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Contra Costa CCD Electrification Study

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Table of Contents

Table of Contents

INTERFACE ENGINEERING

0.

Introduction

Introduction

The purpose of this study is to support the Facilities Master Plan for the Contra Costa Community College with a district-wide electrification plan. The plan provides an analysis of how electrifying the district's natural gas heating systems and deploying renewable energy systems will reduce the district's energy consumption and carbon footprint, as well as alleviate the burden of having to maintain, and rely on, old gas lines and infrastructure.

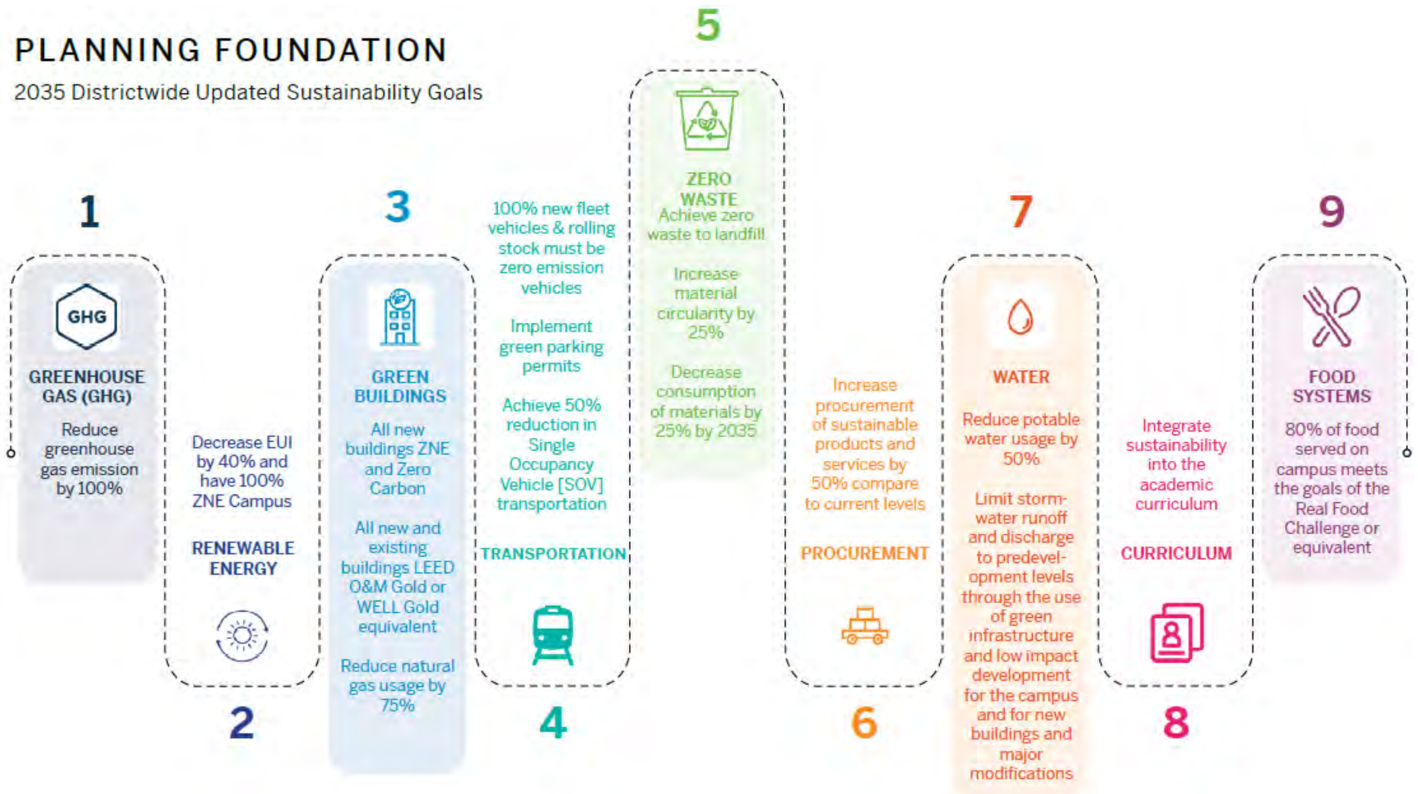
The primary goal of the electrification plan is to assist the district in meeting its sustainability goals, as outlined in the "2022 4CD District Wide Energy & Sustainability Goals" document.

The electrification plan consists of the following components:

- Building Benchmarking Report
- Electrical Systems Assessment
- Campus Photovoltaic Deployment Assessment.
- Building Electrification Strategy
- District Energy and Carbon Timeline

The plan is structured in a way that first benchmarks each campus to understand the current energy and carbon intensity of the various buildings. Next, the utility services at each campus are assessed to determine the available spare capacity for increased electrical load and renewable energy generation. The third step of the study is to identify the potential to deploy additional photovoltaic systems on each campus, corresponding to the available capacity and future electrical load.

The fourth component of the study proposes strategies for electrifying and improving the efficiency of existing buildings and estimates the impact to campus energy and carbon intensity. Finally, a district wide summary of the interventions is presented, accounting for the changes in electricity and gas consumption, as well as renewable energy production through 2040.



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1.

Los Medanos College/Brentwood Education Center

Carbon and Energy Benchmarking

Building Benchmarking Study - Introduction

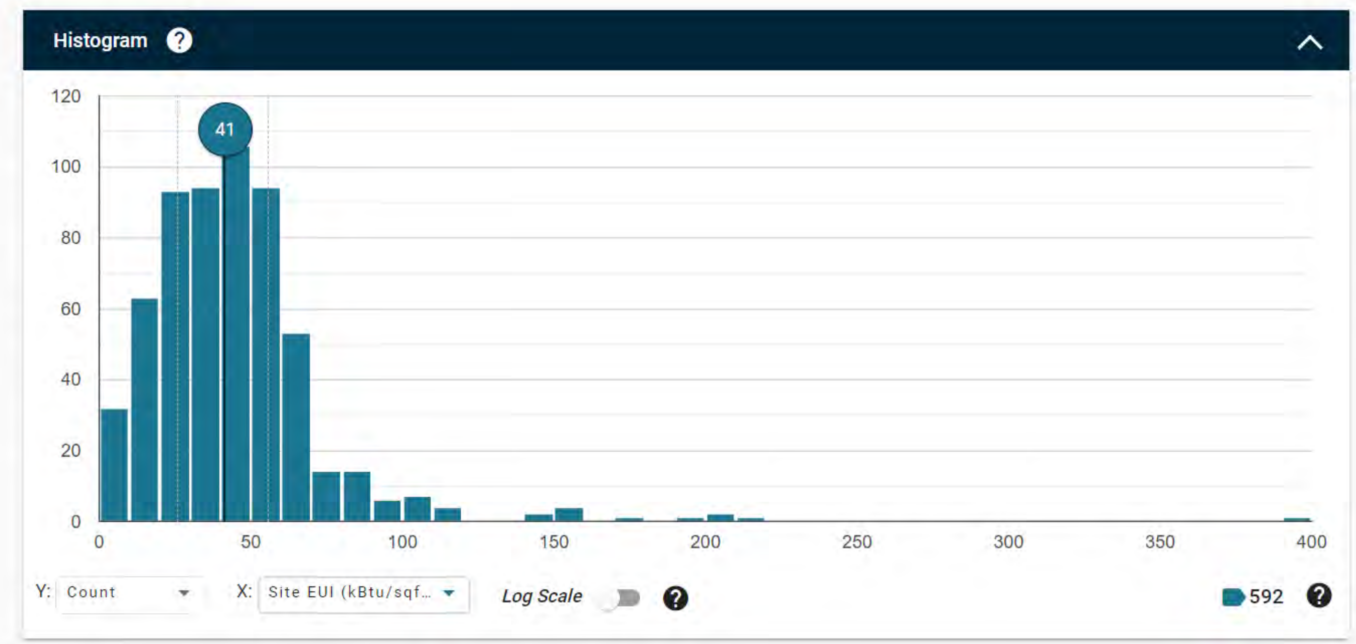
As part of the District Sustainability and Electrification plan, the portfolio of campus buildings has been subject to a benchmarking study to attempt to determine the highest priority target buildings for electrification and chart a path for the district towards meeting its sustainability goals. The data used for this benchmarking study consists of engineering and architectural drawings provided by the community college district, campus wide electricity and gas usage data, and results from a building equipment and facilities audit performed by Bureau Veritas. Building EUIs were also adjusted based on known operational configurations for particular campuses and buildings, as well as the mechanical and air systems.

Electricity and gas usage was estimated for each individual building on the campus based on available benchmarking data by building type for the bay area climate zones, the state of California as a whole, and available campus wide billing data. These estimates were then adjusted based on known building specific characteristics. Large multi-purpose campus buildings were divided into the various use-types they are composed of in order to provide an accurate EUI estimate for the building, as well as a use-type specific EUI for that campus.

The estimates were then revised based on a dialogue with the district on the values, particular building meter data, multi-building line meter data, and site electricity data that was made available.

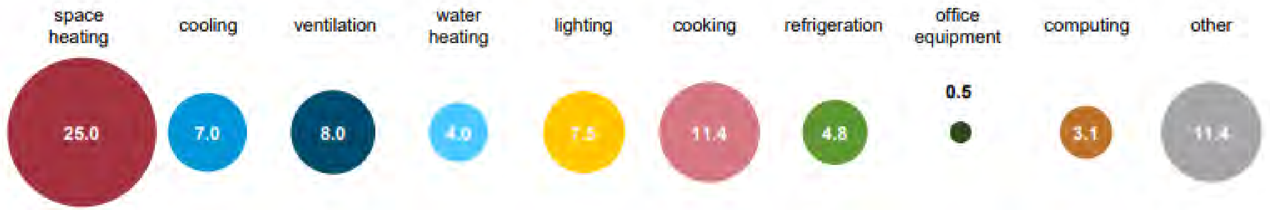
The energy and carbon impact of the pools were estimated based on available boiler data for the Contra Costa College pool and then a gas usage per square foot per year was applied to the Diablo Valley College pool in order to estimate the portion of the gas usage that is not part of a building EUI.

Building type energy data from the bay area, California, and the United States came from the Lawrence Berkley National Laboratory Building Performance Database and was adjusted or compiled into campus use types based on engineering judgement.

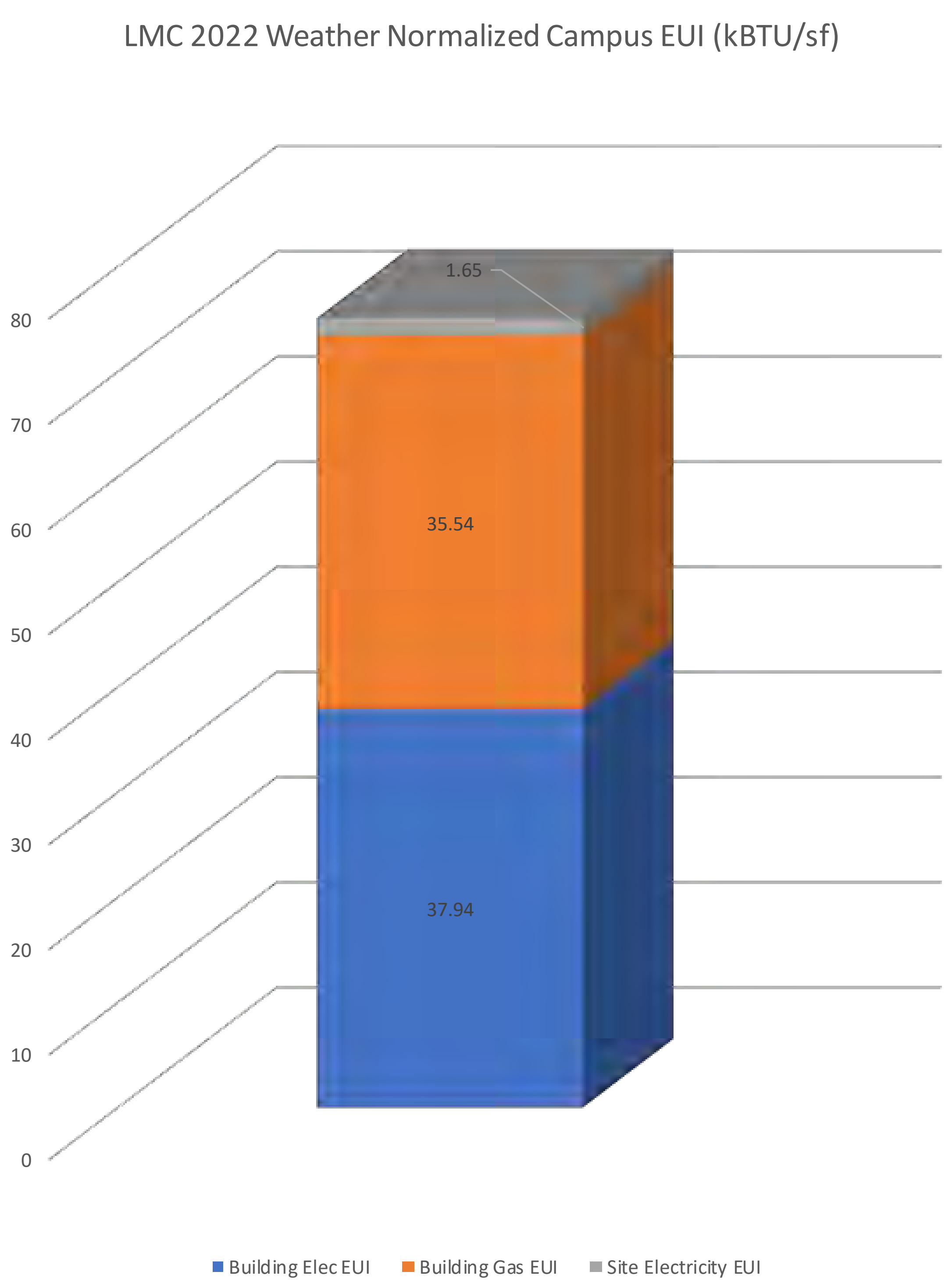


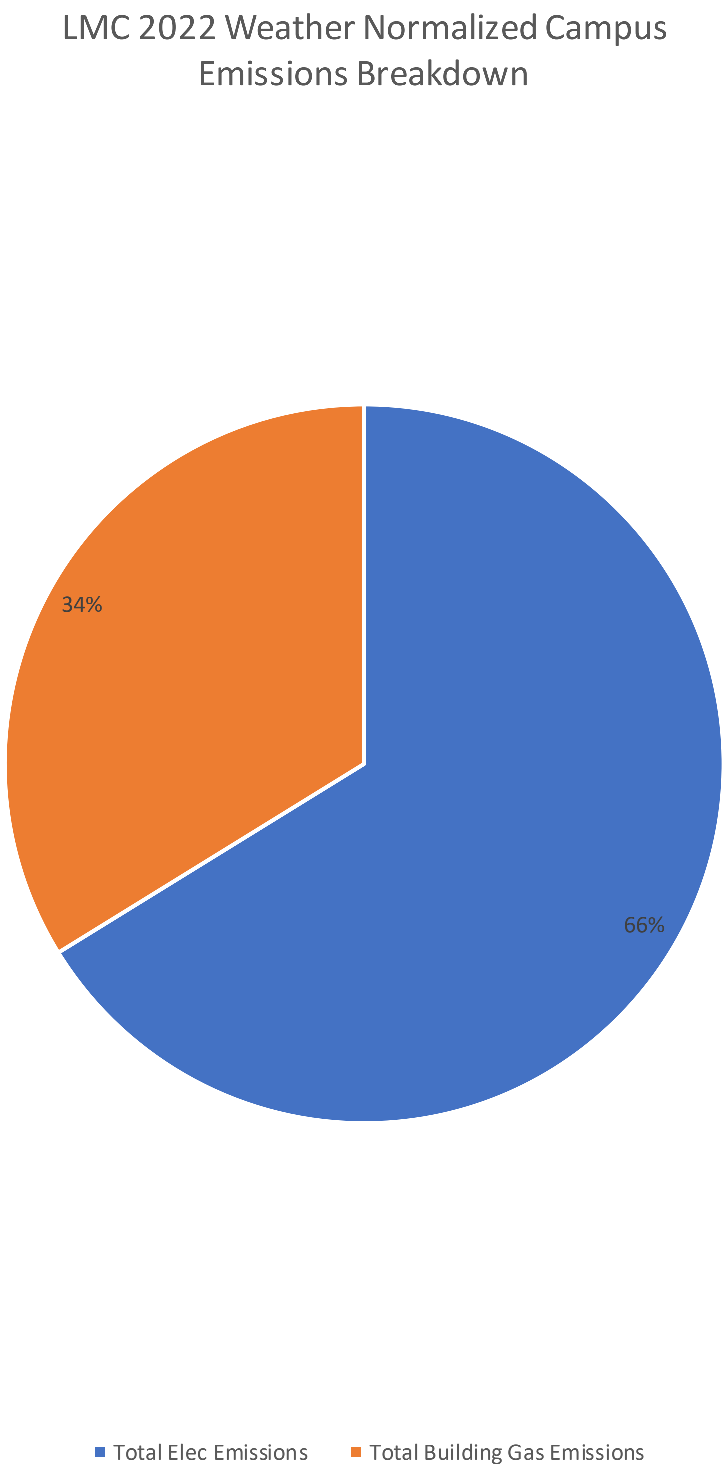
Sample BPD Query

The Energy Star Commercial Buildings Energy Consumption Survey and data from the Higher Education Benchmarking Initiative were also used to estimate end-use breakdowns and as a comparison point for realistic data for particular types of campuses.



Sample CBECs Data





LMC

Campus-Level Benchmarking

The campus EUI graph sums the total gas and electricity associated with the campus and divides them by the square footage of campus buildings included in the EUI study. The breakdown is representative of the split between gas and electricity use on the campus. The campus emissions chart shows the portion of the campuses total emissions that are associated with each fuel type. This data is all based on weather normalized data for the gas and electricity use and does not exactly match the real quantities but is better for a forward-looking analysis of the campus energy. LMC electricity use is associated with Constellation energy which as a grid emissions rate of 701 lbs CO2e per MWH of electricity. The area for EUI calculations in 2022 was 411,600 ft^2

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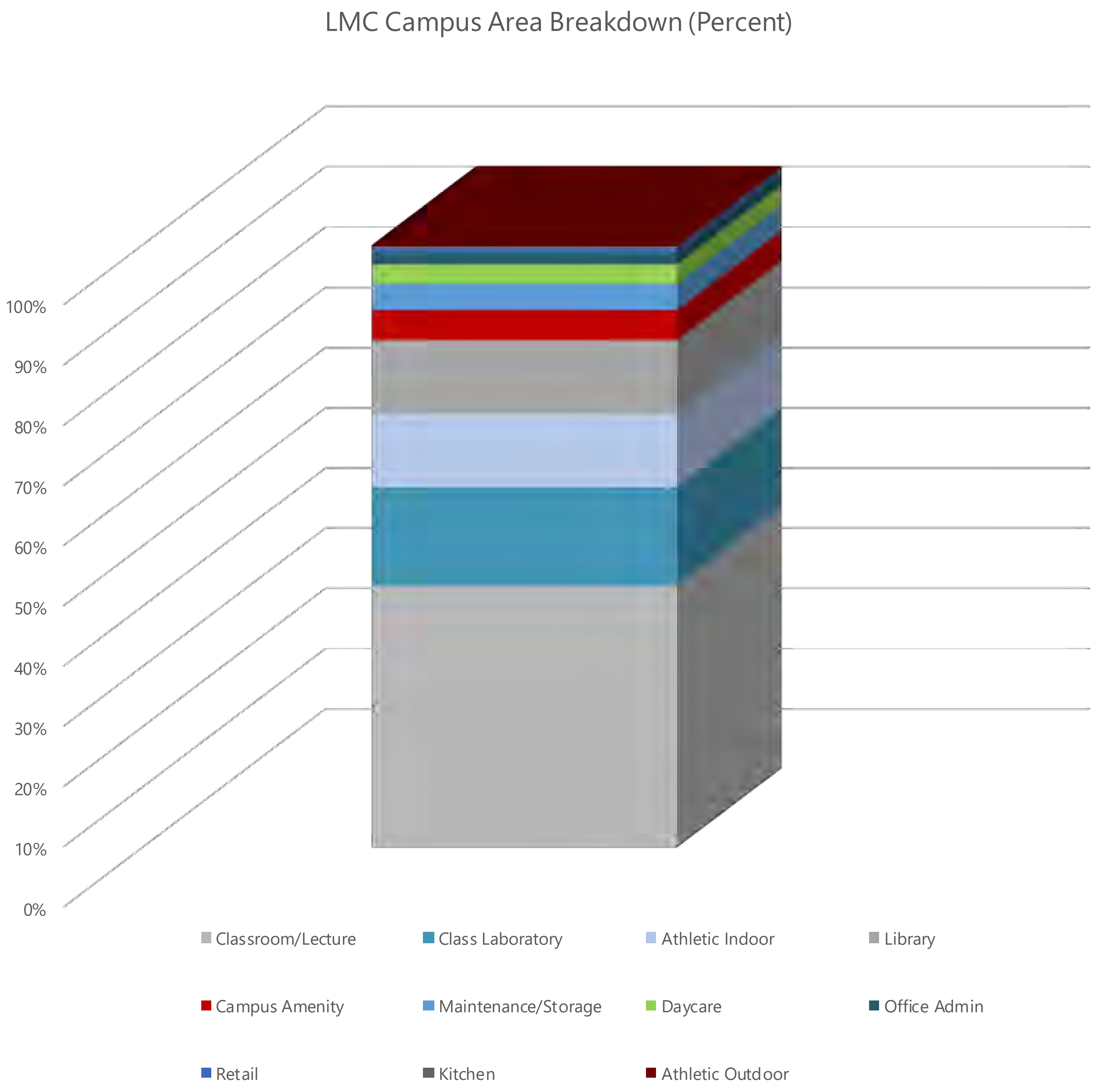

LMC

Campus Program Breakdown

The campus area breakdown shows the portion of the campus square footage associated with each of the program type categories in our study. Buildings with multiple use types have had their square footage distributed proportionally.

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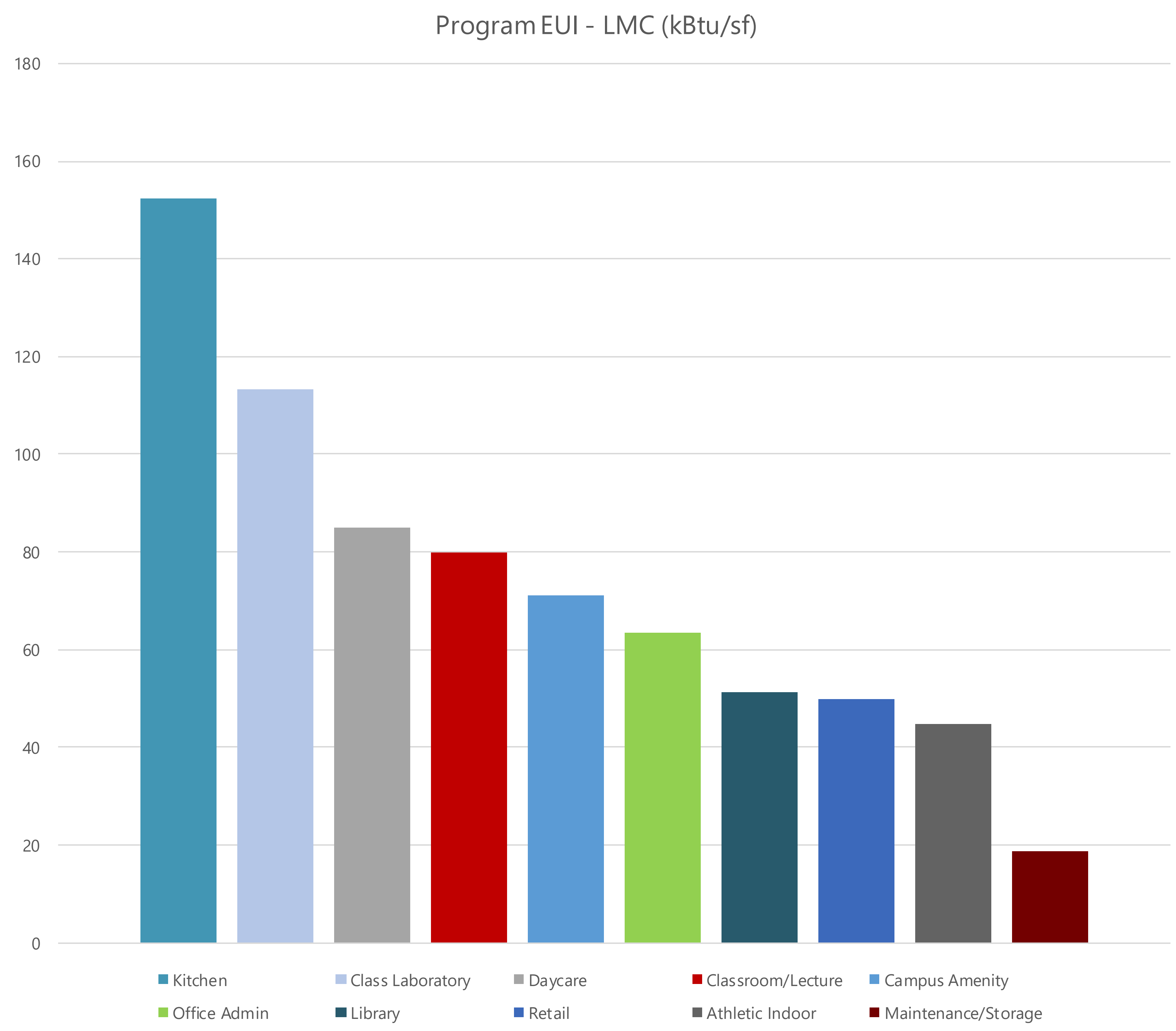


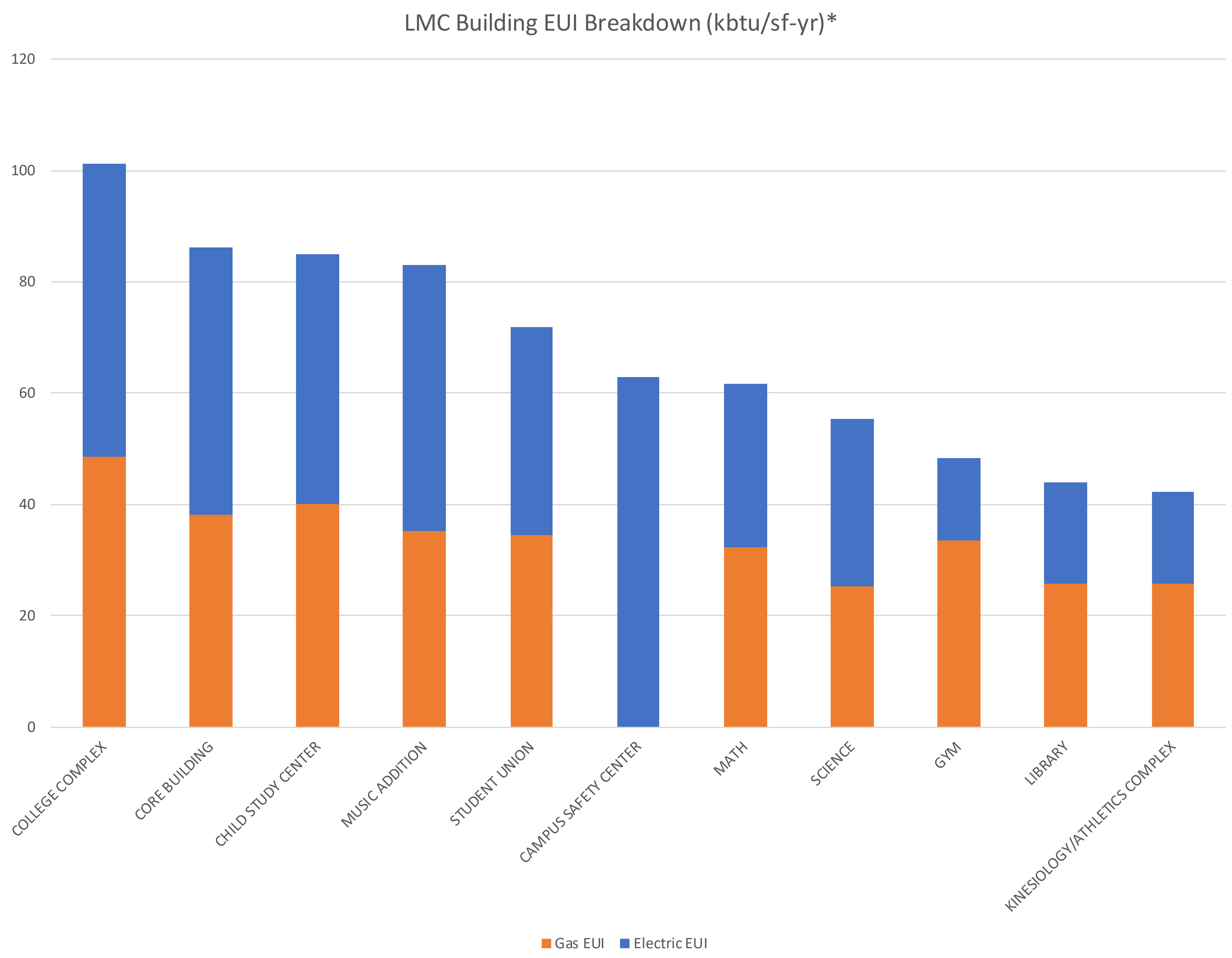
LMC

EUI per Program Type

The program EUIs are based on the weighted average of individual EUIs of buildings in each program classification, which may vary. These programs were assigned for energy analysis purposes and may not match other campus program breakdowns.

LMC

Energy Breakdown by Building



*Some buildings with negligible energy use are excluded from this graph

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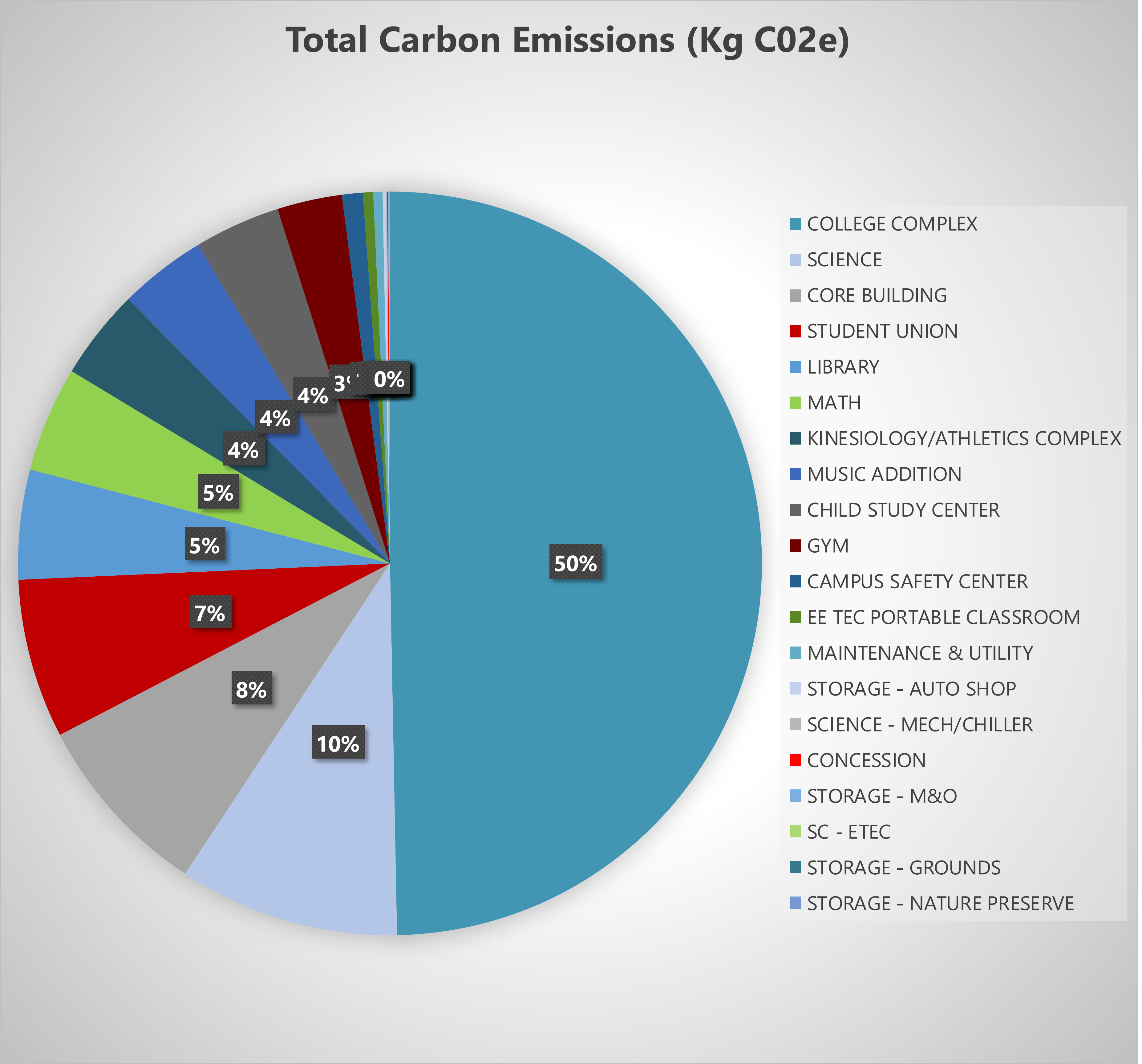

LMC

Carbon Emissions by Building

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LMC Benchmark Data Summary Table

Building	Age	Area	EUI	Gas EUI	Electric EUI	Total kBTU	Gas kBTU	Elec kBTU	Gas Carbon Emissions (metric tons CO2)	Electricity Carbon Emissions (metric tons CO2)	Total Carbon Emissions (metric tons CO2)
COLLEGE COMPLEX	1977	148,126	101.3	48.6	52.7	15,002,426	7,201,930	7,800,496	382	728	1,111
SCIENCE	2008	51,469	55.4	25.2	30.2	2,853,441	1,297,019	1,556,423	69	145	214
CORE BUILDING	1974	27,726	86.2	38.1	48.2	2,391,090	1,055,806	1,335,284	56	125	181
STUDENT UNION	2020	29,017	72.0	34.4	37.6	2,088,744	997,883	1,090,860	53	102	155
LIBRARY	2006	34,677	44.0	25.8	18.2	1,525,355	893,366	631,988	47	59	106
MATH	2008	23,009	61.6	32.2	29.4	1,417,354	740,890	676,465	39	63	102
KINESIOLOGY/ATHLETICS COMPLEX	2020	30,153	42.4	25.8	16.6	1,277,643	777,465	500,178	41	47	88
MUSIC ADDITION	1994	13,345	83.2	35.3	47.9	1,109,770	470,812	638,959	25	60	85
CHILD STUDY CENTER	1974	13,197	85.0	40.0	45.1	1,122,197	527,497	594,700	28	56	84
GYM	1974	19,940	48.2	33.4	14.8	961,587	665,916	295,670	35	28	63
CAMPUS SAFETY CENTER	2019	3,430	63.0	0.0	63.0	216,090	0	216,090	0	20	20
EE TEC PORTABLE CLASSROOM	2008	2,179	49.0	0.0	49.0	106,771	0	106,771	0	10	10
MAINTENANCE & UTILITY	1973	5,848	16.5	0.0	16.5	96,492	0	96,492	0	9	9
STORAGE - AUTO SHOP	2000	2,300	15.0	0.0	15.0	34,500	0	34,500	0	3	3
SCIENCE - MECH/CHILLER	2008	851	15.0	0.0	15.0	12,765	0	12,765	0	1	1
CONCESSION	1963	900	11.0	0.0	11.0	9,900	0	9,900	0	1	1
STORAGE - M&O	1973	480	15.0	0.0	15.0	7,200	0	7,200	0	1	1
SC - ETEC	2008	480	15.0	0.0	15.0	7,200	0	7,200	0	1	1
STORAGE - GROUNDS	1973	166	15.0	0.0	15.0	2,490	0	2,490	0	0	0
STORAGE - NATURE PRESERVE	1999	164	15.0	0.0	15.0	2,460	0	2,460	0	0	0

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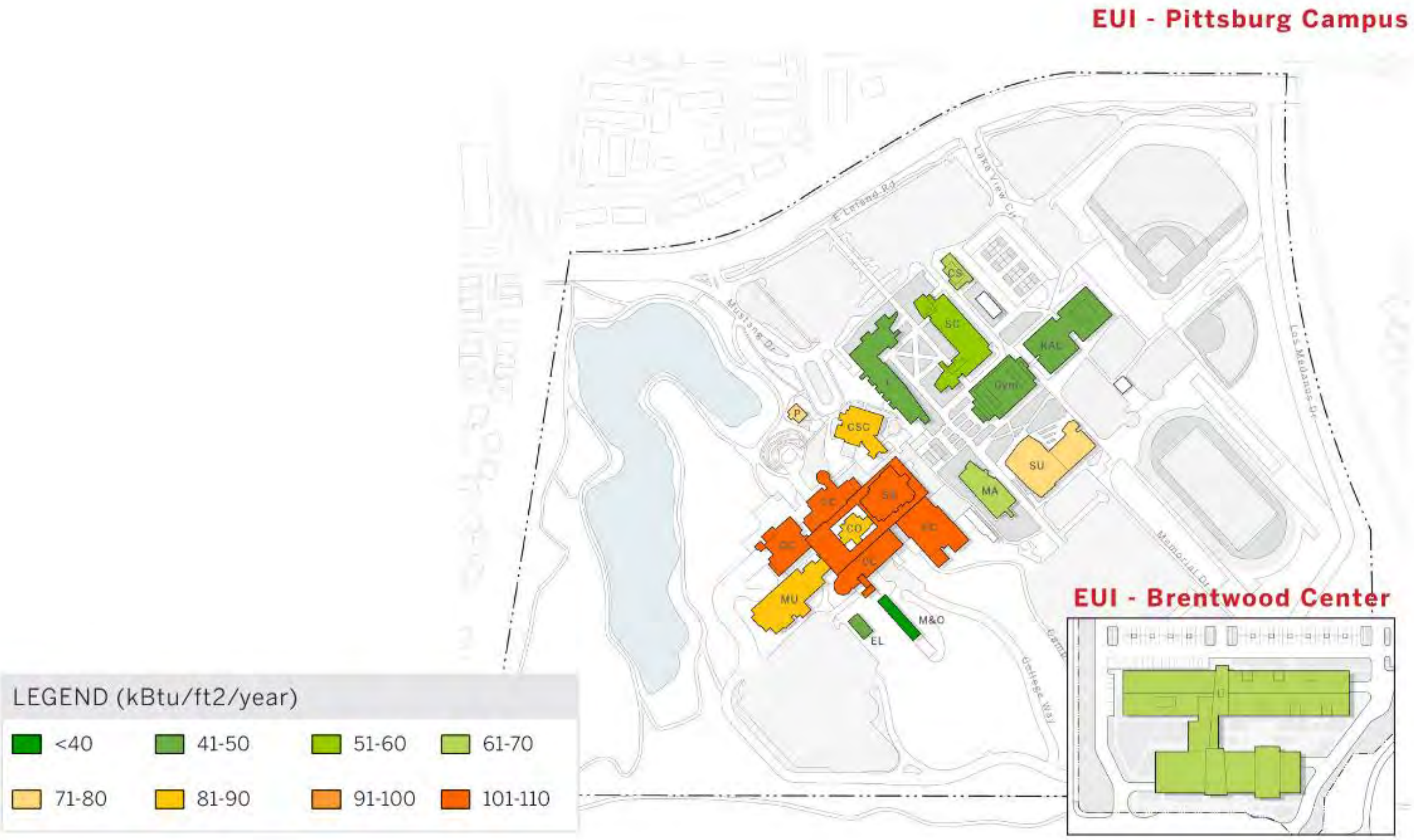
LMC EUI Map



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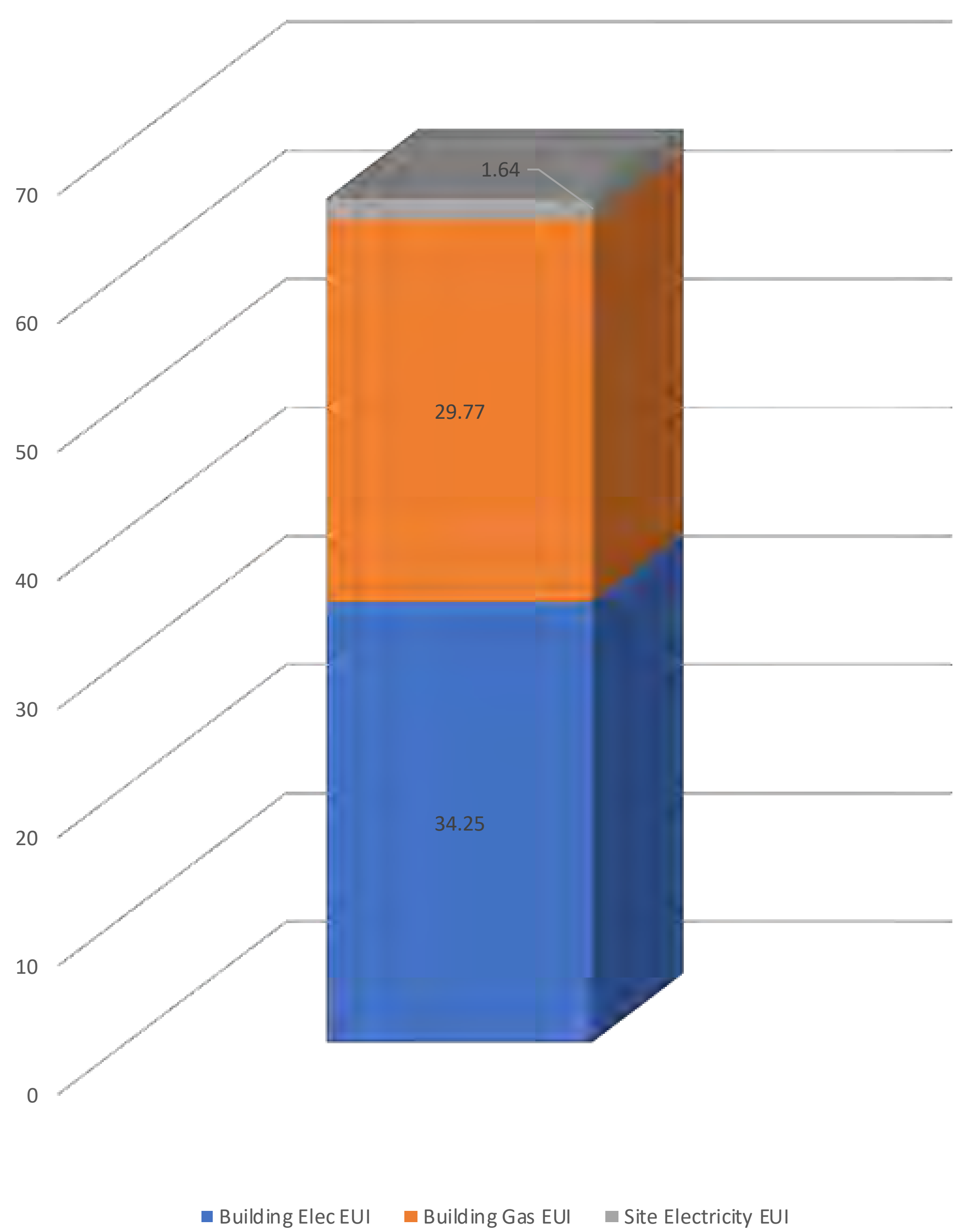
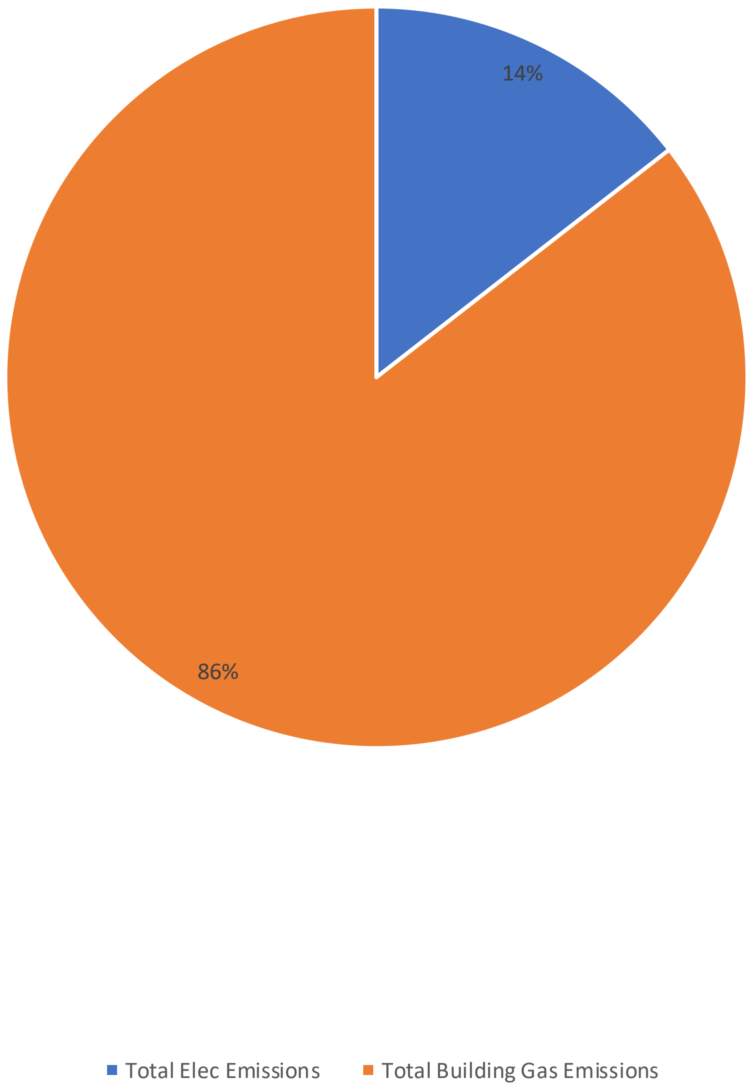
BEC 2022 Weather Normalized Campus EUI (kBTU/sf)



BEC 2022 Weather Normalized Campus Emissions Breakdown



Brentwood Education Center

Campus-Level Benchmarking

The Brentwood Education Center has a somewhat lower EUI than the main LMC campus and significantly lower electric emissions due to being associated with PG&Es grid which has a much lower emissions rate of 56 lbs CO2e per MWH of electricity. The facility has an area of 55,000 ft^2 and was constructed in 2020.

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Brentwood Education Center Building Benchmark Data Summary

Building	Age	Area	EUI	Gas EUI	Total kBTU	Gas kBTU	Elec KBTU	Gas Carbon Emissions (kg CO2)	Electricity Carbon Emissions	Total Carbon Emissions (Kg C02e)
BRENTWOOD EDUCATION CENTER	2020	54,973	64.0	29.8	34.2	3,519,479	1,636,712	1,882,767	191,201	30,892

Electric Infrastructure Assessment

Electrical Infrastructure Assessment - Introduction

As part of the Electrification Plan, Interface Engineering evaluated the available electrical system capacity at each campus to accommodate the future electrical demands from electrification, renewable energy deployment, and EV charging. The goal of this assessment is to confirm the capacity at the main campus feeders and switchgear. Downstream equipment, such as panels, wiring, and transformers, are not included in this assessment.

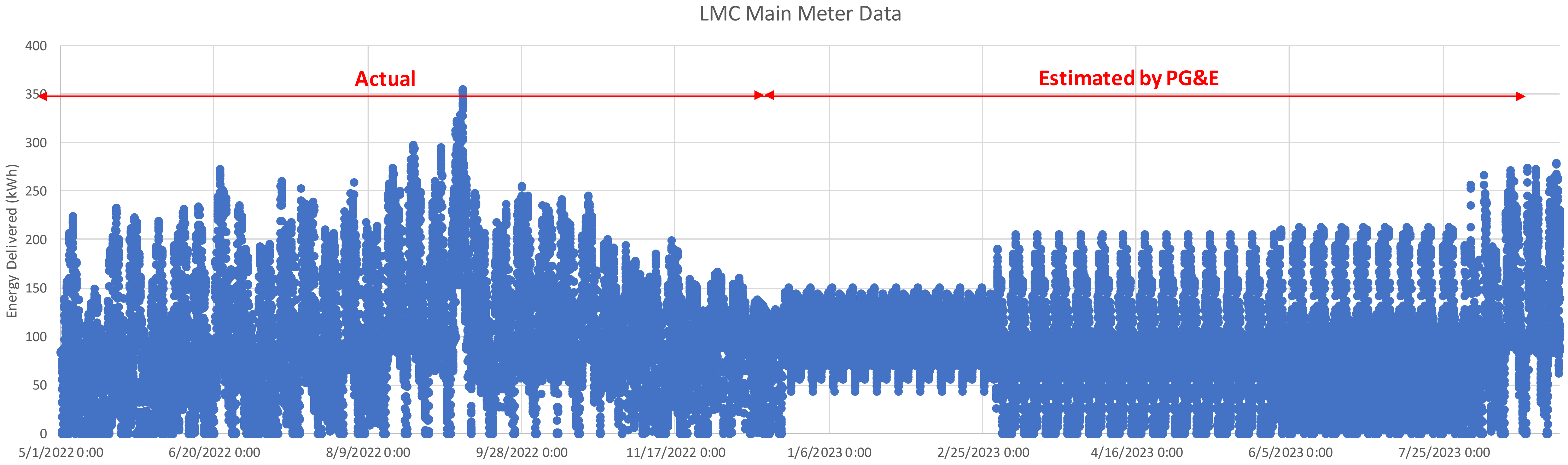
We have assessed the available electrical capacity at each of the District's campuses, as well as the District Offices and Brentwood Building. The available capacity has been evaluated using PG&E utility data (15-minute interval data) and PV inverter output data (hourly data provided from the district) for the period of May 2022 through August 2023.

For electrical services that include PV production, the generation data from net generation output (NGOM) meters and/or direct inverter output data is added to the consumption data reported at the main revenue meter, establishing the true demand on the service.

The demand (kW) reported for each service is a calculated value, using the consumption and PV production data (kWh). For example, if 100 kWh are consumed in a 15-min timestep, then the calculated demand for that timestep would be reported as 400 kW (100 kWh X (1/4 hours)).

Los Medanos College

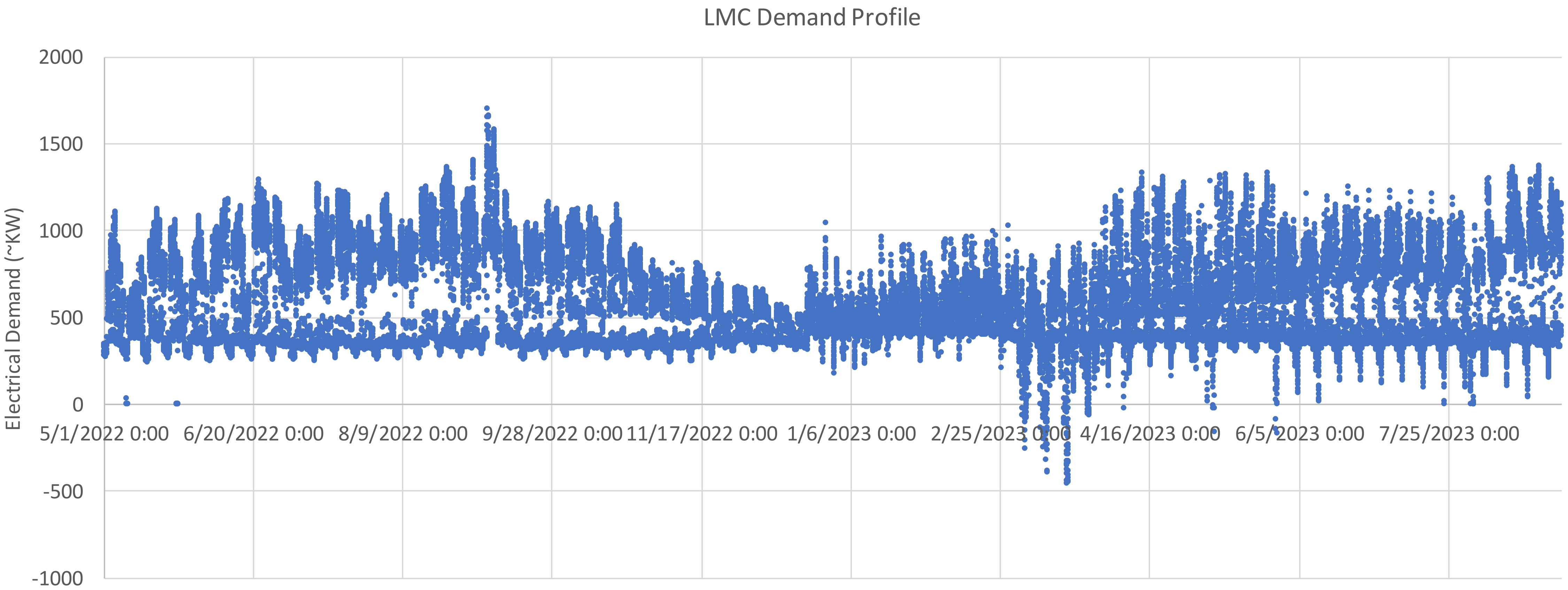
The chart below shows the energy delivered data from LMC's main meter. Visual inspection reveals the periods with "real" data vs estimated data.



Los Medanos College

- LMC campus is powered by an existing 1200A, 4.16kV service with a total capacity of 8646.6kW. The maximum demand on this service was 1700.5kW.
- LMC's data is from the main revenue meter, seemingly between January 2023 and early August 2023.
  - Peak occurs in September of 2022; therefore it is expected that the missing data is not impacting the projection of peak demand.
- In the missing data period, PG&E has automatically provided an estimated load profile, which causes anomalies in the calculated demand, as seen in March 2023 where demand is shown as negative.
- Demand values include PV system generation data and service consumption data.
- The existing service has an available capacity of 75.4%, or 6520.8kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	1457.7 kW
2	Maximum Demand	1700.5 kW
3	Maximum Demand Occurrence	9/6/2022 13:00
4	Service Voltage	4.16 kV
5	Service Amperage	1200 A
6	Service Capacity	8646.4 kW
7	Maximum Demand [2]	1700.5 kW
8	Maximum Demand * 125%	2125.6 kW
9	**Available Capacity [6-8]**	**6520.8 kW**
10	**Percent Available Capacity [9/6]**	**75.4%**



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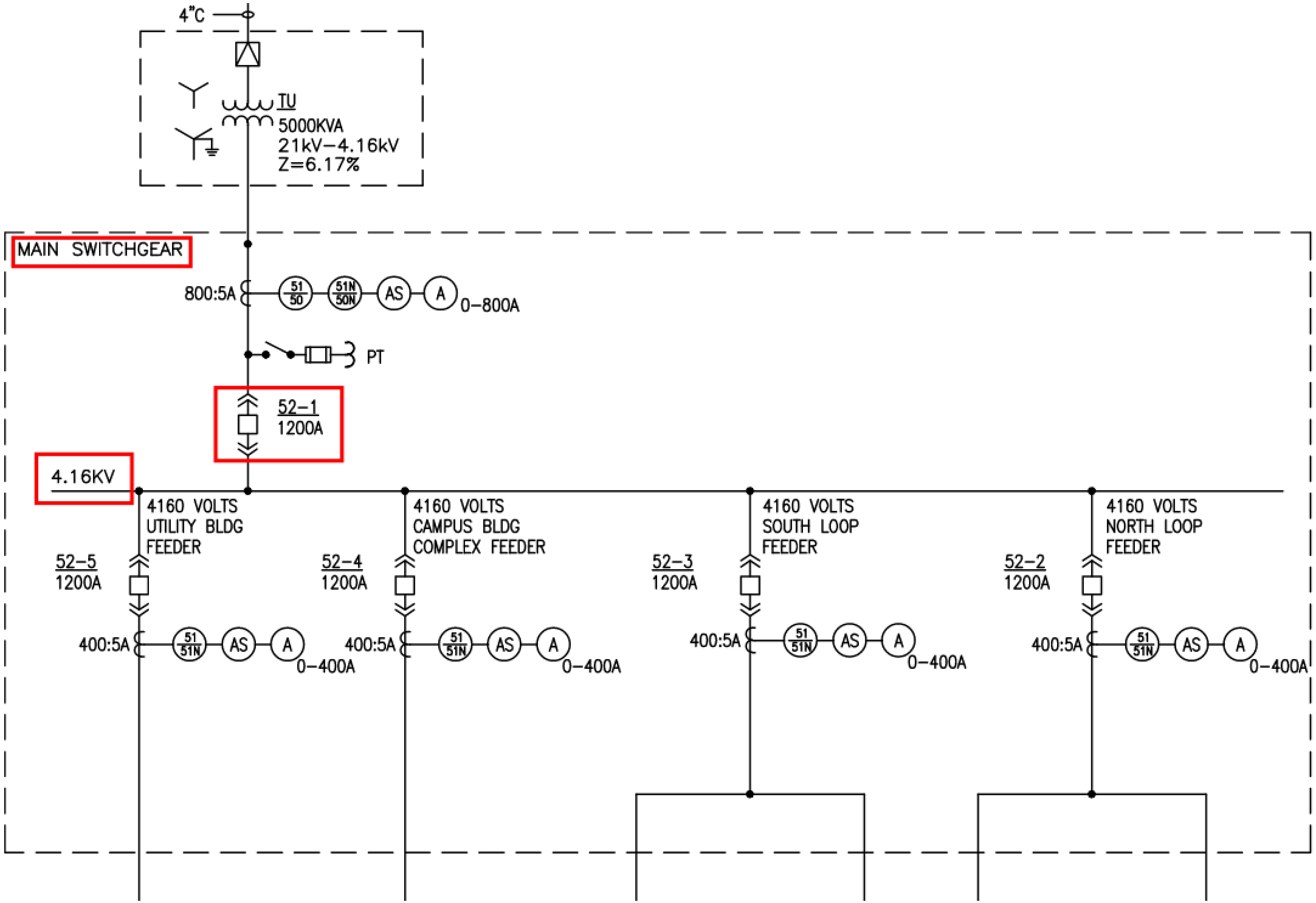
Los Medanos College Single Line Diagram



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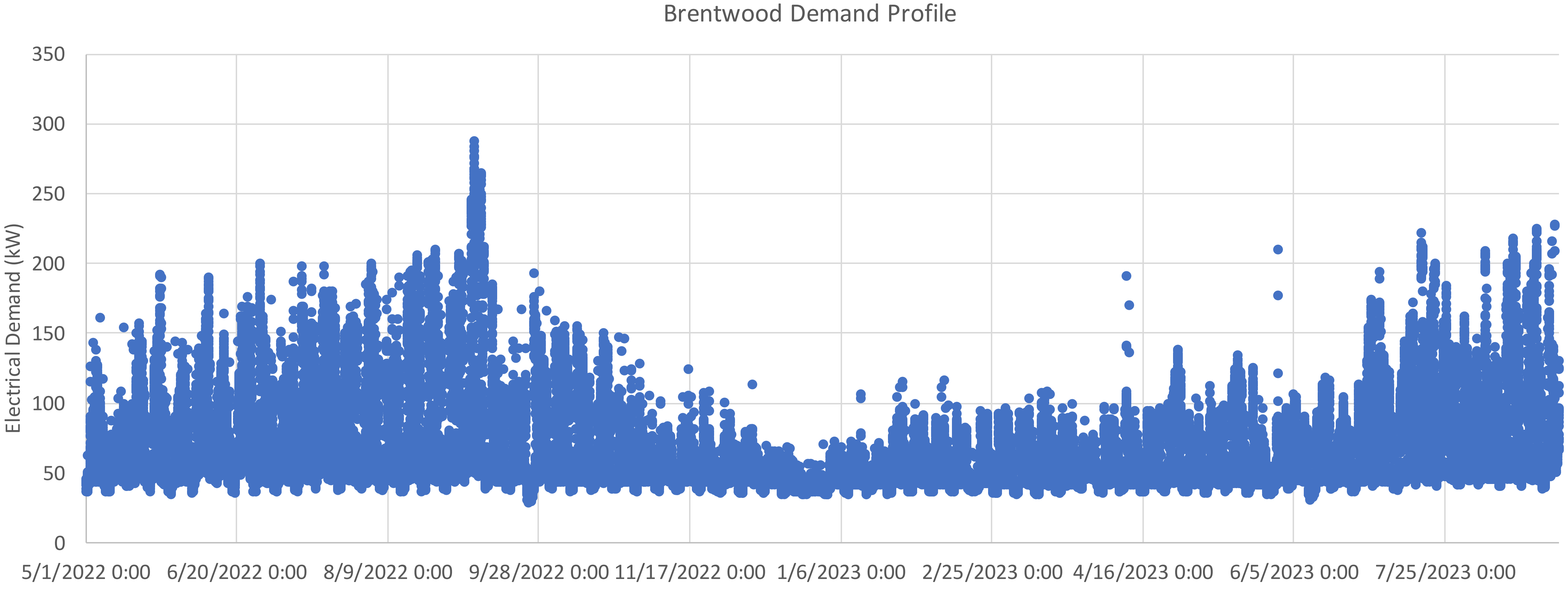
Brentwood

- Brentwood is powered by an existing 1600A, 480V service with a total capacity of 1330.2kW. The maximum demand on this service was 287.4kW.
- Brentwood data appears complete.
- The existing service has an available capacity of 73%, or 971kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	244.5 kW
2	Maximum Demand	287.4 kW
3	Maximum Demand Occurrence	9/6/2022 15:15
4	Service Voltage	480 V
5	Service Amperage	1600 A
6	Service Capacity	1330.2 kW
7	Maximum Demand [2]	287.4 kW
8	Maximum Demand * 125%	359.2 kW
9	**Available Capacity [6-8]**	**971.0 kW**
10	**Percent Available Capacity [9/6]**	**73.0%**



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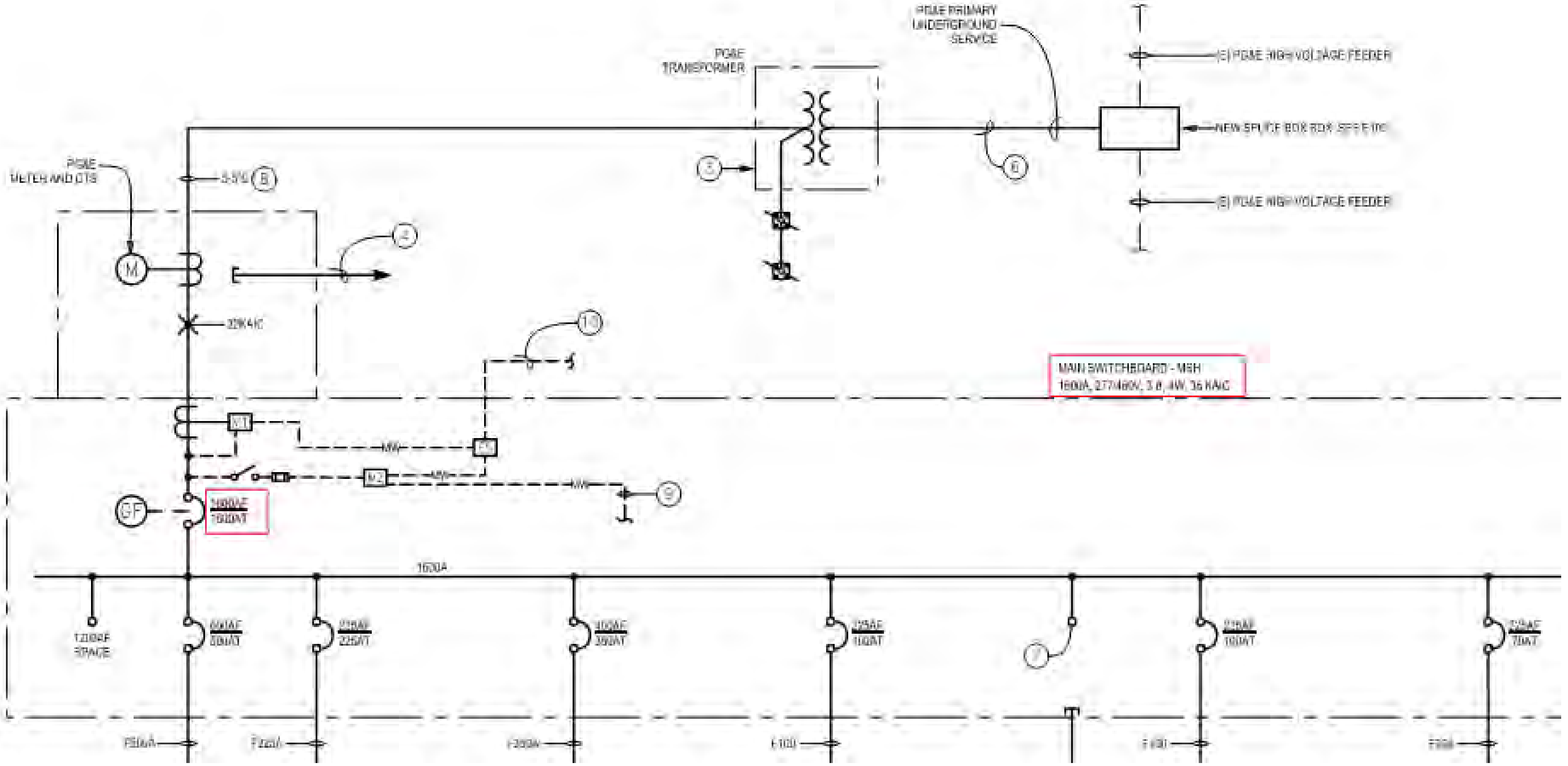
Brentwood Single Line Diagram



Renewable Energy Deployment

Renewable Energy Deployment Strategy Introduction

On-site renewable energy generation is a critical component of 4CD's sustainability plan to achieve net zero carbon emissions by 2035. The district currently has approximately 3.2 MW of photovoltaic (PV) solar panel systems across CCC, DVC, and LMC, which produce nearly 3.8 MWh annually. This represents approximately 19% of the district's electricity consumption.

As part of its plan to increase on-site renewable production, 4CD has five additional PV projects approved by PG&E for installation but have yet to be funded. For the purposes of estimating the impact of these approved projects, it is assumed that these systems will be installed in 2026. An estimate of the total development costs are shown in the table below, which based on the information provided by Sage Renewables. These costs are based on recent quote that 4CD received for the Brentwood system, which indicated a total cost of $7.87/watt for carport arrays. The Brentwood, DVC, and LMC installations are also planned to include battery energy storage systems (BESS), which will further enhance the cost reduction capabilities of these systems.

The tables to the right summarize the existing and planned PV systems, including their DC capacity, orientation and expected annual production rate (which vary slightly by campus and by array orientation). The table at the bottom indicates the % of electrical consumption that is met with the existing and future PV systems.

The campus site plans on the subsequent slides indicate the existing and planned PV locations on each campus, including the context of the newly planned buildings as part of the FMP. The site plans also indicate areas that may potentially be used for additional PV in the future.

The energy and carbon impact of the existing and planned arrays are discussed in more detail in the "District Energy and Carbon Timeline" chapter of this report.

The table below shows the future PV, beyond what is currently planned, that would be required in order to achieve net zero emissions for the specific campuses in 2035, and the associated cost of deployment in 2024 PV costs.

Future PV Summary (Scenario A)

Campus	Size (kW)	Cost*	Est. Annual Production (kWh/yr)	Predicted Electrical Consumption in 2035	% Future Load Met by Future PV
DVC	3,844	$30,252,280	5,766,000	8,782,110	66%
CCC	2,167**	$17,054,290	3,250,500	5,143,509	63%
LMC	**591**	**$4,651,170**	**886,500**	**4,276,119**	**21%**
SRC	433	$3,407,710	649,500	1,413,618	46%
DO	468***	$3,683,160	702,000	701,838	100%
BEC	**166**	**$1,306,420**	**249,000**	**749,521**	**33%**

*costs are based on estimates for PV projects for the district in 2024
**based on offsetting kWh instead of carbon emissions, due to the utility split for CCC between MCE and Constellation
***Due to limited space at this facility, this PV could be installed on another Constellation Campus like DVC, LMC, or SRC to have the same effect.

Existing PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	Kwh/KW*	Annual Energy Production (kWh)
Contra Costa College - Lot 9	403	225	1053	424,359
Diablo Valley College - Lot 1	567	270	1297	735,289
Diablo Valley College - Lot 3	267	270	1297	346,247
Diablo Valley College - Lot 4	548	270	1297	710,650
Los Medanos College - Lot B	**763**	**150**	**1139**	**868,904**
Los Medanos College - Lot C	**638**	**230**	**1128**	**719,953**
Total	3,186			3,805,402

*The existing PV production rates are 20-30% below the expected rate, based on the location and orientation of the systems. This may indicate performance issues with the panels and inverters.

Planned PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	kWh/KW	Annual Energy Production (kWh)	Project Development Costs ($)
Diablo Valley College - Lot 5	878	270	1564	1,373,000	$6,909,860
Contra Costa College - Lot 1	947	225	1551	1,469,000	$7,452,890
Los Medanos College	**1,154**	**150**	**1560**	**1,800,000**	**$9,081,980**
San Ramon Center - Main Lot	483	225	1580	763,000	$3,801,210
Brentwood Center - Main Lot	**322**	**180**	**1556**	**501,032**	**$2,534,140**
Total	3,784			5,906,032	$29,780,080

Renewable Energy Summary

	Annual Electricity Consumption (kWh)*	% Met by Existing PV	% Met by Planned PV	Total Planned Renewable %
CCC	4,414,407	10%	33%	43%
DVC	8,618,555	21%	16%	37%
LMC	**4,783,853**	**33%**	**38%**	**71%**
SRC	1,200,248	0%	64%	64%
Brentwood	**573,479**	**0%**	**87%**	**87%**
District Offices	657,697	0%	0%	0%
District	20,248,239	19%	28%	47%

*True 2022 value that is not weather normalized

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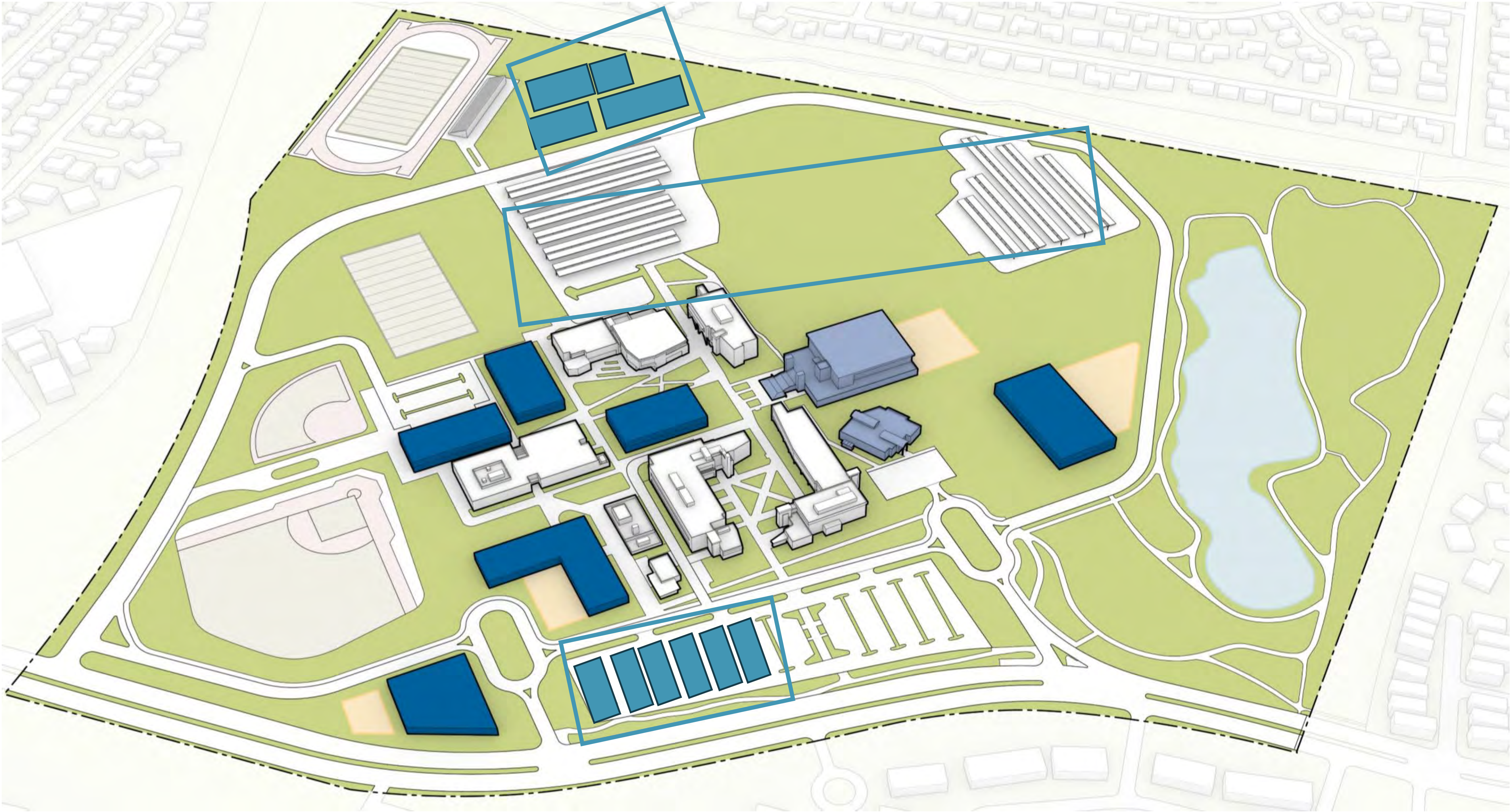
Los Medanos College PV Systems



Planned System
- 1,154 KW South of Lot B
- Planned PV offsets ~ 38% of the campus's 2022 electricity

Existing System
- 1,401KW @ parking lot B/C
- Existing PV offsets ~ 33% of the campus's 2022 electricity

Potential Future System
- 591KW @ parking lot A
- Potential PV offsets remaining based on electrical consumption and emissions in 2035 projections
- Approximately 29.5k ft^2 panel area, based on current PV technology

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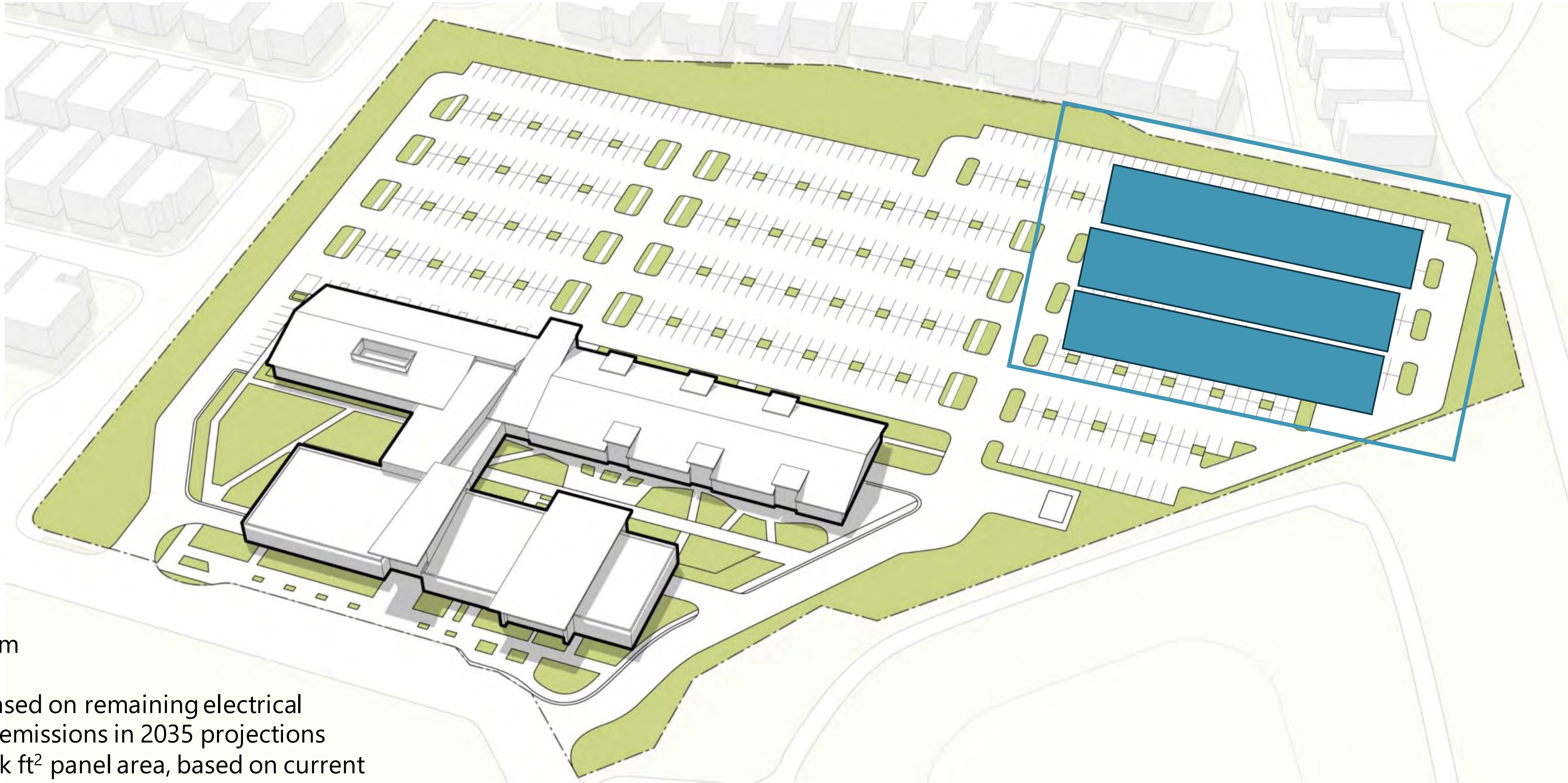
Brentwood Center PV Systems

Planned System

- 322 KW at Main Lot
- Existing PV offsets ~ 87% of the Brentwood's 2022 electricity



Potential Future System

- 166KW
- Future PV sized based on remaining electrical consumption and emissions in 2035 projections
- Approximately 8.5k ft^2 panel area, based on current PV technology
- Future location not determined at this time

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District Energy Projects

Electrification Plan Introduction

In 2022, more than 48% of the electricity delivered by California's grid was generated by renewable sources such as solar photovoltaics, wind, biomass, and hydroelectric. This percentage will increase over time, as state laws such as SB100 mandate that CA's grid achieve 100% carbon-free generation by 2045. This means that by electrifying legacy natural gas heating systems, the carbon footprint associated with these loads will trend towards zero. For the Contra Costa Community College district in 2022, ~45% of its electricity was provided by renewable resources (including grid-supplied and on-site generation).

The purpose of this study is to support the master-planning effort for the Contra Costa Community College District (4CD) with a district-wide electrification plan. The plan provides an analysis of how electrifying the district's natural gas heating systems and deploying renewable energy systems will reduce the district's energy consumption and carbon footprint.

The primary goal of the electrification plan is to assist the district in meeting its sustainability goals, as outlined in the "2022 4CD District Wide Energy & Sustainability Goals" document.

The electrification plan consists of the following components:

- Building Benchmarking Report
- Electrical Systems Assessment
- Campus Photovoltaic Deployment Assessment.
- Building Electrification Strategy
- District Energy and Carbon Timeline

4CD has adopted a set of sustainability goals which target significant reductions in carbon emissions across the entire organization by 2035. The electrification study addresses the greenhouse gas (GHG) and renewable energy goals by proposing and quantifying the impacts of building replacement and renovation projects, renewable energy systems, as well as additional efficiency projects such as LED lighting, building management controls, metering upgrades and HVAC electrification.

4CD's goals are focused on the two primary dates of 2030 and 2035. The 2030 goals include reducing GHG emissions by 75% below the 2013 baseline and reducing the district energy use intensity (EUI) by 25%. The 2035 goals include reducing GHG emissions by 100% and reducing district EUI by 40%.

HVAC Electrification Strategy

Contra Costa Community College District has adopted a broad set of sustainability goals and practices that will result in dramatic reductions in energy consumption and carbon emissions from its buildings. A key component of these goals is the requirement that all newly constructed buildings are all-electric (no fossil fuel combustion used for space heating). This approach leverages the fact that California's grid is becoming cleaner (emitting less carbon) each year, which inherently reduces the carbon footprint of the campus.

There are a range of all-electric heating technologies that work well for new construction projects. However, converting the existing natural gas heating systems to all-electric has historically been challenging from a technological and financial standpoint. Air-source heat pump (ASHP) technology which use traditional refrigerants have limitations on the temperatures they can produce (typically a maximum supply temperature of approximately 130F), which may make them incompatible with typical legacy heating systems which utilize 160-180F temperatures. The renovations required to make existing buildings compatible with ASHP technology can be prohibitively expensive. These renovations may require replacement of some heating coils to accommodate lower water temperature, and often piping/coupling systems need to also be replaced. Furthermore, ASHP technology is limited to a lower ambient temperature of ~25F, which means that supplemental heating may be required on the coldest days of the year.

Water-source heat pumps (WSHP) are more flexible, with supply temperatures as high as 170F. These require a water-based heat source/sink, such as a ground loop via a geo-exchange system. Geo-exchange systems are often very costly due to the cost of drilling vertical wells or excavating for horizontal systems. These costs and space constraints typically preclude water-source heat pumps as a retrofit solution.

Transcritical heat pump (TCHP) technology is relatively new to building comfort heating and cooling which is addressing the traditional challenges of ASHPs and WSHPs. This technology utilizes CO^2 as its refrigerant (known as R744), which enables hot water delivery temperatures of 180F at outdoor ambient conditions down to -15F. This allows "direct replacement" of natural gas boilers and domestic hot water heaters. This technology is still "emerging", with a limited number of installations in the U.S., however, it is expected that this technology will develop rapidly over the next 5 years.

For existing buildings with traditional boiler-based hydronic systems, an assessment process is recommended to determine what modifications are required in order electrify these systems with the highest possible efficiency. The primary goal of this assessment is to determine if the existing hydronic systems is capable of operating at lower heating hot water temperatures while still maintaining design temperatures. Lowering the hot water temperatures allows for compatibility with a wider range of heat pump technology, and also allows them to operate much more efficiently. The following bullet points outline the assessment process:

- Review heating coils configuration - heating coil performance will be reduced when operating at lower hot water temperatures, however, in some cases, this performance derating can be overcome with modification to control sequences. In most cases, two-row heating coils at air handling units and VAV boxes can be utilized when lowering hot water temperatures from 180F to 140F, or even lower. The peak capacity of the coils is reduced with lower water temperatures, but simply increasing the warm-up time of the building may overcome these limitations. Also, reducing the temperature setback of the space will reduce the load that the coils must meet. Single-row coils will likely struggle to meet the load with reduced water temperatures and may need to be replaced.
- Conduct a hot water reset investigation – During the winter months, reduce the heating hot water temperature in 5-degree increments for one to two weeks at a time. This process will reveal which zones/coils are able to meet space loads with reduced water temperatures. As zones are discovered to be out of setpoint, increase the warm-up period or limit the temperature setback. Continue to reduce water temperatures and increase warmup period to determine if a lower water temperature will allow the building to maintain functionality. This process may reveal that certain zones/coils will function adequately, while others may need to be upgraded. The desired outcome of the reset investigation is a custom outdoor air reset control sequence that reduces hot water temperatures to a minimum, as a function of outside air temperature. For example, the goal may be to operate at 140F supply/ 100F return as often as possible but allows for increases up to 180F supply / 140F return on the coldest days of the year.

HVAC Electrification Strategy
Transcritical Heat Pumps

While this heat pump technology has long been used in commercial refrigeration for 20 years or more, it is more recently being applied to building HVAC and domestic hot water. Typically, these machines use CO_2, or R-744, as its refrigerant, which has a global warming potential (GWP) of 1, which is far below traditional refrigerants like R-410a (GWP of 2088) or R-134a (GWP of 1430). Furthermore, R-744 is able to operate with much higher temperatures, at or above 180F. However, like traditional heat pumps, transcritical heat pumps operate much more efficiently with lower supply water temperatures.

As the technology continues to advance, it may become a critical component of electrifying existing buildings that utilize hydronic heating. The graph on the right shows the efficiency curves for various operating conditions for Flow Environmental System's model H transcritical heat pump. These trends show that while operating at "traditional" boiler system temperatures of 180F supply / 140F return, a COP of 1.75 is achieved. However, lowering the supply temperature to 140F dramatically improves efficiency, approaching a COP of 3.5. This highlights the importance of the hot water reset assessment process outline on the previous page.

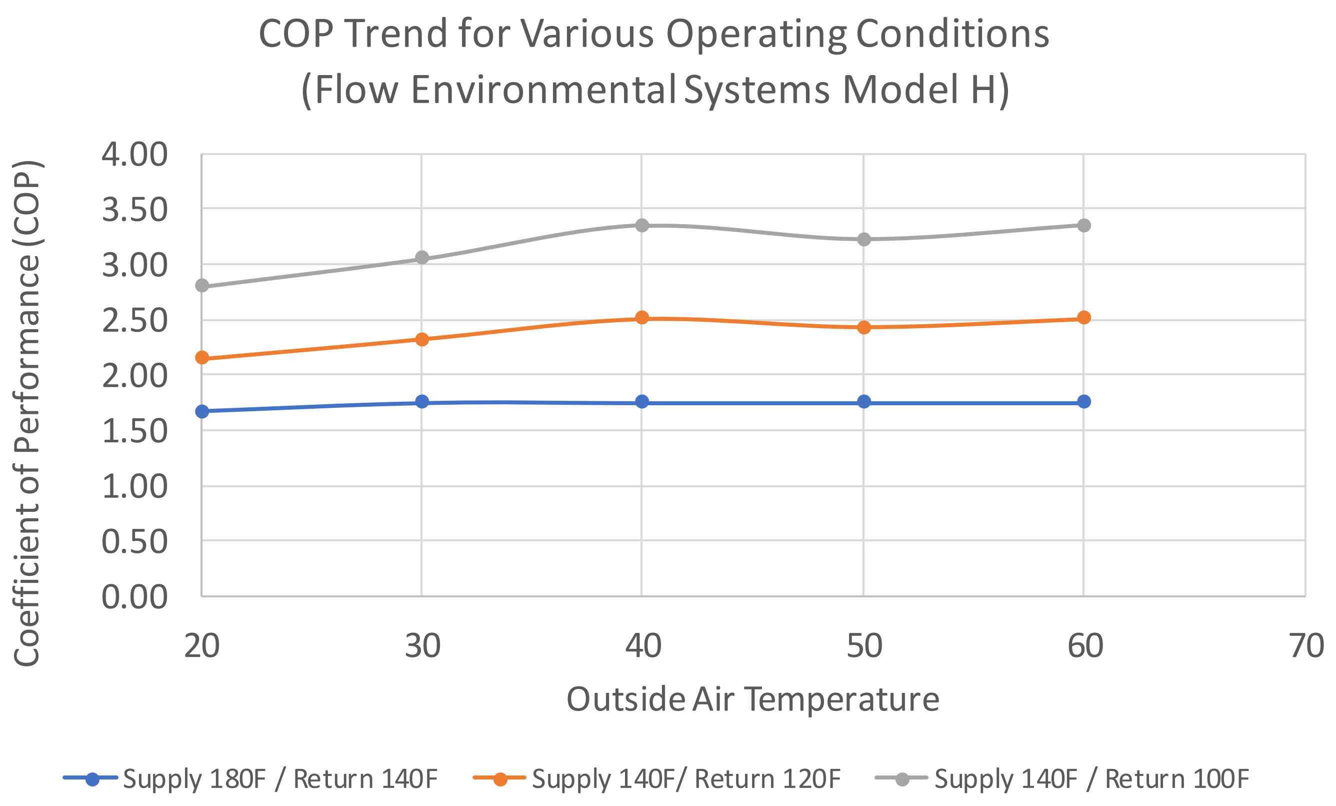
Transcritical heat pump technology is also well suited for domestic hot water applications, where storage temperatures typically range from 125F – 140F. Systems like Sanden and Lync are able to achieve COPs above 5, which allows for significant improvements to operation cost and carbon emissions associated with domestic hot water.

The links below are examples of transcritical heat pump technology that are recommended for investigation by future design teams for use in both new construction and retrofit projects.

https://www.flowenvirosys.com/products

https://www.smallplanetsupply.com/sanc02

https://www.lyncbywatts.com/



HVAC Electrification Strategy
Central Plant Opportunities

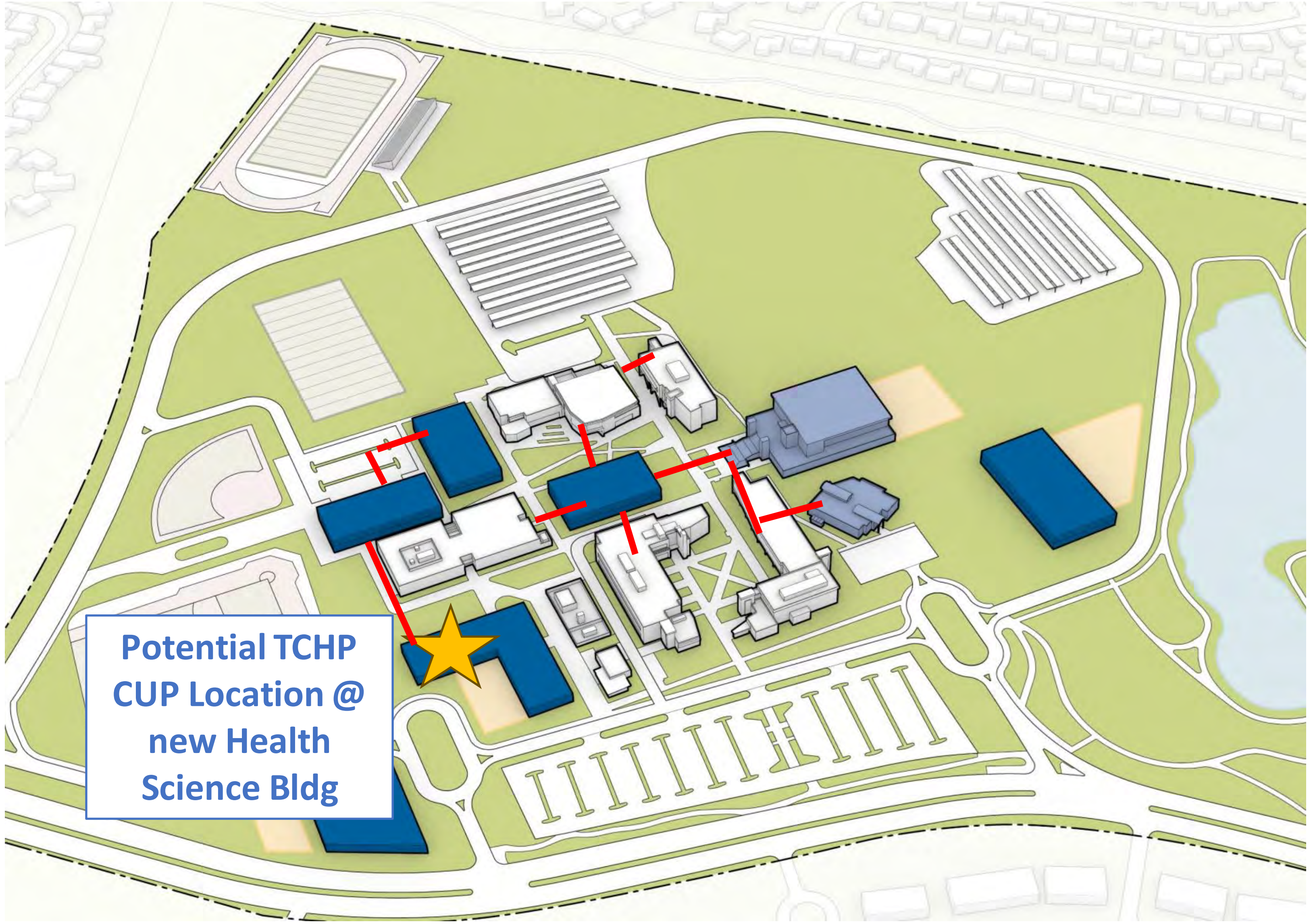
An all-electric central utility plant (CUP) may be an effective strategy to employ as part of the early FMP projects. At Los Medanos College, the newly planned Health Sciences building is one of the first major projects that will occur within the core of the campus. It is in relatively close proximity to several other newly planned or renovated building. A central plant can be designed and planned at the new Health Sciences building with the intent to expand over time, as new buildings are built, and existing buildings are retrofitted.

For Contra Costa College, a central plant may be feasible as part of the renovation of Student Services or General Education buildings. However, space constrains may make this challenging.

For Diablo Valley College, a central plant may be feasible as part of the new academic complex, which is planned for construction in 2030. this central plant could then be available to serve the renovation projects as they occur in the later 2030's.

Utilizing a central plant, as opposed to each building having standalone heating and cooling equipment, offers many benefits in terms of efficiency, redundancy, and heat recovery. Centralizing the load of multiple buildings offers diversity in the load profile, which may allow for energy to be recovered (using heat recovery heat pumps) when simultaneous heating and cooling loads are required across a campus. Central plant equipment can be designed with proper modularity to allow for very efficient part load operation, as well as inherent redundancy. Thermal storage systems can be readily added to a central plant, allowing primary heating and cooling equipment to be dramatically downsized, as well as offering the ability to load shift to times when energy is cheap or when the grid is the cleanest (depending on District priority).

The downsides of a central plant approach are primarily cost and complexity. A significant infrastructure investment is required to install the initial phases of a central plant, sizing piping and electrical systems for their anticipated future loads. However, future buildings that connect to the central plant will be lower cost. The equipment is typically of a larger scale, often requiring specialized contractors to perform major maintenance. A relatively large are is often required to house the central plant equipment, which can be challenging for some campuses.



HVAC Electrification Strategy
Los Medanos College

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HVAC Electrification Strategy
Los Medanos College – FMP Projects Pt.1: New

The 2024 Facilities Master Plan identifies 10 projects (new construction and renovation) that will enhance the usability of the campus and increase building efficiency. The new construction projects consist of 7 new buildings. 4 of them are planned to occur within a period that impacts the energy timeline, and 3 are planned to occur outside of that period.

As part of the 4CD sustainability goals, each of these new buildings will be all-electric and LEED gold certified. The predicted EUI of these buildings is shown in the table below, along with the assumptions of building size and what year the projects will be built.

New Construction Projects					
Building	Area (ft2)	Year of Construction	Predicted EUI (kBtu/sf-yr)	Annual Electricity Consumption (kWH)	Notes
New Administrative Building	30,000	2034	28	246,180	Coincides with FMP demolition of Core Building
New Child Study Center	18,000	2027	25	131,882	Same year as old child study center converted to welcome center
New Health Sciences	36,000	2029	35	369,270	
New Interdisciplinary Lab Building	46,000	2032	45	606,657	

Projects that are expected to occur further in the future are:

1. New Gymnasium
2. New General Academic Building
3. New Athletic Stadium

HVAC Electrification Strategy
Los Medanos College – FMP Projects Pt.2

The 2024 Facilities Master Plan identifies 10 projects that will enhance the usability of the campus. These projects include 3 renovations, 2 of which occur during the timeline of the energy study.

Renovation projects are anticipated to eliminate natural gas from the HVAC and plumbing systems, resulting in a substantial energy and carbon emissions reduction. These savings are summarized in the table below.

Renovation Projects							
Building	Area (ft2)	Year of Renovation	Existing EUI	Predicted EUI (kBtu/sf-yr)	Natural Gas Reduction (kBtu)	Electricity Reducton (kWh)	Notes
COLLEGE COMPLEX	148,126	2034	101.3	56.2	7,201,930	1,679,606	75% of building demolished and ALC/LED/Electrification Included
CHILD STUDY CENTER	13,197	2027	85.0	45.5	527,497	42,397	25% of building demolished and ALC/LED/Electrification for remainder

Renovations of the following buildings occur after and outside our energy timeline:
Student Services

INTERFACE ENGINEERING

HVAC Electrification Strategy
Los Medanos College – Additional Efficiency Projects

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWH	Gas Reduction kBTU	Starting EUI	EUI After
LIBRARY	34,677	2026		x	x (Boiler)	Boiler at end of life, AHUs close		$568,022	$1,136,045	$1,704,067	-58,852	893,366	44.0	24.0
MATH	23,009	2034		x	x (Boiler)	Boiler has 14 years left, renovation recommended at 10 years for climate goals		$535,984	$1,071,968	$1,607,952	-54,553	740,890	61.6	37.5
SCIENCE	51,469	2025	x		x (Boiler)	AHUs have 4 years left, boilers not in inventory	$537,851		$1,613,553	$2,151,404	22,023	1,297,019	55.4	28.8
KINESIOLOGY/ATHLETICS COMPLEX	30,153	2028		x	x (Boiler)	Hot water provided by 400 MBH commercial water heater with 16 years useful remaining life per BV		$539,370	$1,078,740	$1,618,111	-51,242	777,465	42.4	22.4
STUDENT UNION	29,017	2034		x	x (Boiler)	Boiler has 11 years left, AHU has 16		$675,938	$1,351,875	$2,027,813	-75,448	997,883	72.0	46.5
GYM	19,940	2025		x	x (Boiler)	Roof AHU at end of life, same boiler as science, so same year		$312,560	$625,119	$937,679	-49,773	665,916	48.2	23.3
MUSIC ADDITION	13,345	2026	x	x	x (Furnace)	Furnaces one year away from end of life	$145,731	$218,596	$364,327	$728,654	6,923	470,812	83.2	47.5

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

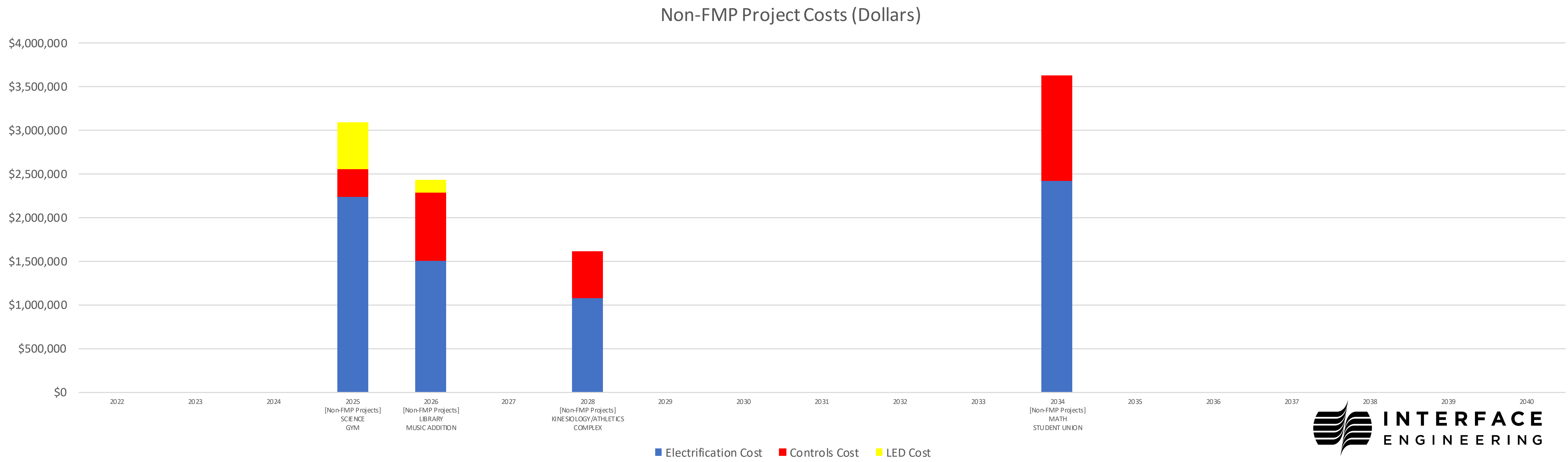
HVAC Electrification Strategy
Los Medanos College – District Energy Project Savings and Cost Summary

District Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$683,582	$2,850,470	$7,241,628	$10,775,679

District Energy Project Annual Cost Savings (2023 LMC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$47,685	$36,011	$115,698	-$146,787	$52,608

District Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
677,954	511,981	3,756,440	5,843,351

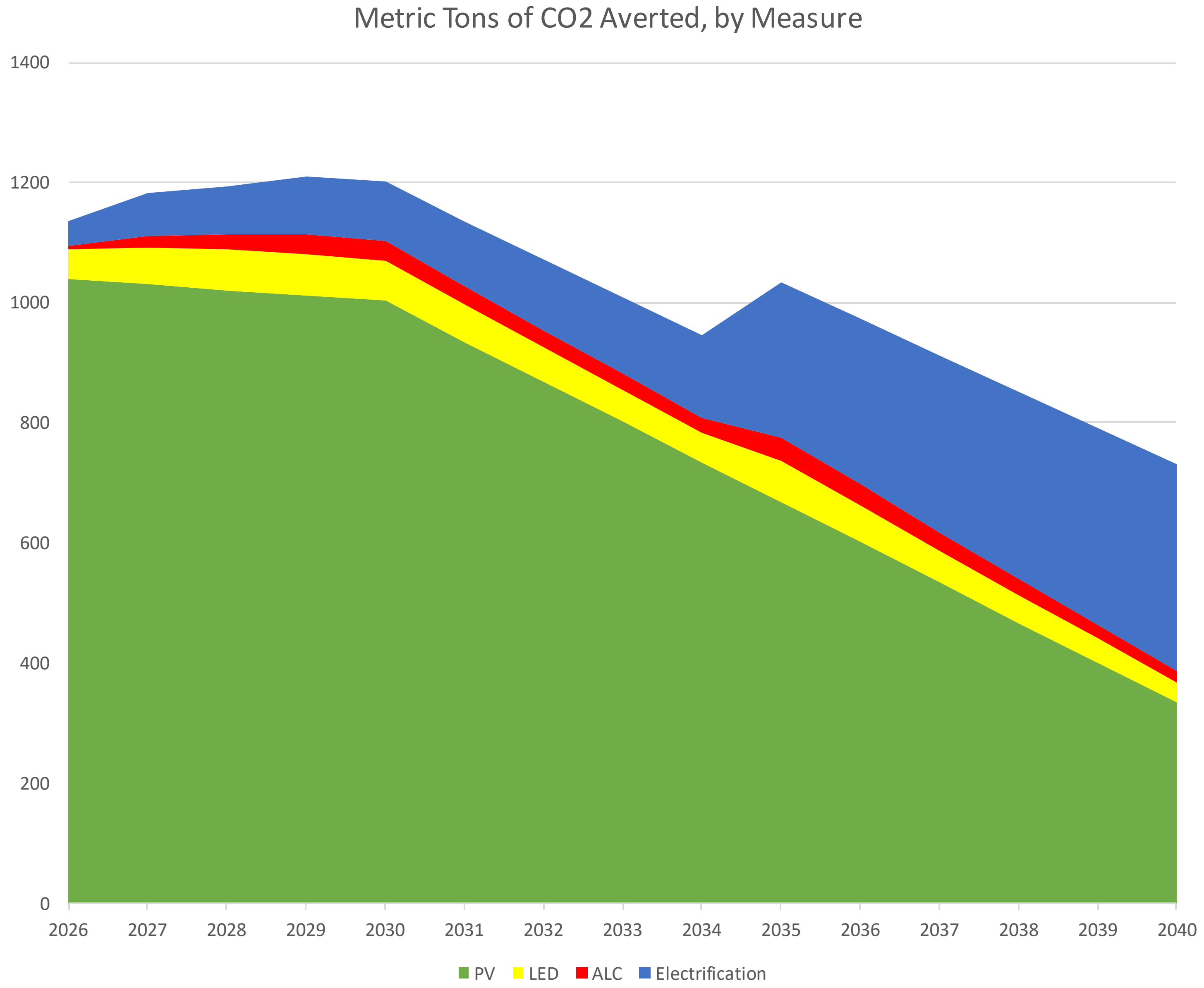
District Energy Project Annual Cost Savings (2035 Estimated LMC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$85,155	$64,308	$206,610	-$262,128	$93,945

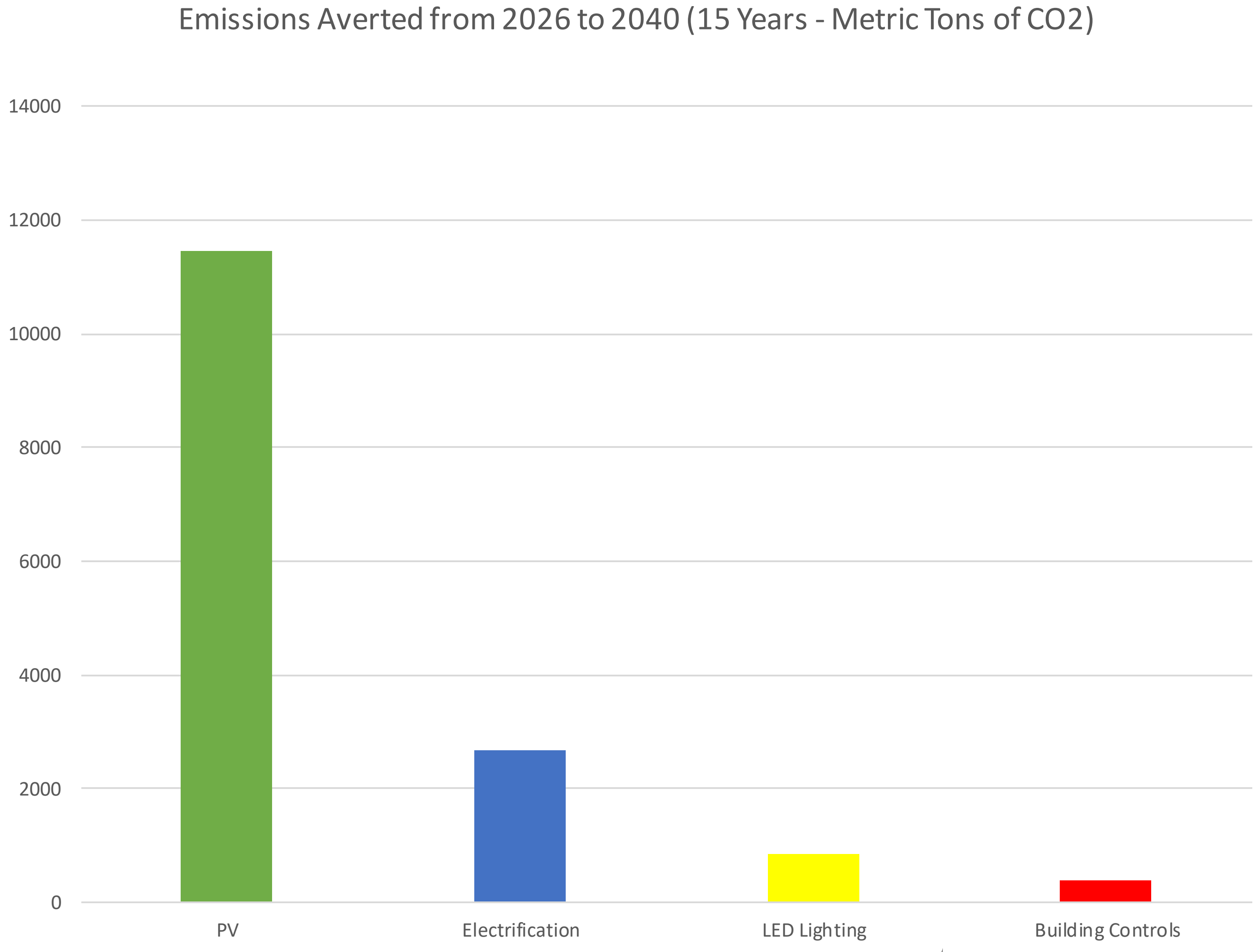


INTERFACE ENGINEERING

HVAC Electrification Strategy
Los Medanos College – District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. In this graph it is clear that PV offers a majority of the emissions reduction in the short term and electrification has less impact, for a relatively higher price. However, as the grid becomes cleaner, the impact of PV and other electrical consumption decreases, and the remaining gas emissions become a dominant source of emissions that is hard to offset. Electrification is also very important for meeting the campus building EUI targets.





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HVAC Electrification Strategy
Brentwood Education Center – Additional Efficiency Projects

The following matrix outlines the electrification planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWh	Gas Reduction kBTU	Starting EUI	EUI After
BRENTWOOD EDUCATION CENTER	54,973	2034			X (Boiler)	Unknown boiler age, but it is a new boiler since building was constructed in 2020			$2,561,142	$2,561,142	-171,312	1,636,712	64.0	44.9

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

INTERFACE ENGINEERING

HVAC Electrification Strategy
Brentwood Education Center – District Energy Project Savings and Cost Summary

BEC Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$953,678	$1,430,517	$2,561,142	$4,945,337

2023 BEC Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$0	$0	-$92,508	$35,517	-$56,992

BEC Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
0	0	1,052,172	1,636,712

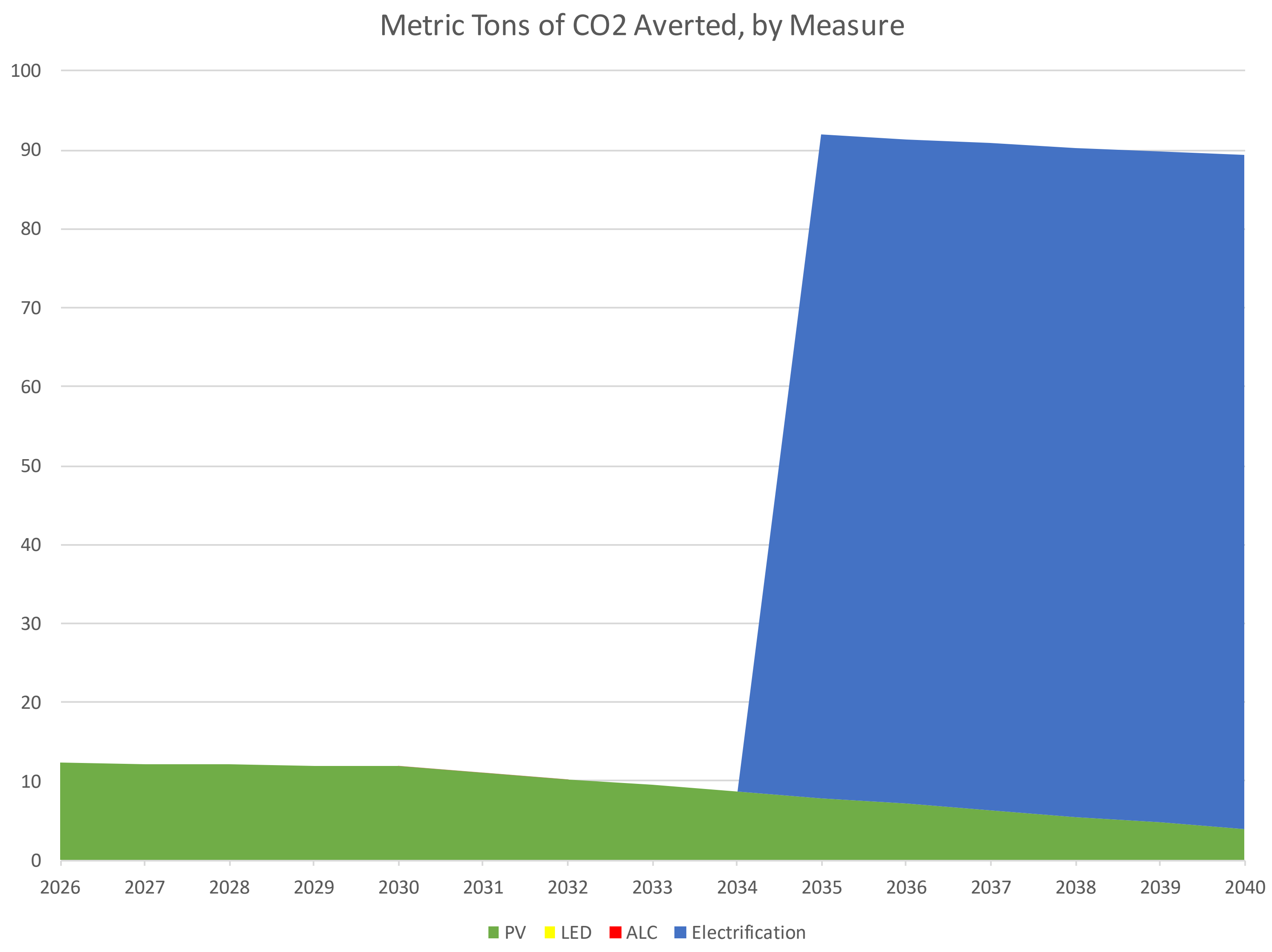
2035 BEC Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$0	$0	-$165,198	$63,424	-$101,774

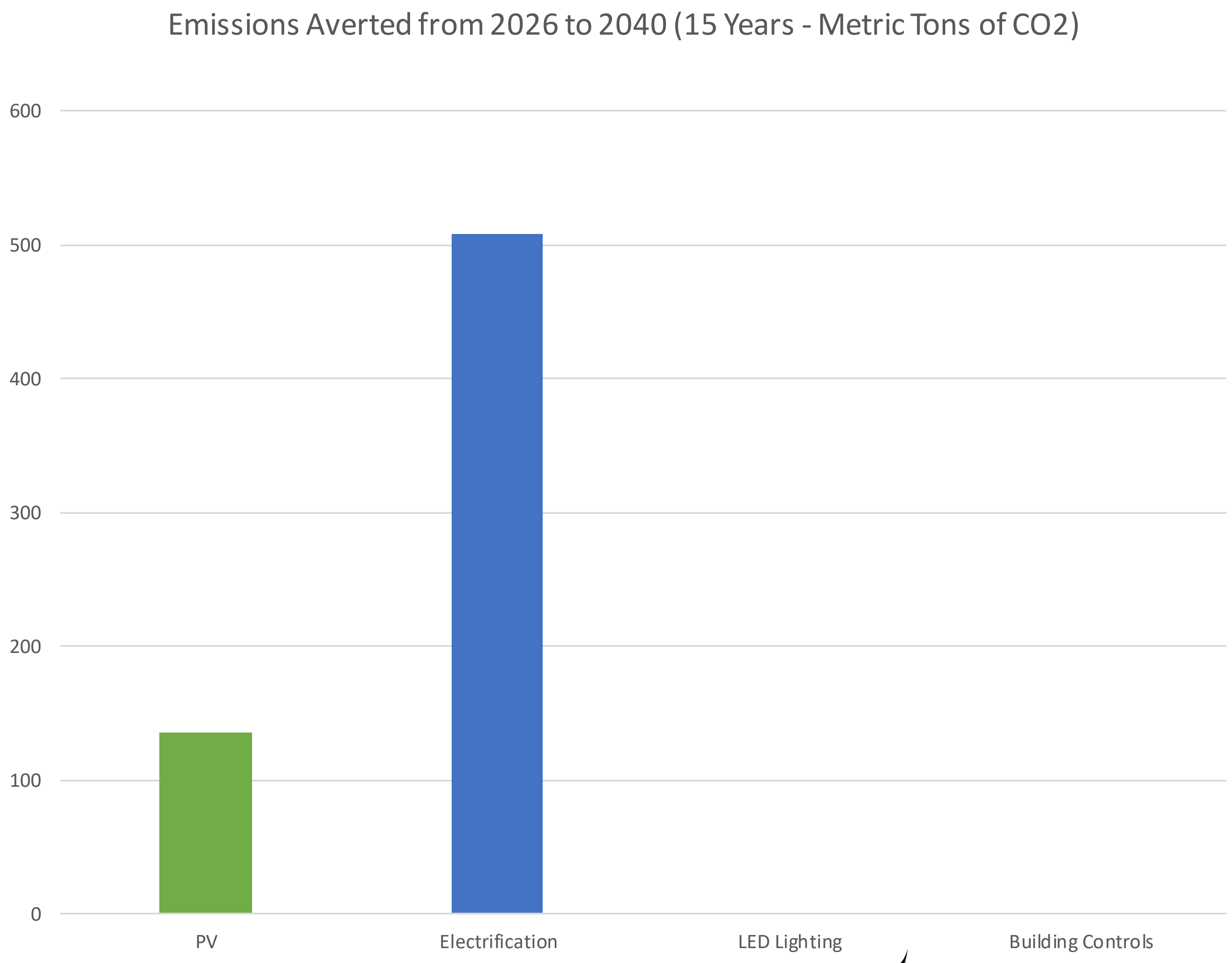
All of the Brentwood Education Cener projects are scheduled for 2034.

INTERFACE ENGINEERING

HVAC Electrification Strategy
Brentwood Education Center– District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. PV provides a low amount of offset emissions, due to Brentwood's lower emitting electric utility, so the majority of emissions averted come from the electrification project. The planned PV has a more significant impact on the operational costs of the campus, relative to its small emissions impact.





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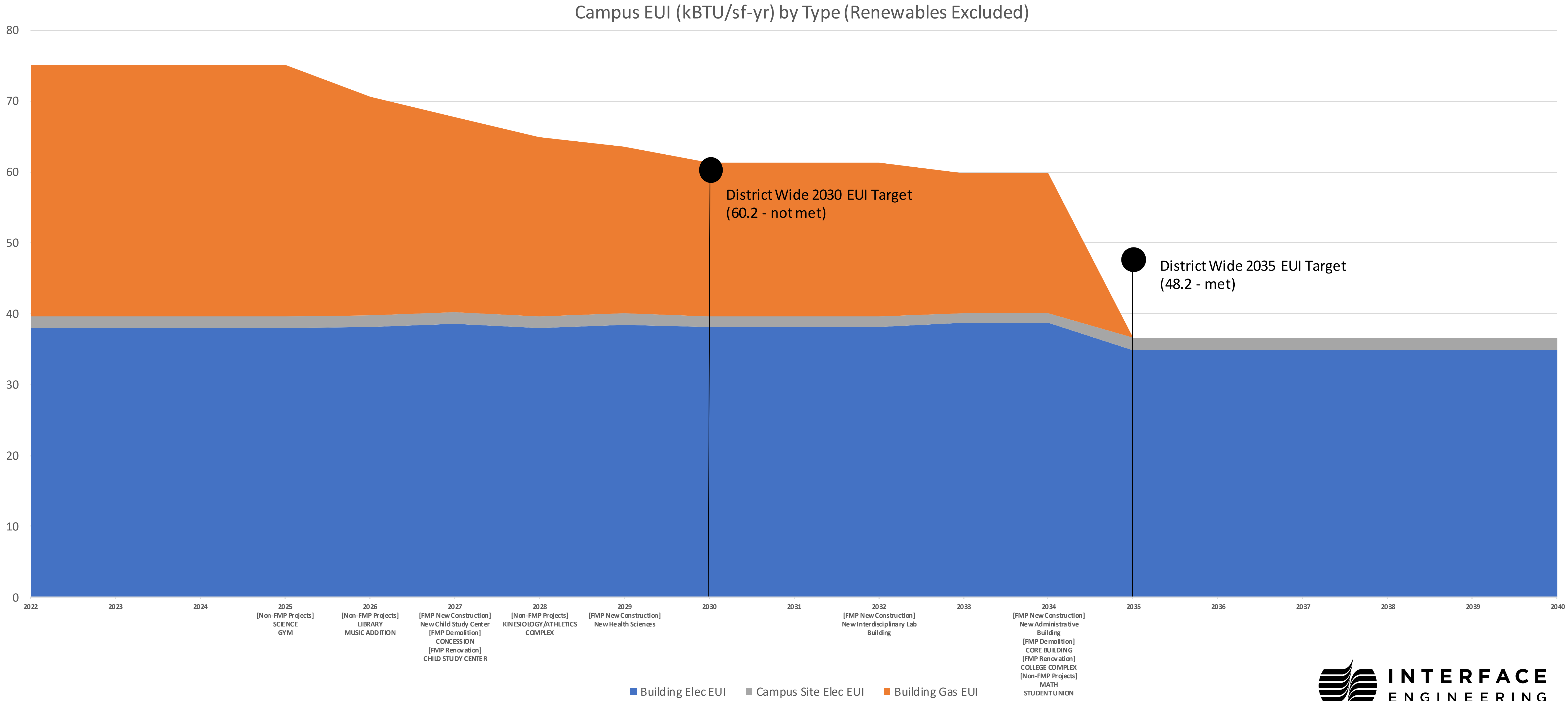
Energy Timeline

HVAC Electrification Strategy
Los Medanos College – Campus EUI Trend

The EUI of the LMC campus is very sensitive to the high gas use associated with the college complex. This means that there will be a large EUI reduction when large portions of the college complex building are demolished. With this work planned for 2034, the 2035 EUI goal is much more achievable than the 2030 EUI goal. Overall, electrification is very important to achieving campus EUI and emissions goals, as large reductions in gas kBTU results in much smaller increases in electric kBTU.



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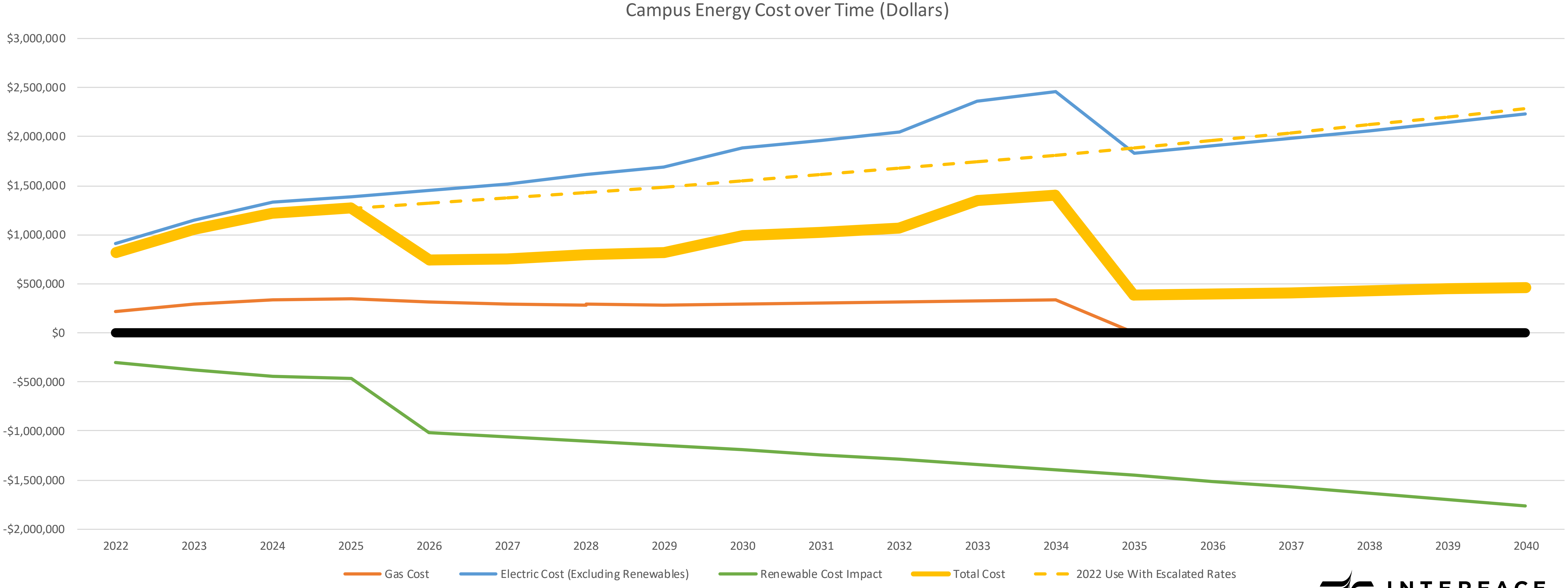
HVAC Electrification Strategy
Los Medanos College – Campus Utility Costs Trend

The chart below shows the total and fuel specific utility costs for the campus going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus. Renewables and efficiency upgrades like controls and LEDs reduce the operating cost of the campus. In this case, the planned renewables and demolition/renovation of the college complex both cause a significant reduction in the operating costs for the facility. The 0.591 MW of additional future PV required to offset emissions by 2035 would result in an estimated additional $380,000 a year of cost savings with 2035 utility rates.



Planned PV is assumed to be installed in the year prior to the start of 2026.

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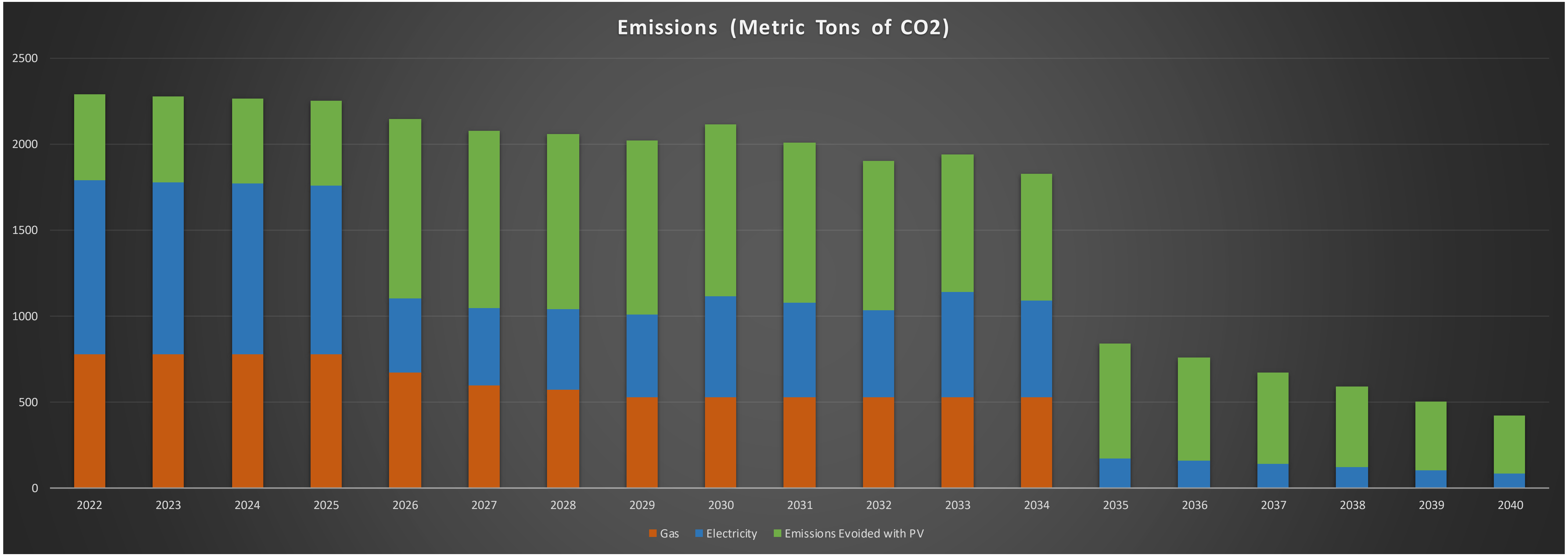
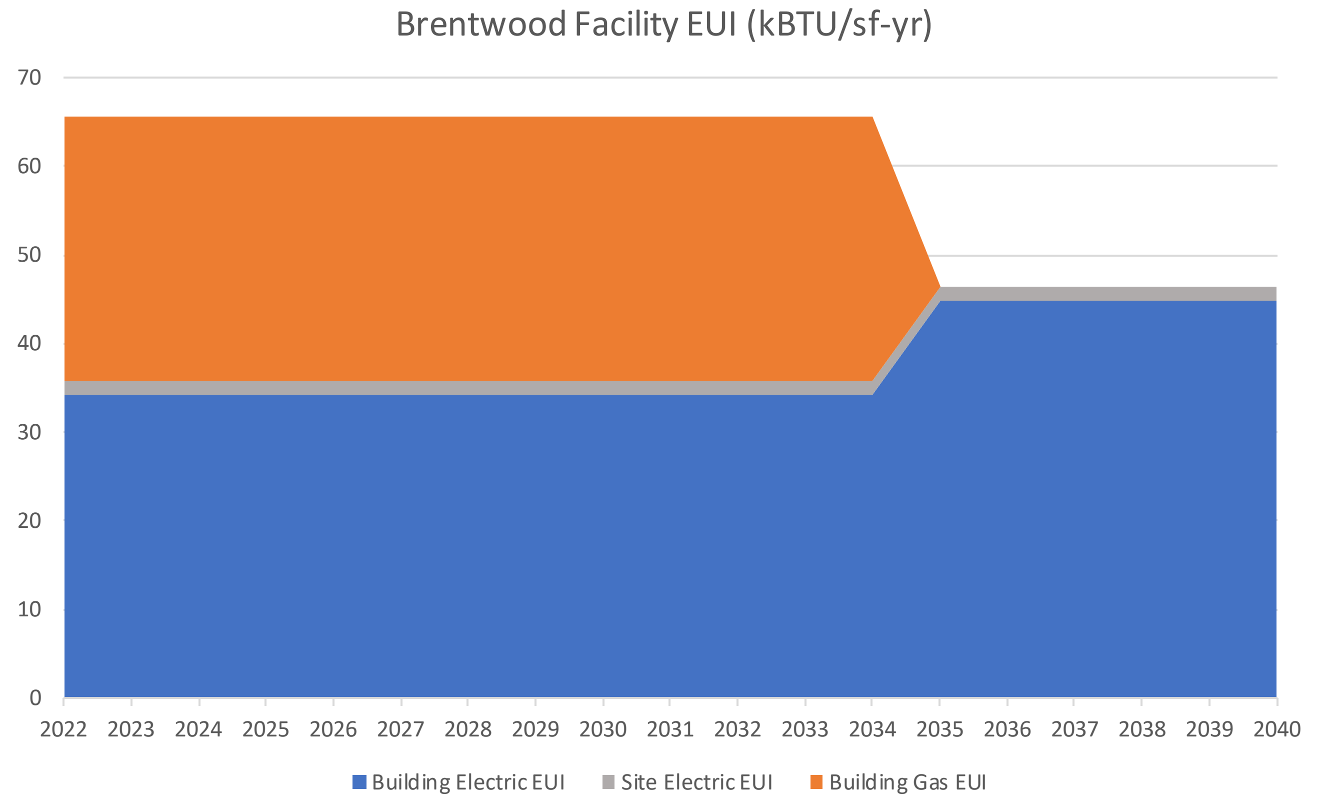
HVAC Electrification Strategy
Los Medanos College – Campus Emissions Trend

The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. Emissions from electrical consumption deprecate at the same rate. The starting emissions are based on weather normalized data. Even with these projects, a moderate amount of carbon would still need to be offset to reach net zero by 2035. If this takes the form of PV, 591 kW of additional PV capacity beyond what is currently planned would be needed to reach net zero emissions by 2035. Otherwise, to meet the goal, offsets would need to be purchased until the California grid is legislated to be emissions free by 2045. This amount would start at about 175 tons per year in 2035 and decrease to 87 tons per year by 2040 as the grid approaches the legislative targets. If the CA grid/Constellation emissions rate approaches zero carbon faster or slower than legislatively required, the offsets required could go up or down. A good efficiency and emissions reduction strategy may not require each individual campus to meet the sustainability goals, but rather the ensemble of campuses meeting the goals. This will allow for taking advantage of deploying PV where it is most effective (campuses associated with higher emitting utilities) or where there is the most capacity, and purchasing offsets or clean energy at a district level for the net emissions that remain.

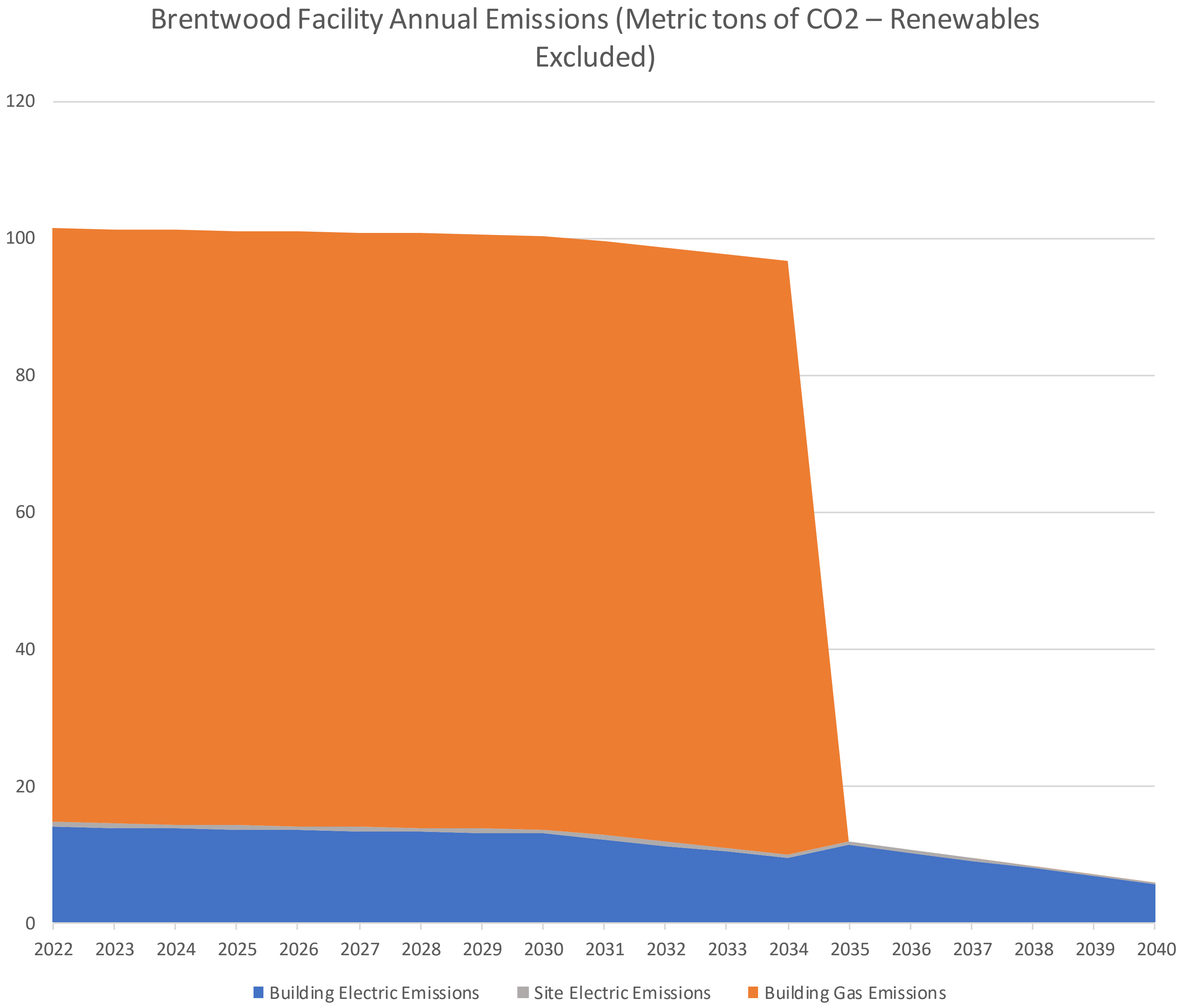


HVAC Electrification Strategy
Brentwood Education Center - Energy and Emissions Information

Information regarding Brentwood Education Center PV and its role in the overall campus emissions and EUI reduction will be included in the district wide version of the report. Below are graphs of the EUI and emissions of the facility over time, without goals or PV/Carbon Offset/Purchased Green Energy interventions. We have also included data for an electrification project associated with Brentwood Education center. Due to Brentwood's very low electric grid emissions rate, electrification can have an extreme impact on its emissions.



Brentwood Education Center Electrification							
Area	Year	Cost	Starting EUI	EUI After	Electric kWH Increase	Gas kBTU reduction	Annual Cost Penalty (2034 Dollars)
54,973	2034	$2,561,142	64	45	584,540	1,636,712	$24,442



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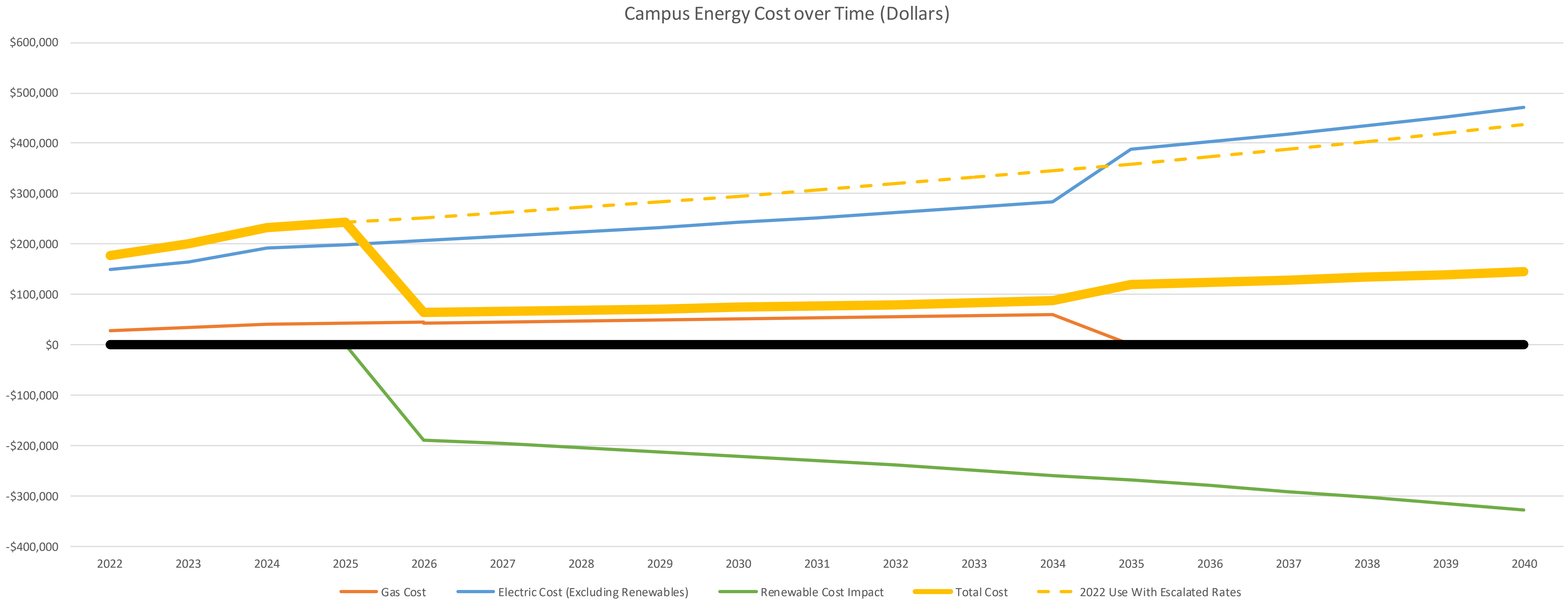
HVAC Electrification Strategy
Brentwood Education Center – Facility Utility Costs Trend

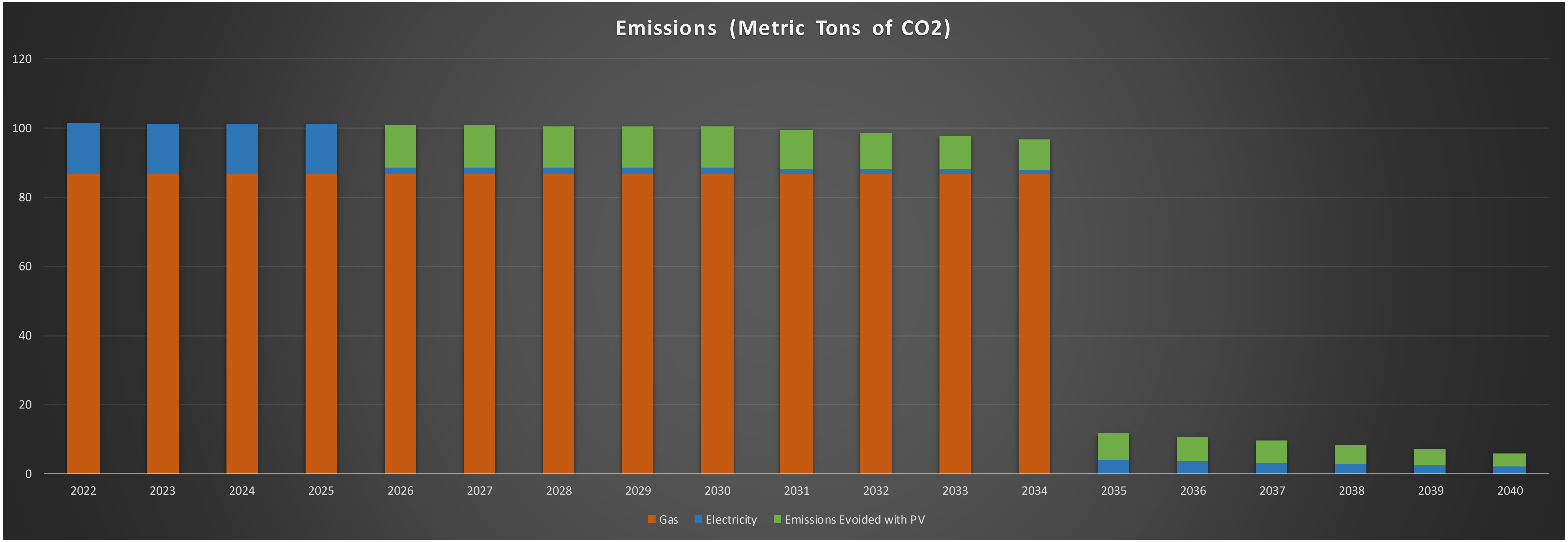
The chart below shows the total and fuel specific utility costs for the BEC campus going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus. Renewables reduce the operating cost of the campus. The 166 kW of additional PV required to offset emissions by 2035 would result in an estimated additional 133 thousand dollars a year of cost savings with 2035 utility rates.



Planned PV is assumed to be installed in the year prior to the start of 2026.

HVAC Electrification Strategy
Brentwood Education Center – Campus Emissions Trend

The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. The extreme drop in emissions is associated with the electrification of the facility in 2034. The emissions rate for the utility serving the center is low, and because of this, there is a drastic reduction in emissions from electrification. The campus would need 166 additional kW of PV to offset its emissions completely in 2035.



2.

Contra Costa College

Carbon and Energy Benchmarking

Building Benchmarking Study - Introduction

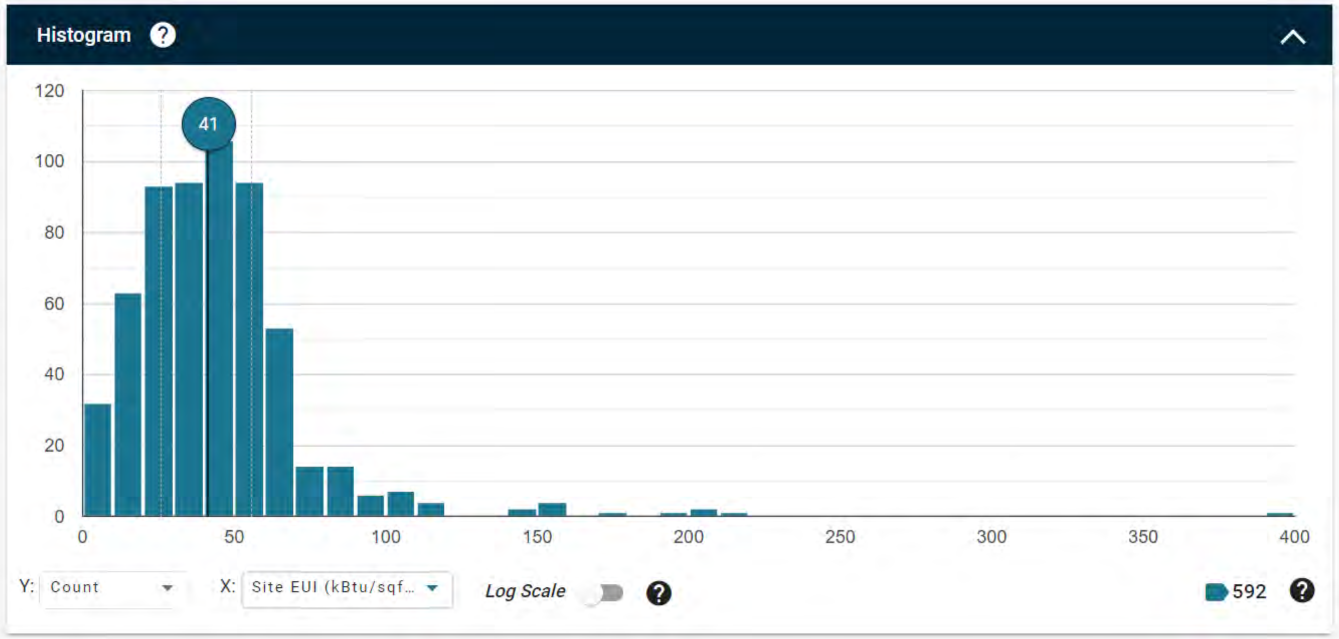
As part of the District Sustainability and Electrification plan, the portfolio of campus buildings has been subject to a benchmarking study to attempt to determine the highest priority target buildings for electrification and chart a path for the district towards meeting its sustainability goals. The data used for this benchmarking study consists of engineering and architectural drawings provided by the community college district, campus wide electricity and gas usage data, and results from a building equipment and facilities audit performed by Bureau Veritas. Building EUIs were also adjusted based on known operational configurations for particular campuses and buildings, as well as the mechanical and air systems.

Electricity and gas usage was estimated for each individual building on the campus based on available benchmarking data by building type for the bay area climate zones, the state of California as a whole, and available campus wide billing data. These estimates were then adjusted based on known building specific characteristics. Large multi-purpose campus buildings were divided into the various use-types they are composed of in order to provide an accurate EUI estimate for the building, as well as a use-type specific EUI for that campus.

The estimates were then revised based on a dialogue with the district on the values, particular building meter data, multi-building line meter data, and site electricity data that was made available.

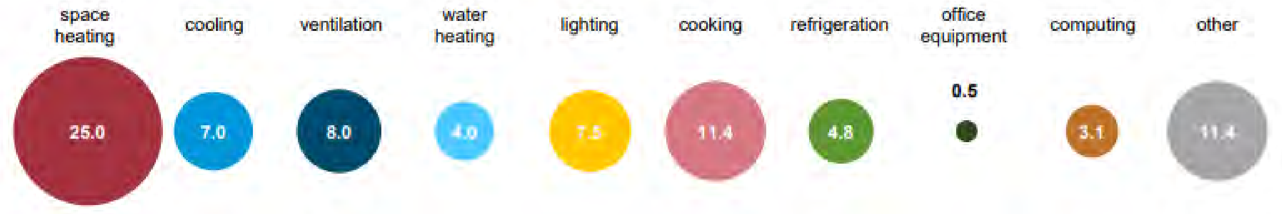
The energy and carbon impact of the pools were estimated based on available boiler data for the Contra Costa College pool and then a gas usage per square foot per year was applied to the Diablo Valley College pool in order to estimate the portion of the gas usage that is not part of a building EUI.

Building type energy data from the bay area, California, and the United States came from the Lawrence Berkley National Laboratory Building Performance Database and was adjusted or compiled into campus use types based on engineering judgement.

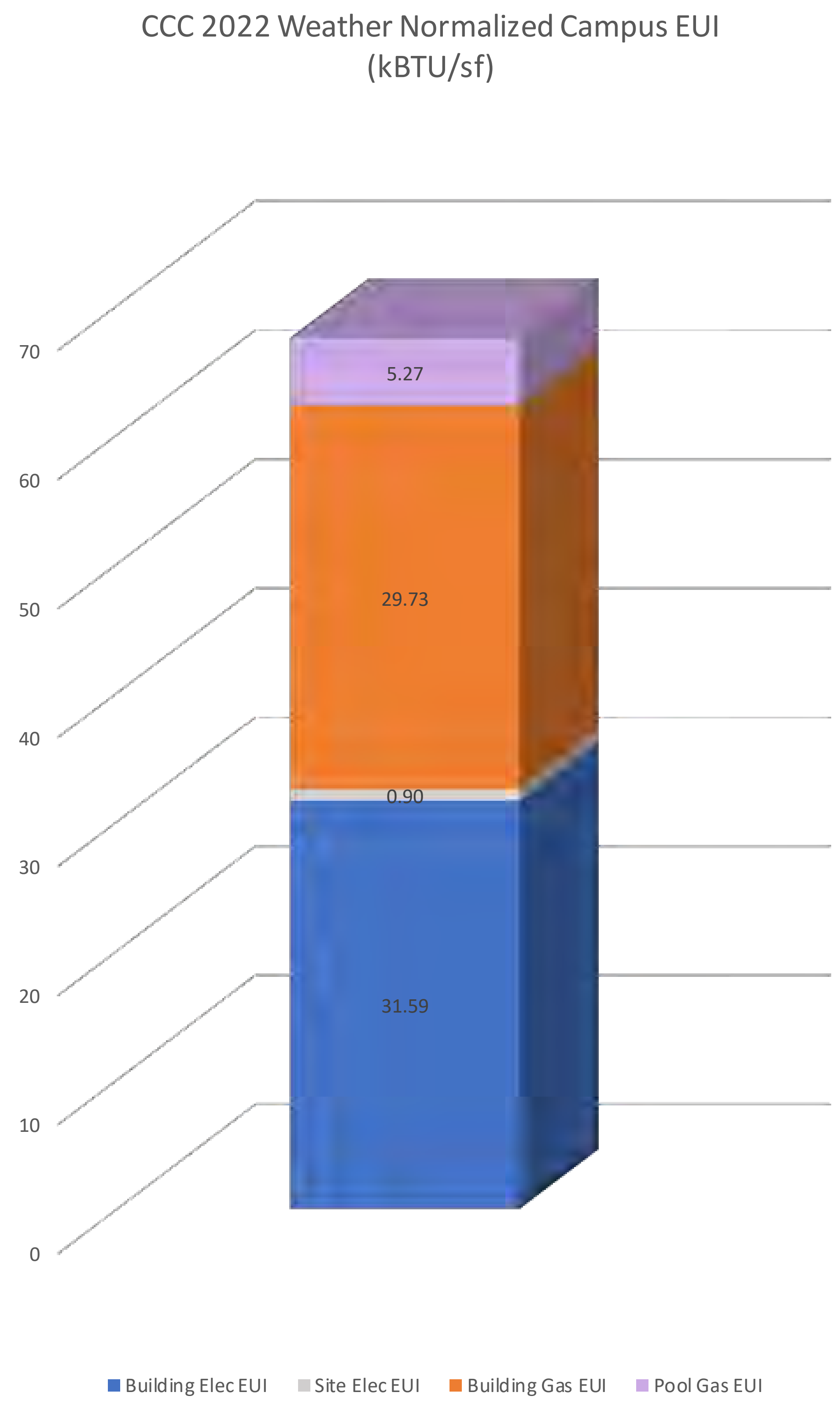


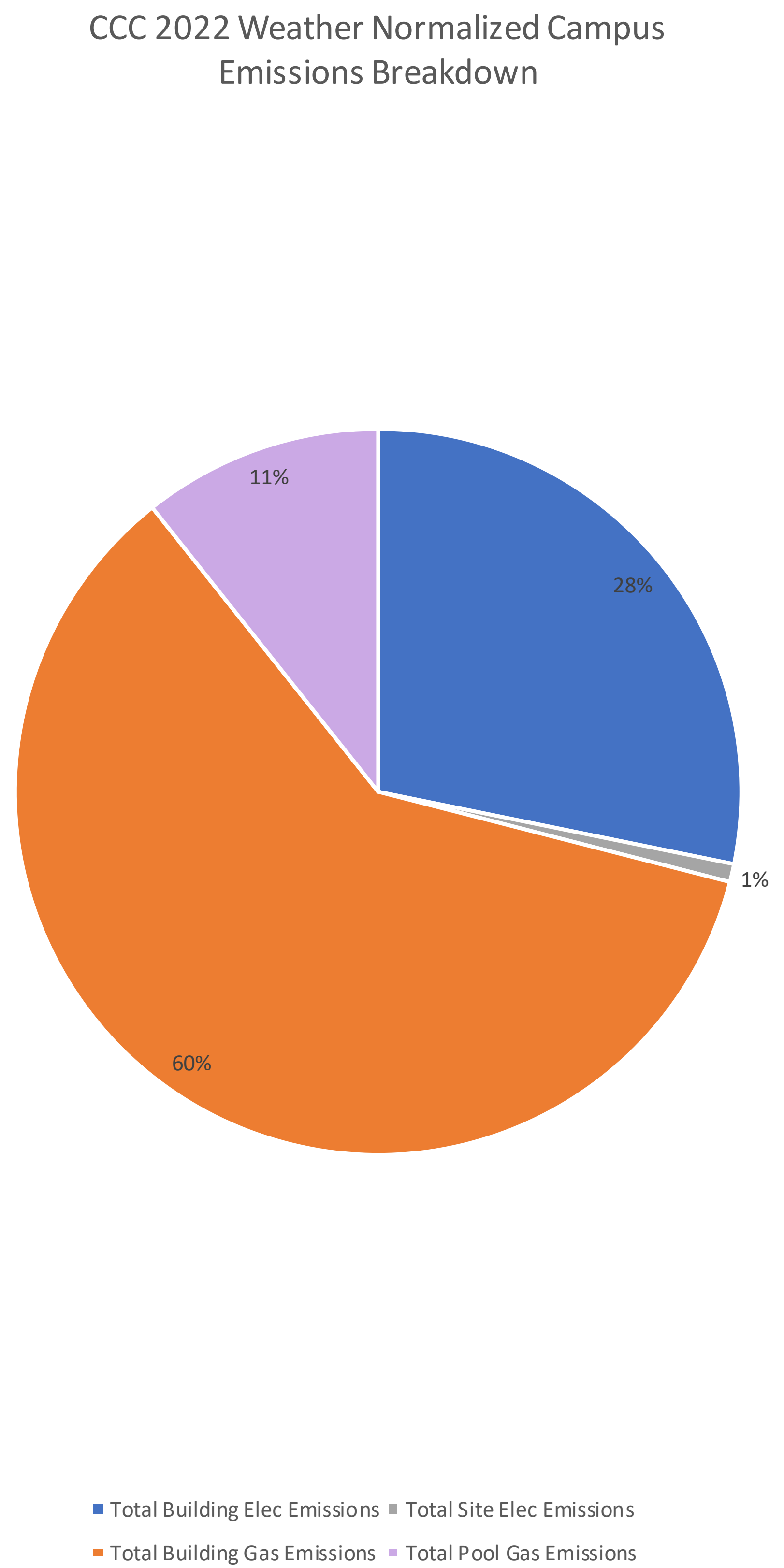
Sample BPD Query

The Energy Star Commercial Buildings Energy Consumption Survey and data from the Higher Education Benchmarking Initiative were also used to estimate end-use breakdowns and as a comparison point for realistic data for particular types of campuses.



Sample CBECs Data





CCC

Campus-Level Benchmarking

The campus EUI graph sums the total gas and electricity associated with the campus and divides them by the square footage of campus buildings included in the EUI study. The breakdown is representative of the split between gas and electricity use on the campus. The campus emissions chart shows the portion of the campuses total emissions that are associated with each fuel type. This data is all based on weather normalized data for the gas and electricity use and does not exactly match the real quantities but is better for a forward-looking analysis of the campus energy. CCC electricity use is associated with a mix of Constellation energy which as a grid emissions rate of 701 lbs CO2e per MWH of electricity and MCE which has a grid emissions rate of 44 lbs CO2e per MWH of electricity. This results in an average campus emissions rate of 175 lbs CO2e per MWH of electricity. The low emissions rate for the grid here means that a majority of the emissions for the campus come from gas use. The area for EUI calculations in 2022 was 467,113 ft^2.

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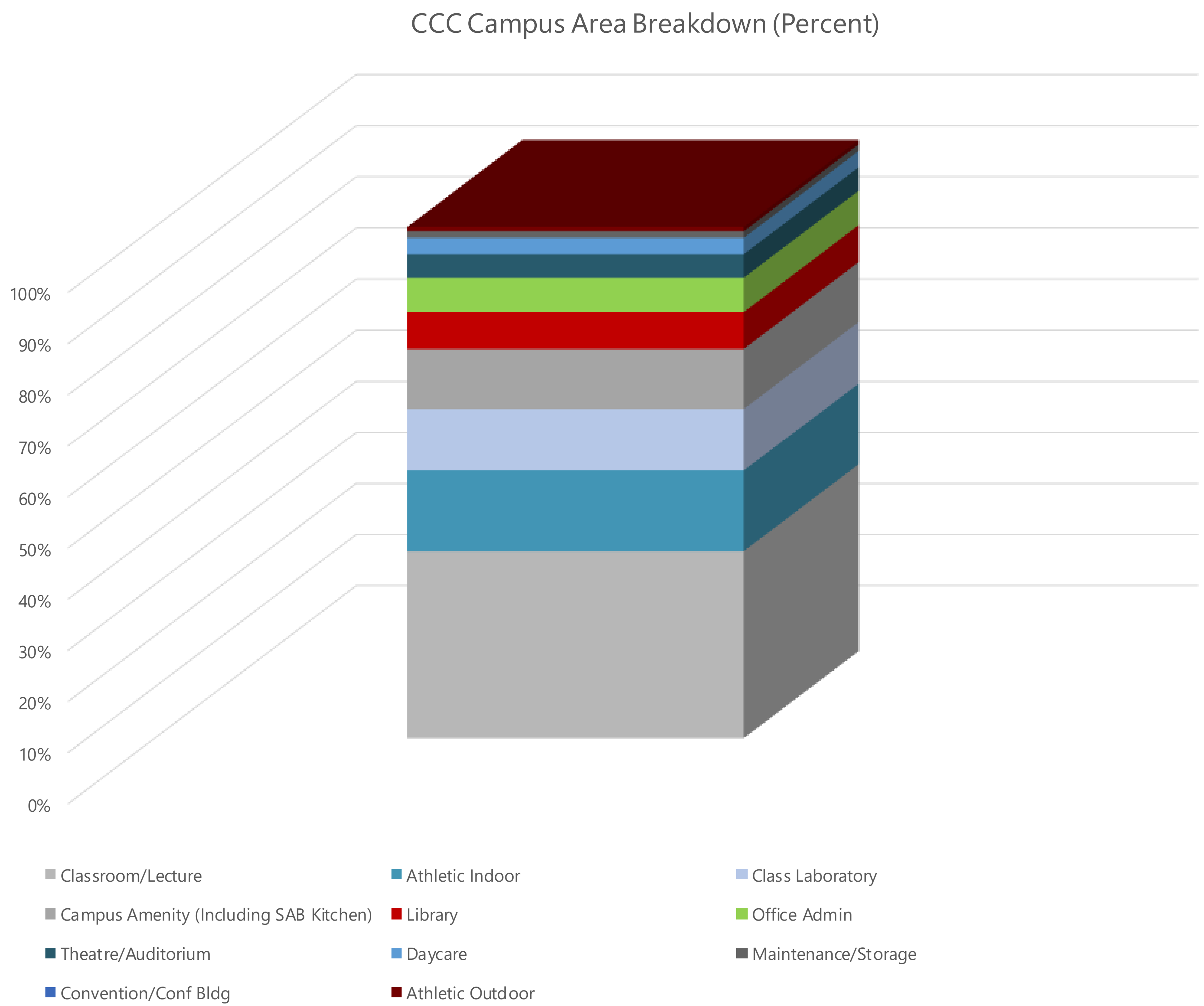

CCC

Campus Program Breakdown

The campus area breakdown shows the portion of the campus square footage associated with each of the program type categories in our study. Buildings with multiple use types have had their square footage distributed proportionally.

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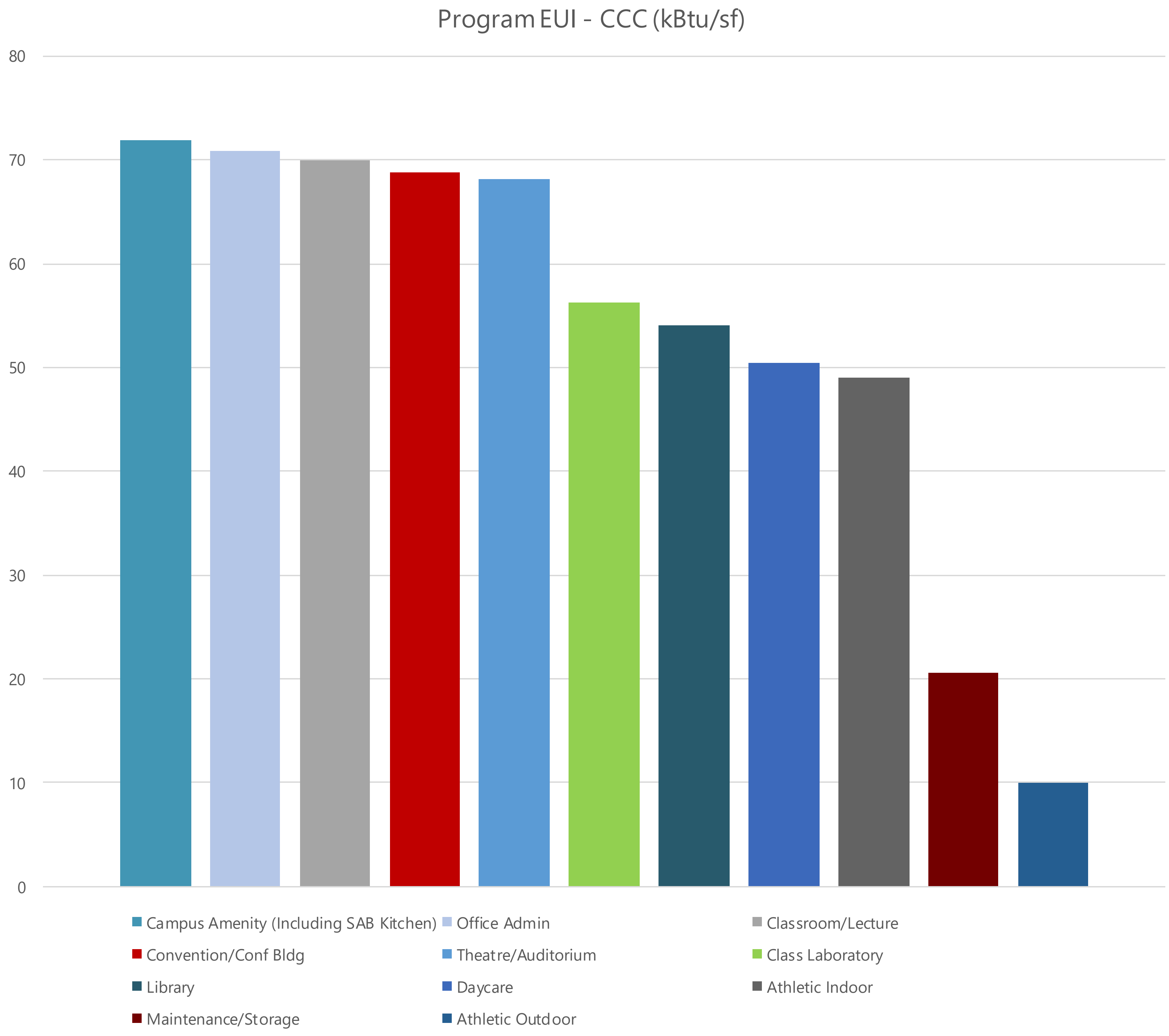

CCC

EUI per Program Type

The program EUIs are based on the weighted average of individual EUIs of buildings in each program classification, which may vary. These programs were assigned for energy analysis purposes and may not match other campus program breakdowns.

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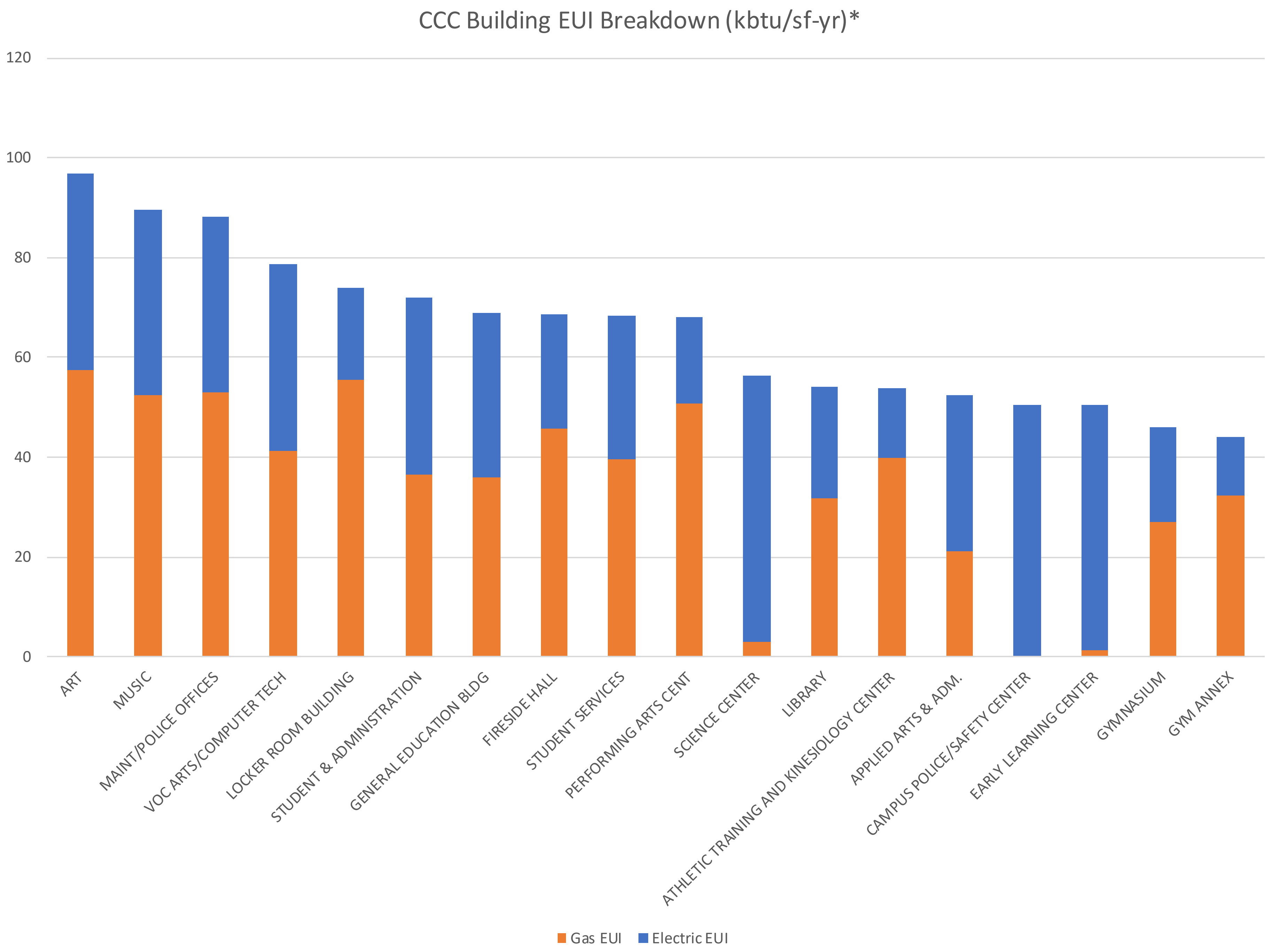
CCC

Energy Breakdown by Building



*Some buildings with negligible energy use are excluded from this graph

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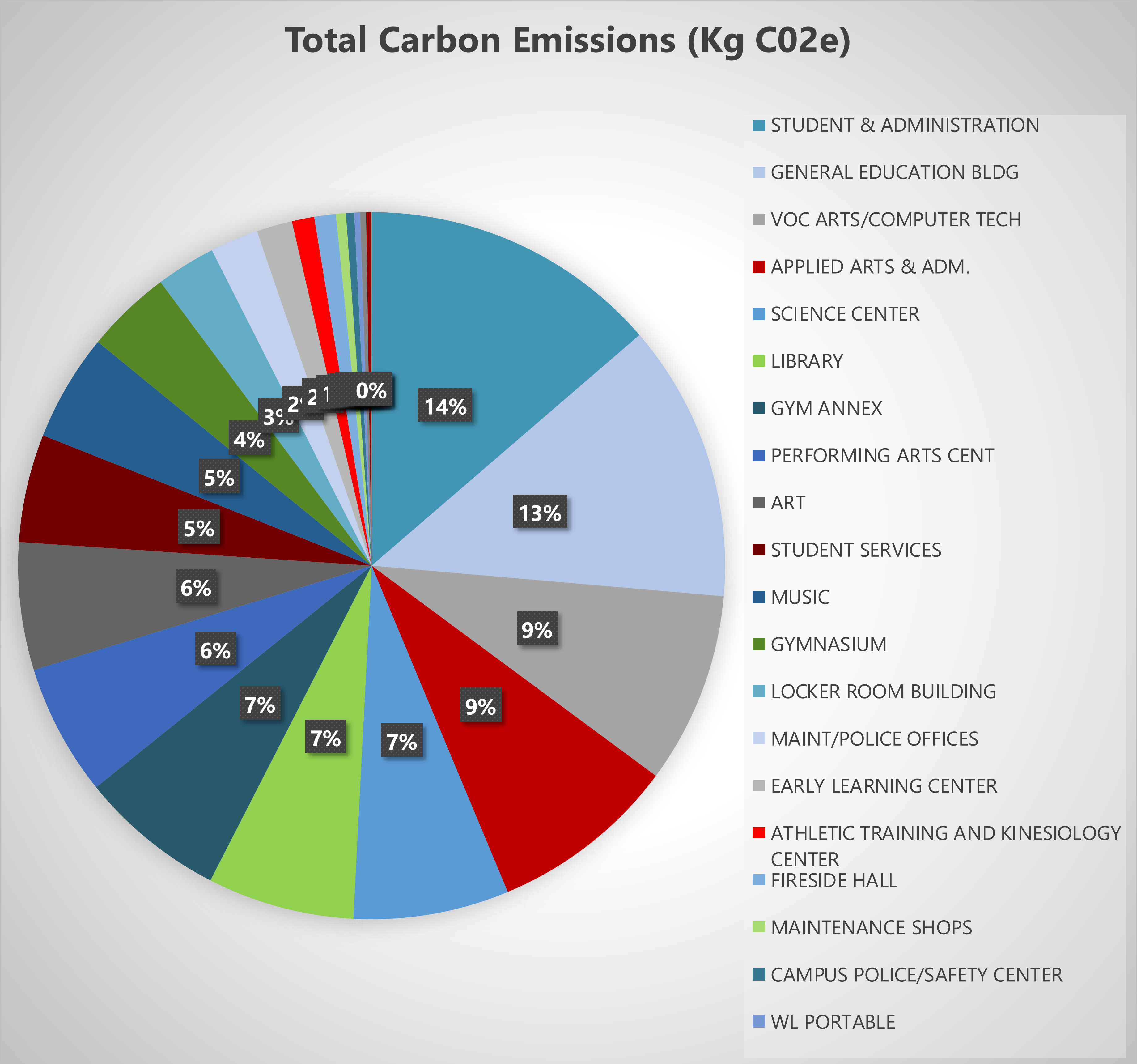

CCC

Total Emissions

CCC Benchmark Data Summary Table

Building	Age	Area	EUI	Gas EUI	Electric EUI	Total kBTU	Gas kBTU	Elec kBTU	Gas Carbon Emissions (metric tons CO2)	Electricity Carbon Emissions (metric tons CO2)	Total Carbon Emissions (metric tons CO2)
STUDENT & ADMINISTRATION	2016	53,577	71.9	36.4	35.5	3,854,501	1,952,641	1,901,860	104	44	148
GENERAL EDUCATION BLDG	2016	51,234	69.0	35.9	33.1	3,534,736	1,841,247	1,693,489	98	40	137
VOC ARTS/COMPUTER TECH	1957	30,912	78.8	41.2	37.6	2,434,796	1,272,035	1,162,761	68	27	95
APPLIED ARTS & ADM.	1982	50,000	52.4	21.3	31.1	2,618,000	1,063,650	1,554,350	56	36	93
SCIENCE CENTER	2021	54,965	56.3	2.9	53.4	3,094,023	160,484	2,933,539	9	69	77
LIBRARY	1963	32,904	54.0	31.8	22.2	1,777,556	1,045,915	731,641	56	17	73
GYM ANNEX	1969	36,327	44.2	32.2	11.9	1,603,934	1,170,611	433,323	62	10	72
PERFORMING ARTS CENT	1980	21,000	68.1	50.8	17.4	1,430,444	1,065,926	364,518	57	9	65
ART	1971	15,900	96.8	57.5	39.3	1,538,611	913,550	625,061	49	15	63
STUDENT SERVICES	2008	19,280	68.3	39.6	28.7	1,316,378	763,183	553,196	41	13	53
MUSIC	1964	14,522	89.6	52.4	37.2	1,301,171	760,372	540,799	40	13	53
GYMNASIUM	1957	22,551	46.1	26.9	19.1	1,038,512	606,985	431,527	32	10	42
LOCKER ROOM BUILDING	1957	8,732	73.9	55.5	18.4	645,431	484,578	160,853	26	4	29
MAINT/POLICE OFFICES	1967	6,570	88.1	53.0	35.1	578,795	348,032	230,763	18	5	24
EARLY LEARNING CENTER	2003	14,504	50.4	1.3	49.1	731,002	18,275	712,727	1	17	18
ATHLETIC TRAINING AND KINESIOLOGY CENTER	1962	4,531	53.9	40.0	13.9	244,221	181,122	63,099	10	1	11
FIRESIDE HALL	2016	3,590	68.7	45.8	23.0	246,781	164,306	82,475	9	2	11
MAINTENANCE SHOPS	1959	5,636	21.0	12.9	8.1	118,217	72,775	45,442	4	1	5
CAMPUS POLICE/SAFETY CENTER	2019	3,430	50.4	0.0	50.4	172,872	0	172,872	0	4	4
WL PORTABLE	2022	2,100	59.5	0.0	59.5	124,950	0	124,950	0	3	3
ML PORTABLE	2022	2,100	59.5	0.0	59.5	124,950	0	124,950	0	3	3
CUSTODIAL OFFICES	1998	1,392	75.6	1.3	74.3	105,235	1,754	103,481	0	2	3
AUTO COMPRESSOR BLDG	1997	300	14.3	0.3	14.0	4,275	90	4,185	0	0	0
REFEREE TRAILER	2000	300	10.0	0.0	10.0	3,000	0	3,000	0	0	0

The pool uses 2,460,000 kBTU per year, or about 177 kBTU/sf/yr, and is associated with the same boiler as the gym annex building.

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CCC EUI Map

Energy Use Intensity (EUI)

Electric Infrastructure Assessment

Electrical Infrastructure Assessment - Introduction

As part of the Electrification Plan, Interface Engineering evaluated the available electrical system capacity at each campus to accommodate the future electrical demands from electrification, renewable energy deployment, and EV charging. The goal of this assessment is to confirm the capacity at the main campus feeders and switchgear. Downstream equipment, such as panels, wiring, and transformers, are not included in this assessment.

We have assessed the available electrical capacity at each of the District's campuses, as well as the District Offices and Brentwood Building. The available capacity has been evaluated using PG&E utility data (15-minute interval data) and PV inverter output data (hourly data provided from the district) for the period of May 2022 through August 2023.

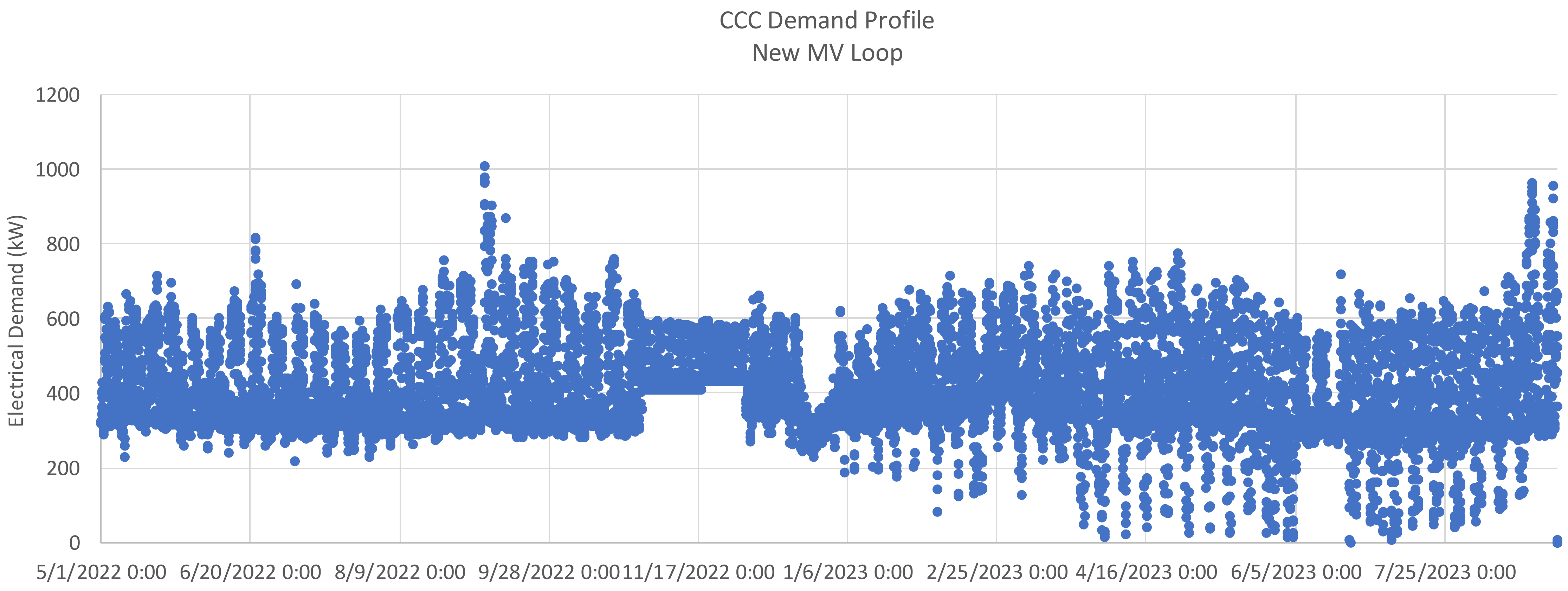
For electrical services that include PV production, the generation data from net generation output (NGOM) meters and/or direct inverter output data is added to the consumption data reported at the main revenue meter, establishing the true demand on the service.

The demand (kW) reported for each service is a calculated value, using the consumption and PV production data (kWh). For example, if 100 kWh are consumed in a 15-min timestep, then the calculated demand for that timestep would be reported as 400 kW (100 kWh X (1/4 hours)).

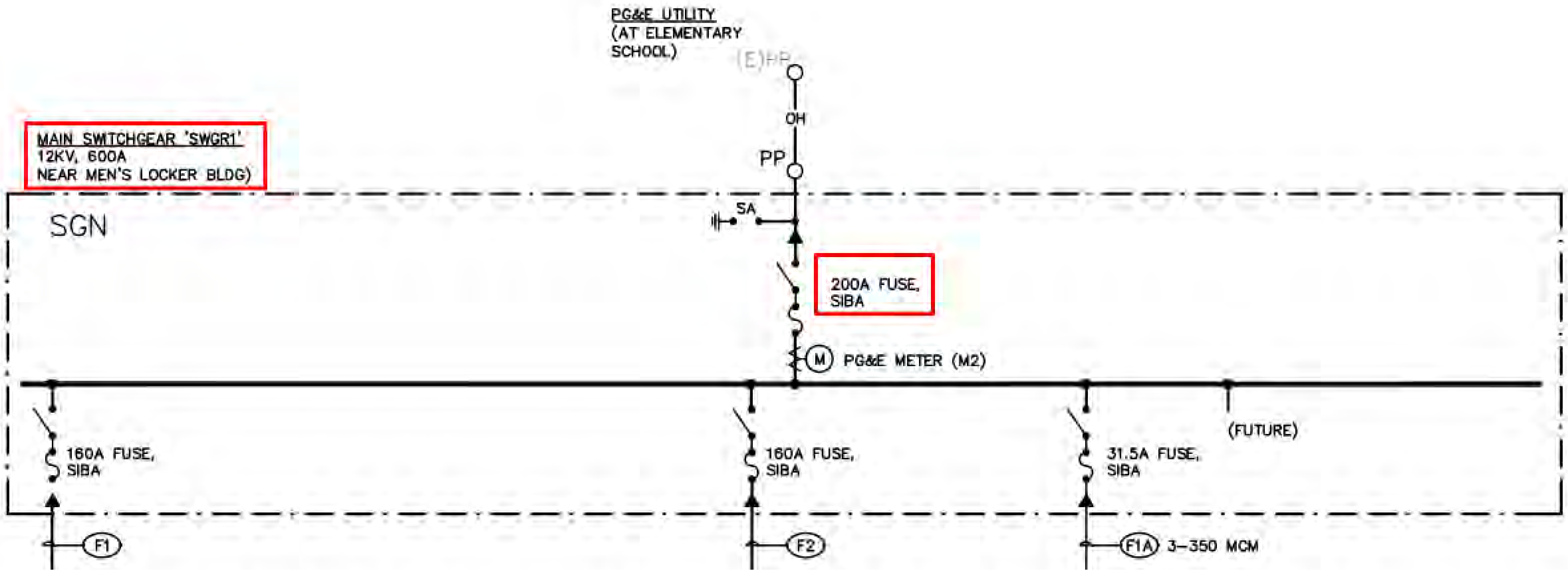
Contra Costa College (New Service)

- CCC's New MV Loop, that serves a majority of the campus, is powered by an existing 200A, 12kV service with a total capacity of 4156.9kW. The maximum demand on this service was 10007.4kW.
- Demand data for the "New MV Loop" is mostly complete. There is a missing period of data around November of 2022, but the peak demand is not expected to occur in this period.
- Demand values include PV system generation data and service consumption data.
- The existing service has an available capacity of 69.7%, or 2897.7kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	905.1 kW
2	Maximum Demand	1007.4 kW
3	Maximum Demand Occurrence	9/6/2022 13:00
4	Service Voltage	12 kV
5	Service Amperage	200 A
6	Service Capacity	4156.9 kW
7	Maximum Demand [2]	1007.4 kW
8	Maximum Demand * 125%	1259.3 kW
9	**Available Capacity [6-8]**	**2897.7 kW**
10	**Percent Available Capacity [9/6]**	**69.7%**



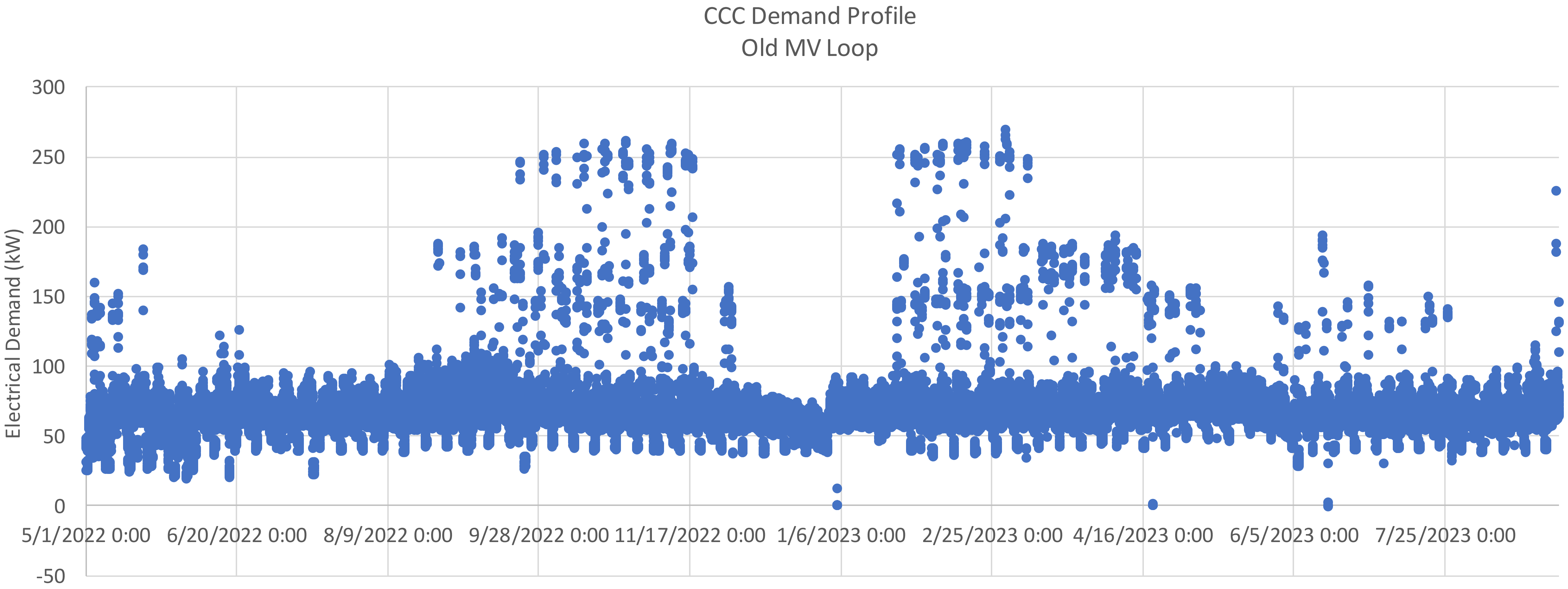
Contra Costa College (New Service) Single Line Diagram



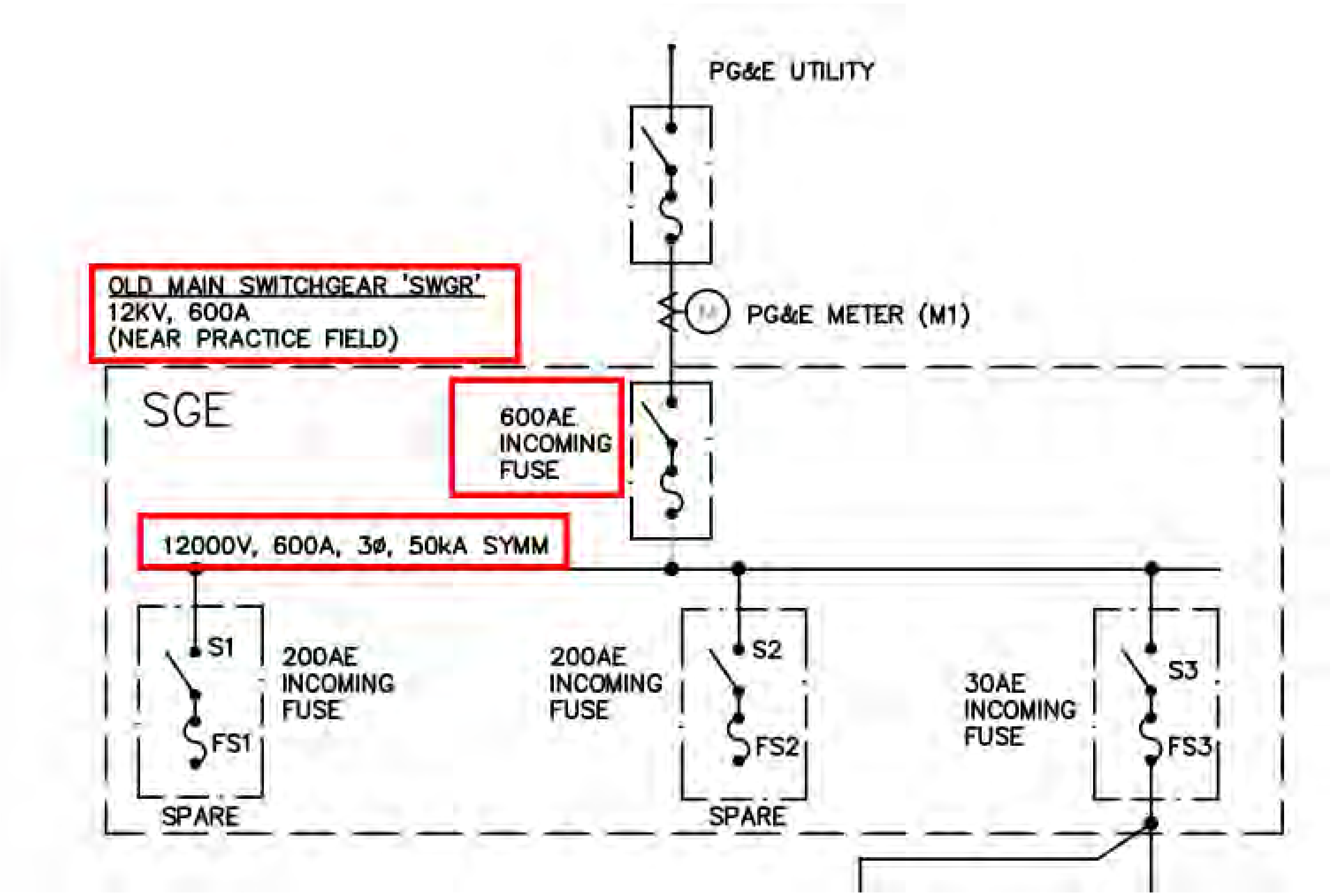
Contra Costa College (Old Service)

- CCC's Old MV Loop, that serves the sports and field of the campus, is powered by an existing 600A, 12kV service with a total capacity of 12470.8kW. The maximum demand on this service was 269.8kW.
- CCC old service data appears complete.
- The existing service has an available capacity of 97.3%, or 12133.6kW. This service appears to be under-utilized.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	252.3 kW
2	Maximum Demand	269.8 kW
3	Maximum Demand Occurrence	3/1/2023 18:30
4	Service Voltage	12 kV
5	Service Amperage	600 A
6	Service Capacity	12470.8 kW
7	Maximum Demand [2]	269.8 kW
8	Maximum Demand * 125%	337.2 kW
9	**Available Capacity [6-8]**	**12133.6 kW**
10	**Percent Available Capacity [9/6]**	**97.3%**



Contra Costa College (Old Service) Single Line Diagram



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Renewable Energy Deployment

Renewable Energy Deployment Strategy Introduction

On-site renewable energy generation is a critical component of 4CD's sustainability plan to achieve net zero carbon emissions by 2035. The district currently has approximately 3.2 MW of photovoltaic (PV) solar panel systems across CCC, DVC, and LMC, which produce nearly 3.8 MWh annually. This represents approximately 19% of the district's electricity consumption.

As part of its plan to increase on-site renewable production, 4CD has five additional PV projects approved by PG&E for installation but have yet to be funded. For the purposes of estimating the impact of these approved projects, it is assumed that these systems will be installed in 2026. An estimate of the total development costs are shown in the table below, which based on the information provided by Sage Renewables. These costs are based on recent quote that 4CD received for the Brentwood system, which indicated a total cost of $7.87/watt for carport arrays. The Brentwood, DVC, and LMC installations are also planned to include battery energy storage systems (BESS), which will further enhance the cost reduction capabilities of these systems.

The tables to the right summarize the existing and planned PV systems, including their DC capacity, orientation and expected annual production rate (which vary slightly by campus and by array orientation). The table at the bottom indicates the % of electrical consumption that is met with the existing and future PV systems.

The campus site plans on the subsequent slides indicate the existing and planned PV locations on each campus, including the context of the newly planned buildings as part of the FMP. The site plans also indicate areas that may potentially be used for additional PV in the future.

The energy and carbon impact of the existing and planned arrays are discussed in more detail in the "District Energy and Carbon Timeline" chapter of this report.

The table below shows the future PV, beyond what is currently planned, that would be required in order to achieve net zero emissions for the specific campuses in 2035, and the associated cost of deployment in 2024 PV costs.

Future PV Summary (Scenario A)

Campus	Size (kW)	Cost*	Est. Annual Production (kWh/yr)	Predicted Electrical Consumption in 2035	% Future Load Met by Future PV
DVC	3,844	$30,252,280	5,766,000	8,782,110	66%
CCC	**2,167****	**$17,054,290**	**3,250,500**	**5,143,509**	**63%**
LMC	591	$4,651,170	886,500	4,276,119	21%
SRC	433	$3,407,710	649,500	1,413,618	46%
DO	468***	$3,683,160	702,000	701,838	100%
BEC	166	$1,306,420	249,000	749,521	33%

*costs are based on estimates for PV projects for the district in 2024
**based on offsetting kWh instead of carbon emissions, due to the utility split for CCC between MCE and Constellation
***Due to limited space at this facility, this PV could be installed on another Constellation Campus like DVC, LMC, or SRC to have the same effect.

Existing PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	Kwh/KW*	Annual Energy Production (kWh)
Contra Costa College - Lot 9	**403**	**225**	**1053**	**424,359**
Diablo Valley College - Lot 1	567	270	1297	735,289
Diablo Valley College - Lot 3	267	270	1297	346,247
Diablo Valley College - Lot 4	548	270	1297	710,650
Los Medanos College - Lot B	763	150	1139	868,904
Los Medanos College - Lot C	638	230	1128	719,953
Total	3,186			3,805,402

*The existing PV production rates are 20-30% below the expected rate, based on the location and orientation of the systems. This may indicate performance issues with the panels and inverters.

Planned PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	kWh/KW	Annual Energy Production (kWh)	Project Development Costs ($)
Diablo Valley College - Lot 5	878	270	1564	1,373,000	$6,909,860
Contra Costa College - Lot 1	**947**	**225**	**1551**	**1,469,000**	**$7,452,890**
Los Medanos College	1,154	150	1560	1,800,000	$9,081,980
San Ramon Center - Main Lot	483	225	1580	763,000	$3,801,210
Brentwood Center - Main Lot	322	180	1556	501,032	$2,534,140
Total	3,784			5,906,032	$29,780,080

Renewable Energy Summary

	Annual Electricity Consumption (kWh)*	% Met by Existing PV	% Met by Planned PV	Total Planned Renewable %
CCC	**4,414,407**	**10%**	**33%**	**43%**
DVC	8,618,555	21%	16%	37%
LMC	4,783,853	33%	38%	71%
SRC	1,200,248	0%	64%	64%
Brentwood	573,479	0%	87%	87%
District Offices	657,697	0%	0%	0%
District	20,248,239	19%	28%	47%

*True 2022 value that is not weather normalized

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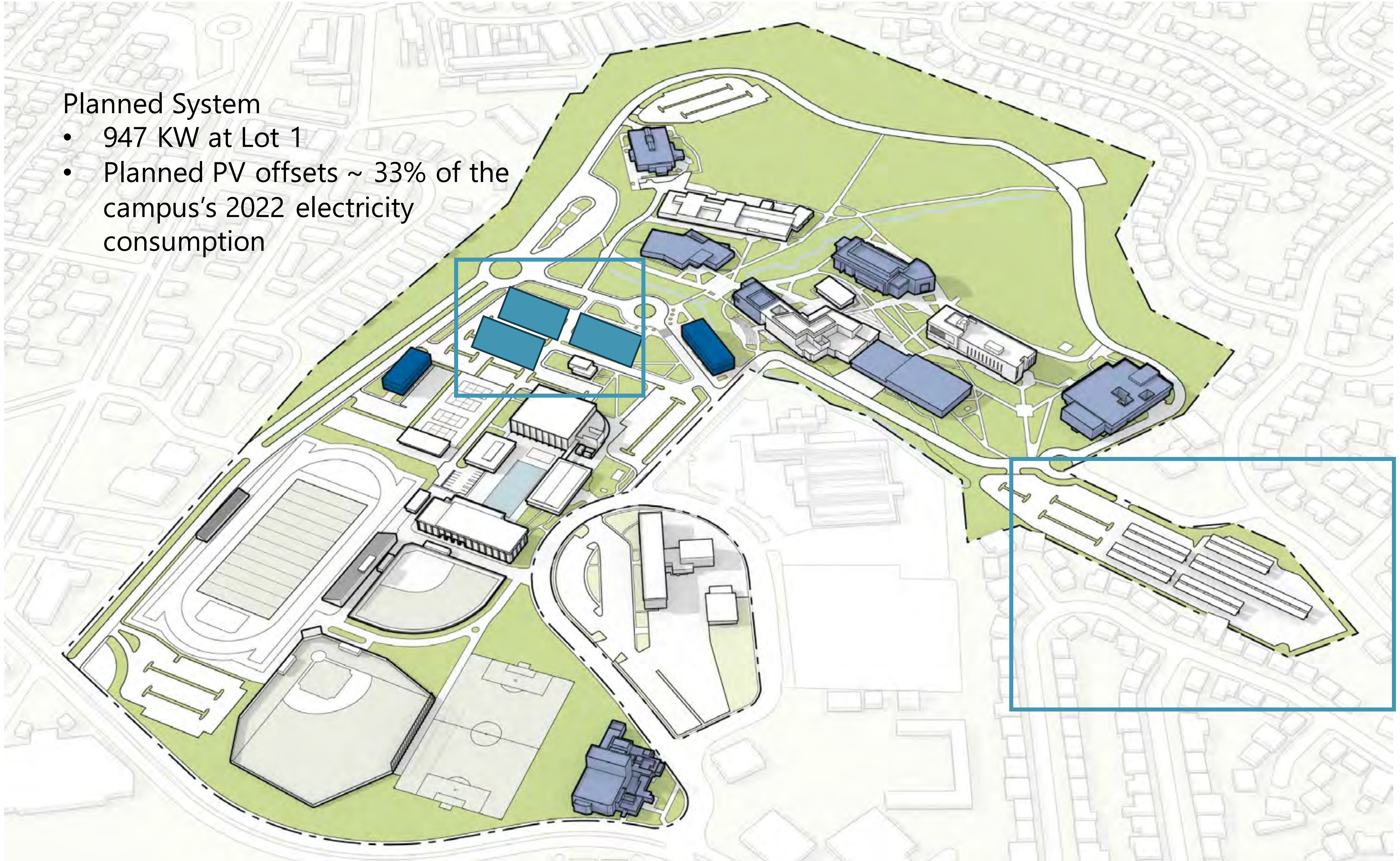
Contra Costa College
PV Systems



Potential Future System
- Potential PV offsets remaining based on projected electrical consumption in 2035
- 2.682 MW required, approximatly134k ft^2 panel area, based on current PV technology (future location not determined at this time).

Existing System
- 403KW @ parking lot 9/10
- Existing PV offsets ~ 10% of the campus's 2022 electricity consumption

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District Energy Projects

Electrification Plan Introduction

In 2022, more than 48% of the electricity delivered by California's grid was generated by renewable sources such as solar photovoltaics, wind, biomass, and hydroelectric. This percentage will increase over time, as state laws such as SB100 mandate that CA's grid achieve 100% carbon-free generation by 2045. This means that by electrifying legacy natural gas heating systems, the carbon footprint associated with these loads will trend towards zero. For the Contra Costa Community College district in 2022, ~45% of its electricity was provided by renewable resources (including grid-supplied and on-site generation).

The purpose of this study is to support the master-planning effort for the Contra Costa Community College District (4CD) with a district-wide electrification plan. The plan provides an analysis of how electrifying the district's natural gas heating systems and deploying renewable energy systems will reduce the district's energy consumption and carbon footprint.

The primary goal of the electrification plan is to assist the district in meeting its sustainability goals, as outlined in the "2022 4CD District Wide Energy & Sustainability Goals" document.

The electrification plan consists of the following components:

- Building Benchmarking Report
- Electrical Systems Assessment
- Campus Photovoltaic Deployment Assessment.
- Building Electrification Strategy
- District Energy and Carbon Timeline

4CD has adopted a set of sustainability goals which target significant reductions in carbon emissions across the entire organization by 2035. The electrification study addresses the greenhouse gas (GHG) and renewable energy goals by proposing and quantifying the impacts of building replacement and renovation projects, renewable energy systems, as well as additional efficiency projects such as LED lighting, building management controls, metering upgrades and HVAC electrification.

4CD's goals are focused on the two primary dates of 2030 and 2035. The 2030 goals include reducing GHG emissions by 75% below the 2013 baseline and reducing the district energy use intensity (EUI) by 25%. The 2035 goals include reducing GHG emissions by 100% and reducing district EUI by 40%.

HVAC Electrification Strategy

Contra Costa Community College District has adopted a broad set of sustainability goals and practices that will result in dramatic reductions in energy consumption and carbon emissions from its buildings. A key component of these goals is the requirement that all newly constructed buildings are all-electric (no fossil fuel combustion used for space heating). This approach leverages the fact that California's grid is becoming cleaner (emitting less carbon) each year, which inherently reduces the carbon footprint of the campus.

There are a range of all-electric heating technologies that work well for new construction projects. However, converting the existing natural gas heating systems to all-electric has historically been challenging from a technological and financial standpoint. Air-source heat pump (ASHP) technology which use traditional refrigerants have limitations on the temperatures they can produce (typically a maximum supply temperature of approximately 130F), which may make them incompatible with typical legacy heating systems which utilize 160-180F temperatures. The renovations required to make existing buildings compatible with ASHP technology can be prohibitively expensive. These renovations may require replacement of some heating coils to accommodate lower water temperature, and often piping/coupling systems need to also be replaced. Furthermore, ASHP technology is limited to a lower ambient temperature of ~25F, which means that supplemental heating may be required on the coldest days of the year.

Water-source heat pumps (WSHP) are more flexible, with supply temperatures as high as 170F. These require a water-based heat source/sink, such as a ground loop via a geo-exchange system. Geo-exchange systems are often very costly due to the cost of drilling vertical wells or excavating for horizontal systems. These costs and space constraints typically preclude water-source heat pumps as a retrofit solution.

Transcritical heat pump (TCHP) technology is relatively new to building comfort heating and cooling which is addressing the traditional challenges of ASHPs and WSHPs. This technology utilizes CO^2 as its refrigerant (known as R744), which enables hot water delivery temperatures of 180F at outdoor ambient conditions down to -15F. This allows "direct replacement" of natural gas boilers and domestic hot water heaters. This technology is still "emerging", with a limited number of installations in the U.S., however, it is expected that this technology will develop rapidly over the next 5 years.

For existing buildings with traditional boiler-based hydronic systems, an assessment process is recommended to determine what modifications are required in order electrify these systems with the highest possible efficiency. The primary goal of this assessment is to determine if the existing hydronic systems is capable of operating at lower heating hot water temperatures while still maintaining design temperatures. Lowering the hot water temperatures allows for compatibility with a wider range of heat pump technology, and also allows them to operate much more efficiently. The following bullet points outline the assessment process:

- Review heating coils configuration - heating coil performance will be reduced when operating at lower hot water temperatures, however, in some cases, this performance derating can be overcome with modification to control sequences. In most cases, two-row heating coils at air handling units and VAV boxes can be utilized when lowering hot water temperatures from 180F to 140F, or even lower. The peak capacity of the coils is reduced with lower water temperatures, but simply increasing the warm-up time of the building may overcome these limitations. Also, reducing the temperature setback of the space will reduce the load that the coils must meet. Single-row coils will likely struggle to meet the load with reduced water temperatures and may need to be replaced.
- Conduct a hot water reset investigation – During the winter months, reduce the heating hot water temperature in 5-degree increments for one to two weeks at a time. This process will reveal which zones/coils are able to meet space loads with reduced water temperatures. As zones are discovered to be out of setpoint, increase the warm-up period or limit the temperature setback. Continue to reduce water temperatures and increase warmup period to determine if a lower water temperature will allow the building to maintain functionality. This process may reveal that certain zones/coils will function adequately, while others may need to be upgraded. The desired outcome of the reset investigation is a custom outdoor air reset control sequence that reduces hot water temperatures to a minimum, as a function of outside air temperature. For example, the goal may be to operate at 140F supply/ 100F return as often as possible but allows for increases up to 180F supply / 140F return on the coldest days of the year.

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HVAC Electrification Strategy
Transcritical Heat Pumps

While this heat pump technology has long been used in commercial refrigeration for 20 years or more, it is more recently being applied to building HVAC and domestic hot water. Typically, these machines use CO_2, or R-744, as its refrigerant, which has a global warming potential (GWP) of 1, which is far below traditional refrigerants like R-410a (GWP of 2088) or R-134a (GWP of 1430). Furthermore, R-744 is able to operate with much higher temperatures, at or above 180F. However, like traditional heat pumps, transcritical heat pumps operate much more efficiently with lower supply water temperatures.

As the technology continues to advance, it may become a critical component of electrifying existing buildings that utilize hydronic heating. The graph on the right shows the efficiency curves for various operating conditions for Flow Environmental System's model H transcritical heat pump. These trends show that while operating at "traditional" boiler system temperatures of 180F supply / 140F return, a COP of 1.75 is achieved. However, lowering the supply temperature to 140F dramatically improves efficiency, approaching a COP of 3.5. This highlights the importance of the hot water reset assessment process outline on the previous page.

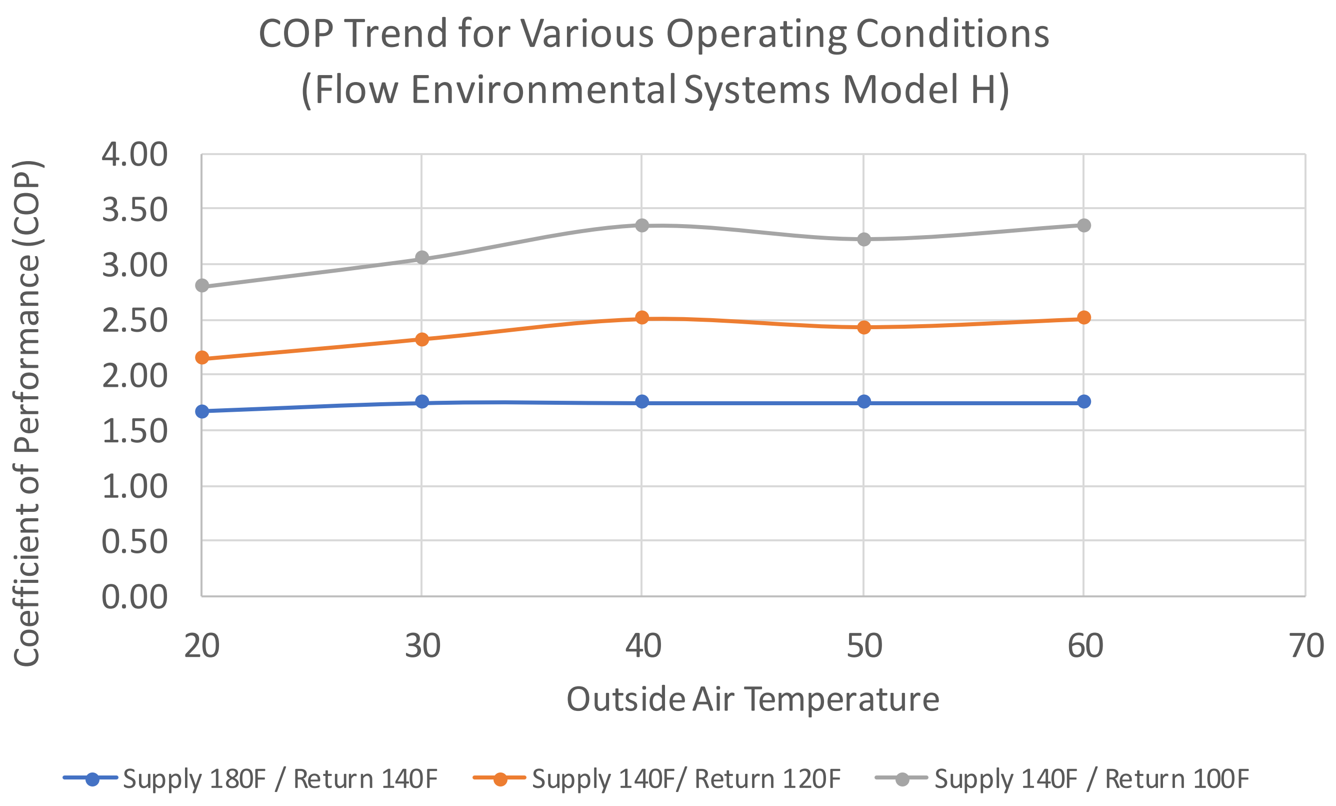
Transcritical heat pump technology is also well suited for domestic hot water applications, where storage temperatures typically range from 125F – 140F. Systems like Sanden and Lync are able to achieve COPs above 5, which allows for significant improvements to operation cost and carbon emissions associated with domestic hot water.

The links below are examples of transcritical heat pump technology that are recommended for investigation by future design teams for use in both new construction and retrofit projects.

https://www.flowenvirosys.com/products

https://www.smallplanetsupply.com/sanc02

https://www.lyncbywatts.com/



HVAC Electrification Strategy
Central Plant Opportunities

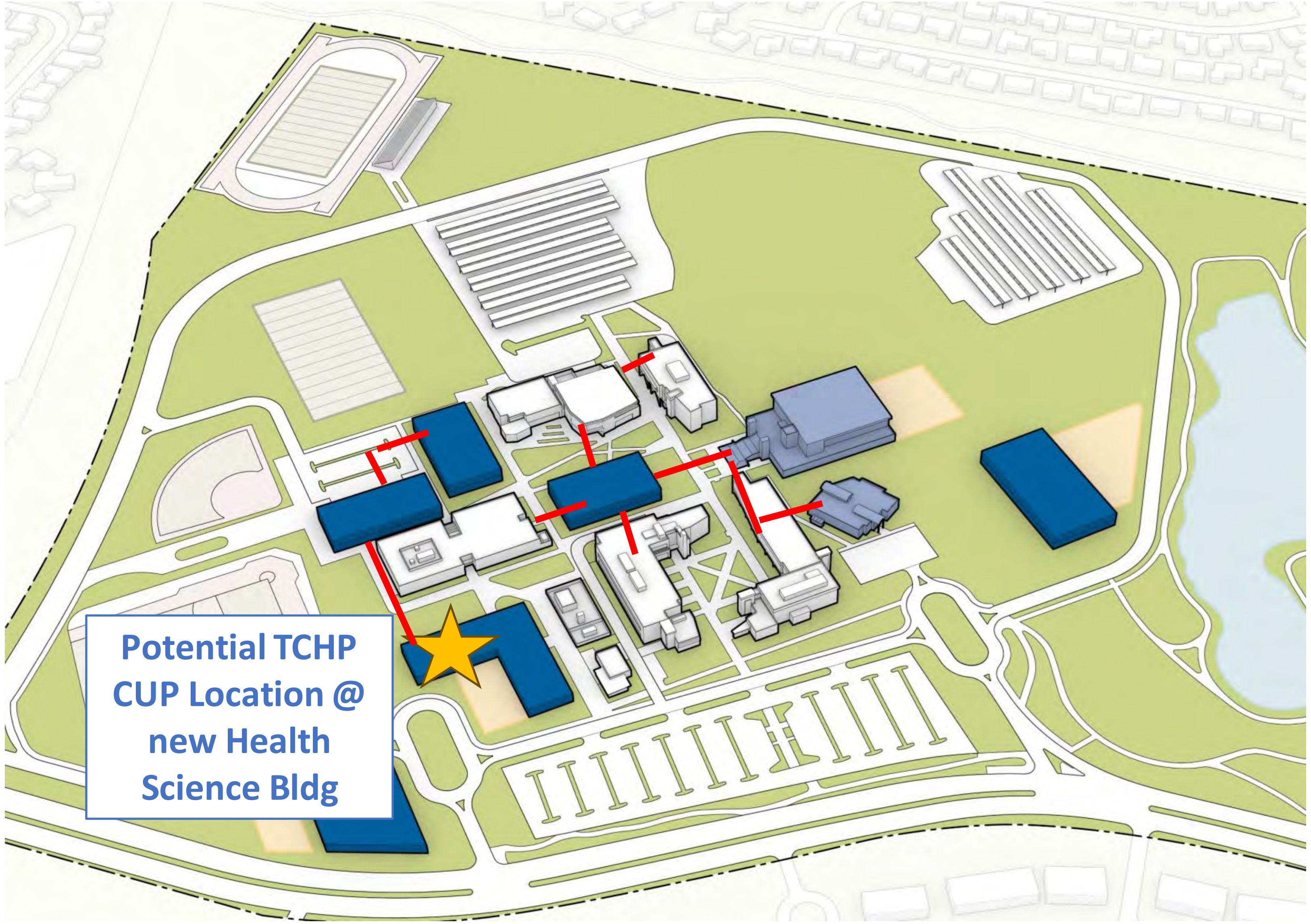
An all-electric central utility plant (CUP) may be an effective strategy to employ as part of the early FMP projects. At Los Medanos College, the newly planned Health Sciences building is one of the first major projects that will occur within the core of the campus. It is in relatively close proximity to several other newly planned or renovated building. A central plant can be designed and planned at the new Health Sciences building with the intent to expand over time, as new buildings are built, and existing buildings are retrofitted.

For Contra Costa College, a central plant may be feasible as part of the renovation of Student Services or General Education buildings. However, space constrains may make this challenging.

For Diablo Valley College, a central plant may be feasible as part of the new academic complex, which is planned for construction in 2030. this central plant could then be available to serve the renovation projects as they occur in the later 2030's.

Utilizing a central plant, as opposed to each building having standalone heating and cooling equipment, offers many benefits in terms of efficiency, redundancy, and heat recovery. Centralizing the load of multiple buildings offers diversity in the load profile, which may allow for energy to be recovered (using heat recovery heat pumps) when simultaneous heating and cooling loads are required across a campus. Central plant equipment can be designed with proper modularity to allow for very efficient part load operation, as well as inherent redundancy. Thermal storage systems can be readily added to a central plant, allowing primary heating and cooling equipment to be dramatically downsized, as well as offering the ability to load shift to times when energy is cheap or when the grid is the cleanest (depending on District priority).

The downsides of a central plant approach are primarily cost and complexity. A significant infrastructure investment is required to install the initial phases of a central plant, sizing piping and electrical systems for their anticipated future loads. However, future buildings that connect to the central plant will be lower cost. The equipment is typically of a larger scale, often requiring specialized contractors to perform major maintenance. A relatively large are is often required to house the central plant equipment, which can be challenging for some campuses.



HVAC Electrification Strategy
Contra Costa College

HVAC Electrification Strategy
Contra Costa College – FMP Projects Pt.1

The 2024 Facilities Master Plan identifies 11 projects that will enhance the usability of the campus. These projects include new construction of 2 new buildings.

As part of the 4CD sustainability goals, each of these new buildings will be all-electric and LEED gold certified. The predicted EUI of these buildings is shown in the table below, along with the assumptions of building size and what year the projects will be built.

New Construction Projects

Building	Area (ft2)	Year of Construction	Predicted EUI (kBtu/sf-yr)	Annual Electricity Consumption (kWH)	Notes
NEW MAINTENANCE AND OPERATIONS	15,000	2035	20	87,921	Coincides with demolition of Maintenance Shop and other low energy buildings
NEW STUDENT AND COMMUNITY BUILDING	30,000	2033	25	219,803	Coincides with demolition of Music and Art Buildings

HVAC Electrification Strategy
Contra Costa College – FMP Projects Pt.2

The 2024 Facilities Master Plan identifies 11 projects that will enhance the usability of the campus. These projects include 9 renovations, 6 of which occur in the timeline of the energy study,

Renovation projects are anticipated to eliminate natural gas from the HVAC and plumbing systems, resulting in a substantial energy and carbon emissions reduction. These savings are summarized in the table below.

Renovation Projects							
Building	Area (ft2)	Year of Renovation	Existing EUI	Predicted EUI (kBtu/sf-yr)	Natural Gas Reduction (kBtu)	Electricity Reducton (kWh)	Notes
LIBRARY	32,904	2031	54.0	23.1	1,045,915	-8,606	Electrification and LED as part of FMP Renovation
APPLIED ARTS & ADM.	50,000	2030	52.4	33.5	1,063,650	-34,692	Electrification and second half of LEDs as part of FMP renovation, if lighting not done before
STUDENT SERVICES	19,280	2027	68.3	32.1	763,183	-19,483	LED and electrification as part of FMP Refresh Renovation, full renovation is too far out to save this stuff and meet energy goals (2040). Boiler has 14 years left of RUL.
GENERAL EDUCATION BLDG	51,234	2029	69.0	35.4	1,841,247	-35,661	Represents electrificationa and LED retrofit as part of FMP renovation
POOL	NA	2026	NA	NA	2,460,335	NA	Electrification of pool coinciding with FMP renovation of pool and timed with electrification of gym annex since they use the same boiler
GYM ANNEX*	36,327	2026	44.2	23.4	1,170,611	-122,526	Electrification before end of equipment life to also electrify the boiler

Renovations of the following buildings occur after and outside our energy plan:
Performing Arts Center
Child Development Center
Full Student Services Renovation

*The gym annex shares a boiler with the pool and it is recommended to electrify this boiler at the pool renovation year, but no FMP work is planned for the Gym Annex building itself.

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HVAC Electrification Strategy
Contra Costa College – Additional Efficiency Projects

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWH	Gas Reduction kBTU	Starting EUI	EUI After
GYMNASIUM	22,551	2034			x (Furnace)	Furnace Heating- RTUs have 16-18 years of RUL, other single zone equipment has RUL of 11-16 years.			$875,525	$875,525	-63,532	606,985	46.1	28.7
LOCKER ROOM BUILDING	8,732	2034			x (Boiler)	Boiler 11 Years, recommend electric heat pump swap			$406,816	$406,816	-50,720	484,578	73.9	38.2
VOC ARTS/COMPUTER TECH	30,912	2025	x		x (Furnace)	RTU at 1	$323,030		$807,576	$1,130,606	-38,380	1,272,035	78.8	41.9
ATHLETIC TRAINING AND KINESIOLOGY CENTER	4,531	2034			x (Furnace)	RTU at 18			$175,913	$175,913	-18,958	181,122	53.9	28.2
MAINT/POLICE OFFICES	6,570	2025	x		x (Furnace)	RTU at 0 (EOL)	$68,657		$171,641	$240,298	-16,287	348,032	88.1	43.6
STUDENT & ADMINISTRATION	53,577	2034	x		x (Boiler)	boilers and ahus at 12 years, boiler type upgrade	$832,034		$2,496,103	$3,328,138	-40,138	1,952,641	71.9	38.1
PERFORMING ARTS CENT	21,000	2027			x (Boiler)	19 years (out of 30) of remaining useful life for boilers			$718,935	$718,935	-111,569	1,065,926	68.1	35.5

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

INTERFACE ENGINEERING

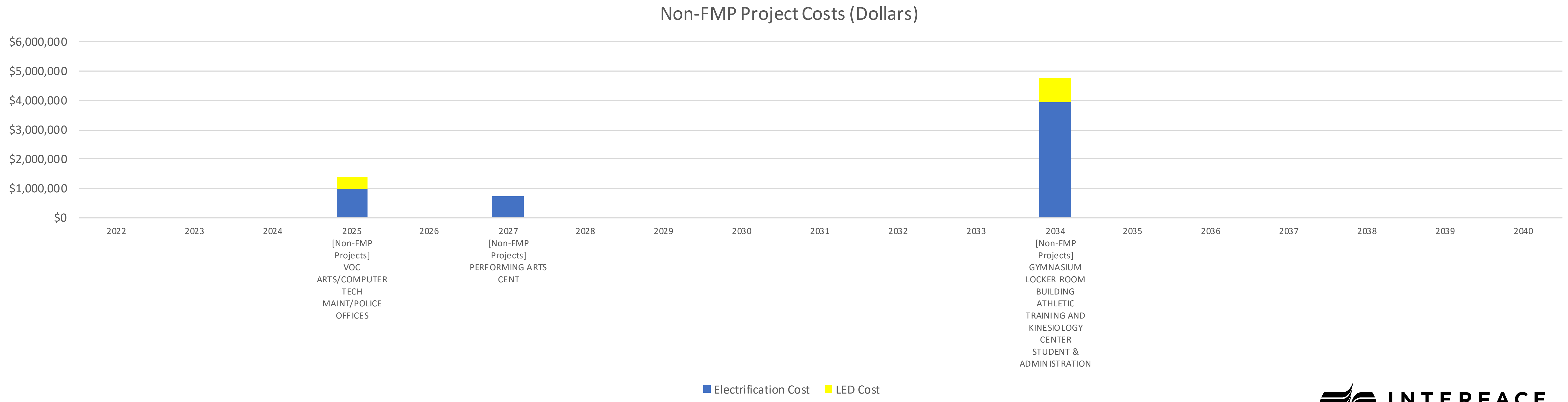
HVAC Electrification Strategy
Contra Costa College – District Energy Project Savings and Cost Summary

District Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$1,223,721	$0	$5,652,509	$6,876,230

District Energy Project Annual Cost Savings (2023 CCC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 66,994	$ -	$ 122,364	-$148,495	$40,864

District Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
952,477	0	3,800,134	5,911,320

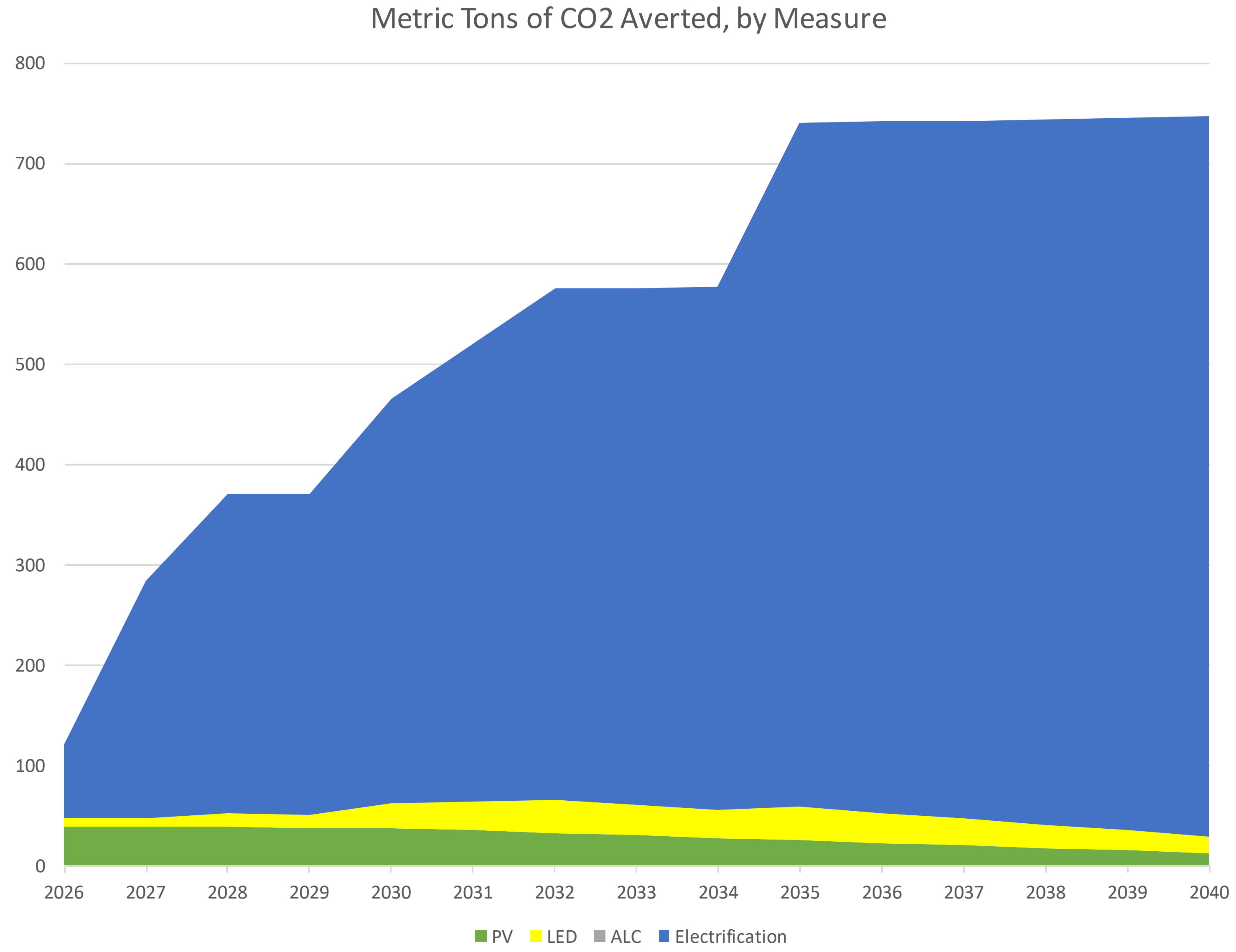
District Energy Project Annual Cost Savings (2035 Estimated CCC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 119,636	$ -	$ 218,514	-$265,177	$72,974

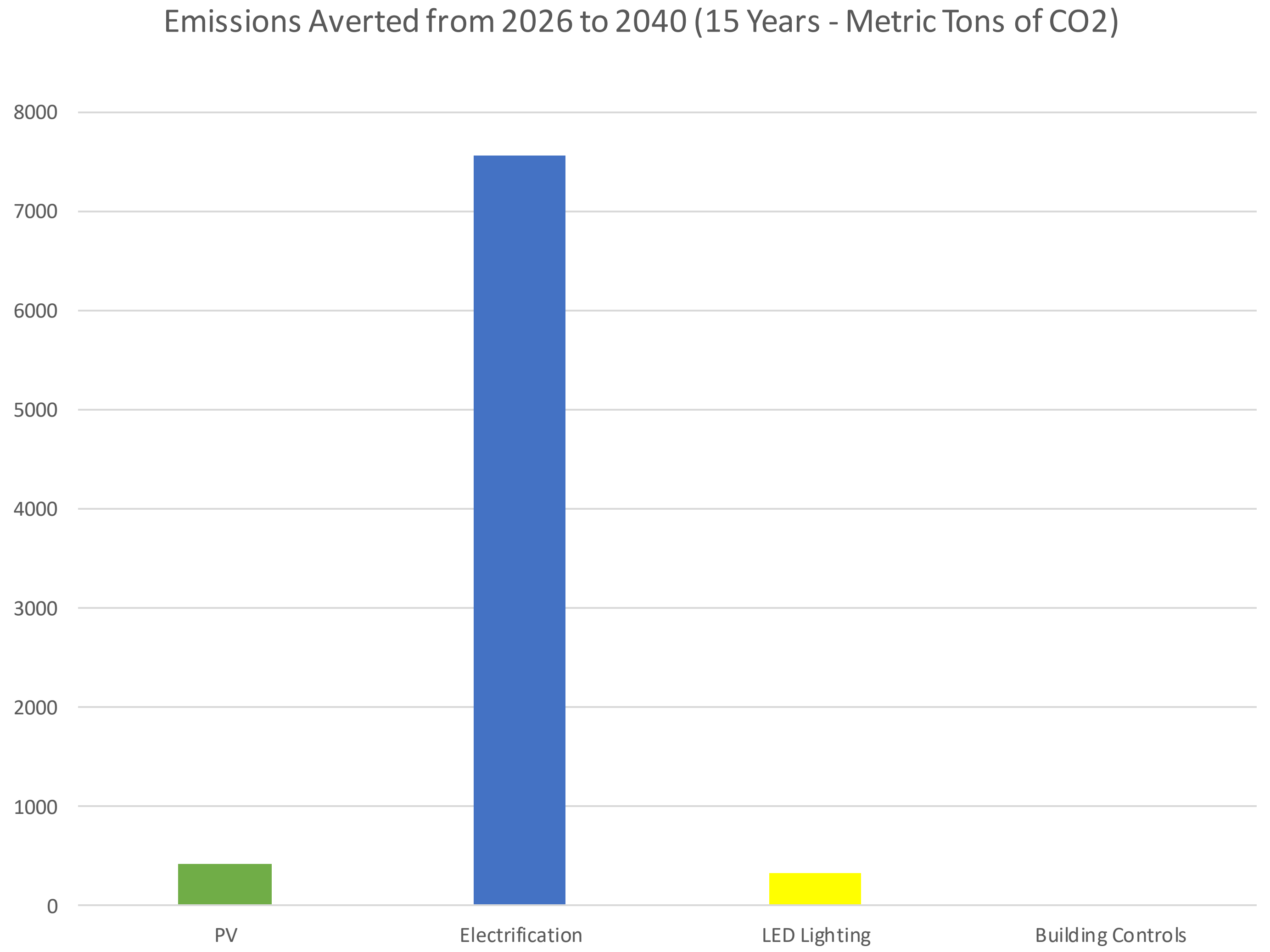


INTERFACE ENGINEERING

HVAC Electrification Strategy
Contra Costa College – District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO_2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. In this graph electrification provides a much larger source of emissions reduction than PV for the CCC campus. This is due to the PV being associated with the lower emitting MCE account/grid for the campus. The advantage of the PV being associated with MCE energy is that it has a large effect on the annual utility costs of the campus. Electrification is also very important for meeting the campus building EUI targets.



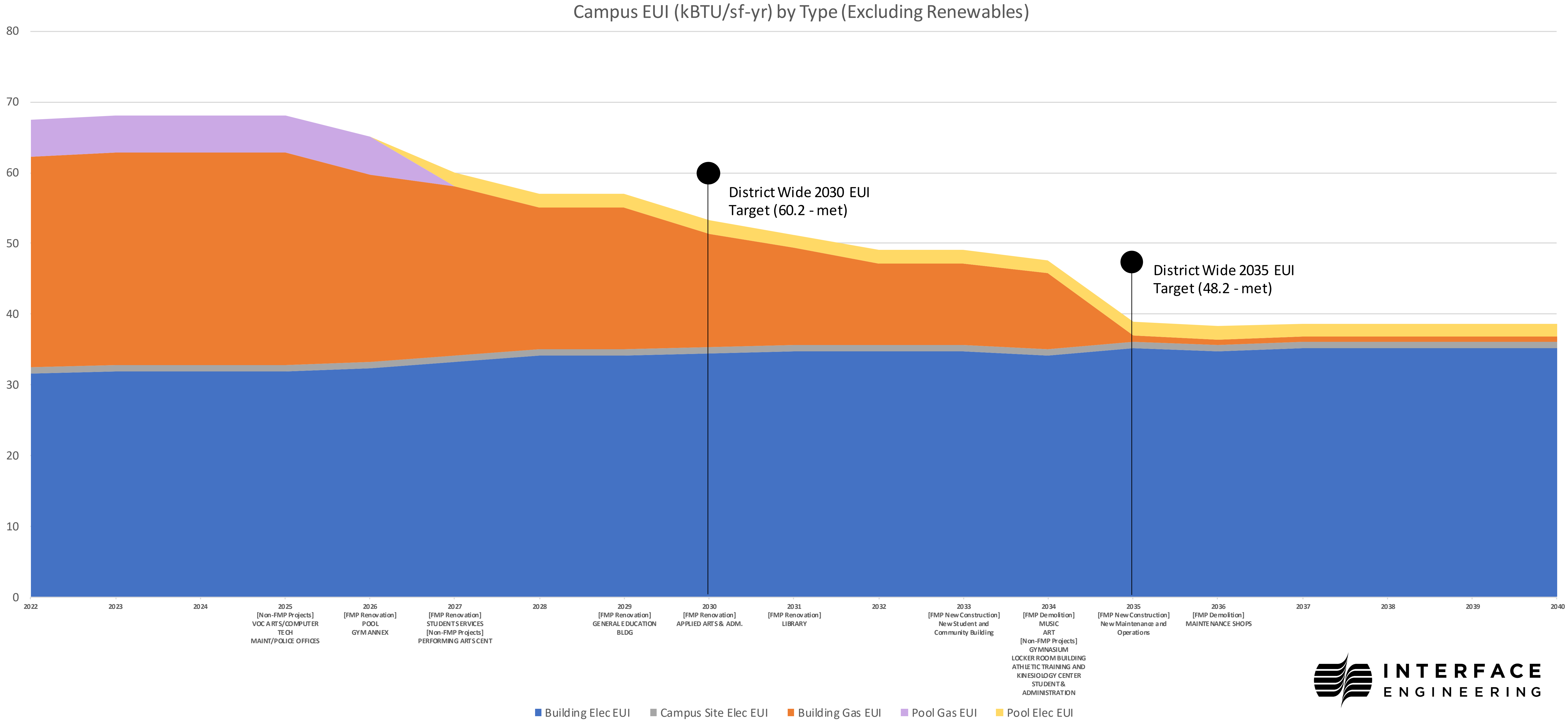


INTERFACE ENGINEERING

Energy Timeline

HVAC Electrification Strategy
Contra Costa College – Campus EUI Trend

Overall, electrification is very important to achieving campus EUI and emissions goals, as large reductions in gas kBTU results in much smaller increases in electric kBTU. This campus presents an opportunity to reduce EUIs below the district 2030 and 2035 targets in order to reduce the district wide average to meet the target. The electrification that results in these high EUI reductions is also important for this campuses emissions reduction, since the PV has a relatively low carbon impact.



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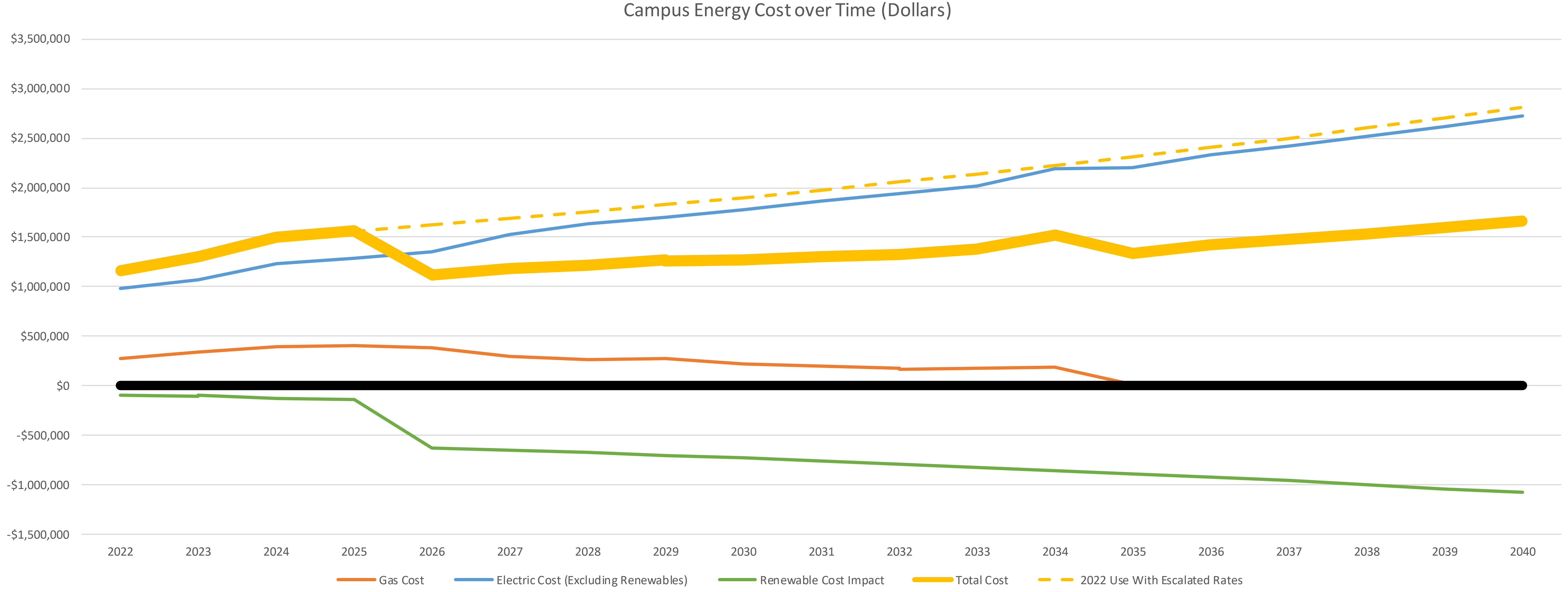
HVAC Electrification Strategy
Contra Costa College – Campus Utility Costs Trend

The chart below shows the total and fuel specific utility costs for the campus going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus. Renewables and efficiency upgrades like controls and LEDs reduce the operating cost of the campus. The renewables being associated with the more expensive MCE electricity allow for a higher campus cost reduction, with a tradeoff of less CO2 offset compared to potential PV associated with constellation. The 2.167 MW of additional future PV required to offset electricity consumption for the campus in 2035 would result in an estimated additional around $1,521,202 a year of cost savings with 2035 utility rates (Assuming the future PV is associated with MCE).

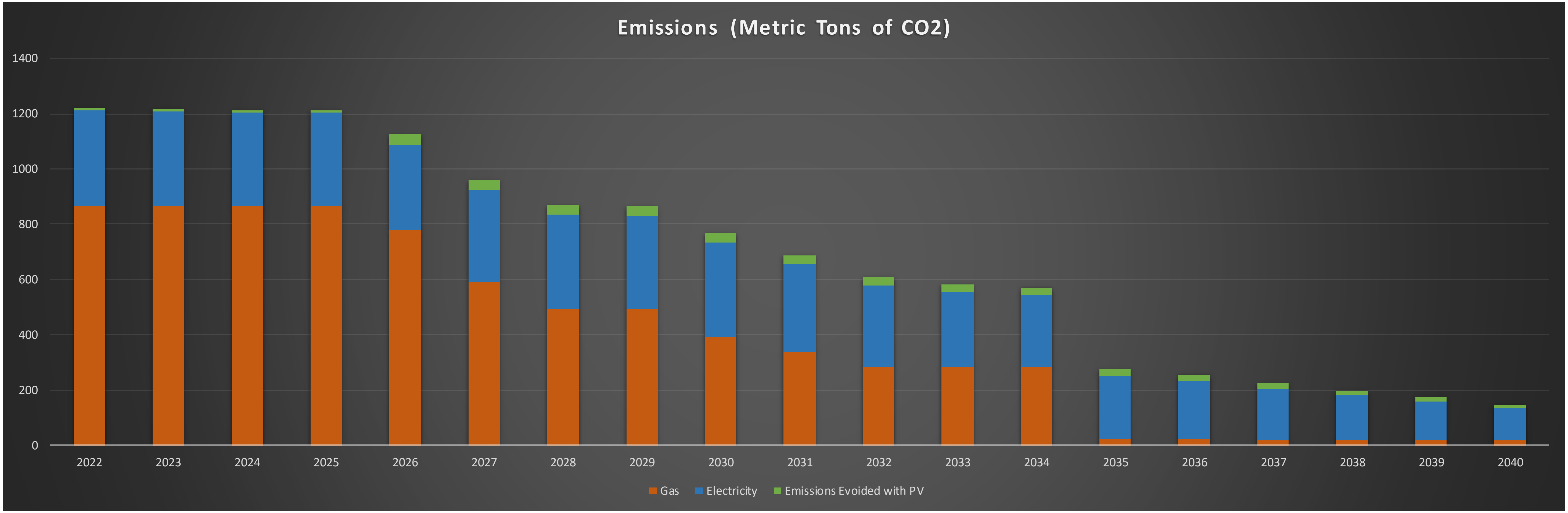


Planned PV is assumed to be installed in the year prior to the start of 2026.

INTERFACE ENGINEERING

HVAC Electrification Strategy
Contra Costa College – Campus Emissions Trend

The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. Emissions from electrical consumption deprecate at the same rate. The starting emissions are based on weather normalized data. Due to the PV being associated with the low emission MCE electricity, very large amounts of additional PV would be needed to offset the remaining emissions. If future PV was associated with MCE, and the MCE and constellation grids become cleaner at a similar rate, 13.6 MW of additional PV capacity would need to be installed to offset all emissions by 2035. If the PV was associated with constellation, this would go down to less than 1 MW. The rate of emissions for Constellation and MCE is likely to change over time, and the relative difference in emissions between the two providers is likely to change. It is recommended to consider these emissions rates for future PV installation. Otherwise, to meet the goal, offsets would need to be purchased until the California grid is legislated to be emissions free by 2045. This amount would start at about 252 tons per year in 2035 and decrease to 135 tons per year by 2040 as the grid approaches the legislative targets. If the CA grid/Constellation emissions rate approaches zero carbon faster or slower than legislatively required, the offsets required could go up or down. A good efficiency and emissions reduction strategy may not require each individual campus to meet the sustainability goals, but rather the ensemble of campuses meeting the goals. This will allow for taking advantage of deploying PV where it is most effective (campuses associated with higher emitting utilities) or where there is the most capacity, and purchasing offsets or clean energy at a district level for the net emissions that remain.



INTERFACE ENGINEERING

3.

Diablo Valley College/ San Ramon Center

Carbon and Energy Benchmarking

Building Benchmarking Study - Introduction

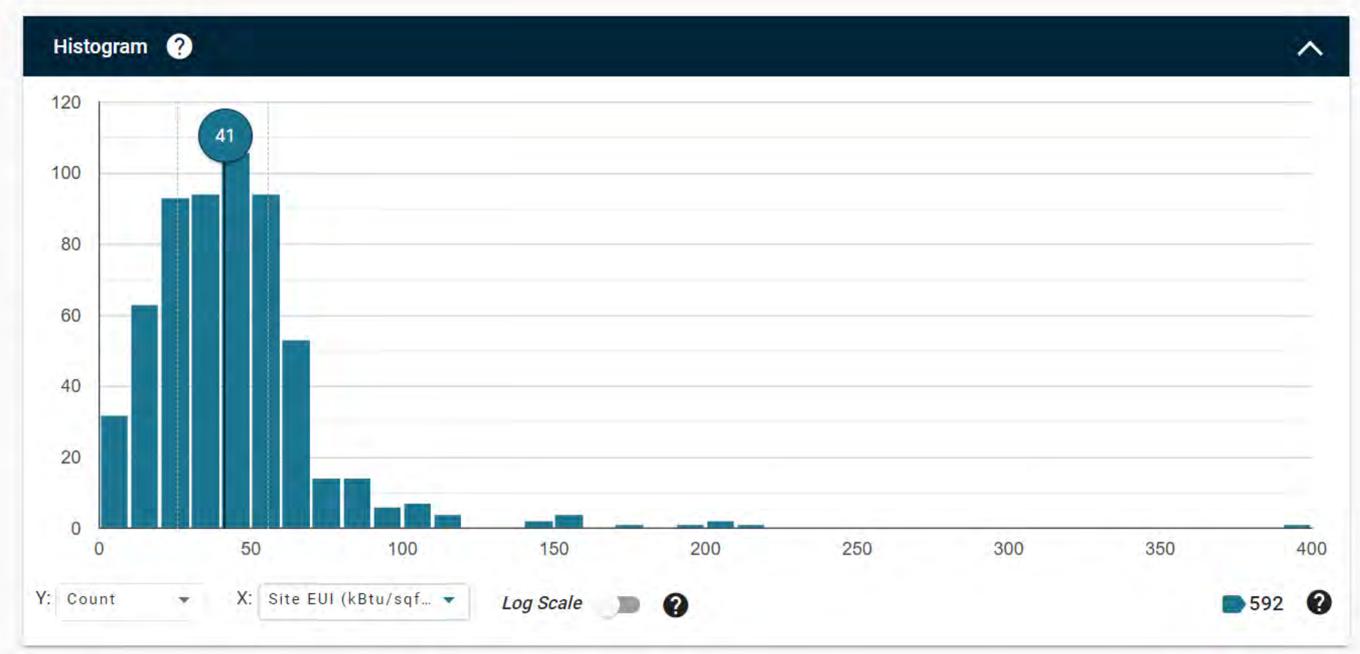
As part of the District Sustainability and Electrification plan, the portfolio of campus buildings has been subject to a benchmarking study to attempt to determine the highest priority target buildings for electrification and chart a path for the district towards meeting its sustainability goals. The data used for this benchmarking study consists of engineering and architectural drawings provided by the community college district, campus wide electricity and gas usage data, and results from a building equipment and facilities audit performed by Bureau Veritas. Building EUIs were also adjusted based on known operational configurations for particular campuses and buildings, as well as the mechanical and air systems.

Electricity and gas usage was estimated for each individual building on the campus based on available benchmarking data by building type for the bay area climate zones, the state of California as a whole, and available campus wide billing data. These estimates were then adjusted based on known building specific characteristics. Large multi-purpose campus buildings were divided into the various use-types they are composed of in order to provide an accurate EUI estimate for the building, as well as a use-type specific EUI for that campus.

The estimates were then revised based on a dialogue with the district on the values, particular building meter data, multi-building line meter data, and site electricity data that was made available.

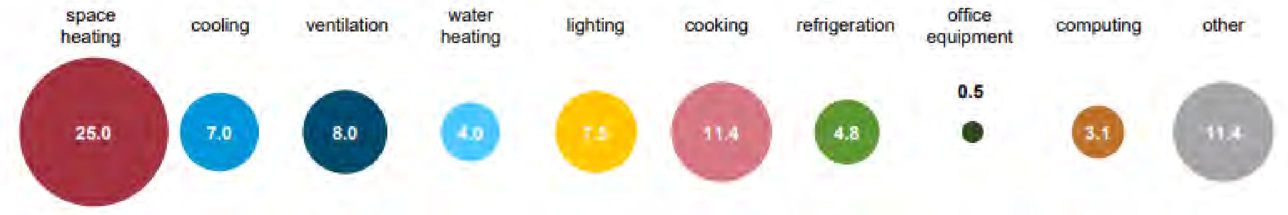
The energy and carbon impact of the pools were estimated based on available boiler data for the Contra Costa College pool and then a gas usage per square foot per year was applied to the Diablo Valley College pool in order to estimate the portion of the gas usage that is not part of a building EUI.

Building type energy data from the bay area, California, and the United States came from the Lawrence Berkley National Laboratory Building Performance Database and was adjusted or compiled into campus use types based on engineering judgement.



Sample BPD Query

The Energy Star Commercial Buildings Energy Consumption Survey and data from the Higher Education Benchmarking Initiative were also used to estimate end-use breakdowns and as a comparison point for realistic data for particular types of campuses.



Sample CBECs Data

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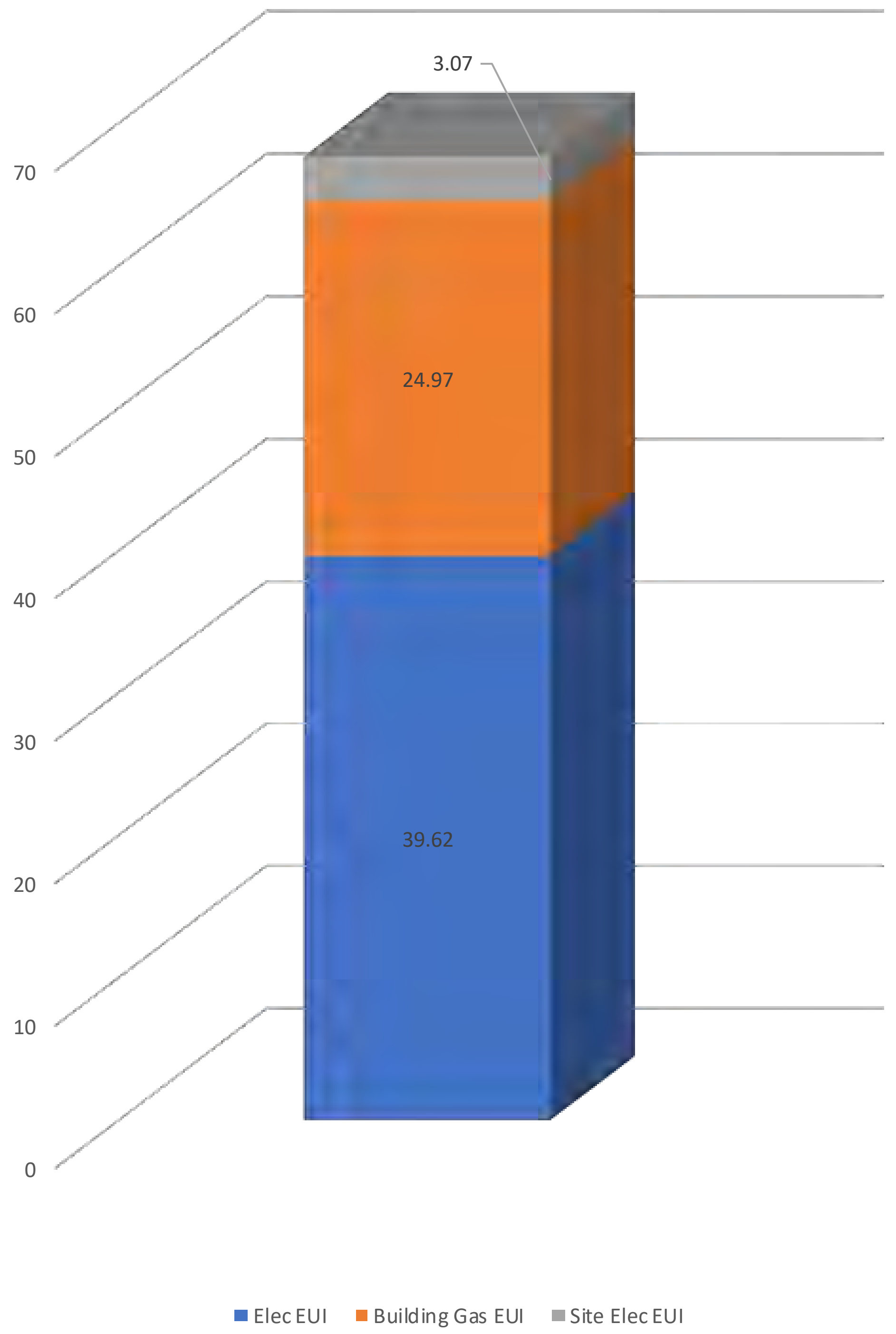
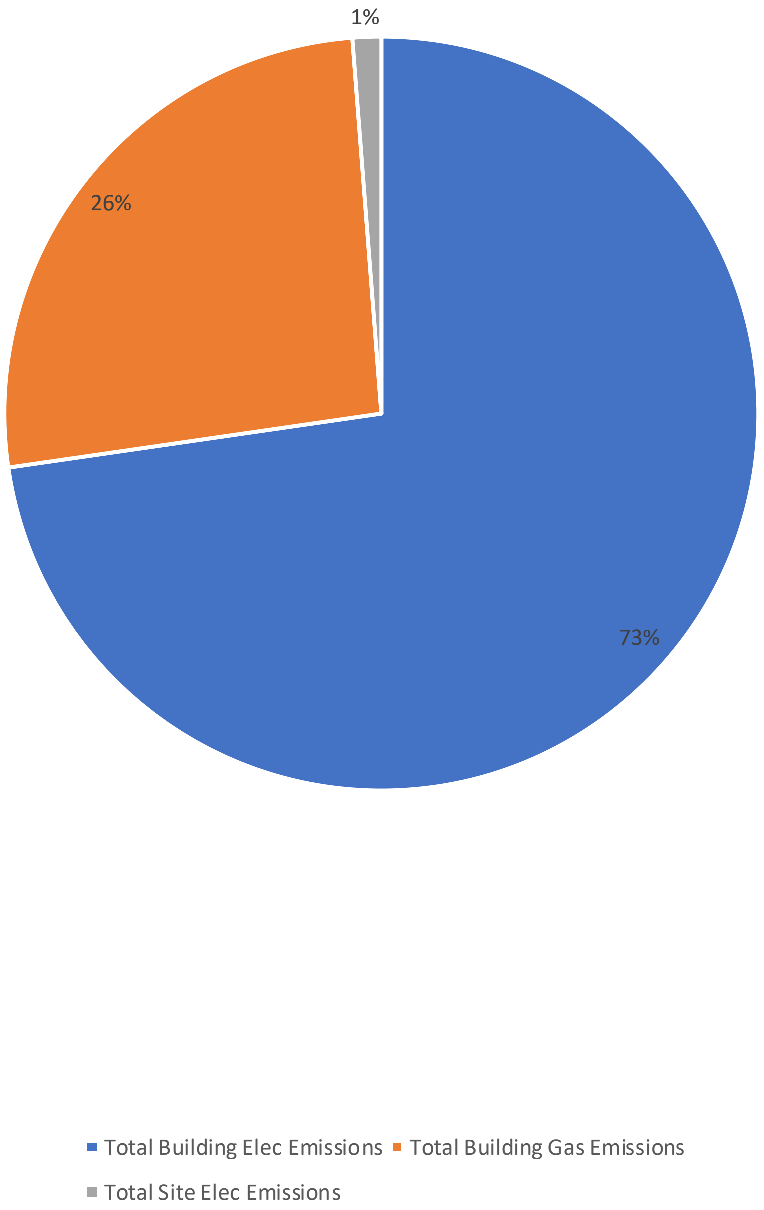
DVC 2022 Weather Normalized DVC Campus EUI (kBTU/sf) (Pool not active in 2022)



DVC 2022 Weather Normalized DVC Campus Emissions (Pool not active in 2022)



DVC

Campus-Level Benchmarking

The campus EUI graph sums the total gas and electricity associated with the campus and divides them by the square footage of campus buildings included in the EUI study. The breakdown is representative of the split between gas and electricity use on the campus. The campus emissions chart shows the portion of the campuses total emissions that are associated with each fuel type. This data is all based on weather normalized data for the gas and electricity use and does not exactly match the real quantities but is better for a forward-looking analysis of the campus energy. DVC electricity use is associated with a Constellation energy which as a grid emissions rate of 701 lbs CO_2e per MWH of electricity. The high emissions rate for the grid here means that a majority of the emissions for the campus come from electricity use. The area for EUI calculations in 2022 was 746,198 ft^2. The pool did not operate in 2022 but its energy was including in following years for the campus.

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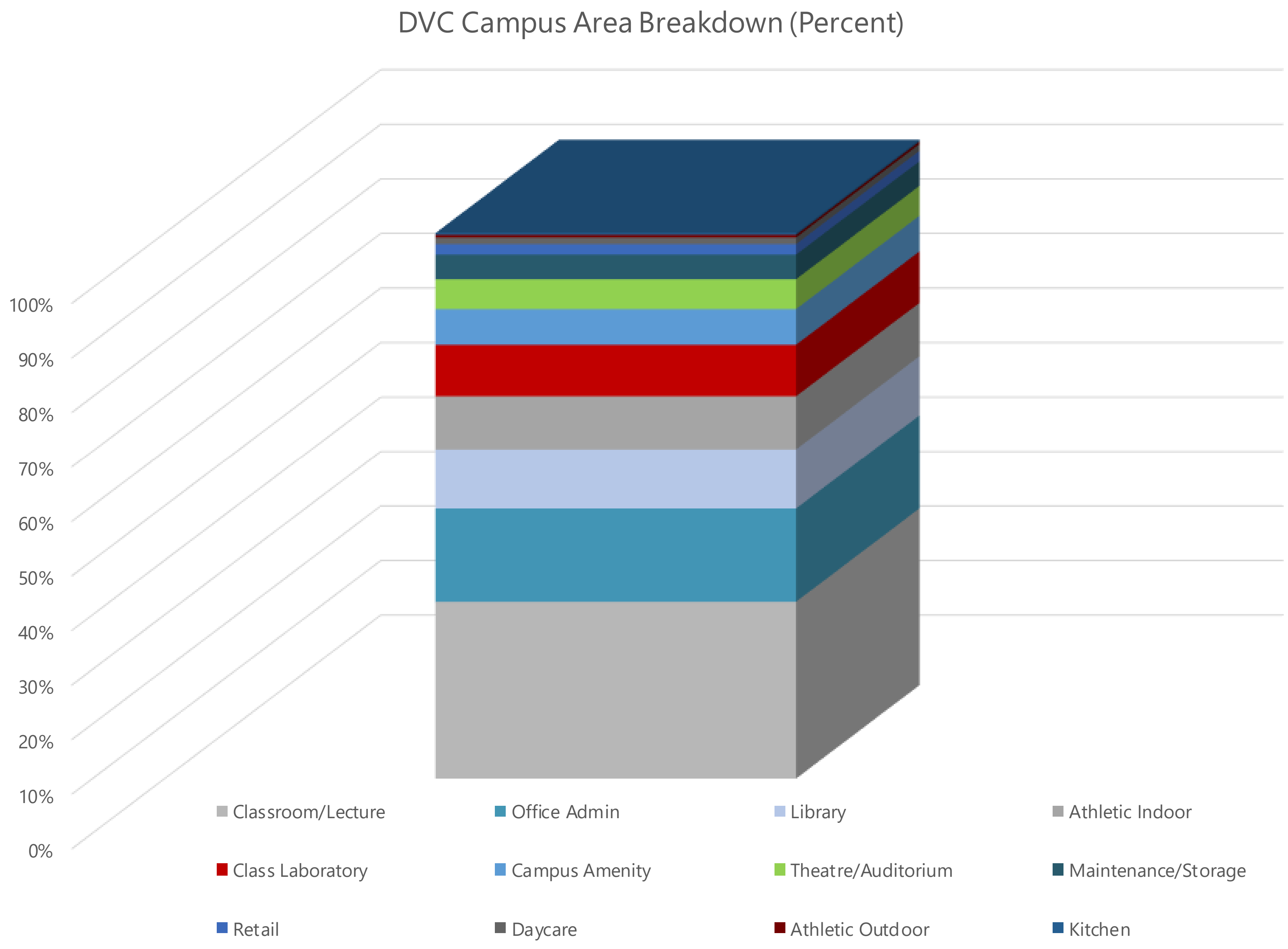

DVC

Campus Program Breakdown

The campus area breakdown shows the portion of the campus square footage associated with each of the program type categories in our study. Buildings with multiple use types have had their square footage distributed proportionally.

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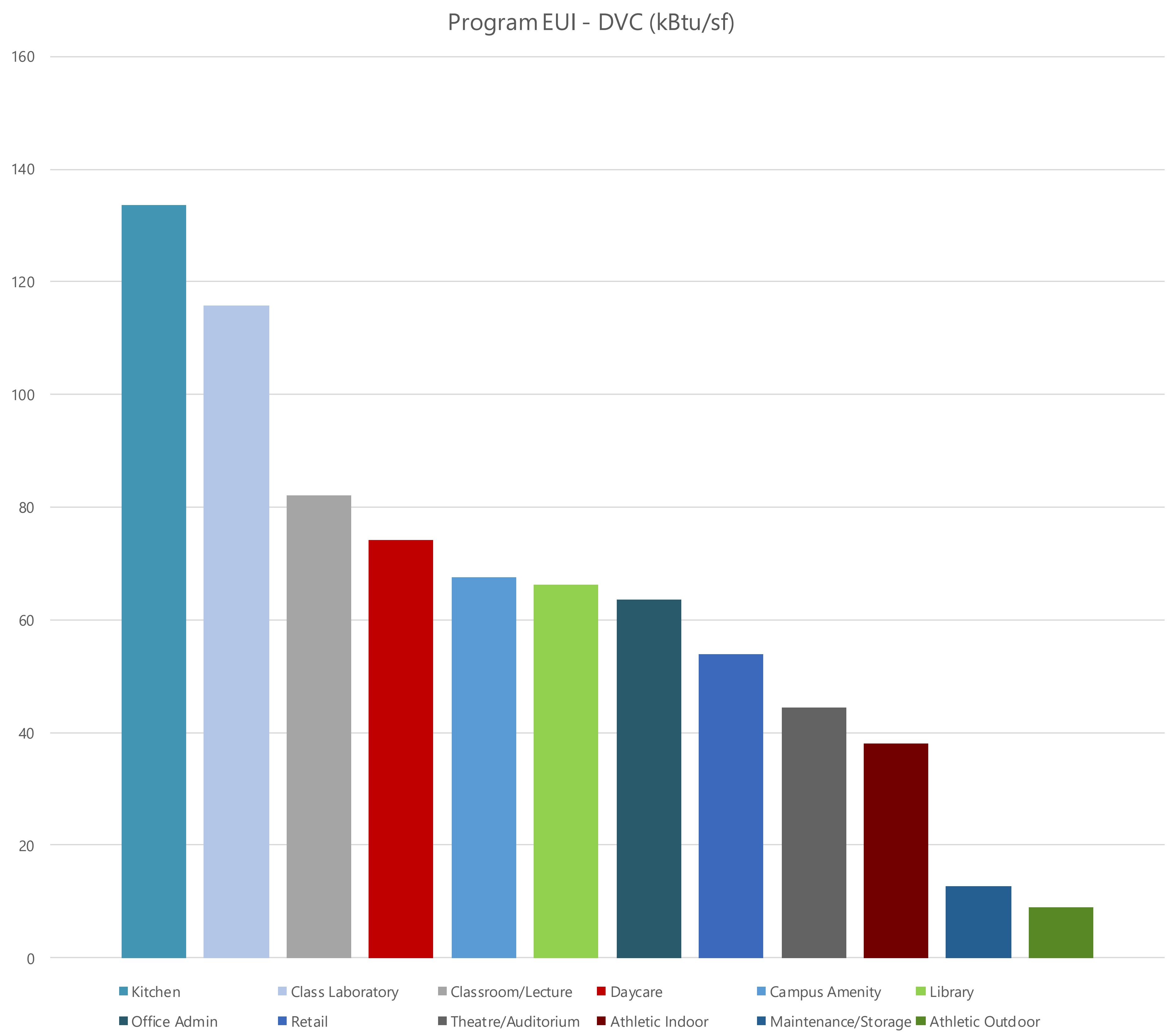

DVC

EUI per Program Type

The program EUIs are based on the weighted average of individual EUIs of buildings in each program classification, which may vary. These programs were assigned for energy analysis purposes and may not match other campus program breakdowns.

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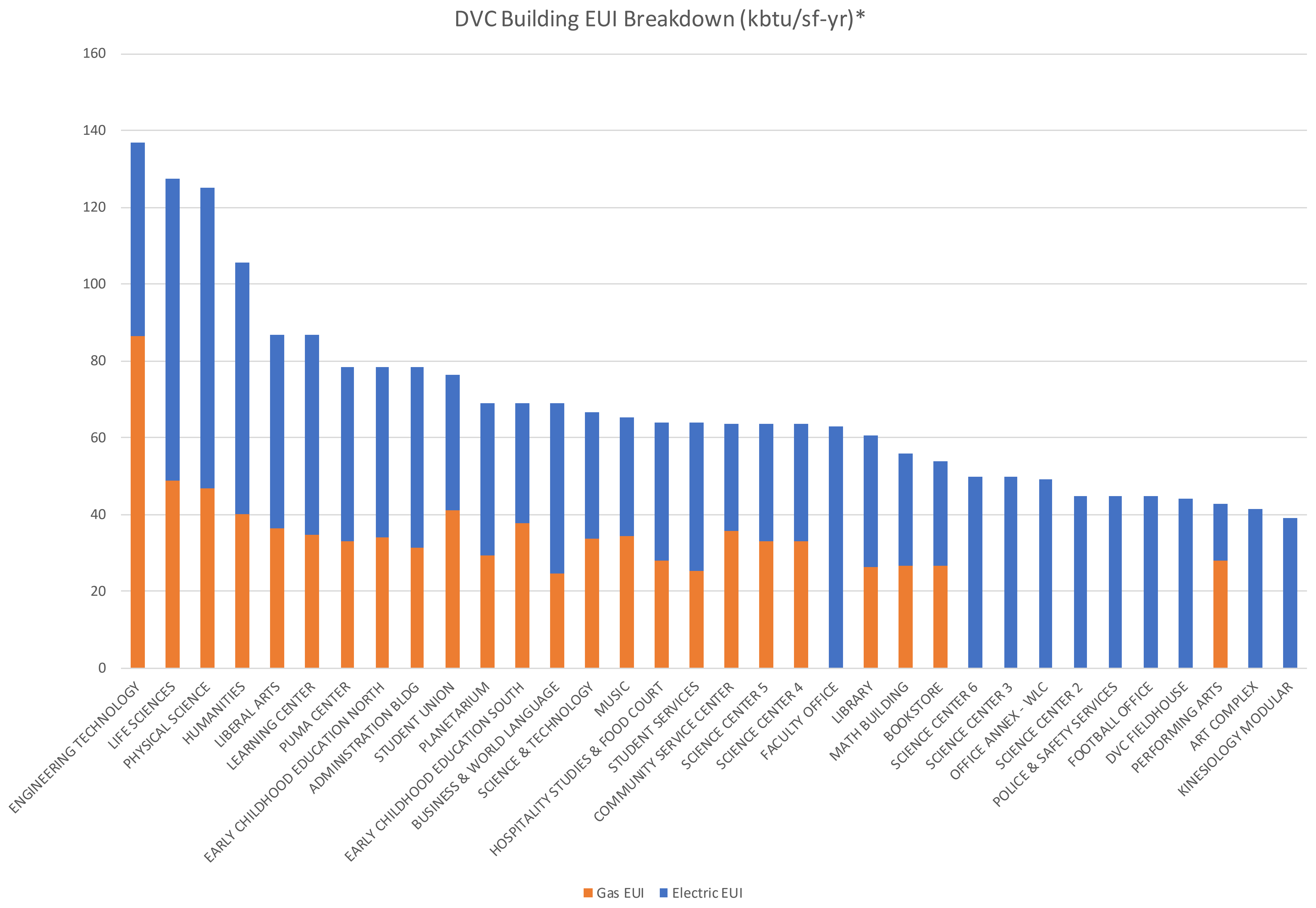
DVC

Energy Breakdown by Building



*Some buildings with negligible energy use are excluded from this graph

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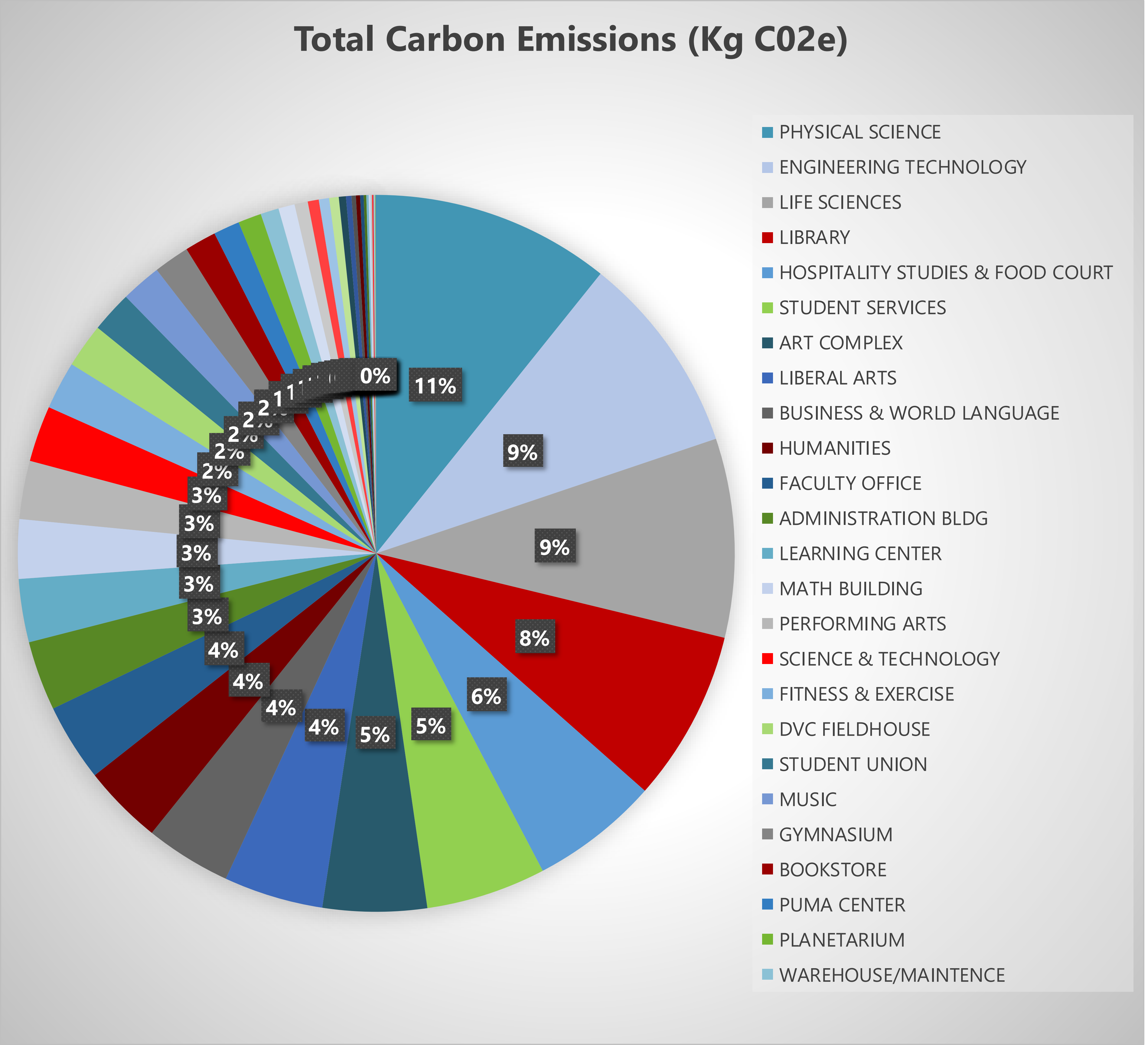


DVC

Total Emissions

INTERFACE ENGINEERING

DVC Benchmark Data Summary Table (Part 1)

Building	Age	Area	EUI	Gas EUI	Electric EUI	Total kBTU	Gas kBTU	Elec kBTU	Gas Carbon Emissions (metric tons CO2)	Electricity Carbon Emissions (metric tons CO2)	Total Carbon Emissions (metric tons CO2)
PHYSICAL SCIENCE	2000	41,220	125.0	46.9	78.2	5,154,479	1,931,487	3,222,992	103	301	403
ENGINEERING TECHNOLOGY	1971	36,551	136.8	86.4	50.4	5,000,708	3,157,794	1,842,914	168	172	340
LIFE SCIENCES	1960	33,844	127.4	48.7	78.7	4,311,049	1,646,849	2,664,200	87	249	336
LIBRARY	1970	63,201	60.4	26.2	34.2	3,819,552	1,655,945	2,163,607	88	202	290
HOSPITALITY STUDIES & FOOD COURT	2014	44,779	64.0	28.0	36.0	2,866,894	1,253,717	1,613,177	67	151	217
STUDENT SERVICES	2013	41,103	63.8	25.4	38.4	2,621,456	1,044,184	1,577,272	55	147	203
ART COMPLEX	2022	45,600	41.3	0.0	41.3	1,883,280	0	1,883,280	0	176	176
LIBERAL ARTS	1972	25,246	86.9	36.2	50.7	2,194,887	914,006	1,280,881	49	120	168
BUSINESS & WORLD LANGUAGE	2002	26,676	68.8	24.4	44.4	1,836,435	651,396	1,185,039	35	111	145
HUMANITIES	1964	16,428	105.4	40.1	65.4	1,732,300	658,536	1,073,764	35	100	135
FACULTY OFFICE	1972	22,316	63.0	0.0	63.0	1,405,908	0	1,405,908	0	131	131
ADMINISTRATION BLDG	1973	19,437	78.2	31.2	47.0	1,520,586	607,315	913,271	32	85	118
LEARNING CENTER	1974	15,914	86.9	34.8	52.1	1,383,563	553,871	829,692	29	77	107
MATH BUILDING	1998	24,211	55.8	26.7	29.1	1,351,410	645,945	705,465	34	66	100
PERFORMING ARTS	1978	34,423	42.7	28.1	14.7	1,470,840	965,573	505,267	51	47	98
SCIENCE & TECHNOLOGY	1960	19,505	66.5	33.5	32.9	1,296,107	653,422	642,685	35	60	95
FITNESS & EXERCISE	1967	24,274	35.8	0.0	35.8	867,796	0	867,796	0	81	81
DVC FIELDHOUSE	2021	18,178	44.0	0.0	44.0	799,832	0	799,832	0	75	75
STUDENT UNION	1997	12,744	76.4	41.1	35.2	973,081	524,186	448,895	28	42	70
MUSIC	1963	14,522	65.1	34.3	30.8	945,382	498,308	447,074	26	42	68
GYMNASIUM	1955	18,092	35.8	0.0	35.8	646,789	0	646,789	0	60	60
BOOKSTORE	2006	13,462	53.9	26.5	27.4	725,602	356,205	369,397	19	34	53

The pool uses 2,143,000 kBTU per year, or about 177 kBTU/sf/yr.

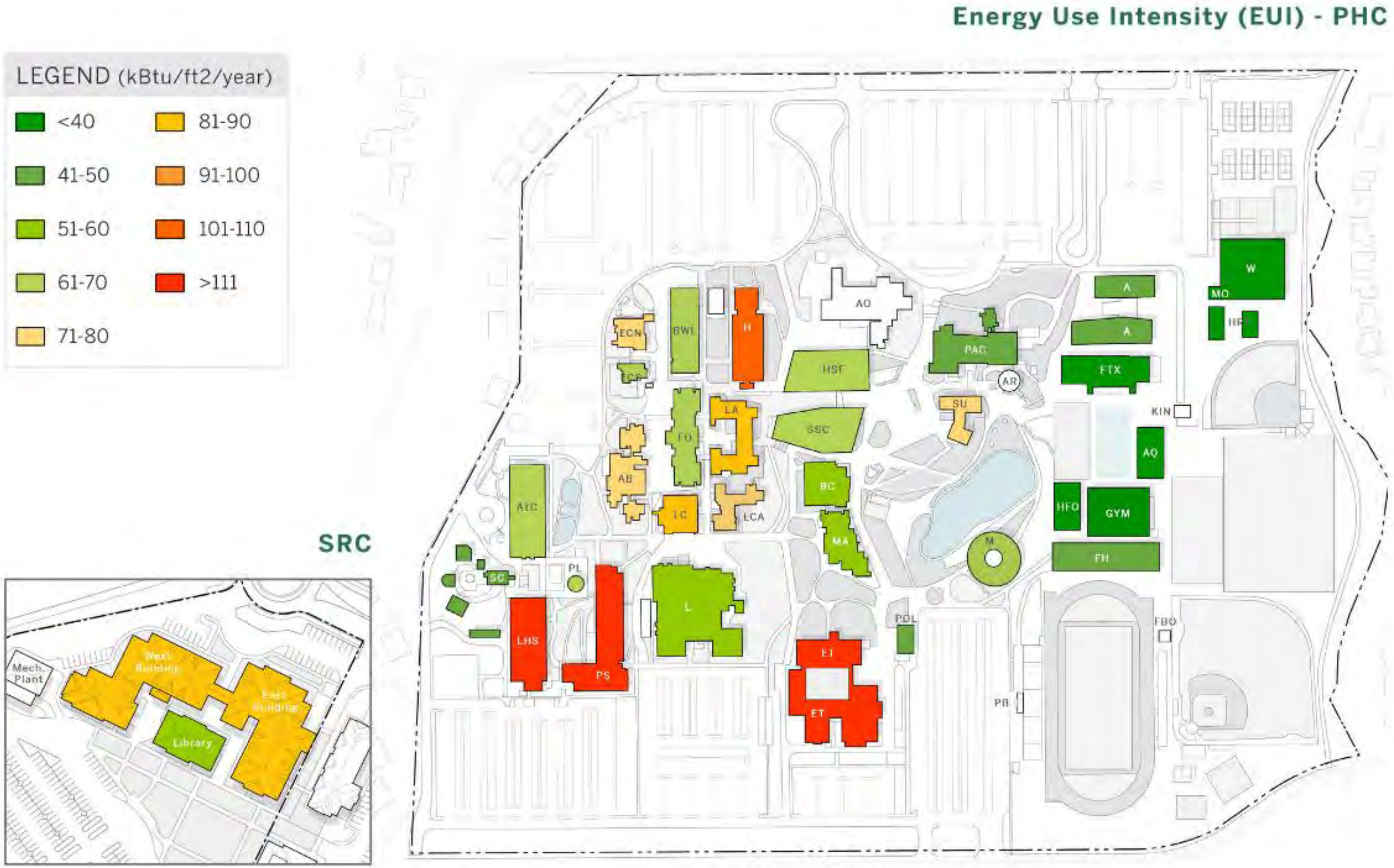
DVC Benchmark Data Summary Table (Part 2)

Building	Age	Area	EUI	Gas EUI	Electric EUI	Total kBTU	Gas kBTU	Elec kBTU	Gas Carbon Emissions (metric tons CO2)	Electricity Carbon Emissions (metric tons CO2)	Total Carbon Emissions (metric tons CO2)
PUMA CENTER	1972	7,375	78.5	32.9	45.6	579,202	242,562	336,639	13	31	44
PLANETARIUM	1960	7,481	69.0	29.4	39.6	516,277	219,660	296,617	12	28	39
WAREHOUSE/MAINTENCE	1980	25,900	12.8	0.0	12.8	330,225	0	330,225	0	31	31
EARLY CHILDHOOD EDUCATION NORTH	1980	4,639	78.5	34.1	44.4	364,328	158,421	205,907	8	19	28
AQUATICS	2023	6,700	35.8	0.0	35.8	239,525	0	239,525	0	22	22
EARLY CHILDHOOD EDUCATION SOUTH	1972	3,792	69.0	37.5	31.4	261,553	142,377	119,176	8	11	19
SCIENCE CENTER 2	1976	4,184	44.7	0.0	44.7	187,150	0	187,150	0	17	17
HFO FACULTY OFFICES	2021	4,570	37.8	0.0	37.8	172,746	0	172,746	0	16	16
POLICE & SAFETY SERVICES	2009	2,880	44.7	0.0	44.7	128,822	0	128,822	0	12	12
OFFICE ANNEX - WLC	1991	2,006	49.1	0.0	49.1	98,575	0	98,575	0	9	9
SCIENCE CENTER 5	1976	1,597	63.5	33.0	30.5	101,416	52,631	48,785	3	5	7
COMMUNITY SERVICE CENTER	2002	1,569	63.5	35.6	27.9	99,650	55,864	43,785	3	4	7
SCIENCE CENTER 3	1976	1,281	49.7	0.0	49.7	63,666	0	63,666	0	6	6
HORTICULTURE GREENHOUSE 1-2	1975	4,409	10.8	0.3	10.5	47,397	1,102	46,295	0	4	4
SCIENCE CENTER 4	1976	846	63.5	33.0	30.5	53,724	27,881	25,844	1	2	4
KINESIOLOGY MODULAR	2007	956	39.1	0.0	39.1	37,332	0	37,332	0	3	3
POLICE-ET STORAGE BUILDING	1965	2,000	12.8	0.0	12.8	25,500	0	25,500	0	2	2
TEMP 14 ORNAMENTAL HORT	1966	2,200	12.5	4.5	8.0	27,442	9,834	17,608	1	2	2
FOOTBALL OFFICE	2002	451	44.7	0.0	44.7	20,173	0	20,173	0	2	2
SCIENCE CENTER 6	1976	330	49.7	0.0	49.7	16,401	0	16,401	0	2	2
SCIENCE CENTER 7	1976	389	21.3	0.0	21.3	8,286	0	8,286	0	1	1
SCIENCE CENTER 8	1976	260	21.3	0.0	21.3	5,538	0	5,538	0	1	1

The pool uses 2,143,000 kBTU per year, or about 177 kBTU/sf/yr.

INTERFACE ENGINEERING

DVC EUI Map



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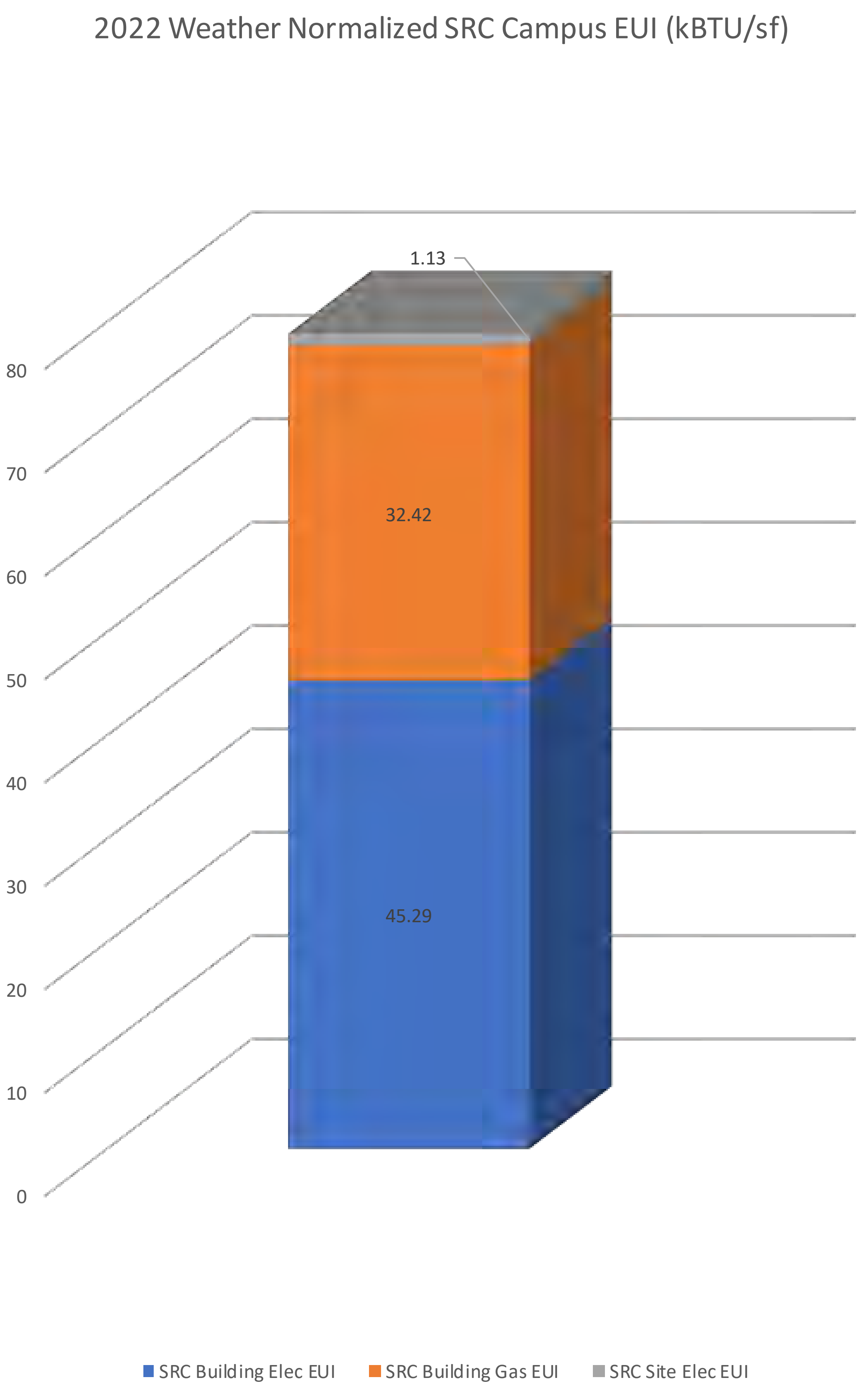
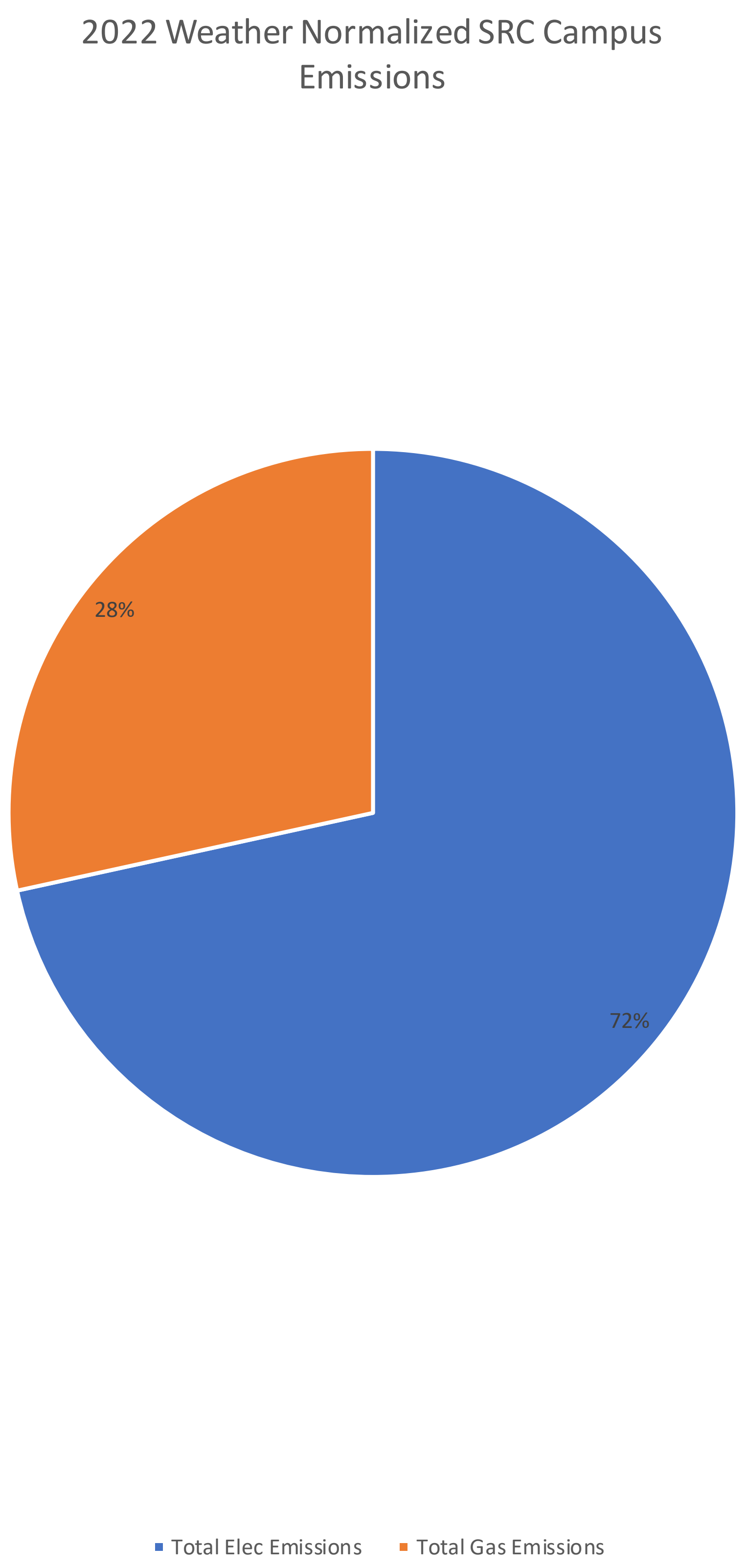




San Ramon Center

Campus-Level Benchmarking

The San Ramon facility is associated with Constellation and as an emissions rate of 701 lbs CO_2e per MWH of electricity. The facility is 88,500 sf.

San Ramon Center Building Benchmark Data Summary

Building	Age	Area	EUI	Gas EUI	Total kBTU	Gas kBTU	Elec KBTU	Gas Carbon Emissions (kg CO2)	Electricity Carbon Emissions	Total Carbon Emissions (Kg C02e)
SAN RAMON MAIN BUILDING*	2006	76,528	83.5	34.3	49.2	6,389,418	2,621,282	3,768,136	306,218	773,942
SAN RAMON LIBRARY*	2021	8,842	55.5	28.1	27.3	490,399	248,582	241,818	29,039	49,667

*Energy from the SRC mechanical plant facility is associated with the buildings that it serves, while its area is still included in SRC campus wide EUI calculations.

Electric Infrastructure Assessment

Electrical Infrastructure Assessment - Introduction

As part of the Electrification Plan, Interface Engineering evaluated the available electrical system capacity at each campus to accommodate the future electrical demands from electrification, renewable energy deployment, and EV charging. The goal of this assessment is to confirm the capacity at the main campus feeders and switchgear. Downstream equipment, such as panels, wiring, and transformers, are not included in this assessment.

We have assessed the available electrical capacity at each of the District's campuses, as well as the District Offices and Brentwood Building. The available capacity has been evaluated using PG&E utility data (15-minute interval data) and PV inverter output data (hourly data provided from the district) for the period of May 2022 through August 2023.

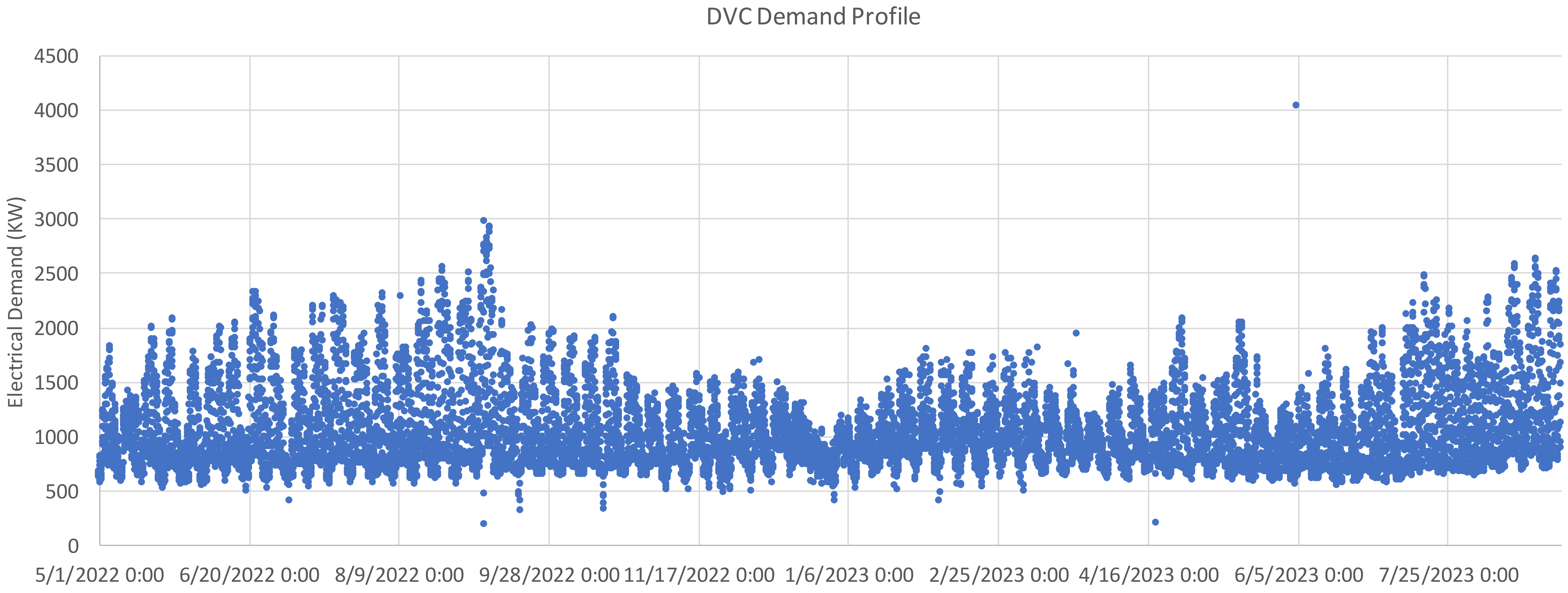
For electrical services that include PV production, the generation data from net generation output (NGOM) meters and/or direct inverter output data is added to the consumption data reported at the main revenue meter, establishing the true demand on the service.

The demand (kW) reported for each service is a calculated value, using the consumption and PV production data (kWh). For example, if 100 kWh are consumed in a 15-min timestep, then the calculated demand for that timestep would be reported as 400 kW (100 kWh X (1/4 hours)).

Diablo Valley College

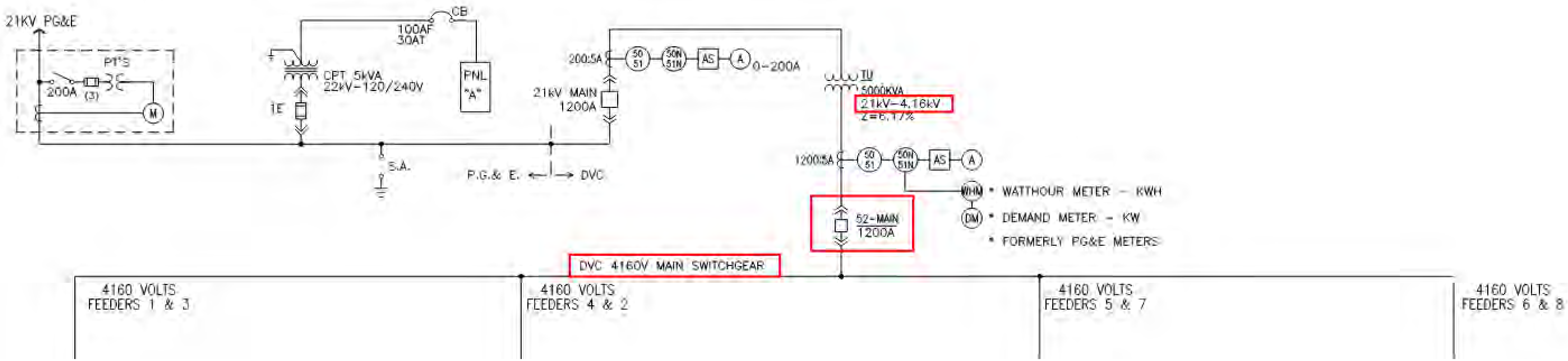
- DVC campus is powered by an existing 1200A, 4.16kV service with a total capacity of 8646.4 kW. The measured maximum demand on this service was 2733.6 kW.
- DVC data appears complete.
- Demand values include PV system generation data and service consumption data.
- An outlier datapoint of 4043.9 KW is ignored.
- Top 0.1% of demand used for maximum service demand.
- The existing service has an available capacity of 60.5%, or 5229.4kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	2733.6 kW
2	Maximum Demand	4043.9 kW
3	Maximum Demand Occurrence	6/4/2023 15:00
4	Service Voltage	4.16 kV
5	Service Amperage	1200 A
6	Service Capacity	8646.4 kW
7	Maximum Demand [2]	2733.6 kW
8	Maximum Demand * 125%	3417.0 kW
9	**Available Capacity [6-8]**	**5229.4 kW**
10	**Percent Available Capacity [9/6]**	**60.5%**



INTERFACE ENGINEERING

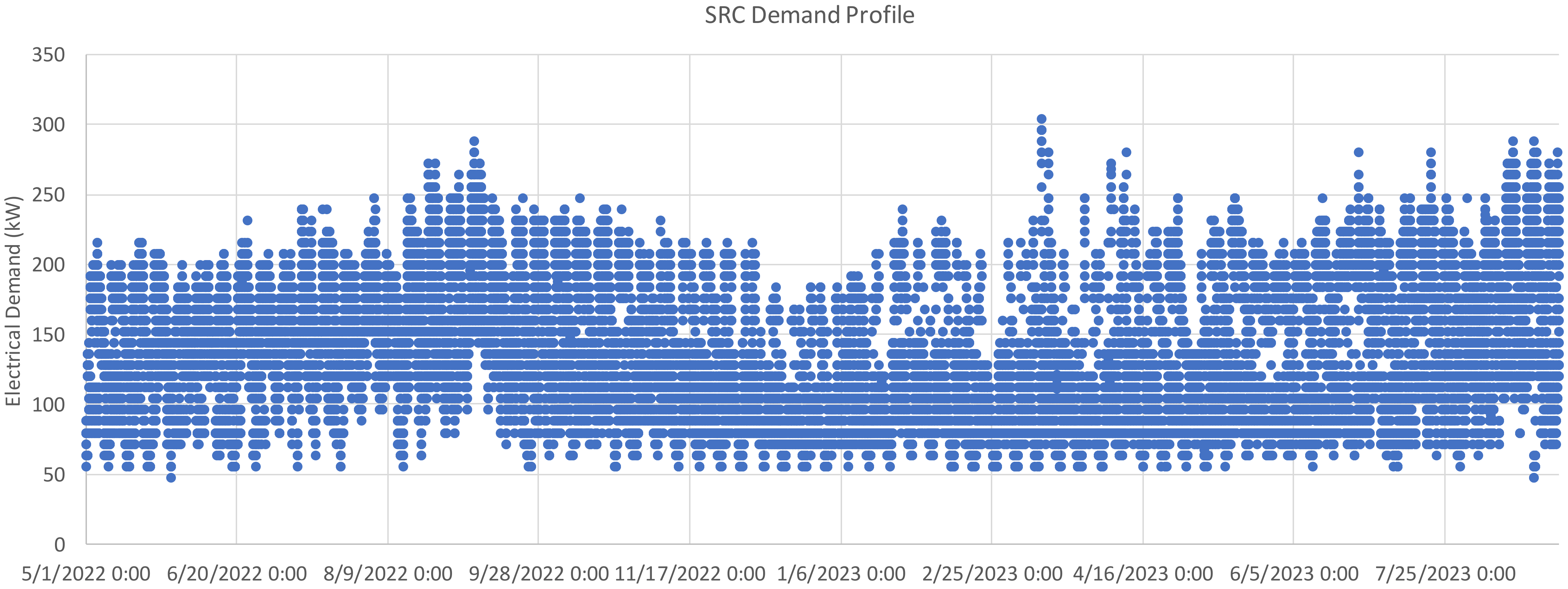
Diablo Valley College Single Line Diagram



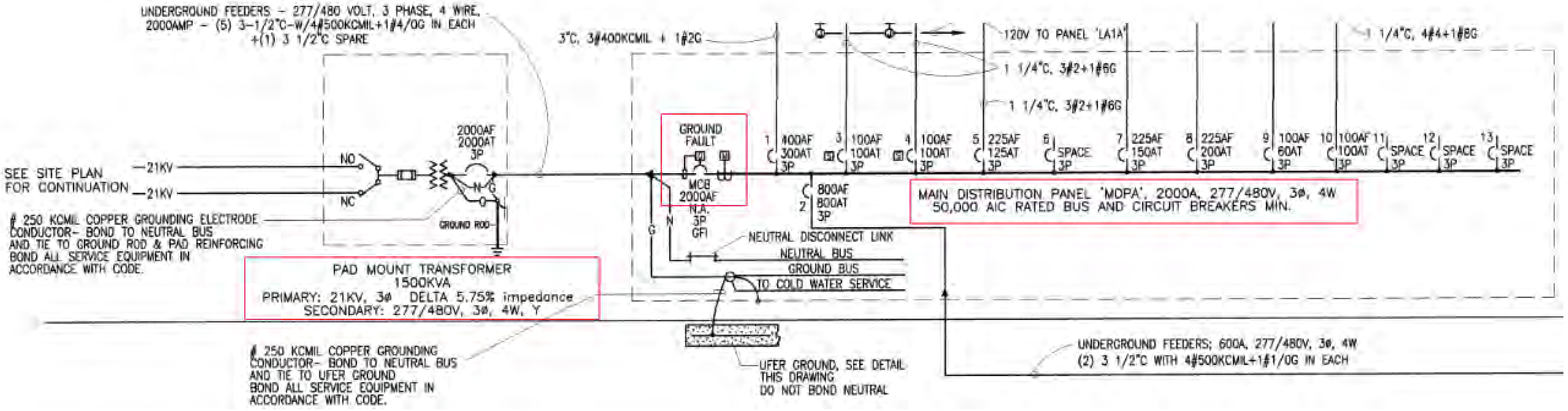
San Ramon College

- SRC campus is powered by an existing 2000A, 480V service with a total capacity of 1662.8kW. The maximum demand on this service was 304.0kW.
- SRC data appears complete.
- The existing service has an available capacity of 77.1%, or 1282.8kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	272.0 kW
2	Maximum Demand	304.0 kW
3	Maximum Demand Occurrence	3/13/2023 13:00
4	Service Voltage	480 V
5	Service Amperage	2000 A
6	Service Capacity	1662.8 kW
7	Maximum Demand [2]	304.0 kW
8	Maximum Demand * 125%	380.0 kW
9	**Available Capacity [6-8]**	**1282.8 kW**
10	**Percent Available Capacity [9/6]**	**77.1%**



San Ramon College Single Line Diagram



Renewable Energy Deployment

Renewable Energy Deployment Strategy Introduction

On-site renewable energy generation is a critical component of 4CD's sustainability plan to achieve net zero carbon emissions by 2035. The district currently has approximately 3.2 MW of photovoltaic (PV) solar panel systems across CCC, DVC, and LMC, which produce nearly 3.8 MWh annually. This represents approximately 19% of the district's electricity consumption.

As part of its plan to increase on-site renewable production, 4CD has five additional PV projects approved by PG&E for installation but have yet to be funded. For the purposes of estimating the impact of these approved projects, it is assumed that these systems will be installed in 2026. An estimate of the total development costs are shown in the table below, which based on the information provided by Sage Renewables. These costs are based on recent quote that 4CD received for the Brentwood system, which indicated a total cost of $7.87/watt for carport arrays. The Brentwood, DVC, and LMC installations are also planned to include battery energy storage systems (BESS), which will further enhance the cost reduction capabilities of these systems.

The tables to the right summarize the existing and planned PV systems, including their DC capacity, orientation and expected annual production rate (which vary slightly by campus and by array orientation). The table at the bottom indicates the % of electrical consumption that is met with the existing and future PV systems.

The campus site plans on the subsequent slides indicate the existing and planned PV locations on each campus, including the context of the newly planned buildings as part of the FMP. The site plans also indicate areas that may potentially be used for additional PV in the future.

The energy and carbon impact of the existing and planned arrays are discussed in more detail in the "District Energy and Carbon Timeline" chapter of this report.

The table below shows the future PV, beyond what is currently planned, that would be required in order to achieve net zero emissions for the specific campuses in 2035, and the associated cost of deployment in 2024 PV costs.

Future PV Summary (Scenario A)

Campus	Size (kW)	Cost*	Est. Annual Production (kWh/yr)	Predicted Electrical Consumption in 2035	% Future Load Met by Future PV
DVC	**3,844**	**$30,252,280**	**5,766,000**	**8,782,110**	**66%**
CCC	2,167**	$17,054,290	3,250,500	5,143,509	63%
LMC	591	$4,651,170	886,500	4,276,119	21%
SRC	433	$3,407,710	649,500	1,413,618	46%
DO	468***	$3,683,160	702,000	701,838	100%
BEC	166	$1,306,420	249,000	749,521	33%

*costs are based on estimates for PV projects for the district in 2024
**based on offsetting kWh instead of carbon emissions, due to the utility split for CCC between MCE and Constellation
***Due to limited space at this facility, this PV could be installed on another Constellation Campus like DVC, LMC, or SRC to have the same effect.

Existing PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	Kwh/KW*	Annual Energy Production (kWh)
Contra Costa College - Lot 9	403	225	1053	424,359
Diablo Valley College - Lot 1	**567**	**270**	**1297**	**735,289**
Diablo Valley College - Lot 3	**267**	**270**	**1297**	**346,247**
Diablo Valley College - Lot 4	**548**	**270**	**1297**	**710,650**
Los Medanos College - Lot B	763	150	1139	868,904
Los Medanos College - Lot C	638	230	1128	719,953
Total	3,186			3,805,402

*The existing PV production rates are 20-30% below the expected rate, based on the location and orientation of the systems. This may indicate performance issues with the panels and inverters.

Planned PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	kWh/KW	Annual Energy Production (kWh)	Project Development Costs ($)
Diablo Valley College - Lot 5	**878**	**270**	**1564**	**1,373,000**	**$6,909,860**
Contra Costa College - Lot 1	947	225	1551	1,469,000	$7,452,890
Los Medanos College	1,154	150	1560	1,800,000	$9,081,980
San Ramon Center - Main Lot	483	225	1580	763,000	$3,801,210
Brentwood Center - Main Lot	322	180	1556	501,032	$2,534,140
Total	3,784			5,906,032	$29,780,080

Renewable Energy Summary

	Annual Electricity Consumption (kWh)*	% Met by Existing PV	% Met by Planned PV	Total Planned Renewable %
CCC	4,414,407	10%	33%	43%
DVC	**8,618,555**	**21%**	**16%**	**37%**
LMC	4,783,853	33%	38%	71%
SRC	1,200,248	0%	64%	64%
Brentwood	573,479	0%	87%	87%
District Offices	657,697	0%	0%	0%
District	20,248,239	19%	28%	47%

*True 2022 value that is not weather normalized

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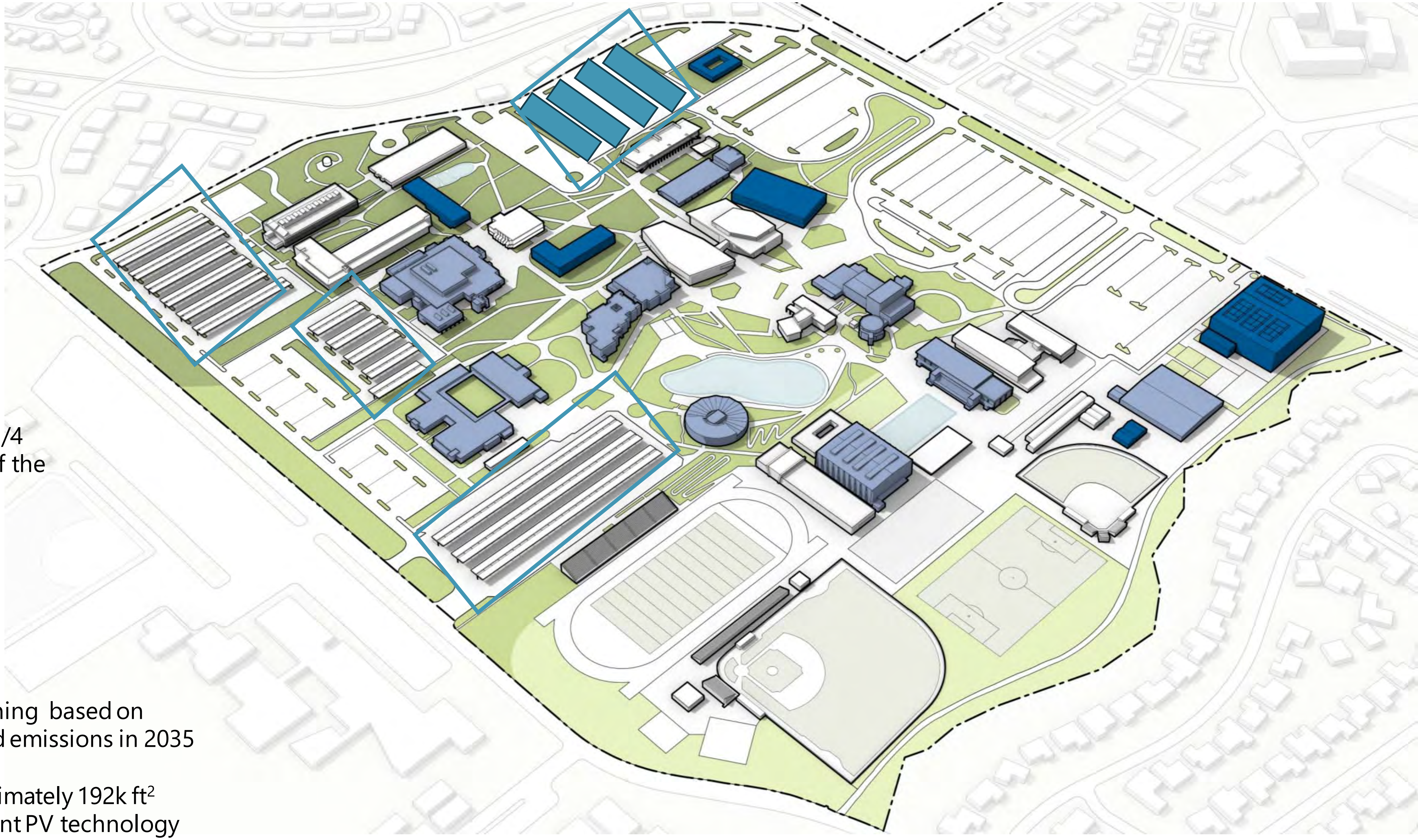
Diablo Valley College PV Systems

Planned System
- 878 KW @ parking lot 5
- Planned PV offsets ~ 16% of the campus's 2022 electricity



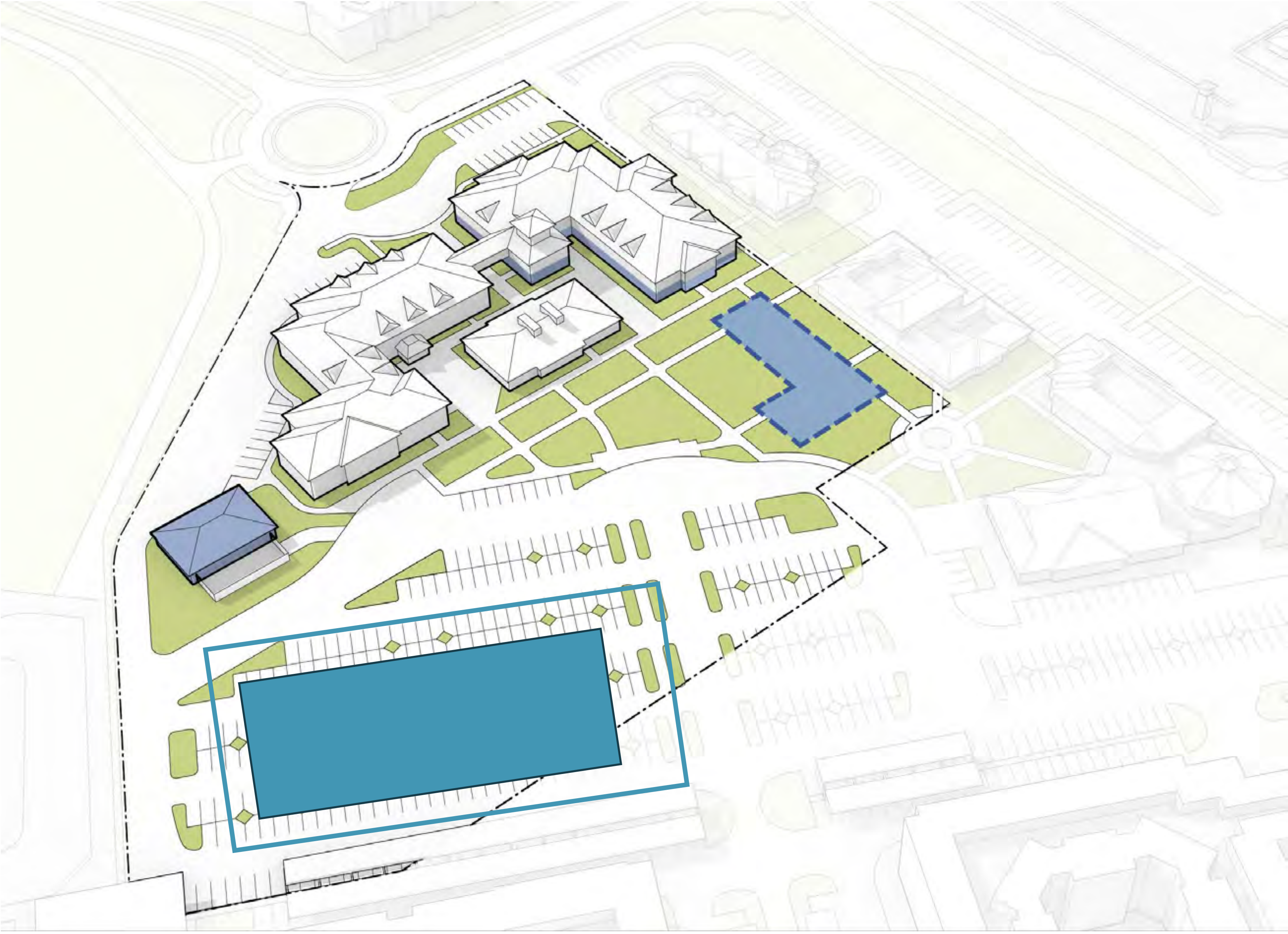
Existing System
- 1,382 KW @ parking lot 1/3/4
- Existing PV offsets ~ 21% of the campus's 2022 electricity

Potential Future System
- Potential PV offsets remaining based on electrical consumption and emissions in 2035 projections
- 3.84 MW required, approximately 192k ft^2 panel area, based on current PV technology (future location not determined at this time)

INTERFACE ENGINEERING

San Ramon Center
PV Systems

Potential Future System
- 433KW
- Potential PV offsets remaining based on electrical consumption and emissions in 2035 projections
- Approximately 21.5k ft^2 panel area, based on current PV technology
- Location of future PV not determined at this time.



Planned System
- 483 KW at main lot
- Planned PV offsets ~ 64% of the campus's 2022 electricity

INTERFACE ENGINEERING

District Energy Projects

Electrification Plan Introduction

In 2022, more than 48% of the electricity delivered by California's grid was generated by renewable sources such as solar photovoltaics, wind, biomass, and hydroelectric. This percentage will increase over time, as state laws such as SB100 mandate that CA's grid achieve 100% carbon-free generation by 2045. This means that by electrifying legacy natural gas heating systems, the carbon footprint associated with these loads will trend towards zero. For the Contra Costa Community College district in 2022, ~45% of its electricity was provided by renewable resources (including grid-supplied and on-site generation).

The purpose of this study is to support the master-planning effort for the Contra Costa Community College District (4CD) with a district-wide electrification plan. The plan provides an analysis of how electrifying the district's natural gas heating systems and deploying renewable energy systems will reduce the district's energy consumption and carbon footprint.

The primary goal of the electrification plan is to assist the district in meeting its sustainability goals, as outlined in the "2022 4CD District Wide Energy & Sustainability Goals" document.

The electrification plan consists of the following components:

- Building Benchmarking Report
- Electrical Systems Assessment
- Campus Photovoltaic Deployment Assessment.
- Building Electrification Strategy
- District Energy and Carbon Timeline

4CD has adopted a set of sustainability goals which target significant reductions in carbon emissions across the entire organization by 2035. The electrification study addresses the greenhouse gas (GHG) and renewable energy goals by proposing and quantifying the impacts of building replacement and renovation projects, renewable energy systems, as well as additional efficiency projects such as LED lighting, building management controls, metering upgrades and HVAC electrification.

4CD's goals are focused on the two primary dates of 2030 and 2035. The 2030 goals include reducing GHG emissions by 75% below the 2013 baseline and reducing the district energy use intensity (EUI) by 25%. The 2035 goals include reducing GHG emissions by 100% and reducing district EUI by 40%.

HVAC Electrification Strategy

Contra Costa Community College District has adopted a broad set of sustainability goals and practices that will result in dramatic reductions in energy consumption and carbon emissions from its buildings. A key component of these goals is the requirement that all newly constructed buildings are all-electric (no fossil fuel combustion used for space heating). This approach leverages the fact that California's grid is becoming cleaner (emitting less carbon) each year, which inherently reduces the carbon footprint of the campus.

There are a range of all-electric heating technologies that work well for new construction projects. However, converting the existing natural gas heating systems to all-electric has historically been challenging from a technological and financial standpoint. Air-source heat pump (ASHP) technology which use traditional refrigerants have limitations on the temperatures they can produce (typically a maximum supply temperature of approximately 130F), which may make them incompatible with typical legacy heating systems which utilize 160-180F temperatures. The renovations required to make existing buildings compatible with ASHP technology can be prohibitively expensive. These renovations may require replacement of some heating coils to accommodate lower water temperature, and often piping/coupling systems need to also be replaced. Furthermore, ASHP technology is limited to a lower ambient temperature of ~25F, which means that supplemental heating may be required on the coldest days of the year.

Water-source heat pumps (WSHP) are more flexible, with supply temperatures as high as 170F. These require a water-based heat source/sink, such as a ground loop via a geo-exchange system. Geo-exchange systems are often very costly due to the cost of drilling vertical wells or excavating for horizontal systems. These costs and space constraints typically preclude water-source heat pumps as a retrofit solution.

Transcritical heat pump (TCHP) technology is relatively new to building comfort heating and cooling which is addressing the traditional challenges of ASHPs and WSHPs. This technology utilizes CO^2 as its refrigerant (known as R744), which enables hot water delivery temperatures of 180F at outdoor ambient conditions down to -15F. This allows "direct replacement" of natural gas boilers and domestic hot water heaters. This technology is still "emerging", with a limited number of installations in the U.S., however, it is expected that this technology will develop rapidly over the next 5 years.

For existing buildings with traditional boiler-based hydronic systems, an assessment process is recommended to determine what modifications are required in order electrify these systems with the highest possible efficiency. The primary goal of this assessment is to determine if the existing hydronic systems is capable of operating at lower heating hot water temperatures while still maintaining design temperatures. Lowering the hot water temperatures allows for compatibility with a wider range of heat pump technology, and also allows them to operate much more efficiently. The following bullet points outline the assessment process:

- Review heating coils configuration - heating coil performance will be reduced when operating at lower hot water temperatures, however, in some cases, this performance derating can be overcome with modification to control sequences. In most cases, two-row heating coils at air handling units and VAV boxes can be utilized when lowering hot water temperatures from 180F to 140F, or even lower. The peak capacity of the coils is reduced with lower water temperatures, but simply increasing the warm-up time of the building may overcome these limitations. Also, reducing the temperature setback of the space will reduce the load that the coils must meet. Single-row coils will likely struggle to meet the load with reduced water temperatures and may need to be replaced.

- Conduct a hot water reset investigation – During the winter months, reduce the heating hot water temperature in 5-degree increments for one to two weeks at a time. This process will reveal which zones/coils are able to meet space loads with reduced water temperatures. As zones are discovered to be out of setpoint, increase the warm-up period or limit the temperature setback. Continue to reduce water temperatures and increase warmup period to determine if a lower water temperature will allow the building to maintain functionality. This process may reveal that certain zones/coils will function adequately, while others may need to be upgraded. The desired outcome of the reset investigation is a custom outdoor air reset control sequence that reduces hot water temperatures to a minimum, as a function of outside air temperature. For example, the goal may be to operate at 140F supply/ 100F return as often as possible but allows for increases up to 180F supply / 140F return on the coldest days of the year.

HVAC Electrification Strategy
Transcritical Heat Pumps

While this heat pump technology has long been used in commercial refrigeration for 20 years or more, it is more recently being applied to building HVAC and domestic hot water. Typically, these machines use CO_2, or R-744, as its refrigerant, which has a global warming potential (GWP) of 1, which is far below traditional refrigerants like R-410a (GWP of 2088) or R-134a (GWP of 1430). Furthermore, R-744 is able to operate with much higher temperatures, at or above 180F. However, like traditional heat pumps, transcritical heat pumps operate much more efficiently with lower supply water temperatures.

As the technology continues to advance, it may become a critical component of electrifying existing buildings that utilize hydronic heating. The graph on the right shows the efficiency curves for various operating conditions for Flow Environmental System's model H transcritical heat pump. These trends show that while operating at "traditional" boiler system temperatures of 180F supply / 140F return, a COP of 1.75 is achieved. However, lowering the supply temperature to 140F dramatically improves efficiency, approaching a COP of 3.5. This highlights the importance of the hot water reset assessment process outline on the previous page.

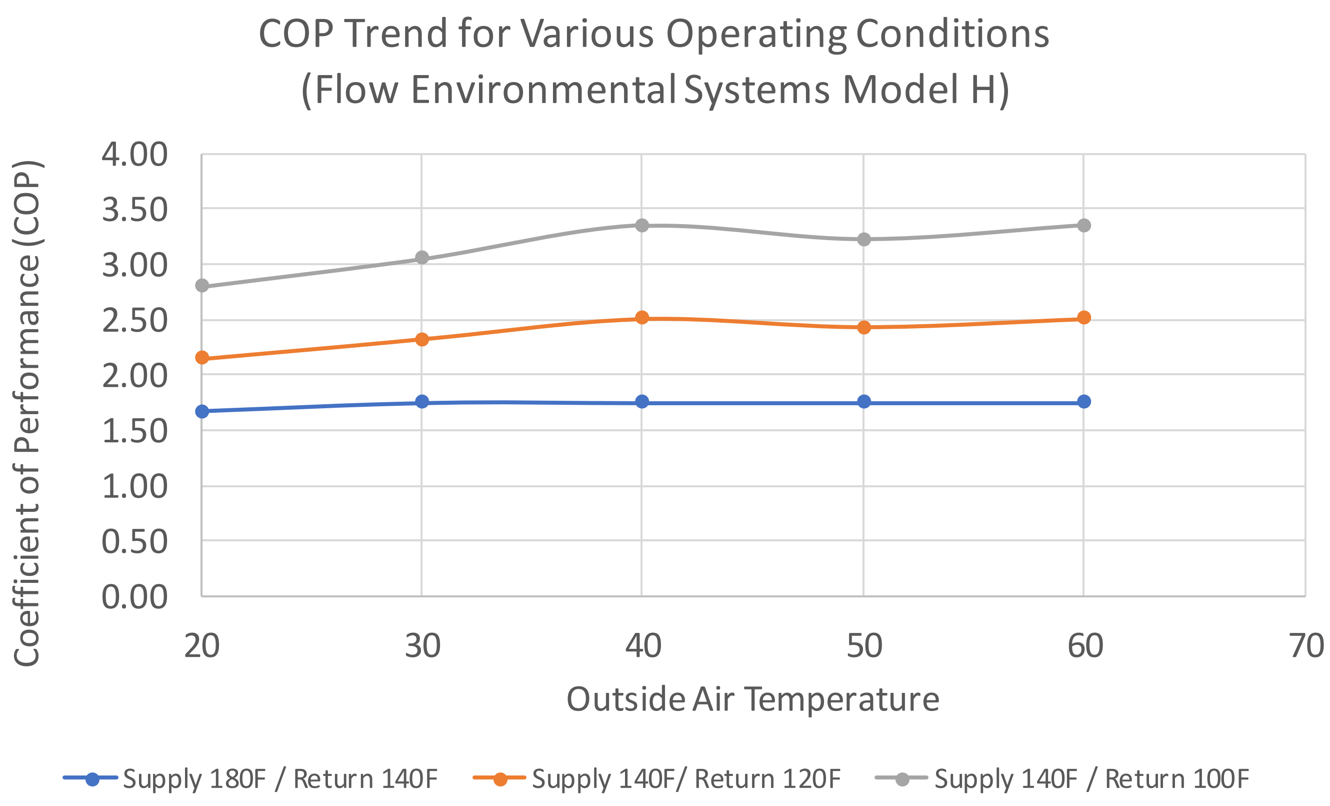
Transcritical heat pump technology is also well suited for domestic hot water applications, where storage temperatures typically range from 125F – 140F. Systems like Sanden and Lync are able to achieve COPs above 5, which allows for significant improvements to operation cost and carbon emissions associated with domestic hot water.

The links below are examples of transcritical heat pump technology that are recommended for investigation by future design teams for use in both new construction and retrofit projects.

https://www.flowenvirosys.com/products

https://www.smallplanetsupply.com/sanc02

https://www.lyncbywatts.com/



HVAC Electrification Strategy
Central Plant Opportunities

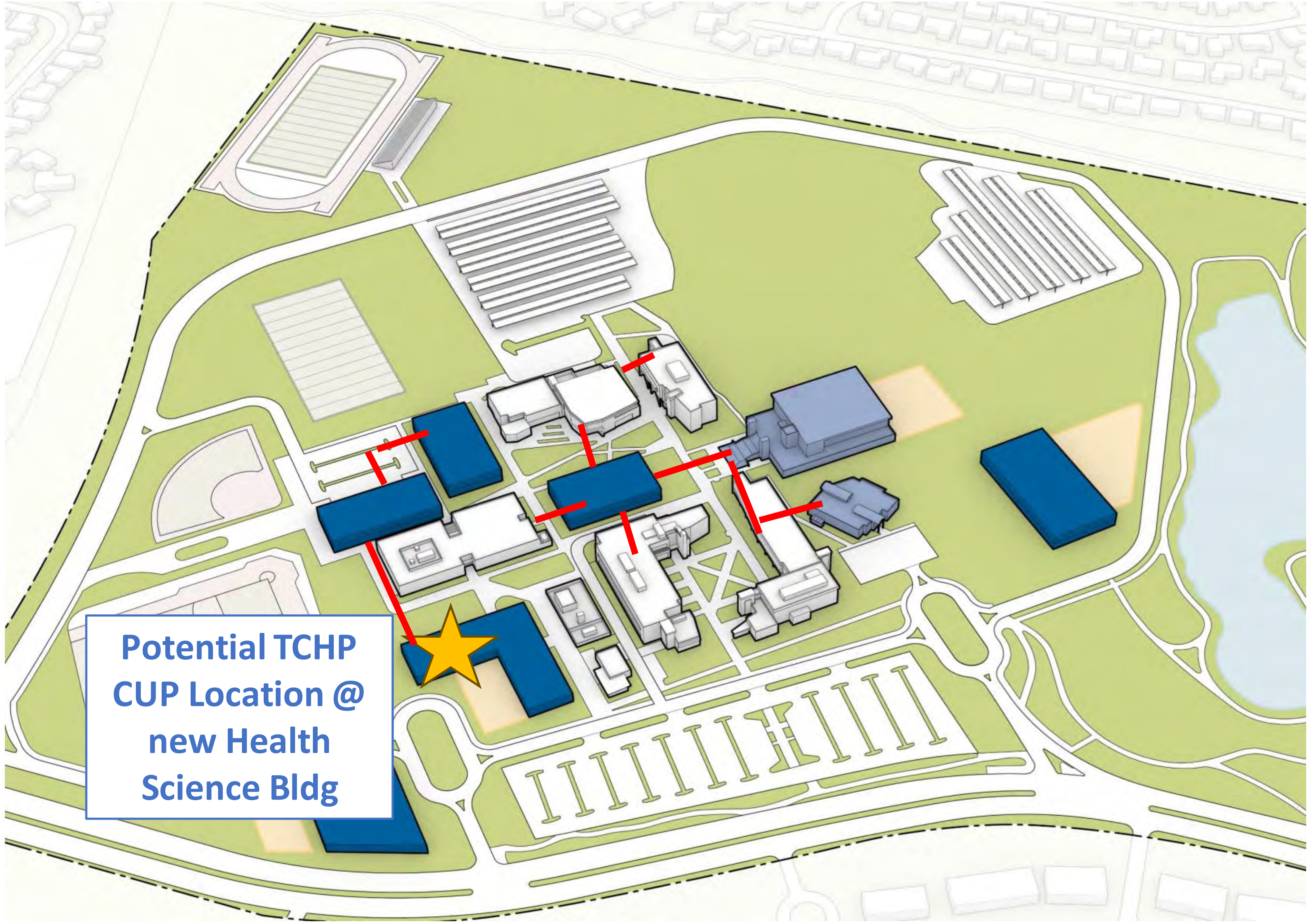
An all-electric central utility plant (CUP) may be an effective strategy to employ as part of the early FMP projects. At Los Medanos College, the newly planned Health Sciences building is one of the first major projects that will occur within the core of the campus. It is in relatively close proximity to several other newly planned or renovated building. A central plant can be designed and planned at the new Health Sciences building with the intent to expand over time, as new buildings are built, and existing buildings are retrofitted.

For Contra Costa College, a central plant may be feasible as part of the renovation of Student Services or General Education buildings. However, space constrains may make this challenging.

For Diablo Valley College, a central plant may be feasible as part of the new academic complex, which is planned for construction in 2030. this central plant could then be available to serve the renovation projects as they occur in the later 2030's.

Utilizing a central plant, as opposed to each building having standalone heating and cooling equipment, offers many benefits in terms of efficiency, redundancy, and heat recovery. Centralizing the load of multiple buildings offers diversity in the load profile, which may allow for energy to be recovered (using heat recovery heat pumps) when simultaneous heating and cooling loads are required across a campus. Central plant equipment can be designed with proper modularity to allow for very efficient part load operation, as well as inherent redundancy. Thermal storage systems can be readily added to a central plant, allowing primary heating and cooling equipment to be dramatically downsized, as well as offering the ability to load shift to times when energy is cheap or when the grid is the cleanest (depending on District priority).

The downsides of a central plant approach are primarily cost and complexity. A significant infrastructure investment is required to install the initial phases of a central plant, sizing piping and electrical systems for their anticipated future loads. However, future buildings that connect to the central plant will be lower cost. The equipment is typically of a larger scale, often requiring specialized contractors to perform major maintenance. A relatively large are is often required to house the central plant equipment, which can be challenging for some campuses.



HVAC Electrification Strategy
Central Plant Opportunities – San Ramon Center

The San Ramon Center may be a prime target for electrification of its central plant. The assessment report indicates that the boilers still have 12 years of remaining life, however the chilled water system is nearing the end of its life. The cooling tower is indicated with 0 years remaining, while the chiller still has 5 years.

The SRC's central plant utilizes nominally 86% efficient natural gas boilers to deliver 180F (140F return) hot water (140F return) to the buildings. The plant's current total heating capacity is 3,440 MBH, with expansion to 6,880 MBH planned into the piping system.

The chilled water system is comprised of 2 water-cooled chillers with a total of capacity of 645 Tons (7,740 MBH) and 2 cooling towers of 700 Tons capacity.

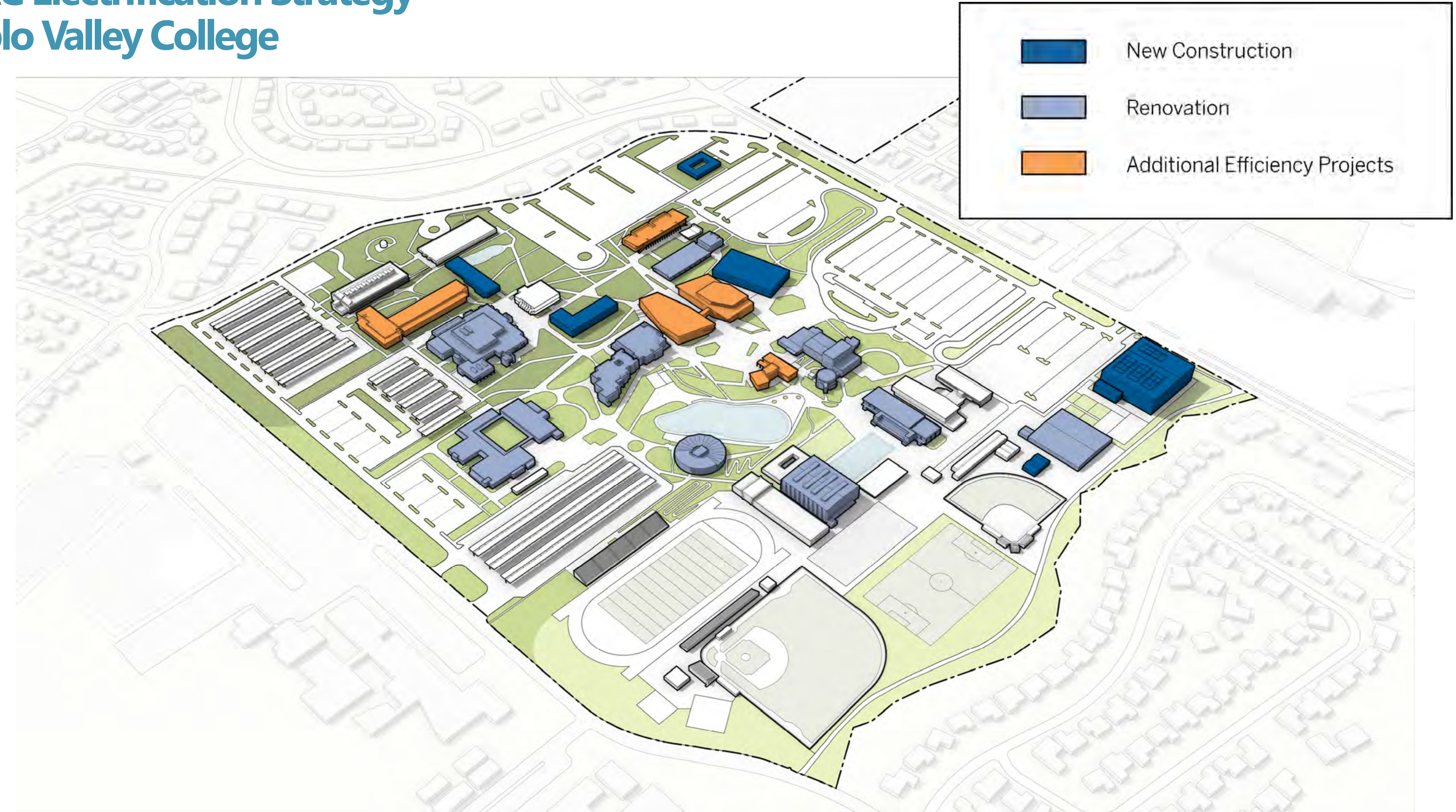
A transcritical heat pump (TCHP) may be an ideal solution to directly replace the boilers while also providing a portion of the cooling load. When simultaneous heating and cooling loads are present, the TCHP is able to operate in heat recovery mode to meet both demands with an extremely high efficiency (total COPs above 7). ASHPs may also be a viable solution if water temperatures can successfully be reduced.

A high-level design concept is to, at the end of the life of the chilled water system, replace the 3,440 MBH of boiler capacity with an equivalent capacity of TCHP. This would also provide approximately 2,900 MBH of cooling (~240 Tons). The two existing water-cooled chillers are replaced with one high efficiency water-cooled chiller to meet the remaining load of approximately 400 Tons. This approach would dramatically reduce the EUI and carbon emissions of the facility, as well as reduce water consumption from cooling tower evaporation and blowdown.

Combined with thermal storage (hot and/or cold water), a TCHP plant can utilize load shifting strategies to reduce energy demand charges and more effectively leverage heat recovery. Carbon emissions can also be greatly reduced by shifting the load to times when the grid is cleanest or when onsite renewable energy production is plentiful.

Thermal energy storage systems, like solar PV systems may be eligible to have 30-40% of their costs covered by the Inflation Reduction Act (IRA).

HVAC Electrification Strategy
Diablo Valley College



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HVAC Electrification Strategy
Diablo Valley College – FMP Projects Pt.1

The 2024 Facilities Master Plan identifies 12 projects that will enhance the usability of the campus. These projects include new construction of 6 new buildings, 4 of which occur during the timeline of the energy study.

As part of the 4CD sustainability goals, each of these new buildings will be all-electric and LEED gold certified. The predicted EUI of these buildings is shown in the table below, along with the assumptions of building size and what year the projects will be built.

New Construction Projects					
Building	Area (ft2)	Year of Construction	Predicted EUI (kBtu/sf-yr)	Annual Electricity Consumption (kWH)	Notes
NEW SCIENCE COMPLEX	18,500	2031	50	271,091	Coincides with demolition of science center and planetarium buildings
NEW ACADEMIC COMPLEX	69,000	2030	25	505,548	Coincides with the demolition of Faculty Office, Liberal Arts building, and Administration Building
NEW EARLY CHILDHOOD EDUCATION	11,300	2027	25	82,793	Replaces North and South Early Childhood Education buildings
BOOKSTORE EXPANSION	7,375	2028	30	64,842	Numbers provided are for just the expanded area and the addition is assumed to be supplied its own separate ASHP electric heating, LEDs and ALC

Additional projects in the MFP outside of the scope of the energy study are the new Inter-disciplinary Building and new Police and Safety Services building.

HVAC Electrification Strategy
Diablo Valley College – FMP Projects Pt.2

The 2024 Facilities Master Plan identifies 12 projects that will enhance the usability of the campus. These projects include 6 renovations. None of those renovations occur during the period of time of the energy study, but the bookstore addition also coincides with a renovation of the existing facility, so the energy impact of that portion of the bookstore project is shown below.

Renovation projects are anticipated to eliminate natural gas from the HVAC and plumbing systems, resulting in a substantial energy and carbon emissions reduction. These savings are summarized in the table below.

Renovation Projects							
Building	Area (ft2)	Year of Renovation	Existing EUI	Predicted EUI (kBtu/sf-yr)	Natural Gas Reduction (kBtu)	Electricity Reducton (kWh)	Notes
BOOKSTORE	13,462	2028	53.9	30.9	356,205	17,438	Electrification, LEDS and Controls included in FMP renovation. Numbers shown are for existing portion of the building.

Renovations of the following buildings occur after and outside our energy plan:

Humanities
Library
Math
Performing Arts
Music
M&O/Warehouse

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HVAC Electrification Strategy
Diablo Valley College – Additional Efficiency Projects

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWH	Gas Reduction kBTU	Starting EUI	EUI After
POOL	NA	2030			x (Boiler)	Unkown			$750,000	$750,000	NA	0	NA	NA
SCIENCE & TECHNOLOGY	19,505	2033	x	x	x (Boiler)	AHU at 0, Boiler not in inventory	$289,863	$434,794	$869,589	$1,594,246	10,893	653,422	66.5	31.0
HUMANITIES	16,428	2026	x	x	x (Furnace)	Furnaces with 2-3 years of RUL	$179,398	$269,097	$448,495	$896,989	-2,150	658,536	105.4	65.8
LIFE SCIENCES	33,844	2034	x	x	x (Boiler)	Boiler and two of 3 AHUs have 10 years. One AHU has 5	$525,587	$788,380	$1,576,761	$2,890,728	-34,800	1,646,849	127.4	82.2
LIBRARY	63,201	2027	x		x (Boiler)	Boiler age unknown	$721,228		$2,163,685	$2,884,914	-173,325	1,655,945	60.4	43.6
ENGINEERING TECHNOLOGY	36,551	2026	x	x	x (Furnace)	AHUs at one, non-FMP ALC + LED + electrification plus HVAC improvement due to very high existing building HVAC EUI	$399,146	$598,719	$997,865	$1,995,730	-181,945	3,157,794	136.8	67.4
LEARNING CENTER	15,914	2032	x	x	x (Furnace)	Several AHUs at 0 years left	$226,313	$339,470	$565,783	$1,131,565	22,916	553,871	86.9	50.7

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

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HVAC Electrification Strategy
Diablo Valley College – Additional Efficiency Projects Cont.

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWH	Gas Reduction kBTU	Starting EUI	EUI After
STUDENT UNION	12,744	2027	x	x	x (Furnace)	Severall AHUs at 0 and 2 of remaining useful life	$145,430	$218,145	$363,576	$727,151	-3,063	524,186	76.4	36.0
MATH BUILDING	24,211	2031	x	x	x (Boiler)	8 Years left on boiler	$329,478	$494,217	$988,435	$1,812,130	30,805	645,945	55.8	24.8
PHYSICAL SCIENCE	41,220	2025	x	x	x (Boiler)	Boiler at 0, AHUs at 7, of remaining useful life	$430,749	$646,124	$1,292,247	$2,369,120	-34,610	1,931,487	125.0	81.1
BUSINESS & WORLD LANGUAGE	26,676	2026	x	x	x (Boiler)	Boiler at 0, AHUs at 7, of remaining useful life	$291,309	$436,963	$873,926	$1,602,197	40,255	651,396	68.8	39.3
POLICE & SAFETY SERVICES	2,880	2026	x			5 years of remaining useful life on HVAC Equipment, LED is only energy related recommended project	$31,450			$31,450	8,829	0	44.7	34.3
STUDENT SERVICES	41,103	2034	x	x	x (Boiler)	AHU at 10 years of remaining useful life, Boiler is from HSF 119 and in good shape	$638,317	$957,476	**See HSF Below**	$1,595,793	57,787	1,044,184	63.8	33.6
HOSPITALITY STUDIES & FOOD COURT	44,779	2034	x	x	x (Boiler)	Equipment is in good shape, boiler also serves Student Services 118	$695,404	$1,043,106	$4,001,164	$5,739,674	50,798	1,253,717	64.0	32.2

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

INTERFACE ENGINEERING

HVAC Electrification Strategy
Diablo Valley College – Additional Efficiency Projects Cont.

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWH	Gas Reduction kBTU	Starting EUI	EUI After
PERFORMING ARTS	34,423	2032			x (Boiler)	8 years of remaining useful life on boiler			$1,468,589	$1,468,589	-101,065	965,573	42.7	24.7
MUSIC	14,522	2030	x			14 years of remaining useful life on the boiler	$189,114			$189,114	44,518	0	65.1	54.6

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

INTERFACE ENGINEERING

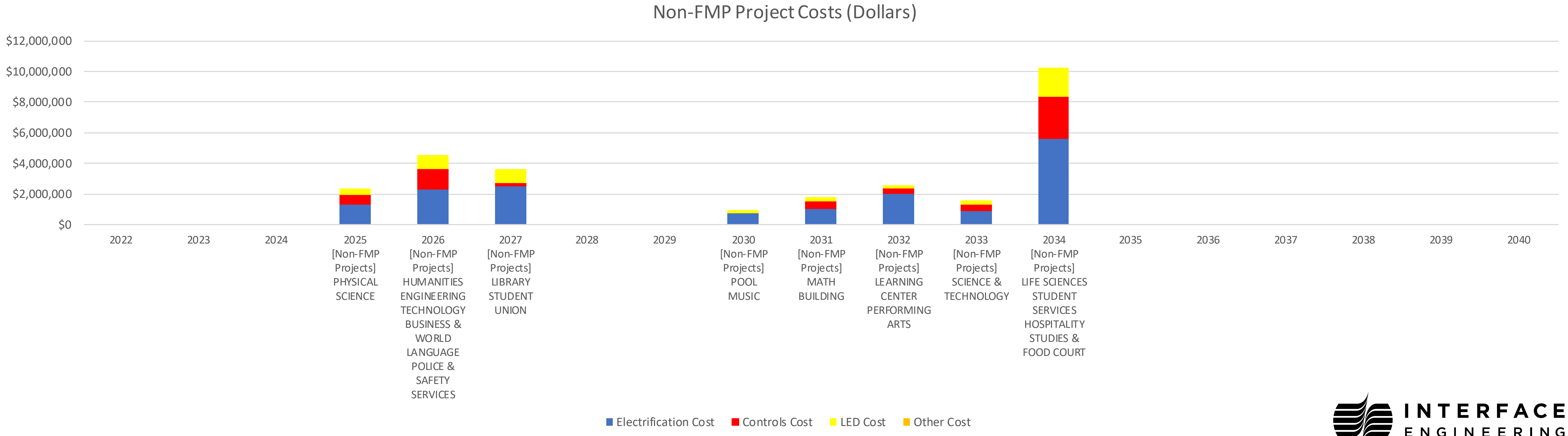
HVAC Electrification Strategy
Diablo Valley College – District Energy Project Savings and Cost Summary

Non-FMP Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$5,092,787	$6,226,491	$16,360,113	$27,679,391

Non-FMP Energy Project Annual Cost Savings (2023 DVC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 265,435	$ 68,811	$ 323,481	-$402,638	$255,089

Non-FMP Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
4,116,826	1,067,245	11,240,652	17,485,458

Non-FMP Energy Project Annual Cost Savings (2035 Estimated DVC Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 474,005	$ 122,881	$ 577,662	-$719,018	$455,530



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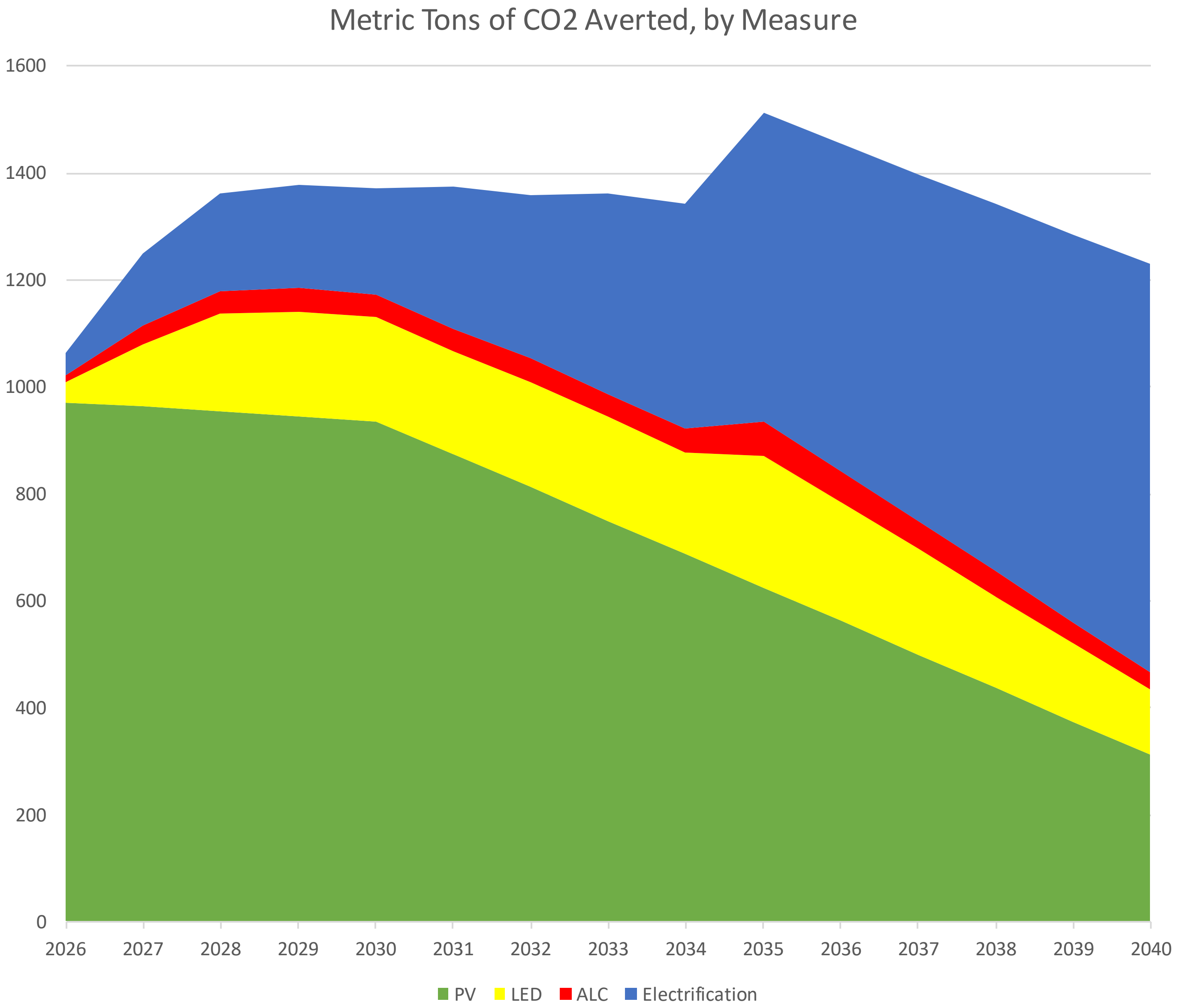
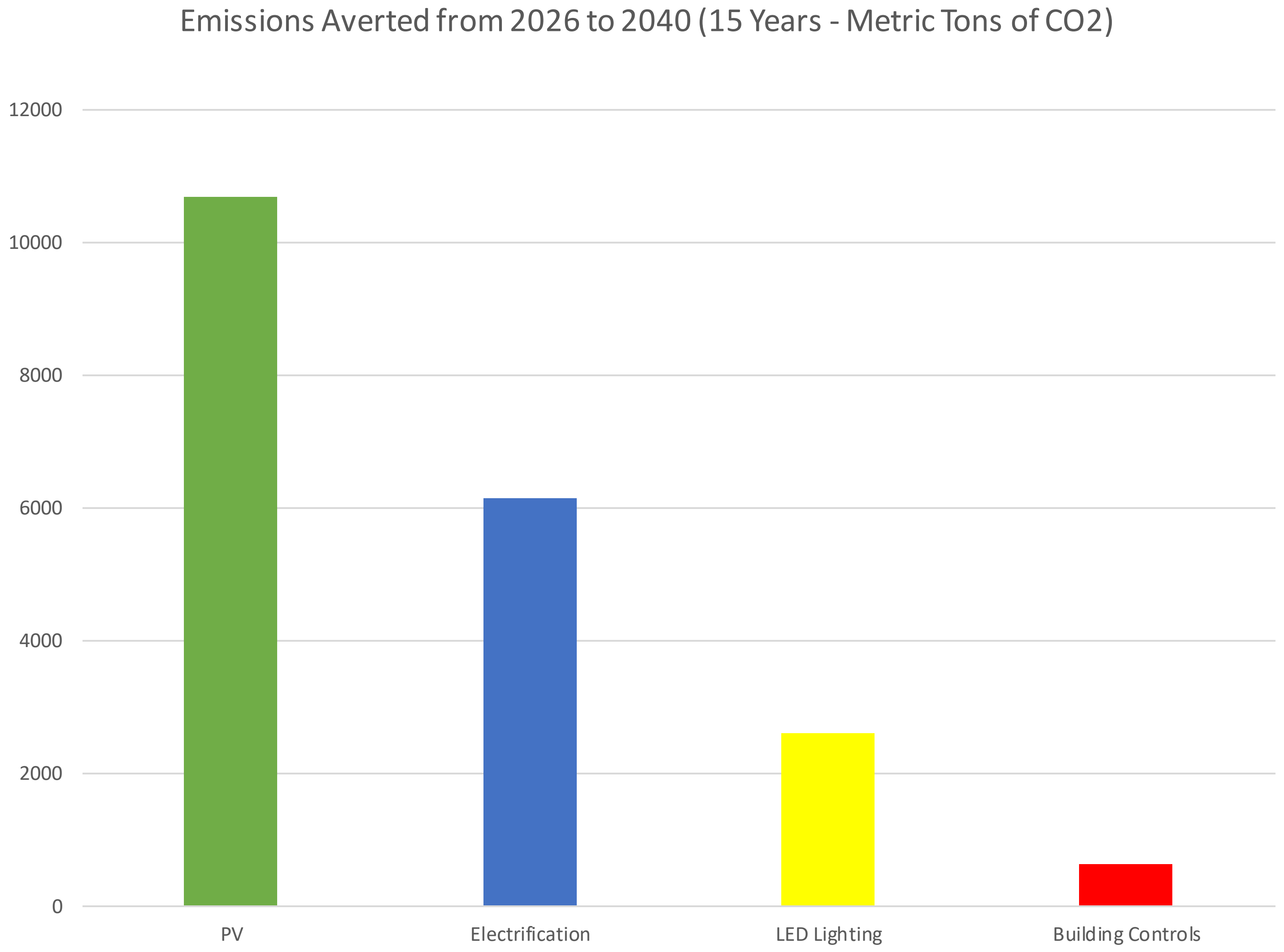
HVAC Electrification Strategy
Diablo Valley College – District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO_2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. PV provides a greater source of averted emissions early on, while electrification provides a greater amount of averted emissions by the end of the study. This is due to the improving grid emissions rate lowering the offset impact of PV and increasing the gas replacement impact of electrification. There is also PV at the start of the study, whereas it takes time for a portfolio of electrified buildings to accumulate.





INTERFACE ENGINEERING

HVAC Electrification Strategy
San Ramon Center – New Construction

The following building is planned to be constructed at the San Ramon campus in the 2024 FMP.

New Construction Projects					
Building	Area (ft2)	Year of Construction	Predicted EUI (kBtu/sf-yr)	Annual Electricity Consumption (kWH)	Notes
SRC SCIENCE / STEM PATHWAY BUILDING	15,000	2028	50	219,803	New Science Building

INTERFACE ENGINEERING

HVAC Electrification Strategy
San Ramon Center – Additional Efficiency Projects

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWh	Gas Reduction kBTU	Starting EUI	EUI After
SAN RAMON CAMPUS	76,528	2029	x	x	X (Boiler)	12 years of RUL for boiler, same boiler replace from central plant as Library Learning Resource Center	$953,678	$1,430,517	$2,861,034	$5,245,230	36,713	2,621,282	83.5	47.6
LIBRARY LEARNING RESOURCE CENTER	8,842	2029			X (Boiler)	12 years RUL for boiler, same boiler replace from central plant as San Ramon Campus			$330,562	$330,562	-88,779	248,582	55.5	37.4

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

HVAC Electrification Strategy
San Ramon Center – District Energy Project Savings and Cost Summary

SRC Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$953,678	$1,430,517	$3,191,597	$5,575,792

2023 SRC Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$56,304	$18,355	-$129,766	$60,554	$5,447

SRC Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
800,483	260,960	1,844,913	2,869,864

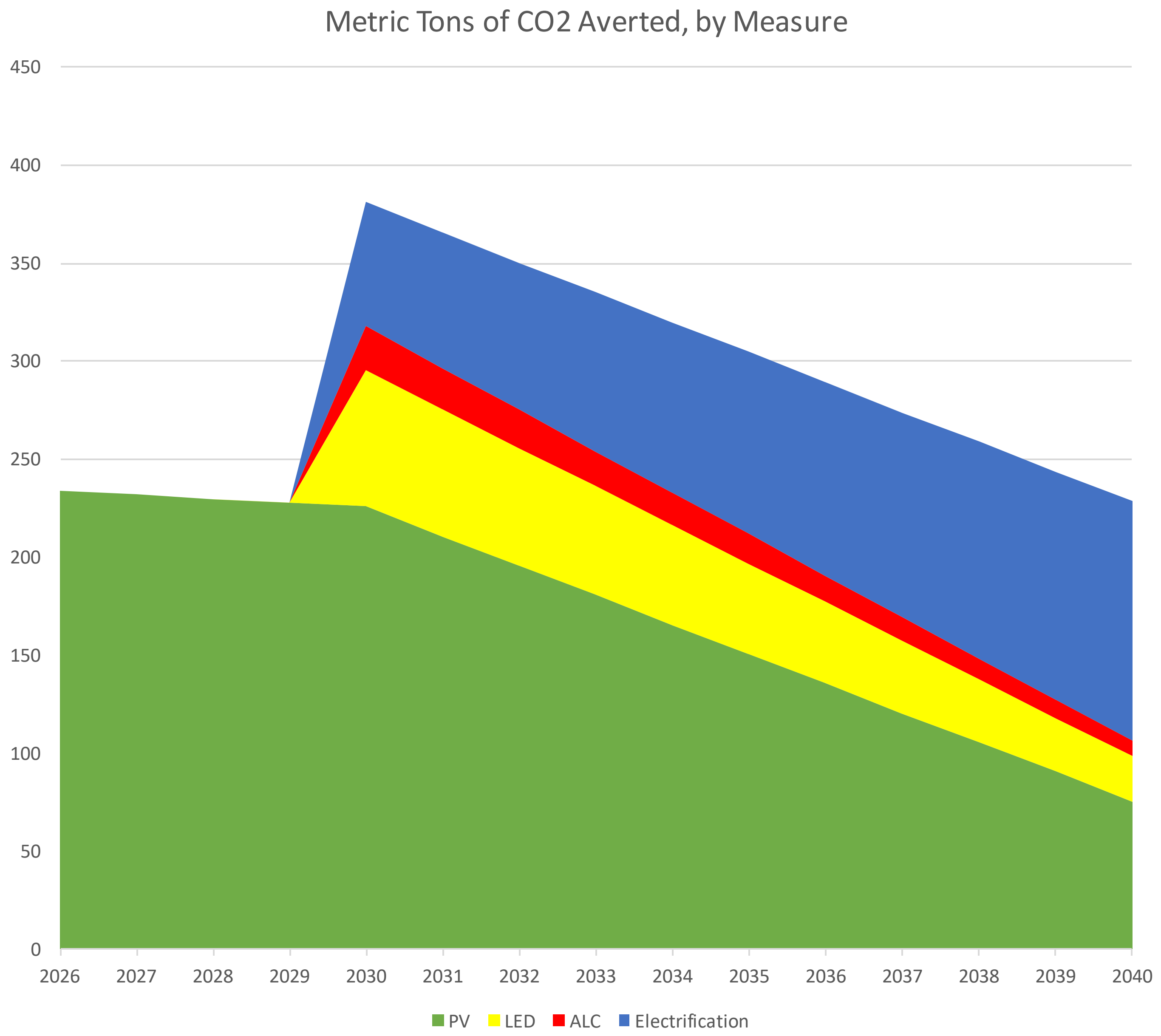
2035 SRC Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$100,545	$32,778	-$231,731	$108,136	$9,727

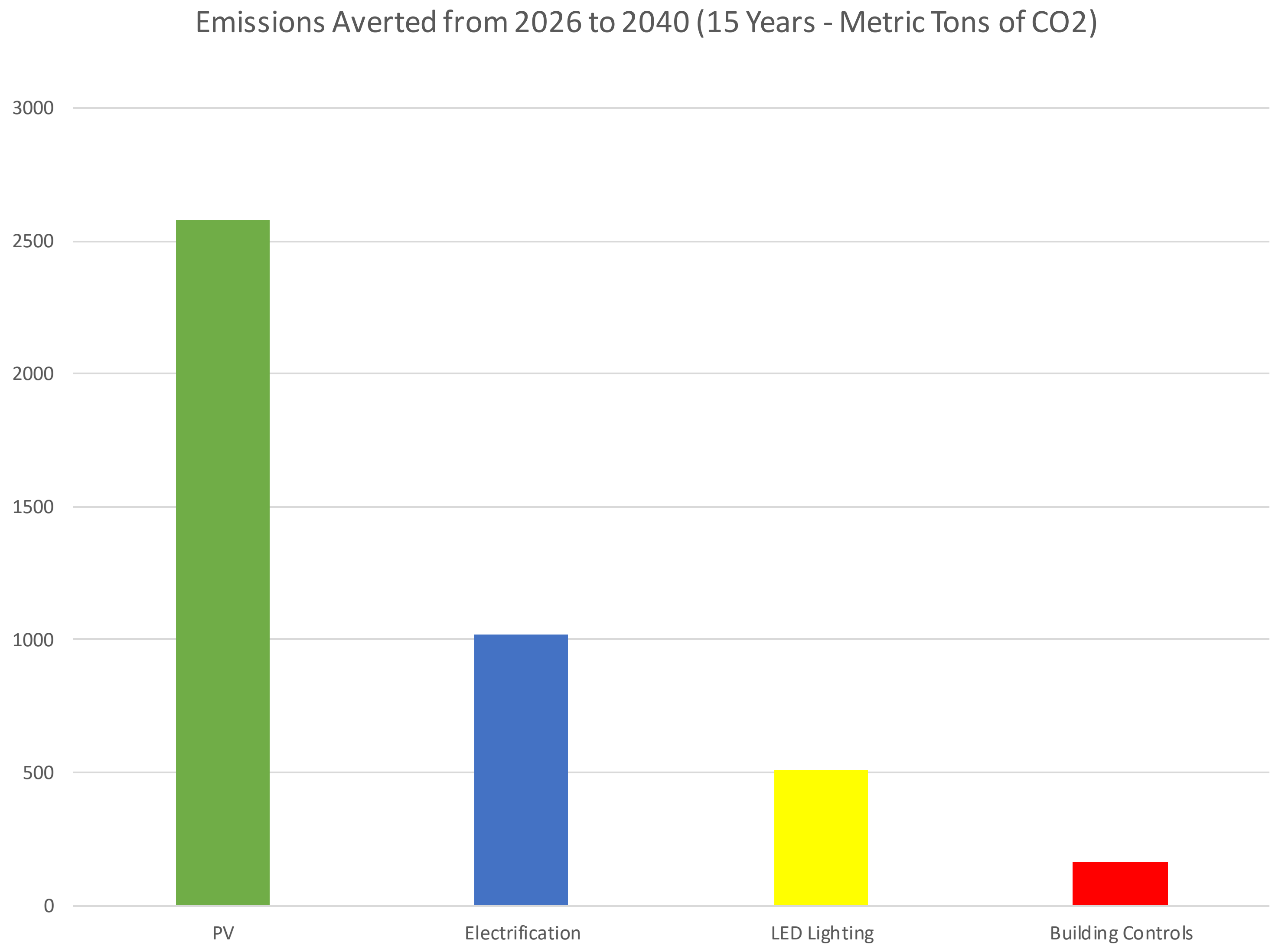
All of the San Ramon Center projects are scheduled for 2029.

INTERFACE ENGINEERING

HVAC Electrification Strategy
San Ramon Center– District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. PV provides the most benefits in the initial years of the study, but the electrification component becomes more impactful as the electric emissions rate associated with the campus decreases.



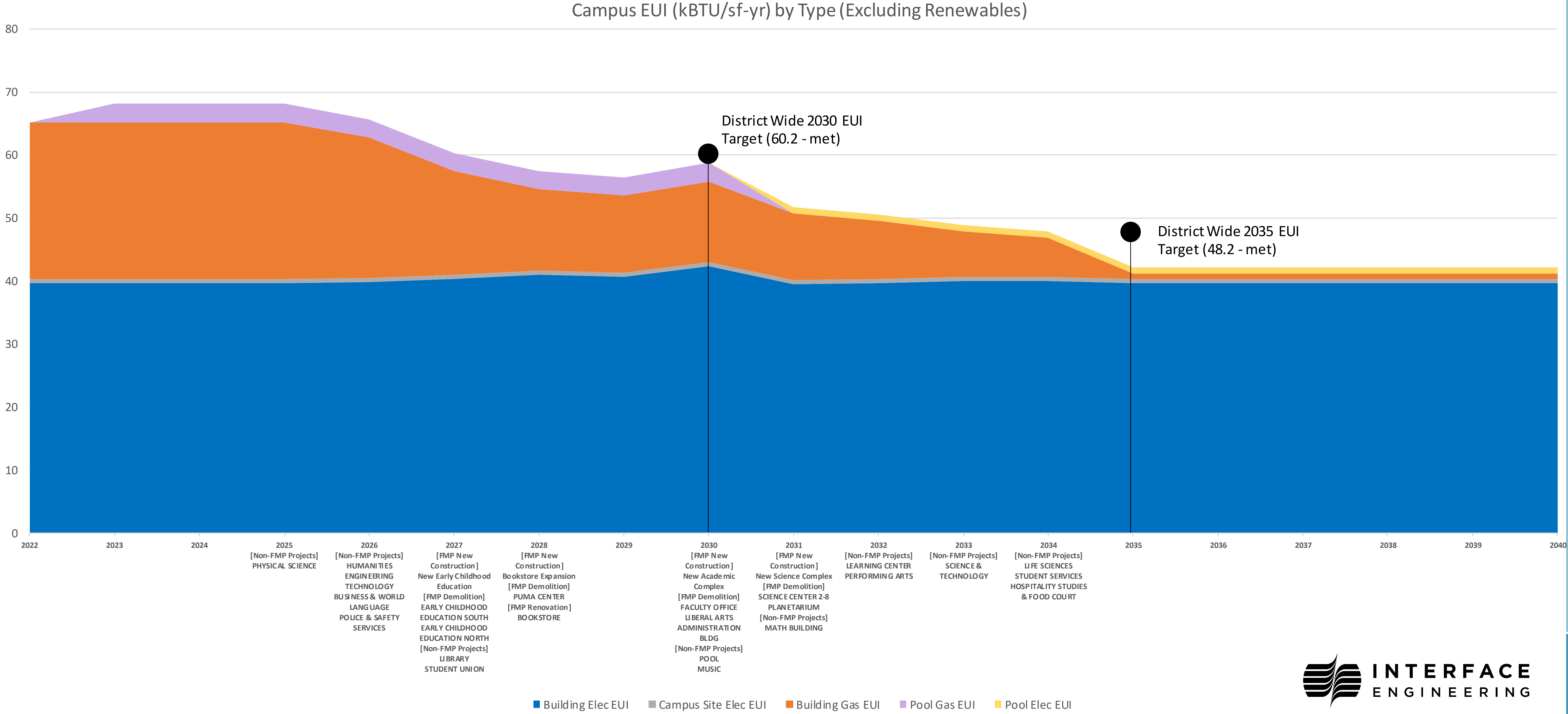


INTERFACE ENGINEERING

Energy Timeline

HVAC Electrification Strategy
Diablo Valley College – Campus EUI Trend

Overall, electrification is very important to achieving campus EUI and emissions goals, as large reductions in gas kBTU results in much smaller increases in electric kBTU. This campus presents an opportunity to reduce EUIs below the district 2030 and 2035 targets in order to reduce the district wide average to meet the target. The electrification that results in these high EUI reductions is also important for this campuses emissions reduction, since the PV has a relatively low carbon impact.



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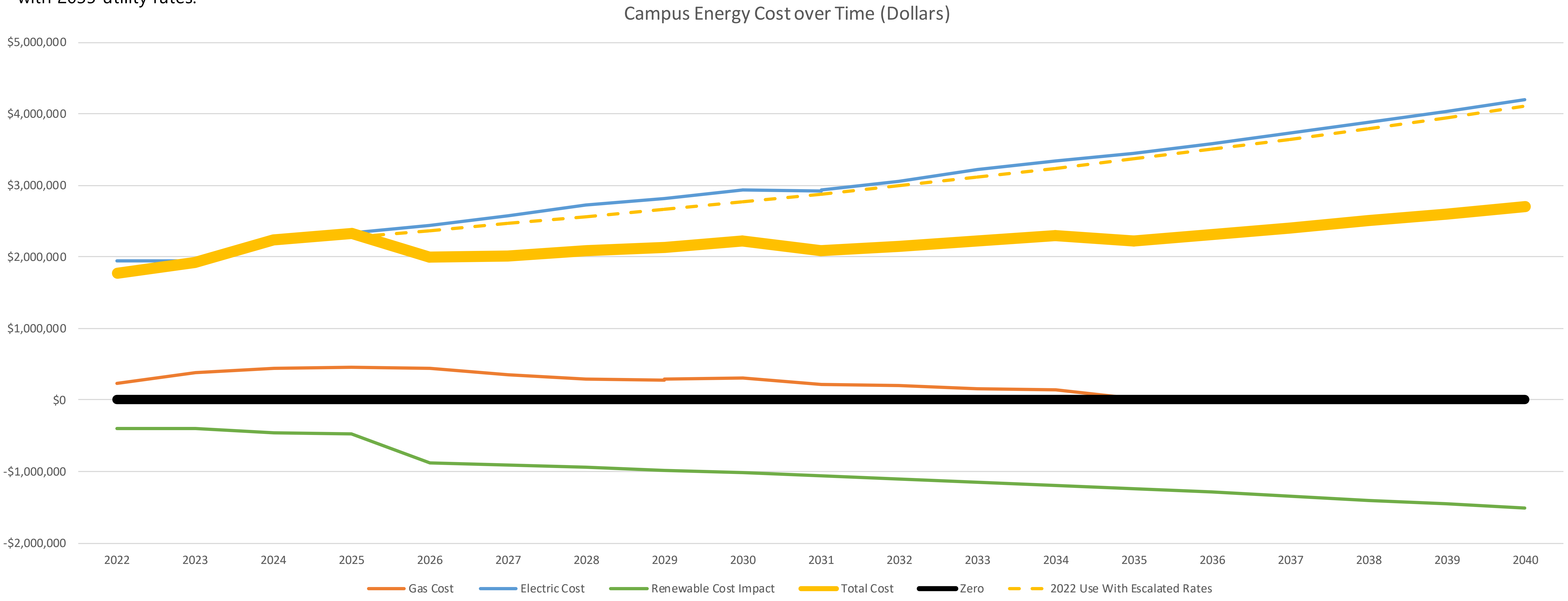
HVAC Electrification Strategy
Diablo Valley College – Campus Utility Costs Trend

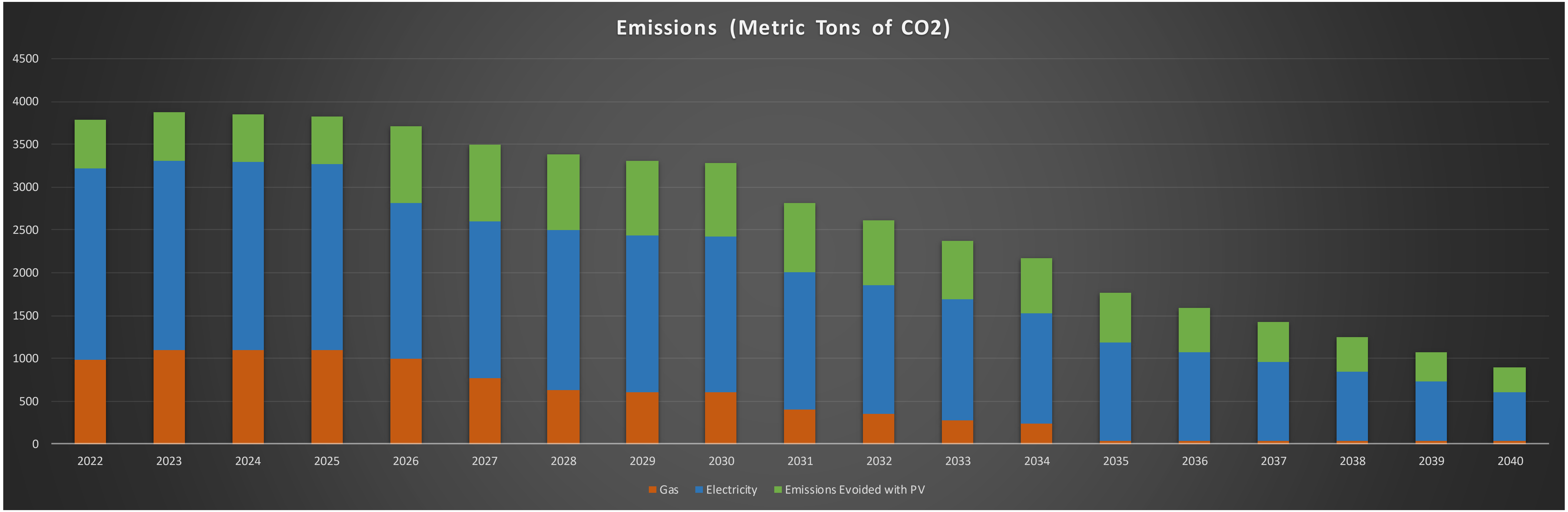
The chart below shows the total and fuel specific utility costs for the campus going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus. Renewables and efficiency upgrades like controls and LEDs reduce the operating cost of the campus. The 3.844 MW of additional future PV required to offset emissions by 2035 would result in an estimated additional 2.27 million dollars a year of cost savings with 2035 utility rates.



Planned PV is assumed to be installed in the year prior to the start of 2026.

HVAC Electrification Strategy
Diablo Valley College – Campus Emissions Trend

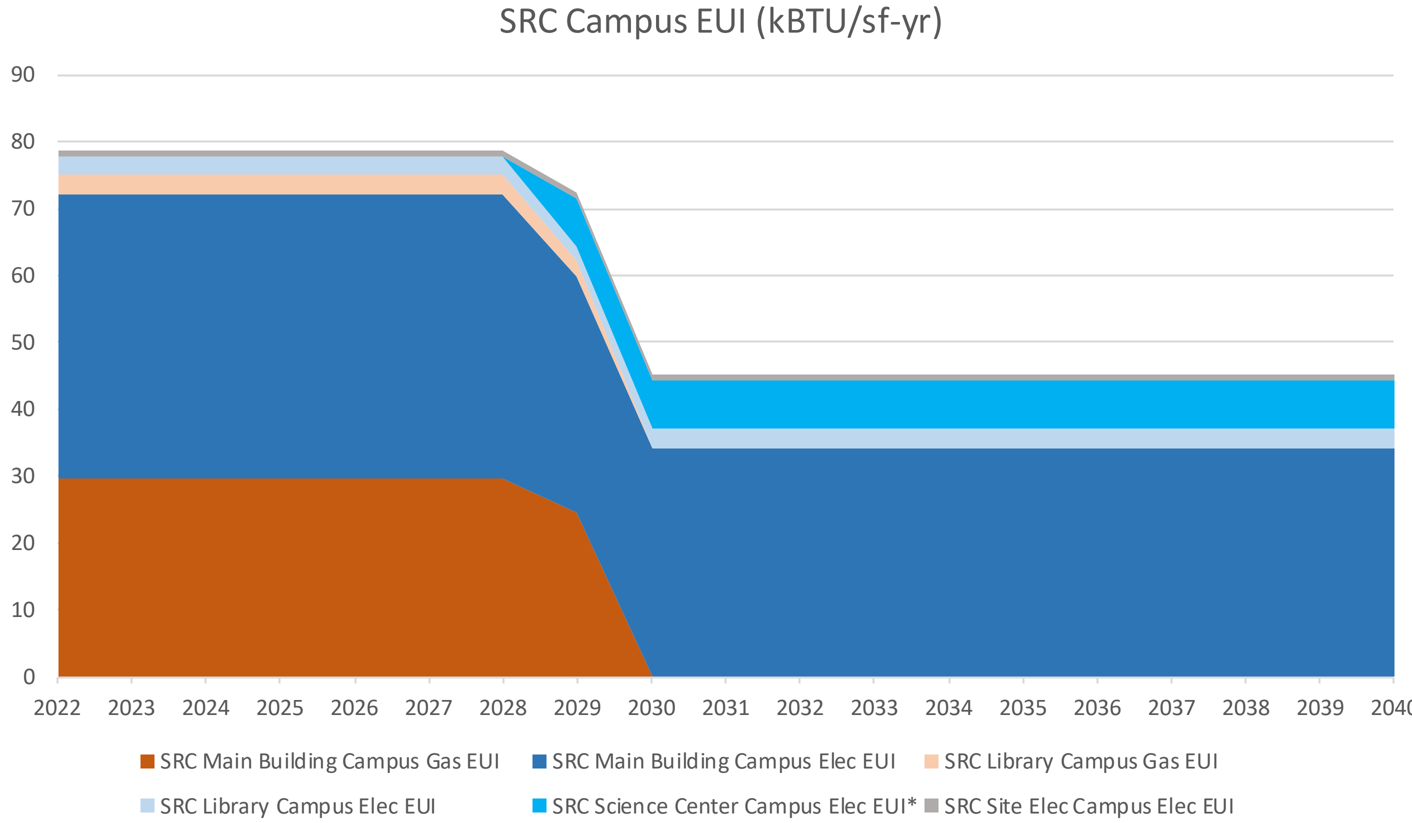
The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. Emissions from electrical consumption deprecate at the same rate. The starting emissions are based on weather normalized data. About 3.84 MW of additional future PV would be required to bring these emissions down to zero in 2035. Otherwise, to meet the goal, offsets would need to be purchased until the California grid is legislated to be emissions free by 2045. This amount would start at about 1,100 tons per year in 2035 and decrease to about 600 tons per year by 2040 as the grid approaches the legislative targets. If the CA grid/Constellation emissions rate approaches zero carbon faster or slower than legislatively required, the offsets required could go up or down. A good efficiency and emissions reduction strategy may not require each individual campus to meet the sustainability goals, but rather the ensemble of campuses meeting the goals. This will allow for taking advantage of deploying PV where it is most effective (campuses associated with higher emitting utilities) or where there is the most capacity, and purchasing offsets or clean energy at a district level for the net emissions that remain. There is a small amount of ongoing gas use associated with the Music building which was not electrified due to the large remaining useful life of the gas boiler and relatively low impact of the building. This is easy to offset with PV, but ought to be dealt with in the early 2040's when the equipment is at the end of its life and the FMP phase 2 calls for work on this building.



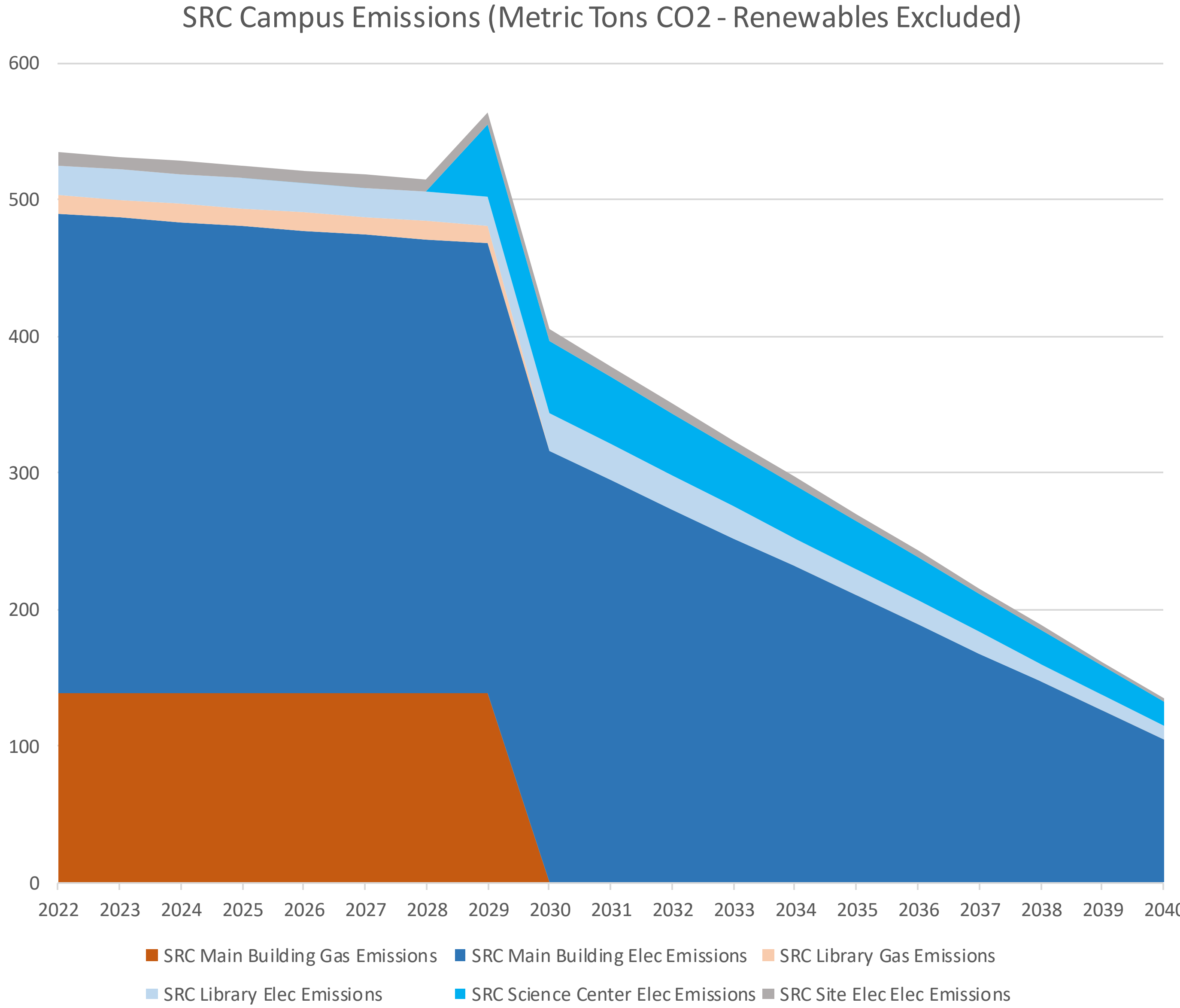
INTERFACE ENGINEERING

HVAC Electrification Strategy
San Ramon Center - Energy and Emissions Information

Information regarding the San Ramon facility and its role in the overall campus emissions and EUI reduction will be included in the district wide version of the report. Below are graphs of the EUI and emissions of the facility over time, without goals or PV/Carbon Offset/Purchased Green Energy interventions. We have also included data for an electrification/LED project associated with the facility. Due to the San Ramon Center's high electric grid emissions rate, more CO_2 reduction comes from future grid improvements than directly from electrification. The SRC Science Center is a new building planned to be constructed in the FMP.



*This is a new building as part of the FMP that doesn't currently exist on the campus



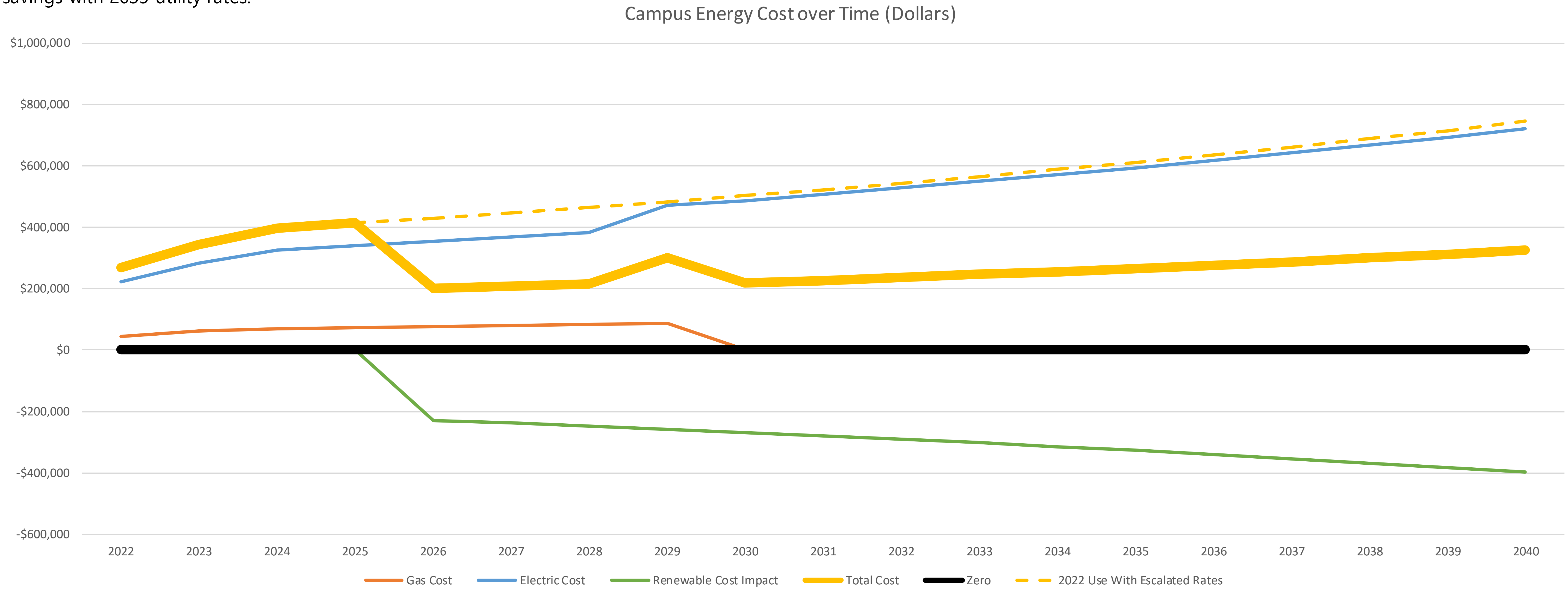
SRC/SRC Library Electrifcation and ALC/LED Upgrade (ALC/LED only for main building)

Area	Year	Cost	Starting EUI	EUI After	Electric kWH Increase	Gas kBTU reduction	Annual Cost Savings (2029 Dollars)
85,370	2029	$5,575,792	80.6	46.5	52,066	2,869,864	$67,826

INTERFACE ENGINEERING

HVAC Electrification Strategy
San Ramon Center – Campus Utility Costs Trend

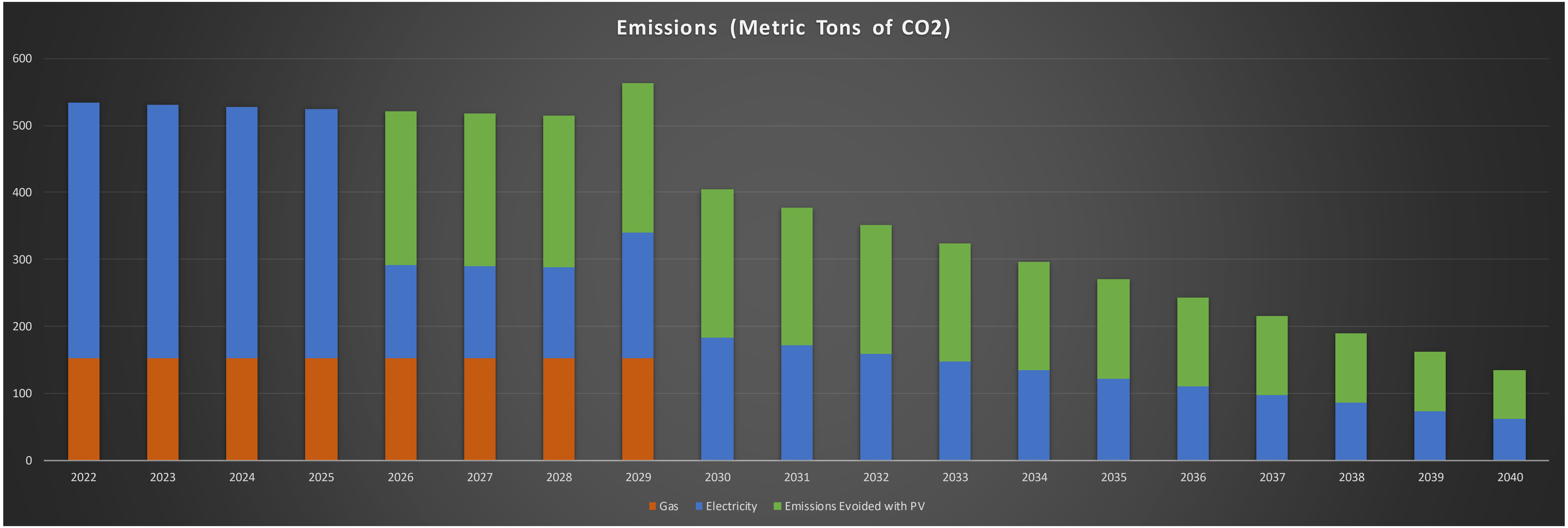
The chart below shows the total and fuel specific utility costs for the San Ramon Center going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus. Renewables and efficiency upgrades like controls and LEDs reduce the operating cost of the campus. The 433 kW of additional PV required to offset emissions by 2035 would result in an estimated additional 278 thousand dollars a year of cost savings with 2035 utility rates.



Planned PV is assumed to be installed in the year prior to the start of 2026.

HVAC Electrification Strategy
San Ramon Center – Campus Emissions Trend

The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. The campus would need 433 additional kW of PV to offset its emissions completely in 2035.



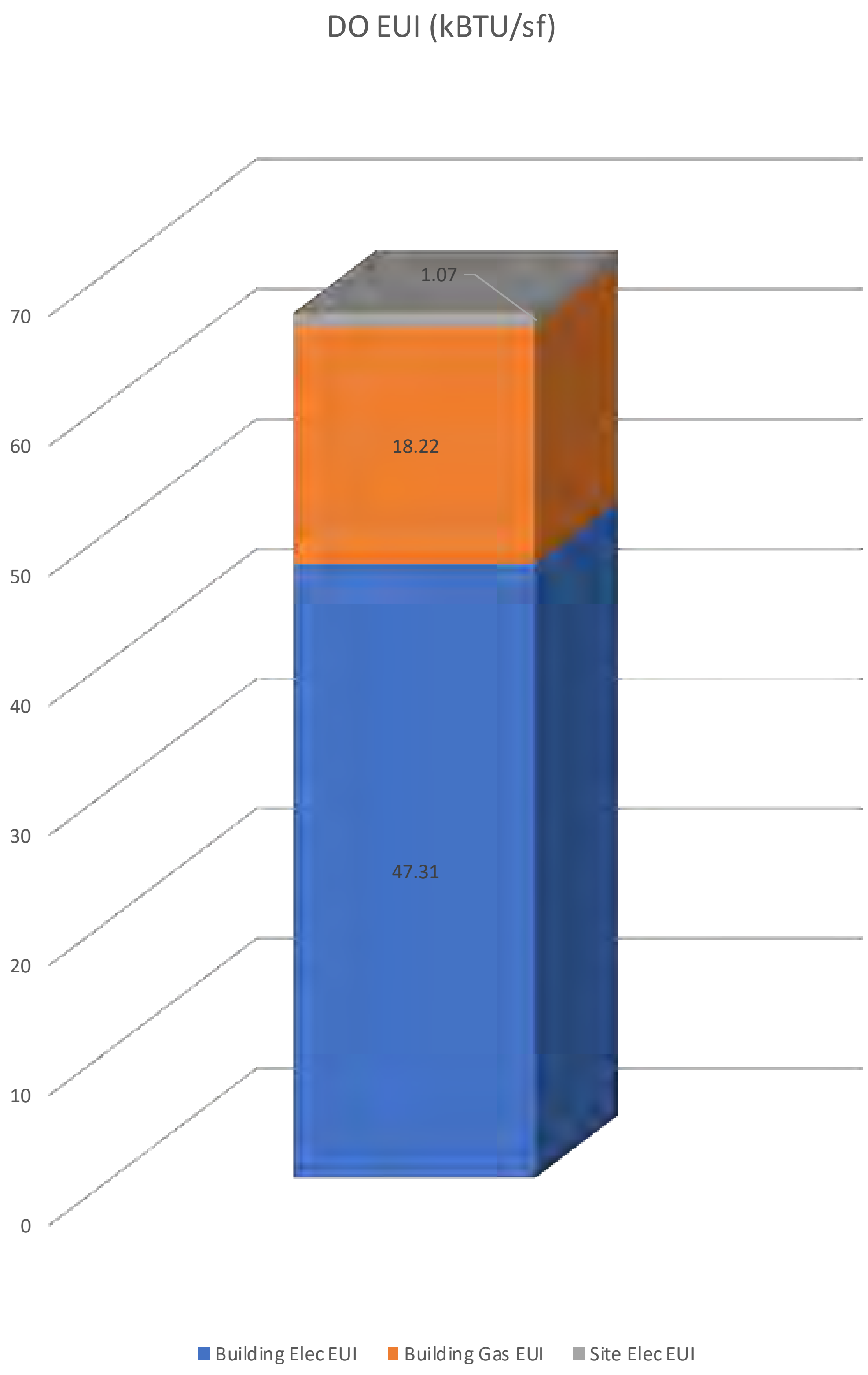
4.

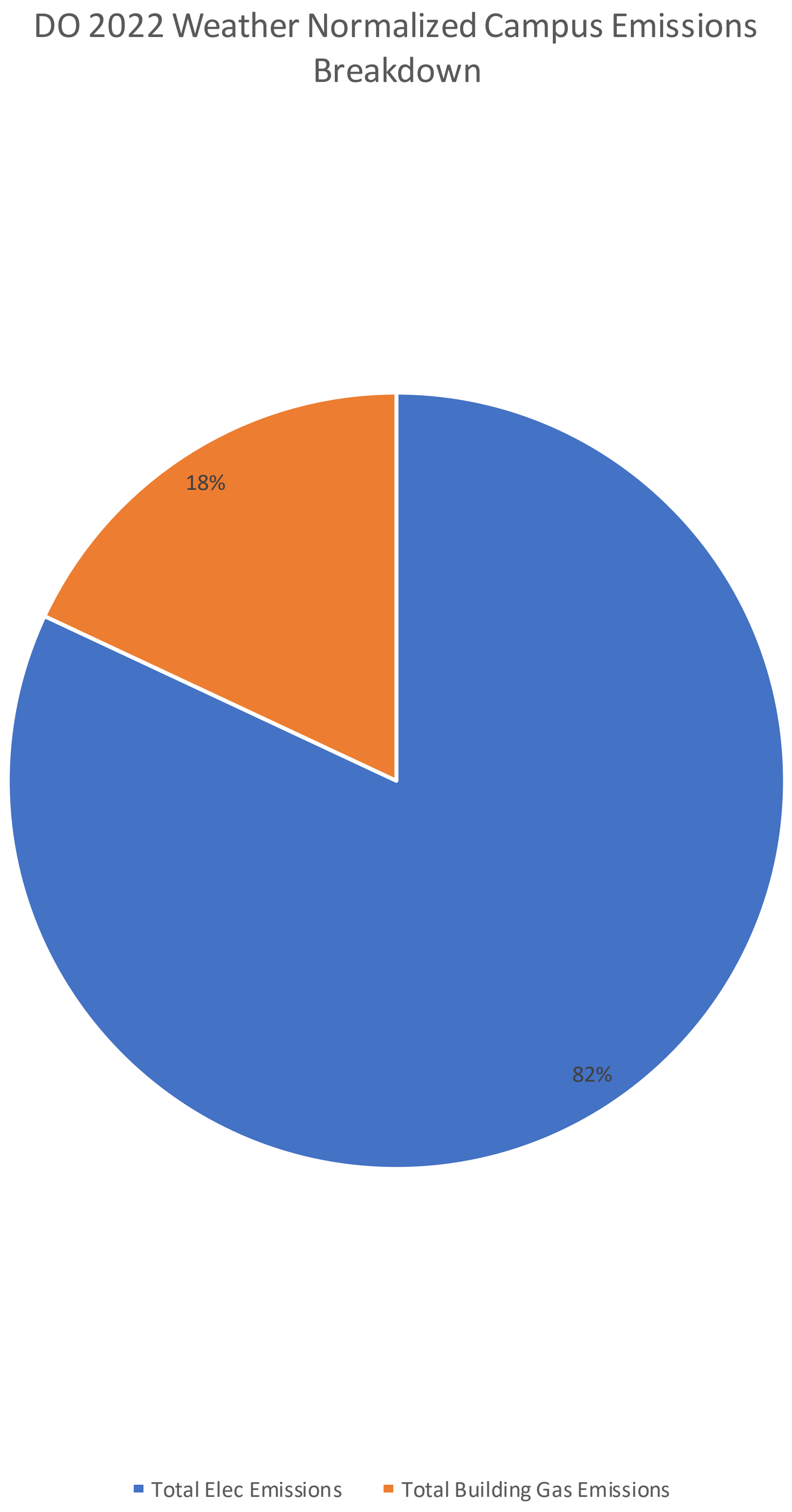
District Office

Carbon and Energy Benchmarking

District Offices/Education Center

Campus-Level Benchmarking





The District Offices facility is associated with Constellation and as an emissions rate of 701 lbs CO2e per MWH of electricity. The facility is 46,500 sf.

District Offices Building Benchmark Data Summary

Building	Age	Area	EUI	Gas EUI	Total kBTU	Gas kBTU	Elec KBTU	Gas Carbon Emissions (kg CO2)	Electricity Carbon Emissions	Total Carbon Emissions (Kg C02e)
EDUCATION CENTER	1973	46,521	65.5	18.2	47.3	3,048,232	847,506	2,200,726	99,006	452,010

INTERFACE ENGINEERING

Electric Infrastructure Assessment

Electrical Infrastructure Assessment - Introduction

As part of the Electrification Plan, Interface Engineering evaluated the available electrical system capacity at each campus to accommodate the future electrical demands from electrification, renewable energy deployment, and EV charging. The goal of this assessment is to confirm the capacity at the main campus feeders and switchgear. Downstream equipment, such as panels, wiring, and transformers, are not included in this assessment.

We have assessed the available electrical capacity at each of the District's campuses, as well as the District Offices and Brentwood Building. The available capacity has been evaluated using PG&E utility data (15-minute interval data) and PV inverter output data (hourly data provided from the district) for the period of May 2022 through August 2023.

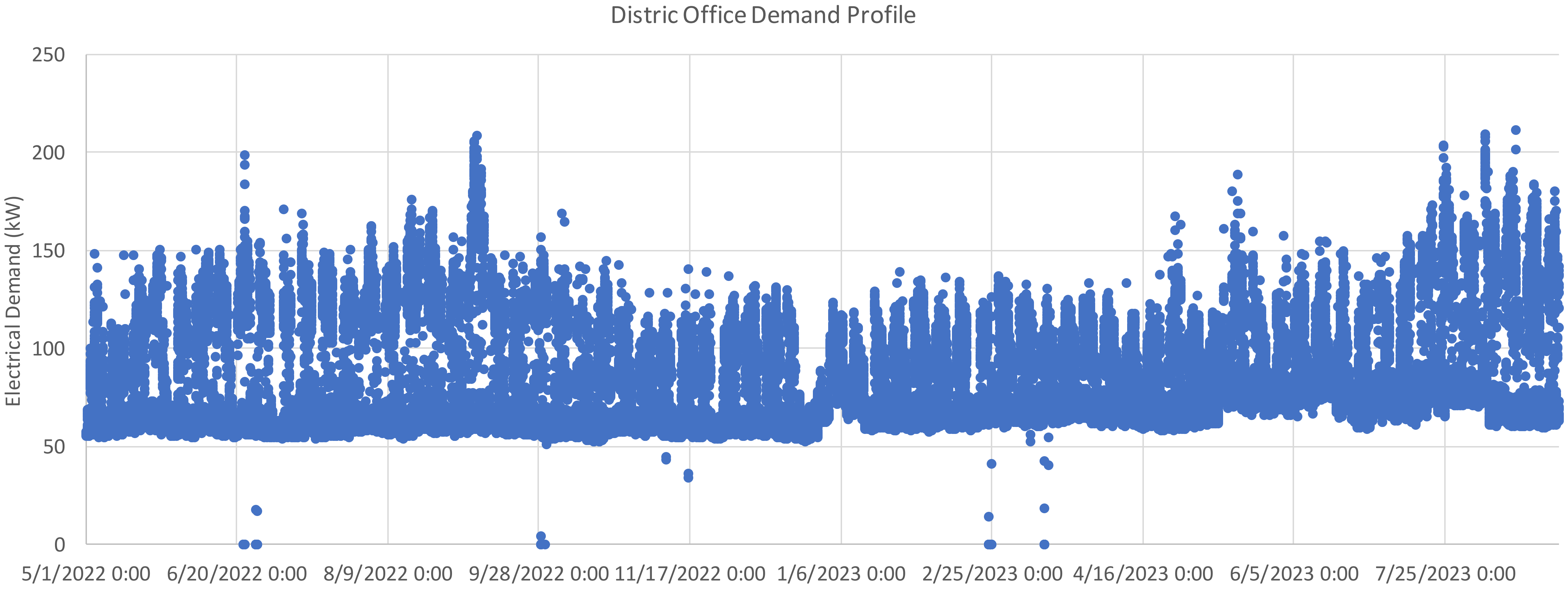
For electrical services that include PV production, the generation data from net generation output (NGOM) meters and/or direct inverter output data is added to the consumption data reported at the main revenue meter, establishing the true demand on the service.

The demand (kW) reported for each service is a calculated value, using the consumption and PV production data (kWh). For example, if 100 kWh are consumed in a 15-min timestep, then the calculated demand for that timestep would be reported as 400 kW (100 kWh X (1/4 hours)).

District Offices

- District office is powered by an existing 1000A, 480V service with a total capacity of 831.4kW. The maximum demand on this service was 211.9kW.
- District Office data appears complete.
- The existing service has an available capacity of 68.1%, or 566.5kW.

	Electrical Capacity Calculation	
1	Top 0.1% of Demand	192.0 kW
2	Maximum Demand	211.9 kW
3	Maximum Demand Occurrence	8/17/2023 13:45
4	Service Voltage	480 V
5	Service Amperage	1000 A
6	Service Capacity	831.4 kW
7	Maximum Demand [2]	211.9 kW
8	Maximum Demand * 125%	264.9 kW
9	**Available Capacity [6-8]**	**566.5 kW**
10	**Percent Available Capacity [9/6]**	**68.1%**



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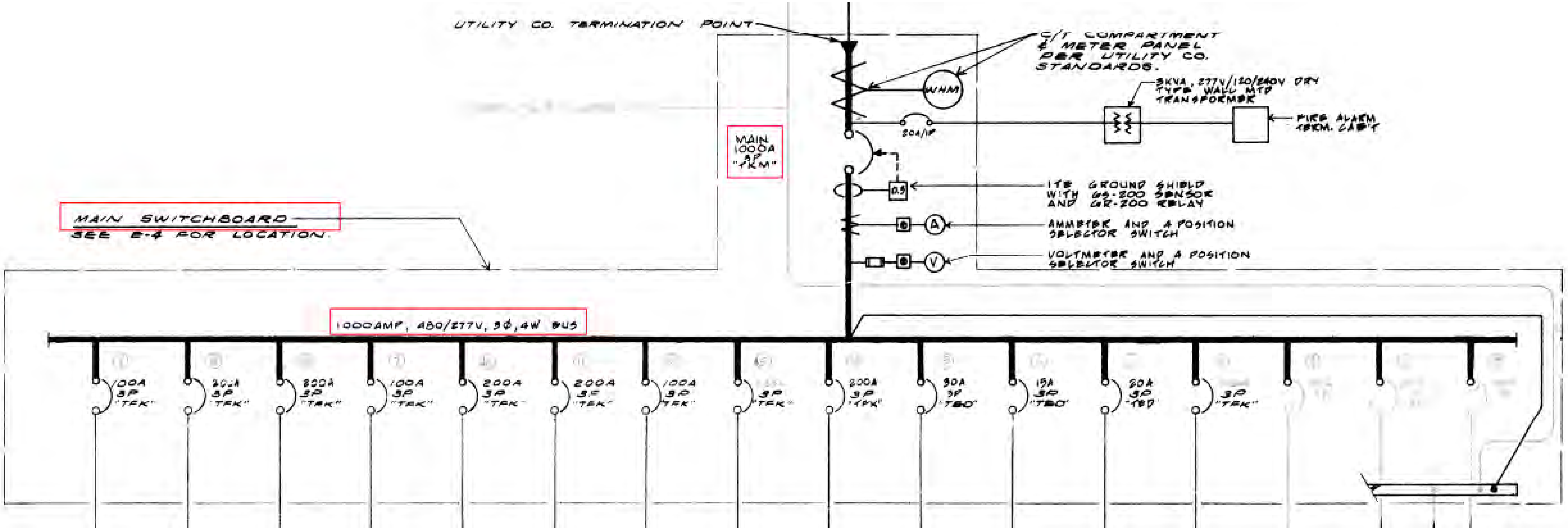
District Offices Single Line Diagram



Renewable Energy Deployment

Renewable Energy Deployment Strategy Introduction

On-site renewable energy generation is a critical component of 4CD's sustainability plan to achieve net zero carbon emissions by 2035. The district currently has approximately 3.2 MW of photovoltaic (PV) solar panel systems across CCC, DVC, and LMC, which produce nearly 3.8 MWh annually. This represents approximately 19% of the district's electricity consumption.

As part of its plan to increase on-site renewable production, 4CD has five additional PV projects approved by PG&E for installation but have yet to be funded. For the purposes of estimating the impact of these approved projects, it is assumed that these systems will be installed in 2026. An estimate of the total development costs are shown in the table below, which based on the information provided by Sage Renewables. These costs are based on recent quote that 4CD received for the Brentwood system, which indicated a total cost of $7.87/watt for carport arrays. The Brentwood, DVC, and LMC installations are also planned to include battery energy storage systems (BESS), which will further enhance the cost reduction capabilities of these systems.

The tables to the right summarize the existing and planned PV systems, including their DC capacity, orientation and expected annual production rate (which vary slightly by campus and by array orientation). The table at the bottom indicates the % of electrical consumption that is met with the existing and future PV systems.

The campus site plans on the subsequent slides indicate the existing and planned PV locations on each campus, including the context of the newly planned buildings as part of the FMP. The site plans also indicate areas that may potentially be used for additional PV in the future.

The energy and carbon impact of the existing and planned arrays are discussed in more detail in the "District Energy and Carbon Timeline" chapter of this report.

The table below shows the future PV, beyond what is currently planned, that would be required in order to achieve net zero emissions for the specific campuses in 2035, and the associated cost of deployment in 2024 PV costs.

Future PV Summary (Scenario A)

Campus	Size (kW)	Cost*	Est. Annual Production (kWh/yr)	Predicted Electrical Consumption in 2035	% Future Load Met by Future PV
DVC	3,844	$30,252,280	5,766,000	8,782,110	66%
CCC	2,167**	$17,054,290	3,250,500	5,143,509	63%
LMC	591	$4,651,170	886,500	4,276,119	21%
SRC	433	$3,407,710	649,500	1,413,618	46%
DO	**468*** **	**$3,683,160**	**702,000**	**701,838**	**100%**
BEC	166	$1,306,420	249,000	749,521	33%

*costs are based on estimates for PV projects for the district in 2024
**based on offsetting kWh instead of carbon emissions, due to the utility split for CCC between MCE and Constellation
***Due to limited space at this facility, this PV could be installed on another Constellation Campus like DVC, LMC, or SRC to have the same effect.

Existing PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	Kwh/KW*	Annual Energy Production (kWh)
Contra Costa College - Lot 9	403	225	1053	424,359
Diablo Valley College - Lot 1	567	270	1297	735,289
Diablo Valley College - Lot 3	267	270	1297	346,247
Diablo Valley College - Lot 4	548	270	1297	710,650
Los Medanos College - Lot B	763	150	1139	868,904
Los Medanos College - Lot C	638	230	1128	719,953
Total	3,186			3,805,402

*The existing PV production rates are 20-30% below the expected rate, based on the location and orientation of the systems. This may indicate performance issues with the panels and inverters.

Planned PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	kWh/KW	Annual Energy Production (kWh)	Project Development Costs ($)
Diablo Valley College - Lot 5	878	270	1564	1,373,000	$6,909,860
Contra Costa College - Lot 1	947	225	1551	1,469,000	$7,452,890
Los Medanos College	1,154	150	1560	1,800,000	$9,081,980
San Ramon Center - Main Lot	483	225	1580	763,000	$3,801,210
Brentwood Center - Main Lot	322	180	1556	501,032	$2,534,140
Total	3,784			5,906,032	$29,780,080

Renewable Energy Summary

	Annual Electricity Consumption (kWh)*	% Met by Existing PV	% Met by Planned PV	Total Planned Renewable %
CCC	4,414,407	10%	33%	43%
DVC	8,618,555	21%	16%	37%
LMC	4,783,853	33%	38%	71%
SRC	1,200,248	0%	64%	64%
Brentwood	573,479	0%	87%	87%
District Offices	**657,697**	**0%**	**0%**	**0%**
District	20,248,239	19%	28%	47%

*True 2022 value that is not weather normalized

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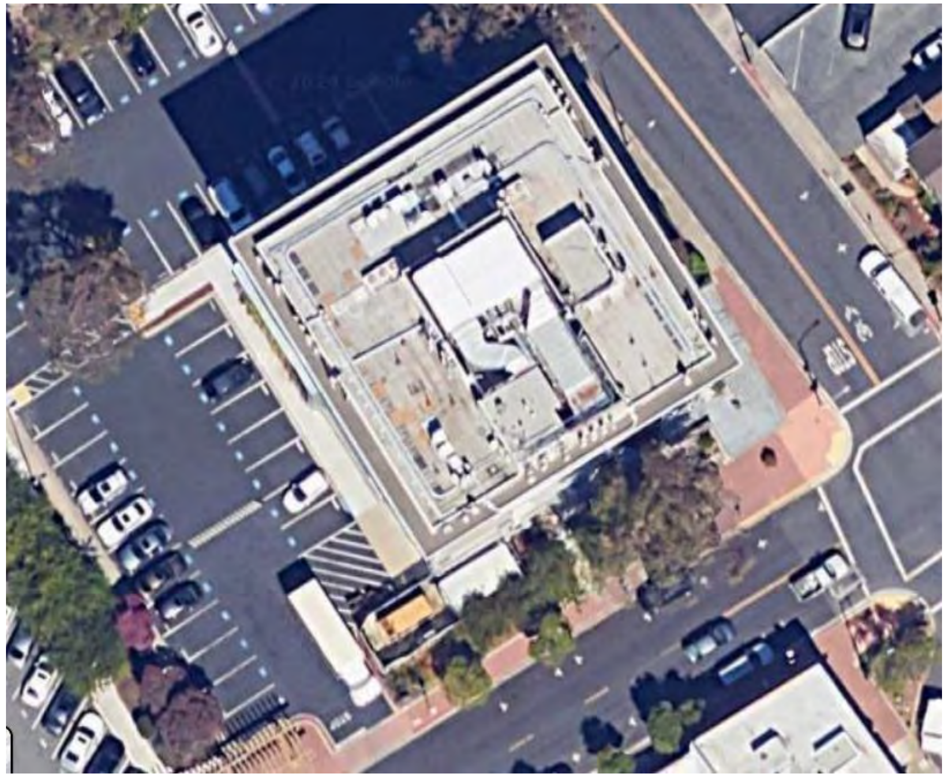
District Office/Education Center
PV Offset



As an existing building with unknown structural conditions and limited roof and parking area, there are no recommendations to install PV at this site. However, in order to meet emissions targets, PV could be installed at another campus being served by the same utility in order to offset the emissions and electricity associated with this building.

Potential Future Offsite System

- 468 KW
- Future PV sized based on remaining electrical consumption and emissions in 2035 projections
- Approximately 23.5k ft^2 panel area, based on current PV technology

INTERFACE ENGINEERING

District Energy Projects

Electrification Plan Introduction

In 2022, more than 48% of the electricity delivered by California's grid was generated by renewable sources such as solar photovoltaics, wind, biomass, and hydroelectric. This percentage will increase over time, as state laws such as SB100 mandate that CA's grid achieve 100% carbon-free generation by 2045. This means that by electrifying legacy natural gas heating systems, the carbon footprint associated with these loads will trend towards zero. For the Contra Costa Community College district in 2022, ~45% of its electricity was provided by renewable resources (including grid-supplied and on-site generation).

The purpose of this study is to support the master-planning effort for the Contra Costa Community College District (4CD) with a district-wide electrification plan. The plan provides an analysis of how electrifying the district's natural gas heating systems and deploying renewable energy systems will reduce the district's energy consumption and carbon footprint.

The primary goal of the electrification plan is to assist the district in meeting its sustainability goals, as outlined in the "2022 4CD District Wide Energy & Sustainability Goals" document.

The electrification plan consists of the following components:

- Building Benchmarking Report
- Electrical Systems Assessment
- Campus Photovoltaic Deployment Assessment.
- Building Electrification Strategy
- District Energy and Carbon Timeline

4CD has adopted a set of sustainability goals which target significant reductions in carbon emissions across the entire organization by 2035. The electrification study addresses the greenhouse gas (GHG) and renewable energy goals by proposing and quantifying the impacts of building replacement and renovation projects, renewable energy systems, as well as additional efficiency projects such as LED lighting, building management controls, metering upgrades and HVAC electrification.

4CD's goals are focused on the two primary dates of 2030 and 2035. The 2030 goals include reducing GHG emissions by 75% below the 2013 baseline and reducing the district energy use intensity (EUI) by 25%. The 2035 goals include reducing GHG emissions by 100% and reducing district EUI by 40%.

INTERFACE ENGINEERING

HVAC Electrification Strategy

Contra Costa Community College District has adopted a broad set of sustainability goals and practices that will result in dramatic reductions in energy consumption and carbon emissions from its buildings. A key component of these goals is the requirement that all newly constructed buildings are all-electric (no fossil fuel combustion used for space heating). This approach leverages the fact that California's grid is becoming cleaner (emitting less carbon) each year, which inherently reduces the carbon footprint of the campus.

There are a range of all-electric heating technologies that work well for new construction projects. However, converting the existing natural gas heating systems to all-electric has historically been challenging from a technological and financial standpoint. Air-source heat pump (ASHP) technology which use traditional refrigerants have limitations on the temperatures they can produce (typically a maximum supply temperature of approximately 130F), which may make them incompatible with typical legacy heating systems which utilize 160-180F temperatures. The renovations required to make existing buildings compatible with ASHP technology can be prohibitively expensive. These renovations may require replacement of some heating coils to accommodate lower water temperature, and often piping/coupling systems need to also be replaced. Furthermore, ASHP technology is limited to a lower ambient temperature of ~25F, which means that supplemental heating may be required on the coldest days of the year.

Water-source heat pumps (WSHP) are more flexible, with supply temperatures as high as 170F. These require a water-based heat source/sink, such as a ground loop via a geo-exchange system. Geo-exchange systems are often very costly due to the cost of drilling vertical wells or excavating for horizontal systems. These costs and space constraints typically preclude water-source heat pumps as a retrofit solution.

Transcritical heat pump (TCHP) technology is relatively new to building comfort heating and cooling which is addressing the traditional challenges of ASHPs and WSHPs. This technology utilizes CO^2 as its refrigerant (known as R744), which enables hot water delivery temperatures of 180F at outdoor ambient conditions down to -15F. This allows "direct replacement" of natural gas boilers and domestic hot water heaters. This technology is still "emerging", with a limited number of installations in the U.S., however, it is expected that this technology will develop rapidly over the next 5 years.

For existing buildings with traditional boiler-based hydronic systems, an assessment process is recommended to determine what modifications are required in order electrify these systems with the highest possible efficiency. The primary goal of this assessment is to determine if the existing hydronic systems is capable of operating at lower heating hot water temperatures while still maintaining design temperatures. Lowering the hot water temperatures allows for compatibility with a wider range of heat pump technology, and also allows them to operate much more efficiently. The following bullet points outline the assessment process:

- Review heating coils configuration - heating coil performance will be reduced when operating at lower hot water temperatures, however, in some cases, this performance derating can be overcome with modification to control sequences. In most cases, two-row heating coils at air handling units and VAV boxes can be utilized when lowering hot water temperatures from 180F to 140F, or even lower. The peak capacity of the coils is reduced with lower water temperatures, but simply increasing the warm-up time of the building may overcome these limitations. Also, reducing the temperature setback of the space will reduce the load that the coils must meet. Single-row coils will likely struggle to meet the load with reduced water temperatures and may need to be replaced.

- Conduct a hot water reset investigation – During the winter months, reduce the heating hot water temperature in 5-degree increments for one to two weeks at a time. This process will reveal which zones/coils are able to meet space loads with reduced water temperatures. As zones are discovered to be out of setpoint, increase the warm-up period or limit the temperature setback. Continue to reduce water temperatures and increase warmup period to determine if a lower water temperature will allow the building to maintain functionality. This process may reveal that certain zones/coils will function adequately, while others may need to be upgraded. The desired outcome of the reset investigation is a custom outdoor air reset control sequence that reduces hot water temperatures to a minimum, as a function of outside air temperature. For example, the goal may be to operate at 140F supply/ 100F return as often as possible but allows for increases up to 180F supply / 140F return on the coldest days of the year.

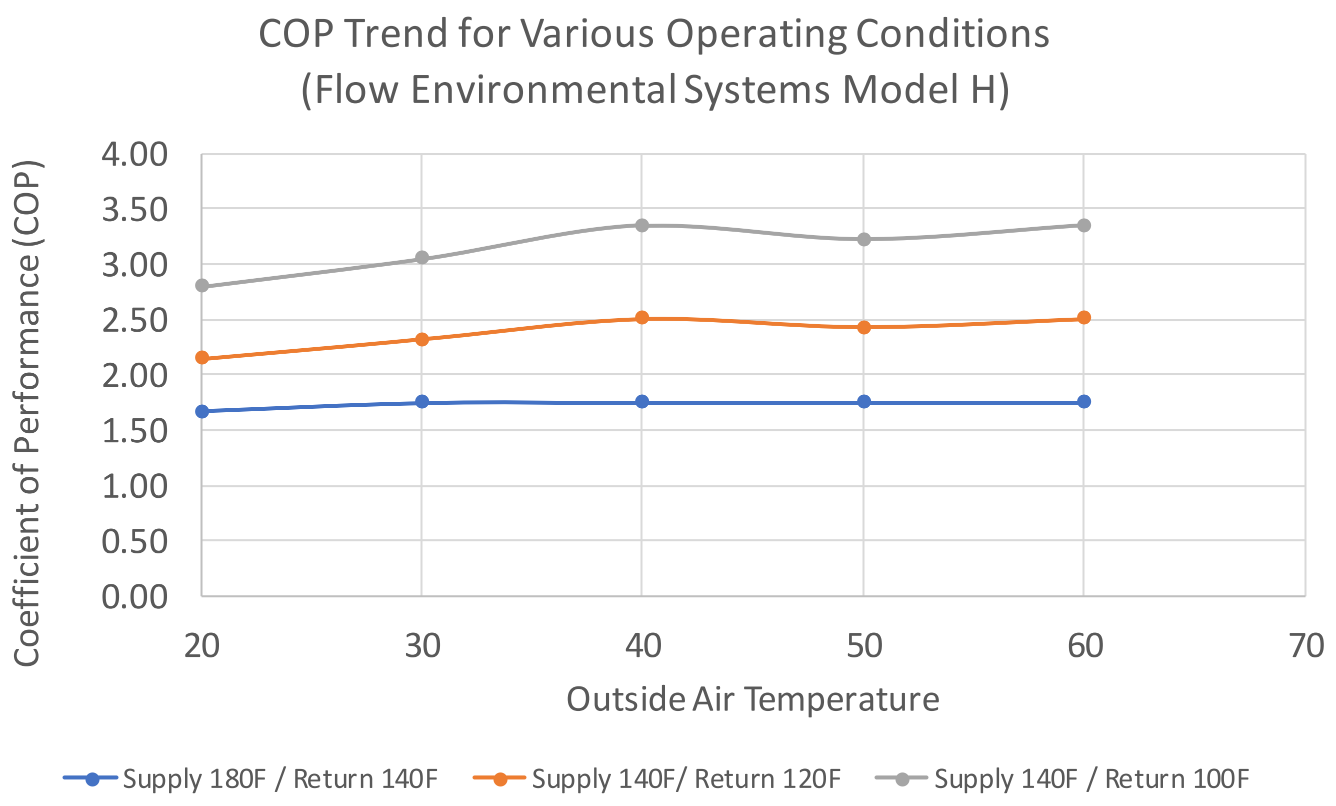
HVAC Electrification Strategy
Transcritical Heat Pumps

While this heat pump technology has long been used in commercial refrigeration for 20 years or more, it is more recently being applied to building HVAC and domestic hot water. Typically, these machines use CO_2, or R-744, as its refrigerant, which has a global warming potential (GWP) of 1, which is far below traditional refrigerants like R-410a (GWP of 2088) or R-134a (GWP of 1430). Furthermore, R-744 is able to operate with much higher temperatures, at or above 180F. However, like traditional heat pumps, transcritical heat pumps operate much more efficiently with lower supply water temperatures.

As the technology continues to advance, it may become a critical component of electrifying existing buildings that utilize hydronic heating. The graph on the right shows the efficiency curves for various operating conditions for Flow Environmental System's model H transcritical heat pump. These trends show that while operating at "traditional" boiler system temperatures of 180F supply / 140F return, a COP of 1.75 is achieved. However, lowering the supply temperature to 140F dramatically improves efficiency, approaching a COP of 3.5. This highlights the importance of the hot water reset assessment process outline on the previous page.

Transcritical heat pump technology is also well suited for domestic hot water applications, where storage temperatures typically range from 125F – 140F. Systems like Sanden and Lync are able to achieve COPs above 5, which allows for significant improvements to operation cost and carbon emissions associated with domestic hot water.

The links below are examples of transcritical heat pump technology that are recommended for investigation by future design teams for use in both new construction and retrofit projects.



https://www.flowenvirosys.com/products

https://www.smallplanetsupply.com/sanc02

https://www.lyncbywatts.com/

HVAC Electrification Strategy
District Offices – Additional Efficiency Projects

The following matrix outlines the energy efficiency upgrades planned in order to meet the district energy and sustainability goals.

Cost Assumptions	Construction Cost Assumptions ($/sf) (2024) (costs escalated 4.5% per annum)
Lighting Retrofit	$10
Controls Retrofit	$15
Electrification – Boiler Replacement	$30
Electrification – Furnace Replacement	$25

District Energy Projects

Building	Area (ft2)	Project Year	Lighting Retrofit Required	Controls Retrofit Required	Electrification Required	Remaining Useful Life on Primary Mechanical Equipment	Lighting Retrofit Cost	Controls Retrofit Cost	Electrification Cost	Total Cost	Electric Reduction* kWh	Gas Reduction kBTU	Starting EUI	EUI After
EDUCATION CENTER	46,521	2031		x	X (Boiler)	Unknown boiler age		$949,630	$1,899,260	$2,848,889	-42,215	847,506	65.5	50.4

*Electrified projects tend to have a negative reduction in kWh, an increase, due to the conversion of gas to electric load. Projects with ALC and or LED upgrades and no electrification will have a positive decrease in kWH.

INTERFACE ENGINEERING

HVAC Electrification Strategy
District Office/Education Center – District Energy Project Savings and Cost Summary

DO Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$0	$949,630	$1,899,260	$2,848,889

DO Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
486,610	0	1,052,172	1,636,712

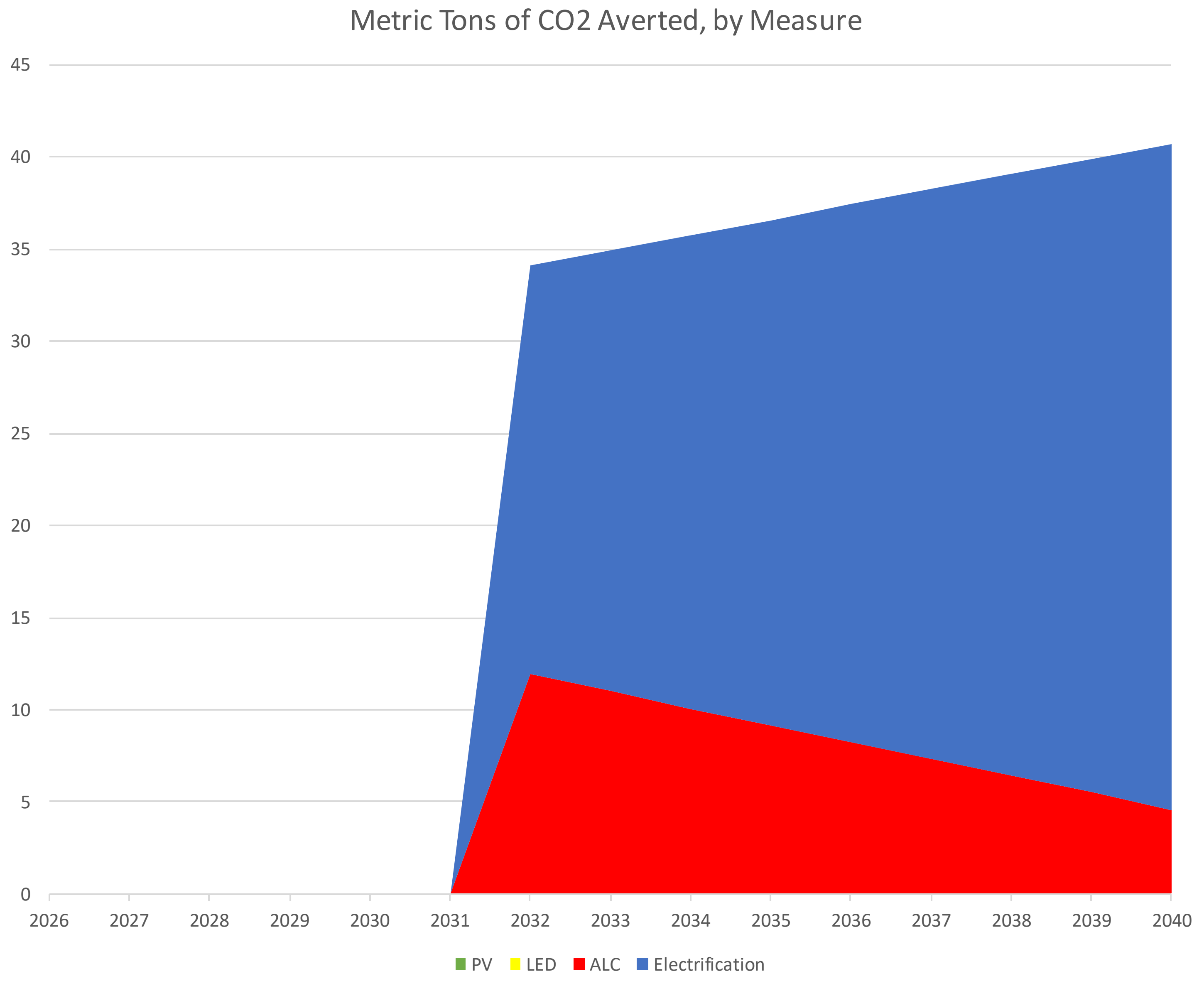
2023 DO Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$37,079	$0	-$80,174	$36,990	-$6,105

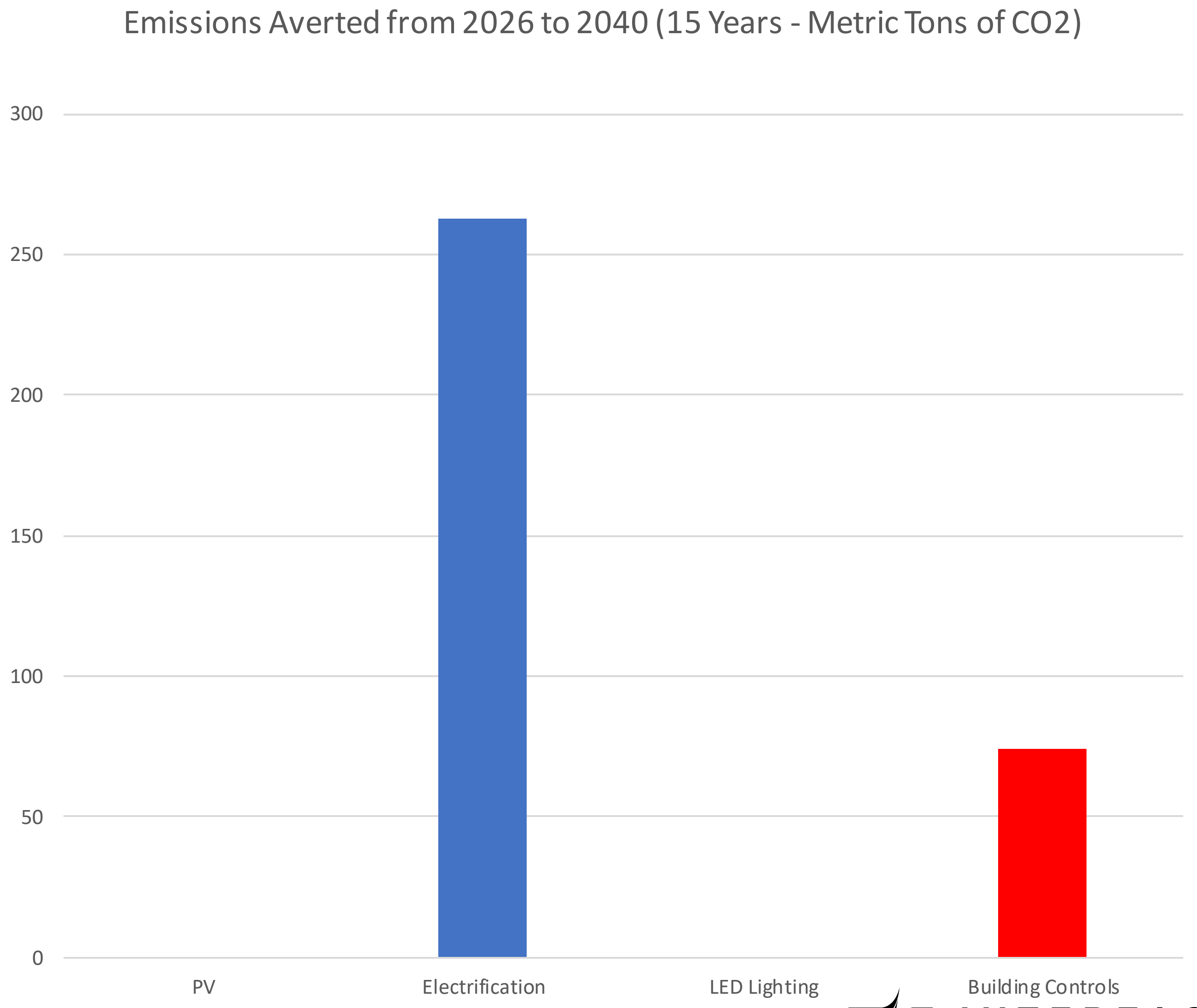
2035 DO Energy Project Energy Cost Savings (Annual Impact - Not Cumulative)				
Lighting Savings	Controls Savings	Electrification Electric Penalty	Electrification Gas Savings	Total Annual Savings
$66,214	$0	-$143,172	$66,055	-$10,903

All of the District Office projects are scheduled for 2031.

HVAC Electrification Strategy
District Offices/Education Center– District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. The electrification component of the recommended energy project averts more emissions than the controls upgrade component.



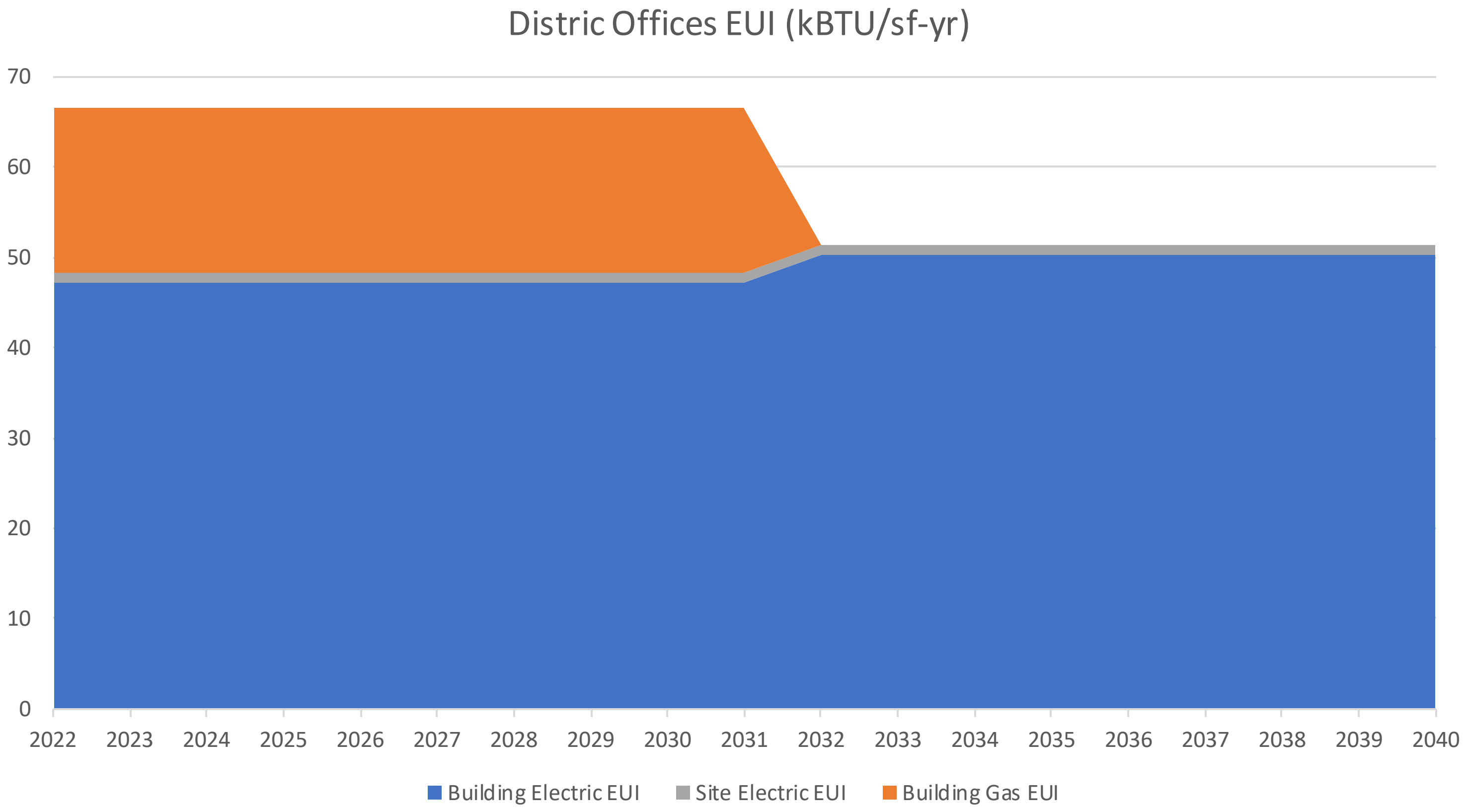


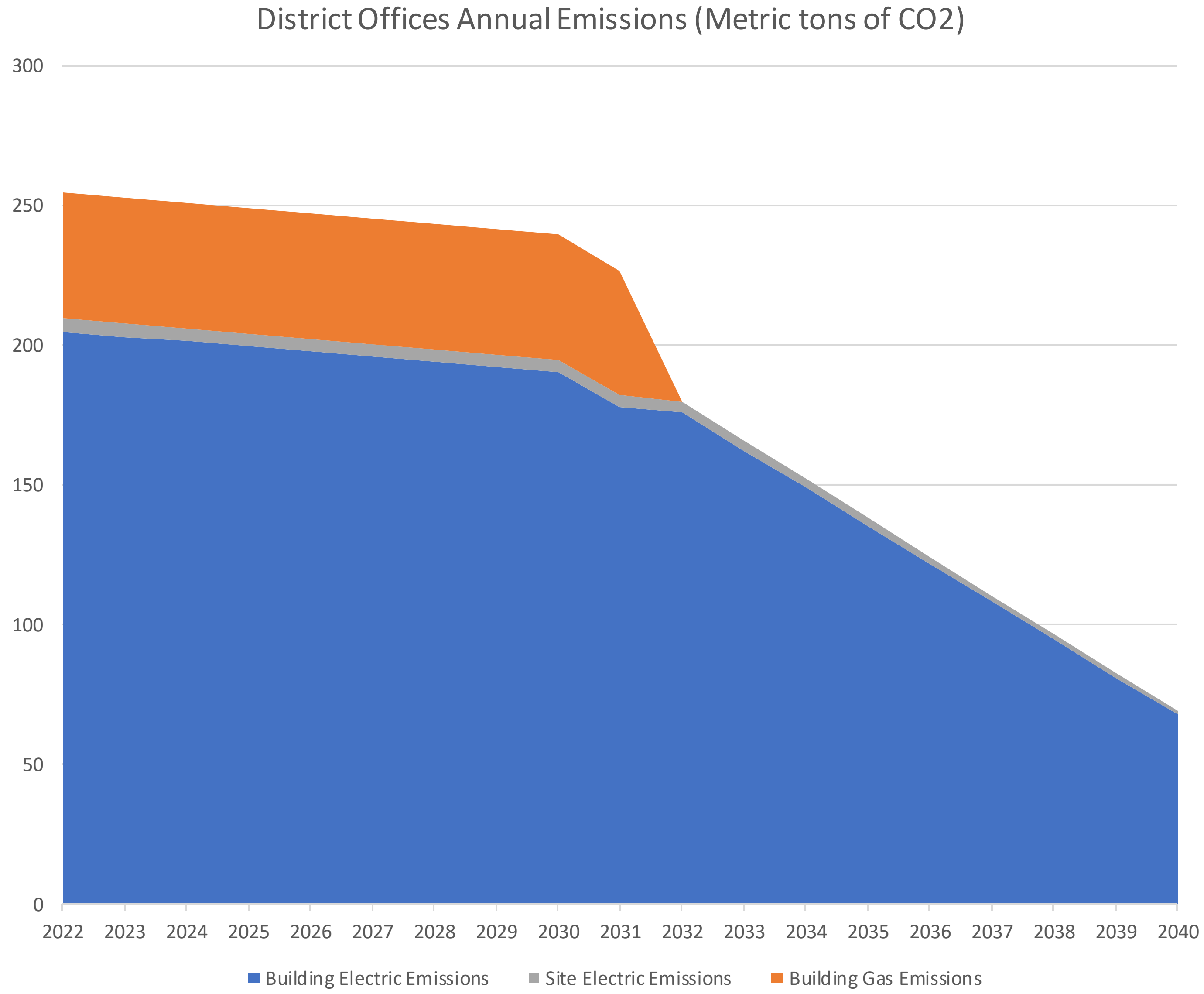
INTERFACE ENGINEERING

Energy Timeline

HVAC Electrification Strategy
District Offices/Education Center - Energy and Emissions Information

Information regarding the District Offices facility and its role in the overall campus emissions and EUI reduction will be included in the district wide version of the report. Below are graphs of the EUI and emissions of the facility over time, without goals or PV/Carbon Offset/Purchased Green Energy interventions. We have also included data for an electrification project associated with the facility. Due to the District Offices high electric grid emissions rate, more CO2 reduction comes from future grid improvements than directly from electrification.



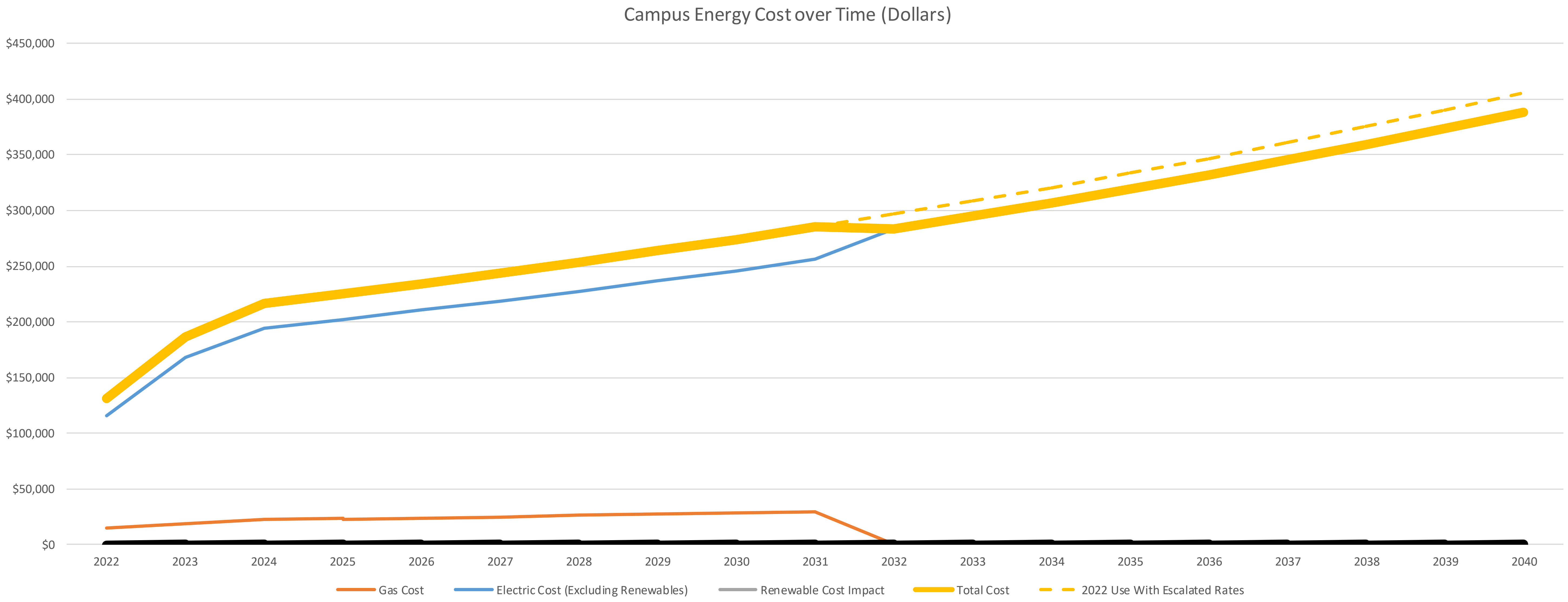


District Offices/Education Center Electrification and Controls Upgrade

Area	Year	Cost	Starting EUI	EUI After	Electric kWH Increase	Gas kBTU reduction	Annual Cost Savings (2031 Dollars)
46,521	2031	$2,848,889	66	50	42,215	847,506	$12,483

HVAC Electrification Strategy
District Offices/Education Center– Facility Utility Costs Trend

The chart below shows the total and fuel specific utility costs for the District Office Facility going forwards. This is based on an assumption of a 4% escalation of electricity and gas costs per year, as well as the campus being in a net metering scheme which allows for the PV kWH to have the same value as electric consumption kWH. The 2022 use with escalated electricity and gas costs are also shown with a dotted line, to show the impact of the cumulative interventions performed on the campus.

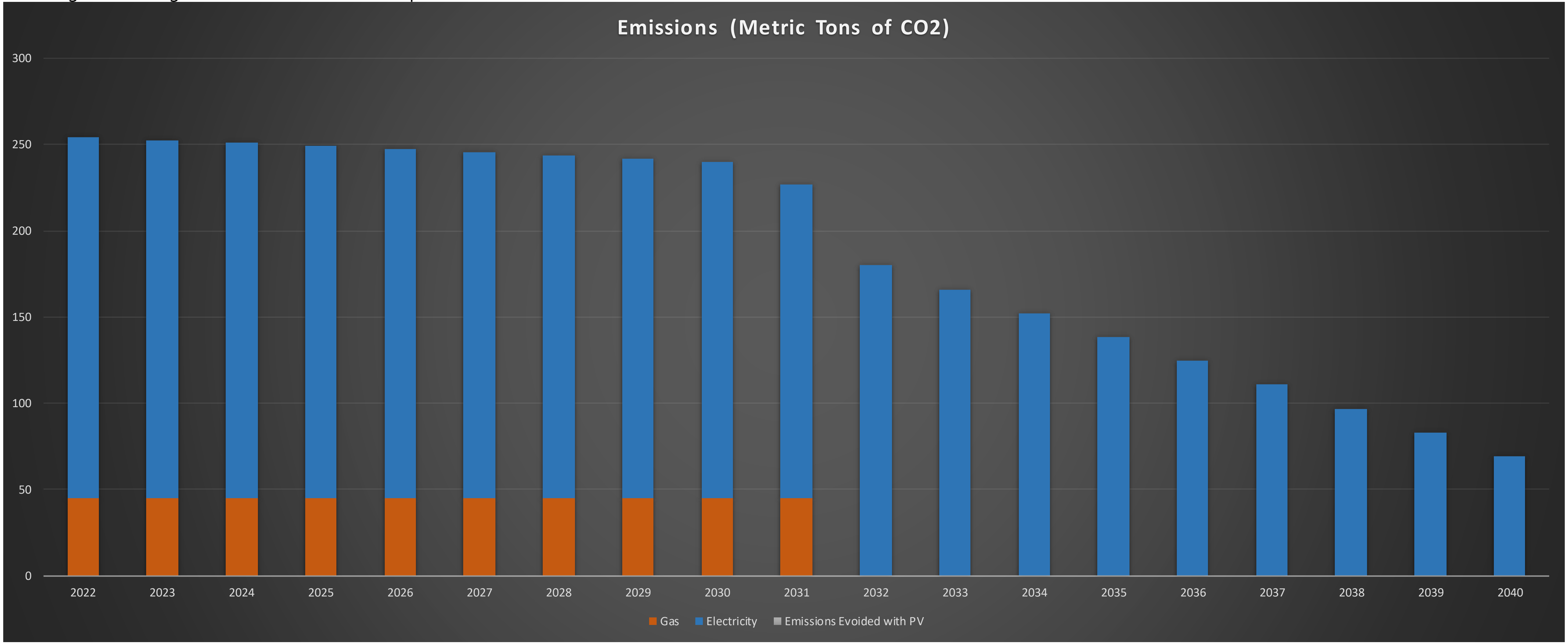


Planned PV is assumed to be installed in the year prior to the start of 2026.

INTERFACE ENGINEERING

HVAC Electrification Strategy
District Offices/Education Center – Campus Emissions Trend

The graph below shows the emissions trend accounting FMP and non-FMP projects. Emissions offset by renewables deprecate over time due to decreasing grid emissions. The campus would need 468 additional kW of PV to offset its emissions completely in 2035. This campus does not have the capability of having this quantity of PV installed, so it is recommended to install this at an alternate campus, or to consider purchasing offsets instead. The facility would require 138 tons of offsets in 2035, going down to 69 tons in 2040, assuming the gride converges to the legislated emissions rates as expected.



5.

District Wide Summary

Electric Infrastructure Assessment

Electrical Infrastructure Assessment - Introduction

As part of the Electrification Plan, Interface Engineering evaluated the available electrical system capacity at each campus to accommodate the future electrical demands from electrification, renewable energy deployment, and EV charging. The goal of this assessment is to confirm the capacity at the main campus feeders and switchgear. Downstream equipment, such as panels, wiring, and transformers, are not included in this assessment.

We have assessed the available electrical capacity at each of the District's campuses, as well as the District Offices and Brentwood Building. The available capacity has been evaluated using PG&E utility data (15-minute interval data) and PV inverter output data (hourly data provided from the district) for the period of May 2022 through August 2023.

For electrical services that include PV production, the generation data from net generation output (NGOM) meters and/or direct inverter output data is added to the consumption data reported at the main revenue meter, establishing the true demand on the service.

The demand (kW) reported for each service is a calculated value, using the consumption and PV production data (kWh). For example, if 100 kWh are consumed in a 15-min timestep, then the calculated demand for that timestep would be reported as 400 kW (100 kWh X (1/4 hours)).

Observations from Electrical Capacity Analysis

There is significant spare capacity in each of the campus's electrical system, which will allow flexibility for electrification, PV deployment and EV charging capacity.

Electrification of natural gas systems is not expected to increase the peak demands on the existing electrical systems. This is because HVAC electrical demands are typically driven by the cooling load. I.E. more fan and compressor power is required during the summer than during the winter.

- In most cases where buildings already utilize mechanical cooling, a building electrical service upgrade will not be required solely due to electrification.

	CCC	DVC	LMC	SRC	Brentwood	District Offices
Service Capacity (kW)	12,471	8,646	8,646	1,663	1,330	831
Max Demand + 25% (kW)	337	3,417	2,126	380	359	265
Available Capacity (kW)	12,134	5,229	6,521	1,283	971	566
% Spare Capacity	97%	60%	75%	77%	73%	68%

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EV Charger Planning

Given the substantial capacity remaining in each of the district's electrical services, there is flexibility to add EV charging in strategic locations. As a hypothetical scenario, the table below indicates the number of chargers that a given campus can support. This calculation is based on using 25% of the spare capacity can be made available for EV charging. 9.6 KW chargers are used as an example, which represents high-capacity Level II chargers.

It should be noted that growth in EV charging is not accounted for in the GHG emissions calculations presented in subsequent sections of the report, as it is difficult to project how usage will increase on each campus.

	CCC	DVC	LMC	SRC	Brentwood	District Offices
Service Capacity (kW)	12,471	8,646	8,646	1,663	1,330	831
Max Demand + 25% (kW)	337	3,417	2,126	380	359	265
Available Capacity (kW)	12,134	5,229	6,521	1,283	971	566
% Spare Capacity	97%	60%	75%	77%	73%	68%
# of 9.6 KW Chargers EV using 25% Spare Capacity	315	136	169	33	25	14

INTERFACE ENGINEERING

Review of Facilities Condition Assessment (Electrical)

The following observations and commentary are made based on our review of the facilities condition assessment provided by Bureau Veritas, completed in November of 2023.

- The report indicates a large number of equipment and wiring has reached the end of its useful life. However, many of these items are still functional and there is no indication of anything faulty with the equipment. Instead of replacing this equipment, we recommend performing regular preventative maintenance, including cleaning, operating breakers, and infrared scanning to extend the useful life of the existing equipment.
- We concur with recommendations to replace equipment where there are safety concerns or replacement parts are no longer able to be sourced. For example, this would apply to panels where the original manufacturers are no longer in business, such as Zinsco and Federal Pacific gear that have known safety issues.
- We concur with recommendations to replace equipment where there are specific issues identified, such as rust, or boxes breaking off supports, etc.
- We concur with the recommendations to replace lighting greater than 15 years old to modern, energy-efficient LED lighting.

Renewable Energy Deployment

Renewable Energy Deployment Strategy

Introduction

On-site renewable energy generation is a critical component of 4CD's sustainability plan to achieve net zero carbon emissions by 2035. The district currently has approximately 3.2 MW of photovoltaic (PV) solar panel systems across CCC, DVC, and LMC, which produce nearly 3.8 MWh annually. This represents approximately 19% of the district's electricity consumption.

As part of its plan to increase on-site renewable production, 4CD has five additional PV projects approved by PG&E for installation but have yet to be funded. For the purposes of estimating the impact of these approved projects, it is assumed that these systems will be installed in 2026. An estimate of the total development costs are shown in the table below, which based on the information provided by Sage Renewables. These costs are based on recent quote that 4CD received for the Brentwood system, which indicated a total cost of $7.87/watt for carport arrays. The Brentwood, DVC, and LMC installations are also planned to include battery energy storage systems (BESS), which will further enhance the cost reduction capabilities of these systems.

The tables to the right summarize the existing and planned PV systems, including their DC capacity, orientation and expected annual production rate (which vary slightly by campus and by array orientation). The table at the bottom indicates the % of electrical consumption that is met with the existing and future PV systems.

The campus site plans on the subsequent slides indicate the existing and planned PV locations on each campus, including the context of the newly planned buildings as part of the FMP. The site plans also indicate areas that may potentially be used for additional PV in the future.

The energy and carbon impact of the existing and planned arrays are discussed in more detail in the "District Energy and Carbon Timeline" chapter of this report.

The table below shows the future PV, beyond what is currently planned, that would be required in order to achieve net zero emissions for the specific campuses in 2035, and the associated cost of deployment in 2024 PV costs.

Future PV Summary (Scenario A)

Campus	Size (kW)	Cost*	Est. Annual Production (kWh/yr)	Predicted Electrical Consumption in 2035	% Future Load Met by Future PV
DVC	3,844	$30,252,280	5,766,000	8,782,110	66%
CCC	2,167**	$17,054,290	3,250,500	5,143,509	63%
LMC	591	$4,651,170	886,500	4,276,119	21%
SRC	433	$3,407,710	649,500	1,413,618	46%
DO	468***	$3,683,160	702,000	701,838	100%
BEC	166	$1,306,420	249,000	749,521	33%

*costs are based on estimates for PV projects for the district in 2024
**based on offsetting kWh instead of carbon emissions, due to the utility split for CCC between MCE and Constellation
***Due to limited space at this facility, this PV could be installed on another Constellation Campus like DVC, LMC, or SRC to have the same effect.

Existing PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	Kwh/KW*	Annual Energy Production (kWh)
Contra Costa College - Lot 9	403	225	1053	424,359
Diablo Valley College - Lot 1	567	270	1297	735,289
Diablo Valley College - Lot 3	267	270	1297	346,247
Diablo Valley College - Lot 4	548	270	1297	710,650
Los Medanos College - Lot B	763	150	1139	868,904
Los Medanos College - Lot C	638	230	1128	719,953
Total	**3,186**			**3,805,402**

*The existing PV production rates are 20-30% below the expected rate, based on the location and orientation of the systems. This may indicate performance issues with the panels and inverters.

Planned PV systems

Site Name	DC Array Size (KW)	Orientation (deg from North)	kWh/KW	Annual Energy Production (kWh)	Project Development Costs ($)
Diablo Valley College - Lot 5	878	270	1564	1,373,000	$6,909,860
Contra Costa College - Lot 1	947	225	1551	1,469,000	$7,452,890
Los Medanos College	1,154	150	1560	1,800,000	$9,081,980
San Ramon Center - Main Lot	483	225	1580	763,000	$3,801,210
Brentwood Center - Main Lot	322	180	1556	501,032	$2,534,140
Total	**3,784**			**5,906,032**	**$29,780,080**

Renewable Energy Summary

	Annual Electricity Consumption (kWh)*	% Met by Existing PV	% Met by Planned PV	Total Planned Renewable %
CCC	4,414,407	10%	33%	43%
DVC	8,618,555	21%	16%	37%
LMC	4,783,853	33%	38%	71%
SRC	1,200,248	0%	64%	64%
Brentwood	573,479	0%	87%	87%
District Offices	657,697	0%	0%	0%
District	**20,248,239**	**19%**	**28%**	**47%**

*True 2022 value that is not weather normalized

District Energy Projects

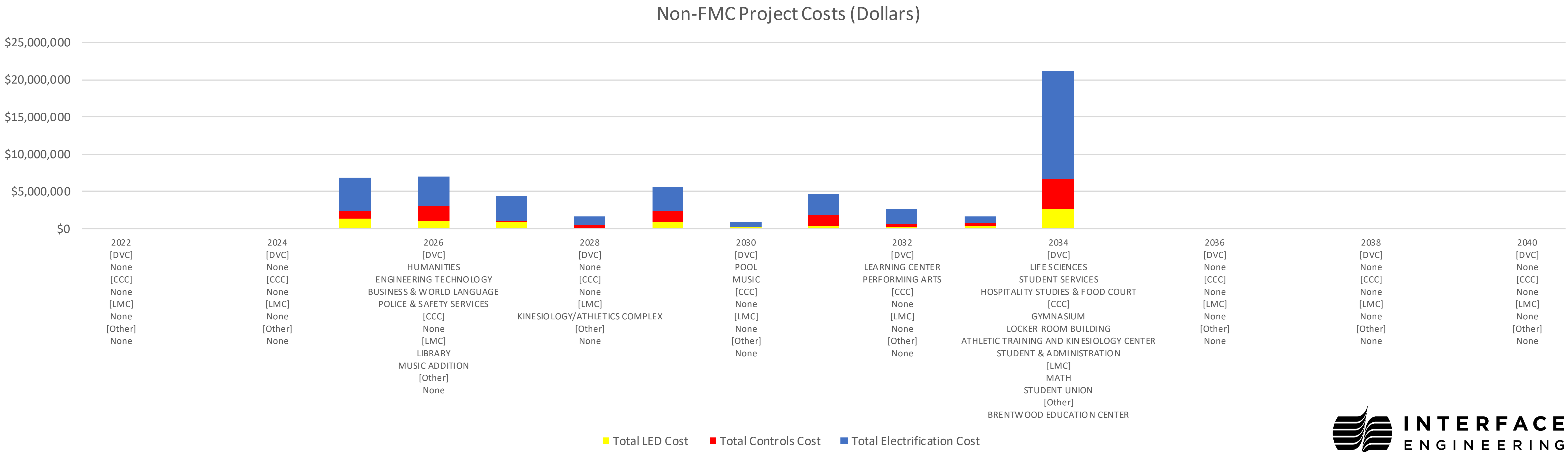
HVAC Electrification Strategy
District Wide– District Energy Project Savings and Cost Summary

Non-FMP Energy Projects Cumulative Cost			
Lighting	Controls	Electrification	Total
$8,907,446	$12,887,625	$36,906,247	$58,701,319

Non-FMP Energy Project Annual Cost Savings (2023 Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 473,497	$ 123,178	$ 694,604	-$1,000,368	$290,911

Non-FMP Energy Project Energy Savings (Annual Impact - Not Cumulative)			
Lighting (Electric kBTU)	Controls (Electric kBTU)	Electrification (net kBTU)	Electrification (Gas kBTU)
7,034,350	1,840,186	22,746,482	35,383,416

Non-FMP Energy Project Annual Cost Savings (2035 Estimated Utility Rates)				
Lighting Savings	Controls Savings	Electrification Gas Savings	Electrification Electric Penalty	Total Annual Savings
$ 845,556	$ 219,967	$ 1,240,401	-$1,786,424	$519,500



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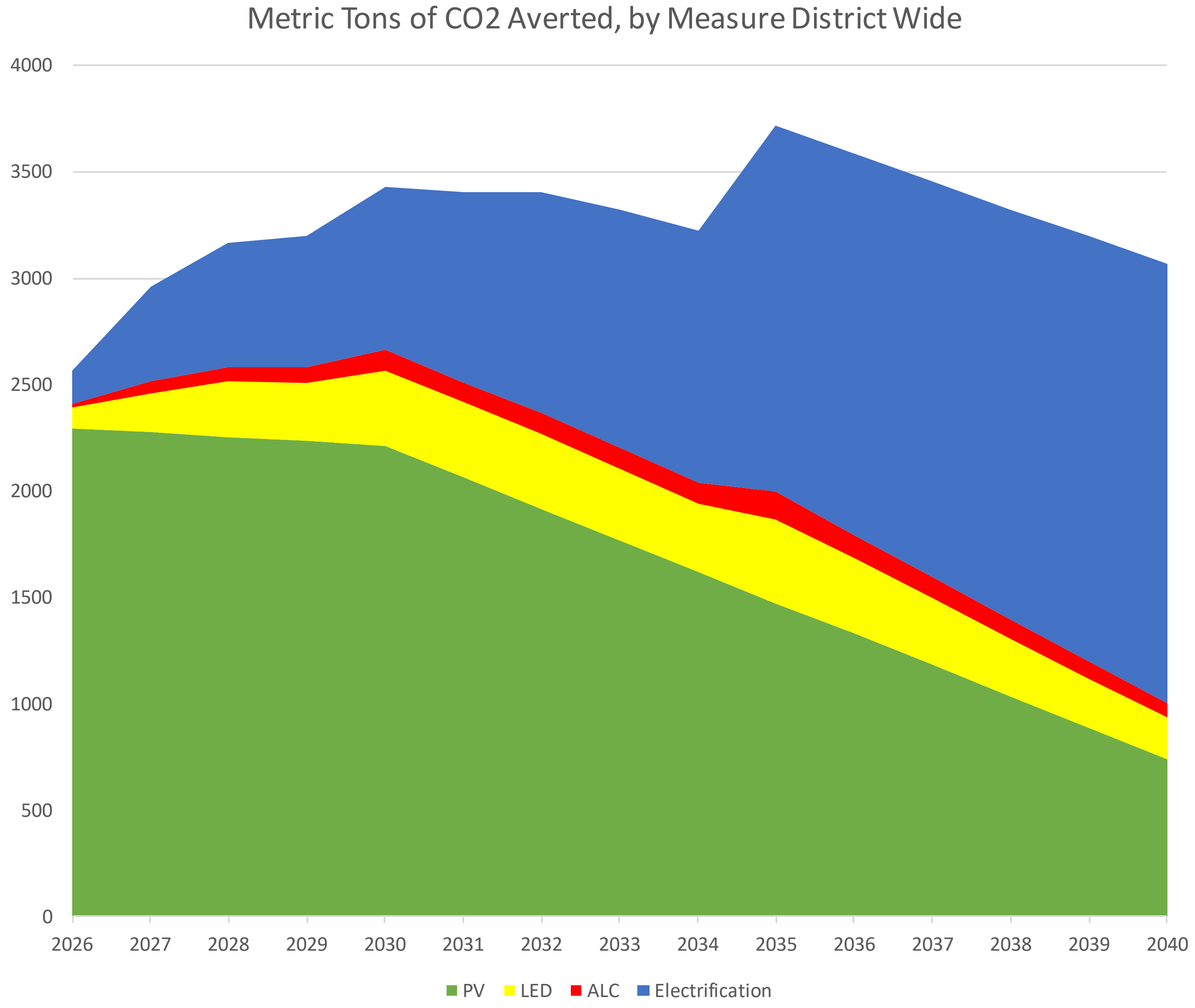
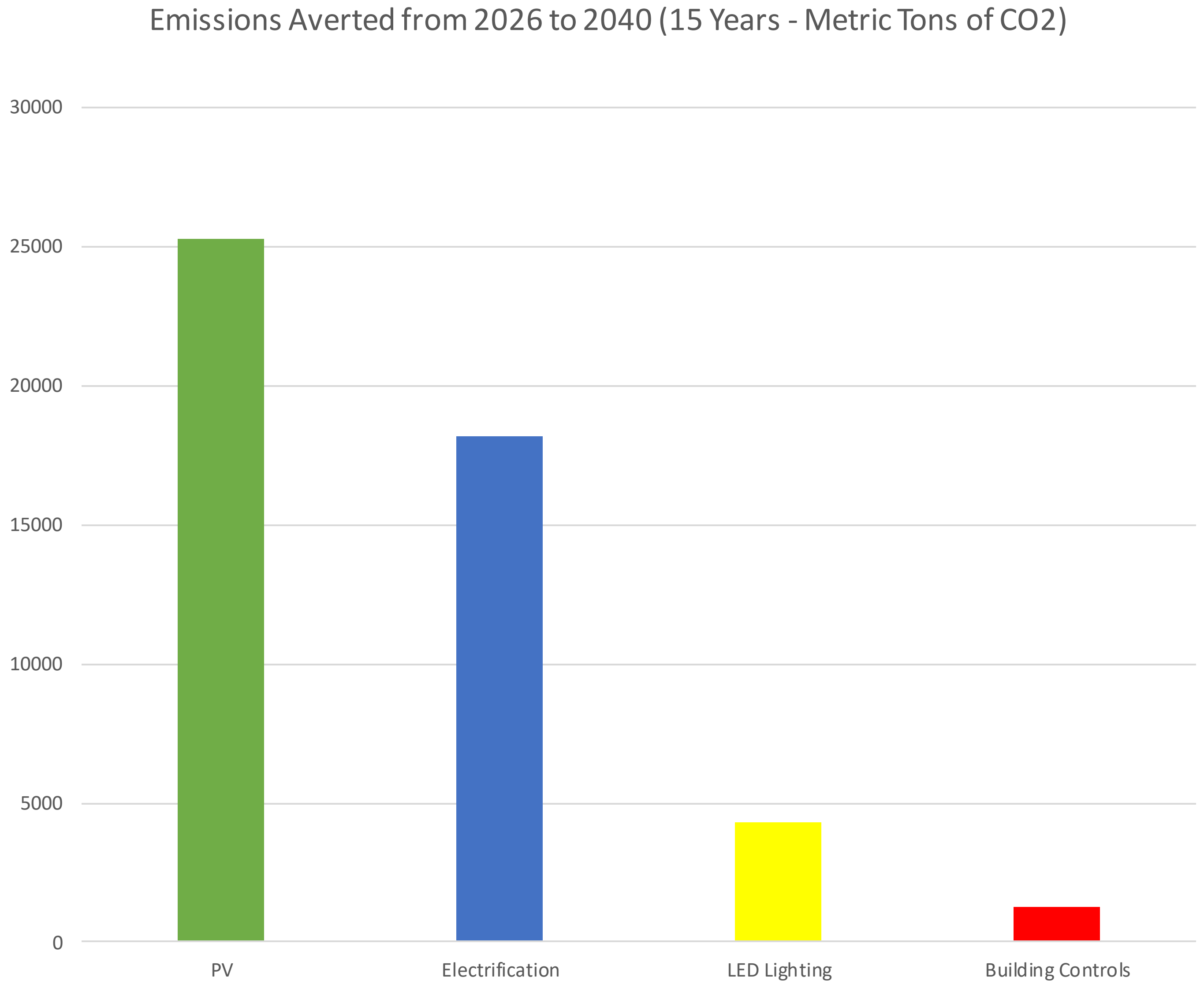
HVAC Electrification Strategy
District Wide– District Energy GHG Reductions by Decarbonization Measure

The graph below shows the tons of CO2 averted by the type of measure. The graph shows the 15 years from the start of 2026 to the end of 2040, as well as a summation. PV provides a greater source of averted emissions early on, while electrification provides a greater amount of averted emissions by the end of the study. This is due to the improving grid emissions rate lowering the offset impact of PV, and increasing the gas replacement impact of electrification. There is also PV at the start of the study, whereas it takes time for a portfolio of electrified buildings to accumulate.

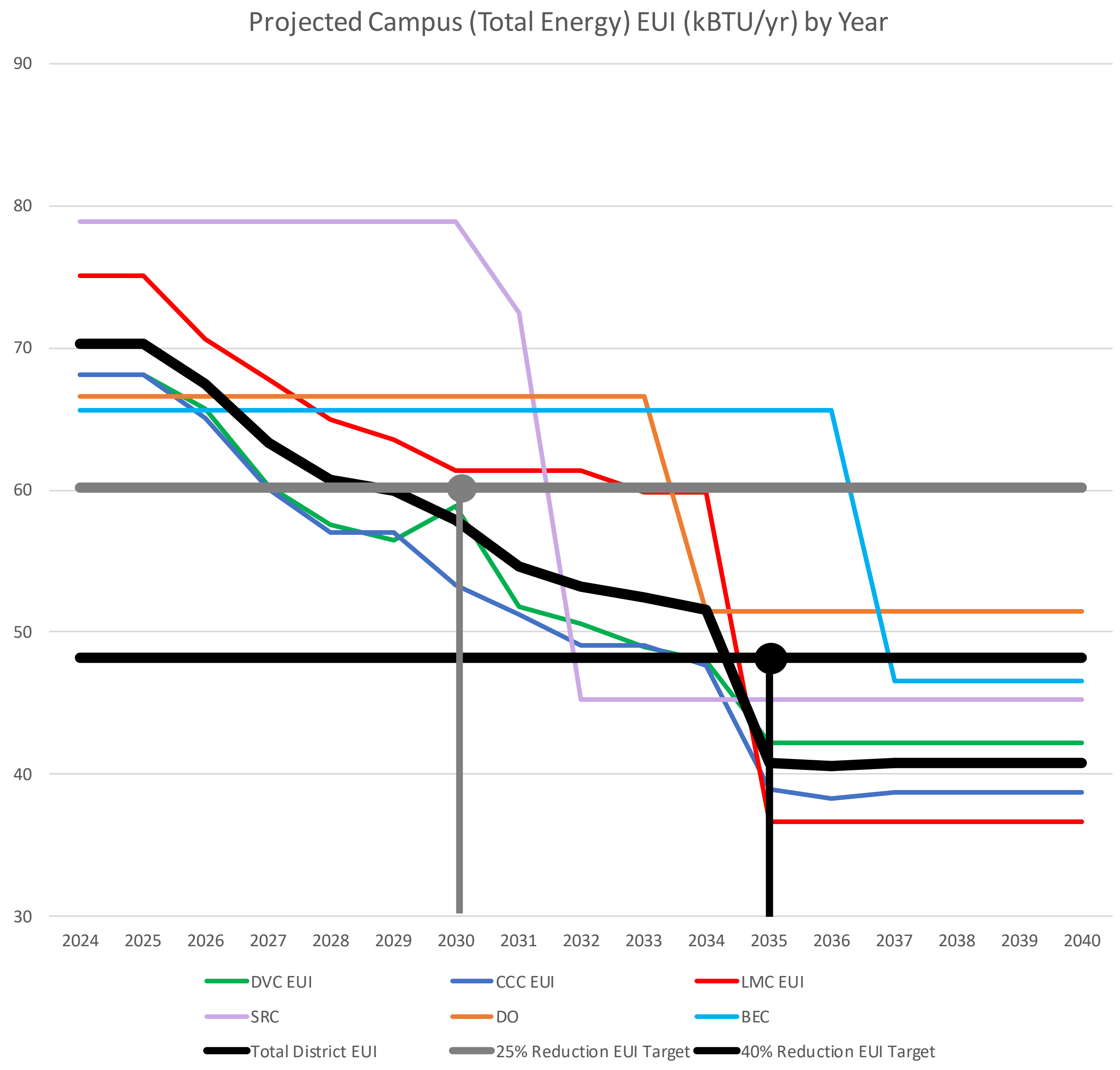




INTERFACE ENGINEERING

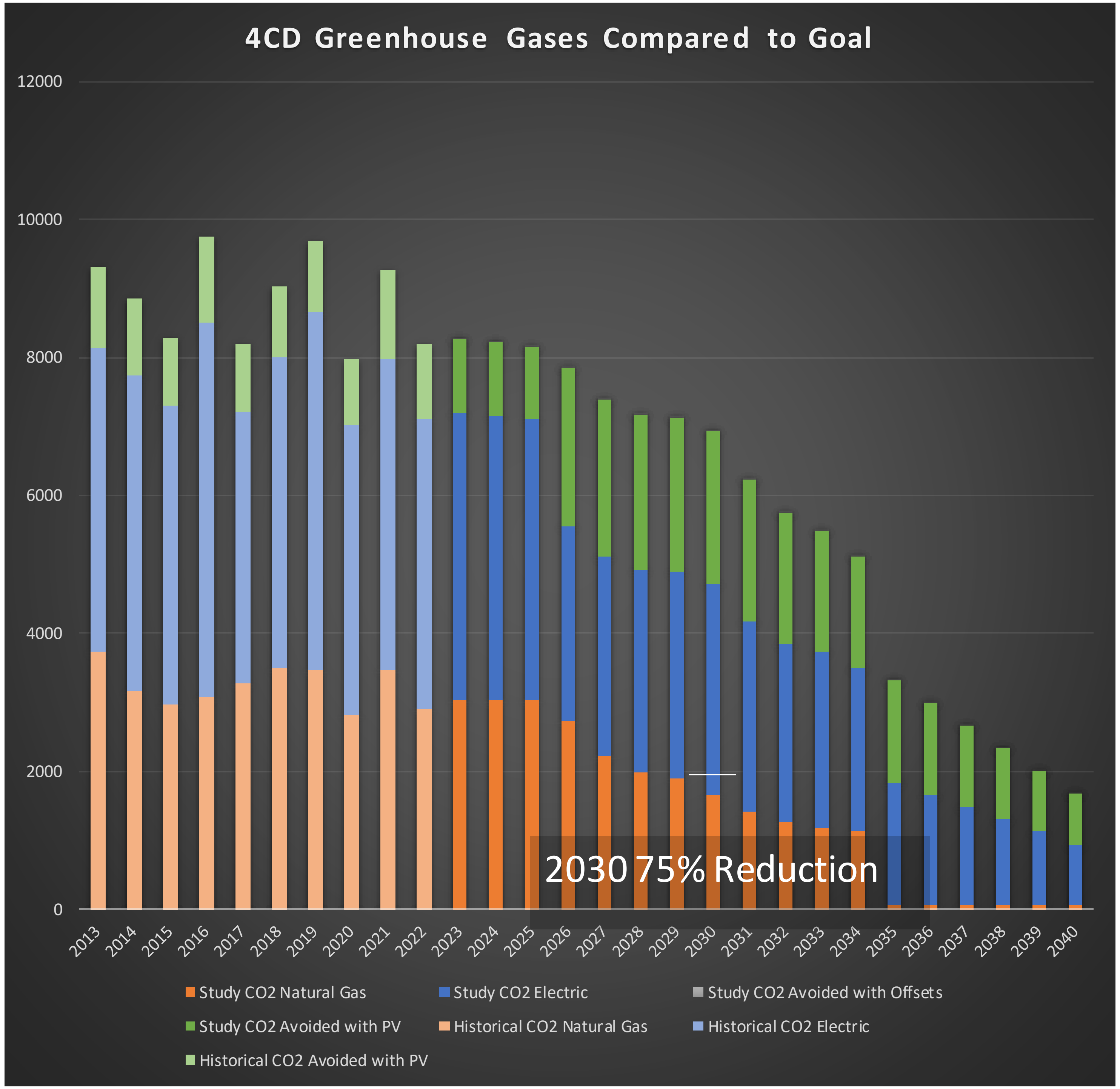
District Wide Energy Timeline

District Energy and Carbon Timeline – EUI Targets



The EUIs are displayed on a per year basis, along with a campus average and 25%/40% reduction targets outlined in the 4CD sustainability report. These targets are based on 2013 benchmark campus EUIs. In order to meet these targets, significant electrification and building upgrades are necessary. The projects around the college complex of the Los Medanos College campus have a very strong impact on this campuses EUI. While both the 2030 and 2035 goals are met only one year ahead of schedule with this plan, the portfolio of electrification projects in 2034 overshoot the EUI requirements for that year. This is helpful for meeting emissions targets as well, but alternatives with some of the less convenient electrification projects removed and more PV/Offsets to replace them are shown in the District Future Energy and Carbon Scenarios portion of this report.

District Energy and Carbon Timeline – Net Emissions

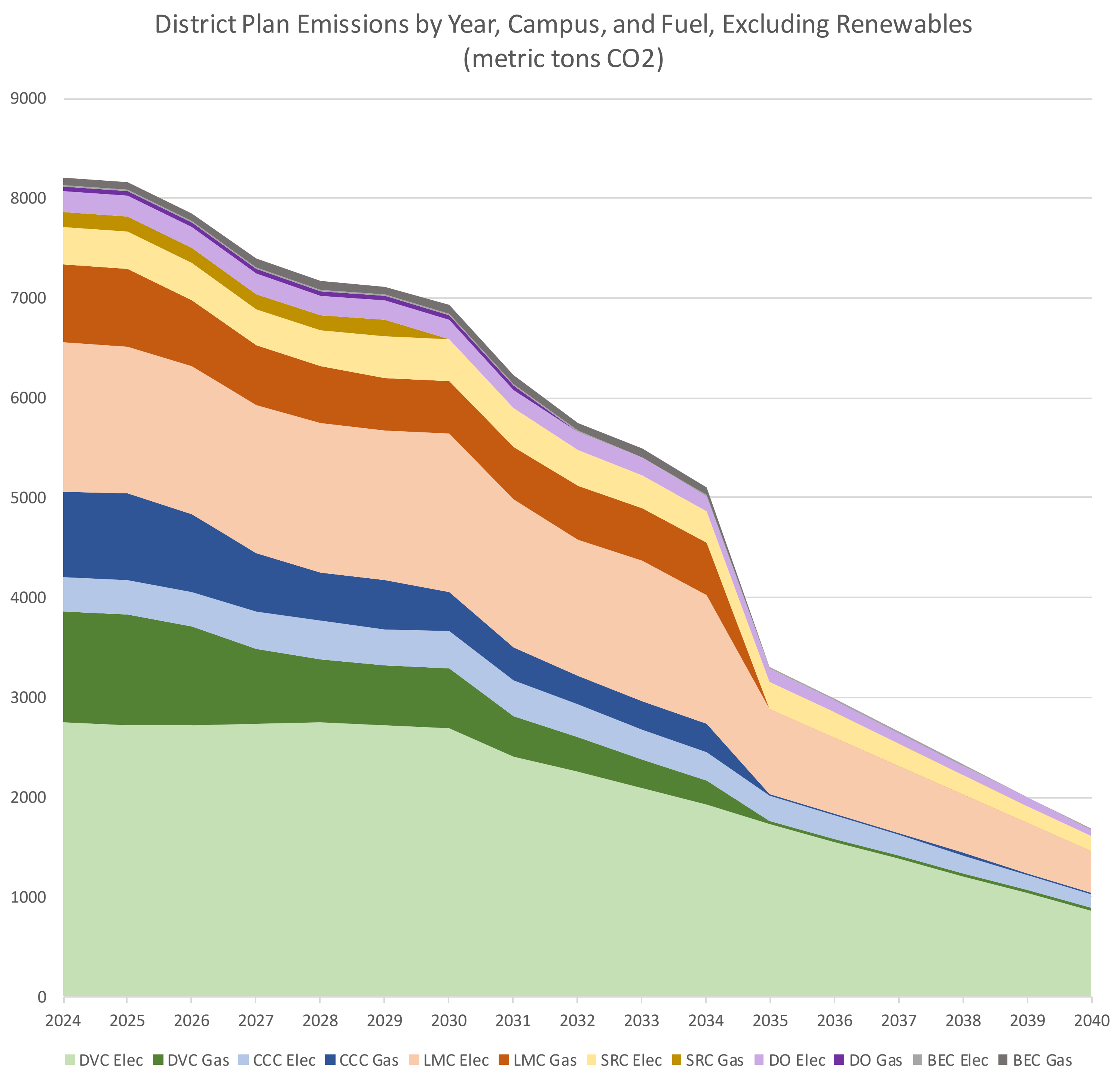


This graph shows the progress towards the District's emissions goals as outlined in the 4CD sustainability report. These targets are based on the 2013 baseline emissions. While the current plan of extensive electrification does help make this target more feasible, more on-site renewable generation or purchased offsets will be needed to achieve the 2030 and 2035 targets. The green portion of the graph shows emissions that are offset by renewable energy, so the true campus emissions are at the point where the green and blue bars intersect.

Scenarios to mitigate the remaining portion of emissions are covered in the District Future Energy and Carbon Scenarios portion of this report.

INTERFACE ENGINEERING

District Energy and Carbon Timeline – Emissions

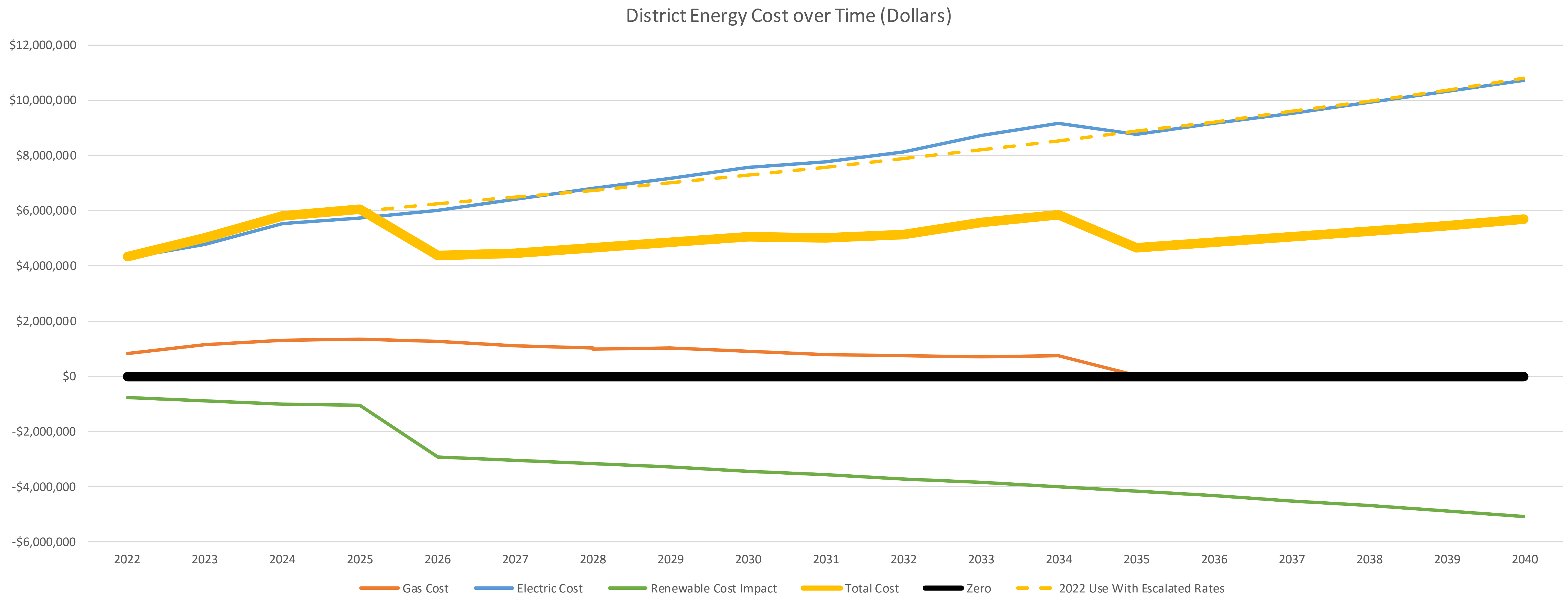


This graph shows the emissions breakdown of the entire district by fuel type, and campus. It does not include any offsetting effects of renewable proliferation in order to allow a direct comparison of the electric and gas-based emissions from consumption. The District's sustainability plan dictates a pace of building EUI reduction and emissions reduction, and electrification is critical to meeting those goals. The reduction in gas emissions over time is driven by the electrification of the campus facilities, while the reduction in electric emissions is predominantly driven by a decrease in the emissions rate of the grid electricity occurring simultaneously with a slowly increasing electric consumption across the campuses and centers.

INTERFACE ENGINEERING

District Energy and Carbon Timeline – Utility Cost Trend

The current quantities of existing and planned PV for the district cancel out the expected escalation of the utility rates over time and result in a more stable total operating cost for the district. Once the planned PV is deployed, it results in more cost savings for the district than the planned portfolio of building energy projects, but the latter still has some impact. The demolition and replacement of less efficient existing buildings also has a meaningful impact on operating costs. Future PV installed to meet energy and sustainability goals will further reduce the operating costs of the district.



Planned PV is assumed to be installed in the year prior to the start of 2026.

6.

District Future Energy and Carbon Scenarios

Emissions Cost Comparison

District Energy and Carbon Timeline – Cost Per Ton of Averting Carbon

Table: Cost of Averting 1 Metric Ton of Carbon Emissions by Initial Cost (20-Year Time Horizon)

Year	2025	2035
MCE Clean Energy Purchase	$515	NA
Constellation Clean Energy Purchase	$131	NA
MCE PV	$22,474	$125,078
Constellation PV	$1,411	$7,851
Electrification	$949	$1,093
LED	$813	$4,526
ALC	$3,287	$18,294
Cheap Offsets Cost per Ton*	$18	$55
Carbon Capture Cost per Ton*	$750	$650

*Middle of the road estimate between upper and lower bounds estimates

Table: Simple Payback in Years for Strategies Across the District

Year	2025	2035
MCE PV	11.6	12.2
Constellation PV	13.9	14.6
Electrification	NA	NA
LED	6.8	7.2
ALC	31.4	32.9

These tables show the district wide value of strategies that are available for dealing with carbon and operating cost goals. The values are based on the portfolio of the Non-FMP district energy projects, and hypothetical value of future PV. The initial costs are adjusted to reflect the year for the comparison, and the cost and emissions rates are averaged over a 20-year period that also constitutes the length of the comparison.

The MCE PV option is by far the most expensive in terms of dollars per ton averted. This is because of the low emissions rate associated with MCE (The positive case for deploying PV on the MCE account is that it has the best financial payback for the district, compared to the other utilities.). The two methods of carbon aversion that have the best costs in 2035, relative to their 2025 costs, are electrification projects, and carbon capture projects. The decrease in emissions from the grid over time results in a higher net savings for electrification projects over time, whilst it undercuts savings based on projects like PV, LED upgrades, and controls upgrades.

The overall cheapest option of “Cheap Offsets” are offsets that are available to purchase but use methodologies to calculate their impact which have fallen out of favor with researchers and practitioners because they have been found to not be resilient. The more expensive “Carbon Capture” projects are based on things like direct air capture and bio-char or bio-oil projects that store these CO2 products underground. This is new technology that is expected to advance in the coming years, and so our cost estimate window ranges from $500 to $1000 in 2025, and $300 to $1000 in 2035, with the middle of these windows being represented in the table. We can also see that the LED projects have the best payback of any energy project, and the ALC/controls upgrades have the least desirable cost payback (unless they are being done on a very poorly operating building), and should likely be lumped in with other work on the buildings.

District Energy and Carbon Timeline – Cost Per Ton of Averting Carbon – Cont.

These numbers are approximations based on assumptions around future emissions rates, project cost escalations, and utility cost escalations, that are likely to diverge from our forecast. The important take-away is not any specific value, but that as time goes on, a reduction in the emissions rate of the electrical grid will profoundly change the carbon impacts per dollar of the various strategies, and electrification, as well as advanced carbon capture techniques, are going to become comparatively more cost-effective ways to avert carbon as this change occurs. It is worth noting that as the grid becomes "cleaner", the emissions that the district will have to offset from electricity use will also go down significantly. If the California grid does reach zero emissions by 2045 as legislated, complete electrification will be all that is necessary to have no emissions after that point. This also means that the best time to install PV from a carbon and utility cost perspective is as early as possible.

There are also clean energy purchase options from Both MCE and Constellation. These are cheaper up front, but the money spent on them is lost permanently, instead of contributing to a payback like PV. The Constellation option is more expensive per kWh but is cheaper per ton of carbon due to Constellation's higher emissions rate. These estimates are provided for 2025, but not 2035, due to uncertainty around the costs of these specific services in the future.

From a financial perspective, the ROI of the projects are much more stable over the duration of the study, compared to the emissions impact.

More resources regarding carbon offsets and capture and the issues with some of the cheaper types of offsets available today are located in the appendix of this report.

Future Scenario A: Main Scenario

Scenario A Details

Rationale

The over-arching strategy of Scenario A is to use PV where it has a strong impact on emissions to offset emissions, electric consumption, and operating costs. For the campuses where PV is not applicable, or less impactful to the campus emissions, offsets are used to achieve the carbon goals. This is the main scenario and doesn't make any changes to the non-FMP projects outlined in the previous pages of the report.

Future PV

Campus	PV Quantity (MW)	PV Rationale	PV Cost*
DVC	3.844	100% of 2035 emissions	$30,252,280
CCC	2.167	100% of 2035 electric consumption	$17,054,290
LMC	1.059 (468 for DO + 0.591 for LMC)	100% of 2035 emissions for LMC plus 100% of 2035 emissions for DO**	$8,334,330
DO	0 – see LMC	100% of 2035 emissions offset at LMC	0 – see LMC
SRC	0.433	100% of 2035 emissions	$3,407,710
BEC	0.166	100% of 2035 emissions	$1,306,420
Total	7.669		$60,355,030

*All PV costs are based on 2024 project costs

**DO emissions could be associated with any of the facilities with the same emissions as DO and retain the same value and estimated cost.

Offsets

Campus	Offset Quantity (Tons)	Offset Rationale	Offset Cost (x$1,000)
DVC	None	Emissions covered by PV	None
CCC	2035: 212 2036: 197 2037: 173 2038: 154 2039: 135 2040: 115	Remaining Emissions not covered by PV	2035 Offset: 2-21, 2035 Capture: 42-212 2036 Offset: 2-20, 2036 Capture: 39-197 2037 Offset: 2-17, 2037 Capture: 35-173 2038 Offset: 2-15, 2038 Capture: 31-153 2039 Offset: 1-13, 2039 Capture: 27-135 2040 Offset: 1-12, 2040 Capture: 23-115
LMC	None	Emissions covered by PV	None
DO	None	Emissions covered by LMC PV	None
SRC	None	Emissions covered by PV	None
BEC	None	Emissions covered by PV	None
Total	2035-2040: 986		2035-2040 Offset:10-99 2035-2040 Capture: 197-986

Building Projects

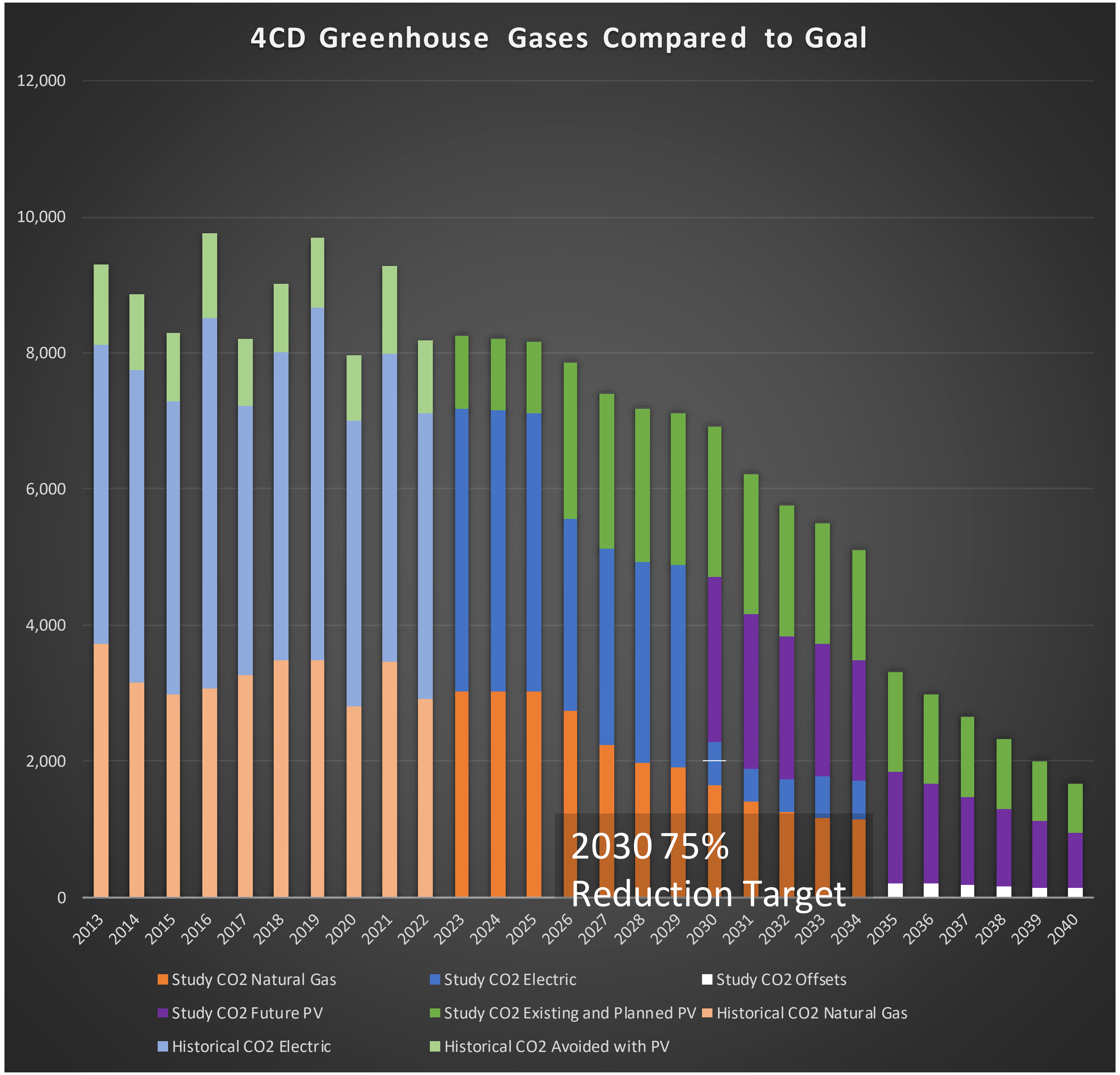
This plan includes all of the FMP and Non-FMP energy projects shown in the previous sections.

Offset vs PV Cost Analysis

Offsets are the most cost effective method of carbon reduction in the later years of the study (based on up front costs) with even a high end estimate of $1000 a ton offering more tons per dollar than PV. With that being said, the money spent on CO2 offsets is lost permanently, whereas the cost of PV panels is eventually recuperated in electrical cost savings.

INTERFACE ENGINEERING

Scenario A – Net Emissions



In this scenario, the district is just shy of meeting its interim 2030 25% emissions goal but achieves it in the next year. It does meet its 2035 goal of net-zero emissions, using offsets to handle the last bits of gas usage and constellation electricity from CCC. Although the future PV is sized to meet the 2035 parameters for the campus, it is shown as being deployed in 2030 to approach the 25% reduction target set for that year.

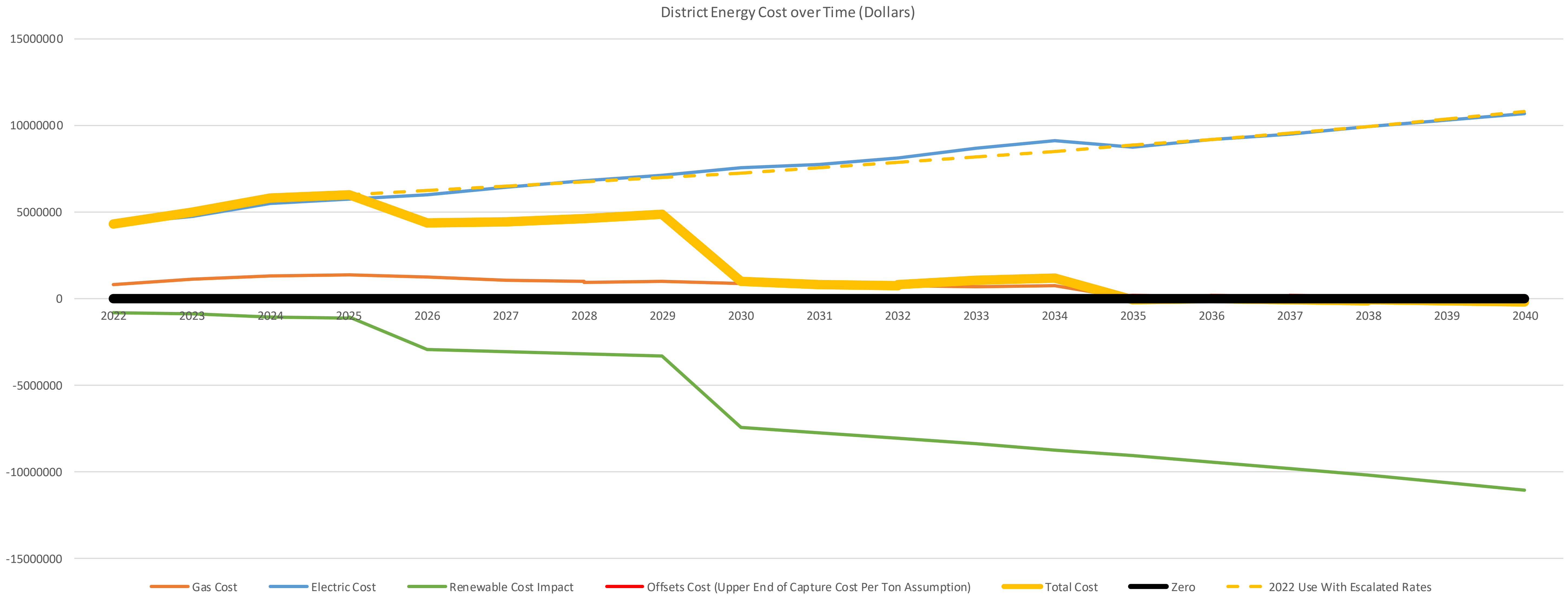
District Energy Goal	2030 Goal	2030 Goal Met	2035 Goal	2035 Goal Met
Emissions	75% Reduction	Met	100% Reduction	Met
Natural Gas Reduction	30% Reduction	Met	75% Reduction	Met
Electric Percent Renewable	75% of Electricity from Renewables	Met	NA	NA
Campus EUI Reduction	25% EUI Reduction	Met	40% EUI Reduction	Met

This scenario meets all of the campus sustainability goals.

INTERFACE ENGINEERING

Scenario A – Utility Cost Trend

The additional future PV added with scenario A results in near zero utility costs for the district. The cost of the offsets, which start in 2035, are included in this graph and data, but are so small that they are not visible on this graph. The more conservative future $1000 per ton cost for carbon capture still results in offsets per year that measure in the hundreds of thousands of dollars. This low cost of offsets is enabled by the large amount of PV and electrification in this scenario.



Planned PV is assumed to be installed in the year prior to the start of 2026 and Future PV is assumed to be installed in the year prior to the start of 2030.

INTERFACE ENGINEERING

Future Scenario B: No Future PV, More Offsets

Scenario B Details

Rationale

The over-arching idea of Scenario B is to consider offsets in place of PV for all future emissions reductions. The advantage of this strategy is to avoid the expensive cost as well as district labor and planning burden of future PV. The downside is that money that is spent on using offsets to avert CO_2 instead of PV is lost permanently, whereas PV projects have a payback. There is also broad skepticism around the merits of cheaper CO_2 offset mechanisms, as well as issues with high uncertainty in future costs. Carbon capture much more reliably results in a quantity of offsets that have the advertised impact, but the cost is orders of magnitude higher. This cost is expected to go down over time as the industry grows. Due to the better financial value of PV projects, offsets only make sense in a scenario where the district is unable to finance, doesn't have space for, or is otherwise unable to pursue any future PV projects. Scenarios between A and B are a more realistic path for a partially constrained deployment of future PV relative to what is expected in scenario A.

Future PV

Campus	PV Quantity (MW)	PV Rationale	PV Cost
District-Wide	None	None	None

Offsets

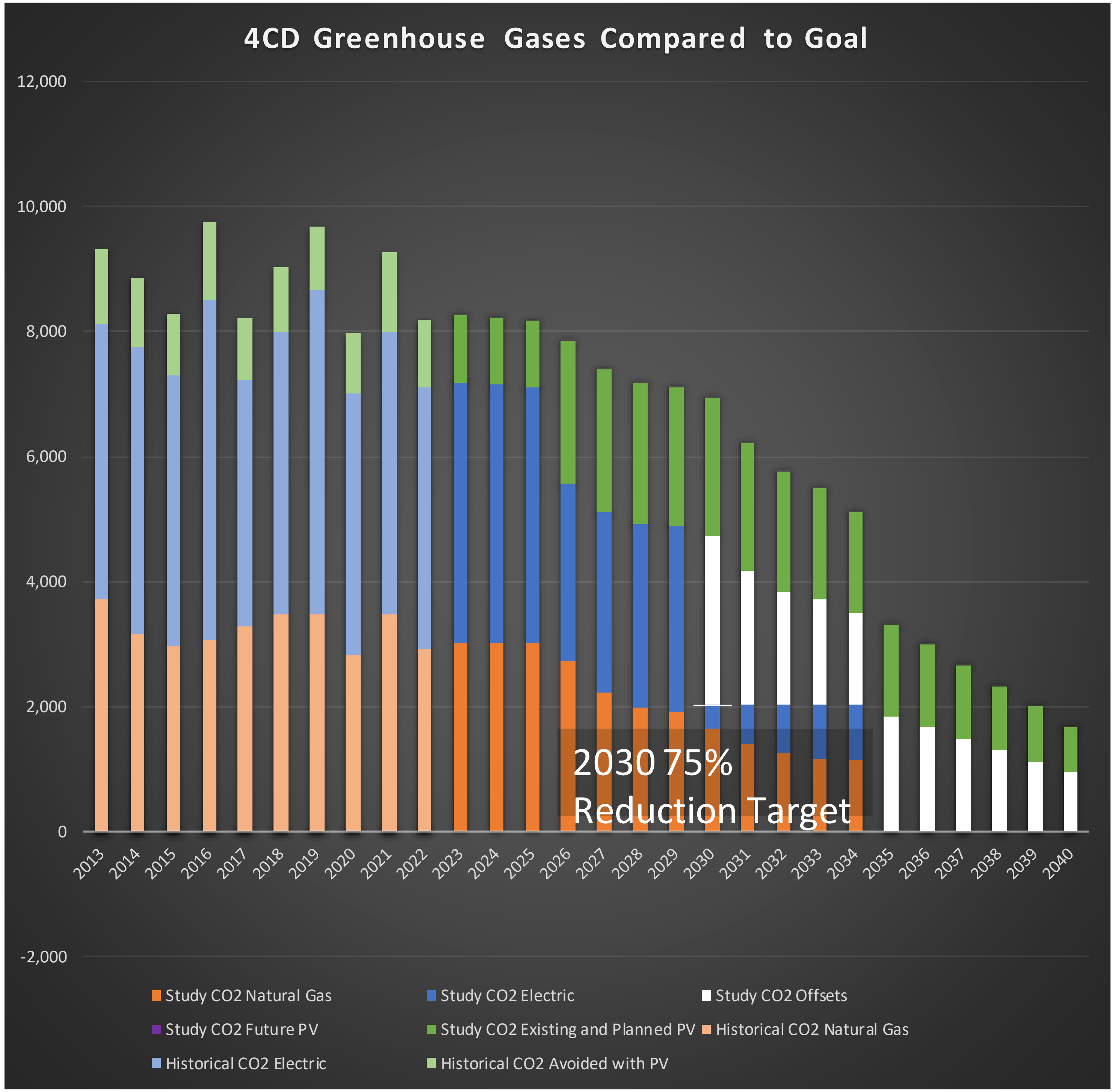
Campus	Offset Quantity (Tons)	Offset Rationale	Offset Cost (x$1,000)
District-Wide	2030-2040: 18,112	Offset all emissions exceeding campus emissions goals	2030-2040 Offset:166-1,606 2030-2040 Capture: 4,501-18,112

Building Projects

This plan includes all of the FMP and Non-FMP energy projects shown in the previous sections/included in scenario A.

INTERFACE ENGINEERING

Scenario B – Net Emissions



The offsets only scenario is aligned to the 2030 and 2035 emissions target, with the offsets required per year after 2035 decreasing as the grid becomes more clean. The limit of this reduction is the remaining gas usage which drives the offsets required into the distant future, for both this scenario and scenario A. This means that PV is really an interim carbon solution, as in the long term, once the CA grid is non-emitting, the carbon emissions solution for the campus will be a trade-off between electrification and offsets. The only way to have net zero emissions and avoid offsets entirely after 2045 is to completely electrify the district.

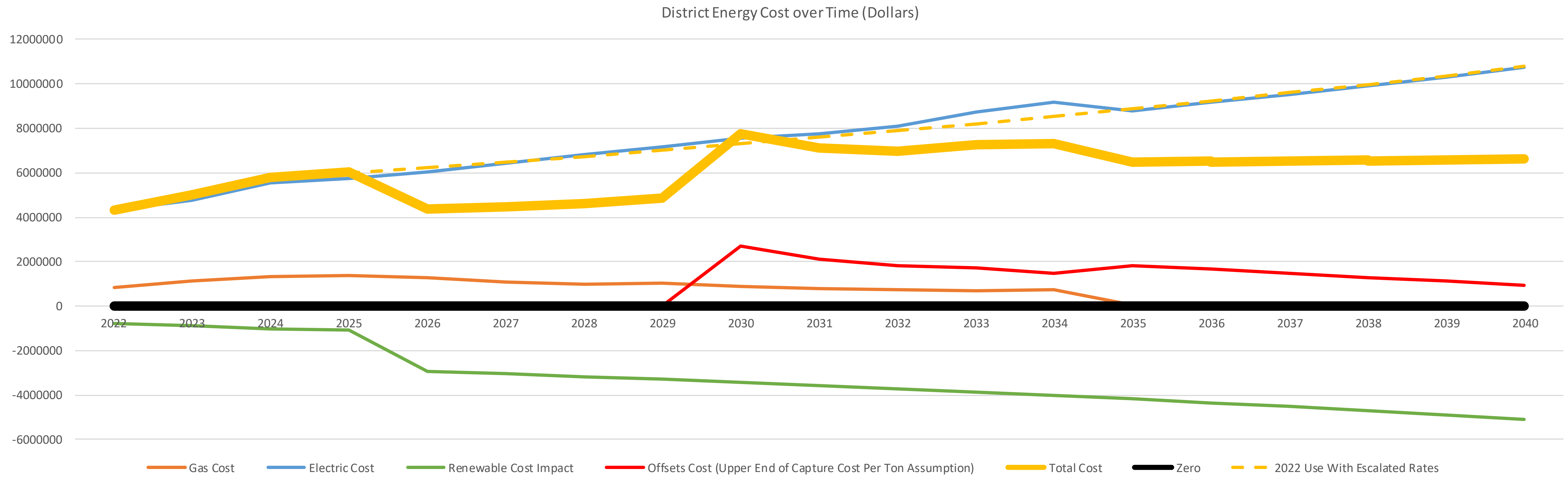
District Energy Goal	2030 Goal	2030 Goal Met	2035 Goal	2035 Goal Met
Emissions	75% Reduction	Met	100% Reduction	Met
Natural Gas Reduction	30% Reduction	Met	75% Reduction	Met
Electric Percent Renewable	75% of Electricity from Renewables	**Not Met**	NA	NA
Campus EUI Reduction	25% EUI Reduction	Met	40% EUI Reduction	Met

This scenario meets all of the campus sustainability goals, except those around the percentage of electricity that is renewable.

INTERFACE ENGINEERING

Scenario B – Utility Cost Trend

This graph shows the operating energy and offset costs for the campus under scenario B. This scenario has significant offset costs, which diminish over time. This presence of annual offset costs, and lack of future PV from scenario A, means that the operating costs are much higher than scenario A. However, Scenario A has about 60 million dollars worth of PV projects that are completely avoided in this scenario. However, with operating costs that are around 4-6 million dollars higher per year over the course of the 10 years of the study impacted by these projects (2030-2040), this seems like a clearly less valuable financial option in the long run. In a carbon emission constrained future, the cost of the offsets can be considered as a sort of boost to the payback of PV projects, in the window of time where PV still has a carbon impact before the grid is completely non-emitting. The fact that these cost savings will also continue for another decade after the study makes scenario A a financially obvious choice compared to this one. However, in a situation where PV deployment is limited by some other factor, or where the way that PV is credited back to the campus changes, this scenario could become much more compelling. This scenario is also conservative in its estimate of the cost of carbon offsets ($1,000 per ton for a carbon capture technique), and real-life expected decreases in the cost of this technology could help make this scenario less financially harmful. The majority of the carbon offset purchases in this scenario occur in a window ending just beyond a decade from now, so it may be unwise to bank on significant decreases in cost. It is also important to consider that there could be constraints on carbon capture deployment beyond cost, as many organizations attempt to purchase offsets based on these technologies to meet their sustainability goals. Even if the cost were to decrease, there may still be scarcity in the actual availability of the offsets.



Planned PV is assumed to be installed in the year prior to the start of 2026.

INTERFACE ENGINEERING

Future Scenario C: Clean Electricity Purchase, Minimal Offsets

Scenario C Details

Rationale

Scenario C switches to 100% renewable energy electricity purchase options from MCE and Constellation, for all electricity on the 5 facilities served by those utilities. This switch occurs in 2030, to align with the campus energy goals. The remaining emissions that need to be offset from gas and the Brentwood Education Center Electricity are handled with offsets. This scenario avoids the high initial cost of PV deployment, but is less financially beneficial in the long run, since the money spent on the clean energy is lost forever, where PV has a payback. In addition, clean power agreements can be subject to some of the same issues as carbon offsets, where the savings may be double counted or used to support PV that would have already been deployed by the utility company anyway in order to meet their legislative requirements.

Future PV

Campus	PV Quantity (MW)	PV Rationale	PV Cost
District-Wide	None	None	None

Offsets

Campus	Offset Quantity (Tons)	Offset Rationale	Offset Cost (x$1,000)
District-Wide	2030-2040: 315	Offsets are purchased for all remaining gas use for the district, as well as electric use for BEC where clean energy purchase agreements from PG&E have not yet been explored by the district	2030-2040 Offset:3-31 2030-2040 Capture: 63-315

Building Projects

This plan includes all of the FMP and Non-FMP energy projects shown in the previous sections/included in scenario A.

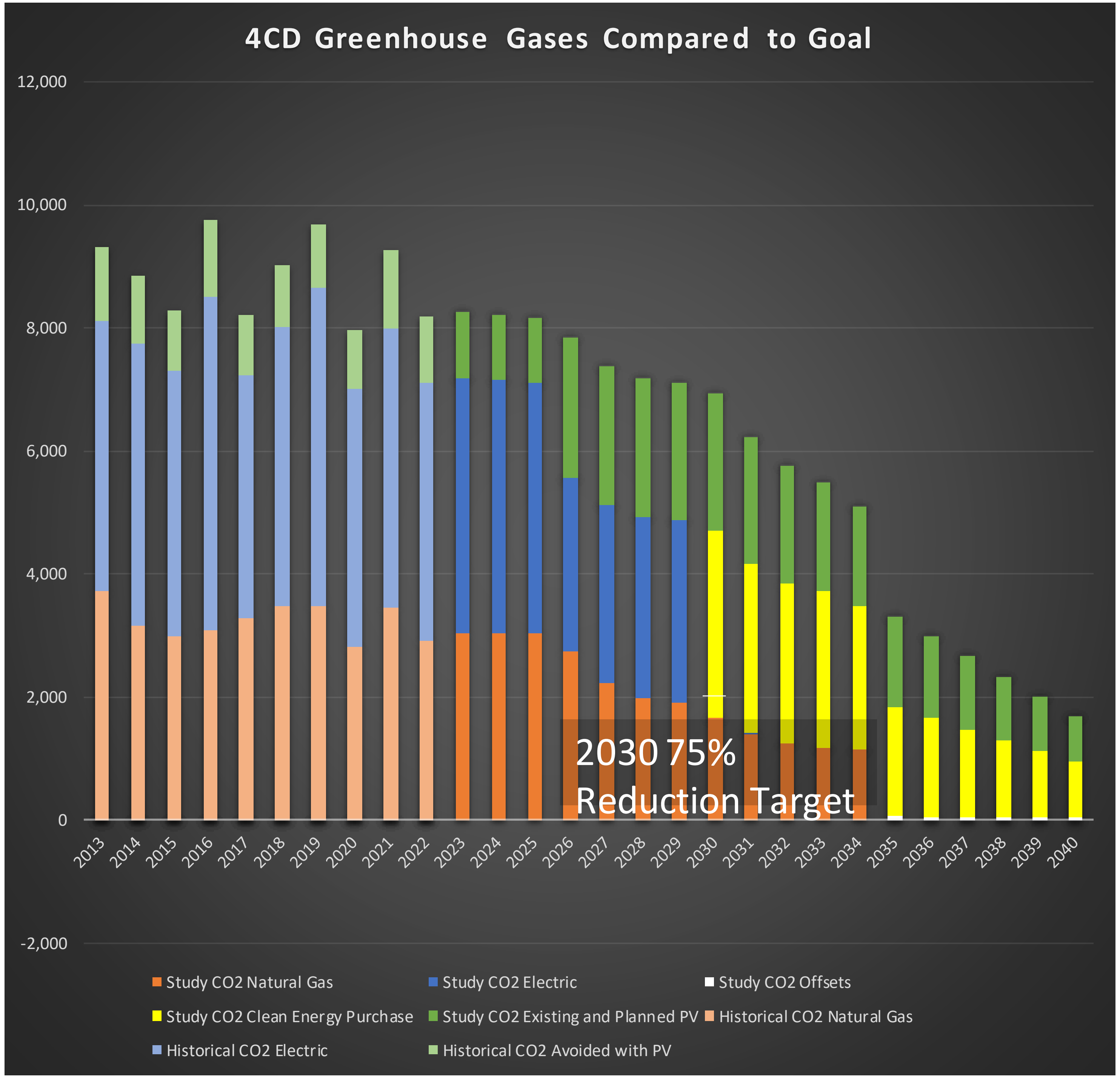
Clean Energy Purchase

Campus	Clean Energy Purchase Quantity	Clean Energy Purchase Rationale	Clean Energy Purchase Premium*
District-Wide	100% of electricity consumption for all campuses except BEC (~300,000 MWH)	Clean energy purchased for 100% of all electricity from all campuses except BEC	2030: $817,000 (in addition to regular electricity cost) 2040: $1,131,000 (in addition to regular electricity cost)

*The future costs shown for clean energy purchase are based on the current premiums escalating at the same assumed rate as electricity. In reality – the continued operation of these purchase programs and predictions of the premium cost cannot be guaranteed.

INTERFACE ENGINEERING

Scenario C – Net Emissions



This scenario has the campus meeting its 2030 75% emissions reduction target, as well as its 2035 100% emissions reduction target. Only a small amount of offsets are needed, which deal with the small amount of remaining gas consumed each year after the electrifications are completed.

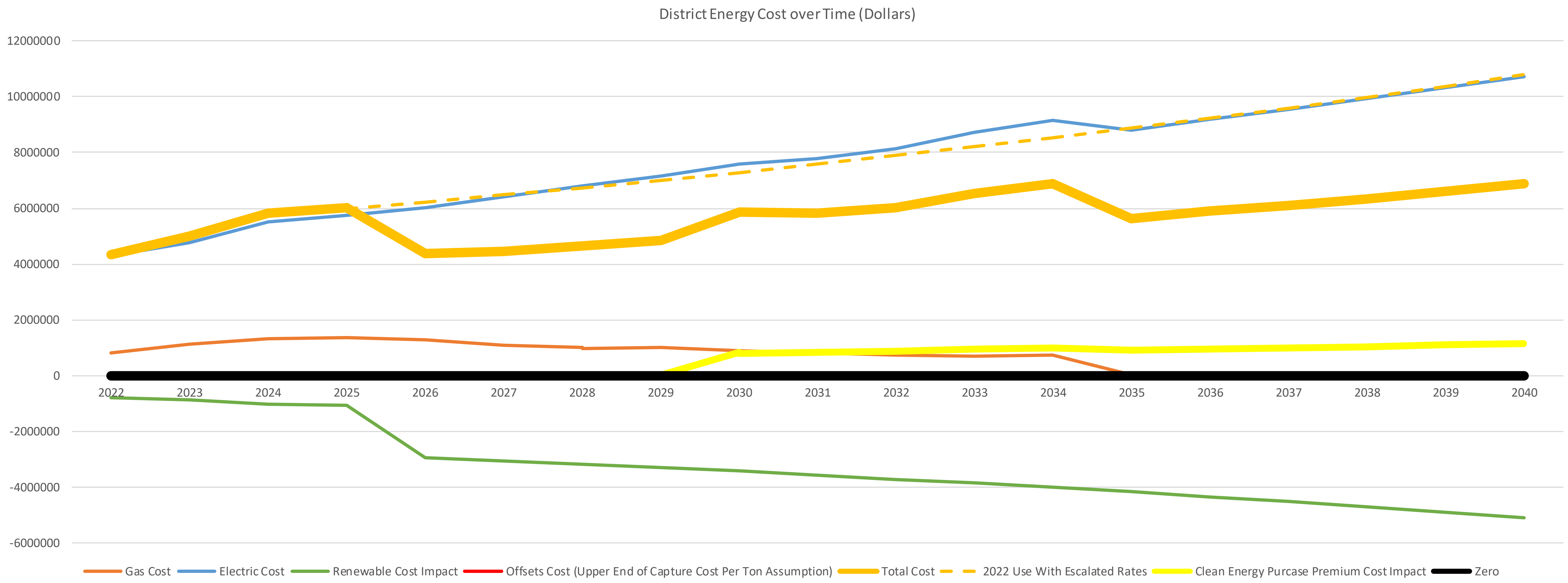
District Energy Goal	2030 Goal	2030 Goal Met	2035 Goal	2035 Goal Met
Emissions	75% Reduction	Met	100% Reduction	Met
Natural Gas Reduction	30% Reduction	Met	75% Reduction	Met
Electric Percent Renewable	75% of Electricity from Renewables	Met	NA	NA
Campus EUI Reduction	25% EUI Reduction	Met	40% EUI Reduction	Met

This scenario meets all of the campus sustainability goals.

INTERFACE ENGINEERING

Scenario C – Utility Cost Trend

This scenario incurs about a million dollars a year in operating cost from the clean energy premiums, and also loses out on about 6 million dollars of 2030 operational cost savings compared to the "Future" PV that is planned for scenario A. This plan does avert the 60 million dollars of PV installation costs in scenario A (based on 2024 PV costs), but with the higher utility operating costs, and clean energy premium cost, the payback for that investment in scenario A compared to this scenario is around 10 years. Clean energy purchase could be a good small piece of a larger strategy that still relies primarily on PV, especially for a facility like the district offices, which doesn't have space for its own PV. There is also a lot of uncertainty around the availability and cost of these clean energy purchase programs in the future, and relying on them heavily as a strategy, only for them to be taken away as an option by a utility, could leave the district scrambling to find other ways to meet its goals.



Planned PV is assumed to be installed in the year prior to the start of 2026.

Future Scenario D: Delayed Electrification, PV Matched to kWh Consumption, Offsets for Gas

Scenario D Details

Rationale

This scenario removes some of the non-FMP electrifications and matches the PV to kWh consumption and offsets to the consumption of gas. The main benefit of this scenario is that in the other scenarios, all of the large gas using facilities across the district were electrified by 2035. For most of the projects, this was fine and could coincide with the end of remaining useful life on the major HVAC equipment being electrified. Some projects, however, have newer gas using equipment and electrifications were assigned well before the end of the useful life, as well as before planned "Phase 2" renovations in the full master plan. Delaying these electrifications will avert the waste of replacing equipment that still has significant RUL.

Future PV

Campus	PV Quantity (MW)	PV Rationale	PV Cost*
DVC	3.584	100% of 2035 electricity consumption	$28,206,080
CCC	1.988	100% of 2035 electricity consumption	$15,645,560
LMC	0.953 (468 for DO + 0.485 for LMC)	100% of 2035 electricity consumption for LMC plus 100% of 2035 electricity for DO**	$7,500,110
DO	0 – see LMC	100% of 2035 electricity offset at LMC	See LMC
SRC	0.434	100% of 2035 electricity consumption	$3,415,580
BEC	0.051	100% of 2035 electricity consumption	$401,370
Total	7.01	100% of 2035 electricity consumption	$55,168,700

*All PV costs are based on 2024 project costs

**DO emissions could be associated with any of the facilities with the same emissions as DO and retain the same value and estimated cost.

Offsets

Campus	Offset Quantity (Tons)	Offset Rationale	Offset Cost (x$1,000)
District-Wide	2030-2040: 4333	All gas use, up to carbon goal	2030-2040 Offset: 42-413 2030-2040 Capture: 952-4333

Building Projects

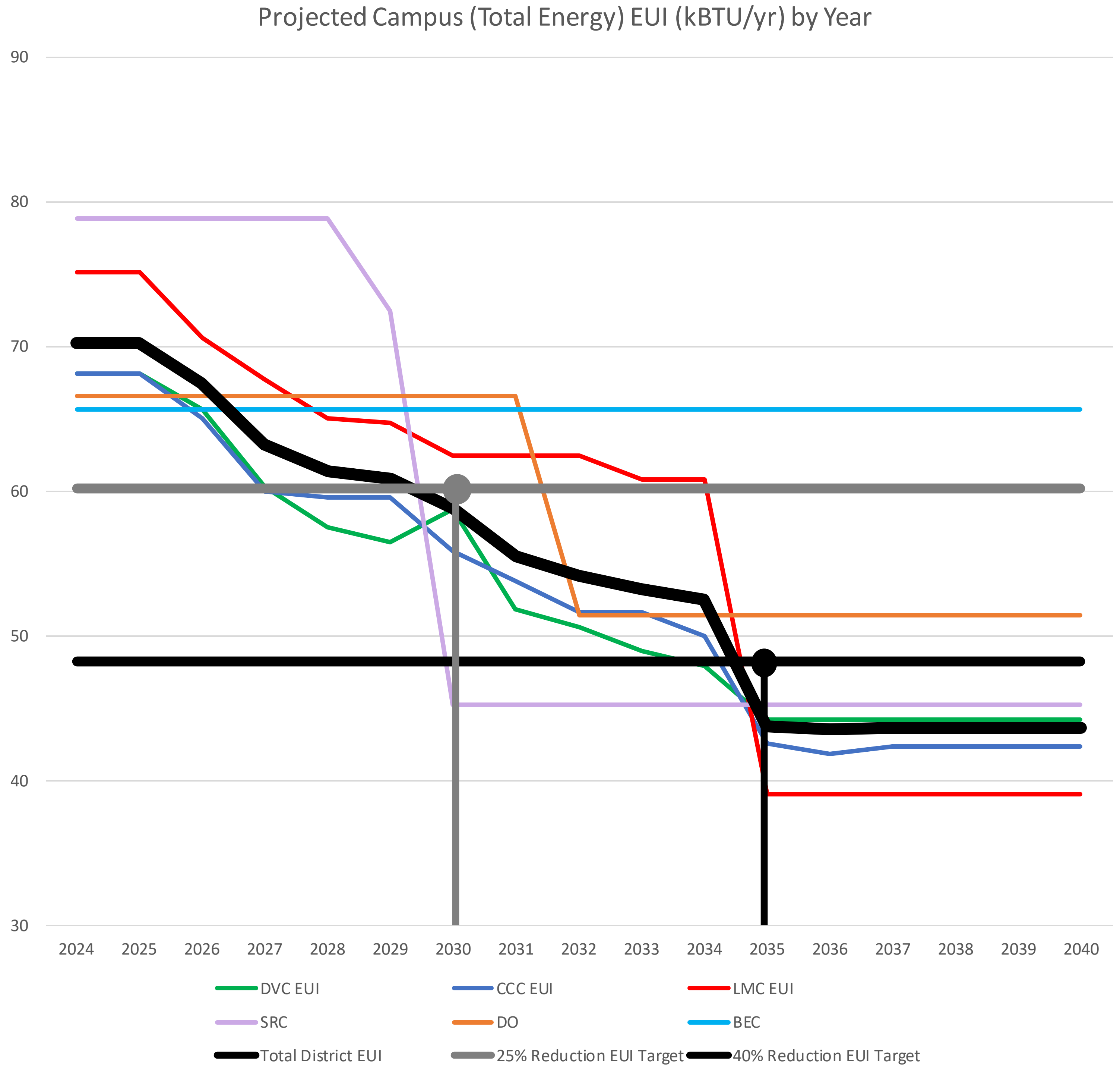
This plan includes all of the FMP and Non-FMP energy projects shown in the previous sections, except the following projects electrifications:

Building	Electrification Cost Averted
BEC	$2,561,142
LMC Math	$1,071,968
LMC Kinesiology/Athletics	$1,078,740
CCC Performing Arts Center	$718,935
CCC Atheltic Training and Kinesiology Center	$175,913
CCC Gymnasium	$875,525
CCC Student Services	$660,050
DVC Student Services	See HSF Below
DVC Hospitality/Food Court	$4,001,164

Collectively, avoiding these electrifications saves 11 million out of the 37 million dollars prescribed for electrification in scenarios A, B, and C.

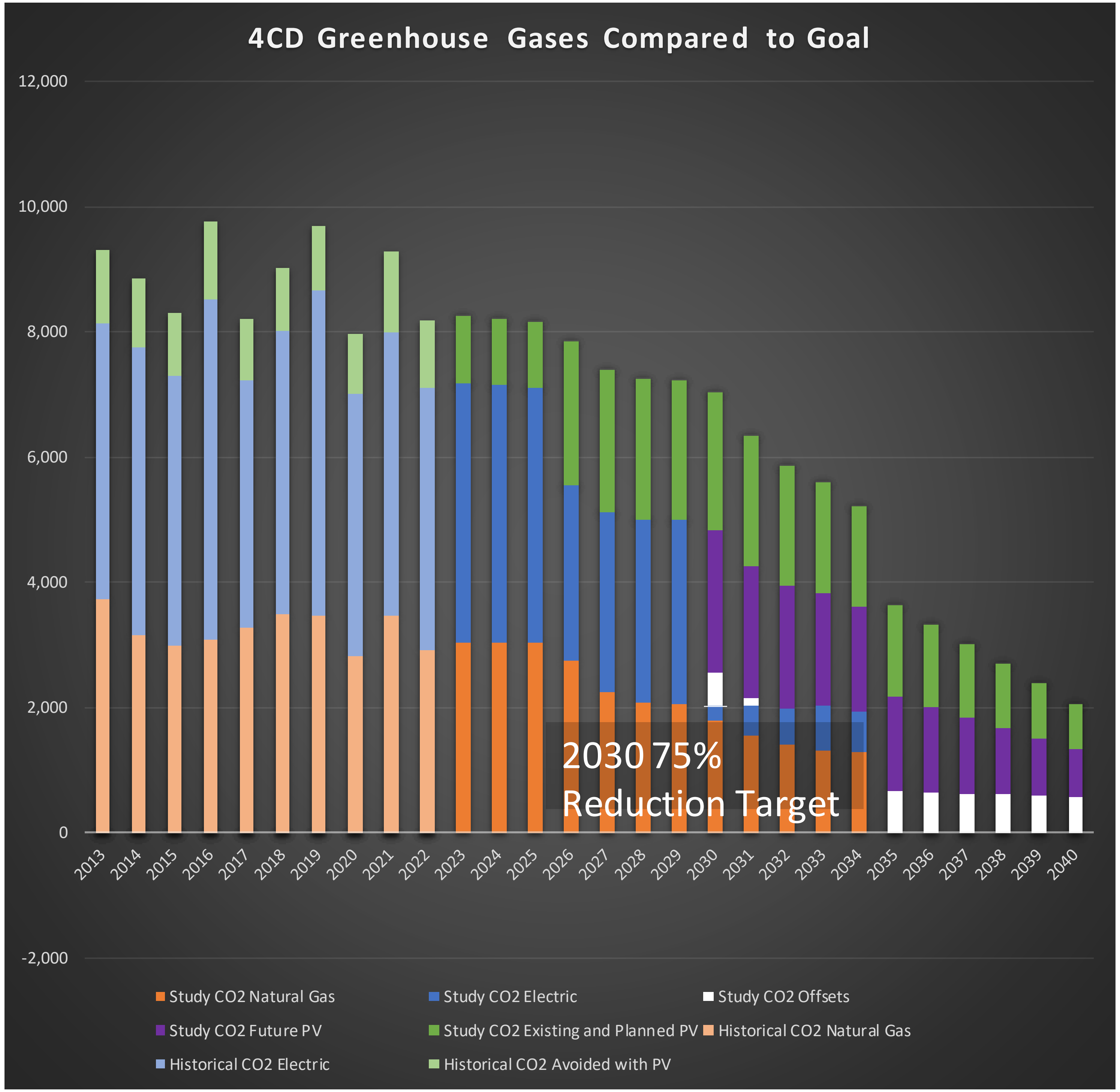
INTERFACE ENGINEERING

Scenario D – EUI Targets



The removed electrifications increase the district wide EUI about halfway from its 2035 value in scenarios A, B, and C, to its value defined by the sustainability goals. There is room to cut electrification further, if necessary, but this would require more offsets to be purchased in the later years of the study. It is still recommended to electrify these buildings when the equipment is at the end of its life, just not during the study window in this scenario.

Scenario D – Net Emissions



This scenario is somewhere in between scenarios A and B in terms of its use of PV vs Offsets. It affixes the quantity of PV to the 2035 electricity consumption, which means that going forward, as the grid becomes less emitting, both the electricity emissions and PV emissions offset are impacted equally, meaning there is no change caused to the campus emissions from the grid level change. The PV is installed in 2030, in order to help meet the 2030 campus targets. Offsets are then paired with gas consumption to handle the remaining gas from the non-electrified facilities.

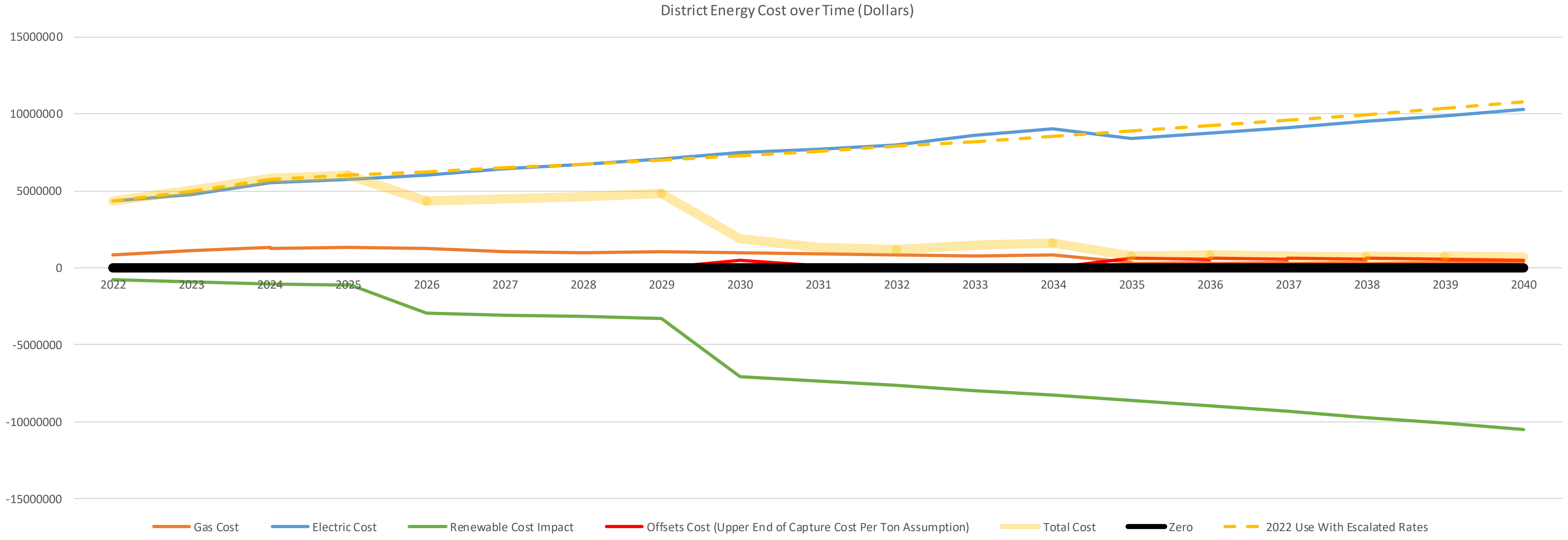
District Energy Goal	2030 Goal	2030 Goal Met	2035 Goal	2035 Goal Met
Emissions	75% Reduction	Met	100% Reduction	Met
Natural Gas Reduction	30% Reduction	Met	75% Reduction	Met
Electric Percent Renewable	75% of Electricity from Renewables	Met	NA	NA
Campus EUI Reduction	25% EUI Reduction	Met	40% EUI Reduction	Met

This scenario meets all of the campus sustainability goals.

INTERFACE ENGINEERING

Scenario D – Utility Cost Trend

This scenario averts about 5 million dollars of PV spending (2024 PV costs) relative to scenario A, and about 11 million dollars of electrification spending (based on the scheduled years of the projects in scenario A and B) relative to scenarios A and B. It has operating costs that are millions of dollars below scenario B and about $800,000 more per year than scenario A, assuming $1000 per ton of offsets purchased, which is a conservative assumption given that this scenario has the offsets being purchased later on in the study on average than in scenario B. The main financial benefit of this scenario is delaying the investment in electrification for many buildings where the equipment still has significant remaining useful life. This gives the opportunity to delay this investment until the end of the useful life, at which point the electrification cost is less impactful, since new equipment is required anyway.



Planned PV is assumed to be installed in the year prior to the start of 2026
and Future PV is assumed to be installed in the year prior to the start of 2030.

INTERFACE ENGINEERING

Scenario Future Implementation

The previously described scenarios are all different viable ways of reaching the district goals, and it is likely that the path that the district ends up taking to meet them will end up somewhere between the scenarios, instead of matching any one of them perfectly. The important thing is to consider the factors by which deviations from our predictions could impact what strategies are most valuable:

1. If the grid were to fail to improve its emissions rates at speed legislated by CA SB100, then this would increase the relative strength of PV projects and LED projects, whilst decreasing the positive impacts of electrification. Likewise, if the grid were to lower its emissions significantly faster than expected, electrification should become a higher priority.

2. Changes to the cost and efficacy of various carbon offset and removal programs should be monitored in order to make a judgement call of how much the district can rely on those offerings. Many organizations and institutions are moving away from offsets as academic research often finds the actual carbon impacts to be overstated. There is also a belief among some that the costs of offsets will change drastically in the coming years. Carbon removal technology is currently at a priced around $1,000 per ton and is not widely available to purchase, but is expected to decrease in cost and expand in scale with government support and economies of scale. It is important to monitor changes to this technology in the future. Luckily, there is a still a few years before the district would need to decide how much to rely on this tool. More resources on Carbon Offset and Removal are located in appendix A.

Scenario Future Implementation – Cont.

The effectiveness of electrification increases with improvements to the emissions rate of the grid, so it is important to consider that both the trans-critical heat pump technology, and the grid, will improve significantly over the period of time covered in this study. The current scenarios save a large amount of electrification projects until near the 2035 net zero district goal. Moving around the campus projects within the window of 2024-2034 will not impact the campus' ability to meet its goals, but it may be a good idea to make sure some earlier electrification and trans-critical heat pump projects are done, so that there is familiarity with the nature of the projects when the larger bulk of planned electrifications approach in the 2030s.

The building benchmarking study was primarily based on 2022 weather normalized data, due to the impacts of covid and construction/demolition to the campus operation in prior years. This means that we should expect the energy trends of the campus to vary going forward, based on both the small chronological sample of our data, as well as year by year weather differences. The quantities of PV and carbon offsets needed could go up or down in the long run due to changes in operation relative to 2022. Individual years with weather that causes higher or lower energy use than expected may cause the district to not have its energy and emissions completely covered by PV, or the district could end up with more PV than needed.

APPENDIX A

Resources and Information Around Carbon Offsets and Capture

Carbon Offset Resources and Information

The University of California has all but dropped carbon offsets—and thinks you should, too | MIT Technology Review
https://www.technologyreview.com/2023/11/30/1084104/the-university-of-california-has-all-but-dropped-carbon-offsets-and-thinks-you-should-too/

2023 Climate Tech Companies to Watch: Climeworks and its carbon-sucking fans | MIT Technology Review
https://www.technologyreview.com/2023/10/04/1080109/2023-climate-tech-companies-climeworks-carbon-removal-direct-air-capture/

What is the most cost-effective way to buy carbon offsets? | MIT Climate Portal
https://climate.mit.edu/ask-mit/what-most-cost-effective-way-buy-carbon-offsets

Carbon offsets price may rise 3,000% by 2029 under tighter rules | Insights | Bloomberg Professional Services
https://www.bloomberg.com/professional/insights/trading/carbon-offsets-price-may-rise-3000-by-2029-under-tighter-rules/

Price slump in 2023 clouds outlook for voluntary carbon market | S&P Global Commodity Insights (spglobal.com)
https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010524-price-slump-in-2023-clouds-outlook-for-voluntary-carbon-market