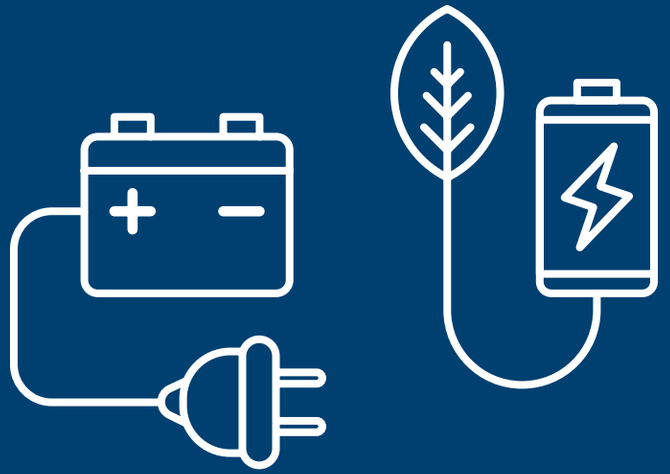
CALIFORNIA CLEAN ENERGY ALMANAC

2020

Road to 100 Percent Clean Energy



California's Energy Governing Institutions

California Energy Commission

The California Energy Commission (CEC) is leading the state to a 100 percent clean energy future. It has seven core responsibilities: developing renewable energy, transforming transportation, increasing energy efficiency, investing in energy innovation, advancing state energy policy, certifying thermal power plants, and preparing for energy emergencies.

California Public Utilities Commission

The California Public Utilities Commission (CPUC) regulates services and utilities, protects consumers, safeguards the environment, and assures Californians' access to safe and reliable utility infrastructure and services.

California Independent Service Operator

The California Independent Service Operator (CAISO) is responsible for managing the flow of electricity that serves 80 percent of California and a small portion of Nevada. The CAISO also runs a real-time energy market for utilities in eight western states and conducts reliability coordinator services to most balancing authorities in the West.

California Air Resources Board

The California Air Resources Board (CARB) is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards.

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CHAIR | CALIFORNIA ENERGY COMMISSION

David Hochschild

As California's energy policy and planning agency, the California Energy Commission (CEC) continuously tracks the state's progress toward a 100 percent clean energy future.

The California Clean Energy Almanac presents statistics and examples showing how far we've come—and need to go—on the road toward a more resilient, affordable, equitable and environmentally sustainable energy system.

The 2020 Almanac uses fewer words and more graphics than earlier editions. It is not meant to be comprehensive but rather illustrative of the progress achieved to date, including:

- The state beat by four years its 2020 target of reducing greenhouse gas emissions to 1990 levels. The electricity sector is leading the way—emissions from power generation have dropped 43 percent since 1990.
- California arrived three years early in meeting its 2020 goal of having 33 percent of its electricity coming from solar, wind and other renewable sources.
- A review of 22 recent energy innovation startups showed their total private investment nearly tripled after they received a CEC award funded by the ratepayers' Electric Program Investment Charge.
- About 65 percent of CEC-funded demonstration projects are in low-income or disadvantaged communities, more than double the required proportion.

Transforming California's energy requires accurate and timely information for decision makers, consumers and businesses. I know I speak for my fellow commissioners and our staff of 700 professionals in saying we all take great pride and care in providing this public service.

01

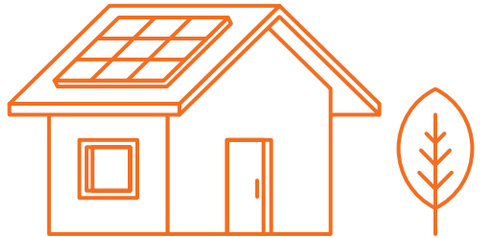
COVID-19

California's energy use plummeted during stay-at-home period.

COVID-19

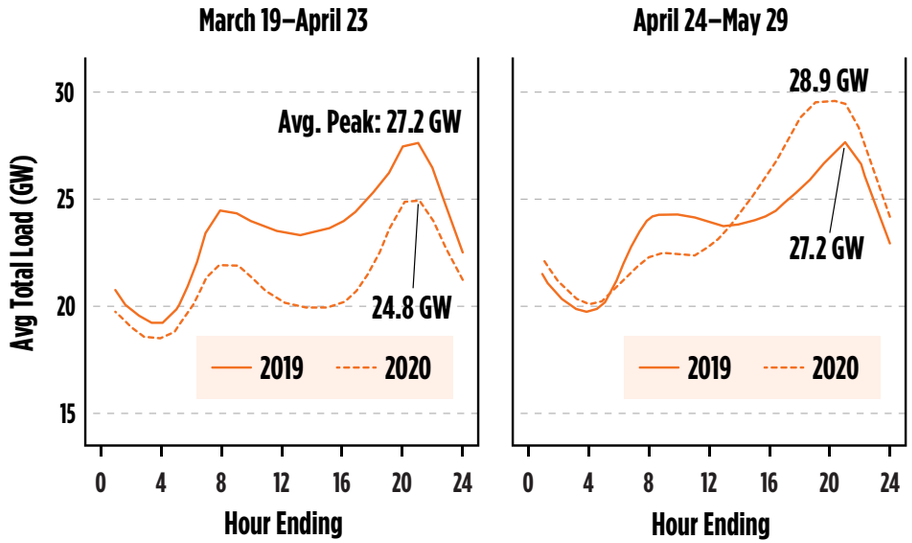
Global pandemic dramatically affected California's energy sector

Though electricity demand at home increased, overall use declined following the state's March 19 stay-at-home order. The CEC also reported record-low production of gasoline, diesel and jet fuels at California refineries.



Electricity

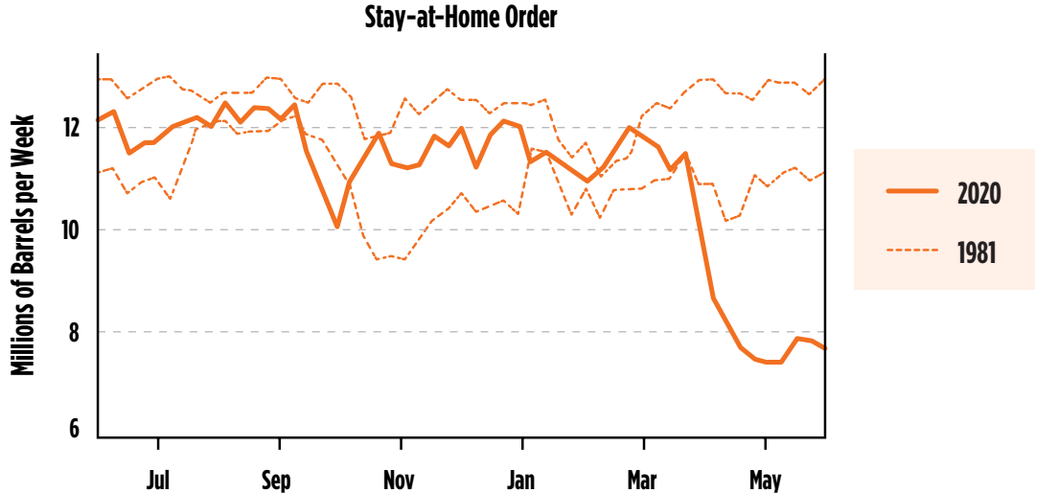
The decrease was greatest during morning and midday hours and evening peak hours.

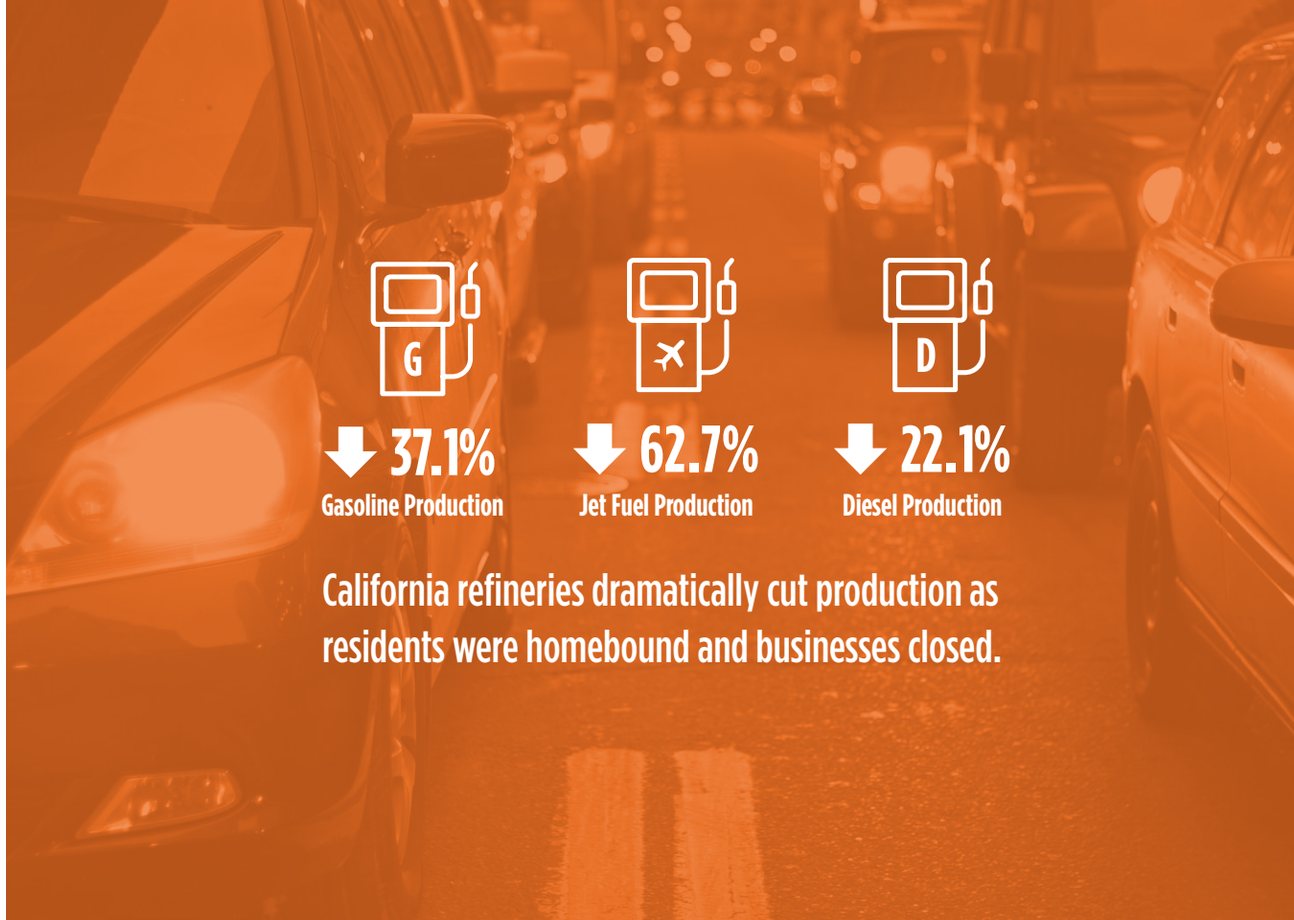


Year-over-year, weekday demand for air conditioning shot up 9 percent as more Californians stayed home during the spring and summer.

Transportation Fuels

The amount of crude oil processed in California at the end of April 2020 dropped to the lowest point on state record, which dates back to 1981.





California refineries dramatically cut production as residents were homebound and businesses closed.

02

GREENHOUSE GAS EMISSIONS REDUCTIONS

Electricity sector leads the way.

Greenhouse Gas Emission Reductions

Greenhouse gas emissions from generating electricity continue to decline.

California met its 2020 goal of reducing greenhouse gas (GHG) emissions economywide to 1990 levels four years ahead of schedule. The electric power sector leads the way. Emissions from power generation have dropped 43 percent since 1990. These gains are largely attributable to three factors:

1. California's energy efficiency standards
2. Increased use of renewable energy, primarily solar
3. Greatly reduced use of coal-fired power plants

Low-Carbon Communities

Turning the corner on carbon

In 2017, for the first time ever, California had most of its electricity produced from "carbon-free" sources—those that do not emit GHGs.

Next challenge: 'decarbonize' buildings

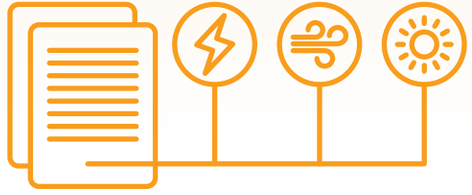
Next to transportation, the second highest source of California's GHG emissions are those linked to everyday use of buildings, mainly natural gas heating and cooking. To meet the state's 2030 and 2050 climate goals, the CEC is identifying ways to decarbonize energy use in new and existing buildings.

The End of Coal is Near

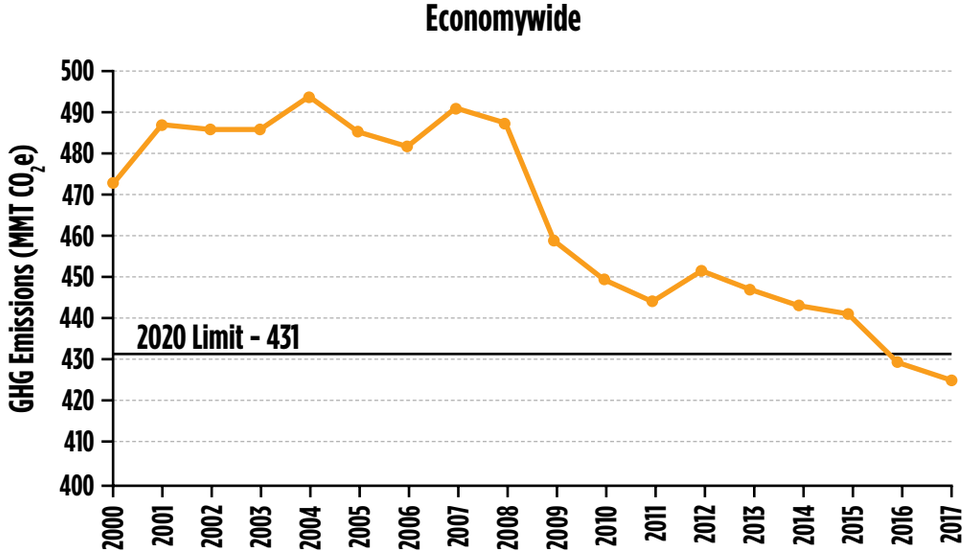
Between 2007 and 2019, coal's share of generation to meet California's electricity demand shrank from 16.6 percent to 3 percent and is expected to drop to almost zero by 2026. The state's multiple emission reduction policies, such as the Cap-and-Trade program, are accelerating the phaseout of coal-fired generation.

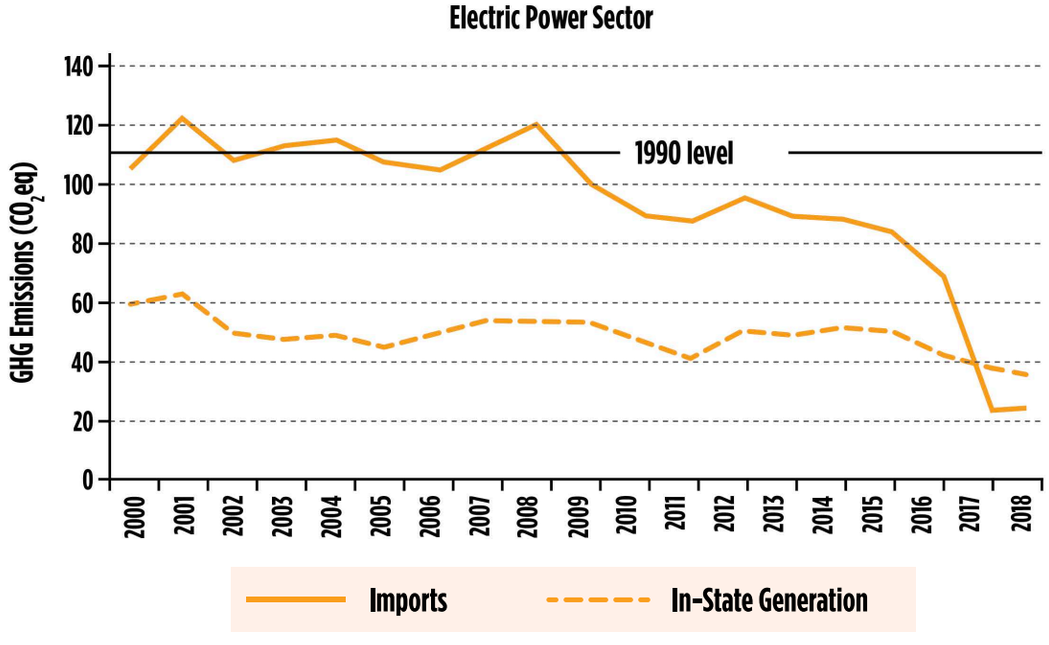
California Law

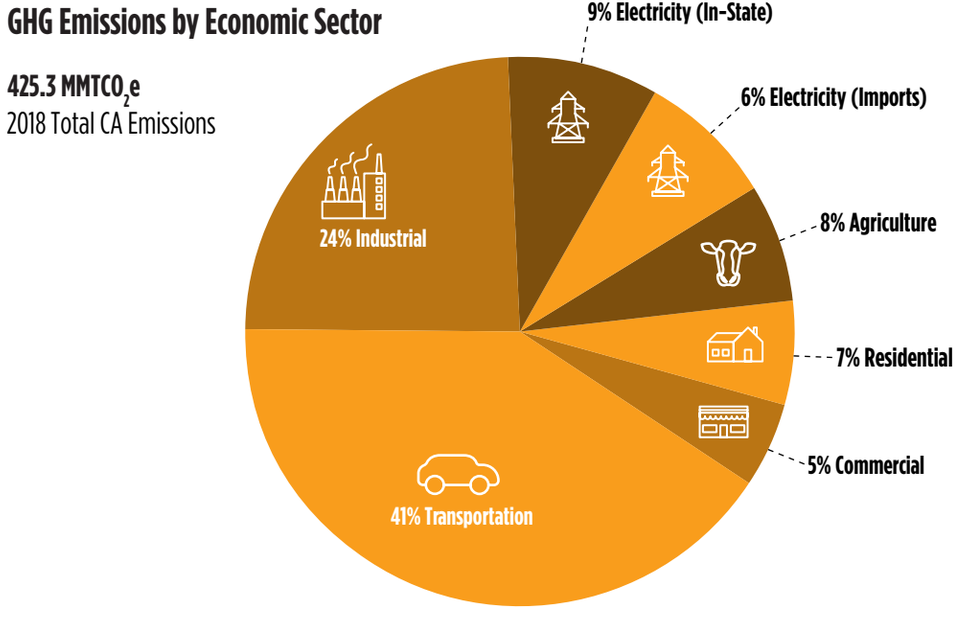
- **Assembly Bill 32 (2006):** Requires state to lower GHG emissions to 1990 levels by 2020.
- **Senate Bill 350 (2015):** Raises renewable electricity procurement goal from 33 percent by 2020 to 50 percent by 2030. Sets a 2030 target for doubling energy efficiency economywide.
- **Senate Bill 1383 (2016):** Sets a goal to cut emissions of highly potent GHGs — mainly methane and hydrofluorocarbon refrigerants — to 40 percent below 2013 levels by 2030.
- **Senate Bill 32 (2016):** Updates AB 32, raising GHG emissions reduction target to 40 percent below 1990 levels.
- **Senate Bill 100 (2018):** Increases the 2030 renewables goal from 50 percent to 60 percent and requires all retail electricity to be carbon-free by 2045.
- **Assembly Bill 3232 (2018):** Directs the CEC to develop a plan by 2021 to cut GHG emissions from buildings 40 percent below 1990 levels by 2030.
- **Senate Bill 1477 (2018):** Requires the California Public Utilities Commission to create a $50 million annual incentive program to decarbonize energy uses in buildings, with the CEC offering the incentives to builders of low-income homes.



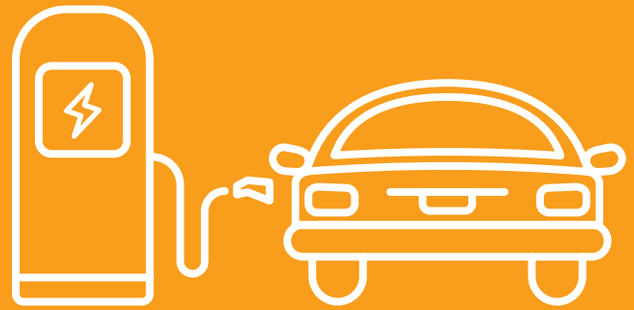
By the Numbers




Electric Power Sector
GHG Emissions (CO_2eq)
140
120
100
80
60
40
20
0
1990 level
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Imports
In-State Generation


GHG Emissions by Economic Sector
425.3 MMTCO$_2$e
2018 Total CA Emissions
9% Electricity (In-State)
6% Electricity (Imports)
8% Agriculture
7% Residential
5% Commercial
41% Transportation
24% Industrial

03



CLEAN TRANSPORTATION

Steady investment in ever-cleaner vehicles and fuels promotes Californians' health and prosperity.

Clean Transportation

Zero-emission vehicles lead the way

The CEC invests up to $100 million each year toward achieving the state's ambitious alternative fuels and transportation goals on climate change and air quality. Most of the funding goes to these three areas:

1. Infrastructure

Building a statewide network of charging outlets and hydrogen fueling stations for the growing numbers of zero-emission vehicles.

2. Low-carbon fuels

Expanding in-state production of economically competitive renewable fuels from waste resources with very low (or even net negative) carbon footprints, relative to gasoline and standard diesel.

3. Medium/heavy-duty vehicles

Funding new technologies to reduce emissions from heavy construction equipment, local delivery trucks, school buses and the like.

Zero-Emission Vehicles

Fast chargers

California is half way toward meeting its 2025 goal of having 10,000 publicly available direct current (DC) "fast" chargers that can repower an electric vehicle in about 30 minutes

Cleaner school buses

The CEC completed its funding of $75 million to replace old school buses with all-electric ones, which will reduce students' exposure to harmful diesel exhaust. Nearly all 235 of the new buses will be going to school districts in low-income communities.

Fortifying the grid

Funding the development of technologies that allow power to flow from zero-emission vehicle batteries back to the state's power grid to help balance demand and supply.

By the Numbers

41%

Of state's GHG emissions come from transportation.

67,343

Electric vehicle charging ports in California. The state aims to reach 250,000 by 2025.

763,816

Cumulative sales of zero-emission vehicles in California. The state law sets a target of 5 million on the road by 2030.

04

ENERGY EQUITY

The CEC is committed to ensuring the benefits of cleaner, more efficient energy are enjoyed by all Californians, including those in low-income and disadvantaged communities.

Clean Energy Equity

Helping communities overcome barriers

The CEC identifies barriers to clean energy, develops strategies to overcome them and measures progress with three objectives in mind:

1. Access

Advance access to clean energy, including high-quality jobs, non-debt financial offerings and small business contracting opportunities.

2. Investment

Increase clean energy investment, including funding of job training, technology development and demonstration projects.

3. Resilience

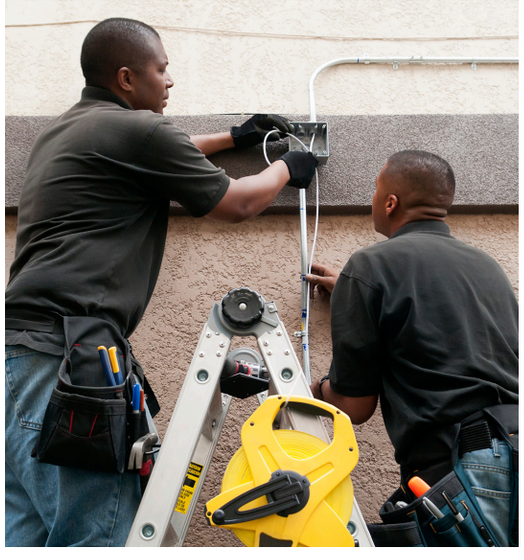
Strengthen communities' ability to function during power outages and enjoy reliable and affordable energy in a changing climate.

Diversity and Access

'Disadvantaged Communities'

California's energy and environmental policies give preferential funding to low-income and "disadvantaged communities," a state designation for low-income census tracts that suffer additional burdens, such as poor health, high unemployment and poor air or water quality.

The CEC targets apartment buildings and rental homes for many of its energy efficiency demonstration projects that will benefit low-income residents.



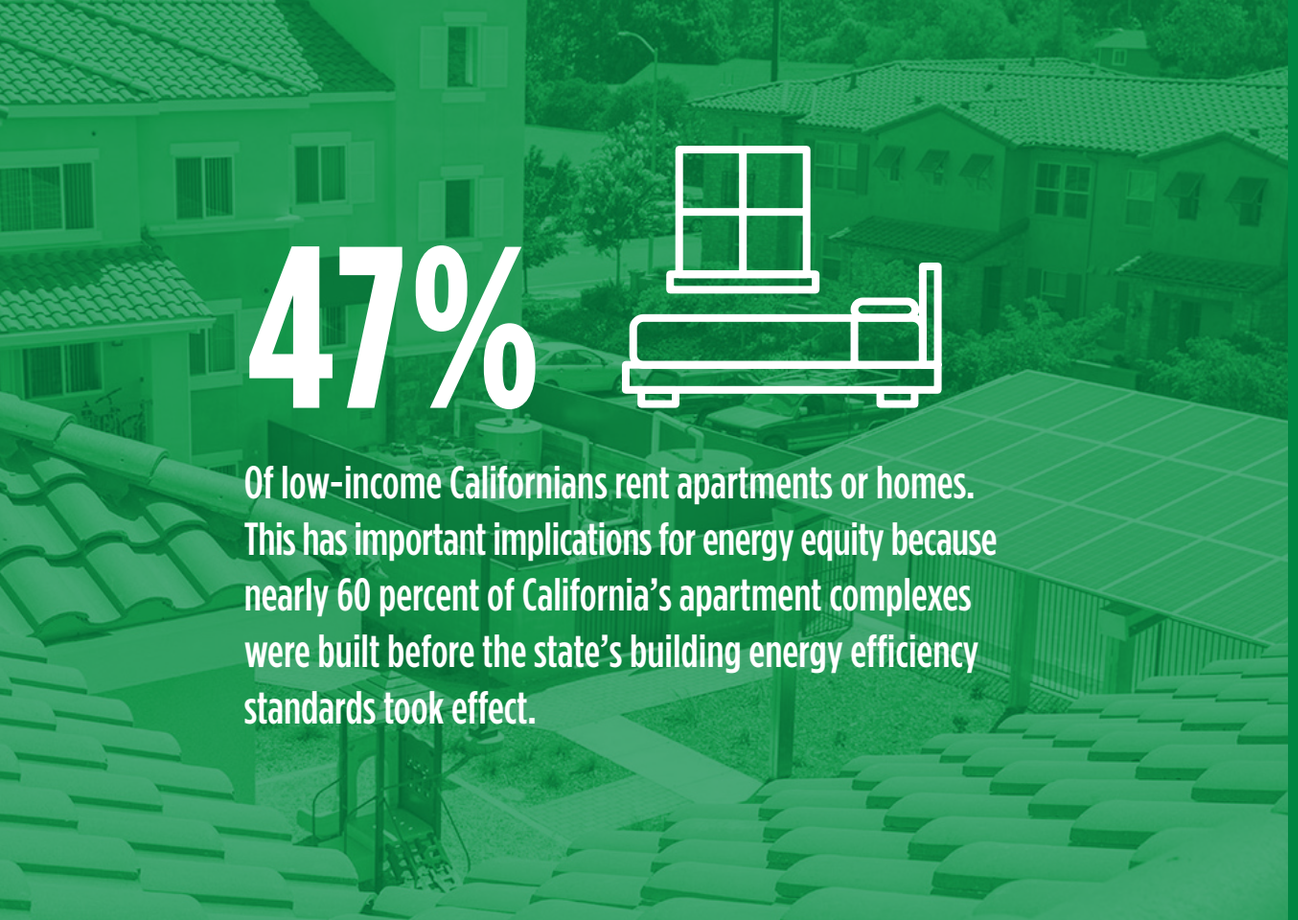
The CEC assesses energy equity using nine indicators:

- Energy efficiency
- High energy bills
- Rooftop solar systems
- Zero-emission vehicles
- Abatement of health and safety issues
- Energy resilience
- Clean energy jobs
- Small business contracts
- Amount invested in innovation

By the Numbers

65% Of the CEC technology demonstration projects are in low-income or disadvantaged communities, exceeding the 25 percent target set in Assembly Bill 523 (Reyes, 2017).

36% Of the CEC's investment in low-carbon fuels and clean vehicle technologies have gone to projects in low-income or disadvantaged communities.



47%

Of low-income Californians rent apartments or homes. This has important implications for energy equity because nearly 60 percent of California's apartment complexes were built before the state's building energy efficiency standards took effect.

05

INVESTMENT IN CLEAN ENERGY

Continuous public investment overcomes the technical and financial hurdles of advancing clean energy.

Investment in Clean Energy

Portfolio spans all economic sectors

The CEC has put billions of dollars to work reducing greenhouse gas (GHG) emissions, strengthening the economy and improving public health and the environment, particularly in disadvantaged communities. Here are three major investment areas:

1. Clean Transportation

A 2007 law (Assembly Bill 118, Núñez) authorized the CEC to fund projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." The funds come from motor vehicle and vessel fees.

2. Electric Program Investment Charge (EPIC)

Since 2011, California ratepayers have benefited from this program by funding research and development of commercially viable clean technologies that help make energy more affordable, reliable and environmentally sustainable.

3. Food Processing Plants

Established in 2018, the Food Production Investment Program funds renewable energy projects and energy efficiency upgrades at these high GHG-emitting facilities. Funding comes from proceeds of the state's Cap-and-Trade program for curbing GHG emissions.

Clean Energy

Electric vehicle readiness

California has the nation's largest network of publicly accessible electric vehicle chargers, partly because of the CEC's $183 million investment in these installations.

Return on investment

California's decades-long investment in energy research and technology has enabled the state to attract half the country's clean energy venture funding and create more than 530,000 clean energy jobs.

Clean Transportation Program projects since 2008 include:

- 11,276 electric vehicle chargers installed or planned
- 3,000 natural gas vehicles on the road or soon to be
- 61 new or upgraded hydrogen stations for fuel-cell vehicles
- 54 clean medium- and heavy-duty vehicle technology demonstration projects

By the Numbers

$1.7 Billion

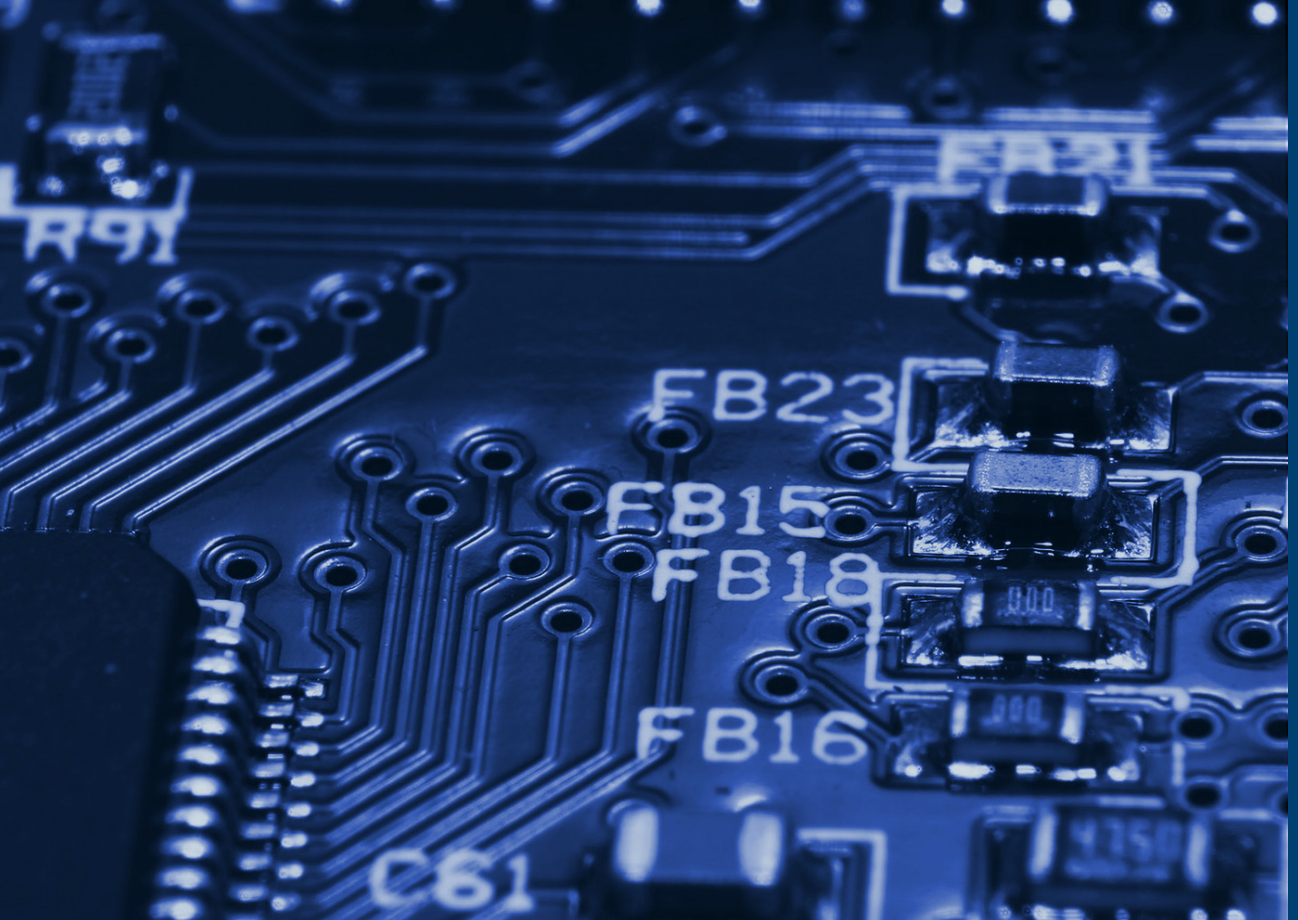
Investment in alternative vehicle fuels and technologies since 2008. About $865 million came from Clean Transportation Program funds, which the CEC used to leverage an additional $880 million from industry and other public agencies.

>$1 Billion

Investment in clean energy technologies economywide. The investment since 2012 through the EPIC program has benefited more than 580 organizations across California.

$118 Million

Investment in clean, energy-saving technologies for state's food processing plants. The investment since 2018 has improved energy efficiency at 65 facilities across the state so far and the resulting GHG emissions reductions are the equivalent of removing 35,400 cars from the road.



06

INNOVATION

The CEC drives clean energy innovation and entrepreneurship to help meet the state's climate goals.

Innovations

Bridging the gap between laboratory and markets

The CEC's Electric Program Investment Charge (EPIC) and Natural Gas Research and Development grant programs help commercialize technologies that will improve California's energy system in these ways:

1. Cleaner

With CEC grants, scientists have recently invented promising technologies to cleanly and efficiently mine an immense Southern California deposit of lithium—a key ingredient of most batteries—enough to power the state's green economy for decades.

2. Safer

Following the fatal 2010 explosion of a gas pipeline in San Bruno, the CEC funded the creation of a database and search tool for utilities to stay abreast of the latest close-to-market technologies for monitoring the safety and performance of natural gas lines.

3. More Affordable

The CEC is funding the development of smart charging technologies that will make it easier for electric vehicle drivers to charge up with enough energy for their trips at the least possible cost.

4. More Resilient

EPIC-funded community "microgrids" have demonstrated the effectiveness of using locally generated renewable energy to keep hospitals, fire stations and other critical facilities operating during power outages.

Microgrids for safer communities

Microgrids act as a small electric grid that can keep essential community services running during outages on the main grid. These systems combine locally generated electricity with energy storage systems such as batteries. The CEC has funded many solar-powered microgrids to test their readiness in a wide variety of venues, from fire stations to hospitals, jails, college campuses, military bases and tribal communities.

Current areas of energy research and development include:

- Improved wildfire behavior modeling
- Mobile solar energy units for emergencies
- Smart chargers for medium- and heavy-duty electric vehicles
- Increasing life of large energy storage systems
- Portable and affordable heat pumps for renters
- Prefabricated, super-efficient building fascades

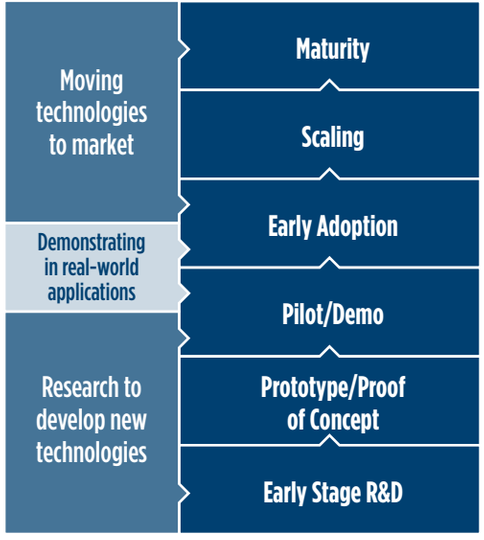
Interactive climate change maps

Visitors to the Cal-Adapt website can now view maps showing how global climate change is likely to affect temperatures and precipitation in any region of the state over the next 30 years. The CEC-funded site provides data, visualizations and planning tools to help communities adapt to climate change.

Public investment attracts private investment

A review of 22 recent energy innovation startups showed their total private investment nearly tripled after they received an EPIC award.

Accelerating Innovation at Every Stage



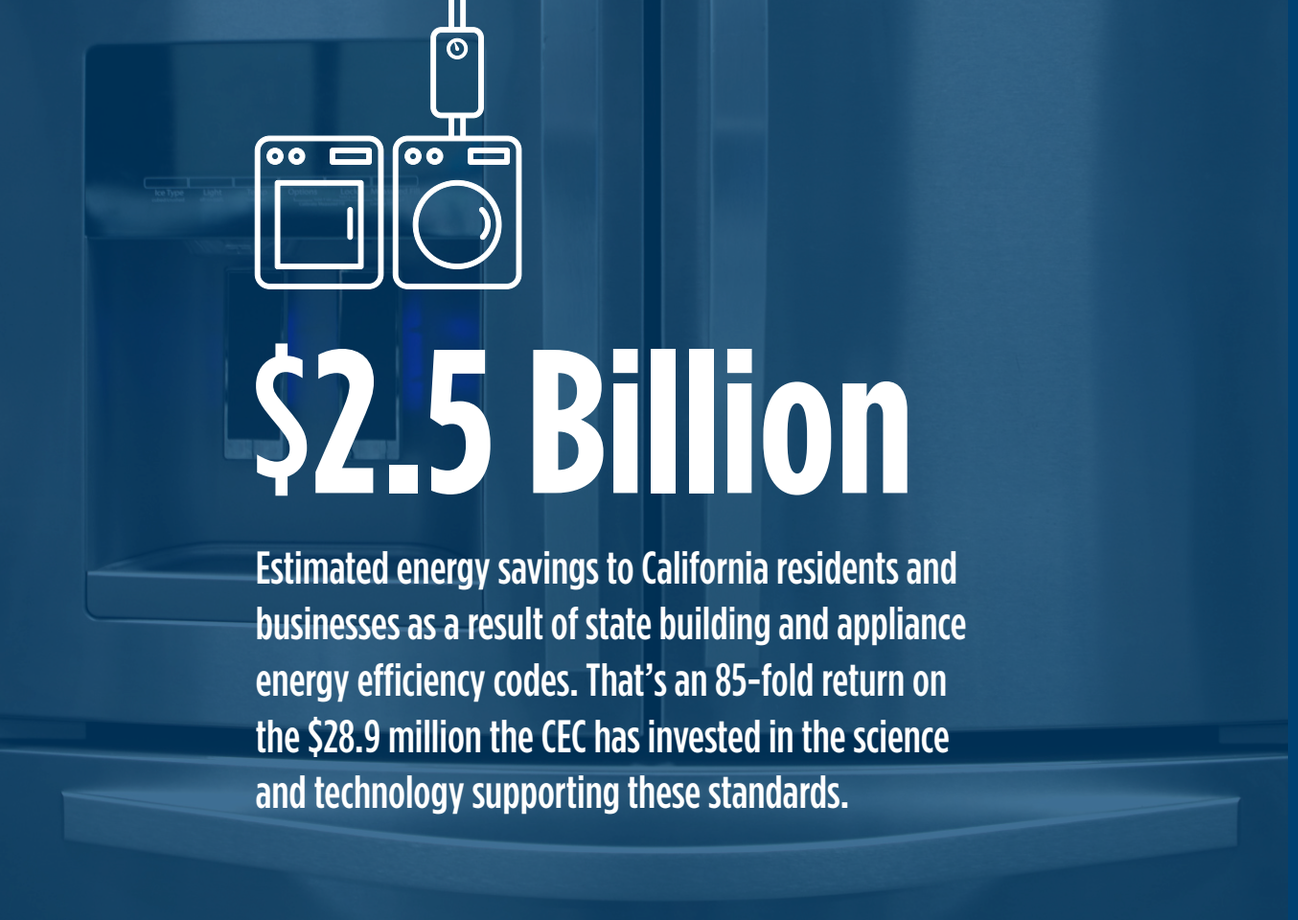
By the Numbers

$1.8 Billion

Private investment received by recipients of EPIC grants (2012–2019).

$160 Million

The CEC's approximate annual investment to accelerate the introduction of cleaner, more affordable and more resilient energy systems.



$2.5 Billion

Estimated energy savings to California residents and businesses as a result of state building and appliance energy efficiency codes. That's an 85-fold return on the $28.9 million the CEC has invested in the science and technology supporting these standards.

07

ENERGY STORAGE

California is vastly expanding energy storage systems, allowing more solar and wind power into the grid.

Energy Storage

Climate-friendly power at any hour

Because wind power is generated only when the wind blows, and solar energy is reduced on cloudy days, technologies that can store and supply extra power are becoming increasingly important. Energy storage benefits Californians in at least three ways:

1. Steady generation of clean power

Unlike solar and wind farms, energy storage systems can feed electricity to the power grid at any time.

2. Lower energy costs

When electricity demand from the grid peaks and prices rise, switching to stored power can save money.

3. Reduced climate-warming emissions

When demand peaks, grid operators can tap the cleaner stored energy instead of natural gas "peaking" plants.

Highlights

- California has the nation's largest energy storage market.
- After a decade of driving, the average electric vehicle battery has 60 percent capacity left and can be repurposed to feed the grid for another 7 to 10 years.
- California's energy agencies are exploring multiple ways residents and businesses can store energy on site for use during costly periods of peak demand on the grid.

Types of energy storage

Batteries: Rising demand for electrical vehicles and consumer electronics is expected to dramatically reduce battery prices.

Flywheels: A motor spins up the wheel with excess electricity from the grid. When power is needed, the process is reversed and the wheel's spinning runs the motor, converting kinetic energy back to electricity.

Compressed Air: Pressurized air stored underground is heated and expanded to drive a generator for electricity.

Pumped storage: Electricity generated by moving water between upper and lower reservoirs helps balance swings in power load on the grid.

Thermal energy: For example, some solar farms use molten salt to store heat for generating electricity after sunset.

By the Numbers

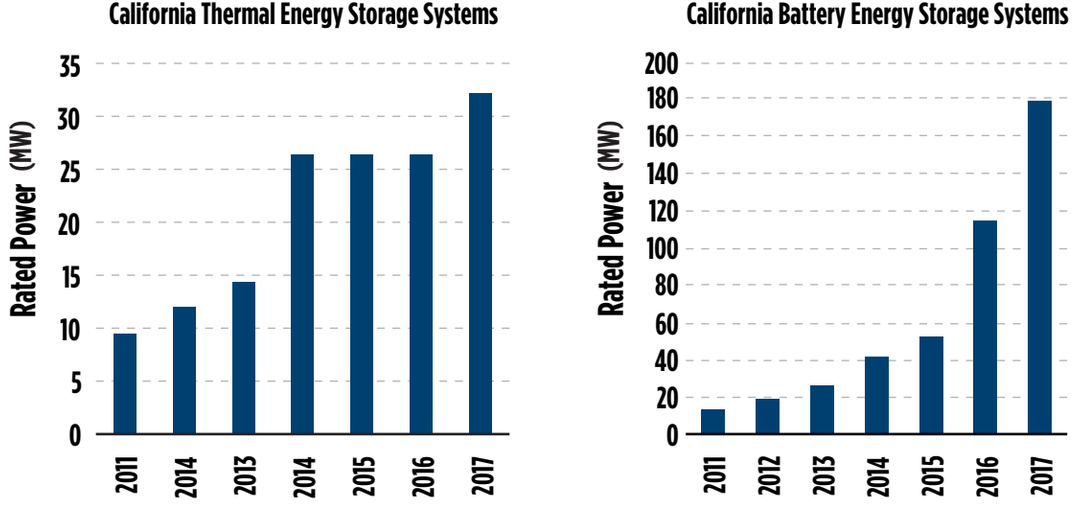
1,200 MWh

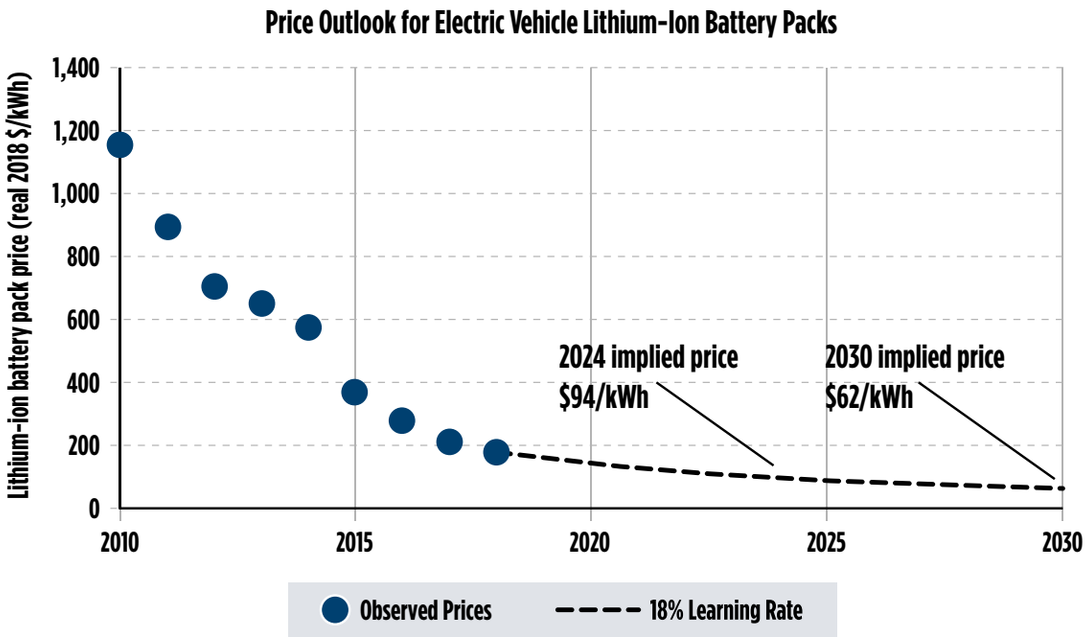
Capacity of the world's largest battery, under construction at the new AES Alamitos Energy Center in Long Beach.

$50 Million

CEC's planned 2020 investment in energy storage technologies, primarily those with longer durations than lithium-ion batteries.

Growth in California Thermal and Battery Energy Storage Systems




Price Outlook for Electric Vehicle Lithium-Ion Battery Packs
Lithium-ion battery pack price (real 2018 $/kWh)
1,400
1,200
1,000
800
600
400
200
0
2010
2015
2020
2025
2030
2024 implied price
$94/kWh
2030 implied price
$62/kWh
Observed Prices
18% Learning Rate

08

ENERGY EFFICIENCY

California leads the world in appliance and building energy standards.

Energy Efficiency

Making California more healthful, resilient and affordable

The CEC sets energy efficiency standards for new construction and appliances, delivering multiple benefits to residents and businesses:

1. Lowers utility bills

Upgrading furnaces, air conditioners and water heaters more than 10 years old saves significant money over time.

2. Cuts air pollution

Increasing energy efficiency is the most cost-effective way to reduce generation from fossil fuel-burning power plants that emit harmful smog-forming pollutants and climate-warming gases.

3. Saves water

Saving energy saves water—and vice versa—because of the enormous amount of electricity used to capture, treat, distribute and use water.

Conserving

New homes going solar

A state building code that took effect in January 2020 requires all new homes to be powered by the sun. The first-in-the-nation rule requires single-family houses and multifamily residences up to three stories to be built with solar panels or powered by a larger solar array nearby.

Flattening the curve

California's per capita electricity use has stayed relatively flat since the mid-1970's, largely due to the state's energy efficiency standards and utility incentive programs.

The CEC's energy efficiency standards have revolutionized building construction in California and beyond. They affect much of our home and work environments, including:

- Faucets
- Household appliances
- Roofing
- Insulation
- Doors and windows
- Water heaters
- Lighting
- HVAC systems
- Data center cooling
- Computers
- Televisions
- Toilets

Local Conservation

Raising the bar

One third of Californians live in communities with local ordinances that exceed the state's energy efficiency standards for new construction. Increasingly, cities are requiring convenient access to electric vehicle chargers and banning natural gas hookups in favor of climate-friendly electrified heating and cooking.

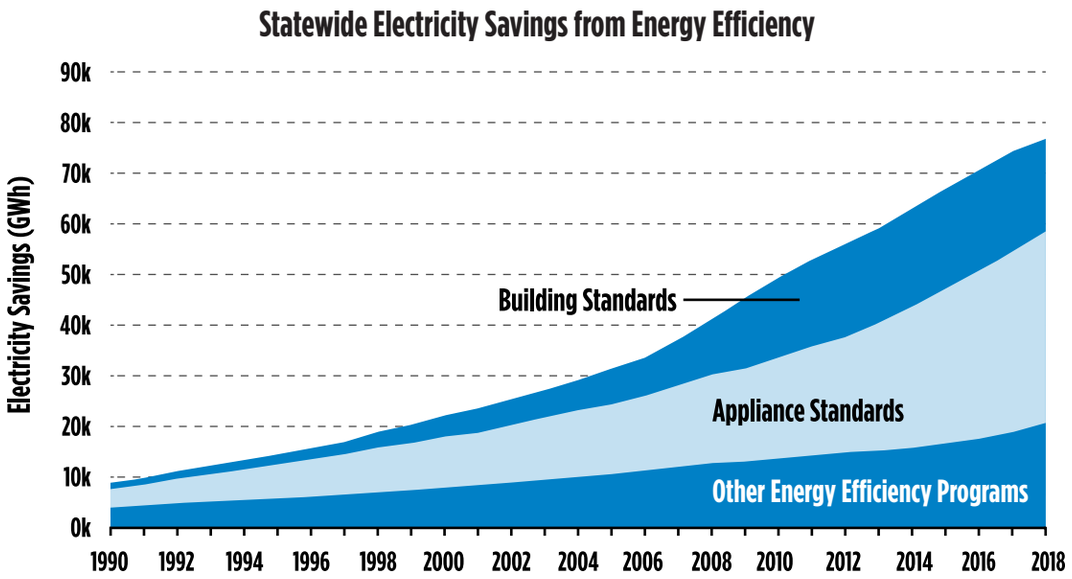
By the Numbers

$100 Billion

Consumer savings resulting from appliance and building energy efficiency standards over the past 40 years.

20%

Of electricity used in California goes to supplying municipal water.


Statewide Electricity Savings from Energy Efficiency
Electricity Savings (GWh)
90k
80k
70k
60k
50k
40k
30k
20k
10k
0k
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Building Standards
Appliance Standards
Other Energy Efficiency Programs

09

RENEWABLE ENERGY

An increasing percentage of California's electricity comes from renewable sources.

Renewables

California leads the nation in use and availability of renewable energy

California has a suite of policies and programs to increase the use and availability of energy from sunlight, wind and other natural sources that are continuously replenished. Here are three major drivers:

1. Renewables Portfolio Standard

The 2002 California law and subsequent amendments require the state's electric utilities to make renewables an ever-greater percentage of their power base.

2. California Solar Initiative

Since 2006, thousands of home and business owners have earned cash-back rebates by installing solar energy systems through this suite of incentives, offered by the state energy and public utility commissions and the state's publicly owned utilities.

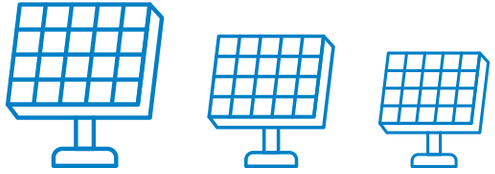
3. Community Choice Aggregators

Growing numbers of California communities have formed these local agencies to buy electricity at lower rates and from greener sources than offered by the default utility. The rise of these agencies is increasing demand for renewable energy.

Clean Resources

Trendsetter

The University of California has pledged to run its 10 campuses and 5 medical centers completely on carbon-free electricity by 2025 — 20 years ahead of the state's goal set by Senate Bill 100.



State-designated renewable energy sources include:

- Solar
- Wind
- Geothermal
- Small hydroelectric
- Biomass, such as crop residues and landscape trimmings
- Ocean waves

By the Numbers

36%

Of California's electricity comes from renewable sources.

42%

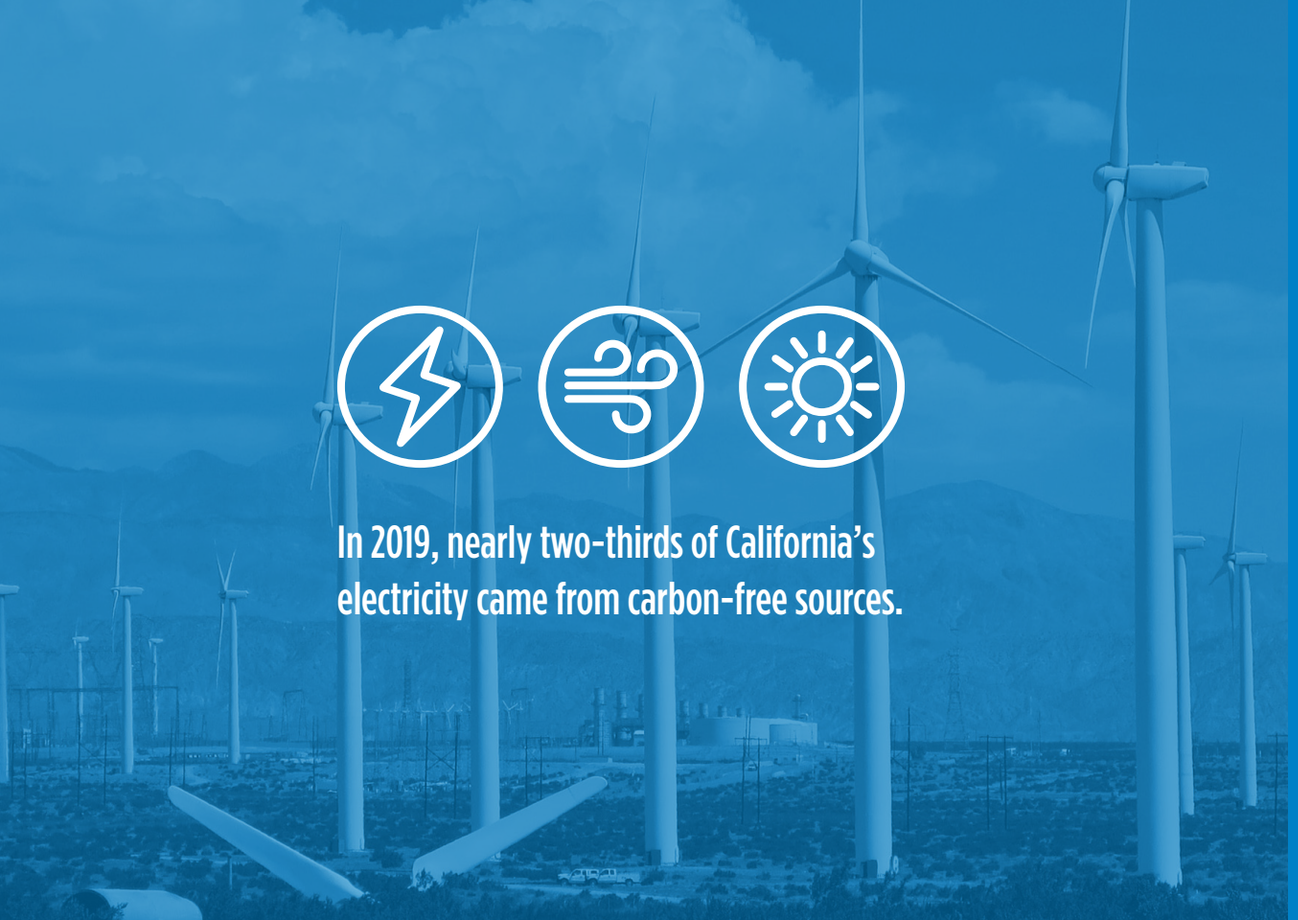
Of California's renewable generation comes from solar, the state's No. 1 renewable energy source.

$3.70 PER WATT

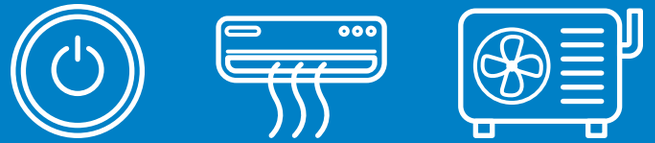
National median price to install a residential rooftop solar energy system in 2019, compared with nearly $12 per watt in 2000.

2045

When all of California's electricity will come from renewable or carbon-free energy sources, as required by Senate Bill 100.



In 2019, nearly two-thirds of California's electricity came from carbon-free sources.



References

For more information about the data and programs presented in this almanac, visit the CEC's "Tracking Progress" Webpage at **https://www.energy.ca.gov/data-reports/tracking-progress**

Price Outlook for Electric Vehicle Lithium-Ion Battery Packs
https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

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