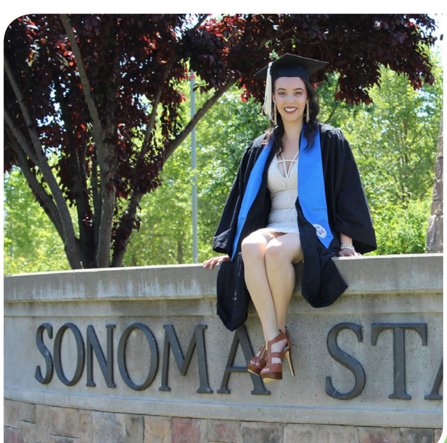
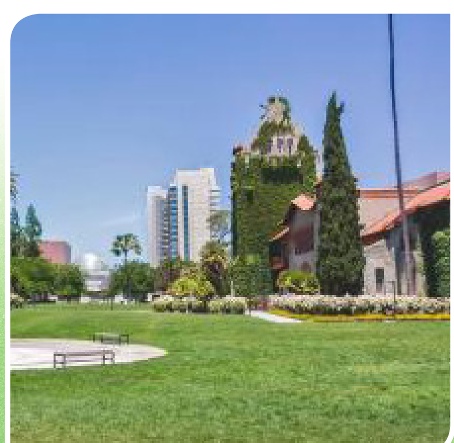
CARBON NEUTRALITY ROADMAP

SONOMA STATE UNIVERSITY





LETTER FROM SUSTAINABILITY CO-CHAIRS

Under the visionary leadership of SSU President Judy Sakaki, SSU joined the University Presidents' Climate Commitment on April 5, 2019. Her signature set in motion a series of efforts to address climate change impacts affecting our education and research mission and placing our students, employees and communities at risk.

The SSU Climate Action Plan, scheduled for completion in May 2022, will lay out a path with concrete, measurable actions needed to: (1) reduce our carbon emissions, (2) increase resilience to climate-related events, and (3) prepare our students for careers in a changing world. We hope to inspire every SSU student to magnify what they learn while at SSU to greater effect around the world.

This document, the Carbon Neutrality Roadmap (CNR), is an integral part of the Climate Action Plan. It establishes a path to carbon neutrality by 2043 and will be appended in its entirety to the Climate Action Plan.

In the coming months, we will be working with stakeholders to synthesize ideas, strategies, and approaches that integrate the carbon neutrality goals with resilience and academic planning to create a concise and actionable Climate Action Plan.

The 1.5 degrees C tipping point is not far off, but we have the tools, creativity, and willpower to change our trajectory. Let's get to work!

Megan Varnadore
Director of Resiliency and Sustainability Operations

Claudia Luke
Sustainability Programs Director

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

As a member of the 23-campus California State University system, Sonoma State University (SSU) is proud to serve a diverse student population on campus, its three environmental preserves, and satellite campuses. In 2019, President Judy K. Sakaki signed two seminal documents to guide the future of SSU. “Building Our Future: Strategic Plan 2025” highlights the university’s commitment to the core values of diversity and social justice; sustainability and environmental inquiry; connectivity and community engagement; and adaptability and responsiveness. The “Presidents’ Climate Leadership Commitment,” a program of Second Nature, committed SSU to draft a Climate Action Plan that lays out a pathway for achieving carbon neutrality, increasing regional resilience, and integrating sustainability across curriculum and research.

This document, the Carbon Neutrality Roadmap (CNR), outlines a plan to achieve **carbon neutrality by 2043**. Carbon neutrality is defined as reducing campus greenhouse gas (GHG) emissions to zero (i.e., net zero emissions). This bold commitment necessitates ambitious strategic policies and programs that are outlined in this report.

APPROACH AND BACKGROUND

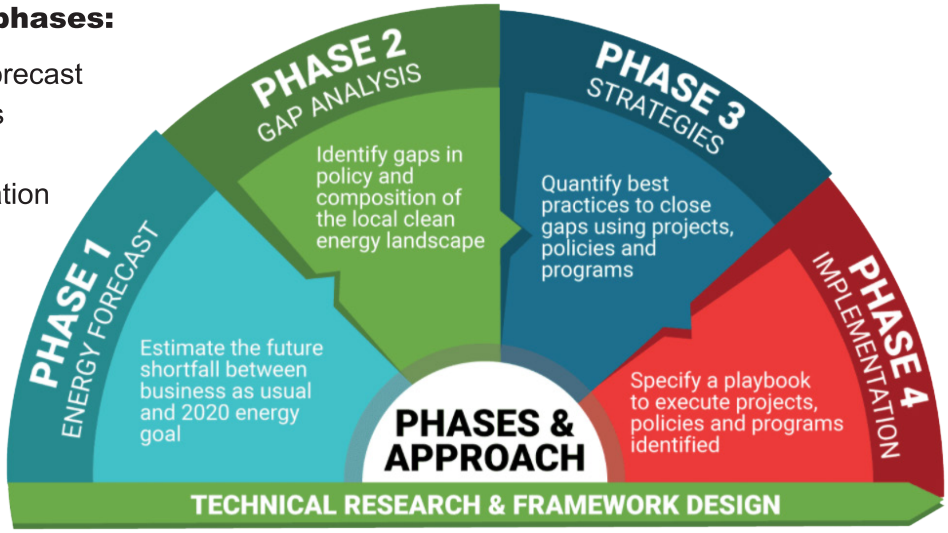
The CNR is an actionable, relevant document that identifies strategies and actions needed to meet SSU’s net zero emissions goal. An accompanying Climate and Energy Scenario Analysis (CESA) tool allows the campus to track efforts and quantitatively assess progress towards this goal.

REPORTING TO SECOND NATURE

As CNR strategies are implemented over time, progress is captured using a Sustainability Tracker. This progress is then reported annually to Second Nature through the STARS (Sustainability Assessment Tracking & Rating System) framework.

The report is divided into four phases:

Phase 1: Baseline and Emission Forecast
Phase 2: Framing the Gap Analysis
Phase 3: Scenarios and Individual Strategies for Implementation
Phase 4: Implementation Timeline and Budget



For the purposes of carbon accounting, carbon emissions can be divided into three scopes known as Scope **1**, Scope **2** and Scope **3**.[1]

Scope 1

Carbon emissions relating directly from fuel burned on campus (primarily natural gas for heating) or university-owned vehicles.

Scope 2

Carbon emissions associated with energy purchased by SSU and generated elsewhere, (primarily grid electricity used on campus).

Scope 3

Carbon emissions resulting indirectly from SSU operations such as those associated with student, faculty and staff commuting, faculty and staff travel, waste, food purchasing or other procurement activities.

The Presidents' Climate Leadership Commitment does not specifically define the parameters for carbon neutrality accounting which leaves flexibility in defining which scope emissions to include in the planning process. SSU has included all **Scope 1 and 2 emissions** in this CNR. Although Scope 3 emissions are more difficult to quantify, SSU remains committed to prioritizing behavioral change programs and policies which address these emissions. Specific Scope 3 strategies are outlined on page xxx.

This CNR identifies solutions that result in **carbon reduction rather than carbon offsets**. This decision was made for three reasons. First, the spirit in which the commitment was made sought to challenge the campus community to develop its own solutions, rather than simply pay for offsets produced by others. Second, there is significant difficulty in determining the additionality of carbon offsets. Additionality is the concept of whether purchased carbon offsets actually resulted in carbon emissions reductions that would not have happened without the investment used to purchase the offsets. Third, there are important local benefits in the form of air quality improvements, energy cost savings and campus resilience that can be achieved through carbon reduction strategies that require investments on campus. Accordingly, carbon offsets are not included in any of the scenarios.

[1] *https://www.epa.gov/greeningepa/greenhouse-gases-epa#:~:text=Scope%201%20GHG%20emissions%20are, combustion%20and%20fleet%20fuel%20consumption.*

The implementation of the CNR has significant potential to support other initiatives on campus, in the region, and across the state, including efforts in climate action planning, economic development and resilience to extreme events (**Figure A**).

BENEFITS AND OUTCOMES

ALIGN WITH LOCAL CLIMATE ACTION PLAN	CONTRIBUTE TO GLOBAL CLIMATE ACTION	PROMOTE LOCAL ECONOMIC DEVELOPMENT	ENHANCE DISASTER RESILIENCY	REACH CSU GOALS
Align with the priorities to be outlined in the 2022 Climate Action Plan.	Decrease greenhouse gas emissions by 100% by XXX.	Produce green jobs in the solar and the energy efficiency industries.	Continue operation of critical facilities and services during disasters.	Share best practices with other CSU campuses.

Figure A. *Benefits and outcomes of strategies*

RECOMMENDED STRATEGIES

Phases 1-3 identify four strategies needed for SSU to achieve carbon neutrality:

1: Reduce building electricity consumption with energy efficiency. This will require a budgetary commitment towards new energy efficient technologies (lighting, HVAC recommissioning, and other various building systems).

2: Achieve 100% building electrification (e.g., replace fossil fuel energy sources with heat pump water heaters). This will require a budgetary commitment towards new mechanical systems.

3: Replace fossil fueled vehicles with electric options. This will require a budgetary commitment towards the purchase of new electric vehicles and infrastructure for charging.

4: Implement behavior change actions with conscious focus on social and environmental impacts.

Recommended scenarios were determined using specific, measurable, achievable, relevant, and timely (SMART) considerations. These specific measurements allow SSU to follow a concrete time frame for strategy completion driven by the feasibility and costs of each action. For each strategy, we provide a list of specific actions and projects.

SCENARIOS

We used the Climate and Energy Scenario Analysis (CESA) tool to test and create three scenarios to carbon reduction. The scenarios (Figure B) align growth, phasing, and infrastructure investment over various time horizons and can be adjusted as market trends change or to account for budgetary uncertainty.

SCENARIO LEVEL I	SCENARIO LEVEL II	SCENARIO LEVEL III
Key Characteristics	**Key Characteristics**	**Key Characteristics**
6 Solar projects with installations in 2022, ‘24, ‘26 and ‘30 Fleet Replacement with EVs according to existing schedule Lighting and HVAC retrofits completed over next ten years, plus base central heating upgrades.[2]	6 Rooftop Solar projects with installations in 2022, ‘24, ‘26 and ‘30 Fleet Replacement with EVs according to existing schedule Lighting and HVAC retrofits, plus retro-commissioning and building electrification; plus base central heating upgrades[1] and partial CUP electrification.	6 Rooftop Solar projects with installations in 2022, ‘24, ‘26 and ‘30 Fleet Replacement with EVs according to existing schedule Lighting and HVAC retrofits, plus retro-commissioning and building electrification; plus base central heating upgrades[1] and partial CUP electrification.
Considerations	**Considerations**	**Considerations**
Follows SSU’s standard HVAC and fleet replacement schedules Additional cost considerations (price premiums) Benefits of improvements accrue more slowly Will not achieve carbon neutrality without offsets	Higher investment required relative to the Level I approach Additional cost considerations (price premiums) Benefits accrue more rapidly than Level I Will not achieve carbon neutrality without offsets	Higher investment required each year relative to the Level I Phased approach Additional cost considerations (price premiums) Benefits accrue more rapidly than Levels I or II Achieves full carbon neutrality without the use of offsets by 2043
Impact	**Impact**	**Impact**
Achieves 18% GHG reductions by 2043 Total GHG Reductions = 52,950 MT CO2e	Achieves 49% GHG reductions by 2050 Total GHG Reductions = 97,863 MT CO2e	Achieves 100% of GHG reductions by 2043 Total GHG Reductions = 146,689 MT CO2e

Figure B. *Key Characteristics with each Scenario*

The three scenarios are differentiated by the level of investment required and impact on GHG levels. Level 1 scenario includes the installation of six solar PV projects on campus property, full replacement of fleet with electric vehicles (according to the existing schedule), and over 60 energy efficiency measures from lighting to HVAC retrofits. It also includes vital repairs to HHW leaks and optimizing HHW controls. Level II scenario includes all the measures from Level I, but adds additional energy efficiency measures including a series of retro-commissioning and building electrification projects, and a heat recovery chiller to the central plant. Level III scenario includes projects in Levels I and II, but adds additional building electrification, and an air-source heat pump for full electrification of the central plant. The Level III scenario is the only one to achieve full carbon neutrality without the use of carbon offsets.

RESOURCES REQUIRED

The CNR includes a thorough breakdown of costs and benefits associated with individual projects and each scenario.

Senario 1	Senario 2	Senario 3
$XX Million, **18%** GHG reduction	**$XX Million**, **49%** GHG reduction	**$XX Million**, **100%** GHG reduction

Depending on the scenario, capital costs range from an average of $1.4 million per year to $2.5 million per year.

In addition to capital costs, dedicated staff (at least 1.0 FTE) are needed to secure funding for projects, coordinate implementation, and monitor and report on results. New systems installed may require training or new maintenance staff.

The good news is that **cost savings far outweigh the costs of implementation** (i.e., the Net Present Value (NPV) of these investments is overwhelmingly positive) for all scenarios and the majority of individual projects, Cost savings accrue primarily from a reduction in energy used and maintenance savings.

Achieving carbon neutrality and the associated financial benefits requires early upfront investments. The greater the initial level of investment, the greater the financial and environmental reward. With early investment, the campus can benefit from significant cost savings that can also be used for other timely investments. On the flip side, the investments tend to become more costly the longer they are delayed.

SSU has an opportunity to lead by example and take the necessary steps to reach carbon neutrality by 2043.

[2] *The base heating hot water plant upgrade is a deferred maintenance project that includes repairing leaks, heat exchanger replacements and system optimization to reduce heating hot water temperatures. Since little is known about the extent of the leakage in the system, costs have not been estimated for this project. Furthermore, this project appears as the first central plant project in all Investment Level Scenarios since it will be required before other central plant and electrification projects are completed.*

CARBON NEUTRALITY ROADMAP

SONOMA STATE UNIVERSITY

PLANNING PROCESS

PHASE 1

PHASE 1: BASELINE & EMISSIONS FORECAST

An emissions baseline represents the amount of emissions in a baseline year (in this case 2020), and an emissions forecast provides a projection of the amount and sources of emissions SSU would most likely generate through 2043. The baseline and forecast serve as reference points for reduction targets and inform the strategy and action selection process. This is referred to as a business-as-usual (BAU) scenario. Under a business-as-usual scenario, as shown by the black line in **Figure B**, in which SSU does not change its operations in any way, emissions are projected to decrease by 6,000 metric tons (MT), from a high in 2023 of 10,757 MT, to 4,702 MT by 2043. The reduction is due to the assumption that California's renewable portfolio standards (RPS) will be realized by electricity providers. (The dip in 2021 represents the effect of COVID-19 on campus activities. An increase in emissions is expected, as full campus functions return to 2019 levels.)

Though the decrease in emissions from RPS is significant, it is clear that SSU will not achieve its carbon neutrality goal without significant operational changes. For example, SSU's current energy efficiency levels represent a significant challenge to achieving its carbon neutrality goal. The current level of building efficiency creates both challenges and opportunities in relation to achieving carbon neutrality. Challenges arise if important investments are not made; however, opportunities exist to harmonize investments in maintenance with emission reduction goals. Further, though student enrollments are currently below normal levels, this trend is not expected to continue. Eventual campus growth could easily result in increased carbon emissions, if nothing is done to mitigate those emissions. However, the revenue that also results from growth, can be leveraged to realize the significant rewards discussed in this report, including the move toward a carbon neutral future.

COVID CONSIDERATIONS

The COVID virus has had significant impacts on campus life and operations at SSU, the most significant of which will be realized in financial year (FY) 2021. Electricity use in FY2020 fell by 43% from 2019, and natural gas usage fell by 21%.Consumption totals in both categories are expected to fall further in FY2021 before rising in 2022 and 2023 as normal campus activities begin again.

Additionally, SSU can build on its track record of successful energy management achieved during past campus growth. To date, SSU has effectively managed carbon emissions related to campus growth through strategic energy efficiency improvements and renewable energy development. Since xxx, building energy use intensity (EUI) has decreased while building square footage has increased indicating that campus energy usage has remained stable despite growth. Additionally, in 2022, SSU will build a 5 MW solar array to meet a portion of its electricity demand with 100% renewable energy.

[3] https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx. [4] Figures based on SIMAP inputs from FY2019, and utility bills from FY2020.

EMISSIONS FORECAST

- Onsite renewable generation
- Natural gas usage
- Fertilizer usage
- Annual solid waste volume
- Employee travel information
- Liquid fuel usage in campus vehicles
- Staff/student commute data
- Capital Improvement Plan
- A 1% increase in student and faculty population

Figure B: *SSU Emissions Sources & Scopes*

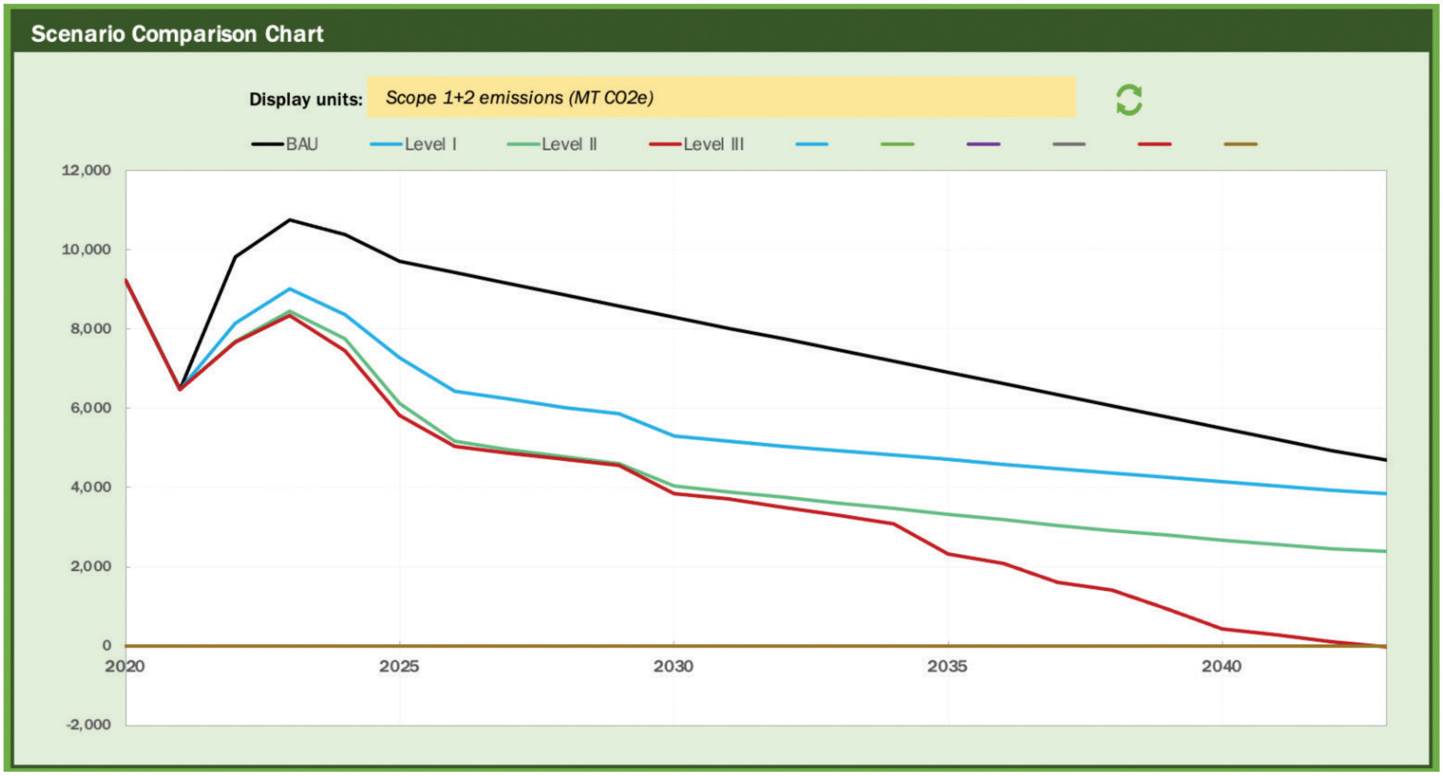


Figure C*: BAU Energy Use and Emissions (2020-2050)*

Figure C represents emission reductions from the BAU and the three investment levels. The initial dip and rise are the effects of COVID and the recovery period. The black BAU line shows a steady decrease in emissions as grid suppliers gradually source electricity from renewable generation. The blue line shows investment Level I. Reductions in GHG from renewable energy installations, fleet replacement and some energy efficiency retrofits accelerate the BAU pathway. The green line shows the effects of investment Level II. GHG reductions from this scenario are realized from additional energy efficiency measures (especially HVAC retrofits, building electrification, and central plant projects). The red line shows the effects of investment Level III. As can be seen, the investments are similar to Level II through 2030, but then increase to accelerate the achievement of carbon neutrality, which is realized by 2043. These additional investments include a full suite of building electrification and additional investments in the central plant.

BRITISH THERMAL UNITS

(Btu) are units of energy equivalent to the amount of heat required to increase the temperature of one pound of water by one degree. By measuring energy use in Btu, it is possible to combine energy from energy, natural gas, and vehicle use into one common metric. kBtu is equivalent to 1,000 Btu.

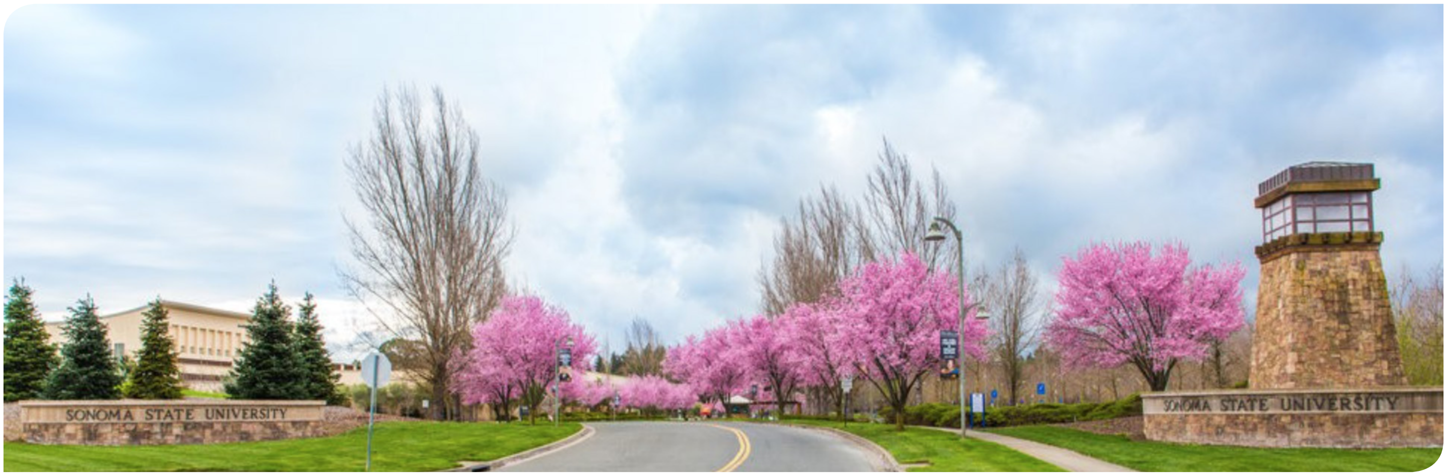
PHASE 2

PHASE 2: FRAMING THE GAP ANALYSIS

As part of this process, SSU reviewed current policies and programs and produced a comprehensive, annotated list of high-impact strategies that could be analyzed and prioritized based on feasibility, financial considerations, health benefits, and equity. Figure D outlines strategies and considerations focused primarily on energy use and fleet management which contribute the largest percentage of GHG emissions. Broad sustainability strategies such as procurement, food and waste were also considered. Although these sectors contribute very little to reducing GHG emissions, they are mentioned in this CNR and will serve as foundational elements for the upcoming 2022 Climate Action Plan.

KEY FINDINGS:

- Buildings represent the largest component of SSU energy and emissions
- Powering buildings on clean electricity is one of the most cost-effective ways to reduce emissions
- Adopting clean vehicle technology will have a major impact on reducing transportation emissions
- Without further action, SSU will not meet internal greenhouse gas reduction goals and is not aligned with statewide goals or scientific consensus on avoiding the worst impacts of climate change



STRATEGIES & CONDITIONING

POLICY	STRATEGIES	CONSIDERATIONS
Green building policy	Adopt requirements for EV charging installations	Are there ways to promote SSU as a leader in the state?
Fleet purchasing policy **Disaster planning policy**	Target net zero emissions in all facilities Eliminate natural gas use in all facilities Right size the fleet so vehicles are used more efficiently and therefore replaced more frequently, allowing for faster adoption of electric vehicles Transition to electric or hybrid vehicles Focus on energy resiliency	
Resolution to commit to 100% renewable energy	Install rooftop solar Improve Building Energy Management Systems Increase energy efficiency in buildings and waste water treatment	How many projects can SSU implement each year given the allocation of staff and funding? What are the trade-offs to investing more money upfront versus phasing projects over a longer period of time? What role do renewable energy credits play in helping SSU reach its goal and what type of credits should be considered?
Adopt new approaches to financing	Streamline the internal Green Revolving Fund process Consider Pilot Projects Align Capital Improvement Plan budget Access third party financing Consider Public Private Partnerships	How can the SSU align the annual budget with the strategies in the CNR?

Figure D: *Strategies and Considerations for carbon neutrality*

PHASE 3

PHASE 3 PART 1: SUMMARY OF SCENARIOS

The primary difference between scenarios is the level of investment that occurs, the rate at which benefits accrue, the level of GHG that is reduced, and the expense per MT of that reduction. Implementing projects earlier in the process will reduce GHG emissions earlier (thus increasing the overall reduction) while increasing return on investment.

LEVEL I SCENARIO

The Level I Investment Scenario accelerates the reduction of GHG, from a BAU case; however, by 2043 the reductions from the BAU case largely catch up with those from Level I. Reductions primarily come from solar installations on campus, and the replacement of the campus fleet with electric vehicles. It also includes lighting and HVAC retrofits in many campus buildings. The investment cost for Level I is $29.9 million, which occurs mostly between the years of 2022 (when the SunPower project will be initiated) and 2030. The fleet replacements (including golf carts) are scheduled to happen during the regular replacement cycle of current vehicles, and therefore are not considered in the budget. What is considered, however, is the electrical charging infrastructure that will be required to keep the new vehicles charged.

Importantly, this scenario (and the others as well) also includes an unbudgeted assessment and repair of heating and hot water (HHW) leaks and HHW control optimization. Currently little is known about the extent of the leaks, and to adequately assess the costs for repair, a full study is required. The cost of the study and repairs have therefore not been included in the initial investment for Level I. However, this measure must be accomplished in order for later interventions to be effective. Under this Scenario it is recommended for completion in 2025.

As outlined in Figure F, the Level I Scenario would accelerate the reduction of GHG for SSU compared to the baseline. The acceleration reduces GHG by 52,950 MT. The cost of this reduction is $171/MT of CO2 reduced. Moreover, the NPV for the scenario is $9.1 million, which means the discounted cash flows are net positive by this amount, signifying a highly cash-positive investment[5].

[5] NPVs for all of the Scenarios are calculated using the same financing pathway. The pathway consists of PPAs for all solar PV projects, cash for all electricity efficiency projects and capital improvements (vehicle charging infrastructure), and a business-as-usual expense for fleet replacement to electric vehicles according to existing replacement schedule. This pathway does not necessarily represent an optimized financing structure. For example, the use of low and zero interest borrowing for early energy efficiency projects will raise scenario NPVs.

LEVEL II SCENARIO

The Level II Investment Scenario accelerates the reduction of GHG further, and has the added benefit of maintaining a lower total of GHG emissions than the BAU well beyond the year 2043. Level II reductions come from all projects in Level I, but also include a series of retro-commissioning projects, two significant HVAC retrofits, over a dozen building electrification projects, and one additional central plant project. This is one of the more expensive projects from the menu, costing $2.4 million. Under this scenario the first phase of the central plant electrification project would occur in 2025, while the HHW leak repair and optimization project mentioned under Level I would be required in 2022. The most significant investments under this scenario happen between the years of 2022 and 2030, with two additional large projects (the HVAC retrofits mentioned above, each costing about $1.3 million) being added in 2035 and 2040. The total cost of the series of Level II projects is $36.1[6] million.

The series of Level II investments brings overall reductions of 97,863 MT at a cost of $105 per MT of reduced CO2. The NPV for Level II is slightly higher than that of Level I, at $10.3 million, indicating additional projects that aggregate to positive returns. The reason is the added value of maintenance and energy cost savings that accrue to the additional energy efficiency projects included in this scenario.

LEVEL III SCENARIO

The Level III Investment Scenario adds additional investments to those found in Levels I and II, and reduces GHG emissions to zero in 2043 and beyond. Level III reductions come from nearly all projects in Levels I and II, but also include two dozen additional building electrification projects, and a final central plant project that adds an air-source heat pump for full electrification. This heat pump and one of the building electrification projects (at Sauvignon Village), are the two most expensive projects from the menu, costing $2.8 and $3.2 million respectively. However, they bring large benefits from a GHG reduction perspective as they transfer energy usage from large quantities of natural gas, to electricity, which can then be supplied from renewable sources. These investments are scheduled to take place in 2035 (heat pump) and 2039 (building electrification). The full cost of all projects in the Level III recommendations is $53.3[7] million, over 20 years.

Level III has several advantages over the other scenarios, despite its price tag. It is able to reach lower emission levels sooner, thereby reducing total emissions. It also brings SSU to full carbon neutrality without having to resort to the ongoing purchases of carbon offsets. The NPV is close to the other two investment scenarios at $9.1 million, and still demonstrates strong positive cash flow and investment returns from maintenance and energy savings. Furthermore, there are a series of available, innovative financing strategies that will allow SSU to leverage a relatively small amount of capital to realize these gains.

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[6] *This does not include the cost of base heating hot water upgrades (required for central plant electrification) . This is being treated as deferred maintenance cost - upgrades are required regardless of carbon neutrality targets.*

[7] *This does not include the cost of base heating hot water upgrades (required for central plant electrification) . This is being treated as deferred maintenance cost - upgrades are required regardless of carbon neutrality targets.*

INVESTMENT LEVEL	INCLUDES	NPV ($ MILLION)	INITIAL COSTS ($ MILLION)	$/MT CO2E REDUCED	TOTAL CO2E REDUCTIONS
Level I	All RE, Fleet and some EE	9.06	29.9	171	52,950
Level II	All RE, Fleet, additional EE	10.31	36.1	105	97,863
Level III	All RE, Fleet and all EE	9.14	53.3	62	146,689

CSU WIDE COMMUNITY CHOICE AGGREGATION

Currently, a CCA program has been considered in the past at the Chancellor's office which might influence the timing and implementation of this CNR. CCA is a mechanism used throughout California to provide local control over a community's electricity mix. A CSU-wide CCA would be a Joint Powers Authority with the ability to sign long-term power procurement contracts on behalf of every CSU campus. By shifting the authority to determine the mix of electricity supplied to campuses, a CCA would enable the transition of SSU's electricity supply to 100% carbon free energy faster than California's statewide Renewable Energy Portfolio standard (currently targeted for 2045).

Without a CCA, SSU would have to invest significantly in local renewable energy and energy efficiency to achieve its carbon neutrality goal without carbon offsets, making its goal less financially feasible. A CSU-wide CCA provides a mechanism to address not only current emissions associated with electricity but also future emissions resulting from increased electricity use caused by the vehicle and heating electrification included in the CNR carbon reduction measures. Additionally, a CCA provides another mechanism for the Chancellor's Office to fund carbon reduction efforts on campus (e.g. building electrification), as all campuses that join would be paying the CCA for electricity, enabling excess revenue to be easily redirected back to campus specifically targeted for climate projects.

PHASE 3

PHASE 3 PART 2: SUMMARY OF INDIVIDUAL STRATEGIES FOR IMPLEMENTATION

From this point, SSU can drill down to specific actions and metric criteria for each of the developed scenarios. Specific details for each strategy will allow SSU to follow a concrete time frame for strategy completion driven by the feasibility and costs of each action within SSU. Strategies are designed to align with other SSU plans such as the 2022 Climate Action Plan, Resiliency Plan and the Capital Improvement Plan.

Within each scenario, strategies were first ranked based on Net Present Value and the highest potential for greenhouse gas emission reductions. A second review assigned social and environmental co-benefits to each strategy; the most prominent co-benefits are outlined in **Figure G**.

SSU has identified four objectives that will help the campus reach its carbon neutrality goal: (1) improve building performance, (2) increase renewable energy generation, (3) increase vehicle fleet efficiency and (4) increase the impact of behavioral change programs. A careful analysis was conducted and challenges and strategies were considered in order to frame each objective. An objective is defined as an end result or target that provides a broad framework for SSU to work within. From these objectives, specific actions are then defined that will lead to greenhouse gas emissions reductions.

SYMBOL				
CO-BENEFIT	High potential to **save money**	High potential to **ensure equity**	High potential to **create jobs**	High potential to **improve public health**

OBJECTIVE 1 – IMPROVE BUILDING PERFORMANCE

SSU has over two million square feet of buildings including academic classrooms, administrative offices and residential apartments. Reducing energy consumption in existing facilities and optimizing existing operations is an essential part of reducing overall carbon emissions and meeting the SSU climate action plan goals. Approximately 60% of campus buildings were built pre-2000s when energy codes were not as stringent as modern standards. There are significant opportunities to reduce energy demand and carbon emissions by optimizing existing heating, ventilation and air conditions (HVAC) and lighting systems. Given California's path toward 100% carbon free electricity by 2045, reducing natural gas consumption will be critical for SSU to meet their carbon neutrality goals. Energy projects can be implemented as energy retrofit projects or part of larger building renewal efforts. The Stevenson Building renovation project is a great example of how a whole building renovation can support SSU's long term carbon neutrality goals.

Outlined below are specific strategies and actions that are recommended. A key strategy for SSU is to develop a campus energy efficiency program, which will require a full-time, dedicated energy/sustainability manager. This person will be responsible for establishing energy efficiency criteria, managing energy funding and financing, supporting project execution and overseeing retrofit and commissioning programs. This energy manager can be supported by student interns which will also provide hands-on work experience prior to graduation.

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
1A	Establish a campus energy efficiency (EE) program to reduce energy demand	Hire a full-time energy manager and establish an annual energy investment plan		Annual energy efficiency investment ($)	Short Term	Facilities Management
		Complete a campus LED lighting retrofit program		Annual EUI reduction (kBtu/sf-yr)	Short Term	
		Establish a campus RCx / continuous commissioning program			Short Term	
		Identify optimal HVAC upgrade projects and establish funding & financing sources			Mid to Long Term	
1B	Transition to an all-electric, fossil fuel free campus	Implement a no-new gas policy and update campus design standards to support electrification		Campus natural gas consumption (therms/sf-yr)	Short Term	Facilities Management
		Replace natural gas system during buildings retrofit projects and at equipment failure			Mid to Long Term	
		Electrify existing heating and DHW systems, as outlined in the CESA tool			Mid to Long Term	

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
1C	Electrify Central Plant	Complete a CUP electrification study and establish a long-term implementation plan		HW supply temperature (F)	Short Term	Facilities Management
		Implement base heating system upgrades to reduce HW temperatures		CUP natural gas consumption (therms)	Short Term	
		Implement Phase 1 (partial electrification)			Mid Term	
		Implement Phase 2 (full electrification)				

STRATEGIC IMPACT METRICS	
Cost Effectiveness of Policy in Dollars Spent per emission reduced	\$46/MT CO_2e reduced
Emissions Reduction Potential through 2043 ($MtCO_2e$)	113,896 MT
Glumac Recommendations • Campus energy use intensity (EUI) excluding on-site generation (solar PV) • Campus & central utility plant natural gas consumption • Annual investment in energy efficiency & electrification projects	

OBJECTIVE 2 – INCREASE RENEWABLE ENERGY GENERATION

Within the CNR planning process, SSU explored the development of solar PV systems as the main avenue to increase renewable electricity generation on campus. Prior to the planning process, SSU had approved a 5 MW solar and battery storage project for development and eventual conversion into a microgrid. Based on advice from the Chancellor's Office related to regulatory and economic risk of signing long-term power contracts in a rapidly changing electricity market, this project was intended to be "Phase 1" of a larger development. As such,this project did not take advantage of all viable space for solar development. Accordingly, the CNR process focused on identifying additional solar potential to be considered for future phases of solar development. Overall, an additional 3.3 MW of carport solar and 1.4 MW of ground mount solar was identified.

Given California's path toward 100% carbon free electricity by 2045, on-campus renewable electricity is not absolutely necessary to meet the University's carbon neutrality goal. Assuming California archives its statewide goal, as the carbon intensity of the statewide electricity mix falls, so too will SSU's carbon emissions related to electricity use, including any increased use from vehicle and building electrification, until they eventually reach zero. This is demonstrated in the relationship between the BAU and Level I scenarios discussed in previous sections. However, there are several significant benefits remaining that SSU can capture by developing renewable electricity generation on campus. These include faster reduction in emissions and lower cumulative emissions, potential utility cost savings and increased resilience potential made available by additional electricity generated on site (when renewable generation is paired with battery storage, such as on SSU's currently proposed project),

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
2A	Complete Development of Currently Contracted Solar + Storage Project with SunPower	Complete contract signing Implement agreed upon site improvements prior to construction Monitor system construction performed by SunPower		Percentage of renewable electricity generated on-site compared with overall SSU usage	Near Term	Facilities Management
2B	Complete feasibility analysis, procure and install additional on-site carport and/or ground mount solar projects at 1-5 locations on the SSU campus	Complete a financial and technical feasibility study, assessing multiple financing options, for each potential project included in the CESA tool Engage with PG&E to gain a complete understanding of electricity export limits and solar upgrade costs Release RFP Approve contract(s)		Percentage of renewable electricity generated on-site compared with overall SSU usage	Mid-Term	Facilities Management

STRATEGIC IMPACT METRICS	
Cost Effectiveness of Policy in Dollars Spent per emission reduced	\$46/MT CO_2e reduced
Emissions Reduction Potential through 2043 ($MtCO_2e$)	113,896 MT

OBJECTIVE 3 –INCREASE VEHICLE FLEET EFFICIENCY & FUEL SWITCHING

While University-owned vehicles only account for **2%** of overall emissions, these emissions must be addressed in order for the University to meet its goal. The analysis of transitioning the university's fleet away from fossil fuels covered three main strategies; (1) streamlining fleet management and operations, (2) vehicle electrification and (3) infrastructure development. From the data collected, it is clear that vehicle mileage (range) is unlikely to be a barrier to conversion of the campus vehicles to electric. Rather, vehicle and infrastructure cost and, to a lesser extent, operational requirements are the major barriers to electrification.

There are 36 on-road vehicles in SSU's fleet and every vehicle has an applicable EV alternative currently on the market. The fleet replacement analysis identified 16 existing vehicles that are due for replacement in 2022, 5 in 2023 and between 1-3 each year from 2025 - 2035. The analysis also assessed vehicle electrification on a total cost of ownership (TCO) basis, to understand the costs of owning and operating a new EV compared to a new internal combustion engine (ICE) vehicle. Unfortunately, due primarily to the low mileage nature of the university vehicles, only the Campus Police/Safety and Parking Vehicles are likely to experience TCO savings (~\$125,000 over the lifespan of the vehicles) if electrified.

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
3A	Transition the fleet to electric vehicles	Replace all 36 fleet passenger vehicles with electric vehicles by 2035, averaging ~3 per year Implement "EV-first" vehicle purchasing policy to ensure that EVs are considered as the primary replacement option for every vehice		MTCO2e/year reduced Number of electric vehicles purchased per year Percent of fleet that is EV Increased MPGe Increased fuel savings Savings in fleet maintenance	Mid Term	Facilities Management
3B	Increase the number of EV charging station ports on campus	Develop vehicle charging infrastructure in select on-campus lots Follow the replacement scheduled outlined in the CESA tool		Total # of SSU-owned EV charging stations	Mid-Term	Facilities Management

STRATEGIC IMPACT METRICS	
Cost Effectiveness of Policy in Dollars Spent per emission reduced	\$101/MT CO_2e reduced
Emissions Reduction Potential through 2043 ($MtCO_2e$)	2,468 MT

[8] Note: The CESA tool includes a vehicle replacement schedule recommended based on the age and usage of SSU's current vehicles. However, this timeline can be adjusted based on budget availability

OBJECTIVE 4 –INCREASE IMPACT OF BEHAVIORAL CHANGE PROGRAMS

Behavior change programs can achieve additional cost saving and carbon reduction benefits beyond the traditional infrastructure projects. As more students and faculty reduce energy use on campus, there are less GHG emissions to tackle. The benefits of a campus-wide behavior change program focused on energy conservation are diverse and varied. There are immediate benefits in the form of emissions and cost savings from reduced energy use and long-term impacts from increased awareness of energy use and increased self-efficacy related to sustainable behaviors. Given the formative age of college students, experiences during a short-lived energy conservation program may result in long-term impacts in the form of normative behaviors and lifestyle changes, career choices and cultural shifts. Additionally, many people underestimate the impacts that their behavior can have on energy conservation.

Demonstrating to students the potential impact that their behaviors can have on carbon emissions in order to increase their capabilities and self-efficacy related to energy conservation activities is another benefit that SSU can achieve through behavior change programs. Capturing these long-term benefits aligns with SSU's educational mission as a university and offers a good opportunity to engage with students living on campus. The 2022 Climate Action Plan will include a suite of recommended behavior change strategies that SSU can draw on to launch campus-wide behavior change programs in support of its carbon neutrality efforts.

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
3A	Reduce electricity use	Implement a campaign to turn off the lights if offices do not have occupancy sensors. Assign each department an "energy owl" to support energy reductions within departments and offices. Encourage the use of power strips	 	No of staff, faculty and students who are aware of behavioral change programs	Ongoing	Green Team

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
4B	Reduce water use	Promote table cards near faucets to turn off the water while lathering		No of staff, faculty and students who are aware of behavioral change programs	Ongoing	Green Team
4C		Remind staff to close all laboratory hoods. “Shut the Sash”		No of staff, faculty and students who are aware of behavioral change programs	Ongoing	Green Team

SCOPE 3 EMISSIONS

Given the focus of SSU’s carbon neutrality commitment on Scope 1 and Scope 2 emissions, the carbon neutrality modeling and strategy recommendation efforts focused primarily on these scopes. However, Scope 3 emissions should not be ignored due to their comparatively large contribution to emissions across all three scopes.

Based on the Scope 3 emission data collected by SSU and currently available, in Fiscal Year 2020, Scope 3 emissions represented 33.5% of SSU’s total carbon emissions across all scopes. The strategies and actions below will be further developed as part of the 2022 Climate Action Plan.

Tracking and addressing this large portion of total Scope 3 carbon emissions has unique challenges. First, the diverse nature of activities that contribute to Scope 3 emissions means that the data needed to fully measure Scope 3 emissions may not be collected and may not be easily available to SSU staff. Second, SSU does not have direct control over all activities that contribute to Scope 3 emissions. The most significant example of this is faculty, staff and student commuting, which is the single largest source of Scope 3 emissions for SSU.

To assist in addressing the first challenge associated with Scope 3 emissions, data tracking, the SSU reviewed all available data on Scope 3 emissions currently collected and identified key data gaps. **Figure G** includes a list of all Scope 3 emissions sources, the primary data source associated with each source and an indication of whether or not SSU is currently collecting that data. Increasing collection of Scope 3 emissions data for analysis is an area where SSU can use student participation to drive success.

STRATEGY NO.	STRATEGY	ACTION	BENEFITS	METRIC	TIMELINE	LEAD ACTOR
CAP$_1$	Increase % plant-based meals served	Create educational programs that reward low impact diets		No. of plant-based meals served	Short Term	Culinary
CAP$_2$	Increase % of locally purchased food	Consider partnering with a local farm Provide produce or products that may be gathered through field “gleening” programs or programs similar to “imperfect produce”.		Increase in % local food purchased	Short Term	Culinary
CAP$_3$	Develop a Carbon Farming program	Assess ways for campus and preserves to increase carbon sequestration Develop garden classroom as demonstration site for carbon farming		MTCO2e/ hectare	Mid Term	Geography, Environment and Planning
CAP$_4$	Incentivize carpooling and public transport. such as SMART train and buses	Offer preferred parking for staff who participate in carpooling Include an annual bus/ SMART train pass to all new employees who express interest Distribute commuting survey to all staff, faculty and students in Fall 2022		MTCO2e/ hectare	Mid Term	Geography, Environment and Planning
CAP$_5$	Promote Bike Share program	Partner with Sonoma County Transportation Authority		No. of annual bike trips; number bikes used for movement across campus		Sustainability Director

The 2022 Climate Action Plan

will identify how SSU can improve data collection across all sectors.

EMISSIONS SOURCE & DESCRIPTION	PRIMARY DATA SOURCE	DATA COLLECTED?
Commuting: Emissions associated with faculty, staff and student commutes.	Commute survey will be distributed in Fall 2021	Yes
Business Travel & Study Abroad: Emissions associated with faculty and staff travel on SSU business and student travel for study abroad.	Expense receipts, study abroad program statistics	Yes
Food: Emissions associated with food procured and prepared on campus	Inventory of all food & beverages purchased, inventory or sustainable food & beverages purchased	No
Purchasing: Emissions associated with SSU procurement activities relating to goods used on campus and services provided by third-party vendors	Collated records of all purchases of goods & services enabling an assessment of purchase supply chain	No
Waste: Emissions associated with waste generated on campus	Total waste generated & landfill diversion rate	Yes
Wastewater: Emissions associated with the treatment of wastewater generated on campus	Total annual volume of wastewater generated	No
Paper: Emissions associated with the production of paper purchased for use on campus	Records of annual paper purchased by type (e.g. virgin or 100% recycled content)	No
Transmission & Distribution Losses from Electricity: Emissions associated with energy that is lost to heat during the transmission and distribution process of the electricity purchased by SSU.	Estimated from annual electricity purchased	No

Figure G: *Scope 3 Emissions Sources & Data Collection Assessment*

PHASE 4

PHASE 4: IMPLEMENTATION TIMELINE AND BUDGET[9]

[9] *The implementation and spending schedule presented includes the following financing arrangements: PPAs for all solar PV projects, cash for all electricity efficiency projects and capital improvements (vehicle charging infrastructure), and a business-as-usual expense for fleet replacement to electric vehicles according to existing replacement schedule. This pathway does not necessarily represent an optimized financing structure. For example, the use of low and zero interest borrowing for early energy efficiency projects would distribute early capital requirements (spending) over several years.*

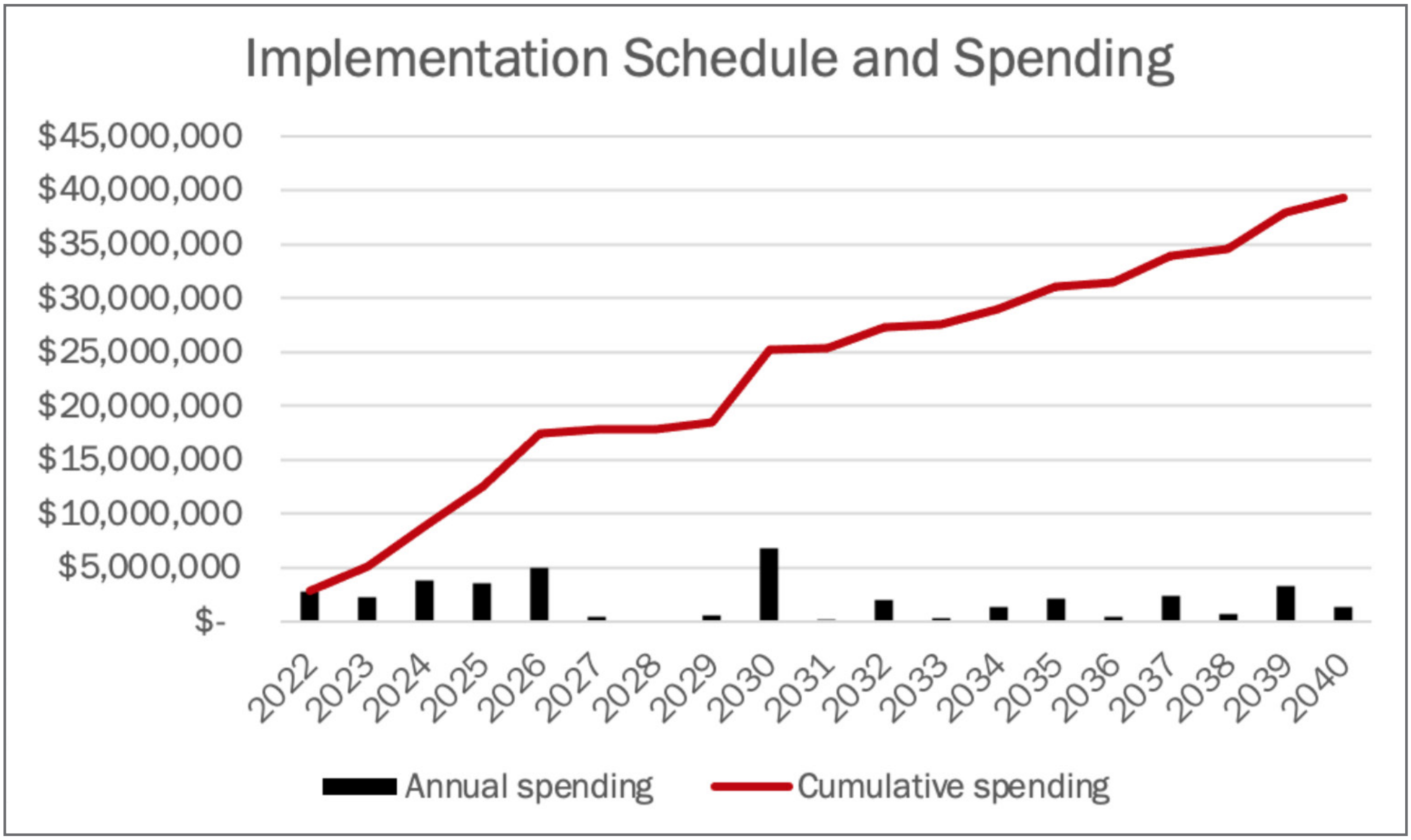


***Figure H**: Implementation Schedule and Spending*

The Implementation and Spending Schedule shown in Figure H shows the annual and cumulative initial project costs for the Level III Investment Scenario. It does not include any financing arrangements, but simply illustrates the initial capital requirements for the combined projects. (This means that financing charges that have been integrated into the total costs of the program above, are not included.) Also note that the figure does not include the SunPower solar PV and storage facility since **the project is financed from SSU's operational budget and the figure addresses capital budget costs only**.

FUNDING

To fund the full suite of recommended projects, and achieve full carbon neutrality by 2043, the following three steps are recommended. Step 1: Pursue PPAs for all solar PV projects through contracts similar to that with SunPower. Step 2: Take full advantage of low cost financing for emissions mitigating and energy saving projects. Step 3: Improve the Green Revolving Fund (an established, innovative way to fund sustainability efforts) by seeding it with an initial investment; then fully leverage the Fund by paying for all projects out of proceeds from efficiency gains.

NET PRESENT VALUE

(NPV) is the value in present-day dollars of a series of cash flows over a period of time, and is a common metric to evaluate different investments. By using NPV to evaluate different options, SSU can determine the most cost-effective pathway to achieving its renewable energy targets.

STEP 1:

Pursue PPAs for all solar PV projects. Power purchase agreements allow the campus to avoid large, up front capital outlays, instead transferring payments for energy project installation to an expense. In the case of the SunPower PPA the amortized cost of the initial installation plus the energy charge are less than the energy savings benefit that results from purchasing electricity from the new supplier, when storage is considered. We expect other PPA terms to be similar in nature.

STEP 2:

Take full advantage of low cost financing for emissions mitigating and energy saving projects. There are many ways to finance projects such as those suggested in this proposal. Several state programs offer low and zero cost financing for up to 20 years. We recommend making use of at least two borrowing programs if available to SSU. First, the CEC loan program allows entities to borrow up to $3 million over 20 years at 1% interest. Second, PG&E's on-bill financing allows borrowing of up to $4 million at 0% for 10 years for public entities. Other options including ESCOs and lease/financing options should also be fully explored.

STEP 3:

Establish a Green Revolving Fund with an initial investment. The size and timing of the capital investment will depend on the optimized financing arrangements and the cash availability of the campus during the initial years of implementation. Early capital infusions will ensure that the fund has sufficient operating cash to pay for projects that come early in the implementation schedule. From that point forward, we estimate that the Fund will be able to fully pay for all projects out of proceeds from efficiency gains. Efficiency gains are measured against a baseline and tracked in real time. All savings from the measures implemented are placed in the fund, which is a special account within the university accounting system. An increasing balance will accrue to the Fund as efficiency gains add up; the balance can be used to pay cash for subsequent projects. Then, once the critical investment period is over (about 12 years), that balance can be used for a host of other purposes from funding the general budget, investing in student-initiated sustainability ideas, or reducing the deferred maintenance backlog. The initial capital for the Fund may come from a variety of places including the endowment, cash balances, or short-term investments that are currently on the balance sheet. In fact the Fund itself can be viewed as an investment, with a payback period and IRR that can be calculated once other financing arrangements are in place.

SUMMARY

This CNR outlines a specific approach which allows SSU to reach carbon neutrality by 2043. This approach has been vetted using qualitative data and a deep understanding of the financial impacts. However, the approach remains flexible and can be adjusted to meet the needs of the campus. It is possible to adjust the years that different projects are implemented based on SSU's budget, though delaying action too long increases uncertainty and leaves more up to chance, risking not reaching the target on time.

The CSU Office of the Chancellor has encouraged campuses CSU wide to consider carbon neutrality. SSU is one of XXX that have stepped forward as a leader. But SSU can't do this alone. Even with SSU's best efforts, the goals of this plan will require financial support from the CSU Office, Improving the Green Revolving Fund offers a cash flow positive solution with minimal initial investment. This is a win -win opportunity.

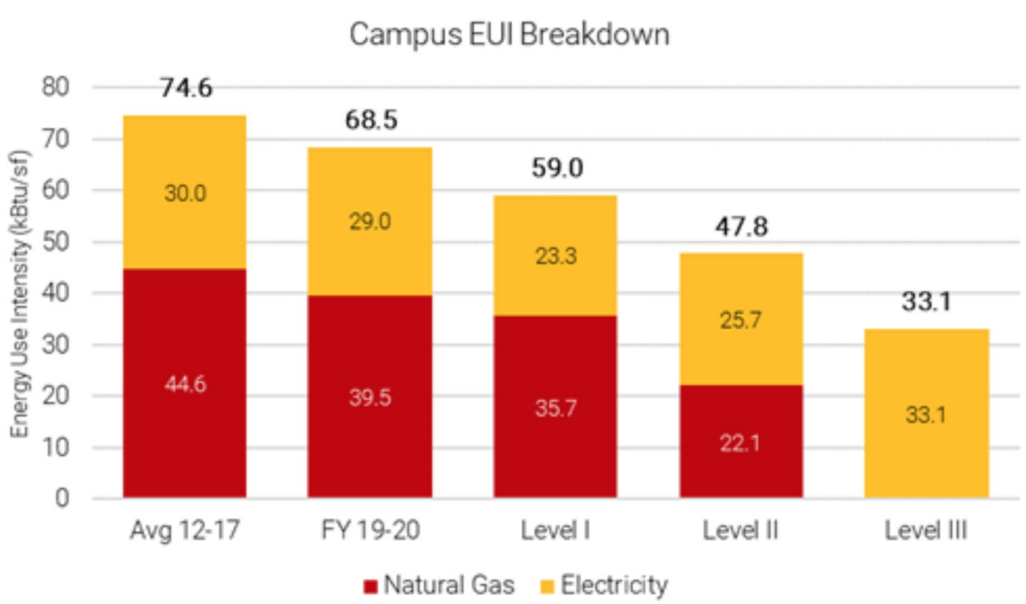
OBJECTIVE 1 – IMPROVE BUILDING PERFORMANCE

CAMPUS ENERGY USE

Between 2012 and 2020 (pre-pandemic) SSU operated with an EUI of between 68.5 and 79.7 kBtu/sf. Roughly 60% of all energy use is direct combustion of natural gas on campus. Reducing natural gas demands will be critical for SSU to cost effectively achieve their carbon neutrality goals. Campus operations during Fiscal Year 20-21 was significantly impacted due to the COVID-19 pandemic. The campus saw a significant reduction in energy consumption due to limiting campus operations.

Year	SF	Electricity			Natural Gas			Total Energy	
		kWh	MBtu	kBtu/sf	therms	MBtu	kBtu/sf	MBtu	kBtu/sf
FY 12-13	2,003,643	18,115,745	61,811	30.8	884,140	88,414	44.1	150,225	75.0
FY 13-14	2,128,084	18,423,841	62,862	29.5	987,876	98,788	46.4	161,650	76.0
FY 14-15	2,157,609	18,342,019	62,583	29.0	851,059	85,106	39.4	147,689	68.5
FY 15-16	2,154,382	18,967,122	64,716	30.0	947,549	94,755	44.0	159,471	74.0
FY 16-17	2,154,382	19,247,728	65,673	30.5	1,059,312	105,931	49.2	171,604	79.7
FY 19-20	2,154,382	18,310,209	62,474	29.0	851,369	85,137	39.5	147,611	68.5
FY 20-21	2,154,382	13,266,112	45,264	21.0	588,254	58,825	27.3	104,089	48.3

The following graph shows the energy reduction potential for the various investment scenarios identified during the CNR project. SSU has the potential to reduce the campus energy use (EUI) to 33.1 kBtu/sf by implementing most of the building decarbonization projects through 2040. This does not include additional on-site Solar PV generation which would further reduce the campus EUI.



BUILDING DECARBONIZATION PROJECTS

An assessment of the campus building stock was completed by the project team, with projects being identified through an assessment of existing conditions and building energy consumption. The first step involved creating a database of campus buildings that contained information regarding the building mechanical, electrical, and plumbing systems. System type and condition were gathered from existing campus reports and with input from SSU facilities staff. Using this database, energy projects across campus were identified. Projects were grouped into the following categories.

1. LIGHTING

Lighting projects were identified to replace existing lighting fixtures with LED bulbs and install modern lighting controls. The majority of SSU buildings have non-LED lighting. Projects were identified from the campus lighting database. This includes 0.9 million SF of residential buildings and 1.2 million SF of other academic and support facilities.

2. RETRO-COMMISSIONING

1 million SF of buildings were identified to be included in a future campus RCx / Continuous-Cx program at SSU. The RCx process involves identifying operational deficiencies and optimizing building control systems. RCx is most effective for newer facilities with modern variable volume HVAC systems and DDC-controls.

3. HVAC RETROFITS

HVAC retrofit projects were identified for buildings with older, inefficient mechanical systems. These are generally more capital intensive energy projects that require upgrading legacy HVAC equipment to modern variable volume systems. Most HVAC Retrofit projects identified at SSU are for systems that are already beyond the expected useful life and can be considered deferred maintenance.

4. ELECTRIFICATION (BUILDINGS)

Electrification projects were identified for building with existing natural gas heating and domestic hot water equipment. Additional engineering studies will be required to assess electrical system impacts.

5. ELECTRIFICATION (CENTRAL PLANT)

The central utility plant has natural gas boilers that provide heating and domestic hot water to roughly one million square feet of buildings. Electrifying the existing central heating system will be critical for reducing carbon emissions as roughly 50% of SSU’s natural gas use is at the central plant. A phased approach to decarbonizing the central plant system has been identified for SSU. An additional detailed engineering study is required to establish a full implementation roadmap.

The project team has identified (164) different energy projects on campus aimed to reduce overall campus EUI over the next 20 years. Reduction in energy consumption on campus, both electrical and natural gas, is vital to ensure SSU can economically meet its carbon neutrality goals, whilst investments made to reduce energy consumption may also improve building operations and allow campus buildings to operate in line with current engineering and energy codes. The following table show the project identified for each building on campus.

Building Number	Building Name	Building Category	Age	Area	Electrification (Heating)	Electrification (DHW)	HVAC Retrofit	Retro-Commissioning	Lighting
001	Stevenson Hall	07 - Classroom - General	1967	130,160			Y	Y	Y
002	Darwin Hall	26 - Science	1967	111,821				Y	Y
003	Field House	22 - Physical Education	1965	15,826			Y		Y
004	Ives Hall	19 - Music	1967	48,510			Y	Y	Y
005	Physical Education	22 - Physical Education	1969	65,985			Y		Y
006	Ruben Salazar Hall	01 - Administration	1969	117,384				Y	Y
007	Student Health Center	13 - Health Clinic	1975	18,573			Y	Y	Y
008	Rachel Carson Hall	07 - Classroom - General	1975	20,000		Y	Y	Y	Y
009	Nichols Hall	07 - Classroom - General	1975	27,892			Y	Y	Y
010	Plant Operations Office	99 - Other	1974	2,692		Y			Y
011	Corporation Yard Shops	09 - Corporation Yard	1967	8,300	Y	Y			Y
012	Boiler Plant	99 - Other	1967	11,500		Y			Y
013	Wastewater Equalization	99 - Other	2009	1,200					Y
014	Corporation Yard Support Service	09 - Corporation Yard	1975	8,000					Y
015	Campus Residential Housing	24 - Dormitories	1972	684,560					Y
038	Tuscany Village	24 - Dormitories	2009	215,512	Y	Y			Y
016	Wine Spectator Learning	35 - Food Sales/Vendor	1968	18,500					
018	International Hall	07 - Classroom - General	1975	17,600			Y	Y	Y
019	Art Building	03 - Art	1978	46,604		Y	Y	Y	Y
020	Pump House	09 - Corporation Yard	1967	960					Y
021	Pump House Fire	09 - Corporation Yard	1967	1,225					Y
022	Shop North	30 - Warehouse	1978	9,600	Y				Y
023	Physical Education Storage Building	22 - Physical Education	1967	1,480					Y
024	Child Care Center	37 - Day Care Center	1977	3,884	Y	Y			Y
025	Athletic Field Facility	22 - Physical Education	1979	860					Y
027	Evert B. Person Theatre	28 - Theater Arts	1987	20,655			Y	Y	Y
028	Aquatic Facility	22 - Physical Education	1982	6,000					
029	Anthropology Studies	07 - Classroom - General	1996	5,440	Y	Y			Y
032	Schulz Information Center	18 - Library	2000	215,500	Y	Y		Y	Y
035A	Student Recreation Center	08 - University Union	2004	53,442	Y			Y	Y
035B	Student Center	08 - University Union	2010	130,065				Y	Y
036	Police Services Building	99 - Other	1990	3,860	Y	Y			Y
039	Green House	26 - Science	2004	5,160	Y				Y
041	Recycle	99 - Other	1999	900					Y
042	Stadium	99 - Other	1999	1					
043	Baseball Field	99 - Other	1969	250,000		Y			
046	Environmental Technology	26 - Science	1905	3,120		Y			Y
049	Pre-College Programs	99 - Other	1996	6,750	Y	Y			Y
050	Green Music Center	19 - Music	2008	49,724	Y	Y		Y	Y
050A	Music / Faculty Office Building	19 - Music	2008	37,920	Y	Y			Y
051	Restaurant / Meeting Facility	35 - Food Sales/Vendor	2011	28,560	Y	Y			Y
001	Osborn Education Center	07 - Classroom - General	1996	2,837	Y	Y			Y
001	Ukiah Center	07 - Classroom - General	1998	2,880					Y
017	CAPS and Four Classrooms	31 - Student Services	2019	6,480					Y

LIGHTING

Existing Conditions

The project team was provided a database from SSU that outlined the (3) major lighting fixture types and percent within building. This database indicated that only (2) buildings on campus have undergone full LED retrofits, with the majority of campus buildings being lit through fluorescent lighting fixtures.

Project Description: Two lighting energy projects were assessed:

1. LED Lamp Retrofits

- Retrofit existing fixtures with LED lamps, fixtures and controls remain.
- This approach is well suited when fixtures are in good condition and lighting occupancy controls have already been installed

2. LED & Controls Retrofit – replace existing fixtures with new LED fixtures and modernize lighting controls in alignment with current code requirements

- Installation of modern lighting fixtures will allow for integration of lighting control systems into the building automation system and may allow for the HVAC zone systems being integrated into the occupancy sensor, shutting down airflow to the zone when it’s unoccupied. This control strategy is mandated in certain occupancy types by the 2019 California Energy Code and can result in significant energy savings in spaces with fluctuations in occupancy over the course of the day.

015-	RESIDENTIAL HALL AND DINING	684,560	Residence Hall	Yes	CFL Can Light		25
043-	BASEBALL FIELD	250,000	Outdoor Field/Area				
038-	STUDENT HOUSING GROWTH-TUSCANY VILLAGE	220,025	Residence Hall	Yes	4Pin CFL Can Light		5
032-	SCHULZ INFORMATION CENTER	215,500	Library	Yes	T8 Troffer		85
001-	STEVENSON HALL	130,160	Classroom	Yes	Troffer T8		95
035B	STUDENT CENTER	130,065	University Union	Yes	Linear 4Ft T5		40
006-	RUBEN SALAZAR HALL	116,186	Administration	Yes	Troffer T8		80
002-	DARWIN HALL (SCIENCE)	111,821	Science	Yes	Linear/ troffers T8		90
005-	PHYSICAL EDUCATION	65,985	Physical Education	Yes	Troffer T8		100
035A	STUDENT RECREATION CENTER	53,442	Recreation Center	Yes	Troffer T8		75
050-	DONALD AND MAUREEN GREEN MUSIC CENTER	49,724	Music	No			
004-	IVES HALL (MUSIC)	48,510	Music	Yes	Troffer T8		97
019-	ART BUILDING	46,604	Art	Yes	Troffer T8		80
050A	MUSIC/FACULTY OFFICE BUILDING	37,920	Music	Yes	Troffer T8		95
009-	NICHOLS HALL (CLASSROOM)	30,700	Classroom	Yes	Troffer T8		90
051-	RESTAURANT/MEETING FACILITY	28,560	Food Sales/Vendor	Yes	A19 Chandelier		75
027-	EVERT B. PERSON THEATRE	20,655	Theater Arts	Yes	Troffer T8		80
008-	RACHEL CARSON HALL (CLUS)	20,000	Classroom	Yes	Troffer T8		85
007-	STUDENT HEALTH CENTER	19,457	Student Health Center	Yes	Troffer T8		90
016-	WINE SPECTATOR LEARNING CENTER	18,500	Business Administration	No	Troffer LED		
018-	INTERNATIONAL HALL	17,600	Classroom	Yes	Troffer T8		80
003-	FIELD HOUSE	15,826	Field House	Yes	Troffer T5		50
012-	BOILER PLANT	11,500	Central Plant	Yes	Linear T5		90
022-	CORP YARD WAREHOUSE	9,600	Warehouse/Storage	Yes	Linear T8		100
011-	CORPORATION YARD SHOPS	8,300	Corporation Yard	Yes	Linear T8		100
014-	CORP YARD SUPPORT SERVICE	8,000	Corporation Yard	Yes	Troffer T8		100
047-	CAMPUS STORAGE BLDG	7,350	Warehouse/Storage	Yes	Linear T8		65
048-	GORDON SMITH TRAINING FACILITY	6,963	Physical Education	Yes	Linear T5		100
049-	PRECOLLEGE PROGRAMS/NVIC-NORTHWEST	6,750	Other	Yes	Troffer T8		
017-	CAPS AND FOUR CLASSROOMS	6,480	Classroom	Yes	Troffer T8		100
028-	AQUATIC FACILITY (POOL)	6,000	Outdoor Swimming Pool	Yes	Linear T8		80
029-	ANTHROPOLOGY STUDIES	5,440	Classroom	Yes	Linear T8		100
039-	GREEN HOUSE	5,160	Science	Yes	Vapor Tight T8		100
024-	CHILD CARE CENTER	3,884	Child Care Instruction	Yes	Troffer T8		80
036-	POLICE SERVICES BUILDING	3,860	Public Safety	Yes	Linear T8		30
046-	ENVIRONMENTAL TECHNOLOGY CENTER	3,120	Social Science	Yes	Linear T8		100
010-	PLANT OPERATIONS OFFICE	2,692	Corporation Yard	Yes	Troffer T8		100
023-	PHYSICAL ED STORAGE BLDG	1,480	Physical Education	Yes	Linear T8		100
021-	PUMP HOUSE FIRE	1,225	Corporation Yard	Yes	Linear T8		100
013-	WASTEWATER EQUALIZATION TANK STRUCTURE	1,200	Campus Support Service	No	Vapor Tight T8		
020-	PUMP HOUSE	960	Corporation Yard	Yes	Linear tT8		100
041-	RECYCLE	900	Campus Support Service	Yes	Linear T8		100
025-	ATHLETIC FIELD FACILITY	860	Physical Education	Yes	Linear T8		
034A	SOUTH ENTRY KIOSK	144	Campus Support Service	Yes	Troffer T8		100
034B	NORTH ENTRY KIOSK	144	Campus Support Service	Yes	Troffer T8		100
042-	STADIUM	1	Outdoor Field/Area	Yes			
001-	OSBORNE EDUCATION CENTER	2,810	Science	Yes	Ennear S2	T8 Wrap	
001-	UKIAH CENTER	2,880	Social Science		Ntnear K2		

Recommendations

It is recommended that LED retrofits are prioritized based on buildings with longer hours of operation to maximize energy saving. These buildings have the highest lighting energy consumption, thus have the greatest potential for energy savings. Through discussions with SSU facilities staff, the buildings with the longest operating hours are as follows:

- Shultz Information Center
- Student Center
- Music Building
- Nichols Hall
- Rachel Carson Hall

Analysis Methodology

Energy savings as a result of LED retrofits were determined based on the typical building occupancy schedule and the anticipated lighting power density (watt / sf) reduction. SSU facilities staff provided the building HVAC schedules for the campus building stock. Using this schedule, the lighting equivalent full load hours (EFLH) per year was determined, with the EFLH per building then adjusted to account for the lighting controls per ASHRAE 90.1 guidelines.

To estimate project costs the project team compiled cost data from several CSU campuses that have undergone lighting retrofit projects to determine a $ / sf that could be assigned to each building. The retrofit cost will be dependent on the lighting fixture density within the building, along with the configuration of fixtures and their ease of access, thus the lighting costs estimates should be used as a guideline. It is recommended that SSU work with a local contractor and gather project cost estimates for the larger buildings on campus.

RETRO-COMMISSIONING

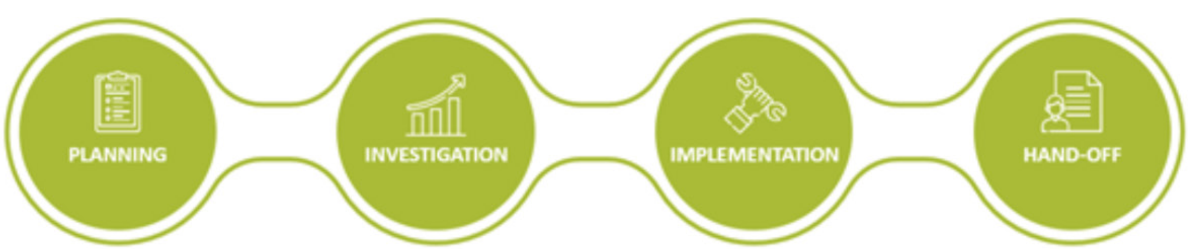
Existing Conditions

SSU has multiple campus buildings with full DDC controls that are 10-15+ years old. These facilities are good candidates for a retro-commissioning process to optimize the existing building systems and control sequences.

Project Description

Retro-commissioning is a term that refers to the commissioning of a building that has either not been previously commissioned, or operations have changed over time and the building has diverged from the original commissioned operations. The goal of retro-commissioning is to find ways to make a building and its equipment operate more efficiently and effectively, saving the owner money, reducing environmental impact, and increasing occupant comfort. Retro-commissioning measures are typically controls based, meaning that the changes require less capital investment to implement than equipment or structural changes. For example, retro-commissioning measures might include adjusting temperature setpoints, equipment schedules, damper operation, or address problems of simultaneous heating and cooling.
It would not include upgrading old equipment to more efficient ones. As the changes are to the operation of the equipment and can normally be implemented by the owner, retro-commissioning changes typically do not have significant capital investment yet can drastically improve the operations and efficiency of equipment.

The typical retro-commissioning process is outlined below.



SCOPE:	• Data Collection • Facility Review • Site Walkthrough • Utility Benchmarking • RCx / Audit Plan	• RCx Testing • Site Assessment • Identify Deficiencies & Efficiency Measures • Energy & Financial Analysis	• Implementation Plan • Project Scoping • Design Review • Post-Implementation Testing	• Training • Final Reporting • Measurement & Verification (M&V) • Utility Incentives

Recommendations

As RCx focuses on updating equipment controls and operations it is best suited to centralized HVAC systems that can implement advanced control strategies. Variable speed air handling units with DDC controls are optimal for RCx as they can operate with more complex control strategies, thus RCx energy projects focused on buildings with modern HVAC system. Constant volume systems with pneumatic controls throughout are not able to operate with advanced control sequences, resulting in less savings potential in these buildings. Likewise, buildings with small, non-centralized systems such as packaged unit have a lower savings potential as fewer control sequences are available. Although this is the case, RCx does present potential for energy savings in all buildings through projects such as updating HVAC scheduling, thus some older buildings with pneumatic controls have been identified with potential for RCx savings.

Analysis Methodology

Energy savings for all RCx projects were identified on a building-by-building basis. Building HVAC energy usage was broken into heating, cooling and electricity, which includes items such as fan and pumping energy. Once end uses EUIs were either calculated from trended data or benchmarked based on campus energy consumption, RCx savings were estimated.

Retro-commissioning project costs vary depending on the size complexity of a building. The initial stages of a project, investigating and documenting issues with existing operations may identify several issues, or very few. Costs for potential projects were estimated based on a typical cost ($ / sf) for a full RCx process. This cost does not include any implementation replacement costs, such as upgrading from pneumatic to DDC controls.

HVAC UPGRADES

Existing Conditions

SSU's building stock consists of several buildings that have either pneumatic controls at the zone level, or pneumatic controls throughout the building. Replacement of pneumatic systems has been prioritized as these systems are typically the oldest on campus, and do not allow for advanced control sequences to be implemented. Constant volume systems were also prioritized for replacement, whether they were larger air-handling units or small packaged units. Replacement of constant volume system with variable flow has significant energy saving potential, both in fan energy and heating energy. Constant volume systems cannot adjust flowrate to space temperature, thus during periods that a building requires heating a higher volume of airflow needs to be heated. The latest sequences for variable flow systems have a dual maximum airflow setting, one for heating and one for cooling. This cannot be achieved in a constant volume system and leads to excessive loads being put on the heating distribution system. As campus heating is primarily provided by natural gas, conversion of constant volume systems to variable volume will have a direct impact on campus Scope 1 emissions.

Project Description

The HVAC upgrade projects focus on upgrades of older air-handling units that are either constant volume and/or pneumatically controlled. HVAC upgrades vary in scope dependent on existing conditions. In some locations a controls upgrade may suffice, with existing air handling unit fans, coils and dampers remaining in place. Other buildings will be better suited to full air handling unit replacement projects with custom packaged units. Projects will be scoped on a project-by-project basis dependent on site conditions within the building.

Recommendations

Develop an energy efficiency program and establish criteria to fund and finance projects. Determine a plan to implement HVAC upgrade projects to bring campus buildings to current code levels, focusing on buildings that are regularly occupied.

Analysis Methodology

Energy savings were derived from the existing HVAC end use energy from heating, cooling and electricity. The project team assessed each end-use against a benchmark, whilst analyzing the existing HVAC system and potential replacement options. Energy savings were then estimated once and understanding of existing systems

Estimating HVAC upgrades project costs was completed on a project-by-project basis, with HVAC system types and replacement scopes being assessed and estimated.

ELECTRIFICATION (BUILDINGS)

Existing Conditions

Heating and campus domestic hot water are currently being provided primarily by natural gas burning equipment. Several buildings are connected to the campus central heating plant for both heating and DHW needs, whilst others are connected for heating alone with natural gas water heaters within the building. Buildings that are isolated from the central heating plant typically have boilers and/or natural gas furnaces for heating needs and natural gas water heaters for water heating needs. The building electrification projects focused on buildings with natural gas consuming equipment within the facility.

Project Description

Heating electrification projects include replacement of existing boilers or furnaces with heat pumps, for both hydronic and airside systems. DHW electrification replacement options were determined based on the anticipated hot water load. In buildings with minimal hot water load, hybrid electric heat pumps are suitable and provide a high efficiency method to generate hot water. These systems often come with integral storage tanks and can be installed with minimal infrastructure upgrades required. In buildings with larger hot water loads, such as residential buildings, high capacity air-to-water heat pumps are suitable alternatives and can be designed to be integrated into a traditional separate storage tank system.

Electrified Equipment	Application
Hybrid Tank Type Water Heater	Buildings with low DHW loads, such as academic and office buildings
Built Up Heat Pump Water Heaters	Buildings with significant DHW loads, such as residential buildings and sports facilities
Air-Source Heat Pumps	Buildings with existing heating hot water boilers that can be replaced, reusing existing distribution infrastructure in place
Packaged Rooftop Units	Replacement packaged DX units with natural gas furnaces
Wall Heaters	Replacement of natural gas furnaces in residential units that may not limited in space for installation of heat pumps

Recommendations

Electrification should focus on buildings with the highest heating and hot water loads, such as the residential buildings, as electrification of these buildings will have the greatest impact on campus emission outside of the central plant.

Analysis Methodology

Replacement of natural gas equipment with heat pumps may result in a significant decrease in building energy consumption due to the increased performance of heat pumps. Typical natural gas equipment will operate in the range of 80-95% efficiency dependent on system type. A heat pump is capable of operating at an average COP > 3.0. With a COP > 3.0, the heat pumps are operating at over 300% efficiency, resulting in significantly less energy being required for the same hot water output.

All electrification projects replace all natural gas consumption with electricity. Heat pumps will operate at different efficiencies over the course of the year, dependent on outside air conditions and system loads. A COP > 3.0 is achievable in the Sonoma climate, however it was assumed that the heat pumps would operate at an average of 3.0. Natural gas energy for each building was converted to electricity consumption using this COP value.

Electrification costs were determined on a $ / MBH basis. The SSU Critical Infrastructure Report provided the system design load for heating and DHW for all campus buildings. It was assumed that the electrified equipment would need to meet these design loads, however it is recommended that the systems are sized correctly for the actual building loads to ensure the heat pumps are not oversized, which is common in old natural gas heating systems. Using the report and design loads, and the $ / MBH values provided by equipment manufacturers, an estimate was made for equipment costs per project. These were then adjusted to account for design and construction costs in Sonoma.

ELECTRIFICATION (CENTRAL PLANT)

Existing Conditions

The existing plant serves several buildings across campus and provides high temperature hot water for heating and domestic hot water needs. Currently, the existing natural gas fired boilers provide 100% of these heating loads, supplying approximately 200F hot water in the summer, with winter supply temperatures reaching 240F.

The existing plant operates continuously throughout the year to maintain loop temperatures. Loop temperature must be maintained as there are issues with the hot water piping distribution that results in pipe leaks when pipe temperatures are reduced. This results in natural gas being burned to maintain loop temperature and not to provide hot water load.

Old heating hot water to domestic hot water heat exchangers within buildings also require high temperature hot water as these have been sized for 240F entering hot water temperature. The use of these heat exchangers results in high temperature hot water being produced at times when heating loads are low.

Project Description

Limitations in the current technologies limit the ability for heat pumps to generate heating hot water at temperatures higher than 165F, thus ensuring that campus heating loads can be met with lower temperature water is key. To understand the required hot water supply temperature the campus should study how different buildings operate whilst in heating, and if higher temperature hot water is required as a result of specific buildings or specific air handling units.

Another key requirement for any electrified heating system is to ensure the systems are sized correctly. It has been identified that the current central heating plant needs to maintain high temperatures within the piping distribution network to avoid pipes contracting and leaking. The plant burns natural gas to ensure there are no leaks, not to provide heating, thus there are significant opportunities to reduce natural gas consumption through optimization of existing operations. Fixing the piping distribution network will allow the existing boilers to shut down when there are minimal campus heating loads, reducing natural gas consumption, and allow engineers to better size decarbonized heating systems based on actual heating loads on campus.

Recommendations

It is recommended that SSU provide a detailed engineering study to assess existing infrastructure and central plant electrification options. This is required to understand the full scope and cost of these projects. The campus should approach electrifying the central plant as a phased implementation. The first phase should provide necessary upgrades to campus hot water infrastructure that will allow heating hot water supply temperatures to be lowered. Making these upgrades will reduce the number of hours the boiler plant operates and will allow the condensing pony boilers to operate in their condensing temperature range, improving the overall plant efficiency.

The first phase of electrification can include the installation of a heat recovery chiller in the CUP. This allows heat from the chilled water return loop to be used to generate hot water using heat recovery technologies. This will partially electrify the CUP as existing gas pony boilers will be required to meet campus heating loads during the heating dominated winter season. The next phase of the CUP electrification process can include additional heat sources to maximize the heat recovery chiller operation and fully electrify the plant. Some potential heat sources include waste water heat recovery, geothermal wells, air-source heat pumps and electric boilers.

The following diagram shows the strategy, approach and rough order of magnitude (ROM) budget for a phased central plant electrification process.

PHASE 0 — **BASE UPGRADES**

- **STRATEGY:** Provide base heating hot water loop infrastructure & controls upgrades
- **APPROACH:** Fix water leaks, replace heat exchangers, reset supply temperatures
- **ROM BUDGET:** TBD *(requires engineering study)*

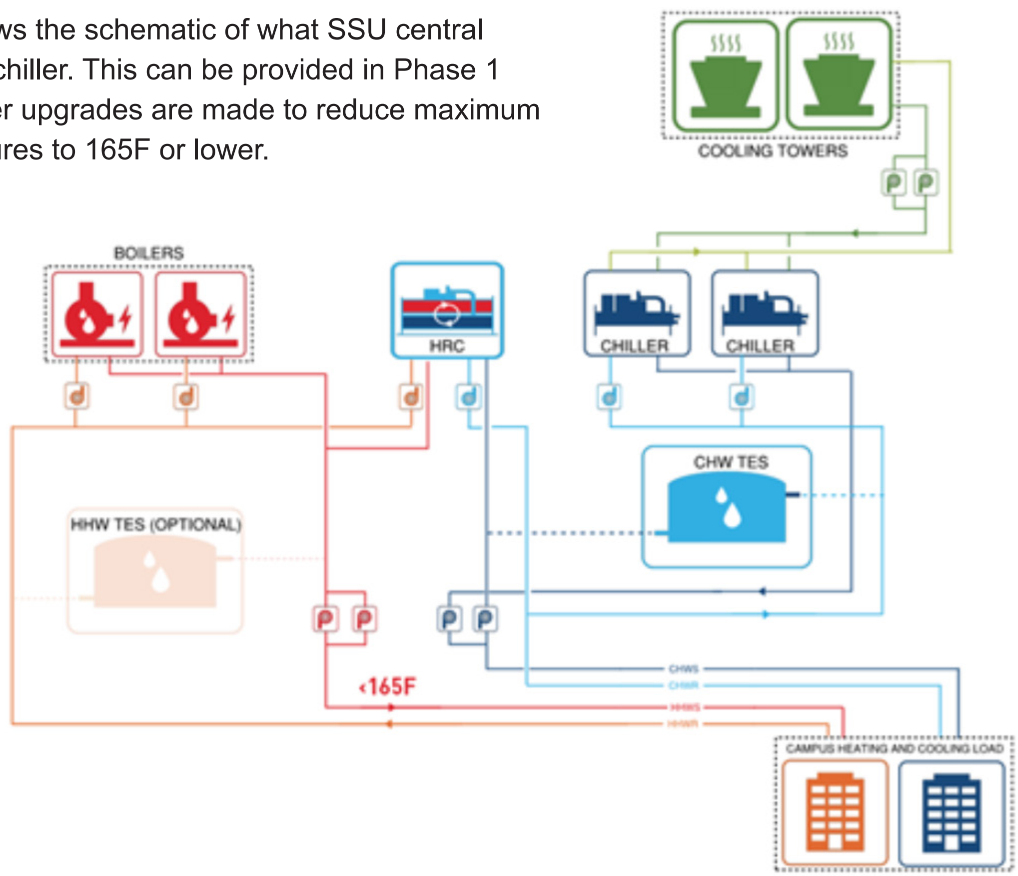
PHASE 1 — **PARTIAL ELECTRIFICATION**

- **STRATEGY:** Partial CUP electrification with heat recovery chillers
- **APPROACH:** Install at central plant (decentralized options are also possible)
- **ROM BUDGET:** $2.5-4 million

PHASE 2 — **99% ELECTRIFICATION**

- **STRATEGY:** Near full electrification with additional heating sources (long term)
- **APPROACH:** Various possible approaches (to be determined with addition assessment)
- **ROM BUDGET:** $4-10 million

The following diagram shows the schematic of what SSU central plant with a heat recovery chiller. This can be provided in Phase 1 after base heating hot water upgrades are made to reduce maximum hot water supply temperatures to 165F or lower.



Analysis Methodology

The campus hot water load profile was developed using a combination of trends from the building automation system showing actual usage and central heating plant natural gas consumption trends. Using these data sources, the monthly heating load profile was determined, and estimates for equipment sizes could be made to electrify the hot water production. Natural gas saved was estimated based on the efficiency of heat recovery and heat pump technologies.

The central plant electrification projects were priced on a $ / MBH basis. Equipment capacities were determined to optimize simultaneous heating and cooling efficiencies and allow the campus to fully decarbonize the hot water production. The base heating hot water plant upgrade (Phase 0) is a deferred maintenance project that includes repairing leaks, heat exchanger replacements and system optimization to reduce heating hot water temperatures. Since little is known about the extent of the leakage in the system, costs have not been estimated for this project.

OBJECTIVE 2 – INCREASE RENEWABLE ENERGY GENERATION

On-Site Solar (Net-Metered Projects)

Where technically and economically feasible, SSU can install solar PV systems on campus facilities and parking lots to decrease the carbon intensity of the campus electricity supply and reduce utility costs. Solar systems installed on campus on the customer side of the meter are eligible for net energy metering (NEM) through Pacific Gas & Electric, as long as the total production of the system is less than or equal to 100% of the campus' electricity usage. Prior to the beginning of the CNR planning process, SSU had already procured a large on-site solar and battery storage project and selected SunPower as the preferred vendor. This project jumpstarts SSU's progress on CNR implementation and will provide important information (e.g. interconnection capacity of PG&E distribution system) and experience to support any future on-site solar development. A summary of potential solar projects identified, divided into phases and including the project already underway, is provided in the table below. Based on 2019 electricity usage, if all projects below are developed solar production will account for 49.5% of SSU's total electricity usage. As electricity demand increases due to vehicle and building electrification, this percentage is likely to fall.

Project Name	Estimated Size (kW)	Estimated Production (kWh)	Estimated NPV ($)
Phase 1			
Lots J & F (contracted)	*5,037*	*7,361,412*	*3,932,995*
Phase 2			
Lot E (Carport)	556	921,647	-137,225
Lot A (Carport)	285	433,204	-134,665
Lots L, M, N & O (Carport)	2,066	3,409,847	178,633
Phase 3			
Green Music Center (Ground Mount)	1,474	2,280,590	267,272
Lot D (Carport)	408	678,694	-94,966

***Table A**: A Summary of solar projects identified and estimated NPV.*

OBJECTIVE 3 –INCREASE VEHICLE FLEET EFFICIENCY & FUEL SWITCHING

Streamlining Fleet Management

There are several policy and procedure changes that SSU should consider to support fleet electrification. First, it may be necessary for the campus to adopt a vehicle purchasing policy that requires electric alternatives to first be considered for each vehicle being replaced. Currently, the campus has no formal vehicle replacement plan or procurement policy and the decentralized nature of vehicle purchasing has the potential to result in purchases that do not align with the campus' larger carbon neutrality goals. Second, while a small vehicle fleet does not require the robust data collection and vehicle monitoring that a larger fleet does, formalizing and improving data collection related to asset usage (fuel, mileage) will help support vehicle purchase decisions. Currently, SSU does not track vehicle mileage and can only access fuel information through fuel card invoices which are difficult to digest. Improving vehicle data by requiring department's to submit monthly mileage reports from their vehicles will provide fleet staff with additional data needed to justify purchases.

Fleet Electrification & Infrastructure Deployment

As discussed previously, the first step in assessing the long-term electrification of the campus fleet was to identify an estimated replacement year for each vehicle and create a "replacement timeline". Currently, the university does not have an established set of vehicle replacement criteria and vehicles remain in use "until the doors fall off". Without established practices, industry best practices for vehicle lifespan (5-10 years, depending on type) and lifetime utilization (70,000-100,000 miles, depending on vehicle type) were used to establish a replacement timeline, shown below in **Figure I**.

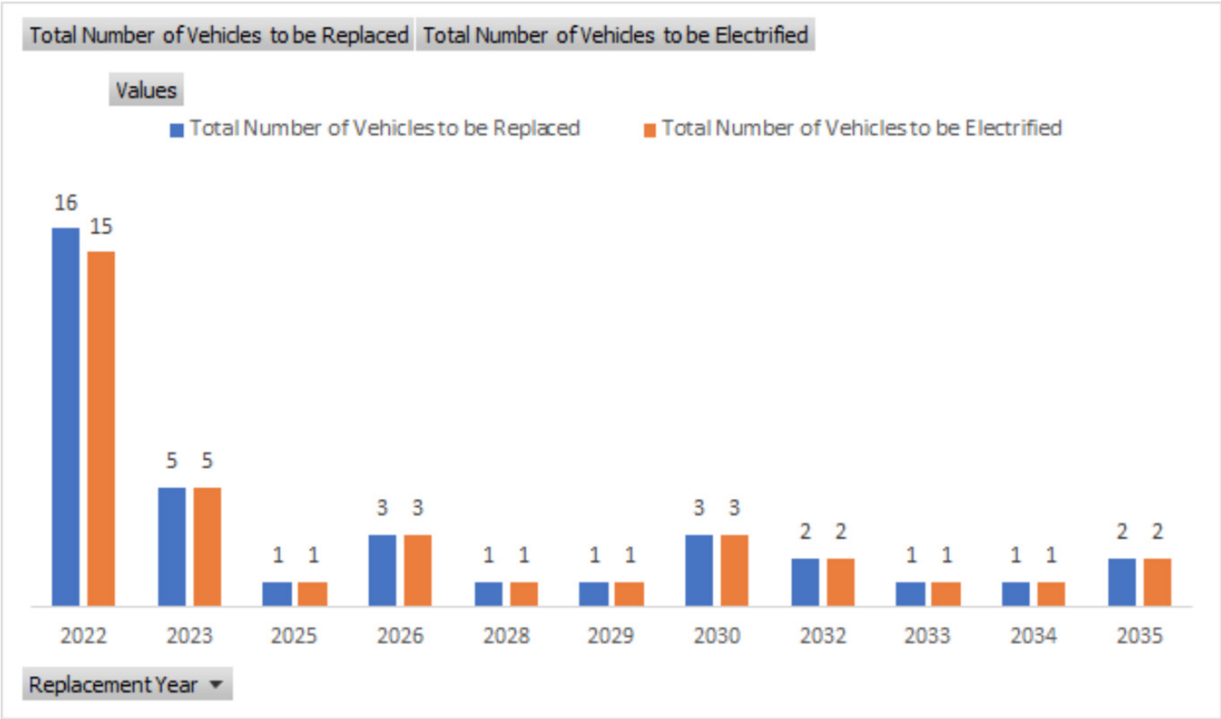


***Table I**: SSU Campus Fleet Replacement Timeline*

There are several challenges relating to additional on-site solar development that will need to be addressed by SSU prior to procurement. First, given the expected development timeline for future Phases, it is likely that these projects will not be installed until after California updates its NEM rules. Thus, the economics of additional solar under the so-called NEM 3.0 regime will need to be understood before Phases 2 and 3 are implemented. Additionally, there is significant uncertainty about the capacity of the distribution grid feeding the SSU campus to accept solar exports. SSU should use the interconnection process completed during Phase 1 to gather additional information from PG&E related to the technical feasibility of expanding on-site solar capacity via NEM interconnection.

RESILIENCE AND BATTERY STORAGE

Since energy storage does note contribute additional renewable energy generation, the role of batteries and other storage technologies was not analyzed in detail during the CNR process. However SSU's current soloar + storage project is expected to be converted into a microgrid soon after installation, providing uninterrupted power to five priority building on campus. Additional on-site solar generation will increase the ability for on-site energy storage to provide valuable resilience benefits to SSU, potentially enabling expansin of the microgrid to additional campus facilities.

Given the past impacts of wildfires on SSU's operations and the university's carbon neutrality goal, leveraging on-site renewable generation for carbon-free will continue to be extremely important in achieving SSU's sustainability goals at large.

Potential on-site solar projects were identified, designed and modeled using a licensed solar modeling software called HelioScope. Initial meetings with SSU staff revealed that during past solar efforts carport arrays were preferred over rooftop or ground mount installations. This preference stemmed from a desire to take advantage of the large parking lots on campus, the old age of most campus roofs and the small, relative to carports, potential of rooftop installations. With this prioritization in mind, Initial conceptual solar designs were created and vetted with campus staff. Project locations were then grouped into potential implementation phases based on the ease of installation (proximity to campus switchgear) and desirability of the location. For example, it was identified that a ground mount project located next to the Green Music Center might impact the operations of certain campus events, so that project was included in Phase 3. Once all potential projects were established, expected solar production was simulated in HelioScope and input into the CESA tool.

System costs (both capital costs and PPA rates) were also estimated for each potential solar array based on market data for an all-in dollar per watt ($/Watt) cost.

This replacement timeline could be accelerated or delayed depending on budget availability. Based on historical vehicle replacement practices and budget availability, it is likely to be delayed.

Following creation of the replacement timeline, a recommended EV Type was assigned to each existing vehicle based on EV models currently available in the market. Based on the data provided and understanding of vehicle operations, every on-road vehicle in the campus fleet, except one “bucket truck”, has an appropriate electric vehicle currently available in the market. However, some of the university’s medium- and heavy-duty vehicles, as well as specialized vehicles (e.g. street sweeper), have limited electric models available or only have custom-built chassis conversions (.e.g the SEA Electric Isuzu NPR) options available, both of which may be financially prohibitive at present.

To understand the costs of owning and operating a new EV compared to a new internal combustion engine (ICE) vehicle, the analysis also assessed vehicle electrification on a total cost of ownership (TCO) basis. TCO is a function of vehicle capital cost, operating costs (fuel, maintenance) and resale value. Generally, as the upfront costs of EVs have fallen in recent years, light-duty EVs have experienced a lower TCO than their ICE counterparts due to reduced fueling (charging) and maintenance costs. In the case of SSU, however, due primarily to the low mileage nature of most university vehicles, only the Campus Police/Safety and Parking Vehicles are likely to experience TCO savings (~$125,000 over the lifespan of the vehicles) if electrified. Since the majority of savings resulting from vehicle electrification stem from reduced operating costs, low usage vehicles without already high operating costs do not have a large savings opportunity when electrified. However, given the rapidly changing nature of the EV market, it is recommended that, prior to any new vehicle replacement, SSU completes a detailed assessment of all available EVs on a TCO basis prior to making a replacement decision.

Regardless of the specific EV models being purchased by SSU, long-term EV charging infrastructure planning is necessary to enable any widespread fleet electrification effort. Accordingly, charging infrastructure needs were identified for each domicile facility currently in use by the campus fleet. Currently, fleet vehicles are scattered across the campus with many domicile locations housing only a single vehicle. After completing an initial infrastructure cost estimate, it became clear that maintaining the current parking strategy would lead to unnecessarily high infrastructure costs, resulting primarily from increased trenching costs and increased project overhead related to managing multiple projects. Thus, after discussion with SSU staff, final infrastructure recommendations included an additional “parking centralization” aspect designed to reduce the infrastructure cost related to fleet electrification. EV infrastructure recommendations were combined into three locations, two of which already house a significant number of vehicles (the Facilities Corp Yard and the Police Lot) and a third (Lot D) that would require changing the parking location of a handful of vehicles around campus. Long-term charging needs for each centralized charging location are included in the table below.

Centralized Parking Location	**Estimated Number of Electric Vehicles (2035)**	**Estimated Number of L2 Charging Ports (2035)**
Facilities Corp Yard	14	5
Police Lot (R4)	6	5
Lot D	16	7

Given the high-level nature of the analysis, standard Level 2 commercial charging stations were assumed for all locations. Generally, Level 2 charging is expected to be sufficient given the short daily mileage and long dwell-times common across the fleet. Additionally, a vehicle to charger ratio of 1 to 1 is not likely to be necessary, as vehicles will be able to operate for multiple days on a single charge. In some cases, such as the Campus Police, a single fast charger may be required to ensure vehicle uptime.

Beyond on-road vehicles, an additional project related to cart electrification was assessed and included in the CESA tool. Electrification of the university's 24 remaining gas Kawasaki Mules has been contemplated in the past but was deferred due to budget constraints. It is recommended that this project be implemented as soon as possible.

Analysis

Figure J summarizes the fleet electrification analysis completed to inform the CNR. The analysis addressed all active vehicles in the University's fleet, and was intended as a high level summary of the University fleet's electrification potential. A detailed site by site analysis may still be needed to guide implementation.

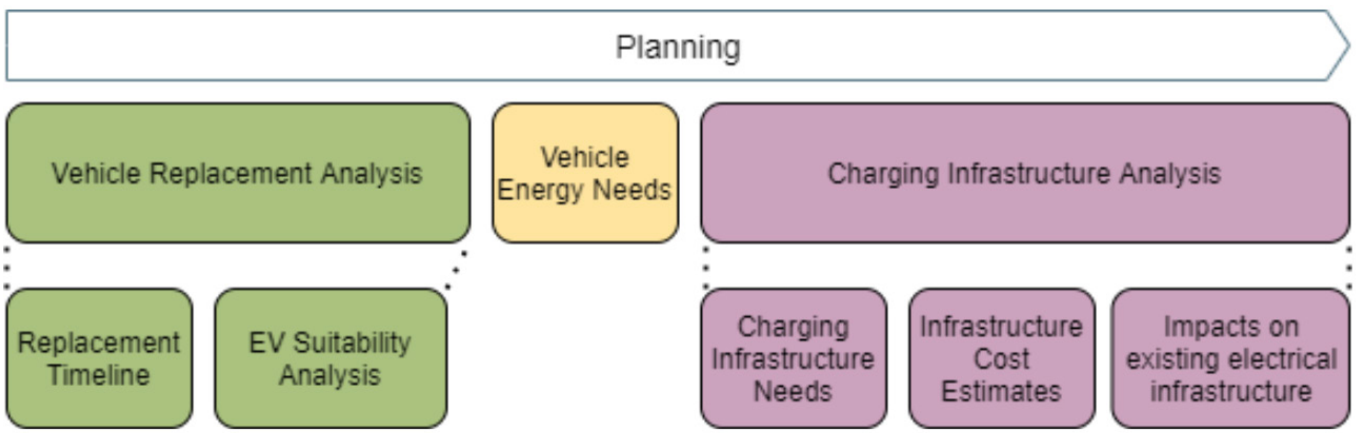


***Figure J**: Fleet electrification analysis*

SSU vehicle data including vehicle body type, vehicle department, gross vehicle weight, expected vehicle lifespan and annual mileage were used to calculate a replacement year, "best fit" electric vehicle type and estimated annual electrical energy required for each existing vehicle. Data was provided by SSU and gathered by the Project Team using an online "VIN decoder" that enables identification of specific vehicle attributes based on the Vehicle Identification Number (VIN). These calculations, combined with data on fuel cost, electricity cost and assumptions on estimated maintenance costs, enabled the creation of a vehicle replacement timeline and total cost of ownership savings estimates. Vehicle parking locations were assigned to each vehicle based on information provided by SSU staff. This data was used to inform vehicle charging infrastructure estimates based on the total electric vehicle charging load expected at each facility/parking lot in question. Infrastructure needs were determined for all parking facilities/locations currently used by the campus fleet. However, as discussed above, in order to minimize infrastructure costs, specifically potential trenching and installation costs, several recommendations were made to centralize vehicle parking into a handful of locations in coordination with electrification. Once the centralization recommendations were established, infrastructure cost was estimated based on charger hardware costs, install costs, trenching costs and contingency to account for university design and engineering costs.