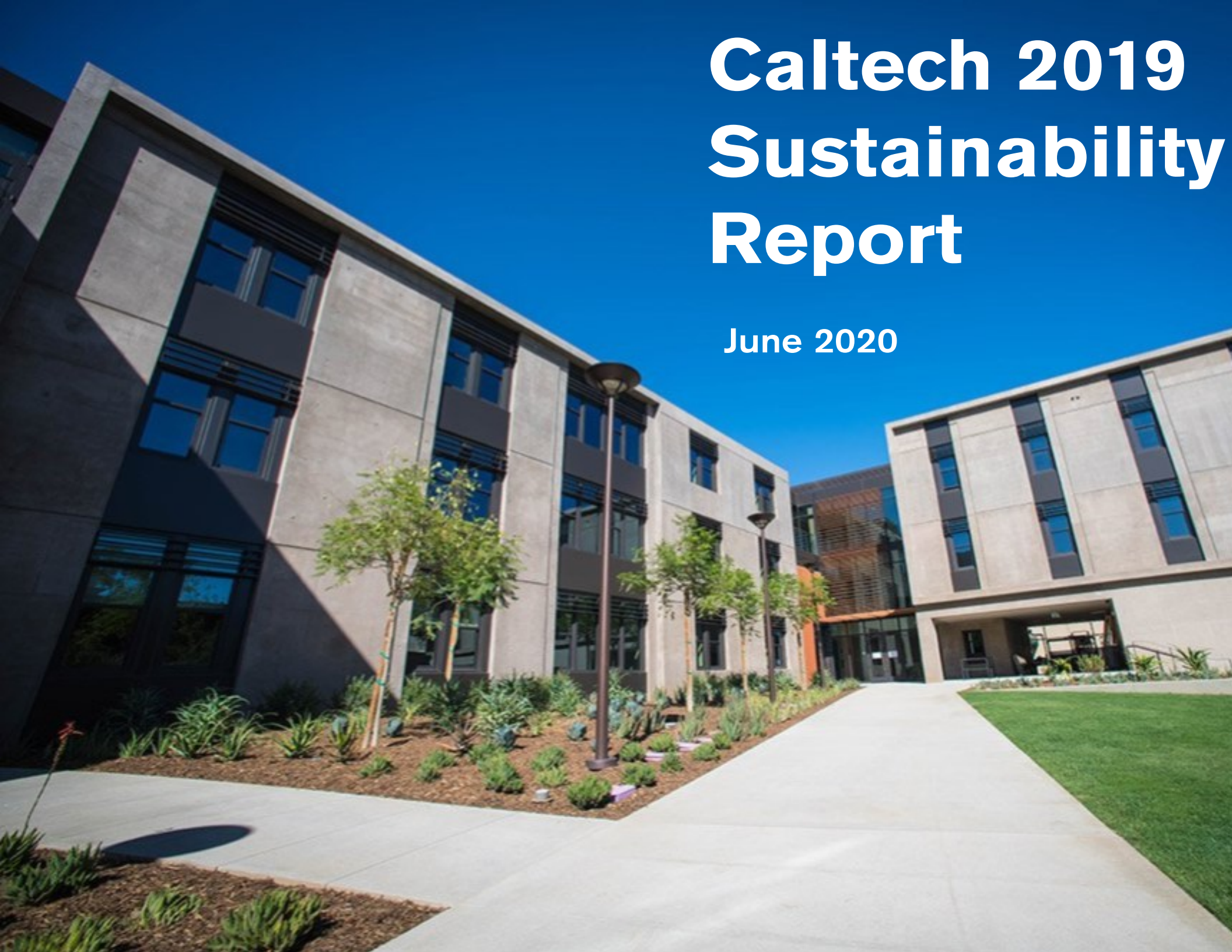



Caltech 2019 Sustainability Report

June 2020





From Arie Haagen-Smit's explanation of the photochemistry of smog formation, to ongoing investigations into the changes in anthropogenic emissions during the coronavirus pandemic, Caltech has a long history of contributing to sustainability research. A significant milestone in that progression was set in 2019 with the pledge from Lynda and Stewart Resnick to energize and expand the research initiatives of the Resnick Institute.

This investment and the increasing momentum in sustainability research has spurred on our efforts to improve operational sustainability and find ways to better integrate research and operations. The KPIs presented in this report also highlight the need to match the vigor of our research colleagues by finding new initiatives to drive continued performance. New initiatives are being developed in the areas of green labs, composting, mobility, water recycling, distributed power generation, and utility infrastructure modernization and resilience.

There is great promise ahead with regard to sustainability at Caltech, and we look forward to realizing that potential.



John Onderdonk

Senior Director, Facilities Services & Integrated Planning
Chief Sustainability Officer

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Fiscal Year 2019 At A Glance — Key Performance Indicators

Energy While achieving the lowest demand since FY08, Caltech has enhanced supply and price reliability through smart energy management and purchasing strategies.	↓ 5% total electricity demand since peak in FY16, lowest demand since FY08	100% electricity produced on-site, marking three consecutive years as net exporter	↓ 3% energy intensity by area since FY17 peak but 7% increase since FY11	\$11.2M in annual energy costs, flat since FY17 and a 22% decrease since FY11	\$17M in cumulative energy cost reductions compared to FY11 baseline	
Water Water consumption fell slightly in FY19 due to conservation measures at the utility plants and irrigation savings that resulted from turf removal and an unusually rainy winter.	↑ 12% water consumption since FY17 but a 44% decrease since FY06 peak	↓ 30% irrigation water use from FY18 mostly due to significantly wetter year in FY19	↓ 12% water use per square foot from FY14 peak but constant since FY11	\$1.3M in annual water costs, down 15% from FY18 but up 20% from FY11	↑ 10% in campus costs per gallon since FY11 but down 13% from FY18	
Materials Waste generation fell again in FY19, as we've begun to establish a new baseline after the closure of the Recycling Center. Recycling markets continue to be unreliable.	27% campus non-hazardous waste diversion rate, down from 37% in FY17	↓ 35% municipal solid waste per capita, down to .24 tons from .41 in FY14	↓ 22% hazardous waste diversion since FY17, down to 55%	\$771K in total campus waste costs, up 15% from FY14	↓ 95% drop in net recycling revenue compared to FY17 due to commodity prices	
Built Environment Caltech continues to transition towards more sustainable land use practices. 2019 saw progress in lawn care electrification, drought resistant vegetation, and sustainable buildings.	2 buildings pursuing LEED certification in 2020	176K square feet of LEED building space to be added by 2021	16% of campus now covered with low-water vegetation, up from 4% in 2012	8,000 square feet of turf removed from campus in 2019	14% of campus building square footage is now LEED certified, up from 6% in 2011	
Mobility 2019 saw a mixed bag of indicators for progress. While drive alone rates and campus AVR are trending in the wrong direction, new programs should bring progress in commuting trends in 2020.	1.60 campus occupants per vehicle, down from 1.63 in 2018	↑ 2% campus drive alone rate, up to 44%	8.7 miles average commute distance, up from 8.0 in 2018	72% staff drive alone rate, highest since record keeping began in 2005	145/10 carpools and vanpools at the end of 2019, respectively	
Emissions Caltech's emissions were flat from last year, continuing a trend in place since 2012. Despite emissions intensity improvements, we will not meet our 2020 Climate Action Plan goal.	↓ 1% regulated greenhouse gas emissions since 2016	↓ 22% total greenhouse gas emissions since 2008	↓ 3% emissions intensity per capita from 2017 but flat since 2015	1.12 pounds of CO2e per research dollar, down 2% since 2018	14.1 MTCO2e per person, down 6% since 2014 but flat since 2015	

Resnick Family Provides Historic Gift For Sustainability Institute



On September 26, 2019, Caltech received a \$750 million gift from Lynda and Stewart Resnick, owners of The Wonderful Company. This is the largest pledge in Caltech's history, the largest ever for sustainability research, and the second largest ever to a U.S. higher education institution. This gift will provide permanent funding for sustainability-related research and will dramatically expand the Resnick Institute, founded in 2009; it will also help create a new 75,000 square foot building, the Resnick Sustainability Resource Center. In addition to housing the Resnick Institute, this new facility will provide for undergraduate teaching laboratories and shared spaces for collaboration across Caltech's six academic divisions.



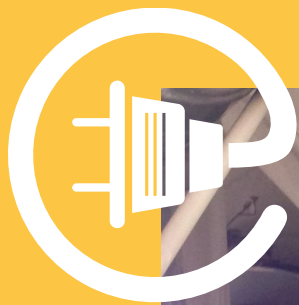
Four Core Sustainability Research Topics Will Guide Resnick Institute

This historic pledge will allow Caltech to pursue groundbreaking research in four key initiatives:

- Sunlight To Everything: harnessing sunlight while reducing greenhouse gas emissions and waste
- Climate Science: diagnosing, adapting to, and mitigating against climate change
- Water Resources: improving our ability to predict, manage, and improve the availability of fresh water
- Ecology and Biosphere Engineering: understanding, restoring, and sustaining the biosphere

According to Jonas Peters, director of the Resnick Institute and Bren Professor of Chemistry, “We want Caltech to be the world’s academic center for innovation and education in the science and engineering of sustainability.”

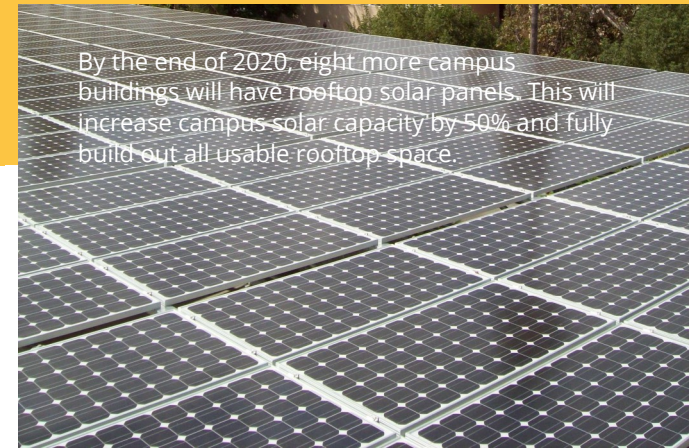




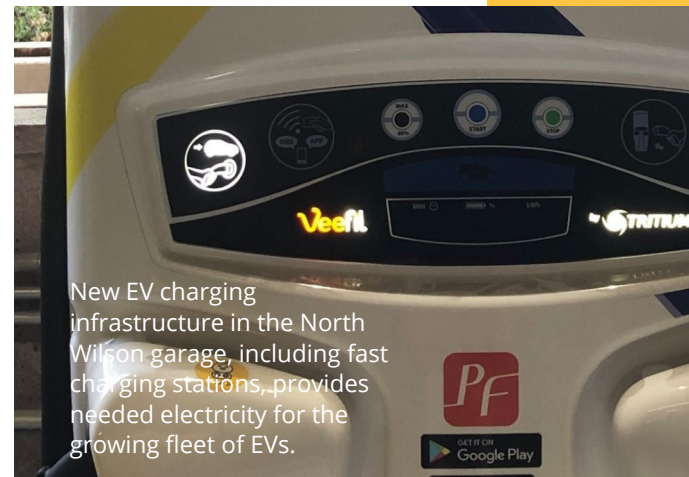
Energy



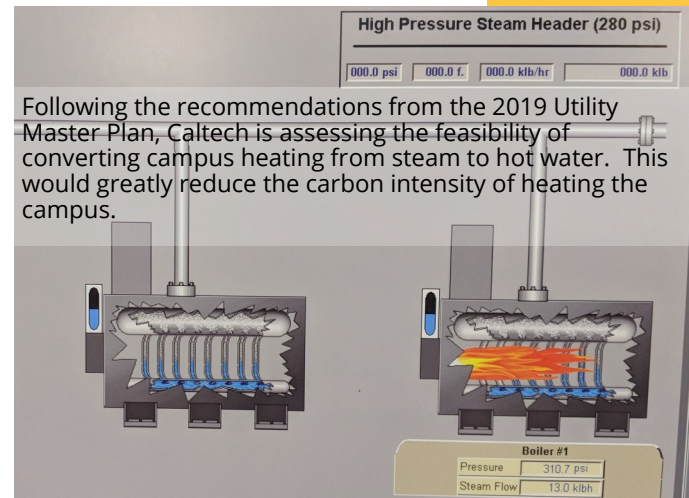
Heating, ventilation, and air conditioning is often the highest energy use in buildings. Whereas older systems supply a constant volume of air regardless of need, Caltech continues to install variable systems that can adjust air flow.



By the end of 2020, eight more campus buildings will have rooftop solar panels. This will increase campus solar capacity by 50% and fully build out all usable rooftop space.



New EV charging infrastructure in the North Wilson garage, including fast charging stations, provides needed electricity for the growing fleet of EVs.



Following the recommendations from the 2019 Utility Master Plan, Caltech is assessing the feasibility of converting campus heating from steam to hot water. This would greatly reduce the carbon intensity of heating the campus.



Goals for Viability

Identify and recommend sources of high quality, reliable and environmentally preferable energy to support research and education while working with the campus community to improve efficiency and reduce demand.

2019 Highlights



Energy Services Brings In New Expertise

May 2019



Energy Services welcomed two new team members in 2019 as Seth Fink took over as Energy Associate and Vatsal Verma stepped in as Energy Manager. Their considerable expertise will support CECIP, utility planning, and campus wide energy management.

CECIP 2019 Fiscal Year Update

September 2019



CECIP celebrated its tenth year in FY19. LEED retrofits continued as more campus buildings received highly efficient lightbulbs, and South Mudd's air handlers were upgraded with digital controls. These two projects alone are estimated to provide approximately \$270,000 in annual savings.

Caltech UMP Study Assists With Future Planning

December 2019



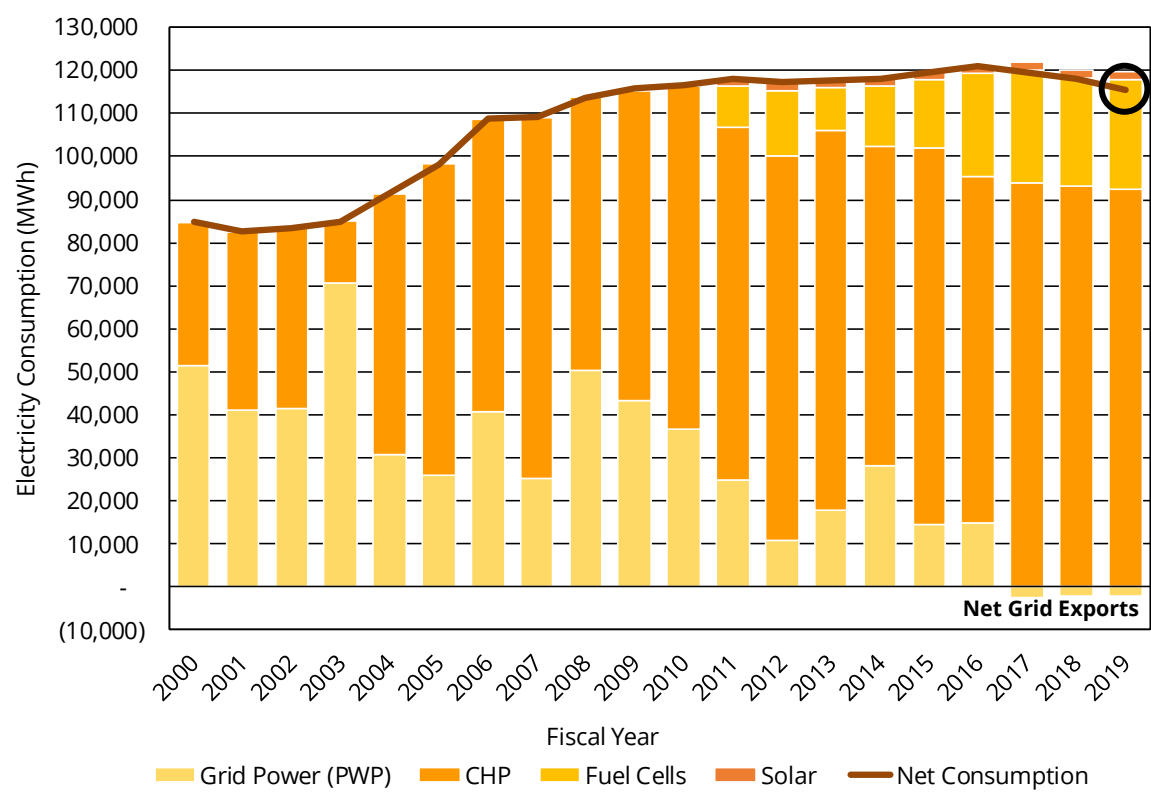
Caltech, in association with Affiliated Engineers Inc., recently completed our Utility Master Plan for the campus. General recommendations include electric and cooling system upgrades to meet new demands and further study of the heating system.

2019 Energy Update

↓ 5%
total electricity
consumption
from FY16 and
lowest since FY08

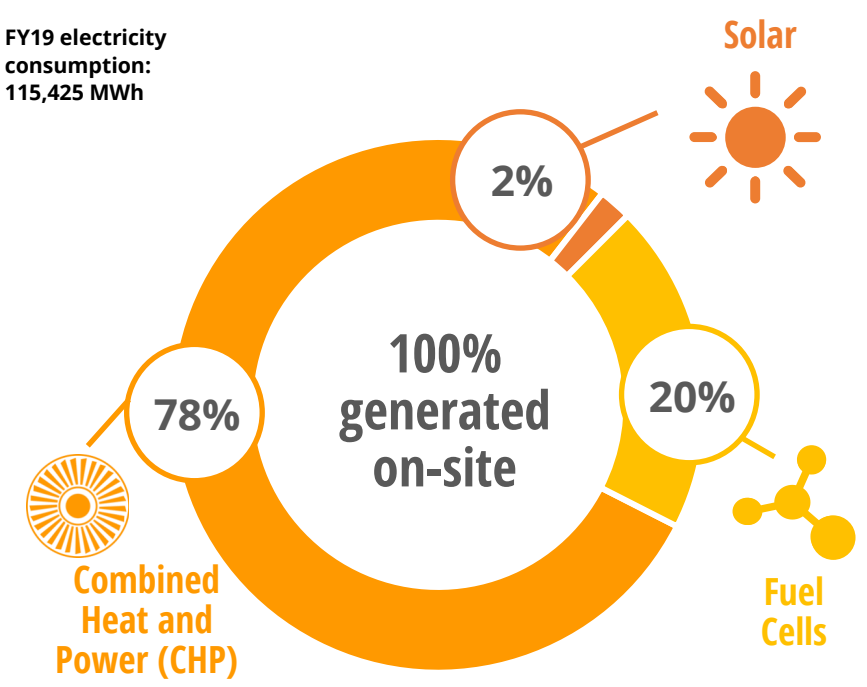
Caltech has continued to reduce consumption and diversify the energy supply portfolio. On-site¹ energy sources including fuel cells, solar, and natural gas cogeneration continue to supply more than 100% of the campus net needs throughout the entire year. Upcoming additions for solar PV and fuel cells will supply growing demand for planned campus growth through 2021. CECIP continues to demonstrate that reduced carbon emissions and financial savings often accompany each other; the program, along with other targeted energy strategies, has now reduced cumulative campus energy expenditures by \$17 million since 2011. The continued utility master planning process will help address energy uncertainties and help prepare the entire campus for the coming decade.

Historical Campus Electricity Consumption



FY19 electricity
consumption:
115,425 MWh

2019 Electricity Portfolio



100%

net electricity
produced on-
site for third
consecutive
year



3%

in energy use
per square foot
compared to
FY17

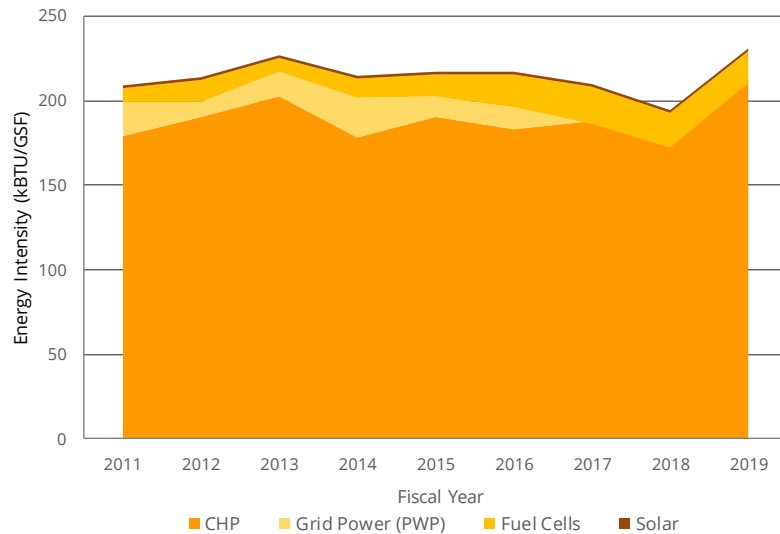
\$11.2 M

in energy costs
in FY19, a 22%
decrease since
FY11

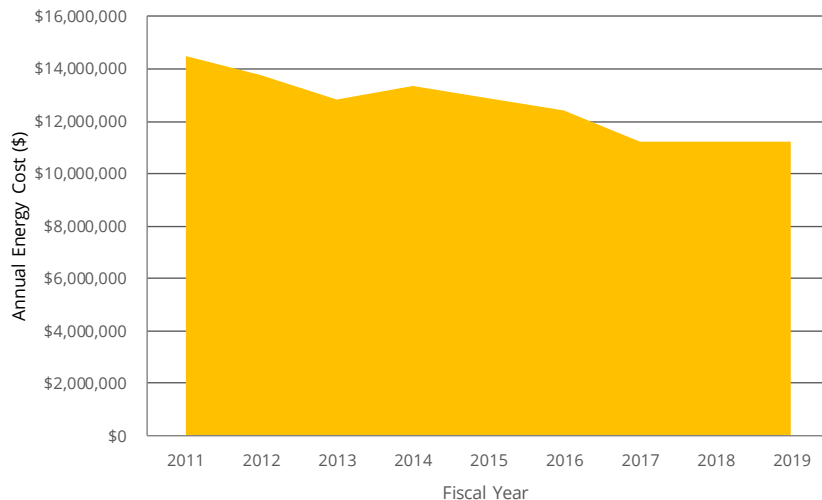


Managing Energy Use & Costs

Site Energy Use Intensity²



Historical Energy Cost



Satellite Utility Plant Upgrades Support New Research



Opening the Chen Neuroscience Research Center at Caltech means more than just completing the building. Caltech is busy preparing its utility infrastructure to support the exciting new structure. During the winter of 2020, Caltech is expanding its chiller and cooling tower capacity at the Satellite Utility Plant to meet Chen's expected cooling demand. The work must be completed during the winter when chilled water use on campus is at its lowest. The expansion will be completed before the Center opens in the fall of 2020.





Water



2019 saw more turf replacements throughout the campus as Caltech continues to reduce our irrigation water consumption.



Caltech's famous Gene Pool uses condensate to replace water lost to evaporation. This condensate is also being explored as a potential source for other campus water needs.



Caltech hosted Pasadena Water and Power's Large User Meeting in April at the Athenaeum.



While recent years have lifted California out of its most recent drought, mounting climate stresses exacerbate risks from future droughts.

Goals for Viability

Responsibly steward water resources by focusing on efficiency, cultivating climate adapted landscape, minimizing potable water use, and maximizing use of reclaimed water.

2019 Highlights

Pasadena Continues Water System Resource Plan

January 2019



Caltech's role on the Advisory Committee for the Pasadena Water System Resource Plan came to an end in 2019. As a member of the Committee, Caltech provided valuable input on City water system infrastructure upgrades, future supply challenges, and water recycling and reuse opportunities.

Heavy Winter Snowpack Increases Water Supply

April 2019



Increased precipitation in the Sierra Nevada range in the winter of 2019 brought a needed influx of water to the state. Rain and snowfall was 15-30% above normal amounts in most of the state; augmenting the current stock of fresh water in rain-heavy years could increase resiliency during future droughts.

Caltech Explores Water Recycling and Reuse

November 2019



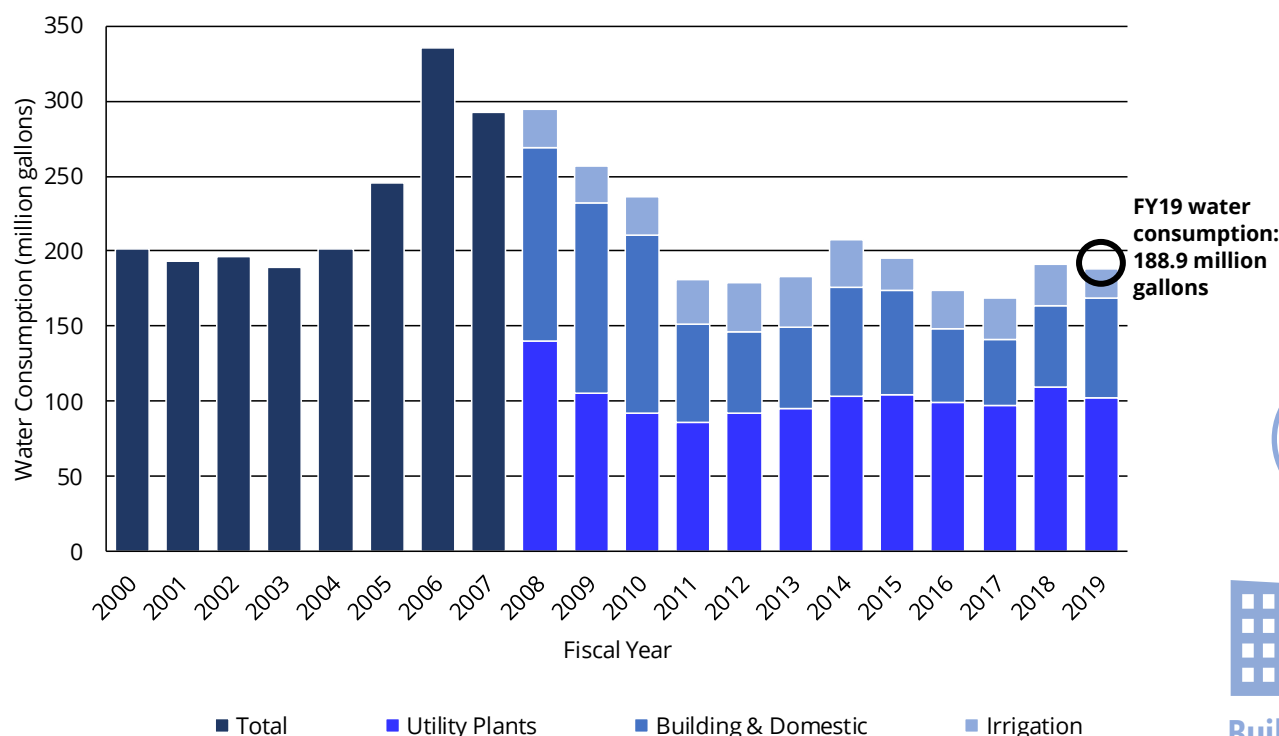
Following the energy-focused work of the utility master plan and water reuse measures built into the Chen Neuroscience Research Building, Caltech has taken an in-depth look at water recycling strategies including graywater treatment and condensate capture.

2019 Water Update

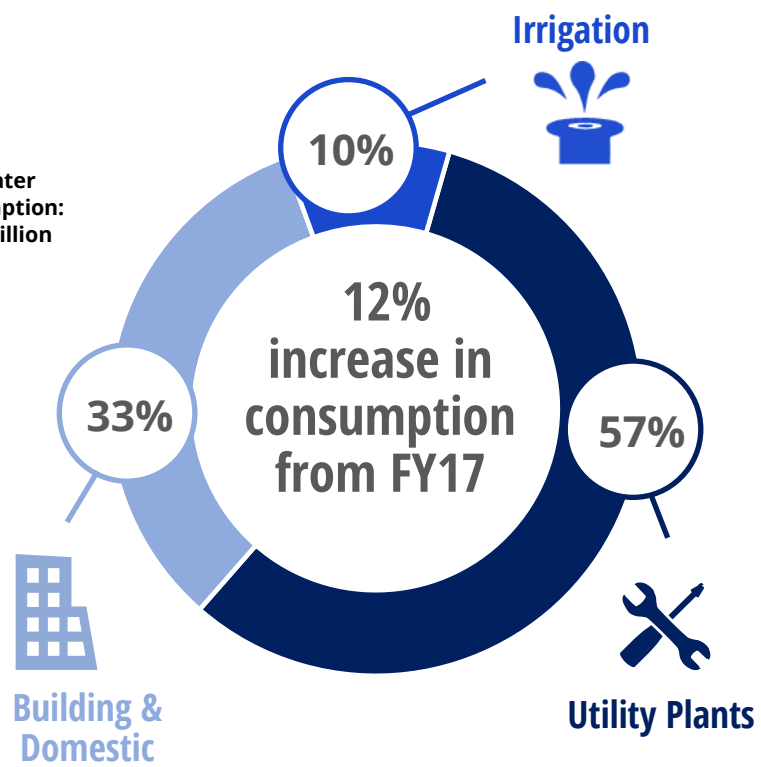
↑ 12% total water consumption from FY17 but 44% decrease since FY06

Water consumption reached a low point in 2017 after years of decreases but saw a rebound in 2018. Consumption was lower in 2019 than the previous year but still 12% above the 2017 minimum. As irrigation and utility water uses have remained relatively consistent, building water use has seen an increase in its share of the water use profile in recent years. With the continued threat of drought further exacerbated by climate change, this trend highlights the need for further investment in water efficient technologies and water reuse strategies. An above average year of rainfall in 2019 was welcomed, but a repeat of the 2012-2017 drought has become increasingly likely. With historical increases in water costs and further price escalation expected from local water distribution upgrades, Caltech is investigating systemic water conservation.

Historical Campus Water Consumption



2019 Water Use Profile





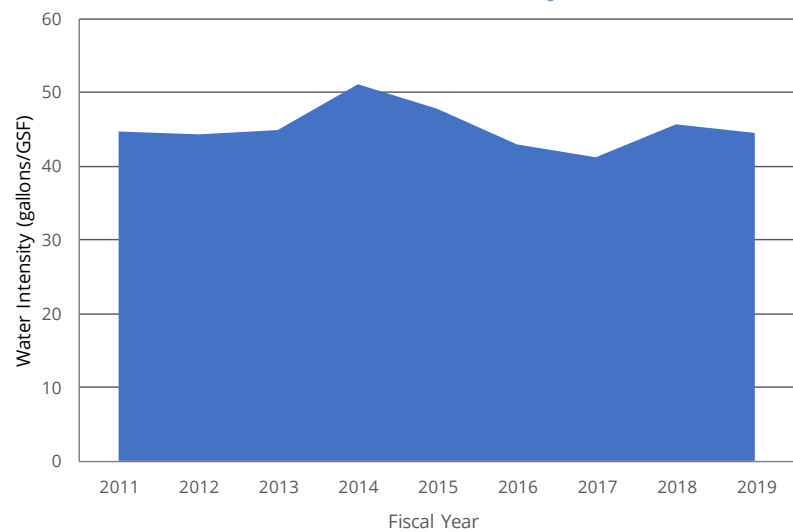
↓ 12% campus water use per square foot from FY14 peak but constant since FY11

57/33/10
FY19 use percentages for utility plants, building & domestic, and irrigation

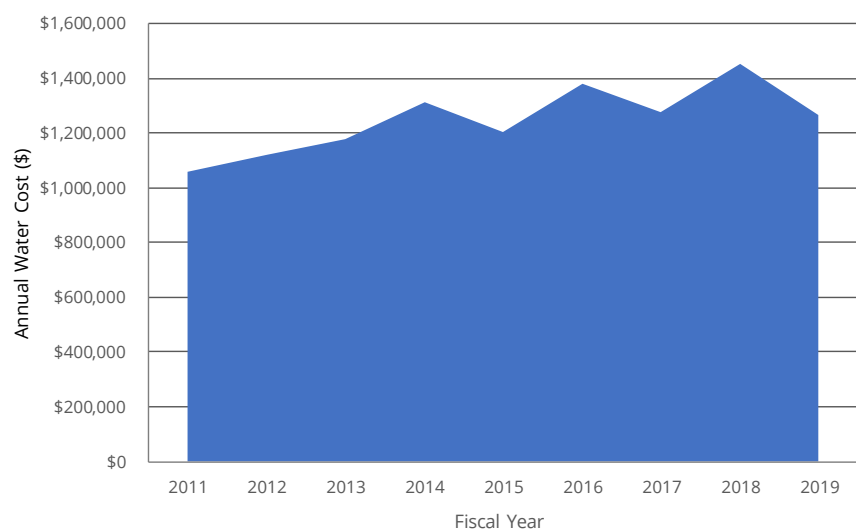
\$1.3M in water costs in FY19, up 10% since FY11

Rising Water Costs Outpace Conservation Measures

Site Water Use Intensity



Historical Water Cost

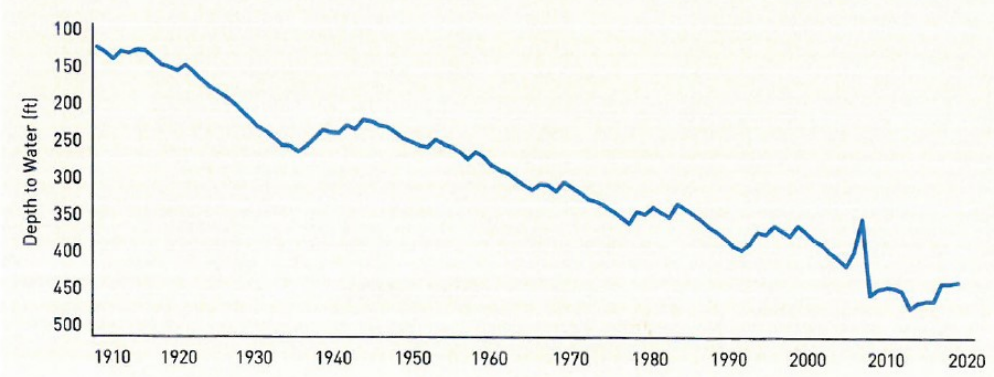


Pasadena Water System Resource Plan

Starting in late 2018, Pasadena Water and Power began the process of creating a Water System Resource Plan that would encompass both supply and demand considerations for Pasadena's water future. This ambitious project began with a year-long set of committee meetings to set goals, priorities, and a path forward. As a major stakeholder in Pasadena, Caltech sat on this committee to provide insight and input for this Plan which is nearing final approval.

Pasadena, along with many other local municipalities, has seen increased water stresses in recent years due to increasing consumption, persistent droughts, and mounting climate pressures. As seen below, Pasadena groundwater levels have fallen continuously over the past century.

Historic Pasadena Area Groundwater Levels



Source: RMBM, Draft Opportunities to Enhance Groundwater Levels in Pasadena Subarea.

Throughout multiple committee meetings, Caltech and other stakeholders provided recommendations for balancing deferred distribution system maintenance needs with the importance of supply resiliency and sustainability as we plan for our local water future.



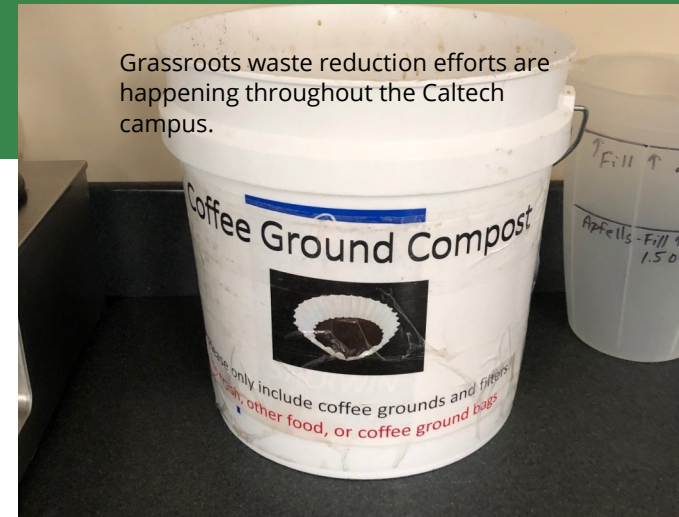


Materials

Student-led projects have assisted Caltech Dining Services with evaluating circular models for reducing waste through composting, local sourcing, and purchasing decisions.



Grassroots waste reduction efforts are happening throughout the Caltech campus.



Caltech has begun to address food waste by composting not just expired and discarded food but also compostable cups, napkins, and plates.



All undergraduate and graduate students receive Caltech Sustainability water bottles at the beginning of the academic year to encourage reducing plastic usage.



Goals for Viability

Reduce waste through responsible procurement practices and encourage materials reuse and recycling.

2019 Highlights

Composting Begins At Caltech

August 2019



August marked the beginning of a long-awaited waste reduction program at Caltech. Starting with food services areas including Chandler and the Athenaeum, collection of food waste and compostable material has since expanded to undergraduate housing.

Recycling Market Shocks Continue

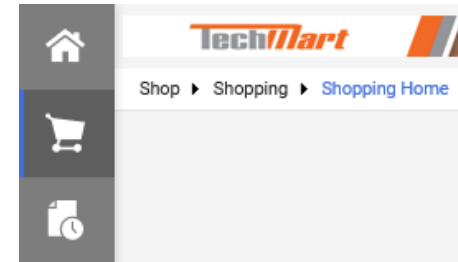
September 2019



Changes in recycling markets continue to decrease the value of most recycling commodities including glass, paper, cardboard, and metal. While the markets have changed, recycling remains a worthwhile and sustainable industry providing economic and environmental benefits.

Procurement Dives Into Sustainability Data

December 2019



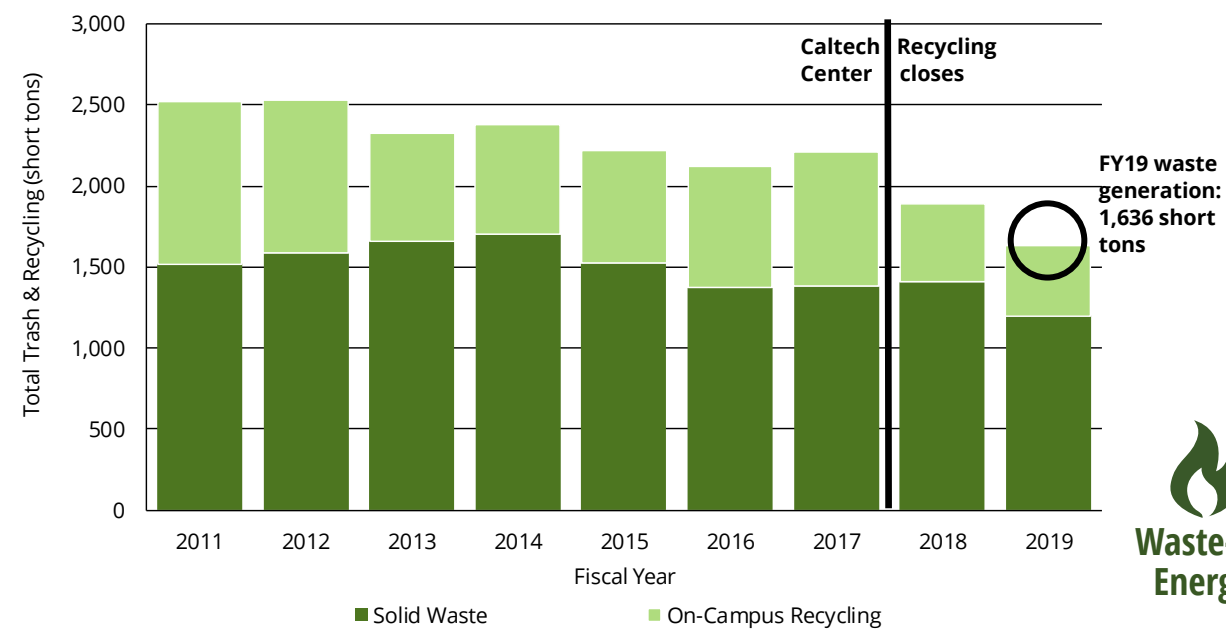
For the first time, Caltech has asked our suppliers of laboratory consumables, chemicals, and other items to begin providing environmental attribute data for their products. As this program grows into the future, Caltech will gain an understanding of how sustainable the items we buy every day are.

2019 Materials Update

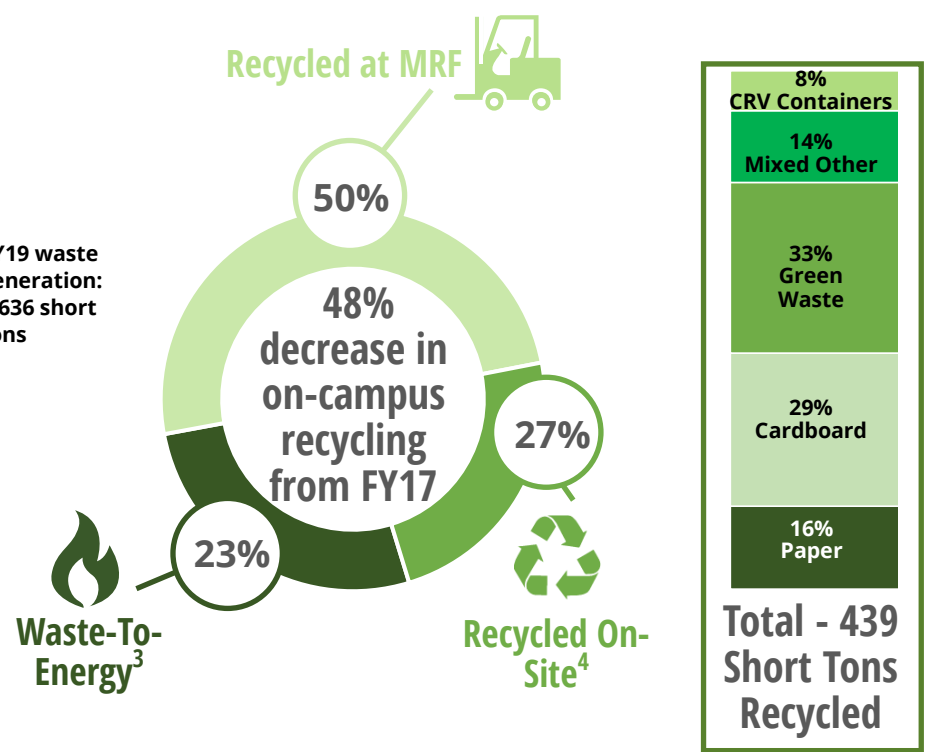
↓ 22% hazardous waste diversion from FY17, down to 55%

The fallout from restrictive international policies on recycling continued in 2019. With strict contamination standards imposed by east Asian countries that typically receive U.S. recyclables and limited domestic infrastructure, the value of many recyclables has plummeted to historic lows. While metal, CRV bottles and cans, and certain plastics (types 1, 2, and 5) retain value in the current markets, items like mixed paper and other plastics are difficult to recycle in a cost-effective manner. The realities of waste continue to change rapidly, but Caltech derives significant value from intelligent waste management practices. One such practice is eliminating the need to dispose of waste in the first place by minimizing item packaging and optimizing supply allocation. Purchasing Services has helped Caltech to begin understanding this enormous opportunity.

Historical Campus Waste & Recycling Generation



2019 Waste & Recycling Profile



480

pounds
municipal waste
generated per
person, down
from 755 in FY17

27%

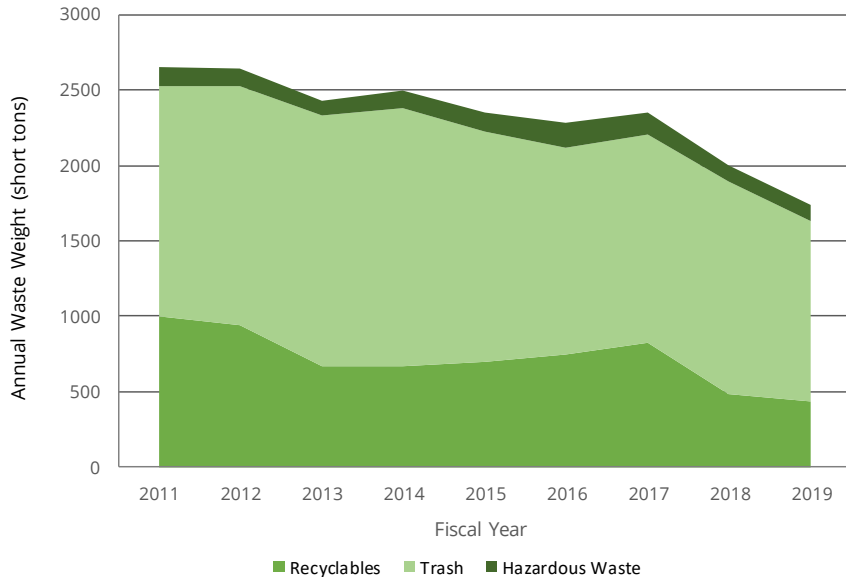
diversion via on-
campus recycling,
down from 37%
in FY17

\$771K

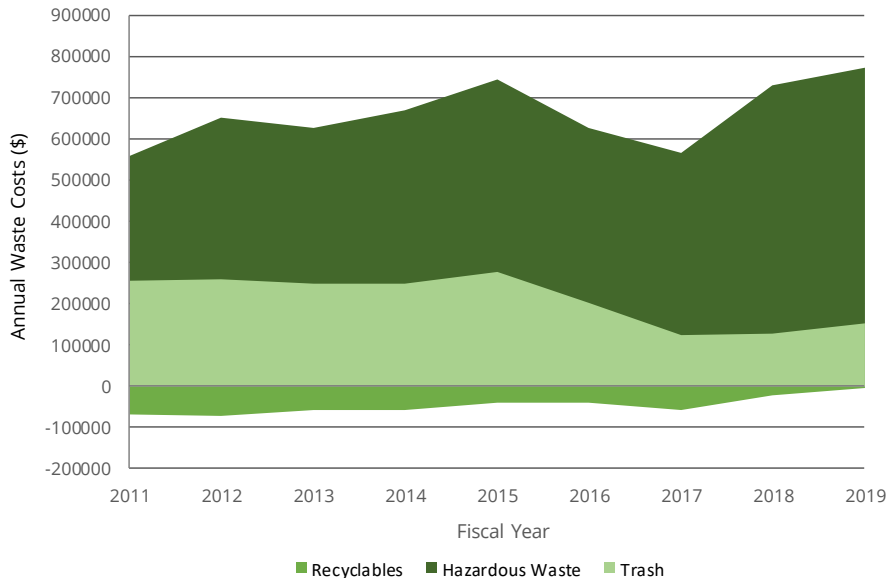
in total waste
costs, up 15%
from FY14

Waste Generation Versus Price

Historical Waste Generation By Type



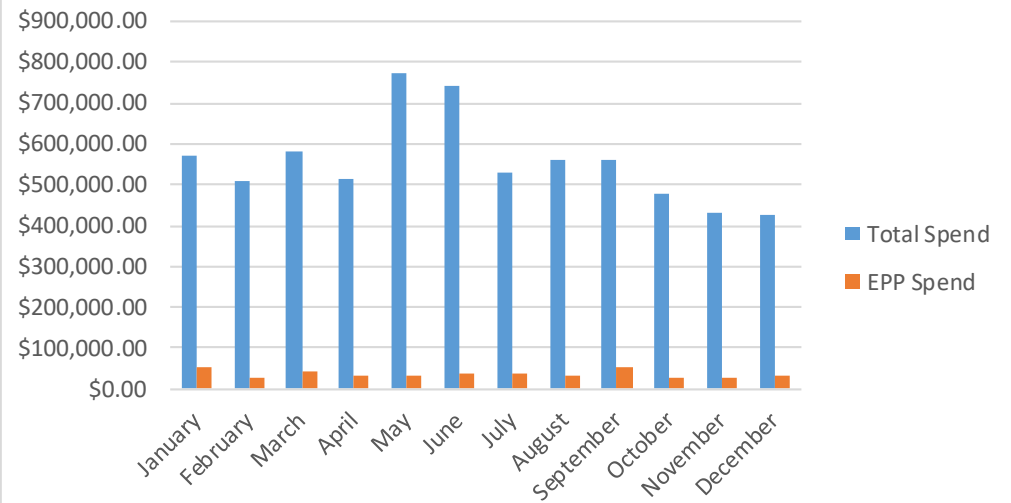
Historical Waste Cost By Type



Caltech Works Towards Sustainable Purchasing

Caltech Purchasing Services started down the path of more sustainable procurement practices in 2019. Genelle Vinci, contracting manager, worked with Caltech Sustainability on gathering data from vendors to help understand current practices. One key method is to report what percentage of purchases are sustainable or an “environmentally preferred product” (EPP). From a small subset of vendor data, Caltech determined that EPP expenditures represented 6.6% of total purchases in 2019. This is down from 8.2% in 2018, and monthly data is broken out in the below graphic.

2019 Caltech Total vs. EPP Spend



EPP designation generally means that a product has a lower carbon impact and conserves resources, but precise definitions vary significantly between vendors. Collecting this EPP data is the first step towards increasing the amount of sustainable products that Caltech buys.



Built Environment



Constructing the bungalows was the most extensive historical restoration project that Caltech has ever done.



Caltech continues to work towards a balanced built environment that reflects the need for harmony between manmade structures and nature.



Caltech's community gardens continue to offer productive spaces and learning environments for students, staff, and faculty.



San Pasqual Walk is one of the main campus thoroughfares and cuts right through the heart of the Caltech campus in Pasadena.

Goals for Viability

Ensure existing and future facilities meet and maintain a high level of energy, water, and resource efficiency.

2019 Highlights

Resnick Sustainability Gift Includes New Building

September 2019



In recognition of the incredible \$750 million Resnick gift to further Caltech's sustainability research programs, the Institute will construct a new 75,000 square foot building to house the Resnick Sustainability Resource Center and undergraduate teaching laboratories.

Bechtel Residence Achieves LEED Platinum

October 2019



The new Bechtel Residence became the fourth LEED Platinum building on campus and the tenth Caltech building to achieve LEED certification. 14% of Caltech's campus building square footage has now achieved either LEED Gold or Platinum status, and upcoming new buildings are expected to add to this total.

Lawn Equipment Transition Nearing Completion

December 2019



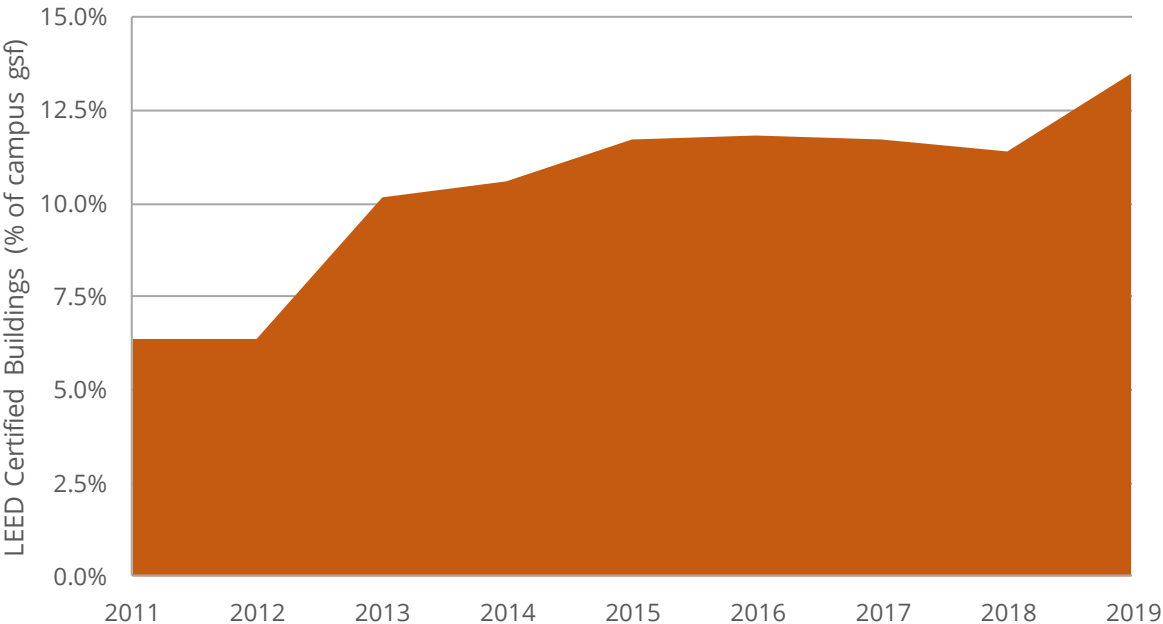
Caltech has continued to phase out gasoline powered lawn equipment to improve campus occupant health and lower carbon emissions. Full transition to electric equipment for routine work is expected to be completed by the end of 2021.

2019 Built Environment Update

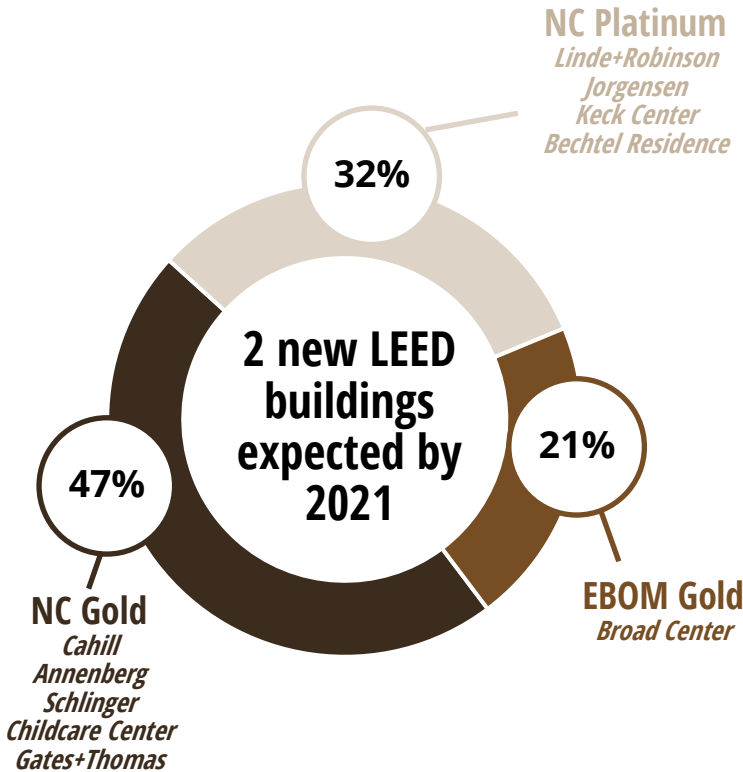
10 LEED certified buildings, 14% of Caltech's total campus space, with two more expected by 2021

Caltech continues to progress towards a more sustainable built environment which prioritizes low impact buildings, native land use, and responsible stewardship. Caltech is pressing forward with LEED certifications for new buildings and removing turf in favor of native vegetation wherever possible. As we enter a new decade, these trends should continue and perhaps accelerate as highly efficient buildings are under construction or in planning. Stricter regulations will drive further progress on lawn care, green cleaning, and building energy and water consumption. Caltech is working to get ahead of these likely changes by going beyond compliance in responsible land use. Further campus development will be conducted in a sustainable manner as new technologies emerge and we continue to connect human health, environmental health, and campus sustainability.

Historical LEED Building Growth



2019 LEED Building Breakdown



↑300% increase in low water vegetated campus cover since 2012

176,000

square feet of LEED space scheduled to be added by 2021

2

construction projects currently pursuing LEED certification

Continuing To Transform Our Built Environment

2019 Campus Land Use Breakdown

21% High Water Use⁵

79% Low Water Use⁶

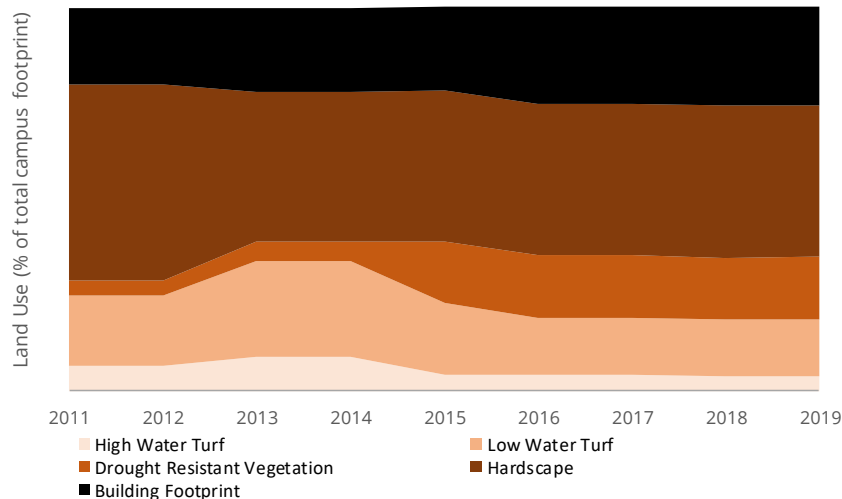
39% Hardscape

26% Buildings⁷

19% Turf

16% Vegetation

Historical Campus Land Use Change



Chen Neuroscience Research Building Comes Into Focus



Caltech's new Chen Neuroscience Research Building is on the cutting edge of innovation not just for the research that will come out of the new home of the Chen Neuroscience Research Institute but because of the building itself. With highly efficient HVAC systems and installation of best-in-class freezers amongst other large equipment, this building will consume 30% less energy than a baseline scenario. While research of this type requires a significant consumption of energy, the Chen Neuroscience Research Building will be powered by a 1.2 megawatt fuel cell. This energy supply is less carbon intensive than grid power or the campus cogeneration plant and will be able to operate even if local electric grid disruptions occur.

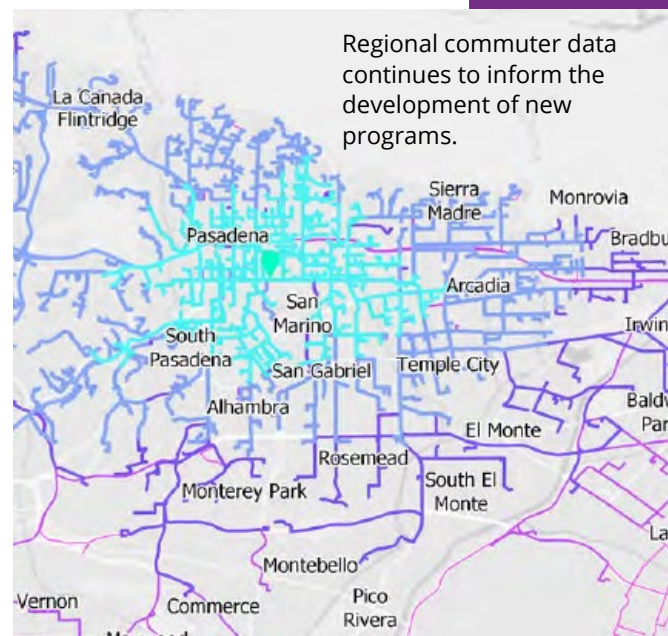
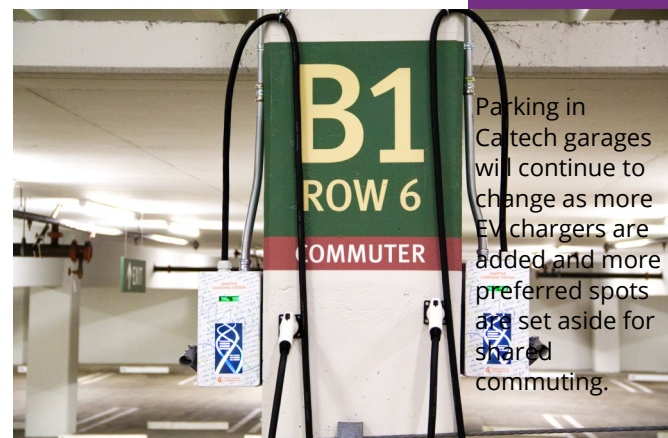
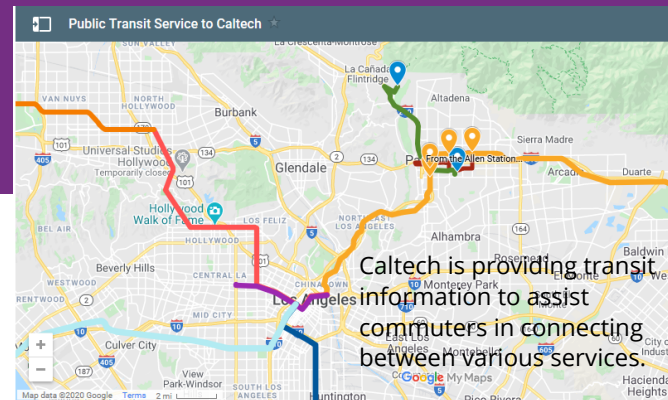
The Chen Neuroscience Research Building will be submitted to the Green Business Certification Inc. under the stringent LEED Version 4 standards. As Caltech pursues these credits, it will need to achieve higher standards with more documentation than previous certification standards.



Mobility

OPTIMIZED BY
POWERFLEX SYSTEMS
ADAPTIVE CHARGING NETWORK

Powerflex recently installed over 50 new chargers in the North Wilson garage. This provides further EV capacity for the rising number of electric vehicles commuting to campus.



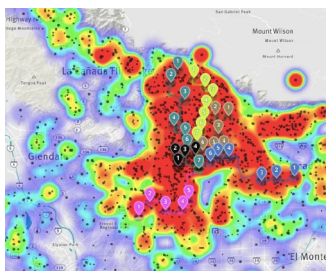
Goals for Viability

Maintain a fuel-efficient fleet of vehicles and actively promote and enhance mobility options for the Caltech community.

2019 Highlights

Mobility Study Wraps Up

September 2019



Caltech wrapped up a year-long transportation demand management study that included best practice and benchmark reviews of the industry, in-depth data analysis, discussions with local transit agencies, and focus group interviews of the Institute's commuting population.

Caltech Sees Unchanging Commuter Patterns

October 2019



Caltech's commuter population has remained relatively unchanged for the past 10 years despite significant changes in mobility and commuting over that same time period. Our average vehicle ridership (AVR) of 1.6 performs well against the rest of LA County but dropped from 1.63 last year.

Preparations For New Programs Begin

November 2019



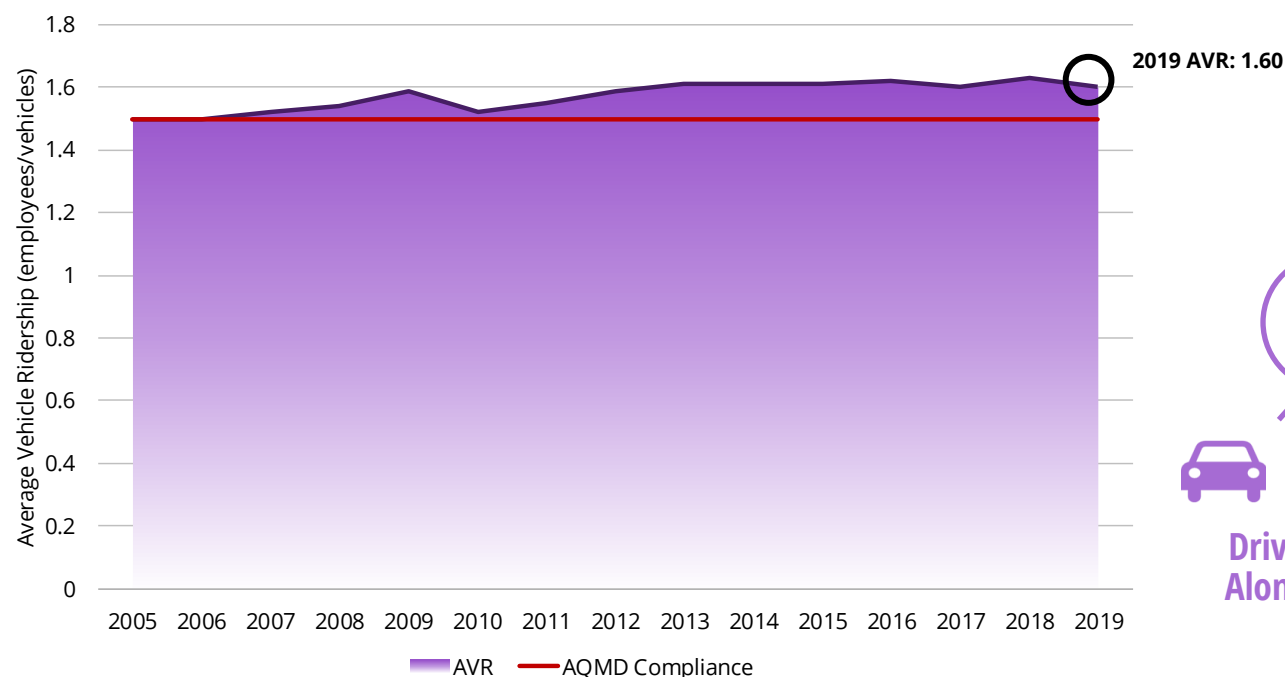
Following the recommendations of the mobility study, Caltech began preparations to launch a series of new programs and rate changes starting in January 2020. These changes should bring Caltech's Parking & Commuter Services programs in-line with the rest of the industry and effectively incentivize low-emission commuting.

2019 Mobility Update

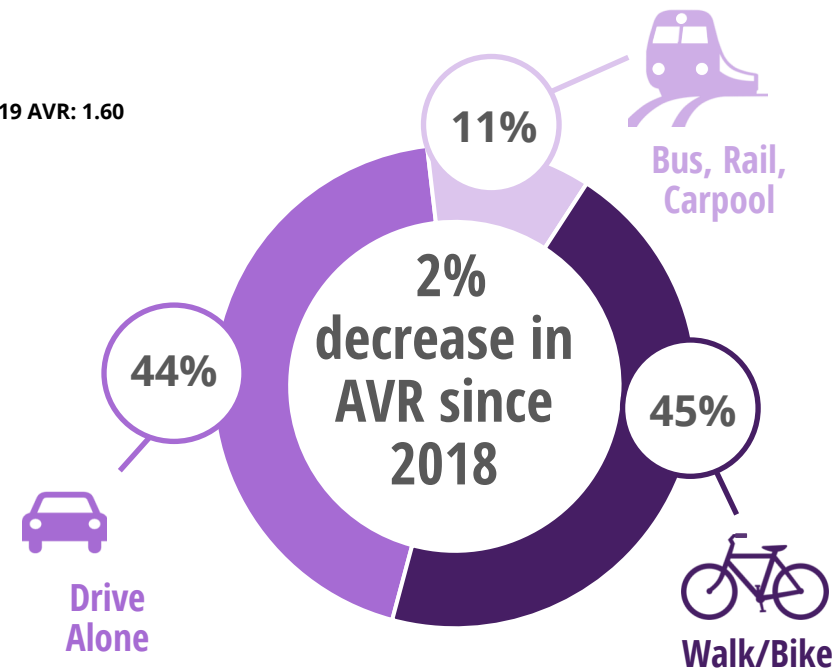
1.60 occupants per vehicle, a 2% decrease from 2018

Caltech's mobility and parking programs and incentives have remained consistent for the past decade while campus average vehicle ridership (AVR) has slowly risen to 1.60 in 2019. Commute distance and commute modes continue to be highly correlated, while staff, faculty, and students have very different commuting portfolios. Parking allocation challenges have emerged, and campus commuter programs have seen stagnating participation in recent years. In response to these trends and to the rapid mobility changes in recent years, Caltech embarked on a campus wide planning effort for transportation demand management in 2019. With the assistance of a consultant, Caltech conducted the most significant data analysis the Institute has ever attempted on campus commuting, and those recommendations have begun to be implemented in 2020. By shifting incentives from driving alone to lower carbon commuting, Caltech hopes to drastically enhance how the community gets to and from the campus.

Historical Campus Average Vehicle Ridership⁸



2019 Commuter Breakdown



56% of commuters used alternative transportation, down from 57% in 2018

72% of staff drive alone, up from 70% in 2017

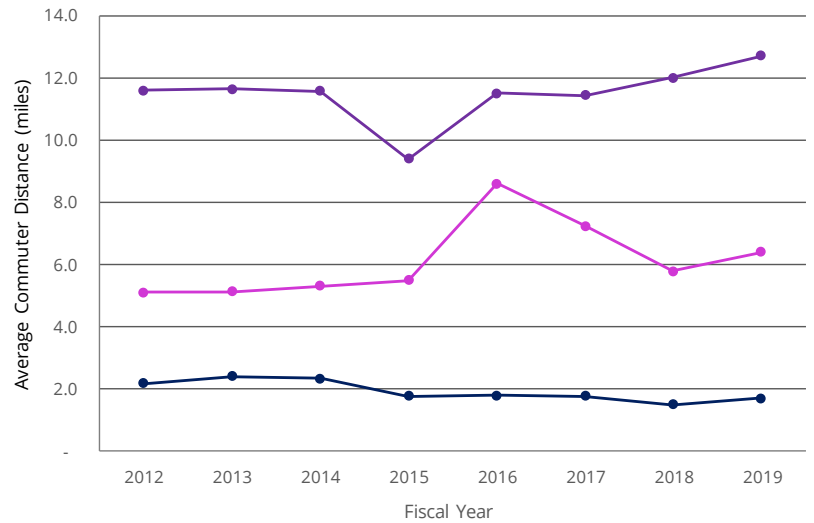
8.7 average miles to work, up from 8.0 in 2018

16/975 lockers and outdoor bicycle parking spaces on campus

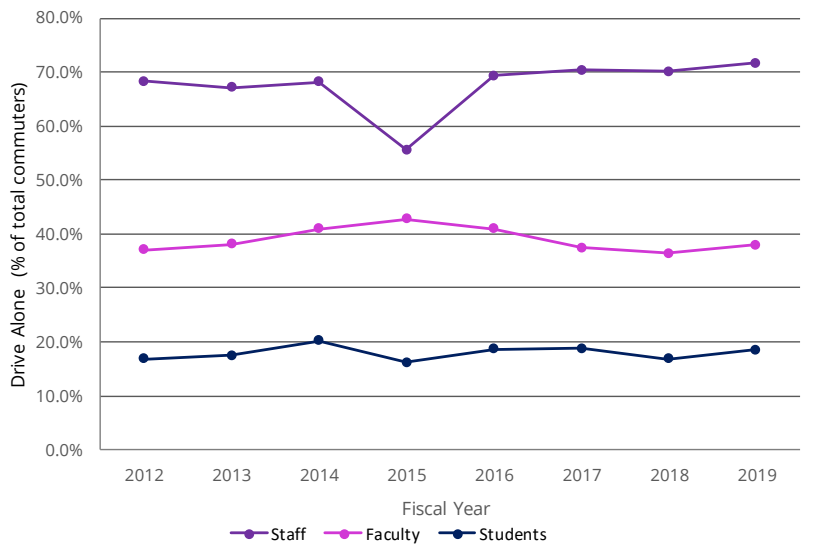


Location Drives Commute Modes

Historical Commute Distance

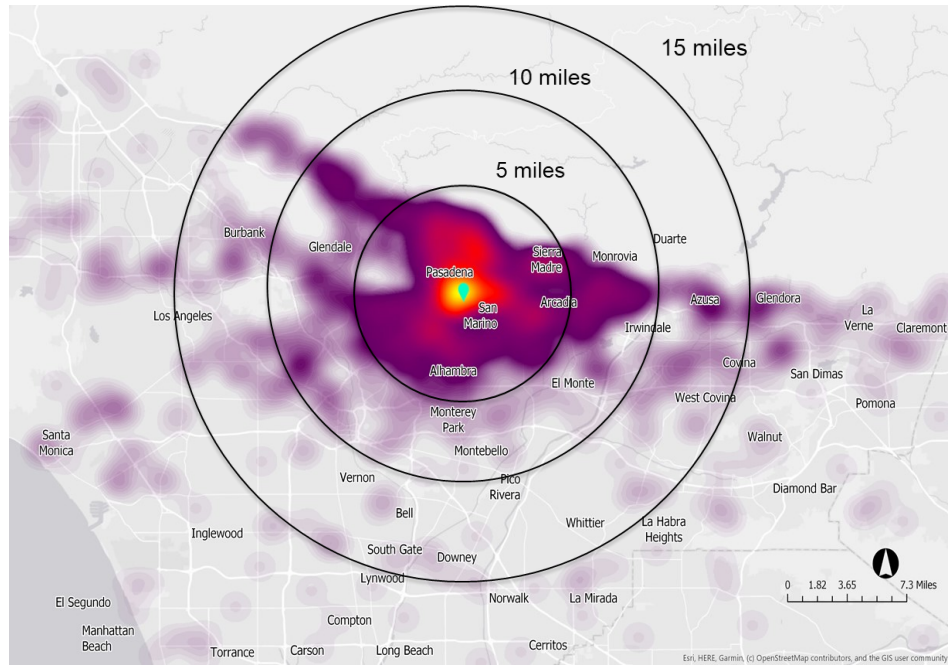


Historical Drive Alone Trends



New Commuting Programs Set Stage For Changing Trends in 2020s

Caltech has built four parking structures since 1988 to meet the needs of a growing campus, and parking is perceived to be constrained once again. Mobility options are changing rapidly, and Caltech's commuter and parking programs haven't been examined in a comprehensive fashion in over a decade. With the assistance of TMS/UrbanTrans consultants, Caltech just wrapped up a year-long planning process that examined commuter data, parking statistics, local and regional mobility trends, and peer best practices. One prominent discovery was the fact that 69% of single-occupant commuters originate within 10 miles of campus.

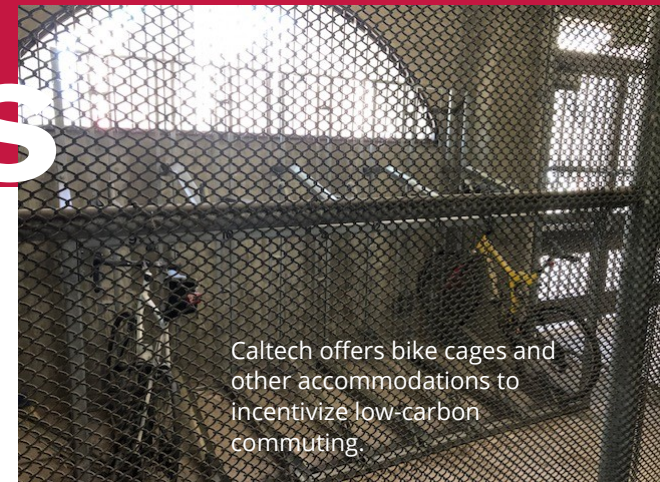


This and other discoveries informed a series of commuter program improvements that will be phased in over the next couple of years.

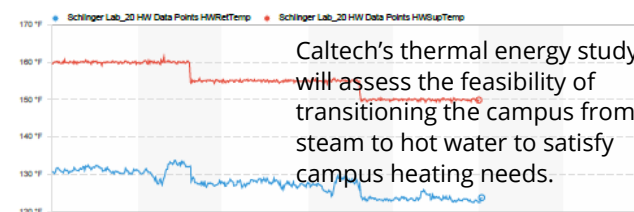
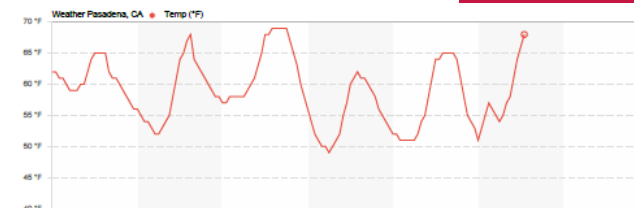
Emissions Effluents & Waste



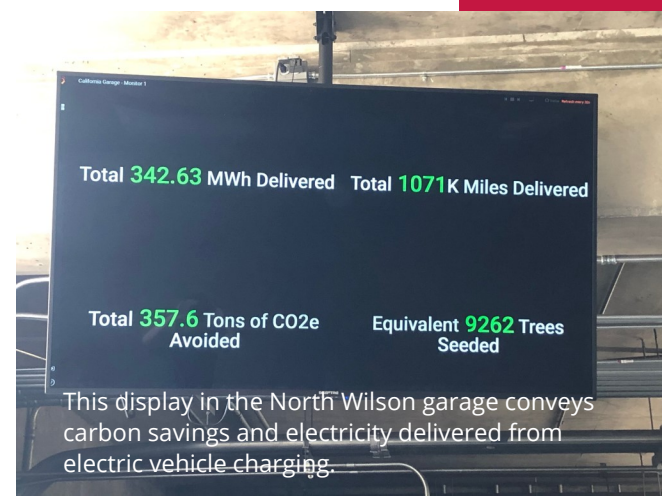
Additional fuel cells installed near the bungalows will power the new Chen Neuroscience Research Building. This installation assists Caltech with controlling carbon emissions as the campus continues to grow.



Caltech offers bike cages and other accommodations to incentivize low-carbon commuting.



Caltech's thermal energy study will assess the feasibility of transitioning the campus from steam to hot water to satisfy campus heating needs.



This display in the North Wilson garage conveys carbon savings and electricity delivered from electric vehicle charging.

Goals for Viability

Explore, evaluate, and implement innovative techniques for minimizing the impact of campus emission, effluent, and waste streams.

2019 Highlights

Student Projects Offer Campus Emissions Solutions

April 2019



As part of the winter quarter, graduate students organized an interactive one-credit class for undergraduate and graduate students to examine campus sustainability projects. Students offered solutions including rooftop garden vermicomposting, housing laundry solutions, and sustainable dining service ware changes.

Caltech Presents Utility Master Plan At AASHE

October 2019



Caltech presented with AEI on the Utility Master Plan at the Association for the Advancement of Sustainability in Higher Education's Conference in Spokane, WA. Attendees learned about Caltech's comprehensive process and engaged in a discussion on how to start similar planning efforts at their campuses.

North Wilson Parking Structure Receives EV Chargers

November 2019



Over 50 new electric vehicle chargers were recently installed in the North Wilson parking structure. This expansion of Caltech's charger infrastructure brings total campus charging capacity to nearly 150 stations and includes 4 new Level 3 chargers that can provide an 80% charge in less than an hour.

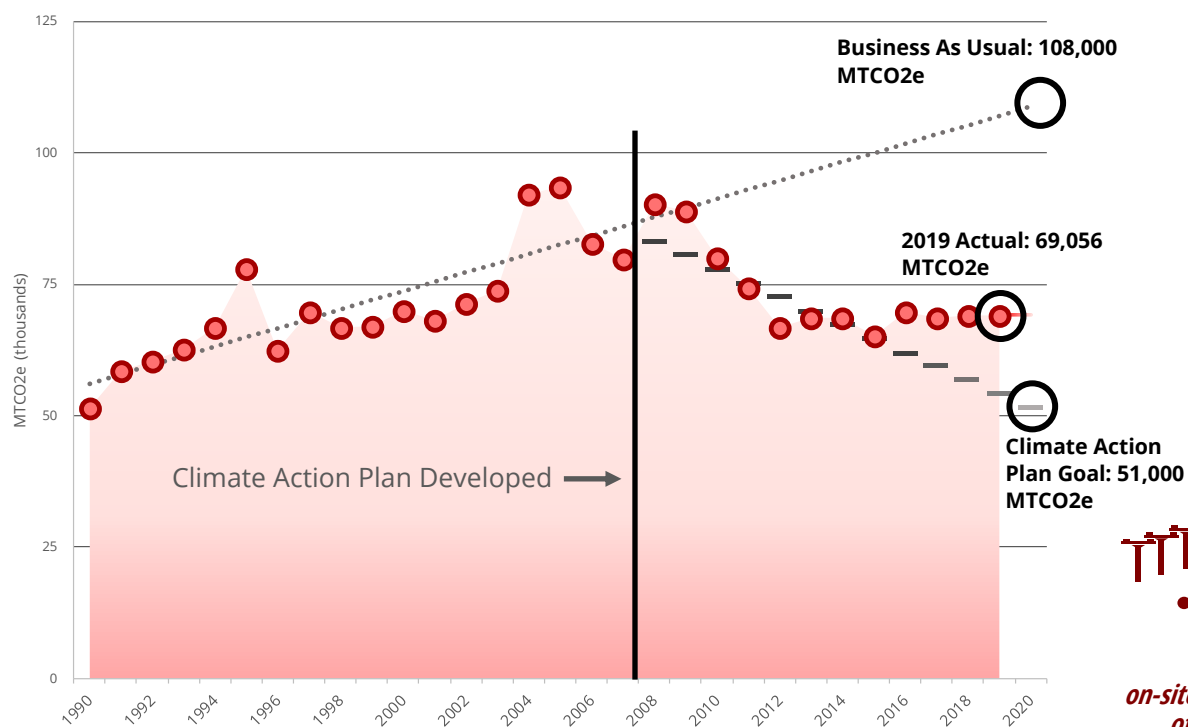


2019 Emissions, Effluent & Waste Update

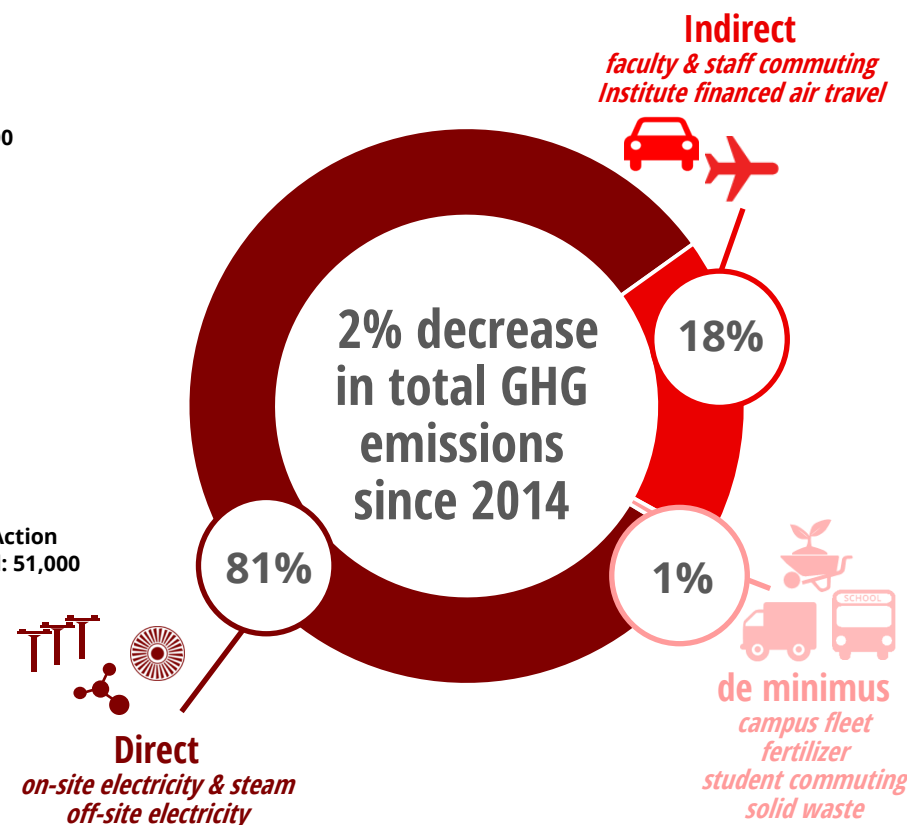
↓ 1% regulated greenhouse gas emissions from 2016¹⁰

Caltech's regulated emissions remained relatively constant for the seventh straight year. Sitting at 69,056 metric tons of direct⁹ emissions in 2019, the Institute is not on track to meet our 2020 goal of 51,000 metric tons of annual carbon dioxide equivalent. Total¹⁰ emissions increased 1% from 2018 to 84,738. Campus emissions intensity (metric tons of carbon per research dollar) has seen an overall increase from 2011 but has leveled off since 2017. With the current campus system leveling out around 70,000 metric tons of direct emissions per year, Caltech will need a paradigm shift in how the campus generates and distributes energy in order to achieve the 2020 and future carbon goals. Current energy master planning will guide Caltech towards this future for Scope 1 and 2 emissions, and anticipated data from purchasing will help us begin to understand more of our Scope 3 emissions.

Historical Greenhouse Gas Goal Progress



2019 Emissions Profile



↓22% total greenhouse gas emissions since 2008¹¹

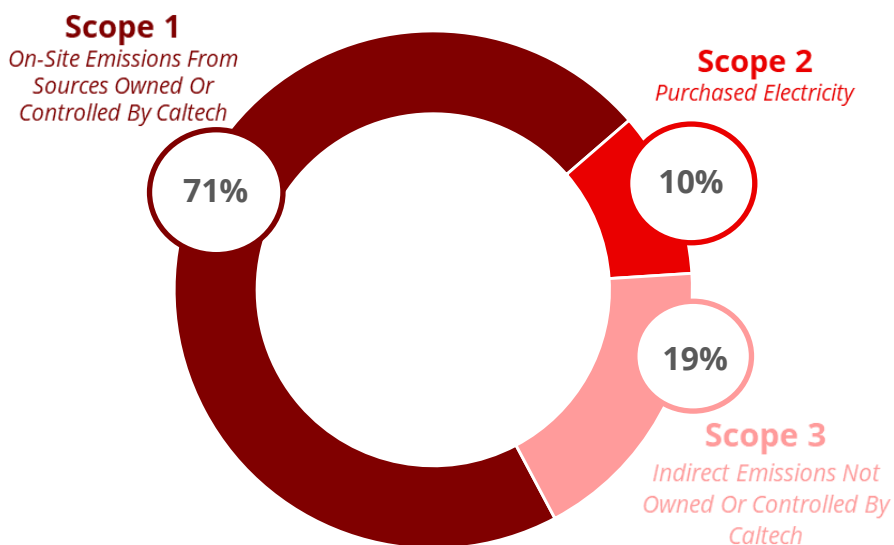
14.1 MTCO₂e per person, a 3% decrease from 2017 but flat since 2015

1.12 pounds of CO₂e per research dollar, down 2% since 2018

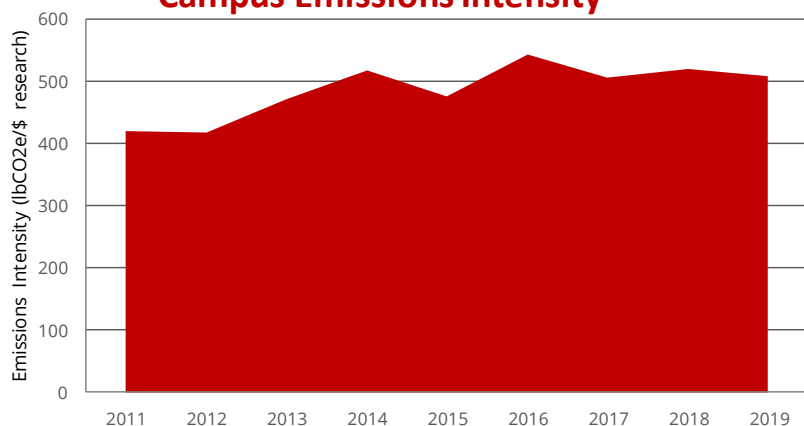


Emissions Deep Dive

2019 Emission Profile By Scope



Campus Emissions Intensity



Utility Master Planning For Our Campus Carbon Future

Following upon the Energy Resource Plan (ERP) that laid out our energy supply decisions for the coming decade, Caltech recently embarked on a utility master planning (UMP) process. This UMP will guide our energy distribution and recovery system planning to create a cohesive path forward. With the ERP conclusions as our business as usual option, Caltech and our engineering partner, Affiliated Engineers Inc., laid out three additional options for our campus cooling, heating, and electricity systems.

	Cooling	Electricity	Heating
Business as Usual – Energy Resource Plan	<ul style="list-style-type: none"> Continue current operation 		<ul style="list-style-type: none"> Retire co-generation system in 2025 Existing natural gas boilers provide steam heat
Opt A – Cooling Optimization		<ul style="list-style-type: none"> Retire co-generation system in 2025 Purchase off-site renewables 	
Opt C – Hot Water Conversion	<ul style="list-style-type: none"> All VFD plant (pumps, fans, chillers) Improved dispatch strategy 		<ul style="list-style-type: none"> Convert campus to hot water system w/ two HRCs Existing natural gas boilers provide steam heat
Opt B – Co-gen Operation		<ul style="list-style-type: none"> Continue operating co-generation system 	<ul style="list-style-type: none"> Continue operating co-generation system + boilers

As we analyzed these options further, we discovered numerous tradeoffs. The most notable was between emissions and total 20-year life cycle cost. Caltech considered a variety of carbon prices, but even a high carbon price didn't tip the scales between various options. Three key takeaways emerged from this UMP process:

- Electric and cooling upgrades were approved and funded for the purpose of meeting critical campus needs for the foreseeable future
- Exploration will continue of off-site renewables with the purpose of retiring the campus cogeneration system in 2025
- The campus thermal system requires further analysis

Key Institutional Data

Metric	Unit of Measure	FY18	FY19	% Change
Core Campus Building Square Footage	Square Feet	4,193,534	4,232,602	+0.9%
Research Square Footage	Square Feet	1,925,600	1,893,852	-1.6%
Population ¹¹	Number (#)	5,947	5,993	+0.8%
Faculty & Post Doctoral Scholars	Number (#)	1,423	1,418	-0.4%
Staff	Number (#)	2,286	2,337	+2.2%
Students	Number (#)	2,238	2,237	-0.0%

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Thank you to all of the people who helped assemble the data and content of this report and for their time reviewing the content of this report:

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Photos and Images

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 - ZGF Architects

Footnotes

1. On-site electricity generation refers to electricity produced on the core campus through the co-generation plant, solar PV and fuel cell systems.
2. Site energy use intensity is calculated by taking the total usable energy consumed (electricity and steam) on-campus and does not include fugitive energy from heat or transmission losses.
3. Caltech's waste hauler sends a portion of the waste collected from the core campus to the Southeast Resource Recovery Facility (SERRF) in Long Beach. This facility employs a technology generally known as "mass burn" where solid waste is incinerated with little to no pre-combustion while recovering electrical energy. This technology reduces solid waste by as much as 80 percent. The remaining ash residue can be used as top cover at landfills. For more information, please visit the SERRF facility website at <http://www.covantaenergy.com/facilities/facility-by-location/long-beach.aspx>
4. Includes recyclables collected from the municipal solid waste stream (ie CRV containers, metals, plastics, paper, cardboard etc); excludes e-waste recycling.
5. High water use turf is defined by any turf species with an irrigation factor of at least 20.72gallons/sqft/yr, according to the Department of Energy cool season turf regional irrigation factors.
6. Low water use turf is defined by any turf species with an irrigation factor of at most 14.64gallons/sqft/yr, according to the Department of Energy warm season turf regional irrigation factors.
7. The building footprint is the sum of the first floor area (above grade) for all buildings on the core campus; includes applicable parking structures. Additionally, this report includes the North Athletic Field artificial turf in the building footprint total, as it was installed to serve as a high-use outdoor space, drains water like a building and does not provide any habitat to biodiversity like other turf.
8. Average vehicle ridership (AVR) is calculated using the South Coast Air Quality Management District's Employee Commute Reduction Program measurement methodology. The Caltech campus is surveyed for a week each year, providing the total number of vehicle trips to campus and the average number of riders per vehicle trip. The commuter profile is determined by finding the dominant commute mode during this survey period for each respondent and extrapolating to the total campus population. Thus, AVR and drive alone trends may differ over time.
9. Direct emissions are those from sources owned or operated by the Institute. Caltech's direct emissions inventory includes on-campus stationary sources, purchased electricity and transmission and distribution (T&D) losses. Purchased electricity and T&D losses are included in this category because the amount of electricity purchased is a direct result of operational decisions and campus activities.
10. Total emissions include regulated, indirect, and de minimus emissions. Indirect emissions result from the activities of Caltech but occur at sources owned or controlled by another entity. Indirect emissions include faculty and staff commuting and directly financed air travel. De minimus emissions comprise less than five percent of the Institute's total emissions and are not traditionally inventoried on an annual basis. These emissions may be direct or indirect emissions but are tracked separately. Caltech's de minimus emissions result from university owned fleet transportation, refrigerants and chemicals, fertilizer application, student commuting and solid waste disposal.
11. Human Resources provided faculty, post doc and staff population statistics. The Office of the Registrar provided population statistics and include those seeking undergraduate and graduate degrees.



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