Annual Sustainability Update 2017
In the Last Year...
the Caltech community maintained its strong environmental performance, while exploring large-scale efforts to transform campus sustainability. The past year has also brought change that provides the opportunity to re-evaluate our programs from how we recycle to what it means to conserve water. The following update highlights this dynamic balance between continuing past successes and fostering the evolution of what it means to be a sustainable campus.

John Onderdonk
Senior Director, Facilities Services & Integrated Planning
Chief Sustainability Officer

Table of Contents

3  At A Glance
4  Energy
10  Water
14  Materials
18  Built Environment
22  Transportation
26  Emissions
30  References & Acknowledgements
## Energy
Total consumption remained relatively flat (-1%) due to continued efficiency investment. Less on-site co-generation downtime for maintenance increased on-site generation to 100%.

### Water
Total consumption decreased (-3%) due to a 10% reduction in building & domestic use. The plants account for over half of all consumption, which is driven by research & energy demands.

### Materials
Total municipal solid waste generation increased (+5%) but diversion grew more than waste (+7%). The Institute completed the roll out of changes to the recycling program in all buildings.

### Built Environment
12% of campus building space is LEED certified and LEED space has grown 19% annually since 2008. Turf removal and climate adapted species projects enhance campus drought tolerance.

### Transportation
Average vehicle ridership decrease slightly (-1%). While most faculty and staff continue to drive alone (58%), campus ridesharing using carpool, vanpool, bus or rail increased (+9%).

### Emissions
Emissions shrunk (-2%) from higher on-site generation, which is cleaner than the utility grid. The Institute intends to move to off-site renewable electricity, which will greatly cut emissions.
3.1. MW of solid oxide fuel cells provide up to 21% of Caltech’s electricity.

Caltech’s 10MW Gas Turbine generates electricity and produces waste heat used to generate steam for the campus.

Most campus buildings are connected to centrally supplied steam and chilled water loops piped through utility tunnels.
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.

2017 Highlights

**Energy Strategy Continues Transition to Renewables**
April 2017

The ad-hoc committee completed its comprehensive evaluation of long-term energy supply options and recommended that Caltech prepare to move from on-site natural gas generation to off-site renewable electricity.

**Utility Master Plan Kicks Off**
August 2017

The energy resource strategy identified the need to address challenges facing the Institute's utility system and infrastructure. The utility master plan will evaluate options to meet current and future utility needs while optimizing performance.

**CECIP Program Updates Expand Eligible Projects**
September 2017

CECIP draws on a green revolving loan fund to invest in energy efficiency. Caltech has extended CECIP's payback requirements to make complex projects with higher up front investments or lower annual savings eligible for investment.

**Lab Freezer Rebate Program Launches**
October 2017

Ultra-low temperature freezers are often one of the largest energy users in a laboratory. Caltech's rebate program offers incentives for purchasing high-efficiency ULT freezers that can reduce electricity use over 65 percent.
2017 Energy Update

In FY2017, the Institute adjusted the maintenance schedule for the gas turbine and faced fewer operational disruptions, which helped the Institute meet 100% percent of its net electricity demand with on-site\(^1\) generation. Caltech’s on-site electricity portfolio\(^1\) was 7 percent cleaner than the power from the municipal utility in 2017\(^2\). Reducing utility purchases has helped progress towards emissions reduction targets, but this strategy may change as the electricity from the grid continues to become cleaner. Continued investment in energy efficiency through the CECIP program held total electricity demand flat. However, energy use per square foot\(^3\) rose 5 percent due to increased on-site natural gas combustion.

**Historical Campus Electricity Consumption**

\[\text{Electricity consumption (mWh)} \]

\[\begin{array}{c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c|c}
\hline
\hline
\text{electricity consumption (mWh)} & \text{20,000} & \text{40,000} & \text{60,000} & \text{80,000} & \text{100,000} & \text{120,000} & \text{140,000} & \text{160,000} & \text{180,000} & \text{200,000} & \text{220,000} & \text{240,000} & \text{260,000} & \text{280,000} & \text{300,000} & \text{320,000} & \text{340,000} & \text{360,000} \\
\hline
\end{array}\]

\[\downarrow 1\% \text{ in total campus electricity consumption from prior year}\]

**2017 Electricity Portfolio**

- **Solar PV**: 2%
- **Combined heat and power**: 77%
- **Fuel cells**: 21%
- **100% generated on site\(^1\)**

\[\text{total electricity demand from FY2016. Growth flattening since FY2010}\]

\[\begin{array}{c}
2017 \\
119,500 \\
MWh
\end{array}\]
Caltech Energy Conservation Investment Program (CECIP)

Energy green fund update

Caltech’s green revolving fund, CECIP, continues to tackle the challenge of minimizing energy consumption using efficient technology, data integration, and advanced controls. Since 2008, CECIP investments have helped the Institute hold overall energy consumption flat despite continued campus growth. However, as projects become more complex, it was necessary to revisit the CECIP guidelines. In 2017, Caltech extended its CECIP payback requirement from 6 to 8 years. The change allows CECIP to explore projects with significant energy savings, but

9 GWh | $900K avoided utility cost | 7K MTCO2e

since CECIP II initiated in FY2015

that may have been ineligible due to high upfront costs or lower annual payback. In fiscal year 2017, CECIP projects include lighting retrofits, replacing pneumatic controls with digital controls, smart building commissioning, variable air volume and HVAC retrofits. For example, CECIP installed new LED lamps in 16 buildings and the campus tunnel network. Since CECIP’s inception in 2008, the program has aided in cutting over 27GWh of electricity demand. For more information on CECIP, please visit the sustainability website or download the most recent CECIP Annual Report here.
For the past decade, Caltech has reduced costs and met energy needs through efficient energy generation, energy conservation, and procurement of alternative and low carbon energy sources. However, as Caltech moves into the future, continuing to meet energy requirements in an economical manner while remaining sensitive to environmental concerns will become increasingly complex. In 2016, the Institute convened an ad-hoc committee to explore the Institute’s energy supply options and priorities and recommend a path forward.

Energy Challenge: Even with growth in research space, Caltech has held energy demand flat. However, as • efficiency projects become more complex, • energy intensive research grows, and • greenhouse gas emission reductions level off, the Institute must explore more transformative changes to its energy portfolio.

Supply Options: The plan evaluated 15+ technologies across 65+ scenarios covering combustion, on- and off-site renewables, fuel cells, and other options.

Team & Guiding Principles: The committee tasked with exploring this challenge included Faculty from three divisions and leaders in strategy implementation and was supported by Facilities staff and internal and external advisors. Early on, the committee established the principles and criteria to measure a successful outcome:

- minimize total cost of ownership
- enable adaptive capacity & maintain reliability
- demonstrate leadership and a scalable solution

8 committee members from 3 academic divisions and the Office of the President
15+ energy technologies evaluated, including renewables, combustion, fuel cells and others
65+ scenarios modeled showing the cost, emissions, and infrastructure impacts of energy supply choices
...envisioning Caltech’s energy future

Energy Planning Model: Caltech utilized a custom, bottom-up model that starts with energy demand projections and layers on conservation, distribution, operating parameters, generation efficiency and supply preferences to create scenarios.

Model Results Analysis: The team combined quantitative scenario outputs with qualitative factors such as price volatility, reputational risk, regulatory uncertainty, flexibility, resource availability, maintenance burden, and the strength of environmental claims. High performing scenarios were further evaluated through a sensitivity lenses (cost, emissions, energy demand) to identify tipping points and the range of outcomes under potential future conditions.

Utility System Complexity: During the planning process, the team determined that further analysis was needed to address the challenges present by the on-site utility distribution network. The committee recommended that Facilities complete a utility master plan (underway now) to identify options to optimize system performance.

After a year of analysis and discussion, the committee found that:

- **The current energy portfolio has reduced costs and emissions** and will continue to perform well over the short-term.
- **Renewable energy is the most consistent option over the long-term** due in part to the regulatory, financial, and environmental risks of continued natural gas combustion.
- The Institute should prepare to retire the on-site gas turbine and transition to off-site renewables in 2024.
- However, achieving more extensive emissions reductions will require the campus to address gas used to produce thermal energy.

---

2024

**target date to retire on-site gas turbine and transition to off-site renewables**

50%

campus direct greenhouse gas emissions cut from the transition to renewables

25-40 MW

off-site renewables projects under consideration in 2024
The campus tree canopy has been stressed by the ongoing drought. Water is central to life at Caltech, both work and play—students celebrate the ditch day tradition in the iconic Gene Pool. Several fountains on campus are fed using recycled air conditioning water. Ella Watkins, a graduate student in the Arnold Lab, uses a water bath for her research.
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.

2017 Highlights

Replaced 152 Urinals with Low Flow Fixtures
December 2016

In FY17, the Institute finished a project that installed 152 pint flush urinals that use 87% less water than a standard model. These urinals contributed to the campus reducing building and domestic water use by 4 million gallons in FY17.

California Ends Drought State of Emergency
April 2017

Following state-wide efforts to conserve water and a wet winter season, California ended its mandatory water use restrictions. The state is working with local water providers to develop long-term water conservation standards.

Utility Plants Conserve Water Used in Cooling Towers
September 2017

Over half of the Institute’s water is used in the utility plants to provide chilled water, heat, and electricity to campus. In FY17, plant staff increased the efficiency of water cycling in the towers by over 50% with less water being sent to the sewer.
2017 Water Update

While California ended its drought state of emergency in FY2017, the Institute continued its efforts to conserve water resources. Caltech reduced overall consumption by 3 percent in FY2017, led by a 10 percent cut in building and domestic use and 3 percent cut in utility plant use. Building and domestic conservation is primarily driven by behavior change from the Caltech community, but is also supported by conservation projects such as the replacement of 152 old, inefficient urinals with models that use much less water per flush. Coupled with an over 50% improvement in cooling tower water recirculation, Caltech saved over 5 million gallons of water in FY2017.

Historical Campus Water Consumption

2017 Water Use Profile

†3% in total campus water consumption from prior year

†10% building & domestic from FY2016

†16% irrigation

58% utility plants

26% building & domestic
Historical Campus Water Use Intensity

Water use by gross square foot

On-Site Water Conservation

District water recycling

Doing our work with less potable water is the new normal in California. While the state of drought emergency has ended, future water shortages and increased scrutiny over water use are here to stay. Caltech is preparing for that future by implementing feasible water conservation projects and exploring sources of non-potable water. For example, all LEED buildings on campus are plumbed to use recycled water for appropriate uses and three fountains on campus are filled using recycled condensate water from the air conditioning systems.

In 2017, Facilities also explored a district water recycling facility for the buildings along the east portion of Moore Walk. The facility would process all sewer effluent leaving these buildings, clean the water to graywater standards using membrane bio-reactor technology, and use the water in the Satellite Plant for industrial purposes. Ultimately, Facilities found that a larger project would be needed to save enough water to justify the project cost. The Institute plans to investigate a large-scale, campus-wide system as part of the utility master planning process.

2017 Utility Plant Use Profile

70% evaporation 16% research water 9% blowdown 5% heating

total - 97 million gallons

4% campus water use per square foot from FY2016

FY2017 use percentages between utility plants, building & domestic users and irrigation

152 high efficiency urinals installed on campus, reducing water wasted from flushing

4% campus water use intensity by gsf from prior year

2017 41 gal/gsf


gallons/gsf fiscal year

District water recycling

reused water could be used in the plants, including the cooling towers shown here

The Cahill Center is one of 9 LEED buildings on campus piped to use reclaimed water

3 fountains 9 LEED buildings >60% campus demand

using or eligible to use recycled water
Student Affairs installed new outdoor recycling bins at the Catalina Apartments and the Avery Courtyard.

The growth of e-commerce has increased cardboard collection.

Caltech custodial and recycling teams empty every recycling station on campus at least once a week.

Surplus furniture that is no longer needed is stored and available for purchase.
Goals for Viability

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

2017 Highlights

Changes to Campus Recycling Complete
February 2017

Caltech completed the roll-out of new recycling bins and signage to all campus buildings. Over 1,000 bins were deployed to over 75 campus buildings. The roll-out helped increase recyclables collected by 11% in FY2017.

Truck Scale Increases Visibility into Waste
August 2017

Caltech’s waste hauler has installed a scale onto the truck that services the campus, increasing visibility into campus waste data and trends. The scale data has helped identify locations with high levels of food waste to target for composting.

Caltech Explores Food Waste Recycling Options
August 2017

The Institute is exploring ways to reduce food waste and increase recycling. seedLA, a pro bono consultancy, evaluated the benefits and drawbacks of handling food waste on campus with in-vessel composting units.

Community Recycling Center Closed
November 2017

The Caltech Recycling Center, located in Parking Lot 12, has closed to accommodate the development of the north end of campus including the construction of the Tianqiao and Chrissy Chen Institute for Neuroscience building.
2017 Materials Update

In FY2017, the total municipal solid waste\(^9\) increased by 4 percent to roughly 755 pounds per person. However, almost all of the rise was due to recyclables collected, which increased 11%. This trend suggests that the roll-out of the streamlined, comprehensive recycling program, completed in FY2017, has already yielded results. In fact, the campus increased its recycling diversion rate by 3% to 38 percent of waste from the landfill via on-campus recycling\(^10\), with an additional 34 percent of waste processed for recycling in the municipal solid waste service provider’s material resource recovery facility. Additionally, in FY2017, 70 percent of hazardous and electronic waste was recycled safely by a certified third party.

**Historical Campus Municipal Solid Waste (MSW)**

- **2017**: 2,200 tons
- **↑4% in total campus municipal solid waste from prior year**

**2017 MSW & Recycling Profile**

- **34%** recycled directly from campus\(^10\)
- **38%** recycled at material recovery facility
- **28%** energy from waste transformation\(^11\)
- **↑11%** on-campus recycling from FY2016

**Municipal Solid Waste (MSW) from FY2016, all from increased recyclables collected**

**9% CRV containers**
**13% mixed load**
**24% green waste**
**26% cardboard**
**28% paper**
**Total - 825 short tons recycled**
Historical Campus MSW Intensity

MSW generated per person

Historical Campus Hazardous Waste

hazardous waste breakdown

Organics Recycling

Food waste strategy update

In 2014, AB1826 became law in California and created a mandatory organics recycling program that will be phased in over time. Organics recycling has multiple benefits, including reducing methane emissions from landfills. Methane is a potent greenhouse gas. Caltech currently recycles a portion of the organic waste generated on campus, but is exploring ways to expand this program to all major sources of organics. This includes landscape green waste and food waste from campus eateries, catered events, and house dinners. Recycling this food waste would not only reduce the waste sent to the landfill, but could also reduce waste costs. In 2017 a team of pro-bono consultants from seedLA explored Caltech’s organic waste reduction and recycling options, including the costs to compost on site. The seedLA analysis, combined with expanding local capacity to handle organic material, has helped Caltech move closer to expanding its organics recycling program.
The Powell-Booth computing cluster uses hot-aisle/cold-aisle technology to reduce energy used for cooling.

Climate adapted aloe plants use less water.

BBB pond is one of three natural ponds on campus.

Linde+Robinson landscaping with climate-adapted species.
Goals for Viability

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

2017 Highlights

Bechtel Residence Breaks Ground on Construction
November 2016
Construction commenced for the Bechtel Residence in the fall of 2016 and is on track to be ready for students in the fall of 2018. The 95,000 square-foot residence will house over 200 students and 3 faculty in residence.

Design Begins on Chen Institute for Neuroscience
April 2017
The Tianqiao and Chrissy Chen Institute for Neuroscience at Caltech, founded in 2016, brings together a cross-disciplinary team to investigate the brain and how it works. The institute's home will be a 150,000 square foot high-performance building.

Caltech Dining Installs a Rooftop Garden
August 2017
Caltech Dining installed 48 aeroponic towers on the roof of Chandler Café that grow veggies for meals provided to the Caltech community. The rooftop garden is literally "roof-to-table" according to Jonathon Webster, senior director of Caltech Dining.

Hameetman Center Construction Underway
September 2017
The Hameetman Center will replace the Winnett Center as Caltech's central community gathering place. When complete in 2018, the center will include a public lounge, an expanded Red Door Marketplace, the Caltech Store, rehearsal space, and more.
2017 Built Environment Update

Over the past ten years, Caltech has managed its environmental impact while continuing to grow—the Institute has added over 225,000 square feet of research space; renovated over 250,000 square feet of research space; now operates over 700 fume hoods; and eliminated over 250,000 square feet of turf. Over the next three years, the Institute will continue its growth by adding three new high-performance buildings: The Bechtel Residence, The Hameetman Center, and the Chen Neuroscience Research Building. Caltech is automating performance by integrating buildings into the campus-wide building management system that allows Facilities staff to remotely monitor operations and respond to issues in real time.

2017 Land Use Profile

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>hardscape</td>
</tr>
<tr>
<td>25%</td>
<td>building footprint</td>
</tr>
<tr>
<td>19%</td>
<td>turf cover</td>
</tr>
<tr>
<td>16%</td>
<td>vegetated</td>
</tr>
</tbody>
</table>

Total - 125 acres

LEED certified building space
percent of total campus space

9 LEED Certified Buildings

LEED certified buildings, 12% of Caltech’s total campus space, an increase from 1 building in FY2008

2.8 Million Square Feet

NC Gold
Cahill
Annenberg
Schlinger
Childcare Center
Gates+Thomas

NC Platinum
Linde+Robinson
Jorgensen
Keck Center

EBOM Gold
Broad Center
Bechtel Residence
Climate Adapted Landscape
The Institute prioritizes plant species that are climate adapted, save water, reduce runoff and mitigate heat\textsuperscript{19}. The plans for the Bechtel Residence (examples below) demonstrate these goals.

The building area will be controlled with a \textit{weather based irrigation system} that monitors weather and soil moisture to limit water waste.

\textbf{Tree Species:} The Bechtel site will be home to \textit{over 60 trees}, all of which are native or climate adapted and use limited water.

\textbf{Shrub Species:} Shrubbs will be the \textit{most numerous plant type} at Bechtel and, like the trees, will require little water.

\textbf{Grasses \& Perennials:} Caltech’s landscape planners work diligently to replace high water use turf with drought resistant \textit{grasses, flowers, and ground cover}.

Caltech Dining Rooftop Garden
\textbf{Roof to table food production}
Ever wonder where the food served in Chandler Café comes from? You might be surprised to know that some of what you order may have been grown steps away on the roof. Caltech Dining Services worked with L.A. Urban Farms to install 48 towers during the summer of 2017 that grow a wide variety of vegetables and herbs for use in the kitchen below. Executive chef Zach Chambers and the Chandler team use the produce for a variety of dishes, cooking seasonal dishes to integrate the garden’s outputs. Jonathon Webster, the Senior Director of Dining Services, is exploring ways to make the garden more sustainable and profitable by developing their own seedlings, exploring alternative water sources, and integrating Caltech students, staff, and faculty into the process. The Dining team has given multiple tours of the garden for both Caltechers and outside community groups such as local schools. Should the project prove successful, there is room to expand on the rooftop.
Caltechers use a built-in skateboard/scooter rack in the Gates+Thomas Lab.

Caltech's 12 vanpools and 208 carpools receive preferred parking spaces.

Electric vehicle charging using the Powerflex Adaptive Charging Network in the California Parking Structure.

LA Metro bikeshare users cycle through campus.
Goals for Viability

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

2017 Highlights

**Earth Week Explores Future of Autonomous Vehicles**
April 2017

During Earth Week 2017 the Caltech Associates hosted a diverse panel of experts, from technological, business, and societal viewpoints, for a discussion about the future of driverless vehicles and how they will impact our lives.

**Caltech Hosts Bike to Work Day Breakfast**
May 2017

Caltech’s Comuter Services hosted a bike to work day pit stop where staff, faculty, and students who rode their bikes to campus could stop by the Sustainability Park on Wilson Avenue for a free breakfast.

**LA Metro Bikeshare Launches in Pasadena**
July 2017

LA Metro Bikeshare has come to Caltech with two stations on campus: Caltech East on San Pasqual and Holliston, and Caltech West on Wilson and San Pasqual. However, financial challenges will force Pasadena to end the program 2018.

**Caltechers Ride for Free on Pasadena Transit in FY17**
August 2017

In partnership with Pasadena transit, Caltech students, staff, and faculty were able to ride all Pasadena buses for free beginning in August 2017. This free promotional college pass program will run through the summer of 2018.
In 2017, the Institute maintained its vehicle ridership at 1.6 occupants per vehicle. While most faculty and staff drove alone\textsuperscript{21}, total rideshare\textsuperscript{22} usage grew by 9\%. The Institute offers many incentives to promote alternative transportation, including transit subsidies, parking discounts for rideshares, showers and storage facilities for walk and bike commuters and more\textsuperscript{23}. Caltech students help lead bicycling efforts at the Institute. Students operate a free Bikeshare\textsuperscript{24} program with 6 bikes available for use as well as a Bike Lab where students can go for bicycle maintenance and bicycling events. While LA Metro introduced a bike share program in Pasadena in 2017, financial challenges will force the program to end in 2018.
57% of commuters used alternative transportation, flat from FY2016

4/483 Zipcars and active users on campus

8.4 average miles to work, down from 8.7 in FY2016

16/975 caged and outdoor bicycle parking spaces on campus

Campus Commuter Details

drive alone trends

2017 campus total: 43% drive alone

2017 modal split

Shared Mobility at Caltech

Bikeshare programs update

For many at Caltech, bicycling is a way of life. 20% of Faculty and 13% of students primarily bike to campus. Bike sharing provides access to bicycles for those who do not own a bike and can connect places like Caltech with alternative forms of transportation (bus, train, etc.). Bike sharing options in Pasadena and Caltech have grown over the past several years. Caltech students launched a bikeshare program that is free for the Caltech community with 6 bikes at the Sherman Fairchild Library.

6 Caltech Bikeshare bikes at SFL

500+ rides/month to & from Caltech w/ Metro Bikeshare

20 minute average Metro Bikeshare ride to or from Caltech

Additionally, LA Metro launched bikeshare in Pasadena in 2017 with two stations at Caltech. While LA Metro will be forced to end the bikeshare program in FY2018, their data has shown that many Caltechers used the bikeshare to travel to and from Caltech during peak commuting periods: arriving on campus for work between 7 and 10AM and leaving after work between 5 and 9PM.

As Pasadena considers “dockless” bike and scooter systems to replace the LA Metro bikes, Caltech will work closely with the city to design a program that meets the Institute’s needs and continues to support Caltech’s biking community.
Directly financed air travel accounts for roughly 13% of Caltech’s total emissions—research has shown that avoiding one transatlantic flight per year can greatly reduce an individual’s carbon footprint.

Fume hoods are part of the lifeblood of Caltech—they are critical for conducting research, are tested and monitored by the Environmental Health and Safety Office, and use a large amount of fan energy to keep lab users safe. Advancements in fume hood technology have reduced energy needs and the resulting greenhouse gas emissions.

Maya Golden-Krasner gives an Earth Week lecture on Environmental Justice and climate action.

Pumps used to circulate chilled water are large energy users. Upgrades explored in the utility master plan could reduce emissions from pumping.
Goals for Viability

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

2017 Highlights

**Energy Strategy Targets Emissions Reductions**
April 2017

The transition to renewable electricity could cut the Institute’s direct greenhouse gas emissions in half in 2024. However, the Institute must address its thermal energy needs to achieve greater gains, which will be studied in the utility master plan.

**Caltech Joins University Climate Coalitions**
July 2017

Caltech joined the University Climate Coalition and the Ivy+ Consortium in 2017. Both are groups of prominent universities across North America that are committed to emissions cuts and collaborating to advance effective policies and practices.

**California Renews Cap-and-Trade Program**
July 2017

Lawmakers extended the state’s cap-and-trade program to 2030. The program’s goal is to reduce emissions 80% below 1990 levels by 2050. The emissions from Caltech’s co-generation facility are regulated under cap-and-trade.

**Utility Master Plan to Assess Emissions from Heating**
August 2017

The master plan will evaluate options to optimize performance in the campus utility system, including options to address emissions from heating the campus through electrification, fuel switching, efficiency, and other methods.
2017 Emissions, Effluent & Waste Update

The Institute experienced a 2% decrease in direct emissions in calendar year 2017\(^{27,28}\) due primarily to minimizing electricity purchases from the grid. A large portion of grid electricity in Pasadena is provided by coal generation. While the Institute has continued to reduce in accordance with its 2008 Climate Action Plan, the Institute appears to have reached the limit of possible reductions while continuing to rely on natural gas to generate electricity and steam for the campus. The Energy Resource Plan completed in 2017 explored a variety of energy supply options and recommended that the Institute transition to off-site renewable electricity in 2024, which will cut direct greenhouse gas emissions in half. However, more work will need to be done to address emissions from thermal energy production.

Direct Greenhouse Gas Emissions History & Goal\(^{27}\)

2017 Emissions Profile

- **2017 Actual**: 68,500 MTCO2e
- **2020 Business as Usual**: 108,000 MTCO2e
- **2020 Goal**: 51,000 MTCO2e

\(\downarrow 2\% \text{ in total GHG emissions from 2015}\)

- **Indirect**
  - faculty & staff commuting
  - Institute financed air travel

- **Direct**
  - on-site electricity & steam
  - off-site electricity

\(\downarrow 2\% \text{ in direct emissions from prior year}\)

- **De minimus**
  - campus fleet
  - fertilizer
  - student commuting
  - solid waste

\(\downarrow 2\% \text{ in total greenhouse gas emissions from 2016 and 23\% cut since 2008}\)
Historical Campus Emissions Intensity

- Emissions intensity per $research from 2016, and 28% cut since 2008
- MTCO2e per person, a 3% decrease from 2016 and a 26% cut since 2008
- 15 pounds chemical & hazardous waste disposed per person, a 21% reduction from FY2016

Caltech Joins Climate Coalitions

- Peer groups focused on climate research and emissions reductions
- The Institute is committed to addressing climate change both through leading climate research central to the missions of many labs and research institutes and through greenhouse gas emissions reductions from campus operations. To further strengthen this commitment, the Institute joined two prominent groups of universities in 2017 that are focused on advancing climate research, developing and communicating a model for successful climate action, and delivering meaningful emissions reductions.

- 35+ universities | 3 countries | 22 states represented by universities in the University Climate Coalition and the IVY+ Consortium

Historical Campus Hazardous Waste

- Chemical & hazardous waste disposal
- 2017 total: 43 short tons
Key Institutional Data

<table>
<thead>
<tr>
<th>Metric</th>
<th>Unit of Measure</th>
<th>FY2017</th>
<th>FY2016</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Campus Building Square Footage</td>
<td>sq ft</td>
<td>4,080,000</td>
<td>4,045,000</td>
<td>+0.9%</td>
</tr>
<tr>
<td>Research Square Footage</td>
<td>sq ft</td>
<td>1,890,000</td>
<td>1,820,000</td>
<td>+3.9%</td>
</tr>
<tr>
<td>Population^31</td>
<td>Number (#)</td>
<td>5,845</td>
<td>5,755</td>
<td>+1.6%</td>
</tr>
<tr>
<td>Faculty &amp; Post Doctoral Scholars</td>
<td>Number (#)</td>
<td>1,305</td>
<td>1,230</td>
<td>+6.1%</td>
</tr>
<tr>
<td>Staff</td>
<td>Number (#)</td>
<td>2,300</td>
<td>2,250</td>
<td>+2.2%</td>
</tr>
<tr>
<td>Students</td>
<td>Number (#)</td>
<td>2,240</td>
<td>2,275</td>
<td>-1.5%</td>
</tr>
</tbody>
</table>

Acknowledgements

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

- Wayne Bottomley, Design & Construction
- Lynne Caver, Facilities Finance
- Michael Chuah, Environment, Health & Safety
- Jim Cowell, Facilities Department
- Delmy Emerson, Building and Grounds
- Zachary Erickson, Graduate Student, Geological and Planetary Sciences
- Neil Fromer, Resnick Institute
- Michelle Gonzalez, Financial Services
- Sandy Karhu, Human Resources
- Erin Kilduff, Energy Services
- davidkremers, Visitor in Aerospace
- Tina Lowenthal, Procurement Services
- Chris McAlary, Facilities Management
- Warren Midkiff, Central Utility Plant Supervisor
- Brad Nielsen, Facilities Management
- Monique Olah, Facilities Purchasing Services
- Don O’Neil, Design and Construction
- Tim Rao, Central Plant Lead Control Specialist
- Cynthia Rowand, Procurement Services
- Heidi Rusina, Resnick Institute
- Caz Scislowicz, Environment, Health & Safety
- Art Seiden, Environmental Health & Safety
- Thomas Shaffer, Energy Services
- Margo Steurbaut, Business & Finance, Office of the President
- Todd Swart, Transportation and Parking Services
- Michael Uvaney, Design and Construction
- Jonathan Webster, Dining Services
- Judy Young, Student Affairs Administration
- Steven Zwick, Buildings and Grounds

Prepared by

Tyler Durchslag-Richardson, Senior Analyst, Facilities Services and Integrated Planning
John Onderdonk, Senior Director, Facilities Services & Integrated Planning

Photography

- Caltech Bikeshare
- Caltech Dining Services
- Caltech Energy Services
- Caltech Office of Strategic Communications
- Caltech Sustainability Programs
- Christine Cho, Independent Photographer
- Gonzalex Goodale Architects
- Nicola Wilkins-Miller
- Smith Group
- The Arnold Lab
- 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. A large portion of electricity from the local utility, Pasadena Water and Power, is generated using coal. PWP is exploring options to replace this electricity with cleaner sources.
3. Energy intensity is calculated using natural gas purchased to operate the co-generation plant, boilers and fuel cells (including efficiency losses) and the electricity from solar PV and the utility grid.
4. In 2003, Caltech replaced its aging 5.5MW combined heat and power (CHP) system with a high efficiency 12.5MW system. With CHP, waste heat is captured from the combustion of natural gas and used in a steam turbine to generate additional electricity. Caltech’s CHP co-generation system consists of a 10MW gas turbine and a 2.5MW steam turbine generator. Additionally, waste heat is captured to heat campus buildings. This upgrade affected the amount of natural gas and electricity grid purchases, contributing to a decline in energy intensity per gross square foot trend.
5. Direct research dollars includes only expenses on the core campus, not remote facilities such as the Palomar Observatory. Energy consumption is heavily driven by the amount and type of research being conducted on campus. Thus, indirect expenses, such as overhead and utilities, are not included. This metric shows an increasing trend, which is due to changes in federal research spend.
6. Caltech’s fountains re-circulate water, which reduces total water use. However, water lost through evaporation or leaks must be replaced. Condensate water from building air conditioning systems typically collects in utility rooms and is sent to the sewer. By connecting several fountains to these condensate water discharge systems, the fountains are re-filled using recycled water and not potable water.
7. Gallons per gross square foot was determined by dividing total campus water consumption by the total campus size.
8. Water and energy use are closely linked at Caltech as the majority of water use within the utility plants, especially evaporation, is the result of providing chilled water to cool the campus.
9. Municipal solid waste refers to non-hazardous materials thrown in the trash and is calculated by weight. MSW excludes electronic waste, which is classified as hazardous. Totals for fiscal years 2010 through 2015 were restated from prior reports due to past measurement errors from the Institute’s waste hauler.
10. Includes recyclables collected from the municipal solid waste stream (ie CRV containers, metals, plastics, paper, cardboard etc); excludes e-waste recycling.
11. 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.covartaenergy.com/facilities/facility-by-location/long-beach.aspx
12. Staff, faculty (includes post docs) and degree seeking students are included in the per capita calculation.
13. Hazardous waste profile is calculated by weight and includes chemicals, solvents and e-waste.
14. High water use turf is defined by any turf species with a irrigation factor of at least 20.72g/sqft/yr, according to the Department of Energy cool season turf regional irrigation factors.
15. Low water use turf is defined by any turf species with an irrigation factor of at most 14.64g/sqft/yr, according to the Department of Energy warm season turf regional irrigation factors.
16. Hardscape includes surface level parking lots, walkways through campus and any other permeable or non-permeable paved surface.
17. Vegetated (non turf) means any area with landscaping on the core campus that is neither considered turf nor hardscape.
18. 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.
19. Caltech’s plant palette and land use priorities were developed in coordination with the Office of James Burnett, landscape architect and the campus community through town halls. The plan was approved by the Caltech Board of Trustees Buildings and Grounds committee in 2011.
20. While 8 of the Institute’s 9 LEED certified buildings are certified under LEED for new construction, several are renovations of existing buildings. These renovations are so extensive that they are certified by LEED as a new construction, despite significant re-use of structural and other building elements to reduce new material use in construction.
21. Drive alone includes those who commute to campus as a single driver and motorcycle riders.
22. Ride sharing includes carpools, vanpools and mass transit options (rail and bus).
23. For a full list of alternative incentives offered to the Caltech community please visit the Rideshare Program’s website: https://www.parking.caltech.edu/Transportation
24. The Bikeshare program offers 24 hour bicycle rentals to anyone with a Caltech I.D. card. Bicycles can be picked up at Sherman Fairchild Library and include a helmet, lock and light.
25. 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.
27. 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.
28. Greenhouse gas emissions are reported by calendar year and not fiscal year due to reporting requirements from the California Air Resources Board and the U.S. Environmental Protection Agency.
29. 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.
30. De minimis 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 minimis emissions result from university owned fleet transportation, refrigerants and chemicals, fertilizer application, student commuting and solid waste disposal.
31. As a research intensive institution, energy consumption and the associated GHG emissions are driven by the amount and type of research performed on campus. As such, the annual GHG emissions have been normalized by direct research expenses to represent the campus GHG intensity. This normalization factor more closely reflects Caltech’s core mission than per capita or gross square feet.
32. 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.