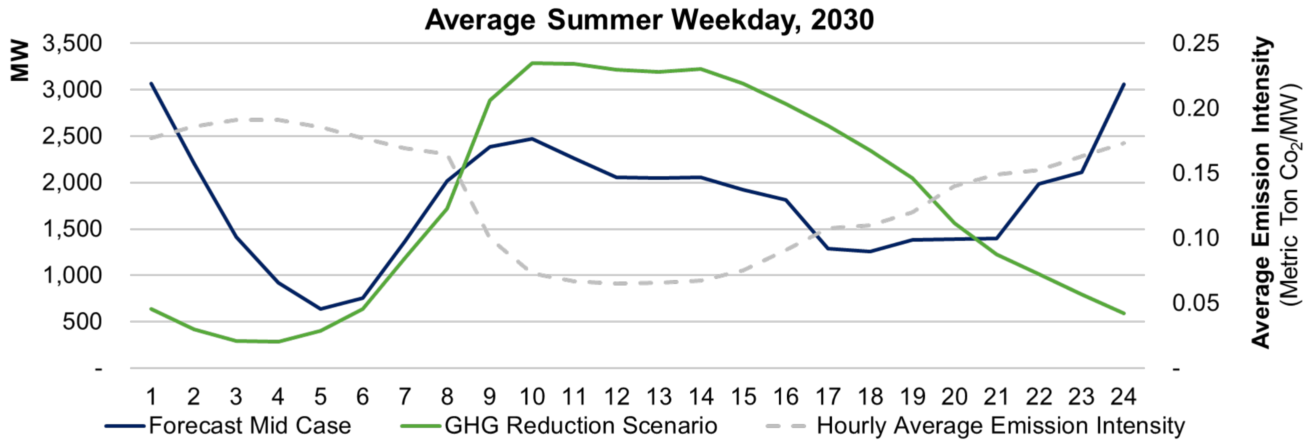
26 CEC staff projections based on *2019 IEPR* mid demand PLEXOS simulation results, July 2020.

Figure 17: Average Summer Weekday Load Shape in 2030



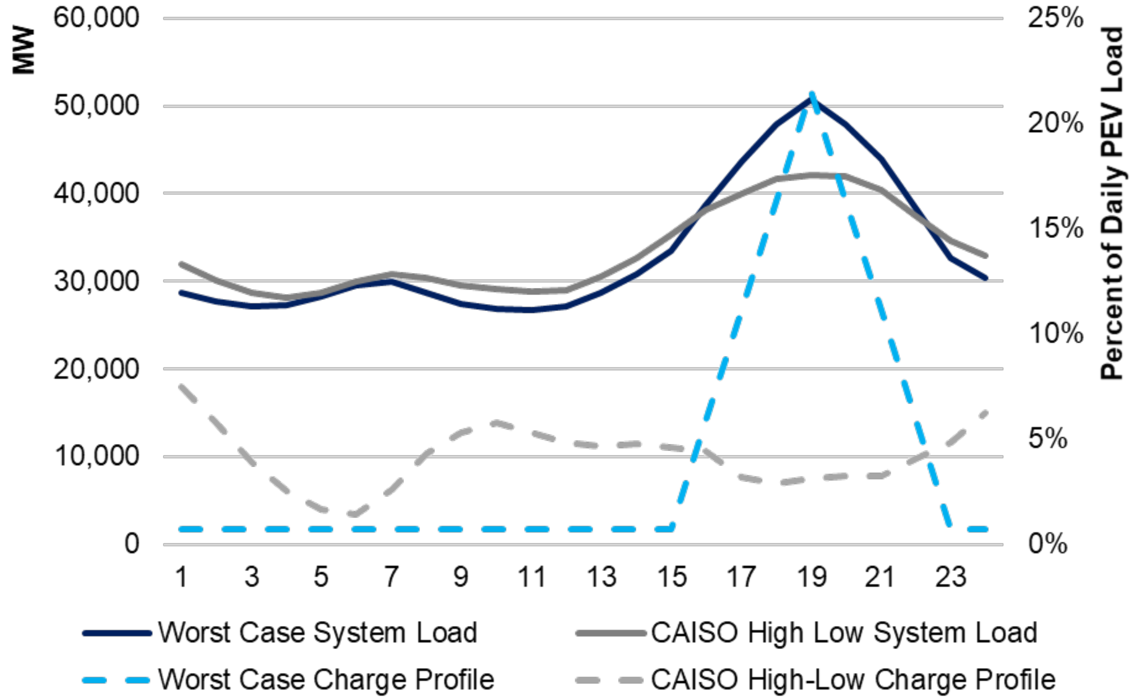
Credit: CEC

Worst-Case Load Shape Scenario

The worst-case charging scenario estimates the impacts on the California ISO system in 2030 if all PEVs were charged during the peak demand hours. Staff used the annual PEV electricity consumption from the high-electricity demand case along with the *2019 IEPR* hourly forecast for the California ISO region for the high demand and low additional achievable energy efficiency case (high-low case) in 2030. Similar to the GHG emission reduction scenario, staff used the EV Infrastructure Load Model to determine daily electricity consumption and then applied the worst-case load shapes to disaggregate to each hour of the day.

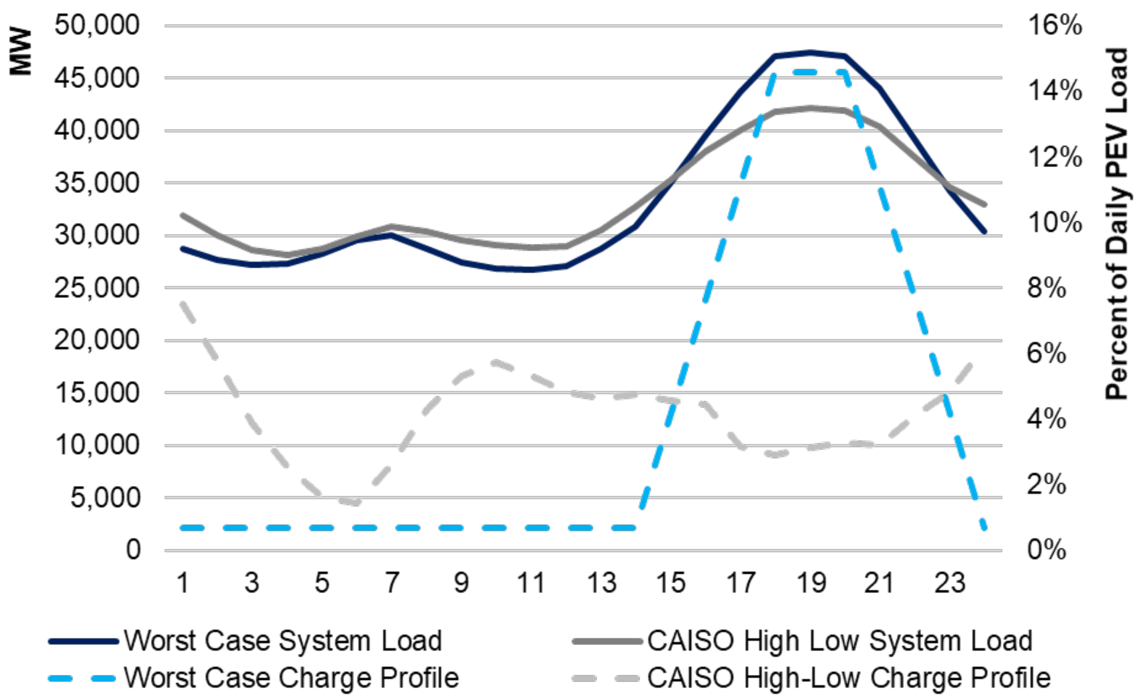
Staff developed two worst-case PEV charging load profiles where most charging occurs during the peak hours, shown in Figure 18 and Figure 19. Both figures compare the worst-case scenario load profiles to the EV Infrastructure Load Model (labeled as CAISO high-low charge profile). The dashed lines show the load profiles for the EV Infrastructure Load Model (gray) and the worst-case load profile (blue) as a percentage of the daily load. In Profile 1, the charging happens over a shorter duration with a sharper ramp than in Profile 2. In Profile 2, charging happens over a longer duration, and the increase in load is more gradual. Applying Profile 1 (in Figure 18) increases the peak California ISO system demand by 8,501 MW and results in a steep ramp rate, which can be challenging for system operators to meet. Applying Profile 2 (in Figure 19) increases the peak California ISO system demand by 5,295 MW. These scenarios highlight the importance of TOU rates or other strategies to discourage PEV owners from charging during the peak system hours.

Figure 18: Worst-Case Scenario Load Profile 1



Credit: CEC

Figure 19: Worst-Case Scenario Load Profile 2



Credit: CEC

Exploratory MD and HD Ozone Attainment Scenario

The second exploratory scenario the CEC studied was the energy impact from the projected number of MD and HD ZEVs for the SCAQMD to achieve federal public health standards for ozone in the South Coast Air Basin. SCAQMD faces significant challenges in meeting the eight-hour ozone standard set by the U.S. Environmental Protection Agency by 2031.[27] Oxides of nitrogen (NO_x) are a precursor to ozone, and NO_x emissions in the South Coast Air Basin must be reduced by 55 percent to meet the ozone standard. On-road internal combustion engine (ICE) MD-HD vehicles make up 32 percent of total NO_x emissions statewide.[28] Increasing the market share of zero-emission MD-HD vehicles is one strategy that SCAQMD is pursuing to meet the federal ozone standards. SCAQMD collaborated with CARB to estimate that just over 79,000 of the MD-HD vehicle population in 2031 would need to be ZEVs to meet the federal ozone standard.[29] The CEC's mid-electricity demand case results in just over 34,000 MD-HD ZEVs (scaled to SCAQMD) in 2031, which is less than half of the SCAQMD projections. If SCAQMD's proposed strategies were put in place, utilities in the region will need to plan for the impacts to electricity demand. Therefore, this scenario estimated the impacts on electricity demand for the additional MD-HD ZEVs needed in 2031 for SCAQMD to meet the federal ozone standard.

CEC staff used the mid-electricity demand case as the starting point for this scenario and adjusted incentive levels and retirement rates while holding the other variables constant. Because the total population (for trucks of all fuels) and VMT forecasted by the CEC was different from the total stock and VMT provided by SCAQMD, CEC staff used the ICE truck fuel consumption provided by SCAQMD as the target, rather than the ZEV population so as to not over- or underestimate the electricity consumption. For example, if the total stock in the mid-electricity demand case was higher than SCAQMD's projections (and VMT was the same), then using ZEV population alone as a target would have resulted in too many ICE trucks and would not have met the required NO_x reductions. Therefore, CEC staff adjusted incentive levels and retirement rates in the forecast to reach the ICE fuel usage target to account for these differences.

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27 South Coast Air Quality Management District. *Final Contingency Measure Plan: Planning for Attainment of the 1997 80 ppb 8-Hour Ozone Standard in the South Coast Air Basin*. December 2019. http://www.aqmd.gov/docs/default-source/planning/1997-ozone-contingency-measure-plan/1997-8-hour-ozone-draft-contingency-measure-plan---120619.pdf.

28 CARB 2020 Mobile Source Strategy. Public Webinar held October 7, 2020. https://ww2.arb.ca.gov/sites/default/files/2020-10/2020_MSS_October_Webinar_Presentation.pdf.

29 These are preliminary estimates shared by SCAQMD and CARB to support this analysis.

CEC staff tested different incentive levels and retirement rates targeting the ICE truck fuel consumption for each class. The resulting incentives varied by class and ranged from 25 percent of the purchase price for Class 3 to 65 percent of the purchase price for Class 8 tractors. The retirement rates used in the mid-electricity demand case were used for all classes except Class 8 tractors, where the retirement age was reduced to 13 years. For more details on the methodology, see the presentation from the IEPR workshop held on December 3, 2020.[30]

The scenario resulted in nearly 104,000 zero-emission trucks, which was higher than SCAQMD's projection of just over 79,000 zero-emission trucks because of differences in VMT and total stock. In the Class 8 trucks category, which are the largest contributor to NOx emissions, the number of zero-emission trucks increased by 25,000 from the mid-electricity demand case. Approximately 800 of the zero-emission trucks were hydrogen fuel cell trucks, and the remaining trucks were battery-electric.

The increase in the number of battery-electric trucks resulted in 1,684 GWh of added electricity consumption over the mid-electricity demand case in 2031. Of this, roughly 71 percent is attributed to SCE, 27 percent to the Los Angeles Department of Water and Power, and 2 percent to Burbank Water and Power. Staff applied the EV Infrastructure Load Model load shapes for SCE to the portion of electricity attributed to SCE and estimate that 164 MW are added to SCE's summer peak in 2031.

Exploratory Telecommute Scenario

The last exploratory scenario the CEC considered was energy impacts due to changes in the number of people who telecommute. The increase in telecommuting seen under COVID-19 prompted the development of three scenarios to explore the impacts of different levels of continued telecommuting after the pandemic. Staff estimated the reduction in GHG emissions and gasoline consumption for each scenario.

Staff used four types of data to develop these scenarios:

- Workforce data from the 2018 American Community Survey (ACS)[31]

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30 Link to workshop documents for the December 3, 2020, workshop on the California Energy Demand Forecast. https://www.energy.ca.gov/event/workshop/2020-12/session-1-transportation-energy-demand-forecast-update-commissioner-workshop.

31 U.S Census Bureau American Community Survey 2018 data release. https://www.census.gov/programs-surveys/acs.

- Commuting data from ACS and the California Statewide Travel Demand Model (CSTDM)[32]
- Emissions rates from EMFAC2017[33]
- Fuel efficiency from staff analysis of Department of Motor Vehicle (DMV) data

The analysis is limited to two sectors (as defined by ACS) that account for 22 percent of California's workforce and 41 percent of California's work-at-home force in 2018:

- Information and finance and insurance, and real estate and rental and leasing
- Professional, scientific, and management, administrative, and waste management services

Other sectors, such as construction, were excluded because this type of work requires most workers to be onsite.

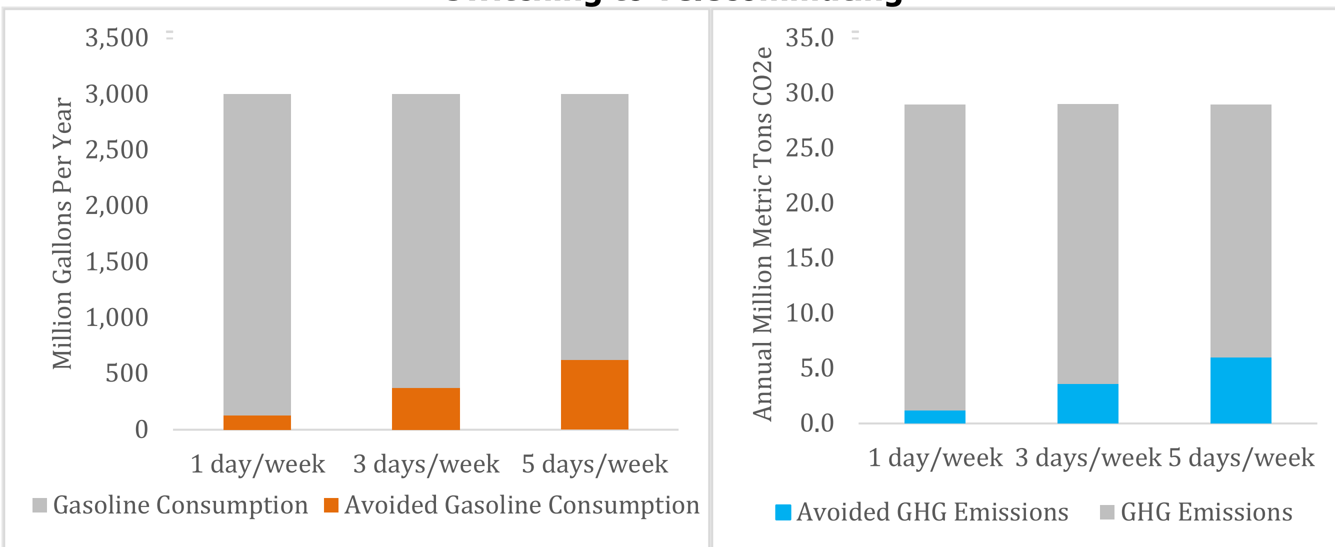
Staff assumed that only single drivers provide reductions in gasoline consumption and GHG emissions, which excludes those who take public transit, carpool, or already work at home. Applying these assumptions results in 2.8 million single commuters eligible for this analysis, out of 13.7 million single commuters in the state.

Figure 20 shows the results. The top of the bars shows the estimated gasoline consumption and GHG emissions for the 13.7 million single commuters in the state. If all 2.8 million single commuters in the two sectors worked at home once a week, gasoline consumption and GHG emissions for the entire workforce would be reduced by 4 percent. Gasoline consumption and GHG emissions would be reduced by 12 percent if they worked at home three days per week, and by 21 percent if they did so five days per week.

32 Caltrans shared CTP2040 CSTDM data with CEC staff under the Transportation Travel and Energy Demand Data contract with Cambridge Systematics in 2014.

33 CARB EMission FACtor (EMFAC) 2017 database. https://arb.ca.gov/emfac/.

Figure 20: Gasoline and GHG Impacts from Single Commuters in Two Sectors Switching to Telecommuting



Credit: CEC

Future Energy Demand Scenarios to Assess Decarbonization Strategies

Future IEPRs will continue to explore new programs, policies, and potential market changes that are currently outside the scope of the 10-year energy demand forecast. Energy-demand scenarios will be designed as a distinct product to assess various demand-side policies and strategies to meet California's long-term decarbonization goals. Senate Bill 100 (De León, Chapter 312, Statutes of 2018) set the goal that 100 percent of electric retail sales come from renewable and zero-carbon resources by 2045. Furthermore, sector-specific goals such as Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) building decarbonization, and Executive Orders B-48-18 and N-79-20 zero-emission vehicle goals, need to be assessed as not only stand-alone policies, but as significant policy milestones toward achieving the long-term economywide carbon-neutrality goal.

For example, California's transportation sector must evolve at a near-revolutionary pace to achieve its decarbonization goals. Within the energy-demand scenarios, CEC staff must examine dramatic shifts to the way people and goods move throughout the state, including assessing the concept of the Three Revolutions of electrification, autonomy, and mobility as a service. (See Volume I~~1~~ for more information.) Fully autonomous vehicles are not yet market-ready, and there is a high level of uncertainty around the timing and way that consumers would use these vehicles. Also, there are limited data on mobility as a service, and the effects will be based largely on consumer decisions and behavior. One outcome of the Three Revolutions is widespread adoption of ridesharing using electric autonomous vehicles, which could decrease VMT, transportation fuel consumption, and emissions. Conversely, if autonomous gasoline vehicles are used by individuals riding alone or if vehicles frequently travel unoccupied between drop-off and pick-up locations, then VMT, fuel consumption, and emissions could increase. These types of scenarios, where there is high uncertainty, are the types of scenarios that are more appropriate to explore as a separate analysis from the forecast. In fact, the exploratory scenarios presented in this chapter reflect future analysis that should be conducted within the broader development of energy demand scenarios.

Acronyms

AAEE	additional achievable energy efficiency
ACS	American Community Survey
ACT	Advanced Clean Trucks
BEV	battery-electric vehicle
BTM	behind-the-meter
California ISO	California Independent System Operator
CARB	California Air Resources Board
CEC	California Energy Commission
CED 2019	California Energy Demand 2019 forecast
CEDU	California Energy Demand Update
CO_2e	carbon dioxide equivalent
CPUC	California Public Utilities Commission
CVRP	California Vehicle Rebate Project
DCFC	direct-current fast charger
DG stats	California Distributed Generation Statistics
DOF	California Department of Finance
EMFAC	CARB EMission FACtor database
EV	electric vehicle
FAF	Freight Analysis Framework
FCEV	fuel-cell electric vehicle
GVWR	gross vehicle weight rating
ICE	internal combustion engine
IEPR	Integrated Energy Policy Report
IOU	investor-owned utility
IRP	Integrated Resource Plan
GHG	greenhouse gas
GVWR	gross vehicle weight rating
GWh	gigawatt hour

HD	heavy-duty
HVIP	Hybrid and Zero-Emission Truck and Bus Incentive Program
kWh	kilowatt hour
LSE	load-serving entity
LDV	light-duty vehicle
MD	medium-duty
Moody's	Moody's Analytics
MPG	miles per gallon
MW	megawatt
NEM	net energy metering
NREL	National Renewable Energy Laboratory
NO_x	oxides of nitrogen
OEM	original equipment manufacturer
PEV	plug-in electric vehicle
PG&E	Pacific Gas and Electric
PHEV	plug-in hybrid electric vehicle
PHFCEV	plug-in hybrid fuel cell electric vehicle
PV	photovoltaic
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
TAC	transmission access charge
TOU	time of use
TPP	Transmission Planning Process
U.S. EIA	United States Energy Information Administration
VMT	vehicle miles traveled
ZEV	zero-emission vehicle

Glossary

Behind-the-meter refers to energy generated onsite, on the customer's side of the meter. Anything generated on the grid side is considered "in front of the meter."

There are three **electricity demand cases** in the California Energy Demand Update 2020:

- ***High-electricity demand case*** incorporates relatively high economic/demographic growth, relatively low electricity rates, high adoption of zero-emission vehicles, and relatively low efficiency program, self-generation, and climate change impacts.
- ***Low-electricity demand case*** includes lower economic/demographic growth, higher assumed rates, low adoption of zero-emission vehicles, and higher efficiency program and self-generation impacts.
- ***Mid-electricity demand case*** uses input assumptions at levels between the high and low cases.

Straight trucks have a single frame, while a tractor truck (or articulated truck) consists of two or more separate frames and the tractor can be removed from the back of the truck.

The **Three Revolutions** refer to new technologies — electrified transportation, vehicle automation, and shared mobility services — which are converging to create potentially disruptive changes in the transportation system. If these three interdependent trends evolve in accordance with a best-case scenario, California could foster more sustainable and equitable transportation systems while reducing transportation GHG emissions by 80 percent. (This is known as the "Blue Skies scenario".) To the contrary, if these three trends are not strategically managed by governments and other key stakeholders, they could exacerbate many of the state's most serious transportation issues, including increases in vehicle miles traveled, congestion, fuel use, and vehicle emissions. (This is known as the "Dirty Skies scenario.")

Zero-emission vehicles are those that do not emit exhaust gas from the onboard source of power. Zero-emission vehicles include plug-in electric vehicles, fuel cell electric vehicles, and battery-electric vehicles. Plug-in hybrid electric vehicles may have emissions from combustion drivetrains but may operate as an electric vehicle with no emissions.