Solar Energy Assessment of California State University, Chico

Jordan Alm

Department of Geological and Environmental Sciences, CSU, Chico

ABSTRACT

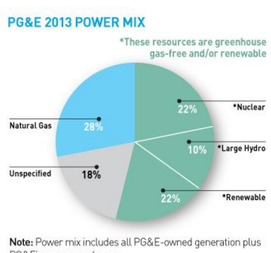
Ensuring a sustainable future is a core mission of CSU, Chico after Dr. Paul Zingg became one of the founding signatories to the American College and University Presidents' Climate Commitment (ACUPCC). The ACUPCC is an agreement to achieve total climate neutrality by the year 2030. Currently, a huge portion of our greenhouse gas emissions result from the energy needed to heat, cool, light and support the plug loads of CSU, Chico. Over the '14/'15 fiscal year our energy consumption amounted to just over 23,300 MWh to meet the energy needs of a fully functioning college campus. A majority of that energy comes from fossil fuel sources which are primary contributors to greenhouse gas emissions that are keeping us from our net neutrality goal.

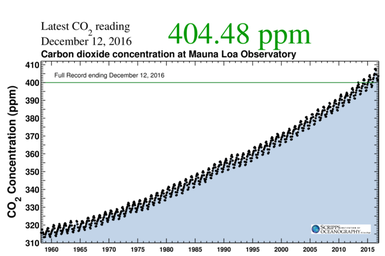
We can drastically reduce the emissions and cost associated with powering CSU, Chico by installing solar panels on unused rooftops. I performed a solar energy assessment of CSU, Chico in an attempt to see how much energy we could offset from that 23,300 MWh total. Using Google Earth Pro and a solar energy calculator provided by the National Renewable Energy Laboratory I calculated that, using just the unused rooftop space on campus, CSU, Chico could install a 6533 kW solar array to offset a proportion of power we consume on campus. The conclusion of my research is that a 6533 kW system has the potential to produce 9,950 MWh per year, nearly 43% of the total power consumption in the '14/'15 fiscal year.

INTRODUCTION

CSU, Chico currently purchases power from Pacific Gas and Electric company. Pacific Gas and Electric has a combined grid mix of power sources, 68% of them being non-renewable fossil based or nuclear sources. Atmospheric carbon dioxide is an unfortunate but necessary byproduct of fossil fuel combustion for power generation coming from that 68%. Climate scientists and lawmakers have all begun to realize the significance of increasing greenhouse gas concentrations due to anthropogenic sources and what that could mean for the climate of the planet. Relying on finite resources like fossil fuels for a predictably constant or growing factor like energy consumption impacts the security and energy independence of any economic, industrial or residential entity.

Photovoltaic cells, or solar panels, are a power generation source that requires no continual resource consumption and does not emit harmful pollutants or carbon dioxide while generating power. Solar panels have become much more technologically advanced within the last decade, which has increased the efficiency and economic viability of solar panels on the market. Utility companies are even offering rebate programs to facilities that incorporate solar energy production in order to meet environmental goals set by the State of California. The technological, economic and legislative climate for on-site solar power generation has never been better.





Left: PG&E's power grid mix, unspecified refers to its power purchases. Right: the Keeling Curve from Mauna Loa Observatory that shows the increasing carbon dioxide concentrations that now exceed the landmark 400 parts per million.

METHODS

- Rooftop area was calculated by creating polygons over the rooftops of the buildings at CSU, Chico with Google Earth Pro (purple regions below).
- The total area was used to determine the system size of a theoretical solar array that could be installed on the rooftops of CSU, Chico.
- A solar calculator was used to determine the potential system energy output based on the average solar irradiance per month, measured at a weather station in Sacramento.
- The National Renewable Energy Laboratory recommends making system calculations with a 14% solar irradiance capture rate in our area due to system losses.
- The resulting AC energy output of the theoretical solar system was compared to the historical energy use of CSU, Chico over the last fiscal year.

- Image of the polygons (pink) placed over the rooftops of CSU, Chico in Google Earth Pro to establish available rooftop area.

RESULTS

Building	Rooftop Area (square feet)
Student Services Center	19479
Bell Memorial Union	30000
Performing Arts Center	41134
Meriam Library	57754
Physical Science Center	25716
Kendall Hall	13218
Ayres Hall	27130
Colusa Hall	10363
Glen Hall	10597
Siskiyou	19333
Langdon	23330
O'Connell Engineering Center	12920
Trinity Hall	6168
Plumas Hall	21626
Tehama Hall	9963
Whitney Hall	9790
UHUB	3118
Sutter Hall	13431
Student Health Center	8057
Shasta Hall	8376
Lassen Hall	8368
Housing and Food Services	3047
Butte Hall	8939
Sylvester's Café	5600
WREC	44650
Vesta Holt Hall	25363
Modoc Hall	13448
Aymer J. Hamilton Building	21391
Total Rooftop Square Footage	502309

The rooftop area of every building was totaled to 502,309 square feet. That area was converted to square meters for convenience of calculation. Before calculating for system losses, each square meter of rooftop space increased the system output capacity by 1kW. According to the National Renewable Energy Laboratory a 14% capture rate is a standard predictive measure when determining the system size of a solar array. The resulting system size for the area available at CSU, Chico was 6533 kW. A system size of 6533kW represents the maximum amount of power that can be generated by the solar panels at any given moment. The system output capacity is multiplied by the solar radiation, which fluctuates throughout the year, in order to determine the energy harnessed by the system.

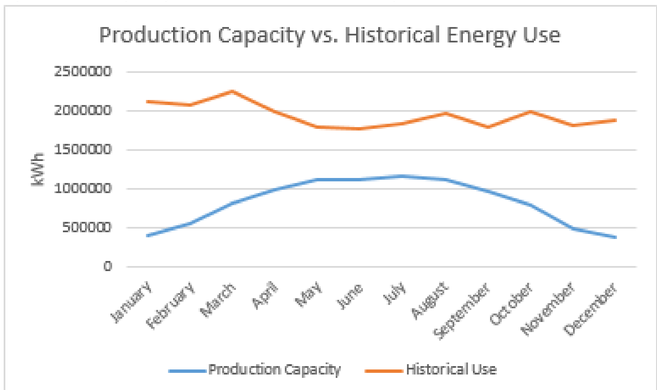
RESULTS

Month	Solar Radiation (kWh/m^2/day)	Harnessed Energy (kWh)	Energy Value [$0.14/kWh] ($)
January	2.42499042	408693	57,544.01
February	3.79984927	562059	79,138.02
March	5.01207018	813597	114,554.50
April	6.41797733	985775	138,797.23
May	7.32695198	1124885	158,383.83
June	7.68374348	1120164	157,719.13
July	7.8894558	1167765	164,421.35
August	7.54219866	1120683	157,792.11
September	6.69728804	974635	137,228.53
October	5.08942795	787594	110,893.36
November	3.1753459	494036	69,560.41
December	2.33704209	386636	54,438.33
Total		9946522	1,400,470.81

The above table shows the energy produced by the solar panels each month, along with the monetary value of that energy.

Month	Harnessed Energy (kWh)	Historical Use (kWh)	% Produced compared to use
January	408693	2,113,172	0.193402619
February	562059	2,081,851	0.269980416
March	813597	2,260,179	0.359970162
April	985775	1,986,605	0.496210872
May	1124885	1,797,204	0.625908355
June	1120164	1,773,182	0.631725339
July	1167765	1,837,862	0.635393191
August	1120683	1,962,547	0.571034987
September	974635	1,791,699	0.543972509
October	787594	1,990,174	0.395741277
November	494036	1,826,238	0.270521148
December	386636	1,879,329	0.205730875
Total	9946522	23,300,042	0.426888587

The above table shows a comparison between historical energy use and the production capacity of the theoretical solar array.



Above is a graphical representation of the solar production capacity versus the campus's historical use over the year.

CONCLUSION

During the summer months, CSU, Chico is capable of generating more than half of the electrical power used. However, during the winter months when the sun angle is low and the days are shorter the solar array would only be capable of producing 20%. On an annual basis the integrated electrical production potential is about 43%. The energy produced would be non-polluting, reliable and in line with the climate goals of CSU, Chico. Taking advantage of the unused rooftop area for solar power would be a huge step in reaching our 2030 climate neutrality goal.

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