California Polytechnic State University Greenhouse Gas Inventory

Photo: Poly Canyon Village construction by Kevin Waldron

California Polytechnic State University
Facilities Management & Development
City and Regional Planning Department

Prepared by

Dr. Adrienne I. Greve
Dr. William Riggs
Kai Lord Farmer
Lance Knox
Jana Schwartz

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Introduction

California Polytechnic State University (Cal Poly) initiated an effort to develop a campus climate action plan (PolyCAP) in spring of 2015. A CAP is a strategic plan that identifies ways to reduce greenhouse gas (GHG) emissions and adapt to the unavoidable consequences of climate change.[1] Plan development is built on the development of background data detailing current GHG emissions sources and projected points of vulnerability to climate impacts. Most often, the first step in a climate planning process is development of a GHG emissions inventory. This document describes the inventory of Cal Poly's GHG emissions for the baseline year of 2014. Cal Poly already inventories GHG emissions resulting from buildings operation and university owned vehicles. This inventory expands on these data adding GHG emissions associated with agricultural activities, commute transportation behavior, solid waste, and water treatment.

The GHG Emissions Inventory details the methods and source data used to estimate the GHG emissions resulting from activities associated with campus. Based on the data generated as part of the GHG inventory, the campus can identify an emissions reduction goal, project future GHG emissions, and ultimately develop GHG emissions reduction measures to reach the goal. In the *2014 Sustainability Report* for the California State University (CSU) system, Chancellor White and the CSU board of trustees adopted a policy goal for GHG emissions reduction to 1990 levels by 2020 and 80% below 1990 levels by 2040. These policy goals meet and exceed the state targets of 1990 levels by 2020, 40% reduction by 2030 (SB 32), and 80% reduction by 2050 (EO S- 3-05 & B-30-15). The PolyCAP aims to exceed the CSU mandate and achieve net zero GHG emissions by 2050, in accordance with Cal Poly's signing of the Second Nature Climate Commitment.

The Cal Poly Climate Action Plan is being developed as part of the fourth year community planning laboratory in the City and Regional Planning Department during the 2015-2016 academic year. The GHG Emissions Inventory is the first part in POLYCAP development. A review of relevant federal, state, city, and campus policies were assessed during the fall 2015 quarter. Policies were evaluated for their compatibility with climate goals. In addition to this assessment, campus vulnerability to climate change also was assessed, best practices for addressing campus climate needs identified, and public outreach initiated. In combination with the GHG Inventory, these data provide the basis for POLYCAP development (fig. 1).

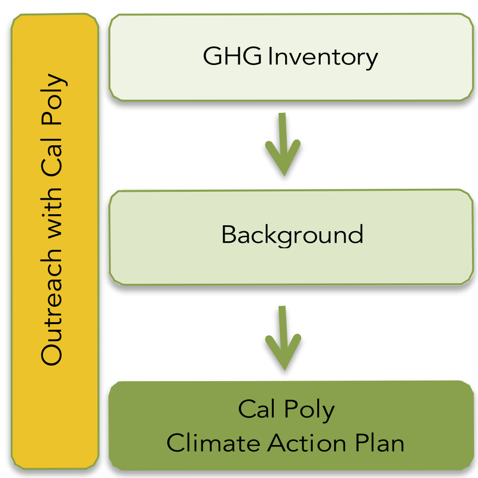

Figure 1. Cal Poly CAP Development Steps

[1] Boswell, MR, AI Greve, & TL Seale. (2012). *Local Climate Action Planning*. Washington D.C.: Island Press, 284 p.

[2] IPCC Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability: Glossary. Retrieved from https://www.ipcc.ch/ipccreports/tar/wg1/518.htm

[3] NASA. (2016). NASA, NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015. Retrieved on 1/21/16

Climate Change

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."[2]

Through a variety of human activities, the increased emission of GHGs into the atmosphere ultimately contributes to a larger percentage of the energy received from the sun remaining within the atmosphere. This increased presence of solar radiation within the atmosphere warms the earth's surface, causing a wide variety of changes to the earth's climate. Through direct measurements and remote sensing from satellites, scientists have observed a warming atmosphere, with the last three decades being successively warmer than any previous decade since records began in the 1850's, with 2015 being the warmest on record.[3]

The increase in the global average temperature results in a series of consequences. There are five direct consequences of increased global temperature: altered temperature pattern, changed precipitation (timing, amount, and form), sea level rise, ocean acidification, and wind or storm events. Each of these direct impacts either alone or in combination have the potential to result in many secondary impacts such as flooding, drought, wildfire, pest outbreaks, increase in disease vectors, habitat shifts, human health consequences, and more. GHGs can remain in the atmosphere for centuries after they are emitted. As a result, taking action to address climate change requires two complementary courses of action: reduction of GHG emissions to limit the severity of future climate change and adaptation to address the impacts that cannot be avoided.

Greenhouse Gas Emissions

The increased levels of GHGs within the atmosphere over the last century has largely been attributed to a variety of human activities which emit GHGs such as carbon dioxide, nitrous oxide, and methane. The most common human activity contributing emissions is fuel combustion from transportation, heating, and energy generation. A challenge in developing an inventory of emissions is quantifying the various types of GHGs, each behaving slightly differently in the atmosphere, and the diversity of activities that result in emissions. CAP development has progressed to where accepted methods have been developed to address both challenges.

GHGs are expressed using carbon dioxide equivalents (CO2e), converting all pollutants that contribute to global warming into a single measurement. CO2e is calculated by multiplying GHGs, methane, nitrous oxide, and fluorinated gases, by their potential role in global warming termed, Global Warming Potential (GWP). The State of California Air Resources Board and the CSU use the conversion factors from the Fourth Assessment Report released by the IPCC[4] (table 1). Based on these conversions all GHG emissions can be compared regardless of source.

2 IPCC Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability: Glossary

3 NASA. (2016). NASA, NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015. Retrieved on 1/21/16

Table 1. The **global warming potential** from the Fourth IPCC Assessment Report (AR4)[4], used by the California Air Resources Board and CSU for the calculation of carbon dioxide equivalents (CO2e)

Gas Name	Formula	Global Warming Potential (AR4)
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298
Fluorinated Gases		124 to 22,800

GHG emissions for a given jurisdiction, such as a campus, are typically divided into scopes (fig. 2). *Scope 1* refers to direct emissions from sources such as machinery or other emissions occurring within the campus boundary. GHG emissions associated with energy purchased from outside providers such as electricity are referred to as *Scope 2*. Finally, *Scope 3* emissions refer to emissions over which the jurisdiction or entity does not have direct control such commute behavior outside entity boundaries.

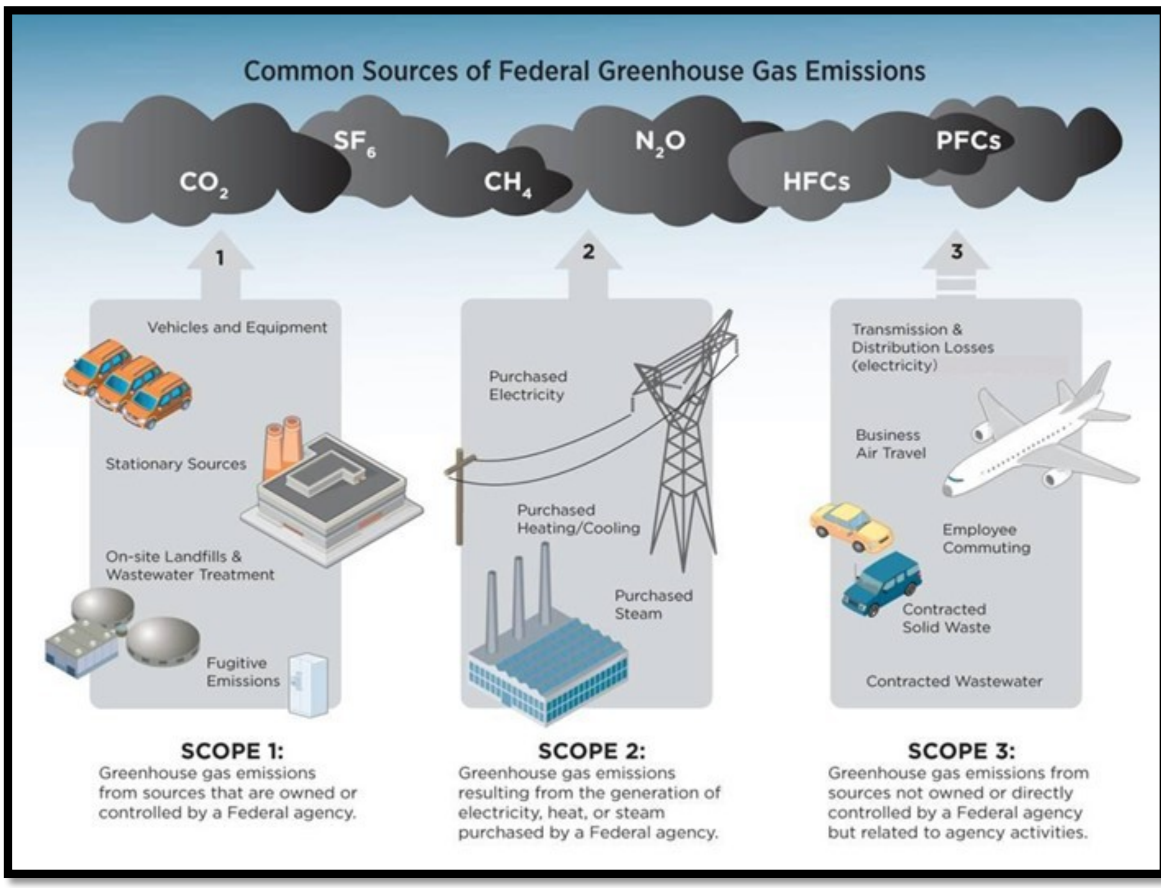

Figure 2. Greenhouse gas (GHG) scopes

[4] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change[Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.
[5] Environmental Protection Agency (EPA). (2015). Greenhouse Gases at EPA. Retrieved on January 15, 2016 from http://www2.epa.gov/greeningepa/greenhouse-gases-epa.

The U.S. Environmental Protection Agency (EPA) develops an annual report called the *Inventory of U.S. Greenhouse Gas Emissions*[6]. The U.S. GHG emissions totaled 6,673 MMTCO2e. GHG emissions were organized by sector, 31% of emissions came from electricity generation, transportation contributed 27%, industrial production contributed 21%, commercial and residential buildings contributed 12% and agricultural operations accounted for nine-percent.[6] Comparatively, California's GHG emissions totaled 459.3 MMTCO2e in 2013 with transportation contributing 37% of emissions; industrial production, 23%; electricity generation, 20%; commercial and residential buildings, 12%; and agricultural activity, eight percent.[7]

The Cal Poly GHG Emissions Inventory report summarizes the methods and totals estimated for activities associated with Cal Poly. Because the inventory is for a campus, there are differences in the contribution of each emissions source. The majority of emissions from Cal Poly are split between buildings (44%) and transportation (52%) with approximately four percent coming from other sectors such as agriculture and solid waste. The total campus GHG emissions were estimated to be 47,114 MTCO2e. This comes to approximately two MTCO2e per capita based on the campus population of students, faculty, and staff (22,997 in 2014). This is a very low per capita emissions rate, but it is helped by the fact that the majority of the Cal Poly community does not live on campus, meaning all emissions associated with off-campus residential activity is not included in this inventory.

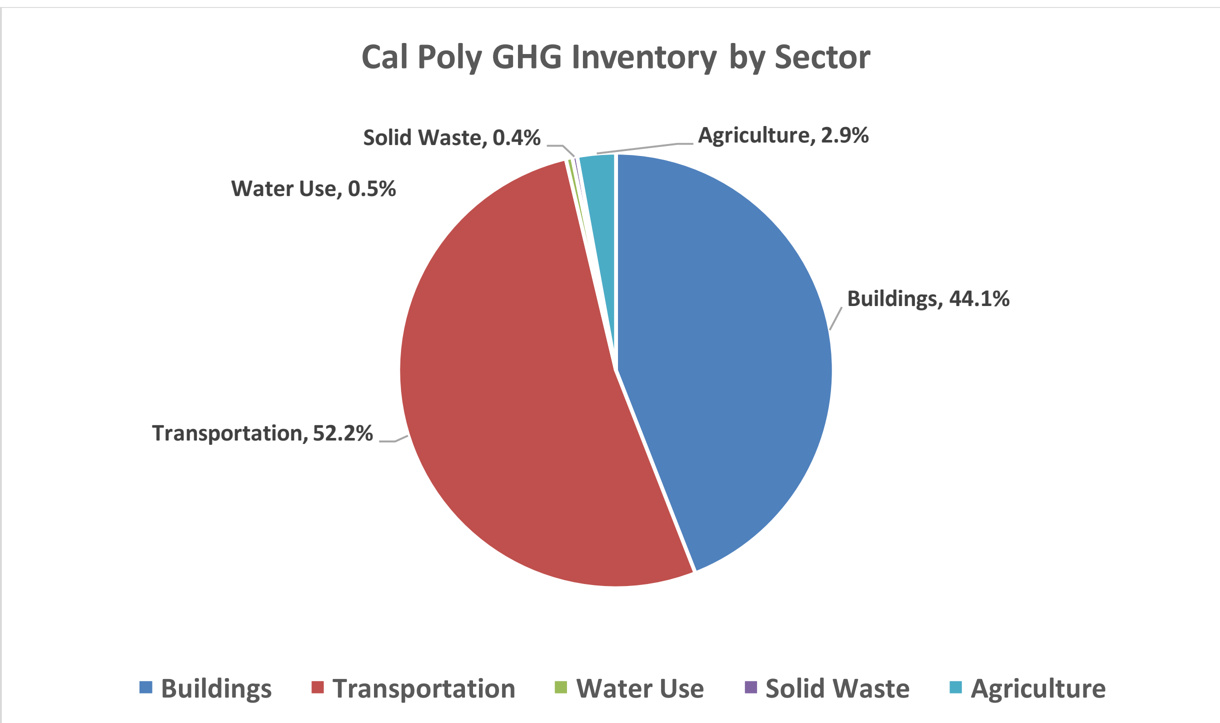

Figure 3. Cal Poly Greenhouse Gas Inventory (2014)

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[6] Environmental Protection Agency (EPA). (2013). EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks Report, 2013. Retrieved on January 20, 2016 from http://www3.epa.gov/climatechange/ghgemissions/usinventoryreport.html.
[7] California EPA & Air Resources Control Board. (2015). Greenhouse Gas Emissions Inventory, 2015. Retrieved on January 20, 2016 from http://www.arb.ca.gov/cc/inventory/data/data.htm.

Campus Climate Planning

There are several generally accepted guidance documents intended to inform communities embarking on development of a CAP. These resources all identify similar critical steps[8]. A climate action planning process relies on a GHG emissions inventory. The inventory typically splits emissions into two broad categories: municipal operations and communitywide. A campus inventory is similar, but has some distinct differences from a municipality. A campus inventory is most similar to a municipal operations inventory as the campus has control over the design and operation of all facilities on campus. What makes a campus inventory distinct from a municipal operations inventory is the existence of residential land uses and the narrow spatial extent of the campus boundaries, which results in commute behavior that occurs outside campus property. In a city, residential areas are included in the communitywide inventory and the majority of commute travel occurs inside the city limits. For a campus, the residential buildings are owned and run by campus facilities, but many aspects of their operation (e.g. water and energy use) are related to the choices of residents. Similarly, the majority of the campus community lives outside campus boundaries and commutes each day. Both of these emissions sources, on-campus residential use and commute, are included in the Cal Poly GHG Emissions Inventory.

The Cal Poly GHG Emissions Inventory, conducted in summer 2015, is organized into the following sectors: Agriculture, Buildings, Solid Waste, Transportation, and Water. The first step in developing an inventory is to identify a baseline year that represents a "typical" operational year. This task was made more difficult for Cal Poly due to the fact that the transportation survey was distributed in 2015. As a result, GHG emissions estimates for daily commute used a baseline year of 2015. Many of the other sectors used a baseline year of 2013 or 2014 as these were the years with complete annual data. Finally, California is in the midst of a four year drought. In response to the drought, agricultural operations have changed (e.g. the number of beef cattle on campus is much lower), meaning 2013 to 2015 do not represent typical years. The agricultural sector used 2010 as the baseline year in some cases.

The specific considerations, steps to acquiring data, and potential data limitations are described in the chapters dedicated to each sector. The chapters are presented in descending order based on estimated GHG emissions: Transportation, Buildings, Agriculture, Solid Waste, Water, and Other. With this GHG Emissions Inventory, there are two companion resources that accompany the document. The first are excel spreadsheets documenting all GHG emissions and the factors and data used to estimate them. The other is a document containing a detailed summary of the findings resulting from analysis of the Travel Survey conducted in Spring 2015.

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[8] Boswell, MR, Greve, AI, and Seale, TL. (2012). *Local Climate Action Planning*. Washington DC: Island Press, 304 p.
California Air Resources Board (CARB). (2008). Climate Change Scoping Plan. Sacrmento: author, 152 p.
Local Governments for Sustainability (ICLEI). (2012). U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Oakland: author, 70 p.
University of New Hampshire, The Sustainability Institute. (2015). Campus Carbon Calculator, v. 8.0. Retrieved on January 5, 2016 from http://www.sustainableunh.unh.edu/calculator

Transportation

Transportation GHG emissions, comprising more than half of all campus emissions, result from the burning of fossil fuels in the engine of a vehicle or plane. Quantifying these emissions requires an understanding of travel behavior, primarily the daily commute of faculty, staff, and students (fig. 4). In addition to commute behavior in private vehicles, this sector includes emissions associated with buses, campus-owned vehicles, and air travel. While Cal Poly keeps detailed records on the fuel consumed by all campus-owned vehicles (including tractors, ATVs, and motorcycles), it does not track emissions from vehicles that support faculty, staff, or student commutes. This data was derived from a campus-wide transportation survey conducted in the spring of 2015.

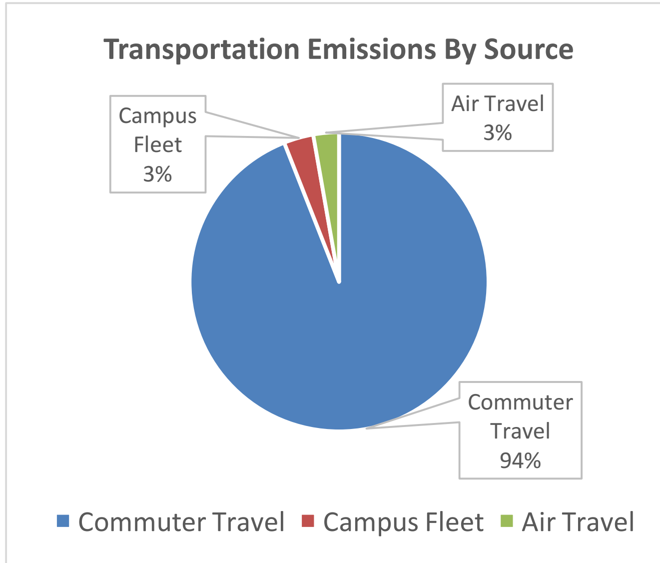

Figure 4. Cal Poly Transportation Emissions (2014)

GHG emissions from private vehicles being operated off-campus are considered Scope 3. Despite these emissions not being directly controlled by campus they have been included for two reasons. First, it is among the GHG emissions sources included in the Campus Carbon Calculator recommended by the CSU for GHG inventory efforts (University of New Hampshire Campus Carbon Calculator, 2015). Second, commute behavior is influenced by campus actions such as parking management, incentives to encourage non-auto-related travel and the provision of on-campus housing for students or affordable housing options for faculty and staff. Despite a lack of direct control, campus actions do strongly influence commute emissions that not only affect the GHG emissions of campus, but also those of the surrounding communities.

The transportation survey represents spring 2015 commute behavior (Appendix A). It was issued to all full and part-time Cal Poly faculty, staff, students and auxiliaries. The total number of responses was 3,961, or 17% of the entire campus population of roughly 23,000. Unsurprisingly, the majority of respondents were students, totaling 68.6%, while the rest were made up of faculty, staff, and visitors. The response rate to the survey yielded results significant at the 99% confidence interval with a margin of error of ± 1.68%. This confidence level assures that the resulting emissions estimate provides a good foundation on which to base policy in a Climate Action Plan.

Interpreting Transportation Survey Results

Figure 5 illustrates a breakdown of the findings from the transportation survey by travel mode. The survey not only asked questions aimed at understanding how the Cal Poly community commutes and moves around on campus, but also the reasons for these transportation choices. Additional information including items such as race, age, gender, and income also were obtained. An analysis of these data are available in a separate report detailing all survey results.[9]

[9] Riggs 2016. CalPoly 2015 Transportation Survey Report. *City & Regional Planning Studios and Projects.* Available at: digitalcommons.

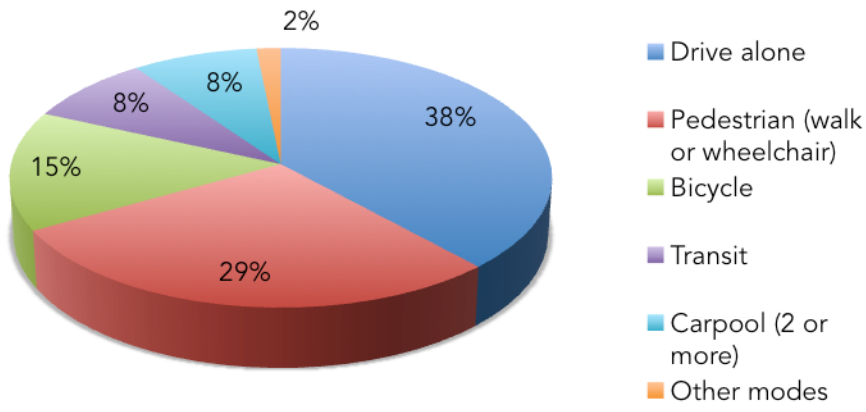

Figure 5. Transportation survey mode share results for Spring 2015

Transportation GHG Emissions

Information that aids in understanding the data represented in the above pie chart include the following (table 2):

- Most campus community members use only one mode of travel (e.g. not multi-modal).
- The periods between 7:30am and 8:30am and 4:30pm and 5:30pm, Monday through Thursday are the most common times for arrival and departure from campus.
- Eighteen percent do not come to campus on Fridays and over 70% do not come to campus on the weekends.
- Most respondents walk or bicycle around campus after they have arrived.
- The most common 'Other Modes' of travel were skateboard and motorcycle.
- Air travel is a very small component of the transportation emissions (less than 1%). Most respondents do not fly within California, domestically, or internationally for Cal Poly-related purposes each year, while those who do average less than 10 trips per year.

Table 2. Travel Mode Split by Cohort Relative to Population Size

	Student	Faculty	Staff / Other	Total
Bicycle	18%	16%	5%	15%
Drive Alone	24%	68%	68%	38%
Carpool / Vanpool	5%	8%	19%	8%
Public Transit (Bus)	10%	5%	4%	8%
Walk	41%	3%	1%	29%
Other	1%	1%	2%	2%

Driver and Vehicle Characteristics

The travel survey not only provided data critical to estimating GHG emissions, but also helpful to understanding commute behavior. These data, particularly regarding private car travel, include the following:

- The predominant type of vehicle coming to campus is a 4-door sedan.
- Sixty-six percent of commuters using a car have a model newer than 2005.
- Roughly 10% of car commuters drive a hybrid or electric vehicle.
- Ninety percent of drivers use campus structures or lots for parking, while others use off-campus street and lot parking.
- Most common "Other" parking space was designated vanpool parking.
- About 87% of all respondents have a campus-parking permit.
- Campus parking structures were utilized, with the Grand Avenue and Facilities parking garages being the most common on campus parking areas.
- Respondents were equally split on whether they frequently must drive around looking for spaces. Of those who frequently look, most spend less than 20 minutes looking.

Of those who bike to campus, 14% do so at least five days per week (table 3). Most of those who bicycle, drive alone, and walk, use these respective modes at least five days per week. This is unlike those who vanpool or use public transit, with most these commuters using these transportation modes only one day per week or less.

Table 3. Travel mode by days of the week (percent and number of responses)

	Never Use this mode	Less than once per	1-2 days per week	3-4 days per week	5+ days per week	Responses
Bicycle	63.4 % 2,099	10.1 % 334	6.2 % 204	6.4 % 213	14.0 % 463	3313
Drive Alone	31.2 % 1,132	16.5 % 597	11.4 % 414	13.1 % 475	27.7 % 1,005	3623
Carpool / Vanpool	56.7 % 1,838	21.2 % 688	12.6 % 409	4.9 % 159	4.5 % 145	3239
Public Transit	64.9 % 2,066	15.6 % 496	7.3 % 231	6.4 % 204	5.8 % 186	3183
Walk	41.1 % 1,333	12.5 % 405	7.0 % 227	5.9 % 193	33.5 % 1,088	3246
Other	91.6 % 2,500	4.4 % 119	1.5 % 40	0.7 % 20	1.8 % 50	2729

GHG Emissions Calculation

The total GHG emissions resulting from transportation-related activities result from four different activities. The clear majority of the total GHG transportation emissions were generated during the daily commute for faculty and staff in private vehicles. Other emissions result from city buses, work-related, non-commute vehicle trips to areas such as San Francisco Bay, Los Angeles, or other California cities. For those who do not drive, but take the bus, emissions resulting from bus travel on campus was included. Finally, GHG's generated from air travel associated with campus activities (e.g. conference and research travel for faculty) were estimated

Commute Using Private Vehicles

The transportation survey (Appendix A) asked respondents to provide the nearest intersection to their residence. This location was then geo-coded using standard geo-spatial software and the network distance (through the existing road network) was determined. A standard Institute of Transportation Engineers (ITE) factor was also used to account for any 'linked' trips beyond the standard commute.

The resulting distances were then averaged to provide an average commute length. The total number of trips was taken directly from the percentage of respondents who reported driving to campus in the campus survey and applied proportionally to the campus population. For those who drive alone two trips are assumed per day however for carpoolers there are assumed to be two occupants, the number of trips was divided in half (table 4). The average vehicle miles traveled (VMT) to campus was roughly 17.4 miles. The total VMT was calculated by multiplying the total number of trips by the average VMT. Only one adjustment was made for the academic calendar, 260 vs. 365 working days per year were assumed. In addition to the daily commute, it was assumed that 50% of Faculty and 10% of Staff make a trip of at least 200 miles via light duty automobiles at least once per year. This yields roughly 802 trips per year of 200 miles each.

The travel survey allowed for total number of trips and the total vehicle miles traveled (VMT) to be estimated. The average GHG emissions per VMT are required to estimate total emissions. This is based on the fuel efficiency of commute vehicles. Because many vehicles represented in the survey are likely registered in San Luis Obispo County, the "typical" vehicle was defined using DMV registration for the county (SLOCOG/EMFAC standard). This yields a factor of 305.9 gCO2e/mile. The use of this factor was chosen because it is regularly updated by the local regional transportation agency (SLOCOG) and will allow for consistent commute-related GHG emissions estimates in future years.

Table 4. Data and factors used to estimate GHG emissions associated with commute by private vehicle or carpool/vanpool.

Variable	Amt.	Year	Notes
Average Trip Length (miles)	17.4	2015	Calculated from 2015 Travel Survey using ArcGIS
Average Daily Automobile Trips	13,727	2015	From Travel Survey; assume 2 trips/day
Average Daily Carpool Trips	1,273	2015	From Travel Survey; assumes 2 trips/day & 2 pal/cars
Average Daily Vanpool	10	2015	Based on Cal Poly Vanpool Data
Number of work days/year	260	2015	Based on academic year
Annual number of in-state trips by faculty or staff of 200 mi	802	2015	Assumes 50% of faculty & 10% of staff
GHG Emissions (CO2e g/mile)	305.9	2014	Light Duty Autos (SLOCOG, 2015)
TOTAL (MTCO$_2$e)	23, 138		

Buses

To calculate bus trips, the average number of weekly bus trips and the segment length of those trips on the campus were used. The number of weekly trips based on 2015 estimates was 840. This was normalized to a daily rate by dividing by 7. This does not include routes served the Regional Transit Authority (RTA), which serves the campus population but does not come on to campus property. The segment length for each bus trip within campus boundaries was calculated using GIS as 1.4 miles. This was used to calculate daily bus VMT. Since buses make a circular route through the campus, there is no 'return' trip. GHG emissions were calculated using the 2014 SLOCOG standard for urban bus diesel of 2,497 gCO2e/mile. The total GHG emissions attributed to bus travel on campus were 154.2 MTCO2e (table 5).

Table 5. Data and factors used to determine GHG emissions associated with bus commute behavior.

Variable	Amt.	Year	Notes
Number of Bus Trips	10	2015	Average based on current bus schedule
Segment Length on Campus (Mi)	1.25	2015	Estimated using GIS
GHG Emissions (CO2e g/mile)	2497.0	2014	Urban Bus Diesel (SLOCOG, 2015)
TOTAL (MTCO$_2$e)	**154**		

Air Travel

The transportation survey asked respondents to estimate the number of air travel trips they had taken during the most recent school year for campus purposes. This number of trips was just under 5,000 total trips of varying lengths (table 6). The resulting scope three GHG emissions from these trips were quite small, but for completeness of transportation data they have been included.

Table 6. GHG emissions resulting from Cal Poly related air travel trips in a single year.

Air Travel Type	gCO2e/mi[10]	Assumed Distance (mi)	Number of Trips	GHG Emissions (gCO2e)	GHG Emissions (MTCO2e)
Long Haul	0.0030384	2200	254	103,379,594	103
Medium Haul	0.0030824	863	2240	442,638,699	442
Short Haul	0.0031304	431	1138	136,005,659	136
TOTAL (MTCO2e)				682	

Fleet

Fleet refers to vehicles owned and operated by campus and campus employees. Fleet includes licensed (can be used off campus) and unlicensed vehicles such as golf carts, tractors, ATVs, and motorcycles. These vehicles burn unleaded gasoline, diesel, or propane. Different from the commute GHG emissions, fleet emissions can be more accurately estimated using fuel usage (table 7). Because most campus-owned vehicles are fueled on campus, the total fuel used can be the basis for GHG emissions estimates.

Table 7. GHG Emissions Associated Campus Vehicle Fleet (vehicles, trucks, ATVs, tractors, etc.)

Fuel Type	Gallons	$MTCO_2e$/gal[11]	Year	MTCO2e
Unleaded gasoline	49,715.00	0.0089	2013	442
Diesel	29,858.70	0.0102	2013	303
Propane	7,721.20	0.0058	2013	45
TOTAL ($MTCO_2e$)		790		

[10] Environmental Protection Agency (EPA). (2008). TERC Intermodal Emissions Calculator. Retrieved on 1/15/2026 from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjx146N88jKAhUQ0mMKHQUjAeYQFggdMAA&url=http%3A%2F%2Fwww.tercenter.org%2FIntermodalEmissionsCalculator.xlsx&usg=AFQjCNFhBr2cbN0ocD6w2WrhJrOqYKH70Q&sig2=kFX8GyUQ6WCMnKd-PAXNY

[11] California Air Resources Board (CARB). (2014). California's 2000-2012 Greenhouse Gas Emissions Inventory Technical Support Document. Sacramento: author, 168 p. http://www.arb.ca.gov/cc/inventory/doc/methods_00-12/ghg_inventory_00-12_technical_support_document.pdf

Buildings

Energy generated outside campus, electricity, natural gas as well as stationary operations such as pumps or generators that run-on propane or diesel are included in the Buildings sector. While the campus has a growing number of renewable energy projects (e.g. solar and cogeneration), these do not factor into an estimate of GHG emissions save for reducing the amount of energy brought in from elsewhere (scope two emissions). Data needed to estimate GHG emissions for this sector were the amount of energy used such as kWh of electricity or gallons of fuel.

The various energy sources are used for a wide variety of operations such as heating and lighting all buildings on campus. In addition, any campus operation that uses energy falls into this category such as exterior lighting, operation and heating of the pools, powering of electric pumps for agricultural field irrigation and any other campus operation requiring electricity or other energy. These operations are closely monitored, because the campus must pay an external supplier for them. The resolution of the data allows for precise GHG emissions estimates (Table 8). While water is used in buildings and has GHG emissions associated with its treatment and delivery, these emissions are accounted for in the Water section.

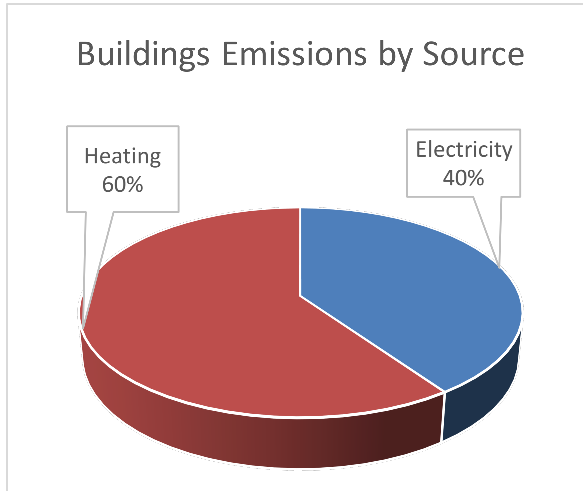

Figure 6. Building GHG emissions breakdown by energy source.

Table 8. GHG Emissions from buildings operation and stationary operations

Imported Energy	Year	Annual total	Factor[12]	$MTCO_2e$
Electricity (kWh)	2013	43,080,017	.194 $MTCO_2e$/MWh	8358
Natural gas (therms)	2014	2,329,402	0.00531 MT CO_2e/therm	12,369
Diesel (therms) -	2014	1441	22.38 lbs CO_2e/therm	15
Propane (gal) - stationary	2014	6608	12.7 lbs. CO_2e/gal	27
TOTAL ($MTCO_2e$)		20,759		

For policy development, much greater detail will be necessary to identify the actions that result in energy use such as heating and lighting preferences of building occupants. The buildings will be evaluated during PolyCAP development by use (e.g. residential, laboratory, administrative, etc.), connection to the utilidor, age, and more. Also, hidden within the above table, is the amount of electricity produced on campus. Over two and a half million kilowatt hours are produced annually through co-generation facilities and more than a quarter million are generated via solar energy installations on campus.

12 Pacific Gas and Electric (PG&E). (2015). Greenhouse Gas Emissions Factors. Retrieved on January 15, 2016 from http://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf Cal Poly. (2014). Strategic Energy Plan. San Luis Obispo: author. 66 p.

Agriculture

The Agriculture sector of the inventory accounts for GHG emissions associated with agricultural operations on the university campus. The emissions estimates for this section include GHG emissions from a variety of agricultural operations focusing on four key components: methane production through **enteric fermentation** from livestock; nitrous oxide emissions from **fertilizer application;** methane emissions produced from livestock waste **lagoons;** and methane produced during **compost management**. The GHG inventory focuses on agricultural operations conducted within Cal Poly's "Main Campus" and does not include the universities associated ranches and properties. Cal Poly owns and operates considerably more agricultural land than is being included in this inventory (Swanton Ranch, Bartle son Ranch, etc.). The PolyCAP team chose to limit the scope of the inventory to include only agricultural operations on the Main Campus because these areas are part of the College of Agriculture Food & Environmental Sciences (CAFES) and are directly influenced by campus operations. The main campus has less influence over the operational choices made on the associated properties.

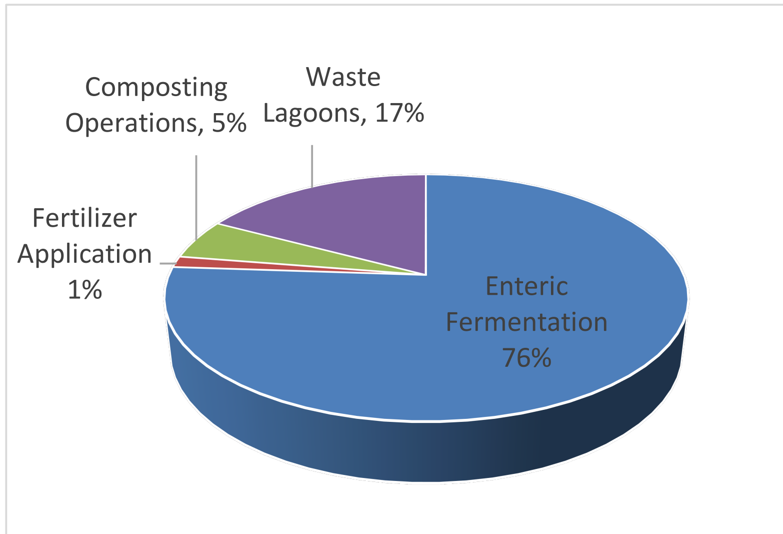

Figure 7 - Agricultural Emissions by Source (Total: 1,344 MTCO2e)

Agricultural operations include sources of GHG emissions accounted for by other sectors such as water use and vehicle operations that are included as part of the Water and Transportation sectors. For all calculations included in this section of the inventory, the California Air Resource Board's (CARB) 2014 Greenhouse Gas Emissions Inventory Technical Support Document, which details methods for quantifying agricultural GHG emissions, was used. During the inventory process, various faculty and staff within the CAFES were consulted and provided data. It was through these discussions that appropriate years to serve as a baseline representing typical operations were chosen. Using agricultural operations data and calculation methodology from the CARB Support Document, GHG emissions for four components of agricultural operations on the campus were compiled. As a percentage of the campus total, agricultural operations on campus accounts for 3.50% of the total. It is the largest emitter outside of the Buildings and Transportation sectors.

There is no single source that tracks the number of livestock animals on campus. The numbers below represent efforts to obtain accurate numbers for a typical year of agricultural operations, but these estimates may be improved in future updates to the GHG Emissions Inventory. When the baseline year is listed as 2010 in table 9, the data reflects units that have adjusted operations due to the drought such as reducing total animal numbers. In other cases such as compost and lagoon operations, the campus keeps careful track of total mass and volumes of waste as these operations are subject to regulations. In these cases, data were examined to determine that 2014 was an appropriate year to use as a baseline. Fertilizer application posed a different problem in that it was not carefully tracked. Data for several fields for 2014 were obtained, but not all. These data were the only information available and are used for baseline in the absence of more refined information.

Table 9. GHG Emissions from Enteric Fermentation[12]

Animal Type	Year	# of Animal	kgCH4/head/year	Total kg of CH4/year	Annual CH4 (MT)	MTCO2e
Dairy Cows (Confined)	2010	167	128	21376	21.4	534.4
Beef Cattle (Confined)	2010	39	53	2067	2.1	51.7
Sheep	2012	89	8	712	0.7	17.8
Goats	2015	73	5	365	0.4	9.13
Swine	2010	7	1.5	10.5	0.01	0.26
Horses	2010	100	18	1800	1.8	45.00
Beef Cattle Grazing*	2010	275	53	14575	14.6	364.4
TOTAL (MTCO2e)						1023

*Estimate

Table 10. GHG Emissions from Composting Operations[12]

Animal Type	Total VS (kg)	g of Methane/Yr	Annual CH4 (MT)	MTCO2e
Dairy Cow (Confined)	464800	2481273.45	2.48	62.03
Beef Cattle (Confined)	25584	82746.34	0.083	2.07
Horses	100300	262938.46	0.26	6.57
TOTAL (MTCO2e)			71	

Table 11. GHG Emissions from Fertilizer Application[13]

Field	Year	Fertilizer Type	kg N applied	kg N_2O Direct	kg N_2O Indirect	MTCO2e
Orchards	2015	Synthetic	1496.4000	23.51	9.99	9.98
Chorro Creek	2014	Calcium Nitrate	1299.9	20.5	4.1	8.71
Silage Fields						
Field 25	2014	Calcium Nitrate	10.88	0.17	0.073	0.07
Field 29	2014	Calcium Nitrate	65.30	1.03	0.438	0.44
Field 45	2014	Calcium Nitrate	24.49	0.39	0.164	0.16
Gallo Vineyard	2014	Various	7.21	0.11	0.048	0.05
Trestles Vineyard	2014	Various	32.47	0.51	0.218	0.21
TOTAL ($MTCO_2e$)					20	

Table 12. Agriculture Department - GHG Emissions from Waste Lagoon Operations[12]

Animal Type	g of Methane/Yr	Annual CH4 (MT)	MTCO2e
Swine	323705.29	0.32	8.09
Dairy Cow (Confined)	8849875.29	8.85	221.25
Beef Cattle (Confined)	82746.34	0.083	2.07
TOTAL (MTCO2e)		231	

[13] All GHG calculation based on equations provided by: California Air Resources Board (CARB). (2014). California's 2000-2012 Greenhouse Gas Emissions Inventory Technical Support Document. Sacramento: author, 168 p. Retrieved on 1/15/2016 from http://www.arb.ca.gov/cc/inventory/doc/methods_00-12/ghg_inventory_00-12_technical_support_document.pdf

Water/Wastewater

The Water sector of the GHG emissions inventory focuses on the GHG emissions associated with all water use on the university campus. In 2014, the Cal Poly community included nearly 23,000 students, faculty and staff with over 7,000 undergraduate students living in on-campus residential halls. Along with agricultural operations in the CAFES, the Cal Poly campus consumes a considerable amount of water annually. The emissions associated with water use on campus include all energy used for collecting, extracting, conveying, treating, and distributing water to the campus as well as the energy demand for treating and disposing of the wastewater. Water use for the campus is organized into four basic categories. Agricultural uses include all water used for crop irrigation and livestock facilities. Campus landscaping includes water used to irrigate the areas around the buildings in the campus core. All water used in residential and academic facilities including sinks, toilets, showers and campus dining facilities is labeled domestic use. Facilities uses water for the central plant heating and cooling operations.

The POLYCAP team received Cal Poly water use data from Eric Veium[14] for the years 2013 and 2014. Cal Poly's water-related GHG emissions were calculated for the year 2013. Considering the variety of water uses on the Cal Poly Campus (Agriculture, Landscaping, Domestic Use, Facilities), one key consideration in conducting the calculations was what energy demands were associated with specific water uses. For instance, calculations for outdoor water uses such as irrigation did not included energy demands for the treating and disposing of wastewater.

As a percentage of the campus' total GHG emissions, water use on campus accounts for only one third of a percent of GHG emissions. However, water plays a critical role in positioning campus for preparing for the future in the context of climate change. Many the measures that increase resilience to events such as drought, also reduce GHG emissions by reducing the amount of water that must be conveyed and/or treated.

Table 13. GHG emissions associated with water use on campus

Cal Poly Water 2013	Total Annual Use (millions of gallons)	Total Energy Use (MWh)	MTCO2e
Ag. Use			
Ag. Well Pumps	98.6	0.0*	0.0*
Whale Rock Reservoir	154.5	206.3	40.3
Landscaping			
General	99.0	272	52.8
Sports Field Complex	25.8	34.5	6.7
Domestic	81.2	329.0	64.37
Facilities	6.5	35.0	6.93
Total			**171**

[14] Personal Communication, July 2015, Cal Poly Facilities Services Energy and Sustainability Analyst

*Ag. Well Pump energy use accounted for in Buildings Sector

Solid Waste

With a campus population of almost 23,000, the Cal Poly community produces a considerable amount of solid waste each year. In 2013, the campus produced approximately 7,440 tons of solid waste material to be either recycled or sent to the Cold Canyon Solid Waste Disposal Site. In an effort to reduce and divert this waste, Cal Poly's Facilities Services uses an integrated waste management system which includes source reduction, recycling, green waste, resale of scrap metal and surplus equipment, and zero waste event catering. Considering the measures in place, the university saw 72% of the waste produced on campus diverted from being sent to landfills in 2013. In the same year the campus produced 2,062 tons of solid waste that was sent to Cold Canyon Solid Waste Disposal Site (SWDS). Through biodegradation, the disposal of solid waste produces GHG emissions, contributing to the Cal Poly campus's overall GHG emissions.

The Solid Waste section of the inventory focuses on GHG emissions related to all solid waste disposal on the university campus. This inventory accounts for all biodegradable, carbon-bearing waste that is not diverted and is sent to a Solid Waste Disposal Site (SWDS) from the campus. Carbon-bearing waste sent to a SWDS degrades mainly through anaerobic biodegradation generating CH_4 (Methane) as a byproduct. Currently, under the California Global Warming Solutions Act ("AB 32"), the state requires all SWDS's in the state to install landfill gas collection and control systems, capturing a portion of the gases produced in the decomposition of biodegradable, carbon-bearing waste. This Solid Waste GHG inventory accounts for the total CH_4 emissions produced by the campus's solid waste that is not captured in the gas collection and control system.

Using the California Air Resource Board's *Greenhouse Gas Emissions Inventory Technical Support Document*[15] to guide inventory calculations, methodology consistent with the EPA and IPCC protocols for greenhouse gas emissions inventories was used. The POLYCAP team received recycling and solid waste data for the year 2013 from Eric Veium, the Energy and Sustainability Analyst for Facilities Services. The team also consulted Brian Aunger, engineer with the SLO County Air Pollution Control District Brian, to obtain the methane capture efficiency for Cold Canyon SWDS. Using methane capture efficiency data, the EPA Cold Canyon Landfill's emissions inventory for 2013 and the CARB's methodology, the POLYCAP team calculated the GHG emissions associated with Cal Poly's solid waste disposal for the year 2013.

In 2013, the Cal Poly campus produced 2,062.67 tons of solid waste sent to Cold Canyon Landfill. Accounting for the landfills gas collection and control systems, this solid waste emitted 9.07 Metric tons of methane. The total GHG emissions associated with the universities solid waste disposal for the year 2013 was 227 MtCO2e. As a percentage of the campuses total GHG emissions, solid waste produced on campus accounts for .59% of the total GHG emissions.

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[15] California Air Resources Board (CARB). (2014). California's 2000-2012 Greenhouse Gas Emissions Inventory Technical Support Document. Sacramento: author, 168 p. Retrieved on 1/15/2016 from http://www.arb.ca.gov/cc/inventory/doc/methods_00-12/ghg_inventory_00-12_technical_support_document.pdf

Table 14. Source data and conversion factors for solid waste GHG emissions estimation

Quantity	Total (Metric Tons)	Year
Cold Canyon Total Annual Waste Disposal	136,364.38	2013
Annual Modeled Methane Generation	599.9	2013
Methane emission per Ton of Solid Waste	0.004	2013

Table 15. GHG emissions associated with solid waste

Quantity	Total (Metric Tons)	Year
Total Solid Waste Sent to Landfill (Cold Canyon)	2,062.67	2013
Total Annual Methane Emissions	9.074	2013
Total CO2e	227	2013

* Cold Canyon GHG Inventory Report 2013 (EPA)

Other Sources

Sports fields and other landscaped areas on Cal Poly's campus result in GHG emissions due to water use and fertilizer application. The water use is included in the Water sector above. The fertilizer used is treated separately because all other calculations regarding fertilizer were agricultural. Because the sports fields and landscaped areas are operated and managed by a different entity than the fields in the CAFES, it is quantified separately. The calculation is similar to that for fertilizer use on agricultural fields (table 16).

Table 16. GHG emissions associated with landscaping fertilizer

Type	Year	kg N (synthetic)	kg N_2O Direct*	kg N_20 Indirect*	Total kg	$MTCO_2e$
Landscaping Fertilizer	2015	950.7	14.9	1.4	16.3	**4.45**

GHG Projections and Reduction Targets

A GHG emissions inventory is the first step in the larger climate planning process. The data provided in the inventory is used as the basis for development of GHG emissions reduction measures. The development of measures is preceded by several steps including a series of additional projections that are used to determine the reductions that need to be achieved through the measures in the climate plan. The first projection calculated is termed a 'Business as Usual' (BAU) projection. This projection assumes no changes to the relative energy efficiency of campus or other state or federal laws that influence GHG emissions. The BAU examines how projected growth may influence future GHG emissions if no reduction actions are taken. This is a worst-case scenario. For campus, this projection was developed based on future enrollment levels. Faculty and staff campus population were increased proportionally with students based on projections included in the Cal Poly 2035 Master Plan. Based on specific growth assumptions for each emissions sector on campus, a future emissions projection was calculated through the year 2050.

In addition to the BAU projection, the CSU 2040 GHG emissions reduction target can be graphed (fig. 7). The 2040 target allows for measurement of the amount of GHG emissions that must be reduced through a combination of federal, state, and campus actions. These actions that influence campus emissions allow for development of an Adjusted Business-as-Usual forecast (ABAU). The reductions that must be achieved by the campus is the difference between the ABAU and the emissions target. Based on the BAU and ABAU 2050 projections, the Cal Poly campus must reduce annual emissions by 37,692 MTCO2e to reach the CSU 2040 Target.

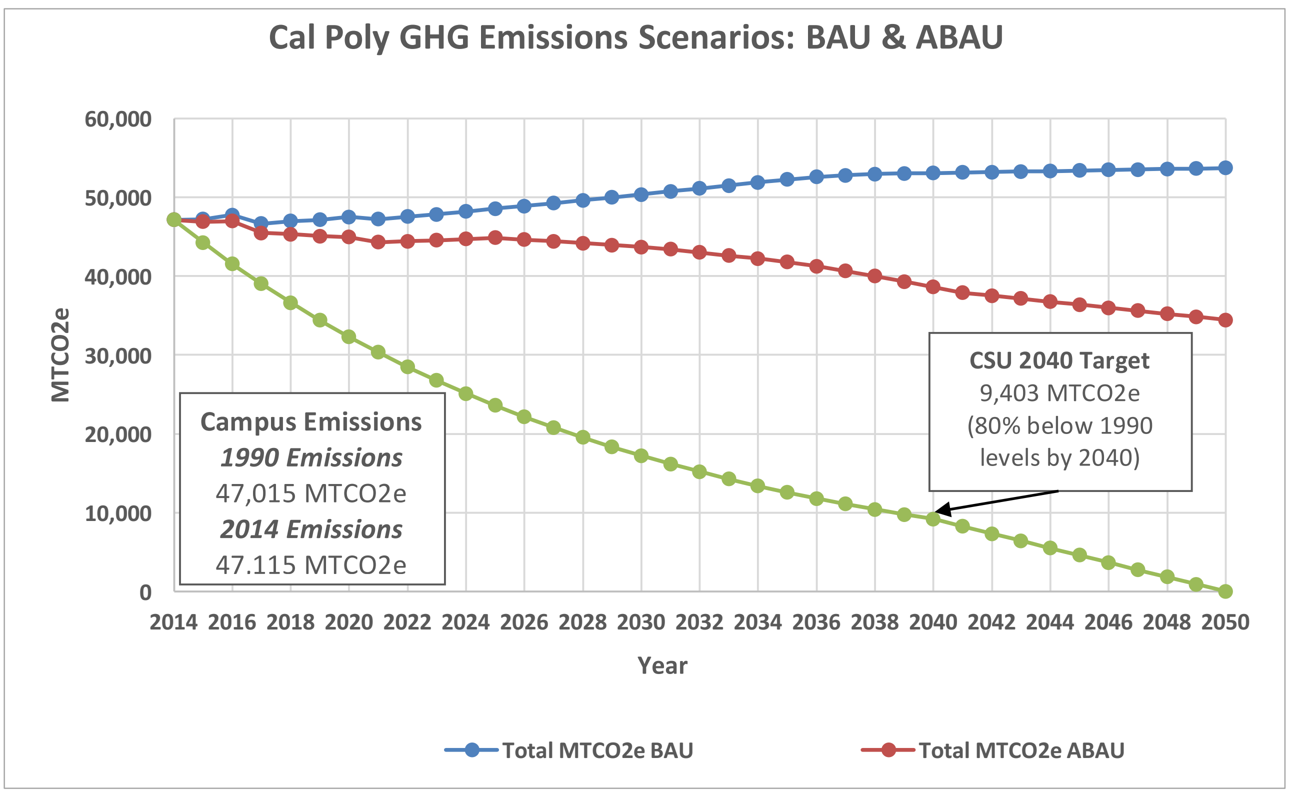

Figure 8 - Cal Poly Emissions Forecast