

PROGRAM OVERVIEW

The Facilities Management department has Institute-wide responsibility for minimizing energy uses and for implementing and maintaining an energy management program. Caltech's program considers all avenues for achieving energy savings, from replacing obsolete equipment, to the design and construction of energy conservation measures, the implementation of energy saving operation and maintenance procedures, the utilization of a campus-wide building energy management system, and a commitment to educating faculty, staff and students to decrease energy consumption.

The Energy Management team is finding innovative ways to incorporate these principles into campus operations and implementing energy conservation measures with funding from the [Caltech Energy Conservation Investment Program \(CECIP\)](#).

GOALS & STRATEGIES

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.

Strategies

- Integrated strategic energy plan
- Central plant optimization
- Energy conservation & efficiency retrofits (CECIP)
- Laboratory equipment energy use
- Active energy management

ENERGY PORTFOLIO

To expand the Institute's use of renewable and low carbon power sources and to minimize risk, Caltech leverages four sources of power:

- 1) on-site natural gas combine heat and power system
- 2) on-site solar photovoltaic arrays
- 3) on-site Bloom fuel cells
- 4) electricity purchased from our municipal utility Pasadena Water & Power

For more information on the electricity provided by Pasadena Water & Power, you can view the most recent [Power Content Label](#).



ENERGY PORTFOLIO

Combined Heat and Power



In 2003, Caltech replaced its aging 5.5-megawatt (MW) combined heat and power system with a high efficiency 12.5-MW system. A year later, the Institute was awarded the EPA and DOE Energy Star CHP award for the system's high efficiency and low emissions.

Once in operation, our on-site power generation increased by more than 100 percent; however, our total NOx and

CO2 emissions decreased by 17.4 percent. This system meets approximately 60 percent of the campus energy demand.

Technical

- 10 MW Solar Mars gas turbine
- Heat Recovery Steam Generator (HRSG)
- 2.5 MW Steam Turbine Generator (STG)
- Operates on natural gas fuel
- Operates about 330 days per calendar year

Steam Generation and Distribution

- Cogeneration Heat Recovery Steam Generator (HRSG) capacity: 44,500 lbs per hour steam at 300 Psig
- #1 Boiler: 50,000 lbs per hour steam at 285 Psig
- #2 Boiler: 50,000 lbs per hour steam at 285 Psig
- #3 Boiler: 58,000 lbs per hour steam at 285 Psig
- Steam distribution to campus at 55-65 Psig through a 10" and a 4" piping located in the tunnel systems
- Steam condensate returned to plant via a 4" line

Operational

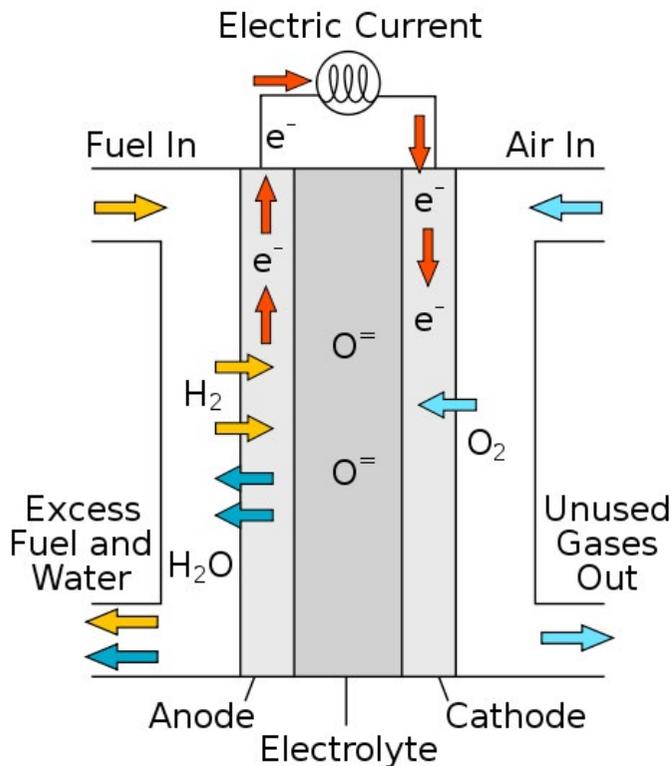
- In 2004, produced about 85–90 percent of campus power consumption
- In 2007, due to campus growth, produced about 74 percent of campus power consumption.
- In 2012, we used about 80 percent of our power on campus, 20 percent is injected to the PWP grid and Caltech buys it back.



ENERGY PORTFOLIO

Fuel Cells

The Chemistry of the Solid Oxide Fuel Cell
 $\text{CH}_4 + 2\text{O}_2 \longrightarrow \text{CO}_2 + 2\text{H}_2\text{O} + e^- \text{ Heat}$



In 2010, Caltech installed the first of twenty solid oxide fuel cells on campus, which each provide 100 kilowatts of base load electricity. These fuel cell energy servers chemically react directed biogas (captured landfill methane emissions) to produce electricity. As a complete system, the fuel cells produce about 17,000 megawatt hours of electricity annually (enough to power 2,300 California homes every year), meeting between 10-20 percent of campus energy demand.

The cells are 88 percent cleaner than the displaced grid power Caltech would otherwise purchase, resulting in as much as 10,000 metric tons of avoided greenhouse gas emissions – roughly equivalent to the amount of carbon sequestered by 2,000 acres of pine forest.

Want to know more about how Caltech's fuel cells work? Check out this [video](#).

Solar Photovoltaic Panels



Street level view of Holliston Solar Array

Caltech has eight solar photovoltaic (PV) arrays on campus capable of producing 1.3-megawatts (MW) of electricity. The arrays are located on three parking structures and five building roofs. The arrays were installed based on power purchase agreements (PPAs) with minimal investment of Institute funds. These agreements provide electricity to the Institute at a lower rate than the City of Pasadena, contributing to utility

budget stabilization as electricity costs continue to rise. With our PPAs, we are able to take advantage of rebates and Federal tax credits for solar energy facilities for which we would not otherwise be eligible. These PV arrays demonstrate our leadership in generating and using renewable energy and reducing the Institute's carbon footprint and impact on climate.



Aerial view of Holliston Solar Array

Caltech finances energy conservation projects through a green revolving loan fund called the Caltech Energy Conservation Investment Program (CECIP). CECIP is the process by which capital to implement energy conservation measures is borrowed from the endowment and, through a rigorous system of measurement and verification, savings are moved from the utility budget back to the endowment.

In a collaborative effort with 32 other leading U.S. institutions, Caltech helped launch the [Billion Dollar Green Challenge](#), an initiative to invest a cumulative total of one billion dollars to fund energy-efficiency upgrades on campuses across the country. Caltech was the first institution to make the commitment to use a self-managed green revolving fund for sustainability improvements as part of the challenge. These profitable investments help create green jobs in campus communities while lowering operating costs on college and university campuses. As part of the Billion Dollar Green Challenge, the Sustainable Endowment Institute has prepared a [case study](#) of CECIP.

To learn more about CECIP, please download our [white paper](#) or review the most recent [annual report](#).

Energy Conservation Measures

Some of our energy conservation measures include:

- Installing motion sensors
- Installing high efficiency lighting
- Re-roofing existing buildings with reflective material to prevent excess heat absorption
- Placing LED signage standard throughout campus
- Increasing diameter of distribution piping to reduce friction
- Installing VFDs on all pumps, compressors, and fans
- Utilizing cycle of concentration methods in cooling towers and participating in the City of Pasadena's energy efficiency appliance replacement program
- Replacing existing air handling equipment with high efficiency chillers and motors

[Click here for a map of our energy efficiency projects](#)

[Click here for our energy conservation measure checklist](#)

We are also aggressively retro-commissioning our buildings to ensure facilities comply with the EPA's EnergyStar Building Program with the goal that 20 percent of buildings on campus be completed each year.

